TECHNICAL REPORT

O'CALLAGHAN'S STUDY AREA

LEVEL 2 FLORA AND FAUNA SURVEY

JANUARY 2013

FOR
NEWCREST MINING LTD



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EXECUTIVE SUMMARY

Newcrest Mining Ltd engaged Syrinx Environmental PL (Flora and Vegetation) with Bamford Consulting Ecologists (BCE) (Fauna) to undertake a Level 2 assessment of the O'Callaghan's Study Area, near the Telfer Gold Mine (Telfer), located in the Great Sandy Desert in the Paterson Province of Western Australia, 485km from Port Hedland. The O'Callaghan's Study Area is located immediately south west of existing operations within Newcrest tenements M45/203, 205, part 204, 206 and 207.

The O'Callaghan's Study Area is a 2,727.75ha portion of the overall 10,471ha Telfer Optimisation Project, where Newcrest is investigating opportunities for enhancement of current mining activities and potential development of satellite deposits. The O'Callaghan's Study Area represents one of five study areas within the Telfer Optimisation Project Area. All five study areas were assessed simultaneously.

The Level 2 assessment was required in order to inform planning and assess impacts of potential developments on vegetation, flora, groundwater dependent ecosystems, vertebrate fauna and short range endemics.

This report summarises the flora, vegetation and fauna survey results undertaken in the O'Callaghan's Study Area and compares these 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 O'Callaghan's Study Area, including an assessment of the likelihood of potential conservation significant species (determined via the database searches as 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 water dependency and significance 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, including;

a. Documentation of Short Range Endemic (SREs) 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 Environmental Significance or other plants regarded as invasive weeds.

FLORA

A total of 36 50 x 50m quadrats were sampled during the survey resulting in identification of 176 species from 32 families and 77 genera. In addition, three specimens were unidentifiable at the species level.

The most commonly recorded family was Fabaceae, which accounted for 23.8% of all taxa collected in the O'Callaghan's Study Area, constituting 42 taxa and 12 genera. Other dominant families recorded were Poaceae (14.7% of taxa), which consisted of 26 taxa from 11 genera, Malvaceae (7.4% of taxa) with 13 taxa from seven genera and Myrtaceae (7.4% of taxa), which consisted of 13 taxa from five genera.

No Threatened Flora (T) listed under the *Wildlife Conservation Act 1950* or Threatened Flora listed under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) were recorded within the O'Callaghan's Study Area. Five *Goodenia hartiana* populations were recorded in the O'Callaghan's Study Area; however, it is possible three of the populations are part of one larger population containing hundreds of plants.

There were five range extension species recorded: *Fimbristylis leucocolea, F. neilsonii, Maireana triptera, Sclerolaena eriacantha* and *S. minuta.*

Using a combination of multivariate analysis and field observations, 15 Vegetation Associations occurring within seven broad floristic groups were mapped and described in the O'Callaghan's Study Area. None of the Vegetation Associations mapped and described are listed as Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs).

A Vegetation Association, dominated *Acacia wanyu*, has been assessed as a unique and distinct Vegetation Association:

- Vegetation Association 5b: *Acacia wanyu* Open Shrubland over *Eremophila tietkensii* and *Senna glutinosa* subsp. *x luerssenii* Open Shrubland over *Triodia basedowii* complex and *T. epactia* Open Hummock Grassland over *Maireana melanocoma*, *M. triptera*, *Sclerolaena eriacantha* Very Open Herbland.

This Vegetation Association occurs across 3.7% of the O'Callaghan's Study Area, on a landform not common regionally and was also found on a contemporaneous survey at Pit 15 (Fallows Field). Eight species are restricted to Vegetation Association 5b. Almost all of the restricted species are common south of the Great Sandy Desert Bioregion. Six of the species are restricted to the O'Callaghan's Study Area when assessed against the remaining four study areas within the Telfer Optimisation Project Area.

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 5b is likely to be at the northern extreme of their distribution due to the lack of potential habitat north of the O'Callaghan's Study Area; and
- novel combination of species criteria as the eight species recorded restricted to this Vegetation Association are more common to the Pilbara of which six species restricted to this Vegetation Association in the O'Callaghan's Study Area when assessed against the remaining four study areas.

Vegetation Association 2a has been identified as either surface or groundwater dependent ecosystem:

- Vegetation Association 2a is a Low *Melaleuca lasiandra* - *M. glomerata* Woodland identified as relying on sub-surface perching of meteoric water and runoff. These ecosystems are present throughout the Telfer region as they are associated with occluded paleo-drainage channels that traverse the Great Sandy Desert and are of low conservation significance;

The vegetation condition across the majority of the O'Callaghan's Study Area is Pristine to Excellent. The lesser condition ranking was attributed to tracks and exploration drilling in the south east corner of the O'Callaghan's Study Area.

There were no introduced species recorded in the O'Callaghan's Study Area during the current survey. However a weed survey undertaken by Syrinx Environmental PL (2011b) in May identified two introduced species found in the O'Callaghan's Study Area. *Cenchrus ciliaris* (Buffel Grass) and *Aerva javanica* (Kapok) were recorded in disturbed areas around the Telfer Gas Power station and Powerlines, located within the north west region of the O'Callaghan's Study Area.

FAUNA

The fauna investigations were based on a desktop review of data with an aim of establishing a list of expected species, a site reconnaissance trip in July 2011, and intensive sampling trips in September 2011 and June 2012. The 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 study areas within the Telfer Optimisation Project Area, with two sampling sites in the O'Callaghan's Study Area. Sampling included collection of potential Short Range Endemic invertebrates.

The desktop assessment identified 275 vertebrate fauna species potentially occurring in the Optimisation Project Area of which 255 may occur within the O'Callaghan's Study Area. This includes seven frog, 95 reptile, 129 bird and 44 mammal species. A total of 68 fauna species were confirmed in the O'Callaghan's Study area comprising 19 reptile, 39 bird and ten mammal species. Conservation significant fauna recorded for the O'Callaghan's Study Area included the Greater Bilby, Northern Marsupial Mole and Mulgara.

Key fauna values identified are as follows:

Fauna assemblage – rich despite the local extinction of some mammal species. Assemblage includes elements from the Pilbara and Great Sandy Desert regions. The O'Callaghan's Study Area was expected to only support a subset of the total fauna assemblage, but a fauna assemblage can vary over time. Therefore, a precautionary approach is taken and the fauna assemblage is based upon the desktop results, with some interpretation based upon the availability of habitats.

Significant species – 27 species of conservation significance may be present, including three reptiles, 13 birds (but with an uncertain number of migratory waterbirds occasionally visiting the area) and 12 mammals. Potential SRE invertebrate species are the scorpions *Lychas sp. nov.* "Telfer" and *Urodacus sp. nov.* "Telfer", the isopod *Buddelundia* sp. nov. 58 and possibly the trapdoor spider *Aname* sp. indet.. 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 O'Callaghan's Study Area, the Greater Bilby, Northern Marsupial Mole and Mulgara were recorded.

Vegetation and Substrate Associations – Eight VSAs were identified across the Telfer project areas: 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 in the region, and the O'Callaghan's Study Area is dominated by sand dunes and interdune plains, with small areas of rocky hills and calcrete rises.

Patterns of biodiversity – There were no major patterns of biodiversity identified, but areas with a substrate of deep sand to sandy-loam, and well-developed spinifex grasslands, supported a rich reptile assemblage.

Key ecological processes - Main processes affecting the fauna assemblage in the Telfer region and O'Callaghan's Study Area are local hydrology, fire regimes and fauna interactions. Local hydrology may be important along dunes and in some broad valleys across the region. 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 investigation.

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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

The Telfer Optimisation Project comprises of several tenements areas adjacent to the Telfer Gold Mine (Figure 1), where Newcrest is investigating opportunities for potential development of satellite deposits.

Newcrest Mining Ltd (Newcrest) engaged Syrinx Environmental PL (Syrinx) (Flora and Vegetation) with Bamford Consulting Ecologists (BCE) (Fauna) to undertake an assessment of the O'Callaghan's Study Area, a 2,727.75 ha portion of the overall 10,471 ha Telfer Optimisation Project Area (Figure 2), in order to assess the likely environmental impacts of the proposal on flora, vegetation, groundwater dependent ecosystems (GDEs), vertebrate fauna and short range endemics (SREs).

This report addresses the O'Callaghan's 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 O'Callaghan's 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 in the vicinity of the O'Callaghan's 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 GDEs;
6. A Level 2 Vertebrate Fauna Survey to document vertebrate fauna species identified at sampling locations and through opportunistic observations;
    a. Documentation of 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.

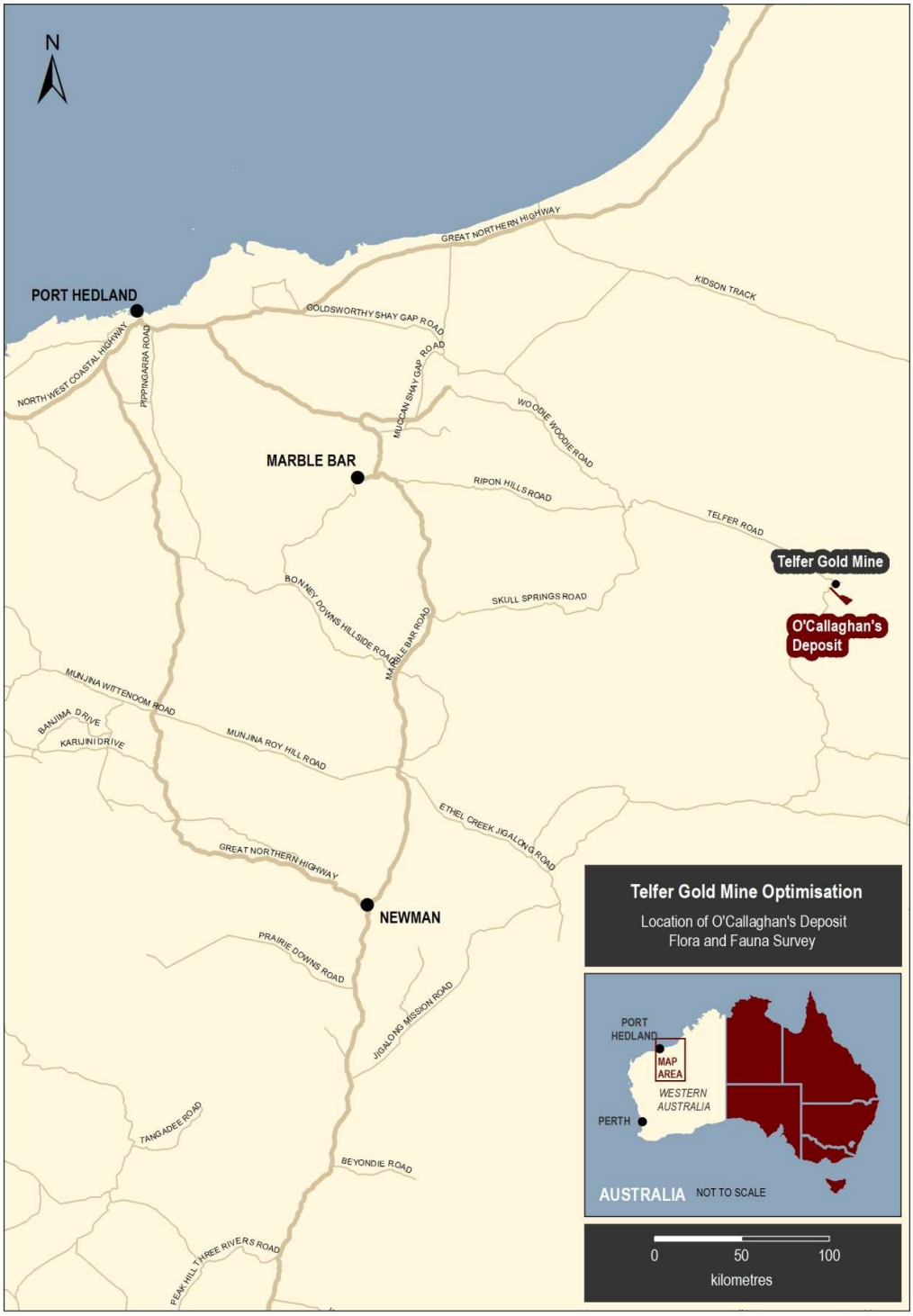


Figure 1 Location of Telfer Gold Mine

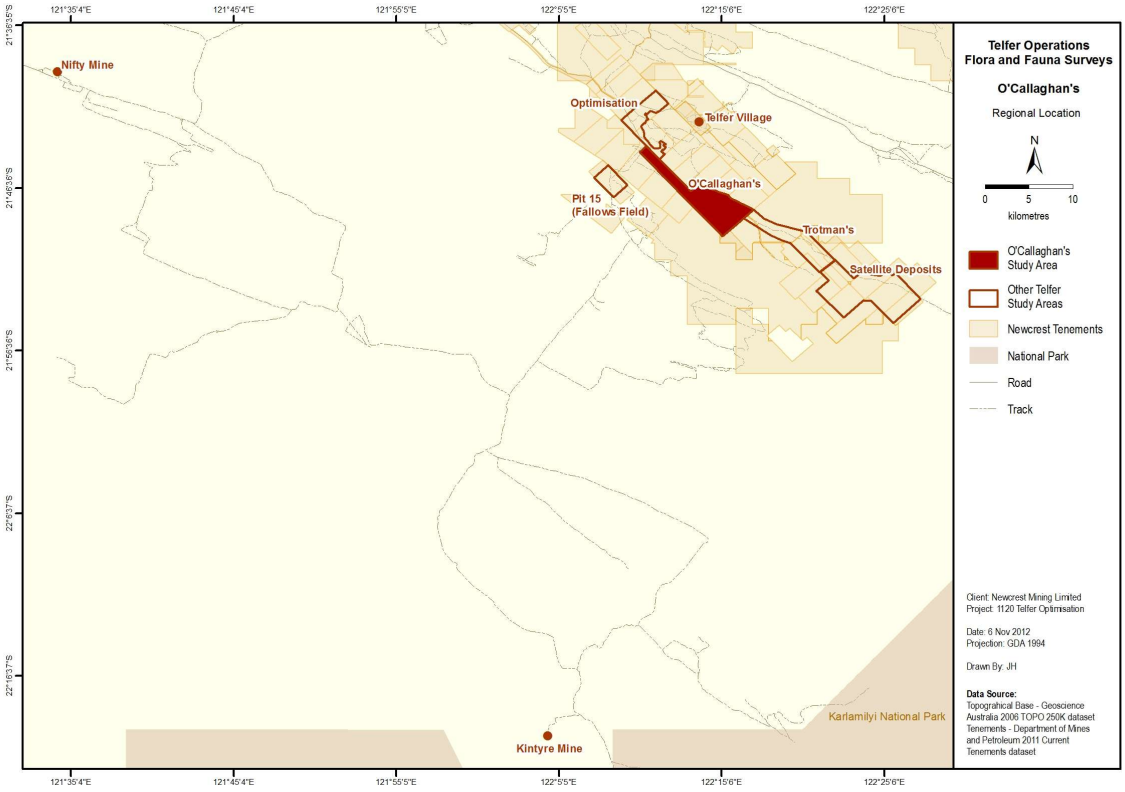


Figure 2 Location of the O'Callaghan's Study Area in comparison to other Newcrest tenements in the Great Sandy Desert, Western Australia

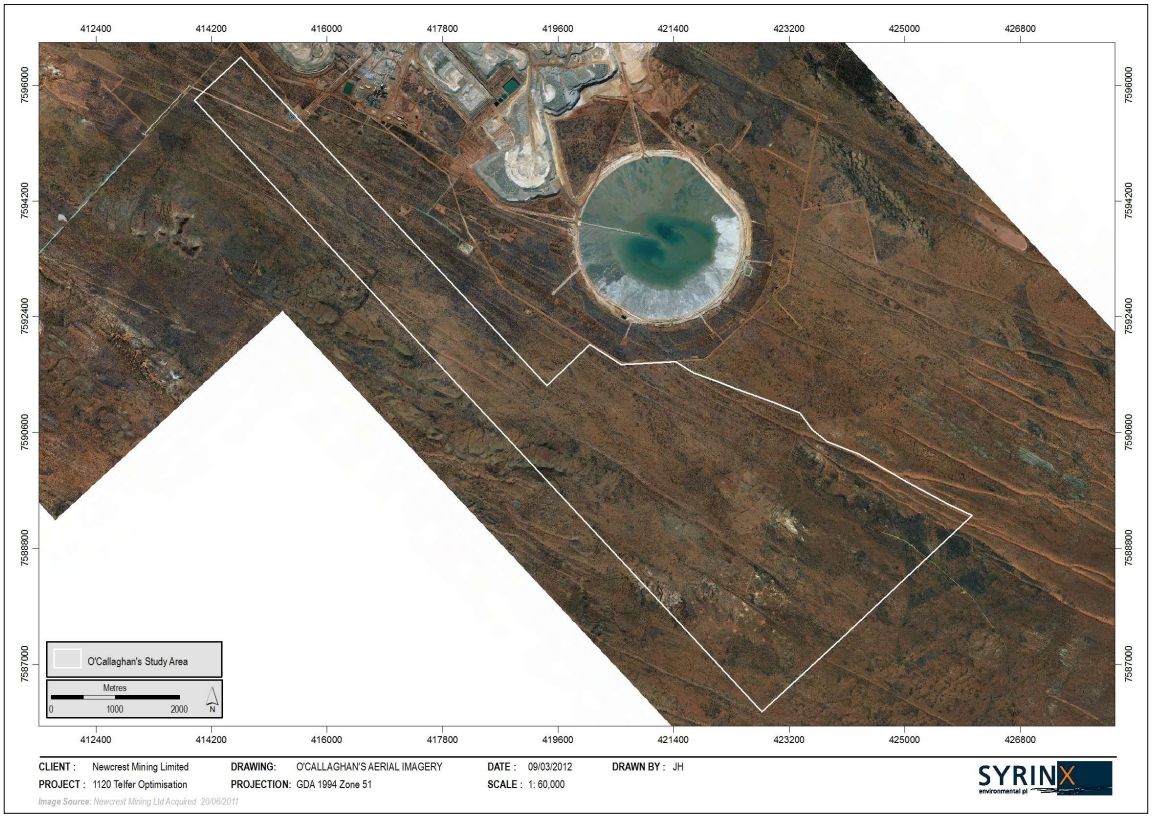


Figure 3 O'Callaghan's Study Area

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 O'Callaghan's Study Area occurs across two of the bioregions, the Great Sandy Desert and Little Sandy Desert (Figure 4).

The O'Callaghan's 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 O'Callaghan's Study Area is within the Mackay subregion, which represents 0.009% of the subregion.

The O'Callaghan's 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 37.51ha of the O'Callaghan's Study Area is within the Rudall subregion, which represents 0.00003% of the subregion.

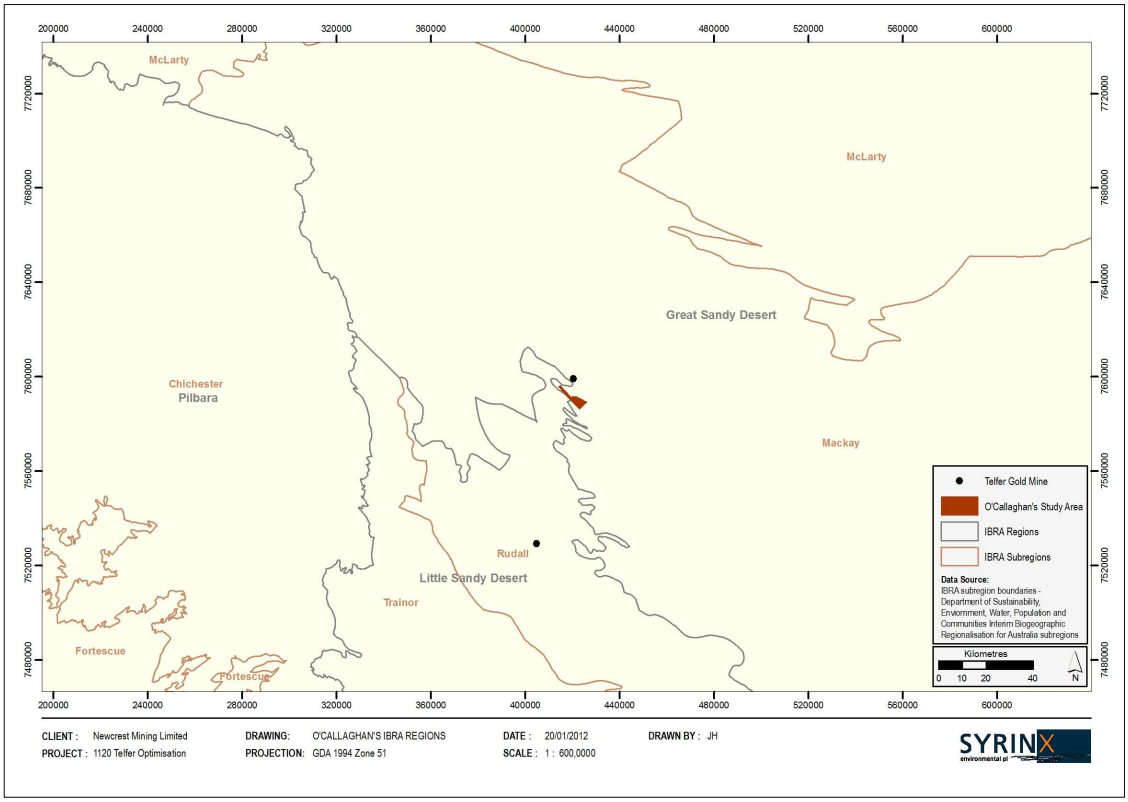


Figure 4 IBRA Regions of the O'Callaghan's Study Area

3.2 GEOLOGY, LANDFORM 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, and 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 Paleo-proterozoic 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 O'Callaghan's Study Area (Geoscience Australia 2008).

- Wilki Formation (Nsaw): Occurring in the North Eastern portion, as well as the central and southern parts of the O'Callaghan's Study Area. This formation is characterized 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 O'Callaghan's Study Area as well as a small pocket in the western corner. It is

characterized 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 O'Callaghan's 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 O'Callaghan's 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 O'Callaghan's 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, and deliver 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.

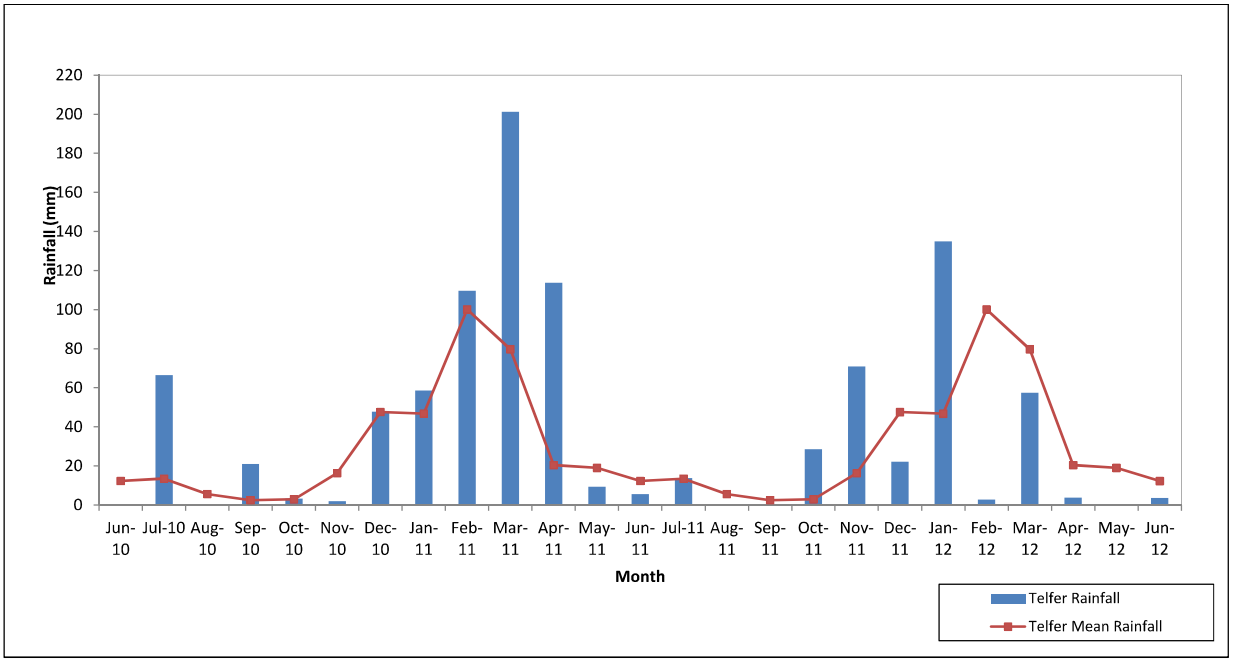


Figure 5 Climate Data for Telfer Weather Station (BOM Station 13030; BOM 2012)

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, 2001a). 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 O'Callaghan's 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 16 September 2010 (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).

Definitions of Threatened and Priority Ecological Communities and Threatened (DRF) and Priority Flora are provided in Appendix 1.

Searches of the DEC Threatened (Declared Rare) Flora database, the WAH Specimen database, and DEC Declared Rare and Priority Flora List were conducted on the 13th June 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 Mining Ltd (Newcrest) reports pertaining to the areas surrounding the study area were obtained. 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 (DRF) and Priority Flora 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 (t3Hi); and
- Shrub steppe: Mixed shrub steppe between sandhills with Triodia schinzii (anSr.tpHi).

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.

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 Association 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 (2001a) 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 (2001b) listed Vegetation Association 157 as being of medium reservation priority in the Little Sandy Desert.

This dataset is congruent with mapping by Beard (1974) 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.

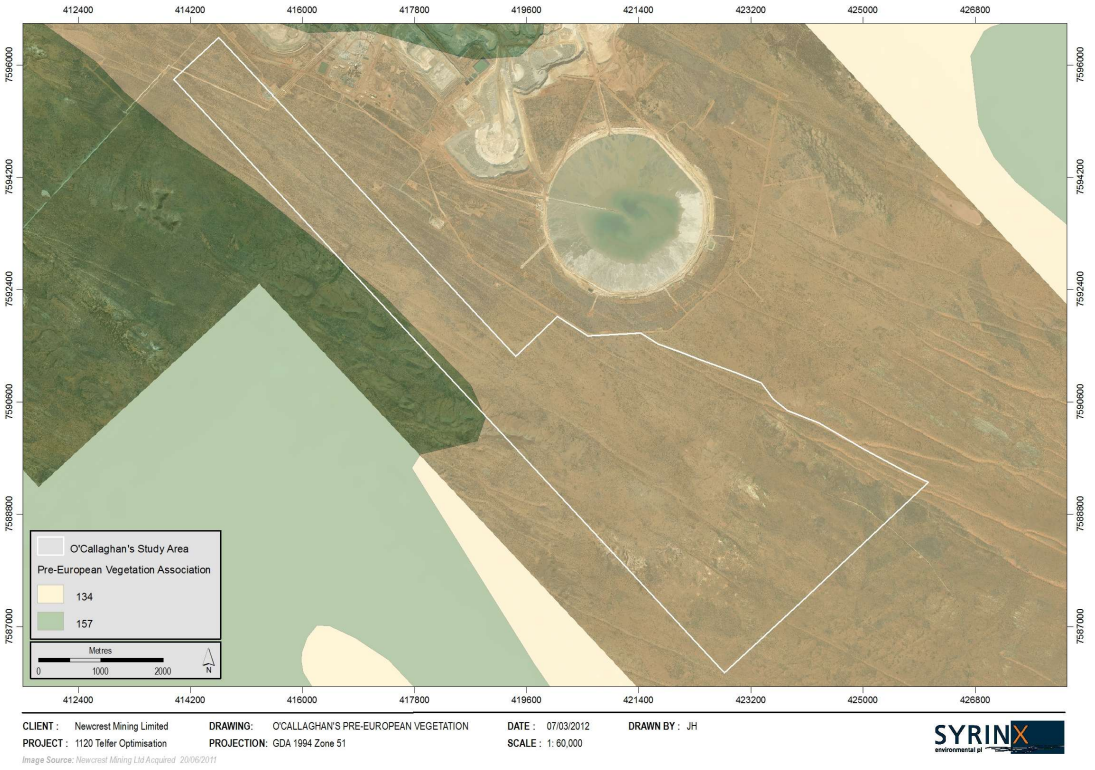


Figure 6 Pre-European Extent of Vegetation Associations

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 (Kintyre), 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 (MBS 2005) Native Vegetation Management Plan. Prepared for Birla (Nifty) Pty Ltd.
- Martinick Bosch Sell Pty Ltd (MBS 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 2010. Report prepared for Cameco Australia.

Most relevant in terms of proximity to the O'Callaghan's 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). Data collected for this current study was compared with the vegetation types/associations recorded in these previous reports, where possible.

