Appendix 16

Mount Emerald Wind Farm Flora Report (R72444)

Prepared by RPS

Mount Emerald Wind Farm

Flora Report

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Contents

Tables

Figures

Plates

Appendices

Glossary of Terms, Terms & Acronyms

Term	Definition
ASL	Above Sea Level
Edaphic	Referring to the qualities of the soil (e.g. drainage, fertility, structure).
Endemic	Restricted to a geographical area. Narrow endemic refers to plants with a very restricted distribution range and usually only found in a particular environment, rock or soil type (e.g. ridges, rock pavements and other niche habitats).
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
Land zone	Land zones are categories that describe the major geologies and associated landforms and geomorphic processes of the State of Queensland (Wilson and Taylor, 2012).
Montane	Referring to the mountain environment; and in this report, especially above 900 m ASL.
NCA	*Nature Conservation Act 1992* (Queensland).
Nomenclature	The names of plants. Nomenclature for plants in this report follows Bostock and Holland (2010).
RE	Regional Ecosystem
Regional ecosystem	Vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil (Sattler and Williams, 1999).
Rhyolite	A close grained, igneous, acid-volcanic rock. The primary geological unit of the site is described as the Walsh Bluff Volcanics.
Rock outcrop	A soil-less group of rocks exposed and pronounced beyond the surrounding ground surface.
Rock pavement	An area of continuous rock more or less in a near-horizontal plane. Can be exposed or obscured by a thin veneer soil and plant cover. May also be referred to in this report as rock plates or rock platforms.
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Federal Government). Administers the EPBC Act.
Skeletal	Pertaining to the thin veneer of soil matter which develops on rocky landscapes, scoops on rock pavement surfaces and on rocky ridges.
VMA	*Vegetation Management Act 1999* (Queensland).

Executive Summary

The Mount Emerald Wind Farm project proposed by RAC (RATCH-Australia Corporation) intends to develop a wind farm comprising up to 70 turbines and associated power generation infrastructure on land located in the vicinity of Walkamin, north Queensland. The land is properly described as Lot 7 on SP235244 and occupies an area of 2422 ha.

This report details the findings relevant to the spot locations of the wind turbines and the potentially affected environment where the interconnecting access and cabling tracks are proposed. It also discusses vegetation and flora-related matters relevant to Kippen Drive - the main access road into the site.

The project is subject to the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) because of the presence of matters of National Environmental Significance (NES). It has been determined by the administering Department of the Environment (DotE) that the appropriate level of assessment under the EPBC Act for the wind farm project is by Environmental Impact Statement (EIS). The matters of NES discussed in this report are plants.

As a component of the EIS, investigations were completed of the project site and regional environs to characterise the vegetation and its flora, and to understand the landscape and biophysical attributes that underpin and constitute the habitats for plants of interest to conservation.

Numerous field surveys of the site and in environmentally relevant regional locations have been conducted from May 2010 to the most recent in May 2013. These surveys were performed to elucidate and describe the ecology of the vegetation and its flora, and to determine the level of impacts that could occur as a result of construction and operation of the wind farm. A strategic focus has been on the presence and dynamics of conservation significant and poorly known flora, with attention given to those species listed under the EPBC Act.

The Mount Emerald wind farm project area is characterised by elevated and dissected mountainous landforms on rhyolite geology with skeletal soils. The highest point is 1089 m ASL (above sea level) in the south of the project area; while Kippen Drive is the lowest point at 540 m ASL. Because of the combination of elevation, exposure and landform, unique and poorly represented vegetation communities are supported in some locations of the site.

Virtually the entire site, with the exception of cleared land along the existing access tracks and below the powerline is covered by remnant vegetation as defined under Queensland's *Vegetation Management Act 1999* (VMA). Applicable under the VMA is the presence of two bioregions: the Wet Tropics and the Einasleigh Uplands, where the former is mapped at a scale of 1:50 000 and the latter at 1:100 000. Remnant vegetation across the site has a conservation status under the VMA of Least Concern and Of Concern. The Of Concern communities are only found in the Wet Tropics bioregion section. The entire Einasleigh Uplands section is shown on mapping to have a conservation status of Least Concern.

The boundary between the two bioregions is approximately demarcated by the route of the Chalumbin to Woree 275 kV electrical transmission line. The section between Woree and Springmount was completed in 1998. This bioregion boundary also broadly corresponds with the change in landform of dissected rhyolite ridges and precipitous slopes of the Wet Tropics bioregion, to the more gentler landform and different vegetation communities of the Einasleigh Uplands bioregion section. Within the project site, all the significant populations of conservation significant plants listed under the EPBC Act are found in the Wet Tropics bioregion section, while only a few isolated populations are found north of the transmission line in the Einasleigh Uplands.

The Wet Tropics bioregion is also the location of the montane heath vegetation, which characterises the ridge country and rock pavements at elevations greater than 900 m ASL, where "cloud stripping" of moisture is a key determinant of its position in the landscape and its unique floristic composition. The montane heath community is equivalent to the subunit remnant vegetation type regional ecosystem (RE) 7.12.57c, which is listed under the VMA as Of Concern. This RE is the hosting community for at least two species of conservation significant plants listed under the EPBC Act: *Grevillea glossadenia* and *Homoranthus porteri*; whilst the unit also hosts other conservation significant plants including *Melaleuca uxorum* and *Plectranthus amoenus* (endangered and vulnerable respectively under Queensland's *Nature Conservation Act 1992*). Although not being listed under the EPBC Act, the highly restricted *M. uxorum* is considerably 'rarer' and at threat than the species cited here for the EPBC Act. Two populations of this shrub have been recorded from ridges in the SW of the site.

RE 7.12.57c is constrained to high elevation, exposed country in the southwest sector of the wind farm site. Consequently, the community is found at locations where a number of wind turbines are proposed to be constructed. Due to the width constraint of ridges, the montane heath community is at greatest risk of being impacted by construction pads and the interconnecting cabling tracks that link the turbine arrays. In some instances, the formation of tracks along ridges could result in an almost total loss of heath vegetation.

In contrast to the highly diverse Wet Tropics bioregion section of the site, all woodland communities in the Einasleigh Uplands bioregion section of the project site are listed as Least Concern under the VMA. Interestingly, this bioregion section also hosts the fewest plant species of conservation interest - both at the species level and the number of individuals present (i.e. population sizes are smallest). Two species of plants listed under the EPBC Act have been located in relation to proposed access tracks and turbine footprints of the wind farm in this section: *Grevillea glossadenia* and *Homoranthus porteri*. Another species, *Plectranthus amoenus* (vulnerable under the NCA) is also present on rock pavements in the vicinity of one turbine. Generally though, the north and east-facing sections of the project area are least constrained in terms of important vegetation communities and conservation significant plants.

