Pilbara Iron Ore Project – Blacksmith Flora and Vegetation Survey

Flinders Mines Ltd

science+design

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Shaun Grein, Grein Environmental, undertook the technical review of the draft report.

summary

Flinders Mines Ltd commissioned Worley Parsons Service Pty Ltd to coordinate pre-feasibility surveys for its approximately 10,870 hectare mineral exploration tenement in the Hamersley Ranges known as Blacksmith. In turn, WorleyParsons have appointed Ecoscape to conduct the flora and vegetation assessment required for environmental approval.

Exploration has identified five main areas of inferred and indicated resources known as 'Ajax', 'Blackjack', 'Champion', 'Delta' and 'Eagle', and two smaller areas known as 'Paragon' and 'Badger'.

The desktop assessment for this project was conducted by WorleyParsons. The desktop assessment has determined that:

- the study area is in the Pilbara bioregion and Hamersley sub-region of the Interim Biogeographic Regionalisation for Australia (IBRA), described as being a mountainous area south of the Fortescue Valley consisting of sedimentary ranges and plateaux with Mulga (*Acacia aneura*) low woodland in valleys and Snappy Gum (*Eucalyptus leucophloia*) over *Triodia* on the ranges
- the study area is located within the Hamersley Basin, with the geology comprising of Brockman Iron Formation and McRae Shale intruded by mafic sills and dykes
- the targeted geology is the Channel Iron Deposit (CID) and Bedded Iron Deposit (BID) in the lower-lying valley floors
- the drainage of surface water is to the Fortescue River via Weelumurra and Caliwingina Creeks
- there are no permanent waterways or rivers in the study area, however there is a permanent waterhole in 'Ajax'
- Beard (WA Herbarium & DEC 1980) described the area as being within the Fortescue Botanical District of the Eremaean Botanical Province, with the vegetation typically consisting of *Acacia* or Eucalypt woodland and *Triodia* hummock grassland
- there are no known Environmentally Sensitive Areas (ESAs) within or adjacent to the study area
- the study area is within a DEC 'Schedule 1' area based on its location within a water supply area and therefore vegetation clearing must be approved under Part IV of the Environmental Protection Act, Programme of Work or native vegetation clearing permit.

The flora and vegetation of the Blacksmith tenement was assessed by Ecoscape at Level 2 according to the EPA's *Guidance for the Assessment of Environmental Factors No 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (2004) and *Terrestrial Biological Surveys as an Element of Biodiversity Protection Position Statement No. 3* (EPA 2002). Field surveys were conducted between May 25 – June 3 2010, August 26 – 30 2010 and March 25 – 28 2011. The data collected was used to:

- describe and map the vegetation types and indicate the distribution and relative abundance of each to help to define units of particular conservation value
- document the vascular flora of the area and provide a measure of the overall floristic richness
- identify species of particular conservation significance and introduced plant species.

Prior to the field surveys, DEC database search requests identified:

- the *vulnerable* Threatened Ecological Community (TEC) '*Themeda* grasslands on cracking clays (Hamersley Station, Pilbara)' within 50 km of the study area, with the 28 km administrative buffer applied by the DEC overlapping the south-eastern third of the Blacksmith study area
- Priority 3 Priority Ecological Community (PEC) 'Four Plant Assemblages of the Wona Land System', north of the study area in the Chichester Ranges
- 31 conservation significant flora species (DRF and Priority Listed Flora) occurring within 50 km of the study area.

During the field surveys, 50 floristic quadrats measuring 50 m x 50 m were assessed twice, recording vegetation descriptions, site characteristics and a floristic inventory from each quadrat. The vegetation types were mapped and opportunistic searches for conservation significant flora species were conducted.

The vegetation surveys identified:

- that approximately 80% of the study area had been burnt in February 2010 and could not be assessed, however sufficient unburnt vegetation remained to characterise the area
- 10 vegetation types from the unburnt areas, determined from a combination of field survey and floristic analysis conducted on the quadrat data. These vegetation types were:
    - *Acacia maitlandii* Shrubland, on rocky hillsides and stony valleys in the north-eastern portion of the study area
    - *Acacia orthocarpa* (atypical form) Shrubland, on lower slopes and hill spurs in 'Ajax'
    - *Corymbia ferriticola/Eucalyptus leucophloia* Low Open Woodland, in gorges and deep gullies
    - *Corymbia hamersleyana/Eucalyptus gamophylla* Low Open Woodland, in the broad floodplain and outwash areas associated with the major drainage channel in 'Ajax' and part of 'Champion'
    - *Eucalyptus gamophylla/Corymbia hamersleyana/Eucalyptus leucophloia* Low Woodland, from valley floors throughout the study area
    - *Eucalyptus leucophloia* Low Open Woodland, from hills throughout the study area
    - *Eucalyptus victrix* Open Woodland, associated with the major drainage channel in 'Ajax'
    - *Triodia epactia* Hummock Grassland, in valley floors
    - *Triodia* aff. *melvillei* Hummock Grassland, on low hills and rises in the northern and western portions of the study area

- *Triodia wiseana* Hummock Grassland, on lower slopes and low rises in the valley floors in the eastern portion of the study area

- there were no TECs or PECs.

Due to burnt extent of the vegetation, any conclusions in relation to local representativeness of vegetation are preliminary only.

Of the vegetation types identified from the study area, *Acacia maitlandii* Shrubland, *Acacia orthocarpa* (atypical form) Shrubland, *Corymbia ferriticola/Eucalyptus leucophloia* Low Open Woodland, *Corymbia hamersleyana/Eucalyptus gamophylla* Low Open Woodland and *Eucalyptus victrix* Open Woodland are considered to have local conservation significance due to either their small local extent or localised occurrence, being restricted to specific landforms that occupy only a small proportion of the area, no similar vegetation being recorded in other Pilbara surveys, or their extent being under threat .

Acacia orthocarpa (atypical form) Shrubland is considered to be the vegetation type with the highest local conservation significance. *Eucalyptus victrix* Open Woodland can be considered to be included in the 'Ecosystem at Risk' 'All major ephemeral water courses', and is thus also of conservation significance.

Floristic analysis conducted on the quadrat data using PATN© delineated four major floristic groups from the Blacksmith tenement, including floristic groups associated with riparian areas, floodplain and outwash areas, valley floors and uplands. The floristic group corresponding with upland vegetation was interpreted to belong to a number of vegetation types based on dominant and characteristic species.

Regional floristic analysis determined that most of the floristic groups included in Griffin and Trudgen's 600-group that were identified from the Blacksmith tenement are restricted to the central Hamersley Range, where most are locally common or moderately common.

Except for a small area (0.03% of the total area) in Good condition (assessed using the Trudgen vegetation condition scale), all other unburnt areas were in Very Good or Excellent condition. Approximately 80% of the study area was burnt in February 2010: subsequently the vegetation condition of the burnt areas could not be assessed as the area was devoid of vegetation in 2010 and had immature growth in 2011. The fires were not considered a form of degradation as they were not caused by human activities.

The flora assessment resulted in 269 taxa being identified from the study area, however 21 of these (7.8%) could not be identified to species level due to lack of diagnostic reproductive material.

Forty one families and 117 general were recorded in the study area, represented by Fabaceae (including the former Mimosaceae, Caesalpiniaceae and Papilionaceae, up to 61 taxa), Poaceae (up to 41 taxa), Malvaceae (up to 36 taxa) and Amaranthaceae (16 taxa). *Acacia* (24 taxa), *Senna* (up to 15 taxa) and *Ptilotus* (10 taxa) were the most commonly represented genera.

Five Priority Listed flora species were located during the field surveys. *Indigofera* sp. Bungaroo Creek (S. van Leeuwen 4301) (P3), *Rostellularia adscendens* var. *latifolia* (P3), *Sida* sp. Barlee Range (P3), *Goodenia nuda* (P4), and *Rhynchosia bungarensis* (P4). No Declared Rare Flora species were recorded.

As a result of the extent of burnt vegetation, the following recommendations are made:

- areas identified for infrastructure should be surveyed for conservation significant species, particularly if they are located in upland areas (upper slopes and hilltops), riparian or burnt areas
- additional floristic quadrats should be established in the riparian area of 'Ajax' and in 'Eagle' when the areas have recovered sufficiently from fire (2013)
- map the vegetation of the remainder of the tenement when it has recovered from fire.

1.0 introduction

1.1 Project Overview

Flinders Mines Limited has commissioned WorleyParsons Service Pty Ltd to conduct the pre-feasibility study of its mineral exploration tenement E47/882, known as Blacksmith. Subsequently WorleyParsons appointed Ecoscape to coordinate the flora and vegetation assessment to support the environmental approvals process.

Exploration has identified five main areas of inferred and indicated iron ore resources in the Blacksmith tenement, known as 'Ajax', 'Blackjack', 'Champion', 'Delta' and 'Eagle', with 'Delta' likely to be the first area to be developed. Two smaller areas within the tenement, known as 'Paragon' and 'Badger', were also included in the field survey.

This assessment will be used as supporting documentation for the environmental impact assessment of the proposal by the Environmental Protection Authority (EPA).

1.1.1 STUDY AREA LOCATION

The Blacksmith tenement is location within the Mt Sheila locality in the Shire of Ashburton, approximately 70 km north-north-west of Tom Price, in the Pilbara region.

The location of the Blacksmith tenement (the study area) is shown in **Figure 1.**

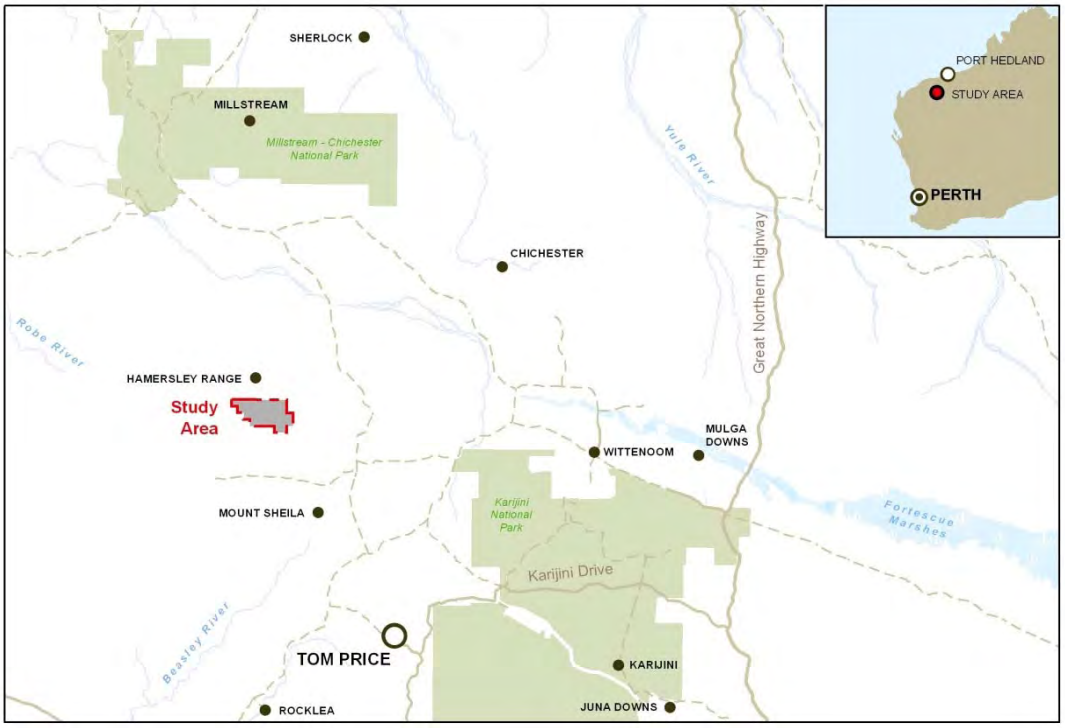

Figure 1: Regional location of Flinders Blacksmith Tenement

1.2 Project Objectives

A Level 2 Flora and Vegetation survey in accordance with Ecoscape's interpretation of Environmental Protection Authority (EPA) *Guidance Statement No. 51* (2004), of the Blacksmith tenement and subsequent reporting requires:

- a flora and vegetation desktop assessment, including database and literature reviews
- a flora and vegetation survey, resulting in an understanding of the flora species and vegetation communities present and their representation over a broader area
- targeted searches for significant flora species and vegetation, including threatened flora, Threatened Ecological Communities (TECs), Declared Rare Flora (DRF), Priority Ecological Communities (PECs) and Declared weeds
- an environmental impact assessment report including background information, details of database searches and literature reviews, methodology, survey results and discussion, and advice on potential environmental impacts
- figures showing quadrat locations, significant flora species, introduced flora species, vegetation assemblages/communities and vegetation condition.

The assessment was conducted over two survey seasons (autumn and winter). Fifty floristic quadrats were established in May-June 2010, the vegetation of the unburnt extent was mapped and opportunistic searches for conservation significant flora species were conducted. In August 2010, the floristic quadrats were rescored, the vegetation mapping was ground truthed and additional opportunistic searches for conservation significant flora species were conducted.

1.3 Previous Botanical Surveys

Previous botanical surveys in the Pilbara, reviewed to reference flora and vegetation information, included:

- Ecoscape (2010) *Level Two Flora and Vegetation Assessment, Firetail Mining Area*, Unpublished report for Fortescue Metals Group Limited
- Coffey Environments (2010a) *Flora and Vegetation Assessment, Solomon Project and Investigator*, 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
- Coffey Environments (2007) *Supplementary Vegetation and Flora Surveys of the Port Hedland to Cloud Break Rail Corridor and Associated Borrow Pits and Infrastructure*, Unpublished report for Fortescue Metals Group Ltd
- Mattiske (2005) *Flora and Vegetation on the Cloud Break 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 Stage B Rail Corridor, Christmas Creek, Mt Lewin, Mt Nicholas and Mindy Mindy Mine Areas*, Unpublished report for Fortescue Metals Group Ltd.

Additional reports referenced during this assessment are included in the 'references' section.

2.0 method

The flora and vegetation assessment methodology used was developed to comply with Ecoscape's interpretation of the requirements of a Level 2 survey based upon the EPA's *Guidance for the Assessment of Environmental Factors No 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (2004) and *Terrestrial Biological Surveys as an Element of Biodiversity Protection Position Statement No. 3* (EPA 2002). Prior to the survey commencing, Ecoscape and Flinders Mines met with Dr Stephen van Leeuwen, DEC's Biogeography Program Leader & Partnerships Manager, to discuss the survey.

Based on information in *Guidance Statement No. 51*, a Level 2 flora survey is required for the Blacksmith tenement, as the extent of native vegetation loss or habitat loss is considered to be high impact.

Level 2 surveys incorporate background research and a reconnaissance survey as preparation for a more intensive and detailed survey. This requires one or more visits in the main flowering season followed by visits in other seasons. Level 2 surveys also involve replication of the survey, greater coverage than a Level 1 survey and displacement of plots over the target areas.

In order to determine the overall value of the vegetation and flora of the study area, data collected during the field survey was used to:

- describe and map the vegetation types of the Blacksmith tenement to indicate the distribution and relative abundance of each vegetation unit and to help to define units of particular conservation value
- document the vascular flora of the area and provide a measure of the overall floristic richness of the area
- identify species of particular conservation significance and introduced plant species.

The vegetation and floristic data was collected and described from 50 quadrats, 50 m x 50 m in dimension or equivalent area if linear (eg along a drainage line), and floristic, biological and physical data was collected and recorded from each of these quadrats. The flora records provided the names used in the vegetation descriptions and contributed to the flora species lists and frequency of occurrence data. Several parameters relating to the individual quadrats were used to assist in both the description of vegetation types and the determination of flora distribution, particularly in terms of defining associated landforms.

2.1 Desktop Assessment

The background research (desktop assessment) was undertaken by WorleyParsons and is included in **Appendix One**.

Results of additional desktop assessments including updated DEC Threatened Flora and Ecological Community database search requests, conducted using a 50 km buffer, are included in **Section 3.1**.

The DEC Threatened Flora results consist of data from validated populations of Declared Rare and some Priority flora from the Threatened Flora Database (DEFL), specimens in the Western Australian Herbarium (WAHERB) and the DEC Declared Rare Flora and Priority Flora Database (Access database).

Threatened Ecological Communities (TECs) are categorised at both State level (DEC 2010a) and Commonwealth level (Australian Government 1999), while Priority Ecological Communities (PECs) are also classed at State level (DEC 2010a). The status of the State and Commonwealth ratings are summarised in **Table 12** and **Table 13**, **Appendix Two**.

A search of Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) online database was also conducted to identify potential nationally significant areas within 10 km of the study area. The results of this search are reproduced in **Appendix Three**.

