

# A Vegetation and Flora Survey of the Brockman Syncline 4 Project Area, near Tom Price



Prepared for  
**Hamersley Iron Pty Ltd**

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# 1.0 Summary

## 1.1 Background

Hamersley Iron Pty Ltd (HI) is proposing to develop the Brockman Syncline 4 (BS4) Project, situated approximately 25 km south-west of the existing Brockman No. 2 Mine, and approximately 58 km west of Tom Price in the Pilbara Region of Western Australia.

To provide input to the environmental assessment process, Biota Environmental Sciences (Biota) was commissioned to conduct a vegetation and flora survey of the BS4 Project area. This comprised an area of ~16 km by 5.5 km surrounding the range of hills that includes the BS4 deposits, together with a ~35 km by 500 m transport corridor extending north from BS4 to existing operations at Brockman 2.

The main elements of the study were:

- description and mapping of vegetation types, based on 49 standard 50 x 50m floristic survey quadrats and additional relevés; and
- identification of flora within the BS4 Project area, particularly with respect to rare and/or restricted species; this included review of results of extensive rare flora searches done previously in the area by HI.

## 1.2 Vegetation

Fifty-three (53) broad vegetation types were defined for the BS4 Project area. These included hummock grasslands of *Triodia* species (mainly *T. wiseana*) with a variable shrub overstorey on low stony hills; tall shrublands of mixed species, usually with an overstorey of *Eucalyptus* or *Corymbia*, in creeklines; open woodlands of Coolibah *Eucalyptus victrix* over herblands in the gravelly bed of Boolgeeda Creek; and Mulga *Acacia "aneura"* and Snakewood *A. xiphophylla* tall shrublands over spinifex on plains.

One vegetation type is considered to be of high conservation significance:

- P11 (*Acacia synchronicia* scattered shrubs over *Triodia angusta* hummock grassland); this vegetation type contained a large population of the Priority 1 species *Ptilotus* sp. Brockman, and is unlikely to be well represented in the Hamersley subregion.

Thirteen vegetation types were considered to be of moderate conservation significance:

- H11, H12, H13 and H16 (mixed shrublands over hummock grasslands dominated by suites of species preferring rocky habitats); these vegetation types of narrow gorges, gullies and breakaways support species restricted to such rocky habitats, including an apparently undescribed species of *Sida*; in addition these habitats, while widespread within the Hamersley subregion, comprise a small proportion of the total area;
- P1 (*Acacia* aff. *aneura* (narrow fine veined; site 1259), *A. ayersiana*, *A. tetragonophylla* tall shrubland over *Eremophila forrestii*, *Acacia bivenosa* shrubland over *Triodia epactia* mid-dense hummock grassland); this vegetation type was restricted within the BS4 Project area to a single broad drainage area within a valley, and may be poorly represented in the locality;
- P9 and P10 (*Triodia wiseana* / *T. angusta* hummock grasslands with variable overstoreys occurring on stony calcrete plains); calcrete areas are not well represented in the Hamersley subregion and these vegetation types may have a restricted distribution;
- C1, C2, C3 and C18 (vegetation of the largest creeklines within the BS4 Project area); these vegetation types occur in habitats that are of value as surface drainage features (particularly Boolgeeda Creek) and support numerous species restricted to such habitat (including the Priority 3 flora *Phyllanthus aridus*); C1 and C18 also contain Coolibahs *Eucalyptus victrix*, which may behave as a phreatophyte and thus be influenced by groundwater drawdown; and

- C17 and C20 (creekline vegetation dominated by Mulga); these vegetation types are likely to be restricted in terms of area of extent in the Hamersley subregion, and would also be particularly susceptible to degradation through fire.

The only vegetation types within the BS4 Project area that are considered to have no particular conservation significance are those creeklines degraded by dense infestations of Buffel Grass \**Cenchrus ciliaris* (ie. vegetation type C4), although these would still have some value as surface drainage features.

The remainder of the vegetation types identified are considered to be of low conservation significance, representing units that are likely to be widely distributed and relatively well represented in the Hamersley Range subregion.

## 1.3 Flora

A total of 367 taxa of native vascular flora from 149 genera belonging to 52 families was recorded from the BS4 Project area. In addition, six introduced flora species were recorded (Ruby Dock \**Acetosa vesicaria*, Buffel Grass \**Cenchrus ciliaris*, Birdwood Grass \**C. setigerus*, Whorled Pigeon Grass \**Setaria verticillata*, Beggars Ticks \**Bidens bipinnata* and Spiked Malvastrum \**Malvastrum americanum*).

The BS4 Project area has a moderate species richness, which is neither atypically high nor low given the location of the area, its size and the variety of habitats encompassed. The families and genera with the greatest number of species were those that are typically predominant in the vegetation of the central Pilbara, and usually have most representatives on flora lists from this region.

No Declared Rare Flora have been recorded from the BS4 Project area, and none would be expected to occur.

Five Priority flora species have been recorded within the BS4 Project area;

- the Priority 1 species, *Ptilotus* sp. Brockman (E. Thoma & A. Joder ET & AJ 145);
- three Priority 3 species, *Abutilon trudgenii* ms., *Phyllanthus aridus* and *Sida* sp. Wittenoom (W.R. Barker 1962); and
- one Priority 4 species, *Eremophila magnifica* subsp. *magnifica*.

An additional Priority 4 species, *Goodenia stellata*, was recorded outside the BS4 Project area and could occur within in similar habitat.

## 1.4 Management Recommendations

Generic impacts that will or may arise from the proposed development include:

- vegetation clearing;
- disturbance to surface drainage systems;
- groundwater drawdown;
- introduction / spread of weeds;
- fire;
- erosion; and
- dust.

The following management measures are proposed to minimise impact to the flora and vegetation of the BS4 Project area:

- The transport route and any infrastructure areas that have not been systematically searched for rare flora should be surveyed prior to construction.
- The population of the Priority 1 *Ptilotus* sp. Brockman within the BS4 Project area south of the central mine pit should not be disturbed. The access track through this area should be closed to prevent further erosion, and all staff and contractors should be made aware of the significance of this area as part of the on-site induction programme.
- The locations of the other Priority flora should be considered as part of the mine planning process and avoided if possible.
- Wherever possible, avoid disturbance to surface drainage features through sensitive mine planning. Where disturbance is unavoidable, install sufficient culverting to maintain surface water flows.
- Undertake an assessment of the likely impacts of groundwater drawdown on vegetation of the BS4 Project area once hydrological studies are complete, potentially including a stable isotope study to determine the source of water sustaining Mulga within vegetation type P1.
- Review the assessment of vegetation conservation significance following completion of an additional PATN floristic analysis, to be conducted once further data from the locality becomes available.
- Vegetation clearing should be kept to the minimum necessary for safe construction and operation of the BS4 Project, particularly in areas adjacent to vegetation of higher conservation significance.
- Weed control measures should be developed and implemented to prevent the introduction or spread of weeds in the BS4 Project area. A Weed Hygiene and Management Plan should be prepared in consultation with CALM prior to construction commencing.
- Prepare and implement a Fire Management Plan to minimise the risk of unplanned fires in the BS4 Project area.
- A Topsoil Management and Rehabilitation Plan should be prepared for all non-permanent cleared areas, in liaison with CALM, the Department of Environment and Department of Industry and Resources prior to the commencement of construction activities. This plan should include use of provenance collected native seed, characterisation and management of topsoil, and the respreading of cleared vegetative material. Recovery monitoring should also be carried out, with any rehabilitation failure subject to additional treatment to a suitable standard.
- Standard dust suppression measures should be implemented across the BS4 Project area during construction and operation to minimise effects on surrounding vegetation.
- Hamersley Iron should consider providing funding towards further scientific research. Appropriate topics could include the distribution, ecology and/or genetics of *Ptilotus* sp. Brockman.



## 2.0 Introduction

### 2.1 Background to the BS4 Project and Location of the Project Area

Hamersley Iron Pty Ltd (HI) is proposing to develop the Brockman Syncline 4 (BS4) Project. The BS4 Project is situated approximately 25 km south-west of the existing Brockman 2 Mine (B2), and approximately 58 km west of Tom Price in the Pilbara Region of Western Australia (Figure 2.1).

The major components of the BS4 Project are:

- three new mine pits (eastern, western and central);
- associated mine infrastructure (waste dumps, haul roads);
- an extension of the existing B2 rail spur to BS4 (approximately 35 km in length); and
- other associated infrastructure (a new camp, mine offices, a new airstrip, bore fields, power transmission lines, bulk fuel storage, vehicle workshops, waste water treatment plant, etc).

While the final locations for these components have not yet been determined, indicative locations are shown in Figure 2.2.

The BS4 Project was referred to the EPA on 22 October 2004 and the level of assessment set as Public Environmental Review (PER) with a four-week public review period. No appeals were made against the level of assessment.

To provide input to the environmental assessment process, Biota Environmental Sciences was commissioned to conduct biological surveys of the BS4 Project area.

### 2.2 Scope and Objectives of this Study

This report documents the results of the vegetation and flora study done for the BS4 Project. The surveyed Project area comprised an area of approximately 16 km by 5.5 km surrounding the range of hills that includes the BS4 deposits, together with a transport corridor of approximately 32 km by 500 m extending north from BS4 to existing operations at Brockman 2.

The vegetation and flora survey was planned and implemented as far as practicable according to the Environmental Protection Authority (EPA) Position Statement No. 3 "Terrestrial Biological Surveys as an Element of Biodiversity Protection" (EPA 2002) and Guidance Statement No. 51 "Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia" (EPA 2004).

As such, this study aimed to:

- provide detailed baseline information regarding vegetation and flora values of the BS4 Project area (this incorporated a desktop review of available information, together with a field study, utilising techniques generally accepted as standard for the region, which addressed: description and mapping of vegetation types occurring in the BS4 Project area; identification of any vegetation types of particular conservation significance; cataloguing of the flora present within the Project area; and collation of information regarding any rare flora or other flora of conservation interest);
- place the information from the BS4 Project area in regional context by comparison with available data from other localities;
- provide management recommendations to minimise impact to vegetation types and flora species of particular conservation significance within the BS4 Project area.

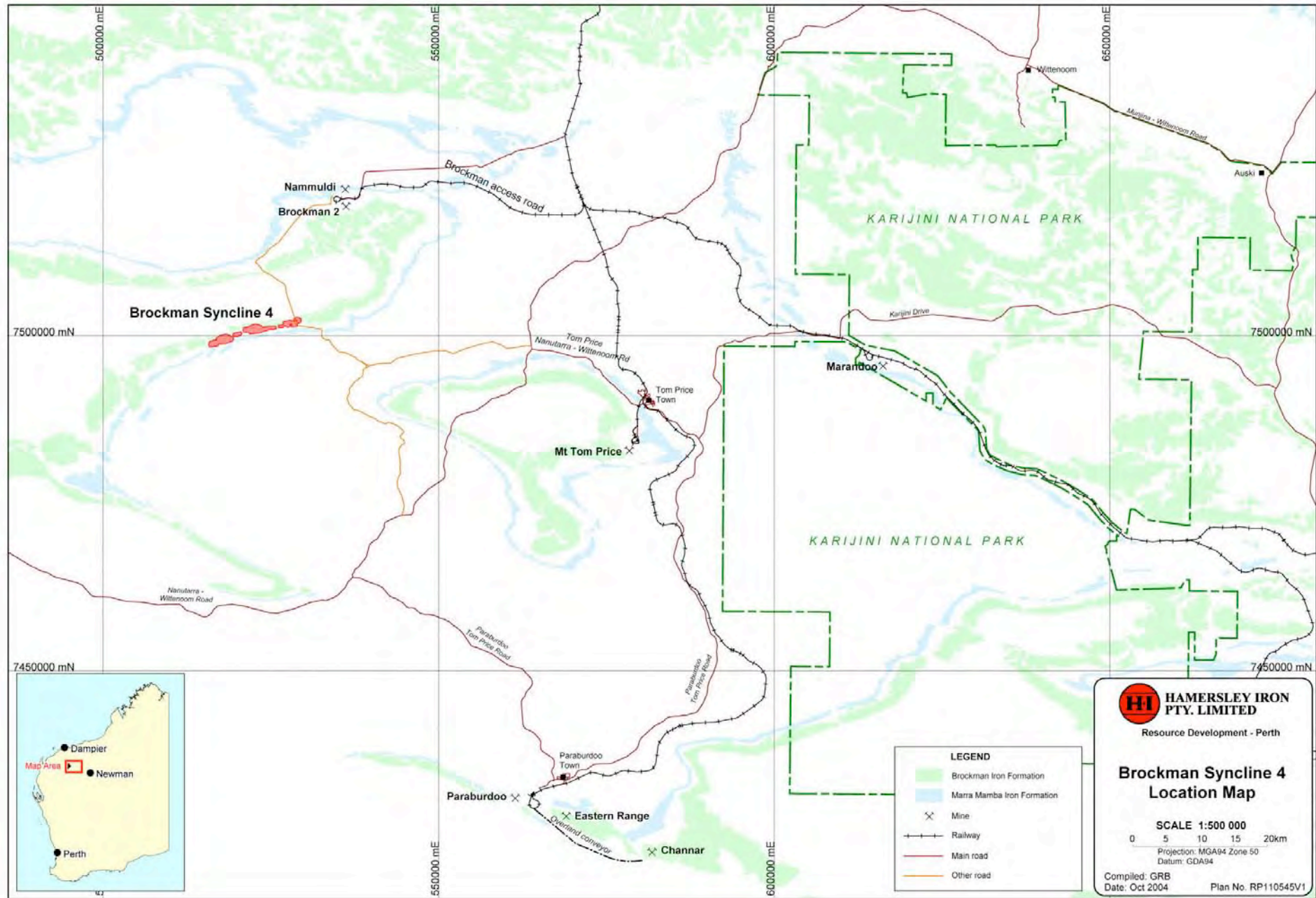


Figure 2.1: Location of the BS4 Project area, in relation to other existing or proposed mining areas near Tom Price.

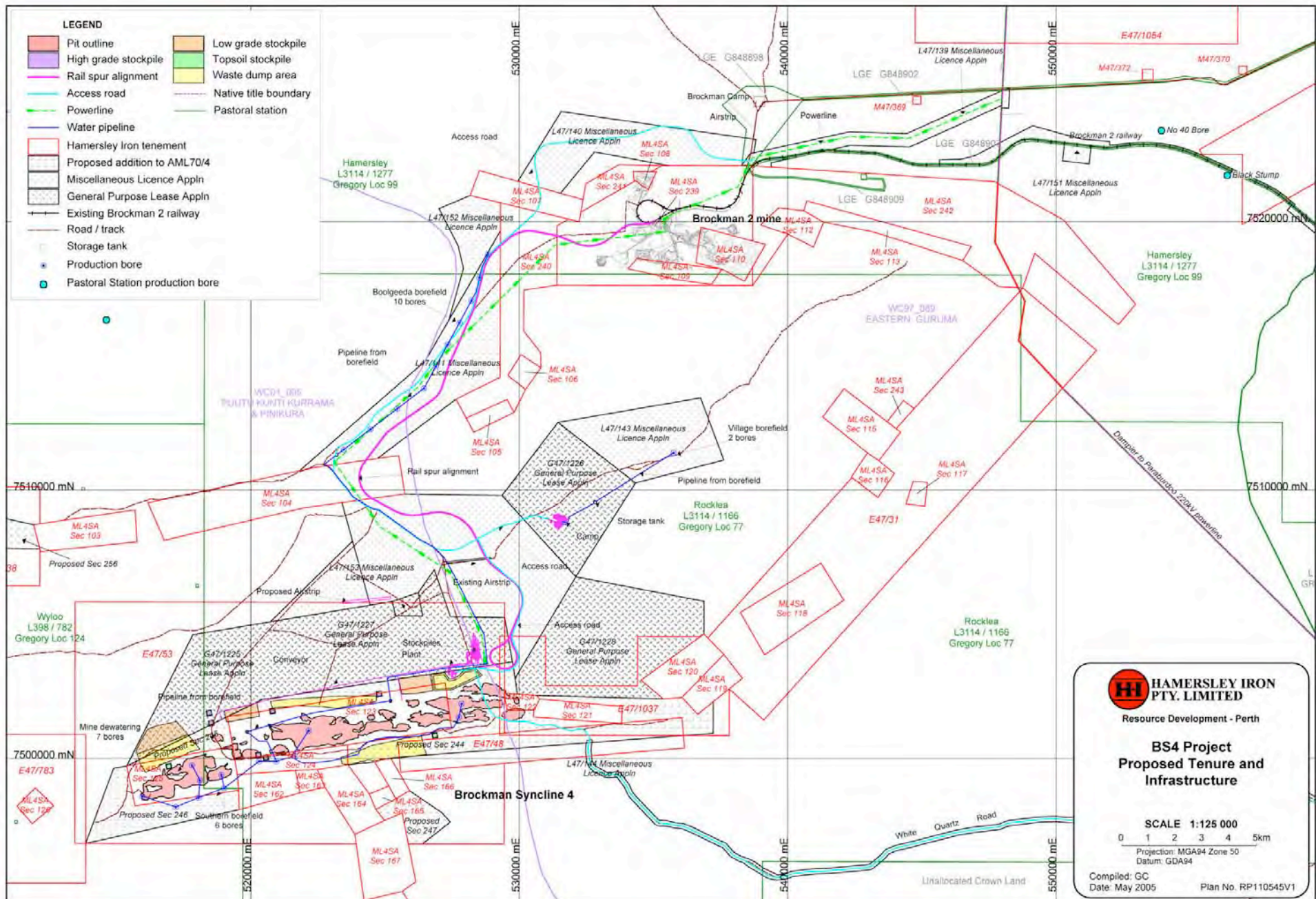


Figure 2.2: **Proposed** layout of the BS4 Project.

## 2.3 Purpose of this Report

This report describes the methodology employed for the vegetation and flora survey of the BS4 Project area, documents the findings of the survey, and presents management recommendations to minimise impacts of the Project. It is intended for use as a supporting document to the Public Environmental Review (PER) for the BS4 Project, to be assessed as part of the Environmental Impact Assessment process. The survey itself and this document are subject to certain limitations, outlined in Section 3.9).

## 2.4 Existing Environment

### 2.4.1 Geology of the BS4 Project Area

The BS4 Project area includes a variety of geological types. On the Geological Survey of Western Australia 1:500,000 scale map sheets (Thorne and Trendall 2001), these are:

- AFm (Maddina Formation: massive to amygdaloidal basaltic flows and breccia, andesite, dacite and rhyolite; local thin beds of sandstone and dolomite: metamorphosed),
- AFj (Jeerinah Formation: Carbonaceous mudstone and siltstone, thin-bedded sandstone, chert, felsic volcanoclastic rock, basalt, and dolomite: metamorphosed), and
- AHm (Marra Mamba Iron Formation: chert, banded iron-formation, mudstone, and siltstone; metamorphosed); all dominating the low hills of the BS4 Project area;
- Qx (Undivided Quaternary Deposits: includes colluvium, reworked alluvium, eolian sand, and clay) dominating the broad valley in the north of the main Project area; and
- PHb (Brockman Iron Formation: banded iron-formation, chert, mudstone and siltstone; metamorphosed) around the margins of the broad valley.

### 2.4.2 Major Physiographic Units

Beard (1975) identified four major physiographic units within the Fortescue District:

- Abydos Plain - extending from Cape Preston east to Pardoo Creek, and south to the Chichester Range; including alluvial plains, low stony hills and granite outcrops; comprising largely granitic soils, with alluvial sands on the coastal portion;
- Chichester Plateau - a plateau of mainly basalts, with included siltstone, mudstone, shale, dolomite and jaspilite; forming a watershed between numerous rivers flowing north through the Abydos Plain to the coast, and the Fortescue drainage on the southern side of the range;
- Fortescue Valley - occupying a trough between the Chichester and Hamersley Plateaux; the eastern portion drains into the Fortescue Marshes; and
- Hamersley Plateau - rounded hills and ranges, mainly of jaspilite and dolomite with some shale, siltstone and volcanics.

The BS4 Project area lies towards the western end of the Hamersley Plateau.

### 2.4.3 IBRA Bioregion

The Interim Biogeographic Regionalisation for Australia (IBRA) recognises 85 bioregions (Environment Australia 2000). The BS4 Project area lies within the Pilbara bioregion, which is divided into four subregions: Roebourne Plains, Chichester, Fortescue Plains and Hamersley. These subregions are largely equivalent to the physiographic regions of Beard (1975) (see Section 2.4.2), although the coastal portion of Beard's Abydos Plain unit comprises the Roebourne Plains subregion, while the inland portion is included under the Chichester subregion. The BS4 Project is located at the western end of the Hamersley subregion.

With increasing survey work in the Pilbara, it is becoming apparent that this region is one of the centres of biodiversity in the State. This appears to be related to the diversity of geological, altitudinal and climatic elements in the region, as well as a function of its location. The Pilbara is located in a transitional zone between the floras of the Bassian (southwest), Eyrean (central desert) and southern Torresian (tropical) bioclimatic regions, and contains elements of all of these floras (see for example van Leeuwen and Bromilow (2002) for a detailed discussion of the significance of the Hamersley Range). In recognition of this high species diversity and the high levels of endemism in the region, the Pilbara has been nominated as one of 15 national biodiversity “hotspots” by the Minister for the Environment and Heritage (go to [www.deh.gov.au/minister/env/2003/mr03oct03.html](http://www.deh.gov.au/minister/env/2003/mr03oct03.html)).

#### **2.4.4 Conservation Reserves in the Locality**

The main conservation reserve in the locality is Karijini National Park, some 90 km to the east of the BS4 Project area.

The Pilbara bioregion is listed as a medium priority for funding for land purchase under the National Reserves System Co-operative Program due to the limited representation of the area in conservation reserves. Portions of various pastoral leases in the region have been nominated for exclusion for public purposes in 2015, when the leases come up for renewal. Many of the submissions are from the Department of Conservation and Land Management, with the intention of adding these areas to the existing conservation estate in order to provide a comprehensive, adequate and representative reserve system. None of these proposed exclusions are located in the vicinity of the BS4 Project.

#### **2.4.5 Land Systems of the BS4 Project Area**

Land System (Rangelands) mapping covering the BS4 Project area has been prepared by the Western Australian Department of Agriculture (Payne et al. 1988, Department of Agriculture 2002) (see Figure 2.3). These are broad units that each consist of a series of “land units” that occur on characteristic physiographic types within the Land System.

One hundred and seven (107) Land Systems occur in the Pilbara bioregion (see Section 2.4.3). [This information was obtained by merging the Ashburton Land System mapping (Payne et al. 1988) and Pilbara Land System mapping (Department of Agriculture 2002) and intersecting this with the Pilbara bioregion (Environment Australia 2000) in ArcView 3.2.]

The Project area includes areas of the Land System units listed in Table 2.1. (Note that the areas of calcrete in the northwestern corner of the main BS4 Project area that were mapped by Payne et al. (1988) as Robe Land System have been reclassified by us as Table Land System, as the latter is believed to be a more accurate representation.)

With the exception of the Table Land System, all of the Land Systems in the BS4 Project area are relatively extensive in terms of their area within the Pilbara bioregion. When the resultant Land System areas are ranked from 1 (smallest area within the Pilbara bioregion) to 107 (greatest area), Rocklea ranked 107<sup>th</sup>, Newman 106<sup>th</sup>, Boolgeeda 103<sup>rd</sup>, River 101<sup>st</sup>, Platform 92<sup>nd</sup> and Robe 76<sup>th</sup>. The Table Land System ranked 31<sup>st</sup>, with a total area of 20,645 ha or approximately 0.1% of the total area of the Pilbara bioregion.

The area of each Land System within the BS4 Project area is less than 1% of the total mapped for the Pilbara with the exception of the area of Table Land System, which is 1.5% of the total (Table 2.2).

Most of the Land Systems occurring in the BS4 Project area are widespread through at least the Hamersley subregion, whilst the River, Newman and Rocklea Land Systems are widespread through the entire Pilbara bioregion (see Table 2.2). The Table Land System has scattered occurrences within the Pilbara bioregion, but is relatively widespread in the northern Gascoyne region (the extent of the Ashburton Land System mapping).

All of the Land Systems occurring within the BS4 Project area are also represented within the Karijini National Park, some 90 km to the east.

Table 2.1: Land Systems in the BS4 Project area (data from Payne et al. 1988, Department of Agriculture 2002).

Land System	Description
Boolgeeda	Stony lower slopes and plains found below hill systems supporting hard and soft spinifex grasslands and mulga shrublands; occupies the north-eastern section of the main BS4 Project area as well as the majority of the transport corridor.
Newman	Rugged jaspillite plateaux, ridges and mountains supporting hard spinifex grasslands; coincides with the orebodies and a small section of the transport corridor.
Platform	Dissected slopes and raised plains supporting hard spinifex grasslands; occurs as small areas within the centre and on the eastern edge of the main BS4 Project area and within the transport corridor.
River	Active flood plains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands; common throughout the Pilbara in major river systems such as the Yule, de Grey and Fortescue Rivers, and Weeli Wolli Creek; only one occurrence mapped, along the northern edge of the main BS4 Project area within Boolgeeda Creek.
Robe*	Low limonite mesas and buttes supporting soft spinifex (and occasionally hard spinifex) grasslands; occurs as narrow areas along the southern boundary of the main BS4 Project area.
Rocklea	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands; small occurrences along the southern edge of the main BS4 Project area.
Table*	Low calcrete plateaux; occurs as two areas in the north-western section of the main BS4 Project area.

\* Based on our ground-truthing of the BS4 Project area, two polygons ascribed to the Robe Land System by Payne et al. (1988) actually represent the Table Land System, as characterized by the presence of calcrete outcroppings. Both of these polygons are in the north-western portion of the main Project area.

Table 2.2: Distribution of Land Systems within the BS4 Project area and wider Pilbara region (data from Payne et al. 1988 and Department of Agriculture 2002).

Land System	Total Area in the Pilbara Bioregion (Rank†)	Number of Mapping Polygons in the Pilbara Bioregion	General Distribution through the Pilbara Bioregion	Area within BS4 Project Area	
				Hectares	% of total in Pilbara bioregion
Boolgeeda	961,634 ha (103 <sup>rd</sup> )	588	Widespread with a large number of occurrences, particularly through the Hamersley Range subregion.	5409.05	0.6%
Newman	1,993,741 ha (106 <sup>th</sup> )	321	Relatively widespread through the Hamersley Range, also occurring as a band along the Chichester Range to the north of the Fortescue Marsh; numerous occurrences.	4,518.07	0.2%
Platform	236,335 ha (92 <sup>nd</sup> )	169	Occurs predominantly in the Hamersley Range with small occurrences also in the Chichester Range.	518.18	0.2%
River	482,175 ha (101 <sup>st</sup> )	126	Widespread in major river systems.	697.96	0.1%
Robe*	128,859 ha (76 <sup>th</sup> )	251	Occurs within the central and western region of the Hamersley subregion, with a few occurrences in the Chichester subregion.	100.76	0.1%
Rocklea	2,881,199 ha (107 <sup>th</sup> )	385	Widespread through both the Hamersley and Chichester Ranges.	247.65	<0.1%
Table*	20,645 ha (31 <sup>st</sup> )	47	Scattered occurrences in the south of the Pilbara bioregion and also within the Gascoyne bioregion.	304.09	1.5%
Pilbara Total	17,800,478 ha	5636			

† Ranking of Land System in terms of area out of the 107 Land Systems in the Pilbara bioregion; ranked from least abundant in terms of area (1) to most abundant (107).

\* Based on our ground-truthing of the BS4 Project area, two polygons ascribed to the Robe Land System by Payne et al. (1988) actually represent the Table Land System, as characterized by the presence of calcrete outcroppings. Both of these polygons are in the north-western portion of the main Project area.

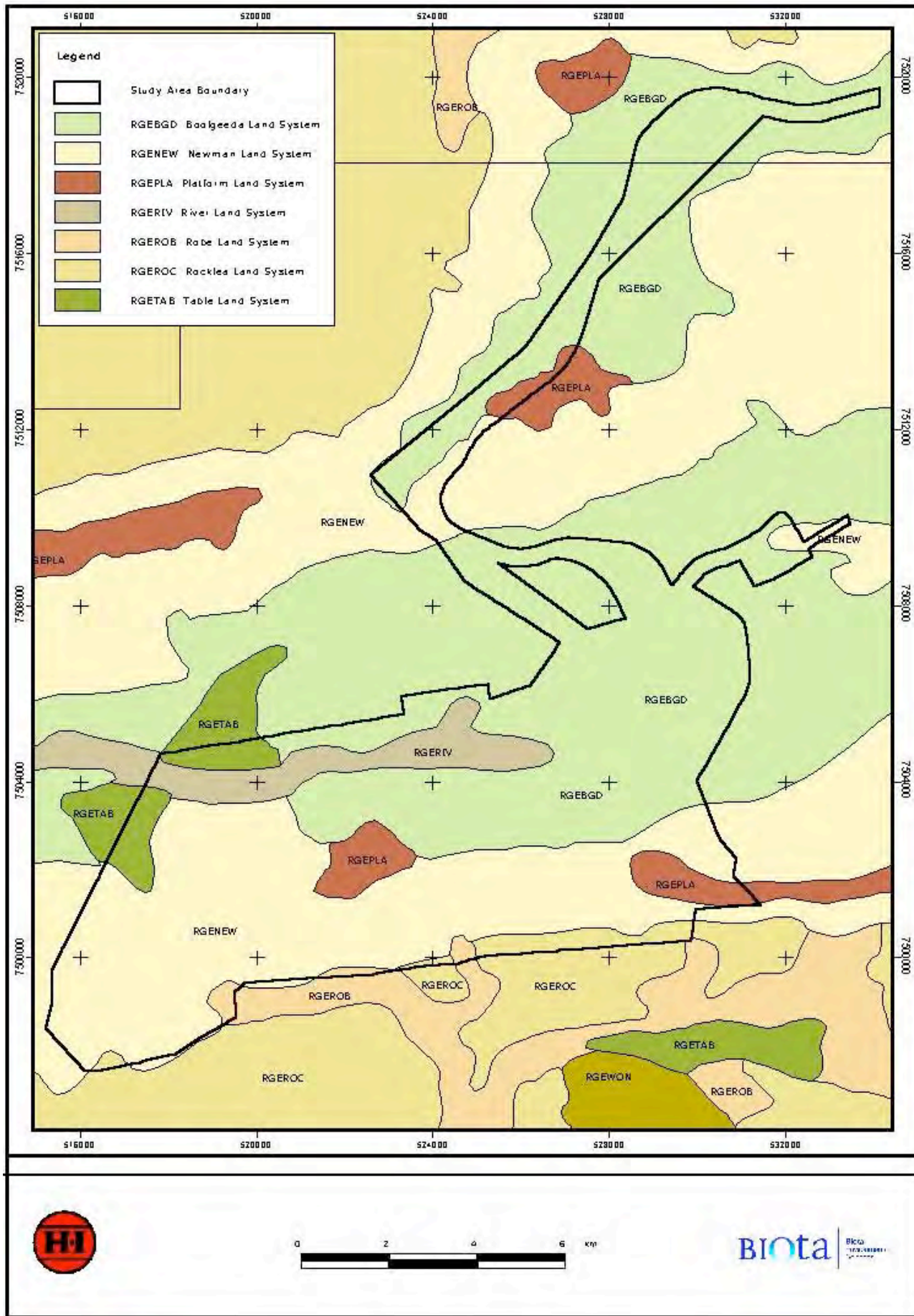


Figure 2.3: Land Systems of the region including the BS4 Project area.



