Fortescue Valley Flora and Vegetation Survey

Fortescue Metals Group Limited

ecoscape

VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
Draft rev0	Lyn Atkins Stephen Kern	 Jared Nelson Group Leader Environment	 Jared Nelson Group Leader Environment	4/12/2017
Final	Lyn Atkins	 Marc Wohling, Director-Environment	 Marc Wohling, Director-Environment	28/03/2018

Direct all inquiries to:
Ecoscape (Australia) Pty Ltd
9 Stirling Highway • PO Box 50 NORTH FREMANTLE WA 6159
Ph: (08) 9430 8955 Fax: (08) 9430 8977

TABLE OF CONTENTS

FIGURES

TABLES

MAPS

PLATES

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Ecoscape would like to acknowledge the assistance of Matt Dowling, Senior Environment Advisor, Fortescue Metals Group Limited.

Ecoscape would also like to acknowledge the various tenement holders and pastoralists and their contacts within the study area that permitted Ecoscape to access their lands and were available in case of emergency:

- Rio Tinto (David Raison, Yandi Emergency Services Superintendent)
- BHP (Jay Boffey and Simon Wheeler, Field Supervisors)
- BCI/Polaris Metals (Les Purves, Senior Environmental Advisor)
- Brockman Mining (Blair Smith, General Manager, Operations)
- Hancock Prospecting/HPPL (Ben Lamb, Tenement Officer)
- Roy Hill (Annie Oxford, Specialist Tenements and Land Tenure).

During the September field survey Ecoscape was hosted by Mineral Resources at its Phil's Creek camp. Ecoscape gratefully acknowledges MinRes' assistance.

Parts of the field surveys were also conducted while Ecoscape personnel were based at Fortescue's Cloudbreak and Christmas Creek villages.

EXECUTIVE SUMMARY

Fortescue Metals Group Limited (Fortescue) currently operates four mines in Western Australia and holds a number of exploration tenements in varying stages of development. In order to understand key environmental factors that may be impacted by future developments, including mines and associated infrastructure, and indirectly impacted by other factors, Fortescue conducts a range of surveys to allow for quality environmental assessment.

Fortescue appointed Ecoscape to conduct a detailed flora and vegetation survey of the Upper Fortescue Valley to identify key environmental factors should it proceed with developing the Nyidinghu (or other nearby) tenements in the eastern Hamersley Range.

The Fortescue Valley study area occupied 230,934 ha and included part of the Fortescue Marsh and areas on the northern flanks of the Hamersley Range. A number of previous surveys have been conducted in parts of the study area, including a Fortescue Marsh survey by the then Department of Parks and Wildlife (DPaW). The results of these surveys were taken into account during the survey.

The desktop assessment identified the following significant factors known to be associated with the study area:

- the P1 *Fortescue Marsh (Marsh Land Systems)* Priority Ecological Community (PEC), the P3 *Vegetation of sand dunes of the Hamersley Range/Fortescue Valley* PEC and the P3 *Narbung Land System* PEC all occur (or partly occur) within the study area
- the Fortescue Marsh is listed in the Directory of Important Wetlands of Australia as a *Wetland of National Significance* and is being considered for inclusion as a Ramsar site; significant portions of the Marsh are under the management of the Department of Biodiversity, Conservation and Attractions (DBCA) for conservation purposes, and are pastoral exclusion areas
- a number of flora and vegetation surveys have been conducted within or partly within the study area, including the DPaW floristic and mapping survey of the Fortescue Marsh
- 80 conservation significant flora species have been identified as occurring within 40 km of the study area, 19 of which occur within it
- as well as vegetation representative of the known PECs within the study area, Mulga vegetation (particularly Sheet Flow Dependent Vegetation) and Groundwater Dependent Ecosystems have been identified as being significant.

Ecoscape conducted a two phase detailed flora and vegetation survey of the study area during June and September 2017. The seasonal conditions were considered excellent with above average rainfall prior to the first survey.

Ecoscape established 186 new floristic quadrats in 2017, scoring 110 of these during both phases, and rescored 22 previously established quadrats (representative of one per previously mapped vegetation type). Overall, 506 quadrats have been recorded within the study area, most of which have been scored over two phases.

A total of 522 vascular flora species were identified, including:

- 17 conservation significant flora species; all were listed as Priority Flora by DBCA (although one former TF is still listed as Vulnerable under the Commonwealth EPBC Act despite being delisted in Western Australia): *Eremophila spongiocarpa* (P1), *Euphorbia inappendiculata* var. *queenslandica* (P1), *Myriocephalus scalpellus* (P1), *Nicotiana heterantha* (P1), *Samolus* sp. Fortescue Marsh (A. Markey & R. Coppen FM 9702) (P1), *Synostemon hamersleyensis* (P1), *Tecticornia globulifera* (P1), *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063) (P1), *Euphorbia australis* var. *glabra* (P2), *Euphorbia inappendiculata* var. *inappendiculata* (P2*), Isotropis parviflora* (P2), *Atriplex flabelliformis* (P3), *Sida* sp. Barlee Range (S. van Leeuwen 1642) (P3), *Tecticornia medusa* (P3), *Eremophila youngii* subsp. *lepidota* (P4), *Goodenia nuda* (P4), *Lepidium catapycnon* (DPAW P4, EPBC VU).
- 17 introduced species (weeds) although none were Declared Pest plants or Weeds of National Significance; two were considered to have a significant ecological impact in the study area : **Cenchrus ciliaris* and **Cenchrus setiger*

Forty one vegetation types, derived from a combination of structural composition and floristic analysis and taking into account previous mapping, were recorded. Of these, 26 were associated with the valley landform, one occurred on sand dunes, one was associated with riparian areas, two were associated with claypans, seven occurred on the Fortescue Marsh, one occurred on low undulating hills, and three on higher hills and plateaux. The vegetation types considered of significance were:

- the seven vegetation types associated with the Fortescue Marsh land system and within the Marsh landform (and therefore included in the *Fortescue Marsh* PEC), dominated by *Tecticornia* species or *Muellerolimon salicorniaceum* (vegetation types **Ms**, **Ta[1]**, **Ta[2]**, **TD**, **Ti**, **Tm** and **Tv**); these are also considered to be representative of Groundwater Dependent Ecosystems (GDEs)
- the vegetation associated with the Vegetation of sand dunes of the Hamersley Range/Fortescue Valley PEC dominated by *Acacia dictyophleba* and *Aristida holathera* var. *holathera* (vegetation type **AdAh**)
- GDEs or potential GDEs dominated by *Eucalyptus victrix* or *Melaleuca xerophila* (that DPaW considers likely to be phreatophytic in the Marsh); vegetation type **EvAcCc** associated with riparian areas, vegetation types **EvDf** and **EvDfEb** associated with clay pans, vegetation type **EvMxTl** associated with clay depression, and vegetation type **MxCc** on low-lying parts of the Fortescue Valley
- Mulga-dominated vegetation typically dominated by *Acacia aptaneura* in the study area; vegetation types **AaAsCc**, **AaAtRa**, **AaEfEp**, **AaTp** and **AaSaEp**. The latter is considered to be representative of Sheet Flow Dependent Vegetation.
- vegetation types associated with the Narbung Land System, part of which is included in the *Narbung Land System* PEC; **AxEcTe**, **AaEfEp**, **AaSaEp**, **AaTp**, **AbTl**, **AsTe**, **AxEcSc**, **EvMxTl**, **EyAb** and **Tl**.

The vegetation condition ranged from Completely Degraded to Excellent, with less than 10% of the total extent being in Completely Degraded, Degraded and Poor condition.

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Fortescue Metals Group Limited (Fortescue) is an iron ore producer based in Western Australia. It operates an integrated business comprising of mines and supporting rail and port operations in the Pilbara region of Western Australia, with its head office based in Perth. Currently, Fortescue operates four mines; two in the Chichester Range (Cloudbreak and Christmas Creek) and two in the Hamersley Range (Firetail and Kings Valley).

In order to maintain its position as one of the world's leaders in the production of iron ore, Fortescue also holds a number of exploration tenements at various stages of development, including Nyidinghu in the eastern Hamersley Range.

To support future environmental approvals, should the Nyidinghu (or other nearby) tenements be developed, Fortescue requires a thorough understanding of the key environmental factors that may be directly impacted by its developments that include mines, support facilities and transport infrastructure (roads, rail, conveyors) and indirectly impacted by other factors such as hydrological change due to altered surface and subsurface water flows, including as a result of groundwater abstraction, mine dewatering and reinjection. Fortescue undertakes a range of surveys in order to understand the size and scale of these impacts to allow for quality environmental assessment.

1.2 PROJECT PURPOSE

Fortescue appointed Ecoscape to undertake a detailed flora and vegetation survey of the Upper Fortescue Valley. The primary purpose of the survey was to:

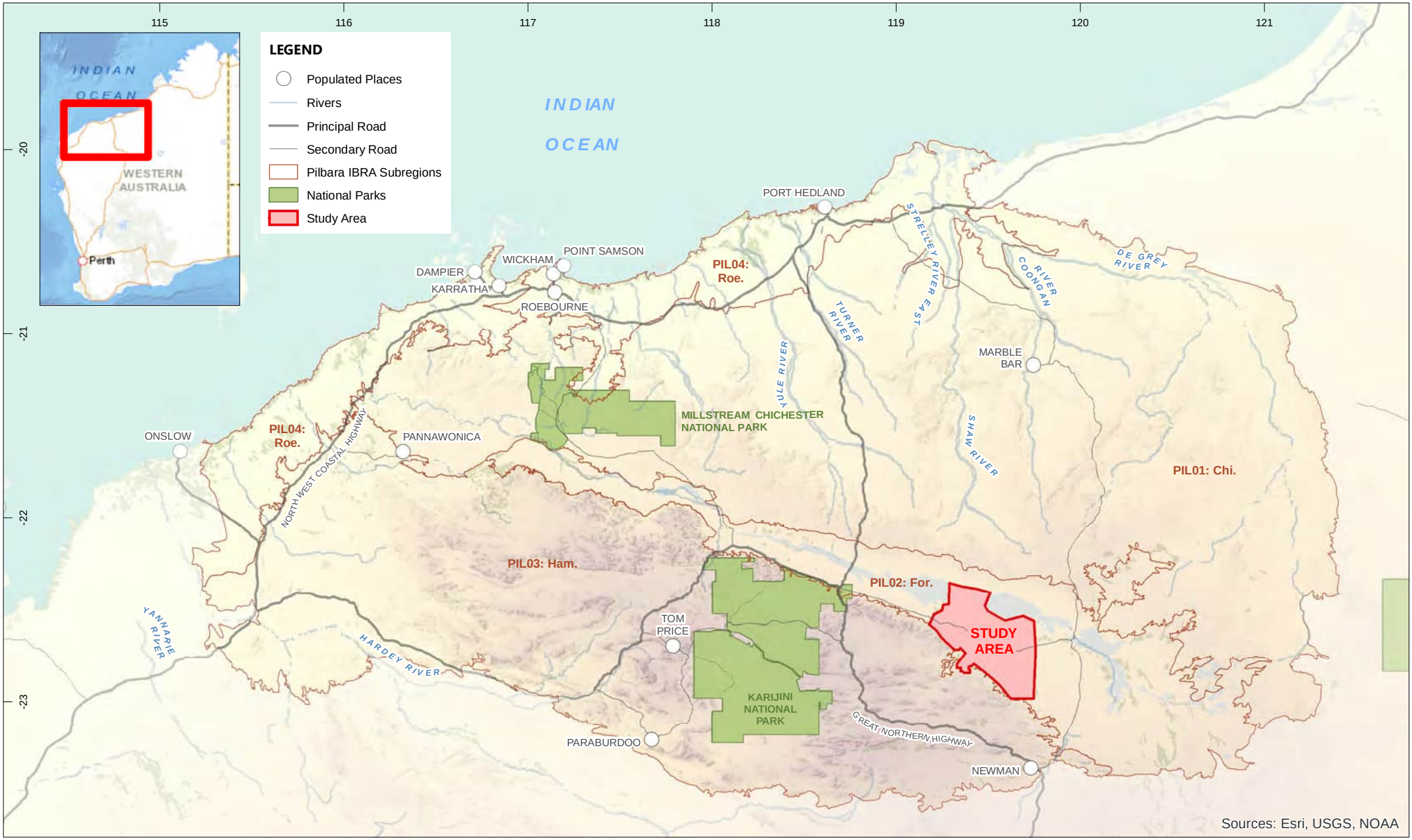
- identify and map vegetation types
- locate occurrences of conservation significant ecological communities
- conduct targeted conservation significant flora searches.

The survey was required to be conducted in accordance with Environmental Protection Authority (EPA) guidance and Fortescue's (2014) *Flora and Vegetation Assessment Guidelines* (100-GU-EN-0005).

1.2.1 PROJECT SCOPE

The scope of works was to conduct a detailed flora and vegetation survey that includes:

- a desktop assessment including a literature review and demonstrating that the survey meets the relevant guidelines
- a field survey at optimal times that includes:
  - establishment and sampling of new floristic quadrats ('quadrats') in areas not yet surveyed, over two phases
  - re-sampling of previously established quadrats to re-confirm vegetation mapping and condition
  - describing and mapping of vegetation types, particularly where they may represent a conservation significance ecological community
  - describing and mapping vegetation condition, including identifying and recording the abundance of weeds
  - targeted conservation significant flora searches
- a comprehensive flora and vegetation assessment report that includes:
  - desktop and field survey methods, results and discussion
  - regional statistical assessment of floristic data to demonstrate wider occurrence of vegetation types found to be of limited spatial distribution
- preparation of digital data to Fortescue's standards.



SCALE: 1:3,000,000 @ A4
COORDINATE SYSTEM: GCS GDA 1994
DATUM: GDA 1994
UNITS: DEGREE

ecoscape

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	27/11/2017

N 0 20 40 60 80 100 km (approx.)

REGIONAL LOCATION OF THE STUDY AREA

FORTESCUE VALLEY FLORA AND VEGETATION SURVEY
CLIENT: FORTESCUE METALS GROUP

FIGURE 01

1.3 STUDY AREA

The study area occupies 230,934 ha within the Pilbara bioregion of Western Australia, in the Shire of East Pilbara (**Figure 1**). It is located within the Upper Fortescue Valley and corresponds with part of the Fortescue Marsh and areas on the northern flanks of the Hamersley Range.

Portions of the study area have been previously subject to a two phase Level 2 flora and vegetation survey (Cardno 2012a; 2012b; 2012c) and two season DPAaW floristic survey of the Fortescue Marsh (Markey 2016).

1.4 STATUTORY FRAMEWORK AND GUIDANCES

This assessment was conducted in accordance with Commonwealth and State legislation and guidelines:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Western Australian *Wildlife Conservation Act 1950* (WC Act)
- Western Australian *Environmental Protection Act 1986* (EP Act)
- Western Australian *Biodiversity Conservation Act 2016* (BC Act), partly enacted
- Department of Environment Water Heritage and the Arts (2009) *Matters of National Environmental Significance. Significant impact guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999.*

In addition, the Minister for the Environment has published lists of flora species in need of special protection because they are considered rare, likely to become extinct, or are presumed extinct. The current listings were published in the *Government Gazette* on 6 January 2017 (Government of Western Australia 2017) and were taken into account.

As well as those listed above, the assessment complied with the EPA requirements for environmental survey and reporting in Western Australia, as outlined in:

- EPA (2016d) *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment*, known as *Flora and Vegetation Technical Guidance*
- EPA (2016c) *Statement of Environmental Principles, Factors and Objectives*.

1.4.1 WESTERN AUSTRALIAN BIODIVERSITY CONSERVATION ACT 2016

The Western Australian *Biodiversity Conservation Act 2016* (BC Act, the Act), parts of which were enacted on 21 September 2016, provides for the conservation, protection and ecologically sustainable use of biodiversity and biodiversity components in Western Australia. The BC Act replaces the *Wildlife Conservation Act 1950*. The parts of the BC Act currently in effect are listed on the DBCA website (BDCA 2017, accessed 17 September 2017).

Threatened species (both flora and fauna) that meet the categories listed within the Act are highly protected and require authorisation by the Ministerial to take or disturb. These are known as Threatened Flora and Threatened Fauna. The conservation categories of critically endangered, endangered and vulnerable have been aligned with those detailed in the EPBC Act, as below.

Flora and fauna species may be listed as being of special conservation interest if they have a naturally low population, restricted natural range, are subject to or recovering from a significant population decline or reduction of range or are of special interest, and the Minister considers that taking may result in depletion of the species. Migratory species and those subject to international agreement are also listed under the Act. These are known as specially protected species in the Act.

Threatened Ecological Communities are also protected under the Act and are categorised using the same criteria as threatened species.

At the time of writing this report, only some sections of the BC Act have been enacted, with the remaining sections yet to be proclaimed including those relating to penalties for breaches of the Act's provisions. As species of conservation interest (Specially Protected Species) and Threatened Ecological Communities are not included in the WC Act, there is currently no specific legal protection afforded to these within Western Australia beyond the usual protection of unlisted species and native vegetation under the Native Vegetation

Clearing Regulations (Government of Western Australia 2004), unless they are protected under the Commonwealth EPBC Act.

1.4.2 WESTERN AUSTRALIAN ENVIRONMENTAL PROTECTION ACT 1986

The Western Australian *Environmental Protection Act 1986* was created to provide for an Environmental Protection Authority (the EPA) that has the responsibility for:

- prevention, control and abatement of pollution and environmental harm
- conservation, preservation, protection, enhancement and management of the environment
- matters incidental to or connected with the above.

The EPA is responsible for providing the guidance and policy under which environmental assessments are conducted. It conducts environmental impact assessments (based on the information included in environmental assessments and provided by the proponent), initiates measures to protect the environment and provides advice to the Minister responsible for environmental matters.

1.4.3 COMMONWEALTH ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

At a Commonwealth level, Threatened taxa are protected under the EPBC Act, which lists species and ecological communities that are considered Critically Endangered, Endangered, Vulnerable, Conservation Dependent, Extinct, or Extinct in the Wild (detailed in **Table 13** in **Appendix One**).

1.4.4 FLORA

1.4.4.1 Threatened and Priority Flora

Conservation significant flora species are those that are listed as TF (Threatened Flora) and (within Western Australia) as PF (Priority Flora). TF species are listed as threatened by the Western Australian DBCA, formerly known as DPaW, and protected under the provisions of the BC Act. Some State-listed TF are provided with additional protection as they are also listed under the Commonwealth EPBC Act.

Flora are listed as PF where populations are geographically restricted or threatened by local processes, or where there is insufficient information to formally assign them to TF categories. Whilst PF are not specifically listed in the BC Act, some may qualify as being of special conservation interest and these have a greater level of protection than unlisted species.

There are seven categories covering State-listed TF and PF species (DPaW 2017) which are outlined in **Table 14** in **Appendix One** (noting that the definitions for TF included in the BC Act have been aligned with those in the EPBC Act). PF for Western Australia are regularly reviewed by DBCA whenever new information becomes available, with species status altered or removed from the list when data indicates that they no longer meet the requirements outlined in **Table 14**.

1.4.4.2 Other Significant Flora

According to the *Flora and Vegetation Technical Guidance* (EPA 2016d) other than being listed as Threatened or Priority Flora, a species can be considered as significant if it is considered to be:

- locally endemic or association with a restricted habitat type (e.g. GDEs or SFDV as above)
- a new species or has anomalous features that indicate a potential new species
- at the extremes of range, recently discovered range extensions (generally considered greater than 100 km or in a different bioregion), or isolated outliers of the main range)
- unusual species, including restricted subspecies, varieties or naturally occurring hybrids
- relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

1.4.4.3 Introduced Flora

Introduced plant species, known as weeds, are plants that are not indigenous to an area and have been introduced either directly or indirectly (unintentionally) through human activity. Species are regarded as introduced if they are listed as 'alien' on *FloraBase* (Western Australian Herbarium [WAH] 1998-2017).

Weeds of National Significance (WONS)

At a national level there are thirty-two weed species listed as Weeds of National Significance (WONS) (Weeds Australia 2012). The Commonwealth *National Weeds Strategy: A Strategic Approach to Weed Problems of National Significance* (2012) describes broad goals and objectives to manage these species.

Declared Plants

The Western Australian Organism List (WAOL) details organisms listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act). Under the BAM Act, Declared Pests are listed as one of the three categories: (Government of Western Australia 2007)

- C1 (exclusion), that applies to pests not established in Western Australia; control measures are to be taken to prevent their entry and establishment
- C2 (eradication), that applies to pests that are present in Western Australia but in low numbers or in limited areas where eradication is still a possibility
- C3 (management), that applies to established pests where it is not feasible or desirable to manage them in order to limit their damage.

1.4.5 ECOLOGICAL COMMUNITIES AND VEGETATION

1.4.5.1 Threatened and Priority Ecological Communities

Nationally Listed Threatened Ecological Communities

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat (Department of Environment and Conservation 2010; Government of Western Australia 2016b). At Commonwealth level, Threatened Flora and Threatened Ecological Communities (TECs) are protected under the Commonwealth EPBC Act. An ecological community may be categorised into one of the three sub-categories:

- Critically Endangered, if it is facing an extremely high risk of extinction in the wild in the immediate future.
- Endangered, if it is not critically endangered and is facing a very high risk of extinction in the wild in the near future.
- Vulnerable, if it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

State Listed Threatened Ecological Communities

The Western Australian DBCA also maintains a list of TECs which are further categorised into three subcategories much like those of the EPBC Act. The full details of DBCA criteria are shown in **Table 15** in **Appendix One**.

State Listed Priority Ecological Communities

DBCA maintains a list of Priority Ecological Communities (PECs). PECs include potential TECs that do not meet survey criteria, or that are not adequately defined.

1.4.5.2 Other Significant Vegetation

Groundwater Dependent Ecosystems

Groundwater Definition

Groundwater is water that is found in the saturated zone of the soil, where all soil pores are filled with water. The water table is the upper surface of the saturated zone in an unconfined aquifer. Groundwater may also

occur as a perched aquifer located above unsaturated rock formations as a result of a discontinuous permeable layer or held under pressure in a confined aquifer (Goulburn-Murray Water 2010).

Groundwater Dependent Ecosystems Definition

Groundwater Dependent Ecosystems (GDEs) have been defined as ecosystems that are dependent on groundwater for their survival at some stage or stages of their lifecycle, however groundwater use cannot be equated with groundwater dependence (Eamus 2009b). In some contexts, GDEs are also known as Groundwater Dependent Vegetation.

Hatton and Evans (1998) identified four types of GDEs based on their geographic setting: terrestrial vegetation (vegetation communities and dependent fauna that have seasonal or episodic dependence on groundwater), river base flow systems (aquatic and riparian ecosystems that exist in or adjacent to streams that are fed by groundwater base flow), aquifer and cave ecosystems, and wetlands.

Eamus *et al.* (2006) identified three primary classes based on type of groundwater reliance:

1. Aquifer and cave ecosystems.
2. All ecosystems dependent on the surface expression of groundwater:
    a) river base flows
    b) wetlands, swamplands
    c) seagrass beds in estuaries
    d) floodplains
    e) mound springs
    f) riparian vegetation
    g) saline discharge to lakes
    h) low lying forests.
3. All ecosystems dependent on the subsurface presence of groundwater, often accessed via the capillary fringe (non-saturated zone above the water table) when roots penetrate this zone:
    a) River Red Gum (*Eucalyptus camaldulensis*) forests
    b) Banksia woodlands
    c) Riparian vegetation in the wet/dry tropics.

GDEs in the Pilbara are generally determined to be vegetation associated with riparian areas. GDEs dependent on the surface expression of groundwater (Eamus *et al.* 2006 class 2) includes vegetation associated with wetlands (permanent or semi-permanent pools) within riparian areas, and generally includes *Melaleuca argentea* in association with other species described below. GDEs associated with the subsurface presence of groundwater (Eamus *et al.* 2006 class 3) includes riparian vegetation characterised by the phreatophytic species described below.

Direct impacts on GDEs i.e. clearing, and indirect impacts, including from dewatering and reinjection, frequently feature as being a significant environmental impact in mining approvals documents e.g. (Office of the Appeals Convenor 2016c; 2016d; Rio Tinto 2016).

Phreatophytic Species

Phreatophytic species rely on groundwater sources for water intake (Maunsell Australia Pty Ltd 2006); essentially the water requirements of phreatophytes are greater than can be provided from the surface soil profile (e.g. riparian vegetation) or they are dependent on free water availability (e.g. wetland species). They frequently show low tolerance to extended water stress due to a lack of physiological and/or morphological adaptation to drought, and respond to significant water deficit by a decline in health and eventual death (*ibid.*).

Obligate phreatophytes are dependent on free access to water (i.e. they are wetland species) whereas facultative phreatophytes can switch their water source between the soil surface profile in times of rain, to groundwater in times of drought when the soil surface profile (vadosphere) is depleted (Grierson 2010).

Phreatophytic species likely to occur in the study area include:

- *Eucalyptus camaldulensis* subsp. *refulgens*, which is regarded as a facultative phreatophyte that is dependent on groundwater for part of its lifecycle and/or in times of drought. This species has been reported to be tolerant of groundwater falls of up to 4 m per year (Maunsell Australia Pty Ltd 2006), has both lateral and sinker roots and is tolerant of waterlogging (Grierson 2010).
- *Eucalyptus victrix*, which may be regarded as a facultative phreatophyte. It is considered to be relatively drought tolerant and likely to be tolerant of gradual declines to the water table (to a degree) (Maunsell Australia Pty Ltd 2006). *Eucalyptus victrix* has lateral and sinker roots (i.e. a dimorphic root system) but is not tolerant of waterlogging (Grierson 2010). There is some conjecture that this species is actually a vadophyte (i.e. relies on water from within the soil surface profile, and is independent of groundwater; Equinox Environmental 2017) or, at best, weakly phreatophytic (Resource and Environmental Management Pty Ltd 2007). Depth to groundwater is likely to be an important indicator of groundwater dependence (Equinox Environmental 2017).
- wetland species such as *Melaleuca argentea*, although this species has a low likelihood of occurring in the study area as it is not known from the Fortescue IBRA subregion in the vicinity of the study area (DPaW 2007-2017)
- DPaW (Markey 2016) considers *Melaleuca xerophila* may be groundwater dependent in the Fortescue Marsh area.

Vegetation containing *Eucalyptus camaldulensis* subsp. *refulgens* and *Melaleuca argentea* is generally considered to represent a GDE. In the Fortescue Marsh area, vegetation characterised by *Melaleuca xerophila* is similarly considered to represent a GDE.

However, that there is supporting evidence that, in some circumstances (Batini 2009; Eamus 2009a; EPA & Hamersley Iron Pty Ltd 2010; Resource and Environmental Management Pty Ltd 2007) including north of the study area at Christmas Creek (Equinox Environmental 2017), *Eucalyptus victrix* does not always depend on groundwater. Therefore vegetation containing this species is considered to represent a potential GDE.

Atlas of Groundwater Dependent Ecosystems

The Groundwater Dependent Ecosystems Atlas (Australian Government & BoM 2017) indicates the presence of known GDEs and Inflow Dependent Ecosystems (IDEs) in Australia.

An Inflow Dependent Ecosystem is one in which the vegetation within the landscape is likely to be accessing water in addition to rainfall, from soil or surface water or groundwater, assessed using remotely sensed data. The likelihood of a landscape using additional water is rated from one to 10 (low to high), with a rating above six indicating that a landscape is likely to be inflow dependent (Australian Government & BoM 2017).

Mulga Vegetation

Mulga is the common name for a group of closely related *Acacia* species that were formerly known as *Acacia aneura* and its subtaxa. A recent taxonomic review (Maslin & Reid 2012) has resulted in a revision of this group, and Mulga now includes *Acacia aneura*, *A. aptaneura*, *A. ayersiana*, *A. caesaneura*, *A. craspedocarpa*, *A. fuscaneura*, *A. incurvaneura*, *A. macraneura*, *A. minyura*, *A. mulganeura*, *A. paraneura* and *A. pteraneura*, although not all are present in the Pilbara.

Mulga vegetation on valley floors can be considered as significant, and are recognised as such in a number of publications including the *Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002* (McKenzie *et al.* 2003) and various EPA approvals documents where environmental objectives are set or conditions imposed to restrict impacts on Mulga vegetation (EPA 2010; 2011; 2012; 2014; 2016b; Office of the Appeals Convenor 2016b).

Valley floor Mulga can be considered as significant vegetation due to:

- threats associated with the hydrological change, particularly in relation to linear infrastructure (EPA 2010; 2011; 2012; 2014; 2016b; Office of the Appeals Convenor 2016b);
  - potential effects of changed hydrology as a result of interruptions to surface flows caused by linear infrastructure is most apparent in Sheet Flow Dependent Mulga (also known more generally as Sheet

Flow Dependent Vegetation, SFDV) that occurs in groves (also known as 'grove-intergrove') or bands and can be inferred from species composition, community structure and topography. SFDV relies on overland (sheet) flow of water across a relatively flat landscape to regenerate (Muller 2005; The University of Western Australia *et al.* 2012), and as such changes in topography caused by mining or linear infrastructure, including roads and railways, can have a significant impact. Mulga groves are formed when obstacles, including existing groves or piles of vegetation or timber (in a natural environment), impede water flow, and debris carried in the water (including seeds and plant material containing nutrients) is deposited upslope of the obstacle, forming the characteristic grove (depositional feature)/intergrove (erosional feature) formation. Sheet Flow Dependent Vegetation may also occur at the base of hills, when surface water sheets off the rocky formations carrying soil and plant debris; where the water loses sufficient velocity to deposit plant debris, linear groves of Mulga may occur, usually as a single band.

  - the effects of hydrological change on other valley floor Mulga vegetation types is less well understood, however, the potential for impacts to occur is recognised in the EPA's use of the phrase 'surface water and significant vegetation' and similar in relation to valley floor Mulga in a number of approvals documents (e.g. Office of the Appeals Convenor 2014; 2016a)

- threats associated with grazing pressure from both livestock (cattle) and feral species including donkeys and horses (Kendrick 2002a; 2002b); Ecoscape field observations from many parts of the Pilbara confirm that Mulga vegetation is favoured for grazing by cattle over most other vegetation types, potentially due to the understorey frequently consisting of tussock grasses that are more palatable than hummock grasses (*Triodia* species), and shade
- threats associated with weed invasion (Kendrick 2002b); the referenced document considers **Rumex vesicarius* (Ruby Dock) as the most significant threat, however, Ecoscape observations suggest **Cenchrus ciliaris* (Buffel Grass) and **Bidens subalternans* var. *simulans* (Beggartick) are more significant in many parts of the Pilbara
- threats associated with changed fire regimes (Kendrick 2002a; 2002b), specifically large or frequent fires. Fire impacts are more likely to have a significant effect in combination with grazing, where Mulga may be preferentially grazed over other species, and weed invasion where weeds, potentially **Cenchrus ciliaris* (Buffel Grass) in particular, outcompete Mulga. Most Mulga species are fire sensitive and killed by even cool burns (Maslin & Reid 2012), although some are known to resprout from trunks or roots particularly if only scorched (Maslin *et al.* 2010).
- the vegetation may be associated with species of restricted distribution (Biota Environmental Sciences 2004a)
- that Mulga is at the northern limit of its extent (EPA 2014), which aligns with one of the EPA's reasons that vegetation may be significant, specifically that the vegetation type has a restricted distribution (EPA 2016d).

Other Significant Vegetation

According to the *Flora and Vegetation Technical Guidance* (EPA 2016d), other than being listed as a TEC or PEC, vegetation can be considered as significant if it is considered to have:

- restricted distribution
- a degree of historical impact from threatening processes
- a role as a refuge
- provides an important function required to maintain ecological integrity of a significant ecosystem.

1.4.6 ENVIRONMENTALLY SENSITIVE AREAS

There are a number of areas around Western Australia identified as being of environmental significance within which the exemptions to the Native Clearing Regulations do not apply. These are referred to as Environmentally Sensitive Areas (ESAs), and are declared under section 51B of the EP Act and described in the Environmental Protection (Environmentally Sensitive Areas) Notice (Government of Western Australia 2005).

1.4.7 CONSERVATION ESTATE

The National Reserve System is a network of protected areas managed for conservation under international guidelines. The objective of placing areas of bushland into the Conservation Estate is to achieve and maintain a comprehensive, adequate and representative reserve system for Western Australia. The Conservation and Parks Commission is the vesting body for conservation lands, forest and marine reserves that are managed by DBCA (Government of Western Australia 2018).

2 EXISTING ENVIRONMENT

2.1 PHYSICAL ENVIRONMENT

2.1.1 CLIMATE

The study area is located within the Pilbara region, which includes two broad climatic zones. Coastal areas, as well as some higher rainfall inland areas, have a semi-desert tropical climate which experience 9-11 months of dry weather, with hot humid summers and warm winters. The remaining inland areas have a dry desert climate, typically with higher temperatures and lower rainfall, and often experience up to 12 months of dry weather, with hot dry summers and mild winters (Leighton 2004). The study area is within the dry inland area.

Monthly maximum temperatures range from an average of 25°C in July to 37°C in January, while minimum temperatures are experienced in these same months, with an average of 12°C in July and 25°C in January (McKenzie *et al.* 2009). December and January are the hottest months in inland areas, while coastal areas often experience their highest temperatures later in February or March due to the dampening effect of the ocean (Leighton 2004).

Annual rainfall in the Pilbara has substantial yearly variation, but generally follows an inland to coastal and southern to northern increasing trend (Leighton 2004). Tropical cyclones, many of which originate in the Timor Sea, along with local thunderstorms, produce much of the summer and early autumn rainfall. The driest months are in spring (September to October) (McKenzie *et al.* 2009), and winter rainfall is highly variable, generally decreasing from the coast through to inland areas (Leighton 2004).

According to the Köppen-Geiger climate classification, the study area has a hot desert climate (Class BWh) (Peel *et al.* 2007). This classification includes arid regions where annual evaporation exceeds annual precipitation, and with a mean annual temperate ≥18°C.

Figure 2 outlines the monthly rainfall averages for the Marillana Bureau of Meteorology (BoM) station, located within the study area, derived from data collected between 1936 and 2017 (BoM 2017c), and monthly rainfall and temperate averages for Newman Aero, approximately 50 km south of the study area, derived from data collected between 1971 and 2017 (BoM 2017a; 2017b; 2017d).

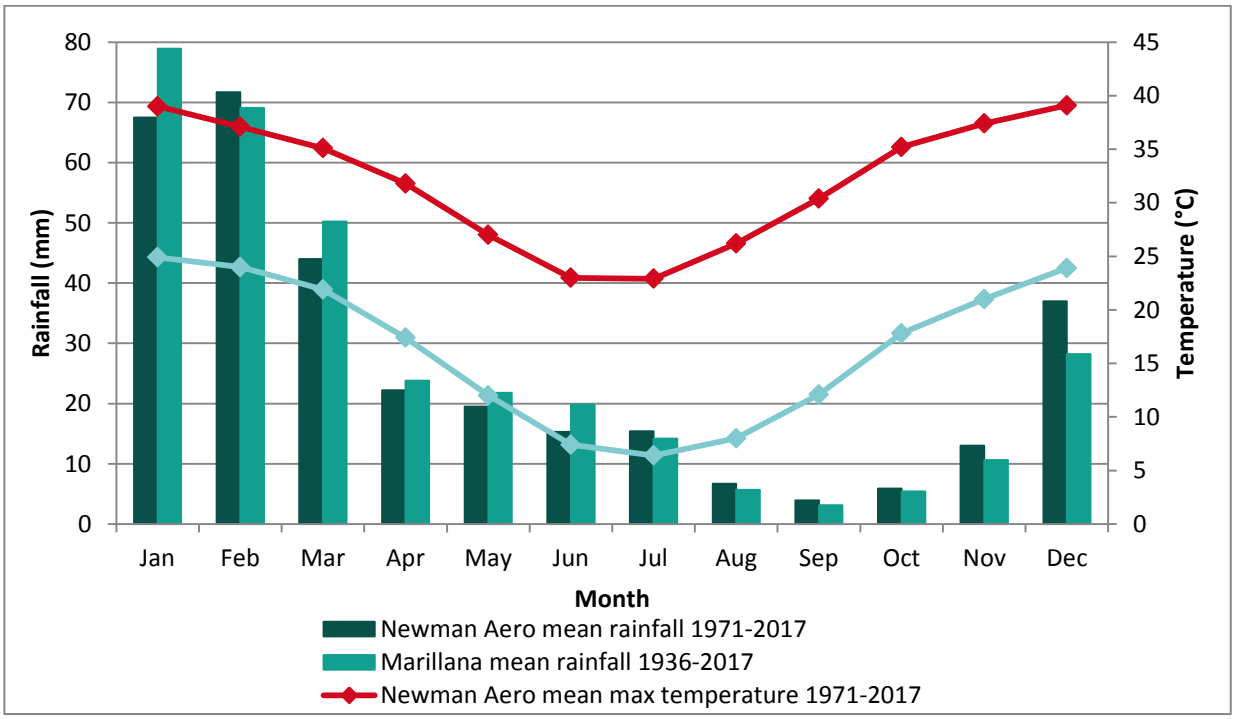


Figure 2: Rainfall and temperature data (BoM 2017a; 2017b; 2017c)

2.1.2 LAND SYSTEMS

As part of the rangeland resource surveys, the then-Department of Agriculture comprehensively described and mapped the biophysical resources of the Pilbara together with an evaluation of the condition of the soils and vegetation (from an agricultural perspective) throughout (Van Vreeswyk *et al.* 2004). As part of this process an inventory of land types, land systems and land units with particular use capabilities, habitats or conservation values were established to assist in land use planning. The land systems occurring within the study area are listed in **Table 1** and shown on **Map 1**.

Table 1: Land Systems of the Pilbara occurring within the study area (Van Vreeswyk *et al.* 2004)

Land system	Description	Extent (ha)	Proportion (%)
Adrian	Level stony plains and low silcrete hills supporting hard spinifex grasslands.	3,248.31	1.41
Boolgeeda	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.	16,720.81	7.24
Calcrete	Low calcrete platforms and plains supporting shrubby hard spinifex grasslands.	26,124.31	11.31
Coolibah	Flood plains with weakly gilgaied clay soils supporting coolibah woodlands with tussock grass understorey.	1,186.82	0.51
Cowra	Plains fringing the Marsh land system and supporting snakewood and mulga shrublands with some halophytic undershrubs.	568.93	0.25
Divide	Sandplains and occasional dunes supporting shrubby hard spinifex grasslands.	25,479.07	11.03
Fan	Washplains and gilgai plains supporting groved mulga shrublands and minor tussock grasslands.	49,649.72	21.50
Fortescue	Alluvial plains and flood plains supporting patchy grassy woodlands and shrublands and tussock grasslands.	4,940.18	2.14
Marillana	Gravelly plains with large drainage foci and unchannelled drainage tracts supporting snakewood shrublands and grassy mulga shrublands.	41,767.93	18.09
Marsh	Lakebeds and flood plains subject to regular inundation, supporting samphire shrublands, salt water couch grasslands and halophytic shrublands.	20,091.04	8.70
Narbung	Alluvial washplains with prominent internal drainage foci supporting snakewood and mulga shrublands with halophytic low shrubs.	2,082.19	0.90
Newman	Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.	12,015.17	5.20
River	Active flood plains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands.	2,525.12	1.09
Robe	Low plateaux, mesas and buttes of limonite supporting soft spinifex and occasionally hard spinifex grasslands.	50.28	0.02
Turee	Stony alluvial plains with gilgaied and non-gilgaied surfaces supporting tussock grasslands and grassy shrublands.	11,004.18	4.77
Urandy	Stony plains, alluvial plains and drainage lines supporting shrubby soft spinifex grasslands.	13,480.04	5.84

2.1.3 GEOLOGY

The geological units that intersect the study area are provided in **Table 2** (Thorne & Tyler 1996).

Table 2: Geological units that intersect the study area (Thorne & Tyler 1996)

Code	Description
AHs	Mount McRae Shale and Mount Sylvia Formation: pelite, chert, and banded iron-formation
Cza	Alluvium-partly consolidated silt, sand, and gravel; old alluvium dissected by present-day drainage
Czc	Colluvium-partly consolidated quartz and rock fragments in silt and sand matrix; old valley-fill deposits
Czk	Calcrete-sheet carbonate; found along major drainage lines
Czp	Robe Pisolite: pisolitic limonite deposits developed along river channels
Czr	Hematite-goethite deposits on banded iron-formation and adjacent scree deposits
Czz	Brecciated siliceous caprock over dolomitic rock; angular chert fragments in a chert matrix; overlies Wittenoom Formation
PLHb	Brockman Iron Formation: banded iron-formation, chert, and pelite
PLHj	Weeli Wolli Formation: banded iron-formation (commonly jaspilitic), pelite, and numerous metadolerite sills
PLHo	Boolgeeda Iron Formation: fine-grained, finely laminated iron-formation; pelite and chert
Qa	Alluvium unconsolidated silt, sand, and gravel; in drainage channels and on adjacent floodplains
Ql	Lacustrine deposits-clay and silt; claypan (predominantly freshwater) deposits
Qs	Eolian deposit-sand; in sheets and longitudinal dunes
Qw	Alluvium and colluvium-red-brown sandy and clayey soil; on low slopes and sheetwash areas

2.1.4 WATERWAYS, HYDROLOGY AND WETLANDS

The catchment is associated with the Fortescue River, and occupies part of the Fortescue Marsh or Marshes (herein also referred to as the Marsh) and its floodplains. The Fortescue River has a number of tributaries within or close to the study area including Weeli Wolli and Mindy Mindy Creeks.

The northern portion of the study area includes part of the Fortescue Marsh. The hydrology of the Marsh is described in some detail in Markey (2016). In summary, the Upper Fortescue River catchment terminates in the Fortescue Marsh, which has little surface connection to the Lower Fortescue River catchment west of the Goodiadarrie Hills. These hills form a barrier between the two sub-catchments such that they are only rarely connected following large flood events. The Marsh is fed by direct rainfall, surface runoff and groundwater sources, however, except for some permanent pools east of the study area, is only filled during years of extreme rainfall. The Fortescue Marsh wetland is considered to be saline, with surface waters becoming more saline over time due to the high evaporation rate.

The Fortescue Marsh is a Draft Proposed Ramsar Addition (*NatureMap*, DPaW 2007; Heydenrych *et al*. 2015).

The Fortescue Marsh is listed in the Directory of Important Wetlands of Australia as a *Wetland of National Significance* (Australian Government & Department of the Environment and Energy [DotEE] 2010) as it satisfies the following criteria for inclusion:

1. It is a good example of a wetland type occurring within a biogeographic region in Australia.
2. It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.
3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.
4. The wetland is of outstanding historical or cultural significance.

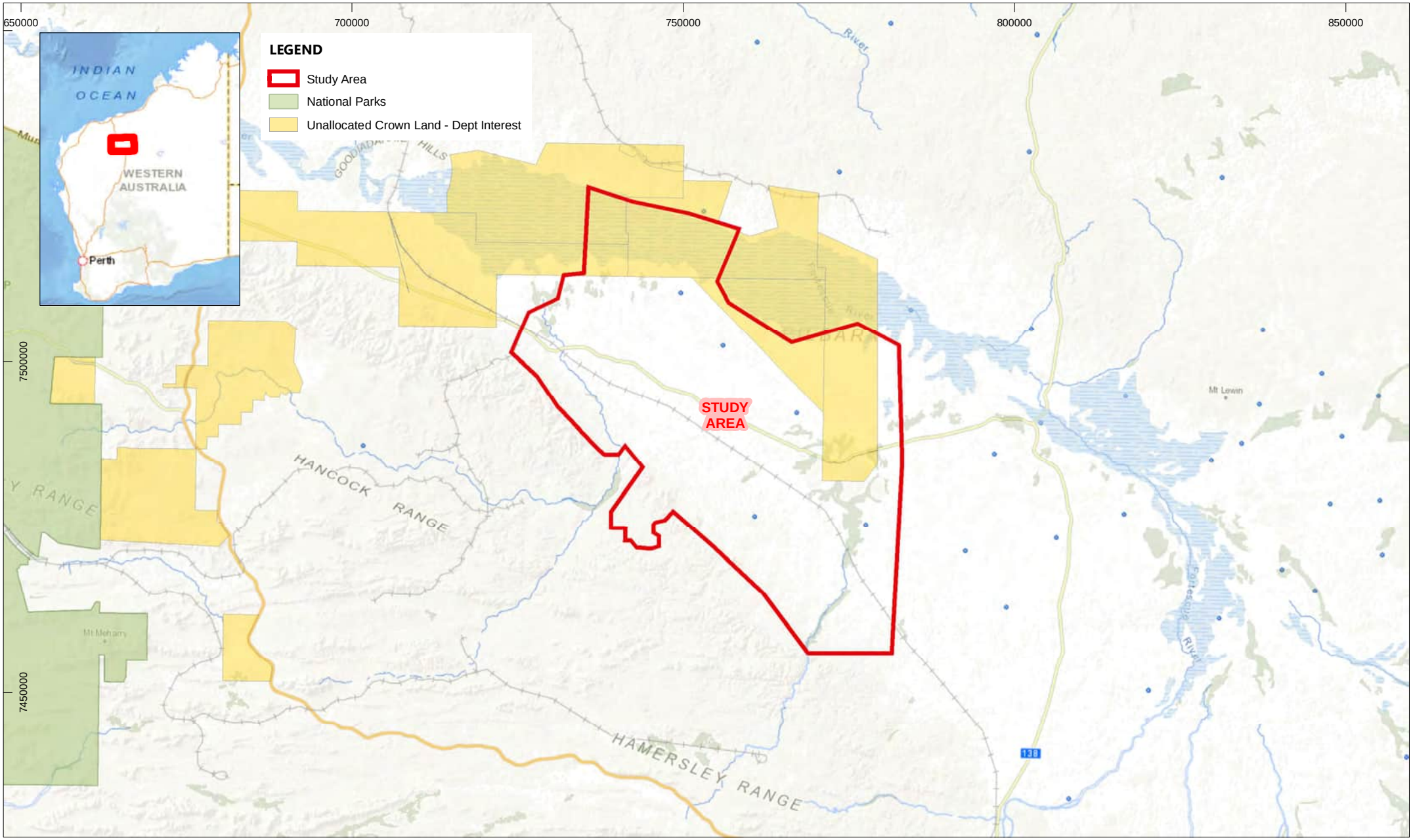
2.1.5 CONSERVATION ESTATE

The study area does not correspond with any official conservation estate i.e. it does not correspond with any nature reserves, national parks or other areas vested for conservation. However, parts of the study area (**Figure 3**) have been identified as being of conservation interest by DBCA and are managed by the DBCA as a pastoral exclusion zone.

As indicated in **Figure 3**, the DBCA managed lands includes a significant portion of the Fortescue Marsh and the study area.

2.1.6 RESTRICTED LANDFORMS AND SOIL TYPES

Restricted landforms, as defined in the *Flora and Vegetation Technical Guidance* (EPA 2016d) and identified from the desktop study and aerial imagery, include the Fortescue Marsh, sand dune fields, Mulga groves and clay pans. These were targeted for field survey. All have been identified by DBCA and others as being of significance (see **Section 2.2.3** below).



SCALE: 1:750,000 @ A4
COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ecoscape

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	27/11/2017

N

0 10 20 km

DBCA MANAGED LAND NEAR STUDY AREA

FORTESCUE VALLEY FLORA AND VEGETATION SURVEY
CLIENT: FORTESCUE METALS GROUP

FIGURE 03

2.2 BIOLOGICAL ENVIRONMENT

2.2.1 BIOREGION

Biogeographic regions are delineated on the basis of similar climate, geology, landforms, vegetation and fauna and are defined in the Interim Biogeographical Regionalisation for Australia (IBRA) (Australian Government & DotEE 2017a).

The study area is located entirely within the Pilbara biogeographic region that includes four subregions; Chichester, Fortescue Plains, Hamersley and Roebourne (Thackway & Cresswell 1995). Two subregions intersect the study area; they are described in the *2002 Biodiversity Audit of Western Australia's 53 Biogeographical Subregions* (McKenzie *et al*. 2003) as:

Fortescue Plains (PIL2, Kendrick 2002a):

> *Alluvial plains and river frontage. Extensive salt marsh, mulga-bunch grass, and short grass communities on alluvial plains in the east. Deeply incised gorge systems in the western (lower) part of the drainage. River Gum woodlands fringe the drainage lines. Northern limit of Mulga (*Acacia aneura*). An extensive calcrete aquifer (originating within a palaeo-drainage valley) feeds numerous permanent springs in the central Fortescue, supporting large permanent wetlands with extensive stands of River Gum and Cadjeput Melaleuca woodlands. Climatic conditions are semi desert tropical, with average rainfall of 300 mm, falling mainly in summer cyclonic events. Drainage occurs to the north-west. Subregional area is 2 041 914 ha.*

Hamersley (PIL3, Kendrick 2002b):

> *Mountainous area of Proterozoic sedimentary ranges and plateaux, dissected by gorges (basalt, shale and dolerite). Mulga low woodland over bunch grasses on fine textured soils in valley floors, and* Eucalyptus leucophloia *over* Triodia brizoides *on skeletal soils of the ranges. The climate is semi-desert tropical, average 300 mm rainfall, usually in summer cyclonic or thunderstorm events. Winter rain is not uncommon. Drainage into either the Fortescue to the north, the Ashburton to the south, or the Robe to the west. Subregional area is 6 215 092 ha.*

2.2.2 REGIONAL VEGETATION

During the 1970s, John Beard and associates conducted a systematic survey of native vegetation, describing the vegetation systems in Western Australia at a scale of 1:250,000 in the south-west and at a scale of 1:1 000,000 in less developed areas. The vegetation survey of Western Australia maps and explanatory memoirs (1974-1981) are credited to J.S. Beard (or Beard with various co-authors).

Beard's vegetation maps attempt to depict the native vegetation as it was presumed to be at the time of settlement, and is known as the pre-European vegetation type and extent. They have since been developed in digital form by Shepherd *et al.* (2002), and updated by the Department of Agriculture and Food Western Australia (Department of Agriculture and Food Western Australia [DAFWA] 2012).

The pre-European vegetation associations identified from the study area (DAFWA 2012) and their pre-European and current extents (Government of Western Australia 2016a) are listed in **Table 3** and shown on **Map 2**. The total extent of the Pilbara bioregion is 17,823,125.84 ha.

Table 3: Pre-European associations within the study area (Government of Western Australia 2016a)

Vegetation Association	Extent in study area (ha)	Pilbara Bioregion		
		Pre-European Extent (ha)	Current Extent (ha)	% Remaining
Fortescue Valley 29	167,749.90	877,822.10	877,652.90	99.98
Fortescue Valley 82	585.64	30,239.87	30,044.09	99.35
Hamersley 82	11,670.68	2,168,702.10	2,156,557.85	99.44
Fortescue Valley 111	35,035.36	430,960.63	430,906.09	99.99
Fortescue Valley 676	15,891.79	81,984.10	81,976.20	99.99

2.2.3 SIGNIFICANT VEGETATION

2.2.3.1 Threatened and Priority Ecological Communities

A search was conducted of the DBCA ecological communities database for the study area and surrounding 40 km radius (DBCA search reference 21-0517EC; study area supplied as a shapefile).

A search, using the DotEE's Protected Matters Search Tool (PMST), was also conducted (Australian Government & DotEE 2017b) and did not identify any Commonwealth-listed TECs as occurring within the study area. No Commonwealth-listed TECs occur in the Pilbara.

The searches identified one TEC and nine PECs within the search radius, with three of the PECs intersecting with the study area (highlighted), outlined in **Table 4** and shown on **Map 3**.

Table 4: Ecological communities database search results

Community name	EPBC ACT status	DBCA status
Fortescue Marsh (Marsh Land System)	-	P1 PEC
Vegetation of sand dunes of the Hamersley Range/Fortescue Valley (previously 'Fortescue Valley Sand Dunes')	-	P3 PEC
Narbung Land System	-	P3 PEC
Brockman Iron cracking clay communities (Brockman Iron cracking clay communities of the Hamersley Range)	-	P1 PEC
Coolibah-Lignum Flats, sub type 1 (Coolibah-Lignum Flats: subtype 1: Coolibah and mulga woodlands over lignum and tussock grasses on clay plains (Coondewanna and Wanamunna flats and Mt Bruce Flats)	-	P3 PEC
Ethel Gorge (Ethel Gorge aquifer stygobiont community)	-	Endangered TEC
Freshwater clay pans of the Fortescue Valley (Freshwater claypans downstream of the Fortescue Marsh – Goodiadarrie Hills on Mulga Downs Station)	-	P1 PEC
Kumina Land System	-	P3 PEC
Weeli Wollli (Weeli Wolli Spring community)	-	P1 PEC
Wona Land System (Four plant assemblages of the Wona Land System, previously Cracking clays of the Chichester and Mungaroona Range)	-	P1 PEC

The PECs identified from the database search are described as (Species and Communities Branch DBCA 2017):

Fortescue Marsh (Marsh Land System):

> *Fortescue Marsh is an extensive, episodically inundated samphire marsh at the upper terminus of the Fortescue River and the western end of Goodiadarrie Hills. It is regarded as the largest ephemeral wetland in the Pilbara. It is a highly diverse ecosystem with fringing mulga woodlands (on the northern side), samphire shrublands and groundwater dependant riparian ecosystems. It is an arid wetland utilized by waterbirds and supports a rich diversity of restricted aquatic and terrestrial invertebrates. Recorded locality for night parrot and bilby and several other threatened vertebrate fauna. Endemic Eremophila species, populations of priority flora and several near endemic and new to science samphires.*
>
> *Threats: mining, altered hydrology (watering with fresh water), grazing and weed invasion*

Vegetation of sand dunes of the Hamersley Range/Fortescue Valley (previously 'Fortescue Valley Sand Dunes')

> *These red linear iron-rich sand dunes lie on the Divide Land system at the junction of the Hamersley Range and Fortescue Valley, between Weeli Wolli Creek and the low hills to the west. A small number are vegetated with* Acacia dictyophleba *scattered tall shrubs over* Crotalaria

cunninghamii, Trichodesma zeylanicum *var.* grandiflorum *open shrubland. They are regionally rare, small and fragile and highly susceptible to threatening processes.*

Threats: weed invasion especially buffel grass, grazing by cattle, too frequent fire, erosion and impacts of mining.

Narbung Land System

Alluvial washplains with prominent internal drainage foci supporting snakewood and mulga shrublands with halophytic low shrubs.

Threats: over grazing

2.2.3.2 Fortescue Marsh

As described above in its PEC description, the Fortescue Marsh is considered significant for a number of reasons including its unique vegetation.

DPaW, as it was known at the time, conducted a floristic survey and mapped the vegetation of the Marsh and its surrounds (Markey 2016). A total of 128 floristic quadrats were established on the Marsh and surrounds, approximately half of which were established and scored in 2013 and rescored in 2014 (excluding 11 that could not be accessed as they were inundated), and the remainder established and scored over a single season, in 2014.

The DPaW survey identified 352 flora taxa, including 14 of conservation significance (DBCA Priority-listed flora), and 18 species listed as new records for the Fortescue Marsh, 11 of these being significant range extensions.

Floristic analysis, using only 2014 data, identified three broad floristic groups associated with landscape position (marsh interior, marsh margins –interior and marginal – non-marsh), and ultimately identified 21 vegetation communities, although a number of these could not be resolved as on-ground units and were combined into mapping units (17 units). One mapping unit, in particular, was considered poorly resolved: Unit JA colluvial shrublands (*Acacia* shrublands over succulent chenopods on stony plains) that were variously dominated by Mulga (*Acacia aptaneura*) or Snakewood (*Acacia xiphophylla*).

2.2.3.3 Groundwater Dependent Ecosystems

The Groundwater Dependent Ecosystems Atlas (Australian Government & BoM 2017) was interrogated to determine the presence of known GDEs and Inflow Dependent Ecosystems (IDEs) within the study area. The following were identified as having potential for groundwater interaction:

- class 2 GDEs (ecosystems that rely on the surface expression of groundwater):
  - Fortescue Marshes, with the potential for the ecosystem to be a GDE described as 'high potential for groundwater interaction'
  - Weeli Wolli and Coondiner Creeks, having the potential for the ecosystem to be a GDE described as 'moderate potential for groundwater interaction'
- multiple mapped incidences of various class 3 GDEs (ecosystems that rely on subsurface presence of groundwater) described by vegetation:
  - lakebeds and floodplains subject to regular inundation, supporting samphire shrublands, salt water couch grasslands and halophytic shrublands, with the potential for the ecosystem to be a GDE described as 'high potential for groundwater interaction'
  - low calcrete platforms and plains supporting shrubby hard spinifex grasslands, with the potential for the ecosystem to be a GDE described as 'moderate potential for groundwater interaction'
  - gravelly plains with large drainage foci and unchannelled drainage tracts supporting snakewood shrublands and grassy mulga shrublands, with the potential for the ecosystem to be a GDE described as 'moderate potential for groundwater interaction'
  - bare lake beds inundated for short periods after rain, with the potential for the ecosystem to be a GDE described as 'high potential for groundwater interaction'

- flood plains with weakly gilgaied clay soils supporting coolibah woodlands with tussock grass understorey, with the potential for the ecosystem to be a GDE described as low potential for groundwater interaction'
- stony plains and low silcrete hills supporting hard spinifex grasslands, with the potential for the ecosystem to be a GDE described as 'moderate potential for groundwater interaction'.

2.2.3.4 Mulga

A number of previous surveys in areas overlapping with, or close to, the Fortescue Valley study area have identified Mulga vegetation as being of significance. Some of these reports, or Ministerial Statements detailing environmental approval conditions, have considered all valley floor Mulga-dominated vegetation as significant (e.g. EPA 2013; Office of the Appeals Convenor 2012; 2016b), whilst others consider only subsets that include Sheet Flow Dependent Mulga and/or riparian Mulga and/or Mulga restricted to specific landforms or of small extent as being of significance (e.g. Biota Environmental Sciences 2004b; Cardno 2012b; ENV 2010a).

2.2.3.5 Claypans and Clay Flats

Lyons (2015) identified claypans and clay flats as capturing a large component of the Pilbara wetland flora. Species richness, as identified during this survey of riparian areas in the Pilbara, was greatest in less permanent wetlands, particularly in fine soils that occur in claypans and clay flats, as well as along turbid linear creeks and rockpools.

As such claypans and clay flats, and their flora and vegetation, can be considered to be significant.

2.2.3.6 Significant Vegetation Identified During Previous Surveys

Cardno Surveys

Portions of the study area have been subject to a Level 2 flora and vegetation survey (Cardno 2012b). This survey identified 22 vegetation communities, with the following considered to be significant:

- vegetation associated with the *Fortescue Valley Sand Dune Community* PEC (now known as the *Vegetation of sand dunes of the Hamersley Range/Fortescue Valley* PEC), community SsTs comprising of *Stylobasium spathulatum* over *Corchorus tectus* and *Triodia* species
- grove-intergrove Mulga dominated by *Acacia aneura* (communities AaAsCc, AaAsTp, AaAsEs, AaAtCc, AaEfTp and AaPlCf), considered significant due to their dependence on surface water flow (note that Mulga taxonomy has changed since this survey).

Cardno also conducted a similar survey along a proposed rail spur between Fortescue's Cloudbreak mine and Nyidinghu exploration area (Cardno 2012c). This survey identified 39 vegetation communities, with the following being considered significance:

- vegetation associated with the *Vegetation of sand dunes of the Hamersley Range/Fortescue Valley* PEC (as above) and Fortescue Marsh PEC
- Mulga woodlands (AaAsTp, AaEfTp, AaAsCc, AaAsEs and AaPlCf); also in the above list
- MlTl (*Melaleuca linophylla* and *Acacia sclerosperma* mid to tall open shrubland over *Triodia longiceps* low hummock grassland) associated with minor creeklines in the Fortescue Valley
- others not associated with landforms occurring in the current study area.

A single phase supplementary survey of nearby areas was also conducted by Cardno (Cardno 2012a) and identified additional vegetation types although none were considered significant. The report also refined the description of the vegetation associated with the *Fortescue Valley Sand Dunes* PEC to *Acacia dictyophleba*, *Stylobasium spathulatum* and *Petalostylis cassioides* tall sparse shrubland over *Triodia schinzii* and *Triodia lanigera* open hummock grassland with a low shrub layer of *Sida cardiophylla*, *Senna notabilis* and *Corchorus* aff. *elachocarpus*, *Corchorus sidoides* subsp. *sidoides* and *Corchorus tectus.*

Ecologia Marillana Survey

In 2009, Ecologia published a report for Brockman Resources, detailing its 2008 flora and vegetation survey of the Marillana tenement, which is located within the current study area (Ecologia Environment 2009a). This survey identified eight vegetation types, with all of them being conserved representative of the area and none considered of significance.

Biota Stage A Rail Survey

Parts of the southern portion of the Fortescue Metals Group Stage A Rail survey (Biota Environmental Sciences Pty Ltd 2004a) corresponded the study area. While mapping is not readily available to identify intersecting vegetation types, Biota considered the following, which may have corresponded with the current study area, to have high conservation significance:

- Fh1 *Acacia aneura* high open shrubland to high shrubland (Mulga on low hills)
- Fa1 *Acacia aneura* open scrub to low open forest (groving Mulga)
- Fa2 *Acacia aneura* low woodland (drainage line Mulga)
- Fa3 *Acacia xiphophylla*, *A. aneura* high open shrubland to low woodland (Mulga on plains)
- Fa4 *Acacia aneura*, A. *pruinocarpa* closed scrub (groving Mulga)
- Fa5 *Acacia pruinocarpa*, *A. aneura* high open shrubland (Mulga on clay)
- Fa6 *Acacia aneura*, *A. citrinoviridis* open scrub (Mulga on clay)
- Fa7 *Corymbia deserticola* scattered low trees over *Acacia aneura*, *A. pruinocarpa* high open shrubland to low open woodland (sandy plain Mulga with scattered trees)
- Fa9 *Acacia aneura* high open shrubland (Mulga on plains)
- Fc2 *Eucalyptus victrix* scattered low trees (major drainage)
- Fx1 *Acacia xiphophylla* open scrub (clay plains)
- Fx9 Samphire low shrubland (central Fortescue Valley)
- Hp4 *Acacia aneura* groved low open forest
- Hd1 *Acacia dictyophleba* scattered tall shrubs (linear dunes).

In the above, the prefix 'F' refers to vegetation units of the Fortescue Valley, whereas 'H' refers to vegetation units in the Hamersley Range. Note also that Mulga taxonomy has been revised since this survey (Maslin & Reid 2012).

Biota Koodaideri Survey

The south western corner of the study area is immediately adjacent to or slightly overlapping with an area surveyed by Biota for Rio Tinto (Biota Environmental Sciences 2012). The Biota Koodaideri study area was largely within the Hamersley Range, extending northwards into the footslopes.

Biota identified 25 vegetation units in its study area, and considered one, associated with riparian vegetation in a gorge with an apparently permanent spring, as being of moderate to high conservation significance, and three other units of low to moderate conservation significance, associated with gorges, gullies and moderate-sized creeklines.

2.2.4 SIGNIFICANT FLORA

2.2.4.1 Database Searches

A search of the Western Australian DBCA databases (search reference 17-0517FL, study area supplied as a shapefile) and the Commonwealth DotEE PMST was undertaken for State and Commonwealth listed TF and PF within a 40 km radius of the study area.

Combined, these searches identified 80 conservation significant vascular flora species. None of these are TF, 22 is listed as P1, 13 are P2, 39 are P3, and 6 are P4 (**Table 19** in **Appendix Two**). Previously recorded locations are shown on **Map 3**.

Table 19 lists all identified TF and PF vascular flora and their habitats, as well as their likelihood of occurrence. The likelihood of a species occurring in the study area is based on the following attributes, as

listed on *FloraBase* (WAH 1998-2017; 2017a), tailored to Pilbara populations, *Rare and Priority Plants of the Pilbara mobile app edition* (Rio Tinto & DPaW 2015) and including information from recent nearby surveys.

The attributes were:

- broad soil type usually associated with the species
- broad landform usually associated with the species
- usual vegetation (characteristic species) with which the species is usually associated
- species having previously been recorded from within approximately 40 km of the study area (considered as 'nearby').

The likelihood rating is assigned using the following categories:

- Recorded
- Possible: it may occur within the study area (but was not recorded); broadly, 2-4 of the required attributes (but always including records from nearby) are present in the study area
- Unlikely: it could occur but is not expected; 1-3 of the required attributes are present in the study area but:
  - it is not known from nearby, or
  - it is known from nearby but has no other required attributes, or
  - it is known from nearby but has at least one well-defined attribute that does not occur in the study area (e.g. it is associated with a specific landform or soil type that does not occur in the study area)
- Highly Unlikely: the species characteristics include none of the required attributes of soil, landform, associated vegetation and having previously been recorded nearby, or a critical element (often landform) is not within the study area and as such it almost certainly does not occur within the study area.

Nineteen species have been previously recorded from within the study area, and a further 25 have been identified as having a 'possible' occurrence, based on the assessment described above.

2.2.4.2 Fortescue Database

Fortescue maintains a database of conservation significant flora and other flora of conservation interest associated with its operational and exploration tenements. This database consists of DBCA database search results requested for flora and vegetation assessments and the results of field surveys it has commissioned. The resultant list, and associated location data, provides a comprehensive understanding of the conservation significant flora and other flora of conservation interest (e.g. significant range extensions, unusual forms) within and close to Fortescue's areas of interest. Fortescue's significant flora records for the study area are provided in **Table 5**.