Direct impacts such as vegetation clearing will result in the loss of hosting vegetation communities for conservation significant plants, and in some instances the possible total loss of individual populations. If the project were to proceed in the areas associated with narrow ridges south of the transmission line, the plant species populations most at risk are *Homoranthus porteri* (vulnerable under the EPBC Act); and *Melaleuca uxorum* (endangered under the NCA) and *Plectranthus amoenus* (vulnerable under the NCA).

Less conspicuous, but long-term impacts include the introduction of weeds adjacent to access tracks and cabling routes. A range of other impacts are associated with the establishment of weeds, and these include altered fire regimes, shifts in floristic composition; species replacement and displacement; and the introduction of pathogens. The potential for deleterious pathogens such as Phytophthora and more recently, myrtle rust is increased with the presence of vehicles, machinery and construction activities in formerly pathogen-free areas.

Following an assessment of the categories of impacts, a range of strategic mitigation measures are recommended. Given the unique qualities of large sections of the project area, these mitigation measures are focussed on site-specific characteristics and landscape situations. Included are measures and concepts regarding environmental offsets, identification and preservation of high value ecological zones within the project site, land rehabilitation, weed control, fire management and production of training material and interpretive media for construction workers, as well as project managers.

It is recognised that when the wind farm is operational and environmental controls have been put in place, there are additional opportunities for managing impacts. Fencing, property access constraints, the role of land caretakers and maintenance of the operational footprint are important strategies that will need to be considered if the ongoing nature of the project is to be sustainably managed with a commensurate level of environmental due diligence. Management of the project in this sense does not incur an environmental imposition, but has merits in cost-saving efficiencies (weed control for example) and sets the precedent and ethos for sustainable energy generation - the platform from which the wind farm is presented.

1.0 Introduction

1.1 Overview

RATCH-Australia Corporation Limited (RACL) is the proponent of the Mount Emerald Wind Farm project near Walkamin, north Queensland. A referral under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) was submitted to the administering Federal Government authority SEWPaC (Department of Sustainability, Environment, Water, Population and Communities) for assessment. Subsequently, the project was deemed by SEWPaC to be a *Controlled Action* under the Act and designated to be further assessed through an Environmental Impact Statement (EIS).

RPS were commissioned on behalf of RAC to prepare selected components of the EIS, one of these being an account of the flora and the potential impacts.

The assessment of impacts discussed in this report are based on the design layout and concept provided by the proponent of the project and dated July 2012, with the amended plan from March 2013 (see **Appendix A**). This report does not account for new turbine layouts, construction designs or information provided after March 2013. Certain calculations (e.g. impacted areas) therefore, should be treated as provisional in light of new information or design changes being submitted.

1.2 Terms of Reference and Scope of Works

The Terms of Reference (ToR) for the EIS were developed by SEWPaC (2012) in accordance with the guidelines set out under the EPBC Act. RPS (Australia East Coast) were commissioned on behalf of RAC to prepare the EIS document. This report presents the information relating to plant species listed under the EPBC Act and other conservation significant matters, such as habitats for plants, special vegetation types, and narrowly restricted species with limited habitat ranges.

Part 5, and specifically section 5.9 and 5.10 of the EIS Guidelines (SEWPaC (DotE), 2012) outline the content for the EIS for assessing the wind farm proposal and its potential impacts. The EIS Guidelines provides the framework for the scope of this report, and is centred around providing information relating to the potential impacts to the existing environment and Matters of National Environmental Significance (MNES), and a description of the proposed mitigation measures and strategies to reduce or eliminate such impacts.

1.3 Project Summary

RACL proposes to construct the "Mt Emerald Wind Farm" on elevated land located approximately 20 km SSW of the town of Mareeba on the Atherton Tablelands in north Queensland. The project site occupies a total area of 2422 ha.

The wind farm's electrical energy generation facility and infrastructure will comprise 63 wind turbines and associated tracks for underground cabling and access between the turbine arrays (**Appendix A**). An electricity substation is also proposed and will feed energy generated from the wind farm into the existing Chalumbin to Woree 275 kV transmission line. A conspicuous section of this transmission line more or less dissects the site and closely corresponds with bioregional boundaries.

The wind farm site occurs at the northern extent of the Herberton Range and includes the prominent landmark of Walsh Bluff at the most northern end. Mount Emerald (proper) is located off the site at the southern boundary. The undisturbed landform and vegetation is contiguous with Mt Emerald. Land to the north, east and west is characterised by agriculture and is generally cleared and modified.

1.4 The Study Area - Project Site

1.4.1 Overview of Landscape

The Mount Emerald wind farm project site is situated over mountainous terrain coinciding with the northern extent of the Herberton Range. The site is characterised by acid igneous rhyolite geology forming windswept ridges and rock outcrops interspersed with rock pavements, which support skeletal soils. Between these prominent features are undulating valleys with sheltered aspects and with deeper, more improved soil.

Thin veneers of soil with low fertility, wind-shearing and exposure to extremes of temperature and solar radiation prevent the growth of tall vegetation on ridges and rock pavements. Soils developed from rhyolite parent rock are naturally low in important plant nutrients such as nitrogen and phosphorus. Exposure, depth, drainage, water availability and the nutrient status of soil are factors affecting the physiognomy of the vegetation (Groves, 1981). This is notably relevant to the heath-like vegetation which occurs as a mosaic along ridges and upper slopes. It is this landscape position where several turbines and connecting tracks are proposed to be established.

Specialist habitats for plants are afforded by the fireproof nature of rock outcrops and rock pavements. These habitats support heath, low woodland and shrublands, which are also the preferred habitats for plants of interest to conservation. The montane heath vegetation of the Herberton Range is known for its special qualities and important habitats for a range of conservation significant plants and narrow endemic species (Craven and Ford, 2004).

Generally within the site, taller woodlands found on lower slopes and in valleys with areas of deeper soil support fewer conservation significant plants; although poorly known terrestrial orchids exist in the grassy ground layer of these communities and include *Habenaria elongata* and possibly *Diuris oporina*.

The site is broadly divided in terms of the degree of surface relief. This has bearing on the landforms, vegetation types and ultimately, the constructability of the project. To the south of the Chalumbin to Woree 275 kV transmission line the land is conspicuously dissected, rugged and characterised by narrow, high ridges and in some instances, precipitous slopes. Heath vegetation and low, windswept sparse woodlands characterise this landform. This area falls into the Wet Tropics bioregion section of the site and corresponds with the highest level of biodiversity in terms of vegetation and conservation significant flora, as well as being the least disturbed. It is a contiguous tract of land with Mt Emerald on the southern boundary and holds exceptionally high levels of environmental integrity.

The land to the north of the transmission line exhibits less surface relief, dissected ridges and steep slopes become far less frequent, and the landform generally becomes more undulating. Consequently, different vegetation types are hosted; where woodlands are generally taller, more widely represented on a regional basis, and conspicuously fewer conservation significant plants are present. This part of the site corresponds with the Einasleigh Uplands bioregion section of the site, and holds the lower environmental values than the Wet Tropics section. From a constructability viewpoint, the Einasleigh Uplands section is least constrained and offers the most opportunities with the potential for notably reduced environmental impacts on important plant habitats and conservation significant plant species.