## 2.4.6 Previous Botanical Studies in the Area

### *Beard's Vegetation Mapping*

Beard (1975) mapped the vegetation of the Pilbara at a scale of 1:1,000,000. The BS4 Project area lies entirely within the Fortescue Botanical District of the Eremaean Botanical Province as defined by Beard. The vegetation of this province is typically open, and frequently dominated by spinifex, wattles and occasional Eucalypts.

The BS4 Project area contains two of Beard's broad mapping units:

- Snappy Gum *Eucalyptus leucophloia* scattered trees over *Triodia wiseana* hummock grassland on the hills of the BS4 range and the stony undulating plains of the transport corridor; and
- An area of Mulga *Acacia aneura* continuous low woodland on the broad stony plain to the north of the BS4 range.

Given the coarse scale of Beard's mapping, these mapping units show only a broad correspondence with the vegetation types identified by the current study (see Section 4.2).

### *Other Botanical Studies*

Like much of the Pilbara region, the area surrounding and including the BS4 Project area is relatively poorly known. There are no published studies relating specifically to the area.

We are aware of only two botanical studies that have been done in the Brockman area, both of which are unpublished:

- A flora and vegetation survey of the Brockman 2 detritals and transport corridor (Mattiske and Associates 1990); and
- A flora and vegetation survey of the Nammuldi and Silvergrass areas, near Brockman 2 (Halpern Glick Maunsell 1999).

As mentioned previously, the Department of Agriculture (2002) has carried out a broadscale survey of parts of the Pilbara. This will result in brief descriptions of the vegetation of the Land Systems (Rangelands), however these are not yet available. CALM has also sampled flora of numerous hilltops in the Hamersley Range (van Leeuwen and Bromilow 2002).

## 3.0 Methodology

### 3.1 Desktop Review

Information reviewed for this study included:

- internal reports by Hamersley Iron Pty Ltd describing rare flora searches of the BS4 Project area;
- a search of the CALM and Western Australian Herbarium databases for Declared Rare Flora (DRF) and Priority Flora recorded in the vicinity of Brockman; and
- review of information provided by the documents described in Section 2.4.6.

The search of the CALM and WA Herbarium databases was done in January 2005 for DRF and Priority Flora recorded within a ~150 km<sup>2</sup> area centred on the BS4 Project area. The search area was bounded by the following coordinates:

- NW: 116° 30' E, 22° S;
- NE: 118° E, 22° S;
- SE: 118° E, 23° 30' S; and
- SW: 116° 30' E, 23° 30' S.

The search yielded 88 records of 37 Priority species (no Declared Rare Flora records were returned for this area). The locations of these records were investigated in ArcView to indicate populations in the vicinity of the BS4 Project area.

### 3.2 Botanical Survey Team and Field Survey Timing

Rare flora searches of the BS4 Project core area were carried out by Emil Thoma and Anna Joder (botanists with Hamersley Iron) from the 27th of February to the 7th of March, the 10th to 15th of April, the 26th to 29th of May, and the 4th to 11th of June 2003. Michi Maier and Kelli McCreery (botanists with Biota) also participated in the searches from the 4th to 7th of March 2003. Additional rare flora searches were done along some proposed hydrological drill lines immediately west of the BS4 Project area between 4th and 9th of May and on June 3rd by Emil Thoma and Anna Joder.

The vegetation survey and the overall flora survey were carried out by Michi Maier, Raimond Orifici and Hana Eynon (botanists with Biota) between the 6th and 16th of October 2004.

There were no particularly heavy rainfall events over the summer of 2003, however rainfall was sustained and relatively consistent (see Figure 3.1). Numerous annual species were recorded during the rare flora searches done in 2003, and it is believed that ephemeral rare flora (and other cryptophytes such as the Priority 4 *Goodenia stellata*, which dies back to a perennial rootstock on a seasonal basis) would have been observed if present. Conditions during the vegetation and flora survey in 2004 were dry and many ephemeral flora were dead, however most species were still recognisable. It is estimated that greater than 90% of the flora present within the BS4 Project area would have been recorded through the survey work conducted in the area to date.

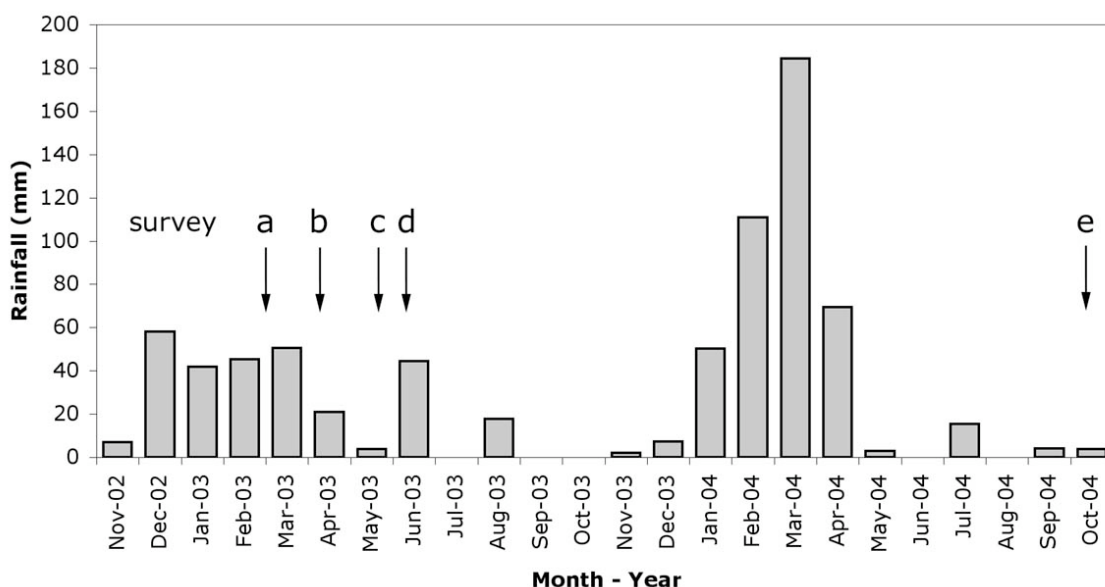


Figure 3.1: Monthly rainfall for Tom Price from November 2002 to October 2004 and timing of the flora surveys (data supplied by Bureau of Meteorology). Survey codes: a, b, c, d = rare flora searches in early March, April, May and June of 2003 respectively; e = vegetation and flora survey in October 2004.

### 3.3 Rare Flora Searches

A total of 66 person days was spent searching the BS4 Project core area for rare flora between February and June 2003 (see Section 3.2). The BS4 range and sections of the flats surrounding it were traversed systematically on foot, with observers spaced between 50-80 m apart depending on the terrain and density of vegetation (see Figure 3.2). The transport corridor has not been surveyed for rare flora, however the final transport route and any other infrastructure areas not yet searched will be surveyed prior to construction.

The locations of any Priority flora or other flora of interest were recorded using a hand-held GPS in WGS84 datum, Zone 50 (equivalent to GDA94 datum). Estimates were made of population size, and other details such as habitat and associated flora species were also noted. Voucher specimens were also collected for lodgement with the Western Australian Herbarium. Rare Flora Report forms will be completed and lodged with CALM by Hamersley Iron.

### 3.4 Assessment of Floristic Quadrats

The locations of the detailed flora recording quadrats were chosen to represent the range of vegetation types occurring within the BS4 Project area.

Quadrats were typically 50 m x 50 m, as this size gives a good sample of flora presence in the Pilbara. It also gives a good indication of the shrub and grass layer vegetation structure for most vegetation types in the Pilbara that occur in 'uniform' habitats (eg. plains and hillslopes, where vegetation stands are typically greater than this quadrat size). Quadrat shape and/or size were adjusted as necessary to fit smaller or oddly shaped habitats (eg. flowlines).

Quadrats were permanently marked using a steel fence dropper at one corner of the quadrat (usually the NW corner). Quadrats were uniquely numbered from BRO01 to BRO50 (note that "BRO48" was not used). Relevés were assigned a unique code using the BRO prefix, followed by the initial of the recording botanist, followed by sequential letters (eg. BRO-MF).

The following parameters were recorded for each quadrat:

1. Location: AMG coordinates recorded in WGS84 datum (within 1-2 m of GDA94) using a hand-held Global Positioning System (GPS), to an accuracy usually within 5 m; readings usually taken for all four corners of the quadrat;
2. Vegetation Description: Broad description based on the height and estimated cover of dominant species after Aplin's (1979) modification of the vegetation classification system of Specht (1970) (see Appendix 4);
3. Habitat: Description of landform and habitat;
4. Soil: Broad description of soil type and stony surface mantle;
5. Disturbance Details: Evidence of grazing, mining exploration activities, weed invasion, frequent fires etc. Note that fire effects are only considered as a negative impact if they are caused by repeated burning (such as that done for pastoral purposes). Fire is a natural and frequent process in the Pilbara to which the vegetation has adapted, and to class areas as being in poor condition simply because they have been recently burnt is misleading; and
6. Percentage Foliar Cover: Cover was estimated visually for each species. Estimates were made to the nearest percent where possible, or a range (eg. 5-10%) was used. '+' was used where only occasional individuals were present, with a cover of less than 1%.

Colour photographs of the vegetation at each site were taken using a digital camera.

Opportunistic flora collections were also made to supplement the list of species recorded from the flora survey sites. Particular attention was paid to searching habitats likely to support flora species with sporadic distributions (eg. creeklines and gorges).

### 3.5 Vegetation Description

In the current study, vegetation descriptions were based on the height and estimated cover of dominant species using Aplin's (1979) modification of the vegetation classification of Specht (1970) to include a hummock grassland category (see Appendix 4). Descriptions were made at each of the 49 quadrats (see Section 3.4), and at numerous relevés (unbounded flora survey sites).

The vegetation descriptions were grouped to arrive at vegetation units that were defined on the basis of a shared suite of perennial species with a similar range of cover values. These have been listed under the main landform/habitat type in which they were found to occur. Alternative approaches could utilise another framework, such as Land System mapping or geology.

An arbitrary coding system was used for the vegetation types, which incorporated:

- a letter designating the habitat / vegetation type: stony hills and ridges (including gorges) (H); creeks and floodplains (C); plains (P); and
- a number to further separate vegetation types within each group.

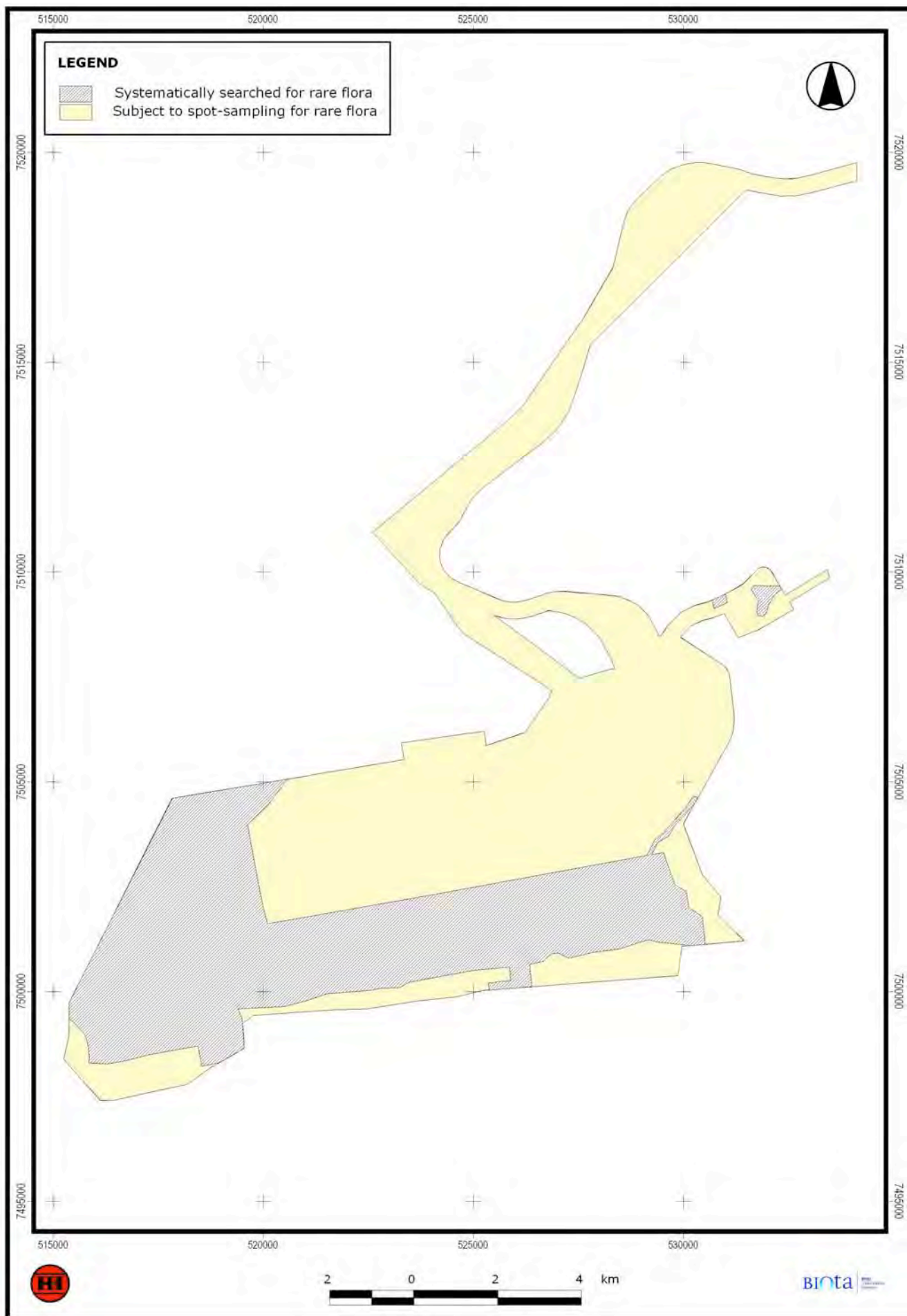


Figure 3.2: Rare flora survey effort within the BS4 Project area. Grey areas have been systematically searched for rare flora; other areas have been spot-sampled only.

### 3.6 Vegetation Mapping

To gather the spatial information, the quadrat and relevé vegetation descriptions were used together with the other mapping notes gathered in the field to prepare a draft map of vegetation, using rectified 1:20,000 scale colour digital photography as the background. Some of the vegetation units (mainly small flowlines) were frequently too small to show at the scale of mapping; only large occurrences of these were individually mapped.

The vegetation boundaries were subsequently digitised on-screen using the ArcView 3.2 package. The resulting shapefiles were "tagged" to provide each polygon with the vegetation unit code. Other point source datasets, such as locations of quadrats, weeds and priority flora, were generated into spatial data using MapInfo. These datasets were subsequently saved as separate MapInfo shapefiles.

These datasets, in conjunction with other data supplied from other organisations, were used in the production of the vegetation maps (Appendix 1) contained in this report. All maps were produced using the MapInfo package.

### 3.7 Specimen Identification, Nomenclature and Data Entry

Common species that were well known to the survey botanists were identified in the field. Voucher specimens of all other species were collected and assigned a unique number to facilitate tracking of data. These were pressed in the field, and dried in a drying oven.

These vouchers were then identified by keying out, reference to appropriate publications, use of a reference collection held by ME Trudgen and Associates, and comparison to the collections held at the Western Australian Herbarium. Most specimens were identified by Michi Maier and Raimond Orifici of Biota, with assistance from Mr Malcolm Trudgen of M.E. Trudgen and Associates for various problematic groups (see Section 7.0). Specimens will be lodged with the Western Australian Herbarium and Karratha Regional Herbarium for all taxa for which suitable material is available.

Nomenclature was checked against the current listing of scientific names recognised by the Western Australian Herbarium and updated as necessary. The only outdated nomenclature retained was that relating to *Cassia*. This genus is currently recognised as *Senna* (see Randell 1989), however the older *Cassia* classification (Symon 1966) was perceived to be a more realistic level of separation of the taxa (eg. with taxa such as '*glutinosa*' and '*pruinosa*' recognised at specific rather than subspecific level). A more detailed discussion is contained in Trudgen and Casson (1998), while a comparison of the nomenclature under the two classifications is presented in Appendix 3.

All raw site data was entered into an Access database structure developed by Malcolm Trudgen and Ted Griffin (private consultant) held at Biota, with species names entered following identification of the specimens.

### 3.8 PATN Analysis of the BS4 Floristic Data

To provide an understanding of the vegetation of the survey area in relation to the surrounding region, a floristic analysis was carried out using the PATN software package (Belbin 1987). This analysis compared the floristic composition of the 50 by 50m quadrats (and some relevés) recorded in the BS4 Project area with quadrats and relevés recorded in a series of survey areas from both nearby and some distance away in the Hamersley and Chichester Ranges. The PATN analysis was run by Mr Ted Griffin (private consultant), with assistance from Mr Malcolm Trudgen (ME Trudgen and Associates) to ensure that datasets were rationalised.

The analysis was run on presence/absence data for some 789 sites (standard 50m by 50m floristic survey quadrats, or well-recorded relevés). The combined dataset included 66 sites from the current study of the BS4 Project area, together with 723 sites from nine other survey areas in the Pilbara:

- 119 sites from Cape Preston, west of Dampier (Biota and Trudgen 2001); ~220 km northwest of BS4;
- 55 sites from Mesa A and Mesa G, near Pannawonica (Biota 2005c); ~150 km northwest of BS4;
- 12 sites from the Mesa J Extension, near Pannawonica (Biota 2003); ~150 km northwest of BS4;
- 102 sites from the West Angelas Millstream Rail Segment, extending from the Fortescue Slopes study area along the lower slopes of the Chichester Range parallel to the existing Hamersley Iron rail line, then to Barowanna Hill; ~120 km north of BS4;
- 46 sites from a rail corridor in the Four Corners Bore area on Hamersley Station (Trudgen and Casson 1998); ~60 km east of BS4;
- 2 sites from near Eight Mile Well on Hamersley Station (Trudgen and Casson 1998); ~60 km east of BS4;
- 305 sites from the core area surveyed for Robe River Iron Associates' West Angelas mine (Trudgen and Casson 1998); ~175 km east-southeast of BS4;
- 45 sites from Hamersley Iron's Yandi Expansion area (Biota 2004d); ~210 km east of BS4; and
- 37 sites from the Mindy Mindy area (Biota 2004c); ~225 km east of BS4.

Incompletely recorded floristic survey quadrats were excluded from the analysis, and relevés (unbounded floristic survey sites) were included where the list of species recorded was believed to be a good sample of the available flora.

The combined species list from the 10 projects was reviewed for errors and inconsistencies in nomenclature. Where there were multiple taxa that were considered likely to represent the same species, these were all referred to a single taxon identification code and thus treated as a single entity in the analysis (eg. records of *Convolvulus "angustissimus"* and *C. "clementii"* were treated as belonging to the same taxon, as were records of *Triodia epactia* and *Triodia pungens*). Where a taxon name could potentially refer to more than one entity across different projects (eg. *Euphorbia* sp., *Tephrosia* sp.), it was excluded from the analysis.

### 3.9 Limitations of this Study

A number of limitations of the field survey and subsequent conservation assessments are discussed in the following section. These are factors that must be considered when reviewing and applying the results of this study. Despite these limitations, the field study and the subsequent analyses are believed to give a reasonable representation of the flora and vegetation values of the BS4 Project area.

The main limitations of this study are as follows:

- Some areas of the BS4 Project area have not yet been searched for rare flora (particularly the transport corridor), however this is planned to be done prior to construction.
- Fungi and nonvascular flora (eg. algae, mosses and liverworts) were not specifically sampled.
- Although the field work was done at an appropriate time for detecting most ephemeral flora, some species (eg. annual daisies that would germinate mostly after late winter rains) would not have been present or identifiable at the time of survey.
- As the sites were only sampled once, additional species would probably be recorded if the sites were revisited. The species lists should therefore be taken as indicative rather than exhaustive.
- As the study sampled only a portion of the BS4 Project area, not all of the variation in vegetation, nor all the flora species, would have been identified.
- The vegetation units for this study were defined based on interpretation of aerial photography signatures combined with the site data and field mapping notes recorded

during the field survey. As it was not possible to map areas outside the BS4 Project area in this way, the distribution of these units outside the Project area can only be inferred by their correlation with the Land Systems mapping prepared by the Department of Agriculture. This means that there is a level of uncertainty regarding the assessment of distribution of these vegetation types outside the current Project area.

- The PATN floristic analysis is limited by a lack of comparable sites in the Brockman / Tom Price area. Sites from the two closest survey areas (Four Corners Bore and Eight Mile Well, both ~60 km from BS4) were mainly located on plains and lower slopes with substantial amounts of Mulga; only a small number of sites from Four Corners Bore were located in similar physiographic units to those occurring in the BS4 Project area (eg. *Triodia wiseana* hummock grasslands on low stony spurs).
- There would be some level of error associated with the species identifications contained in the combined dataset utilised for the PATN floristic analysis. Although most of the species identifications were done using comparison with a single reference set, some of the data comes from field identifications. The degree of such errors in this dataset is not believed to be of an order that would affect the outcomes. In addition, the various projects were done over a substantial timeframe (several years), and some taxa that were differentiated relatively recently (eg. *Triodia epactia*) would not have been distinguished in earlier surveys. The latter issue was dealt with by treating suspect taxa as a single entity (see above).
- The combined dataset used for the floristic analysis includes relevé as well as quadrat data. Some of the relevés in the datasets would have been less well sampled than others due to time / access restrictions. Any noted to be incomplete (or to sample mixed habitats) were excluded from the analysis, however some incomplete sites or sites representing mosaics may have been left in the dataset. As such sites would not be likely to group with well recorded sites, this was not considered to be a significant problem in the analysis, which was intended to see if variation in the BS4 Project area was replicated in the other survey areas.



## 4.0 Vegetation

### 4.1 Overview of Vegetation Types

Fifty-three (53) broad vegetation types were defined for the BS4 Project area. These included:

- hummock grasslands of *Triodia* species (mainly *T. wiseana*) with a variable shrub overstorey on low stony hills;
- tall shrublands of mixed species, usually with an overstorey of *Eucalyptus* or *Corymbia*, in creeklines;
- open woodlands of Coolibah *Eucalyptus victrix* over herblands in the gravelly bed of Boolgeeda Creek; and
- Mulga *Acacia "aneura"* and Snakewood *A. xiphophylla* tall shrublands over spinifex on plains.

#### 4.1.1 Level of the Vegetation Types

The vegetation types defined for the study would each incorporate a range of structural and floristic variants. The units described are considered to range from at, to somewhat higher than, the vegetation association level, although they are not strictly defined as vegetation associations. The structural and floristic variation they include undoubtedly covers a large number of vegetation communities. The broad nature of the units defined needs to be taken into account when using them for assessing conservation value of the vegetation.

### 4.2 Descriptions of Vegetation Types

A description of each vegetation type is given below, grouped under the main habitat type in which each was found to occur. Maps of the distribution of the vegetation types are presented in Appendix 1, together with representative photographs. The raw data from the individual detailed flora survey sites is contained in Appendix 4.

Note that an asterisk (\*) preceding a scientific name denotes that the species is introduced (not native). Note also that *Cassia* has been retained in preference to *Senna* in this document (see Section 3.7).

#### 4.2.1 Vegetation of Stony Hills

H1 *Corymbia hamersleyana* scattered trees over *Cassia pruinosa* open shrubland over *Triodia wiseana* hummock grassland

This vegetation type was recorded from low stony hills within the transport corridor. Other associated species: *Acacia exilis*, *A. inaequilatera*, *Amphipogon sericeus*, *Aristida contorta*, *Eriachne aristidea* and *Hibiscus sturtii* var. aff. *platyklamys*. Site BRO35.

H2 *Eucalyptus leucophloia* scattered low trees over *Acacia atkinsiana* open shrubland over *Triodia wiseana* mid-dense hummock grassland

This vegetation type was widespread on the tall stony hills of the BS4 range. Other associated species: *Acacia aneura*, *Cassia glutinosa*, *Hakea chordophylla*, *Paraneurachne muelleri*, *Paspalidium clementii*, *Ptilotus calostachyus* var. *calostachyus* and *Solanum lasiophyllum*. Relevés BRO-HA, BRO-MB, BRO-RA.

H3 *Eucalyptus leucophloia* scattered low trees over *Acacia maitlandii* shrubland to open heath over *Triodia wiseana* mid-dense hummock grassland

This vegetation type was recorded from the crests and upper slopes of tall stony hills in the southern section of the BS4 Project area. Scattered tall shrubs of *Hakea chordophylla* were also typically present. Other associated species: *Acacia atkinsiana*, *A. hamersleyensis*, *Dampiera candicans*, *Eriachne mucronata*, *Indigofera monophylla*, *Keraudrenia nephrosperma* and *Triodia epactia*. Sites BRO16, BRO29 and relevés BRO-MA, BRO-MF.

- H4 *Acacia hamersleyensis* tall open shrubland over *Triodia wiseana* closed hummock grassland  
This vegetation type was recorded from the slopes of the BS4 range. Other associated species: *Acacia maitlandii*, *Cassia pruinosa*, *Eriachne mucronata*, *Eucalyptus leucophloia* subsp. *leucophloia*, *Goodenia stobbsiana* and *Hakea chordophylla*. Site BRO18.
- H5 *Eucalyptus leucophloia* scattered low trees over *Acacia exilis* (*A. bivenosa*) open shrubland over *Triodia wiseana* mid-dense hummock grassland  
This vegetation type was recorded from low stony hills northeast of the airstrip. Other associated species: *Cassia luerssenii*, *C. pruinosa*, *Ptilotus exaltatus* var. *exaltatus* and *P. rotundifolius*. Site BRO39.
- H6 *Acacia pruinocarpa* tall open shrubland over *Acacia stowardii* open shrubland over *Acacia exilis* low shrubland over *Triodia wiseana* mid-dense hummock grassland  
This vegetation type was recorded from a single low stony hillcrest in the western section of the BS4 Project area. Other associated species: *Acacia* aff. *aneura* (scythe-shaped; MET 15,743), *A. marramamba* and *Grevillea berryana*. Relevé BRO-ML.
- H7 *Acacia stowardii* low open woodland over *Eremophila exilifolia* scattered shrubs over *Triodia epactia* mid-dense hummock grassland  
This vegetation type occurred on low stony ridges southwest of the existing BS4 camp. Other associated species: *Acacia ancistrocarpa*, *A. aneura*, *A. atkinsiana* and *A. bivenosa*. Site BRO47.
- H8 *Acacia ancistrocarpa* open heath to tall open shrubland over *Triodia wiseana* mid-dense to closed hummock grassland  
This vegetation type was recorded from areas of low stony hillslopes in the western and southern sections of the BS4 Project area. Other associated species: *Acacia bivenosa*, *A. marramamba*, *A. pruinocarpa*, *A. synchronicia*, *Cassia pruinosa*, *Indigofera monophylla* and *Ptilotus calostachyus* var. *calostachyus*. Site BRO20 and relevé BRO-RB.
- H9 *Eucalyptus leucophloia* scattered low trees over *Acacia inaequilatera* tall shrubland over *Triodia wiseana* mid-dense hummock grassland  
This vegetation was recorded along footslopes on the southern side of the BS4 range and on low hills in the transport corridor. A low shrubland of *Gompholobium karjini* ms. was present in places. Other associated species: *Acacia maitlandii*, *Amphipogon sericeus*, *Fimbristylis simulans*, *Goodenia stobbsiana*, *Indigofera monophylla*, *Paraneurachne muelleri* and *Ptilotus calostachyus* var. *calostachyus*. Sites BRO07, BRO24.
- H10 *Eucalyptus leucophloia* low open woodland over *Acacia bivenosa* open shrubland over *Triodia brizoides*, *T. epactia* hummock grassland and *Themeda* sp. Mt. Barricade, *Cymbopogon ambiguus* open tussock grassland  
This vegetation type was recorded from broad gorges in the BS4 range. Other associated species: *Acacia pyrifolia*, *Eriachne tenuiculmis*, *Gossypium robinsonii*, *Indigofera monophylla*, *Petalostylis labicheoides* and *Triodia wiseana*. Site BRO26 and relevé BRO-MM.
- H11 *Eucalyptus leucophloia* scattered low trees over *Gossypium robinsonii*, *Dodonaea pachyneura* (*Acacia maitlandii*) open shrubland over *Triodia epactia* mid-dense hummock grassland  
This vegetation type was recorded from narrow gorges in the BS4 range and occasionally in the transport corridor. Other associated species: *Acacia monticola*, *A. pyrifolia*, *Cassia glutinosa*, *Corymbia ferriticola* subsp. *ferriticola*, *Cymbopogon ambiguus*, *Eriachne mucronata*, *Indigofera monophylla*, *Jasminum didymum* subsp. *lineare*, *Themeda* sp. Mt. Barricade and *T. triandra*. Site BRO14 and relevé BRO-MH.
- H12 *Eucalyptus leucophloia* low open woodland over *Acacia hamersleyensis* open shrubland over *Triodia brizoides*, *T. epactia* mid-dense hummock grassland and *Themeda triandra*, *Eriachne mucronata* open tussock grassland  
This vegetation type was recorded from gorges in the BS4 range. *Eucalyptus pilbarensis* was also sometimes present. Other associated species: *Cymbopogon ambiguus* and *Themeda* sp. Mt. Barricade. Site BRO17 and relevé BRO-MC.
- H13 *Corymbia ferriticola*, *Eucalyptus leucophloia* scattered low trees over *Acacia hamersleyensis* scattered tall shrubs over *Dodonaea pachyneura* open shrubland over *Eriachne mucronata*, *E. tenuiculmis*, *Cymbopogon ambiguus* open tussock grassland and *Triodia epactia* open hummock grassland  
This vegetation was recorded from a narrow rocky gully in the BS4 range. Other associated species: *Petalostylis labicheoides* and *Themeda* sp. Mt. Barricade. Relevé BRO-ME.

