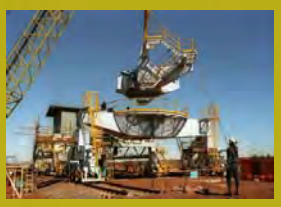
October 2009


Brockman Resources Limited
Marillana (E47/1408)
Vegetation and Flora Report

Version 5

Providing sustainable environmental strategies, management and monitoring solutions to industry and government.

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Executive Summary

Brockman Resources Limited (Brockman) is proposing to conduct iron ore mining operations at its Marillana tenement, E47/1408. The tenement spans approximately 16 km along the base of the Hamersley Range, and covers an area of approximately 94 km^2. Brockman plans to mine the detrital iron ore deposits that are found along the base of the Range.

The tenement is located approximately 100 km north-west of Newman in the Pilbara region of Western Australia.

Following appropriate consultation with relevant stakeholders, Brockman commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase survey of the vegetation and flora of its Marillana project area.

The primary objective of this survey was to provide sufficient information to the Environmental Protection Authority (EPA) to assess the impact of the project on the vegetation and flora of the area. The EPA's objectives with regards to management of native flora and vegetation are to:

- Avoid adverse impacts on biological diversity comprising the different plants and the ecosystems they form at the levels of genetic, species and ecosystem diversity.
- Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.
- Protect declared rare flora consistent with the provisions of the *Wildlife Conservation Act 1950*.
- Protect other flora species of conservation significance.

The first phase of the survey was carried out in June 2008 and the second in September 2008. Systematic and opportunistic sampling methods were used. A total of 137 quadrats was assessed over both phases, 82 during phase 1 and 72 during phase 2; 17 of these 72 quadrats had been assessed during phase 1 also.

The Marillana survey area crosses six of the land systems that have been mapped in the Pilbara - the Fortescue, Turee, Fan, Boolgeeda, Divide and River land systems.

Vegetation

The vegetation of the survey area was mapped into eight main vegetation units, with some further classified into sub-units on the basis of landform and the structure and species composition of the dominant strata. The vegetation types mapped were associated with the following landforms: creek lines, drainage channels on the footslopes, clay pans, minor channel or drainage depressions, floodplains, longitudinal sand dunes, sandy plains and a minor footslope. The eight vegetation units follow:

1. *Eucalyptus victrix* and *Acacia citrinoviridis* low woodland (with two sub-units);

2. *Acacia tumida* and *Grevillea wickhamii* tall shrubland;

3. *Acacia aneura* low woodland, over *Acacia synchronicia* tall shrubland, over **Cenchrus* spp. tussock grassland;

4. *Acacia aneura* low open forest (with two sub-units);

5. *Acacia citrinoviridis, Corymbia hamersleyana, Acacia aneura* and *Acacia pruinocarpa* open woodland, over *Acacia* spp. tall shrubland, over **Cenchrus* spp. closed tussock grassland (with three sub-units);

6. *Acacia dictyophleba* tall shrubland, over *Triodia schinzii* open hummock grassland;

7. *Acacia* spp. medium to high open shrubland, over *Triodia basedowii* and *Triodia schinzii* hummock grassland; and

8. *Corymbia hamersleyana* isolated low trees, over *Eucalyptus gamophylla* mallee woodland, over *Acacia* spp. and *Grevillea wickhamii* tall shrubland, over *Triodia basedowii* hummock grassland (with five sub-units).

These vegetation units are similar to the vegetation recorded during other surveys conducted in this area of the Pilbara.

Database searches indicate that no threatened ecological communities occur within 50 km of the Marillana survey area. One State-listed priority ecological community (PEC) occurs within the survey area, the Priority 3 'Vegetation of sand dunes of the Hamersley Range and Fortescue Valley'. In addition, the Weeli Wolli Spring PEC occurs within 50 km of the survey area and the Fortescue Marsh PEC is approximately 15 km north of the survey area; both are Priority 1 PECs.

Flora

A total of 302 taxa resulted from the combined records for both phases of the survey. These taxa included 42 families and 116 genera. Of this combined total, 224 taxa from 38 families and 100 genera were recorded during the first phase of the survey and 244 taxa from 39 families and 104 genera during the second.

Diversity at the survey area was slightly higher than at other areas surveyed in the Pilbara.

Results of database searches carried out indicate that two declared rare flora taxa have been collected within 50 km of the survey area; *Lepidium catapycnon* and *Thryptomene wittweri.* Due to the habitat requirements of the species the likelihood of their occurrence in the survey area is low.

No declared rare flora species were recorded at the Marillana survey area.

Eighteen priority flora taxa have been recorded within 50 km of the survey area: *Calotis squamigera, Eremophila spongiocarpa, Myriocephalus nudus* (all Priority 1), *Acacia daweana*, *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662), *Olearia fluvialis*, *Spartothamnella puberula* (all Priority 2), and *Acacia bromilowiana, Calotis latiuscula, Hibiscus brachysiphonius, Indigofera gilesii* subsp. *gilesii , Polymeria* sp. Hamersley (ME Trudgen 11353), *Rhagodia* sp. Hamersley (M. Trudgen 17794), *Rhynchosia bungarensis, Rostellularia adscendens* var. *latifolia, Tephrosia* sp. Cathedral Gorge (F.H. Mollemans 2420)*, Triumfetta leptacantha and Eremophila magnifica* subsp. *magnifica* (all Priority 3).

One Priority 3 flora species, *Goodenia nuda*, was recorded at two sites in the survey area.

No declared weeds were recorded in the area while 10 weed species were recorded over the two phases of the survey: **Aerva javanica*, **Argemone ochroleuca* subsp. *ochroleuca*, **Cenchrus ciliaris*, **Cenchrus setiger, *Chloris virgata, *Datura leichhardtii, *Malvastrum americanum*, **Portulaca oleracea, *Setaria verticillata* and **Vachellia farnesiana. *Argemone ochroleuca* subsp. *ochroleuca* and **Datura leichhardtii* are declared weeds in other parts of the State, but not in the East Pilbara.

Conformance of the Project to relevant EPA statements is addressed in Table S.1 of this summary while the conservation significance of the vegetation and flora of the survey area, and an assessment of potential impacts, are discussed in Sections 6 and 7.

Table S.1 – Conformance of the Marillana Survey to Relevant EPA Statements

Requirement	EPA Statement	Relevance to Project	Project Compliance
Impact on Biodiversity	Position Statement No. 3	Where impact on biodiversity cannot be avoided, the proponent must demonstrate that the impact will not result in unacceptable loss.	No declared rare flora species were recorded during the survey. One Priority 3 flora species, *Goodenia nuda,* was recorded once during phase 1, and once during phase 2. If impact to this species cannot be avoided, it is considered unlikely that it would result in the extinction of the species and consequent loss of biodiversity. *Goodenia nuda* is a relatively widespread priority species that can grow in a variety of habitats and is not restricted to the Marillana survey area. Impacts to biodiversity within proposed infrastructure areas have not been estimated in this report, however, they are included in the PER.
State, National and International Agreements, Legislation and Policy on Biodiversity	Position Statement No. 3	Information gathered for environmental impact assessment in Western Australia meets State, National and International Agreements, Legislation and Policy in regard to biodiversity conservation.	Impacts to species and communities listed under relevant legislature are addressed in Section 6. The relevance of the project to principles outlined in the *Environmental Protection Act 1986, Wildlife Conservation Act 1950* and *Environment Protection* and *Biodiversity Conservation Act 1999* is discussed in Sections 1.2, 1.3 and 6.
EPA Standards, Requirements and Protocols	Position Statement No. 3	The quality of information and scope of field surveys meets the standards, requirements and protocols as determined and published by the EPA.	The current survey conforms to a Level 2 survey, comprising a reconnaissance survey, a comprehensive two phase vegetation and flora survey and mapping of the vegetation of the area, as per Environmental Protection Authority Guidance Statement 51.
Biodiversity Conservation and Ecological Function Values	Position Statement No. 3	Sufficient information is provided to address biodiversity conservation and ecological function values.	Impacts to biodiversity and ecological function are discussed in Section 6. The value of the vegetation associations and conservation significant flora taxa occurring in the project area is also discussed in a bioregional context in Section 6.
State Biological Databases	Position Statement No. 3	Terrestrial biological surveys will be made publicly available and will contribute to the bank of data available for the region.	Voucher specimens of the priority flora species collected will be lodged at the WA Herbarium. Information collated from this survey will be included in public documents available for use by others.

Requirement	EPA Statement	Relevance to Project	Project Compliance
Sampling design and intensity at two levels – regional and area specific	Guidance Statement No. 51	Sites were assessed at the area specific level.	Data was collected on an area specific level. A two-phase survey was carried out and 137 quadrats were assessed at the survey area (17 sites were surveyed in both phases). Regional data is available from other surveys undertaken in the area.
Landform – scale, rarity, heterogeneity	Guidance Statement No. 51	Sites should be established in the different landforms occurring across the study area.	Sites were selected from aerial photography before going to the field. Vegetation units occurring on the different landforms of the area were verified in the field, and sites were assessed based on their representation on those landforms. In most cases multiple sites were assessed on each landform.
Habitat – scale, rarity, heterogeneity	Guidance Statement No. 51	Sites should be established in the different habitats occurring across the study area.	Sites were selected from aerial photography before going to the field and ground-truthing of the vegetation types occurring in the different habitats took place during the survey. Sites were selected depending on a habitat's representation in the area. In most cases multiple sites were assessed in each habitat.
Potential for conservation significant flora to occur, based on habitat analysis	Guidance Statement No. 51	Sufficient information is to be provided to indicate the potential for significant flora to occur based on habitats in the area.	Lists of the conservation significant taxa recorded in the vicinity of the survey area are provided in Appendix A1. An analysis has been carried out on the likelihood of these taxa occurring in the survey area. Habitats where conservation significant taxa could potentially occur were targeted during the field surveys.
Information on adjacent areas – previous surveys and herbarium records	Guidance Statement No. 51	Adequate information was already available on the wider project area, as other surveys have been undertaken in the area.	Information was requested from relevant government databases and also was collated from reports on other surveys undertaken in the vicinity of Brockman's Marillana project area.

Requirement	EPA Statement	Relevance to Project	Project Compliance
Vegetation structure, diversity and seasonality	Guidance Statement No. 51	Sufficient information is to be provided in the report on vegetation structure, diversity and seasonality.	The report details the results of a vegetation mapping exercise carried out over the survey area. The data collected was analysed using multivariate statistical analysis. Following analysis the main vegetation associations occurring in the area were mapped and the structure of the vegetation associations was described. The two phases of the survey were carried out in different seasons, the first in winter and the second in spring. The diversity and seasonality in the flora of the survey area are represented in the species list.
Results including species/area curves, species and ecosystem diversity and heterogeneity	Guidance Statement No. 51	Adequate information is provided in the report to comply with this requirement.	A species accumulation curve is included in Section 5.1. Details on the flora of the survey area are included in this report and comparisons with the flora of other areas in the region are also included in Section 5.1. A vegetation map and detailed vegetation descriptions are provided for the survey area.

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1 INTRODUCTION

1.1 BACKGROUND

Brockman Resources Limited (Brockman) is proposing to conduct iron ore mining operations at Marillana (tenement E47/1408). The tenement covers approximately 16 km along the base of the Hamersley Range, and is approximately 94 km^2 in area. Brockman plans to mine the detrital iron ore deposits that are found along the base of the Hamersley Range.

The tenement is located approximately 100 km north-west of Newman in the Pilbara region of Western Australia (Figure 1.1).

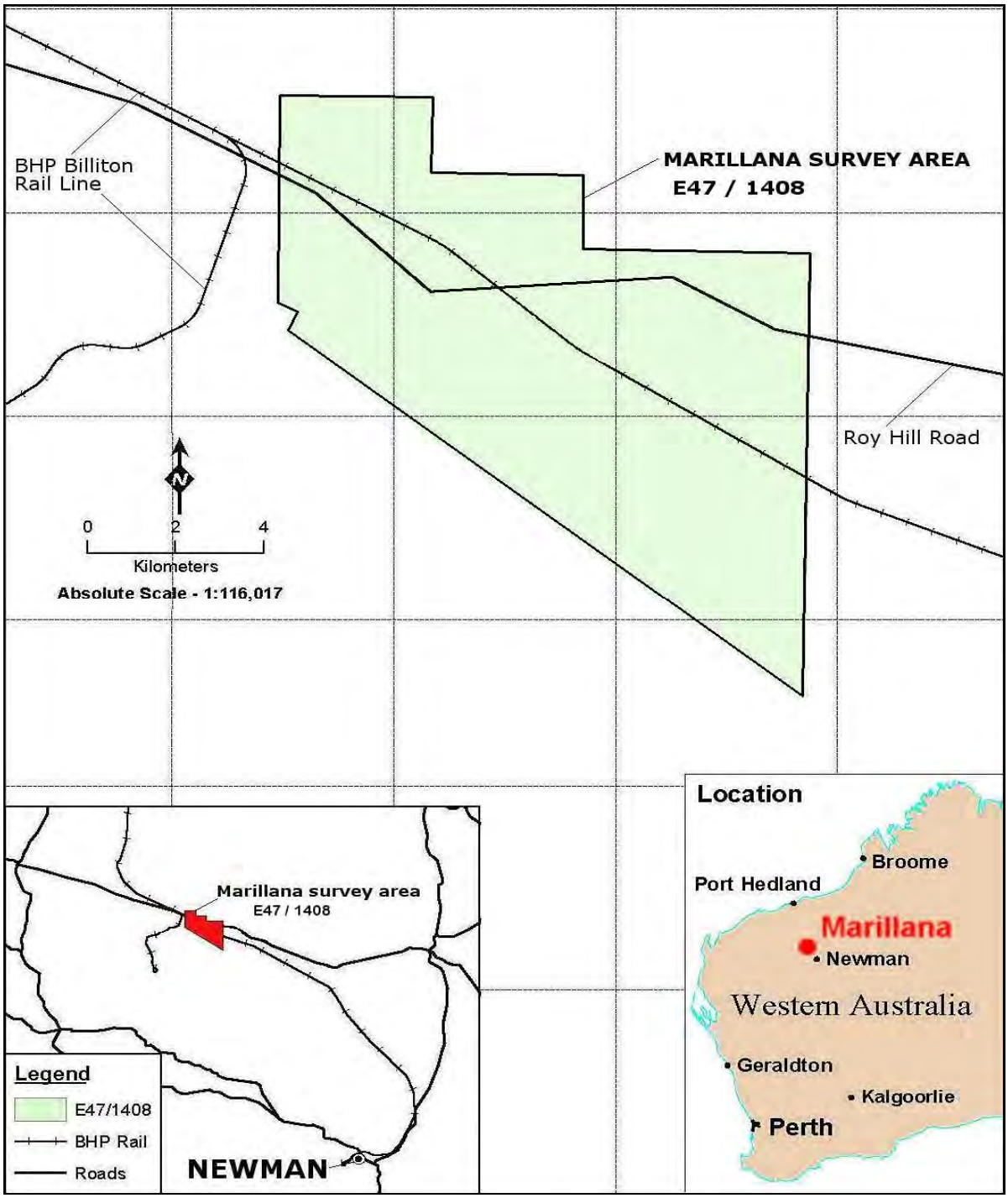

Figure 1.1 – Location of the Marillana Survey Area

1.2 LEGISLATIVE FRAMEWORK

Federal and State legislation applicable to the conservation of native flora and fauna includes, but is not limited to, the *Environmental Protection Act 1986* (*EP Act*), the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) and the *Wildlife Conservation Act 1950* (*WC Act*).

Section 4a of the *EP Act* requires that developments take into account the following principles applicable to native flora and fauna:

The Precautionary Principle

Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

The Principle of Intergenerational Equity

The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

The Principle of the Conservation of Biological Diversity and Ecological Integrity

Conservation of biological diversity and ecological integrity should be a fundamental consideration.

Native flora in Western Australia is protected at a federal level under the *EPBC Act* and at a state level under the *WC Act.*

The *EPBC Act* was developed to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance. It aims to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, and to promote the conservation of biodiversity. The *EPBC Act* includes provisions to protect native species and, in particular, to prevent the extinction and promote the recovery of threatened species. In addition to the principles outlined in Section 4a of the *EP Act*, Section 3a of the *EPBC Act* includes a principle of ecologically sustainable development dictating that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.

The *WC Act* was developed to provide for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all flora within Western Australia is protected; however, the Minister may, via a notice published in the *Government Gazette*, declare a list of flora taxa identified as likely to become extinct, or as rare, or otherwise in need of special protection. The current listing was gazetted on the 5th August 2008.

Biological surveys undertaken as part of the Environmental Impact Assessment (EIA) process in Western Australia are required to address the Environmental Protection Authority's (EPA) Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA, 2002), Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004a) and Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004b).

Following appropriate consultation with relevant stakeholders, Brockman commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase survey of the vegetation and flora of its Marillana project area, as part of the EIA process for the project.

1.3 SURVEY OBJECTIVES

The EPA's objectives with regards to management of native flora and vegetation are to:

- Avoid adverse impacts on biological diversity comprising the different plants and the ecosystems they form at the levels of genetic, species and ecosystem diversity.
- Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.
- Protect declared rare flora consistent with the provisions of the *WC Act*.
- Protect other flora species of conservation significance.

Hence, the primary objective of this study was to provide sufficient information to the EPA to assess the impact of the project on the vegetation and flora of the area, thereby ensuring that these objectives are upheld.

More specifically, the objectives were to undertake a survey that satisfies the requirements documented in EPA Guidance Statement 51 and Position Statement No. 3, thus providing:

- A review of background information (including literature and database searches).
- An inventory of vegetation units and flora species occurring in the study area, incorporating recent published and unpublished records.
- An inventory of species of biological and conservation significance recorded or likely to occur within the project area and surrounds.
- A map and detailed description of vegetation units occurring in the study area.
- A description of the characteristics of the vegetation units.
- An appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area, which are relevant to the current study.
- A review of regional and biogeographical significance, including the conservation status of species recorded in the project area.

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2 EXISTING ENVIRONMENT

2.1 CLIMATE

Marillana is situated in the Pilbara region of Western Australia and experiences an arid-tropical climate with two distinct seasons; a hot summer from October to April and a mild winter from May to September. Annual evaporation exceeds rainfall by as much as 500 mm per year. Seasonally low but unreliable rainfall, together with high temperatures and high diurnal temperature variations are also characteristic of the region.

In the past the region has received zero rainfall during the year, which is typical of a desert climate. Within the Pilbara, the temperature range is large and maxima are high. Summer temperatures may reach as high as 49°C, with a mean maximum of 30°C, while the winter mean maximum is 23°C (ranging from 14–35°C). Light frosts occasionally occur during July and August. The climate experienced throughout the year is usually very dry since high temperatures and humidity seldom occur simultaneously (Beard, 1975).

Rainfall in the Pilbara is highly unpredictable and recordings are highest at stations around the Hamersley Range which reach altitudes of up to 900 m. The majority of the Pilbara has a bimodal rainfall distribution, resulting in two rainfall maxima per year. From January to March rains result from tropical storms producing sporadic thunderstorms. Tropical cyclones moving south from northern Australian waters also bring sporadic heavy rains. From May to June extensive cold fronts move easterly across the state and occasionally reach the Pilbara. These fronts produce only light winter rains that are ineffective for the growth of plants other than herbs and grasses. Larger perennial species require the intense and prolonged storms of summer. Surface water can be found in some pools and springs in the Pilbara all year round, although watercourses only flow briefly due to the short wet season (Beard, 1975).

The closest Bureau of Meteorology (BOM) weather station to the project area is at Sand Hill (22.78° S, 119.62° E) (BOM 2008); however, data collection ceased at this station in 1984. Newman Aero weather station (23.42° S, 119.80° E) is the next closest to the Marillana tenement (75 km to the south) and its data have been used to provide an indication of climatic conditions at the project area (Figure 2.1).

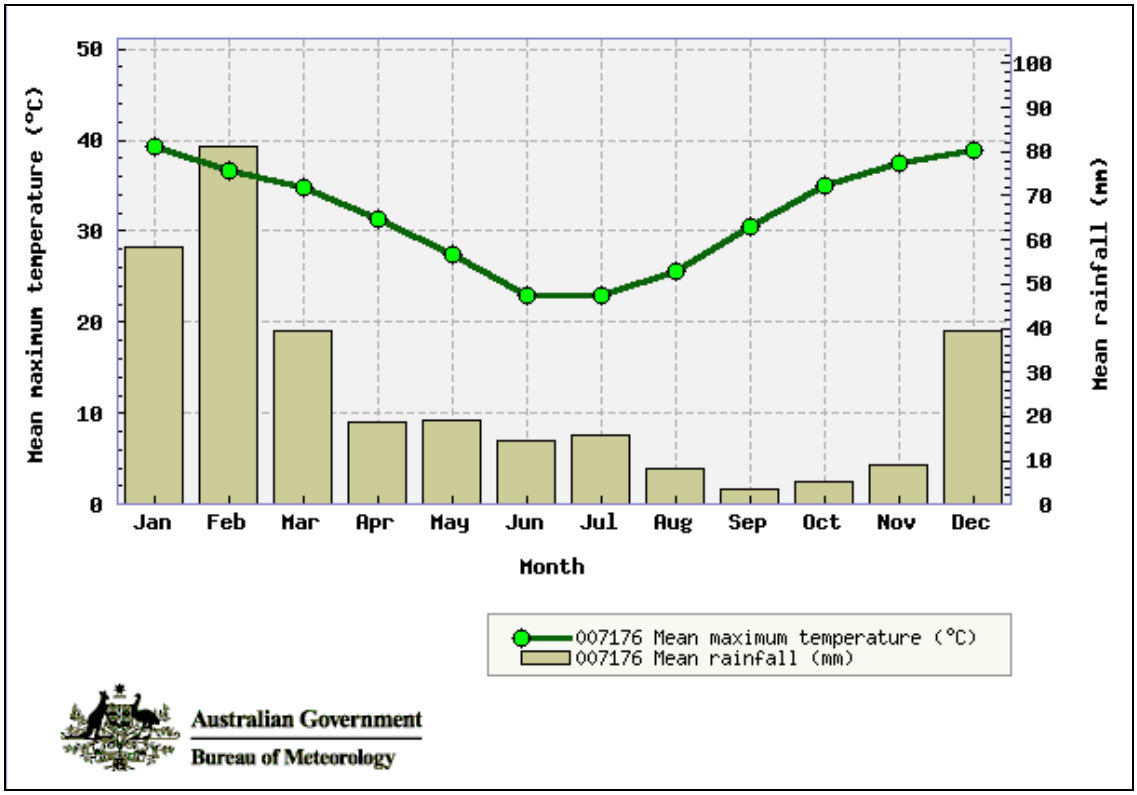

Figure 2.1 – Newman Aero Climatic Data.

The average annual rainfall at Newman Aero is 317.6 mm, occurring over 40.1 rain days (Table 2.1). It loosely follows the typical Pilbara bimodal distribution pattern, with a peak between December and March (Figure 2.1). Most of the rainfall is received in the summer period, with over 68% of it falling between December and March.

Mean annual maximum and minimum temperatures for Newman Aero are 31.9°C and 15.9°C respectively. Mean monthly maxima range from 39.3°C during January to 22.9°C in June, while mean monthly minima range from 24.8°C in January to 6.3°C in June (Table 2.1).

Table 2.1 – Newman Aero Climatic Data.

Latitude: 23.42 °S			Longitude: 119.80 °E			Commenced: 1971		Last record: April 2009			Elevation: 524 m	
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily max. temp (°C)												
39.3	36.6	34.7	31.4	27.4	22.9	23.0	25.6	30.5	34.9	37.5	38.8	31.9
Mean daily min. temp (°C)												
24.8	23.7	21.4	17.0	11.7	6.3	5.7	7.3	11.9	17.1	20.6	23.5	15.9
Mean monthly rainfall (mm)												
58.5	81.2	39.5	18.7	19.0	14.3	15.7	8.2	3.6	5.0	8.9	39.5	317.6
Highest monthly rainfall (mm)												
239.8	305.6	214.2	89.6	110.3	77.8	139.8	79.6	35.6	34.8	50.2	236.0	
Mean no. of rain days												
6.1	7.1	4.6	3.2	2.7	2.9	2.6	1.4	0.9	1.3	2.2	5.1	40.1

Source: Bureau of Meteorology, April 2009.

Total rainfall in the three months preceding the Marillana phase 1 survey (in June 2008) was 36.2 mm, which is 50.9 mm less than the long-term mean for the same three months of the year (87.1 mm) (Table 2.2).

The total rainfall in the three months preceding the phase 2 survey (in September 2008) was 40.8 mm, which is 7.3 mm less than the long-term mean for the same three months of the year (48.1 mm) (Table 2.2).

Table 2.2 – Newman Aero Monthly Rainfalls for 2008 / 2009 Compared with the Long-term Mean.

