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.

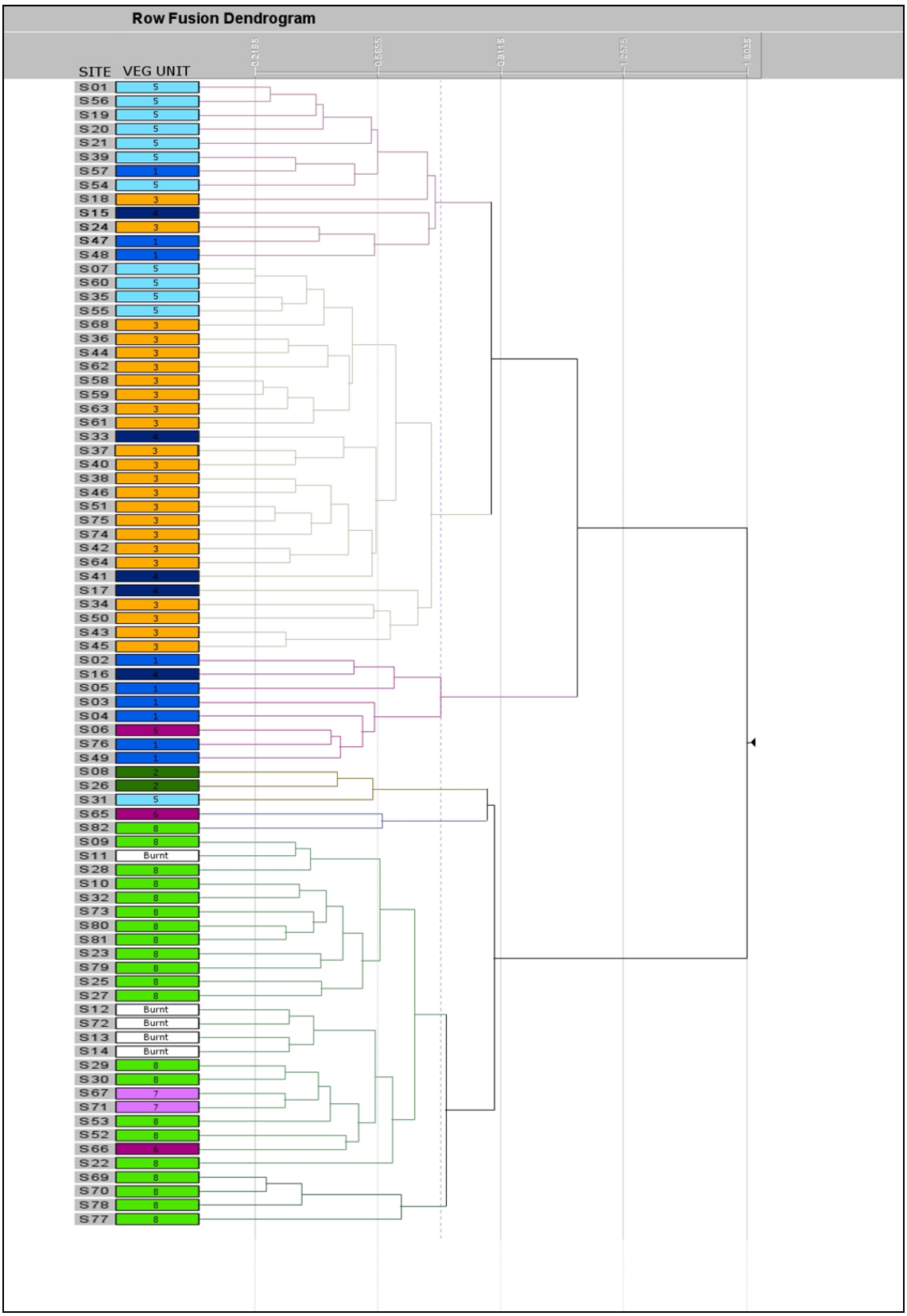

Figure 4.1 – Dendrogram Produced by PATN^{TM} Analysis.