H14 *Eucalyptus leucophloia* scattered low trees over *Triodia wiseana* mid-dense hummock grassland  
This vegetation was recorded from the crests of low stony hills in the BS4 core area and also occasionally in the transport corridor. Apart from the dominant flora, other species occurred at very low densities. Other associated species: *Acacia pruinocarpa*, *Hakea chordophylla* and *Solanum lasiophyllum*. Site BRO44.

H15 *Eucalyptus leucophloia* scattered low trees over *Triodia epactia* mid-dense hummock grassland  
This vegetation was recorded from the lower slopes of hills in the BS4 core area and also occasionally in the transport corridor. As for vegetation type H14, species other than the dominant flora occurred as only scattered individuals. Other associated species: *Acacia pruinocarpa*, *Goodenia stobbsiana*, *Indigofera monophylla* and *Ptilotus calostachyus* var. *calostachyus*. No sites from this study.

H16 *Eucalyptus leucophloia* scattered low trees to low open woodland over *Astrotricha hamptonii*, *Ficus brachypoda* scattered tall shrubs over *Themeda* sp. Mt Barricade, *Eriachne mucronata* open tussock grassland and *Triodia brizoides*, *T. epactia* open hummock grassland  
This vegetation was recorded from the small breakaways that occur on the southern side of hills within the BS4 range. Pockets of Mulga were often present. Other associated species: *Cassia glutinosa*, *Dodonaea pachyneura* and *Harnieria kempeana* subsp. *muelleri*. No sites from this study.

#### 4.2.2 Vegetation of Plains

P1 *Acacia* aff. *aneura* (narrow fine veined; site 1259), *A. ayersiana*, *A. tetragonophylla* tall shrubland over *Eremophila forrestii*, *Acacia bivenosa* shrubland over *Triodia epactia* mid-dense hummock grassland

This vegetation type was recorded only in the western section of the BS4 Project area, from the broad drainage area through the valley south of the BS4 range. Other associated species: *Acacia synchronicia*, *Corymbia hamersleyana* and *Petalostylis labicheoides*. Relevé BRO-MD.

P2 *Acacia ayersiana* low open forest/woodland over *Eremophila forrestii* open shrubland over *Triodia epactia*, *T. wiseana* hummock grassland

This vegetation was recorded from plains at the head of a drainage system in the eastern section of the BS4 Project area. Other associated species: *Acacia atkinsiana*, *Eriachne pulchella* subsp. *dominii*, *Streptoglossa bubakii* and *Trichodesma zeylanicum* var. *zeylanicum*. Site BRO04.

P3 *Eucalyptus leucophloia* scattered low trees over *Acacia aneura* (various forms), *A. ayersiana* tall open shrubland over *Triodia epactia*, *T. wiseana* mid-dense hummock grassland

This vegetation was recorded from plains surrounding the BS4 range. Three forms of Mulga (*Acacia aneura*) were present as dominants in the overstorey strata: *Acacia* aff. *aneura* (narrow fine veined; site 1259), *A. aff. aneura* (scythe-shaped; MET 15,743), and *A. aneura* var. *longicarpa*. The hummock grassland was dominated by varying amounts of *Triodia epactia* and/or *T. wiseana*. Other associated species: *Acacia bivenosa*, *A. stowardii*, *A. synchronicia*, *Ptilotus exaltatus* var. *exaltatus* and *P. polystachyus* var. *polystachyus*. Sites BRO01, BRO05, BRO28.

P4 *Acacia xiphophylla*, *A. aneura* (flat curved; MET 15,548) low woodland to tall open shrubland over *Eremophila cuneifolia*, *Rhagodia eremaea* low open shrubland over *Triodia wiseana* open to mid-dense hummock grassland

This vegetation type was recorded from stony plains surrounding the BS4 range. The hummock grassland was very occasionally dominated by *Triodia epactia*. Other associated species: *Acacia bivenosa*, *A. synchronicia*, *Cassia oligophylla*, *C. "stricta"*, *Enchylaena tomentosa*, *Maireana georgei*, *Ptilotus obovatus* var. *obovatus*, *Salsola tragus* and *Solanum lasiophyllum*. Sites BRO19, BRO23.

P5 *Acacia xiphophylla*, *A. aff. aneura* (narrow fine veined; site 1259) tall shrubland over *Triodia brizoides*, *T. epactia* open hummock grassland

This vegetation type occurred in patches on the stony plain in the valley at the southernmost edge of the BS4 Project area. Other associated species: *Acacia synchronicia*, *Cassia "stricta"*, *Eucalyptus leucophloia* subsp. *leucophloia*, *Ptilotus schwartzii* var. *schwartzii* and *Triodia longiceps*. Site BRO43 and relevé BRO-MI.

P6 *Corymbia deserticola* scattered low trees over *Acacia atkinsiana*, *A. exilis* tall open shrubland over *Triodia wiseana* closed hummock grassland

This vegetation type occurred on stony undulating plains surrounding the BS4 range and in the transport corridor. The shrub overstorey was dominated by varying amounts of *Acacia atkinsiana* and *A. exilis*, sometimes with other species such as *A. inaequilatera*. Other associated species: *Acacia ancistrocarpa*, *A. bivenosa*, *A. stowardii*, *Cassia pruinosa*, *Goodenia stobbsiana*, *Haloragis gossei*, *Ptilotus rotundifolius* and *Stackhousia intermedia*. Sites BRO02, BRO03, BRO15, BRO30, BRO37.

- P7 *Corymbia deserticola* low open woodland over *Acacia atkinsiana* shrubland to tall shrubland over *Triodia epactia*, *T. wiseana* mid-dense hummock grassland  
This vegetation type was recorded from areas of the stony undulating plains that were extensively dissected by minor flowlines. The vegetation was similar to vegetation type P6 but had a more dense shrub overstorey and included *Triodia epactia* in the hummock grassland understorey. Other associated species: *Acacia ancistrocarpa*, *A. aneura* var. *longicarpa*, *A. exilis*, *A. tenuissima*, *Amphipogon sericeus*, *Codonocarpus cotinifolius*, *Eucalyptus gamophylla*, *Hakea lorea* subsp. *lorea*, *Paraneurachne muelleri* and *Ptilotus helipteroides* var. *helipteroides*. Sites BRO08, BRO33, BRO36.
- P8 *Eucalyptus xerothermica* low open woodland over *Eremophila fraseri* scattered shrubs over *Triodia wiseana* mid-dense hummock grassland  
This vegetation type was recorded only from areas of stony undulating plain north of the existing BS4 camp. Other associated species: *Acacia exilis*, *Cassia luerssenii*, *Solanum lasiophyllum* and *Triodia epactia*. Site BRO50.
- P9 *Eucalyptus socialis* low open woodland over *Triodia wiseana* open hummock grassland  
This vegetation type was recorded from small patches of calcrete in the transport corridor. Other associated species: *Goodenia microptera*, *Haloragis gossei*, *Paraneurachne muelleri*, *Ptilotus exaltatus* var. *exaltatus*, *P. clementii*, *Salsola tragus* and *Templetonia egena*. Site BRO34.
- P10 *Eucalyptus leucophloia*, *E. xerothermica* scattered low trees over *Acacia bivenosa*, *A. exilis* open shrubland to tall open shrubland over *Triodia wiseana*, *T. angusta* mid-dense hummock grassland  
This vegetation type was recorded from areas of stony calcrete plain in the western and southern sections of the BS4 Project area. The shrub layer was dominated by *Acacia bivenosa* and/or *A. exilis*. Other associated species: *Acacia bivenosa* (wispy/weeping form), *A. synchronicia*, *Cassia luerssenii*, *C. oligophylla*, *Corymbia hamersleyana*, *Gossypium australe* (Burrup Peninsula form), *Solanum lasiophyllum* and *Triodia epactia*. Site BRO21 and relevés BRO-MJ, BRO-MK.
- P11 *Acacia synchronicia* scattered shrubs over *Triodia angusta* mid-dense hummock grassland  
This vegetation type was recorded only from the very fine depositional substrates within the valley immediately south of the BS4 range. This was the main area from which the Priority 1 shrub *Ptilotus* sp. Brockman was collected (see Section 5.2.4). Other associated species: *Acacia bivenosa*, *Eucalyptus socialis*, *Maireana georgei*, *Pluchea dentex*, *Triodia brizoides* and *T. longiceps*. Site BRO13.
- P12 *Acacia synchronicia*, *A. bivenosa*, *Cassia pruinosa*, *C. luerssenii* mixed shrubland over *Triodia brizoides* closed hummock grassland  
This vegetation type was recorded from the broad stony plain in the valley at the southernmost edge of the BS4 Project area. Other associated species: *Acacia exilis*, *Cassia ? oligophylla* x, *Solanum lasiophyllum*, *Triodia epactia* and *T. longiceps*. Site BRO42.
- P13 *Acacia ancistrocarpa*, *A. bivenosa*, *A. synchronicia* open shrubland over *Triodia epactia* mid-dense hummock grassland  
This vegetation type occurred on stony plains, mainly at the western edge of the BS4 Project area. Other associated species: *Acacia pruinocarpa*. No sites from this study.
- P14 *Acacia inaequilatera*, *A. exilis*, *A. bivenosa* open shrubland over *Triodia epactia* mid-dense hummock grassland  
This vegetation type occurred on a broad plain surrounding a minor creekline northeast of the BS4 airstrip. No sites from this study.
- P15 *Acacia bivenosa*, *A. exilis*, *A. ancistrocarpa* open shrubland over *Triodia wiseana* mid-dense hummock grassland  
This vegetation type was recorded from stony plains through the western end of the BS4 Project area. Other associated species: *Petalostylis labicheoides*. No sites from this study.
- P16 *Triodia angusta*, *T. longiceps* mid-dense hummock grassland  
This vegetation type was recorded from stony plains within a valley at the eastern end of the BS4 Project area. No sites from this study.

### 4.2.3 Vegetation of Drainage Areas

- C1 *Eucalyptus victrix* scattered low trees to open woodland over *Goodenia lamprosperma*, *Pluchea dentex* very open hermland  
This vegetation occurred in the broad gravelly, cobbly bed of Boolgeeda Creek, in the channel of a moderate-sized creekline running north-south through the most western part of the BS4 Project area, and in a creekline in the transport corridor. Other associated species: *Ammannia multiflora*, *Bergia trimera*, *Digitaria brownii*, *Gomphrena cunninghamii* and *Stemodia grossa*. Sites BRO09, BRO49.

- C2 *Acacia pyrifolia*, *A. ancistrocarpa*, *Petalostylis labicheoides* shrubland over *Bonamia rosea*, *Tephrosia rosea* var. *glabrior* low open shrubland over *Triodia epactia* hummock grassland and *Themeda triandra* very open tussock grassland  
This vegetation type occurred on the broad, cobbly banks of Boolgeeda Creek, and also on low islands within it. Other associated species: *Acacia citrinoviridis*, *Corchorus lasiocarpus*, *Cullen lachnostachys*, *Eragrostis eriopoda*, *Eriachne mucronata*, *Indigofera monophylla*, *Jasminum didymum* subsp. *lineare*, *Ptilotus helipteroides* var. *helipteroides*, *P. obovatus* var. *obovatus*, *Scaevola spinescens* (broad form) and *Trichodesma zeylanicum* var. *zeylanicum*. Sites BRO10, BRO46.
- C3 *Eucalyptus xerothermica* scattered low trees over *Acacia citrinoviridis*, *Stylobasium spathulatum* tall shrubland over *Ptilotus obovatus* var. *obovatus* scattered shrubs over *Themeda triandra*, *Chrysopogon fallax* very open tussock grassland  
This vegetation type was recorded only from the floodplain of the moderate-sized creekline running north-south through the most western part of the BS4 Project area. Other associated species: *Acacia bivenosa*, *Amaranthus pallidiflorus*, *\*Cenchrus ciliaris*, *Cleome viscosa* and *Digitaria brownii*. Site BRO22.
- C4 *Acacia citrinoviridis* tall closed scrub over *\*Cenchrus ciliaris* closed tussock grassland  
This vegetation type was recorded from northern sections of the floodplain of the moderate-sized creekline running north-south through the most western part of the BS4 Project area. No sites from this study.
- C5 *Eucalyptus xerothermica*, *Corymbia hamersleyana* scattered low trees over *Acacia bivenosa*, *A. cowleana*, *A. elachantha*, *A. exilis* tall shrubland over *Triodia epactia* hummock grassland and *Eulalia aurea* open tussock grassland  
This vegetation type occurred in a moderate-sized creekline towards the northern end of the transport corridor. Other associated species: *Acacia ancistrocarpa*, *A. pyrifolia*, *Alternanthera nana*, *Bonamia rosea*, *Cassia oligophylla*, *Chrysopogon fallax*, *Digitaria brownii*, *Eremophila longifolia*, *Paraneurachne muelleri*, *Ptilotus obovatus* var. *obovatus*, *Solanum sturtianum*, *Themeda triandra* and *Triodia wiseana*. Site BRO32.
- C6 *Eucalyptus xerothermica* scattered low trees over *Gastrolobium grandiflorum* open heath over *Chrysopogon fallax*, *Eulalia aurea* tussock grassland  
This vegetation type occurred in patches along the centre of the moderate-sized creekline towards the northern end of the transport corridor. Other associated species: *Acacia pyrifolia*, *Alternanthera nana*, *Jasminum didymum* subsp. *lineare*, *Ptilotus obovatus* var. *obovatus* and *Themeda triandra*. Relevé BRO-RC.
- C7 *Corymbia hamersleyana*, *Eucalyptus xerothermica* scattered trees over *Acacia bivenosa* open heath over *Triodia angusta* open hummock grassland and *Themeda triandra* very open tussock grassland  
This vegetation type was recorded from a single drainage through the calcareous stony plain west of the existing BS4 camp. Other associated species: *Goodenia forrestii*, *Indigofera monophylla*, *Petalostylis labicheoides*, *Rulingia luteiflora* and *Santalum lanceolatum*. Site BRO45.
- C8 *Corymbia hamersleyana* low open woodland over *Triodia epactia* hummock grassland and *Eriachne tenuiculmis*, *E. mucronata*, *Themeda* sp. Mt. Barricade open tussock grassland  
This vegetation type was recorded from moderate-sized creeklines northeast of the BS4 airstrip and near the existing BS4 camp. Other associated species: *Digitaria brownii*, *Gossypium robinsonii*, *Grevillea wickhamii* subsp. *aprica* and *Rulingia luteiflora*. Site BRO38.
- C9 *Corymbia hamersleyana*, *Eucalyptus leucophloia* low woodland over *Grevillea wickhamii* tall shrubland over *Gossypium robinsonii* open shrubland over *Themeda* sp. Mt. Barricade, *Eulalia aurea* and *Paraneurachne muelleri* open tussock grassland and *Triodia epactia* open hummock grassland  
This vegetation type was recorded from moderate-sized creeklines northeast of the BS4 airstrip and in the transport corridor. Other associated species: *Acacia bivenosa*, *A. exilis*, *A. monticola*, *A. pyrifolia*, *Eriachne tenuiculmis*, *Gastrolobium grandiflorum* and *Jasminum didymum* subsp. *lineare*. Site BRO40.
- C10 *Eucalyptus leucophloia*, *Corymbia deserticola* scattered low trees over *Acacia tumida* var. *pilbarensis* tall open scrub over *Triodia epactia*, *T. wiseana* open hummock grassland  
This vegetation type occurred in minor flowlines through the stony undulating plain of the transport corridor. Other associated species: *Acacia atkinsiana*, *A. bivenosa*, *Corymbia hamersleyana*, *Digitaria brownii*, *Eulalia aurea* and *Themeda triandra*. Site BRO31.

C11 *Acacia citrinoviridis*, *A. ancistrocarpa* tall open shrubland to tall closed scrub over *Triodia epactia* mid-dense hummock grassland

This vegetation was recorded from drainage areas in the southern section of the BS4 Project area. Other associated species: *Acacia bivenosa*, *A. maitlandii*, *A. synchronicia*, \**Bidens bipinnata*, *Cassia oligophylla*, *Eriachne tenuiculmis*, *Ptilotus obovatus* var. *obovatus* and *Scaevola spinescens* (broad form). Site BRO27 and relevé BRO-MG.

C12 *Acacia monticola*, *A. maitlandii*, *A. atkinsiana* tall open shrubland over *Triodia epactia*, *T. wiseana* mid-dense to open hummock grassland

This vegetation type was recorded from minor drainage lines through the BS4 range. Other associated species: *Acacia bivenosa*, *A. citrinoviridis*, *Gossypium robinsonii*, *Grevillea wickhamii* subsp. *hispidula*, *Petalostylis labicheoides*, *Porana commixta*, *Rulingia luteiflora* and *Themeda triandra*. Sites BRO06, BRO11.

C13 *Corymbia hamersleyana*, *Eucalyptus gamophylla* low open woodland over *Acacia monticola*, *A. ancistrocarpa*, *A. bivenosa*, *Rulingia luteiflora* tall closed scrub over *Triodia epactia* hummock grassland

This vegetation type was recorded from a flowline through the stony plain in the eastern section of the BS4 Project area. Other associated species: *Acacia atkinsiana*, *A. exilis*, *Aristida contorta*, *Dysphania rhadinostachya* subsp. *rhadinostachya*, *Goodenia microptera* and *Pterocaulon sphaeranthoides*. Site BRO41.

C14 *Eucalyptus leucophloia* low woodland over *Acacia citrinoviridis*, *Acacia monticola*, *Dodonaea pachyneura* tall shrubland over *Triodia epactia* mid-dense hummock grassland

This vegetation type was recorded from a single rocky creekline in the southern section of the BS4 Project area. Other associated species: *Acacia maitlandii*, *A. pruinocarpa*, *Capparis lasiantha*, *Cassia glutinosa*, *Cymbopogon ambiguus*, *Eriachne tenuiculmis*, *Grevillea berryana* and *Solanum diversiflorum*. Site BRO12.

C15 *Stylobasium spathulatum* shrubland over *Triodia epactia* hummock grassland

This vegetation type was recorded from a creekline in the base of a gully in the western section of the BS4 Project area. Other associated species: *Indigofera monophylla* (BRO-46.12). No sites from this study.

C16 *Corymbia hamersleyana* scattered low trees over *Acacia bivenosa*, *Petalostylis labicheoides* shrubland over *Triodia epactia* hummock grassland

This vegetation type was recorded from a broad creekline through stony plains in the southern section of the BS4 Project area. Other associated species: *Acacia tetragonophylla*, *Amaranthus pallidiflorus*, *Eriachne mucronata*, *E. tenuiculmis*, *Rhagodia eremaea* and *Santalum lanceolatum*. Site BRO25.

C17 *Acacia aneura* low woodland to low open forest over *Chrysopogon fallax*, *Triodia epactia* open tussock / hummock grassland

This vegetation type was recorded from a small number of creeklines with clayey substrates in the north-western section of the main BS4 Project area and from a single creekline in the transport corridor. Other associated species: *Alternanthera nana*, *Digitaria brownii*, *Goodenia heterochila*, *Ptilotus macrocephalus*. No sites from this study.

C18 *Eucalyptus victrix*, *E. xerothermica* low open woodland over *Acacia citrinoviridis* tall open shrubland over *Themeda triandra*, *Chrysopogon fallax* tussock grassland

This vegetation type was recorded from a small number of creeklines with clayey substrates in the north-western section of the BS4 Project area. Other associated species: *Acacia aneura*, \**Cenchrus ciliaris*. No sites from this study.

C19 *Corymbia hamersleyana* scattered low trees over *Acacia atkinsiana* tall shrubland over *Triodia epactia* hummock grassland

This vegetation type was recorded from minor drainages through stony plains in the north-eastern section of the BS4 Project area. Other associated species: *Acacia kempeana*. No sites from this study.

C20 *Acacia* aff. *aneura* (narrow fine veined; site 1259) low open forest over *Acacia citrinoviridis* tall open shrubland over *Triodia epactia* open hummock grassland

This vegetation type was recorded from some creeklines through the low stony hills in the south-eastern section of the BS4 Project area. No sites from this study.

C21 *Petalostylis labicheoides* shrubland over *Triodia epactia* mid-dense hummock grassland

This vegetation type occurred in some minor flowlines through the stony hills in the southern section of the BS4 Project area. No sites from this study.

### 4.3 Results of the PATN Floristic Analysis

The primary output of the PATN analysis was a dendrogram indicating relationships between sites on the basis of floristic composition, with sites with similar species clustering out together. Given the size of the dataset analysed, the entire dendrogram has not been reproduced here, however it is available for inspection if required.

Following generation of the dendrogram by PATN, arbitrary cut-off points were selected to generate three levels of grouping within the resultant site clusters; a 20-group level (ie. the level dividing the 789 sites into 20 groups, based on floristic composition), a 50-group level (the level dividing the 789 sites into 50 groups) and a 100-group level (the level dividing the 789 sites into 100 groups). These groups, and the vegetation types and sites from the BS4 Project area within each group, are indicated in the table in Appendix 2.

A summary of the groups at the 20-group level that contained sites from the BS4 Project area is presented in Table 4.1. None of these groups was restricted to the Project area.

Table 4.1: Summary of vegetation\* and broad habitat types for the floristic groups defined at the 20-group level of the PATN analysis that contained sites within the BS4 Project area (\*based on vegetation descriptions for the component sites).

20-group	Description of dominant vegetation types and habitats
Group 2	Predominantly <i>Triodia wiseana</i> hummock grasslands on stony hills and plains, usually with a sparse to open shrub overstorey of <i>Acacia bivenosa</i> and/or <i>A. pyrifolia</i> , sometimes with <i>A. xiphophylla</i> or <i>A. synchronicia</i> ; also some creekline vegetation; groups 9-20 at the 100-group level.
Group 3	Riverine vegetation (River Red Gum <i>Eucalyptus camaldulensis</i> and Coolibah <i>Eucalyptus victrix</i> woodlands) and vegetation of smaller creeks and floodplains (particularly including <i>Eucalyptus xerothermica</i> , <i>Acacia pyrifolia</i> , <i>Triodia epactia</i> and perennial tussock grasses); groups 21-29 at the 100-group level.
Group 15	Mainly stony hills with <i>Triodia wiseana</i> (some <i>Triodia</i> aff. <i>basedowii</i> ) hummock grasslands with open shrublands of <i>Grevillea wickhamii</i> or <i>Acacia atkinsiana</i> and <i>A. exilis</i> ; also some Mulga shrublands on alluvial clayey plains; groups 68-70 at the 100-group level.
Group 17	Mainly Mulga and other mixed <i>Acacia</i> shrublands of rocky gullies and gorges; groups 77-82 at the 100-group level.
Group 19	Mainly <i>Triodia</i> aff. <i>basedowii</i> / <i>T. "pungens"</i> (some <i>T. wiseana</i> ) hummock grasslands on stony hills, usually with an overstorey including <i>Eucalyptus leucophloia</i> , <i>Corymbia hamersleyana</i> , <i>Acacia bivenosa</i> , <i>A. maitlandii</i> and/or <i>A. pruinocarpa</i> ; groups 91-93 at the 100-group level.

In contrast, one of the groups at the 50-group level contains only sites from the BS4 Project area:

- group 36 contains most of the *Triodia wiseana* hummock grassland sites from the stony hills habitats, which typically had a shrubland overstorey including *Acacia inaequilatera*, *A. atkinsiana* and *A. exilis*. *Acacia exilis* has a relatively narrow distribution in the Hamersley Range compared to the other dominant species, and within the dataset used for the PATN analysis, was only present in the quadrats and relevés assessed at BS4. The most similar floristic cluster (group 35) contained numerous sites in similar habitats further east in the Hamersley Range, particularly at Yandi and Mindy Mindy. It appears that group 36 is largely separated on the presence of *Acacia exilis* and the absence of some other species more common in the eastern Hamersley Range (eg. *Acacia hilliana* and *Triodia* aff. *basedowii*).

At the 100-group level, six groups contain only sites from the BS4 Project area:

- group 16 comprised sites on stony plains, often with calcareous soils, supporting variable shrublands (particularly including *Acacia bivenosa*) above hummock grasslands of *Triodia wiseana*, *T. angusta* and/or *T. brizoides*. Similar habitats occur along the Hope Downs and Fortescue Metals Group rail corridors between Port Hedland and Newman, and most of the vegetation types included within this group would not be expected to be restricted to this area.

- group 26 comprised sites in the creekline and floodplain vegetation types C2, C3, C5, C7, C8, C9 and C11. The reason for these sites clustering out separately from other creekline sites in this 50-group (ie. groups 28 and 29) is unclear, as the species present are not uncommon, however this cluster may be influenced by the absence of certain species such as *Acacia dictyophleba* that were relatively common in the latter groups. These creekline vegetation types would appear to be restricted to the vicinity of the BS4 Project area, however they are likely to be common in this locality.
- group 27 contained a single relevé (BRO-RC) that sampled an unusual vegetation type (C6: *Eucalyptus xerothermica* scattered low trees over *Gastrolobium grandiflorum* open heath over *Chrysopogon fallax*, *Eulalia aurea* tussock grassland). This vegetation type represents an unusual floristic combination that would not be expected to be common in the region.
- group 70 comprised the vegetation types of the stony hills and plains that were dominated by *Acacia atkinsiana*, *A. exilis* and/or *A. inaequilatera* over *Triodia wiseana* (H1-H6, H9, H14 and P6). As mentioned above, it is quite probable that the presence of *A. exilis* at these sites influenced the separation of this floristic cluster. While the vegetation types within this group are floristically dissimilar from the other survey areas included in the PATN analysis, they would be expected to be common in the Brockman locality.
- group 69 comprised vegetation types that also contained *Acacia atkinsiana* and/or *A. exilis* but occurred in more mesic areas and included species such as *Triodia epactia* (eg. the stony plain vegetation types P6 and P7 and minor flowlines C10, C12, C13 and C14). It also included some Mulga vegetation types of clayey alluvial plains (P2 and P3). Similar to group 70, most of these vegetation types (with the exception of the Mulga types P2 and P3), would be expected to be common in the Brockman locality, however there is currently no data to indicate that they are more widespread in the region.
- group 81 comprised vegetation types H10, H11, H12 and H13, all of which occurred in rocky gullies and gorges. (H16 would also be expected to occur within this floristic group, however no sites were assessed within this vegetation type.) This group clustered out in the same 50-group division with another group of gorge sites from the West Angelas area (group 82), however there are obviously floristic differences between the two areas. The isolated habitats provided by gorges would be expected to support different suites of species in different areas, hence it is not surprising that the current analysis, which lacks additional directly comparable sites from the Brockman – Tom Price area outside of BS4, indicates that these gorge vegetation types are floristically distinct. In the absence of additional data, these gorge vegetation types should be considered restricted to the Brockman locality.

## 4.4 Conservation Significance of the Vegetation Types

The following discussion has been prepared using Land Systems mapping for the Pilbara bioregion (Payne et al. 1988, Department of Agriculture 2002), review of vegetation types defined for the Nammuldi / Silvergrass study areas (Halpern Glick Maunsell 1999), and review of the results of the PATN floristic analysis to assist in the identification of uncommon vegetation types.

### 4.4.1 Vegetation Condition

As discussed in Section 3.4, the Pilbara is subject to natural wildfires, arising mainly from summer lightning strikes. Sections of the BS4 Project area had been burnt at varying times within the last five years, however as none of the area appeared degraded as a result of frequent fires arising from pastoral or other human activities, this issue is not considered further.

The vegetation types of the low stony hills habitats were generally in very good to excellent condition. These areas are not preferred grazing habitat for stock, and the stony, relatively dry substrates also tend to discourage germination and growth of weed species. The main disturbance noted in such areas was clearing of a substantial network of access tracks for mining exploration on the BS4 range.



Several creeklines in the western section of the main BS4 Project area were substantially degraded by invasion from Buffel Grass \**Cenchrus ciliaris*, and were also subject to grazing and trampling by cattle. These were considered to be in poor condition. These mesic environments have loose substrates that are favourable for germination and growth of weed species, which may also be spread by stock movement and/or encouraged by grazing. Weed invasion through the remainder of the Project area was very low.

The vegetation of the BS4 Project area was therefore generally considered to be in good (or better) condition, apart from some localised areas within creeklines that were substantially degraded by weeds and considered to be in poor condition.

#### 4.4.2 Probable Distribution of the BS4 Project Vegetation Types based on their Correspondence with Land Systems

The main vegetation types identified by this study as occurring within each Land System are indicated in Table 4.2. Given the different scales of the two mapping exercises, an element of discretion has been used to generate the association between vegetation type and Land System to avoid spurious associations. For example, the vegetation types C1 and C2 defined by this study within Boolgeeda Creek are clearly associated with the River Land System, however the mapping of this Land System does not extend over the entirety of this major creek system. Without some interpretation of the two mapping schemes, these two vegetation types could be wrongly associated with other Land Systems.

The hummock grassland vegetation types occurring on low stony hills and plains (most of the H- and P- prefixed vegetation types) occurred through most of the Land Systems (see Table 4.2). Some vegetation types were associated with more than one Land System (eg. although vegetation type P3 occurred mainly within the Boolgeeda Land System, there were also numerous small patches within the Newman Land System).

Vegetation types C1 and C2 were strongly linked to the River Land System, which would correspond to the extent of Boolgeeda Creek. Vegetation type P10 occurred in the north-western corner of the BS4 Project area, which corresponds to the Table Land System (see Section 2.4.5). Mulga *Acacia "aneura"* and Snakewood *Acacia xiphophylla* dominated vegetation types were most prominent within the Boolgeeda Land System, and to a lesser extent within the Newman Land System, but also occurred sporadically in the Platform and Rocklea Land Systems.

With the exception of the Table Land System, all of the Land Systems are widespread in the Pilbara and relatively abundant (see Section 2.4.5). On the basis of the Land Systems mapping, none of the vegetation types occurring within the BS4 Project area would be expected to be restricted to the Project area, however vegetation type P10 of the Table Land System may be poorly represented in the region.

Table 4.2: Association between Land Systems mapped within the BS4 Project area and vegetation types identified for this study.