Table 5: Significant flora listed on the Fortescue database

Family	Species	EPBC status	DBCA status
Chenopodiaceae	*Atriplex flabelliformis*	None	Priority 3
Asteraceae	*Calotis squamigera*	None	Priority 1
Poaceae	*Eragrostis crateriformis*	None	Priority 3
Scrophulariaceae	*Eremophila spongiocarpa*	None	Priority 1
Scrophulariaceae	*Eremophila youngii* subsp. *lepidota*	None	Priority 4
Goodeniaceae	*Goodenia nuda*	None	Priority 4
Myrtaceae	*Melaleuca xerophila*	None	Other (Range Extension - GS51)
Solanaceae	*Nicotiana heterantha*	None	Priority 1
Primulaceae	*Samolus* sp. Fortescue Marsh (A. Markey & R. Coppen FM 9702)	None	Priority 1
Chenopodiaceae	*Tecticornia globulifera*	None	Priority 1
Chenopodiaceae	*Tecticornia medusa*	None	Priority 3
Chenopodiaceae	*Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063)	None	Priority 1

There were no TF species considered likely to occur in the study area as a result of the known distribution and associated habitat of the three species currently listed as TF in the Pilbara.

2.2.4.3 Previous Surveys

There have been a number of flora and vegetation surveys conducted in the area that in part correspond with the current study area. Their extents are indicated on **Figure 4**.

Portions of the study area had been subject to Level 2 flora and vegetation surveys (Cardno 2012a; 2012b; 2012c). These surveys identified the following PF:

- *Calotis squamigera* (P1)
- *Eremophila spongiocarpa* (P1)
- *Eragrostis crateriformis* (P3)
- *Eremophila youngii* subsp. *lepidota* (P4)
- *Goodenia nuda* (P4)
- *Vigna* sp. Central (M.E. Trudgen 1626), at the time listed as P2, and is now considered synonymous with *Vigna* sp. Hamersley Clay (A.A. Mitchell PRP 113) that has no specific conservation significance.

Cardno (2012b) also considered *Melaleuca xerophila* as a species of interest as it is at the northern edge of its range and uncommon in the Pilbara.

Parts of the southern portion of the Fortescue Metals Group Stage A Rail survey (Biota Environmental Sciences 2004a) corresponded the study area. PF species recorded within or close to this alignment (that may correspond in part with the current study area) were:

- *Eremophila spongiocarpa* (P1)
- *Stylidium weeliwolli* (P2)
- *Goodenia omearana*, at the time listed as P1, and is now considered synonymous with *Goodenia* sp. East Pilbara (A.A. Mitchell PRP 727) (P3)
- *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3)
- *Lepidium catapycnon* at the time listed as Declared Rare Flora (now known as TF), now listed as P4.
- *Abutilon trudgenii*, at the time listed as P3, and is now considered synonymous with *Abutilon* sp. Pilbara (W.R. Barker 2025) that has no specific conservation significance
- *Sida* sp. Wittenoom, at the time listed as P3, and is now considered synonymous with *Sida arsiniata* that has no specific conservation significance
- *Eriachne tenuiculmis*, at the time listed as P3 that has no current conservation significance.

Mattiske Consulting conducted a survey that included the northern side of the Fortescue Marsh in 2004 and 2005 (Mattiske 2005). The conservation significant flora reported from this investigation included:

- *Eremophila spongiocarpa* (P1)
- *Rostellularia adscendens* var. *latifolia* (P3)
- *Themeda* sp. Hamersley Station (M.E.Trudgen 11431) (P3)
- *Eremophila youngii* subsp. *lepidota* (P4).

Taxonomy and current conservation status of the above species were checked on *FloraBase* (WAH 1998-2017).

2.3 LITERATURE REVIEW

The following documents have been reviewed for relevance to the current investigation:

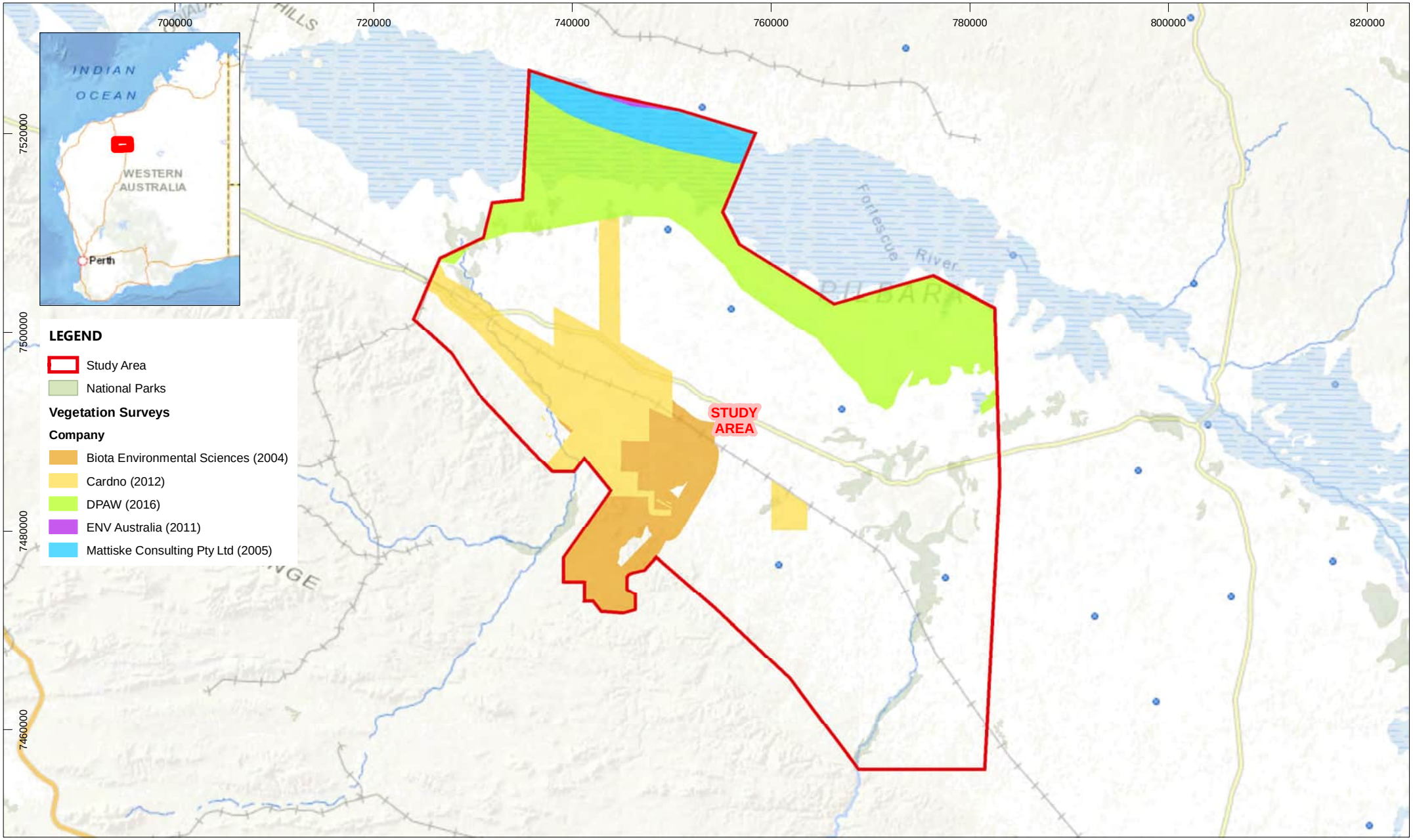
- Markey (2016) *Floristic Survey and Mapping of the Riparian and Halophyte Dominated Communities on the Fortescue Marsh (Martuyitha), Western Australia* - DRAFT
- ecologia Environment (2016) *Pilbara Bulk Ore Transportation System Project. Assessment on Proponent Information - Environmental Review Document*, report prepared for Mineral Resources Limited
- Lyons (2015) *The riparian flora and plant communities of the Pilbara region of Western Australia*
- Rio Tinto (2016) *Yandicoogina Pocket and Billiard South: detailed responses to public submissions in relation to flora and vegetation*

- Phoenix Environmental Sciences (2014a) *Flora and fauna desktop review for the Extension Project and Bulk Sample*, report prepared for Maiden Iron Pty Ltd
- Phoenix Environmental Sciences (2014b) *Flora and vegetation survey for the Extension Project*, report prepared for Australian Aboriginal Mining Corporation Pty Ltd
- ENV Australia Pty Ltd (2013) *Christmas Creek Life of Mine flora and vegetation assessment - update*, unpublished report for Fortescue Metals Group Ltd
- EPA (2013) *Environmental and water assessments relating to mining and mining-related activities in the Fortescue Marsh management area. Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986*
- Astron Environmental Services (2012a) *Cloudbreak Life of Mine Conservation Significant Flora Survey Phase 1*, report prepared for Fortescue Metals Group Limited
- Astron Environmental Services (2012b) *Iron Valley Project Flora and Vegetation Survey*, unpublished report for URS Australia Pty Ltd on behalf of Iron Ore Holdings Ltd
- Biota Environmental Sciences (2012) *A vegetation and flora survey of the Koodaideri study area*, report prepared for Rio Tinto
- Cardno (2012a) *Addendum: Nyidinghu Flora and Vegetation Assessment*, prepared for Fortescue Metals Group
- Cardno (WA) Pty Ltd (2012b) *Nyidinghu flora and vegetation assessment*, unpublished report for Fortescue Metals Group
- Cardno (WA) Pty Ltd (2012c) *Nyidinghu Rail Spur Flora and Vegetation Assessment*, report prepared for Fortescue Metals Group.
- Astron Environmental Services (2011) *Literature Review on Samphire Vegetation Focusing on the Water Requirements of the Community Associate with Fortescue Marsh*, unpublished report prepared for Fortescue Metals Group Limited
- ENV Australia Pty Ltd (2011b) *Cloudbreak Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Limited
- G&G Environmental Pty Ltd (2011) *Flora and vegetation surveys of the FerrAus Limited rail corridor options*, unpublished report for FerrAus Ltd
- Mattiske Consulting Pty Ltd (2011) *Review of Flora and Vegetation Along Weeli Wolli, Mindy Mindy and Coondiner Creeklines*, unpublished report for Rio Tinto
- Onshore Environmental (2011) *Area C and Surrounds Flora and Vegetation Survey*, report prepared for BHP Billiton Iron Ore
- ENV Australia Pty Ltd (2010a) *Christmas Creek flora and vegetation assessment*, unpublished report for Fortescue Metals Group Ltd
- Batini (2009) *Eucalyptus victrix, Karijini National Park*, report to EPA
- Department of Environment and Conservation (2009) *Resource Condition Report for Significant Western Australian Wetland. Wetlands of the Fortescue River System*
- ecologia Environment (2009a) *Brockman Resources Limited Marillana (E47/1408) Vegetation and Flora Report Version 5*, unpublished report for Brockman Resources Limited
- ecologia Environment (2009c) *Roy Hill 1 Project Flora and Vegetation Assessment*, unpublished report for Hancock Prospecting Pty Ltd
- ecologia Environment (2009b) *Roy Hill 1 Infrastructure flora assessment*, unpublished report for Hancock Prospecting Pty Ltd
- G&G Environmental Pty Ltd (2009) *Flora and Vegetation Survey of a Proposed Borefield for the Roy Hill 1 Iron Ore Project*, unpublished report for Roy Hill Iron Ore Pty Ltd
- Mattiske Consulting Pty Ltd (2009b) *Flora and Vegetation on the Creeklines (Coondiner, Kalgan, Mindy Mindy and Unnamed) Associated with Hope Downs 4*, unpublished report for Pilbara Iron
- Mattiske Consulting Pty Ltd (2009c) *Review of flora and vegetation on Mindy Mindy and unnamed transects north of Hope Downs 4 2008 and 2009*, unpublished report for Rio Tinto
- ecologia Environment (2008) *BHP Billiton Iron Ore Rapid Growth Project 5 (RGP5) Chichester Deviation Vegetation and Flora Report (Version 3)*, unpublished report for BHPBIO

- Mattiske Consulting Pty Ltd (2008) *Review of flora and vegetation on Coondiner and Kalgan Creeks north of Hope Downs 4*, unpublished report for Rio Tinto
- Mattiske Consulting Pty Ltd (2007) *Flora and Vegetation near Fortescue Marshes*, unpublished report for Fortescue Metals Group Ltd
- Greg Barrett & Associates Pty Ltd (2005) *Likely Impact of Drawdown of Groundwater from the Cloud Break Operations on Vegetation Communities*
- Mattiske Consulting Pty Ltd (2005) *Flora and Vegetation on the Cloudbreak and White Knight Leases*, unpublished report for Fortescue Metals Group Ltd
- Biota Environmental Sciences (2004a) *Vegetation and Flora Survey of the Proposed FMG Stage A Rail Corridor*, unpublished report for Fortescue Metals Group Ltd
- Biota Environmental Sciences (2004b) *Vegetation and Flora Survey of the Proposed FMG Stage B Rail Corridor and Mines Areas*, unpublished report for Fortescue Metals Group Ltd.

Common factors that are considered to be environmentally significant in many of the above documents and are also likely to be significant within the Fortescue Valley study area (the subject of this report) are:

- the vegetation of the Fortescue Marsh, which is a PEC characterised by Samphire species
- Sheet Flow Dependent Mulga vegetation
- Groundwater Dependent Ecosystems (riparian vegetation characterised by *Eucalyptus camaldulensis*)
- Priority Flora species.



SCALE: 1:500,000 @ A4
COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ecoscape

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	27/11/2017

N

0 5 10 15 km

PREVIOUS SURVEY EXTENTS WITHIN STUDY AREA

FORTESCUE VALLEY FLORA AND VEGETATION SURVEY
CLIENT: FORTESCUE METALS GROUP

FIGURE 04

3 METHODS

3.1 DETAILED FLORA AND VEGETATION SURVEY

The assessment was conducted as a detailed flora and vegetation survey, incorporating desktop study and targeted survey, as described in the *Flora and Vegetation Technical Guidance* (EPA 2016d). The combination of desktop, detailed and targeted field surveys is considered to represent the equivalent of a Level 2 flora and vegetation survey, according to the superseded *Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessments in Western Australia* (EPA 2004).

According to the *Flora and Vegetation Technical Guidance*:

- the purpose of the desktop study (referred to as 'Existing Environment' in this report) is to gather contextual information on the study area. It should incorporate literature reviews (including previous surveys), database searches and spatial information. One of the aims of the desktop study is to identify flora and vegetation of conservation and other significance, and associated habitat that may occur in the study area.
- the purpose of the detailed survey (i.e. the field survey component) is to provide adequate local and regional context relative to the values of flora and vegetation of the survey and adequately address the EPA's objectives. The survey requires comprehensive survey design, including optimal survey timing, and may require multiple sampling events. Multiple quadrats are required throughout each preliminary vegetation type, with three quadrats recorded from each vegetation type. Field survey techniques can include a combination of quadrats, relevés (although not as a primary sampling technique), transects, traverses and opportunistic surveys.
- the purpose of the targeted survey component is to gather comprehensive information on significant flora and/or vegetation, and includes systematic searches of all potentially suitable habitat.

In addition to the above, the survey was conducted in accordance with Fortescue's (2014) *Flora and Vegetation Assessment Guidelines (100-GU-EN-0005)*.

3.1.1 FLORA AND VEGETATION FIELD SURVEY

The field survey was conducted by two teams of two personnel, over two phases of survey.

Following the requirements of the *Flora and Vegetation Technical Guidance* (EPA 2016d), the field survey was conducted by sampling using marked quadrats (as described below). Quadrats were located in representative vegetation of Good and better condition, and sampled vegetation over an area of 2,500 m^2 (generally 50 m x 50 m).

Opportunistic observations were conducted to contribute to a complete species inventory. The survey also included searches for conservation significant flora.

On ground observations, supported by aerial photography, were used to describe the vegetation of the study area.

The survey also incorporated rescoring of a proportion of quadrats previously established and recorded over two phases by Cardno (Cardno 2012b; 2012c). One quadrat per vegetation type was rescored to confirm that 2011 results were still valid (i.e. not significantly changed), and to familiarise the field personnel with collation of vegetation type interpretation.

In 2016, DPaW conducted a floristic and mapping survey of the Fortescue Marsh (Markey 2016) that included the establishment of floristic quadrats within and on the fringes of the Marsh. Eighteen of the 128 quadrats were within the study area; data from these were included in the floristic analysis. The vegetation types identified from within the Marsh (but not the non-Marsh/Marsh fringe vegetation) have been accepted as being an accurate representation of the vegetation, and the DPaW mapping has been used (subject to ground-truthing with new quadrats) in this report. The fringing vegetation, termed 'non-Marsh communities' on off-Marsh land systems (Groups J, K, L and Unclassified Communities, Markey 2016), which were not the focus of the DPaW survey, were re-mapped during this survey.

3.1.1.1 Field Survey Timing

The field survey was conducted over two phases, in June and September 2017. This corresponds with the recommended timing, as detailed in the *Flora and Vegetation Technical Guidance* (EPA 2016d), of vegetation surveys in the Eremaean province having the primary survey 6-8 weeks post wet season (March-June) and the supplementary survey in the dry season.

3.1.1.2 Floristic Quadrats

Floristic quadrat ('quadrat') locations were selected using aerial photography, environmental values and field observations to represent the vegetation values existing at the site. The quadrats sampled were 50 m x 50 m in size, or equivalent area in linear habitats, and were marked with a metal stake in the northwest corner.

The following information was collected from within each quadrat sampled:

- observer
- date
- quadrat/site number, numbered according to Fortescue's (2015) *Sample Point Naming Convention*
- GPS location (GDA94) of all four corners
- digital photograph (spatially referenced with a reference number), taken from the northwest corner, looking diagonally across the quadrat
- soil type and colour
- topography
- list of flora species recorded with the average height, total cover and reproductive status within the quadrat for each species
- vegetation description (as per below)
- vegetation condition.

Where there was sufficient representation, three quadrats were recorded from each vegetation type as identified during the field survey.

Phase two rescoring concentrated on detecting new species that were not observed, either because they were not present (ephemeral species) or not readily visible (i.e. low numbers of plants easily overlooked without flowering material), and to recollect for identification due to flowering period.

Rescoring in quadrats established in 2011 concentrated on confirming species presence, especially where there have been taxonomic updates, and targeted searches for conservation significant flora in quadrats (where suitable habitat was present), as well as familiarising field personnel with interpreting previous vegetation mapping to assist correlation.

3.1.1.3 Conservation Significant Flora Searches (Targeted Searches)

Accessible areas of potentially suitable habitat, as identified during the desktop study, were searched for conservation significant flora. Searches were conducted by the two field surveyors walking approximately parallel meandering transects, spaced an appropriate distance (generally 30-50 m) to view the target species, viewing either side of the walked line. Where potential species were observed, or areas of particularly suitable habitat noted, or where viewing was obscured, the surveyors altered their walked line towards the target.

Previously recorded locations of P1 and P2 species were visited to confirm the species presence or location accuracy.

3.1.1.4 Range Extensions

Taxa recorded during the current survey that are outside of their known distribution were identified as range extensions. Known taxa records (WAH 1998-2017) were used as a guide to determine if each taxon recorded in the study area was representative of a range extension (in this case defined as greater than 100 km from nearest record) or outlier population.

3.1.1.5 Introduced Species

Declared Pest plants (listed under the BAM Act) were searched in DAFWA's website (2017) for the local government areas that the study area is located within to determine if any of the recorded species are listed as Declared Pests.

3.1.1.6 Vegetation Description and Classification

Vegetation was described from each of the quadrats using the height and estimated cover of dominant and characteristic species of each stratum based on the National Vegetation Information System (NVIS; Executive Steering Committee for Australian Vegetation Information [ESCAVI] 2003) (**Table 16** and **Table 17** in **Appendix One**), recorded at Level V. Up to three species per stratum from each stratum (upper, mid and ground) were used to formulate vegetation descriptions for each quadrat and each vegetation type.

Vegetation type descriptions were created by combining quadrat descriptions and modifying, where necessary, based on the wider vegetation. Vegetation codes for these were formulated using the names of the dominant species of each stratum e.g. **AaAtRa** is code for *Acacia aptaneura* low open forest over *Acacia tetragonophylla* tall sparse shrubland over *Rostellularia adscendens* var. *clementii*, **Setaria verticillata* and *Paspalidium clementii* low herbland/ grassland. Where the same species or species with the same initials form the same code for more than one vegetation type they are designated with a superscript e.g. **AsCc**^{1} is code for *Acacia synchronicia* tall open shrubland over **Cenchrus ciliaris*, *Sclerolaena costata* and *Trianthema triquetrum* low open chenopod shrubland/ tussock grassland and **AsCc**^{2} is code for *Acacia sclerosperma* subsp. *sclerosperma* tall open shrubland over **Cenchrus ciliaris* and *Triodia pungens* mid tussock grassland/ hummock grassland.

3.1.1.7 Vegetation Condition and Mapping

Vegetation condition was assessed continuously throughout the study area and at each quadrat using the Vegetation Condition Scale for the Eremaean and Northern Botanical Provinces (EPA 2016d), which has been adapted from Trudgen (1991) (**Table 18** in **Appendix One**).

The spatial extent of the varying vegetation condition was mapped using GIS and vegetation condition maps are provided in this report.

3.2 STATISTICAL ANALYSIS

3.2.1 STUDY AREA FLORISTIC ANALYSIS

PATN© software (Belbin & Collins 2006) was used to undertake statistical analysis to generate floristic groups using the data collected from the floristic quadrats, in order to better understand local significance of floristic units. PATN analysis has been used for several local floristic analyses including Gibson *et al.* (1994) for the Swan Coastal Plain.

PATN is a multivariate analysis tool that generates estimates of association (resemblance, affinity, distance) between sets of objects described by a suite of variables (attributes), and classifies the objects into groups and condenses the information and displays the patterns in the data graphically.

PATN offers a choice of data transformations prior to multivariate analysis.

Floristic groups, identified using a dendrogram output of the analysis, are used as a tool to inform vegetation type groups at various levels and scales. Floristic quadrat data is used for the analysis.

For this analysis, the Kulczynski similarity coefficient was the appropriate association to use as it has proven to be a good estimation of association for ecological applications (Belbin & Collins 2006). This was followed by Flexible UPMGA (Un-weighted Pair Group Using Arithmetic Averaging) fusion to produce clusters of related objects (species); these are the floristic groups that are displayed as a dendrogram.

Interpretation of these purely floristic groups into recognisable and mappable on-ground units is a tool used to identify broad vegetation types. Generally, quadrats that are closely floristically related on the dendrogram form identifiable vegetation units, however, as presence-absence data is usually used in the analysis and there is no weighting given to dominant species, at times the floristic groups are not easily

related to on-ground vegetation types. Vegetation types are therefore determined as a combination of floristic analysis and on-ground interpretation using dominant and characteristic species.

3.2.2 REGIONAL FLORISTIC ANALYSIS

Fortescue has supplied floristic quadrat data from surveys it has commissioned in the area surrounding the study area. This data was used in a similar manner, using PATN to identify floristic groups, to form a regional floristic analysis.

The data included in the analysis was from Fortescue surveys, from this survey, Nyidinghu (mine and rail), Christmas Creek, Cloudbreak, Fig Tree, Kutayi, Roy Hill, Solomon (including Life of Mine surveys), Investigator, Solomon Rail (including re-alignment) and Mt Macleod (full references not available). The DPaW Fortescue Marsh quadrat data (Markey 2016) was also included. In total, 2,351 sites were included in the analysis.

Data was reconciled by removing all singletons (i.e. those species that only occurred once within the data) and all entries with doubtful identification (i.e. those that included a '?' or were only identified to genus or family level), combining taxa where there has been taxonomic review and combining species as a *sens. lat.* where there were entries to both species and subtaxa level and it was not possible to determine which subtaxa was applicable. Exceptions were for the *Senna artemisioides* complex of infrataxa and hybrids and *Tephrosia rosea* complex that were not combined.

The aim of the regional floristics analysis is to determine if the study area includes unique vegetation (at a floristic level) or if it is similar to other areas at a regional scale (broad analysis). The aim is not do provide a detailed analysis and discussion regarding floristics.

3.2.3 ADEQUACY OF SAMPLING

In order to demonstrate adequacy of sampling, a species accumulation curve was generated by the computer programme Species Diversity and Richness (Pisces Conservation Ltd 2010) using five random selections of sample order, and using only quadrat data.

A taxa by area plot was also created using floristic quadrat data for the study area and nearby. This plot gives an indication of relative species richness, and can also provide an indication of survey adequacy.

Adequacy of sampling is also assessed in terms of representation of various attributes, including vegetation types and representation of land systems.

3.3 BOTANICAL LIMITATIONS

3.3.1 FIELD SURVEY TIMING

Survey design: The survey consisted of a detailed two phase, quadrat-based flora and vegetation survey, incorporating previous adequate survey results. Taking into consideration previous two phase surveys, more than 70% of floristic quadrats were scored over two phases. The survey design was such that quadrats were located in representative areas as identified from aerial imagery (with addition quadrats in poorly defined or variable areas during the second phase), and were spread spatially over as much of the study area as possible, given the practicality of lack of access in some parts.

Survey type: Detailed flora and vegetation survey with targeted conservation significant flora searches conducted over two phases. The study area is largely uncleared (although grazed by cattle and feral herbivores) and includes conservation significant species and ecological communities that may be directly or, more likely, indirectly impacted by potential mining activities.

Type of vegetation classification system: Vegetation classified at NVIS Level V (ESCAVI 2003) using largely structural vegetation types defined using dominant and characteristic species and vegetation structure as recorded during the field surveys. Floristic analysis, using reconciled data collected during these field surveys supplemented by earlier records (Cardno 2012a; 2012b; 2012c) and DPaW Fortescue Marsh data (Markey 2016), was used to identify major floristic groups and outlier groups of floristic interest.

Table 6: Botanical limitations

Possible limitations	Constraints (yes/no): Significant, moderate or negligible	Comment
Availability of contextual information at a regional and local scale	No	A significant number of reports were available to provide local and regional context (**Section 2.3**).
Competency/experience of the team conducting the survey, including experience in the bioregion surveyed	No	Field surveys were conducted by teams of two personnel led by an experienced botanist. The June field survey was led by Jared Nelson and the September field survey by Stephen Kern, both with 10 years' experience with flora and vegetation surveys in the Pilbara, assisted by personnel with at least five years' relevant experience. Plant identification was largely undertaken by Stephen Kern.
Proportion of the flora recorded and/or collected, and any identification issues	No	Ten of 522 taxa (1.91%) recorded during the field survey were not identified to species level due to lack of reproductive material. None are likely to be of conservation significance. The species accumulation curve, when taking opportunistic observation records, indicates that most species have been recorded.
Was the appropriate area fully surveyed (effort and extent)	Negligible	The appropriate area was fully and adequately surveyed at sufficient intensity over two phases in 2017, with some areas surveyed in great detail over two phases in 2011 (Cardno 2012b; 2012c) and the Fortescue Marsh surveyed over two seasons in 2013 and 2014 (Markey 2016). Some sections of the study area including the northeast corner, were largely inaccessible and were not assessed, however, they are unlikely to be of any particular significance in terms of conservation significant flora or ecological communities.
Access restrictions within the survey area	Negligible	Parts of the study area were inaccessible due to the distance from tracks. Most notable was the northwest corner of the study area, which largely corresponded with the Calcrete land system that was adequately surveyed in adjacent areas to gain a thorough understanding of the flora and vegetation. There was also an area near the north-central portion of the study area that was also inaccessible due to distance from tracks; this area corresponded with the Marillana land system that was adequately surveyed in adjacent areas. All other areas were sufficiently accessible to gain a thorough understanding of the flora and vegetation of the study area. Part of the northeast of the study area was burnt by a bushfire that burnt during the second phase of survey, however, as there were few new species being recorded during this period, the impact of some quadrats not being able to be rescored was considered negligible.
Survey timing, rainfall, season of survey	No	The survey was conducted over two phases, in June and September 2017. The first phase coincided with the primary survey period (post wet season) and the second phase coincided with the supplementary survey period (dry season), as outlined for Eremaean Botanical Provinces in the *Flora and Vegetation Technical Guidance* (EPA 2016d). Mean rainfall and monthly rainfall for the 12 months prior to the last survey are shown in **Figure 5**. Rainfall deciles for the June survey (**Figure 6** left) indicate that the six months prior to the field survey

Possible limitations	Constraints (yes/no): Significant, moderate or negligible	Comment
		had above average rainfall. The Fortescue Marsh was inundated during the June survey period. However, the three months prior to the September field survey (**Figure 6** right) were drier than average based on the BoM modelling.
Disturbance that may have affected the results of the survey e.g. fire, flood, clearing	No	The study area is grazed by cattle and feral herbivores. Quadrat locations were established in areas away from intense grazing or disturbance (i.e. not on trails or near water sources) to minimise the effects of grazing, trampling etc. A bushfire, started by a lightning strike, burnt part of the northeast corner of the study area during the phase two survey. This restricted access to the vicinity during part of the survey, and some quadrats were burnt and could not be rescored. No other disturbances affecting the survey results were observed.

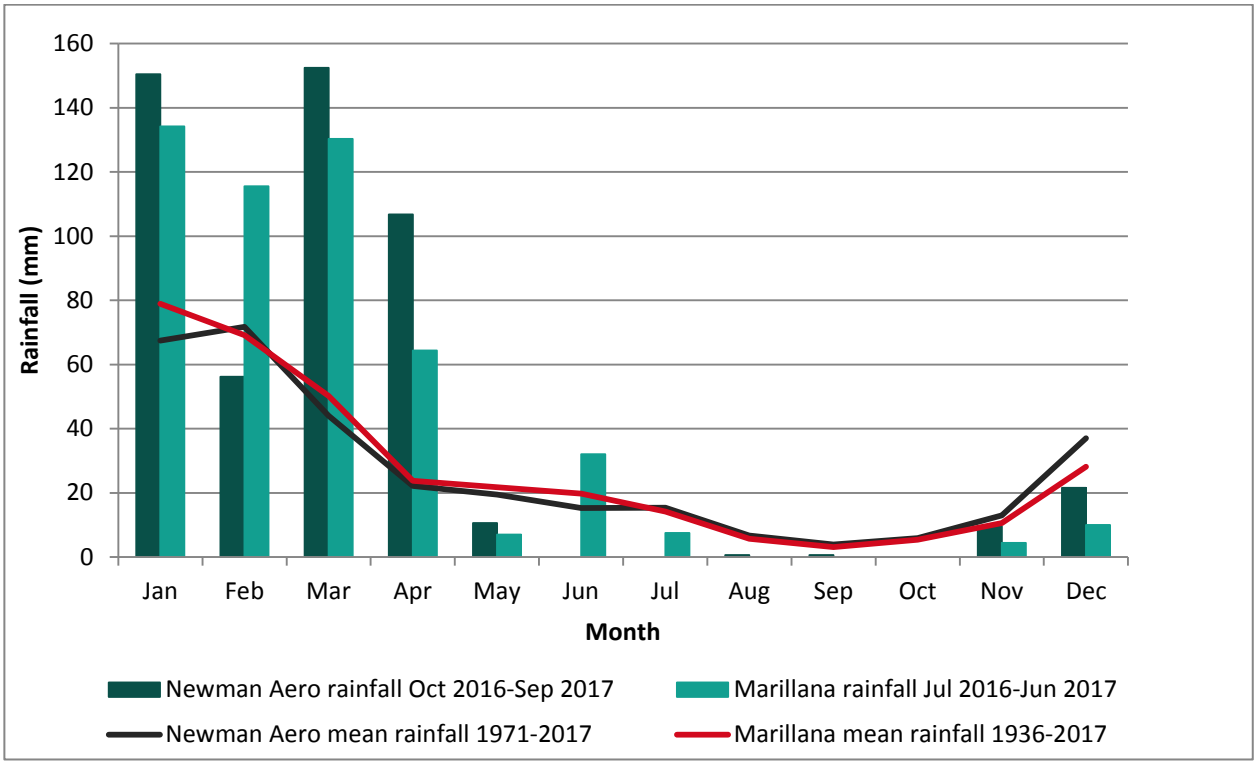


Figure 5: Monthly rainfall data compared with average conditions (BoM 2017c; 2017d)

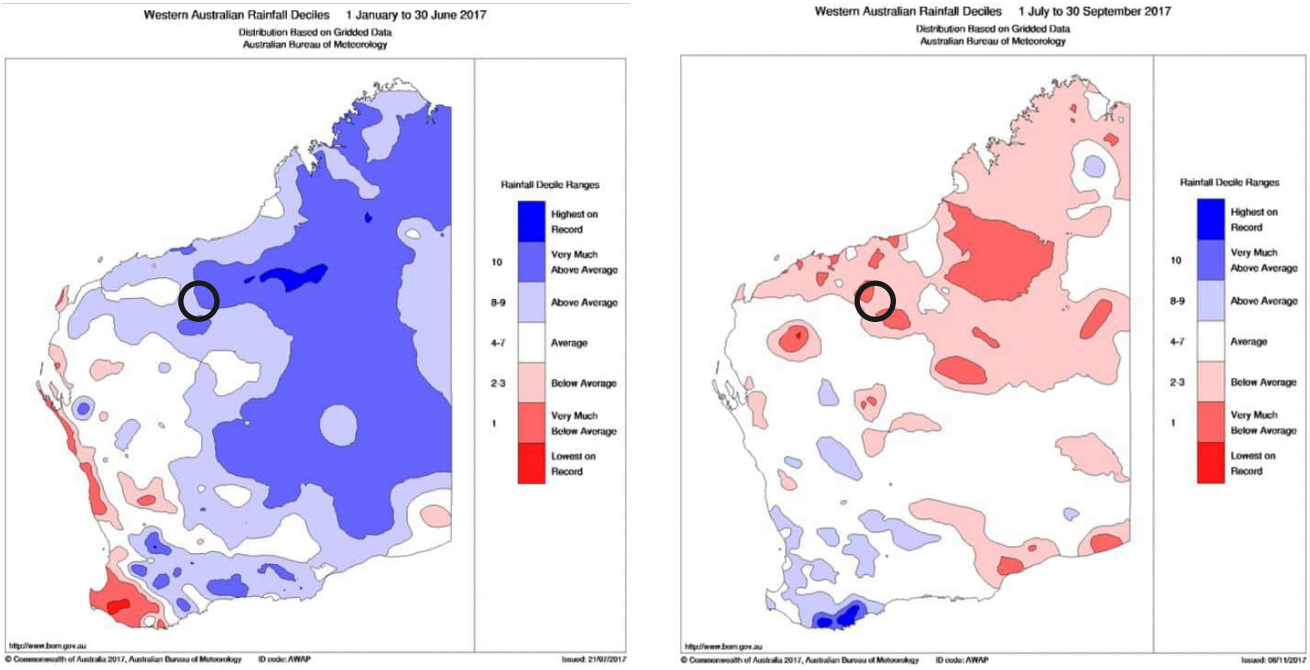


Figure 6: Rainfall deciles (BOM 2017e): approximate location of study area indicated

4 RESULTS

The Phase one flora and vegetation survey was conducted by Jared Nelson, (Flora Collecting Permit SL012010), Andrew Fry (SL012009), Daniel Roberts (SL012088) and Linda Vaughan during 26-30 May and 12-25 June 2017.

The Phase two flora and vegetation survey was conducted by Stephen Kern (SL012012), Andrew Fry, Daniel Roberts and Jordan Vos during 12-24 September 2017.

4.1 FLORA

4.1.1 FLORA INVENTORY

A flora inventory was collated by combining species recorded in the quadrats, from opportunistic observations and during the targeted conservation significant flora search.

A total of 522 vascular flora taxa (inclusive of species, subspecies, varieties and forms) from 203 genera and 62 families were recorded from within the study area during the Ecoscape 2017 surveys. Sixteen (3.06%) of these were introduced. Ten taxa (1.91%) of the taxa recorded could not be identified to species level because of insufficient (sterile) material. When including previous surveys for which data is available (Cardno 2012a; 2012b; 2012c; Markey 2016) there have been a total of 675 flora taxa from 213 genera and 64 families. However, this figure is likely an overestimate as it includes numerous taxa that were not fully resolved at the time of survey which may already be represented in the inventory (for example numerous Mulga taxa, for which a recent treatment is available).

The full list of vascular flora inventory is shown in **Table 20** in **Appendix Three**. The full site by species table has been provided to Fortescue in electronic format.

The families with the highest number of taxa (according to Ecoscape 2017 data) were Fabaceae with 83 taxa, Poaceae (80 taxa), Malvaceae (48 taxa), Chenopodiaceae (40 taxa), Asteraceae (29 taxa) and Amaranthaceae (25 taxa). The most commonly recorded genera were *Acacia* (33 taxa), *Ptilotus* (16 taxa), *Maireana* (14 taxa), *Senna* and *Sida* (13 taxa each), *Eremophila* and *Euphorbia* (12 taxa each), *Eragrostis* (11 taxa), *Abutilon* and *Goodenia* (10 taxa each).

The number of flora taxa recorded per quadrat ranged from one (several quadrats towards the centre of Fortescue Marsh) to 78 (FV17086). Average species diversity was 34.3 flora taxa per quadrat. The most frequently recorded flora taxa were *Cleome viscosa* (123 quadrats), *Ptilotus nobilis* subsp. *nobilis* (119), **Cenchrus ciliaris* (117), *Solanum lasiophyllum* (115) and *Sporobolus australasicus* (104).

Overall, 209 floristic quadrats were recorded within the study area during 2017, consisting of 186 newly established quadrats and 22 previously established quadrats recorded by Cardno which were rescored. During Phase 1 (May-June 2017), the 22 Cardno quadrats were rescored and 112 new quadrats were established. During Phase 2 (September 2017), 110 of the new quadrats established during Phase 1 were rescored and 74 new floristic quadrats were established. Floristic quadrat details are provided in a separate document. Additionally, there have been 295 floristic quadrats recorded within the study area for which data is available including 275 by Cardno (2012a; 2012b; 2012c) and 20 by DPaW (Markey 2016). Therefore the total number of floristic quadrats that are known to have been recorded within the study area is 506. The 2017 quadrats and previous quadrats are displayed on the **Map 7** series.

4.1.2 FLORA OF CONSERVATION SIGNIFICANCE

4.1.2.1 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

Lepidium catapycnon is listed as Vulnerable under the EPBC Act, where it was listed in 2008. At the time it was listed as Rare Flora (also known as Declared Rare Flora) under the Western Australian WC Act, but was delisted in 2015, and is now listed as P4 in Western Australia (Australian Government & DotEE 2017c).

4.1.2.2 Western Australian Biodiversity Conservation Act 2016

No BC Act listed Threatened Flora were recorded in the study area.

4.1.2.3 Priority Flora

Seventeen PF were recorded from the study area during the 2017 survey:

- *Eremophila spongiocarpa* (P1)
- *Euphorbia inappendiculata* var. *queenslandica* (P1)
- *Myriocephalus scalpellus* (P1)
- *Nicotiana heterantha* (P1)
- *Samolus* sp. Fortescue Marsh (A. Markey & R. Coppen FM 9702) (P1)
- *Synostemon hamersleyensis* (P1)
- *Tecticornia globulifer*a (P1)
- *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063) (P1)
- *Euphorbia australis* var. *glabra* (P2)
- *Euphorbia inappendiculata* var. *inappendiculata* (P2)
- *Isotropis parviflora* (P2)
- *Atriplex flabelliformis* (P3)
- *Sida* sp. Barlee Range (S. van Leeuwen 1642) (P3)
- *Tecticornia medusa* (P3)
- *Eremophila youngii* subsp. *lepidota* (P4)
- *Goodenia nuda* (P4)
- *Lepidium catapycnon* (P4).

Targeted searches were conducted in areas of potential habitat as identified by the conservation significant flora likelihood assessment.

Other species that have been previously recorded but not during 2017 include:

- *Calotis squamigera* (P1); the previously recorded location was searched but the species was not re-located. Ecoscape considers the Cardno record to be most likely be valid, however, the species is an annual and is potentially not always recorded from the same areas as previously.
- *Helichrysum oligochaetum* (P1); the previous location was searched during each phase of field survey, however, the species was not re-located. Ecoscape considers the record (from 2014) to be valid and location accurate, however, as an annual it may not always be present or in the same location.
- *Acacia subtiliformis* (P3); the previous record was from 1992 and locational information is considered to be inaccurate; the record is considered to be unlikely as it corresponds with unsuitable habitat
- *Eragrostis crateriformis* (P3); the previously recorded location was searched but the species not re-located. Two plants of this species were recorded by Cardno (2012b), however, there is no corresponding vouchered specimen and, as it is outside of the typical range, the accuracy of the identification cannot be verified.
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3); the leaf width of the *Rhagodia* in the study area is generally intermediate between the P3 species, which is not formally described, and the common *Rhagodia eremaea*. *Rhagodia* sp. Hamersley may occur in the study area.
- *Stylidium weeliwolli* (P3); the previous record is from 1959 and locational information is likely to be inaccurate. The location was extensively searched, however, the area is now heavily grazed and choked with Buffel Grass and if it did occur previously it is now unlikely.

The locations of conservation significant flora recorded during the field surveys are shown on the **Map 4** series. Details of the recorded conservation significant flora are included in **Table 7**.

Table 7: Conservation significant flora recorded during the field surveys

Priority	Description and notes	Habitat	Survey results	Photo
Priority 1	***Eremophila spongiocarpa* (P1)** An intricately branching shrub, appearing to be spinescent, to 1 m high. Fruit are spongy in appearance. *NatureMap* (DPaW 2007-2017) lists 36 records for this species.	Occurs on low-lying saline areas, particularly associated with samphire dominated vegetation types within and close to the Fortescue Marsh. Vegetation Types AaAsCc, AbTl, AsCc[1], AsCc[2], EvMxTl, Ms, Ta[1], Ta[2], TD	**Records**: 37 locations were recorded during 2017, totalling approximately 3,500 plants from areas that were traversed. Twelve additional records of this species have been recorded by previous surveys within the study area. **Populations**: considered to be a largely continuous population across the Fortescue Marsh section of the study, particularly abundant towards the fringes.	
Priority 1	***Euphorbia inappendiculata* var. *queenslandica* (P1)** A prostrate, much-branched, diffuse herb with milky latex. Stems to 0.3 m long, covered in sparse, white long, spreading hairs. *NatureMap* (DPaW 2007-2017) lists 36 records for this taxa, mostly in the Pilbara bioregion.	Red loamy depressions on plains Vegetation Types AaAsCc, SaEx/AsCc[1]	**Records**: Three locations totalling 25 plants from the areas that were traversed. Not previously recorded in the study area by other surveys. **Populations**: The locations recorded are considered to represent a single population, near the western boundary of the study area.	

Priority	Description and notes	Habitat	Survey results	Photo
Priority 1	***Myriocephalus scalpellus* (P1)** Prostrate to semi-erect annual herb to 10 cm high. Stems and leaves cottony. Globular flower head consisting of white bracts surrounding the yellow florets. *NatureMap* (DPaW 2007-2017) lists three records for this species, all from the Fortescue IBRA subregion in the Pilbara bioregion.	On the edges of freshwater claypans and watercourses Vegetation Types AxEcSc, EvDf, EvDfEb	**Records**: 25 locations totalling an at least 4,724 plants, most of which were on the edges of Coondiner pools and nearby clay soils, where this species had been previously documented **Populations**: two, most records are from the banks or nearby surrounds of Coondiner Pool with an outlier population recorded approximately 11 km northeast.	
Priority 1	***Nicotiana heterantha* (P1)** Annual or short-lived herb with long (2.5-4 cm) white tubular flowers. Leaves forming a basal tuft. Forms spreading colonies. *NatureMap* (DPaW 2007-2017) lists 32 records for this species, mostly from the Pilbara bioregion but also occurring in the Dampierland and Great Sandy Desert bioregions.	Saline flats of the Fortescue Marsh Vegetation Types EvDf, Ms, Ta[1], Ta[2]	**Records**: 57 locations were recorded during 2017, from areas that were traversed, including at least 9,135 plants. Twenty one additional records of this species have been recorded by previous surveys within the study area. **Populations**: A largely continuous population across much of the Fortescue Marsh section of the study area and surrounding vegetation. This ephemeral species appeared to be particularly abundant during the excellent 2017 seasonal conditions.	

Priority	Description and notes	Habitat	Survey results	Photo
Priority 1	***Samolus* sp. Fortescue Marsh (A. Markey & R. Coppen FM 9702) (P1)** Perennial herb or shrub to approximately 1 m high with bright green, tangling stems. White terminal flowers. *NatureMap* (DPaW 2007-2017) lists 13 records for this species, mostly from the Pilbara bioregion.	Saline flats of the Fortescue Marsh Vegetation Types AaCc[2], AbTl, Ms, Ta[2], TD	**Records**: Two records during 2017 within the areas traversed, including approximately 20 plants. An additional seven records from previous surveys have been documented. **Populations**: scattered populations within the Fortescue Marsh section of the study area.	
Priority 1	***Synostemon hamersleyensis* (P1)** Shrub to 1 m high, apparently leafless with wiry stems. *NatureMap* (DPaW 2007-2017) lists five records for this species, all from the Pilbara bioregion.	Hillslopes with rocky soil. Vegetation Type ElGwTv	**Records**: Six records from the traversed sections of the study area, totalling 16 plants **Populations**: two populations in close proximity to each other (3.5 km) near the south-western boundary of the study area.	

Priority	Description and notes	Habitat	Survey results	Photo
Priority 1	***Tecticornia globulifera* (P1)** Spreading to erect samphire shrub to 0.5 m high. Distinctive (usually) bright red, terminal, globular articles appearing like balls on the end of the stems. *NatureMap* (DPaW 2007-2017) lists 14 records for this species, mostly from the Pilbara bioregion..	Saline flats of the Fortescue Marsh Vegetation Types Ms, Ta^1, Ta^2, TD, Tm, Tv	**Records**: 30 records totalling 8373 plants within the sections traversed. There were 12 previous record known from the study area **Populations**: Numerous scattered across the Fortescue Marsh particularly the interior zone.	
Priority 1	***Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063) (P1)** Erect or spreading samphire shrub to 1 m high. Distinctive opposite and decussate perpendicular fruiting branchlets. *NatureMap* (DPaW 2007-2017) lists 22 records for this species, mostly from the Pilbara bioregion.	Saline flats of the Fortescue Marsh Vegetation Types Ms, Ta^1, Ta^2	**Records**: 17 records totalling 5204 plants within the sections traversed. There were 13 previous record known from the study area **Populations**: Numerous scattered across the Fortescue Marsh section of the study area.	

Priority	Description and notes	Habitat	Survey results	Photo
Priority 2	***Euphorbia australis* var. *glabra* (P2)** Prostrate much-branched herb with milky latex; upper surface of leaves glabrous. *NatureMap* (DPaW 2007-2017) lists 15 records for this taxa, all from the Pilbara bioregion.	Alluvial cracking clay loamy soil. Vegetation Types AaAsCc, AaEfEp, Ta[2]	**Records**: Five isolated records were taken from the areas that were traversed, totalling an estimated 100 plants. One previous record occurs within the study area. **Populations**: Up to five isolated populations recorded across the study area, though this species is relatively cryptic and there is plenty of suitable habitat within the study area.	
Priority 2	***Euphorbia inappendiculata* var. *inappendiculata* (P2)** A prostrate, much-branched, diffuse herb with milky latex. Stems to 0.3 m long, without hairs (glabrous). *NatureMap* (DPaW 2007-2017) lists six records for this taxa, mostly from the Pilbara bioregion.	Clay soils. Vegetation Types SaEx/AsCc[1]	**Records**: One location where it was present at <1% cover. This species had not been previously recorded within the study are. **Populations**: One recorded, towards the western boundary of the study area	

Priority	Description and notes	Habitat	Survey results	Photo
Priority 2	***Isotropis parviflora* (P2)** Shrub to approximately 20 cm high with single leaves and hairy stems. White to pink pea flowers. *NatureMap* (DPaW 2007-2017) lists 27 records for this species. Most are from the Pilbara bioregion, however, there are also records from the Great Sandy Desert and Tanami bioregions.	Low rocky hills. Vegetation Types AaTb, AbTv	**Records**: seven records from areas that were traversed. **Populations**: Up to six populations (though several may be continuous) located on the low hills within a 5 km radius of Coondiner Pool towards the eastern end of the study area.	
Priority 3	***Atriplex flabelliformis* (P3)** Erect, rounded perennial herb to 35 cm high. Fan-shaped or deltoid (inverted triangle) shaped fruit. *NatureMap* (DPaW 2007-2017) lists seven records for this species. Most are associated with the Fortescue Marsh in the Pilbara bioregion, however, there are also records from the Great Sandy Desert and Tanami bioregions.	Clay soil, floodplain. Vegetation Types Ms, Ta^1, Ta^2	**Records**: 13 records from areas that were traversed, totalling 95 plants. **Populations**: Scattered populations across the Fortescue Marsh, particularly interior zones.	

Priority	Description and notes	Habitat	Survey results	Photo
Priority 3	***Sida* sp. Barlee Range (S. van Leeuwen 1642) (P3)** Rounded or spreading woolly or velvety shrub to 50 cm high. Yellow flowers. *NatureMap* (DPaW 2007-2017) lists 45 records for this species, mostly from the Pilbara bioregion.	Sheltered areas in ironstone. Vegetation Types ElGwTv	**Records**: One record from the areas traversed **Populations**: One, adjacent to the southernmost boundary of the study area.	
Priority 3	***Tecticornia medusa* (P3)** Erect shrub to 1 m high with large, bright green or yellowish green articles. Long fruiting branchlets distinctively narrower than stem articles. *NatureMap* (DPaW 2007-2017) lists 18 records for this species, mostly from the Pilbara bioregion.	Clay soils, seasonally inundated. Vegetation Types Ta^1, Ta^2, Tm, Tv	**Records**: Nine records totalling 5,063 plants within the sections traversed. There were 13 previous record known from the study area **Populations**: Several scattered across the Fortescue Marsh, particularly the interior zone.	

Priority	Description and notes	Habitat	Survey results	Photo
Priority 4	***Eremophila youngii* subsp. *lepidota* (P4)** Medium or large shrub to 4 m high. Leaves narrow and scaly. Tubular pink-purple flowers. *NatureMap* (DPaW 2007-2017) lists 47 records for this taxa, mostly from the Pilbara bioregion but also in the Carnarvon, Gascoyne and Little Sandy Desert bioregions, with a record in the Northern Territory.	Clay or loamy soils, calcrete. Vegetation Types AaAsCc, AaEfEp, AbTl, AsCc[1], AsCc[2], AxEcSc, AxEcTe, EvDfEb, EvMxTl, EyAb, MgCc, MxCc, Tl	**Records**: 124 records from the areas traversed, totalling 4,155 plants. **Populations**: Numerous populations within the northern half of the study area, including Fortescue Marsh. Likely to be a largely continuous across the study area.	
Priority 4	***Goodenia nuda* (P4)** Prostrate or erect herb to 50 cm high with three-veined basal leaves. Yellow flowers with maroon centre. *NatureMap* (DPaW 2007-2017) lists 112 records for this species, mostly from the Pilbara bioregion.	Generally in alluvial soils (clay or rocky loams/sand). Vegetation Types AaAsCc, AaAtRa, AaEfEp, AaSaEp, AaTp, AbTl, EvMxTl, MgCc, SaEx/AsCc1, Tl	**Records**: 18 records totalling 51 plants within areas traversed. **Populations**: At least twelve populations, commonly encountered across the study area from a variety of vegetation types.	

Priority	Description and notes	Habitat	Survey results	Photo
Priority 4	***Lepidium catapycnon* (P4)** Open herb or shrub to 70 cm high with small succulent leaves and zig zag branch tips. White flowers. *NatureMap* (DPaW 2007-2017) lists 89 records for this species, all from the Pilbara bioregion.	Skeletal ironstone soils. Vegetation Types ElGwTv	**Records**: Seven records totalling 82 plants. **Populations**: One, near the southern boundary of the study area, recorded near a previously known location	

4.1.2.4 Significant Flora

The flora taxa that are of significance according to the *Flora and Vegetation Technical Guidance* (EPA 2016d) are shown in **Table 8** and on the **Map 4** series.

Table 8: Significant flora

Taxon	Significant Attribute
Basilicum polystachyon	The presence of this species at Coondiner Pool represents a minor range extension of approximately 30 km southwest of the nearest location according to *NatureMap* (DPaW 2007-2017) and *Atlas of Living Australia* (ALA 2017).
Chrysocephalum eremaeum	This species has a wide range throughout central Australia (ALA 2017) and is a minor (approximately 40 km) western range extension.
Ehretia saligna var. *saligna*	According to *NatureMap* (DPaW 2007-2017) and mapping, this taxon is approximately 100 km south southwest of the nearest location, although *ALA* (2017) indicates a closer record. This taxon has also been previously recorded within the study area by Cardno (2012b) and was also collected by DPaW during its Fortescue Marsh survey (Markey 2016) and as such represents limited vouchering effort rather than a new range extension.
Einadia nutans subsp. *eremaea*	According to *NatureMap* (DPaW 2007-2017) and *ALA* (2017) mapping, this taxon is approximately 300 km from its nearest collection and in a previously unrecorded bioregion. However, DPaW (Markey 2016) recorded it in its Fortescue Marsh survey (but, to date, no voucher specimens have been added to the database), indicating that this species is not a new range extension.
Eragrostis exigua	The nearest vouchered records of this species are approximately 200 km to the southwest and north (ALA 2017), however, it occurs at variable (but greater) distances to the west, north and east of the study area and is therefore considered to be fitting within a range gap rather than being a range extension.
Eriachne gardneri	According to *NatureMap* (DPaW 2007-2017) and *ALA* (2017) mapping, this species is more commonly recorded from the Carnarvon IBRA region and coastal parts of the Pilbara IBRA region. There is one record from the Hamersley subregion and one outlier record from the Fortescue subregion, with the latter being within the study area. Therefore, *Eriachne gardneri* is a previously documented outlier population.
Euphorbia inappendiculata var. *inappendiculata* (P2)	According to *NatureMap* (DPaW 2007-2017), this taxon is at least a 100 km eastern range extension and 200 km southern range extension from existing records, and is considered to be an range outlier (although *ALA* (2017) indicates a range outlier in the Northern Territory). However, it is likely that this species is undercollected due to its similarity to other species.
Frankenia ambita	*Frankenia ambita* is generally a coastal species, however, there is a vouchered outlier population in the Fortescue IBRA subregion from less than 10 km from the study area (ALA 2017). DPaW, in its Fortescue Marsh survey, documented the species as being common and characteristic of several vegetation types (Markey 2016). Therefore, the presence of *Frankenia ambita* within the study area is unlikely to be significant.
Halgania solanacea var. *solanacea*	The nearest vouchered specimen is from approximately 70 km to the east (DPaW 2007-2017), representing a range extension.
Trichodesma zeylanicum var. *grandiflorum*	The nearest vouchered specimen is at least 100 km north east of the study area (ALA 2017), representing a range extension. However, Cardno (2012b) recorded this taxa as a characteristic species of the Fortescue Valley Sand Dunes, thus this taxa represents limited vouchering effort rather than a new range extension.
Triglochin hexagona	This is the first record of this species from the Pilbara bioregion according to *NatureMap* (DPaW 2007-2017) and *ALA* (2017). It was recorded from the Fortescue Marsh section of the study area, approximately 200 km southwest of the nearest recorded location. DPaW, in its Fortescue Marsh survey, also reported this species (Markey 2016) but no specimens have as yet been vouchered with the herbarium, thus it is not a new range extension. This species has a widespread distribution across inland Australia.
Uvedalia linearis	The record of this species within the study area represents filling of a range gap, according to *ALA* (2017) as this species is widespread across Northern Australia.

4.1.2.5 Flora of Taxonomic Interest

A *Corchorus* species was collected from 53 floristic quadrats, hence locally common within the study area. Ecoscape's collections match vouchered specimens described as *C. elachocarpus* (Mitchell PRP1462 and Mitchel PRP1135 from Marillana Station) in Halford (2004), with this paper noting that these collections differ

from *C. elachocarpus* in '*having narrowly ovate leaves, longer peduncles and pedicels, and broader fruit. This entity warrants formal recognition. However, more material is required before this can be undertaken*.'

Ecoscape's specimens match voucher specimens housed in the Western Australian Herbarium (P. Sweeny & D. Roberts ONS MC250.06 and J. Bull & A. Buckeridge ONS MTM 60.01) that are filed under the name of *C.* aff. *tectus*. Steve Dillon, Western Australian Herbarium Taxonomist, has confirmed that Ecoscape's specimens match the Herbarium specimens of *C.* aff. *tectus*, which differs from *C. tectus sens. str.* by having dendritic hairs on the fruit amongst other characteristics, and considers that this taxon is of taxonomic interest rather than conservation significance as it is reasonably frequently collected.

For consistency reasons, this species is known as *C.* aff. *tectus* in this report.

DPaW (Markey 2016) considered *Frankenia ambita* to be a species of taxonomic interest, this species was frequently encountered within the Fortescue Marsh section of the study area.

4.1.3 INTRODUCED FLORA (WEEDS)

Seventeen species recorded during 2017 were introduced species (weeds). The species and their ecological impact and invasiveness ratings (DPaW 2016a) are shown in **Table 9**.

None of the species recorded within the study area are listed as WONS (Weeds Australia 2012) or Declared Pest plants listed under the BAM Act recorded within the study area.

Table 9: Introduced species (DPaW 2016a)

Species	Ecological Impact	Invasiveness	Code
**Aerva javanica*	H	R	**Ecological impact:**
**Argemone ochroleuca* subsp. *ochroleuca*	U	R	L = low
**Bidens subalternans* var. *simulans* (under **Bidens bipinnata*)	U	R	M = medium
**Cenchrus ciliaris*	H	R	H = high
**Cenchrus setiger*	H	R	U = unknown
**Chloris virgata*	H	R	
**Citrullus lanatus*	U	M	**Invasiveness:**
**Echinochloa colona*	H	R	S = slow
**Flaveria trinervia*	Not listed		M = moderate
**Malvastrum americanum*	H	R	R = rapid
**Portulaca pilosa*	Not listed		U = unknown
**Pseudognaphalium luteoalbum*	Not listed		
**Rumex vesicarius* (under **Acetosa vesicaria*)	H	R	
**Setaria verticillata*	H	R	
**Sisymbrium orientale*	Not listed		
**Sonchus oleraceus*	L	R	
**Vachellia farnesiana*	H	R	
Previously recorded from the study area (Fortescue database record) but not recorded during this survey			
**Bidens pilosa*	U	R	
**Datura leichhardtii*	U	U	
**Solanum nigrum*	L	R	
**Stylosanthes hamata*	H	M	
**Tribulus terrestris*	U	M	

**Sisymbrium orientale* is rarely collected in the Pilbara, with only two collections indicated on *NatureMap* (DPaW 2007-2017). The collection from within the study area is an approximately 140 km eastern extension for this species. It was observed to be common along Weeli Wolli Creek.

4.1.3.1 Introduced Flora Descriptions

Table 10: Introduced flora (weed) descriptions

Photos are by Ecoscape unless credited otherwise.

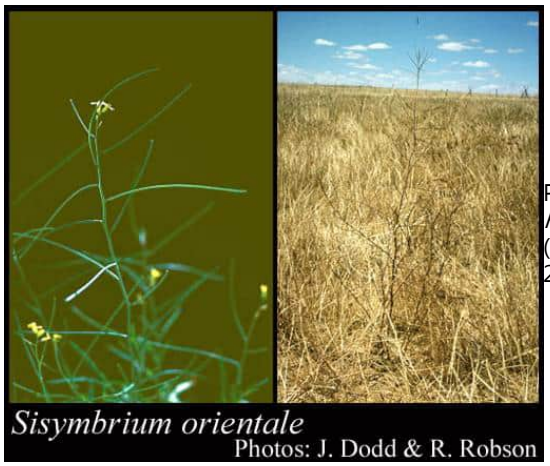
Description and notes	Survey results	Photo
***Aerva javanica* (Kapok Bush)** Perennial herb to 1.6 m high (but usually less) with greyish white flowers throughout much of the year (WAH 1998-2017). Usually associated with disturbed areas and drainage lines, and is found throughout much of northern Western Australia.	Records: 23 Location: widespread but scattered, mostly associated with drainage lines, railway, cattle wells and tracks. Impact: not significant.	
***Argemone ochroleuca* subsp. *ochroleuca* (Mexican Poppy)** Mexican Poppy is a prickly annual herb to 1 m high with cream or yellowish flowers mainly produced in spring. It occurs over much of Western Australia but is more commonly recorded in the Pilbara region (WAH 1998-2017) where it generally occurs in association with rivers and creeks.	Records: 8 Location: mostly associated with drainage lines in the west of the study area. Impact: localised but not significant.	

Description and notes	Survey results	Photo
***Bidens subalternans* var. *simulans* (Beggartick)** Specimens of *Bidens* previously recorded as **Bidens bipinnata* have been identified as **Bidens subalternans* according to the most recent treatment of the genus in *Flora of Australia Vol. 37* (Orchard 2015). Many records of *Bidens* in the Pilbara are still listed as **B. bipinnata* (WAH 1998-2017), however, this species does not occur within Western Australia based on the recent revision of the genus. Presumably these records represent specimens yet to be formally reviewed and databased at the WAH. **Bidens subalternans* is considered an introduced species. **Bidens subalternans* is an annual herb growing to 1.5 m high in good conditions, although it is more typically less than 0.5 m high. It occurs over much of Western Australia north of Geraldton (WAH 1998-2017).	Records: 25 Location: widespread over the study area but mostly associated with Mulga. Impact: common at low density so impact unlikely to be significant.	
***Cenchrus ciliaris* (Buffel Grass)** **Cenchrus ciliaris* is a perennial tussock-forming grass to 1 m high (WAH 1998-2017). It is generally associated with drainage lines and floodplains, and is more common in grazed areas. **Cenchrus ciliaris* was either deliberately planted for pasture or accidently introduced (Van Vreeswyk *et al.* 2004), and has been known from the Pilbara bioregion since the early 1900s (Keighery 2010).	Records: 119 Location: Marsh fringe and Weeli Wolli Creek Impact: significant.	
***Cenchrus setiger* (Birdwood Grass)** **Cenchrus setiger* is a perennial tussock grass to 0.8 m high (WAH 1998-2017). It differs from **C. ciliaris* in its more robust seed heads but vegetatively the two are virtually identical. It occurs over much of the northern portion of Western Australia, and, like **C. ciliaris*, has been known from the Pilbara bioregion since the early 1900s (Keighery 2010).	Records: 27 Location: Marsh fringe and Weeli Wolli Creek Impact: significant, similar to Buffel Grass in some areas, but less commonly encountered within the study area	

Description and notes	Survey results	Photo
***Chloris virgata* (Feathertop Rhodes Grass)** Feathertop Rhodes Grass is an annual or short-lived perennial grass to 50 cm high. It occurs over much of Western Australia high (WAH 1998-2017) and in all mainland states of Australia (ALA 2017). It is sometimes planted as a pasture grass.	Records: 4 Location: southeast of study area in Mulga. Impact: insignificant	 Photo: *Atlas of Living Australia* (2017). Photo credited to Forest & Kim Starr.
***Citrullus lanatus* (Pie Melon)** **Citrullus lanatus* is an trailing or climbing annual herb with yellow flowers and striped or mottled melon fruits, found over much of Western Australia where it favours disturbed areas (WAH 1998-2017).	Records: 1 Location: road verge near BHP rail Impact: insignificant	
***Echinochloa colona* (Awnless Barnyard Grass)** **Echinochloa colona* is an annual grass to 0.6 m high that is widespread across the Pilbara and Kimberley regions, with isolated records in the Perth region (WAH 1998-2017).	Records: 7 Location: depressions in Mulga Impact: very low	

Description and notes	Survey results	Photo
***Flaveria trinervia* (Speedy Weed)** **Flaveria trinervia* is an annual herb with distinctive red stems and three-veined leaves and is found throughout much of northern Western Australia. It is listed on *FloraBase* (WAH 1998-2017) as 'alien' (introduced), however Hussey *et al.* (2007) and the Pilbara Ranking Summary (of the Weed Prioritisation Process) (DPaW 2016a) do not list this species, indicating there is debate in relation to **Flaveria trinervia* being native or introduced. DPaW, in its Fortescue Marsh report (Markey 2016), considers it to be native.	Records: 7 Location: widespread especially along Marsh edge and drainage lines Impact: minor	
***Malvastrum americanum* (Spiked Malvastrum)** **Malvastrum americanum* is a perennial herb or shrub to 1.3 m high (WAH 1998-2017), although within the study area it has generally been recorded as being less than 0.5 m high. It is usually, but not always, associated with drainage lines and has a wide distribution through northern and arid Western Australia.	Records: 48 Location: widespread at low density, under Mulga and along drainage lines Impact: minor	
***Portulaca pilosa* (Djanggara)** This species is a succulent herb that may be either erect or more usually prostrate, with linear leaves and most commonly with pink flowers. Within Australia it is distributed mostly in the northern part of the continent (ALA 2017). Until recently (2016) this species was not listed as a weed.	Records: 35 Location: widespread at low density across the study area, typically from Mulga woodlands/groves Impact: insignificant	

Description and notes	Survey results	Photo
***Pseudognaphalium luteoalbum* (Jersey Cudweed)** **Pseudognaphalium luteoalbum* is an annual herb to 50 cm high with greyish woolly leaves and stems, and an Australia-wide distribution (ALA 2017). According to *FloraBase* (DPaW 2007-2017) *Pseudognaphalium luteoalbum* is described as being Native in part of its range and Naturalised elsewhere. *Atlas of Living Australia* (2017), under *Pseudognaphalium luteoalbum*, does not indicate the species' origin, however, under the pseudonym *Helichrysum luteoalbum* indicates it is naturalised in the 'New World' (which includes Australia). For the purposes of this report, Ecoscape is considering the species to be introduced, however, it is well recorded from the vicinity of the study area (ALA 2017) and is not considered to have any significant impact.	Records: 2 Location: Coondiner Pool and edge of Fortescue Marsh Impact: insignificant	 Photo: *Atlas of Living Australia* (2017). Photo credited to Michael Bedingfield.
***Rumex vesicarius* (Ruby Dock)** Until recently **Rumex vesicarius* was known as **Acetosa vesicaria*. It is a fleshy annual herb to 80cm high with red fruit and recorded from most of Western Australia except the tropics (DPaW 2007-2017). It is frequently found in the Pilbara in disturbed areas including road verges and drainage lines.	Records: 3 Location: Weeli Wolli Creek Impact: localised but not significant	
***Setaria verticillata* (Whorled Pigeon Grass)** **Setaria verticillata* is an annual grass to 1 m high (WAH 1998-2017), but more usually approximately 0.5 m. It is widely distributed within Western Australia and, within the Pilbara region, is mostly associated with drainage lines.	Records: 33 Location: widespread at low density, particularly in Mulga and creeklines Impact: insignificant	

Description and notes	Survey results	Photo
***Sisymbrium orientale* (Indian Hedge Mustard)** **Sisymbrium orientale* is an annual or biennial herb to 1 m high with yellow flowers and pods to 11 cm long, native to western Asia and the Mediterranean (Hussey *et al.* 2007). It is found in all Australian states (ALA 2017), however, *NatureMap* (DPaW 2007-2017) indicates only two records from the Pilbara (including one near Roy Hill Homestead on calcrete soils).	Records: 1 Location: Weeli Wolli Creek Impact: insignificant	 Photo: *FloraBase* (DPaW 2007-2017).
***Sonchus oleraceus* (Common Sowthistle)** **Sonchus oleraceus* is an annual or biennial herb to 1.5 m high (WAH 1998-2017) with an almost State-wide distribution.	Records: 3 Location: mostly Fortescue Marsh Impact: minor	
***Vachellia farnesiana* (Mimosa Bush)** **Vachellia farnesiana* is an erect spinescent tree or, more often, a shrub to 4 m high. It is widely distributed through the north of Western Australia, however it occurs sporadically in areas closer to Perth (WAH 1998-2017). Hussey *et al.* (2007) consider it to have been introduced to Australia prior to European settlement.	Records: 9 Location: widespread except not in hills or Marsh Impact: locally significant especially around cattle bores and sumps	

4.2 VEGETATION

4.2.1 VEGETATION TYPES

Forty one vegetation types, shown in **Table 11** and in the **Map 7** series, were recorded from within the study area, taking into account consolidated and rectified vegetation mapping by Cardno (2012a; 2012b; 2012c) and DPaW (DPaW 2016b; Markey 2016) and floristic analysis. The formulation of vegetation types took into account floristic analysis and vegetation species and structure (i.e. both floristic composition and structural vegetation classifications) from all surveys, and ground-truthing. Where possible, existing vegetation type boundaries, as determined by previous surveys, were not altered. However, some vegetation types were amalgamated as, with the additional information available from a larger survey area, the fine-scale

separations based on species dominance order were not sustainable, with ground truthing supporting the amalgamation.