At a regional level, the most relevant studies are:

- The MBS (2005) vegetation survey at Nifty, 67km west of Telfer. The MBS (2005) report also refers to a Hart, Simpson and Associates (2002) survey of the Nifty area, and although this report was not accessible, it was summarised in MBS (2005).
- The most recent regional surveys have been completed for the Kintyre Uranium Project (Bennett Environmental 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 were *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 *Eucalyptus 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
- 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 there was no description of it, or discussion of its significance, 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 (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 in 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 Telfer Optimisation Project Area, but not within the 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 O'Callaghan's Study Area, which is the subject of this current work, and covered an area of 2,073 ha.

The Level 1 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. As with other comments elsewhere in this document, it should be noted that as the survey was a Level 1 survey a comprehensive species list was not required. The Priority Flora species recorded were *Goodenia hartiana* (P2) and the potential Priority Flora *Dampiera ?atriplicina* (insufficient material to determine).

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 were considered 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 51 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 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 species 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	Landforms 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 species 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 20km from the study area	Opportunistic observation; Fauna and Flora collections during vehicle and foot traverses. Completed May 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)	No Threatened Flora (T) recorded *Goodenia hartiana* (P2) found in small numbers in the mine and in the Freedom Rd Borefield *Fuirena incrassata* (P 3) 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 51 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) *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 51 Requirements
Syrinx Environmental PL (2004a) Vegetation and Fauna Survey: Proposed Freedom Road Bypass EIA. Report	Approximately 40km west of study area	Points 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	67km 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: Sand dunes (1 vegetation unit), Sandplains/swale (4 vegetation units), and Shallow sand/gravelly plains (1 vegetation unit) One of the sandplain vegetation units *Triodia*/*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 a 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 that are 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 that no Priority 5 flora are 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 a 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 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 7) on the scree slopes of the Paterson Ranges near Christmas Pool. All populations have been recorded on stony hill sides;
- *Goodenia hartiana* (P2), which was recorded during the waste dump expansion survey (Syrinx Environmental PL 2006) conducted immediately adjacent to the north and south of existing Telfer operations and also the borefields expansion survey (Syrinx Environmental PL 2007). 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 mis-identified as the species are superficially similar to *Goodenia azurea,* another species present in the area.

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

Location details (coordinates) for all the priority species recorded (and still current) are provided in Table 2 and Appendix 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.
- 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 species on the DEC database.

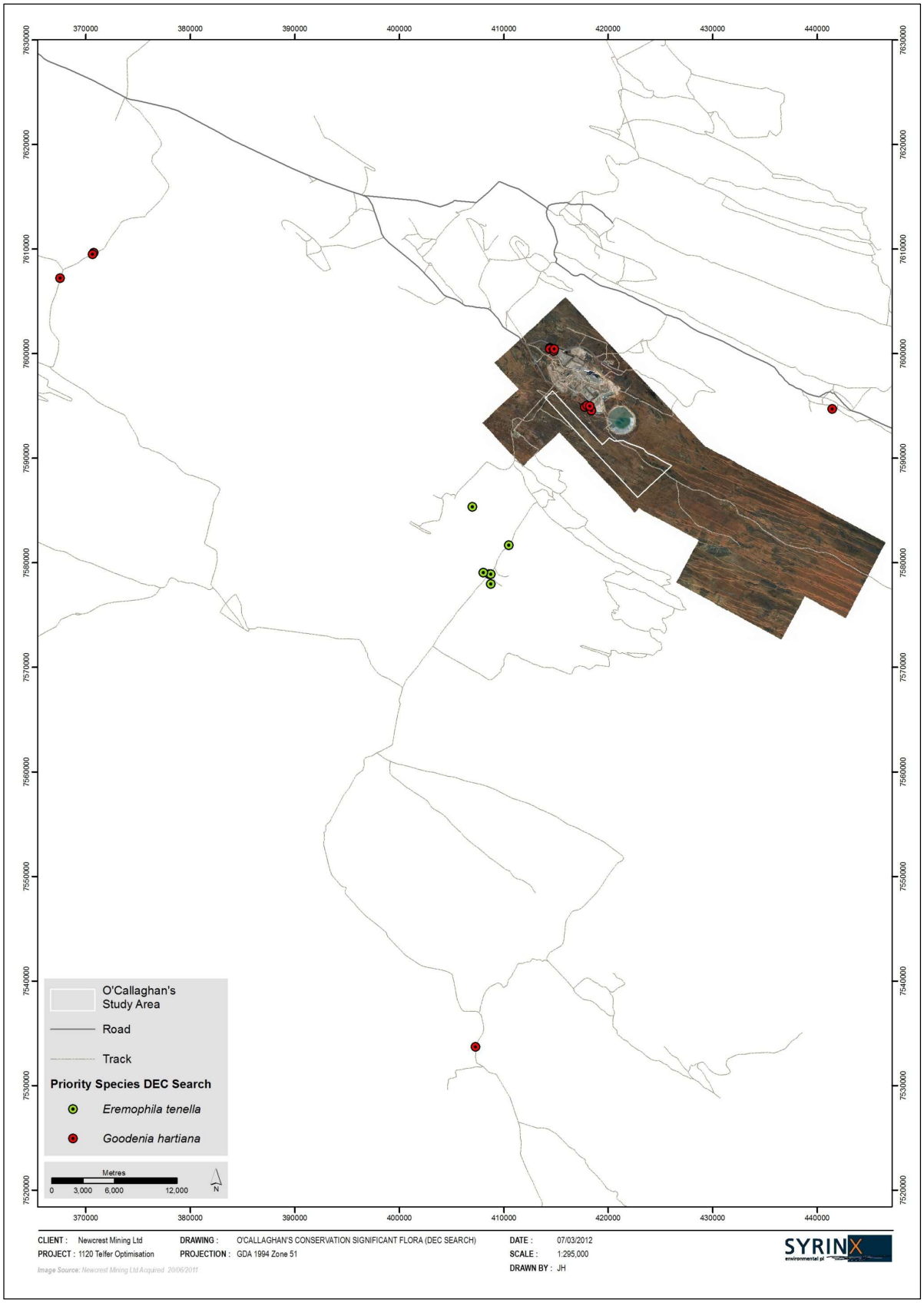


Figure 7 Priority Flora recorded within a 60km buffer of the O'Callaghan's Study Area from DEC and WAH Database Searches

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* spp., *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, F. dichotoma, Triodia brizoides, Eriachne mucronata, Corchorus parviflorus, Cassytha capillaris,*

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 cusackiana, G. stobbsiana, and *Dodonaea coriacea*
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, Acacia 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.

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 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*
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	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*

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
	(pink tinge), yellow stamens. Axillary corolla 5 mm long. Cylindrical flower head 20 mm long x 7 mm wide. Bracts incurved						
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 west	*Corymbia* and *Eucalyptus, Acacia, Gossypium, Ficus* shrubland, *Petalostylis, Dodonaea* shrubland, *Indigofera* and *Triodia pungens*
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	100km 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's west	*Eucalyptus leucophloia, E. gamophylla* over Open Low Scrub A/B of *Acacia hamersleyensis, A. maitlandii, Petalostylis labicheoides, Triodia wiseana* and *T. basedowii*

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
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*
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 revealed no TECs were known to occur within the Great Sandy Desert or Little Sandy Desert bioregions.

A search of the DEC TEC database revealed no TECs were 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 2012b). PECs are classed at a State level only.

Currently there are no PECs listed for the Great Sandy Desert or Little Sandy Desert bioregion (DEC 2012b). The nearest PEC to the O'Callaghan's Study 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* occur within the vicinity of the O'Callaghan's 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, 2011b) are found within the boundary of the O'Callaghan's 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 present, 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 march, 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 groundwater table dependent (pans) are types of wetlands. These systems can be reliant on either groundwater or surface water.
Groundwater Dependent Ecosystem	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 GDEs 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 Blackwood 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 of groundwater. Excluded from this definition are perched aquifer wetland systems (Hatton and Evans 1998).
Perched Aquifer Ecosystems	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 2000). These systems are not connected to the confined aquifers below these ecosystems. These systems are typically reliant on surface run off of meteoric water.
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 northwestern Great Sandy Desert, 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 O'Callaghan's Study Area.

Underground waters associated with calcrete deposits along paleo-drainage lines were also identified) as wetlands of subregional significance in Mackay (Kendrick 2001a). Given the geology present (see Section 3.3) it is unlikely these wetlands are present in the O'Callaghan's Study Area. Groundwater characteristics in the paleo-valley 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, occurs 67km west of the study area at Nifty Copper Mine 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 minesite (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 2004a, 2004b, 2006, 2007). In low lying areas of some interdunal swales 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 (*Acacia aneura* species complex) 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 recorded 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 the *Acacia aneura* species complex. 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. The closest records of *Acacia pteraneura* on Florabase (WAH 2012) are 200km south of Telfer, associated with 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**

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**
Sonchus oleraceus	Common Sowthistle	No	Not Declared	Moderate	**3**
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 (9^{th} – 12^{th} 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 (Figure 8).

Thirty six (36) quadrats were established to survey vegetation in the O'Callaghan's 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 (90o 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.

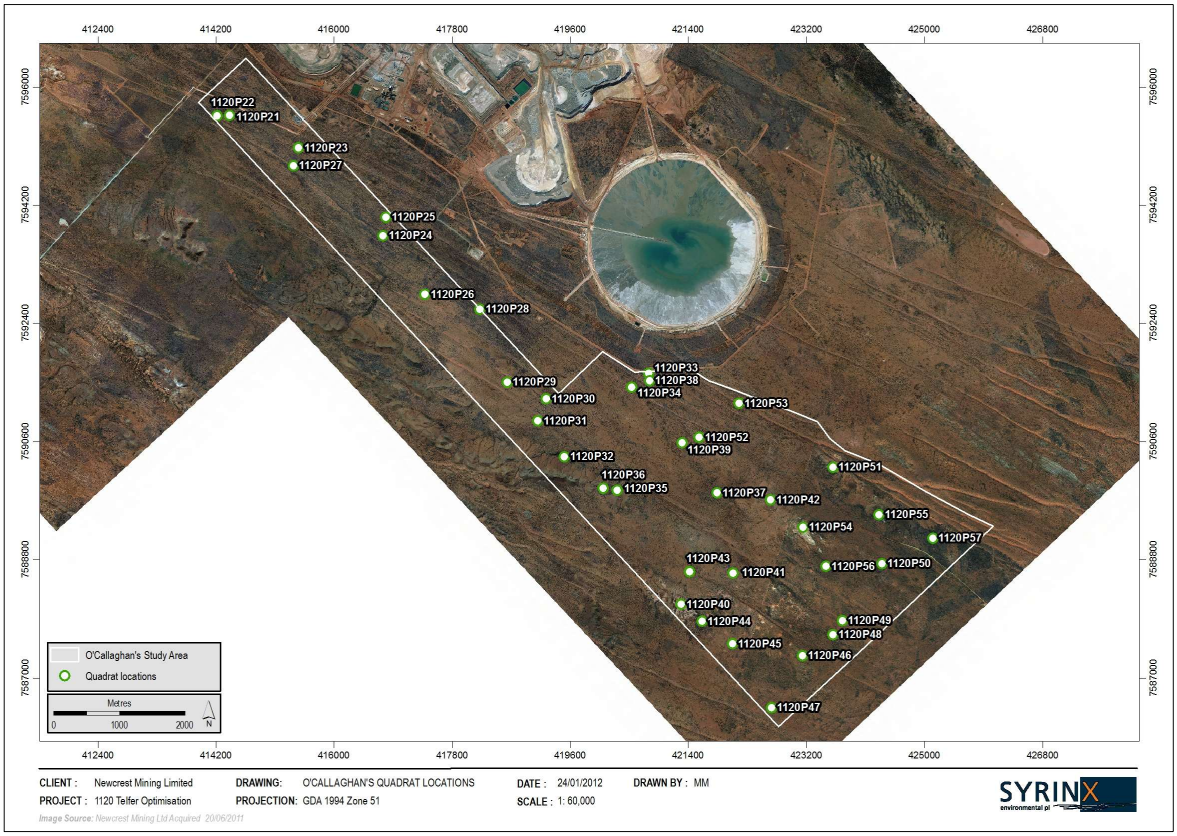


Figure 8 Flora Survey Quadrat Locations

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 2004b). 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 O'Callaghan's Study Area and the adjacent Optimisation Study Area (Syrinx Environmental 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 linked 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 O'Callaghan's 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 O'Callaghan's 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 O'Callaghan's 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 O'Callaghan's Study Area, but the data had not been published at the time of data analysis for the O'Callaghan's Study Area. 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 TEC's and State PEC's. 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 2010).

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 2 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 Shrubs
Hummock Grass	Closed Hummock Grassland	Hummock Grassland	Open Hummock Grassland	Very Open Hummock Grassland	Scattered Hummock Grass
Tussock Grass	Closed Tussock Grassland	Tussock Grassland	Open Tussock Grassland	Very Open Tussock Grassland	Scattered Tussock Grass
Bunch Grass	Closed Bunch Grassland	Bunch Grassland	Open Bunch Grasslands	Very Open Bunch Grassland	Scattered Bunch Grass
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 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 O'Callaghan's 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 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 existing hydrogeological data overlaid over aerial photography for Telfer, provided by Newcrest, an initial assessment of vegetation potentially containing water dependent species was undertaken. These areas were traversed during the first field survey in October 2011, when the survey sites were at their driest. The unseasonally dry months prior to the June 2012 field survey also provided the opportunity to assess potential groundwater dependent Vegetation Associations.

From the Vegetation Associations mapped post-fieldwork, those that contained water dependent species observed in the field were identified. This was overlaid with the hydrogeological data provided by Newcrest to gain an understanding of the distribution of water dependent species.

A literature review was undertaken of current information for all ground or surface water dependent species identified in the field to assess the dependence of the species 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), in its Guidance to Terrestrial Flora and Vegetation Surveys, lists a number 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 plant specimens collected during the fieldwork has more than eight 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 mining developments on flora and vegetation of the Study Area.
Proportion of flora identified	Yes	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 was 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.
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 ha) having only one plot.

Aspect	Constraint	Comment
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	Approximately 20% of the O'Callaghan's Study Area (south east section of the Study Area) was affected by fire in 2007 resulting in altered species dominance (i.e. abundance or cover) and species composition to some extent. A drilling program conducted at the time of survey resulted in many tracks being present in the south east corner of the Study Area, fragmenting the Vegetation Associations in this location. The south east corner where the drilling program was present represents 6.5% of the Study Area.
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 O'Callaghan's Study Area covers 2727.75ha. 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, a total of 15 Vegetation Associations were mapped in the O'Callaghan's Study Area (Figure 9 and Figure 10) and these fall into seven broad floristic groups (Appendix 4). Descriptions of each of the Vegetation Associations and the broad floristic group to which they belong are detailed in Table 9 and Appendix 5.

Seven landforms were identified in the O'Callaghan's Study Area. The proportion of the study area and the number of Vegetation Associations for each landform were:

- swales between dunes (55% of the Study Area with four Vegetation Associations);
- ironstone rocky hill (2% of the Study Area with two Vegetation Associations);
- quartzite rocky hill crest (2.2% of the Study Area with one Vegetation Association);
- quartzite rocky slope (3.7% of the Study Area with one Vegetation Association);
- sand dunes (6.1% of the Study Area with one Vegetation Association);
- drainage channels (0.5% of the Study Area and two Vegetation Associations); and
- swales between rocky outcrops (28.4% of the Study Area and four Vegetation Associations).

It should be noted the number of quadrats per Vegetation Association area also includes quadrats located in adjacent Study Areas within 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.

4.3.2 Vegetation Condition

The vegetation condition across the O'Callaghan's Study Area is primarily Excellent (87.1% of the Study Area) with some Pristine areas (11.6% of the study area) where there has been no evidence of disturbance such as tracks and stakes. There are disturbed areas (1.3% of the Study Area) associated with the Telfer gas power station and power lines to the north west and where drilling has commenced to the south east.

Table 9 Broad Floristic Groups and Vegetation Associations

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater Dependent	Restricted Distribution	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 ha (43 ha and 3 quadrat in Optimisation Study Area)	Drainage Channel	Nil	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)	
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	126.67 ha (5) (115.65 ha and 1 quadrat Optimisation Study Area)	Rocky Hill Swale	*Goodenia hartiana* population 5 Range Extension Species - *Fimbristylis neilsonii*	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 Dependent	Restricted Distribution	Other Locations Recorded	Unique and Distinct Vegetation Association
Melaleuca Low Open Woodland								
2a	Scattered Trees of *Eucalyptus victrix* over *Melaleuca lasiandra* and *M. glomerata* Low Woodland over *Acacia stipuligera* High Open Shrubland over *Aluta maisonneuvei* subsp. *maisonneuvei* and *Gompholobium polyzygum* Low Open Shrubland over *Triodia* aff. *lanigera* Open Hummock Grassland	4.43 ha (1)	Dune Swale	Nil	Yes, groundwater dependent species present.	No, typical vegetation of occluded paleochannels common throughout the region	Sandplain - Variation 6: typical shrub species are *Melaleuca lasiandra, M. glomerata* and *Grevillea wickhamii* (Hart, Simpson and Associates 2002)	No
Acacia Open Scrub								
3b	Scattered Trees of *Corymbia candida* subsp. *dipsodes* over *Acacia monticola, A. stipuligera* and *Grevillea wickhamii* Open Scrub over Low Scattered Shrubs of *Indigofera boviperda* subsp. *boviperda*, *Mirbelia viminalis* and *Dicrastylis cordifolia* over *Triodia pungens* Open Tussock Grassland	8.63 ha (1)	Drainage Channel	Nil	No	No, typical of minor drainage channels throughout the region	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

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater Dependent	Restricted Distribution	Other Locations Recorded	Unique and Distinct Vegetation Association
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	301.82 ha (1) (116.66 ha and 1 quadrat in the Optimisation 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 *A. 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
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	284.54 ha (2) (417.22 ha and 4 quadrats Optimisation Study Area)	Rocky Hill 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 *A. stellaticeps* low open shrubland over *Triodia basedowii* grassland, (Syrinx Environmental PL 2007); and	No

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater Dependent	Restricted Distribution	Other Locations Recorded	Unique and Distinct Vegetation Association
	Hummock Grassland						F8: Shrub steppes, *Grevillea* and *Acacia* shrubs over mixed spinifex on sand (Bennett Environmental Consulting 2010)	
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	670.08 ha(7)	Dune Swale	Yes, largest, most widespread population of *Goodenia hartiana* in this VA	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)	
4d	*Eucalyptus kingsmillii* subsp. *kingsmillii* and *Eucalyptus odontocarpa* Very Open Mallee over *Codonocarpus cotinifolius*, *Grevillea wickhamii* subsp. *hispidula* and *G. stenobotrya* High Shrubland over *Triodia basedowii* complex Open Hummock Grassland	306.9 ha(4)	Rocky Hill Swale	Range Extension Species - *Fimbristylis leucocolea*	No	No, typical of long unburnt dune swales in the region, typical of dune swales south east of Telfer	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	

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater Dependent	Restricted Distribution	Other Locations Recorded	Unique and Distinct Vegetation Association
							0: Mallees of *Eucalyptus odontocarpa* over the hard spinifex *Triodia basedowii* (Bennett Environmental Consulting 2010)	
Acacia Open Shrubland								
5b	*Acacia wanyu* Open Shrubland over *Eremophila tietkensii* and *Senna glutinosa* subsp. x *luerssenii* Open Shrubland over *Triodia basedowii* complex and *T. epactia* Open Hummock Grassland over *Maireana triptera, M. melanocoma, Sclerolaena eriacantha* Very Open Herbs	100.9 ha (3)	Quartzite Rocky Slope	Range extension species: *Maireana triptera, Sclerolaena eriacantha* and *S. minuta* Six Species restricted to this VA in the O'Callaghan's Study Area	No	Yes, restricted in the study area	Most similar to the 'Clayey Areas' Vegetation Association identified in the Telfer Expansion Project, (Hart, Simpson and Associates 2002). 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 O'Callaghan's Study Area; and Also potentially similar is Q: Complex, white quartzite scree slopes (Bennett Environmental Consulting 2010)	yes

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater Dependent	Restricted Distribution	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	0.6 ha (41.42 ha and 3 quadrats in Optimisation Study Area)	Ironstone Rocky Hill	Nil	No	Restricted in the study area, however recorded on the Optimisation Study Area and 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 is uncertain; however, the *Triodia* spp. present differs from the O'Callaghan's Study Area.	
6c	Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* High Open Shrubland over *A. stellaticeps* and *Mirbelia viminalis* Low Open Shrubland over *Triodia basedowii* Hummock Grassland	545.06ha (4)	Dune Swale	*Goodenia hartiana* population 4	No	No, typical of long unburnt dune swales in the region, typical of dune swales south east of Telfer	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

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater Dependent	Restricted Distribution	Other Locations Recorded	Unique and Distinct Vegetation Association
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	167.21 ha (4)	Dune	Nil	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
6e	Scattered Trees of *Eucalyptus leucophloia* over *Grevillea wickhamii* subsp. *hispidula* and *Hakea lorea* High Open Shrubland over *Acacia hilliana* and *A. adoxa* Low Open Shrubland over *Triodia basedowii* complex Hummock Grassland	60.8 ha(3)	Quartzite Hill Crest	Nil	No	No typical of low quartz hills south east of Telfer	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)	

Code	Vegetation Association	VA Area (Ha) (Number of quadrats)	Dominant Landform	Conservation Significant Flora	Groundwater Dependent	Restricted Distribution	Other Locations Recorded	Unique and Distinct Vegetation Association
6f	*Eucalyptus odontocarpa* Open Mallee over *Acacia ancistrocarpa* and *Grevillea stenobotrya* High Open Shrubland over Low Scattered Shrubs of *Acacia ligulata* and *A. stellaticeps* over *Triodia basedowii* complex Open Hummock Grassland	57.41 ha (3)	Rocky Hill Swale	Nil	No	No, typical of dune swales south east of Telfer	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). F1: Shrub steppe, *Acacia ancistrocarpa* and *A. ligulata* over the hard spinifex, *Triodia basedowii* (Bennett Environmental Consulting 2010)	
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	54.18 ha (1) (57.22ha and 3 quadrats in Optimisation Study Area)	Ironstone Rocky Hill	Nil	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

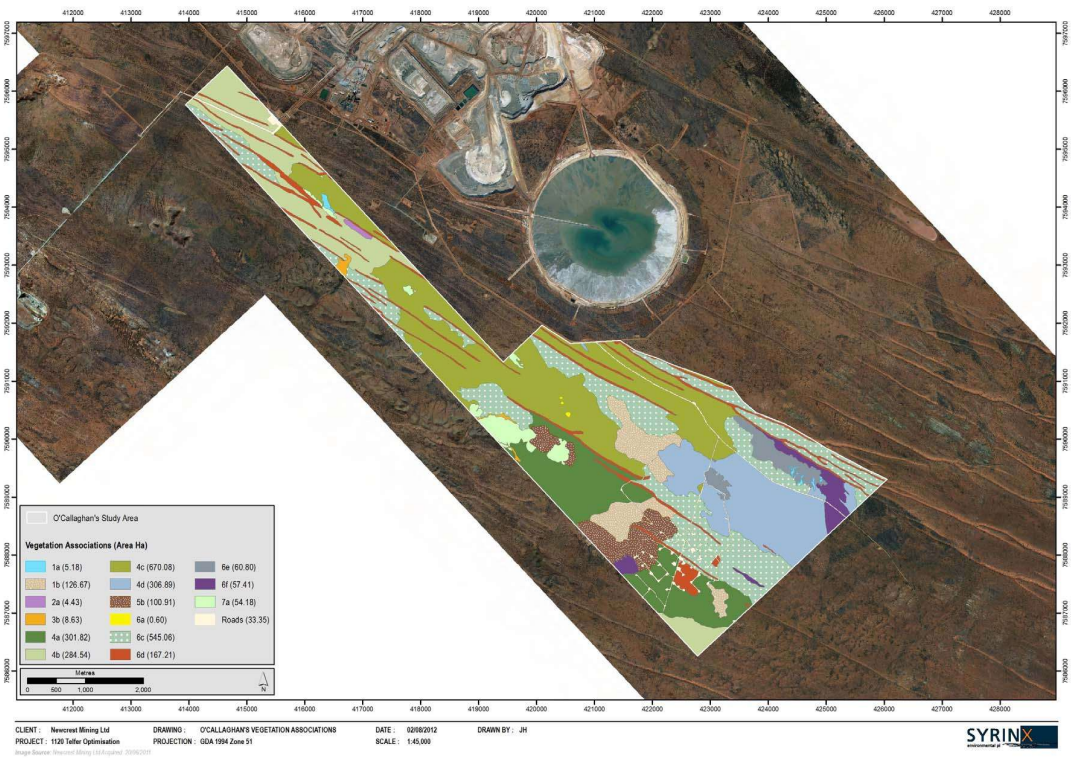


Figure 9 Vegetation Association Map

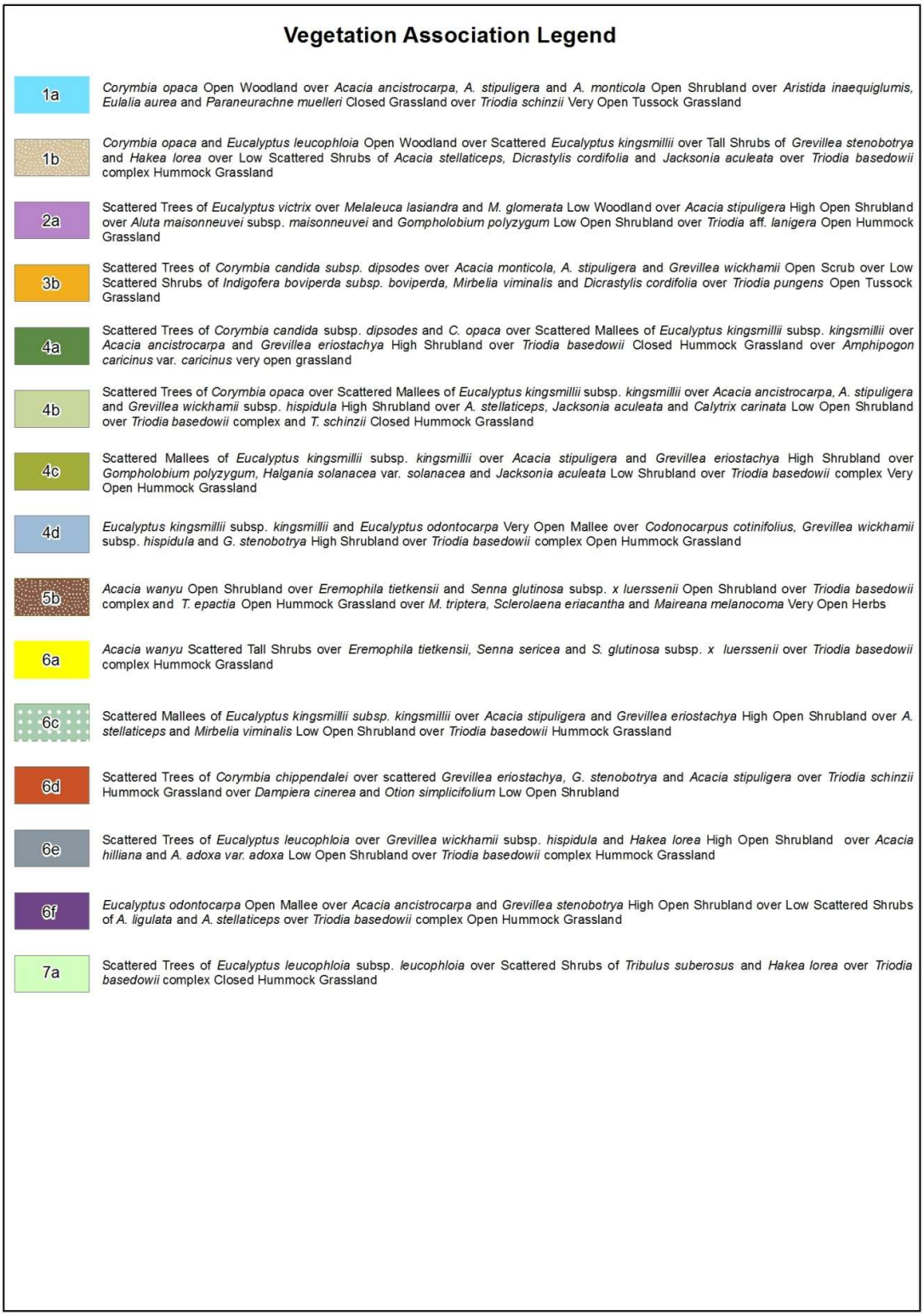


Figure 10 Vegetation Association Legend

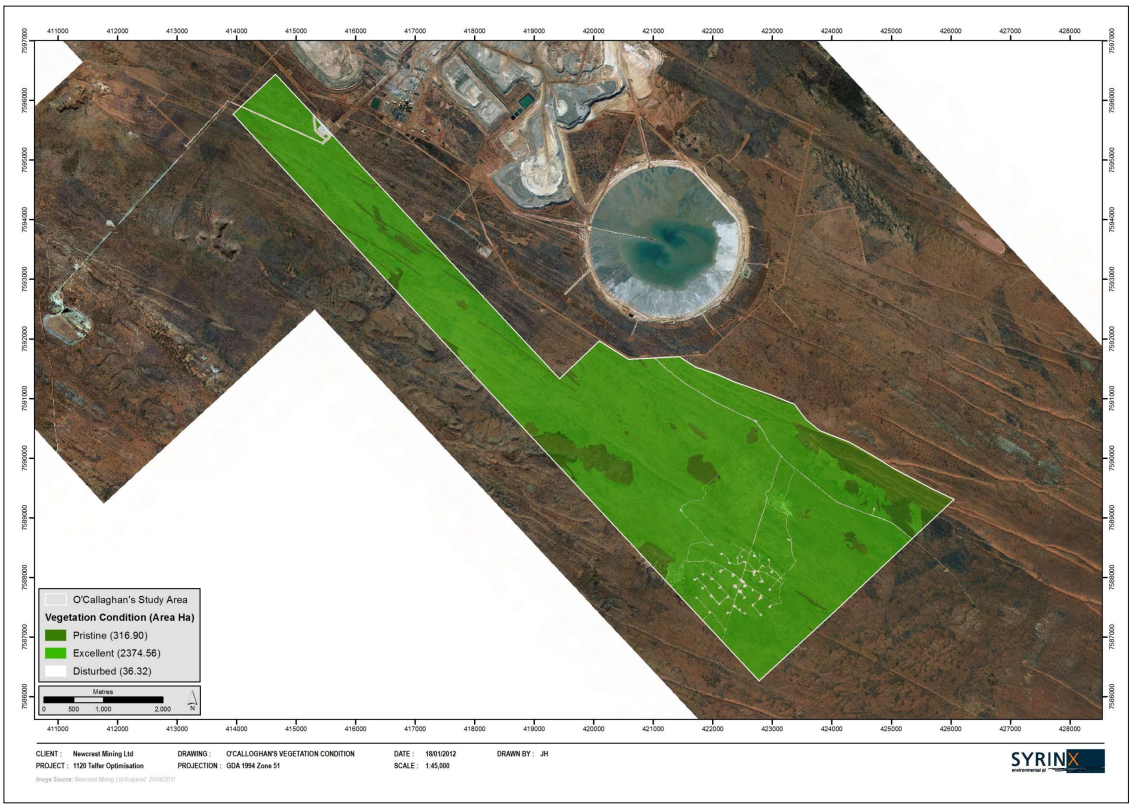


Figure 11 Vegetation Condition Map

4.3.3 Threatened Ecological Communities

None of the Vegetation Associations within the O'Callaghan's Study Area were TECs or PECs under DEC or DSEWPaC databases.

