TECHNICAL REPORT

OPTIMISATION STUDY AREA

LEVEL 2 FLORA AND FAUNA SURVEY

JANUARY 2013

FOR
NEWCREST MINING LTD



SYRINX environmental pl

Perth
12 Monger Street
Perth WA, Australia 6000
t +61[0]8 9227 9355
f +61[0]9 9227 5033

Melbourne
2/26-36 High Street
Northcote VIC Australia 3070
t +61[0]3 9481 6288
f +61[0]3 9481 6299

ABN : 39 092 638 410

www.syrinx.net.au

SYRINX ENVIRONMENTAL PL
REPORT NO. RPT-1120-001 V5

LIMITATIONS OF REPORT

Syrinx Environmental PL has prepared this report as an environmental consultant provider. No other warranty, expressed or implied, is made as to the professional advice included in this report. This report has not been prepared for the use, perusal or otherwise, by parties other than the Client, the Owner and their nominated consulting advisors without the consent of the Owner. No further information can be added without the consent of the Owner, nor does the report contain sufficient information for purposes of other parties or for other uses. The information contained in this report has been prepared in good faith, and accuracy of data at date of issue has been compiled to the best of our knowledge. However, Syrinx Environmental PL is not responsible for changes in conditions that may affect or alter information contained in this report before, during or after the date of issue.

Syrinx Environmental PL accepts site conditions as an indeterminable factor, creating variations that can never be fully defined by investigation. Measurements and values obtained from sampling and testing are indicative within a limited time frame and unless otherwise specified, should not be accepted as actual realities of conditions on site beyond that timeframe.

REPORT DETAILS:

Version No.	Date	Author	Reviewer	Comment
	02.02.12	SD/BCE	KM	Internal Review
1	03.02.12	SD/BCE	KM	Draft submitted to Newcrest
	14.02.12		TG/RB	Feedback from Newcrest
2	14.03.12	SD/BCE	AM	2nd Draft Submission to Newcrest
3	03.08.12	SD/BCE	WT	3rd Draft Submission to Newcrest
	15.10.12		TG/PM	Feedback from Newcrest
4	10.11.12	SD/BCE	WT	4th Submission to Newcrest
	31.12.12		PM	Feedback from Newcrest
5	15.01.13	SD/BCE	AP	Final Submission to Newcrest

Filename/ filepath: *J:\JOB FILES\1120 NMTFFS\C10 Deliverables*

© **2013** Syrinx Environmental/Bamford Consulting Ecologists

Except as provided by the Copyright Act 1968, no part of this document may be reproduced, stored in a retrieval system or transmitted in any form or by any means without the prior written permission of Syrinx Environmental PL. Enquiries should be directed to the Corporate Intellectual Property Officer.

	Signature		Signature
Author **SD**		**Reviewer** AP	
Position: Senior Botanist		**Position**: Environmental Scientist	

© **2013** Syrinx Environmental/Bamford Consulting Ecologists

Except as provided by the Copyright Act 1968, no part of this document may be reproduced, stored in a retrieval system or transmitted in any form or by any means without the prior written permission of Syrinx Environmental PL. Enquiries should be directed to the Corporate Intellectual Property Officer.

EXECUTIVE SUMMARY

Newcrest Mining Limited engaged Syrinx Environmental PL (Flora and Vegetation) with Bamford Consulting Ecologists (BCE) (Fauna) to undertake a Level 2 assessment of the Optimisation Study Area, which is part of the Telfer Gold Mine (Telfer), located in the Great Sandy Desert in the Paterson Province of Western Australia, 485km from Port Hedland. The Optimisation Study Area is located immediately north west of existing operations within Newcrest tenements M45/33 and part of M45/7.

The Optimisation Study Area is a 1,237ha portion of the overall 10,471ha Telfer Optimisation Project where Newcrest is investigating opportunities for enhancement of current mining activities and potential for satellite deposits. The Optimisation Study Area is one of five study areas that comprise the Telfer Optimisation Project Area. All five study areas were assessed simultaneously.

The assessment was required in order to assess the likely environmental impacts of the proposal on vegetation, flora, groundwater dependent ecosystems, vertebrate fauna and short range endemics.

This report summarises the flora, vegetation and fauna survey results for the Optimisation Study Area and compares those results with those of previous surveys in the Telfer region.

The scope of works for the flora, vegetation and fauna assessment included:

1. A flora, vegetation and fauna database review for the Optimisation Study Area, including an assessment of the likelihood of potential conservation significant species (determined via the database searches being present within the study area), i.e. based on available habitat or groundwater dependent ecosystems;
2. A summary of previous flora, vegetation and fauna surveys undertaken within, or within the vicinity of the study area;
3. Liaison with regulatory agencies to confirm scope and intensity of survey;
4. A Level 2 Flora and Vegetation Survey to characterise the vegetation and document perennial and annual plant taxa present in vegetation associations;
5. A field assessment of groundwater dependency of potential Groundwater Dependent Ecosystems (GDE's);
6. A Level 2 Vertebrate Fauna Survey to document vertebrate fauna species identified at sampling locations and through opportunistic observations, including;

a) Documentation of Short Range Endemic (SRE's) species identified at sampling locations and through opportunistic observations;

b) Identification and locations of significant flora, vertebrate fauna and SRE species and vegetation communities/GDEs/habitats; and

7. Identification of introduced flora and fauna and locations of any Declared Plants under the *Agriculture and Related Resources Protection Act 1976*, Weeds of National Environmental Significance or other plants regarded as invasive weeds.

FLORA AND VEGETATION

A total of 21, 50 x 50m quadrats were sampled during the survey resulting in identification of 214 species from 38 families and 97 genera. In addition, six specimens were unidentifiable at the species level.

The most commonly recorded family was Fabaceae, which accounted for 17.8% of all taxa collected in the Optimisation Study Area, constituting 38 taxa and 10 genera. Other dominant families recorded were Poaceae (16.3% of taxa) which consists of 35 taxa from 18 genera, Malvaceae (7.5% of taxa) with 16 taxa from seven genera and Goodeniaceae (14.0% of taxa) which consists of 13 taxa from five genera.

No Threatened Flora (T) listed under the *Wildlife Conservation Act 1950* or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were recorded within the Optimisation Study Area. Two new populations of the Priority 2 species, *Goodenia hartiana*, were recorded in the Optimisation Study Area, and one population previously recorded was reconfirmed.

There were seven range extension species recorded: *Acacia pteraneura*, *Maireana triptera Sclerolaena crenata*, *S. eriacantha* and *S. minuta*, *Peripleura virgata* and *Synaptantha tillaeacea* var. *tillaeacea*.

Using a combination of multivariate analysis and field observations, 12 vegetation associations occurring within six broad floristic groups were mapped and described in the Optimisation Study Area. None of the vegetation associations mapped and described are listed as Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs).

Previously mapped vegetation associations across Western Australia were assessed in terms of their reservation priorities as part of the WA Biodiversity Audit (Kendrick 2001a, 2001b). Vegetation Association 134 is a high priority for reservation in the Little Sandy Desert and of low priority for reservation in the Great Sandy Desert. The total area of

Vegetation Association 134 of high priority for reservation in the Optimisation Study Area is 12.85ha.

One vegetation association was assessed as a unique and distinct vegetation association:

- Vegetation Association 3a: *Acacia pteraneura* High Shrubland over *A. wanyu*, *Anthobolus leptomerioides* and *Psydrax latifolia* Shrubland over *Eremophila tietkensii* and *E. latrobei* subsp. *latrobei* Low Open Shrubland over *Triodia basedowii* Open Hummock Grassland.

This vegetation association occurs across 4.89% of the Optimisation Study Area, on a landform not common regionally and with dominant species more common in the Pilbara region, including two range extension species, *Acacia pteraneura* and *Maireana triptera,* which are restricted to this vegetation association in the Optimisation Study Area. A total of five species are restricted to vegetation association 3a.

Acacia pteraneura was not recorded in the other four study areas for the Telfer Optimisation Project. It is a species which is part of a taxonomic complex commonly known as 'Mulga'. Therefore, it has also been identified as a potential sheet flow dependent ecosystem and slope analysis may be needed to be conducted to confirm this.

The vegetation association described above could potentially meet the following EPA (2004a) criteria for assessing regional significance of flora and vegetation:

- restricted distribution in the study area (<5% of the study area), may have restricted distribution regionally as they occur on an uncommon landform of the Great Sandy Desert;
- being representative of the range of a unit (particularly at the extremes of range) as vegetation association 3a is likely to be at the northern extreme of its distribution due to the lack of potential habitat north of the Optimisation Study Area. It is recommended this is confirmed through further investigations; and
- novel combination of species as the species recorded in the first survey are more common to the Pilbara and include two species restricted to the vegetation association.

The vegetation condition across the Optimisation Study Area ranges from Good to Pristine. The lesser condition assignment is due to impacts on the vegetation structure due to clearing for mining activities around the waste dumps. The Pristine areas were to the north west and south east of the Optimisation Study Area where there has been no evidence of human disturbance such as tracks and stakes. A large portion of the Optimisation Study Area was in excellent condition (47%). The disturbed areas include all tracks and areas with no vegetation.

A weed survey was undertaken by Syrinx Environmental PL in May 2011. Information from the Syrinx Environmental PL (2011) weed survey was utilised to supplement the current

study. There were three introduced species found in the Optimisation Study Area; *Cenchrus ciliaris* (Buffel Grass), *Aerva javanica* (Kapok) and *Portulaca oleracea* (Purslane). Buffel Grass and Kapok were recorded to the south of the Optimisation Study Area along edges of the roads and tracks while Purslane was to the north and within the Mulga vegetation.

An additional population of Buffel Grass was found in one location in a drainage channel with a grassy understorey at the base of small rocky hills in the northern portion of the Optimisation Study Area. Only one plant was seen at the time of survey. The vegetation association was otherwise in pristine condition and the presence of Buffel Grass had made no impact to vegetation structure or condition. This represents the first record of Buffel Grass away from the immediate areas of mine impact where it is typically found only in disturbed areas.

FAUNA

The fauna investigations comprised a desktop review of data to produce a list of expected species, a site reconnaissance trip in July 2011, and intensive sampling trips in September 2011 and June 2012. The September 2011 and June 2012 sampling involved the deployment of 11 sampling sites (each with 10 pitfall traps, five funnel traps, five Elliott traps and 10 census points), and a range of sampling and census techniques across the five survey areas comprising the overall Telfer Optimisation Project Area, with two sampling sites in the Optimisation Study Area. Sampling included some collection of potential Short Range Endemic invertebrates.

The desktop assessment identified 275 vertebrate fauna species that may occur in the Optimisation Project Area, including seven frog, 95 reptile, 129 bird and 44 mammal species. Twelve reptile, 27 bird and six mammal species were confirmed in the Optimisation Study Area.

Key fauna values are:

- ***Fauna assemblage*** – Rich and substantially intact except for the loss of some, mostly medium-sized, mammal species. Distinctive in that it contains elements from both the Pilbara and Great Sandy Desert regions. The Optimisation Study Area is likely to contain only a subset of the fauna assemblage predicted for the entire region, but fauna are mobile and an assemblage can change over time.
- ***Significant species*** – 26 species of conservation significance may be present, including three reptile species, at least 13 bird species (but with the potential for occasional visits by additional migratory waterbirds), and ten mammal species. The status with respect to significant invertebrates is uncertain but at least one scorpion may be a Short Range Endemic. Most significant species are widespread and occur in very extensive regional

landscapes, with interdune sand-plains being important for a number of species. Within the Optimisation Study Area, the Bilby and Mulgara (*Dasycercus* sp.) are certain to be present (based on nearby records for the Telfer Optimisation Project Area) and the Northern Marsupial Mole may also occur within the sand dune systems. These dunes are minor within the Optimisation Study Area, but extensive within the overall Telfer Optimisation Project Area. Individuals of the Bilby and Mulgara are mobile and populations can fluctuate, so even if not recorded at one time, these species may be present later

- ***Vegetation and Substrate Associations (VSAs)*** – Eight VSAs were identified across the Telfer Optimisation Project Area: sand dunes; interdune plains; possible groundwater dependent ecosystems in plains; calcrete rises; rocky hills, Mulga woodland, artificial wetlands and disturbed areas. Most are very widespread, with interdune plains, rocky hills, Mulga woodland, artificial wetlands and disturbed areas and limited dunes present in the Optimisation Study Area. The Mulga woodland is notable as being restricted, isolated and confined to the Optimisation Study Area.
- ***Patterns of biodiversity*** - The key finding of studies into patterns of biodiversity was the high abundance and richness of bird species in the Mulga woodland within the Optimisation Study Area.
- ***Key ecological processes –*** The main processes affecting the fauna assemblage in the Telfer region and Optimisation Study Area are local hydrology, fire regime and fauna interactions. Local hydrology may be important along dunes and in some broad valleys across the region, but in the Optimisation Study Area the main significance of local hydrology is likely to be around the Mulga VSA. Altered fire regimes have probably contributed to low levels of abundance and possibly local extinction of a number of species of conservation significance, while the effect of feral predators (Dingo, Cat and Fox) warrants further consideration.

TABLE OF CONTENTS

EXECUTIVE SUMMARY **I**

PART 1 INTRODUCTION **1**

1.0 PROJECT BACKGROUND **1**

2.0 SCOPE OF WORK **1**

3.0 EXISTING ENVIRONMENT **6**

3.1 BIOGEOGRAPHIC REGION 6

3.2 GEOLOGY AND SOILS 8

3.2.1 Geology 8

3.2.2 Landform 9

3.2.3 Soils 9

3.3 HYDROLOGY 10

3.4 CLIMATE 11

3.5 LANDUSE 13

PART 2 FLORA AND VEGETATION **14**

4.0 FLORA AND VEGETATION **14**

4.1 LITERATURE REVIEW 14

4.1.1 Sources for literature review and database searches 14

4.1.2 Regional Flora and Vegetation Surveys 15

4.1.3 Local Vegetation Surveys 19

4.1.4 Potential Flora and Vegetation of Conservation Significance 28

4.1.5 Ground and Surface Water Dependent Ecosystems 38

4.1.6 Introduced Flora 42

4.2 METHODOLOGY 45

4.2.1 Floristic Survey 45

4.2.2 Field Survey 45

4.2.3 Flora and Vegetation Survey Limitations and Constraints 54

4.3 FLORA AND VEGETATION RESULTS 56

4.3.1 Vegetation Association General Description 56

4.3.2 Vegetation Condition 65

4.3.3 Threatened Ecological Communities 67

4.3.4 Ground and Surface Water Dependent Ecosystems 67

4.4 FLORA DESCRIPTION 68

4.4.1 Flora of Conservation Significance 69

4.4.2 Introduced Flora 75

4.5 FLORA AND VEGETATION DISCUSSION 77

4.5.1 Flora 77

4.5.2 Conservation Significant Flora 78

4.5.3 Introduced Flora 78

4.5.4 Vegetation Associations 79

4.6 CONSERVATION STATUS 80

4.6.1 International and National Significance 80

4.6.2 State Significance 80

4.6.3 Regional Significance 81

4.6.4 Local Significance 87

PART 3 VERTEBRATE FAUNA 90

5.0 VERTEBRATE FAUNA 90

5.1 OVERALL APPROACH 90

5.2 VERTEBRATE FAUNA METHODOLOGY 90

5.2.1 Overview 90

5.2.2 Literature Review 91

5.2.3 Interpretation of species lists 94

5.2.4 Field investigations 95

5.2.5 Summary of survey effort 98

5.2.6 Survey limitations 98

5.3 RESULTS 100

5.3.1 Fauna Assemblage 100

5.3.2 Species of conservation significance 101

5.3.3 Short Range Endemics (SRE) 108

5.3.4 Summary of species of conservation significance 109

5.3.5 Vegetation and Substrate Associations (VSAs) 109

5.3.6 Patterns of Biodiversity 114

5.3.7 Key Ecological Processes 118

5.4 DISCUSSION 119

5.4.1 Summary of fauna values 119

PART 4 SYNTHESIS AND RECOMMENDATIONS 122

6.0 SYNTHESIS 122

6.1 ASSESSMENT OF SIGNIFICANCE 124

6.2 RECOMMENDATIONS FOR FURTHER INVESTIGATIONS 128

6.2.1 Flora 128

6.2.2 Fauna 128

6.3 CONCLUSION 129

6.3.1 Flora and Vegetation 129

6.3.2 Fauna 129

PART 4 REFERENCES 131

APPENDICES 142

LIST OF TABLES

Table 1 Summary of previous flora and vegetation surveys within the vicinity of Telfer 25

Table 2 Potential Priority Flora in the Telfer Region from the DEC and WAH Databases – species that have been recorded previously within a 60km buffer 32

Table 3 Potential Priority Flora in the Great Sandy Desert Bioregion from the DEC and WAH Databases 32

Table 4 Definitions of Wetlands and Water Dependency 38

Table 5 Introduced Species 43

Table 6 Vegetation Classifications 51

Table 7 Vegetation Condition Scale 52

Table 8 Summary of Potential Flora and Vegetation Survey Constraints 54

Table 9 Broad Floristic Groups and Vegetation Associations 57

Table 10 Comparison of flora results with remaining study areas within the Telfer Optimisation Project Area 69

Table 11 *Goodenia hartiana* populations 71

Table 12 Vegetation Associations with restricted distributions (<61ha) within the Optimisation Study Area 86

Table 13 Vegetation Association extent and status in the Great Sandy Desert and Little Sandy Desert IBRAs region showing extent of vegetation in the Telfer Optimisation Study Area 89

Table 14 Types of records held on database, area searched and their source location 92

Table 15 Outline of fauna sampling methods 96

Table 16 Descriptions of systematic sampling sites in the Telfer Optimisation Study Area 97

Table 17 Summary of Survey Effort 98

Table 18 Survey limitations as outlined by EPA (2004c) 99

Table 19 Composition of vertebrate fauna assemblage expected to occur in the Telfer Optimisation Area, and numbers of species recorded during field investigations 101

Table 20 Conservation significant fauna species with potential to occur in the Optimisation Study Area 102

Table 21 Numbers of captures of reptiles and small mammals in the two sampling sites in the Optimisation Study Area, September 2011 and June 2012 115

Table 22 Comparison of numbers of captures of reptiles and small mammals between the Optimisation Study Area and other Study Areas in the Telfer Optimisation Project Area; September 2011 116

Table 23 Numbers of records (cumulative count across five mornings) of birds in the two sampling sites in the Optimisation Study Area, September 2011 and June 2012 116

Table 24 Comparison of numbers of bird census records between the Optimisation Study Area and other Study Areas in the Telfer Optimisation Project Area; September 2011 and June 2012 118

Table 25 Synthesis of key habitats in the Optimisation Study Area 122

Table 26 Rankings of Assets recorded within the Optimisation Study Area 124

Table 27 Amphibians recorded or that may be present in the Optimisation Project Area 216

Table 28 Reptiles recorded or that may be present in the Optimisation Project Area 217

Table 29 Birds recorded or that may be present in the Optimisation Project Area 221

Table 30 Mammals recorded or that may be present in the Optimisation Project Area 227

Table 31 Vertebrate fauna considered extinct in the region; records from Hart, Simpson and Associstes (2002), based on examination of skeletal remains in owl pellets from a location about 80km SSW of Telfer 230

Table 32 Vertebrate fauna returned in databases but for which there is no suitable habitat in the Optimisation Study Area 231

Table 33 Reptile and small mammal trapping data; results of surveys at all sites across Telfer Optimisation Project Area in September 2011 232

Table 34 Bird census data; results of surveys at all sites across Telfer Optimisation Project Area in September 2011. 234

LIST OF FIGURES

Figure 1 Location of Telfer Optimisation Project 3

Figure 2 Location of the Telfer Optimisation Study Area and Project Area in comparison to other Newcrest tenements in the Great Sandy Desert, Western Australia 4

Figure 3 Telfer Optimisation Study Area 5

Figure 4 IBRA Regions of the Optimisation Study Area 7

Figure 5 Climate Data for Telfer Weather Station (BOM Station 013030) (BOM 2012) 12

Figure 6 Pre-European Extent of Vegetation Associations 18

Figure 7 Priority Flora recorded within a 60km buffer from the Optimisation Study Area from DEC and WAH Database Searches 31

Figure 8 Flora Survey Quadrat Locations 48

Figure 9 Vegetation Association Map 63

Figure 10 Vegetation Association Legend 64

Figure 11 Vegetation Condition Map 66

Figure 12 *Goodenia hartiana* population within the Optimisation Study Area 72

Figure 13 Locations of *Goodenia hartiana* 73

Figure 14 Locations and Extent of Infestations for Introduced Flora Species (Syrinx Environmental PL 2011a) 76

Figure 15 Sampling site 10, illustrating a sandy plain with shrubs and Spinifex (*Triodia* spp.), and a low rocky hill on the background left 112

Figure 16 Sampling site 11, Mulga with, in this location, a mixed understorey of *Acacia* and *Eremophila* over *Triodia* 112

Figure 17 VSAs of Optimisation Study Area with fauna survey locations 113

Figure 18 Management Rankings - Flora 126

Figure 19 Management Rankings - Fauna 127

LIST OF APPENDICES

Appendix 1 Definitions of Threatened and Priority Ecological Communities and Threatened (T) and Priority Flora 143

Appendix 2 Coordinates of Conservation Significant Flora Species 149

Appendix 3 Flora Quadrat Data Sheets 151

Appendix 4 Analysis and Classification of Vegetation Associations 194

Appendix 5 Vegetation Association Descriptions 195

Appendix 6 Flora species list 207

Appendix 7 Explanation of fauna values. 212

Appendix 8 Fauna species recorded or expected in the local region based on desktop review 216

Appendix 9 Ecological and Threatening Processes 235

Appendix 10 Coordinates (Zone 51) and sampling deployment at sampling locations in the Telfer Optimisation Study Area. 237

Appendix 11 Summary letter of invertebrate specimens collected in the Telfer Optimisation Study Area. 238

ABBREVIATIONS

The following abbreviations have been used

BCE	Bamford Consulting Ecologists
DEC	Department of Environment and Conservation
EPBC Act	Environment Protection and Biodiversity Conservation Act
GDE	Groundwater Dependent Ecosystem
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
OEPA	Office of the Environmental Protection Authority
SRE	Short Range Endemic
PEC	Priority Ecological Community
TEC	Threatened Ecological Community
VA	Vegetation Association
VSA	Vegetation Substrate Association

PART 1 INTRODUCTION

1.0 PROJECT BACKGROUND

Newcrest Mining Limited (Newcrest) is investigating the viability of expanding the existing operations at Telfer Gold Mine (Telfer), located in the Great Sandy Desert of the Eastern Pilbara, Western Australia (Figure 1). The current operation is comprised of two mines, Telfer Open Pit and Telfer Underground. Telfer Open Pit contains two open pits, Main Dome and West Dome. The underground mine is located beneath the Main Dome open pit.

The Telfer Optimisation Project comprises of several tenements where Newcrest is investigating opportunities for enhancement of current mining activities and developing potential satellite deposits.

Newcrest engaged Syrinx Environmental PL (Syrinx) (Flora and Vegetation) with Bamford Consulting Ecologists (BCE) (Fauna) to undertake an assessment of the Optimisation Study Area, a 1,237ha portion of the overall 10,471ha Telfer Optimisation Project Area (Figure 2), in order to assess the likely environmental impacts of the proposal on vegetation, flora, groundwater dependent ecosystems, vertebrate fauna and short range endemics.

This report addresses the Optimisation Study Area (Figure 3) and presents the results of investigations to document flora, vegetation and fauna values during field surveys undertaken between July 2011 and June 2012.

2.0 SCOPE OF WORK

The scope of works for the flora, vegetation and fauna assessment included:

1. A flora, vegetation and fauna database review for the Optimisation Study Area, including an assessment of the likelihood of potential conservation significant species (determined via the database searches being present within the study areas), i.e. based on available habitat or groundwater dependent ecosystems;
2. A summary of previous flora, vegetation and fauna surveys undertaken within, or within the vicinity of the Optimisation Study Area;
3. Liaison with regulatory agencies to confirm scope and intensity of survey;
4. A Level 2 Flora and Vegetation Survey to characterise the vegetation and document perennial and annual plant taxa present in vegetation associations;
5. A field assessment of potential Groundwater Dependent Ecosystems (GDEs);

6. A Level 2 Vertebrate Fauna Survey to document vertebrate fauna species identified at sampling locations and through opportunistic observations;

a) Documentation of Short Range Endemic (SRE) species identified at sampling locations and through opportunistic observations;

b) Identification and locations of significant flora, vertebrate fauna and SRE species and vegetation communities/GDEs/habitats; and

7. Identification of introduced flora and fauna and locations of any Declared Plants under the *Agriculture and Related Resources Protection Act 1976* (WA), Weeds of National Significance as listed by the Australian Weeds Committee on behalf of the Natural Resources Management Ministerial Council, or other plants regarded as invasive weeds.

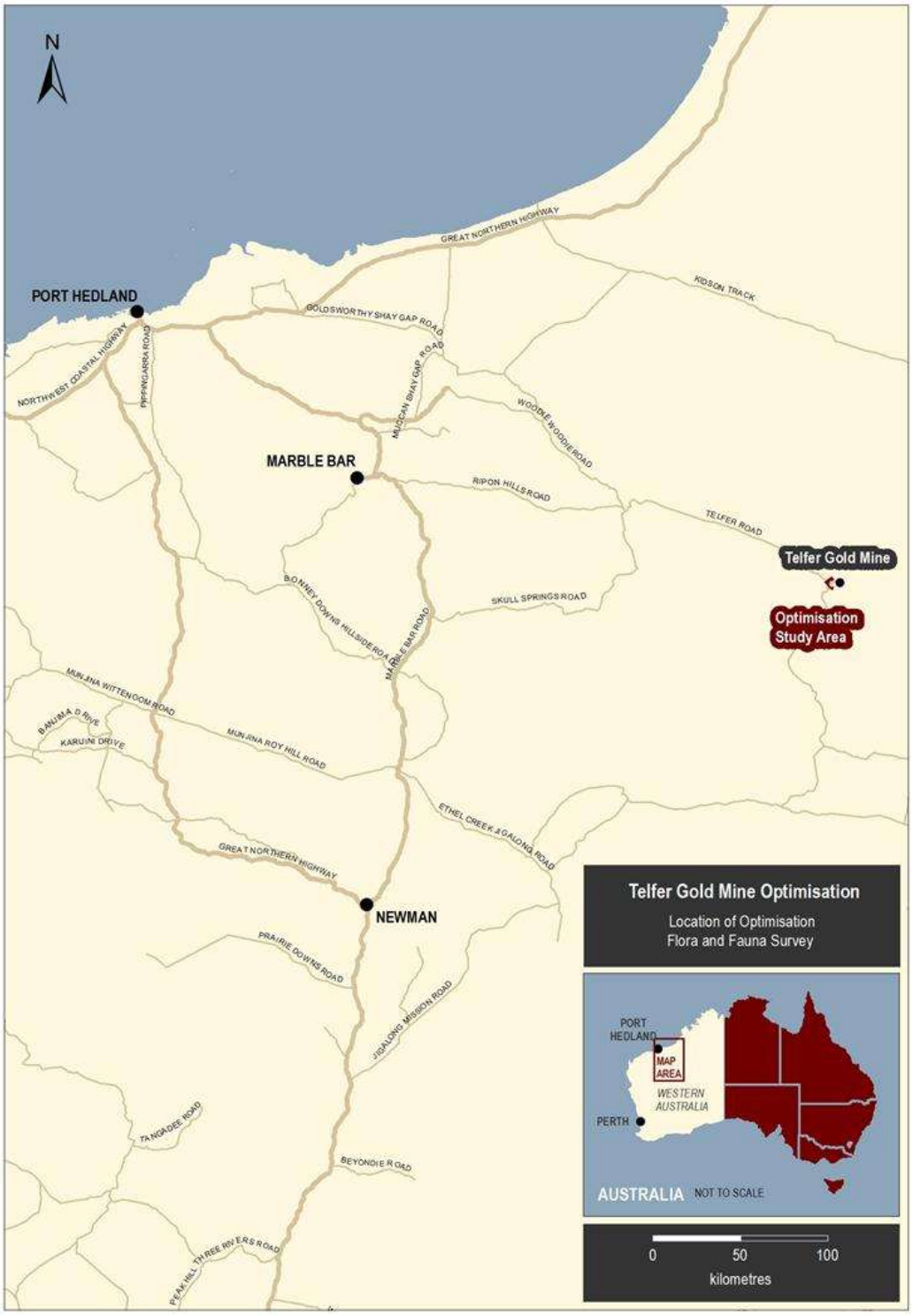


Figure 1 Location of Telfer Optimisation Project

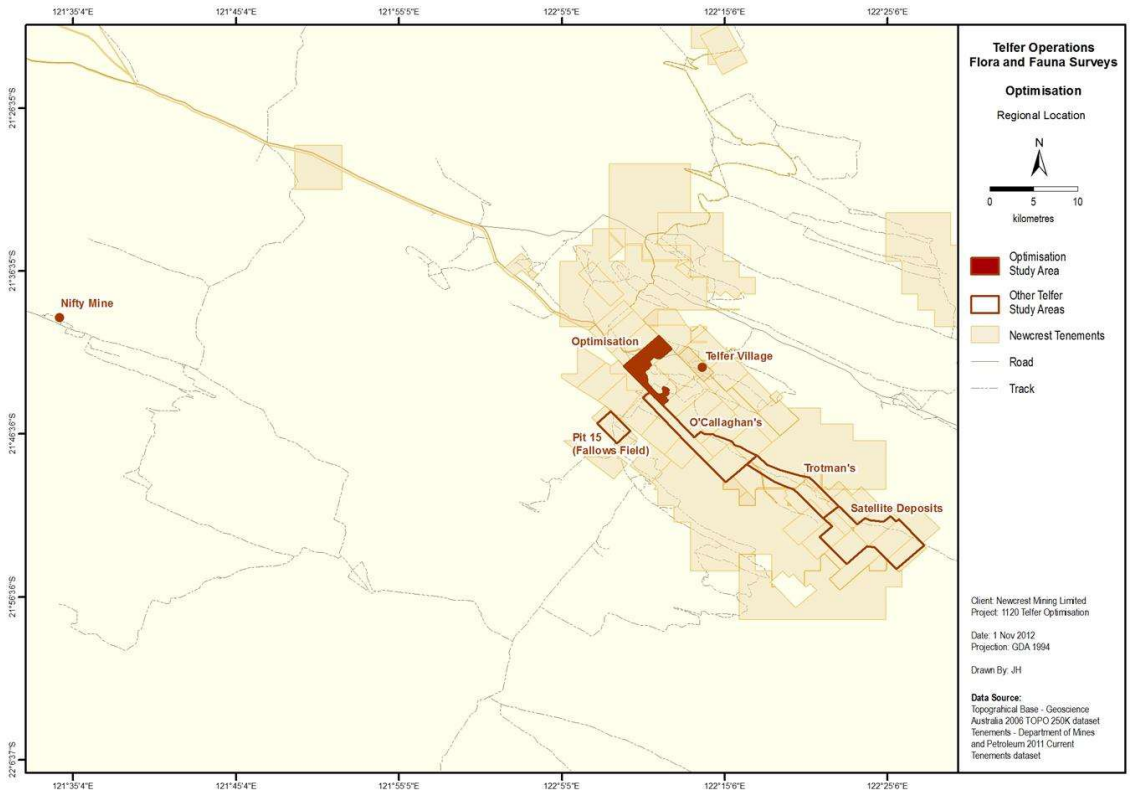


Figure 2 Location of the Telfer Optimisation Study Area and Project Area in comparison to other Newcrest tenements in the Great Sandy Desert, Western Australia



Figure 3 Telfer Optimisation Study Area

3.0 EXISTING ENVIRONMENT

3.1 BIOGEOGRAPHIC REGION

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into 89 bioregions based on climate, geomorphology, landform, lithology and biological attributes (DSEWPaC 2012) and includes 419 subregions. The bioregions and subregions are the reporting unit for assessing the status of native ecosystems. The Optimisation Study Area occurs across two bioregions, the Great Sandy Desert and Little Sandy Desert (Figure 4).

The Optimisation Study Area is predominantly within the Mackay (GSD2) subregion, which is typified by tree steppe grading to shrub steppe in the south. This subregion comprises open hummock grassland of *Triodia pungens* and *T. schinzii* with scattered trees of *Owenia reticulata* and bloodwood (*Corymbia* spp.), and shrubs of *Acacia* spp., *Grevillea wickhamii* and *G. refracta*. The dominant geomorphology of the Mackay has been described as Quaternary red longitudinal sand dune fields overlying Jurassic and Cretaceous sandstones of the Canning and Amadeus Basins (Kendrick 2001a). Gently undulating laterised uplands support shrub steppe, such as *A. pachycarpa* shrublands over *T. pungens* hummock grass. Calcrete and evaporite surfaces are associated with occluded paleo-drainage systems that traverse the desert; these include extensive salt lake chains with samphire low shrublands, and *Melaleuca glomerata* - *M. lasiandra* shrublands (Kendrick 2001a). The Mackay subregional area in Western Australia is 18,636,695 ha, or 72% of the total area of the Mackay subregion. A total of 2,690.24 ha of the Optimisation Project Area is within the Mackay subregion, which represents 0.009% of the subregion.

The Optimisation Study Area is partially within the Rudall (LSD1) subregion, which is typified by sparse shrub-steppe over *Triodia basedowii* on stony hills with River Gum (*Eucalyptus camaldulensis*) communities and bunch grasslands on alluvial deposits in and around ranges (Kendrick 2001b). This subregion comprises extensive areas of tussock grasses associated with footslopes and River Gum communities along drainage. The Rudall subregion includes extensive *Triodia* hummock grasslands on hills and surrounding plains and the headwaters and course of the Rudall River (Kendrick 2001b), and also includes the Proterozoic hill country of Throssell, Mount Sears, Broadhurst and Harbutt Ranges. The total area of the Rudall subregion is 1,078,070ha. A total of 37.41ha of the Optimisation Study Area is within the Rudall subregion, which represents 0.00003% of the subregion.

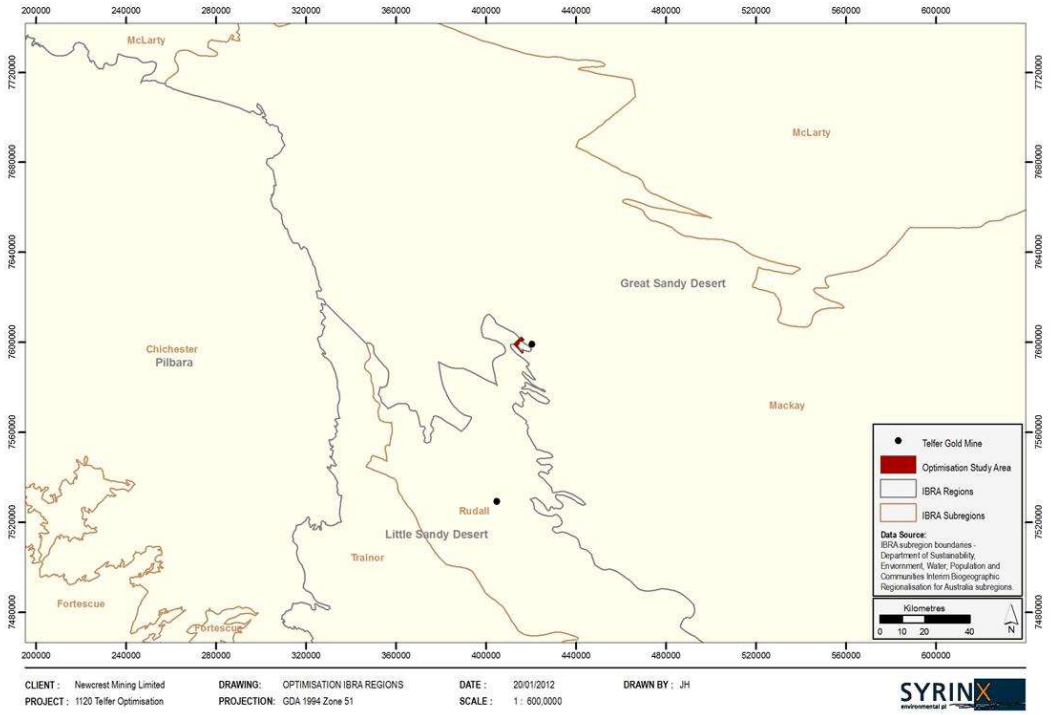


Figure 4 IBRA Regions of the Optimisation Study Area

3.2 GEOLOGY AND SOILS

3.2.1 Geology

The Great Sandy Desert region is underlain by a range of Precambrian, Mesozoic and Cainozoic materials. Precambrian rocks, an extension of the Pilbara region, form outcrops and subcrops in the southern part of the Great Sandy Desert region. Sedimentary rocks of Mesozoic age (Purcell 1984), assigned to three formations, variably crop out and form subcrops throughout the entire desert region, forming as ranges, local hills, mesas, buttes and exhumed rock pavements (VCSRG 2004). A vast sheet of red aeolian sediment, late Cainozoic to Quaternary in age, forms the near-surface materials through the entire desert (VCSRG 2004).

An important component of the Quaternary stratigraphy in the region is a muddy sand sheet in the shallow subsurface under the dune terrains (VCSRG 2004). These sheets have formed by the infiltration and accumulation of fine grained dust into the aeolian stratigraphic profile, resulting in the semi-impregnation of the dune sands into muddy sands at the water table (VCSRG 2004).

Regionally, Telfer is within the Paterson – Yeneena province (Tille 2006) which overlies the north-western Patterson Orogen and Yeneena Basin. In the south of the Patterson Orogen is the non-concealed portion of the Gibson Sub-basin (Officer Basin) that contains Neoproterozoic sandstone, siltstone, mudstone, and stromatolitic and non-stromatolitic dolomite. In the north-west is the Rudall Complex that includes Paleoproterozoic granitoid rock, amphibolite, quartzite, orthogneiss, schist, chert, metamorphosed ultramafic rock, carbonate rocks and banded iron-formation (Tille 2006).

The Yeneena Basin in the north contains Mesoproterozoic and Neoproterozoic sandstone, shale and carbonate. Also included is a small portion of the Waukarlycarly Embayment (Canning Basin) which contains Phanerozoic sedimentary rocks (Tille 2006).

Telfer is within the Paterson province which contains multiple geological formations. A geographic information system (GIS) map at a resolution of 1:250,000 was used for the identification of several formations that are present within the Optimisation Study Area (Geoscience Australia 2008):

- Wilki Formation (Nsaw): Occurring in the North Eastern portion, as well as the central and southern parts of the study area. This formation is characterised by quartzite, dark grey shale, siltstone, arenaceous schist and sheared sandstone.

- Dunes 38496 (Qd): This formation constitutes the majority of the North Eastern portion of the study area as well as a small pocket in the Western corner. It is characterised by sandplains with dunes and swales; it may include numerous interdune claypans with residual, aeolian, minor silt and clay sands. Generally, dunes are characterised by aeolian red quartz sands, in places gypsiferous, also yellow hummocky sand.
- Puntapunta Formation (Nlap): Located throughout the whole Optimisation Study Area. It is characterised by well bedded, medium to coarse grained clastic dolomite containing detrital quartz and muscovite, fine to coarse dark grey calcarenite, quartz sandstone and shale.
- Colluvium 38491 (Qrc): Located in the Southern and Western corners of the study area. It is characterised by colluvium, sheetwash and talus; gravel piedmonts and aprons over and around bedrock; clay silt sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite.

3.2.2 Landform

Regionally, aeolian plains dominate the Great Sandy Desert, with a surface comprising red-sand linear sand dunes, oriented east-west to west-northwest. The lowland areas between the linear dunes are interdunal depressions, termed sand sheet (VCSRG 2004). Ranges form conspicuously dominant, though isolated topographic structures throughout the Great Sandy Desert. They are composed of Mesozoic rocks, or in southern areas, Precambrian rocks (VCSRG 2004).

3.2.3 Soils

The Great Sandy Desert Region is divided into four soil-landscape provinces within which there is a further breakdown into soil-landscape zones (Tille 2006). The Telfer Optimisation Project Area extends approximately East to West and passes over a soil-landscape zone boundary. Consequently, there are two soil-landscape zones within the greater Telfer area. The Optimisation Study Area lies within the soil-landscape zone 152.

- Zone 152 – Yeneena Zone (26,650km^2) - Sandplains and dunes (with hills, ranges and some salt lakes) on sedimentary rocks of the Yeneena Basin and Gibson Sub-basin. Red sandy earths with red deep sands and some salt lake soils, stony soils, red loamy earths, red shallow loams and bare rock.

Tille (2006) noted that as much of this region has not been surveyed, soil descriptions and component province and zones should be viewed as educated estimates at best. The Tille (2006) maps and descriptions form part of Western Australia's contribution to the Australian Soil Resource Information System (ASRIS), describing the broadest levels of the mapping

hierarchy. No further detailed soil descriptions are available on ASRIS due to lack of field surveys being completed in the Telfer region.

3.3 HYDROLOGY

The Great Sandy Desert region can be subdivided into five major hydrologic zones as described by VCSRG (2004):

1. the region to the south of the Salt Creek - Sandfire drainage line, comprising aeolian sand plains, buried channels systems, calcrete and gypsum at the water table, subcrops of Precambrian rock as bedrock aquifers, and proximity of the Pilbara region;
2. the region along the Salt Creek - Sandfire drainage line, comprising, again, aeolian sand plains, but superimposed on a major buried channels system, with calcrete at the water table, and subcrops of Mesozoic rock;
3. the region to the north of the Salt Creek - Sandfire drainage line, comprising aeolian sand plains, some buried channels systems, subcrop of Mesozoic rock as a regional aquifer;
4. the region at the junction of the Great Sandy Desert and the Fitzroy River valley tract, comprising aeolian sand plains, extant rock-incised channels systems, outcrop and subcrop of Mesozoic rock as a regional aquifer;
5. the region along the coast, comprising sandy and muddy coastal deposits, where there is local freshwater storage, and seepage induced by seaward discharge from regional aquifers interfacing with coastal muddy deposits.

Telfer is within Zone 1, the region to the south of the Salt Creek - Sandfire drainage line:

The buried valley tracts in the region are hydrologically the most complicated units in the Great Sandy Desert. They receive water by direct recharge, as well as from harvested run-off in their immediate vicinity, and in harvested base flow from the buried channel and catchment topography. Long term evolution of such systems has resulted in a complex interaction between valley deposits, dune fill of the valley tracts, and groundwater expression of the complex subsurface stratigraphy (VCSRG 2004).

Salt lakes act as sumps to inflow of freshwater deriving from subsurface drainage during the wet season or the cyclone season, and later in the dry season, when the surface waters have been concentrated to saline by evaporation, act as recharge zones, delivering plumes of salt water to the surrounding aquifers (VCSRG 2004).

3.4 CLIMATE

An important factor with surveying flora and fauna in the Great Sandy Desert is the impact of climate, as many of the herbaceous plant species are predominantly ephemeral. The Great Sandy Desert area has a climate from Tropical Arid in its southern to central parts, with an annual precipitation of approximately 350 mm, to Tropical Semi-arid, with an annual precipitation of approximately 500 mm near its junction with the Fitzroy River (VCSRG 2004). The regional annual evaporation is approximately 3000 mm. Cyclones are a major source of rain, crossing the coast on average every 1-2 years, and bringing 200-400 mm of rainfall for a given cyclonic event (VCSRG 2004).

Telfer receives an average annual rainfall of 364.9 millimetres (mm) (data from 1974 – 2012, Station 013030, BOM 2012). The majority of the rain occurs in the summer months with February being the wettest month with an average of 102.7 mm (Figure 5).

In 2011, the total rainfall received for Telfer was 512.2mm. This suggests that 2011 was favourable for growth and germination of many grasses and herb species in particular and therefore provided a good floristic season for the first field survey. The rainfall received for the four months (February to May 2012) prior to the second field survey was 30% of the mean rainfall usually received. The floristic season was not as good as the first field survey, resulting in less favourable conditions for germination and growth of grasses and herbs.

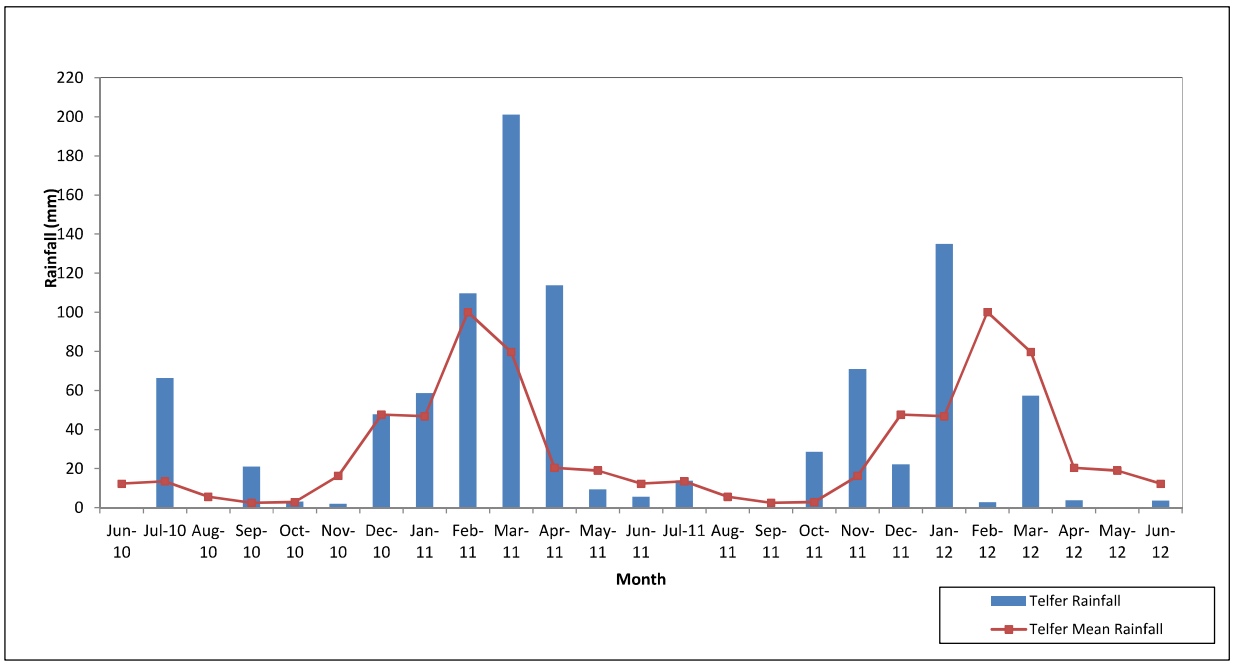


Figure 5 Climate Data for Telfer Weather Station (BOM Station 013030) (BOM 2012)

3.5 LANDUSE

Telfer is within two IBRA subregions Mackay (GSD2) subregion of the Great Sandy Desert and Rudall (LSD1) subregion of the Little Sandy Desert (DSEWPaC 2012).

Land uses in the Mackay (GSD2) subregion consist of Unallocated Crown Land, Conservation, Mining leases, and small areas of Urban (Kendrick 2001a). The Mackay (GSD2) subregion is reservation class 2b with 4.6% of the area in conservation reserves (Karlamilyi National Park (formerly Rudall River National Park) and McLarty Hills Nature Reserve), and >30% natural vegetation (Kendrick 2001a).

Land uses in the Rudall (LSD1) subregion consist of Unallocated Crown Land, Conservation (Karlamilyi National Park), Mining leases and Urban (Parngurr Aboriginal Community) (Kendrick 2001b). The Rudall (LSD1) subregion is reservation class 2 with 37% of the area in conservation reserve, and >30% natural vegetation (Kendrick 2001b). Trainor (LSD2) has 1.4% in conservation reserves so there is subregional bias to Rudall (LSD1) in the Little Sandy Desert (Kendrick 2001b).

PART 2 FLORA AND VEGETATION

4.0 FLORA AND VEGETATION

4.1 LITERATURE REVIEW

4.1.1 Sources for literature review and database searches

4.1.1.1 Database Searches

To determine the species and status of protected flora and vegetation the following searches were undertaken for the Optimisation Study Area and a 60km buffer:

- Protected Matters search tool (DSEWPaC 2011a) and Threatened Ecological Communities (TECs) listed under the EPBC Act;
- Department of Environment and Conservation (DEC) TECs and Priority Ecological Communities (PECs) database (DEC 2011a) (DEC ref 17-0611EC);
- DEC Threatened (Declared Rare) Flora database (DEC 2011b) (DEC ref 20-0611FL);
- DEC Declared Rare and Priority Flora List (DEC 2011b) (DEC ref 20-0611FL);
- Western Australian Herbarium (WAH) specimen database for Threatened (DRF) and Priority Flora (DEC 2011b) (DEC ref 20-0611FL);
- FloraBase (WAH 2012);
- NatureMap database for all flora species records occurring within the study area (DEC 2011c); and
- International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2011).

Searches of the DEC Threatened Flora database, the WAH Specimen database, and DEC Threatened (Declared Rare) and Priority Flora List were conducted on the 27th of August 2011 to provide information on Threatened (T) and Priority Flora in the study area.

The search co-ordinates (AMG Zone 51K) used were selected at the upper left corner of site Easting 411455.90E / Northing 7612852.05N, and lower right corner of site Easting 436711.84E / Northing 7566521.98N. The search was conducted within a 60km radial buffer around the centre point between the two coordinates provided. As very few Threatened (T)

or Priority Flora records were returned within the 60km radial buffer, on 27th of August 2011 the DEC expanded the search to the entire Great Sandy Desert Bioregion.

4.1.1.2 Previous Flora and Vegetation Reports

All available hardcopy and digital Newcrest reports pertaining to the areas surrounding the study area were sourced from Newcrest. The information in the reports was reviewed and the relevant data extracted (e.g. location of significant flora, introduced flora and types of vegetation communities with relevance to landforms).