Twenty five of the vegetation types were associated with the valley landform (i.e. on ± flat plains that also included sandplain and calcrete plains), one occurred on sand dunes, one was associated with riparian areas, three were associated with claypans or clay depressions, seven occurred on the Fortescue Marsh, one occurred on low undulating hills, and three on higher hills and plateaux.

Table 11: Vegetation types

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AaAsCc**	*Acacia aptaneura* low woodland over *Acacia synchronicia*, *A. tetragonophylla* and *Senna artemisioides* subsp. *oligophylla* mid sparse shrubland over **Cenchrus ciliaris* mid closed tussock grassland	B108 C052 C070 FV17073 FV17074 FV17075 FV17076 FV17078 FV17079 FV17092 FV17159		*Abutilon lepidum, Blumea tenella, Centipeda minima* subsp. *macrocephala, Chloris pectinata, Cleome viscosa, Dichanthium sericeum* subsp. *humilius, Enchylaena tomentosa* var. *tomentosa, Eremophila longifolia, Eulalia aurea, Evolvulus alsinoides* var. *villosicalyx, Gomphrena affinis* subsp. *pilbarensis, *Malvastrum americanum, Pterocaulon sphacelatum, Rhagodia eremaea, Rhynchosia minima, Salsola australis, Solanum lasiophyllum, Sporobolus australasicus, Streptoglossa bubakii*	12,370 ha 5.36%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AaAtRa**	*Acacia aptaneura* low open forest over *Acacia tetragonophylla* tall sparse shrubland over *Rostellularia adscendens* var. *clementii*, **Setaria verticillata* and *Paspalidium clementii* low herbland/ grassland	FV17053 FV17054		*Abutilon cryptopetalum, Abutilon lepidum, Acacia pruinocarpa, Alternanthera denticulata, *Bidens subalternans* var. *simulans, Blumea tenella, Calandrinia ptychosperma, Chloris pectinata, Chrysopogon fallax, Cleome viscosa, Convolvulus clementii, Corymbia candida, Cucumis melo, Dysphania rhadinostachya, Enchylaena tomentosa* var. *tomentosa, Eragrostis exigua, Eragrostis leptocarpa, Euphorbia biconvexa, Evolvulus alsinoides* var. *villosicalyx, Fimbristylis* sp., *Ipomoea muelleri, *Malvastrum americanum, Nicotiana occidentalis, Portulaca oleracea, *Portulaca pilosa, Pterocaulon sphacelatum, Ptilotus gomphrenoides, Ptilotus macrocephalus, Ptilotus obovatus, Senna artemisioides* subsp. *oligophylla, Solanum lasiophyllum, Streptoglossa bubakii*	665 ha 0.29%
Valley/Plain (±flat)	**AaEfEp**	*Acacia aptaneura* low woodland over *Eremophila forrestii* subsp. *forrestii*, *Acacia tetragonophylla* and *Senna artemisioides* subsp. *helmsii* mid sparse shrubland over *Enneapogon polyphyllus*, *Rostellularia adscendens* var. *clementii* and **Cenchrus ciliaris* low tussock grassland/ herbland	FV17057 FV17082 FV17084 FV17086 FV17087 FV17090 FV17091 FV17114		*Abutilon lepidum, Aristida latifolia, *Bidens subalternans* var. *simulans, Cleome viscosa, Dichanthium sericeum* subsp. *humilius, Enchylaena tomentosa* var. *tomentosa, Eremophila longifolia, Evolvulus alsinoides* var. *villosicalyx, Maireana planifolia, Psydrax latifolia, Ptilotus nobilis* subsp. *nobilis, Ptilotus obovatus, Rhagodia eremaea, Salsola australis, Sida* sp. verrucose glands (F.H. Mollemans 2423), *Solanum lasiophyllum, Sporobolus australasicus*	21,193 ha 9.18%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AaSaEp**	**Grove** (shown in photograph) *Acacia aptaneura* and *A. pruinocarpa* low woodland over *Senna artemisioides* subsp. *oligophylla*, *Ptilotus obovatus* and *Acacia tetragonophylla* mid open shrubland over *Enneapogon polyphyllus*, *Aristida contorta* and *Chrysopogon fallax* low grassland **Intergrove** *Aristida contorta*, **Cenchrus ciliaris* and *Ptilotus aervoides* low grassland/tussock grassland/forbland with *Acacia synchronicia* tall scattered shrubs	FV17055 FV17056 FV17058 FV17059 FV17060 FV17061 FV17062 FV17063 FV17064 FV17065 FV17067 FV17071		Grove: *Abutilon lepidum, Abutilon otocarpum, Acacia synchronicia, Cleome viscosa, Cucumis variabilis, Evolvulus alsinoides* var. *villosicalyx, Goodenia prostrata, Ipomoea muelleri, *Malvastrum americanum, Polycarpaea corymbosa* var. *corymbosa, Portulaca oleracea, Pterocaulon sphacelatum, Ptilotus nobilis* subsp. *nobilis, Rhynchosia minima, Sclerolaena cornishiana, Senna notabilis, Sida* sp. verrucose glands (F.H. Mollemans 2423), *Solanum lasiophyllum, Sporobolus australasicus*	34,661 ha 15.01%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AaTb**	*Acacia ancistrocarpa*, *Grevillea wickhamii* and *Acacia pachyacra* mid open shrubland over *Triodia basedowii* and *T. schinzii* low hummock grassland with *Corymbia opaca* low scattered trees	A066 B049 FV17006 FV17010 FV17013 FV17016 FV17017 FV17018 FV17046 FV17049 FV17052		*Acacia dictyophleba, Aristida holathera* var. *holathera, Bonamia erecta, Cleome viscosa, Corchorus* aff. *tectus, Cymbopogon obtectus, Dicrastylis cordifolia, Eriachne aristidea, Indigofera monophylla, Scaevola parvifolia* subsp. *pilbarae, Senna notabilis, Sida cardiophylla, Sida* sp. Rabbit Flat (B.J. Carter 626), *Trianthema pilosum, Trichodesma zeylanicum* var. *zeylanicum, Yakirra australiensis* var. *australiensis*	1,095 ha 0.47%
Valley/Plain (±flat)	**AaTp**	*A. aptaneura* and *A. pruinocarpa* low woodland over *Triodia pungens* and **Cenchrus ciliaris* hummock grass mid hummock grassland/ tussock grassland	B122 C047 FV17019 FV17066 FV17068 FV17125		*Abutilon lepidum, Aristida contorta, Cleome viscosa, Enneapogon polyphyllus, Evolvulus alsinoides* var. *villosicalyx, Polycarpaea corymbosa* var. *corymbosa, Ptilotus nobilis* subsp. *nobilis, Ptilotus obovatus, Senna artemisioides* subsp. *oligophylla, Solanum lasiophyllum, Sporobolus australasicus*	2,987 ha 1.29%

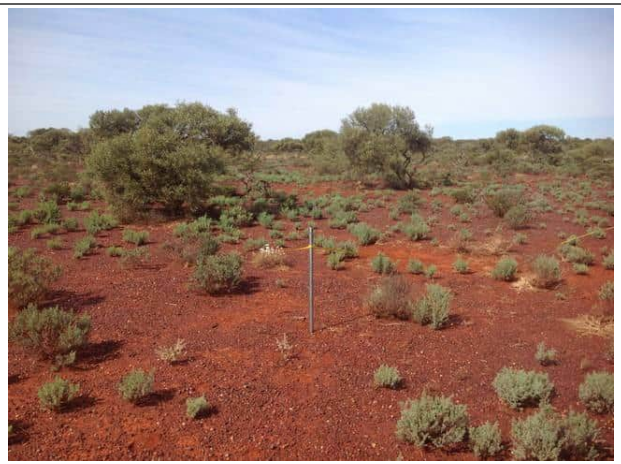
Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AbTl**	*Acacia bivenosa* and *A. sclerosperma* subsp. *sclerosperma* mid open shrubland over *Triodia longiceps* hummock grassland	FV17020 FV17022 FV17023 FV17025 FV17027 FV17028 FV17117		*Abutilon lepidum, Acacia aptaneura, Acacia synchronicia, Acacia tetragonophylla, *Cenchrus ciliaris, Cleome viscosa, Cucumis variabilis, Enneapogon caerulescens, Enneapogon polyphyllus, Euphorbia tannensis* subsp. *eremophila, Evolvulus alsinoides* var. *villosicalyx, Hibiscus sturtii* var. *campylochlamys, Indigofera monophylla, Petalostylis labicheoides, Pterocaulon sphacelatum, Ptilotus nobilis* subsp. *nobilis, Ptilotus obovatus, Rhagodia eremaea, Senna artemisioides* subsp. *helmsii, Senna glutinosa* subsp. *x luerssenii, Sida fibulifera, Solanum lasiophyllum, Sporobolus australasicus*	20,474 ha 8.87%
Low Hills	**AbTv**	*Acacia bivenosa*, *A. ancistrocarpa* and *Grevillea wickhamii* mid sparse shrubland over *Triodia vanleeuwenii* and *Acacia hilliana* low hummock grassland/ shrubland	FV17001 FV17002 FV17003 FV17004 FV17005 FV17007 FV17008		*Aristida holathera* var. *holathera, Calytrix carinata, Eriachne mucronata, Eriachne pulchella* subsp. *dominii, Fimbristylis dichotoma, Fimbristylis simulans, Goodenia stobbsiana, Hakea chordophylla, Hibiscus sturtii* var. *truncatus, Hybanthus aurantiacus, Indigofera monophylla, Isotropis parviflora, Ptilotus calostachyus, Schizachyrium fragile, Senna artemisioides* subsp. *oligophylla, Senna glutinosa* subsp. *glutinosa, Senna glutinosa* subsp. *pruinosa, Senna glutinosa* subsp. *x luerssenii, Solanum lasiophyllum, Stackhousia intermedia, Trachymene oleracea* subsp. *oleracea*	2,943 ha 1.28%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AcAsCc**	*Acacia citrinoviridis* and *Atalaya hemiglauca* low woodland over *Acacia sclerosperma* subsp. s*clerosperma, Senna artemisioides* subsp. *helmsii* and *Acacia pyrifolia* var. *pyrifolia* mid sparse shrubland over **Cenchrus ciliaris* low tussock grassland	B009 B028 FV17142 FV17143 FV17178 FV17179 FV17180		*Acacia aptaneura, *Aerva javanica, Boerhavia coccinea, *Cenchrus setiger, Cleome viscosa, Duperreya commixta, Evolvulus alsinoides* var. *villosicalyx, Hakea lorea* subsp. *lorea, Polycarpaea corymbosa* var. *corymbosa, Ptilotus obovatus, Solanum lasiophyllum*	2,547 ha 1.10%
Sand Dunes	**AdAh**	*Acacia dictyophleba* and *Grevillea juncifolia* subsp. *juncifolia* and *Crotalaria cunninghamii* tall open shrubland over *Aristida holathera* var. *holathera* and *Triodia schinzii* low tussock grassland/ hummock grassland	C014 C119 FV17047 FV17048 FV17050 FV17169 FV17185		*Anthobolus leptomerioides, Bonamia erecta, *Cenchrus ciliaris, Chrysocephalum eremaeum, Corchorus* aff. *tectus, Dicrastylis cordifolia, Eragrostis eriopoda, Eriachne aristidea, Hibiscus brachychlaenus, Paraneurachne muelleri, Petalostylis cassioides, Ptilotus polystachyus, Scaevola parvifolia* subsp. *pilbarae, Senna notabilis, Sida cardiophylla, Trianthema pilosum, Trichodesma zeylanicum* var. *grandiflorum, Triodia basedowii*	477 ha 0.21%

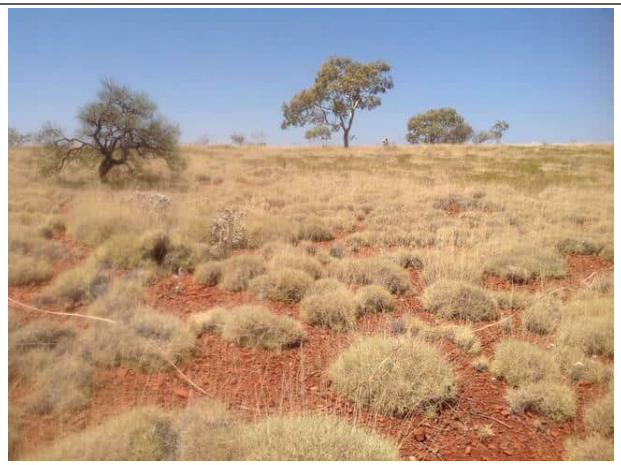
Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AdTe**	*Acacia dictyophleba* tall open shrubland over *Triodia epactia* mid hummock grassland	A030		*Indigofera colutea, Abutilon otocarpum, Acacia synchronicia, *Cenchrus ciliaris, *Cenchrus setiger, Chrysopogon fallax, Cleome viscosa, Corchorus sidoides* subsp. *sidoides, Cullen leucochaites, Enneapogon polyphyllus, Eragrostis eriopoda, Gomphrena affinis* subsp. *pilbarensis, Hakea lorea* subsp. *lorea, Hibiscus sturtii* var. *platychlamys, Indigofera linifolia, Indigofera linnaei, Rhynchosia minima, Senna artemisioides* subsp. *helmsii, Senna artemisioides* subsp. *oligophylla, Senna notabilis, Sporobolus australasicus, Tephrosia* sp. Newman (A.A. Mitchell PRP 29)	1,335 ha 0.58%
Valley/Plain (±flat)	**AiAh**	*Acacia inaequilatera*, *Hakea lorea* subsp. *lorea* and *Acacia sericophylla* tall sparse shrubland over *Aristida holathera* var. *holathera*, *Chrysopogon fallax* and *Paraneurachne muelleri* mid tussock grassland	A015 FV17137 FV17174		*Acacia pruinocarpa, Acacia pyrifolia* var. *pyrifolia, *Cenchrus ciliaris, Corchorus* aff. *tectus, Goodenia microptera, Hybanthus aurantiacus, Petalostylis labicheoides, Polycarpaea corymbosa* var. *corymbosa, Ptilotus astrolasius, Senna artemisioides* subsp. *oligophylla, Tephrosia rosea* var. Fortescue creeks (M.I.H. Brooker 2186), *Trianthema pilosum, Trichodesma zeylanicum* var. *zeylanicum*	509 ha 0.22%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**ApTp**	*Acacia pachyacra*, *A. ancistrocarpa* and *A. inaequilatera* mid sparse shrubland over *Triodia pungens*, **Cenchrus ciliaris* and *Eragrostis eriopoda* low hummock grassland/ tussock grassland	C064 D19 D20 FV17012 FV17015 FV17051 FV17069 FV17164 FV17165		*Abutilon otocarpum, Acacia dictyophleba, Aristida contorta, Aristida holathera* var. *holathera, Aristida inaequiglumis, Cleome viscosa, Corchorus* aff. *tectus, Cucumis variabilis, Dysphania rhadinostachya, Eriachne aristidea, Hibiscus sturtii* var. *platychlamys, Paraneurachne muelleri, Senna notabilis, Solanum lasiophyllum, *Trianthema pilosum, Yakirra australiensis* var. *australiensis*	10,060 ha 4.36%
Valley/Plain (±flat)	**AsCc**[1]	*Acacia synchronicia* tall open shrubland over **Cenchrus ciliaris*, *Sclerolaena costata* and *Trianthema triquetrum* low open chenopod shrubland/ tussock grassland	A020 FV17152 FV17153 FV17154 FV17156 FV17157 FV17158		*Aristida latifolia, Cleome viscosa, Enneapogon polyphyllus, Eragrostis xerophila, Eulalia aurea, Pterocaulon sphacelatum, Ptilotus aervoides, Ptilotus nobilis* subsp. *nobilis, Ptilotus obovatus, Salsola australis, Sclerolaena cornishiana, Sida fibulifera, Sida platycalyx, Sporobolus australasicus, Streptoglossa bubakii*	8,330 ha 3.61%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AsCc**[2]	*Acacia sclerosperma* subsp. *sclerosperma* tall open shrubland over **Cenchrus ciliaris* and *Triodia pungens* mid tussock grassland/ hummock grassland	FV17093 FV17109 FV17110 FV17170		*Acacia aptaneura, Acacia synchronicia, Acacia tetragonophylla, Atriplex bunburyana, Cleome viscosa, Dactyloctenium radulans, Enchylaena tomentosa* var. *tomentosa, Enneapogon polyphyllus, Eragrostis dielsii, Eragrostis setifolia, Eremophila forrestii* subsp. *forrestii, Eremophila longifolia, Portulaca oleracea, Pterocaulon sphacelatum, Ptilotus aervoides, Ptilotus nobilis* subsp. *nobilis, Ptilotus obovatus, Rhagodia eremaea, Salsola australis, Senna artemisioides* subsp. *helmsii, Senna glutinosa* subsp. *glutinosa, Solanum lasiophyllum, Sporobolus australasicus*	1,415 ha 0.61%
Valley/Plain (±flat)	**AsSc**	*Acacia synchronicia* and *Eremophila youngii* subsp. *lepidota* mid shrubland over *Sclerolaena cuneata*, *Maireana carnosa* and *Trianthema triquetrum* low open chenopod shrubland	FV17039 FV17040 FV17041 FV17042 FV17175		*Acacia xiphophylla, Aristida contorta, Atriplex bunburyana, Atriplex codonocarpa, Boerhavia coccinea, Brachyachne prostrata, *Cenchrus ciliaris, Dactyloctenium radulans, Enchylaena tomentosa* var. *tomentosa, Enteropogon ramosus, Eragrostis dielsii, Eremophila cuneifolia, Eremophila spongiocarpa, Gomphrena canescens, Maireana pyramidata, Ptilotus nobilis* subsp. *nobilis, Salsola australis, Senna* sp. Meekatharra (E. Bailey 1-26), *Solanum lasiophyllum, Sporobolus australasicus*	599 ha 0.26%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AsTe**	*Acacia synchronicia* mid sparse shrubland over *Triodia epactia* low hummock grassland	FV17120		*Acacia ancistrocarpa, Acacia aptaneura, Bonamia erecta, Dicrastylis cordifolia, Enchylaena tomentosa* var. *tomentosa, Eremophila forrestii* subsp. *forrestii, Indigofera monophylla, Ptilotus obovatus, Senna artemisioides* subsp. *oligophylla x helmsii, Senna glutinosa* subsp. *x luerssenii, Senna notabilis, Senna* sp. Meekatharra (E. Bailey 1-26), *Solanum lasiophyllum, Sporobolus australasicus, Stylobasium spathulatum*	427 ha 0.19%
Valley/Plain (±flat)	**AxEcSc**	*Acacia xiphophylla* low open woodland over *Eremophila cuneifolia, Maireana pyramidata* and *Senna artemisioides* subsp. *oligophylla* x *helmsii* mid sparse shrubland over *Sclerolaena cuneata* and *Maireana triptera* low open chenopod shrubland	B097 FV17009 FV17029 FV17070 FV17077 FV17081 FV17083 FV17085 FV17088 FV17089 FV17115 FV17116 FV17161		*Acacia synchronicia, Boerhavia coccinea, Brachyachne prostrata, *Cenchrus ciliaris. Cleome viscosa, Dactyloctenium radulans, Enchylaena tomentosa* var. *tomentosa, Enneapogon polyphyllus, Enteropogon ramosus, Gomphrena affinis* subsp. *pilbarensis, Maireana georgei, Maireana tomentosa* subsp. *tomentosa, Ptilotus nobilis* subsp. *nobilis, Ptilotus obovatus, Rhagodia eremaea, Salsola australis, Sclerolaena eriacantha, Sclerolaena lanicuspis, Sporobolus australasicus, Trianthema triquetrum*	21,228 ha 9.19%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**AxEcTe**	*Acacia xiphophylla* low open woodland over *Eremophila cuneifolia*, *Maireana pyramidata* and *Senna artemisioides* subsp. *oligophylla* x *helmsii* mid sparse shrubland over *Triodia epactia*, *T. longiceps* and *Enteropogon ramosus* low open hummock grassland/ grassland	FV17123 FV17124		*Acacia tetragonophylla, Aristida contorta, Atriplex bunburyana, Brachyachne prostrata, *Cenchrus ciliaris, Dactyloctenium radulans, Enchylaena tomentosa* var. *tomentosa, Eragrostis dielsii, Eremophila forrestii* subsp. *forrestii, Maireana georgei, Maireana planifolia, Maireana triptera, Ptilotus obovatus, Rhagodia eremaea, Sclerolaena cuneata, Sclerolaena eriacantha, Senna* sp. Meekatharra (E. Bailey 1-26), *Solanum lasiophyllum, Sporobolus australasicus, Trianthema turgidifolium, Tripogon loliiformis*	777 ha 0.34%
Valley/Plain (±flat)	**EgAbTb/ AaTb mosaic**	Mosaic of *Eucalyptus gamophylla* mid open mallee woodland over *Acacia bivenosa*, *A. ancistrocarpa* and *A. dictyophleba* tall sparse shrubland over *Triodia basedowii*, *Triodia schinzii* mid hummock grassland with **AaTp** (see separate description)	FV17011 FV17014 FV17043 FV17044 FV17045 FV17163 FV17186		*Acacia inaequilatera, Acacia sericophylla, Aristida holathera* var. *holathera, Bonamia erecta, Corchorus* aff. *tectus, Cymbopogon obtectus, Dicrastylis cordifolia, Eragrostis eriopoda, Eriachne aristidea, Indigofera monophylla, Paraneurachne muelleri, Ptilotus astrolasius, Scaevola parvifolia* subsp. *pilbarae, Sida cardiophylla, Solanum lasiophyllum, Triodia pungens*	44,709 ha 19.36%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Hills	**ElAaTv**	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia arida* mid open shrubland over *Triodia vanleeuwenii* low hummock grassland	FV17134 FV17173		*Calytrix carinata, Dampiera candicans, Fimbristylis dichotoma, Goodenia stobbsiana, Ptilotus calostachyus, Schizachyrium fragile*	307 ha 0.13%
Hills	**ElGwTv**	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Grevillea wickhamii*, *Acacia bivenosa* and *Senna glutinosa* subsp. x *luerssenii* mid sparse shrubland over *Triodia vanleeuwenii* and *Fimbristylis simulans* low hummock grassland/ sedgeland	A012 FV17126 FV17127 FV17128 FV17129 FV17130 FV17131 FV17132 FV17133 FV17135 FV17136 FV17138 FV17139 FV17140 FV17141		*Acacia pruinocarpa, Dampiera candicans, Dysphania rhadinostachya, Eriachne mucronata, Eriachne pulchella* subsp. *dominii, Goodenia stobbsiana, Mollugo molluginea, Polycarpaea holtzei, Ptilotus astrolasius, Ptilotus calostachyus, Ptilotus nobilis* subsp. *nobilis, Senna artemisioides* subsp. *oligophylla, Senna glutinosa* subsp. *glutinosa, Trichodesma zeylanicum* var. *zeylanicum*	10,910 ha 4.72%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**Es**	*Eragrostis setifolia*, *Eragrostis xerophila* and *Dichanthium sericeum* subsp. *humilius* low closed tussock grassland	FV17162		*Acacia synchronicia, Acacia xiphophylla, Aristida latifolia, *Cenchrus ciliaris, Chloris pectinata, Cullen cinereum, Dactyloctenium radulans, Enchylaena tomentosa* var. *tomentosa, Eragrostis exigua, Eragrostis tenellula, Maireana triptera, Malvastrum americanum, Neptunia dimorphantha, Operculina aequisepala, Rhagodia eremaea, Salsola australis, Sclerolaena cornishiana, Sclerolaena cuneata, Sclerolaena diacantha, Sporobolus australasicus, Streptoglossa liatroides, Urochloa occidentalis* var. *occidentalis*	4.48 ha 0.00%
Riparian	**EvAcCc**	*Eucalyptus victrix* and *Eucalyptus camaldulensis* subsp. *refulgens* mid woodland over *Acacia citrinoviridis*, *A. pyrifolia* var. *pyrifolia* and *A. tumida* var. *pilbarensis* tall sparse shrubland over **Cenchrus ciliaris*, *Tephrosia rosea* var. Fortescue creeks (M.I.H. Brooker 2186) and *Cymbopogon ambiguus* mid open tussock grassland/ shrubland	FV17072 FV17144 FV17145 FV17146 FV17177		*Aristida contorta, Atalaya hemiglauca, Cleome viscosa, Corchorus crozophorifolius, Duperreya commixta, Euphorbia australis, Gomphrena canescens, Indigofera monophylla, Phyllanthus maderaspatensis, Polycarpaea longiflora, Triodia pungens, Waltheria indica*	830 ha 0.36%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Claypan	**EvDf**	*Eucalyptus victrix* low open woodland over *Duma florulenta*, *Atriplex amnicola* and *Eriachne flaccida* mid sparse shrubland/ tussock grassland	FV17032 FV17033 FV17036 FV17172		*Aeschynomene indica, Alternanthera nodiflora, Centipeda minima* subsp. *macrocephala, Dactyloctenium radulans, Enneapogon polyphyllus, Eragrostis exigua, Eragrostis leptocarpa, Gomphrena affinis* subsp. *pilbarensis, Melaleuca glomerata, Ptilotus nobilis* subsp. *nobilis, Teucrium racemosum*	352 ha 0.15%
Claypan	**EvDfEb**	*Eucalyptus victrix* low open woodland over *Eriachne benthamii* and *Cyperus concinnus* low open tussock grassland/ sedgeland with isolated *Duma florulenta* mid shrubs	FV17166 FV17167 FV17168		*Abutilon macrum, Acacia tetragonophylla, Alternanthera nodiflora, Boerhavia coccinea, Centipeda minima* subsp. *macrocephala, Elytrophorus spicatus, Eragrostis leptocarpa, Evolvulus alsinoides* var. *villosicalyx, Goodenia lamprosperma, *Malvastrum americanum, Marsilea hirsuta, Myriocephalus scalpellus, Portulaca oleracea, *Portulaca pilosa, *Setaria verticillata, Solanum lasiophyllum, Sporobolus australasicus, Urochloa occidentalis* var. *occidentalis*	47 ha 0.02%

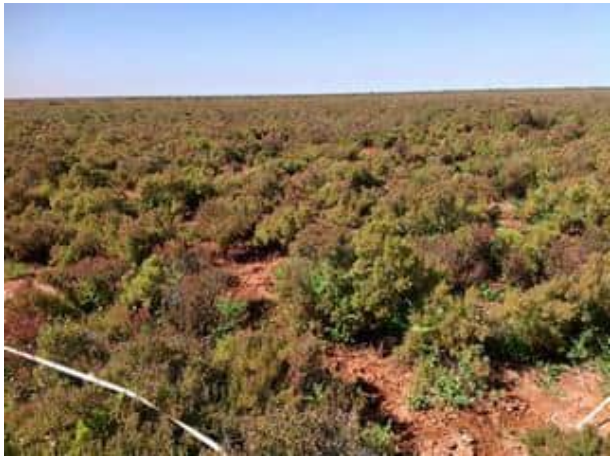
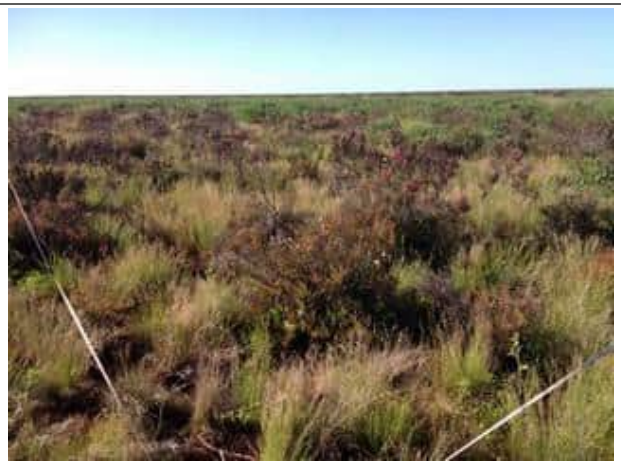
Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Clay Depression	**EvMxTl**	*Eucalyptus victrix*, *Acacia citrinoviridis* and *A. aptaneura* low open woodland over *Melaleuca xerophila* and *Acacia synchronicia* tall sparse shrubland over *Triodia longiceps* and *Eragrostis setifolia* low sparse hummock grassland/ tussock grassland	FV17021 FV17024 FV17026 FV17034 FV17035 FV17037		*Abutilon lepidum*, *Acacia sclerosperma* subsp. *sclerosperma*, *Aristida contorta*, **Cenchrus ciliaris*, *Cleome viscosa*, *Enneapogon polyphyllus*, *Eragrostis dielsii*, *Evolvulus alsinoides* var. *villosicalyx*, *Gomphrena affinis* subsp. *pilbarensis*, *Melaleuca glomerata*, *Portulaca oleracea*, **Portulaca pilosa*, *Ptilotus gomphrenoides*, *Ptilotus nobilis* subsp. *nobilis*, *Ptilotus obovatus*, *Salsola australis*, **Setaria verticillata*, *Sida fibulifera*, *Sida* sp. verrucose glands (F.H. Mollemans 2423), *Solanum lasiophyllum*, *Solanum morrisonii*, *Sporobolus australasicus*, *Streptoglossa bubakii*, *Trianthema triquetrum*, *Urochloa occidentalis* var. *occidentalis*	1,808ha 0.78%
Valley/Plain (±flat)	**EyAb**	*Eremophila youngii* subsp. *lepidota*, *Senna artemisioides* subsp. *helmsii* and *Acacia synchronicia* mid open shrubland over *Atriplex bunburyana*, *Maireana pyramidata* and *Eragrostis xerophila* mid open chenopod shrubland/ tussock grassland	FV17080 FV17118 FV17119 FV17122		*Aristida contorta*, *Boerhavia coccinea*, *Brachyachne prostrata*, *Bulbostylis barbata*, **Cenchrus ciliaris*, *Cleome viscosa*, *Cyperus iria*, *Dactyloctenium radulans*, *Enchylaena tomentosa* var. *tomentosa*, *Enteropogon ramosus*, *Eragrostis dielsii*, *Eragrostis eriopoda*, *Eragrostis leptocarpa*, *Eriachne aristidea*, *Maireana amoena*, *Salsola australis*, *Sclerolaena cuneata*, *Sclerolaena diacantha*, *Senna artemisioides* subsp. *helmsii*, *Senna* sp. Meekatharra (E. Bailey 1-26), *Solanum lasiophyllum*, *Sporobolus australasicus*, *Streptoglossa decurrens*	533 ha 0.23%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Hills	**GwTp**	*Grevillea wickhamii* and *Acacia inaequilatera* tall open shrubland over *Triodia pungens* and *T. vanleeuwenii* mid hummock grassland	FV17147 FV17148 FV17176		*Acacia pruinocarpa, Calytrix carinata, Dysphania rhadinostachya, Eremophila exilifolia, Eremophila latrobei* subsp. *glabra, Eriachne lanata, Eriachne mucronata, Eriachne pulchella* subsp. *dominii, Goodenia stobbsiana, Petalostylis labicheoides, Ptilotus calostachyus, Senna glutinosa* subsp. *glutinosa, Senna glutinosa* subsp. *pruinosa, Senna glutinosa* subsp. *x luerssenii, Solanum lasiophyllum*	31 ha 0.01%
Valley/Plain (±flat)	**MgCc**	*Melaleuca glomerata*, *M. xerophila* and *Acacia tetragonophylla* tall open shrubland over **Cenchrus ciliaris*, *Dichanthium sericeum* subsp. *humilius*, *Eulalia aurea* low tussock grassland	C050		*Acacia xiphophylla, Aristida latifolia, Atalaya hemiglauca, Atriplex codonocarpa, Bothriochloa ewartiana, Chloris pectinata, Duma florulenta, Enneapogon polyphyllus, Eragrostis dielsii, Eragrostis setifolia, Eremophila longifolia, Eremophila youngii* subsp. *lepidota, Psydrax latifolia, Rhagodia eremaea, Santalum lanceolatum, Scaevola spinescens, Solanum lasiophyllum, Sporobolus australasicus, Swainsona kingii, Tragus australianus, Urochloa occidentalis* var. *occidentalis*	235 ha 0.10%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Marsh	**Ms**	*Muellerolimon salicorniaceum*, *Tecticornia indica* subsp. *leiostachya* and *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063) low shrubland/ samphire shrubland	FV17097 FV17107 FV17108		*Alternanthera nodiflora, Eragrostis tenellula, Eremophila spongiocarpa, *Malvastrum americanum, Nicotiana heterantha, Pterocaulon sphacelatum, Ptilotus nobilis* subsp. *nobilis, Schenkia clementii, Tecticornia auriculata, Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552), *Vigna* sp. Hamersley Clay (A.A. Mitchell PRP 113)	1,299 ha 0.56%
Valley/Plain (±flat)	**MxCc**	*Melaleuca xerophila*, *Eremophila youngii* subsp. *lepidota* and *Acacia synchronicia* tall open shrubland over **Cenchrus ciliaris*, *Eragrostis dielsii* and *Sclerolaena costata* low tussock grassland/ chenopod shrubland	FV17030 FV17031		*Acacia xiphophylla, Atriplex bunburyana, Atriplex codonocarpa, Cleome viscosa, Dactyloctenium radulans, Dissocarpus paradoxus, Enchylaena tomentosa* var. *tomentosa, Gomphrena affinis* subsp. *pilbarensis, Lotus cruentus, Sclerolaena cornishiana, Sporobolus australasicus*	348 ha 0.15%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**SaEx/ AsCc[1] mosaic**	Mosaic of *Senna artemisioides* subsp. *oligophylla* mid open shrubland over *Eragrostis xerophila*, *Aristida latifolia* and **Cenchrus ciliaris* low tussock grassland with **AsCc[1]** (see separate description)	FV17149 FV17150 FV17151 FV17155 FV17160		*Acacia synchronicia, Cleome viscosa, Enneapogon polyphyllus, Gomphrena affinis* subsp. *pilbarensis, Operculina aequisepala, Portulaca oleracea, Ptilotus gomphrenoides, Ptilotus macrocephalus, Ptilotus nobilis* subsp. *nobilis, Rhagodia eremaea, Rhynchosia minima, Salsola australis, Sida* sp. verrucose glands (F.H. Mollemans 2423), *Solanum lasiophyllum, Sporobolus australasicus*	2,487 ha 1.08%
Valley/Plain (±flat)	**SsCc**	*Cenchrus ciliaris* and *Aristida inaequiglumis* low tussock grassland with *Stylobasium spathulatum* mid isolated shrubs	B050		*Acacia dictyophleba, Acacia pyrifolia* var. *pyrifolia, Acacia tumida* var. *pilbarensis, Boerhavia coccinea, Bonamia pilbarensis, *Cenchrus setiger, Chrysopogon fallax, Cleome viscosa, Eremophila longifolia, Gossypium robinsonii, Grevillea wickhamii, Polymeria ambigua, Senna notabilis, Solanum lasiophyllum, Streptoglossa bubakii, Swainsona formosa, Tephrosia rosea* var. Fortescue creeks (M.I.H. Brooker 2186), *Themeda triandra*	55 ha 0.02%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Marsh	**Ta[1]**	*Tecticornia auriculata* and *Muellerolimon salicorniaceum* mid open samphire shrublands over *Eragrostis pergracilis* and *Swainsona tanamiensis* low open grassland/ herbland	FV17105 FV17171		*Atriplex flabelliformis, Maireana luehmannii, Nicotiana heterantha, Ptilotus nobilis* subsp. *nobilis, Salsola australis, Tecticornia globulifera, Tecticornia indica* subsp. *leiostachya, Tecticornia medusa, Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063), *Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	5,733 ha 2.48%
Marsh	**Ta[2]**	*Tecticornia auriculata*, *Muellerolimon salicorniaceum* and *Tecticornia indica* subsp. *leiostachya* mid open samphire shrubland/ shrubland over *Eragrostis pergracilis*, *Swainsona tanamiensis* and *Maireana luehmannii* low open grassland/ herbland/ chenopod shrubland	FV17094 FV17096 FV17098 FV17099 FV17102 FV17103 FV17104 FV17111 FV17112		*Atriplex flabelliformis, Cressa australis, Cullen cinereum, Eragrostis dielsii, *Flaveria trinervia, Frankenia ambita, Nicotiana heterantha, Ptilotus nobilis* subsp. *nobilis, Tecticornia globulifera*	9,901 ha 4.29%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Marsh	TD	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552), *Tecticornia indica* subsp. *leiostachya* and *Swainsona tanamiensis* low samphire shrubland/ herbland	FV17106 FV17101		*Cullen cinereum, Eragrostis falcata, Eragrostis pergracilis, Maireana luehmannii, Muellerolimon salicorniaceum, Nicotiana heterantha, Ptilotus nobilis* subsp. *nobilis, Streptoglossa bubakii*	209 ha 0.09%
Marsh	Ti	*Tecticornia indica* subsp. *leiostachya*, *Cullen cinereum* and *Eremophila spongiocarpa* low samphire shrubland/ herbland/ shrubland	FV17113		*Alternanthera nodiflora, *Cenchrus ciliaris, Enchylaena tomentosa* var. *tomentosa, Eragrostis falcata, Eragrostis tenellula, *Flaveria trinervia, Gomphrena* affinis *subsp. pilbarensis, Lotus cruentus, Nicotiana heterantha, Pluchea rubelliflora, Pterocaulon sphacelatum, Ptilotus gomphrenoides, Ptilotus nobilis* subsp. *nobilis, Ptilotus obovatus, Sida fibulifera, Streptoglossa bubakii, Swainsona tanamiensis*	209 ha 0.09%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Valley/Plain (±flat)	**Tl**	*Triodia longiceps* and *Sclerolaena cuneata* low hummock grassland/ chenopod shrubland	FV17038 FV17121		*Acacia aptaneura, Acacia synchronicia, Acacia tetragonophylla, Brachyachne prostrata, *Cenchrus ciliaris, Dactyloctenium radulans, Enneapogon polyphyllus, Eremophila forrestii* subsp. *forrestii, Maireana carnosa, Maireana pyramidata, Maireana triptera, Ptilotus nobilis* subsp. *nobilis, Sclerolaena diacantha, Senna artemisioides* subsp. *helmsii, Sporobolus australasicus*	4,156 ha 1.80%
Marsh	**Tm**	*Tecticornia medusa*, *T. globulifera* and *T. verrucosa* low open samphire shrubland	FV17100 FV17181		*Cressa australis, Heliotropium curassavicum, Tecticornia auriculata, Uvedalia linearis*	263 ha 0.11%

Landform	Mapping Unit	Vegetation Type	Floristic Quadrats	Representative Photograph	Other Characteristic Species	Area (ha) and Extent (%) of Study Area
Marsh	**Tv**	*Tecticornia verrucosa* low open samphire shrubland	FV17095 FV17182 FV17183 FV17184		*Tecticornia globulifera,* *Uvedalia linearis*	2,493 ha 1.08%
	Claypan (no vegetation)					48 ha, 0.02%
	Cleared					462 ha, 0.20%
	Open water (no vegetation)					10.82 ha, <0.01%

4.2.1.1 PECs and Significant Vegetation

PECs

Three PECs are known to occur within the study area.

Fortescue Marsh

Seven vegetation types were recorded as occurring within this PEC that corresponds with the Marsh land system. Vegetation types **Ms**, **Ta[1]**, **Ta[2]**, **TD**, **Ti**, **Tm** and **Tv** occur within the Marsh and **AaAsCc**, **AbTl**, **AsCc[1]**, **AsCc[2]**, **AsSc**, **EvAcCc**, **EvMxTl** and **MgCc** are within the land system but considered to occur on the Marsh fringes.

Vegetation of sand dunes of the Hamersley Range/Fortescue Valley **PEC (previously 'Fortescue Valley Sand Dunes')**

The linear sand dunes that characterise this PEC were mapped as vegetation type **AdAh**, the description of which closely matches that of the PEC including dominant flora species present. Interdunal areas and surrounding sandplains were almost entirely mapped as **AaTb** or as mosaic vegetation type **EgAbTb/AaTb**. The mapping of **AdAh** occurs almost entirely within and closely corresponds with the extent of previously mapped boundaries of this PEC by DBCA.

Narbung Land System

Ten vegetation types were associated with this PEC/land system: **AaEfEp**, **AaSaEp**, **AaTp**, **AbTl**, **AsTe**, **AxEcSc**, **AxEcTe**, **EvMxTl**, **EyAb** and **Tl**. Of these, vegetation types **AxEcTe** and **EyAb** are dominant, characteristic and occur largely within this land system, with most of their extents outside the land system being adjacent to it.

However, the significance of this PEC lies in the restricted extent of the land system, described as *alluvial washplains with prominent internal drainage foci supporting snakewood and mulga shrublands with halophytic low shrubs* (Van Vreeswyk *et al.* 2004). It is the combination of landform/geology and vegetation that defines the land system and there is no implication that the flora species or vegetation corresponding with it are in any way confined to it or unusual in the area.

Significant Vegetation

Mulga

Vegetation dominated by Mulga species (*Acacia aneura*, *A. aptaneura*, *A. ayersiana*, *A. fuscaneura*, *A. incurvaneura*, *A. macraneura*, *A. minyura*, *A. mulganeura*, *A. paraneura* and *A. pteraneura*) is considered to be significant for a number of reasons including potential threats caused by hydrological change, grazing, weed invasion and changed fire regimes, and that the characteristic species is at or near the northern edge of its usual range (see **Section 1.4.5.2**).

There were five vegetation types dominated by Mulga (*Acacia aptaneura*) occurring on valley floors within the study area: **AaAsCc**, **AaAtRa**, **AaEfEp**, **AaTp** and **AaSaEp**. **AaSaEp** is considered to be representative of SFDV and displays the characteristic grove-intergrove formation; it is therefore the most obvious vegetation type to be potentially adversely affected by hydrological change. However, other valley floor Mulga vegetation types are also potentially affected by changes to surface water flow (EPA 2010; 2011; 2014; 2016b; Office of the Appeals Convenor 2016b) and all are subject to threats caused by grazing, including weed invasion. Four of the Mulga vegetation types (**AaAsCc**, **AaEfEp**, **AaTp** and **AaSaEp**) are significant affected by weed invasion, with **Cenchrus ciliaris* (Buffel Grass) being one of the characteristic ground stratum species.

These combined Mulga-dominated vegetation types are widespread across the study area including a total mapped extent of 71,876 ha which represents 31.12 % of the study area. Sheet Flow Dependent Mulga Vegetation occupied 34,661 ha (15.01%), or close to half of all Mulga vegetation in the study area. All valley floor Mulga vegetation types are potentially of significance as all may be affected by changes to surface water flow, and are threatened by the effects of grazing, weed invasion and alterations to natural fire regimes (most likely in combination with grazing and weed invasion).

GDEs

Eucalyptus camaldulensis sens. lat. is considered to be an obligate phreatophyte, and therefore vegetation with this species included is representative of a GDE (Eamus *et al.* 2006; Grierson 2010). *Eucalyptus camaldulensis* subsp. *refulgens* was recorded from one vegetation type (**EvAcCc**) as a characteristic but not dominant species; this vegetation type occurred in three riparian areas (i.e. associated with creeks and rivers) across the study area, the main occurrence corresponding with Weeli Wolli Creek. Vegetation type **EvAcCc** occupied 830 ha or 0.36% of the study area.

DPaW (Markey 2016) considers *Melaleuca xerophila* likely to be groundwater dependent in the Fortescue Marsh area, therefore vegetation types with this species are considered to be representative of a GDE. This species was commonly encountered on the fringes or slightly elevated areas of the Fortescue Marsh, and in clay depressions south of the Marsh, near the eastern boundary of the study area. *Melaleuca xerophila* was the characteristic species of the **MxCc** vegetation type, which was mapped as occurring within a single area adjacent to the western boundary of the study area and occupying 348 ha (0.15% of the study area). Vegetation type **EvMxTl**, occupying 1,808 ha (0.78% of the study area) was associated with clay depressions within calcrete south of the Marsh.

Eucalyptus victrix may be regarded as a facultative phreatophyte although there is some evidence that it is not dependent on groundwater in all circumstances (Batini 2009; Eamus 2009a; EPA & Hamersley Iron Pty Ltd 2010; Equinox Environmental 2017; Resource and Environmental Management Pty Ltd 2007). Therefore, vegetation dominated or characterised by *Eucalyptus victrix* is considered to be representative of a potential GDE (unless it also occurs with *Eucalyptus camaldulensis* or *Melaleuca xerophila* as a component). Excluding vegetation type **EvAcCc** associated with riparian areas and **EvMxTl** associated with clay depressions (and considered to represent a GDE; see above), there are two vegetation types dominated or characterised by *Eucalyptus victrix*: **EvDf** and **EvDfEb** associated with clay pans. These vegetation types have a scattered distribution across the extent of the study area, most prominently associated with Weeli Wolli Creek and Coondiner Pool (**Plate 1**). These potential GDE vegetation types occupy 399 ha or 0.17% of the study area.

Plate 1: *Eucalyptus victrix* dominated vegetation at Coondiner Pool

Clay pans

Clay pans occurred commonly over a significant portion of the study area, particularly directly south of the Fortescue Marsh. They were most common in the eastern part of the study area, occurring most obviously on the Coolibah land system but also on the Calcrete, Marillana and Narbung land systems, and in the western part mainly on the Calcrete, Marillana, Marsh and Turee land systems. The larger clay pans occurred on the Coolibah land system.

Two vegetation types (**EvDf** and **EvDfEb**) were characteristic of clay pans, and vegetation type **EvMxTl** was characteristic of clay depressions that were more vegetated and less likely to hold water for extended

periods. Clay pans and depressions were also extensive amongst the **AbTl**, **AsCc**^{2} and **Tl** vegetation types, though typically forming a mosaic that could not be feasibly mapped at an appropriate scale.

Plate 2 and **Plate 3** are representative of clay pans.

Plate 2: *Eucalyptus victrix* dominated clay pan to the northeast of Coondiner Pool

Plate 3:Clay pan dominated by *Eriachne flaccida* to the northeast of Coondiner Pool

4.2.2 FLORISTIC ANALYSIS

4.2.2.1 Study Area Floristic Analysis

The study area floristic analysis dendrogram is included in **Appendix Four**.

Overall, the floristic groups corresponded with structural vegetation types and landforms for:

- vegetation types associated with hills (vegetation types **ElAaTv**, **ElGwTv** and **GwTp**)
- vegetation types **AbTv** and **ApAsTv** that occurred on low, undulating hills
- vegetation types on the Fortescue Marsh (vegetation type **Ms**, **Ta1**, **Ta2**, **TD**, **Ti**, **Tm** and **Tv**)
- vegetation types dominated by *Eucalyptus victrix* on claypans and clay depressions, although there was some intermingling of the clay depression vegetation type **EvMxTl** and the clay pan vegetation types **EvDf** and **EvDfEb** (noting that some **EvMxTl** quadrats were also located in the dendrogram with other low-lying valley floor vegetation types)
- riparian vegetation type **EvAcCc** grouped with low-lying vegetation type **AcAsCc**; both strongly featured *Acacia citrinoviridis* and **Cenchrus ciliaris*
- *Acacia xiphophylla*-dominated vegetation types **AxEcSc** and **AxEcTe**
- vegetation type **AdAh** on sand dunes formed a discrete group.

However, most of the valley floor vegetation types including those dominated by Mulga (*Acacia aptaneura*), while broadly grouping, did not form clear floristic groups. It is likely that variations in age since fire and grazing intensity/weeds density may have sufficiently altered the floristics to show this effect.

With respect to Ecoscape floristic analysis for the Marsh vegetation types matching DPaW's Marsh vegetation units (Markey 2016), floristic analysis was used to determine vegetation units for DPaW and utilised Domin-Krajina density groups whereas Ecoscape's analysis utilised presence/absence data. Ecoscape's vegetation mapping within the Marsh was aligned (as much as possible) with DPaW's mapping, and floristics played no role in defining these units. As such, the alignment of floristic units between Ecoscape and DPaW is therefore not of significance.

4.2.2.2 Regional Floristic Analysis

The regional floristic analysis, the dendrogram for which is included in **Appendix Five**, indicates that overall the quadrats included in the study area ('FortValley' for this survey, highlighted in green, and 'Nyidinghu' for the Cardno (2012a; 2012b; 2012c) surveys, highlighted in blue) were grouped together, and the quadrats from this survey associated with the Fortescue Marsh were grouped with DPaW's Marsh quadrats (DPaW

2016b, designated 'DPaW Marsh', highlighted in yellow). There were also occasionally quadrats from Christmas Creek ('ChrisCrk') and Cloudbreak ('Cloudbreak') in these amongst the Fortescue Valley quadrats, which is unsurprising since these sites also extend into the Fortescue Valley, and a few quadrats from Roy Hill for the same reason. The highlighting in **Appendix Five** forms a rapid visual assessment of floristic similarity.

The dendrogram indicates regional clustering of quadrats, suggesting that the vegetation of the study area is largely unique and shares little with the surrounding area. The exceptions are quadrats FV17144, FV17145, FV17146 and FV17177 in vegetation type **EvAcCc** that is associated with riparian areas and is therefore expected to be widespread and quadrats FV17022 and FV17023 in vegetation type **AbTl**.

The data used in this analysis was sourced from the following surveys:

- this survey, annotated as 'FortValley'
- Biota Environmental Sciences (2004a), *Vegetation and Flora Survey of the Proposed FMG Stage A Rail Corridor*, unpublished Report for Fortescue Metals Group Ltd – annotated as associated with Cloudbreak
- Biota Environmental Sciences (2004b), *Vegetation and Flora Survey of the Proposed FMG Stage B Rail Corridor and Mines Areas*, unpublished Report for Fortescue Metals Group Ltd – annotated as associated with Christmas Creek ('ChrisCrk')
- Cardno (2012a), *Addendum: Nyidinghu Flora and Vegetation Assessment*, prepared for Fortescue Metals Group
- Cardno (2012b), *Nyidinghu flora and vegetation assessment*, unpublished report for Fortescue Metals Group
- Cardno (2012c), *Nyidinghu Rail Spur Flora and Vegetation Assessment*, report prepared for Fortescue Metals Group
- Coffey Environments (2010a), *Flora and Vegetation Assessment, Solomon Project and Investigator - Volume 1*, unpublished report for Fortescue Metals Group Ltd – annotated as 'SolInv'
- Coffey Environments (2010b), *Flora and Vegetation Assessment, Solomon Rail Project - Volume 1*, unpublished report for Fortescue Metals Group Ltd – annotated as SolRail
- DPaW (2016b) *Samphire Mapping of the Fortescue Marsh: Digital Dataset* – annotated as 'DPaW Marsh'
- Ecologia Environment (2009d), *Roy Hill 1: Flora and Vegetation Assessment*, unpublished report for Hancock Prospecting Pty Ltd
- Ecologia Environment (2013), *Kutayi Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Ltd
- Ecologia Environment (2014a), *Fig Tree Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Ltd
- Ecologia Environment (2014b), *Investigator Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Ltd, included in 'SolInv'
- Ecologia Environment (2014c), *Mt MacLeod Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Ltd, annotated as 'MtMac'
- Ecologia Environment (2014d), *Solomon South Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Ltd, annotated as 'SolSouth'
- Ecologia Environment (2015), *Solomon Restricted Vegetation Assessment Supplementary Report*, unpublished report for Fortescue Metals Group Ltd, annotated as 'SolLOM'
- Ecoscape (2010a), *Level Two Flora and Vegetation Assessment, Firetail Mining Area*, unpublished report for Fortescue Metals Group Ltd, included in 'Solomon'
- Ecoscape (2010b), *Solomon Project Rail Re-alignment Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Ltd, included in 'SolRail'
- ENV (2010a), *Christmas Creek flora and vegetation assessment*, unpublished report for Fortescue Metals Group Ltd
- ENV (2010b), *Solomon Project: Kings Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Ltd
- ENV (2011a), *Christmas Creek Airstrip Flora, Vegetation and Fauna Assessment*, unpublished report for Fortescue Metals Group Ltd

- ENV (2011b), *Cloudbreak Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Limited
- ENV (2012), *Christmas Creek Life of Mine Flora and Vegetation Assessment*, unpublished report for Fortescue Metals Group Ltd.

4.2.3 VEGETATION CONDITION

The vegetation condition of the quadrats and the overall study area is shown on the **Map 8** series, and displayed in **Table 12**.

Table 12: Vegetation condition (EPA 2016d)

Vegetation condition	Extent (ha)	Extent (%)
Excellent	64,472.85	27.92
Very Good	112,328.11	48.64
Good	34,672.56	15.01
Poor	18,219.62	7.89
Degraded	778.60	0.34
Completely Degraded	462.30	0.20

Vegetation condition of the study area was predominantly influenced by the presence of weeds, particularly **Cenchrus ciliaris* (Buffel Grass) which dominated the understory across large areas. Impacts of grazing were also an important factor on vegetation rating, and also mostly corresponded with the most weed infested parts of the study area.

4.3 ADEQUACY OF SAMPLING

A species accumulation curve (**Figure 7**) was generated to display adequacy of sampling: if the curve has reached (or nearly reached) an asymptote, it is considered likely that most species have been recorded from the study area.

Species accumulation curves were generated for the study area using both Ecoscape and combined data ('all sites', inclusive of available Ecoscape, Cardno and DPaW floristic quadrats from the study area).

Using Ecoscape data the Michaelis-Menten estimation of total species richness is 490 whilst the alternative Bootstrap estimation is 526.2 flora taxa. Taking into account opportunistic observation records, the total flora richness recorded was 522 taxa, indicating that most taxa have been recorded.

Similarly for combined data, the Michaelis-Menten estimation of total species richness is 649 whilst the Bootstrap estimation is 707.2 taxa. In total, 675 taxa were estimated to have been recorded from the combined data, indicating that, while the vast majority of taxa are likely to have been recorded from the Fortescue Valley study area, additional species may have been detected if further survey had been conducted. However, as 675 is an estimated species number due to difficulties with reconciling some species names, the Ecoscape-only curve is likely to be the most accurate predictor of survey adequacy.

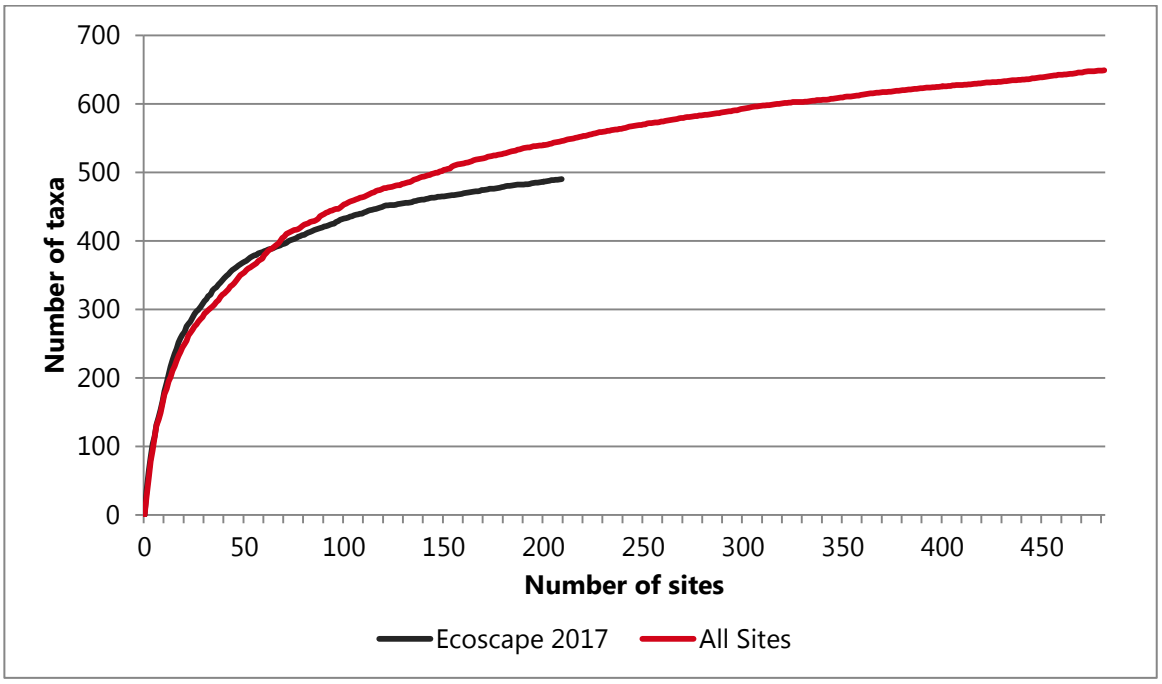


Figure 7: Species accumulation curve

5 DISCUSSION

At the time of writing this report details of proposed or potential works are not available, thus the scale and extent of future potential impacts are unknown.

As potential impacts cannot be detailed or quantified, discussion is in regard to the significance of the study area rather than how significant factors may be affected in the future.

5.1 FLORA SIGNIFICANCE

The 2017 Ecoscape survey recorded 522 vascular flora taxa from within the study area, including 10 (1.91%) that were not identified with certainty to species level. Taking previous surveys into account (Cardno 2012a; 2012b; 2012c; Markey 2016), a total of 675 have been identified as occurring within the study area although this is may be slightly overestimated as it includes numerous unresolved taxa from the previous surveys that may have been already represented in the 2017 inventory.

5.1.1 THREATENED AND PRIORITY FLORA

No TF species listed under the Western Australia BC Act were recorded from within the study area during the current survey. None that are currently listed as TF have previously been recorded from within the study area and, based on the likelihood assessment conducted as part of this project, none are expected to occur.

Lepidium catapycnon is listed as Vulnerable under the EPBC Act; it was delisted by DPaW in 2015 and is now considered as a P4 species. Discussion in this report is based on its DPaW/DBCA conservation ranking.

Seventeen PF were recorded from within the study area during the current survey:

- *Eremophila spongiocarpa* (P1); there are 36 records on *NatureMap* (DPaW 2007-2017) for this species, most of which are indicated to occur within or close to the edge of the Fortescue Marsh
- *Euphorbia inappendiculata* var. *queenslandica* (P1); there are seven records on *NatureMap* (DPaW 2007-2017) for this species. One is from the Kimberley with the remaining records from the Hamersley Range indicating a minor IBRA subregion extension, however, the taxon has a wide distribution over much of Australia (ALA 2017). It is possible that the taxon is under collected due to its similarity to a number of other prostrate species of the same genus.
- *Myriocephalus scalpellus* (P1); there are only three *NatureMap* (DPaW 2007-2017) records for this species, two of which are associated with the population within the study area (Coondiner Pool). *Atlas of Living Australia* (2017) does not indicate any additional populations.
- *Nicotiana heterantha* (P1); *NatureMap* (DPaW 2007-2017) indicates there are 32 records for this species, distributed through the Pilbara (mainly associated with the Fortescue Marsh) and Kimberley regions. However, *Atlas of Living Australia* (2017) indicates 62 records over a wider portion of Western Australia, including into the Murchison and Central Ranges IBRA regions.
- *Samolus* sp. Fortescue Marsh (A. Markey & R. Coppen FM 9702) (P1); *NatureMap* (DPaW 2007-2017) indicates 13 records for this species, most associated with the Fortescue Marsh
- *Synostemon hamersleyensis* (P1); *NatureMap* (DPaW 2007-2017) indicates there are five records for this species and *Atlas of Living Australia* (2017) indicates 11 records. However, all are distributed within an approximate 20 km east-west distribution within the northern Hamersley Range.
- *Tecticornia globulifer*a (P1); *NatureMap* (DPaW 2007-2017) indicates there are 14 records of this species, all except one of which are associated with the Fortescue Marsh
- *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063) (P1); there are 22 records for this species listed on *NatureMap* (DPaW 2007-2017) and 26 on *Atlas of Living Australia* (2017). There are two population clusters; one is in the Little Sandy Desert IBRA region, with the main cluster associated with the Fortescue Marsh.
- *Euphorbia australis* var. *glabra* (P2); this species is restricted to the Pilbara bioregion. Most of the 15 records listed on *NatureMap* (DPaW 2007-2017) are located within the Hamersley IBRA subregion; the existing *NatureMap* record (within the study area, in the Fortescue IBRA subregion) is the eastern-most population extent.

- *Euphorbia inappendiculata* var. *inappendiculata* (P2); according to *NatureMap* (DPaW 2007-2017) there are six records for this species, and the population within the study area has potential to be a range extension or outlier. However, it is likely that this species is undercollected due to its similarity to other prostrate *Euphorbia* species and is therefore underrepresented in herbaria collections.
- *Isotropis parviflora* (P2); within Western Australia there are 27 *NatureMap* (DPaW 2007-2017) records, most in the Hamersley IBRA subregion. However, this species is distributed across northern Australia, with 68 records listed on *Atlas of Living Australia* (2017). Ecoscape botanists have observed this species in abundance following fire elsewhere in the Pilbara
- *Atriplex flabelliformis* (P3); *NatureMap* (DPaW 2007-2017) lists seven records for this species, most in the vicinity of the Fortescue Marsh. However, *Atlas of Living Australia* (2017) indicates a wider distribution over much of Western Australia (except the far north and south), and lists 30 records for the species including one in New South Wales.
- *Sida* sp. Barlee Range (S. van Leeuwen 1642) (P3); *NatureMap* (DPaW 2007-2017) lists 45 records for this species, most in the Hamersley IBRA subregion of the Pilbara bioregion, however, the species' range also extends into the Gascoyne IBRA region
- *Tecticornia medusa* (P3); there are 18 records for this species listed on *NatureMap* (DPaW 2007-2017), most associated with the Fortescue Marsh
- *Eremophila youngii* subsp. *lepidota* (P4); *NatureMap* (DPaW 2007-2017) indicates there are 47 records for this taxon, with *Atlas of Living Australia* (2017) indicating 93 records. Overall, this taxon is distributed from coastal Western Australia (Carnarvon IBRA region) and inland in the Gascoyne, Little Sandy and (most frequently) Pilbara IBRA regions, and also in the Northern Territory.
- *Goodenia nuda* (P4); while occurring most frequently in the Pilbara IBRA region, *NatureMap* (DPaW 2007-2017) indicates the distribution of this species also occurs in surrounding IBRA regions, and is known from 112 records
- *Lepidium catapycnon* (P4); *NatureMap* (DPaW 2007-2017) lists 89 records for this species, most in the Hamersley Range. Until recently this species was listed as a TF.

Eight (47%) of the PF species recorded from within the study area are listed as P1. P1 species are poorly known, all occurrences are either very small, not on conservation lands, or are under threat of habitat destruction or degradation and as such may be under immediate threat, or do not meed adequate survey requirements (DPaW 2017). As such, clearing of these may have significant impacts at a local and population level. Species with few records (*Myriocephalus scalpellus*, *Synostemon hamersleyensis*) have the most potential to be adversely impacted by environmental change.

Three (18%) of the PF species are P2. P2 species are poorly known with few known populations, some of which are within conservation lands, may be inadequately surveyed and have some populations under threat from known threatening processes (DPaW 2017). Species with few records (*Euphorbia inappendiculata* var. *inappendiculata*) have the potential to be impacted at a local and population scale by environmental change.

Three (18%) of the PF species are P3; P3 species are poorly known but occur in several locations and are not considered under immediate threat (DPaW 2017). Impacts due to environmental change are less likely to be significant for P3 populations. A further three species are P4; P4 species are rare, near threatened, in need of monitoring or have been removed from the list of threatened species within the last five years. As such, impacts due to environmental change are less likely to be significant.