4.3.4 Ground and Surface Water Dependent Ecosystems

One Vegetation Association was identified in the O'Callaghan's Study Area as containing species dependent on either surface water runoff or groundwater.

4.3.4.1 Perched Aquifer Dependent Vegetation Association – *Melaleuca lasiandra* and *M. glomerata* Low Open Woodland

- Vegetation Association 2a - Scattered Trees of *Eucalyptus victrix* over *Melaleuca lasiandra* and *M. glomerata* Low Woodland over *Acacia stipuligera* High Open Shrubland over *Aluta maisonneuvei* subsp. *maisonneuvei* and *Gompholobium polyzygum* Low Open Shrubland over *Triodia* aff. *lanigera* Open Hummock Grassland

This Vegetation Association was restricted to a relatively small area (4.43 ha) at the base of a dune in the north-west portion of the study area. It was characterised by the presence of a low *Melaleuca* woodland structure that is in contrast to the open shrublands and *Triodia* grasslands adjacent. Although the understorey species were common and widespread throughout the study area, the mature representative understorey species were of larger size when compared to the same species in a more 'typical' dune swale Vegetation Association.

Vegetation Association 2a is not a TEC, PEC or Ecosystems at Risk. *Melaleuca* low woodlands are present, although uncommon, in the Telfer region, occurring in isolated areas of occluded paleo-drainage systems.

The *Melaleuca* Low Open Woodland is present in only one location in the O'Callaghan's Study Area (4.43ha, 0.16% of the study area) and, as it is dependent on meteoric water runoff, will require adequate surface water management to ensure no impact to the Vegetation Association.

Assessment of dependence on ground or surface water

Typically in the Telfer region *Melaleuca* woodlands are maintained through the sub-surface perching of meteoric water and run-off. The dominant upper storey species, *M. lasiandra* and *M. glomerata*, are typical wetland species indicative of seasonal inundation, and have been found in the Telfer region previously, outside of the Study Area, in areas of flooding (Hart, Simpson and Associates 2002; Syrinx Environmental PL 2004a 2004b). *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).

The presence of *Melaleuca glomerata* as one of the dominant species indicates that the wetland is perched, and will be typical of similar wetlands in the region. These wetlands are considered to have formed in ancient incised river channels (since filled by sedimentary deposits and now serving as superficial creek systems). They were either formed from the development of impeding layers of fine muds and clays, or from artesian (spring-fed) upwelling. Similar undocumented wetlands were visible from the air heading south of Telfer during fieldwork for the Freedom Road Bypass Flora and Vegetation Survey (Syrinx Environmental PL 2004a).

The presence of *Eucalyptus victrix* (Coolibah) also indicates a possible perched groundwater system is present, with the species using both groundwater from the perched groundwater system and surface runoff.

Eucalyptus victrix is predominantly distributed in the Pilbara Region of WA and central Northern Territory and has extensive lateral roots (>18m) and vertical tap roots that likely tap groundwater (Elith and Bidwell 2004; Fox and Wilcox 1992). Importantly, the plasticity of *E. victrix* roots relative to other Myrtaceae species is limited which has implications for any assumptions involving tree root extension downwards to adapt to groundwater drawdown (Froend 2009) and maximum depth to groundwater the roots can grow (Eamus 2009). Therefore, *E. victrix* would not adapt to groundwater drawdown at a rate greater than its root growth and a maximum drawdown at a depth greater than the maximum rooting depth. Both variables are currently unknown in the literature. Although Batini (2009) describes *E. victrix* roots in the Pilbara as 'possibly' growing at 0.5mm/day and a peer review by Eamus (2009) states that it is 'probably true' but that maximum root depth must also be known and recommended field investigations of drilling at a diagonal to 20m deep to confirm maximum root depth.

The recommendation for a field investigation would have been due to *E. victrix* root depth varying depending on landform and depth to groundwater ranging from shallow groundwater where depth was <1.5m in semi arid tropical Australia (Pfautsch *et al.* 2011), < 7m in the Ti tree basin, Central Australia (O'Grady *et al.* 2009) to the Pilbara where root depth maybe up to 20m (although field investigation was required to confirm this) (Eamus 2009).

Eucalyptus victrix is an opportunistic water user with 'intermediate' groundwater dependency as evidenced by leaf potential, daily transpiration rates and canopy conductance when compared to other phreatophytic vegetation (O'Grady *et al.* 2009). *Eucalyptus victrix* has been described as having a range of plant water use mechanisms depending on location in the landscape, including:

- a facultative phreatophyte in the western Pilbara along creeklines where it is less reliant on groundwater and more reliant on available soil water compared to high dependency GDE's such as *Melaleuca argentea* (Astron 2010);
- a facultative phreatophyte in the floodplain of the Fortescue River, Pilbara (Florentine 1999); and
- an obligate phreatophyte, in the central Pilbara, where it required the presence of groundwater to maintain the structure and function of the ecosystem (Eamus 2009).

In addition to the above, recent literature suggests a change in definition of 'obligate phreatophyte' where it is now considered the need for groundwater does not have to be expressed every day for an ecosystem to be an obligate user of groundwater (Eamus 2009). For this reason *E. victrix* woodlands in the Karijini National Park have been described recently as obligate users of groundwater, but that dependency is infrequently expressed, relying on infrequent run-on events (with subsequent flooding) (Eamus 2009).

Eucalyptus victrix, when part of a terrestrial GDE vegetation community, has been previously assessed in the western Pilbara as having medium-low dependency on groundwater (Astron 2009). However, Eamus (2009) states that if recruitment is dependent on flood events and access to shallow groundwater for establishment then the woodlands must be an obligate user of groundwater. Therefore, if a drop in the water table and capillary fringe is out of the range of the roots, and the *E. victrix* are obligate groundwater users, they will suffer a decline in health and a possible decline in viability (Eamus 2009).

Therefore it is important to understand root depth of the *E. victrix* to predict impact of hydrological change. *Eucalyptus victrix* has extensive lateral roots (>18m) and vertical tap roots that tap groundwater when present on floodplains (Elith and Bidwell 2004; Fox and Wilcox 1992). Importantly, the plasticity of *E. victrix* roots relative to other Myrtaceae is limited which has important implications for any assumptions involving tree root extension downwards to adapt to groundwater drawdown (Froend 2009). O'Grady *et al*. (2009) recently demonstrated a seasonality of water use by *E. victrix* trees in the arid zone on a floodplain in the Northern Territory suggesting a year round access to groundwater in these locations; however no root depth data was collected as part of that study.

No research on root depth of *E. victrix* has been conducted in a desert environment similar to the hydrogeology present at Telfer so it is not possible to predict root depths, or hydrogeological processes. If the unconfined aquifer in this location is to be impacted then further field investigation will be required.

4.4 FLORA DESCRIPTION

A total of 176 species from 32 families and 77 genera were recorded across the O'Callaghan's Study Area. This list includes subspecies (subsp.), variations (var.), affinities (aff.) and hybrids (x). Of the 176 taxa that have were collected there were three that contain some form of taxonomic uncertainty (taxa with '?' in front of the Species name). However, these collections are different to any other specimen identified for the O'Callaghan's Study Area and their accurate identification is dependent on analysis of flowers and/or fruiting bodies. The species are included in the species list for O'Callaghan's Study Area (Appendix 6).

From the collection of field specimens, there were taxa 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 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 23.8% of all taxa collected in the O'Callaghan's Study Area constituting 42 taxa from 12 genera. Other dominant families were Poaceae (14.7% of taxa) which consists of 26 taxa from eleven genera, Malvaceae (7.4% of taxa) with 13 taxa from seven genera and Myrtaceae (7.4% of taxa) which consists of 13 taxa from five genera.

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In terms of the overall Telfer Optimisation Project Area, the number of species recorded in O'Callaghan's Study Area compared with the remaining Study Areas is shown in Table 10.

A list of species found in the O'Callaghan's Study Area is shown in Appendix 6.

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 *Wildlife Conservation Act 1950* or Threatened Flora species listed under the *EPBC Act* have been found in the O'Callaghan's Study Area.

4.4.1.2 Priority Flora

The Priority 2 Flora taxon, *Goodenia hartiana* (Goodeniaceae; Figure 12) was recorded in the O'Callaghan's Study Area (Figure 13). Previous surveys in the vicinity of the O'Callaghan's Study Area that have recorded *G. hartiana* are 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 is superficially similar to the related and similar looking *G. azurea*, a common species throughout the O'Callaghan's Study Area, particularly along disturbed road edges.

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, where 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*'s the preferred habitat, 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 24 months. These areas represented the highest density of *Goodenia hartiana* present whilst the adjacent unburnt areas had very low densities of *Goodenia 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 10cm thick. The only population found within a dune swale was dead. The most common Vegetation Association where *Goodenia hartiana* was present was general scattered shrubs over *Triodia basedowii* or *T. schinzii*. The most common species of scattered shrubs were *Acacia ancistrocarpa, A. stipuligera* and *Grevillea wickhamii* (Syrinx Environmental PL 2010).

Goodenia hartiana populations were recorded at five locations in the O'Callaghan's Study Area (as noted in Table 11); however as scattered individuals were noted between these populations, the three central populations are part of one larger population. The full extent of the three central populations was not recorded, as it was at a very low density through a substantial area of recently burnt dune swale. However, a one ha sub sample of the area was groundtruthed and the number extrapolated over the whole central estimated population extent (using the landforms and area of recently burnt dune as the boundary) to provide an estimate of the total numbers. As this population is in an area of mature dune swale vegetation, it is highly likely the numbers of plants in this population will substantially increase if this dune swale was burnt.

Table 11 *Goodenia hartiana* locations

Population No	Population Size	Vegetation Association	GPS Location (GDA 94 Zone 51)
1	The central population is estimated to be at 350	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 Scattered healthy plants through its Vegetation Association.	416697/7594126 416829/7593938 417001/7593877
2			418177/7592575 418348/7592440 418499/7592437
3			418593/7591727 418657/7591684 418404/7591623 418631/7591645
4	6	6c: Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* High Open Shrubland over *A. stellaticeps* and *Mirbelia viminalis* Low Open Shrubland over *Triodia basedowii* Hummock Grassland At deep sands at base of sandy covered rocky hill	421304/7590584
5	25	1b: *Corymbia opaca* and *Eucalyptus leucophloia* Open Woodland over Scattered *E. 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 In deeper sand around the base of the hill but most unhealthy or dead	423131/7587340



Figure 12 *Goodenia hartiana* within the O'Callaghan's Study Area

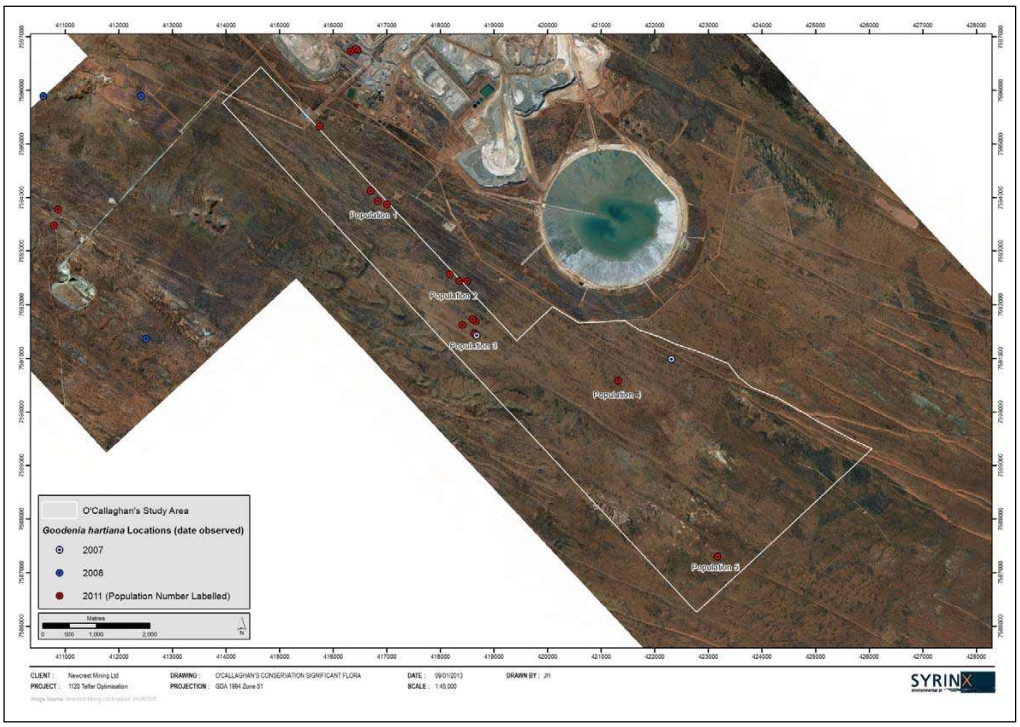


Figure 13 Locations of *Goodenia hartiana*

4.4.1.3 Range Extensions

Based on the existing vouchered specimen information available through Florabase (WAH 2012), five taxa represent a significant extension to the previously known range of distribution of those particular taxa. These species were not recorded previously within the nearby Newcrest tenements and FloraBase (WAH, 2012) shows that no records have been vouchered within at least 200km of Telfer.

Within the O'Callaghan's Study Area, *Fimbristylis leucocolea* (Cyperaceae) was found on low rocky hills where it was a common ground species. The collection of *F. leucocolea* represents a range extension of approximately 250km, with the nearest collection at Marble Bar. Previously, there were only five collections on record (WAH 2012). Previous collections have been made at near Marble Bar, Gorge Creek in the Pilbara and Ord River Dam in the Kimberley. It is a tufted annual sedge, which can grow from 0.15-0.35m high. It produces green / brown flowers February or June. It is generally found growing in red clayey sand or skeletal soils near rocky sandstone hills (WAH 2012).

Fimbristylis neilsonii was recorded on a dune swale adjacent to a quartz rocky hill in the eastern portion of the O'Callaghan's Study Area. This represents the ninth collection recorded in Western Australia (WAH 2012) and represents a 400km range extension from previous records. Previous collections have been made near Port Hedland in the Pilbara and near Broome and Bungle Bungle National Park in the Kimberley. It is a tufted perennial sedge which typically grows from 0.15-0.8m high. It is generally found growing in red sand or siliceous loamy sand in floodplains or near creeks (WAH 2012).

Three species were restricted to the *Acacia wanyu* Vegetation Association (5b) on quartz slopes on the south east boundary of the O'Callaghan's Project Area:

- *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; however, it has not been collected as far North as Telfer.
- *Sclerolaena minuta* is a short-lived herb, 0.08-0.2m high and flowering in September. This species is mostly found with weathered granite and rocky hillsides in the Gascoyne. The collection of this species represents a northern range extension; and
- *Sclerolaena eriacantha* is 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.

4.4.2 New Species

There are no new taxonomic entities recorded in the O'Callaghan's Study Area.

4.4.3 Introduced Flora

A weed survey was undertaken by Syrinx Environmental PL in May 2011 (Syrinx Environmental PL 2011a). As this data is current the weed information from the May 2011 survey has been used to inform this survey. There were two introduced species found in the northwest of the O'Callaghan's Study Area; *Cenchrus ciliaris* (Buffel Grass) and *Aerva javanica* (Kapok) around the Telfer Gas Power station and Powerlines (Figure 14).

During the June 2012 survey, an individual of Kapok was recorded at two locations. One location was close (~200m) to drilling operations being conducted during the time of survey. The other location was in a pristine area but was at the base of a tree which suggests it may have been present due to fauna movement. The individuals were removed to prevent the spread of the species through these areas.



Figure 14 Locations and Extent of Infestation for Introduced Flora Species

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 O'Callaghan's Study Area.

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

The vegetation of the O'Callaghan's Study Area is considered relatively diverse with a total of 176 taxa from 32 families and 77 genera. As the study area represents a transition between the Mackay subregion to the north and Rudall subregion to the south and east, the species diversity is typical of such transitional environments. The species diversity is also related to the varied landforms and geomorphology within the study area boundary.

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

The higher number of species recorded in the O'Callaghan's Study Area compared to Trotmans, Satellite Deposits and Pit 15 (Fallows Field) reflects the number of survey seasons. In particular late summering annual herbs and grasses would not be captured in the species lists for the Trotman's, Satellite Deposits and Pit 15.

When compared regionally, the species richness is lower than the 323 taxa from 48 plant families and 149 genera recorded at Kintyre (Bennett Environmental Consulting 2010). However, the Kintyre survey area, at 5,200ha, is almost twice the survey size of the O'Callaghan's Study Area of 2,727.75ha. The Kintyre survey area also contains landforms not present in the O'Callaghan's Study Area such as alluvium along major drainage lines (Yandagooge Creek) and claypan areas. When taking into account the area and the lower

complexity of land forms (dunes, dune swales and rocky hills), the species richness is comparable.

When compared to previous surveys at Telfer, the species richness in O'Callaghan's Study Area is higher than recorded in the Waste Dump Expansion Survey (104 species) (Syrinx Environmental PL 2006) and the Borefield Expansion Survey (112 species) (Syrinx Environmental PL 2007). These surveys were both one season surveys in late winter, so would not have captured the suite of annual herbs and grasses typically present in late autumn, which were captured in the O'Callaghan's Study Area during the second field survey.

However it is lower the 249 species recorded by Hart, Simpson and Associates (2002) over a larger survey area and the survey was completed over 3 survey seasons, while the Syrinx Environmental PL (2006, 2007) surveys were only one season surveys. The Hart, Simpson and Associates (2002) survey was conducted over a much wider area (the actual total area is unclear in the report), and more landform types, such as the large drainage depressions near Freedom Road west of the Telfer minesite. Taking into account the size of the survey area, and the variety of landforms present, the species richness in the O'Callaghan's Study Area compares well with previous surveys.

There were five range extension species recorded *Fimbristylis leucocolea*, *F. neilsonii, Maireana triptera, Sclerolaena eriacantha* and *S. minuta*.

4.5.2 Conservation Significant Flora

No Threatened (T) listed flora under the *Wildlife Conservation Act 1950* or Threatened Flora listed under the EPBC Act were identified in the O'Callaghan's Study Area.

Goodenia hartiana, P2, was recorded at five locations in the O'Callaghan's Study Area, although three of the populations part of a greater population containing hundreds of plants throughout a continuous dune swale. Calculations during the field trip estimated the population to be ~380 live plants. However, given the widespread nature of its preferred habitat it could be greater than this estimate.

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

4.5.3 Introduced Flora

There were two populations of introduced species recorded in the O'Callaghan's Study Area (Syrinx Environmental PL 2011a): *Cenchrus ciliaris* (Buffel Grass) and *Aerva javanica* (Kapok), which were located in the disturbed areas around the Telfer Gas Power station and Powerlines to the north-west. Both species 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.

Neither of the species recorded are Declared Plants listed under the Agriculture and Resources *Agriculture and Related Resources Protection Act 1976* or WONS.

During the June 2012 survey at two locations an individual of Kapok was recorded. One location was close (~200m) to drilling operations being conducted during the time of survey. The other location was in a pristine area but was at the base of a tree which suggests it may have been present due to fauna movement. The individuals were removed to prevent the spread of the species through these areas.

4.5.4 Vegetation Associations

A total of 15 Vegetation Associations were mapped in the O'Callaghan's Study Area and these fall into seven broad floristic groups. One of the Vegetation Associations is likely to be dependent on groundwater. Seven landforms were identified in the study area.

The number and types of landforms compares well with previous surveys. All landforms have been recorded in previous surveys, including quartzite rocky (scree) slopes recently recorded at Kintyre (Bennett Environmental Consulting 2010).

The broad floristic groups also compares well with previous surveys and broad vegetation mapping of Beard (1974) and Shepherd *et al*. (2002) with *Triodia* dominated floristic groups (33% of the study area) and *Acacia* dominated floristic groups (62% of the study area).

The presence of the less widely distributed broad floristic groups such as the *Melaleuca* and *Corymbia* Woodlands (0.16% and 4.83% respectively) reflects the more detailed survey methods conducted in the study area compared to the previous broad mapping of Beard (1974) and Shepherd *et al*. (2002).

When compared with the Vegetation Associations/types recorded previously, most have been recorded previously and described as being characteristic of the region, particularly the dune swale vegetation associations.

While *Melaleuca*'s have been recorded during previous studies (Syrinx Environmental PL 2004a, 2004b and 2007), this survey represents the first time a *Melaleuca* Woodland has been mapped in the Telfer Region. *Melaleuca lasiandra* was scattered through a small area of the Borefields expansion survey area, but was locally dominant in an area of *Acacia stipuligera* Open Shrubland (Syrinx Environmental PL 2007).

Eucalyptus Woodlands have been mapped further west in the Telfer Study Area (Syrinx Environmental PL 2006); however, the woodlands were dominated by *E. leucophloia* subsp. *leucophloia* rather than *E. victrix*.

Vegetation communities that include *E. victrix* and *Melaleuca glomerata* have been recorded previously by Hart, Simpson and Associates (2002). *Eucalyptus victrix* was described as being common in the dune swales of the Dolphy area, east of the O'Callaghan's Study Area, and part of the Satellite Deposits Study Area. Although the mapping is not at a scale to determine the actual locations the Hart, Simpson and Associates (2002) report suggests a presence within the region, outside of the O'Callaghan's Study Area at the following locations:

- *Eucalyptus victrix* was described as being present along the northern side of the existing mine in the SEP borefield in low lying areas of more clayey sand, as well as common in the dune swales of the Dolphy area; and
- *Melaleuca glomerata* and *M. lasiandra* present in the Freedom Road borefield area in numerous small areas prone to flooding, with the best developed of these having a clayed surface. A suite of unusual herbaceous species were associated with the best of the low lying areas.

All Vegetation Associations have been described in previous reports as being either present to the west of the O'Callaghan's Study Area, or in the case of the Borefields Expansion Survey, within the O'Callaghan's Study Area. Seven of the 15 Vegetation Associations are also present in the Optimisation Study Area (Syrinx Environmental PL 2012 in draft).

The only exception is the 5b: *Acacia wanyu* Vegetation Association on rocky (scree) quartzite slopes. It is possible it is similar to the 'Q: Complexes, White quartzite scree slope' vegetation type recorded at Kintyre Uranium Project (Kintyre), 90km south of Telfer (Bennett Environmental Consulting 2010). This Vegetation Association was not recorded in the remaining four study areas of the Telfer Optimisation Project

In terms of previous surveys within the Telfer tenements, when compared to much more extensive (although not plot based) survey by Hart, Simpson and Associates (2002) almost all Vegetation Associations have been recorded previously. However, Hart, Simpson and Associates (2002) used more broad vegetation descriptions relating more to landform rather

than dominant species present so comparisons have been conducted on dominant species only rather than a complete species list of Vegetation Associations.

The most relevant study to compare the results with regionally is the survey at Kintyre (Bennett Environmental Consulting 2010). Currently the only information known about the Vegetation Associations are vegetation type names listed in the Environmental Scoping Document (Environ Australia 2011). Therefore assessment was based on comparison of O'Callaghan's Study Area Vegetation Association and Kintyre Study Area vegetation type names only. Based on that comparison, all of the O'Callaghan's Study Area dune and dune swale associations are present at Kintyre. Three vegetation types encompass seven Vegetation Associations at O'Callaghan's Study Area. This may reflect differing nomenclature for each survey, as the Vegetation Associations for O'Callaghan's Study Area are described at the NVIS Level 5 whereas the Kintyre mapping is not.

A vegetation type was called 'White quartzite scree slope', and while that landform is present at Telfer, it is not possible to confirm whether it is the same as the restricted vegetation Association 5b within the O'Callaghan's Study Area. The information to make a more meaningful assessment will be in Environmental Review and Management Plan for Kintyre when it's released in 2012 (Cameco 2012).

When compared to the Nifty vegetation and habitat assessment (MBS 2005), 67km west of Telfer, a general comparison can be made. The naming of Vegetation Associations by MBS (2005) was much broader, although with more detailed vegetation units. The vegetation descriptions nomenclature used in the MBS (2005) assessment is not consistent with NVIS requirements for with vegetation association names e.g. MBS (2005) used names such as *Calytrix* low rises, *Triodia* sandplain and Grassy herbland making direct comparisons of with the Vegetation Associations of the O'Callaghan's Study Area limited. Only dunes and dune swales were present at Nifty with no rocky outcrops in the study area.

The general structure and species composition of the vegetation units of the dunes were generally similar to those in the O'Callaghan's Study Area, although no mention was made of *Corymbia chippendalei* being present on the dunes at Nifty. *Corymbia chippendalei* was recorded in three sandplain vegetation units at Nifty. *Corymbia chippendalei* is a common species on the top of sand dunes in the O'Callaghan's Study Area.

The dune swales at Nifty (called sand plains at Nifty) had a mosaic of vegetation units with a mixture of shrub and *Triodia* species similar to those present at O'Callaghan's Study Area. *Eucalyptus kingsmillii*, *E. victrix* and *Corymbia opaca* were also emergent species in the sandplain vegetation units at Nifty, which is comparable to dune swale Vegetation Associations in the O'Callaghan's Study Area. *Eucalyptus victrix*, *Melaleuca glomerata* and *M. lasiandra* were listed in two of the sandplain units described by MBS (2005);

- *Triodia* sandplain and sandplain rises; and
- *Triodia*/ *Melaleuca glomerata* sandplain and low sandy rises.

It is likely to be similar to the Vegetation Association 2a within the O'Callaghan's Study Area. An assessment of water dependency was not conducted. However, *M. lasiandra* was described as being present in areas prone to inundation.

4.6 CONSERVATION STATUS

The significance of the ecological communities and flora occurring within the O'Callaghan's 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 International Union for Conservation of Nature (IUCN) on the Red List of Threatened Species.

National significance refers to those features of the environment which are recognised under Commonwealth legislation such as the EPBC Act.

No vegetation communities of national or international significance were identified in the O'Callaghan's 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 O'Callaghan's Study Area. However, five records of the *Goodenia hartiana* (P2) were recorded within the O'Callaghan's 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). There were five populations of *G. hartiana* were identified during this survey, with three of those populations potentially part of a larger population consisting of hundreds of plants.

4.6.3 Regional Significance

Regional significance refers to the representation of the species and Vegetation Associations within the O'Callaghan's 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 O'Callaghan's Study Area have been found previously in the limited surveys in adjacent areas (Syrinx Environmental PL 2006; Hart, Simpson and Associates 2002) and within the additional four study areas within the Telfer Optimisation Project Area.

4.6.3.2 Vegetation Associations

Most Vegetation Associations and species are widespread through the bioregional area, particularly the dune and dune swale Vegetation Associations which represent 62% of the Study Area. Vegetation assemblages not widespread regionally are those restricted to landforms not common throughout the region such as quartzite hills in the south east corner of the study area where Vegetation Associations dominated by *Acacia wanyu* occur.

