5.3.3 *Ptilotus mollis*

Ptilotus mollis

BHP Billiton Iron Ore Management Hierarchy:

LEVEL 3

Description: Compact perennial shrub with soft grey foliage. Grows up to 0.5 m.

Flowers: White/pink flowers between May and September.

Habitat: Stony hills and screes.

Status: Priority 4 (DEC) - Rare Taxa. Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

Known Locations at Goldsworthy:

- Not identified at Goldsworthy to date.
- Stony hills and scree slopes which may be suitable for this species occur at Goldsworthy along ridgelines, plateaus and their lower slopes.

General Management Measures:

- Implement the management measures described in Section 4.

Specific Management Measures:

- The BHP Billiton Iron Ore Goldsworthy Environmental Advisor (or nominated delegate) will review the results of any additional baseline or targeted surveys conducted within Goldsworthy to determine whether *Ptilotus mollis* has been recorded.
- The BHP Billiton Iron Ore Goldsworthy Environmental Advisor (or nominated delegate) will develop and implement specific management measures for *Ptilotus mollis* if required.

Further Information: BHP Billiton Iron Ore Goldsworthy Environmental Advisor.

Further Reading: DEC (2008) *Florabase – The Western Australian Flora*.
Website: http//florabase.calm.wa.gov.au

5.3.4 Long-tailed Dunnart (*Sminthopsis longicaudata*)

Long-tailed Dunnart (*Sminthopsis longicaudata*)

BHP Billiton Iron Ore Management Hierarchy: LEVEL 3

Description: Grey above, pale cream to white below, legs and feet white. Tail scaly with short hairs except at the tip, where long hairs make a fine brush. The head is flattened and the snout is long. Approximate body length is 90 mm (males) and 85 mm (females).

Habitat: Restricted to rocky outcrops in the western arid zone; may be locally common at times.

Feeding: In winter feeds on arthropods: mainly beetles and nuts, but also spiders, cockroaches, centipedes, grasshoppers, flies and various larvae.

Status: Priority 4 (DEC) - Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands.

Known Locations at Goldsworthy:

- Not identified at Goldsworthy to date.
- Rocky outcrops which may be suitable for this species occur at Goldsworthy along ridgelines, plateaus and their lower slopes.

General Management Measures:

- Implement the management measures described in Section 4.

Specific Management Measures:

- The BHP Billiton Iron Ore Goldsworthy Environmental Advisor (or nominated delegate) will review the results of any additional baseline or targeted surveys conducted within Goldsworthy to determine whether the Long-tailed Dunnart has been recorded.
- The BHP Billiton Iron Ore Goldsworthy Environmental Advisor (or nominated delegate) will develop and implement specific management measures for the Long-tailed Dunnart if required.

Further Information: BHP Billiton Iron Ore Goldsworthy Environmental Advisor.

Further Reading: Van Dyck, S. and Strahan, R. (2008). *The Mammals of Australia*, Third Edition. Queensland Museum, Reed New Holland Sydney.

Image Source: Lochman Transparencies ©

5.3.5 Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*)

Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*)

BHP Billiton Iron Ore Management Hierarchy: LEVEL 3

Description: Brown above hairs with white tips. Bright orange ring around eyes. White hip stripe. Feet are pale grey-brown. Tail with sparse, short, grey-brown hairs, darker near the tip, no tuft or crests. Stocky, thickset, short-necked. Body length is approximately 435 mm.

Habitat: Inhabits shrub and tropical grasslands.

Feeding: Browses mainly on colonising shrubs and also eats the tups of Spinifex leaves. Does not drink.

Status: Priority 3 (DEC) - Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Known Locations at Goldsworthy:

- Not identified at Goldsworthy to date.
- Pockets of thick grassland which may be suitable for this species occur around Egg and Eel Creeks. However, these pockets are usually small and are therefore unlikely to be capable of sustaining a population of Spectacled Hare-wallaby.

General Management Measures:

- Implement the management measures described in Section 4.

Specific Management Measures:

- The BHP Billiton Iron Ore Goldsworthy Environmental Advisor (or nominated delegate) will review the results of any additional baseline or targeted surveys conducted within Goldsworthy to determine whether the Spectacled Hare-wallaby has been recorded.
- The BHP Billiton Iron Ore Goldsworthy Environmental Advisor (or nominated delegate) will develop and implement specific management measures for the Spectacled Hare-wallaby if required.

Further Information: BHP Billiton Iron Ore Goldsworthy Environmental Advisor.

Further Reading: Van Dyck, S. and Strahan, R. (2008). *The Mammals of Australia*, Third Edition. Queensland Museum, Reed New Holland Sydney.

Image Source: Lochman Transparencies ©

6 REPORTING PROCEDURES

The AER will include a summary of any significant species that are recorded during baseline or targeted surveys. It will also include a summary of how the management measures contained in this SSMP have been implemented.

7 TIMELINE FOR IMPLEMENTATION OF THIS PLAN

This revision of the SSMP will be implemented once approved by the Government administering authorities, and will be updated as required during the life of Goldsworthy (i.e. at least every five years) to include changes to the conservation status of species identified on-site, new species populations and changes to management measures. Any further revisions of this SSMP will be submitted to DEC as required by Condition 6-1 of Ministerial Statement of Approval No.000682.

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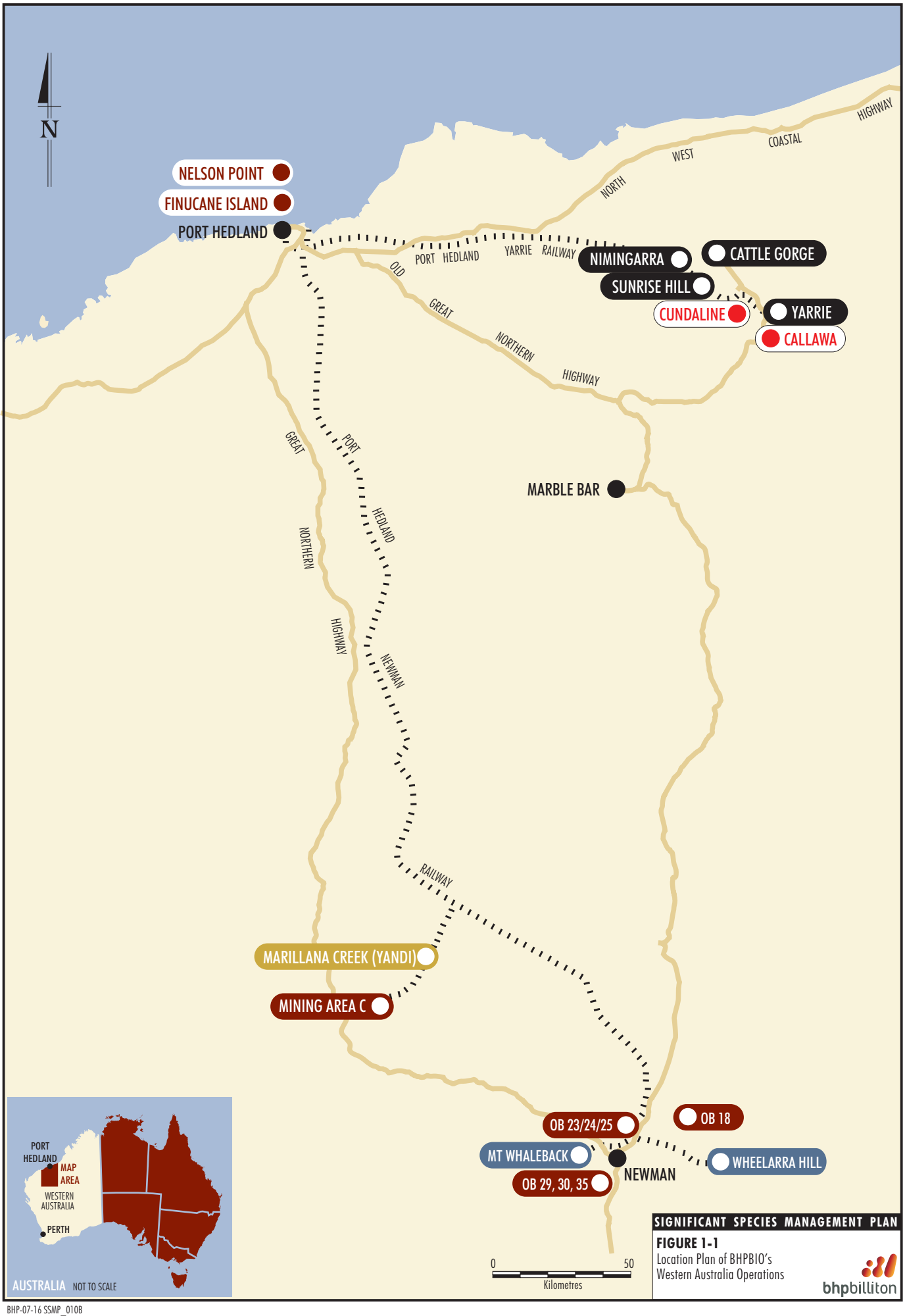
FIGURES



SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 1-1
Location Plan of BHPBIO's Western Australia Operations

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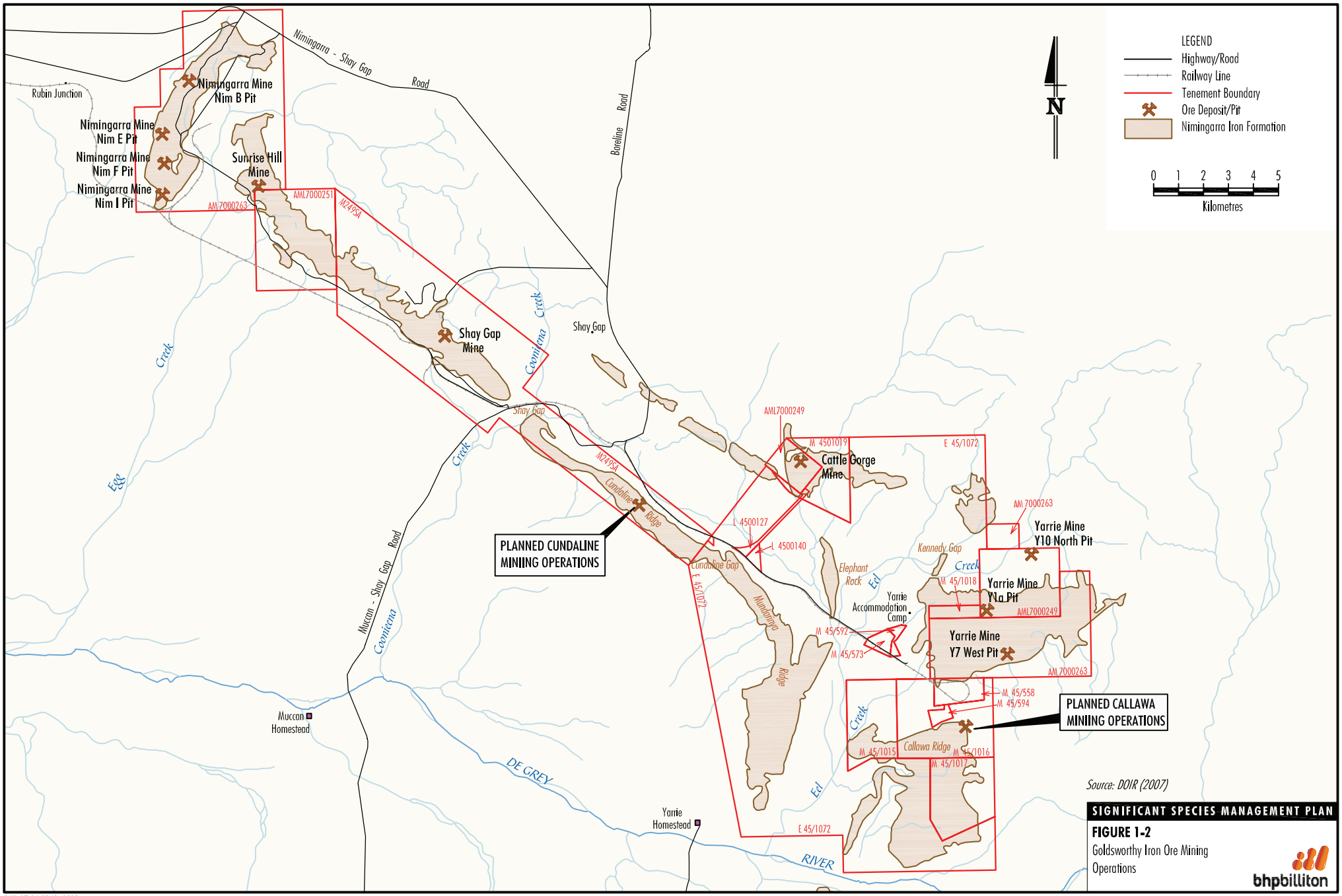
BHP-07-16 SSMP_010B



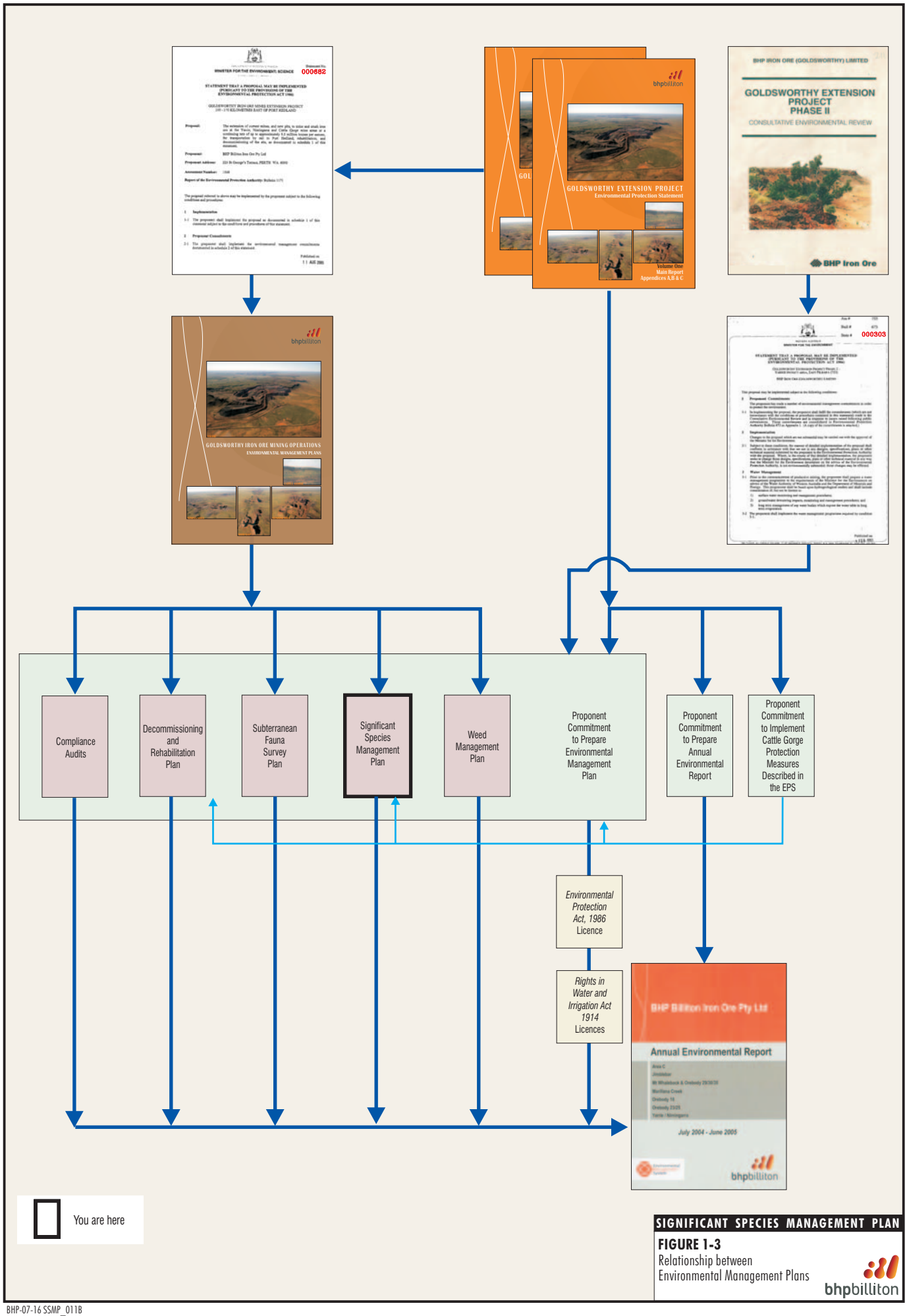
Source: DOIR (2007)

SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 1-2
Goldsworthy Iron Ore Mining Operations

bhpbilliton

BHP-07-16 SSMP_101B



SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 1-3
Relationship between
Environmental Management Plans

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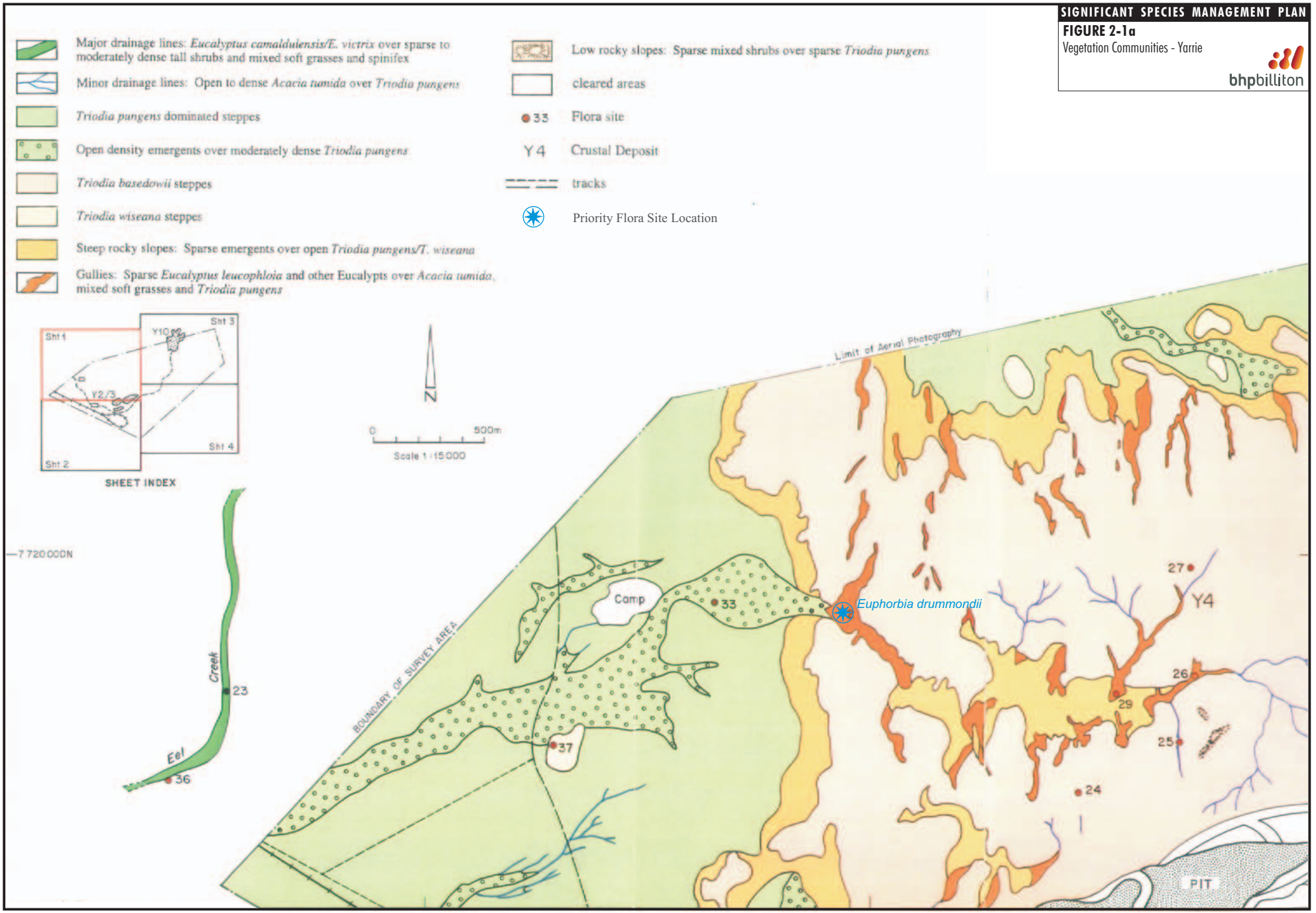
SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-1a

Vegetation Communities - Yarrie

bhpbilliton



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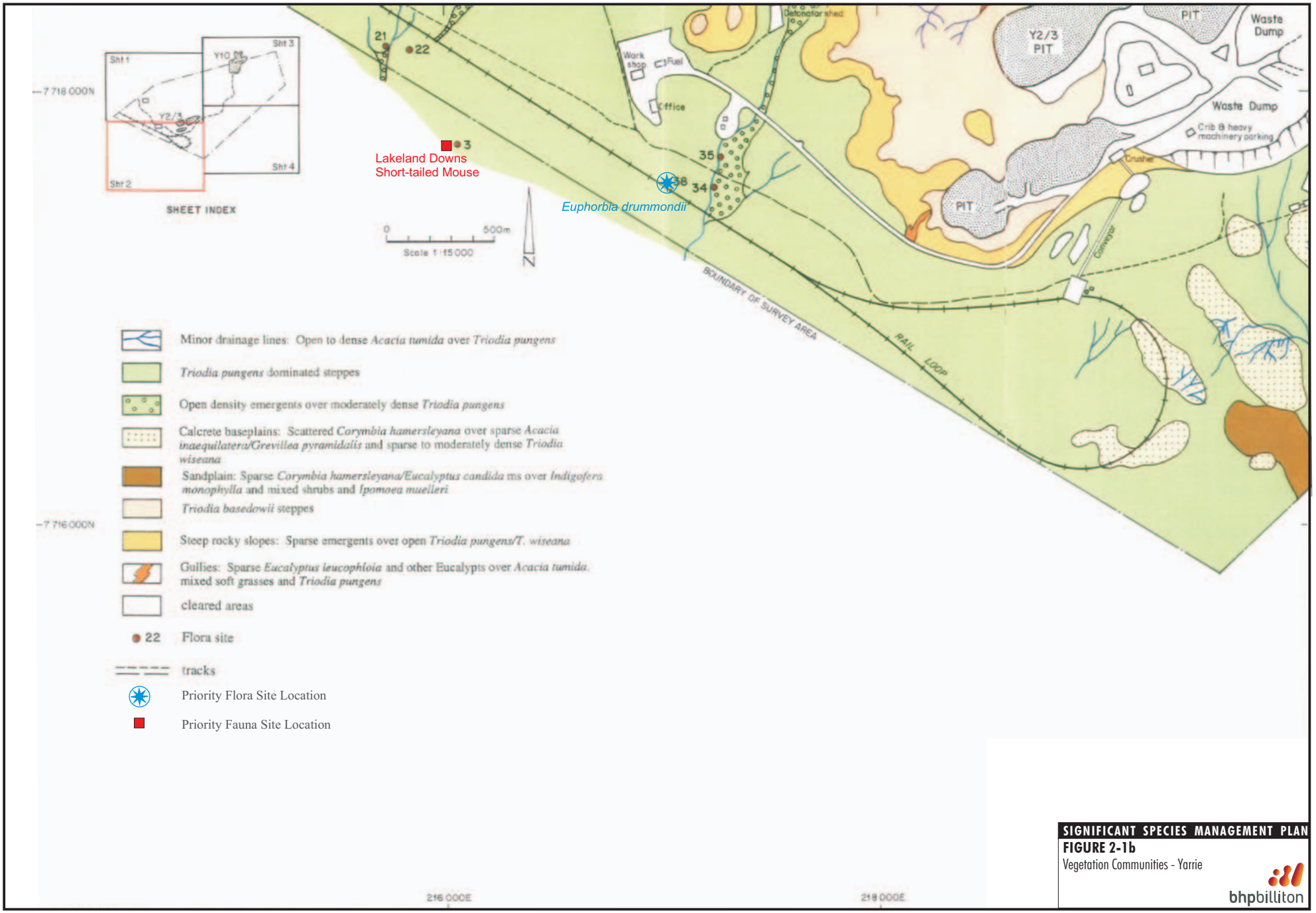
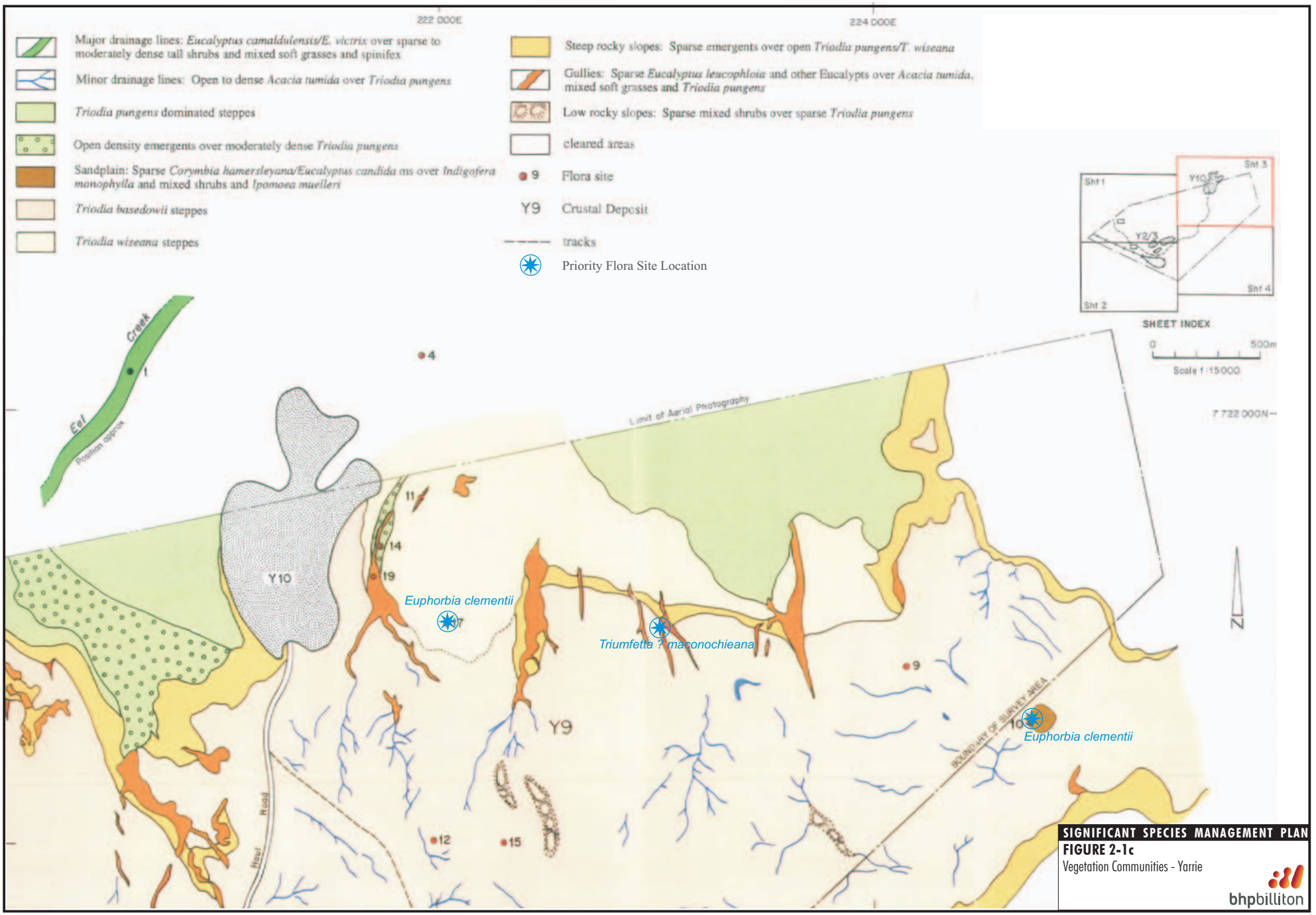


SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-1b

Vegetation Communities - Yarrie

bhpbilliton



SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-1c

Vegetation Communities - Yarrie

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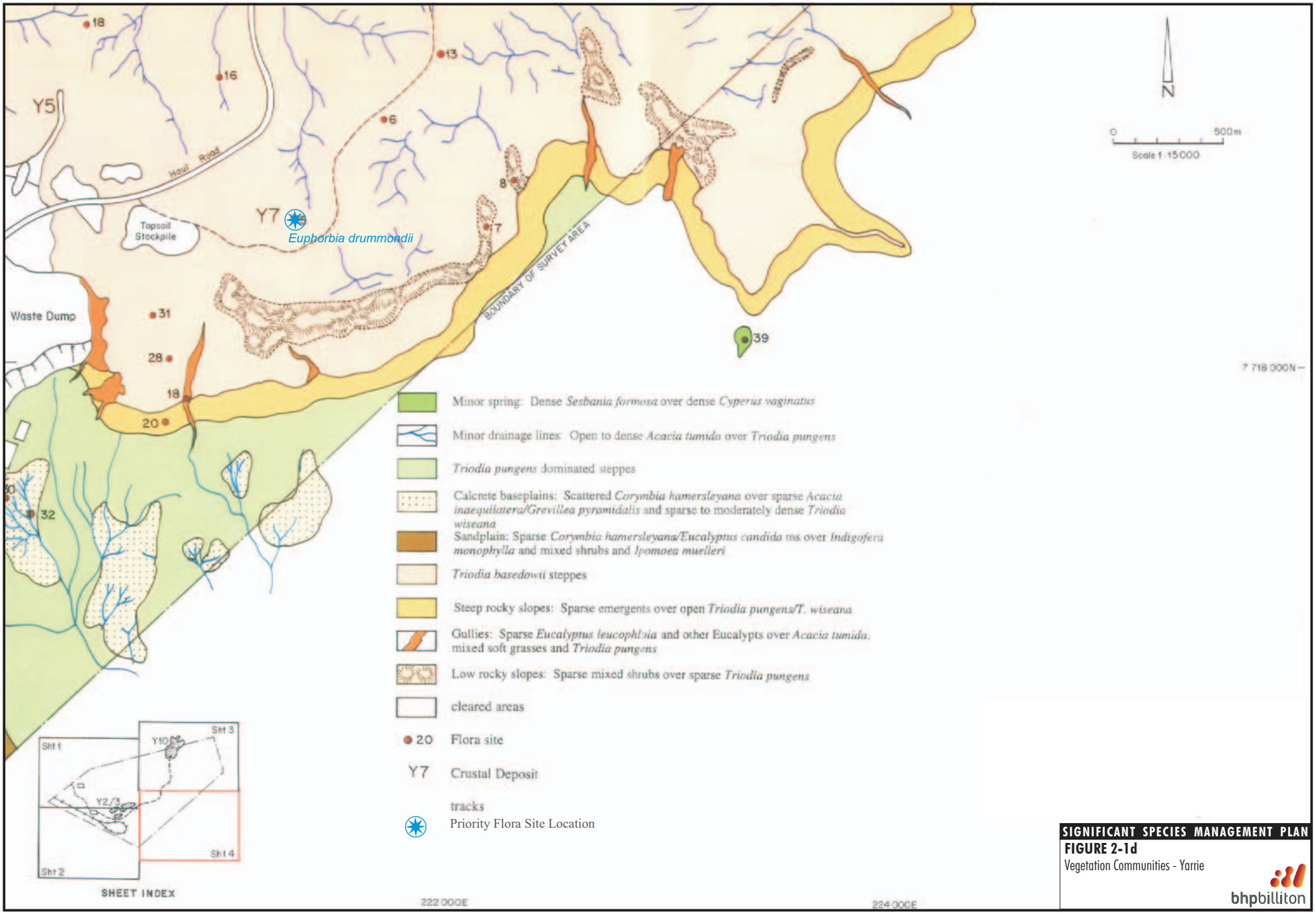
BHP-07-16 SSMP_003B



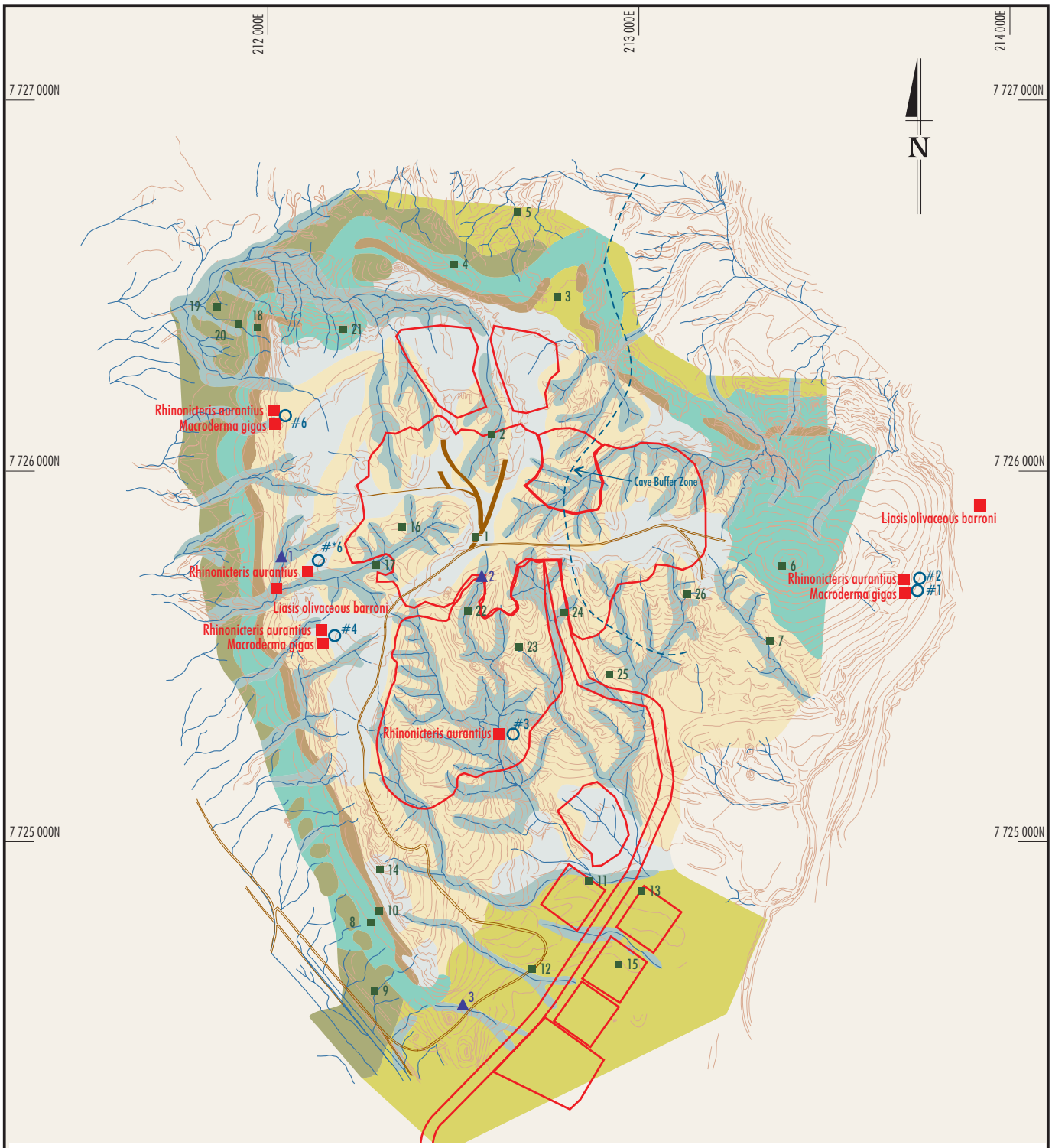
SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-1d

Vegetation Communities - Yarrie

bhpbilliton

BHP-07-16 SSMP_004B



Site Vegetation Units

- Open to scattered Grevillea wickhamii over Acacia tumida/Tephrosia spechtii with moderately dense Triodia epactia steppe on hill crests and gentle slopes.
- Moderately dense Grevillea wickhamii / Acacia tumida often with scattered Corymbia hamersleyana, over moderately dense Triodia epactia steppe along moderate to gentle gullies and hill slopes.
- Scattered Grevillea pyramidalis / Acacia pyrifolia / Senna glutinosa over sparse medium shrubs, over Acacia ptychophylla with open to moderately dense Triodia wiseana steppe on steep scarp slopes.
- Moderately dense to dense Acacia tumida with sparse to scattered medium / low shrubs over soft grasses such as Cymbopogon ambiguus with open to sparse Triodia epactia at rocky outcrops on steep upper scarp slopes.
- Scattered Eucalyptus leucophloia with scattered Corymbia hamersleyana or Grevillea wickhamii, over Acacia spondylophylla with open to moderately dense Triodia epactia / Triodia wiseana on moderaly steep hill slopes.
- Scattered Acacia inaequilatera / Grevillea pyramidalis sometimes with Corymbia hamersleyana, over Grevillea wickhamii / Acacia ptychophylla, with moderately dense Triodia epactia / Triodia wiseana steppe.
- Scattered Acacia inaequilatera sometimes with Corymbia hamersleyana or Corymbia flavescens, over scattered meduim to low Acacia species, with open to dense Triodia wiseana steppe on gentle lower

- Vegetation Site
- Fauna Site
- Fauna Species of Conversation Significance
- #2 Cave
- Cattle Gorge Mining and Infrastructure Areas

Source: Ecologia (2005)

SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-2

Vegetation Communities and Fauna Sampling Sites - Cattle Gorge

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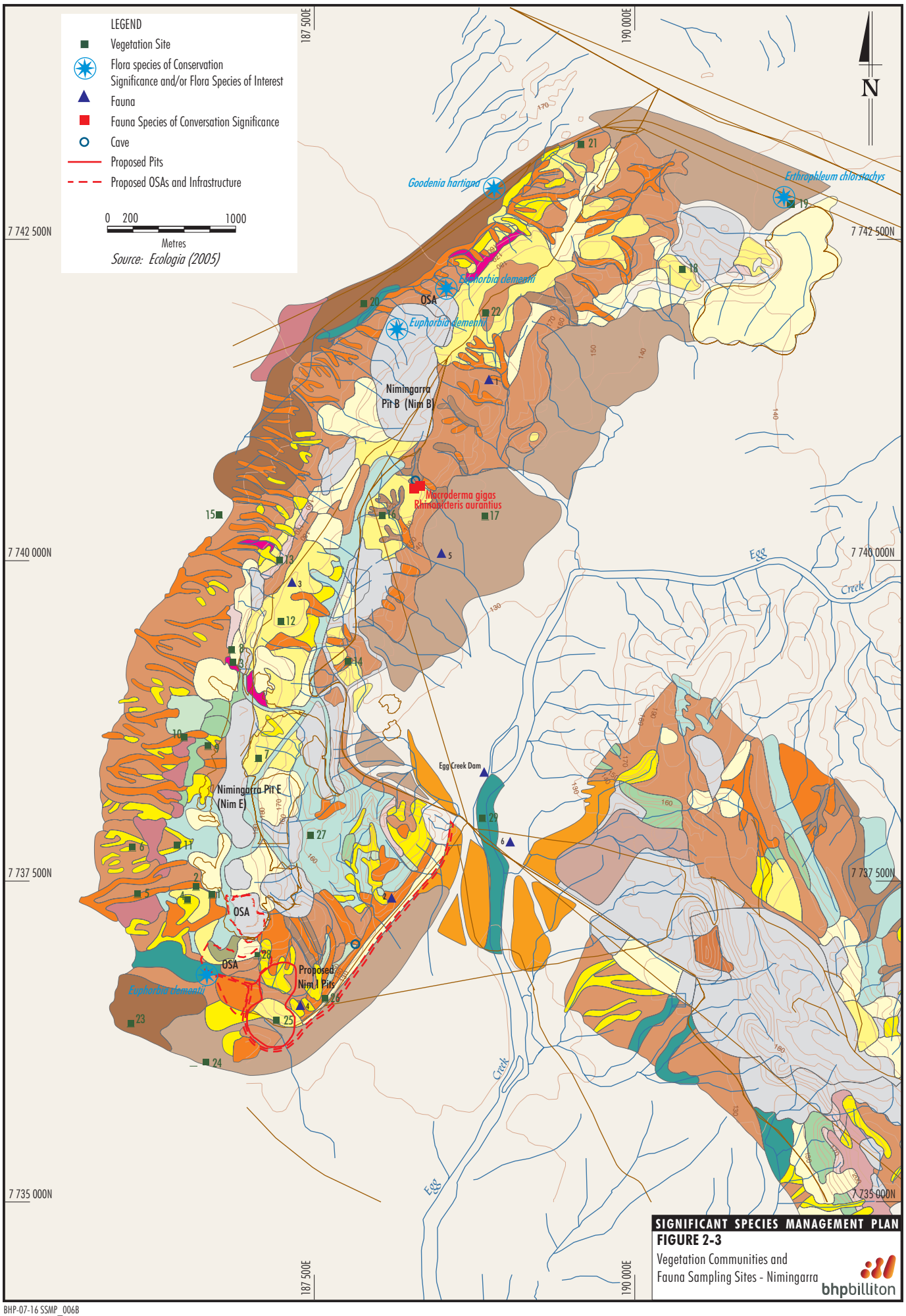
BHP-07-16 SSMP_005B



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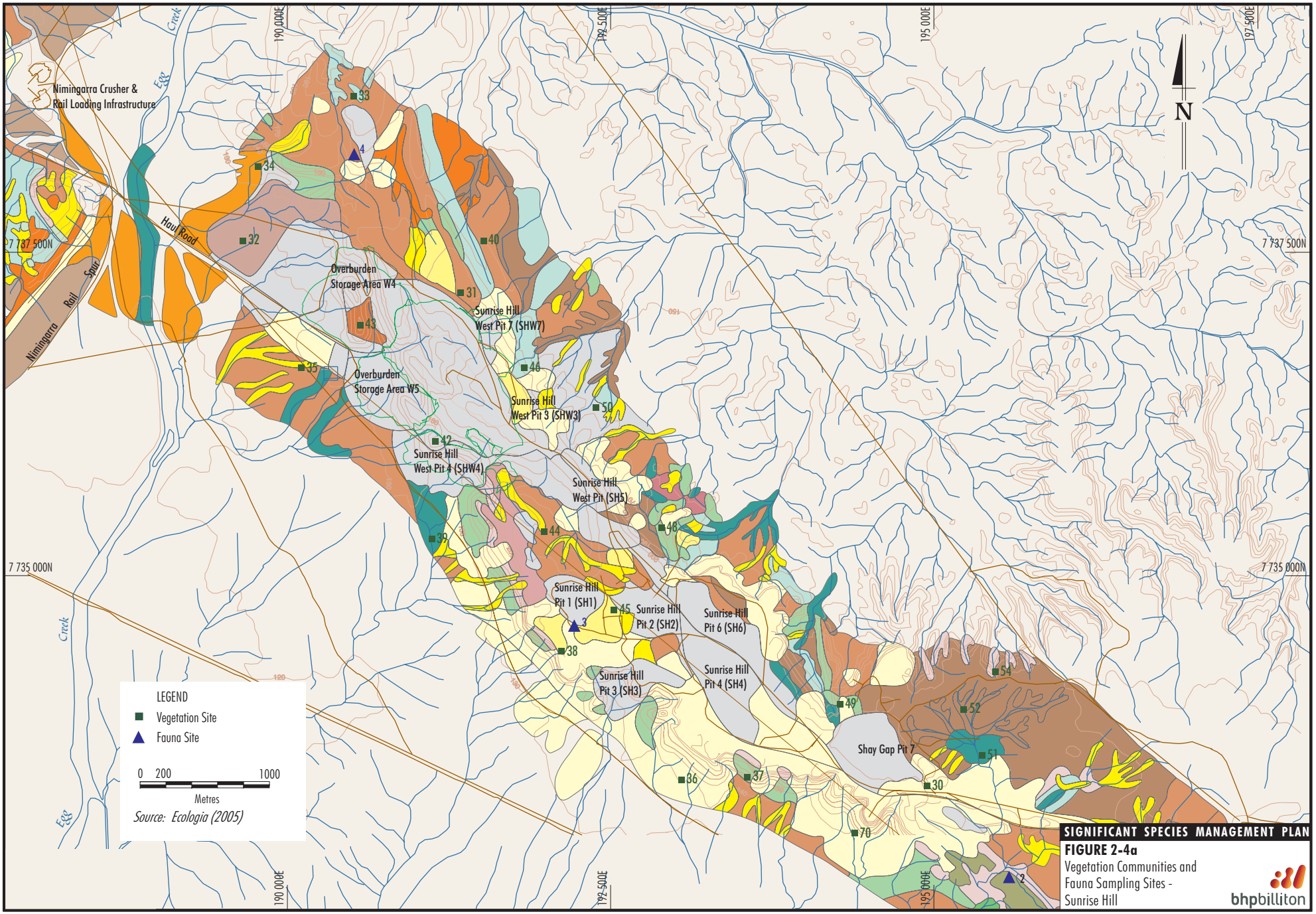

SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-4a

Vegetation Communities and Fauna Sampling Sites - Sunrise Hill

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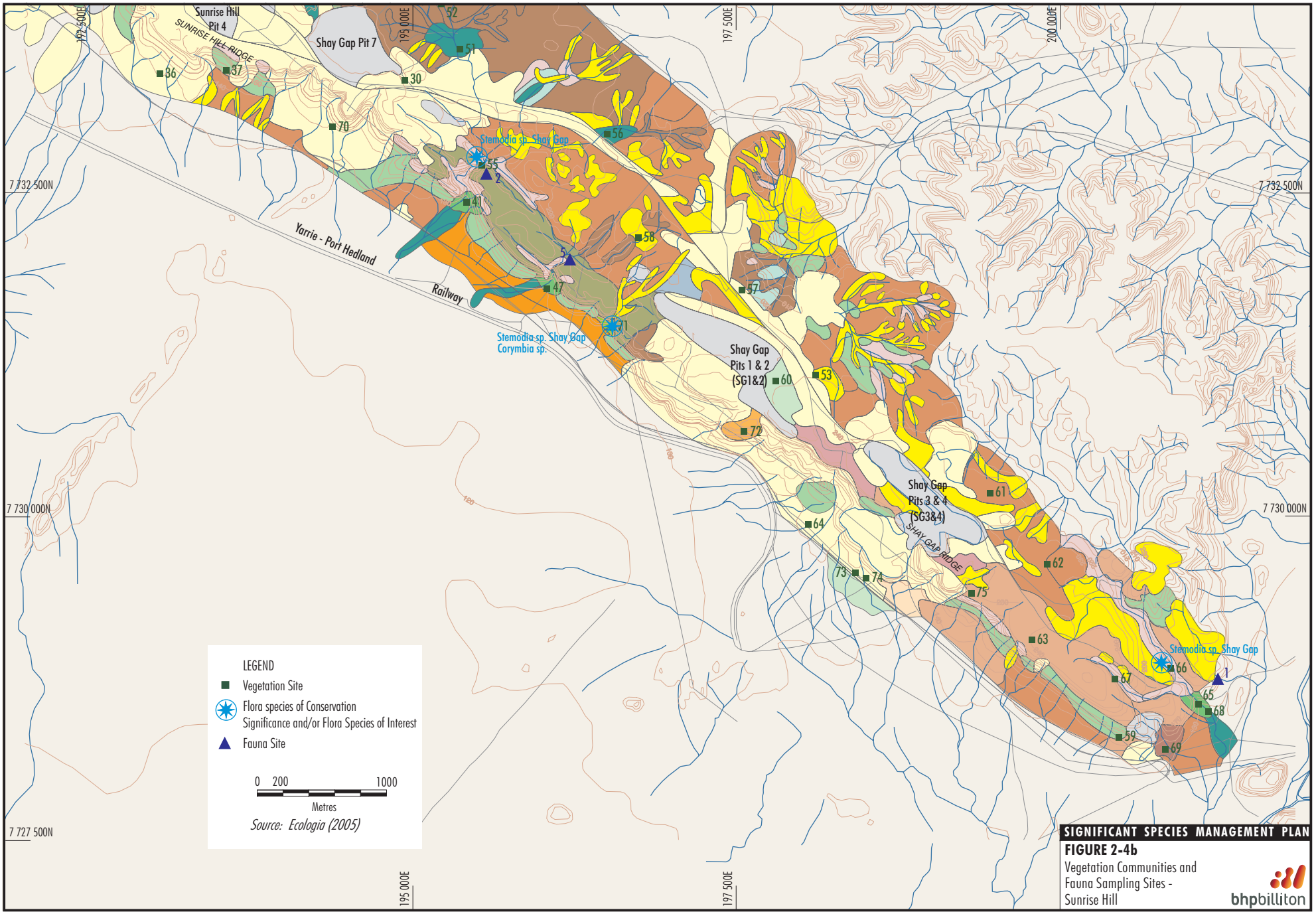
BHP-07-16 SSMP_007B



BHP-07-16 SSMP_008B

A) Forest

Melaleuca argentea / *Eucalyptus victrix* tall to medium forest, over *Atalaya hemiglauca* and *Ficus* spp. low trees and other shrubs, over *Typha domingensis* rushes, over *Cyperus vaginatus* sedgeland.

Corymbia hamersleyana / *Corymbia flavescens* / *Eucalyptus victrix* medium forest to woodland, sometimes with Melaleuca argentea, over *Acacia tumida* var. *pilbarensis* / *Acacia colei* var. *colei* tall to low shrubland, often with mixed herbs and *Cyperus* spp. sedges.

Ficus virens / *Ficus brachypoda* and other associated species mixed dense medium to low forest with *Tinospora smilacina lianas* and *Stemodia* sp. Shay Gap.

B) Woodland

Eucalyptus leucophloia medium woodland, over mixed shrubs such as *Senna glutinosa* subsp. *glutinosa* / *Acacia inaequilatera* / *Acacia adoxa* var. *adoxa* / *Indigofera monophylla* (small calyx form), over *Triodia epactia* hummock.

Acacia ampliceps / *Sesbania formosa* / *Corymbia hamersleyana* open medium trees, over *Ficus opposita* var. *indecora*, over *Typha domingensis* and *Cyperus vaginatus* rushes and sedges.

Corymbia hamersleyana low woodland, over *Grevillea wickhamii* subsp. *aprica* / *Corchorus* aff. *parviflorus* (2) and other medium to low shrubs, over *Acacia hilliana* dwarf shrubs, over *Triodia epactia* open hummock grassland.

Corymbia hamersleyana / *Corymbia flavescens* low trees over mixed *Acacia* spp. and other shrubs over *Acacia adoxa* var. *adoxa* / *Indigofera monophylla* (small calyx form) / *Bonamia* spp./ *Tephrosia* sp. Bungaroo Creek / *Isotropis atropurpurea,* over *Triodia epactia* hummock grassland.

Corymbia hamersleyana low trees, often found with *Eucalyptus odontocarpa* mallee, over *Acacia tumida* var.*pilbarensis* tall shrubland, over *Templetonia hookeri* and other shrubs and herbs including *Acacia adoxa* var.*adoxa,* over *Triodia epactia* hummock grass.

Corymbia zygophylla low trees, over *Acacia tumida* var.*pilbarensis* / *Acacia ancistrocarpa* / *Jacksonia aculeata* / *Jasminum didymum* *Bulbostylis barbata* medium to low shrubs, with sedges, over *Triodia epactia* or *T. wiseana* or *T. schinzii* hummock grassland.

Eucalyptus leucophloia / *Grevillea pyramidalis* subsp.*pyramidalis* scattered low trees, over *Acacia colei* var.*colei* and *Solanum horridum* medium / low shrubs over *Triodia epactia* hummock grassland.

Acacia inaequilatera low trees with or without *Corymbia hamersleyana,* over *Grevillea* subsp. *aprica,* over *Acacia hilliana* / *Acacia adoxa* var. *adoxa* dwarf shrubs, over *Triodia epactia* open to moderately dense hummock grassland.

Acacia inaequilatera low trees over *Grevillea wickhamii* subsp.aprica medium shrubs over *Acacia ptychophylla* over *Triodia epactia* hummock grassland.

Acacia inaequilatera scattered low trees with *Acacia pyrifolia* and *Eucalyptus leucophloia,* over *Acacia* sp. Ruddall River(B.R.Maslin 2046A) scattered medium shrubland, over *Triodia epactia* moderately dense hummock grassland steppe.

Acacia inaequilatera low trees, over *Grevillea wickhamii* var. *aprica* / *Acacia tumida* var. *pilbarensis* and other shrubs including *Acacia hilliana,* with *Fimbristylis simulans* / *Goodenia stobbsiana* over *Triodia epactia* moderately dense hummock grassland.

Ficus brachypoda or *Ficus virens* low trees, over *Atalaya hemiglauca* over *Jasminum didymum,* over*Triumfetta maconochieana* and other shrubs and herbs, with *Stemodia* sp. Shay Gap.

C) Shrublands

Acacia tumida var.*pilbarensis* tall to low shrubland with or without *Corymbia hamersleyana* / *Grevillea wickhamii* subsp. *aprica*, over *Acacia hilliana* / *Acacia adoxa* dwarf shrubs, over *Triodia epactia* hummock grassland.

Acacia orthocarpa tall/medium shrubland with *Acacia inaequilatera*, over *Acacia adoxa* var. *adoxa* / *Acacia hilliana* dwarf shrubs, over *Triodia epactia* open to moderately dense hummock grassland.

Acacia tumida var. *pilbarensis* / *Acacia colei* var. *colei* tall to low shrubland, over other *Acacia* spp. / *Ptilotus* spp. and other shrubs, including *Salsola tragus,* over *Aristida* spp. and *Cymbopogon ambiguus* grasses, with lianas over *Triodia epactia* / *Triodia lanigera* / *Triodia wiseana* hummock grass on rehabilitated areas.

Mixed medium to tall shrubland including *Tephrosia spechtii,* over *Acacia adoxa* var.*adoxa* / *Acacia hilliana* sparse to moderately dense dwarf shrubland, over sparse to open *Triodia epactia* hummock grassland.

Mixed medium shrubs over *Acacia inaequilatera* low shrubs or *Acacia adoxa* var. *adoxa* dwarf shrubs, over *Indigofera monophylla* (small calyx form) aff. / *Corchorus parviflorus* / *Bonamia media* var. *villosa,* over *Triodia epactia* or *Triodia wiseana* hummock grassland.

Grevillea wickhamii subsp. *aprica* open to scattered medium - low shrubland usually with *Corymbia hamersleyana* low trees, over *Acacia adoxa* var. *adoxa* dwarf shrubland over *Triodia epactia* open hummock grassland.

Acacia inaequilatera scattered medium shrubland over *Acacia stellaticeps* / *Acacia hilliana* / *Acacia adoxa* var. *adoxa*, *Acacia* sp. Ruddall River(B.R. Maslin) / *Acacia tumida* var. *pilbarensis* / *Ptilotus calostachyus,* over *Triodia epactia* moderately dense hummock grassland.

Acacia ptychophylla, Acacia ancistrocarpa, Acacia pyrifolia, *Grevillea wickhamii* subsp. *aprica* scattered low shrubland over *Dodonaea coriacea*. *Acacia colei* var. *colei* dwarf shrubs over *Triumfetta maconochieana* over *Triodia wiseana* moderately dense hummock grassland.

Melaleuca glomerata sparse medium shrubland with *Ficus opposita* var. *indecora*, over *Typha domingensis* and *Cyperus vaginatus* rushes and sedges, over *Flaveria australasica* herbs.

Mixed shrubs including *Triumfetta* spp. over *Trachymene oleracea* over *Evolvulus alsinoides* var. *villosicalyx*, over *Bulbostylis barbata* sedges, over *Triodia epactia* / *Triodia wiseana* hummock steppe.

Areas of no vegetation - cleared (Open-cut mine pits, tracks, roads, active waste rock dumps etc.)