Data sourced from the reports together with digital mapping information (orthophotos, land systems map, geology etc.) was used to collect information on location, types and extent of vegetation associations mapped within the vicinity of the study area. The literature review also focussed on identifying previously mapped significant flora and vegetation, including TECs, PECs, Threatened and Priority Flora species as well as significant landforms.

This information was over-laid on digital aerial photography to help guide the identification of vegetation associations, based on the mapping information from previous reports. Boundaries of vegetation associations and the locations of landforms supporting possible Threatened (T) and Priority Flora requiring field verification were delineated on the aerial map prior to the field trip.

4.1.2 Regional Flora and Vegetation Surveys

4.1.2.1 Beard's Mapping

Historically, the flora and vegetation of the Great Sandy Desert and Little Sandy Desert regions have been recorded only at a broad scale (1:1,000,000) in vegetation surveys conducted by Beard (1974) that mapped only major structural vegetation formations. The vegetation units that are broadly applicable to the Telfer region on the basis of Beard's mapping are:

- Grass steppe: *Triodia wiseana* (t_3Hi) and
- Shrub steppe: Mixed shrub steppe between sandhills with *Triodia schinzii (*a_nSr.^t_pHi).

4.1.2.2 National Vegetation Information System

The site was also broadly mapped as part of the National Vegetation Information System (NVIS) using data provided in most part by the Department of Agriculture and Food WA. NVIS information has been compiled to enable Australia-wide analyses of the Major

Vegetation Groups (MVGs) and Major Vegetation Subgroups (MVSs), which are based on the detailed NVIS Level I-VI data (Commonwealth of Australia 2010a). This broad scale mapping was limited to approximately 30 MVGs and 67 MVSs that represent the dominant vegetation in each spatial feature and is available in Present (Extant) and Estimated Pre-1750 vegetation themes. It is important to note that the exact number of Groups and Subgroups varies between different NVIS versions.

The data from NVIS is not appropriate for assessment of regional significance in the Great Sandy Desert or Little Sandy Desert as it is only suitable for data analysis at a national level (DSEWPaC 2011b).

4.1.2.3 WA Biodiversity Audit

In 2001, DEC conducted a biodiversity audit of Western Australia's 53 Biogeographical Subregions (McKenzie *et al*. 2003). According to this audit, the study area occurs in two subregions:

- Mackay (GSD2) subregion; and
- Rudall (LSD1) subregion.

The Mackay (GSD2) subregion was described by Kendrick (2001b) as a mainly tree steppe grading to shrub steppe in the south; comprising open hummock grassland of *Triodia pungens* and *T. schinzii* with scattered trees of *Owenia reticulata* and bloodwood (*Corymbia* spp.), and shrubs of *Acacia* spp., *Grevillea wickhamii* and *G. refracta*. Gently undulating laterised uplands support shrub steppe such as *Acacia pachycarpa* shrublands over *Triodia pungens* hummock grass (Kendrick 2001a).

The Rudall (LSD1) subregion was described by Kendrick (2001b) as typified by sparse shrub-steppe over *Triodia basedowii* on stony hills with River Gum (*Eucalyptus camaldulensis*) communities and bunch grasslands on alluvial deposits in and around ranges. This subregion comprises extensive areas of tussock grasses associated with footslopes and river gum communities along drainage

As part of the vegetation and land use audit Shepherd, *et al*. (2002) classified vegetation occurring in the study area as:

- Vegetation association 134: Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex on sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills. The vegetation assocation covers an area of 28,339,332ha in extent of which 100% remains, with 3.3% in conservation reserves; and

- Vegetation association 157: Hummock grasslands, grass steppe; hard spinifex, *Triodia wiseana*. The vegetation association covers an area of 542,861ha of which 100% remains, with 17.6% in conservation reserves.

Kendrick (2001b) listed Vegetation association 134 as being of low reservation priority in the Great Sandy Desert and a high reservation priority in the Little Sandy Desert. Kendrick (2001a) listed Vegetation association 157 as being of medium reservation priority in the Little Sandy Desert.

This dataset is congruent with mapping by Beard and is used to describe the status and distribution of vegetation in relation to boundaries of natural resource areas (e.g. mining and pastoral leases). The extent of each vegetation association is shown in Figure 6.



Figure 6 Pre-European Extent of Vegetation Associations

4.1.3 Local Vegetation Surveys

The only local vegetation surveys to date have been conducted for environmental approvals at Telfer, the nearby Birla Nifty Copper Mine (Nifty) 67km west of Telfer and Kintyre Uranium Project, 80km south of Telfer.

Surveys relevant to the current study (in chronological order) are:

- Hart, Simpson and Associates Pty Ltd (1997) Telfer Minesite. Topsoil Areas Flora and Vegetation. Report Prepared for Newcrest Mining Limited.
- Hart, Simpson and Associates Pty Ltd (2000) Telfer Satellite Pits, Access and Water Release Area. Ecological Survey. Report Prepared for Newcrest Mining Limited.
- Hart, Simpson and Associates Pty Ltd (2002) Telfer Project Ecological Survey. Report Prepared for Newcrest Mining Limited.
- Ecologia (2003) Telfer Project-Power Supply and Infrastructure Corridor Rare and Priority Fauna and Flora Survey. Report Prepared for Newcrest Mining Limited.
- Syrinx Environmental PL (2004a) Vegetation and Fauna Survey: Proposed Freedom Road Bypass EIA. Report Prepared for Newcrest Mining Limited.
- Syrinx Environmental PL (2004b) Vegetation and Fauna Survey: Proposed Gas Pipeline Bypass EIA. Report Prepared for Newcrest Mining Limited.
- Martinick Bosch Sell Pty Ltd (2005) Native Vegetation Management Plan. Prepared for Birla (Nifty) Pty Ltd.
- Martinick Bosch Sell Pty Ltd (2006) Vegetation Survey and Targeted Rare Flora and Fauna Search of the Waste Rock Dump, Airstrip and Heap Leach Pad Extension Areas, Nifty Copper Operations, Western Australia. Prepared for Birla (Nifty) Pty Ltd.
- Syrinx Environmental PL (2006) Telfer Waste Dump Expansion Flora and Fauna Survey. Prepared for Newcrest Mining Limited.
- Syrinx Environmental PL (2007) Borefields Expansion Flora and Fauna Survey. Prepared for Newcrest Mining Limited.
- Bennett Environmental Consulting (2007) Flora and Vegetation Kintyre Leases. August 2007. Report prepared for Cameco Australia.
- Bennett Environmental Consulting (2010) Flora and Vegetation Kintyre Leases. August 2007. Report prepared for Cameco Australia.

Most relevant in terms of proximity to the Optimisation Study Area and currently available information are the adjacent Telfer Waste Dump Expansion survey data (Syrinx Environmental PL, 2006) and Borefields Expansion Survey data (Syrinx Environmental PL

2007). Naming of vegetation associations during the current surveys will be consistent with the vegetation types/associations recorded in these previous reports where possible.

At a regional level, the most relevant studies are:

- The Martinick Bosch Sell Pty Ltd (MBS 2005) vegetation survey at Nifty, 67km west of Telfer. The MBS (2005) report also refers to a Hart, Simpson and Associates (1992) survey of the Nifty area, and although this report was not accessible, it was summarised in MBS (2005).
- Recent surveys for the Kintyre Uranium Project (Bennett Environment Consulting 2007, 2010) 90km south of Telfer. These documents were not available for review, however were summarised in the Environmental Scoping Document for the Project (Environ Australia, 2011).

Nifty Native Vegetation Management Plan (Martinick Bosch Sell Pty Ltd 2005)

The flora and vegetation surveys conducted for the Nifty Copper Mine Native Vegetation Management Plan were conducted for a Purpose Permit to Clear Land under the *Environmental Protection* (*Clearing of Native Vegetation) Regulations* 2004. The survey was conducted for a proposed gas pipeline corridor.

The description of vegetation in the report refers to a Level 1 flora and vegetation survey conducted by MBS (2004, full reference not provided in MBS 2005) and a flora and vegetation survey by Hart, Simpson and Associates (1992). Both surveys were conducted by undertaking vehicle based searches and foot transects (i.e. not plot based). Regular stops were made in the survey area with each vegetation unit traversed by foot with approximately 30 minutes being spent at each site. Dominant species, soil, vegetation structure and indication of vegetation health were recorded at each site.

Four vegetation associations were described with 19 vegetation units. These were

- Sand Dunes (deep sand hills and upper slopes) (3 vegetation units);
- Sandplains (12 vegetation units);
- Shallow sand/laterite plains (3 vegetation units); and
- Plains of shallow sand over exposed calcrete (1 vegetation unit).

The vegetation associations and units were described by landform type rather the vegetation species or structure as is now typically required by EPA Guidance Statement 51 (EPA 2004a).

A total of 89 taxa were recorded and the most common genera was *Acacia* (nine taxa). It should be noted that, as the survey was a Level 1 survey, a comprehensive species list was

not required. *Goodenia hartiana* (P2) was recorded in four vegetation units: grassland, grassy herbland, shrubland and *Triodia* sandplain. It was found predominantly in disturbed areas such as on the edge and middle of the existing track. The report also mentions that *Goodenia hartiana* was recorded by Ecologia (2003) in the swales east of Mt Cecilia and along Telfer Road

The vegetation units were dominated by *Triodia* species, typically *Triodia basedowii* on the sandplains and *Triodia schinzii* in deep sand and on sand dunes. Occasional shrub species recorded across the vegetation units included *Acacia translucens*, *Calytrix carinata*, *Gompholobium polyzygum, Jacksonia aculeata* and *Mirbelia viminalis*. Typical grasses were *Aristida holathera* and *Eragrostis eriopoda.* Tall shrub species included *Acacia ancistrocarpa, Grevillea eriostachya, G. stenobotrya* and *G. wickhamii.* Emergent species included *Corymbia opaca*, *Eucalyptus victrix* and *E. kingsmillii*.

The *Goodenia hartiana* records described in the report are not vouchered in the Department of Environment and Conservation (DEC) or Western Australian Herbarium (WAH) databases.

No assessment was made of the survey results in a regional context.

Kintyre Uranium Project Flora and Vegetation Surveys (Bennett Environmental Consulting 2007 and 2010)

The 2007 survey was limited to proposed drill areas, while the 2010 survey covered the entire Kintyre Project lease area of 5,200ha to meet the requirements of a Level 2 survey under EPA Guidance No. 51 (EPA 2004a). Further survey work was proposed for May 2011 including investigations into the potential groundwater dependent vegetation. The report is yet to be published and will be part of the Environment Review and Management Plan of the Kintyre project when submitted to the EPA. However the results to date were summarised in the Environmental Scoping Document (Environ Australia 2011) and are described below.

The key vegetation units identified (based on previous mapping by Hart, Simpson and Associates (1994) were:

- Mixed low shrubs over the hard spinifex *Triodia basedowii*;
- *Acacia ancistrocarpa* and *A. ligulata* over the hard spinifex *Triodia basedowii*;
- Hard spinifex *Triodia wiseana*;
- Sand dunes;
- *Senna* spp. over grass; and
- Sparse shrubs over the hard spinifex *Triodia basedowii*.

Within these key vegetation units a total of 34 vegetation units were recorded during the 2007 and 2010 surveys and were grouped according to the following landforms: hillsides, base of hills, sand dunes, flat red sandy soils, lower slopes above creek, creek lines and claypans.

Eucalyptus leucophloia was only recorded on a few hillslopes and was not a common taxon. Mulga shrubland (*Acacia aneura* species complex) was mapped in a very small area on the vegetation map in Environ Australia (2011) however no description of it, or discussion of its significance, was made in the text.

One plant of a Priority 3 taxon, *Comesperma pallidum (*Polygalaceae), was recorded in 2007, but none were located in the 2010 survey.

A total of 48 vascular plant families, 149 genera and 323 taxa were recorded during the 2010 survey. Poaceae and Fabaceae were the dominant families with 32 and 16 genera, and 60 and 59 taxa respectively. The other dominant family was Malvaceae with 10 genera and 38 taxa. No species list was provided in Environ Australia Pty Ltd (2011).

Five introduced taxa were recorded including *Cenchrus ciliaris* (Buffel Grass), *Aerva javanica* (Kapok), *Bidens bipinnata* (Beggars Ticks), *Cucumis melo* subsp. *agrestis* (melon) and *Citrullus lanatus*. Most introduced taxa occurred in the drainage lines of the site and around disturbed areas.

Seven vegetation units were identified as being potentially groundwater dependent:

- Minor drainage line with Woodland of *Corymbia opaca*;
- River channels with Woodland of *Eucalyptus camaldulensis*;
- Chenopod Dwarf Scrub on low lying areas adjacent to claypans;
- Open Grassland of *Xerochloa laniflora* and *Dactyloctenium radulans* on claypans;
- Low Open Forest of *Acacia aneura* subsp. *macrocarpa* on lower slopes above creek;
- Low Open Woodland of *Eucalyptus odontocarpa* on lower slope above creek; and
- Low Shrubland of *Eremophila tietkensii* at the base of hills within the White Quartzite Scree Complex.

Report for Waste Dump Expansion Survey (Syrinx Environmental PL 2006)

The waste dump expansion survey was conducted immediately adjacent to the north and south of existing Telfer operations. It is within the Optimisation Study Area which is the subject of this current work and covers an area of 510ha.

The Level 2 flora and vegetation survey was conducted in 2006 by undertaking walking transects across the study area and establishing six 50 x 50m quadrats. The vegetation survey identified three broad landform units during the survey. These were:

- Sandplain (Dune Swales) (three vegetation types);
- Rocky Outcrop (two vegetation types); and
- Dune Crest and Slope (one vegetation type).

The vegetation types were dominated by scattered trees (*Corymbia* spp.) and/or *Acacia* shrubs over *Triodia basedowii*. On rocky slopes *Triodia schinzii* was the dominant understorey species.

A total of 104 taxa were recorded during this survey. When combined with the Hart, Simpson and Associates (2002) data the combined number of taxa found within the entire waste dump expansion area was 277 taxa. The only Priority Flora species recorded was *Goodenia hartiana* (P2).

The landform units were considered common regionally in the eastern Pilbara and Great Sandy Desert. The vegetation types present were closely related to the landform types. All vegetation types are common regionally, although an unusual plant assemblage was recorded on the dune crest.

Report for the Borefields Expansion (Syrinx Environmental PL 2007)

The Borefields Expansion survey was conducted immediately adjacent to the east and southwest of existing Telfer operations. It is within the Optimisation Study Area which is the subject of this current work and covered an area of 2,073ha.

The Level 2 flora and vegetation survey was conducted in 2006 by undertaking walking transects across the study area and establishing eighteen 50 x 50m quadrats. The vegetation survey identified three broad landform units during the survey.

A total of 112 taxa were recorded during this survey. The Priority Flora species recorded were *Goodenia hartiana* (P2) and potentially *Dampiera atriplicina* (insufficient material to determine identification).

The vegetation survey identified three broad landform units during the survey. These were:

- Sandplain (Swales) (nine vegetation types);
- Dune Crest and Slope (three vegetation types); and
- Rocky Outcrop (five vegetation types).

These landform units are common regionally in the eastern Pilbara and Great Sandy Desert. A modified landform of topsoil stockpiles was also located within the survey area. All vegetation types were common regionally except the following vegetation types, which were uncommon both in the study area and regionally:

- *Acacia aneura* and *Eremophila tietkensii* low open Shrubland over *Triodia basedowii* grassland; and
- *Eucalyptus leucophloia* subsp. *leucophloia* / *Corymbia candida* subsp. *dipsodes* Tall Woodland over *Acacia monticola* over mixed grass species.

A short summary of other studies in the area surrounding the site are provided in the summary table on the next page (Table 1).

Table 1 Summary of previous flora and vegetation surveys within the vicinity of Telfer

Report	Proximity to Study Area	Survey Technique + Time of Survey	Vegetation Associations + Landforms	Floristic Composition	Significant Flora	Completed to EPA Guidance Statement Requirements
Hart, Simpson and Associates Pty Ltd (1997) Telfer Minesite. Topsoil Areas Flora and Vegetation Report	Approximately 5km	Recorded by extensive traverses on foot. Completed in October 1997	Vegetation Associations are not specified	A total of 110 taxa from 61 genera and 33 families. Fabaceae (12 taxa); Goodeniaceae (10 taxa); and Poaceae (9 taxa)	No Threatened Flora (T) recorded No Priority Flora recorded	Yes – partially, one season survey, not plot based Conducted prior to EPA Guidance being released
Hart, Simpson and Associates Pty Ltd (2000) Telfer Satellite Pits, Access and Water Release Area. Ecological Survey	Approximately 40km east of study area	Opportunistic observation; Fauna and Flora collections during vehicle and foot traverses. Completed April 2000	Land forms consisted of flat sandplains, low stony rises, and sheet flow. Associations not recorded	A total of 169 taxa spread over 93 genera and 41 families. The dominant families being Fabaceae (28 taxa), Poaceae (23 taxa), Myrtaceae (10 taxa), and Amaranthaceae (9 taxa) High number of *Eucalyptus victrix* found in low – lying areas	No Threatened Flora (T) recorded No Priority Flora recorded	Yes – partially, one season survey, not plot based Conducted prior to EPA Guidance being released
Hart, Simpson and Associates Pty Ltd (2002) Telfer Project Ecological Survey. Report Prepared for Newcrest Mining Limited	Multiple survey locations: the closest is approximately 5km South East from the study area, the furthest is approximately 20 km from the study area	Opportunistic observation; Fauna and Flora collections during vehicle and foot traverses. Completed May of 1999; May and June 2001	Vegetation communities were identified as: Sandplain; Sandplain with gravel; Sand dunes; Stony hills; White quartzite scree slopes; Clayey areas; *Acacia wanyu* on clayey sand	Total flora recorded = 249 taxa in 142 genera and 49 families. Dominants were: Poaceae (34 taxa), Fabaceae (20 taxa), Chenopodiaceae (19 taxa) High number of *Eucalyptus victrix* found in low – lying areas	No Threatened Flora (T) recorded *Goodenia hartiana* (P2) occurred in small numbers in the mine and in the Freedom Rd Borefield *Fuirena incrassata* (P3) found in small numbers in a low-lying site in the Freedom Rd borefield	Yes – partially, one season survey, not plot based. Conducted prior to EPA Guidance being released

Report	Proximity to Study Area	Survey Technique + Time of Survey	Vegetation Associations + Landforms	Floristic Composition	Significant Flora	Completed to EPA Guidance Statement Requirements
Ecologia (2003) Telfer Project- Power Supply and Infrastructure Corridor Rare and Priority Fauna and Flora Survey	Along pipeline corridor (440km in length) from Port Hedland to Telfer	Three stage survey, during July and August 2004, combining intensive searches, driving along the alignment and spot checks in different vegetation communities	The associations are not comprehensively presented in this report but it is suggested to use Hart, Simpson and Associates (2002)	Total of 348 taxa from 59 families and 150 genera. Dominant families consist of Fabaceae (72) and Poaceae (37 taxa)	*Goodenia hartiana* (P2) occurred sporadically in medium densities along the alignment between chainages KP177 and KP373 *Dampiera atriplicina* (P2) occurs at the base, sides and crests of red sand dunes and sandplains of the Great Sandy Desert (currently listed as P3) *Euphorbia clementii* (P2) one location on a rocky scree slope *Abutilon trudgenii* (P3) occurs sporadically at long densities along road verges (Currently not listed as a Priority Flora) *Acacia glaucocaesia* (P3) occurs on loam floodplain flats of the Strelley and De Grey rivers *Comesperma pallidum* (P3) occurs on the sandy loam interdunal plains of the Great Sandy Desert section of the route	No

Report	Proximity to Study Area	Survey Technique + Time of Survey	Vegetation Associations + Landforms	Floristic Composition	Significant Flora	Completed to EPA Guidance Statement Requirements
Syrinx Environmental PL (2004a) Vegetation and Fauna Survey: Proposed Freedom Road Bypass EIA. Report	Approximately 40km west of study area	Point transect method along proposed bypass. Completed April 2004	Seven vegetation assemblages, including two wetlands, two dune swale, one dune slope, two dune crest vegetation assemblages. The wetland assemblages were: 1. Open *shrubland* of *Melaleuca glomerata;* and 2. Low shrubland of *Melaleuca glomerata* and *Acacia translucens* over *Triodia lanigera*	A total of 70 taxa representing 20 families with the dominant families being Poaceae (12 taxa), Myrtaceae (seven taxa) and Fabaceae (six taxa) No weed species were recorded	No Threatened Flora (T) recorded *Goodenia hartiana* (P2) was locally abundant through a 3km section of the study area	Yes – partially, one season survey, not plot based Conducted prior to EPA Guidance being released
Martinick Bosch Sell Pty Ltd (2006) Vegetation Survey and Targeted Rare Flora and Fauna Search of the Waste Rock Dump, Airstrip and Leach Pad Extension Areas, Nifty Copper Operations, Western Australia	70km west of Telfer	Four survey areas, systematically walked by at least four people with two to four hours spent at each site, Completed late October 2005	Three vegetation associations: 1. Sand dunes (1 vegetation unit) 2. Sandplains/swale (4 vegetation units) 3. Shallow sand/gravelly plains (1 vegetation unit) One of the sandplain vegetation units T*riodia*/*Acacia translucens*/*Melaleuca glomerata* Plain is described as having *Melaleuca glomerata* which becomes denser in areas prone to inundation. The overstorey is predominantly scattered *Eucalyptus victrix*	Not mentioned in report and no species list provided	No significant flora found	Completed to Level 1 survey requirements although the naming of vegetation units is not consistent with NVIS naming standards

4.1.4 Potential Flora and Vegetation of Conservation Significance

4.1.4.1 Threatened Flora (T)

Conservation significant flora species are classified as Threatened Flora (T) or Priority Flora. These flora have populations that are either geographically restricted, threatened by local processes or both.

Prior to August 2010 the highest conservation ranking was termed DRF, referring to Declared Rare Flora and this term has now changed to Threatened Flora (T). The conservation significance remains unchanged.

Threatened Flora (T) are gazetted under the *Wildlife Conservation Act 1950* thereby making it an offence to remove or damage these flora species without Ministerial approval.

Currently there are no Threatened Flora (T) species recorded for the Mackay (GSD1) or Rudall (LSD1) IBRA subregions.

4.1.4.2 Priority Flora

Priority Flora are those flora species that are known from only a few collections, or a few sites, but which have not been adequately surveyed (DEC 2012a). Such flora may be rare or threatened, but cannot be considered for declaration as rare flora until such survey has been undertaken. These flora are included on a supplementary conservation list called the Priority Flora List (DEC 2012a).

There are three categories of Priority Flora covering these poorly known species (Appendix 1). The categories are arranged to give an indication of the priority for undertaking further surveys based on the number of known sites, and the degree of threat to those populations. A fourth category of Priority Flora is included for those species that have been adequately surveyed and are considered to be rare but not currently threatened.

Since February 2012, a fifth category of Priority Flora has been included for those species not considered to be threatened but are subject to a specific conservation program. Therefore, the Priority 5 category had been added subsequent to the database searches completed in June 2011. A search of Florabase (WAH 2012) in October 2012 revealed no Priority 5 flora listed for the Great or Little Sandy Desert Bioregions.

From the database searches and previous surveys conducted in the area, a total of 17 Priority Flora species were identified as potentially occurring in the study area (Table 2 and Table 3). As limited survey data has been collected within the Telfer Region, the DEC

database searches were also extended to the entire Great Sandy Desert Bioregion where an additional 15 species were provided from the DEC database.

The sources of the Priority Flora records were:

- DEC Database search for the study area and within the 60km buffer – two species; plus an additional 15 species outside of the buffer but located within the Great Sandy Desert Bioregion; and
- Western Australian Herbarium (WAH) records and Naturemap searches – one species.

Two of the Priority Flora species found in the database searches have been previously recorded within the Telfer area. These are:

- *Eremophila tenella* (P1) has been found at five locations south of Telfer (Figure 5) on the scree slopes of the Paterson Ranges near Christmas Pool. All populations have been recorded on stony hill sides; and
- *Goodenia hartiana* (P2), which was found during the waste dump expansion survey (Syrinx Environmental PL 2006), was recorded immediately adjacent to the north and south of existing Telfer operations and also the borefields expansion survey (Syrinx Environmental PL 2007) within the Optimisation Project Area. Additional regional surveys were also conducted in 2008 and 2010 (Syrinx Environmental PL 2008, 2010). Goodenia hartiana was also recorded near Nifty Copper Mine along the gas pipeline corridor (MBS 2005), however these collections do not appear in DEC or WAH records. As text in the reports suggest formal notification had been provided to the Department of Conservation and Land Management (now the DEC) it is possible the specimens may have been misidentified as the species are superficially similar to *G. azurea*, another species present in the area.

None of the Priority Flora species listed in the database search or those previously found on site are listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth; EPBC Act).

Location details (coordinates) for all the Priority Flora species recorded (and still current) are provided in Appendix 2 and Table 2.

4.1.4.3 IUCN Threatened flora

The IUCN Red List of Threatened Species is recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species (IUCN 2011). The data set used for the formulation of the Red List, does have however, some important limitations, amongst which is the strong bias towards animals, rather than plants.

The Red List database was queried and one IUCN Threatened Flora was listed for the study area or the surrounding areas.

The species was *Byblis filifolia* (Byblidaceae) and is listed as 'lower risk, least concern'. A taxon is Lower Risk when it has been evaluated and does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable (IUCN 2012). Taxa included in the Lower Risk category can be separated into three subcategories:

- Conservation Dependent (cd). Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years;
- Near Threatened (nt). Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable; and
- Least Concern (lc). Taxa which do not qualify for Conservation Dependent or Near Threatened.

Byblis filifolia was previously recorded in the Borefield Expansion Survey (Syrinx Environmental PL 2007), in a swale area outside of the current survey area. A total of 147 records exist in the WAH database, mainly occurring in the Kimberley, however there have been two previous records in the Telfer region.

Byblis filifolia is not classified as a Threatened (T) or Priority Flora species on the DEC database.

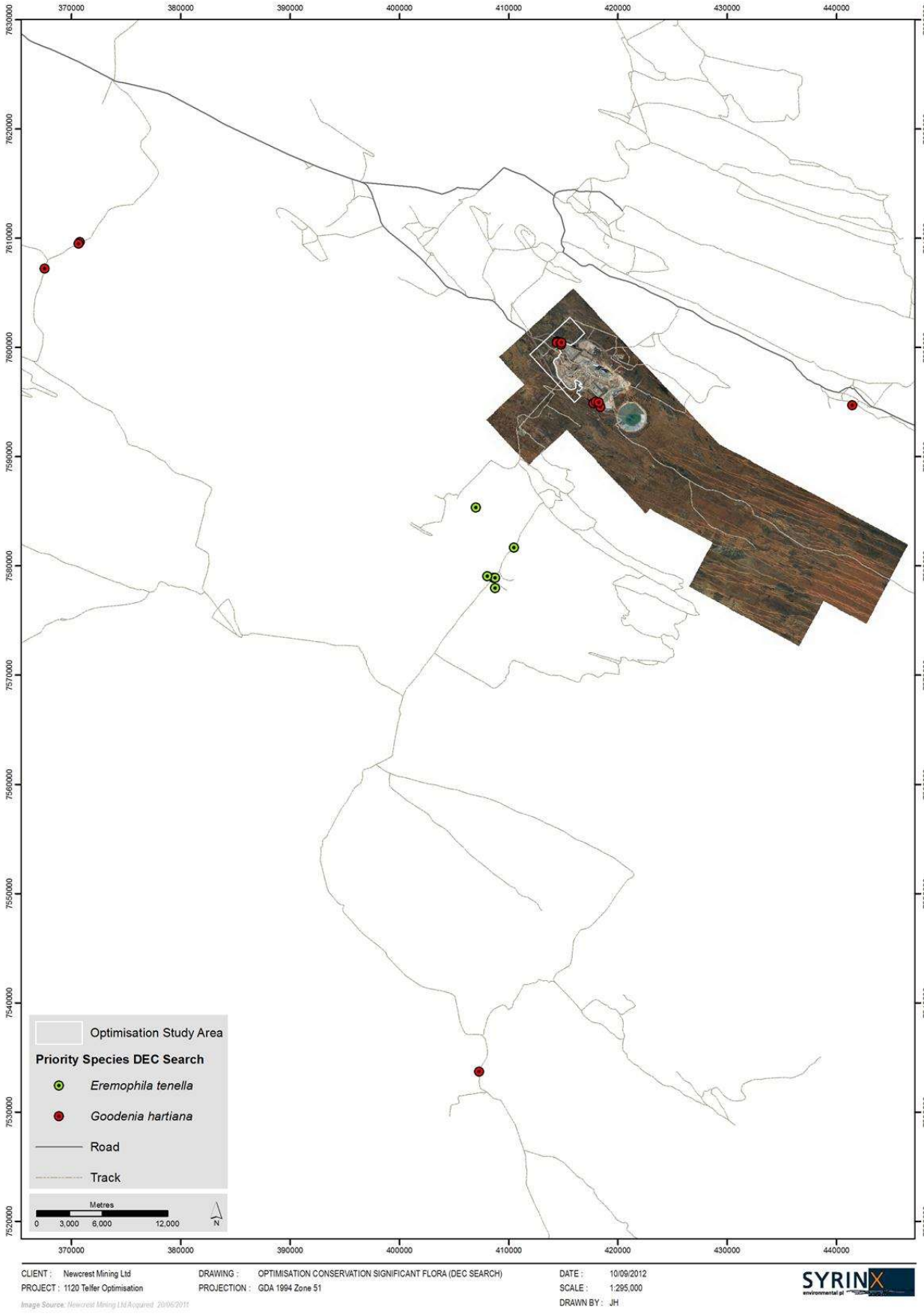


Figure 7 Priority Flora recorded within a 60km buffer from the Optimisation Study Area from DEC and WAH Database Searches

Table 2 Potential Priority Flora in the Telfer Region from the DEC and WAH Databases – species that have been recorded previously within a 60km buffer

Species Name	Plant Description as per *FloraBase*	DEC Status	Habitat Type	Flowering Time	Nearest Location to the Study Site	Approximate Distance from Project Area	Associated Species
Eremophila tenella	Spindly, weeping shrub, 1.8–2.5 m high. Gray Foliage with blue flowers	P1	Slopes of stony hillsides	May/Aug –Sep	Telfer, Paterson Range	2km	*Acacia, Ptilotus, Cassia, Eremophila*
Goodenia hartiana	Perennial herb with viscid stems and leaves, approx 0.5 m high x 0.5 m wide. Flowers purple - blue	P2	Valley of interdunal swales with dry red sand over siltstone and shale. Base of rocky outcrops	Aug.	Rudall River, Telfer, Nifty Copper Mine, Jimblebar, Warrawagine Station.	0km	*Acacia ancistrocarpa, Jacksonia aculeata, Grevillea wickhamii, Aluta maisonneuvei, Scaevola parvifolia,* and *Newcastelia cladotricha*

Table 3 Potential Priority Flora in the Great Sandy Desert Bioregion from the DEC and WAH Databases

Species Name	Plant Description as per *FloraBase*	DEC Status	Habitat Type	Flowering Time	Nearest Location to the Study Site	Approximate Distance from Project Area	Associated Species
Acacia aphanoclada	A wispy, single trunked wattle up to 4m high with a trunk no more than 10cm in diameter. Bark colour, green to reddish/brown. In flower and bud. Globular flower heads, yellow	P1	Skeletal stony soils. Rocky hills, ridges & rises, gentle to steep slopes	Aug-Oct	Nullagine	220km west	*Triodia epactia, T. wiseana, T. longiceps, Indigofera monophylla, Eucalyptus leucophloia, Senna glaucifolia, Fimbristylis elegans, Triodia brizoides, Eriachne mucronata, Corchorus parviflorus, Fimbristylis dichotoma, Cassytha capillaris. Goodenia stobbsiana, G. cusackiana , Dodona coriacea*

Species Name	Plant Description as per *FloraBase*	DEC Status	Habitat Type	Flowering Time	Nearest Location to the Study Site	Approximate Distance from Project Area	Associated Species
Acacia cyperophylla var. *omearana*	Tree, 4–10 m high, up to 6 m across, 'minni-ritchi' bark. Fl. Yellow. Pendulous branchlets and phyllodes	P1	Stony & gritty alluvium. Along drainage lines. River Gravel	Mar–Apr, May	Nullagine	220km west	*Eucalyptus victrix, E. camaldulensis, Acacia tumida, A. eriopoda, Grevillea wickhamii*
Acacia fecunda	Erect, obconic shrub, to 3 m high, bark grey, smooth becoming yellow-brown on upper branches; phyllodes more or less sub-glaucous with a slight sheen; inflorescence of spikes. Flowers yellow. Branchlets dull whitish. Phyllodes wide-spreading, dimidiate and straight to shallowly falcate, dull, green. Pods linear, more or less shallowly raised over seeds and very shallowly constricted between them, dark brown over seeds, lighter brown between seeds. Seeds longitudinal, uniformly dark brown, slightly shiny; aril white	P3	Favors water-gaining sites. Quartzite gibbers over grey-red skeletal soil. Along shallow creeks and drainage lines, hills, road verges. Regenerates from seed following fire. Shallow gully adjacent to low calcrete hill	Apr, May, Aug	Nullagine, Skull Springs, Oakover River	120km west	*Eucalyptus leucophloia, Scaevola acacioides* and *Melaleuca eleuterostachya* over Mid-Dense Hummock Grass of *Triodia longiceps* over Dwarf Scrub C of *Sclerolaena* spp.
Acacia levata	Spreading, multi-stemmed shrub, 1–3 m high, to 5 m wide. Fl. Yellow. Pods pendulous, linear, coarsely longitudinally wrinkled, straw coloured (i.e. brownish yellow), neither constricted between nor raised over seeds. Seeds dull, dark brown, the areole slightly raised; heart shaped and slightly shiny	P3	Sand or sandy loam over granite. Hillslopes	May	Marble Bar, Woodstock H/S, Hillside	260km west	*Acacia stellaticeps, A. orthocarpa,* (weeping form), *A. translucens, Triodia pungens*

Species Name	Plant Description as per *FloraBase*	DEC Status	Habitat Type	Flowering Time	Nearest Location to the Study Site	Approximate Distance from Project Area	Associated Species
Acacia sp. Marble Bar	Shrub, inflorescence in spikes, to 30mm long. Fl. Yellow. Foliage dull green	P1		Sep	Marble Bar	400km west	Unknown
Acacia sp. Nullagine	Erect, spindly shrub, to 3 m high, bark minni-ritchi, grey above, red underneath	P1	Rocky clay. Low-lying areas between rocky hills		Nullagine	220km west	Unknown
Atriplex spinulosa	Monoecious, erect, rounded annual, herb, 0.2 m high. Small weak stemmed ephemeral	P1	On stony pavement (phylite & quartz). slopes of creek, clay flats	No information	Nullagine	100km west	*Triodia longiceps*, *Scaevola acacioides, Goodenia stobbsiana, Petalostylis labicheoides*. Scattered chenopods, *Sclerolaena, Atriplex* and *Maireana*
Gomphrena leptophylla	Prostrate, compact herb 20 cm high x 60 cm wide. Stem leaves acute, mucronate, revolute linear leaves 10-30 mm long x 1-2 mm wide. Flowers white (pink tinge), yellow stamens. Axillary corolla 5 mm long. Cylindrical flower head 20 mm long x 7 mm wide. Bracts incurved	P3	On plains or flats formed from granite. Red loams	May, Sep	Yandeyarra, Nerrima Station, Marble Bar	400km west	Hard hummock grassland of *Triodia longiceps, Eragrostis falcata*
Goodenia sp. East Pilbara	Open, erect annual or biennial, herb, to 0.2 m high. Fl. Yellow	P3	Red-brown clay soil, calcrete pebbles. Low undulating plain, swampy plains	Aug, Sep	Weeli Wolli, Mulga Downs, Nullagine, NW of Newman	200km's west	*Corymbia* and *Eucalyptus*, *Acacia, Gossypium, Ficus* shrubland, *Petalostylis, Dodonaea* shrubland, *Indigofera* sp. and *Triodia pungens*

Species Name	Plant Description as per *FloraBase*	DEC Status	Habitat Type	Flowering Time	Nearest Location to the Study Site	Approximate Distance from Project Area	Associated Species
Goodenia pedicellata	Single-stemmed perennial, herb (with dense, cottony and strigose hairs), to 0.25 m high. Fl. yellow, Jun. Rocky clayey soils. Rocky slopes and crests of small hills	P1	In rocky substrate in exposed areas. Restricted to East facing hillslope	Jun	Nifty Copper Mine	67km west	In sparse shrubland with occasional *Triodia* sp.
Indigofera ammobia	Many-stemmed open and erect shrub, to 0.5 m high and 0.5 m across. Fl. Purple - cream	P3	Red sand. Sand dunes or plains in rangelands	Aug, Sep	Telfer, Great Sandy Desert, Wolfe Creek, shay Gap	70km west	*Triodia* grassland, *Triodia melvillei*
Indigofera ixocarpa	Shrub, to 1 m high. Fl. pink	P2	High in landscape. Skeletal red soils over massive ironstone	Mar, May	Marandoo, Tom Price, Nullagine, Karijini	235km west	*Eucalyptus leucophloia, E. gamophylla* over Open Low Scrub A/B of *Acacia hamersleyensis, A. maitlandii, Petalostylis labicheoides, Triodia wiseana* and *T. basedowii.*
Nicotiana umbratica	Erect, short-lived annual or perennial, herb, 0.3–0.7 m high. Fl. white	P3	Reddish to pink granite range. Shallow sand soil. Pebbly red-brown loam	Apr, Jun	Newman, Karijini N.P., Marble Bar, Woodstock, Abydos	400km west	*Acacia cyperophylla, Triodia*
Pityrodia sp. Marble Bar	Soft, grey woody shrub to 1.5 m high, buds pale pink, borne at the ends of branches. Flowers with pink spots on lower lobe, pink stripes in throat	P1	Base or Middle of very steep slopes. Skeletal brown sandy loam over massive sandstone	Aug	Marble Bar	400km west	Tall shrubland of *Terminalia canescens* and *Acacia tumida* var. *pilbarensis* over hummock grassland of *Triodia longiceps*, with *Eriachne mucronata, Sarcostemma viminale* subsp. *australe*

Species Name	Plant Description as per *FloraBase*	DEC Status	Habitat Type	Flowering Time	Nearest Location to the Study Site	Approximate Distance from Project Area	Associated Species
Tribulus minutus	Prostrate herb, plants villous; leaflet pairs 5-7; petals 2.5-7 mm long; spines on fruit not well-developed	P1	Stony rise; growing on old track clear of Triodia. Calcrete/silcrete limestone; red sand	Sep	Nullagine	170km north-west	Unknown

4.1.4.4 Threatened Ecological Communities

A TEC is defined as a community which is found to fit into one of the following categories: "presumed totally destroyed", "critically endangered", "endangered" or "vulnerable" (DEC 2010). TECs are categorised at both State level and Commonwealth level. The status of the State and Commonwealth community rankings are summarised in Appendix 1.

The EPBC Protected Matters Search Tool (DSEWPaC 2011a) search found no TECs were known to occur within the Great Sandy Desert or Little Sandy Desert bioregions.

Additionally, a search of the DEC TEC database found no TECs are known to occur within the Great Sandy Desert or Little Sandy Desert bioregions (DEC 2011a).

4.1.4.5 Priority Ecological Community

Possible TECs that do not meet survey criteria or that are not adequately defined are added to the PEC list under Priorities 1, 2 and 3 (DEC 2010). PECs are classed at a State level only.

Currently there are no PEC's listed for the Great Sandy Desert or Little Sandy Desert bioregion (DEC 2012b). The nearest PEC to the Optimisation Project Area is PEC 25 'Riparian vegetation including phreatophytic species associated with creeklines and watercourses of the Rudall River'' located in Karlamilyi National Park (formerly Rudall River National Park) 90km south of Telfer.

4.1.4.6 Environmentally Sensitive Areas

A search of the DEC's Native Vegetation Viewer indicated that no Environmentally Sensitive Areas (ESAs) as declared by a Notice under section 51B of the *Environmental Protection Act 1986* (WA) occur within the vicinity of the Optimisation Study Area (DEC 2011d).

4.1.4.7 Ecosystems at Risk

Ecosystems at Risk were identified by Kendrick (2001a, 2001b) as part of a Biodiversity Audit of Western Australia's Biogeographical Subregions. There is currently no legislation covering the conservation of Ecosystems at Risk.

No Ecosystems at Risk as listed by Kendrick (2001a, 2001b) are found within the boundary of the Optimisation Study Area.

4.1.5 Ground and Surface Water Dependent Ecosystems

In the EPA's Bulletin 1059 (2002a) it states that within the Telfer region the groundwater levels are naturally 40-70m below the ground surface therefore it is unlikely there are any groundwater dependent ecosystems as such, although there are surface water dependent species such as *Melaleuca glomerata* and *M. lasiandra* that rely on intermittent surface water and rain generated from cyclones to pond rain water in perched aquifers.

For the purpose of this study the following definitions were used for wetlands and water dependency (Table 4).

Table 4 Definitions of Wetlands and Water Dependency

Term	Definition
Wetlands	The EPA (2004b) defines a wetland according to the RAMSAR definition which is 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 metres' (UNESCO 1971). In Western Australia a geomorphic-hydrologic approach is used to classify inland wetlands, based on their host landform and hydroperiod (Semenuik and Semenuik 2011). The terms groundwater dependent (springs) and perched aquifer dependent (pans) are types of wetlands. These systems can be reliant on either groundwater or surface water.
Groundwater Dependent Ecosystem (GDE)	An ecosystem whose processes are reliant on either the surface or sub-surface presence of groundwater. For a groundwater dependent species, the long-term persistence of the population would need to depend critically on attributes of groundwater. Three classifications of GDE's have been described by (Eamus *et al.* 2006): 1. Aquifer and cave ecosystems where stygofauna reside within the groundwater resource: An example of this is Yanchep Caves, Perth, Western Australia; 2. All ecosystems dependent on the surface expression of groundwater. This includes base flow rivers and streams, wetlands, some floodplains and mound springs. An example of this is the Backwood River, south west Western Australia; and 3. All ecosystems dependent on the subsurface presence of groundwater often accessed via the capillary fringe when roots penetrate this zone. An example of this is the Gnangara Mound, Perth. These systems are reliant on groundwater. Excluded from this definition are perched aquifer wetland systems (Hatton and Evans 1998).
Perched Aquifer Ecosystems (PAE)	These are common perched aquifer wetlands of inland arid zones where low depressions, often lined with clay, act to pond rain water, resulting in perching of water after the wet season (VCSRG 2004). These systems are not connected to the confined aquifers below these ecosystems. These systems are typically reliant on surface run off of meteoric water.

Term	Definition
Sheet flow Dependent Ecosystem	Sheet flow refers to the surface water flow as a thin layer not concentrated in a channel across the ground surface. Mabbutt and Fanning (1987) indicated that sheet flow usually occurs over slopes of 0.2 – 2%.

Wetland Ecosystems

A regional survey was conducted by VCSRG (2000) to identify wetland types in the north-western Great Sandy Desert, identify wetlands of significance and determine the hydrological mechanisms maintaining them. A major part of the work was a desktop study with some field work undertaken to verify aerial photograph patterns. No fieldwork was undertaken within the vicinity of Telfer; however, the classification system used is suitable as a basis for identification of water dependent ecosystems within the project area.

The regional survey by VCSRG (2000) identified the main wetland types in the region to be:

- Seasonally inundated flat – floodplain; and
- Intermittently inundated flat – barlkarra.

More locally the wetlands of the Telfer Region are part of the Kidson Track Suite, present in the linear sand dunes of the inland Great Sandy Desert (VCSRG 2000). Wetlands are formed in the Kidson Suite in two ways: as basin floors proximal to the water table or as perched water basins through accumulation of clays on interdunal swale floors that act to pond and perch meteoric water (VCSRG 2000). These were not identified amongst the wetlands considered significant by VCSRG (2000).

In the Telfer region there are five mechanisms (VCSRG 2000) that can maintain wetlands hydrologically:

- Window to water table (perched aquifer);
- Surface perching of meteoric water (perched aquifer);
- Subsurface perching of meteoric water and runoff (perched aquifer);
- Run-off recharged (perched aquifer and groundwater dependent); and
- Groundwater upwelling (springs) inland (groundwater dependent).

No targeted field surveys for wetlands, including perched aquifers and groundwater dependent ecosystems within or surrounding the Telfer area have been conducted.

In terms of IBRA subregions, the following wetlands have been identified in the Mackay (GSD2) and Rudall (LSD1) subregions (Kendrick 2001a, 2001b):

- Lake Dora (A Wetland of National Significance);
- Minor rockholes of various ranges (Wetlands of subregional significance);
- Minor spring wetlands of Percival Lakes and other lake systems (Wetlands of subregional significance);
- Small permanent wetlands associated with paleo-drainage lines, now occupied by salt lake. These small fresh-water springs and seepages are locally significant water sources (e.g. Percival Lakes, Lake Dora, Joanna Spring); and
- Rudall River draining into Lake Dora, the only example of an arid zone river, with near permanent wetlands along its course.

None of these wetlands occur within the Optimisation Study Area.

Underground waters associated with calcrete deposits along paleo-drainage lines were also identified) as wetlands of subregional significance in Mackay (GSD2; Kendrick 2001a). Given the geology present (see Section 3.2) it is unlikely these wetlands are present in the Optimisation Study Area. Groundwater characteristics in the paleovalley aquifers of this region are currently poorly understood (Magee 2009).

Groundwater Dependent Flora and Vegetation

Eucalyptus victrix has been recorded previously in the Telfer area (Syrinx Environmental PL 2004b; Hart Simpson and Associates 2000) and is a facultative phreatophyte, therefore has been known to use groundwater to satisfy at least some of its water requirements (Eamus 2009).

Most relevant to the study area, 67km west of the study area at Nifty Copper Mine (Nifty) the *E. victrix* present in interdunal swales displayed a spreading, heavily laterised root system, with most major roots extending laterally but within two metres often began to grow downwards, sometimes almost vertically (Grigg 2009). These areas typically displayed an extremely dense gravel layer within 10cm of the surface, which became heavily conglomerated by 50cm impeding manual digging efforts (Grigg 2009); therefore maximum root depth was not recorded. *E. victrix* was recorded in locations at Nifty with brackish groundwater at 5m suggesting that in the desert environment where groundwater is inaccessible, *E. victrix* accesses shallow perched aquifers.

Perched Aquifer Dependent Ecosystems

Melaleuca glomerata - *M. lasiandra* shrublands have been identified as being indicative of calcrete and evaporite surfaces associated with occluded paleo-drainage systems that traverse the Great Sandy Desert (Kendrick 2001a). Both species have been recorded in the

survey area previously (Syrinx Environmental PL 2004a, 2004b, 2007) and at Nifty (MBS 2005).

An ecophysiological study was conducted to determine whether an ecophysiological approach could be used to resolve minesite rehabilitation at Nifty (Grigg 2009), 67km west of Telfer. The benefit of this approach is that it seeks to determine the physiological mechanisms that underlie plant ecological observation (Lambers *et al.* 1998).

This study primarily focused on gaining an understanding of the ecophysiology of plants and soil conditions in the Great Sandy Desert. Plant species assessed included *Acacia ancistrocarpa*, *Corymbia chippendalei*, *Grevillea stenobotrya* and *G. wickhamii,* all of which are species previously recorded within the study area (Syrinx Environmental PL 2004, 2006 and 2007). In low lying areas of some interdunal swales at Nifty small statured *Eucalyptus victrix* and *Melaleuca* species co-occurred on gravelly patches with a brackish water table often within 5m of the surface (Grigg 2009).

Investigations include, plant water relations (leaf gas exchange, leaf water potentials, soil hydraulic conductivity), phenotypic attributes (morphology, hydraulic architecture and anatomy) and plant nutrition. The study demonstrated that many shrubs in the Great Sandy Desert display lateral roots to access nutrients and pulses of water in shallow soil layers and sinker roots to access more reliable, deeply stored moisture (Grigg 2009). Grigg (2009) concluded that soil depth and associated moisture storage are the primary factors determining plant-habitat associations in the desert environment. Grigg (2009) also found dunes provide a greater storage of water and facilitate higher water use further into the dry season. This has implications for perched aquifer water dependent species in the interdunes where a smaller store of water would be present in the dry season and therefore any impacts to perched aquifers would require appropriate management.

Sheet Flow Dependent Vegetation

Mulga vegetation communities existing in slopes of 0.2 – 2% are determined to be sheet flow dependant (Mabbutt and Fanning 1987). The major factors affecting sheet flow (run-off, run-on) are the grade of slope and the length of slope. The slight variation of topography and the slope allows for the formation of water sheet flow and is responsible for maintenance of typical Mulga patterned vegetation through retention of resources (water, soil and nutrients) in the landscape. Interruption to the sheet flow can cause detrimental effects to Mulga due to water and nutrient run-off (Ludwig *et al.* 1997).

Mulga has been identified previously at Telfer (Syrinx Environmental PL 2006). This was identified as meeting the EPA (2004a) regional significance criteria of 'the presence of unusual associations of plants' as it was assessed as being at the northern extent of *Acacia aneura*. Since that time, the Mulga complex has been taxonomically revised and the species

present at Telfer is now recognised as *Acacia pteraneur*a. Although the names have been revised, the Mulga vegetation described in Syrinx Environmental PL (2006) is still likely to be at the northern extent of the range, as the closest records of *A. pteraneura* on Florabase (WAH 2012) are 200km south of Telfer more typically on red-brown clay flats, stony gibber plains, stony quartz plains, low laterite hills and alluvial plains. These landforms are uncommon north of the study area in the Great Sandy Desert.

Studies have been conducted in the Pilbara bioregion where Mulga has been assessed as being sheet flow dependent (Grierson and Page 2010; Grierson *et al.* 2011). No studies have been conducted to determine whether Mulga is sheet flow dependent in the Great Sandy Desert bioregion.