Six PF have previously been recorded from within the study area, based on DBCA database search results, Fortescue records and previous surveys, but were not recorded during the current survey:

- *Calotis squamigera* (P1); despite targeted searches in the previously recorded locality, this species was not re-located. As it is an annual species, it may require specific conditions to germinate that were not replicated in 2017 (e.g. it may respond to winter rain rather than summer rain that tends to favour grasses), may have only had a sparse occurrence previously and the population has not persisted, may have been grazed and is no longer present, may not have germinated in the same area as previously, or was present in very small numbers and was not observed. There are only six records (five populations) of *Calotis squamigera* in Western Australia listed on *NatureMap* (DPaW 2007-2017), two of which are in (or

near) the Fortescue Valley (the others are in the Hamersley Range) associated with either Mulga or *Acacia xiphophylla*. DPaW, in the Fortescue Marsh survey (Markey 2016), also recorded *Calotis squamigera*; the record (or records) have not yet been vouchered in the herbarium, however, DPaW noted that it was found to be highly seasonally variable in presence and abundance. *Calotis squamigera* also occurs in the Northern Territory and Queensland (ALA 2017).

- *Helichrysum oligochaetum* (P1); the previous location was searched, however, the species was not re-located. Ecoscape botanists have encountered this species clay soils dominated by *Eucalyptus victrix* to the north of Tom Price and the habitat at the location of the previous record is considered suitable based on this experience. As for the previous species, there are several explanations for not having recorded this annual in 2017. There are 116 records for this species listed on *NatureMap* (DPaW 2007-2017), mostly coastal with some outlier populations in the Ashburton subregion of the Gascoyne IBRA region and in the inland Pilbara. The population within the study area is the second-most eastern population, however, there are no abundance notes with the species record (WAH 2017b).
- *Acacia subtiliformis* (P3); the previous record is considered to be erroneous.
- *Eragrostis crateriformis* (P3); the previously recorded location was searched but the species not re-located. Ecoscape considers the accuracy of the identification is questionable, although DPaW did record this species during the Fortescue Marsh survey (Markey 2016) and considered it to be a large (>200 km) range extension.
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3); this taxon may occur, however, the *Rhagodia* present in the study area is intermediate in form between a commonly occurring species (*Rhagodia eremaea*) and the undescribed P3 taxon.
- *Stylidium weeliwolli* (P3); the previous location was extensively searched, however, the area is now heavily grazed and choked with Buffel Grass and if it did occur previously (noting the age of the record – 1959 – suggests that location information may be inaccurate) it is now unlikely.

In summary, P1 species *Calotis squamigera* and *Helichrysum oligochaetum* most likely occur within the study area, although (as annuals) they may not always be present or their abundance may vary (temporal variation), and their distribution may change over time (spatial variation). Any impacts on these species may be significant at a species level (especially for *Calotis squamigera* that has only five known populations).

Based on the likelihood assessment, 22 PF were deemed to have the potential to occur within the study area (i.e. they were considered to have a 'possible' likelihood; **Table 19**, based on broad characteristics of habitat requirements as understood prior to the field survey) but were not recorded as being present during the field survey. Given the additional information available following the field survey, the likelihoods of occurrence were further analysed and are discussed below.

Four species, highlighted in **bold** below, have a strong likelihood of occurring, however, all are listed as P3 and, if they do occur within the study area and are impacted by future development, any effects at a species level are unlikely to be significant.

Further analysis of likelihood of occurrence of PF species are as follows:

- *Eremophila pilosa* (P1); this distinctive species has only nine records listed on *NatureMap* (DPaW 2007-2017), all except one of which is from close to the Marble Bar Road approximately 25 km east of the study area. This indicates a very narrow species distribution and, although similar habitat occurs within the study area, it is unlikely to occur.
- *Stemodia* sp. Battle Hill (A.L. Payne 1006) (P1); only three records of this species are listed on *NatureMap* (DPaW 2007-2017), indicating its poorly known status. The nearest record is from approximately 45 km east of the study area on the Fortescue River floodplain. Given its apparent rarity, it is unsurprising that it was not recorded despite likely similar habitat occurring within the study area. It is considered unlikely to occur.
- *Aristida lazaridis* (P2); *NatureMap* (DPaW 2007-2017) indicates 19 records of this species, all from within the Hamersley Range and all approximately 17 km (or more) south of the northern Range edge. While the study area incorporates small areas of the Hamersley Range, the study area does not extend more

than 10 km into the range and as such, while similar habitat may exist within the study area, it is possible that the precise habitat (sand and loamy soil) does not and as such it is unlikely to occur.

- *Eremophila pusilliflora* (P2); this species, formerly known as *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662), is known from 11 records on *NatureMap* (DPaW 2007-2017), all except one of which is within the Hamersley Range and at least 60 km from the study area. The only record not within the Hamersley Range (and the one closest to the study area) appears to be wrongly attributed for location as the locality description indicates it is within the Hamersley Range National Park (now Karijini National Park). Additionally, this species' published details indicate it is associated with the Ashburton River catchment (Buirchell & Brown 2016). Given the species actual known distribution does not include areas close to the study area, it is unlikely to occur.
- *Ipomoea racemigera* (P2); five of the six records of this species on *NatureMap* (DPaW 2007-2017) are within the Pilbara bioregion or close (in the Gascoyne bioregion), with an east-west distribution of over 350 km (plus an outlier north of Kununurra in the Kimberley bioregion, although it is widespread in the Northern Territory and Queensland and also occurs in South Australia (ALA 2017)), indicating a very scattered and sparse distribution within Western Australia. As such it is unsurprising that this species was not recorded in the study area, despite similar floodplain habitat occurring. It is unlikely to occur.
- *Amaranthus centralis* (P3); there are four records of this species in the Pilbara bioregion, from both floodplains of the Fortescue River and watercourses in the Hamersley Range (DPaW 2007-2017), however, the Pilbara population is an outlier of its usual extent, which is in Central Australia (ALA 2017). Given the few records it is likely to be sparsely distributed and as such it is unsurprising that it was not recorded from the study area. It is considered unlikely to occur.
- *Aristida jerichoensis* var. *subspinulifera* (P3); *NatureMap* (DPaW 2007-2017) indicates that there have been 35 records of this species within Western Australia, and most are from the Hamersley Range. The study area incorporates small portions of the Hamersley Range, however, given that this species (in Western Australia) is almost entirely confined to the Range, it is unsurprising that it was not recorded from within the study area and is considered unlikely to occur.
- *Crotalaria smithiana* (P3); the nearest record for this species is approximately 30 km southeast of the study area. *NatureMap* (DPaW 2007-2017) indicates that three of the five (uncultivated) Western Australian records for this species are associated with the Fortescue River, however, the paucity of records for this species in Western Australia indicate that it is not commonly encountered and as such it is unsurprising that it was not recorded from within the study area despite suitable habitat occurring. It is considered unlikely to occur.
- ***Dysphania congestiflora*** (P3); there are only five records for this species on *NatureMap* (DPaW 2007-2017), three of which are within the Fortescue Marsh west of the study area. Given that suitable habitat occurs within the study area and that the nearest record is only approximately 11 km to the west, it is possible that this species does occur within the study area but was not observed. DPaW recorded this species during the Fortescue Marsh survey (Markey 2016), however, this population has not yet been vouchered in the Western Australian herbarium.
- ***Eleocharis papillosa*** (P3); this species has 10 records from within Western Australia, and these are widespread over much of the State (DPaW 2007-2017). Only one record is from the Pilbara, and is approximately 6 km from the study area in habitat that occurred within the study area. As such it is possible that the species occurs within the study area, however, the area in the vicinity of the known occurrence (which is described as consisting of 1,000+ plants (WAH 2017b)) was inaccessible due to lack of track access. DPaW recorded this species during the Fortescue Marsh survey (Markey 2016), however, this population has not yet been vouchered in the Western Australian herbarium.
- ***Eucalyptus rowleyi*** (P3); this species occurs on loamy plains approximately 20 km east of the study area. Nicolle and French (2012), who described the species consider that additional unrecorded populations are likely as the species occurs in small pure stands in a largely remote and unsurveyed area. As it is not possible to inspect every clump of mallee in study area, it must be considered that additional populations have at reasonable likelihood of occurring as suitable habitat does occur. DPaW, in its Fortescue Marsh survey (Markey 2016), recorded a single population of this species on the southern edge of the Fortescue Marsh, however, this population has not yet been vouchered in the Western Australian herbarium.

Similarly, Ecoscape collected this species at Cloudbreak in 2016; this specimen also has not yet been added to the Western Australian Herbarium's records.

- *Glycine falcata* (P3); this species is known from 18 records in Western Australia, most in the Pilbara bioregion (DPaW 2007-2017), associated with cracking clay and drainage lines. All records are at least 40 km west of the study area (i.e. are downstream) and, although suitable habitat does occur, it is unlikely that *Glycine falcata* occurs within the study area.
- *Goodenia* sp. East Pilbara (A.A. Mitchell PRP 727) (P3); there are 59 records of this species listed on *NatureMap* (DPaW 2007-2017), however, there is some disagreement regarding its similarity to *Goodenia pascua*, and some taxonomists consider them to be indistinguishable i.e. the same species (Rio Tinto & DPaW 2015). Neither species was recorded from the study area. Most records of both species are to the west of the study area when associated with the Fortescue River or are in the ranges north and south of the study area, and as such it is unlikely that *Goodenia* sp. East Pilbara occurs in the study area.
- *Gymnanthera cunninghamii* (P3); this species is occurs in scattered locations in the inland Pilbara (DPaW 2007-2017), generally in association with watercourses but is not known from the Fortescue River floodplain. As such, suitable habitat most likely occurs within the study area, however, the scattered nature of its occurrence and lack of nearby records (the nearest is 12 km south, in the Hamersley Range) indicates it is unlikely.
- *Iotasperma sessilifolium* (P3); this species is known from 14 Western Australian records on *NatureMap* (DPaW 2007-2017), and is common on cracking clays on Hamersley Station (Rio Tinto & DPaW 2015). However few records are from the Fortescue Valley and as such it is unsurprising that it was not recorded and is unlikely to occur despite suitable habitat occurring.
- *Polymeria distigma* (P3); this species occurs primarily in the Kimberley region, with only three records from the Hamersley Range (DPaW 2007-2017). The nearest record is approximately 6 km south of the study area (or 15 km south if measured along Weeli Wolli Creek, with which the record is associated). While small areas of suitable creekline habitat within the Hamersley Range may occur within the study area, these are likely to be infested with Buffel Grass and as such unlikely to have *Polymeria distigma*.
- *Rostellularia adscendens* var. *latifolia* (P3); this taxon has 35 records indicated on *NatureMap*, most of them from the Hamersley Range (DPaW 2007-2017) where it occurs near watercourses, in shady areas and in gullies and gorges (Rio Tinto & DPaW 2015). While small areas of suitable habitat may occur within the study area it is unsurprising that it was not recorded due to the small extent such habitat.
- ***Themeda* sp. Hamersley Station (M.E. Trudgen 11431)** (P3); there are 43 Western Australian records for this species listed on *NatureMap* (DPaW 2007-2017). The usual habitat is cracking clay soils and drainage lines. The study area is towards the eastern extent of its main distribution. As suitable habitat occurs within the study area, it must be considered possible to occur, however, it is likely to occur as sparse plants rather than as a characteristic species (as it does on Hamersley Station) and it is unsurprising that it was not recorded.
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3); there are 33 records of this species in *NatureMap* (DPaW 2007-2017), all except two of which are located in the Hamersley or Ophthalmia Ranges. As only a small portion of the study area is included in the Hamersley Range, and all records (except east of Newman) are at least 30 km south of the Range northern edge (i.e. well into the Range), this species must be considered as being unlikely to occur.
- *Xerochrysum boreale* (P3); this is a newly described species (Wilson 2017) that has four records listed on *NatureMap*, three of which are in the Hamersley Range (DPaW 2007-2017). The species is not yet listed on *Atlas of Living Australia*, however, the taxonomic literature indicates that it occurs across much of northern Australia (Wilson 2017). The Western Australian records indicate it is associated with clay soils and Mulga. As only a small portion of the study area is included in the Hamersley Range, it is unlikely to occur.
- *Eremophila magnifica* subsp. *magnifica* (P4); this taxon has 53 records listed on *NatureMap*, most of which are within the Hamersley Range (DPaW 2007-2017) where it grown on steep rocky slopes. As only a small portion of the study area is included in the Hamersley Range, it is unlikely to occur.
- *Rhynchosia bungarensis* (P4); there are 202 records of this species listed on *NatureMap* (DPaW 2007-2017) indicating that it occurs sparsely but frequently. It is known to be associated with rock piles,

drainage lines, gorges and alluvial soils which are frequently occurring habitat types within the study area, however, the study area is approximately 13 km east of the most eastern record for this species and as such *Rhynchosia bungarensis* is considered unlikely to occur.

In summary, four species (in **bold** above) have a strong likelihood of having occurred within the study area but were not recorded. All are P3 species. Therefore, if these species do occur within the study area, and if they are impacted by any future developments, any effects at a species level are unlikely to be significant.

5.1.2 SIGNIFICANT FLORA

Cardno (2012b) identified *Melaleuca xerophila* as significant (range edge, unusual in Pilbara).

DPaW (Markey 2016) considered *Tecticornia auriculata* as significant as it is mostly a coastal species. While DPaW's observation is reasonable, it also occurs in two other inland locations; Lake Disappointment and Lake Sunshine, both in the Little Sandy Desert IBRA region (DPaW 2007-2017) thus its suggested significance in association with the Fortescue Marsh is limited. Many halophytic species have very scattered distributions due to the scattered nature of their habitat e.g. *Tecticornia indica* subsp. *leiostachya*, *Tecticornia verrucosa* (DPaW 2007-2017).

No species recorded by Ecoscape was considered to represent a significant range extension of over 100 km or in a new bioregion as all potential candidates listed in **Table 8** had been identified from other nearby surveys, although they appear to have not (as yet) been vouchered with the Western Australian Herbarium, or other herbaria. Thus they represent limited vouchering effort rather than are true new range extensions.

The species in **Table 8** can be considered to be occurring on their range edge, as an outlier population or filling in a distribution gap: *Basilicum polystachyon* (edge), *Chrysocephalum eremaeum* (edge), *Ehretia saligna* var. *saligna* (edge), *Einadia nutans* subsp. *eremaea* (edge), *Eragrostis exigua* (gap), *Eriachne gardneri* (outlier), *Euphorbia inappendiculata* var. *inappendiculata* (outlier), *Frankenia ambita* (outlier), *Halgania solanacea* var. *solanacea* (edge), *Trichodesma zeylanicum* var. *grandiflorum* (gap), *Triglochin hexagona* (edge) and *Uvedalia linearis* (gap).

There were no new (undescribed) species or species considered as unusual recorded during the survey.

5.1.3 LOCAL AND REGIONAL SIGNIFICANCE OF FLORA

A number of species are locally endemic or nearly so, and thus can be considered as both locally and regionally significant. Their significance has already been identified by DBCA as they are all listed as Priority Flora. The locally endemic (or nearly so) species are:

- *Eremophila spongiocarpa* (P1)
- *Myriocephalus scalpellus* (P1)
- *Samolus* sp. Fortescue Marsh (A. Markey & R. Coppen FM 9702) (P1)
- *Tecticornia globulifer*a (P1)
- *Tecticornia medusa* (P3)
- *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063) (P1).

5.1.4 INTRODUCED FLORA

Seventeen introduced flora species (weeds) were recorded from within the study area: **Aerva javanica*, **Argemone ochroleuca* subsp. *ochroleuca*, **Bidens subalternans* var. *simulans*, **Cenchrus ciliaris*, **Cenchrus setiger*, **Chloris virgata*, **Citrullus lanatus*, **Echinochloa colona*, **Flaveria trinervia* (although there is some debate regarding its status as native or introduced), **Malvastrum americanum*, **Portulaca pilosa*, **Pseudognaphalium luteoalbum*, **Rumex vesicarius*, **Setaria verticillata*, **Sisymbrium orientale*, **Sonchus oleraceus* and **Vachellia farnesiana*.

None are Declared Pest plants or WONS species.

Nine species have high ecological impact and rapid invasiveness according to DPaW's weed prioritisation ranking (DPaW 2016a): **Aerva javanica*, **Cenchrus ciliaris*, **Cenchrus setiger*, **Chloris virgata*, **Echinochloa colona*, **Malvastrum americanum*, **Rumex vesicarius*, **Setaria verticillata* and **Vachellia farnesiana*.

Of these, **Cenchrus ciliaris* and **Cenchrus setiger* have been observed as having a significant effect on large areas of vegetation within the study area. Both species can form dense swards, outcompeting native species and can form virtual monocultures in favourable areas (generally in association with drainage lines and, in this study area, on the fringes of the Fortescue Marsh). These grasses commonly occur throughout the Pilbara (and other parts of Australia) and are favoured by pastoralists as cattle feed. They were originally grown as a pasture species or accidently introduced (Van Vreeswyk *et al.* 2004), and have been known from the Pilbara bioregion since the early 1900s (Keighery 2010). Within the study area they were most common in places favoured by cattle.

Currently there is no requirement for Fortescue to control of any of these weed species, and no reason to consider that Fortescue's activities within the study area has contributed to any species' presence, abundance or distribution.

5.2 VEGETATION SIGNIFICANCE

5.2.1 VEGETATION TYPES

Forty one vegetation types were recorded from the study area, 26 of these occurred on valley landform (i.e. on more-or-less flat plains that also included sandplain and calcrete plains), one occurred on sand dunes, one was associated with riparian areas, two were associated with claypans, seven occurred on the Fortescue Marsh, two occurred on low undulating hills, and three on higher hills and plateaux.

5.2.2 THREATENED AND PRIORITY ECOLOGICAL COMMUNTIES

No vegetation was considered similar to any current Western Australian-listed or Commonwealth EPBC Act-listed TEC.

Three PECs have been previously recorded as corresponding, at least in part, with the study area. These PECs, and the vegetation types associated with them, are described below.

5.2.2.1 Fortescue Marsh (Marsh Land System)

The Fortescue Marsh PEC occurs as a single unit, associated with the Marsh Land System. The study area corresponds with approximately 200 km^2 of the land system (approximately 20% of the total land system extent (Payne 2004)) and approximately 562 km^2 of mapped PEC including a 5 km buffer. The vegetation occurring within the Marsh portion of the study area is considered to be similar to the vegetation occurring in adjacent Marsh areas.

Seven vegetation types were recorded within the Fortescue Marsh. They, and their DPaW equivalents (DPaW 2016b; Markey 2016), are:

- **Ms** (*Muellerolimon salicorniaceum*, *Tecticornia indica* subsp. *leiostachya* and *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063) low shrubland/ samphire shrubland)
  - equivalent to DPaW (2016b) map unit '6: Tall *Muellerolimon salicorniaceum* inundated shrubland' (DPaW 2016b), including floristic groups 'FA: *Muellerolimon salicorniaceum* and *Tecticornia indica* subsp. *bidens* samphire shrublands' and 'FB: *Muellerolimon salicorniaceum* and mixed *Tecticornia* samphire shrublands' (Markey 2016)
- **Ta[1]** (*Tecticornia auriculata* and *Muellerolimon salicorniaceum* mid open samphire shrublands over *Eragrostis pergracilis* and *Swainsona tanamiensis* low open grassland/ herbland)
  - equivalent to DPaW (2016b) map unit '21: *Tecticornia auriculata* / *Muellerolimon* marsh interior shrublands' described in (Markey 2016) as floristic group 'BB: Species poor *Tecticornia auriculata* samphire shrublands'
- **Ta[2]** (*Tecticornia auriculata*, *Muellerolimon salicorniaceum* and *Tecticornia indica* subsp. *leiostachya* mid open samphire shrubland/ shrubland over *Eragrostis pergracilis*, *Swainsona tanamiensis* and *Maireana luehmannii* low open grassland/ herbland/ chenopod shrubland)
  - equivalent to DPaW (2016b) map unit '29: *T. indica bidens*, *Muellerolimon* and *T. auriculata* interior vegetation communities', including floristic groups 'EA: *Tecticornia auriculata*, *Tecticornia indica*, *Eremophila spongiocarpa* mixed samphire shrubland', 'EB: *Tecticornia indica* subsp. *bidens* and

Tecticornia auriculata vegetation community' and 'EC: *Muellerolimon salicorniaceum*, *Tecticornia auriculata* samphire shrublands' (Markey 2016). Note that Ecoscape's sites demonstrated *Tecticornia auriculata* to be the most dominant for this vegetation type within the study area.

- **TD** (*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552), *Tecticornia indica* subsp. *leiostachya* and *Swainsona tanamiensis* low samphire shrubland/ herbland)
  - equivalent to DPaW (2016b) map unit '28: Marginal *Tecticornia* sp. Dennys Crossing / *Tecticornia indica* vegetation community' that includes floristic groups 'DA: Low *Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) samphire shrublands' and 'DB: Tall *Melaleuca xerophila* over samphires and chenopods marginal shrublands' (Markey 2016)
- **Ti** (*Tecticornia indica* subsp. *leiostachya*, *Cullen cinereum* and *Eremophila spongiocarpa* low samphire shrubland/ herbland/ shrubland)
  - equivalent to DPaW (2016b) map unit '22: *Tecticornia indica* ssp. *bidens* and *Eremophila spongiocarpa* edge samphire shrubland' that is combined from floristic groups 'CA: *Tecticornia indica* subsp. *bidens*, *Eremophila spongiocarpa* mixed samphire shrublands' and 'CB: Marginal *Tecticornia indica* subsp. *bidens*, *Eremophila spongiocarpa* mixed samphire shrublands' (Markey 2016)
- **Tm** (*Tecticornia medusa*, *T. globulifera* and *T. verrucosa* low open samphire shrubland)
  - equivalent to DPaW (2016b) map unit '20: *Tecticornia medusa/Tecticornia pergranulata* lake bed community' that is also described as floristic group 'AB: *Tecticornia medusa* and *Tecticornia pergranulata* samphire shrublands' (Markey 2016)
- **Tv** (*Tecticornia verrucosa* low open samphire shrubland)
  - presumably equivalent to DPaW (2016b) map unit '5: Bare Lake Bed'. There is, however, no equivalent unit (to the mapping data) within the DPaW report (Markey 2016) with the nearest equivalent most likely being 'Group B: Species poor *Tecticornia* spp. interior shrublands' consisting of floristic group 'BA: *Tecticornia globulifera* / *Tecticornia pergranulata* / *Tecticornia indica* subsp. *bidens* samphire shrublands' (Map Unit: 27). It is presumed that this annual species (*Tecticornia verrucosa*) was absent or inconsistently present during the DPaW survey periods.

All were characterised by Samphire species (*Tecticornia* species in the Chenopodiaceae family), although one vegetation type was dominated by, and others characterised by, *Muellerolimon salicorniaceum* (a halophyte of similar structure in the Plumbaginaceae family) that mainly occurs in coastal salt flats (Western Australian Herbarium 1998-2017).

DPaW (Markey 2016) considered *Tecticornia medusa*, *T. pergranulata* (not recorded during this survey) and *T. globifera* to be particularly tolerant of submergence, high salinity and drought; these species characterised vegetation types occurring at lower elevations in the Marsh. *Tecticornia auriculata* and *T. indica* were considered to be physiologically suited to more moderate conditions and were widely distributed across the Marsh at middle to high elevations, and characterised many vegetation types. *Muellerolimon salicorniaceum* was considered to tolerate a wide range of conditions except total submergence.

These species were distributed in the interior of the marsh as dominant and characteristic species in several vegetation types. Ecoscape's interpretation of the Fortescue Marsh vegetation is similar to DPaW's, noting that DPaW mapped a 'bare lake bed' vegetation type where Ecoscape recorded *Tecticornia verrucosa* in similar landforms, and formulated a vegetation type (**Tv**) taking this into consideration. DPaW (Markey 2016) considered that only annual species, including this and *Heliotropium curassavicum*, *Marsilea* species and *Trigonella suavissima* to be physiological able to survive in otherwise bare areas after water has receded. Ecoscape recorded only three species within this vegetation type, with *Tecticornia globulifera* and *Uvedalia linearis* also occurring in the vegetation type in only one of the four Ecoscape quadrats (the other tree quadrats contained only the definitive species).

DPaW (Markey 2016) considered a number of species with low tolerance for inundation to characterise Marsh edge vegetation types, and subtle changes in elevation, topography and soil determined which species were characteristic. Marsh edge vegetation included types characterised by *Tecticornia auriculata*, *Muellerolimon salicorniaceum*, *Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552), *Eremophila spongiocarpa* and *Melaleuca xerophila*, and *Duma florulenta* associated with freshwater flows.

5.2.2.2 Vegetation of sand dunes of the Hamersley Range/Fortescue Valley (previously 'Fortescue Valley Sand Dunes')

Fourteen occurrences of the 'Vegetation of sand dunes of the Hamersley Range/Fortescue Valley' PEC were identified by DBCA database search as occurring within the study area, although three of these also extend outside. These 14 occurrences represent the entire PEC.

The sand dunes were occupied by a single vegetation type: **AdAh** (*Acacia dictyophleba*, *Grevillea juncifolia* subsp. *juncifolia* and *Crotalaria cunninghamii* tall open shrubland over *Aristida holathera* var. *holathera* and *Triodia schinzii* low tussock grassland/ hummock grassland), recorded from five quadrats located in the more eastern occurrences of the PEC.

Cardno (2012b) described the vegetation of the Fortescue Valley Sand Dunes as (firstly) *Acacia dictyophleba* scattered tall shrubs over *Crotalaria cunninghamii*, *Trichodesma zeylanicum* var. *grandiflorum* open shrubland (also corresponding with the description of the PEC; Species and Communities Branch DBCA 2017), and (more commonly) as *Stylobasium spathulatum* and *Acacia dictyophleba* sparse shrubland over *Triodia schinzii* and *Triodia basedowii* open hummock grassland, then refined the description (Cardno 2012a) as *Acacia dictyophleba*, *Stylobasium spathulatum* and *Petalostylis cassioides* tall sparse shrubland over *Triodia schinzii* and *Triodia lanigera* open hummock grassland with a low shrub layer of *Sida cardiophylla*, *Senna notabilis* and *Corchorus* aff. *elachocarpus*, *Corchorus sidoides* subsp. *sidoides* and *Corchorus tectus*. Cardno (2012a) state that DEC confirmed the vegetation as being representative of the PEC, however, DPaW, as an 'aside' in the Fortescue Marsh survey report (Markey 2016) describes the vegetation of the PEC as being Mulga and *Hakea lorea* over *Crotalaria cunninghamii*, *Corchorus laniflorus* and dense *Triodia* hummocks.

The varying descriptions of the Fortescue Valley Sand Dunes vegetation by Cardno (2012a; 2012b) and Ecoscape indicate that the dunes vary slightly over their distribution, however, the characteristic species of *Acacia dictyophleba* and *Triodia schinzii* (and most other listed taxa, notably excluding *Stylobasium spathulatum* that was only recorded in one Ecoscape quadrat and *Triodia lanigera* that was not recorded by Ecoscape) are relatively consistent. Ecoscape observed that the more western occurrences of this PEC were more disturbed by grazing and consequently more weedy, with **Cenchrus ciliaris* being a common component. Vegetation condition in this western occurrence ranged from Good to Poor. In comparison, the vegetation condition in the south eastern occurrences was Very Good or Excellent.

The interdunal areas and surrounding sandplains were almost entirely mapped as **AaTb** or as the mosaic vegetation type **EgAbTb/AaTb**.

5.2.2.3 Narbung Land System

The Narbung Land System occupies 15,900 ha (Payne 2004), a small part of which is within the study area. However, DBCA mapping indicates that the *Narbung Land System* PEC almost entirely occurs within the study area, but does not correspond with the entirety of the land system.

The *Narbung Land System* PEC is described as (Species and Communities Branch, DBCA 2017):

> *Alluvial washplains with prominent internal drainage foci supporting snakewood and mulga shrublands with halophytic low shrub.*

Ecoscape recorded the vegetation within the Narbung land system as being predominantly:

- **AxEcTe**: *Acacia xiphophylla* low open woodland over *Eremophila cuneifolia*, *Maireana pyramidata* and *Senna artemisioides* subsp. *oligophylla* x *helmsii* mid sparse shrubland over *Triodia epactia*, *T. longiceps* and *Enteropogon ramosus* low open hummock grassland/ grassland
- **EyAb**: *Eremophila youngii* subsp. *lepidota*, *Senna artemisioides* subsp. *helmsii* and *Acacia synchronicia* mid open shrubland over *Atriplex bunburyana*, *Maireana pyramidata* and *Eragrostis xerophila* mid open chenopod shrubland/ tussock grassland.

Both of these vegetation types were largely confined to the land system or immediately adjacent to it, and broadly match the description of the PEC (except for the presence of Mulga, which was included in the less common vegetation types occurring). Ecoscape observed that this land system supported vegetation that

responded to slight changes of topography, however, a more detailed study would be required to garner a greater understanding of these changes and the accompanying floristics. The vegetation itself is not considered to have any particular significance.

5.2.3 SIGNIFICANT VEGETATION

Based on the criteria provided in the *Flora and Vegetation Technical Guidance*, a number of vegetation types may be considered as significant. These are discussed below.

5.2.3.1 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems are those characterised by phreatophytic species that require access to groundwater for at least part of their life cycle. The Fortescue Marsh is, by definition as a wetland (Eamus *et al*. 2006) is a Groundwater Dependent Ecosystem, and is discussed above in terms of its vegetation.

Other than Marsh (wetland) species, the only confirmed obligate phreatophytic species within the study area is *Eucalyptus camaldulensis sens. lat*., therefore vegetation with this species occurring within it is considered representative of a GDE. Vegetation type **EvAcCc** (*Eucalyptus victrix* and *Eucalyptus camaldulensis* subsp. *refulgens* mid woodland over *Acacia citrinoviridis*, *A. pyrifolia* var. *pyrifolia* and *A. tumida* var. *pilbarensis* tall sparse shrubland over **Cenchrus ciliaris*, *Tephrosia rosea* var. Fortescue creeks (M.I.H. Brooker 2186) and *Cymbopogon ambiguus* mid open tussock grassland/ shrubland) is characterised by this species.

Vegetation type **EvAcCc** was associated with riparian areas, largely with the three creeks flowing into and (at times discontinuously) through the southern side of the study area (Weeli Wolli, Mindy Mindy and Coondiner Creeks). GDE mapping, **Figure 8** (Australian Government & BoM 2017), indicates that these creeks (where they have surface flow) correspond with areas considered to be 'moderate potential for groundwater interaction'. (Note that Mindy Mindy Creek is approximately midway between Weeli Wolli and Coondiner Creeks, and, like Coondiner Creek, does not have surface water flow all the way to the Marsh).

Any changes to groundwater have the potential to affect this vegetation.

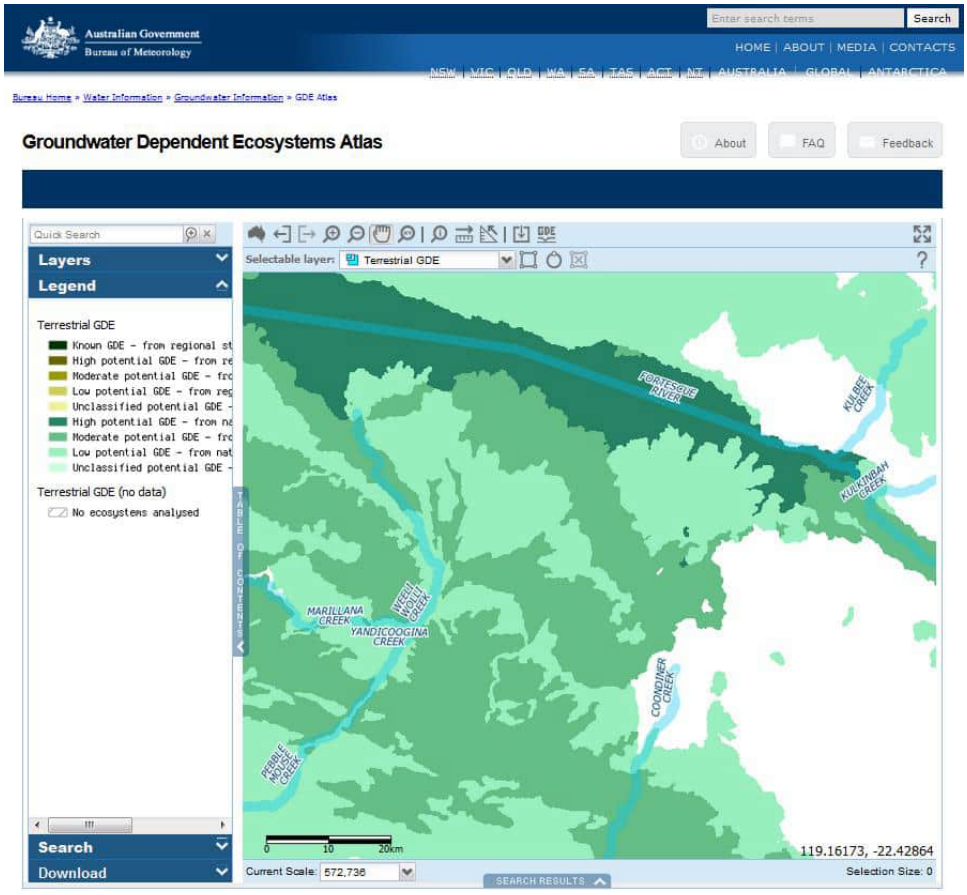


Figure 8: Groundwater Dependent Ecosystem Atlas (Australian Government & BoM 2017)

DPaW (Markey 2016) considered *Melaleuca xerophila* likely to be groundwater dependent in the Marsh region. Similarly, Mattiske (2009a) considered that *Melaleuca xerophila* may be groundwater dependent in the Sandstone area. This contrasts with the finding that this species did not access groundwater in the Lake Torrens area of South Australia (EBS Ecology 2017), although this was considered to be due to the salinity of the groundwater. The groundwater consideration within the latter reference implies that this species is generally considered to access groundwater, however, does not imply dependence on groundwater, and further implies that this species use of and/or dependence on groundwater may be variable. Therefore additional research is likely to be required in relation to *Melaleuca xerophila*'s association with groundwater in the Marsh region.

For the purposes of this report, *Melaleuca xerophila* is considered to be groundwater dependent and therefore vegetation dominated or characterised by this species is considered representative of a GDE.

Vegetation type **MxCc** (*Melaleuca xerophila*, *Eremophila youngii* subsp. *lepidota* and *Acacia synchronicia* tall open shrubland over **Cenchrus ciliaris*, *Eragrostis dielsii* and *Sclerolaena costata* low tussock grassland/ chenopod shrubland) is dominated by this species. There was only one occurrence of this vegetation type in the study area, adjacent to the western boundary close to the southern edge of the Marsh.

Vegetation type **EvMxTl** (*Eucalyptus victrix*, *Acacia citrinoviridis* and *A. aptaneura* low open woodland over *Melaleuca xerophila* and *Acacia synchronicia* tall sparse shrubland over *Triodia longiceps* and *Eragrostis setifolia* low sparse hummock grassland/ tussock grassland) has *Melaleuca xerophila* as a dominant and characteristic mid stratum species. This vegetation type was associated with clay depressions within calcrete, south of the Marsh in both the west, and more commonly, east of the study area.

Any changes to groundwater have the potential to affect these vegetation types.

5.2.3.2 Potential Groundwater Dependent Ecosystems

Vegetation types **EvDf** (*Eucalyptus victrix* low open woodland over *Duma florulenta*, *Atriplex amnicola* and *Eriachne flaccida* mid sparse shrubland/ tussock grassland) and **EvDfEb** (*Eucalyptus victrix* low open woodland over *Eriachne benthamii* and *Cyperus concinnus* low open tussock grassland/ sedgeland with isolated *Duma florulenta* mid shrubs) were dominated by *Eucalyptus victrix* that is considered to be a facultative phreatophyte, although there is some evidence that in some circumstances this species is not dependent on groundwater (see **Section 1.4.5.2**). These vegetation types were associated with clay pans (including Coondiner Pool), predominantly on the eastern side of the study area, south of the Fortescue Marsh.

These vegetation types are considered to be representative of potential GDEs. Any changes to groundwater have the potential to affect these vegetation types.

5.2.3.3 Mulga Communities

There were five valley floor vegetation types dominated by Mulga (*Acacia aptaneura*) within the study area, occupying almost one third (71,876 ha, 31.12%) of the study area and forming a broad band almost continuously across its width:

- **AaAsCc** (*Acacia aptaneura* low woodland over *Acacia synchronicia*, *A. tetragonophylla* and *Senna artemisioides* subsp. *oligophylla* mid sparse shrubland over **Cenchrus ciliaris* mid closed tussock grassland)
- **AaAtRa** (*Acacia aptaneura* low open forest over *Acacia tetragonophylla* tall sparse shrubland over *Rostellularia adscendens* var. *clementii*, **Setaria ver*ticillata and *Paspalidium clementii* low herbland/ grassland)
- **AaEfEp** (*Acacia aptaneura* low woodland over *Eremophila forrestii* subsp. *forrestii*, *Acacia tetragonophylla* and *Senna artemisioides* subsp. *helmsii* mid sparse shrubland over *Enneapogon polyphyllus*, *Rostellularia adscendens* var. *clementii* and **Cenchrus ciliaris* low tussock grassland/ herbland
- **AaTp** (*Acacia aptaneura* and *A. pruinocarpa* low woodland over *Triodia pungens* and **Cenchrus ciliaris* hummock grass mid hummock grassland/ tussock grassland)

- Sheet Flow Dependent **AaSaEp** (*Acacia aptaneura* and *A. pruinocarpa* low woodland over *Senna artemisioides* subsp. *oligophylla*, *Ptilotus obovatus* and *Acacia tetragonophylla* mid open shrubland over *Enneapogon polyphyllus*, *Aristida contorta* and *Chrysopogon fallax* low grassland in Mulga groves and *Aristida contorta*, **Cenchrus ciliaris* and *Ptilotus aervoides* low grassland/tussock grassland/forbland with *Acacia synchronicia* tall scattered shrubs in intergroves).

All valley floor vegetation dominated by Mulga species (*Acacia aneura*, *A. aptaneura*, *A. ayersiana*, *A. fuscaneura*, *A. incurvaneura*, *A. macraneura*, *A. minyura*, *A. mulganeura*, *A. paraneura* and *A. pteraneura*) can be considered as significant according to previous survey reports (Biota Environmental Sciences 2004a; Cardno 2012b; 2012c; Kendrick 2002a; 2002b) and approvals documentation (EPA 2010; 2011; 2012; 2014; 2016b; Office of the Appeals Convenor 2014; 2016a; 2016b), outlined in **Section 1.4.5.2**. There are a number of reasons for significance including:

- restricted distribution
- the species (as a group) are at (or close to) the northern extent of their range in the study area
- fire sensitivity (changes to fire regimes including extent and intensity)
- potential to be affected by disturbance (including weeds and lack of regeneration as a result of grazing, which is most likely to be significant in combination with fire)
- potential to be impacted by changes to surface water flow.

Sheet Flow Dependent Vegetation (**AaSaEp**) has the most obvious potential to be affected by changes to surface water flows that may be caused by obstacles, including roads or railways (or any linear infrastructure), or any changes to topography that prevents heavy rainfall from moving across the slightly-sloping landscape as a 'sheet'.

The effects of altered surface water flow on other Mulga vegetation is less well understood, however, all valley floor Mulga is considered to have some interaction with surface water flows and is therefore potentially impacted by hydrological change (see **Section 1.4.5.2**). Within the study area the valley floor Mulga vegetation largely corresponded with the pastoral leases, and evidence of cattle grazing (i.e. tracks, scats and evidence of browsing) was frequently observed. **Cenchrus ciliaris* (Buffel Grass), favoured for grazing, was a common ground stratum component.

Fire is also a threat to Mulga vegetation as most Mulga species are fire sensitive and killed by even cool burns (Maslin & Reid 2012), although some are known to resprout from trunks or roots particularly if only scorched (Maslin *et al*. 2010). Frequent burning has led to the loss of Mulga communities in some areas including in the Pilbara (Maslin & Reid 2012), and it is likely that Mulga seedlings or resprouts within reach of cattle or feral herbivores in particular would be preferentially grazed before *Triodia* species and similar less palatable plants, leading to the loss of Mulga or reduction in the numbers of plants. Native herbivores would also likely preferentially graze Mulga seedlings or resprouts.

The grazing, weed invasion and fire threats to Mulga vegetation are applicable to all of the Mulga vegetation types within the study area, and therefore all Mulga is of potential significance.

5.2.3.4 Other Significant Vegetation

Claypans

Lyons (2015) considered less permanent wetlands (i.e. non-riparian wetlands including clay pans and turbid linear creeks with fine clay soil) to have higher species richness than riparian wetlands, and captured a high component of Pilbara flora especially on their margins. They are also threatened by unrestricted grazing leading to degradation and were therefore considered as significant. Claypans were widespread across the study area, and were characterised by two vegetation types: **EvDf** and **EvDfEb**. Species richness varied significantly in the quadrats within these vegetation types, ranging from three to 65 species; the highest species richness was associated with vegetation type **EVDfEb** (65, 49 and 45), corroborating Lyons' observations that clay pans have high species richness, although none of the observed species (except *Myriocephalus scalpellus*, P1) was considered to be restricted in distribution.

DBCA have determined that freshwater claypans of the Fortescue Valley, downstream of the Fortescue Marsh, represent a unique community and has recognised their significance by listing them as a PEC. The only description available (Species and Communities Branch, DBCA 2017) indicates that the PEC community is described as *Eriachne* spp. and *Eragrostis* spp. grasslands; these two genera are also characteristic of the Fortescue Valley claypan communities recorded during this survey, with the most obvious floristic difference being that the PEC communities are described as having few Coolibah (*Eucalyptus victrix*), which is characteristic in the Fortescue Valley.

While there are most likely distinct similarities between claypans of the Upper Fortescue Valley (i.e. those in this study area) and the *Freshwater claypans of the Fortescue Valley* PEC, there are also obvious differences including the presence of Coolibah and the location of the study area that does not meet the geographical description of 'downstream of the Fortescue Marsh – Goodiadarrie Hills on Mulga Downs Station' included in the PEC definition (Species and Communities Branch, DBCA 2017). Therefore, due to floristic composition and location of the study area, the claypans within the study area are unlikely to be included in the PEC based on the current PEC description.

***Acacia xiphophylla*-dominated vegetation**

Biota (2004a) considered *Acacia xiphophylla*-dominated vegetation to be significant. *Acacia xiphophylla*-dominated vegetation occupied almost 10% of the study area (combined extents of vegetation types **AxEcSc** and **AxEcTe** was 22,006 ha, 9.53%) thus is extensive across the study area. The composition of these vegetation types was consistent across the study area, and comparable with other similar vegetation Ecoscape has recorded across the Pilbara, thus Ecoscape does not consider *Acacia xiphophylla* vegetation as being of any particular significance.

5.2.4 LOCAL AND REGIONAL SIGNIFICANCE OF VEGETATION

Twenty four (58%) of vegetation types within the study area had small extents relative to other vegetation types, indicating that they are locally significant. These were:

- **Es**, occupying 4.49 ha (0.002%)
- **GwTp**, occupying 30.67 ha (0.01%)
- **EvDfEb**, occupying 47.44 ha (0.02%)
- **SsCc**, occupying 55.03 ha (0.02%)
- **TD**, occupying 208.61 ha (0.09%)
- **Ti**, occupying 209.11 ha (0.09%)
- **MgCc**, occupying 234.79ha (0.10%)
- **Tm**, occupying 262.64 ha (0.11%)
- **ElAaTv**, occupying 306.54 ha (0.13%)
- **MxCc**, occupying 348.44 ha (0.15%)
- **EvDf**, occupying 351.72 ha (0.15%)
- **AsTe**, occupying 427.32 ha (0.20%)
- **AdAh**, occupying 477.24 ha (0.21%)
- **AiAh**, occupying 509.22 ha (0.22%)
- **EyAb**, occupying 533.13 ha (0.23%)
- **AsSc**, occupying 599.22 ha (0.26%)
- **AaAtRa**, occupying 664.992 ha (0.29%)
- **AxEcTe**, occupying 777.14 ha (0.34%)
- **EvAcCc**, occupying 829.96 ha (0.36%)
- **AaTb**, occupying 1094.78 ha (0.47%)
- **Ms**, occupying 1298.91 ha (0.56%)
- **AdTe**, occupying 1334.91 ha (0.58%)
- **AsCc^2**, occupying 1415.03 ha (0.61%)
- **EvMgTl**, occupying 1808.01 ha (0.78%).

Aside from their small extent, they are not considered as significant unless they are significant for reasons other than their size (see above).

The above listed vegetation types are those occupying less than 1% of the study area. Only two vegetation types occupy more than 10% of the study area: **AaSaEp**, occupying 34,660 ha (15.01%) and mosaic **EgAbTb/AaTb**, occupying 44,709 ha (19.36%).

Vegetation type **AbTv** (*Acacia bivenosa*, *A. ancistrocarpa* and *Grevillea wickhamii* mid sparse shrubland over *Triodia vanleeuwenii* and *Acacia hilliana* low hummock grassland/ shrubland) occupied 2,943 ha (1.28% of the study area), corresponding with the low hills of the Adrian land system. Ecoscape considers this vegetation type to be locally significant due to its restricted landform within the study area, its small extent, and that the land system upon which it occurs also has only a small extent. The Adrian land system occupies only 23,500 ha (Payne 2004).

5.3 FORTESCUE MARSH

The study area incorporates a small portion of the Fortescue Marsh. The Marsh is considered to be significant for a number of reasons, reflected in its listing in the Directory of Important Wetlands of Australia as a *Wetland of National Significance* (Australian Government & DotEE 2010). The vegetation of the Marsh, as it relates to the corresponding PEC, is discussed above in **Section 5.2.2.1** above.

Threats to the Marsh ecosystem include (Department of Environment and Conservation 2009):

- cattle; grazing native vegetation, introduction and spread of weeds, soil damage by trampling and wallowing
- altered hydrology including changes due to the construction of Ophthalmia Dam in 1981 that has reduced inflow into the Marsh (although DPaW (Markey 2016) indicates that flood frequency has been increasing in the last 20 years)
- surrounding mining operations including dewatering, groundwater extraction, long-term or accidental discharge into creeks altering local hydrology, reinjection
- weeds
- climate change that may alter the frequency and longevity of inundation, temperature rise, changes to drought and flood frequency
- eutrophication caused by cattle
- fire, especially late dry season fires that are hotter and expose more soil to erosion, weed invasion and loss of nitrogen in smoke.

6 CONCLUSION AND SUMMARY

6.1 SUMMARY

The 2017 two phase detailed flora and vegetation survey of the Fortescue Valley study area conducted by Ecoscape identified:

- 522 vascular flora species (approximately 675 species if taking previous surveys into account), including 17 DBCA-listed PF species and 17 introduced species
- 41 vegetation types including:
  - seven only associated with the *Fortescue Marsh* PEC (plus a number from the Marsh fringes that were more widespread)
  - one associated with the *Vegetation of sand dunes of the Hamersley Range/Fortescue Valley* PEC
  - 10 occurring within the Narbung Land System, part of which is included in the *Narbung Land System* PEC (two of which were dominant, characteristic and almost confined to the land system)
  - one Groundwater Dependent Ecosystem that included *Eucalyptus camaldulensis* as a characteristic species and was associated with riparian areas, and four potential GDEs characterised by *Eucalyptus victrix* (two of which were associated with clay pans) and *Melaleuca xerophila*
  - five Mulga (*Acacia aptaneura*)-dominated vegetation types including one Sheet Flow Dependent Vegetation type
- the vegetation condition covered a wide range, with less than 10% in Completely Degraded to Poor condition (8.43%) and more than 90% in Good to Excellent Condition (91.57%).

Overall there were no or negligible limitations associated with the survey.

6.2 CONSIDERATIONS FOR EIA

Considerations for EIA for the factor Flora and Vegetation (EPA 2016a) include, but are not necessarily limited to:

- application of the mitigation hierarchy to avoid and minimise impacts to flora and vegetation, where possible
- the flora and vegetation affected by the proposal
- the potential impacts and the activities that will cause them, including direct and indirect impacts
- the implications of cumulative and residual impacts
- whether surveys and analyses have been undertaken to a standard consistent with guidance
- the scale at which impacts to flora and vegetation are considered
- the significance of the flora and vegetation, and the risk to the flora and vegetation
- the current state of knowledge of flora and vegetation and the level of confidence underpinning the predicted residual impacts
- whether proposed management and mitigation approaches are technically and practically feasible
- whether the proposal area will be revegetated in a manner that promotes biological diversity and ecological integrity.

Various issues are frequently of significance within the environmental impact assessment process. Common issues, and the potential impact from the proposed works, are summarised below.

This survey was conducted to provide detailed environmental information should Fortescue proceed with developing resources in the eastern Hamersley Range or impacting on parts of the Fortescue Valley. At the stage of conducting this survey and writing this report there are no detailed proposed works plans available, thus no indication of areas proposed for clearing or potentially indirectly affected by any works.

Threats

Threats to the study area, not including directly as a result of clearing for mines and infrastructure, or indirectly as a result of these, include climate change affecting the Fortescue Marsh and grazing that appears to be directly related to weed infestation in some parts of the study area and in some vegetation types.

Some PF species in the study area have only very restricted extents, both within the study area and overall; these species (*Myriocephalus scalpellus* and *Synostemon hamersleyensis* recorded during the field survey and *Calotis squamigera* that has been previously recorded but was not re-located during the field survey) are the most threatened by any future works.

Habitat loss, degradation and fragmentation

As there are no detailed development plans available at this stage it is not possible to quantify habitat loss, degradation or fragmentation as a result of any future works. However, all pre-European vegetation associations corresponding with the study area have more than 99% of their original extent remaining.

The areas that have the most potential to be significantly affected by habitat loss or degradation by direct clearing are associated with the Fortescue Marsh that is a *Wetland of National Significance*, proposed as a Ramsar wetland and is being considered to inclusion in the conservation estate.

The *Vegetation of sand dunes of the Hamersley Range/Fortescue Valley* PEC and land system also have the potential to be significantly affected by direct clearing. The current threats to the PEC are from cattle grazing and weed invasion (and potentially fire); Ecoscape recorded that the western occurrence of the PEC is more weed invaded and degraded than the more eastern occurrences and consider these latter occurrences to have higher conservation value than the western occurrence.

Indirect impacts include the potential for hydrological change from groundwater drawdown or reinjection. GDE vegetation types have the most potential to be affected, including Marsh vegetation types dominated by *Muellerolimon salicorniaceum* or *Tecticornia* species and riparian vegetation characterised by *Eucalyptus camaldulensis*. Potential GDE vegetation types including those dominated by *Eucalyptus victrix* (including areas within clay pans) and *Melaleuca xerophila* that DBCA considers to be phreatophytic in the Fortescue Marsh area may also be affected by changes to groundwater.

Sheet Flow Dependent Vegetation characterised by Mulga (*Acacia aptaneura*) has the potential to be impacted by changes to surface water flow, particularly where linear infrastructure crosses the line of flow. Other Mulga-dominated vegetation may also be affected by surface water changes.

Invasive species

Seventeen introduced species were recorded from the study area, two of which (**Cenchrus ciliaris* and **Cenchrus setiger*) were considered to be having a significant effect on the vegetation of the study area. These species were most likely introduced as pasture species when the area was opened up for grazing and have colonised and are spreading in riparian areas and Mulga vegetation. Direct clearing is unlikely to affect the distribution or density of these species, however, indirect impacts from mining and infrastructure including soil disturbance may result in an increase in extent of density. However, these changes are unlikely to be significant if compared with the current causes of weed invasion, being cattle grazing.

Fire regimes

Fire is a natural occurrence in the Pilbara, particularly prior to the wet season when thunderstorms are common.

Fire regimes are not expected to change as a result of any potential works.

Changing climate

The Fortescue Marsh has the greatest potential to be affected by climate change as a result of changes to inflow and evaporation rates. Any future works by Fortescue will not have any significant effect on climate change, however, the cumulative effect of climate change and changes affecting the Fortescue Marsh (directly, including clearing, or indirectly including changes to groundwater and/or surface hydrology) should be considered.

State of Knowledge

Knowledge regarding potential hydrological changes and their effect on vegetation are not well understood.

As a result of this and previous surveys, knowledge regarding the flora and vegetation of the study area is relatively well understood.

6.3 GENERAL CONCLUSION

Some portions of the study area and some flora and vegetation have a high potential to be adversely affected by direct or indirect changes in land use, including the Fortescue Marsh and its associated vegetation (a significant portion of which is endemic or near endemic), the *Vegetation of sand dunes of the Hamersley Range/Fortescue Valley* PEC and a number of PF that have restricted distributions. Effects on these, in particular, should be taken into account when future works are planned.

Other potentially significant effects on GDE and Mulga vegetation (particularly Sheet Flow Dependent Vegetation) should also be taken into account during the planning stages of future works.

REFERENCES

Astron Environmental Services 2011, *Literature Review on Samphire Vegetation Focusing on the Water Requirements of the Community Associate with Fortescue Marsh*, Unpublished report prepared for Fortescue Metals Group Limited.

Astron Environmental Services 2012a, *Cloudbreak Life of Mine Conservation Significant Flora Survey Phase 1*, Report prepared for Fortescue Metals Group Limited.

Astron Environmental Services 2012b, *Iron Valley Project Flora and Vegetation Survey*, Unpublished report for URS Australia Pty Ltd on behalf of Iron Ore Holdings Ltd.

Atlas of Living Australia. 2017. *Atlas of Living Australia website*. Available from: https://www.ala.org.au/.

Australian Government. *Environment Protection and Biodiversity Conservation Act 1999.*

Australian Government & Bureau of Meteorology. 2017. *Groundwater Dependent Ecosystems Atlas*. Available from: http://www.bom.gov.au/water/groundwater/gde/map.shtml.

Australian Government & Department of the Environment and Energy. 2010. *Directory of Important Wetlands in Australia - Information Sheet: Fortescue Marshes - WA066*. Available from: http://www.environment.gov.au/cgi-bin/wetlands/report.pl.

Australian Government & Department of the Environment and Energy. 2017a. *Australia's bioregions (IBRA)*. Available from: http://www.environment.gov.au/land/nrs/science/ibra.

Australian Government & Department of the Environment and Energy. 2017b. *Protected Matters Search tool*. Available from: http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf.

Australian Government & Department of the Environment and Energy. 2017c. *Species Profile and Threats Database: Lepidium catapycnon - Hamersley Lepdium, Hamersley Catapycnon*. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=9397.

Batini, F. 2009, *Eucalyptus victrix, Karijini National Park.*, Report to EPA.

Belbin, L. & Collins, A. 2006. PATN Version 3.11. Blatant Fabrications Pty Ltd.

Biota Environmental Sciences 2012, *A vegetation and flora survey of the Koodaideri study area*, Report prepared for Rio Tinto.

Biota Environmental Sciences Pty Ltd 2004a, *Vegetation and Flora Survey of the Proposed FMG Stage A Rail Corridor*, Unpublished Report for Fortescue Metals Group Ltd, August 2004.

Biota Environmental Sciences Pty Ltd 2004b, *Vegetation and Flora Survey of the Proposed FMG Stage B Rail Corridor and Mines Areas*, Unpublished Report for Fortescue Metals Group Ltd, December 2004.

Buirchell, B.J. & Brown, A.P. 2016. New speices of *Eremophila* (Scrophulariaceae): thirteen geographically restricted species from Western Australia. *Nuytsia*, vol. 27, pp. 253-283. Available from: https://florabase.dpaw.wa.gov.au/science/nuytsia/780.pdf

Bureau of Meteorology. 2017a. *Daily maximum temperature: Newman Aero (station 7176)*. Available from: http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=122&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=007176.

Bureau of Meteorology. 2017b. *Daily minimum temperature: Newman Aero (station 7176)*. Available from: http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=123&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=007176.

Bureau of Meteorology. 2017c. *Daily rainfall: Marillana (Station 5009)*. Available from: http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_stn_num=005009&p_startYear=.

Bureau of Meteorology. 2017d. *Daily rainfall: Newman Aero (station 7176)*. Available from: http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=2016&p_c=-10383994&p_stn_num=007176.

Bureau of Meteorology. 2017e. *Six-monthly rainfall deciles for Western Australia*. Available from: http://www.bom.gov.au/jsp/awap/rain/index.jsp?colour=colour&time=latest&step=1&map=decile&period=6month&area=wa.

Cardno (WA) Pty Ltd 2012a, *Addendum: Nyidinghu Flora and Vegetation Assessment*, Prepared for Fortescue Metals Group.

Cardno (WA) Pty Ltd 2012b, *Nyidinghu flora and vegetation assessment*, Unpublished report for Fortescue Metals Group.

Cardno (WA) Pty Ltd 2012c, *Nyidinghu Rail Spur Flora and Vegetation Assessment*, Report prepared for Fortescue Metals Group.

Coffey Environments 2010a, *Flora and Vegetation Assessment, Solomon Project and Investigator - Volume 1*, Unpublished report for Fortescue Metals Group Ltd.

Coffey Environments 2010b, *Flora and Vegetation Assessment, Solomon Rail Project - Volume 1*, Unpublished report for Fortescue Metals Group Ltd.

Department of Agriculture and Food Western Australia. 2012. *DAFWA Pre-European Vegetation Spatial Dataset*. Available from: [November 2012].

Department of Agriculture and Food Western Australia. 2017. *Westrn Australian Organism List (WAOL)*. Available from: https://www.agric.wa.gov.au/organisms.

Department of Biodiversity Conservation and Attractions. 2017. *Biodiversity Conservation Act 2016*. Available from: https://www.dpaw.wa.gov.au/plants-and-animals/biodiversity-conservation-act.

Department of Environment and Conservation 2009, *Resource Condition Report for Significant Western Australian Wetland. Wetlands of the Fortescue River System*.

Department of Environment and Conservation. 2010. *Definitions, categories and criteria for Threatened and Priority Ecological Communities*. Available from: http://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/tecs/tec-definitions-dec2010.pdf.

Department of Environment and Conservation. 2013. *Definitions, categories and criteria for Threatened and Priority Ecological Communities*. Available from: https://www.dpaw.wa.gov.au/images/plants-animals/threatened-species/definitions_categories_and_criteria_for_threatened_and_priority_ecological_communities.pdf.

Department of Environment Water Heritage and the Arts 2009, *Matters of National Environmental Significance. Significant impact guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999*, Australian Government.

Department of Parks and Wildlife. 2007. *NatureMap: Mapping Western Australia's Biodiversity*. Available from: http://naturemap.dpaw.wa.gov.au.

Department of Parks and Wildlife. 2016a. *Pilbara Rankings Summary: Pilbara Region Species Prioritisation Process 2014*. Available from: https://www.dpaw.wa.gov.au/images/documents/plants-animals/plants/weeds/pilbara_region_-_impact_and_invasiveness_ratings.xlsx.

Department of Parks and Wildlife. 2016b. Samphire Mapping of the Fortescue Marsh: Digital Dataset.

Department of Parks and Wildlife. 2017. *Conservation Codes for Western Australia Flora and Fauna (updated 23 May 2017)*. Available from: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/conservation_code_definitions.pdf.

Department of Sustainability Environment Water Population and Communities. 2012. *Species Profile and Threats Database*. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl. [May 2012].

Eamus, D. 2009a, *A review of the report written by Frank Batini entitled "Eucalyptus victrix, Karijini National Park"*, Unpublished report for Rio Tinto Iron Ore.

Eamus, D. 2009b. *Identifying groundwater dependent ecosystems: a guide for land and water managers*. Available from: http://lwa.gov.au/files/products/innovation/pn30129/pn30129_1.pdf.

Eamus, D., Froend, R., Loomes, R., Hose, G., & Murray, B. 2006. A functional methodology for determining the groundwater regime needed to maintain the health of groundwater-dependent vegetation. *Australian Journal of Botany*, vol. 54, pp. 97-114

EBS Ecology 2017, *Carrapateena Project Ecological Baseline Assessment*, Unpublished report for OZ Minerals.

ecologia Envionment 2016, *Pilbara Bulk Ore Transportation System Project. Assessment on Proponent Information - Environmental Review Document*, Report prepared for Mineral Resources Limited.

Ecologia Environment 2008, *BHP Billiton Iron Ore Rapid Growth Project 5 (RGP5) Chichester Deviation Vegetation and Flora Report (Version 3)*, Unpublished report for BHPBIO.

Ecologia Environment 2009a, *Brockman Resources Limited Marillana (E47/1408) Vegetation and Flora Report Version 5*, Unpublished report for Brockman Resources Limited.

Ecologia Environment 2009b, *Roy Hill 1 Infrastructure flora assessment*, Unpublished report for Hancock Prospecting Pty Ltd.

Ecologia Environment 2009c, *Roy Hill 1 Project Flora and Vegetation Assessment*, Unpublished report for Hancock Prospecting Pty Ltd.

Ecologia Environment 2009d, *Roy Hill 1: Flora and Vegetation Assessment*, Unpublished report for Hancock Prospecting Pty Ltd.

Ecologia Environment 2013, *Kutayi Flora and Vegetation Assessment*, Unpublished report for Fortescue Metals Group Ltd.

Ecologia Environment 2014a, *Fig Tree Flora and Vegetation Assessment*, Unpublished report for Fortescue Metals Group Ltd.

Ecologia Environment 2014b, *Investigator Flora and Vegetation Assessment*, Unpublished report for Fortescue Metals Group Ltd.

Ecologia Environment 2014c, *Mt MacLeod Flora and Vegetation Assessment*, Unpublished report for Fortescue Metals Group Ltd.

Ecologia Environment 2014d, *Solomon South Flora and Vegetation Assessment*, Unpublished report for Fortescue Metals Group Ltd.

Ecologia Environment 2015, *Solomon Restricted Vegetation Assessment Supplementary Report*, Unpublished report for Fortescue Metals Group Ltd.

Ecoscape (Australia) Pty Ltd 2010a, *Level Two Flora and Vegetation Assessment, Firetail Mining Area*, Unpublished report for Fortescue Metals Group Ltd.

Ecoscape (Australia) Pty Ltd 2010b, *Solomon Project Rail Re-alignment Flora and Vegetation Assessment*, Unpublished report for Fortescue Metals Group Ltd.

ENV Australia Pty Ltd 2010a, *Christmas Creek flora and vegetation assessment*, Unpublished report for Fortescue Metals Group Ltd.

ENV Australia Pty Ltd 2010b, *Solomon Project: Kings Flora and Vegetation Assessment*, Unpublished report for Fortescue Metals Group Ltd.

ENV Australia Pty Ltd 2011a, *Christmas Creek Airstrip Flora, Vegetation and Fauna Assessment* Unpublished report for Fortescue Metals Group Ltd.

ENV Australia Pty Ltd 2011b, *Cloudbreak Flora and Vegetation Assessment*, Unpublished report for Fortescue Metals Group Limited.

ENV Australia Pty Ltd 2012, *Christmas Creek Life of Mine Flora and Vegetation Assessment*, Unpublished report for Fortescue Metals Group Ltd.

ENV Australia Pty Ltd 2013, *Christmas Creek Life of Mine flora and vegetation assessment - update*, Unpublished report for Fortescue Metals Group Ltd.

Environmental Protection Authority 2004, *Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessments in Western Australia*, Environmental Protection Authority.

Environmental Protection Authority 2010, *Jimblebar Iron Ore Project, BHP Billiton Iron Ore Pty Ltd. Report and recommendations of the Environmental Protection Authority* 1371.

Environmental Protection Authority 2011, *Report and recommendations of the Environmental Protection Authority. West Pilbara Iron Ore Project Stage 1 Mine and Rail Proposal, API Management Pty Ltd. Report 1409*.

Environmental Protection Authority 2012, *Cloudbreak Life of Mine Project. Report and Recommendations of the Environmental Protection Authority. Report 1429*, Government of Western Australia.

Environmental Protection Authority 2013, *Environmental and water assessments relating to mining and mining-related activities in the Fortescue Marsh management area. Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986*.

Environmental Protection Authority 2014, *Report and recommendations of the Environmental Protection Authority. Roy Hill Mining Project Stage 2 - inquiry under s46 of the Environmental Protection Act 1986 to amend Ministerial Statement 829. Roy Hill Iron Ore Pty Ltd. Report 1520*.

Environmental Protection Authority. 2016a. *Environmental Factor Guideline: Flora and Vegetation*. Available from: http://epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Flora-Vegetation-131216_4.pdf.

Environmental Protection Authority 2016b, *Report and recommendations of the Environmental Protection Authority. Solomon Iron Ore Project - Sustaining Production. Report 1588*.

Environmental Protection Authority. 2016c. *Statement of Environmental Principles, Factors and Objectives*. Available from: http://www.epa.wa.gov.au/statement-environmental-principles-factors-and-objectives.

Environmental Protection Authority. 2016d. *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment*. Available from: http://www.epa.wa.gov.au/policies-guidance/technical-guidance-flora-and-vegetation-surveys-environmental-impact-assessment.

Environmental Protection Authority & Hamersley Iron Pty Ltd 2010, *Marandoo Mine Phase 2: Report and recommendations of the Environmental Protection Authority*, Environmental Protection Authority, Perth, Western Australia.

Equinox Environmental 2017, *Christmas Creek vegetation health investigation*, Unpublished report for Fortescue Metals Group Limited, CC-EN-0319.

Executive Steering Committee for Australian Vegetation Information [ESCAVI]. 2003. *Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0*. Available from:

http://www.environment.gov.au/system/files/pages/06613354-b8a0-4a0e-801e-65b118a89a2f/files/vegetation-attribute-manual-6.pdf.

Fortescue Metals Group Limited 2014, *Flora and Vegetation Assessment Guidelines (100-GU-EN-0005) 23 June 2014*, Unpublished report.

Fortescue Metals Group Limited 2015, *Sample Point Naming Convention (100-GU-EN-0041)*.

G&G Environmental Pty Ltd 2009, *Flora and Vegetation Survey of a Proposed Borefield for the Roy Hill 1 Iron Ore Project*, Unpublished report for Roy Hill Iron Ore Pty Ltd.

G&G Environmental Pty Ltd 2011, *Flora and vegetation surveys of the FerrAus Limited rail corridor options*, Unpublished report for FerrAus Ltd.

Gibson, N., Keighery, B., Keighery, G., Burbidge, A., & Lyons, M. 1994. *A Floristic Survey of the Southern Swan Coastal Plain* Perth, Department of Conservation and Land Management.