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 the conservation significance of the Vegetation Associations is based on the context of known information 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, 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 P2 species, but has been recorded previously as being locally common in the dune swales and base of rocky outcrops in the Telfer region.

There were five range extension species *Fimbristylis leucocolea, Fimbristylis neilsonii Maireana triptera, Sclerolaena eriacantha* and *Sclerolaena minuta.*

Within the O'Callaghan's Study Area, *Fimbristylis leucocolea* was found on low rocky areas within rocky dune swales in Vegetation Association 4d.

Fimbristylis neilsonii was recorded on a dune swale adjacent to a quartz rocky hill in the eastern portion of the O'Callaghan's Study Area (Vegetation Association 1b).

Three species were restricted to the *Acacia wanyu* Vegetation Association (5b) on quartz slopes on the south east boundary of the O'Callaghan's Study Area: *Maireana triptera*, *Sclerolaena eriacantha* and *S. minuta.*

Ten of the Vegetation Associations (1a, 2a, 3b, 4a, 4b, 6a, 6d, 6e, 6f, 7a) representing 34.6% contain no Priority or range extension flora in the O'Callaghan's Study Area

This criterion has been met as Vegetation Associations 1b, 4c and 6c and Vegetation Associations 1b, 4d and 5b 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 5b. Species restricted to Vegetation Association 5b within the O'Callaghan's Study Area were *Acacia sibirica*, *Brachyachne convergens*, *Maireana georgei*, *Sclerolaena densiflora*, *S. eriacantha, S. minuta*, *Senna stricta* and *Tripogon loliiformis*.

Sclerolaena eriacantha and S. minuta were recorded in *Acacia wanyu* and *A. pteraneura* dominated Vegetation Associations within the adjacent Optimisation Study Area.

When assessing against the results of all study areas for the Telfer Optimisation Project, the species restricted to the O'Callaghan's Study Area were *Acacia sibirica*, *Brachyachne convergens, Maireana georgei*, *Sclerolaena densiflora, Senna stricta* and *Tripogon loliiformis.*

This criterion has been met as Vegetation Association 5b may contain a novel combination of species in the Great Sandy Desert Bioregion. The species restricted to this Vegetation Association are more typical of the Pilbara Bioregion.

Role as a Refuge

For the purpose of assessment of refugia, the EPA considers refugia as restricted environments that have been isolated for an extended period of time, or are the last remnants of such areas EPA, 2004b). 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 for permanent water.

In terms of context of information already known then none of the vegetation associations present meet the above criteria.

Role as key habitat for threatened species

The *Goodenia hartiana* (P2) is present in three dune swale vegetation associations (1b, 4c and 6c) representing 49.2% of the O'Callaghan's Study Area. These vegetation associations are common and widespread throughout the Telfer Region, and have been recorded at Nifty and Kintyre.

The vegetation associations are habitat for Goodenia hartiana, but as Goodenia hartiana is found in a variety of habitats throughout the Telfer region, none of the Vegetation Associations are considered key habitat, this criterion 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)

The Vegetation Association that is most likely at the extreme of their main range in the O'Callaghan's Study Area is 5b. The species present in these Vegetation Associations are more typical of the Pilbara. This may represent the northern geographic range of the Vegetation Association as north of the O'Callaghan's Study Area are the more typical dunes and dune swales of the Great Sandy Desert. Therefore the landforms with these Vegetation Associations are unlikely to be present north of the Study Area. Three of the five range extension species are restricted to Vegetation Association 5b.

Species restricted to Vegetation Association 5b within the O'Callaghan's Study Area were *Acacia sibirica*, *Brachyachne convergens*, *Maireana georgei*, *Sclerolaena densiflora*, *S. eriacantha, S. minuta*, *Senna stricta* and *Tripogon loliiformis*. Most of these species are common species south of the Great Sandy Desert Bioregion.

When assessing against the results of all study areas for the Telfer Optimisation Project, the species restricted to the O'Callaghan's Study Area were *Acacia sibirica*, *Brachyachne convergens, Maireana georgei*, *Sclerolaena densiflora, Senna stricta* and *Tripogon loliiformis*. These species are all present in Vegetation Association 5b.

This criterion has been met as Vegetation Association 5b is likely to be at the northern distribution due to the lack of potential habitat north of the O'Callaghan's Study Area.

The following five taxa represent an extension to the previously known range of distribution of those particular taxa. These species were not recorded previously within the nearby Newcrest tenements and FloraBase (WAH 2012) shows that no records have been vouchered within at least 300km of Telfer.

Within the O'Callaghan's Study Area, *Fimbristylis leucocolea* was found on low rocky areas within rocky dune swales in Vegetation Association 4d.

Fimbristylis neilsonii was recorded on a dune swale adjacent to a quartz rocky hill in the eastern portion of the O'Callaghan's Study Area (Vegetation Association 1b).

Three species were restricted to the *Acacia wanyu* Vegetation Association (5b) on quartz slopes on the south east boundary of the O'Callaghan's Study Area: *Maireana triptera*, *Sclerolaena eriacantha* and *S. minuta.*

Vegetation Associations 1b, 4d and 5b meet this criterion as they are host to range extension species.

A Restricted Distribution

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 2004b).

Vegetation Associations with restricted distribution within the Study Area (i.e. are 5% or <114ha of the O'Callaghan's Study Area) and assessment of significance is described in Table 12.

Of the 15 Vegetation Associations, eight of the Vegetation Associations are restricted in area as they are associated with landforms that aren't widespread within the survey area but are common regionally such as:

- low lying area of *Melaleuca* Woodland in a dune swale at the base of a dune, common to the west of the study area (2a)
- drainage lines at the base of rocky hills (1a and 3b);
- a quartzite rocky slope, common to the south and east of the study area (5b);
- low ironstone rocky hills, very common to the west of the study area (6a);
- quartzite rocky hills, common to the east of the study area (6e);
- the rocky swale Vegetation Associations very common to the east of the study area (6f); and
- the area of a large rocky hill in the study area, although common to the south of the study area (7a).

One of the restricted Vegetation Associations (2a) has also been identified as water dependent Vegetation Association. The restricted distribution is likely due to the localised hydrogeological conditions where surface water runoff and/or groundwater is accessible at these locations. These Vegetation Associations have been recorded previously in the Telfer region surrounding Telfer and outside of the O'Callaghan's Study Area, and at Nifty, although the extent is unknown.

Therefore, although these Vegetation Associations comprise less than 5% of the study area they do not meet the criterion for restricted distribution as they have been recorded in previous surveys and have been described as widespread in the region.

The Vegetation Association with restricted distribution in the study area and possibly regionally is 5b. Eight species are restricted to Vegetation Association 5b; these are common species south of the Great Sandy Desert Bioregion. Of the eight species, six are not found within any of the other study areas of the Telfer Optimisation Project.

Vegetation Association 5b meets the criterion of restricted distribution as it is:

- *poorly represented within the Study Area; and*
- *hasn't been recorded in previous surveys in the Telfer region, although may be present at Kintyre, pending further data to be released during 2012.*

Table 12 Vegetation Associations with restricted distributions (<114ha) within the O'Callaghan's Study Area

Code	Vegetation Association	Area (Ha)	Assessment of Significance
***Melaleuca* Low Open Woodland**			
2a	Scattered Trees of *Eucalyptus victrix* over *Melaleuca lasiandra* and *M. glomerata* Low Woodland over *Acacia stipuligera* High Open Shrubland over *Aluta maisonneuvei* subsp. *maisonneuvei* and *Gompholobium polyzygum* Low Open Shrubland over *Triodia* aff. *lanigera* Open Hummock Grassland	4.43	Locally restricted, although likely to be common regionally in areas where groundwater is accessible to *Melaleuca*'s. Widespread in large areas (>100ha's) of flooding after Cyclone Fay along Freedom Road (Syrinx Environmental, 2004a, 2004b). *Triodia epactia* restricted to this VA
***Acacia* Open Scrub**			
3b	Scattered Trees of *Corymbia candida* subsp. *dipsodes* over *Acacia monticola*, *A. stipuligera* and *Grevillea wickhamii* Open Scrub over Low Scattered Shrubs of *Indigofera boviperda* subsp. *boviperda*, *Mirbelia viminalis* and *Dicrastylis cordifolia* over *Triodia pungens* Open Tussock Grassland	8.63	Locally restricted but likely to be common regionally at the base of large rocky hills where surface water flows off to the adjacent plains
***Acacia* Open Scrub**			
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	Locally restricted but likely to be common regionally at the base of medium rocky hills where surface water flows off to the adjacent plains. 43 ha present in the nearby Optimisation Study Area
***Acacia* Open Shrubland**			
5b	*Acacia wanyu* Open Shrubland over *Eremophila tietkensii* and *Senna glutinosa* subsp. *x luerssenii* Open Shrubland over *Triodia basedowii* complex *and T. epactia* Open Hummock Grassland over *Maireana triptera, Sclerolaena eriacantha* and *M. melanocoma* Very Open Herbs	100.9	The landform this VA is present on is present on low rocky slopes between the Pilbara and Telfer, however how common the landform is uncertain. 8 species restricted to this VA within the O'Callaghan's 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	10.76	Present on a small area of rocky hills that are more common in the Optimisation Study Area. 51.42 ha present in the adjacent Optimisation Study Area on a landform common to the west of Telfer
6e	Scattered Trees of *Eucalyptus leucophloia* over *Grevillea wickhamii* subsp. *hispidula* and *Hakea lorea* High Open Shrubland over *Acacia hilliana* and A. *adoxa* Low Open Shrubland over *Triodia basedowii* complex Hummock Grassland	60.8	Present on quartzite rocky hills that are common to the east of the O'Callaghan's Study Area
6f	*Eucalyptus odontocarpa* Open Mallee over *Acacia ancistrocarpa* and *Grevillea stenobotrya* High Open Shrubland over Low Scattered Shrubs of *Acacia ligulata* and *A. stellaticeps* over *Triodia basedowii* complex Open Hummock Grassland	57.4	This Vegetation Association as found on the lower slopes of rocky hills and in swales between rocky hills. It is a common landform in the region and contained species found commonly within other swale Vegetation Associations
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	54.18	The Vegetation Association is typical of low rocky hills to the west of the study area where the landform is more common. 57.22 ha present in the adjacent Optimisation 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.

One Vegetation Association has restricted species present and is located on a habitat that is not common locally (5b) and therefore is considered locally significant.

4.6.5 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 under represented 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 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.

All Vegetation Associations have more than 97% remaining however less than 5% is currently in reserves (Table 13).

Table 13 Vegetation extent and status in the Great Sandy Desert IBRA region showing extent of vegetation in the O'Callaghan's Study Area

Vegetation Association Number	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)
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%	675032.71	4.96%	505.79
157	Hummock grasslands, grass steppe; hard spinifex, *Triodia wiseana*		33127	33088	99.88%	0.00	0.00%	16.49
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%	121647.03	1.65%	12.85
157	Hummock grasslands, grass steppe; hard spinifex, *Triodia wiseana*		82902	81020	97.73%	1652.82	2.04%	292.47

PART 3 VERTEBRATE FAUNA

5.0 VERTEBRATE FAUNA

5.1 OVERALL APPROACH

Bamford Consulting Ecologists (BCE) uses an impact assessment process that examines the fauna values of a study area, and reviews impacting processes. The Fauna section of this report presents the results of investigations to document fauna values of the O'Callaghan's Study Area 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 O'Callaghan's 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 a proposed development. The methods used in these investigations are based upon the general approach to fauna investigations for impact assessment and with reference to Appendix 7. Thus, the investigations involve the identification of fauna values of the O'Callaghan's Study Area.

In addition, the approach to fauna impact assessment was carried out with reference to guidelines and recommendations set out by the EPA on fauna surveys and environmental protection, and Commonwealth biodiversity legislation (EPA 2002; EPA 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 surrounding environment in which the disturbance is planned, and the availability of pre-existing data. O'Callaghan's Study Area lies in the transition between two major bioregions (Little Sandy Desert and Great Sandy Desert) and close to a third bioregion (Pilbara),with some existing data from previous studies carried out at Telfer and at the Kintyre Uranium Project (Kintyre) project area about 80km to the south (Figure 2).

5.2.2 Literature Review

Due to the extended history of the Telfer Gold Mine (from the 1970s), many fauna investigations conducted in the Telfer region precede Position and Guidance Statements provided by the Environmental Protection Authority (EPA 2002, 2004c and 2010).

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 O'Callaghan's Study 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 (incorporating the Western Australian Museum's FaunaBase), Birds Australia's (2011) Atlas Database (BA), Global Biodiversity Information Facility (GBIF) and the EPBC Protected Matters Search Tool (Table 14).

Note these database searches cover much larger areas than the O'Callaghan's Study Area, as many database records are location specific and a buffer around the O'Callaghan's Study Area is needed to capture such records.

Regional information on fauna was available from Kendrick (2001a and 2001b), who reported on vertebrate fauna, and particularly those of conservation significance. Species lists were also available from Karlamilyi National Park over 100km to the south (NatureMap; DEC 2011; Appendix 8), from BCE records, including from work carried out in the Kintyre area, 80km south of Telfer, and from work carried out by Martinick Bosch Sell (MBS 2004, 2006) and Ecological Horizons (2011) in the Nifty project area, 67km to the west.

Information from the above sources was supplemented with species expected in the 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 and Swan (2008);
- Birds: Blakers *et al.* (1984); Johnstone and Storr (1998, 2005) and Barrett *et al*. (2003); and
- Mammals: Menkhorst and 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 2011c)	Records in the WAM and DEC databases. Includes historical data.	418205E, 7596639N, Zone 51, Buffer = 40 km
Birds Australia (2011) 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, Bamford 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 O'Callaghan's Study Area (in chronological order) are:

- 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 (2006) Telfer Waste Dump Expansion Flora and Fauna Survey. Prepared for Newcrest Mining Limited.
- Syrinx Environmental (2007) Borefields Expansion Flora and Fauna Survey. Prepared for Newcrest Mining Limited.
- Syrinx Environmental (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.

The desktop study identified 255 vertebrate fauna species as potentially occurring in the O'Callaghan's Study Area. (Table 21, Appendix 8). Species extinct in the region are listed separately under Appendix 8, as are species returned by databases but for which no suitable habitat is available within the O'Callaghan's Study Area. 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 O'Callaghan's Study Area. The assemblage includes 24 species of conservation significance.

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 Vertebrates 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 O'Callaghan's 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 O'Callaghan's 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 O'Callaghan's Study Area, but most would not be expected to rely upon it 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 O'Callaghan's Study 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 study 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 study area;
- Regular migrant or visitor: species that occur within the study area regularly in at least moderate numbers, such as part of annual cycle;
- Irregular Visitor: species that occur within the study 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 study area in at least moderate numbers and for some time;

- Vagrant: species that occur within the study area unpredictably, in small numbers and/or for very brief periods. Therefore, the study area is unlikely to be of important for the species; and
- 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 study area.
- 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 assemblages: 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 study area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the O'Callaghan's Study Area's ecological processes that maintain the fauna. Note that field investigations cannot confirm the presence of an entire assemblage, or confirm 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 Optimisation Project Area were:

- 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 Telfer Optimisation Project Areas);
- 10th – 19th April 2012 for systematic and opportunistic sampling (O'Callaghan's (part) Study Area, Satellite Deposits, Trotman's and Pit 15 Study Areas); and
- 1st – 7th June 2012 for completion of systematic and opportunistic sampling (O'Callaghan's (part) Study Area and Optimisation Study Area), 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 and April, and mild in June. During the September field trip, strong easterly winds blew consistently most days.

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

Sampling sites within the O'Callaghan's Study Area are detailed in Figure 19. Sampling conducted in the O'Callaghan's Study Area is described in Appendix 10 and Table 16. Details of transects surveyed in the O'Callaghan's Study Area in Table 16 and locations of transects are given on Figure 19. Each transect was approximately 100m wide and the total transect length surveyed in the O'Callaghan's Study Area was 11.7km.

This sampling procedure is consistent with the transect method outlined by Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2011) who 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 (2011) 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 6 and Line 7) in O'Callaghan's Study Area (Tables 3 and 4, Appendix 10), sampled for five nights in each period: 5-14 September 2011 (Lines 6 and 7), 10-19 April 2012(Line 6) and 1-7 June 2012 (Line 7).
Bird census. Based around systematic trapping transects	Birds identified and counted within 25m of trapping transect; thus area 50m wide and 500m long surveyed.
Transect searching for evidence of significant species (burrows, tracks and scats of Bilby, Mulgara and Great Desert Skink)	Transect searching involves walking in a line with team members approximately 50m apart (see Appendix 10, Figure 19).
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 and litter collection (see Appendix 10). In addition, some specimens

Approach	Description and comments
	were found in pitfall traps. Main taxa targeted were mygalomorph spiders, isopods (slaters) and scorpions
Bat surveys (Anabat recording system and cave searching). Conducted at suitable locations outside O'Callaghan's Study 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; Appendix 10).
Waterbird counts	Telfer sewage ponds, 10th September 2011. Outside all survey 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 only. Effort in O'Callaghan's 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 (two sites within the O'Callaghan's Study Area, see Appendix 10).

Table 16 Descriptions of systematic sampling sites (trapping and bird census sites) in the O'Callaghan's Study Area

Transect code	Vegetation and Substrate Association	Vegetation types (Syrinx code)	Soils	Landform
Line 6	Eucalypt open woodland over *Acacia* shrubland over spinifex	4d, 6f	Red sandy-loams.	Plain
Line 7	*Acacia* and *Hakea* open shrubland with some thickets and scattered mallee over spinifex	4c	Red sand with some embedded rocks and low rocky rises (ironstone)	Plain between dunes

Table 17 Start and finish points of searching transects across O'Callaghan's Study Area

Date	Start		Finish	
	Easting	Northing	Easting	Northing
13/08/2011	423100	7591000	422700	7590600
13/08/2011	422700	7590600	422600	7589900
13/08/2011	423100	7591000	423500	7590700
13/08/2011	423500	7590700	422600	7589900
14/09/2011	425300	7589700	425600	7588000
14/09/2011	425600	7589500	424800	7588000
14/09/2011	425300	7589700	424300	7588200
14/09/2011	424300	7588200	424800	7588000
15/09/2011	420200	7591900	419600	7591200
15/09/2011	420000	7591000	420500	7591700
15/09/2011	421300	7590400	421800	7591100
15/09/2011	421800	7591100	422182	7590200
15/09/2011	422182	7590872	421700	7590200

Table 18 Motion Sensor Camera Locations

Camera	Northing	Easting
1	424927	7588134
2	424917	7588734
3	421513	7591112
4	421284	7591215

5.2.5 Summary of survey effort

Overall survey effort in the O'Callaghan's Study Area, and in all study areas that comprise the Telfer Optimisation Project, are summarised in Table 19.

Table 19 Summary of Survey Effort in September 2011 and April/June 2012

Survey Method	O'Callaghan's Study Area	All Study Areas in 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	38 Camera Trap nights across 12 locations	16 locations surveyed over 50 camera-nights
Bat surveys	-	1 evening with anabat; searching of cave used by bats (outside the Telfer Optimisation Project Area)
Transect searching (on foot)	Ca. 15 km	Ca. 30km
Opportunistic observations and collection	at all times	at all times
Mole trenches	2 sites totalling 6 trenches	7 sites totalling 22 trenches
SRE invertebrate samples	Opportunistic searching; two litter samples	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 within the O'Callaghan's Study Area in Table 20.

Table 20 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 2011 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. (In retrospect, was the intensity adequate?)	No	Survey intensity adequate to record conservation significant fauna and habitats. Trapping programme 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 (sometimes 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 O'Callaghan's Study Area, with a larger proportion (about half of all species) confirmed across the entire Telfer Optimisation Project Area. A substantial field effort is required to be able to conclude species are not present. Therefore, the precautionary approach has been taken and species are assumed to be present (based on results of the desktop review and habitat assessment) unless there is good evidence, such as lack of suitable habitat, that the species would not utilise the O'Callaghan's Study Area.

Key features of the assemblage are:

- Uniqueness: The assemblage has an unusual composition reflecting its position on the edge of the Pilbara and the Great Sandy Desert; it thus has elements of both regions 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/Great Sandy Desert 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 33). 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 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 Great Sandy Desert bioregion.

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 255 vertebrate fauna species as potentially occurring in the O'Callaghan's Study Area (of 275 species predicted across the entire Optimisation Project Area), of which 163 were recorded across all surveys, and 68 in the O'Callaghan's 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 21. Species extinct

in the region are listed separately under Table 21 as are species returned by databases but for which no suitable habitat within the project area is available. The assemblage includes 27 species of conservation significance.

Table 21 Composition of vertebrate fauna assemblage expected to occur in the O'Callaghan's Study Area

Taxon	Number of species expected	Number Recorded throughout Telfer Optimisation Project Area	Number Recorded O'Callaghan's Study Area	Significant fauna expected		
				CS1	CS2	CS3
Frogs	7	2	0	-	-	-
Reptiles	95	53	11	2	1	1
Birds	109	86	39	6	4	1
Native Mammals	38	17	5	5	5	2
Introduced Mammals	6	5	2			
Total	**255**	**163**	**57**	**13**	**10**	**4**

5.3.2 Species of conservation significance

Details on species of conservation significance are presented in Table 22 with additional information on each species provided in Section 5.3.2.1. The list includes four reptile species, 11 bird species and 12 mammal species.

Table 22 Conservation significant fauna species with potential to occur in the O'Callaghan's Study Area

Species		Reason For Significance				Comments			
		EPBC Act	WA Wildlife Conservation Act	DEC Priority	Other	Recorded current Project	Suitable habitat in Study Area	Expected Status in Study Area	Local Records[4]
CONSERVATION SIGNIFICANCE 1 (CS1)[1]									
Liopholis kintorei	Great Desert Skink	Vulnerable	Schedule 1				Possibly	Unlikely	Karlamilyi 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
Glareola maldivarum	Oriental Pratincole	Migratory					Possibly	Vagrant	Unknown
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
Notoryctes caurinus	Northern Marsupial Mole	Endangered	Schedule 1			**Recorded**	Yes	Resident	Telfer and Nifty areas
Dasycercus cristicauda	Crest-tailed Mulgara	Vulnerable				**Recorded**	Yes	Resident	Kintyre and Nifty

Species	Reason For Significance				Comments			
	EPBC Act	WA Wildlife Conservation Act	DEC Priority	Other	Recorded current Project	Suitable habitat in Study Area	Expected Status in Study Area	Local Records[4]
Dasycercus blythi Brush-tailed Mulgara			P4					
Rhinonicteris aurantius Orange Leaf-nosed Bat	Vulnerable	Schedule 1				Not for roosting	Irregular visitor	Kintyre
CONSERVATION SIGNIFICANCE 2 (CS2)[2]								
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
Lagorchestes conspicillatus Spectacled Hare-Wallaby			P4			Possibly	Unlikely	Unknown
Macroderma gigas Ghost Bat			P4			Not for roosting	Irregular Visitor	Kintyre and Nifty
Leggadina lakedownensis Lakeland Downs Mouse			P4			Possibly	Resident	Karlamilyi NP
CONSERVATION SIGNIFICANCE 3 (CS3)[3]								

Species	Reason For Significance				Comments			
	EPBC Act	WA Wildlife Conservation Act	DEC Priority	Other	Recorded current Project	Suitable habitat in Study Area	Expected Status in Study Area	Local Records[4]
Stipiturus ruficeps Rufous-crowned Emu-wren				CS3		Yes	Resident	Karlamilyi 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

[1]CS1: Listed under legislation, [2]CS2: Listed as priority by the DEC, [3]CS3: Population locally significant.

[4]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 and Hart reports to Cameco), Nifty (70km to the west, from reports provided by Birla Nifty Copper Operations) and Joanna Spring (150km north, Graham-Taylor and Bamford 1996).

5.3.2.1 Conservation Significance Level 1

Great Desert Skink. Not recorded either in the O'Callaghan's Study Area or in other Study 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, the species is associated with sandy soils, including alongside dunes.

Woma. One specimen found in Trotman's (September 2011) and one between the Telfer Gold Mine and O'Callaghan's Study Area (April 2012), and is therefore expected to be resident in the O'Callaghan's Study Area. Generally associated with sandy to sandy-loam soils, although the one specimen found was near a calcrete rise.

Princess Parrot. Expected only as an occasional visitor as the O'Callaghan's 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 O'Callaghan's Study Area and the entire Telfer region lacks critical nesting habitat (large trees with hollows and/or cliffs).

Oriental Pratincole. A migratory species of grasslands, expected only as a vagrant.

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 O'Callaghan's Study Area.

Rainbow Bee-eater. A regular, breeding visitor to the region; likely to construct nesting burrows nest on the sides of roads. Recorded in the O'Callaghan's Study Area in September 2011 and nesting in roadside ridge of earth.

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, available within the O'Callaghan's Study Area.

Bilby. Active Bilby burrows, fresh foraging holes and fresh tracks were found in O'Callaghan's Study Area in April and June 2012 (Figure 15) with at least two animals present, an adult and a recently-independent juvenile. There are also recent records (Syrinx Environmental PL 2006) of the species around Telfer, suggesting that the species is a long-term resident at least on a regional scale. It favours sandy to sandy-loam soils, so suitable habitat is present throughout O'Callaghan's Study Area.

Northern Marsupial Mole. Marsupial Mole burrows were recorded at both sites where surveying was conducted within the O'Callaghan's Study Area in June 2012 (Figure 16). Burrows were also recorded at all locations where searching was carried out in the Satellite Deposits and Trotman's Study Areas in April 2012. The species is known from nearby areas and suitable habitat (sandy soils, especially along the edge of dunes) is present regionally and within the O'Callaghan's 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.

Orange Leaf-nosed Bat. No critical roosting habitat (deep caves with high temperatures and humidity) in the O'Callaghan's Study Area or overall 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 Study Area.



Figure 15 Juvenile Bilby outside its burrow on O'Callaghan's Study Area, June 2012



Figure 16 Marsupial Mole trench, with two burrows visible (one circular, the other elliptical) about 15cm below the soil surface

5.3.2.2 Conservation Significance Level 2

Skink (*Lerista macropisthopus remota*). Not recorded either in the O'Callaghan's Study Area or in other study areas and range of the 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 2008), which is a very widespread habitat

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

Australian Bustard. Recorded regularly in the O'Callaghan's Study Area and other study areas in September 2011. 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 O'Callaghan's Study Area.

Spectacled Hare-Wallaby. Possibly locally extinct, but if present most likely to occur in areas of tall, long-unburnt spinifex.

Ghost Bat. No critical roosting habitat (deep caves with high temperatures and humidity) in the O'Callaghan's Study Area or the overall Telfer Optimisation 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 O'Callaghan's 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 O'Callaghan's 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 (M. Bamford pers. obs.). While it is considered unlikely they occur in the O'Callaghan's 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 O'Callaghan's 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 O'Callaghan's Study Area and other study 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. Results of SRE sampling for the Project area are presented in Appendix 11. 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 O'Callaghan's, while the remaining species were recorded in sandy soils at some of the other Study Areas.

The O'Callaghan's Study Area does not have the characteristics typical of environments where SRE invertebrates may evolve, although the small area of Mulga and the rocky hills to the west (Optimisation) that are outliers of the Pilbara may be suitable. The lack of previous sampling means several species may be recorded for the first time in this project.

5.3.4 Summary of Species of Conservation Significance

Species of greatest interest with respect to impacts from the O'Callaghan's 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 and recorded within the O'Callaghan's Study Area. The small population makes the Bilby vulnerable to impacts upon even just a few animals.
- Mulgara. Present regionally in low numbers, recorded in areas adjacent to the O'Callaghan's 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 within the Study Area. Generally restricted to sand dune habitat.
- 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)

The position of Telfer on the edge of the Pilbara and Great Sandy Desert regions means that the vegetation and substrates are complex, with "typical" desert landscapes (dunal ridges) close to rocky hills and Mulga woodland.

Within the O'Callaghan's Study Area, interdunes and plains are very well-represented, as are dunes and low rocky hills (Figure 19). Figure 17 and Figure 18 provide examples of the main VSAs in the O'Callaghan's Study Area at the two trapping sites. A description of each VSA is provided below:

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

- *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.

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, 6c.

- *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.

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.

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 local 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.

Plains or depressions; often interdunal, with potentially groundwater-dependent vegetation. Eucalypt open woodland to mixed shrubland, often including *Melaleuca* spp., over *Triodia* spp., sometimes with other grasses. Soils area a clayey-sand. Vegetation Associations 1a, 2a.

- *Conservation significance*: Limited in distribution to a few broad valleys in the region, but this VSA occurs elsewhere in similar landscapes. Shrubs in the VSA provide seasonal nectar sources. In the central Great Sandy Desert, Bilbies are often associated with this VSA (M. Bamford pers. obs.).