Land System	Main Associated Vegetation Types of this Study Colour-coded for the following values: <b>Mulga/Snakewood dominated</b> (including Mulga creeks); <b>other creeklines</b> ; <b>vegetation occurring on calcrete</b> ; <b>stony plains and hills</b> ; <b>gorges and breakaways</b>
Boolgeeda	H1, H7, H9; P3, P6, P7, P8, P9, P14; C5, C6, C8, C9, C10, C13, C17, C18, C19
Newman	H2, H3, H4, H5, H6, H8, H9, H10, H11, H12, H13, H14, H15, H16; P1, P3, P4, P7, P11, P13, P15, P16; C3, C4, C11, C12, C14, C15, C16, C21
Platform	H14, H15; C20; P2, P6
River	C1, C2
Robe*	H8; C7
Rocklea	P5, P12; C16
Table*	P10

\* Based on our ground-truthing of the BS4 Project, two polygons ascribed to the Robe Land System by Payne et al. (1988) actually represent the Table Land System, as characterized by the presence of calcrete outcroppings. Both of these polygons are in the north-western portion of the main Project area.

#### 4.4.3 Occurrence of the BS4 Project Vegetation Types in Nearby Areas

On the basis of the only other recent botanical survey done in the area (the survey of the Nammuldi and Silvergrass study areas, near Brockman 2; Halpern Glick Maunsell 1999), most of the vegetation types occur in similar habitats outside the BS4 Project area (see Table 4.3).

Thirteen of the vegetation types defined for the BS4 Project area could not be correlated with the broader vegetation units defined for the Nammuldi and Silvergrass project areas (Table 4.3; Halpern Glick Maunsell 1999). These comprised three of the stony hills vegetation types, five of the plains vegetation types and five of the creekline vegetation types. Some of these vegetation types (eg. units H4, H7, H8, P8, P12, P16, C7 and C16) are likely to occur in the Nammuldi and/or Silvergrass study areas as similar habitats are present and the species are relatively common, however they cannot be matched with the vegetation descriptions given in Halpern Glick Maunsell (1999) (probably partly because they are defined at a finer level). Other vegetation types that occur on habitats with a relatively small representation in the area (eg. units P9, P11), or that include relatively uncommon species or uncommon combinations of species as dominants (eg. units C6, C15 and C20) are more likely to be genuinely absent from either the Nammuldi or Silvergrass areas (although some are known to occur elsewhere in the vicinity).

Table 4.3: Correspondence of vegetation units defined for the BS4 Project area (this study) and for the nearby Nammuldi and Silvergrass study areas (Halpern Glick Maunsell 1999).

Vegetation types of this study	Corresponding vegetation type at Nammuldi (Halpern Glick Maunsell 1999)	Corresponding vegetation type at Silvergrass (Halpern Glick Maunsell 1999)
H1, H9, H14	A2	A2
H2, H5, H6	A5	-
H3	A1	A1
H4	-	-
H7	-	-
H8	-	-
H10, H12	A4	-
H11, H13, H16	A3	A3
H15	A6	A6
P1, P2, P3	B2, B3	B2, B5
P4, P5	A7	-
P6, P7, P15	A5	-
P8	-	-
P9	-	-
P10	A8	-
P11	-	-
P12	-	-
P13, P14	A6	A6
P16	-	-
C1, C3, C4, C11, C18	B1	B1
C2, C5, B8	B4	B4
C6	-	-
C7	-	-
C9, C10, C14, C19, C21	B7	-
C12, C13	B6	B6
C15	-	-
C16	-	-
C17	B2	B2
C20	-	-

#### 4.4.4 Assessment at the Level of the Vegetation Types Defined by this Study

None of the vegetation types occurring within the BS4 Project area are listed as Threatened Ecological Communities by CALM, however "valley floor mulga" (which may correspond to vegetation type P1) and "all major ephemeral water courses" (which may correspond to vegetation types C1 and C2 of Boolgeeda Creek) are considered to be ecosystems at risk,

principally from grazing and trampling by stock, weed invasion and large fires (see Kendrick 2001).

While the PATN analysis run for the current study indicates that a number of floristic groups have only been recorded from the BS4 Project area (see Section 4.3), it is unlikely that all of these vegetation types are genuinely restricted in the Pilbara region. The current analysis was limited by a lack of additional sites in comparable habitats in the Brockman – Tom Price locality outside of the immediate BS4 Project area. It is hoped that a second PATN analysis planned for later in 2005 will further clarify the floristic groups identified by the current exercise. This will include additional sites from the Brockman area (as data from further sampling becomes available), as well as all sites from the Hope Downs and Fortescue Metals Group surveys.

On the basis of interpretation of the current PATN analysis along with the results of the field study, one vegetation type from the BS4 Project area was considered to be of high conservation significance:

- P11 (*Acacia synchronicia* scattered shrubs over *Triodia angusta* hummock grassland); this did not belong to a restricted floristic group, but was the main associated vegetation type for the Priority 1 species *Ptilotus* sp. Brockman (see Section 5.2.4). This vegetation type occurs extensively outside the Project area on similar substrates along the White Quartz Road (Michi Maier, Biota, pers. obs.), but is unlikely to be well represented in the Hamersley subregion.

Eighteen vegetation types were considered to be of moderate conservation significance:

- H10, H11, H12, H13 and H16 (mixed shrublands over hummock grasslands dominated by suites of species preferring rocky habitats); these vegetation types of narrow gorges, gullies and breakaways belong to a floristic group apparently restricted in the region, and support species restricted to such rocky habitats, including an apparently undescribed species of *Sida* (see Section 5.2.5); in addition these habitats, while widespread within the Hamersley subregion, comprise a small proportion of the total area;
- P1 (*Acacia* aff. *aneura* (narrow fine veined; site 1259), *A. ayersiana*, *A. tetragonophylla* tall shrubland over *Eremophila forrestii*, *Acacia bivenosa* shrubland over *Triodia epactia* mid-dense hummock grassland); this vegetation type was restricted within the Project area to a single broad drainage area within a valley and may be poorly represented in the locality; while it does not belong to a restricted floristic group, floristically similar Mulga woodlands in drainage habitats appear to be uncommon in the region;
- P2, P3, P8, P9 and P10 (*Triodia wiseana* / *T. angusta* hummock grasslands with variable overstoreys occurring on stony plains); these vegetation types belong to floristic groups that are apparently not widespread in the region; calcrete areas in particular are not well represented in the Hamersley subregion and these vegetation types (P9 and P10) may have a restricted distribution;
- C1, C2, C3 and C18 (vegetation of the largest creeklines within the BS4 Project area); these vegetation types occur in habitats that are of value as surface drainage features (particularly Boolgeeda Creek) and support numerous species restricted to such habitat (including the Priority 3 flora *Phyllanthus aridus*); C2 and C3 occur within a floristic group that does not appear to be widespread in the region; C1 and C18 contain Coolibahs *Eucalyptus victrix*, which may behave as a phreatophyte and thus be influenced by groundwater drawdown (see Section 6.1.3);
- C6 (*Gastrolobium grandiflorum* open heath in a flowline); this vegetation type has an unusual floristic composition that is likely to have a restricted distribution in the region; and
- C17 and C20 (creekline vegetation dominated by Mulga); these vegetation types are likely to be restricted in terms of area of extent in the Hamersley subregion, and would also be particularly susceptible to degradation through fire.

The only vegetation types within the BS4 Project area that are considered to have no particular conservation significance are those creeklines degraded by dense infestations of

Buffel Grass \**Cenchrus ciliaris* (ie. vegetation type C4), although these would still have some value as surface drainage features.

The remainder of the vegetation types identified are considered to be of low conservation significance, representing units that are likely to be widely distributed and relatively well represented in the Hamersley Range subregion. Note that this should not be interpreted as meaning that they are of no importance, merely that they are less significant than the other vegetation types within the Project area; as their condition is typically good to excellent, these vegetation types still have conservation value.

The BS4 Project area thus has moderate conservation value for overall vegetation.

## 5.0 Flora

### 5.1 Overview of the Flora of the BS4 Project Area

#### 5.1.1 Species Richness

A total of 367 taxa of native vascular flora from 149 genera belonging to 52 families was recorded from the BS4 Project area (see Appendix 3). In addition, six introduced flora species were recorded (see Section 5.3).

As a comparison, 358 species (including 5 weed species) from 161 genera and 56 families were recorded from the combined study areas at Nammuldi and Silvergrass, near the existing Brockman 2 mining operation to the north of the BS4 Project area (Halpern Glick Maunsell 1999). The BS4 Project area thus has a moderate species richness, which is neither atypically high nor low given the location of the Project area, its size and the variety of habitats encompassed.

#### 5.1.2 Dominant Species

The families and genera with the greatest number of species are shown in Table 5.1 and Table 5.2. These families and genera are typically predominant in the vegetation of the central Pilbara, and usually have most representatives on flora lists from this region, due to their prominence in the Eremaean flora. Some of the families (eg. the Amaranthaceae, Malvaceae and Poaceae) are more species rich in the Northern flora and poorer in the Southern flora, while others (such as the Mimosaceae) are abundant in all three.

Table 5.1: Plant families with the highest number of native species within the area.

Family	No. of Native Taxa
Poaceae (grass family)	46
Malvaceae (hibiscus family)	37
Mimosaceae (acacia family)	31
Amaranthaceae (mulla-mulla family)	25
Caesalpiniaceae (cassia family)	22
Asteraceae (daisy family)	20
Papilionaceae (pea family)	20
Chenopodiaceae (saltbush, bluebush family)	14
Goodeniaceae (leschenaultia family)	13
Myrtaceae (eucalypt/myrtle family)	12
Euphorbiaceae (spurge family)	11

Table 5.2: Plant genera with the highest number of native species within the area.

Genus	No. of Native Taxa
<i>Acacia</i> (wattle family)	30
<i>Cassia</i> (cassia family)	21
<i>Ptilotus</i> (mulla-mulla family)	16
<i>Sida</i> (hibiscus family)	16
<i>Hibiscus</i> (hibiscus family)	11
<i>Goodenia</i> (leschenaultia family)	8
<i>Abutilon</i> (hibiscus family)	7
<i>Eremophila</i> (myoporum family)	7

The most frequently encountered species through the area included: *Acacia atkinsiana*, *A. bivenosa*, *A. exilis*, *A. maitlandii*, *A. synchronicia*, *Amphipogon sericeus*, *Aristida contorta*, *A. holathera* var. *holathera*, *Bulbostylis barbata*, *Cassia glutinosa*, *C. luerssenii*, *C. oligophylla*, *C. pruinosa*, *Codonocarpus cotinifolius*, *Corchorus lasiocarpus*, *Cymbopogon ambiguus*, *Dysphania rhadinostachya* subsp. *rhadinostachya*, *Eriachne mucronata*, *Eucalyptus leucophloia* subsp. *leucophloia*, *Goodenia microptera*, *G. stobbsiana*, *Jasminum didymum* subsp. *lineare*, *Paraneurachne muelleri*, *Paspalidium clementii*, *Polycarpaea holtzei*, *Porana*

*commixta*, *Ptilotus calostachyus* var. *calostachyus*, *P. exaltatus* var. *exaltatus*, *P. helipteroides* var. *helipteroides*, *P. obovatus* var. *obovatus*, *Solanum lasiophyllum*, *Trachymene oleracea* subsp. *oleracea*, *Trichodesma zeylanicum* var. *zeylanicum*, *Triodia epactia* and *T. wiseana*.

Some of these species were common dominant species in the area (eg. the spinifex *Triodia* spp.) or frequently contributed to vegetation structure (eg. the wattles *Acacia bivenosa*, *A. exilis* and *A. atkinsiana* and the eucalypt *Eucalyptus leucophloia* subsp. *leucophloia*). Others were species with wide environmental tolerance, but usually with low abundance (eg. *Eriachne pulchella* subsp. *dominii* and *Trichodesma zeylanicum* var. *zeylanicum*).

## 5.2 Flora of Conservation Significance

### 5.2.1 Legislative and Administrative Levels of Flora Protection

While all native flora are protected under the Western Australian *Wildlife Conservation Act 1950-1979*, a number of plant species are assigned an additional level of conservation significance based on the limited number of known populations and the perceived threats to these populations (Table 5.3). Species of the highest conservation significance are designated Declared Rare Flora (DRF), either extant or presumed extinct. Species that appear to be rare or threatened, but for which there is insufficient information to properly evaluate their conservation significance, are assigned to one of four Priority flora categories by CALM. This is an administrative (rather than legislated) level of protection.

In addition, the presence of some flora species means that it may be necessary to refer proposals to the Federal Minister for the Environment under the Federal *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. In the Pilbara, only the two Declared Rare Flora species (*Lepidium catapycnon* and *Thryptomene wittweri*) are currently listed under the *EPBC Act 1999*.

Table 5.3: Categories of conservation significance for flora species (Atkins 2005).

Declared Rare Flora - Extant Taxa. Taxa that 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.
Declared Rare Flora - Presumed Extinct. Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently.
Priority 1 - Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations which are under threat.
Priority 2 - Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under threat.
Priority 3 - Poorly Known Taxa. Taxa which are known from several populations, at least some of which are not believed to be under threat.
Priority 4 - Rare Taxa. Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

### 5.2.2 Flora of Conservation Significance Previously Recorded in the Vicinity of Brockman

The search of the CALM and WA Herbarium rare flora databases (see Section 3.1) yielded 88 records of 37 Priority species. The search was of a relatively large area, and only seven of these records (of four species) occur in the vicinity of the BS4 Project area (ie. within 10 km).

A single record was within the BS4 Project area. This was a location for the Priority 1 *Ptilotus* sp. Brockman (E. Thoma & A. Joder ET & AJ 145), which was submitted by Emil Thoma and Anna Joder of Hamersley Iron after the discovery of this species in the valley south of the BS4 range (see Section 5.2.4).

Specimens of three other Priority flora have been lodged from the vicinity of the BS4 Project area:

- *Tephrosia* sp. Cathedral Gorge (F.H.Mollemans 2420) (Priority 3): two records from ~9 km ENE and ~10.5 km NNW of the northern end of the transport corridor;
- *Triumfetta leptacantha* (Priority 3): two records from ~1.5 km N and ~6 km E of the northern end of the transport corridor; and
- *Goodenia stellata* (Priority 4): two records from ~7 km ENE and ~8.5 km N of the northern end of the transport corridor.

### 5.2.3 Probability of Declared Rare Flora Occurring in the BS4 Project Area

There are currently only two Declared Rare Flora (DRF) in the Pilbara; Mountain Thryptomene *Thryptomene wittweri* and Hamersley Lepidium *Lepidium catapycnon*. Neither species has been recorded from the BS4 Project area, nor from the vicinity (see Section 5.2.2).

*T. wittweri* is much less common than *L. catapycnon*. Within the Pilbara bioregion, it occurs only on high-altitude hilltops further east in the Hamersley subregion. There are also records from the Gascoyne and Great Victoria Desert bioregions. As there is no suitable habitat for *T. wittweri* in the BS4 Project area, this species would not be expected to occur.

*L. catapycnon* occurs in hummock grasslands on low stony hills and occasionally stony plains in the Hamersley subregion. This relatively short-lived low shrub species is often recorded from areas that have recently been disturbed, apparently persisting for only a few years. While suitable habitat for *L. catapycnon* is present throughout the BS4 Project area, searches of the main area by botanists with extensive familiarity of this species have not located any populations. Although unlikely, it is still a possibility that this species may occur in the transport corridor, and the proposed alignment of the transport route should be searched for rare flora prior to construction.

There are thus no listed Threatened Flora Species under the EPBC Act 1999 within the BS4 Project area.

### 5.2.4 Priority Flora Occurring in the BS4 Project Area

Five Priority flora species were recorded from the BS4 Project area during the surveys in 2003 and 2004, comprising one Priority 1, three Priority 3 and one Priority 4 species (Table 5.4). An additional Priority 4 species was recorded outside the Project area and could occur within in similar habitat (Table 5.4). Each species is discussed individually below, and the locations of all Priority flora recorded are shown on the vegetation mapping in Appendix 1.

Table 5.4: Number of records of Priority flora within the BS4 Project area and additional records in the vicinity.

Species	Number of Records within the BS4 Project Area (Number in Vicinity)
Priority 1 <i>Ptilotus</i> sp. Brockman (E. Thoma & A. Joder ET & AJ 145)	31 (13)
Priority 3 <i>Abutilon trudgenii</i> ms. <i>Phyllanthus aridus</i> <i>Sida</i> sp. Wittenoorn (W.R. Barker 1962)	8 (9) 1 (0) 8 (12)
Priority 4 <i>Eremophila magnifica</i> subsp. <i>magnifica</i> <i>Goodenia stellata</i>	25 (0) 0 (1)

- *Ptilotus* sp. Brockman (E. Thoma & A. Joder ET & AJ 145) Priority 1

The first collection of this undescribed flora species was from the BS4 Project area, by Emil Thoma and Anna Joder of Hamersley Iron. This low shrub species is very distinctive in appearance, both in habit and floral characters (see Plate 5.1).



Plate 5.1: *Ptilotus* sp. Brockman: (a) habit (shown next to a spinifex hummock); and (b) flowering branchlets.

According to Rob Davis of the WA Herbarium, who specialises in this genus, *Ptilotus* sp. Brockman has a particular floral character (an elongated staminal cup) that is shared by only one other species in this genus, although it is common within the closely related genus *Gomphrena*. The majority of *Ptilotus* species produce nectar and are largely insect pollinated, although this has not been recorded in the literature to date (Rob Davis, WA Herbarium, pers. comm. 2005). Rob Davis considers that the presence of the elongated staminal cup suggests that this species may have a specific pollinator.

Within the BS4 Project area, a large population of *Ptilotus* sp. Brockman occurs within the depositional valley between the BS4 range and the range of hills along the southern edge of the Project area (see Appendix 1). Thirty-one separate records of this species were made in this area, however the population is essentially continuous (see Table 5.5).

Outside the Project area, recent recordings made by Hamersley Iron personnel include:

- three records from the calcareous stony plain immediately west of the BS4 Project area;
- two records immediately south of the BS4 Project area, in the area referred to by Hamersley Iron as the "Beasley River area"; and
- eight records to the east of the BS4 Project area along the White Quartz Road (the access road between BS4 and Tom Price), extending over some 19 km (see Table 5.5 and Figure 5.1).

The populations along the White Quartz Road in particular are very large, estimated at 2-3000 individuals (Emil Thoma, Hamersley Iron, pers. comm.). It is not known whether the three areas from which this species has been recorded support genetically distinct populations.

The distribution of *Ptilotus* sp. Brockman could not be correlated with any particular Land System as it has been recorded from the Robe, Newman and Rocklea Land Systems. However, at a finer scale, it is typically associated with fine silt / clay substrate and *Triodia angusta* and/or *T. longiceps* hummock grasslands.

Hamersley Iron offered to provide funding for the taxonomic description of this species, however the WA Herbarium was unable to resolve the manner in which it could be accepted. Rob Davis has proceeded with the description nonetheless, and this is believed to be nearing completion.



Table 5.5: Locations of *Ptilotus* sp. Brockman records in the BS4 Project area and additional records in the vicinity.

Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)
Records in the Project area	
521918	7500023
521948	7500099
522053	7500095
522093	7500072
522279	7500031
522313	7500138
522313	7499990
522335	7500035
522359	7500200
522378	7500019
522398	7500178
522421	7499988
522487	7500133
522519	7500014
522522	7500177
522538	7500095
522584	7500173
522760	7500226
522834	7500076
522856	7500208
522859	7500175
522886	7500107

Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)
523021	7500090
523091	7500117
523108	7500219
523111	7500253
523129	7500158
523425	7500320
523555	7500352
523749	7500333
523758	7500262
Records in the vicinity	
516693	7503424
516987	7503788
517063	7503309
519675	7498952
519742	7498255
534138	7498634
534324	7498305
535812	7497429
540338	7495729
541301	7495826
544896	7496854
548418	7495738
553061	7497850

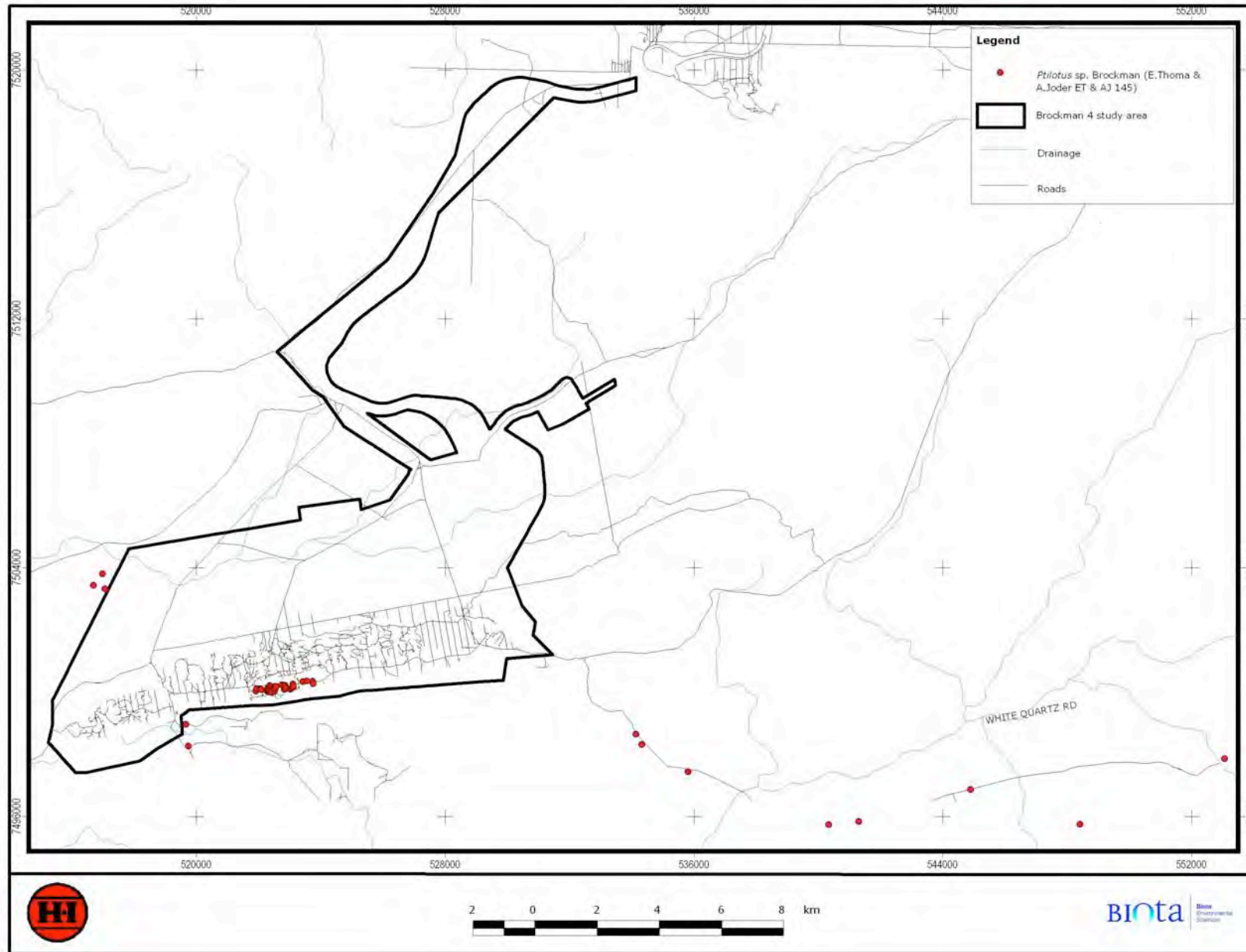


Figure 5.1: Distribution of *Ptilotus* sp. Brockman in the vicinity of the BS4 Project area.

- *Abutilon trudgenii* ms.

Priority 3

This low shrub species has a relatively straggly habit (see Plate 5.2) and tends to occur in recently burnt areas. Both factors probably contribute to the fact that it was poorly collected in the past, however it is now recorded routinely on surveys in the Hamersley Range.



Plate 5.2: *Abutilon trudgenii* ms.: young plant, leaf, and fruit (note pendant pedicels).

Specimens of *A. trudgenii* are lodged at the WA Herbarium from Cane River, Hillside Station, Goldsworthy and Tom Price. However, according to the Priority Species List this species is known from other locations including Warralong, Woodstock, Point Sampson, Karratha and Pannawonica (Atkins 2005). It has also been recorded from Yanrey Station on the eastern side of the Exmouth Gulf (M. Maier, pers. obs.), west of Dampier (Halpern Glick Maunsell 2000), and south-southeast of Port Hedland (Trudgen et al. 2002). Further inland in the vicinity of Newman, *A. trudgenii* was recorded 23 times by Trudgen and Casson (1998) during the West Angelas surveys, seven times during the initial survey of the Hope Downs rail corridor (Biota and Trudgen 2002), once during the Hamersley Range Extension to the Hope Downs rail corridor (Biota 2004a), three times during the survey of the FMG Stage A rail corridor between Port Hedland and Mindy Mindy (Biota 2004b), and four times from the FMG Stage B rail corridor and tenements (Biota 2004c). This species has been recorded recently from areas around Pannawonica, including the Mesa J Extension (1 record; Biota 2005a), Mesa L Minor (7 records; Biota 2005b), and Mesa A and Mesa G (46 records; see Biota 2005c). This species is thus poorly vouchered rather than genuinely rare, and is considered to warrant removal from the Priority flora listing.

There were several records of *Abutilon trudgenii* from the BS4 Project area, mainly from the broad clayey plains on the northern side of the BS4 range, and a similar number of records were also made outside the Project area (Table 5.6).

Table 5.6: Locations of *Abutilon trudgenii* ms. records in the BS4 Project area and additional records in the vicinity.

Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)
Records in the Project area	
515800	7498833
519561	7503678
520072	7504577
529963	7504256
530098	7504395
530841	7509396
523750	7504401
527494	7515582

Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)
Records in the vicinity	
526725	7513879
513584	7503962
514812	7503929
515275	7504117
515622	7504268
516042	7504527
516419	7504674
516730	7504886
517199	7504818

- *Phyllanthus aridus*

Priority 3

This annual herb is infrequently recorded in the Pilbara, typically from creeklines but also occasionally from rocky outcrops. It is likely to be poorly collected due to its inconspicuous habit.

Three individuals of *P. aridus* were recorded from the broad gravelly bed of Boolgeeda Creek (Table 5.7). This species may well occur more widely in this habitat.

Table 5.7: Location of *Phyllanthus aridus* record in the BS4 Project area.

Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)
Records in the Project area	
524422	7504838

- *Sida* sp. Wittenoom (W.R. Barker 1962)

Priority 3

This low to medium-height shrub is similar in appearance to the more common *Sida echinocarpa*, but differs in some key features, including having fewer carpels to its spiny fruit, and calyx lobes that are depressed or concave in the centers (Plate 5.3).



Plate 5.3: *Sida* sp. Wittenoom (W.R. Barker 1962): habit and fruit (note spiny carpels and concave calyx lobes).

Similar to *Abutilon trudgenii*, *Sida* sp. Wittenoom has been poorly collected in the past but is now recorded frequently during surveys in the Hamersley Range. This species is widespread through the Pilbara bioregion, occurring in both the Hamersley and Chichester subregions. Specific records include two locations in the Hope Downs rail corridor (Biota 2004a), nine locations in the FMG Stage A rail corridor (Biota 2004b), two locations in the FMG Stage B rail corridor (Biota 2004c), 5 locations in the Mesa J Extension (Biota 2005a), 1 location at Mesa L Minor (Biota 2005b), 24 locations at Mesa A and Mesa G (Biota 2005c) and 95 locations at Bungaroo Creek (Biota 2005d).

This species was recorded eight times from the BS4 Project area and 12 times in the vicinity (Table 5.8). It tended to occur as scattered individuals, often together with *Abutilon trudgenii*, and was most frequently recorded on the clayey plains north of the BS4 range.

Table 5.8: Locations of *Sida* sp. Wittenoom (W.R. Barker 1962) records in the BS4 Project area and additional records in the vicinity.

Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)	Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)
Records in the Project area		Records in the vicinity	
519963	7504861	515502	7498038
520063	7504788	513584	7503962
521072	7500422	514812	7503929
523750	7504401	515275	7504117
524920	7504642	515521	7500666
524956	7504864	515622	7504268
525959	7506007	516042	7504527
527494	7515582	516419	7504674
		516730	7504886
		517199	7504818
		523520	7505742
		526754	7513872

- *Eremophila magnifica* subsp. *magnifica*

Priority 4

This moderate-height shrub was recorded 25 times from the BS4 Project area (Table 5.9). All records were from the stony hillslopes associated with Mt West (the tall hill in the western section of the Project area), which is typical habitat for this species. *Eremophila magnifica* subsp. *magnifica* is distributed through the central-eastern Hamersley Ranges, and there are a number of records from Tom Price.

Table 5.9: Locations of *Eremophila magnifica* subsp. *magnifica* records in the BS4 Project area.

Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)	Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)
Records in the Project area		Records in the vicinity	
516135	7499557	516862	7499262
516184	7499590	516868	7499240
516205	7499548	516906	7499184
516219	7499544	516927	7499213
516337	7499637	516934	7498786
516374	7499033	517033	7499286
516384	7498921	517040	7499045
516461	7499109	517041	7499480
516623	7499402	517044	7499369
516679	7499437	517054	7499103
516680	7499192	517107	7499069
516818	7498977	517159	7498967
		517180	7498930

- *Goodenia stellata*

Priority 4

This small perennial herb is known from numerous populations in the Hamersley subregion, where it typically occurs within relatively dense hummock and tussock grasslands on clayey substrates in drainage areas.

*G. stellata* was recorded from a single creekline west of the BS4 Project area (Table 5.10), where it was associated with *Acacia citrinoviridis*, *Chrysopogon fallax* and *Corymbia hamersleyana*. It is possible that it may occur within the *Acacia citrinoviridis* creeklines in the western section of the Project area, however targeted searches have not recorded it to date.

Table 5.10: Location of *Goodenia stellata* record in the vicinity of the BS4 Project area.

Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)
Records in the vicinity of the Project area	
514913	7503586

## 5.2.5 Other Flora of Conservation Interest in the BS4 Project Area

- *Indigofera monophylla*

The species complex *Indigofera* “*monophylla*” in the Pilbara contains a number of undescribed taxa which differ in leaf and floral characters and also in habit. While the typical forms are low to moderate height shrubs, there are occasional taller forms (up to 2 m in height).

Of note within the BS4 Project area is the taxon *Indigofera monophylla* (BRO46-12), a tall shrub (to 1.5 m in height) that was associated with creeklines. This taxon was recorded from five locations associated with Boolgeeda Creek (sites BRO08, BRO09, BRO10, BRO46 and BRO49), and one location in the moderate-sized creek at the western end of the Project area (515480 mE, 7499517 mN).