1.4.2 Geology

The primary geological unit described for the entire site is the Walsh Bluff Volcanics. The Walsh Bluff Volcanics (Pb) are included in the Early Permian, Koolmoon Volcanic Group and described as "Buff, greenish-grey or dark grey, welded rhyolitic ignimbrite; minor rhyolite lava, quartzose sandstone, volcanic breccia, tuff." (Donchack and Bultitude, 1998).

Regionally, the Walsh Bluff Volcanics (Pb) unit is not represented elsewhere on the ATHERTON 1:250 000 geological series map sheet (Donchak, *et al*., 1997). The unit's northern limit is the landmark of Walsh Bluff. It extends southwards to incorporate Hoot Hill and Mount Emerald, east to Bones Knob, and includes parts of the ranges west of Atherton, and Rocky Bluff north of the Walsh River. The distribution of the unit is shown in **Figure 1**.

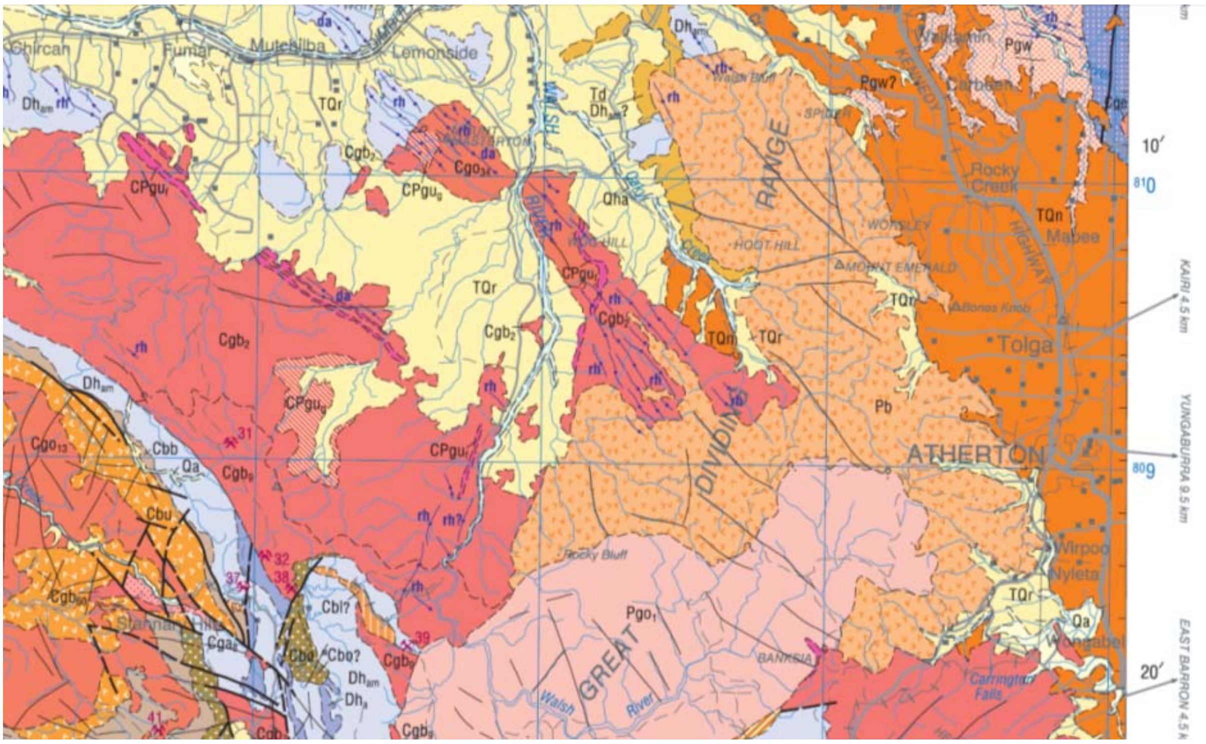

Figure 1 Extract from the ATHERTON 1:250 000 geological map sheet (Donchak, *et al*., 1997) showing the limit of the Walsh Bluff Volcanics (Pb).

1.4.3 Queensland Land Zone Concept

Land zones are central to the concept and categorisation of Queensland's remnant vegetation communities and the regional ecosystem classification (RE) after Sattler and Williams (1999). Wilson and Taylor (2012) define land zones as major geologies and associated landforms. Queensland is classified into 12 land zones.

The site is mapped as land zone 12, which is broadly defined as older Mesozoic to Proterozoic igneous rocks. Another wide definition is given as "Metamorphosed Cretaceous and older igneous rocks" (Wilson and Taylor, 2012).

The detailed description of land zone 12 (Wilson and Taylor, 2012) is "Mesozoic to Proterozoic igneous rocks, forming ranges, hills and lowlands. Acid, intermediate and basic intrusive and volcanic rocks such as granites, granodiorites, gabbros, dolerites, andesites and rhyolites, as well as minor areas of associated interbedded sediments. Excludes serpentinites (Land Zone 11) and younger igneous rocks (Land Zone 8). Soils are mainly Tenosols on steeper slopes with Chromosols and Sodosols on lower slopes and gently undulating areas. Soils are typically of low to moderate fertility."

1.4.4 Natural Integrity and Specialist Habitats

The wind farm site holds high levels of natural landscape integrity. Highest integrity broadly coincides with the highest points and elevated land across the site, and notably in the southern portion of the site - south of the 275 kV transmission line in the Wet Tropics bioregion. The environmental qualities of the site are reported by Craven and Ford (2004) and Ford and Hardesty (2012), who note the environmental diversity of the western side of the Atherton Tableland, and furthermore summarise the unique and special habitat characteristics created by the interaction between altitude, climate and geology. The EIS compiled for the Chalumbin to Woree 275 kV transmission line (Kutt*, et al*., 1995) also records the very high biodiversity and environmental values associated with the Wet Tropics bioregion section of the site.

1.4.5 Past Disturbance and Land Use

The site is part of the former Springmount Cattle Station. The higher elevation sections of the site where the wind farm is proposed is not fenced, and it possible that some incursions by cattle may have been made several years ago. Evidence of grazing though is very limited and might account for at least one species of introduced pasture plant (*Stylosanthes scabra*).

Some sections of lower land on east facing slopes and areas north of the powerline shows signs of past disturbance: possibly from cattle grazing on the most fertile ground (protected, wetter and flatter sites). This disturbance is evidenced by moderate to heavy occurrences of the introduced grass *Melinis minutiflora* (molasses grass) and the pasture legume *Stylosanthes scabra* (shrubby stylo). The herbaceous Asteraceae weed *Praxelis clematidea* (Praxelis) is widespread across the site, with higher densities observed on rock pavements and around outcropping rock. This species is wind-dispersed; hence its broad distribution. It is possible that seed of Praxelis may also be carried on the fur of mammals, and definitely by machinery (CRC Weed Management, 2003).