= 16 (small squares of cleared areas linked together into a roughly triangular shape)

SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-5

Vegetation Legend - Nimingarra and Sunrise Hill

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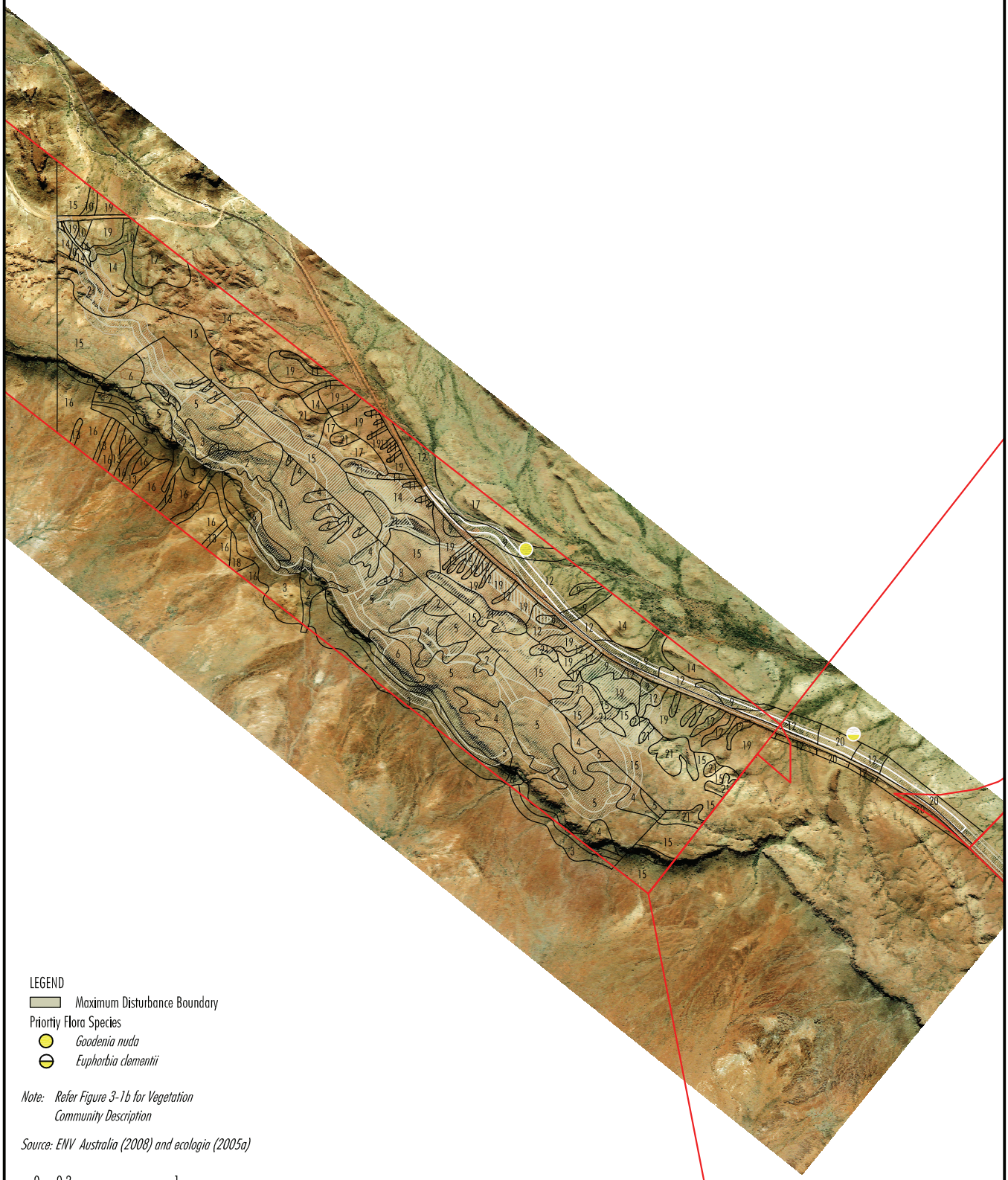
BHP-07-16 SSMP_009B



SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-6a

Vegetation Mapping- Cundaline

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No	Description
1	*Corymbia flavescens* and/or *Atalaya hemiglauca* and/or *Ficus brachypoda* (sometimes with *Eucalyptus leucophloia* subsp. *leucophloia* moderately dense medium forest to sparse low woodland, over medium shrubs such as *Acacia tumida* var. *pilbarensis/Grevillea wickhamii* subsp. *hispidula/G. pyramidalis* subsp. *leucadendron/Petalostylis labicheoides/Flueggea virosa* subsp. *melanthesoides* medium shrubs, over low shrubs such as *Solanum dioicum* and *Indigofera monophylla*, over tussock grasses such as *Cymbopogon ambiguous/Eriachne mucronata* (typical form), over *Triodia epactia* or *T. wiseana* moderately dense to sparse hummock grassland.
2	*Eucalyptus leucophloia* subsp. *leucophloia* (or *Corymbia hamersleyana*) open medium/low woodland or trees (sometimes with *Terminalia canescens* or *C. flavescens*) over *Acacia tumida* subsp. *pilbarensis* (or *Petalostylis labicheoides*) moderately dense to scattered tall/medium shrubland, over medium shrubs such as *A. pyrifolia*, over low shrubs such as *Dampiera candicans/Sida* sp. A Kimberley Flora or *Triumfetta plumigera/T. maconochieana*, over dwarf shrubs such as *Indigofera monophylla* over mixed tussock grass and Spinifex hummock grasses.
3	*Eucalyptus leucophloia* subsp. *leucophloia* open low woodland, over *Hakea chordophylla* scattered tall shrubland, over *Triumfetta maconochieana/Senna glutinosa* subsp. *glutinosa* scattered low shrubland over *Triodia wiseana* moderately dense hummock grassland.
4	*Acacia tumida* var. *pilbarensis* (also with *Grevillea wickhamii* subsp. *hispidula/A. pyrifolia/Petalostylis labicheoides*) moderately dense to open tall/medium shrubland, sometimes with *Corymbia hamersleyana* open low woodland to scattered trees, or with *Eucalyptus odontocarpa* open medium/low mallee, over open to low shrubs such as *Dampiera candicans/A. ptychophylla/Indigofera monophylla* (small calyx form), over tussock grasses and *Triodia epactia* or *T. biflora* hummock grasses.
5	*Grevillea wickhamii* subsp. *hispidula* open to sparse tall/medium shrubland (sometimes with *Corymbia hamersleyana/Acacia pyrifolia/Acacia tumida* var. *pilbarensis*), over *A. ptychophylla/Dampiera candicans* moderately dense to sparse dwarf shrubland (occasionally with *Indigofera monophylla* (small calyx form), over *Goodenia stobbsiana* herbs, over *Triodia epactia* or *T. wiseana* open (to moderately dense) hummock grassland.
6	*Grevillea wickhamii* subsp. *hispidula/Acacia inaequilatera* open medium to tall shrubland, over *Goodenia stobbsiana* scattered herbs, over *Triodia epactia* moderately dense hummock grassland.
7	*Petalostylis labicheoides/Acacia tumida* var. *pilbarensis/Grevillea wickhamii* subsp. *hispidula* moderately dense to sparse medium shrubland (sometimes with *Corymbia hamersleyana* or *C.* aff *hamersleyana*) over *Triodia epactia* moderately dense to sparse hummock grassland.
8	*Grevillea wickhamii* subsp. *hispidula* moderately dense to sparse medium/low shrubland (sometimes with *Eucalyptus leucophloia* subsp. *leucophloia, Petalostylis labicheoides* and *Acacia tumida* var. *pilbarensis* trees and shrubs), over *A. spondylophylla* (and sometimes *Solanum dioicum/Corchorus* spp.)/*A. ptychophylla* moderately dense to scattered low/dwarf shrubland, over *Triodia epactia* moderately dense to sparse hummock grassland.
9	*Corymbia hamersleyana* scattered low trees over *Acacia tumida* var. *pilbarensis*, *A. pyrifolia* and *A. colei* var. *colei* shrubland over *Tephrosia* aff. *rosea* (HD292-37) low shrubland over *Triodia epactia* very open hummock grassland over *Pluchea rubelliflora* and *Stemodia grossa* very open herbland.
10	*Corymbia hamersleyana* scattered low trees over *Acacia tumida* var. *pilbarensis* high shrubland over *Acacia pyrifolia* open shrubland over *A. ptychophylla* and *A. adoxa* var. *adoxa* low scattered shrubs over *Triodia epactia* closed hummock grassland.
11	*Acacia inaequilatera* high open shrubland over *Acacia ptychophylla* low open health over *Triodia epactia* hummock grassland.
12	*Corymbia hamersleyana* low open woodland over *Grevillea wickhamii* subsp. *hispidula* shrubland over *Triodia epactia* hummock grassland.
13	*Grevillea wickhamii* subsp. *hispidula* high open shrubland over *Acacia stellaticeps* open shrubland over *Dampiera candicans* and *Leptosema anomalum* scattered low shrubs over *Triodia epactia* hummock grassland.
14	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia inaequilatera* open shrubland over *Triodia wiseana* hummock grassland.
15	*Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Grevillea wickhamii* subsp. *hispidula* and *Acacia tumida* var. *pilbarensis* high shrubland over *Triodia epactia* hummock grassland.
16	*Grevillea pyramidalis* subsp. *leucadendron* and *G. wickhamii* subsp. *hispidula open* shrubland over *Acacia ptychophylla, A. adoxa* var. *adoxa* and *Tephrosia* aff. *rosea* (HD292-37) low shrubland over *Triodia epactia hummock* grassland.
17	*Corymbia hamersleyana* scattered low trees over *Grevillea wickhamii* subsp. *hispidula* and *Acacia pyrifolia* shrubland over *Triodia epactia* hummock grassland.
18	*Acacia orthocarpa*, *Grevillea pyramidalis* subsp. *leucadendron* and *G. wickhamii* subsp. *hispidula* high shrubland over *Corchorus* aff. *parviflorus* (1)(GLD SRH67-5) and *Acacia adoxa* var. *adoxa* low open shrubland over *Triodia epactia* hummock grassland over *Cymbopogon ambiguus* scattered tussock grasses.
19	*Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia ptychophylla* low open shrubland over *A. stellaticeps* low open shrubland over *Triodia epactia* and *T. epactia* closed hummock grassland.
20	*Corymbia hamersleyana* scattered low trees over *Acacia bivenosa* and *A. victoriae* open shrubland over *Triodia wiseana* hummock grassland.
21	*Corymbia hamersleyana, C. flavescens* and *Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia tumida* var. *pilbarensis* and *Grevillea wickhamii* subsp. *hispidula* open shrubland over *Eriachne mucronata* (typical form) very open tussock grassland over *Triodia biflora, T. epactia* and *T. wiseana* hummock grassland.

Source: ENV Australia, 2008

SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-6b
Cundaline Vegetation Mapping Description

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SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-7a

Vegetation Mapping - Callawa

bhpbilliton

BHP-07-16 SSMP_103C

No	Description
1	*Terminalia canescens* and/or *Corymbia flavescens* and/or *Atalaya hemiglauca* and/or *Ficus brachypoda* (sometimes with *Eucalyptus leucophloia* subsp. *leucophloia* or *E. camaldulensis*) moderately dense medium forest to sparse low woodland, over medium shrubs such as *Acacia tumida* var. *pilbarensis*/*Grevillea wickhamii* subsp. *hispidula*/*G. pyramidalis* subsp. *leucadendron*/*Petalostylis labicheoides*/*Flueggea virosa subsp. melanthesoides* medium shrubs, over low shrubs such as *Solanum dioicum* and *Indigofera monophylla*, over tussock grasses such as *Cymbopogon ambiguous*/*Eriachne mucronata* (typical form), over *Triodia epactia*/*T. wiseana* moderately dense to sparse hummock grassland.
2	*Eucalyptus leucophloia* subsp. *leucophloia* (or *Corymbia hamersleyana*) open medium/low woodland or trees (sometimes with *Terminalia canescens* or *C. flavescens*) over *Acacia tumida* subsp. *pilbarensis* (or *Petalostylis labicheoides*) moderately dense to scattered tall/medium shrubland, over medium shrubs such as *A. pyrifolia*, over low shrubs such as *Dampiera candicans*/*Sida* sp. A (Kimberley Flora) or *Triumfetta plumigera*/*T. maconochieana*, over dwarf shrubs such as *Indigofera monophylla*, over mixed tussock grass and Spinifex hummock grasses.
3	*Petalostylis labicheoides*/*Acacia tumida* var. *pilbarensis*/*Grevillea wickhamii* subsp. *hispidula* moderately dense to sparse medium shrubland (sometimes with *Corymbia hamersleyana* or *C.* aff. *hamersleyana*), over *Triodia epactia* moderately dense to sparse hummock grassland.
4	*Grevillea wickhamii* subsp. *hispidula*/*Petalostylis labicheoides*/*Acacia tumida* var. *pilbarensis* open to sparse medium shrubland (sometimes with *Corymbia hamersleyana* [or *C.* aff. *hamersleyana*] or *Eucalyptus leucophloia* subsp. leucophloia low trees), over *Acacia spondylophylla* (or *A. ptychophylla*) sparse dwarf shrubland, occasionally with *Solanum dioicum*/*Goodenia stobbsiana*/*Dampiera candicans*, over *Triodia wiseana* open hummock grassland.
5	Scattered to open medium shrubs such as *Grevillea pyramidalis* subsp. *leucadendron*/*Grevillea wickhamii* subsp. *hispidula*/*Terminalia canescens*/*Atalaya hemiglauca*, over scattered dwarf shrubs such as *Corchorus* aff. *parviflorus* (1)/*Cullen stipulaceum*, over *Triodia wiseana* moderately dense to sparse hummock grassland.
6	*Grevillea wickhamii* subsp. *hispidula* moderately dense to sparse medium/low shrubland (sometimes with *Eucalyptus leucophloia* subsp. *leucophloia*, *Petalostylis labicheoides* and *Acacia tumida* var. *pilbarensis* trees and shrubs), over *A. spondylophylla* (and sometimes *Solanum dioicum*/*Corchorus* spp.)/*A. ptychophylla* moderately dense to scattered low/dwarf shrubland, over *Triodia epactia* moderately dense to sparse hummock grassland.
7	*Corymbia opaca* and *C. flavescens* low woodland over *Grevillea wickhamii* subsp. *hispidula*, *Acacia tumida* var. *pilbarensis* and *A. inaequilatera* high open shrubland over *Hibiscus leptocladus* and *Corchorus elachocarpus* low open shrubland over *Eragrostis cumingii* and **Cenchrus ciliaris* open tussock grassland.
8	*Corymbia hamersleyana* low woodland over *Acacia tumida* var. *pilbarensis*, *A. inaequilatera* and *A. spondylophylla* shrubland over *Triodia epactia* closed hummock grassland.
9	*Grevillea pyramidalis* subsp. *leucadendron* and *G. wickhamii* subsp. *hispidula* shrubland over *Acacia spondylophylla* low shrubland over *Triodia epactia* hummock grassland.
10	*Grevillea wickhamii* subsp. *hispidula* and *G. pyramidalis* subsp. *leucadendron* high open shrubland over *Triodia wiseana* hummock grassland.
11	*Corymbia hamersleyana*, *C. opaca* and *C. flavescens* low open woodland over *Grevillea wickhamii* subsp. *hispidula* and *G. pyramidalis* subsp. *leucadendron* open shrubland over *Triodia epactia* and *T. wiseana* closed hummock grassland.
12	*Acacia colei* var. *colei*, *A. inaequilatera* and *Grevillea pyramidalis* subsp. *leucadendron* high open shrubland over *Triodia epactia* hummock grassland.
13	*Corymbia flavescens* low woodland over *Acacia tumida* var. *pilbarensis* high shrubland over *Cajanus cinereus* and *Sida rohlenae* subsp. *rohlenae* open low shrubland over *Triodia epactia* open hummock grassland.
14	*Grevillea pyramidalis* subsp. *leucadendron* and *Acacia ptychophylla* open shrubland over *Triodia epactia* open hummock grassland.

Source: ENV Australia (2008)

SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-7b
Callawa Vegetation Mapping Description

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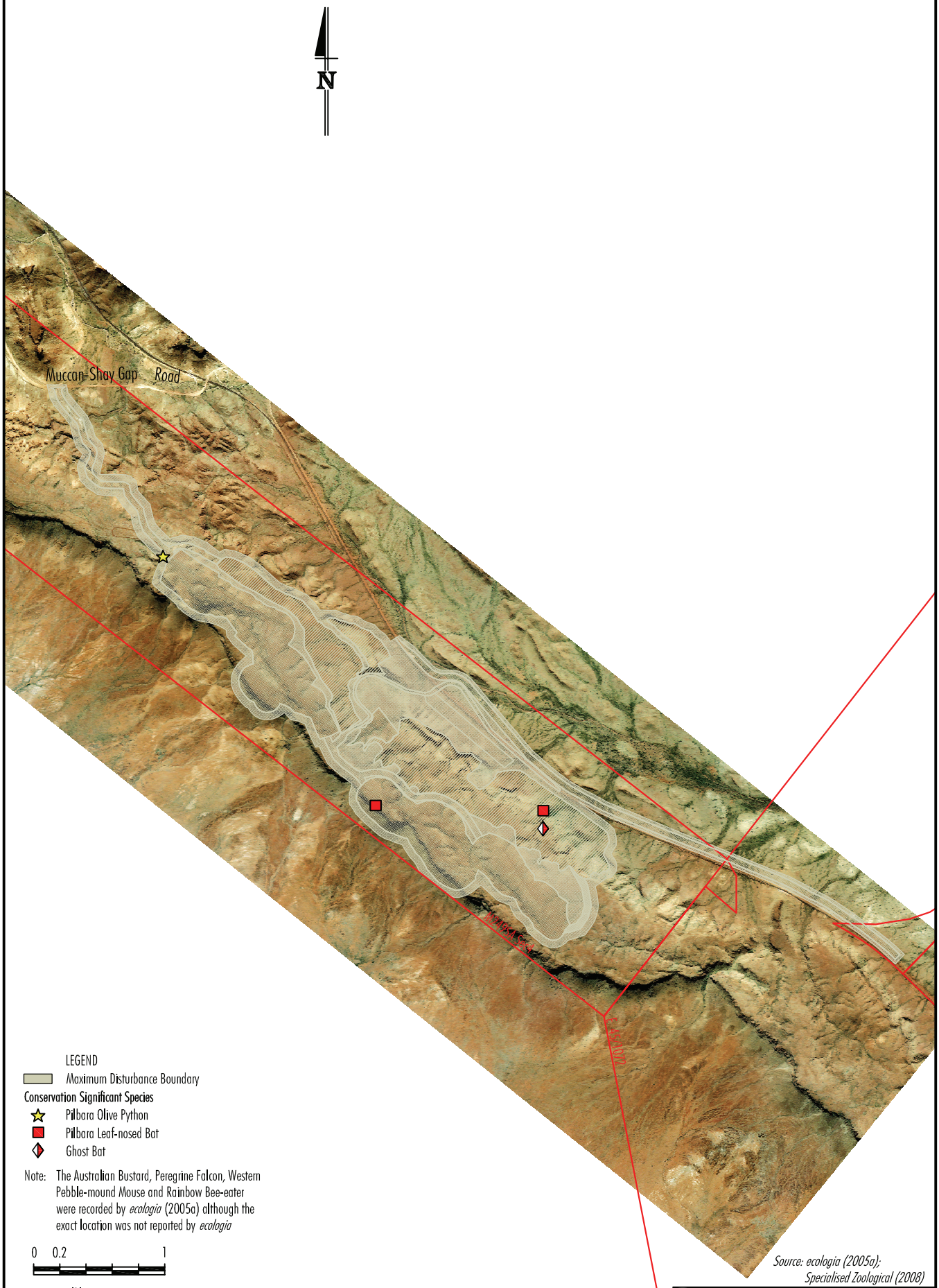
BHP-07-16 SSMP_013B



Source: ecologia (2005a); Specialised Zoological (2008)

SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 2-8

Cundaline Conservation Significant Fauna Species

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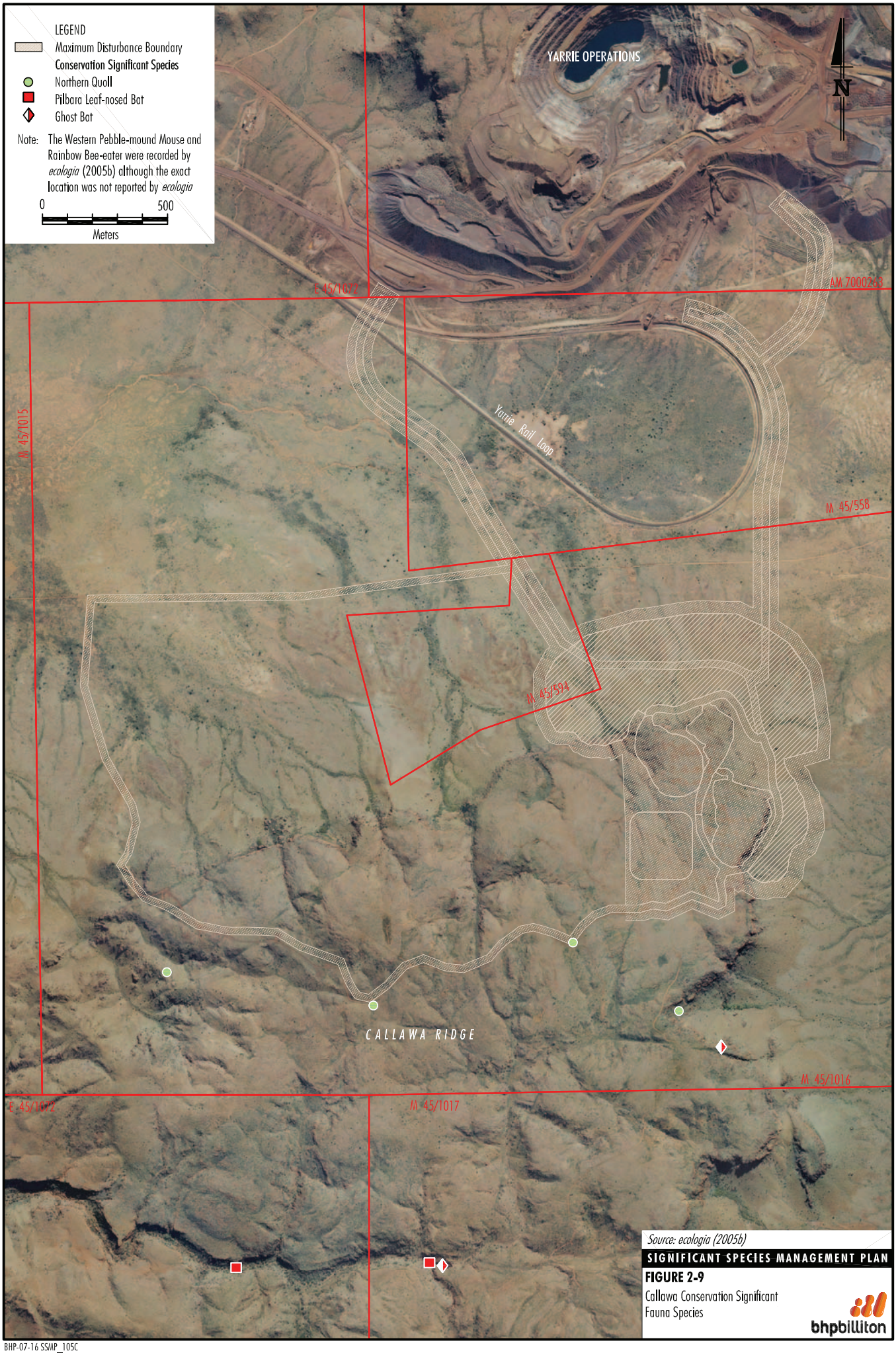
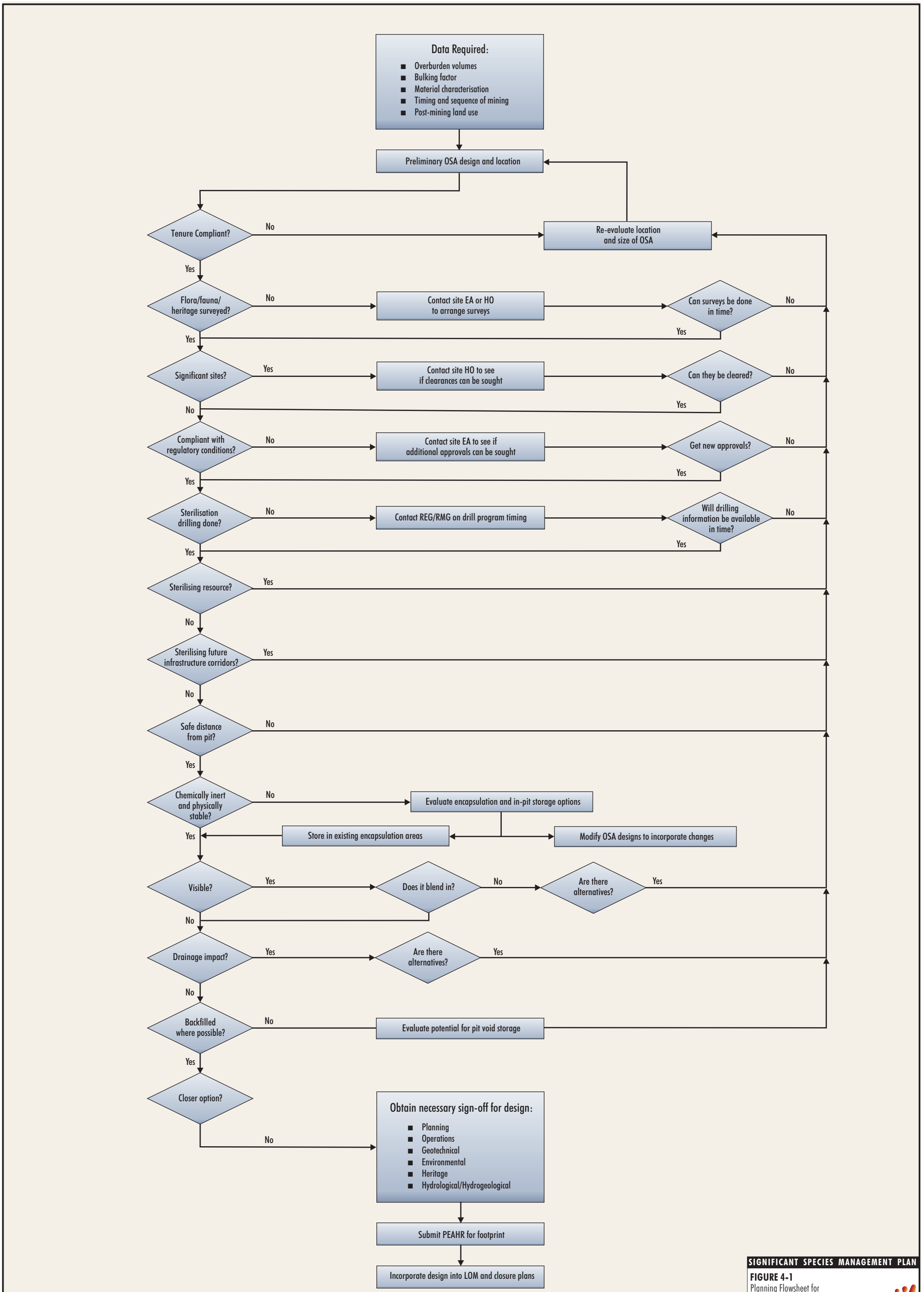
BHP-07-16 SSMP_104C



BHP-07-16 SSMP_105C



SIGNIFICANT SPECIES MANAGEMENT PLAN

FIGURE 4-1
Planning Flowsheet for Major Mine Landforms

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BHP-07-16 SSMP_014B

ATTACHMENT A

EXPLANATION OF CONSERVATION CODES USED IN WESTERN AUSTRALIA

Source: *ecologia* (2005a)

FLORA

Environment Protection and Biodiversity Conservation Act 1999

At a National level, flora and fauna are protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Act contains a list of species that are considered Critically Endangered, Endangered, Vulnerable, Conservation Dependent, Extinct or Extinct in the Wild.

Definition of Categories Described under the EPBC Act

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

Wildlife Conservation Act 1950

Rare Flora is also protected under the *Western Australian Wildlife Conservation (Rare Flora) Notice 2005* of the *Wildlife Conservation Act 1950*. The notice lists protected flora taxa that are extant and considered likely to become extinct or rare. Generally speaking, species of flora are considered as being of Declared Rare Flora (DRF) or Priority conservation status where their populations are restricted geographically or threatened by local processes. DEC maintains a list of all DRF and Priority Flora taxa within Western Australia (Atkins, 2003). Definitions of categories of DRF and Priority Flora are provided below. Priority Flora are either poorly known, believed to be uncommon, rare or under threat but have not been designated as DRF and thereby legally protected because the detailed survey work to justify this has not been carried out. Priority species are maintained on a "Reserve List" and assigned to one of four Priority categories (Atkins, 2003).

Definition of Declared Rare and Priority Flora Categories

Code	Definition
DRF	Declared Rare Flora – Extant Taxa. Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection.
P1: Priority One	Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations which are under threat.
P2: Priority Two	Poorly Known Taxa. Taxa which are known from one or a few (generally <5) population, at least some of which are not believed to be under immediate threat.
P3: Priority Three	Poorly Known Taxa. Taxa which are known from several populations, at least some of which are not believed to be under immediate threat.
P4: Priority Four	Rare Taxa. Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

(From Atkins, K.J., Declared Rare and Priority Flora List April 2003, DEC)

FAUNA

Commonwealth EPBC Act

Schedule 1 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* contains a list of species that are considered Critically Endangered, Endangered, Vulnerable, Extinct, Extinct in the wild and Conservation Dependent.

Explanation of codes for fauna under the Commonwealth EPBC Act

Conservation Category	Definition
Critically Endangered	The species is facing an extremely high risk of extinction in the wild in the immediate future.
Endangered	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Extinct	A species is presumed extinct if it has not been located in the last 50 years, or it has not been located in the last 10 years despite thorough searching.
Extinct in the wild	The species is only known to survive in cultivation, in captivity or as a naturalised population well outside its past range or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a timeframe appropriate to its life cycle and form.
Conservation Dependent	The species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

WA Wildlife Conservation Act 1950 (Specially Protected Fauna) Notice

Classification of rare and endangered fauna under the WA *Wildlife Conservation (Specially Protected Fauna) Notice 2005*, recognises four distinct schedules.

Explanation of codes under the WA *Wildlife Conservation Act 1950 (Specially Protected Fauna) Notice*

Code	Definition
Schedule 1	"fauna which are Rare or likely to become extinct, are declared to be fauna that is in need of special protection"
Schedule 2	"fauna which are presumed to be extinct, are declared to be fauna that is in need of special protection"
Schedule 3	"birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of special protection"
Schedule 4	"declared to be fauna that is in need of special protection, otherwise than for the reasons mentioned in paragraphs (a), (b) and (c)."

DEC Priority Fauna

Species on the DEC Priority Fauna list include those removed from the Scheduled fauna list and other species known from only a few populations or in need of monitoring. Four Priority Codes are recognised.

Explanation of DEC Priority Fauna Categories

Priority Category	Definition
Priority One **Taxa with few, poorly known populations on threatened lands.**	Taxa which are known from few specimens or sight records from one or a few localities, on lands not managed for conservation, *e.g.* agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority Two **Taxa with few, poorly known populations on conservation lands.**	Taxa which are known from few specimens or sight records from one or a few localities, on lands not under immediate threat of habitat destruction or degradation, *e.g.* national parks, conservation parks, nature reserves, State forest, vacant crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna
Priority Three **Taxa with several, poorly known populations, some on conservation lands.**	Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority Four **Taxa in need of monitoring**	Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands.
Priority Five **Taxa in need of monitoring**	Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

IUCN Redbook v3.3

Explanation of IUCN Fauna Categories

Category	Definition
Extinct (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Extinct in the Wild (EW)	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria, does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for, or is likely to qualify for, a threatened category in the near future.
Least Concern (LC)	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.
Not Evaluated (NE)	A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

IUCN categories are further classified based on the following criteria:

Critically Endangered (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing an extremely high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of 90% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:

    a. direct observation;
    b. an index of abundance appropriate to the taxon;
    c. a decline in area of occupancy, extent of occurrence and/or quality of habitat;
    d. actual or potential levels of exploitation; and
    e. the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of 80% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of a-e under A1.

3. A population size reduction of 80%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of b-e under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of 80% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of a-e under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 100 km², and estimates indicating at least two of a-c:

    a. Severely fragmented or known to exist at only a single location.

    b. Continuing decline, observed, inferred or projected, in any of the following:
        (i) extent of occurrence;
        (ii) area of occupancy;
        (iii) area, extent and/or quality of habitat;
        (iv) number of locations or subpopulations; and
        (v) number of mature individuals.

c. Extreme fluctuations in any of the following:
   (i) extent of occurrence;
   (ii) area of occupancy;
   (iii) number of locations or subpopulations; and
   (iv) number of mature individuals.

2. Area of occupancy estimated to be less than 10 km², and estimates indicating at least two of a-c:

   a. Severely fragmented or known to exist at only a single location.

   b. Continuing decline, observed, inferred or projected, in any of the following:
      (i) extent of occurrence;
      (ii) area of occupancy;
      (iii) area, extent and/or quality of habitat;
      (iv) number of locations or subpopulations; and
      (v) number of mature individuals.

   c. Extreme fluctuations in any of the following:
      (i) extent of occurrence
      (ii) area of occupancy
      (iii) number of locations or subpopulations
      (iv) number of mature individuals.

C. Population size estimated to number fewer than 250 mature individuals and either:

1. An estimated continuing decline of at least 25% within three years or one generation, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):

   a. Population structure in the form of one of the following:
      (i) no subpopulation estimated to contain more than 50 mature individuals, OR
      (ii) at least 90% of mature individuals in one subpopulation.

   b. Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 50 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer (up to a maximum of 100 years).

Endangered (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a very high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of 70% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
   a. direct observation;
   b. an index of abundance appropriate to the taxon;
   c. a decline in area of occupancy, extent of occurrence and/or quality of habitat;
   d. actual or potential levels of exploitation; and
   e. the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of 50% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of a-e under A1.

3. A population size reduction of 50%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of b-e under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of 50% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of a-e under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 5000 km², and estimates indicating at least two of a-c:

   a. Severely fragmented or known to exist at no more than five locations.

   b. Continuing decline, observed, inferred or projected, in any of the following:
      (i) extent of occurrence;
      (ii) area of occupancy;
      (iii) area, extent and/or quality of habitat;
      (iv) number of locations or subpopulations; and
      (v) number of mature individuals.

   c. Extreme fluctuations in any of the following:
      (i) extent of occurrence;
      (ii) area of occupancy;
      (iii) number of locations or subpopulations; and
      (iv) number of mature individuals.

2. Area of occupancy estimated to be less than 500 km², and estimates indicating at least two of a-c:

   a. Severely fragmented or known to exist at no more than five locations.

   b. Continuing decline, observed, inferred or projected, in any of the following:
      (i) extent of occurrence;
      (ii) area of occupancy;
      (iii) area, extent and/or quality of habitat;
      (iv) number of locations or subpopulations; and
      (v) number of mature individuals.

   c. Extreme fluctuations in any of the following:
      (i) extent of occurrence;
      (ii) area of occupancy;
      (iii) number of locations or subpopulations; and
      (iv) number of mature individuals.

C. Population size estimated to number fewer than 2500 mature individuals and either:

1. An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):

   a. Population structure in the form of one of the following:
      (i) no subpopulation estimated to contain more than 250 mature individuals, OR
      (ii) at least 95% of mature individuals in one subpopulation.

   b. Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 250 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).

Vulnerable (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of 50% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are: clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
   a. direct observation
   b. an index of abundance appropriate to the taxon
   c. a decline in area of occupancy, extent of occurrence and/or quality of habitat
   d. actual or potential levels of exploitation
   e. the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of 30% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of a-e under A1.

3. A population size reduction of 30%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of b-e under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of 30% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of a-e under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 20,000 km², and estimates indicating at least two of a-c:

   a. Severely fragmented or known to exist at no more than 10 locations.

   b. Continuing decline, observed, inferred or projected, in any of the following:
      (i) extent of occurrence;
      (ii) area of occupancy;
      (iii) area, extent and/or quality of habitat;
      (iv) number of locations or subpopulations; and
      (v) number of mature individuals.

   c. Extreme fluctuations in any of the following:
      (i) extent of occurrence
      (ii) area of occupancy
      (iii) number of locations or subpopulations
      (iv) number of mature individuals.

2. Area of occupancy estimated to be less than 2000 km², and estimates indicating at least two of a-c:

   a. Severely fragmented or known to exist at no more than 10 locations.

   b. Continuing decline, observed, inferred or projected, in any of the following:
      (i) extent of occurrence;
      (ii) area of occupancy;
      (iii) area, extent and/or quality of habitat;
      (iv) number of locations or subpopulations; and
      (v) number of mature individuals.

   c. Extreme fluctuations in any of the following:
      (i) extent of occurrence;
      (ii) area of occupancy;
      (iii) number of locations or subpopulations; and
      (iv) number of mature individuals.

C. Population size estimated to number fewer than 10,000 mature individuals and either:

1. An estimated continuing decline of at least 10% within 10 years or three generations, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):

   a. Population structure in the form of one of the following:
      (i) no subpopulation estimated to contain more than 1000 mature individuals, OR
      (ii) all mature individuals are in one subpopulation.

b. Extreme fluctuations in number of mature individuals.

D. Population is very small or restricted in the form of either of the following:

1. Population size estimated to number fewer than 1000 mature individuals.

2. Population with a very restricted area of occupancy (typically less than 20 km²) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period.

E. Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

ATTACHMENT B

LIST OF PREVIOUS FLORA AND FAUNA STUDIES CONDUCTED AT GOLDSWORTHY

Summary of Flora and Fauna Surveys

Date	Author	Report Title
1986	Goldsworthy Mining Limited (GML)	Goldsworthy Extension Project- Notice of Intent – Environmental Aspects at Nimingarra Mine Site and Finucane Island Port Facility near Port Headland, Western Australia.
1992	Dames and Moore Pty Ltd	Goldsworthy Extension Project Phase II Consultative Environmental Review. Unpublished report prepared for BHP Iron Ore (Goldsworthy) Limited.
1993	Piggott, M. S.	An Assessment of the local distribution of Pebble Mice (*Pseudomys chapmani*) at Yarrie. A technical note prepared for BHP-Utah Iron Ore. Enviroscan technical Note 18-02-02/1, April 1993.
1994	Piggott, M. S.	Yarrie Project Pebble-mound Mouse Monitoring. Unpublished report prepared for BHP Iron Ore. Enviroscan technical Note 18-03-04/3, February 1994.
1994	Piggott, M. S.	The Pebble-mound Mouse at Yarrie and Area C. Unpublished report prepared for BHP Iron Ore. Enviroscan technical Note 18-02-03/2, November 1994.
1994	Ecologia Environmental Consultants	Yarrie-Y10-Botanical Survey. Unpublished report for BHP Iron Ore Pty Ltd.
1995	Piggott, M. S.	The Yarrie Project Pebble-mound Mouse Monitoring Programme, 1993-1994. Unpublished report prepared for BHP Iron Ore. Enviroscan technical Note 18-02-06, February 1995.
1997	Halpern Glick Maunsell	Yarrie Western Pebble-mound Mouse (*Pseudomys chapmani*) 1996 Research Programme, Summer 1996. Unpublished report for BHPIO.
1997	Halpern Glick Maunsell	Yarrie Western Pebble-mound Mouse (*Pseudomys chapmani*) 1996 Research Programme, Autumn 1996. Unpublished report for BHPIO.
1997	Halpern Glick Maunsell	Yarrie Western Pebble-mound Mouse (*Pseudomys chapmani*) 1996 Research Programme, Winter 1996. Unpublished report for BHPIO.
1997	Halpern Glick Maunsell	Yarrie Western Pebble-mound Mouse (*Pseudomys chapmani*) 1996 Translocation Programme, Phase V. Unpublished report for BHPIO.
1997	Halpern Glick Maunsell	Yarrie Western Pebble-mound Mouse (*Pseudomys chapmani*) 1996 Monitoring and Research Programme, Winter 1997. Unpublished report for BHPIO.
1998	Halpern Glick Maunsell	Yarrie Western Pebble-mound Mouse (*Pseudomys chapmani*) 1996 Monitoring and Research Programme, Summer 1997. Unpublished report for BHPIO.
1998	Halpern Glick Maunsell	Yarrie Crustal Deposits Baseline Biological and Soil Survey. Unpublished report No. ES984992 prepared for BHP Iron Ore Pty Ltd.
1999	*ecologia* Environmental Consultants	Yarrie Biological and Soil Survey. Unpublished report for BHP Iron Ore Pty Ltd.
2004	*ecologia* Environmental Consultants	Yarrie Cattle Gorge Biological Survey. Unpublished report for BHP Billiton Iron Ore Pty Ltd.
2004	*ecologia* Environmental Consultants	Nim B Extension Priority Flora Search. Unpublished report for BHP Billiton Iron Ore Pty Ltd.
2004	*ecologia* Environmental Consultants	Goldsworthy Extension Project Pre-feasibility Study – Assessment of Flora and Fauna of Conservation Significance. Unpublished report of BHP Billiton Iron Ore Pty Ltd.
2005	*ecologia* Environmental Consultants	Goldsworthy Extension Project Biological Assessment Survey. Unpublished Report for BHP Billiton Ore Pty Ltd.
2005	*ecologia* Environmental Consultants	Pilbara Leaf-nosed Bat (*Rhinonicteris aurantius*) and Ghost Bat (*Macroderma gigas*) Monitoring Survey at Nimingarra and Cattle Gorge. Unpublished Report for BHP Billiton Ore Pty Ltd.
2005	*ecologia* Environmental Consultants	Goldsworthy Extension Project Follow-up Flora Surveys. Unpublished Report for BHP Billiton Ore Pty Ltd.
2005	*ecologia* Environmental Consultants	Cundaline Biological Assessment Survey. Unpublished Report for BHP Billiton Ore Pty Ltd.
2005	*ecologia* Environmental Consultants	Callawa Biological Assessment Survey. Unpublished Report for BHP Billiton Ore Pty Ltd.
2008	ENV Australia	Goldsworthy Iron Ore Mining Operations – Cundaline and Callawa Mining Operations – Flora and Vegetation Assessment. Prepared for BHP Billiton Iron Ore.

ATTACHMENT C

GOLDSWORTHY IRON ORE MINING OPERATIONS MANAGEMENT PLAN FOR BAT SPECIES

BHP Billiton Iron Ore

GOLDSWORTHY IRON ORE MINING OPERATIONS

MANAGEMENT PLAN FOR BAT SPECIES

Revision 3

May 2009

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1 INTRODUCTION

1.1 OVERVIEW OF THE CONTENT AND STRUCTURE OF THIS MANAGEMENT PLAN

This management plan has been prepared in order to minimise the potential impacts of BHP Billiton Iron Ore Pty Ltd's (BHP Billiton Iron Ore) mining activities at the Goldsworthy Iron Ore Mining Operations (Goldsworthy) on the Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), and the Ghost Bat (*Macroderma gigas*). Both of these species have been recorded in the Goldsworthy area during biological surveys of proposed mining areas and their surrounds.

The Pilbara Leaf-nosed Bat is listed as 'Vulnerable' under the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act), and as a Schedule 1 species (i.e. fauna that is rare or likely to become extinct) under the Western Australian *Wildlife Conservation Act, 1950.* The Ghost Bat is listed as a Priority 4 Species by the Western Australian Department of Environment and Conservation (DEC).

This management plan is structured as follows:

Section 1	Presents an overview of the content and structure of this management plan.
Section 2	Provides an overview of the Goldsworthy Extension Project.
Section 3	Provides a description of both of the bat species and their habitat requirements.
Section 4	Documents monitoring methods that will be used and management measures that will be implemented to minimise impacts.
Section 5	Presents the monitoring and reporting mechanisms that will be used by BHP Billiton Iron Ore.
Section 6	Lists the documents referred to in this management plan.

1.2 BACKGROUND

Prior to 2004, the only record of either the Pilbara Leaf-nosed Bat or the Ghost Bat at Goldsworthy was a single mummified Ghost Bat specimen which was recorded in 1992 on a barbwire fence near the Yarrie rail loop (Dames and Moore, 1992). No live specimens or calls had been recorded in the area, despite the presence of suitable habitat features in the area (e.g. caves), and Goldsworthy being located within the broad distribution zone of both species.

In late 2004, BHP Billiton Iron Ore commissioned *ecologia* Environment Pty Ltd (*ecologia*) to undertake baseline fauna and flora surveys of the Nimingarra, Sunrise Hill and Cattle Gorge ridgelines as a component of the Goldsworthy Extension Project (GEP) environmental impact assessment. During the baseline survey, *ecologia* recorded the Pilbara Leaf-nosed Bat at Goldsworthy using an Anabat detector. Figure 1-1 shows the location of the record at a cave on the Nimingarra ridgeline (*ecologia*, 2005a). An individual was also opportunistically observed foraging in the sandplain habitat type located to the south east of Cattle Gorge during the same survey. The Ghost bat was not recorded during the surveys.

In February 2005, BHP Billiton Iron Ore provided a draft of the GEP Environmental Protection Statement (EPS) to stakeholders for review and comment as part of its consultation programme for the project. The EPS included a draft of the *ecologia* (2005a) GEP biological assessment report, which described where and when the bat species had been recorded at the site. BHP Billiton Iron Ore met with the Department of Conservation and Land Management (CALM) (now DEC) and specifically discussed these records.

In March 2005 CALM provided comments on the draft EPS which included a recommendation that BHP Billiton Iron Ore conduct a targeted search and survey for the likely roost site of the Pilbara Leaf-nosed Bat in the Goldsworthy area. In the comments provided to BHP Billiton Iron Ore, CALM considered that the records presented in the *ecologia* (2005a) draft report indicated that both individuals were likely to be foraging at the time of recording. CALM indicated that the Pilbara Leaf-nosed Bat forages up to 10 kilometres (km) from their roost site which generally has quite specific characteristics (i.e. almost always a deep cave or old mine with high humidity, and usually with open water internally).

In accordance with the recommendation by CALM, zoologists from *ecologia* returned to the GEP area in early April 2005 to search the proposed GEP disturbance areas and surrounds for possible roost caves. A total of eight caves that may be potential roost sites for the species were described, marked, and their location recorded by GPS. Two of the caves were at Nimingarra (including the cave within which the original acoustic recording of the species was made in 2004) and the remaining six sites were at the Cattle Gorge area. During this survey, the Pilbara Leaf-nosed Bat was not recorded; however several call records of the Ghost Bat were made. Two records of the Pilbara Leaf-nosed Bat were made in the vicinity of Cattle Gorge; including the collection of one road kill that was subsequently vouchered to the WA Museum, and as opportunistic observation in flight along the Yarrie access road.

Following the April 2005 roost cave investigation, BHP Billiton Iron Ore consulted further with CALM and it was discussed and agreed with CALM to prepare a draft Management Plan for Bat Species that would document the methodology of the proposed cave surveys, as well as management measures for the Pilbara Leaf-nosed Bat and the Ghost Bat that would be implemented during the GEP. The draft Management Plan for Bat Species (Revision 1, April 2005) was included in the GEP EPS (BHP Billiton Iron Ore, 2005). Revision 1 was subsequently reviewed and revised to address Condition 6-3 of Ministerial Statement of Approval No. 000682 and was attached to the GEP Significant Species Management Plan (SSMP) as Revision 2 (BHP Billiton Iron Ore, 2006).

A component of the Management Plan for Bat Species is quarterly monitoring surveys of caves with known records as well as caves with potential habitat for the Pilbara Leaf-nosed Bat and Ghost Bat. Since monitoring surveys commenced there have been numerous records of the Pilbara Leaf-nosed Bat and Ghost Bat at Goldsworthy. These records are shown on Figure 1-1 and summarised below:

- May and June of 2005 (*ecologia*, 2005b; *ecologia*, 2005c; *ecologia*, 2005d):
  - large populations of the Pilbara Leaf-nosed Bat in caves #1, #2 and #3, and large populations of the Ghost Bat at caves #2 and #3.
  - Pilbara Leaf-nosed Bat was recorded at caves #4, #6 and #6*, and the Ghost Bat was recorded at cave #6.
  - Ghost Bat was recorded numerous times at one cave on the Cundaline ridge, and was observed once in flight, and a single Pilbara Leaf-nosed Bat call was also recorded at the same cave.

  - Ghost Bat was observed on three occasions at Callawa but not recorded using the Anabat detector, and the Pilbara Leaf-nosed Bat was observed and recorded on several occasions at two caves at the Callawa ridge.

- November/December 2005 (*ecologia*, 2006)
  - Pilbara Leaf-nosed Bats were recorded in lower numbers than in May/June 2005 at cave #1 and #2, but were not recorded at cave #6* at Cattle Gorge.
  - Ghost bats were recorded at cave #2 but not at the other two caves.
  - Large numbers of Pilbara Leaf-nosed Bat calls were recorded at the Callawa cave.

Further surveys and quarterly bat monitoring since the above records have identified numerous caves in the Goldsworthy region where the Pilbara Leaf-nosed Bat has been recorded (*ecologia*, 2005e, 2006a, 2006b, 2006c, 2007; ENV Australia, 2007a, 2007b; Specialised Zoological, 2008a, 2008a). Monitoring also suggests that a stable community uses Callawa Gorge, located approximately 1 km south of the proposed Callawa mining operations (ENV Australia, 2007a).

1.3 PURPOSE OF THIS MANAGEMENT PLAN FOR BAT SPECIES

This revision of the Goldsworthy Management Plan for Bat Species (i.e. Revision 3) has been prepared to provide specific management strategies for the Pilbara Leaf-nosed Bat and the Ghost Bat and is provided as Attachment C to Revision 3 of the Goldsworthy SSMP (BHP Billiton Iron Ore, 2008a). Revision 3 of the SSMP was prepared to satisfy Condition 6-3 of Ministerial Statement of Approval No. 000682 and was updated to include site specific characteristics of the Cundaline and Callawa mining operations, and as supporting documentation to the Cundaline and Callawa Environmental Protection Statement (EPS) (BHP Billiton Iron Ore, 2008b).

2 OVERVIEW OF THE GOLDSWORTHY IRON ORE MINING OPERATIONS

The development of the Goldsworthy Operations has been conducted in phases over the past 50 years. The Mount Goldsworthy mine was the first mining operation in the mid-1960s. Once it was mined out, the Shay Gap, Sunrise Hill and Nimingarra mining areas were progressively developed between 1972 and 1992. These areas are located approximately 50 to 70 km to the east of Mount Goldsworthy. In 1992, approval was obtained for the development of the Yarrie operations, located a further 20 km to the east. In 2005, approval was obtained for the Cattle Gorge operations (located between Yarrie and Sunrise Hill), plus extensions to the Nimingarra mining areas (Nim I) and Yarrie (Y10, Y7 and Y4B).

BHP Billiton Iron Ore's current Goldsworthy Operations are centred at Yarrie, with some mining still taking place at the Nimingarra, Cattle Gorge and Sunrise Hill deposits. The Mount Goldsworthy and Shay Gap mining areas are no longer operational, with the majority of activities at these sites directed towards the monitoring and maintenance of rehabilitated landforms.

BHP Billiton Iron Ore's Goldsworthy Operations are conducted under the *Iron Ore (Goldsworthy) Agreement Act, 1964,* and the *Iron Ore (Goldsworthy-Nimingarra) Agreement Act, 1972*. Environmental requirements for the operations are specified in the Goldsworthy Operations Notice of Intent (Goldsworthy Mining Limited, 1986), and the conditions of Ministerial Statement's No. 000303 and No. 000682 issued by the Minister for the Environment under Part IV of the WA *Environmental Protection Act, 1986* (EP Act), and Licences 5561 and 4412 issued under Part V of the EP Act.

BHP Billiton Iron Ore's exploration programme has identified iron ore deposits on the Cundaline and Callawa ridges. BHP Billiton Iron Ore is proposing to develop the Cundaline and Callawa deposits as satellite mining operations and would use the existing Goldsworthy Operations infrastructure and facilities as far as practicable. Major components of mining infrastructure and activities of the proposed Cundaline and Callawa mining operations would include:

- pre-stripping, open pit mining above the watertable and stockpiling of overburden and ore at the Cundaline pits;
- pre-stripping of open pit mining above and below the watertable and stockpiling of overburden and ore at the Callawa pits;
- placement of overburden in mined-out voids and out-of-pit overburden stockpile areas (OSAs) adjacent to the Cundaline and Callawa pits;
- trucking of the Callawa ore to the Yarrie crushing, screening and rail loading facilities, which are located approximately 2 km to the north;
- trucking of the Cundaline ore to the Yarrie crushing, screening and rail loading facilities, which are located approximately 12 km to the south-east, or use of a mobile crushing and screening plant to be located within the Cundaline area;
- stockpiling, crushing, screening and load-up of iron ore at the Yarrie processing facilities and/or the mobile Cundaline facilities;
- continued groundwater abstraction from the Shay Gap Wellfield to meet operational demands, and distribution through the existing water supply system and pipeline extensions to the Cundaline and Callawa areas; and
- construction and use of small day rooms, workshop facilities and storage areas at the Cundaline and Callawa areas.

A detailed description of the existing approved Goldsworthy operations and proposed Cundaline and Callawa mining operations is provided in the GEP EPS (BHP Billiton Iron Ore, 2005) and the Cundaline and Callawa Mining Operations EPS (BHP Billiton Iron Ore, 2008), respectively.

3 SPECIES DESCRIPTIONS

3.1 PILBARA LEAF-NOSED BAT (*Rhinonicteris aurantia*)

General Description

Head and Body Length	45 – 53 mm
Tail Length	24 – 28 mm
Forearm Length	47 – 50 mm
Weight	8 – 10 g
Identification	• Orange fur, occasionally darkened by brown-tipped hairs; darker fur around the eyes, dark brown wings. Colonies of brown, yellow and all white individuals can occur. • Noseleaf complex; lower part broad with central gap at the front; upper part scalloped. • Nasal pits deep. • Ears small and acutely pointed.
Other Names	Orange Leaf-nosed Bat Golden Horseshoe Bat

Sources: Van Dyck and Strahan (1998); Churchill (1998).

Taxonomy

The Pilbara Leaf-nosed Bat was first described by Gray (1845) as *Rhinolophus aurantius* from a specimen found flying around Port Essington on the Cobourg Peninsula. Subsequently the Genus name was changed to *Rhinonicteris aurantius* (Gray, 1847), the spelling of which was amended in 1982 by Hill and again in 2008 to *Rhinonicteris aurantia*. The species is phylogenetically quite old, and has been found in the Riversleigh deposits (Churchill, 1998; Armstrong, 2002), and dated at 3 to 5 million years old (Armstrong, 2003).

Distribution

The Pilbara Leaf-nosed Bat is found from the Pilbara Region of Western Australia, through the Kimberley and across the Top End into north-western Queensland, and is endemic to Australia (Churchill, 1998). Hall (1989) concludes that their fragility in temperature regulation is the limiting factor in their range. The Pilbara population is geographically the most isolated population of this species, as it is separated from the northern Australian populations by nearly 400 km of sand-ridge desert (Duncan *et al*., 1999). It differs from the northern Australian population in terms of its call frequency (Armstrong, 2003).

Prior to the surveys in 2004/2005 (Section 1.2), scattered records of the species had been recorded from less than 10 localities across the Pilbara Region since 1925 and from a single locality in the north-western corner of the adjacent Gascoyne Region (Duncan *et al*., 1999). The persistence of a tropical, highly constrained species in the semi-arid Pilbara is noted as unusual (Armstrong, 2001). Armstrong (2000) notes that the geology of the Pilbara is markedly different to that of the other parts of the bat's range, and potential roost sites and roost availability may be even more restricted in the Pilbara population of the species. Mines are the only deep formations that were known to be used by this bat in the Pilbara until Armstrong's (2001) study. Following Armstrong (2001), 14 known roosts were recognised in the Pilbara, including cave roosts in the Barlee Range Nature Reserve. The species also inhabits mines in the Marble Bar area, at Bamboo Creek Mining Centre and near Nullagine, but is limited to only the deepest and most complex mines that breach the water table, such as Bamboo Creek, Comet and Klondyke Queen (Armstrong, 2001), however it is suggested that smaller mines may function as temporary roosts.

Genetic Studies

BHP Billiton Iron Ore commissioned Mohlar Pty Ltd (company of which Dr Armstrong is a collaborative partner), to conduct genetic studies on the Pilbara Leaf-nosed Bat to increase the understanding of the Pilbara Leaf-nosed Bat at a State and National level through building a genetic database spanning different bat populations. The initial study results are indicating an emerging pattern of population connection between Pilbara Leaf-nosed Bats from Goldsworthy and Bamboo Creek (located 30 km south of the Yarrie Ridge) (Mohlar, 2008).

Habitat and Characteristics

The Pilbara Leaf-nosed Bat is very selective when it comes to roost caverns. The species is associated with gorges and watercourses in areas of high relief, at least in the Pilbara of Western Australia (Armstrong, 2001). This seems to be related to maintaining high ambient temperatures and relative humidity, such that in the Northern Territory they favour temperatures between 28°C and 32°C (Jolly, 1988; Churchill *et al.,* 1988). Armstrong (2000) found further support of such figures in Western Australia, noting that these bats were only found to roost in parts of a cave in Gieke Gorge (Kimberley) that had temperatures of 27.7 to 28.0°C and 90.3 – 100% relative humidity.

Caves with these conditions are uncommon. It is thought that the species chooses roosting sites that are warm and humid because it is unable to maintain its high body temperature when resting. However it does not cluster for warmth, with individuals hanging from the roof of the roost cave with a separation distance of approximately 12 centimeters (cm) (Strahan 1998).

In the Northern Territory the species usually only leaves its dry season roost caves from November to February, during the wet season, when the outside climatic conditions are similar to the roost microclimate. It is thought that these bats become forest dwellers (Churchill, 1998), or occupy smaller, less complex caves and mines nearby (Duncan *et al*., 1999), as records in hollow timber or rock over hangs during this season are not uncommon where the species occurs.

The species is sensitive to human interference and quickly takes to the wing at a slight disturbance (Strahan, 1998). It is known to abandon its roost caves if disturbed.

At dusk the Pilbara Leaf-nosed Bat emerges from its roosting site to feed (Hall, 1989; Jolly and Hand, 1995). It is an opportunistic, aerial insectivore, with no records of these bats landing on the ground or gleaning insects. Prey is typically captured in the tail membrane and passed to the mouth (Hall, 1989). According to Churchill (1998) the diet is composed of approximately 70% moths, 17% beetles and 8% termites. They are often seen flying along roads at night and their bright fur is very distinctive in the car headlights (Churchill, 1998).

The species mates in July and the females give birth to a single young in late December or early January after a five month gestation. The young grow quickly and are almost indistinguishable from the adults when they are weaned in late February (Churchill, 1998). The females are reproductively mature at seven months, but males do not mature until their second year at 18 months.

3.2 GHOST BAT (*Macroderma gigas*)

General Description

Head and Body Length	100 – 130 mm
Forearm Length	102 – 112 mm
Weight	140 – 165 g
Identification	• Light to dark grey or light brown fur above, paler fur below, with pale cream to brown wings. Individuals tend to be paler, almost white, in inland populations, with flesh coloured pink wing membranes. • Long ears joined together above the head. • Large eyes. • Simple noseleaf complex. • No tail, but retains a full tail membrane.
Other Names	False Vampire False Vampire Bat Australian False Vampire Bat

Sources: Strahan (1998); Churchill (1998)

Distribution

The Ghost Bat was once distributed across most of inland and northern Australia as far south as the Flinders Ranges. Contraction of its range may be coincident with the onset of more arid conditions about 10,000 years ago, leading to a reduction in food resources (Strahan, 1998). The species was recorded until 1960 in central Australia but is now restricted to the tropical north (Churchill, 1998).

The population in the Pilbara is geographically isolated from the northern populations by extensive sandy deserts.

Habitat and Characteristics

The Ghost Bat is the largest Microchiropteran bat in Australia. Ghost bats forage in a variety of habitats, from arid spinifex grassland, to open tall forest and tropical rainforest (Churchill, 1998). Their distribution is determined by the availability of suitable roosting sites. The preferred roosting habitats of Ghost bats in the Pilbara are caves beneath bluffs of low rounded hills composed of, but not limited to, Marra Mamba geology and granite rock piles (Armstrong and Anstee, 2000). They are also found in mine adits. In other parts of Australia they have also been known to roost in large colonies in sandstone caves, under boulder piles and in abandoned mines (Churchill, 1998). Each population appears to have a regionally centralised maternity site (Duncan *et al*., 1999). Populations are known to disperse in the non-breeding (dry) season.

The Ghost Bat is carnivorous and insectivorous. It is recorded as eating birds, bats, small mammals, frogs and geckoes. It also eats a variety of invertebrates, particularly locusts, as well as millipedes, spiders, cockroaches, termites, crickets, moths, beetles, caterpillars and ants. It often returns to its cave roost to eat its food (Churchill, 1998). It uses several techniques for catching prey including: active hunting using echolocation; passive sit-and-wait hunting using eyesight and passive listening; and listening for noises made by prey (Churchill, 1998). The species is recorded as foraging at distances up to 2 km from its roost caves, and is believed to use the same forage area each night (Churchill, 1998; Richardson, 2002).

Ghost bats roost individually or in colonies of up to 1500. When roosting, the distance between individuals is generally approximately 25 cm, but can be closer when they have young. The species mates in May, and females give birth to a single young in July to August after an 11 to 12 week gestation period. The young remain with their mothers for several months until they become completely independent (Churchill, 1998; Strahan, 1998).

4 MANAGEMENT MEASURES

4.1 ESTABLISHMENT AND MANAGEMENT OF BUFFER ZONES

The 2004 record of these two species at the Nimingarra B cave suggests that both bat species can occupy caves within several hundred meters of active mining, blasting and road haulage activities. Notwithstanding, buffer zones will be established between mining activities at Cattle Gorge and Nimingarra and caves where the Pilbara leaf-nosed Bat and/or Ghost Bat have been recorded. Permission to enter the buffer zones will be restricted to employees and contactors authorised by BHP Billiton Iron Ore. The induction process will be used to promote awareness of the known roost caves and their buffer zones.

Cattle Gorge Buffer Zone

A buffer zone with a minimum width of 400 m has been established on the eastern side of the Cattle Gorge mining area and the gorge itself. The buffer zone has been established in recognition of cultural significance of the gorge to the Njamal Aboriginal people, and the overall environmental value of the flora, fauna and landform features of the gorge. The gorge provides suitable habitat for several fauna species of conservation significance (including the Pilbara Leaf-nosed Bat and Ghost Bat), as well as the Pilbara Olive Python (*Liasis olivaceus barroni*) and Northern Quoll (*Dasyurus hallucatus*).

Nimingarra B Buffer Zone

A buffer zone with a minimum width of 200 m has been established around the cave to the south east of the Nimingarra B open pit. This buffer zone has been established in recognition of the cultural significance of the cave to the Njamal Aboriginal people, and because of the 2004/2005 records of both the Pilbara leaf-nosed Bat and Ghost Bat at the cave entrance (Section 1.2).

Other Buffer Zones

If required, other buffer zones will be established at caves that may be affected by proposed mining activities if additional populations of the Pilbara Leaf-nosed Bat and/or the Ghost Bat are recorded during future monitoring or baseline surveys. The width and management of any additional buffer zones will be determined in consultation with the DEC. This management plan will be revised as necessary to provide details of any additional buffer zones.