4.1.6 Introduced Flora

Declared Plants are those introduced flora listed under the *Agriculture and Related Resources Protection Act 1976*. Weeds of National Significance (WONS) were identified in 2000 at the Commonwealth level, with a list of 20 species signed off by all states and territories, which were then declared under each State's legislation. The WONS program coordinates the national weed strategy for each WONS species (Commonwealth of Australia 2010b). In late 2010 there was a call for nominations for new WONS species and these are currently being assessed.

A Telfer weed survey conducted by Syrinx Environmental PL (2011a) found a total of 19 weed species, all of which were restricted to areas of mine impact. The species previously recorded by Syrinx Environmental PL, along with their ratings, are listed in Table 5 below.

The most abundant species were *Cenchrus ciliaris* (Buffel Grass) and *Aerva javanica* (Kapok). Two declared weeds have been recorded, which are also WONS; *Tamarix aphylla* (Athel Pine) and *Parkinsonia aculeata* (Parkinsonia).

Table 5 Introduced Species

Weed Species		Rating			
Scientific Name	**Common Name**	**Weed of National Significance**	**Declared Plant Status (DAFWA 2011)**	**Priority Rating (EWSWA (CALM 1999))**	**Site Specific Priority Rating**
Aerva javanica	Kapok Bush	No	Not Declared	High	**2**
Cenchrus ciliaris	Buffel Grass	No	Not Declared	High	**1**
Cenchrus echinatus	Burr Grass	No	Not Declared	Low	**1**
Cenchrus setiger	Birdwood Grass	No	Not Declared	High	**1**
Chloris virgata	Feathertop Rhodes Grass	No	Not Declared	Low	**3**
Citrullus vulgaris	Watermelon	No	Not Declared	Not Available	**3**
Cynodon dactylon	Common Couch	No	Not Declared	Moderate	**2**
Digitaria ciliaris	Summer Grass	No	Not Declared	Low	**3**
Lactuca serriola	Prickly Lettuce	No	Not Declared	Moderate	**4**
Lamarckia aurea	Goldentop Grass	No	Not Declared	Moderate	**4**
Panicum repens	Torpedo Grass	No	Not Declared	Not Available	**4**
Parkinsonia aculeata	Parkinsonia	Yes	Declared - P1 , P2, P4	Moderate	**1**
Portulaca oleracea	Pigweed	No	Not Declared	Not Available	**2**
Rumex crispus	Curly Docks	No	Not Declared	Mild	**2**
Sonchus asper	Prickly Sowthistle	No	Not Declared	Moderate	**3**
Sonchus oleraceus	Common Sowthistle	No	Not Declared	Moderate	**3**

Weed Species		Rating			
Scientific Name	**Common Name**	**Weed of National Significance**	**Declared Plant Status (DAFWA 2011)**	**Priority Rating (EWSWA (CALM 1999))**	**Site Specific Priority Rating**
Stenotaphrum secundatum	Buffalo Grass	No	Not Declared	Moderate	**3**
Tamarix aphylla	Athel Pine	Yes	Declared - P1	Moderate	**1**
Washingtonia sp.	Cotton Palm	No	Not Declared	Mild	**4**

EWSWA - Environmental Weed Strategy for WA

DAFWA - Department of Agriculture and Food WA

Site specific - 1 - Very High, 2 - High, 3 - Moderate, 4 – Low (Syrinx Environmental PL 2011a)

4.2 METHODOLOGY

4.2.1 Floristic Survey

4.2.1.1 Rationale

The survey methodology was based on a Level 2 flora and vegetation survey as outlined in Guidance Statement 51 (EPA 2004a).

The EPA lists the Great Sandy Desert Region as being in Group 4, that is, bioregions where native vegetation is largely contiguous but is generally not used for commercial grazing. In Group 4 the level of surveying is expected to be a Level 2 survey when the scale and the impact of a survey is considered high (EPA 2004a). The Great Sandy Desert region is considered to have species at low/moderate densities (EPA 2004a) and with low landform and habitat heterogeneity, therefore a relatively large plot size is required.

In the Pilbara, a plot size of 50 x 50m at a rate of 1 plot for 100ha is considered suitable to capture data suitable for Level 2 flora and vegetation surveys in areas of low landform and habitat heterogeneity (Syrinx Environmental PL 2011b). As the Study Area is in a transition zone between the Pilbara and the Great Sandy Desert, this approach of plot size and survey intensity is also considered suitable for the Study Area. The 50 x 50m plot size has also been used for previous surveys at Telfer (Syrinx Environmental PL 2006, 2007).

Representatives from Newcrest and Syrinx attended a meeting with the Office of the EPA (OEPA) on the 4th October 2011 to discuss the proposed scope and intensity of survey and the OEPA agreed on the plot size and intensity of the field survey method described below.

4.2.2 Field Survey

4.2.2.1 Survey Team

The survey was conducted with a valid flora license: Flora License No. SL009263. The following staff carried out the required survey activities.

- Field Survey 1 (October 2011): Sandra Dunn (Senior Botanist), Jacqui Purvis (Conservation Biologist), Anita Cole (Conservation Scientist), Annabel Craig (Environmental Officer) and Gabriel Steel (Environmental Officer).
- Field Survey 2 (June 2012): Sandra Dunn (Senior Botanist), Kelli McCreery (Consultant Botanist), Rada Tomanovic (Environmental Scientist) and Gabriel Steel (Environmental Officer).

4.2.2.2 Survey Timing

The field work was conducted over two field surveys.

- Field Survey 1: Five days (16th – 20th October 2011)
    - Despite well above average rainfall in March and April 2011, the timing of the survey allowed for the capture of very few annual grasses and herbs and most were senescent. Nevertheless, the unusually large rainfall period did produce healthy growth and flowering of many perennial species.
- Field Survey 2: Four days (6th – 9th June 2011)
    - The timing allowed for the capture of annual grasses and herbs not collected during the first field survey. Due to below average rainfall the three months prior to the field survey, some annuals had completed flowering and were sterile at the time of collection.

4.2.2.3 Field Survey Method

The study area was traversed by vehicle (restricted to access tracks only) and on foot. Quadrats (50 x 50m) were established in areas that were representative of a vegetation assemblage as determined from aerial photography interpretation at 1:10,000.

Twenty one (21) quadrats were established to survey vegetation in the Optimisation Study Area. All quadrats were permanently marked using wooden stakes located in the north-west corner of the quadrat. These were individually numbered for future reference (e.g. 1120-01). All quadrats were marked out by recording the GPS point in the north west corner of the quadrat using a GPS. The location of all quadrats within the study area is presented in Figure 8.

The following parameters were recorded for each quadrat:

- Person / recorder;
- Date;
- GPS location (UTM GDA94; north-west corner);
- Quadrat dimension;
- Quadrat orientation (90° from base of quadrat, e.g. north-south);
- Slope/aspect;
- Soil colour;
- Vegetation condition;
- List of vascular plants;

- Plant life form (e.g. trees, mallees shrubs, herbs, grass, sedges);
- Vegetation layer/s cover (assigned to a cover class; >70%, 30 – 70%, 10 – 30%, 10-2%, <2%) and height;
- Dominant species exact cover and height;
- Disturbances;
- Broad floristic formations;
- Vegetation association;
- Vegetation sub-association; and
- Photograph of the quadrat taken from the north west corner.

At least one voucher specimen was collected for each species for later identification and verification by a plant taxonomist. Nomenclature and taxonomy follow the conventions currently adopted by the Western Australian Herbarium (WAH 2012).

Any flora not previously collected within the quadrat but encountered during traverses between the quadrats, while still in the same vegetation association, was collected opportunistically.

All species present within each quadrat are presented in Appendix 3



Figure 8 Flora Survey Quadrat Locations

4.2.2.4 Vegetation Association Mapping and Statistical Analysis

The survey methodology was based on a Level 2 flora and vegetation survey as outlined in Guidance Statement 51 (EPA 2004a). Quadrat data as well as field observations were used to delineate vegetation association mapping boundaries. The data was then analysed and the vegetation associations synthesised based on the dominant species and life form of each strata and similarities in environmental attributes, such as soil types and position within the landscape.

Species data was analysed with Primer v6.0 statistical software (Clarke and Gorley 2006) incorporating quadrat data from both surveys (October 2011 and June 2012) conducted in the Optimisation Study Area and the O'Callaghan's Study Area (Syrinx Environmental PL 2012 in draft). Classification of survey sites was determined utilising the hierarchical agglomerative technique, which produces a dendrogram diagram displaying similarity between survey sites (Clarke and Warwick 2001). Cluster analysis of a species similarity matrix is a recognised method for describing species assemblages (i.e. vegetation communities; Clarke and Warwick 2001). This method has also been used recently in Western Australia for classification of vegetation associations (Sandiford and Barrett 2010).

The data matrix of 128 perennial taxa occurring at more than a single site was analysed using classification techniques in PRIMER. Annuals, singletons (taxa occurring at a single survey site) and indeterminant collections were excluded from the analyses. Certain taxa were amalgamated prior to analyses, where subspecies, variants or forms were not identifiable for all specimens. For example, *Eremophila latrobei, E. latrobei* subsp. *glabra* and *E. latrobei* subsp. *latrobei* were amalgamated and analysed as *E. latrobei*. The dissimilarity between sites was determined using the Bray-Curtis measure and the Resemblance routine in PRIMER v6 (Clarke and Gorley 2006). The Bray-Curtis measure is a widely-used assessment of ecological distance, which reflects compositional change (Legendre and Legendre 1998; Anderson and Robinson 2003), providing quantitative output for similarity between samples (Faith *et al.* 1987). The resulting dendrogram provided the framework for the vegetation associations and assigning survey sites to the particular groups (Appendix 4).

The clustering of the quadrats in the dendrogram was allied with particular landforms (i.e. dunes, dune swales and rocky hills) and within particular landforms. For example, multiple dune swales vegetation associations associated with particular substrates, such as a layer of rocky substrate compared to deep sand. This aligned with field observations of vegetation patterns. Clustering on the dendrogram was used to refine the vegetation associations identified during the vegetation survey and to assist in identification of uncommon vegetation types. Field observations are particularly important to describing vegetation associations that are limited in either geographic extent or replication in the data set. Vegetation associations

based on the clustering and field mapping were used for creating the vegetation mapping on the 1: 10,000 colour aerial photographs across the entire Telfer Optimisation Project Area (of which the Optimisation Study Area is a portion).

Vegetation mapping was undertaken using ArcGIS 10 and orthorectified digital aerial imagery supplied by Newcrest. For areas not traversed on foot, the vegetation associations were extrapolated using aerial photography and the knowledge of the landforms and vegetation associations gained during the survey. Vegetation association boundaries are not always discrete. Therefore, where mosaics of different vegetation associations occurred, often occurring as small scale patches (e.g. 5 x 5 m), the area was mapped as the predominant vegetation community.

There are low numbers of replication of plots across several vegetation associations, due to limited distribution within the Optimisation Study Area. Furthermore, there is a lack of plot-based data available for the region; thus limiting the scope of interpretation of the results. The results of the statistical analysis can only be interpreted within the context of the study area and not within a broader regional or bioregional framework (i.e. how widespread or restricted a particular vegetation association exists outside the study area).

Data analyses did not incorporate data collected from previous surveys located beyond the boundary of the Optimisation Study Area. The only plot based data relevant for regional analysis has been recently completed field surveys by Bennett Environmental Consulting (2010) for the Kintyre project 90km south of the Optimisation Study Area, but the data had not been published at the time of data analysis. Therefore, the analysis of regional significance is based on a qualitative comparison of vegetation assemblages described for the surrounding areas.

Once the vegetation associations were determined, they were checked against the listing of Federal and State TECs and State PECs. The vegetation associations were also checked against regional databases, such as Beard (1974) and Shepherd *et al.* (2002) to determine their regional representation.

4.2.2.5 Vegetation Association Nomenclature and Scale

The nomenclature and scale was defined as a unit equivalent to the NVIS (National Vegetation Information System) Level 5 (Association) which records the dominant growth form, cover, height and dominant genus and species for each of the three traditional strata. (i.e. Upper, Mid and Ground; Commonwealth of Australia 2010a).

Vegetation classifications were based on the classifications used for the Pilbara based on Specht (1970) with modification by Aplin (1979) and Trudgen (2002) based on the height and foliar cover of each strata (Table 6). This classification was used to allow species with cover

of less than two percent to be considered as it allows for the low cover of many strata in the vegetation of more arid area (Trudgen 2002).

Table 6 Vegetation Classifications

Height Class	Canopy Cover				
	100 – 70%	70-30%	30 – 10%	10 – 2%	<2%
Trees >30m	High Closed Forest	High Open Forest	High Woodland	High Open Woodland	Scattered Tall Trees
Trees 10 – 30m	Closed Forest	Open Forest	Woodland	Open Woodland	Scattered Trees
Trees < 10m	Low Closed Woodland	Low Open Forest	Low Woodland	Low Open Woodland	Scattered Low Trees
Mallee	Closed Mallee	Mallee	Open Mallee	Very Open Mallee	Scattered Mallees
Shrubs >2m	Closed Scrub	Open Scrub	High Shrubland	High Open Shrubland	Scattered Tall Shrubs
Shrubs 1-2m	Closed Heath	Open Heath	Shrubland	Open Shrubland	Scattered Shrubs
Shrubs <1m	Low Closed Heath	Low Open Heath	Low Shrubland	Low Open Shrubland	Low Scattered
Hummock Grass	Closed Hummock	Hummock Grassland	Open Hummock	Very Open Hummock	Scattered Hummock
Tussock Grass	Closed Tussock	Tussock Grassland	Open Tussock	Very Open Tussock	Scattered Tussock
Bunch Grass	Closed Bunch	Bunch Grassland	Open Bunch	Very Open Bunch	Scattered Bunch
Sedges	Closed Sedges	Sedges	Open Sedges	Very Open Sedges	Scattered Sedges
Herbs	Closed Herbs	Herbs	Open Herbs	Very Open Herbs	Scattered Herbs

4.2.2.6 Vegetation Condition

Condition of vegetation within the study area was assessed in accordance with the Government of Western Australia (2000) Bush Forever Volume 2 (Table 7).

Table 7 Vegetation Condition Scale

Vegetation Condition	Description
(1) Pristine	Pristine or nearly so, no obvious signs of disturbance
(2) Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non- aggressive species
(3) Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing
(4) Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing
(5) Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing
(6) Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs

4.2.2.7 Survey for Flora of Conservation Significance

Prior to fieldwork, Florabase records were accessed to provide detail of associated species and habitat types for all flora of conservation significance that had been identified during desktop study to have a potential to occur on the study area. A visit to the Western Australian Herbarium (WAH) was undertaken to familiarise team members with the key identifying features of Priority Flora. Aerial photography interpretation was undertaken to identify areas of major landforms to target during the survey, taking into account the knowledge gained from the desktop study.

During the September 2011 and June 2012 survey periods, potential habitats for conservation significant flora were traversed on foot.

Where flora specimens indicative of the Priority flora were located, the GPS position and photograph were taken and population counts conducted. Voucher specimens of the species were also collected in anticipation of them being lodged with the WAH.

4.2.2.8 Plant Identification

Common species known to the survey team were identified in the field with a single collection of the specimen taken. Voucher specimens of the remaining flora were collected and tagged with a unique number for ease of recording and tracking data.

The plant specimens were pressed prior to drying for 48 hours and then sorted for identification at the WAH where verifications were provided by Consultant Botanists Sharnya Thomson and WAH botanist Mike Hislop. Nomenclature was checked against the current listing of scientific names recognised by Florabase (WAH 2012).

A list of all species recorded within the Optimisation Study Area can be found in Appendix 6.

4.2.2.9 Water Dependent Ecosystems

Prior to fieldwork, aerial photography was utilised to identify potential sites to undertake an assessment and associated targeted survey of groundwater and perched aquifer water dependent species, which included drainage areas. Targeted species included species recorded previously in the region including *Eucalyptus victrix, Melaleuca lasiandra* and *M. glomerata*.

Utilising the existing hydrogeological data provided by Newcrest for Telfer, an initial assessment of vegetation associations containing groundwater or perched aquifer water dependent species was undertaken during the first survey in October 2011, when the survey sites were at their driest.

From the vegetation associations mapped, those that contained groundwater or perched aquifer water dependent species were identified and mapped. This was overlayed with the hydrogeological data provided by Newcrest to gain an understanding of the distribution of groundwater or perched aquifer water dependent species.

A literature review was undertaken of current information for all groundwater or perched aquifer water dependent species identified in the field to assess their dependence on ground or surface water.

4.2.3 Flora and Vegetation Survey Limitations and Constraints

There are a number of factors that can impact of the results of a flora and vegetation survey. The EPA (2004a) provides a list of possible limitations and constraints that can impact on the adequacy of flora surveys. These are listed in Table 8 with an assessment against the survey conducted for this project.

Table 8 Summary of Potential Flora and Vegetation Survey Constraints

Aspect	Constraint	Comment
Competency/ Experience of consultants	No	The team leader of the field team has seven years experience in flora and vegetation surveys of the Great Sandy Desert, and 12 years across Western Australia. One additional team member has over 15 years experience across Western Australia, mostly in the Pilbara. Two additional team members have 5 years experience across Western Australia. The consultant botanist who identified the samples post-fieldwork has 8 years experience in the identification of Pilbara and Kimberley flora. As there have been very few surveys in the Great Sandy Desert, very few botanists have a significant amount of experience for that bioregion.
Scope	No	The scope was clearly defined to ensure the survey could be used for assessing impact of the proposed expansion on flora and vegetation of the project area.
Proportion of flora identified	No	No identification process is 100% accurate. This is due to a number of factors, including how relatively unresolved the WA flora is. Taking into account the experience of the botanists completing the identifications, it is estimated there would normally be an approximate accuracy of 90%. Some specimens collected were lacking fully developed vegetative parts and fruits or flowers. This meant that identification to species and in some cases genus level was not possible. All dominant species were identified; therefore the naming of all vegetation associations is completed.
Information sources (e.g. historic or recent)	Yes	No regional and very limited local studies (<5) had been conducted previously in a 50km radius of the study area. The OEPA recognised there is very limited existing flora and vegetation information from the Telfer region and therefore requires a description of vegetation in a local context, and contextualised. All relevant information sources were accessed and used in the literature review at the time of reporting.

Aspect	Constraint	Comment
Proportion of task achieved, and further work which may be needed	No	All potential habitats for *Goodenia hartiana* have been foot traversed, at least partially. When *Goodenia hartiana* was observed in a habitat with wide distribution (such as a recently burnt sandy dune swale) then the occurrence was extrapolated to include all area of that habitat. All vegetation associations were ground-truthed and had at least two plots located in each vegetation association with only relatively small associations (i.e. less than 80 hectares (ha)) having only one plot.
Timing / weather / season / cycle	Yes (minor)	February to April 2011 preceding the first survey had received above mean rainfall which had followed a year of below average rainfall. October 2011 - January 2012 received well above mean rainfall, but this was followed with 4 months of well below mean rainfall prior to the second field survey. Whilst most of the annual grasses were still identifiable at the time of both field surveys, many were senescent resulting in a decreased quality of specimens collected for identification.
Disturbances	Yes	Tracks were present throughout the study area. Areas in the central portion of the Optimisation Study Area are the remains of evaporation ponds. A total of 5.28% of the Optimisation Study Area were characterised by a loss of vegetation structure, in particular loss of the ground layer due to impacts such as construction of evaporation ponds or borrow pits.
Intensity	No	Survey intensity was consistent with a Level 2 survey.
Completeness	No	The survey is considered complete as all vegetation associations were able to be identified, and greater the 80% of species identified.
Resources	No	Resources were adequate to conduct the survey satisfactorily.
Remoteness / access problems	No	The Optimisation Study Area covers 1237ha. Access to the south western half of the study area was limited as there was no vehicle access. This area was accessed in most part on foot somewhat limiting number of quadrats in the area. Access to the remaining areas was available with one well defined road and several well defined tracks within the study area.
Availability of contextual information	Yes	Information was available for the Shepherd *et al.* (2002) vegetation types in WA, extent type and status, FloraBase, DEC lists, and Bureau of Meteorology (2012). Compared to other areas of WA, such as the Pilbara where, for instance, where NVIS and Van Vreeswyk *et al.* (2004) data is also available, data was limited for the Telfer region.

4.3 FLORA AND VEGETATION RESULTS

4.3.1 Vegetation Association General Description

Based on a combination of the cluster diagram and field observations, 12 vegetation associations were mapped in the Optimisation Study Area (Figure 10 and Figure 9) and these fall into six broad floristic groups (Appendix 4). Descriptions of each of the associations and the broad floristic group to which they belong are detailed in Table 9 and Appendix 5.

Seven landforms were identified in the Optimisation Study Area. The proportion of the study area and the number of vegetation associations for each landform were:

- rocky hill swales (55.03% of the study area with three vegetation associations);
- dune swales (11.19% with two vegetation associations);
- ironstone rocky hill (8.81% of the study area with two vegetation associations);
- scree plain (4.88% with one vegetation association);
- drainage channel (3.49% with one vegetation association);
- dunes (1.9% of the study area with two vegetation associations); and
- siltstone rocky hill (1.81% with one vegetation association).

One vegetation association, mapped in Figure 9, but not described below, consisted of scattered trees and shrubs (5.28% of the Optimisation Study Area). These areas were characterised by a loss of vegetation structure, in particular loss of the ground layer due to impacts such as construction of evaporation ponds or borrow pits. Due to the loss of vegetation structure, these areas were unable to be assigned a Vegetation Association name similar to the remaining study area. The remaining 8.45% of the Optimisation Study Area consists of roads and infrastructure.

It should be noted that, as discussed in the methodology, the number of quadrats per vegetation association area also includes quadrats located in the adjacent study areas for the Telfer Optimisation Project Area (Syrinx Environmental PL, 2012 in draft); therefore where vegetation associations have multiple quadrats across study areas, these are shown in Table 9.

Table 9 Broad Floristic Groups and Vegetation Associations

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater, Perched Aquifer or Sheet flow Dependent Vegetation	Restricted Distribution (<5% of survey area)	Other Locations Recorded	Unique and Distinct Vegetation Association
***Corymbia* Open Woodland**								
1a	*Corymbia opaca* Open Woodland over *Acacia ancistrocarpa, A. stipuligera* and *A. monticola* Open Shrubland over *Aristida inaequiglumis*, *Eulalia aurea* and *Paraneurachne muelleri* Closed Grassland over *Triodia schinzii* Very Open Tussock Grassland	5.18 (3) (43 in O'Callaghan's Study Area)	Drainage Channel	Range extensions – *Scleroleana minuta* and *Synaptantha tillaeacea* var. *tillaeacea*	No	Yes, however this VA would be present at the base of the many large rocky outcrops south and west of the study area	Type 9: *Corymbia opaca*, *C. candida* subsp. *dipsodes* woodland over *Acacia monticola* tall open shrubland over mixed grassland (Syrinx Environmental PL 2007); Sandplain – areas of dense *Acacia stipuligera* thickets (Hart, Simpson and Associates 2002); and N: Complexes, Drainage lines of Acacia and other shrubs over the soft spinifex Triodia pungens (Bennett Environmental Consulting 2010).	No
1b	*Corymbia opaca* and *Eucalyptus leucophloia* Open Woodland over Scattered *Eucalyptus kingsmillii* over Tall Shrubs of *Grevillea stenobotrya* and *Hakea lorea* over Low Scattered Shrubs of *Acacia stellaticeps, Dicrastylis cordifolia* and *Jacksonia aculeata* over *Triodia basedowii* complex Hummock Grassland	115.65 (1) (126.67 (5) in O'Callaghan's Study Area)	Rocky Hill Swale	*Goodenia hartiana* in this VA in the O'Callaghan's Study Area	No	No, typical of long unburnt rocky hill swales in the region	Sandplain - Variation 5: typical species are *Eucalyptus victrix, Corymbia opaca, Acacia ancistrocarpa, A. eriopoda* and *Triodia basedowii* (Hart, Simpson and Associates 2002).	No

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater, Perched Aquifer or Sheet flow Dependent Vegetation	Restricted Distribution (<5% of survey area)	Other Locations Recorded	Unique and Distinct Vegetation Association
***Acacia* High Shrubland**								
3a	*Acacia pteraneura* High Shrubland over *Acacia wanyu, Anthobolus leptomerioides* and *Psydrax latifolia Shrubland* over *Eremophila tietkensii and E. latrobei* subsp. *latrobei* Low Open Shrubland over *Triodia basedowii* Open Hummock Grassland	60.21(2)	Scree Plain between rocky hills	Range Extensions - *Acacia pteraneura* and *Maireana triptera* Species restricted to the vegetation association: *Acacia pteraneura, Evolvulus alsinoides* var. *villosicalyx, Psydrax latifolia, Ptilotus obovatus* and *Sida fibulifera*	Potentially sheet flow dependent. Further investigation required	Yes	This vegetation association was recorded in the Telfer Borefield Flora and Fauna Survey (Syrinx Environmental PL 2007) at the same location and was named; *Acacia aneura* and *Eremophila tietkensii* low open shrubland over *Triodia basedowii* grassland. R:Shrublands, Mulga shrubland (Bennett Environmental Consulting 2010)	Yes
Mixed High Shrubland								
4a	Scattered Trees of *Corymbia candida* subsp. *dipsodes* and *C. opaca* over Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia ancistrocarpa* and *Grevillea eriostachya* High Shrubland over *Triodia basedowii* Closed Hummock Grassland over *Amphipogon caricinus* var. *caricinus* very open grassland	116.66 (1) (301.82 (1) in the O'Callaghan's Study Area)	Dune Swale	Nil	No	No, typical of long unburnt dune swales in the region	Vegetation Type 1: Mixed Acacia's over *Triodia basedowii* (Syrinx Environmental PL 2006); Sandplain Variation 1 (Hart, Simpson and Associates 2002); Type 5: Scattered *Eucalyptus kingsmillii* subsp. *kingsmillii* and/or *Corymbia opaca* over *Acacia stipuligera* open shrubland over *Acacia stellaticeps* low open shrubland over *Triodia basedowii* grassland, (Syrinx Environmental PL 2007); and F8: Shrub steppes, *Grevillea* and *Acacia* shrubs over mixed spinifex on sand (Bennett Environmental Consulting 2010)	No

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater, Perched Aquifer or Sheet flow Dependent Vegetation	Restricted Distribution (<5% of survey area)	Other Locations Recorded	Unique and Distinct Vegetation Association
4b	Scattered Trees of *Corymbia opaca* over scattered *Grevillea wickhamii* subsp. *hispidula* and *Anthobolus leptomerioides* over *Acacia stellaticeps* Low Open Shrubland over *Triodia basedowii*, *T. schinzii* and *T. pungens* Closed Hummock Grassland	417.22 (6)	Rocky Hill Swale	*Goodenia hartiana* (P2). Range Extension – *Peripleura virgata*	No	No, typical of rocky dunes in the region, particularly to the west of Telfer	Recorded within the survey area (Vegetation Type 1; Syrinx Environmental PL 2006); and East of the survey area surrounding Telfer (Sandplain – Variation 1, (Hart, Simpson and Associates, 2002); and Vegetation Type 3 (Syrinx Environmental PL 2007)	No
4c	Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* High Shrubland over *Gompholobium polyzygum*, *Halgania solanacea* var. *solanacea* and *Jacksonia aculeata* Low Shrubland over *Triodia basedowii* complex Very Open Hummock Grassland	21.40 (670.08 ha (7) in O'Callaghan's Study Area)	Dune Swale	*Goodenia hartiana* (P2). Largest, most widespread population of *G. hartiana* in this VA in O'Callaghan's Study Area	No	No, typical of recently (<5yrs) burnt dune swales in the region	Vegetation Type 1: Mixed *Acacia* over *Triodia basedowii* (Syrinx Environmental PL 2006); Sandplain Variation 1 (Hart, Simpson and Associates 2002); Type 6: *Eucalyptus kingsmillii* subsp. *kingsmillii* low open woodland over mixed shrubland over *Triodia basedowii* grassland (Syrinx Environmental PL 2007); and F8: Shrub steppes, *Grevillea* and *Acacia* shrubs over mixed spinifex on sand (Bennett Environmental Consulting 2010)	No
4e	Scattered Tall Shrubs of *Acacia dictyophleba* over *A. stipuligera* and *Grevillea stenobotrya* Open Shrubland over *Triodia schinzii* Hummock Grassland over *Otion simplicifolium* Low Open Shrubland	2.99 (1)	Dune	Nil	No	No	Recorded previously within the Optimisation Study Area; Vegetation Type 6: Mixed shrubs on dunes (Syrinx Environmental PL 2006); To the east of the survey area as Sand Dunes (Hart, Simpson and Associates, 2002) ;	

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater, Perched Aquifer or Sheet flow Dependent Vegetation	Restricted Distribution (<5% of survey area)	Other Locations Recorded	Unique and Distinct Vegetation Association
							Type 12: *Grevillea stenobotrya* shrubland over *Triodia schinzii* grassland (Syrinx Environmental PL 2007); and J: Complexes, sand dune (Bennett Environmental Consulting 2010)	
***Acacia* High Shrubland**								
5a	*Acacia wanyu* Open Shrubland over *A. stellaticeps* and *Dodonaea coriacea* Low Open Shrubland over *Triodia basedowii* and *T. pungens* Hummock Grassland	145.58 (1)	Rocky Hill Swale	Range Extensions - *Maireana triptera* and *Scleroleana crenata*	No	No	Type 3: Mixed shrubland over *Acacia stellaticeps* open shrubland over *Triodia basedowii* grassland (Syrinx Environmental PL 2007) recorded within the survey area; Also similar to the 'Clayey Areas' vegetation association identified in the Telfer Expansion Project (Hart, Simpson and Associates, 2002); Hart, Simpson and Associates (2002) described the clayey areas as not an unusual unit regionally, however no data was provided to support this. The closest vegetation type at Kintyre is F10: Shrub Steppes. *Acacia wanyu* over the hard spinifex *Triodia wiseana* (Bennett Environmental Consulting 2010). No further description was available so similarity to the vegetation type are uncertain; however, the *Triodia* spp. present differs from the Optimisation Study Area	No

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater, Perched Aquifer or Sheet flow Dependent Vegetation	Restricted Distribution (<5% of survey area)	Other Locations Recorded	Unique and Distinct Vegetation Association
***Triodia* Hummock Grassland**								
6a	*Acacia wanyu* Scattered Tall Shrubs over *Eremophila tietkensii*, *Senna sericea* and *S. glutinosa* subsp. x *luerssenii* over *Triodia basedowii* complex Hummock Grassland	41.42 (3) (0.6 in O'Callaghan's Study Area)	Ironstone Rocky Hill	Range extensions - *Maireana triptera, Scleroleana minuta* and *S. eriacantha*	No	Common on rocky hills west of Telfer	The closest vegetation type at Kintyre is F10: Shrub Steppes. *Acacia wanyu* over the hard spinifex *Triodia wiseana* (Bennett Environmental Consulting 2010). No further description was available so similarity to the vegetation type are uncertain; however, the *Triodia* spp. present differs from the Optimisation Study Area	
6b	*Grevillea wickhamii* subsp. *hispidula*, *Acacia acradenia* and *A. synchronicia* Open Shrubland over *Triodia epactia* Hummock Grassland	22.26 (1)	Sandstone Rocky Hill	No	No	Yes	This Vegetation Association is most similar to Type 15: Scattered shrubs over mixed *Triodia* grassland (Syrinx Environmental PL 2007) recorded east of the survey close to Telfer mine site	No
6d	Scattered Trees of *Corymbia chippendalei* over scattered *Grevillea eriostachya*, *G. stenobotrya* and *Acacia stipuligera* over *Triodia schinzii* Hummock Grassland over *Dampiera cinerea* and *Otion simplicifolium* Low Open Shrubland	10.54 (1) (167.21 (4) in O'Callaghan's Study Area	Dune	No	No	No, typical of sand dunes south east of Telfer	Vegetation Type 6: Mixed shrubs on dunes (Syrinx Environmental PL 2006); Sand Dunes (Hart, Simpson and Associates 2002); Vegetation Type 11: Scattered *Corymbia chippendalei* over mixed shrubland over *Triodia schinzii* grassland (Syrinx Environmental PL 2007); and J: Complexes, sand dune (Bennett Environmental Consulting 2010)	No

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater, Perched Aquifer or Sheet flow Dependent Vegetation	Restricted Distribution (<5% of survey area)	Other Locations Recorded	Unique and Distinct Vegetation Association
***Triodia* Open Hummock Grassland**								
7a	Scattered Trees of *Eucalyptus leucophloia* subsp. *leucophloia* over Scattered Shrubs of *Tribulus suberosus* and *Hakea lorea* over *Triodia basedowii* complex Closed Hummock Grassland	57.22 (3) (54.18 (1) in O'Callaghan's Study Area)	Ironstone Rocky Hill	No	No	No, typical of small rocky hills in the region	Vegetation Type 5: *Triodia schinzii* on stony hills (Syrinx Environmental PL 2006); Stony Hills (Hart, Simpson and Associates 2002); Type 16: Scattered *Eucalyptus leucophloia* subsp. *leucophloia* over *Senna glutinosa* subsp. *x luerssenii* over *Triodia basedowii* grassland (Syrinx Environmental PL 2007); and G: Shrub steppes, sparse shrubs over the hard spinifex *Triodia basedowii* (Bennett Environmental Consulting 2010)	No

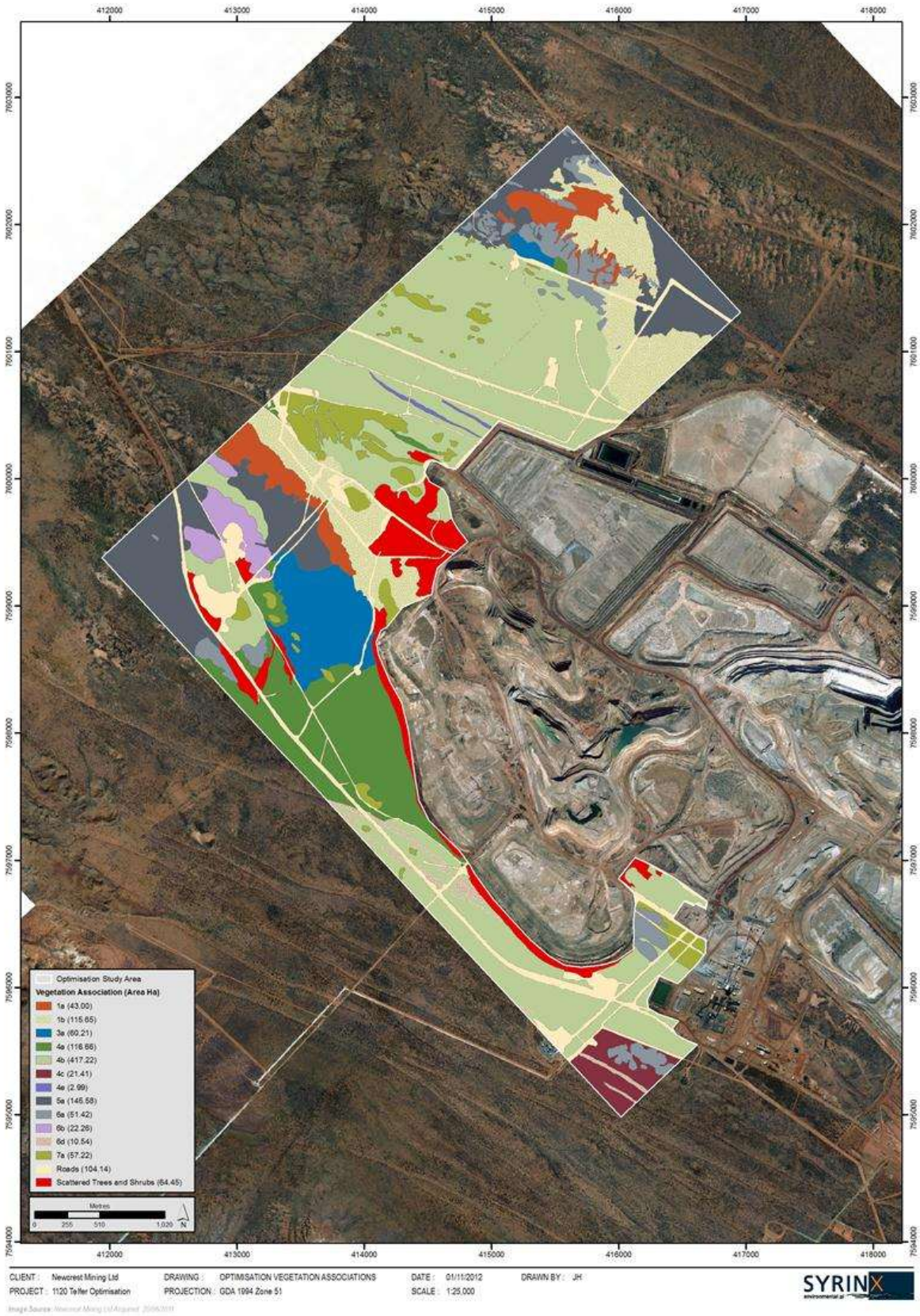


Figure 9 Vegetation Association Map

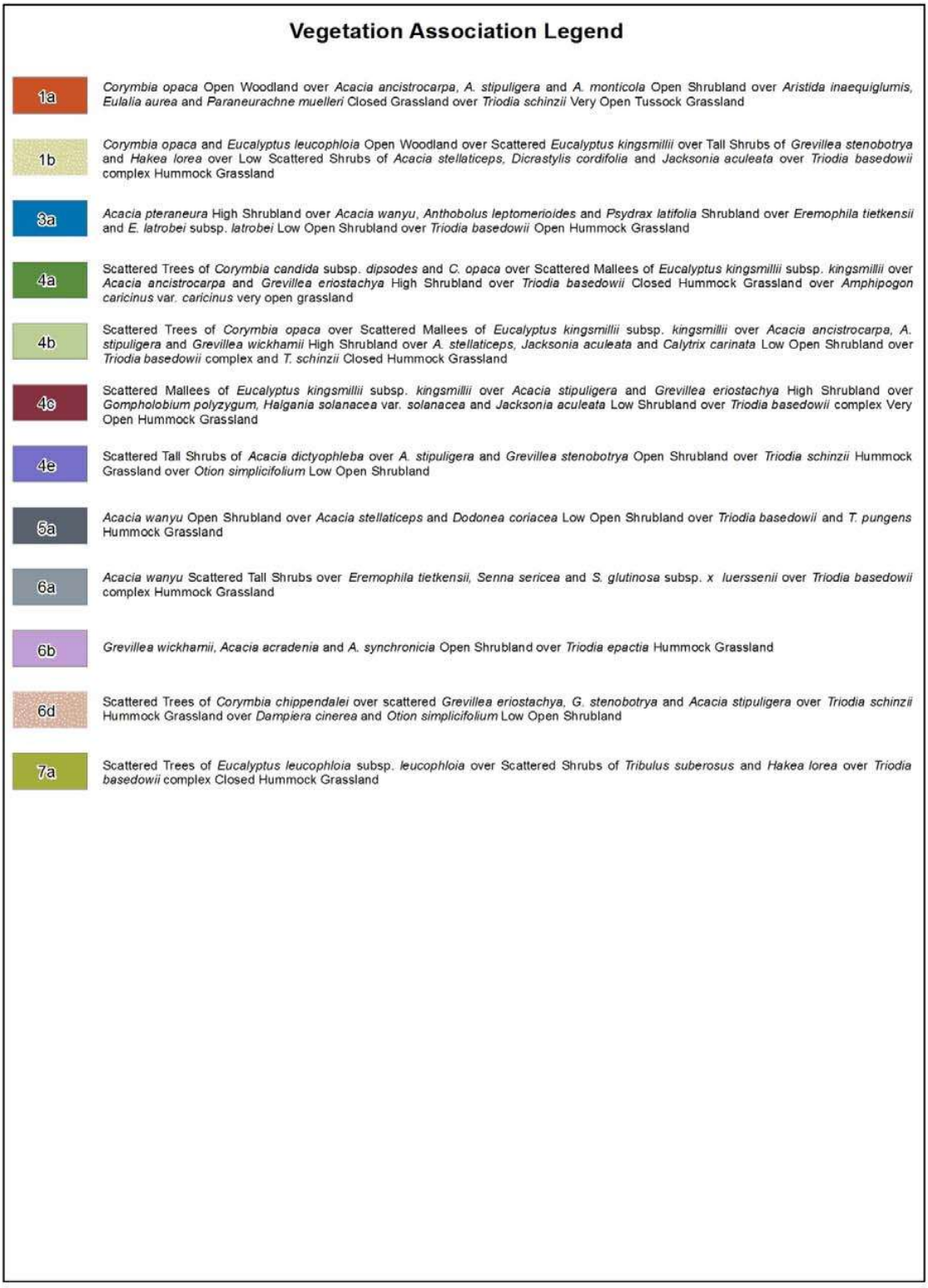


Figure 10 Vegetation Association Legend

4.3.2 Vegetation Condition

The vegetation condition across the Optimisation Study Area ranged from Good to Pristine. The degradation in condition was due to impacts on the vegetation structure due to clearing for mining activities around the waste dumps. The Pristine areas were to the north-west and south east of the Optimisation Study Area where there has been no evidence of human disturbance such as tracks and stakes Figure 11. A large portion of the Optimisation Study Area was in excellent condition (47%). The disturbed areas include all tracks and areas with no vegetation.



Figure 11 Vegetation Condition Map

4.3.3 Threatened Ecological Communities

None of the Vegetation Associations within the Optimisation Study Area were TECs or PECs.

4.3.4 Ground and Surface Water Dependent Ecosystems

In the Optimisation Study Area the Vegetation Association (VA) identified as likely to be sheet flow dependent present was:

> 3a: *Acacia pteraneura* High Shrubland over *A. wanyu, Anthobolus leptomerioides* and *Psydrax latifolia* Shrubland over *Eremophila tietkensii* and *E. latrobei* subsp. *latrobei* Low Open Shrubland over *Triodia basedowii* Open Hummock Grassland.

This vegetation was typified by the presence *Acacia pteraneura* as it was the dominant species and was clearly distinguishable from adjacent vegetation associations more typical of the Telfer region. It was present, adjacent to a drainage channel and, typical of 'Mulga' Woodlands in the Murchison and Pilbara, may be dependent on surface water flow, or sheet flow, that currently drains towards the drainage channel.

The term Mulga refers to a highly variable species complex consisting of *Acacia aneura* F.Muell. ex Benth. and its close relatives (e.g. *A. ayersiana*, *A. minyura* and *A. paraneura*). The members of this complex are small trees that dominate the vegetation of arid regions, in all occupying around 20% of Australia. Mulga vegetation communities are extensive in the Pilbara region. Mulga vegetation exhibits a high degree of structural, morphological and genetic variability.

Whilst Mulga vegetation types are not considered to be TECs, the DEC nonetheless considers them as significant vegetation types as they:

- Appear to play an important role in water and nutrient capture and are important to ecosystem function;
- Exhibit a high degree of morphological variability between populations;
- Are susceptible to disturbance from fire, grazing, weeds and development; and
- May support or provide refuge to restricted flora and fauna species.

Sheet flow refers to the surface water flow as a thin layer not concentrated in a channel across the ground surface. Mabbutt and Fanning (1987) indicated that sheet flow usually occurs over slopes of 0.2 – 2%. Mulga vegetation communities that exist within slopes within this range are therefore determined to be sheet flow dependant.

The major factors affecting sheet flow (run-off, run-on) are the grade of slope and the length of slope. The slight variation of topography and the slope allows for the formation of water sheet flow and is responsible for maintenance of typical Mulga patterned vegetation through retention of resources (water, soil and nutrients) in the landscape. Interruption to the sheet flow can cause detrimental effects to Mulga (Ludwig *et al*. 1997).

4.4 FLORA DESCRIPTION

A total of 214 taxa from 38 families and 97 genera were recorded across the Optimisation Study Area. This list includes subspecies (subsp.), variations (var.), affinities (aff.) and hybrids (x). Of the 214 taxa that were collected there were seven that contain some form of uncertainty (taxa with '?' in front of Species name). However, these collections are different to any other specimen identified for the Optimisation Study Area and their accurate identification is dependent on analysis of flowers and/or fruiting bodies. The species list for Optimisation Study Area is presented in (Appendix 6).

From the collection of field specimens, taxa were indeterminant beyond family (26), genus (7 taxa) and species (26 taxa – these have ? in front of species name) level identification (excluding the three collections previously mentioned). Where other collections were fully identified as the species with ? in front of the species name (e.g. *Acacia* ?*stellaticeps* and *Acacia stellaticeps*), or of a Family of which other species had already been identified (e.g. Poaceae sp.), these are considered to be the duplicate of fully identified specimens. However, poor condition of the specimen, immature (e.g. seedling), or missing flowering or fruiting material did not allow for the final identification.

The most commonly recorded family was Fabaceae, which accounted for 17.8% of all taxa collected in the Optimisation Study Area, constituting 38 taxa and 10 genera. Other dominant families recorded were Poaceae (16.3% of taxa), which consisted of 35 taxa from 18 genera, Malvaceae (7.5% of taxa) with 16 taxa from seven genera and Goodeniaceae (14.0% of taxa), which consisted of 13 taxa from five genera.

The dominant genus across the study area was *Acacia*, which recorded 17 taxa followed by, *Senna* (10 taxa) and *Ptilotus* (nine taxa). The most commonly found species were *Triodia basedowii*, *Aristida holathera* var. *holathera* and *Anthobolus leptomerioides*, which were all recorded in 17 quadrats (80% of quadrats) followed by *Eriachne aristidea* (16 quadrats, 76%) and *Eragrostis eriopoda* (15 quadrats, 71%).

Table 10 Comparison of flora results with remaining study areas within the Telfer Optimisation Project Area

Study Area	Number of Taxa	Number of Families	Most Commonly Recorded Families (In descending order)	Number of Survey Seasons
O'Callaghan's	176	32	Fabaceae, Poaceae, Malvaceae, Myrtaceae	2
Optimisation	214	38	Fabaceae, Poaceae, Malvaceae, Goodeniaceae, Chenopodiaceae	2
Trotmans	123	23	Fabaceae, Poaceae, Goodeniaceae, Myrtaceae	1
Satellite Deposits	84	18	Fabaceae, Goodeniaceae, Myrtaceae, Poaceae	1
Pit 15 (Fallows Field)	124	23	Fabaceae, Poaceae, Goodeniaceae, Malvaceae	1

4.4.1 Flora of Conservation Significance

4.4.1.1 Threatened Flora (T)

No Threatened Flora (T) listed under the WA *Wildlife Conservation Act 1950* or Threatened Flora species listed under the EPBC Act have been found in the Optimisation Study Area.

4.4.1.2 Priority Flora

The Priority 2 taxon *Goodenia hartiana* (Goodeniaceae; Figure 12) was recorded in the Optimisation Study Area. *Goodenia hartiana* has been recorded in previous surveys including Syrinx Environmental PL (2006, 2007, 2008, 2010), Ecologia, (2003), and Hart, Simpson and Associates (2002; Figure 13).

Goodenia hartiana is an erect to spreading multi-stemmed perennial herb that generally grows in recently burnt sand dune swales and at the base of sandhills where there is sufficient sand cover (Syrinx Environmental PL 2008, 2010). It can be confused with the related and similar looking *G. azurea*.

The Western Australian Herbarium has 18 records of *G. hartiana* (Western Australian Herbarium 2012). Of these, 14 populations were recorded by Syrinx Environmental PL (2008,

2010) and two populations recorded by Ray Hart surrounding Telfer. The remaining populations have been recorded at Shay Gap on a sand dune burnt six months previously. A population 350km south of Telfer has also been recorded, where 10 plants were recorded at the base of a sand dune.

The distribution of *G. hartiana* populations in the Telfer region have been reported previously (Syrinx Environmental PL 2008, 2010). During those surveys the recording of a total of almost 40,000 live plants within 10 populations, outside of Newcrest tenements, provided a significant amount of information of the distribution of a species, about which previously very limited information was available. The known population around the Telfer immediate impact area was approximately 11,000 plants prior to this survey (Syrinx Environmental PL 2010).

Given the widespread nature of *G. hartiana*, it is likely the species will be found in additional locations.

From the previous surveys it has been determined the main contributing factors influencing distribution are:

- underlying landform;
- vegetation association; and
- time elapsed since fire.

The landforms where the largest populations were found previously were always low lying hills with silcrete rocks and deep sands within interdunal swales that had been burnt within the previous 12 months. These areas represented the highest density of *G. hartiana* present whilst the adjacent unburnt areas had very low densities of *G. hartiana* present.

The majority of populations recorded during previous surveys (Syrinx Environmental PL 2008, 2010) were found on the south east of Telfer minesite on small rocky outcrops which were mainly silt stone or red rock, overlaid with a layer of soil between 1 and 10 cm thick. The only population found within a dune swale was dead. The most common vegetation association where *G. hartiana* was present was generally scattered shrubs over *Triodia basedowii* or *T. schinzii*. The most common species of scattered shrubs were *Grevillea wickhamii*, *Acacia stipuligera* and *A. ancistrocarpa* (Syrinx Environmental PL 2010).

Two new populations were recorded in the Optimisation Study Area, and one previously documented population was reconfirmed (as noted in Table 11).

Population 1 in the Optimisation Study Area had been previously recorded in surveys, between 2006 and 2010. This population had recovered from the previous senescence observed in 2007 and has returned to being a healthy population with approximately 1000

plants. This improvement in population health is likely due to the average rainfall of the summer 2010 and 2011.

Population 2 was recorded in dune swales near the south eastern corner of the study area. This population extends over the boundary into the adjacent O'Callaghan's Study Area. The population consisted of a range of ages from very mature to seedlings and were all healthy. The *G. hartiana* population was found under *Acacia stipuligera* High Shrubland at the base of a sand dune in areas where there were relatively large gaps (>5m^2) in the *Triodia basedowii* ground layer.

Population 3 was present in highly modified vegetation within the mine impact area, between waste dumps, with a population of up to 40 plants. The majority of the plants were large but under stress from being covered in dust from mining activities.