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
2008	15.6	125	35	1.2	0	34.6	0	6.2	0.8	1	17.8	41.6
2009	39											
Mean	51.4	80.1	38.6	25.3	23.2	25.0	12.6	10.5	4.1	3.9	9.8	27.0

2.2 LANDFORMS

The survey area lies in the Fortescue Valley and follows the northern-eastern escarpment of the Hamersley Range. The mining operations will focus on the iron rich detrital deposits at the base of the Range that are a result of erosion from this escarpment.

The Hamersley Plateau is comprised mainly of the Hamersley and Ophthalmia Ranges, characterised by long strike ridges rising 300 m or more above the valley floors. Flats of Cainozoic sediments are found on the Fortescue Valley floors, which were deposited on the less resistant units of the lower Hamersley Group (Thorne and Tyler, 1997).

2.3 GEOLOGY

The Pilbara region comprises a portion of the ancient continental Western Shield, which dominates the geology of Western Australia. The Western Shield comprises of pre-Cambrian Proterozoic and Archaean rocks. The Pilbara Craton dates back to the Archaean, and includes some of the oldest rocks in the world. It is overlain by Proterozoic rocks deposited in the Hamersley and Bangemall Basins. The Hamersley Basin, which overlies most of the southern part of the Pilbara Craton, can be divided into three stratigraphic groups; the Fortescue, Hamersley and Turee Creek Groups (Beard, 1975).

The Marillana survey area occurs in the Fortescue Group (Fortescue Valley), bordering the Hamersley Group. The Fortescue Valley geology is generally described as Quaternary alluvium, colluvium and sand plains overlying the Tertiary Oakover formation (limestone and calcareous gravels) and chert breccia can be exposed locally (Beard, 1975).

The Hamersley Group is important as it contains both the Brockman and Marra Mamba Iron Formations, which together are the most economically important formations and provide most of the known major iron ore deposits in the Pilbara region (O'Brien and Associates, 1992).

Thorne and Tyler (1997) mapped the geological units of Western Australia (1:250,000). Locally the Marillana survey area is characterised by:

- Alluvium and colluvium deposits forming red-brown clayey and sandy soils on the lower slopes and sheet-wash areas (flat clay pans);
- Eolian sand deposits in sheets and longitudinal dunes (sandy plains and sand dunes);
- Alluvium, unconsolidated silt, sand and gravel in drainage channels and adjacent floodplains (creek lines and floodplains);
- Hematite-goethite deposits on banded iron-formations and adjacent scree deposits (rocky hill slopes); and,

- Banded Iron formation and pelite (as part of the Brockman Iron Formation on the rocky hill slopes).

2.4 SOILS

The Fortescue Valley is characterised by alluvial plains, hard pan wash plains and sandplains (with stony plains, floodplains and some salt lakes) on alluvial deposits over sedimentary rocks of the Hamersley Basin. The soils associated with these habitat types include; red deep sands, red loamy earths and red-brown non-cracking clays with some red shallow loams and hard cracking clays. These soils support mulga shrublands and spinifex grasslands (with some tussock grasslands and halophytic shrublands).

The areas of Marillana that extend into the hills and dissected plateaus of the Hamersley Range have stony soils with red shallow loams, some red-brown non-cracking clays and red-loamy earths. These soils support spinifex grasslands with Snappy Gum (*Eucalyptus leucophloia*) and Kanji (*Acacia inaequilatera*) (Beard, 1975).

2.5 LAND SYSTEM CLASSIFICATION

The Marillana survey area spans six land systems (Figure 2.2) as mapped by Van Vreeswyk *et al.* (2004). Table 2.3 shows the total area of each land system in the survey area and in Western Australia and presents the percentage total impact to each land system if all of the survey area was to be impacted by the proposed mining activities.

Table 2.3 – Land Systems of the Marillana Survey Area.

Land system	Habitat	Total area in the Pilbara (km^2)	Approx. area at Marillana E47/1408 (km^2)	Proportion of the total area in the Marillana survey area (%)
Fortescue	Alluvial plains and floodplains supporting patchy grassy woodlands, shrublands and tussock grasslands	504	42	**8.31**
Turee	Stony alluvial plains with gilgaied and non-gilgaied surfaces supporting tussock grasslands and grassy shrublands of mulga and snakewood	581	6.8	1.16
Fan	Wash plains and gilgai plains supporting groved mulga shrublands and minor tussock grasslands	1,482	10.5	0.70
Boolgeeda	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands	7,748	20.6	0.26
Divide	Sandplains and occasional dunes supporting shrubby hard spinifex grasslands	5,293	12.2	0.23
River	Active floodplains and major rivers supporting grassy *Eucalyptus* spp. woodlands, tussock grasslands and soft spinifex grasslands	4,088	3.4	0.08

Information in columns 2 and 3 sourced from Van Vreeswyk *et al*. (2004).

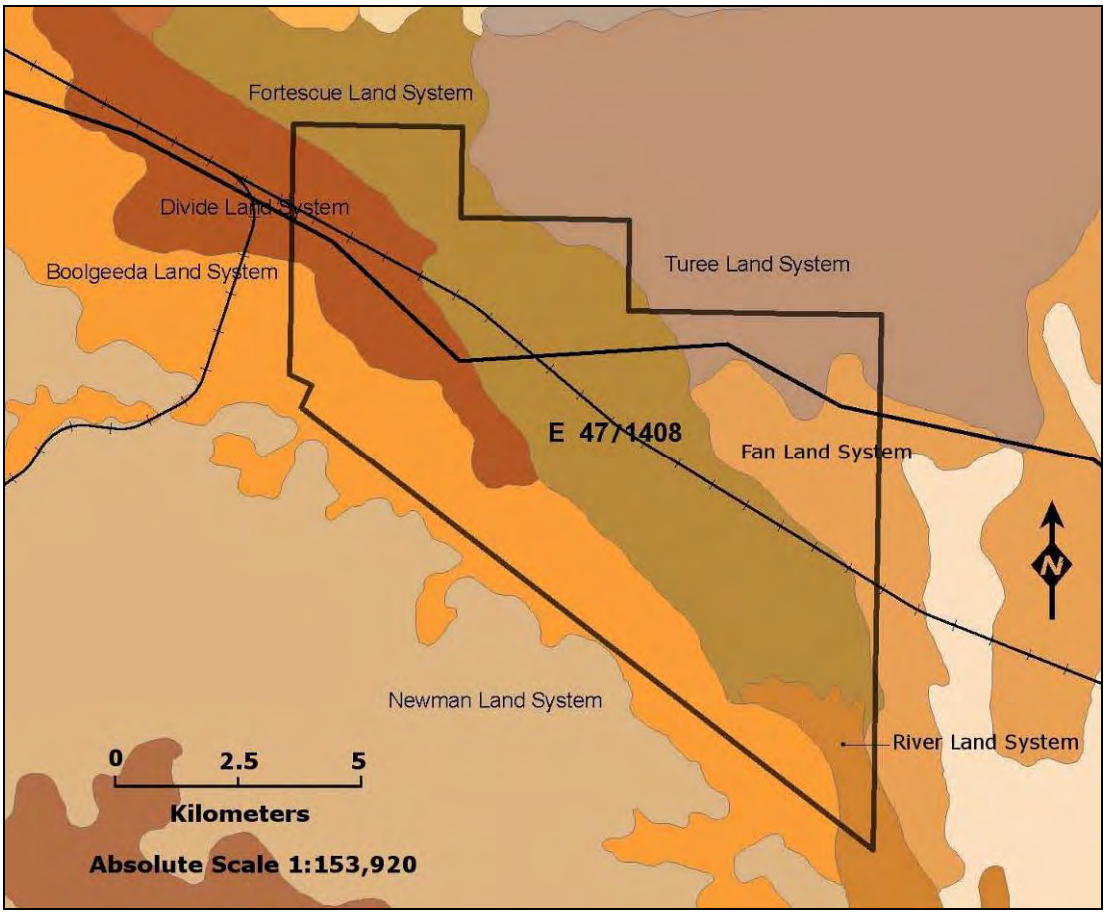

Figure 2.2 – Land Systems of the Marillana Survey Area.

2.6 PILBARA IBRA BIOGEOGRAPHIC REGION

The survey area lies in the Pilbara biogeographic region of the Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway and Cresswell, 1995). This is a system of some 85 biogeographic regions covering the whole of Australia, and is the result of collaboration between all state conservation agencies with co-ordination by the Australian Nature Conservation Agency (ANCA). Bioregions are defined on the basis of climate, geology, landforms, vegetation and fauna.

With an area of 179,287 km^2, the Pilbara bioregion is in the largest area class. Other bioregions vary from 2,372 to 423,751 km^2, most being between 14,000 and 200,000 km^2. The size of the Pilbara bioregion is fairly typical of bioregions situated in remote arid and semi-arid areas.

Dominant limiting factors and constraints for the Pilbara bioregion listed by Thackway and Cresswell (1995) include extinction of critical weight range (CWR) mammals, wildfire, feral animals (in particular the cat and fox), weeds, and grazing or pastoral activities. The reservation status of the bioregion is 1-5%, which is relatively low (some bioregions have a greater than 10% reservation status).

The Pilbara bioregion is divided into four sub-regions; the Hamersley, Fortescue Plains, Chichester and Roebourne sub-regions. Most of the Marillana survey area is located within the Fortescue sub-region, with a small section occurring in the Hamersley sub-region (Figure 2.3).

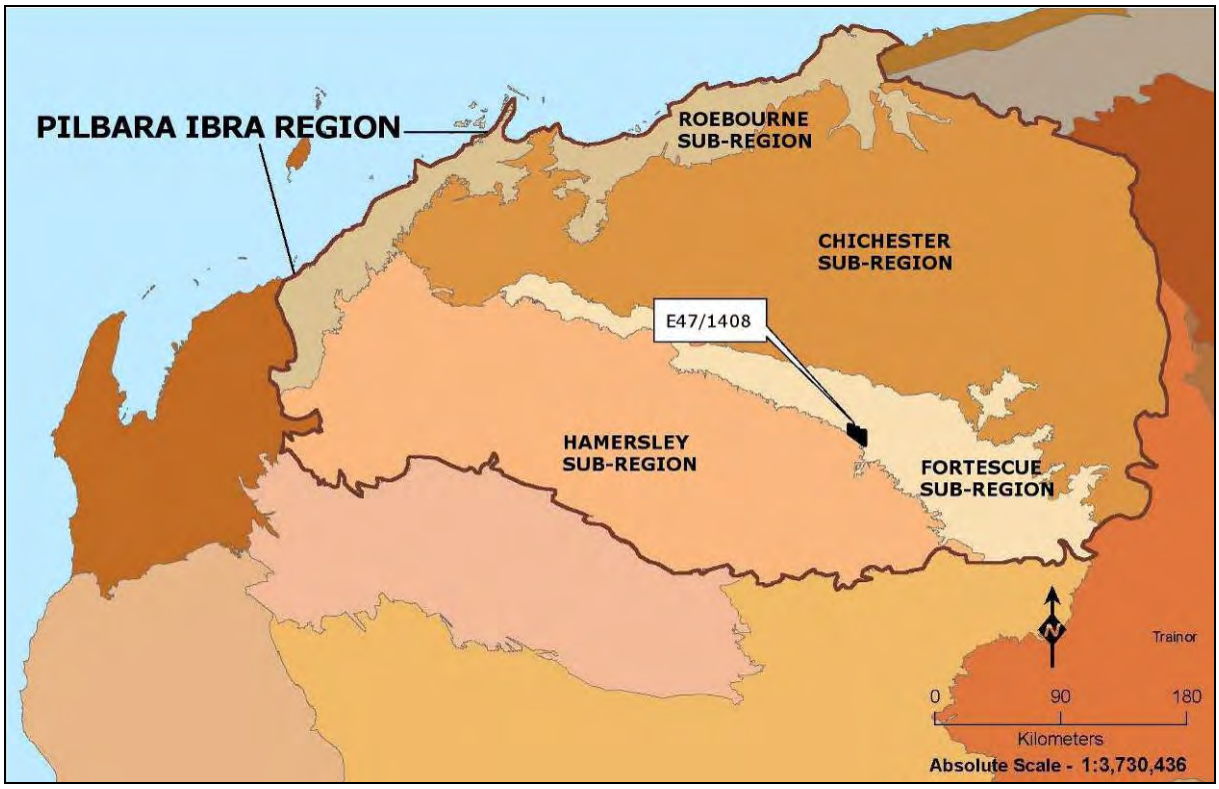

Figure 2.3 – Pilbara IBRA Sub-regions.

2.7 LAND USE HISTORY

The mineral exploration history of the Pilbara began in 1888 when gold was found in the Pilbara Creek. Although this did not prove productive, more consistent deposits were subsequently discovered at Marble Bar. Tin was discovered in 1899 and since then manganese and asbestos have been mined. Massive iron-ore deposits were discovered, with exploitation expanding in the 1960s when the Commonwealth embargo on exporting iron-ore was relaxed (Beard, 1975). Subsequently, a number of mining towns were constructed. Newman was developed in the early 1970s to provide accommodation for workers at the Mount Whaleback iron-ore mine. Ports, such as Port Hedland and Dampier, and standard gauge railways from Mt. Tom Price and Paraburdoo to Dampier, Pannawonica to Cape Lambert and Mt. Goldsworthy and Mt. Newman to Port Hedland, were also constructed. The development of the iron ore industry has resulted in activity within the Pilbara changing from cattle and sheep stations and small coastal ports, to a large mining economic base with a commensurate increase in the population.

Tourism is a smaller but rapidly developing industry within the region. The nearest conservation reserve to the Marillana survey area is Karijini National Park, located approximately 70 km to the west.

2.8 PREVIOUS BIOLOGICAL SURVEYS

The Pilbara is a region of considerable environmental significance, lying on the southern limits of the Northern Botanical Province (Burbidge, 1959; Beard, 1979). The region includes species from the north-west, a region of high species endemism, and the arid interior, as well as numerous species which are either endemic to the Pilbara or have restricted geographic distributions (Beard, 1975). Beard (1975) provides a detailed account of previous exploration in the area. Early flora survey work was carried out by Royce (1948) and Burbidge (1959), while broad scale vegetation mapping was first carried out by Burbidge (1945) and later refined by Beard (1975, 1979). The increased development of mineral resources in the region during the last 20 to 30 years has resulted in site-specific detailed flora and fauna surveys being conducted. The surveys conducted in the local and wider area and of relevance to the Marillana survey area are discussed below.

A number of flora and vegetation assessments have been undertaken in the areas surrounding the Marillana survey area. To the west surveys of the flora of the Yandi mining lease have been conducted (*ecologia* 1995a, 2004a; Maunsell, 2003). A soil and vegetation survey (*ecologia*, 1998a), rare and priority flora surveys along the Yandi airstrip access road (*ecologia*, 2002), Newman to Yandi powerline (*ecologia*, 2003) and a survey at Koodaideri (*ecologia*, 2008a) have been carried out in addition to flora and vegetation surveys of the Yandicoogina Junction area (EM Mattiske and Assoc., 1995), Marillana (*ecologia*, 2007) and the Upper Marillana exploration lease (*ecologia*, 2005).

Southwest of the Marillana survey area, surveys of the Weeli Wolli Creek area have been conducted by Trudgen (1984) and *ecologia* (1998b) and biological surveys of Hope Downs and Area C by *ecologia* (1997, 2000a, 2004) and Biota (2004a). Additionally, numerous surveys at West Angelas have been conducted. These include a number of vegetation and flora surveys of the mine site and along the rail line (Weston and Trudgen, 1997; ME Trudgen and Assoc., 1998; Trudgen and Casson, 1999; *ecologia*, 2000b, 2000c, 2000d, 2001a, 2001b). While Biota (2004b) conducted a flora and vegetation survey for the entire FMG rail corridor from Port Hedland to the Mindy Mindy mine site.

2.8.1 Vegetation Described by Beard

The Marillana survey area falls within Beard's (1975) Fortescue Botanical region of the Pilbara. Beard mapped the vegetation communities of the area (Figure 2.4) and they are described as:

- *Acacia aneura* (mulga) in groved patterns;
- *Eucalyptus gamophylla* sparse shrubs, over *Triodia basedowii* (spinifex) hummock grassland; and
- *Eucalyptus brevifolia* (Snappy Gum) sparse low trees, over *Triodia wiseana* open hummock grassland.

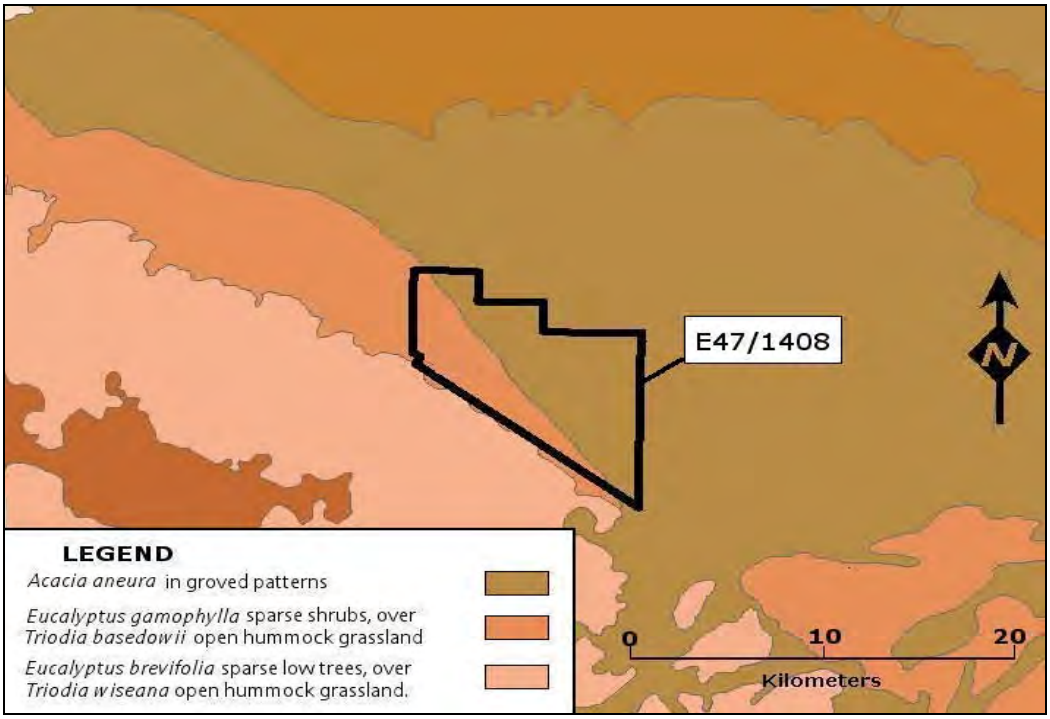

Figure 2.4 – Vegetation Described by Beard at the Marillana Survey Area.

2.8.2 Vegetation Described by IBRA

The Marillana survey area lies in the IBRA Pilbara biogeographic region. Approximately 95% of the area lies in the Fortescue Plains sub-region and the remainder in the Hamersley sub-region.

The vegetation of the Fortescue Plains sub-region is described by Kendrick (2001a) as:

- Salt marshes fringing salt lakes;
- *Acacia aneura* (mulga) and tussock grasses on alluvial plains;
- Short grass communities on alluvial plains; and
- *Eucalyptus camaldulensis* (River Gum) woodlands fringing drainage lines.

The vegetation of the Hamersley sub-region is described by Kendrick (2001b) as:

- *Acacia aneura* (mulga) low woodlands, over tussock grasses on valley floors; and
- *Eucalyptus leucophloia* (Snappy Gum) over *Triodia brizoides* on skeletal soils of the ranges.

2.8.3 Vegetation Previously Recorded Adjacent to the Survey Area

The closest area to Marillana previously surveyed by *ecologia* is a mining tenement located directly adjacent to the Marillana survey area. A single phase flora and vegetation survey for

this area was conducted by *ecologia* in 2005 (*ecologia*, 2007). Sixteen vegetation units were recorded in this area and these are described in Table 2.4.

Table 2.4 – Vegetation Units Recorded at Marillana (*ecologia*, 2007).

Habitat	Vegetation Description
Hill crest – high relief	*Eucalyptus leucophloia* low open woodland *(+/- E. gamophylla, E. kingsmillii* low mallee), over *Acacia spondylophylla, Grevillea wickhamii, Goodenia stobbsiana (+/- A. hilliana)* low shrubland, over *Triodia basedowii (+/- T. wiseana)* hummock grassland.
Hill crest – low relief	*Eucalyptus leucophloia* scattered low trees (+/- *E. gamophylla. kingsmillii* low mallee), over *Grevillea wickhamii*, *Hakea chordophylla* scattered tall shrubs, over *Acacia hilliana* low shrubland, over *Triodia basedowii* hummock grassland.
	Eucalyptus leucophloia scattered low trees, over *E. gamophylla* low mallee, over *Acacia spondylophylla, A. hilliana* low shrubland over *Triodia basedowii* hummock grassland.
	Eucalyptus leucophloia scattered low trees, over *E. gamophylla* low mallee, over *Acacia spondylophylla* low shrubland over *Triodia basedowii* hummock grassland.
	Eucalyptus leucophloia scattered low trees, over *Grevillea wickhamii* high open shrubland, over *Acacia spondylophylla* low shrubland, over *Triodia basedowii* hummock grassland.
Hill slope	*Eucalyptus leucophloia* scattered low trees, over low open shrubland, over *Triodia basedowii* hummock grassland.
Upper hill slope	Low scattered shrubs, over *Triodia basedowii* hummock grassland.
Lower hill slope	*Eucalyptus leucophloia* scattered low trees, over low open shrubland, over *Triodia basedowii* hummock grassland.
Footslope	*Corymbia hamersleyana* scattered low trees, over *Eucalyptus gamophylla* open low mallee (restricted to base of ridge), over *Acacia inaequilatera, Grevillea wickhamii* high open shrubland, over *Triodia wiseana* (+/- *T. basedowii*) hummock grassland and **Cenchrus ciliaris* tussock grassland.
Breakaway slope above gorge	*Triodia basedowii* hummock grassland.
Upper floodplain	*Corymbia hamersleyana* low open woodland, over *Grevillea wickhamii, Senna glutinosa* subsp. *glutinosa, S. artemisioides* subsp. *oligophylla* open shrubland, over *Aristida contorta* tussock grassland. This includes localised patches of mulga (*Acacia aneura* var. *intermedia*) tall shrubland.
Floodplain	*Corymbia hamersleyana* low open woodland, over *Grevillea wickhamii* high open shrubland over *Acacia* spp. shrubland, *over *Cenchrus ciliaris* and other mixed species tussock grassland.
Gorge	*Eucalyptus leucophloia, Corymbia ferriticola, Ficus brachypoda* low woodland over *Grevillea wickhamii, Petalostylis labicheoides* high shrubland over *Acacia monticola* low shrubland over *Themeda triandra, *Cenchrus ciliaris* tussock grassland, with +/- *Cyperus cunninghamii* sedges.
Gully	*Eucalyptus leucophloia* scattered low trees over *Acacia* spp. shrubland over *Themeda triandra* open tussock grassland.
Minor drainage channel	*Grevillea wickhamii / Acacia tumida* closed scrub over **Cenchrus ciliaris* closed grassland (+/- *Corymbia hamersleyana* scattered low trees).
Major drainage channel	*Eucalyptus victrix* woodland over *Acacia* spp. shrubland over **Cenchrus ciliaris* tussock grassland.

2.9 GROUNDWATER DEPENDENT ECOSYSTEMS

Groundwater dependent ecosystems (GDEs) are defined as "ecosystems that must have access to groundwater to maintain their ecological structure and function" (Murray *et al*., 2006) or "ecosystems that are dependent on groundwater for their existence and health" (National Water Commission, 2006).

The extent to which ecosystems are dependent on groundwater is classified into five categories: ecosystems entirely dependent on groundwater; ecosystems highly dependent on groundwater; ecosystems with proportional dependence on groundwater; ecosystems which may only use groundwater opportunistically or to a very limited extent; and ecosystems with no apparent dependence on groundwater (Hatton and Evans, 1998). The dependency of ecosystems on groundwater is based on groundwater flow or flux, level, pressure, and quality. The ecosystem response to alterations in these groundwater parameters is variable (Sinclair Knight Merz Pty Ltd, 2001).

Less than 1% of the land area of Australia is represented by ecosystems that are entirely dependent on groundwater, and the percentage is the same for ecosystems highly dependent on groundwater. Less than 5% of the land area is associated with ecosystems that are proportionally dependent on groundwater (Hatton and Evans, 1998). These ecosystems represent a small but unique and important part of the Australian environment (Hatton and Evans, 1998; Sinclair Knight Merz Pty Ltd, 2001).

Australian GDEs that are entirely dependent on groundwater include the Pilbara spring ecosystems and arid zone groundwater calcrete ecosystems. The importance of these two GDEs (based on vulnerability, value and risk) is rated as high (Sinclair Knight Merz Pty Ltd, 2001).