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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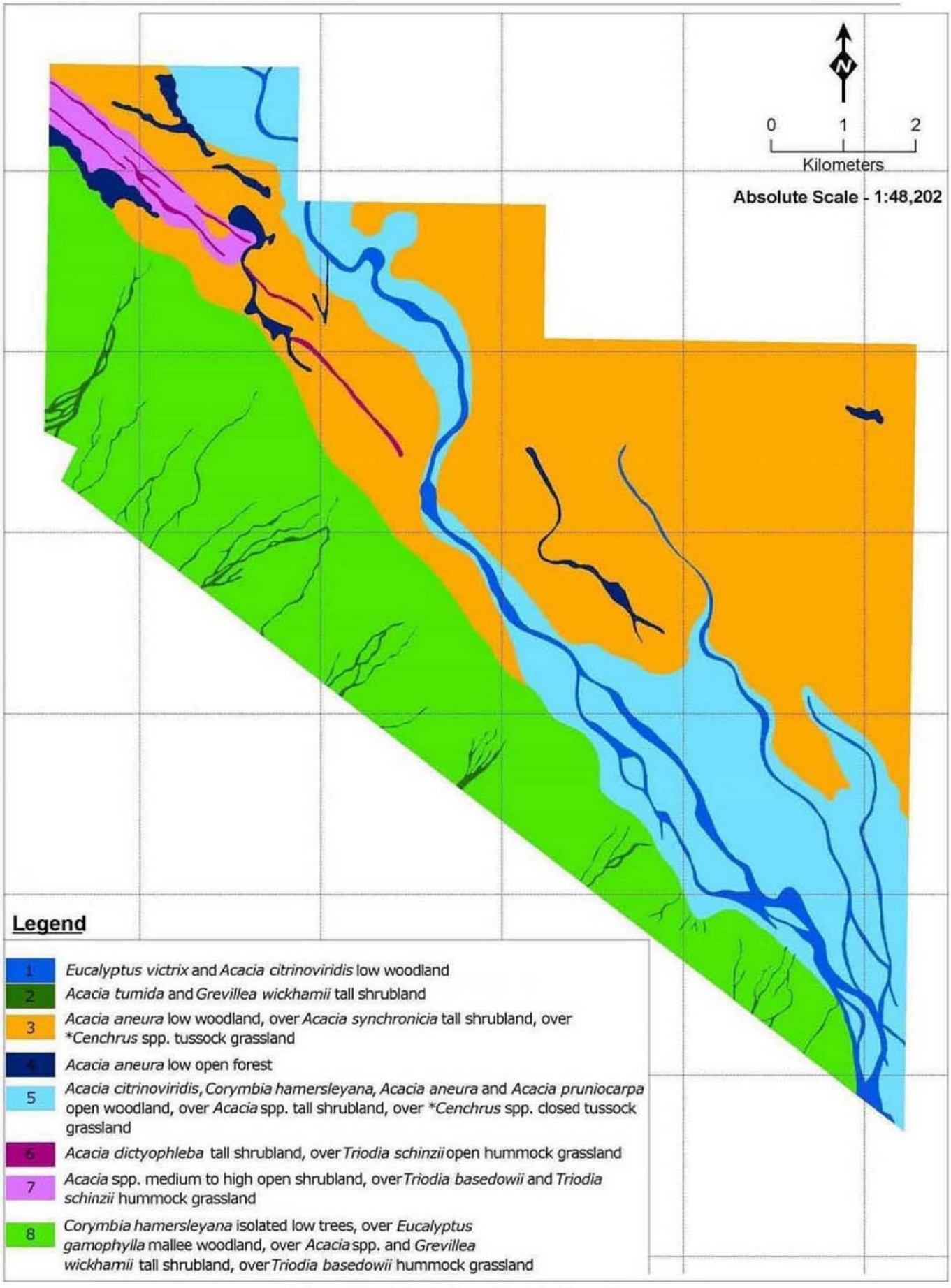

Figure 4.2 – Vegetation of the Marillana Survey Area

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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.