- Malvaceae family

The Malvaceae family in the Pilbara contains numerous undescribed taxa, many of which are poorly collected. Undescribed taxa within the genera *Abutilon*, *Hibiscus* and *Sida* are regularly recorded. The taxon *Sida* sp. (BROMH-1), which was recorded from a single gully (vegetation type H11; relevé BROMH) in the southern half of the transport corridor, appears to be a new entity that has not been previously collected.

## 5.3 Introduced Flora (Weeds)

Six introduced flora species were recorded from the BS4 Project area (Table 5.11), all of which are common and widespread weeds of the Pilbara region. An additional species, Mexican Poppy *\*Argemone ochroleuca* subsp. *ochroleuca*, was recorded to the west of the Project area and may well occur within it.

None of these species are Declared Plants for the Pilbara under the *Agriculture and Related Resources Protection Act 1976*, although Mexican Poppy is Declared for other regions. Ruby Dock, Buffel Grass and Birdwood Grass are all considered to be serious environmental weeds by CALM.

Table 5.11: Number of records of each weed species recorded within the BS4 Project area.

Family / Species	Number of Records	Locations (WGS84, Zone 50)
Polygonaceae <i>*Acetosa vesicaria</i> (Ruby Dock)	1	516244 mE, 7500874 mN
Poaceae <i>*Cenchrus ciliaris</i> (Buffel Grass)	12	515480 mE, 7499517 mN; 515668 mE, 7498792 mN; 515772 mE, 7498756 mN; 517965 mE, 7500800 mN; 519484 mE, 7503477 mN; 519561 mE, 7503678 mN; 520994 mE, 7500162 mN; 521495 mE, 7504719 mN; 524422 mE, 7504838 mN; 524694 mE, 7504835 mN; 527494 mE, 7515582 mN; 530841 mE, 7509396 mN
<i>*Cenchrus setigerus</i> (Birdwood Grass)	1	521495 mE, 7504719 mN
<i>*Setaria verticillata</i> (Whorled Pigeon Grass)	4	515772 mE, 7498756 mN; 519257 mE, 7499238 mN; 521086 mE, 7500696 mN; 530841 mE, 7509396 mN
Asteraceae <i>*Bidens bipinnata</i> (Beggars Ticks)	6	515772 mE, 7498756 mN; 516264 mE, 7498816 mN; 518683 mE, 7498768 mN; 520994 mE, 7500162 mN; 521086 mE, 7500696 mN; 531929 mE, 7509535 mN
Malvaceae <i>*Malvastrum americanum</i> (Spiked Malvastrum)	6	515772 mE, 7498756 mN; 519257 mE, 7499238 mE; 520994 mE, 7500162 mN; 521086 mE, 7500696 mN; 527494 mE, 7515582 mN; 530841 mE, 7509396 mN

A brief discussion of each species follows:

- Ruby Dock \**Acetosa vesicaria* was recorded from a single location at the western edge of the Project area. This perennial herb was initially introduced to the Pilbara for minesite rehabilitation, and has since spread to surrounding areas. It is an aggressive weed that spreads by vegetative material as well as seed.
- Buffel Grass \**Cenchrus ciliaris* and the less common Birdwood Grass \**C. setigerus* were introduced by pastoralists as fodder species. Buffel Grass has demonstrated allelopathic capacities, whereby it releases chemicals that inhibit the growth of other plants, and both species are aggressive and effective competitors with native flora. These perennial grasses form dense tussock grasslands, particularly along creeklines, floodplains and in sandy coastal areas. Infestations of these species are common throughout the Hamersley Range, particularly in major creeklines. Buffel Grass was recorded from 12 locations within the BS4 Project area, and Birdwood Grass was recorded once; virtually all records were from creeklines.
- Whorled Pigeon Grass \**Setaria verticillata* is a common weed of creeklines and Mulga vegetation in the Pilbara, but rarely occurs in large numbers. There were four records of this species within the BS4 Project area; three were from creeklines while one was from a Snakewood *Acacia xiphophylla* shrubland.
- Beggars Ticks \**Bidens bipinnata* is a common weed of Mulga vegetation and creeklines of the Pilbara. This annual daisy may occur in very high densities within suitable habitat and given appropriate conditions, but on its own does not appear to cause exclusion of native flora species. Beggars Ticks was recorded from six locations in the BS4 Project area, all of which were associated with drainage areas.
- Spiked Malvastrum \**Malvastrum americanum* is a common weed of Mulga vegetation and creeklines. This low shrub species was recorded from six locations in the BS4 Project area; five records were from creeklines, while one was from a Snakewood shrubland.
- Mexican Poppy \**Argemone ochroleuca* subsp. *ochroleuca* is a relatively common weed of major creeks in the Hamersley Range, where it typically occurs in the open, gravelly creekbeds. This species is difficult to control as it produces very large quantities of seed, and flooding of its preferred habitat can spread this seed for large distances. This annual herb was recorded from three locations in Boolgeeda Creek west of the Project area (Table 5.12). It is quite likely that this species also occurs in this habitat within the BS4 Project area.

Table 5.12: Locations of \**Argemone ochroleuca* subsp. *ochroleuca* records west of the BS4 Project area.

Easting (WGS84, Zone 50)	Northing (WGS84, Zone 50)
Records in the vicinity of the Project area	
516816	7504472
515628	7504509
513584	7503962

## 6.0 Generic Impacts of the BS4 Project and Recommendations for Management

### 6.1 Probable Impacts of the Proposed BS4 Project on Flora and Vegetation

#### 6.1.1 Clearing of Vegetation

Clearing of vegetation will be required within the pit areas, along the transport route, and for establishment of infrastructure such as an airstrip, borrow pits, laydown areas, water bores and access tracks. Some cut and fill will be required where the proposed transport route traverses low hills and shallow valleys, which would extend the limit of clearing beyond the immediate vicinity of the transport route itself.

Additional impacts on vegetation may result from other project-related activities including off-road driving and fire (see below). Spinifex (*Triodia* spp.) is particularly susceptible to physical damage from vehicle movements and may take extended periods to recover.

Indicative areas of disturbance are presented in Table 6.1 based on the most current mine layout. These were calculated by intersecting the combined areas of the mine pits and associated infrastructure with the vegetation mapping in MapInfo.

More than 30% of the area mapped within the BS4 Project area would be cleared for 13 of the vegetation types identified: C15 (100% cleared), H2/H16 (75% cleared), P5 (67% cleared), H4 (63% cleared), P2 (62% cleared), H12 (62% cleared), C21 (54% cleared), H2 (48% cleared), C14 (46% cleared), P12 (33% cleared), H9 (31% cleared), H16 (31% cleared) and C11 (30% cleared). Most of these vegetation types are known to occur outside the BS4 Project area, or would be expected to occur outside given that the habitats and the dominant species are relatively common. Two units (the gorge vegetation types H12 and H16) were identified as being of moderate conservation significance (Section 4.4.4).



Table 6.1: Indicative area of each vegetation type that would be cleared for the proposed development.

Vegetation Code	Total area mapped within Project area (ha)	Indicative area to be impacted (ha)	% of area within Project area to be impacted
C1	184.82	1.30	0.70
C1/C10	14.03	1.82	13.00
C2	561.96	3.31	0.59
C3	16.90	0.39	2.32
C4	12.30	2.38	19.34
C5	113.25	5.15	4.55
C6	1.30	0.01	0.60
C7	8.41	0.00	0.00
C8	60.46	0.00	0.00
C9	34.88	1.88	5.40
C10	20.25	3.47	17.16
C11	13.95	4.21	30.17
C12	84.28	14.80	17.56
C13	6.86	0.42	6.19
C14	4.43	2.02	45.63
C15	0.96	0.96	100.00
C16	27.68	2.32	8.39
C17	18.88	0.06	0.31
C18	42.91	0.00	0.00
C19	55.08	3.75	6.81
C20	13.26	2.45	18.48
C21	3.92	2.13	54.34
H1	24.11	2.09	8.68
H2	1174.19	564.41	48.07
H2/H16	42.75	32.01	74.89
H3	364.32	100.62	27.62
H4	29.37	18.60	63.31
H5	36.90	0.57	1.55
H6	4.23	0.30	7.10
H7	171.37	0.00	0.00
H8	234.94	29.04	12.36
H9	125.28	39.24	31.32
H10	138.22	24.25	17.54
H11	4.81	1.12	23.29
H12	14.29	8.87	62.07
H13	0.57	0.14	25.17
H14	739.38	165.15	22.34
H15	347.30	44.67	12.86
H16	6.90	2.11	30.59
P1	46.39	0.84	1.82
P2	15.81	9.82	62.08
P3	449.26	41.53	9.24
P3/P6	798.32	145.95	18.28
P4	198.73	51.13	25.73
P5	5.02	3.35	66.83
P6	3176.42	591.82	18.63
P7	1343.02	88.59	6.60
P8	16.63	0.00	0.00
P9	73.38	3.41	4.65
P10	292.14	35.17	12.04
P11	80.13	0.00	0.00
P12	107.59	35.74	33.22
P13	61.32	6.09	9.94
P14	89.69	2.73	3.05
P15	271.48	54.74	20.17
P16	0.98	0.00	0.00

### 6.1.2 Disturbance to Surface Drainage Systems

The proposed transport route crosses a number of moderate-sized creeklines and the very broad drainage system of the Boolgeeda Creek. Disturbance to surface drainage flow has the potential to negatively impact downstream vegetation in such creeklines.

Some areas of vegetation containing Mulga (*Acacia "aneura"*) are present towards the southern end of the transport corridor (see Plate 6.1). These are not of the grove / intergrove form that is typically associated with surface sheet flow across areas of very low topography. (Construction of linear infrastructure through such areas of surface sheet flow can result in Mulga mortality through upstream ponding and downstream drainage shadow effects.)



Plate 6.1: Typical Mulga vegetation on plains of the BS4 Project area. This vegetation does not take the form of grove / intergrove Mulga, which is particularly susceptible to disruption to surface sheet flow.

### 6.1.3 Groundwater Drawdown

Drawdown of water levels in underground aquifers may arise from mine pit dewatering, where the ore body extends below the water table, or from extraction of process water from borefields. The extent of groundwater drawdown potentially associated with the BS4 Project is not known, however hydrological studies are underway.

Groundwater drawdown can potentially lower water levels beyond the reach of dependent species (termed "phreatophytes"). The majority of vegetation within the BS4 Project area is not phreatophytic. Vegetation types that could be impacted by groundwater drawdown comprise C1 (Coolibah *Eucalyptus victrix* woodlands of creeklines; mainly along Boolgeeda Creek) and possibly P1 (the Mulga woodlands in the broad drainage area within the valley south of Mt West). Current studies indicate that Mulga in the Pilbara utilises either deep soil water, or predominantly groundwater with some soil water (Dr Pauline Grierson, University of Western Australia, pers. comm. 2004). In the event that any groundwater drawdown associated with the BS4 Project is shown to extend below the Mulga vegetation type P1, a stable isotope study should be undertaken to determine the source of water utilised by these trees, and hence the likelihood of impact to this vegetation type.

### 6.1.4 Introduction / Spread of Weeds

Six introduced flora species were recorded from the BS4 Project area, and a further weed species is likely. Physical disturbance and additional movement of vehicles within the Project area may result in the introduction of additional weed species and/or the spread of the existing weed populations (particularly with respect to the Buffel Grass infestations along creeks in the western section of the Project area). Control of most of the weed species recorded would be extremely difficult, however the single population of Ruby Dock *\*Acetosa*

*vesicaria* should be able to be eradicated. Management measures for the remaining species are aimed at limiting their spread.

### 6.1.5 Fire

Construction and operation of the proposed BS4 Project has the potential to increase the frequency of fires in the area. The hummock grassland vegetation types that dominate the BS4 Project area are typically very flammable, but are also adapted to fire and recover relatively quickly. Increased frequency of fires can, however, lead to changes in floristic composition and a prevalence of early seral stages of the vegetation (the climax vegetation is prevented from developing; Biota and Trudgen 2002). Mulga communities may be killed by hot fires; the Mulga woodlands and tall shrublands within the Project area would be particularly susceptible to damage.

### 6.1.6 Erosion

Clearing of vegetation has the potential to lead to increased rates of erosion, and the extremely fine-textured soils of the valley containing the Priority 1 *Ptilotus* sp. Brockman would be particularly susceptible to this. This valley has been designated an “Environmentally Sensitive Area” by Hamersley Iron, with signposting at either end of the single access track through this area. Measures have been put in place by Hamersley Iron to prevent more than one vehicle travelling on this access track at one time, so that passing is not required and the track does not become wider than necessary. However, the track is already showing signs of erosion, and this is likely to increase over time (see Plate 6.2).



Plate 6.2: Access track through the valley containing the population of *Ptilotus* sp. Brockman (note lowering of track surface compared to surrounding soil level).

### 6.1.7 Dust

Dust generated during the construction and operation of the BS4 Project has the potential to negatively affect surrounding vegetation, but this is considered likely to be a minor impact provided standard dust suppression measures are implemented.

## 6.2 Management Recommendations

The following management measures are proposed to minimise impact to the flora and vegetation of the BS4 Project area:

- The transport route and any infrastructure areas that have not been systematically searched for rare flora should be surveyed prior to construction.
- The population of the Priority 1 *Ptilotus* sp. Brockman within the BS4 Project area south of the central mine pit should not be disturbed. The access track through this area should be closed to prevent further erosion, and all staff and contractors should be made aware of the significance of this area as part of the on-site induction programme.
- The locations of the other Priority flora should be considered as part of the mine planning process and avoided if possible.
- Wherever possible, avoid disturbance to surface drainage features through sensitive mine planning. Where disturbance is unavoidable, install sufficient culverting to maintain surface water flows.
- Undertake an assessment of the likely impacts of groundwater drawdown on vegetation of the BS4 Project area once hydrological studies are complete, potentially including a stable isotope study to determine the source of water sustaining Mulga within vegetation type P1.
- Review the assessment of vegetation conservation significance following completion of an additional PATN floristic analysis, to be conducted once further data from the locality becomes available.
- Vegetation clearing should be kept to the minimum necessary for safe construction and operation of the BS4 Project, particularly in areas adjacent to vegetation of higher conservation significance.
- Weed control measures should be developed and implemented to prevent the introduction or spread of weeds in the BS4 Project area. A Weed Hygiene and Management Plan should be prepared in consultation with CALM prior to construction commencing.
- Prepare and implement a Fire Management Plan to minimise the risk of unplanned fires in the BS4 Project area.
- A Topsoil Management and Rehabilitation Plan should be prepared for all non-permanent cleared areas, in liaison with CALM, the Department of Environment and Department of Industry and Resources prior to the commencement of construction activities. This plan should include use of provenance collected native seed, characterisation and management of topsoil, and the respreading of cleared vegetative material. Recovery monitoring should also be carried out, with any rehabilitation failure subject to additional treatment to a suitable standard.
- Standard dust suppression measures should be implemented across the BS4 Project area during construction and operation to minimise effects on surrounding vegetation.
- Hamersley Iron should consider providing funding towards further scientific research. Appropriate topics could include the distribution, ecology and/or genetics of *Ptilotus* sp. Brockman.

## 7.0 Acknowledgements

The following persons are gratefully acknowledged for their assistance with this study:

- Mr Emil Thoma and Ms Anna Joder (Hamersley Iron) provided information regarding the targeted rare flora searches at BS4;
- Mr Malcolm Trudgen (ME Trudgen and Associates) identified the Mulga *Acacia aneura* specimens and made available his reference set of Pilbara flora;
- Mr Rob Davis (WA Herbarium) provided information regarding *Ptilotus* sp. Brockman.

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










# Appendix 1

Vegetation Types, Priority Flora Locations and Weed Locations within the BS4 Project Area





**Vegetation of Drainage Areas**

-  **C1** *Eucalyptus victrix* scattered low trees to open woodland over *Goodenia lamprosperma*, *Pluchea dentex* very open herbland
-  **C2** *Acacia pyrifolia*, *A. ancistrocarpa*, *Petalostylis labicheoides* shrubland over *Bonamia rosea*, *Tephrosia rosea* var. *glabrior* low open shrubland over *Triodia epactia* hummock grassland and *Themeda triandra* very open tussock grassland
-  **C3** *Eucalyptus xerothermica* scattered low trees over *Acacia citrinoviridis*, *Stylobasium spathulatum* tall shrubland over *Ptilotus obovatus* var. *obovatus* scattered shrubs over *Themeda triandra*, *Chrysopogon fallax* very open tussock grassland
-  **C4** *Acacia citrinoviridis* tall closed scrub over *Cenchrus ciliaris* closed tussock grassland
-  **C5** *Eucalyptus xerothermica*, *Corymbia hamersleyana* scattered low trees over *Acacia bivenosa*, *A. coyleana*, *A. elachantha*, *A. exilis* tall shrubland over *Triodia epactia* hummock grassland and *Eulalia aurea* open tussock grassland
-  **C6** *Eucalyptus xerothermica* scattered low trees over *Gastrolobium grandiflorum* open heath over *Chrysopogon fallax*, *Eulalia aurea* tussock grassland
-  **C7** *Corymbia hamersleyana*, *Eucalyptus xerothermica* scattered trees over *Acacia bivenosa* open heath over *Triodia angusta* open hummock grassland and *Themeda triandra* very open tussock grassland
-  **C8** *Corymbia hamersleyana* low open woodland over *Triodia epactia* hummock grassland and *Eriachne tenuiculmis*, *E. mucronata*, *Themeda* sp. Mount Barricade open tussock grassland
-  **C9** *Corymbia hamersleyana*, *Eucalyptus leucophloia* low woodland over *Grevillea wickhamii* tall shrubland over *Gossypium robinsonii* open shrubland over *Themeda* sp. Mount Barricade, *Eulalia aurea* and *Paraneurachne muelleri* open tussock grassland and *Triodia epactia* open hummock grassland
-  **C10** *Eucalyptus leucophloia*, *Corymbia deserticola* scattered low trees over *Acacia tumida* var. *pilbarensis* tall open scrub over *Triodia epactia*, *T. wiseana* open hummock grassland
-  **C11** *Acacia citrinoviridis*, *A. ancistrocarpa* tall open shrubland to tall closed scrub over *Triodia epactia* mid-dense hummock grassland
-  **C12** *Acacia monticola*, *A. maitlandii*, *A. atkinsiana* tall open shrubland over *Triodia epactia*, *T. wiseana* mid-dense to open hummock grassland
-  **C13** *Corymbia hamersleyana*, *Eucalyptus gamophylla* low open woodland over *Acacia monticola*, *A. ancistrocarpa*, *A. bivenosa*, *Rulingia lutiflora* tall closed scrub over *Triodia epactia* hummock grassland
-  **C14** *Eucalyptus leucophloia* low woodland over *Acacia citrinoviridis*, *Acacia monticola*, *Dodonaea pachyneura* tall open shrubland over *Triodia epactia* mid-dense hummock grassland
-  **C15** *Stylobasium spathulatum* shrubland over *Triodia epactia* hummock grassland
-  **C16** *Corymbia hamersleyana* scattered low trees over *Acacia bivenosa*, *Petalostylis labicheoides* shrubland over *Triodia epactia* hummock grassland
-  **C17** *Acacia aneura* low woodland to low open forest over *Chrysopogon fallax*, *Triodia epactia* open tussock/hummock grassland
-  **C18** *Eucalyptus victrix*, *E. xerothermica* low open woodland over *Acacia citrinoviridis* tall open shrubland over *Themeda triandra*, *Chrysopogon fallax* tussock grassland
-  **C19** *Corymbia hamersleyana* scattered low trees over *Acacia atkinsiana* tall shrubland over *Triodia epactia* hummock grassland
-  **C20** *Acacia aneura* low open forest over *Acacia citrinoviridis* tall open shrubland over *Triodia epactia* hummock grassland
-  **C21** *Petalostylis labicheoides* shrubland over *Triodia epactia* mid-dense hummock grassland



**Vegetation Types in the Brockman Syncline 4 Study Area**

Legend Sheet 2 of 3



Biota  
Environmental  
Sciences

## Miscellaneous

### Vegetation / Flora Sites

- BRO20: Site identification number, indicated by a brown point if no Priority Flora or Weeds
- Sw: Species code(s) for Priority Flora, indicated by a red point
- Bc: Species code(s) for weeds, indicated by a blue dot if no Priority Flora

### Priority Flora Species Codes

- Pb *Ptilotus* sp. Brockman (E. Thoma & A. Joder ET & AJ 145)
- At *Abutilon trudgeniims.*
- Pa *Phyllanthus aridus*
- Sw *Sida* sp. Wittenoom (W.R.Barker 1962)
- Em *Eremophila magnifica* subsp. *magnifica*
- Gs *Goodenia stellata*

### Weed Species Codes

- Av *Acetosa vesicaria*
- Bb *Bidens bipinnata*
- Cc *Cenchrus ciliaris*
- Cs *Cenchrus setigerus*
- Ma *Malvastrum americanum*
- Sv *Setaria verticillata*
- Ao *Argemone ochroleuca* subsp. *ochroleuca*

-  Study Area
-  Rail
-  Roads
-  Creeks



## Vegetation Types in the Brockman Syncline 4 Study Area

Legend Sheet 3 of 3

BIota

Biota  
Environmental  
Sciences

520000

528000



7520000

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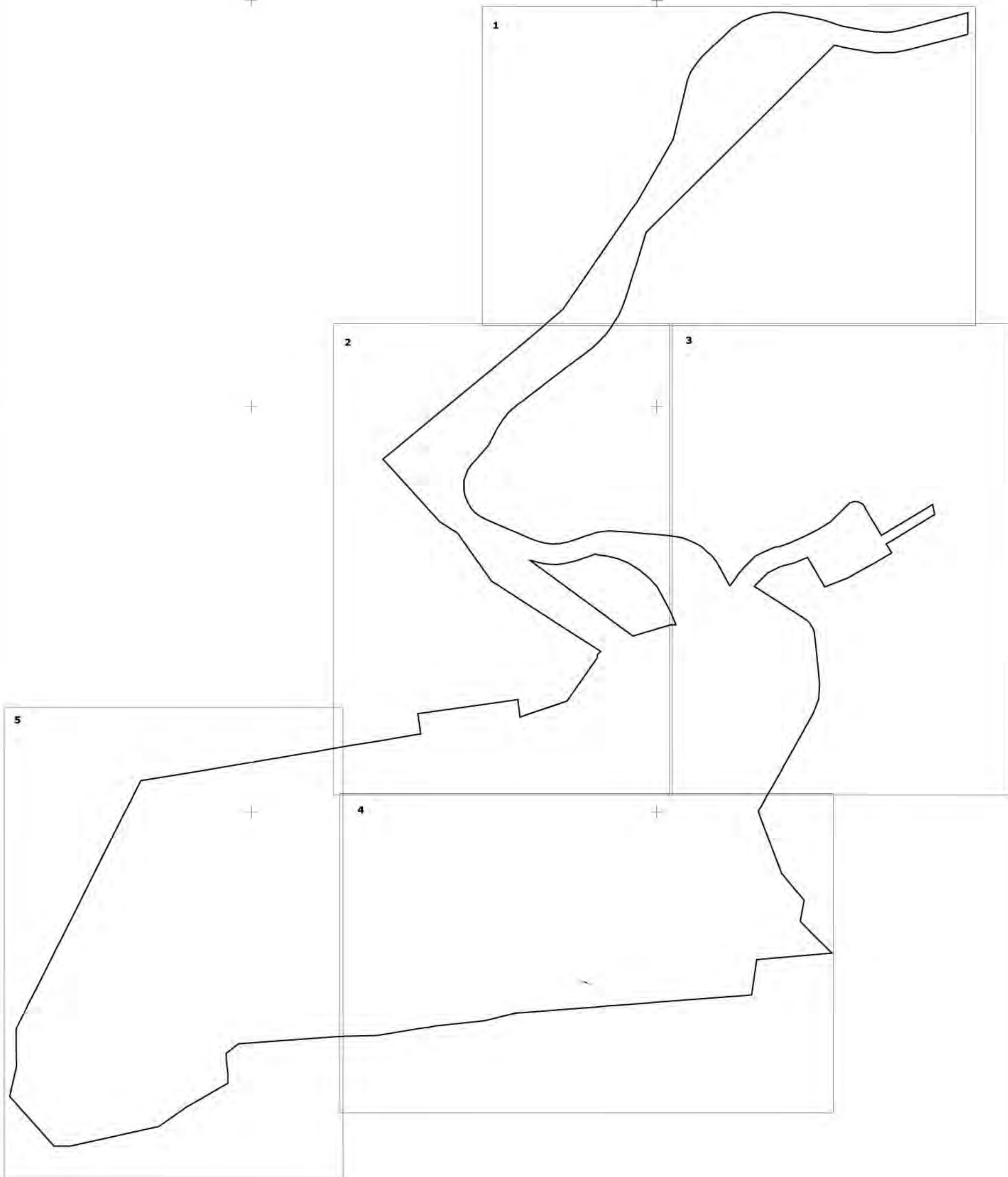
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**Overview of Brockman Syncline 4  
1:25,000 Mapping Sheets**

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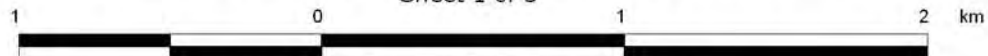
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**Vegetation Mapping of the Brockman Syncline 4 Survey Area**

Sheet 1 of 5

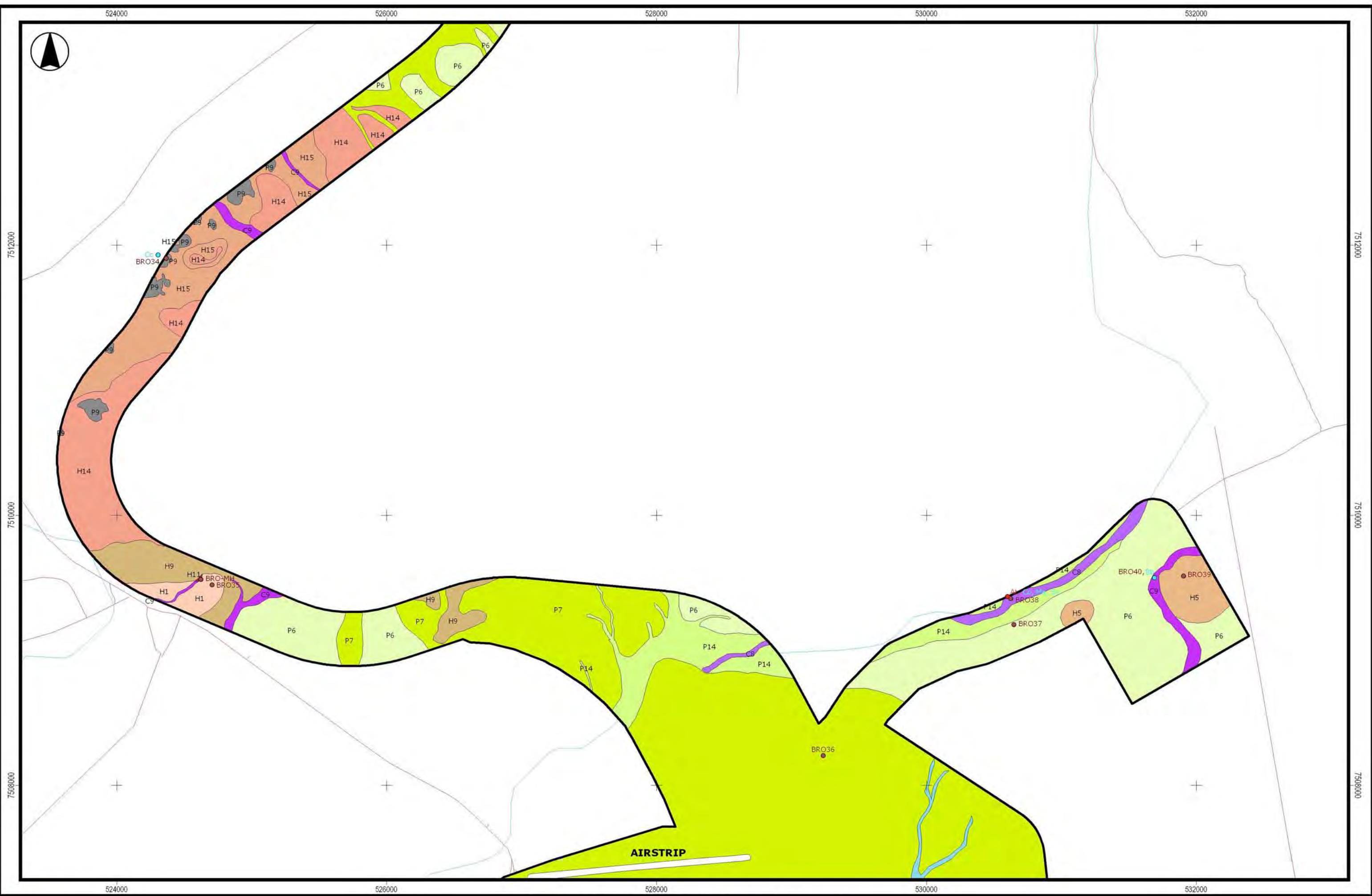


See legend and overview sheets for more information



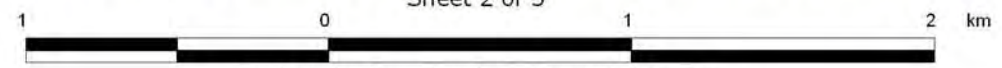
Biota  
Environmental  
Sciences





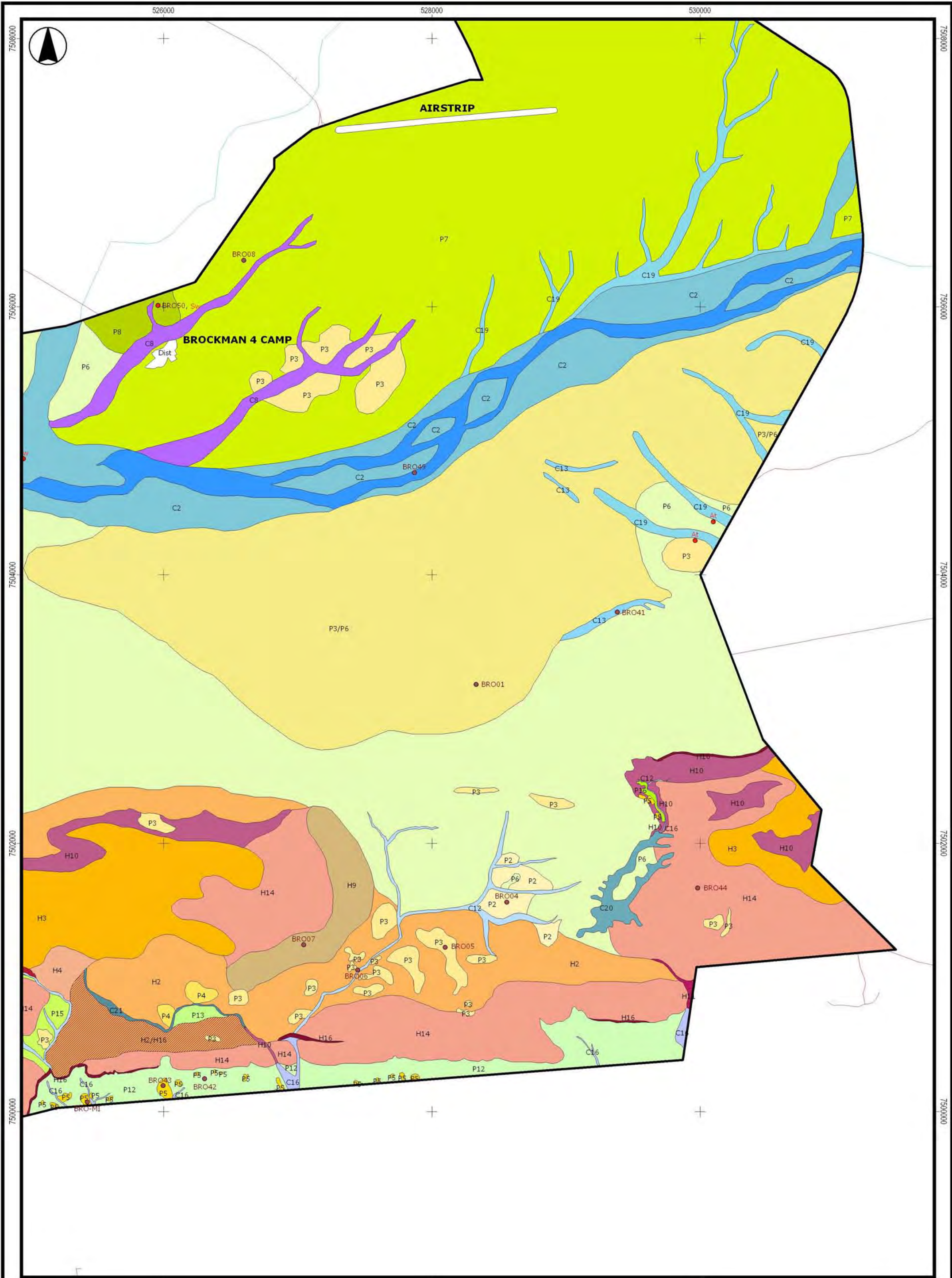
**Vegetation Mapping of the Brockman Syncline 4 Survey Area**