Currently, six distinct types of GDEs are recognized in Australia: terrestrial vegetation, river base flow systems; aquifer and cave ecosystems; wetlands; terrestrial fauna; and estuarine and near-shore marine ecosystems (Sinclair Knight Merz Pty Ltd, 2001).

The National Water Commission (2006) reported on the Pilbara Groundwater Management Unit. Two GDE types, terrestrial vegetation and wetlands, were identified within this unit in 1995, and the environmental water requirements and environmental water provisions for these GDEs have been determined.

Determination of the environmental water requirements of GDEs is associated with the following factors: the nature of ecosystem dependency on groundwater; the water requirements of the ecosystem; the groundwater regime that will meet the requirements of the ecosystem; and impacts of change in groundwater regime on ecological processes (Sinclair Knight Merz Pty Ltd, 2001). Sustainable borefield developments require an understanding of the use of ecosystem groundwater requirements and adaptability (Eamus and Froend, 2006).

Phreatophytes (deep-rooted plants that can access the water table) utilise groundwater the most during the driest season of the year, when alternative sources of water become exhausted and transpiration is highest. The risk to GDEs from borefield operations is affected by the timing and modification of abstraction, and the magnitude and rate of drawdown. Therefore, the risk to GDEs may be lowered considerably by avoiding periods of peak environmental demand and allowing adaptation of dependent biota to a lower water table. Information concerning the process of adaptation to changes in groundwater availability is limited (Eamus and Froend, 2006).

The maintenance of GDEs is directly related to the maintenance of specific ecosystem processes such as: flowering, seed set and germination; growth and persistence; seedling establishment and recruitment to reproductive age; mortality; and nutrient cycling (Eamus *et al*., 2006). A GDE may experience a decline in the functioning of the ecosystem following

the extraction of groundwater, as opposed to a total collapse of the ecosystem (Murray *et al*., 2006).

In March 2009 the National Water Commission (2009) initiated a project that seeks to identify major GDEs across Australia with the aim of producing a national, comprehensive geographic database inventory (an atlas) of GDEs.

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3 METHODOLOGY

3.1 DATABASE SEARCHES

Before the Marillana vegetation and flora survey was undertaken, searches of the Department of Environment and Conservation (DEC) electronic databases were requested for the survey area. Coordinates of the boundaries of the tenement were provided to the DEC and a 50 km buffer was added to produce a more comprehensive list of any conservation significant flora species that could potentially occur in the area. Searches were undertaken of:

- The DEC's Threatened (Declared Rare) Flora Database.
- The WA Herbarium Database for priority species opportunistically collected in the area of interest.
- The DEC's Declared Rare and Priority Flora List.
- The DEC's Threatened Ecological Communities and Protected Ecological Communities Database.

The Department of Environment and Water Resources' Protected Matters database was also searched and the combined results of these database searches are provided in Appendix A1.

3.2 FLORA AND VEGETATION SURVEY METHODS

The EPA *Guidance for the Assessment of Environmental Factors No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (Environmental Protection Authority 2004a), and EPA *Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA, 2002) were taken into consideration when survey methods were developed.

Detailed methods employed during the flora survey are provided in Sections 3.2.1 to 3.2.4 below.

3.2.1 Survey Timing

The survey was carried out in two phases. The first phase was conducted in winter from the 4th – 12th of June 2008 totalling 16 person survey days. The survey was conducted after a low rainfall season (in the three months prior to the survey, rainfall was 50.9 mm less than the long term mean). However, rain in February 2008 was 125 mm, which is 44.9 mm higher than the long-term mean for that month (80.1 mm).

The second phase was conducted in spring from the 10th – 15th of September 2008 totalling 15 person survey days. In the three months prior to the survey, rainfall was 7.3 mm less than the long-term mean for that month (48.1 mm).

3.2.2 Survey Sites

The field surveys involved systematic flora sampling using quadrats. Sites were either 50 m x 50 m quadrats in large areas of similar vegetation or of an equivalent area (2 500 m^2) along drainage lines or in irregularly shaped patches of vegetation. This quadrat size / area is standard for surveys conducted in the Pilbara bioregion.

Quadrats were chosen from aerial photography before going to site. They were selected on the basis of topography, habitat and vegetation. Ground truthing of quadrat locations was

carried out in the field and locations were amended as necessary. The number of quadrats surveyed was determined by the size and the heterogeneity of the area.

One hundred and thirty-seven quadrats were assessed at the survey area; 82 during phase 1 (phase 1 quadrats = A) and 72 during phase 2 (phase 2 quadrats = B). Seventeen of the sites assessed during phase 2 had also been assessed in phase 1 (resurveyed sites = R). These quadrats are mapped in Figure 3.1 and listed in Appendix A2. The following information was collected at each quadrat:

- The height range and percentage cover (or abundance) for each species recorded in the quadrat.
- GPS coordinates for the centre of each quadrat (WGS84, UTM).
- A digital photograph and photo direction.
- Habitat, including information on drainage lines, slope intensity, soil texture, soil colour, surface layer and rock presence, type and abundance.
- Leaf and wood litter levels and distribution.
- Vegetation condition, based on Bush Forever (2000).
- Fire history of the area.

Specimens of each species recorded in the field were collected multiple times for later identification and verification by a plant taxonomist. Nomenclature and taxonomy follow the conventions currently adopted by the Western Australian Herbarium (FloraBase, 2009). Data collected at individual quadrats are included electronically as Appendix A3.

3.2.3 Opportunistic Collections

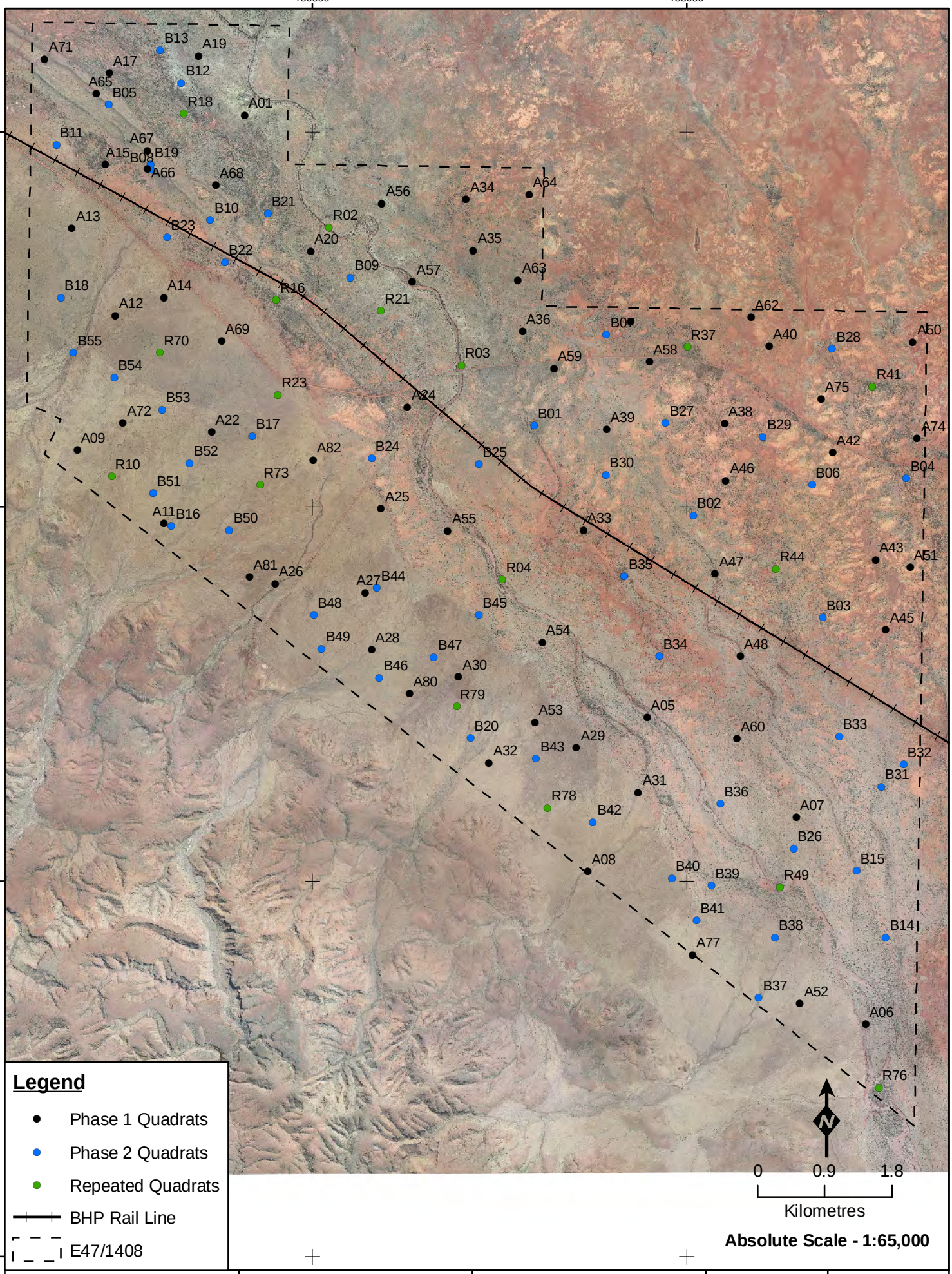
While traversing between quadrats the botanists made opportunistic collections of any flora taxa not already collected at the quadrats. This ensured that a more comprehensive species list was produced for the survey area.

3.2.4 Vegetation Mapping

Vegetation mapping is the delineation of plant communities into groups or associations. The distinctive characteristics that these groups or associations share include features such as species dominance, stratum structure and species composition (Heddle *et al.,* 1980). Data collected within quadrats was analysed using the multivariate statistical programme PATN™, using species presence/absence records with Pearson complete linkage analysis to produce a dendrogram to statistically show the similarities between sites. This method provides an objective means of defining boundaries between vegetation types when mapping. However, it is constrained by the limited number of quadrats that can be surveyed in the field. Therefore quadrat information is supplemented by notes made on vegetation community boundaries while in the field and these notes are used to confirm vegetation boundaries.

Phase 1 data was used for the statistical analysis, as the quadrats were more evenly distributed across the Marillana survey area. Aerial photographs (1:15,000) were used to map the vegetation associations of the survey area, and information gathered during phase 2 was used to confirm the distribution and bundaries of the mapped units.

The vegetation assemblages have been described using the National Vegetation Information System (NVIS) methodology as described in Appendix A4.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ecologia
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Flora Quadrats Surveyed in the Project Area
Figure: 3.1
Project ID: 1140
Drawn: SG
Date: 22/10/09
Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
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3.2.5 Survey Limitations and Constraints

According to the EPA Guidance Statement for Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004), flora and vegetation surveys may be constrained by the following:

- Scope (i.e. the influence in terms of reference, such as what life forms etc. were sampled);
- Proportion of flora collected and identified (based on sampling, timing and intensity);
- Sources of information (i.e. pre-existing background versus new material);
- The proportion of the task achieved and further work which might be needed;
- Timing/weather/season/cycle;
- Disturbances (e.g. fire, flood, accidental human intervention, etc.);
- Intensity (i.e. in retrospect, was the intensity adequate?);
- Completeness (e.g. was the relevant area fully surveyed?);
- Resources (e.g. degree of expertise available in plant identification to taxon level);
- Access problems;
- Availability of contextual information; and
- Experience levels.

These constraints are addressed in Table 3.1 below.

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Table 3.1 – Vegetation and Flora Survey Constraints.

Constraint	Comment
Sources of information and availability of contextual information *(i.e.* pre-existing background versus new material)	Areas of the Pilbara region have been relatively well surveyed by *ecologia* and others. The results of these surveys provide comparative data for analysis. See section 2.8 for details of other surveys undertaken in the vicinity of the current survey area.
The scope *(i.e*. what life forms were sampled)	The vascular flora of the survey area was sampled during both phases of the assessment. The survey scope was prepared in consultation with the relevant government agencies (via Brockman), and was designed to comply with EPA requirements.
Proportion of flora collected and identified (based on sampling, timing and intensity)	Approximately 1451 voucher specimens were collected during the two phases of this survey and the following identifications were made from these specimens. Taxa identified to species, subspecies and variety (including forms and affinities): 302. Identified to family only: 1 taxon. Identified to genus only: 15 taxa. From the 820 voucher specimens collected during the first phase of the survey in June 2008 a species list of 224 taxa resulted. The second phase survey was carried out in September 2008 and 244 taxa were recorded from the 631 voucher specimens collected. Forty-five annual or weakly perennial species were recorded during phase 1 of the survey and 54 during phase 2. A species accumulation curve analysis indicates 85.6% of the flora of the area was recorded.
Completeness and further work which might be needed *(e.g.* was the relevant area fully surveyed)	Aerial photography was used to determine different areas to be sampled during the survey. This ensured that all areas displaying potentially different or unique vegetation were visited during the survey. In addition, the botanists undertaking the survey ground-truthed the vegetation associations occurring in the sites chosen from the aerial photography, and added or removed sites depending on the vegetation encountered while traversing the survey area. The first phase of the survey was carried out in June after the summer rains and the second phase in September following the winter rains. Because of this and the large number of quadrats surveyed in the area, no further work should be needed to define the vegetation of the area. Further work might be needed to identify and mark populations of priority flora once infrastructure locations are known.
Mapping reliability	Good aerial imagery was used to select sites and to map the vegetation of the area. Sampling intensity was relatively high, as 137 quadrats were surveyed over the 94 km^2 tenement.
Timing/weather/season/cycle	Rainfall recorded at Newman in the three months preceding the first phase of the survey (June 2008) was 36.2 mm which is 50.9 mm less than the long-term mean of 87.1 mm for the same three months. Rainfall in the three months preceding the second phase of the survey was 40.8 mm, which is comparable with the long term mean of 48.1 mm for those three months. Despite the below average rainfall prior to phase 1, the year's first significant rains (125 mm in February 2008, and 44.9 mm above the long term mean) occurred approximately 12 weeks before the first phase survey.

Constraint	Comment
Disturbances (e.g. fire, flood, accidental human intervention)	A portion of the survey area had been affected by fire approximately 1-3 years before phase 1 of the survey. This was a small area and it is believed that the vegetation units occurring in these areas were assessed in other un-burnt areas.
Intensity (in retrospect, was the intensity adequate?)	The intensity of these surveys was adequate and will add to existing knowledge on the vegetation and flora in the vicinity of the survey area. Thirty-one person days were spent on the survey. Two vegetation units occurring in the survey area were sampled only once. All other vegetation units were surveyed more than once. One hundred and thirty-seven quadrats were assessed over the two phases of the survey.
Resources	Resources were adequate for the botanical survey as 31 person days were spent in the field.
Access problems	All sections of the survey area were accessible by foot.
Experience levels (e.g. degree of expertise in plant identification to taxon level)	The field botanists each had more than two years experience in conducting botanical surveys of this type. Plant specimens were collected from each quadrat assessed. The plant taxonomist had more than eight years of experience of the flora of the Pilbara.

4 VEGETATION

4.1 VEGETATION OF THE MARILLANA SURVEY AREA

The vegetation at the Marillana survey area has been classified on the basis of field observation, species presence / absence, densities and data analysis and classification. The dendrogram produced from the PATN™ analysis is shown in Figure 4.1.

The vegetation of the Marillana survey area has been separated into eight main units (listed below) with 12 sub-units;

1. *Eucalyptus victrix* and *Acacia citrinoviridis* low woodland (with two sub-units);

2. *Acacia tumida* and *Grevillea wickhamii* tall shrubland;

3. *Acacia aneura* low woodland, over *Acacia synchronicia* tall shrubland, over **Cenchrus* spp. tussock grassland;

4. *Acacia aneura* low open forest (with two sub-units);

5. *Acacia citrinoviridis*, *Corymbia hamersleyana*, *Acacia aneura* and *Acacia pruinocarpa* open woodland, over *Acacia* spp. tall shrubland, over **Cenchrus* spp. closed tussock grassland (with three sub-units);

6. *Acacia dictyophleba* tall shrubland, over *Triodia schinzii* open hummock grassland;

7. *Acacia* spp. medium to high open shrubland, over *Triodia basedowii* and *Triodia schinzii* hummock grassland;

8. *Corymbia hamersleyana* isolated low trees, over *Eucalyptus gamophylla* mallee woodland, over *Acacia* spp. and *Grevillea wickhamii* tall shrubland, over *Triodia basedowii* hummock grassland (with five sub-units).

The sub-units were not visible on the aerial photographs and consequently the vegetation has been mapped into the eight main units described above. The vegetation units and sub-units of the Marillana survey area are described in Table 4.1, and mapped in Figure 4.2.

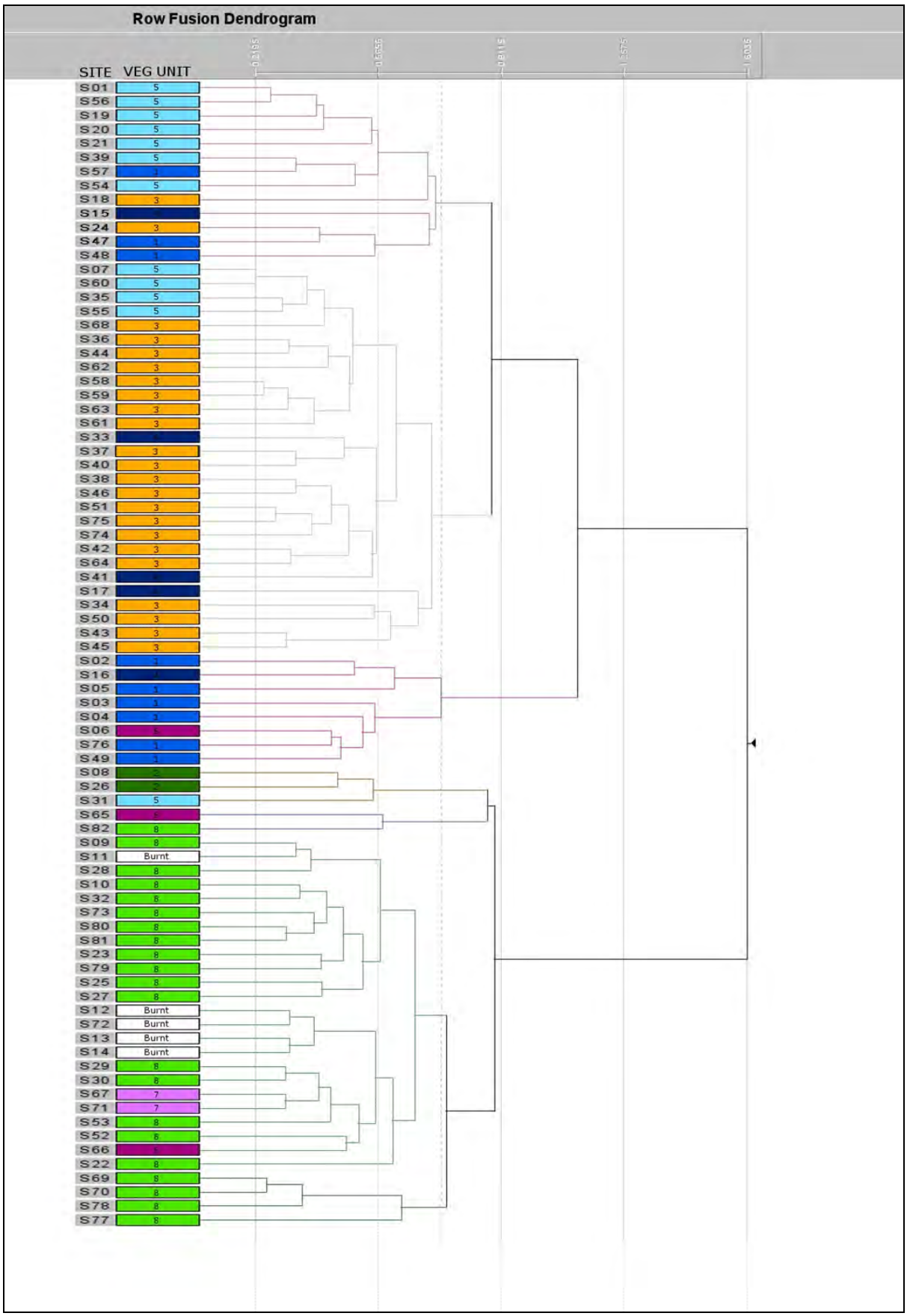

Figure 4.1 – Dendrogram Produced by PATN™ Analysis.

Table 4.1 – Vegetation Units Recorded at the Marillana Survey Area.

Vegetation Description	Priority Flora Recorded?	Habitat	Quadrats Surveyed	Photograph
1 – *Eucalyptus victrix* and *Acacia citrinoviridis* low to tall woodland.				
1a: *Eucalyptus victrix* tall woodland, over *Acacia citrinoviridis*, *Atalaya hemiglauca, Acacia coriacea* subsp. *pendens* and *Acacia aneura* var. *aneura* low woodland, over **Cenchrus setiger* and **Cenchrus ciliaris* tussock grassland. Species richness = 21 ± 7 (n = 8)	No	Creek line	**Phase 1** A2, A3, A5, A49, A57 **Phase 2** R2, R3, R49	
1b: *Acacia citrinoviridis* low open forest, with *Eucalyptus victrix*, *Corymbia hamersleyana* and *Atalaya hemiglauca* isolated low trees, over *Corchorus crozophorifolius* and *Corchorus tectus* low open shrubland, over **Cenchrus ciliaris* and **Cenchrus setiger* open tussock grassland. Species richness = 17 ± 4 (n = 6)	No	Creek line	**Phase 1** A4, A47, A48, A76 **Phase 2** R4, R76	

Table 4.1 continued

Vegetation Description	Priority Flora recorded?	Habitat	Quadrats Surveyed	Photograph
2 – *Acacia tumida* and *Grevillea wickhamii* tall shrubland.				
Corymbia hamersleyana isolated low trees, over *Eucalyptus gamophylla* open mallee woodland, over *Acacia tumida* var. *pilbarensis* and *Grevillea wickhamii* subsp. *hispidula* tall shrubland, over *Grevillea wickhamii* subsp. *hispidula*, *Acacia tumida* var. *pilbarensis* and *Acacia pachyacra* mid open shrubland, over *Indigofera monophylla* and *Tephrosia rosea* var. *glabrior* low shrubland, over *Themeda triandra*, *Paraneurachne muelleri,* **Cenchrus ciliaris* and **Cenchrus setiger* sparse tussock grassland and *Triodia* ?*epactia* sparse hummock grassland. Species richness = 44 ± 11 (n = 5)	No	Minor drainage channel on footslope	**Phase 1** A8, A26 **Phase 2** B37, B49, B55	
3 – *Acacia aneura* low woodland, over *Acacia synchronicia* tall shrubland, over **Cenchrus* spp. tussock grassland.				
3a: *Acacia aneura* var. *aneura*, *Acacia pruinocarpa* and *Hakea lorea* subsp. *lorea* isolated tall shrubs, over *Acacia synchronicia* mid to tall open shrubland, over *Sclerolaena cornishiana*, *Senna artemisioides* subsp. *helmsii*, *Senna artemisioides* subsp. *oligophylla*, *Eremophila lanceolata* and *Sida fibulifera* low open shrubland, over *Chrysopogon fallax*, **Cenchrus ciliaris*, *Enneapogon polyphyllus*, *Aristida contorta* and *Eulalia aurea* open tussock grassland. The Priority 3 species, *Goodenia nuda*, was recorded in this vegetation unit. Species richness = 20 ± 8 (n = 15)	**Yes**	Clay pan	**Phase 1** A18, A36, A42, A43, A45, A50, A62, A64, A75 **Phase 2** B2, B3, B6, B7, B29, R18	

Table 4.1 continued

Vegetation Description	Priority Flora recorded?	Habitat	Quadrats Surveyed	Photograph
3b: *Acacia aneura* var. *aneura* low woodland, over *Hakea lorea* subsp. *lorea*, *Acacia pruinocarpa*, *Corymbia hamersleyana* and *Acacia citrinoviridis* isolated low trees, over *Acacia synchronicia* and *Acacia aneura* var. *aneura* (seedlings) tall shrubland, over *Sclerolaena cornishiana* and *Eremophila lanceolata* low shrubland, over **Cenchrus ciliaris*, **Cenchrus setiger*, *Enneapogon polyphyllus*, *Chrysopogon fallax* and *Eulalia aurea* open tussock grassland. Species richness = 19 ± 7 (n = 27)	No	Clay pan	**Phase 1** A24, A34, A37, A38, A40, A44, A46, A51, A58, A59, A61, A63, A68, A74 **Phase 2** B1, B12, B21, B22, B23, B24, B25, B27, B28, B30, B45, R37, R44	
4 – *Acacia aneura* low open forest.				
4a: *Acacia aneura* var. ?*aneura* and var. ?*macrocarpa* low closed forest, over *Acacia synchronicia* and *Acacia sclerosperma* var. *sclerosperma* isolated mid shrubs, over *Abutilon dioicum* and **Malvastrum americanum* low shrubland, over **Cenchrus ciliaris* and **Cenchrus setiger* closed tussock grassland. Species richness = 18 ± 5 (n = 8)	No	Minor channel Drainage depression	**Phase 1** A15, A17, A33, A41 **Phase 2** B4, B13, B35, R41	