1.4.6 Landscape Condition

The rugged and remote south-west portion of the site is in a near-pristine state. This condition is evidenced by large-class trees of *Eucalyptus reducta* (white stringybark) forming well-structured woodlands, where weeds are absent. The ridge country in this section of the site is of exceptionally high natural value and is the principal habitat for many conservation significant and locally endemic plant species including *Grevillea glossadenia*, *Homoranthus porteri*, *Melaleuca borealis*, *M. uxorum*, *Cryptandra debilis*, and numerous other species reliant on the particular biophysical character created by geology, altitude and climate, as well as separation from coastal influences (Craven, *et al*., 2003; Craven and Ford, 2004).

The plants with very narrow distributions grow in a mosaic of outcropping rock and rock pavements with skeletal soils supporting heath and sparse low woodland vegetation (**Plate 1**). With the exception of *G. glossadenia*, they have a particularly restricted habitat range. Their distribution coincides with some of proposed turbine locations and the connecting tracks and cabling network in the southern sector of the project site.

Plate 1 Ridges and rock pavements shape the preferred habitat for plants of conservation significance. (*Melaleuca uxorum* site).

In contrast to the Wet Tropics bioregion section, the northern sector of the site (mainly north of the 275 kV transmission line) supports far less plant species with narrow distribution. This land hosts significantly fewer plants of conservation interest; where for example, *Homoranthus porteri* is found only at two locations associated with rock pavements. Narrow endemic species such as *Melaleuca borealis*, *Cryptandra debilis*, *Indigofera bancroftii*, *Hovea nana*, *Mirbelia speciosa* subsp. *ringrosei* and *M. pungens* plus others occur much less frequently, and in the case of many species, do not occur at all or are represented by a few individuals found in micro-sites of suitable habitat and usually at elevations greater than 900 m ASL.

With the exception of the gorge associated with Granite Creek at the northern end of the site, plus a number of outlying rocky features and steeper slopes, the northern portion of the site has a more uniform surface, with fewer dissected features and rocky drop-offs. Because of the less dramatic landscape, gentler slopes and wider reaching zones of flat land found in relation to the plateau, different vegetation types are present on differently textured and slightly better quality soils.

The differences in vegetation in the northern section are both structural and floristic. Heath vegetation is only found in very small areas along the ridge and spur of land just north of the transmission line on the most western edge. Again, these patches of heath are found at elevations higher than 900 m ASL. Woodlands however, predominate even on higher parts of the site such as Walsh Bluff. These woodlands do not support the same component of flora with limited distributions and rarely support conservation significant plants (**Plate 2**).

Plate 2 The gentler and more uniform landscape of the northern half of the project site supports woodlands and notably fewer conservation significant plants. Here at Walsh Bluff, kangaroo grass (*Themeda triandra*) is the dominant species under a woodland of lemon-scented gum (*Corymbia citriodora*).

1.4.7 Regional Significance

Regionally, the site has physiographic affinities with the Baal Gammon-Watsonville landscape to the southwest. Although geologically different, there are many floristic similarities - notably in the ground flora - with the mountainous, dissected terrain that broadly follows the route of the existing Chalumbin to Woree 275 kV transmission line. The wind farm site is also located and forms the most northern extent of the Mount Emerald and Herberton Range mountain country, which subsequently corresponds with the distribution limit for many important populations of plant species.

Due to the high elevation vegetation affinities with Mt Emerald, the site is considered regionally significant for its montane heath vegetation and many plant species solely reliant on the specific mountain environment.

These plants include *Melaleuca uxorum*, *Homoranthus porteri* and several narrow endemic species described elsewhere in this report.

1.4.8 Modified Plant Habitats

Landscape modification and alienation by weeds is prevalent along both sides of the unsealed entry road of Kippen Drive from where it enters the property from Springmount Road to the base of the ascent into the wind farm site. The length of this disturbance zone is approximately 4.5 km. Grader grass (*Themeda quadrivalvis*), shrubby stylo (*Stylosanthes scabra*) and Hyptis (*Hyptis suaveolens*) are dominant species forming exclusive stands, and are a legacy of intensive agricultural land use and road maintenance (**Plate 3**). Along Kippen Drive, vegetation integrity is at its lowest and it is only the riparian fringe of Granite Creek and at the major stream crossings where the situation improves because of vegetation shading and seasonal flood pulses that scour surface vegetation.

Plate 3 Weeds such as grader grass, stylo and Hyptis form dominant stands either side of the main access road into the site (Kippen Drive).

On the wind farm site proper (i.e. the mountain country of dissected landform above the farms and cropping lands of Walkamin and Arriga), anthropogenic disturbance is limited to an existing powerline easement and associated tracks providing access to towers; plus two tracks associated with the wind farm development.

Entry to the wind farm site is from the end of Kippen Drive, where a winding track of 3.98 km provides access to the powerline corridor. Initially, the track is steep as it enters the rocky, rhyolite landform that characterises the site at higher elevation. On this track weeds are conspicuously less evident in both abundance and the number of species. Isolated occurrences of thatch grass (*Hyparrhenia rufa*) are found on the climb into the site's interior, but the species is absent thereafter. Other notable incidences of weeds are found on the cleared land and track associated with the powerline corridor. Species include small populations of *T. quadrivalvis*, sparse to moderate populations of *P. clematidea*, and isolated incidences of *Stylosanthes scabra* (stylo)

The power line corridor coincides with the boundary between the Wet Tropics and Einasleigh Uplands bioregions and represents a linear clearing disturbance footprint of 2.96 km across the site in an approximate east-west orientation. Along this corridor and restricted to the land affected by the immediate influence of the vehicle track are weeds such as Lantana (*Lantana camara*), molasses grass (*Melinis minutiflora*) and pigeon grass (*Setaria pumila*). In May 2013, a small population of a tall rat's tail grass (*Sporobolus* sp.) was recorded from two powerline tower pads. It is most likely that this grass is introduced and poses a noteworthy environmental threat if allowed to spread.

Lantana occurs as a small, isolated thicket at the base of a powerline tower; whilst a swath of pigeon grass (*Setaria* sp.) and molasses grass (*Melinis minutiflora*) has a more deleterious presence on the slope leading into the most eastern stream crossing along the main powerline maintenance track. After the stream crossings (heading west) weeds become less frequent, with common species such as red natal grass (*Melinis repens*), and Praxelis (*Praxelis clematidea*) and the legacy of grazing - stylo (*Stylosanthes scabra*) mostly concentrated around bases of powerline towers. Weeds along the powerline corridor in the western sector of the project site are progressively replaced by native successional species: typically *Acacia umbellata*, which form thickets in response to maintenance clearing of the low open woodland of silver-leaf ironbark (*Eucalyptus shirleyi*) below the powerline.