Figure 17 Sampling site 6, illustrating a sandy plain with scattered shrubs and mallee over spinifex



Figure 18 Sampling site 7, sandy plain with shrubs and spinifex on shallow sand overlying rock, with some patches of rock exposed

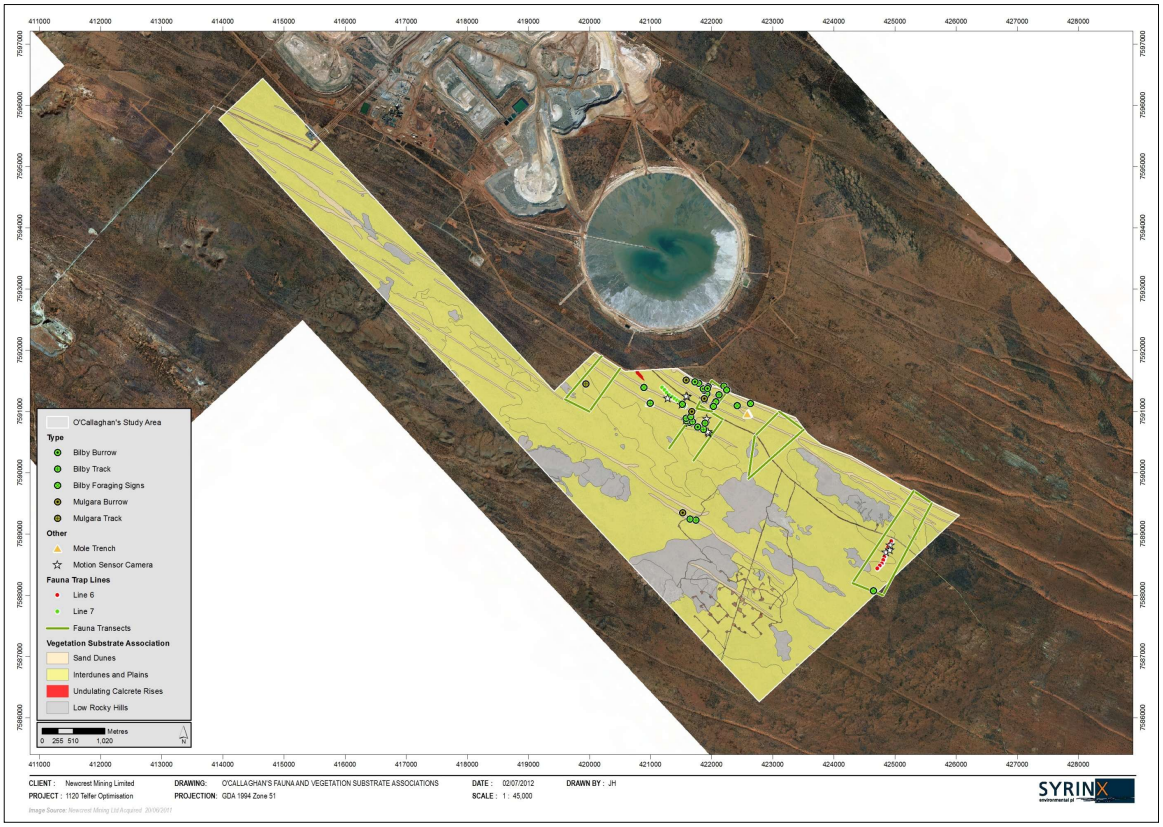


Figure 19 VSAs of O'Callaghan's Study Area with fauna survey locations

5.3.6 Patterns of Biodiversity

Systematic sampling in the O'Callaghan's Study Area was limited to two sampling sites (Figure 19). Captures (reptiles and small mammals) and census (birds) results are presented in Table 23 and Table 25.

Table 24 and Table 26 provide a comparison with abundance and species richness with other sampling sites in the region. Both Sites 6 and 7 were very similar, (primarily interdunes and plains); although Site 7 had some rock exposed through the sand, with dunes nearby.

Sites 6 and 7 differed in their numbers of captures; particularly with reptiles (Table 23). The difference was due largely to the Military Dragon (10 captures at Site 6 versus one capture at Site 7) and the skink *Ctenotus pantherinus* (six versus no captures). *Lerista bipes* was common at both sites. Other reptile species were caught in low numbers. The trapped mammal assemblage was much lower (five species across both sites). Compared with other sites studied in the Optimisation Project Area (Table 24), Site 6 had a high number of captures of reptiles; other sites with high numbers of reptile captures were also locations with dense spinifex and a firm sandy to sandy-loam substrate.

No bird species are of conservation significance. Sites 6 and 7 had similar bird assemblages (Table 25), reflecting broadly similar vegetation structure and floristics. The main difference in species and abundance was due to a large flock of Masked Woodswallows observed at Site 6 and large flocks of Zebra Finch at Site 7. The Masked Woodswallow is an aerial species and therefore can appear and disappear very quickly; it also forms large flocks that can complicate census data. Zebra Finches are common across a wide range of habitat types. Across all sites, Sites 6 and 7 had moderate numbers of bird records and species (Table 26). Honeyeaters dominated the bird records in Site 6 in 2012, with 69 of the 110 records. In contrast, in September 2011 honeyeaters contributed only 7 of 77 bird records. This difference was due to the flowering of Bloodwoods (*Corymbia* spp.) at Site 6 in April 2012. While Bloodwoods are widespread across the landscape, they were slightly concentrated at Site 6, forming a very open woodland on the sandplain. Site 7 also had more honeyeaters in June 2012 than in September 2011, but the June sample was dominated by Zebra Finches. Short-term seasonal variations in abundance appear to be a feature of the bird assemblage in the region.

Table 23 Numbers of captures of reptiles and small mammals in the two sampling sites in O'Callaghan's Study Area

Common Name	Species Name	2011		2012	
		6	7	6	7
Long-nosed Dragon	*Amphiboluris longirostris*				1
Military Dragon	*Ctenophorus isolepis*	8	1	2	
Central Netted Dragon	*Ctenophorus nuchalis*		1		
Fat-tailed Gecko	*Diplodactylus conspicillatus*			1	
Sandplain Gecko	*Lucasium stenodactylum*	1			
Beaked Gecko	*Rhynchoedura ornata*	1	1		
Wellington's Spiny-tailed Gecko	*Strophurus wellingtonae*	1		1	
Skink	*Ctenotus ariadnae*			1	
Skink	*Ctenotus helenae*			4	
Skink	*Ctenotus pantherinus*	6		2	
Skink	*Ctenotus piankai*	1			
Narrow Banded Sandswimmer	*Eremiascincus fasciolatus*			1	
Skink	*Lerista bipes*	4	2	8	6
Dwarf Skink	*Menetia greyii*			1	
Firetail Skink	*Morethia ruficauda*			1	
Skink	*Notoscincus ornatus*			3	
Desert Monitor	*Varanus eremius*	1			
Western Brown Snake	*Pseudonaja mengdeni*			1	
Little Red Kaluta	*Dasykaluta rosamondae*		3	1	
Lesser Hairy-footed Dunnart	*Sminthopsis youngsoni*	1			
Spinifex Hopping Mouse	*Notomys alexis*			10	3
Sandy Inland Mouse	*Pseudomys hermannsburgensis*	8	11	16	30
House Mouse	*Mus musculus*			1	

Common Name	Species Name	2011		2012	
		6	7	6	7
Number of captures all species		32	19	54	40
Number of reptile captures (species)		23 (8)	5 (4)	26 (12)	7 (2)
Number of small mammal captures (species)		9 (2)	14 (2)	28 (4)	33 (2)
Total number of species		10	6	16	4

Table 24 Comparison of numbers of captures of reptiles and small mammals between all Study Areas in the Telfer Optimisation Project, 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 number of 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	10	28	48	32 (9)	45 (6)	15
	11	23	31	23 (10)	31 (3)	13

Table 25 Numbers of records (cumulative count across five mornings) of birds in the two sampling sites in O'Callaghan's Study Area

Species	2011 Site No.		2012 Site No.	
	6	7	6	7
Australian Bustard	0	0	1	0
Brown Quail	0	0	0	1
Diamond Dove	10	0	0	2
Little Button-quail	2	1	0	0
Nankeen Kestrel	1	0	0	0
Budgerigar	8	0	6	14
Cockatiel	0	2	0	0
Variegated Fairy-wren	0	0	3	0
Striated Pardalote	0	0	1	0
Yellow-throated Miner	0	1	0	0
Grey-headed Honeyeater	1	1	17	20
Singing Honeyeater	5	12	21	2
Brown Honeyeater	0	2	1	0
Black Honeyeater	1	2	25	0
Pied Honeyeater	0	0	3	0
Black-chinned Honeyeater	0	0	2	0
Crimson Chat	2	0	0	2
Zebra Finch	0	3	6	169
Willie Wagtail	0	0	0	1
Masked Woodswallow	43	0	24	0
Black-faced Woodswallow	4	2	0	5
Number of records	**77**	**26**	**110**	**216**
Number of species	**10**	**9**	**12**	**9**

Table 26 Comparison of numbers of bird census records between O'Callaghan's Study Area and other Study Areas in the Telfer Optimisation Project Area

Study 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	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 upon fauna. Major ecological processes that currently act upon and mould the fauna assemblage are discussed below.

5.3.7.1 Local Hydrology

The O'Callaghan's Study Area has low relief and no drainage lines as the rocky areas are very low. However, there are dunes where there may be some interaction between groundwater and substrate particle size that supports the growth of large eucalypts in this position in the landscape (Refer Section 4.1.5).

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. Fire regime may have an effect on reptile species richness and abundance in spinifex grasslands that are particularly well developed in the vicinity of Site 6.

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) notes 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 upon other wildlife is unknown.

5.4 DISCUSSION

5.4.1 Summary of Fauna Values

5.4.1.1 Fauna Assemblage

The fauna assemblage in the O'Callaghan's 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 and Great Sandy Desert regions. The O'Callaghan's 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 four reptile species, 10 bird species and 12 mammal species. 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 O'Callaghan's Study Area, the Bilby, Mulgara (*Dasycercus* sp.) and Northern Marsupial Mole are present and are expected to have resident populations in the local 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. The Bilby record is of local interest, as there appeared to be two animals present, an adult and a recently-independent juvenile, and these were the only Bilbies actually recorded (as opposed to finding tracks) across all study areas. 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.

5.4.1.3 Vegetation and Substrate Associations

The VSAs in O'Callaghan's Study Area are regionally widespread. The Study Area is dominated by the interdunal sandplains.

5.4.1.4 Patterns of Biodiversity

The reptile assemblage was particularly rich and abundant at Site 6, which may be related to a substrate of deep sand to sandy-loam, and well-developed spinifex grasslands. Site 7, in contrast, was notable for the highest number of captures of a dasyurid marsupial, the Little Red Dasykaluta; although this is not a species of conservation significance.

5.4.1.5 Key Ecological Processes

Main processes affecting the fauna assemblage in the Telfer region and O'Callaghan's Study Area are local hydrology, fire regime and fauna interactions. Local hydrology may be important along dunes. 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 O'Callaghan's Study

Area is close to the Telfer mine and Village, and is therefore in an area with high levels of abundance of feral species.

PART 4 SYNTHESIS AND RECOMMENDATIONS

6.0 SYNTHESIS

The following key habitats (Vegetation Associations) where conservation significant flora, GDEs, terrestrial vertebrate and SRE were found during the Level 2 flora and fauna survey of the O'Callaghan's Study Area are described and discussed in Table 27.

Table 27 Synthesis of key habitats in the O'Callaghan's Study Area

Parameter	Description	Vegetation Association (Area Ha)
Vegetation Associations	The *Acacia wanyu* dominated Vegetation Association 5b, is on an uncommon landform in the Telfer region, with species that are not common through the O'Callaghan's Study area This includes eight species restricted to the Vegetation Association 5b, with six species restricted to the O'Callaghan's Study Area when assessed against the remaining study areas of the Telfer Optimisation Project. The six species recorded only in the O'Callaghans Study area and are restricted to the *Acacia wanyu* Vegetation Association (5b) are: *Acacia sibrica, Brachyachne convergens, Maireana georgei, Sclerolaena densiflora, Senna stricta and Tripogon loliformis.* This Vegetation Association is present in the south-east portion of the O'Callaghan's Study Area	5b (100.91)
GDEs	One Vegetation Association was identified as either a perched aquifer or groundwater dependent ecosystems: 2a: A Low *Melaleuca lasiandra* - *M. glomerata* Woodland had been identified as relying on sub-surface perching of meteoric water and runoff. These ecosystems are present throughout the Telfer region as they are associated with occluded paleo drainage channels that traverse the Great Sandy Desert They are present in the central and western portion of the study area. *Melaleuca* woodlands are also present in the Satellite Tenements Study Area. The *Eucalyptus victrix* woodlands were not seen in the remaining four study areas within the Telfer Optimisation Project Area	2a (4.43)

Parameter	Description	Vegetation Association (Area Ha)
Flora	*Conservation Significance Level 1* No Threatened Flora (T) listed under the *Wildlife Conservation Act* or EPBC Act were found in the O'Callaghan's Study Area. *Conservation Significance Level 2* *Goodenia hartiana*, a Priority 2 species, was found in 5 populations consisting of at least 380 plants. Due to time constraints the population has not been fully groundtruthed. Additional populations were found in all remaining study areas. *Conservation Significance Level 3* The range extension species recorded were: *Fimbristylis leucocolea* was found on low rocky areas within rocky dune swales *Fimbristylis neilsonii* was recorded on a dune swale adjacent to a quartz rocky hill in the eastern portion of the O'Callaghan's Study Area. *Maireana georgei, Sclerolaena ericantha* and *Sclerolaena minuta* were recorded in Vegetation Association 5b on low rocky quartzite hills with gentle slopes and is located in the central and southern parts of the study area	1b (126.67) 4c (670.08) 6c (545.06) 1b (126.67), 4d (306.89), 5b (100.91)
Terrestrial Vertebrate	Significant fauna species sited were: • Bilby. The Bilby record is of local interest, as there appeared to be two animals present, an adult and a recently-independent juvenile, and these were the only Bilbies actually recorded (as opposed to finding tracks) across all study areas; • Mulgara. Active and recently-active burrows of the Mulgara (species uncertain) were found in O'Callaghan's Study Area in April and June 2012; • Northern Marsupial Mole. Burrows were recorded at both sites where surveying was conducted within the O'Callaghan's Study Area in June 2012. Burrows were also recorded at all locations where searching was carried out in the Satellite and Trotman's Study Areas in April 2012.	N/A
SRE	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.	N/A

6.1 ASSESSMENT OF SIGNIFICANCE

The following key habitats (Vegetation Associations) where conservation significant flora, terrestrial vertebrate and Short Range Endemics and perched aquifer dependent ecosystems were ranked according to either conservation significance or management requirements. The rankings are described in Table 28.

Table 28 Rankings of Assets recorded within the O'Callaghan's Study Area

Ranking	Definition of Asset Type	Asset
1	Critical Assets - the most important assets in the State that must be fully protected. Threatened (DRF), TEC's, areas protected under international, national or State conservation titles. Conservation Significant Level 1 Fauna Species	No flora Bilby, Mulgara and Northern Marsupial Moles sited within the O'Callaghan's Study Area
2	Assets likely to assessed as significant by the EPA and management will be required to avoid impact. Also Priority Flora Unique VSAs critical to local persistence of CS2 and/or CS3 fauna species.	*Goodenia hartiana* in Vegetation Associations 1b, 4c and 6c; *Acacia wanyu* Vegetation Association (5b) Low rocky hills. Melaleuca Shrubland (2a)
3	Ground, perched aquifer or sheet flow water dependent vegetation not covered by legislation but require surface or groundwater water management to avoid impact	2a: A Low *Melaleuca lasiandra* - *M. glomerata* Woodland
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	*Fimbristylis leucocolea* was found on low rocky areas within rocky dune swales in Vegetation Association 1b; *Fimbristylis neilsonii* was recorded on a dune swale adjacent to a quartz rocky hill in the eastern portion of the O'Callaghan's Study Area in Vegetation Association 4d; Three species were restricted to the *Acacia wanyu* Vegetation Association (5b): *Maireana triptera*, *Sclerolaena eriacantha* and *S. minuta*

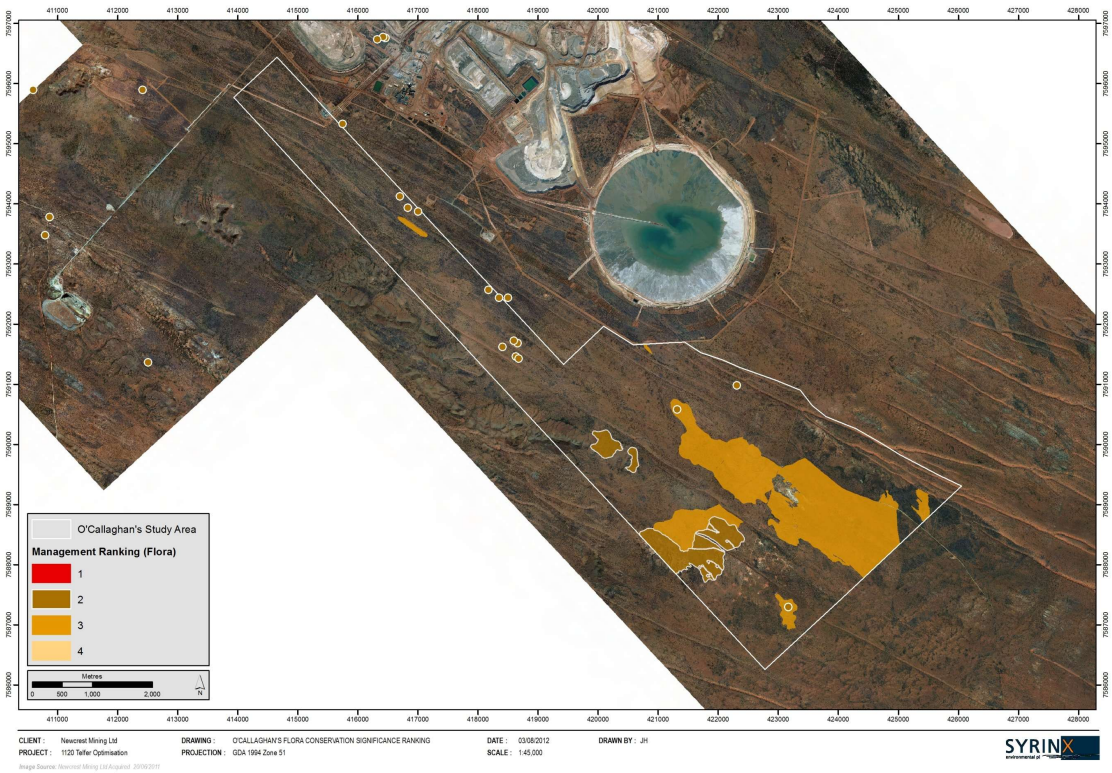


Figure 20 Management Rankings – Flora

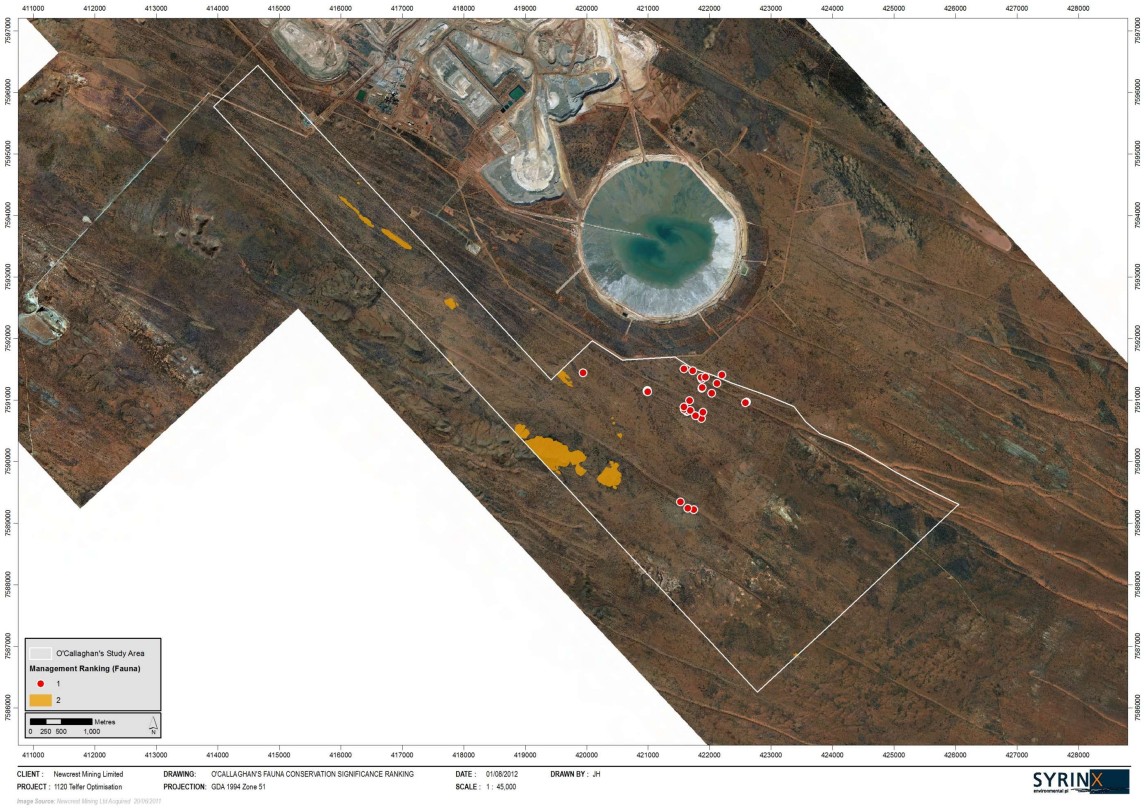


Figure 21 Management Rankings – Fauna

6.2 RECOMMENDATIONS FOR FURTHER INVESTIGATIONS

6.2.1 Flora

The following recommendation is made for future investigations related to the O'Callaghan's Study Area:

- If Vegetation Association 2a (the area of the *Eucalyptus victrix)* is identified as being impacted by groundwater drawdown of local confined aquifers for the O'Callaghan's Project, it is recommended investigations are made into characterising the hydrogeological requirements of the *E. victrix* to predict impact of hydrological change and determine what management is required to minimise impact. It is likely to be dependent on a confined aquifer at a shallow depth (at Nifty *E. victrix* have been recorded in locations with brackish groundwater at 5m). No research on root depth of *E. victrix* has been conducted in a desert environment similar to the hydrogeology present at Telfer so it is not possible to predict root depths, or hydrogeological processes. If mining activities are going to impact the confined aquifer the *E. victrix* is accessing, further field investigation to understand rooting depth will be required to assess impacts. The hydrogeology of the unconfined aquifer at this location will also need to be characterised to assess impacts.

6.2.2 Fauna

Key management actions recommended with respect to the development of O'Callaghan's Study Area are:

- 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 distribution and density of this species across the wider region.

Other recommendations specific to O'Callaghan's Study Area that would be considered minesite best practice include footprint minimisation, control of runoff/spills, speed limits and signage to help minimise road kill and rehabilitation.

6.3 CONCLUSION

6.3.1 Flora and Vegetation

No Threatened Flora (T) listed under the *Wildlife Conservation Act 1950* or Threatened Flora listed under the EPBC Act were recorded within the O'Callaghan's Study Area. Five *Goodenia hartiana* (P2) populations were recorded in the O'Callaghan's Study Area; however, three of the populations are part of one larger population containing hundreds of plants.

There were five range extension species recorded: *Fimbristylis leucocolea, F. neilsonii, Maireana triptera, Sclerolaena eriacantha* and *S. minuta*

Fifteen Vegetation Associations recorded within seven broad floristic groups were mapped and described in the O'Callaghan's Study Area. None of the Vegetation Associations mapped and described are listed as TECs or PECs.

One *Acacia wanyu* dominated Vegetation Association have been assessed as a unique and distinct Vegetation Association:

- Vegetation Association 5b: *Acacia wanyu* Open Shrubland over *Eremophila tietkensii* and *Senna glutinosa* subsp. x *luerssenii* Open Shrubland over *Triodia basedowii* complex and *T. epactia* Open Hummock Grassland over *Maireana melanocoma, M. triptera* and *Sclerolaena eriacantha* Very Open Herbs

Species restricted to this Vegetation Association were *Acacia sibirica, Brachyachne convergens, Maireana georgei, Sclerolaena densiflora, S. eriacantha, S. minuta, Senna stricta* and *Tripogon loliiformis.* Six of these species were not recorded outside the O'Callaghan's Study Area when assessing against the results of all Telfer Optimisation Project Areas.

One Vegetation Association has been identified as either perched aquifer or groundwater dependent ecosystem:

- Vegetation Association 2A: Scattered Trees of *Eucalyptus victrix* over *Melaleuca lasiandra and M. glomerata* Low Woodland over *Acacia stipuligera* High Open Shrubland over *Aluta maisonneuvei* subsp. *maisonneuvei* and *Gompholobium polyzygum* Low Open Shrubland over *Triodia* aff. *lanigera* Open Hummock Grassland

6.3.2 Fauna

Within the O'Callaghan's Study Area, the Bilby, Mulgara (*Dasycercus* sp.) and Northern Marsupial Mole are present and are expected to have resident populations in the local 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. The Bilby record is of local interest, as there appeared to be two animals present, an adult and a recently-independent juvenile, and these were the only Bilbies actually recorded (as opposed to finding tracks) across all project areas.

The status with respect to significant invertebrates is uncertain and while several species may be SREs, they occur in widespread environments so may only appear to have restricted distributions because of inadequate regional sampling.

The O'Callaghan's Study Area is dominated by sand dunes and interdune plains, with small areas of rocky hills. There were no major patterns of biodiversity identified, but areas with a substrate of deep sand to sandy-loam, and well-developed spinifex grasslands, supported a rich reptile assemblage. Out of the 4 VSAs present in the O'Callaghan's Study Area the undulating Calcrete rises and low rocky hills are critical to local persistence of CS2 and/or CS3 fauna species. The *Melaleuca* Shrubland within the interdunal swales is also an isolated unique habitat that may support SRE species and unique fauna assemblages.

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APPENDICES

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

EPBC Definition for Priority Ecological Communities based on 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.

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.

Conservation Code	Definition
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

Criteria	Definition
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).
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).

Criteria	Definition
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.

Criteria	Definition
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.