Communities identified from either of these database searches were specifically targeted during the vegetation survey, according to potential areas of shared landform, geological and habitat characteristics within the study area. Any vegetation types encountered during the field surveys exhibiting floristic or structural affinities with identified TECs/PECs, based upon available descriptions, were highlighted for further analysis.

Recent rainfall data for the Wittenoom Bureau of Meteorology (BoM) site is included in **Section 2.3.1**. The Wittenoom site was the closest site with complete data; nearer sites (eg Hamersley Station) included unverified 'null' data.

2.2 Reconnaissance Survey

A reconnaissance survey was undertaken by Lyn Atkins and Hayley Hughes on May 25, 2010 to select locations of floristic quadrats. Floristic quadrats were spatially distributed over the study area, within representative, replicated vegetation types (where possible) and throughout the landscape. Quadrats were entirely located within one vegetation type (not including an ecotone) to assist with interpretation of floristic data. Quadrats were not located in Aboriginal Heritage areas, and not in areas considered likely to be affected by imminent exploration activities.

2.3 Floristic Surveys

Three floristic surveys were conducted by Lyn Atkins (flora licence SL008869), Hayley Hughes (SL008943) and Jared Nelson (SL008870), assisted by Richard Daniel, Claudia McHarrie, Casey Murphy and Gemma Greig. Survey teams consisted of two people.

The first survey was conducted over eight days during May 26th – June 2nd, 2010, when the following tasks were carried out:

- a total of 50 floristic quadrats were established in the 'Delta' (14 quadrats), 'Champion' (11 quadrats), 'Blackjack' (four quadrats), 'Ajax' (10 quadrats), 'Eagle' (two quadrats), 'Paragon' (seven quadrats) and 'Badger' (two quadrats) resource areas
- preliminary mapping of vegetation units, including mapping burnt and unburnt areas
- targeted searches for conservation significant species.

Quadrat locations were spatially distributed over the study area in unburnt areas.

The quadrats were numbered FL (representing Flinders Mines), 10 (representing the year the quadrats were established, 2010) and xx (representing the quadrat number). Except for quadrats associated with riparian areas and gorges, all quadrats were 50 m x 50 m in size and orientated north-south and east-west. Where it was not possible to establish quadrats 50 m x 50 m in dimension, a comparable quadrat area of 2,500 m^2 was maintained as this size gives a good sample of flora presence in the Pilbara, and is in line with the DEC's Draft Botanical Survey Requirements for the Pilbara Region (Department of Conservation and Land Management 2003) and EPA Guidance Statement *No. 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004).

The second survey was conducted over five days during August 26 – 30th, 2010. The following tasks were undertaken:

- a reassessment of the previously established quadrats
- vegetation mapping types and boundaries were confirmed
- additional targeted searches for conservation significant species.

As 2010 was a poor year in terms of rainfall, a third survey was conducted over four days during March 25 – 28, 2011. During this survey the quadrats were rescored.

2.3.1 TIMING OF SURVEYS

The first two floristic surveys were conducted during autumn (May-June), when grasses are generally flowering and therefore identifiable following summer/early autumn (usually cyclonic) rainfall, and in winter (August) when ephemeral species are generally flowering, in 2010.

Seasonal conditions during the 2010 surveys were considered to be poor for the collection of ephemeral flora and flowering grasses. The region had received 148.1 mm of rain for the November 2009 - April 2010 period, which is approximately 40% of the summer average. The two previous years rainfall, 451.3 mm in 2009 and 434.0 mm in 2008, were close to the mean annual rainfall of 457.6 mm (Bureau of Meteorology (BoM) 2011).

January and February 2011 rainfall (79.9 and 294.0 mm respectively) was approximately 174% of the mean rainfall for these months (102.7 and 112.2 mm) (BoM 2011) and therefore seasonal conditions were considered to be good.

Figure 2 outlines monthly rainfall totals recorded at the BoM Wittenoom site during the November 2009 to March 2011 period, compared with long term averages.

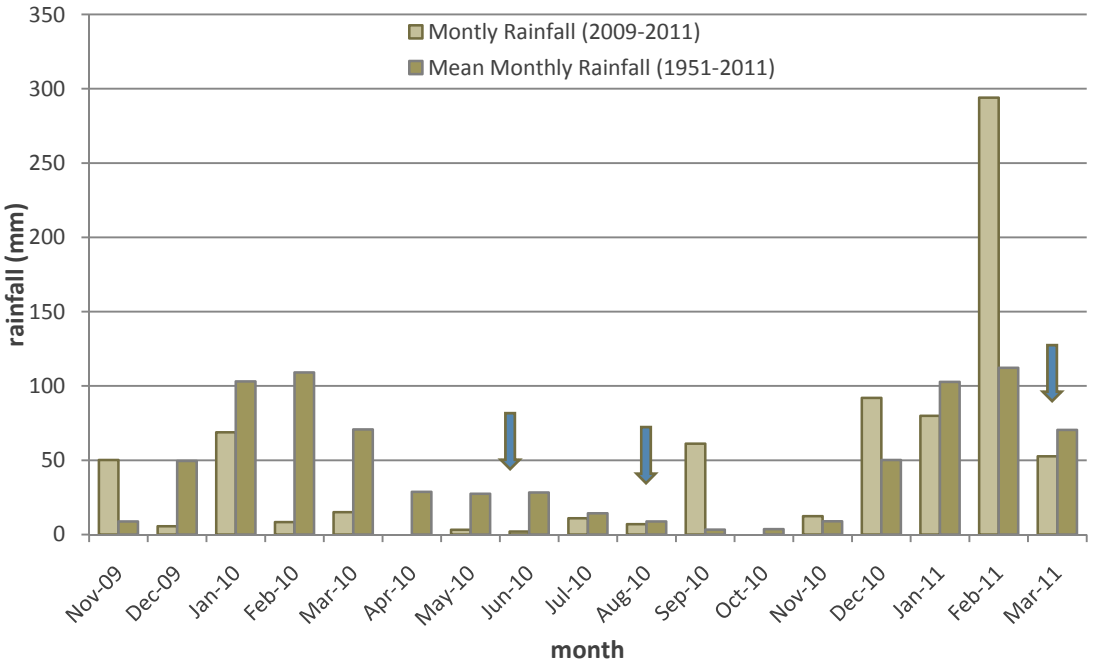

Figure 2: Annual and mean monthly rainfall totals for the Wittenoom BoM site. The timing of the field surveys are indicated by the blue arrows.

Data collected during 2010 resulted in fewer than anticipated flora species being recorded, and difficulty interpreting the floristic data analysis. An additional survey in March 2011, following good summer rainfall, was undertaken to supplement the data.

Plate 1 illustrates the poor seasonal conditions in 2010. **Plate 2** illustrates the good seasonal conditions in 2011.

Plate 1: Quadrat FL1008 in May 2010

Plate 2: Quadrat FL1008 in March 2011

2.3.2 VEGETATION DESCRIPTION AND MAPPING

Two standard vegetation classification and description systems were used during the vegetation surveys. Descriptions were defined using the height and estimated cover of dominant species of each stratum and the framework of Muir (1977) and Aplin (1979), which is a modification of the vegetation classification system of Specht (1970) to include a hummock grassland category (**Table 1**). Subsequent advice from the DEC determined that National Vegetation Inventory System (NVIS, National Heritage Trust 2003) complaint descriptions, recorded at a minimum of Level V, were required (**Table 2**). These were recorded during the March 2011 field survey. Both descriptions are included in the report.

Floristic data and vegetation structural characteristics collected from each of the 50 quadrats were used to develop vegetation descriptions. These descriptions were then grouped to arrive at vegetation units that were defined on the basis of shared structural, disturbance and floristic (species, abundance and cover) data. These units were also linked to the main landform/habitat types in which they were found to occur. Where possible, a minimum of three quadrats were sampled per vegetation type (as recognised during the field survey) from across the study site. Quadrat locations were determined on the basis of topography/landform, field observations of vegetation structure and composition, interpretation and ground truthing of aerial photography, and spatial representation.

Floristic analysis was conducted using both the 2010 and complete (2010 and 2011) data. Regional floristic analysis was conducted using the complete data.

Table 1: Vegetation structural classes (modified from Muir (1977) and Aplin (1979)

Stratum	Canopy Cover				
	70%-100%	30%-70%	10%-30%	2%-10%	<2%
Trees over 30m	Tall Closed Forest	Tall Open Forest	Tall Woodland	Tall Open Woodland	Scattered Tall Trees
Trees 10-30 m	Closed Forest	Open Forest	Woodland	Open Woodland	Scattered Trees
Trees under 10 m	Low Closed Forest	Low Open Forest	Low Woodland	Low Open Woodland	Scattered Low Trees
Shrubs over 2 m	Tall Closed Scrub	Tall Open Scrub	Tall Shrubland	Tall Open Shrubland	Scattered Tall Shrubs
Shrubs 1-2 m	Closed Heath	Open Heath	Shrubland	Open Shrubland	Scattered Shrubs
Shrubs under 1 m	Low Closed Heath	Low Open Heath	Low Shrubland	Low Open Shrubland	Scattered Low Shrubs
Hummock Grasses	Closed Hummock Grassland	Mid-dense Hummock Grassland	Hummock Grassland	Open Hummock Grassland	Scattered Hummock Grasses
Grasses, Sedges and Herbs	Closed Tussock Grassland/ Sedgeland/ Herbland	Tussock Grassland/ Sedgeland/ Herbland	Open Tussock Grassland/ Sedgeland/ Herbland	Very Open Tussock Grassland/ Sedgeland/ Herbland	Scattered Tussock Grasses/ Sedges/ Herbs

Table 2: NVIS information hierarchy (National Heritage Trust 2003)

Level	Description	NVIS structure/floristic components required
1	Class	Dominant growth form for the ecologically dominant stratum
2	Structural Formation	Dominant growth form, cover and height for the ecologically dominant stratum
3	Broad Floristic Formation	Dominant growth form, cover, height and broad floristic code usually dominant land cover genus for the upper most or dominant stratum
4	Sub-Formation	Dominant growth form, cover, height and broad floristic code usually dominant genus and family for the three traditional strata (upper, mid and ground)
5	Association	Dominant growth form, cover, height and species (3 species) for the three traditional strata (upper, mid and ground)
6	Sub-Association	Dominant growth form, cover, height and species (5 species) for all layers/strata

Vegetation condition was assessed using a rating scale that was developed based on a scale devised by Trudgen (1991), which the DEC has previously advised as the most appropriate for assessing vegetation condition in the Pilbara region (Coffey Environments 2007). This rating scale is outlined in **Table 3**.

Table 3: Vegetation condition rating scale (Trudgen 1991)

Condition Rating	Description
E=Excellent	Pristine or nearly so; no obvious signs of damage caused by activities of European man.
VG= Very Good	Some relatively slight signs of damage caused by activities of European man. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds such as **Ursinia anthemoides* or **Briza* spp., or occasional vehicle tracks.
G=Good	More obvious signs of damage caused by activities of European man, including some obvious signs of impact on the vegetation structure such as that caused by low levels of grazing or by selective logging. Weeds as above, possibly plus some more aggressive ones such as **Ehrharta* spp.
P=Poor	Still retains basic vegetation structure or ability to regenerate to it after very obvious activities of European man, such as grazing, partial clearing (chaining) or frequent fires. Weeds as above, probably plus some aggressive ones such as **Ehrharta* spp.
VP=Very Poor	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 including very aggressive species.
D=Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; ie areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

To collect spatial information, 1:15 000 scale rectified and geo-referenced aerial images were marked up with vegetation type boundaries. These hand drafted vegetation boundaries were then digitised and attributed in ArcGIS Version 10.

2.3.3 FLORA SURVEY

The flora survey involved the sampling of floristic quadrats, with the following parameters recorded at each quadrat:

- MGA coordinates recorded in GDA 94 datum using a hand-held Global Positioning System (GPS), to an accuracy usually within 5 m
- broad vegetation description based on the height and estimated cover of dominant species
- an inventory of all species, with estimated maximum height and percent foliage cover
- description of landform and habitat
- broad description of surface soil type and stony surface mantle
- percentage of litter cover and depth
- percentage of bare ground
- evidence of grazing, mining exploration activities, weed invasion, frequent fires etc. Fire effects were only considered a negative impact if they were caused by repeated burning eg for pastoral purposes.

Photographs of the vegetation at each site were taken from the north-west corner of each quadrat using a digital camera.

Flora species were also opportunistically recorded on traverses between quadrat locations. To supplement the list of species recorded from the flora survey sites, specific searches of habitats likely to support flora species with sporadic or restricted distributions (eg drainage lines, rock piles and cracking clay areas) were also undertaken.

Voucher specimens of all species were collected, assigned a unique number to facilitate tracking of data, and pressed in the field. Specimens collected were dried and treated in accordance with the requirements of the West Australian Herbarium. These voucher specimens were identified by ME Trudgen, using appropriate publications, and/or comparison with pressed specimens housed at the West Australian Herbarium, but have not yet been submitted to the Herbarium.

Nomenclature was checked against the current listing of scientific names recognised by the Western Australian Herbarium and listed on FloraBase (Western Australian Herbarium & DEC 2010) and updated as necessary.

All raw site data was entered into a Microsoft Access database, with species names entered following formal identification of the collected specimens.

Conservation Significant Flora

Flora species are classified as Declared Rare Flora (DRF) or listed as Priority Flora where populations are geographically restricted or threatened by local processes. The DEC enforces regulations under Government of Western Australia's *Wildlife Conservation Act* (1950) to conserve DRF and protect significant populations. Rare flora species are gazetted under Sub-section 2 of Section 23F of the *Wildlife Conservation Act*, thereby making it an offence to remove or damage rare flora without Ministerial approval.

There are six categories covering DRF and Priority listed species (DEC 2010b; Western Australian Herbarium & DEC 2010), which are outlined in **Table 14**, **Appendix Two**. DRF species may also be listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Australian Government). Definitions of the Commonwealth (DSEWPC) categories are also provided in **Table 15**, **Appendix Two**.

Prior to the survey, an initial review of previous flora and vegetation survey reports from the region, in conjunction with interrogation of the DEC Threatened (Declared Rare) and Priority Listed Flora database (search request) was undertaken to identify conservation significant flora known to occur within 50 km of the Blacksmith study area. The search identified the list of species indicated in **Table 16, Appendix Four**.

A review of the DSEWPC online databases (Protected Matters Search Tool and Species Profile and Threats Database) was also conducted to identify any additional threatened flora with

Commonwealth protection nearby. The results of the Protected Matters Search are reproduced in **Appendix Three**.

Due to the size of the study area, no systematic grid search of the study area for conservation significant flora was undertaken. However, when traversing between sites, every opportunity was taken to search for threatened species, especially where preferred habitats were encountered. The search spacing between surveyors was approximately 20-30 m (ie when walking between sites, the two surveyors walked parallel lines, searching either side of the walked line for species identified by the DEC database search), but varied largely due to topographic features. Additional targeted searches were also conducted within gorge areas.

2.4 Floristic Analysis

Floristic analysis on the quadrat data, using PATN©, was undertaken on two levels:

1. To determine the floristic groups within the study area (undertaken by Ecoscape)
2. To compare the quadrat data to a regional dataset (undertaken by Griffin and Trudgen).

2.4.1 STUDY AREA FLORISTIC ANALYSIS

PATN© software (Belbin & Collins 2006) was used to undertake statistical analysis and generate floristic groups using the data collected from the floristic quadrats. PATN© analysis has been used for several local floristic analyses including Gibson *et al* (1994) for the Swan Coastal Plain, Markey (1997) for the northern Darling Scarp, initially by Craig *et al* (2008) for the Ravensthorpe Ranges, and by Ecoscape for the Geraldton Regional Flora and Vegetation Survey (Department of Planning & Ecoscape (Australia) Pty Ltd 2010).

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. In this case, because the analysis used presence / absence data, 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.

Further interpretation of these purely floristic groups was required to identify recognisable and mappable on-ground vegetation units. This interpretation was largely based on dominant species from several strata, from quadrats that were closely spaced on the dendrogram.

2.4.2 REGIONAL FLORISTIC ANALYSIS

Floristic quadrat data from the Blacksmith tenement was compared with the quadrat data from other surveys in the Pilbara to provide a regional assessment of the vegetation types in the study area. DEC advised that only surveys from the Hamersley Range were required for regional floristic analysis.

Griffin and Trudgen use the numerical classification package PATN© (Belbin 1987) as their experience has been that the resulting classification of datasets can be interpreted to give an understanding of the floristic variations and to make assessments in relation to the importance of these variations.

PATN© provides a classification of vegetation quadrat data into groups of sites with similar floristic composition (that is, groups of quadrats with similar lists of species in the quadrats are placed together). Results need to be interpreted with care as floristic groups are not directly comparable with plant communities based on structure and dominance, or the broader groupings of vegetation associations or vegetation formations.