Goulburn-Murray Water. 2010. *Groundwater. Terms and definitions*. Available from: http://www.g-mwater.com.au/downloads/Groundwater/2977263-v5-GROUNDWATER_TERMS_AND_DEFINITIONS_GLOSS-1.pdf.

Government of Western Australia. *Wildlife Conservation Act 1950.*

Government of Western Australia. *Environmental Protection Act 1986.*

Government of Western Australia. *Environmental Protection (Clearing of Native Vegetation) Regulations 2004.*

Government of Western Australia. *Environmental Protection (Environmentally Sensitive Areas) Notice 2005.*

Government of Western Australia. *Biosecurity and Agriculture Management Act 2007.*

Government of Western Australia. 2016a. *2016 Statewide Vegetation Statistics incorporting the CAR Reserve Analysis (Full Report).* Available from:

Government of Western Australia. *Biodiversity Conservation Act 2016b.*

Government of Western Australia. 2017. *Government Gazette No. 4, 6 January 2017*. Available from: https://www.slp.wa.gov.au/gazette/gazette.nsf/searchgazette/7C15F291EA2FAEBC4825809F00146526/$file/TocGg004.pdf.

Government of Western Australia. 2018. *About the Conservation and Parks Commission*. Available from: https://www.conservation.wa.gov.au/.

Greg Barrett & Associates Pty Ltd 2005. Likely Impact of Drawdown of Groundwater from the Cloud Break Operations on Vegetation Communities.

Grierson, P. 2010, Ecological water requirements of riparian vegetation, *In Kwongan Workshop 2010: On the ecology of WA's arid zone*, University of Western Australia.

Halford, D.A. 2004. Notes on Tiliaceae in Australia, 4. A revision of the stellate-haired species of the genus *Corchorus* L. *Austrobaileya*, vol. 6, no. 4, pp. 581-629

Hatton, T. & Evans, R. 1998, *Dependence of ecosystems on groundwater and its significance to Australia*, Land and Water Research and Development Corporation (Australia), Occasional Paper No. 12/98, Canberra, ACT.

Heydenrych, B., Parsons, B., & Berkinshaw, T. 2015, *Conservation action plan for the Pilbara bioregion: summary report*, Greening Australia, Perth.

Hussey, B., Keighery, G., Dodd, J., Lloyd, S., & Cousens, R. 2007. *Western Weeds: A guide to the weeds of Western Australia*, Second edn, Victoria Park, Western Australia, The Plant Protection Society of Western Australia (Inc.).

Keighery, G. 2010. The naturalised vascular plants of the Pilbara region. *Records of the Western Australian Museum, Supplement 78*, pp. 299-311

Kendrick, P. 2002a, "Pilbara 2 (PIL2 - Fortescue Plains subregion)," in *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002*, N. L. McKenzie, J. E. May, & S. McKenna eds., Department of Conservation and Land Management, pp. 559-567.

Kendrick, P. 2002b, "Pilbara 3 (PIL3 - Hamersley subregion)," in *A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002*, Department of Conservation and Land Management, Perth, pp. 568-580.

Leighton, K. A. 2004, "Climate," in *Technical Bulletin 92 - An inventory and condition survey of the Pilbara region, Western Australia*, Western Australian Department of Agriculture, Perth, pp. 19-38.

Lyons, M.N. 2015. The riparian flora and plant communities of the Pilbara region of Western Australia. *Records of the Western Australian Museum, Supplement*, vol. 78, pp. 485-513. Available from: http://museum.wa.gov.au/sites/default/files/WAM_Supp78(B)_Lyons%20pp485-513.pdf

Markey, A. 2016, *Floristic Survey and Mapping of the Riparian and Halophyte Dominated Communities on the Fortescue Marsh (Martuyitha), Western Australia - DRAFT*, Department of Parks & Wildlife Science and Conservation Division.

Maslin, B. & Reid, J. 2012. A taxonomic revision of Mulga (*Acacia aneura* and its close relatives: Fabaceae) in Western Australia. *Nuytsia*, vol. 22, no. 4, pp. 129-267. Available from: http://florabase.dec.wa.gov.au/science/nuytsia/604.pdf

Maslin, B. R., van Leeuwen, S., & Reid, J. E. 2010. *Wattles of the Pilbara Fact Sheet: Acacia aneura*. Available from: file:///X:/02_References/Flora/Flora/taxonomy/Electronic%20Keys/Pilbara_Wattles%20(E)/key/Wattles%20of%20the%20Pilbara/Media/Html/aneura.htm.

Mattiske Consulting Pty Ltd 2005, *Flora and Vegetation on the Cloudbreak and White Knight Leases*, Unpublished report for Fortescue Metals Group Ltd.

Mattiske Consulting Pty Ltd 2007, *Flora and Vegetation near Fortescue Marshes*, Unpublished report for Fortescue Metals Group Ltd.

Mattiske Consulting Pty Ltd 2008, *Review of flora and vegetation on Coondiner and Kalgan Creeks north of Hope Downs 4*, Unpublished report for Rio Tinto.

Mattiske Consulting Pty Ltd 2009a, *Flora and vegetation of Barrambie survey area, bore fields and water suppy pipeline corridor*, Unpublished report for Aquaterra and Reed Resources Ltd.

Mattiske Consulting Pty Ltd 2009b, *Flora and Vegetation on the Creeklines (Coondiner, Kalgan, Mindy Mindy and Unnamed) Associated with Hope Downs 4*, Unpublished report for Pilbara Iron.

Mattiske Consulting Pty Ltd 2009c, *Review of flora and vegetation on Mindy Mindy and unnamed transects north of Hope Downs 4 2008 and 2009*, Unpublished report for Rio Tinto.

Mattiske Consulting Pty Ltd 2011, *Review of Flora and Vegetation Along Weeli Wolli, Mindy Mindy and Coondiner Creeklines*, Unpublished report for Rio Tinto.

Maunsell Australia Pty Ltd 2006, *Pit Dewatering and Vegetation Monitoring Plan - Iron Ore Mine and Downstream Processing, Cape Preston, Western Australia*, Unpublished report prepared for Mineralogy Pty Ltd.

McKenzie, N.L., May, J.E., & McKenna, S. 2003. Bioregional Summary of the 2002 Biodiversity Audit for Western Australia.

McKenzie, N.L., van Leeuwen, S., & Pinder, A.M. 2009. Introduction to the Pilbara Biodiversity Survey, 2002–2007. *Records of the Western Australian Museum, Supplement*, vol. 78, pp. 3-89

Muller, C. 2005, *Water flow in Mulga areas adjoining Fortescue Marsh*, Unpublished report for Fortescue Metals Group Limited.

Nicolle, D. & French, M.E. 2012. Two new mallee box species (*Eucalyptus* sect. *Adnataria* ser. *Lucasianae*, Myrtaceae) from the Pilbara region of Western Australia. *Nuytsia*, vol. 22, no. 1, pp. 17-29

Office of the Appeals Convenor. 2012. *Ministerial Statement No. 899. Statement that a propopsal may be implemented (pursuant to the provisions of the Environmental Protection Act 1986). Cloudbreak Life of Mine, Pilbara*. Available from: http://www.epa.wa.gov.au/sites/default/files/1MINSTAT/Statement%20No.%20899.pdf.

Office of the Appeals Convenor. 2014. *Ministerial Statement No. 980. Statement to amend conditions applying to a proposal (pursuant to the provisions of Section 46 of the Environmental Protection Act 1986). Roy Hill 1 Iron Ore Mining Project Stage 2 110 Kilometers North of Newman, Shire of East Pilbara*. Available from: http://www.epa.wa.gov.au/sites/default/files/1MINSTAT/Statement%20No.%20980.pdf.

Office of the Appeals Convenor. 2016a. *Ministerial Statement No. 1026. Statement to change the implementation conditions applying to a proposal (Section 46 of the Environmental Protection Act 1986). West Pilbara Infrastructure Project - Rail*. Available from: http://www.epa.wa.gov.au/sites/default/files/1MINSTAT/Statement%20No.%201026.pdf.

Office of the Appeals Convenor. 2016b. *Ministerial Statement No. 1033. Statement that a revised proposal may be implemented (Environmental Protection Act 1986): Pilbara Iron Ore and Infrastructure Project (Christmas Creek Mine, East-west Railway and Mindy Mindy Mine) - Revised Proposal*. Available from: http://www.epa.wa.gov.au/sites/default/files/1MINSTAT/Statement%20No.%201033.pdf.

Office of the Appeals Convenor. 2016c. *Ministerial Statement No. 1038. Statement that a proposal may be implemented (Environmental Protection Act 1986) Yandicoogina Iron Ore Project - revised proposal*. Available from: http://www.epa.wa.gov.au/sites/default/files/1MINSTAT/Statement%20No.%201038.pdf.

Office of the Appeals Convenor. 2016d. *Ministerial Statement No. 1044. Statement that a proposal may be implemented (Environmental Protection Act 1986) Revised Iron Valley Iron Ore Project*. Available from: http://www.epa.wa.gov.au/sites/default/files/1MINSTAT/Statement%20No.1044.pdf.

Onshore Environmental 2011, *Area C and Surrounds Flora and Vegetation Survey*, Report prepared for BHP Billiton Iron Ore.

Orchard, A. E. 2015, "Bidens," in *Flora of Australia*, vol. 37, A. Wilson ed., CSIRO Publishing, Collingwood, pp. 458-468.

Payne, A. L. 2004, "Land Systems," in *An inventory and condition survey of the Pilbara region, Western Australia*, A. M. E. Van Vreeswyk et al. eds., Western Australian Department of Agriculture.

Peel, M.C., Finlayson, B.L., & McMahon, T.A. 2007. Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth System Sciences*, vol. 11, pp. 1633-1644

Phoenix Environmental Sciences 2014a, *Flora and fauna desktop review for the Extension Project and Bulk Sample*, Report prepared for Maiden Iron Pty Ltd.

Phoenix Environmental Sciences 2014b, *Flora and vegetation survey for the Extension Project*, Report prepared for Australian Aboriginal Mining Corporation Pty Ltd.

Pisces Conservation Ltd. 2010. Species Diversity and Richness IV.

Resource and Environmental Management Pty Ltd 2007, *Pirraburdoo Creek Groundwater Dependent Ecosystems study*, Unpublished report for Pilbara Iron.

Rio Tinto 2016, *Yandicoogina Pocket and Billiard South: detailed responses to public submissions in relation to flora and vegetation*.

Rio Tinto & Department of Parks and Wildlife. 2015. *Rare and Priority Plants of the Pilbara mobile app edition*. Available from: https://itunes.apple.com/au/app/rare-priority-plants-pilbara/id945178469?mt=8.

Shepherd, D.P., Beeston, G.R., & Hopkins, A.J.M. 2002. Native Vegetation in Western Australia: Extent, Type and Status. *Resource Management Technical Report 249*

Species and Communities Branch Department of Biodiversity Conservation and Attractions. 2017. *Priority Ecological Communities for Western Australia Version 27 (30 June 2017)*. Available from: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/priority_ecological_communities_list.pdf.

The University of Western Australia, Grierson, P., & Page, G. 2012, *West Turner Syncline Stage 2: Potential impacts of mining operations on overland flow dependent vegetation, preliminary assessment*, Unpublished report for Rio Tinto.

Thorne, A. M. and Tyler, I. M., 1996. *Roy Hill, WA, Sheet SF 50-12*, 1:250 000 Geological Series. Perth, Western Australia: Geological Survey of Western Australia.

Trudgen, M. E. 1991, "Vegetation Condition Scale," in *1993 Urban Bushland Policy*, National Trust of Australia (WA) ed., Wildflower Society of Western Australia (Inc.) and the Tree Society (Inc.), Perth, Western Australia.

Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A., & Hennig, P. 2004. *Technical Bulletin 92 - An inventory and condition survey of the Pilbara region, Western Australia* South Perth, Department of Agriculture.

Walker, J. & Hopkins, M. 1990, "Vegetation," in *Australian Soil and Land Survey. Field Handbook.*, 2nd edn, R. McDonald et al. eds., Inkata Press, Melbourne.

Weeds Australia. 2012. *Weeds of National Significance*. Available from: http://www.weeds.org.au/WoNS/.

Western Australian Herbarium. 1998. *FloraBase - the Western Australian Flora. Department of Parks and Wildlife*. Available from: http://florabase.dpaw.wa.gov.au/.

Western Australian Herbarium. 2017a. *FloraBase: Descriptions by the Western Australian Herbarium, Department of Parks and Wildlife. Text used with permission*. Available from: https://florabase.dpaw.wa.gov.au/help/copyright; https://florabase.dpaw.wa.gov.au/search/advanced.

Western Australian Herbarium. 2017b. *FloraBase: Search the Herbarium Specimens (online specimen search)*. Available from: https://florabase.dpaw.wa.gov.au/search/specimen/.

Wilson, P.G. 2017. An examination of the Australian genus *Xerochrysum* (Asteraceae: Gnaphalieae). *Nuytsia*, vol. 28, pp. 11-38. Available from: https://florabase.dpaw.wa.gov.au/science/nuytsia/772.pdf

MAPS

720100 740100 760100 780100

7519970 7499970 7479970 7459970

FORTESCUE MARSH

MARILLANA HOMESTEAD

MUNJINA ROY HILL ROAD

MARILLANA CREEK

YANDICOOGINA CREEK

WEELIWOLLI CREEK

COONDINER CREEK

LEGEND

- Homestead
- Study Area
- Roads
- Rivers
- Creeks

Land Systems

- Ad: Adrian System
- Bg: Boolgeeda System
- Ca: Calcrete System
- Ch: Christmas System
- Co: Coolibah System
- Cw: Cowra System
- Dv: Divide System
- Eg: Egerton System
- Fa: Fan System
- Ft: Fortescue System
- Jm: Jamindie System
- Mk: McKay System
- Mr: Marillana System
- Ms: Marsh System
- Na: Narbung System
- Ne: Newman System
- Ok: Oakover System
- Pd: Pindering System
- Pl: Platform System
- Ri: River System
- Rk: Rocklea System
- Ro: Robe System
- Tu: Turee System
- Ur: Urandy System
- Wa: Warri System

OVERVIEW

ecoscape

LAND SYSTEMS UNDERLYING THE STUDY AREA

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:300,000 @ A3

0 2 4 6 8 10 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 01

720100 740100 760100 780100

7519970 7499970 7479970 7459970

157 29 562 173 562 676 29 111 29 18 111 111 111 111 82 18 18 82 111

FORTESCUE MARSH

MARILLANA HOMESTEAD

MUNJINA ROY HILL ROAD

MARILLANA CREEK YANDICOOGINA CREEK WEELI WOLLI CREEK PEBBLE MOUSE CREEK COONDINER CREEK

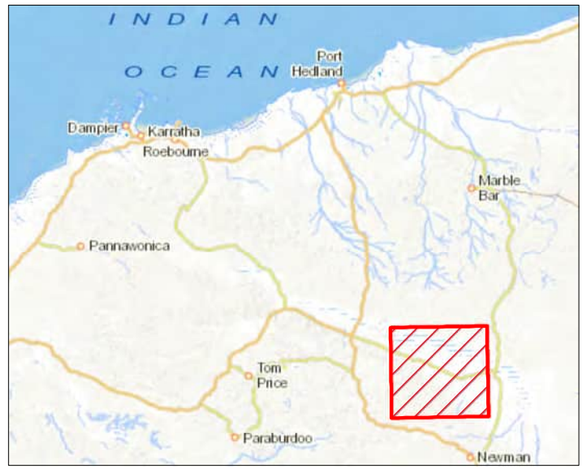
LEGEND

- Homestead
- Study Area
- Roads
- Rivers
- Creeks

Vegetation Association

- 18: Low woodland; mulga (*Acacia aneura*)
- 29: Sparse low woodland; mulga, discontinuous in scattered groups
- 82: Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*
- 111: Hummock grasslands, shrub steppe; *Eucalyptus gamophylla* over hard spinifex
- 157: Hummock grasslands, grass steppe; hard spinifex, *Triodia wiseana*
- 173: Hummock grasslands, shrub steppe; kanji over soft spinifex and *Triodia wiseana* on basalt
- 197: Sedgeland; sedges with scattered medium trees; coolabah over various sedges and forbes
- 562: Mosaic: Low woodland; mulga in valleys / Hummock grasslands, open low tree-steppe; snappy gum over *Triodia wiseana*
- 676: Succulent steppe; samphire

OVERVIEW



ecoscape

PRE-EUROPEAN VEGETATION ASSOCIATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:300,000 @ A3

0 2 4 6 8 10 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 02

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FORTESCUE MARSH

MARILLANA HOMESTEAD

MUNJINA ROY HILL ROAD

MARILLANA CREEK

WEELI WOLLI CREEK

COONDINER CREEK

PEBBLE MOUSE CREEK

LEGEND

- Homestead
- Roads
- Rivers
- Creeks
- Waterbodies
- Study Area

FMG Flora Database*

- Priority 1 (DBCA)
- Priority 3 (DBCA)
- Priority 4 (DBCA)

DBCA Flora Databases

- Priority 1 (DBCA)
- Priority 2 (DBCA)
- Priority 3 (DBCA)
- Priority 4 (DBCA)

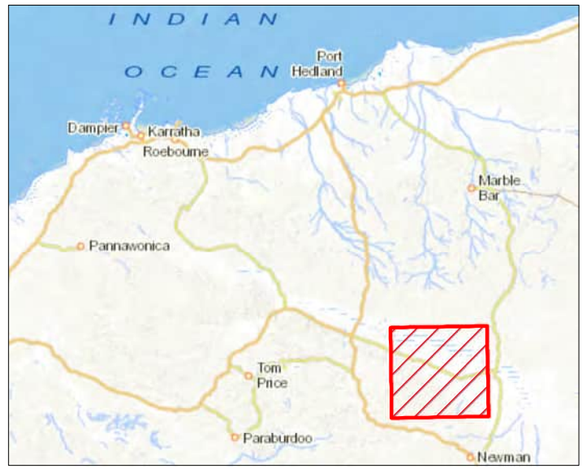
DBCA Ecological Communities Database

- Endangered
- Priority 1
- Priority 3

***Flora Label Codes**

Af: *Atriplex flabelliformis* - Priority 3
Cs: *Calotis squamigera* - Priority 1
Ec: *Eragrostis crateriformis* - Priority 3
Es: *Eremophila spongiocarpa* - Priority 1
Ey: *Eremophila youngii* subsp. *lepidota* - Priority 4
Gn: *Goodenia nuda* - Priority 4
Nh: *Nicotiana heterantha* - Priority 1
Ss: *Samolus* sp. Fortescue Marsh
(A. Markey and R. Coppen FM 9702) - Priority 1
Tg: *Tecticornia globulifera* - Priority 1
Tm: *Tecticornia medusa* - Priority 3
Ts: *Tecticornia* sp. Christmas Creek
(K.A. Shepherd and T. Colmer et al. KS 1063) - Priority 1

OVERVIEW



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DATABASE SEARCH RESULTS FLORA & COMMUNITIES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:300,000 @ A3

0 2 4 6 8 10 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 03

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FORTESCUE MARSH

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Conservation Significant Flora Locations

Ecoscape 2017 Observations

- Ecoscape, Priority 1
- Ecoscape, Priority 2
- Ecoscape, Priority 3
- Ecoscape, Priority 4

DBCA Databases

- DBCA, Priority 1
- DBCA, Priority 2
- DBCA, Priority 3
- DBCA, Priority 4

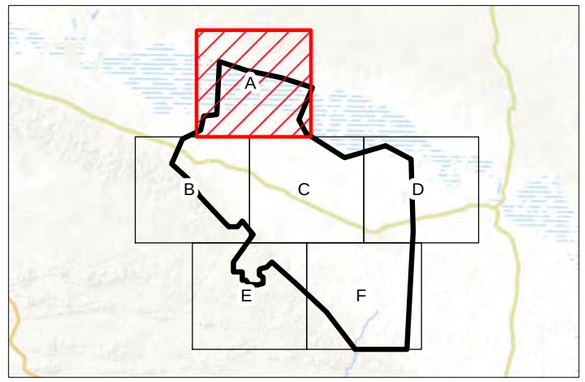
Fortescue Database

- Fortescue, Priority 1
- Fortescue, Priority 3
- Fortescue, Priority 4

***Flora Label Codes**

As: *Acacia subtiliformis* - Priority 3
Af: *Atriplex flabelliformis* - Priority 3
Cs: *Calotis squamigera* - Priority 1
Ec: *Eragrostis crateriformis* - Priority 3
Es: *Eremophila spongiocarpa* - Priority 1
Ey: *Eremophila youngii* subsp. *lepidota* - Priority 4
Ea: *Euphorbia australis* var. *glabra* - Priority 2
Eii: *Euphorbia inappendiculata* var. *inappendiculata* - Priority 2
Eiq: *Euphorbia inappendiculata* var. *queenslandica* - Priority 1
Gn: *Goodenia nuda* - Priority 4
Ho: *Helichrysum oligochaetum* - Priority 1
Ip: *Isotropis parviflora* - Priority 2
Lc: *Lepidium catapycnon* - Priority 4
Ms: *Myriocephalus scalpellus* - Priority 1
Nh: *Nicotiana heterantha* - Priority 1
Rs: *Rhagodia* sp. Hamersley (M. Trudgen 17794) - Priority 3
SF: *Samolus* sp. Fortescue Marsh (A. Markey and R. Coppen FM 9702) - Priority 1
SB: *Sida* sp. Barlee Range (S. van Leeuwen 1642) - Priority 3
Sw: *Stylidium weeliwolli* - Priority 3
Sh: *Synostemon hamersleyensis* - Priority 1
Tg: *Tecticornia globulifera* - Priority 1
Tm: *Tecticornia medusa* - Priority 3
Ts: *Tecticornia* sp. Christmas Creek (K.A. Shepherd and T. Colmer et al. KS 1063) - Priority 1

OVERVIEW



ecoscape

PRIORITY FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 4A

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MUNJINA ROY HILL ROAD

MARILLANA CREEK

WEELI WOLLI CREEK

Ea Ea Eiq Gn Eii Gn Eiq Gn Lc Ec Sh Sh Sh Sw Cs

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Conservation Significant Flora Locations

Ecoscape 2017 Observations

- Ecoscape, Priority 1
- Ecoscape, Priority 2
- Ecoscape, Priority 3
- Ecoscape, Priority 4

DBCA Databases

- DBCA, Priority 1
- DBCA, Priority 2
- DBCA, Priority 3
- DBCA, Priority 4

Fortescue Database

- Fortescue, Priority 1
- Fortescue, Priority 3
- Fortescue, Priority 4

***Flora Label Codes**

As: *Acacia subtiliformis* - Priority 3
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Eii: *Euphorbia inappendiculata* var. *inappendiculata* - Priority 2
Eiq: *Euphorbia inappendiculata* var. *queenslandica* - Priority 1
Gn: *Goodenia nuda* - Priority 4
Ho: *Helichrysum oligochaetum* - Priority 1
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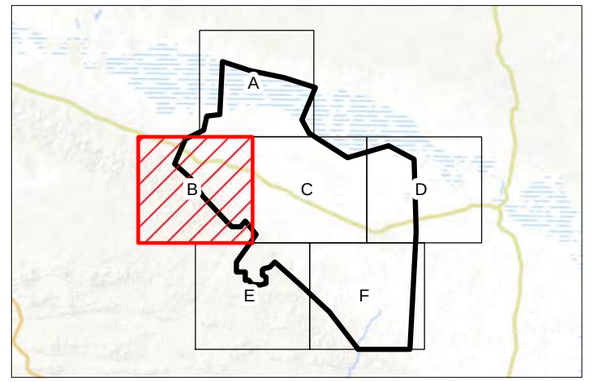
Tg: *Tecticornia globulifera* - Priority 1
Tm: *Tecticornia medusa* - Priority 3
Ts: *Tecticornia* sp. Christmas Creek (K.A. Shepherd and T. Colmer et al. KS 1063) - Priority 1

OVERVIEW



ecoscape

PRIORITY FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

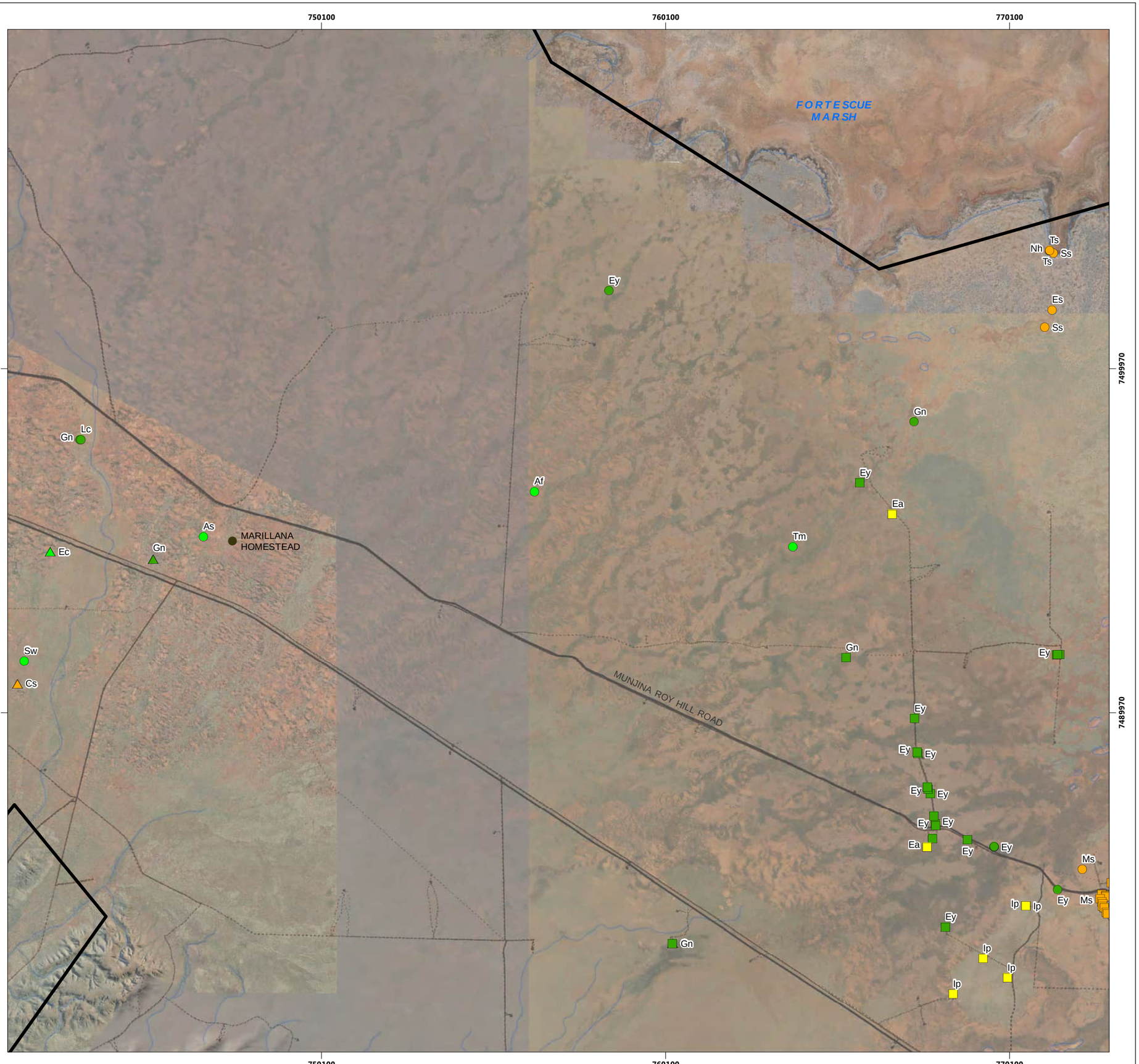
SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 4B



LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Conservation Significant Flora Locations

Ecoscape 2017 Observations

- Ecoscape, Priority 1
- Ecoscape, Priority 2
- Ecoscape, Priority 3
- Ecoscape, Priority 4

DBCA Databases

- DBCA, Priority 1
- DBCA, Priority 2
- DBCA, Priority 3
- DBCA, Priority 4

Fortescue Database

- Fortescue, Priority 1
- Fortescue, Priority 3
- Fortescue, Priority 4

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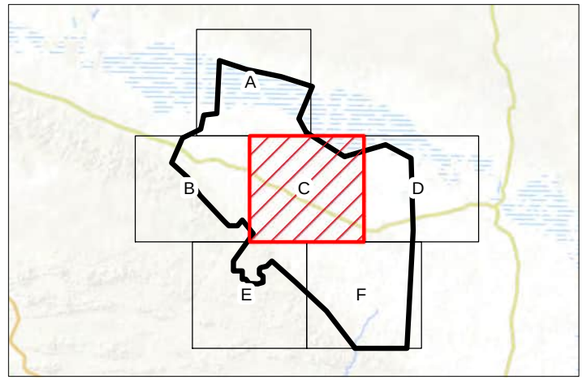
OVERVIEW



ecoscape

PRIORITY FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 4C

770100 780100 790100 800100

7499970

7489970

FORTESCUE MARSH

FORTESCUE RIVER

KULBEE CREEK

MUNJINA ROY HILL ROAD

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Conservation Significant Flora Locations

Ecoscape 2017 Observations

- Ecoscape, Priority 1
- Ecoscape, Priority 2
- Ecoscape, Priority 3
- Ecoscape, Priority 4

DBCA Databases

- DBCA, Priority 1
- DBCA, Priority 2
- DBCA, Priority 3
- DBCA, Priority 4

Fortescue Database

- Fortescue, Priority 1
- Fortescue, Priority 3
- Fortescue, Priority 4

***Flora Label Codes**

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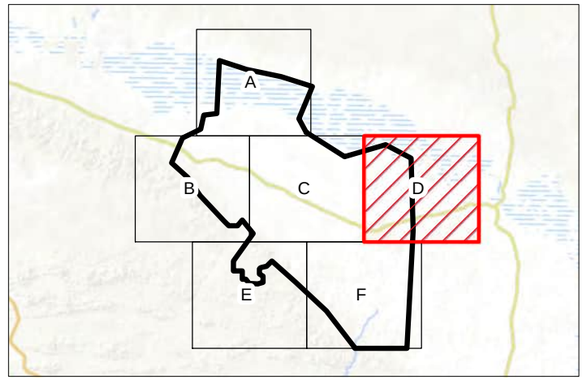
OVERVIEW



ecoscape

PRIORITY FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 4D

730100 740100 750100

7479970 7469970 7459970

MARILLANA CREEK
YANDICOOGINA CREEK
WEELIWOLLI CREEK

Lc
Rs

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Conservation Significant Flora Locations

Ecoscape 2017 Observations

- Ecoscape, Priority 1
- Ecoscape, Priority 2
- Ecoscape, Priority 3
- Ecoscape, Priority 4

DBCA Databases

- DBCA, Priority 1
- DBCA, Priority 2
- DBCA, Priority 3
- DBCA, Priority 4

Fortescue Database

- Fortescue, Priority 1
- Fortescue, Priority 3
- Fortescue, Priority 4

***Flora Label Codes**

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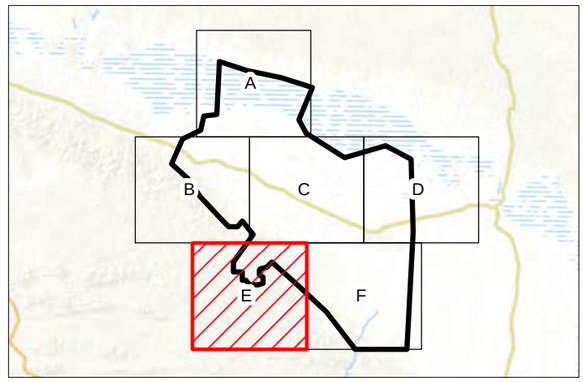
Gn: *Goodenia nuda* - Priority 4
Ho: *Helichrysum oligochaetum* - Priority 1
Ip: *Isotropis parviflora* - Priority 2
Lc: *Lepidium catapycnon* - Priority 4
Ms: *Myriocephalus scalpellus* - Priority 1
Nh: *Nicotiana heterantha* - Priority 1
Rs: *Rhagodia* sp. Hamersley (M. Trudgen 17794) - Priority 3
SF: *Samolus* sp. Fortescue Marsh (A. Markey and R. Coppen FM 9702) - Priority 1
SB: *Sida* sp. Barlee Range (S. van Leeuwen 1642) - Priority 3
Sw: *Stylidium weeliwolli* - Priority 3
Sh: *Synostemon hamersleyensis* - Priority 1
Tg: *Tecticornia globulifera* - Priority 1
Tm: *Tecticornia medusa* - Priority 3
Ts: *Tecticornia* sp. Christmas Creek (K.A. Shepherd and T. Colmer et al. KS 1063) - Priority 1

OVERVIEW



ecoscape

PRIORITY FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP
4E

760100 770100 780100

7479970 7469970 7459970

Gn Ey Ip Ip Ip Ip Ip Gn Gn Gn Gn Lc Lc Lc Ss

COONDINER CREEK

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Conservation Significant Flora Locations

Ecoscape 2017 Observations

- Ecoscape, Priority 1
- Ecoscape, Priority 2
- Ecoscape, Priority 3
- Ecoscape, Priority 4

DBCA Databases

- DBCA, Priority 1
- DBCA, Priority 2
- DBCA, Priority 3
- DBCA, Priority 4

Fortescue Database

- Fortescue, Priority 1
- Fortescue, Priority 3
- Fortescue, Priority 4

***Flora Label Codes**

As: *Acacia subtiliformis* - Priority 3
Af: *Atriplex flabelliformis* - Priority 3
Cs: *Calotis squamigera* - Priority 1
Ec: *Eragrostis crateriformis* - Priority 3
Es: *Eremophila spongiocarpa* - Priority 1
Ey: *Eremophila youngii* subsp. *lepidota* - Priority 4
Ea: *Euphorbia australis* var. *glabra* - Priority 2
Eii: *Euphorbia inappendiculata* var. *inappendiculata* - Priority 2
Eiq: *Euphorbia inappendiculata* var. *queenslandica* - Priority 1
Gn: *Goodenia nuda* - Priority 4
Ho: *Helichrysum oligochaetum* - Priority 1
Ip: *Isotropis parviflora* - Priority 2
Lc: *Lepidium catapycnon* - Priority 4
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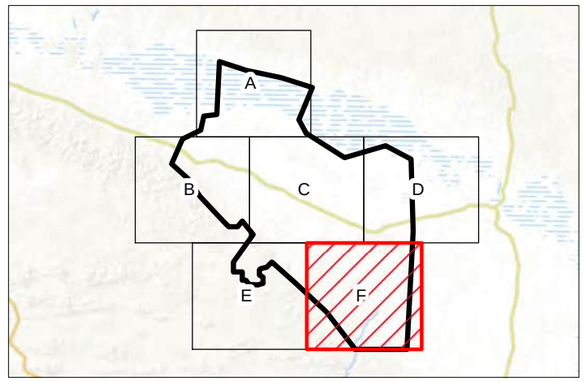
OVERVIEW



ecoscape

PRIORITY FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

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0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 4F

730100 740100 750100

7529970 7519970 7509970

FORTESCUE MARSH

Fa Ul Ul Fa En Fa Fa Fa Fa Fa Th Fa Fa Ee Es Ee Es Ee Ei

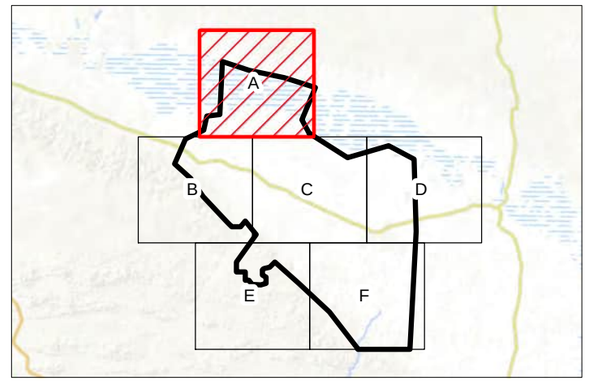
LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Other Significant Flora (according to EPA Technical Guidance)

- Bp: *Basilicum polystachyon*
- Ce: *Chrysocephalum eremaeum*
- Cp: *Cymbopogon procerus*
- Ee: *Eragrostis exigua*
- Eg: *Eriachne gardneri*
- Ei: *Euphorbia inappendiculata* var. *inappendiculata*
- En: *Einadia nutans* subsp. *eremaea*
- Es: *Ehretia saligna* var. *saligna*
- Fa: *Frankenia ambita*
- Hs: *Halgania solanacea* var. *solanacea*
- Th: *Triglochin hexagona*
- Tz: *Trichodesma zeylanicum* var. *grandiflorum*
- Ul: *Uvedalia linearis*

OVERVIEW



ecoscape

OTHER SIGNIFICANT FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

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0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 5A

720100 730100 740100

7499970

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Es Ee

Ei

MUNJINA ROY HILL ROAD

MARILLANA CREEK

WEELI WOLLI CREEK

LEGEND

- Homestead
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- Ecoscape Survey Tracks
- Rivers
- Creeks
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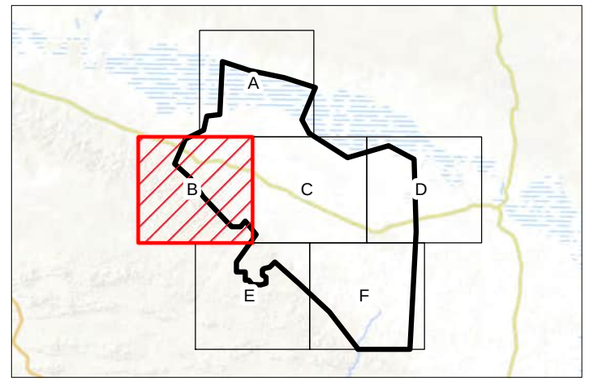
OVERVIEW



ecoscape

OTHER SIGNIFICANT FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

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0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
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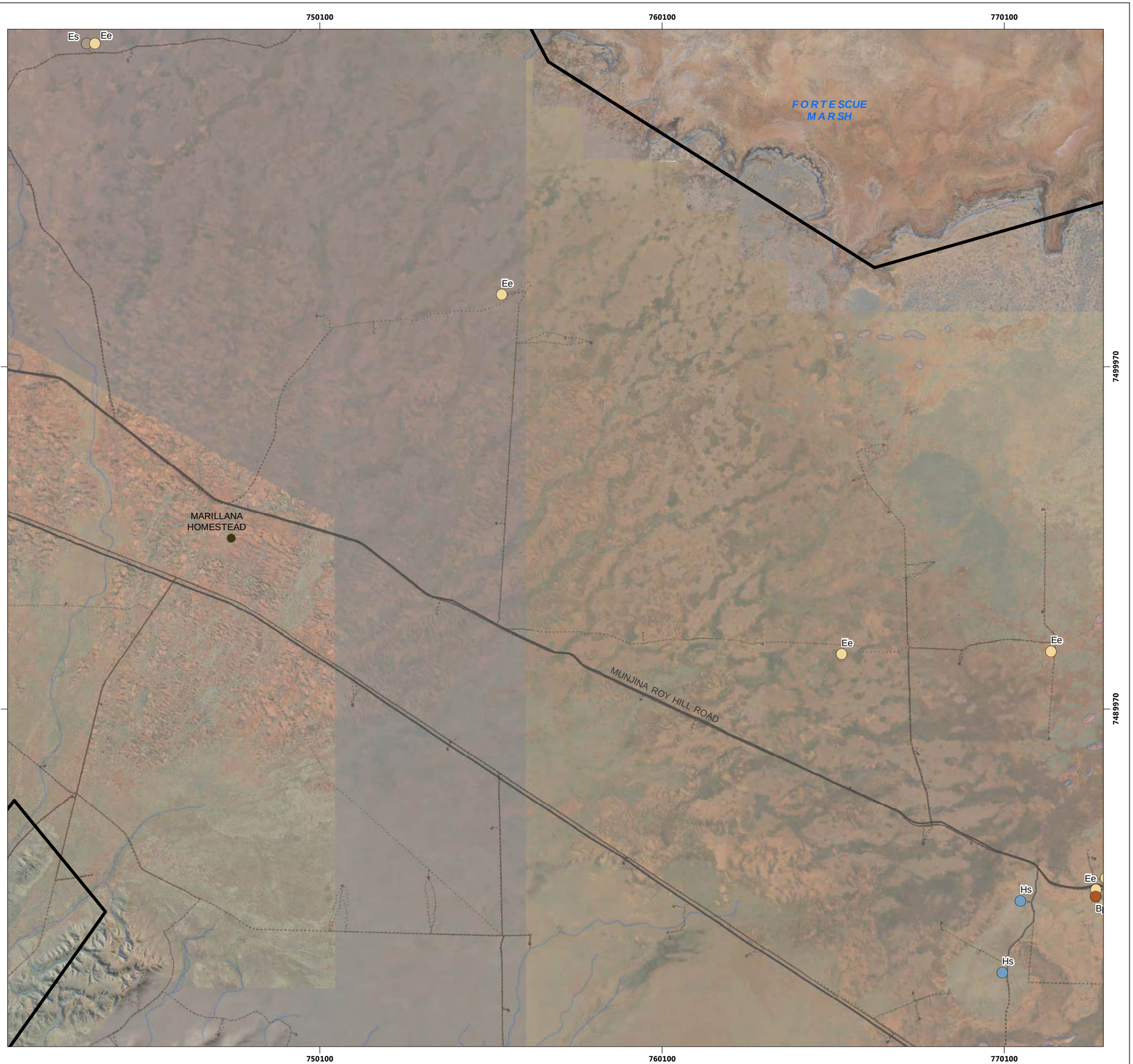
MAP 5B



LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Other Significant Flora (according to EPA Technical Guidance)

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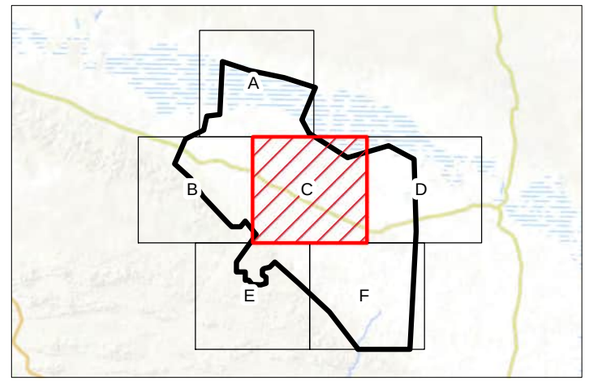
- Ul: *Uvedalia linearis*

OVERVIEW



ecoscape

OTHER SIGNIFICANT FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

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N

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0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 5C

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FORTESCUE MARSH

FORTESCUE RIVER

KULBEE CREEK

MUNJINA ROY HILL ROAD

Ee Ee Ee Ee Ee Hs Bp Hs

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Other Significant Flora (according to EPA Technical Guidance)

- Bp: *Basilicum polystachyon*
- Ce: *Chrysocephalum eremaeum*
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- Eg: *Eriachne gardneri*
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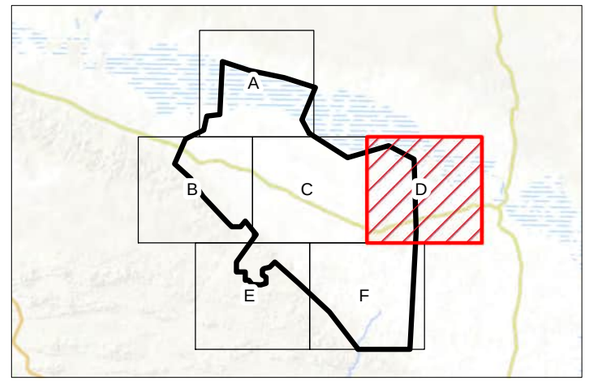
- Ul: *Uvedalia linearis*

OVERVIEW



ecoscape

OTHER SIGNIFICANT FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

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PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
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MAP 5D

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MARILLANA CREEK
YANDICOOGINA CREEK
WEELIWOLLI CREEK

Cp Cp Cp

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Other Significant Flora (according to EPA Technical Guidance)

- Bp: *Basilicum polystachyon*
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- Es: *Ehretia saligna* var. *saligna*
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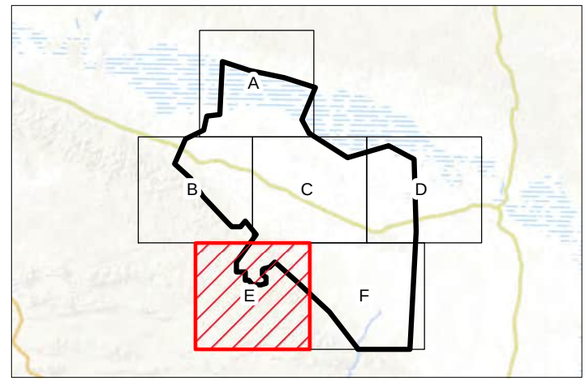
- Tz: *Trichodesma zeylanicum* var. *grandiflorum*
- Ul: *Uvedalia linearis*

OVERVIEW



ecoscape

OTHER SIGNIFICANT FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

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DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 5E

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7479970
7469970
7459970

Hs
Cp
Cp
Tz
Tz
Ee
Ee
Ee
Ee
COONDINER CREEK
Ce
Tz
Tz
Tz
Ce
Eg
Ce
Tz
Cp

760100
770100
780100

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Other Significant Flora (according to EPA Technical Guidance)

- Bp: *Basilicum polystachyon*
- Ce: *Chrysocephalum eremaeum*
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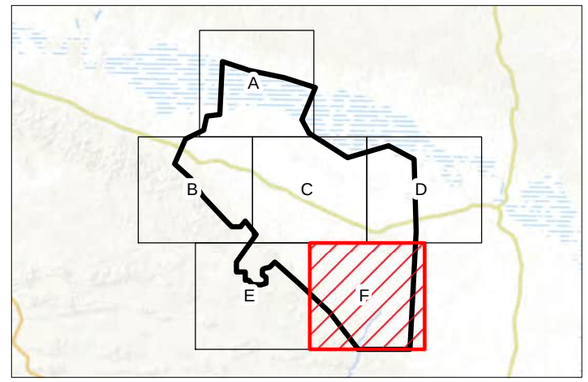
- Ei: *Euphorbia inappendiculata* var. *inappendiculata*
- En: *Einadia nutans* subsp. *eremaea*
- Es: *Ehretia saligna* var. *saligna*
- Fa: *Frankenia ambita*
- Hs: *Halgania solanacea* var. *solanacea*
- Th: *Triglochin hexagona*
- Tz: *Trichodesma zeylanicum* var. *grandiflorum*
- Ul: *Uvedalia linearis*

OVERVIEW



ecoscape

OTHER SIGNIFICANT FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

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MAP 5F

730100 740100 750100

7529970 7519970 7509970

FORTESCUE MARSH

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Introduced Flora Locations

High Ecological Impact

- Aj: *Aerva javanica*
- Cc: *Cenchrus ciliaris*
- Cs: *Cenchrus setiger*
- Cv: *Chloris virgata*
- Ec: *Echinochloa colona*
- Ma: *Malvastrum americanum*
- Rv: *Rumex*
- Sv: *Setaria verticillata*
- Vf: *Vachellia*

Low Ecological Impact

- So: *Sonchus oleraceus*

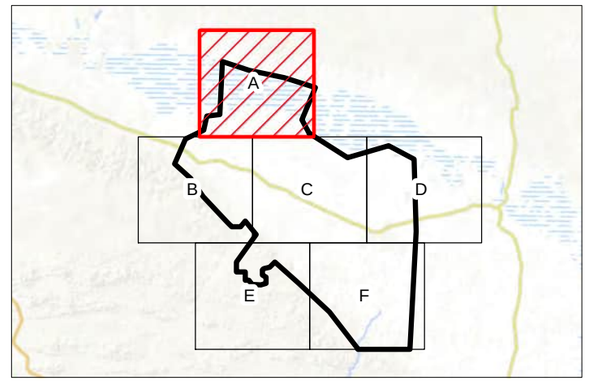
Unknown Ecological Impact

- Ao: *Argemone ochroleuca* subsp. *ochroleuca*
- Bs: *Bidens subalternans* var.
- Cl: *Citrullus lanatus*

Unlisted

- Ft: *Flaveria trinervia*
- Pp: *Portulaca*
- Pl: *Pseudognaphalium luteoalbum*
- Si: *Sisymbrium orientale*

OVERVIEW



ecoscape

INTRODUCED FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

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MAP 6A

720100 730100 740100

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MUNJINA ROY HILL ROAD

MARILLANA CREEK

WEELI WOLLI CREEK

LEGEND

- Homestead
- Roads
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- Ecoscape Survey Tracks
- Rivers
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- Study Area

Introduced Flora Locations

High Ecological Impact

- Aj: *Aerva javanica*
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- Cv: *Chloris virgata*
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Low Ecological Impact

- So: *Sonchus oleraceus*

Unknown Ecological Impact

- Ao: *Argemone ochroleuca* subsp. *ochroleuca*
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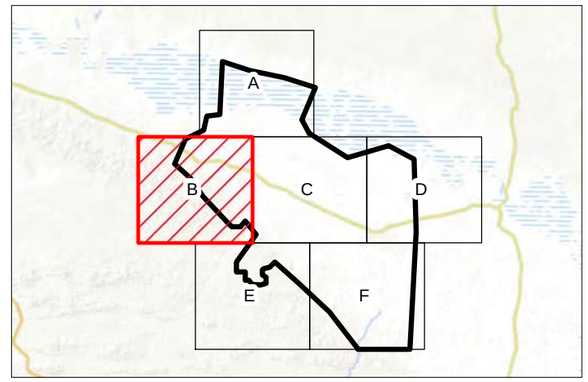
OVERVIEW



ecoscape

INTRODUCED FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

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PROJECT NO: 3937-17

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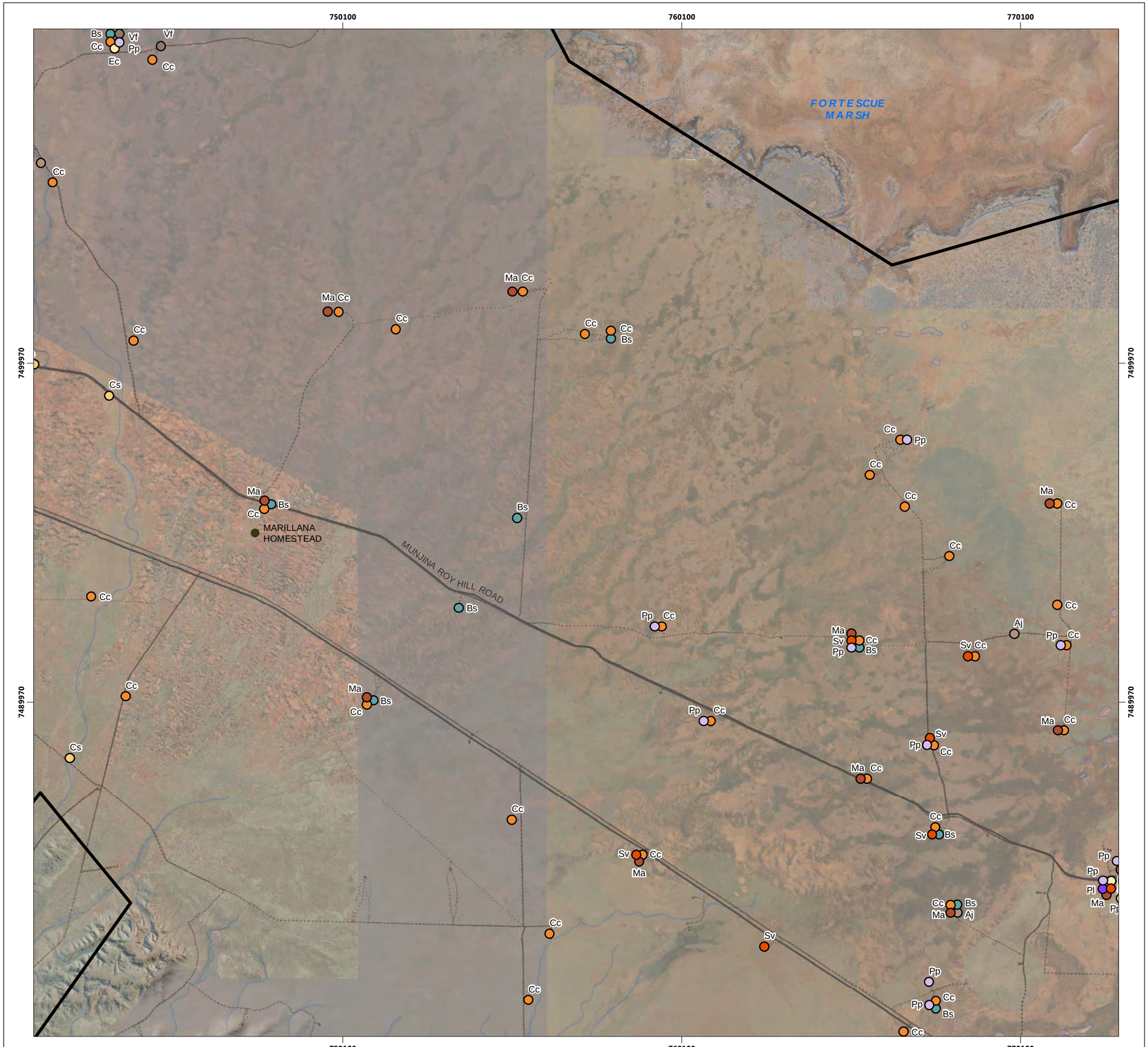
MAP 6B



LEGEND

- Homestead
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Introduced Flora Locations

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- Pp: *Portulaca*
- Pl: *Pseudognaphalium luteoalbum*
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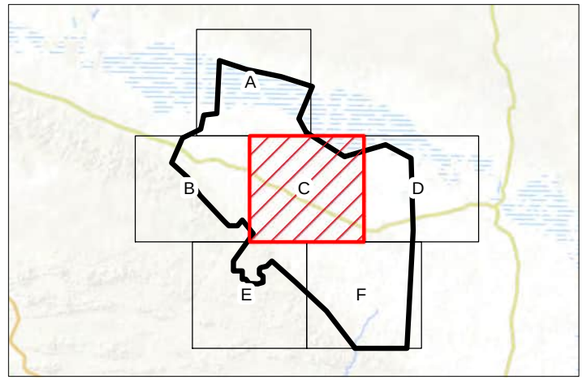
OVERVIEW



ecoscape

INTRODUCED FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

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REV	AUTHOR	APPROVED	DATE
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MAP 6C

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FORTESCUE MARSH

FORTESCUE RIVER

KULBEE CREEK

MUNJINA ROY HILL ROAD

Ma Cc Sv Pp Ma Pp Pp Cc Sv Ma Cc Pp Sv Aj Pp Cc Cc Aj Sv Pp Cc Sv Cc Ma Ma Cc Pp Cc Pp Cc Pp Cc Pp Cc Cc Pp Sv Pp Ma Ec Pl Sv Ec Ma Pp Sv Ma Bs

770100 780100 790100 800100

LEGEND

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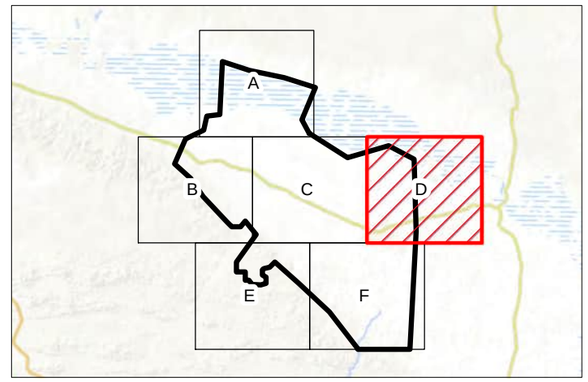
- Si: *Sisymbrium orientale*

OVERVIEW



ecoscape

INTRODUCED FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 6D

730100 740100 750100

7479970 7469970 7459970

MARILLANA CREEK
YANDICOOGINA CREEK
WEELIWOLLI CREEK

Cc Cc Cc Cc Cc Cc
Ma Ao Sv Rv

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Introduced Flora Locations

High Ecological Impact

- Aj: *Aerva javanica*
- Cc: *Cenchrus ciliaris*
- Cs: *Cenchrus setiger*
- Cv: *Chloris virgata*
- Ec: *Echinochloa colona*
- Ma: *Malvastrum americanum*
- Rv: *Rumex*
- Sv: *Setaria verticillata*
- Vf: *Vachellia*

Low Ecological Impact

- So: *Sonchus oleraceus*

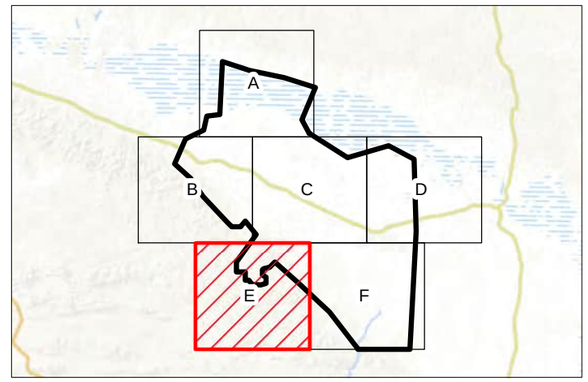
Unknown Ecological Impact

- Ao: *Argemone ochroleuca* subsp. *ochroleuca*
- Bs: *Bidens subalternans* var.
- Cl: *Citrullus lanatus*

Unlisted

- Ft: *Flaveria trinervia*
- Pp: *Portulaca*
- Pl: *Pseudognaphalium luteoalbum*
- Si: *Sisymbrium orientale*

OVERVIEW



ecoscape

INTRODUCED FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 6E

760100 770100 780100

7479970 7469970 7459970

COONDINER CREEK

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Ecoscape Survey Tracks
- Rivers
- Creeks
- Waterbodies
- Study Area

Introduced Flora Locations

High Ecological Impact

- Aj: *Aerva javanica*
- Cc: *Cenchrus ciliaris*
- Cs: *Cenchrus setiger*
- Cv: *Chloris virgata*
- Ec: *Echinochloa colona*
- Ma: *Malvastrum americanum*
- Rv: *Rumex*
- Sv: *Setaria verticillata*
- Vf: *Vachellia*

Low Ecological Impact

- So: *Sonchus oleraceus*

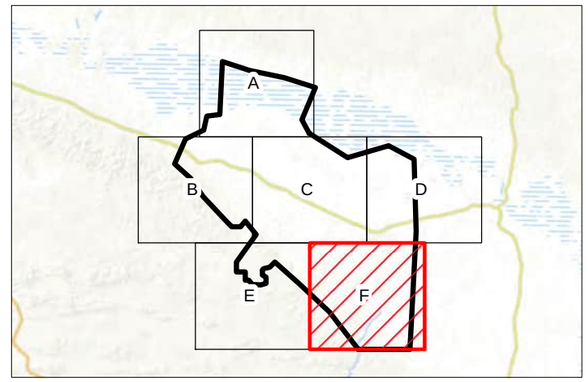
Unknown Ecological Impact

- Ao: *Argemone ochroleuca* subsp. *ochroleuca*
- Bs: *Bidens subalternans* var.
- Cl: *Citrullus lanatus*

Unlisted

- Ft: *Flaveria trinervia*
- Pp: *Portulaca*
- Pl: *Pseudognaphalium luteoalbum*
- Si: *Sisymbrium orientale*

OVERVIEW



INTRODUCED FLORA LOCATIONS

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

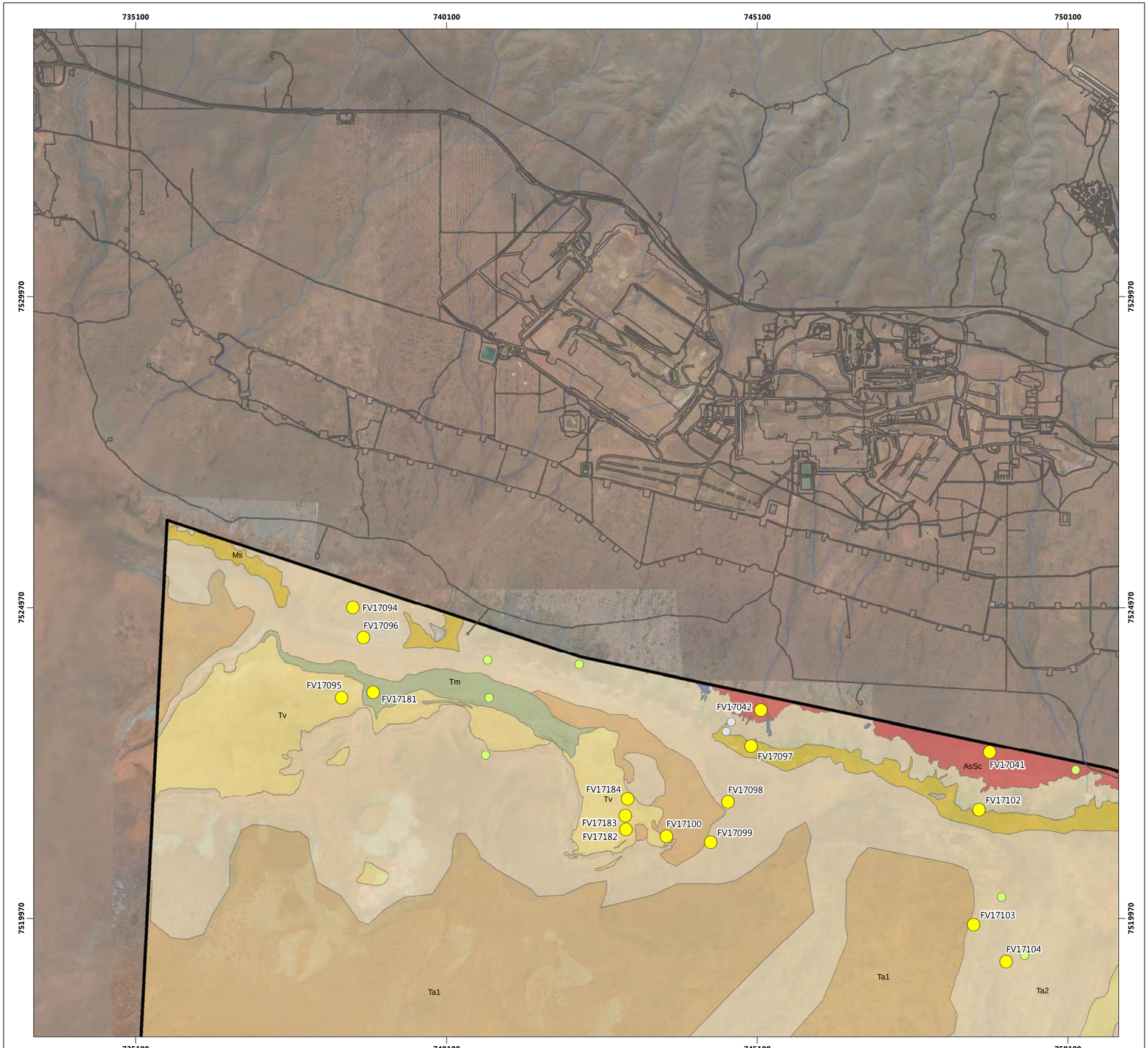
SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 6F



LEGEND

- Homestead
- Study Area

Survey Quadrats

Established by

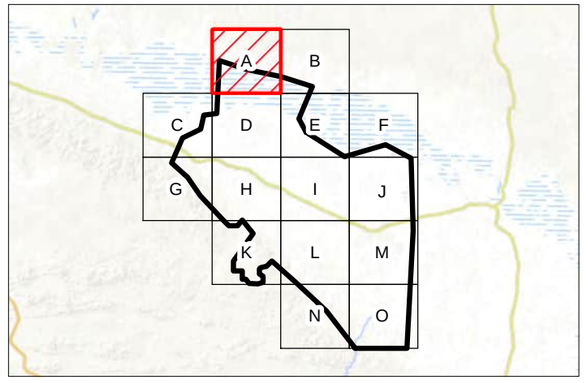
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type

Mapping Unit

- AsSc
- EvMxTl
- Ms
- TD
- Ta1
- Ta2
- Tm
- Tv

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

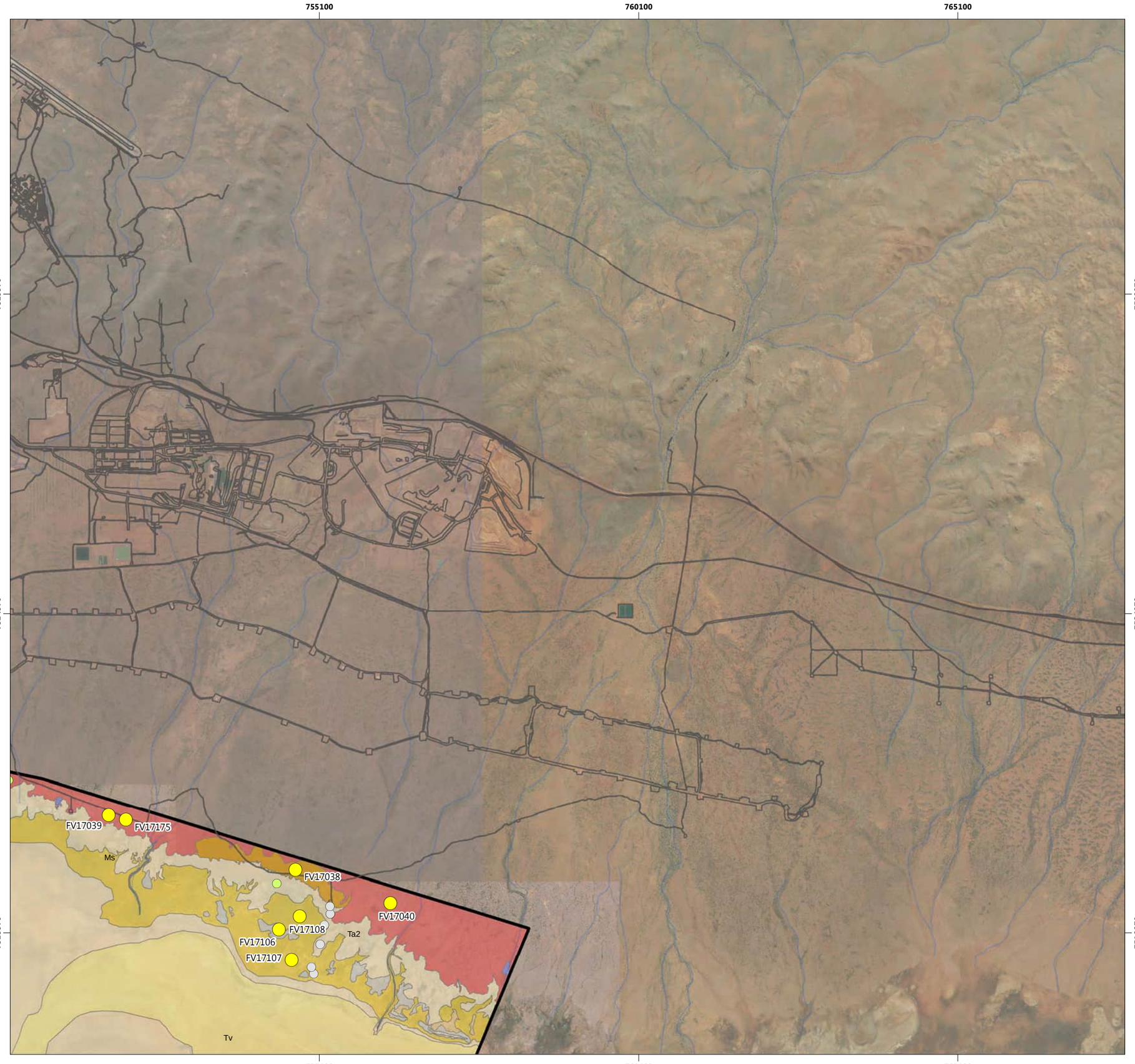
SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 7A