Definitions and criteria for DRF and Priority Flora – DEC

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

Species	Conservation Significance	GPS E	GPS N	Year	Source
Goodenia hartiana	2	435813	7582282	2011	Satellite Deposits Level 2 Flora Survey
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 and Images

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans -21**	**Date** 08.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0414401 **Northing:** 7595570	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune Swale/Level°	**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 21

Species List

Acacia ligulata
Acacia stellaticeps
Acacia stipuligera
**Aerva javanica*
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Bonamia erecta
Brunonia suffruticosa
Calytrix carinata
Corymbia ? opaca
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Gonocarpus eremophilus
Goodenia azurea
Grevillea stenobotrya
Gyrostemon ? tepperi
Hakea lorea subsp. *lorea*
Halgania solanacea
Jacksonia aculeata
Logania centralis
Mirbelia viminalis
Newcastelia cladotricha
Petalostylis cassioides
Salsola australis
Sida sp.
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Stylobasium spathulatum
Triodia basedowii
Triodia schinzii
Velleia connata

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans -22**	**Date** 08.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0414213 **Northing:** 7595566	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Dune Swale/Level°	**Disturbance Type** nil
Vegetation Condition	Excellent	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Mallees** of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* **High Open Shrubland** over *A. stellaticeps* and *Mirbelia viminalis* **Low Open Shrubland** over *Triodia basedowii* **Hummock Grassland**	



Quadrat 22

Species List

Acacia sphaerostachya
Acacia stellaticeps
Acacia stipuligera
Amphipogon sericeus
Calytrix carinata
Dampiera candicans
Eriachne aristidea
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Gonocarpus eremophilus
Goodenia azurea
Grevillea eriostachya
Hakea chordophylla
Hakea lorea
Heliotropium glanduliferum
Jacksonia aculeata
Mirbelia viminalis
Polygala isingii
Scaevola parvifolia
Senna artemisioides subsp. *helmsii*
Stackhousia muricata
Stylobasium spathulatum
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans -23**	**Date** 09.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0415456 **Northing:** 7595075	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune / 270°	**Disturbance Type** nil
Vegetation Condition	Excellent	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**Scattered Trees** of *Corymbia chippendalei* over **Scattered Shrubland** of *Grevillea eriostachya*, *G. stenobotrya* and *Acacia stipuligera* over *Triodia schinzii* **Hummock Grassland** over *Dampiera cinerea* and *Otion simplicifolium* **Low Open Shrubland**	



Quadrat 23

Species List

Acacia ancistrocarpa
Acacia ligulata
Acacia stellaticeps
Acacia stipuligera
Amphipogon caricinus var. *caricinus*
Aristida holathera var. *holathera*
Calytrix carinata
Dampiera cinerea
Eriachne aristidea
Eriachne helmsii
Eucalyptus odontocarpa
Grevillea eriostachya
Grevillea stenobotrya
Gyrostemon tepperi
Halgania solanacea
Otion simplicifolium
Ptilotus polystachyus
Scaevola parvifolia
Solanum ? gilesii
Stylobasium spathulatum
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans -24**	**Date** 09.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0416746 **Northing:** 7593738	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune swale / Level°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Melaleuca Low Open Woodland**	
Vegetation Association	**Scattered Trees** of *Eucalyptus victrix* over *Melaleuca lasiandra* and *M. glomerata* **Low Woodland** over *Acacia stipuligera* **High Open Shrubland** over *Aluta maisonneuvei* subsp. *maisonneuvei* and *Gompholobium polyzygum* **Low Open Shrubland** over *Triodia* aff. *lanigera* **Open Hummock Grassland**	



Quadrat 24

Species List

Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Amphipogon caricinus var. *caricinus*
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Bonamia erecta
Brunonia suffruticosa
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eriachne aristidea
Eucalyptus kingsmillii
Eucalyptus victrix
Gompholobium polyzygum
Grevillea eriostachya
Grevillea wickhamii
Jacksonia aculeata
Logania centralis
Melaleuca glomerata
Melaleuca lasiandra
Oldenlandia crouchiana
Santalum lanceolatum
Scaevola parvifolia
Sida sp. B Kimberley Flora (A.A. Mitchell 2745)
Stackhousia sp.
Triodia aff. *lanigera*
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans -25**	**Date** 09.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0416790 **Northing:** 7594018	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune swale / Level°	**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 25

Species List

Acacia stellaticeps
Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Amphipogon caricinus var. *caricinus*
Calytrix carinata
Dicrastylis cordifolia
Eucalyptus kingsmillii
Exocarpos sparteus
Gompholobium polyzygum
Grevillea eriostachya
Halgania solanacea
Jacksonia aculeata
Scaevola parvifolia
Stylobasium spathulatum
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans -26**	**Date** 09.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0417385 **Northing:** 7592844	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune swale / Level°	**Disturbance Type** Fire 2 – 5 years old
Vegetation Condition	Excellent	
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 26

Species List

Acacia ancistrocarpa
Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Amphipogon caricinus var. *caricinus*
Aristida holathera var. *holathera*
Calytrix carinata
Cassytha capillaris
Dampiera candicans
Dampiera cinerea
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eucalyptus kingsmillii
Exocarpos sparteus
Gompholobium polyzygum
Goodenia azurea
Goodenia hartiana **(P2)**
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea subsp. *lorea*
Halgania solanacea
Jacksonia aculeata
Keraudrenia velutina subsp. *elliptica*
Logania centralis
Newcastelia cladotricha
Polygala isingii
Ptilotus calostachyus
Stackhousia muricata
Tribulus macrocarpus
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-27**	**Date** 06.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0415379 **Northing:** 7594803	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune / 270°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**Scattered Trees** of *Corymbia chippendalei* over **Scattered Shrubland** of *Grevillea eriostachya*, *G. stenobotrya* and *Acacia stipuligera* over *Triodia schinzii* **Hummock Grassland** over *Dampiera cinerea* and *Otion simplicifolium* **Low Open Shrubland**	



Quadrat 27

Species List

Acacia ligulata
Acacia stipuligera
Aristida holathera var. *holathera*
Calytrix carinata
Corymbia chippendalei
Crotalaria cunninghamii
Cucumis maderaspatanus
Dampiera cinerea
Dicrastylis cordifolia
Eriachne aristidea
Grevillea eriostachya
Jacksonia aculeata
Newcastelia cladotricha
Oldenlandia crouchiana
Otion simplicifolium
Scaevola canescens
Scaevola parvifolia
Solanum ? *gilesii*
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Stylobasium spathulatum
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-28**	**Date** 09.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0418222 **Northing:** 7592618	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune swale / Level°	**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 28

Species List

Acacia acradenia
Acacia ancistrocarpa
Acacia colei var. *colei*
Acacia stellaticeps
Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Aristida holathera var. *holathera*
Brunonia suffruticosa
Calytrix carinata
Cassytha capillaris
Corchorus sidoides
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eriachne aristidea
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Gompholobium polyzygum
Gonocarpus eremophilus
Goodenia armitiana
Goodenia azurea
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Jacksonia aculeata
Logania centralis
Melaleuca lasiandra
Mirbelia viminalis
Newcastelia cladotricha
Polygala isingii
Ptilotus calostachyus
Scaevola parvifolia
Stackhousia muricata
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Streptoglossa odora
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-29**	**Date** 10.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0418636 **Northing:** 7591507	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune swale / Level°	**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 29

Species List

Acacia ancistrocarpa
Acacia ligulata
Acacia sphaerostachya
Acacia stellaticeps
Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Amphipogon aff. *caricinus* var. *caricinus*
Calytrix carinata
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Gompholobium polyzygum
Goodenia hartiana **(P2)**
Grevillea stenobotrya
Grevillea wickhamii
Halgania solanacea
Jacksonia aculeata
Mirbelia viminalis
Petalostylis cassioides
Scaevola parvifolia
Stylobasium spathulatum
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-30**	**Date** 10.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0419231 **Northing:** 7591251	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune swale / 270°	**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 30

Species List

Acacia stellaticeps
Acacia stipuligera
Amphipogon caricinus var. *caricinus*
Calytrix carinata
Cassytha capillaris
Codonocarpus cotinifolius
Dampiera candicans
Dicrastylis cordifolia
Eriachne aristidea
Gompholobium polyzygum
Goodenia azurea
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea subsp. *lorea*
Halgania solanacea
Heliotropium glanduliferum
Jacksonia aculeata
Logania centralis
Mirbelia viminalis
Newcastelia cladotricha
Ptilotus calostachyus
Stackhousia muricata
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Streptoglossa odora
Stylobasium spathulatum
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-31**	**Date** 10.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0419108 **Northing:** 7590916	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hillslope / 130°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**Scattered Mallees** of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* **High Open Shrubland** over *A. stellaticeps* and *Mirbelia viminalis* **Low Open Shrubland** over *Triodia basedowii* **Hummock Grassland**	



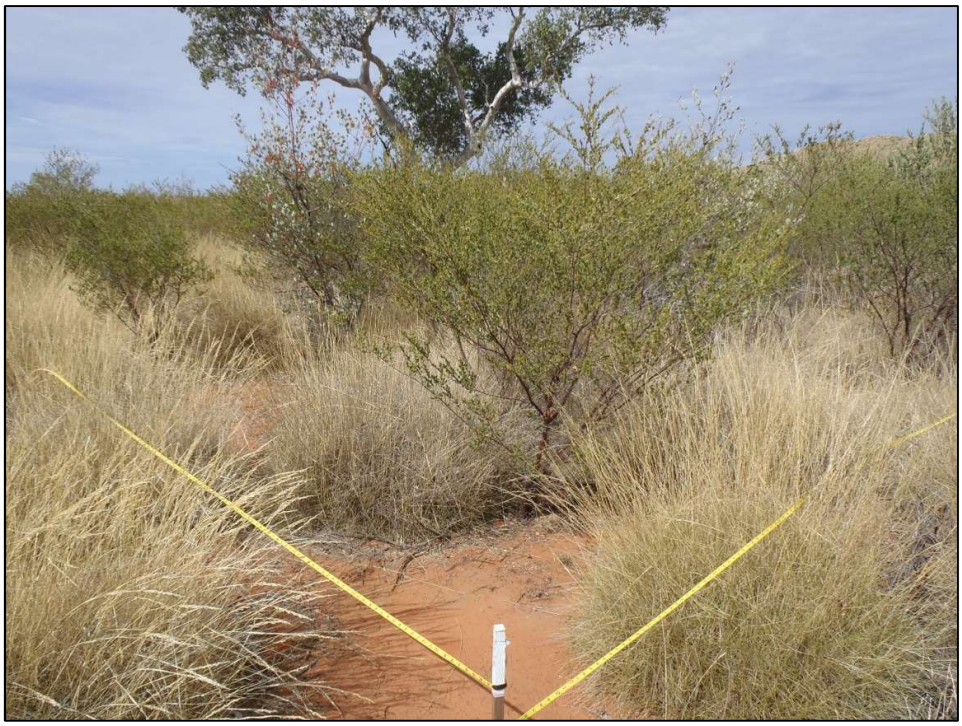
Quadrat 31

Species List

Acacia hilliana
Acacia stellaticeps
Amphipogon caricinus var. *caricinus*
Dampiera candicans
Dicrastylis cordifolia
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Gompholobium polyzygum
Goodenia azurea
Grevillea eriostachya
Grevillea stenobotrya
Halgania solanacea
Heliotropium glanduliferum
Jacksonia aculeata
Mirbelia viminalis
Scaevola parvifolia
Senna artemisioides subsp. *oligophylla*
Senna sericea
Stylobasium spathulatum
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-32**	**Date** 10.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0419510 **Northing:** 7590372	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Drainage Channel / Level°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Acacia Open Scrub**	
Vegetation Association	**Scattered Trees** of *Corymbia candida* subsp. *dipsodes* over *Acacia monticola*, *A. stipuligera* and *Grevillea wickhamii* **Open Scrub** over **Low Scattered Shrubs** of *Indigofera boviperda* subsp. *boviperda*, *Mirbelia viminalis* and *Dicrastylis cordifolia* over *Triodia pungens* **Open Tussock Grassland**	



Quadrat 32

Species List

Acacia acradenia
Acacia ancistrocarpa
Acacia hilliana
Acacia monticola
Acacia stipuligera
Amphipogon sericeus
Aristida holathera var. *holathera*
Aristida inaequiglumis
Calytrix carinata
Cassytha capillaris
Corchorus sidoides subsp. *sidoides*
Corymbia candida subsp. *dipsodes*
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eucalyptus kingsmillii subsp. *kingsmillii*
Evolvulus alsinoides var. *decumbens*
Gompholobium polyzygum
Goodenia stobbsiana
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea subsp. *lorea*
Halgania solanacea
Hibiscus leptocladus
Hybanthus aurantiacus
Indigofera boviperda
Isotropis atropurpurea
Keraudrenia velutina subsp. *elliptica*
Mirbelia viminalis
Paraneurachne muelleri
Scaevola parvifolia
Triodia basedowii
Triodia pungens
Triumfetta deserticola

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-33**	**Date** 10.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0420845 **Northing:** 7591644	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Rocky hill / Level°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	*Eucalyptus kingsmillii* subsp. *kingsmillii* and *E. odontocarpa* **Very Open Mallee** over *Codonocarpus cotinifolius*, *Grevillea wickhamii* subsp. *hispidula* and *G. stenobotrya* **High Shrubland** over *Triodia basedowii* complex **Open Hummock Grassland**	



Quadrat 33

Species List

? *Anthobolus leptomerioides*
Acacia hilliana
Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Amphipogon caricinus var. *caricinus*
Cassytha capillaris
Codonocarpus cotinifolius
Corymbia chippendalei
Dicrastylis cordifolia
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Gompholobium polyzygum
Goodenia azurea
Goodenia stobbsiana
Grevillea stenobotrya
Grevillea wickhamii subsp. *hispidula*
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Indigofera boviperda
Jacksonia aculeata
Paraneurachne muelleri
Ptilotus calostachyus
Scaevola parvifolia
Sida ? *cardiophylla*
Stackhousia muricata
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-34**	**Date** 09.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0420537 **Northing:** 7591428	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune / Level°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**Scattered Trees** of *Corymbia chippendalei* over **Scattered Shrubland** of *Grevillea eriostachya*, *G. stenobotrya* and *Acacia stipuligera* over *Triodia schinzii* **Hummock Grassland** over *Dampiera cinerea* and *Otion simplicifolium* **Low Open Shrubland**	



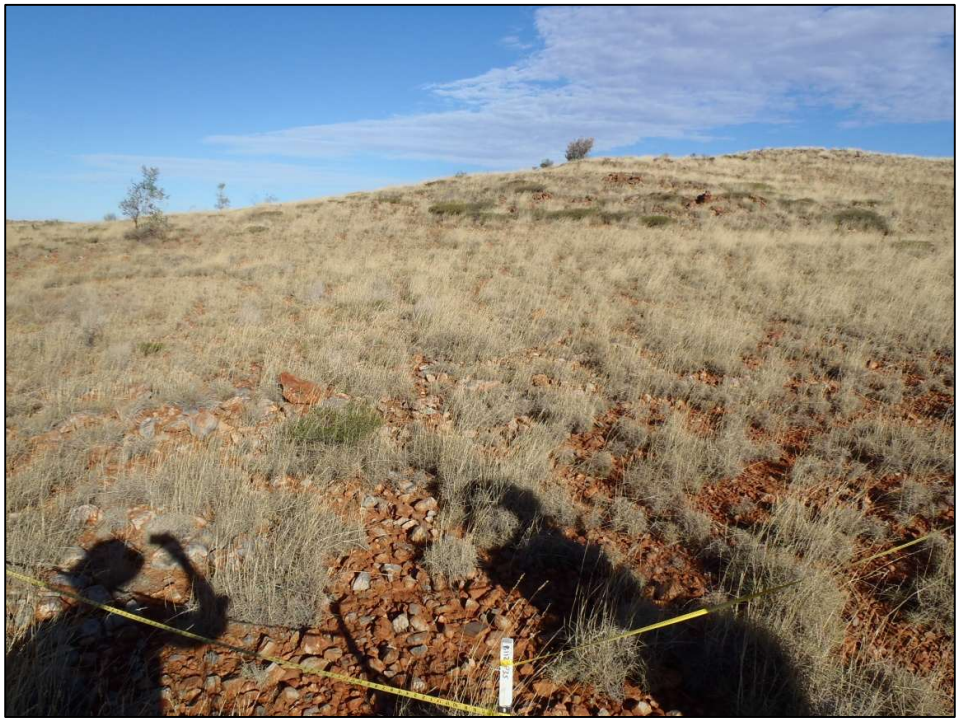
Quadrat 34

Species List

Acacia stellaticeps
Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Aristida holathera var. *holathera*
Calytrix carinata
Corymbia chippendalei
Dampiera cinerea
Dicrastylis doranii
Dodonaea coriacea
Duboisia hopwoodii
Eragrostis eriopoda
Eriachne aristidea
Goodenia armitiana
Grevillea stenobotrya
Halgania solanacea
Jacksonia aculeata
Otion simplicifolium
Scaevola parvifolia
Solanum ? gilesii
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-35**	**Date** 10.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0420314 **Northing:** 7589861	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hillslope / 270°	**Disturbance Type** nil
Vegetation Condition	Pristine	
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 35

Species List

Acacia hilliana
Acacia wanyu
Amphipogon caricinus
Codonocarpus cotinifolius
Corchorus sidoides
Eremophila latrobei subsp. *latrobei*
Eriachne ? *mucronata*
Goodenia stobbsiana
Grevillea wickhamii
Hakea lorea
Halgania solanacea
Hibiscus sturtii var. *campylochlamys*
Ptilotus calostachyus
Sporobolus australasicus
Tribulus suberosus
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-36**	**Date** 10.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0420099 **Northing:** 7589888	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hillslope / 90°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	***Acacia* Open Shrubland**	
Vegetation Association	*Acacia wanyu* **Open Shrubland** over *Eremophila tietkensii* and *Senna glutinosa* subsp. *x luerssenii* **Open Shrubland** over *Triodia basedowii* complex and *T. epactia* **Open Hummock Grassland** over *Maireana triptera*, *Sclerolaena eriacantha* and *Maireana melanocoma* **Very Open Herbs**	



Quadrat 36

Species List

Acacia adsurgens
Acacia wanyu
Aristida holathera var. *holathera*
Codonocarpus cotinifolius
Corymbia candida subsp. *dipsodes*
Enneapogon caerulescens
Eremophila tietkensii
Eriachne pulchella subsp. *dominii*
Eucalyptus kingsmillii
Fimbristylis dichotoma
Goodenia stobbsiana
Halgania solanacea
Maireana georgei
Maireana melanocoma
Polycarpaea corymbosa
Ptilotus calostachyus
Ptilotus nobilis
Scaevola spinescens
Sclerolaena densiflora
Sclerolaena eriacantha
Senna glutinosa subsp. *x luerssenii*
Senna stricta
Sporobolus australasicus
Triodia basedowii
Triodia epactia

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-37**	**Date** 10/10/2011 **Surveyor** Kelly McCreery, Radmila Tomanovic.	
Quadrat Dimension	50x50m		
GPS Location	**Easting:** 0421838 **Northing:** 7589817	**GPS Location Relative to Quadrat**	NW
Soil Type	Sand	**Soil Colour** Red	
Topography/Aspect	Level	**Disturbance Type** Dust	
Vegetation Condition	Pristine		
Broad Floristic Formation	**Corymbia Open Woodland**		
Vegetation Association	*Corymbia opaca* and *Eucalyptus leucophloia* **Open Woodland** over **Scattered** *E. 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**		



Quadrat 37

Speceis List

Abutilon otocarpum
Acacia acradenia
Acacia ancistrocarpa
Acacia ligulata
Acacia sericophylla
Acacia tenuissima
Amphipogon caricinus
Amphipogon sericeus
Aristida holathera var. *holathera*
Aristida inaequiglumis
Calytrix carinata
Corchorus sidoides subsp. *sidoides*
Corymbia opaca
Cucumis maderaspatanus
Dicrastylis cordifolia
Eragrostis eriopoda
Eriachne helmsii
Eucalyptus kingsmillii
Eucalyptus victrix
Grevillea stenobotrya
Halgania solanacea
Indigofera boviperda
Jacksonia aculeata
Paraneurachne muelleri
Scaevola parvifolia
Senna artemisioides subsp. *oligophylla*
Senna notabilis
Sida arenicola
Sida sp. Rabbit Flat (B.J. Carter 626)
Solanum ? *gilesii*
Solanum centrale
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-38**	**Date** 10/10/2011 **Surveyors** S. Dunn, G. Steel, Kelly McCreery, Radmila Tomanovic	
Quadrat Dimension	50x50m		
GPS Location	**Easting:** 0420810 **Northing:** 7591529	**GPS Location Relative to Quadrat**	NW
Soil Type	Sand	**Soil Colour** Red	
Topography/Aspect	Level	**Disturbance Type** None	
Vegetation Condition	Excellent		
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 38

Species List

Acacia ancistrocarpa
Acacia stipuligera
Aluta maisonneuvei subsp. *maisonneuvei*
Amphipogon caricinus var. *caricinus*
Brunonia suffruticosa
Calytrix carinata
Cassytha capillaris
Dampiera candicans
Dicrastylis cordifolia
Eriachne aristidea
Eucalyptus kingsmillii
Gompholobium polyzygum
Goodenia sp.
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii subsp. *hispidula*
Halgania solanacea
Indigofera boviperda
Jacksonia aculeata
Ptilotus calostachyus
Scaevola parvifolia
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-39**	**Date** 10.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel, Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0421304 **Northing:** 7590584	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hillslope / 0°	**Disturbance Type** nil
Vegetation Condition	Excellent	
Broad Floristic Formation	**Corymbia Open Woodland**	
Vegetation Association	*Corymbia opaca* and *Eucalyptus leucophloia* **Open Woodland** over **Scattered** *E. 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**	



Quadrat 39

Species List

Acacia ancistrocarpa
Acacia ligulata
Acacia wanyu
Amphipogon sericeus
Aristida holathera var. *holathera*
Capparis umbonata
Codonocarpus cotinifolius
Dicrastylis cordifolia
Enneapogon polyphyllus
Eremophila latrobei
Eriachne aristidea
Eucalyptus kingsmillii subsp. *kingsmillii*
Eucalyptus leucophloia
Eucalyptus odontocarpa
Fimbristylis dichotoma
Fimbristylis neilsonii
Grevillea stenobotrya
Hakea chordophylla
Halgania solanacea
Heliotropium glanduliferum
Jacksonia aculeata
Paraneurachne muelleri
Polycarpaea corymbosa
Ptilotus calostachyus
Ptilotus nobilis
Scaevola spinescens
Sclerolaena cornishiana
Senna glutinosa subsp. *glutinosa*
Senna sericea
Sida sp. Rabbit Flat (B.J. Carter 626)
Solanum centrale
Streptoglossa odora
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-40**	**Date** 11.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0421287 **Northing:** 7588121	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hillslope / 270°	**Disturbance Type** Camel
Vegetation Condition	Excellent	
Broad Floristic Formation	**Acacia Open Shrubland**	
Vegetation Association	*Acacia wanyu* **Open Shrubland** over *Eremophila tietkensii* and *Senna glutinosa* subsp. x *luerssenii* **Open Shrubland** over *Triodia basedowii* complex and *T. epactia* **Open Hummock Grassland** over *Maireana melanocoma, M. Triptera* and *Sclerolaena eriacantha* **Very Open Herbs**	



Quadrat 40

Species List

Acacia wanyu
Anthobolus leptomerioides
Aristida contorta
Brachyachne prostrata
Enneapogon caerulescens
Eremophila latrobei subsp. *latrobei*
Eremophila tietkensii
Eriachne pulchella subsp. *dominii*
Fimbristylis dichotoma
Maireana melanocoma
Maireana triptera
Salsola sp.
Scaevola spinescens
Sclerolaena eriacantha
Sclerolaena minuta
Senna artemisioides subsp. *helmsii*
Senna artemisioides subsp. *oligophylla*
Senna glutinosa subsp. *chatelainiana*
Senna glutinosa subsp. *x luerssenii*
Sporobolus actinocladus
Sporobolus australasicus
Trianthema triquetra
Triodia basedowii
Triodia epactia
Tripogon loliiformis

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-41**	**Date** 11.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0422082 **Northing:** 7588591	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hillslope / 0°	**Disturbance Type** Vehicle triacks and drilling nearby
Vegetation Condition	Excellent	
Broad Floristic Formation	**Acacia Open Shrubland**	
Vegetation Association	*Acacia wanyu* **Open Shrubland** over *Eremophila tietkensii* and *Senna glutinosa* subsp. x *luerssenii* **Open Shrubland** over *Triodia basedowii* complex and *T. epactia* **Open Hummock Grassland** over *Maireana melanocoma, M. Triptera* and *Sclerolaena eriacantha* **Very Open Herbs**	



Quadrat 41

Species List

Acacia adsurgens
Acacia sibirica
Acacia tenuissima
Acacia wanyu
Anthobolus leptomerioides
Aristida contorta
Brachyachne convergens
Brachyachne prostrata
Codonocarpus cotinifolius
Enneapogon caerulescens
Enneapogon polyphyllus
Eremophila latrobei subsp. *glabra*
Eremophila latrobei subsp. *latrobei*
Eremophila tietkensii
Eriachne pulchella subsp. *dominii*
Eucalyptus leucophloia subsp. *leucophloia*
Exocarpos sparteus
Fimbristylis dichotoma
Maireana georgei
Maireana triptera
Polycarpaea corymbosa
Ptilotus nobilis
Salsola australis
Scaevola spinescens
Sclerolaena densiflora
Sclerolaena eriacantha
Senna glutinosa subsp. *chatelainiana*
Senna glutinosa subsp. *x luerssenii*
Sida arenicola
Sporobolus australasicus
Tribulus macrocarpus
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-42**	**Date** 11.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0422656 **Northing:** 7589711	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hillslope / 90°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	*Eucalyptus kingsmillii* subsp. *kingsmillii* and *E. odontocarpa* **Very Open Mallee** over *Codonocarpus cotinifolius*, *Grevillea wickhamii* subsp. *hispidula* and *G. stenobotrya* **High Shrubland** over *Triodia basedowii* complex **Open Hummock Grassland**	



Quadrat 42

Species List

Acacia adoxa
Acacia ancistrocarpa
Acacia hilliana
Acacia pruinocarpa
Acacia sericophylla
Acacia stipuligera
Amphipogon caricinus
Anthobolus leptomerioides
Aristida holathera var. *holathera*
Cassytha capillaris
Codonocarpus cotinifolius
Corymbia candida subsp. *dipsodes*
Dicrastylis cordifolia
Eragrostis eriopoda
Eriachne aristidea
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Fimbristylis ? *neilsonii*
Fimbristylis dichotoma
Fimbristylis leucocolea
Fimbristylis oxystachya
Gompholobium polyzygum
Goodenia azurea
Goodenia stobbsiana
Goodenia triodiophila
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Hybanthus aurantiacus
Indigofera boviperda
Keraudrenia velutina subsp. *elliptica*
Paraneurachne muelleri
Polygala isingii
Ptilotus axillaris
Ptilotus calostachyus
Scaevola parvifolia
Senna glaucifolia
Senna glutinosa subsp. *x luerssenii*
Senna symonii
Sida arenicola
Sida cardiophylla
Solanum centrale
Stackhousia muricata
Streptoglossa odora
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-43**	**Date** 11.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0421419 **Northing:** 7588613	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Lower Slope / 270°	**Disturbance Type** nil
Vegetation Condition	Excellent	
Broad Floristic Formation	**Corymbia Open Woodland**	
Vegetation Association	*Corymbia opaca* and *Eucalyptus leucophloia* **Open Woodland** over **Scattered** *E. 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**	



Quadrat 43

Species List

Acacia sphaerostachya
Acacia stellaticeps
Acacia stipuligera
Acacia wanyu
Amphipogon sericeus
Anthobolus leptomerioides
Dicrastylis cordifolia
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Grevillea wickhamii subsp. *hispidula*
Hakea chordophylla
Halgania solanacea
Heliotropium glanduliferum
Jacksonia aculeata
Lepidium pholidogynum
Pluchea tetranthera
Polycarpaea corymbosa
Ptilotus calostachyus
Senna artemisioides subsp. *oligophylla*
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-44**	**Date** 11.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0421610 **Northing:** 7587860	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Lower Slope / 130°	**Disturbance Type** Exploration tracks
Vegetation Condition	Excellent	
Broad Floristic Formation	**Corymbia Open Woodland**	
Vegetation Association	*Eucalyptus odontocarpa* **Open Mallee** over *Acacia ancistrocarpa* and *Grevillea stenobotrya* **High Open Shrubland** over **Low Scattered Shrubs** of *A. ligulata* and *A. stellaticeps* over *Triodia basedowii* complex **Open Hummock Grassland**	



Quadrat 44

Species List

Acacia ligulata
Acacia stellaticeps
Anthobolus leptomerioides
Calytrix carinata
Eucalyptus kingsmillii subsp. *kingsmillii*
Eucalyptus odontocarpa
Exocarpos sparteus
Grevillea eriostachya
Grevillea stenobotrya
Hakea lorea
Paraneurachne muelleri
Scaevola spinescens
Senna artemisioides subsp. *helmsii*
Senna sericea
Solanum ? gilesii
Stylobasium spathulatum
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-45**	**Date** 11.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0422072 **Northing:** 7587519	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Plain / Level°	**Disturbance Type** Exploration tracks and drilling nearby
Vegetation Condition	Very Good	
Broad Floristic Formation	**Corymbia Open Woodland**	
Vegetation Association	*Eucalyptus odontocarpa* **Open Mallee** over *Acacia ancistrocarpa* and *Grevillea stenobotrya* **High Open Shrubland** over **Low Scattered Shrubs** of *A. ligulata* and *A. stellaticeps* over *Triodia basedowii* complex **Open Hummock Grassland**	



Quadrat 45

Species List

Acacia adsurgens
Acacia ancistrocarpa
Acacia ligulata
Acacia stellaticeps
Acacia synchronicia
Acacia tenuissima
**Aerva javanica*
Alternanthera angustifolia
Amphipogon caricinus
Cassytha capillaris
Corchorus sp.
Corymbia sp.
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eriachne aristidea
Goodenia armitiana
Goodenia azurea
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Indigofera boviperda
Jacksonia aculeata
Polygala isingii
Scaevola parvifolia
Scaevola spinescens
Sclerolaena cuneata
Sida ? *cardiophylla*
Sida sp. B Kimberley Flora (A.A. Mitchell 2745)
Streptoglossa macrocephala
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-46**	**Date** 11.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0423138 **Northing:** 7587340	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hillslope / Level°	**Disturbance Type** Exploration tracks
Vegetation Condition	Excellent	
Broad Floristic Formation	**Corymbia Open Woodland**	
Vegetation Association	*Corymbia opaca* and *Eucalyptus leucophloia* **Open Woodland** over **Scattered** *E. 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**	



Quadrat 46

Species List

Acacia ligulata
Acacia stellaticeps
Acacia wanyu
Amphipogon caricinus
Aristida holathera var. *holathera*
Aristida inaequiglumis
Calytrix carinata
Codonocarpus cotinifolius
Dicrastylis cordifolia
Enneapogon caerulescens
Eragrostis eriopoda
Eriachne aristidea
Eriachne pulchella subsp. *dominii*
Eucalyptus kingsmillii subsp. *kingsmillii*
Eucalyptus leucophloia subsp. *leucophloia*
Fimbristylis dichotoma
Goodenia armitiana
Goodenia triodiophila
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea
Heliotropium glanduliferum
Jacksonia aculeata
Paraneurachne muelleri
Ptilotus axillaris
Ptilotus calostachyus
Scaevola parvifolia
Senna artemisioides subsp. *helmsii*
Senna artemisioides subsp. *oligophylla*
Senna glaucifolia
Senna sericea
Senna sericea x ? *artemisioides* subsp. *helmsii*
Solanum centrale
Stylobasium spathulatum
Tribulus macrocarpus
Triodia basedowii
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-47**	**Date** 11.06.2012 **Surveyors** Radmila Tomanovic, Kelly McCreery
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0422670 **Northing:** 7586548	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Flat / Level°	**Disturbance Type** Exploration tracks
Vegetation Condition	Excellent	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	**Scattered Trees** of *Corymbia opaca* over **Scattered Mallees** of *E. 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 47