Sheet 2 of 5

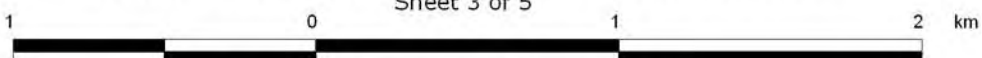


See legend and overview sheets for more information





Vegetation Mapping of the Brockman Syncline 4 Survey Area  
Sheet 3 of 5



See legend and overview sheets for more information



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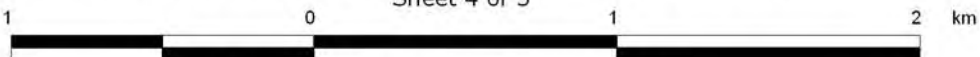
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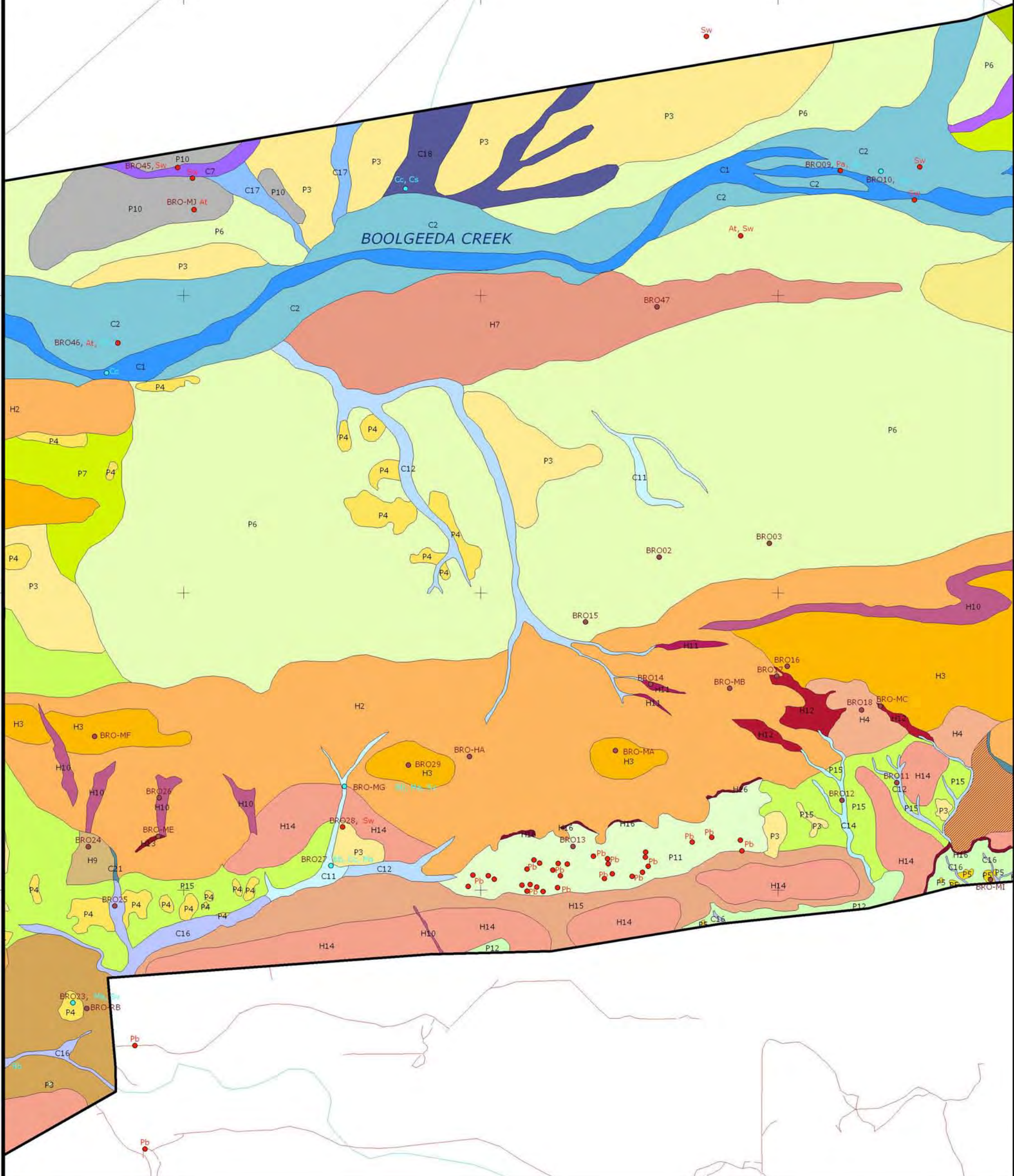
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### Vegetation Mapping of the Brockman Syncline 4 Survey Area

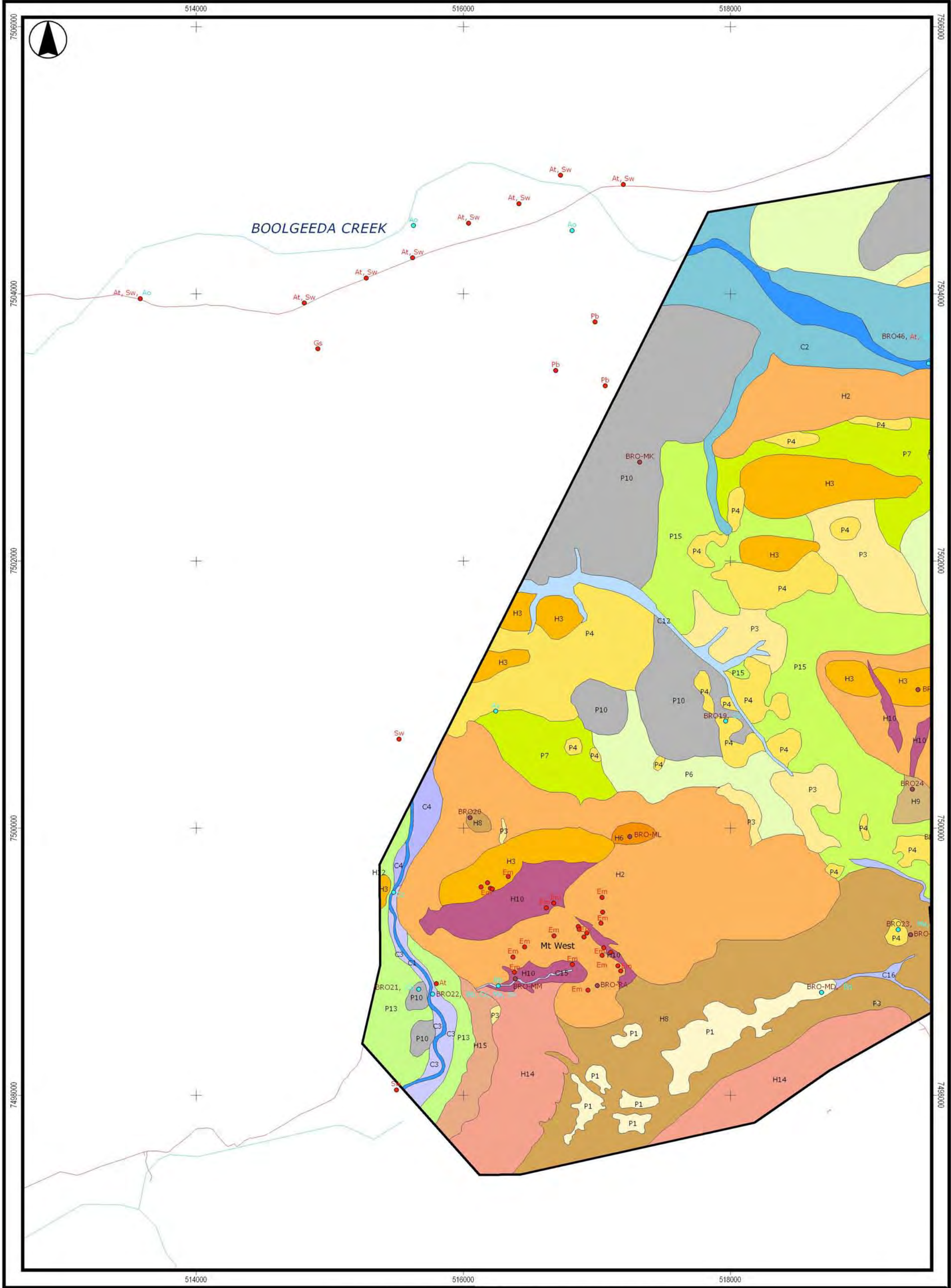
Sheet 4 of 5



See legend and overview sheets for more information

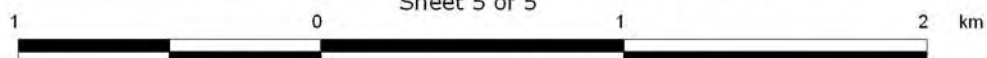






Vegetation Mapping of the Brockman Syncline 4 Survey Area

Sheet 5 of 5



See legend and overview sheets for more information



Representative photographs of vegetation types in the BS4 Project area.



H1: *Corymbia hamersleyana* scattered trees over *Cassia pruinosa* open shrubland over *Triodia wiseana* hummock grassland



H2: *Eucalyptus leucophloia* scattered low trees over *Acacia atkinsiana* open shrubland over *Triodia wiseana* mid-dense hummock grassland



H3: *Eucalyptus leucophloia* scattered low trees over *Acacia maitlandii* shrubland to open heath over *Triodia wiseana* mid-dense hummock grassland



H4: *Acacia hamersleyensis* tall open shrubland over *Triodia wiseana* closed hummock grassland



H5: *Eucalyptus leucophloia* scattered low trees over *Acacia exilis* (*A. bivenosa*) open shrubland over *Triodia wiseana* mid-dense hummock grassland



H7: *Acacia stowardii* low open woodland over *Eremophila exilifolia* scattered shrubs over *Triodia epactia* mid-dense hummock grassland



H8: *Acacia ancistrocarpa* open heath to tall open shrubland over *Triodia wiseana* mid-dense to closed hummock grassland



H9: *Acacia inaequilatera* tall shrubland over *Triodia wiseana* mid-dense hummock grassland



H10: *Eucalyptus leucophloia* low open woodland over *Acacia bivenosa* open shrubland over *Triodia brizoides*, *T. epactia* hummock grassland and *Themeda* sp. Mt. Barricade, *Cymbopogon ambiguus* open tussock grassland



H11: *Eucalyptus leucophloia* scattered low trees over *Gossypium robinsonii*, *Dodonaea pachyneura* (*Acacia maitlandii*) open shrubland over *Triodia epactia* mid-dense hummock grassland



H12: *Eucalyptus leucophloia* low open woodland over *Acacia hamersleyensis* open shrubland over *Triodia brizoides*, *T. epactia* mid-dense hummock grassland and *Themeda triandra*, *Eriachne mucronata* open tussock grassland



H14: *Eucalyptus leucophloia* scattered low trees over *Triodia wiseana* mid-dense hummock grassland



P2: *Acacia ayersiana* low open forest/woodland over *Eremophila forrestii* open shrubland over *Triodia epactia*, *T. wiseana* hummock grassland



P3: *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia aneura* (various forms), *A. ayersiana* tall open shrubland over *Triodia epactia*, *T. wiseana* mid-dense hummock grassland



P4: *Acacia xiphophylla*, *A. aneura* (flat curved; MET 15,548) low woodland to tall open shrubland over *Eremophila cuneifolia*, *Rhagodia eremaea* low open shrubland over *Triodia wiseana* open to mid-dense hummock grassland



P5: *Acacia xiphophylla*, *A. aff. aneura* (narrow fine veined; site 1259) tall shrubland over *Triodia brizoides*, *T. epactia* open hummock grassland



P6: *Corymbia deserticola* scattered low trees over *Acacia atkinsiana*, *A. exilis* tall open shrubland over *Triodia wiseana* closed hummock grassland



P7: *Corymbia deserticola* low open woodland over *Acacia atkinsiana* shrubland to tall shrubland over *Triodia epactia*, *T. wiseana* mid-dense hummock grassland



P8: *Eucalyptus xerothermica* low open woodland over *Eremophila fraseri* scattered shrubs over *Triodia wiseana* mid-dense hummock grassland



P9: *Eucalyptus socialis* low open woodland over *Triodia wiseana* open hummock grassland



P10: *Eucalyptus leucophloia*, *E. xerothermica* scattered low trees over *Acacia bivenosa*, *A. exilis* open shrubland to tall open shrubland over *Triodia wiseana*, *T. angusta* mid-dense hummock grassland



P11: *Acacia synchronicia* scattered shrubs over *Triodia angusta* mid-dense hummock grassland



P12: *Acacia synchronicia*, *A. bivenosa*, *Cassia pruinosa*, *C. luerssenii* mixed shrubland over *Triodia brizoides* closed hummock grassland



C1: *Eucalyptus victrix* scattered low trees to open woodland over *Goodenia lamprosperma*, *Pluchea dentex* very open herbland



C2: *Acacia pyrifolia*, *A. ancistrocarpa*, *Petalostylis labicheoides* shrubland over *Bonamia rosea*, *Tephrosia rosea* var. *glabrior* low open shrubland over *Triodia epactia* hummock grassland and *Themeda triandra* very open tussock grassland



C3: *Eucalyptus xerothermica* scattered low trees over *Acacia citrinoviridis*, *Stylobasium spathulatum* tall shrubland over *Ptilotus obovatus* var. *obovatus* scattered shrubs over *Themeda triandra*, *Chrysopogon fallax* very open tussock grassland



C5: *Eucalyptus xerothermica*, *Corymbia hamersleyana* scattered low trees over *Acacia bivenosa*, *A. cowleana*, *A. elachantha*, *A. exilis* tall shrubland over *Triodia epactia* hummock grassland and *Eulalia aurea* open tussock grassland



C6: *Eucalyptus xerothermica* scattered low trees over *Gastrolobium grandiflorum* open heath over *Chrysopogon fallax*, *Eulalia aurea* tussock grassland



C7: *Corymbia hamersleyana*, *Eucalyptus xerothermica* scattered trees over *Acacia bivenosa* open heath over *Triodia angusta* open hummock grassland and *Themeda triandra* very open tussock grassland



C8: *Corymbia hamersleyana* low open woodland over *Triodia epactia* hummock grassland and *Eriachne tenuiculmis*, *E. mucronata*, *Themeda* sp. Mt. Barricade open tussock grassland



C9: *Corymbia hamersleyana*, *Eucalyptus leucophloia* low woodland over *Grevillea wickhamii* tall shrubland over *Gossypium robinsonii* open shrubland over *Themeda* sp. Mt. Barricade, *Eulalia aurea* and *Paraneurachne muelleri* open tussock grassland and *Triodia epactia* open hummock grassland



C10: *Eucalyptus leucophloia*, *Corymbia deserticola* scattered low trees over *Acacia tumida* var. *pilbarensis* tall open scrub over *Triodia epactia*, *T. wiseana* open hummock grassland



C11: *Acacia citrinoviridis*, *A. ancistrocarpa* tall open shrubland to tall closed scrub over *Triodia epactia* mid-dense hummock grassland



C12: *Acacia monticola*, *A. maitlandii*, *A. atkinsiana* tall open shrubland over *Triodia epactia*, *T. wiseana* mid-dense to open hummock grassland



C13: *Corymbia hamersleyana*, *Eucalyptus gamophylla* low open woodland over *Acacia monticola*, *A. ancistrocarpa*, *A. bivenosa*, *Rulingia luteiflora* tall closed scrub over *Triodia epactia* hummock grassland



C14: *Eucalyptus leucophloia* low woodland over *Acacia citrinoviridis*, *A. monticola*, *Dodonaea pachyneura* tall shrubland over *Triodia epactia* mid-dense hummock grassland



C16: *Corymbia hamersleyana* scattered low trees over *Acacia bivenosa*, *Petalostylis labicheoides* shrubland over *Triodia epactia* hummock grassland



## Appendix 2

### Summary of Results of the PATN Floristic Analysis

Summary table showing the 20-group, 50-group and 100-group levels defined for the current PATN analysis, and the vegetation types and sites from the BS4 Project area within each group.

group 20	group 50	group 100	Cape Preston	Mesa A/ Mesa G	Mesa J Extension	MILL	Brockman	WAEIMIWE	WAFCBOR	WASA	Yandi Expansion	Mindy Mindy	Biota Vegetation Mapping Types (and Associated Sites / Relevés) from the BS4 Study (see Section 4.2 for explanation of vegetation codes)				
1	1	1							2	14							
		2								13							
	2	3								8							
		4								4							
		5								2							
3	6							16									
	7							2	3								
4	8								5								
	9								5								
2	5	10							2			1					
		11										1					
		12							1	1							
	6	13						1	1	1			H8 (BRO20)				
		14		1	1					1							
	8	15						3		1			P5 (BRO43, BRO-M), P11 (BRO13)				
		16						8					P3 (BRO28), P4 (BRO19), P8 (BRO50), P9 (BRO34), P10 (BRO21, BRO-MJ, BRO-MK), P12 (BRO42)				
		17	1					3		2			P1 (BRO-MD), P4 (BRO23), C16 (BRO25)				
		18								2							
		19								17							
9	20								3								
	21								1								
3	10	22				1			1								
		23		1	2		2				7	1	C1 (BRO09, BRO49)				
	24					6											
	25										4						
	13	26						9						C2 (BRO10, BRO46), C3 (BRO22), C5 (BRO32), C7 (BRO45), C8 (BRO38), C9 (BRO40), C11 (BRO27, BRO-MG)			
27							1				9	4	C6 (BRO-RC)				
28											7	2					
29																	
4	14	30							2								
		31							2								
5	16	32										2					
		33		2	6												
6	17	34									1	10					
		35							2								
		36					2										
		37					4										
7	20	38															
		39	4														
		40	6														
		41	2														
8	21	42	4														
		43	1														
		44	1														
		45	4														
9	23	46	24														
		47	15														
		48	18														
	24	13															
	25	10															
10	26	49															
		50															
		51	2														
11	27	52				2				1							
		53				1											
12	30	54				10											
		55								7							
		56									2						
13	32	57	10									2					
		58															
14	33	59	3														
		60	1														
		61		2						2							
		62					4				1		1				
		63					18										
15	34	64				5											
		65		1			12										
		66					20										
		67					5										
16	35	68							2		15	13		H7 (BRO47), P2 (BRO04), P3 (BRO01, BRO05), P6 (BRO37), P7 (BRO08, BRO33, BRO36), C10 (BRO31), C12 (BRO11), C13 (BRO41), C14 (BRO12)			
		69					12										
		70					18									H1 (BRO35), H2 (BRO-HA, BRO-MB, BRO-RA), H3 (BRO16, BRO29, BRO-MA, BRO-MF), H4 (BRO18), H5 (BRO39), H6 (BRO-ML), H9 (BRO07, BRO24), H14 (BRO44), P6 (BRO02, BRO03, BRO15, BRO30)	
		71		19													
		72		5													
17	40	73		4													
		74		5													
		75			3												
		76		15			1										
		77						1			13				C12 (BRO06)		
18	41	78								1		1					
		79								10							
		80									18						
		81									7						H10 (BRO26, BRO-MM), H11 (BRO14, BRO-MH), H12 (BRO17, BRO-MC), H13 (BRO-ME)
19	42	82								9							
		83				1											
		84									5						
		85									2						
		86									1						
		87									1						
20	43	88								2							
		89								2							
		90									2						
		91									29						H8 (BRO-RB)
		92									22						
20	44	93								10							
		94									28						
		95									18						
		96									7						
		97									32						
		98									7						
20	49	99								2							
		100								4							

EXPLANATION OF PROJECT CODES

Cape Preston	Cape Preston mine area, west of Dampier (Biota and Trudgen 1998)
Mesa A/ Mesa G	Mesa A and Mesa G mine areas (Biota 2005c)
Mesa J Extension	Mesa J Extension mine area (Biota 2003)
MILL	West Angelas Millstream Rail Segment (Trudgen)
Brockman	Brockman 4 survey area (this study)
WAEIMIWE	West Angelas Eight Mile Well survey (Trudgen and Casson 1998)
WAFCBOR	West Angelas Four Corners Bore rail corridor (Trudgen and Casson 1998)
WASA	West Angelas mine area (Trudgen and Casson 1998)
Yandi Expansion	Hammersley Iron Yandi Expansion area (Biota 2004d)
Mindy Mindy	Mindy Mindy mine area surveyed as part of FMG Stage B rail corridor and mines survey (Biota 2004c)

Colour-coding as follows: stony hills: stony plains: gorges: Mulga/Snakewood vegetation: creeklines



## Appendix 3

### List of Vascular Flora Recorded from the BS4 Project Area

NB. \* denotes introduced species (weeds).

Correspondence of *Cassia* / *Senna* nomenclature:

<i>Cassia artemisioides</i>	-	<i>Senna artemisioides</i> subsp. x <i>artemisioides</i>
<i>Cassia ferraria</i>	-	<i>Senna ferraria</i>
<i>Cassia glaucifolia</i>	-	<i>Senna glaucifolia</i>
<i>Cassia glutinosa</i>	-	<i>Senna glutinosa</i> subsp. <i>glutinosa</i>
<i>Cassia helmsii</i>	-	<i>Senna artemisioides</i> subsp. <i>helmsii</i>
<i>Cassia luerssenii</i>	-	<i>Senna glutinosa</i> subsp. x <i>luerssenii</i>
<i>Cassia notabilis</i>	-	<i>Senna notabilis</i>
<i>Cassia oligophylla</i>	-	<i>Senna artemisioides</i> subsp. <i>oligophylla</i>
<i>Cassia pruinosa</i>	-	<i>Senna glutinosa</i> subsp. <i>pruinosa</i>
<i>Cassia 'stricta'</i>	-	<i>Senna stricta</i>
<i>Cassia sturtii</i>	-	<i>Senna artemisioides</i> subsp. x <i>sturtii</i>
<i>Cassia venusta</i>	-	<i>Senna venusta</i>

ACANTHACEAE (325)

*Di cladantha forrestii*

*Dipteracanthus australasicus* subsp. *australasicus*

*Harnieria kempeana* subsp. *muelleri*

ADIANTACEAE (7)

*Cheilanthes brownii*

*Cheilanthes sieberi* subsp. *sieberi*

AMARANTHACEAE (106)

*Alternanthera nana*

*Alternanthera nodiflora*

*Amaranthus mitchellii*

*Amaranthus pallidiflorus*

*Amaranthus* sp.

*Gomphrena canescens* subsp. *canescens*

*Gomphrena cunninghamii*

*Gomphrena kanisii*

*Gomphrena leptoclada* subsp. *leptoclada*

*Ptilotus aervoides*

*Ptilotus astrolasius* var. *astrolasius*

*Ptilotus auriculifolius*

*Ptilotus calostachyus* var. *calostachyus*

*Ptilotus carinatus*

*Ptilotus clementii*

*Ptilotus exaltatus* var. *exaltatus*

*Ptilotus fusiformis* var. *fusiformis*

*Ptilotus gomphrenoides* var. *gomphrenoides*

*Ptilotus helipteroides* var. *helipteroides*

*Ptilotus macrocephalus*

*Ptilotus obovatus* var. *obovatus*

*Ptilotus polystachyus* var. *polystachyus*

*Ptilotus rotundifolius*

*Ptilotus schwartzii* var. *schwartzii*

*Ptilotus* sp. Brockman (E.Thoma & A.Joder ET & AJ 145)

APIACEAE (281)

*Trachymene oleracea* subsp. *oleracea*

ARALIACEAE (280)

*Astrotricha hamptonii*

ASCLEPIADACEAE (305)

*Rhyncharhena linearis*

*Sarcostemma viminale* subsp. *australe*

ASTERACEAE (345)

\**Bidens bipinnata*

*Calocephalus knappii*

*Calotis plumulifera*

*Centipeda minima*

*Chrysocephalum apiculatum*

*Chrysocephalum pterochaetum*

*Flaveria australasica*

*Olearia sturtii*

*Pentalepis trichodesmoides*

*Pluchea dentex*

*Pterocaulon sphaeranthoides*

*Rhodanthe floribunda*

*Rhodanthe margarethae*

*Rutidosis helichrysoides*

*Streptoglossa bubakii*

*Streptoglossa decurrens*

*Streptoglossa tenuiflora*

*Streptoglossa* sp.