LEGEND

- Homestead
- Study Area

Survey Quadrats

Established by

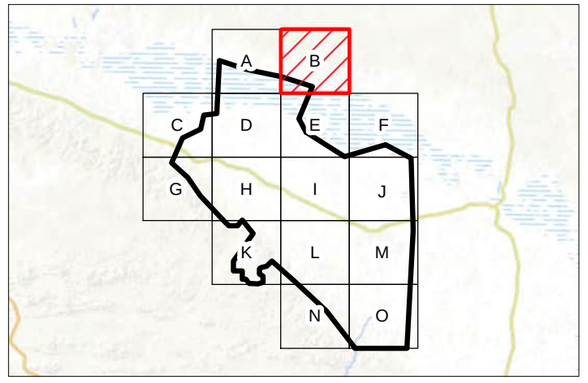
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type

Mapping Unit

- AsSc
- EvAcCc
- EvMxTl
- Ms
- Open Water
- TD
- Ta1
- Ta2
- Tl
- Tv

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 7B

720100
725100
730100
7514970
7509970
7504970

AxEcSc
FV17116
FV17076
FV17075
FV17159
SaEx/AsCc1
FV17156
FV17160
C014
AaAsCc
FV17074
AsCc1
EvAcCc
AdAh
C119
B050
EgAbTb/AaTb
AaTb

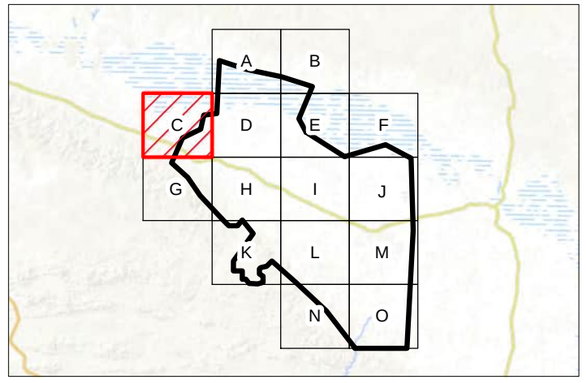
LEGEND

- Homestead
- Study Area

Survey Quadrats
Established by
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type
Mapping Unit
- AaAsCc
- AaTb
- AdAh
- AsCc1
- AxEcSc
- Cleared
- EgAbTb/AaTb
- EvAcCc
- MxCc
- SaEx/AsCc1
- SsCc

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

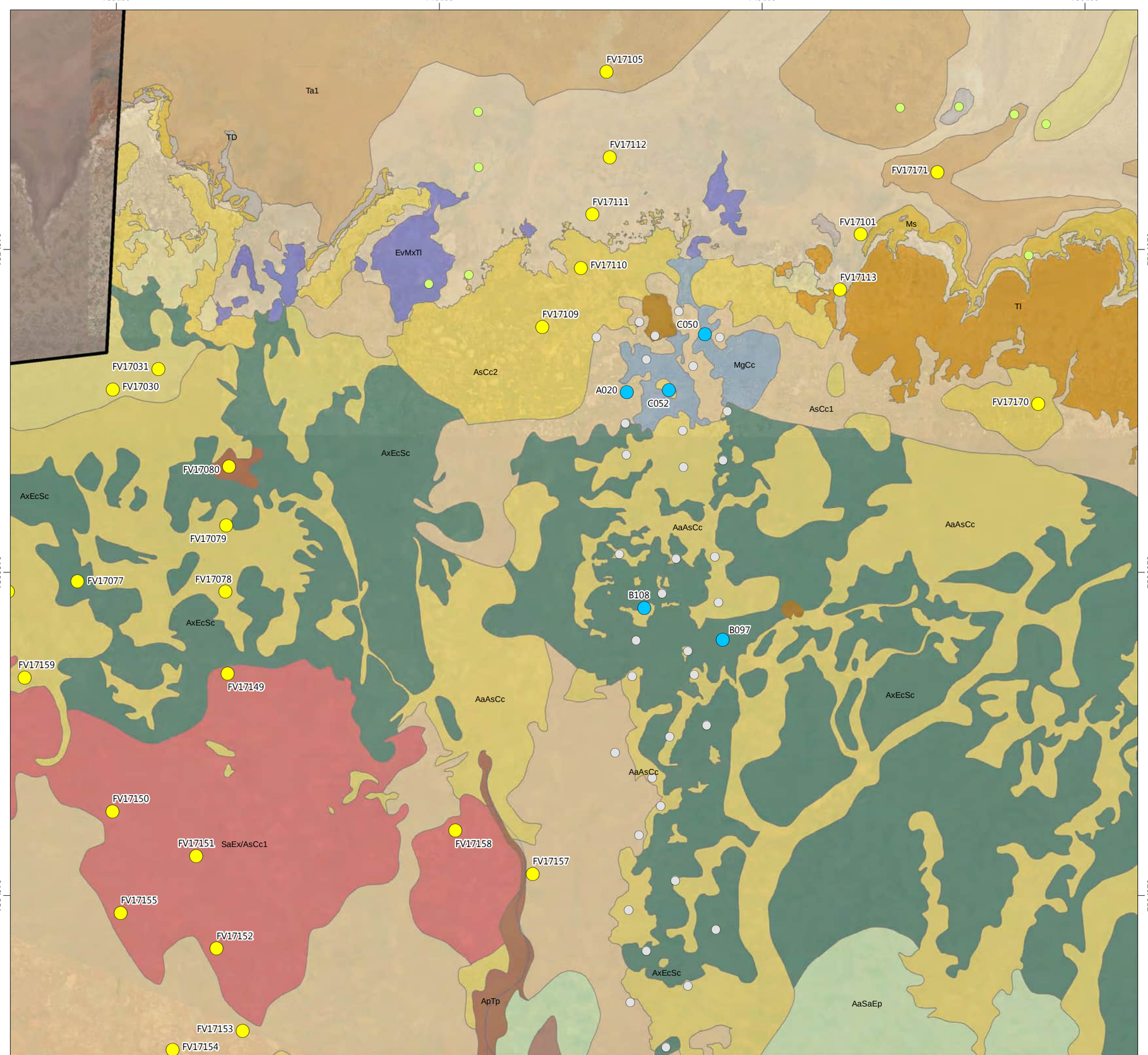
SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

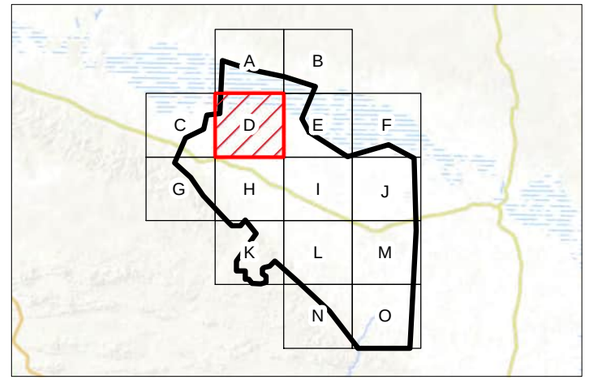
MAP 7C



LEGEND

- Homestead
- **Survey Quadrats**
- **Established by**
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area
- **Vegetation Type**
- **Mapping Unit**
- AaAsCc
- AaSaEp
- AdTe
- ApTp
- AsCc1
- AsCc2
- AxEcSc
- Claypan
- EvMxTl
- EyAb
- MgCc
- Ms
- MxCc
- SaEx/AsCc1
- TD
- Ta1
- Ta2
- Ti
- Tl
- Tv

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

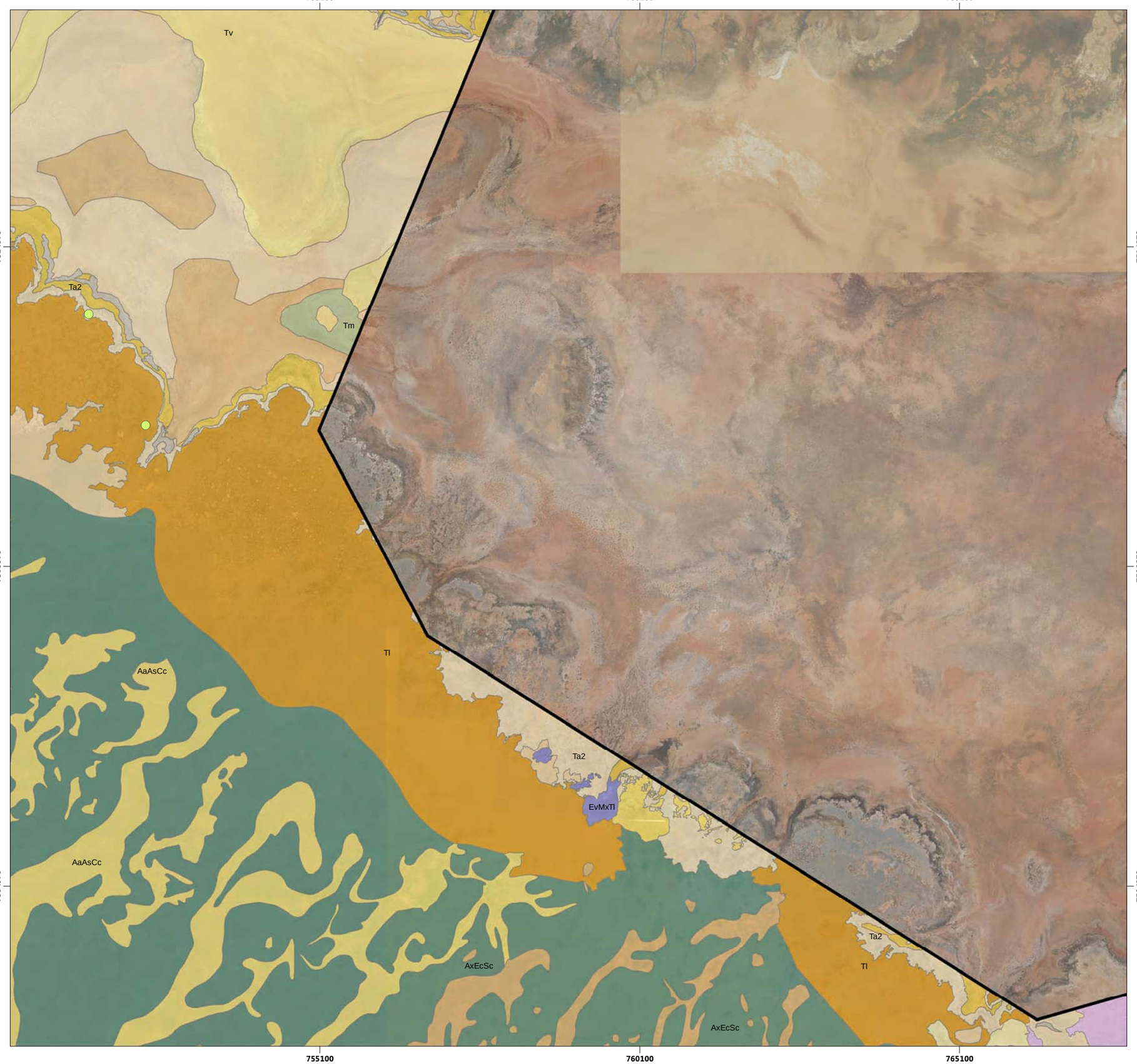
SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

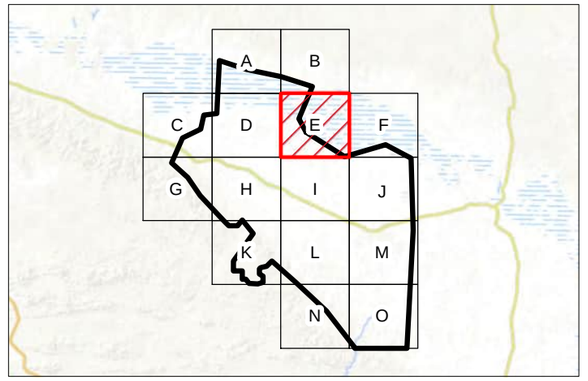
MAP 7D



LEGEND

- Homestead
- **Survey Quadrats**
- **Established by**
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area
- **Vegetation Type**
- **Mapping Unit**
- AaAsCc
- AaEfEp
- AbTl
- AsCc1
- AsCc2
- AxEcSc
- EvMxTl
- Ms
- Open Water
- TD
- Ta1
- Ta2
- Ti
- Tl
- Tm
- Tv

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 7E

770100
775100
780100
7514970
7509970
7504970
Ta2
AbTl
Ta1
Ms

LEGEND

- Homestead
- Study Area

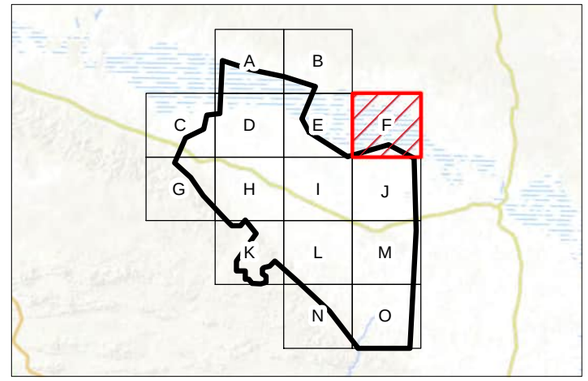
Survey Quadrats Established by

- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type Mapping Unit

- AbTl
- Ms
- TD
- Ta1
- Ta2
- Ti
- Tl

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 7F

720100
725100
730100
7499970
7494970
7489970

B049
A066
C070
FV17072
FV17073
FV17018
SsCc
AaAsCc
AaTb
ElGwTv
AdTe
EgAbTb/AaTb
EvAcCc
FV17141
ElGwTv
A015
FV17140
FV17139
AiAh
FV17138
FV17137
EgAbTb/AaTb
ElGwTv

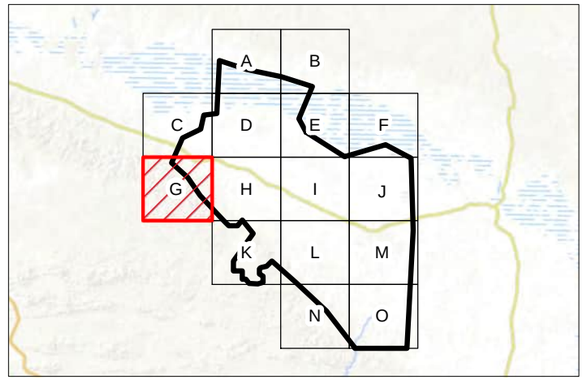
LEGEND

- Homestead
- Study Area

Survey Quadrats
Established by
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type
Mapping Unit
- AaAsCc
- AaTb
- AcAsCc
- AdAh
- AdTe
- AiAh
- AsCc1
- Cleared
- EgAbTb/AaTb
- ElGwTv
- EvAcCc
- SsCc

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

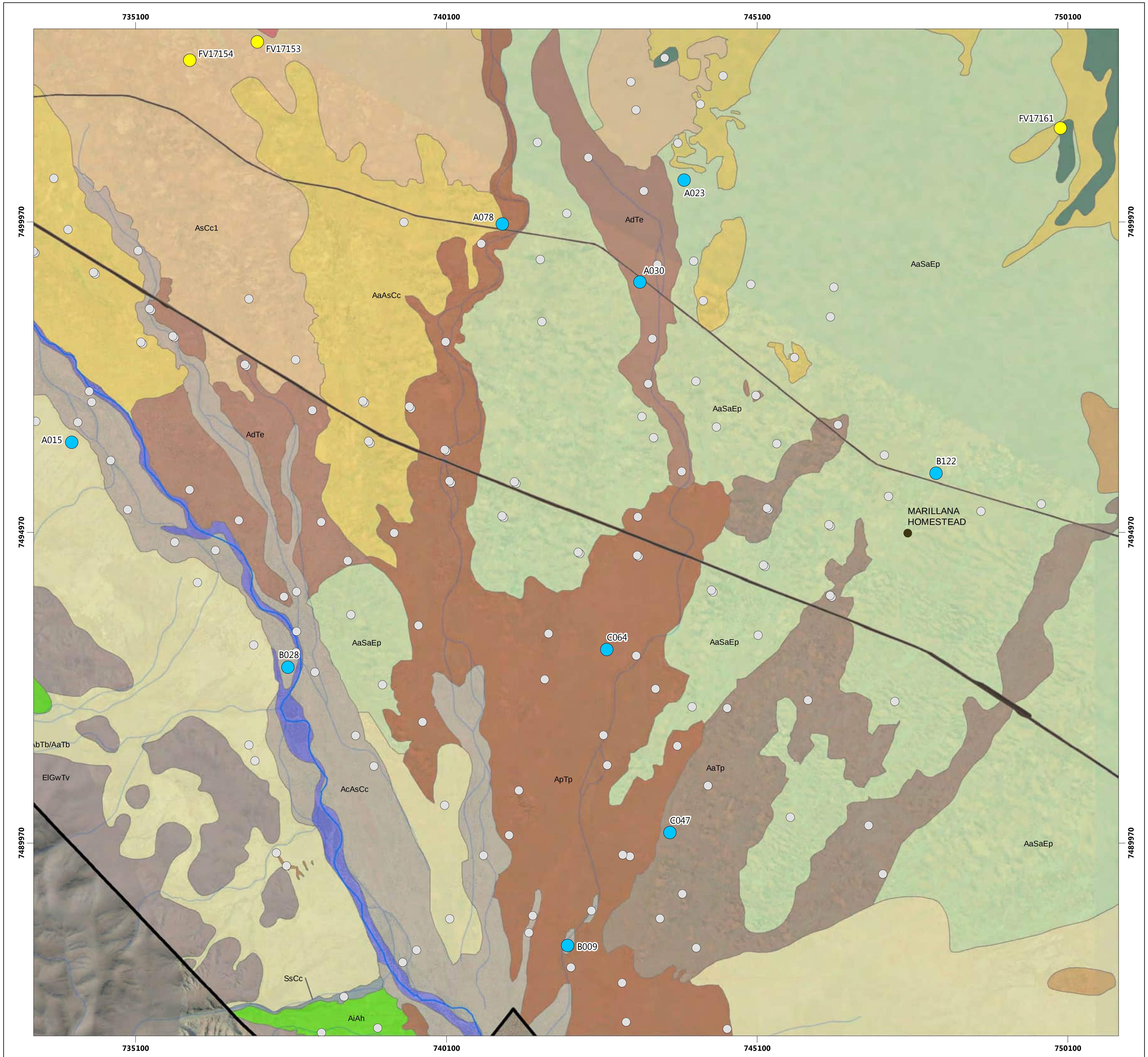
SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP
7G



LEGEND

- Homestead

Survey Quadrats Established by

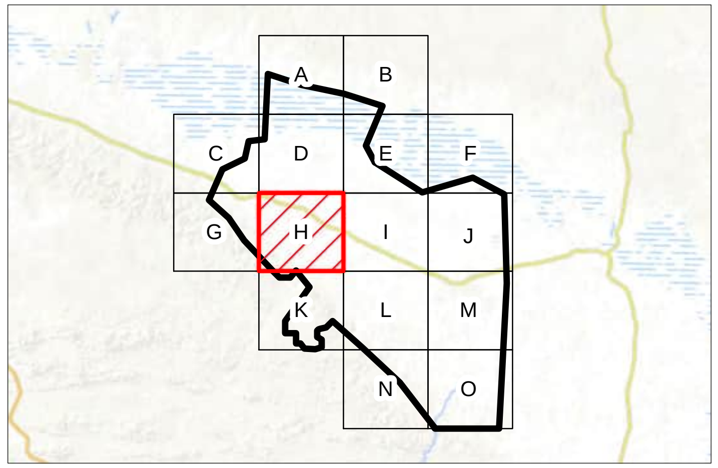
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

- Study Area

Vegetation Type Mapping Unit

- AaAsCc
- AaEfEp
- AaSaEp
- AaTp
- AcAsCc
- AdAh
- AdTe
- AiAh
- ApTp
- AsCc1
- AxEcSc
- Cleared
- EgAbTb/AaTb
- ElGwTv
- EvAcCc
- SaEx/AsCc1
- SsCc

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:60,000 @ A3

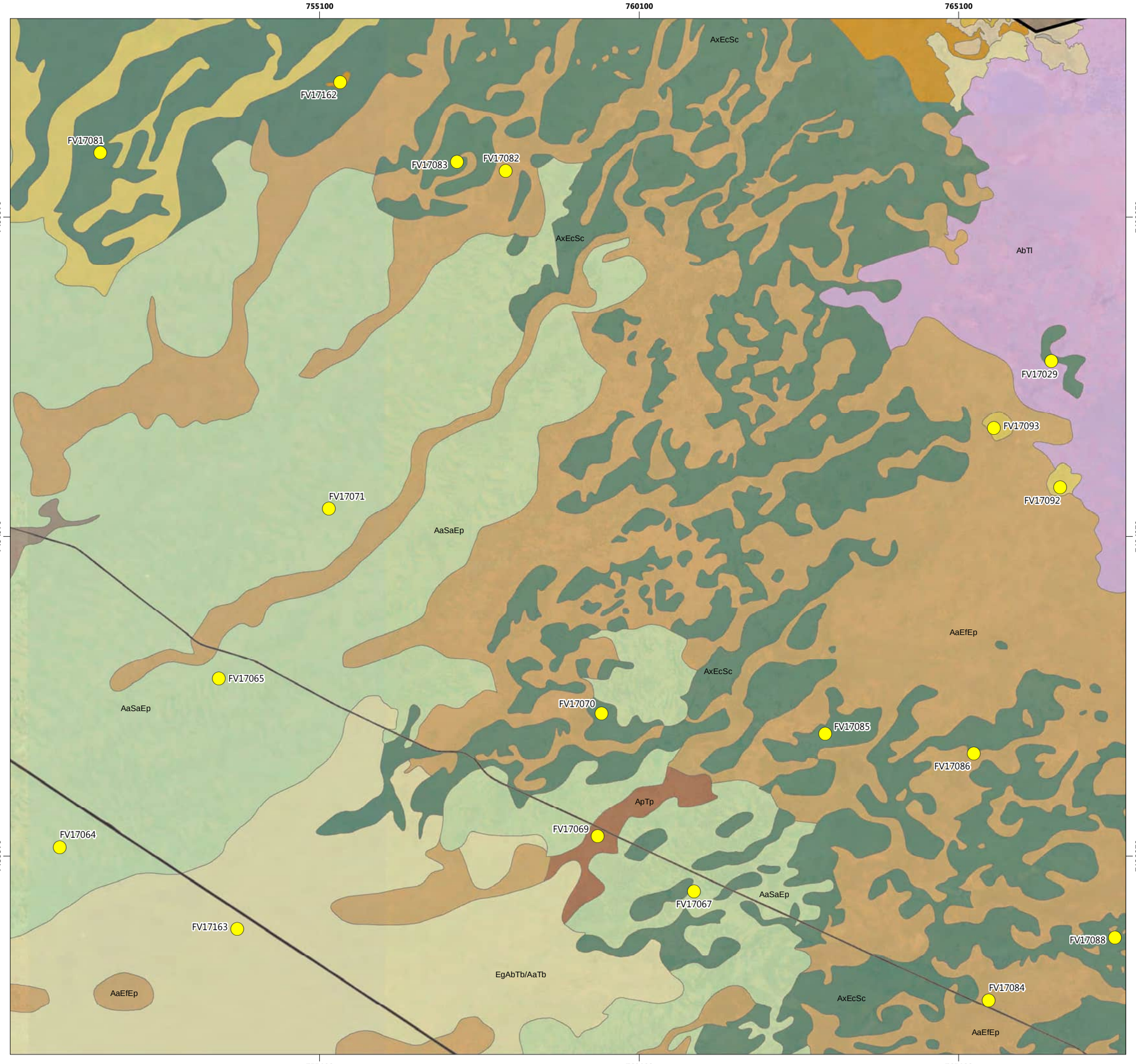
0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP

7H



LEGEND

- Homestead

Survey Quadrats

Established by

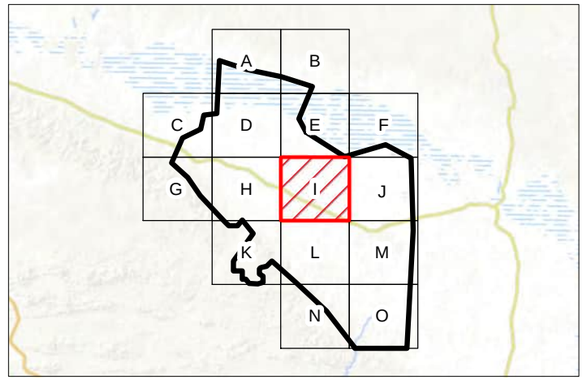
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area

Vegetation Type

Mapping Unit

- AaAsCc
- AaEfEp
- AaSaEp
- AaTp
- AbTl
- ApTp
- AsCc1
- AsCc2
- AxEcSc
- Cleared
- EgAbTb/AaTb
- Es
- Ms
- TD
- Ta2
- Ti
- Tl

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

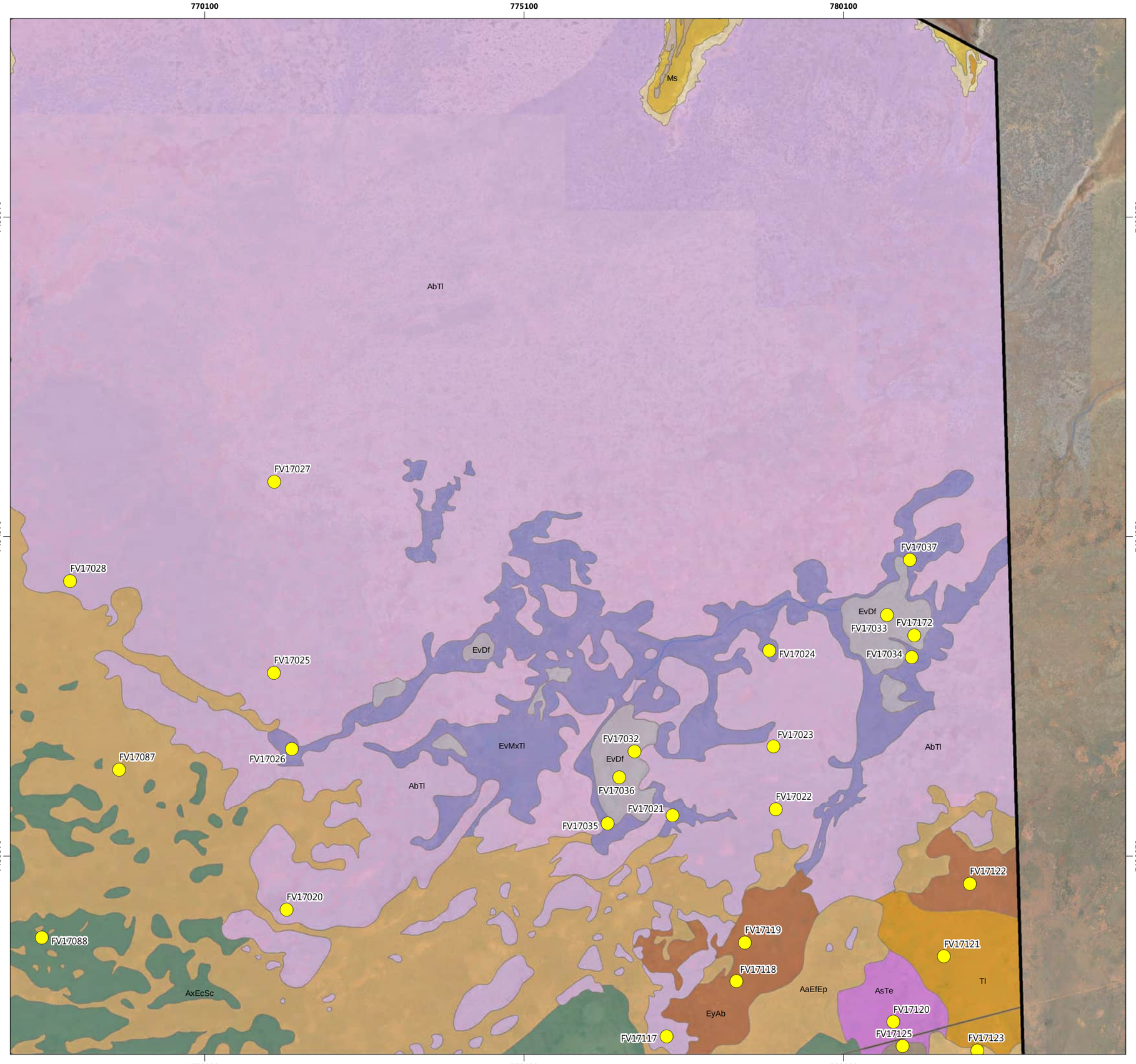
SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 71



LEGEND

- Homestead
- Study Area

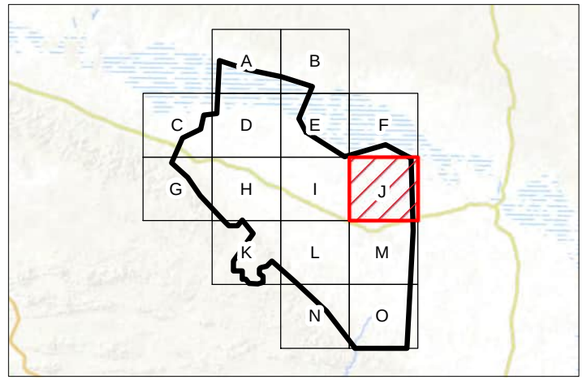
Survey Quadrats
Established by

- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type
Mapping Unit

- AaEfEp
- AaTp
- AbTl
- AsTe
- AxEcSc
- AxEcTe
- Cleared
- EvDf
- EvMxTl
- EyAb
- Ms
- TD
- Ta1
- Ta2
- Ti
- Tl

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP
7 J

735100 740100 745100 750100

7484970 7479970 7474970

AiAh
ElGwTv
A012
FV17045
EgAbTb/AaTb
AdAh
FV17173
ElAaTv
FV17134
ElGwTv
ElGwTv
FV17016
FV17133
FV17135
FV17017
YANDICOOGINA CREEK
WEELIWOLLI CREEK
ElGwTv
AaTb
ElGwTv
FV17174
AiAh
FV17136

735100 740100 745100 750100

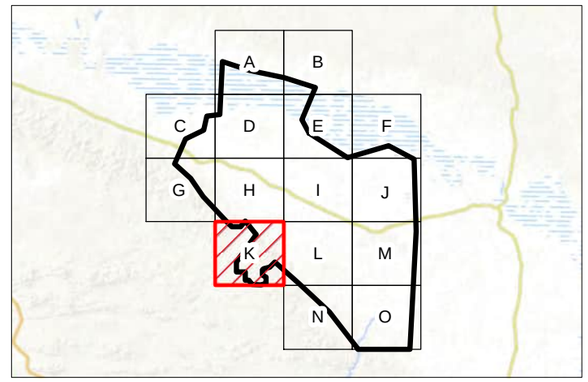
LEGEND

- Homestead
- Study Area

Survey Quadrats
Established by
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type
Mapping Unit
- AaTb
- AcAsCc
- AdAh
- AiAh
- ApTp
- EgAbTb/AaTb
- ElAaTv
- ElGwTv
- EvAcCc
- SsCc

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

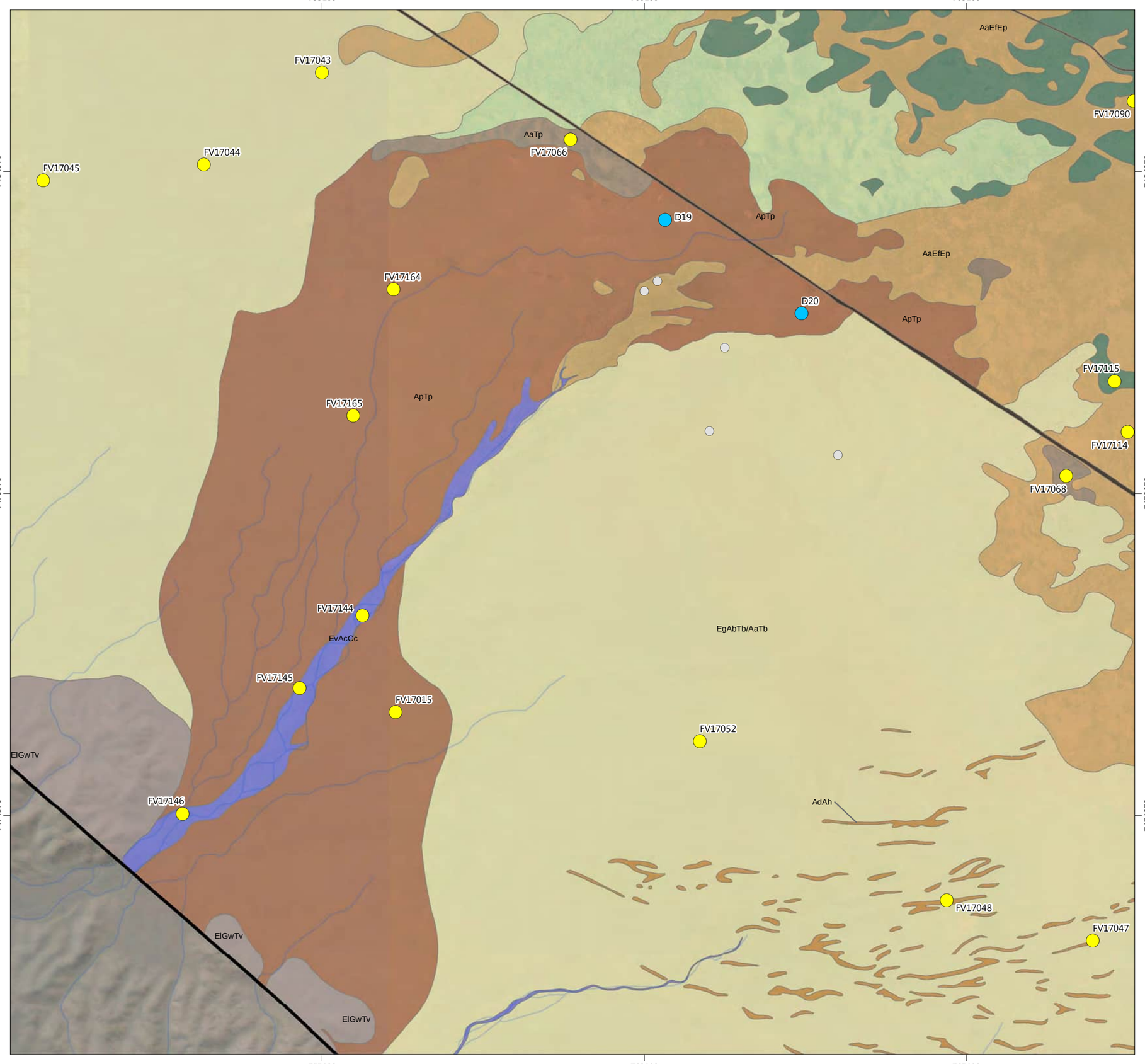
SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP
7K



LEGEND

- Homestead
- Study Area

Survey Quadrats

Established by

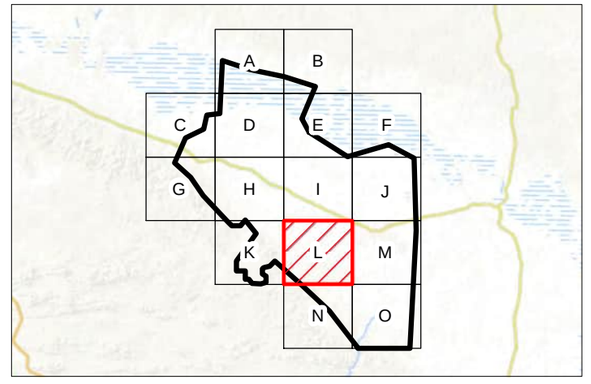
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type

Mapping Unit

- AaEfEp
- AaSaEp
- AaTb
- AaTp
- AdAh
- ApTp
- AxEcSc
- Cleared
- EgAbTb/AaTb
- ElGwTv
- EvAcCc

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 7L

770100
775100
780100
7484970
7479970
7474970

FV17090
FV17089
FV17009
FV17168
FV17166
FV17003
FV17008
FV17167
FV17091
FV17002
FV17115
FV17114
FV17117
FV17004
FV17007
FV17120
FV17125
FV17123
FV17124
FV17001
FV17054
FV17055
FV17047
FV17057
FV17053
FV17006
FV17005

AxEcSc
AxEcTe
EvDfEb
AaSaEp
AbTv
AaTb
AsTe
AaEfEp
EgAbTb/AaTb
AaAtRa

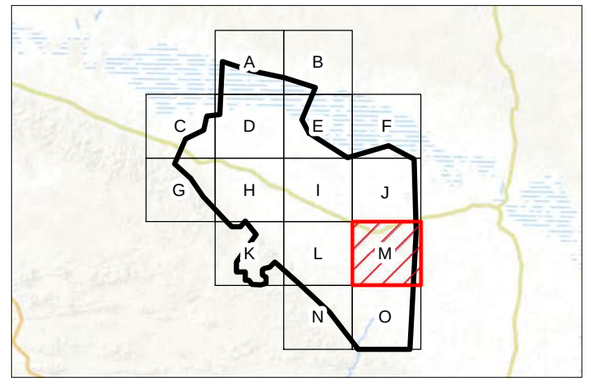
LEGEND

- Homestead
- Study Area

Survey Quadrats
Established by
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type
Mapping Unit
- AaAtRa
- AaEfEp
- AaSaEp
- AaTb
- AaTp
- AbTl
- AbTv
- AdAh
- AsTe
- AxEcSc
- AxEcTe
- Claypan
- Cleared
- EgAbTb/AaTb
- EvDfEb
- EyAb
- Open Water
- Tl

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

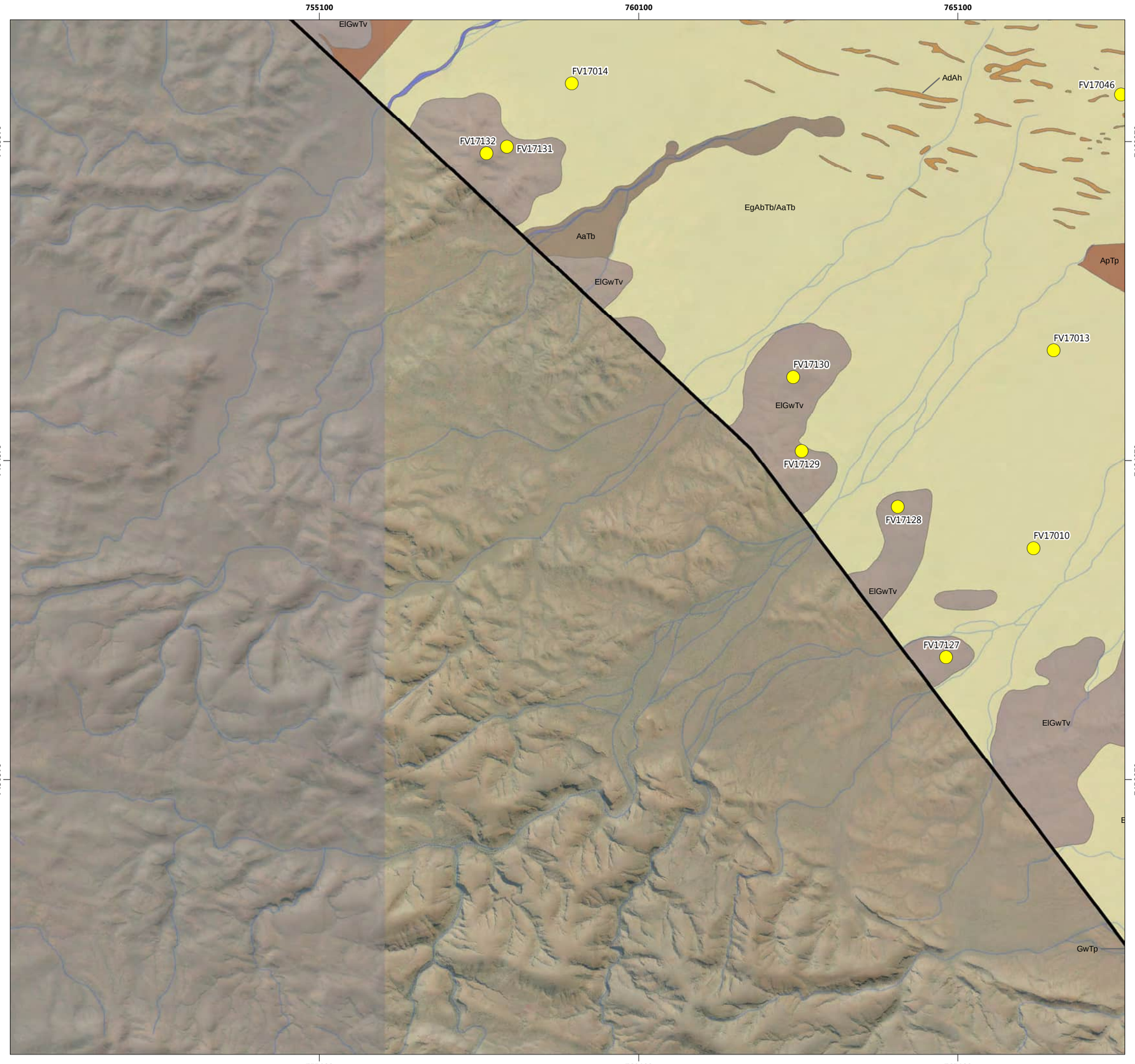
SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP
7 M



LEGEND

- Homestead
- Study Area

Survey Quadrats

Established by

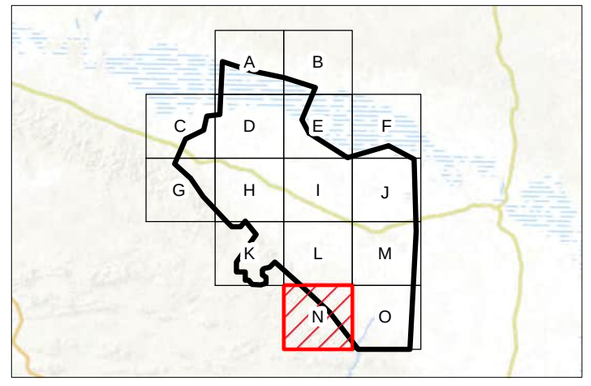
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks

Vegetation Type

Mapping Unit

- AaTb
- AdAh
- ApTp
- EgAbTb/AaTb
- ElGwTv
- EvAcCc

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

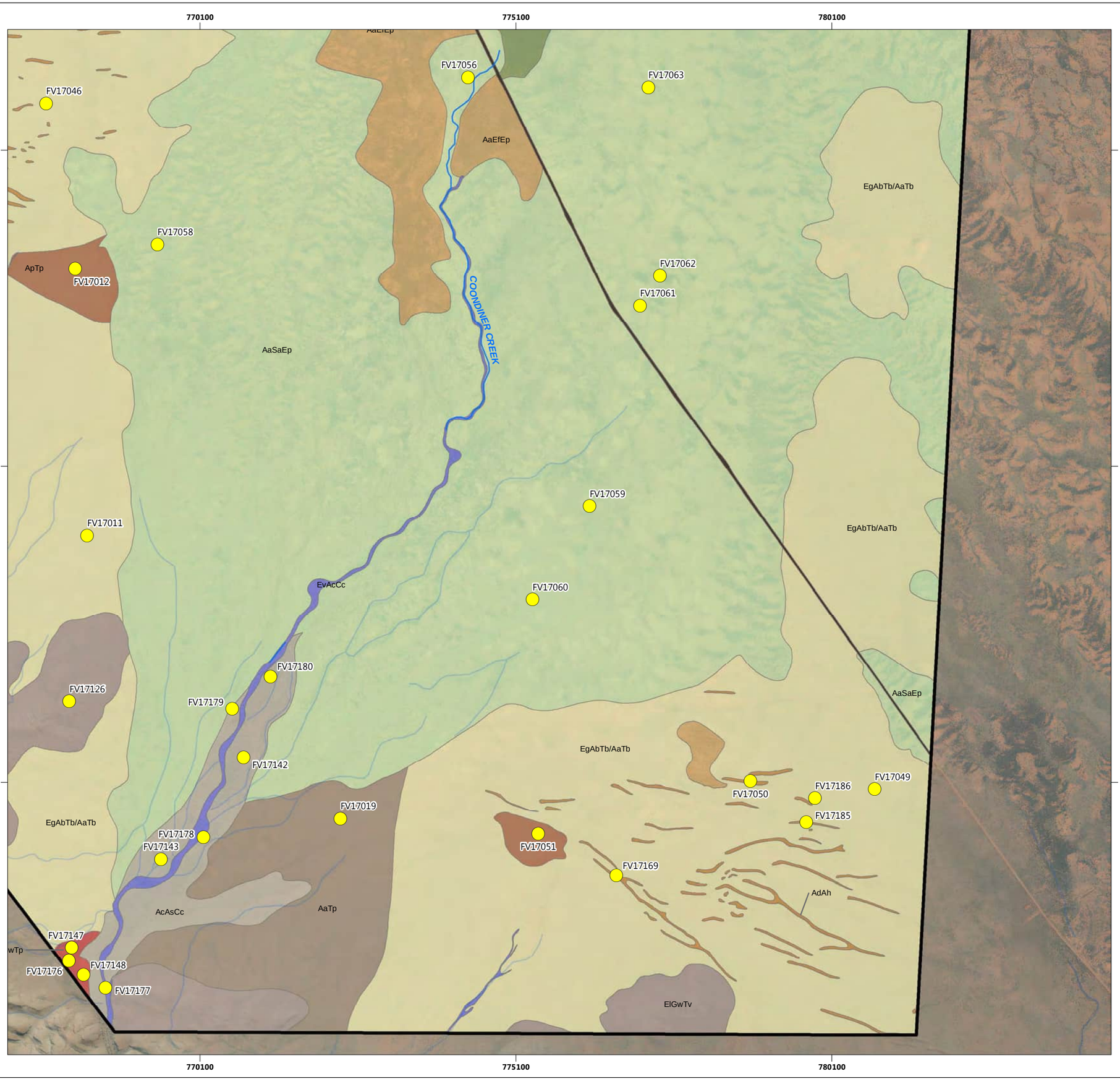
SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 7N



LEGEND

- Homestead

Survey Quadrats

Established by

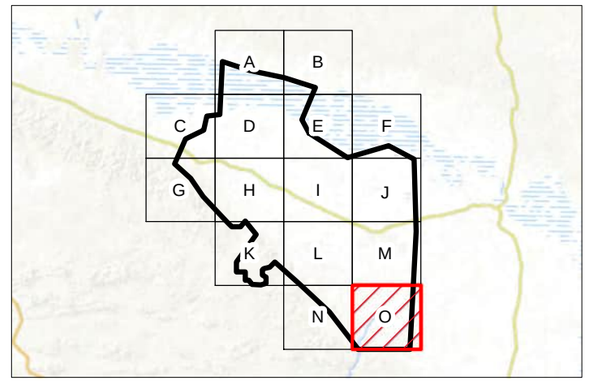
- Cardno (2012)
- Ecoscape (2017)
- Cardno (2012) Quadrats not re-scored
- Intersecting DBCA (2016) Quadrats
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area

Vegetation Type

Mapping Unit

- AaAtRa
- AaEfEp
- AaSaEp
- AaTp
- AcAsCc
- AdAh
- ApTp
- Cleared
- EgAbTb/AaTb
- ElGwTv
- EvAcCc
- GwTp

OVERVIEW



ecoscape

QUADRAT LOCATIONS AND VEGETATION TYPES

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:60,000 @ A3

0 0.5 1 1.5 2 2.5 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 70

730100 740100 750100

7529970 7519970 7509970

FV17094 FV17096 FV17095 FV17181 FV17042 FV17097 FV17184 FV17098 FV17183 FV17182 FV17099 FV17100 FV17041 FV17102 FV17039 FV17175 FV17038 FV17106 FV17108 FV17040 FV17107 FV17103 FV17104 FV17105 FV17112 FV17111 FV17110 FV17109 C050 FV17031 FV17030 A020 C052 FV17171 FV17101 FV17113 FV17170 FV17080 FV17079 FV17116 FV17077 FV17075 FV17076 FV17078 B108 B097 FV17159 FV17149 FV17156 FV17160 FV17150

730100 740100 750100

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area

Survey Quadrats

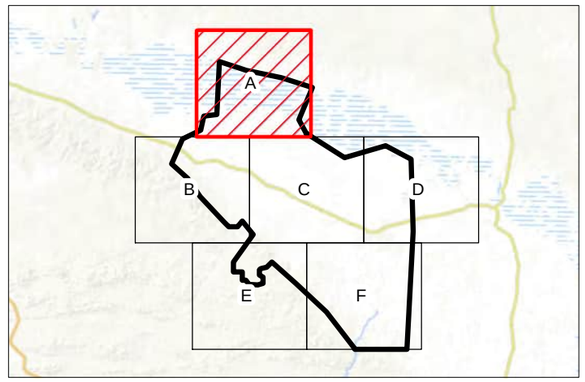
Vegetation Condition Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

Vegetation Condition Mapping Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

OVERVIEW



ecoscape

VEGETATION CONDITION MAPPING

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

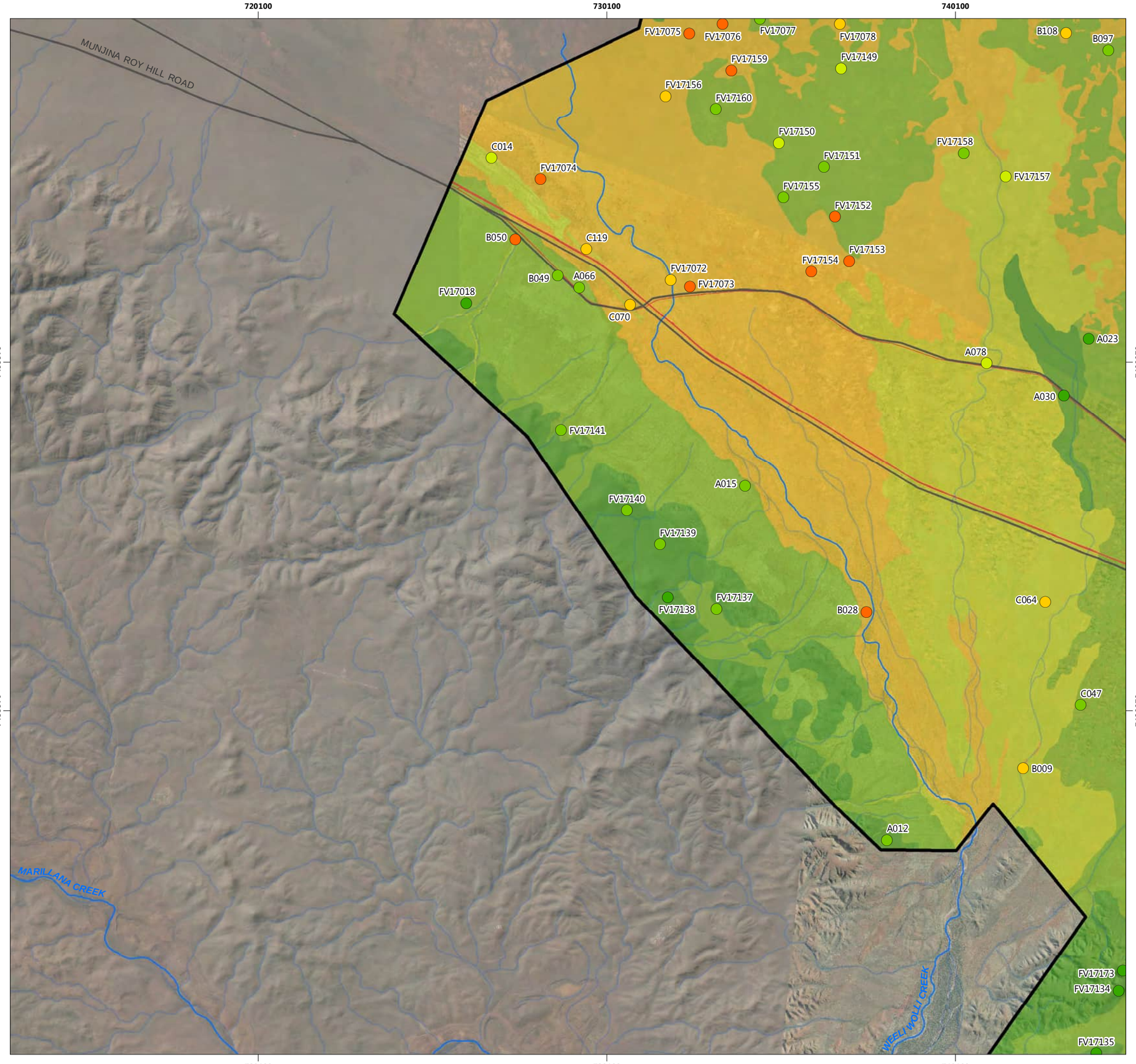
SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 8A



LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area

Survey Quadrats

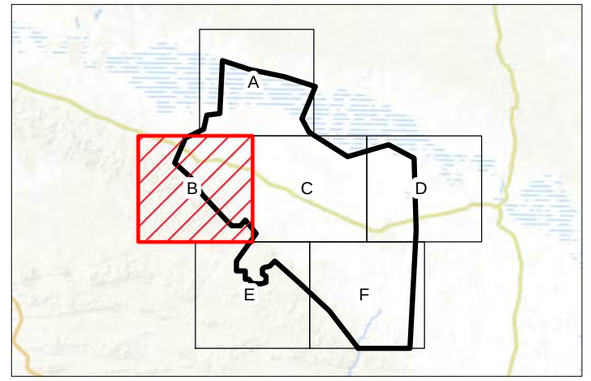
Vegetation Condition Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

Vegetation Condition Mapping Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

OVERVIEW



ecoscape

VEGETATION CONDITION MAPPING

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP

8B

750100 760100 770100

7499970 7489970

B108 B097 FV17157 FV17161 FV17162 FV17081 FV17083 FV17082 A023 A078 A030 B122 FV17071 FV17029 FV17093 FV17092 FV17027 MARILLANA HOMESTEAD FV17028 C064 FV17065 FV17070 FV17085 FV17086 FV17087 FV17025 FV17026 MUNJINA ROY HILL ROAD C047 FV17064 FV17069 FV17067 FV17020 FV17088 FV17163 B009 FV17084 FV17043 FV17090 FV17089 FV17009 FV17066 FV17045 FV17044 FV17003 FV17166 D19 FV17091 FV17164 FV17173 D20 FV17002 FV17134 FV17115 FV17165 FV17114 FV17133 FV17135 FV17016 FV17068

750100 760100 770100

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area

Survey Quadrats

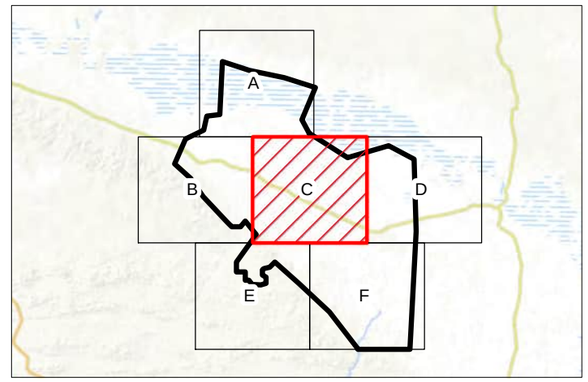
Vegetation Condition Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

Vegetation Condition Mapping Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

OVERVIEW



ecoscape

VEGETATION CONDITION MAPPING

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

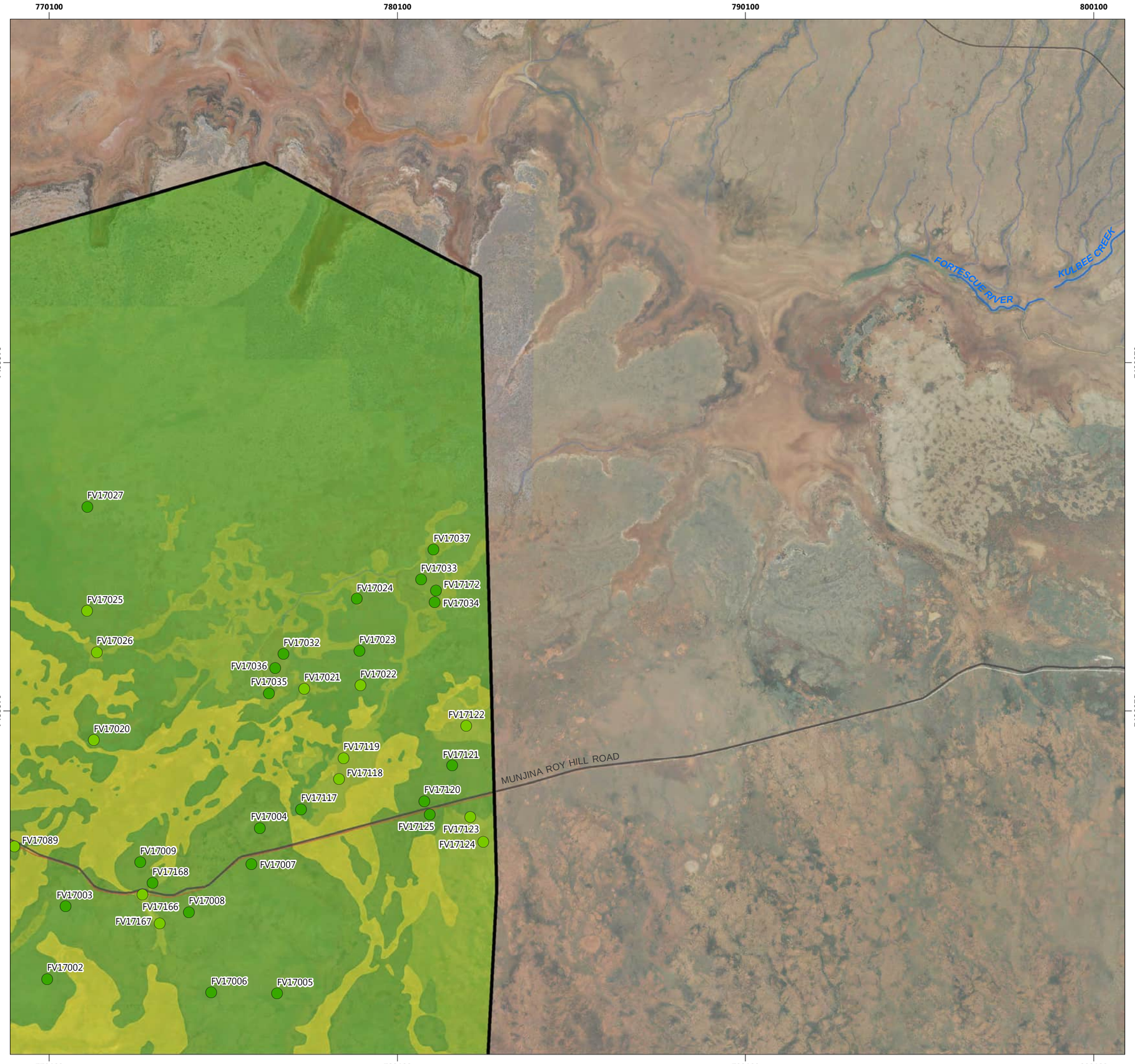
SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 8C



LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area

Survey Quadrats

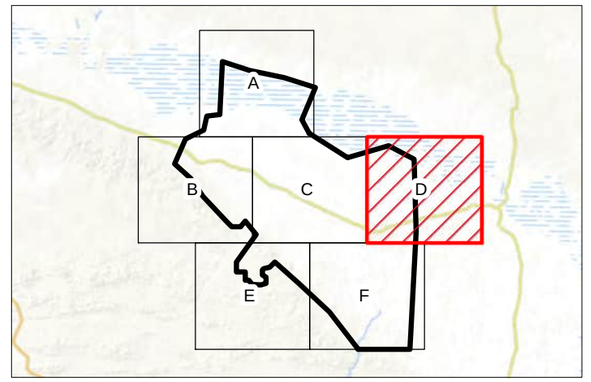
Vegetation Condition Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

Vegetation Condition Mapping Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

OVERVIEW



ecoscape

VEGETATION CONDITION MAPPING

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 8D

730100
740100
750100
7479970
7469970
7459970

MARILLANA CREEK
YANDICOOGINA CREEK
WEELIWOLLI CREEK

FV17164
FV17173
FV17134
FV17165
FV17133
FV17135
FV17016
FV17017
FV17144
FV17145
FV17015
FV17174
FV17146
FV17136
FV17131
FV17132

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area

Survey Quadrats

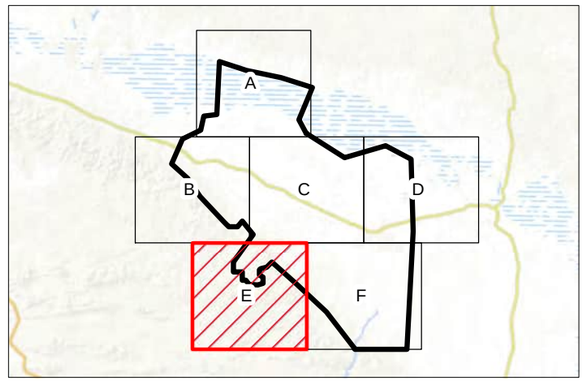
Vegetation Condition Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

Vegetation Condition Mapping Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

OVERVIEW



ecoscape

VEGETATION CONDITION MAPPING

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP
8 E

760100 770100 780100

7479970 7469970 7459970

FV17164 FV17091 D20 FV17002 FV17115 FV17006 FV17005 FV17165 FV17114 FV17068 FV17144 FV17001 FV17015 FV17052 FV17048 FV17054 FV17055 FV17047 FV17057 FV17053 FV17014 FV17046 FV17056 FV17063 FV17131 FV17132 FV17058 FV17012 FV17062 FV17061 FV17013 FV17130 FV17129 FV17128 FV17059 FV17010 FV17011 FV17060 FV17127 FV17126 FV17180 FV17179 FV17142 FV17050 FV17186 FV17019 FV17051 FV17185 FV17049 FV17178 FV17143 FV17169 FV17147 FV17176 FV17177

COONDIWER CREEK

760100 770100 780100

LEGEND

- Homestead
- Roads
- FMG Chichester Infrastructure
- Rivers
- Creeks
- Study Area

Survey Quadrats

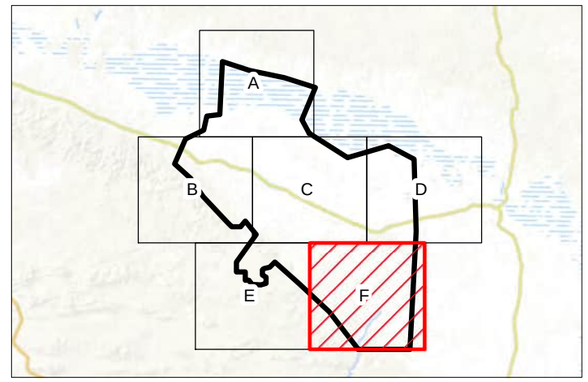
Vegetation Condition Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

Vegetation Condition Mapping Rating

- Excellent
- Very Good
- Good
- Poor
- Degraded
- Completely Degraded

OVERVIEW



ecoscape

VEGETATION CONDITION MAPPING

FORTESCUE VALLEY FLORA AND VEGETATION ASSESSMENT

CLIENT: FORTESCUE METALS GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:110,000 @ A3

0 1 2 3 4 km

PROJECT NO: 3937-17

REV	AUTHOR	APPROVED	DATE
0	JN	MW	28/11/2017

MAP 8F

APPENDIX ONE DEFINITIONS AND CRITERIA

Table 13: EPBC Act categories for flora and fauna

EPBC ACT 1999 category	Definition
Extinct	A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
Extinct in the wild	A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time: (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CE)	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered (EN)	A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable (VU)	A native species is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent	A native species is eligible to be included in the conservation dependent category at a particular time if, at that time: (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Table 14: Conservation codes for Western Australian flora and fauna (DPaW 2017)

Conservation Codes for Western Australian Flora and Fauna	
T	**Threatened species*** Published as Specially Protected under the *Wildlife Conservation Act 1950*, and listed under Schedules 1 to 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora (which may also be referred to as Declared Rare Flora). • ***Threatened fauna*** is that subset of 'Specially Protected Fauna' declared to be ' likely to become extinct' pursuant to section 14(4) of the Wildlife Conservation Act. • ***Threatened flora*** is flora that has been declared to be 'likely to become extinct or is rare, or is otherwise in need of special protection' pursuant to section 23F(2) of the Wildlife Conservation Act. The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.
CR	**Critically Endangered species** Threatened species considered to be facing an extremely high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.
EN	**Endangered species** Threatened species considered to be facing a very high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.
VU	**Vulnerable species** Threatened species considered to be facing a high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.
EX	**Presumed extinct species** Species which have been adequately searched for and there is no reasonable doubt that the last individual has died. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 4 of the Wildlife Conservation (Specially Protected Fauna) for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.
IA	**Migratory birds protected under an international agreement** Birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and the Bonn Convention, relating to the protection of migratory birds. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice.
CD	**Conservation Dependent fauna** Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice
OS	**Other specially protected fauna** Fauna otherwise in need of special protection to ensure their conservation. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice
P	**Priority species** Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna. Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.
P1	**Priority One: Poorly-known species** Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road or rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
P2	**Priority Two: Poorly-known species** Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
P3	**Priority Three: Poorly-known species** Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

Conservation Codes for Western Australian Flora and Fauna	
P4	**Priority Four: Rare, Near Threatened and other species in need of monitoring** (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable, but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
[1]The definition of flora includes algae, fungi and lichens. [2]Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).	