Species List

Acacia adoxa
Acacia ancistrocarpa
Amphipogon sericeus
Bonamia erecta
Calytrix carinata
Dicrastylis cordifolia
Eucalyptus kingsmillii subsp. *kingsmillii*
Eucalyptus odontocarpa
Gompholobium polyzygum
Goodenia azurea
Grevillea stenobotrya
Grevillea wickhamii subsp. *hispidula*
Hakea chordophylla
Hakea lorea
Halgania solanacea
Hybanthus aurantiacus
Indigofera boviperda
Ptilotus calostachyus
Scaevola parvifolia
Stackhousia sp. swollen gynophore (W.R. Barker 2041)
Tephrosia arenicola
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-48**	**Date** 11.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0423603 **Northing:** 7587661	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Rocky rise / 180°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Corymbia Open Woodland**	
Vegetation Association	*Eucalyptus odontocarpa* **Open Mallee** over *Acacia ancistrocarpa* and *Grevillea stenobotrya* **High Open Shrubland** over **Low Scattered Shrubs** of *A. ligulata* and *A. stellaticeps* over *Triodia basedowii* complex **Open Hummock Grassland**	



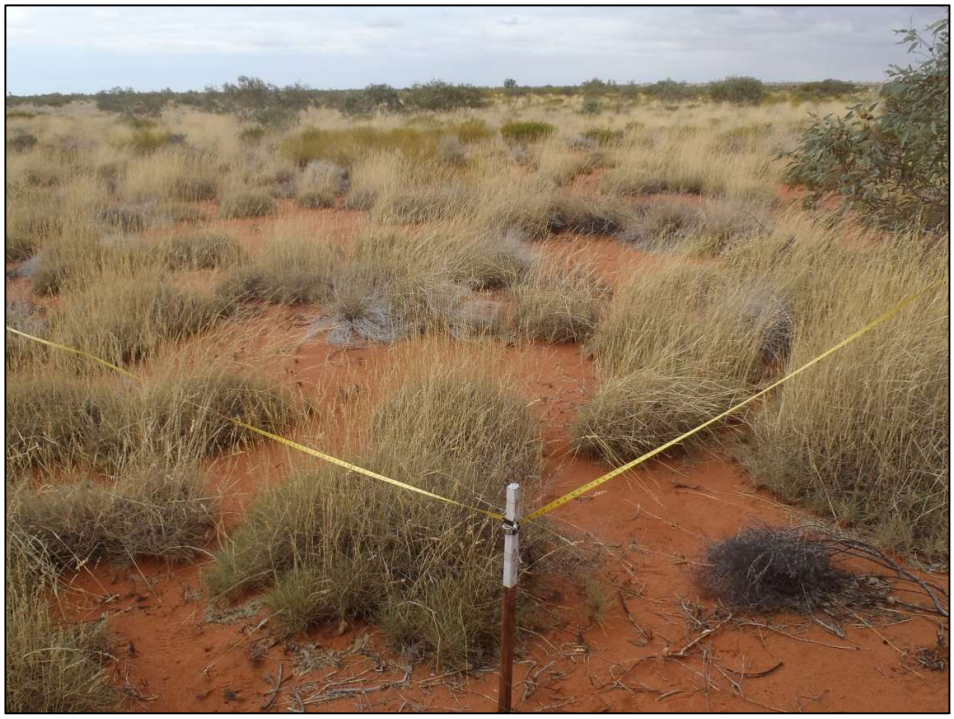
Quadrat 48

Species List

Acacia ancistrocarpa
Acacia ligulata
Acacia sphaerostachya
Acacia stellaticeps
Aristida holathera var. *holathera*
Codonocarpus cotinifolius
Eragrostis eriopoda
Eucalyptus odontocarpa
Goodenia azurea
Grevillea stenobotrya
Grevillea wickhamii subsp. *hispidula*
Heliotropium glanduliferum
Hibiscus sp.
Indigofera boviperda
Paraneurachne muelleri
Ptilotus astrolasius
Scaevola parvifolia
Senna sericea
Sida ? sp. Rabbit Flat (B.J. Carter 626)
Sida arenicola
Triodia basedowii
Triodia pungens

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-49**	**Date** 11.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0423748 **Northing:** 7587871	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Flat / Level°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**Scattered Mallees** of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* **High Open Shrubland** over *A. stellaticeps* and *Mirbelia viminalis* **Low Open Shrubland** over *Triodia basedowii* **Hummock Grassland**	



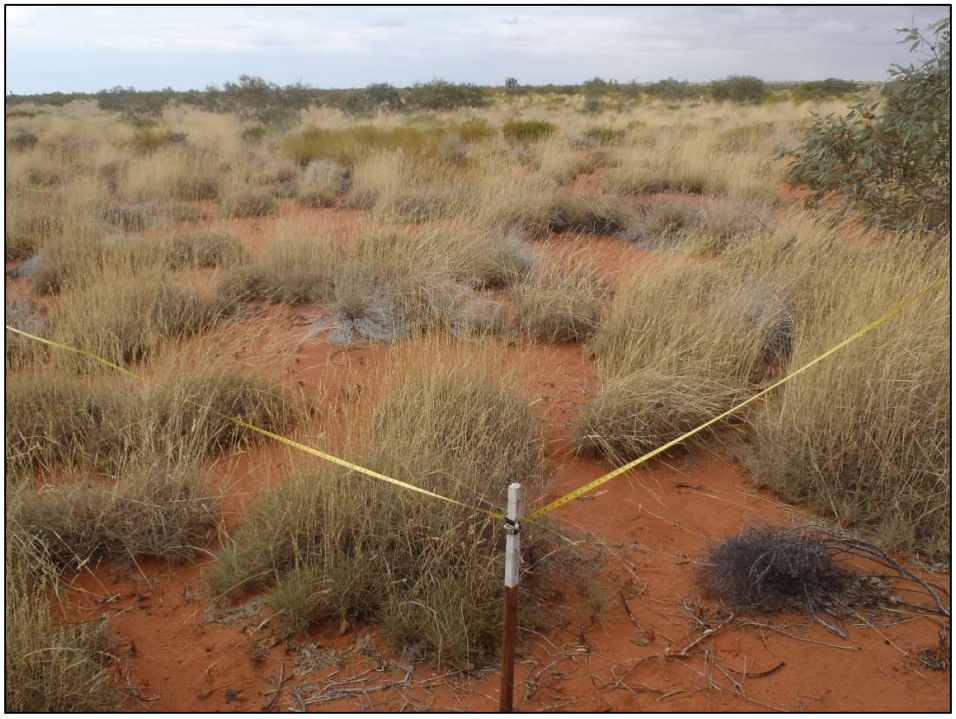
Quadrat 49

Species List

Acacia ancistrocarpa
Acacia stellaticeps
Acacia stipuligera
Amphipogon sericeus
Codonocarpus cotinifolius
Corchorus sidoides subsp. *sidoides*
Corymbia opaca
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eragrostis eriopoda
Eucalyptus kingsmillii
Gompholobium polyzygum
Goodenia azurea
Grevillea eriostachya
Grevillea stenobotrya
Hakea chordophylla
Hakea lorea
Halgania solanacea
Jacksonia aculeata
Leptosema anomalum
Mirbelia viminalis
Sida ? sp. B Kimberley Flora (A.A. Mitchell 2745)
Streptoglossa macrocephala
Stylobasium spathulatum
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-50**	**Date** 12.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0424351 **Northing:** 7588739	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Hillslope / 90°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	*Eucalyptus kingsmillii* subsp. *kingsmillii* and *E. odontocarpa* **Very Open Mallee** over *Codonocarpus cotinifolius*, *Grevillea wickhamii* subsp. *hispidula* and *G. stenobotrya* **High Shrubland** over *Triodia basedowii* complex **Open Hummock Grassland**	



Quadrat 50

Species List

Acacia adoxa
Acacia ancistrocarpa
Acacia sericophylla
Acacia stellaticeps
Amphipogon caricinus
Aristida holathera var. *holathera*
Codonocarpus cotinifolius
Corchorus sidoides
Dampiera candicans
Dicrastylis cordifolia
Eragrostis eriopoda
Exocarpos sparteus
Gompholobium polyzygum
Goodenia azurea
Grevillea wickhamii
Gyrostemon sp.
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Indigofera boviperda
Jacksonia aculeata
Keraudrenia velutina subsp. *elliptica*
Ptilotus astrolasius
Ptilotus calostachyus
Scaevola parvifolia
Tephrosia arenicola
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-51**	**Date** 12.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0423605 **Northing:** 7590212	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Rocky Hillslope / 180°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**Scattered Trees** of *Eucalyptus leucophloia* over *Grevillea wickhamii* subsp. *hispidula* and *Hakea lorea* **High Open Shrubland** over *Acacia hilliana* and *A. adoxa* var. *adoxa* **Low Open Shrubland** over *Triodia basedowii* complex **Hummock Grassland**	



Quadrat 51

Species List

Acacia adoxa
Acacia hilliana
Amphipogon sericeus
Calytrix carinata
Dicrastylis cordifolia
Gompholobium polyzygum
Goodenia stobbsiana
Goodenia triodiophila
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea subsp. *lorea*
Halgania solanacea
Hybanthus aurantiacus
Jacksonia aculeata
Mirbelia viminalis
Ptilotus calostachyus
Tribulus suberosus
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-52**	**Date** 09.06.2012 **Surveyors** Kelly McCreey, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0421565 **Northing:** 7590666	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Low Hillslope / Level°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**Scattered Mallees** of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* **High Open Shrubland** over *A. stellaticeps* and *Mirbelia viminalis* **Low Open Shrubland** over *Triodia basedowii* **Hummock Grassland**	



Quadrat 52

Species List

Acacia ancistrocarpa
Acacia ligulata
Acacia stellaticeps
Acacia stipuligera
Amphipogon sericeus
Calytrix carinata
Codonocarpus cotinifolius
Corymbia opaca
Dampiera candicans
Dicrastylis cordifolia
Dodonaea coriacea
Eucalyptus kingsmillii
Eucalyptus leucophloia subsp. *leucophloia*
Eucalyptus odontocarpa
Gompholobium polyzygum
Goodenia armitiana
Goodenia azurea
Goodenia triodiophila
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii
Hakea chordophylla
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Jacksonia aculeata
Leptosema anomalum
Mirbelia viminalis
Ptilotus axillaris
Ptilotus calostachyus
Ptilotus polystachyus
Senna sericea
Stackhousia intermediate s. lat.
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-53**	**Date** 09.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0422174 **Northing:** 7591184	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Dune / 0°	**Disturbance Type** nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**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**	



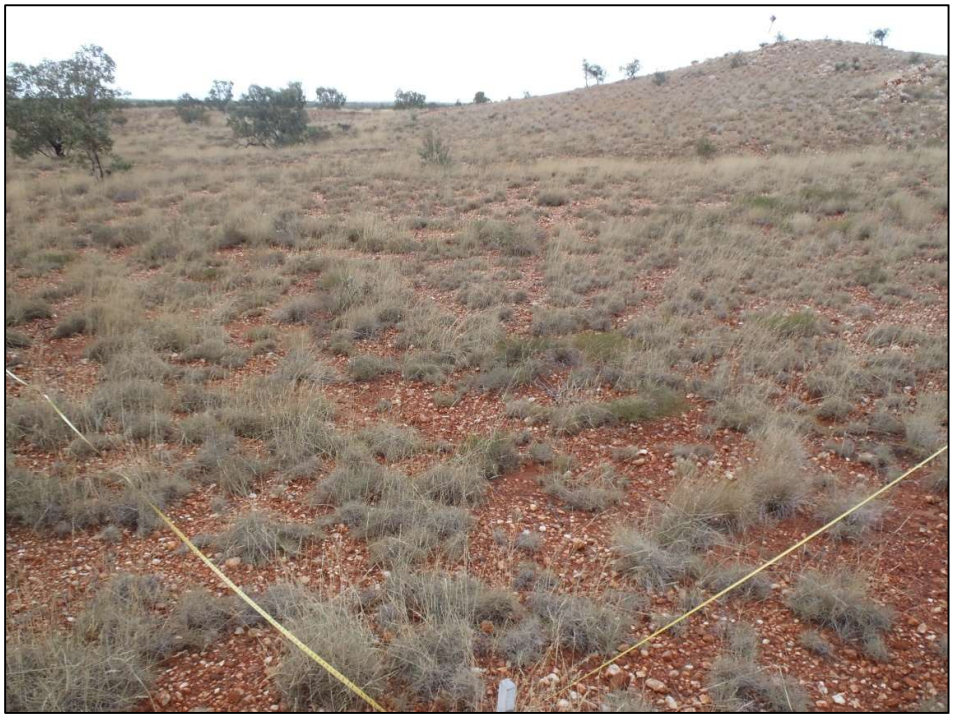
Quadrat 53

Species List

Acacia sabulosa
Aluta maisonneuvei subsp. *maisonneuvei*
Aristida holathera var. *holathera*
Corymbia chippendalei
Crotalaria cunninghamii
Dampiera cinerea
Dicrastylis doranii
Eragrostis eriopoda
Eriachne aristidea
Grevillea stenobotrya
Gyrostemon tepperi
Oldenlandia pterospora
Otion simplicifolium
Paractaenum refractum
Scaevola parvifolia
Sida sp. sand dunes (A.A. Mitchell PRP1208)
Solanum ? *gilesii*
Solanum ? *horridum*
Triodia schinzii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-54**	**Date** 09.06.2012 **Surveyors** Sandra Dunn, Gabriel Steel
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0423152 **Northing:** 7589295	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Low Hillslope / 0°	**Disturbance Type** Old Vehicle track
Vegetation Condition	Excellent	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**Scattered Trees** of *Eucalyptus leucophloia* over *Grevillea wickhamii* subsp. *hispidula* and *Hakea lorea* **High Open Shrubland** over *Acacia hilliana* and *A. adoxa* var. *adoxa* **Low Open Shrubland** over *Triodia basedowii* complex **Hummock Grassland**	



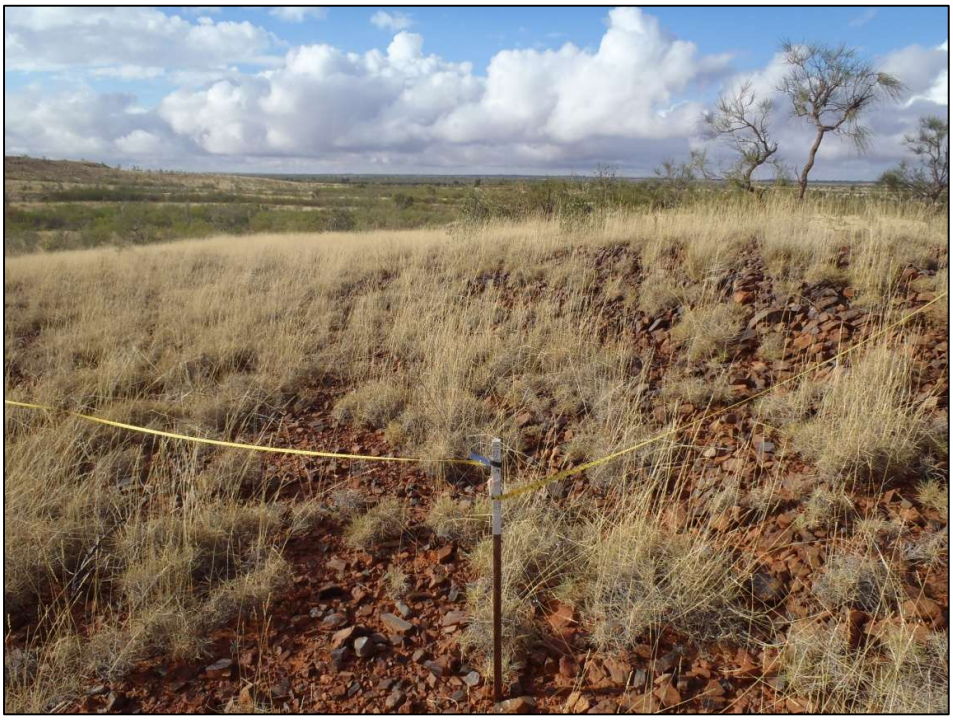
Quadrat 54

Species List

Acacia adoxa
Acacia adsurgens
Acacia hilliana
Acacia ligulata
Amphipogon sericeus
Aristida holathera var. *holathera*
Codonocarpus cotinifolius
Dicrastylis cordifolia
Eucalyptus leucophloia
Fimbristylis oxystachya
Gompholobium polyzygum
Goodenia stobbsiana
Goodenia triodiophila
Grevillea wickhamii
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Jacksonia aculeata
Keraudrenia velutina subsp. *elliptica*
Ptilotus axillaris
Ptilotus calostachyus
Ptilotus nobilis
Senna artemisioides subsp. *oligophylla*
Senna symonii
Tribulus suberosus
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-55**	**Date** 12.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0424309 **Northing:** 7589488	**GPS Location Relative to Quadrat** NW
Soil Type	Clayey Sand	**Soil Colour** Red
Topography/Aspect	Mid Hillslope / 140°	**Disturbance Type** Nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	**Scattered Trees** of *Eucalyptus leucophloia* over *Grevillea wickhamii* subsp. *hispidula* and *Hakea lorea* **High Open Shrubland** over *Acacia hilliana* and *A. adoxa* var. *adoxa* **Low Open Shrubland** over *Triodia basedowii* complex **Hummock Grassland**	



Quadrat 55

Species List

Acacia adsurgens
Acacia hilliana
Acacia ligulata
Acacia stipuligera
Acacia synchronicia
Acacia tetragonocarpa
Amphipogon sericeus
Codonocarpus cotinifolius
Dicrastylis cordifolia
Eriachne helmsii
Eucalyptus leucophloia
Fimbristylis dichotoma
Fimbristylis oxystachya
Fimbristylis simulans
Gompholobium polyzygum
Goodenia triodiophila
Grevillea stenobotrya
Grevillea wickhamii subsp. *hispidula*
Hakea chordophylla
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Ptilotus axillaris
Ptilotus calostachyus
Ptilotus polystachyus
Scaevola parvifolia
Senna sericea
Senna symonii
Solanum centrale
Triodia basedowii complex

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-56**	**Date** 11.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0423498 **Northing:** 7588698	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Flat / Level°	**Disturbance Type** Nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Mixed High Shrubland**	
Vegetation Association	*Eucalyptus kingsmillii* subsp. *kingsmillii* and *E. odontocarpa* **Very Open Mallee** over *Codonocarpus cotinifolius*, *Grevillea wickhamii* subsp. *hispidula* and *G. stenobotrya* **High Shrubland** over *Triodia basedowii* complex **Open Hummock Grassland**	



Quadrat 56

Species List

Acacia ancistrocarpa
Acacia sphaerostachya
Acacia stellaticeps
Acacia stipuligera
Amphipogon caricinus
Codonocarpus cotinifolius
Corchorus sidoides subsp. *sidoides*
Dampiera candicans
Dicrastylis cordifolia
Eragrostis eriopoda
Eriachne aristidea
Eucalyptus odontocarpa
Goodenia azurea
Grevillea stenobotrya
Hakea lorea
Halgania solanacea
Heliotropium glanduliferum
Indigofera boviperda
Jacksonia aculeata
Paraneurachne muelleri
Ptilotus calostachyus
Scaevola parvifolia
Senna symonii
Sida sp. B Kimberley Flora (A.A. Mitchell 2745)
Stackhousia muricata
Streptoglossa odora
Stylobasium spathulatum
Tephrosia arenicola
Triodia basedowii

FLORA QUADRAT DATA SHEET

Location	**O'Callaghans-57**	**Date** 12.06.2012 **Surveyors** Kelly McCreery, Radmila Tomanovic
Quadrat Dimension	50x50m	
GPS Location	**Easting:** 0425127 **Northing:** 7589128	**GPS Location Relative to Quadrat** NW
Soil Type	Sand	**Soil Colour** Red
Topography/Aspect	Low Hillslope / 310°	**Disturbance Type** Nil
Vegetation Condition	Pristine	
Broad Floristic Formation	**Triodia Hummock Grassland**	
Vegetation Association	*Eucalyptus odontocarpa* **Open Mallee** over *Acacia ancistrocarpa* and *Grevillea stenobotrya* **High Open Shrubland** over **Low Scattered Shrubs** of *A. ligulata* and *A. stellaticeps* over *Triodia basedowii* complex **Open Hummock Grassland**	

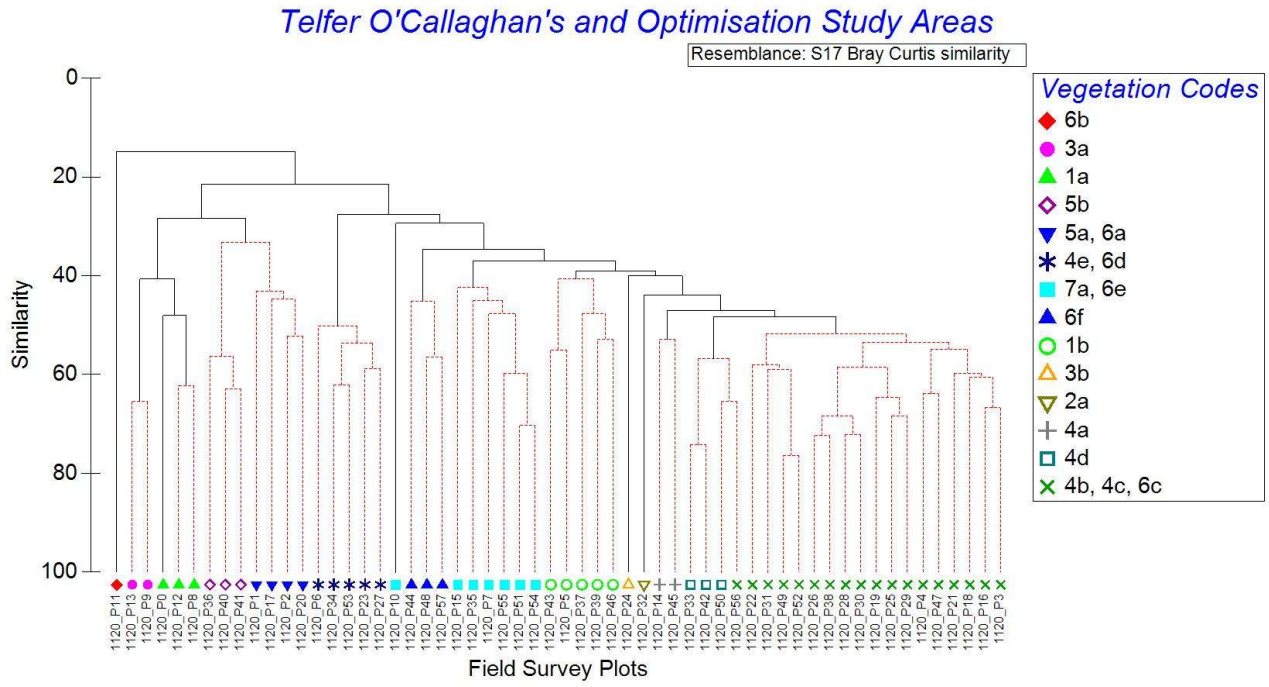


Quadrat 57

Species List

Acacia ancistrocarpa
Acacia ligulata
Acacia stellaticeps
Corchorus sidoides subsp. *sidoides*
Eragrostis eriopoda
Eriachne aristidea
Eucalyptus kingsmillii
Eucalyptus odontocarpa
Gossypium australe
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii
Hakea lorea
Heliotropium glanduliferum
Paraneurachne muelleri
Ptilotus astrolasius
Ptilotus calostachyus
Ptilotus fusiformis
Ptilotus nobilis
Senna notabilis
Senna symonii
Sida sp. B Kimberley Flora (A.A. Mitchell 2745)
Stackhousia muricata
Stylobasium spathulatum
Triodia basedowii
Triodia pungens

Appendix 4 Analysis and Classification of Vegetation Associations



Appendix 5 Vegetation Association Description

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: 5.18 ha (0.19 % of the study area)

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

Location + Landform

This Vegetation Association occurs in a dune swale area at the base of a rocky outcrop where drainage concentrates. The location is in the northern central portion of the O'Callaghan's Study Area at the base of rocky outcrop that occurs between dunes.

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	Nil
Introduced Species	Nil
Vegetation Condition	Pristine
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 *E. 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: 126.67ha (6.64 % 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 central - eastern portion of the O'Callaghan's Study Area.

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	*Goodenia hartiana* (P2), *Fimbristylis neilsonii* (Range Extension)
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

This Vegetation Association is not like any previously identified association in this area.



2 *Melaleuca* Low Open Woodland

2a **Scattered Trees of *Eucalyptus victrix* over *Melaleuca lasiandra* and *M. glomerata* Low Woodland over *Acacia stipuligera* High Open Shrubland over *Aluta maisonneuvei* subsp. *maisonneuvei* and *Gompholobium polyzygum* Low Open Shrubland over *Triodia* aff. *lanigera* Open Hummock Grassland**

Area Mapped: 4.43 ha (0.16 % of the study area)

ID of quadrats sampled: 1120_P24

Location + Landform

Occurs within a dune swale on the northern of a dune in the central - north western portion of the O'Callaghan's Study Area.

Vegetation Stratum Levels

Upper	*Eucalyptus victrix, E. kingsmillii, Melaleuca glomerata, M. lasiandra,*
Middle	*Aluta maisonneuvei, Gompholobium polyzygum, Jacksonia aculeata*
Ground	*Triodia lanigera, Aristida holathera* var. *holathera, Scaevola parvifolia*
Species of Conservation Significance	Nil
Introduced Species	Nil
Vegetation Condition	Pristine
Geology	Puntapunta Formation (Nlap), (Geoscience Australia, 2008).
Soil Attributes	Red Sand

Other Locations

This Vegetation Association is most similar to Sandplain - Variation 6: typical shrub species are *Melaleuca lasiandra, M. glomerata and Grevillea wickhamii* (Hart, Simpson and Associates 2002).



3 *Acacia* Open Scrub

3b Scattered Trees of *Corymbia candida* subsp. *dipsodes* over *Acacia monticola, A. stipuligera* and *Grevillea wickhamii* Open Scrub over Low Scattered Shrubs of *Indigofera boviperda* subsp. *boviperda, Mirbelia viminalis* and *Dicrastylis cordifolia* over *Triodia pungens* Open Tussock Grassland

Area Mapped: 8.63 ha (0.32 % of the study area)

ID of quadrats sampled: 1120_P32

Location + Landform

This Vegetation Association occurs at the bases of hills where drainage from the hills is concentrated forming wide drainage channels. It is located near the south western boundary at the base of the largest rocky outcrop in the study area. It is typical of vegetation found at the base of large rocky outcrops south of the Telfer.

Vegetation Stratum Levels

Upper	*Corymbia candida* subsp. *dipsodes*
Middle	*Acacia monticola, A. stipuligera, A. acradenia, A. ancistrocarpa*
Ground	*Indigofera boviperda* subsp. *boviperda, Keraudrenia velutina* subsp. *elliptica, Mirbelia viminalis, Dicrastylis cordifolia, Triodia pungens, Triumfetta deserticola*
Species of Conservation Significance	Nil
Introduced Species	Nil
Vegetation Condition	Pristine
Geology	Dunes 38496 (Qd), (Geoscience Australia, 2008)
Soil Attributes	Red Clayey Sand

Other Locations

This Vegetation Association is most similar to Type 9: *Corymbia opaca, C. candida* subsp. *dipsodes* woodland over *Acacia monticola* tall open shrubland over mixed grassland – identified in the Telfer Borefield Flora Survey (Syrinx Environmental PL 2007). It is also similar to the sandplain – areas of dense *A. stipuligera* thickets described by Hart Simpson and Associates (2002).



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: 301.82 ha (11.06 % 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, C. 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 *H. lorea* over *Acacia stellaticeps* open shrubland over *T. 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: 284.5 ha (10.42 % 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, A. stipuligera, Grevillea wickhamii* subsp. *hispidula*
Ground	*Calytrix carinata, Jacksonia aculeata, Triodia schinzii, T. basedowii*

Species of Conservation Significance	Nil
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, (Hart, Simpson and Associates 2002); and Type 3: Mixed shrubland over *A. stellaticeps* open shrubland over *T. 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: 670.08 ha (24.54 % 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 East, North East and the central parts of the 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* – (P2; 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 *T. basedowii* grassland (Syrinx Environmental PL 2007).