Praxelis is found even in remote areas of windswept ridges elsewhere on the site, but is less abundant in developed woodland where the native kangaroo grass (*Themeda triandra*) is dominant. Based on seasonal observations of Praxelis, the species readily responds to disturbed, rocky ground and the spoil of pushed-up track edges, and may have an effect on influencing the growth and reproduction of native species, particularly grasses and the low subshrubs that typically grow on undisturbed rocky ground with skeletal soil (**Plate 4**).

Plate 4 The weed Praxelis (*Praxelis clematidea*) rapidly colonises skeletal soil and disturbed rocky ground.

Two unrelated tracks branch from the powerline corridor and give access to a wind monitoring tower on the south of the site, and another wind monitoring tower in the northern half. These tracks, when measured from their junctions with the powerline corridor, have a length of 0.81 km and 3.9 km respectively.

The main 80 m wind monitoring tower to the south of the powerline has the largest footprint and consequently, a higher level of associated ground disturbance. A suite of weeds have established in the construction pad soil-base mix imported into the site. These included sicklepod (*Senna obtusifolia*) - a Class 2 declared plant under Queensland's *Land Protection (Pest and Stock Route Management) Act 2002* - and wynn cassia (*Chamaecrista rotundifolia* var. *rotundifolia*): both are leguminous species that can suppress native plant development. In contrast, the conservation significant native shrub *Grevillea glossadenia* has successfully colonised disturbed, rocky ground around the tower and subsequently constitutes one of the commonest woody plants in the ground and lower shrub layer.

1.4.9 The Role of Cloud Stripping and Water Harvesting

Much of the literature regarding cloud stripping concerns vine forest or closed forest vegetation (for example, McJannet, *et al*., 2011). Given the scarcity of information relating to montane sclerophyll heathlands in the

Wet Tropics, some concepts underpinning the phenomenon of cloud stripping and water harvesting can be extrapolated to the montane environment of the Mt Emerald wind farm site.

Cloud stripping is reported to produce potentially up to 40% of the total water input for upland forests in the Wet Tropics (Laurance and Peres, 2006). Tracey (1982) provides an altitudinal scale of four zones in relation to the vegetation types which broadly correlates with the communities which occur within the Wet Tropics bioregion boundary. This scale describes the altitudinal zone of between 400-800 m ASL as the *Uplands*. A majority of the proposed locations for wind turbines intersects contours between 790 and 1040 m ASL. Tracey (1982) defines this zone as *Highlands*, and given the site's position on the western and drier fringe of the Wet Tropics bioregion where sclerophyll vegetation is considerably more dominant than vine forest (closed forests), it can be expected that the water budget available through cloud stripping is lower (i.e. there are greater sunlight hours and less rainfall than for example, on the Lamb Range).

Ford and Hardesty (2012) identify the cloud base in the vicinity of the Mt Emerald wind farm site as being approximately 900 m ASL; and further describe the role that cloud interception and moisture stripping has in relation to the distribution and presence of conservation significant plants and the heath community identified as being specific to the ridge country of that region. Personal observations (S. Gleed) of the cloud base over the site confirm the findings of Ford and Hardesty (2012) and the correlation between altitude, vegetation community, water harvesting from the local cloud base (**Plate 5**), and the occurrence of montane heath vegetation.

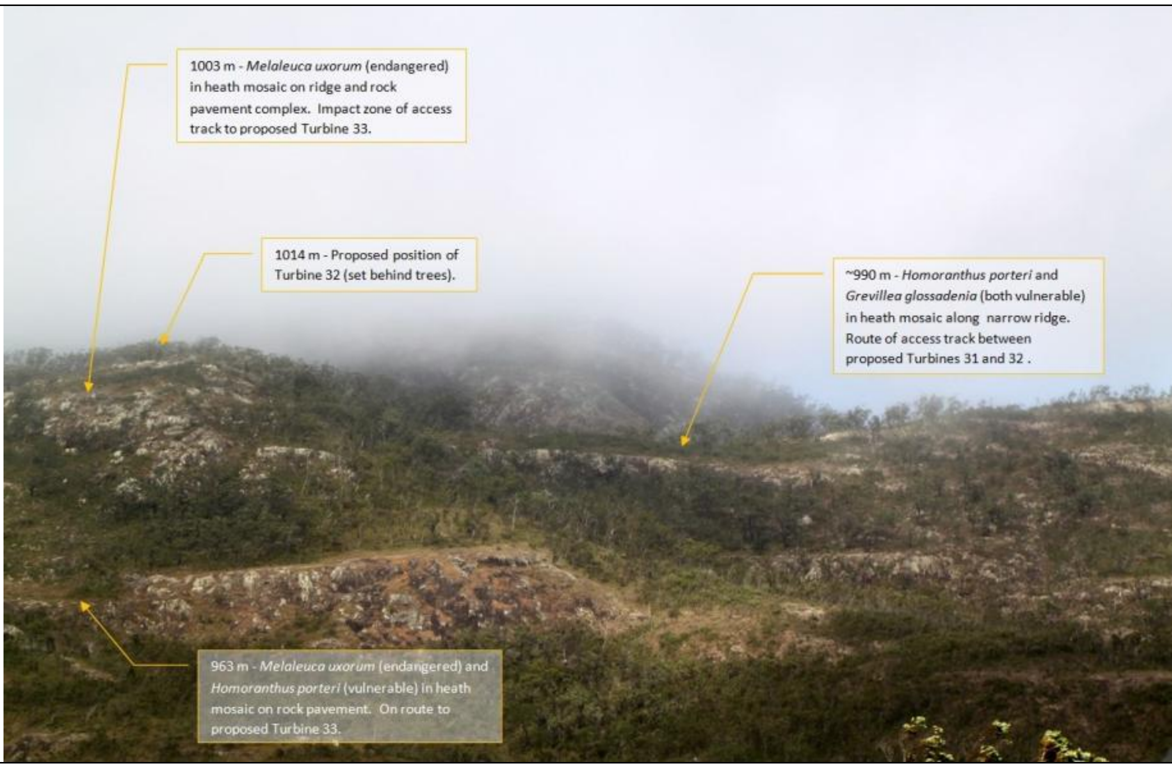

Plate 5 The cloud base over the south western portion of the site, which corresponds with the presence of tropical montane heath communities and several conservation significant plants as well as the primary habitat for many narrow endemic species. Photo taken in February 2013.

GPS tracking of the montane heath community south of the powerline determined that key plant indicator species of the community 'dropped out' at an elevation of approximately 900 m (± 30 m) and below. For example, characteristic plants of montane heath on the site include *Cryptandra debilis*, *Homoranthus porteri*, *Mirbelia pungens*, *M. speciosa* subsp. *ringrosei*, *Melaleuca borealis* and *Plectranthus* sp.