Table 11 *Goodenia hartiana* populations

Population No	Population Size	Vegetation Association	GPS Location (GDA 94 Zone 51)
1	1000	4b: Scattered Trees of *Corymbia opaca* over Scattered Mallees *of Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia ancistrocarpa, A. stipuligera* and *Grevillea wickhamii* subsp. *hispidula* High Shrubland over *A. stellaticeps, Jacksonia aculeata* and *Calytrix carinata* Low Open Shrubland over *Triodia basedowii* complex and *T. schinzii* Closed Hummock Grassland **Previously recorded population**	0414508/ 7600492
2	30	4b: Scattered Trees of *Corymbia opaca* over Scattered Mallees *of Eucalyptus kingsmillii* subsp. *kingsmillii over Acacia ancistrocarpa, A. stipuligera* and *Grevillea wickhamii* subsp. *hispidula* High Shrubland over *A. stellaticeps, Jacksonia aculeata* and *Calytrix carinata* Low Open Shrubland over *Triodia basedowii complex* and *T. schinzii* Closed Hummock Grassland	0415761/ 7595366
3	40	4c: Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* High Shrubland over *Gompholobium polyzygum, Halgania solanacea* var. *solanacea* and *Jacksonia aculeata* Low Shrubland over *Triodia basedowii* complex Very Open Hummock Grassland	0416404/ 7596664



Figure 12 *Goodenia hartiana* population within the Optimisation Study Area

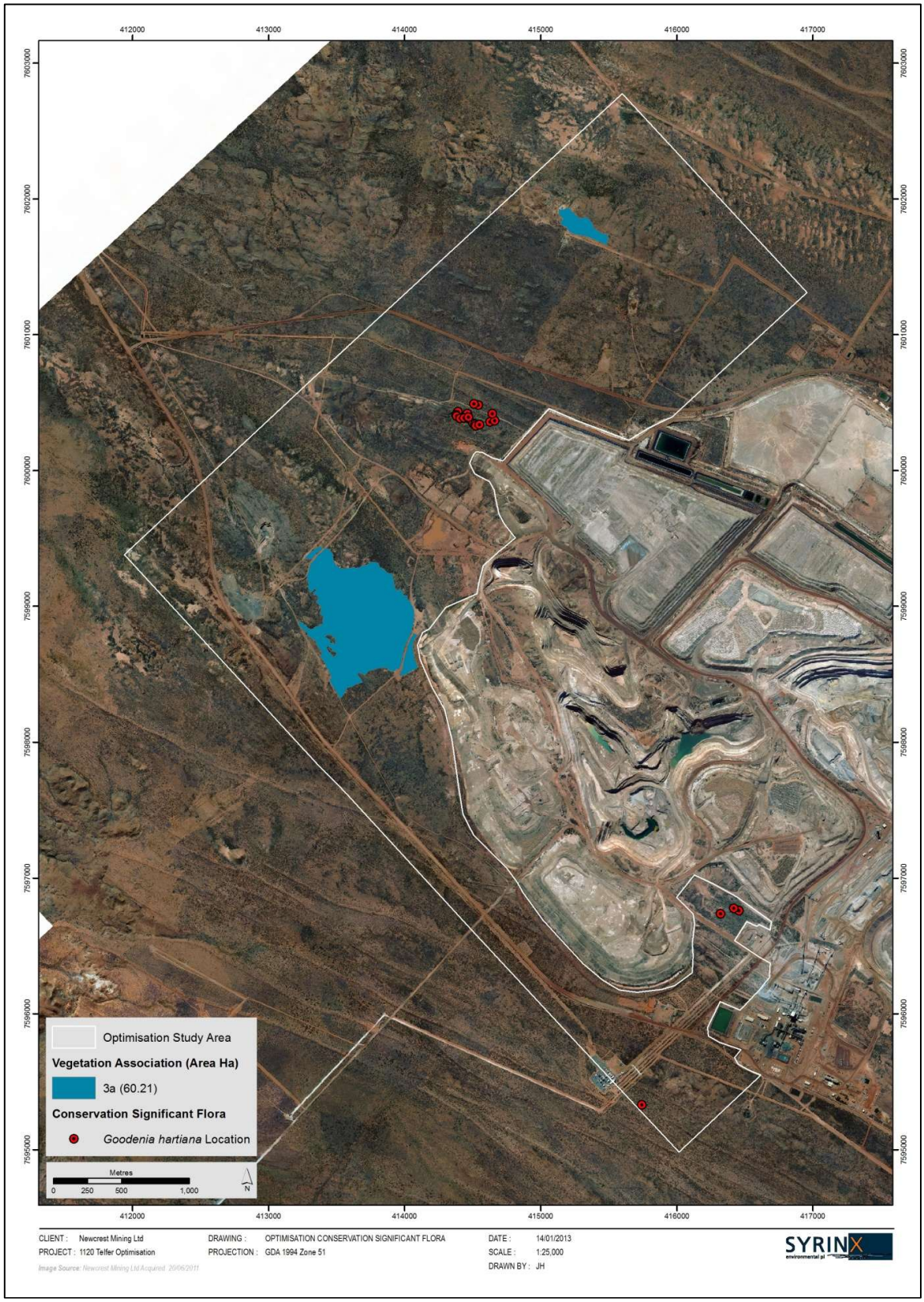


Figure 13 Locations of *Goodenia hartiana*

4.4.1.3 Range Extensions

Based on the existing vouchered specimen information available through Florabase (WAH 2012), the following taxa represent an extension to the previously known range of distribution of those particular taxa:

- *Acacia pteraneura* (previously known as *A. aneura* var. *conifer)* is an obconic tree ranging in height from 3-5m; crown dense and greenish grey with new shoots dark brown; phyllodes erect, slender, dull green and often tinged sub-glaucous; collections have been made in a variety of soils throughout the Murchison although has not been recorded as far North as Telfer;
- *Maireana triptera* is a compact bluish green shrub ranging from 0.2-0.6m high. Found in soils of sandy loam or red sandy clay on rocky hills and samphire flats. It is widely distributed throughout the Northern, Eremaean and South-west biozones of Western Australia, although it has not been collected as far North as Telfer;
- *Peripleura virgata* is an annual herb with purple flowers growing to 0.6m and usually found high in the landscape on rocky hills or breakaways in the Pilbara, with two collections in the Kimberley. The closest collection is 500km west, between Marble Bar and Shay Gap. At Telfer, it was found in a drainage channel within a *Corymbia opaca* woodland
- *Sclerolaena crenata* is an annual or short lived perennial herb to 0.4m high. Only seven previous collections have been vouchered of this species, the closest being in the Rudall River area. Previously recorded in loam or washplain areas, at Telfer this species was found in *Acacia wanyu* shrubland in the northern portion of the Optimisation Study Area;
- *Sclerolaena minuta* is a short-lived herb, 0.08-0.2m high and flowering in September. Mostly found with weathered granite and rocky hillsides in the Gascoyne. The collection of this species represents a Northern range extension;
- *Sclerolaena eriacantha* is a woolly perennial herb ranging in height from 0.1-0.3m high and generally flowering in August. It is distributed widely in the Pilbara and further south; and
- *Synaptantha tillaeacea* var. *tillaeacea* is a prostrate to weakly ascending annual or perennial, herb to 0.1m high. The flowers are yellow/green-yellow/white-blue-pink/red-green. It occurs on a variety of soils, frequently in sandy or loamy soils. At Telfer, it was found in a minor drainage channel within an *Acacia monticola* tall shrubland. The 93 previous collection records are mainly scattered from the Pilbara to near Esperance; however, this collection represents the second collection in the Great Sandy Desert. The nearest collection is 100km to the south in the Rudall River area.

4.4.1.4 New Species

There were no new taxonomic entities recorded in the Optimisation Study Area.

4.4.2 Introduced Flora

A weed survey was undertaken by Syrinx Environmental PL in May 2011 (Syrinx Environmental PL 2011a), as this data is current it has been extracted to inform this survey. There were three introduced species were found in the Optimisation Study Area; *Cenchrus ciliaris* (Buffel Grass), *Aerva javanica* (Kapok) and *Portulaca oleracea* (Purslane). Buffel Grass and Kapok were to the south of the project area while Purslane was to the north along the edges of the roads and tracks.

An additional population of Buffel Grass was found in one location in a drainage channel with a grassy understorey at the base of small rocky hills in the northern portion of the study area. The location of the specimen was at 0415359, 7602079. Only one plant was seen at the time of survey. The vegetation association was otherwise in pristine condition and the presence of the Buffel Grass had made no impact to vegetation structure or condition. This represents the first record of Buffel Grass away from the immediate areas of mine impact where it is typically found only in disturbed areas.

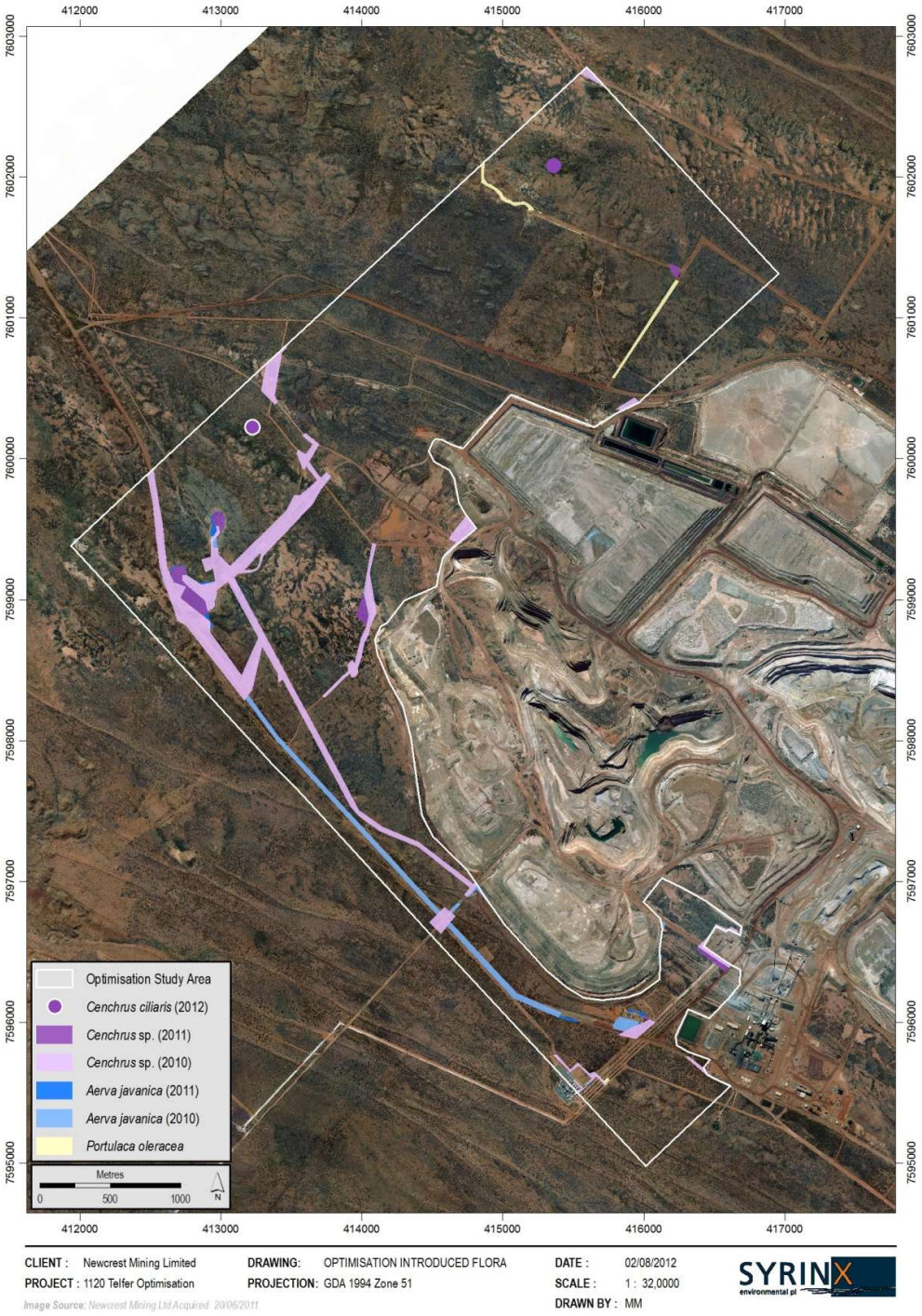


Figure 14 Locations and Extent of Infestations for Introduced Flora Species (Syrinx Environmental PL 2011a)

4.5 FLORA AND VEGETATION DISCUSSION

4.5.1 Flora

Typically for Level 2 surveys, species richness is compared to other surveys undertaken within the region, but located outside of the study area tenements. Due to lack of quadrat based available survey data regionally, this is not possible.

The most relevant data currently available is from 2010 and 2011 surveys completed for Kintyre by Bennett Environmental Consulting (2010). The quadrat data was not publically available; however, a summary of flora results was provided the Environmental Scoping Document for the Kintyre project (Environ Australia 2011) and therefore compared with the results in the Optimisation Study Area.

The species richness is also compared to the two previous plot based surveys in the study area (Syrinx Environmental PL 2006, 2007) and two surveys where collections were made opportunistically (Hart Simpson and Associates 2002, 2000).

The vegetation of the Optimisation Study Area is considered relatively diverse with a total of 214 taxa from 38 families and 97 genera. The species richness is higher than recorded in the Waste Dump Expansion Survey (104 species; Syrinx Environmental PL 2006) west of the Optimisation Study Area. However, it is lower than the 249 species recorded by Hart, Simpson and Associates (2002) over a larger survey area and completed over three survey seasons, while the Syrinx Environmental PL (2002, 2006) surveys were only one season surveys. Taking into account the size of the survey area, and the variety of landforms present the species richness in this current work compares well with previous surveys.

Compared to the four remaining study areas in the Optimisation Project Area, the Optimisation Study area is more diverse then O'Callaghan's Study Area. The Optimisation Study Area has a higher number of species, which is potentially a derivation of the higher diversity of landforms. This is also reflected in the higher number of Families (38) and Genera (97).

The higher number of species recorded the Optimisation Study Area compared to Trotmans, Satellite Deposits and Pit 15 (Fallows Field) is likely the result of differences in the number of survey seasons; late summering annual herbs and grasses would not be captured in the species lists for those areas with only a single season survey.

There were seven range extension species recorded being *Acacia pteraneura*, *Maireana triptera, Peripleura virgata, Sclerolaena crenata, S. eriacantha* and *S. minuta*, *Synaptantha tillaeacea* var. *tillaeacea*. An additional taxon *Tephrosia* ?*sphaerospora* could also be range

extension; however, there was insufficient material to confirm its identification. It was located on a small rocky hill near the south-western boundary of the Optimisation Study Area.

4.5.2 Conservation Significant Flora

No Threatened Flora (T) listed flora under the *Wildlife Conservation Act 1950* or Threatened Flora listed under the *EPBC Act* were identified in the Optimisation Study Area.

The Priority 2 taxon *Goodenia hartiana* was recorded in three locations in the Optimisation Study Area. One population had been recorded previously.

There is potential for these numbers to change over a relatively short period of time (<2 years) as previous studies of populations of *G. hartiana* surrounding Telfer have demonstrated that populations are highly dynamic, with some staying relatively similar between survey events (2 year period) and others decreasing dramatically due to increasing age of vegetation since fire (Syrinx Environmental PL 2010).

4.5.3 Introduced Flora

The introduced species *Aerva javanica* (Kapok) and *Cenchrus ciliaris* (Buffel Grass) are typically found along edges of disturbance such as tracks and cleared areas where there is a water source. These water sources may include puddles which form after rain and near pipes that move water around the mine site. Kapok seems to be restricted to areas of siltstone that retain moisture, in low to high densities, while Buffel Grass is more likely to encroach into native vegetation up to 10m from the edge of the disturbance and in high densities (Syrinx Environmental PL 2011).

It was observed during the weed survey undertaken in May 2011 that the distribution of Portulaca *oleracea* (Purslane) had significantly increased due to the large rainfall received the previous wet season. This species is a succulent that thrives in moist conditions. It was also recorded in the open areas within the Mulga Vegetation (refer Figure 9).

An additional population of Buffel Grass was found in a drainage channel in the northern portion of the study area. This is the first record of the species to be found outside of the mine impact area in vegetation of otherwise pristine condition and emphasises the ability of Buffel Grass to encroach into native vegetation.

4.5.4 Vegetation Associations

A total of 12 vegetation associations were mapped in the Optimisation Study Area and these fall into six broad floristic groups. One of the vegetation associations, 3a, is likely to be sheet flow dependent. Six landforms were identified in the study area.

The number and types of landforms compares well with previous surveys. The exception is siltstone rocky hill, which has not been described previously. All species on this landform type are widespread throughout the study area. This landform was present in the furthest south-west portion of the Optimisation Study Area.

The broad floristic groups also compares well with previous surveys and broad vegetation mapping of Beard (1974) and Shepherd *et al*. (2002).with a dominance of *Acacia* dominated floristic groups (62% of the study area) and *Triodia* dominated floristic groups (11.5% of the study area) were most prolific.

The presence of the less widely distributed broad floristic group of *Corymbia* Woodland (12.87%) reflects the more detailed survey methods conducted in the study compared to the broad vegetation mapping of Beard (1974) and Shepherd *et al*. (2002).All Vegetation Associations have been described either in previous reports within the study area (Syrinx Environmental PL 2007) and to the east of the Optimisation Study Area (Syrinx Environmental PL 2006). When compared to Hart, Simpson and Associates (2002) much more extensive survey almost all vegetation associations have been recorded previously, although with more broad vegetation descriptions relating more to landform rather than dominant species present.

One vegetation association was assessed as unique and distinct:

- Vegetation Association 3a: *Acacia pteraneura* High Shrubland over *A. wanyu*, *Anthobolus leptomerioides* and *Psydrax latifolia* Shrubland over *Eremophila tietkensii* and *E. latrobei* subsp. *latrobei* Low Open Shrubland over *Triodia basedowii* Open Hummock Grassland.

This vegetation association occurs over 4.89% of the Optimisation Study Area, on a landform not common regionally and with dominant species more common in the Pilbara region. Two range extension species, *Acacia pteraneura* and *Maireana triptera* are restricted to this vegetation association. It also been identified as a potential sheet flow dependent ecosystem. Slope analysis will need to be conducted to confirm if it is sheet flow dependent.

4.6 CONSERVATION STATUS

The significance of the ecological communities and flora occurring within the Optimisation Study Area has been assessed at five spatial scales: International, National, State, Regional and Local.

4.6.1 International and National Significance

International significance refers to those species that are listed by the IUCN on the Red List of Threatened Species.

National significance refers to those features of the environment recognised under the EPBC Act.

No vegetation associations or flora of international or national significance were identified in the Optimisation Study Area.

4.6.2 State Significance

State significance refers to those features of the environment recognised under the *Wildlife Conservation Act*, *Environmental Protection Act or* otherwise listed by the DEC.

No TECs or PECs or threatened flora are present within the Optimisation Study Area. However three records of the Priority 2 taxon *Goodenia hartiana* were recorded within the Optimisation Study Area.

The WAH has 18 records of *Goodenia hartiana* (Western Australian Herbarium 2012). Of these, 14 populations were recorded by Syrinx Environmental PL (2008, 2010) and two populations recorded by Ray Hart surrounding Telfer. The remaining populations have been recorded at Shay Gap on a sand dune burnt six months previously. A population 350km south of Telfer has also been recorded where 10 plants were recorded at the base of a sand dune.

During the Syrinx Environmental PL (2008, 2010) surveys the recording of a total of almost 40,000 live plants within 10 populations, outside of Newcrest tenements, provided a significant amount of information of the distribution of a species, about which previously there was very limited information available. The known population around the Telfer immediate impact area was approximately 11,000 plants prior to this survey (Syrinx Environmental PL 2010). Two new populations were recorded in the Optimisation Study Area

representing an additional 70 plants, and one previously documented population of 1000 plants was reconfirmed.

Goodenia hartiana was recorded in two dune swale vegetation associations (4b and 4c) representing 33.7% of the Optimisation Study Area. These vegetation associations are common and widespread throughout the Telfer Region, and have been recorded at Nifty.

4.6.3 Regional Significance

Regional significance refers to the representation of the species and vegetation assemblages within Optimisation Study Area compared to the species and habitats in the greater bioregional area.

4.6.3.1 Flora

The survey did not reveal a high level of endemism as the majority of species found in the Optimisation Study Area have been found previously in the limited surveys in adjacent areas (Syrinx Environmental PL 2007; Hart, Simpson and Associates 2002).

4.6.3.2 Vegetation Associations

Most vegetation associations are widespread through the bioregional area, particularly the rocky hill swale vegetation associations which represent 55% of the Optimisation Study Area. The low rocky hillslopes, and corresponding hill swales, present in the Optimisation Study Area continue for at least 30km west of the study area to the north of Freedom Road. The Vegetation Associations not widespread regionally are those restricted to landforms not common throughout the region such as scree slopes, where an *Acacia pteraneura* dominated Vegetation Association is present; and also a Vegetation Association on a sandstone rocky hill.

As discussed previously, due to lack of previous regional plot based data it is difficult to assess regional significance. However, in the absence of regional data the assessment of vegetation associations is based on the context of the information already known of the Telfer Region.

Significant Vegetation Units

For the purposes of EPA assessment, Significant Vegetation Units are those that may be significant for a number of reasons, other than a Statutory listing as TEC or because the extent is less than a threshold, which may include the following:

- Scarcity and unusual species;
- novel combinations of species;
- role as a refuge;
- role as key habitat for threatened species;
- being representative of the range of a unit (particularly at the extremes of range, recently discovered range extensions, or isolated outliers of the main range); or
- a restricted distribution.

The vegetation associations are compared against each criterion below.

Scarcity and unusual species

One species, *Goodenia hartiana,* is a Priority 2 species, but has been recorded previously as being locally common in the dune swales and base of rocky outcrops in the Telfer region.

Goodenia hartiana (P2) was recorded in two dune swale vegetation associations (4b and 4c) representing 35.4% of the Optimisation Study Area. These vegetation associations are common and widespread throughout the Telfer Region, and have been recorded at Nifty

Seven species collected represent range extensions and almost all are species more commonly recorded in the Pilbara region. Five are small, annual species on a landform that is common west of the Telfer Optimisation Study Area. Two of the species are present in the restricted Vegetation Association 3a.

The range extension species were recorded in the following Vegetation Associations:

- *Acacia pteraneur*a in Vegetation Association 3a (4.9% of the Optimisation Study Area),
- *Maireana triptera* in Vegetation Associations 3a, 5a, 6a (20% of the Optimisation Study Area),
- *Peripleura virgata* in Vegetation Association 4b (33.7% of the Optimisation Study Area),
- *Sclerolaena crenata* in Vegetation Association 5a (11.8% of the Optimisation Study Area),
- *Sclerolaena minuta* in Vegetation Associations 1a, 6a (3.8% of the Optimisation Study Area),
- *Sclerolaena eriacantha* in Vegetation Association 6a (3.3% of the Optimisation Study Area); and
- *Synaptantha tillaeacea* var. *tillaeacea* in Vegetation Association 1a (0.4% of the Optimisation Study Area).

Six of the Vegetation Associations (1b, 4a, 4e, 6b, 6d, 7a) representing 26.3% contain no Priority or range extension flora in the Optimisation Study Area.

This criteria has been met as Vegetation Associations 4b and 4c contain the Priority 2 species Goodenia hartiana and Vegetation Associations 1b, 4a, 4e, 6b, 6d, and 7a contain range extension species.

Novel combinations of species

Most species are widespread across the Telfer region and most of the vegetation associations represent varying proportions of the common species. The vegetation association with species not present in the surrounding areas, and therefore represents a novel combination of species is Vegetation Association 3a. Species restricted to Vegetation Association 3a are *Acacia pteraneura, Evolvulus alsinoides* var. *villosicalyx*, *Psydrax latifolia*, *Ptilotus obovatus* and *Sida fibulifera*. These are common species south of the Great Sandy Desert Bioregion.

Refugia

For the purpose of assessment of refugia, the EPA considers refugia restricted environments that have been isolated for an extended period of time, or are the last remnants of such areas (EPA 2004a). They may be of high significance for plant taxa with very restricted distributions. Arid zone refuges may include taxa with preferences for stability/low seasonality, seclusion from fire or presence of permanent water.

In terms of context of information already known then the vegetation association possibly meeting the above criteria of *arid zone refugia* is:

Vegetation Association 3a: *Acacia pteraneura* High Shrubland over *Acacia wanyu*, *Anthobolus leptomerioides* and *Psydrax latifolia* Shrubland over *Eremophila tietkensii* and *Eremophila latrobei* subsp. *latrobei* Low Open Shrubland over *Triodia basedowii* Open Hummock Grassland.

The Mulga community is likely to meet the refugia criteria, as Mulga in the Pilbara are considered to be of regional significance as they represent the northern and western extent of its distribution (Kendrick 2001a). Therefore, the presence of a Mulga vegetation association further north at Telfer could be considered a refugia as it potentially represents a restricted environment that has been isolated for an extended period from the Pilbara Mulga communities, already considered regionally significant.

No further Mulga communities were found in the remaining four study areas of the Optimisation Project Area. Additional investigations are required to confirm distribution extent

of Mulga surrounding the Optimisation Project Area to adequately assess against this criterion.

Role as key habitat for threatened species

Goodenia hartiana (P2) was recorded in two dune swale vegetation associations (4b and 4c) representing 33.7% of the Optimisation Study Area. These vegetation associations are common and widespread throughout the Telfer Region, and have been recorded at Nifty.

The vegetation associations are habitat for *G. hartiana*, but as it is found in a variety of habitats throughout the Telfer region, none of the vegetation associations are considered key habitat. This criteria has not been met.

Being representative of the range of a unit (particularly at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)

In terms of context of information already known then the vegetation association meeting the criteria of *being representative of the range of a unit (particularly at the extremes of range, recently discovers range extensions, or isolated outliers of the main range);* is:

Vegetation Association 3a: *Acacia pteraneura* High Shrubland over *A. wanyu*, *Anthobolus leptomerioides* and *Psydrax latifolia* Shrubland over *Eremophila tietkensii* and *E. latrobei* subsp. *latrobei* Low Open Shrubland over *Triodia basedowii* Open Hummock Grassland

This Vegetation Association occurs over 5.33% of the study area, on a landform not common regionally and with dominant species more common in the Pilbara region. *Acacia pteraneura* is a species that is part of a taxonomic complex commonly known as 'Mulga'.

Mulga communities in the Pilbara are considered to be of regional significance as the groves and inter-grove mulga communities represent the northern and western extent of the species distribution (Kendrick 2001a). Therefore the presence of a Mulga vegetation association at Telfer could be considered significant as it represents an even further northern extent. This is based on interim data and further data analysis is required to confirm regional significance.

According to current distribution maps (WAH 2012), the populations at Telfer would represent the northernmost distribution of *Acacia pteraneura*, with the closest population recorded in 1979 approximately 400km to the south east in the Little Sandy Desert. *Acacia pteraneura* is a very common species of the Murchison.

This vegetation association was typified by the presence *Acacia pteraneura* as it was the dominant species and was clearly distinguishable from adjacent vegetation associations more typical of the Telfer region. It was present adjacent to a drainage channel and, typical

of Mulgas in the Murchison and Pilbara, may be dependent on surface water flow that currently drains towards the drainage channel.

Hart, Simpson and Associates (2002) describes the landform this vegetation association is found on as 'clayey areas' and described the distribution "as a mosaic within the common sandplain where they appear to represent the paths of old drainage lines. Clayey areas are sparse but widespread regionally". They were also described as occurring in the borefield located within the northern portion of Optimisation Study Area (named 'SEP Borefield' in the report), but not in the Pit 15 or Freedom Rd borefields.

Bennett (2010) has described and mapped a vegetation type as R: Shrubland, Mulga Shrubland at Kintyre, 80 km south of Telfer.

The Mulga woodland is potentially a sheet flow dependent ecosystem (see Section (4.3.4).

Additional investigations are required to confirm distribution extent of Mulga surrounding the Optimisation Project Area to adequately assess against this criterion.

Restricted Distributions

For the purpose of assessment of restricted distribution, the EPA considers a restricted vegetation association is one that naturally comprises less than 5% in the local area (15km radius) or the bioregion (EPA 2004a).

For Vegetation Associations with restricted distribution within the study area (i.e. are 5% or <61 ha of the Optimisation Study Area) an assessment of significance is described in Section 4.4.1.

Of the twelve vegetation associations, eight comprise less than 5% of the study area. Of these, six are restricted to landforms that are not widespread within the survey area but are common regionally including:

- drainage lines at the base of rocky hills (1a and 5a);
- dunes where the linear nature of this landform has resulted in a low overall total hectares (4e and 6d); and
- low rocky hills, very common to the west of the study area (6a and 7a).

Vegetation association 6b is restricted in area on a landform that is not common regionally; however no species are restricted to this vegetation association.

Table 12 Vegetation Associations with restricted distributions (<61ha) within the Optimisation Study Area

Code	Vegetation Association	Area (Ha)	Comment
Corymbia Open Woodland			
1a	*Corymbia opaca* Open Woodland over *Acacia ancistrocarpa, A. stipuligera* and *A. monticola* Open Shrubland over *Aristida inaequiglumis, Eulalia aurea* and *Paraneurachne muelleri* Closed Grassland over *Triodia schinzii* Very Open Tussock Grassland	43	This VA is located in the lowest part of the landscape between two rocky outcrops. The structure and species present reflect the increased access to water in this location, including *Acacia monticola* and *Chrysopogon fallax*. This VA would be present at the base of the many large rocky outcrops south and west of the study area.
Acacia Open Shrubland			
3a	*Acacia pteraneura* High Shrubland over *A. wanyu*, *Anthobolus leptomerioides* and *Psydrax latifolia* Shrubland over *Eremophila tietkensii* and *E. latrobei* subsp. *latrobei* Low Open Shrubland over *Triodia basedowii* Open Hummock Grassland	60.21	The landform this VA is present on is present on scree slopes between the Pilbara and Telfer, however how common the landform is uncertain.
Mixed High Shrubland			
4c	Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera and Grevillea eriostachya* High Shrubland over *Gompholobium polyzygum*, *Halgania solanacea* var. *solanacea* and *Jacksonia aculeata* Low Shrubland over *Triodia basedowii* complex Very Open Hummock Grassland	21.42	This VA, characteristic of a recently burnt dune swale, is the northern extreme of what is much larger extent in the O'Callaghan's Study Area where 670 ha is present.
4e	Scattered Tall Shrubs of *Acacia dictyophleba* over *A. stipuligera* and *Grevillea stenobotrya* Open Shrubland over *Triodia schinzii* Hummock Grassland over *Otion simplicifolium* Low Open Shrubland	2.99	This VA represents a dune swale, similar to the most common dune, however it does not have the scattered tree layer present on the rest of the dune in the Optimisation Study Area
Triodia Hummock Grassland			
6a	*Acacia wanyu* Scattered Tall Shrubs over *Eremophila tietkensii*, *Senna sericea* and *S. glutinosa* subsp. *x luerssenii* over *Triodia basedowii* complex Hummock Grassland	51.42	Common regionally west of the study area. Similar to other rocky hills but with a species poor shrub layer compared to other rocky hills.
6b	*Grevillea wickhamii* subsp. *hispidula, Acacia acradenia* and *Acacia synchronicia Open Shrubland* over *Triodia epactia* Hummock Grassland	22.6	This siltstone rocky hill landform was the only found in the Optimisation Study Area and wasn't described in Hart Simpson and Associates 2002 in their wider survey of the region. It is present for the first 10km along the pipeline corridor from Telfer (Syrinx Environmental PL 2004)
6d	Scattered Trees of *Corymbia chippendalei*	10.54	This VA represents typical dunes in the region.

Code	Vegetation Association	Area (Ha)	Comment
	over scattered *Grevillea eriostachya, G. stenobotrya* and *Acacia stipuligera* over *Triodia schinzii* Hummock Grassland over *Dampiera cinerea* and *Otion simplicifolium* Low Open Shrubland		The linear nature of this landform has resulted in a restricted distribution. However, 162.71 ha are present in the O'Callaghan's Study Area.
Triodia Open Hummock Grassland			
7a	Scattered Trees of *Eucalyptus leucophloia* subsp. *leucophloia* over Scattered Shrubs of *Tribulus suberosus* and *Hakea lorea* over *Triodia basedowii* complex Closed Hummock Grassland	57.22	The vegetation association is typical of low rocky hills to the west of the study area where the landform is more common. 54.18 ha is present in the adjacent O'Callaghan's Study Area on a landform common to the west of Telfer

4.6.4 Local Significance

At a local level, ecological significance is given to those vegetation communities that support greatest biodiversity with a mosaic of vegetation assemblages. Species confined to a specific habitat not common locally are considered locally significant as removal or damage to that particular habitat would cause the local extinction of that particular species.

Vegetation association 3a is of local significance as it includes the species: *Acacia pteraneura, Evolvulus alsinoides* var. *villosicalyx*, *Psydrax latifolia*, *Ptilotus obovatus* and *Sida fibulifera,* which are confined to a habitat not common locally.

4.6.4.1 Assessment of Vegetation Representation on the Basis of Pre-European Vegetation Extent

Based on the Bioregional Conservation Status of Ecological Vegetation Classes (Department of Natural Resources and Environment 2002) a vegetation type is considered underrepresented if there is less than 30% of its original (i.e. pre European or pre 1750) distribution remaining. Therefore, 30% is considered as the threshold level below which species loss appears to accelerate exponentially at an ecosystem level.

From a biodiversity perspective, and not taking into account any other land degradation issues, there are several key criteria that can be applied to vegetation where clearing is still occurring. These criteria are broad scale criteria and are supplementary to clearing principles outlined in the Western Australian Schedule 5 of the *Environmental Protection Amendment Act 2003*. The criteria which would place the threat level into the category of Depleted or above should be avoided.

Presumed extinct	Probably no longer present in the bioregion;
Endangered	<10% of pre-European extent remains;
Vulnerable	10-30% of pre-European extent exists;
Depleted	>30% and up to 50% of pre-European extent exists; and
Least concern	>50% pre-European extent exists and subject to little or no degradation over a majority of this area.

Native vegetation associations that are present in the study area have been quantified in a regional context based on their extent and reservation status by Shepherd et al. (2002). Table 13 outlines the status of those communities in the Pilbara region.

Kendrick (2001a, 2001b) also assessed the vegetation associations in terms of the reservation priorities of ecosystems. Vegetation Association 134 is a high priority for reservation in the Little Sandy Desert and of low priority for reservation in the Great Sandy Desert. Vegetation Association 157 is a medium priority for reservation in both the Little Sandy Desert and the Great Sandy Desert.

The total area of vegetation association 134 of high priority for reservation in the Telfer Optimisation Study Area is 12.85ha (Table 13).

Table 13 Vegetation Association extent and status in the Great Sandy Desert and Little Sandy Desert IBRAs region showing extent of vegetation in the Telfer Optimisation Study Area

Vegetation Association Number	Vegetation Association Description	IBRA Name	Pre-European Extent in the IBRA region (Ha)	Current Extent in the IBRA region (Ha)	% remaining	Pre-European Current Extent in IUCN Class 1a-4 Reserves (Ha)	% Pre-European Current Extent in IUCN Class 1a-4 Reserves	Pre-European Current Extent within Study Area (Ha)	Reservation Priority (Kendrick, 2001a, 2001b)
134	Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex on sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills	Great Sandy Desert	13618143	13616267	99.99%	675032	4.96%	505.79	Low
157	Hummock grasslands, grass steppe; hard spinifex, *Triodia wiseana*		33127	33088	99.88%	0	0.00%	16.49	Medium
134	Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex on sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills	Little Sandy Desert	7386985	7386916	99.999%	121647	1.65%	12.85	High
157	Hummock grasslands, grass steppe; hard spinifex, *Triodia wiseana*		82902.22	81020.50	97.73%	1652.82	2.04%	292.47	Medium

PART 3 VERTEBRATE FAUNA

5.0 VERTEBRATE FAUNA

5.1 OVERALL APPROACH

Bamford Consulting Ecologists (BCE) used an impact assessment process that examines the fauna values of a project area, and reviews impacting processes. The fauna section of this report presents the results of investigations to document fauna values of the Optimisation Study Area are as follows:

- assemblage uniqueness, completeness and composition/richness;
- vegetation/substrate associations (VSAs) that provide habitat for fauna;
- patterns of biodiversity across the landscape;
- species of conservation significance; and
- ecological processes upon which the fauna depend.

Descriptions and background information on these values can be found in Appendix 7.

The purpose of the literature review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the Optimisation Study Area based on unpublished and published data using a precautionary approach.

5.2 VERTEBRATE FAUNA METHODOLOGY

5.2.1 Overview

The purpose of an impact assessment is to compare project variables against baseline studies to identify development alternatives with the lowest practicable impact and provide government agencies with the information they need to determine the acceptability of impacts of a proposed development. The methods used in these investigations are based upon the general approach to fauna investigations for impact assessment with reference to Appendix 7. Thus, the investigations involve the identification of fauna values of the Optimisation Study Area.

In addition, the approach to fauna impact assessment was carried out with reference to guidelines and recommendations set out by the Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation

(EPA 2002, 2004c). The EPA proposes two levels of investigation that differ in the approach to field investigations: Level 1 being a review of data and a site reconnaissance to place data into the perspective of the site, and Level 2 being a literature review and intensive field investigations (e.g. trapping and other intensive sampling).

The level of assessment recommended by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surroundings, the environment in which the disturbance is planned, and the availability of pre-existing data. The Optimisation Study Area lies in the transition between two major bioregions (Little Sandy Desert and Great Sandy Desert), with some existing data from previous studies carried out at Telfer and at the Kintyre project area about 80km to the south (Figure 2).

5.2.2 Literature Review

As an existing mine with a long history, some fauna investigations have been carried out in the Telfer area that precede Position and Guidance Statements provided by the Environmental Protection Authority (EPA 2002, 2004c and 2010) for Environmental Impact Assessment.

5.2.2.1 Sources of information

A review of available data from previous reports and databases has been carried out. These included state and federal government databases and results of regional studies. The purpose of this review is to provide an inventory list of the fauna of the region in which the Project Area lies.

The primary source of information for this review was from field surveys conducted at Telfer by Hart Simpson and Associates (2002) and Syrinx Environmental PL (2006). Databases accessed were the DEC Naturemap (DEC 2011b) (incorporating the Western Australian Museum's FaunaBase), Birds Australia's Atlas Database (BA), Global Biodiversity Information Facility (GBIF) and the EPBC Protected Matters Search Tool (Table 14). Note that these database searches covered much larger areas than the Optimisation Study Area, as many database records are location specific and a buffer around the Optimisation Study Area is needed to capture such records.

Regional information on fauna was available from Kendrick (2001a, 2001b), who reported on vertebrate fauna, and particularly those of conservation significance, in the region. Species lists were also available from Karlamilyi National Park over 100km to the south (NatureMap, 2011b, see Appendix 8), from BCE records, including from work carried out in the Kintyre area, 80km south of Telfer (Bamford 2007, 2011) and from work carried out by Martinick Bosch Sell in the Birla (Nifty) project area, 70km to the west (MBS 2004, 2006).

Information from the above sources was supplemented with species expected in the Optimisation Study Area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler, Smith and Johnstone (2000);
- Reptiles: Storr et al. (1983); Storr et al. (1990); Storr et al. (1999); Storr et al. (2002) and Wilson & Swan (2008);
- Birds: Blakers et al. (1984); Johnstone and Storr (1998, 2005) and Barrett et al. (2003); and
- Mammals: Menkhorst & Knight (2001); Churchill (2008); and Van Dyck and Strahan (2008).

Table 14 Types of records held on database, area searched and their source location

Database	Type of records held on database	Area Searched
Naturemap (DEC 2011b)	Records in the WAM and DEC databases. Includes historical data	418205E, 7596639N, Zone 51, Buffer = 40 km
Birds Australia Atlas Database	Records of bird observations in Australia, 1998 – 2008	One degree square containing 122.22586E, 21.7093S
Global Biodiversity Information Facility	Records from WA Museum, SA Museum, Australia Museum and Australian National Wildlife Collection	1 degree cell bounded by 21S and 22S and 122E and 123E
EPBC Protected Matters Search Tool	Records on matters protected under the EPBC Act, including threatened species and conservation estate	-21.71375, 122.22859; Buffer =10 km

5.2.2.2 Previous Fauna Surveys

Local records from beyond Telfer include Rudall River (Karlamilyi) National Park (100km to the south from databases), Lake Disappointment (200km to the south from databases), Kintyre (80 km to the south, from Bamford Consulting (2007, 2011)), Nifty (70km to the west, Ecological Horizons (2011)) and Joanna Spring (150km north, Graham-Taylor and Bamford 1996).

The survey effort for previous fauna surveys within the Telfer Gold Mine tenement have been focused adjacent to the active mine and have been classified as Level 1 Surveys under the Guidance Statement No. 56 (EPA 2004c) and includes targeted surveys for significant fauna

and opportunistic surveys, which have focused on avifauna. There have been no comprehensive fauna surveys completed; although, there has been:

- Limited systematic trapping for reptiles and mammals;
- Spotlighting for nocturnal reptiles, birds and mammals;
- The use of ultra-sonic detector for bats;
- Hand searching for reptiles; and
- Opportunistic sightings of birds and other animals.

Surveys relevant to the current study (in chronological order) are:

- Hart, Simpson and Associates Pty Ltd (1994) Kintyre Project. Fauna studies 1986 to 1992. Unpubl. report by Hart Simpson and Assoc. Pty Ltd. to Canning Resources
- Hart, Simpson and Associates Pty Ltd (2000) Telfer Satellite Pits, Access and Water Release Area. Ecological Survey. Report Prepared for Newcrest Mining Limited.
- Hart, Simpson and Associates Pty Ltd (2002) Telfer Project Ecological Survey. Report Prepared for Newcrest Mining Limited.
- Ecologia (2003) Telfer Project-Power Supply and Infrastructure Corridor Rare and Priority Fauna and Flora Survey. Report Prepared for Newcrest Mining Limited.
- Syrinx Environmental PL (2004a) Vegetation and Fauna Survey: Proposed Freedom Road Bypass EIA. Report Prepared for Newcrest Mining Limited.
- Syrinx Environmental PL (2004b) Vegetation and Fauna Survey: Proposed Gas Pipeline Bypass EIA. Report Prepared for Newcrest Mining Limited.
- Martinick Bosch Sell Pty Ltd (2006) Vegetation Survey and Targeted Rare Flora and Fauna Search of the Waste Rock Dump, Airstrip and Heap Leach Pad Extension Areas, Nifty Copper Operations, Western Australia. Prepared for Birla (Nifty) Pty Ltd.
- Syrinx Environmental PL (2006) Telfer Waste Dump Expansion Flora and Fauna Survey. Prepared for Newcrest Mining Limited.
- Syrinx Environmental PL (2007) Borefields Expansion Flora and Fauna Survey. Prepared for Newcrest Mining Limited.
- Syrinx Environmental PL (2009) Greater Bilby Survey; Telfer Mine Site. Prepared for Newcrest Mining Limited.
- Ecological Horizons (2011) Birla Nifty Copper Operations. Fauna Monitoring Programme Report November 2011.
- Bamford, M. (2011). Targeted Fauna Survey for the Kintyre Haul Route. Unpublished report to Cameco Australia Pty Ltd by Bamford Consulting Ecologists, Kingsley

5.2.2.3 Nomenclature and taxonomy

As recommended in EPA (2004c), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) Checklist of the Terrestrial Vertebrate Fauna of Western Australia 2008. The authorities used for each vertebrate group were: amphibians (Doughty and Maryan 2009a), reptiles (Doughty and Maryan 2009b), birds (Christidis and Boles 2008), and mammals (How *et al*. 2009). English names of species, where available, are used throughout the text; Latin species names are presented with corresponding English names in the appendices.

5.2.3 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the Optimisation Study Area. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment within the Optimisation Study Area, meant that it was highly unlikely that these species would be present. For example, waterbirds are known from the region and may fly over the Optimisation Study Area, but most would not be expected to rely upon the site as there were no wetlands present; thus most waterbirds were removed from the expected species list. In general, however, species returned by the desktop review process are considered to be potentially present in the project area whether or not they were recorded during field surveys. This is because fauna are highly mobile, often seasonal and frequently cryptic. This is particularly important for significant species that are often rare and hard to find.

Interpretation of species lists generated through the desktop review included assigning an expected status within the Telfer Optimisation Project Area to species of conservation significance. This is particularly important for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive. Observations made during field investigations assisted with this determination. The status categories used are:

- Resident: species with a population permanently present in the Project Area;
- Regular migrant or visitor: species that occur within the Project Area regularly in at least moderate numbers, such as part of annual cycle;
- Irregular Visitor: species that occur within the Project Area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the Project Area in at least moderate numbers and for some time;
- Vagrant: species that occur within the Project Area unpredictably, in small numbers and/or for very brief periods. Therefore, the Project Area is unlikely to be of important for the species;

- Locally extinct: species that has not been recently recorded in the local area despite surveys deemed adequate, and therefore is almost certainly no longer present in the Project Area; and
- A final category, Unlikely, is used where it is considered unlikely that a species is present (e.g. probably outside range or outside environmental preferences), but the possibility cannot be dismissed.

5.2.4 Field investigations

Field investigations are conducted to gather information on the fauna assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment of the project area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the Optimisation Study Area's ecological processes that maintain the fauna. Note that field investigations cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than would generally be undertaken for an EIA process. For example, in an intensive trapping study, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford (2010) has found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling.

Field trips undertaken for fauna investigations over the entire Telfer Optimisation Project Area included:

- 21st – 25th July 2011 for reconnaissance, selection of intensive sampling sites and opportunistic observations;
- 5th – 14th September 2011 for site installation, systematic and opportunistic sampling (all project areas);
- 10th – 19th April 2012 for systematic and opportunistic sampling (O'Callaghan's (part), Satellite, Trotman's and Pit 15); and
- 1st – 7th June 2012 for completion of systematic and opportunistic sampling (O'Callaghan's (part) and Optimisation), and targeted surveying for conservation significant fauna.

Weather conditions during each field trip were typical for the time of year: mild in July and warm to hot in September. During the September field trip, strong easterly winds blew consistently most days.

Except in June 2012, field work in the Optimisation Study Area was undertaken at the same time as investigations of the other project areas: O'Callaghan's, Satellite, Trotman's and Pit 15. Thus, survey effort was divided across the five Study Areas.

Sampling sites within the Optimisation Study Area are detailed in Figure 17. Sampling conducted in the Optimisation Study Area is described in Table 15 and Table 16. The locations of fauna sampling sites are listed in Appendix 10. Details of transects surveyed in the Optimisation Study Area in Table 16 and locations of transects are given on Figure 17.

This sampling procedure is consistent with the transect method outlined by DSEWPaC (2011c) which suggests smaller and more intensive areas be searched. This is not appropriate in the Telfer region where population densities are very low and small search areas would probably miss the species. Similarly, while DSEWPAC (2011c) proposes some trapping techniques for Mulgara, these would only be appropriate for the species if uncertain.

Table 15 Outline of fauna sampling methods

Approach	Description and comments
Systematic trapping for reptiles and small mammals along a transect; each transect with 10 sampling points at 50m intervals. Pitfall trap at each point, funnel and Elliott traps at alternate points	• Pitfall Traps (10): 40cm deep and 28cm diameter, with three 1.5m drift fences. • Funnel Traps (5): 60cm by 20cm by 20cm, placed along one of the drift fences, with a 1.5m extension to the drift fence beyond the funnel trap. • Elliott Traps (5): 30cm by 10cm by 12cm, baited with universal bait. Two transects (Line 10 and Line 11) in Optimisation Study Area, sampled for five nights in each period: 5-14 September 2011 and 1-7 June 2012
Bird census. Based around systematic trapping transects	Birds identified and counted within 25m of trapping transect; thus area 50m wide and 500m long surveyed five times in each field trip
Transect searching for evidence of significant species (burrows, tracks and scats of Bilby, Mulgara and Great Desert Skink). Not carried out systematically in the Optimisation Study Area due to scarcity of suitable habitat, but opportunistic searching for evidence carried out when walking around vicinity of traplines	Transect searching involves walking in a line with team members approximately 50m apart
SRE Invertebrate surveys	Where potential habitats for SREs were located, a targeted search was undertaken as outlined in Guidance Statement No 20 (EPA 2009), using hand foraging methods. In addition, some specimens were found in pitfall traps. Leaf-litter samples were collected in Optimisation and O'Callaghan's Study Areas in June 2012 for sorting in the laboratory. Main taxa targeted were mygalomorph spiders, isopods (slaters) and scorpions

Approach	Description and comments
Bat surveys (Anabat recording system and cave searching). Conducted at suitable locations outside the Telfer Optimisation Project Area to gain a general understanding of bats in the region	Anabat recording on the evening of 10th September 2011 at the Telfer sewage ponds (a location where bats from the region were expected to concentrate). In addition, a cave 5km south-west of the Telfer security gate was visited on 17th April 2012
Motion-sensitive cameras (Bushnell Trophycams)	Set at three locations in September 2011, one location in April 2012 and 12 locations in June 2012. Most cameras set with universal bait (peanut paste, rolled oats and sardines, see Appendix 2). Cameras were set where there was evidence of species such as Mulgara and Bilby
Waterbird counts	Telfer sewage ponds, 10th September 2011. Outside all project areas but visited to gain a general understanding of waterbirds that occur in the area
Searching for reptiles and SRE invertebrates	Turning over spinifex clumps and raking through leaf-litter: two person-hours in September 2011 and 10 hours in April 2012
Spotlighting; vehicle and on foot	8th and 13th September 2011. Effort in the Optimisation Study Area limited to driving slowly along roads on both evenings
Opportunistic observations	Fauna observed opportunistically at all times, such as when travelling between sites. Included following footprint trails of Bilbies
Mole Trenches	To survey for the presence of Marsupial Moles standardised trenches (Benshemesh 2005) were dug to detect the burrows of the species at seven sites (for Study Areas adjacent to the Optimisation Study Area, see Appendix 2)

Table 16 Descriptions of systematic sampling sites in the Telfer Optimisation Study Area

Transect Code	Vegetation and Substrate Association	Vegetation types (Syrinx code)	Soils	Landform
Line 10	Interdunes and plains. A sandy to sandy-loam plain sloping gradually towards several low, rocky hills. Vegetation mixed shrubland with scattered mallee over *Triodia* spp.	4a, 4b, 7a	Red sand and sandy loams. Rocky hills in north-east	Plain and low rocky hills
Line 11	*Acacia* tall shrubland ('Mulga') over mixed shrubs and grasses/annuals on clayey soil. Several species of *Eremophila* dominate understorey	3a	Clay and clayey-loams with some veneer of small rocks/pebbles	Plain with some sheet flow

5.2.5 Summary of survey effort

The survey effort in the Optimisation Study Area and overall Telfer Optimisation Project Area are summarised in Table 17.