Floristic quadrat data from the current project and earlier nearby Pilbara projects (the Pilbara dataset) are imported and 'queries' (short programs used to carry out the analysis) incorporated into a Microsoft Access database. Plant species names were reconciled to ensure that nomenclature is compatible over time, there was less likely to be confusion in relation to infrataxa, some taxa combined where there may have been misidentification, and omitting ambiguous records.

The analysis is undertaken using presence / absence data; cover values are not used. The ASO (calculation of similarity matrix), FUSE (classification), DEND (representation of classification) and SSH (a form of ordination) modules of PATN© are used in the analysis, using the default parameters. The output from the analyses include an ASO matrix, used to determine similarity, and a dendogram, showing groups of sites (quadrats).

A second statistical analysis, 'nearest neighbour' analysis, was then conducted to find sites with the most similar flora list to infer the most likely floristic group.

Limitations for this process are listed in the floristic analysis report (**Appendix Nine**).

3.0 results

3.1 Desktop Assessment

3.1.1 DATABASE SEARCHES

Ecological Communities

The DEC Ecological Community database search request identified two potential significant communities:

1. The *vulnerable* TEC '*Themeda* grasslands on cracking clays (Hamersley Station, Pilbara)' was identified during the DEC database search as occurring within 50 km of the study area. The administrative buffer applied by the DEC around this TEC, within which the DEC must be notified of any proposed impacts, overlaps the south-eastern third of the Blacksmith study area (**Map 1, Appendix Five**).

There were, however, no vegetation types or soil types matching the description of this TEC in the study area, and therefore the TEC does not occur in the Flinders tenement.

Additionally, as the surface and subsurface drainage from the study area is northwards towards the Fortescue River rather than southwards towards the TEC, there are likely to be no impacts on the TEC from activities in the Finders tenement.

2. The Priority 3 PEC 'Four Plant Assemblages of the Wona Land System', occurring within 50 km of the study area.

The Wona Land System does not occur in the study area therefore by definition the PEC does not occur in the study area. Additionally there is no vegetation matching the descriptions of the floristic assemblages of the PEC in the study area.

The PEC occupies an area north of the Fortescue River and upstream of the study area, thus there are unlikely to be any downstream impacts on the PEC by activities on the Flinders tenement.

Conservation Significant Flora Species

Thirty conservation significant flora species were identified from the DEC database search as occurring within 50 km of the Blacksmith study area (**Table 16, Appendix Four**). **Map 1, Appendix Five** illustrates the locations of species closest to the study area.

3.2 Vegetation Survey

Approximately 80% of the Flinders Blacksmith tenement had been burnt by fires ignited by lightning strikes in February 2010, prior to the flora and vegetation survey. Floristic quadrats were established on unburnt areas (although some had a very small proportion of their extent burnt) and vegetation mapping was only conducted on unburnt areas. Vegetation type mapping was not conducted on burnt areas (eg **Plate 3**) as vegetation types could not be ground truthed with certainty.

Plate 3: Recently burnt area

3.2.1 VEGETATION TYPES

The field survey and subsequent floristic analysis and interpretation identified 11 vegetation types from the study area. These vegetation types and their extents are summarised below in and their distribution is illustrated in **Map 2**. Vegetation descriptions associated with each quadrat are included in **Appendix Six**.

Table 4: Extents of each vegetation type in the study area

Code	Vegetation Type	Area (ha)	Proportion	Proportion of unburnt area
B	Burnt	8 633.24	80.08%	-
AmS	*Acacia maitlandii* Shrubland	17.87	0.17%	0.83%
AoS	*Acacia orthocarpa* (atypical form) Shrubland	24.53	0.23%	1.14%
CfLW	*Corymbia ferriticola/Eucalyptus leucophloia* Low Open Woodland	5.69	0.05%	0.26%
ChEgLOW	*Corymbia hamersleyana/Eucalyptus gamophylla* Low Open Woodland	16.21	0.15%	0.75%
EgChElLW	*Eucalyptus gamophylla/Corymbia hamersleyana/E. leucophloia* Low Woodland	442.88	4.11%	20.62%
ElLOW	*Eucalyptus leucophloia* Low Open Woodland	1 243.99	11.54%	57.91%
EvOW	*Eucalyptus victrix* Open Woodland	7.46	0.07%	0.35%
TeHG	*Triodia epactia* Hummock Grassland	230.00	2.13%	10.71%
TmHG	*Triodia* aff. *melvillei* Hummock Grassland	105.06	0.97%	4.89%
TwHG	*Triodia wiseana* Hummock Grassland	54.28	0.50%	2.53%
TOTAL		**10 781.22**	**100.00%**	**100.00%**

Most areas had discrete vegetation boundaries, with little merging between adjacent vegetation types. Therefore vegetation type boundaries could usually be accurately determined by interpreting aerial imagery.

The vegetation types determined to occur in the unburnt portion of the study area are described on the following pages.

AmS*: Acacia maitlandii* Shrubland

Vegetation type description: *Acacia maitlandii* Shrubland to scattered shrubs over *Triodia wiseana* and *T. epactia* Open to Mid-dense Hummock Grassland, with *Corymbia hamersleyana* or *Eucalyptus leucophloia* Low Open Woodland to scattered trees. *T. epactia* and *C. hamersleyana* occurred on the valley floor sites and *T. wiseana* occurred on hillsides and at a lower density on valley floors, with *E. leucophloia* occurring largely on hillsides. Other common species include *Acacia adoxa* var. *adoxa, A. pyrifolia, A. retivenea, A. tenuissima, Dodonaea coriacea, Eriachne mucronata, Indigofera monophylla, Jasminum didymum* subsp. *lineare, Ptilotus astrolasius* and *Senna* spp.

U ^*Corymbia hamersleyana*, *Eucalyptus leucophloia*\^tree\6\r; M ^*Acacia maitlandii*\^shrub\3\i;G+ ^*Triodia wiseana*, *T. epactia*\^hummock grass\2\i;

Acacia maitlandii Shrubland occupied approximately 17.87ha or 0.17% of the study area (0.83% of the unburnt extent), occurring on rocky hillsides and stony valley floors in the north-eastern corner of the study area ('Paragon'). The vegetation was assessed as being largely in Excellent condition.

Three quadrats were sampled in this vegetation type (FL1018, FL1019 and FL1021). **Plate 4** illustrates *Acacia maitlandii* Shrubland.

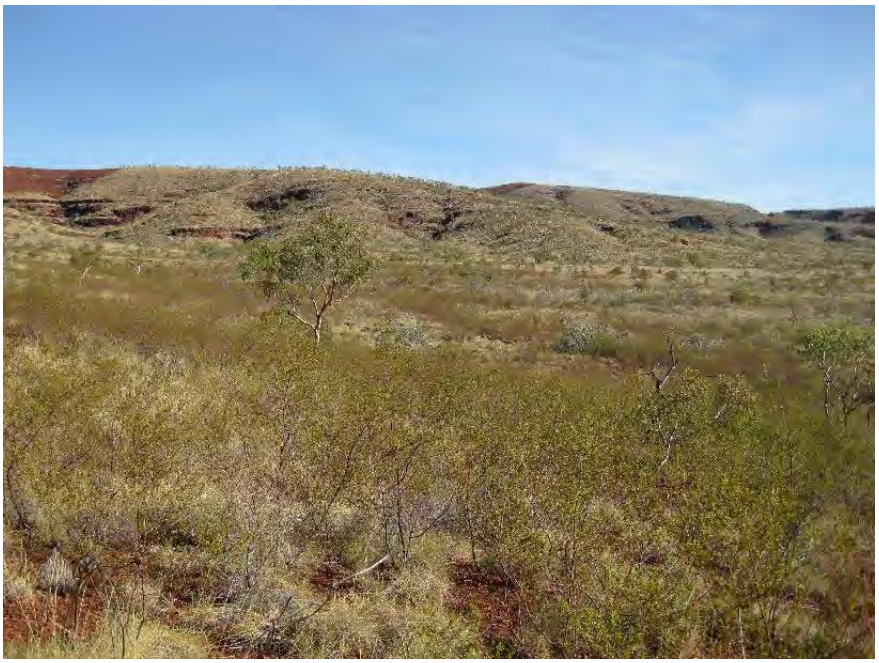

Plate 4: *Acacia maitlandii* Shrubland (near quadrat FL1018)

AoS: *Acacia orthocarpa* (atypical form) Shrubland

Vegetation type description: *Acacia orthocarpa* (atypical form) Shrubland to Low Open Shrubland over *Triodia wiseana* and *T. epactia* Open to Mid-dense Hummock Grassland, with *Corymbia hamersleyana* and *Eucalyptus leucophloia* scattered trees. All occurrences were on areas with exposed sheet rock, on lower slopes and hill spurs. Other common species include *Corchorus lasiocarpus, Cymbopogon ambiguum* and *Waltheria virgata*.

U ^*Corymbia hamersleyana*, *Eucalyptus leucophloia*\^tree\6\r;M ^*Acacia orthocarpa* (atypical form)\^shrub\3\i;G+ ^*Triodia wiseana*, *T. epactia*\^hummock grass\2\i;

Acacia orthocarpa (atypical form) Shrubland occupied approximately 24.53 ha or 0.23% of the study area (1.14% of the unburnt extent), largely in the far north-western portion, with an outlying area in the central western area (all in 'Ajax'). The vegetation was assessed as being in Excellent condition.

Due to the extent of burnt vegetation it was not possible to determine if it occurred in other areas.

Three quadrats were sampled in this vegetation type (FL1039, FL1040 and FL1042). **Plate 5** illustrates *Acacia orthocarpa* (atypical form) Shrubland.

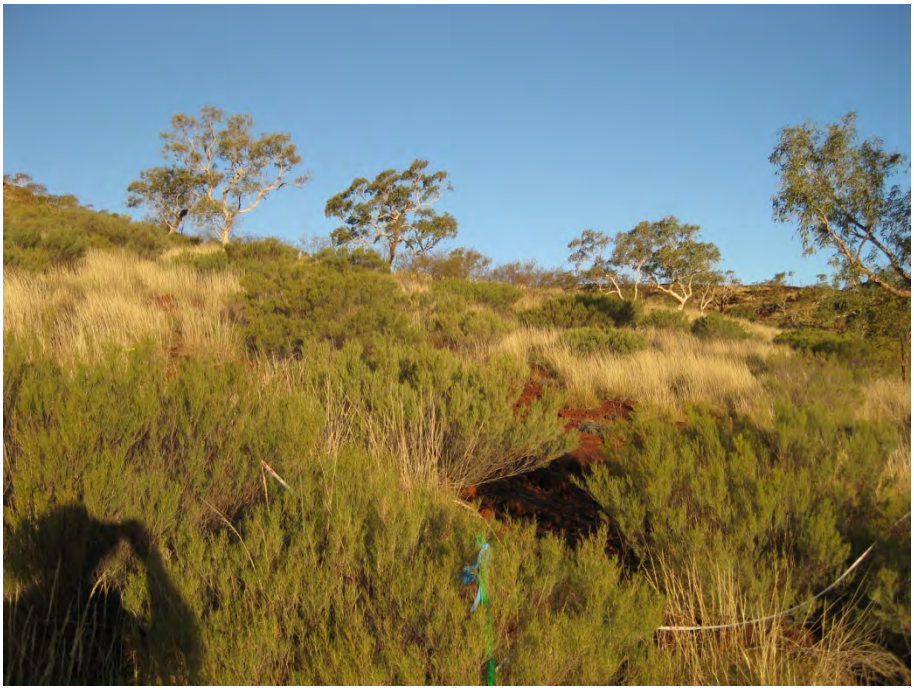

Plate 5: *Acacia orthocarpa* (atypical form) Shrubland (quadrat FL1042)

CfLW: *Corymbia ferriticola/Eucalyptus leucophloia* Low Open Woodland

Vegetation type description: *Corymbia ferriticola* and *Eucalyptus leucophloia*, occasionally with *Ficus brachypoda* and *Brachychiton acuminatus,* Low Woodland to Low Open Woodland over *Acacia monticola, A. pruinocarpa, Flueggea virosa* and *Gossypium robinsonii* Tall Open Shrubland over *Triodia epactia* and occasionally *T. wiseana* Hummock Grassland, and *Cymbopogon ambiguus, Themeda* spp*. Eulalia aurea, Enneapogon lindleyanus, Eriachne mucronata* and *Eragrostis* aff. *eriopoda* Open Tussock Grassland. Other common species include *Astrotricha hamptonii, Capparis spinosa* and *Rhagodia eremaea*.

U ^*Corymbia ferriticola* subsp*. ferriticola, Eucalyptus leucophloia* subsp*. leucophloia*\^tree\7\r;M ^*Acacia monticola, ^A. pruinocarpa* and ^*Gossypium robinsonii*\^shrub\2\c;G+ ^*Triodia epactia, Themeda* sp. Mt Bruce, *Cymbopogon ambiguus*\^hummock grass, tussock grass\3\c;

Corymbia ferriticola/Eucalyptus leucophloia Woodland occupied approximately 5.69 ha or 0.05% of the study area (0.26% of the unburnt extent), and was confined to gorges and deep gullies. The vegetation was assessed as being in Very Good or Excellent condition.

There is probably more of this vegetation type however, due to fire, it is not possible to ground truth these.

Three quadrats were sampled in this vegetation type (FL1026, FL1027 and FL1035). **Plate 6** illustrates *Corymbia ferriticola/Eucalyptus leucophloia* Woodland.

Plate 6: *Corymbia ferriticola/Eucalyptus leucophloia* Woodland (quadrat FL1026)

ChEgLOW: *Corymbia hamersleyana/Eucalyptus gamophylla* Low Open Woodland

Vegetation type description: *Corymbia hamersleyana* and *Eucalyptus gamophylla* Low Open Woodland over *Eulalia aurea, Paraneurachne muelleri* and *Themeda* spp. open tussock grassland and *Triodia epactia* hummock grassland with scattered *Acacia pyrifolia* var. *pyrifolia* and *Gossypium robinsonii* tall shrubs.

U ^*Corymbia hamersleyana, Eucalyptus gamophylla*\6\r;M ^*Acacia pyrifolia* var*. pyrifolia, Gossypium australe*\3\bi;G+ ^*Eulalia aurea*, *Triodia epactia, Paraneurachne muelleri*\^tussock grass, hummock grass\2\c

Corymbia hamersleyana/*Eucalyptus gamophylla* Low Open Woodland occupied approximately 16.21 ha or 0.15% of the study area (0.75% of the unburnt extent), occupying broad floodplain and outwash areas associated with the major drainage channel in 'Ajax' and in an area of converging streams in 'Champion'.

Two quadrats were recorded in this vegetation type. One unburnt but heavily grazed quadrat was located and sampled in this vegetation type during the field survey (FL1043); the other quadrat (FL1031) was identified during the floristic analysis, with review of aerial imagery confirming the similarity of landform and enabling mapping of the area. All other areas that would have been mapped as this vegetation type had been burnt, with the landform and associated vegetation only occurring in the 'Ajax' area in the western portion of the Blacksmith tenement, and the mapped area in 'Champion'. **Plate 7** illustrates *Corymbia hamersleyana* Open Woodland.

Plate 7: *Corymbia hamersleyana* Open Woodland (quadrat FL1043)

EgChElLW: *Eucalyptus gamophylla/Corymbia hamersleyana/E. leucophloia* Low Woodland

Vegetation type description: *Eucalyptus gamophylla* and *Corymbia hamersleyana* and *Eucalyptus leucophloia* Low Open Woodland to Open Woodland over *Acacia spp.* Tall Open Shrubland over *Triodia epactia* Open to Mid-dense Hummock Grassland, with *Aristida holathera* var. *holathera* and other Poaceae spp. Very Open Tussock Grassland. *Acacia* species include *Acacia dictyophleba, A. pyrifolia, A. elachantha, A. retivenea, A. monticola, A. atkinsiana* and *A. tumida* var. *pilbarensis.* Other common species include *Paraneurachne muelleri, Themeda* sp., *Ptilotus astrolasius, Acacia adoxa* var *adoxa, Gossypium australe, Jasminum lineare, Bonamia rosea* and *Senna artemisioides* subsp. *oligophylla*.

U ^*Eucalyptus gamophylla, Corymbia hamersleyana, Eucalyptus leucophloia*\^tree\6\r;M ^*Acacia* spp. \^shrub\4\i;G+ ^*Triodia epactia, Aristida holathera* var. *holathera*\^hummock grass, tussock grass\2\i

Eucalyptus gamophylla/Corymbia hamersleyana/E. leucophloia Low Woodland occupied approximately 442.88 ha (4.11%) of the study area (20.62% of the unburnt extent), occupying valley floors throughout the study area. The vegetation was assessed as being in Very Good or Excellent condition.