*Vittadinia arida*

*Vittadinia virgata*

BORAGINACEAE (310)

*Ehretia saligna* var. *saligna*

*Heliotropium chrysocarpum*

*Heliotropium cunninghamii*

*Heliotropium inexplicitum*

*Trichodesma zeylanicum* var. *zeylanicum*

BRASSICACEAE (138)

*Lepidium pedicellosum*

*Lepidium pholidogynum*

*Lepidium platypetalum*

CAESALPINIACEAE (164)

*Cassia artemisioides*

*Cassia ferraria*

*Cassia glaucifolia*

*Cassia glaucifolia* x ? (site 626)

*Cassia glutinosa*

*Cassia glutinosa* x *luerssenii*

*Cassia helmsii*

*Cassia luerssenii*

*Cassia luerssenii* x '*stricta*'

*Cassia notabilis*

*Cassia oligophylla*

*Cassia* aff. *oligophylla* (thinly sericeous)

*Cassia* ? *oligophylla* x

<i>Cassia ?oligophylla x glaucifolia</i> (HD13-14)	<i>Euphorbia biconvexa</i>
<i>Cassia oligophylla x helmsii</i>	<i>Euphorbia boophthona</i>
<i>Cassia pruinosa</i>	<i>Euphorbia</i> aff. <i>boophthona</i> (large seed form)
<i>Cassia pruinosa x ?glutinosa</i>	<i>Euphorbia coghlanii</i>
<i>Cassia pruinosa x luerssenii</i>	<i>Euphorbia tannensis</i> subsp. <i>eremophila</i>
<i>Cassia 'stricta'</i>	(Hamersley form)
<i>Cassia sturtii</i>	<i>Euphorbia</i> sp.
<i>Cassia venusta</i>	<i>Flueggea virosa</i> subsp. <i>melanthesoides</i>
<i>Petalostylis labicheoides</i>	<i>Leptopus decaisnei</i> var. <i>decaisnei</i>
CAMPANULACEAE (339)	<i>Phyllanthus aridus</i>
<i>Wahlenbergia tumidiflora</i>	<i>Phyllanthus erwinii</i>
CAPPARACEAE (137A)	<i>Phyllanthus maderaspatensis</i>
<i>Capparis lasiantha</i>	GOODENIACEAE (341)
<i>Capparis umbonata</i>	<i>Dampiera candicans</i>
<i>Cleome viscosa</i>	<i>Goodenia cusackiana</i>
CARYOPHYLLACEAE (113)	<i>Goodenia forrestii</i>
<i>Polycarpaea corymbosa</i> var. <i>corymbosa</i>	<i>Goodenia heterochila</i>
<i>Polycarpaea holtzei</i>	<i>Goodenia lamprosperma</i>
<i>Polycarpaea longiflora</i>	<i>Goodenia microptera</i>
CHENOPODIACEAE (105)	<i>Goodenia muelleriana</i>
<i>Chenopodium melanocarpum</i>	<i>Goodenia stobbsiana</i>
<i>Dysphania kalpari</i>	<i>Goodenia triodiophila</i>
<i>Dysphania rhadinostachya</i> subsp. <i>rhadinostachya</i>	<i>Scaevola amblyanthera</i>
<i>Dysphania sphaerosperma</i>	<i>Scaevola parvifolia</i> subsp. <i>pilbarae</i>
<i>Enchylaena tomentosa</i>	<i>Scaevola spinescens</i> (broad form)
<i>Maireana georgei</i>	<i>Velleia connata</i>
<i>Maireana melanocoma</i>	GYROSTEMONACEAE (108)
<i>Maireana planifolia</i>	<i>Codonocarpus cotinifolius</i>
<i>Maireana tomentosa</i>	HALORAGACEAE (276)
<i>Maireana triptera</i>	<i>Haloragis gossei</i>
<i>Maireana villosa</i>	LAMIACEAE (313)
<i>Rhagodia eremaea</i>	<i>Clerodendrum floribundum</i> var. <i>angustifolium</i>
<i>Salsola tragus</i>	<i>Clerodendrum tomentosum</i> var. <i>lanceolatum</i>
<i>Sclerolaena cornishiana</i>	<i>Prostanthera albiflora</i>
COMMELINACEAE (47)	LOBELIACEAE (340)
<i>Commelina ensifolia</i>	<i>Lobelia heterophylla</i>
CONVOLVULACEAE (307)	LORANTHACEAE (97)
<i>Bonamia media</i> var. <i>villosa</i>	<i>Amyema fitzgeraldii</i>
<i>Bonamia rosea</i>	<i>Amyema miquelii</i>
<i>Convolvulus angustissimus</i> subsp. <i>angustissimus</i>	<i>Amyema</i> sp. Fortescue (M.E.Trudgen 5358)
<i>Evolvulus alsinoides</i> var. <i>decumbens</i>	<i>Diplatia grandibractea</i>
<i>Evolvulus alsinoides</i> var. <i>villosicalyx</i>	<i>Lysiana casuarinae</i>
<i>Operculina aequisejala</i>	LYTHRACEAE (265)
<i>Polymeria</i> sp.	<i>Ammannia multiflora</i>
<i>Porana commixta</i>	MALVACEAE (221)
CUCURBITACEAE (337)	<i>Abutilon cunninghamii</i>
<i>Mukia maderaspatana</i>	<i>Abutilon lepidum</i>
<i>Mukia</i> sp.D Flora of Australia(A.A.Mitchell PRP 1121)	<i>Abutilon</i> aff. <i>lepidum</i> (1) (MET 15 352)
CYPERACEAE (32)	<i>Abutilon otocarpum</i>
<i>Bulbostylis barbata</i>	<i>Abutilon oxycarpum</i> subsp. <i>prostratum</i>
<i>Bulbostylis turbinata</i>	<i>Abutilon trudgenii</i>
<i>Cyperus cunninghamii</i> subsp. <i>cunninghamii</i>	<i>Abutilon</i> sp.
<i>Cyperus iria</i>	<i>Gossypium australe</i> (Burrup Peninsula form)
<i>Cyperus squarrosus</i>	<i>Gossypium robinsonii</i>
<i>Fimbristylis dichotoma</i>	<i>Gossypium sturtianum</i>
<i>Fimbristylis simulans</i>	<i>Hibiscus brachychlaenus</i>
<i>Lipocarpha microcephala</i>	<i>Hibiscus burtonii</i>
ELATINACEAE (235)	<i>Hibiscus coatesii</i>
<i>Bergia pedicellaris</i>	<i>Hibiscus</i> aff. <i>coatesii</i>
<i>Bergia trimera</i>	<i>Hibiscus</i> aff. <i>coatesii</i> (MET 16,542)
EUPHORBIACEAE (185)	<i>Hibiscus</i> aff. <i>coatesii</i> (site 664)

- Hibiscus goldsworthii*  
*Hibiscus platyklamys*  
*Hibiscus sturtii* var. aff. *platyklamys*  
*Hibiscus* aff. *sturtii*  
*Hibiscus* sp.  
 \**Malvastrum americanum*  
*Sida arenicola*  
*Sida atrovirens*  
*Sida cardiophylla*  
*Sida* aff. *cardiophylla*  
*Sida* aff. *cardiophylla* (site 1215)  
*Sida echinocarpa*  
*Sida excedentifolia*  
*Sida* aff. *fibulifera*  
*Sida* aff. *fibulifera* (oblong; MET 15 220)  
*Sida rohlena* subsp. *rohlena*  
*Sida* sp. (BRO MH-1)  
*Sida* sp. Shovelanna Hill (S.van Leeuwen 3842)  
*Sida* sp. spiciform panicles (E.Leyland s.n.14/8/90)  
*Sida* sp. Wittenoom (W.R.Barker 1962)  
*Sida* sp. 'rugose'  
*Sida* sp.  
 MENISPERMACEAE (122)  
*Tinospora smilacina*  
 MIMOSACEAE (163)  
*Acacia ancistrocarpa*  
*Acacia aneura* var. *longicarpa*  
*Acacia aneura* (flat curved; MET 15 548)  
*Acacia* aff. *aneura* (grey flat recurved tips;  
 MET 15,828)  
*Acacia* aff. *aneura* (narrow fine veined; site 1259)  
*Acacia* aff. *aneura* (scythe-shaped; MET 15,743)  
*Acacia atkinsiana*  
*Acacia ayersiana*  
*Acacia bivenosa*  
*Acacia bivenosa* (wispy/weeping form)  
*Acacia citrinoviridis*  
*Acacia colei* var. *colei*  
*Acacia cowleana*  
*Acacia elachantha*  
*Acacia exilis*  
*Acacia farnesiana*  
*Acacia hamersleyensis*  
*Acacia inaequilatera*  
*Acacia kempeana*  
*Acacia maitlandii*  
*Acacia marramamba*  
*Acacia monticola*  
*Acacia pruinocarpa*  
*Acacia pyrifolia*  
*Acacia rhodophloia*  
*Acacia stowardii*  
*Acacia synchronicia*  
*Acacia tenuissima*  
*Acacia tetragonophylla*  
*Acacia tumida* var. *pilbarensis*  
*Acacia xiphophylla*  
*Neptunia dimorphantha*  
 MOLLUGINACEAE (110A)  
*Mollugo molluginis*  
 MORACEAE (87)  
*Ficus brachypoda*  
*Ficus virens*  
 MYOPORACEAE (326)  
*Eremophila cuneifolia*  
*Eremophila exilifolia*  
*Eremophila forrestii* subsp. *forrestii*  
*Eremophila fraseri* subsp. *fraseri*  
*Eremophila latrobei* subsp. *glabra*  
*Eremophila longifolia*  
*Eremophila magnifica* subsp. *magnifica*  
 MYRTACEAE (273)  
*Corymbia deserticola*  
*Corymbia ferritcola* subsp. *ferritcola*  
*Corymbia hamersleyana*  
*Corymbia zygophylla*  
*Eucalyptus gamophylla*  
*Eucalyptus leucophloia* subsp. *leucophloia*  
*Eucalyptus pilbarensis*  
*Eucalyptus socialis*  
*Eucalyptus victrix*  
*Eucalyptus xerothermica*  
*Melaleuca eleuterostachya*  
*Melaleuca glomerata*  
 NYCTAGINACEAE (107)  
*Boerhavia coccinea*  
 OLEACEAE (301)  
*Jasminum didymum* subsp. *lineare*  
 PAPILIONACEAE (165)  
*Crotalaria medicaginea*  
*Cullen lachnostachys*  
*Cullen martinii*  
*Cullen pogonocarpum*  
*Gastrolobium grandiflorum*  
*Glycine canescens*  
*Gompholobium karijini* ms.  
*Indigofera colutea*  
*Indigofera monophylla*  
*Indigofera monophylla* (BRO 46-12)  
*Isotropis atropurpurea*  
*Rhynchosia minima* var. *australis*  
*Swainsona maccullochiana*  
*Templetonia egena*  
*Tephrosia arenicola*  
*Tephrosia* aff. *clementii* (11)  
*Tephrosia densa*  
*Tephrosia rosea* var. *glabrior*  
*Tephrosia* sp. Bungaroo Creek (M.E.Trudgen  
 11601)  
*Tephrosia* sp. Pilbara Ranges (S.van Leeuwen  
 4246)  
 POACEAE (31)  
*Amphipogon sericeus*  
*Aristida contorta*  
*Aristida holathera* var. *holathera*  
*Aristida inaequiglumis*  
*Aristida latifolia*  
*Aristida* sp.  
*Brachyachne convergens*  
 \**Cenchrus ciliaris*  
 \**Cenchrus setigerus*  
*Chrysopogon fallax*

*Cymbopogon ambiguus*  
*Cymbopogon bombycinus*  
*Cymbopogon obtectus*  
*Dichanthium sericeum* subsp. *humilius*  
*Digitaria brownii*  
*Enneapogon caerulescens* var. *caerulescens*  
*Enneapogon clelandii*  
*Enneapogon lindleyanus*  
*Enneapogon polyphyllus*  
*Enteropogon acicularis*  
*Eragrostis cumingii*  
*Eragrostis eriopoda*  
*Eragrostis leptocarpa*  
*Eragrostis pergracilis*  
*Eragrostis tenellula*  
*Eriachne aristidea*  
*Eriachne ciliata*  
*Eriachne mucronata*  
*Eriachne mucronata* (arid form) (MET 12 736)  
*Eriachne pulchella* subsp. *dominii*  
*Eriachne tenuiculmis*  
*Eulalia aurea*  
*Iseilema vaginiflorum*  
*Panicum decompositum*  
*Paraneurachne muelleri*  
*Paspalidium clementii*  
*Schizachyrium fragile*  
*Setaria dielsii*  
 \**Setaria verticillata*  
*Sporobolus australasicus*  
*Themeda* sp. Mt Barricade(M.E.Trudgen 2471)  
*Themeda triandra*  
*Tragus australianus*  
*Triodia angusta*  
*Triodia brizoides*  
*Triodia epactia*  
*Triodia longiceps*  
*Triodia wiseana*  
*Yakirra australiensis* var. *australiensis*  
 POLYGALACEAE (183)  
*Polygala* aff. *isingii*  
 POLYGONACEAE (103)  
 \**Acetosa vesicaria*  
 PORTULACACEAE (111)  
*Calandrinia ptychosperma*  
 PROTEACEAE (90)  
*Grevillea berryana*  
*Grevillea pyramidalis*  
*Grevillea wickhamii* subsp. *aprica*  
*Grevillea wickhamii* subsp. *hispidula*  
*Grevillea wickhamii* (sterile; subsp. not determined)

*Hakea chordophylla*  
*Hakea lorea* subsp. *lorea*  
 RUBIACEAE (331)  
*Oldenlandia crouchiana*  
*Psydrax suaveolens*  
*Synaptantha tillaeacea* var. *tillaeacea*  
 SANTALACEAE (92)  
*Santalum lanceolatum*  
 SAPINDACEAE (207)  
*Dodonaea coriacea*  
*Dodonaea lanceolata* var. *lanceolata*  
*Dodonaea pachyneura*  
 SCROPHULARIACEAE (316)  
*Peplidium muelleri*  
*Stemodia grossa*  
*Striga curviflora*  
 SOLANACEAE (315)  
*Nicotiana benthamiana*  
*Nicotiana cavicola*  
*Nicotiana* sp.  
*Solanum diversiflorum*  
*Solanum horridum*  
*Solanum lasiophyllum*  
*Solanum phlomoides*  
*Solanum sturtianum*  
 STACKHOUSIACEAE (202)  
*Stackhousia intermedia*  
 STERCULIACEAE (223)  
*Keraudrenia nephrosperma*  
*Melhania* sp. Turee Creek (MJ1-35)  
*Rulingia luteiflora*  
*Waltheria indica*  
 SURIANACEAE (160)  
*Stylobasium spathulatum*  
 TILIACEAE (220)  
*Corchorus crozophorifolius*  
*Corchorus lasiocarpus*  
*Corchorus sidoides* subsp. *sidoides*  
*Corchorus tridens*  
*Triumfetta maconochieana*  
 VIOLACEAE (243)  
*Hybanthus aurantiacus*  
 ZYGOPHYLLACEAE (173)  
*Tribulus astrocarpus*  
*Tribulus hirsutus*  
*Tribulus* aff. *hirsutus* (site 500)  
*Tribulus macrocarpus*  
*Tribulus suberosus*  
*Tribulus terrestris*  
*Zygophyllum iodocarpum*

## Appendix 4

Site Data from Quadrats and  
Relevés Assessed within the BS4  
Project Area



## Vegetation Structural Classes\* used for this Survey

Stratum	Canopy Cover (%)				
	70-100%	30-70%	10-30%	2-10%	<2%
Trees over 30 m	Tall closed forest	Tall open forest	Tall woodland	Tall open woodland	Scattered tall trees
Trees 10-30 m	Closed forest	Open forest	Woodland	Open woodland	Scattered trees
Trees under 10 m	Low closed forest	Low open forest	Low woodland	Low open woodland	Scattered low trees
Shrubs over 2 m	Tall closed scrub	Tall open scrub	Tall shrubland	Tall open shrubland	Scattered tall shrubs
Shrubs 1-2 m	Closed heath	Open heath	Shrubland	Open shrubland	Scattered shrubs
Shrubs under 1 m	Low closed heath	Low open heath	Low shrubland	Low open shrubland	Scattered low shrubs
Hummock grasses	Closed hummock grassland	Mid-dense hummock grassland	Hummock grassland	Open hummock grassland	Scattered hummock grasses
Grasses, Sedges, Herbs	Closed tussock grassland / sedgeland / herbland	Tussock grassland / sedgeland / herbland	Open tussock grassland / sedgeland / herbland	Very open tussock grassland / sedgeland / herbland	Scattered tussock grasses / sedges / herbs

\* Based on (Muir 1977), and Aplin's (1979) modification of the vegetation classification system of Specht (1970):  
 Aplin T.E.H. (1979). The Flora. Chapter 3 In O'Brien, B.J. (ed.) (1979). *Environment and Science*. University of Western Australia Press; Muir B.G. (1977). Biological Survey of the Western Australian Wheatbelt. Part II: Vegetation and habitat of Bendering Reserve. *Records of the Western Australian Museum, Suppl. No. 3*; Specht R.L. (1970). Vegetation. In *The Australian Environment*. 4th edn (Ed. G.W. Leeper). Melbourne.

## Vegetation Condition Scale\* used for this Survey

E = Excellent (=Pristine of BushForever) Pristine or nearly so; no obvious signs of damage caused by the activities of European man.
VG = Very Good (= Excellent of BushForever) Some relatively slight signs of damage caused by the activities of European man. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds such as <i>*Ursinia anthemoides</i> or <i>*Briza spp.</i> , or occasional vehicle tracks.
G = Good (= Very Good of BushForever) More obvious signs of damage caused by the activities of European man, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or by selective logging. Weeds as above, possibly plus some more aggressive ones such as <i>*Ehrharta spp.</i>
P = Poor (= Good of BushForever) Still retains basic vegetation structure or ability to regenerate to it after very obvious impacts of activities of European man, such as grazing, partial clearing (chaining) or frequent fires. Weeds as above, probably plus some more aggressive ones such as <i>*Ehrharta spp.</i>
VP = Very Poor (= Degraded of BushForever) Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species including very aggressive species.
D = Completely Degraded (= Completely Degraded of BushForever) Areas that are completely or almost completely without native species in the structure of their vegetation; ie. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

\* Based on Trudgen M.E. (1988). A Report on the Flora and Vegetation of the Port Kennedy Area. Unpublished report prepared for Bowman Bishaw and Associates, West Perth.

BS4 Site BRO01			
Described by	Raimond Orifici	Quadrat size	35 x 70m
Date	6/10/2004		
AMG Zone	50 528330mE, 7503181mN	528370mE, 7503190mN	
	528376mE, 7503118mN	528341mE, 7503113mN	
Habitat	Stony alluvial clay plain		
Soil	Red clay with ironstone pebbles		
Rock Type	Ironstone		
Vegetation	<i>Acacia</i> aff. <i>aneura</i> (narrow fine veined; site 1259) tall open shrubland over <i>Acacia bivenosa</i> scattered shrubs over <i>Triodia epactia</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Patchily burnt in the last 1-2 years		
BS4 Site BRO02			
Described by	Raimond Orifici	Quadrat size	50x50 m
Date	7/10/2004		
AMG Zone	50 523202mE, 7502239mN	523251mE, 7502245mN	
	523258mE, 7502196mN	523209mE, 7502194mN	
Habitat	Mild colluvial footslope		
Soil	Red colluvial clay loam with lots of ironstone pebbles on surface		
Rock Type	Ironstone		
Vegetation	<i>Acacia inaequilatera</i> , <i>A. atkinsiana</i> scattered tall shrubs over <i>Triodia wiseana</i> closed hummock grassland		
Veg. Condition	Excellent		
Fire	Not burnt in the last 3-5 years		
Notes	Some parts of the surrounding area have been patchily burnt		
BS4 Site BRO03			
Described by	Michi Maier	Quadrat size	50 x 50 m
Date	7/10/2004		
AMG Zone	50 523943mE, 7502331mN	523986mE, 7502353mN	
	524011mE, 7502307mN	523964mE, 7502287mN	
Habitat	Stony colluvial lower slope		
Soil	Red clay loam with small ironstone pebbles		
Rock Type	Ironstone		
Vegetation	<i>Acacia exilis</i> tall open shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	No sign of recent fire		
BS4 Site BRO04			
Described by	Raimond Orifici	Quadrat size	50 x 50m
Date	7/10/2004		
AMG Zone	50 528559mE, 7501560mN	528604mE, 7501583mN	
	528628mE, 7501539mN	528586mE, 7501514mN	
Habitat	Alluvial clayey plain		
Soil	Red alluvial clay loam		
Rock Type	Ironstone		
Vegetation	<i>Acacia ayersiana</i> low open forest over <i>Eremophila forrestii</i> subsp. <i>forrestii</i> open shrubland over <i>Triodia epactia</i> , <i>T. wiseana</i> open hummock grassland		
Veg. Condition	Excellent		
Fire	No evidence of fire in the last 5+ years		
BS4 Site BRO05			
Described by	Michi Maier	Quadrat size	50 x 50m
Date	7/10/2004		
AMG Zone	50 528101mE, 7501223mN	528147mE, 7501228mN	
	528158mE, 7501180mN	528106mE, 7501172mN	
Habitat	Colluvial stony undulating plain (very gentle westerly slope)		
Soil	Red clay loam with ironstone pebbles		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> low open woodland over <i>Acacia ayersiana</i> , <i>A. aff. aneura</i> (scythe-shaped; MET 15743), <i>A. aff. aneura</i> (narrow fine veined; site 1259), <i>A. aneura</i> var. <i>longicarpa</i> low woodland over <i>Triodia epactia</i> , <i>T. wiseana</i> hummock grassland		
Veg. Condition	Excellent		
Fire	No evidence of recent fire		

BS4 Site BRO06			
Described by	Raimond Orifici	Quadrat size	100 x 15-25 m
Date	7/10/2004		
AMG Zone	50 527449mE, 7501054mN	527459mE, 7501046mN	
	527408mE, 7500963mN	527391mE, 7500974mN	
Habitat	Minor drainage line		
Soil	Red alluvial sand, fine ironstone gravel and clay-loam		
Rock Type	Ironstone		
Vegetation	<i>Petalostyllis labicheoides</i> , <i>Grevillea wickhamii</i> subsp. <i>hispidula</i> tall open shrubland over <i>Acacia monticola</i> , <i>A. maitlandii</i> , <i>A. bivenosa</i> , <i>Rulingia luteiflora</i> open shrubland over <i>Triodia epactia</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Possibly burnt in the last 3-5 years.		
Note	At South end, quadrat is 25 m wide; at North end 15 m wide;		
BS4 Site BRO07			
Described by	Michi Maier	Quadrat size	50 x 50m
Date	7/10/2004		
AMG Zone	50 527045mE, 7501242mN	527080mE, 7501207mN	
	527045mE, 7501175mN	527010mE, 7501209mN	
Habitat	Colluvial hillslope (southerly aspect, moderate gradient)		
Soil	Red clay loam with continuous surface layer of ironstone gravel and pebbles		
Rock Type	Ironstone		
Vegetation	<i>Acacia inaequilatera</i> scattered shrubs to open shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Burnt ~3 years ago		
BS4 Site BRO08			
Described by	Raimond Orifici	Quadrat size	50 x 50m
Date	7/10/2004		
AMG Zone	50 526600mE, 7506345mN	526646mE, 7506368mN	
	526667mE, 7506324mN	526622mE, 7506300mN	
Habitat	Stony alluvial clay flat		
Soil	Red alluvial clay loam with ironstone pebbles on soil surface		
Rock Type	Ironstone		
Vegetation	<i>Acacia atkinsiana</i> tall open shrubland over <i>Triodia wiseana</i> ( <i>T. epactia</i> ) mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Not burnt in the last 5 years (or more)		
BS4 Site BRO09			
Described by	Michi Maier	Quadrat size	25 x 100 m
Date	8/10/2004		
AMG Zone	50 524422mE, 7504838mN	524520mE, 7504821mN	
	524520mE, 7504799mN	524421mE, 7504812mN	
Habitat	Broad cobbly bed of major creek		
Soil	Red-brown cobbly, pebbly and gravelly sand		
Vegetation	<i>Eucalyptus victrix</i> scattered low trees over <i>Pluchea dentex</i> , <i>Goodenia lamprosperma</i> very open hermland		
Veg. Condition	Very Good; very occasional individuals of Buffel grass and presence of cattle		
Fire	No evidence of recent fire in creekbed		
Note	Surrounds burnt approx. 3 years ago		
BS4 Site BRO10			
Described by	Raimond Orifici	Quadrat size	50 x 50m
Date	8/10/2004		
AMG Zone	50 524694mE, 7504835mN	524729mE, 7504802mN	
	524700mE, 7504766mN	524659mE, 7504800mN	
Habitat	Floodplain / broad bank of major creekline		
Soil	Red fine sandy clay-loam (alluvial deposited)		
Rock Type	Ironstone		
Vegetation	<i>Acacia pyrifolia</i> shrubland over <i>Bonamia rosea</i> low open shrubland over <i>Triodia epactia</i> closed hummock grassland		
Veg. Condition	Very Good; Buffel grass on road edge, and occasional one in quadrat		
Fire	Burnt in the last 2-3 years		

BS4 Site BRO11			
Described by	Raimond Orifici	Quadrat size	20 x 125 m
Date	8/10/2004		
AMG Zone	50 524800mE, 7500722mN	524821mE, 7500722mN	
	524801mE, 7500617mN	524786mE, 7500613mN	
Habitat	Minor drainage line		
Soil	Red clay-loam (alluvial deposition)		
Rock Type	Ironstone		
Vegetation	<i>Acacia atkinsiana</i> , <i>A. monticola</i> , <i>A. maitlandii</i> tall open shrubland over <i>Triodia wiseana</i> , <i>T. epactia</i> open hummock grassland		
Veg. Condition	Excellent		
Fire	Not burnt in the last 4-5 years (approx.)		
BS4 Site BRO12			
Described by	Michi Maier	Quadrat size	20 x 120 m
Date	8/10/2004		
AMG Zone	50 524432mE, 7500603mN	524445mE, 7500598mN	
	524456mE, 7500491mN	524447mE, 7500598mN	
Habitat	Rocky creekline		
Soil	Red gravelly loam with rock outcropping throughout		
Rock Type	Outcropping ironstone throughout		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> low woodland over <i>Acacia citrinoviridis</i> ( <i>A. monticola</i> , <i>Dodonaea pachyneura</i> ) tall shrubland over <i>Triodia epactia</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	No evidence of recent fire		
Note	Quadrat shape adjusted to fit creekline		
BS4 Site BRO13			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	8/10/2004		
AMG Zone	50 522622mE, 7500292mN	522668mE, 7500283mN	
	522661mE, 7500234mN	522611mE, 7500244mN	
Habitat	Colluvial hillslope		
Soil	Red colluvial clay-loam		
Rock Type	Ironstone with agate		
Vegetation	<i>Acacia synchronicia</i> scattered shrubs over <i>Triodia angusta</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	No evidence of fire in the last 5+ years		
BS4 Site BRO14			
Described by	Raimond Orifici	Quadrat size	2004-25 x 100 m
Date	9/10/2004		
AMG Zone	50 523144mE, 7501383mN	523234mE, 7501360mN	
	523224mE, 7501343mN	523130mE, 7501365mN	
Habitat	Rocky gorge		
Soil	Skeletal red clay soil over outcropping ironstone rock		
Rock Type	Outcropping ironstone rock		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> scattered low trees over <i>Gossypium robinsonii</i> , <i>A. maitlandii</i> open shrubland over <i>Triodia epactia</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Possibly burnt in the last 3-5 years.		
BS4 Site BRO15			
Described by	Michi Maier	Quadrat size	100 x 25 m
Date	9/10/2004		
AMG Zone	50 522707mE, 7501802mN	522777mE, 7501736mN	
	522759mE, 7501711mN	522686mE, 7501780mN	
Habitat	Crest of low stony hill		
Soil	Red-brown fine clay-loam with continuous surface layer of ironstone gravel and stones		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> , <i>Corymbia deserticola</i> scattered low trees over <i>Acacia atkinsiana</i> scattered tall shrubs over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Occasional area burnt ~2 years ago		
Note	Quadrat to fit spur.		

BS4 Site BRO16			
Described by	Raimond Orifici	Quadrat size	100 x 25 m
Date	9/10/2004		
AMG Zone	50 524063mE, 7501504mN	524076mE, 7501524mN	
	524160mE, 7501464mN	524144mE, 7501446mN	
Habitat	Rocky hillslope (near crest of hill)		
Soil	Red clay-loam with lots of ironstone pebbles on soil surface		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> scattered low trees over <i>Acacia maitlandii</i> , <i>Hakea chordophylla</i> tall open scrub over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Not burnt in the last ~5 years		
BS4 Site BRO17			
Described by	Michi Maier	Quadrat size	50 x 50 m
Date	9/10/2004		
AMG Zone	50 523993mE, 7501438mN		
	524037mE, 7501383mN	523994mE, 7501395mN	
Habitat	Rocky head of broad gully		
Soil	Skeletal red-brown fine sandy clay loam		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> low open woodland over <i>Acacia hamersleyensis</i> tall shrubland over <i>Triodia epactia</i> , <i>T. brizoides</i> hummock grassland and <i>Eriachne mucronata</i> scattered tussock grasses		
Veg. Condition	Excellent		
Fire	No evidence of fire for at least 5 years		
BS4 Site BRO18			
Described by	Raimond Orifici	Quadrat size	25-45 x 50m
Date	9/10/2004		
AMG Zone	50 524564mE, 7501210mN	524613mE, 7501200mN	
	524604mE, 7501175mN	524552mE, 7501169mN	
Habitat	Crest of stony hill		
Soil	Skeletal red clay-loam on ironstone with lots of ironstone pebbles on soil surface		
Rock Type	Ironstone		
Vegetation	<i>Acacia hamersleyensis</i> tall open shrubland over <i>Triodia wiseana</i> mid-dense to closed hummock grassland		
Veg. Condition	Excellent		
Fire	No evidence of recent fire.		
BS4 Site BRO19			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	10/10/2004		
AMG Zone	50 517965mE, 7500800mN	518013mE, 7500806mN	
	518019mE, 7500758mN	517971mE, 7500750mN	
Habitat	Stony alluvial clayey plain (gentle slope, at base of hill)		
Soil	Red clay loam with lots of ironstone pebbles on soil surface		
Rock Type	Ironstone		
Vegetation	<i>Acacia xiphophylla</i> tall shrubland / low woodland over <i>Eremophila cuneifolia</i> low open shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Very Good; very occasional weed species present (only in ripped area of quadrat)		
Fire	Unburnt for >5 years		
BS4 Site BRO20			
Described by	Michi Maier	Quadrat size	50 x 50 m
Date	10/10/2004		
AMG Zone	50 516051mE, 7500077mN	516094mE, 7500104mN	
	516118mE, 7500068mN	516080mE, 7500041mN	
Habitat	Rocky colluvial hillslope		
Soil	Red clay loam with continuous surface layer of angular ironstone pebbles and rocks		
Rock Type	Some ironstone outcropping		
Vegetation	<i>Acacia ancistrocarpa</i> open heath over <i>Triodia wiseana</i> closed hummock grassland		
Veg. Condition	Excellent		
Fire	Last fire >5-7 years ago		

BS4 Site BRO21			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	10/10/2004		
AMG Zone	50 515668mE, 7498792mN	515690mE, 7498762mN	
	515637mE, 7498722mN 5	15614mE, 7498749mN	
Habitat	Stony undulating plain		
Soil	Red clay-loam (alluvial deposited?)		
Rock Type	Ironstone, quartzitic rock and calcrete		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> , <i>E. xerothermica</i> scattered low trees over <i>Acacia bivenosa</i> open shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Very good; very occasional weed individuals present		
Fire	Possibly burnt in the last 3-5 years		
BS4 Site BRO22			
Described by	Michi Maier	Quadrat size	50 x 50 m
Date	10/10/2004		
AMG Zone	50 515772mE, 7498756mN	515822mE, 7498753mN	
	515821mE, 7498706mN	515772mE, 7498706mN	
Habitat	Floodplain		
Soil	Red-brown clay-loam; mainly bare clay with scattered pebbles on surface		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus xerothermica</i> scattered low trees over <i>Acacia citrinoviridis</i> , <i>Stylobasium spathulatum</i> tall shrubland over <i>Ptilotus obovatus</i> var. <i>obovatus</i> scattered low shrubs over <i>Themeda triandra</i> , <i>Chrysopogon fallax</i> very open tussock grassland		
Veg. Condition	Good; signs of cattle and a number of weed species (though not much cover overall)		
Fire	Burnt in the last 3-4 years		
BS4 Site BRO23			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	10/10/2004		
AMG Zone	50 519257mE, 7499238mN	519304mE, 7499233mN	
	519297mE, 7499185mN	519249mE, 7499194mN	
Habitat	Stony alluvial clay plain		
Soil	Red colluvial / alluvial clay-loam		
Rock Type	Ironstone		
Vegetation	<i>Acacia xiphophylla</i> , <i>A. synchronica</i> tall open shrubland over <i>Rhagodia eremaea</i> low shrubland over <i>Triodia wiseana</i> open hummock grassland		
Veg. Condition	Very good; occasional weeds		
Fire	Unburnt for > 5 years		
BS4 Site BRO24			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	11/10/2004		
AMG Zone	50 519362mE, 7500290mN	519408mE, 7500309mN	
	519421mE, 7500259mN	519379mE, 7500245mN	
Habitat	Rocky hillslope (medium to steep slope)		
Soil	Red clayey loam with lots of angular and small pisolitic ironstone pebbles		
Rock Type	Ironstone		
Vegetation	<i>Acacia inaequilatera</i> tall shrubland over <i>Gompholobium karjini</i> low shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Possibly burnt 4-5 years ago.		
BS4 Site BRO25			
Described by	Hana Eynon	Quadrat size	50 x 50 m
Date	11/10/2004		
AMG Zone	50 519490mE, 7499889mN	519540mE, 7499890mN	
	519544mE, 7499843mN	519493mE, 7499836mN	
Habitat	Broad drainage area		
Soil	Red-brown gravelly clay loam		
Rock Type	Ironstone		
Vegetation	<i>Acacia bivenosa</i> open heath over <i>Triodia epactia</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Burnt ~2-3 years ago		