Table 17 Summary of Survey Effort

Survey Method	Optimisation Study Area	Telfer Optimisation Project Area
Pitfall traps	200 trap-nights	1100 trap-nights
Funnel traps	100 trap-nights	550 trap-nights
Elliott traps	100 trap-nights	550 trap-nights
Bird census	10 visits to each of 2 transects, 50m by 500m (20 survey events)	10 visits to each of 11 transects, 50m by 500m (110 survey events)
Head-torching	-	Ca. 16 person-hours
Spotlighting (vehicle)	Two evenings	Two evenings
Motion-sensitive cameras	-	16 locations surveyed over 50 camera-nights (O'Callaghan's and Satellite Study Areas)
Bat surveys	-	1 evening with anabat; searching of cave used by bats (outside Optimisation Project Area)
Transect searching (on foot)	Opportunistic only	Ca. 30km
Opportunistic observations	at all times	at all times
Mole Trenches	Conducted in adjacent areas	7 sites totalling 22 trenches
SRE invertebrate samples	Opportunistic searching; one litter sample	Opportunistic searching; three litter samples

5.2.6 Survey limitations

The EPA Guidance Statement 56 (EPA 2004c) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE fauna survey in the Optimisation Study Area in Table 18.

Table 18 Survey limitations as outlined by EPA (2004c)

Aspect	Constraint	Comment
Level of survey.	No	Level 2 (reconnaissance survey, general survey and targeted survey to investigate significant species).
Competency/experience of the consultant(s) carrying out the survey.	No	The authors have had intensive experience in conducting fauna assessments in the region.
Scope (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?).	Yes	Small vertebrates sampled adequately. Limited sampling of SRE invertebrates due to seasonal conditions (hot and dry) and lack of likely sustaining habitat. Survey work was conducted over three survey periods with an emphasis on searching for species of conservation significance.
Proportion of fauna identified, recorded and/or collected.	No	All vertebrate fauna observed were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	No	Sources include previous reports on the fauna of the region (Hart, Simpson and Assoc. BCE) and databases (Naturemap, BA, DEC and EPBC).
The proportion of the task achieved and further work which might be needed.	No	Level 2 Survey complete.
Timing/weather/season/cycle.	Yes	Sampling in September affected by hot, dry and windy conditions, but generally adequate.
Disturbances (e.g. Fire, flood, accidental human intervention etc.), which affected results of survey.	No	No disturbances affected this survey.
Intensity.	No	Survey intensity adequate to record conservation significant fauna and habitats. Trapping program supplemented by extensive targeted searching for conservation significant fauna during April and June 2012.
Completeness (e.g. was relevant area fully surveyed).	No	Relevant area was visited.
Resources (e.g. degree of expertise available in animal identification to taxon level).	No	All vertebrate species identified to species (sometime sub-species) level. All staff are competent to conduct animal identification to taxon level.
Remoteness and/or access problems.	No	No difficulties with access were encountered.
Availability of contextual (e.g. biogeographic) information on the region.	Yes	Contextual information somewhat limited but environments present are typical of vast areas of inland Australia, so records from large areas can be taken as representative.

5.3 RESULTS

5.3.1 Fauna Assemblage

The expected assemblage is drawn from a variety of sources and only a small proportion is confirmed as present in the Optimisation Study Area, with a larger proportion (about half of all species) confirmed across the entire Optimisation Project Area. A substantial field effort is required to conclude species are not present, and therefore, the precautionary approach has been taken and species are assumed to be present (based on the results of the desktop review and habitat assessment) unless there is good evidence, such as lack of suitable habitat, the species would not utilise the Optimisation Study Area. Within the Telfer region, the Optimisation Study Area is unlikely to support as many species as the region as a whole, but fauna species are mobile and assemblages are dynamic.

Key features of the assemblage are:

- Uniqueness: The assemblage has an unusual composition reflecting its position on the transition between the Little Sandy Desert and Great Sandy Desert bioregions, and close to the Pilbara bioregion. It thus has elements of the desert bioregions and the Pilbara, as well as widespread species. Species associated with the sandy desert environment are well-represented. Although an unusual assemblage, it is not restricted as the same assemblage can be expected along the extensive Pilbara/Deserts transition. The assemblage includes a range of introduced species typical for the region, but the presence of the Fox (as discussed later in this report) is of interest as this species is scarce in the Great Sandy Desert to the north (Burbidge and McKenzie 1983; Graham-Taylor and Bamford 1996).
- Completeness: The assemblage is substantially complete but lacks some medium-sized ("critical weight range") mammals (see extinct species list, Appendix 8, Table 31). These have declined across much of central, inland and southern Australia due to factors such as predation by feral species (particularly the Red Fox) and altered fire regimes (Burbidge and McKenzie 1989).
- Richness: The assemblage is moderately rich, especially for reptiles. Note that some of the listed species may not be present, or may not be present regularly, but the variety of habitats present within the Optimisation Study Area does suggest the potential for a rich assemblage to be present.

As a fauna value, the most important features of the assemblage are that it has elements of both the Pilbara and the two Desert bioregions.

The desktop study identified 275 vertebrate fauna species as potentially occurring in the Optimisation Study Area (Table 19, Appendix 8) of which 163 were recorded across the entire Telfer Optimisation Project, and 57 within the Optimisation Study Area.

The full species list is provided in Appendix 8. The composition of vertebrate fauna assemblages recorded during 2011 field investigations is listed in Table 19. Species extinct in the region are listed separately under Appendix 8, as are species returned by databases but for which no suitable habitat within the project area is available. For example, several waterbird species were present in databases and were observed on the Telfer sewage ponds, but there is no suitable habitat for waterbirds in the Optimisation Study Area. The assemblage includes 27 species of conservation significance.

Table 19 Composition of vertebrate fauna assemblage expected to occur in the Telfer Optimisation Area, and numbers of species recorded during field investigations

Taxon	Number of species expected	Number Recorded throughout Telfer Optimisation Project Area	Number Recorded Optimisation Study Area	Significant fauna expected		
				CS1	CS1	CS1
Frogs	7	2	0	-	-	-
Reptiles	95	53	16	2	1	-
Birds	129	86	32	8	4	1
Mammals	38	17	7	6	3	2
Introduced Mammals	6	5	2	-	-	-
Total	**275**	**163**	**57**	**16**	**8**	**3**

5.3.2 Species of conservation significance

Details on species of conservation significance are presented in Table 20 with additional information on each species provided in Sections 5.3.2.1 to 5.3.2.3-. The list includes three reptile species, at least 13 bird species but with the potential for occasional visits by additional migratory waterbirds, and 11 mammal species.

Table 20 Conservation significant fauna species with potential to occur in the Optimisation Study Area

Species		Reason For Significance				Comments			
		EPBC Act	WA Wildlife Conservation Act 1950	DEC Priority	Other	Recorded Current Project	Suitable Habitat in Survey Area	Expected Status in Survey Area	Local Record
CONSERVATION SIGNIFICANCE 1 (CS1)									
Liopholis kintorei	Great Desert Skink	Vulnerable	Schedule 1				Possibly	Unlikely	Rudall River NP
Aspidites ramsayi	Woma		Schedule 4			**Recorded**	Yes	Resident	Caught September 2011
Polytelis alexandrae	Princess Parrot	Vulnerable		P4			Yes	Irregular Visitor	Well 23 Canning Stock Route
Pezoporus occidentalis	Night Parrot	Critically Endangered	Schedule 1				Possibly	Irregular Visitor	Unknown
Falco peregrinus	Peregrine Falcon		Schedule 4				Yes	Resident	Telfer
Apus pacificus	Fork-tailed Swift	Migratory					Yes	Regular Visitor	Telfer
Merops ornatus	Rainbow Bee-eater	Migratory				**Recorded**	Yes	Regular Visitor	Recorded September 2011
Dasyurus hallucatus	Northern Quoll	Endangered	Schedule 1				Yes	Unlikely	Kintyre
Macrotis lagotis	Bilby	Vulnerable	Schedule 1			**Recorded**	Yes	Resident	Recorded September 2011; also Kintyre and Nifty areas

Species	Reason For Significance				Comments			
	EPBC Act	WA Wildlife Conservation Act 1950	DEC Priority	Other	Recorded Current Project	Suitable Habitat in Survey Area	Expected Status in Survey Area	Local Record
Notoryctes caurinus Northern Marsupial Mole	Endangered	Schedule 1				Yes	Resident	Telfer and Nifty areas
Dasycercus cristicauda Crest-tailed Mulgara	Vulnerable					Yes	Resident	Kintyre and Nifty
Dasycercus blythi Brush-tailed Mulgara			P4					
Rhinonicteris aurantius Orange Leaf-nosed Bat	Vulnerable	Schedule 1				Possibly, not for roosting	Irregular visitor	Kintyre
CONSERVATION SIGNIFICANCE 2 (CS2)								
Lerista macropisthopus remota skink			P2			Possibly	Unlikely	70 km south Karlamilyi
Falco hypoleucos Grey Falcon			P4			Yes	Resident	Kintyre
Ardeotis australis Australian Bustard			P4		**Recorded**	Yes	Regular Visitor	Telfer
Burhinus grallarius Bush Stone-curlew			P4			Yes	Resident/ Regular Visitor	Rudall River NP
Amytornis striatus Striated Grasswren			P4			Yes	Resident	Lake Disappointment
Sminthopsis longicaudata Long-tailed Dunnart			P4			Possibly	Resident	Kintyre
Macroderma gigas Ghost Bat			P4			Possibly, not of roosting	Irregular Visitor	Kintyre and Nifty
Leggadina lakedownensis Lakeland Downs Mouse			P4			Possibly	Resident	Rudall River NP

Species	Reason For Significance				Comments			
	EPBC Act	WA Wildlife Conservation Act 1950	DEC Priority	Other	Recorded Current Project	Suitable Habitat in Survey Area	Expected Status in Survey Area	Local Record
CONSERVATION SIGNIFICANCE 3 (CS3)								
Stipiturus ruficeps Rufous-crowned Emu-wren				CS3		Yes	Resident	Rudall River NP
Trichosurus vulpecula Brush tailed Possum				CS3		Yes	Unlikely	Joanna Spring (Great Sandy Desert)
Antechinomys laniger Kultarr				CS3		Yes	Resident	Kintyre
Morethia ruficauda ruficauda Firetail Skink (northern subspecies)				CS3	**Recorded**	Yes	Resident	Caught in September 2011

CS1: Listed under legislation, CS2: Listed as priority by the DEC. CS3: Population locally significant.

5.3.2.1 Conservation Significance Level 1

Great Desert Skink. Not recorded either in the Optimisation Study Area or in other project areas despite searching and burrows of this species typically being quite conspicuous. Species may therefore be locally extinct, or region may be just outside its natural range. If present, it is associated with sandy soils, including alongside dunes.

Woma. One specimen found in Trotman's (September 2011) and one between existing mine areas and O'Callaghan's (April 2012), so the species is expected to be resident in the Optimisation Study Area. Generally the species is associated with sandy to sandy-loam soils; although the specimen in Trotman's was near a calcrete rise.

Princess Parrot. Expected only as an occasional visitor as Optimisation Study Area and the entire Telfer region lacks critical nesting habitat (large trees with hollows).

Night Parrot. An enigmatic and unpredictable species that has to be assumed to be an occasional visitor as there are some records from the general region and it is known to occur in spinifex country.

Peregrine Falcon. Expected only as an occasional visitor as the Optimisation Study Area and the entire Telfer region lacks critical nesting habitat (large trees with hollows and/or cliffs).

Eastern Great Egret. A waterbird classed as migratory that is likely to be a regular visitor in small numbers to wetlands in the region. Individual birds may thus visit flooded borrow pits. Several other migratory waterbirds (Common Greenshank, Common Sandpiper) were observed in the Telfer Sewage ponds in September 2011, and thus may also visit flooded borrow pits in small numbers.

Fork-tailed Swift. An aerial species largely independent of terrestrial environments but likely to be a regular migrant in the Telfer region and to over-fly the Optimisation Study Area.

Rainbow Bee-eater. A regular, breeding visitor to the region; likely to construct nesting burrows nest on the sides of roads.

Northern Quoll. Considered unlikely to be present, and could even be locally extinct, but species was almost certainly present historically and suitable habitat, especially rocky hills, is available within the Optimisation Study Area.

Bilby. Recorded in some of the other Study Areas within the Telfer Optimisation Project Area including O'Callaghan's, and there are recent records (Syrinx Environmental PL 2006) of the species around Telfer, close to the Optimisation Study Area. The species appears to be present in low numbers throughout the region; therefore individuals are certain to make use

of the Optimisation Study Area. Suitable habitat is present through sandy to sandy-loam soils.

Northern Marsupial Mole. Recorded during recent surveys in adjacent Study Areas within the Telfer Optimisation Project Area (e.g. O'Callaghan's). The species is known from nearby and suitable habitat (sandy soils, especially along the edge of dunes) is present regionally. Dunes are very limited in extent in the Optimisation Study Area, but some dunes are present and there is extensive sandy soil in the north. Therefore, the species must be assumed to be present, albeit probably in low numbers and with areas of more favourable habitat outside the Optimisation Study Area.

Crest-tailed and Brush-tailed Mulgara. There is uncertainty regarding the distribution of the Crest-tailed Mulgara and the similar Brush-tailed Mulgara. For most of the last 30 years only the Crest-tailed Mulgara was recognised. More recently, Woolley (2005, 2006) re-assigned the species to the Brush-tailed Mulgara and Crest-tailed Mulgara. The historical taxonomic confusion means that the distribution of the two Mulgara species is unclear (Woolley 2005, 2008) and even museum specimens need to be reviewed. However, both species have suffered significant population reduction and fragmentation over the past 80 years (Woolley, 2008). The Brush-tailed Mulgara is listed as Priority 4 by the DEC in WA, but is not recognised under EPBC legislation (whereas the Crest-tailed Mulgara is). Therefore, under the current EPBC list, any Mulgara found in WA is considered to be *D. cristicauda* by DSEWPaC.

There may be a certain "boom and bust" nature to the lifestyle of the Mulgara, with populations contracting to core habitat during poor seasons (such as low rainfall) for resources, and expanding rapidly when the conditions improve (Woolley 1995). Further, Woolley (1995) cites examples of local populations disappearing for several years before being re-invaded and repopulated by Mulgara in subsequent years.

Active and recently-active burrows of the Mulgara (species uncertain) were found in O'Callaghan's Study Area in April and June 2012. The Mulgara has also been recorded at low densities about 30km to the south-west, between Telfer and Kintyre (Bamford 2011). It favours sandplains of spinifex and is affected by too-frequent fire. It therefore must be assumed to be present, or present at times, in the Optimisation Study Area.

Orange Leaf-nosed Bat. No critical roosting habitat (deep caves with high temperatures and humidity) in the Optimisation Study or region, but the possibility exists of colonies nearby, such as in rocky hills to the south, and therefore individuals may be occasional foraging visitors to the Optimisation Study Area.

5.3.2.2 Conservation Significance Level 2

Skink *Lerista macropisthopus remota*. The range of this species may not extend to the Telfer region. Therefore considered unlikely to be present but possibility cannot be dismissed. Reported to shelter under leaf-litter around bushes and trees (Wilson and Swan, 2003), which is a very widespread habitat.

Grey Falcon. Expected only as an occasional visitor to the Telfer Area, although the Telfer region lacks critical nesting habitat (large trees with hollows and/or cliffs).

Australian Bustard. Recorded regularly in the Optimisation Study Area and other project areas. Common in the region but can vary in abundance annually.

Bush Stone-curlew. Probably occurs throughout the region in very low numbers and birds probably move around in response to rainfall. In the Pilbara, usually associated with trees along seasonal watercourses, and a pair found at Kintyre in such a location in 2010 (Bamford 2011).

Striated Grasswren. The desert sub-species (*Amytornis striatus striatus*) is listed as priority but the Pilbara sub-species (*Amytornis striatus whitei*) is considered secure. The sub-species that may be present in the Telfer region is uncertain but could occur as a resident anywhere there is tall, long-unburnt spinifex. However, the species was not found during field surveys.

Long-tailed Dunnart. Associated with rocky areas and therefore could be a resident in suitable habitat in the Optimisation Study Area.

Ghost Bat. No critical roosting habitat (deep caves with high temperatures and humidity) in the Telfer Optimisation Study Area or Project Area, but small caves present nearby and suitable caves may occur in Karlamilyi National Park. Therefore, individuals may be occasional foraging visitors to the Optimisation Study Area. The species has been recorded at Nifty 70km to the west (Ecological Horizons, 2011).

Lakelands Downs Mouse. Associated with spinifex and shrubs on cracking clay soils (pers. obs.; Biota 2005) so habitat may be limited in the Telfer region generally and the Optimisation Study Area specifically, but habitat data are limited. The species is also highly variable in abundance, so can be absent for some years then suddenly abundant (Covacevich 1995).

5.3.2.3 Conservation Significance Level 3

Rufous-crowned Emu-wren. Could occur as a resident anywhere there is tall, long-unburnt spinifex. This species is rarely-encountered and any population should be considered locally significant.

Brush-tailed Possum. Although a common species in many parts of Australia, the Brush-tailed Possum is rarely encountered in the Pilbara and Great Sandy Desert where it appears to have declined; therefore surviving populations are of interest. In the Pilbara they have been found amongst trees along seasonal watercourses (M. Bamford, pers. obs.) and in the Great Sandy Desert amongst scattered trees along dunes (Graham-Taylor and Bamford 1996). While it is considered unlikely they occur in the Optimisation Study Area, there is some suitable habitat in the vicinity.

Kultarr. A species that is "generally uncommon, patchily distributed....and populations fluctuate..." (Menkhorst and Knight 2001). Suitable habitat (shrubs and spinifex on sandplain) occurs in the Optimisation Study Area so the species may be present, although population fluctuations can mean that it is undetectable much of the time.

Firetail Skink (northern sub-species). The Firetail Skink is a common and widespread species but the animals caught in the Optimisation Study Area and other project areas were of the northern (Kimberley and northern Great Sandy Desert) sub-species (*Morethia ruficauda ruficauda*), not the Pilbara sub-species (*Morethia ruficauda exquisita*). Given the proximity of the Pilbara region this is unexpected, especially as Telfer is listed by Storr *et al.* (1999) as the northern limit of the Pilbara sub-species. The Telfer animals may represent an outlying population, or even a location where the two sub-species are sympatric. One individual caught (at Pit 15) had intermediate characteristics, suggesting that the general region may be a hybrid zone between the two sub-species.

5.3.3 Short Range Endemics (SRE)

SRE invertebrates are considered of Conservation Significance Level 3 as they have no formal level of recognition. Potential SRE species are the scorpions *Lychas sp. nov.* "Telfer" and *Urodacus* sp. nov. "Telfer", and the isopod *Buddelundia* sp. nov. 58. The trapdoor spider *Aname* sp. indet. may also be known only from Telfer; although the identification was based on a female specimen that lacks some characters used to confirm identification. Other scorpions and mygalomorph spiders collected are widespread (Refer to Appendix 11).

The two scorpions, the isopod and the trapdoor spider are potential SRE species because they are currently known only from the specimens collected at Telfer, but this is probably an artefact of inadequate regional sampling. Furthermore, all four species came from sandy soils which are regionally very extensive. *Urodacus* sp. nov. "Telfer" was collected in all

Study Areas including the Optimisation Study Area, while the remaining species were recorded in sandy soils at some of the other Study Areas. No SRE species were found in litter samples collected in the Mulga VSA. With the possible exception of this isolated patch of vegetation, The Optimisation Study Area does not have the characteristics typical of environments where SRE invertebrates may evolve.

5.3.4 Summary of species of conservation significance

Species of greatest interest with respect to impacts from the Optimisation Study Area are those of high significance, that were present or are expected to be present, and for which habitat is regionally limited or which are otherwise vulnerable to impacts. There are few such species of great interest as all significant species were associated with regionally widespread VSAs such as dunes, interdune plains or rocky hills, and the majority were expected to be present only as visitors. Species that may require further consideration and management are:

- Bilby. Present regionally in low numbers, recorded nearby within the O'Callaghan's Study Area and therefore highly likely that individuals will utilise the Optimisation Study Area. The small population makes the Bilby vulnerable to impacts.
- Mulgara. Present regionally in low numbers, recorded in areas adjacent to the Optimisation Study Area and therefore highly likely that individuals will utilise the Optimisation Study Area. The dynamic ecology of the species means that it may disappear and then reappear over periods of several years.
- Northern Marsupial Mole. Present regionally and recorded from adjacent Study Areas. Generally restricted to sand dune habitat, which is present but limited in extent within the Optimisation Study Area.
- SRE invertebrates. The potential for SRE invertebrates appears to be low, but inadequate regional sampling makes interpretation of specimens difficult.

Note that a number of the species are sensitive to ecological processes such as fire and feral predators, which are discussed in Section 5.3.7.

5.3.5 Vegetation and Substrate Associations (VSAs)

Within the Optimisation Study Area, interdunes and plains are very well-represented, with scattered rocky hills, a very small area of calcrete rise, a distinctive patch of Mulga woodland and a few dunes in the south (Figure 17). There is also one flooded quarry/borrow pit that contained water at the time of the September survey, and many roads and tracks forming disturbed areas. Dunes and calcrete rises are much better represented outside the Optimisation Study Area, but the Mulga woodland is the only example of this VSA in the

region. Figure 15 and Figure 16 provide examples of the main VSAs in the Optimisation Study Area. VSAs that can be recognised across the region (all Study Areas visited) are:

Interdunes and plains. Highly variable and complex vegetation and soils. Vegetation ranges from eucalypt open woodland and Mallee to Acacia shrublands, but with *Triodia* spp. as a major understorey component. Soils range from heavy, compacted sand to loamy-clay. Vegetation Associations 1a, 1b, 4a, 4b, 4c, 5a, 6c, 6b, 6f.

- *Conservation significance*: Very extensive regionally. Several fauna species of high conservation significance are closely associated with sandy and sandy-loam soils of this VSA, including Bilby, Mulgara (both species) and Great Desert Skink. Shrubs in the VSA provide seasonal nectar sources.

Low rocky hills surrounded by sandy and gravelly soils. *Acacia* tall shrublands, often with *Grevillea wickhamii*, sometimes with open woodland of eucalypts, over *Triodia* spp.. Includes some short drainage lines. Vegetation Associations 1b, 3b, 4a, 5b, 6a, 6f, 7a.

- *Conservation significance*: Very extensive regionally but more typical of the Pilbara than the Desert bioregions. The rocky substrate means this VSA is likely to support a different suite of reptiles and small mammals from sand dunes and plains, thus contributing to locally high species richness. Low rocky hills may also be sufficiently developed to provide habitat for rock-haunting specialists among the reptiles and small mammals. *Grevillea wickhamii* is an important seasonal nectar source for nectarivorous birds.

Undulating calcrete rises. These often have a sandy veneer but support shrublands and heath of plant species associated with rocky soils, such as *Grevillea wickhamii,* and *Triodia* spp. usually well-represented. Vegetation Association 4d.

- *Conservation significance*: Very extensive regionally but more typical of the Pilbara than the Desert bioregions. The rocky substrate means this VSA is likely to support a different suite of reptiles and small mammals from sand dunes and plains, thus contributing to local high species richness. *Grevillea wickhamii* is an important seasonal nectar source for nectarivorous birds.

Mulga-dominated plain. A tall shrubland/woodland of *Acacia* over mixed shrubs and grasses/annuals on clayey soil. Several species of *Eremophila* dominate understorey. Vegetation Association 3a.

- *Conservation significance*: Regionally present only in a small part of the Optimisation Study Area. The location of the next nearest example of this VSA is not known, so this example may be a small isolate of Mulga VSA that is extensive in the Fortescue Valley north of Newman. The Mulga VSA is likely to be locally important for fauna as it will provide a distinct suite of seed-bearing and flowering plants not present elsewhere. It is

too small to support isolated vertebrate fauna populations, but may have isolated invertebrate fauna.

Sand dunes. These support mixed shrubs and *Triodia* spp. with eucalypt open woodland along lower slopes. Vegetation associations 6d, 4e

- *Conservation significance*: Very extensive regionally although Telfer region is on the edge of the distribution of this VSA. Eucalypts along the lower slopes of dunes are often the only moderately large trees in the landscape, so are locally significant for fauna. Marsupial Moles rely upon dunal systems.

Wetlands. The only wetlands present are artificial: the Telfer village sewage ponds, tailings dams and some borrow pits that flood after rain.

- *Conservation significance*: Although artificial, these wetlands provide "stepping stones" for the movement of waterbirds across the usually arid landscape, and the sewage ponds were found to support large numbers of waterbirds. Artificial wetlands can also attract fauna to the water supply and make some species over-abundant.

Disturbed areas. These include roads, mine pits, buildings and clearings, and also gardens. Disturbed areas may therefore lack vegetation, but can also provide a locally novel vegetation type.

- *Conservation significance*: Disturbed areas have low conservation value, although some species of reptiles and birds (e.g. the CS1 Rainbow Bee-eater) will preferentially construct nesting burrows in disturbed areas. Gardens can also attract fauna and make some species over-abundant, which can adversely affect other species.



Figure 15 Sampling site 10, illustrating a sandy plain with shrubs and Spinifex (*Triodia* spp.), and a low rocky hill on the background left



Figure 16 Sampling site 11, Mulga with, in this location, a mixed understorey of *Acacia* and *Eremophila* over *Triodia*

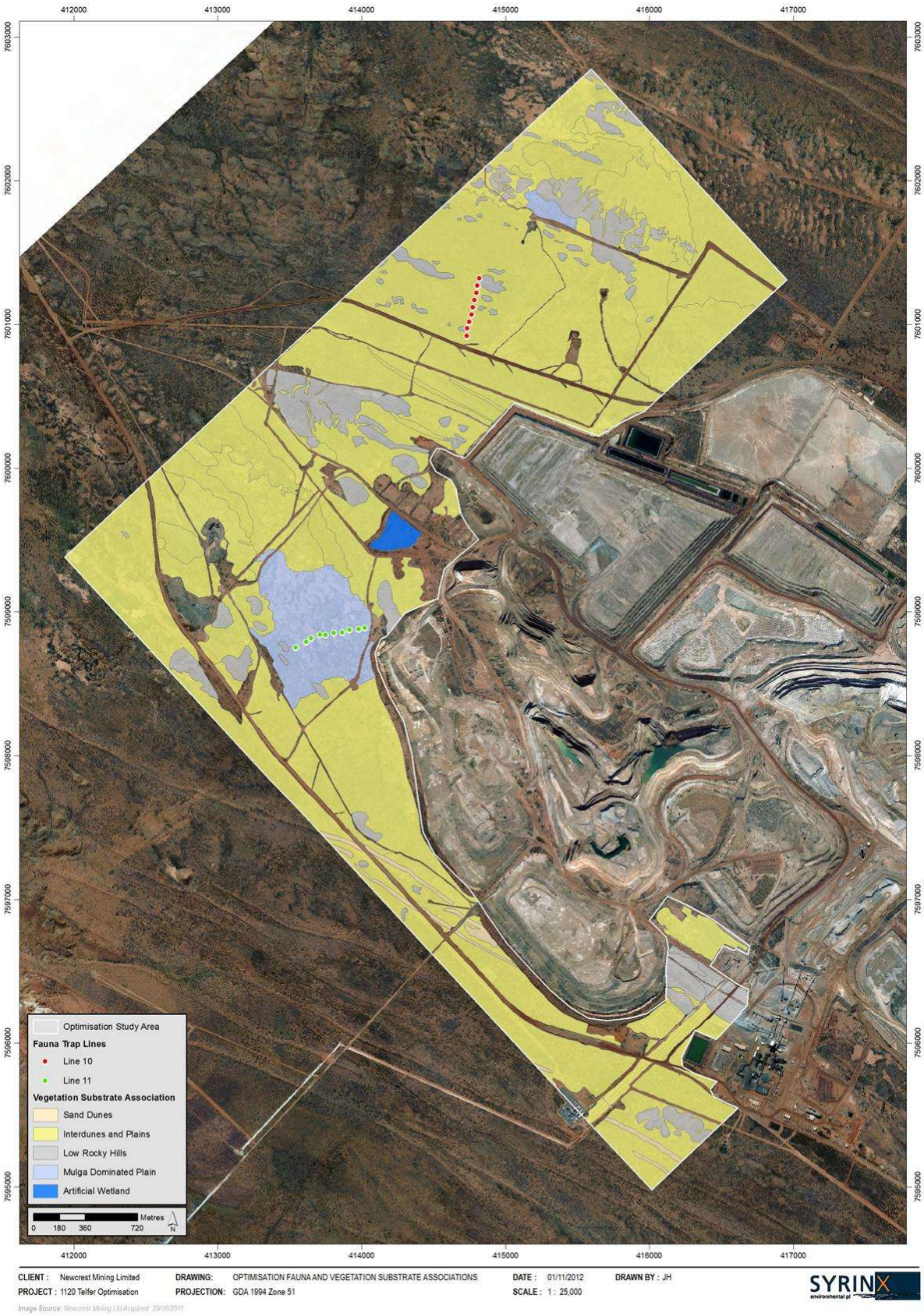


Figure 17 VSAs of Optimisation Study Area with fauna survey locations

5.3.6 Patterns of Biodiversity

Systematic sampling in the Optimisation Study Area was limited to two sampling sites (Figure 17). Captures (reptiles and small mammals) and census (birds) results are presented in Table 21 and Table 23. Table 22 and Table 24 provide a comparison with abundance and species richness with other Study Areas in the region. Note that Site 10 was in interdunes and plains, while Site 11 was in Mulga woodland (Table 19).

Sites 10 and 11 had similar numbers of captures and species or reptiles and small mammals, with most species in very low numbers (Table 21). An exception was the Sandy Inland Mouse, which was abundant in sites 10 and 11 in June 2012. This was probably a seasonal effect. Despite this, sites 10 and 11 had similar numbers of captures and numbers of species of reptiles and small mammals when compared with the remaining Study Areas (Table 22).

Sites 10 and 11 had different bird assemblages (Table 23) reflecting differences in vegetation. Granivores (including Brown Quail, Diamond Dove, Spinifex Pigeon and Zebra Finch) were especially abundant at site 11, being absent or only in small numbers at site 10. Some of these species, such as the Diamond Dove, displayed extreme seasonal variation in abundance. Most nectarivores were more abundant at site 11 (White-plumed, Pied, Black and Brown Honeyeaters), but the Grey-headed Honeyeater was more abundant at site 10. Across all sites (Table 24), site 11 was notable for the second highest number of records (553) during September 2011 and the highest number of species (15). Furthermore, the site with the highest number of records in September 2011 (Site 1 in the Satellite Study Area) had very large numbers of the aerial Masked Woodswallow (845 records out of 1173 records), and of Budgerigars flying through the site (270 records). Site 11 was therefore by far the most important site in terms of usage by birds, particularly granivores and nectarivores, in September. However in the 2012 surveys, sites 10 and 11 in the Optimisation Study Area did not have exceptional numbers of birds.

Table 21 Numbers of captures of reptiles and small mammals in the two sampling sites in the Optimisation Study Area, September 2011 and June 2012

Species	2011 Sampling sites		2012 Sampling sites	
	10	11	10	11
Canegrass Dragon *Diporiphora winneckei*		1		
Bearded Dragon *Pogona minor*	1	2		
Wellington's Spiny-tailed Gecko *Strophurus wellingtonae*		1		
Long-nosed Delma *Delma nasuta*	1			
Skink *Ctenotus helenae*	2	3		1
Leopard Skink *Ctenotus pantherinus*	4	4	7	3
Skink *Ctenotus piankai*	1			
Skink *Lerista bipes*	6		4	1
Dwarf Skink *Menetia greyii*		2		1
Firetail Skink *Morethia ruficauda*	3	2		
Ornate soil-crevice skink *Notoscincus ornatus*			1	
Spiny-tailed Goanna *Varanus acanthurus*	1			
Yellow-faced Whipsnake *Demansia psammophis*				1
Western Brown Snake *Pseudonaja mengdeni*				1
Little Red Kaluta *Dasykaluta rosamondae*			1	
Lesser Hairy-footed Dunnart *Sminthopsis youngsoni*	1		2	2
Planigale sp. 2 (Gibson and *McKenzie* 2009)	1			
House Mouse *Mus musculus*		3	2	3
Desert Mouse *Pseudomys desertor*			1	
Sandy Inland Mouse *Pseudomys hermannsburgensis*	7	5	30	18
Number of captures all species	28	23	48	31
Number of reptile captures (species)	19 (8)	15 (7)	12 (3)	8 (6)
Number of small mammal captures (species)	9 (3)	8 (2)	36 (5)	23 (3)
Total number of species	11	9	8	9

Table 22 Comparison of numbers of captures of reptiles and small mammals between the Optimisation Study Area and other Study Areas in the Telfer Optimisation Project Area; September 2011

Study Area	Site Number	Total Captures 2011	Total Captures 2012	Total Number of reptile captures (species)	Total Number of small mammal captures (species)	Total species
Satellite	1	19	38	56 (18)	1 (1)	19
	2	21	51	53 (17)	19 (4)	21
Trotman's	3	21	27	34 (12)	14 (1)	13
	4	28	18	19 (7)	27 (4)	11
	5	31	29	32 (9)	28 (3)	12
O'Callaghan's	6	32	55	49 (16)	38 (5)	21
	7	19	40	12 (5)	47 (3)	8
Pit 15	8	14	38	45 (16)	7 (3)	19
	9	21	54	65 (13)	10 (3)	16
Telfer Optimisation Study Area	**10**	**28**	**48**	**32 (9)**	**45 (6)**	**15**
	11	**23**	**31**	**23 (10)**	**31 (3)**	**13**

Table 23 Numbers of records (cumulative count across five mornings) of birds in the two sampling sites in the Optimisation Study Area, September 2011 and June 2012

Species	2011 Sampling		2012 Sampling	
	10	11	10	11
Brown Quail	0	17	0	0
Crested Pigeon	0	0	2	0
Diamond Dove	1	413	0	0
Spinifex Pigeon	0	7	0	5
Little Button-quail	1	3	0	0
Brown Falcon	0	0	1	0
Nankeen Kestrel	0	1	0	0

Species	2011 Sampling		2012 Sampling	
	10	11	10	11
Budgerigar	4	1	11	0
Rainbow Bee-eater	0	0	0	7
White-winged Fairy-wren	0	4	0	0
White-plumed Honeyeater	0	7	1	4
Yellow-throated Miner	1	0	0	0
Grey-headed Honeyeater	10	0	29	0
Spiny-cheeked Honeyeater	2	0	1	3
Singing Honeyeater	10	11	12	14
Brown Honeyeater	0	2	0	0
Black Honeyeater	1	3	0	2
Pied Honeyeater	0	3	6	0
Crimson Chat	1	0	0	0
Rufous Whistler	0	1	0	0
Zebra Finch	0	78	3	0
Black-faced Cuckoo Shrike	0	0	1	0
White-winged Triller	0	2	0	0
Willie Wagtail	0	0	0	1
Black-faced Woodswallow	0	0	9	0
Masked Woodswallow	1	0	0	0
Number of records	**32**	**553**	**76**	**36**
Number of species	**10**	**15**	**11**	**7**

Table 24 Comparison of numbers of bird census records between the Optimisation Study Area and other Study Areas in the Telfer Optimisation Project Area; September 2011 and June 2012

Project Area	Site	2011 Number of records	2011 Number of species	2012 Number of records	2012 Number of species
Satellite	1	1173	8	43	7
	2	42	10	98	13
Trotman's	3	41	8	36	6
	4	38	5	24	7
	5	37	6	204	13
O'Callaghan's	6	77	10	110	12
	7	26	9	216	9
Pit 15	8	19	5	190	13
	9	59	7	101	15
Telfer Optimisation Study Area	**10**	**32**	**10**	**76**	**11**
	11	**553**	**15**	**36**	**7**

5.3.7 Key Ecological Processes

The fauna assemblage of a region is to some extent determined by ecological processes, and the interaction of a development project with ecological processes can be a major source of impact on fauna. Major ecological processes currently acting upon and moulding the fauna assemblage are discussed below.

5.3.7.1 Local Hydrology

While there is little surface drainage due to low relief and often very sandy soils, there are short drainage lines off some of the rocky hills which create thickets of vegetation. The Optimisation Study Area includes a borrow pit that contained shallow water in September 2011, probably from surface runoff. The Mulga VSA was in heavy soils and may be reliant on localised hydrological patterns.

5.3.7.2 Fire

Fire is an integral part of regional ecosystems, and is recognised as a factor in the dynamics of fauna populations in Western Australia (Bamford and Roberts 2003); it is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species, notably in the arid zone where the fire regime has been profoundly altered since European settlement (Burbidge and McKenzie 1989). In terms of conservation management, it is not fire *per se* but the fire regime that is important, with evidence that infrequent, extensive and intense fires adversely affect biodiversity, whereas frequent fires that cover small areas and are variable in both season and intensity can enhance biodiversity. Note that fire regime can interact with feral species in providing greater access to habitats and native fauna hence impacting on native fauna populations.

Fire regimes post European settlement may have contributed to the low population of the Bilby and Mulgara, and possibly the local extinction of the Great Desert Skink. The Striated Grasswren and Rufous-crowned Emu-wren are also sensitive to altered fire regimes.

5.3.7.3 Feral predators and interactions with over-abundant native species

Feral predators are a major factor in the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1989), and there is growing evidence that over-abundant native species can adversely affect biodiversity (e.g. Harrington 2002). Within the Telfer region, the Dingo is very common and probably over-abundant close to the village. Tracks of Cats were abundant and the tracks and scat of one Fox were found. These are likely to affect local fauna populations, and the appearance of a Fox is of particular concern. Ecological Horizons (2011) noted that a decline in Mulgara and Bilbies around Nifty appears to have coincided with an increase in the abundance of Foxes and Cats. The effect of over-abundant Galahs around the Telfer village on other wildlife is unknown.

5.4 DISCUSSION

5.4.1 Summary of fauna values

Fauna values in the Telfer region and the Optimisation Study Area can be summarised as follows:

5.4.1.1 Fauna assemblage

The fauna assemblage in the Optimisation Study Area is rich and substantially intact except for the loss of some, mostly medium-sized, mammal species. It is distinctive in that it contains elements from both the Pilbara, Little Sandy Desert and Great Sandy Desert

regions. The Optimisation Study Area is likely to contain only a subset of the fauna assemblage predicted for the entire region, but fauna are mobile and an assemblage can change over time.

5.4.1.2 Species of conservation significance

This list includes three reptile species, at least 13 bird species (but with the potential for occasional visits by additional migratory waterbirds), and ten mammal species. The status with respect to significant invertebrates is uncertain; two scorpions, an isopod and a trapdoor spider may be SREs, but they were found in widespread environments (sandy soils) so the lack of previous collections is probably an artefact of inadequate sampling. Most significant species are widespread and occur in very extensive regional landscapes, with interdune sand-plains being important for a number of species. Within the Optimisation Study Area, the Bilby and Mulgara (*Dasycercus* sp.) are certain to be present (based on nearby records). The Northern Marsupial Mole may also occur within the sand dune systems although these are minor within the Optimisation Study Area. Individuals of the Bilby and Mulgara are mobile and populations can fluctuate, so even if not recorded at one time, these species may be present later.

5.4.1.3 Short Range Endemics (SRE)

SRE invertebrates are considered of Conservation Significance Level 3 as they have no formal level of recognition. Potential SRE species are the scorpions *Lychas* sp. nov. "Telfer" and *Urodacus* sp. nov. "Telfer", and the isopod *Buddelundia* sp. nov. 58. The trapdoor spider *Aname* sp. indet. may also be known only from Telfer, although the identification was based on a female specimen that lacks some characters used to confirm identification. Other scorpions and mygalomorph spiders collected are widespread.

The two scorpions, the isopod and the trapdoor spider are potential SRE species because they are currently known only from the specimens collected at Telfer, but this is probably an artefact of inadequate regional sampling. Furthermore, all four species came from sandy soils which are regionally very extensive. *Urodacus* sp. nov. "Telfer" was collected in all Study Areas including the Optimisation Study Area, while the remaining species were recorded in sandy soils at some of the other Study Areas. No SRE species were found in litter samples collected in the Mulga VSA. With the possible exception of this isolated patch of vegetation, The Optimisation Study Area does not have the characteristics typical of environments where SRE invertebrates may evolve.

5.4.1.4 Vegetation and Substrate Associations

Most VSAs are regionally widespread. The Optimisation Study Area is dominated by the interdune sandplain VSA, but includes an area of Mulga woodland that appears to be the only regional example of this VSA (Figure 17).

5.4.1.5 Patterns of biodiversity

The key finding of studies into patterns of biodiversity was the high abundance and richness of bird species in the Mulga woodland within the Optimisation Study Area.

5.4.1.6 Key ecological processes

Altered fire regimes (i.e. infrequent, extensive fires compared with a mosaic of fire ages created by small, frequent fires) have probably contributed to low levels of abundance and possibly local extinction of a number of species of conservation significance. The effect of feral predators (Dingo, Cat and Fox) is complicated as it interacts with the fire regime, and the feral species interact with each other. For example, the abundance of Cats and Foxes is suppressed by Dingoes and in some cases this has been found to be of benefit to native species (Southgate *et al*. 2007). The Optimisation Study Area is close to the Telfer mine and Village, and is therefore in an area with high levels of abundance of feral species. Local hydrology may be significant around the Mulga VSA.

PART 4 SYNTHESIS AND RECOMMENDATIONS

6.0 SYNTHESIS

The following key habitats (Vegetation Associations) where conservation significant flora, terrestrial vertebrate and Short Range Endemics and sheet flow dependent ecosystem were found during the Level 2 flora and fauna survey of the Optimisation Study Area are described and discussed in Table 25.

Table 25 Synthesis of key habitats in the Optimisation Study Area

Parameter	Description	Vegetation Association (Area (Ha))
Vegetation Associations	**The vegetation association described is considered a unique and distinct vegetation association.** 3a: *Acacia pteraneura* High Shrubland over *Acacia wanyu*, *Anthobolus leptomerioides* and *Psydrax latifolia* Shrubland over *Eremophila tietkensii* and *E. latrobei* subsp. *latrobei* Low Open Shrubland over *Triodia basedowii* Open Hummock Grassland. This vegetation was typified by the presence *Acacia pteraneura* as it was the dominant species and was clearly distinguishable from adjacent Vegetation Associations more typical of the Telfer region. It was present adjacent to a drainage channel and, may be dependent on surface water flow that currently drains towards the drainage channel. This Mulga Vegetation Association represents 4.89% of the Study Area, on a landform not common regionally and with dominant species more common in the Pilbara region. Mulga communities in the Pilbara are considered to be of regional significance as the groves and inter-grove mulga communities represent the northern and western extent of the species distribution, therefore the presence of a Mulga Vegetation Association at Telfer may be at the extreme northern extent however further data analysis is required to clarify conservation significance. According to current distribution maps (Florabase, November 2011), the populations at Telfer would represent the northernmost distribution of *Acacia pteraneura*, with the closest population recorded in 1979 approximately 400km's to the south east in the Little Sandy Desert. *Acacia pteraneura* is a very common species of the Murchison. Kendrick (2001a, 2001b) also assessed the Vegetation Associations in terms of the reservation priorities of ecosystems. Vegetation Association 134 is a high priority for reservation in the Little Sandy Desert. The total area of vegetation association 134 of high priority for reservation in the Telfer Optimisation Study Area is 12.85ha	3a (60.21)

Parameter	Description	Vegetation Association (Area (Ha))
Water Dependent Ecosystem	The Mulga Vegetation Association (3a) has been identified as potential sheet flow dependent ecosystems. Sheet flow refers to the surface water flow as a thin layer not concentrated in a channel across the ground surface. Sheet flow usually occurs over slopes of 0.2 – 2%. Mulga vegetation communities that exist within slopes within this range are therefore determined to be sheet flow dependant. The slope of the Mulga Vegetation Association is unknown. This would need to be determined to resolve whether the vegetation is sheet flow dependent.	3a (60.21)
Flora	*Conservation Significance Level 1* No Threatened Flora (T) listed under the *Wildlife Conservation Act* or EPBC Act were found in the Telfer Optimisation Study Area. *Conservation Significance Level 2* The Priority 2 taxon, *Goodenia hartiana*, was found in two new populations consisting of ~1000 plants. A previously recorded population (Population 1) was reconfirmed with a large population (>1000 plants) is still present. A total of six populations have now been recorded in the Telfer Optimisation Study Area since 2007. *Conservation Significance Level 3* The range extension species recorded were: ▪ *Acacia pteraneura* discussed previously as being restricted to Vegetation Association 3a; ▪ *Maireana triptera* was recorded in Vegetation Association 3a; ▪ *Sclerolaena crenata* was found in *Acacia wanyu* shrubland in the northern portion of the Optimisation Study Area. ▪ *Sclerolaena minuta* was found on a low rocky hill adjacent to the *Acacia wanyu* dominated vegetation; ▪ *Sclerolaena eriacantha* was recorded on low rocky hills near the south eastern boundary of the Optimisation Study Area. ▪ *Peripleura virgata* was found in a in a drainage channel within a *Corymbia opaca* woodland; and ▪ *Synaptantha tillaeacea* var. *tillaeacea* found in a minor drainage channel within an *Acacia monticola* tall shrubland.	4b (417.22), 4c (21.40), 1a (43), 3a (5.33), 4b (417.22), 5a (145.58), 6a (51.42), 7a (57.22),
Terrestrial Vertebrate	No sightings were made of significant fauna species but both Bilbies and Mulgara are known regionally. • Bilby. Present regionally in low numbers, recorded nearby within the O'Callaghan's Study Area and therefore highly likely that individuals will utilise the Optimisation Study Area. The small population makes	N/A

Parameter	Description	Vegetation Association (Area (Ha))
	the Bilby vulnerable to impacts. • Mulgara. Present regionally in low numbers, recorded in areas adjacent to the Telfer Optimisation Study Area and therefore highly likely that individuals will utilise the Study Area. The dynamic ecology of the species means that it may disappear and then reappear over periods of several years. • Northern Marsupial Mole. Present regionally and recorded from adjacent Study Areas. Generally restricted to sand dune habitat, which is present but limited in extent within the Telfer Optimisation Study Area.	
SREs	Several invertebrate species collected are known only from those specimens found in the Project Area, but this is probably an artefact of inadequate regional sampling. They occurred in widespread environments so are probably themselves widespread.	N/A

6.1 ASSESSMENT OF SIGNIFICANCE

The following key habitats (Vegetation Associations) where conservation significant flora, terrestrial vertebrate and Short Range Endemics and sheet flow dependent ecosystem were ranked according to either conservation significance or management requirements. The rankings are described in Table 26.

Table 26 Rankings of Assets recorded within the Optimisation Study Area

Ranking	Definition of Asset Type	Asset
1	Critical Assets - the most important assets in the State that must be fully protected. Threatened Flora (DRF), TECs, areas protected under international, national or State conservation titles. Conservation Significant Level 1 Fauna Species.	None
2	Assets likely to be assessed as significant by the EPA and management will be required to avoid impact. Includes Priority Flora and PECs. Unique VSAs critical to local persistence of CS2 and/or CS3 fauna species.	Mulga Vegetation Association (3a), *Goodenia hartiana* Mulga dominated plain and Low rocky hills

Ranking	Definition of Asset Type	Asset
3	Ground, perched aquifer or sheet flow water dependent vegetation not covered by legislation but require surface or groundwater water management to avoid impact	Mulga Vegetation Association (3a)
4	Unique flora and Range Extensions. These have no legislative protection unless part of a TEC. A habitat for priority species. Of taxonomic interest but restricted species.	The following species were identified as range extensions in the Telfer Optimisation Area: *Acacia pteraneura* discussed previously as being restricted to Vegetation Association 3a; *Maireana triptera* was recorded in the Vegetation Association 3a (this species was also recorded in O'Callaghan's Study Area); *Sclerolaena crenata* was found in *Acacia wanyu* shrubland in the northern portion of the Optimisation Study Area. *Sclerolaena minuta* was found on a low rocky hill adjacent to the *Acacia wanyu* dominated vegetation (also recorded in O'Callaghan's Study Area); *Sclerolaena eriacantha* was recorded on low rocky hills near the south eastern boundary of the Optimisation Study Area (also recorded in O'Callaghan's Study Area); and *Peripleura virgata* was found in a in a drainage channel within a *Corymbia opaca* woodland; and *Synaptantha tillaeacea* var. *tillaeacea* found in a minor drainage channel within an *Acacia monticola* tall shrubland.