Table 4.1 continued

Vegetation Description	Priority Flora recorded?	Habitat	Quadrats Surveyed	Photograph
4b: *Acacia aneura* var. *?aneura*, *Corymbia hamersleyana* and *Eucalyptus ?victrix* low open forest, over **Cenchrus setiger* and **Cenchrus ciliaris* open tussock grassland. The Priority 3 species, *Goodenia nuda*, was recorded in this vegetation unit. Species richness = 24 ± 1 (n = 3)	**Yes**	Minor channel Drainage depression	**Phase 1** A16 **Phase 2** B15, R16	
5 – *Acacia citrinoviridis, Corymbia hamersleyana, Acacia aneura* and *Acacia pruinocarpa* open woodland, over *Acacia* spp. tall shrubland, over **Cenchrus* spp. closed tussock grassland.				
5a: *Corymbia hamersleyana, Acacia citrinoviridis*, *Acacia aneura* var. *aneura, Acacia pruinocarpa, Hakea lorea* subsp. *lorea* and *Eucalyptus victrix* low open woodland, over *Acacia synchronicia, Acacia sclerosperma* subsp. *sclerosperma*, *Acacia dictyophleba* and *Acacia inaequilatera* tall open shrubland, over *Sclerolaena cornishiana*, *Eremophila lanceolata* and *Sida fibulifera* isolated low shrubs, over **Cenchrus ciliaris* and **Cenchrus setiger* closed tussock grassland. Species richness = 15 ± 6 (n = 15)	No	Floodplain	**Phase 1** A1, A6, A7, A19, A21, A39, A54, A55, A60 **Phase 2** B14, B31, B32, B34, B36, R21	

Table 4.1 continued

Vegetation Description	Priority Flora recorded?	Habitat	Quadrats Surveyed	Photograph
5b: *Acacia aneura* var. *aneura*, *Acacia citrinoviridis*, *Hakea lorea* subsp. *lorea* and *Acacia inaequilatera* low open woodland, over *Acacia synchronicia* and *Acacia sclerosperma* var. *sclerosperma* tall open shrubland, over **Cenchrus ciliaris, *Cenchrus setiger* and *Chrysopogon fallax* closed tussock grassland. Species richness = 13 ± 4 (n = 7)	No	Floodplain	**Phase 1** A20, A35, A56 **Phase 2** B9, B26, B33, B39	
5c: *Corymbia hamersleyana* isolated low trees, over *Acacia dictyophleba* tall shrubland, over *Acacia dictyophleba* and *Acacia ancistrocarpa* mid shrubland, over **Cenchrus ciliaris* tussock grassland and *Triodia basedowii* hummock grassland. Species richness = 18 (n = 1)	No	Floodplain	**Phase 1** A31	

Table 4.1 continued

Vegetation Description	Priority Flora recorded?	Habitat	Quadrats Surveyed	Photograph
6 - *Acacia dictyophleba* tall shrubland, over *Triodia schinzii* open hummock grassland.				
Eucalyptus gamophylla isolated mallee trees, over *Acacia dictyophleba* tall shrubland, over *Sida cardiophylla* and *Crotalaria cunninghamii* mid shrubland, over *Corchorus tectus* low shrubland, over *Eragrostis eriopoda* and **Cenchrus ciliaris* open tussock grassland and *Triodia schinzii* open hummock grassland. Species richness = 19 ± 5 (n = 4)	No	Sand dune	**Phase 1** A65, A66	
			Phase 2 B5, B19	
7 – *Acacia* spp. medium to tall open shrubland, over *Triodia basedowii* and *Triodia schinzii* hummock grassland.				
Acacia inaequilatera and *Hakea lorea* subsp. *lorea* isolated low trees, over *Eucalyptus gamophylla* isolated mallee trees, over *Acacia sclerosperma* subsp. *sclerosperma*, *Acacia pachyacra* and *Acacia dictyophleba* medium to tall open shrubland, over *Corchorus tectus*, *Petalostylis cassioides* and *Bonamia rosea* low open shrubland, over *Triodia basedowii* and *Triodia schinzii* hummock grassland. Species richness = 25 ± 6 (n = 4)	No	Sand dune swale	**Phase 1** A67, A71	
			Phase 2 B8, B10	

Table 4.1 continued

Vegetation Description	Priority Flora recorded?	Habitat	Quadrats Surveyed	Photograph
8 – *Corymbia hamersleyana* isolated low trees, over *Acacia* spp., *Eucalyptus gamophylla* and *Grevillea wickhamii* mid to tall shrubland, over *Triodia basedowii* hummock grassland.				
8a: *Corymbia hamersleyana* isolated low trees, over *Eucalyptus gamophylla* mallee woodland, over *Acacia inaequilatera, Acacia ancistrocarpa*, *Acacia pachyacra, Grevillea wickhamii* subsp. *hispidula*, *Senna artemisioides* subsp. *oligophylla* and *Scaevola spinescens* isolated mid shrubs, over *Triodia basedowii* hummock grassland. Species richness = 24 ± 7 (n = 11)	No	Footslope Sandy plain	**Phase 1** A27, A30, A73, A79, A81 **Phase 2** B17, B20, B40, B44, R73, R79	
8b: *Acacia pachyacra* mid to tall open shrubland, over *Acacia ancistrocarpa*, *Corchorus tectus*, *Bonamia rosea*, *Dicrastylis cordifolia* and *Indigofera monophylla* isolated low shrubs, over *Triodia basedowii* hummock grassland. Species richness = 18 ± 8 (n = 8)	No	Footslope	**Phase 1** A23, A25, A69, A70 **Phase 2** B18, B50, R23, R70	

Table 4.1 continued

Vegetation Description	Priority Flora recorded?	Habitat	Quadrats Surveyed	Photograph
8c: *Corymbia hamersleyana* isolated low trees, over *Eucalyptus gamophylla* isolated mallee trees, over *Acacia inaequilatera* open tall shrubland, over *Acacia pachyacra*, *Acacia dictyophleba*, *Petalostylis labicheoides* and *Hakea chordophylla* mid to tall shrubland, over *Corchorus tectus, Hibiscus sturtii* var. *platychlamys* and *Ptilotus astrolasius* var. *astrolasius* low open shrubland, over *Triodia basedowii* closed hummock grassland. Species richness = 20 ± 5 (n = 12)	No	Sandy plain	**Phase 1** A22, A29, A52, A53, A78, A82 **Phase 2** B38, B41, B42, B43, B47, R78	
8d: *Acacia pyrifolia* var. *pyrifolia* isolated low trees, over *Acacia tumida* var. *pilbarensis* and *Acacia ancistrocarpa* tall open shrubland, over *Petalostylis labicheoides*, *Indigofera monophylla* and *Corchorus parviflorus* low open shrubland, over *Aristida inaequiglumis* and *Aristida holathera* var. *holathera* tussock grassland, over *Triodia basedowii* isolated hummock grasses. Species richness = 24 (n = 1)	No	Sandy plain	**Phase 1** A77	

Table 4.1 continued

Vegetation Description	Priority Flora recorded?	Habitat	Quadrats Surveyed	Photograph
8e: *Grevillea wickhamii* subsp. *hispidula* mid to tall shrubland, over *Acacia inaequilatera* and *Hakea chordophylla* isolated tall shrubs, over *Acacia ancistrocarpa*, *Senna artemisioides* subsp. *oligophylla*, *Gossypium australe*, *Bonamia rosea, Indigofera monophylla* and *Corchorus tectus* low shrubland, over *Triodia basedowii* and *Triodia epactia* hummock grassland. Species richness = 25 ± 5 (n = 9)	No	Footslope	**Phase 1** A9, A10, A28, A32, A80 **Phase 2** B46, B48, B51, R10	
Note: ± after mean species richness indicates standard deviation.				

The vegetation units recorded at Marillana are mostly typical of this area of the Pilbara. They are broadly comparable with earlier mapping of Western Australia (as described in Kendrick (2001a & 2001b) and Beard (1975)). This partial match reflects the broad-scale mapping of Beard, and by extension that of Kendrick and McKenzie. The number of quadrats established at the Marillana survey area is significantly larger than the number of sampling points established for these earlier mapping exercises and therefore the resulting vegetation types will differ.

The vegetation previously recorded in the area by *ecologia* (2007) also partially matches that recorded during the current survey. However, the earlier survey focused more on the flora and vegetation of the upper hill slopes of the Hamersley Range, and vegetation described for these areas does not match any of the units mapped in the current survey. The vegetation described for the lower slopes and flat areas surveyed by *ecologia* (2007) matches that recorded and mapped during this current Marillana survey. The dune vegetation of the survey area is similar to that mapped by Biota (2004b).

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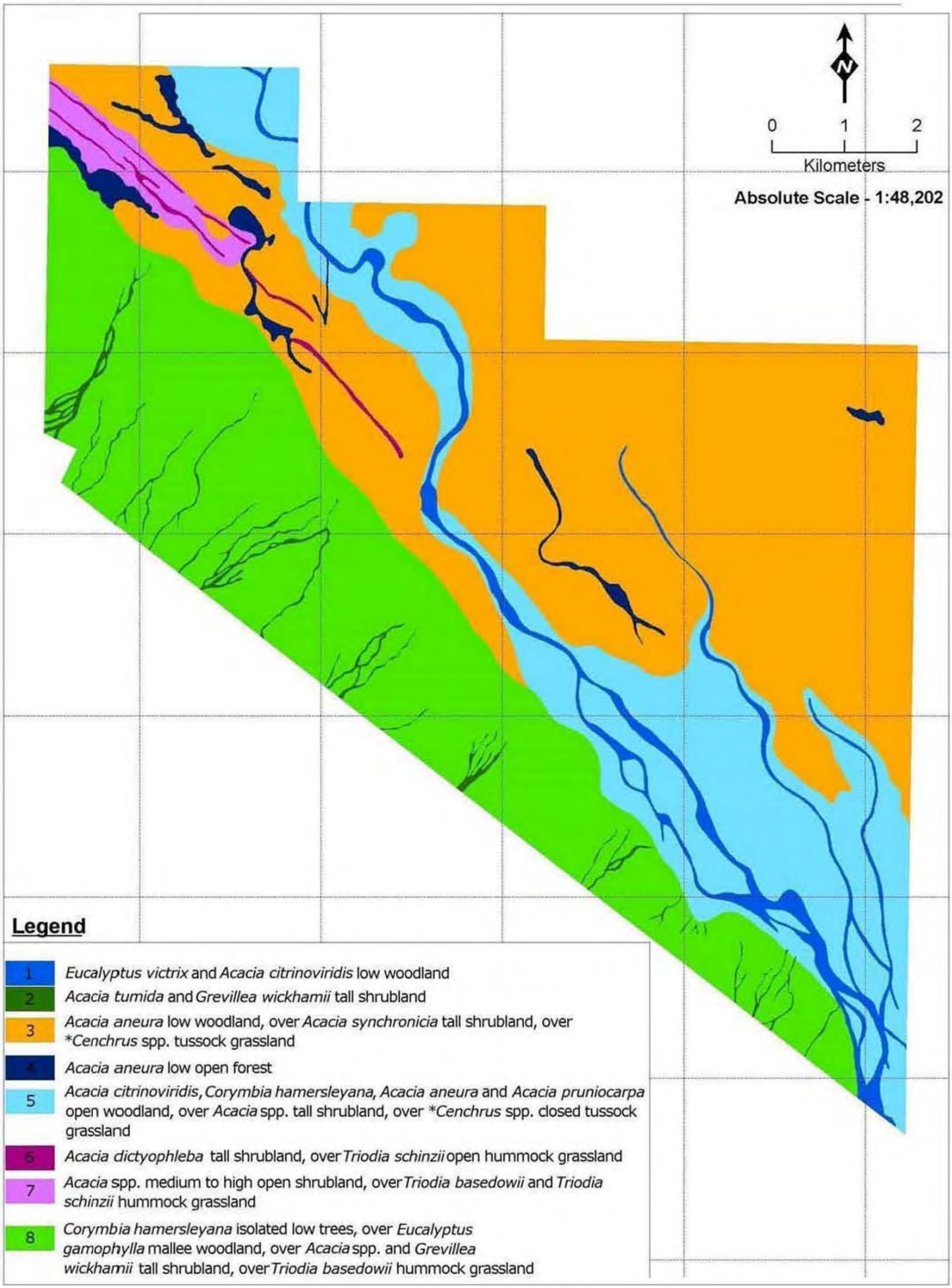

Figure 4.2 – Vegetation of the Marillana Survey Area

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4.1.1 Vegetation Condition

Vegetation condition at the Marillana survey area was noted in the field using the levels indicated in Table 4.2. Factors considered when determining these levels were the presence of weeds, tracks, litter, grazing and any other ground disturbances and were based on the vegetation scales in column three of Table 12 of Bush Forever Volume 2 (Bush Forever, 2000).

Table 4.2 – Vegetation Condition Assessment.

Vegetation condition	Level	Proportion of survey area (%)
Pristine	No disturbance	0
Excellent	Minimal disturbance	11
Good	Moderate disturbance	44
Poor	Significant disturbance	45
Degraded	Very high disturbance	0

The vegetation of the creek banks, floodplains and flat clay pan areas at Marillana is generally in a poor condition. These areas are characterised by high levels of cattle grazing and significant weed populations. The introduced taxa, **Cenchrus ciliaris* and **Cenchrus setiger,* are the dominant tussock grasses at Marillana, and the dominance of these introduced grasses is likely to be decreasing the diversity of native grasses and other species in the lower shrub and herb layers.

The rocky footslope located along the southern boundary of the Marillana survey area is dominated by spinifex. Because of this cattle grazing pressure is low, and there is minimal weed establishment except along tracks which have been populated by **Cenchrus ciliaris* at the edges; vegetation condition in these areas is much better than in the creek bank, floodplain and clay pan areas mentioned above. Vegetation condition at each site surveyed is recorded in Appendix A2.

4.1.2 Fire History

The Marillana survey area had been partially affected by fire approximately 1 - 3 years before phase one of the survey. The fire affected an area in the south-western section of the tenement. Ten quadrats were assessed throughout this area during both phases. The locations of the survey sites, and the vegetation of the area is described and shown in Table 4.3.

Table 4.3 – Burnt Vegetation Recorded at the Marillana Survey Area.

Quadrat	Vegetation Description	Photograph
Phase 1 A11 A12 A13 A14 A72	*Corymbia hamersleyana* isolated low trees, over *Acacia inaequilatera* and *Hakea lorea* subsp. *lorea* isolated tall shrubs, over *Bonamia rosea, Ptilotus obovatus* var. *obovatus* and *Corchorus tectus* low shrubland, over *Aristida inaequiglumis*, *Eragrostis eriopoda* and *Aristida holathera* var. *holathera* open tussock grassland and *Triodia basedowii* (regrowth seedlings) open hummock grassland.	
Phase 2 B11 B16 B52 B53 B54		

4.2 ECOLOGICAL COMMUNITIES

4.2.1 State and Nationally Recognised Threatened Ecosystems within the Survey Area

Ecological communities are naturally occurring biological assemblages located in a particular type of habitat. At a national level, threatened ecological communities (TECs) are protected under the *EPBC Act*. TECs are listed under this Act as either 'Critically Endangered', 'Endangered' or 'Vulnerable'. A definition of these codes is provided in Appendix A5.

No nationally listed TEC occurs in the Marillana survey area.

The Western Australian DEC also maintains a list of TECs that are categorised as being either 'Presumed Totally Destroyed', 'Critically Endangered', 'Endangered' or 'Vulnerable'. A definition of these codes is also provided in Appendix A5.

No State-listed TEC occurs in the Marillana survey area.

Possible TECs that do not meet survey criteria, or that are not adequately defined, are added by the DEC to a list of priority ecological communities (PECs). Communities are placed in this category while consideration can be given to their declaration as a TEC. Five priority codes exist for PECs and these are defined in Appendix A5.

One State-listed PEC occurs within the survey area, the Priority 3 'Vegetation of sand dunes of the Hamersley Range and Fortescue Valley'.

The PEC occurs in the Divide Land System (Van Vreeswyk *et al.* (2004), and the dunes are considered to be regionally rare, small, fragile and susceptible to threatening processes.

4.2.2 Weeli Wolli Spring Community

During the database searches for TEC and PEC communities of the area the Priority 1 Weeli Wolli Spring PEC was located within 50 km of the survey area.

The Weeli Wolli Spring PEC has an unusual sedge and herb field understorey composition that fringes the pools and associated water bodies, which has not been recorded at any other area in the Pilbara. Potential threats to this PEC are dewatering and re-watering activities that could alter the patterns of inundation (DEC, 2008). The boundary of the PEC does not stretch as far as Brockman's Marillana tenement, as the PEC is confined to the extent of the *Melaleuca leucadendron* growing around the pools in the creek that are fed by the spring (pers. comm. Dr. S. van Leeuwen, DEC, April 2009).

4.2.3 Fortescue Marsh

The Fortescue Marsh is located approximately 15 km north of the survey area, and it has recently been listed as a Priority 1 PEC. The Marsh is believed to be a surface water fed body and should not be impacted by borefield / pumping activities at the Marillana project area.

4.2.4 Groundwater Dependent Ecosystem

The vegetation mapped along the large creeks of the Marillana survey area, especially the trees and tall shrubs lining the banks of the Weeli Wolli Creek (Unit 1), is probably phreatophytic and utilises groundwater at least at some times during the year.

A potential indirect impact of the proposed mine is the lowering of groundwater levels in the project area.

4.2.5 Mulga Communities in the Survey Area

The *Acacia aneura* (mulga) low woodland unit represents a major vegetation type in the survey area (Units 3 and 4) particularly across the north-eastern section of the survey area.

Mulga is a bushy shrub or tree ranging in height from 2-10 m, and comprises a range of taxa with considerable variation in growth form and phyllode morphology. Mulga communities are defined as those that contain and are frequently dominated by mulga (Fortech, 1999). These communities may occur in patches in valleys, in sheltered sites associated with hills and breakaways, or in distinctive grove arrangements. Mulga occurs on a variety of soils and in a variety of habitats across the semi-arid shrublands of Australia (Paczkowska and Chapman, 2000).

Mulga has a root system that is adapted for taking up water from thin surface soils and has adaptations that concentrate soil water near the plant and conserve water within the plant. Consequently, the distribution and abundance of mulga is particularly influenced by soil moisture and the pattern of surface drainage (Paczkowska and Chapman, 2000).

A potential indirect impact of the proposed mine site is disturbance to surface hydrology. As surface water is important for stands of mulga, mining activities could have an adverse effect on the mulga communities in this area unless adequate measures are taken to maintain current surface water flow patterns.

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5 FLORA

5.1 GENERAL FLORA

Three hundred and two taxa were recorded during the Marillana survey and this total includes subspecies, varieties, forms and affinities. Of this combined total, 224 taxa from 38 families and 100 genera were recorded during the first phase of the survey and 244 from 39 families and 104 genera during the second. The species list for the Marillana survey area is included as Appendix A6.

Ten of the 302 taxa were introduced species and one was a priority flora species. Sixteen taxa collected during the survey could not be confirmed to species level.

A summary of the number of flora taxa recorded during the survey is provided in Table 5.1, while Table 5.2 provides details of the dominant flora groups of the survey area. Floristic richness at the Marillana survey area has been compared with that at neighbouring areas (Table 5.3), and it is similar to that recorded at these other areas.

Table 5.1 – Floristic Diversity at the Marillana Survey Area.

	Number of taxa recorded	Number of families	Number of genera	Number of families represented by a single taxon	Number of genera represented by a single taxon	Annuals
Phase 1	224	38	100	12	60	49
Phase 2	244	39	104	18	58	54
Combined Total	302	42	116	13	63	103

Table 5.2 – Dominant Flora Groups at the Marillana Survey Area.

	Family	Number of taxa recorded	Genera	Number of taxa recorded
Phase 1	Poaceae	40	*Acacia*	31
	Mimosaceae	32	*Ptilotus*	10
	Malvaceae	19	*Sida*	7
Phase 2	Poaceae	40	*Acacia*	30
	Mimosaceae	31	*Ptilotus*	16
	Malvaceae	19	*Senna*	9
Combined total	Poaceae	50	*Acacia*	38
	Mimosaceae	39	*Ptilotus*	17
	Malvaceae	25	*Senna*	10

Table 5.3 – A Comparison of Floristic Richness with Other Areas.

Site surveyed	Total no. of flora taxa	No. of quadrats (50 × 50 m)	Total area surveyed (m^2)	Date surveyed	Average no. of species per quadrat	Source
Marillana Phase 1	**224**	**82**	**202 500** m^2	**June, 2008**	**36**	**Current Survey**
Marillana Phase 2	**244**	**72**	**180 000** m^2	**September, 2008**	**29**	**Current Survey**
Marillana (BHP Billiton)	244	78	195 000 m^2	Oct, 2005	32	*ecologia*, 2007
Yandi Mine Extension Phase 1	212	56	140, 000 m^2	Nov, 2007	26	*ecologia*, 2008b
Yandi Mine Extension Phase 2	260	62	155, 000 m^2	March, 2008	24	*ecologia*, 2008b

5.1.1 Sampling Adequacy

Species accumulation curves provide a theoretical basis for understanding the relationship between sampling effort and the accumulation of species, and hence provide a means of estimating survey adequacy. As sampling effort increases with a corresponding increase in survey area and time, the rate at which new species are recorded is reduced, and the number recorded levels out (i.e. becomes asymptotic). At this point, where there is a diminishing return with regards to increases in species richness in relation to sampling effort, the survey size is deemed sufficient.

Flora sampling adequacy for the Marillana survey was estimated using a species accumulation curve and extrapolation of the curve to the asymptote using Michaelis-Menten Mean modelling (Colwell, 2005). Estimates from the data indicate that approximately 85.6% of the vascular flora taxa potentially present within the Marillana survey area was recorded. However, the data used for plotting include only the species found at each quadrat (excluding repeat quadrats), and opportunistic collections were made outside of the sites (along tracks and adjacent to quadrats) and a higher proportion of the flora was actually sampled. The species accumulation curve for the Marillana survey area is shown in Figure 5.1.

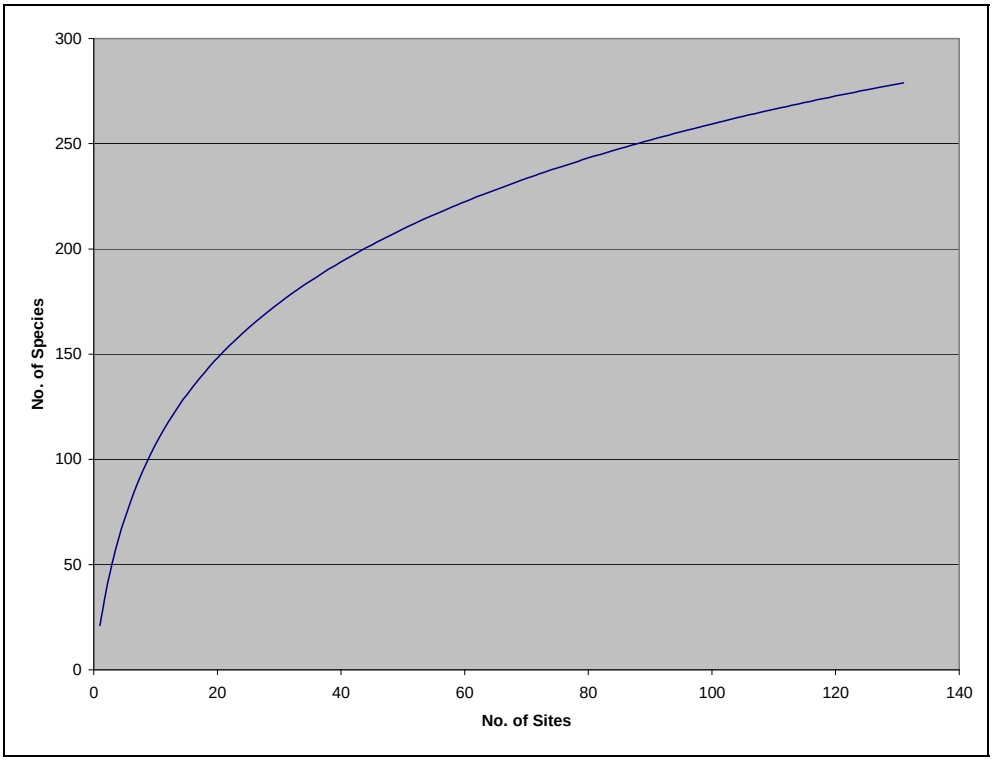

Figure 5.1 – Species Accumulation Curve for the Marillana Survey Area.