Management of Buffer Zones

The following buffer zone management measures will be implemented:

- Relevant mine plans will show the buffer zones.
- Signposts will be installed on access roads at the edge of the buffer zones. The signposts will state that the buffer zone is a restricted area, and that permission from BHP Billiton Iron Ore is required before proceeding.
- Only employees and contactors authorised by BHP Billiton Iron Ore will be allowed within the buffer zones. Authorised employees and contactors will be advised of the significance of the area, and the management requirements when entering the area (including this management plan, and any other cultural heritage or environmental requirements of relevance).

- Authorised access within the buffer zones will be on foot or light vehicle only, with appropriate speed restrictions on all vehicle movements.
- No land clearing, or operation of heavy equipment is permitted within the buffer zones.
- Entry into all caves within the buffer zone for scientific (ie. monitoring/research) or cultural purposes is prohibited, except where specific authorisation is provided by DEC and the Njamal Aboriginal people.
- The induction process will be used to promote awareness of the known roost caves, buffer zones, and their management requirements.

4.2 MANAGEMENT OF MINING ACTIVITIES

Blasting and night-time lighting at mining areas adjacent to buffer zones will managed to minimise potential impacts (eg. restricting blasting to daylight hours, use of directional lighting, etc.).

Blasting Activities

Blasting activities at the Cattle Gorge and Nim B mining areas will restricted to daylight hours.

The physical condition of the entrance to each of the potential roost caves will be assessed and photographed during each quarterly bat monitoring event (refer to Section 5.2). The assessments will be used to detect any gross physical changes that may be due to blast-related affects.

In the event that monitoring results suggest that blasting is having an adverse effect on the Pilbara Leaf-nosed Bat and/or the Ghost Bat, a review of the situation will be conducted and contingency measures will be implemented where necessary. These measures will be developed and implemented to the satisfaction of the DEC and may include, but are not necessarily restricted to: altering mine designs, adjusting blasting times, reducing the size of blasts, changing their frequency, or using alternative methods.

Lighting

Directional night lighting, or alternative shields will be used where there is a direct line of sight between a known bat roost cave and the area where lighting is required, if the distance between the two is less than 500 m. The directional lighting will be used to minimise the potential impact of new light sources disturbing bats as they emerge from their roosting sites.

In the event that monitoring results suggest that night lighting is having an adverse effect on the Pilbara leaf-nosed Bat and/or the Ghost Bat, a review of the situation will be conducted and contingency measures will be implemented where necessary. These measures will be developed and implemented to the satisfaction of the DEC and may include, but are not necessarily restricted to: altering mine designs, adjusting the locations of night lights, further screening of lighting point sources, including on/off switches, using light dimmers or low irradiation globes, and using insect repellent lighting.

5 MONITORING AND REPORTING

5.1 MONITORING METHODS

In early 2005, BHP Billiton Iron Ore consulted with CALM about the timing and methodology for conducting bat surveys at Goldsworthy. CALM indicated that acoustic recordings of all possible roost and breeding roost caves should be undertaken for no less than four consecutive nights from mid-twilight onward at each cave. The window of activity for the Pilbara Leaf-nosed Bat is believed to be short, so 2 to 3 hours of recording per night has been confirmed by CALM as being sufficient. CALM also indicated that cave entrances should be visually monitored during the acoustic recording, using a light source that attracts insects and may also attract the bats as they depart the cave. To avoid the disturbance of roosts, which can be detrimental to colonies, CALM requested that caves not be entered during the surveys and that the entrance of each of the caves be photographed during the survey.

BHP Billiton Iron Ore will conduct future monitoring for the Pilbara Leaf-nosed Bat and Ghost Bat using the above methods. Any modifications to the methods, or additional types of monitoring will be discussed and approved by the DEC prior to being enacted. This Plan will be revised as necessary to incorporate any changes to the monitoring methods.

5.2 MONITORING PROGRAMME

The Bat Monitoring Programme that will be conducted during mining operations at Goldsworthy is presented in Table 5-1.

Table 5-1
Bat Monitoring Programme

Aspect	Monitoring Programme
Known Bat Cave Monitoring	Known caves occupied by populations of the two bat species (ie. Nim B cave; Cattle Gorge caves #1, #2, #6*; Callawa cave POTCA5) will be monitored on a quarterly basis during the first year of operations, with a review of the frequency after the first year (with any changes to monitoring frequency at this point being subject to agreement with the DEC). Parameters that will be monitored will include: • Bat use (using the methods described in Section 5.1). • Condition of the cave entrance and surrounds (by taking photographs and describing the overall condition of the entrance – eg. rock falls or other physical disturbance, evidence of fire, evidence of predation, significant changes to adjoining vegetation etc). • Qualitative and/or quantitative evaluation/monitoring of mine-related noise and lighting effects in the vicinity of the cave entrance (whether mining activities can be heard and/or seen).
Buffer Zones	The enforcement of the buffer zones will be monitored by BHP Billiton Iron Ore during Goldsworthy mining operations by periodically checking (ie. at least every 3 months) to confirm that all signs are in place, the zones are shown on relevant plans, and there is no evidence of prohibited activities having occurred (eg. unauthorised access, clearing etc).
Mining Activities	A record of all blasting times and activities in areas adjacent to buffer zones will be maintained. The locations of lights in mining areas adjoining buffer zones will be periodically checked (ie. at least every 3 months) to confirm that appropriate directional lighting is being used. Visual assessments of whether bats are using the areas around mine lights for feeding will be conducted during the quarterly monitoring of the known bat caves (see above), and opportunistically at other times. If necessary bat detectors will be used in these areas to confirm whether the Pilbara Leaf-nosed Bat and/or Ghost Bat are amongst the bats that are visually observed.

5.3 REPORTING

Reports will be prepared that present the results of the quarterly surveys of the known bat caves. The report will indicate which species were detected, the approximate number of individuals recorded, a description and photographs of the condition of each cave entrance, qualitative/quantitative assessments of mining noise and lighting, and other observations of relevance. The quarterly report will also provide a status report of the implementation of each of the management measures contained in this plan. Where it is identified that a particular action has not been fully implemented, the quarterly report will describe what measures will be enacted to rectify the situation.

A summary of the results of quarterly monitoring and reporting will be provided in the Annual Environmental Report.

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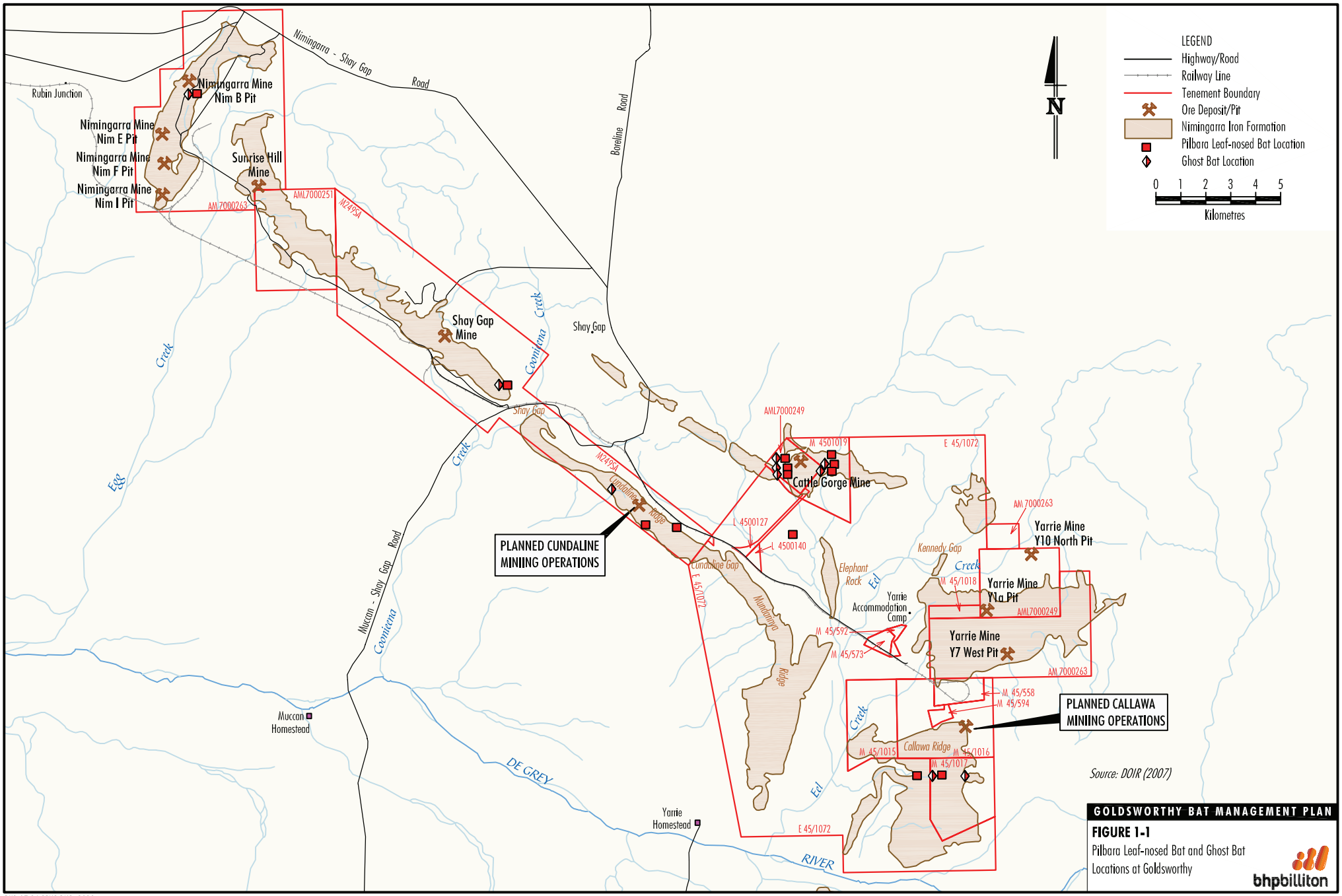
FIGURES



GOLDSWORTHY BAT MANAGEMENT PLAN

FIGURE 1-1

Pilbara Leaf-nosed Bat and Ghost Bat Locations at Goldsworthy

bhpbilliton

BHP-07-16 SSMP BMP_103C

APPENDIX D

WEED MANAGEMENT PLAN
(BHP BILLITON IRON ORE, 2009d)

bhpbilliton


YARRIE

GOLDSWORTHY IRON ORE MINING OPERATIONS
WEED MANAGEMENT PLAN


CATTLE GORGE


NIMINGARRA


SHAY GAP


SUNRISE HILL

REVISION 2
May 2009

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BHP Billiton Iron Ore

GOLDSWORTHY IRON ORE MINING OPERATIONS

WEED MANAGEMENT PLAN

Revision 2

May 2009

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EXECUTIVE SUMMARY

The Goldsworthy Iron Ore Mining Operations (Goldsworthy) are located approximately 200 kilometres east of Port Hedland, in the north of the Pilbara region of Western Australia. Goldsworthy is situated within mining tenements AML7000249, AML7000263, AML7000251, ML45/594, ML 45/558 and ML45/1016 and is operated by BHP Billiton Iron Ore Pty Ltd.

This revision (i.e. Revision 2) of the Weed Management Plan has been prepared to satisfy Condition 7-1 of the Ministerial Statement of Approval No. 00682 and to guide the management of weeds at Goldsworthy. It replaces Revision 1 and has been updated to include the site specific characteristics of the Cundaline and Callawa mining operations, and as supporting documentation to the Cundaline and Callawa Environmental Protection Statement.

Baseline biological and flora surveys have recorded 11 weed species at Goldsworthy to date. Another 17 weed species, which have not been previously recorded within the site, have the potential to occur.

BHP Billiton Iron Ore has developed a number of general and species-specific measures to monitor, control and prevent the spread of weed species previously recorded at Goldsworthy and to minimise the potential for the introduction of any additional weed species which have the potential to occur. This WMP has been prepared with a focus on preventing the introduction and spread of weed species.

1 INTRODUCTION

1.1 BACKGROUND

The Goldsworthy Iron Ore Mining Operations (Goldsworthy) are located approximately 200 kilometres (km) east of Port Hedland, in the north of the Pilbara region of Western Australia (WA) (Figure 1-1). Goldsworthy is situated within mining tenements AML7000249, AML7000263, AML7000251, ML45/594, ML 45/558 and ML45/1016 and is operated by BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore).

Figure 1-2 shows the main deposits, mining areas, infrastructure facilities and BHP Billiton Iron Ore's mining tenements at Goldsworthy.

1.2 PURPOSE OF THIS PLAN

This revision (i.e. Revision 2) of the Weed Management Plan (WMP) has been prepared to satisfy Condition 7-1 of Ministerial Statement of Approval No. 000682 and Proponent Commitment 7-16 of Ministerial Statement of Approval No. 303, and to guide the management of weeds at Goldsworthy. It replaces Revision 1 (BHP Billiton Iron Ore, 2006a) and has been updated to include the site specific characteristics of the Cundaline and Callawa mining operations, and as supporting documentation to the Cundaline and Callawa Environmental Protection Statement (EPS) (BHP Billiton Iron Ore, 2008). The relevant Conditions/Commitments within the Statements which are relevant to this WMP are presented below, along with the corresponding sections of the WMP that address each condition.

	Ministerial Condition / Proponent Commitment	Section
Ministerial Statement of Approval No. 000682		
7-1	• The Proponent shall not carry out land-disturbing activities other than in accordance with a Weed Management Plan prepared to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority and the Department of Conservation and Land Management. • The objective of this plan is to control or eradicate both noxious and environmental weeds in the proposed area. • This plan shall: – describe the location and area affected for each weed species which occurs in the proposal area; – identify any additional weed species which have the potential to occur in the proposal area; and shall set out procedures and measures to: – monitor weed species; – control or eradicate weed species; – prevent the spread of weed species; and – prevent the introduction of any additional weed species. • A copy of each new revision of the Weed Management Plan would be provided to stakeholders, and other interested parties if requested.	 2.1 4 3,.5 3, 5 3 5
Ministerial Statement of Approval No. 000303		
7-16	*Weeds* • Regular inspections of the vegetation adjacent to the railway line, roads and rehabilitated areas to ensure that weed infestation is not occurring. Any infestations discovered in the area will be dealt	3. 5

Obligations under the WMP

The purpose of this WMP is to assist BHP Billiton Iron Ore and its contractors in the implementation of appropriate weed management measures, ongoing monitoring programmes, and reporting procedures for weed species during the operation of Goldsworthy. Where there is any conflict between the provisions of this WMP and a contractor's obligations under the relevant contract, including the various statutory requirements (i.e. licences, permits, consent conditions and relevant laws), the contract and statutory requirements are to take precedence. In the case of any real or perceived ambiguity between elements of this WMP and the above statutory requirements the contractor shall first request clarification from BHP Billiton Iron Ore prior to implementing that element of this WMP over which the ambiguity is identified.

1.3 STRUCTURE AND CONTENT OF THIS PLAN

The WMP is structured as follows:

Section 1 Introduction to the WMP – describes the background of Goldsworthy, outlines the structure and purpose of this WMP, lists relevant legislation and describes the relationship between this WMP and other Goldsworthy management plans.

Section 2 Recorded Weed Species – identifies the location, approximate number and type of each weed species recorded in previous vegetation surveys.

Section 3 Management of Recorded Weed Species – describes weed control/eradication measures and weed monitoring activities relevant to recorded species.

Section 4 Weed Species with the Potential to Occur – identifies weed species which have not been recorded within the Goldsworthy area, but have the potential to occur.

Section 5 Management of Weed Species with the Potential to Occur - describes the weed control/eradication measures and weed monitoring activities relevant to species with the potential to occur.

Section 6 Performance Indicators – outlines the system that will be used to assess the performance of weed control/eradication measures.

Section 7 Reporting Procedures – describes the reporting to be undertaken as part of the WMP.

Section 8 Timeframe for the Implementation of this Plan – describes the timeframe for implementation and revision of this WMP.

Section 9 Lists the references cited in this WMP.

1.4 RELEVANT LEGISLATION

The management measures contained within this WMP have been developed with reference to Commonwealth, State and Local government weed management strategies, policies and action plans, which are summarised below. It should be noted that the information presented is intended only to provide a summary of the subject matter covered. It does not purport to be comprehensive or to render legal advice.

Declared Weeds

The management of weeds in WA is primarily regulated through the provisions of the *Agriculture and Related Resources Act, 1976* (ARRP Act), which is administered by the Department of Agriculture and Food Western Australia (DAFWA). The ARRP Act lists gazetted 'Declared' weeds that require control in WA. The *Declared Plant Control Handbook (6th Edition)* prepared by the WA Department of Agriculture in 2002 and was reviewed by DAFWA in 2005. It provides recommendations for the control of 'Declared' weeds (Peirce and Pratt, 2005).

No 'Declared' weeds have been recorded at Goldsworthy to date. Ongoing monitoring and implementation of preventative management measures will be conducted at Goldsworthy throughout the life of mining operations to minimise the potential for 'Declared' weed species to be introduced.

Environmental Weeds

'Environmental Weeds' are introduced plants which establish themselves in natural ecosystems and proceed to modify natural processes, usually adversely, which may result in the decline of the communities they invade (Department of Conservation and Land Management [CALM], 1999). The *Environmental Weed Strategy for Western Australia* (CALM, 1999) details management priorities and general control measures and monitoring of environmental weeds.

Several environmental weed species have been recorded at Goldsworthy to date, whilst other environmental species which have not been recorded at Goldsworthy to date are considered to have the potential to occur. Sections 3 and 5 describe the management measures for the recorded and potential environmental weed species respectively.

National Weeds Strategy

The Commonwealth *Australian Weeds Strategy: A National Strategy for Weed Management in Australia*, prepared by the Australian Weeds Committee (2007), describes broad strategies which aim to reduce the impact of weeds through nationally co-ordinated weed management programmes. The Strategy provides a national framework to guide and complement state, territory, regional and local government strategies and industry initiatives. The Strategy includes the creation of a list of 'Weeds of National Significance' and the development of national management strategies for each of these species. 'Weeds of National Significance' are selected based upon their high rankings for invasiveness, potential to spread, and impact on socioeconomic and environmental assets.

No weed species identified as being of 'National Significance' have been recorded at Goldsworthy to date. Ongoing monitoring and implementation of preventative management measures will be conducted at Goldsworthy throughout the life of the mine to minimise the potential for weed species of 'National Significance' to be introduced.

State Weed Plan

A Weed Plan for Western Australia (Department of Agriculture, 2001), known as the State Weed Plan, is a broad overarching document which aims to achieve co-ordinated, collaborative and effective weed management throughout WA.

Where appropriate, the State Weed Plan has been used in the development of weed management practices at Goldsworthy.

1.5 RELATIONSHIP BETWEEN THIS PLAN AND OTHER GOLDSWORTHY MANAGEMENT PLANS

BHP Billiton Iron Ore has developed an Environmental Management Plan (EMP) for Goldsworthy. The EMP is a broader document than this WMP in that it describes the overall programme to be used to manage potential impacts of Goldsworthy on all environmental values relevant to the site. The EMP contains an overview of weed management measures used at Goldsworthy, as well as referring to this WMP for specific detail (Figure 1-3).

2 RECORDED WEED SPECIES

2.1 FINDINGS OF PREVIOUS VEGETATION SURVEYS IN THE PROJECT AREA

Baseline biological and flora surveys, assessments and reviews that have been undertaken at Goldsworthy to date are included in Attachment A. These surveys, assessments and reviews have identified the following 11 introduced flora within the Goldsworthy area:

- Kapok Bush (*Aerva javanica*);
- Buffel Grass (*Cenchrus ciliaris*);
- Rhodes Grass (*Chloris gayana*);
- Feathertop Rhodes Grass (*Chloris virgata*);
- Ulcardo Melon (*Cucumis melo* subsp. *agrestis*);
- Awnless Barnyard Grass (*Echinochloa colona*);
- Spiked Malvastrum (*Malvastrum americanum*);
- Oleander (*Nerium oleander*);
- Stinking Passion Flower (*Passiflora foetida* var. *hispida*);
- Purslane (*Porulaca oleracea*); and
- Mimosa Bush (*Vachellia farnesiana*).

The location and approximate area affected for each of these weed species (where recorded) is provided in Table 2-1.

Table 2-1
Location of Recorded Weed Species

Species	Common Name	Mine Area	Location	Reference
Aerva javanica	Kapok Bush	Yarrie	Recorded at low densities within *Triodia wiseana* dominated base plains.	*ecologia* (2005a)
		Nimingarra	Found in a number of locations in the Nimingarra area, mainly along disturbed road sides and old rehabilitation on rock waste dumps.	*ecologia* (2005a)
		Sunrise Hill	Found associated with disturbance due to roads, waste rock dumps, rehabilitation area, and cattle grazing on the lower slope areas.	*ecologia* (2005a)
		Shay Gap to Yarrie	Along the rail corridor.	*ecologia* (2004a)
Cenchrus ciliaris	Buffel Grass	Yarrie	Widely distributed along Eel Creek and Chinaman's Creek.	*ecologia* (2005a)
		Sunrise Hill	Found associated with disturbance due to roads, waste rock dumps, rehabilitation area, and cattle grazing on the lower slope areas.	*ecologia* (2005a)
		Cundaline	Single location within a drainage line.	ENV Australia (2008)
		Callawa	Recorded at several sites on Callawa Ridge in cattle disturbance areas.	ENV Australia (2008)

Table 2-1 (Continued)
Location of Recorded Weed Species

Species	Common Name	Mine Area	Location	Reference
Chloris gayana	Rhodes Grass	Yarrie	Single location at site office.	*ecologia* (2005a)
Chloris virgata	Feathertop Rhodes Grass	Cundaline	Located in a drainage line near a track.	ENV Australia (2008)
		Callawa	Located in a disturbed floodplain area and in a drainage line.	ENV Australia (2008)
Cucumis melo subsp. *agretis*	Ulcardo Melon	Cundaline	Located in a drainage line near a track.	ENV Australia (2008)
Echinochola colona	Awnless Barnyard Grass	Callawa	Located in a disturbed floodplain area.	ENV Australia (2008)
Malvastrum americanum	Spiked Malvastrum	Cattle Gorge	Found along the area of the Cattle Gorge rail corridor flora survey, but was relatively uncommon within the survey area.	*ecologia* (2005a)
Nerium oleander	Oleander	Sunrise Hill	Found associated with disturbance due to roads, waste rock dumps, rehabilitation area, and cattle grazing on the lower slope areas.	*ecologia* (2005a)
Passiflora foetida	Stinking Passion Flower	Callawa	Located in a drainage line with flowing water.	*ecologia* (2005b)
Porulaca oleracea	Purslane	Cundaline	Found in two locations within drainage lines	ENV Australia (2008)
		Callawa	Recorded at several sites on Callawa Ridge in cattle disturbance areas.	ENV Australia (2008)
Vachellia farnesiana	Mimosa Bush	Yarrie	Recorded at low densities within Eel Creek.	*ecologia* (2005a)
		Shay Gap to Yarrie	Along the rail corridor.	*ecologia* (2004a)

3 MANAGEMENT OF RECORDED WEED SPECIES

3.1 GENERAL WEED MANAGEMENT, HYGIENE AND MONITORING MEASURES

The following control measures are applicable to all weeds recorded at Goldsworthy to date:

- Areas of known weed infestation will be shown as 'Weed Risk' areas on mine plans and marked on the ground (using signs or other clearly recognisable measures) through the PEAHR (Project Environment Aboriginal Heritage Review) procedure in order to minimise the potential for inadvertent access and spread of weeds.
- Access to 'Weed Risk' areas with known infestations will be restricted to authorised personnel.
- The induction programme will be used to promote awareness of weed management measures that are to be used at Goldsworthy. An example 'Enviro Alert' fact sheet for Ruby Dock is provided in Attachment B.
- Mobile machinery and equipment will be inspected, cleaned and certified prior to being brought to the site, being moved from a 'Weed Risk' area to another part of the site, or being removed from the Goldsworthy area. Details of inspections and cleaning will be and documented via a Vehicle/Equipment Weed Hygiene Certificate (Attachment C).
- All inspections and cleaning of mobile machinery and equipment will be conducted in accordance with procedures specified by the BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate).
- Vegetation and topsoil stripped from 'Weed Risk' areas with known infestations will be stripped and stockpiled separately, and the stockpiles marked and recorded on relevant databases and plans by the BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate).
- Topsoil stripped from 'Weed Risk' areas with known weed records will either be buried within OSA or pit infill areas (ie. if treatment is not practicable), or it will be treated (several times if necessary) for physical signs of weed growth (either by covering, or using control methods appropriate to the particular species and preferably after rainfall events) before being re-used in rehabilitation programmes. Soils from 'Weed Risk' areas that are used in the rehabilitation programme will be closely monitored after rehabilitation, and any residual weeds that germinate will be treated as appropriate.
- The decision to bury or treat stripped topsoil from 'Weed Risk' areas will involve an assessment of the volume of material involved, the dormancy of the particular weed species, the likely number of treatments required, the likely success in eradicating the weed species from the stripped soil, and whether the treatment will significantly affect the viability of native seeds and/or the fertility of the soil.
- The BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate) will undertake, supervise and/or guide all weed eradication programmes to be conducted in a manner that minimises impacts on native species.
- The BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate) will conduct quarterly inspections of disturbance areas and 'Weed Risk' areas within the Goldsworthy area in order to monitor for the presence of weeds. Where possible, the inspections will be conducted in the weeks following rainfall events in order to maximise the potential for weed species being observed and for effective weed treatment to be implemented.

- The BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate) will document weed records, locations, and' Weed Risk' areas in BHP Billiton Iron Ore's environmental management database.
- Specific control measures and treatment programmes for weed species that have been recorded at Goldsworthy will be developed in consultation with DEC, where appropriate, and will be documented in this WMP (refer to Sections 3.2.1 to 3.2.11).
- Specific training in weed identification and eradication measures will be provided to relevant BHP Billiton Iron Ore personnel and contractors.
- The BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate) will regularly review the classification status of weed species (ie. Declared, Environmental or other), and the development of State and Commonwealth weed management strategies and action plans,
- The BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate) will regularly consult with DEC and DAFWA to determine the most recent developments in weed control methods.

3.2 SPECIFIC WEED MANAGEMENT, HYGIENE AND MONITORING MEASURES

Species-specific weed management measures for the 11 weed species previously recorded at Goldsworthy are provided in the following sub-sections.

3.2.1 Kapok Bush (*Aerva javanica*)

Kapok Bush

Aerva javanica

Description: Erect, multi-branched perennial shrub which may reach 0.4-1.4 m in height. The leaves are 2 to 7 cm long and alternate along the stems (*ecologia*, 2001).

Flowers: White flowers are produced between January and October and resemble 'woolly' clusters at the tops of stems which contain thousands of seeds (*ecologia*, 2001).

Habitat: Sandy soils (DEC, 2008).

Status: Environmental weed (CALM, 1999; WAPC, 2003).

Recorded Locations at Goldsworthy

- Refer to Section 2.1. Kapok occurs widely in the Goldsworthy area. It is recognised by DEC as an invasive weed and is widespread through many areas of the Pilbara, particularly in and around pastoral leases.

Target Areas

- OSAs and along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- In early 2004 when BHP Billiton Iron Ore consulted the owner of the Yarrie pastoral station about the control of Kapok at Goldsworthy, he indicated that it is one of the preferred feedstocks for his cattle and stated that he does not want any Kapok weed control to occur. In order to resolve this apparent conflict BHP Billiton Iron Ore consulted CALM (now DEC) in July 2004. CALM advised that if Kapok already occurred in the adjoining pastoral leases, the benefits of undertaking a Kapok control programme would be negligible, and it would not have any significant objections if BHP Billiton Iron Ore wished to discontinue the Kapok control programme. CALM did state however, that if other weed species such as Ruby Dock were to appear, it would expect control measures to be enacted.
- The need for, and extent of, management strategies for Kapok Bush is subject to ongoing consultation with DEC, DAFWA and local pastoralists. Specific control strategies (e.g. targeted herbicide spraying) will be developed and implemented as required.
- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Kapok Bush eradication programmes if required.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within eight weeks of the initial eradication programme.
- A summary of Kapok Bush eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

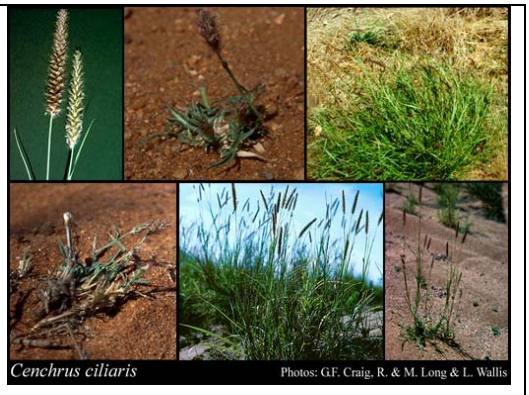
Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by G.F Craig, M. Hancock & L. Wallis. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

3.2.2 Buffel Grass (*Cenchrus ciliaris*)

Buffel Grass

Cenchrus ciliaris



Description: Tufted or stoloniferous perennial, grass-like or herb which may reach 0.2 to 1.5 m in height (DEC, 2008). Buffel Grass produces an allelopathic substance which prevents the germination and growth of native plants.

Flowers: Purple flowers produced February to October (DEC, 2008).

Habitat: Sand, loam or clay soils (DEC, 2008).

Status: Environmental weed (CALM, 1999; WAPC, 2003).

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- OSAs and along creek lines.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- Buffel Grass was widely introduced in the Pilbara via air-seeding for pastoralists. As a result, the need for, and extent of management strategies for Buffel Grass is subject to ongoing consultation with DEC, DAFWA and local pastoralists. Specific control strategies (eg. targeted herbicide spraying) will be developed and implemented as required.
- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Buffel Grass herbicide spraying programmes to achieve weed management objectives in consultation with DEC and DAFWA if required (preferably after rainfall events and prior to seed set).
- The personnel or contractor commissioned to undertake the Buffel Grass eradication programmes will use the following methodology (unless otherwise specified by BHP Billiton Iron Ore's Environmental Advisor):
  - A foliar spray of Fusilade or glyphosate (20 mL/10 L) will be used when the plant is actively growing and in accordance with the manufacturers specifications.
  - PPE and Mine safety measures will be followed in accordance with the herbicide manufacturer's specifications and BHP Billiton Iron Ore's Goldsworthy requirements.

  Note: Buffel Grass is resistant to fire and difficult to control using manual removal techniques.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within eight weeks of the initial eradication programme.
- Details of all Buffel Grass eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Buffel Grass eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by G.F. Craig, R. & M. Long & L. Wallis. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright).
Accessed: 10 September 2008.

3.2.3 Rhodes Grass (*Chloris gayana*)

Rhodes Grass

Chloris gayana

Description: Annual, grass-like or herb, which may reach 0.45 m-1.2 m in height (DEC, 2008).

Flowers: Green and purple flowers are produced between January and May (DEC, 2008).

Habitat: Sand or loam (DEC, 2008).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- OSAs and along drainage and creek lines.

General Control Measures:

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Rhodes Grass herbicide spraying programmes as required.
- The personnel or contractor commissioned to undertake the Rhodes Grass eradication programmes will use the following methodology (unless otherwise specified by BHP Billiton Iron Ore's Environmental Advisor):
  - Dalapon (6kg/ha) (or an equivalent herbicide) will be used when the plant is actively growing and in accordance with the manufacturers specifications.
  - Application of PPE and Mine safety measures in accordance with the herbicide manufacturer's specifications and BHP Billiton Iron Ore's Goldsworthy requirements.

  Note: Fire has also been effectively used to manage Rhodes Grass. Fire may only be used for weed control at the Goldsworthy where risks are acceptable and all necessary permits have been obtained.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within 8 weeks of the initial eradication programme.
- Details of all Rhodes Grass eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Rhodes Grass eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by J.F. Smith. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

3.2.4 Feathertop Rhodes Grass (*Chloris virgata*)

Feathertop Rhodes Grass

Chloris virgata

Description: Grass-like or herb, which usually reaches 0.45 - 0.95 m in height (DEC, 2008).

Flowers: Green and purple flowers are produced between April and May/September (DEC, 2008).

Habitat: Clay, sand and sand dunes (DEC, 2008).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- OSAs and along drainage lines.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Feathertop Rhodes Grass eradication programmes if required (preferably after rainfall events and prior to seed set).
- The personnel or contractor commissioned to undertake the Feathertop Rhodes Grass eradication programmes will use the methodology specified by BHP Billiton Iron Ore's Environmental Advisor.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within eight weeks of the initial eradication programme.
- Details of all Feathertop Rhodes Grass eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Feathertop Rhodes Grass eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: The Weeds Society of Western Australia Inc (WSWA) (undated a) *Poaceae*.
Website: http://members.iinet.net.au/~weeds/western_weeds/poaceae_three.htm||
Accessed: 10 September 2008.

3.2.5 Ulcardo Melon (*Cucumis melo* subsp. *agrestis*)

Ulcardo Melon

Cucumis melo subsp. *agrestis*

Description: Trailing annual herb or climber to 5 m long (DEC. 2008; RGBDT, 2008)

Flowers: Yellow, February to June and September to October, fruit green to yellow (DEC, 2008; RGBDT, 2008))

Habitat: Woodland or grassland on clay (DEC, 2008)

Status: Environmental weed.

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- OSAs and along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Ulcardo Melon eradication programmes if required (preferably after rainfall events and prior to seed set).
- The personnel or contractor commissioned to undertake the Ulcardo Melon eradication programmes will use the methodology specified by BHP Billiton Iron Ore's Environmental Advisor.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within eight weeks of the initial eradication programme.
- Details of all Ulcardo Melon eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Ulcardo Melon eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Website: www.anbg.gov.au/images/photo_cd/QLD_033/126_2.jpg

3.2.6 Awnless Barnyard Grass (*Echinochloa colona*)

Awnless Barnyard Grass

Echinochloa colona


Echinochloa colona Photos: S.M. Armstrong & J. English

Description: Tufted annual grass-like or herb which grows to 0.9 m (DEC, 2008).

Flowers: Green/purple flowers are produced between February and July (DEC, 2008).

Habitat: Black sandy soils or black clay near watercourses or swamps (DEC, 2008).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- Along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Awnless Barnyard Grass eradication programmes if required (preferably after rainfall events and prior to seed set).
- The personnel or contractor commissioned to undertake the Awnless Barnyard Grass eradication programmes will use the methodology specified by BHP Billiton Iron Ore's Environmental Advisor.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within eight weeks of the initial eradication programme.
- Details of all Awnless Barnyard Grass eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Awnless Barnyard Grass eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by S.M. Armstrong & J. English. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

3.2.7 Spiked Malvastrum (*Malvastrum americanum*)

Spiked Malvastrum

Malvastrum americanum

Description: Erect perennial herb or shrub which may reach 1.3 m in height. Leaves are hairy and serrated (*ecologia*, 2003).

Flowers: Yellow/orange flowers are produced between April and July (DEC, 2008).

Habitat: Gritty alluvial sand, black/brown clay, alluvial cracking clays, limestone and calcrete along stony ridges and hillsides, woodlands, floodplains and drainage lines (DEC, 2008; *ecologia*, 2003).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- OSAs, mine pits and along creek lines.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Spiked Malvastrum eradication if required (preferably after rainfall events and prior to seed set).
- The personnel or contractor commissioned to undertake the Spiked Malvastrum eradication programmes will use the methodology specified by the BHP Billiton Iron Ore's Environmental Advisor.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within 8 weeks of the initial eradication programme.
- Details of all Spiked Malvastrum eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Spiked Malvastrum eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by J.F. Smith & E. Wajon. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

3.2.8 Oleander (*Nerium oleander*)

Oleander

Nerium oleander

Description: Widely spread, erect herb which grows up to 5 m in height (DEC, 2008).

Flowers: White or pink (DEH, 2008).

Habitat: Along the edges of river at the base of limestone cliffs (DEC, 2008).

Status: Potential environmental weed (DEH, 2008).

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- Along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Oleander eradication programmes if required (preferably after rainfall events and prior to seed set).
- The personnel or contractor commissioned to undertake the Oleander eradication programmes will use the methodology specified by BHP Billiton Iron Ore's Environmental Advisor.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within 8 weeks of the initial eradication programme.
- Details of all Oleander eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Oleander eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

DEH (2008) *Potential Environmental Weeds in Australia.*
Website: http:www.deh.gov.au

Image Source: Queensland Health (2008) *Pink Oleander.*
Website: http://www.health.qld.gov.au/poisonsinformationcentre/plants_fungi/oleander.asp
Accessed: 10 September 2008.

3.2.9 Stinking Passion Flower (*Passiflora foetida*)

Stinking Passion Flower

Passiflora foetida

Description: Woody climber with an unpleasant smell, which may grow up to 9 m in height (DEC, 2008).

Flowers: Cream, white and blue flowers are produced between February and November (DEC, 2008).

Habitat: Coastal areas and on the banks of waterways (DEC, 2008).

Status: Environmental weed (CALM, 1999; WAPC, 2003).

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- Along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Stinking Passion Flower eradication programmes if required (preferably after rainfall events and prior to seed set).
- The personnel or contractor commissioned to undertake the Stinking Passion Flower eradication programmes will use the methodology specified by BHP Billiton Iron Ore's Environmental Advisor.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within eight weeks of the initial eradication programme.
- Details of all Stinking Passion Flower eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Stinking Passion Flower eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by B.J. Carter, A.S. George, R. Robson, T. Tapper & WA Herbarium. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

3.2.10 Purslane (*Porulaca oleracea*)

Purslane

Porulaca oleracea

Description: Succulent, prostrate to decumbent, annual herb. (DEC, 2008).

Flowers: Yellow, from April to May (DEC, 2008).

Habitat: Clay loam to sand soils, often in disturbed areas (DEC, 2008).

Status: Environmental weed

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- Disturbed areas such as roadsides, OSAs and creek crossings.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Purslane eradication programmes if required (preferably after rainfall events and prior to seed set).
- The personnel or contractor commissioned to undertake the Purslane eradication programmes will use the methodology specified by BHP Billiton Iron Ore's Environmental Advisor.
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within eight weeks of the initial eradication programme.
- Details of all Purslane eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Purslane eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by G. Byrne, C.P. Campbell and L. Fontanini. Used with permission of the Western Australian Herbarium, Department of Environment and Conservation.
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

3.2.11 Mimosa Bush (*Vachellia farnesiana*)

Mimosa Bush

Vachellia farnesiana

Description: Highly branched spiny shrub or tree, which may reach 4 m in height (DEC, 2008).

Flowers: Yellow flowers are produced between June and August (DEC, 2008).

Habitat: Found along waterways, in low-lying areas and disturbed areas (DEC, 2008).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- Refer to Section 2.1.

Target Areas

- Along creek drainage lines.

General Control Measures

- Implement the management measures described in Section 3.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Mimosa Bush eradication programmes if required (preferably after rainfall events and prior to seed set).
- The personnel or contractor commissioned to undertake the Mimosa Bush eradication programmes will use the following methodology (unless otherwise specified by BHP Billiton Iron Ore's Environmental Advisor):
  - A basal bark spray can be applies from ground level to 30 cm above the ground in Autumn when plants are actively growing and stems are less than 15 cm in diameter (Land Protection, 2006a).
  - Alternatively the plants can be cut at any time of year as close to the ground as possible and herbicide applied immediately to the stump (Land Protection, 2006a).
  - Both of the techniques can use Fluoxypr (3L/100L diesel) or Triclopyr (1L/60L diesel) (Land Protection, 2006a).
- BHP Billiton Iron Ore's Environmental Advisor will undertake and/or co-ordinate follow-up inspections (and respraying if necessary) of treated areas within eight weeks of the initial eradication programme.
- Details of all Mimosa Bush eradication programmes and follow-up inspections/programmes will be recorded and will include, but are not necessarily limited to, the following: location and approximate numbers of plants in each of the areas treated, methods used and timing.
- A summary of Mimosa Bush eradication programmes (if conducted) will be provided in the AER.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by J. Dodd, S.D. Hopper & K. Kenneally. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed on Monday, 10 December 2007.

4 WEED SPECIES WITH THE POTENTIAL TO OCCUR

Based on the Western Australian Planning Commission (WAPC, 2003), the definition of an 'Environmental Weed' (Section 1.4) and weed records at BHP Billiton Iron Ore's other Pilbara operations, 17 additional weed species, which have not been previously recorded at Goldsworthy, are considered to have the potential to occur. These species include:

- Ruby Dock (*Acetosa vesicaria*);
- Mexican Poppy (*Argemone ochroleuca*);
- Bipinnate Beggartick *(Bidens bipinnata*);
- Burr or Mossman Grass (*Cenchrus echinatus*);
- Birdwood Grass (*Cenchrus setigerus*);
- Tickweed (*Cleome viscosa*)*;*
- Flaxleaf Fleabane (*Conyza bonariensis*);
- Bellyache Bush (*Jatropha gossypiifolia*);
- Prickly Lettuce (*Lactuca serriola*);
- Parkinsonia (*Parkinsonia aculeata*);
- Mesquite (*Prosopis pallida*);
- Whorled Pigeon Grass (*Setaria verticillata*);
- Indian Weed (*Sigesbeckia orientalis*);
- Indian Hedge Mustard (*Sisymbrium orientale*);
- Black Berry Nightshade (*Solanum nigrum*);
- Common Sowthistle (*Sonchus oleraceus*)*;* and
- Verano Stylo (*Stylosanthes hamata*).

In the event that one or more of these species is recorded at Goldsworthy, the level of management would be adjusted as necessary, and the descriptions in this WMP would be revised (ie. moved from Section 5 to Section 3). Other weed species, which are found in the Pilbara but are considered to be unlikely to be recorded at Goldsworthy, are listed in Table 4-1.

Table 4-1
Other Weed Species Occurring in the Pilbara Region

Scientific Name	Common Name
Acanthospermum hispidum	Starburr
Alternanthera pungens	Khaki Weed
Amaranthus viridis	Green Amaranth
Andropogon gayanus	
Argemone ochroleuca subsp. *ochroleuca*	
Arundo donax	Giant Reed
Asclepias curassavica	Redhead Cottonbush
Asphodelus fistulosus	Onion Weed
Bidens pilosa	Cobbler's Pegs
Catharanthus roseus	Pink Periwinkle
Cenchrus biflorus	Gallon's Curse
Chenopodium murale	Nettle-leaf Goosefoot
Chloris barbata	Purpletop Chloris
Citrullus colocynthis	
Citrullus lanatus	Pie Melon
Clitoria ternatea	
Coccinia grandis	
Crotalaria juncea	Sunnhemp
Cucumis melo	
Cucumis myriocarpus	Prickly Paddy Melon
Cyclospermum leptophyllum	
Cynodon dactylon	Couch
Cyperus involucratus	
Cyperus polystachyos	
Cyperus rotundus	Nut Grass
Datura leichhardtii	Native Thornapple
Datura metel	Downy Thornapple
Desmodium scorpiurus	
Digitaria ciliaris	Summer Grass
Eragrostis pilosa	
Gomphrena celosioides	Gomphrena Weed
Gossypium hirsutum	Upland Cotton
Indigofera oblongifolia	
Indigofera sessiliflora	
Lactuca saligna	
Lactuca serriola	
Lamarckia aurea	Goldentop
Lepidium didymum	
Leptochloa fusca subsp. *uninervia*	N. Snow
Leucaena leucocephala	Leucaena
Malvastrum coromandelianum	
Melochia pyramidata	

Table 4-1 (Continued)
Other Weed Species Occurring in the Pilbara Region

Scientific Name	Common Name
Merremia dissecta	
Moringa oleifera	
Opuntia stricta	Common Prickly Pear
Opuntia stricta var. *stricta*	
Oxalis corniculata	Yellow Wood Sorrel
Paspalum fasciculatum	
Passiflora foetida var. *hispida*	Killip
Pennisetum setaceum	Fountain Grass
Phoenix dactylifera	Date Palm
Phyla nodiflora	
Phyla nodiflora var. *nodiflora*	
Physalis angulata	
Polypogon monspeliensis	Annual Beardgrass
Prosopis glandulosa x velutina	
Prospis pallida	
Pupalia lappacea	
Ricinus communis	Castor Oil Plant
Salvinia molesta	Salvinia
Senna occidentalis	
Setaria italica	Italian Millet
Setaria sphacelate	South African Pigeon Grass
Solidago canadensis	Goldenrod
Stylosanthes guianensis	Stylo
Tamarindus indica	Tamarind
Trianthema portulacastrum	Giant Pigweed
Tribulus terrestris	
Washingtonia filifera	

Source: DEC (2008)

5 MANAGEMENT OF WEED SPECIES WITH THE POTENTIAL TO OCCUR

5.1 GENERAL WEED MANAGEMENT, HYGIENE AND MONITORING MEASURES

The following control measures are applicable to all weed species that have the potential to occur at Goldsworthy but have not been recorded to date:

- The induction programme will be used to promote awareness of weed management measures that are to be used at Goldsworthy. An example 'Enviro Alert' fact sheet for Ruby Dock is provided in Attachment B.
- Mobile machinery and equipment will be inspected, cleaned and certified prior to being brought to the site, being moved from a 'Weed Risk' area to another part of the site, or being removed from the Goldsworthy area. Details of inspections and cleaning will be documented via a Vehicle/Equipment Weed Hygiene Certificate (Attachment C).
- All inspections and cleaning of mobile machinery and equipment will be conducted in accordance with procedures specified by the BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate).
- The BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate) will conduct quarterly inspections of disturbance areas and areas with known weed records within the Goldsworthy area in order to monitor for the presence of weeds. Where possible, the inspections will be conducted in the weeks following rainfall events in order to maximise the potential for weed species being observed.
- The BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate) will regularly review the classification status of weed species (ie. Declared, Environmental or other), development of State and Commonwealth weed management strategies and action plans.
- The BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate) will regularly consult with DEC and DAFWA to determine the most recent developments in weed control methods.
- In the event that any potential weed species are identified, the BHP Billiton Iron Ore Environmental Advisor for Goldsworthy (or nominated delegate) will adjust the level of management as necessary, and document the species name, population, location (on relevant mine plans) and control method to be used in BHP Billiton Iron Ore's environmental management database.
- BHP Billiton Iron Ore and/or its consultants will provide details (and samples where possible) of new weeds or any weeds found outside their (current) known range to the DEC herbarium.
- BHP Billiton Iron Ore and/or its consultants will, report any new weeds to the Pilbara or WA to DEC and DAFWA.

5.2 SPECIFIC WEED MANAGEMENT, HYGIENE AND MONITORING MEASURES

Species-specific weed management measures for the 16 weed species that have not been previously recorded at Goldsworthy, but have the potential to occur, are provided in the following sub-sections.

5.2.1 Ruby Dock (*Acetosa vesicaria*)

Ruby Dock

Acetosa vesicaria

Description: Succulent, multi-stemmed annual herb which reproduces vegetatively or via seed production. The plants (which may reach 0.2 to 1 m in height) are in growth stage between April and May (DEC, 2008).

Flowers: Red/pink flowers are clustered at the ends of stems between July and September (DEC, 2008).

Fruit: Bright red/pink fruit.

Habitat: Sandy alluvial or gravely ironstone soils along roadsides or in disturbed areas (DEC, 2008).

Status: Environmental weed (CALM, 1999; WAPC, 2003).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- Railway spur line, haul roads, mine access roads and OSAs.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Ruby Dock eradication if required.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by T.J. Alford & M. Hancock. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

5.2.2 Mexican Poppy (*Argemone ochroleuca)*

Mexican Poppy

Argemone ochroleuca

Description: Erect herbaceous annual, which reaches 0.2-1 m in height. Cylindrical stems produce yellow latex (DEC, 2008). Waxy leaves have prickles along the midrib of the underside (DAFWA, 2008). Reproduction occurs via seed production and seeds are contained in prickly oblong capsules, which may reach 3.5 cm in length.

Flowers: Solitary flowers (produced February/March and July/November) feature white-yellow petals and a dark red stigma (6cm across) (DEC, 2008; *ecologia,* 2001).

Habitat: Sandy soils and red/brown clay loam on moist flats or open, cobble creekbeds where there is no competition with native species (DEC, 2008; *ecologia,* 2001).

Status: Environmental weed (CALM ,1999)

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- OSAs, haul roads and along creek lines.

General Control Measures:

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- Mexican Poppy is a highly vigorous coloniser that can spread rapidly on disturbed areas, and hence requires priority treatment if located.
- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Mexican Poppy eradication programmes if required.
- Control measures that have been used elsewhere and which may be used if required include the following:
  - Wear rubber gloves and a face shield when treating Mexican Poppy.
  - Use of roundup or a similar glyphosate product and the associated wetting agent in accordance with the manufacturer's specifications.
  - Application of PPE and Mine safety measures in accordance with the herbicide manufacturer's specifications and BHP Billiton Iron Ore's Goldsworthy requirements.
  - Spraying using vehicle mounted units where plants are easily accessible and back pack spray units where infestations are less accessible.
  - Removal of young plants manually (grubbed out) using rubber gloves, after the flowers and seeds have been removed using secateurs and placed in a plastic container.
  - Washed hands immediately after treating Mexican Poppy.
  - Medical advice should be sought promptly in the event of direct contact with Mexican Poppy.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

DAFWA (2008) *Mexican Poppy* (*Argemone mexicana and Argemone ochroleuca*).

Image Source: Photography by R. Knox & Anon. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 December 2008.

5.2.3 Bipinnate Beggartick (*Bidens bipinnata)*

Bipinnate Beggartick

Bidens bipinnata

Description: Erect annual herb reaching from 0.1 to 1.5 m in height (DEC, 2008).

Flowers: Yellow flowers are produced between March and September (DEC, 2008).

Habitat: Favours wetlands but is also found in alluvium, clay or loam along rivers and creeks or on rocky hillsides (DEC, 2008).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- Along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Bipinnate Beggartick eradication if required.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

5.2.4 Burr or Mossman Grass (*Cenchrus echinatus*)

Burr or Mossman Grass

Cenchrus echinatus


Cenchrus echinatus Photo: J.D. Dodd

Description: Tufted annual or sometimes perennial, grass-like or herb, reaching up to 1.2 m in height. Seedlings are erect and hairless with bright green leaves (Land Protection, 2006b). Mature plants form prostrate or ascending tufts with stout stems and purplish-red leaf sheaths (*ibid.*).

Flowers: Green flowers are produced between January and August. Reproduction occurs via seed production (in a cluster of 12 to 14 burrs) or via rhizomes (Land Protection, 2006b).

Habitat: Sand, red loam or black, peaty clay (DEC, 2008).

Status: Environmental weed (CALM, 1999; WAPC, 2003).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- OSAs.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Burr/Mossman Grass eradication programmes if required.
- Young plants can be killed before they set seed by applying herbicide, cultivation, manual removal and burning off using flame throwers or steam jets (Land Protection, 2006b). Around buildings and public areas, spraying can be conducted using glyphosate from back pack units to the point of runoff, or ropewick application of glyphosate to individual plants (1 part Glyphosate 360 or Round-Up to 2 parts water or undiluted Zero) (*ibid*.). For residual pre-emergent control of annual grasses, Dichlobenil herbicide (e.g. Casoron 600 grams (g)/100 square metres [m^2]) granules can be applied evenly over soil and remove existing weeds by hand or cultivation (*ibid*.). Where weeds have become established in revegetation, plants may be thoroughly wetted using a Fluazifop herbicide (e.g. 100 mL of Fusilade 50 per 10 L water) and surfactant as per label (*ibid*.).

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by G.F Craig, M. Long & L. Wallis. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

5.2.5 Birdwood Grass (*Cenchrus setigerus*)

Birdwood Grass

Cenchrus setigerus

Description: Tufted perennial, grass-like or herb which may reach 1.5 m in height.

Flowers: Purple, black and green flowers are produced between February and August. May reproduce via rhizomes.

Habitat: Alluvial or red sand, red loam and stony clay.

Status: Environmental weed (CALM, 1999; WAPC, 2003).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- OSAs and mine pits.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Birdwood Grass eradication programmes if required.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: WSWA (undated a) *Poaceae*.
Website: http://members.iinet.net.au/~weeds/western_weeds/poaceae_three.htm
Accessed: 10 September 2008.

5.2.6 Tickweed (*Cleome viscosa*)

Tickweed

Cleome viscosa

Description: Viscid annual or perennial herb, reaching up to 1.5 m in height (DEC, 2008).

Flowers: Yellow flowers are produced between February and October (DEC, 2008).

Habitat: Grows in a variety of soils (DEC, 2008).

Status: Environmental weed.

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- OSAs.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Burr/Mossman Grass eradication programmes if required.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by C.P Campbell & E. Wajon. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 8 September, 2008.

5.2.7 Flaxleaf Fleabane (*Conyza bonariensis*)

Flaxleaf Fleabane

Conyza bonariensis

Description: Erect, annual herb which can grow up to 1.5 m high (DEC, 2008). Leaves are grey covered with stiff hairs (Peltzer *et al*., 2006). Distinguished by its stem which branches below each pyramid of flowers (Peltzer *et al*., 2006).

Flowers: White to pale green flowers produced between January and December (DEC, 2008; Peltzer *et al*., 2006).

Habitat: Grows in a variety of soils, generally in cultivation, waste places and roadsides (DEC, 2008). Often associated with summer rain (Peltzer *et al*., 2006).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- Railway spur line, haul roads, mine access roads and along drainage lines.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Flaxleaf Fleabane eradication programmes if required.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by R. Randall. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

5.2.8 Bellyache Bush (*Jatropha gossypiifolia*)

Bellyache Bush

Jatropha gossypiifolia

Description: Erect viscid shrub, ranging from 0.7 to 4 m in height (DEC, 2008; Land Protection, 2006b). Young leaves are divided into three purple, rounded lobes. Mature leaves are green, with up to five lobes that have brown hairs around the edges (*ibid.*). Smooth oval shaped seed pods contain three to four seeds each (*ibid.*).

Flowers: Red and yellow flowers are produced between February and May.

Fruit: Contain the toxin albumin (Land Protection, 2006c).

Habitat: Disturbed areas, especially near waterways (DEC, 2008).

Status: P4 'Declared' Plant (ARRP Act), Environmental weed (CALM, 1999; WAPC, 2003).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- Haul roads, mine access roads, OSAs and along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Bellyache Bush eradication programmes if required.
- Control measures that have been used elsewhere and which may be used if required include the following:
  - Use of either Metsulfuron/Brushoff (10 g/100 g + wetting agent) or Fluroxypyr/Starane 200 (500 mL/100 L + wetting agent) to thoroughly wet actively growing plants (Land Protection, 2006c). In addition, Bellyache Bush plants have shallow roots so manual removal can be effective (*ibid.*). Repeated slashing of infested areas may also help to reduce weed density (*ibid.*).
  - Fire may result in high kill rates, but only if there is sufficient fuel load to carry a fire through the entire area of weed infestation (Land Protection, 2006c).

    Note: Fire may only be used for weed control at the Goldsworthy where risks are acceptable and all necessary permits have been obtained.
  - Wear rubber gloves and a face shield when treating Bellyache Bush, and ensure hands are washed immediately after treatment. Medical advice should be sought promptly in the event of direct contact with Bellyache Bush.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by R. Randall & R. Smith. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

5.2.9 Prickly Lettuce (*Lactuca serriola*)

Prickly Lettuce

Lactuca serriola

Description: Erect annual or biennial herb. 0.4 to 2 m high (DEC, 2008). Similar to and often confused with *Lactuca selinga* and *Chondrilla juncea* (State Skeleton Weed Committee [SSWC] *et al.,* 2008). Leaves are stemless and deeply lobed or toothed. Seeds aided by a parachute are dispersed by air (SSWC *et al.,* 2007).

Flowers: Pale Yellow – Yellow (SSWC *et al.,* 2008; DEC, 2008).

Habitat: Roadsides, gardens cultivated fields, and disturbed areas (DEC, 2008). Common in townsites and around farm buildings (SSWC *et al.,* 2007).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- Haul roads, access road, OSAs and mine pits.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Prickly Lettuce eradication if required.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by S.M Armstrong & J.F. Smith. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

5.2.10 Parkinsonia (*Parkinsonia aculeata*)

Parkinsonia (or Jerusalem Thorn and Jelly Bean Tree)

Parkinsonia aculeata

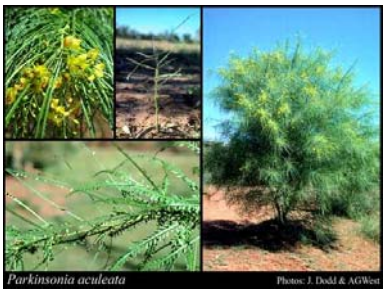
Description: Spiny shrub or tree, which may reach 8-10 m in height (DEC, 2008; Land Protection, 2006d). The branches are zig-zagged with sharp spines and leaf branches 20-40 cm long, with leaflets along each edge (*ibid.*).

Flowers: Fragrant flowers with four yellow petals and one with an orange spot, or which is completely orange. Flowers are arranged in 20 cm long drooping sprays which are produced between March and December.

Seed: Seed pods are hard and oval-shaped, usually 5-10 cm long (Land Protection, 2006d).

Habitat: Found near waterways in sandy or clayey soils (DEC, 2008).

Status: P1 and P2 'Declared' Plant (ARRP Act), Weed of National Significance (Thorp and Lynch, 2000) and Environmental weed (CALM, 1999; WAPC, 2003).



Recorded Locations at Goldsworthy

- None to date.

Target Areas

- Along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Parkinsonia eradication if required.
- Control measures that have been used elsewhere and which may be used if required include the following:
  - Initial clearing by stick raking, blade ploughing and ripping.

    Note: This is not recommended near watercourses and will require follow-up, as it hastens seed generation (Land Protection, 2006d).
  - Fire can be used to destroy seedlings and seeds, provided there is sufficient fuel load (Land Protection, 2006d).

    Note: Fire may only be used for weed control at the Goldsworthy where risks are acceptable and all necessary permits have been obtained.
  - For actively growing seedlings 1-2 m tall or 12-24 months old, herbicide may be applied using aerial methods (Grazon DS/picloram and triclopyr (3 L/ha) with 1 L/ha of Uptake wetting agent by helicopter only) or using a foliar spray such as Grazon DS/picloram and triclopyr (0.35 L/100 L water) and a wetting agent (Land Protection, 2006d). Another option for actively growing weeds with stems up to 5 cm in diameter is applying a basal bark spray of Access/Triclopyr and picloram (1 L/60 L diesel), taking care not to wet the stems (*ibid*.). Weeds may be cut at any time of year and Access/Triclopyr and picloram (1 L/60 L diesel) applied immediately to the stump (*ibid*.).
  - Velpar L/hexazinone may be applied using a spot gun (4 mL per spot and one spot per plant up to 5 m tall) any time of year (Land Protection, 2006d). The chemical requires moisture to be activated.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by J. Dodd & A.G. West. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

5.2.11 Mesquite (*Prosopis pallida*)

Mesquite (or Algaroba)

Prosopis pallida

Description: Tree or shrub between 3 and 15 m in height, with zig-zagged branches and rough grey-brown bark (DEC, 2008; Land Protection, 2006e; 2006f). Bipinnate leaves look 'fernlike' and consist of one to three pairs of opposite segments with 6 to 18 pairs of leaflets (Department of Primary Industries [DPI] [Victoria], 2004). A pair of spines is located on the branch above each leaf stalk.

Flowers: Cylindrical green/yellow flowers between 5 and 10 cm long are produced February/July to September (DEC, 2008; DPI, 2004).

Seed: The plants reproduce via seeds. Approximately 5-20 are encased in each 10-20 cm pod, which has slight constrictions between the seeds (Land Protection, 2006e; DPI, 2004).