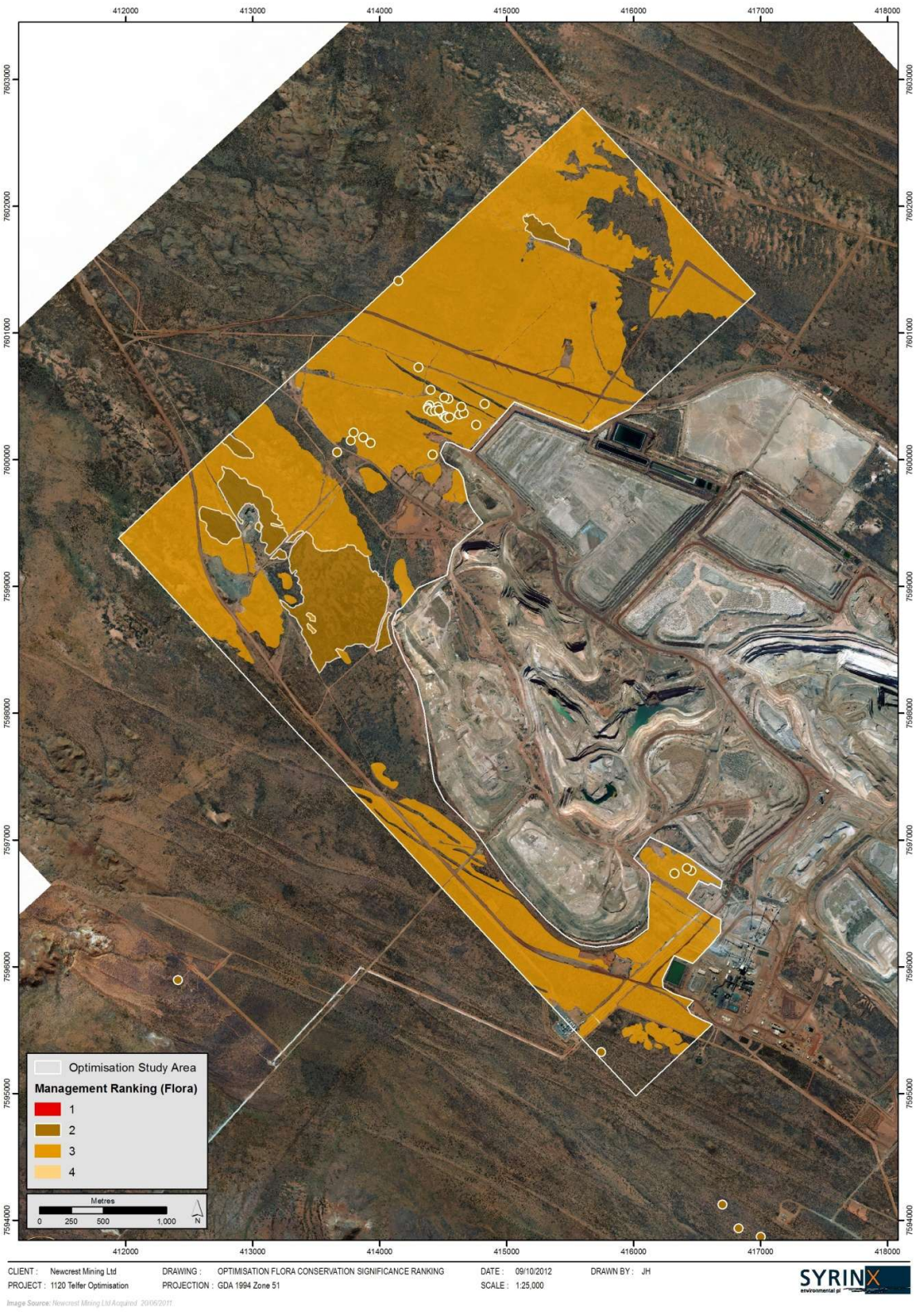


Figure 18 Management Rankings - Flora



Figure 19 Management Rankings - Fauna

6.2 RECOMMENDATIONS FOR FURTHER INVESTIGATIONS

6.2.1 Flora

The following recommendations are made for future investigations related to the Optimisation Study Area:

- Additional investigations are required to confirm regional distribution of Mulga surrounding the Optimisation Study Area to adequately assess the regional significance of Vegetation Association 3a, which hasn't been recorded in previous surveys in the Telfer Region. As it is reasonably distinct on aerial photography (although quite similar to Acacia wanyu dominated Vegetation Associations), it is recommended a desktop analysis of aerial photography followed by a targeted field survey is conducted to determine if additional Mulga woodlands are present regionally.
- Slope analysis is required to determine if Vegetation Association 3a is a sheet flow dependent ecosystem. If confirmed, appropriate surface water management will be required to minimise impacts to sheet flows.

6.2.2 Fauna

Key management actions recommended with respect to the development of the Optimisation Study Area are:

- Investigate retention of the Mulga VSA.
- Prepare a site-specific fire management plan aimed at developing a mosaic of fire ages through the frequent occurrence of small fires and the prevention of large fires. Such a plan would preferably form part of a wider, regional plan that would be developed in consultation with local industry stakeholders and relevant statutory authorities.
- Develop a predator management programme aimed at suppressing the abundance of the Fox and Cat and maintaining the Dingo population level at a natural density.
- Develop a regional monitoring programme for the Bilby to assess the effectiveness of the distribution and density of this species across the wider region.

Apart from retention of the Mulga VSA, other fauna management recommendations specific to the Optimisation Study Area, which sit under typical minesite best practice, include minimising the footprint, control of runoff/spills, speed limits and signage to minimise road kill and rehabilitation.

6.3 CONCLUSION

6.3.1 Flora and Vegetation

No Threatened Flora (T) listed under the *Wildlife Conservation Act* or EPBC Act were recorded within the Optimisation Study Area. Two new populations of the Priority 2 species, *Goodenia hartiana*, were recorded in the Optimisation Study Area, and one population previously recorded was reconfirmed.

There were seven range extension species recorded: *Acacia pteraneura*, *Maireana triptera Sclerolaena crenata*, *S. eriacantha* and *S. minuta*, *Peripleura virgata* and *Synaptantha tillaeacea* var. *tillaeacea*.

Using a combination of multivariate analysis and field observations, 12 Vegetation Associations occurring within six broad floristic groups were mapped and described in the Optimisation Study Area. None of the Vegetation Associations mapped and described are listed as TECs or PECs.

One Vegetation Association was assessed as unique and distinct:

- Vegetation Association 3a: Acacia pteraneura High Shrubland over Acacia wanyu, Anthobolus leptomerioides and Psydrax latifolia Shrubland over Eremophila tietkensii and E. latrobei subsp. latrobei Low Open Shrubland over Triodia basedowii Open Hummock Grassland.

This Vegetation Association occurs across 4.89% of the Optimisation Study Area, on a landform not common regionally and with dominant species more common in the Pilbara region, including two range extension species, *Acacia pteraneura* and *Maireana triptera,* which are restricted to this Vegetation Association in the Optimisation Study Area. A total of five species are restricted to Vegetation Association 3a.

6.3.2 Fauna

Within the landscape of the southern edge of the Great Sandy Desert, the Optimisation Study Area is small and consists of widespread VSAs except for the area of Mulga. This VSA is restricted, isolated and confined to the Optimisation Study Area, and was notable for high abundance and richness of bird species. Overall, the fauna assemblage is composed of species that mostly have broad distributions, with few of conservation significance. Those of greatest interest are the Bilby and Mulgara. An undescribed buthid scorpion may be an SRE species but can be expected to be regionally widespread as it occurred in a widespread VSA.

Impacts of development in the Optimisation Study Area upon fauna include localised habitat loss, but the significance of this impact is minor except in the case of the Mulga VSA. This small patch of Mulga may be locally important for biodiversity.

With significant species, there was no indication that the Optimisation Study Area supports locally important populations, and thus the significance of localised habitat loss for such species is also expected to be low. Of greatest concern for significant species, and particularly the Bilby and Mulgara, are the effects of fire regimes and predators. Ecological Horizons (2011) has noted a decline in both species around Nifty, apparently associated with an increase in the number of Cats and Foxes, and has recommended the maintenance of a natural density of the Dingo in order to suppress the abundance of these other predator species. Development projects can affect the abundance of these species and also provide opportunities for active conservation management, which may be assessed as offsets to development.

PART 4 REFERENCES

Anderson, M.J. and Robinson, J. (2003). Generalised discrimination analysis based on distances. Australian and New Zealand Journal of Statistics 45, 301-318.

Aplin, T.E.H. (1979). The Flora. Chapter 3 in O'Brien, B.J. (ed.) (1979) Environment and Science. University of Western Australia Press.

Bamford, M. (2007). Personal Observations; Kintyre Project Area. Fauna observations from site visit, October 2007. Report for Canning Resources Pty Ltd.

Bamford, M. (2011). Targeted Fauna Survey for the Kintyre Haul Route. Unpubl. report to Cameco Australia Pty Ltd by Bamford Consulting Ecologists, Kingsley.

Bamford, M.J. and Roberts, J.D. (2003). The impact of fire on frogs and reptiles in south-west Western Australia. Fire in Ecosystems of South-west Western Australia: Impacts and Management. pp. 349-361. eds I. Abbott and N. Burrows. Backhuys Publishers, The Netherlands.

Barrett, G., Silcocks, A., Barry, S.,Cunningham, R., and Poulter, R. (2003). The New Atlas of Australian Birds. (Royal Australasian Ornithologists Union, Melbourne).

Beard, J.S. (1974a). Vegetation Survey of Western Australia. 1:1 000 000 Series. Sheet 2 – Great Sandy Desert. Part II. Map and Explanatory Notes. University of Western Australia Press.

Bennett Environmental Consulting. (2007). Flora and Vegetation Kintyre Leases. August 2007. Report prepared for Cameco Australia.

Bennett Environmental Consulting. (2010). Flora and Vegetation Kintyre Leases. August 2010. Report prepared for Cameco Australia.

Benshemesh, J. (2005). Manual for Marsupial Mole Survey and Monitoring by Trenches, Version 1.0. Report to Anangu-Pitjantjatjara Land Management and the Department of Heritage and Environment (SA).

Biota Environmental Sciences. (2005). 'Fauna Habitats and Fauna Assemblages of the Proposed F Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas.' Fortescue Metals Group Ltd.

Birds Australia. (2011). Atlas 2 database.http://www.birdata.com.au/maps.vm

Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984). The Atlas of Australian Birds. Melbourne, Victoria: Melbourne University Press.

Burbidge, A.A. and McKenzie, N.L. (1983). Wildlife of the Great Sandy Desert, Western Australia. Wildl. Res. Bulletin WA. 12: 1-127.

Burbidge, A.A. and McKenzie, N.L. (1989). Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. Biol. Cons. 50: 143-198.

Burbidge, A. A. (2004). Threatened Animals of Western Australia. Department of Conservation and Land Management, Kensington, Western Australia.

Bureau of Meteorology. (2012). Observations from Telfer Aero (Station 013030). http://www.bom.gov.au/climate/dwo/201105/html/IDCJDW6122.201105.shtml

Calver, M., Lymbery, A., McComb, J. and Bamford, M. (2009). Environmental Biology. Cambridge University Press.

Cameco. (2012). http://www.cameco.com/australia/kintyre/community_information/. Accessed July 2012.

Christidis, L. and Boles, W.E. (2008). Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Victoria.

Churchill, S. (2008). Australian Bats. Reed New Holland Press, Sydney.

Clarke, K.R., and Gorley, R.N. (2006). Primer v6: User Manual/Tutorial, PRIMER-E, Plymouth.

Clarke, K.R. and Warwick, R.M. (2001). Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. PRIMER-E: Plymouth.

Commonwealth of Australia. (2010a). National Vegetation Information System (NVIS). http://www.environment.gov.au/erin/nvis/index.html.

Commonwealth of Australia. (2010b) Weeds of National Significance Update 2010. Australian Weeds Committee, Launceston, Tasmania.

Cork S., Sattler P. and Alexandra J. (2006). 'Biodiversity' theme commentary prepared for the 2006 Australian State of the Environment Committee, Department of the Environment and Heritage, Canberra, http://www.deh.gov.au/soe/2006/commentaries/biodiversity/index.html; viewed on 30 December 2008).

Covacevich, J. (1995), 'Lakeland Downs Mouse Leggadina lakedownensis.' in R. Strahan (ed.), The Mammals of Australia, Reed, Chatswood, N.S.W., pp. 556 - 557.

Department of Agriculture and Food Western Australia (2011). List of Declared Plants January 2011. Como, Western Australia.

Department of Conservation and Land Management (1999) Environmental Weed Strategy for Western Australia. Como, Western Australia.

Department of Environment and Conservation. (2010). Definitions, Categories and Criteria for Threatened Ecological Communities and Priority Ecological Communities. December 2010. URL http://www.dec.wa.gov.au/management-and-protection/threatened-species/wa-s-threatened-ecological-communities.html

Department of Environment and Conservation. (2011a). DEC Threatened Ecological Communities and Priority Ecological Communities Database Search. DEC ref 17-0611EC.

Department of Environment and Conservation. (2011b). Request for Rare and Priority Flora Information. DEC ref 20-0611FL).

Department of Environment and Conservation. (2011c). Naturemap: Mapping Western Australia's Biodiversity. Department of Environment and Conservation. URL: http://naturemap.dec.wa.gov.au/

Department of Environment and Conservation. (2011d). Native Vegetation Map Viewer. URL: http://maps.dec.wa.gov.au/idelve/nv/index.jsp

Department of Environment and Conservation. (2012a). Threatened Flora. URL : http://www.dec.wa.gov.au/content/view/5385/2233/.

Department of Environment and Conservation. (2012b). Priority Ecological Communities List. Released 4th April 2012. Department of Environment and Conservation, Perth Western Australia.

Department of Natural Resources and Environment. (2002). Biodiversity Action Planning. Action planning for native biodiversity at multiple scales; catchment bioregional, landscape, local. Department of Natural Resources and Environment, Victoria.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2011a). http://www.environment.gov.au/epbc/pmst/index.html Accessed 17112011.

Department of Sustainability, Environment, Water, Population and Communities. (2011b). http://www.environment.gov.au/erin/nvis/mvg/index.html#nvis31 Accessed 17112011.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2011c). Survey guidelines for Australia's threatened mammals. EPBC Act survey guidelines 6.5. [Online]. EPBC Act policy statement: Canberra, ACT: DSEWPaC. Available from:http://www.environment.gov.au/epbc/publications/threatened-mammals.html.

Department of Sustainability, Environment, Water, Population and Communities (2012) Australia's Bioregions (IBRA Version 7.0) http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html. Accessed October 2012.

Doughty, P. and Maryan, B. (2009a). Checklist of the Amphibians of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Doughty, P. and Maryan, B. (2009b). Checklist of the Reptiles of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Doughty, P., Kealley, L. and Donnellan, S.C. (2011). Revision of the Pygmy Spiny-tailed Skinks (*Egernia depressa* species-group) from Western Australia, with descriptions of three new species. Rec. West. Aust. Mus. 26: 115–137

Duncan, A., Baker, G.B. and Mongomery, N. (1999). The Action Plan for Australian Bats. Environment Australia, Canberra.

Eamus, D., Froend, R., Loomes, R., Hose, G.C. & Murray, B.R. (2006) 'A functional methodology for determining the groundwater regime needed to maintain the health of groundwater-dependent vegetation', Australian Journal Of Botany, vol. 54, no. 2, pp. 97-114.

Eamus, D. (2009). A review of the report written by Frank Batini entitled "Eucalyptus victrix, Karijini National Park. Unpublished report for Rio Tinto Iron Ore.

Ecologia. (2003). Telfer Project-Power Supply and Infrastructure Corridor Rare and Priority Fauna and Flora Survey. Report Prepared for Newcrest Mining Limited.

Ecological Horizons. (2011). Birla Nifty Copper Operations. Fauna Monitoring Programme Report November 2011. Unpubl. report to Birla (Nifty) Pty Ltd by Ecological Horizons Pty Ltd.

Elith, J. and Bidwell, S. (2004) Identification and assessment of nationally threatened woodlands. Description of ecological communities: Arid Eucalypt Woodlands. Report to the Department of Environment and Heritage, Canberra.

Environmental Protection Authority. (2002a). Telfer Project, Expansion of Telfer Gold Mine, Great Sandy Desert. Bulletin 1059. Report and recommendations of the Environmnetal Protection Authority. Perth, Western Australia.

Environmental Protection Authority. (2002b). Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3. Environmental Protection Authority, Perth, Western Australia.

Environmental Protection Authority. (2004a). Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. Guidance Statement No. 51.

Environmental Protection Authority. (2004b). Environmental Protection of Wetlands. Position Statement No. 4.

Environmental Protection Authority. (2004c). Guidance for the assessment of environmental factors: Terrestrial fauna surveys for environmental impact assessment in Western Australia. No. 56. Environmental Protection Authority, Perth, Western Australia.

Environmental Protection Authority. (2009). Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia. Environmental Protection Authority, Perth, Western Australia.

Environmental Protection Authority. (2010). Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment in Western Australia. Environmental Protection Authority, Perth, Western Australia.

Environ Australia Pty Ltd. (2011). Kintyre Uranium Project Environmental Scoping Document. August 2011. Prepared for Cameco Australia Pty Ltd. Perth, Western Australia.

Faith, D., Minchin, P. and Belbin, L. (1987). Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio* 69, 57 – 68.

Garnett, S. and Crowley, G. (2000). The Action Plan for Australian Birds. Environment Australia and the Royal Australasian Ornithologists Union.

Geoscience Australia. (2008). Published 1:250,000 scale geological maps (Geological Survey of WA, and Geoscience Australia), supplemented in parts by more recent GA Solid Geology interpretation of the Patterson area

Gibson, L.A. and McKenzie, N.L. (2009). Environmental associations of small ground-dwelling mammals in the Pilbara region, Western Australia. Records of the Western Australian Museum, Supplement 78: 91 – 122 (2009).

Government of Western Australia. (2000). Bush Forever Volume 2. Government of Western Australia, Pert.h

Graham-Taylor, C. and Bamford, M.J. (1996). The Discovery Project 1996. Unpubl. report to sponsors, Bamford Consulting Ecologists, Kingsley.

Grigg, A.M. (2009). An ecophysiological approach to determine problems associated with mine-site rehabilitation: a case study in the Great Sandy Desert, north-western Australia. Thesis presented for the Doctor of Philosophy at the University of Western Australia.

Grierson, P. and Page, G. (2010). 'Review of State of Knowledge - Ecological Water Requirements of Mulga in Pilbara', Fortescue Metals Group Chichester Metals Pty Ltd

Grierson, P., Page, G., Bleby, T and Argus, R. (2011) 'Ecophsiological Monitoring of *Eucalyptus victrix* & Mulga within the Coolibah Woodland Karijini National Park - Additional Funding for LP0776626', Rio Tinto Limited.

Harrington, R. (2002). The effects of artificial watering points on the distribution and abundance of avifauna in an arid and semi-arid mallee environment. PhD thesis, Department of Zoology, The University of Melbourne.

Hart, Simpson and Associates Pty Ltd. (1992). Nifty Project – Environmental Appraisal and Management. WMC Engineeering Services Pty Limited. Perth, Western Australia.

Hart, Simpson and Associates Pty Ltd. (1994). Kintyre Project. Fauna studies 1986 to 1992. Unpubl. report by Hart Simpson and Assoc. Pty Ltd. to Canning Resources.

Hart, Simpson and Associates Pty Ltd. (1997). Telfer Minesite. Topsoil Areas Flora and Vegetation. Report Prepared for Newcrest Mining Limited.

Hart, Simpson and Associates Pty Ltd. (2000). Telfer Satellite Pits, Access and Water Release Area. Ecological Survey. Report Prepared for Newcrest Mining Limited.

Hart, Simpson and Associates Pty Ltd. (2002). Telfer Project Ecological Survey. Report Prepared for Newcrest Mining Limited.

Hart, Simpson and Associates Pty Ltd. (2007). Kintyre Project- Extention of Vegetation Mapping. Dames and Moore.

Harvey, M.S. (2002). Short-range endemism in the Australian fauna: some examples from non-marine environments. Invertebrate Systematics 16: 555-570.

Hatton, T. and Evans, R. (1998). Dependence of Ecosystems on Groundwater and its Significance to Australia. Occasional Paper 12/98. Land and Water Resources Research and Development Corporation.

How, R.A. and Dell, J. (1990). Vertebrate fauna of Bold Park, Perth. West. Aust. Nat. 18: 122-131.

How, R. A., Cooper, N. K. and Bannister, J. L. (2009). Checklist of the Mammals of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

IUCN. (2011). IUCN Red List Categories and Criteria, Version 3.1. IUCN Species Survival Commission, IUCN, Gland, Switzerland and Cambridge, UK.

IUCN (2012). IUCN Red List of Threatened Species. Version 2011.1. www.iucnredlist.org.

Johnstone, R. E. (2001). Checklist of the birds of Western Australia. Records of the Western Australian Museum Suppl. No. 63.bers.

Johnstone, R. E. and Storr, G. M. (1998). Handbook of Western Australian birds. Volume 1: Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth, Western Australia.

Johnstone, R. E. and Storr, G. M. (2005). Handbook of Western Australian birds. Volume 2: Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth, Western Australia.

Kendrick, P. (2001a). Great Sandy Desert 2 (GSD2 – Mackay sub region) in A biodiversity audit of Western Australia's 53 Biogeographical Subregions in 2002. Department of Conservation and Land Management, Western Australia.

Kendrick, P. (2001b). Little Sandy Desert 1 (LSD1 – Rudall sub region) in A biodiversity audit of Western Australia's 53 Biogeographical Subregions in 2002. Department of Conservation and Land Management, Western Australia.

Lambers, H., Chapin III, F.S., and Pons, T.L. (1998). Mineral nutrition. In: H. Lambers, F.S. Chapin III, and T.L. Pons. Plants Physiological Ecology. Springer-Verlag New York, Inc.

Legendre, P. and Legendre, L. (1998). Numerical Ecology. 2nd Ed. Elsevier Science, Amsterdam.

Ludwig, J., Tongway, D., Freudenberger, D., Noble, J. and Hodgkinson, K. (1997). Landscape ecology - function and management. Principles from Australia's rangelands. CSIRO, Australia.

Mabbutt, J.A. and Fanning, P.C. (1987). Vegetation banding in arid Western Australia. Journal of Arid Environments, 12: 41-59.

Mace, G. and Stuart, S. (1994). Draft IUCN Red List Categories, Version 2.2. Species; Newsletter of the Species Survival Commission. IUCN - The World Conservation Union. 21-22: 13-24.

Magee, J. (2009). Palaeovalley Groundwater Resources in Arid and Semi-Arid Australia – A Literature Review. 2009/03. Geoscience Australia Record 2009/3.

Martinick Bosch Sell Pty Ltd. (2004). Targeted rare fauna search for proposed tailings storage facility at Nifty Copper Operations. Unpubl. report to Birla (Nifty) Pty Ltd by Martnick Bosch Sell Pty Ltd, West Perth.

Martinick Bosch Sell Pty Ltd. (2005). Native Vegetation Management Plan. Prepared for Birla (Nifty) Pty Ltd.

Martinick Bosch Sell Pty Ltd. (2006). Vegetation Survey and Targeted Rare Flora and Fauna Search of the Waste Rock Dump, Airstrip and Heap Leach Pad Extension Areas, Nifty Copper Operations, Western Australia. Prepared for Birla (Nifty) Pty Ltd.

Maxwell, S., Burbidge, A.A. and Morris, K. (1996). Action Plan for Australian Marsupials and Monotremes. Environment Australia, Canberra.

McKenzie N.L., May J.E. and McKenna S. (2003). Bioregional Summary of the 2002 Biodiversity Audit for Western Australia. Department of Conservation and Land Management, Perth, Western Australia.

Menkhorst, P. and Knight, F. (2001). A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne.

O'Grady, A.P, Cook, P.G., Eamus D., Duigid, A., Wischusen, J.DH., Fass, T. and Wordlredge, D. (2009). Convergence of tree water use within an arid zone woodland. Oecologia 160, 643-655.

Purcell, P.G. (1984). The Canning Basin, WA: Proceedings of the Geological Society of Australia/Petroleum Exploration Society of Australia Symposium. Perth, Western Australia.

Pfautsch, S., Keitel, C., Turnbull, T.L., Braimbridge, M.J., Wright, T.E., Simpson, R.R., O'Brien J.A., and Adams, M.A. (2011). Diurnal patterns of water use in *Eucalyptus victrix* indicate pronounced desiccation–rehydration cycles despite unlimited water supply. *Tree Physiol*. 31 (10): 1041-1051

Sandiford, E.M. and Barrett, S. (2010). Albany Regional Vegetation Survey: Extent Type and Status. A project funded by the Western Australian Planning Comission, South Coast Natural Resource Management Inc and City of Albany for the Department of Environment and Conservation.

Semeniuk, V. & Semeniuk, C.A. (2011). A comprehensive classification of inland wetlands of Western Australia using the geomorphic-hydrological approach. *Journal of the Royal Society of Western Australia.* 94: 449 – 464.

Shepherd, D.P., Beeston, G.R., Hopkins, A.J.M. (2002). Native Vegetation in Western Australia- Extent, Type and Status. Resource Management Technical Report 249. Department of Agriculture, Western Australia, South Perth.

Soule, M. E., Mackey, B. G., Recher, H. F., Williams, J. E., Woinarski, J. C. Z., Driscoll, D., Dennison, W. C. and Jones, M. E. (2004). The role of connectivity in Australian conservation. *Pacific Conservation Biology* 10: 266-279

Southgate, R., Paltridge, R., Masters, P. and Carthew, S. (2007). Bilby distribution and fire a test of alternative models of habitat suitability in the Tanami Desert Australia. Ecography 30: 758-776.

Specht, R.L. (1970). Vegetation. In the Australian Environment. 4th edn (Ed. G.W. Leeper). Melbourne

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1983). Lizards of Western Australia. II. Dragons and Monitors. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1990). Lizards of Western Australia. III. Geckoes and Pygopodids. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1999). Lizards of Western Australia. I. Skinks. Revised Edition. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (2002). Snakes of Western Australia. W.A. Museum, Perth.

Syrinx Environmental PL. (2004a). Vegetation and Fauna Survey: Freedom Road Bypass EIA. Report Prepared for Newcrest Mining Limited.

Syrinx Environmental PL. (2004b). Vegetation and Fauna Survey: Proposed Gas Pipeline Bypass EIA. Report Prepared for Newcrest Mining Limited.

Syrinx Environmental PL. (2006). Telfer Waste Dump Expansion Flora and Fauna Survey. Report Prepared for Newcrest Mining Limited.

Syrinx Environmental PL. (2007). Borefields Expansion Flora and Fauna Survey. Prepared for Newcrest Mining Limited.

Syrinx Environmental PL. (2008). *Goodenia hartiana* Survey. Technical Report. Prepared for Newcrest Mining Limited.

Syrinx Environmental PL. (2009). Greater Bilby Survey; Telfer Mine Site. Prepared for Newcrest Mining Limited.

Syrinx Environmental PL. (2010). *Goodenia hartiana* Survey. Technical Report. Prepared for Newcrest Mining Limited.

Syrinx Environmental PL. (2011a). Telfer Gold Mine Annual Weed Survey. Technical Report. Prepared for Newcrest Mining Limited.

Syrinx Environmental PL. (2011b). Orebody 31 Flora and Vegetation Assessment. Technical Report. Prepared for BHP Billiton Iron Ore.

Syrinx Environmental PL. (2012, in draft). O'Callaghan's Study Area. Level 2 Flora and Fauna Survey. Report to Newcrest Mining Limited.

Tille P. (2006). Soil–landscapes of Western Australia's Rangelands and Arid Interior. Resource management Technical Report 313. Department of Agriculture and Food, Perth, Western Australia.

Trudgen, M.E. (2002). A Flora, Vegetation and Floristic Survey of the Burrup Peninsula, Some adjoinging Areas and Part of the Dampier Archipelago, with Comparisons to the Floristics of Areas on the Adjoining Mainland. Unpublished Report prepared by M.E. Trudgen and Associates for The Department of Mineral and Petroleum Resources, Perth, W.A.

Tyler, M.J., Smith, L.A. and Johnstone, R.E. (2000). Frogs of Western Australia. W.A. Museum, Perth.

United Nations Educational, Scientific and Cultural Organization. (1971). The Contracting Parties to the Convention on Wetlands of Importance Especially as Waterfowl Habitat. Ramsar, Iran.

V & C Semeniuk Research Group. (2000). Wetlands of the northwestern Great Sandy Desert in the LaGrange hydrological sub-basin. Report to the Water & Rivers Commission, East Perth, W.A.

V & C Semeniuk Research Group on behalf of Syrinx Environmental PL. (2004). Stage 1 Report: History of Cyclones and Terrain Inundation in the Great Sandy Desert, W.A. 1996 – 2004.

Van Dyck, S. and Strahan, R. (2008). The Mammals of Australia. Third Edition. New Holland Publishers, Sydney.

Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P. (2004). An Inventory and Condition Survey of the Pilbara Region, Western Australia. Technical Bulletin No. 92, Department of Agriculture, South Perth, Western Australia.

Western Australian Herbarium. (2011). Specimen database for Threatened (DRF) and Priority Flora (DEC ref 20-0611FL).

Western Australian Herbarium. (2012). FloraBase - The Western Australian Flora. Department of Environment and Conservation. http://florabase.dec.wa.gov.au.

Western Australian Museum (WAM). (2008). Checklist of the Terrestiral Vertebrate Fauna of Western Australia.

Wilson, S. and Swan, G. (2008). Reptiles of Australia. Princeton University Press, Australia.

Woolley, P. A. (1995). 'Mulgara Dasycercus cristicauda.' in R. Strahan (ed.), The Mammals of Australia, Reed Books, Sydney, pp. 55 - 56.

Woolley, P.A. (2005). The species of Dasycercus Peters 1875 (Marsupialia: Dasyuridae). Memoirs of Museum Victoria 62: 213-221.

Woolley, P.A. (2006). Studies on the crest-tailed mulgara Dasycercus cristicauda and the brush-tailed mulgara D. blythi (Marsupialia: Dasyuridae). Australian Mammalogy 28: 117-120.

Woolley P. (2008). Brush-tailed Mulgara Dasycercus blythi In: Van Dyck, S. and Strahan, R. (ed).(2008). The Mammals of Australia. Third edition. Australian Museum / New Holland Publishers.

APPENDICES

Appendix 1 Definitions of Threatened and Priority Ecological Communities and Threatened (T) and Priority Flora

EPBC Definition for Priority Ecological Communities (Environment Protection and Biodiversity Conservation Act 1999)

EPBC Act Category	Definition
Priority Ecological Communities	
Critically Endangered (CR)	An ecological community that is facing an extremely high risk of extinction in the wild in the immediate future.
Endangered (EN)	An ecological community that is not critically endangered, and is facing a very high risk of extinction in the wild in the near future.
Vulnerable (VU)	An ecological community that is not critically endangered or endangered, and is facing a high risk of extinction in the medium-term future.

EPBC Categories of Threatened Flora Species (Environment Protection and Biodiversity Conservation Act 1999)

Conservation Code	Definition
Threatened Flora Species	
Ex	**Extinct** Taxa which at a particular time if, at the time, there is no reasonable doubt that the last member of the species has died.
ExW	**Extinct in the Wild** Taxa which is known only 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 time frame appropriate to its life cycle and form.
CE	**Critically Endangered** Taxa which at a particular time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	**Endangered** Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
V	**Vulnerable** Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** Taxa which at a particular time if, at that time, 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.

DEC Definitions and criteria for Threatened Ecological Communities

Criteria	Definition
Threatened Ecological Communities	
Presumed Totally Destroyed (PD)	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B): **A)** Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats or **B)** All occurrences recorded within the last 50 years have since been destroyed
Critically Endangered (CR)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): **A)** The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii): **i)** geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years); **ii)** modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated. **B)** Current distribution is limited, and one or more of the following apply (i, ii or iii): **i)** geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years); **ii)** there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes; **iii)** there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes. **C)** The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).

Criteria	Definition
Endangered (EN)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B, or C): **A)** The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement and either or both of the following apply (i or ii): **i)** the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years); **ii)** modification throughout its range is continuing such that in the short term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated. **B)** Current distribution is limited, and one or more of the following apply (i, ii or iii): **i)** geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years); **ii)** there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes; **iii)** there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes. **C)** The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).
Vulnerable (VU)	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long term future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B or C): **A)** The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated. **B)** The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations. **C)** The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

DEC Definitions and criteria for Priority Ecological Communities

Criteria	Definition
Priority Ecological Communities	
Priority One	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority Two	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, state forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities, but do not meet adequacy of survey requirements, and / or are not well defined, and appear to be under threat from known threatening processes.
Priority Three	Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or; **ii.** Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; **iii.** Communities made up of large, and/or widespread occurrences, which may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities, but do not meet adequacy of survey requirements and / or are not well defined, and known threatening processes exist that could affect them.
Priority Four	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. **a. Rare.** Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change These communities are usually represented on conservation lands. **b. Near Threatened.** Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. **c.** Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority Five	*Conservation Dependent Ecological Communities* Ecological Communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

DEC Definitions for Threatened and Priority Flora

Conservation Code	Definition
Threatened and Priority Flora	
T	**Threatened Flora** Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the Wildlife Conservation Act 1950).Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria: * CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild * EN: Endangered – considered to be facing a very high risk of extinction in the wild * VU: Vulnerable – considered to be facing a high risk of extinction in the wild.
X	**Presumed Extinct Flora** Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the Wildlife Conservation Act 1950). Species that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora List under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna. Species that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.
P1	**Priority One: Poorly-known species** Species that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
P2	**Priority Two: Poorly-known species** Species that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
P3	**Priority Three: Poorly-known species** Species that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

Conservation Code	Definition
P4	**Priority Four: Rare, Near Threatened and other species in need of monitoring** **(a) Rare.** Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. **(b) Near Threatened.** Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. **(c) Species that have been removed from the list of threatened species** during the past five years for reasons other than taxonomy.
P5	**Priority Five: Conservation Dependent species** Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Appendix 2 Coordinates of Conservation Significant Flora Species

Species	Conservation Significance	GPS E	GPS N	Year	Source
Goodenia hartiana	2	422311	7590980	2007	Borefield expansion Survey
Goodenia hartiana	2	418672	7591427	2007	Borefield expansion Survey
Goodenia hartiana	2	413926	7600135	2007	Borefield expansion Survey
Goodenia hartiana	2	413772	7600153	2007	Borefield expansion Survey
Goodenia hartiana	2	413793	7600216	2007	Borefield expansion Survey
Goodenia hartiana	2	413869	7600178	2007	Borefield expansion Survey
Goodenia hartiana	2	414303	7600732	2007	Borefield expansion Survey
Goodenia hartiana	2	414414	7600043	2007	Borefield expansion Survey
Goodenia hartiana	2	413662	7600062	2007	Borefield expansion Survey
Goodenia hartiana	2	414758	7600278	2007	Borefield expansion Survey
Goodenia hartiana	2	414826	7600441	2007	Borefield expansion Survey
Goodenia hartiana	2	414399	7600552	2007	Borefield expansion Survey
Goodenia hartiana	2	412503	7591363	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	410586	7595897	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	412410	7595897	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	414144	7601415	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	406225	7605270	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	406522	7604661	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	408194	7604653	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	427210	7575502	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	402422	7605340	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	396228	7610808	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	397631	7612371	2008	*Goodenia hartiana* Survey
Goodenia hartiana	2	417380	7592844	2011	O'Callaghan's Level 2 Flora survey
Goodenia hartiana	2	418220	7592618	2011	O'Callaghan's Level 2 Flora survey
Goodenia hartiana	2	416697	7594126	2011	O'Callaghan's Level 2 Flora survey
Goodenia hartiana	2	418177	7592575	2011	O'Callaghan's Level 2 Flora survey
Goodenia hartiana	2	418593	7591727	2011	O'Callaghan's Level 2 Flora survey
Goodenia hartiana	2	421304	7590584	2011	O'Callaghan's Level 2 Flora survey
Goodenia hartiana	2	423131	7587340	2011	O'Callaghan's Level 2 Flora survey
Goodenia hartiana	2	414508	7600492	2011	Optimisation Level 2 Flora Survey
Goodenia hartiana	2	415761	7595366	2011	Optimisation Level 2 Flora Survey
Goodenia hartiana	2	416404	7596664	2011	Optimisation Level 2 Flora Survey
Goodenia hartiana	2	420618	7593962	2011	Pit 15 (Fallows Field) Level 2 Flora Survey
Goodenia hartiana	2	410618	7593783	2011	Pit 15 (Fallows Field) Level 2 Flora Survey
Goodenia hartiana	2	439701	7580158	2011	Satellite Deposits Level 2 Flora Survey
Goodenia hartiana	2	435338	7579630	2011	Satellite Deposits Level 2 Flora Survey
Goodenia hartiana	2	441222	7580762	2011	Satellite Deposits Level 2 Flora Survey
Goodenia hartiana	2	439590	7579796	2011	Satellite Deposits Level 2 Flora Survey
Goodenia hartiana	2	435813	7582282	2011	Satellite Deposits Level 2 Flora Survey

Species	Conservation Significance	GPS E	GPS N	Year	Source
Goodenia hartiana	2	435813	7582282	2011	Satellite Deposits Level 2 Flora Survey
Goodenia hartiana	2	434569	7580991	2011	Satellite Deposits Level 2 Flora Survey
Goodenia hartiana	2	437769	7581218	2011	Satellite Deposits Level 2 Flora Survey

Appendix 3 Flora Quadrat Data Sheets

FLORA QUADRAT DATA SHEET

Location	**Optimisation -00**	**Date** 06.06.2012 **Surveyors** Sandra Dunn, Kelly McCreery, Radmila Tomanovic, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0415359 **Northing:** 7602079	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey sand.	**Soil Colour** Red
Topography/Aspect	Plain/0°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Corymbia Open Woodland**	
Vegetation Association	*Corymbia opaca* **Open Woodland** over *Acacia ancistrocarpa*, *A. stipuligera* and *A. monticola* **Open Shrubland** over *Aristida inaequiglumis*, *Eulalia aurea* and *Paraneurachne muelleri* **Closed Grassland** over *Triodia schinzii* **Very Open Tussock Grassland**	



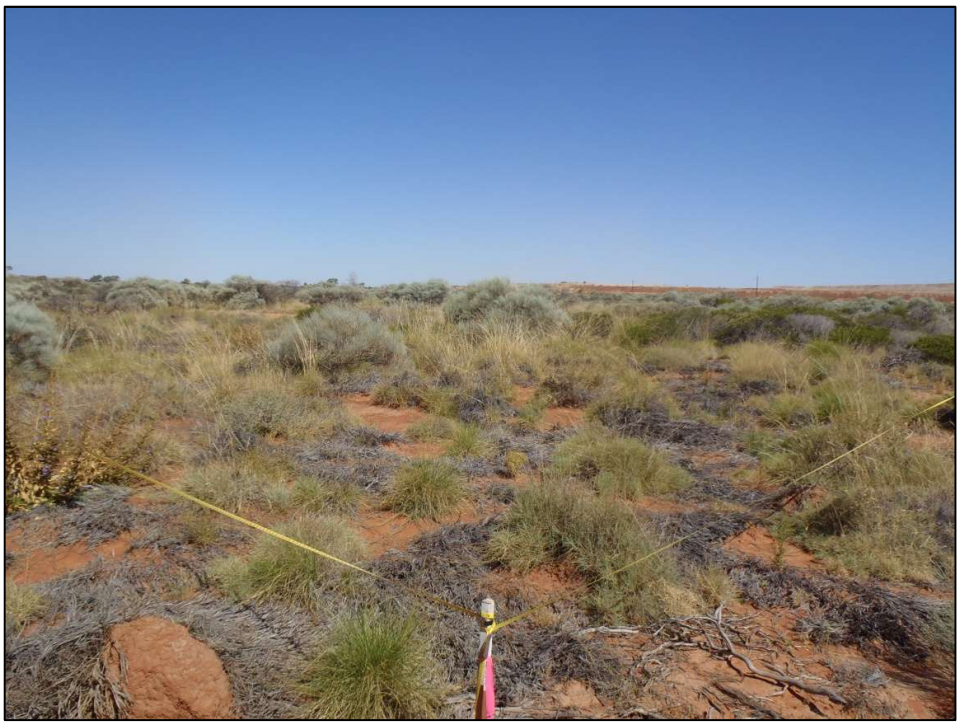
Quadrat 00

Species List

Abutilon otocarpum
Acacia ancistrocarpa
Acacia monticola
Acacia stipuligera
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Aristida inaequiglumis
Calytrix carinata
**Cenchrus ciliaris*
Clerodendrum floribundum var. *angustifolium*
Corchorus sidoides subsp. *sidoides*
Corymbia chippendalei
Dysphania rhadinostachya subsp. *rhadinostachya*
Eragrostis eriopoda
Eragrostis speciosa
Eriachne aristidea
Eriachne obtusa
Eulalia aurea
Euphorbia boophthona
Evolvulus alsinoides
Fimbristylis dichotoma
Gossypium australe
Haloragis gossei var. *gossei*
Hibiscus leptocladus
Indigofera monophylla
Isotropis atropurpurea
Keraudrenia velutina subsp. *elliptica*
Paraneurachne muelleri
Pluchea tetranthera
Polycarpaea corymbosa
Pterocaulon sphaeranthoides
Ptilotus gaudichaudii
Scaevola parvifolia
Sclerolaena cornishiana
Sclerolaena minuta
Senna artemisioides subsp. *helmsii*
Setaria surgens
Sida sp. Rabbit Flat (B.J. Carter 626)
Sporobolus actinocladus
Sporobolus australasicus
Streptoglossa odora
Stylobasium spathulatum
Synaptantha tillaeacea var. *tillaeacea*
Triodia pungens
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -01**	**Date** 06.06.2012 **Surveyors** Sandra Dunn, Kelly McCreery, Radmila Tomanovic, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting**: 0416391 **Northing**: 7601751	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey sand.	**Soil Colour** Red
Topography/Aspect	Depression/0°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	Acacia Open Scrub	
Vegetation Association	*Acacia wanyu* **Open Shrubland** over *Acacia stellaticeps* and *Dodonea coriacea* **Low Open Shrubland** over *Triodia basedowii* and *Triodia pungens* ***Hummock Grassland***	



Quadrat 01

Species List

Acacia colei var. *colei*
Acacia ligulata
Acacia stellaticeps
Acacia wanyu
Anthobolus leptomerioides
Aristida contorta
Aristida holathera var. *holathera*
Aristida inaequiglumis
Brachyachne prostrata
Bulbostylis barbata
Cassytha capillaris
Dactyloctenium radulans
Dodonaea coriacea
Enchylaena tomentosa var. *tomentosa*
Eragrostis dielsii
Eragrostis eriopoda
Eremophila tietkensii
Eriachne aristidea
Eriachne obtusa
Fimbristylis dichotoma
Goodenia armitiana
Goodenia stobbsiana
Grevillea wickhamii
Haloragis gossei var. gossei
Heliotropium glanduliferum
Indigofera boviperda
Lepidium pholidogynum
Maireana triptera
Paraneurachne muelleri
Pluchea rubelliflora
Pluchea tetranthera
Polycarpaea corymbosa
Pterocaulon serrulatum
Ptilotus calostachyus
Ptilotus nobilis
Ptilotus polystachyus
Scaevola spinescens
Schizachyrium fragile
Sclerolaena crenata
Senna notabilis
Senna sericea
Setaria surgens
Sida ? *cardiophylla*
Sida sp. Rabbit Flat (B.J. Carter 626)
Solanum centrale
Sporobolus australasicus
Stemodia linophylla
Streptoglossa bubakii
Streptoglossa macrocephala
Stylobasium spathulatum
Synaptantha tillaeacea var. *hispidula*
Trianthema triquetra
Trianthema turgidifolia
Triodia ? *epactia*
Triodia basedowii
Triodia pungens
Yakirra australiensis

FLORA QUADRAT DATA SHEET

Location	**Optimisation -02**	**Date** 06.06.2012 **Surveyors** Sandra Dunn, Kelly McCreery, Radmila Tomanovic, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0415752 **Northing:** 7601731	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey sand.	**Soil Colour** Red
Topography/Aspect	Rocky hill/40°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	*Acacia wanyu* **Scattered Tall Shrubs over** *Eremophila tietkensii, Senna sericea* and *S. glutinosa* subsp. *x luerssenii* over *Triodia basedowii* complex **Hummock Grassland**	



Quadrat 02

Species List

Acacia acradenia
Acacia adoxa var. *adoxa*
Acacia adsurgens
Acacia ancistrocarpa
Acacia stipuligera
Acacia wanyu
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Codonocarpus cotinifolius
Corymbia opaca
Eremophila tietkensii
Eriachne aristidea
Eriachne pulchella subsp. *dominii*
Fimbristylis ? *dichotoma*
Fimbristylis simulans
Gompholobium polyzygum
Goodenia stobbsiana
Goodenia triodiophila
Grevillea wickhamii subsp. *hispidula*
Haloragis gossei var. *gossei*
Heliotropium glanduliferum
Hybanthus aurantiacus
Paraneurachne muelleri
Ptilotus axillaris
Ptilotus calostachyus
Ptilotus clementii
Ptilotus nobilis
Senna glutinosa subsp. *glutinosa*
Senna glutinosa subsp. x *luerssenii*
Senna sericea
Solanum centrale
Sporobolus australasicus
Trianthema glossostigma
Tribulus hirsutus
Tribulus suberosus
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -03**	**Date** 07.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0414750 **Northing:** 7601238	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey sand.	**Soil Colour** Red
Topography/Aspect	Footslope/230°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Trees** of *Corymbia opaca* over **Scattered Mallees** of *Eucalyptus kingsmilii* subsp. *kingsmilii* over *Acacia ancistrocarpa, A. stipuligera* and *Grevillea wickhamii* subsp. *hispidula* **High Shrubland** over *Acacia stellaticeps, Jacksonia aculeata* and *Calytrix carinata* **Low Open Shrubland** over *Triodia basedowii* complex and *T. schinzii* **Closed Hummock Grassland**	



Quadrat 03

Species List

Acacia ancistrocarpa
Acacia colei
Acacia ligulata
Acacia stellaticeps
Acacia stipuligera
Amphipogon sericeus
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Calytrix carinata
Cassytha capillaris
Corymbia opaca
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eriachne aristidea
Eucalyptus kingsmillii subsp. *kingsmillii*
Gompholobium polyzygum
Goodenia ? *microptera*
Goodenia armitiana
Goodenia azurea
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea subsp. *lorea*
Haloragis gossei var. *gossei*
Heliotropium glanduliferum
Hibiscus leptocladus
Hybanthus aurantiacus
Isotropis atropurpurea
Jacksonia aculeata
Oldenlandia pterospora
Polygala isingii
Pterocaulon serrulatum
Scaevola parvifolia
Senna notabilis
Sida arenicola
Sida sp. Rabbit Flat (B.J. Carter 626)
Solanum centrale
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Triodia basedowii
Triodia pungens
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -04**	**Date** 06.06.2012 **Surveyor** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0415582 **Northing:** 7601046	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey sand.	**Soil Colour** Red
Topography/Aspect	Plain/0°	**Disturbance Type** Vehicle tracks
Vegetation Condition	Excellent	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Trees** of *Corymbia candida* subsp. *dipsodes* and *C. opaca* over **Scattered Mallees** of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia ancistrocarpa* and *Grevillea eriostachya* **High Shrubland** over *Triodia basedowii* **Closed Hummock Grassland** over *Amphipogon caricinus* var. *caricinus* **very open grassland**	



Quadrat 04

Species List

Acacia adoxa var. *adoxa*
Acacia ancistrocarpa
Acacia stellaticeps
Acacia stipuligera
Amphipogon sericeus
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Bonamia ? *erecta*
Calytrix carinata
Cassytha capillaris
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eriachne aristidea
Gompholobium polyzygum
Goodenia armitiana
Goodenia azurea
Grevillea eriostachya
Grevillea wickhamii
Hakea lorea
Halgania solanacea
Indigofera boviperda
Jacksonia aculeata
Oldenlandia pterospora
Paraneurachne muelleri
Polygala isingii
Ptilotus astrolasius
Ptilotus calostachyus
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Tephrosia arenicola
Triodia basedowii
Velleia connata

FLORA QUADRAT DATA SHEET

Location	**Optimisation -05**	**Date** 06.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0416317 **Northing:** 7600977	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey sand.	**Soil Colour** Red
Topography/Aspect	Swale/0°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Trees** of *Corymbia candida* subsp. *dipsodes* and *C. opaca* over **Scattered Mallees** of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia ancistrocarpa* and *Grevillea eriostachya* **High Shrubland** over *Triodia basedowii* **Closed Hummock Grassland** over *Amphipogon caricinus* var. *caricinus* **very open grassland**	