Nine quadrats were sampled in this vegetation type (FL1006, FL1007, FL1009, FL1011, FL1012, FL1023, FL1029, FL1030, FL1049). **Plate 8** illustrates *Eucalyptus gamophylla/Corymbia hamersleyana* Low Woodland.

Plate 8: *Eucalyptus gamophylla/Corymbia hamersleyana/E. leucophloia* Low Woodland (quadrat FL1023)

ElLOW: *Eucalyptus leucophloia* Low Open Woodland

Vegetation type description: *Eucalyptus leucophloia* and *Corymbia hamersleyana* Low Open Woodland to scattered trees over *Triodia wiseana* and occasionally *T. epactia* Open to Mid-dense Hummock Grassland over occasional *Cymbopogon ambiguus* and *Eriachne mucronata* Open Tussock Grassland usually associated with rock outcrops. Minor gullies associated with this vegetation type included *Grevillea pyramidalis* subsp. *leucadendron, G. wickhamii* subsp. *hispidula* and *Acacia maitlandii*. Other common species include *Acacia melleodora, Acacia tenuissima, Hakea chordophylla, Jasminum didymum* subsp. *lineare, Senna glutinosa* subsp. *glutinosa, Acacia monticola, Corchorus lasiocarpus* and *Dampiera candicans*.

U ^*Eucalyptus leucophloia*, *Corymbia hamersleyana*\^tree\6\r;G+ ^*Triodia wiseana*, *T. epactia, Cymbopogon ambiguous*\^hummock grass, tussock grass\2\c

Eucalyptus leucophloia Low Open Woodland occupied approximately 1,243.99 ha or 11.54% of the study area (57.91% of the unburnt extent), and occurred on hillslopes and hilltops throughout the study area. The vegetation was assessed as being in Excellent condition.

Fifteen quadrats were sampled in this vegetation type (FL1001, FL1002, FL1003, FL1004, FL1008, FL1010, FL1015, FL1016, FL1017, FL1025, FL1028, FL1033, FL1034, FL1047, FL1050). Quadrats were located throughout the catenary sequence from lower slopes to hilltops, however mesa tops could not be accessed for assessment and have been interpreted to be included as this vegetation type. **Plate 9** and **Plate 10** illustrate *Eucalyptus leucophloia* Low Open Woodland.

Plate 9: *Eucalyptus leucophloia* Low Open Woodland (quadrat FL1001; midslope)

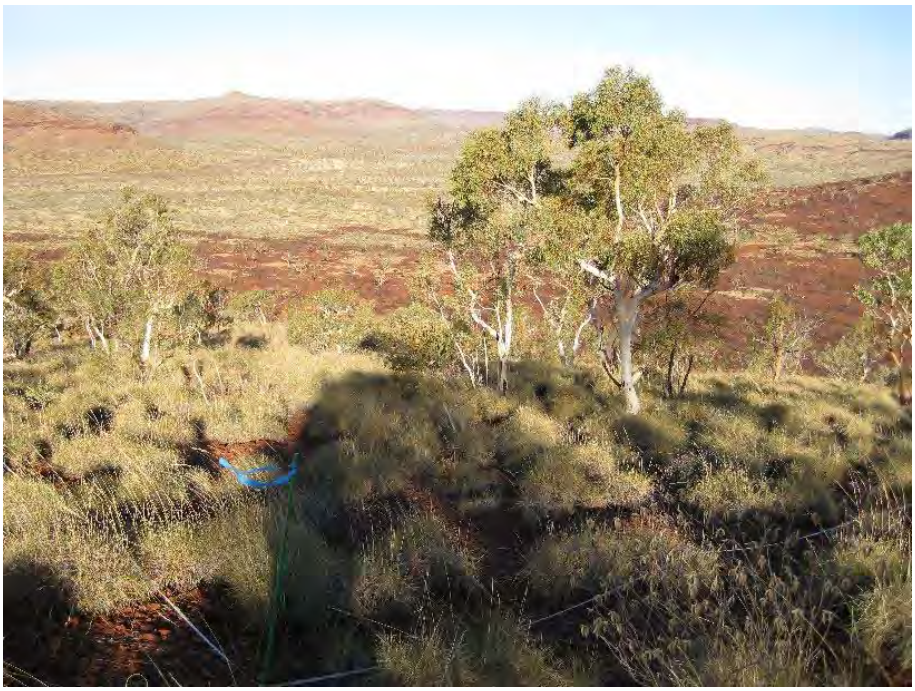

Plate 10: *Eucalyptus leucophloia* Low Open Woodland (quadrat FL1016; upper slope)

EvOW: *Eucalyptus victrix* Open Woodland

Vegetation type description: *Eucalyptus victrix* Open Woodland over *Acacia monticola, Dodonaea lanceolata* var. *lanceolata* and *Gossypium robinsonii* Tall Shrubland over *Stemodia grossa* Low Open Shrubland over *Triodia epactia* Hummock Grassland over *Eulalia aurea, Themeda* sp. and *Eriachne mucronata* open tussock grassland. *Ficus brachypoda, Eucalyptus leucophloia* and *Rhynchosia bungarensis* were also common. It is possible that *Eucalyptus camaldulensis* also occurred along the major drainage channel, however areas that were likely to have this species were burnt (eg **Plate 11**) and not included in the assessment.

U ^*Eucalyptus victrix*\^tree\6\r;M ^*Acacia monticola, Dodonaea lanceolata* var. *lanceolata*, *Gossypium robinsonii*\^shrub\4\c;G+ ^*Triodia epactia, Eulalia aurea, Themeda* sp.\^hummock grass, tussock grass\2\i

Plate 11: Burnt riparian area

Eucalyptus victrix Open Woodland occupied approximately 7.46 ha or 0.07% of the study area (0.35% of the unburnt extent), occurring along the major drainage channel (riparian area) through the western portion of the study area ('Ajax') and as a disturbed (grazed) and partly burnt small area on the far south-eastern corner of 'Eagle'. The unburnt vegetation was assessed as being in Very Good condition.

Only one quadrat was sampled in this vegetation type (FL1045) as all other areas had been recently burnt or heavily grazed. **Plate 12** and **Plate 13** illustrate *Eucalyptus victrix* Open Woodland.

Plate 12: *Eucalyptus victrix* Open Woodland (quadrat FL1045, north-western end)

Plate 13: *Eucalyptus victrix* Open Woodland (quadrat FL1045, south-eastern end)

TeHG: *Triodia epactia* Hummock Grassland

Vegetation type description: *Triodia epactia* Closed to Open Hummock Grassland. *Triodia wiseana* is occasionally included, and there are often emergent *Corymbia hamersleyana, C. deserticola* or *Eucalyptus gamophylla* or *E. leucophloia* scattered trees or *Acacia melleodora, A. tumida, A. ancistrocarpa, A. pyrifolia, A. tenuissima, A. maitlandii* or *Grevillea wickhamii* scattered shrubs. Other common species include *Aristida holathera* var. *holathera, Eriachne mucronata, Ptilotus astrolasius* and *Senna glutinosa* subsp. *glutinosa*.

U ^*Corymbia hamersleyana, C. deserticola* or *Eucalyptus gamophylla*\^*tree*\6\r;M ^*Acacia melleodora, A. tumida, A. ancistrocarpa*\shrub\3\r;G+ ^*Triodia epactia, T. wiseana*\^hummock grass\2\d

Triodia epactia Hummock Grassland occupied approximately 230 ha or 2.13% of the study area (10.71% of the unburnt extent), occurring on valley floors throughout much of the study area. The vegetation was assessed as being in Very Good or Excellent condition.

Four quadrats were sampled in this vegetation type (FL1014, FL1020, FL1022 and FL1036). **Plate 14** illustrates *Triodia epactia* Hummock Grassland.

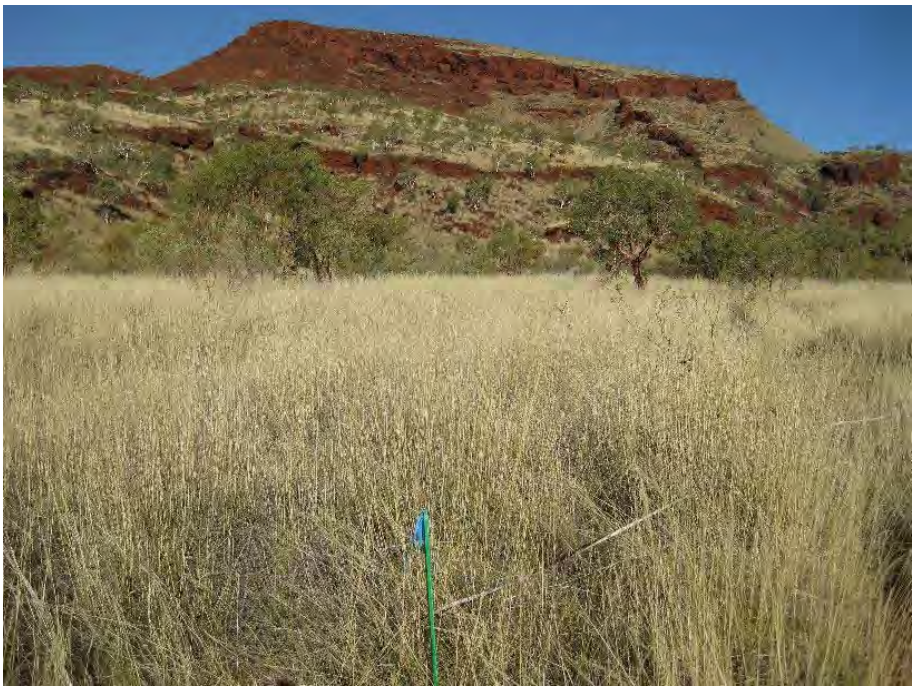

Plate 14: *Triodia epactia* Hummock Grassland (quadrat FL1036)

TmHG: *Triodia* aff. *melvillei* Hummock Grassland

Vegetation type description: *Triodia aff. melvillei* Hummock Grassland to Mid-dense Hummock Grassland, occasionally with *T. wiseana*, at times with *Corymbia hamersleyana* scattered trees. Other common species include *Goodenia stobbsiana, Hakea chordophylla* and *Acacia adoxa* var. *adoxa*.

U ^*Corymbia hamersleyana*\^tree\6\r;G+ ^*Triodia aff. melvillei, T. wiseana*\^hummock grass\1\c

Triodia aff. *melvillei* Hummock Grassland occupied approximately 105 ha or 0.97% of the study area (4.89% of the unburnt extent), occurring on low hills and rises in valley floors in the northern and western portions of the study area. The vegetation was assessed as being in Excellent condition.

Six quadrats were sampled in this vegetation type (FL1024, FL1032, FL1037, FL1038, FL1044 and FL1046). **Plate 15** illustrates *Triodia* aff. *melvillei* Hummock Grassland.

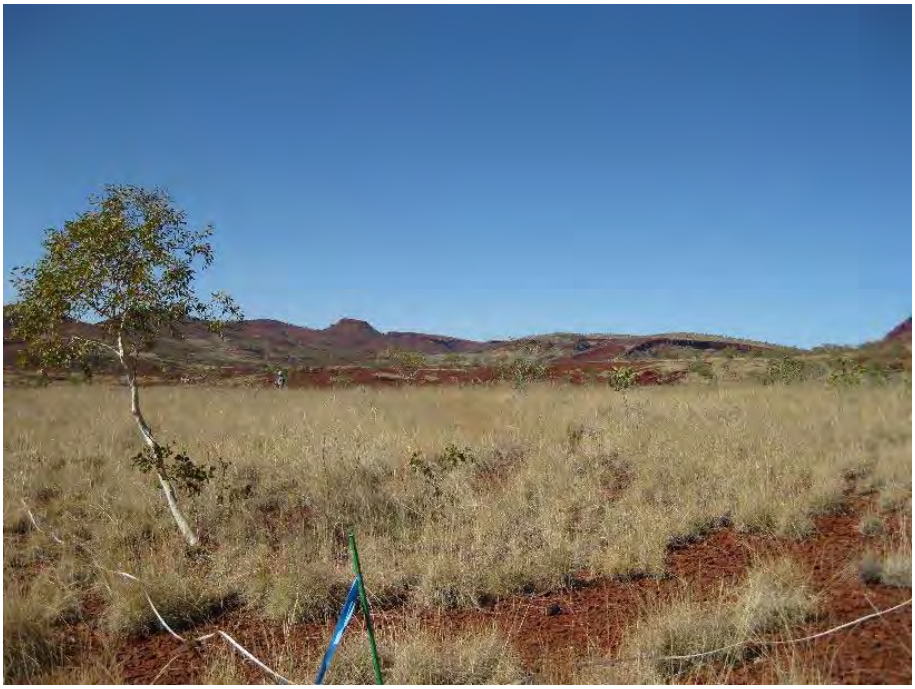

Plate 15: *Triodia* aff. *melvillei* Hummock Grassland (quadrat FL1046)

TwHg: *Triodia wiseana* Hummock Grassland

Vegetation type description: *Triodia wiseana* Hummock Grassland to Mid-dense Hummock Grassland, with emergent *Corymbia deserticola* scattered trees and occasionally *C. hamersleyana* and *Eucalyptus leucophloia* and emergent *Acacia melleodora, Hakea chordophylla* and *Senna glutinosa* subsp. *glutinosa* scattered shrubs. Other common species include *Acacia adoxa* var. *adoxa, A. elachantha, A. retivenea, A. tenuissima, Cymbopogon ambiguus, Dodonaea coriacea, Gompholobium* sp. Pilbara (N.F. Norris 908) and *Senna* spp.

U ^*Corymbia deserticola, ^C. hamersleyana, Eucalyptus leucophloia* subsp*. leucophloia*\^tree\6\r;M ^ *melleodora, Hakea chordophylla* and *Senna glutinosa* subsp. *glutinosa*\^shrub\4\r;G+ ^*Triodia wiseana*\^hummock grass\1\c

Triodia wiseana Hummock Grassland occupied approximately 54.28 ha or 0.5% of the study area (2.53% of the unburnt extent), occurring on lower slopes and low rises in the valley floors in the eastern portion of the study area. The vegetation was assessed as being in Very Good or Excellent condition.

Three quadrats were sampled in this vegetation type (FL1005, FL1013 and FL1048). **Plate 16** and **Plate 17** illustrate *Triodia wiseana* Hummock Grassland.

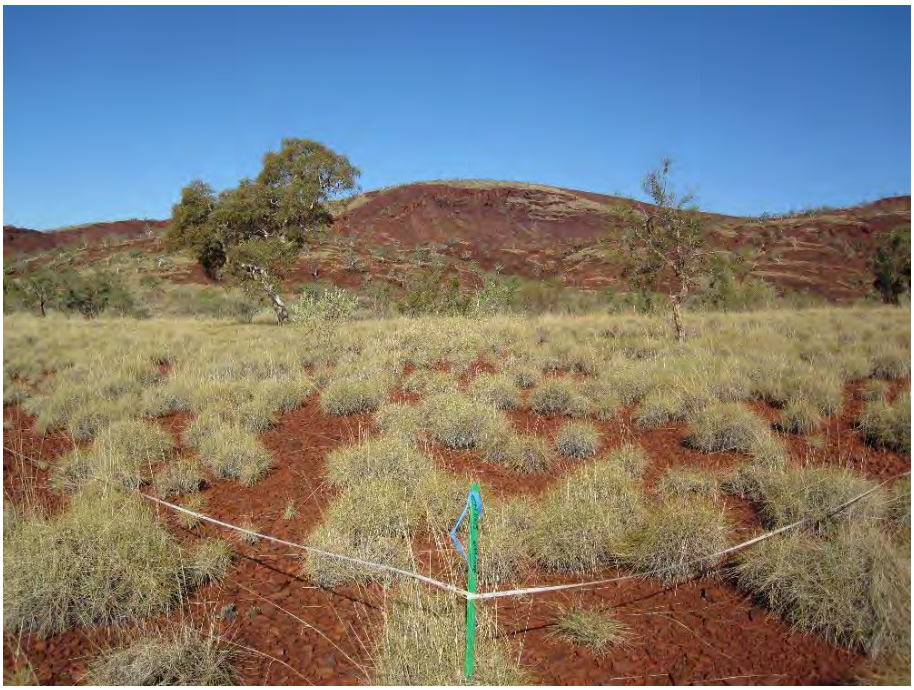

Plate 16: *Triodia wiseana* Hummock Grassland (quadrat FL1005)

Plate 17: *Triodia wiseana* Hummock Grassland (quadrat FL1048)

3.2.2 VEGETATION CONDITION

The vegetation condition in the floristic quadrats was recorded using the Trudgen (1991) scale (**Table 3**).