2.0 Methodology

The extensive area of land to be covered and the difficulty and time constraints associated with accessing remote parts of mountainous terrain, necessitated several field surveys. These comprised walking surveys between proposed turbine locations (i.e. surveying the interconnecting track network), and point surveys of the proposed turbine construction area. Several turbine location revisions became apparent during the course of the fieldwork and this presented a number of spatial challenges in terms of identifying the correct survey site.

Interpretation of high resolution multi-spectral imagery and aerial photography informed the route planning and investigation areas for specialist habitats. Navigation on foot was primarily by handheld GPS with a stated accuracy of ±3 m.

Sample size for the heath community was derived from the minimal area recommended by Mueller-Dombois and Ellenberg (1974), which is 10-25 m^2. In reality this sampling area was considerably larger given the linear orientation of ridges where the community occurs, and the route of foot traverses which followed the line of the ridges and the proposed location of the interconnecting tracks.

Woodland communities were sampled with a view of investigating a minimum area of 500 m^2 recommended by Neldner, *et al*. (2012). Again, due to a number of repeated surveys, a larger area was often investigated. This had the benefit of elucidating a wider range of species.

Surveys over three years were completed in February, March, April, May, June and August. Effectively this leaves a six-month gap in survey effort and this has been identified as a knowledge gap in the investigation process. Wannan (2009) advises that additional dry season surveys may be appropriate for the Herberton-Wairuna subregion of the Einasleigh Uplands bioregion; and therefore, ideally, surveys would have been completed during every month to account for seasonal changes and fluctuations.

As many of the turbine sites and interconnecting tracks were surveyed on foot. At each turbine location (several revisions), the entire vascular flora was recorded including the tree layers, shrub layers and ground layer. Particular attention was given to the ground layer component as this is generally considered to be the most diverse in woodland and sclerophyll communities.

Opportunities were also taken to participate in a number of CORVEG sites completed by botanists from the Queensland Herbarium. Improved vegetation mapping and descriptions were compiled during this time.

With the exception of common, easily identifiable species, all vascular plant species were collected and photographed. A voucher collection extending back to May 2010 has been compiled and is awaiting formal submission and identification by the Queensland Herbarium.

Additional surveys were undertaken of regional areas for conservation significant plants to determine their preferred habitats and centres of distribution. The species targeted included: *Acacia purpureopetala*, *Grevillea glossadenia*, *Homoranthus porteri*, *Prostanthera clotteniana* and other *Prostanthera* species, *Micromyrtus delicata*, *Zieria obovata* and *Melaleuca sylvana.* A majority of these surveys were in the Herberton, Stannary Hills, Silver Valley, Mount Misery, Watsonville and Irvinebank areas to the south and south-west of the wind farm site.

A literature review was made of the most relevant information, published articles and some key texts.

3.0 Information Gaps

3.1 Seasonality of Flora Surveys & Detection of Cryptic Species

In excess of 140 sites were investigated between May 2010 and May 2013 of vegetation and the presence of flora of interest to conservation, as well as locally endemic and restricted plant species. These surveys were performed over a range of months. On all occasions, new species occurrences were recorded. For survey completeness, flora surveys to detect ground layer plants would ideally take place each month of the year, and preferably with an overlap period extending into a second year to capture seasonal variation in flowering phenology.

Although nearly 250 species of vascular plants (including naturalised species) were recorded over the three-year period, concerns have been expressed regarding detection of transient plants (R. Jenson, J. Kemp, pers. comms.). Many of these types of plants have short periods of vegetative and flowering phenology and emerge after seasonal rain periods or pulses. Because of their diminutive size they are often obscured by taller growing grasses.

Highlighting this was the discovery of the ground orchid *Habenaria elongata* some 100 km south of its known southern distribution. Unfortunately, because of time and financial constraints, a voucher specimen was unable to be collected and the record therefore remains anecdotal and unconfirmed, although the photograph was sufficient for positive identification (**Plate 6**). The range extension of this orchid is considerable in terms of plant distribution, and further evidences the biodiversity importance of the Wet Tropics bioregion section of the project area.

Plate 6 The ground orchid *Habenaria elongata* was found in the grass layer below a ridge in the southwest of the project area.

3.2 Plant Succession in Tropical Montane Environments

Little is known or documented about plant succession in montane environments in north Queensland. Some parallels and related information can be gained from literature documenting range of disturbances in alpine regions of southern Australia and also some areas of New South Wales. However, the effects of linear clearing in these types of environment are not fully understood.

The Springmount section of the Chalumbin-Woree 275 kV electrical transmission line was completed in 1998 (Powerlink, n.d.). The corridor of this transmission line passes through the project area and approximately forms the boundary between the Wet Tropics and Einasleigh Uplands bioregions. This is the only firsthand reference from which to gauge the responses to linear clearing and disturbance to the rhyolite landform of the project area. However, there are subtle, but nevertheless important differences between the soil composition, flora and vegetation attributes of the Einasleigh Uplands section to those of the Wet Tropics section.

For example, it is understood of the Einasleigh Uplands section that plant succession on cleared ground generally results in thickets of *Acacia umbellata* and a suite of weeds such as Praxelis (*Praxelis clematidea*) establishing on silty clay soils which have accumulated after surface washing following heavier seasonal rainfall events.

Only a short section of track traverses a morphologically similar ridge found elsewhere in this bioregion section.

The Wet Tropics bioregion section of the project area has very high ecological and biodiversity value because of its isolation through rugged, inaccessible topography; altitude; and proximity and landscape connectivity to the Mt Emerald mountain region immediately to the south.

Floristically and in a vegetation sense, there are several examples that reinforce the regional significance of this zone in the project area; and include the presence of the exceptionally rare and endangered shrub *Melaleuca uxorum*, healthy populations of *Homoranthus porteri* and *Grevillea glossadenia*, pristine montane heath communities along high elevation ridges which host several narrow endemic plant species, contiguous landscape connectivity plus physical separation from areas susceptible to ecological modification (e.g. no edge effects, transformer weeds or surface alienation).

A more complete understanding of the effects and impacts associated with clearing narrow ridgelines is required. Appropriate methods for rehabilitation will need to be investigated because of the unique characteristics of this landform and the poorly represented heath communities that rely on ridges. As yet, there is limited evidence to suggest that heath communities will recover to the original floristic composition and structure. Moreover, there is reasonable evidence which supports the tendency for deflected climax (plagioclimax) communities to establish along track edges. These communities more or less stagnate and regenerate their own species composition, often precluding the regeneration of formerly-present climax species.