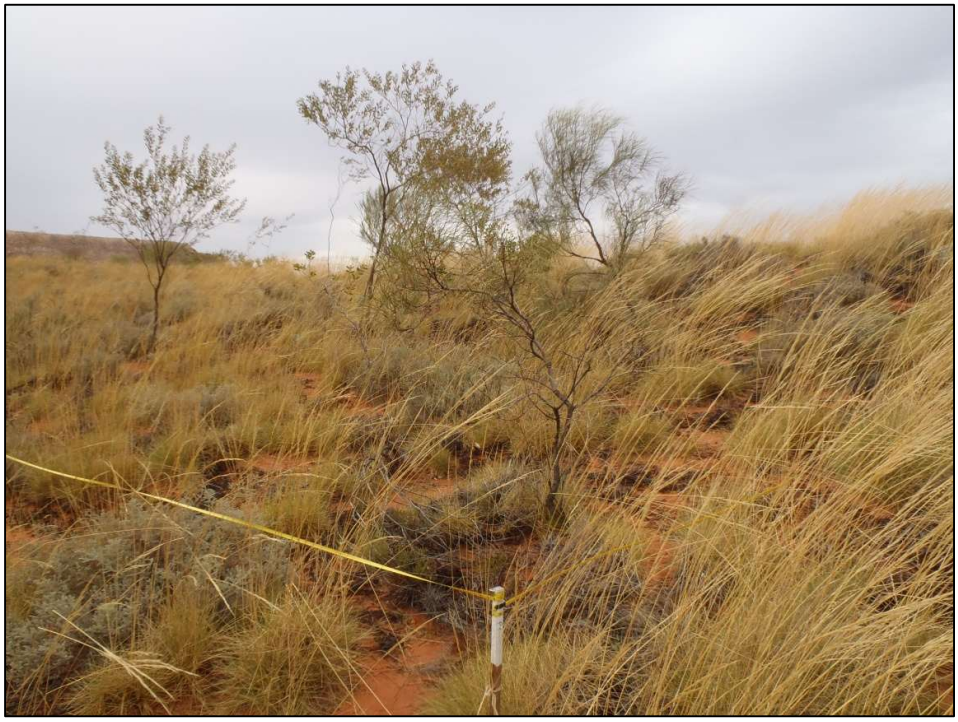
Quadrat 05

Species List

Acacia adsurgens
Acacia ancistrocarpa
Acacia colei var. *colei*
Acacia sphaerostachya
Acacia stellaticeps
Acacia stipuligera
Amphipogon sericeus
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Calytrix carinata
Codonocarpus cotinifolius
Corymbia deserticola subsp. *deserticola*
Eragrostis eriopoda
Eriachne aristidea
Eucalyptus kingsmillii subsp. *kingsmillii*
Goodenia armitiana
Grevillea wickhamii subsp. *hispidula*
Hakea chordophylla
Heliotropium glanduliferum
Ptilotus astrolasius
Ptilotus calostachyus
Scaevola parvifolia
Senna notabilis
Senna sericea
Sida ? cardiophylla
Solanum centrale
Tribulus macrocarpus
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -06**	**Date** 07.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0414536 **Northing:** 760054	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune/0°	**Disturbance Type** Multiple tracks nearby
Vegetation Condition	Excellent	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Trees** of *Corymbia candida5* subsp. *dipsodes* and *C. opaca* over **Scattered Mallees** of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia ancistrocarpa* and *Grevillea eriostachya* **High Shrubland** over *Triodia basedowii* **Closed Hummock Grassland** over *Amphipogon caricinus* var. *caricinus* **very open grassland**	



Quadrat 06

Species List

Acacia dictyophleba
Acacia ligulata
Acacia stellaticeps
Acacia stipuligera
Amphipogon sericeus
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Bonamia ? *erecta*
Brunonia suffruticosa
Calytrix carinata
Cassytha capillaris
Corymbia chippendalei
Cucumis maderaspatanus
Dampiera cinerea
Dicrastylis cordifolia
Dicrastylis doranii
Eragrostis eriopoda
Eriachne aristidea
Eriachne obtusa
Gonocarpus eremophilus
Grevillea stenobotrya
Gyrostemon tepperi
Halgania solanacea
Jacksonia aculeata
Oldenlandia pterospora
Otion simplicifolium
Petalostylis cassioides
Polygala isingii
Scaevola parvifolia
Setaria surgens
Sida sp. Rabbit Flat (B.J. Carter 626)
Triodia pungens
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -07**	**Date** 07.06.2012 **Surveyor** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0413892 **Northing:** 7600485	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Low rocky hill/40°	**Disturbance Type** Old tracks and rubbish
Vegetation Condition	Excellent	
Broad Floristic Formation	**Triodia Closed Hummock Grassland**	
Vegetation Association	**Scattered Trees** of *Eucalyptus leucophloia* subsp. *leucophloia* over **Scattered Shrubs** of *Tribulus suberosus* and *Hakea lorea* over *Triodia basedowii* complex **Closed Hummock Grassland**	



Quadrat 07

Species List

Acacia adoxa
Acacia hilliana
Acacia stipuligera
Amyema sanguinea var. *sanguinea*
Aristida holathera var. *holathera*
Calytrix carinata
Cassytha capillaris
Dodonaea coriacea
Eriachne aristidea
Eucalyptus kingsmillii
Eucalyptus leucophloia subsp. *leucophloia*
Exocarpos sparteus
Gompholobium polyzygum
Goodenia armitiana
Goodenia stobbsiana
Goodenia triodiophila
Grevillea wickhamii
Hakea chordophylla
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Hybanthus aurantiacus
Polygala isingii
Pterocaulon serrulatum
Ptilotus calostachyus
Ptilotus nobilis
Ptilotus polystachyus
Scaevola spinescens
Senna artemisioides subsp. *helmsii*
Senna sericea
Stackhousia muricata
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Streptoglossa odora
Tribulus suberosus
Triodia basedowii complex
Triodia epactia
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -08**	**Date** 07.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0413819 **Northing:** 7599451	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Swale/320°	**Disturbance Type** Camel tracks
Vegetation Condition	Excellent	
Broad Floristic Formation	**Corymbia Open Woodland**	
Vegetation Association	*Corymbia opaca* **Open Woodland** over *Acacia ancistrocarpa*, *A. stipuligera* and *A. monticola* **Open Shrubland** over *Aristida inaequiglumis*, *Eulalia aurea* and *Paraneurachne muelleri* **Closed Grassland** over *Triodia schinzii* **Very Open Tussock Grassland**	



Quadrat 08

Species List

Acacia adsurgens
Acacia ancistrocarpa
Acacia monticola
Acacia stipuligera
Acacia wanyu
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Aristida inaequiglumis
Bonamia erecta
Cassytha capillaris
Cheilanthes sieberi subsp. *sieberi*
Chrysopogon fallax
Corchorus sidoides subsp. *sidoides*
Corymbia opaca
Cucumis maderaspatanus
Dampiera candicans
Dodonaea coriacea
Eragrostis eriopoda
Eriachne aristidea
Eulalia aurea
Euphorbia australis
Evolvulus alsinoides var. *decumbens*
Evolvulus alsinoides var. *villosicalyx*
Hakea lorea
Hibiscus sturtii var. *campylochlamys*
Indigofera boviperda
Isotropis atropurpurea
Jacksonia aculeata
Keraudrenia velutina subsp. *elliptica*
Paraneurachne muelleri
Peripleura virgata
Pluchea tetranthera
Pterocaulon sphaeranthoides
Ptilotus calostachyus
Scaevola parvifolia
Schizachyrium fragile
Senna glaucifolia
Senna sericea
Setaria surgens
Sida sp. Rabbit Flat (B.J. Carter 626)
Solanum ? *horridum*
Streptoglossa odora
Triodia basedowii
Triodia epactia
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -09**	**Date** 07.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0413821 **Northing:** 7598696	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Swale/90°	**Disturbance Type** Camel scats
Vegetation Condition	Excellent	
Broad Floristic Formation	**Acacia High Shrubland**	
Vegetation Association	*Acacia pteraneura* **High Shrubland** over *A. wanyu*, *Anthobolus leptomerioides* and *Psydrax latifolia* **Shrubland** over *Eremophila tietkensii* and *E. latrobei* subsp. *latrobei* **Low Open Shrubland** over *Triodia basedowii* **Open Hummock Grassland**	



Quadrat 09

Species List

Acacia pteraneura
Acacia wanyu
Anthobolus leptomerioides
Bulbostylis barbata
**Cenchrus ciliaris*
Corchorus sidoides subsp. *sidoides*
Dactyloctenium radulans
Dysphania kalpari
Enneapogon polyphyllus
Eremophila latrobei subsp. *latrobei*
Eremophila tietkensii
Eulalia aurea
Fimbristylis dichotoma
Goodenia stobbsiana
Hibiscus sturtii var. *campylochlamys*
Maireana triptera
Maireana villosa
Paraneurachne muelleri
Pluchea tetranthera
Polycarpaea corymbosa
**Portulaca oleracea*
Psydrax latifolia
Pterocaulon sphaeranthoides
Ptilotus calostachyus
Ptilotus nobilis
Ptilotus obovatus
Ptilotus polystachyus
Santalaceae sp.
Scaevola spinescens
Sclerolaena cornishiana
Sclerolaena cuneata
Senna artemisioides subsp. helmsii
Senna glutinosa subsp. x luerssenii
Sida sp.
Sporobolus actinocladus
Sporobolus australasicus
Streptoglossa odora
Tribulus macrocarpus
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -10**	**Date** 07.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0414123 **Northing:** 7599311	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Rocky hill/90°	**Disturbance Type** Old Tracks at base
Vegetation Condition	Excellent	
Broad Floristic Formation	**Triodia Closed Hummock Grassland**	
Vegetation Association	**Scattered Trees** of *Eucalyptus leucophloia* subsp. *leucophloia* over **Scattered Shrubs** of *Tribulus suberosus* and *Hakea lorea* over *Triodia basedowii* complex **Closed Hummock Grassland**	



Quadrat 10

Species List

Acacia ancistrocarpa
Amyema sanguinea
Aristida contorta
Cassytha capillaris
Dodonaea coriacea
Eriachne aristidea
Eucalyptus leucophloia subsp. *leucophloia*
Euphorbia drummondii
Euphorbia drummondii subsp. drummondii
Gompholobium polyzygum
Goodenia armitiana
Goodenia triodiophila
Hakea lorea
Hybanthus aurantiacus
Paraneurachne muelleri
Polygala isingii
Pterocaulon serrulatum
Ptilotus calostachyus
Ptilotus clementii
Ptilotus polystachyus
Scaevola parvifolia
Sida ? macropoda
Sida arenicola
Sida sp. Rabbit Flat (B.J. Carter 626)
Sporobolus australasicus
Stackhousia muricata
Triodia basedowii
Triodia pungens
Triodia schinzii
Triumfetta deserticola

FLORA QUADRAT DATA SHEET

Location	**Optimisation -11**	**Date** 07.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0413067 **Northing:** 7599514	**GPS Location Relative to Quadrat** NW
Soil Type	Sandy clay	**Soil Colour** Orange
Topography/Aspect	Low hill/90°	**Disturbance Type** Tracks present
Vegetation Condition	Excellent	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	*Grevillea wickhamii* subsp. *hispidula*, *Acacia acradenia* and *A. synchronicia* **Open Shrubland** over *Triodia epactia* **Hummock Grassland**	



Quadrat 11

Species List

Acacia acradenia
Acacia synchronicia
Anthobolus leptomerioides
Cassytha capillaris
Codonocarpus cotinifolius
Enneapogon caerulescens
Grevillea wickhamii subsp. *hispidula*
Heliotropium glanduliferum
Polygala isingii
Pterocaulon serrulatum
Ptilotus axillaris
Ptilotus clementii
Salsola australis
Scaevola amblyanthera var. *centralis*
Senna glutinosa subsp. *pruinosa*
Solanum centrale
Sporobolus australasicus
Tribulus hirsutus
Triodia epactia

FLORA QUADRAT DATA SHEET

Location	**Optimisation -12**	**Date** 07.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0413225 **Northing:** 7600225	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Swale/Level	**Disturbance Type** Tracks present
Vegetation Condition	Excellent	
Broad Floristic Formation	**Corymbia Open Woodland**	
Vegetation Association	*Corymbia opaca* **Open Woodland** over *Acacia ancistrocarpa*, *A. stipuligera* and *A. monticola* **Open Shrubland** over *Aristida inaequiglumis*, *Eulalia aurea* and *Paraneurachne muelleri* **Closed Grassland** over *Triodia schinzii* **Very Open Tussock Grassland**	



Quadrat 12

Species List

Acacia acradenia
Acacia ancistrocarpa
Acacia monticola
Acacia stellaticeps
Acacia stipuligera
Amphipogon sericeus
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Aristida inaequiglumis
Bonamia erecta
Cassytha capillaris
Corymbia candida subsp. *dipsodes*
Corymbia opaca
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eremophila latrobei
Eriachne aristidea
Eucalyptus kingsmillii
Eulalia aurea
Evolvulus alsinoides var. *decumbens*
Goodenia armitiana
Grevillea wickhamii
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Hibiscus sturtii var. *campylochlamys*
Indigofera boviperda
Paraneurachne muelleri
Paspalidium rarum
Pluchea dentex
Pluchea ferdinandi-muelleri
Pluchea tetranthera
Polygala isingii
Pterocaulon serrulatum
Ptilotus fusiformis
Ptilotus nobilis
Scaevola parvifolia
Schizachyrium fragile
Senna artemisioides subsp. *oligophylla*
Senna notabilis
Setaria surgens
Sida arenicola
Sida sp. Rabbit Flat (B.J. Carter 626)
Streptoglossa ? *odora*
Streptoglossa macrocephala
Tephrosia arenicola
Triodia basedowii
Triodia epactia
Triodia schinzii
Velleia connata

FLORA QUADRAT DATA SHEET

Location	**Optimisation -13**	**Date** 07.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0413509 **Northing:** 7598664	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Orange
Topography/Aspect	Footslope/120°	**Disturbance Type** nil
Vegetation Condition	Excellent	
Broad Floristic Formation	**Acacia High Shrubland**	
Vegetation Association	*Acacia pteraneura* **High Shrubland** over *A wanyu*, *Anthobolus leptomerioides* and *Psydrax latifolia* **Shrubland** over *Eremophila tietkensii* and *E. latrobei* subsp. *latrobei* **Low Open Shrubland** over *Triodia basedowii* **Open Hummock Grassland**	



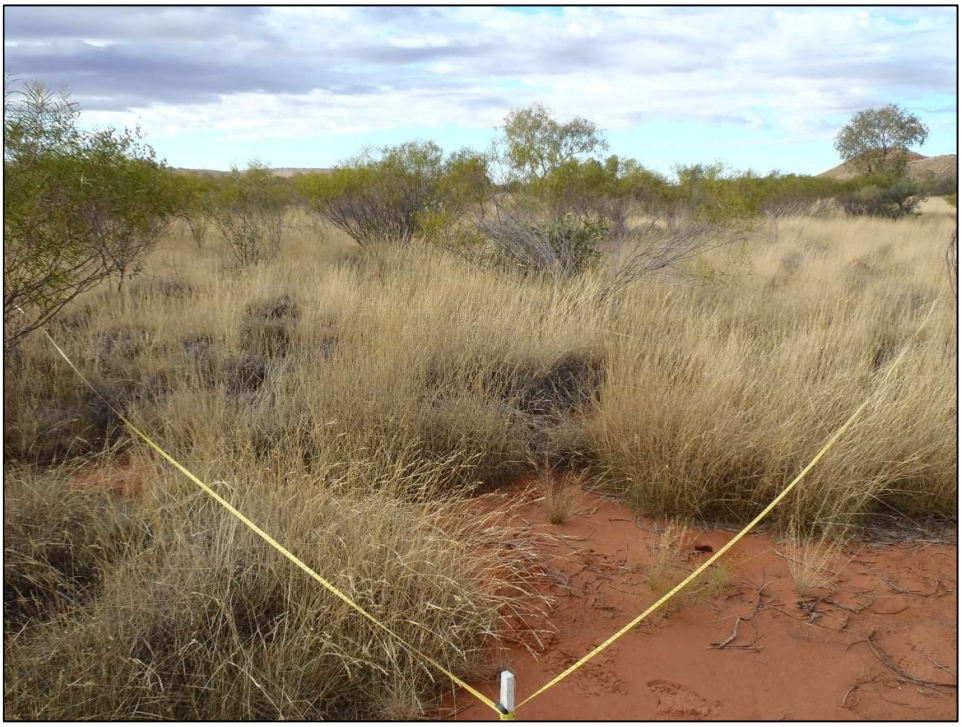
Quadrat 13

Species List

Acacia ancistrocarpa
Acacia pteraneura
Acacia wanyu
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Bulbostylis barbata
Cassytha capillaris
Cheilanthes sieberi subsp. *sieberi*
Corchorus sidoides subsp. *sidoides*
Corymbia ? *opaca*
Enchylaena tomentosa var. *tomentosa*
Enneapogon polyphyllus
Eragrostis eriopoda
Eremophila latrobei subsp. *latrobei*
Eremophila tietkensii
Eriachne aristidea
Eulalia aurea
Euphorbia boophthona
Evolvulus alsinoides var. *villosicalyx*
Fimbristylis ? *dichotoma*
Goodenia armitiana
Hakea lorea subsp. *lorea*
Heliotropium glanduliferum
Hibiscus sturtii var. *campylochlamys*
Maireana triptera
Owenia reticulata
Paraneurachne muelleri
Paspalidium rarum
Pluchea tetranthera
Polycarpaea corymbosa
Psydrax latifolia
Pterocaulon serrulatum
Ptilotus calostachyus
Ptilotus clementii
Ptilotus nobilis
Scaevola spinescens
Senna artemisioides subsp. *helmsii*
Senna artemisioides subsp. *oligophylla*
Senna glutinosa subsp. *glutinosa*
Senna glutinosa subsp. x *luerssenii*
Setaria surgens
Sida ? *macropoda*
Sida arenicola
Sida fibulifera
Sporobolus australasicus
Streptoglossa odora
Synaptantha tillaeacea var. *hispidula*
Tribulus macrocarpus
Triodia basedowii
Triodia epactia

FLORA QUADRAT DATA SHEET

Location	**Optimisation -14**	**Date** 07.06.2012 **Surveyor** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0413951 **Northing:** 7597827	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Swale/Level°	**Disturbance Type** Vehicle tracks
Vegetation Condition	Excellent	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Trees** of *Corymbia candida* subsp. *dipsodes* and *C. opaca* over **Scattered Mallees** of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia ancistrocarpa* and *Grevillea eriostachya* **High Shrubland** over *Triodia basedowii* **Closed Hummock Grassland** over *Amphipogon caricinus* var. *caricinus* **Very Open Grassland**	



Quadrat 14

Species List

Acacia ancistrocarpa
Amphipogon caricinus var. *caricinus*
Amphipogon sericeus
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Brunonia ? *suffructicosa*
Cassytha capillaris
Corymbia candida subsp. *dipsodes*
Corymbia opaca
Cucumis maderaspatanus
Dampiera candicans
Dodonaea coriacea
Eragrostis eriopoda
Eriachne aristidea
Eucalyptus kingsmillii subsp. *kingsmillii*
Euphorbia drummondii subsp. *drummondii*
Goodenia armitiana
Goodenia azurea
Grevillea eriostachya
Grevillea wickhamii
Hakea chordophylla
Hakea lorea
Halgania solanacea
Heliotropium glabellum
Indigofera boviperda subsp. *boviperda*
Isotropis atropurpurea
Jacksonia aculeata
Pterocaulon serrulatum
Ptilotus axillaris
Scaevola parvifolia
Sida ? *macropoda*
Tephrosia arenicola
Triodia basedowii
Triodia epactia
Velleia connata

FLORA QUADRAT DATA SHEET

Location	**Optimisation -15**	**Date** 08.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0414006 **Northing:** 7597592	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Hillcrest/270°	**Disturbance Type** nil
Vegetation Condition	Excellent	
Broad Floristic Formation	**Triodia Closed Hummock Grassland**	
Vegetation Association	**Scattered Trees** of *Eucalyptus leucophloia* subsp. *leucophloia* over **Scattered Shrubs** of *Tribulus suberosus* and *Hakea lorea* over *Triodia basedowii* complex **Closed Hummock Grassland**	



Quadrat 15

Species List

Acacia acradenia
Acacia ancistrocarpa
Acacia ligulata
Acacia synchronicia
Amphipogon sericeus
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Bonamia ? *erecta*
Calytrix carinata
Cassytha capillaris
Codonocarpus cotinifolius
Corchorus sidoides
Cucumis maderaspatanus
Dodonaea coriacea
Enneapogon polyphyllus
Eragrostis eriopoda
Eremophila latrobei subsp. *latrobei*
Eremophila tietkensii
Eriachne aristidea
Eucalyptus leucophloia subsp. *leucophloia*
Fimbristylis dichotoma
Fimbristylis oxystachya
Goodenia armitiana
Goodenia stobbsiana
Goodenia triodiophila
Grevillea eriostachya
Grevillea wickhamii
Hakea lorea
Heliotropium chrysocarpum
Heliotropium glanduliferum
Hibiscus coatesii
Hybanthus aurantiacus
Jacksonia aculeata
Maireana melanocoma
Oldenlandia crouchiana
Oldenlandia pterospora
Paraneurachne muelleri
**Portulaca oleracea*
Ptilotus axillaris
Ptilotus calostachyus
Ptilotus nobilis
Ptilotus polystachyus
Scaevola parvifolia
Sclerolaena cornishiana
Senna glutinosa subsp. *glutinosa*
Senna glutinosa subsp. *pruinosa*
Senna symonii
Tephrosia ? *sphaerospora*
Tribulus macrocarpus
Tribulus suberosus
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -16**	**Date** 08.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0414416 **Northing:** 7596739	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Swale/0°	**Disturbance Type** Mining dust
Vegetation Condition	Excellent	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Trees** of *Corymbia opaca* over **Scattered Mallees** of *Eucalyptus kingsmilii* subsp. *kingsmilii* over *Acacia ancistrocarpa*, *A. stipuligera* and *Grevillea wickhamii* subsp. *hispidula* **High Shrubland** over *A. stellaticeps*, *Jacksonia aculeata* and *Calytrix carinata* **Low Open Shrubland** over *Triodia basedowii* complex and *T. schinzii* **Closed Hummock Grassland**	



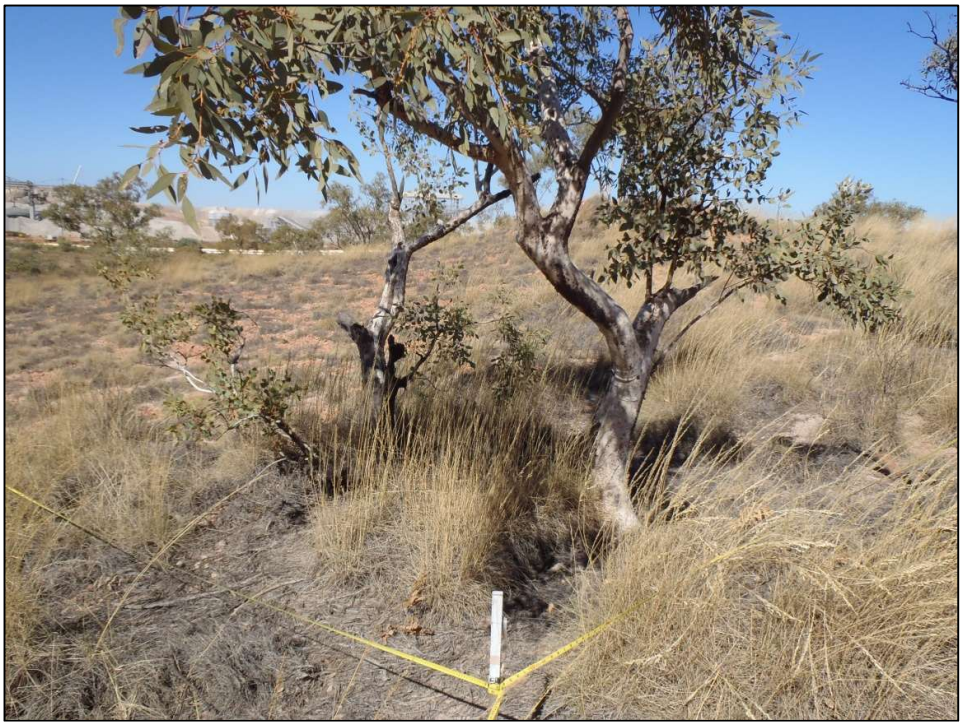
Quadrat 16

Species List

Acacia ancistrocarpa
Acacia ligulata
Acacia stellaticeps
Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Anthobolus leptomerioides
Aristida holathera
Bonamia erecta
Brunonia suffruticosa
Calytrix carinata
Cassytha capillaris
Corymbia opaca
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eriachne sp.
Eucalyptus kingsmillii
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii subsp. *hispidula*
Hakea lorea
Halgania solanacea
Jacksonia aculeata
Pterocaulon serrulatum
Sida ? sp. Rabbit Flat (B.J. Carter 626)
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**Optimisation -17**	**Date** 08.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0416319 **Northing:** 7596501	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hill/	**Disturbance Type** Mining dust
Vegetation Condition	Very Good	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	*Acacia wanyu* **Scattered Tall Shrubs** over *Eremophila tietkensii*, *Senna sericea* and *S. glutinosa* subsp. x *luerssenii* over *Triodia basedowii* complex **Hummock Grassland**	



Quadrat 17

Species List

Acacia adoxa
Acacia hilliana
Acacia stipuligera
Aristida holathera var. *holathera*
Eragrostis eriopoda
Eremophila tietkensii
Eriachne aristidea
Eucalyptus leucophloia subsp. *leucophloia*
Fimbristylis dichotoma
Goodenia triodiophila
Heliotropium glanduliferum
Maireana triptera
Pterocaulon serrulatum
Ptilotus calostachyus
Ptilotus nobilis
Santalum sp.
Senna glutinosa subsp. x *luerssenii*
Senna sericea
Stylobasium spathulatum
Trianthema turgidifolia
Tribulus suberosus
Triodia basedowii
Triodia epactia
Triodia pungens

FLORA QUADRAT DATA SHEET

Location	**Optimisation -18**	**Date** 08.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0416404 **Northing:** 7596664	**GPS Location Relative to Quadrat** NW
Soil Type	Silty Clay Loam	**Soil Colour** Yellow
Topography/Aspect	Flat/Level	**Disturbance Type** Mining – In amongst waste dumps
Vegetation Condition	Good	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Trees** of *Corymbia opaca* over **Scattered Mallees** of *Eucalyptus kingsmilii* subsp. *kingsmilii* over *Acacia ancistrocarpa*, *A. stipuligera* and *Grevillea wickhamii* subsp. *hispidula* **High Shrubland** over *A. stellaticeps*, *Jacksonia aculeata* and *Calytrix carinata* **Low Open Shrubland** over *Triodia basedowii* complex and *T. schinzii* **Closed Hummock Grassland**	



Quadrat 18

Species List

Acacia adoxa
Acacia ancistrocarpa
Acacia hilliana
Acacia ligulata
Acacia stellaticeps
Acacia stipuligera
Amphipogon sericeus
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Brunonia suffruticosa
Calytrix carinata
Cucumis maderaspatanus
Cynanchum floribundum
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eriachne aristidea
Eucalyptus kingsmillii
Eucalyptus leucophloia subsp. *leucophloia*
Eucalyptus odontocarpa
Gompholobium polyzygum
Goodenia azurea
Goodenia hartiana **(P2)**
Grevillea stenobotrya
Grevillea wickhamii
Halgania solanacea
Heliotropium glanduliferum
Hybanthus aurantiacus
Jacksonia aculeata
Paraneurachne muelleri
Peripleura virgata
Pluchea ? *tetranthera*
Polygala isingii
Pterocaulon ? *sphaeranthoides*
Pterocaulon serrulatum
Ptilotus axillaris
Ptilotus calostachyus
Ptilotus clementii
Scaevola parvifolia
Senna notabilis
Sida ? sp. B Kimberley Flora (A.A. Mitchell 2745)
Sida sp. Rabbit Flat (B.J. Carter 626)
Solanum centrale
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Streptoglossa macrocephala
Stylobasium spathulatum
Thysanotus aff. *exiliflorus*
Trichodesma zeylanicum
Triodia basedowii
Triodia schinzii
Velleia connata

FLORA QUADRAT DATA SHEET

Location	**Optimisation -19**	**Date** 08.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0415761 **Northing:** 7595366	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Swale/320°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Mallees** of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* **High Shrubland** over *Gompholobium polyzygum*, *Halgania solanacea* var. *solanacea* and *Jacksonia aculeata* **Low Shrubland** over *Triodia basedowii* complex **Very Open Hummock Grassland**	



Quadrat 19

Species List

Acacia stellaticeps
Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Amphipogon caricinus var. *caricinus*
Aristida holathera var. *holathera*
Bonamia erecta
Calytrix carinata
Dicrastylis ? *doranii*
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Exocarpos sparteus
Gompholobium polyzygum
Goodenia hartiana **(P2)**
Grevillea eriostachya
Grevillea wickhamii subsp. *hispidula*
Hakea lorea subsp. *lorea*
Halgania solanacea
Jacksonia aculeata
Otion simplicifolium
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Triodia aff. *lanigera*
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**Optimisation-20**	**Date** 08.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0416038 **Northing:** 7595505	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Rocky hill/90°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	*Acacia wanyu* **Scattered Tall Shrubs** over *Eremophila tietkensii*, *Senna sericea* and *S. glutinosa* subsp. x *luerssenii* over *Triodia basedowii* complex **Hummock Grassland**	

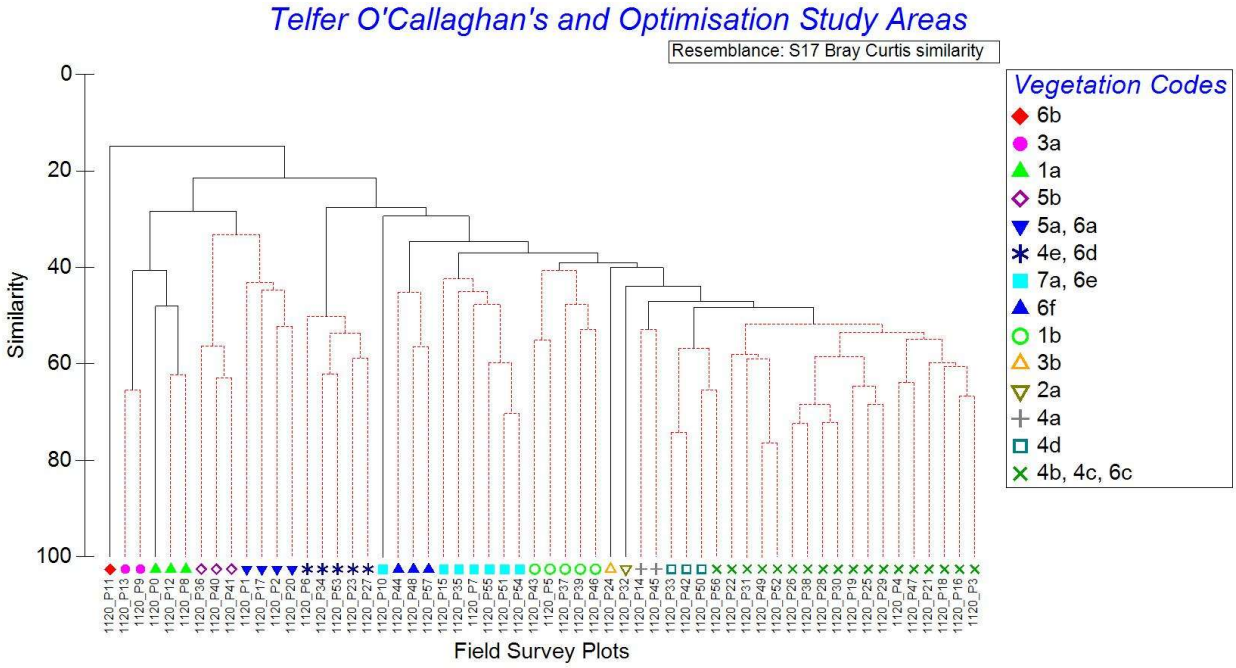


Quadrat 20

Species List

Acacia stipuligera
Acacia wanyu
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Calytrix carinata
Cassytha capillaris
Dodonaea coriacea
Eremophila tietkensii
Eriachne pulchella subsp. *dominii*
Eucalyptus kingsmillii subsp. *kingsmillii*
Fimbristylis dichotoma
Gompholobium polyzygum
Goodenia stobbsiana
Hakea lorea subsp. *lorea*
Iseilema dolichotrichum
Lepidium sp.
Maireana triptera
Mirbelia viminalis
Paraneurachne muelleri
Paspalidium clementii
Polygala isingii
Pterocaulon ? *sphaeranthoides*
Ptilotus calostachyus
Ptilotus nobilis
Ptilotus polystachyus
Sclerolaena eriacantha
Sclerolaena minuta
Senna glutinosa subsp. *glutinosa*
Senna glutinosa subsp. *x luerssenii*
Senna sericea
Sida ? sp. Excedentifolia (J.L. Egan 1925)
Sida arenicola
Sporobolus australasicus
Triodia basedowii
Triodia epactia

Appendix 4 Analysis and Classification of Vegetation Associations



Appendix 5 Vegetation Association Descriptions

1 *Corymbia* Open Woodland

1a ***Corymbia opaca* Open Woodland over *Acacia ancistrocarpa, A. stipuligera* and *A. monticola* Open Shrubland over *Aristida inaequiglumis, Eulalia aurea* and *Paraneurachne muelleri* Closed Grassland over *Triodia schinzii* Very Open Tussock Grassland**

Area Mapped: 43 ha (3.49% of the study area)

ID of quadrats sampled: 1120_P00, 1120_P12, 1120_P8

Location + Landform

Located at one location in the central west part of the study area, this Vegetation Association is found in a drainage channel between rocky outcrops.

Vegetation Stratum Levels

Upper	*Corymbia opaca*
Middle	*Acacia ancistrocarpa, A. stipuligera, A. monticola, Anthobolus leptomerioides*
Ground	*Aristida inaequiglumis, Eulalia aurea, Scaevola parvifolia, Triodia schinzii*
Species of Conservation Significance	Range extensions – *Scleroleana minuta* and *Synaptantha tillaeacea* var. *tillaeacea*
Introduced Species	Nil
Vegetation Condition	Excellent.
Geology	Malu Formation (Nsat), (Geoscience Australia, 2008).
Soil Attributes	Red to brown sandy to silty loam.

Other Locations

This Vegetation Association is most similar to vegetation type 2 from the Waste Dump Expansion Survey in the same vegetation type (Syrinx Environmental PL 2006), however the description varies due to the variable cover of dominant species where the quadrat was located (which are the same for all locations).



1 *Corymbia* Open Woodland

1b *Corymbia opaca* and *Eucalyptus leucophloia* Open Woodland over Scattered *Eucalyptus kingsmillii* over Tall Shrubs of *Grevillea stenobotrya* and *Hakea lorea* over Low Scattered Shrubs of *Acacia stellaticeps*, *Dicrastylis cordifolia* and *Jacksonia aculeata* over *Triodia basedowii* complex Hummock Grassland

Area Mapped: 1115.65ha (9.39 % of the study area)

ID of quadrats sampled: 1120_P5, 1120_P37, 1120_39, 1120_43, 1120_46

Location + Landform

Occurring on shallow sand (<0.5m) over low rocky outcrops, with areas of occasional small rocky outcrops in the northern portion of the Optimisation Study Area adjacent rocky outcrops and Acacia wanyu dominated vegetation association (1a)

Vegetation Stratum Levels

Upper	*Corymbia opaca, Eucalyptus leucophloia*
Middle	*Eucalyptus kingsmillii, Grevillea stenobotrya, Hakea lorea*
Ground	*Acacia stellaticeps, Dicrastylis cordifolia, Ptilotus calostachyus, Triodia basedowii* complex
Species of Conservation Significance	Nil
Introduced Species	Nil
Vegetation Condition	Excellent – Vehicle tracks from nearby exploration activities
Geology	Wilki Formation (Nsaw), (Geoscience Australia, 2008).
Soil Attributes	Thin layer (<10cm) red sand over rocky outcrop

Other Locations

Vegetation Type 2: *Corymbia opaca* and *Hakea lorea* over *Triodia basedowii* (Syrinx Environmental PL 2006); Sandplain Variation 5 (Hart, Simpson and Associates 2002); and Type 2: Scattered *Corymbia opaca* and *Hakea lorea* over *Acacia stellaticeps* open shrubland over *Triodia basedowii* grassland (Syrinx Environmental PL 2007).



3 *Acacia* High Shrubland

3a ***Acacia pteraneura High Shrubland over Acacia wanyu, Anthobolus leptomerioides and Psydrax latifolia Shrubland over Eremophila tietkensii and E. latrobei subsp. latrobei Low Open Shrubland over Triodia basedowii Open Hummock Grassland*.**

Area Mapped: 60.21 ha (5.89 % of the study area)

ID of quadrats sampled: 1120_P9, 1120_P13

Location + Landform

This Vegetation Association forms on flats in swales and between low rock hills and it is located in the central part of the study area.

Vegetation Stratum Levels

Upper	N/A
Middle	*Acacia pteraneura, A. wanyu, Anthobolus leptomerioides, Psydrax latifolia*
Ground	*Eremophila tietkensii, E. latrobei* subsp. *latrobei, Triodia basedowii*
Species of Conservation Significance	Range Extension - *Acacia pteraneura* and *Maireana triptera*
Introduced Species	Nil
Vegetation Condition	Excellent
Geology	Puntapunta Formation (Nlap), (Geoscience Australia, 2008).
Soil Attributes	Red Clayey Sand

Other Locations

This Vegetation Association was recorded in the Telfer Borefield Flora and Fauna Survey (Syrinx Environmental PL 2007) at the same location and was named; *Acacia aneura* and *Eremophila tietkensii* low open shrubland over *Triodia basedowii* grassland. It has not been recorded at any other locations outside the survey area in the Telfer region.



4 Mixed High Shrubland

4a Scattered Trees of *Corymbia candida* subsp. *dipsodes* and *C. opaca* over Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia ancistrocarpa* and *Grevillea eriostachya* High Shrubland over *Triodia basedowii* Closed Hummock Grassland over *Amphipogon caricinus* var. *caricinus* Very Open Grassland.

Area Mapped: 116.66 ha (9.47 % of the study area)

ID of quadrats sampled: 1120_P14, 1120_P45

Location + Landform

This Vegetation Association occurs on swales between medium sized rocky hills. It occurs in south eastern parts of the study area in the swales adjacent to the *Acacia wanyu* Vegetation Association.

Vegetation Stratum Levels

Upper	*Corymbia candida* subsp. *dipsodes, Corymbia opaca*
Middle	*Acacia ancistrocarpa, Eucalyptus kingsmillii* subsp. *kingsmillii, Grevillea eriostachya*
Ground	*Acacia stellaticeps, Jacksonia aculeata, Scaevola parvifolia, Triodia basedowii*, *T schinzii*
Species of Conservation Significance	Nil
Introduced Species	Nil
Vegetation Condition	Very Good to Excellent – Mining exploration tracks are present in some areas of this association
Geology	Colluvium 38491 (Qrc), (Geoscience Australia, 2008)
Soil Attributes	Red sand

Other Locations

This Vegetation Association is similar to several previously identified associations in the area, these are; Vegetation Type 2: *Corymbia opaca* and *Hakea lorea* over *Triodia basedowii* (Syrinx Environmental PL 2006); Sandplain Variation 5 (Hart, Simpson and Associates 2002); and Type 2: Scattered *Corymbia opaca* and *Hakea lorea* over *Acacia stellaticeps* open shrubland over *Triodia basedowii* grassland (Syrinx Environmental PL 2007).



4 Mixed High Shrubland

4b Scattered Trees of *Corymbia opaca* over Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia ancistrocarpa, A. stipuligera* and *Grevillea wickhamii* subsp. *hispidula* High Shrubland over *A. stellaticeps, Jacksonia aculeata* and *Calytrix carinata* Low Open Shrubland over *Triodia basedowii* complex and *T. schinzii* Closed Hummock Grassland

Area Mapped: 417.25 ha (33.87 % of the study area)

ID of quadrats sampled: 1120_P03, 1120_P04, 1120_P16, 1120_P18, 1120_P21, 1120_P47

Location + Landform

This occurs on dune swales between sand dunes in the north western portion of the study area, and a wide swale downslope of a rocky outcrop in the south west portion of the study area. This Vegetation Association is similar to 4c however 4c has been more recently been impacted by fire (within 3-5 years).

Vegetation Stratum Levels

Upper	*Corymbia opaca*
Middle	*Eucalyptus kingsmillii* subsp. *kingsmillii, Acacia ancistrocarpa, Acacia stipuligera, Grevillea wickhamii* subsp. *hispidula*
Ground	*Calytrix carinata, Jacksonia aculeata, Triodia schinzii, T. basedowii*
Species of Conservation Significance	*Goodenia hartiana* (P2). Range Extension – *Peripleura virgata*
Introduced Species	Nil
Vegetation Condition	Pristine to Excellent – localised areas of Camel disturbance
Geology	Malu Formation (Nsat), Puntapunta Formation (Nlap) and Silcrete 42026 (Czz), (Geoscience Australia, 2008)
Soil Attributes	Red Sand to Red Clayey Sand.

Other Locations

This Vegetation Association is most similar to Vegetation Type 1: Mixed *Acacia* over *Triodia basedowii* (Syrinx Environmental PL 2006); Sandplain Variation 1, (Syrinx Environmental PL 2002); and Type 3: Mixed shrubland over *Acacia stellaticeps* open shrubland over *Triodia basedowii* grassland (Syrinx Environmental PL 2007).



4 Mixed High Shrubland

4c Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* High Shrubland over *Gompholobium polyzygum, Halgania solanacea* var. *solanacea* and *Jacksonia aculeata* Low Shrubland over *Triodia basedowii* complex Very Open Hummock Grassland

Area Mapped: 21.4 ha (1.74 % of the study area)

ID of quadrats sampled: 1120_P19, 120_P25, 1120_P26, 1120_P28, 1120_P29, 1120_P30, 1120_P38

Location + Landform

This Vegetation Association occurs in medium sized dune swales with occasional areas of exposed ironstone. This is located at the south eastern part of the study area and is the northern extent of a common vegetation association of the adjacent O'Callaghan's Study Area. This vegetation association differs from 4b as it has been impacted by fire within the last 5 years therefore the understorey is dominated by early successional species such as *Gompholobium polyzygum* and *Halgania solanacea* var. *solanacea*.

Vegetation Stratum Levels

Upper	*Eucalyptus kingsmillii* subsp. *kingsmillii, E. odontocarpa*
Middle	*Acacia stipuligera, Grevillea eriostachya*
Ground	*Calytrix carinata Dampiera candicans, Dicrastylis cordifolia*, *Gompholobium polyzygum, Halgania solanacea* var. *solanacea*, *Jacksonia aculeata*, *Ptilotus calostachyus*
Species of Conservation Significance	*Goodenia hartiana* – Priority 2 (Major habitat for this species)
Introduced Species	Nil
Vegetation Condition	Excellent – Some vehicle tracks close by due to drilling/exploration
Geology	Colluvium 38491 (Qrc), (Geoscience Australia, 2008)
Soil Attributes	Red Sand

Other Locations

This Vegetation Association is similar to several other previously identified associations, these are; Vegetation Type 1: Mixed *Acacia* over *Triodia basedowii* (Syrinx Environmental PL 2006); Sandplain Variation 1 (Hart, Simpson and Associates 2002); and Type 6: *Eucalyptus kingsmillii* subsp. *kingsmillii* low open woodland over mixed shrubland over *Triodia basedowii* grassland (Syrinx Environmental PL 2007).



4 Triodia Hummock Grassland

4e Scattered Tall Shrubs of *Acacia dictyophleba* over *A. stipuligera* and *Grevillea stenobotrya* Open Shrubland over *Triodia schinzii* Hummock Grassland over *Otion simplicifolium* Low Open Shrubland

Area Mapped: 2.99 ha (0.24 % of the study area)

ID of quadrats sampled: 1120_P6

Location + Landform

Moderately inclined medium sized sand dune. This Vegetation Association is located immediately west of waste dumps in the central of the study area. It differs from the other dune vegetation types due the presence of *Acacia dictyophleba.*

Vegetation Stratum Levels

Upper	
Middle	*Acacia dictyophleba, A. stipuligera, Grevillea stenobotrya*
Ground	*Dicrastylis doranii, Eriachne obtuse, Gonocarpus eremophilus, Otion simplicifolium, Triodia pungens, T. schinzii,*
Species of Conservation Significance	Nil
Introduced Flora	Nil
Vegetation Condition	Excellent – Multiple tracks near by
Geology	Silcrete 42026 (Czz), (Geoscience Australia, 2008).
Soil Attributes	Red to brown sand.

Other Locations

This Vegetation Association is most similar to the following previously identified associations; Vegetation Type 6: Mixed shrubs on dunes, (Syrinx Environmental PL 2006); Sand Dunes, (Hart, Simpson and Associates 2002); and Type 12: Grevillea stenobotrya shrubland over *Triodia schinzii grassland* (Syrinx Environmental PL 2007).



5 *Acacia* Open Shrubland

5a *Acacia wanyu* Open Shrubland over *A. stellaticeps* and *Dodonaea coriacea* Low Open Shrubland over *Triodia basedowii* and *T. pungens* Hummock Grassland

Area Mapped: 145.48 ha (11.82 % of the study area)

ID of quadrats sampled: 1120_P1

Location + Landform

This Vegetation Association is formed on low points and flat areas in both the North and central parts of the study area.

Vegetation Stratum Levels

Upper	*N/A*
Middle	*Acacia colei* var. *colei, A. wanyu, Anthobolus leptomerioides, Senna sericea*
Ground	*Acacia stellaticeps, Brachyachne prostrata, Eragrostis dielsii, Maireana triptera, Triodia basedowii, T. pungens*
Species of Conservation Significance	Range Extension - *Maireana triptera* and *Scleroleana crenata*
Introduced Flora	
Vegetation Condition	Pristine
Geology	Colluvium 38491 (Qrc), (Geoscience Australia, 2008).
Soil Attributes	Red to brown Clayey Sand.

Other Locations

This Vegetation Association is most similar to Type 3: Mixed shrubland over *Acacia stellaticeps* open shrubland over Triodia basedowii grassland (Syrinx Environmental PL 2007).



6 *Triodia* Hummock Grassland

6a *Acacia wanyu* Scattered Tall Shrubs over *Eremophila tietkensii*, *Senna sericea* and *S. glutinosa* subsp. x luerssenii over *Triodia basedowii* complex Hummock Grassland

Area Mapped: 51.4 ha (4.17 % of the study area)

ID of quadrats sampled: 1120_P02, 1120_P17, 1120_P20

Location + Landform

This Vegetation Association occurs on low rocky ironstone hills and in the central parts of the study area. This vegetation association has a larger distribution in the Optimisation Study Area, occurring on large rocky hills with scattered *Eucalyptus leucophloia* present.

Vegetation Stratum Levels

Upper	*Eucalyptus leucophloia*
Middle	*Acacia wanyu, Eremophila tietkensii, Senna sericea* and *S. glutinosa* subsp. *x luerssenii*
Ground	*Acacia hilliana, Goodenia stobbsiana Triodia basedowii,*
Species of Conservation Significance	Range Extensions – *Maireana triptera*, *Scleroleana minuta* and *S. eriacantha*
Introduced Species	Nil
Vegetation Condition	Excellent - Old tracks were found near some of the plots that make up this vegetation association
Geology	Puntapunta Formation (Nlap),
Soil Attributes	Red sand to clayey sand

Other Locations

This Vegetation Association is most similar to Vegetation Type 5: *Triodia schinzii* on stony hills (Syrinx Environmental PL 2006); Stony Hills, (Hart, Simpson and Associates 2002); and Type 16: Scattered *Eucalyptus leucophloia* subsp. *leucophloia* over *Senna glutinosa* subsp. *luerssenii* over *Triodia basedowii* grassland (Syrinx Environmental PL 2007).



6 *Triodia* Hummock Grassland

6b *Grevillea wickhamii subsp. hispidula, Acacia acradenia* and *A. synchronicia* Open Shrubland over *Triodia epactia* Hummock Grassland

Area Mapped: 22.26 ha (1.81 % of the study area)

ID of quadrats sampled: 1120_P11

Location + Landform

This Vegetation Association forms on moderately sloped low sandstone hills located in the central part of the study area.

Vegetation Stratum Levels

Upper	*N/A*
Middle	*Acacia acradenia, A. synchronicia, Anthobolus leptomerioides, Codonocarpus cotinifolius, Grevillea wickhamii* subsp. *hispidula,*
Ground	*Enneapogon caerulescens, Heliotropium glanduliferum, Ptilotus axillaris, P. clementii, Triodia epactia*
Species of Conservation Significance	Nil
Introduced Flora	Nil
Vegetation Condition	Excellent – Tracks are present near by
Geology	Puntapunta Formation (Nlap), (Geoscience Australia, 2008)
Soil Attributes	Orange Clayey Sand.

Other Locations

This Vegetation Association is most similar to Type 15: Scattered shrubs over mixed *Triodia* grassland (Syrinx Environmental PL 2007).



6 *Triodia* Hummock Grassland

6d Scattered Trees of *Corymbia chippendalei* over scattered *Grevillea eriostachya*, *G. stenobotrya* and *Acacia stipuligera* over *Triodia schinzii* Hummock Grassland over *Dampiera cinerea* and *Otion simplicifolium* Low Open Shrubland

Area Mapped: 10.54 ha (0.86% of the study area)

ID of quadrats sampled: 1120_P23, 1120_P27, 1120_P34

Location + Landform

Gently to moderately sloped medium sized dunes and is located in the southern portion of the Optimisation Study area. It is the common dune vegetation association in the adjacent O'Callaghan's Study Area.

Vegetation Stratum Levels

Upper	*Corymbia chippendalei*
Middle	*Grevillea eriostachya, G. stenobotrya, Acacia stipuligera*
Ground	*Aristida holathera* var. *holathera, Calytrix carinata, Dampiera cinerea, Dicrastylis cordifolia, Otion simplicifolium, Triodia schinzii*
Species of Conservation Significance	Nil
Introduced Species	Nil
Vegetation Condition	Excellent to Pristine
Geology	Dunes 38496 (Qd), (Geoscience Australia, 2008).
Soil Attributes	Red sand

Other Locations

This Vegetation Association is most similar to Vegetation Type 6: Mixed shrubs on dunes (Syrinx Environmental PL 2006); Sand Dunes, (Hart, Simpson and Associates 2002); and Type 11: Scattered *Corymbia chippendalei* over mixed shrubland over *Triodia schinzii* grassland (Syrinx Environmental PL 2007).



7 *Triodia* Closed Hummock Grassland

7a Scattered Trees of *Eucalyptus leucophloia* subsp. *leucophloia* over Scattered Shrubs of *Tribulus suberosus* and *Hakea lorea* over *Triodia basedowii* complex Closed Hummock Grassland

Area Mapped: 57.22 ha (4.64 % of the study area)

ID of quadrats sampled: 1120_P07, 1120_P10, 1120_P15, 1120_P35

Location + Landform

This Vegetation Association occurs on the large rocky hills in the central portion of the Optimisation Study Area. At the base of these hills in the vegetation association in the swales (VA 4b) are the largest population of *Goodenia hartiana*.