Vegetation condition varied from Good (in one quadrat), to Very Good (12 quadrats) and Excellent (37 quadrats). The vegetation condition of the quadrats is considered representative of the area in which they are located. Cattle grazing appeared to be largely confined to the valley floors and was most obvious through the valley floor and riparian areas of the western portion of the study area ('Ajax'). In areas other than 'Ajax', grazing does not appear to have been recent and impacts are not apparent. The extent of each vegetation condition is included in **Table 5**.

Table 5: Extents of areas assessed as each vegetation condition

Condition Rating	Extent (ha)	Proportion (%)
Burnt (not assessed)	8633.24	80.08
Excellent	1958.78	18.17
Very Good	185.84	1.72
Good	3.37	0.03
Poor	0	0
Very Poor	0	0
Degraded	0	0
TOTAL	**10781.22**	**100.00**

No vegetation was assessed as Poor, Very Poor or Degraded condition. It is anticipated that at least two years are required to allow vegetation to recover from the fire before further condition

assessments are possible in burnt areas, and impacts of livestock grazing, especially in 'Ajax', become measurable. Livestock grazing in the riparian area appears to be intensive and it is likely that vegetation will not recover fully from the fire as a result.

Tracks and drill pads are also considered to be in Degraded condition as there is no vegetation remaining. These have not been mapped.

3.2.3 CONSERVATION SIGNIFICANCE OF VEGETATION

Discussion in relation to conservation significance of vegetation types within the Blacksmith tenement should be considered as preliminary only, due to the extent of burnt vegetation. Proportions of each vegetation type relate only to unburnt extents, and as vegetation recovers, more accurate mapping and extent calculations will be possible.

3.2.3.1 Threatened or Priority Ecological Communities

No vegetation similar to any known TECs or PECs were recorded from the study area, and there are expected to be no impacts on nearby TECs or PECs as a result of activities on the Flinders tenement.

3.2.3.2 Other Conservation Significant Vegetation Types

'Ecosystems at Risk'

'Ecosystems at Risk' do not have any statutory protection. They were identified by regional ecologists and others as part of the then Department of Conservation and Land Management's (CALM, now DEC) *Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002* (CALM 2002).

The DEC considers 'Hilltop floras, Hamersley Range' as a *vulnerable* 'Ecosystem at Risk' due to frequent fires preventing regeneration and deliberate burning (Kendrick 2002). The resource areas within the Blacksmith tenement are associated with valley floors, therefore future development will have little direct impact on hilltops. However, indirect impacts may include habitat fragmentation, changes to fire regimes and dust.

It is not possible to quantify impacts on different vegetation types at this stage as development plans have not progressed to the stage of identifying locations of infrastructure, although proposed mining areas have been defined.

'All major ephemeral water courses' is also identified as an 'Ecosystem at Risk' in Kendrick (2002). The only major ephemeral water course in the study area is in 'Ajax', which is already threatened by cattle grazing. Buffel grass (*Cenchrus ciliaris*) invasion is a recognised threatening process, however none was observed in 'Ajax' in 2010, although this may have been due to poor seasonal conditions and heavy grazing rather than its general absence. Degradation of the riparian area in 'Ajax' has occurred due to a combination of fire, poor seasonal conditions and heavy grazing.

Other nearby 'Ecosystems at Risk' listed in Kendrick (2002) include 'Valley floor Mulga', and 'Lower slopes Mulga'. No vegetation containing Mulga (*Acacia aneura* sens lat) occurs in the study area and there have been no surveys off-tenement to determine if valley floor mulga occurs downstream from the Flinders tenement. If it does, impacts will be restricted to the effects of changes to surface and subsurface water flow as a result of activities in the study area.

Other Measures of Vegetation Type Significance

In EPA *Guidance Statement No. 51* (2004), the EPA list several reasons why vegetation may be considered to be significant in addition to its listing as a TEC or PEC or because the extent is below a minimum threshold. These reasons, which may apply at a number of scales but are not defined in detail, include:

- scarcity
- unusual species
- novel combinations of species
- role as a refuge
- role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species
- being representative of the range of a unit (particularly a good local and/or regional example of a unit in 'prime' habitat, at the extremes of range, recently discovered range extension or isolated outliers of the main range)
- restricted distribution.

The Blacksmith tenement was largely burnt in February 2010. As a consequence, discussions in relation to local significance should be considered as being of a preliminary nature only, as further surveys will change extents of vegetation types and may alter the vegetation type descriptions.

Locally significant vegetation, unless it is a TEC, do not have any form of statutory protection.

Vegetation types that are poorly represented (in this case, defined as <1% of total unburnt area) within the study area and immediate environs may be considered to have local significance (*Acacia maitlandii* Shrubland, *Acacia orthocarpa* (atypical form) Shrubland, *Corymbia ferriticola/Eucalyptus leucophloia* Low Open Woodland, *Corymbia hamersleyana/Eucalyptus gamophylla* Low Woodland, *Eucalyptus victrix* Open Woodland, *Triodia* aff. *melvillei* Hummock Grassland and *Triodia wiseana* Hummock Grassland). Some of these vegetation types are restricted to specific areas (eg *Acacia maitlandii* Shrubland is confined to 'Paragon' and *Acacia orthocarpa* (atypical form) Shrubland is confined to 'Ajax'), landforms or landscape positions (eg *Corymbia ferriticola/Eucalyptus leucophloia* Low Open Woodland, *Corymbia hamersleyana/Eucalyptus gamophylla* Low Woodland and *Eucalyptus victrix* Open Woodland are confined to drainage lines in valley floors or gorges) and occupy only a small proportion of the study area. As such, these vegetation types may be considered to have 'restricted distribution' but do not have any statutory protection.

*Acacia orthocarp*a (atypical form) Shrubland may also be considered as potentially significant due to the characteristic species being an atypical form that does not appear to occur elsewhere. The typical form of this species is widespread, and also occurs on the Blacksmith tenement.

Eucalyptus gamophylla/*Corymbia hamersleyana* Low Woodland, *Eucalyptus leucophloia* Low Open Woodland, *Triodia epactia* Hummock Grassland, *Triodia* aff. *melvillei* Hummock Grassland and *Triodia wiseana* Hummock Grassland are not considered to have specific significance as they are widespread within the study area and represented elsewhere in the Pilbara.

Potentially significant vegetation types are discussed below, in both local and regional contexts.

***Acacia maitlandii* Shrubland**

Acacia maitlandii Shrubland was recorded from only the north-eastern portion of the tenement, and occupied only 0.83% of the unburnt extent.

Astron Environmental Services (2010) identified two vegetation types with similar characteristics from their reconciliation of vegetation mapping in West Pilbara Iron (WPI) Ore holdings, west of the Blacksmith tenement:

- HBr47 *Eucalyptus leucophloia* scattered low trees *over Acacia maitlandii* open shrubland over *Triodia wiseana, T*. sp. Robe River (M.E. Trudgen MET 12,369) open hummock grassland
- HBr44 *Corymbia hamersleyana* scattered low trees over *Acacia maitlandii* high open shrubland over *Triodia wiseana, T*. sp. Robe River (M.E. Trudgen MET 12,369) very open hummock grassland.

Aston identified HBr47 as a vegetation association with a High Conservation Risk Rating due to its restricted habitat (mesas), having Priority Listed flora, and its occurrence within the disturbance footprint. Whilst mesas, in the form as on the WPI area, do not occur in the Blacksmith tenement, local mesas were not assessed in this survey due to inaccessibility. No Priority Listed flora were recorded from within this vegetation type, however the restricted extent of *Acacia maitlandii* Shrubland in the Blacksmith tenement indicate that this vegetation type may have local significance due to scarcity and a novel combination of species.

***Acacia orthocarpa* (atypical form) Shrubland**

Acacia orthocarpa (atypical form) Shrubland was assessed as occupying 1.14% of the study area. Whilst the characteristic species, *Acacia orthocarpa*, is not considered to be threatened, it is possible that the atypical form has some taxonomic significance (see **Section 3.3.3**). *Acacia orthocarpa* has rarely been identified in other nearby surveys (eg Coffey Environments 2010a; Trudgen & Casson 1998), and has only been identified as a characteristic and dominant species in surveys to the west and north (eg the FMG rail corridor from Port Hedland to Cloudbreak, Coffey Environments 2007), and not in a similar floristic combination.

Therefore, due to its restricted extent within the Blacksmith tenement (scarcity), highly localised occurrence (restricted distribution of atypical form and near range extent of species) and lack of similar vegetation recorded from other areas (novel combination of species), *Acacia orthocarpa* (atypical form) Shrubland may be considered to have local significance.

***Corymbia ferriticola/Eucalyptus leucophloia* Low Open Woodland**

Corymbia ferriticola/Eucalyptus leucophloia Low Open Woodland was recorded from 0.26% of the unburnt extent of the Blacksmith tenement. It was restricted to gorges and gullies.

Similar vegetation has been recorded from the FMG Solomon area (Coffey Environments 2010b; Ecoscape 2010; ENV Australia 2010) and elsewhere in the Pilbara (eg Trudgen & Casson 1998). However it is restricted to specific landforms (gorges and gullies) and is considered to have local significance due to its restricted distribution. It also has significance due to its role as a refuge for plant and animal species.

***Corymbia hamersleyana/Eucalyptus gamophylla* Low Open Woodland**

Corymbia hamersleyana/Eucalyptus gamophylla Low Open Woodland occupied 0.75% of the unburnt extent of the Blacksmith tenement. It was restricted to the floodplain and outwash areas of the main drainage through the 'Ajax' resource area and to a small area in 'Champion', however it is likely that it would have occupied a larger extent in 'Ajax' if the area had not been burnt and the vegetation was able to be mapped. Similar vegetation has been observed elsewhere on similar landforms (eg Ecoscape 2010, in the Firetail mining area), and has not been considered to have local significance.

***Eucalyptus victrix* Open Woodland**

Eucalyptus victrix Open Woodland occupied 0.35% of the unburnt extent of the study area. It was associated with the major drainage channel through the 'Ajax' resource area with a small occurrence in the south-east ('Eagle'), however it is likely to have occupied a larger extent if the tenement had not been largely burnt.

Similar vegetation has been recorded from drainage channels throughout much of the Pilbara (eg Astron Environmental Services 2010; ENV Australia 2010; Trudgen & Casson 1998) and have been identified as having conservation significance (eg Ecoscape 2010; Trudgen & Casson 1998) due to their restricted extent.

This vegetation type is of local significance due to its restricted distribution and its role as a refuge, largely for fauna as it is associated with riparian areas, including water holes.

3.2.4 FLORISTIC ANALYSIS

3.2.4.1 Study Area Floristic Analysis

Ecoscape's floristic analysis was conducted using the quadrat data to assist with identifying floristic units within the study area.

The dendrogram from of the analysis is included as **Figure 3**.

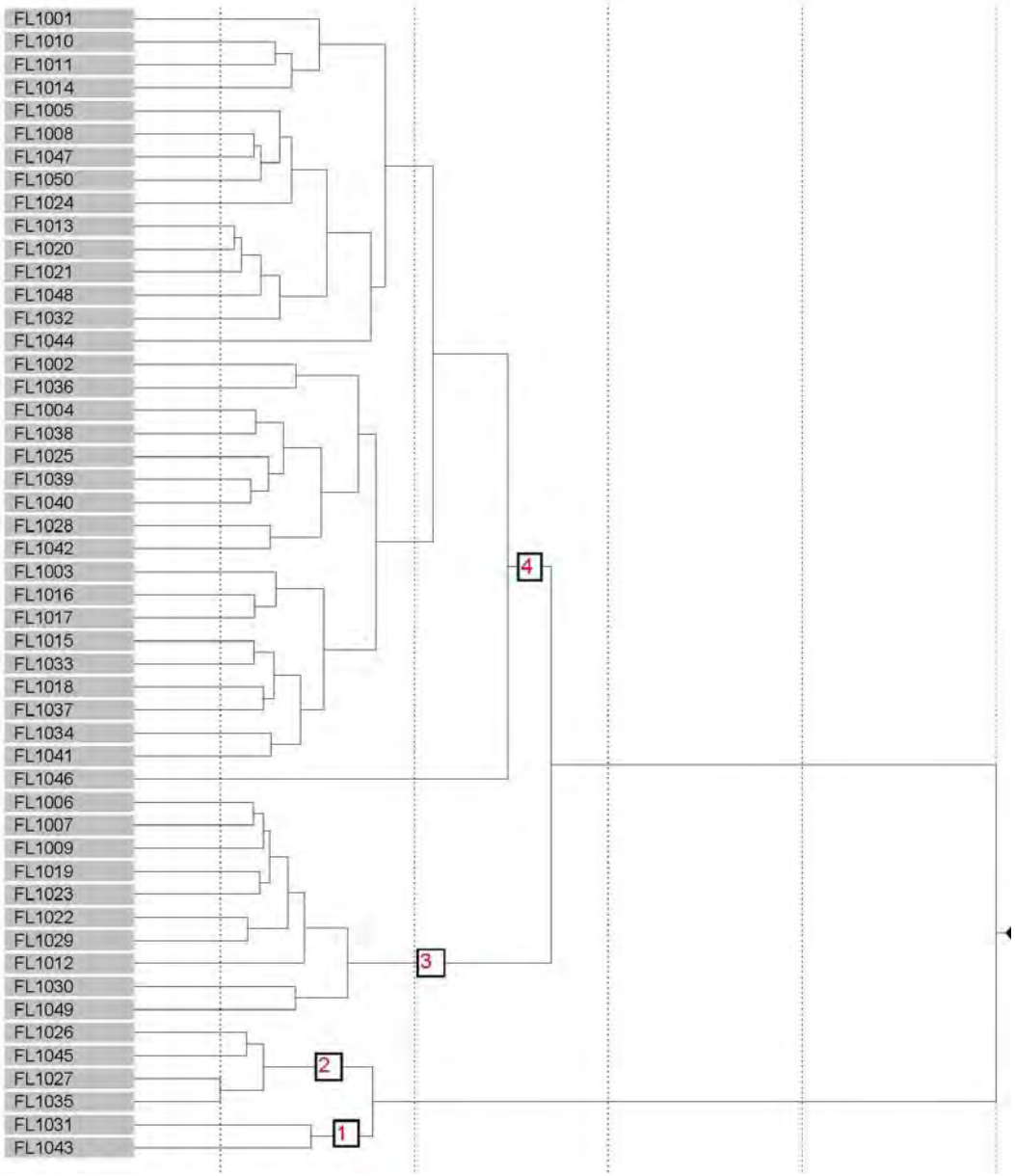

Figure 3: Floristic analysis dendrogram for the study area

Figure 3 shows three clear floristic groups.

The most distinctive group is the group of six quadrats located at the bottom of the dendrogram ('1' and '2'). The quadrats included in this group represent the vegetation of the floodplain and outwash areas ('1', corresponding with *Corymbia hamersleyana/Eucalyptus gamophylla* Low Open Woodland) and vegetation of the riparian areas ('2'). Based on dominant species, interpretation of group '2' has determined two vegetation types from this floristic group; *Corymbia ferriticola/Eucalyptus leucophloia* Low Open Woodland (FL1026, FL1027 and FL1035) and *Eucalyptus victrix* Open Woodland (FL1045).

Group '3' represents vegetation from the valley floors, combined to form vegetation type *Eucalyptus gamophylla/Corymbia hamersleyana/E. leucophloia* Low Woodland. Additional quadrats from group '4' have been interpreted as included in this vegetation type based on dominant species, and one quadrat (FL1019) has been interpreted to be included in a different vegetation type based on dominant species, although the quadrat was located on the valley floor and had other species characteristic of *Eucalyptus gamophylla/Corymbia hamersleyana/E. leucophloia* Low Woodland.

Group '4' represents vegetation from slopes, rises and some valley floor areas. A separate analysis was undertaken on this group, however it did not indicate any groups corresponding with dominant or characteristic species and this group has therefore been interpreted as being included in different vegetation types based on the dominant species and dominant stratum. The vegetation types interpreted from this floristic group are:

- woodlands; *Eucalyptus leucophloia* Low Open Woodland occurring on slopes
- shrublands; *Acacia maitlandii* Shrubland on hillsides and occasionally in valleys downslope from hillside occurrences, and *Acacia orthocarpa* (atypical form) Shrubland in 'Ajax' on slopes and undulating valley floors
- grasslands; *Triodia epactia* Hummock Grassland mostly from lower slopes and valley floors, *Triodia* aff. *melvillei* Hummock Grassland from valley floors and rises within valleys, and *Triodia wiseana* Hummock Grassland from slopes.