Habitat: Red alluvial soil, sand, loam or clay on the banks of waterways.

Status: Mesquite (*Prosopis* sp.) is listed as a P1 and P2 'Declared' Plant by the ARRP Act, Weed of National Significance (Thorp and Lynch, 2000) and an Environmental weed (CALM, 1999; WAPC, 2003).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- Along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Mesquite eradication programmes if required.
- Control measures that have been used elsewhere and which may be used if required include the following:
  - For actively growing plants up to 1.5 m tall (and without seedpods), apply an overall spray of Triclopyr and picloram Access (350 mL/100 L water + wetting agent) (Land Protection, 2006e). Basal bark spraying (wetting the stem from the ground to 30 cm above the ground) using triclopyr and picloram Access (1 L/6 0L diesel) is recommended for plants up to 5 cm in diameter (*ibid.*) during the growing season (approximately October to April) (AWMCRC, 2003). Alternatively, cut the stump close to ground level and triclopyr and picloram Access (1 L/60 L diesel) applied immediately (*ibid.*).
  - Mechanical control methods (and follow up) which remove the root bud zone are effective. Stick raking (late autumn to winter) works for medium/high density infestations and a front/rear mounted blade plough with the blade set to 30 cm has also been successful (Land Protection, 2006e).

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Cooperative Research Centre for Australian Weed Management (AWMCRC) (2003) *Weed Management Guide - Mesquite (Prosopis species).*
Website: www.weedscrc.org.au/documents/wmg_mesquite.pdf

Image Source: Photography by Colin G. Wilson in AWMCRC (2003) *Weed Management Guide – Mesquite (Prosposis species).*
Website: www.weedscrc.org.au
Accessed: 10 September 2008.

5.2.12 Whorled Pigeon Grass (*Setaria verticillata*)

Whorled Pigeon Grass

Setaria verticillata

Description: Loosely tufted, grass-like or herb, reaching 0.1 to 1.3 m in height (DEC, 2008).

Flowers: Flowers are produced between December and June (DEC, 2008).

Habitat: Sandy, clayey and loamy soils (DEC, 2008).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- OSAs, mine pits and along creeks and drainage lines

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Whorled Pigeon Grass eradication programmes if required.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Royal Botanic Gardens and Domain Trust (RBGDT) (2008) *PlantNET.*
Website: http://plantnet.rbgsyd.nsw.gov.au
Accessed: 10 September 2008.

5.2.13 Indian Weed (*Sigesbeckia orientalis*)

Indian Weed

Sigesbeckia orientalis

Description: Erect, slender annual herb which may reach 1 m in height (DEC, 2008).

Flowers: Yellow flowers are produced between January and December (DEC, 2008).

Habitat: Loamy soils in rocky gullies, limestone ranges and creek beds (DEC, 2008).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- Along creek and drainage lines.

General Control Measures:

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Indian Weed eradication programmes if required.

Further Information:	BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.
Further Reading:	DEC (2008) *Western Australian Herbarium – Florabase.* Website: http://florabase.calm.wa.gov.au
Image Source:	Photography by R. Davis. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation Website: http://florabase.calm.wa.gov.au/help/copyright. Accessed: 10 September 2008.

5.2.14 Indian Hedge Mustard (*Sisymbrium orientale*)

Indian Hedge Mustard

Sisymbrium orientale

Description: Widespread annual or biennial herb ranging in size from 0.1 to 1 m in height (DEC, 2008).

Flowers: Yellow flowers are produced between March and November (DEC, 2008).

Habitat: Widespread in the wheatbelt region of WA and also in woodlands and disturbed areas in the arid zone.

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- OSAs, haul roads and mine pits.

General Control Measures:

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Indian Hedge Mustard eradication programmes if required.

  Note: In some instances, Indian Hedge Mustard has developed a resistance to chlorosulphuron and other B/2 type herbicides that work by inhibiting acetolactate synthase (Roberts and Charles, 2002).

Further Information:	BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.
Further Reading:	DEC (2008) *Western Australian Herbarium – Florabase.* Website: http://florabase.calm.wa.gov.au
Image Source:	Photography by R. Robson & J. Dodd. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation Website: http://florabase.calm.wa.gov.au/help/copyright. Accessed: 10 September 2008.

5.2.15 Black Berry Nightshade (*Solanum nigrum*)

Black Berry Nightshade

Solanum nigrum

Description: Erect perennial herb or shrub which may reach 0.8 m in height (DEC, 2008). Heavily veined, diamond shaped, alternating leaves producing fruit in the form of a green berry (black when ripe) (Tamar Valley Weed Strategy Working Group [TVWSWG], undated a).

Flowers: White flowers with yellow centre are produced between January and December (DEC, 2008).

Habitat: Gardens, horticultural crops, wastelands, disturbed woodlands, pastures, creeklines and wetlands (The Weed Society of Western Australia Inc [WSWA], undated b).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- OSAs, mine pits and along creeks and drainage lines.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Black Berry Nightshade eradication programmes if required.

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by S.M. Armstrong, J. Dodd & J.F. Smith. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright).
Accessed: 10 September 2008.

5.2.16 Common Sowthistle (*Sonchus oleraceus*)

Common Sowthistle

Sonchus oleraceus

Description: Erect annual herb ranging from 0.1 to 1.5 m in height (DEC, 2008).

Flowers: Yellow flowers are produced between January and December (DEC, 2008).

Habitat: Grows in a range of soil types in disturbed areas (DEC, 2008).

Status: Environmental weed (CALM, 1999).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- OSAs, mine pits, railway, haul roads and mine access roads.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- Common Sowthistle is adaptive to a range of soil types and hence requires priority control if located.
- The BHP Billiton Iron Ore Goldsworthy Environmental Officer will co-ordinate and manage Common Sowthistle eradication programmes as required (preferably after rainfall events and prior to seed set).
- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Common Sowthistle eradication programmes if required.
- Control measures that have been used elsewhere and which may be used if required include the following:
  - Spot or boom spraying will be conducted using glyphosate, metsulfuron methyl, dicamba, metribuzin, simazine or MCPA (TVWSWG, undated b) in accordance with the manufacturer's specifications.
  - PPE and Mine safety measures will be followed in accordance with the herbicide manufacturer's specifications and BHP Billiton Iron Ore's Goldsworthy Mine requirements.
  - Hand tools or machinery will be used to manually remove (grub out) Common Sowthistle where it can be used effectively.

    Note: In some instances, Common Sowthistle has developed a resistance to chlorosulphuron and other B/2 type herbicides that work by inhibiting acetolactate synthase (Roberts & Charles, 2002).

Further Information: BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.

Further Reading: DEC (2008) *Western Australian Herbarium – Florabase.*
Website: http://florabase.calm.wa.gov.au

Image Source: Photography by S.M Armstrong & L. Fontanini. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation
Website: http://florabase.calm.wa.gov.au/help/copyright.
Accessed: 10 September 2008.

5.2.17 Verano Stylo (*Stylosanthes hamata*)

Verano Stylo (or Caribbean Stylo)

Stylosanthes hamata

Description: Erect or decumbent herb or shrub which grows to 0.7 m in height (DEC, 2008).

Flowers: Yellow flowers are produced between April and December (DEC, 2008).

Habitat: Amongst trees and tall shrubland/grassland. Sandy, loamy or clayey soils along creek banks or in areas which have experienced seepage or vegetation disturbance (DEC, 2008).

Status: Environmental weed (CALM, 1999; WAPC, 2003).

Recorded Locations at Goldsworthy

- None to date.

Target Areas

- Along creek and drainage lines.

General Control Measures

- Implement the management measures described in Section 5.1 of this WMP.

Specific Control Measures

- BHP Billiton Iron Ore's Environmental Advisor will co-ordinate and manage Verano Stylo eradication programmes if required.

Further Information:	BHP Billiton Iron Ore Environmental Advisor for Goldsworthy.
Further Reading:	DEC (2008) *Western Australian Herbarium – Florabase.* Website: http://florabase.calm.wa.gov.au
Image Source:	Photography by G. Byrne. Used with the permission of the Western Australian Herbarium, Department of Environment and Conservation Website: http://florabase.calm.wa.gov.au/help/copyright. Accessed: 10 September 2008.

6 PERFORMANCE INDICATORS

The success of the 'General Weed Management, Hygiene and Monitoring Measures' described in this Plan (ie. Sections 3.1 and 5.1) will be regularly evaluated through the routine inspections of disturbance areas and 'Weed Risk' areas conducted by the BHP Billiton Iron Ore Environmental Advisor for Goldsworthy. These inspections will be conducted at least on a quarterly basis. The overall performance indicators for this WMP are that:

- no new weed infestations occur as a result of the operation, and
- existing weed infestations within the operational area are either contained, eradicated or otherwise managed to the satisfaction of the administering authorities (ie. DAFWA and DEC).

The success of the species-specific weed control measures described in this Plan (ie. Sections 3.2 and 5.2) will be assessed via follow-up inspections. These inspections will be conducted within eight weeks of the initial control programme (preferably after a rainfall event and subsequent quarterly inspections) and will include an evaluation of the success (performance) or the control measures that were used. Records of the inspections will be entered into BHP Billiton Iron Ore's environmental management database and will include qualitative observations and quantitative measurements where relevant. These observations/measurements may include, but are not necessarily limited to the following:

- Whether or not the control measures were effective.
- The size, scale and distribution (eg. estimate of number, cover or density) of the infestation area compared with size and distribution prior to treatment.
- Other observations of relevance to the control of weed species at Goldsworthy.
- Schedule for further treatments and/or inspections if required.

In the event that weed control measures for a particular species appear not to be effective, they will be adjusted as necessary in consultation with DEC and DAFWA. This WMP will be updated if necessary to reflect any significant changes to control measures.

7 REPORTING PROCEDURES AND SCHEDULE

Details of all weed management and eradication programmes and follow-up inspections/programmes conducted at Goldsworthy will be recorded in BHP Billiton Iron Ore's environmental management database. Documentation may include, but is not necessarily limited to:

- the location, timing, and approximate number of individual weeds in each of the areas treated;
- the location of weed risk areas;
- the treatment methods used; and
- the location of new records of weed species.

A summary of all weed management and eradication programmes conducted at Goldsworthy will be provided in the AER. Any changes to the status of the recorded or potential weed species and/or any changes to the species-specific weed control measures will also be noted in the AER.

8 TIMEFRAME FOR IMPLEMENTATION OF THIS PLAN

This revision of the WMP will be implemented once approved by the Government administering authorities, and will be updated as required (ie. at least every five years) to include any changes in weed species identified on-site, weed populations, weed risk areas and weed management. Any further revisions of this WMP will be submitted to DEC and DAFWA as required by Condition 7-1 of Ministerial Statement of Approval No.000682.

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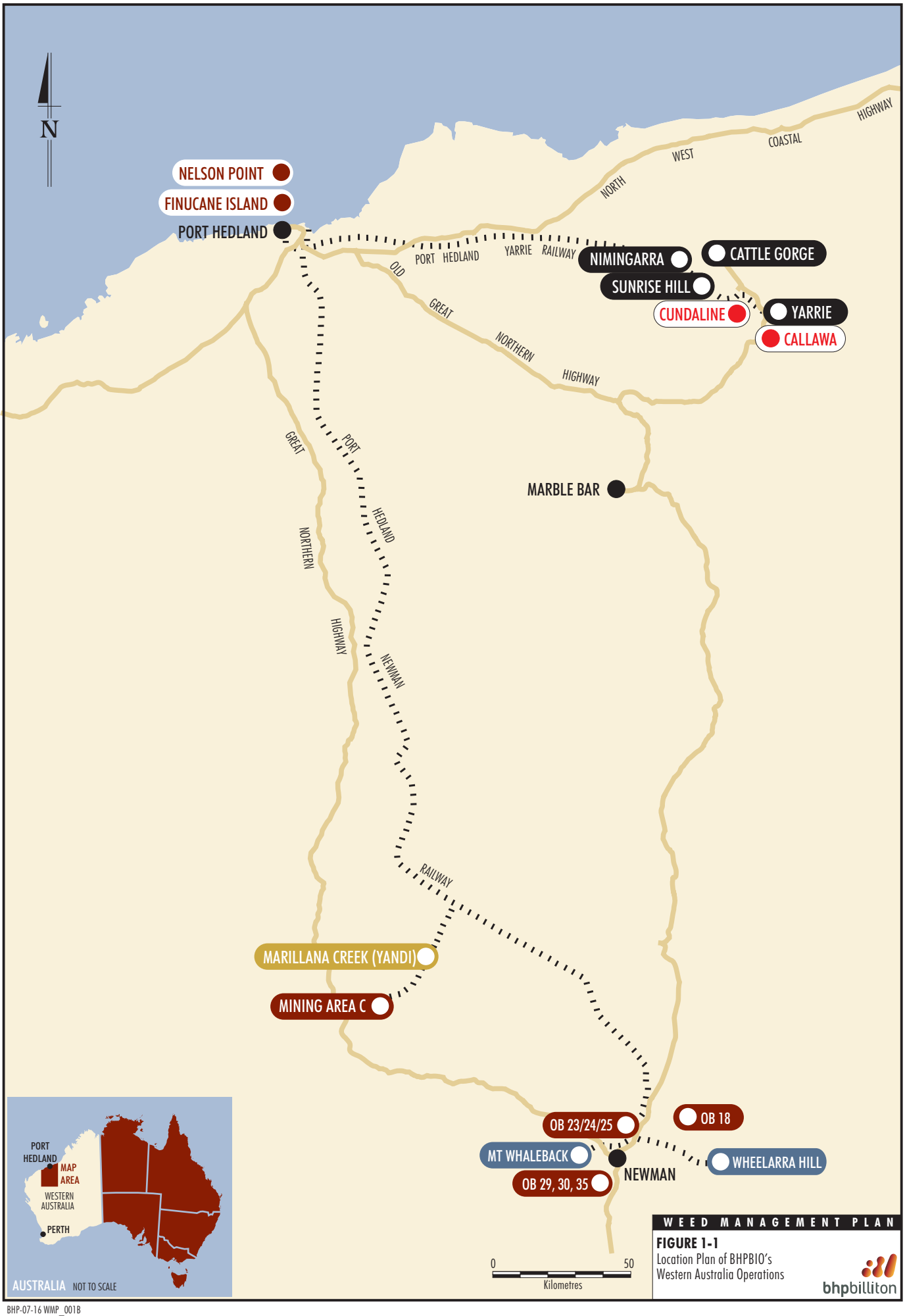
FIGURES



WEED MANAGEMENT PLAN

FIGURE 1-1
Location Plan of BHPBIO's Western Australia Operations

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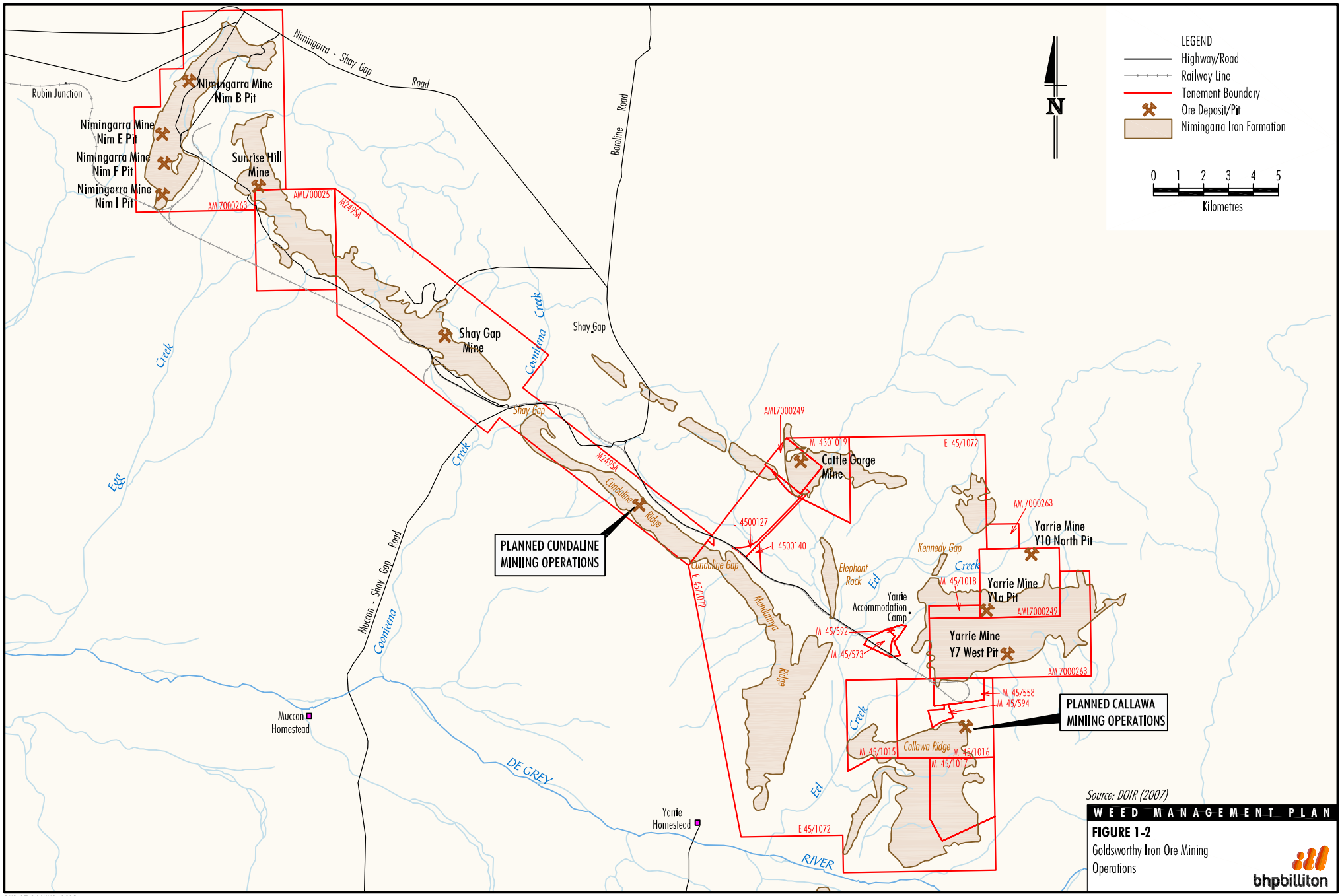
BHP-07-16 WMP_001B



Source: DOIR (2007)

WEED MANAGEMENT PLAN

FIGURE 1-2

Goldsworthy Iron Ore Mining Operations

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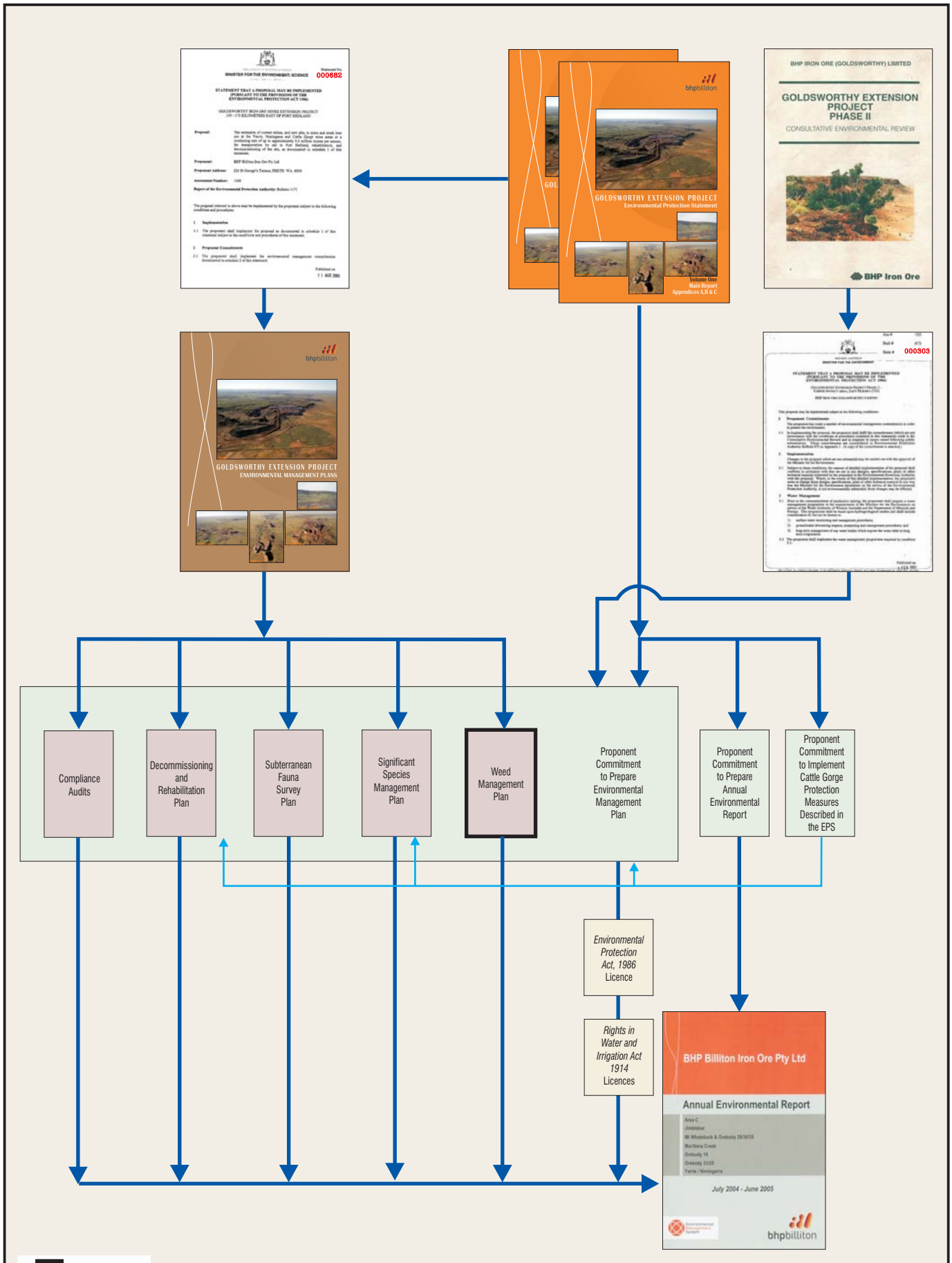
BHP-07-16 WMP_101B



WEED MANAGEMENT PLAN

FIGURE 1-3
Relationship between Environmental Management Plans

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BHP-07-16 WMP_002B

ATTACHMENT A

LIST OF PREVIOUS BASELINE BIOLOGICAL AND FLORA SURVEYS

Year	Author	Report Title
1992	Dames and Moore Pty Ltd	*Goldsworthy Extension Project Phase II Consultative Environmental Review.* Unpublished report prepared for BHP Iron Ore (Goldsworthy) Limited.
1998	BHP Iron Ore Pty Ltd	Goldsworthy Extension Project Phase 2 Expansion – Proposal to Mine Yarrie Crustal Deposits.
1995	Chapman, M.	*Activity Status of the Pebble-mound Mouse on the Yarrie Plateau.* Unpublished report prepared for BHP Iron Ore Pty Ltd.
1994	*ecologia* Environment Consultants (*ecologia*)	*Yarrie-Y10 – Botanical Survey.* Unpublished report prepared for BHP Iron Ore Pty Ltd.
1999	*ecologia*	*Yarrie Biological and Soil Survey.* Unpublished report prepared for BHP Iron Ore Pty Ltd.
2004a	*ecologia*	*Yarrie Cattle Gorge Biological Survey.* Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.
2004b	*ecologia*	*Nim B Extension Priority Flora Search.* Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.
2004c	*ecologia*	*Goldsworthy Extension Project Pre-feasibility Study- Assessment of Flora and Fauna of Conservation Significance.* Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.
2005a	*ecologia*	*Goldsworthy Extension Project Biological Assessment Survey.* Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.
2005b	*ecologia*	*Callawa Biological Assessment Survey.* Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.
2005c	*ecologia*	*Cundaline Biological Assessment Survey.* Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.
2008	ENV Australia	*Goldsworthy Iron Ore Mining Operations – Callawa and Cundaline Mining Operations Flora and Vegetation Assessment.* Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.
1986	Goldsworthy Mining Limited	*Goldsworthy Extension Project - Notice of Intent - Environmental Aspects at Nimingarra Mine Site and Finucane Island Port Facility near Port Hedland, Western Australia.*
1997a	Halpern Glick Maunsell	*Yarrie Western Pebble-mound Mouse Pseudomys chapmani 1996 Research Programme, Summer 1996*. Unpublished report prepared for BHP Iron Ore Pty Ltd.
1997b	Halpern Glick Maunsell	*Yarrie Western Pebble-mound Mouse Pseudomys chapmani 1996 Research Programme, Autumn 1996*. Unpublished report prepared for BHP Iron Ore Pty Ltd.
1997c	Halpern Glick Maunsell	*Yarrie Western Pebble-mound Mouse Pseudomys chapmani 1996 Research Programme, Winter 1996*. Unpublished report prepared for BHP Iron Ore Pty Ltd.
1997d	Halpern Glick Maunsell	*Yarrie Western Pebble-mound Mouse Pseudomys chapmani 1996 Translocation Programme, Phase V*. Unpublished report prepared for BHP Iron Ore Pty Ltd.
1997e	Halpern Glick Maunsell	*Yarrie Western Pebble-mound Mouse Pseudomys chapmani 1996 Monitoring and Research Programme, Winter 1997*. Unpublished report prepared for BHP Iron Ore Pty Ltd.
1998a	Halpern Glick Maunsell	*Yarrie Western Pebble-mound Mouse Pseudomys chapmani 1996 Monitoring and Research Programme, Summer 1997*. Unpublished report prepared for BHP Iron Ore Pty Ltd.
1998b	Halpern Glick Maunsell	*Yarrie Crustal Deposits Baseline Biological and Soil Survey*. Unpublished report prepared for BHP Iron Ore Pty Ltd.
2004	Outback Ecology	*Ecosystem Function Analysis of Rehabilitation at the Yarrie Mine Site.* Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd
1993	Piggott, M.S.	*An Assessment of the Local Distribution of Pebble Mice (Pseudomys chapmani) at Yarrie*. Report prepared for BHP-Utah Iron Ore.
1994	Piggott, M.S.	*Yarrie Project Pebble-mound Mouse Monitoring*. Unpublished report prepared for BHP Iron Ore Pty Ltd.
1994	Piggott, M.S.	*The Pebble-mound Mouse at Yarrie and Area C*. Unpublished report prepared for BHP Iron Ore Pty Ltd.
1995	Piggott, M.S.	*The Yarrie Project Pebble-mound Mouse Monitoring Programme, 1993-1994*. Unpublished report prepared for BHP Iron Ore Pty Ltd.

ATTACHMENT B

RUBY DOCK 'ENVIRO ALERT' FACT SHEET

ENVIRO MATTERS

Environmental Management System

Weed Control Programme – Ruby Dock

A weed control programme is currently being conducted across BHPBIO's inland sites. The programme focuses primarily upon the control of ***Ruby Dock (Acetosa vesicarius)***. ***Ruby Dock*** is the most common weed associated with disturbance around mining operations across the Pilbara and the Goldfields. Ruby Dock is a highly vigorous coloniser that can spread rapidly on disturbed areas, especially along transport and communication corridors. This can result in rapid spread across sites, it may reduce the effectiveness of rehabilitation and impact on neighbouring native vegetation communities.

Ruby Dock was introduced from the Mediterranean and Western Asia for ornamental and, ironically, rehabilitation purposes. As time progressed it was recognised as a threat to the native Australian environment and thankfully this practice has been discontinued.

Ruby Dock is an annual, multi-stemmed succulent that can grow rapidly to 50 cm or more following rain (particularly during the start of the winter period). Leaves are oval to heart-shaped. Flowers are clustered at the ends of stems. The most conspicuous part of the plant is the brightly coloured, red-pink fruit.

What can you do to help control Ruby Dock?

- Maintain Vehicle Hygiene procedures for travel around and between sites. Mud attached to the undercarriage of unwashed vehicles is a prime mechanism for the transport of weeds.
- Keep an eye out for the weed-spraying crew. They will be conducting work at your site over the next couple of months.
- Look for ways to minimise the area of disturbance required for your activities.
- Notify your Site Environmental Officer of areas that you have seen ***Ruby Dock***. This will allow them to direct the weed-spraying crew to the areas of greatest infestation.

Environmental management is everyone's responsibility

For further information please contact your site Environmental Officer

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ATTACHMENT C

VEHICLE/EQUIPMENT WEED HYGIENE CERTIFICATE

FRM-ENV-LAND NW-004	**Vehicle/Equipment Weed Hygiene Certificate**	
Revision: 1		
Date: 05-Oct-2004		

Unit (Asset) No.	Vehicle/Equipment Description	Location of last works undertaken	Where cleaned and inspected	Inspected by and date
List local weeds if known:				

Approval to Depart Site

Company:		**Site:**	
Approved to leave site by		(Print Name)	Signature
Position			Date

Approval to Access Site

Company:		**Site:**	
Approved for access to site by		(Print Name)	Signature
Position			Date

APPENDIX E

VISUAL ASSESSMENT
(RESOURCE STRATEGIES, 2009)

GOLDSWORTHY IRON ORE MINING OPERATIONS - CUNDALINE AND CALLAWA MINING OPERATIONS

VISUAL ASSESSMENT

PREPARED BY
RESOURCE STRATEGIES PTY LTD

MAY 2009
Project No. BHP-07-16
Document No. 00218384

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1 INTRODUCTION

BHP Billiton Iron Ore Pty Ltd (BHPBIO) is a joint venture partner and manages the Goldsworthy Iron Ore Mining Operations (Goldsworthy) which are located approximately 200 kilometres (km) east of Port Hedland in the north of the Pilbara Region of Western Australia (Figure 1).

This visual assessment evaluates the potential visual impact of the planned mining of the Cundaline and Callawa deposits. These deposits would be developed as satellite mining operations and would use existing Goldsworthy infrastructure and facilities as far as practicable (Figure 2).

The following components are included as part of this visual assessment:

- A site inspection to identify the viewshed for the planned Cundaline and Callawa mining operations and potentially sensitive viewing locations within the vicinity.
- Characterisation of the existing visual landscape in terms of topography, existing landuse and vegetation.
- Assessment of the potential visual impacts of the planned Cundaline and Callawa mining operations on sensitive receptors, including night-lighting and the cumulative impact of existing mines in the area.
- Management of potential visual impacts.

This study includes consideration of the relevant visual impact assessment guidelines and policies of the *Statement of Planning Policy No. 2 – Environment and Natural Resources Policy* (Western Australian Planning Commission [WAPC], 2003), *Guidance Statement No. 33 - Environmental Guidance for Planning and Development* (Western Australia Environmental Protection Authority [EPA], 2008), and *Visual Landscape Planning in Western Australia* (WAPC, 2007).

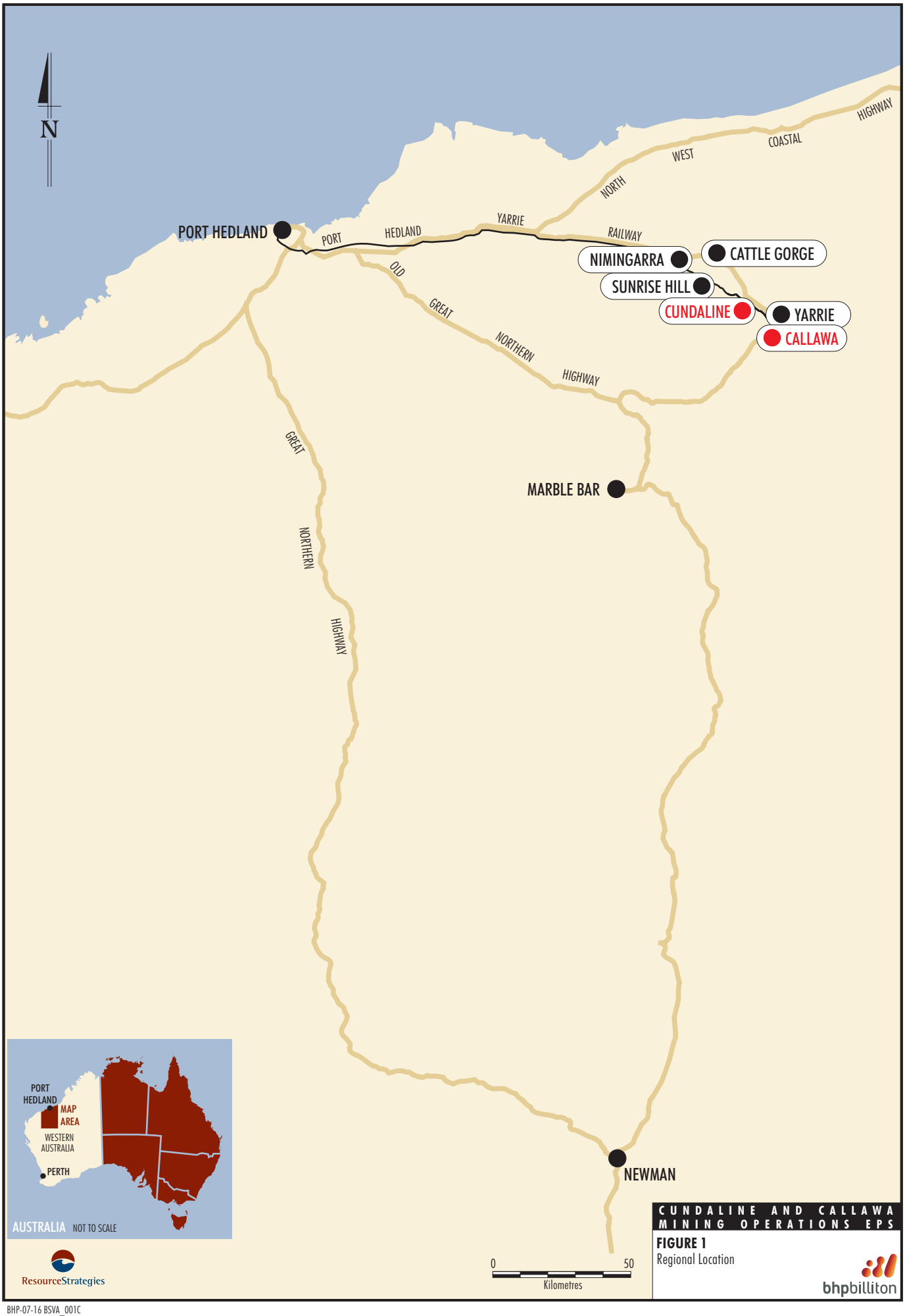
1.1 METHODOLOGY

The methodology employed for this visual assessment was based on analysis of the setting and assessment of the anticipated impacts of the planned Cundaline and Callawa mining operations. The key factors considered included:

- sensitive landuses (e.g. residential areas, public roads and natural/recreation areas); and
- the visual form, scale and colour of the development.

The methodology employed during the preparation of this visual assessment was as follows:

- Characterisation of the existing landscape and visual setting (Section 2).
- Examination of the main components and activities of the planned Cundaline and Callawa mining operations (Section 3).
- Identification of points with potential views of the planned Cundaline and Callawa mining operations (Section 4).
- Qualitative assessment of impacts (Section 4), including:
  - visual modification at key viewpoints – *How does the proposed development contrast with the landscape character of the surrounding setting?;*
  - visual sensitivity at key viewpoints – *How sensitive will viewers be to the proposed development?*; and
  - night-lighting impacts.
- Development of mitigation and management measures (Section 5).



ResourceStrategies

CUNDALINE AND CALLAWA MINING OPERATIONS EPS

FIGURE 1

Regional Location

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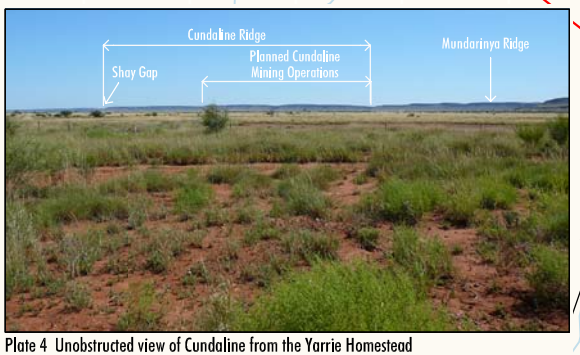

Plate 4 Unobstructed view of Cundaline from the Yarrie Homestead

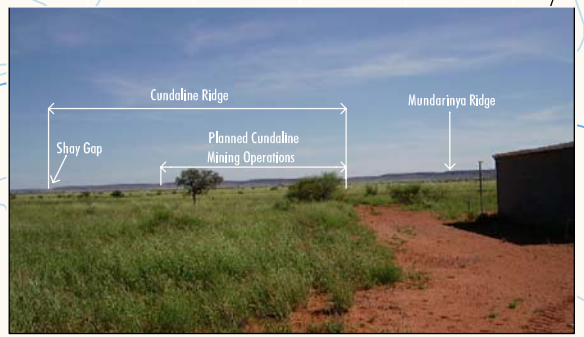

Plate 5 Obstructed view of Cundaline from the Yarrie Homestead

Source: DOIR (2007)

CUNDALINE AND CALLAWA MINING OPERATIONS EPS

FIGURE 2

Regional Location, Tenure and Viewpoints

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BHP-07-16 BSVA_1038

The methodology employed by this visual assessment is based on the United States Department of Agriculture - Forestry Service (USDA-FS) (1974) methodology and *Visual Landscape Planning in Western Australia* (WAPC, 2007). The potential visual impacts were assessed by evaluating the level of visual modification of the development in the context of the visual sensitivity of relevant surrounding landuse areas (i.e. those areas from which the proposed development may be visible) (USD-FS, 1974; WAPC, 2007) (Table 1).

Table 1
Visual Impact Matrix

Visual Modification \ Viewer Sensitivity	H	M	L
H	H	H	M
M	H	M	L
L	M	L	L
VL	L	VL	VL

Level of Visual Impact

VL = Very Low

L = Low

M = Moderate

H = High

Source: USD-FS (1974)

1.1.1 Visual Modification

The level of visual modification can be described as the level of visual contrast between the proposed development and the existing visual environment. The level of visual modification generally decreases with distance, and is categorised as follows:

- Negligible (or very low) level of visual modification – where the development is distant and/or relates to a small proportion of the overall viewscape.
- Low level of visual modification - where there is minimal visual contrast and a high level of integration of form, line, shape, pattern, colour or texture values between the development and the landscape. In this situation the development may be noticeable, but does not markedly contrast with the landscape.
- Moderate level of visual modification - where a component of the development is visible and contrasts with the landscape, while at the same time achieving a level of integration. This occurs where surrounding topography, vegetation or existing modified landscape provide some measure of visual integration or screening.
- High level of visual modification - where the major components of the development contrast strongly with the existing landscape.

1.1.2 Visual Sensitivity

Visual (viewer) sensitivity is a measure of how critically a change to the existing landscape will be viewed, and is a function of both landuse and duration of exposure (i.e. individuals will generally view changes to the visual setting of their residence more critically than changes to the visual setting of the broader setting in which they travel or work).

Landuse areas are generally characterised in terms of low, moderate or high visual sensitivity, as follows:

- Low visual sensitivity – industrial areas and local roads.
- Moderate visual sensitivity – tourist roads and major roads.
- High visual sensitivity – rural residences and natural/recreation areas.

Typical visual sensitivity levels are defined in Table 2.

Table 2
Typical Visual (Viewer) Sensitivity Levels

Use Area	Foreground (Local Setting)		Middleground (Sub-Regional Setting)		Background (Regional Setting)
	0-0.5 km	0.5-1 km	1-2.5 km	2.5-5 km	> 5 km
Natural Area – Recreation	H	H	H	M	L
Residential - Rural	H	H	M	M	L
Highways/Tourist Roads	H	M	M	L	L
Local Roads	L	L	L	VL	VL
Industrial Areas	L	L	L	L	L
Grazing Leases	M	M	L	L	VL
Mining Areas	VL	VL	VL	VL	VL

H = High, M = Moderate, L = Low, VL = Very Low
Source: EDAW Australia (2006)

2 EXISTING LANDSCAPE AND VISUAL SETTING

2.1 LOCAL LANDSCAPE CHARACTER AND SCENIC QUALITY

It has been established through previous studies that scenic quality increases as topographic ruggedness and relative relief increase (Leonard and Hammond, 1984; Burns and Rundell, 1969; Anderson *et al.*, 1976). The planned Cundaline and Callawa mining operations and surrounding areas are comprised of a number of distinct landuse types and landscape units of varying levels of landscape quality. These have been defined as follows:

- ridges and plateaus;
- plains;
- Yarrie and Muccan Stations;
- De Grey River; and
- Muccan to Shay Gap Road.

Ridges and Plateaus

The elevated landforms of the Goldsworthy area are dominated by rocky ridges and plateaus (Plates 1, 2 and 3). The ridges and plateaus rise sharply from the surrounding plains, and in many areas cliffs and steep escarpments have formed. Scree slopes typically form below the escarpments, and areas of the ridges and plateaus are heavily dissected with steep V-shaped valleys, gorges and dendritic drainage patterns.

The existing and planned iron ore deposits in the area (including the planned Cundaline and Callawa mining operations) (Figures 3 and 4) are typically located on the tops or near the edges of these features. The surrounding plains are predominantly used for cattle grazing, and grazing rarely occurs on the ridges and plateaus in the area. Several ridges in the Goldsworthy area have been modified through the existing and historical creation of mine voids and out-of-pit Overburden Storage Areas (OSAs) (Plate 3).

Plate 1: Callawa Ridge looking South-east

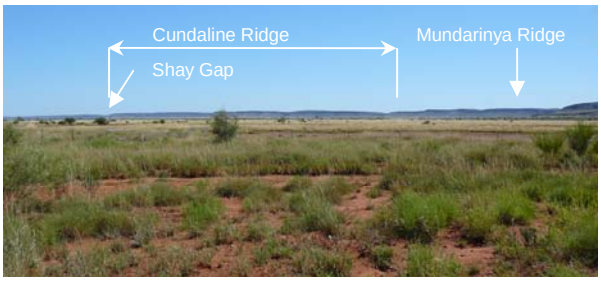
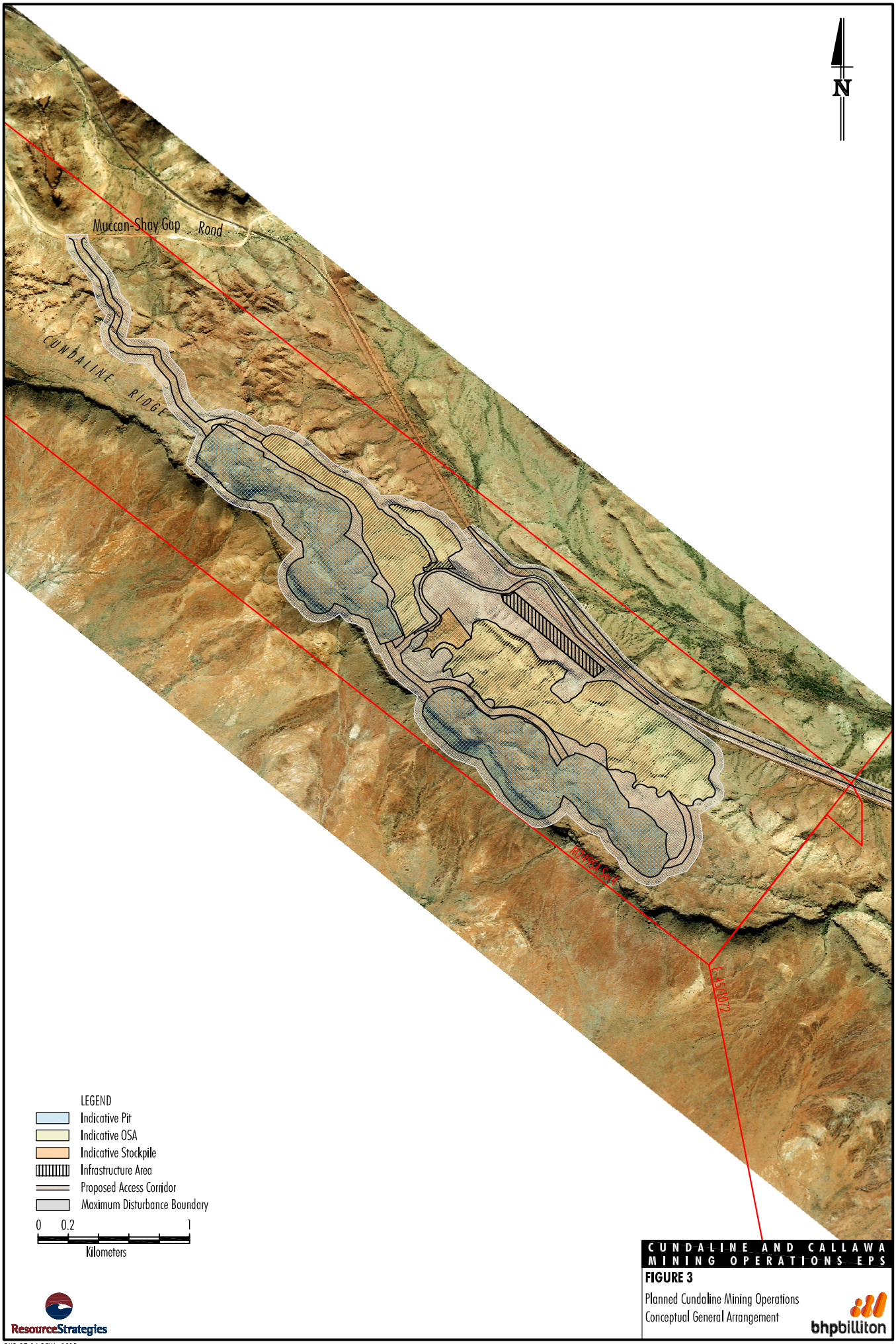


Plate 2: Cundaline Ridge from the Yarrie Homestead (looking North)

Plate 3: Nimingarra Ridge looking North



CUNDALINE AND CALLAWA MINING OPERATIONS EPS

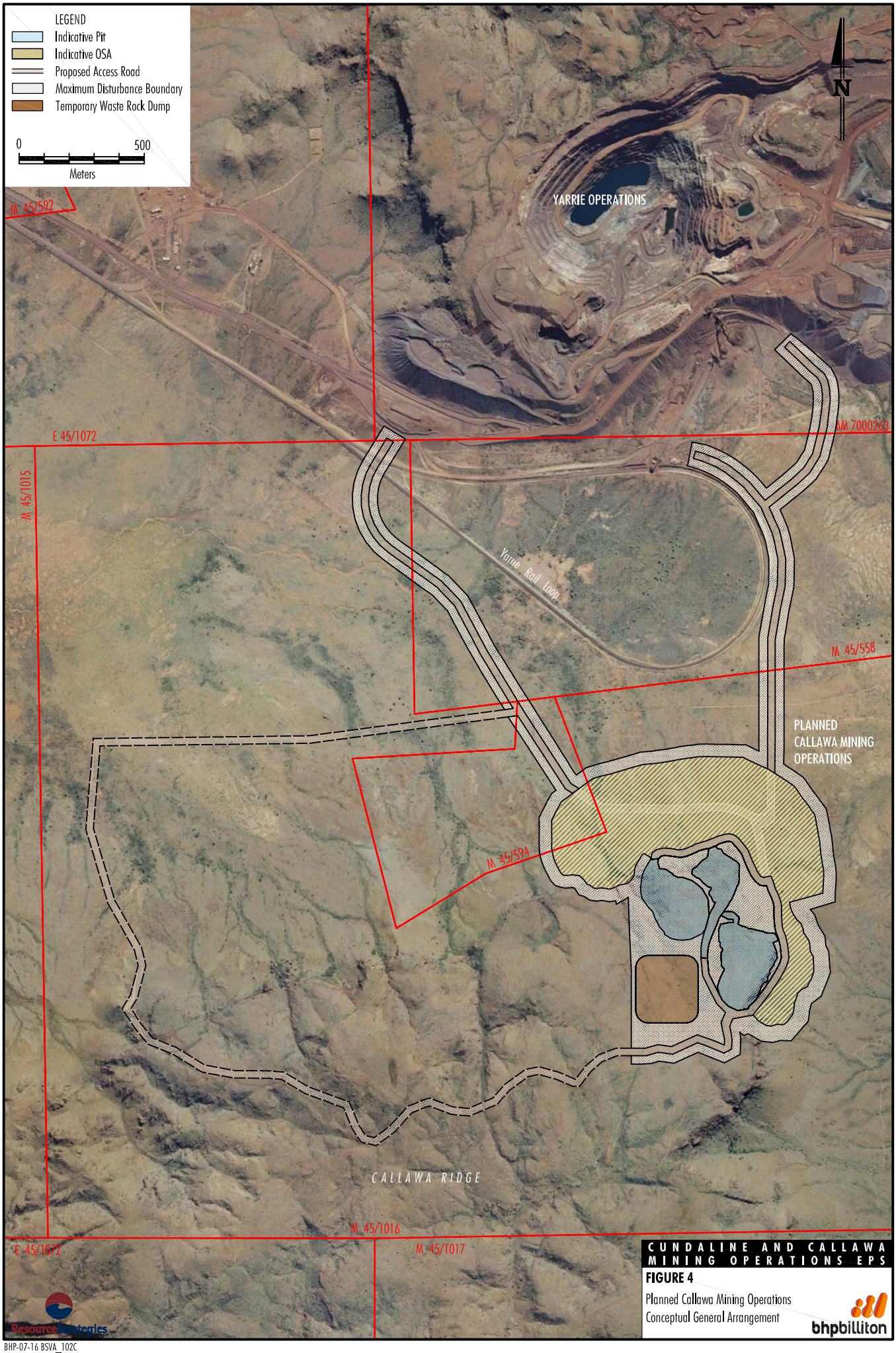
FIGURE 3

Planned Cundaline Mining Operations
Conceptual General Arrangement

ResourceStrategies

bhpbilliton

BHP-07-16 BSVA_101B



CUNDALINE AND CALLAWA MINING OPERATIONS EPS

FIGURE 4

Planned Callawa Mining Operations
Conceptual General Arrangement

bhpbilliton

Resource Industries

BHP-07-16 BSVA_102C

Plains

The ridges and plateaus are surrounded by wide plains and floodplains of the De Grey River and its tributaries. The plains adjoin scree slopes leading up to the escarpments of the surrounding ridges. To the north-east is the predominantly flat expanse of the Great Sandy Desert. The plains are used for cattle grazing. Mine-related infrastructure such as the Goldsworthy to Port Hedland railway line, airstrip, access roads and accommodation/administration areas are also located on the plains (Plate 6).

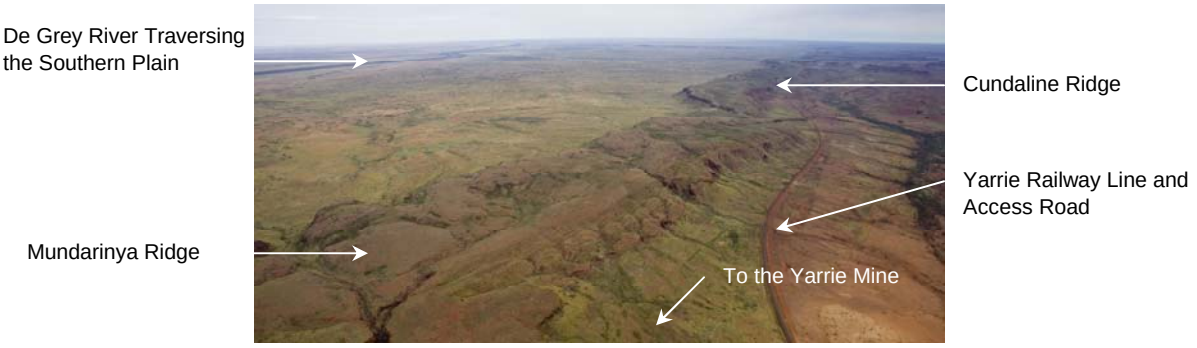


Plate 6: Cundaline Ridge and Immediate Surrounds (looking South-west)

Yarrie and Muccan Stations

These adjoining stations are privately owned and are used for cattle grazing. They are managed as a single pastoral enterprise. The current homestead for the Yarrie Station is located approximately 11 km to the south of the planned Cundaline mining operations (Figure 2). The Yarrie homestead consists of several detached dwellings and sheds. It is listed on the Register of the National Estate as the 'Yarrie Station Group', however no specific aspects relating to visual amenity are described (Commonwealth Department of the Environment, Water, Heritage and the Arts [DEWHA], 2008). Muccan Homestead, Shay Gap is also listed on the Register of National Estate (approximately 14 km south-west of the planned Cundaline mining operations), however no homestead is present at the site, and only a windmill and a water tank remain (BHPBIO, pers. comm. 23 May 2008). No aspects relating to visual amenity are described in the Muccan homestead National Estate listing (DEWHA, 2008).

De Grey River

The wide plains to the south of the Goldsworthy area gently slope towards the De Grey River, which is situated some 10 to 20 km to the south (Plate 7). The De Grey River flows in a westerly direction and is joined by a number of tributaries in the Goldsworthy area including Egg Creek, Eel Creek and Coonieena Creek which generally flow south from the ridges and plateaus of the Goldsworthy area (Figure 2).

Plate 7: De Grey River looking North-west

Muccan to Shay Gap Road

This is the only publicly accessible road in the area. It links the Great Northern Highway to the north with Marble Bar to the south. This road is used by residents, tourist road users (primarily in winter) and mining personnel. The Muccan to Shay Gap Road offers views of the Cundaline and Mundarinya Ridges to the east and north-east (Plate 8), and the Shay Gap and Sunrise Hill Ridges to the north and north-west.

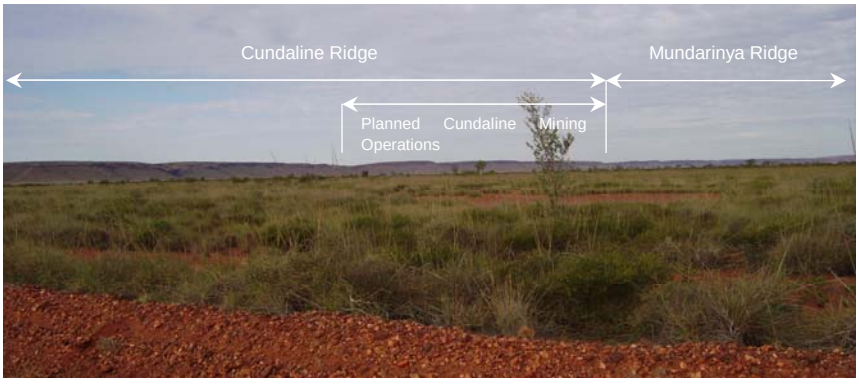


Plate 8: Cundaline Ridge from the Muccan to Shay Gap Road (looking East)

2.2 VISUAL SETTING

The visual setting is based on distance from the proposed development as follows:

- Regional Setting – greater than 5 km from the development;
- Sub-regional Setting – 1 to 5 km from the development; and
- Local Setting – up to 1 km from the development.

Regional Setting (>5 km)

At Goldsworthy, the regional setting has a moderate to high scenic quality due to the presence of the generally north-west oriented ridges and plateaus, and the presence of water (e.g. the De Grey River and its tributaries) (Plate 7).

The regional setting also has some attributes of low scenic quality due to the existing and historical Goldsworthy mining operations, which have altered the natural landforms at Nimingarra, Sunrise Hill, Shay Gap, Cattle Gorge and Yarrie through the creation of mine voids and out-of-pit OSAs. The majority of the pits have been mined into the top surface of the ridges and plateaus (i.e. rather than coming in from the side). As a result, in most cases they are not visible from the surrounding plains, and can only be clearly seen when on the ridge itself or from the air (Plate 3). Some of the open pits have been mined below the watertable. In the areas where mining has ceased, permanent lakes have developed within the pits.

The existing out-of-pit OSAs at Goldsworthy have generally been constructed near the pits by placing overburden over the edge of the natural escarpments. As a result, these OSAs are generally much more visible than the pits, although rehabilitation of the OSAs has mitigated this impact to varying degrees.

Only one non-BHPBIO owned and currently occupied residence is located in the regional area (i.e. the Yarrie homestead). The overall visual character of the regional setting is considered to be of moderate to high scenic quality, taking into account existing and historical mining operations in the regional setting.

Sub-regional Setting (1-5 km)

Within the sub-regional setting the relatively undisturbed Cundaline and Callawa Ridges, and the Mundarinya Ridge (located between the Cundaline and Callawa Ridges), have attributes of high scenic quality. The sub-regional setting also has some attributes of low scenic quality due to the development of the Goldsworthy mining operations (e.g. various mining areas and the nearby Yarrie ore processing and load-out facilities, railway, access roads, mine buildings, etc.) (e.g. Plate 3). Other modifications to this setting include the Muccan to Shay Gap Road, which cuts through Shay Gap as it winds north towards the Great Northern Highway (Figure 2). The combination of the relatively undisturbed ridgelines and developed mining operations and infrastructure in the sub-regional setting results in a moderate scenic quality.

Local Setting (<1 km)

The planned Cundaline and Callawa mining areas are almost undisturbed, however, the local setting has been slightly disturbed by exploration activities (e.g. clearing and earthworks associated with access tracks and drill pad construction). Notwithstanding this disturbance, the visual character of the local setting is considered to be of high scenic quality.

2.3 SITE TOPOGRAPHY

The planned Cundaline and Callawa mining operations are located on the south-eastern portion of the Cundaline Ridge and the north-eastern portion of the Callawa Ridge, respectively (Figure 2).

The elevation of the Cundaline and Callawa Ridges in the vicinity of the planned mining operations are 250 m Australian Height Datum (AHD) and 270 m AHD, respectively. The elevation of the surrounding plains is approximately 130 m AHD. The elevation of topographical features elsewhere at Goldsworthy ranges from approximately 280 m AHD at the Yarrie Plateau, to approximately 80 m AHD at the De Grey River south of Nimingarra. The Yarrie accommodation village lies at approximately 130 m AHD as does the Shay Gap borefield to the north on the edge of the Great Sandy Desert. Coonieena Creek at Shay Gap is at an elevation of approximately 120 m AHD (Figure 2).

3 PROJECT DESCRIPTION – VISUAL CHARACTER

3.1 OVERVIEW

Aspects of the planned Cundaline and Callawa mining operations considered to have the potential to impact on the visual landscape include:

- clearance of vegetation (approximately 450 to 500 hectares [ha]);
- modification of topographic features, including cutting into the southern face of the Cundaline Ridge (Figure 3), cutting into the north-eastern face of the Callawa Ridge (Figure 4) and construction of OSAs on top of and over the edge of natural escarpments (Figures 3 and 4);
- construction of ore stockpiles, topsoil and subsoil stockpiles;
- construction of electrical transmission lines, administration, and other associated minor infrastructure, plant, equipment and activities; and
- lighting associated with night-time mining operations.

A description of the planned Cundaline and Callawa mining operations is provided in Section 2 of the Environmental Protection Statement.

3.2 NIGHT–LIGHTING

Night-lighting is currently emitted from the following sources at the existing Goldsworthy mining operations:

- overhead lighting at the Yarrie process plant area and from other supporting infrastructure at the Yarrie and Cattle Gorge mining operations;
- fixed lights in the pits and on top of OSAs where active mining and overburden dumping is occurring; and
- mobile vehicle-mounted lights (e.g. work vehicles in various locations at Goldsworthy mining areas and access roads).

The development of the planned Cundaline and Callawa mining operations would increase the total number of light sources in the region (i.e. additional lights in the Goldsworthy area) over the mining life. The potential impacts of night-lighting associated with the planned Cundaline and Callawa mining operations are discussed in Section 5.2.