5.2 FLORA OF CONSERVATION SIGNIFICANCE

5.2.1 Environment Protection and Biodiversity Conservation Act 1999

Flora species are protected at a national level under the *EPBC Act*. The *EPBC Act* contains a list of species that are considered either 'Critically Endangered', 'Endangered', 'Vulnerable', 'Conservation Dependent', 'Extinct' or 'Extinct in the Wild' (for category definitions refer to Appendix A5).

Lepidium catapycnon (Vulnerable) is protected by this act and is known to occur in the region.

Lepidium catapycnon was not recorded during this survey.

5.2.2 Wildlife Conservation Act 1950

Conservation significance in Western Australia is determined under the *WC Act* and under this Act flora taxa of conservation significance are protected. Currently, declared rare flora (DRF) taxa are protected under the *Western Australian Wildlife Conservation (Rare Flora) Notice 2008(2)* of the above Act. This notice lists flora taxa that are extant and considered likely to become extinct or rare. They are defined as "taxa which have been adequately searched for and deemed to be either rare, in danger of extinction, or otherwise in need of special protection in the wild". These taxa are legally protected and their removal or impact to their surroundings cannot be conducted without ministerial approval obtained specifically on each occasion for each population (refer to Appendix A5 for category definitions).

Two DRF are protected by this Act in the Pilbara region; *Lepidium catapycnon* and *Thryptomene wittweri*. *Lepidium catapycnon* is commonly found on skeletal soils on steep hill slopes and *Thryptomene wittweri* is found on skeletal red stony soils, breakaways and

stony creek beds. The DEC rare and priority flora database search shows that both of these taxa have been recorded within a 50 km buffer of the survey area.

No DRF taxa were located in the Marillana survey area.

5.2.3 Priority Flora

The DEC maintains a list of priority flora taxa, which are considered poorly known, uncommon, or under threat, but for which there is insufficient justification based on known distribution and population sizes, for inclusion on the DRF schedule. A priority flora is assigned to one of four priority categories (Atkins, 2008 and defined in Appendix A5). Currently, 131 priority flora taxa are listed as occurring in the Pilbara region (FloraBase, October, 2009).

5.2.4 Priority Flora with Potential to Occur at the Marillana Survey Area

Using the DEC's database search results, and taking into consideration habitat preferences and distribution ranges from FloraBase, it is considered that two DRF and 27 priority flora could potentially occur in the Marillana survey area (Table 5.4).

Table 5.4 – Priority Flora with Potential to Occur at the Marillana Survey Area.

Status	Species	Distribution (nearest named location)	Preferred Habitat	Potential	DEC 50 km record
Rare	*Lepidium catapycnon* (Brassicaceae)	Wittenoom, Weeli Wolli Creek, Newman.	Skeletal soils on stony hill slopes.	**Unlikely**	Yes
	Thryptomene wittweri (Myrtaceae)	Hamersley Range, Mt Augustus, Carnarvon Range, White Cliffs Stn, NT.	Skeletal red stony soils, breakaways and stony creek beds.	**Possible**	Yes
Priority 1	*Calotis squamigera* (Asteraceae)	Wittenoom, Hamersley Range.	Pebbly loam.	**Unlikely**	Yes
	Eremophila spongiocarpa (Myoporaceae)	Mt Marsh, Chichester Range, Marillana Station, Mulga Downs Station.	Weakly saline alluvial plain on margins of salt lakes.	**Unlikely**	Yes
	Goodenia sp. East Pilbara (A.A. Mitchell PRP 727) (Goodeniaceae)	Outside mining lease, ca 90 km NW of Newman.	Red-brown clayey pan, swamp on major river floodplain.	**Possible**	No
	Ischaemum albovillosum (Poaceae)	Chichester Plateau, near Fortescue River.	Plateaus, cracking clay.	**Unlikely**	No
	Myriocephalus nudus (Asteraceae)	Hamersley Range, Paynes Find, Yannarie River, Juna Downs, Swan River (Drummond).	Along rivers & creeks, granite.	**Unlikely**	Yes
Priority 2	*Acacia daweana* (Mimosaceae)	Hamersley Range, Karijini N.P.	Stony red loamy soils, low rocky rises, along drainage.	**Possible**	Yes
	Eremophila forrestii subsp. *Pingandy* (M.E. Trudgen 2662) (Myoporaceae)	Karijini NP, Hamersley Range NP, Turee Creek Stn.	Flat terrain, low in landscape, base of broad valley, stony gibber plain above shallow drainage line, red clay-loam.	**Unlikely**	Yes
	Gonocarpus ephemerus (Haloragaceae)	Trugallenden Pool, Port Hedland.	Sand, along drainage lines, granite.	**Unlikely**	No
	Olearia fluvialis (Asteraceae)	Hamersley Range, Karijini N.P., West Angelas, Newman.	Iron rich alluvium, pebbly sand, stony creeks.	**Possible**	Yes
	Spartothamnella puberula (Lamiaceae)	Mt Bruce, Hamersley Range, West Angelas, NT.	Rocky loam, sandy or skeletal soils, clay, sandplains.	**Possible**	Yes
Priority 3	*Acacia bromilowiana* (Mimosaceae)	Tom Price, Balfour Downs Stn, West Angelas, Hope Downs, Hamersley Range, Marillana Stn, Ophthalmia Range.	Red skeletal stony loam, orange-brown pebbles, gravel loam, laterite, banded ironstone, basalt, rocky hills, breakaways, scree slopes, gorges, creek beds.	**Unlikely**	Yes
	Acacia glaucocaesia (Mimosaceae)	Ashburton River, Woodie Woodie, Mardie Station, Karratha, Dampier.	Red loam, sandy loam, clay.	**Possible**	No
	Calotis latiuscula (Asteraceae)	Giles, Warburton, Blackstone Range, Rawlinson Range, Hamersley Range.	Rocky hillsides, floodplains, rocky creeks and river beds.	**Possible**	Yes

Status	Species	Distribution (nearest named location)	Preferred Habitat	Potential	DEC 50 km record
Priority 3	*Eremophila youngii* subsp. *lepidota* (Myoporaceae)	Roy Hill-Munjini Road, Mulga Downs Station, Newman.	Stony red sandy loam, flats plains, floodplains, sometimes semi-saline, clay flats.	**Possible**	No
	Glycine falcata (Papilionaceae)	Munjina Claypan, Juna Downs Station, Bungle Bungle National Park.	Black clayey sand, along drainage depressions in crabhole plains on river floodplains.	**Unlikely**	No
	Goodenia nuda (Goodeniaceae)	Weeli Wolli Creek, Roy Hill, Wittenoom, Mulga Downs, Marillana Creek, Yandi Eastern Pit 2.	Plain, dry, red sand, bare river sand in dry scoured river bed.	**Confirmed**	No
	Goodenia pascua (Goodeniaceae)	Roebourne, Port Hedland, Onslow.	Red sandy soils. Basaltic plains.	**Unlikely**	No
	Gymnanthera cunninghamii (Asclepidiaceae)	Boodarie Landing, Boodarie Homestead, Woodstock Station, Tom Price.	Brown red sand, major drainage, limestone rise, creekline, river sand.	**Possible**	No
	Hibiscus brachysiphonius (Malvaceae)	Balgo Mission, Christmas Creek, Wandagee, Karratha, Tom Price, Millstream, Warrawagine, Hamersley Range.	Red loam over basalt, hard setting red clay pan on limestone, gilgai within clayey plain.	**Possible**	Yes
	Indigofera gilesii subsp. *gilesii* (Papilionaceae)	Hamersley Range, Meekatharra, West Angelas.	Pebbly loam amongst boulders & outcrops, hills.	**Unlikely**	Yes
	Polymeria sp. Hamersley (ME Trudgen 11353) (Convolvulaceae)	Hamersley Stn, Wittenoom, Marandoo, Hamersley Range.	Red-brown cracking clay.	**Unlikely**	Yes
	Rhagodia sp. Hamersley (M. Trudgen 17794) (Chenopodiaceae)	Hamersley Range.	Hard clay pans, under mulga.	**Possible**	Yes
	Rhynchosia bungarensis (Papilionaceae)	Hamersley Range, Chichester Ranges, Yardie Creek, Robe River, Tom Price, Ashburton, East Lewis Island, Burrup, Dampier Archipelago.	Floodplain with deep gorge, creekline within deep gorge, river channels, summit of hill, steep slope, skeletal red stony soil.	**Unlikely**	Yes
	Rostellularia adscendens var. *latifolia* (Acanthaceae)	Hamersley Range.	Ironstone soils, near creeks, rocky hills.	**Possible**	Yes
	Tephrosia sp. Cathedral Gorge (F.H. Mollemans 2420) (Papilionaceae)	Newman, Hamersley Range, Fortescue Valley.	Stony hill slope, ridge crest, skeletal loam, gentle drainage depression.	**Unlikely**	Yes
	Triumfetta leptacantha (Tiliaceae)	Marillana BHP BIO Mining Lease, Yandi Iron Ore Mine, Ministers North, Yandicoogina Creek, Packsaddle Range, Munjina (Auski) Roadhouse.	Red clay over boulder, red loam, fluviatile gravel, rocky breakaway, steep rock slopes, skeletal soil.	**Unlikely**	Yes
Priority 4	*Eremophila magnifica* subsp. *magnifica* (Myoporaceae)	Hamersley Range, Tom Price, Marandoo, Wittenoom.	Skeletal soils over ironstone, rocky scree.	**Possible**	Yes

5.2.5 Priority Flora Taxa Recorded at the Marillana Survey Area

One Priority 3 flora species, *Goodenia nuda* was recorded at low densities (< 2% cover). Its locations are listed and mapped in Appendix A7.

Goodenia nuda is an erect, non woody herb growing to 50 cm high. The leaves and stems are a pale green to grey-green colour, sometimes with a frosted look from a powdery coating, and are between 4 - 10 cm in length and 0.5 - 1 cm in width. The inflorescence can be up to 25 cm long, and the yellow flowers, that are less than 2 cm long, are produced between April and August (Plate 5.1).

The preferred habitat of *Goodenia nuda* is in dry river beds and at the edge of floodplains on stony hard pans and cracking clays. Currently, 17 records exist on FloraBase for *Goodenia nuda* and these are from areas including Newman, Roy Hill and Weeli Wolli Creek (FloraBase, October 2009).

Goodenia nuda was recorded at quadrat A16 (phase 1) on a minor channel and at quadrat B6 (phase 2) on a clay pan.

Plate 5.1 – *Goodenia nuda.*

5.2.6 Introduced Species Recorded at the Marillana Survey Area

Priority weeds that are, or have the potential to become, pests to agriculture can be declared formally under the *Agriculture and Related Resources Protection Act 1976*. Weeds listed under the Act are listed with a coded definition of the requirements for control. Five priority groupings are used and more than one priority may be assigned to a weed species and different municipal districts can have different priority levels (see Appendix A5 for code definitions). Landholders having declared weeds on their property are obliged to control them at their own expense, and are encouraged to follow the standard control codes.

No priority or declared weed species were recorded during the Marillana survey.

Ninety-one species of naturalized alien flora are currently known to occur in the Pilbara region (FloraBase, October 2009). These weeds are not listed as declared plants; however, they can pose a threat to indigenous biota. For this reason populations should be carefully managed to contain them to their present occurrences and prevent further proliferation.

Ten general or environmental weeds were recorded at the Marillana survey area: **Aerva javanica, *Argemone ochroleuca* subsp*. ochroleuca, *Cenchrus ciliaris, *Cenchrus setiger, *Chloris virgata, *Datura leichhardtii, *Malvastrum americanum, *Portulaca oleracea, *Setaria verticillata* and **Vachellia farnesiana*.

**Argemone ochroleuca* subsp*. ochroleuca* and **Datura leichhardtii* are listed as declared weeds in other districts in Western Australia but not in the East Pilbara.

The frequency of occurrence and densities of populations are provided in Table 5.5 and brief descriptions and photographs of each are provided in Appendix A8.

Table 5.5 – Introduced Species Recorded at the Marillana Survey Area.

Weed species	Number of times recorded Phase 1	Number of plants or cover (%) Phase 1	Number of times recorded Phase 2	Number of plants or cover (%) Phase 2
**Aerva javanica*	5	< 10 plants - < 2%	1	< 10 plants
**Argemone ochroleuca subsp. ochroleuca*	Not recorded		1	< 10 plants
**Cenchrus ciliaris*	66	< 10 plants - > 70%	63	< 10 plants - > 70%
**Cenchrus setiger*	35	< 10 plants - > 70%	29	< 10 plants - 70%
**Chloris virgata*	1	2 – 10%	1	< 2%
**Datura leichhardtii*	2	< 10 plants	1	< 2%
**Malvastrum americanum*	10	< 10 plants - 70%	19	< 10 plants - 70%
**Portulaca oleracea*	15	< 10 plants - < 2%	3	< 10 plants - < 2%
**Setaria verticillata*	1	< 2%	1	< 10 plants
**Vachellia farnesiana*	15	< 10 plants - < 2%	12	< 10 plants – 30%

**Cenchrus ciliaris* and **Cenchrus setiger* are the dominant tussock grasses in the Marillana area and extensive populations cover a large proportion of the survey area.

6 CONSERVATION SIGNIFICANCE

The significance of the biota of the survey area has been assessed at four spatial scales; international / national, State, regional and local.

6.1 INTERNATIONAL / NATIONAL SIGNIFICANCE

Vegetation and Flora

National significance refers to those features of the environment which are recognised under legislation as being of importance to the Australian community. Flora species and TECs listed under the *EPBC Act* are regarded as nationally significant.

No flora species or TECs of national significance were recorded during this Marillana vegetation and flora survey.

6.2 STATE SIGNIFICANCE

State significance refers to those features of the environment that are recognised under State legislation as being of importance to the Western Australian community; in particular, species scheduled / listed under the *WC Act*.

Vegetation and Flora

No TEC or DRF of State significance were recorded at the Marillana survey area; however, dunes within the Marillana survey area form part of the State-listed Priority 3 PEC - vegetation of sand dunes of the Hamersley Range and Fortescue Valley.

The State-listed Priority 1 Weeli Wolli Spring PEC is located within 50 km of Brockman's Marillana (E47/1408) project area, but not within it.

The Fortescue Marsh is located approximately 15 km north-east and downstream of Brockman's Marillana (E47/1408) tenement, and the Marsh has recently been listed as a Priority 1 PEC.

6.3 REGIONAL SIGNIFICANCE

Regional significance addresses the representation of species and habitats at a biogeographic regional level. Species or habitat types that are endemic to the Pilbara bioregion and whose distributions are limited or unknown are considered regionally significant.

Vegetation

The conservation significance of the vegetation of the region has been assessed using three sources of information - land systems of the survey area, Beard's vegetation mapping of the survey area and the mapping of vegetation along proposed rail corridors in the vicinity of Brockman's Marillana tenement.

Land Systems Analysis

The survey area includes sections of the Boolgeeda, Divide, Fan, Fortescue, River and Turee land systems.

The **Boolgeeda land system** is a large (7,748 km^2) and widespread land system covering approximately 4.3% of the Pilbara. This land system comprises 20.5 km^2 of Brockman's tenement, which is 0.26% of its area in the Pilbara. The Boolgeeda land system is common along the lower stony slopes and plains at the base of the Hamersley Range. The following vegetation units were mapped on this land system at the Marillana survey area:

- *Acacia tumida* and *Grevillea wickhamii* tall shrubland (Unit 2); and
- *Corymbia hamersleyana* isolated low trees, over *Eucalyptus gamophylla* mallee woodland, over *Acacia* spp. and *Grevillea wickhamii* tall shrubland, over *Triodia basedowii* hummock grassland (with five sub-units) (Unit 8).

Based on the distribution of the Boolgeeda land system, and most of the sub-units of the vegetation units mapped on it, it is considered to have low regional conservation significance.

The **Divide land system** is medium sized (5,293 km^2) and covers 2.9% of the Pilbara. It is mapped as occurring mostly to the east of the Marillana survey area which is at the western-most limit of the land system. The Divide land system comprises 12.2 km^2 of the Marillana survey area, which is 0.23% of its area in the Pilbara. The sandy plains and sand dunes characteristic of this land system occur in the north-west of the tenement and the following vegetation units were mapped on the land system:

- *Acacia dictyophleba* tall shrubland, over *Triodia schinzii* open hummock grassland (Unit 6);
- *Acacia* spp. medium to high open shrubland, over *Triodia basedowii* and *Triodia schinzii* hummock grassland (Unit 7);
- *Acacia aneura* low open forest (Unit 4); and
- *Acacia aneura* low woodland, over *Acacia synchronicia* tall shrubland, over **Cenchrus* spp. tussock grassland (Unit 3).

The sand dunes associated with Units 6 and 7 (above) are considered to be regionally significant because they are regionally rare and make up only 1% of the area of this land system in the Pilbara as a whole.

The other vegetation units (3 and 4) of the Divide land system are common, are in a poor condition and are considered to have low regional conservation significance.

The **Fan land system** is a smaller land system (1,482 km^2) that covers 0.8% of the Pilbara. This land system comprises 10.46 km^2 of the Marillana survey area (0.7% of its area in the Pilbara). It occurs in the north-east of the tenement and the following vegetation unit was mapped on the wash and gilgai plains of that area;

- *Acacia aneura* low woodland, over *Acacia synchronicia* tall shrubland, over **Cenchrus* spp. tussock grassland (Unit 3).

Given the proportional area of the Fan land system in the survey area, the common vegetation unit mapped on it and the poor condition of the vegetation (Buffel grass is a dominant) it is considered to have low regional conservation significance.

The **Fortescue land system** is a small land system (504 km^2) that is mapped over only 0.3% of the Pilbara. This land system comprises 41.9 km^2 of the Marillana survey area, which equates to 8.3% of the land system's area in the Pilbara. The following vegetation units were mapped on the alluvial plains and floodplains of this land system:

- *Acacia aneura* low woodland, over *Acacia synchronicia* tall shrubland, over **Cenchrus* spp. tussock grassland (Unit 3);
- *Eucalyptus victrix* and *Acacia citrinoviridis* low woodland, with two sub-units (Unit 1); and
- *Acacia citrinoviridis*, *Corymbia hamersleyana*, *Acacia aneura* and *Acacia pruinocarpa* open woodland, over *Acacia* spp. tall shrubland, over **Cenchrus* spp. closed tussock grassland (with three sub-units) (Unit 5).

The Fortescue land system is mapped as four discrete units in the Pilbara and the survey area is located at the western end of the western-most unit. Because of its small size this land system has high regional significance. If the whole of the Marillana survey area was cleared, impact to the Fortescue land system would be high; however the mining operations will not impact the section of this land system mapped to the north of the existing rail line, and the actual impact will be much lower than that noted above.

The **River land system** is moderately sized (4,088 km^2) and is mapped over 2.3% of the Pilbara. This land system comprises 3.44 km^2 of the Marillana survey area, which is 0.08% of its area in the Pilbara. The flood plains and major creek lines of this land system occur in the south-east of the survey area (where the Weeli Wolli Creek enters the tenement) and the following vegetation units were mapped on it:

- *Eucalyptus victrix* and *Acacia citrinoviridis* low to high woodland (Unit 1); and
- *Acacia citrinoviridis*, *Corymbia hamersleyana*, *Acacia aneura* and *Acacia pruinocarpa* open woodland, over *Acacia* spp. tall shrubland, over **Cenchrus* spp. closed tussock grassland (with three sub-units) (Unit 5).

Given the small area of the River land system that occurs in the survey area, relative to its area in the Pilbara, it is considered to have low to medium regional conservation significance. However, the common vegetation units mapped on it and the dominance of Buffel grass in these areas, reduces its significance.

The **Turee land system** is another small land system (581 km^2) mapped over 0.3% of the Pilbara. Of this total area, 6.76 km^2 (1.16%) occurs on Brockman's Marillana tenement. The following vegetation units were mapped on its stony alluvial plains:

- *Acacia aneura* low woodland, over *Acacia synchronicia* tall shrubland, over **Cenchrus* spp. tussock grassland (Unit 3); and
- *Acacia aneura* low open forest (Unit 4).

Given the small area of the Turee land system on the tenement, the common vegetation units mapped on it, the dominance of Buffel grass in these areas, and its distance from the proposed mining activities, it is considered to have low regional conservation significance.

Note: the area of each land system noted above is sourced from Van Vreesyck *et al*. (2004).

Beard Mapping Analysis

The Marillana survey area lies in the Fortescue Valley subdivision of Beard's Fortescue Botanical District. Beard mapped three general vegetation units in the survey area - shrub steppe on sandplain, mulga in groved patterns and tree steppe on ranges. More specifically these units were mapped as:

- *Eucalyptus gamophylla* sparse shrubs, over *Triodia basedowii* (spinifex) hummock grassland (shrub steppe on sandplain);
- *Acacia aneura* (mulga) in groved patterns (mulga in groved patterns); and

- *Eucalyptus brevifolia* (Snappy Gum) sparse low trees, over *Triodia wiseana* open hummock grassland (tree steppe on ranges).

ecologia's mapping of the survey is similar to Beard's, however, *ecologia* has mapped additional vegetation units in the area. This is not surprising, as Beard mapped the whole of the Pilbara on a coarser scale than the finer scale mapping exercise carried out for this report.

The majority of the survey area occurs on Beard's "mulga in groved patterns" vegetation unit, and this area was mapped by *ecologia* as four vegetation units (1, 3, 4 and 5 - see above for descriptions of these vegetation units). Beard mapped this vegetation over a large area of the Pilbara and as a result it can be rated as having low regional conservation significance.

The small area running along the Hamersley Range falls within Beard's "tree steppe on ranges" unit and was mapped as two vegetation units during this survey (2 and 8). Beard mapped this vegetation over a large area of the Pilbara and based on this it can be rated as having low regional conservation significance.

The remainder of the survey area occurs on Beard's "shrub steppe on sandplain" and was mapped as six vegetation units during this survey (1, 3, 4, 5, 6 and 7). Beard maps this unit over a much smaller area of the Pilbara and it can be viewed as moderately conservation significance because of this – especially as the project area occurs close to the western edge of Beard's mapped unit.

Analysis based on results of other surveys carried out in the project area

FMG commissioned vegetation and flora surveys of its proposed Stage A and Stage B rail corridors in the Pilbara (Biota 2004b and c). The Stage A report includes mapping of some of the vegetation within the Marillana survey area, while the report produced for the Stage B Rail Corridor includes an assessment of the regional significance of the vegetation units mapped during these and other surveys.

ecologia and Biota's mapping does not agree exactly. This is to be expected given the differences in the number of quadrats established through the survey area, the location of those quadrats and differences in the methods used to analyse and interpret the data collected at the survey sites.

One of the vegetation units identified as having high conservation significance by Biota (Hd1 (shrublands on dunes); Biota, 2004b) occurs on the dunes in the north-west of the Marillana survey area and was mapped by *ecologia* as Unit 6. Biota rated the conservation significance of this vegetation unit as extremely high for a number of reasons i.e. it is regionally rare, small, fragile and highly susceptible to overt threatening processes (Biota, 2004b). Biota and Trudgen (2002) had previously surveyed the dunes occurring within the Hope Downs rail corridor, rated them as highly conservation significant, and suggested that they should be nominated as a TEC.

Buffel grass cover ranged from < 2% to between 30% and 70% at the sites surveyed within Unit 6 on the sand dunes. Buffel grass cover was 0% at only one (A67) of the sites surveyed in Unit 7 (the dune swale vegetation unit). While Buffel grass cover was relatively low on the dune crests (< 2%), its presence lessens the unit's regional significance.

Two of the vegetation units mapped by Biota on the colluvial fans along the escarpment were rated as having low to moderate conservation significance (Hh3 and Hh4) because they are probably restricted to the escarpment at the junction between the Hamersley Range and Fortescue Valley, with smaller occurrences within the Hamersley Range (Biota, 2004b). Biota notes that while these vegetation units are locally common they are probably regionally uncommon. Of these two vegetation types Biota's Hh3 is equivalent to *ecologia's* vegetation Unit 8a. This sub-unit could not be discriminated from the other vegetation sub-units (8b, 8c, 8d & 8e) on the aerial photographs, therefore they were mapped as one vegetation unit – Unit 8.

Flora

One Priority 3 flora species of regional significance was recorded in the survey area - *Goodenia nuda*.

Seventeen records are listed for *Goodenia nuda* on FloraBase (October, 2009). Its distribution is relatively widespread in the Pilbara (Figure 6.1), and it has been recorded from the Little Sandy Desert also. At the Marillana survey area *Goodenia nuda* was recorded at two locations – once on a minor channel and once on a clay pan. Current FloraBase records indicate that *Goodenia nuda's* habitat requirements are not this specific and that plants have also been found in other habitats including spinifex grasslands, hill midslopes and mulga scrub. Because of this, the individuals recorded in the survey area are regarded as having low regional conservation value. In addition to this, *Goodenia nuda* is often collected in surveys carried out by *ecologia* in the Pilbara and its true distribution is probably not reflected on the FloraBase map because voucher specimens are probably not being routinely submitted by botanists.