3.2.4.2 Regional Floristic Analysis

Regional floristic analysis indicated that virtually all of the new sites (quadrats) were floristically similar to the adjacent Fortescue Metals Group (FMG) Serenity Mining Area, within the Central Pilbara Project Area (formerly included in the Solomon Project Area).

Within the dendrogram, the quadrats that were not similar to other nearby sites are either scattered through the dendrogram or clumped together as an individual group.

Interpretation indicates that the clumped group largely includes the same quadrats indentified from the study area floristic analysis as groups '1' and '2' that were associated with riparian areas (floodplains, outwash areas, drainage lines and gorges). Regionally, these quadrats have been interpreted, through 'nearest neighbour' analysis, as being most similar to the Griffin and Trudgen 600-group '301', that has been identified from the FMG Solomon Mining area (east of the Blacksmith tenement) and in areas further to the southwest of the Blacksmith tenement.

Three of the scattered quadrats occur on low hill or valley floor rises, and are dominated by *Triodia* aff. *melvillei*, and have been interpreted as belonging in the same vegetation type. Through 'nearest neighbour' analysis these have been interpreted to have the greatest affinity with the three separate 600-groups, two of which ('277' and '300') are known to include *Triodia* aff. *melvillei*. Two of the

600-group are considered to have only local occurrences ('293' and '300'), whereas '277' is known from the FMG Solomon mining area and the Chichester Ranges to the north.

The remaining scattered quadrat (FL1014) is not structurally different to or have characteristically different dominant species than others from valley floors in the study area. 'Nearest neighbour' analysis indicates that it is most similar to 600-group '293', which is the most common floristic group in the Blacksmith tenement, and was previously known only from the FMG Serenity Mining Area immediately adjacent to the Blacksmith tenement.

The regional distribution of the 600-groups (Griffin & Trudgen 2009) inferred from the Blacksmith tenement area:

- '171', known from alluvial and colluvial soils, restricted to the central Hamersley Range where it is considered to be uncommon (FL1043)
- '174', known from alluvial and colluvial soils, restricted to the western and central Hamersley Range where it is considered to be locally moderately common (FL1029, FL1031)
- '277', known from colluvial soil, basalt, Brockman Iron Formation and Pisolite, known from the FMG Solomon mining area and the Chichester Ranges to the north and is considered to be moderately uncommon (FL1044)
- '293', known from colluvium and the Brockman Iron Formation, has a very localised occurrence, being formerly only recorded from the FMG Serenity Mining Area, but is considered to be locally common (13 quadrats)
- '298', known from colluvial soil, has been previously recorded from the FMG Serenity Mining Area and FMG Solomon Project Area, and is considered to be locally common (seven quadrats)
- '299', known from colluvium and the Brockman Iron Formation, has a very localised occurrence, being formerly only recorded from the FMG Serenity Mining Area but is locally moderately common (11 quadrats)
- '300', known from colluvium and the Brockman Iron Formation, has a localised occurrence, being formerly only recorded from the FMG Solomon Project Area where it is considered to be locally moderately common (FL1015, FL1018, FL1033, FL1046)
- '301', also known from the FMG Solomon Project Area and southwest of the Blacksmith tenement (FL1026, FL1027, FL1035, FL1045)
- '321', known from alluvial and colluvial soils and aeolian sand, largely from the adjacent FMG Serenity Mining Area but also scattered further to the east, and is considered to be locally common (seven quadrats).

'Quadrat' FL_RIP (600-group '257) was accidently included in the data supplied for the regional floristic analysis. Any interpretation from this 'quadrat' should be disregarded as the data is incomplete due to recent fire.

In general, most floristic groups inferred from the Blacksmith tenement are considered to be regionally restricted to the area close to the tenement. There are few similarities with floristic groups known from areas away from the central Hamersley Range.

3.3 Flora Survey

Fifty floristic quadrats were established and recorded in May-June 2010, and reassessed in August 2010 and March 2011. Co-ordinates of the north-west, or nearest equivalent, corner of each quadrat are provided in

Table 6. Quadrat details are included in **Appendix Six** and shown in **Map 2**, **Appendix Five**.

Table 6: Blacksmith floristic quadrat co-ordinates

Quadrat	Peg Position	Co-ordinates (GDA 94)		Quadrat	Peg Position	Co-ordinates (GDA 94)	
		mE	mN			mE	mN
FL1001	NW	552929	7550690	FL1026	NW	543646	7552563
FL1002	NW	552736	7551272	FL1027	NW	545943	7550995
FL1003	NW	552100	7551360	FL1028	NW	545794	7551114
FL1004	NW	552618	7551648	FL1029	N	546729	7555427
FL1005	NW	550529	7551527	FL1030	NW	546037	7553764
FL1006	NW	552113	7551703	FL1031	NW	547187	7555490
FL1007	NW	550653	7551357	FL1032	NW	546473	7555271
FL1008	NW	550407	7551905	FL1033	NW	542220	7554810
FL1009	NW	550768	7551888	FL1034	NW	543044	7554621
FL1010	NW	550324	7552724	FL1035	N	543198	7553516
FL1011	NW	551298	7551968	FL1036	NW	542990	7554070
FL1012	NW	549664	7551917	FL1037	NW	536737	7554553
FL1013	NW	551028	7553232	FL1038	NW	536918	7555188
FL1014	NW	551590	7552884	FL1039	NW	536628	7554785
FL1015	NW	550589	7554901	FL1040	NW	537258	7555579
FL1016	NW	551132	7555132	FL1041	NW	537550	7555689
FL1017	NW	550653	7555642	FL1042	NW	540889	7552849
FL1018	NW	551312	7555785	FL1043	NW	539402	7553285
FL1019	NW	550839	7556114	FL1044	NW	540110	7552145
FL1020	NW	551126	7556102	FL1045	NW	540092	7551408
FL1021	NW	550942	7556057	FL1046	NW	538582	7552891
FL1022	NW	545209	7553086	FL1047	NW	553318	7549876
FL1023	NW	544588	7552188	FL1048	NW	553223	7549170
FL1024	NW	546104	7552984	FL1049	NW	550810	7547584
FL1025	NW	543599	7552496	FL1050	NW	550930	7548095

3.3.1 FLORA INVENTORY

The flora inventory, using species recorded from the floristic quadrats in all three surveys and opportunistic observations, is included in **Appendix Seven.** Plant identification was conducted by Trudgen to infrataxa (subspecies, variety or affinity) level where possible. Names were checked against FloraBase (WA Herbarium & DEC 2011) and are listed using current taxonomy or Trudgen's phrase names where there is no traceable equivalent.

Including opportunistic observations, 269 taxa were identified from the Blacksmith tenement from the combined surveys in May-June and August 2010 and March 2011. Of these, 17 were identified only to genus level, three only to family level and one was not able to be identified to any level, totalling approximately 7.8% of specimens. These may represent taxa already included in the inventory but they could not be identified further due to lack of reproductive material.

Forty one identified families and 117 identified genera are represented in the study area. The most commonly represented families are:

- Fabaceae (including the former Mimosaceae, Caesalpiniaceae and Papilionaceae); 61 taxa, although two taxa are not identified to species level and may represent duplication
- Poaceae; 41 taxa, although four taxa are not identified to genus or species level and may represent duplication
- Malvaceae; 36 taxa, although eight taxa are not identified to genus or species level and may represent duplication
- Amaranthaceae; 16 taxa.

The most commonly represented genera are *Acacia* (24 taxa), *Senna* (15 taxa, one of which is not identified to species level and may represent duplication) and *Ptilotus* (10 taxa).

Almost no ephemeral species were recorded in 2010 and many short-lived plants were dead (eg Malvaceae, Solanaceae). However the 2011 survey, which followed above average summer rainfall, recorded significant numbers of additional species, including annual species that were absent in 2010.

3.3.2 ADEQUACY OF SAMPLING

The species accumulation curve (**Figure 4**) indicates that the number of quadrats was adequate to collect most species occurring within the unburnt portion of the study area, although a significant proportion (approximately 35%) could not be definitely identified. Further, only six additional species were recorded opportunistically in the study area.

It is anticipated that if there was a larger unburnt extent, especially in the riparian areas of 'Ajax' and in the wide valley floor of 'Eagle', additional species and vegetation types would have been recorded, altering the species accumulation curve. The species accumulation curve would also have been different under better seasonal conditions, when a greater proportion of plants could have been identified as they would have had reproductive material, and more annual and ephemeral species would have been recorded.

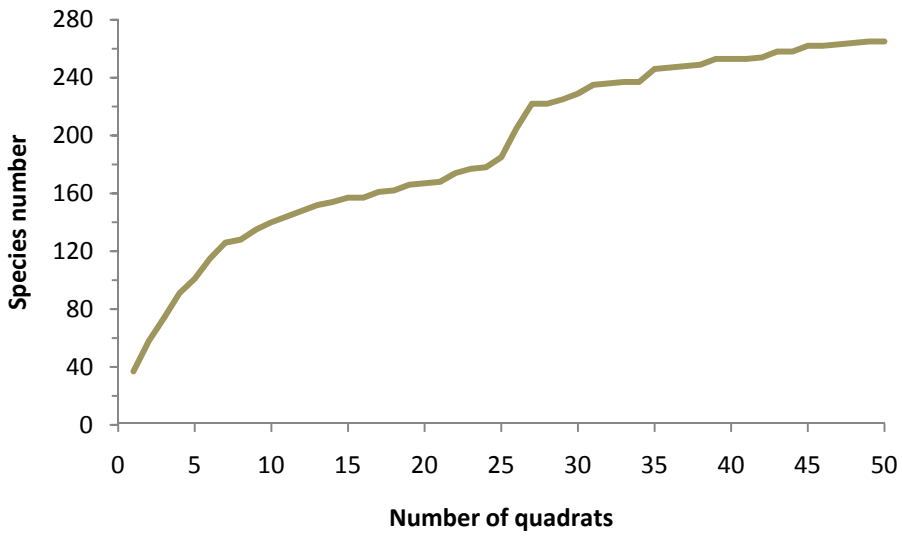

Figure 4: Species accumulation curve

In terms of sampling representative vegetation, Ecoscape considers that 50 floristic quadrats have adequately sampled the common landforms and vegetation types of the unburnt portion of the study area. Although approximately 80% of the Blacksmith tenement had been recently burnt, sufficient areas remained unburnt to characterise the area. Where possible, at least two quadrats were recorded from each vegetation type and quadrats were spatially distributed throughout the study area. The exceptions were:

- the only major drainage line in the study area that was located in the 'Ajax' resource area within the Platform Land System, which was largely burnt
- the tops of tall hills and mesas, which were largely burnt and/or inaccessible due to the steep topography and many vertical escarpments
- the 'Eagle' resource area, which was almost completely burnt.

Of these, only the lack of sampling of the riparian vegetation of the major drainage line and lack of sampling of the broad valley of 'Eagle' are considered to provide significant limitations to the survey.

Adequacy of sampling can also be assessed using a comparison of the number of taxa recorded per unit area (km^2) in nearby areas. The taxa area curve including the Flinders tenement data (included as both the total area of the tenement and the unburnt area that was assessed) is shown in **Figure 5**, with references listed in **Table 7** (points shown as '0' area did not have the project area listed in the reference).

The graph shows that the Flinders tenement data is within the range of number of species recorded per square kilometre for a number of nearby surveys. The surveys with the highest number of species per square kilometre are linear (rail) surveys that traverse many different land systems and

geological units, and would expect a larger number of species per unit area than surveys conducted in a more regularly shaped survey area.

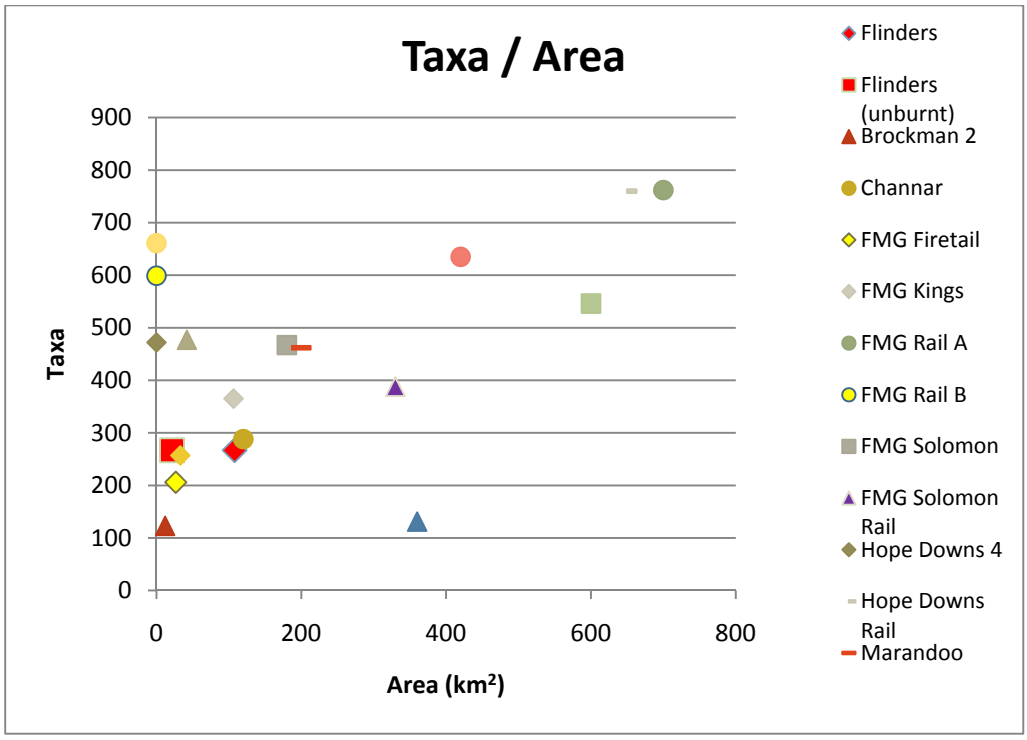

Figure 5: Taxa area curve

Table 7: Taxa numbers recorded from various Pilbara surveys

Survey	Area (km2)	Taxa	Reference
Flinders (total survey area and unburnt survey area)	107.81/21.48	269	This report
Brockman 2 Detritals	12	123	(Mattiske EM & Associates 1989) in (Coffey Environments 2010b)
Channar Survey Area	120	288	(Mattiske E M & Associates 1986) in (Coffey Environments 2010b)
FMG Firetail	26.7	206	(Ecoscape 2010)
FMG Kings	106.45	365	(ENV Australia 2010)
FMG Stage A Rail Corridor	700	762	(Biota Environmental Sciences 2004a) in (Coffey Environments 2010b)
FMG Stage B Rail Corridor		599	(Biota Environmental Sciences 2004b)
FMG Solomon and Investigator Project Areas	180	467	(Coffey Environments 2010a)
Solomon Rail Project	330	388	(Coffey Environments 2010b)
Hope Downs 4		472	(Mattiske Consulting Pty Ltd 2008)
Hope Downs Rail Corridor	650	760	(Biota Environmental Sciences & Trudgen 2002) in (Coffey Environments 2010b)
Karijini National Park	5000	481	(1991 data, Coffey Environments 2010b)
Marandoo	200	462	(Mattiske EM & Associates 1991) in (Coffey Environments 2010b)
Mesa A & Mesa B	33	257	(Biota Environmental Sciences Pty Ltd 2005)
Port Hedland to Cloudbreak Rail, Borrow Pits & Infrastructure Area	600	546	(Coffey Environments 2007) in (Coffey Environments 2010b)
Roy Hill Borefield	360	131	(G&G Environmental Pty Ltd 2009)
Roy Hill 1	42	477	(Ecologia Environment 2009)
West Angelas Survey Area	420	635	(Trudgen & Casson 1998) in (Coffey Environments 2010b)
West Pilbara Iron Ore Reconciliation		661	(Astron Environmental Services 2010)

3.3.3 CONSERVATION SIGNIFICANT FLORA

Environmental Protection and Biodiversity Conservation Act 1999

At a Commonwealth level, flora is protected under the Commonwealth *Environmental Protection and Biodiversity Conservation (EPBC) Act* 1999. This lists threatened species that are considered Critically Endangered, Endangered, Conservation Dependant, Extinct, or Extinct in the Wild.

No plant taxon recorded in the study area is listed as Threatened pursuant to Schedule 1 of the *EPBC Act* (1999).

Wildlife Conservation Act

The DEC enforces regulations under the Government of Western Australia's *Wildlife Conservation Act* (1950) to conserve DRF and protect significant populations. Rare flora species are gazetted under Subsection 2 of Section 23F of the *Wildlife Conservation Act*, thereby making it an offence to remove or damage rare flora without Ministerial approval, obtained on each occasion for each population.

No plant taxon recorded in the survey is gazetted as a DRF pursuant to Subsection 2 of Section 23F of the *Wildlife Conservation Act* (1950).