4 ASSESSMENT OF POTENTIAL VISUAL IMPACTS

4.1 SENSITIVE VISUAL SETTINGS

The main issues to consider in the assessment of visual impacts are:

- the number of sensitive viewing locations; and
- the level to which the proposed works are visible - if they are not seen, then there is no impact.

The sensitive visual receptors in the vicinity of the planned Cundaline mining operations are the Yarrie homestead and the Muccan to Shay Gap Road (Table 3). The planned Callawa mining operations will not be visible from any sensitive receptor and as such no visual impacts are predicted to occur.

Table 3
Locations of Sensitive Viewpoints

Receptor Location	Potential View of Cundaline Landforms
Yarrie homestead*	North towards the southern pit cut through the ridge, east and west OSAs.
Muccan to Shay Gap Road - south of the planned Cundaline mining operations	North-east towards the southern pit cut through the ridge, east and west OSAs.
Muccan to Shay Gap Road – north-west of the planned Cundaline mining operations	Potential partial views south-east towards the east and west OSAs.

* Refer to Figure 2

Viewpoints toward the Cundaline Ridge along the existing Yarrie access road (i.e. immediately north of the Cundaline Ridge) are only accessible to mine traffic and the visual amenity is already affected by mine-related activities. Therefore, no viewpoints along the Yarrie access road were considered sensitive receptors.

4.2 QUALITATIVE ASSESSMENT

A summary of the visual assessment locations analysed in the following subsections is provided in Table 4. The level of potential visual impact is assessed for the planned Cundaline and Callawa mining operations prior to any rehabilitation being undertaken.

Table 4
Summary of Visual Assessment

Location	Sensitivity	Visual Modification Level	Impact*	Impact After Rehabilitation
Regional Setting (Greater than 5 km)				
Yarrie homestead (Plates 4 and 5)	**L**	**L**	**L**	**L**
Muccan to Shay Gap Road - south of the planned Cundaline mining operations	**L**	**L**	**L**	**L**
Sub-Regional Setting (1 – 5 km)	**L**	**L**	**L**	**L**
Muccan to Shay Gap Road - north of the planned Cundaline mining operations	**M**	**L**	**L**	**L**
Local Setting (Up to 1 km)	**-**	**-**	**-**	**-**

* Methodology described in Section 1.1
H – High, M – Moderate, L – Low

4.2.1 Visual Impacts – Regional Setting

Yarrie Homestead

Yarrie homestead is located approximately 11 km south of the planned Cundaline mining operations. It is located close to the northern bank of the De Grey River on a plain with a slight rise in topography that runs north. There are distant views of the Cundaline Ridge from the homestead.

Level of Visual Modification

From this viewpoint, the Mundarinya, Cundaline, Shay Gap and Sunrise Hill Ridges appear as one continuous ridgeline and are dominant elements in the background. The Cundaline Ridge makes up a part of the Yarrie homestead viewshed, however views of the planned Cundaline mining operations would be partially shielded by the garden and shed located between the homestead and the ridgeline. The current landscape viewed from the homestead has not been modified by the existing Goldsworthy mining activities.

Plate 4 (in Figure 2) shows the unobstructed view of the Cundaline Ridge from the Yarrie homestead. This unobstructed view of the planned Cundaline mining operations is currently available when residents at the Yarrie homestead walk out past the shed to the north of the homestead. Plate 5 (in Figure 2) shows the shed obstructing views towards the Cundaline Ridge, and this view would be further shielded by the garden outside the front porch of the Yarrie homestead.

The visual impact at the Yarrie homestead would occur during the latter years of the planned Cundaline mining operations, when the heights of the landforms increase to their maximum elevations and the southern extent of the Cundaline Pits are developed. The visual impact of the pits and OSAs would also result in contrasting the colour and texture of the undisturbed natural areas and the newly placed and unvegetated material before rehabilitation works progress.

Due to the distance and the obstruction of views from the homestead, the planned Cundaline and Callawa mining operations would result in a low level of visual modification.

Viewer Sensitivity, Visual Impact and Cumulative Impacts

Within the regional setting (> 5 km), visual sensitivity at the Yarrie homestead would be low. A low visual modification level coupled with a low visual sensitivity would result in a low visual impact (Table 4). The views available from the Yarrie homestead have not been noticeably modified by past mining activities. Therefore, there would be no cumulative visual impacts associated with other mining activities as a result of the planned Cundaline and Callawa mining operations.

Muccan to Shay Gap Road – south of the planned Cundaline Mining Operations

The Muccan to Shay Gap Road runs approximately 11 km south of Shay Gap to the northern bank of the De Grey River. The closest (and hence most sensitive viewpoint along this road) would occur approximately 5 km to the east of the planned Cundaline mining operations. Viewers from this location would generally be residents, tourist road users and mining personnel.

Level of Visual Modification

From this viewpoint, the Mundarinya, Cundaline, Shay Gap and Sunrise Hill Ridges appear as one continuous ridgeline and are dominant elements in the background. The Cundaline Ridge only makes up a part of the Muccan to Shay Gap Road viewshed. The visual context from this viewpoint is a landscape not noticeably modified by mining activities.

The visual impact at the Muccan to Shay Gap Road would occur during the latter years of the planned Cundaline mining operations, when the heights of the landforms increase to their maximum elevations and the southern extent of the Cundaline Pits are developed. The visual impact of the pits and OSAs would also result in contrasting the colour and texture of the undisturbed natural areas and the newly placed and unvegetated material before rehabilitation works progress. Some sections of the planned Cundaline mining operations are screened by vegetation on the plain to the east of this viewpoint.

Due to the distance and the partial shielding of views from the road, the planned Cundaline and Callawa mining operations would result in a low level of visual modification.

Viewer Sensitivity, Visual Impact and Cumulative Impacts

Within the regional visual setting (> 5 km), the level of visual sensitivity would be low. A low visual modification level coupled with a low visual sensitivity would result in a low visual impact (Table 4). The views available from the Muccan to Shay Gap Road – south of the planned Cundaline mining operations have not been noticeably modified by past mining activities. Therefore, there would be no cumulative visual impacts associated with other mining activities as a result of the planned Cundaline and Callawa mining operations.

4.2.2 Visual Impacts – Sub-Regional Setting

One viewing location is located within the sub-regional setting (Table 4). The potential visual impacts of the planned Cundaline and Callawa mining operations for the Muccan to Shay Gap Road (i.e. to the north-west of the planned Cundaline mining operations) are described below.

Muccan to Shay Gap Road – North-west of the Planned Cundaline Mining Operations

The Muccan to Shay Gap Road continues north of the Cundaline Ridge towards the town of Shay Gap. The closest (and hence most sensitive viewpoint along this road) would occur approximately 1.5 km to the north-west of the planned Cundaline mining operations, however, views are shielded by the local topography. Viewers from this location would generally be local residents, tourist road users and mining personnel.

Level of Visual Modification

From this viewpoint, the Cundaline Ridge is obstructed by views of smaller rock outcroppings and low hills fanning out from the north-western extent of the Cundaline Ridge. The visual context from this viewpoint is a landscape modified by mining activities. The visual impact at the Muccan to Shay Gap Road would occur during the latter years of the planned Cundaline mining operations, when the heights of the landforms increase to their maximum elevations. Views of the pits would be minimal, if visible at all, and the Western OSA may potentially be visible from sections of the road. However, views from the north-west at this distance would be restricted, with various landforms screening potential views of the planned Cundaline mining operations.

Due to the partial shielding of views from the road, and evidence of existing mining in the area, the planned Cundaline and Callawa mining operations would result in a low level of visual modification.

Viewer Sensitivity, Visual Impact and Cumulative Impacts

Within the sub-regional visual setting (1 – 2.5 km), the level of visual sensitivity would be moderate. A low visual modification level coupled with a moderate visual sensitivity would result in a low visual impact (Table 4). The views available from the Muccan to Shay Gap Road – north-west of the planned Cundaline mining operations have been noticeably modified by past mining activities.

Cumulative visual impacts associated with other mining activities and as a result of the planned Cundaline and Callawa mining operations would remain low, due to the low visual impact already associated with existing views of past mining activities from this viewpoint (i.e. Yarrie operations access road and rail).

4.2.3 Visual Impacts – Local Setting

There are no sensitive viewers within the local setting. Therefore, the potential visual impact of the planned Cundaline and Callawa mining operations on the local setting is considered to be very low.

4.3 POTENTIAL IMPACTS OF NIGHT–LIGHTING

The visual setting is generally well-lit in the vicinity of the existing Yarrie Mine through the existing ore processing and mine-related activities. Night-lighting at the planned Cundaline and Callawa mining operations would be emitted from three main sources:

- stationary work lights;
- mobile vehicle mounted lights; and
- overhead lighting of the planned Cundaline mobile processing facilities (i.e. mobile crushing and screening plant).

Direct views of the light emitted from the planned Cundaline ore processing facilities would be shielded from sensitive receptors to the south by the Cundaline Ridge, however, light may be visible to viewers from the north-west. Direct views of light emitted from OSAs and other mining landforms at the planned Cundaline mining operations may be visible to both the southern and north-western viewpoints. Direct views of stationary work lights in the pits may be visible to southern receptors during the latter stages of mining when development starts exposing pits to southern viewpoints.

Potential night-lighting impacts on the regional settings would generally be restricted to a glow above operational areas that contrasts with the night sky. This effect would decrease with distance, however, the glow from the planned Cundaline mining operations may be visible at the Yarrie homestead, and most likely along the Shay Gap to Muccan Road. Some further light spill may occur on nights when there is a low cloud base and reflection off the cloud base occurs.

The potential impact of night-lighting on sensitive visual settings would be low given the generally large distance between light sources and sensitive receptors.

5 VISUAL/LANDSCAPE MITIGATION MEASURES AND MANAGEMENT

5.1 LANDSCAPE DESIGN AND REHABILITATION STRATEGIES

The *Goldsworthy Decommissioning and Rehabilitation Plan* (DRP) (BHPBIO, 2008a) describes the guiding closure principles and rehabilitation plan for the existing operations. It includes commitments to progressively rehabilitate mining landforms at Goldsworthy (BHPBIO, 2005). The DRP states that the rehabilitation programme would commence soon after the completion of re-profiling. After completion of final landform shaping and amelioration works, the appearance of the backfilled landforms and the exposed soils would decline as vegetation cover establishes (BHPBIO, 2005). The following visual/landscape management strategies are included in the Goldsworthy DRP and would assist in reducing the level of visual impact of the planned Cundaline and Callawa mining operations, if adopted (BHPBIO, 2005).

5.1.1 Progressive Rehabilitation and Revegetation

Mine waste rock used to construct OSAs at Goldsworthy is progressively shaped to a final landform prior to revegetation works. The objective for the final landform shaping is for it to be sympathetic with regional landforms (BHPBIO, 2005).

In accordance with the DRP, BHPBIO monitors the stability and revegetation success of the existing rehabilitated OSAs and all rehabilitation trials. The design of any future OSAs takes into consideration the success of design features and overall performance of these existing dumps and trials over time (BHPBIO, 2005).

Final pit voids typically remain when mining is complete. The mine batters are retained as rocky walls within the mine voids at the angle created during the mining process (i.e. sub vertical). These features within the void are generally comparable to natural cliffs and rocky slopes widely found in the Pilbara (BHPBIO, 2005).

BHPBIO's overall final landform concept for the mine voids is for a stepped landform which contains a combination of flat/undulating surfaces with connecting sloped ramps interspersed with elongated rocky scarps. The final design may include ramps and sloped areas so as to facilitate safe entry to the pit voids (e.g. for post-closure monitoring). In areas where the pit crest is highly visible from the plain level, the crest of the pit may be re-contoured to provide a softer profile (BHPBIO, 2005).

Once mining is completed, infrastructure would be removed for off-site reuse, recycling, or where possible resale, in agreement with the State Agreement Acts and stakeholders. Once the infrastructure is removed, the land surface would be reprofiled where necessary to integrate with the surrounding topography, prior to topsoiling and revegetation (BHPBIO, 2005).

5.2 NIGHT-LIGHTING

The following night-lighting management strategies are included in the *Goldsworthy Environmental Management Plan* and *Goldsworthy Extension Project Management Plan for Bat Species* (BHPBIO, 2008b; 2006). The measures for reducing night-lighting impacts on bats at the current Cattle Gorge mining operation were specifically developed to reduce potential impacts on a nearby cave containing bat species of conservation significance. These measures are unlikely to be necessary at either the planned Cundaline or Callawa mining operations, however they should be adopted if deemed appropriate.

Measures to mitigate potential impacts from night-lighting at the planned Cundaline and Callawa mining operations may include, but are not necessarily restricted to the following:

- restriction of night-lighting to the minimum required for operations and safety requirements where appropriate; and
- use of directional lighting techniques, or shields, where practicable.

In the event that night-lighting is considered to be causing adverse impacts on visual amenity, a review of the situation should be conducted and contingency measures implemented where necessary. These measures could include: adjusting the locations of night-lights, screening of lighting point sources, including on/off switches, using light dimmers or low irradiation globes.

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APPENDIX F

SURFACE WATER ASSESSMENT (AQUATERRA, 2008)

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GOLDSWORTHY IRON ORE MINING OPERATIONS - CUNDALINE AND CALLAWA MINING OPERATIONS

SURFACE WATER ASSESSMENT

Prepared for: BHP Billiton Iron Ore Pty Ltd

Ref: 980B/215d
Oct 2008

GOLDSWORTHY IRON ORE MINING OPERATIONS
CUNDALINE AND CALLAWA MINING OPERATIONS
SURFACE WATER ASSESSMENT

Document Status

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Originator:	Vince Piper	Principal Civil/Water Resources Engineer		31 Oct 2008
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EXECUTIVE SUMMARY

BHP Billiton Iron Ore Pty Ltd's (BHPBIO's) exploration programme has identified iron ore deposits at the Cundaline and Callawa ridgelines which are proposed to be developed as satellite mining operations and use the existing Goldsworthy Iron Ore Mining Operations infrastructure and facilities as far as practicable.

Aquaterra Consulting Pty Ltd has been commissioned to undertake a surface water study for the planned Cundaline and Callawa mining operations as supporting documentation to the environmental impact assessment. This report describes the existing surface water resources, identifies the potential impacts of the planned Cundaline and Callawa mining operations on natural drainage systems and discusses management strategies to minimise the impact of the planned Cundaline and Callawa mining operations on drainage systems.

Planned pit and overburden stockpile area (OSA) developments within the planned Cundaline and Callawa mining operations have the potential to impact surface water resources by changing local surface water flow patterns, by affecting surface water runoff volumes and quality, by causing erosion from disturbed areas with downstream sedimentation or by contamination from chemicals/hydrocarbons.

The planned pits are located along the tops of ridge lines and mine plans indicate that minimal if any upstream external catchments would be intercepted by the open pit developments. Where external catchment diversion is required (and is feasible), diversion bunds/channels would be installed. In other areas, pit perimeter safety bunding would be installed. During operations, excess stormwater collected in the pits will be treated to remove the sediments and would then typically be used for ore processing and dust suppression, with any excess discharged to the environment under relevant licence conditions.

The combined Cundaline and Callawa pits intercept a total catchment area of 141 hectares (ha) (1.41 square kilometres [km^2]). Compared with the total Eel Creek's natural catchment area of approximately 500km^2 and the De Grey River's catchment area of approximately of 50,000km^2, the potential loss of runoff volume to the downstream creek systems, due to the pit developments, is not significant to the overall hydrological system, particularly in comparison to the natural seasonal variations in catchment runoff.

Internal runoff from the OSAs is collected by the perimeter bunding and discharged via a sediment basin to the downstream environment. Loss of runoff volume from the OSA structures is estimated to be negligible.

The mining activities will potentially mobilise additional sediments to the natural drainage systems with the main potential sediment sources being the OSAs and ore stockpiles. The most effective method of sediment management is limiting vegetation disturbance and creating stable landforms, however, where sediment is created it will be controlled close to the source. Sediment basins are a means to control surface water sediment, and bunds and sediment basins should be constructed down slope of all OSAs and stockpiles (as appropriate) to manage this issue. The final locations and layouts for these works will need to be determined in association with the detailed mine plans.

BHPBIO will install appropriate diversions and bunding around the mining areas, including sediment basins, as required, downstream of OSAs, stockpiles and other disturbed areas. Any water released off the site will meet relevant licence conditions. The planned Cundaline and Callawa mining operations will have a

localised effect on the surface water runoff through the redirection of flow and the development of voids which may intercept minor drainage lines and collect surface water. Surface water management strategies will be implemented to ensure negligible impact on local surface water resources.

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SECTION 1 - INTRODUCTION

1.1 PROJECT BACKGROUND AND LOCATION

BHP Billiton Iron Ore Pty Ltd (BHPBIO) operates the Goldsworthy Iron Ore Mining Operations (Goldsworthy) which are located approximately 200 kilometres (km) east of Port Hedland in the north of the Pilbara region of Western Australia (Figure 1).

The development of Goldsworthy has been conducted in phases over the past 50 years. The Mount Goldsworthy Mine was the first mining operation and commenced in the mid 1960s. Once it was mined out, the operations were progressively expanded to other Goldsworthy deposits that include the Shay Gap, Nimingarra, Sunrise Hill, Yarrie and Cattle Gorge deposits. Ore processing and rail loading occurs at facilities located at Yarrie and Nimingarra.

The current mining operations are centred at Yarrie, with some mining still taking place at the Nimingarra, Cattle Gorge and Sunrise Hill deposits (Figure 2). The Mount Goldsworthy and Shay Gap mining areas are no longer operational, with the majority of activities at these sites directed towards the monitoring and maintenance of rehabilitated landforms.

BHPBIO's Goldsworthy operations are conducted under the *Iron Ore (Goldsworthy) Agreement Act, 1964*, and the *Iron Ore (Goldsworthy-Nimingarra) Agreement Act, 1972*. Environmental requirements for the operations are specified in the "Goldsworthy Extension Project Notice of Intent" (Goldsworthy Mining Limited, 1986), and the conditions of Ministerial Statement's No. 000303 and No. 000682, issued by the Minister for the Environment under Part IV of the Western Australia *Environmental Protection Act, 1986* (EP Act), and Licences 5561 and 4412 issued under Part V of the EP Act.

BHPBIO's exploration programme has identified iron ore deposits at the Cundaline and Callawa ridgelines (Figure 2). The Cundaline and Callawa deposits are proposed to be developed as satellite mining operations and would use the existing Goldsworthy infrastructure and facilities as far as practicable.

Major components of mining infrastructure and activities at the planned Cundaline and Callawa mining operations would include:

- pre-stripping, open pit mining and stockpiling of overburden and ore at the Cundaline and Callawa pits;
- placement of overburden in mined-out voids and out-of-pit overburden stockpile areas (OSAs) adjacent to the Cundaline and Callawa pits;
- trucking of the Callawa ore to the Yarrie crushing, screening and rail loading facilities, which are located approximately 2km to the north;
- trucking of the Cundaline ore to the Yarrie crushing, screening and rail loading facilities, which are located approximately 12km to the south-east, or use of a mobile crushing and screening plant to be located at the Cundaline area;
- stockpiling, crushing, screening and load-up of iron ore at the Yarrie processing facilities and/or the mobile Cundaline facilities;

- continued groundwater abstraction from the Shay Gap borefield to meet operational demands, and distribution through the existing water supply system and pipeline extensions to the Cundaline and Callawa areas;
- construction and use of small day rooms, workshop facilities and storage areas at the Cundaline and Callawa areas;
- supply of power to the facilities at the Cundaline and Callawa areas either via connecting electricity lines from the existing power network, or use of on-site diesel generators; and
- construction and use of haul and access roads to the Cundaline and Callawa areas.

The general arrangements of the planned Cundaline and Callawa mining operations are shown on Figures 3a and 3b, respectively.

1.2 SCOPE OF THE ASSESSMENT

BHPBIO commissioned Aquaterra Consulting Pty Ltd (Aquaterra) to undertake a surface water assessment for the planned Cundaline and Callawa mining operations. The scope of works for this assessment comprises:

- Characterisation and description of existing surface water resources.
- Identification of potential impacts of the planned Cundaline and Callawa mining operations on natural drainage systems.
- Discussion of management strategies to minimise the impact of the planned Cundaline and Callawa mining operations on the drainage systems.

2.1 CLIMATE

Western Australia has three broad climate divisions. The northern part is dry tropical and the south-west corner has a Mediterranean climate, with long, hot summers and wet winters. The remainder is mostly arid land or desert climates.

The Pilbara region is characterised by an arid climate resulting from the influence of tropical maritime and tropical continental air masses, receiving summer rainfall. Cyclones occur during this period, bringing heavy rain, causing potential destruction to inland and coastal towns.

2.2 TEMPERATURE

The Pilbara region has an extreme temperature range, potentially rising to 50 degrees Celsius (°C) during the summer, and dropping to around 0°C in winter (Bureau of Meteorology [BOM], 2008). Mean monthly maximum temperatures at Marble Bar range from over 40°C in January to 27°C in July, while mean monthly minimum temperatures range from 26°C in January to 12°C in July (BOM, 2008). The mean monthly maximum temperatures on the coast at Port Hedland are 36°C in January and 27°C in July and mean minimum temperatures are 26°C in January and 12°C in July (BOM, 2008). High summer temperatures and humidity seldom occur together, giving the Pilbara its very dry climate.

2.3 RAINFALL AND EVAPORATION

The Pilbara region has a highly variable rainfall, which is dominated by the occurrence of tropical cyclones mainly from January to March. The moist tropical storms from the north bring sporadic and drenching thunderstorms. With the exception of these large events, rainfall can be erratic, and localised, due to thunderstorm activity. Therefore, rainfall from a single site may not be representative of the spatial variability of rainfall over the entire catchment during an event. The driest months are typically September to November.

During the winter months, cold fronts move in an easterly direction across Western Australia and sometimes reach the Pilbara region producing light rains.

The annual average rainfall at Yarrie Station (1898 to 2008) (BOM, 2008), located close to the planned Cundaline and Callawa mining operations, is 356 millimetres (mm). This is slightly higher than Port Hedland, which has an annual average rainfall of 313mm (BOM, 2008). Variability is high with annual rainfall varying between 39mm (1924) and 1120mm (2000).

The mean annual pan evaporation rate in the planned Cundaline and Callawa mining operations area is estimated at about 3500mm (Department of Agriculture, 1987), which exceeds annual rainfall by over 3000mm. Average monthly pan evaporation rates vary between a minimum 200mm in June and a maximum 400mm in December.

2.4 STREAMFLOW

Streamflow in the Pilbara region is directly correlated to rainfall, with the majority of streamflow occurring during the summer months of December through to March. Streamflow in the smaller flow channels is typically short in duration, and ceases soon after the rainfall passes. In the larger river channels, which drain the larger catchments, runoff can persist for several weeks and possibly months following major rainfall events such as those resulting from tropical cyclones.

Streamflow gauging stations are widely spaced in the Pilbara region, with none located near the immediate Goldsworthy area. The nearest gauging station is on the Coongan River at Marble Bar (Western Australia Department of Water [DoW] gauge S710204) located approximately 80km south from the planned Cundaline and Callawa mining operations. Another gauging station is on the De Grey River at Coolenar Pool (DoW gauge S710003) located approximately 100km west from the planned Cundaline and Callawa mining operations. These gauging stations record streamflow from approximately 3,700 square kilometres (km^2) and 50,000km^2 catchments, respectively. However, due to relative catchment sizes and locations, these streamflow data do not necessarily represent the runoff within the planned Cundaline and Callawa mining operations.

Peak streamflow discharges from ungauged catchments in the Pilbara region can be estimated using empirical techniques, such as those recommended in “Australian Rainfall and Runoff” (Institute of Engineers, 1987).

3.1 DE GREY RIVER

The Goldsworthy operations are located within the De Grey River catchment, with the Cundaline and Callawa deposits located on ridgelines around 5 to 10km north from the main river channel. The locations of the Cundaline and Callawa deposits relative to the De Grey River system are shown on Figure 4.

The De Grey River is a major river system that flows in a general north-western direction to discharge on the coast about 60km east of Port Hedland. The De Grey River receives discharges from several large rivers including the Strelley River, Shaw River, Coongan River, Nullagine River and Oakover River, and drains a total catchment area of approximately 50,000km^2. A photograph showing low flow in the De Grey River is given in Plate 1.

Water quality in the De Grey River is measured at the Coolenar Pool gauging station (DoW gauge S710003) located around 100km west from the Cundaline and Callawa deposits. Monitoring data from this station indicates that the river typically has a salinity of between 200 and 1200 milligrams per litre (mg/L) making the water suitable for multiple uses. Within the general Cundaline and Callawa area, there are no known users of surface water, and beneficial use is understood to comprise in-stream support for native flora and fauna, and opportunistic use by stock.

Plate 1
Low Flow in the De Grey River

3.2 EEL CREEK

The Cundaline and Callawa deposits are predominantly located within the Eel Creek catchment which drains southwards into the De Grey River (Figure 5). The Eel Creek catchment extends to around 30km north of the De Grey River and has a total catchment area of approximately 500km^2. The ore deposits and planned mine infrastructure are located on rocky ridgelines and adjacent plains which characterise the southern portion of the catchment, whereas the northern catchment area comprises mainly sandy plains with some isolated rocky outcrops.

The locations of the planned Cundaline pits and OSAs relative to the natural drainage systems are shown on Figure 6. The three planned pits (10K, 13K and 14K) are located on the crest of the ridge with external drainage around the pit perimeters either draining northwards into the Eel Creek catchment or southwards away from the Eel Creek catchment directly towards the De Grey River via a collection of smaller creeks. Locally these smaller creeks have a collective catchment area of around 150km^2 draining towards the De Grey River. The two planned OSAs (10K and 13/14K), stockpile and associated infrastructure are located on the northern side of the ridge crest within the Eel Creek catchment. Drainage from these areas drains northwards into an eastwards flowing tributary to Eel Creek. The Cooneeina Creek lies to the north from the Cundaline deposit and all planned Cundaline pits and OSAs are located outside of this catchment area.

The locations of the planned Callawa pits and OSA relative to the natural drainage systems are shown on Figure 7. The three planned pits (A, B and C) are located on the edge of the ridge with external drainage around the pit perimeters either draining northwards into the Eel Creek catchment or eastwards away from the Eel Creek catchment into an un-named creek. This un-named creek drains southwards to the De Grey River and has a total catchment area of around 80km^2. The planned Callawa OSA wraps around the north and east sides of the planned pits with external drainage discharging either northwards into the Eel Creek catchment or eastwards into the same un-named creek. A temporary waste rock dump is planned to be constructed to the southwest of the planned pits and within a small catchment draining northwards towards the planned OSA.

The existing Yarrie Mine and associated infrastructure are located across the Kimberley Gap north of the Callawa deposit (Figure 7) and are also predominantly located within the Eel Creek catchment, though a small portion does drain eastwards then southwards into the above defined un-named creek. The existing Cattle Gorge Mine (Figure 2) is also fully located within the Eel Creek catchment. Drainage from the existing mine site developments for Shay Gap (closed), Sunrise Hill and Nimingarra (Figure 2) drains to the De Grey River via different creek systems.

4.1 POTENTIAL IMPACTS FROM MINING ACTIVITIES

Potential surface water impacts associated with the planned activities include:

- Interruption to existing surface water flow patterns.
- Increased risk of erosion and sedimentation.
- Contamination of surface water by chemicals or hydrocarbons.

4.2 INTERRUPTION TO EXISTING SURFACE WATER FLOW PATTERNS

Interruption to the natural surface water flow patterns has the potential to reduce and in some cases, locally increase the surface water runoff volume. The potential secondary impact of changes to the surface water runoff volumes is the impact on the ecology of vegetation communities which rely on streamflow and sheetflow.

The natural flowpaths around the planned Cundaline and Callawa mining operations and the existing Yarrie Mine all drain to the De Grey River, as shown in Figure 5. It is noted that the existing mining infrastructure developed for the Yarrie Mine already impacts on the natural drainage systems. Natural flowpaths in the area have been diverted and the impacts are being managed.

The planned Cundaline 10K, 13K and 14K pits will be developed on the crest of the Cundaline Ridge, as shown in Figure 6. Being constructed on a ridge crest, the planned pit developments will have no external catchments and will not block any external catchment runoff from draining to the valley floors. However, the area occupied by the pit developments will be inwardly draining, capturing incident rainfall, and reducing the volume of rainfall runoff discharging to the natural drainage systems. Stormwater captured in the pits will tend to seep into the pit floor with the excess removed by pumping. Where viable, the pumped water will be used for dust suppression with the remainder discharged (after treatment) back into the natural drainage system. If all of the collected in-pit water was pumped back to the environment, there would be no water loss to the natural hydrological cycle. However, as some water will likely be lost to groundwater seepage and some used for dust suppression (likely to be small as dust suppression volumes are relatively small compared to a main runoff event), there will be a net water loss from the surface water system.

The planned Cundaline 10K and 13/14K OSAs and associated stockpile will be developed on the upper north flank of the Cundaline Ridge just downgradient from the planned pits, as shown in Figure 6. With this layout, there will effectively be no external catchment upgradient from the OSAs, as the upgradient area will be occupied by the pits. Although the OSAs will block the natural drainage system under their footprint, internal runoff from the OSAs will be collected by the perimeter bunding and discharged via a sediment basin to the downstream environment. Loss of runoff volume from the OSA areas to the downstream environment is estimated to be negligible, though there will be some redistribution of the runoff. A drainage corridor will be maintained, between the two OSAs, to enable stormwater runoff to drain to the downstream areas.

The planned Callawa A, B and C pits will be developed on the crest of the Callawa Ridge, in the north-east corner, as shown in Figure 7. These three pits are located together on a high level spur and collectively they potentially block a small external catchment area. Hence the pit developments will potentially block runoff from a minimal external catchment area from draining off the ridge. Additionally as with all pits, the area occupied by the pit developments will be inwardly draining, capturing incident rainfall, and reducing the volume of rainfall runoff directly discharging to the natural drainage systems. Stormwater captured in the three pits will tend to seep into the pit floors with the excess removed by pumping. Where viable, the pumped water will be used for dust suppression with the remainder discharged (after treatment) back into the natural drainage system.

The planned Callawa OSA wraps around the north and east sides of the planned Callawa pits on the north-east corner of the Callawa Ridge, as shown on Figure 7. As the OSA will be just downgradient from the planned pits, there will be minimal external catchment upgradient from the OSA adjacent to the pits. However the planned OSA will intercept a small external catchment located to the west of the pits and containing a temporary waste rock dump. Runoff from this catchment will be diverted around the OSA and discharged via a sediment basin to the downstream environment. Although the OSA will block the natural drainage system under its footprint, internal runoff from the OSAs will be collected by the perimeter bunding and discharged via a sediment basin to the downstream environment. Loss of runoff volume from the OSA areas and intercepted external catchments to the downstream environment is estimated to be negligible, though there will be some redistribution of the runoff.

The planned Cundaline pit development areas and the estimated maximum catchment areas intercepted (not diverted) by the pit developments total 125 hectares (ha). Similarly for the planned Callawa pit developments, the estimated pit and intercepted catchment areas total 16ha. The planned combined Cundaline and Callawa pits intercepted areas total 141ha (1.41km^2). Although during mining operations, runoff water will be removed by pumping from the pit, on closure this pumping would cease. Assuming 100% runoff loss from the pit and intercepted upslope catchment areas, then the effective runoff volume loss from the Eel Creek and De Grey River catchment is that from the total 1.41km^2 intercepted area. This compares with the total natural catchment to Eel Creek of around 500km^2 and the total De Grey River catchment of around 50,000km^2. Hence, the potential loss of runoff volume to the downstream creek systems, due to the pit developments, is not significant to the overall hydrological system, particularly in comparison to the natural seasonal variations in catchment runoff.

A haul road and access road will be constructed to transport ore from the planned Callawa pits to the existing Yarrie crushing, screening and rail loading facilities located approximately 2km to the north (Figure 3b). These roads will cross several minor drainage lines.

A haul road may also be constructed to transport ore from the planned Cundaline pits to the existing Yarrie crushing, screening and rail loading facilities located approximately 12km to the south-east. If constructed this haul road would run along the same general alignment as the existing railway route directly to the Yarrie processing facilities. Eel Creek and several drainage lines would be crossed by the haul road.

Runoff from the planned Cundaline and Callawa OSAs is collected by the perimeter bunding and discharged via sediment basins to the downstream environment. Loss of runoff volume from the catchment areas containing the OSA structures is estimated to be negligible.

4.3 INCREASED RISK OF EROSION AND SEDIMENTATION

Runoff from the planned OSAs and other disturbance areas has the potential to significantly increase erosion within the development areas and sediment loads in the natural drainage systems, if appropriate management measures are not implemented.

4.4 CONTAMINATION OF SURFACE WATER BY CHEMICALS OR HYDROCARBONS

Spillage of chemicals or hydrocarbons from storage and/or transfer areas is possible if appropriate control measures and operating procedures are not used.

5.1 GENERAL MANAGEMENT OBJECTIVES

Surface water management objectives for the planned Cundaline and Callawa mining operations include 'general objectives' which primarily relate to operational management activities, and 'closure objectives' which relate to rehabilitation, decommissioning and mine closure.

5.1.1 General Surface Water Management Objectives

- To prevent or minimise impacts on the quality of surface water resulting from mining operations and contain any contaminated water on-site.
- To ensure that the quality of water returned to local and regional surface water resources will not result in significant deterioration of those resources.

5.1.2 Closure Surface Water Management Objectives

- Baseline surface water quality and flow regimes in Eel and Egg Creek will be maintained.

The following sub-sections describe management strategies that will be used by BHPBIO to meet the above management objectives, and to minimise the potential impacts identified in Section 4.

5.2 EXISTING GOLDSWORTHY SURFACE WATER MANAGEMENT AND MONITORING

5.2.1 Existing Environmental Management Programme

In 1993 BHPBIO prepared and implemented a Water Management Plan for the Yarrie mining operations in order to satisfy Condition 3-1 of Ministerial Statement of Approval No. 000303. The 1993 Water Management Plan described the surface water and groundwater management and monitoring procedures for Yarrie, as well as potential impacts to groundwater resources and long-term management procedures for pit salinity development. Since mining activities at Yarrie are now substantially completed, a large proportion of the monitoring and management measures contained in the 1993 Water Management Plan are no longer relevant (e.g. construction water management, monitoring of pit dewatering). However, the Plan does contain relevant information regarding post closure water management (in particular, the management of pit lake water quality at Y2/3).

An Environmental Management Plan (EMP) has been prepared to satisfy the relevant conditions of Ministerial Statement of Approval No. 000682 (issued in August 2005), and the relevant conditions included in Ministerial Statement of Approval No. 000303 (issued in February 1993). The EMP describes the overall environmental management programme that will be used to manage potential impacts of Goldsworthy on environmental aspects relevant to the site. These include soil resources, landforms, surface water, groundwater, air quality, noise, flora, fauna and Aboriginal heritage. For each aspect, the EMP identifies potential impacts, establishes management objectives, outlines relevant strategies/practices/procedures to minimise impacts, establishes performance indicators and sets out monitoring requirements.

BHPBIO has current licences to discharge excess water generated by mine dewatering activities into the creeks adjacent to the Sunrise Hill - Nimingarra and Yarrie mining areas. The water is transferred to the approved discharge points from turkeys nest dams that act as stilling ponds to reduce sediment loads prior to discharge.

5.2.2 Existing Surface Water Monitoring Programme

Water samples are collected from discharge points to assess compliance with the requirements of the EP Act Licences and at locations upstream and downstream of the mining areas. The existing surface water monitoring programme for Goldsworthy is summarised in Table 5-1.

Mining at the planned Cundaline pits will be above the watertable and no dewatering will be required, however, as mining is planned to extend below the watertable at the planned Callawa pits some minor dewatering will be required. The planned Callawa mining operations dewatering discharges will be used for dust suppression and a licence for discharge to the environment is not required.

Table 5.1
Surface Water Monitoring Programme

Area/Aspect to be Monitored	Parameter	Location	Frequency
Mine Dewatering Discharge[1,2]	Flow Rate	Sunrise Hill West 7 (SHW7) Nimingarra B (Nim B) Nimingarra I (Nim I) Nimingarra F East (Nim FE) (emergency discharge point) West Nimingarra B (emergency discharge point) Y2/3 Y10 W1 (contingency discharge point)	Continuous
	Water Quality[a]	Sunrise Hill West 7 (SHW7) Nimingarra B (Nim B) Nimingarra I (Nim I) Y2/3 Y10	Quarterly (Nov, Feb, May, Aug)
	Water Quality[a]	West Nimingarra B (emergency discharge point) Nimingarra F East (Nim FE) (emergency discharge point) W1 (contingency discharge point)	Monthly (during discharge periods)
Stormwater Discharge from Hydrocarbon Storage Area[1]	Total Petroleum Hydrocarbon (TPH) Concentration	Hydrocarbon storage areas	Event Basic (as required)
Surface Water at Egg Creek, Eel Creek, Yarrie OSA[3]	Water Quality[a]	Egg Creek (NMSW003 and NMSW004) and Eel Creek (YASW005 and YASW006), base of the Yarrie W1 OSA (YASW003) and Chinaman Springs (YASW001), Cattle Gorge Creek	Quarterly (when surface flow is present)
Water Use Efficiency[3]	Site Water Balance	Calculate	Annual
Erosion and Sediment Control	Integrity of mine landforms and water management structures	All active and rehabilitated mine landforms and disturbance areas.	After major rainfall events

[1] Programme required as per EP Act Licence No. 4412.
[2] Programme required as per EP Act Licence No. 5611.
[3] Programme internally developed and implemented by BHPBIO.
[a] Water Quality Suite: pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), As, Cr, Cd, Cu, Hg, Mn,

Two existing surface water monitoring sites have been established on Eel Creek. No additional sampling sites are likely to be required as a result of the planned Cundaline and Callawa mining operations.

5.3 GENERAL WATER MANAGEMENT STRATEGIES

The planned Cundaline and Callawa mining operations would have a localised effect on the surface water runoff through the redirection of flow and the development of voids which may intercept minor drainage lines and collect surface water. The implementation of the management strategies outlined below is expected to result in a negligible impact on local surface water resources.

Experience in the Pilbara region has found that the following general surface water management strategies can be used to effectively manage mining related impacts on the hydrological conditions of the region:

- Limiting Clearing: Vegetation is the most effective method of minimising erosion and sedimentation. Initial clearing would be limited to areas of workable size actively being used for construction.
- Vehicle Movements: Keep vehicle movements to the minimum necessary and use existing tracks where possible.
- Buffer Zones: Adequate buffer zones should be provided between the areas of disturbance and the natural drainage lines where possible; to place a high priority on the protection of natural drainage lines from impacts resulting from construction activities.
- Dry Season Construction: Construction on or near natural flowpaths to be planned for the dry season where practicable. Temporary stabilisation measures should be used in high erosion risk zones.
- Topsoil Storage: Topsoil to be stored such that it is protected from internal rainfall and runoff by temporary vegetation or mulching, and protected from external runoff by diversion banks/catch drains. Topsoil should also be located away from drainage lines and upstream of sediment basins.
- Separate Flowpaths: Flows from undisturbed areas should be kept separate from disturbed areas.
- Upstream Diversions: Where feasible, upstream surface water flows to be diverted around structures with appropriate grades into adjacent or downstream defined surface water flow pathways.
- Flow Dispersion: If it is necessary for flow diversions to discharge to sheet flow zones, the diverted surface water should be discharged over spreader mechanisms (e.g. a riprap pad) to encourage the flows to slow and disperse.
- Bunding: All waste dumps and stockpiles have the potential to generate sediment laden runoff water which may require treatment in sediment basins prior to discharge to the environment. Bunding should be provided as appropriate to contain internal surface water runoff for treatment, plus to divert external surface water runoff.
- Culverts: Culverts should be installed where haul and access roads cross main creeks to allow drainage to pass.
- Sediment Basins: Sediment basins should be designed and implemented as required, to intercept sediments and limit their transportation downstream. They should be located within drainage lines downstream of active mine areas, waste dumps and other disturbance areas, and sized appropriately for the rainfall events and catchment area. Sediment basins are generally more effective when they are

located close to the source of sediment, and the sediment laden water is not allowed to mix with the "clean water" (so as to reduce the volume of water to be treated).

- Temporary Works: Surface runoff from disturbed areas will typically contain some sediment, and may also include pollutant loads such as oil and grease. Temporary erosion and sediment control structures should be provided such as diversion banks, drains and sediment traps.
- Internal Stormwater Provisions: Internal stormwater runoff in the development areas may cause localised flow velocity increases around the mine infrastructure, as water is concentrated in diversion channels, or alongside flood bunds or raised pads. This flow is to be handled by the internal stormwater provisions for the developed areas. Formalised drainage networks to be installed in plant site areas.
- Hydrocarbon Management: Hydrocarbon storage areas to be bunded. Potentially hydrocarbon polluted runoff to be directed to basins fitted with baffle mechanisms (e.g. underflow/overflow baffle weirs) to trap possible pollutants before discharge to the downstream environment.

5.4 SURFACE WATER DIVERSIONS

Diversion requires a combination of bunding and excavated channels to carry runoff via a flowpath different from the natural water course. The diverted water is directed into a defined water course, preferably the original water course at a point downstream. Energy may need to be removed from the flow at the entry point (e.g. riprap lining) to match the receiving channel characteristics.

The design capacity selected for the constructed diversion depends on the impacts of failure of the diversion. If there are potential adverse impacts of flood flow in areas normally flood free, or on other mine infrastructure or the environment, then diverted water needs to remain confined within its diversion (e.g. 100 year Average Recurrence Interval [ARI] capacity). If flood flow in areas normally flood free is acceptable or otherwise only represents nuisance flows, then a lesser ARI capacity and less costly diversion (e.g. two year ARI capacity) may be suitable.

Where diversion structures are required, bunding should typically consist of a level top section (minimum) 3 metres (m) wide with side batters of 1:2.5, and be built to an engineering specification using competent materials. Bunding dimensions should be capable of containing or diverting runoff flows up the design flood event, in combination with the diversion channel, where provided, plus a freeboard allowance. Excavated channels should typically have side batters of 1:2 and be of sufficient bottom width and depth to contain the design flood event. Larger flows would overtop the channel and potentially become overbank flow.

5.5 SEDIMENT BASINS

The planned Cundaline and Callawa mining operations would potentially mobilise additional sediments to the natural drainage systems with the main potential sediment sources being the OSAs and stockpiles. The most effective method of sediment management is limiting vegetation disturbance and creating stable landforms, however, where sediment is created it will be controlled close to the source. Sediment basins are a means to control surface water sediment, and should be constructed down slope of all OSAs and stockpiles (as appropriate) to manage this issue. Sediment basins should be used in conjunction with erosion minimisation strategies such as vegetating batters and engineered drainage systems.

Sediment basins collect internal runoff and treat to remove sediments to acceptable levels prior to release to the natural environment. Bunds and drainage diversion works would be constructed around the perimeter of all OSAs and stockpile areas, to divert and prevent natural runoff from outside the development sites from mixing with internal site runoff. Basins are typically located at a low point on the infrastructure perimeter and constructed by a combination of excavation and earth bunds. For design of the sediment basins, a target sediment size of medium sized silt particles > 0.02mm (20 micrometres [µm]) is common for the design storm event. The sediment trap is then expected to be effective in removing sand and medium to coarse silt. The removal of fine silt and clay is generally not as effective.

5.6 SPECIFIC CUNDALINE AND CALLAWA SURFACE WATER MANAGEMENT WORKS

Surface water management measures have been implemented in the existing Goldsworthy mining areas. Management works for the planned Cundaline and Callawa mining operations would include new works, which are described below.

Being constructed on a ridge, the planned Cundaline 10K, 13K and 14K pits would have no external catchments draining towards the pits and would not block any external catchment runoff from draining to the valley floors. Perimeter safety bunding would be installed around the pits which would also protect against, and potentially divert, any minor nuisance runoff from the surrounding areas. During operations, excess stormwater collected in the pit would be treated to remove the sediments and then would typically be used for ore processing and dust suppression, with any excess discharged to the environment under relevant licence conditions.

Perimeter bunding would be installed around the downgradient sides of the planned Cundaline 10K and 13/14K OSAs to catch internal potentially sediment laden runoff. Due to the pits being located adjacent and on the upgradient side of the OSAs, upstream diversion bunding is not required around the OSAs. Drainage within the OSAs would be designed to cater for the design rainfall event and to channel internal runoff through a local sediment basin(s) prior to discharge to an existing creek flowpath to the downstream environment. In the zone between the pits, stormwater drainage works would be installed to manage runoff from the planned stockpile and other development works and discharged via a sediment basin to the environment under relevant licence conditions.

The planned Callawa A, B and C pits would be developed as a cluster on the north-east crest of the Callawa Ridge and would potentially block runoff from a small external catchment area (located south of Pit B) from draining off the ridge (Figure 7). To drain this blocked area to the downstream environment, a small diversion bund/channel would be installed around the south and west side of Pit B. In other areas, perimeter safety bunding would be installed around the pits, as there would be no external catchments draining towards the pits. These safety bunds would also protect against, and potentially divert, any minor nuisance runoff from the surrounding areas. As at the planned Cundaline mining operations, excess stormwater collected in the pit during mining would be treated to remove the sediments and then would typically be used for ore processing and dust suppression, with any excess discharged to the environment under relevant licence conditions.

The planned Callawa OSA wraps around the north and east sides of the planned Callawa pits and perimeter bunding would be installed around the OSA downgradient sides. As the planned pits would be just upgradient from the OSA, there would be minimal external catchment draining towards the OSA from the pits area, though a small external catchment containing the planned temporary waste rock dump area would drain towards the OSA. Drainage around the OSA would be designed to cater for the design rainfall event and to channel internal and intercepted external runoff through local sediment basins prior to discharge to an existing creek flowpath to the downstream environment.

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SECTION 6 - SUMMARY AND CONCLUSIONS

6.1 PROJECT DESCRIPTION

BHPBIO operates Goldsworthy which is located approximately 200km east of Port Hedland. Operations have progressively expanded from the initial Mount Goldsworthy Mine to other deposits that include the Shay Gap, Nimingarra, Sunrise Hill, Yarrie and Cattle Gorge deposits. Ore processing and rail loading occurs at facilities located at Yarrie and Nimingarra. BHPBIO's exploration programme has identified iron ore deposits at the Cundaline and Callawa ridgelines which are proposed to be developed as satellite mining operations and use the existing Goldsworthy infrastructure and facilities as far as practicable.

BHPBIO is in the process of seeking environmental approval for planned future mining at the Cundaline and Callawa deposits. This report details the results of a surface water assessment to characterise the existing surface water resources, identify potential impacts of the project on natural drainage systems and discuss management strategies to minimise the impact of the project on the drainage systems.

Surface water management objectives for the planned Cundaline and Callawa mining operations include 'general objectives' which primarily relate to operational management activities, and 'closure objectives' which relate to rehabilitation, decommissioning and closure.

6.1.1 General Surface Water Management Objectives

- To prevent or minimise impacts on the quality of surface water resulting from mining operations and contain any contaminated water on-site.
- To ensure that the quality of water returned to local and regional surface water resources will not result in significant deterioration of those resources.

6.1.2 Closure Surface Water Management Objectives

- Baseline surface water quality and flow regimes in Eel Creek and Egg Creek will be maintained.

6.2 POTENTIAL IMPACTS

Planned pit and OSA developments within the planned Cundaline and Callawa mining operations have the potential to impact surface water resources by changing local surface water flow patterns, by affecting surface water runoff volumes and quality, by causing erosion from disturbed areas with downstream sedimentation or by contamination from chemicals/hydrocarbons.

The planned pits are located along the tops of ridge lines and mine plans indicate that minimal if any upstream external catchments would be intercepted by the open pit developments. Where external catchment diversion is required (and is feasible), diversion bunds/channels would be installed. In other areas, pit perimeter safety bunding would be installed. During operations, excess stormwater collected in the pits will be treated to remove the sediments and would then typically be used for ore processing and dust suppression, with any excess discharged to the environment under relevant licence conditions. Hence some water will be lost from the natural hydrological cycle due to groundwater seepage, dust suppression usage (likely to be small) and long term capture within disused pits.

The combined Cundaline and Callawa pits intercept a total catchment area of 141ha (1.41km^2). Compared with Eel Creek's natural catchment area of approximately 500km^2 and the De Grey River's catchment area of approximately 50,000km^2, the potential loss of runoff volume to the downstream creek systems, due to the pit developments, is not significant to the overall hydrological system, particularly in comparison to the natural seasonal variations in catchment runoff.

Internal runoff from the OSAs (and any intercepted external runoff) would be collected by the perimeter bunding and discharged via a sediment basin to the downstream environment. Loss of runoff volume to the downstream catchments from the OSA structures is estimated to be negligible.

The mining activities will potentially mobilise additional sediments to the natural drainage systems with the main potential sediment sources being the OSAs and stockpiles. The most effective method of sediment management is limiting vegetation disturbance and creating stable landforms, however, where sediment is created it will be controlled close to the source. Sediment basins are a means to control surface water sediment, and bunds and sediment basins should be constructed down slope of all OSAs and stockpiles (as appropriate) to manage this issue. The final locations and layouts for these works will need to be determined in association with the detailed mine plans.

6.3 MANAGEMENT MEASURES

BHPBIO will install appropriate diversions and bunding around the mining areas, including sediment basins, as required, downstream of OSAs, stockpiles and other disturbed areas. Any water released from the site will meet relevant licence conditions. The planned Cundaline and Callawa mining operations will have a localised effect on the surface water runoff through the redirection of flow and the development of voids which may intercept minor drainage lines and collect surface water. Surface water management strategies will be implemented to ensure negligible impact on local surface water resources.

Surface water management measures for the planned Cundaline and Callawa mining operations include:

- Perimeter safety bunding around all pits.
- Diversion bunding where appropriate along pit perimeters to divert local runoff to the valley floor.
- Perimeter bunding around the planned OSAs to catch internal potentially sediment laden runoff and divert external runoff, as appropriate.
- Culverts installed where haul and access roads cross creeks and drainage lines.
- Sediment basin(s) installed at each OSA to treat internal runoff prior to discharge to the downstream environment.
- Catchment runoff and internal stormwater collected in pits to be treated to remove sediments prior to pumping for discharge to the environment.

SECTION 7 - REFERENCES

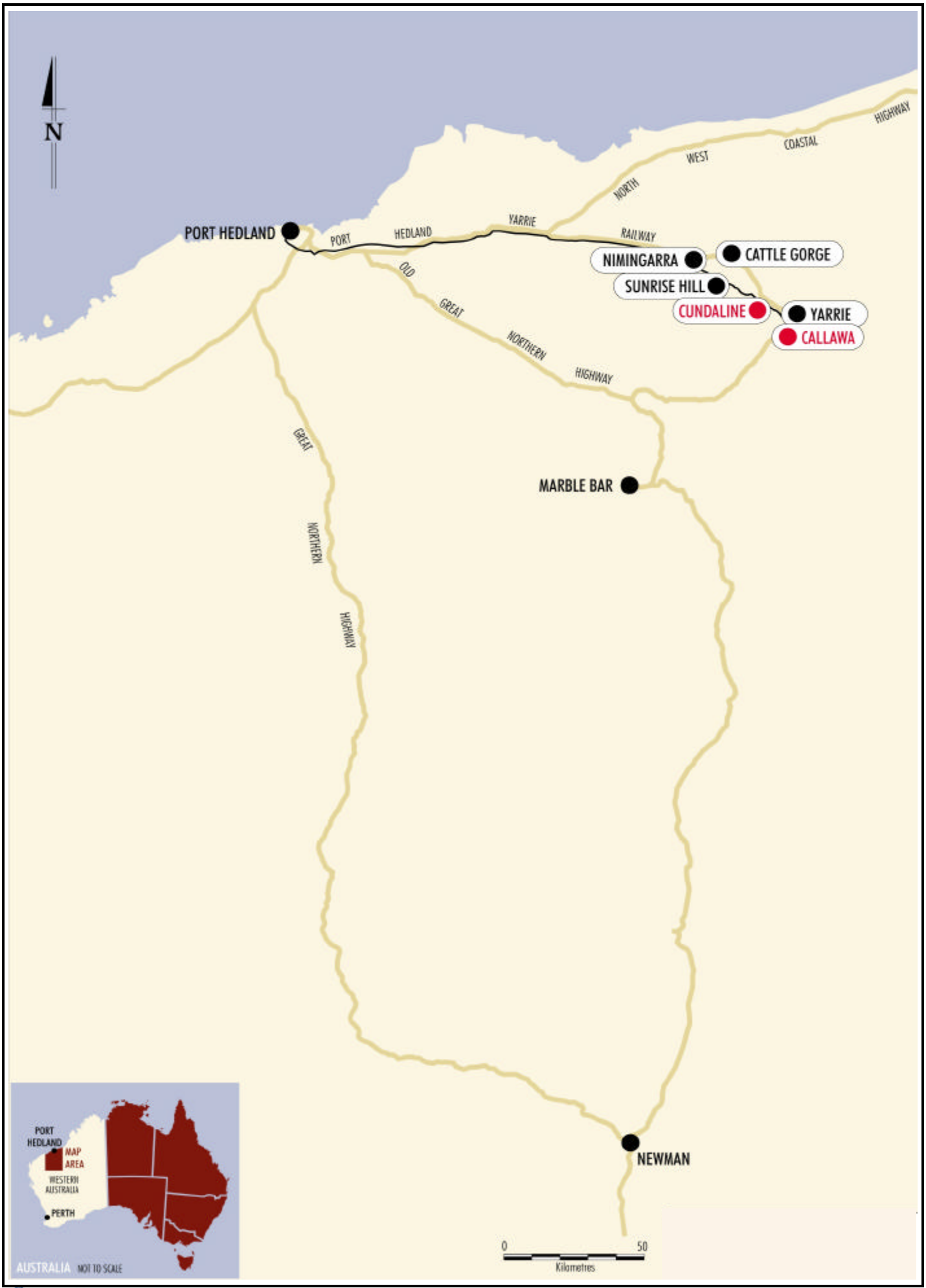
Bureau of Meteorology (2008) Monthly Climatic Statistics for Marble Bar (004020), Yarrie Station (004046) and Port Hedland (004032).

Department of Agriculture (1987) Evaporation Data for Western Australia. Resource Management Technical Report No. 65.

Goldsworthy Mining Limited (1986) Goldsworthy Extension Project Notice of Intent.

The Institution of Engineers, Australia (1987) Australian Rainfall and Runoff. A Guide to Flood Estimation. National Committee on Water Engineering.