4 Mixed High Shrubland

4d ***Eucalyptus kingsmillii* subsp. *kingsmillii* and *E. odontocarpa* Very Open Mallee over *Codonocarpus cotinifolius, Grevillea wickhamii* subsp. *hispidula* and *G. stenobotrya* High Shrubland over *Triodia basedowii* complex Open Hummock Grassland**

Area Mapped: 306.89 ha (11.243 % of the study area)

ID of quadrats sampled: 1120_P33, 120_P42, 1120_P50, 1120_P56

Location + Landform

This Vegetation Association occurs on dune swales where the soil overlay quartz rock, so is most common adjacent to the quartzite hills in the eastern portion of the O'Callaghan's Study Area. It is a common Vegetation Association east of the O'Callaghan's Study Area.

Vegetation Stratum Levels

Upper	*Eucalyptus kingsmillii* subsp. *kingsmillii, E. odontocarpa*
Middle	*Acacia ancistrocarpa, Codonocarpus cotinifolius, Grevillea wickhamii* subsp. *hispidula, G. stenobotrya,*
Ground	*Amphipogon caricinus* var. *caricinus, Acacia hilliana, Gompholobium polyzygum, Triodia basedowii*
Species of Conservation Significance	*Fimbristylis leucocolea* – Range Extension
Introduced Species	Nil
Vegetation Condition	Pristine
Geology	Puntapunta Formation (Nlap), (Geoscience Australia, 2008)
Soil Attributes	Red sand over quartzite rocks

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 *T. basedowii* grassland (Syrinx Environmental PL 2007).



5 *Acacia* Open Shrubland

5b ***Acacia wanyu* Open Shrubland over *Eremophila tietkensii* and *Senna glutinosa* subsp. x *luerssenii* Open Shrubland over *Triodia basedowii* complex and *T. epactia* Open Hummock Grassland over *Maireana triptera*, *Sclerolaena eriacantha* and *M. melanocoma* Very Open Herbs**

Area Mapped: 100.91 ha (4.7 % of the study area)

ID of quadrats sampled: 1120_P36, 1120_P40, 1120_P41

Location + Landform

This Vegetation Association is found on low rocky quartzite hills with gentle slopes and is located in the central and southern parts of the study area. It is characterised by the presence of *Acacia wanyu.*

Vegetation Stratum Levels

Upper	*Acacia wanyu, Senna stricta*
Middle	*Eremophila latrobei* subsp. *latrobei, E. tietkensii, Senna glutinosa* subsp. x *luerssenii*
Ground	*Maireana triptera, Scleroleana eriacantha, Sporobolus australasicus, Triodia epactia, T. basedowii*
Species of Conservation Significance	*Maireana triptera, Sclerolaena minuta* and *S. eriacantha* – Range extensions
Vegetation Condition	Excellent – Some vehicle tracks close by due to drilling/exploration
Geology	Colluvium 38491 (Qrc), (Geoscience Australia, 2008)
Soil Attributes	Red to brown sand to clayey sand.

Other Locations

This Vegetation Association is most similar to the 'Clayey Areas' Vegetation Association identified in the Telfer Expansion Project (Hart, Simpson and Associates 2002).



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: 0.6 ha (0.02 % 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 Survey 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	Nil
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, 2006); Stony Hills, (Hart, Simpson and Associates 2002); and Type 16: Scattered *Eucalyptus leucophloia* subsp. *leucophloia* over *Senna glutinosa* subsp. *x luerssenii* over *T. basedowii* grassland (Syrinx Environmental PL 2007).



6 *Triodia* Hummock Grassland

6c Scattered Mallees of *Eucalyptus kingsmillii* subsp. *kingsmillii* over *Acacia stipuligera* and *Grevillea eriostachya* High Open Shrubland over *A. stellaticeps* and *Mirbelia viminalis* Low Open Shrubland over *Triodia basedowii* Hummock Grassland

Area Mapped: 545.06 ha (19.97% of the study area)

ID of quadrats sampled: 1120_P22, 1120_P31, 1120_P49, 1120_P52

Location + Landform

This Vegetation Association occurs on medium dune swales. It is very widely spread over the eastern side of the study area, with a small portion in the north eastern portion of the O'Callaghan's Study Area. This vegetation Association is characterised by a more scattered overstorey compared to the other dune swale Vegetation Association, primarily with *Acacia stellaticeps* with some emergent shrubs and trees.

Vegetation Stratum Levels

Upper	*Eucalyptus kingsmillii* subsp. *kingsmillii, Corymbia opaca*
Middle	*Acacia ancistrocarpa, A. stipuligera* and *Grevillea eriostachya*
Ground	*Amphipogon caricinus* var. *caricinus, Gompholobium polyzygum*, *Triodia basedowii*
Species of Conservation Significance	*Goodenia hartiana* – P2
Introduced Species	Nil
Vegetation Condition	Pristine to Excellent
Geology	Puntapunta Formation (Nlap) (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, (Hart, Simpson and Associates 2002); and Type 3: Mixed shrubland over *A. stellaticeps* open shrubland over *T. basedowii* 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: 167.21 ha (6.12% 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 throughout the 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).



6 *Triodia* Hummock Grassland

6e Scattered Trees of *Eucalyptus leucophloia* over *Grevillea wickhamii* subsp. *hispidula* and *Hakea lorea* High Open Shrubland over *Acacia hilliana* and *A. adoxa* Low Open Shrubland over *Triodia basedowii* complex Hummock Grassland

Area Mapped: 60.8 ha (2.23 % of the study area)

ID of quadrats sampled: 1120_P51, 1120_P54, 1120_P55

Location + Landform

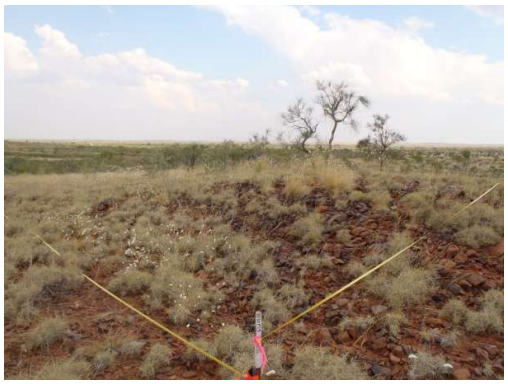
This Vegetation Association occurs on medium sized quartzite rocky hills and is located in the eastern portion of the O'Callaghan's Study Area.

Vegetation Stratum Levels

Upper	*Eucalyptus leucophloia*
Middle	*Grevillea wickhamii* subsp. *hispidula*, *Hakea lorea*
Ground	*Halgania solanacea, Heliotropium glanduliferum, Ptilotus axillaris, Triodia basedowii*
Species of Conservation Significance	Nil
Introduced Species	Nil
Vegetation Condition	Pristine
Geology	Puntapunta Formation (Nlap), (Geoscience Australia, 2008)
Soil Attributes	Red sand

Other Locations

This Vegetation Association is similar to several other previously identified associations in this area, these are; 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 *T. basedowii* grassland (Syrinx Environmental PL 2007).



6 *Triodia* Hummock Grassland

6f ***Eucalyptus odontocarpa* Open Mallee over *Acacia ancistrocarpa* and *Grevillea stenobotrya* High Open Shrubland over Low Scattered Shrubs of *Acacia ligulata* and *A. stellaticeps* over *Triodia basedowii* complex Open Hummock Grassland**

Area Mapped: 57.41 ha (2.10 % of the study area)

ID of quadrats sampled: 1120_P44, 1120_P48, 1120_P57

Location + Landform

This Vegetation Association occurs on swales between medium sized rocky hills. It occurs in the south eastern portion of the O'Callaghan's Study Area.

Vegetation Stratum Levels

Upper	*Eucalyptus odontocarpa*
Middle	*Acacia ancistrocarpa, Grevillea stenobotrya*, *Scaevola spinescens*
Ground	*Acacia ligulata, A. stellaticeps, Triodia basedowii*
Species of Conservation Significance	Nil
Vegetation Condition	Pristine to Excellent, some exploration tacks within this Vegetation Association adjacent to VA 5b.
Geology	Wilki Formation (Nsaw), (Geoscience Australia, 2008)
Soil Attributes	Red Sand to Clayey Sand

Other Locations

This Vegetation Association is similar to an association identified in a Telfer Borefield Flora Survey (Syrinx Environmental PL 2007); Type 15: Scattered shrubs over mixed *Triodia* grassland.



7 *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

Area Mapped: 54.18 ha (1.98 % 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 on the southern boundary of the O'Callaghan's Study Area. It is a common Vegetation Association in the Optimisation Study Area.

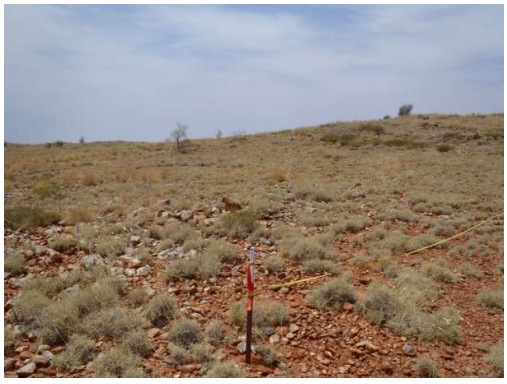
Vegetation Stratum Levels

Upper	*Eucalyptus leucophloia* subsp. *leucophloia*
Middle	*Grevillea wickhamii* subsp. *hispidula, Hakea lorea, Tribulus suberosus*
Ground	*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 the Telfer Borefield Flora Survey (Syrinx Environmental PL 2007); Type 15: Scattered shrubs over mixed *Triodia* grassland.



Appendix 6 Flora species list

Aizoaceae
Trianthema triquetra
Amaranthaceae
Aerva javanica
Alternanthera angustifolia
Ptilotus astrolasius
Ptilotus axillaris
Ptilotus calostachyus
Ptilotus fusiformis
Ptilotus nobilis
Ptilotus polystachyus
Asteraceae
Pluchea tetranthera
Streptoglossa macrocephala
Streptoglossa odora
Boraginaceae
Halgania solanacea
Heliotropium glanduliferum
Brassicaceae
Lepidium pholidogynum
Capparaceae
Capparis umbonata
Caryophyllaceae
Polycarpaea corymbosa
Celastraceae
Stackhousia muricata
Stackhousia sp. swollen gynophore (W.R. Barker *2041)*
Chenopodiaceae
Maireana georgei
Maireana melanocoma
Maireana triptera
Salsola australis
Sclerolaena cornishiana
Sclerolaena cuneata
Sclerolaena densiflora
Sclerolaena eriacantha
Sclerolaena minuta
Convolvulaceae
Bonamia erecta
Evolvulus alsinoides var. *decumbens*
Cucurbitaceae
Cucumis maderaspatanus
Cyperaceae
Fimbristylis dichotoma
Fimbristylis leucocolea
Fimbristylis neilsonii
Fimbristylis oxystachya
Fimbristylis simulans
Fabaceae
Acacia acradenia
Acacia adoxa
Acacia adoxa var. *subglabra*
Acacia adsurgens

Acacia ancistrocarpa
Acacia colei var. *colei*
Acacia hilliana
Acacia ligulata
Acacia monticola
Acacia pruinocarpa
Acacia sabulosa
Acacia sericophylla
Acacia sibirica
Acacia sphaerostachya
Acacia stellaticeps
Acacia stipuligera
Acacia synchronicia
Acacia tenuissima
Acacia tetragonocarpa
Acacia tumida var. *pilbarensis*
Acacia wanyu
Crotalaria cunninghamii
Gompholobium polyzygum
Indigofera boviperda
Isotropis atropurpurea
Jacksonia aculeata
Leptosema anomalum
Mirbelia viminalis
Otion simplicifolium
Petalostylis cassioides
Senna artemisioides subsp. *helmsii*
Senna artemisioides subsp. *oligophylla*
Senna glaucifolia
Senna glutinosa subsp. *chatelainiana*
Senna glutinosa subsp. *glutinosa*
Senna glutinosa subsp. x *luerssenii*
Senna notabilis
Senna sericea
Senna sericea x ? artemisioides subsp. *helmsii*
Senna stricta
Senna symonii
Tephrosia arenicola

Goodeniaceae

Brunonia suffruticosa
Dampiera candicans
Dampiera cinerea
Goodenia armitiana
Goodenia azurea
Goodenia hartiana
Goodenia stobbsiana
Goodenia triodiophila
Scaevola canescens
Scaevola parvifolia
Scaevola spinescens
Velleia connata

Gyrostemonaceae

Codonocarpus cotinifolius
Gyrostemon tepperi

Haloragaceae
Gonocarpus eremophilus
Lamiaceae
Dicrastylis cordifolia
Dicrastylis doranii
Newcastelia cladotricha
Lauraceae
Cassytha capillaris
Loganiaceae
Logania centralis
Malvaceae
Abutilon otocarpum
Corchorus sidoides
Corchorus sidoides subsp. sidoides
Gossypium australe
Hibiscus leptocladus
Hibiscus sturtii var. campylochlamys
Keraudrenia velutina subsp. elliptica
Sida arenicola
Sida cardiophylla
Sida sp. B Kimberley Flora (A.A. Mitchell 2745)
Sida sp. Rabbit Flat (B.J. Carter 626)
Sida sp. sand dunes (A.A. Mitchell PRP1208)
Triumfetta deserticola
Myrtaceae
Aluta maisonneuvei subsp. *maisonneuvei*
Calytrix carinata
Corymbia candida subsp. *dipsodes*
Corymbia chippendalei
Corymbia opaca
Eucalyptus kingsmillii
Eucalyptus kingsmillii subsp. *kingsmillii*
Eucalyptus leucophloia
Eucalyptus leucophloia subsp. *leucophloia*
Eucalyptus odontocarpa
Eucalyptus victrix
Melaleuca glomerata
Melaleuca lasiandra
Poaceae
Amphipogon caricinus
Amphipogon caricinus var. *caricinus*
Amphipogon sericeus
Aristida contorta
Aristida holathera var. *holathera*
Aristida inaequiglumis
Brachyachne convergens
Brachyachne prostrata
Enneapogon caerulescens
Enneapogon polyphyllus
Eragrostis eriopoda
Eriachne ? mucronata
Eriachne aristidea
Eriachne helmsii
Eriachne pulchella subsp. *dominii*

Paractaenum refractum
Paraneurachne muelleri
Sporobolus actinocladus
Sporobolus australasicus
Triodia aff. *basedowii*
Triodia aff. *lanigera*
Triodia basedowii
Triodia epactia
Triodia pungens
Triodia schinzii
Tripogon loliiformis

Polygalaceae
Polygala isingii

Proteaceae
Grevillea eriostachya
Grevillea stenobotrya
Grevillea wickhamii
Grevillea wickhamii subsp. *hispidula*
Hakea chordophylla
Hakea lorea
Hakea lorea subsp. *lorea*

Rubiaceae
Oldenlandia crouchiana
Oldenlandia pterospora

Santalaceae
Anthobolus leptomerioides
Exocarpos sparteus
Santalum lanceolatum

Sapindaceae
Dodonaea coriacea

Scrophulariaceae
Eremophila latrobei
Eremophila latrobei subsp. *glabra*
Eremophila latrobei subsp. *latrobei*
Eremophila tietkensii

Solanaceae
Duboisia hopwoodii
Solanum ? gilesii
Solanum ? horridum
Solanum centrale

Surianaceae
Stylobasium spathulatum

Violaceae
Hybanthus aurantiacus

Zygophyllaceae
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 that 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 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, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (Dell and Banyard 2000).

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 29 Amphibians recorded or that may be present in the O'Callaghan's Study 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 (September 2011 survey) 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	Rudall Rv N.P	BCE 2011
Hylidae (tree frogs and water-holding frogs)						
Main's Frog *Cyclorana maini*	L		X		X	
Water-holding Frog	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 30 Reptiles recorded or that may be present in the O'Callaghan's Study 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 O'Callaghan's area are indicated (O'C) 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	Rudall Rv N.P	BCE 2011
Agamidae (dragon lizards)						
Ring-tailed Dragon *Ctenophorus caudicinctus*	L		X		X	X
Military Dragon *Ctenophorus isolepis*	D		X	X	X	O'C
Central Netted Dragon *Ctenophorus nuchalis*	D				X	O'C
Diporiphora winneckei	L		X	X	X	X
Long-nosed Water Dragon *Amphibolurus longirostris*	L		X		X	X
Thorny Devil *Moloch horridus*	L				X	X
Bearded Dragon *Pogona minor*	D		X			X
Tympanocryptis cephalus	L					
Gekkonidae (geckoes)						
Clawless Gecko *Crenadactylus ocellatus*	D					
Fat-tailed Gecko *Diplodactylus conspicillatus*	D		X			
Sand-plain Gecko *Lucasium stenodactylum*	D		X			O'C
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					
Beaked Gecko *Hynchoedura ornata*	D					O'C
Northern Spiny-tailed Gecko *Strophurus ciliaris*	D					
Jewelled Gecko *Strophurus elderi*	D		X		X	X
Srophurus jeanae	D					X
Strophurus strophurus	L					X
Strophurus wellingtonae	L					O'C
Pygopodidae (legless lizards)						
Delma butleri	D		X			
	D					X

Species	Source	Status	Hart 2002	Syrinx 2006	Rudall Rv N.P	BCE 2011
Delma desmosa						
Delma haroldi	D					
Delma nasuta	D		X			X
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	X
Ctenotus leae	D					
Ctenotus nasutus	D		X			
Ctenotus pantherinus	D		X		X	O'C
Ctenotus piankai	D					O'C
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	
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	O'C
Lerista ips	D		X			X
Lerista labialis	L					
Lerista macropisthopus remota	L	CS2				
Lerista muelleri	L					
Lerista vermicularis	D		X			

Species	Source	Status	Hart 2002	Syrinx 2006	Rudall Rv N.P	BCE 2011
Lerista xanthura	D					
Dwarf Skink *Menetia greyii*	D		X		X	X
Menetia surda	D				X	
Morethia ruficauda	D		X			X
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	O'C
Varanus brevicauda	D		X			
Varanus eremius	D		X			O'C
Perentie *Varanus giganteus*	D					
Pygmy Mulga Monitor *Varanus gilleni*	L					
Gould's Goanna *Varanus gouldii*	D		X			O'C
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					
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 31 Birds recorded or that may be present in the O'Callaghan's Study 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 area under the current survey (BCE 2011) are marked (X). Species recorded in the O'Callaghan's area are indicated (O'C) under BCE 2011.

Species	Source	Status	Hart 2002	Syrinx 2006	Rundall Rv N.P	BCE 2011
Casuariidae (emu)						
Emu *Dromaius novaehollandiae*	D					X
Phasianidae (pheasants and quails)						
Brown Quail *Coturnix ypsilophora*	D					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					X
Brown Goshawk *Accipiter fasciatus*	D		X			X
Collared Sparrowhawk *Accipiter cirrocephalus*	D		X	X		X
Little Eagle *Aquila (Hieraaetus) morphnoides*	D		X	X		X
Wedge-tailed Eagle *Aquila audax*	D					X
Spotted Harrier *Circus assimilis*	D		X			X
Falconidae (falcons)						
Brown Falcon *Falco berigora*	D		X	X		O'C
Nankeen Kestrel *Falco cenchroides*	D		X	X		X
Australian Hobby *Falco longipennis*	D					
Grey Falcon *Falco hypoleucos*	D	CS2			X	
Peregrine Falcon *Falco peregrinus*	L	CS1	X		X	
Otididae (bustard)						
Australian Bustard *Ardeotis australis*	D	CS2	X			O'C
Turnicidae (button-quails)						
Little Button-quail *Turnix velox*	D		X			O'C
Burhinidae (stone-curlews)						
Bush Stone-curlew *Burhinus grallarius*	L	CS2				
Glareolidae (pratincoles)						
Australian Pratincole *Stiltia isabella*	D					
Oriental Pratincole *Glareola maldivarum*	D	CS1				

Species	Source	Status	Hart 2002	Syrinx 2006	Rundall Rv N.P	BCE 2011
Columbidae (pigeons and doves)						
Common Bronzewing *Phaps chalcoptera*	D		X	X		X
Crested Pigeon *Ocyphaps lophotes*	D		X	X		O'C
Spinifex Pigeon *Geophaps plumifera*	D		X	X		X
Diamond Dove *Geopelia cuneata*	D		X	X		O'C
Peaceful Dove *Geopelia striata*	L					
Cacatuidae (cockatoos and corellas)						
Galah *Cacatua roseicapilla*	D		X	X		O'C
Little Corella *Cacatua sanguinea*	D					X
Cockatiel *Nymphicus hollandicus*	D					O'C
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			O'C
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					O'C
Aegothelidae (owlet-nightjars)						
Australian Owlet-Nightjar *Aegotheles cristatus*	D					
Apodidae (swifts)						
Fork-tailed Swift *Apus pacificus*	L	CS1				
Halcyonidae (kingfishers)						
Blue-winged Kookaburra *Dacelo leachii*	L					
Red-backed Kingfisher *Todiramphus pyrrhopygia*	D		X	X		O'C
Sacred Kingfisher *Todiramphus sanctus*	L					O'C
Meropidae (bee-eaters)						
Rainbow Bee-eater *Merops ornatus*	D	CS1		X		O'C
Climacteridae (treecreepers)						
Black-tailed Treecreeper *Climacteris melanura*	D					
Maluridae (fairy-wrens and allies)						
Variegated Fairy-wren *Malurus lamberti*	D		X	X		X

Species	Source	Status	Hart 2002	Syrinx 2006	Rundall Rv N.P	BCE 2011
White-winged Fairy-wren *Malurus leucopterus*	D		X			O'C
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			O'C
Black Honeyeater *Certhionyx niger*	D		X			O'C
Pied Honeyeater *Certhionyx variegatus*	D		X			O'C
Singing Honeyeater *Lichenostomus virescens*	D		X	X		O'C
Grey-headed Honeyeater *Lichenostomus keartlandi*	D		X	X		O'C
Grey-fronted Honeyeater *Lichenostomus plumulus*	D					
White-plumed Honeyeater *Lichenostomus penicillatus*	D		X			O'C
Black-chinned Honeyeater *Melithreptus gularis*	D					X
Yellow-throated Miner *Manorina flavigula*	D		X	X		X
Spiny-cheeked Honeyeater *Acanthagenys rufogularis*	D		X			X
White-fronted Honeyeater *Phylidonyris albifrons*	D		X			
Crimson Chat *Epthianura tricolor*	D		X			O'C
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					O'C
Rufous Whistler *Pachycephala rufiventris*	D		X			X
Grey Shrike-thrush *Colluricincla harmonica*	D					
Dicruridae (flycatchers and allies)						
Grey Fantail *Rhipidura fuliginosa*	L					
Willie Wagtail *Rhipidura leucophrys*						O'C
Magpie-Lark *Grallina cyanoleuca*	D		X	X		O'C

Species	Source	Status	Hart 2002	Syrinx 2006	Rundall Rv N.P	BCE 2011
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			X
Artamidae (woodswallows and allies)						
White-breasted Woodswallow *Artamus leucorynchus*	L			X		
Masked Woodswallow *Artamus personatus*	D			X		O'C
Black-faced Woodswallow *Artamus cinereus*	D		X	X		X
Little Woodswallow *Artamus minor*	D		X	X		
Grey Butcherbird *Cracticus torquatus*	D					X
Pied Butcherbird *Cracticus nigrogularis*	D		X			X
Australian Magpie *Cracticus (Gymnorhina) tibicen*	D		X			X
Corvidae (ravens and crows)						
Torresian Crow *Corvus orru*	D		X	X	X	X?
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		O'C
Passeridae (grassfinches, sparrows and allies)						
Zebra Finch *Taeniopygia guttata*	D		X	X		O'C
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		O'C
Welcome Swallow *Hirundo neoxena*	D			X		
Tree Martin *Hirundo nigricans*	D					
Fairy Martin *Hirundo ariel*	D		X	X		O'C
Sylviidae (old world warblers)						
Spinifexbird *Eremiornis carteri*	D					X
Rufous Songlark *Cincloramphus mathewsi*	D					X
Brown Songlark *Cincloramphus cruralis*	D					X
TOTAL	109	11	45	28	4	70

Table 32 Mammals recorded or that may be present in the O'Callaghan's Study 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 (2006) and in the current survey (BCE 2011) and are marked (X). Species recorded in the Telfer O'Callaghan's study area are indicated (O'C) 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	Rundall Rv N.P	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*		CS1	?X			? O'C
Little Red Kaluta *Dasykaluta rosamondae*	D		X	X	X	O'C
Pilbara Ningaui *Ningaui timealeyi*	D		X		X	X
Planigale sp. *Planigale* sp. 2	D		X			X
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	O'C
Kultarr *Antechinomys laniger*	L	CS3				
Thylacomyidae (bilbies)						
Bilby *Macrotis lagotis*	D	CS1	X	X	X	O'C
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				
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)						

Species	Source	Status	Hart 2002	Syrinx 2006	Rundall Rv N.P	BCE 2011
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	X
Spinifex Hopping-Mouse *Notomys alexis*	D		X			X
Desert Mouse *Pseudomys desertor*	D		X	X		
Sandy Inland Mouse *Pseudomys hermannsburgensis*	D		X	X	X	O'C
Common Rock-Rat *Zyzomys argurus*	D					
Other Introduced Fauna						
Rabbit *Oryctolagus cuniculus*	D					
Dingo *Canis lupus dingo*	D		X	X		O'C
Fox *Vulpes vulpes*	D					X
Feral Cat *Felis catus*	D		X			O'C
Camel *Camelus dromedarius*	D		X	X		X
Donkey *Equus asinus*	D					X
TOTAL	43	12	15	8	16	15

Table 33 Vertebrate fauna considered extinct in the region; records from Hart, Simpson and Associates (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 34 Vertebrate fauna returned in databases but for which there is no suitable habitat in O'Callaghan's 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)	
Pacific Black Duck	*Anas superciliosa*
Grey Teal	*Anas gracilis*
Australian Wood Duck	*Chenonetta jubata*
Pink-eared Duck	*Malacorhynchus membranaceus*
Hardhead	*Aythya australis*
Plumed Whistling-Duck	*Dendrocygna eytoni*
Ardeidae (herons and egrets)	
White-faced Heron	*Egretta novaehollandiae*
White-necked Heron	*Ardea pacifica*
Eastern Great Egret	*Ardea modesta*
Intermediate Egret	*Ardea intermedia*
Little Egret	*Egretta garzetta*
Plataleidae (ibis and spoonbills)	
Royal Spoonbill	*Platalea regia*

Straw-necked Ibis	*Threskiornis spinicollis*
Rallidae (crakes and rails)	
Black-tailed Native Hen	*Gallinula ventralis*
Recurvirostridae (stilts and avocets)	
Black-winged Stilt	Himantopus himantopus
Charadriidae (plovers, dotterels and lapwings)	
Red-capped Plover	Charadrius ruficapillus
Black-fronted Dotterel	Charadrius (Elseyornis) melanops
Red-kneed Dotterel	Erythrogonys cinctus
Oriental Plover	Charadrius veredus
Scolopacidae (sandpipers)	
Common Sandpiper	Actitis hypoleucos
Common Greenshank	Tringa nebularia
Marsh Sandpiper	Tringa stagnatilis
Laridae (gulls and terns)	
Whiskered Tern	*Chlidonias hybrida*
Silver Gull	*Larus novaehollandiae*
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 35 Reptile and small mammal trapping data; results of surveys at all sites across the 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 6 and 7 are located within O'Callaghan's 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		
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

Species	Sampling site										
	1	2	3	4	5	6	7	8	9	10	11
Spinifex Hopping-Mouse *Notomys alexis*				1							
Sandy Inland Mouse *Pseudomys hermannsburgensis*		3	9	8	14	8	11	1	2	7	5
Total	**19**	**21**	**21**	**28**	**31**	**32**	**19**	**14**	**21**	**28**	**23**

Table 36 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. Site numbers 6 and 7 are located within O'Callaghan's Study Area.

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
Cockatiel	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, 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 DSEWPaC.

- 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 (by-catch) of Sea Turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South;
- Incidental catch (or by-catch) 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.

(adapted from Cork *et al*. 2006).

Appendix 10 Coordinates (Zone 51) and sampling deployment at sampling locations in the O'Callaghan's Study Area

Transect code	Sampling point code	Pitfall	Elliott	Funnel	Bird Census	Easting (mE)	Northing (mN)
Line 6	6.1	X		X	X	424944	7588885
Line 6	6.2	X	X		X	424915	7588834
Line 6	6.3	X		X	X	424890	7588789
Line 6	6.4	X	X		X	424872	7588729
Line 6	6.5	X		X	X	424849	7588687
Line 6	6.6	X	X		X	424826	7588629
Line 6	6.7	X		X	X	424813	7588573
Line 6	6.8	X	X		X	424787	7588519
Line 6	6.9	X		X	X	424751	7588483
Line 6	6.10	X	X		X	424715	7588437
Line 7	7.1	X		X	X	421194	7591391
Line 7	7.2	X	X		X	421233	7591350
Line 7	7.3	X		X	X	421270	7591305
Line 7	7.4	X	X		X	421310	7591268
Line 7	7.5	X		X	X	421360	7591238
Line 7	7.6	X	X		X	421400	7591211
Line 7	7.7	X		X	X	421438	7591179
Line 7	7.8	X	X		X	421476	7591158
Line 7	7.9	X		X	X	421514	7591125
Line 7	7.10	X	X		X	421556	7591088

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

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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.