BS4 Site BRO26			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	11/10/2004		
AMG Zone	50 519837mE, 7500619mN		
Habitat	Incised rocky gorge through hill		
Soil	Skeletal red clay-loam over large ironstone plate boulders and outcropping areas		
Rock Type	Outcropping ironstone		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> low open woodland over <i>Acacia bivenosa</i> , <i>A. hamersleyensis</i> open shrubland over <i>Triodia brizoides</i> , <i>T. epactia</i> hummock grassland and <i>Themeda</i> sp. Mt Barricade, <i>Cymbopogon ambiguus</i> open tussock grassland		
Veg. Condition	Excellent		
Fire	Unburnt in the last 5+ years		
BS4 Site BRO27			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	11/10/2004		
AMG Zone	50 520994mE, 7500162mN	521046mE, 7500162mN	
	521046mE, 7500112mN	520996mE, 7500112mN	
Habitat	Seasonally wet drainage line at base of hills		
Soil	Red alluvial clay with small amount of loam and a small amount of ironstone pebbles on the soil surface		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus xerothermica</i> scattered low trees over <i>Acacia citrinoviridis</i> , <i>A. ancistrocarpa</i> tall open shrubland over <i>Acacia bivenosa</i> shrubland over <i>Scaevola spinescens</i> low open shrubland over <i>Triodia epactia</i> mid-dense hummock grassland		
Veg. Condition	Very good; very occasional weeds		
Fire	No evidence of fire in the last 3 years (or more)		
BS4 Site BRO28			
Described by	Hana Eynon	Quadrat size	50 x 50 m
Date	11/10/2004		
AMG Zone	50 521072mE, 7500422mN	521123mE, 7500416mN	
	521120mE, 7500365mN	521068mE, 7500371mN	
Habitat	Broad alluvial plain		
Soil	Red gravelly clay-loam with continuous surface layer of angular ironstone pebbles		
Rock Type	Ironstone		
Vegetation	<i>Acacia</i> aff. <i>aneura</i> (narrow fine veined; site 1259) low open woodland over <i>Acacia stowardii</i> , <i>A. bivenosa</i> open shrubland over <i>Triodia wiseana</i> , <i>T. epactia</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Largely unburnt for 5+ years		
Note	Some areas patchily burnt ~3 years ago		
BS4 Site BRO29			
Described by	Raimond Orifici	Quadrat size	35 x 70 m
Date	11/10/2004		
AMG Zone	50 521515mE, 7500839mN	521551mE, 7500845mN	
	521565mE, 7500778mN	521530mE, 7500772mN	
Habitat	Rocky upper hillslope (mild slope)		
Soil	Red clay-loam; skeletal with lots of ironstone pebbles on the soil surface		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> scattered low trees over <i>Hakea chordophylla</i> scattered tall shrubs over <i>Acacia maitlandii</i> shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Not burnt in the last 5+ years		
BS4 Site BRO30			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	12/10/2004		
AMG Zone	50 529298mE, 7518746mN	529330mE, 7518709mN	
	529294mE, 7518677mN	529261mE, 7518713mN	
Habitat	Rocky undulating plain		
Soil	Red alluvial clay-loam with ironstone pebbles on soil surface		
Rock Type	Ironstone		
Vegetation	<i>Acacia atkinsiana</i> , <i>A. exilis</i> tall open shrubland over <i>Triodia wiseana</i> closed hummock grassland		
Veg. Condition	Excellent		
Fire	No evidence of fire in the last 5+ years		

BS4 Site BRO31			
Described by	Michi Maier	Quadrat size	20 x 120 m
Date	12/10/2004		
AMG Zone	50 532852mE, 7519436mN	532873mE, 7519438mN	
	532863mE, 7519315mN	532841mE, 7519314mN	
Habitat	Shallow drainage line in broad undulating stony plain		
Soil	Red gravelly clay-loam with patchy surface layer of ironstone pebbles		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> , <i>Corymbia deserticola</i> scattered low trees over <i>Acacia tumida</i> var. <i>pilbarensis</i> ( <i>A. atkinsiana</i> ) tall open scrub over <i>Triodia epactia</i> , <i>T. wiseana</i> open hummock grassland		
Veg. Condition	Excellent		
Fire	Surrounding area burnt 3-4 years ago		
Note	Quadrat shape adjusted to follow drainage line		
BS4 Site BRO32			
Described by	Raimond Orifici	Quadrat size	25 x 100 m
Date	12/10/2004		
AMG Zone	50 527494mE, 7515582mN	527521mE, 7515587mN	
	527498mE, 7515472mN	527472mE, 7515485mN	
Habitat	Moderate-sized creekline (floodbanks)		
Soil	Red alluvial clay loam with ironstone pebbles and fine ironstone gravel on soil surface		
Vegetation	<i>Eucalyptus xerothermica</i> scattered low trees over <i>Acacia cowleana</i> tall open shrubland over <i>Acacia ancistrocarpa</i> , <i>A. bivenosa</i> , <i>A. elachantha</i> , <i>A. exilis</i> , <i>A. pyrifolia</i> , <i>Cassia oligophylla</i> , <i>Eremophila longifolia</i> open shrubland over <i>Triodia epactia</i> hummock grassland and <i>Digitaria brownii</i> , <i>Chrysopogon fallax</i> , <i>Eulalia aurea</i> open tussock grassland		
Veg. Condition	Very Good; very few weeds present		
Fire	Burnt in the last 2-3 years		
BS4 Site BRO33			
Described by	Michi Maier	Quadrat size	50 x 50 m
Date	12/10/2004		
AMG Zone	50 527061mE, 7513924mN	527113mE, 7513924mN	
	527112mE, 7513874mN	527061mE, 7513874mN	
Habitat	Gentle slope of stony undulating plain (W aspect)		
Soil	Red clay loam with continuous surface layer of ironstone pebbles and stones		
Rock Type	Ironstone		
Vegetation	<i>Corymbia deserticola</i> , <i>Eucalyptus gamophylla</i> low open woodland over <i>Acacia atkinsiana</i> tall shrubland over <i>Triodia epactia</i> , <i>T. wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Burnt >5-7 years ago.		
BS4 Site BRO34			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	12/10/2004		
AMG Zone	50 524546mE, 7511926mN	524586mE, 7511946mN	
	524607mE, 7511900mN	524562mE, 7511880mN	
Habitat	Valley at base of hills		
Soil	Grey-brown clay loam with lots of calcrete and ironstone pebbles on the soil surface		
Rock Type	Ironstone and calcrete		
Vegetation	<i>Eucalyptus socialis</i> low open woodland over <i>Triodia wiseana</i> open hummock grassland		
Veg. Condition	Very good; very occasional weeds		
Fire	Burnt in the last 1-2 years.		
BS4 Site BRO35			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	12/10/2004		
AMG Zone	50 524946mE, 7509482mN	524991mE, 7509460mN	
	524972mE, 7509414mN	524924mE, 7509438mN	
Habitat	Spur of a low hillslope (S facing)		
Soil	Red alluvial / colluvial clay-loam with lots of ironstone pebbles on soil surface		
Rock Type	Ironstone		
Vegetation	<i>Corymbia hamersleyana</i> scattered low trees over <i>Cassia pruinosa</i> open shrubland over <i>Triodia wiseana</i> hummock grassland		
Veg. Condition	Excellent		
Fire	Possibly burnt in the last 3-4 years		



BS4 Site BRO36			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	13/10/2004		
AMG Zone	50 529475mE, 7508219mN	529508mE, 7508252mN	
	529542mE, 7508215mN	529505mE, 7508178mN	
Habitat	Plain		
Soil	Red clay-loam with ironstone pebbles and fine ironstone particles (1-2 mm size) on soil		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus gamophylla</i> , <i>Codonocarpus cotinifolius</i> scattered low trees over <i>Acacia atkinsiana</i> , <i>A. exilis</i> tall open shrubland over <i>Triodia epactia</i> , <i>T. wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Unburnt for ~5-7 years.		
Note	Area surrounding quadrat patchily burnt 2-3 years ago		
BS4 Site BRO37			
Described by	Hana Eynon	Quadrat size	50 x 50 m
Date	13/10/2004		
AMG Zone	50 530887mE, 7509188mN	530933mE, 7509201mN	
	530949mE, 7509154mN	530901mE, 7509141mN	
Habitat	Very gently undulating stony plain		
Soil	Red clay loam with continuous surface layer of ironstone pebbles		
Rock Type	Ironstone		
Vegetation	<i>Acacia exilis</i> tall open shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Unburnt for at least 5 years		
BS4 Site BRO38			
Described by	Michi Maier	Quadrat size	30 x 80 m
Date	13/10/2004		
AMG Zone	50 530841mE, 7509400mN	530863mE, 7509380mN	
	530815mE, 7509305mN	530786mE, 7509318mN	
Habitat	Broad creekline		
Soil	Red-brown fine silty loam with cobbles		
Rock Type	Fluvial		
Vegetation	<i>Corymbia hamersleyana</i> low open woodland over <i>Acacia bivenosa</i> , <i>A. pyrifolia</i> , <i>Gossypium robinsonii</i> , <i>Rulingia luteiflora</i> scattered shrubs over <i>Themeda</i> sp. Mt Barricade, <i>Eriachne tenuiculmis</i> , <i>E. mucronata</i> tussock grassland		
Veg. Condition	Very good; scattered weeds		
Fire	Burnt ~2-3 years ago		
Note	Quadrat shape adjusted to fit drainage line		
BS4 Site BRO39			
Described by	Hana Eynon	Quadrat size	50 x 50 m
Date	13/10/2004		
AMG Zone	50 532145mE, 7509548mN	532193mE, 7509530mN	
	532173mE, 7509483mN	532129mE, 7509497mN	
Habitat	Crest and slope of low stony hill (NW aspect)		
Soil	Brown clay loam with continuous surface layer of angular ironstone pebbles and cobbles		
Rock Type	Some areas of ?ironstone outcropping		
Vegetation	<i>Acacia exilis</i> , <i>A. bivenosa</i> open shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent; very old track present in part of the quadrat		
Fire	Burnt 2-3 years ago		
BS4 Site BRO40			
Described by	Raimond Orifici	Quadrat size	25 x 100 m
Date	13/10/2004		
AMG Zone	50 531929mE, 7509535mN	531950mE, 7509522mN	
	531903mE, 7509447mN	531878mE, 7509448mN	
Habitat	Drainage line		
Soil	Red alluvial clay loam with some sand and lots of fine ironstone particles; many ironstone pebbles and cobbles		
Rock Type	Ironstone pebbles and cobbles		
Vegetation	<i>Corymbia hamersleyana</i> low woodland over <i>Grevillea wickhamii</i> subsp. <i>hispidula</i> , <i>Gossypium robinsonii</i> tall shrubland over <i>Triodia epactia</i> open hummock grassland and <i>Themeda</i> sp. Mt Barricade, <i>Eulalia aurea</i> , <i>Paraneurachne muelleri</i> open tussock grassland		
Veg. Condition	Very good; very occasional weed		
Fire	Unburnt for 3-4 years or more		

Note	Quadrat shape adjusted to fit creekline		
BS4 Site BRO41			
Described by	Raimond Orifici	Quadrat size	125 x 20 m
Date	13/10/2004		
AMG Zone	50 529383mE, 7503722mN	529486mE, 7503795mN	
	529495mE, 7503776mN	529394mE, 7503704mN	
Habitat	Seasonally wet minor drainage line		
Soil	Red gravelly clay-loam with surface layer of scattered angular pebbles		
Rock Type	Ironstone		
Vegetation	<i>Corymbia hamersleyana</i> , <i>Eucalyptus gamophylla</i> low open woodland over <i>Acacia monticola</i> ( <i>A. ancistrocarpa</i> , <i>A. bivenosa</i> , <i>Rulingia luteiflora</i> ) tall closed scrub over <i>Triodia epactia</i> hummock grassland		
Veg. Condition	Excellent; some minor disturbance in the form of an old track		
Fire	Burnt >5 years ago		
Note	Quadrat shape adjusted to fit drainage line		
BS4 Site BRO42			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	14/10/2004		
AMG Zone	50 526306mE, 7500243mN	525355mE, 7500240mN	
	526351mE, 7500190mN	526300mE, 7500193mN	
Habitat	Base of rocky hillslope		
Soil	Red skeletal clay-loam over solid ironstone with lots of angular ironstone pebbles on		
Rock Type	Ironstone		
Vegetation	<i>Cassia pruinosa</i> , <i>C. luerssenii</i> , <i>Acacia bivenosa</i> , <i>A. synchronicia</i> open shrubland over <i>Triodia brizoides</i> ( <i>T. epactia</i> , <i>T. longiceps</i> ) closed hummock grassland		
Veg. Condition	Excellent		
Fire	Burnt in the last 2 years		
BS4 Site BRO43			
Described by	Hana Eynon	Quadrat size	40 x 80 m
Date	14/10/2004		
AMG Zone	50 525997mE, 7500193mN	526036mE, 7500201mN	
	526049mE, 7500124mN	526015mE, 7500114mN	
Habitat	Footslope of broad valley (S facing, gentle slope)		
Soil	Red gravelly clay-loam with continuous surface layer of large pebbles		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> scattered low trees over <i>Acacia</i> aff. <i>aneura</i> (narrow fine veined; site 1259) low open woodland over <i>Acacia xiphophylla</i> tall open shrubland over <i>Triodia brizoides</i> , <i>T. epactia</i> open hummock grassland.		
Veg. Condition	Excellent		
Fire	Unburnt for >7 years		
BS4 Site BRO44			
Described by	Raimond Orifici	Quadrat size	65 x 40 m
Date	14/10/2004		
AMG Zone	50 529983mE, 7501665mN	530014mE, 7501680mN	
	530059mE, 7501624mN	530018mE, 7501609mN	
Habitat	Crest and slopes of steep hill		
Soil	Red very shallow clay-loam with large angular cobbles, pebbles and gravel		
Rock Type	Some ironstone outcropping		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> , <i>Corymbia zygophylla</i> , <i>C. hamersleyana</i> scattered low trees over <i>Acacia citrinoviridis</i> scattered tall shrubs over <i>Triodia wiseana</i> closed hummock grassland		
Veg. Condition	Excellent; vehicle track through part of the quadrat		
Fire	Unburnt for at least 5 years		
BS4 Site BRO45			
Described by	Raimond Orifici	Quadrat size	50 x 50 m
Date	14/10/2004		
AMG Zone	50 519963mE, 7504861mN	520013mE, 7504850mN	
	520006mE, 7504807mN	519954mE, 7504808mN	
Habitat	Broad seasonally wet drainage line		
Soil	Brown fine alluvial clay-loam		
Rock Type	Ironstone and calcrete		
Vegetation	<i>Corymbia hamersleyana</i> , <i>Eucalyptus xerothermica</i> scattered low trees over <i>Acacia bivenosa</i> open heath over <i>Triodia angusta</i> open hummock grassland and <i>Themeda triandra</i> very open tussock		

Veg. Condition	grassland	
Fire	Excellent; signs of cattle Burnt ~2 years ago	
BS4 Site BRO46		
Described by	Raimond Orifici	Quadrat size 50 x 50 m
Date	15/10/2004	
AMG Zone	50 519561mE, 7503678mN	519603mE, 7503655mN
	519579mE, 7503612mN	519537mE, 7503634mN
Habitat	Floodplain of broad cobbly creekline	
Soil	Red pebbly - gravelly alluvial loamy sand with very small amount of clay	
Rock Type	Ironstone	
Vegetation	<i>Petalostylis labicheoides</i> , <i>Acacia pyrifolia</i> shrubland over <i>Bonamia rosea</i> , <i>Corchorus lasiocarpus</i> , <i>Indigofera monophylla</i> (BRO 46.12), <i>Tephrosia rosea</i> var. <i>glabrior</i> low open shrubland over <i>Triodia epactia</i> open hummock grassland and <i>Eriachne mucronata</i> , <i>Themeda triandra</i> very open tussock grassland.	
Veg. Condition	Very Good; signs of cattle grazing and small localised patches of Buffel grass	
Fire	Probably burnt in the last 2 years	
BS4 Site BRO47		
Described by	Raimond Orifici	Quadrat size 50 x 50 m
Date	15/10/2004	
AMG Zone	50 523187mE, 7503923mN	523230mE, 7503899mN
	523206mE, 7503860mN	523163mE, 7503880mN
Habitat	Broad alluvial plain	
Soil	Red gravelly clay-loam with surface layer of scattered ironstone pebbles and gravel	
Rock Type	Ironstone	
Vegetation	<i>Acacia stowardii</i> tall open shrubland over <i>Eremophila exillifolia</i> scattered shrubs over <i>Triodia epactia</i> mid-dense to closed hummock grassland.	
Veg. Condition	Excellent; signs of cattle	
Fire	Unburnt for the last 5 years	
Note	Painted finch (?) nest in spinifex - parents sighted	
BS4 Site BRO49		
Described by	Raimond Orifici	Quadrat size 20 x 125 m
Date	15/10/2004	
AMG Zone	50 527860mE, 7504772mN	527953mE, 7504827mN
	527971mE, 7504817mN	527871mE, 7504760mN
Habitat	Cobbly bed of broad major creekline	
Soil	Red alluvial sandy loam with lots of ironstone pebbles and gravel on soil surface	
Rock Type	Ironstone	
Vegetation	<i>Eucalyptus victrix</i> open woodland over <i>Goodenia lamprosperma</i> very open herbland	
Veg. Condition	Excellent	
Fire	No evidence of recent fire	
Note	Quadrat shape adjusted to fit drainage line	
BS4 Site BRO50		
Described by	Raimond Orifici	Quadrat size 50 x 50 m
Date	15/10/2004	
AMG Zone	50 525959mE, 7506007mN	526004mE, 7506004mN
	525985mE, 7505943mN	525941mE, 7505965mN
Habitat	Stony undulating plain (mild slope)	
Soil	Red clay-loam with gravel and ironstone pebble surface layer	
Rock Type	Ironstone and some calcrete	
Vegetation	<i>Eucalyptus xerothermica</i> low open woodland over <i>Eremophila fraseri</i> subsp. <i>fraseri</i> scattered shrubs over <i>Triodia wiseana</i> mid-dense hummock grassland	
Veg. Condition	Excellent	
Fire	3-5 years since last fire	
BS4 Relevé BRO-HA		
Described by	Hana Eynon	Quadrat size relevé
Date	11/10/2004	
AMG Zone	50 521926mE, 7500897mN	
Habitat	Crest of a tall stony hill	
Soil	Red sandy clay loam with continuous surface layer of angular cobbles and pebbles	
Rock Type	Ironstone	
Vegetation	<i>Acacia atkinsiana</i> tall shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland.	

Veg. Condition	Excellent; but area dissected by numerous exploration tracks		
Fire	Unburnt for at least 7 years		
BS4 Relevé BRO-MA			
Described by	Michi Maier	Quadrat size	relevé
Date	9/10/2004		
AMG Zone	50 522908mE, 7500936mN		
Habitat	Crest of tall stony hill		
Soil	Red-brown skeletal fine clay loam with continuous surface layer of ironstone pebbles, stones and rocks		
Rock Type	Ironstone		
Vegetation	<i>Acacia maitlandii</i> ( <i>A. atkinsiana</i> , <i>A. marramamba</i> ) open heath over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Unburnt for >5-7 years		
Note	Area dissected by numerous drill lines; no section large enough to fit a quadrat. Very species-poor. Can include in an analysis - equivalent area searched around GPS to a standard quadrat.		
BS4 Relevé BRO-MB			
Described by	Michi Maier	Quadrat size	relevé
Date	9/10/2004		
AMG Zone	50 523676mE, 7501356mN		
Habitat	Crest of tall stony hill		
Soil	Red skeletal fine clay loam with continuous surface layer of pebbles and stones		
Rock Type	Ironstone		
Vegetation	<i>Acacia atkinsiana</i> shrubland over <i>Triodia wiseana</i> mid-dense hummock grassland		
Veg. Condition	Excellent		
Fire	Unburnt for >5-7 years		
Note	Can include in an analysis - equivalent area searched around GPS to a standard quadrat. Very species-poor		
BS4 Relevé BRO-MC			
Described by	Michi Maier	Quadrat size	relevé
Date	9/10/2004		
AMG Zone	50 524690mE, 7501236mN		
Habitat	Rocky gorge		
Soil	Red-brown fine clay loam with scree of pebbles, stones and rocks		
Rock Type	Ironstone		
Vegetation	<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> , <i>E. pilbarensis</i> low open woodland over <i>Acacia hamersleyensis</i> tall open shrubland over <i>Triodia brizoides</i> ( <i>T. epactia</i> ) mid-dense hummock grassland and <i>Themeda triandra</i> , <i>Eriachne mucronata</i> open tussock grassland		
Veg. Condition	What remains is excellent; large exploration track has cleared entire base of gorge		
Fire	Burnt ~3 years ago		
Note	Can use as site. Vegetation description based on intact vegetation south of track		
BS4 Relevé BRO-MD			
Described by	Michi Maier	Quadrat size	relevé
Date	10/10/2004		
AMG Zone	50 518683mE, 7498768mN		
Habitat	Broad drainage plain		
Soil	Red-brown clay loam with ironstone pebbles		
Rock Type	Ironstone		
Vegetation	<i>Acacia</i> aff. <i>aneura</i> (narrow fine veined; site 1259), <i>Acacia ayersiana</i> low open woodland over <i>Acacia tetragonophylla</i> tall open shrubland over <i>Eremophila forrestii</i> subsp. <i>forrestii</i> shrubland over <i>Triodia epactia</i> mid-dense hummock grassland.		
Veg. Condition	Very good; occasional weeds		
Fire	Unburnt for >5 years		
BS4 Relevé BRO-ME			
Described by	Michi Maier	Quadrat size	Relevé
Date	11/10/2004		
AMG Zone	50 519832mE, 7500359mN		
Habitat	Rocky gully		
Soil	Red-brown gravelly loam in pockets between rock outcropping		
Rock Type	Ironstone		
Vegetation	<i>Corymbia ferritcola</i> , <i>Eucalyptus leucophloia</i> scattered low trees over <i>Acacia hamersleyensis</i> scattered tall shrubs over <i>Dodonaea pachyneura</i> open shrubland over <i>Eriachne mucronata</i> , <i>E.</i>		

*tenuiculmis*, *Cymbopogon ambiguus* open tussock grassland and *Triodia epactia* open hummock grassland

Veg. Condition Excellent

## BS4 Relevé BRO-MF

Described by Michi Maier Quadrat size relevé

Date 11/10/2004

AMG Zone 50 519405mE, 7501033mN

Habitat Crest of tall rocky hill

Soil Red-brown skeletal clay loam with continuous surface layer of ironstone pebbles, stones

Rock Type Ironstone

Vegetation *Acacia maitlandii* shrubland over *Triodia wiseana* mid-dense hummock grassland

Veg. Condition Excellent

Fire Burnt ~3 years ago

## BS4 Relevé BRO-MG

Described by Michi Maier Quadrat size Relevé

Date 11/10/2004

AMG Zone 50 521086mE, 7500696mN

Habitat Flowline between stony hills

Soil Red-brown clay loam with ironstone pebbles

Vegetation *Acacia citrinoviridis* (*A. pyriformis*) tall closed scrub over *Triodia epactia* hummock

Veg. Condition Very good; some weeds

## BS4 Relevé BRO-MH

Described by Michi Maier Quadrat size Relevé

AMG Zone 50 524864mE, 7509523mN

Habitat Narrow gully

Vegetation *Corymbia ferritcola* low open woodland over *Gossypium robinsonii*, *Acacia pyriformis* tall open shrubland over *Themeda* sp. Mt Barricade tussock grassland

Veg. Condition Excellent

## BS4 Relevé BRO-MI

Described by Michi Maier Quadrat size relevé

Date 14/10/2004

AMG Zone 50 525432mE, 7500069mN

Habitat Low stony rise in broad valley / stony undulating plain

Soil Red-brown fine clay-loam with continuous surface layer of ironstone gravel, pebbles and stones

Vegetation *Acacia* aff. *aneura* (narrow fine veined; site 1259) and *A. xiphophylla* low woodland over *Cassia 'stricta'* low open shrubland over *Triodia epactia*, *T. longiceps* open hummock grassland

Veg. Condition Excellent

Fire Unburnt for >5 years

## BS4 Relevé BRO-MJ

Described by Michi Maier Quadrat size Relevé

Date 11/10/2004

AMG Zone 50 520072mE, 7504577mN

Habitat Stony plain (calcrete)

Soil Brown calcareous loam

Rock Type Calcrete

Vegetation *Eucalyptus xerothermica* scattered low trees over *Triodia angusta* (*T. wiseana*) mid-dense hummock grassland

Veg. Condition Excellent

## BS4 Relevé BRO-MK

Described by Michi Maier Quadrat size relevé

Date 15/10/2004

AMG Zone 50 517322mE, 7502737mN 517372mE, 7502737mN  
517372mE, 7502687mN 517322mE, 7502687mN

Habitat Stony undulating plain

Soil Brown loam with continuous surface layer of calcrete pebbles and stones

Rock Type Calcrete; some ironstone pebbles also

Vegetation *Corymbia hamersleyana* scattered low trees over *Acacia bivenosa* (wispy/weeping form) open shrubland over *Triodia wiseana* mid-dense hummock grassland

Veg. Condition Excellent

Fire Burnt ~2-3 years ago























Species	BRO-HA	BRO-MA	BRO-MB	BRO-MC	BRO-MD	BRO-ME	BRO-MF	BRO-MG	BRO-MH	BRO-MI	BRO-MJ	BRO-MK	BRO-ML	BRO-MM	BRO-RA	BRO-RB	BRO-RC	BRO-OPP
<i>Sida</i> aff. <i>cardiophylla</i>																		
<i>Sida</i> aff. <i>cardiophylla</i> (site 1215)																		
<i>Sida</i> <i>echinocarpa</i>											1							
<i>Sida</i> <i>excedentifolia</i>				1														
<i>Sida</i> aff. <i>fibulifera</i>																		
<i>Sida</i> aff. <i>fibulifera</i> (oblong; MET 15 220)											1							
<i>Sida</i> <i>rohlena</i> subsp. <i>rohlena</i>									1									
<i>Sida</i> sp. Shovelanna Hill (S.van Leeuwen 3842)				1					1									
<i>Sida</i> sp. spiciform panicles (E.Leyland s.n.14/8/90)								1			1						1	
<i>Sida</i> sp. Wittenoom (W.R.Barker 1962)																		1
<i>Sida</i> sp. (BRO MH-1)									1									
<i>Sida</i> sp. 'rugose'																		1
<i>Sida</i> sp.																		
<i>Solanum</i> <i>diversiflorum</i>				1		1		1			1	1						
<i>Solanum</i> <i>horridum</i>																		
<i>Solanum</i> <i>lasiophyllum</i>		1					1	1		1		1	1		1	1		
<i>Solanum</i> <i>phlomoides</i>																		1
<i>Solanum</i> <i>sturtianum</i>	1																	
<i>Sporobolus</i> <i>australasicus</i>																		
<i>Stackhousia</i> <i>intermedia</i>							1											
<i>Stemodia</i> <i>grossa</i>																		
<i>Streptoglossa</i> <i>bubakii</i>										1								
<i>Streptoglossa</i> <i>decurrens</i>				1											1			
<i>Streptoglossa</i> <i>tenuiflora</i>																		
<i>Streptoglossa</i> sp.											1							
<i>Striga</i> <i>curviflora</i>																		1
<i>Styobasium</i> <i>spathulatum</i>														1				
<i>Swainsona</i> <i>maccullochiana</i>								1										
<i>Synaptantha</i> <i>tillaeacea</i> var. <i>tillaeacea</i>																		
<i>Templetonia</i> <i>egena</i>																		1
<i>Tephrosia</i> <i>arenicola</i>																		1
<i>Tephrosia</i> aff. <i>clementii</i> (11)																		
<i>Tephrosia</i> <i>densa</i>																		
<i>Tephrosia</i> <i>rosea</i> var. <i>glabrior</i>								1										
<i>Tephrosia</i> sp. Bungaroo Creek (M.E.Trudgen 11601)																		
<i>Tephrosia</i> sp. Pilbara Ranges (S.van Leeuwen 4246)																		
<i>Themeda</i> <i>triandra</i>				1	1													1
<i>Themeda</i> sp. Mt Barricade (M.E.Trudgen 2471)						1		1	1					1				
<i>Tinospora</i> <i>smilacina</i>																		
<i>Trachymene</i> <i>oleracea</i> subsp. <i>oleracea</i>			1	1		1	1	1	1				1	1				
<i>Tragus</i> <i>australianus</i>																		
<i>Tribulus</i> <i>astrocarpus</i>																		
<i>Tribulus</i> <i>hirsutus</i>											1							
<i>Tribulus</i> aff. <i>hisutus</i> (site 500)																		
<i>Tribulus</i> <i>macrocarpus</i>																		
<i>Tribulus</i> <i>suberosus</i>	1				1		1			1					1			
<i>Tribulus</i> <i>suberosus</i>																		
<i>Tribulus</i> <i>terrestris</i>																		
<i>Trichodesma</i> <i>zeylanicum</i> var. <i>zeylanicum</i>			1	1	1			1	1		1				1	1		
<i>Triodia</i> <i>angusta</i>					1					1	1							
<i>Triodia</i> <i>brizoides</i>				1						1				1				
<i>Triodia</i> <i>epactia</i>		1		1	1	1		1		1				1				
<i>Triodia</i> <i>longiceps</i>										1								
<i>Triodia</i> <i>wiseana</i>	1	1	1				1			1	1	1	1	1	1	1		
<i>Triumfetta</i> <i>maconochieana</i>				1					1							1		
<i>Velleia</i> <i>connata</i>																		
<i>Vittadinia</i> <i>arida</i>																		
<i>Vittadinia</i> <i>virgata</i>				1					1									
<i>Wahlenbergia</i> <i>tumidifruca</i>																		
<i>Waltheria</i> <i>indica</i>								1										
<i>Yakirra</i> <i>australiensis</i> var. <i>australiensis</i>																		
<i>Zygophyllum</i> <i>iodocarpum</i>											1							