Priority Flora

The DEC also maintains a list of flora taxa which are considered to be poorly known, uncommon, or under threat, but for which there is insufficient justification on the basis of known distribution and population sizes to be included on the DRF schedule. These are classified as Priority Flora.

The Priority Flora recorded from the study area are listed below. The coordinates of their locations are included in **Table 8**. Threatened and Priority Flora Report Forms are included in **Appendix Eight**.

Table 8: Coordinates of Priority Flora species

Species	Cons. Code	GDA mE	GDA mN
Goodenia nuda	P4	538879	7552705
Goodenia nuda	P4	538977	7552753
Goodenia nuda	P4	543890	7552414
Indigofera sp. Bungaroo Creek	P3	540092	7551408
Indigofera sp. Bungaroo Creek	P3	539402	7553285
Indigofera sp. Bungaroo Creek	P3	543599	7552496
Indigofera sp. Bungaroo Creek	P3	543198	7553516
Indigofera sp. Bungaroo Creek	P3	543044	7554621
Indigofera sp. Bungaroo Creek	P3	545943	7550995
Rhynchosia bungarensis	P4	540103	7551393
Rhynchosia bungarensis	P4	540046	7551480
Rhynchosia bungarensis	P4	543156	7553605
Rhynchosia bungarensis	P4	543197	7553487
Rhynchosia bungarensis	P4	543183	7553481
Rhynchosia bungarensis	P4	540092	7551408
Rhynchosia bungarensis	P4	543198	7553516
Rhynchosia bungarensis	P4	545943	7550995
Rostellularia adscendens var. *latifolia*	P3	543198	7553516
Rostellularia adscendens var. *latifolia*	P3	545943	7550995
Sida sp. Barlee Range	P3	543198	7553516

Information on each of the Priority Flora species recorded in the survey area are included below.

Except for *Goodenia nuda*, the preferred habit of the Priority Flora species recorded in the study area is gorges and drainage lines. As these areas were largely burnt, there is a high possibility that these species would also have been found in the burnt area.

***Goodenia nuda* (P4)**

Three individual *Goodenia nuda* (Priority 4) were recorded in the study area, none from within floristic quadrats. Priority 4 species are rare but not threatened (Smith 2010). *Goodenia nuda* is an annual or short-lived (ephemeral) herb, often associated with disturbance. It is considered to be sparsely distributed throughout much of the Pilbara bioregion and into the Little Sandy Desert.

Twenty collections listed on FloraBase (Western Australian Herbarium and DEC 2010) although more are likely to have been identified to DEC through their Threatened and Priority Flora reporting procedures.

It is unlikely that activities in the Flinders tenement will have a significant impact on this species. *Goodenia nuda* has recently been downgraded from the Priority 3 taxa to Priority 4, indicating that DEC considers that it has been adequately surveyed and, whilst rare, is not considered threatened.

***Indigofera* sp. Bungaroo Creek (S. van Leeuwen 4301) (Priority 3 (P3))**

Six individual P3 *Indigofera* sp. Bungaroo Creek were recorded during the surveys all of which were recorded in floristic quadrats.

Indigofera sp. Bungaroo Creek is an undescribed species with eight records included on FloraBase (WA Herbarium & DEC 2011). It is described as a tall shrub to 2.3 m high, with red or purple/violet pea flowers, and is found in rocky drainage lines, gorges and on alluvial flats. All records on FloraBase are from the Hamersley Range.

Priority 3 species are considered to be poorly known taxa with several populations, some of which are not currently endangered. They are considered to be in need of further survey (Smith 2010).

It is unlikely that development of the Flinders tenement will have a significant impact on this species, as the targeted ore bodies are generally not associated with gorges or the main drainage line in 'Ajax'.

***Rostellularia adscendens* var. *latifolia* (P3)**

Two P3 *Rostellularia adscendens* var. *latifolia* were recorded in floristic quadrats, both located in gorges.

Rostellularia adscendens var. *latifolia* has 12 records listed on FloraBase and is described as a herb or shrub to 0.3 m high, with blue, purple or violet flowers in April-May. It has been recorded form creeks and rocky hills in the Newman and Hamersley Range area, including Karijini National Park, in the Pilbara, and from the north-eastern Pilbara near the Oakover River.

Priority 3 species are considered to be poorly known taxa with several populations, some of which are not currently endangered. They are considered to be in need of further survey (Smith 2010).

It is unlikely that development of the Flinders tenement will have a significant impact on this species, as the targeted ore bodies are generally not associated with gorges.

***Sida* sp. Barlee Range (P3)**

One P3 *Sida* sp. Barlee Range was recorded from a floristic quadrat in a gorge.

Sida sp. Barlee Range has 21 records listed on FloraBase, from both the Pilbara and Gascoyne bioregions. It is described as a spreading shrub to 0.5 m high, with yellow flower and is usually associated with skeletal soils, often in gorges and gullies.

Priority 3 species are considered to be poorly known taxa with several populations, some of which are not currently endangered. They are considered to be in need of further survey (Smith 2010).

It is unlikely that development of the Flinders tenement will have a significant impact on this species, as the targeted ore bodies are generally not associated with gorges.

***Rhynchosia bungarensis* (P4)**

Rhynchosia bungarensis (P4) was recorded from eight locations, including three floristic quadrats in gorges and drainage lines. The other records from the study area are from opportunistic searches of small gorges.

Rhynchosia bungarensis has 55 records listed on FloraBase from the Carnarvon, Gascoyne and Pilbara bioregions. It is described as a sticky compact prostrate shrub, sometimes as a creeper, to 0.5 m high, with yellow flowers. It is usually associated with gullies and drainage lines.

Priority 4 taxa are considered to have been adequately surveyed, and whilst rare, they are not considered to be under threat (Smith 2010). Development of the Flinders tenement is unlikely to impact on this species because of its relatively wide distribution in Western Australia and its locations, in the study area, that are not associated with the targeted ore bodies.

Other Significant Species

As part of the Coffey Environments (2010a) assessment of the FMG Solomon mining area, expert Pilbara taxonomist Malcolm Trudgen considers *Triodia* aff. *melvillei*, an undescribed species, as being a 'species of scientific interest'. However, it is common in the Hamersley Range.

The most common form, and characteristic dominant shrubland species in parts of 'Ajax', was identified by Malcolm Trudgen and confirmed by Bruce Maslin, who is acknowledged as a taxonomic expert for this genus, as *Acacia orthocarpa*. World Wide Wattle (Shire of Dalwallinu, DEC & CSIRO 2010) describes the typical form of *A. orthocarpa* as slender, diffuse and often weeping, but it is also known to be bushy and low spreading. However, the form of *A. orthocarpa* in 'Ajax' is a tall (up to 1.7 m high) rounded shrub with dense foliage, which is considered to be atypical. The typical wispy form of *A. orthocarpa* was recorded from quadrat FL1004 in 'Delta', therefore we have differentiated between the two forms and considered them to be different taxa. The dense shrub form of *A.*

orthocarpa in 'Ajax' is denoted as '*A. orthocarpa* (atypical form)'; the usual form is denoted simply as '*A. orthocarpa*'.

A. orthocarpa is on the southern extent of its usual distribution (Shire of Dalwallinu, DEC & CSIRO 2010; WA Herbarium & DEC 2011). The atypical form of this species in 'Ajax' suggests it may have some taxonomic significance although it is unlikely to have conservation significance.

The as yet unidentified *Josephinia* sp. recorded from floristic quadrat FL1027 is considered by Trudgen to be significant as it is either an unidentified species or a range extension.

No other species recorded in the study area have any particular significance.

3.3.4 SPECIES RANGE EXTENSIONS

A number of species are not within their usual extents, and are range extensions. These include:

- *Mitrasacme connata*, that is approximately 100 km west of the nearest FloraBase record, although it has also been collected from the Fortescue Metals Group (FMG) Solomon (Central Pilbara) project area, east of the Blacksmith tenement
- *Mnesithea formosa* has largely been collected from the Kimberley, with only two FloraBase records from the Pilbara; the nearest record is approximately 70 km south-east of the Blacksmith tenement, although it, too, has also been collected from the FMG Solomon (Central Pilbara) project area
- *Polycarpaea involucrata* is approximately 230 km south-west of the nearest FloraBase record.

3.3.5 INTRODUCED FLORA

No introduce flora species were recorded during the 2010 surveys, however the following species were recorded during the 2011 surveys:

- *Bidens pinnata*, from nine quadrats
- *Cenchrus ciliata*, from one quadrat
- *Cucumis melo* subsp. *agrestis*, from eight quadrats
- *Portulaca oleracea*, from one quadrat
- *Sigesbeckia orientalis*, from one quadrat.

According to the DEC *Pilbara Region – Environmental Weed List* (DEC 2011), none of the introduced species have *high* ecological impact. The ratings of each introduced species for potential and current distribution, ecological impact, invasiveness and feasibility of control is included in **Table 9**.

Introduced species have also been ranked according to the *Environmental Weed Strategy of Western Australia (EWSWA)* (Department of Conservation and Land Management 1999). Of the introduced species recorded from the Blacksmith tenement, only *Cenchrus ciliaris* has a high risk rating in Western Australia. Introduced species (weeds) identified as *high* risk are those that have the ability to invade bushland in Good to Excellent condition, have a wide current or potential distribution, and

have the ability to change the structure, composition and function of an ecosystem, in particular to form a monoculture.

Cucumis melo subsp. agrestis is not included in the *Pilbara Region – Environmental Weed List*, and is not rated in the *EWSWA.*

None of the introduced species are listed as *Declared Plants* under the Government of Western Australia's *Agriculture and Related Resources Protection (ARRP) Act* (1976), nor as *Weeds of National Significance* (Weeds Australia 2008).

Whilst it is generally not feasible to control introduced species on a broad scale, localised control along roads and around infrastructure should be considered as a high priority. Preventing spread of introduced species should also be considered a high priority.

Table 9: Weed ratings (DEC Department of Conservation and Land Management 1999; DEC 2011)

Species	Potential Distribution	Current Distribution	Ecological Impact	Invasiveness	Feasibility of Control	EWSWA Risk Rating
Bidens pinnata	H	H		R	L	Unrated
Cenchrus ciliata	H	L	M	R	L	High
Portulaca oleracea			L			Low
Sigesbeckia orientalis	M	M	U	R-M	L	Moderate

Table 9 legend descriptors:

Potential Distribution: area of potential habitat in the Region that could be occupied or the area at risk of invasion by the weed. H = high, M = moderate.

Current Distribution: Area of habitat in the Region currently occupied by the weed. H = high, M = moderate, L = limited (localised).

Ecological Impact: Impact of species within the Region, from low impact (causes minimal disruption to ecological processes or loss of biodiversity) to high (causes acute disruption of ecological processes, dominates and/or significantly alters vegetation structure, composition and function of ecosystems). L = low impact species, M = medium impact species, U = unknown.

Invasiveness: Rate of spread of a weed in native vegetation, encompassing factors of establishment, reproduction (time to seeding, seed production, vegetative reproduction) and dispersal (wind, water, flying animals, ground animals, deliberate human spread, accidental human spread, vehicles, produce contaminant). M = moderate, R = rapid.

Feasibility of Control: The longer a coordinated control program takes to achieve its desired goal, the more expensive and less feasible it becomes. Key factors to consider include how widespread a

weed is, ease of finding infestations, cost of controlling infestations, difficulty of limiting the weed's dispersal, willingness of landholders and governments to control the weed, and commercial use of the plant. L = low feasibility infestation.

EWSWA: Introduced species are scored on their invasiveness, distribution and environmental impacts, and are rated as *high* (scoring 'yes' for all three criteria), *moderate* (scoring 'yes' for two criteria), *mild* (scoring 'yes' for one criteria) and *low* (scoring none of the criteria), indicating priority of control.

Note: *Cucumis melo* subsp. *agrestis* is not included in the *Pilbara Region – Environmental Weed List*, and is not rated in the *EWSWA.*

3.1 Botanical Limitations

Table 10: Statement of Botanical Limitations

Possible Limitations	Constraints (Yes/No); Significant, Moderate or Negligible	Comments
Competency/experience of the consultant botanist	No constraints	Lead field survey staff have relevant recent experience surveying in the Pilbara region. Most plants were identified by Malcolm Trudgen.
Proportion of the flora identified	Negligible	269 taxa were identified from the surveys, with only 21 (7.8%) of these not identifiable to species level, with none likely to be DRF or Priority-listed species.
Sources of information (historic/recent or new data)	Negligible	Adequate information was available from previous surveys.
Proportion of the task achieved and further work that may need to be undertaken	Moderate – Significant	The resource and access areas were adequately surveyed, with 50 floristic quadrats assessed (approximately 0.46 quadrats per square kilometre in the tenement, but 2.33 quadrats per km2 in the unburnt area). Approximately 80% of the tenement was burnt in early 2010 and provided significant constraints on vegetation mapping, however there were sufficient unburnt areas to characterise the flora and vegetation, except the major drainage line (riparian area) through the 'Ajax' resource area that was the only representative of this landform/vegetation type, and the wide valley floor of 'Eagle' that is anticipated to have had different shrubland vegetation types.
Timing/weather/season/cycle	Negligible	The timing of the field surveys and weather during the surveys were optimal to identify plant species. Seasonal conditions in 2010 were poor, however conditions were considered good in March 2011.
Intensity of survey	Negligible	The study area was surveyed at sufficient intensity to describe the flora and vegetation in most areas.
Completeness (eg was relevant area fully surveyed)	Moderate	The resource areas were adequately surveyed, except for the riparian area in the 'Ajax' that was largely burnt. Additional surveys will be required to adequately characterise and map the burnt areas.
Resources (eg degree of expertise available for plant identification)	Negligible	Sufficient resources were available, including the assistance of Malcolm Trudgen for plant identification.
Remoteness and/or access problems	Negligible	The resource areas were readily accessible.
Availability of contextual (eg bioregional) information for the study area	Negligible	Adequate information was available.

4.0 impact assessment

4.1 Conservation Significant Flora Species

Five Priority Listed flora species, *Goodenia nuda* (Priority 4), *Indigofera* sp. Bungaroo Creek (S. van Leeuwen 4301) (P3), *Rostellularia adscendens* var. *latifolia* (P3), *Sida* sp. Barlee Range (S. van Leeuwen 1642) (P3) and *Rhynchosia bungarensis* (P4), were identified from the Blacksmith tenement. *Goodenia nuda* was identified in scattered locations in the study area; this species is not considered to be threatened. The other species were associated with drainage lines (gorges and riparian areas).

Recent exploration has delineated the ore-bodies in the tenement and determined that there is little overlap between the ore bodies and the locations of these Priority Listed flora. It is unlikely that future activities in the Blacksmith tenement will have a significant impact on the known populations of these species within the tenement and overall. Except for *Goodenia nuda*, which is found in scattered locations and not considered threatened, future activities are unlikely to have a significant impact on the known habitat of these species.

Due to approximately 80% of the study area having been recently burnt, it is highly likely that there are greater numbers of the recorded Priority Listed species in the Blacksmith tenement. However, the preferred habitat of most of these species (gorges and riparian areas) are not likely to be highly impacted by proposed mining activities.

It is also possible that there are other Priority Listed flora species occurring within the study area that were not recorded as a result of recent fire. Priority 3 species are considered to be poorly known and Priority 4 species are not considered threatened, however Priority 1 and Priority 2 species have higher conservation significance. Review of the results of the DEC database search request indicates the following P1 and P2 species are known from within 50 km of the Blacksmith tenement. These species, and their known habitat, are:

- *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) (P1), recorded from clay flats and clay pans in the Pilbara (10 records listed on FloraBase (WA Herbarium & DEC Western Australian Herbarium & Department of Environment and Conservation 2010))
- *Goodenia* sp. East Pilbara (A.A. Mitchell PRP 727) (P1), recorded as occurring on clay and calcrete soil in the Pilbara, mostly near Newman (14 records on FloraBase)
- *Helichrysum oligochaetum* (P1), recorded as occurring on clay soils and rocky creeks on alluvial plains in the Pilbara, Gascoyne and Carnarvon bioregions (seven records on FloraBase)
- *Scaevola* sp. Hamersley Range basalts (S. van Leeuwen 3675) (P2), recorded from hilltops in the Hamersley Range (four records on FloraBase)

- *Sida* sp. Hamersley Range (K. Newbey 10692) (P1), recorded from cliffs, gorges and steep slopes in the Hamersley Range (six records on FloraBase)
- *Spartothamnella puberula* (P2), recorded from gorges and gullies in the Hamersley Range and also near Mt Gibson in the south-west (10 records on FloraBase).