FIGURES



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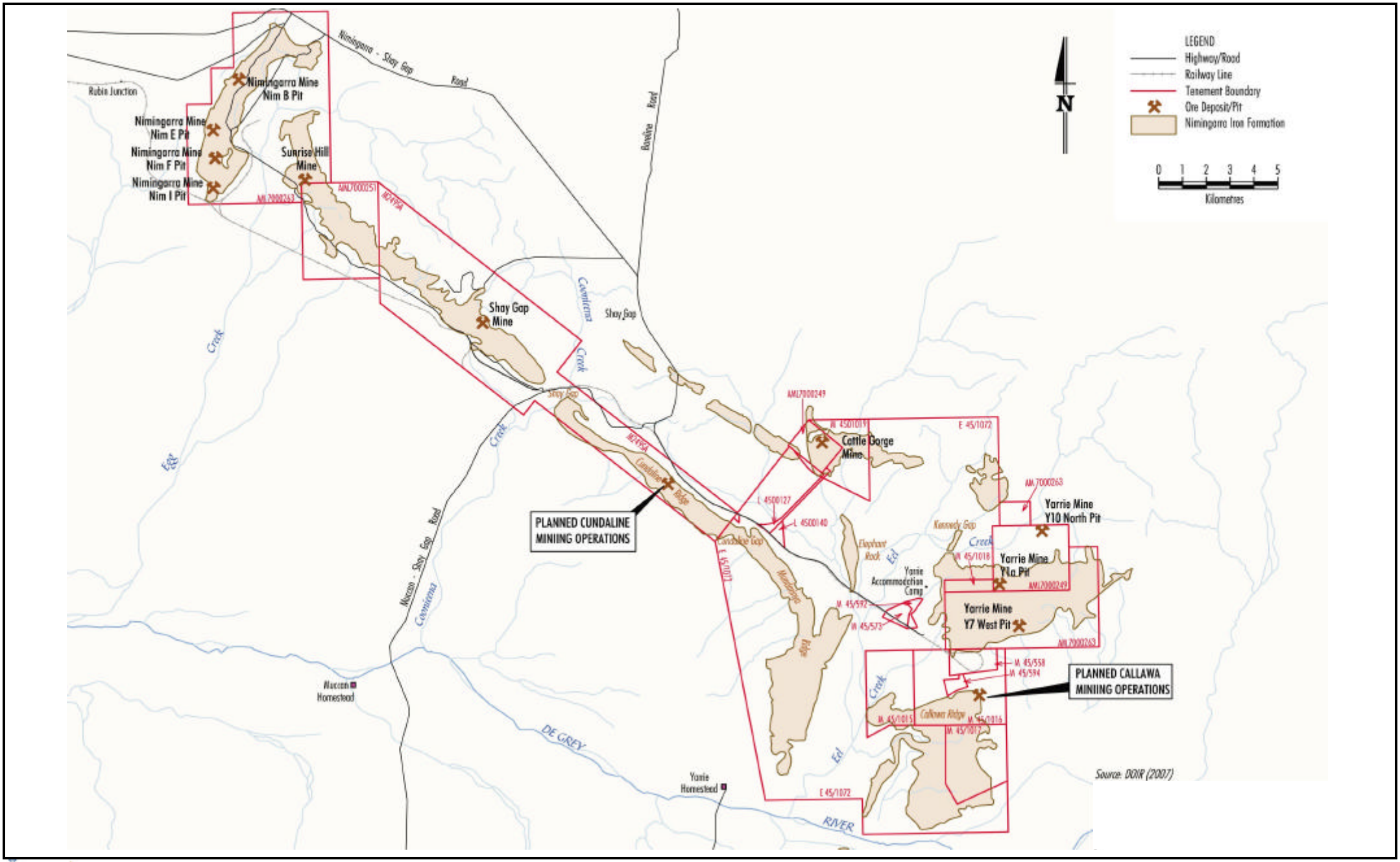
Regional Location
Figure 1



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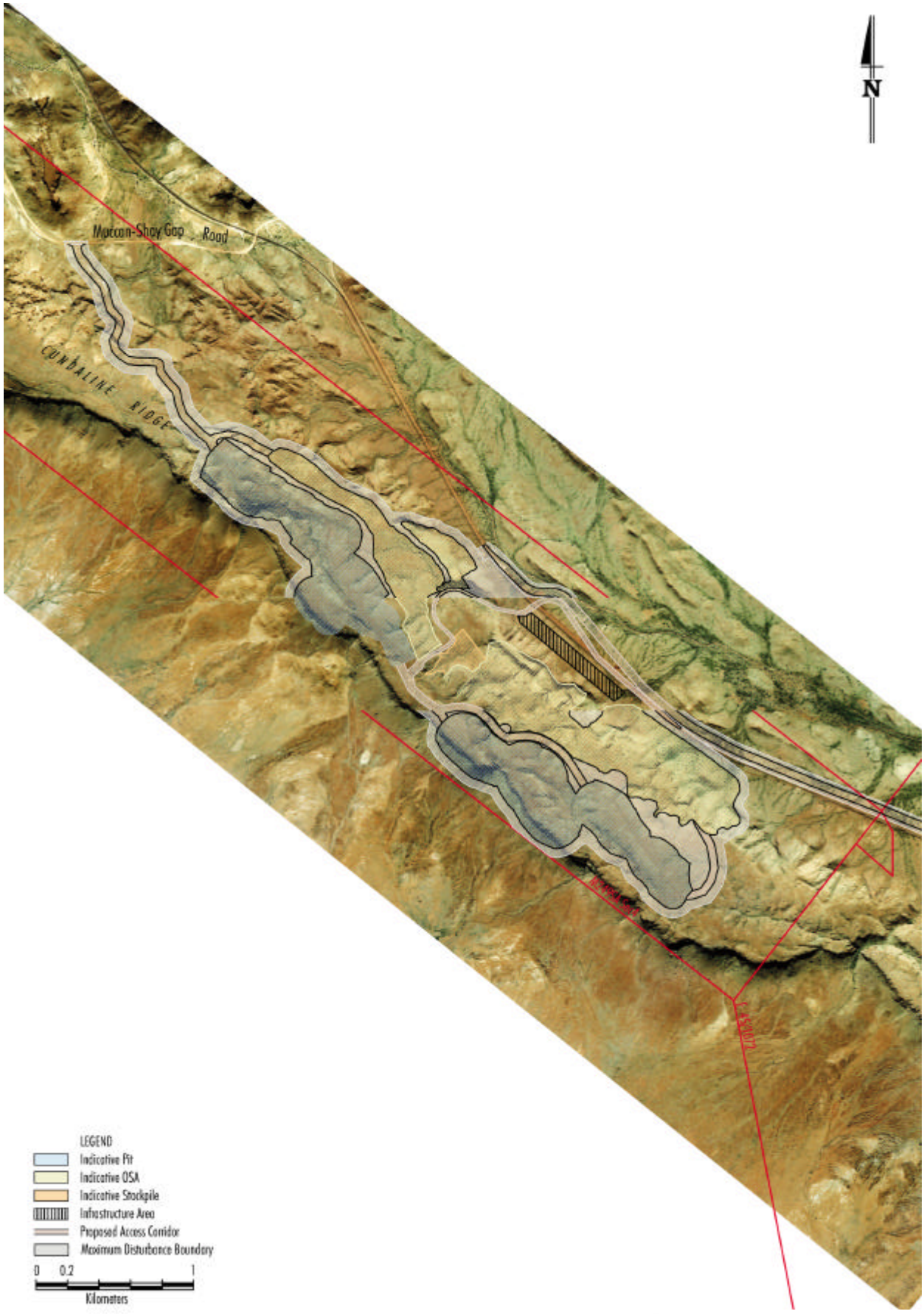
Project Location and Tenements
Figure 2



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Planned Cundaline Mining Operations
Conceptual General Arrangement
Figure 3a

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Planned Callawa Mining Operation
Conceptual General Arrangement
Figure 3b

PORT HEDLAND

NIMINGARRA MINE SITE (EXISTING)

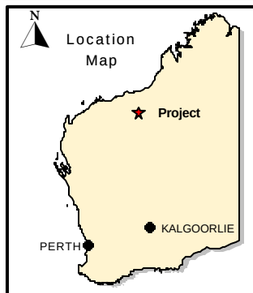
SHAY GAP MINE SITE (ABANDONED)

CUNDALINE MINE SITE (PROPOSED)

YARRIE MINE SITE (EXISTING)

CALLAWA MINE SITE (PROPOSED)

MARBLE BAR



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Kilometers

Scale: 1:600,000

aquaterra

CUNDALINE - CALLAWA
SURFACE WATER MANAGEMENT
LOCATION PLAN
FIGURE 4

Author: VP	Date: 31/10/08
Drawn: PO	Revised:
Job No: 980/B3	Report No: 215c
Projection: GDA 94	Scale: As Shown

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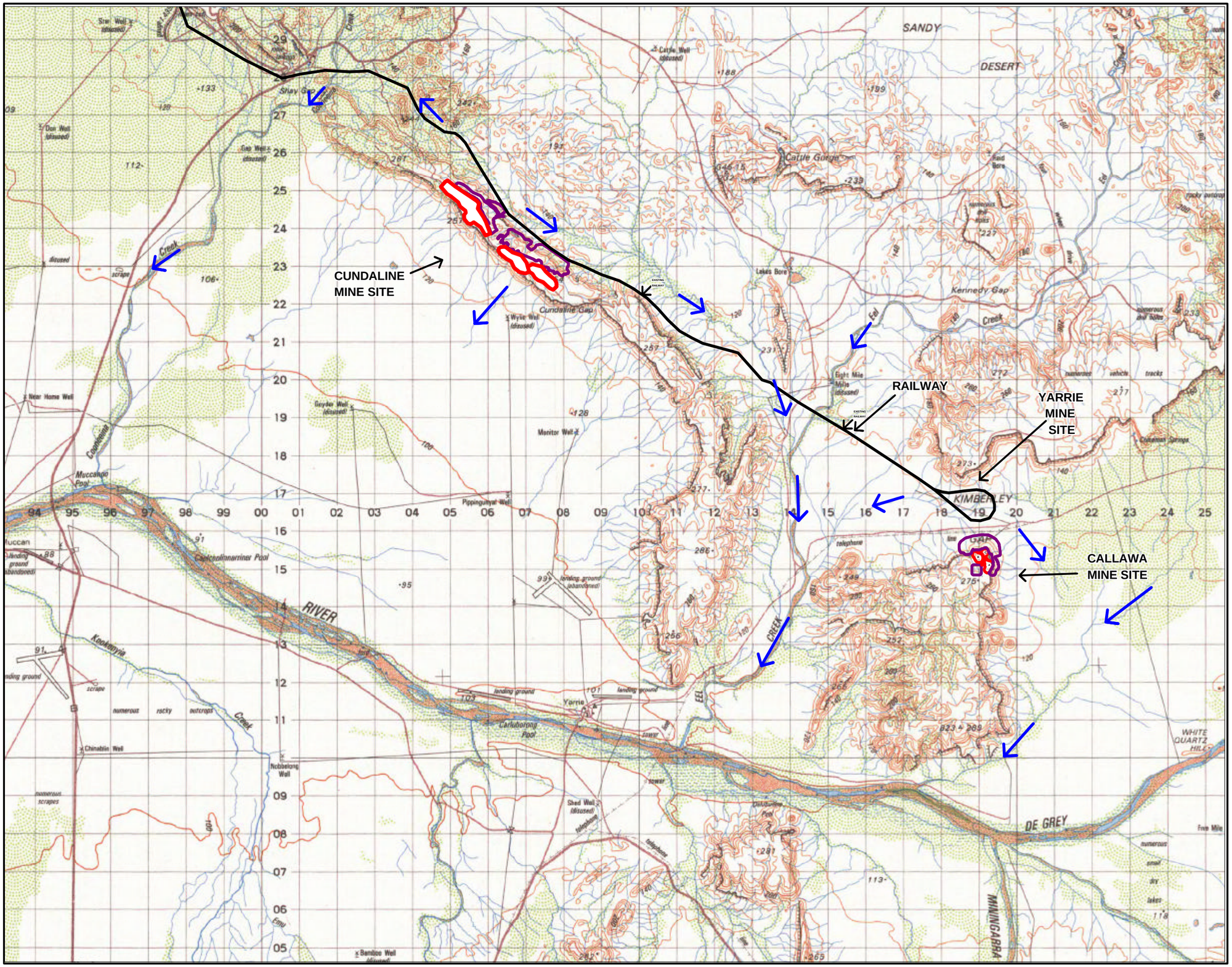

LEGEND

- FLOW PATHS
- RAILWAY
- PIT
- OSA

0 2 4 6

Kilometers

Scale: 1:100,000

aquaterra

CUNDALINE - CALLAWA
SURFACE WATER MANAGEMENT
REGIONAL FLOWPATHS
FIGURE 5

Author: VP	Date: 31/10/08
Drawn: PO	Revised:
Job No: 980/B3	Report No: 215c
Projection: GDA 94 Z 51	Scale: As shown

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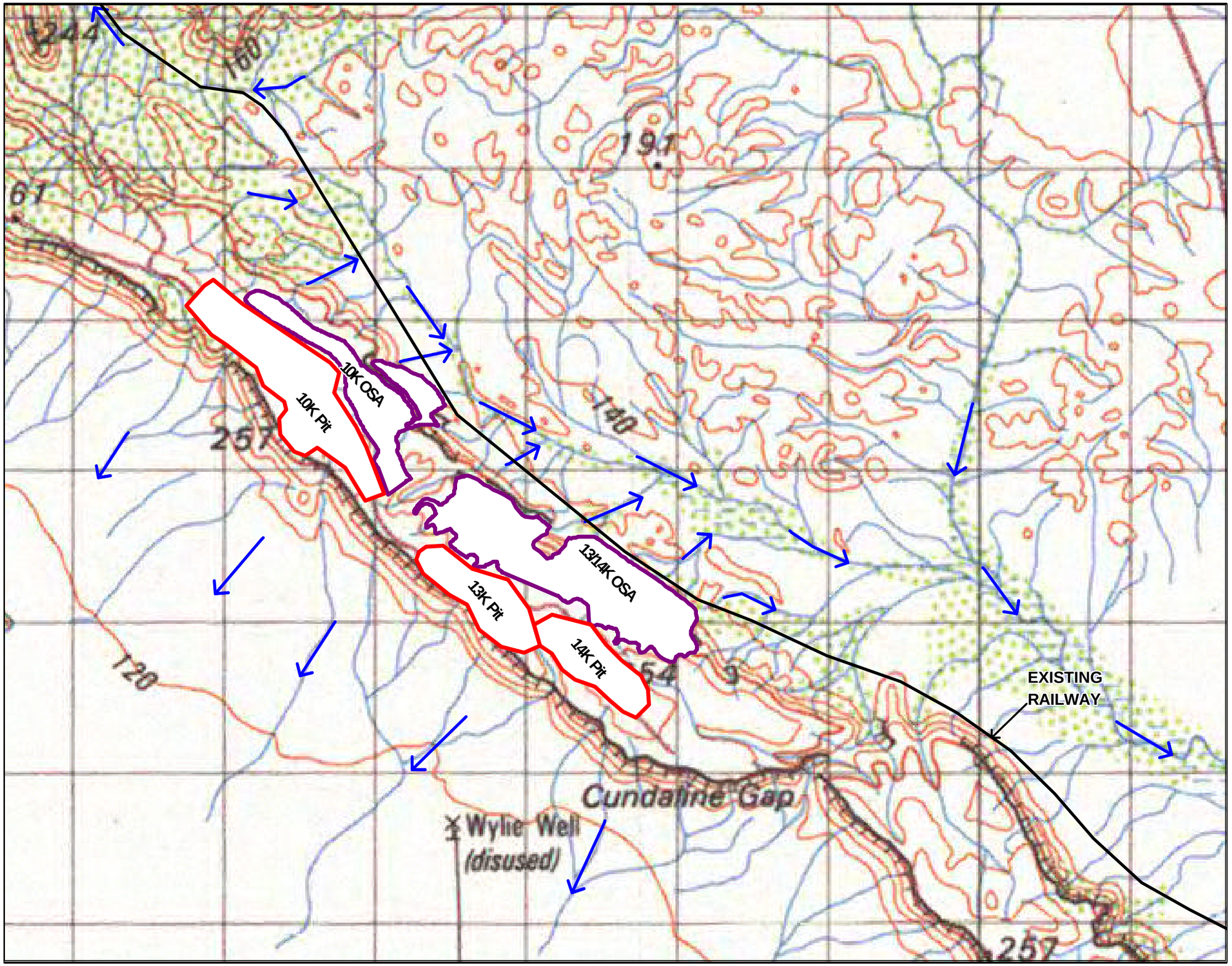

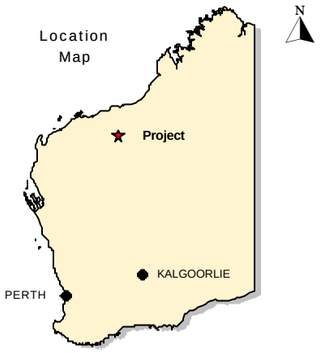

LEGEND

- FLOW PATHS
- RAILWAY
- PIT
- OSA

0 0.5 1 1.5

Kilometers

Scale: 1:25,000

aquaterra

CUNDALINE - CALLAWA
SURFACE WATER MANAGEMENT
CUNDALINE FLOWPATHS
FIGURE 6

Author: VP	Date: 31/10/08
Drawn: PO	Revised:
Job No: 980/B3	Report No: 215c
Projection: GDA 94 Z 51	Scale: As Shown

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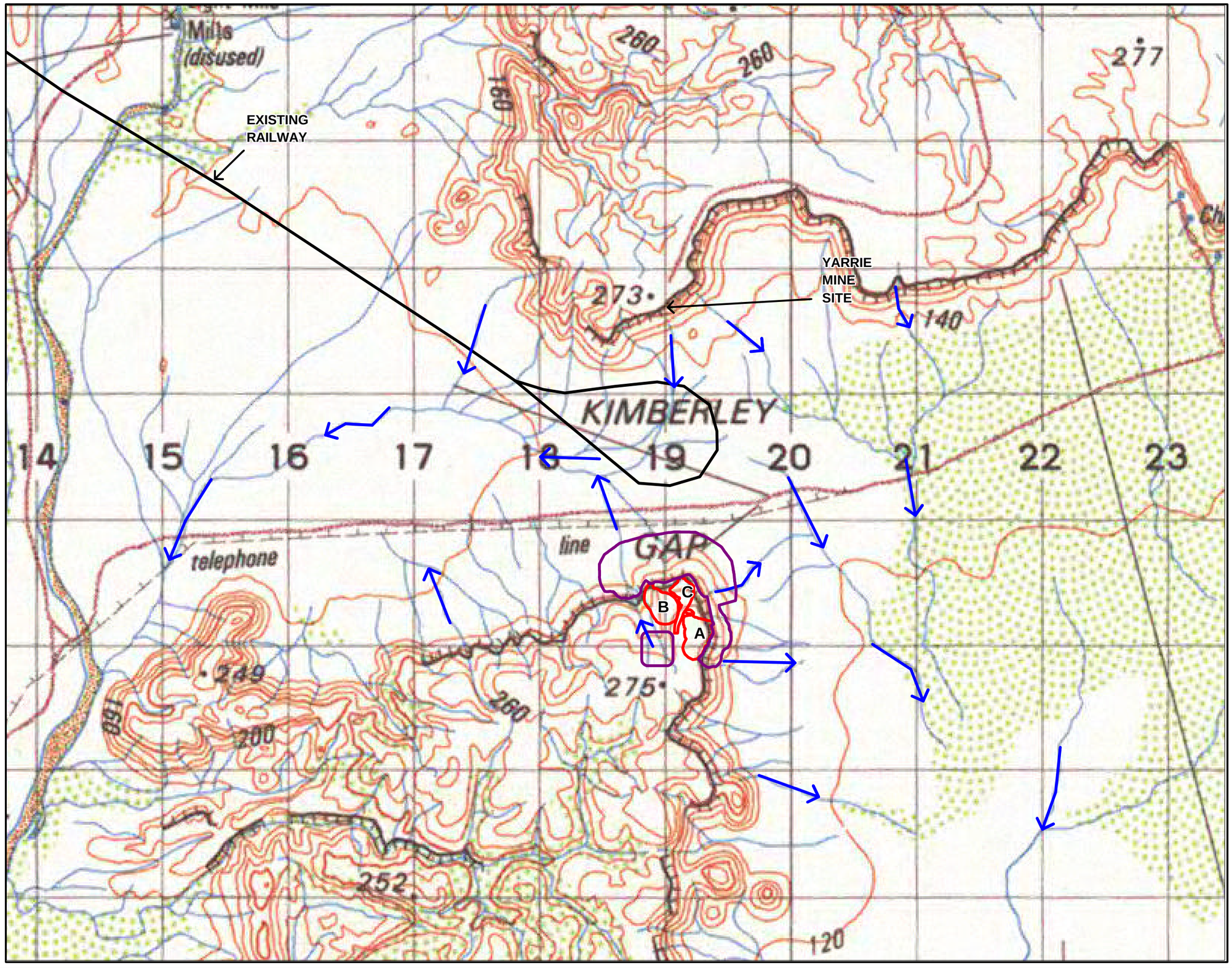

LEGEND

- FLOW PATHS
- RAILWAY
- PIT
- OSA

0 0.5 1 1.5

Kilometers

Scale: 1:30,000

aquaterra

CUNDALINE - CALLAWA
SURFACE WATER MANAGEMENT
CALLAWA FLOWPATHS
FIGURE 7

Author: VP	Date: 31/10/08
Drawn: PO	Revised:
Job No: 980/B3	Report No: 215c
Projection: GDA 94 Z 51	Scale: As Shown

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APPENDIX G

GROUNDWATER ASSESSMENT
(AQUATERRA, 2009b)

Water and Environment

CUNDALINE & CALLAWA HYDROGEOLOGICAL IMPACT ASSESSMENT

Prepared for	BHPBIO
Date of Issue	24 February 2009
Our Reference	980/B2/002i

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CUNDALINE & CALLAWA HYDROGEOLOGICAL IMPACT ASSESSMENT

IRON ORE DEPOSITS AT GOLDSWORTHY

Prepared for	BHPBIO
Date of Issue	24 February 2009
Our Reference	980/B2/002i

CUNDALINE & CALLAWA HYDROGEOLOGICAL IMPACT ASSESSMENT

	Date	Revision Description
Revision g	29/01/09	Final
Revision h	03/02/09	Final
Revision i	24/02/09	Final

	Name	Position	Signature	Date
Originator	Ashley Price	Hydrogeologist		24/02/09
Reviewer	Keith Brown	Principal Hydrogeologist		24/02/09

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EXECUTIVE SUMMARY

BHP Billiton Iron Ore Pty Ltd (BHPBIO) is seeking environmental approval for planned future mining of the Cundaline and Callawa iron ore deposits at Goldsworthy. This report describes the results of a hydrogeological assessment of potential impacts to the local groundwater system as a result of mining at the Cundaline and Callawa deposits. Included in this report is a review of the regional groundwater hydrology at Goldsworthy along with an evaluation of the current condition, and likely closure effects, of the existing and planned Goldsworthy Iron Ore Mining Operations dewatering and water supply borefields.

The results of the assessment specific to the planned Cundaline and Callawa mining operations are summarised as follows:

- Groundwater level information indicates that mining at the Cundaline deposit will not go below the natural water table and no dewatering would be required.
- Groundwater level information indicates that all three proposed pits at the Callawa deposit will intercept the water table and dewatering will be required.
- Hydrogeological interpretation suggests dewatering of the Callawa orebody will not significantly impact on regional groundwater levels beneath the plain adjacent to the mined ridge for the following reasons:
  - The Callawa ridge deposit consists of zones of mineralised ore of moderate permeability surrounded by rock of low permeability consisting mainly of unmineralised Banded Iron Formation horizons and granite. As a result, the hydrogeological impacts of mining (dewatering) will be restricted to the immediate mining area with drawdown in groundwater levels being largely confined to the Callawa ridge.
  - The difference in groundwater elevation between the observed water table on the Callawa ridge and the inferred water table beneath the adjacent plain is readily observed at other similar Goldsworthy deposits and suggests a low degree of hydraulic connectivity.
  - Proposed ultimate pit designs for Callawa are significantly above the elevation of the valley floor.
- Analytical modelling indicates the extent of the drawdown cone for each of the individual pits will be less than 350m from the pit boundaries. Predicted drawdown will be less than 5metres at a radial distance of 100m from edge of each pit. However, the zone of influence may be become elongate to the south and west to compensate for the limited lateral extent of the ridge to the north and east of the pits.
- Backfilling of the pits at Callawa to 5 m above the pre-mining water table is likely to result in the water table recovering to pre-mining levels. Based on observed recovery in similar pits located at Goldsworthy, full recovery should take less than five years with the majority of recovery occurring within the first year. That is, there will be no impact on groundwater levels or quality once mining (dewatering) has been completed.
- Some minor modifications to existing Licences to Take Water under the Rights in Water and Irrigation Act, 1914 would be required to allow water to be taken and used at the planned Cundaline and Callawa mining operations. Specifically, this may require an application to amend the Groundwater Well Licence Operating Strategy for Goldsworthy to include the water use at the two sites.

CONTENTS

TABLES

FIGURES

1 BACKGROUND

BHP Billiton Iron Ore Pty Ltd (BHPBIO) operates the Goldsworthy Iron Ore Mining Operations (Goldsworthy) which are located approximately 200 kilometres (km) east of Port Hedland in the north of the Pilbara Region of Western Australia (Figure 1).

The development of Goldsworthy has been conducted in phases over the past 50 years. The Mount Goldsworthy Mine was the first mining operation and commenced in the mid 1960s. Once it was mined out, the operations were progressively expanded to other Goldsworthy deposits that include the Shay Gap, Nimingarra, Sunrise Hill, Yarrie and Cattle Gorge deposits. Ore processing and rail loading occurs at facilities located at Yarrie and Nimingarra.

The current administration, ore processing, maintenance and accommodation facilities are located at Yarrie. Mining operations are also centred at Yarrie, with some mining still taking place at the Nimingarra, Cattle Gorge and Sunrise Hill deposits (Figure 2). The Mount Goldsworthy and Shay Gap mining areas are no longer operational, with the majority of activities at these sites directed towards the monitoring and maintenance of rehabilitated landforms.

BHPBIO's Goldsworthy operations are conducted under the Iron Ore (Goldsworthy) Agreement Act, 1964, and the Iron Ore (Goldsworthy-Nimingarra) Agreement Act, 1972. Environmental requirements for the operations are specified in the Goldsworthy Extension Project Notice of Intent (Goldsworthy Mining Limited, 1986), and the conditions of Ministerial Statement's No. 000303 and No. 000682, issued by the Minister for the Environment, issued under Part IV of the Environmental Protection Act, 1986 (EP Act), and Licences 5561 and 4412 issued under Part V of the Environmental Protection Act, 1986 (EP Act).

BHPBIO's exploration programme has identified iron ore deposits at the Cundaline and Callawa ridgelines (Figure 2). The Cundaline and Callawa deposits are proposed to be developed as satellite mining operations and would use the existing Goldsworthy infrastructure and facilities as far as practicable.

Major components of mining infrastructure and activities associated with the planned Cundaline and Callawa mining operations include:

- pre-stripping, open pit mining and stockpiling of overburden and ore at the Cundaline and Callawa pits;
- placement of overburden in mined-out voids and out-of-pit overburden stockpile areas (OSAs) adjacent to the Cundaline and Callawa pits;
- trucking of the Callawa ore to the Yarrie crushing, screening and rail loading facilities, which are located approximately 2km to the north;
- trucking of the Cundaline ore to the Yarrie crushing, screening and rail loading facilities, which are located approximately 12km to the south-east, or use of a mobile crushing and screening plant to be located at the Cundaline area;
- stockpiling, crushing, screening and load-up of iron ore at the Yarrie processing facilities and/or the mobile Cundaline facilities;
- continued groundwater abstraction from the Shay Gap Wellfield to meet operational demands, and distribution through the existing water supply system and pipeline extensions to the Cundaline and Callawa areas;
- construction and use of small day rooms, workshop facilities and storage areas at the Cundaline and Callawa areas;
- supply of power to the facilities at the Cundaline and Callawa areas either via connecting electricity lines from the existing power network, or use of on-site diesel generators; and
- construction and use of haul and access roads to the Cundaline and Callawa areas.
- The general arrangements of the planned Cundaline and Callawa mining operations are shown on Figures 3a and 3b, respectively.

2 HYDROGEOLOGY OF THE GOLDWORTHY AREA

The Yarrie, Shay Gap, Sunrise Hill and Nimingarra mining areas occur over a distance of approximately 50km, some 150 to 200km east of Port Hedland. The older Mount Goldsworthy area, which is located approximately 50 to 100km to the west, is topographically and hydrogeologically separate from the current mining areas.

In all of the Goldsworthy mining areas, local aquifers are associated with the hematite orebodies that have developed within distinct Banded Iron Formation (BIF) horizons, which form prominent ridges. The permeability of the local aquifers varies and is a function of the nature of the mineralisation and the degree of fracturing within each deposit. Generally, the higher the level of mineralisation, the higher the permeability of the aquifer orebody. The local aquifers tend to extend along strike, and hence drawdown cones develop an elongated shape (i.e. essentially a strip aquifer). The local aquifers are enveloped by lower permeability unmineralised or subgrade BIF, and/or very low permeability carbonaceous shales and metamorphosed pillow lavas (e.g. Mount Goldsworthy) and granites and mudstones (e.g. Yarrie-Nimingarra).

The main orebody aquifers form zones of higher permeability within the general strip aquifers formed by the ore horizons. Recharge is primarily through direct infiltration at the points where the orebodies outcrop. Given the elevated topography of the orebodies and the limited hydraulic connection, pre-mining water table levels in the orebody aquifers are commonly much higher than beneath the surrounding plains. Minor aquifers associated with local and limited (in areal extent) fractured rock aquifers have been developed by the Egg Creek, Eel Creek and Cundaline Wellfields. These aquifers are likely to be recharged by the infiltration of wet season streamflows via overlying alluvium (Egg Creek and Eel Creek) and the direct infiltration of runoff to the aquifer (Cundaline Wellfield).

The topography surrounding the BIF ridges is generally flat. The topography to the south of the ridges is dominated by the drainage system of the De Grey River. A shallow aquifer associated with alluvial sediments within the De Grey River floodplain was previously developed by the Goldsworthy Borefield to provide mine supplies to Mount Goldsworthy.

The topography to the north of the BIF ridges is characterised by flat to gently undulating sand plains with occasional small rocky outcrops and stony hills. Aquifers in this area are associated with hydraulically isolated sedimentary sequences within the broad Jurassic to Cretaceous-aged Canning Basin. One such aquifer, the Wallal Sandstone, has been developed by the Shay Gap Wellfield at the margin of the Basin. This aquifer system is recharged by infiltration of rainfall runoff at the margins of the basin.

3 LOCAL HYDROGEOLOGY OF THE CUNDALINE AND CALLAWA DEPOSITS

3.1 HYDROGEOLOGY OF THE CUNDALINE DEPOSIT

The Cundaline deposits lie within the north-west/south-east trending Cundaline Ridge. It has a similar stratigraphy to that of the Callawa Ridge deposit (i.e. steeply dipping BIF sequence - the Nimingarra Iron Formation) unconformably overlying the Muccan Granitoid and as per the Callawa deposit the principal aquifer is the mineralised ore zone within the Nimingarra Iron Formation.

Prior to this investigation there is no historical water level or water quality information available in the area of the Cundaline deposits. Water level information obtained from recent mineral exploration drilling shows water levels ranging between approximately 120metres (m) Australian Height Datum (AHD) to approximately 140m AHD (see Section 4 for more detail). Water quality sampling undertaken in February and April 2008 as part of the stygofauna survey showed electrical conductivity was low, averaging 605 micro Siemens per centimetre (µS/cm) in February and 530 µS/cm in April. Acidity of the sampled groundwaters as pH averaged 6.7 in February and a pH 6.5 in April which is in the range of natural groundwaters (6.0 to 8.5). One sample had a pH of 4.3, but this sample was considered erroneous and, therefore, not a representative groundwater sample. The water is hence low in salinity and has a near neutral acidity.

3.2 HYDROGEOLOGY OF THE CALLAWA DEPOSIT

The Callawa deposit is located approximately 2km south of the existing Yarrie Mine. The deposit lies within a prominent ridge that extends approximately 150m above the surrounding plain. The stratigraphy of the ridge consists of a steeply dipping BIF sequence (the Nimingarra Iron Formation) unconformably overlying the Muccan Granitoid. The principal aquifer in the area comprises the mineralised zones of the Nimingarra Iron Formation.

Hydrogeologically, the Callawa ridge is considered to consist of mineralised zones of moderate permeability overlying and surrounded by rock of very low permeability consisting mainly of unmineralised BIF and granite. As such the hydrogeological impacts of mining (dewatering), as observed at other Goldsworthy mining (dewatering) sites, (Section 5) will be restricted to the immediate mining area with drawdown in groundwater levels being confined to the Callawa ridge.

The maximum measured groundwater level was recorded at 227m AHD (Figure 4), which is approximately 43m below the ground surface. The steep hydraulic gradient inferred from the groundwater contours (Figure 4) suggests that there is a low degree of hydraulic connectivity between the Callawa ridge and the groundwater that underlies the valley plain (note that the contours as interpreted rely on limited data outside that obtained from the ridge). The difference in groundwater elevation between ridge and plain is not uncommon and is readily observed at other similar Goldsworthy deposits.

Water quality sampling undertaken in February and April 2008 as part of the stygofauna survey showed electrical conductivity was low, averaging 240 µS/cm in February and 180 µS/cm in April. The pH of the sampled groundwaters averaged 6.25 in February and 6.1 in April which is in the range of natural groundwaters (6 to 8.5). One sample had a pH of 4.89, however, the electrical conductivity of the sample was 53.4 µS/cm which is considered to be too low to be considered a representative of groundwater.

4 EXISTING GOLDSWORTHY BOREFIELDS

4.1 LICENCES

There are currently five existing licenced borefields operated by BHPBIO at Goldsworthy:

- Yarrie Borefield;
- Shay Gap Borefield;
- Sunrise Hill and Nimingarra Borefields;
- Egg Creek Borefield; and
- Cundaline Borefield.

Table 4.1 lists the current Goldsworthy Well Licences (GWLs) to Take Water.

Table 4.1: Current Goldsworthy Well Licences to Take Water

Area	GWL No	Lease No	Allocation (kL/yr)	Expiry Date
Shay Gap	107451(4)	Special Lease 3114/1215	1,200,000	31-Dec-08
Yarrie, Y2/3 and Y10	107453(4)	Mining Lease (ML) 263 SA (Sections 4 and 8)	350,000	31-Dec-08
Sunrise Hill and Nimingarra	107452 (6)	ML251 and ML263 (Sections 1, 2 and 3)	3,500,000	31-Dec-08
Egg Creek	154184(3)	ML263 SA (Section 1)	300,000	31-Dec-08
Cundaline	153404(2)	ML249 SA (Section 4)	90,000	31-Dec-08

kL/yr = kilolitres per year

4.2 LICENCE CONDITIONS

All abstraction and water use at Goldsworthy is subject to the conditions associated with the Licence(s) to Take Water and issued under the Rights in Water and Irrigation Act, 1914, as well as the commitments outlined in the Groundwater Well Licence (GWL) Operating Strategy for Goldsworthy, which is a requirement of the licence. A summary of these commitments is provided in Table 4.2.

Table 4.2: Goldsworthy Operating Strategy Commitments

1	BHPBIO will review the Operating Strategy on an annual basis and revise it if necessary. If revised, a copy will be submitted to the Western Australia Department of Water (DoW).
2	BHPBIO will submit a monitoring report (Aquifer Review) to the DoW by 30 September each year. The report will detail the results of the monitoring for that water year (1 July to 30 June). Three years of data will be presented graphically whilst only the current year's data will be presented in tabular format. The report text will focus on the current water year, however, comment will be made of any apparent trends over the three year period. Every three years a Triennial Aquifer Review will be submitted. This will present and comment on the previous three years of monitoring data.
3	BHPBIO will not exceed the maximum allocations for each GWL.
4	BHPBIO will monitor the following: ▼ water levels in the production/dewatering bores and nominated observation bores on a monthly basis; ▼ abstraction rates from each production/dewatering bore and/or sump on a monthly basis; ▼ water use on a monthly basis (i.e. potable, mine processing, dust suppression, discharge); ▼ salinity (electrical conductivity [EC]) and pH levels at operational production/dewatering bores and/or sumps on a monthly basis; and water quality at operating production/dewatering bores (i.e. hydrochemical analyses of water samples from these bores) on an annual basis (quarterly for potable bores).
5	BHPBIO will maintain a structured data collection and management system with an on-going verification and review process.
6	BHPBIO will maintain a current water circuit diagram for Yarrie-Nimingarra which will be included in the Annual/Triennial Aquifer Review.
7	Regular checks will be made along the water supply system for leaks, etc.
8	The water balance will be assessed on an annual basis and any improvements to water efficiency will be investigated.

5 REVIEW OF EXISTING BOREFIELDS AND POTENTIAL FUTURE IMPACTS

The following provides a summary description of the historical background, the current condition and likely future hydrogeological impacts of the existing Goldsworthy borefields.

5.1 YARRIE BOREFIELD

The Yarrie Mine comprises two pits, Y2/3 and Y10, both of which have historically required dewatering. Pit Y2/3 was originally dewatered via five in-pit production bores which over time have either been decommissioned or lost to mining. All remaining dewatering was achieved via in-pit sumps. Mining ceased in pit Y2/3 in 2004, however, low levels of abstraction continued to provide water for dust suppression and plant supply until October 2006.

Dewatering of the Y10 pit was achieved through in-pit sump pumping as mining went only marginally below the water table. No water has been abstracted since September 2006.

The monitoring network at Yarrie currently comprises five near-pit observation bores (YRP04, YRP15, YRP22, YRP24 and YR1060) and ten regional observation bores (YRP006, YP006, YP009, YP019, YP023, YP027, YP032, YR836, YR1063 and YR1065).

Following commissioning of the original Y2/3 pit dewatering bores in January 1997, significant dewatering of the orebody occurred, with in-pit groundwater levels drawn down by 100 to 120m. Dewatering has had little impact on groundwater levels other than in the immediate pit areas (less than several hundred metres). None of the regional observation bores show discernable effects from dewatering or the subsequent water supply abstraction. This is a reflection of the local hydrogeological conditions where the orebody aquifers that were dewatered, are structurally isolated and/or enveloped by low permeability unmineralised BIF.

Since the cessation of abstraction a pit lake has developed in the Y2/3 Pit. Water levels in the pit are still recovering post-cessation of abstraction (BHPBIO, 2008). This is expected to continue until a steady state water balance is achieved whereby groundwater inflow (rainfall recharge and groundwater throughflow) matches groundwater outflow (evaporative losses).

Pit Y2/3 is expected to act as a groundwater sink. In terms of groundwater quality long-term evaporation from the pit lake surface will result in a gradual increase in pit lake salinity. Sampling, undertaken as part of the latest annual aquifer (YEJ08) review, from the Y2/3 pit lake indicate the water is acidic pH (4.2 to 5.5), and that the salinity, measured as electrical conductivity, ranged between 890 to 1,040 (µS/cm) (BHPBIO, 2008) and as expected, overall salinity of the pit lake water is rising. However, the salinity impact of the pit lake becoming saline will be restricted to the immediate area of the pit due to the hydrogeological isolation of the ore and that it is essentially a groundwater sink. In the long-term, once saline conditions develop, there will be the potential for density driven stratification. However, due to the hydrogeological characteristics of the area, saline migration that may occur will be restricted to the orebody zone. As a result, no post-mining impact on surrounding aquifers is expected.

Water levels at Y10 are currently only marginally below the pre-mining water table. Water samples taken from the Y10 pit lake indicate an overall neutral to alkaline pH ranging from 6.9 to 8.9 and an EC salinity ranging from 370 to 610 µS/cm (BHPBIO, 2008). There has been no observed increase in salinity or change in acidity (pH) at the Y10 pit since the cessation of abstraction. As a result, no post-mining impact on surrounding aquifers is expected.

5.2 SHAY GAP BOREFIELD

The Shay Gap Borefield is located 165km south-east of Port Hedland and approximately 35km north-west of the Yarrie Mine. The borefield supplied water to the township of Shay Gap before the town was dismantled in 1993. The borefield currently supplies potable and raw water to the Yarrie Mine and camp.

The Shay Gap Borefield comprises four production bores (PB1, PB2R, PB3 and PB4), and one centrally located observation bore (OB1).

Historical pumping has had little impact on groundwater levels in the borefield area. Maximum drawdowns during peak pumping periods in the mid 1990s resulted in less than 5m drawdown recorded in the pumping and observation bores. Current water levels in the borefield are at or above pre-pumping water levels, reflecting reduced pumping and higher than average rainfall recharge during recent years. Groundwater quality has remained stable over the years and remains fresh (EC less than 600 µS/cm) and near neutral acidity (pH 6.3 to 7.2).

Groundwater levels in the vicinity of the borefield are expected to recover to pre-mining levels within several years of the cessation of dewatering.

5.3 SUNRISE HILL - NIMINGARRA BOREFIELD

Sunrise Hill West 7

The Sunrise Hill West 7 (SHW7) Borefield consisted of two in-pit dewatering bores (S7B04 and S7B05), but both were decommissioned at the end of 2006. There are two current observation points (S7P13 and the SHW7 sump) at SHW7. Other in-pit observation bores were destroyed over time as mining progressed. In addition there are two observation bores (SHW4-WB1 and SHW4-WB2) in the adjacent pit (SHW4).

Mining ceased at Sunrise Hill in May 2006, however, water was still abstracted until September 2006 and used mainly for dust suppression purposes.

Water levels in the SHW7 area prior to the commencement of dewatering ranged from 90 to 135 m AHD. Water levels in bores within the main orebody aquifer declined by approximately 40 m following the commencement of dewatering. Groundwater levels at the perimeter of the current pit showed responses to rainfall recharge, but no discernable impact of dewatering. This suggests mine dewatering impacts were localised with no impact on regional water levels.

Post the cessation of abstraction a pit lake has developed in SHW7. Water levels in the pit have recovered (and continue) to recover such that they are nearing pre-mining water levels (BHPBIO, 2008). Historical salinity of the pit lake water as EC ranged between 650 to 750 µS/cm and the acidity was near neutral. No adverse water quality trends have been observed during monitoring in the SHW7 pit lake to date (BHPBIO, 2008). SHW7 is similar to the Yarrie 2/3 pit in that it is considered a groundwater sink and as such salinity increases are likely to be contained within the confines of the pit lake due to the surrounding hydrogeological setting with negligible impact on the surrounding aquifer/aquiclude system.

Sunrise Hill 8

Sunrise Hill 8 is not an active pit and there are no dewatering or observation bores in the area. The pit is, however, listed on the groundwater licence as it had been intended to use water from the pit lake for dust suppression. However, this has not been required to date.

Nimingarra

The aquifers at Nimingarra A, Nimingarra B, Nimingarra F East and Nimingarra I comprise mineralised Mineral Member Ore. The pits are bounded on all sides by low permeability units (Middle Mudstone to the north and west and BIF to the south and east), suggesting the orebodies are hydraulically isolated from neighbouring orebodies. In addition, the orebodies are bounded at depth by low permeability BIF (unmineralised Middle Member) and shale/chert (the Middle Mudstone), resulting in a "bath-tub" type aquifer.

Nimingarra A

Mining at Nimingarra A (Nim A) ceased in 1993 although groundwater abstraction continued after mining (to provide a raw water supply). The last bore was decommissioned in 1997. Nim A was the first pit on the Nimingarra Ridge to be mined below the water table. Prior to the commencement of dewatering in 1991, groundwater levels in the mine area were measured at around 110 to 120m AHD in the Nim A area. When dewatering ceased, groundwater levels were around 35m AHD, some 70 m below pre-mining levels. Water levels measured in monitoring bores located at the perimeter of the pit in the basement rocks surrounding the Nim A orebody aquifer were not impacted by dewatering and have been at or near pre-mining levels since they were installed. Since the decommissioning of the last bore in 1997 measured water

levels within the pit and the main aquifer system (along strike of the orebody) have recovered to near pre-mining groundwater levels.

During the later years of borefield operation, between 1995 and 1997, groundwater salinities measured from the Nim A orebody ranged between 900 to 1100 µS/cm, with no adverse water quality impacts recorded as a result of dewatering activities. In late 2004, the pit lake had a measured salinity of 1190 µS/cm.

Nimingarra B

Mining at Nimingarra B recommenced in 2001. An in-pit dewatering bore (NB1) and a network of observation bores were installed in 2001/2 and dewatering commenced in July 2002. NB1 was removed as a result of mining in October 2004. Observation bores at Nimingarra B currently comprise NBP16, NBP57, NBP58, and NBP168. Water levels have remained essentially unchanged over the last three years (BHPBIO, 2008).

Nimingarra F

Mining at Nimingarra F East ceased sump pumping in October 2005. Water levels are monitored in one observation bore (NFE1) and continue to show recovery (BHPBIO, 2008) such that they are near to pre mining water levels.

Nimingarra I

Mining at Nimingarra I occurred during March to September 2006. The in-pit bore (WBNI01) used for the dewatering and associated observation bores (WPNI01 to WPNI03) were installed in November 2005 show water levels have recovered to pre-mining water levels.

As concluded with regard to the Y2/3 and SHW7 pits, no post-mining impact on surrounding aquifers is expected.

5.4 EGG CREEK BOREFIELD

The Egg Creek Borefield is located approximately 3 km west of the Sunrise Hill West 7 pit and comprises three production bores (NPB1, NPB2 and NPB3). The bores draw water from fractured bedrock comprising fractured chert, BIF and shale of the Gorge Creek Group. The aquifer is believed to be recharged by rainfall run-off from the surrounding catchment area.

Historical operating experience suggests that the aquifer is of limited areal extent, being a strip aquifer restricted to the zone of interconnected fractures. Although not quantified precisely, the available drilling and hydraulic data indicate the effective aquifer width is of the order of less than one hundred metres over a strike length of several kilometres. The aquifer thickness penetrated by the bores is between 15 to 25m occurring at depths ranging between 20 and 45m below ground level. The adjacent rocks will also yield some water to the fracture zone under the influence of hydraulic gradients induced by pumping. However, the rate of this contribution is likely to be limited due to the low permeability of the surrounding basement rocks.

Water from the Egg Creek Borefield was used for ore processing in the Sunrise Hill/Nimingarra area up until 1992. Abstraction then ceased and the Borefield was decommissioned in 1997.

The Borefield was recommissioned in 2003 as a temporary process water supply for the Nimingarra/Sunrise Hill Operations. Mining operations subsequently ceased in September 2006. The Egg Creek Borefield is currently in use and small volumes are periodically abstracted from the Borefield for local dust suppression purposes. The water remains fresh (~700 µS/cm) and has neutral acidity.

Historical data suggests that abstraction has had little to no influence on aquifer water levels and that drawdown response impacts of pumping were limited to the immediate borefield. It is not expected that there will be any post-mining impacts on surrounding aquifers.

5.5 CUNDALINE BOREFIELD

There are two bores (WB23 and WB24) located at the foot of the Cundaline deposit which were installed in 1993 to provide water supplies for the construction of the Yarrie Railway. The bores have subsequently been used to provide drilling water supplies at Cattle Gorge and dust

suppression water supplies for the Cattle Gorge-Yarrie haul road. No abstraction has occurred since October 2006.

There are no water level data available for WB24 as it is a flowing artesian bore (i.e. the hydraulic head is above the level of the ground surface). However it does allow for water quality samples to be taken without pumping. The results indicate fresh groundwater with an EC of 300 to 520 µS/cm and a neutral to slightly alkaline pH varying between 6.7 and 8.4 (BHPBIO, 2008). Due to the short periods of use the impacts of pumping are expected to remain localised with no observable impact over time on the aquifer.

5.6 ABSTRACTION AND LICENCING CONDITIONS

All of the borefields have historically operated well below their licenced allocation. In addition, abstraction in most cases has resulted in very low water level declines within the respective aquifers (except where dewatering was occurring) and, therefore, should be able to provide enough water to meet the demands of the planned Cundaline and Callawa mining operations.

Some minor modifications to existing Licences to Take Water would be required to allow water to be taken and used at the planned Cundaline and Callawa mining operations. Specifically, this may require an application to add additional tenements to the Licences and amend the 'GWL Operating Strategy for Goldsworthy' to include water use at the two sites.

6 ASSESSMENT OF THE PLANNED CUNDALINE AND CALLAWA MINING OPERATIONS AND POTENTIAL FUTURE IMPACTS

6.1 PLANNED CUNDALINE MINING OPERATIONS

Observed water levels from the exploration logs were compared with proposed pit depth extents for each of the six proposed pits (Table 6.1). The most recent data show that under the current mine plan (mining schedule V2 Feb 22), all pits for the planned Cundaline mining operations will remain above the natural water table, meaning that no dewatering will be required. The hydrogeological information available for the Cundaline ridge consists primarily of water level data obtained from logs during recent mineral exploration drilling and from the two existing production bores.

Table 6.1: Proposed Cundaline Mining Operations Water Levels and Proposed Pit Depths

Pit	Drill Hole Name	Drill Hole Locations (UTM)		Water Levels (m AHD)	Proposed Pit Base (m AHD)
		Easting	Northing		
14KA and 14KB	CU0015	208066	7722433	141	234
10KW	CU0016	205247	7725074	141	150
10KW	CU0017	205240	7725066	130	150
10KW	CU0018	205211	7725034	131	150
10KW	CU0041	205541	7724947	127	150
10KW	CU0043(a)	205581	7724953	132	150
10KW	CU0043(b)	205583	7724950	130	150
10KW	CU0045	205281	7725036	138	150
14KA and 14KB	CU0073	207877	7722474	138	198 and 234
10KW	CU0289R	204751	7725211	125	150
10KW	CU0290R	204768	7725186	140	150
13KA and 13KB	CU0300R	206947	7723258	118	174 and 180

6.2 PLANNED CALLAWA MINING OPERATIONS

A survey was undertaken by BHPBIO personnel on 27 August 2008 to confirm groundwater levels on the Callawa ridge in the area using previously drilled mineral exploration holes. The results of the survey are shown in Table 6.2.

Table 6.2: Proposed Callawa Mining Operations Groundwater Levels

Pit	Drill Hole Name	Drill Hole Locations (UTM)		Water Level m AHD	Proposed Pit Base m AHD
		Easting	Northing		
A	CA0005	219302	7715072	180	178
A	CA0023	219337	7715311	227	178
A	CA0061	219387	7715211	198	178
A	CA0063	219337	7715161	188	178
B	CA0079	219187	7715411	181	160
-	CA0088	219236	7715161	181	West of Pit A
A	CA0094	219374	7715114	187	178
-	CA0102R	219338	7714954	174	South of Pit A
B	CA0113R	219057	7715585	163	160
B	CA0116R	219112	7715435	179	160
C	CA0141R	219268	7715536	226	209
B	CA0143R	219209	7715507	210	160
B	CA0146R	219116	7715529	182	160

Figure 5 shows the location of water levels relative to the proposed pit areas. The water level data indicates that all three pits will intercept the groundwater table.

The Callawa ridge deposit are conceptualised hydrogeologically as small zones of mineralised ore of moderate permeability surrounded by unmineralised BIF horizons and granite rocks of very low permeability.

An analytical model was used to determine the maximum zone of influence for each pit. The model is a steady state solution for an unconfined aquifer with uniform recharge (Marinelli and Niccoli, 2000). Assumptions of this solution are as follows:

- Groundwater flow is horizontal. The Dupuit-Forcheimer approximation is used to account for changes in saturated thickness.
- The static water table is approximately horizontal.
- Groundwater flow to the pit is axially symmetric.

The model based on the above assumptions is considered appropriate for this scale of work.

Model input parameters and results are tabulated in Table 6.3.

Table 6.3: Analytical Modelling of Callawa Pits

Pit	K (m/d)	Recharge (mm/yr)	Effective Pit Radius (m)	Maximum Pit Drawdown (m)	Maximum Radius of Influence (m)
Pit A	0.005[1]	5[2]	95	22[3]	425[4]
Pit B	0.005[1]	5[2]	120	20[3]	430[4]
Pit C	0.005[1]	5[2]	85	15[3]	330[4]

Notes 1 BIF permeability obtained from airlift testing and used in modelling at Nimingarra B (Aquaterra, 2002).
2 Uniform mean annual recharge rate, from (BRS, 2005)
3 Assumed groundwater water table is horizontal determined from averaged values for each pit (Pit A – 200mAHD, Pit B – 180mAHD, Pit C – 226mAHD).
4 From centre of each pit.

The model was used to estimate groundwater inflow to each pit. Inflow and, therefore, the dewatering requirement for Pit A and Pit B would be approximately 7kL/d, and from Pit C would be approximately 4kL/d. These flows are very small and therefore likely to be used entirely for onsite dust suppression.

The model results suggest a maximum extent of drawdown ranging between 330 to 430m for each individual pit. However, the extent of drawdown to the east and north would be limited by the ridge itself. As a result, it is possible that there may be some minor increase in the predicted extent of drawdown.

Table 6.4: Predicted drawdown at radial distances from the edge of each Pit

Pit	Effective Pit Radius	Estimated drawdown from edge of Pit			Dewatering Rate (kL/d)
		+100 m	+200 m	+250 m	
Pit A	95	4.6	1.2	0.4	7
Pit B	120	4.1	0.9	0.2	7
Pit C	85	2.0	0.1	0.0	4

Table 6.4 shows the predicted drawdown at distances of 100, 200 and 250 m from the edge of each pit as a result of dewatering along with the expected long-term dewatering rate. The predicted drawdown depth at 250m from the pits would be negligible.

Given the limitations of the model as stated above the steady state analytical model was used to assess the combined effects of drawdown assuming the three pits were mined and dewatered at the same time. Figure 6 shows the extent of the zero drawdown contour is limited to less than 350 m from the pit boundary and the five metre drawdown contour is within 100 m of the respective pit boundaries.

Figure 7 is a conceptual hydrogeological cross-section through Pit A (see Figure 5 for location). The section is a hydrogeological conceptual model that shows the likely change in the groundwater table over time as a result of mining. As shown on Figure 7, the water table will decline in the immediate area of each pit as a response to dewatering during the period of mining. It is proposed to backfill the pit to at least 5m above the pre mining water table upon completion of mining. This will remove evaporative losses from the post-mining water balance, and therefore, it is unlikely that there will be detrimental impact on groundwater flows or quality. It is possible that direct rainfall recharge will increase locally in the pits and could potentially lower groundwater salinity of the local aquifer. As a result, water levels are predicted to recover with time to near pre-mining water levels (i.e. no pit lake).

The Goldsworthy pit was mined down to approximately 140m below the groundwater table and it took approximately 20 years after cessation of dewatering for the groundwater to recover to pre-mining levels. Similarly, the Nimingarra A pit was mined down to approximately 70 m below the groundwater table and it took approximately 10 years after cessation of dewatering for the groundwater to recover to pre-mining levels. As the deepest pit depth below the water table at Callawa is 22 m, and assuming similar hydrogeological conditions to what was observed at Goldsworthy and Nimingarra A, water levels in the Callawa pits would recover in less than five years with the majority of recovery occurring within the first year. As stated no pit lakes will develop in the Callawa pits because they are to be backfilled. As a result, there will be no direct evaporation of the pit lake surface during the recovery phase. Hence, recovery in the Callawa pits is expected to be much quicker and to higher levels when compared to those observed at either Goldsworthy or Nimingarra A.

In summary, results from the analytical modelling suggest that dewatering of the pits will not have any significant short term impact on the groundwater system in the vicinity of the proposed pits. By backfilling the pits to at least 5m above the pre-mining water table, negligible long-term impacts on groundwater level and quality is expected.

7 CONCLUSIONS

The following are summary conclusions of assessed hydrogeological impacts to the current Goldsworthy and planned Cundaline and Callawa mining operations:

- A review of the existing Goldsworthy borefields (both dewatering and water supply) show hydrogeological impacts to date have been restricted to the immediate mine areas with drawdown in groundwater levels being largely confined to the orebody aquifers which are bounded by low permeability rocks. There have been no significant impacts observed on regional groundwater levels or surface water/groundwater quality as a result of dewatering or dewatering discharge to date.
- The impacts of continued operation of the existing borefields (dewatering and water supply pumping) are not expected to have any additional impacts on local and regional water resources, to those which have already been observed to date.
- Groundwater level information indicates that mining at the Cundaline deposit will not go below the natural water table and no dewatering would be required.
- Groundwater level information indicates that all three proposed pits at the Callawa deposit will intercept the water table and dewatering will be required.
- Hydrogeological interpretation indicates dewatering of the pits at Callawa ridge is not expected to impact on regional groundwater levels beneath the plain adjacent to the mined ridge for the following reasons:
  - The Callawa ridge deposits are zones of mineralised ore of moderate permeability surrounded by rock consisting mainly unmineralised BIF and granite rock of very low permeability. As a result, the hydrogeological impacts of mining (dewatering) would be restricted to the immediate mining area with drawdown in groundwater levels being largely confined to the Callawa ridge aquifer.
  - The difference in groundwater elevation between the observed water table on the Callawa ridge and the inferred water table beneath the adjacent plain is readily observed at other similar Goldsworthy deposits and suggests a low degree of hydraulic connectivity.
  - Proposed ultimate pit designs for Callawa are significantly above the elevation of the valley floor.
- Analytical modelling indicates the extent of the drawdown cone for each of the individual pits will be less than 350m from each pit boundary. Predicted drawdown will be less than five metres at a radial distance of 100m from edge of each pit. However, the zone of influence may be become elongate to the south and west to compensate for the limited lateral extent of the ridge to the north and east of the pits.
- If all the pits at Callawa were to be dewatered at the same time, the maximum rate predicted from the analytical model would be approximately 18kL/d. This value is considered to be small is likely to be entirely used for onsite dust suppression.
- Backfilling of the pits at Callawa to 5 m above the pre-mining water table is likely to result in the water table recovering to pre-mining levels. Based on observed recovery in similar pits located at Goldsworthy, full recovery should take less than five years with the majority of recovery occurring within the first year. That is, there will be no impact on groundwater levels or quality once mining (dewatering) has been completed.
- Some minor modifications to existing Licences to Take Water would be required to allow water to be taken and used at the planned Cundaline and Callawa mining operations. Specifically, this may require an application to amend the 'GWL Operating Strategy for Goldsworthy' to include the water use at the two site.