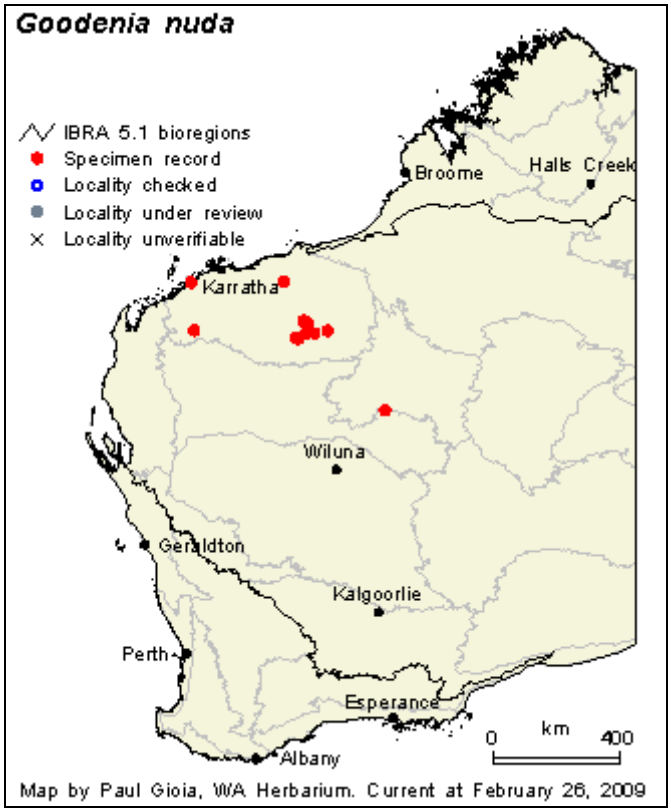

Figure 6.1 – Distribution range of *G. nuda* in Western Australia

Mapping by Paul Gioia. Image used with the permission of the Western Australian Herbarium, Department of Environment and Conservation (http://florabase.dec.wa.gov.au/help/copyright). Accessed on Tuesday, 24 February 2009.

6.4 LOCAL SIGNIFICANCE

Species are of local significance when their presence is confined to a specialised habitat type that is not common within the local area and whose disturbance or removal may lead to local extinction.

Vegetation

Based on the information presented in Section 6.3, and the vegetation mapped within Brockman's Marillana tenement, the vegetation units associated with the dunes in the north-west of the project area and the colluvial fans along the escarpment of the survey area are locally significant.

All other vegetation units and associated land systems are locally common and are considered to have low local conservation significance.

Flora

Goodenia nuda (Priority 3) was recorded twice during the survey, once on a minor channel and once on a clay pan. These habitats are not locally restricted, and if the *Goodenia nuda* located in the quadrats surveyed were to be impacted it is considered unlikely to lead to the local extinction of the species.

6.5 OVERALL CONSERVATION SIGNIFICANCE

Most of the vegetation associations, habitats and landforms found in the survey area are not considered to be of national or State significance, as they are well represented in the Pilbara biogeographic region. Therefore impact to most of the vegetation associations, habitats and landforms found in the Marillana survey area will not constitute a significant loss to biodiversity.

The vegetation of the Fortescue and River land systems is considered to be conservation significant generally. Impact to the Fortescue land system is expected to be low, as the mining operations will be located in the south-western third of the tenement. Direct impact to the River land system is also expected to be low for the same reason. Locally, the vegetation of the River land system within the tenement can be viewed as less significant as it is degraded. It has been grazed and **Cenchrus* spp. are the dominant tussock grasses in these grazed areas.

The vegetation associated with the dunes (Units 6 and 7) is considered to have very high regional and local conservation significance, and while the dunes in this area are not in excellent condition (Buffel grass occurs on them), they form part of a Priority 3 PEC and are of State significance.

Sub-unit 8a that occurs on the colluvial fans of the survey area (combined with four other sub-units and mapped as Unit 8) are considered to be conservation significant because they are probably regionally rare.

7 ENVIRONMENTAL IMPACTS

The main potential impacts from mining and clearing activities on the vegetation and flora of the survey area are:

- Impact to the vegetation of the Fortescue and River land systems;
- Impact to the vegetation of the dunes of the Divide land system to the north-west of the survey area;
- Impact to the colluvial fans running along the base of the escarpment;
- Impact to individuals of the Priority 3 species *Goodenia nuda;*
- Impact to general vegetation and flora through clearing; and,
- Indirect impact to vegetation and flora from infrastructure and ongoing practices e.g. degradation of areas due to alteration of surface water flow, alteration to groundwater levels, dust from tracks, further weed infestation and human activities.

Mining activities can result in the following direct and indirect effects on vegetation and flora.

Direct loss of vegetation and flora

The most substantial environmental impacts arising from the proposed works at the Marillana project area result from the clearing of native vegetation. The most significant impacts would be to the vegetation of the Fortescue and River land systems, to the vegetation of the dunes in the Divide land system, to the vegetation of the colluvial fan areas and to individuals of the Priority 3 species *Goodenia nuda*.

Clearing of vegetation in the regionally and locally significant Fortescue and River land systems could impact on these small and medium (respectively) land systems. Calculated impacts to each land system are included in the PER.

- While these land systems are conservation significant, the mining activities are planned for the lower south-western third of the tenement and therefore should not have a direct impact on large areas of these land systems.

The *Acacia dictyophleba* tall shrubland over *Triodia schinzii* open hummock grassland (Unit 6), is mapped on the dunes of the Divide land system in the north-west of the project area. It forms part of a Priority 3 PEC and has high regional and local conservation significance as it is a rare physiographic unit and is susceptible to threatening processes.

- These dunes should not be impacted by the proposed works, as they are located outside currently proposed infrastructure areas.

The vegetation of the colluvial fans at the base of the escarpment will be directly affected by mining activities.

- Potential impacts to the vegetation unit mapped in this area are included in the PER.

The Priority 3 flora species (*Goodenia nuda*) was located in the survey area and are conservation significant.

- The plants located during the survey are outside the mine and associated infrastructure areas and therefore plants should not be impacted by the proposed works.

Indirect loss of vegetation and flora

Flora habitats can be impacted indirectly by increased activity in an area leading to increased dust, fire and the introduction and / or spread of weeds. Erosion and soil compaction can result from off road driving and the use of saline water in construction and ongoing operations can affect vegetation, as can alterations to surface water flow and ground water levels.

Damage to vegetation from dust

Excessive dust can impact plants by clogging their stomata. This can affect respiration and transpiration and can lead to localised deaths. This occurs particularly at track edges. Correct dust suppression techniques can minimise this impact.

Accidental fires

Fires are a frequent occurrence in Australia's arid zone. Spot fires are known to occur during the summer months, predominantly from lightning strikes.

While native flora is adapted to, and in many instances dependant on, fire for seed germination too frequent or too hot bushfires can result in detrimental changes to the composition and diversity of the vegetation, causing local extinctions of vulnerable species.

The risk of fire as a result of mining activities can be minimised by implementing appropriate fire control measures.

Introduction and spread of weed species

Implementation of the project has the potential to introduce new weed species or spread weed species already in the area. This could result from increased vehicle movements, increased ground disturbance, disposal of water from drilling and dust suppression operations. Ten general environmental weeds with potential to spread were recorded during survey, and these were: **Aerva javanica, *Argemone ochroleuca* subsp*. ochroleuca, *Cenchrus ciliaris, *Cenchrus setiger, *Chloris virgata, *Datura leichhardtii, *Malvastrum americanum, *Portulaca oleracea, *Setaria verticillata* and **Vachellia farnesiana*. Strict weed hygiene procedures will need to be implemented duing the construction and life of the mine.

Erosion and compaction from off-road driving

Water can flow preferentially in areas where vehicles have driven and this can cause erosion. Soil compaction results from off-road driving and plants often cannot re-establish easily in these areas. The risk of damage to the vegetation can be avoided by prohibiting off-road driving.

Use of saline water in dust suppression

The use of saline water in dust suppression along haul roads is common practice at mine sites across Western Australia. Salts in the water help to bind the soil and further reduce the dust particles released into the environment from vehicle movement.

As many plant species are damaged by saline water, its release into the environment must be tightly managed to ensure damage to vegetation does not occur. Regular testing of the groundwater to be used for dust suppression will reduce the potential for damage to vegetation from saline water.

Altered surface water flow and quality

Surface water flow is important for vegetation generally and mulga in particular. Drainage and water flow will need to be managed to maintain surface water flow to minimise the effects on mulga in and beyond the project area. Many small creeks flow down the escarpment and feed into the Weeli Wolli Creek that flows from the south-east to the north-west of the tenement. Water flow in the Creek will need to be managed appropriately,

especially as it feeds into the Fortescue Marsh which is approximately 15 km away from the project area.

Surface water quality will also have to be managed appropriately, as increased sediment load could be transported into the Weeli Wolli Creek and potentially affect the vegetation growing along the creek and further downstream.

Altered groundwater levels

Vegetation dependent on groundwater for all or part of the year can be adversely affected by lowered groundwater levels. The effects depend on the timing and modification of water abstraction, and the magnitude and rate of drawdown. Pumping of water for the proposed works will need to be managed appropriately so that the phreatophytic vegetation on the banks of the Weeli Wolli creek is not irreversibly affected by changes in groundwater levels.

Current groundwater modelling indicates that five years from the start of the project drawdown will result in groundwater levels being 5 m to 10 m lower than pre-mining levels. By 20 years from the start of the project groundwater levels are predicted to be approximately 20 m lower than pre-mining levels. While these figures are based on the worst-case scenario, changes to groundwater levels will nevertheless need to be managed. For example, the risk to GDEs may be lowered considerably by avoiding periods of peak environmental demand and allowing adaptation of dependent biota to a lower water table. For example, if the annual decline in groundwater level was restricted to the maximum rate of downward growth of the roots of those plants dependent on groundwater, they would still be able to access the water in the capillary fringe above the water table as the water table drops.

The River land system covers 2.3% of the Pilbara, and only 0.08% of its area occurs within Brockman's Marillana tenement. Therefore the regional impact to the vegetation of this land system would be low if the vegetation was affected by changes in groundwater levels. Nevertheless, water pumping should be managed appropriately to try to maintain the health of the vegetation during the life of the mine, as the death of vegetation along the creek channels of the project area could have knock on effects such as reduced soil stability in those areas and increased sedimentation in the Weeli Wolli Creek.

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8 STUDY TEAM

The Marillana vegetation and flora survey described in this document was planned, coordinated and executed by:

ecologia Environment

1025 Wellington Street

WEST PERTH

WA 6005

Project Staff		
Christina Cox	PhD	Manager Botany
Melissa Hay	BSc. (Honours)	Project Manager, Botanist
Carmel Winton	BSc.	Botanist
Zoe Benham	BSc. (Honours)	Botanist
Marisa Fulton	BSc	Botanist
Sharnya Thompson	BSc. (Honours)	Taxonomist

Licences - "Licence to take flora for scientific purposes"		
The Marillana flora and vegetation survey was conducted under the authorisation of the following licences issued by the Department of Environment and Conservation:		
Botanist	**Permit Number**	**Valid Until**
Melissa Hay	SL008100	30th April, 2009
Carmel Winton	SL008099	30th April, 2009

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A1. Results of the DEC Database Searches for Rare and Priority Flora

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Priority	Species	Location
Rare	*Lepidium catapycnon*	Wittenoom Gorge, Hamersley Range, Weeli Wolli, Newman
	Thryptomene wittweri	Hamersley Range, Mt Augustus, Carnarvon Range, White Cliffs Stn, NT
1	*Barbula ehrenbergii*	Dale's Gorge, Hamersley Range
	Calotis squamigera	Wittenoom, Hamersley Range
	Eragrostis sp. Mt Robinson (S.van Leeuwen 4109)	Hamersley Range
	Eremophila spongiocarpa	Mt Marsh, Chichester Range, Marillana Station, Mulga Downs Station
	Genus sp. Hamersley Range hilltops (S van Leeuwen 4345)	Hamersley Range
	Myriocephalus nudus	Hamersley Range, Paynes Find, Yannarie River, Juna Downs, Swan River (Drummond)
	Rhagodia sp. Hamersley (M. Trudgen 17794)	Hamersley Range
	Sida sp. Pilbara (S. van Leeuwen 4377)	Hamersley Range, Lawloit Range
	Tetratheca fordiana	West Angelas, Hamersley Range
2	*Acacia daweana*	Hamersley Range, Karijini N.P.
	Eremophila forrestii subsp. *Pingandy* (M.E. Trudgen 2662)	Karijini NP, Hamersley Range NP, Turee Creek Stn
	Olearia fluvialis	Hamersley Range, Karijini N.P., West Angelas, Newman
	Pilbara trudgenii	Hamersley Range
	Scaevola sp. Hamersley Range basalts (S. van Leeuwen 3675)	Hamersley Range
	Spartothamnella puberula	Mt Bruce, Hamersley Range, West Angelas, NT
3	*Acacia bromilowiana*	Tom Price, Balfour Downs Stn, West Angelas, Hope Downs, Hamersley Range, Marillana Stn, Ophthalmia Range
	Acacia subtiliformis	Hamersley Range, Hancock Range, Ophthalmia Range, Hope Down North, Marillana Stn
	Calotis latiuscula	Giles, Warburton, Blackstone Range, Rawlinson Range, Hamersley Range
	Cynanchum sp. Hamersley (M Trudgen 2302)	Hamersley Range, Marandoo, Turner Syncline, West Angelas
	Dampiera anonyma	Mt Bruce, Mt Nameless, Hamersley Range, Mt Sheila, Karijini NP
	Dampiera metallorum	Hamersley Range, Mt Meharry, West Angelas, Karijini NP
	Eremophila magnifica subsp. *velutina*	Hamersley Range, Newman, Marandoo
	Fimbristylis sieberiana	Hamersley Range, Millstream, Fitzroy Crossing, King Leopold Range, Halls Creek, Little Sandy Desert
	Geijera salicifolia	Mt Samson, Mt Howieson, Tom Price, Hamersley Range, Qld, NT
	Hibiscus brachysiphonius	Balgo Mission, Christmas Creek,Wandagee, Karratha, Tom Price, Millstream, Warrawagine, Hamersley Range
	Indigofera gilesii subsp. *gilesii*	Hamersley Range, Meekatharra, West Angelas
	Polymeria sp. Hamersley (ME Trudgen 11353)	Hamersley Stn, Wittenoom, Marandoo,Hamersley Range
	Rhynchosia bungarensis	Hamersley Range, Chichester Ranges, Yardie Creek, Robe River, Tom Price, Ashburton, East Lewis Island, Burrup, Dampier Archipelago
	Rostellularia adscendens subsp.*adscendens* var.*latifolia*	Hamersley Range

Priority	*Species*	Location
3	*Sida* sp. Barlee Range (S van Leeuwen 1642)	Barlee Range, Turee Creek, Paraburdoo, Hamersley Range
	Tephrosia sp. Cathedral Gorge (FH Mollemans 2420)	Newman, Hamersley Range, Fortescue Valley
	Triodia sp. Mt. Ella (ME Trudgen 12739)	Hamersley Range, Mt Ella
	Triumfetta leptacantha	Hamersley Range, Marandoo
4	*Eremophila magnifica* subsp. *magnifica*	Hamersley Range, Tom Price, Marandoo, Wittenoom

Note: these results have been compiled from all database search results.

A2. Quadrat Locations and Vegetation Condition

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Phase	Name	Zone	Easting (mE)	Northing (mN)	Vegetation Condition
Phase 1	A01	50K	729103	7505239	Good
	A05	50K	734476	7497191	Poor
	A06	50K	737392	7493100	Poor
	A07	50K	736467	7495866	Poor
	A08	50K	733679	7495141	Excellent
	A09	50K	726866	7500762	Good
	A11	50K	728027	7499782	Good
	A12	50K	727371	7502554	Good
	A13	50K	726793	7503724	Good
	A14	50K	728019	7502796	Good
	A15	50K	727243	7504575	Poor
	A17	50K	727296	7505798	Good
	A19	50K	728482	7506031	Poor
	A20	50K	729978	7503418	Good
	A22	50K	728662	7501007	Good
	A24	50K	731273	7501331	Poor
	A25	50K	730924	7499980	Good
	A26	50K	729505	7498978	Poor
	A27	50K	730709	7498860	Excellent
	A28	50K	730799	7498102	Poor
	A29	50K	733534	7496787	Good
	A30	50K	731957	7497731	Good
	A31	50K	734360	7496195	Good
	A32	50K	732365	7496584	Good
	A33	50K	733629	7499695	Poor
	A34	50K	732055	7504106	Poor
	A35	50K	732154	7503431	Poor
	A36	50K	732809	7502352	Good
	A38	50K	735509	7501121	Good
	A39	50K	733933	7501040	Poor
	A40	50K	736101	7502151	Poor
	A42	50K	736954	7500731	Poor
	A43	50K	737524	7499296	Poor
	A45	50K	737663	7498365	Poor
	A46	50K	735525	7500355	Good
	A47	50K	735382	7499112	Good
	A48	50K	735721	7498007	Poor
	A50	50K	738027	7502211	Poor
	A51	50K	737986	7499203	Poor
	A52	50K	736517	7493377	Good
	A53	50K	732979	7497129	Good
	A54	50K	733079	7498193	Poor
	A55	50K	731815	7499681	Good
	A56	50K	730932	7504055	Poor
	A57	50K	731339	7503007	Poor
	A58	50K	734504	7501947	Poor
	A59	50K	733233	7501852	Good
	A60	50K	735673	7496904	Poor
	A61	50K	734251	7502478	Poor
	A62	50K	735861	7502541	Poor
	A63	50K	732751	7503031	Poor
	A64	50K	732900	7504177	Good

Phase	Name	Zone	Easting (mE)	Northing (mN)	Vegetation Condition
Phase 1	A65	50K	727115	7505519	Poor
	A66	50K	727800	7504520	Good
	A67	50K	727800	7504765	Excellent
	A68	50K	728714	7504301	Good
	A69	50K	728788	7502219	Excellent
	A71	50K	726429	7505985	Good
	A72	50K	727476	7501125	Good
	A74	50K	738080	7500914	Good
	A75	50K	736797	7501443	Good
	A77	50K	735081	7494023	Good
	A80	50K	731303	7497518	Excellent
	A81	50K	729168	7499069	Good
	A82	50K	730014	7500634	Good
Phase 2	B01	50K	732964	7501099	Poor
	B02	50K	735088	7499895	Poor
	B03	50K	736818	7498525	Good
	B04	50K	737938	7500388	Poor
	B05	50K	727283	7505373	Good
	B06	50K	736675	7500300	Poor
	B07	50K	733929	7502307	Poor
	B08	50K	727845	7504512	Poor
	B09	50K	730515	7503067	Poor
	B10	50K	728643	7503839	Excellent
	B11	50K	726586	7504841	Poor
	B12	50K	728257	7505664	Good
	B13	50K	727969	7506100	Excellent
	B14	50K	737663	7494254	Good
	B15	50K	737270	7495145	Poor
	B16	50K	728124	7499745	Poor
	B17	50K	729201	7500954	Poor
	B18	50K	726645	7502802	Good
	B19	50K	727842	7504573	Good
	B20	50K	732120	7496923	Excellent
	B21	50K	729405	7503923	Excellent
	B22	50K	728836	7503277	Good
	B23	50K	728065	7503607	Poor
	B24	50K	730798	7500650	Poor
	B25	50K	732230	7500574	Poor
	B26	50K	736436	7495448	Poor
	B27	50K	734723	7501124	Poor
	B28	50K	736948	7502119	Poor
	B29	50K	736022	7500939	Poor
	B30	50K	733927	7500428	Good
	B31	50K	737599	7496274	Poor
	B32	50K	737897	7496570	Good
	B33	50K	737039	7496940	Poor
	B34	50K	734638	7498014	Poor
	B35	50K	734172	7499082	Poor
	B36	50K	735456	7496041	Poor
	B37	50K	735965	7493452	Poor
	B38	50K	736183	7494253	Poor
	B39	50K	735331	7494950	Poor
	B40	50K	734806	7495048	Excellent

Phase	Name	Zone	Easting (mE)	Northing (mN)	Vegetation Condition
Phase 2	B41	50K	735133	7494482	Good
	B42	50K	733754	7495797	Poor
	B43	50K	732991	7496640	Poor
	B44	50K	730868	7498927	Excellent
	B45	50K	732224	7498565	Good
	B46	50K	730901	7497729	Excellent
	B47	50K	731626	7498002	Excellent
	B48	50K	730022	7498562	Good
	B49	50K	730129	7498107	Good
	B50	50K	728896	7499695	Good
	B51	50K	727874	7500189	Poor
	B52	50K	728369	7500588	Excellent
	B53	50K	728000	7501299	Good
	B54	50K	727361	7501731	Good
	B55	50K	726814	7502060	Good
Both Phases (repeated sites)	R02	50K	730229	7503733	Poor
	R03	50K	731994	7501900	Poor
	R04	50K	732537	7499035	Good
	R10	50K	727325	7500416	Excellent
	R16	50K	729520	7502769	Poor
	R18	50K	728288	7505261	Poor
	R21	50K	730919	7502630	Poor
	R23	50K	729545	7501506	Excellent
	R37	50K	735010	7502135	Poor
	R41	50K	737484	7501609	Poor
	R44	50K	736198	7499181	Good
	R49	50K	736254	7494928	Poor
	R70	50K	727969	7502067	Good
	R73	50K	729307	7500306	Excellent
	R76	50K	737567	7492245	Poor
	R78	50K	733148	7495985	Good
	R79	50K	731928	7497342	Excellent

Datum GDA94 / WGS84

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A3. Site Information (To be Included Electronically)

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A4. Vegetation Structural Table used in Vegetation Descriptions

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Height classes used for vegetation classification (Department of Environment and Heritage, 2003).

Height Class	Height Range (m)	Tree	Shrub	Mallee	Grass
8	>30	tall	NA	NA	NA
7	10-30	mid	NA	tall	NA
6	<10	low	NA	mid	NA
5	<3	NA	NA	low	NA
4	>2	NA	tall	NA	tall
3	1-2	NA	mid	NA	tall
2	0.5-1	NA	low	NA	mid
1	<0.5	NA	low	NA	low

Structural Formation Classes (Department of Environment and Heritage, 2003).