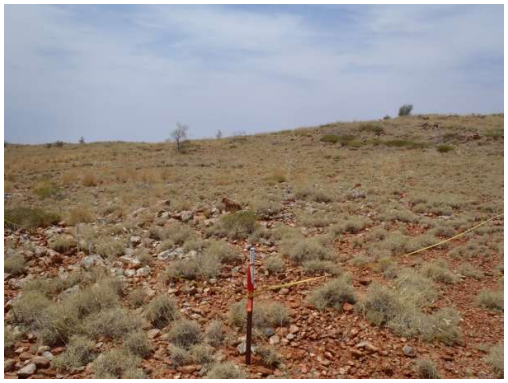
Vegetation Stratum Levels

Upper	*Eucalyptus leucophloia* subsp. *leucophloia*
Middle	*Acacia acradenia, A. ancistrocarpa, Grevillea wickhamii* subsp. *hispidula, Hakea lorea, Tribulus suberosus*
Ground	*Aristida holathera* var. *holathera, Eragrostis eriopoda, Triodia basedowii*

Species of Conservation Significance	Nil
Introduced Species	Nil
Vegetation Condition	Pristine
Geology	Wilki Formation (Nsaw), (Geoscience Australia, 2008)
Soil Attributes	Red sand

Other Locations

This Vegetation Association is similar to an association indentified in a Telfer Borefield Flora Survey (Syrinx Environmental PL 2007); Type 15: Scattered shrubs over mixed *Triodia* grassland.



Appendix 6 Flora species list

Aizoaceae
Trianthema glossostigma
Trianthema triquetra
Trianthema turgidifolia
Amaranthaceae
Ptilotus astrolasius
Ptilotus axillaris
Ptilotus calostachyus
Ptilotus clementii
Ptilotus fusiformis
Ptilotus gaudichaudii
Ptilotus nobilis
Ptilotus obovatus
Ptilotus polystachyus
Apocynaceae
Cynanchum floribundum
Asparagaceae
Thysanotus aff. *exiliflorus*
Asteraceae
Peripleura virgata
Pluchea dentex
Pluchea ferdinandi-muelleri
Pluchea rubelliflora
Pluchea tetranthera
Pterocaulon serrulatum
Pterocaulon sphaeranthoides
Streptoglossa bubakii
Streptoglossa macrocephala
Streptoglossa odora
Boraginaceae
Halgania solanacea
Heliotropium chrysocarpum
Heliotropium glabellum
Heliotropium glanduliferum
Trichodesma zeylanicum
Brassicaceae
Lepidium pholidogynum
Caryophyllaceae
Polycarpaea corymbosa
Celastraceae
Stackhousia muricata
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Chenopodiaceae
Dysphania kalpari
Dysphania rhadinostachya subsp. *rhadinostachya*
Enchylaena tomentosa var. *tomentosa*
Maireana melanocoma
Maireana triptera
Maireana villosa
Salsola australis

Sclerolaena cornishiana
Sclerolaena crenata
Sclerolaena cuneata
Sclerolaena eriacantha
Sclerolaena minuta

Convolvulaceae
Bonamia erecta
Evolvulus alsinoides var. *decumbens*
Evolvulus alsinoides var. *villosicalyx*

Cucurbitaceae
Cucumis maderaspatanus

Cyperaceae
Bulbostylis barbata
Fimbristylis dichotoma
Fimbristylis oxystachya
Fimbristylis simulans

Euphorbiaceae
Euphorbia australis
Euphorbia boophthona
Euphorbia drummondii subsp. *drummondii*

Fabaceae
Acacia acradenia
Acacia adoxa
Acacia adoxa var. *adoxa*
Acacia adsurgens
Acacia ancistrocarpa
Acacia colei
Acacia colei var. *colei*
Acacia dictyophleba
Acacia hilliana
Acacia ligulata
Acacia monticola
Acacia pteraneura
Acacia sphaerostachya
Acacia stellaticeps
Acacia stipuligera
Acacia synchronicia
Acacia wanyu
Gompholobium polyzygum
Indigofera boviperda
Indigofera boviperda subsp. *boviperda*
Indigofera monophylla
Isotropis atropurpurea
Jacksonia aculeata
Mirbelia viminalis
Otion simplicifolium
Petalostylis cassioides
Senna artemisioides subsp. *helmsii*
*Senna artemisioides s*ubsp. *oligophylla*
Senna curvistyla
Senna glaucifolia
Senna glutinosa subsp. *glutinosa*
Senna glutinosa subsp. *pruinosa*
Senna glutinosa subsp. *x luerssenii*
Senna notabilis

Senna sericea
Senna symonii
Tephrosia ? *sphaerospora*
Tephrosia arenicola

Goodeniaceae
Brunonia suffruticosa
Dampiera candicans
Dampiera cinerea
Goodenia ? *microptera*
Goodenia armitiana
Goodenia azurea
Goodenia hartiana
Goodenia stobbsiana
Goodenia triodiophila
Scaevola amblyanthera var. *centralis*
Scaevola parvifolia
Scaevola spinescens
Velleia connata

Gyrostemonaceae
Codonocarpus cotinifolius
Gyrostemon tepperi

Haloragaceae
Gonocarpus eremophilus
Haloragis gossei var. *gossei*

Lamiaceae
Clerodendrum floribundum var. *angustifolium*
Dicrastylis cordifolia
Dicrastylis doranii

Lauraceae
Cassytha capillaris

Loranthaceae
Amyema sanguinea
Amyema sanguinea var. *sanguinea*

Malvaceae
Abutilon otocarpum
Corchorus sidoides
Corchorus sidoides subsp. *sidoides*
Gossypium australe
Hibiscus coatesii
Hibiscus leptocladus
Hibiscus sturtii var. *campylochlamys*
Keraudrenia velutina subsp. *elliptica*
Sida ? *cardiophylla*
Sida ? *macropoda*
Sida ? sp. B Kimberley Flora (A.A. Mitchell 2745)
Sida ? sp. Excedentifolia (J.L. Egan 1925)
Sida arenicola
Sida fibulifera
Sida sp. Rabbit Flat (B.J. Carter 626)
Triumfetta deserticola

Meliaceae
Owenia reticulata

Myrtaceae
Aluta maisonneuvei subsp. *maisonneuvei*
Calytrix carinata

Corymbia candida subsp. *dipsodes*
Corymbia chippendalei
Corymbia deserticola subsp. *deserticola*
Corymbia opaca
Eucalyptus kingsmillii
Eucalyptus kingsmillii subsp. *kingsmillii*
Eucalyptus leucophloia subsp. *leucophloia*
Eucalyptus odontocarpa

Plantaginaceae
Stemodia linophylla

Poaceae
Amphipogon caricinus var. *caricinus*
Amphipogon sericeus
Aristida contorta
Aristida holathera
Aristida holathera var. *holathera*
Aristida inaequiglumis
Brachyachne prostrata
Cenchrus ciliaris
Chrysopogon fallax
Dactyloctenium radulans
Enneapogon caerulescens
Enneapogon polyphyllus
Eragrostis dielsii
Eragrostis eriopoda
Eragrostis speciosa
Eriachne aristidea
Eriachne obtusa
Eriachne pulchella subsp. *dominii*
Eulalia aurea
Iseilema dolichotrichum
Paraneurachne muelleri
Paspalidium clementii
Paspalidium rarum
Schizachyrium fragile
Setaria surgens
Sporobolus actinocladus
Sporobolus australasicus
Triodia ? lanigera
Triodia aff. *basedowii*
Triodia aff. *lanigera*
Triodia basedowii
Triodia epactia
Triodia pungens
Triodia schinzii
Yakirra australiensis

Polygalaceae
Polygala isingii

Portulacaceae
Portulaca oleracea

Proteaceae
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii
Grevillea wickhamii subsp. *hispidula*

Hakea chordophylla
Hakea lorea
Hakea lorea subsp. *lorea*

Pteridaceae
Cheilanthes sieberi subsp. *sieberi*

Rubiaceae
Oldenlandia crouchiana
Oldenlandia pterospora
Psydrax latifolia
Synaptantha tillaeacea var. *hispidula*
Synaptantha tillaeacea var. *tillaeacea*

Santalaceae
Anthobolus leptomerioides
Exocarpos sparteus
Santalum sp.

Sapindaceae
Dodonaea coriacea

Scrophulariaceae
Eremophila latrobei subsp. *glabra*
Eremophila latrobei subsp. *latrobei*
Eremophila tietkensii

Solanaceae
Solanum ? *horridum*
Solanum centrale

Surianaceae
Stylobasium spathulatum

Violaceae
Hybanthus aurantiacus

Zygophyllaceae
Tribulus hirsutus
Tribulus macrocarpus
Tribulus suberosus

Appendix 7 Explanation of fauna values.

Fauna values are the features of a site and its fauna that contribute to biodiversity, and it is these values that are potentially at threat from a development proposal. Fauna values can be examined under the five headings outlined below. It must be stressed these values are interdependent and should not be considered equal, but contribute to an understanding of the biodiversity of a site. Understanding fauna values provides opportunities to predict and therefore mitigate impacts.

Assemblage characteristics.

Uniqueness. This refers to the combination of species present at a site. For example, a site may support an unusual assemblage that has elements from adjacent biogeographic zones, it may have species present or absent that might be otherwise expected, or it may have an assemblage that is typical of a very large region. For the purposes of impact assessment, an unusual assemblage has greater value for biodiversity than a typical assemblage.

Completeness. An assemblage may be complete (i.e. has all the species that would have been present at the time of European settlement), or it may have lost species due to a variety of factors. Note that a complete assemblage, such as on an island, may have fewer species than an incomplete assemblage (such as in a species-rich but degraded site on the mainland).

Richness. This is a measure of the number of species at a site. At a simple level, a species rich site is more valuable than a species poor site, but value is also determined, for example, by the sorts of species present.

Vegetation/substrate associations (VSAs)

VSAs combine broad vegetation types, the soils or other substrate with which they are associated, and the landform. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. The term habitat is widely used in this context, but by definition an animal's habitat is the environment that it utilises (Calver et al. 2009), not the environment as a whole. Habitat is a function of the animal and its ecology, rather than being a function of the environment. For example, a species may occur in eucalypt canopy or in leaf-litter on sand, and that habitat may be found in only one or in several VSAs. VSAs are not the same as vegetation types since these may not incorporate soil and landform, and recognise floristics to a degree that VSAs do not. Vegetation types may also not recognise minor but often significant (for fauna) structural differences in the environment. VSAs also do not necessarily correspond with soil types, but may reflect some of these elements.

Because VSAs provide the habitat for fauna, they are important in determining assemblage characteristics. For the purposes of impact assessment, VSAs can also provide a surrogate for detailed information on the fauna assemblage. For example, rare, relictual or restricted VSAs should automatically be considered a significant fauna value. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna. The disturbance of even small amounts of habitat in a localised area can have significant impacts to fauna if rare or unusual habitats are disturbed.

Patterns of biodiversity across the landscape

This fauna value relates to how the assemblage is organised across the landscape. Generally, the fauna assemblage is not distributed evenly across the landscape or even within one VSA. There may be zones of high biodiversity such as particular environments or ecotones (transitions between VSAs). There may also be zones of low biodiversity. Impacts may be significant if a wide range of species is affected even if most of those species are not significant per se.

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and the Western Australian Wildlife Conservation Act 1950 (Wildlife Conservation Act). In addition, the Western Australian DEC recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 3.

Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts.

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The Wildlife Conservation Act uses a series of Schedules to classify status, but also recognizes the IUCN categories.

Conservation Significance (CS) 2: Species listed as Priority by the DEC but not listed under State or Commonwealth Acts.

In Western Australia, the DEC has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the Wildlife Conservation Act but for which the DEC feels there is cause for concern. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

Conservation Significance (CS) 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DEC (2000), used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan.

Invertebrate species considered to be short range endemics (SREs) also fall within the CS3 category, as they have no legislative or published recognition and their significance is based on interpretation of distribution information. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Introduced species

In addition to these conservation levels, species that have been introduced (INT) are indicated throughout the report. Introduced species may be important to the native fauna assemblage through effects by predation and/or competition.

Ecological processes upon which the fauna depend

These are the processes that affect and maintain fauna populations in an area and as such are very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance, and these are affected by a myriad of factors. The dynamics of fauna populations in a project may be affected by processes such as fire regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species. Threatening processes as outlined below are effectively the ecological processes that can be altered to result in impacts upon fauna.

Appendix 8 Fauna species recorded or expected in the local region based on desktop review

Table 27 Amphibians recorded or that may be present in the Optimisation Project Area

Sources of information for the inclusion of species are indicated: L = recorded in the general area in literature; D = returned on databases searched. Species recorded in the Telfer area included those by Hart, Simpson and Associates (2002), Syrinx Environmental PL (2006) and Bamford (2011) and are marked (X). Species recorded from Rudall River National Park are also listed (x). Conservation status (Status) is indicated as described in Methods.

Species		Source	Status	Hart 2002	Syrinx 2006	RR / NP	BCE 2011
Hylidae (tree frogs and water-holding frogs)							
Main's Frog	*Cyclorana maini*	L		X		X	
Water-holding Frog	*Cyclorana platycephala*	L				X	
Desert Tree Frog	*Litoria rubella*	L		X		X	X
Myobatrachidae (ground frogs)							
Spencer's Frog	*Opisthodon spenceri*	L				X	
Northern Burrowing Frog	*Neobatrachus aquilonius*	D					
Desert Spadefoot	*Notaden nichollsi*	L		X	X	X	X
Tanami Toadlet	*Uperoleia micromeles*	D		X			
TOTAL		7		4	1	5	2

Table 28 Reptiles recorded or that may be present in the Optimisation Project Area

Sources of information for the inclusion of species are indicated: L = recorded in the general area in literature; D = returned on databases searched. Species recorded in the Telfer area include those by Hart, Simpson and Associates (2002), Syrinx Environmental PL (2006) and in the current survey (BCE 2011), and are marked (X). Species recorded (trapped and/or seen) in the Telfer Optimisation area are indicated (TO) under BCE 2011. Species recorded from Rudall River National Park (RRNP) are also listed (x). Conservation status (Status) is indicated as described in Methods.

Species	Source	Status	Hart 2002	Syrinx 2006	RR NP	BCE 2011
Agamidae (dragon lizards)						
Ring-tailed Dragon *Ctenophorus caudicinctus*	L		X		X	X
Military Dragon *Ctenophorus isolepis*	D		X	X	X	TO
Central Netted Dragon *Ctenophorus nuchalis*	D				X	X
Diporiphora winneckei	L		X	X	X	TO
Long-nosed Water Dragon *Amphibolurus longirostris*	L		X		X	X
Thorny Devil *Moloch horridus*	L				X	X
Bearded Dragon *Pogona minor*	D		X			TO
Tympanocryptis cephalus	L					
Gekkonidae (geckoes)						
Clawless Gecko *Crenadactylus ocellatus*	D					
Fat-tailed Gecko *Diplodactylus conspicillatus*	D		X			
Sand-plain Gecko *Lucasium stenodactylum*	D		X			X
Pilbara Dtella *Gehyra pilbara*	D					
Spotted Dtella *Gehyra punctata*	D					
Variegated Dtella *Gehyra variegata*	D		X		X	X
Gehyra purpurasens	D			X	X	
Bynoe's Gecko *Heteronotia binoei*	D		X		X	X
Nephrurus laevissimus	D				X	X
Nephrurus levis	D		X		X	
Nephrurus wheeleri	L					
Marbled Velvet Gecko *Oedura marmorata*	D					

Species	Source	Status	Hart 2002	Syrinx 2006	RR / NP	BCE 2011
Beaked Gecko *Rhynchoedura ornata*	D					X
Northern Spiny-tailed Gecko *Strophurus ciliaris*	D					
Jewelled Gecko *Strophurus elderi*	D		X		X	X
Strophurus jeanae	D					TO
Strophurus strophurus	L					X
Strophurus wellingtonae	L					TO
Pygopodidae (legless lizards)						
Delma butleri	D		X			
Delma desmosa	D					X
Delma haroldi	D					
Delma nasuta	D		X			TO
Burton's Legless Lizard *Lialis burtonis*	D		X		X	
Hooded Scaly-foot *Pygopus nigriceps*	D				X	
Scincidae (skink lizards)						
Fence Skink *Cryptoblepharus buchananii*	D					
Ctenotus ariadne	D		X			
Ctenotus brooksi	D		X			
Ctenotus calurus	D				X	
Ctenotus dux	D					
Ctenotus grandis	D		X		X	
Ctenotus hanloni	D					
Ctenotus helenae	D		X		X	TO
Ctenotus leae	D					
Ctenotus nasutus	D		X			
Ctenotus pantherinus	D		X		X	TO
Ctenotus piankai	D					TO
Ctenotus quattuordecimlineatus	D		X		X	X
Ctenotus saxatilis	D				X	
Ctenotus schomburgkii	D				X	
Ctenotus serventyi	D				X	
Ctenotus uber	L					
Cyclodomorphus melanops	D				X	

Species	Source	Status	Hart 2002	Syrinx 2006	RR / NP	BCE 2011
Pygmy Spiny-tailed Skink *Egernia cygnitos*	D					
Egernia formosa	L					
Liopholis kintorei	D	CS1			X	
Liopholis striata	D		X			
Narrow-banded Sand Swimmer *Eremiascincus fasciolatus*	D		X			X
Broad-banded Sand Swimmer *Eremiascincus richardsonii*	L					
Lerista bipes	D		X		X	TO
Lerista ips	D		X			X
Lerista labialis	L					
Lerista macropisthopus remota	L	CS2				
Lerista muelleri	L					
Lerista vermicularis	D		X			
Lerista xanthura	D					
Dwarf Skink *Menetia greyii*	D		X		X	TO
Menetia surda	D				X	
Morethia ruficauda	D		X			TO
Notoscincus ornatus	D		X		X	X
Proablepharus reginae	D				X	
Central Blue-tongue *Tiliqua multifasciata*	D				X	X
Varanidae (goanna or monitor lizards)						
Ridge-tailed Monitor *Varanus acanthurus*	D		X	X	X	TO
Varanus brevicauda	D		X			
Varanus eremius	D		X			X
Perentie *Varanus giganteus*	D					
Pygmy Mulga Monitor *Varanus gilleni*	L					
Gould's Goanna *Varanus gouldii*	D		X			TO
Varanus panoptes	D				X	
Black-tailed Monitor *Varanus tristis*	D				X	
Typhlopidae (blind snakes)						
Ramphotyphlops endoterus	D		X			
Beaked Blind Snake *Ramphotyphlops grypus*	D					
Pilbara Blind Snake *Ramphotyphlops pilbarensis*	L					

Species	Source	Status	Hart 2002	Syrinx 2006	RR / NP	BCE 2011
Ramphotyphlops waitii	L					
Boidae (pythons)						
Pygmy Python *Antaresia perthensis*	D					
Stimson's Python *Antaresia stimsoni*	D		X			
Black-headed Python *Aspidites melanocephalus*	L					
Woma *Aspidites ramsayi*	D	CS1	X			X
Elapidae (front-fanged snakes)						
Pilbara Death-adder *Acanthophis wellsi*	L					
Desert Death-adder *Acanthophis pyrrhus*	L					
Northwestern Shovel-nosed Snake *Brachyurophis approximans*	D				X	
Narrow-banded Shovel-nosed Snake *Brachyurophis fasciolata*	L					
Yellow-faced Whipsnake *Demansia psammophis*	L					
Moon Snake *Furina ornata*	D					
Mulga Snake *Pseudechis australis*	D		X	X	X	X
Ringed Brown Snake *Pseudonaja modesta*	D					X
Gwardar *Pseudonaja nuchalis*	L					
Desert Bandy-bandy *Simoselaps anomalus*	D					X
Rosen's Snake *Suta fasciata*	D				X	
TOTAL	**96**		**37**	**5**	**36**	**36**

Table 29 Birds recorded or that may be present in the Optimisation Project Area

Sources of information for the inclusion of species are indicated: L = recorded in the general area in literature; obs = observed in the area (or nearby) by Hart, Simpson and Associates (1994). Conservation status (Status) is indicated as described in Methods. Species recorded in the Telfer Optimisation Project Area under the current survey (BCE 2011) are marked (X). Species recorded in the Optimisation Study Area are indicated (TO) under BCE 2011

Species	Source	Status	Hart 2002	Syrinx 2006	RR	BCE
					NP	2011
Casuariidae (emu)						
Emu *Dromaius novaehollandiae*	D					X
Phasianidae (pheasants and quails)						
Brown Quail *Coturnix ypsilophora*	D					TO
Anatidae (ducks and geese)						
Pacific Black Duck *Anas superciliosa*	D				X	X
Grey Teal *Anas gracilis*	D			X		X
Ardeidae (herons and egrets)						
White-faced Heron *Egretta novaehollandiae*	D					
White-necked Heron *Ardea pacifica*	D					
Eastern Great Egret *Ardea modesta*	D	CS1				
Intermediate Egret *Ardea intermedia*	D					
Little Egret *Egretta garzetta*	D					
Plataleidae (ibis and spoonbills)						
Royal Spoonbill *Platalea regia*			X			
Straw-necked Ibis *Threskiornis spinicollis*	D		X	X		X
Accipitridae (osprey, hawks, eagles and harriers)						
Black-shouldered Kite *Elanus caeruleus (axillaris)*	D		X			X
Square-tailed Kite *Hamirostra (Lophoictinia) isura*	L					
Black-breasted Buzzard *Hamirostra melanosternon*	L					
Black Kite *Milvus migrans*	L					X
Whistling Kite *Haliastur sphenurus*	D					TO
Brown Goshawk *Accipiter fasciatus*	D		X			TO
Collared Sparrowhawk *Accipiter cirrocephalus*	D		X	X		X
Little Eagle *Aquila (Hieraaetus) morphnoides*	D		X	X		X

Species	Source	Status	Hart 2002	Syrinx 2006	RR	BCE
					NP	2011
Wedge-tailed Eagle *Aquila audax*	D					X
Spotted Harrier *Circus assimilis*	D		X			X
Falconidae (falcons)						
Brown Falcon *Falco berigora*	D		X	X		X
Nankeen Kestrel *Falco cenchroides*	D		X	X		TO
Australian Hobby *Falco longipennis*	D					
Grey Falcon *Falco hypoleucos*	D	CS2			X	
Peregrine Falcon *Falco peregrinus*	L	CS1	X		X	
Rallidae (crakes and rails)						
Black-tailed Native Hen *Gallinula ventralis*	D					
Otididae (bustard)						
Australian Bustard *Ardeotis australis*	D	CS2	X			X
Turnicidae (button-quails)						
Little Button-quail *Turnix velox*	D		X			TO
Burhinidae (stone-curlews)						
Bush Stone-curlew *Burhinus grallarius*	L	CS2			X	
Recurvirostridae (stilts and avocets)						
Black-winged Stilt *Himantopus himantopus*	D			X		X
Charadriidae (plovers, dotterels and lapwings)						
Red-capped Plover *Charadrius ruficapillus*	L			X		
Black-fronted Dotterel *Charadrius (Elseyornis) melanops*	D		X	X	X	X
Red-kneed Dotterel *Erythrogonys cinctus*	L					X
Oriental Plover *Charadrius veredus*	D	CS1				
Scolopacidae (sandpipers)						
Common Sandpiper *Actitis hypoleucos*	L					X
Common Greenshank *Tringa nebularia*	L					X
Marsh Sandpiper *Tringa stagnatilis*	L					
Glareolidae (pratincoles)						
Australian Pratincole *Stiltia isabella*	D					
Oriental Pratincole *Glareola maldivarum*	D	CS1				
Laridae (gulls and terns)						
Whiskered Tern *Chlidonias hybrida*						TO

Species	Source	Status	Hart 2002	Syrinx 2006	RR NP	BCE 2011
Silver Gull *Larus novaehollandiae*	D					
Columbidae (pigeons and doves)						
Common Bronzewing *Phaps chalcoptera*	D		X	X		X
Crested Pigeon *Ocyphaps lophotes*	D		X	X		X
Spinifex Pigeon *Geophaps plumifera*	D		X	X		TO
Diamond Dove *Geopelia cuneata*	D		X	X		TO
Peaceful Dove *Geopelia striata*	L					
Cacatuidae (cockatoos and corellas)						
Galah *Cacatua roseicapilla*	D		X	X		X
Little Corella *Cacatua sanguinea*	D					X
Cockatiel *Nymphicus hollandicus*	D					TO
Psittacidae (parrots, lorikeets and rosellas)						
Princess Parrot *Polytelis alexandrae*	L	CS1				
Australian Ringneck *Barnardius zonarius*	D					X
Bourke's Parrot *Neophema bourkii*	L					
Budgerigar *Melopsittacus undulatus*	D		X			TO
Night Parrot *Pezoporus occidentalis*	L	CS1				
Cuculidae (cuckoos)						
Pallid Cuckoo *Cuculus pallidus*	D		X			X
Black-eared Cuckoo *Chrysococcyx osculans*	L					
Horsfield's Bronze-Cuckoo *Chrysococcyx basalis*	D					X
Strigidae (hawk owls)						
Southern Boobook *Ninox novaeseelandiae*	D					X
Tytonidae (barn owls)						
Barn Owl *Tyto alba*	L					
Podargidae (frogmouths)						
Tawny Frogmouth *Podargus strigoides*	L					X
Caprimulgidae (nightjars)						
Spotted Nightjar *Eurostopodus argus*	D					X
Aegothelidae (owlet-nightjars)						
Australian Owlet-Nightjar *Aegotheles cristatus*	D					
Apodidae (swifts)						

Species	Source	Status	Hart 2002	Syrinx 2006	RR	BCE
					NP	2011
Fork-tailed Swift *Apus pacificus*	L	CS1				
Halcyonidae (kingfishers)						
Blue-winged Kookaburra *Dacelo leachii*	L					
Red-backed Kingfisher *Todiramphus pyrrhopygia*	D		X	X		X
Sacred Kingfisher *Todiramphus sanctus*	L					X
Meropidae (bee-eaters)						
Rainbow Bee-eater *Merops ornatus*	D	CS1		X		TO
Climacteridae (treecreepers)						
Black-tailed Treecreeper *Climacteris melanura*	D					
Maluridae (fairy-wrens and allies)						
Variegated Fairy-wren *Malurus lamberti*	D		X	X		X
White-winged Fairy-wren *Malurus leucopterus*	D		X			TO
Rufous-crowned Emu-wren *Stipiturus ruficeps*	D	CS3				
Striated Grasswren *Amytornis striatus striatus*	L	CS2				
Pardalotidae (pardalotes and allies)						
Red-browed Pardalote *Pardalotus rubricatus*	D		X			X
Striated Pardalote *Pardalotus striatus*	D					X
Weebill *Smicrornis brevirostris*	D					X
Western Gerygone *Gerygone fusca*	L					
Chestnut-rumped Thornbill *Acanthiza uropygialis*	D					
Banded Whiteface *Aphelocephala nigricincta*	D					
Meliphagidae (honeyeaters and chats)						
Brown Honeyeater *Lichmera indistincta*	D		X			TO
Black Honeyeater *Certhionyx niger*	D		X			TO
Pied Honeyeater *Certhionyx variegatus*	D		X			TO
Singing Honeyeater *Lichenostomus virescens*	D		X	X		TO
Grey-headed Honeyeater *Lichenostomus keartlandi*	D		X	X		TO
Grey-fronted Honeyeater *Lichenostomus plumulus*	D					
White-plumed Honeyeater *Lichenostomus penicillatus*	D		X			TO
Black-chinned Honeyeater *Melithreptus gularis*	D					X
Yellow-throated Miner *Manorina flavigula*	D		X	X		TO
Spiny-cheeked Honeyeater *Acanthagenys rufogularis*	D		X			TO

Species	Source	Status	Hart 2002	Syrinx 2006	RR	BCE
					NP	2011
White-fronted Honeyeater *Phylidonyris albifrons*	D		X			
Crimson Chat *Epthianura tricolor*	D		X			TO
Petroicidae (robins)						
Red-capped Robin *Petroica goodenovii*	D		X			X
Hooded Robin *Petroica (Melanodryas) cucullata*	D					X
Pomatostomidae (babblers)						
Grey-crowned Babbler *Pomatostomus temporalis*	D					
White-browed Babbler *Pomatostomus superciliosus*	D					
Cinclosomatidae (quail-thrush and allies)						
Chiming Wedgebill *Psophodes occidentalis*	L					
Chestnut-breasted Quail-thrush *Cinclosoma castaneothorax*	D					
Neosittidae (sittellas)						
Varied Sittella *Daphoenositta chrysoptera*	L					
Pachycephalidae (shrike-tits, whistlers and allies)						
Crested Bellbird *Oreoica gutturalis*	D					X
Rufous Whistler *Pachycephala rufiventris*	D		X			TO
Grey Shrike-thrush *Colluricincla harmonica*	D					
Dicruridae (flycatchers and allies)						
Grey Fantail *Rhipidura fuliginosa*	L					
Willie Wagtail *Rhipidura leucophrys*	D		X	X		X
Magpie-Lark *Grallina cyanoleuca*	D		X	X		X
Campephagidae (cuckoo-shrikes and trillers)						
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	D		X	X	X	X
Ground Cuckoo-shrike *Coracina maxima*	L					
White-winged Triller *Lalage tricolour (sueurii)*	D		X			TO
Artamidae (woodswallows and allies)						
White-breasted Woodswallow *Artamus leucorynchus*	L			X		
Masked Woodswallow *Artamus personatus*	D			X		TO
Black-faced Woodswallow *Artamus cinereus*	D		X	X		X
Little Woodswallow *Artamus minor*	D		X	X		
Grey Butcherbird *Cracticus torquatus*	D					X

Species	Source	Status	Hart 2002	Syrinx 2006	RR	BCE
					NP	2011
Pied Butcherbird *Cracticus nigrogularis*	D		X			X
Australian Magpie *Cracticus (Gymnorhina) tibicen*	D					X
Corvidae (ravens and crows)						
Torresian Crow *Corvus orru*	D		X	X	X	TO
Little Crow *Corvus bennetti*	D					X?
Alaudidae (larks)						
Singing Bushlark *Mirafra javanica*	D					X
Motacillidae (pipits and wagtails)						
Australian Pipit *Anthus australis (novaeseelandiae)*	D		X	X		TO
Passeridae (grassfinches, sparrows and allies)						
Zebra Finch *Taeniopygia guttata*	D		X	X		TO
Painted Finch *Emblema pictum*	D		X	X		X
Dicaeidae (flowerpeckers)						
Mistletoebird *Dicaeum hirundinaceum*	D					
Hirundinidae (swallows and martins)						
White-backed Swallow *Cheramoeca leucosternus*	D		X	X		X
Welcome Swallow *Hirundo neoxena*	D			X		
Tree Martin *Hirundo nigricans*	D					
Fairy Martin *Hirundo ariel*	D		X	X		X
Sylviidae (old world warblers)						
Spinifexbird *Eremiornis carteri*	D		X			X
Rufous Songlark *Cincloramphus mathewsi*	D					X
Brown Songlark *Cincloramphus cruralis*	D					X
TOTAL	**129**	**14**	**50**	**35**	**7**	**86**

Table 30 Mammals recorded or that may be present in the Optimisation Project Area

Sources of information for the inclusion of species are indicated: L = recorded in the general area in literature; D = returned on databases searched. Species recorded in the Telfer area included those by Hart, Simpson and Associates (2002), Syrinx Environmental PL (2006) and in the current survey (BCE 2011) and are marked (X). Species recorded in the Telfer Optimisation Project Area are indicated (TO) under BCE 2011. Species recorded from Rudall River National Park are also listed (x). Conservation status (Status) is indicated as described in Methods.

Species	Source	Status	Hart 2002	Syrinx 2006	RR NP	BCE 2011
Tachyglossidae (echidnas)						
Echidna *Tachyglossus aculeatus*	D					
Dasyuridae (dasyurid marsupials)						
Northern Quoll *Dasyurus hallucatus*	D	CS1				
Brush-tailed Mulgara *Dasycercus blythi*	D	CS2	X		X	
Crest-tailed Mulgara *Dasycercus cristicauda*	D	CS1	X			?X
Little Red Kaluta *Dasykaluta rosamondae*	D		X	X	X	X
Pilbara Ningaui *Ningaui timealeyi*	D		X		X	X
Planigale sp. *Planigale* sp. 2	D		X			TO
Woolley's Pseudantechinus *Pseudantechinus woolleyae*	D					
Tan Pseudantechinus *Pseudantechinus roryi*	D					
Long-tailed Dunnart *Sminthopsis longicaudata*	D	CS2				
Striped-faced Dunnart *Sminthopsis macroura*	L					X
Lesser Hairy-footed Dunnart *Sminthopsis youngsoni*	D		X		X	TO
Kultarr *Antechinomys laniger*	L	CS3				
Thylacomyidae (bilbies)						
Bilby *Macrotis lagotis*	D	CS1	X	X	X	X
Notoryctidae (marsupial moles)						
Northern Marsupial Mole *Notoryctes caurinus*	D	CS1	X			
Phalangeridae (brushtail-possums)						
Common Brushtail Possum *Trichosurus vulpecula*	L	CS3				
Macropodidae (kangaroos and wallabies)						
Spectacled Hare-Wallaby *Lagorchestes conspicillatus*	L	CS2				

Species	Source	Status	Hart 2002	Syrinx 2006	RR NP	BCE 2011
Euro *Macropus robustus*	D		X		X	
Red Kangaroo *Macropus rufus*	D					
Rothschild's Rock-Wallaby *Petrogale rothschildi*	D					
Emballonuridae (sheathtail bats)						
Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*	L				X	
Common Sheathtail Bat *Taphozous georgianus*	D				X	
Hill's Sheathtail Bat *Taphozous hilli*	D			X	X	
Megadermatidae (ghost bat)						
Ghost Bat *Macroderma gigas*	L	CS2				
Hipposideridae (leaf-nosed bats)						
Orange Leaf-nosed Bat *Rhinonicteris aurantius*	L	CS1				
Vespertilionidae (vesper bats)						
Gould's Wattled Bat *Chalinolobus gouldii*	D			X	X	X
Lesser Long-eared Bat *Nyctophilus geoffroyi*	L					
Inland Broad-nosed Bat *Scotorepens balstoni*	L					
Little Broad-nosed Bat *Scotorepens greyii*	D				X	
Findlayson's Cave Bat *Vespadelus finlaysoni*	D				X	
Molossidae (freetail bats)						
Beccari's Freetail Bat *Mormopterus beccarii*	D				X	
White-striped Freetail Bat *Tadarida australis*	D					
Muridae (rats and mice)						
Short-tailed Mouse *Leggadina lakedownensis*	D	CS2			X	
House Mouse *Mus musculus*	D	Int.	X		X	TO
Spinifex Hopping-Mouse *Notomys alexis*	D		X			X
Desert Mouse *Pseudomys desertor*	D		X	X		
Sandy Inland Mouse *Pseudomys hermannsburgensis*	D		X	X	X	TO
Common Rock-Rat *Zyzomys argurus*	D					
Other Introduced Fauna						
Rabbit *Oryctolagus cuniculus*	D					
Dingo *Canis lupus dingo*	D		X	X		TO
Fox *Vulpes vulpes*	D					X

Species	Source	Status	Hart 2002	Syrinx 2006	RR NP	BCE 2011
Feral Cat *Felis catus*	D		X			TO
Camel *Camelus dromedarius*	D		X	X		X
Donkey *Equus asinus*	D					X
TOTAL	44	12	15	8	17	15

Table 31 Vertebrate fauna considered extinct in the region; records from Hart, Simpson and Associstes (2002), based on examination of skeletal remains in owl pellets from a location about 80km SSW of Telfer

Dasyuridae (dasyurid marsupials)
Chuditch *Dasyurus geoffroii*
Peramelidae (bandicoots)
Pig-footed Bandicoot *Chaeropus ecaudatus*
Golden Bandicoot *Isoodon auratus*
Desert Bandicoot *Perameles eremiana*
Potoridae (bettongs and potoroos)
Boodie *Bettongia lesueur*
Muridae (rats and mice)
Short-tailed Hopping-Mouse *Notomys amplus*
Long-tailed Hopping-Mouse *Notomys longicaudatus*
Centralian Rock-Rat *Zyzomys pedunculatus*
Pale Field-Rat *Rattus tunneyi*
Lesser Stick-nest Rat *Leporillus apicalis*

Table 32 Vertebrate fauna returned in databases but for which there is no suitable habitat in the Optimisation Study Area

Hylidae (tree frogs and water-holding frogs)
Giant Frog *Cyclorana australis*
Cheluidae (side-necked tortoises)
Plate-shelled Tortoise *Chelodina steindachneri*
Podicepididae (grebes)
Australasian Grebe *Tachybabtus novaehollandiae*
Hoary-headed Grebe *Poliocephalus poliocephalus*
Anhingidae (Darter)
Darter *Anhinga melanogaster*
Phalacrocoracidae (cormorants)
Little Pied Cormorant *Phalacrocorax melanoleucos*
Pied Cormorant *Phalacrocorax varius*
Little Black Cormorant *Phalacrocorax sulcirostris*
Anatidae (ducks and geese)
Australian Wood Duck *Chenonetta jubata*
Pink-eared Duck *Malacorhynchus membranaceus*
Hardhead *Aythya australis*
Plumed Whistling-Duck *Dendrocygna eytoni*
Strigidae (hawk-owls)
Barking Owl *Ninox connivens*
Pardalotidae (pardalotes and allies)
Slaty-backed Thornbill *Acanthiza robustirostris*
Muridae (rats and mice)
Western Pebble-mound Mouse *Pseudomys chapmani*
Bovidae
Feral cattle *Bos Taurus*

Table 33 Reptile and small mammal trapping data; results of surveys at all sites across Telfer Optimisation Project Area in September 2011

Each value is the number of individuals caught over a five night trapping period at each site. Site numbers 10 and 11 are located within Optimisation Study Area.

Species	Sampling site										
	1	2	3	4	5	6	7	8	9	10	11
Military Dragon *Ctenophorus isolepis*	4	4		9	6	8	1		2		
Central Netted Dragon *Ctenophorus nuchalis*					1		1				
Diporiphora winneckei								1	1		1
Long-nosed Water Dragon *Amphibolurus longirostris*		1									
Bearded Dragon *Pogona minor*										1	2
Tree Dtella *Gehyra variagata*		4		1							
Bynoe's Gecko *Heteronotia binoei*					2						
Sandplain Gecko *Lucasium stenodactylum*				1		1					
Beaked Gecko *Rhynchoedura ornata*						1	1	1			
Northern Spiny-tailed Gecko *Strophurus ciliaris*									1		
Strophurus elderi								1			
Strophurus wellingtonae				1		1					1
Delma desmosa								1			
Delma nasuta										1	
Ctenotus helenae		1	1		1			1	2	2	3
Ctenotus pantherinus		3	6	1	5	6		1	2	4	4
Ctenotus piankai						1				1	
Ctenotus quattuordecimlineatus	1										
Narrow-banded Sand Swimmer *Eremiascincus fasciolatus*	6	1									
Lerista bipes	7			3	1	4	2	4	6	6	
Dwarf Skink *Menetia greyii*					1						2
Morethia ruficauda		3	3	2				2		3	2
Notoscincus ornatus			1								
Spiny-tailed Goanna *Varanus acanthurus*									1	1	
Varanus eremius						1					
Gould's Sand Goanna *Varanus gouldii*									1		

Species	Sampling site										
	1	2	3	4	5	6	7	8	9	10	11
Mulga Snake *Pseudechis australis*			1								
Five-ringed Snake *Pseudonaja modesta*									1		
Desert Bandy-Bandy *Simoselaps anomala*	1										
Little Red Kaluta *Dasykaluta rosamondae*							3		1		
Pilbara Ningaui *Ningaui timealeyi*		1									
Striped-faced Dunnart *Sminthopsis macroura*				1					1		
Lesser Hairy-footed Dunnart *Sminthopsis youngsoni*						1		1		1	
Planigale sp. 2 (Gibson and McKenzie 2009)										1	
House Mouse *Mus musculus*											3
Spinifex Hopping-Mouse *Notomys alexis*				1							
Sandy Inland Mouse *Pseudomys hermannsburgensis*		3	9	8	14	8	11	1	2	7	5
	19	21	21	28	31	32	19	14	21	28	23

Table 34 Bird census data; results of surveys at all sites across Telfer Optimisation Project Area in September 2011.

Each value is the number of individuals of each species recorded across five mornings at each site.

Species	Site No.										
	1	2	3	4	5	6	7	8	9	10	11
Brown Quail	0	0	0	0	0	0	0	0	0	0	17
Diamond Dove	20	0	0	0	0	10	0	0	0	1	413
Spinifex Pigeon	0	0	0	0	0	0	0	0	0	0	7
Crested Pigeon	0	0	0	0	0	0	0	2	0	0	0
Little Button-quail	2	0	3	5	1	2	1	0	0	1	3
Nankeen Kestrel	0	0	0	2	0	1	0	0	0	0	1
Budgerigar	270	6	3	1	5	8	0	0	8	4	1
Cocketiel	0	5	0	0	0	0	2	0	0	0	0
Galah	0	0	0	0	0	0	0	5	0	0	0
Rainbow Bee-eater	1	0	0	0	0	0	0	0	0	0	0
White-winged Fairy-wren	0	8	0	0	0	0	0	0	0	0	4
White-plumed Honeyeater	0	0	0	0	0	0	0	0	1	0	7
Yellow-throated Miner	0	0	0	0	0	0	1	7	22	1	0
Grey-headed Honeyeater	0	1	2	0	3	1	1	0	8	10	0
Spiny-cheeked Honeyeater	0	0	0	0	0	0	0	0	2	2	0
Singing Honeyeater	1	2	7	0	4	5	12	4	7	10	11
Brown Honeyeater	0	3	0	0	0	0	2	0	11	0	2
Black Honeyeater	0	0	0	0	2	1	2	0	0	1	3
Pied Honeyeater	0	0	1	0	0	0	0	0	0	0	3
Crimson Chat	4	0	1	0	0	2	0	0	0	1	0
Rufous Whistler	0	0	0	0	0	0	0	0	0	0	1
Zebra Finch	30	0	2	2	0	0	3	0	0	0	78
Black-faced Cuckoo-shrike	0	0	0	0	0	0	0	1	0	0	0
White-winged Triller	0	1	0	0	0	0	0	0	0	0	2
Masked Woodswallow	845	14	22	28	22	43	0	0	0	1	0
Black-faced Woodswallow	0	0	0	0	0	4	2	0	0	0	0
White-backed Swallow	0	1	0	0	0	0	0	0	0	0	0
Brown Songlark	0	1	0	0	0	0	0	0	0	0	0
Rufous Songlark	0	1	0	0	0	0	0	0	0	0	0
Number of records	1173	43	41	38	37	77	26	19	59	32	553
Number of species	8	11	8	5	6	10	9	5	7	10	15

Appendix 9 Ecological and Threatening Processes

Ecological processes are processes that maintain ecosystems and biodiversity. They are important for the assessment of impacts of development proposals, because ecological processes make ecosystems sensitive to change. The issue of ecological processes, impacts and conservation of biodiversity has an extensive literature. Following are examples of the sorts of ecological processes that need to be considered.

Ecological processes relevant to the conservation of biodiversity in Australia (Soule *et al.* 2004):

- Critical species interactions (highly interactive species);
- Long distance biological movement;
- Disturbance at local and regional scales;
- Global climate change;
- Hydroecology;
- Coastal zone fluxes;
- Spatially-dependent evolutionary processes (range expansion/gene flow); and
- Geographic and temporal variation of plant productivity across Australia.

(Taken from http://www.wilderness.org.au/articles/wc_science, viewed 30 December 2008)

Threatening processes (EPBC Act)

Under the EPBC Act (1999), a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 17 key threatening processes listed by the federal Department of the Environment, Water, Heritage and the Arts).

- Competition and land degradation by feral/unmanaged Goats (*Capra hircus*);
- Competition and land degradation by feral Rabbits (*Oryctolagus cuniculus*);
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*);
- Incidental catch (bycatch) of Sea Turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South;
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations;
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis;
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris;
- Land clearance;

- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean;
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha);
- Predation by feral Cats (*Felis catus*);
- Predation by the European Red Fox (*Vulpes vulpes*);
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*);
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species;
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (Bufo *marinus*);
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta*.

(taken from http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl. viewed on 30 December 2008)

General processes that threaten biodiversity across Australia (The National Land and Water Resources Audit):

- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology—other such as altered flow regimes affecting riparian vegetation; and
- Pollution.

(taken from Cork S, Sattler P and Alexandra J (2006), 'Biodiversity' theme commentary prepared for the 2006 Australian State of the Environment Committee, Department of the Environment and Heritage, Canberra, http://www.deh.gov.au/soe/2006/commentaries/biodiversity/index.html; viewed on 30

Appendix 10 Coordinates (Zone 51) and sampling deployment at sampling locations in the Telfer Optimisation Study Area.

Transect code	Sampling point code	Pitfall	Elliott	Funnel	Bird Census	Easting (mE)	Northing (mN)
Line 10	10.1	X		X	X	414733	7600921
Line 10	10.2	X	X		X	414735	7600974
Line 10	10.3	X		X	X	414749	7601019
Line 10	10.4	X	X		X	414765	7601070
Line 10	10.5	X		X	X	414775	7601121
Line 10	10.6	X	X		X	414787	7601171
Line 10	10.7	X		X	X	414800	7601221
Line 10	10.8	X	X		X	414809	7601271
Line 10	10.9	X		X	X	414805	7601272
Line 10	10.10	X	X		X	414819	7601322
Line 11	11.1	X		X	X	414023	7598892
Line 11	11.2	X	X		X	413982	7598882
Line 11	11.3	X		X	X	413916	7598877
Line 11	11.4	X	X		X	413867	7598859
Line 11	11.5	X		X	X	413807	7598855
Line 11	11.6	X	X		X	413752	7598841
Line 11	11.7	X		X	X	413713	7598845
Line 11	11.8	X	X		X	413650	7598818
Line 11	11.9	X		X	X	413616	7598794
Line 11	11.10	X	X		X	413543	7598753

Appendix 11 Summary letter of invertebrate specimens collected in the Telfer Optimisation Study Area.

M.J. & A.R. Bamford
CONSULTING ECOLOGISTS
23 Plover Way,
Kingsley, WA, 6026
ph: 08 9309 3671 fx: 08 9409 2710
email: bamford.consulting@iinet.net.au
ABN 84 926 103 081

13th August 2012

Attn: Syrinx Environmental.

Re. Invertebrate specimens collected in the Telfer area

M. Bamford

Background and methods

As part of fauna investigations carried out around Telfer, in the Optimisation, Pit 15, O'Callaghan's, Trotman's and Satellite project areas, invertebrate specimens that potentially represented short range endemic species were collected in September 2011, April 2012 and May 2012. Collection was by searching through leaf-litter and under rocks, from dry pitfall traps set for vertebrates, and through the collection and sorting (in the laboratory by Tulgren funnel) of leaf-litter samples. Collection was carried out in all field trips and in all project areas, although litter samples were collected only in May 2012 in Optimisation and O'Callaghan's. All specimens were lodged with the WA Museum following identification.

Results and Discussion

Invertebrate specimens were found in dry pitfall traps and by searching through leaf-litter, but no specimens were found in litter samples sorted in the laboratory. Specimens were identified by Dr S. Judd (pers. Comm.; isopods) and Phoenix Environmental (scorpions and spiders; 2011 and 2012). Species recorded (and comments provided by S. Judd and Phoenix Environmental with some interpretation by M. Bamford) were:

Trapdoor spider *Aname* 'MYG034' (Nemesiidae). Collected in September 2011 in dry pitfall traps. A widespread species in the northern Pilbara.

Trapdoor spider *Aname* sp. indet. (Nemesiidae). Collected in April 2012 in dry pitfall traps. A female specimen that could not be identified to species, possibly therefore *Aname* 'MYG034' or could be an undescribed species. The genus *Aname* includes a number of SRE species.

Isopod *Buddelundia* sp. nov. 58. Several specimens (both male and female) collected in April 2012; caught in pitfall traps at several of the sites in sandy soils. An undescribed species and no other specimens from this genus found within 150km (although this probably an artefact of inadequate collection). Considered likely to occur over a wide area in the region but this cannot be demonstrated at this stage.

Scorpion *Lychas annulatus* (Buthidae). Collected in April 2012; caught in dry pitfall traps on sandy plains at several of the sites. A widespread species (probably a species complex) across arid Australia and associated with sandy soils.

Scorpion *Lychas sp. nov. "Telfer"* (Buthidae). Collected in April 2012 by searching through eucalypt leaf-litter along dunes in Trotman's project area. An undescribed species currently known only from the specimens collected at Telfer but likely to be regionally widespread.

Scorpion *Lychas multipunctatus* (Buthidae). Collected in April 2012; caught in dry pitfall traps on low gravelly rises. A widespread species in the Pilbara.

Scorpion *Urodacus sp. nov.* "Telfer" (Urodacidae). Collected in September 2011 and April 2012 at all sites where sandy soil was present. An undescribed species currently known only from the specimens collected at Telfer but likely to be regionally widespread.

Comments on short range endemism

The scorpions *Lychas sp. nov.* "Telfer" and *Urodacus sp. nov.* "Telfer", and the isopod *Buddelundia* sp. nov. 58, are currently known only from the specimens collected for the current project. The trapdoor spider *Aname* sp. indet. may also be known only from Telfer, although the identification was based on a female specimen that lacks some characters used in species determination. All of these species are potentially SREs with restricted ranges in the Telfer region, but it is likely that they are at least moderately widespread as they were found in widespread environments; they were not found in the sort of restricted, mesic refugia with which SRE species are typically associated.

References

Phoenix Environmental (2011). Millipedes and trapdoor spiders from Bindoon, Collie and Telfer. Unpubl report to Bamford Consulting Ecologists by Phoenix Environmental, Balcatta.

Phoenix Environmental (2012). Identification and assessment of short range endemism of invertebrates from Telfer. Unpubl report to Dalcon Environmental by Phoenix Environmental, Balcatta.