Two DRF species are also known from within 50 km of the Blacksmith tenement. These, and their known habitats, are:

- *Lepidium catapycnon*, recorded from skeletal soils mainly high in the landscape in the Pilbara (12 records on FloraBase)
- *Thryptomene wittweri*, recorded from upper slopes in the Hamersley Range and also from Mt Augustus in the Gascoyne bioregion and in the Little Sandy Desert bioregion (eight records on FloraBase).

Most of the DRF, P1 and P2 species are found on clay soils, which do not occur in the Blacksmith tenement, or from high in the landscape or gorges and gullies, which are not included in the resource area.

Whilst it is unlikely that DRF, P1 or P2 species occur in the resource areas, there is potential that they occur in areas where infrastructure may be located. Targeted searches for these species should be conducted when potential infrastructure areas are identified.

4.2 Conservation Significant Vegetation Types

4.2.1 TECS AND PECS

No vegetation types listed as TECs by the Commonwealth or State governments, or PECs were identified from the study area.

Further clearing of the study area is unlikely to impact on any TECs or PECs, as the surface and sub-surface drainage from the Blacksmith tenement is to the north towards the Fortescue River. The known TEC '*Themeda* grasslands on cracking clays (Hamersley Station, Pilbara)' is to the south, and the known PEC 'Plant Assemblages of the Wona Land System' is on the northern side of the Fortescue Valley and upstream of the Blacksmith tenement.

4.2.2 'ECOSYSTEMS AT RISK'

The DEC considers 'Hilltop floras, Hamersley Range' as a *vulnerable* 'Ecosystem at Risk' due to frequent fires preventing regeneration and deliberate burning. As the resource areas within the Blacksmith tenement are associated with valley floors, future development will have little direct impact on hilltops. However, indirect impacts may include habitat fragmentation, changes to fire regimes and dust.

'All major ephemeral water courses' is also identified as an 'Ecosystem at Risk' in Kendrick (2002). The only major ephemeral water course in the study area is in 'Ajax', which is already threatened by cattle grazing. However, there has been little in the way of iron ore resources identified from the 'Ajax' riparian area, thus little risk of large-scale disturbance from proposed mining activities. However there is a risk to this ecosystem from infrastructure development.

Other nearby 'Eocsystems at Risk' listed in Kendrick (2002) include 'Valley floor Mulga', and 'Lower slopes Mulga' that do not occur in the Flinders tenement. Impacts are likely to be restricted to the effects of changes to downstream surface and subsurface water flow as a result of activities in the study area.

However, 'Ecosystems at Risk' have no statutory protection.

4.2.3 POORLY REPRESENTED VEGETATION TYPES

Vegetation types that are poorly represented (<1% of total unburnt area) within the study area and immediate environs or poorly represented nearby may be considered to have local significance. These vegetation types are restricted to specific landforms or landscape positions and occupy only a small proportion of the study area, but do not have any statutory protection,. However further surveys after sufficient time has passed for the vegetation to have recovered from fire will be required to more accurately determine local representation of vegetation types.

Vegetation types within the study area that may have local significance are discussed below.

Acacia maitlandii Shrubland

Acacia maitlandii Shrubland was identified from the north-eastern portion of the tenement and occupied <1% of the unburnt extent. It has been observed to occupy a similar proportion on nearby tenements and similar vegetation has been identified as having a High Conservation Risk (Astron Environmental Services 2010). Therefore it is likely that this vegetation type has local conservation significance.

Acacia orthocarpa (atypical form) Shrubland

Acacia orthocarpa (atypical form) Shrubland was assessed as occupying 1.14% of the unburnt extent of the tenement. It was confined to the 'Ajax' area on rocky hills and rises, and the vegetation type is not floristically similar to other vegetation types described in other Pilbara surveys. Therefore it is possible that this vegetation type is unique to the area, and therefore has local conservation significance.

Corymbia ferriticola/Eucalyptus leucophloia Low Open Woodland

Corymbia ferriticola/Eucalyptus leucophloia Low Open Woodland was recorded from 0.26% of the unburnt extent of the Blacksmith tenement, where it was restricted to gorges and gullies. Other

Pilbara flora surveys have identified similar vegetation as having local conservation significance due to its restricted extent.

***Eucalyptus victrix* Open Woodland**

Eucalyptus victrix Open Woodland occupied 0.35% of the unburnt extent of the study area and was associated with the major drainage channel through the 'Ajax' resource area and a small area in 'Eagle'. However it is likely to have occupied a greater extent if the tenement had not been largely burnt. It has been identified as having conservation significance in other areas of the Pilbara (eg Astron Environmental Services 2010; ENV Australia 2010; Trudgen & Casson 1998) due to its restricted extent, and is considered likewise in the Flinders tenement.

4.2.4 POORLY REPRESENTED FLORISTIC UNITS

Similarly, vegetation types that are considered to be poorly represented on a regional scale, including those identified by the regional floristic analysis conducted by Griffin and Trudgen (**Appendix Nine**), also do not have legislative protection.

Almost all of the floristic groups inferred from the regional floristic analysis as occurring on the Blacksmith tenement have distributions restricted to the central Hamersley Range, however most floristic units are locally common or locally moderately common.

4.2.5 VEGETATION TYPE CONCLUSIONS

The vegetation types listed above *Acacia maitlandii* Shrubland, *Acacia orthocarpa* (atypical form) Shrubland, *Corymbia ferriticola/Eucalyptus leucophloia* Low Open Woodland, *Corymbia hamersleyana/Eucalyptus gamophylla* Low Open Woodland, and *Eucalyptus victrix* Open Woodland are considered to have local conservation significance due to either their small local extent or localised occurrence, being restricted to specific landforms that occupy only a small proportion of the area, no similar vegetation being recorded in other Pilbara surveys, or their extent occurring in areas under threat of mining. Although *Acacia orthocarpa* (atypical form) Shrubland is considered to have the highest conservation significance due to a combination of these factors, it is unlikely to be impacted by mining.

Floristic analysis conducted using the quadrat data identified that the valley floor vegetation type *Eucalyptus gamophylla/Corymbia hamersleyana* Low Woodland is likely to consist of several different floristic units/vegetation types that would have been definable if less area had been burnt and more quadrats assessed, although it is unlikely that any of these would have any particular conservation significance.

Regional floristic analysis has determined that most floristic units are restricted to the central Hamersley Range, however most are locally common or moderately common.

4.3 Vegetation Condition

Human impacts affecting vegetation condition include tracks and drill pads and cattle grazing.

Tracks and drill pads were often close together. The impacts of tracks and drill pads are intensive, completely removing native vegetation, but are local in nature, however it was not possible to accurately map the extent of this clearing. There was no indication of weed invasion resulting from this form of soil disturbance.

It is not possible to accurately determine the full extent of clearing due to tracks and drill pads, however it is estimated that less than 0.5% has been cleared.

Grazing cattle, tracks, dung and grazed plants were observed in the riparian area within the 'Ajax' resource area. Cattle grazing was associated with trampling of vegetation and damage to individual plants (including some grazing of *Gossypium* spp. *Acacia pyrifolia*, *Triodia* aff. *epactia* and Poaceae spp.).

Cattle grazing was only observed in this small area, estimated as less than 1% of the study area, therefore the impact is considered to be low. Even if grazing was more widespread than observed, the impact would be lower than clearing as grazing does not completely remove vegetation.

Fire can also be considered a form of disturbance impacting on vegetation condition, however fire is a natural occurrence, usually as a result of lightning strikes. Approximately 80% of the study area was burnt in this manner in early 2010. Despite the large extent of burnt lands, the impact on vegetation and flora is, in the long term, unlikely to be significant. The impact is also not caused by human activities.

4.4 Introduced Species

Five introduced species, *Bidens pinnata*, *Cenchrus ciliata*, *Cucumis melo* subsp. *agrestis*, *Portulaca oleracea* and *Sigesbeckia orientalis*, were observed in the study area during the surveys.

Buffel Grass *Cenchrus ciliaris*, were also observed close to the study area in areas of heavy cattle grazing, however due to heavy grazing in 2010 its presence in the riparian areas may have been overlooked. It is considered likely that low levels of Buffel Grass probably occur in the riparian area of 'Ajax' and possibly also in 'Champion'. However, Buffel Grass is unlikely to have been introduced or spread to new areas as a result of Flinders Mines exploration activities.

However, there is potential to introduce weeds in soil used for road works and Flinders Mines should endeavour to avoid spread of soil from areas with Buffel Grass or other introduced species.

4.5 Potential Environmental Impacts to Vegetation and Flora

4.5.1 CLEARING OF VEGETATION

Clearing significant areas of vegetation and loss of associated flora is typically the most substantial impact of mining and associated infrastructure.

DRF species have statutory protection under the *Wildlife Conservation Act* (Government of Western Australia 1950), and must not be cleared. Priority-listed species do not have statutory protection, however it is usually expected that developments should demonstrate that impacts on Priority 1 and Priority 2-listed species have been minimised.

No DRF, Priority 1 or Priority 2 flora species were recorded from the Blacksmith tenement study area.

No TECs or PECs are expected to be impacted by development of the Blacksmith tenement.

Locally significant vegetation types are expected to be impacted, however none of the characteristic species of these vegetation types have conservation significance, although P4 species *Rhynchosia bungarensis* was a common component in *Eucalyptus victrix* Open Woodland.

The only major riparian areas supporting *Eucalyptus victrix* (and possibly *Eucalyptus camaldulensis*) were in the 'Ajax 'resource area. Impacts on riparian areas include changes to flow volume and turbidity, which may be transported downstream or into riparian areas downstream but not in the mining area.

Riparian areas have particularly high environmental importance, with riparian vegetation known to support a high level of species diversity (eg Mattiske 2005). They are also likely to provide a valuable habitat and food source for fauna species, and assist in stabilising soil during times of high rainfall and subsequent flooding. Thus riparian areas play an important role in ecosystem function.

Recommendations:

- where possible, minimise clearing in locally significant vegetation types
- where possible, avoid or minimise clearing in and near riparian areas.

4.5.2 DUST

Dust from excavation, construction and vehicle movement has the potential to block the stomata of adjacent plants leading to the inability to exchange gases and subsequent loss of vigour or death. The lack of rainfall and its sporadic nature typical of the Pilbara, also limits the opportunities for natural 'washing' of dust from the leaf surfaces.

As well as smothering plants, dust is nutrient-rich in comparison with natural soils and build-up can lead to situations where weed invasion is favoured over native species.

Recommendation:

- implement appropriate dust suppression techniques to minimise this impact.

4.5.3 BUSHFIRES

Bushfires caused by lightning strike are a common natural occurrence in the Pilbara, with 20-30 thunderstorms per annum common for the region (BoM2009).

Bushfires can also be caused by human activities including misuse of electricity, deliberate or accidental activities including welding, grinding, smoking or deliberate burning, spontaneous combustion and mechanical friction (Environ Australia Pty Ltd 2005).

Whilst fire is a natural occurrence, environmental damage can occur if fire is too frequent, too hot or associated with other forms of disturbance (eg grazing or partial clearing). Recently burnt areas carry less flammable vegetation and act as firebreaks between areas that have not been recently burnt. However it is also important to not burn the vegetation at too frequent intervals as many plant species may not have the opportunity to set seed if burnt too frequently. Therefore frequent fire may change the vegetation composition. The situation also applies, with infrequent fire favouring long-lived perennial species (eg *Triodia* spp.) to the detriment of short-lived species (although they are likely to be present in the seed bank). Infrequent fires also increase the fuel loads, leading to more intensive fires that may kill species adapted to less intensive fires (eg some *Triodia* tussocks, some individual eucalypts), as well as having detrimental impacts on fauna species.

Therefore it is important to prevent bushfires not caused by natural conditions. The risk of fire resulting from human activities can be minimised by implementing fire prevention protocols such as:

- appropriate isolation of flammable compounds and explosives
- implementation of a hot work permit
- localised clearing around working plant
- enforcement of responsible smoking practices such as appropriate discarding of cigarette butts.

4.5.4 INTRODUCTION OF WEEDS

Increased vehicular traffic, combined with increased ground disturbance and disposal of water from drilling and domestic operations provide the opportunity for the spread and establishment of environmental weed species. Soil stockpiles also provide an opportunity for weed invasion.

Appropriate weed hygiene and management measures should be implemented to prevent weed invasion and the displacement of native vegetation, including:

- reducing soil movement, especially in areas that are likely to have weeds including riparian areas and areas of heavy livestock grazing
- cleaning machinery before moving to new locations.

4.5.5 ALTERATION OF WATER REGIME

Changes in water regimes resulting from water extraction and reinjection, reduced surface/sheet flows from infrastructure, and diversions of water flow from or into existing creek beds has the potential to impact on the viability and composition of native vegetation. Where water flows are likely to be modified, modelling should be undertaken to evaluate the placement of infrastructure in terms of minimising impact.

Vegetation monitoring sites should also be established in areas mostly likely to be impacted by alterations to groundwater levels and changes to surface water flows, including in areas where groundwater dependent vegetation occur.

Eucalyptus victrix is considered to be at least partly groundwater dependent (ie it is a facultative phreatophyte) (eg Astron Environmental Services 2008; Maunsell Australia Pty Ltd 2006). Therefore any changes to groundwater have potential to impact on this species and the vegetation type in which it occurs (*Eucalyptus victrix* Open Woodland).

There was a *Melaleuca* species recorded in the riparian area of 'Ajax', although it was not possible to identify the species due to lack of reproductive material as a result of being burnt. *Melaleuca* species have a complex pattern of water use, eg *Melaleuca argentea* is at least partly phreatophytic (eg Astron Environmental Services 2008) or almost entirely dependent on surface or near surface water (Grierson 2010). Whilst it is unlikely that the *Melaleuca* observed in 'Ajax' is this species, it may occur in the Flinders tenement as it has been recorded in similar areas nearby (eg Coffey Environments 2010b; ENV Australia 2010).

Melaleuca argentea is well-studied in relation to other *Melaleuca* species, however it is likely that other *Melaleuca* species have a similarly complex pattern of water use. Therefore, any changes to surface or groundwater also have potential to impact on this genus, which although not included as a characteristic species during this survey, is likely to be characteristic of at least some parts of the riparian area that could not be assessed due to fire. Thus, changes to surface water flows or groundwater have potential to impact on other, as yet unidentified, vegetation types.

Additionally, ephemeral water courses are identified as being an 'Ecosystem at Risk', and impacts on riparian areas should be reduced where possible.

There is also potential to impact on downstream vegetation types, including 'Ecosystems at Risk' Mulga vegetation types.

Wherever possible, changes to surface water flow should be minimised. Roads should not be located in valley floors where they may impede flow or add sediment to the stream and any drainage channel should not be obstructed or, if possible, not diverted.

Recommendations to reduce impacts on natural water regimes include:

- undertake modelling of impacts of infrastructure locations to understand impacts of changes to surface and groundwater flows, in order to select locations with the least impact
- avoid locating infrastructure including roads in riparian areas, including minor streams
- avoid impeding natural stream flow.

4.5.6 SUMMARY OF ENVIROMENTAL IMPACTS AND RECOMMENDATIONS

The potential impacts on flora and vegetation and recommendations to reduce these are listed in **Table 11**.

Table 11: Summary of environmental impacts and recommendations

Process	Potential Environmental Impacts	Recommendations
Vegetation clearing	Clearing of locally significant vegetation types	Where possible minimise clearing in these areas
	Changes to flow volume and stream turbidity	Minimise clearing in and near riparian areas
Excavation, construction and vehicle movement	Dust	Implement appropriate dust suppression techniques
Accidental or deliberate burning	Bushfire	Isolate flammable compounds and explosives Localised clearing around working plant (firebreaks) Enforce responsible smoking practises
Soil movement	Introduction of weeds	Reduce soil movement Clean machinery before moving to new areas
Infrastructure locations	Alteration of water regime	Undertake modeling of impacts of infrastructure positioning on ground and surface water to assist with site selection Avoid locating infrastructure, including roads, in riparian areas, including minor streams Avoid impeding natural stream flow

4.6 Recommendations for Future Surveys

Additional surveys, conducted in 2013 or later, are recommended for the riparian areas of 'Ajax' and in 'Eagle' as the vegetation is likely to be different to other areas within the Blacksmith tenement. Surveys may be a requirement if these areas are included in resource or infrastructure areas.

Targeted conservation significant flora surveys should be conducted in areas identified for infrastructure, particularly if they are high in the landscape (ie upper slopes or hilltops), in or close to riparian areas, or in areas burnt in 2010.

Additional vegetation mapping, conducted as a Level 1 flora and vegetation survey, should be conducted over the remainder of the tenement when it has recovered from fire. A Level 1 survey is considered as a reconnaissance survey and is generally conducted to target areas for Level 2 surveys or, as in this case, when additional information is required but the areas is generally considered to have been adequately surveyed for most purposes.

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appendix one: desktop assessment