Observations of numerous disturbed sites indicate that the floristic component will become relatively stable once colonisers such as *Acacia umbellata*, *A. calyculata* and *A. whitei* have established thickets. In many situations the ground layer is also colonised by the heath-like plant *Jacksonia thesioides*. In virtually all situations where rocky ground is disturbed and turned over, the weed *Praxelis clematidea* colonises. Rarely however, do narrow endemic species restricted to ridge topography recuperate following disturbance. There is a concentration of these species in the southwest of the project area, which include: *Cryptandra debilis*, *Boronia bipinnata*, *Homoranthus porteri*, *Hovea nana*, *Indigofera bancroftii*, *Mirbelia pungens*, *M. speciosa* subsp. *ringrosei*, *Sannantha angusta* and others. These narrow endemics are a component of the original climax montane heath community and could be permanently displaced if the ground surface is disturbed.

3.3 Population Viability Analysis

Statistical methods and rigorous scientific approaches to understanding the viability of populations of plants of interest to conservation have not been undertaken.

3.4 Ramifications of Incomplete Data and Knowledge

Due to the limited understanding of the successional traits of montane heath in the project area, robust and site-specific mitigation strategies cannot be proposed for the Wet Tropics section of the project area. Generic rehabilitation methods for re-establishing functional plant communities in this dissected country are unlikely to be successful for the heath environment, but may have better success for woodland communities on gentle slopes found elsewhere on the site, and more so north of the Chalumbin - Woree 275 kV transmission line.

Addressing the data gaps discussed above can be achieved by formulating a focussed research investigation into plant succession in montane heath communities. It is recommended in this report that a specific zone derived from the 900 m contour, which coincides with the mean height of the cloud base and subsequently, the presence of montane heath communities, is set aside and quarantined from track construction and earthworks.

Currently, there is insufficient knowledge and practical examples to support successful rehabilitation of high elevation ridges and the montane heath community. Although a local plant nursery has successfully propagated a number of species from the local region, and quite possibly from the wind farm site, these have been for maintained garden environments and not for rehabilitation of remote tracts of linear clearing. Large scale rehabilitation of dryland and sclerophyll communities cannot rely on tube stock plantings, and to date, has mostly depended on direct-seeding with varying rates of success.

4.0 Desktop Review

Two sources of vegetation mapping were reviewed and are discussed.

4.1 Historical Vegetation Mapping

Earlier mapping and ecological accounts of vegetation are used under the RE framework as supplementary descriptions to the most current work. Tracey and Webb (1975) compiled the first detailed maps of vegetation of the wet tropics bioregion at a scale of 1:100,000.

Although the associated ecological descriptions of vegetation and bioregional perspective published by Tracey in 1982 focussed on vine forests due to its dominance in the region, useful accounts of sclerophyll communities within the mapping area were also given. These descriptions and mapping later formed the basis for Stanton and Stanton (2005).

4.2 Stanton and Stanton (2005)

Tracey and Webb's (1975) vegetation mapping was revised by Stanton and Stanton (2005) and produced with amendments at a scale of 1:50,000. This mapping provided finer resolution for the wet tropics bioregion and subsequently has greater effectiveness for environmental management and planning purposes. The descriptions, which are derived primarily from geology and floristic associations, forms a basis and broad floristic framework for the current regional ecosystem mapping concept and the vegetation descriptions for the Wet Tropics bioregion. Stanton and Stanton 2005 report on the high conservation value of the highland areas mainly extending southwards from the northern limit of the Herberton Range.

4.3 Regional Ecosystems (1999 - current)

Under Queensland's *Vegetation Management Act 1999* (VMA), the State's remnant vegetation is classified, mapped and described as regional ecosystems (Sattler and Williams, 1999). Vegetation is broadly defined as remnant and non-remnant, after which it is more accurately classified and described according to three main criteria: the bioregion in which the unit occurs (Thackway and Cresswell, 1995); the associated land zone (Wilson and Taylor, 2012); and the structural formation (modified from Specht, 1970) and floristic composition of the community (plant nomenclature follows Bostock and Holland, 2010). A unique three-number code is used to signify this combination, and a site-specific example is given below for Regional ecosystem 7.12.57: where:

- **7** corresponds with the biogeographic region (bioregion) in which the ecosystem occurs (Wet Tropics)
- **12** corresponds with the land zone (hills and lowlands on granitic rocks); and
- **57** typifies the structural and floristic characteristics of the vegetation community (Shrubland and low woodland mosaic with *Syncarpia glomulifera*, *Corymbia abergiana*, *Eucalyptus portuensis*, *Allocasuarina littoralis*, and *Xanthorrhoea johnsonii*, on moist and dry uplands and highlands on granite and rhyolite).

The wind farm site is bisected by the boundary of two bioregions, where the Wet Tropics bioregion covers the southern half of the site, and the Einasleigh Uplands bioregion covers the approximate northern half of the site. Regional ecosystem (RE) mapping for the wet tropics bioregion is at a scale of 1:50,000; whereas the Einasleigh Uplands bioregion mapping scale is 1:100,000.

Effectively, the Wet Tropics bioregion is therefore mapped at approximately twice the resolution of Einasleigh Uplands. Consequently, this affects the number of vegetation communities mapped; their conservation status under the VMA; and the spatial accuracy of the mapping. The RE mapping covering the whole wind farm site is provided in **Appendix B**. The Wet Tropics and Einasleigh Uplands RE mapping is provided in **Appendix C** and **Appendix D** respectively.

The following REs are mapped over the site:

Wet Tropics Bioregion Section (Appendix C)

7.12.30: Woodland to open forest mosaic with variable dominance, often including *Eucalyptus cloeziana*, *Corymbia abergiana*, *C. citriodora*, *E. portuensis*, *E. reducta*, *E. lockyeri*, *C. leichhardtii*, *E. atrata*, *E. pachycalyx* and *E. shirleyi*, on rhyolite and granite.

7.12.57: Shrubland and low woodland mosaic with *Syncarpia glomulifera*, *Corymbia abergiana*, *Eucalyptus portuensis*, *Allocasuarina littoralis*, and *Xanthorrhoea johnsonii*, on moist and dry uplands and highlands on granite and rhyolite.

Shrubland/low woodland mosaic with variable dominance, often including *Eucalyptus cloeziana*, *Corymbia abergiana, E. portuensis*, *E. reducta*, *E. lockyeri*, *C. leichhardtii*, *E. atrata*, *E. pachycalyx*, *E. shirleyi* and *Homoranthus porteri*, on rhyolite and granite

7.12.58: *Eucalyptus reducta*, *E. granitica*, *Corymbia dimorpha*, *C. citriodora* and *Syncarpia glomulifera* woodland, on granite and rhyolite.

7.12.65: Rock pavements or areas of skeletal soil, on granite and rhyolite, mostly of dry western or southern areas, often with shrublands to closed forests of *Acacia* spp. and/or *Lophostemon suaveolens* and/or *Allocasuarina littoralis* and/or *Eucalyptus lockyeri* subsp. *exuta*.