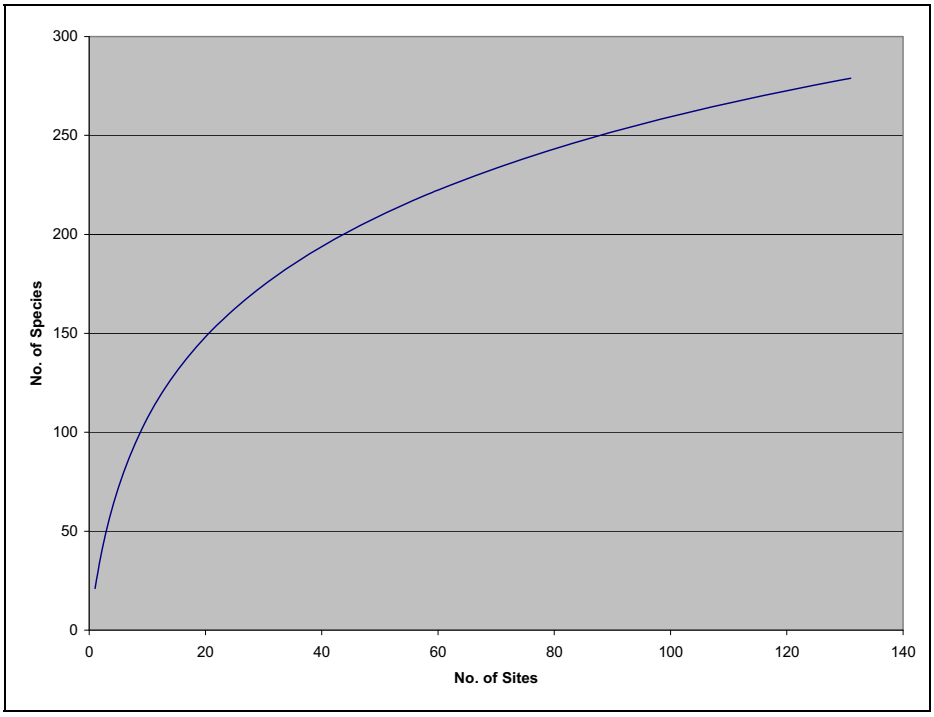

Figure 5.1 – Species Accumulation Curve for the Marillana Survey Area.

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.

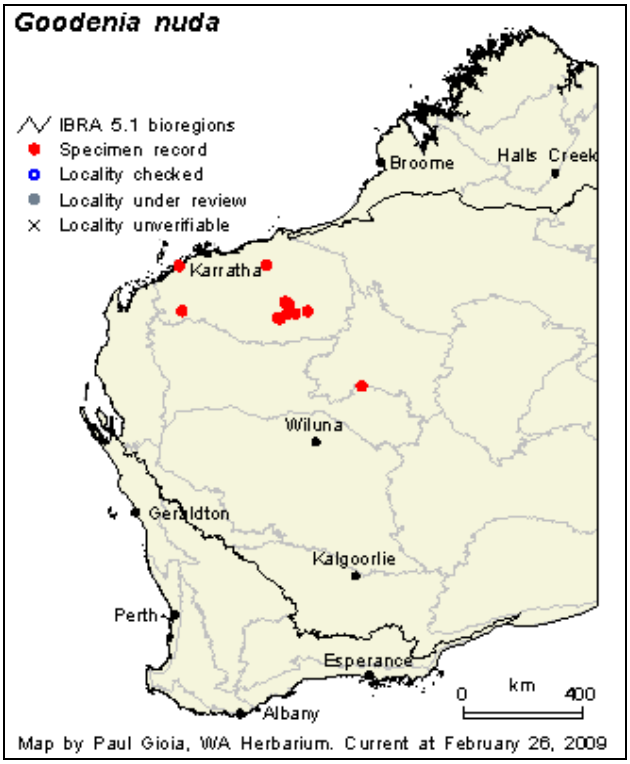

Figure 6.1 – Distribution range of *G. nuda* in Western Australia

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:

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Christina Cox	PhD	Manager Botany
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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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