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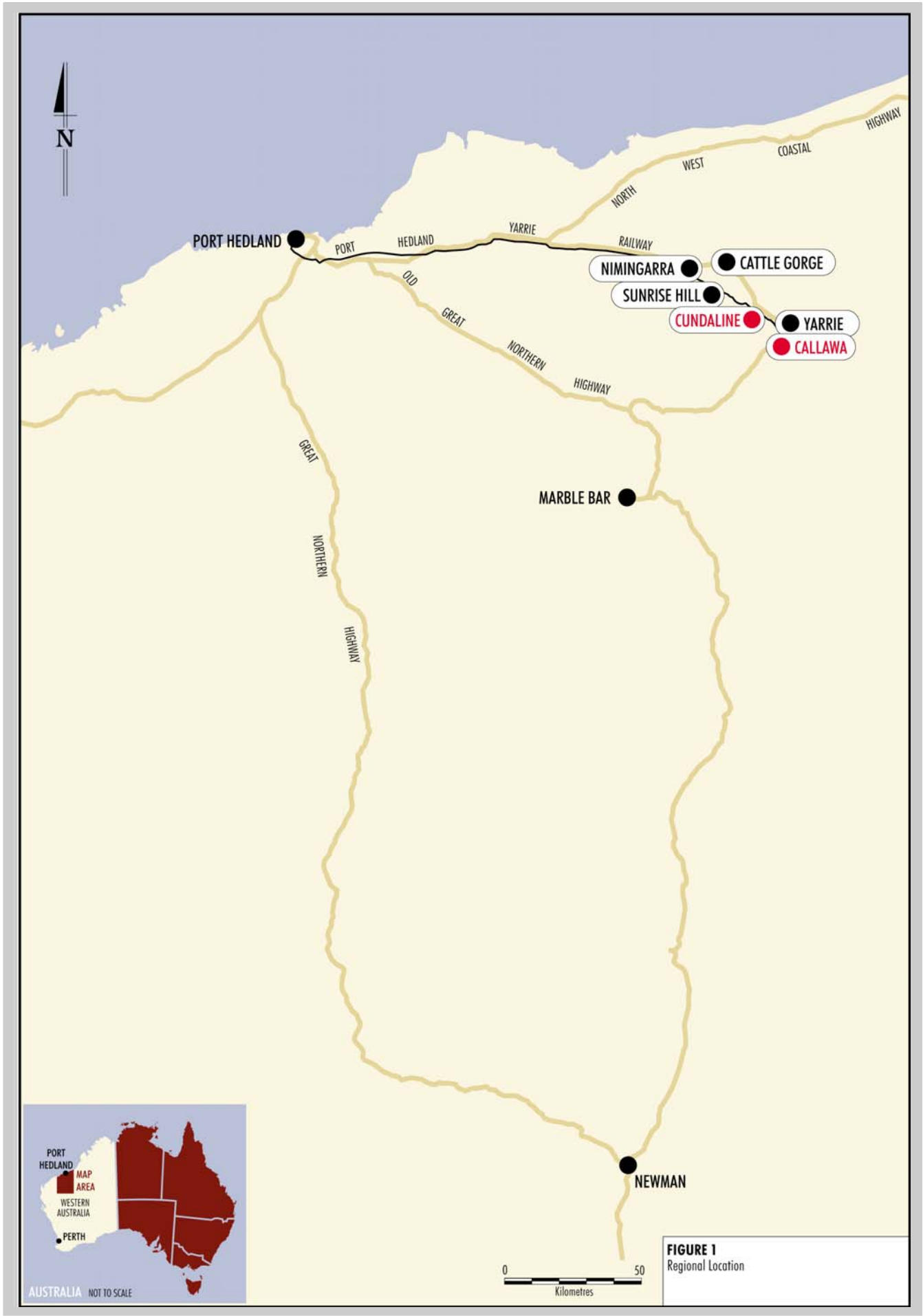
FIGURES



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REGIONAL LOCATION FIGURE 1

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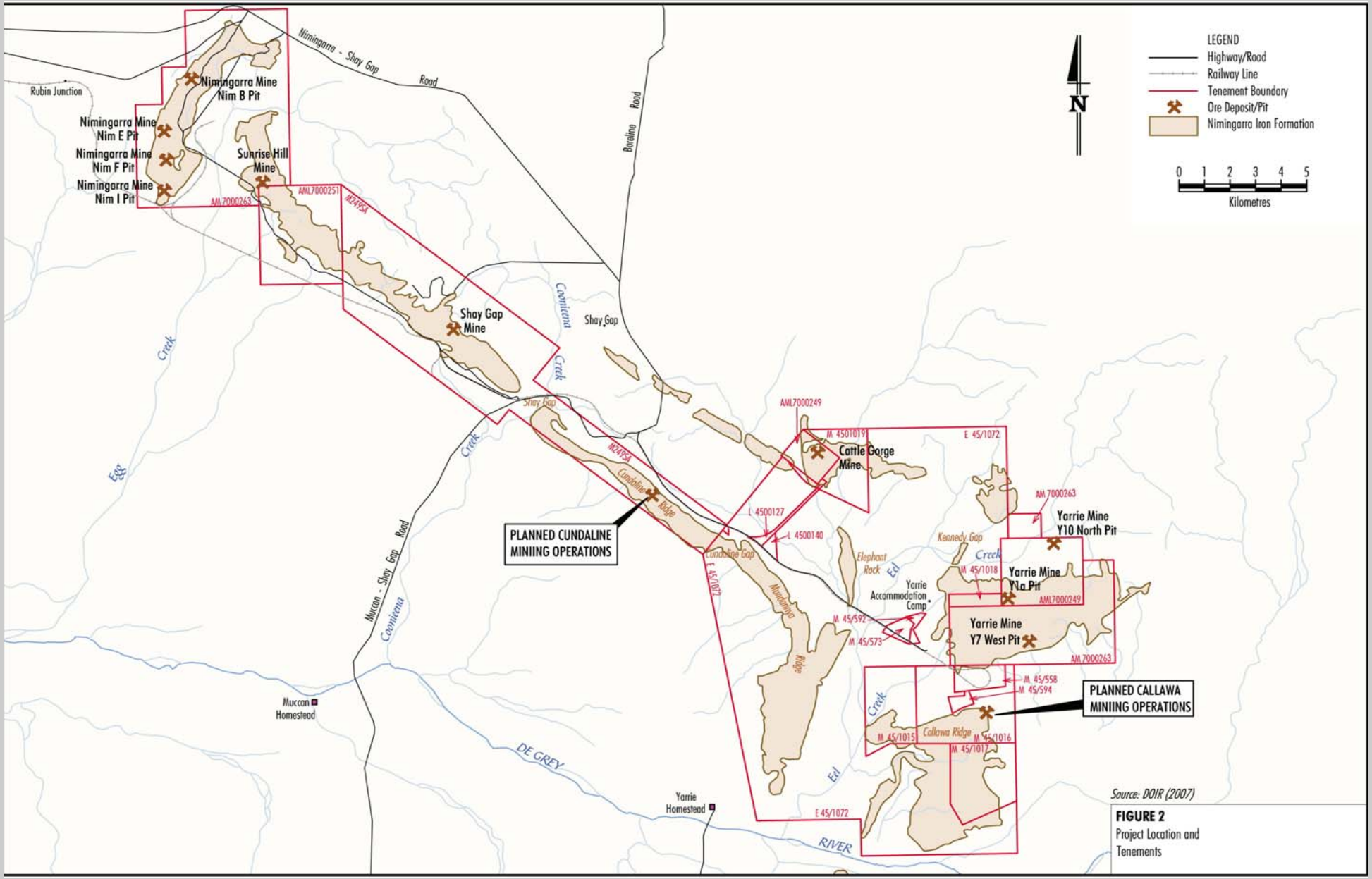

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PROJECT LOCATION AND TENEMENTS FIGURE 2

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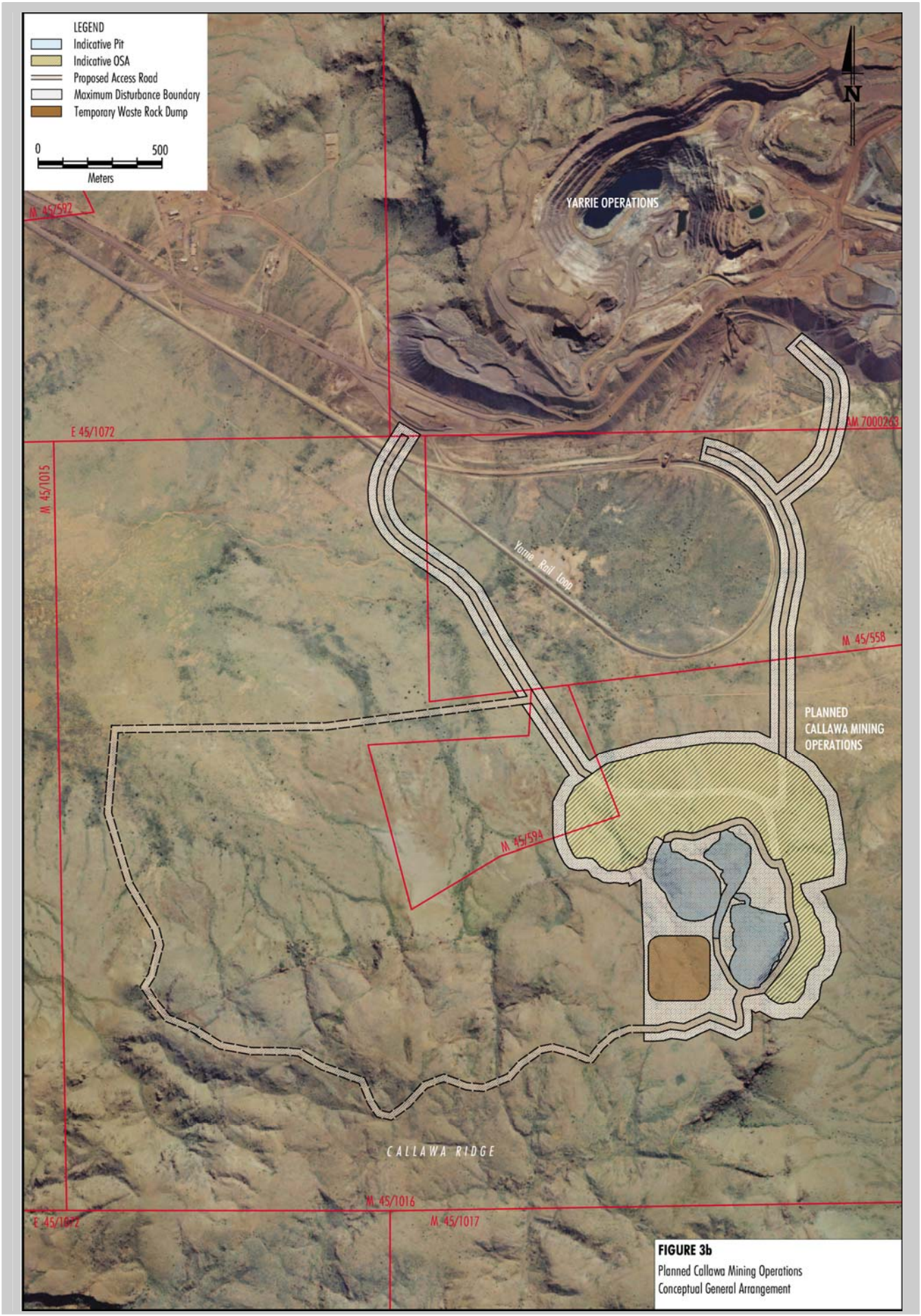

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PLANNED CALLAWA MINING OPERATIONS CONCEPTUAL GENERAL ARRANGEMENT FIGURE 3B

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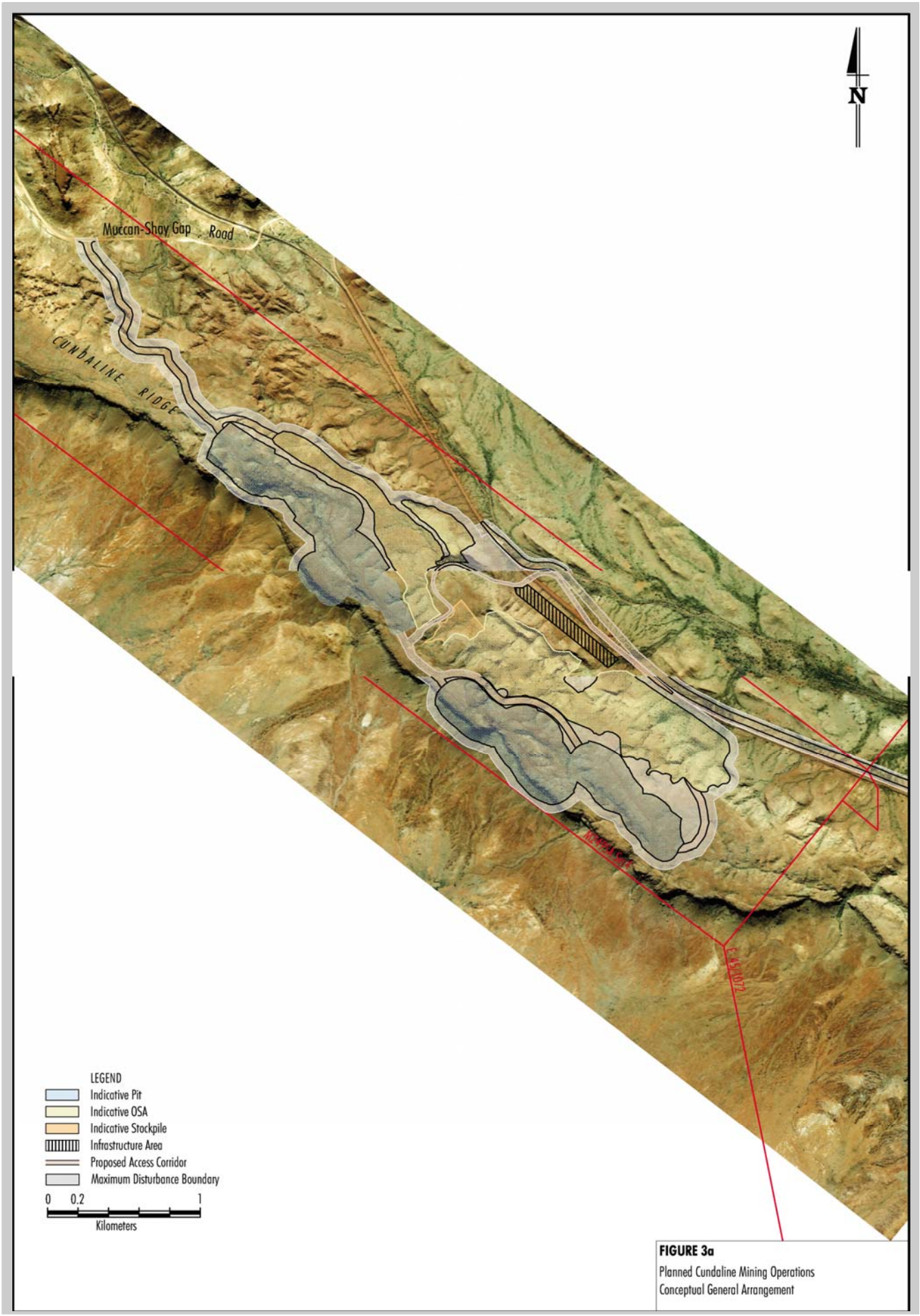

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PLANNED CUNDALINE MINING OPERATIONS CONCEPTUAL GENERAL ARRANGEMENT FIGURE 3A

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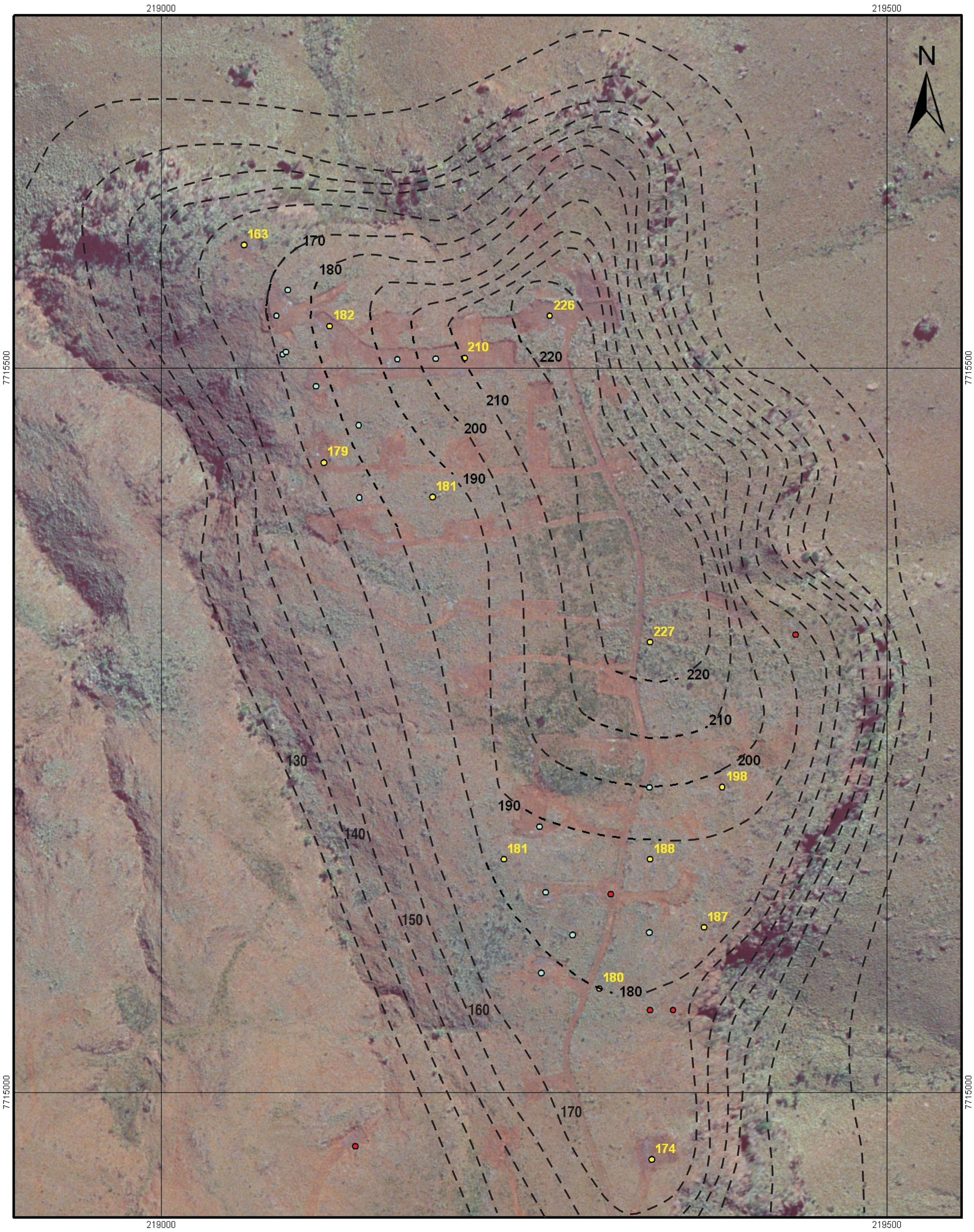

Legend

- Static Water Level (mRL) - 27/08/08
- Lost Holes (Blocked/Inaccessible)
- Other Holes Surveyed by Subterranean Ecology
- Indicative Groundwater Level Contours (mRL)

Scale 1 : 2,500

0 40 80 120 160m

Transverse Mercator Projection
Zone: 51 Datum: GDA 1994 Spheroid: GRS 1980

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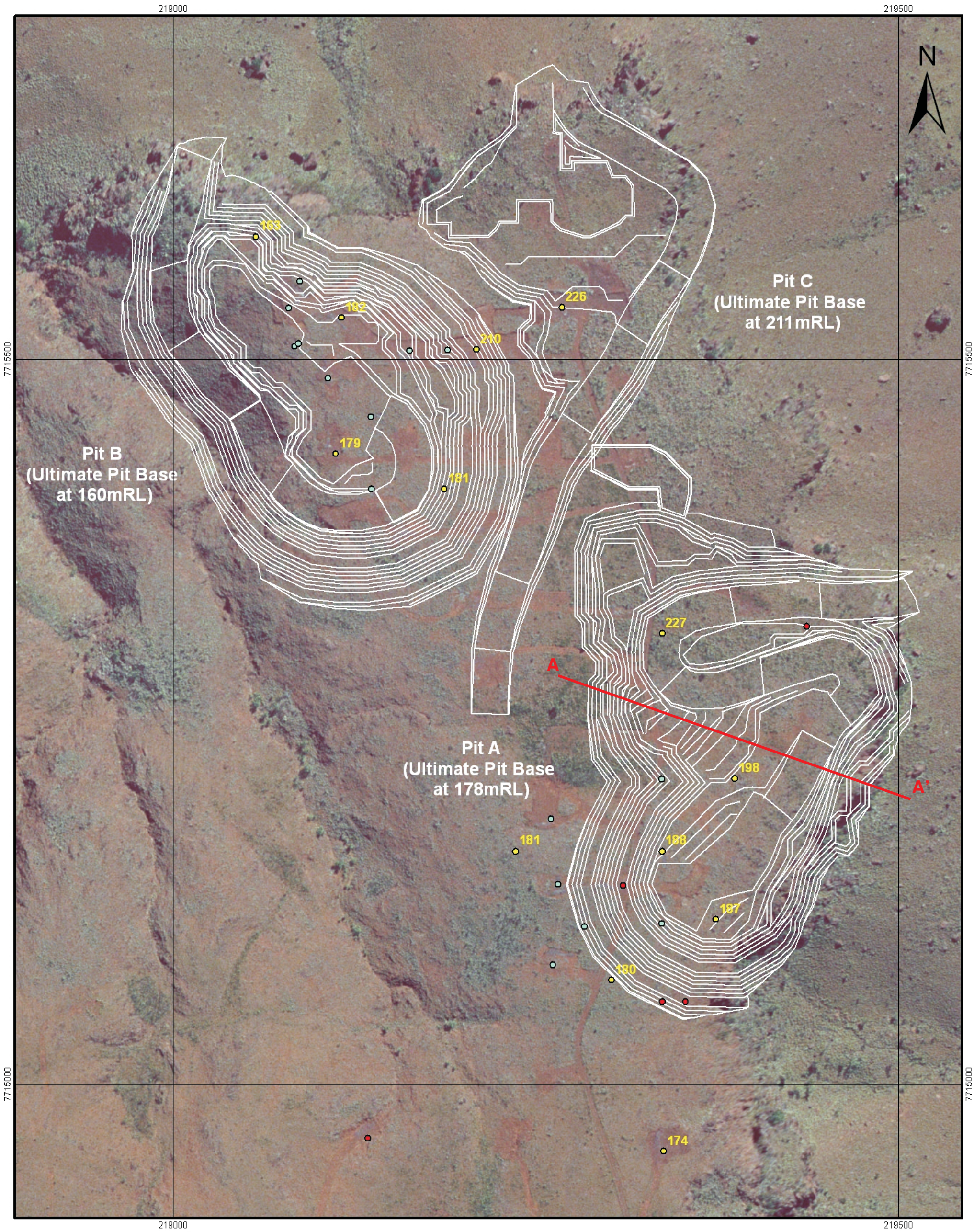
BHP Billiton Iron Ore

Callawa Deposit

Static Water Levels and Indicative Groundwater Level Contours - 27/08/08

Prepared: A Herod	Drg. No:	
Drawn: A Herod	Revisions:	
Centre: Perth	Date : 01/09/2008	Figure 4

Callawa_SWLMemo_PlateA_new.Cdr



Legend

- Static Water Level (mRL) - 27/08/08
- Lost Holes (Blocked/Inaccessible)
- Other Holes Surveyed by Subterranean Ecology

Scale 1 : 2,500

0 40 80 120 160m

Transverse Mercator Projection
Zone: 51 Datum: GDA 1994 Spheroid: GRS 1980

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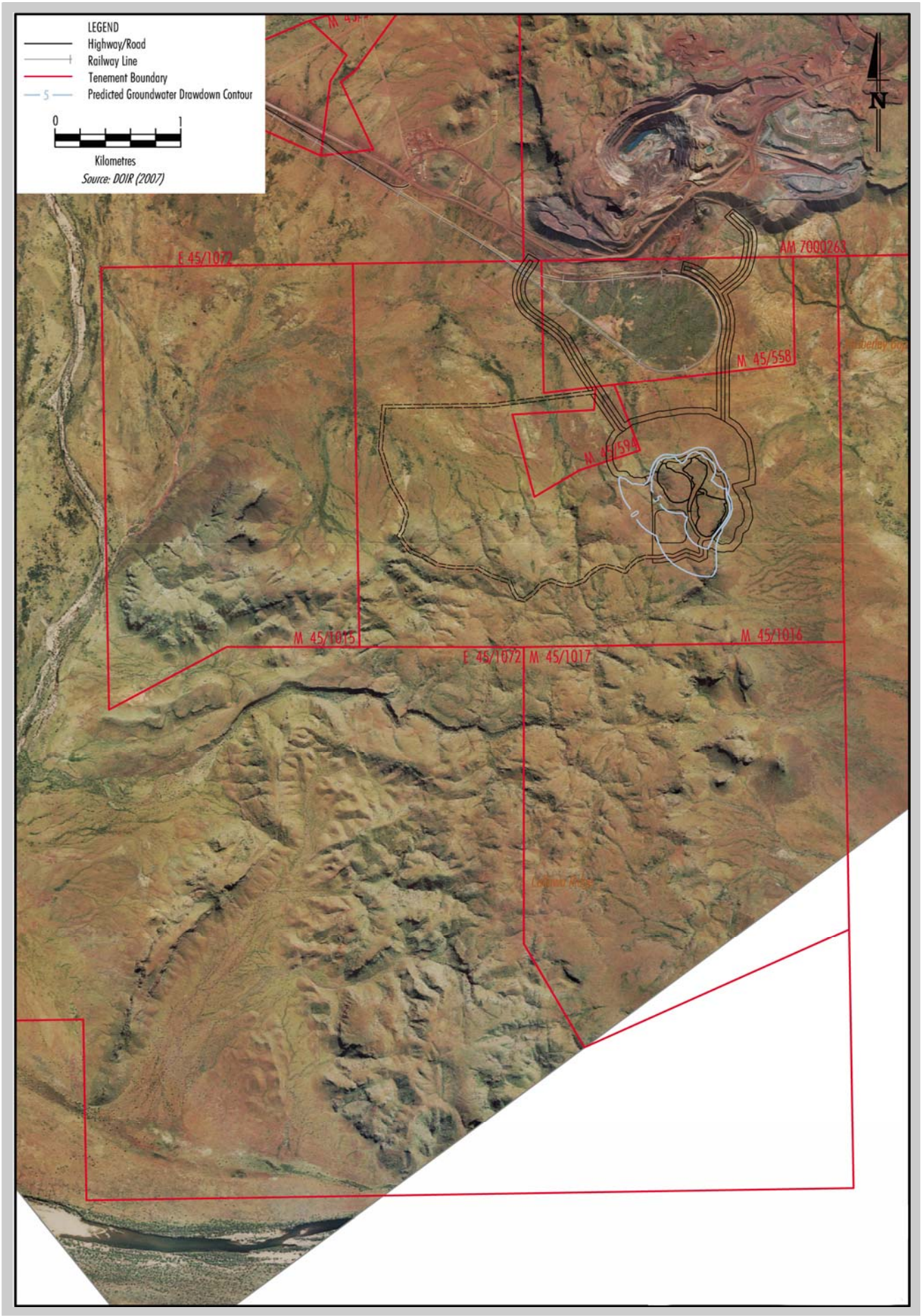
Resource Planning Department
BHP Billiton Iron Ore

Callawa Deposit

Ultimate Pit Design & Static Water Levels - 27/08/08

Prepared: A Herod	Drg. No:
Drawn: A Herod	Revisions:
Centre: Perth	Date : 01/09/2008

Figure 5



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MODELLED CALLAWA DRAWDOWN CONTOURS FIGURE 6

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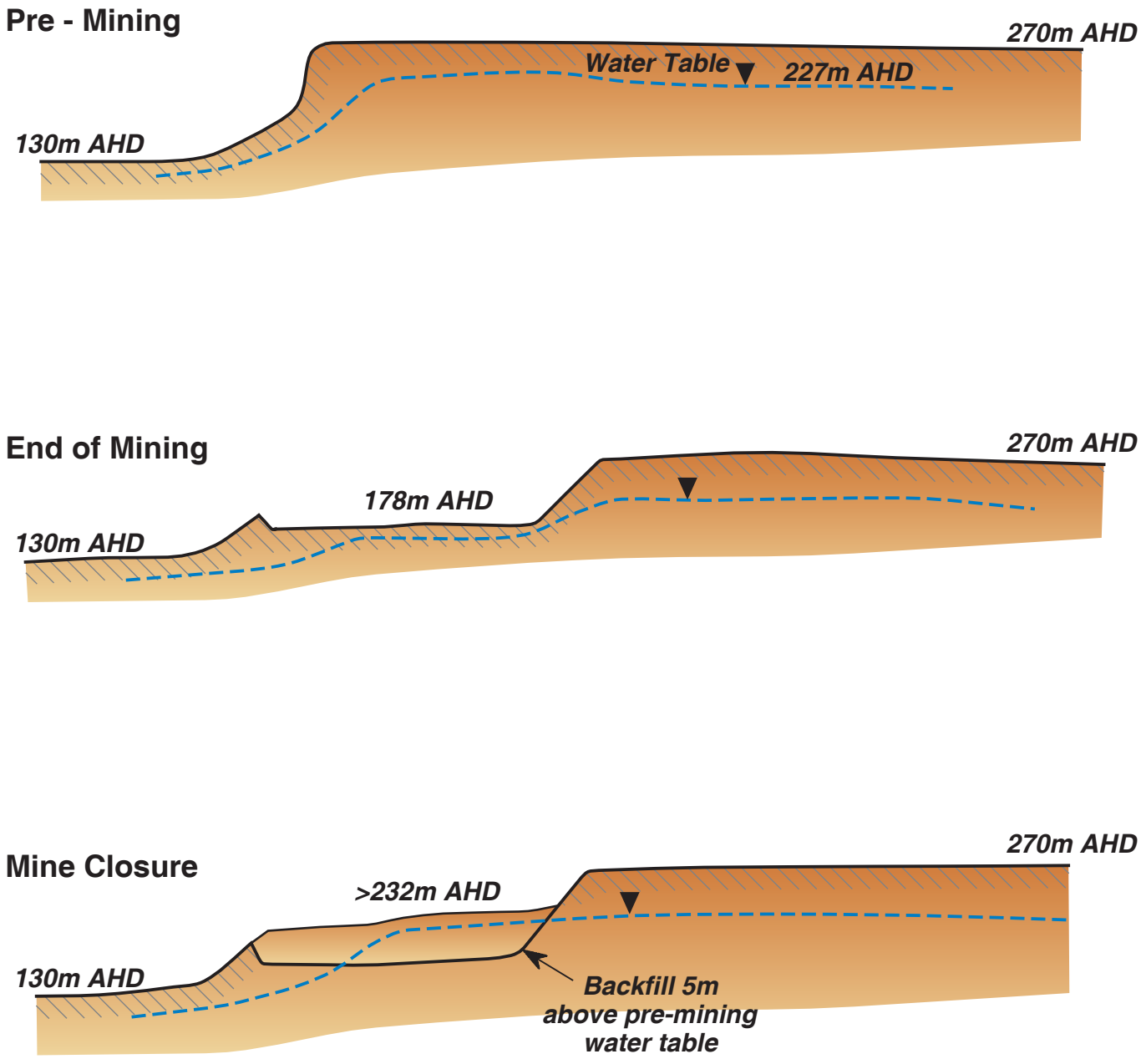
Callawa Conceptual Groundwater Model

Cross-Section through Pit A (refer to Plate B)



Not to scale

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FIGURE 7

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Water and Environment

APPENDIX H

FLORA AND VEGETATION ASSESSMENT (ENV AUSTRALIA, 2008)

GOLDSWORTHY IRON ORE MINING OPERATIONS – CUNDALINE AND CALLAWA MINING OPERATIONS

FLORA AND VEGETATION ASSESSMENT

Prepared for

BHP BILLITON IRON ORE PTY LTD

Job No: 08.123

Report No: RP001

env Australia

GOLDSWORTHY IRON ORE MINING OPERATIONS - CUNDALINE AND CALLAWA MINING OPERATIONS

FLORA AND VEGETATION ASSESSMENT

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Content Review:	*Teresa Gepp*
Date:	*17 October 2008*

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STATEMENT OF LIMITATIONS

Scope of Services

This environmental site assessment report ('the report') has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and ENV.Australia Pty Ltd (ENV) ('scope of services'). In some circumstances the scope of services may have been limited by factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, ENV has relied on data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ('the data'). Except as otherwise stated in the report, ENV has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or in part on the data, those conclusions are contingent upon the accuracy and completeness of the data. ENV will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, unavailable, misrepresented or otherwise not fully disclosed to ENV.

Environmental Conclusions

In accordance with the scope of services, ENV has relied on the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, express or implied, is made.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and for no other party. ENV assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including, without limitation, matters arising from any negligent act or omission of ENV or for any loss or damage suffered by any other party relying on the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions, and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

ENV will not be liable to update or revise the report to take into account any events or circumstances occurring or facts becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report, nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

EXECUTIVE SUMMARY

ENV.Australia was commissioned by BHP Billiton Iron Ore to undertake a flora and vegetation assessment of the Goldsworthy Iron Ore Mining Operations planned Cundaline and Callawa mining operations.

The planned Cundaline and Callawa mining operations are located 180 kilometres and 200 kilometres east of Port Hedland, respectively, on the Callawa and Cundaline ridges.

This flora and vegetation assessment builds upon flora survey work conducted by *ecologia* Environment on the Callawa and Cundaline ridges in 2005. A supplementary flora survey (this survey) was conducted by ENV.Australia in March 2008.

During the supplementary flora survey, 24 quadrats and relevés were surveyed in the Callawa study area and 37 in the Cundaline study area. One hundred and forty-seven taxa were recorded in the Callawa supplementary survey area and 193 taxa were recorded from the Cundaline supplementary survey area.

No Endangered or Vulnerable species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, or Declared Rare Flora species under the Western Australian *Wildlife Conservation Act 1950* have been recorded from the Callawa and Cundaline study areas or are considered likely to occur.

No Priority Flora species are likely to be significantly impacted by the planned Callawa and Cundaline mining operations. Two Priority Flora species have been recorded within the Cundaline study area, but are outside the planned disturbance areas, namely, *Euphorbia clementii* (Priority 2) and *Goodenia nuda* (Priority 3). One Priority Flora species has been previously recorded in the Callawa study area, Euphorbia inappendiculata (Priority 3).

Six introduced species were recorded in the study areas. **Cenchrus ciliaris, *Echinochloa colona*, *Chloris virgata, *Portulaca oleracea* and **Passiflora foetida* var. *hispida* were recorded within the Callawa study area, and **Cenchrus ciliaris, *Portulaca oleracea, *Chloris virgata* and **Cucumis melo* subsp. *agrestis* were recorded within the Cundaline study area.

A total of 14 vegetation communities were identified in the Callawa study area and 21 in the Cundaline study area. Both study areas comprised mainly woodlands and shrublands. No vegetation communities recorded are listed as Threatened Ecological Communities, Priority Ecological Communities or are considered of regional significance.

1 INTRODUCTION

ENV.Australia Pty Ltd (ENV) was commissioned in March 2008 by BHP Billiton Iron Ore (BHPBIO) to undertake a flora and vegetation assessment survey of the Goldsworthy Iron Ore Mining Operations (Goldsworthy) planned Cundaline and Callawa mining operations.

The planned Cundaline and Callawa mining operations are located 180 kilometres (km) and 200 km east of Port Hedland, respectively, on the Callawa and Cundaline ridges.

This flora and vegetation assessment builds upon flora survey work conducted by *ecologia* Environment on the Cundaline and Callawa ridges in 2005. A supplementary flora survey was conducted by ENV in March 2008.

A supplementary Level Two flora and vegetation assessment was conducted in accordance with *Guidance Statement No. 51* of the Western Australian Environmental Protection Authority (EPA) (EPA 2004). The supplementary survey areas lie adjacent to, but do not overlap, areas surveyed in 2005 by *ecologia* Environment (see section 3.1).

The objectives of this flora and vegetation assessment are as follows:

- conduct a flora and vegetation database review for the planned Cundaline and Callawa mining operations;
- document the presence of all plant species of conservation significance within the study area;
- record the occurrence of introduced plant species;
- assess vegetation condition;
- document, describe and map the vegetation communities present; and
- describe the conservation significance of these vegetation communities.

1.1 LOCATION

The planned Cundaline and Callawa mining operations lie 180 km and 200 km east of Port Hedland, respectively, within the Goldsworthy area (Figure 1).

Goldsworthy operations include current mining operations at Yarrie, Cattle Gorge, Nimingarra and Sunrise Hill (Figure 2) and past mining areas at Mount Goldsworthy and Shay Gap.

The planned Cundaline and Callawa mining operations include open pit mining, placement of overburden in mined-out voids and out-of-pit storage areas, and the construction and use of haul roads, small day rooms, workshops and storage areas.

1.2 REGIONAL BIOGEOGRAPHY

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into 85 bioregions based on major biological and geographical/geological attributes (Thackway and Cresswell 1995). These bioregions are subdivided into 404 subregions, as part of a refinement of the IBRA framework (Commonwealth Department of Environment and Water, Heritage and Arts [DEWHA] 2008).

The Callawa and Cundaline study areas are located within the Pilbara bioregion, and are in the transition zone between the Roebourne and Chichester subregions (Thackway and Cresswell 1995).

The Chichester subregion is described by Kendrick and McKenzie (2001) as 'plains supporting shrub steppe of *Acacia inaequilatera* and *Triodia wiseana* hummock grasslands, with *Eucalyptus leucophloia* tree steppe on the ranges'. The Roebourne subregion consists of uplands dominated by *Triodia* hummock grasslands with *Eucalyptus victrix* or *Corymbia hamersleyana* woodlands in ephemeral drainage lines.

1.3 CLIMATE

The Pilbara has an arid-tropical climate with two distinct seasons, a hot summer from October to April and a mild winter from May to September. The nearest accessible long-term climate data to the study area is available from the Marble Bar Bureau of Meteorology (BOM) weather station, with the nearest recent data available from the Port Hedland BOM weather station.

The Marble Bar area experiences a wide range of temperatures, with an average temperature of 35.3 degrees Celsius (°C) (1965 to 1998). In summer, maximum temperatures may reach 49.2 °C, whilst in winter, minimum temperatures may reach 1.1 °C (BOM 2008).

Rainfall in the Pilbara is often sporadic, and can occur in summer and winter. The Marble Bar area has average annual rainfall of 361.7 millimetres (mm) (1901 to 2006; Figure 3). Summer rainfall is typically associated with tropical storms in the north, or tropical cyclones that cross the coast and move inland. Winter rainfall is generally less significant, and is commonly the result of cold fronts moving north-easterly across the State.

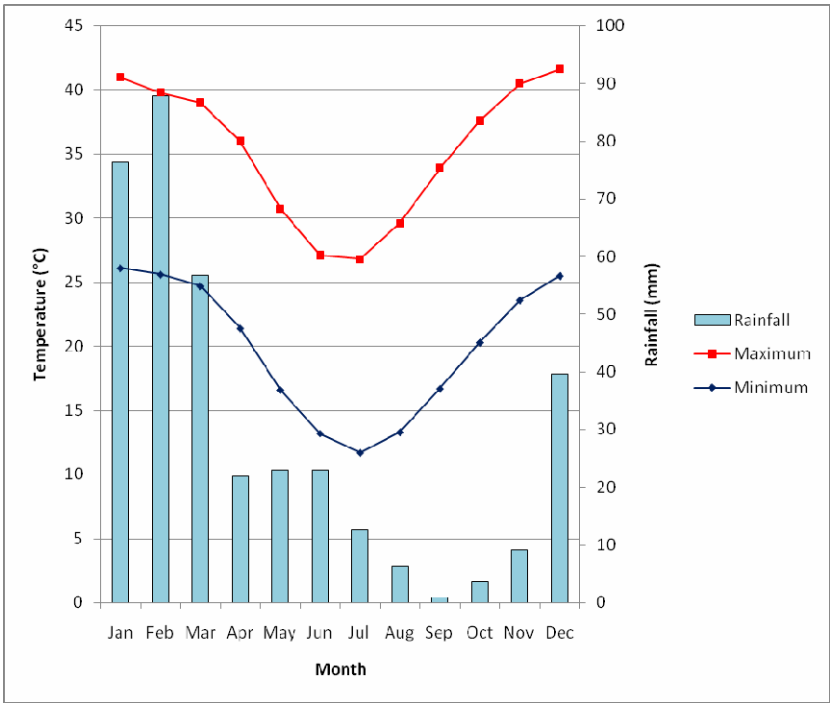

Figure 3: Average Monthly Rainfall and Maximum and Minimum Temperatures at Marble Bar from 1901 to 2006 (BOM 2008).

1.4 GEOLOGY AND LANDFORMS

The study areas comprise landforms that include low hills and rocky slopes, plains and floodplains. Williams (2004) mapped the geology of the area as comprising ten units, as listed below.

Cundaline

AGd: Fine to coarse-grained metadolerite sills intruded into Gorge Creek Group.

AgMmc: Medium to coarse-grained monzogranite and syenogranite; pink-grey to cream; weak metamorphic foliation.

AGn: Nimingarra Iron Formation: Banded iron-formation, jaspilite, banded and ferruginous chert, and black carbonaceous shale; metamorphosed.

AGna: Nimingarra Iron Formation: Basal pebble to cobble-conglomerate, sandstone, siltstone, and shale; metamorphosed.

AGu: Cundaline Formation: weathered brown, grey-green shale, siltstone, lithic wacke, sandstone, and pebble conglomerate; local polymictic, matrix supported conglomerate; metamorphosed.

JKc: Callawa Formation: very fine to coarse grained sandstone; ferruginous towards base, with siltstone and conglomerate interbeds; plant and trace fossils; mainly fluvial deposits.

Qc: Colluvium: sand, silt, and gravel on outwash fans; scree and talus; proximal mass-wasting deposits.

Qaa: Alluvium: undivided clay, silt, sand, and gravel in rivers and creeks.

Callawa

AGn: Nimingarra Iron Formation: Banded iron-formation, jaspilite, banded and ferruginous chert, and black carbonaceous shale; metamorphosed.

AgWmc: Warrawagine Granitoid Complex: pink-grey, medium to coarse grained monzogranite, syenogranite, and granodiorite; metamorphosed.

Qc: Colluvium: sand, silt, and gravel on outwash fans; scree and talus; proximal mass-wasting deposits.

Qs: Eolian sand: light to dark red sand in sheets, and longitudinal (seif) and chain dunes; quartz pebble, ironstone pebble, or rock fragment veneer on some sheets and in interdunal areas.

Qaa: Alluvium: undivided clay, silt, sand, and gravel in rivers and creeks.

1.5 LAND SYSTEM MAPPING

Land system mapping is based on regional patterns in topography, soils and vegetation. The most recent land system mapping of the Pilbara bioregion was completed by van Vreeswyk *et al.* (2004). The mapping divides the Pilbara region into 102 land systems. The Cundaline and Callawa study areas are each made up of four land systems, as listed below.

Cundaline

Cpn: Capricorn: Hills and ridges of sandstone and dolomite supporting shrubby hard and soft Spinifex grasslands; forms 2.9% of the Pilbara bioregion.

Bgd: Boolgeeda: Stony lower slopes and plains below hill slopes; supporting hard and soft Spinifex grasslands and Mulga scrublands; forms 4.3% of the Pilbara bioregion.

Roc: Rocklea: Basalt hills, plateaux, lower slopes and minor stony plains supporting hard Spinifex (and occasionally soft Spinifex) grasslands; forms 12.7% of the Pilbara bioregion.

Cll: Callawa: Highly dissected low hills, mesas and gravelly plains of sandstone and conglomerate supporting soft and hard Spinifex grasslands; forms 0.6% of the Pilbara bioregion.

Callawa

Pds: Paradise: Alluvial plains supporting soft Spinifex grasslands and tussock grasslands; forms 0.8% of the Pilbara bioregion.

Bgd: Boolgeeda: Stony lower slopes and plains below hill slopes; supporting hard and soft Spinifex grasslands and Mulga scrublands; forms 4.3% of the Pilbara bioregion.

Mac: Macroy: Stony plains and occasional tor fields based on granite supporting hard and soft Spinifex grasslands; forms 7.2% of the Pilbara bioregion.

Cpn: Capricorn: Hills and ridges of sandstone and dolomite supporting shrubby hard and soft Spinifex grasslands; forms 2.9% of the Pilbara bioregion.

1.6 BEARD VEGETATION MAPPING

The study areas are located within the Abydos Plain, which forms part of the Fortescue Botanical District in the Eremaean Botanical Province of Western Australia as per Beard (1975). Beard (1975) mapped the area as two vegetation associations:

a_2Sr.t_1Hi: Hummock grasslands, shrub steppe; *Acacia inaequilatera* over soft Spinifex; and

e_{16}Lr.$t^1{}_6$Hi: Hummock grasslands, low tree steppe; Snappy Gum over soft Spinifex and *Triodia brizoides*.

Under the EPA's *Position Statement 2*, proposals should not take vegetation below the 'threshold level' of 30% of the pre-European settlement extent of the vegetation type (EPA 2002). Shepherd, Beeston and Hopkins (2002) give an estimate of the percentage of each of Beard's vegetation associations that

remains compared to its pre-European settlement extent, so an estimate of the scarcity of each complex can be determined. For both the vegetation associations mapped for the study areas, 100% of their pre-European settlement extent is estimated to remain.

1.7 PREVIOUS BIOLOGICAL SURVEYS

Historically, the flora and fauna of the Pilbara has not generally been recorded systematically, with significant exceptions, including flora studies by Burbidge (1959) and Beard (1975). More recently, the Department of Agriculture (van Vreeswyk *et al.* 2004) conducted an inventory and condition survey of the Pilbara. This report provides a regional inventory of flora species and a description of land resources. A comprehensive and systematic field review of Pilbara regional flora is in preparation by the Western Australian Department of Environment and Conservation (DEC) (DEC Pilbara Biological Survey 2002 to 2007).

In recent decades, a boom in large-scale regional resource development projects has resulted in a significant amount of site-specific biological survey work being carried out in the region, most of which is undertaken to obtain environmental approvals. A comprehensive bibliography of biological survey work undertaken in the Pilbara is available at *http://science.dec.wa.gov.au/projects/pilbaradb/.*

Various biological surveys have been conducted within 20 km of the study areas in the last 15 years, mainly in association with Goldsworthy. These include:

- *Callawa Biological Assessment* (*ecologia* Environment 2005a);
- *Cundaline Biological Assessment* (*ecologia* Environment 2005b);
- *Goldsworthy Extension Project Biological Assessment* (*ecologia* Environment 2005c), a pre-feasibility study of Yarrie, Shay Gap, Nimingarra, Finucane Island Goldsworthy Corridor;
- *Yarrie Cattle Gorge Biological Survey* (*ecologia* Environment 2004a), located approximately 5 km away;
- *Nim B Extension Priority Flora Search* (*ecologia* Environment 2004b), located approximately 20 km away;
- *Yarrie Biological Survey* (*ecologia* Environment 1999), located approximately 5 km away; and
- *Yarrie Botanical Survey* (*ecologia* Environment 1994), located approximately 5 km away.

1.7.1 Cundaline Biological Assessment (2005)

ecologia Environment (2005b) undertook the Cundaline flora and vegetation survey from 13-17 May 2005. The objectives of the field survey were to provide:

- an inventory of vascular flora species;
- a description and mapping of vegetation communities;
- an inventory and review of flora species of conservation significance or geographically restricted, which are known to, or may occur, in the study area;
- an inventory of exotic flora, including declared weeds;
- a review of the current impact on landuse on vegetation communities; and
- a review of other potential impacts.

Thirty-five 50 metres (m) x 50 m flora quadrats were surveyed as part of the flora survey, with 91 taxa from 28 families and 48 genera recorded.

No species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Declared Rare Flora species as listed under the Western Australian *Wildlife Conservation Act 1950* (WC Act) or Priority Flora species were recorded.

Two undescribed species of *Stemodia* sp. and *Sida* sp. were recorded. *Stemodia* sp. is referred to by *ecologia* Environment as *Stemodia* sp. Shay Gap and was recorded from two cliff lines on the south-west side of the Cundaline Ridge. A total of 32 plants were recorded on the Cundaline Ridge. *Sida* sp. is referred to by *ecologia* Environment as *Sida* sp. Callawa and was recorded from one site.

The *Stemodia* sp. was reported by *ecologia* Environment (2005c) to be a herb, 30-50 cm in height with serrated lush to dark green leaves that are conspicuous in comparison to other plants growing in the same cliffline environment. The flowers are reported by *ecologia* Environment (2005c) to be slightly tubular in form, asymmetrical in shape and purple to dark lilac in colour. Flowering appears to occur in the cooler parts of the year. The leaves are reported by *ecologia* Environment (2005c) to occur in pairs and are usually openly arranged along the usually sparsely hairy stem.

The *Sida* sp. was reported by *ecologia* Environment (2005c) to be a low shrub, which was found growing 10 to 30 cm tall. The habitat in which the specimens were collected was described as steep rocky breakaway habitat (*ecologia* Environment 2005a and b).

Neither *Stemodia* sp. Shay Gap nor *Sida* sp. Callawa are currently formally recognised or catalogued at the Western Australian Herbarium (WAH) (WAH 2008).

Corchorus pumilio and *Solanum beaugleholei* were recorded from four and 19 sites, respectively. The records of both species are considered to be range extensions from the Kimberley.

No introduced species or Declared Plants were recorded during the survey.

Eight vegetation communities were identified within the study area. No communities listed as Threatened Ecological Communities (TECs) as per the EPBC Act or the State list endorsed by the Minister for Environment, or as Priority Ecological Communities (PECs) as per the DEC Priority list were recorded.

1.7.2 Callawa Biological Assessment (2005)

ecologia Environment (2005a) completed the flora and vegetation assessment of Callawa from 9-17 June 2005, with vegetation mapping completed from 12-14 September 2005. The objectives of the field survey were to provide an inventory of:

- vascular flora occurring in the study area;
- biologically significant species, including rare flora, in the study area;
- vegetation communities observed in the study area; and
- vegetation assemblages in the study area deemed to be poorly represented or essential to the survival of rare flora.

The study also included a review of:

- regional and local conservation value of flora present or likely to be present in the study area;
- flora species of particular conservation value, such as Priority species likely to occur in the study area;
- current impact of the land use on vegetation communities; and
- other potential impacts on the existing environment.

Fifty-five 50 m x 50 m flora quadrats were surveyed as part of the flora survey, with 96 taxa from 35 families and 61 genera recorded.

No EPBC Act listed species, Declared Rare Flora species or Priority Flora species were recorded in the study area.

Two undescribed species, *Stemodia* sp. and *Sida* sp. recorded at Cundaline were also recorded at Callawa.

Stemodia sp. is referred to by *ecologia* Environment as *Stemodia* sp. Shay Gap and a total of 452 plants were recorded from 13 locations on the Callawa Ridge. The number of plants at each location was estimated at up to 100 or more plants. A total of 32 plants were recorded from two locations on Cundaline Ridge (*ecologia* Environment 2005a and b). The *Stemodia* sp. has also been recorded at three locations at Sunrise Hill (*ecologia* Environment 2005c; Section 1.7.3).

Sida sp. is referred to by *ecologia* Environment as *Sida* sp. Callawa and was recorded from eight sites on the Callawa Ridge. The numbers of plants at each location were not reported by *ecologia* Environment (2005a and b). Specimens of *Sida* sp. were recorded from one site on the Cundaline Ridge.

Both of these species are currently not formally recognised or catalogued at the WAH (WAH 2008).

Four species of interest which were recorded include *Enneapogon lindleyanus*, *Eriachne tenuiculmis*, *Phyllanthus exilis* and *Solanum beaugleholei*. *Phyllanthus exilis* and *Solanum beaugleholei* were recorded from one and three sites respectively, with the records of both species considered to be range extensions from the Kimberley (*ecologia* Environment 2005a). Two endemic grass species were also recorded: *Enneapogon lindleyanus* and *Eriachne tenuiculmis*. These species were recorded at one and 10 sites, respectively.

No declared weed species were recorded during the survey, however the introduced species Stinking Passion Vine (**Passiflora foetida* var. *hispida*) was recorded at one site.

Six vegetation communities were identified during the survey. No communities listed as TECs under the EPBC Act or State lists, or as PECs as per the DEC Priority list were recorded in the study area.

1.7.3 Goldsworthy Extension Project Biological Survey (2005)

The Goldsworthy Extension Project survey (*ecologia* Environment 2005c) included survey work at Yarrie, Cattle Gorge, Nimingarra and Sunrise Hill. The results of the Yarrie survey are summarised in Section 1.7.5, and the Cattle Gorge survey is summarised in Section 1.7.4. The survey at Nimingarra was completed from 20-28 October 2004, with vegetation mapping surveyed from 12-14 January 2005. Twenty-nine 50 m x 50 m flora quadrats were completed as

part of this survey. The Sunrise Hill survey was conducted from 29 October to 8 November 2004, with 46 50 m x 50 m quadrats executed.

One hundred and eighty-three taxa from 41 families and 149 genera were recorded from the Nimingarra study area. No EPBC Act listed, Declared Rare or Priority Flora species were recorded in the study area during the survey. One species of interest, *Erythrophleum chlorostachys*, was recorded within the study area, and was considered a new record for the Pilbara region.

Two hundred and one taxa from 45 families and 100 genera were recorded in the Sunrise Hill survey. No EPBC Act listed, Declared Rare or Priority Flora species were recorded in the study area. *Corymbia* sp. (SRH 71.8) was recorded during the survey at Shay Gap. *Corymbia* sp. (SRH 71.8) was considered a new taxon. *Stemodia* sp. (referred by *ecologia* Environment as *Stemodia* sp. Shay Gap), was recorded from a number of populations on Sunrise Hill ridge.

Twenty-six vegetation communities were recorded within the Sunrise Hill and Nimingarra areas. No communities listed as TECs or PECs were recorded in the study area.

1.7.4 Cattle Gorge Biological Survey (2004)

A survey of Cattle Gorge was completed by *ecologia* Environment from 3-7 February and 11-14 March 2004 (*ecologia* Environment 2004a). The objectives of the survey were to provide an assessment of the impact of the development of Cattle Gorge and associated rail corridor on flora conservation values.

Twenty-six 100 m x 100 m flora quadrats were surveyed as part of the flora survey, with 126 species from 29 families and 56 genera recorded.

No EPBC Act listed species, Declared Rare Flora or Priority Flora species were recorded during this study.

Nine vegetation associations were identified within the study area. No communities listed as TECs or PECs were recorded in the study area.

1.7.5 Yarrie Biological Survey (1999)

A survey of the Yarrie study area was completed by *ecologia* Environment from 3-9 June 1998 (*ecologia* Environment 1999). The objectives of the field survey were to provide:

- an inventory of vascular flora species;
- a description and mapping of plant communities;

- a review of plant species considered to be rare and endangered, or geographically restricted, which are known to, or may occur, in the study area;
- an inventory of exotic plants, including declared plants; and
- a review of the significance of the plant communities in a local, regional and state context.

Thirty-eight 100 m x 100 m flora quadrats were surveyed as part of the flora survey, with 209 taxa from 47 families and 105 genera recorded. No EPBC Act listed species or Declared Rare species were recorded in the study area during the survey. At the time of the survey, two Priority 2 species were recorded: *Euphorbia drummondii* and *Euphorbia clementii*. It is thought that this record is referring to *Euphorbia drummondii* subsp. Pilbara, which at the time of the survey was a Priority species. This taxon name is no longer current and is now known as *Euphorbia inappendiculata* (WAH 2008), which is a Priority 3 species.

Twelve vegetation associations were identified within the study area, including *Triodia* steppes, low rocky slopes, gullies, minor and major drainage lines and sandplains. No communities listed as TECs or PECs were recorded in the study area.

1.7.6 Yarrie Botanical Survey (1994)

ecologia Environment completed a survey of an area known as Y10, part of the Yarrie mining operation, on 18 November 1994 (*ecologia* Environment 1994). The objectives of the field survey were to provide:

- an inventory of vegetation associations/communities;
- an inventory species list, including declared rare flora;
- a review of biologically significant species, including declared rare flora;
- a review of environmental impacts and recommendations for species and/or associations requiring special management; and
- an assessment of the regional and local conservational value of the flora of the study area.

Five 100 m x 100 m flora quadrats were surveyed, with 56 taxa from 26 families recorded. No EPBC Act listed, Declared Rare or Priority Flora species were recorded in the study area during the survey.

Nine vegetation associations were identified within the study area. No communities listed as TECs or PECs were recorded in the study area.

2 ASSESSMENT METHOD

2.1 DATABASE AND LITERATURE REVIEW

A request for a database search was submitted to the DEC to ascertain whether any Declared Rare or Priority species have been recorded in the study areas and surrounds (DEC 2008a). In addition, a literature review was conducted, together with a review of historical and current records of flora species for the study areas (*ecologia* Environment 1994, 1999, 2004a, 2004b, 2005c; WAH 2008). Collectively, these sources were used to compile a list of potentially occurring Priority species (Table 1). Definitions of the different levels of conservation significance applied to flora species is presented in Appendix A. No Declared Rare species are considered to potentially occur.

Table 1: Priority Flora Species Potentially Occurring in the Cundaline and Callawa Survey Areas

Code	Species	Description	Previous Records
P1	*Acacia cyperophylla* var. *omearana*	Tree, 4-10 m high. Found on stony and gritty alluvium and along drainage lines.	Previously recorded within 150 km of the study areas (Atkins 1993 cited in *ecologia* Environment 1994).
P1	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)	Tufted annual, grass-like or herb, 0.12–0.15 m high. Found on sandy soils and along drainage lines.	Previously recorded within 50 km of the study areas (Atkins 2005 cited in *ecologia* Environment 2005). Recorded in the DEC search (DEC 2008a).
P2	*Euphorbia clementii*	Erect herb, to 0.6 m high. Found on gravelly hillsides and stony grounds.	This species was recorded during surveys for the Yarrie Mine and Cattle Gorge Mine (*ecologia* Environment 1999, 2004a); and recorded in the DEC search (DEC 2008a).
P2	*Goodenia hartiana*	Erect to spreading, multistemmed perennial, herb or shrub. Found on sandy soils, sand dune swales, and sandhills.	Previously recorded within 50 km of the study areas (*ecologia* Environment 2004b).

Code	Species	Description	Previous Records
P3	*Acacia glaucocaesia*	Dense, glabrous shrub or tree, 1.8–6 m high. Found on red loam, sandy loam, clay and floodplains.	Previously recorded within 160 km of the study areas (*ecologia* Environment 2004a).
P3	*Bulbostylis burbidgeae*	Tufted, erect to spreading annual, 0.03–0.25 m high. Found on granitic soils, granite outcrops and cliff bases.	Previously recorded between 50 km and 100 km of the study areas (Atkins 2005 cited in *ecologia* Environment 2005a).
P3	*Eragrostis crateriformis*	Annual, 0.17–0.42 m high. Found on clayey loam or clay, creek banks and depressions.	Previously recorded within 60 km of the study areas (WAH 2008).
P3	*Euphorbia inappendiculata* (previously recorded as *Euphorbia drummondii*)	Spreading, procumbent herb, to 0.4 m high. Found on clay soils and among broken rocky scree slopes.	Previously recorded within 5 km of the study areas at Yarrie and Cattle Gorge (*ecologia* Environment 1999, 2004a).
P3	*Goodenia nuda*	Erect to ascending herb, to 0.5 m high.	Previously recorded within 200 km of the study areas (ENV 2008a).
P3	*Gymnanthera cunninghamii*	Erect shrub, 1–2 m high. Found on sandy soils.	Previously recorded between 100 km and 200 km of the study areas (*ecologia* Environment 1999).
P3	*Indigofera ammobia*	Many-stemmed shrub, to 0.5 m high. Found on red sands and sand dunes.	Recorded in the DEC search (DEC 2008a).
P3	*Phyllanthus aridus*	Erect, much-branched shrub, to 0.25 m high. Found on sandstone, gravel and red sands.	Recorded in the DEC search (DEC 2008a).
P4	*Ptilotus mollis*	Compact, perennial shrub, to 0.5 m high. Found on stony hills and screes.	Previously recorded within 50 km of the Callawa study area (Atkins 2005 cited in *ecologia* Environment 2005a).

A literature review was also conducted, together with a review of historical and current records of flora species for the study areas (*ecologia* Environment 1994, 1999, 2004a, 2004b, 2005c), to compile a list of potentially occurring species of interest (Table 2).

Table 2: Flora Species of Interest Potentially Occurring in the Cundaline and Callawa Survey Areas

Species	Description	Previous Records
Stemodia sp. Shay Gap	Herb, 0.3-0.5 m in height. Found on cliff faces within gully and breakaway habitats.	Previously recorded at Cundaline, Callawa and Sunrise Hill (ecologia Environment 2005a, 2005b, 2005c).
Sida sp. Callawa	Low shrub, growing 0.1-0.3 m high. Found on steep rocky breakaway habitats.	Previously recorded at Cundaline and Callawa (ecologia Environment 2005a, 2005b).
Corchorus pumilio	Herb or shrub, 0.1-0.7 m high. Found on granite outcrops and hills, rocky areas or river banks.	Previously recorded at Cundaline (ecologia Environment 2005b).
Solanum beaugleholei	Erect or straggling shrub, 0.3-2 m high. Found on rocky soils or dissected limestone ridges.	Previously recorded at Cundaline and Callawa (ecologia Environment 2005a, 2005b).
Enneapogon lindleyanus	Erect, tufted annual or perennial, grass, to 0.5 m high. Found on gravelly red-brown sandy loam to alluvium soil, amongst rocks and boulder outcrops, scree slopes, along creeks and in crevices.	Previously recorded at Callawa (ecologia Environment 2005a).
Eriachne tenuiculmis	Tufted leafy perennial grass or herb, to 0.6 m high. Found in stony creek beds and gullies, and crevices in basalt.	Previously recorded at Callawa (ecologia Environment 2005a).
Phyllanthus exilis	Perennial herb or shrub, to 0.3 m high.	Previously recorded at Callawa (ecologia Environment 2005a).

A similar process was followed to establish whether there were any TECs or PECs in the area. The database search determined that no TECs or PECs are known to occur within the Cundaline and Callawa study areas (DEC 2008a).

2.2 SUPPLEMENTARY SURVEY METHODOLOGY

2.2.1 Background to Survey Methodology

All surveys undertaken by ENV are designed to meet the requirements of the following State and Federal legislation:

- Western Australian *Environmental Protection Act 1986* (EP Act);
- WC Act; and
- EPBC Act.

The supplementary survey was carried out in a manner designed to be compliant with the EPA requirements for the environmental surveying and reporting for flora and vegetation in Western Australia, as set out in the following documents:

- *Environmental Protection of Native Vegetation in Western Australia: Clearing of Native Vegetation with Particular Reference to Agricultural Areas. Position Statement No. 2* (EPA 2000);
- *Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3* (EPA 2002); and
- *EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No. 51* (EPA 2004).

EPA *Guidance Statement No. 51* (EPA 2004) outlines the expectations of the EPA, and details the extent, design and intensity of field surveys for environmental assessments in Western Australia. Two formal levels of flora survey are defined by EPA *Guidance Statement No. 51*:

- Level One: a 'desktop' study to collate historical knowledge, conducted in conjunction with a reconnaissance survey (site inspection).
- Level Two: an intensive survey that incorporates a detailed and comprehensive survey to characterise the flora present, combined with a Level One survey.

A Level Two survey was developed covering the supplementary survey area (see section 3.1).

2.2.2 Sampling Methodology

The field survey took place from 26-31 March 2008, with 24 person-days invested in the supplementary survey. An additional survey was undertaken at Cundaline Ridge on 13-15 September 2008, with three person days invested in specifically targeted species of interest (i.e. *Sida* sp. and *Stemodia* sp.)

Field staff collected flora information using 50 m x 50 m flora quadrats, as preferred by the DEC (*pers. comm.* S. van Leeuwen, DEC), relevés and opportunistic collections. For areas in which a 50 m x 50 m quadrat was inappropriate, suitable quadrat dimensions were used, whilst maintaining the same total search area.

Thirty-seven quadrats and relevés were surveyed within the Cundaline supplementary survey area (Figure 4) and 24 quadrats and relevés were surveyed within the Callawa supplementary survey area (Figure 5). The quadrats were selected as being representative of the flora and vegetation of the study areas. Flora survey quadrat locations are presented in Appendix B, and photographs of the study areas are presented in Appendix C.

Data was recorded using standardised field sheets. The information noted at each quadrat included landscape features, soils, bare ground and disturbance levels (Condition Scales are presented in Appendix D). Each species of plant at each quadrat was recorded, including information on height and percentage cover (Data Sheets are presented in Appendix E). Descriptions of the vegetation present at each quadrat were made using a standardised vegetation matrix (Appendix F). This enabled more accurate vegetation mapping to be undertaken, and provided greater detail of the species present. The opportunistic collections and relévés focussed mainly on the location of new flora taxa not recorded in the quadrats, and in particular, Declared Rare and Priority Flora, and flora not well known or not currently described.

Flora of conservation interest which were previously located within the study area and surrounds were specifically targeted by revisiting locations at which they were previously recorded and targeting potential habitat. Information recorded at each location where these species were found included the number of individuals, GPS location and habitat, with a photograph also taken of each collection.

2.2.3 Taxonomic Identification

Where field identification of plant taxa was not possible, specimens were collected in a systematic manner for later identification by expert taxonomists utilising the resources of the WAH. Species were identified through comparison with the reference collection and the use of identification keys.