Growth Form	Height (m)	Structural Formation Classes					
Foliage cover % (cover #)		70-100% (5)	30-70% (4)	10-30% (3)	<10% (2)	0-5% (1)	≈0% (N)
Tree	<10,10-30, >30	closed forest	open forest	woodland	isolated clumps of trees	isolated trees	isolated clumps of trees
Tree mallee	<3, <10, 10-30	closed mallee forest	open mallee forest	mallee woodland	isolated clumps of mallee trees	isolated mallee trees	isolated clumps of mallee trees
Shrub	<1,1-2,>2	closed shrubland	shrubland	open shrubland	isolated clumps of shrubs	isolated shrubs	isolated clumps of shrubs
Mallee shrub	<3, <10, 10-30	closed mallee shrubland	mallee shrubland	open mallee shrubland	isolated clumps of mallee shrubs	isolated mallee shrubs	isolated clumps of mallee shrubs
Heath shrub	<1,1-2,>2	closed heathland	heathland	open heathland	isolated clumps of heath shrubs	isolated heath shrubs	isolated clumps of heath shrubs
Chenopod shrub	<1,1-2,>2	closed chenopod shrubland	chenopod shrubland	open chenopod shrubland	isolated clumps of chenopod shrubs	isolated chenopod shrubs	isolated clumps of chenopod shrubs
Samphire shrub	<0.5,>0.5	closed samphire shrubland	samphire shrubland	open samphire shrubland	isolated clumps of samphire shrubs	isolated samphire shrubs	isolated clumps of samphire shrubs
Hummock grass	<2,>2	closed hummock grassland	hummock grassland	open hummock grassland	isolated clumps of hummock grasses	isolated hummock grasses	isolated clumps of hummock grasses
Tussock grass	<0.5,>0.5	closed tussock grassland	tussock grassland	open tussock grassland	isolated clumps of tussock grasses	isolated tussock grasses	isolated clumps of tussock grasses
Sedge	<0.5,>0.5	closed sedgeland	sedgeland	open sedgeland	isolated clumps of sedges	isolated sedges	isolated clumps of sedges
Rush	<0.5,>0.5	closed rushland	rushland	open rushland	isolated clumps of rushes	isolated rushes	isolated clumps of rushes

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A5. Explanation of Conservation and Declared Plants Codes

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Explanation of Codes for Threatened Ecological Communities (TEC) - DEC

Code	Definition
PD: Presumed Totally Destroyed	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant
CR: Critically Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as *Critically Endangered* when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
EN: Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as *Endangered* when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future.
VU: Vulnerable	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as *Vulnerable* when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

Explanation of codes for Priority Ecological Communities (PEC) - DEC

Code	Definition
P1: Priority One	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2: Priority Two	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3: Priority Three	(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) Communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
P4: Priority Four	Ecological communities that are adequately known, *Rare* but not threatened or meet criteria for *Near Threatened*, or that have been recently removed from the threatened list. These communities require regular monitoring. (a) *Rare*. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of

Code	Definition
	special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (b) *Near Threatened*. Ecological communities that are considered to have been adequately surveyed and that do not qualify for *Conservation Dependent*, but that are close to qualifying for *Vulnerable*. (c) Ecological communities that have been removed from the list of threatened communities during the past five years.
P5: Priority Five	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Definition of Threatened Flora Species Categories under the EPBC Act

Conservation Category	Description
Extinct	A species is extinct if there is no reasonable doubt that the last member of the species has died.
Extinct in the wild	A species is categorized as extinct in the wild if it is only known to survive in cultivation, in captivity or as a naturalized population well outside its past range; or if it has not been recorded in its known/expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered	The species is facing an extremely high risk of extinction in the wild in the immediate future.
Endangered	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Conservation Dependent	The species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Definition of Declared Rare and Priority Flora Categories (Atkins, 2008(2))

Code	Definition
Declared Rare Flora (DRF)	Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such
P1: Priority One	Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2: Priority Two	Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P3: Priority Three	Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.
P4: Priority Four	Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Control Codes for Declared Weeds in Western Australia

Priority	Requirements
P1 Prohibits movement	The movement of plants or their seeds is prohibited within the State. This prohibits the movement of contaminated machinery and produce including livestock and fodder.
P2 Aim is to eradicate infestation	Treat all plants to destroy and prevent propagation each year until no plants remain. The infested area must be managed in such a way that prevents the spread of seed or plant parts on or in livestock, fodder, grain, vehicles and/or machinery.
P3 Aims to control infestation by reducing area and/or density of infestation	The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery. Treat to destroy and prevent seed set for all plants:- Within 100 metres inside of the boundaries of the infestation. Within 50 metres of roads and high-water mark on waterways. Within 50 metres of sheds, stock yards and houses. Treatment must be done prior to seed set each year. Of the remaining infested area:- Where plant density is 1-10 per hectare treat 100% of infestation. Where plant density is 11-100 per hectare treat 50% of infestation. Where plant density is 101-1000 per hectare treat 10% of infestation. Properties with less than 2 hectares of infestation must treat the entire infestation. Additional areas may be ordered to be treated.
P4 Aims to prevent infestation spreading beyond existing boundaries of infestation	The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery. Treat to destroy and prevent seed set all plants:- Within 100 metres inside of the boundaries of the infested property Within 50 metres of roads and high-water mark on waterways Within 50 metres of sheds, stock yards and houses Treatment must be done prior to seed set each year. Properties with less than 2 hectares of infestation must treat the entire infestation. Additional areas may be ordered to be treated. Special considerations In the case of P4 infestations where they continue across property boundaries there is no requirement to treat the relevant part of the property boundaries as long as the boundaries of the infestation as a whole are treated. There must be agreement between neighbours in relation to the treatment of these areas.
P5	Infestations on public lands must be controlled.

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A6 Flora Taxa Recorded During the Marillana Survey

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Family	Species	Phase 1	Phase 2
Acanthaceae	*Dicladanthera forrestii*		•
Adiantaceae	*Cheilanthes sieberi* subsp. *sieberi*	•	
Aizoaceae	*Trianthema pilosa*	•	•
	Trianthema triquetra	•	
Amaranthaceae	****Aerva javanica***	•	•
	Alternanthera nana		•
	Alternanthera nodiflora		•
	Amaranthus mitchellii	•	
	Gomphrena canescens	•	
	Gomphrena canescens subsp. *canescens*	•	
	Gomphrena cunninghamii	•	•
	Ptilotus aervoides	•	•
	Ptilotus astrolasius		•
	Ptilotus astrolasius var. *astrolasius*	•	•
	Ptilotus calostachyus	•	•
	Ptilotus carinatus		•
	Ptilotus exaltatus	•	•
	Ptilotus exaltatus var. *exaltatus*	•	•
	Ptilotus gomphrenoides	•	•
	Ptilotus helipteroides		•
	Ptilotus latifolius		•
	Ptilotus macrocephalus		•
	Ptilotus obovatus var. *obovatus*	•	•
	Ptilotus polystachyus		•
	Ptilotus polystachyus var. *arthrotrichus*	•	
	Ptilotus polystachyus var. *polystachyus*	•	•
Apiaceae	*Trachymene oleracea* subsp. *oleracea*	•	•
Asclepiadaceae	*Rhyncharrhena linearis*		•
Asteraceae	*Pentalepis ?trichodesmoides*	•	
	Blumea tenella	•	
	Calocephalus sp. Pilbara-Desert (M.E. Trudgen 11454)		•
	Calotis porphyroglossa		•
	Centipeda minima subsp. *macrocephala*	•	•
	Pluchea dunlopii		•
	Pterocaulon ?serrulatum	•	
	Pterocaulon sphaeranthoides	•	•
	Streptoglossa bubakii	•	•
	Streptoglossa decurrens	•	•
	Streptoglossa macrocephala	•	•
	Streptoglossa sp.	•	
Boraginaceae	*Ehretia saligna* var. *saligna*	•	
	Heliotropium cunninghamii		•
	Heliotropium ovalifolium	•	•
Boraginaceae	*Heliotropium pachyphyllum*		•
	Heliotropium tenuifolium	•	•

Family	Species	Phase 1	Phase 2
Boraginaceae	*Trichodesma zeylanicum*	•	•
	Trichodesma zeylanicum var. *zeylanicum*	•	•
Brassicaceae	*Lepidium phlebopetalum*		•
Caesalpiniaceae	*Petalostylis cassioides*	•	•
	Petalostylis labicheoides	•	
	Senna artemisioides subsp. *helmsii*	•	•
	Senna artemisioides subsp. *oligophylla*	•	•
	Senna artemisioides subsp. *oligophylla* x ?	•	•
	Senna artemisioides subsp. *oligophylla* x *helmsii*	•	•
	Senna ferraria		•
	Senna glutinosa	•	
	Senna glutinosa subsp. *glutinosa*	•	•
	Senna glutinosa subsp. *pruinosa*		•
	Senna glutinosa subsp. x *luerssenii*	•	•
	Senna notabilis	•	•
Capparaceae	*Capparis lasiantha*		•
	Capparis spinosa	•	•
	Cleome viscosa	•	•
Caryophyllaceae	*Polycarpaea longiflora*	•	•
Chenopodiaceae	*Atriplex* sp.		•
	Chenopodium melanocarpum	•	
	Dysphania rhadinostachya	•	•
	Dysphania rhadinostachya subsp. *inflata*		•
	Dysphania rhadinostachya subsp. *rhadinostachya*		•
	Enchylaena tomentosa var. *tomentosa*	•	•
	Maireana planifolia	•	•
	Maireana villosa	•	•
	Rhagodia eremaea	•	•
	Salsola australis	•	•
	Salsola tragus subsp. *grandiflora*		•
	Sclerolaena cornishiana	•	•
	Sclerolaena costata	•	•
Chloanthaceae	*Dicrastylis cordifolia*	•	•
Convolvulaceae	*Bonamia media* var. *villosa*		•
	Bonamia rosea	•	•
	Convolvulus angustissimus subsp. *angustissimus*		•
	Convolvulus remotus	•	
	Duperreya commixta	•	•
	Evolvulus alsinoides		•
	Evolvulus alsinoides var. *villosicalyx*	•	•
	Ipomoea muelleri	•	•
	Polymeria ambigua		•
Cucurbitaceae	*Cucumis maderaspatanus*	•	•
Cyperaceae	*Cyperus cunninghamii* subsp. *cunninghamii*	•	
Cyperaceae	*Cyperus vaginatus*	•	•
	Fimbristylis simulans		•

Family	Species	Phase 1	Phase 2
Euphorbiaceae	*Euphorbia ?drummondii*	•	
	Euphorbia australis	•	•
	Euphorbia biconvexa		•
	Euphorbia boophthona		•
	Euphorbia coghlanii	•	•
	Euphorbia schultzii	•	•
	Euphorbia tannensis subsp. *eremophila*	•	•
	Leptopus decaisnei		•
	Phyllanthus erwinii	•	•
	Phyllanthus maderaspatensis	•	•
Goodeniaceae	*Goodenia lamprosperma*		•
	Goodenia microptera	•	•
	Goodenia muelleriana	•	
	***Goodenia nuda* (P3)**	•	•
	Goodenia sp.		•
	Goodenia stobbsiana	•	•
	Scaevola parvifolia		•
	Scaevola parvifolia subsp. *parvifolia*	•	•
	Scaevola parvifolia subsp. *pilbarae*	•	•
	Scaevola spinescens	•	•
	Velleia connata		•
Haloragaceae	*Haloragis gossei* var. *gossei*	•	•
Loranthaceae	*Amyema fitzgeraldii*	•	•
	Amyema hilliana	•	•
Malvaceae	*Abutilon* aff. *dioicum*		•
	Abutilon cunninghamii	•	
	Abutilon dioicum	•	
	Abutilon fraseri	•	•
	Abutilon lepidum	•	•
	Abutilon leucopetalum	•	
	Abutilon otocarpum	•	•
	Gossypium australe	•	•
	Gossypium robinsonii	•	•
	Hibiscus brachychlaenus	•	•
	Hibiscus coatesii		•
	Hibiscus leptocladus		•
	Hibiscus sturtii var. *campylochlamys*	•	•
	Hibiscus sturtii var. *platychlamys*	•	•
	****Malvastrum americanum***	•	•
	Sida arenicola	•	•
	Sida cardiophylla	•	•
	Sida echinocarpa	•	•
	Sida fibulifera	•	•
	Sida kingii		•
	Sida pilbarensis		•
	Sida platycalyx	•	

Family	Species	Phase 1	Phase 2
Malvaceae	*Sida* sp.	•	
	Sida sp. articulation below (A.A. Mitchell PRP 1605)	•	•
	Sida sp. spiciform panicles (E. Leyland s.n. 14/8/90)	•	
Mimosaceae	*Acacia ?victoriae*		•
	Acacia adsurgens	•	•
	Acacia aff. *aneura* (narrow fine veined; site 1259)		•
	Acacia ancistrocarpa	•	•
	Acacia aneura	•	
	Acacia aneura var. *?macrocarpa*	•	•
	Acacia aneura var. *aneura*	•	•
	Acacia aneura var. *intermedia*		•
	Acacia aneura var. *microcarpa*	•	•
	Acacia bivenosa	•	•
	Acacia citrinoviridis	•	•
	Acacia coriacea	•	
	Acacia coriacea subsp. *pendens*	•	•
	Acacia dictyophleba	•	•
	Acacia elachantha	•	•
	Acacia hilliana	•	•
	Acacia inaequilatera	•	•
	Acacia ligulata		•
	Acacia maitlandii	•	
	Acacia monticola	•	
	Acacia pachyacra	•	•
	Acacia pachycarpa		•
	Acacia pruinocarpa	•	•
	Acacia pyrifolia		•
	Acacia pyrifolia var. *morrisonii*	•	•
	Acacia pyrifolia var. *pyrifolia*	•	
	Acacia sclerosperma	•	•
	Acacia sclerosperma subsp. *sclerosperma*	•	•
	Acacia sericophylla	•	•
	Acacia spondylophylla	•	•
	Acacia synchronicia	•	•
	Acacia tenuissima	•	•
	Acacia tetragonophylla	•	•
	Acacia trudgeniana	•	•
	Acacia tumida	•	
	Acacia tumida var. *?tumida*	•	
	Acacia tumida var. *pilbarensis*	•	•
	****Vachellia farnesiana***	•	•
Molluginaceae	*Glinus lotoides*	•	
Molluginaceae	*Mollugo molluginea*	•	•
Myoporaceae	*Eremophila forrestii*	•	
	Eremophila forrestii subsp. *forrestii*	•	•
	Eremophila lanceolata	•	•

Family	Species	Phase 1	Phase 2
Myoporaceae	*Eremophila latrobei* subsp. *filiformis*		•
	Eremophila longifolia	•	•
Myrtaceae	*Corymbia aspera*		•
	Corymbia hamersleyana	•	•
	Eucalyptus camaldulensis var. *obtusa*		•
	Eucalyptus gamophylla	•	•
	Eucalyptus victrix	•	•
	Eucalyptus xerothermica	•	
Nyctaginaceae	*Boerhavia coccinea*	•	•
	Boerhavia gardneri	•	
	Boerhavia repleta	•	•
	Boerhavia sp.	•	•
Papaveraceae	***Argemone ochroleuca* subsp. *ochroleuca***		•
Papilionaceae	*Crotalaria cunninghamii*	•	•
	Crotalaria medicaginea var. *neglecta*	•	
	Cullen lachnostachys	•	•
	Cullen leucanthum	•	•
	Cullen leucochaites	•	•
	Indigofera colutea	•	•
	Indigofera linifolia	•	
	Indigofera linnaei	•	•
	Indigofera monophylla	•	•
	Rhynchosia minima	•	•
	Sesbania cannabina	•	•
	Swainsona formosa	•	•
	Tephrosia arenicola		•
	Tephrosia rosea var. *glabrior*	•	•
	Tephrosia rosea var. *rosea*		•
	Tephrosia sp. Bungaroo Creek (M.E. Trudgen 11601)	•	•
	Tephrosia supina	•	
	Tephrosia ?virens	•	
Poaceae	*Aristida contorta*	•	•
	Aristida holathera	•	
	Aristida holathera var. *holathera*	•	•
	Aristida inaequiglumis	•	•
	Aristida latifolia	•	•
	Aristida sp.		•
	Cenchrus ciliaris	•	•
	Cenchrus setiger	•	•
	Chloris pectinata		•
Poaceae	***Chloris virgata***	•	•
	Chrysopogon fallax	•	•
	Cymbopogon ambiguus		•
	Cymbopogon obtectus	•	
	Cymbopogon procerus		•
	Cymbopogon sp.		•

Family	Species	Phase 1	Phase 2
Poaceae	*Dactyloctenium radulans*	•	
	Dichanthium sericeum subsp. *humilius*	•	•
	Enneapogon caerulescens	•	•
	Enneapogon lindleyanus	•	•
	Enneapogon polyphyllus	•	•
	Enneapogon robustissimus	•	•
	Enteropogon ramosus	•	•
	Eragrostis eriopoda	•	•
	Eragrostis leptocarpa	•	•
	Eragrostis setifolia	•	
	Eragrostis tenellula	•	
	Eragrostis xerophila	•	•
	Eriachne ?mucronata	•	
	Eriachne aristidea	•	•
	Eriachne gardneri		•
	Eriachne pulchella	•	
	Eriachne pulchella subsp. *dominii*	•	•
	Eriachne pulchella subsp. *pulchella*		•
	Eulalia aurea	•	•
	Iseilema eremaeum	•	•
	Paraneurachne muelleri	•	•
	Paspalidium basicladum		•
	Perotis rara	•	
	***Setaria verticillata**	•	•
	Sporobolus australasicus	•	•
	Themeda sp. Mt Barricade (M.E. Trudgen 2471)	•	•
	Themeda triandra	•	•
	Triodia basedowii	•	•
	Triodia epactia	•	•
	Triodia lanigera		•
	Triodia pungens		•
	Triodia schinzii	•	•
	Triodia wiseana	•	
	Triraphis mollis	•	•
	Yakirra australiensis	•	
Portulacaceae	*Calandrinia* sp.	•	
	***Portulaca oleracea**	•	•
Proteaceae	*Grevillea wickhamii*		•
	Grevillea wickhamii subsp. *hispidula*	•	•
Proteaceae	*Hakea chordophylla*	•	•
	Hakea lorea subsp. *lorea*	•	•
Rubiaceae	*Austrobryonia pilbarensis*	•	
	Psydrax latifolia	•	•
Santalaceae	*Santalum lanceolatum*	•	•
Sapindaceae	*Atalaya hemiglauca*	•	•
	Dodonaea coriacea	•	•

Family	Species	Phase 1	Phase 2
Scrophulariaceae	*Stemodia grossa*	•	•
	Striga squamigera		•
Solanaceae	****Datura leichhardtii***	•	•
	Nicotiana occidentalis	•	•
	Solanum horridum		•
	Solanum lasiophyllum	•	•
	Solanum phlomoides	•	•
	Solanum sturtianum	•	•
Sterculiaceae	*Waltheria indica*	•	•
Surianaceae	*Stylobasium spathulatum*	•	•
Tiliaceae	*Corchorus crozophorifolius*	•	•
	Corchorus incanus subsp. *lithophilus*		•
	Corchorus laniflorus	•	•
	Corchorus lasiocarpus subsp. ?*parvus*	•	
	Corchorus lasiocarpus subsp. *lasiocarpus*	•	•
	Corchorus parviflorus	•	
	Corchorus sidoides		•
	Corchorus sidoides subsp. *sidoides*		•
	Corchorus sp.	•	
	Corchorus tectus	•	
	Triumfetta maconochieana		•
Violaceae	*Hybanthus aurantiacus*	•	•
Zygophyllaceae	*Tribulus hirsutus*		•
	Tribulus macrocarpus		•
	Tribulus occidentalis	•	
	Tribulus suberosus		•

(Classification and nomenclature according to the Western Australian Herbarium)

ᵽ plus bold font = priority flora taxon,
* plus bold font = introduced species
var. = variation
subsp. = sub species
aff. = affinity

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A7. Priority Flora Locations, Map and Herbarium Voucher Forms

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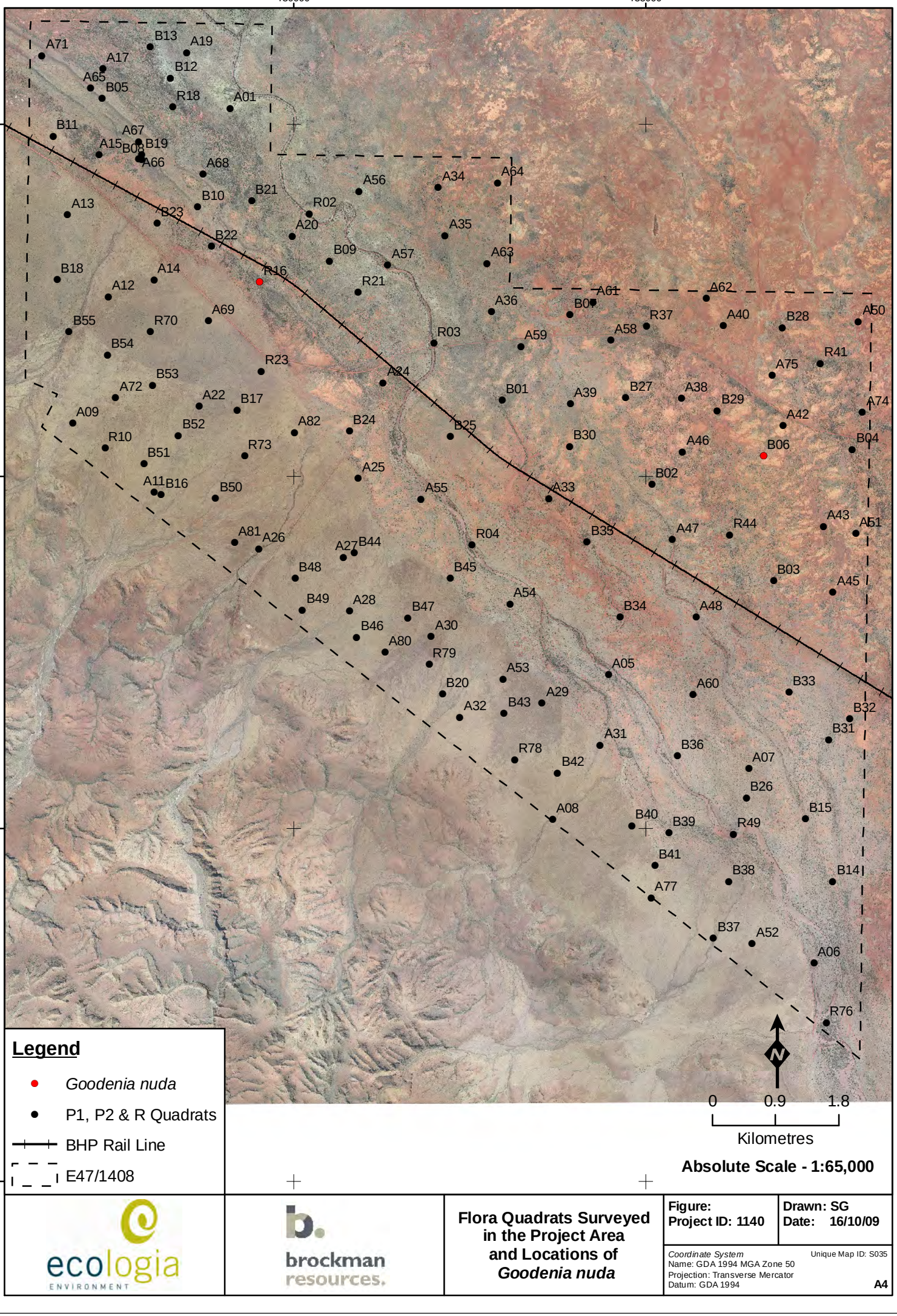
***Goodenia nuda* locations - coordinates.**

Species	Phase	Site	Easting (mE)	Northing (mN)	Cover (%)
Goodenia nuda (Priority 3)	1	A16	729520	7502769	< 2%
	2	B6	736675	7500300	< 2%

(Note: Zone = 50K, Datum = WGS84)


730000
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B21
R02
A13
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B17
B29
A09
A42
B52
A82
B24
B25
B30
A46
B04
R10
R73
B06
B51
A25
B02
A11
B16
B50
A55
A33
A43
A51
A81
A26
R04
B35
A47
R44
A27
B44
B48
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B47
B34
A48
B46
A30
A80
R79
A53
A05
B20
A60
B33
A29
A32
B43
B32
B31
A31
R78
B36
B42
A07
B26
A08
B40
B39
R49
B15
B41
B38
B14
A77
B37
A52
A06
R76
N
0
0.9
1.8
Kilometres
Absolute Scale - 1:65,000
Legend
Goodenia nuda
P1, P2 & R Quadrats
BHP Rail Line
E47/1408
ecologia
ENVIRONMENT
brockman
resources.
Flora Quadrats Surveyed in the Project Area and Locations of Goodenia nuda
Figure:
Project ID: 1140
Drawn: SG
Date: 16/10/09
Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: S035
A4

Department of Environment and Conservation

RARE FLORA REPORT FORM

TAXON: *Goodenia nuda* **DEFL POPULATION No.:** _____

DRF ❒ Priority Species: P3 Partial Survey ❒ Full Survey ☑ New Population ❒

FROM: Carmel Winton (CW-938-1) **TITLE**: _____ **SURVEY DATE:** 09 / 06 / 08

REGION: Pilbara Region **DISTRICT:** Fortescue **SHIRE:** East Pilbara

LOCATION: Marillana – Near the Roy Hill Road and BHPBilliton Newman to Port Hedland Rail line intersection. _____

_____**Reserve No**: _____

ZONE: 50K Easting (mE): 729520 **Northing (mN):** 7502769 **Map Used:** _____

GPS DATUM: AGD84 ❒ GDA94 ❒ GDA94-Compatible (e.g. WGS84) ☒ Unknown ❒ None ❒

LAND STATUS: Nature Reserve ❒ Private ❒ Gravel Res. MRD ❒ Rail Reserve ❒
National Park ❒ Pastoral Lease ☒ Gravel Res. Shire ❒ Rd. Verge Shire ❒
State Forest ❒ UCL ❒ Other Shire Res. ❒ Rd. Verge MRD ❒
Water Reserve ❒ Other ❒ Specify: _____ SLK _____ to _____
Landowner/manager present during inspection: ❒

LANDFORM: Hilltop ❒ Cliff ❒ Slope ❒ Valley ❒ Swamp ❒
Outcrop ❒ Breakaway ❒ Low Plain ❒ Gully ❒ Riverbank ❒
Ridge ❒ Sand Dune ❒ Flat ❒ Drainageline ☒ Lake Edge ❒
Firebreak ❒ Other ❒ Specify: _____

ROCK TYPE: Laterite ❒ Granite ❒ Dolerite ❒ Limestone ❒ Other:____ _____

ROCK FORM: Sheet ❒ Boulder ❒ Fluviatile Gravel ❒ Concretionary Gravel ❒

SOIL TYPE: Sand ☒ Loam ❒ Clay ☒ Peat ❒ Gravel ❒

SOIL COLOUR: Red ☒ Brown ❒ Yellow ❒ White ❒ Grey ❒

SOIL CONDITION: Moist ❒ Inundated ❒ Dry ☒ Saline ❒ Other: _____

VEGETATION CLASSIFICATION (Muir's): *Corymbia hamersleyana, Eucalyptus* ?*victrix* and *Acacia aneura* low woodland over *Atalaya hemiglauca* open shrubland over *Austrobryonia pilbarensis* and *Ipomoea muelleri* scattered climbers, **Malvastrum americanum* herbs and **Cenchrus ciliaris* and **Cenchrus setiger* open tussock grassland.