Table 15: DBCA definitions and criteria for TECs and PECs (Department of Environment and Conservation 2013)

Criteria	Definition
Threatened Ecological Communities	
Presumed Totally Destroyed (PD)	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B): A. Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats or B. All occurrences recorded within the last 50 years have since been destroyed
Critically Endangered (CR)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): A. The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii): i. geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years); ii. modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated. B. Current distribution is limited, and one or more of the following apply (i, ii or iii): i. geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years); ii. there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes; iii. there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes. C. The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).
Endangered (EN)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B, or C): A. The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement and either or both of the following apply (i or ii): i. the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years); ii. modification throughout its range is continuing such that in the short term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated. B. Current distribution is limited, and one or more of the following apply (i, ii or iii): i. geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years); ii. there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes; iii. there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes. The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).

Criteria	Definition
Vulnerable (VU)	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B or C): A. The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated. B. The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations. C. The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.
Priority ecological communities	
Priority One	*Poorly known ecological communities* Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority Two	*Poorly known ecological communities* Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, state forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities, but do not meet adequacy of survey requirements, and / or are not well defined, and appear to be under threat from known threatening processes.
Priority Three	*Poorly known ecological communities* i. Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or; ii. Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; iii. Communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities, but do not meet adequacy of survey requirements and / or are not well defined, and known threatening processes exist that could affect them.
Priority Four	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. i. Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change These communities are usually represented on conservation lands. ii. Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. iii. Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority Five	*Conservation Dependent Ecological Communities* Ecological Communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Table 16: NVIS structural formation terminology, terrestrial vegetation (ESCAVI 2003)

	Cover characteristics							
	Foliage cover *	70-100	30-70	10-30	<10	» 0 (scattered)	0-5 (clumped)	unknown
	Cover code	d	c	i	r	bi	bc	unknown
Growth Form	**Height Ranges (m)**	**Structural Formation Classes**						
tree, palm	<10,10-30, >30	closed forest	open forest	woodland	open woodland	isolated trees	isolated clumps of trees	tree, palm
tree mallee	<3, <10, 10-30	closed mallee forest	open mallee forest	mallee woodland	open mallee woodland	isolated mallee trees	isolated clumps of mallee trees	tree mallee
shrub, cycad, grass-tree, tree-fern	<1,1-2,>2	closed shrubland	shrubland	open shrubland	sparse shrubland	isolated shrubs	isolated clumps of shrubs	shrub, cycad, grass-tree, tree-fern
mallee shrub	<3, <10, 10-30	closed mallee shrubland	mallee shrubland	open mallee shrubland	sparse mallee shrubland	isolated mallee shrubs	isolated clumps of mallee shrubs	mallee shrub
heath shrub	<1,1-2,>2	closed heathland	heathland	open heathland	sparse heathland	isolated heath shrubs	isolated clumps of heath shrubs	heath shrub
chenopod shrub	<1,1-2,>2	closed chenopod shrubland	chenopod shrubland	open chenopod shrubland	sparse chenopod shrubland	isolated chenopod shrubs	isolated clumps of chenopod shrubs	chenopod shrub
samphire shrub	<0.5,>0.5	closed samphire shrubland	samphire shrubland	open samphire shrubland	sparse samphire shrubland	isolated samphire shrubs	isolated clumps of samphire shrubs	samphire shrub
hummock grass	<2,>2	closed hummock grassland	hummock grassland	open hummock grassland	sparse hummock grassland	isolated hummock grasses	isolated clumps of hummock grasses	hummock grass
tussock grass	<0.5,>0.5	closed tussock grassland	tussock grassland	open tussock grassland	sparse tussock grassland	isolated tussock grasses	isolated clumps of tussock grasses	tussock grass
other grass	<0.5,>0.5	closed grassland	grassland	open grassland	sparse grassland	isolated grasses	isolated clumps of grasses	other grass
sedge	<0.5,>0.5	closed sedgeland	sedgeland	open sedgeland	sparse sedgeland	isolated sedges	isolated clumps of sedges	sedge
rush	<0.5,>0.5	closed rushland	rushland	open rushland	sparse rushland	isolated rushes	isolated clumps of rushes	rush
herb	<0.5,>0.5	closed herbland	herbland	open herbland	sparse herbland	isolated herbs	isolated clumps of herbs	herb
fern	<1,1-2,>2	closed fernland	fernland	open fernland	sparse fernland	isolated ferns	isolated clumps of ferns	fern
bryophyte	<0.5	closed bryophyte-land	bryophyte-land	open bryophyteland	sparse bryophyteland	isolated bryophytes	isolated clumps of bryophytes	bryophyte
lichen	<0.5	closed lichenland	lichenland	open lichenland	sparse lichenland	isolated lichens	isolated clumps of lichens	lichen
vine	<10,10-30, >30	closed vineland	vineland	open vineland	sparse vineland	isolated vines	isolated clumps of vines	vine

Table 17: NVIS height classes (ESCAVI 2003)

Height		Growth form				
Height Class	**Height Range (m)**	**Tree, vine (M & U), palm (single-stemmed)**	**Shrub, heath shrub, chenopod shrub, ferns, samphire shrub, cycad, tree-fern, grass-tree, palm (multi-stemmed)**	**Tree mallee, mallee shrub**	**Tussock grass, hummock grass, other grass, sedge, rush, forbs, vine (G)**	**Bryophyte, lichen, seagrass, aquatic**
8	>30	tall	NA	NA	NA	NA
7	10-30	mid	NA	tall	NA	NA
6	<10	low	NA	mid	NA	NA
5	<3	NA	NA	low	NA	NA
4	>2	NA	tall	NA	tall	NA
3	1-2	NA	mid	NA	tall	NA
2	0.5-1	NA	low	NA	mid	tall
1	<0.5	NA	low	NA	low	low

Source: (based on Walker & Hopkins 1990)

Table 18: Vegetation condition scale for the Eremaean and Northern Botanical Provinces (EPA 2016d)

Condition rating	Description
Excellent	Pristine or nearly so, no obvious signs of disturbance or damage caused by human activities since European settlement.
Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

APPENDIX TWO DATABASE SEARCH RESULTS

Table 19: Conservation significant flora database search results (vascular flora)

Species name	EPBC Act status	DBCA status	Habitat	Likelihood of occurrence
Acacia aphanoclada	-	P1	Stony soils. Ridges and rises. *T. wiseana, E. leucophloia, A. inaequilatera.*	Unlikely
Acacia cyperophylla var. *omearana*	-	P1	Alluvium. Creeks. *E. victrix, E. camaldulensis, A. tumida.*	Unlikely
Acacia sp. Nullagine (B.R. Maslin 4955)	-	P1	Clay. *A. trachycarpa.*	Unlikely
Atriplex spinulosa	-	P1	Gibber plains, clay. Creeks. *T. longiceps.*	Unlikely
Calotis squamigera	-	P1	Pebbly loam, clay. Drainage lines. Mulga, *A. xiphophylla.*	Recorded
Cochlospermum macnamarae	-	P1	Granite rocks, skeletal soil. Low hills. *Triodia, A. tumida.*	Highly Unlikely
Dicrastylis mitchellii	-	P1	Sand, clay.	Unlikely
Dipteracanthus chichesterensis	-	P1	Basalt. Tablelands. *A. xiphophylla, T. wiseana, T. epactia.*	Unlikely
Eremophila pilosa	-	P1	Red sand, red clay loam. Flat. *Triodia.*	Possible
Eremophila sp. Hamersley Range (K. Walker KW 136)	-	P1	Ironstone. Upper slopes, scree, hills. Mulga, *E. leucophylla.*	Unlikely
Eremophila spongiocarpa	-	P1	Subsaline clay loams. Marsh. Samphire, Mulga, *A. synchronicia.*	Recorded
Helichrysum oligochaetum	-	P1	Clay. Alluvial plains, depressions. *E. victrix, E. camaldulensis.*	Recorded
Myriocephalus scalpellus	-	P1	Clay pan. *E. victrix*, daisies.	Recorded
Nicotiana heterantha	-	P1	Clay. Floodplains, lake beds. Samphire, *E. victrix.*	Recorded
Ptilotus wilsonii	-	P1	Calcrete. Lower slope. *E. leucophloia, T. longiceps, T. brizoides.*	Unlikely
Rhodanthe ascendens	-	P1	Clay. Gibber plain. Mulga.	Unlikely
Samolus sp. Fortescue Marsh (A. Markey & R. Coppen FM 9702)	-	P1	Calcrete salt pan, clay. Marsh, (fresh) lake margin. Samphire, *Triodia.*	Recorded
Stemodia sp. Battle Hill (A.L. Payne 1006)	-	P1	Cracking clay. Valley, drainage. Grasses.	Possible
Synostemon hamersleyensis	-	P1	Ironstone. Steep hills. *E. leucophloia, Triodia.*	Recorded
Tecticornia globulifera	-	P1	Clay. Saline flats, lake bed. Samphires.	Recorded
Tecticornia sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063)	-	P1	Clay. Marsh, depressions. Samphire.	Recorded
Tribulus minutus	-	P1	Calcrete. Stony rise.	Highly Unlikely
Adiantum capillus-veneris	-	P2	Calcrete. Wet sheltered sites in gorges.	Unlikely
Aristida lazaridis	-	P2	Sand, loamy sand. Plains. Mulga, *E. leucophloia.*	Possible
Cladium procerum	-	P2	Alluvium. Creeks, gorges. *E. victrix, E. camaldulensis, Typha.*	Unlikely
Eremophila pusilliflora	-	P2	Alluvium, colluvium, clay. Plain, alluvial fan, drainage. Mulga, *Acacia* spp.	Possible
Euphorbia australis var. *glabra*	-	P2	Clay, calcrete/silcrete. Plains. Grasses, Mulga.	Recorded
Hibiscus sp. Gurinbiddy Range (M.E. Trudgen MET 15708)	-	P2	Skeletal soil, ironstone. Creeks, gullies. *C. ferriticola, E. leucophloia, A. citrinoviridis.*	Possible
Indigofera ixocarpa	-	P2	Skeletal soil, ironstone, alluvium. Creeks, gullies, high hills. *E. leucophloia*, Mulga.	Unlikely
Ipomoea racemigera	-	P2	Alluvium, sand. Creeklines. *E. camaldulensis, E. victrix.*	Possible
Isotropis parviflora	-	P2	Alluvium, stony sand, ironstone. Upper slope,	Possible

Species name	EPBC Act status	DBCA status	Habitat	Likelihood of occurrence
			hills, plains. *Triodia*.	
Oxalis sp. Pilbara (M.E. Trudgen 12725)	-	P2	Alluvium. Sheltered drainage. *E. leucophloia*.	Unlikely
Paspalidium retiglume	-	P2	Clay, cracking clay. Plains. Grasslands, herblands.	Unlikely
Stylidium weeliwolli	-	P2	Gritty clay, loam. Creeklines, seepage. Sedges, herbs, *E. camaldulensis, E. victrix, M. argentea.*	Recorded
Teucrium pilbaranum	-	P2	Cracking clay, calcrete. Plain, drainage. Herblands, *Acacia*, grasslands.	Unlikely
Acacia daweana	-	P3	Clay, stony loam. Scree, slopes, drainage lines. Emergent Eucalypts, *Acacia* spp.	Unlikely
Acacia effusa	-	P3	Rocky loam. Scree, footslopes, plain. *E. leucophloia, C. deserticola, Triodia.*	Unlikely
Acacia fecunda	-	P3	Alluvium, colluvium. Creek, gullies. *Acacia* spp., *E. leucophloia.*	Unlikely
Acacia levata	-	P3	Sand, sandy loam over granite. Flats, granite outcrops. *Acacia* spp.	Highly Unlikely
Acacia subtiliformis	-	P3	Calcrete, colluvium. Hills, mounds. Eucalypts, *Acacia* spp., *Triodia.*	Recorded
Amaranthus centralis	-	P3	Clay, alluvium. Flat, water courses. Mulga, grassland, *E. victrix.*	Possible
Ampelopteris prolifera	-	P3	Gorges. *E. victrix.*	Highly Unlikely
Aristida jerichoensis var. *subspinulifera*	-	P3	Hardpan clay, clay loam. Plains, low slopes. Mulga, grasslands, *E. leucophloia.*	Possible
Atriplex flabelliformis	-	P3	Clay loam, loam. Marsh, plains. Samphires.	Recorded
Crotalaria smithiana	-	P3	Floodplain. Mulga, grassland.	Possible
Dampiera anonyma	-	P3	Skeletal soils, ironstone, basalt. High hills. *E. gamophylla, E. kingsmillii, E. leucophloia.*	Highly Unlikely
Dampiera metallorum	-	P3	Skeletal soils, ironstone. High hills. *E. gamophylla, E. kingsmillii, E. leucophloia.*	Highly Unlikely
Dysphania congestiflora	-	P3	Saline clay. Marsh, edge of floodplain, lake bed. Samphires, *Eremophila spongiocarpa.*	Possible
Eleocharis papillosa	-	P3	Clay. Seasonally inudated Marsh. Samphires, *Muehlenbeckia florulenta*.	Possible
Eragrostis crateriformis	-	P3	Clay, clay loam. Drainage lines, creek beds, depressions. *Triodia, E. victrix, Acacia* spp.	Recorded
Eragrostis surreyana	-	P3	Alluvium, clay, sandy clay, seasonally wet areas. Drainage lines, floodplains. *E. victrix, E. camaldulensis, Melaleuca* spp.	Unlikely
Eremophila magnifica subsp. *velutina*	-	P3	Skeletal ironstone. Hills. *E. leucophloia, T. wiseana.*	Unlikely
Eremophila rigida	-	P3	Clay. Flats. Mulga.	Unlikely
Eucalyptus rowleyi	-	P3	Red sandy loam. Plains, high hills, creeklines. *Triodia, E. leucophloia, E. gamophylla.*	Possible
Euphorbia stevenii	-	P3	Colluvium, sandy clay loams, basalt. Floodplains, creeklines. Grassland, *A. xiphophylla.*	Unlikely
Glycine falcata	-	P3	Loam, cracking clay. Plain. Grassland.	Possible
Goodenia lyrata	-	P3	Clay loam. Plain. *E. victrix*, Mulga.	Unlikely
Goodenia sp. East Pilbara (A.A. Mitchell PRP 727)	-	P3	Clay, loam, calcrete, ironstone. Low rises, plains, creeklines. *Triodia*, scattered trees.	Possible
Grevillea saxicola	-	P3	Skeletal clay loam. Hills, gullies. *E. leucophloia*, Mulga, *A. pruinocarpa, A. citrinoviridis, Triodia.*	Unlikely
Gymnanthera cunninghamii	-	P3	Alluvium. Drainage lines, floodplain. *E. victrix, E. camaldulensis, Acacia* spp., *Melaleuca* spp.	Possible
Indigofera gilesii	-	P3	Ironstone, scree, alluvium. High hills, cliffs. *E. leucophloia, C. ferriticola, E. gamophylla,*	Unlikely

Species name	EPBC Act status	DBCA status	Habitat	Likelihood of occurrence
			Triodia.	
Iotasperma sessilifolium	-	P3	Cracking clay. Plains, floodplains. Grasslands, herblands.	Possible
Nicotiana umbratica	-	P3	Skeletal soil. Sheltered areas, boulder piles. *E. leucophloia.*	Unlikely
Oldenlandia sp. Hamersley Station (A.A. Mitchell PRP 1479)	-	P3	Cracking clay, basalt. Plains, floodplains. Grassland, herbland.	Unlikely
Olearia mucronata	-	P3	Ironstone, clay. Scree, cliffs, low hills. *E. leucophloia*, Mulga, *G. berryana, Triodia*.	Unlikely
Polymeria distigma	-	P3	Cracking clay, alluvium. Floodplain, drainage line. *E. victrix*, grassland.	Possible
Rhagodia sp. Hamersley (M. Trudgen 17794)	-	P3	Clay, loam. Floodplain, plain. *E. leucophloia*, Mulga, grassland.	Recorded
Rostellularia adscendens var. *latifolia*	-	P3	Ironstone, calcrete. Creeks, gullies, hills. *Acacia* spp., *E. victrix.*	Possible
Sida sp. Barlee Range (S. van Leeuwen 1642)	-	P3	Ironstone. Cliffs, gullies, gorges. *C. ferriticola*, Mulga, *E. leucophloia.*	Possible
Solanum albostellatum	-	P3	Cracking clays. Floodplains. Grassland, *A. xiphophylla.*	Highly Unlikely
Tecticornia medusa	-	P3	Saline clay. Marsh, inundated. Samphire, herbs.	Recorded
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	-	P3	Clay, alluvium. Plains, drainage lines. Mulga, grassland, *E. victrix.*	Possible
Triodia sp. Mt Ella (M.E. Trudgen 12739)	-	P3	Alluvium, skeletal ironstone. Gullies, creeks, scree. *E. leucophloia, C. ferriticola*, Mulga.	Possible
Xerochrysum boreale	-	P3	Stony clay loam. Floodplain. Mulga.	Possible
Acacia bromilowiana	-	P4	Skeletal loam, ironstone. Hills, breakaways, steep slopes, creek beds. *E. leucophloia, C. hamersleyana, T. wiseana, T. epactia.*	Unlikely
Eremophila magnifica subsp. *magnifica*	-	P4	Skeletal loam, ironstone. Scree, hillslopes. *E. leucophloia, C. hamersleyana, T. wiseana, T. epactia.*	Possible
Eremophila youngii subsp. *lepidota*	-	P4	Sandy clay, sandy loam. Drainage line, floodplain. Mulga, chenopods.	Recorded
Goodenia nuda	-	P4	Alluvium, clay. Drainage lines, floodplain. *E. victrix, E. leucophloia*, Mulga, grasses.	Recorded
Lepidium catapycnon	VU	P4	Skeletal ironstone. Hills; pioneer species. *E. leucophloia, T. wiseana.*	Recorded
Rhynchosia bungarensis	-	P4	Alluvium, basalt, clay. Creeklines, gullies, boulder piles, floodplain. *E. victrix, Acacia* spp.	Possible

Highlighted species are those identified as having 'possible' likelihood of occurrence or have been previously recorded within the study area.

Habitat information derived from *FloraBase* descriptions and relevant specimen records (WAH 1998-2017) and *Rare and Priority Plants of the Pilbara mobile app edition* (Rio Tinto and DPaW 2015).

Species removed from the above table due to being identified by DBCA 'place name' database search but having distributions a significant distance from the study area (700-2 500 km) were: *Triodia triticoides* (P1; a Kimberley species), *Aristida calycina* var. *calycina* (P2, a Queensland species), and *Eucalyptus fraseri* subsp. *melanobasis* (P2), *Eucalyptus histophylla* (P3), *Eucalyptus georgei* subsp. *georgei* (P4), *Eucalyptus nigrifunda* (P4) and *Myriophyllum balladoniense* (P4), all Mallee or Coolgardie IBRA region species.

APPENDIX THREE FLORA INVENTORY

Table 20: Flora inventory (Ecoscape 2017 survey)

The complete site by species table is supplied in electronic format due to the large number of records.

Family	Species	Naturalised	WA Conservation Code
Acanthaceae	*Rostellularia adscendens* var. *clementii*		
	Trianthema glossostigmum		
	Trianthema pilosum		
	Trianthema triquetrum		
Aizoaceae	*Trianthema turgidifolium*		
	Aerva javanica	*	
	Alternanthera denticulata		
	Alternanthera nana		
	Alternanthera nodiflora		
	Amaranthus cuspidifolius		
	Gomphrena affinis subsp. *pilbarensis*		
	Gomphrena canescens		
	Gomphrena cunninghamii		
	Gomphrena kanisii		
	Ptilotus aervoides		
	Ptilotus astrolasius		
	Ptilotus axillaris		
	Ptilotus calostachyus		
	Ptilotus carinatus		
	Ptilotus clementii		
	Ptilotus fusiformis		
	Ptilotus gaudichaudii subsp. *gaudichaudii*		
	Ptilotus gomphrenoides		
	Ptilotus helipteroides		
	Ptilotus macrocephalus		
	Ptilotus nobilis subsp. *nobilis*		
	Ptilotus obovatus		
	Ptilotus polystachyus		
	Ptilotus rotundifolius		
Amaranthaceae	*Ptilotus schwartzii* var. *schwartzii*		
	Cynanchum floribundum		
	Marsdenia australis		
Apocynaceae	*Rhyncharrhena linearis*		
Araliaceae	*Trachymene oleracea* subsp. *oleracea*		
	Apowollastonia hamersleyensis		
	Asteraceae sp.		
	Bidens subalternans var. *simulans*	*	
	Blumea tenella		
	Calocephalus beardii		
	Calotis plumulifera		
Asteraceae	*Centipeda minima* subsp. *macrocephala*		

Family	Species	Naturalised	WA Conservation Code
	Chrysocephalum eremaeum		
	Chrysocephalum gilesii		
	Flaveria trinervia	*	
	Ixiochlamys cuneifolia		
	Leiocarpa semicalva		
	Myriocephalus scalpellus		P1
	Peripleura virgata		
	Pluchea dentex		
	Pluchea dunlopii		
	Pluchea ferdinandi-muelleri		
	Pluchea rubelliflora		
	Pseudognaphalium luteoalbum	*	
	Pterocaulon sphacelatum		
	Roebuckiella similis		
	Sonchus oleraceus	*	
	Streptoglossa adscendens		
	Streptoglossa bubakii		
	Streptoglossa decurrens		
	Streptoglossa liatroides		
	Streptoglossa macrocephala		
	Streptoglossa odora		
Asteraceae cont'	*Streptoglossa tenuiflora*		
	Ehretia saligna var. *saligna*		
	Halgania solanacea var. *solanacea*		
	Heliotropium chrysocarpum		
	Heliotropium cunninghamii		
	Heliotropium curassavicum		
	Heliotropium glanduliferum		
	Heliotropium heteranthum		
	Heliotropium inexplicitum		
	Heliotropium ovalifolium		
	Heliotropium pachyphyllum		
	Heliotropium tenuifolium		
	Trichodesma zeylanicum var. *grandiflorum*		
Boraginaceae	*Trichodesma zeylanicum* var. *zeylanicum*		
	Brassicaceae sp.		
	Lepidium catapycnon		P4
	Lepidium muelleri-ferdinandii		
	Lepidium phlebopetalum		
	Lepidium platypetalum		
	Lepidium sp.		
	Sisymbrium orientale	*	
Brassicaceae	*Stenopetalum nutans*		
Campanulaceae	*Wahlenbergia tumidifructa*		
Capparaceae	*Capparis lasiantha*		

Family	Species	Naturalised	WA Conservation Code
	Capparis spinosa var. *nummularia*		
Capparaceae cont'	*Capparis umbonata*		
	Polycarpaea corymbosa var. *corymbosa*		
	Polycarpaea holtzei		
Caryophyllaceae	*Polycarpaea longiflora*		
	Stackhousia intermedia		
Celastraceae	*Stackhousia muricata*		
	Atriplex amnicola		
	Atriplex bunburyana		
	Atriplex codonocarpa		
	Atriplex flabelliformis		P3
	Dissocarpus paradoxus		
	Dysphania kalpari		
	Dysphania melanocarpa forma *melanocarpa*		
	Dysphania rhadinostachya		
	Einadia nutans subsp. *eremaea*		
	Enchylaena tomentosa var. *tomentosa*		
	Maireana ?suaedifolia		
	Maireana amoena		
	Maireana carnosa		
	Maireana eriosphaera		
	Maireana georgei		
	Maireana luehmannii		
	Maireana melanocoma		
	Maireana planifolia		
	Maireana planifolia x villosa		
	Maireana platycarpa		
	Maireana pyramidata		
	Maireana tomentosa subsp. *tomentosa*		
	Maireana triptera		
	Maireana villosa		
	Rhagodia eremaea		
	Salsola australis		
	Sclerolaena cornishiana		
	Sclerolaena costata		
	Sclerolaena cuneata		
	Sclerolaena diacantha		
	Sclerolaena eriacantha		
	Sclerolaena lanicuspis		
	Tecticornia auriculata		
	Tecticornia globulifera		P1
	Tecticornia indica subsp. *leiostachya*		
	Tecticornia medusa		P3
	Tecticornia sp.		
Chenopodiaceae	*Tecticornia* sp. Christmas Creek (K.A. Shepherd & T.		P1

Family	Species	Naturalised	WA Conservation Code
	Colmer et al. KS 1063)		
Chenopodiaceae cont'	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)		
	Tecticornia verrucosa		
Cleomaceae	*Cleome viscosa*		
Convolvulaceae	*Bonamia erecta*		
	Bonamia pilbarensis		
	Convolvulus clementii		
	Cressa australis		
	Duperreya commixta		
	Evolvulus alsinoides var. *decumbens*		
	Evolvulus alsinoides var. *villosicalyx*		
	Ipomoea coptica		
	Ipomoea lonchophylla		
	Ipomoea muelleri		
	Ipomoea plebeia		
	Operculina aequisepala		
	Polymeria ambigua		
Cucurbitaceae	*Citrullus lanatus*	*	
	Cucumis melo		
	Cucumis variabilis		
Cyperaceae	*Bulbostylis barbata*		
	Bulbostylis turbinata		
	Cyperus bulbosus		
	Cyperus concinnus		
	Cyperus cunninghamii		
	Cyperus iria		
	Cyperus rigidellus		
	Cyperus vaginatus		
	Fimbristylis dichotoma		
	Fimbristylis microcarya		
	Fimbristylis simulans		
	Fimbristylis sp.		
Droseraceae	*Drosera finlaysoniana*		
Elatinaceae	*Bergia perennis* subsp. *exigua*		
	Bergia perennis subsp. *obtusifolia*		
	Bergia trimera		
Euphorbiaceae	*Euphorbia ?biconvexa* (sterile)		
	Euphorbia australis		
	Euphorbia australis var. *glabra*		P2
	Euphorbia australis var. *hispidula*		
	Euphorbia australis var. *subtomentosa*		
	Euphorbia biconvexa		
	Euphorbia boophthona		
	Euphorbia coghlanii		

Family	Species	Naturalised	WA Conservation Code
Euphorbiaceae cont'	*Euphorbia inappendiculata* var. *inappendiculata*		P2
	Euphorbia inappendiculata var. *queenslandica*		P1
	Euphorbia tannensis subsp. *eremophila*		
	Euphorbia wheeleri		
Fabaceae	*Acacia adoxa* var. *adoxa*		
	Acacia adsurgens		
	Acacia ancistrocarpa		
	Acacia aneura		
	Acacia aptaneura		
	Acacia arida		
	Acacia bivenosa		
	Acacia citrinoviridis		
	Acacia colei		
	Acacia coriacea subsp. *pendens*		
	Acacia dictyophleba		
	Acacia hilliana		
	Acacia inaequilatera		
	Acacia marramamba		
	Acacia melleodora		
	Acacia monticola		
	Acacia pachyacra		
	Acacia paraneura		
	Acacia pruinocarpa		
	Acacia pteraneura		
	Acacia ptychophylla		
	Acacia pyrifolia var. *pyrifolia*		
	Acacia rhodophloia		
	Acacia sclerosperma subsp. *sclerosperma*		
	Acacia sericophylla		
	Acacia sibirica		
	Acacia spondylophylla		
	Acacia synchronicia		
	Acacia tenuissima		
	Acacia tetragonophylla		
	Acacia trudgeniana		
	Acacia tumida var. *pilbarensis*		
	Acacia xiphophylla		
	Aeschynomene indica		
	Alysicarpus muelleri		
	Crotalaria cunninghamii		
	Crotalaria medicaginea var. *neglecta*		
	Cullen cinereum		
	Cullen graveolens		
	Cullen leucanthum		
	Cullen leucochaites		

Family	Species	Naturalised	WA Conservation Code
	Cullen martinii		
	Cullen pogonocarpum		
	Glycine canescens		
	Gompholobium oreophilum		
	Indigofera colutea		
	Indigofera georgei		
	Indigofera linifolia		
	Indigofera linnaei		
	Indigofera monophylla		
	Isotropis atropurpurea		
	Isotropis parviflora		P2
	Lotus cruentus		
	Mirbelia viminalis		
	Neptunia dimorphantha		
	Petalostylis cassioides		
	Petalostylis labicheoides		
	Rhynchosia minima		
	Senna artemisioides subsp. *helmsii*		
	Senna artemisioides subsp. *oligophylla*		
	Senna artemisioides subsp. *oligophylla x helmsii*		
	Senna ferraria		
	Senna glutinosa subsp. *chatelainiana*		
	Senna glutinosa subsp. *glutinosa*		
	Senna glutinosa subsp. *pruinosa*		
	Senna glutinosa subsp. *x luerssenii*		
	Senna notabilis		
	Senna sericea		
	Senna sp. Meekatharra (E. Bailey 1-26)		
	Senna symonii		
	Senna venusta		
	Sesbania cannabina		
	Swainsona formosa		
	Swainsona kingii		
	Swainsona leeana		
	Swainsona tanamiensis		
	Tephrosia arenicola		
	Tephrosia oxalidea		
	Tephrosia rosea var. Fortescue creeks (M.I.H. Brooker 2186)		
	Tephrosia sp. Bungaroo Creek (M.E. Trudgen 11601)		
	Tephrosia sp. Newman (A.A. Mitchell PRP 29)		
	Vachellia farnesiana	*	
Fabaceae cont'	*Vigna* sp. Hamersley Clay (A.A. Mitchell PRP 113)		
	Frankenia ambita		
Frankeniaceae	*Frankenia setosa*		

Family	Species	Naturalised	WA Conservation Code
Gentianaceae	*Schenkia clementii*		
	Dampiera candicans		
	Goodenia cusackiana		
	Goodenia forrestii		
	Goodenia lamprosperma		
	Goodenia microptera		
	Goodenia muelleriana		
	Goodenia nuda		P4
	Goodenia prostrata		
	Goodenia stobbsiana		
	Goodenia triodiophila		
	Goodenia vilmoriniae		
	Scaevola browniana subsp. *browniana*		
	Scaevola parvifolia subsp. *pilbarae*		
	Scaevola spinescens		
Goodeniaceae	*Velleia connata*		
Gyrostemonaceae	*Codonocarpus cotinifolius*		
Haloragaceae	*Haloragis gossei* var. *gossei*		
Hemerocallidaceae	*Corynotheca pungens*		
Juncaginaceae	*Triglochin hexagona*		
	Basilicum polystachyon		
	Clerodendrum floribundum var. *angustifolium*		
	Dicrastylis cordifolia		
	Newcastelia sp. Hamersley Range (S. van Leeuwen 4264)		
	Prostanthera albiflora		
Lamiaceae	*Teucrium racemosum*		
Lauraceae	*Cassytha capillaris*		
	Amyema fitzgeraldii		
	Amyema sanguinea		
Loranthaceae	*Lysiana casuarinae*		
	Ammannia multiflora		
Lythraceae	*Rotala diandra*		
	Abutilon cryptopetalum		
	Abutilon fraseri subsp. *fraseri*		
	Abutilon lepidum		
	Abutilon macrum		
	Abutilon malvifolium		
	Abutilon otocarpum		
	Abutilon oxycarpum subsp. Prostrate (A.A. Mitchell PRP 1266)		
	Abutilon sp.		
	Abutilon sp. Dioicum (A.A. Mitchell PRP 1618)		
	Abutilon sp. Pilbara (W.R. Barker 2025)		
	Androcalva loxophylla		
Malvaceae	*Corchorus* aff. *tectus*		

Family	Species	Naturalised	WA Conservation Code
	Corchorus crozophorifolius		
	Corchorus laniflorus		
	Corchorus lasiocarpus		
	Corchorus lasiocarpus subsp. *lasiocarpus*		
	Corchorus sidoides subsp. *sidoides*		
	Corchorus tridens		
	Gossypium australe		
	Gossypium robinsonii		
	Hibiscus brachychlaenus		
	Hibiscus burtonii		
	Hibiscus coatesii		
	Hibiscus leptocladus		
	Hibiscus sp. Mt Robinson (G. Byrne 3537)		
	Hibiscus sturtii var. *campylochlamys*		
	Hibiscus sturtii var. *platychlamys*		
	Hibiscus sturtii var. *truncatus*		
	Lawrencia densiflora		
	Malvastrum americanum	*	
	Melhania oblongifolia		
	Seringia elliptica		
	Sida arenicola		
	Sida arsiniata		
	Sida cardiophylla		
	Sida echinocarpa		
	Sida fibulifera		
	Sida platycalyx		
	Sida sp. Barlee Range (S. van Leeuwen 1642)		P3
	Sida sp. Excedentifolia (J.L. Egan 1925)		
	Sida sp. Pilbara (A.A. Mitchell PRP 1543)		
	Sida sp. Rabbit Flat (B.J. Carter 626)		
	Sida sp. spiciform panicles (E. Leyland s.n. 14/8/90)		
	Sida sp. verrucose glands (F.H. Mollemans 2423)		
	Sida trichopoda		
	Triumfetta leptacantha		
	Triumfetta maconochieana		
Malvaceae cont'	*Waltheria indica*		
	Marsilea exarata		
Marsileaceae	*Marsilea hirsuta*		
	Glinus lotoides		
Molluginaceae	*Mollugo molluginea*		
Moraceae	*Ficus brachypoda*		
	Calytrix carinata		
	Corymbia candida		
	Corymbia deserticola subsp. *deserticola*		
Myrtaceae	*Corymbia ferriticola*		

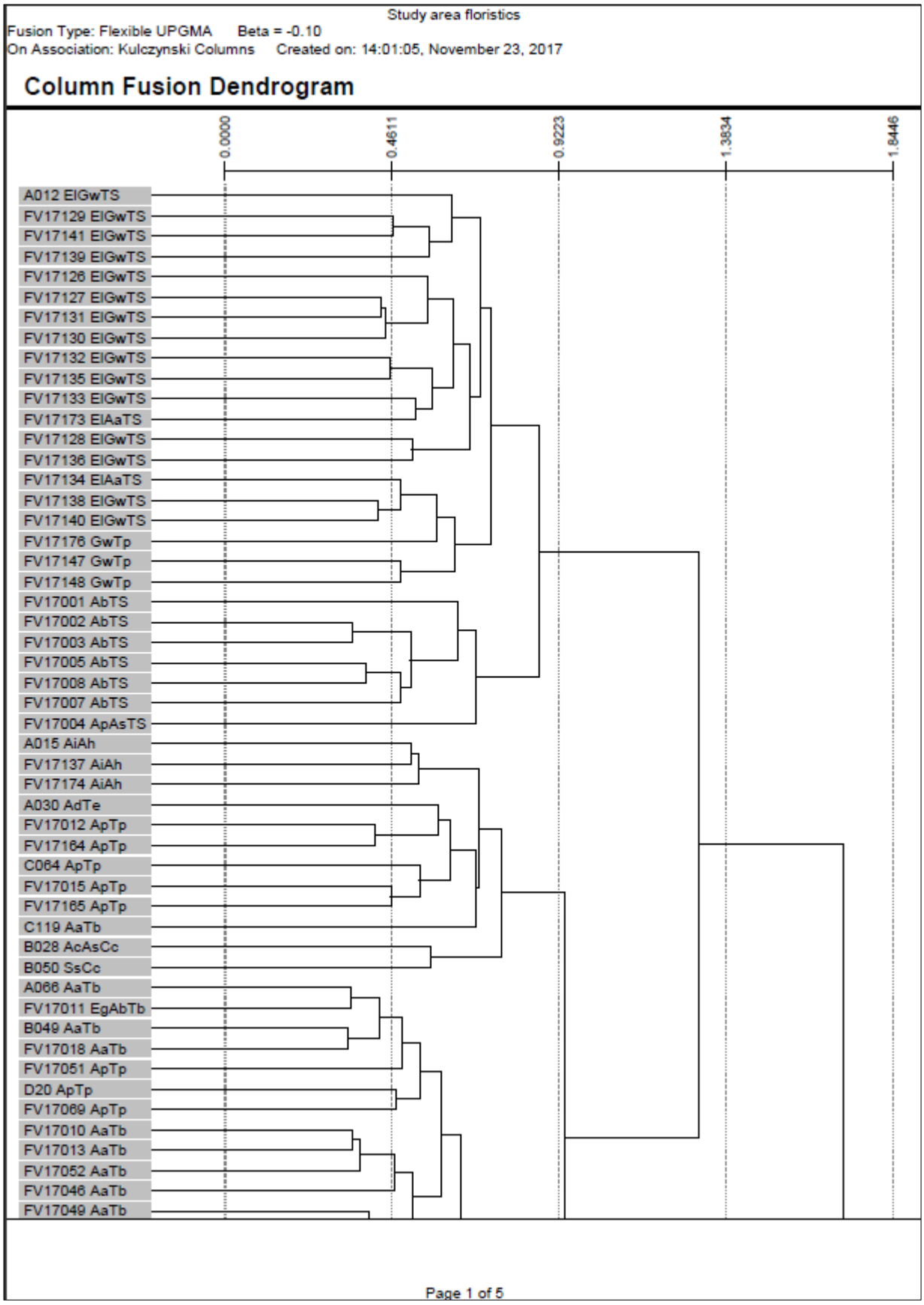
Family	Species	Naturalised	WA Conservation Code
	Corymbia hamersleyana		
	Corymbia opaca		
	Eucalyptus camaldulensis subsp. *refulgens*		
	Eucalyptus gamophylla		
	Eucalyptus leucophloia subsp. *leucophloia*		
	Eucalyptus socialis subsp. *eucentrica*		
	Eucalyptus victrix		
	Eucalyptus xerothermica		
	Melaleuca argentea		
	Melaleuca glomerata		
	Melaleuca linophylla		
Myrtaceae cont'	*Melaleuca xerophila*		
	Boerhavia burbidgeana		
	Boerhavia coccinea		
Nyctaginaceae	*Boerhavia repleta*		
Oleaceae	*Jasminum didymum* subsp. *lineare*		
Orobanchaceae	*Striga squamigera*		
Papaveraceae	*Argemone ochroleuca* subsp. *ochroleuca*	*	
	Mimulus gracilis		
	Peplidium aithocheilum		
	Peplidium sp. C Evol. Fl. Fauna Arid Aust. (N.T. Burbidge & A. Kanis 8158)		
Phrymaceae	*Uvedalia linearis*		
	Notoleptopus decaisnei var. Orbicularis (A.B. Craig 428)		
	Phyllanthus erwinii		
	Phyllanthus maderaspatensis		
Phyllanthaceae	*Synostemon hamersleyensis*		P1
Plantaginaceae	*Stemodia grossa*		
Plumbaginaceae	*Muellerolimon salicorniaceum*		
	Amphipogon sericeus		
	Aristida burbidgeae		
	Aristida contorta		
	Aristida holathera var. *holathera*		
	Aristida inaequiglumis		
	Aristida latifolia		
	Astrebla elymoides		
	Bothriochloa ewartiana		
	Brachyachne convergens		
	Brachyachne prostrata		
	Cenchrus ciliaris	*	
	Cenchrus setiger	*	
	Chloris pectinata		
	Chloris pumilio		
	Chloris virgata	*	
Poaceae	*Chrysopogon fallax*		

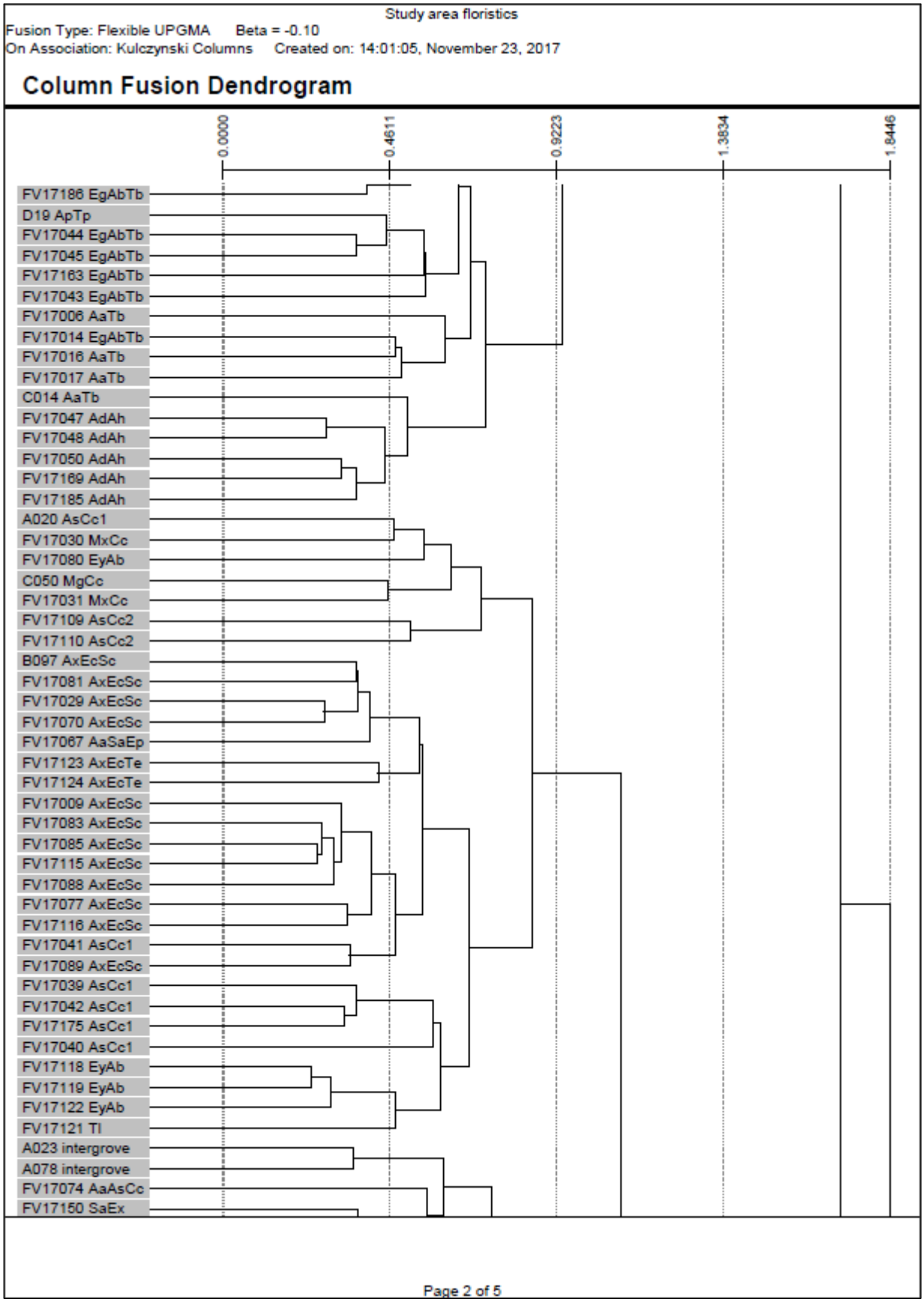
Family	Species	Naturalised	WA Conservation Code
	Cymbopogon ambiguus		
	Cymbopogon obtectus		
	Dactyloctenium radulans		
	Dichanthium sericeum subsp. *humilius*		
	Digitaria brownii		
	Digitaria ctenantha		
	Diplachne fusca		
	Echinochloa colona	*	
	Elytrophorus spicatus		
	Enneapogon caerulescens		
	Enneapogon lindleyanus		
	Enneapogon polyphyllus		
	Enneapogon robustissimus		
	Enteropogon ramosus		
	Eragrostis cumingii		
	Eragrostis desertorum		
	Eragrostis dielsii		
	Eragrostis eriopoda		
	Eragrostis exigua		
	Eragrostis falcata		
	Eragrostis leptocarpa		
	Eragrostis pergracilis		
	Eragrostis setifolia		
	Eragrostis tenellula		
	Eragrostis xerophila		
	Eriachne aristidea		
	Eriachne benthamii		
	Eriachne flaccida		
	Eriachne gardneri		
	Eriachne helmsii		
	Eriachne lanata		
	Eriachne mucronata		
	Eriachne pulchella subsp. *dominii*		
	Eriachne pulchella subsp. *pulchella*		
	Eulalia aurea		
	Iseilema macratherum		
	Iseilema sp.		
	Iseilema vaginiflorum		
	Panicum decompositum		
	Panicum laevinode		
	Paraneurachne muelleri		
	Paspalidium clementii		
	Paspalidium jubiflorum		
	Perotis rara		
Poaceae cont'	Poaceae sp.		

Family	Species	Naturalised	WA Conservation Code
	Schizachyrium fragile		
	Setaria verticillata	*	
	Sporobolus australasicus		
	Sporobolus mitchellii		
	Themeda triandra		
	Tragus australianus		
	Triodia basedowii		
	Triodia epactia		
	Triodia longiceps		
	Triodia pungens		
	Triodia schinzii		
	Triodia vanleeuwenii		
	Triodia wiseana		
	Tripogon loliiformis		
	Triraphis mollis		
	Urochloa occidentalis var. *ciliata*		
	Urochloa occidentalis var. *occidentalis*		
	Xerochloa barbata		
Poaceae cont'	*Yakirra australiensis* var. *australiensis*		
	Polygala glaucifolia		
Polygalaceae	*Polygala isingii*		
	Duma florulenta		
Polygonaceae	*Rumex vesicarius*	*	
	Calandrinia ptychosperma		
	Calandrinia pumila		
	Calandrinia stagnensis		
	Portulaca cyclophylla		
	Portulaca oleracea		
Portulacaceae	*Portulaca pilosa*	*	
Potamogetonaceae	*Potamogeton tricarinatus*		
Primulaceae	*Samolus* sp. Fortescue Marsh (A. Markey & R. Coppen FM 9702)		P1
	Grevillea juncifolia subsp. *juncifolia*		
	Grevillea pyramidalis subsp. *leucadendron*		
	Grevillea striata		
	Grevillea wickhamii		
	Grevillea wickhamii subsp. *aprica*		
	Grevillea wickhamii subsp. *hispidula*		
	Hakea chordophylla		
Proteaceae	*Hakea lorea* subsp. *lorea*		
Pteridaceae	*Cheilanthes sieberi* subsp. *sieberi*		
Rubiaceae	*Oldenlandia crouchiana*		
	Psydrax latifolia		
	Psydrax suaveolens		
Rubiaceae cont'	*Spermacoce brachystema*		

Family	Species	Naturalised	WA Conservation Code
	Synaptantha tillaeacea var. *tillaeacea*		
	Anthobolus leptomerioides		
	Santalum lanceolatum		
Santalaceae	*Santalum spicatum*		
	Atalaya hemiglauca		
	Dodonaea coriacea		
	Dodonaea pachyneura		
Sapindaceae	*Dodonaea petiolaris*		
	Eremophila cuneifolia		
	Eremophila exilifolia		
	Eremophila forrestii subsp. *forrestii*		
	Eremophila jucunda subsp. *pulcherrima*		
	Eremophila lanceolata		
	Eremophila latrobei subsp. *filiformis*		
	Eremophila latrobei subsp. *glabra*		
	Eremophila longifolia		
	Eremophila maculata subsp. *brevifolia*		
	Eremophila sp.		
	Eremophila spongiocarpa		P1
Scrophulariaceae	*Eremophila youngii* subsp. *lepidota*		P4
	Nicotiana benthamiana		
	Nicotiana heterantha		P1
	Nicotiana occidentalis		
	Nicotiana occidentalis subsp. *obliqua*		
	Nicotiana occidentalis subsp. *occidentalis*		
	Solanum elatius		
	Solanum horridum		
	Solanum lasiophyllum		
	Solanum morrisonii		
Solanaceae	*Solanum phlomoides*		
Surianaceae	*Stylobasium spathulatum*		
Violaceae	*Hybanthus aurantiacus*		
	Tribulus astrocarpus		
	Tribulus hirsutus		
	Tribulus macrocarpus		
	Tribulus occidentalis		
Zygophyllaceae	*Tribulus suberosus*		

APPENDIX FOUR STUDY AREA FLORISTIC ANALYSIS




Study area floristics
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Column Fusion Dendrogram
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FV17014 EgAbTb
FV17016 AaTb
FV17017 AaTb
C014 AaTb
FV17047 AdAh
FV17048 AdAh
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FV17169 AdAh
FV17185 AdAh
A020 AsCc1
FV17030 MxCc
FV17080 EyAb
C050 MgCc
FV17031 MxCc
FV17109 AsCc2
FV17110 AsCc2
B097 AxEcSc
FV17081 AxEcSc
FV17029 AxEcSc
FV17070 AxEcSc
FV17067 AaSaEp
FV17123 AxEcTe
FV17124 AxEcTe
FV17009 AxEcSc
FV17083 AxEcSc
FV17085 AxEcSc
FV17115 AxEcSc
FV17088 AxEcSc
FV17077 AxEcSc
FV17116 AxEcSc
FV17041 AsCc1
FV17089 AxEcSc
FV17039 AsCc1
FV17042 AsCc1
FV17175 AsCc1
FV17040 AsCc1
FV17118 EyAb
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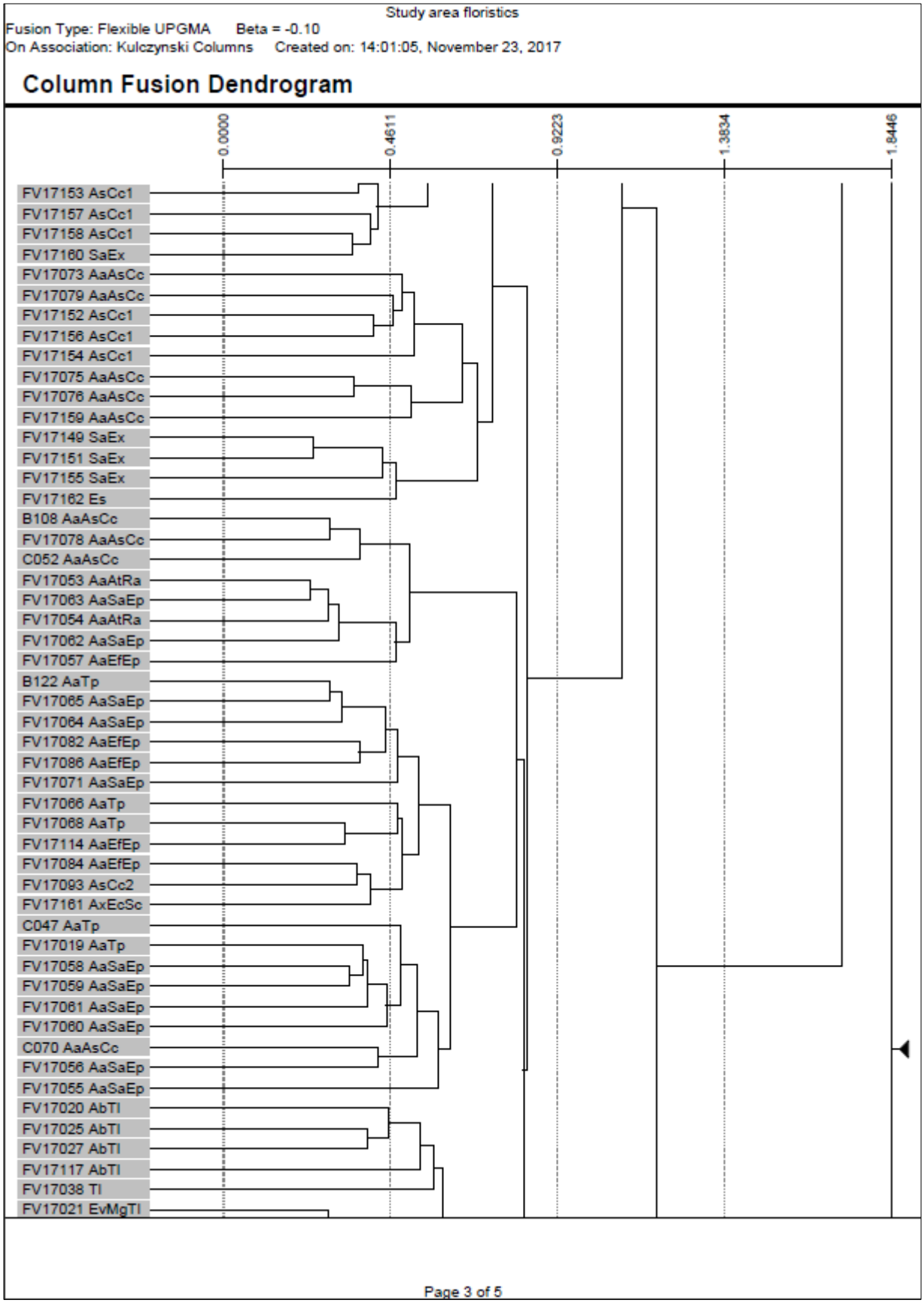
Page 2 of 5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1.8446
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FV17157 AsCc1
FV17158 AsCc1
FV17160 SaEx
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FV17159 AaAsCc
FV17149 SaEx
FV17151 SaEx
FV17155 SaEx
FV17162 Es
B108 AaAsCc
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FV17084 AaEfEp
FV17093 AsCc2
FV17161 AxEcSc
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FV17019 AaTp
FV17058 AaSaEp
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FV17060 AaSaEp
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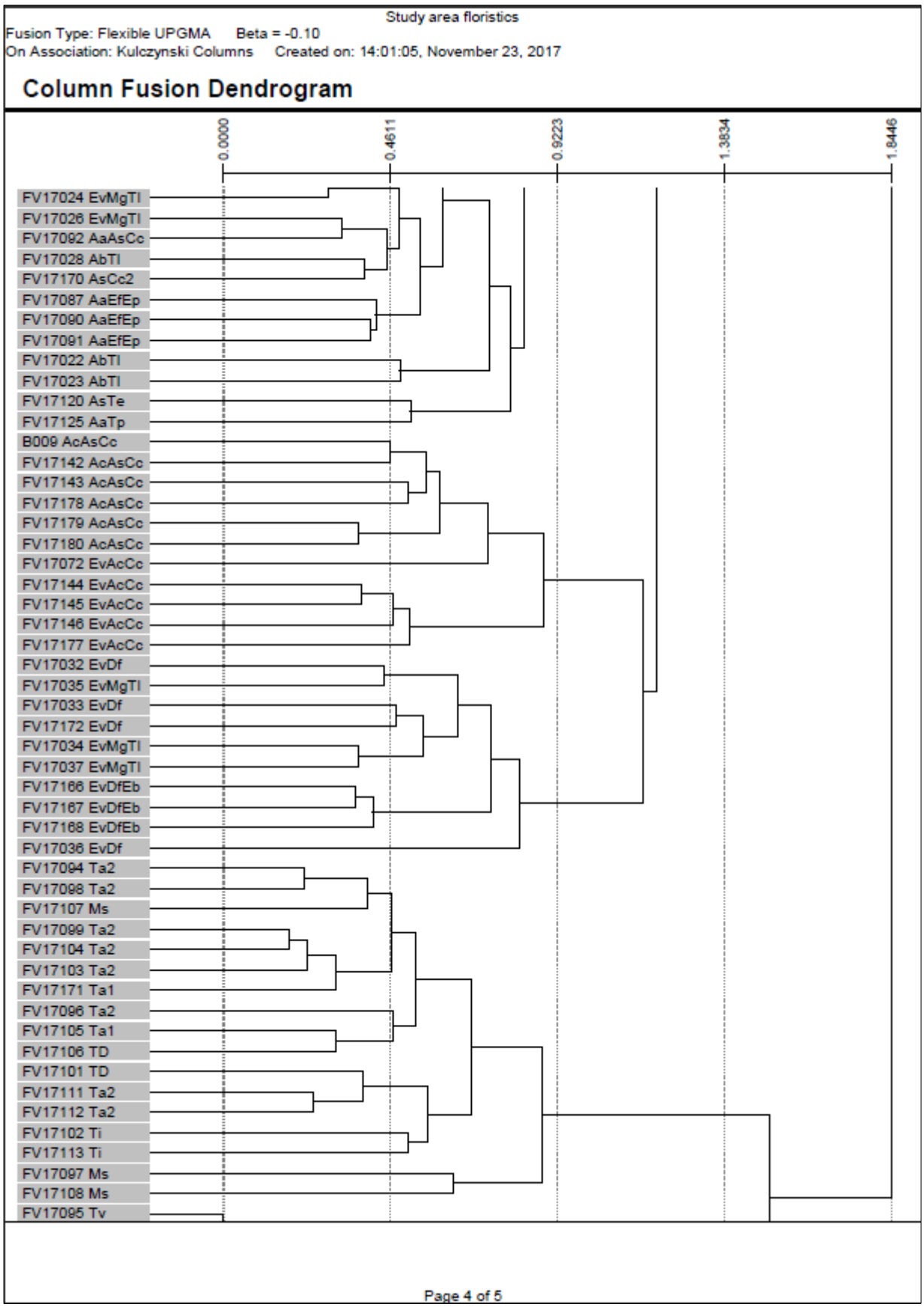
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FV17028 AbTl
FV17170 AsCc2
FV17087 AaEfEp
FV17090 AaEfEp
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FV17035 EvMgTl
FV17033 EvDf
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FV17168 EvDfEb
FV17036 EvDf
FV17094 Ta2
FV17098 Ta2
FV17107 Ms
FV17099 Ta2
FV17104 Ta2
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Study area floristics

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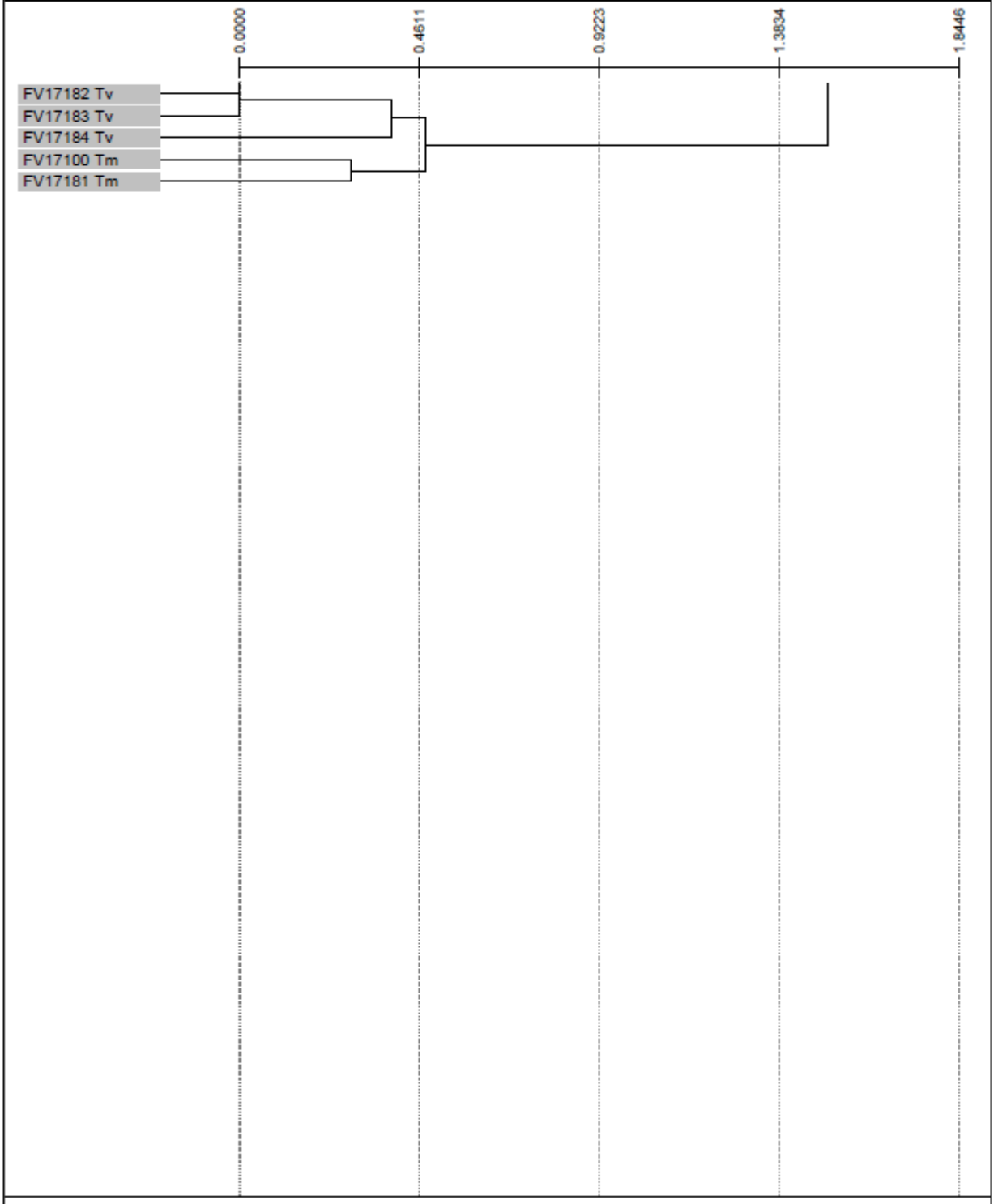

Page 5 of 5

APPENDIX FIVE REGIONAL FLORISTIC ANALYSIS

Fortescue Valley Regional Floristics
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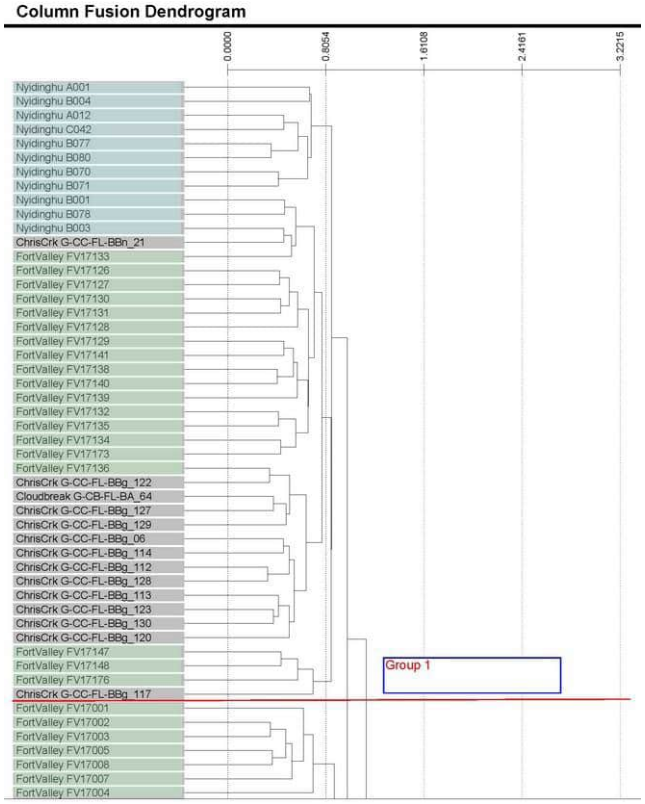

Page 1 of 47

Fortescue Valley Regional Floristics
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Column Fusion Dendrogram

Page 2 of 47

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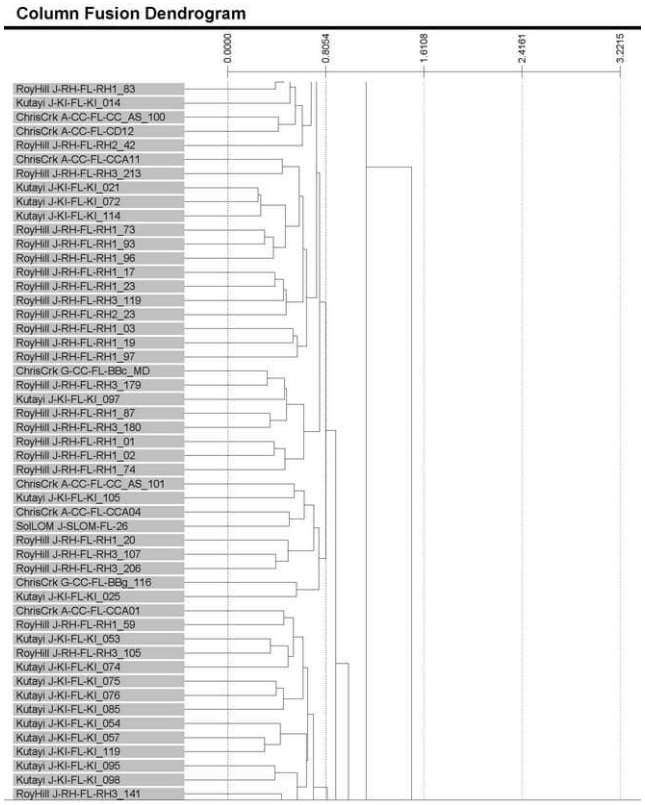