Taxonomic identification of supplementary survey areas were completed by Malcolm Trudgen to provide consistency with previous identifications. Taxonomic identification was also completed by Malcolm Trudgen for the Cundaline and Callawa surveys conducted by *ecologia* Environment (2005a, 2005b).

The project species list was checked against FloraBase (WAH 2008) and Atkins (2008) Declared Rare and Priority Flora list to determine whether any of the species were listed as Rare or Priority species. Species were also checked against the EPBC Act listing of Threatened species to determine whether any species were federally listed (DEWHA 2008).

2.2.4 Vegetation Mapping

Vegetation communities were determined by multivariate statical analysis. Quadrat data was transformed to improve normality (square root), and a similarity matrix based on Bray-Curtis similarity was computed. A dendrogram was then computed, using hierarchical agglomerative cluster analysis, using Primer 6.1.5 (Clarke and Warwick 2001). Non-metric Multivariate Dimensional Scaling analysis of quadrat data was then used to compliment hierarchical agglomerative cluster analysis to help define vegetation communities. Outliers were combined into larger groups of similar quadrats where appropriate, to allow meaningful mapping.

These vegetation communities were then mapped using this information, together with notes and maps created in the field.

An attempt to correlate vegetation community structure and composition in this survey and those mapped by *ecologia* Environment (2005a) and *ecologia* Environment (2005b) was made (Sections 4.1 and 4.2).

Floristic analysis of vegetation data from the survey areas at Cundaline and Callawa survey areas assessed by *ecologia* Environment (2005a, 2005b) were undertaken by Griffin and Trudgen (2005). PATN (Belbin 1987) was used to compute ASO (a similarity matrix), FUSE (classification), DEND (representation of classification) and NNB (determination of sites most similar to each other). These are similar analyses to those conducted for the supplementary survey areas, and used to identify vegetation communities.

Griffin and Trudgen (2005) also conducted regional comparisons of vegetation communities, using datasets from surveys at Nimingarra, Sunrise Hill, Yarrie, Cattle Gorge, Cattle Gorge haul road and Shaw River. The purpose of their analysis was to interpret the regional importance of the vegetation communities.

Once the vegetation communities were determined, they were checked against the listing of Federal and State TECs and State PECs.

2.2.5 Permits

Specimens collected during the supplementary survey were taken by permit and subject to the conditions of the following licences issued under sections 23C and 23F of the WC Act:

- SL008009 to Breanne Cook;
- SL008010 to Todd Edwards
- SL008114 to Katherine Chuk; and
- SL008113 to Justin Freeman.

2.2.6 Flora Survey Limitations and Constraints

It is important to note the specific constraints imposed on individual surveys. Constraints are often difficult to predict, as is the extent to which they influence survey outcomes. Survey constraints of the supplementary survey are detailed in Table 3. It should be noted that this survey is supplementary to the more comprehensive surveys undertaken by *ecologia* Environment (2005a, 2005b) within the study areas. Considering this, the survey effort is appropriate.

Table 3: Limitations and Constraints Associated with the Supplementary Survey

Variable	Impact on Survey Outcomes
Access Problems	All areas were accessible and adequately surveyed during the supplementary survey.
Experience levels	The biologists who executed these surveys and completed relevant taxonomy were practitioners suitably qualified in their respective fields: • Todd Edwards – Botanist / Environmental Scientist; • Breanne Cook – Environmental Biologist; • Katherine Chuk – Environmental Biologist; • Justin Freeman – Environmental Biologist; and • Malcolm Trudgen – Taxonomist.
Timing, weather, season.	The supplementary survey was undertaken at an appropriate time in autumn from 26-31 March 2008. The area had received 75.6 mm of rain in the three months preceding the supplementary survey (January-March 2008). The year preceding the survey (January-December 2007) the area received 507.6 mm of rainfall, with 427.2 mm of this falling in March 2007. The area received very little rainfall during the summer months, as few cyclones crossed the WA coast in the 2007-2008 cyclone season (BOM 2008).

Variable	Impact on Survey Outcomes
	Flora composition changes over time, with flora species having specific growing periods, especially annuals and ephemerals (some plants lasting for a markedly brief time, some only a day or two). Therefore the results of future botanical surveys in this location may differ from the results of this survey.
Completeness	Due to the low level of rainfall received by the area over the summer months, few annuals and ephemerals were present during the supplementary survey, and some species were not in flower. Species that were insufficiently mature or dead were identified in the field to genus or family level only (where possible).
Determination	This survey makes inferences about vegetation types that have the potential to be TECs. However, a decision as to the presence of TECs at the site remains the responsibility of the DEC's Species and Communities Branch. The taxonomy and conservation status of the Western Australian flora are dynamic. This report was prepared in reliance on taxonomy and conservation current at the time, but it should be noted this may change.

3 RESULTS

3.1 VEGETATION COMMUNITIES

Cundaline

Twelve vegetation communities were identified within the Cundaline supplementary survey area, including grasslands, woodlands and shrublands. Vegetation within the Cundaline supplementary survey area is shown on Figure 6. Figure 6 shows the supplementary survey areas covered in this report and denotes areas surveyed previously by *ecologia* Environment (2005b).

Grasslands

ChApTe *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia ptychophylla* low open shrubland over *Acacia stellaticeps* low open shrubland over *Triodia epactia* and *Triodia epactia* closed hummock grassland. This vegetation community is located in the plains.

Gp/GwTe *Grevillea pyramidalis* subsp. *leucadendron* and *Grevillea wickhamii* subsp. *hispidula* open shrubland over *Acacia ptychophylla*, *Acacia adoxa* var. adoxa and *Tephrosia* aff. *rosea* (HD292-37) low shrubland over *Triodia epactia* hummock grassland.

Woodlands

ChAcCf *Corymbia hamersleyana* scattered low trees over *Acacia tumida* var. *pilbarensis*, *Acacia pyrifolia* and *Acacia colei* var. *colei* shrubland over *Tephrosia* aff. *rosea* (HD292-37) low shrubland over *Triodia epactia* very open hummock grassland over *Pluchea rubelliflora* and *Stemodia grossa* very open herbland. This vegetation community is found in drainage lines.

ChAtTe *Corymbia hamersleyana* scattered low trees over *Acacia tumida* var. *pilbarensis* high shrubland over *Acacia pyrifolia* open shrubland over *Acacia ptychophylla* and *Acacia adoxa* var. *adoxa* low scattered shrubs over *Triodia epactia* closed hummock grassland. This vegetation community is found in drainage lines in the north-west of the supplementary survey area.

ChTe *Corymbia hamersleyana* low open woodland over *Grevillea wickhamii* subsp. *hispidula* shrubland over *Triodia epactia* hummock grassland. Forms the drainage lines in the eastern section of the supplementary survey area.

ElAiTw *Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia inaequilatera* open shrubland over *Triodia wiseana* hummock grassland. Covers the slopes to the north of the ridge.

Ch/ElGwTe *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Grevillea wickhamii* subsp. *hispidula* and *Acacia tumida* var. *pilbarensis* high shrubland over *Triodia epactia* hummock grassland. This vegetation community dominates the slopes closest to the ridge.

ChGwTe *Corymbia hamersleyana* scattered low trees over *Grevillea wickhamii* subsp. *hispidula* and *Acacia pyrifolia* shrubland over *Triodia epactia* hummock grassland. Found on low hilltops and slopes.

ChAbTw *Corymbia hamersleyana* scattered low trees over *Acacia bivenosa* and *Acacia victoriae* open shrubland over *Triodia wiseana* hummock grassland. This vegetation community is also found in the plains, mainly in the south-eastern end of the supplementary survey area.

Ch/ElAtEm *Corymbia hamersleyana*, *Corymbia flavescens* and *Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia tumida* var. *pilbarensis* and *Grevillea wickhamii* subsp. *hispidula* open shrubland over *Eriachne mucronata* (typical form) very open tussock grassland over *Triodia biflora*, *Triodia epactia* and *Triodia wiseana* hummock grassland. This vegetation type is located in the gorges, gullies and breakaways.

Shrublands

AiTe *Acacia inaequilatera* high open shrubland over *Acacia ptychophylla* low open health over *Triodia epactia* hummock grassland. Located in minor drainage lines.

GwTe *Grevillea wickhamii* subsp. *hispidula* high open shrubland over *Acacia stellaticeps* open shrubland over *Dampiera candicans* and *Leptosema anomalum* scattered low shrubs over *Triodia epactia* hummock grassland. Forms the drainage lines running to the south of the main ridge.

AoTe *Acacia orthocarpa*, *Grevillea pyramidalis* subsp. *leucadendron* and *Grevillea wickhamii* subsp. *hispidula* high shrubland over *Corchorus* aff. *parviflorus* (1)(GLD SRH67-5) and *Acacia adoxa* var. *adoxa* low open shrubland over *Triodia epactia* hummock grassland over *Cymbopogon ambiguus* scattered tussock grasses. This vegetation community is located to the south of the main range.

Callawa

Eight vegetation communities were identified within the Callawa supplementary survey area. The Vegetation Community types include grasslands, woodlands and shrublands. Vegetation within the Callawa supplementary survey area is shown on Figure 7. Figure 7 shows the supplementary survey areas covered in this report and denotes areas surveyed previously by *ecologia* Environment (2005a).

Grasslands

GpTe *Grevillea pyramidalis* subsp. *leucadendron* and *Acacia ptychophylla* open shrubland over *Triodia epactia* open hummock grassland. Forms the plains in the north-east of the supplementary survey area.

AcTe *Acacia colei* var. *colei*, *Acacia inaequilatera* and *Grevillea pyramidalis* subsp. *leucadendron* high open shrubland over *Triodia epactia* hummock grassland. Forms most of the plains/minor drainage systems throughout the west of the supplementary survey area.

Woodlands

Cc/CfGw*Cc *Corymbia opaca* and *Corymbia flavescens* low woodland over *Grevillea wickhamii* subsp. *hispidula*, *Acacia tumida* var. *pilbarensis* and *Acacia inaequilatera* high open shrubland over *Hibiscus leptocladus* and *Corchorus elachocarpus* low open shrubland over *Eragrostis cumingii* and **Cenchrus ciliaris* open tussock grassland. This vegetation community forms drainage lines in the north-east of the supplementary survey area.

ChAtTe *Corymbia hamersleyana* low woodland over *Acacia tumida* var. *pilbarensis*, *Acacia inaequilatera* and *Acacia spondylophylla* shrubland over *Triodia epactia* closed hummock grassland. This community is located in the drainage lines coming down from the hills in the south of the supplementary survey area.

ChGwTe *Corymbia hamersleyana*, *Corymbia opaca* and *Corymbia flavescens* low open woodland over *Grevillea wickhamii* subsp. *hispidula* and *Grevillea pyramidalis* subsp. *leucadendron* open shrubland over *Triodia epactia* and *Triodia wiseana* closed hummock grassland. The vegetation community covers the slopes of the hills in the south of the supplementary survey area.

CfAcTe *Corymbia flavescens* low woodland over *Acacia tumida* var. *pilbarensis* high shrubland over *Cajanus cinereus* and *Sida rohlenae*

subsp. *rohlenae* open low shrubland over *Triodia epactia* open hummock grassland. This community is located in the plains throughout the middle of the supplementary survey area.

Shrublands

GpAsTe *Grevillea pyramidalis* subsp. *leucadendron* and *Grevillea wickhamii* subsp. *hispidula* shrubland over *Acacia spondylophylla* low shrubland over *Triodia epactia* hummock grassland. Located in a drainage system which runs to the east from the hill in the south of the supplementary survey area.

GwTw *Grevillea wickhamii* subsp. *hispidula* and *Grevillea pyramidalis* subsp. *leucadendron* high open shrubland over *Triodia wiseana* hummock grassland. This vegetation community forms the lower slopes in the south-east and through the middle of the supplementary survey area.

3.2 VEGETATION CONDITION

Cundaline

All of the sites in the Cundaline supplementary survey area were described as being in very good or excellent condition (Appendix D). The main disturbances noted in the supplementary survey area were the presence of tracks and impacts from cattle.

The fire age of sites in the Cundaline supplementary survey area were recorded as young to very old, with the majority of sites fire ages recorded as old (23 quadrats; 7-10 years). Two sites had very old fire ages (over 10 years). Nine sites had young fire ages (2-5 years), whilst two had recent fire ages (less than 2 years). Those sites with recent to young fire ages were in the north-east of the study area, along the north side of the Yarrie Mine site access track.

Callawa

Most of the sites in the Callawa supplementary survey area were described as being in very good to excellent condition (Appendix D). Only one site was described as in good condition (Appendix D), due to grazing and a track being located only 30 m away. The main disturbances recorded in the supplementary survey area were the presence of tracks and the impacts of cattle (i.e. grazing and trampling).

The fire age of sites in the Callawa supplementary survey area were recorded as moderate to old, with the majority of sites fire ages recorded as old (19 quadrats;

7-10 years). Three sites had moderate fire ages (5-7 years), CA01, CA15 and CA17. These three sites were geographical spread across the study area.

3.3 THREATENED ECOLOGICAL AND PRIORITY ECOLOGICAL COMMUNITIES

No communities listed as TECs under the EPBC Act or on the State list were recorded in the Callawa or Cundaline supplementary survey areas.

No communities listed as PECs as per the DEC Priority list were recorded in the Callawa or Cundaline supplementary survey areas.

No vegetation communities considered of regional significance were recorded in the Callawa or Cundaline supplementary survey areas.

3.4 FLORA SPECIES

Cundaline

One hundred and ninety-three taxa (including species, subspecies and variants) were recorded in the Cundaline supplementary survey area. These 193 taxa consisted of 37 families, 14 of which were represented by only one taxon, and 91 genera, 53 of which were represented by only one taxon (refer to Appendix G for the flora species inventory).

The plant families most frequently recorded from the supplementary survey were as follows:

- Poaceae (35 taxa);
- Papilionaceae (17 taxa); and
- Malvaceae (15 taxa).

The most frequently recorded genera from the supplementary survey were:

- *Acacia* (13 taxa); and
- *Euphorbia* (eight taxa).

The most common taxon recorded in the Cundaline supplementary survey area was *Grevillea wickhamii* subsp*. hispidula*, which was recorded at 27 of the 37 sites, followed by *Acacia ptychophylla* and *Triodia epactia,* which were recorded at 26 of the 37 sites (flora species by site matrix is presented in Appendix H).

Callawa

One hundred and forty-seven taxa (including species, subspecies and variants) were recorded within the Callawa supplementary survey area. These 147 taxa consisted of 32 families, 12 of which were represented by only one taxon, and 74 genera, 44 of which were represented by only one taxon (refer to Appendix G for the flora species inventory).

The plant families most frequently recorded from the supplementary survey were as follows:

- Poaceae (32 taxa);
- Papilionaceae (21 taxa); and
- Mimosaceae (13 taxa).

The most frequently recorded genera from the supplementary survey were:

- *Acacia* (13 taxa); and
- *Eriachne* (seven taxa).

The most common taxon recorded in the Callawa supplementary survey area was *Triodia epactia*, which was recorded at 21 of the 22 sites, followed by *Grevillea wickhamii* subsp. *hispidula*, which was recorded at 19 sites (flora species by site matrix is presented in Appendix H).

3.5 CONSERVATION SIGNIFICANT FLORA

3.5.1 Declared Rare and Threatened Flora

No Endangered or Vulnerable species pursuant to the EPBC Act were located during the supplementary survey. No plant taxa gazetted as Declared Rare pursuant to the WC Act were located in the supplementary survey areas.

3.5.2 Priority Flora

Cundaline

Two Priority Flora species were located in the Cundaline supplementary survey area (Table 4). The locations of these species are presented in Figure 8.

Table 4: Priority Flora Species Recorded in the Cundaline Supplementary Survey Area

Taxa	Conservation Code	Site	Number of Individuals	Habitat	Easting	Northing
Euphorbia clementii	Priority 2	CU26	One	Floodplain	209758	7722972
Goodenia nuda	Priority 3	CU15	One	Drainage Line	207302	7724304

Callawa

No Priority Flora species were recorded in the Callawa supplementary survey area.

3.6 FLORA OF INTEREST

Cundaline

Two species of interest were recorded during the supplementary survey (*Stemodia* sp. and *Sida* sp.) *Stemodia* sp. was recorded from six locations while *Sida* sp. was recorded from 11 locations on Cundaline Ridge. The locations of these collections are presented in Appendix I.

Records of what is believed to be *Solanum beaugleholei* were also made during the supplementary survey, however, these collections were unable to be positively identified at the WAH.

Enneapogon lindleyanus was also recorded at two sites, this species was considered of interest as an endemic grass species by *ecologia* Environment (2005a) which collected the species on Callawa Ridge.

Callawa

Eriachne tenuiculmis, an endemic grass species was recorded at three locations. This species was considered of interest as an endemic grass species by *ecologia* Environment (2005a). The locations where the species was recorded are presented in Appendix I.

Records of what is believed to be *Solanum beaugleholei* were also made during the supplementary survey, however, these collections were unable to be positively identified at the WAH.

3.7 INTRODUCED FLORA

Cundaline

Four introduced flora species were recorded in the Cundaline supplementary survey area. Their ratings and criteria according to the Environmental Weed Strategy for Western Australia (Western Australian Department of Conservation and Land Management (CALM) 1999) are listed below with the number of sites these species were recorded at (Table 5). Only two sites contained more than one introduced species. Site 15, a drainage line, contained **Cenchrus ciliaris* and **Portulaca oleracea*. This site had signs of disturbance by cattle and was close to a track. A cover of 2% was recorded for **C. ciliaris* at the site, and a cover of less than one percent was recorded for **P. oleracea.* **Chloris virgata* and **Cucumis melo* subsp. *agrestis* were both recorded at Site 19. This site is also a drainage line near a track (refer to Appendix J and Figure 9 for the locations of introduced species).

No Declared Plant species were recorded in the Cundaline supplementary survey area.

Table 5: Introduced Species Recorded in the Cundaline Supplementary Survey Area

Taxon	Common Name	Criteria				Number of Sites
		Rating	Invasiveness	Distribution	Impacts	
**Cenchrus ciliaris*	Buffel Grass	High	Yes	Yes	Yes	1
**Chloris virgata*	Feathertop Rhodes Grass	Low	N/A	N/A	N/A	1
**Cucumis melo* subsp. *agrestis*	Ulcardo Melon	N/A	N/A	N/A	N/A	1
**Portulaca oleracea*	Purslane	N/A	N/A	N/A	N/A	2

Source: Environmental Weed Strategy for Western Australia (CALM 1999). An explanation the criteria and ratings is given in Appendix K.

Callawa

Four introduced flora species were recorded in the Callawa supplementary survey area. Their ratings and criteria according to the Environmental Weed Strategy for Western Australia (CALM 1999) are listed below, with the number of sites these species were recorded at (Table 6). Only three sites contained more than one introduced species. Site 13, a floodplain, contained **Echinochloa colona*, **Chloris virgata* and **Portulaca oleracea*. These species were all recorded with a cover of less than one percent at this site. The site was close to a

track and the rail line, and had signs of disturbance from cattle. **Cenchrus ciliaris* and **Chloris virgata* were both recorded at Site 8, a drainage line. This site had signs of disturbance by cattle. Site 2, also a drainage line, contained **Cenchrus ciliaris* and **Portulaca oleracea,* and also had signs of disturbance by cattle (refer to Appendix J and Figure 10 for the locations of introduced species).

No Declared Plant species were recorded in the Callawa supplementary survey area (definitions of introduced species categories are presented in Appendix K, together with a list of potentially occurring introduced species for the area).

Table 6: Introduced Species Recorded in the Callawa Supplementary Survey Area

Taxon	Common Name	Criteria				Number of Sites
		Rating	Invasiveness	Distribution	Impacts	
**Cenchrus ciliaris*	Buffel Grass	High	Yes	Yes	Yes	7
**Chloris virgata*	Feathertop Rhodes Grass	Low	N/A	N/A	N/A	2
**Echinochloa colona*	Awnless Barnyard Grass	Mild	Yes	N/A	N/A	1
**Portulaca oleracea*	Purslane	N/A	N/A	N/A	N/A	3

Source: Environmental Weed Strategy for Western Australia (CALM 1999). An explanation to the criteria and ratings is given in Appendix K.

4 DISCUSSION

The flora and vegetation within the Callawa study area is discussed in Section 4.1 and the flora and vegetation within the Cundaline study area is discussed in Section 4.2.

4.1 CUNDALINE

Flora

One hundred and ninety-three taxa were recorded during the supplementary survey (Section 3.4; Appendix G), with 49 of these taxa having been previously recorded in the area by *ecologia* Environment (2005b). Again, a higher number of taxa were recorded within the supplementary survey - 193 compared to 91 (*ecologia* Environment 2005b), probably because a wider range of habitats were surveyed during the supplementary survey. The 2005 survey focused mainly on the Cundaline Ridge, whilst the supplementary survey included parts of the ridge as well as the plains surrounding it.

Conservation Significant Flora

No Threatened species under the EPBC Act or Declared Rare Flora species under the WC Act have been recorded within the Cundaline study area (Section 3.5; *ecologia* Environment 2005b).

Two Priority Flora species, *Euphorbia clementii* (Priority 2) and *Goodenia nuda* (Priority 3), were recorded within the supplementary survey area. These species are discussed below. No Priority Flora species were previously recorded from the Cundaline Ridge by *ecologia* Environment (2005b).

Euphorbia clementii is an erect herb to 0.6 m, and is usually found on gravelly hillsides and stony grounds (WAH 2008). During the supplementary survey it was recorded in a stony plain. This species appears particularly after fire, and was recorded in a plot that had a young fire age (2-5 years). The taxon has been recorded from three unverified and one verified locations in the Pilbara bioregion; one in the south of the Pilbara bioregion, one near Port Hedland and the other near Yarrie (WAH 2008).

Locally it has been recorded at Yarrie mining operations, where it was recorded at four locations, and is considered to be widely spread on the Spinifex plateaus in the Yarrie project area (*ecologia* Environment 1999). The species has also been recorded at two sites at the Cattle Gorge mining operations (*ecologia* Environment 2004a). The species showed a preference for disturbed soil (*ecologia* Environment 2004a).

Goodenia nuda is a herb to 0.5 m, and was recorded in a drainage line. This species has not previously been recorded in the area, with most historical records for this species located further inland. Twelve records of this species have been made, predominantly in the Pilbara bioregion (WAH 2008).

Flora Species of Interest

The records of *Solanum beaugleholei* in the Cundaline and Callawa study area and records of *Corchorus pumilio* in the Cundaline study area may represent range extensions for these species, which largely inhabit the Kimberley region (WAH 2008). These species are moderately widespread within their range in the Kimberley, but have not been previously recorded as far south as the current records. The WAH have reviewed the specimens of *Solanum* collected by ENV and are not able to provide a definitive identification.

Enneapogon lindleyanus was recorded at Cundaline and Callawa. *ecologia* Environment (2005b) discussed *Enneapogon lindleyanus* as a conservation significant species within the Cundaline study area, although this species is not considered of particular conservation, because it is widespread in the Pilbara bioregion (WAH 2008), for example there are over 55 unverified recorded of the species at the WAH.

As discussed in Sections 1.7.2 and 1.7.3, *ecologia* Environment (2005a, 2005b) reported the occurrence of undescribed species of *Stemodia* sp. and *Sida* sp. within the Cundaline and Callawa survey areas. Further specimens were recorded by ENV (Section 3.6). These species are not formally recognised as species and are currently being lodged with the WAH (*pers. comm.* S. Dillon, WAH).

Introduced Species

Four introduced flora species were recorded within the Cundaline supplementary survey area: *Cenchrus ciliaris, *Portulaca oleracea, *Chloris virgata and **Cucumis melo* subsp. *agrestis.* These species were all present in sites with some level of disturbance, especially by cattle. No introduced species were recorded by *ecologia* Environment (2005b). This increase in introduced species recorded is due to different habitats and areas being surveyed.

The supplementary survey included floodplains with tracks and rail lines, which may have helped the spread of introduced species. The previous survey focused on the Cundaline Ridge, which is relatively undisturbed.

No Declared Plant species were recorded within the Cundaline supplementary survey area. This was expected as none were recorded in the adjacent Cundaline survey area (*ecologia* Environment 2005a).

Vegetation Communities

A total of 21 vegetation communities have been identified in the Cundaline survey area (Table 7). Eight were recorded in the Cundaline survey area by *ecologia* Environment (2005a), and an additional 13 were recorded in the supplementary survey area (Section 3.1 and Figure 6).

No known communities listed as TECs or PECs or communities considered of regional significance have been recorded within the Cundaline study area and none are considered likely to occur.

Table 7: Vegetation Communities within the Cundaline Survey Area

No.	Description	Author
1	*Corymbia flavescens* and/or *Atalaya hemiglauca* and/or *Ficus brachypoda* (sometimes with *Eucalyptus leucophloia* subsp. *leucophloia* moderately dense medium forest to sparse low woodland, over medium shrubs such as *Acacia tumida* var. *pilbarensis/Grevillea wickhamii* subsp. *hispidula/G. pyramidalis* subsp. *leucadendron/Petalostylis labicheoides/Flueggea virosa* subsp. *melanthesoides* medium shrubs, over low shrubs such as *Solanum dioicum* and *Indigofera monophylla*, over tussock grasses such as *Cymbopogon ambiguous/Eriachne mucronata* (typical form), over *Triodia epactia* or *T. wiseana* moderately dense to sparse hummock grassland.	*ecologia* Environment (2005b)
2	*Eucalyptus leucophloia* subsp. *leucophloia* (or *Corymbia hamersleyana*) open medium/low woodland or trees (sometimes with *Terminalia canescens* or *C. flavescens*) over *Acacia tumida* subsp. *pilbarensis* (or *Petalostylis labicheoides*) moderately dense to scattered tall/medium shrubland, over medium shrubs such as *A. pyrifolia*, over low shrubs such as *Dampiera candicans/Sida* sp. A Kimberley Flora or *Triumfetta plumigera/T. maconochieana*, over dwarf shrubs such as *Indigofera monophylla* over mixed tussock grass and Spinifex hummock grasses.	*ecologia* Environment (2005b)
3	*Eucalyptus leucophloia* subsp. *leucophloia* open low woodland, over *Hakea chordophylla* scattered tall shrubland, over *Triumfetta maconochieana/Senna glutinosa* subsp. *glutinosa* scattered low shrubland over *Triodia wiseana* moderately dense hummock grassland.	*ecologia* Environment (2005b)
4	*Acacia tumida* var. *pilbarensis* (also with *Grevillea wickhamii* subsp. *hispidula/A. pyrifolia/Petalostylis labicheoides*) moderately dense to open tall/medium shrubland, sometimes with *Corymbia hamersleyana* open low woodland to scattered trees, or with *Eucalyptus odontocarpa* open medium/low mallee, over open to low shrubs such as *Dampiera candicans/A. ptychophylla/Indigofera monophylla* (small calyx form), over tussock grasses and *Triodia epactia* or *T. biflora* hummock grasses.	*ecologia* Environment (2005b)
5	*Grevillea wickhamii* subsp. *hispidula* open to sparse tall/medium shrubland (sometimes with *Corymbia hamersleyana/Acacia pyrifolia/Acacia tumida* var. *pilbarensis*), over *A. ptychophylla/Dampiera candicans* moderately dense to sparse dwarf shrubland (occasionally with *Indigofera monophylla* (small calyx form), over *Goodenia stobbsiana* herbs, over *Triodia epactia* or *T. wiseana* open (to moderately dense) hummock grassland.	*ecologia* Environment (2005b)
6	*Grevillea wickhamii* subsp. *hispidula/Acacia inaequilatera* open medium to tall shrubland, over *Goodenia stobbsiana* scattered herbs, over *Triodia epactia* moderately dense hummock grassland.	*ecologia* Environment (2005b)

No.	Description	Author
7	*Petalostylis labicheoides/Acacia tumida* var. *pilbarensis/Grevillea wickhamii* subsp. *hispidula* moderately dense to sparse medium shrubland (sometimes with *Corymbia hamersleyana* or *C.* aff *hamersleyana*) over *Triodia epactia* moderately dense to sparse hummock grassland.	*ecologia* Environment (2005b)
8	*Grevillea wickhamii* subsp. *hispidula* moderately dense to sparse medium/low shrubland (sometimes with *Eucalyptus leucophloia* subsp. *leucophloia, Petalostylis labicheoides* and *Acacia tumida* var. *pilbarensis* trees and shrubs), over *A. spondylophylla* (and sometimes *Solanum dioicum/Corchorus* spp.)/*A. ptychophylla* moderately dense to scattered low/dwarf shrubland, over *Triodia epactia* moderately dense to sparse hummock grassland.	*ecologia* Environment (2005b)
9	*Corymbia hamersleyana* scattered low trees over *Acacia tumida* var. *pilbarensis*, *A. pyrifolia* and *A. colei* var. *colei* shrubland over *Tephrosia* aff. *rosea* (HD292-37) low shrubland over *Triodia epactia* very open hummock grassland over *Pluchea rubelliflora* and *Stemodia grossa* very open herbland.	Section 3.1
10	*Corymbia hamersleyana* scattered low trees over *Acacia tumida* var. *pilbarensis* high shrubland over *Acacia pyrifolia* open shrubland over *A. ptychophylla* and *A. adoxa* var. *adoxa* low scattered shrubs over *Triodia epactia* closed hummock grassland.	Section 3.1
11	*Corymbia hamersleyana* low open woodland over *Grevillea wickhamii* subsp. *hispidula* shrubland over *Triodia epactia* hummock grassland.	Section 3.1
12	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia inaequilatera* open shrubland over *Triodia wiseana* hummock grassland.	Section 3.1
13	*Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Grevillea wickhamii* subsp. *hispidula* and *Acacia tumida* var. *pilbarensis* high shrubland over *Triodia epactia* hummock grassland.	Section 3.1
14	*Corymbia hamersleyana* scattered low trees over *Grevillea wickhamii* subsp. *hispidula* and *Acacia pyrifolia* shrubland over *Triodia epactia* hummock grassland.	Section 3.1
15	*Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia ptychophylla* low open shrubland over *A. stellaticeps* low open shrubland over *Triodia epactia* and *T. epactia* closed hummock grassland.	Section 3.1
16	*Corymbia hamersleyana* scattered low trees over *Acacia bivenosa* and *A. victoriae* open shrubland over *Triodia wiseana* hummock grassland.	Section 3.1
17	*Corymbia hamersleyana*, *C. flavescens* and *Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia tumida* var. *pilbarensis* and *Grevillea wickhamii* subsp. *hispidula* open shrubland over *Eriachne mucronata* (typical form) very open tussock grassland over *Triodia biflora*, *T. epactia* and *T. wiseana* hummock grassland.	Section 3.1
18	*Acacia inaequilatera* high open shrubland over *Acacia ptychophylla* low open health over *Triodia epactia* hummock grassland.	Section 3.1
19	*Grevillea wickhamii* subsp. *hispidula* high open shrubland over *Acacia stellaticeps* open shrubland over *Dampiera candicans* and *Leptosema anomalum* scattered low shrubs over *Triodia epactia* hummock grassland.	Section 3.1
20	*Acacia orthocarpa*, *Grevillea pyramidalis* subsp. *leucadendron* and *G. wickhamii* subsp. *hispidula* high shrubland over *Corchorus* aff. *parviflorus* (1)(GLD SRH67-5) and *Acacia adoxa* var. *adoxa* low open shrubland over *Triodia epactia* hummock grassland over *Cymbopogon ambiguus* scattered tussock grasses.	Section 3.1
21	*Grevillea pyramidalis* subsp. *leucadendron* and *G. wickhamii* subsp. *hispidula open* shrubland over *Acacia ptychophylla, A. adoxa* var. *adoxa* and *Tephrosia* aff. *rosea* (HD292-37) low shrubland over *Triodia epactia hummock* grassland.	Section 3.1

A number of the vegetation communities mapped in the supplementary survey area correlate to those mapped by *ecologia* Environment (2005b) in the Cundaline survey area (Table 7).

Vegetation Communities 5 and 6 are similar to Vegetation Community 13. These three communities are characterised by a number of similar dominant species, including *Corymbia hamersleyana* trees scattered over *Grevillea wickhamii* subsp. *hispidula, Acacia tumida* var. *pilbarensis* and *A. ptychophylla* over *Dampier candicans* low shrubland over *Triodia epactia* hummock grassland.

Acacia inaequilatera was recorded as a dominant in Vegetation Community 6, but was not recorded in any of the supplementary survey plots in Vegetation Community 13. However, superficially similar, and species from the same taxonomic group, *Acacia pyrifolia* was commonly recorded in Vegetation Community type 13. *Acacia pyrifolia* is typically recorded on plains and along water courses (WAH 2008), thus this might represent an inaccuracy in species identification by *ecologia* Environment.

Goodenia stobbsiana was also common in Vegetation Communities 5 and 6, but was absent from Vegetation Community 13. This species occurs after disturbance or fire (Flora of Australia 1992). Very little disturbance was recorded in quadrats in the supplementary survey area, which might explain this species absence.

Vegetation Communities 2, 4 and 8 are similar to Vegetation Community 17. These three communities are characterised by a number of similar dominant species, *including Corymbia hamersleyana*, *C. flavescens* and *Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia tumida* var. *pilbarensis* and *A. pyrifolia, Grevillea wickhamii* subsp. *hispidula* open shrubland over *A. ptychophylla and Dampier candicans* low shrubland over *Eriachne mucronata* (typical form) very open tussock grassland over *Triodia biflora*, *T. epactia* and *T. wiseana* hummock grassland.

The remaining Vegetation Communities 9-21 were unique and only mapped in the supplementary survey. These community types were predominantly on the northern slopes and plains within the supplementary survey area, and were different from the vegetation communities recognised by *ecologia* Environment (2005a) on the ridge itself and southern slopes. Vegetation communities tend to differ due to abiotic factors such as aspect and landform.

The differences in the vegetation communities mapped in the Cundaline survey area and supplementary survey area are also considered to be a result of a number of other factors, these are:

- variation in species composition and structure (i.e. fire, drought and grazing);

- variation in intensity of survey (i.e. number of surveys plots);
- differences in source material used for mapping (scales, topography and aerials);
- differences in analysis of vegetation data; and
- differences in data interpretation and description.

Despite these factors, the vegetation community boundaries between the two survey areas do generally correlate with one another.

ecologia Environment (2005a) describes Vegetation Community 1 as a forest although this community is more appropriately considered to be a shrubland/woodland. No forests occur within the study area.

None of the vegetation communities identified were considered to be TECs or PECs, so any differences between reports do not have an impact on conservation.

Vegetation Condition

Few disturbances were recorded in the project area, except for a few tracks and impact from cattle, with only four introduced species recorded that were not significantly impacting vegetation condition.

Majority of sites were recorded as having an old fire age. Sites that had a young or recent fire age were in the north-east of the study area, along the north side of the Yarrie mine site access track. Such an area would potentially be more prone to greater fire risk from humans and vehicles.

4.2 CALLAWA

Flora

One hundred and forty-seven taxa were recorded in the Callawa supplementary survey area, with 33 of these taxa having previously been recorded in the area by *ecologia* Environment (2005a). A higher number of taxa were recorded in the supplementary survey (147 taxa) when compared to the survey by *ecologia* Environment (2005a) (98 taxa), most likely because a wider range of habitats were surveyed in the supplementary survey. The large difference in species recorded between the two surveys is also considered to be due to the different habitats that were surveyed as part of the different study areas. The *ecologia* Environment (2005a) survey included a number of gorges and gullies, while the supplementary survey focused mainly on the lower slopes and plains. The number of taxa recorded in the supplementary survey compares well with two

other surveys conducted in the area, which recorded between 100-200 taxa (*ecologia* Environment 1999, 2004a).

Conservation Significant Flora

No threatened species under the EPBC Act, Declared Rare Flora species under the WC Act or DEC listed Priority Flora species were recorded in the Callawa study area during the supplementary survey (Section 3.5; *ecologia* Environment 2005a).

One Priority Flora species has been previously recorded in the Callawa study area, *Euphorbia inappendiculata* (Priority 3), was recorded by *ecologia* Environment (1999) (Section 1.7.4). This species was recorded outside of the proposed disturbance areas.

Flora Species of Interest

Flora of interest relevant to both Cundaline and Callawa are discussed in Section 4.1. Additional flora relevant to Callawa are discussed below.

ecologia Environment (2005a) discussed *Eriachne tenuiculmis* as a species of conservation significance within the Callawa study area, although it is moderately widespread in the Pilbara region (WAH 2008). There are over 23 unverified records of *E. tenuiculmis*, predominantly in the Pilbara bioregion at the WAH (2008).

ecologia Environment (2005a) discussed *Phyllanthus exilis* in the Callawa study area as potentially a range extension for this species, which largely inhabits the Kimberley region (WAH 2008). However, this species is moderately widespread within its range in the Kimberley and has been recorded in the Pilbara (WAH 2008).

Introduced Species

Four introduced flora species were recorded in the Callawa supplementary survey area, **Cenchrus ciliaris, *Echinochloa colona*, **Chloris virgata* and **Portulaca oleracea*. These species were recorded in drainage lines and floodplain sites which had some level of disturbance, mainly from cattle.

One introduced species, **Passiflora foetida* var. *hispida,* was recorded by *ecologia* Environment (2005a). The increase in number of introduced species recorded in the supplementary survey is probably because the supplementary survey was located closer to roads.

No Declared Plant species were recorded in the Callawa supplementary survey area. This was expected since none were recorded in the adjacent Callawa survey area (*ecologia* Environment 2005a).

Vegetation Communities

A total of 14 vegetation communities were identified in the Callawa survey area (Table 8). Six were recorded in the Callawa survey area by *ecologia* Environment (2005a), and an additional eight were recorded in the supplementary survey area (Section 3.1; Figure 7).

No known communities listed as TECs or PECs or communities considered of regional significance have been recorded within the Cundaline study area and none are considered likely to occur.

Table 8: Vegetation Communities within the Callawa Survey Area

No.	Description	Author
1	*Terminalia canescens* and/or *Corymbia flavescens* and/or *Atalaya hemiglauca* and/or *Ficus brachypoda* (sometimes with *Eucalyptus leucophloia* subsp. *leucophloia* or *E. camaldulensis*) moderately dense medium forest to sparse low woodland, over medium shrubs such as *Acacia tumida* var. *pilbarensis*/*Grevillea wickhamii* subsp. *hispidula*/*G. pyramidalis* subsp. *leucadendron*/*Petalostylis labicheoides/Flueggea virosa* subsp. *melanthesoides* medium shrubs, over low shrubs such as *Solanum dioicum* and *Indigofera monophylla*, over tussock grasses such as *Cymbopogon ambiguous*/*Eriachne mucronata* (typical form), over *Triodia epactia/T. wiseana* moderately dense to sparse hummock grassland.	*ecologia* Environment (2005a)
2	*Eucalyptus leucophloia* subsp. *leucophloia* (or *Corymbia hamersleyana*) open medium/low woodland or trees (sometimes with *Terminalia canescens* or *C. flavescens*) over *Acacia tumida* subsp. *pilbarensis* (or *Petalostylis labicheoides*) moderately dense to scattered tall/medium shrubland, over medium shrubs such as *A. pyrifolia*, over low shrubs such as *Dampiera candicans*/*Sida* sp. A (Kimberley Flora) or *Triumfetta plumigera/T. maconochieana*, over dwarf shrubs such as *Indigofera monophylla*, over mixed tussock grass and Spinifex hummock grasses.	*ecologia* Environment (2005a)
3	*Petalostylis labicheoides*/*Acacia tumida* var. *pilbarensis*/*Grevillea wickhamii* subsp. *hispidula* moderately dense to sparse medium shrubland (sometimes with *Corymbia hamersleyana* or *C.* aff. *hamersleyana*), over *Triodia epactia* moderately dense to sparse hummock grassland.	*ecologia* Environment (2005a)
4	*Grevillea wickhamii* subsp. *hispidula*/*Petalostylis labicheoides*/*Acacia tumida* var. *pilbarensis* open to sparse medium shrubland (sometimes with *Corymbia hamersleyana* [or *C.* aff. *hamersleyana*] or *Eucalyptus leucophloia* subsp. leucophloia low trees), over *Acacia spondylophylla* (or *A. ptychophylla*) sparse dwarf shrubland, occasionally with *Solanum dioicum/Goodenia stobbsiana/Dampiera candicans*, over *Triodia wiseana* open hummock grassland.	*ecologia* Environment (2005a)
5	Scattered to open medium shrubs such as *Grevillea pyramidalis* subsp. *leucadendron/Grevillea wickhamii* subsp. *hispidula/Terminalia canescens*/*Atalaya hemiglauca*, over scattered dwarf shrubs such as *Corchorus* aff. *parviflorus* (1)/*Cullen stipulaceum*, over *Triodia wiseana* moderately dense to sparse hummock grassland.	*ecologia* Environment (2005a)

No.	Description	Author
6	*Grevillea wickhamii* subsp. *hispidula* moderately dense to sparse medium/low shrubland (sometimes with *Eucalyptus leucophloia* subsp. *leucophloia*, *Petalostylis labicheoides* and *Acacia tumida* var. *pilbarensis* trees and shrubs), over *A. spondylophylla* (and sometimes *Solanum dioicum/Corchorus* spp.)/*A. ptychophylla* moderately dense to scattered low/dwarf shrubland, over *Triodia epactia* moderately dense to sparse hummock grassland.	*ecologia* Environment (2005a)
7	*Corymbia opaca* and *C. flavescens* low woodland over *Grevillea wickhamii* subsp. *hispidula*, *Acacia tumida* var. *pilbarensis* and *A. inaequilatera* high open shrubland over *Hibiscus leptocladus* and *Corchorus elachocarpus* low open shrubland over *Eragrostis cumingii* and **Cenchrus ciliaris* open tussock grassland.	Section 3.1
8	*Corymbia hamersleyana* low woodland over *Acacia tumida* var. *pilbarensis*, *A. inaequilatera* and *A. spondylophylla* shrubland over *Triodia epactia* closed hummock grassland.	Section 3.1
9	*Corymbia hamersleyana, C. opaca* and *C. flavescens* low open woodland over *Grevillea wickhamii* subsp. *hispidula* and *G. pyramidalis* subsp. *leucadendron* open shrubland over *Triodia epactia* and *T. wiseana* closed hummock grassland.	Section 3.1
10	*Corymbia flavescens* low woodland over *Acacia tumida* var. *pilbarensis* high shrubland over *Cajanus cinereus* and *Sida rohlenae* subsp. *rohlenae* open low shrubland over *Triodia epactia* open hummock grassland.	Section 3.1
11	*Acacia colei* var. *colei*, *A. inaequilatera* and *Grevillea pyramidalis* subsp. *leucadendron* high open shrubland over *Triodia epactia* hummock grassland.	Section 3.1
12	*Grevillea pyramidalis* subsp. *leucadendron* and *G. wickhamii* subsp. *hispidula* shrubland over *Acacia spondylophylla* low shrubland over *Triodia epactia* hummock grassland.	Section 3.1
13	*Grevillea wickhamii* subsp. *hispidula* and *G. pyramidalis* subsp. *leucadendron* high open shrubland over *Triodia wiseana* hummock grassland.	Section 3.1
14	*Grevillea pyramidalis* subsp. *leucadendron* and *Acacia ptychophylla* open shrubland over *Triodia epactia* open hummock grassland.	Section 3.1

A number of the vegetation communities mapped in the supplementary survey area correlate to those mapped by *ecologia* Environment (2005a) in the Callawa survey area (Table 8).

Vegetation Community 9 is similar to Vegetation Community 5. Both communities are characterised by *Grevillea wickhamii* subsp. *hispidula* and *G. pyramidalis* subsp. *leucadendron* shrubland over low shrubs of *Corchorus* aff. *parviflorus* over *Triodia wiseana* hummock grasses. Since the survey sites in the supplementary survey were located lower on the foothills and the plains in the study area, Vegetation Community 9 had subtle differences in structure to Vegetation Community 5, for example *Corymbia* low open woodland, and *Triodia epactia* recorded in the grass layer.

Vegetation Community 9 also shared characteristics with Vegetation Community 4. Vegetation Community 4 was mapped predominantly by *ecologia* Environment (2005a) on the hill tops, which the supplementary survey area did not cover. Therefore, Vegetation Community 4 was not mapped in the supplementary survey area, and any occurrence of the Community in the south-east of the

project area probably is represented by a transitional community between Vegetation Community 4 proper and Vegetation Community 13.

Vegetation Community 13 was similar to Vegetation Community 5. Vegetation Community 5 was recognised as a distinctive community type on the low foot hills in the north-east of the Callawa Ridge. Vegetation Communities 13 and 5 both were dominated by *Grevillea wickhamii* subsp. *hispidula* and *G. pyramidalis* subsp. *leucadendron* shrubland over *Triodia wiseana* hummock grassland.

Vegetation Community 8 is similar to Vegetation Community 1. Both are characterised by woodland of *Corymbia* species over *Grevillea pyramidalis* subsp. *leucadendron, G. wickhamii* subsp. *hispidula Acacia tumida* var. *pilbarensis* and *Petalostylis labicheoides* shrublands over *Triodia epactia* grasslands. Vegetation Community 1 occurs mainly in gorges and gullies, and changes, as the drainage line becomes more open and smaller, to Vegetation Community 8, which is located on the plains and footslopes.

The remaining Vegetation Communities 7, 10-12 and 14 were unique and only mapped in the supplementary survey. These community types were restricted to the plains, and were different from the vegetation communities recognised by *ecologia* Environment (2005a) on the ridge. Vegetation communities are usually different between ridges and plains, for example Beard (1975) mapped most vegetation types according to landform, and these were very different between plains and ridges.

Differences in the vegetation communities mapped in the Callawa survey area and supplementary survey area are considered to be a result of a number of factors, these are:

- variation in species composition and structure (i.e. fire, drought and grazing);
- variation in intensity of survey (i.e. number of surveys plots);
- differences in source material used for mapping (scales, topography and aerials);
- differences in analysis of vegetation data; and
- differences in data interpretation and description.

Despite these factors, the vegetation community boundaries between the two survey areas do generally correlate with one another.

ecologia Environment (2005a) describes Vegetation Community 1 as a forest although this community is more appropriately considered to be a shrubland/woodland. No forests occur within the study area.

None of the vegetation communities identified were considered to be TECs or PECs, so any differences between reports do not have an impact on conservation.

Vegetation Condition

Some signs of grazing, old tracks and scattered occurrences of introduced species were recorded from sites mostly located in the eastern and central sections of the supplementary survey area. Sites within northern area of the supplementary study area appeared to have fewer disturbances from mining activities and pastoralism.

Majority of sites were recorded as having an old fire age. Sites with a moderate fire age were not geographically localised, and probably represent past localised fires.

5 IMPACT ASSESSMENT

The potential impacts from the planned Cundaline and Callawa mining operations on flora and vegetation is assessed below.

Vegetation Removal

The main impact associated with the proposed Callawa and Cundaline mining operations will be the loss of vegetation through the construction of open pit mining operations and associated infrastructure.

The planned mining operation will significantly impact vegetation communities mapped across the entire Cundaline study area, except for Vegetation Communities 11, 19 and 20 (Table 7 and Figure 6). Those most impacted will be Vegetation Communities 4, 5, 13 and 17 (Table 7). None of these vegetation communities are of conservation significance.

All vegetation communities within the Callawa survey area will be impacted to some extent by the planned mining operation (Table 8 and Figure 7). Those most impacted will be Vegetation Communities 1, 5, 4 and 6 (Table 8). The greatest disturbance by the planned mining operation will be in the north eastern end of the Callawa Ridge, where these vegetation communities are mapped. They also occur across the rest of the Callawa range. Therefore, whilst the mining operations will result in a loss of a portion of these vegetation types, they are represented across the rest of the Callawa range. None of the vegetation communities at the Callawa survey area are of conservation significance.

Griffin and Trudgen (2005) conducted regional comparisons of vegetation community data from the Callawa and Cundaline surveys with that of surveys at Nimingarra, Sunrise Hill, Yarrie, Cattle Gorge, Cattle Gorge haul road and Shaw River. Regional comparisons of data from the supplementary survey areas were not included.

The analysis indicated that the Goldsworthy (Callawa, Cundaline, Nimingarra, Sunrise Hill, Yarrie, Cattle Gorge and Cattle Gorge haul road) surveys vegetation data was distinct from that of the Shaw River (80 km south). This indicates the vegetation communities of the Goldsworthy area are significantly different from other regions of the Pilbara.

Within the Goldsworthy area the vegetation data of the Callawa and Cundaline surveys was found to be significantly similar to Cattle Gorge and Cattle Gorge haul road surveys. This suggests the vegetation communities within the Callawa and Cundaline survey areas are locally represented outside the survey areas.

This said, nearby surveys at Yarrie, Sunrise Hill and Nimingarra were found to have 'somewhat' (sic) different vegetation communities from the Callawa and Cundaline surveys (Griffin and Trudgen 2005). This indicates that whilst the Callawa and Cundaline vegetation communities are represented in the surrounding locality, they are somewhat unique. Griffin and Trudgen (2005) hypothesised that these differences may conversely be attributed to differences in quadrat size, identification of specimens and the types of habitats being sampled (i.e. more creeklines and plains in these areas).

There is considered to be no constraint to clearing with regard to the regional significance of the vegetation communities.

Conservation Significant Flora Species

The results of the surveys indicate that no threatened species listed under the EPBC Act or Declared Rare Flora species under the WC Act would be impacted by the planned Callawa and Cundaline mining operations.

The location at which a single specimen of the Priority Flora species, *Goodenia nuda* (Priority 3) was recorded, is unlikely to be impacted by the planned Callawa and Cundaline mining operations, as this species was located outside of the disturbance footprint (*pers. comm*. BHPBIO, 2008). The management of this species should be covered in a significant species management plan.

Goodenia nuda has not previously been recorded in the Yarrie area, with most records of this species located further inland. However, there are 12 records of this species occurring predominantly in the Pilbara bioregion (WAH 2008). ENV has also previously recorded this species in the Port Hedland area, at West Jimblebar and along the Jimblebar to Yandi railway line (ENV 2007, 2008). Therefore the species is not restricted to the current survey area.

Euphorbia clementii (Priority 2) was recorded outside the planned disturbance areas (Figure 8). This species has previously been recorded at Yarrie and Nimingarra, with two individuals identified at both locations. Four records of *E. clementii* have been made at the WAH (2008), three of which are within the Goldsworthy region. Therefore the species is not restricted to the current survey area.

Euphorbia inappendiculata (Priority 3) was previously recorded by *ecologia* Environment (1999). The location at which this species was recorded would not be impacted by planned Callawa and Cundaline mining operations.

Flora Species of Interest

Two previously undescribed species have been recorded from within the Cundaline and Callawa survey areas, these being *Stemodia* sp. Shay Gap and

Sida sp. Callawa (Sections 4.1 and 4.2). Neither species are formally recognised or catalogued at the WAH (WAH 2008).

Locations of these species at Callawa Ridge will not be impacted as part of the planned mining operations. Although some of the locations at which specimens were recorded on the Cundaline Ridge will be impacted by the proposed disturbance, a significant impact on these taxa is unlikely. This is because specimens have been collected from outside the disturbance footprint on Cundaline Ridge and there is potential habitat for these species elsewhere, namely Cattle Gorge Plateua, Mundarinya Ridge, Shay Gap Ridge and Sunrise Hill Ridge. Survey results over the last four years also suggest that both species occur more widely across the ridges in the Goldsworthy area then previously expected (*ecologia* Environment 2005c).

As discussed in Sections 4.1 and 4.2, *Solanum beaugleholei* and *Corchorus pumilio* are moderately widespread within their range in the Kimberley (WAH 2008), but have not been previously recorded as far south as the current records. The planned disturbances may result in a localised loss of individuals of these species, but the wider occurrence of potential habitat on the Cundaline and Callawa ridges, and the wide distribution in the Kimberley region, suggests that the planned disturbance is unlikely to affect the species as a whole.

Introduced Flora Species

Introduced flora species may be dispersed during clearing by soil movement or from seeds present on heavy machinery. The increase in traffic associated with mining operations may also aid the spread of introduced flora species.

Considering the measures to manage introduced flora outlined in the previous *Goldsworthy Operation Environmental Management Plan – Weed Management Plan* (BHPBIO 2005a) (e.g. weed management and monitoring), it is thought that the continuation of those measures for the planned Callawa and Cundaline mining operations should minimise potential introduced flora impacts on native flora.

Bushfire Risk

Increase risk of bushfire caused by clearing and mining operations may impact on vegetation. Changes to bushfire regimes can result in changes in structure and function of the natural Pilbara landscape.

Considering the measures to manage bushfires outlined in the previous *Goldsworthy Operation Environmental Management Plan* (BHPBIO 2005b) (e.g. Fire hazard awareness and management training), it is thought that the continuation of those measures for the planned Callawa and Cundaline mining operations should minimise potential impacts on flora.

Dust

Dust caused by clearing and mining operations may also impact on surrounding vegetation.

Considering the measures to manage dust outlined in the previous *Goldsworthy Operation Environmental Management Plan* (BHPBIO 2005b) (e.g. watering of haul roads), it is thought that the continuation of those measures for the planned Callawa and Cundaline mining operations should minimise potential impacts on flora.

6 CONCLUSIONS

The results of the surveys by ENV and *ecologia* Environment (2005a, 2005b) indicate that no Threatened species under the EPBC Act or Declared Rare Flora species under the WC Act would be impacted by the planned Callawa and Cundaline mining operations.

No Priority Flora species are likely to be significantly impacted by the planned Callawa and Cundaline mining operations. Two Priority Flora species were recorded within the Cundaline study area, but are outside the planned disturbance areas, namely, *Euphorbia clementii* and *Goodenia nuda*. One Priority Flora species, *Euphorbia inappendicalata*, has been previously recorded in the Callawa study area, also only recorded outside the planned disturbance areas.

No vegetation communities of conservation significance will be impacted by the development.

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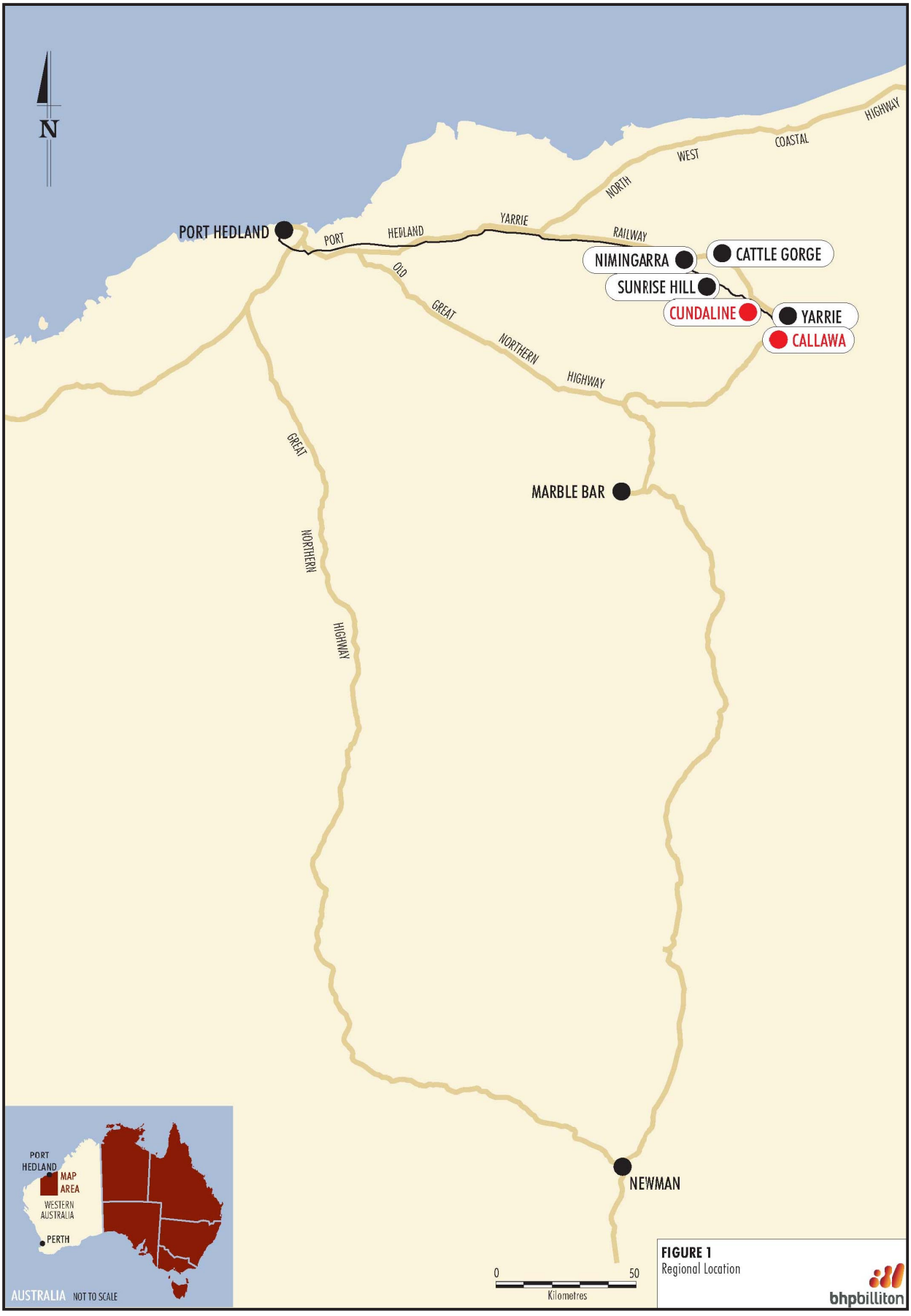
FIGURES

PRINTED: Wed 15 Oct 08



08-123-f01.dgn
DATUM: MGA50
DRAWN: EDS 06-08-08
AUTHOR: BC 03-10-08

SOURCE: BHP Billiton

BHP Billiton Iron Ore Pty Ltd
CALLAWA AND CUNDALINE
FLORA AND VEGETATION ASSESSMENT
Site Location
FIGURE 1

env Australia

PRINTED: Fri 03 Oct 08

Rubin Junction
Nimingarra Mine
Nim B Pit
Nimingarra Mine
Nim E Pit
Nimingarra Mine
Nim F Pit
Nimingarra Mine
Nim I Pit
Sunrise Hill
Mine
AM 7000263
AML 7000251
Nimingarra - Shay Gap Road
Airstrip
Boreline Road
Egg Creek
Shay Gap
Port Hedland
Yarrie
Railway
Creek
Egg Creek
AML 7000249
PROPOSED
CUNDALINE MINE
Figure 3
AML 7000249
M 45/1019
Cattle Gorge
Mine
L 4500140
L 4500127
Creek
AM 7000263
Yarrie Mine
Y10 North Pit
M 45/1018
Yarrie Mine
Y4a Pit
AML 7000249
Yarrie Mine
Camp
M 45/573
M 45/592
Yarrie Mine
Y7 West Pit
AM 7000263
M 45/558
M 45/594
PROPOSED CALLAWA
MINE
M 45/1015
M 45/1016
M 45/1017
Figure 4
Eel
Nuccan - Shay Gap Road
Coomeina
De Grey
River
E 45/1072

N

LEGEND
Highway / Road
Railway Line
Tenement Boundary
Ore Deposit /Pit
Nimingarra Iron Formation
0 1 5
Kilometres

Source: DOIR, 2007

FIGURE 2
Goldsworthy Iron
Mining Operations

bhpbilliton

08-123-f02.dgn
DATUM: Not Spatially Correct
DRAWN: EDS 06-08-08
AUTHOR: BC 03-10-08

SOURCE: BHP Billiton

BHP Billiton Iron Ore Pty Ltd
CALLAWA AND CUNDALINE
FLORA AND VEGETATION ASSESSMENT
Goldsworthy Iron Mining Operations
FIGURE 2

env Australia