ASSOCIATED SPECIES:_____

_____

_____

No. of PLANTS: Mature: __<10 plants_ Seedlings: _____ Dead**:** _____ Actual ❒Estimate ☒ Area Occupied: _____
(Leave blank if unable to observe, or no attempt made to count plants)

REPRODUCTIVE STATE: Clonal ❒ Flower bud ❒ Flower ☒ Immat. fruit ❒ Fruit ❒ Old Fruit ❒ Vegetative ❒

POLLINATORS: Native bees ❒ Honey bees ❒ Other insects ❒ Birds ❒ Mammals ❒
Other observations: _____

CONDITION OF POPULATION: Healthy ❒ Moderate ❒ Poor ☒ Disturbed ❒ Comment:

_____

_____

_____

POTENTIAL THREATS: Firebreaks ❒ Mining ☒ Recreation ❒ Roadworks ❒ Grazing ☒ Weeds ☒
Salinity ❒ Disease ❒ Prescribed Burning ❒ Other ❒ Comment:_____

FIRE HISTORY: Not known ☒ Burnt in 19____ Summer ❒ Autumn ❒ Winter ❒ Spring ❒

FENCING: Not Required ❒ Fenced ❒ Required ❒ Replace/Repair ❒

ROADSIDE MARKERS: Not Required ☒ Present ❒ Required ❒ Replace ❒ Reposition ❒

OTHER COMMENTS (include action taken/required):_____

_____

VOUCHER SPECIMEN: Regional Herb. ❒ District Herb. ❒ WA Herb. ☒ Other ❒ _____

ATTACHED: Map ❒ Mudmap ❒ Illustration ❒ Photo ❒ Field Notes ❒

COPY SENT TO: Regional Office ❒ District Office ❒ Other ❒ Specify: _____

Signed: Carmel Winton (ecologia Environment) Date: 13th Feb 2009

NOTE: Map or further information may be attached or given on the back of this form.

Please return completed form to Director General, DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: PLEASE FORWARD TO ADMINISTRATIVE OFFICER, FLORA, SPECIES AND COMMUNITIES BRANCH

Department of Environment and Conservation

RARE FLORA REPORT FORM

TAXON: *Goodenia nuda* **DEFL POPULATION No.:** _____

DRF ❒ Priority Species: P3 Partial Survey ❒ Full Survey ☑ New Population ❒

FROM: Melissa Hay (MH-938-2) **TITLE:** _____ **SURVEY DATE:** 12 / 09 / 08

REGION: Pilbara Region **DISTRICT:** Fortescue **SHIRE:** East Pilbara

LOCATION: Marillana – Near the Roy Hill Road and BHPBilliton Newman to Port Hedland Rail line intersection. _____

_____ **Reserve No**: _____

ZONE: 50K Easting (mE): 736675 **Northing (mN):** 7500300 **Map Used:** _____

GPS DATUM: AGD84 ❒ GDA94 ❒ GDA94-Compatible (e.g. WGS84) ☒ Unknown ❒ None ❒

LAND STATUS: Nature Reserve ❒ Private ❒ Gravel Res. MRD ❒ Rail Reserve ❒
National Park ❒ Pastoral Lease ☒ Gravel Res. Shire ❒ Rd. Verge Shire ❒
State Forest ❒ UCL ❒ Other Shire Res. ❒ Rd. Verge MRD ❒
Water Reserve ❒ Other ❒ Specify: _____ SLK _____ to _____
Landowner/manager present during inspection: ❒

LANDFORM: Hilltop ❒ Cliff ❒ Slope ❒ Valley ❒ Swamp ❒
Outcrop ❒ Breakaway ❒ Low Plain ❒ Gully ❒ Riverbank ❒
Ridge ❒ Sand Dune ❒ Flat ❒ Drainageline ☒ Lake Edge ❒
Firebreak ❒ Other ❒ Specify: _____

ROCK TYPE: Laterite ❒ Granite ❒ Dolerite ❒ Limestone ❒ Other:____ _____
ROCK FORM: Sheet ❒ Boulder ❒ Fluviatile Gravel ❒ Concretionary Gravel ❒
SOIL TYPE: Sand ☒ Loam ❒ Clay ☒ Peat ❒ Gravel ❒
SOIL COLOUR: Red ☒ Brown ❒ Yellow ❒ White ❒ Grey ❒
SOIL CONDITION: Moist ❒ Inundated ❒ Dry ☒ Saline ❒ Other: _____

VEGETATION CLASSIFICATION (Muir's): *Corymbia hamersleyana, Eucalyptus* ?*victrix* and *Acacia aneura* low woodland over *Atalaya hemiglauca* open shrubland over *Austrobryonia pilbarensis* and *Ipomoea muelleri* scattered climbers, **Malvastrum americanum* herbs and **Cenchrus ciliaris* and **Cenchrus setiger* open tussock grassland.

ASSOCIATED SPECIES:_____

_____

_____

No. of PLANTS: Mature: __<10 plants_ Seedlings: _____ Dead**:** _____ Actual ❒Estimate ☒ Area Occupied: _____
(Leave blank if unable to observe, or no attempt made to count plants)

REPRODUCTIVE STATE: Clonal ❒ Flower bud ❒ Flower ☒ Immat. fruit ❒ Fruit ❒ Old Fruit ❒ Vegetative ❒

POLLINATORS: Native bees ❒ Honey bees ❒ Other insects ❒ Birds ❒ Mammals ❒
Other observations: _____

CONDITION OF POPULATION: Healthy ❒ Moderate ❒ Poor ☒ Disturbed ❒ Comment:

_____

_____

_____

POTENTIAL THREATS: Firebreaks ❒ Mining ☒ Recreation ❒ Roadworks ❒ Grazing ☒ Weeds ☒
Salinity ❒ Disease ❒ Prescribed Burning ❒ Other ❒ Comment:_____

FIRE HISTORY: Not known ☒ Burnt in 19____ Summer ❒ Autumn ❒ Winter ❒ Spring ❒

FENCING: Not Required ❒ Fenced ❒ Required ❒ Replace/Repair ❒

ROADSIDE MARKERS: Not Required ☒ Present ❒ Required ❒ Replace ❒ Reposition ❒

OTHER COMMENTS (include action taken/required):_____

_____

VOUCHER SPECIMEN: Regional Herb. ❒ District Herb. ❒ WA Herb. ☒ Other ❒ _____

ATTACHED: Map ❒ Mudmap ❒ Illustration ❒ Photo ❒ Field Notes ❒

COPY SENT TO: Regional Office ❒ District Office ❒ Other ❒ Specify: _____

Signed: Melissa Hay (ecologia Environment) (MH-938-02) Date: 23rd March 2009

NOTE: Map or further information may be attached or given on the back of this form.

Please return completed form to Director General, DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: PLEASE FORWARD TO ADMINISTRATIVE OFFICER, FLORA, SPECIES AND COMMUNITIES BRANCH

A8. Introduced Flora Locations, Descriptions and Photographs

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Locations of introduced flora species recorded at the Marillana survey area.

Species	Phase	Site	Easting (mE)	Northing (mN)	No. plants / cover (%)
**Aerva javanica*	1	A6	737392	7493100	< 2%
		A24	731273	7501331	< 2%
		A47	735382	7499112	< 10 plants
		A49	736254	7494928	< 2%
		A76	737567	7492245	< 10 plants
	2	R76	737583	7492257	< 10 plants
**Argemone ochroleuca* subsp. *ochroleuca*	2	Opp coll	732476	7498939	< 10 plants
**Cenchrus ciliaris*	1	A1	729103	7505239	> 70%
		A2	730229	7503733	10 – 30%
		A3	731995	7501900	30 – 70%
		A4	732537	7499035	2 – 10%
		A5	734476	7497191	> 70%
		A6	737392	7493100	10 – 30%
		A7	736467	7495866	30 – 70%
		A8	733679	7495141	10 – 30%
		A9	726866	7500762	2 – 10%
		A11	728027	7499782	2 – 10%
		A15	727243	7504575	30 – 70%
		A16	729520	7502769	10 – 30%
		A17	727296	7505798	> 70%
		A18	728288	7505261	30 – 70%
		A19	728482	7506031	30 – 70%
		A20	729978	7503418	> 70%
		A21	730919	7502630	30 – 70%
		A22	728662	7501007	10 – 30%
		A24	731273	7501331	10 – 30%
		A26	729505	7498978	2 – 10%
		A27	730709	7498860	< 2%
		A28	730799	7498102	10 – 30%
		A29	733534	7496787	< 2%
		A30	731957	7497731	2 – 10%
		A31	734360	7496195	10 – 30%
		A33	733629	7499695	10 – 30%
		A34	732055	7504106	30 – 70%
		A35	732154	7503431	10 – 30%
		A36	732809	7502352	30 – 70%
		A38	735509	7501121	10 – 30%
		A39	733933	7501040	30 – 70%
		A40	736101	7502151	10 – 30%
		A41	737484	7501609	2 – 10%
		A42	736954	7500731	< 2%
		A43	737524	7499296	< 2%
		A44	736198	7499181	10 – 30%
		A45	737663	7498365	2 – 10%
		A46	735525	7500355	10 – 30%
		A47	735382	7499112	30 – 70%
	1	A48	735721	7498007	30 – 70%
		A49	736254	7494928	2 – 10%

Species	Phase	Site	Easting (mE)	Northing (mN)	No. plants / cover (%)
**Cenchrus ciliaris*	1	A50	738027	7502211	< 2%
		A51	737986	7499203	10 – 30%
		A52	736517	7493377	2 – 10%
		A53	732979	7497129	2 – 10%
		A54	733079	7498193	10 – 30%
		A55	731815	7499681	30 – 70%
		A56	730932	7504055	> 70%
		A57	731339	7503007	10 – 30%
		A58	734504	7501947	30 – 70%
		A59	733233	7501852	2 – 10%
		A60	735673	7496904	30 – 70%
		A61	734251	7502478	< 2%
		A62	735861	7502541	2 – 10%
		A63	732751	7503031	> 70%
		A64	732900	7504177	< 2%
		A65	727115	7505519	30 – 70%
		A66	727800	7504520	2 – 10%
		A68	728714	7504301	30 – 70%
		A71	726429	7505985	10 – 30%
		A73	729307	7500306	2 – 10%
		A74	738080	7500914	10 – 30%
		A75	736797	7501445	< 2%
		A76	737567	7492245	30 – 70%
		A77	735081	7494023	< 10 plants
		A82	730014	7500634	2 – 10%
	2	B1	732964	7501099	10 – 30%
		B2	735088	7499895	2 – 10%
		B4	737938	7500388	30 – 70%
		B5	727283	7505373	2 – 10%
		B6	736675	7500300	< 2%
		B7	733929	7502307	30 – 70%
		B8	727845	7504512	< 2%
		B9	730515	7503067	10 – 30%
		B9	730515	7503067	10 – 30%
		B10	728643	7503839	2 – 10%
		B11	726586	7504841	< 2%
		B12	728257	7505664	10 – 30%
		B13	727969	7506100	30 – 70%
		B14	737663	7494254	10 – 30%
		B15	737270	7495145	10 – 30%
		B16	728124	7499745	2 – 10%
		B17	729201	7500954	2 – 10%
		B19	727842	7504573	2 – 10%
		B20	732120	7496923	10 – 30%
		B21	729405	7503923	30 – 70%
		B22	728836	7503277	10 – 30%
		B23	728065	7503607	< 2%
		B24	730798	7500650	10 – 30%
		B25	732230	7500574	30 – 70%
		B26	736436	7495448	30 – 70%

Species	Phase	Site	Easting (mE)	Northing (mN)	No. plants / cover (%)
**Cenchrus ciliaris*	2	B27	734723	7501124	30 – 70%
		B28	736948	7502119	10 – 30%
		B30	733927	7500428	30 – 70%
		B31	737599	7496274	30 – 70%
		B32	737897	7496570	10 – 30%
		B33	737039	7496940	30 – 70%
		B34	734638	7498014	30 – 70%
		B35	734172	7499082	30 – 70%
		B36	735456	7496041	30 – 70%
		B37	735965	7493452	2 – 10%
		B38	736183	7494253	2 – 10%
		B39	735331	7494950	10 – 30%
		B41	735133	7494482	2 – 10%
		B43	732991	7496640	< 10 plants
		B44	730868	7498927	30 – 70%
		B45	732224	7498565	30 – 70%
		B47	731626	7498002	< 2%
		B49	730129	7498107	2 – 10%
		B50	728896	7499695	< 10 plants
		B52	728369	7500588	2 – 10%
		B53	728000	7501299	< 2%
		B55	726814	7502060	2 – 10%
		R2	730180	7503835	30 – 70%
		R3	731987	7501882	30 – 70%
		R4	732536	7499029	30 – 70%
		R16	729520	7502757	2 – 10%
		R18	728291	7505260	10 – 30%
		R21	730907	7502660	> 70%
		R37	735013	7502158	10 – 30%
		R44	736203	7499152	10 – 30%
		R49	736203	7499152	< 2%
		R76	737583	7492257	30 – 70%
		Opp coll	735515	7495337	< 2%
		Opp coll	733194	7497146	< 2%
		Opp coll	727393	7503233	< 2%
		Opp coll	733065	7497555	10 – 30%
		Opp coll	730573	7502335	10 – 30%
		Opp coll	732073	7497261	30 – 70%
**Cenchrus setiger*	1	A1	729103	7505239	2 – 10%
		A2	730229	7503733	> 70%
		A4	732537	7499035	< 10 plants
		A5	734476	7497191	> 70%
		A6	737392	7493100	2 – 10%
		A7	736467	7495866	30 – 70%
		A8	733679	7495141	< 10 plants
		A16	729520	7502769	10 – 30%
		A18	728288	7505261	30 – 70%
		A19	728482	7506031	30 – 70%
		A20	729978	7503418	10 – 30%
		A22	728662	7501007	< 2%

Species	Phase	Site	Easting (mE)	Northing (mN)	No. plants / cover (%)
**Cenchrus setiger*	1	A24	731273	7501331	10 – 30%
		A26	729505	7498978	2 – 10%
		A28	730799	7498102	2 – 10%
		A31	734360	7496195	< 2%
		A33	733629	7499695	10 – 30%
		A35	732154	7503431	2 – 10%
		A37	735010	7502135	2 – 10%
		A38	735509	7501121	2 – 10%
		A39	733933	7501040	30 – 70%
		A40	736101	7502151	10 – 30%
		A44	736198	7499181	< 10 plants
		A46	735525	7500355	< 2%
		A47	735382	7499112	2 – 10%
		A48	735721	7498007	30 – 70%
		A49	736254	7494928	< 10 plants
		A52	736517	7493377	< 10 plants
		A54	733079	7498193	30 – 70%
		A55	731815	7499681	2 – 10%
		A56	730932	7504055	30 – 70%
		A57	731339	7503007	10 – 30%
		A60	735673	7496904	30 – 70%
		A68	728714	7504301	10 – 30%
		A76	737567	7492245	30 – 70%
	2	B1	732964	7501099	10 – 30%
		B2	735088	7499895	2 – 10%
		B6	736675	7500300	< 10 plants
		B10	728643	7503839	2 – 10%
		B12	728257	7505664	10 – 30%
		B15	737270	7495145	10 – 30%
		B22	728836	7503277	10 – 30%
		B24	730798	7500650	10 – 30%
		B25	732230	7500574	2 – 10%
		B26	736436	7495448	10 – 30%
		B31	737599	7496274	30 – 70%
		B32	737897	7496570	< 2%
		B33	737039	7496940	10 – 30%
		B35	734172	7499082	10 – 30%
		B36	735456	7496041	30 – 70%
		B38	736183	7494253	< 2%
		B39	735331	7494950	10 – 30%
		B45	732224	7498565	2 – 10%
		R2	730180	7503835	30 – 70%
		R3	731987	7501882	< 2%
		R4	732536	7499029	< 2%
		R16	729520	7502757	2 – 10%
		R18	728291	7505260	10 – 30%
		R21	730907	7502660	< 2%
		R37	735013	7502158	< 10 plants
		R49	736203	7499152	< 2%
		R76	737583	7492257	< 2%

Species	Phase	Site	Easting (mE)	Northing (mN)	No. plants / cover (%)
**Cenchrus setiger*	2	Opp coll	735515	7495337	< 2%
		Opp coll	727393	7503233	< 2%
**Chloris virgata*	1	A41	737484	7501609	2 – 10%
	2	R41	737481	7501609	< 2%
**Datura leichhardtii*	1	A16	729520	7502769	< 10 plants
		Opp coll	734534	7496331	< 10 plants
	2	R16	729520	7502757	< 2%
**Malvastrum americanum*	1	A2	730229	7503733	< 10 plants
		A16	729520	7502769	30 – 70%
		A24	731273	7501331	< 2%
		A37	735010	7502135	< 2%
		A40	736101	7502151	2 – 10%
		A41	737484	7501609	2 – 10%
		A46	735525	7500355	< 2%
		A51	737986	7499203	2 – 10%
		A58	734504	7501947	< 2%
		A74	738080	7500914	< 2%
	2	B1	732964	7501099	2 – 10%
		B3	736818	7498525	< 10 plants
		B4	737938	7500388	< 10 plants
		B12	728257	7505664	< 10 plants
		B15	737270	7495145	2 – 10%
		B32	737897	7496570	< 10 plants
		B33	737039	7496940	< 10 plants
		B35	734172	7499082	< 2%
		R2	730180	7503835	< 2%
		R16	729520	7502757	10 – 30%
		R18	728291	7505260	< 2%
		R37	735013	7502158	< 2%
		R41	737481	7501609	< 2%
		Opp coll	734266	7498996	< 2%
		Opp coll	730573	7502335	2 – 10%
		Opp coll	732476	7498939	2 – 10%
		Opp coll	734601	7498387	2 – 10%
		Opp coll	732969	7500212	< 10 plants
		Opp coll	732989	7500198	< 10 plants
**Portulaca oleracea*	1	A9	726866	7500762	< 2%
		A11	728027	7499782	< 10 plants
		A17	727296	7505798	< 10 plants
		A38	735509	7501121	< 2%
		A40	736101	7502151	< 2%
		A41	737484	7501609	< 2%
		A42	736954	7500731	< 10 plants
		A44	736198	7499181	< 2%
		A45	737663	7498365	< 10 plants
		A50	738027	7502211	< 10 plants
		A58	734504	7501947	< 2%
		A59	733233	7501852	< 10 plants
		A61	734251	7502478	< 10 plants
		A74	738080	7500914	< 10 plants

Species	Phase	Site	Easting (mE)	Northing (mN)	No. plants / cover (%)
**Portulaca oleracea*	1	A75	736797	7501445	< 2%
	2	B11	726586	7504841	< 2%
		B23	728065	7503607	< 2%
		R41	737481	7501609	< 10 plants
**Setaria verticillata*	1	A2	730229	7503733	< 2%
	2	R2	730180	7503835	< 2%
**Vachellia farnesiana*	1	A1	729103	7505239	< 10 plants
		A15	727243	7504575	< 2%
		A18	728288	7505261	< 2%
		A19	728482	7506031	< 2%
		A20	729978	7503418	< 10 plants
		A21	730919	7502630	< 2%
		A35	732154	7503431	< 10 plants
		A37	735010	7502135	< 2%
		A40	736101	7502151	< 2%
		A46	735525	7500355	< 10 plants
		A58	734504	7501947	< 2%
		A59	733233	7501852	< 10 plants
		A62	735861	7502541	< 2%
		A63	732751	7503031	< 10 plants
		A64	732900	7504177	< 10 plants
	2	B6	736675	7500300	< 10 plants
		B7	733929	7502307	< 2%
		B12	728257	7505664	< 2%
		B13	727969	7506100	< 2%
		B27	734723	7501124	< 10 plants
		R18	728291	7505260	< 2%
		R21	730907	7502660	< 10 plants
		R37	735013	7502158	< 10 plants
		Opp coll	730573	7502335	< 2%
		Opp coll	727181	7507231	2 – 10%
		Opp coll	732969	7500212	2 – 10%
		Opp coll	727483	7506860	10 – 30%

(Note: Zone = 50K, Datum = WGS84, Opp coll = opportunist collection)

***Aerva javanica* (Kapok Bush), Amaranthaceae,** is an erect, many-branched perennial herb, growing to 1.6 m in height. **Aerva javanica* is densely covered in short, branched hairs, giving it a greyish appearance. Its flowers are white and are produced for most of the year (FloraBase, 2009). Native to northern Africa and south west Asia, **Aerva javanica* was originally introduced to Western Australia to assist with the re-vegetation of degraded rangelands, it is now widespread in many types of vegetation from Carnarvon to the Kimberley (Hussey *et al.,* 2007).

***Argemone ochroleuca subsp. ochroleuca* (Mexican Poppy), Papaveraceae,** is an annual, herb, 0.3 – 1 m high, with very spiny leaves that produce a yellow latex substance when broken. Its flowers are white, cream and yellow, and are produced from February to March and July to November (FloraBase, 2009). Native to America *Argemone ochroleuca* subsp. *ochroleuca* is now widespread in coarse sand banks and cobble river beds in arid Western Australia as well as pastures in parts of the Avon Valley, and on wasteland in the south-west (Hussey *et al.* 2007).

***Cenchrus ciliaris* (Buffel Grass), Poaceae,** is a tufted, perennial grass growing to 1 m high with purplish flowers produced for much of the year (FloraBase, 2009). Native to Africa and India, **Cenchrus ciliaris* has been widely planted in pastoral regions of Western Australia for cattle fodder and has now become a widespread weed along roadsides, creeklines and river edges, and occurs in most vegetation types from Geraldton to the Pilbara (Hussey *et al.,* 2007).

***Cenchrus setiger* (Birdwood Grass), Poaceae,** is an erect, tussocky, perennial, grass-like herb, growing to 0.5 m high, with a compact, green spike-like inflorescence occurring from May to April (FloraBase, 2009). Native to Africa and India, it was introduced to Australia as a fodder plant in pastoral regions and has now become a serious weed of watercourses from Geraldton to the Kimberley (Hussey *et al.,* 2007).

***Chloris virgata* (Feathertop Rhodes Grass / Windmill Grass), Poaceae,** is a tufted annual, grass-like herb growing 0.23 to 0.45 m high; it occurs on clay and sand (FloraBase, 2009). Green-purple flowers are produced in autumn and winter; the inflorescence is shorter, softer and less widely branched than other *Chloris* species. Native to tropical Africa, this species is found on disturbed sites, such as roadsides, throughout the Kimberley, Pilbara, Gascoyne and South West regions of Western Australia (Hussey *et al.,* 2007). Photograph not available.

***Datura leichhardtii* (Native Thornapple / Leichhardt's Thornapple), Solanaceae,** is a stout, annual herb growing 0.2 to 1 m high (FloraBase, 2009). It has ovate, lobed leaves and white flowers are produced from June to October. Native to Mexico, this species grows on alluvium and is often found along creeklines in the Pilbara and Gascoyne (Hussey *et al.,* 2007). Photograph not available.

***Malvastrum americanum* (Spiked Malvastrum)**, **Malvaceae**, is an erect, hairy, perennial herb or shrub growing to between 0.5 and 1.3 m in height (FloraBase, 2009). Native to tropical America, this species is a weed of river and creek margins, wastelands, and many arid zone habitats from the Kimberley to the Pilbara and Gascoyne regions of Western Australia (Hussey *et al.,* 2007).

***Portulaca oleracea* (Pigweed / Purslane), Portulacaceae,** is a succulent, prostrate to decumbent annual herb, growing to 0.2 m high; under water stress this plant becomes reddish. Flowers are yellow and occur from April to May (FloraBase, 2009). Commonly found on clay loams, sand and often disturbed sites, **Portulaca oleracea* is a widespread weed of horticulture, paddocks and gardens, it is considered a native in most of Western Australia, but is probably introduced to the South-West (Hussey *et al.,* 2007).

***Setaria verticillata* (Whorled Pigeon Grass), Poaceae,** is a loosely tufted annual, grass-like herb growing to 0.1 to 1.3 m in height. Its flowers are produced from December to June and form dense, cylindrical panicles (FloraBase, 2009). It is a common widespread weed of disturbed land, riverine edges and shrublands from the Kimberley to the Pilbara; often found on sand, clay and loam (Hussey *et al.,* 2007). Photograph not available.

***Vachellia farnesiana* (Mimosa Bush), Mimosaceae,** is an erect, spreading, thicket-forming, thorny tree or shrub growing to 4 m in height and has dark grey, rough bark. The leaves of **Vachellia farnesiana* are pinnate and it produces yellow flowers from June to August (FloraBase, 2009). **Vachellia farnesiana* is common in low-lying areas, creek banks and disturbed sites. A South American species, it is now widely distributed throughout Western Australia (Hussey *et al.,* 2007).

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