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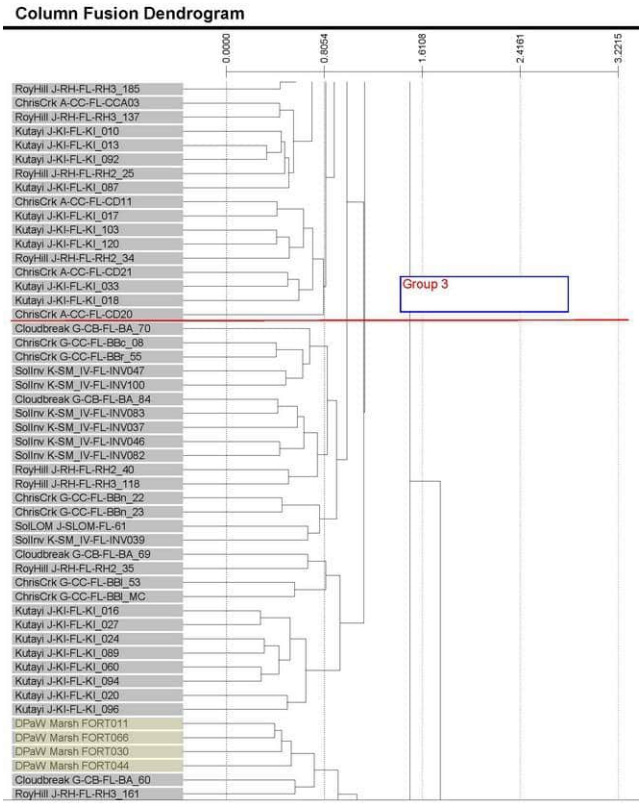

Page 4 of 47

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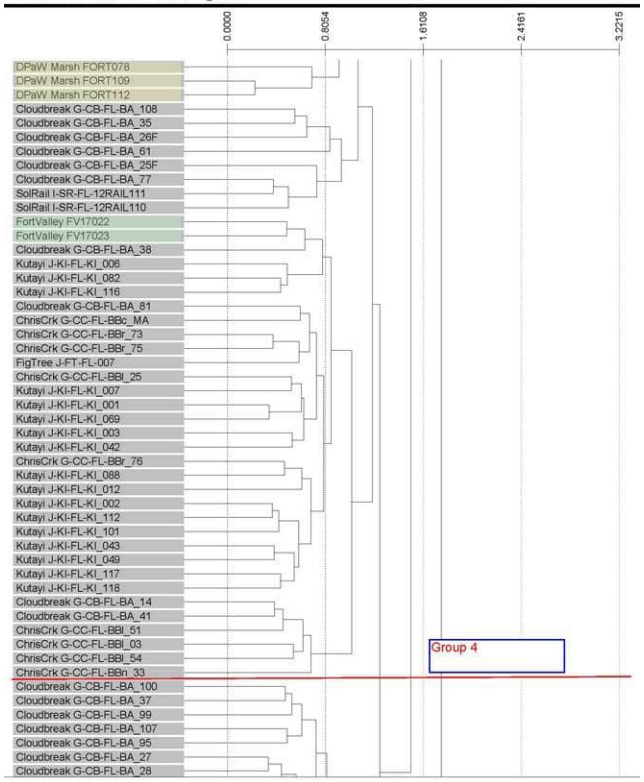

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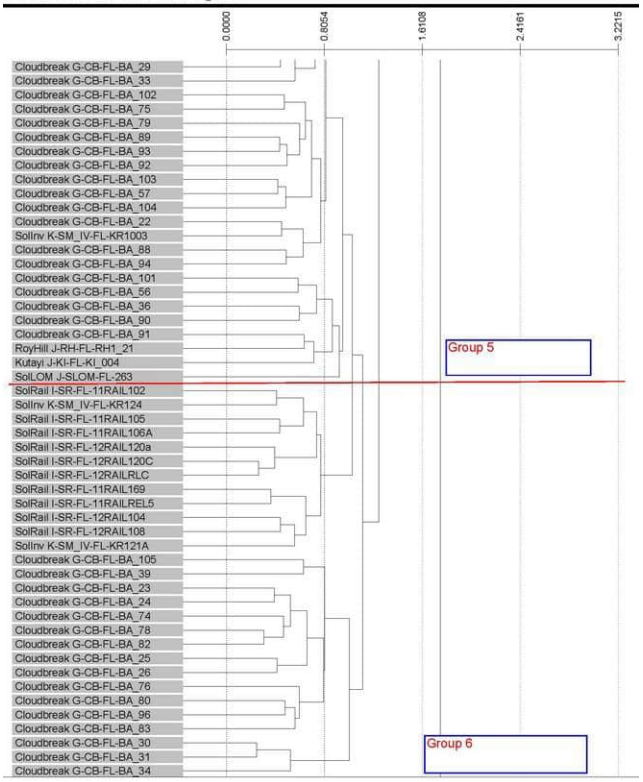

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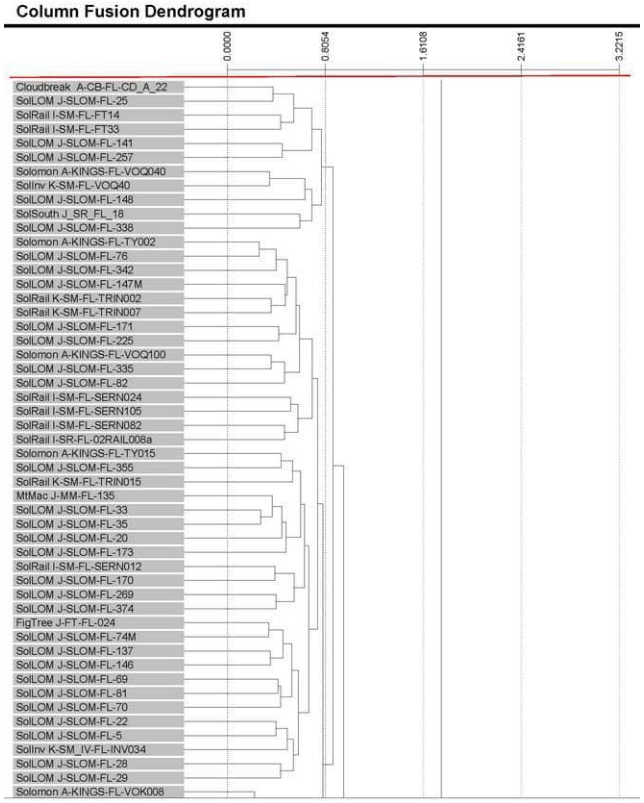

Fortescue Valley Regional Floristics

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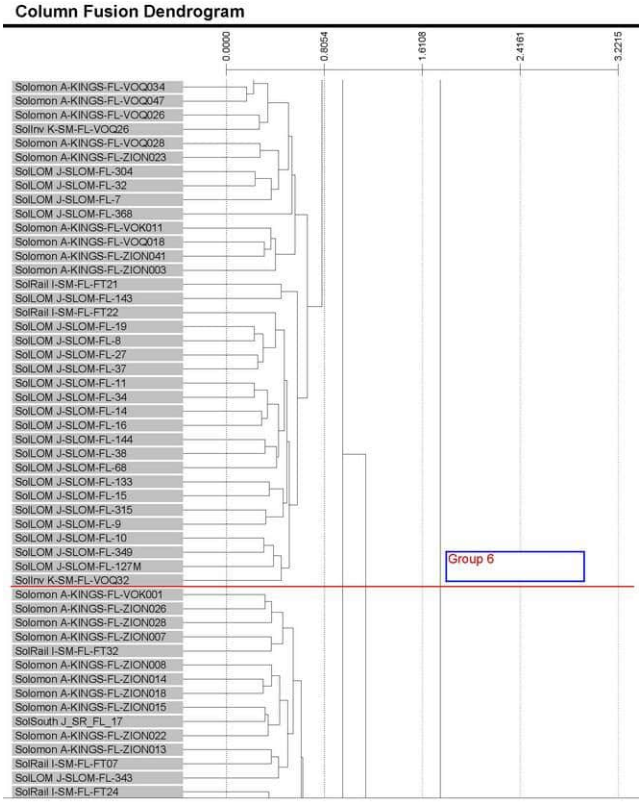

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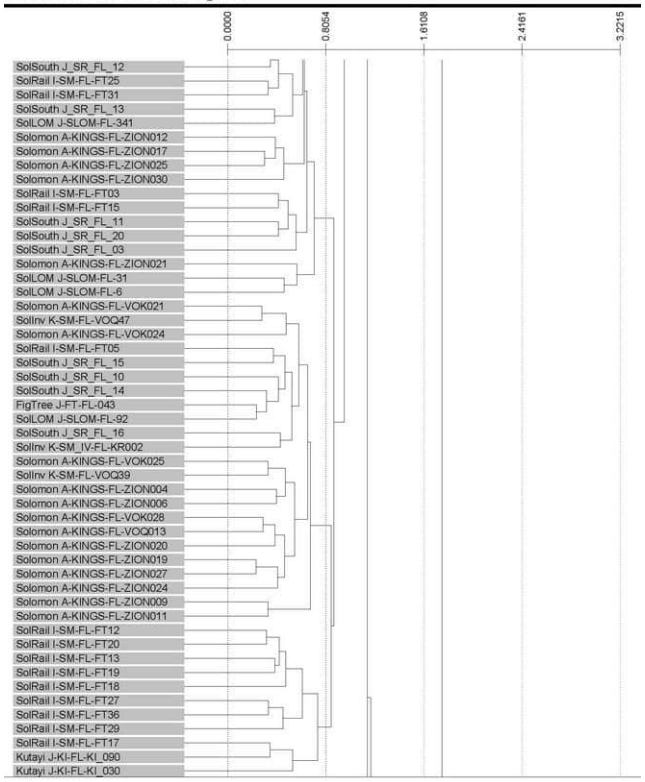

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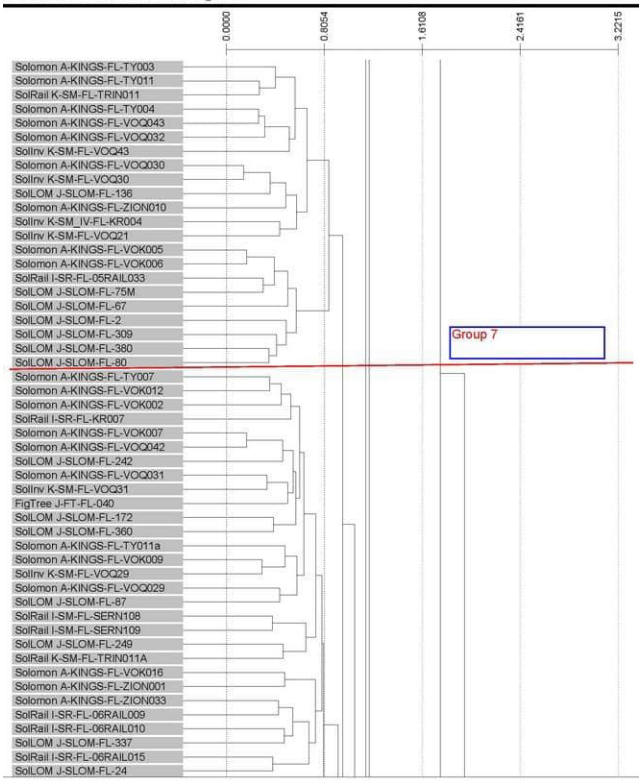

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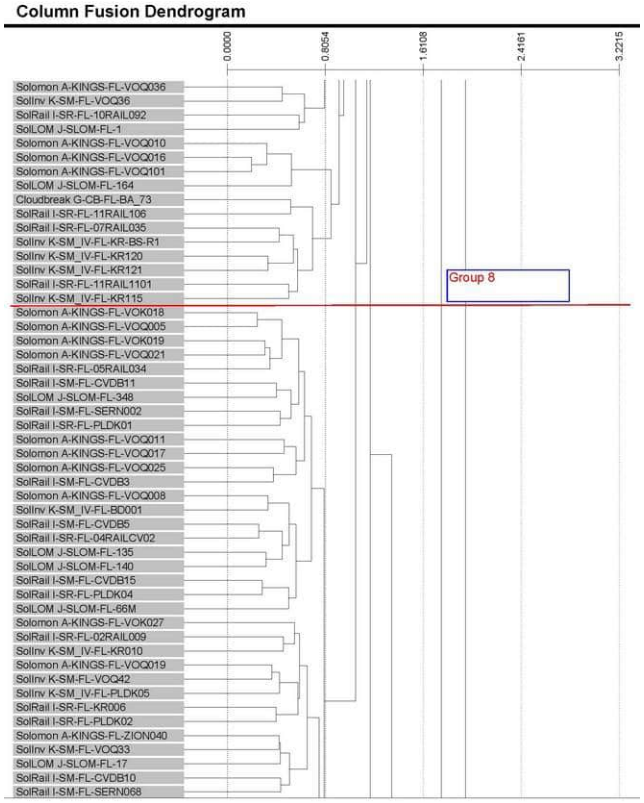

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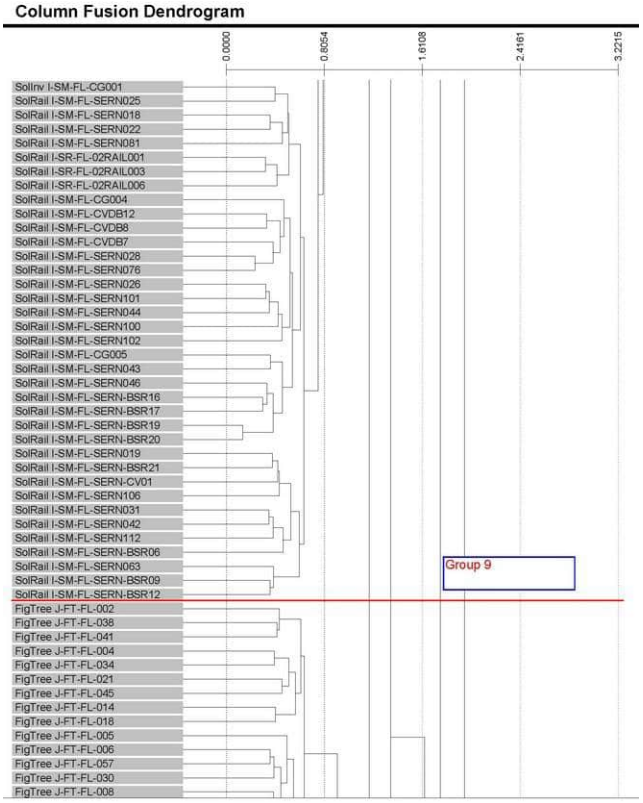

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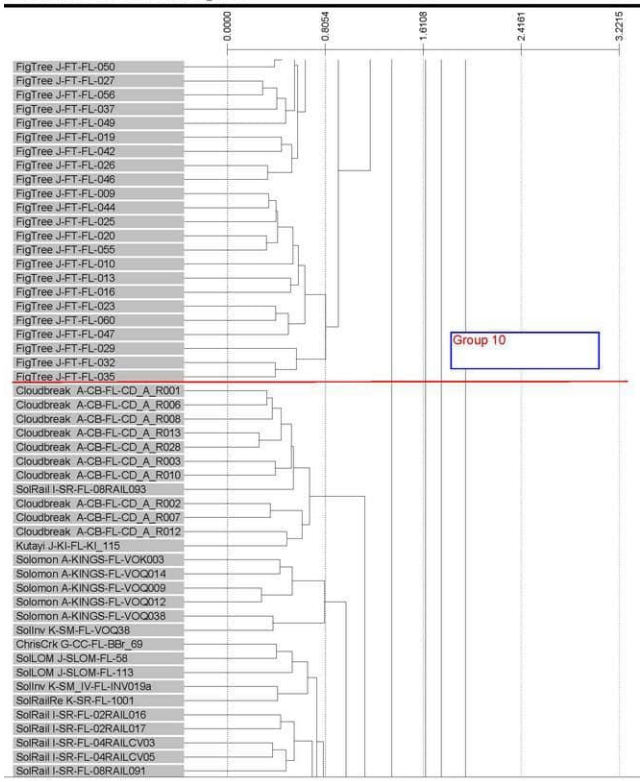

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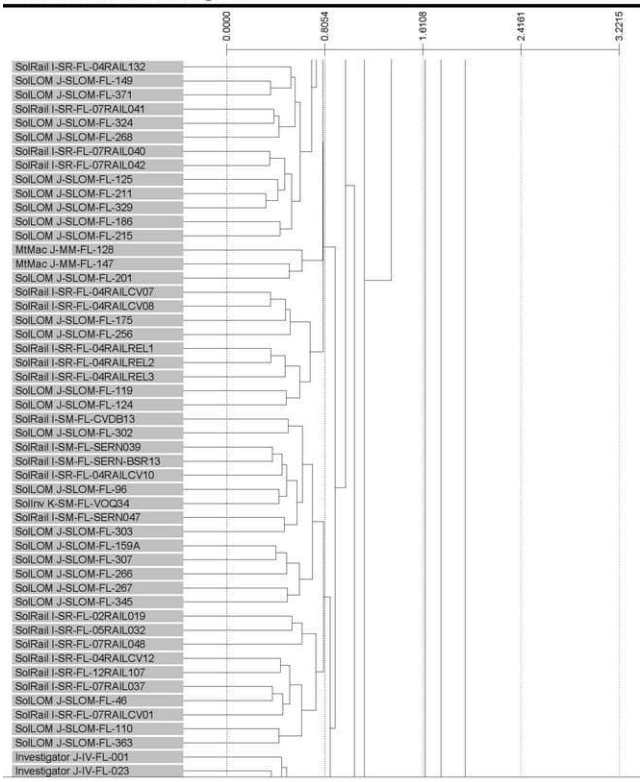

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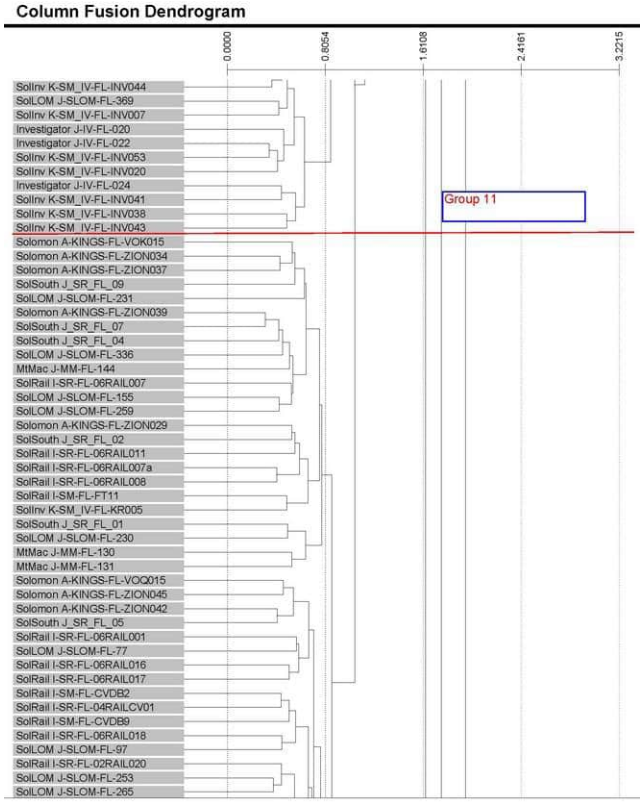

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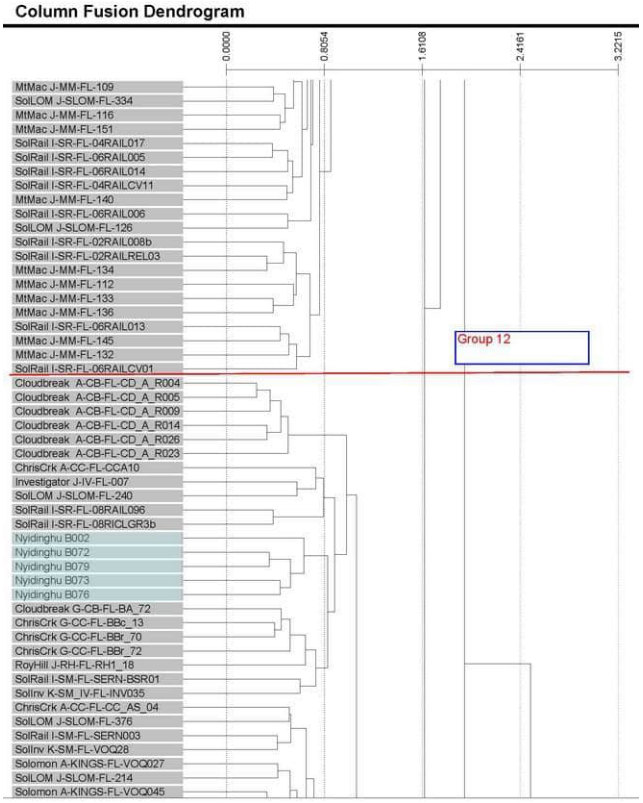

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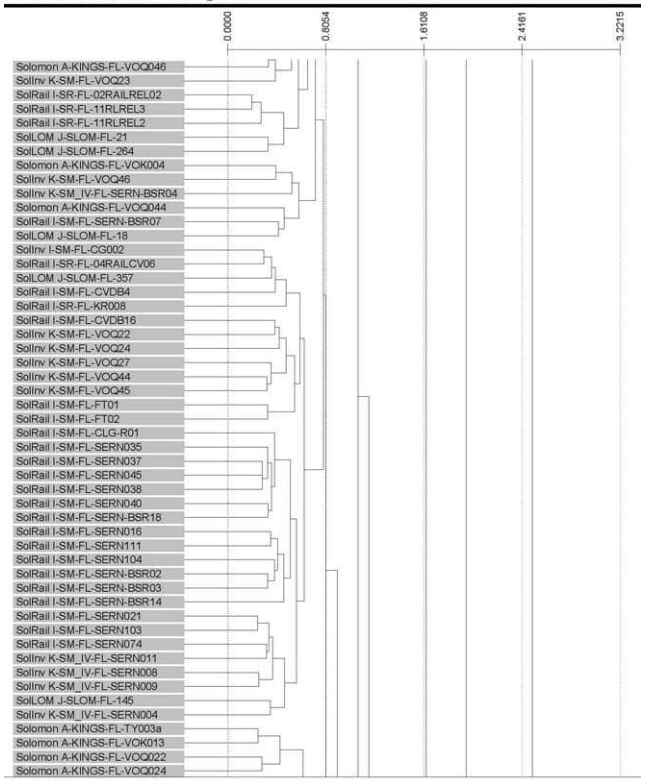

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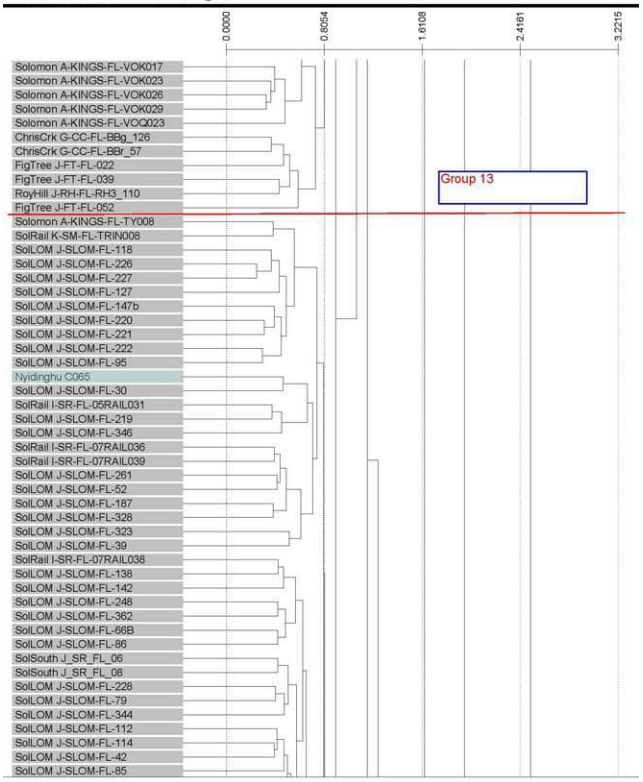

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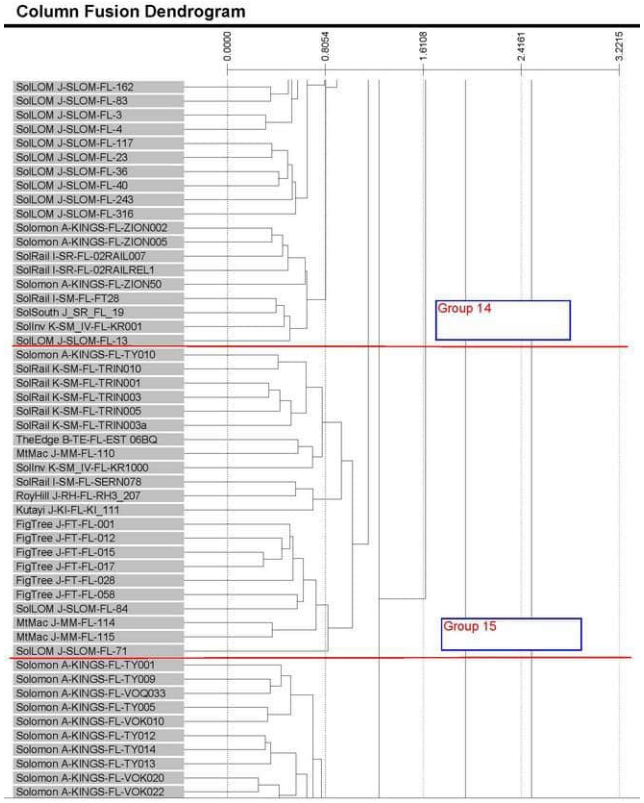

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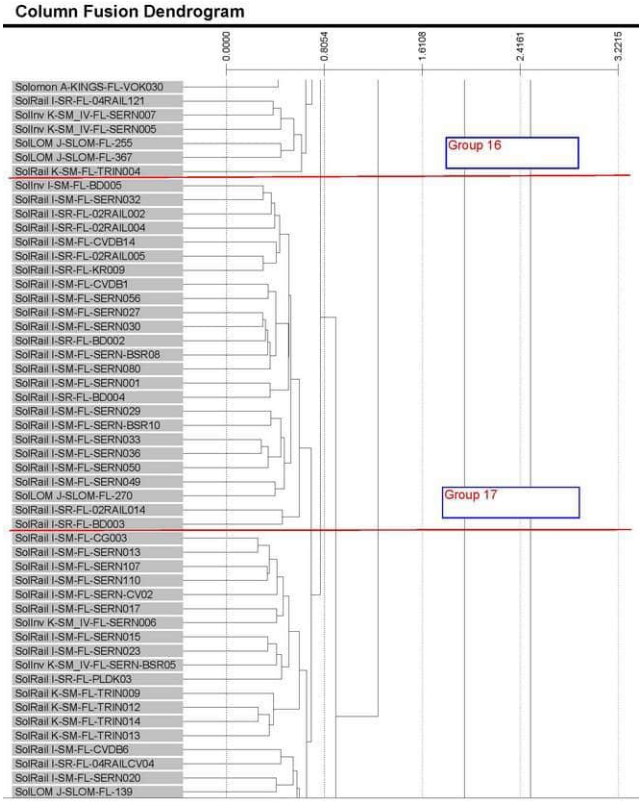

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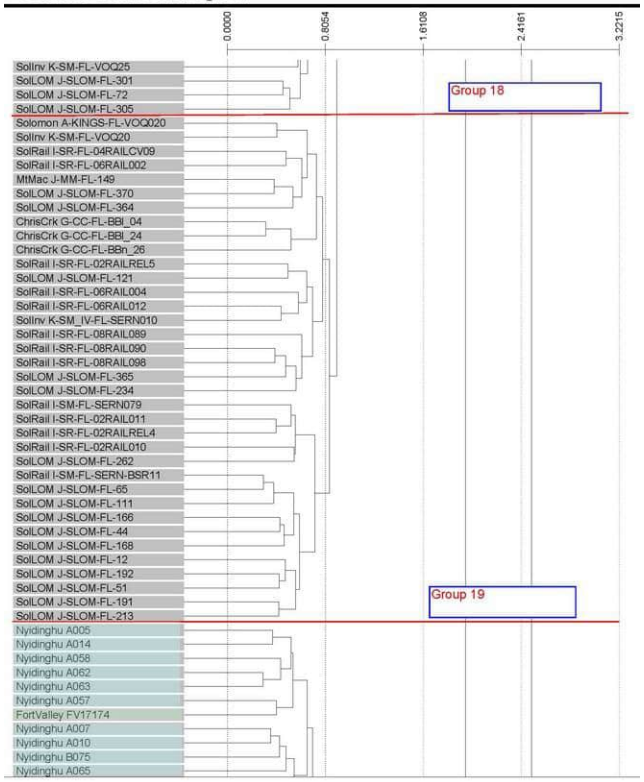

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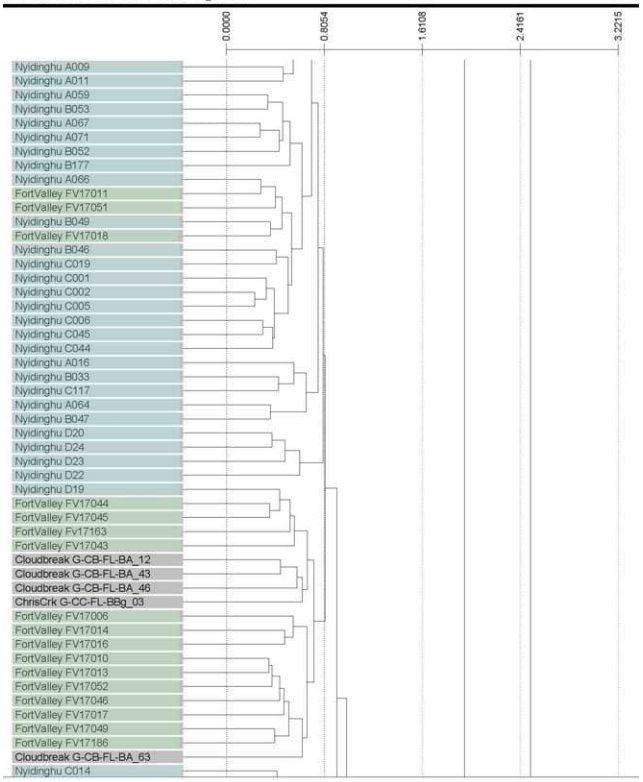

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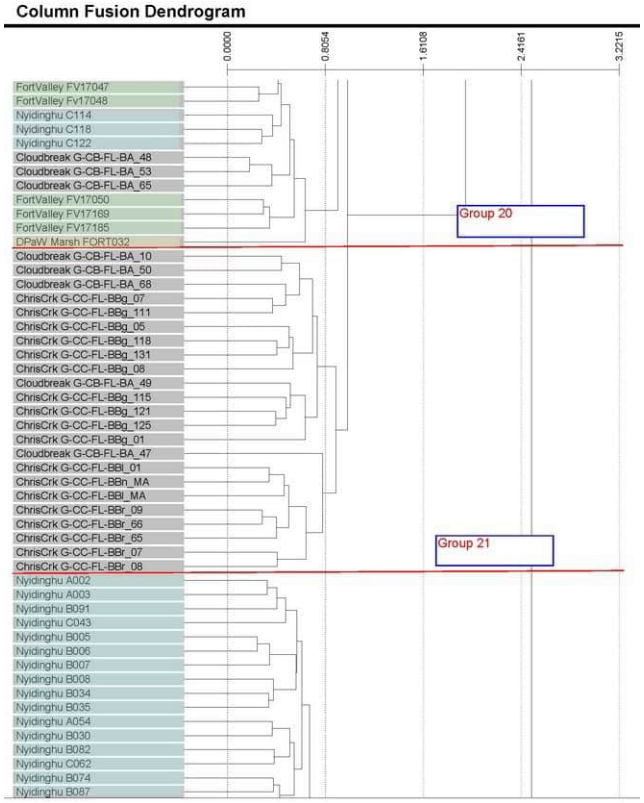

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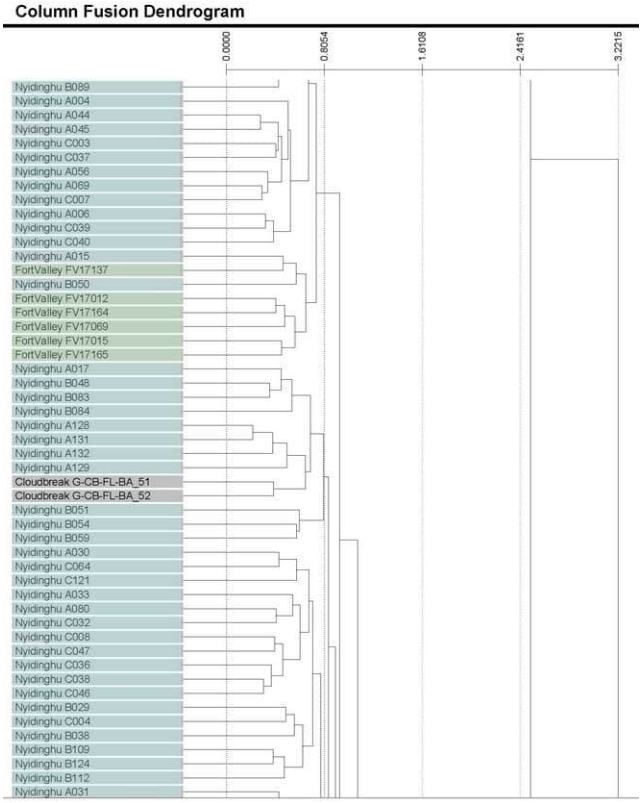

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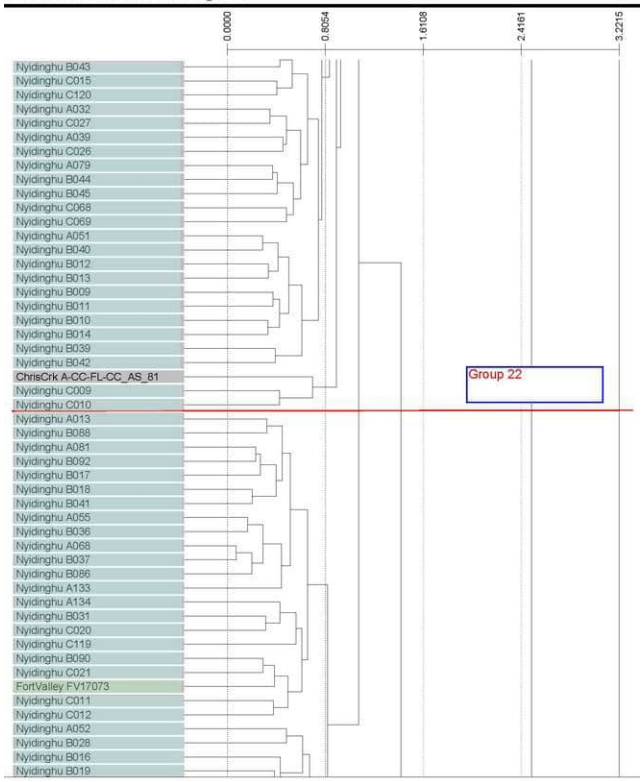

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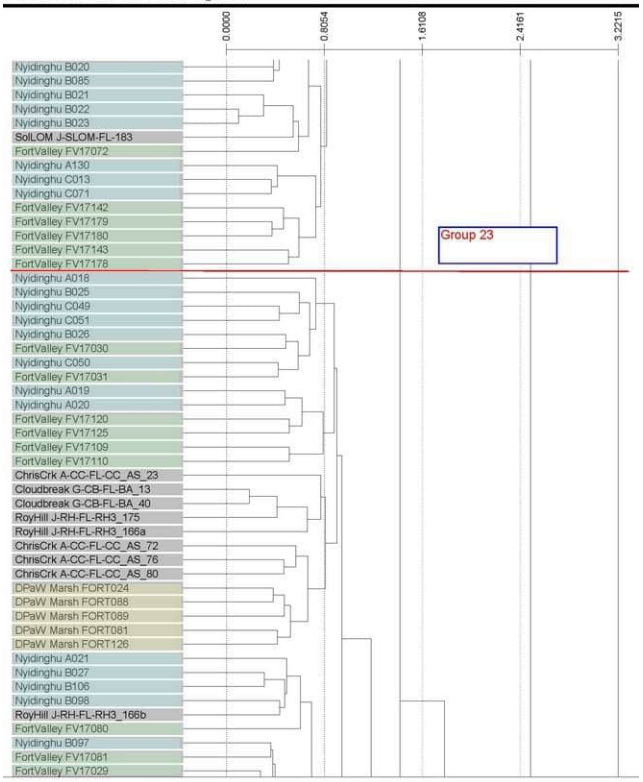

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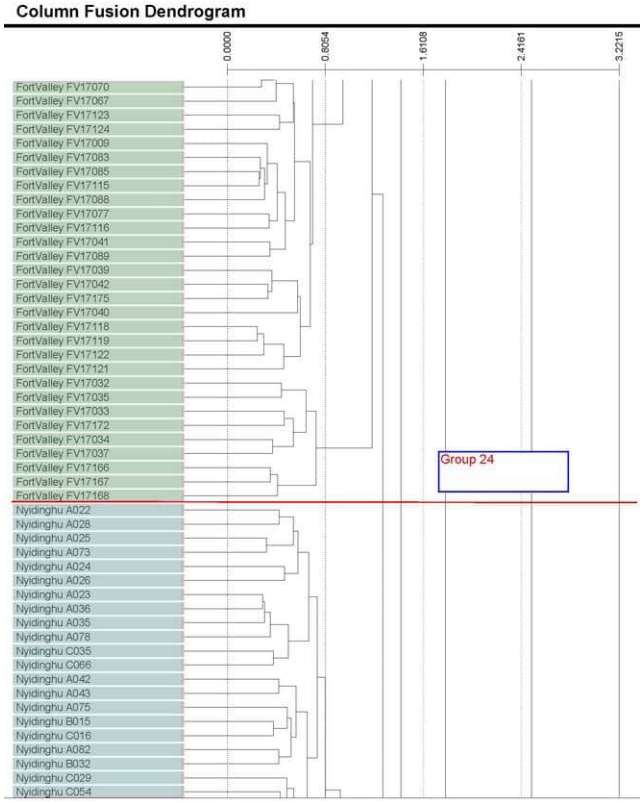

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Column Fusion Dendrogram

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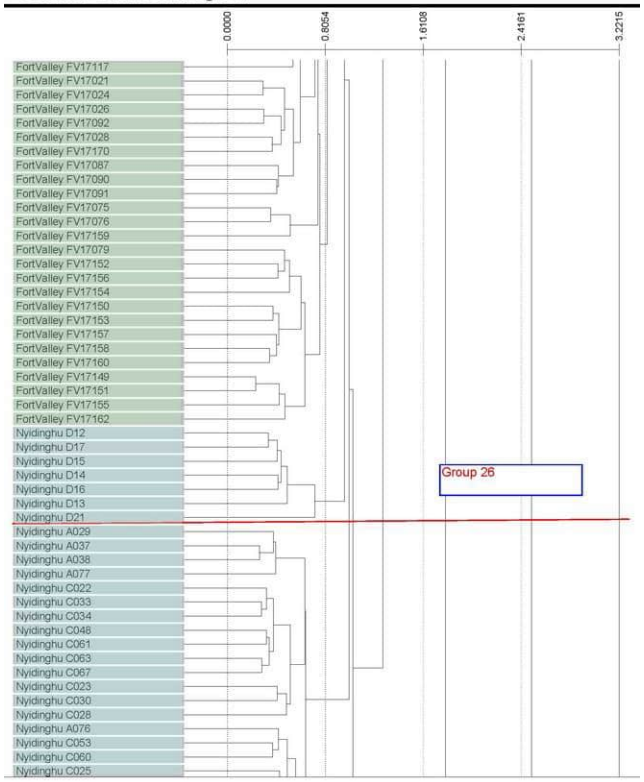

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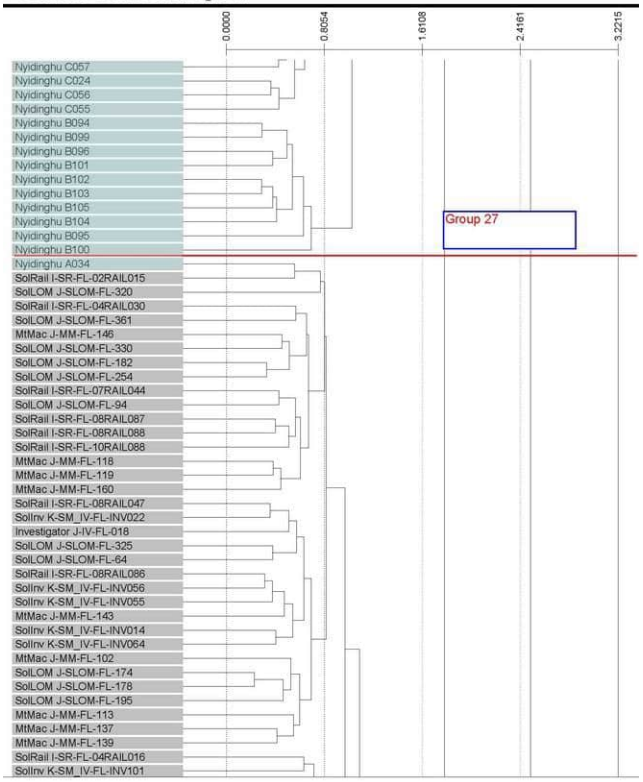

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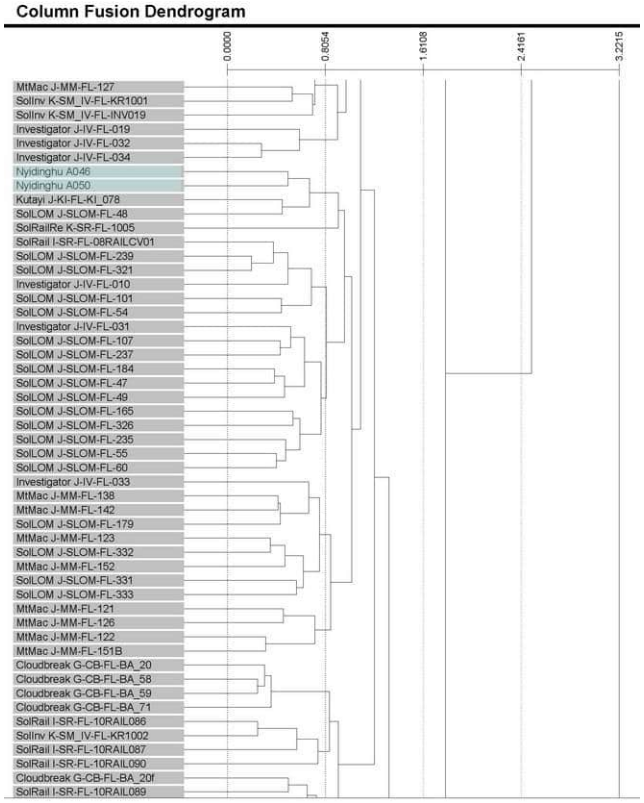

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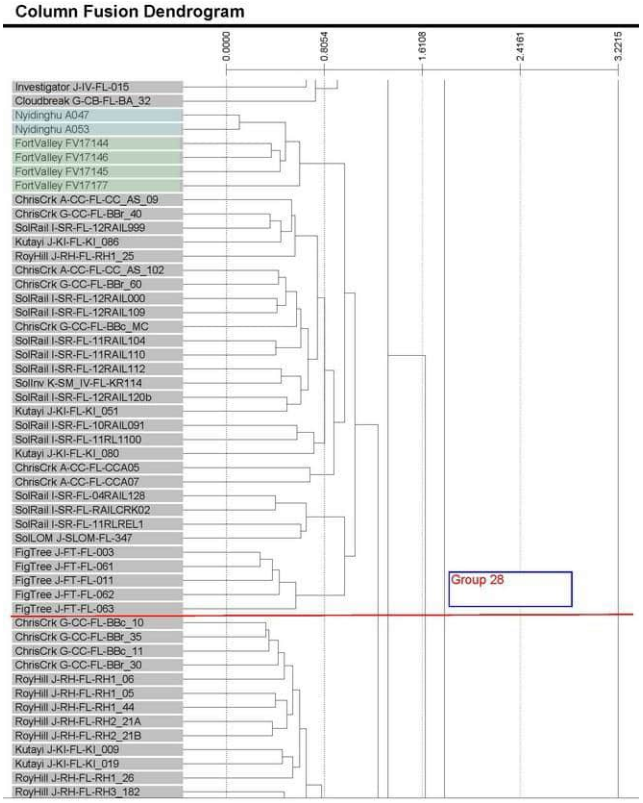

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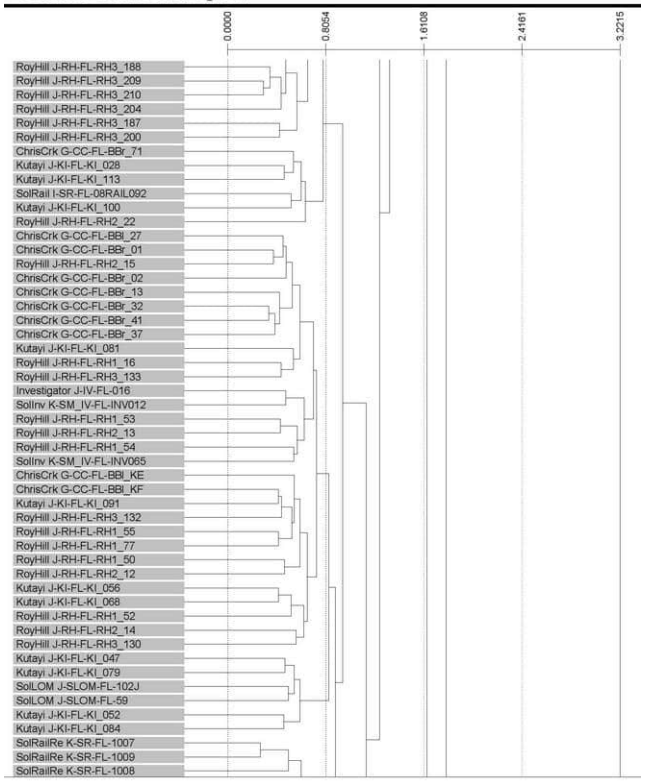

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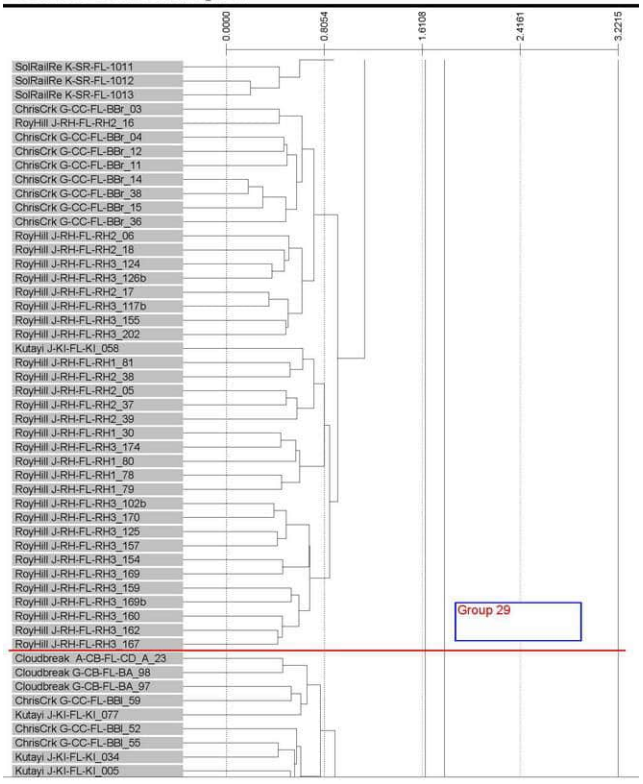

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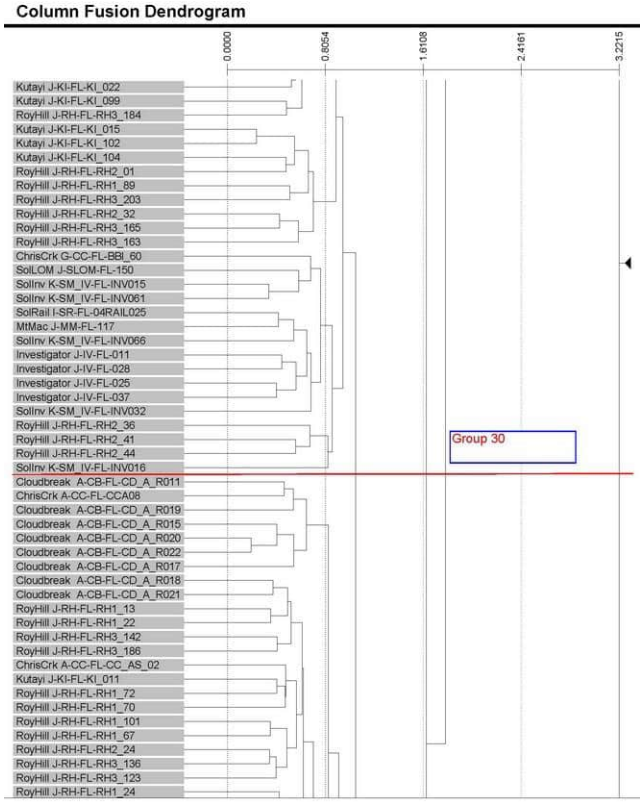

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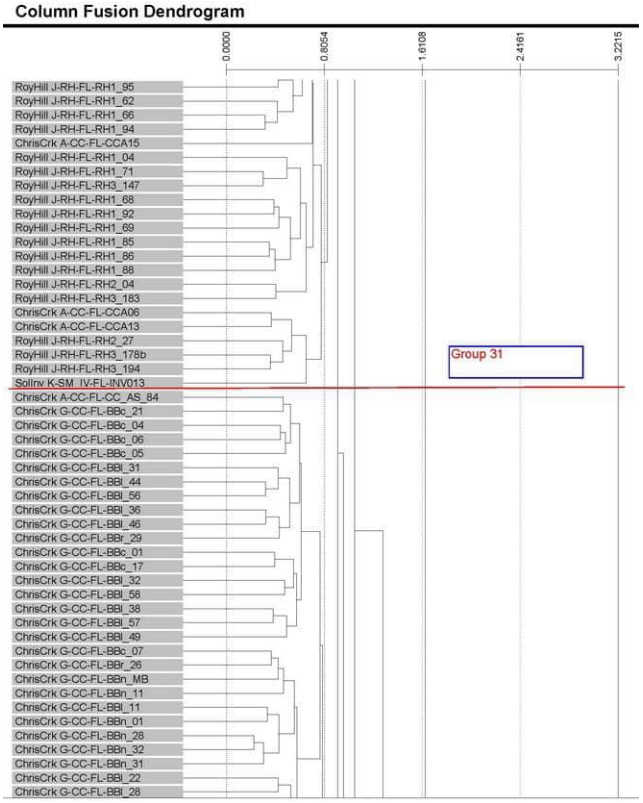
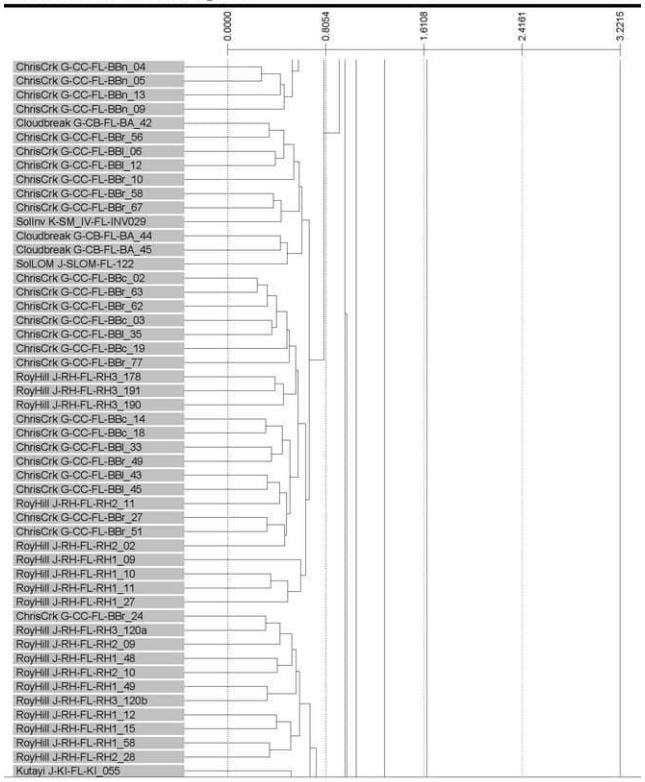
On Association: Kulczynski Columns Created on: 13:32:14, November 24, 2017

Column Fusion Dendrogram



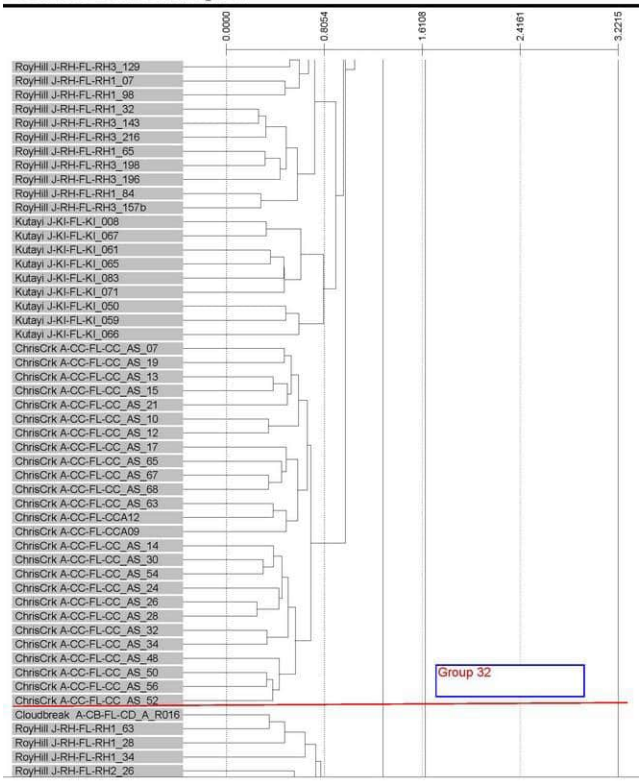
Fortescue Valley Regional Floristics
Fusion Type: Flexible UPGMA Beta = -0.10
On Association: Kulczynski Columns Created on: 13:32:14, November 24, 2017

Column Fusion Dendrogram



Fortescue Valley Regional Floristics
Fusion Type: Flexible UPGMA Beta = -0.10
On Association: Kulczynski Columns Created on: 13:32:14, November 24, 2017

Column Fusion Dendrogram



Fortescue Valley Regional Floristics
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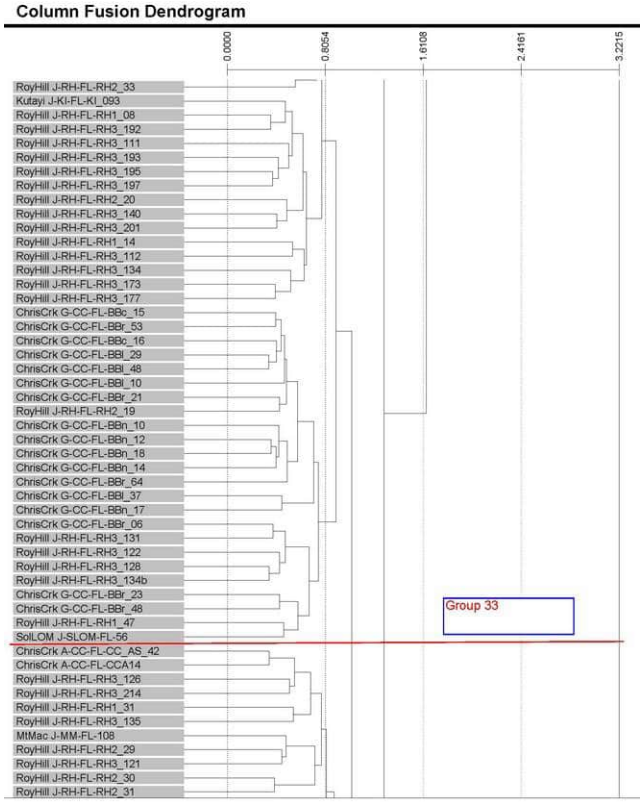
On Association: Kulczynski Columns Created on: 13:32:14, November 24, 2017

Column Fusion Dendrogram



Fortescue Valley Regional Floristics
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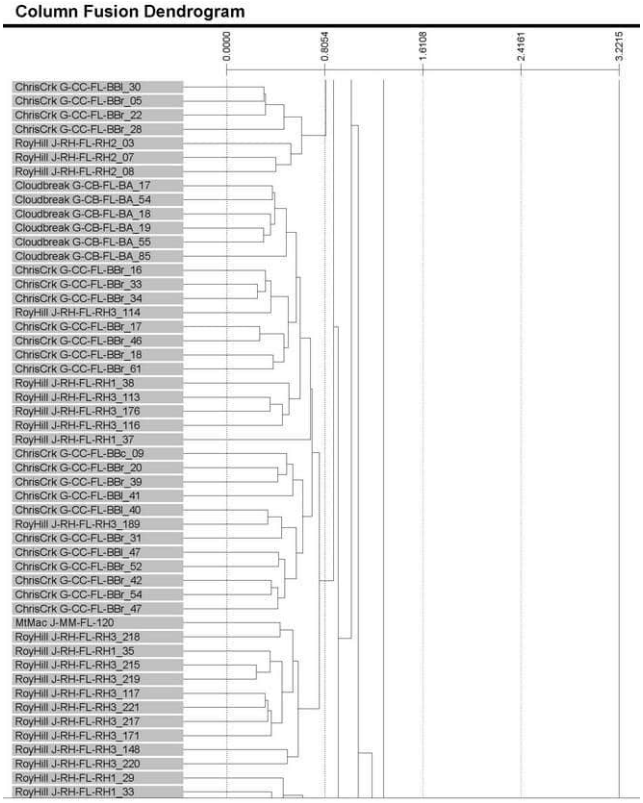
Column Fusion Dendrogram



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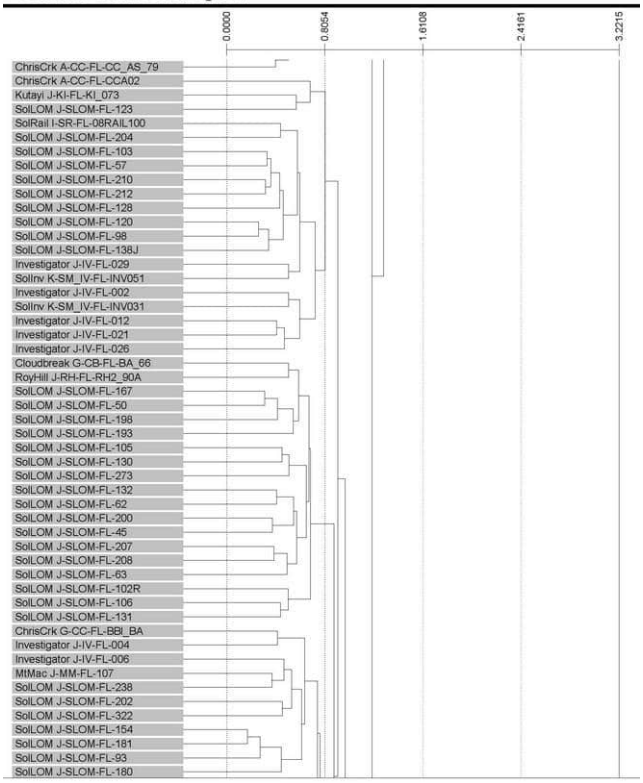
Column Fusion Dendrogram



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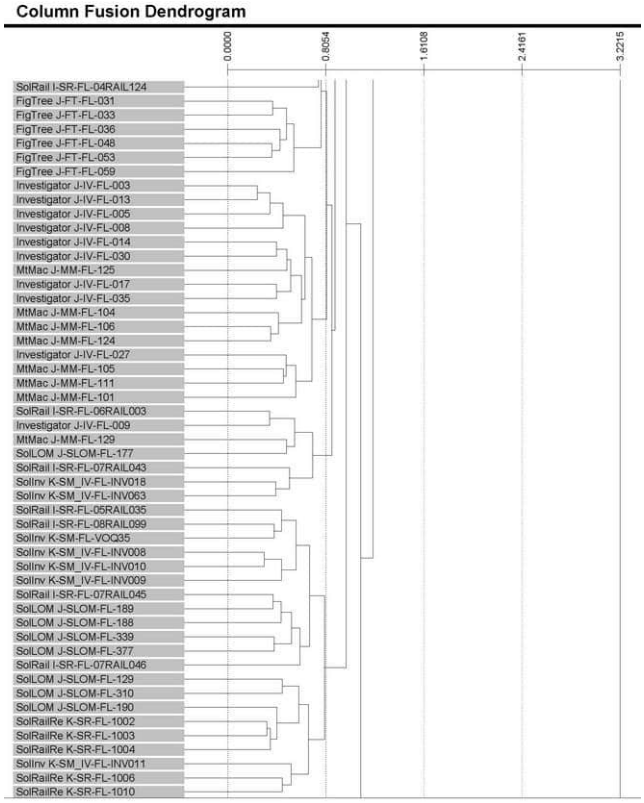
Column Fusion Dendrogram



Fortescue Valley Regional Floristics
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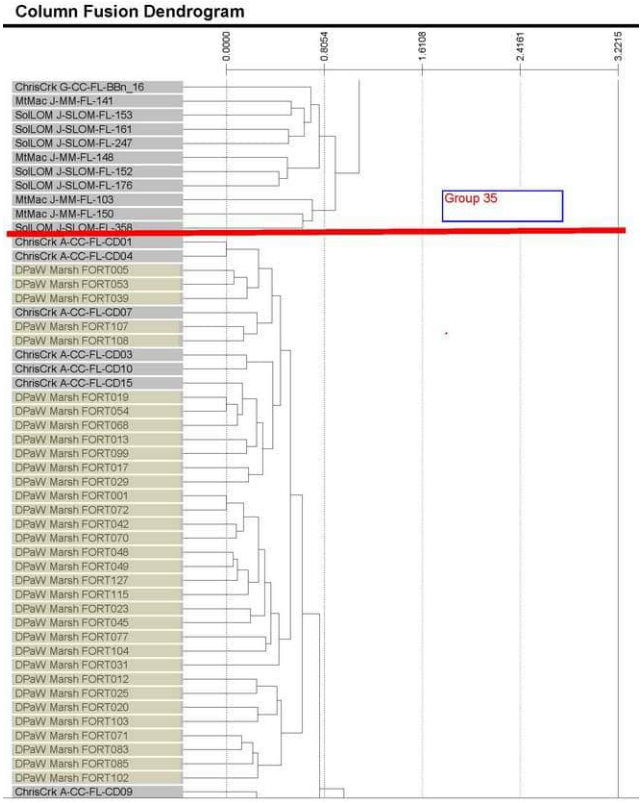
On Association: Kulczynski Columns Created on: 13:32:14, November 24, 2017

Column Fusion Dendrogram



Fortescue Valley Regional Floristics
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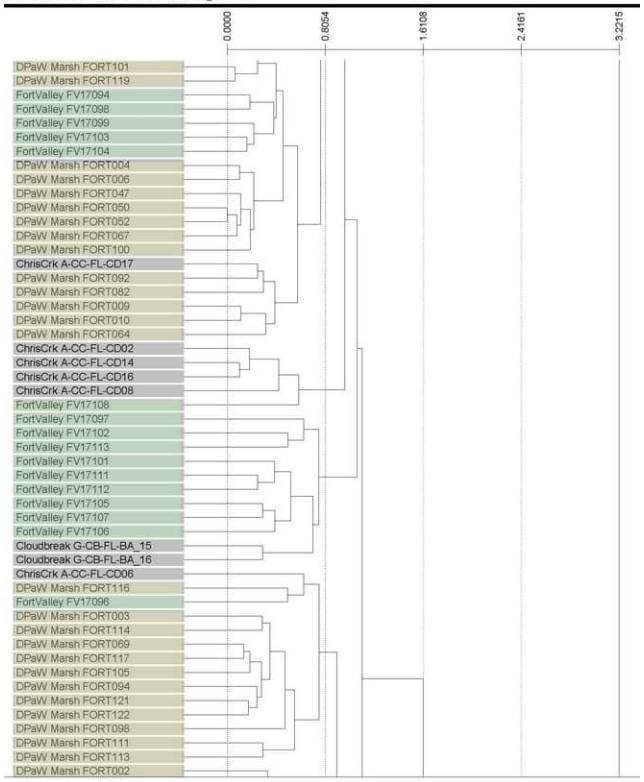
Column Fusion Dendrogram



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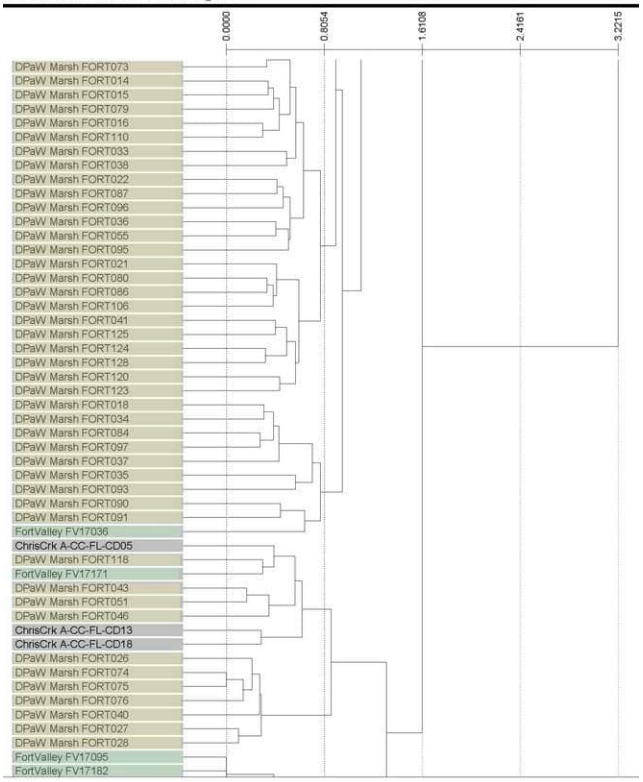

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