Einasleigh Uplands Bioregion Section (Appendix D)

9.12.4/9.12.2: (9.12.4) - *Eucalyptus shirleyi or E. melanophloia* with *Corymbia peltata* and/*or C. leichhardtii* low open woodland to low woodland on acid volcanic rocks. / (9.12.2) - Open forest commonly including *Eucalyptus portuensis*, *E. crebra* (sens. lat.), *Corymbia clarksoniana*, *C. citriodora* on steep hills and ranges on acid and intermediate volcanics close to Wet Tropics boundary.

9.12.30/9.12.20/9.12.4: (9.12.30) - *Corymbia leichhardtii +/- Callitris intratropica +/- Eucalyptus shirleyi* low woodland to low open woodland on rhyolite hills. / (9.12.20) - *Eucalyptus pachycalyx* and *E. cloeziana* woodland on acid volcanics. / (9.12.4) - *Eucalyptus shirleyi* or *E. melanophloia* with *Corymbia peltata* and/or *C. leichhardtii* low open woodland to low woodland on acid volcanic rocks.

Wet Tropics Bioregion (1:50 000)

Regional Ecosystem 7.12.30d

7.12.30d	
Description	Open-woodland to open-forest (10-20m tall) mosaic with variable dominance, often including *Eucalyptus cloeziana*, *C. citriodora*, *E. portuensis*, *E. lockyeri*, *C. leichhardtii*, *E. atrata*, *E. pachycalyx*, *E. reducta*, *C. intermedia* and *E. shirleyi.* There is often a very sparse to mid-dense secondary tree layer of *C. abergiana* and/or *C. stockeri*. A very sparse to sparse tall shrub layer may be present and can include *Acacia flavescens*, *Persoonia falcata*, *Bursaria spinosa* subsp. *spinosa*, *Allocasuarina inophloia*, *Petalostigma pubescens* and *Grevillea glauca*. A sparse to dense lower shrub layer may include *Jacksonia thesioides*, *Acacia calyculata*, *Xanthorrhoea johnsonii* and *Grevillea glossadenia*. The ground layer may be dominated by species such as *Themeda triandra*, *Heteropogon triticeus*, *Mnesithea rottboellioides*, *Arundinella setosa*, *Cleistochloa subjuncea*, *Eriachne pallescens* var. *pallescens*, *Lepidosperma laterale* and *Xanthorrhoea johnsonii*.
Special Values	Habitat for several locally restricted and disjunct species. Threatened species include *Micromyrtus delicata*, *Melaleuca sylvana*, *Diuris oporina*, *Homoranthus porteri*, *Grevillea glossadenia*, *Prostanthera* sp. (Dinden P.I.Forster+ PIF17342), *Acacia purpureopetala*, *Corymbia rhodops* and *Prostanthera clotteniana*. Other species of local significance are *Eucalyptus lockyeri*.
VMA Status	Least Concern
Biodiversity Status	No Concern at Present

Regional Ecosystem 7.12.57c

7.12.57c	
Description	Shrubland/low woodland (1.5-9m tall) mosaic with variable dominance, often including *Eucalyptus cloeziana*, *Corymbia abergiana*, *E. portuensis*, *E. reducta*, *E. lockyeri*, *C. leichhardtii*, *Callitris intratropica*, *E. atrata*, *E. pachycalyx*, *E. shirleyi*, *E. drepanophylla* and *Homoranthus porteri*, on rhyolite and granite. There is occasionally a very sparse to sparse secondary tree layer of *C. abergiana* and/or *C. stockeri*. A very sparse to sparse tall shrub layer may be present and can include *Persoonia falcata*, *Exocarpos cupressiformis* and *Melaleuca viridiflora* var. *viridiflora*. A sparse to dense lower shrub layer may include *Jacksonia thesioides*, *Acacia calyculata*, *Pogonolobus reticulatus*, *Xanthorrhoea johnsonii*, *Acacia humifusa*, *Dodonaea lanceolata* var. *subsessilifolia*, *Grevillea dryandri* subsp. *dryandri*, *Grevillea glossadenia*, *Acacia umbellata* and Ericaceae spp. The ground layer may be dominated by species such as *Themeda triandra*, *Xanthorrhoea johnsonii*, *Eriachne pallescens* var. *pallescens*, *Cleistochloa subjuncea*, *Borya septentrionalis*, and *Eriachne* spp. Includes open rocky areas dominated by herbs and grasses. This RE includes areas of 7.12.65k (rocky areas with shrubby/herbaceous cover) which are too small to map.
Special Values	Habitat for several locally restricted and disjunct species. Threatened species include *Micromyrtus delicata*, *Melaleuca sylvana*, *Melaleuca uxorum*, *Diuris oporina*, *Homoranthus porteri*, *Grevillea glossadenia*, *Prostanthera* sp. (Dinden P.I.Forster+ PIF17342), *Acacia purpureopetala*, *Corymbia rhodops* and *Prostanthera clotteniana*. Other species of local significance are *Eucalyptus lockyeri.*
VMA Status	Of Concern
Biodiversity Status	Of Concern

Regional Ecosystem 7.12.58

7.12.58	
Description	*Eucalyptus reducta* (Queensland stringybark), *E. granitica* (granite ironbark), *Corymbia dimorpha* (yellow jacket), *C. citriodora* (lemon-scented gum) and *Syncarpia glomulifera* (turpentine) woodland to open-forest. Granite and rhyolite. (BVG1M: 9d)
Special Values	None listed.
VMA Status	Of Concern
Biodiversity Status	Of Concern

Regional Ecosystem 7.12.65k

7.12.65k	
Description	Bare granite and rhyolite rock, of dry western areas, associated with shrublands to closed forests of *Acacia* spp. (wattles) and/or *Lophostemon suaveolens* (swamp mahogany) and/or *Allocasuarina littoralis* (black sheoak) and/or *Eucalyptus lockyeri* subsp. *exuta*. Dry western areas. Granite and rhyolite. (BVG1M: 28e).
Special Values	None listed; although habitat for several narrow endemic and threatened species including: *Grevillea glossadenia*, *Homoranthus porteri*, *Melaleuca uxorum* and *Plectranthus amoenus*.
VMA Status	Least Concern
Biodiversity Status	Of Concern

Einasleigh Uplands Bioregion (1:100 000)

Regional Ecosystem 9.12.4c/9.12.2 (mixed polygon)

9.12.4c	
Description	Low woodland to low open-woodland of *Callitris intratropica* (cypress pine) and *Eucalyptus shirleyi* (silver-leaved ironbark) and/or *E. melanophloia* (silver-leaved ironbark) +/- *Corymbia leichhardtii* (yellowjacket). The sparse mid layer can include juvenile canopy species, *Melaleuca* spp., *Dolichandrone heterophylla* (lemonwood), *Alphitonia pomaderroides*, *Petalostigma pubescens* (quinine), *Acacia bidwillii* (corkwood wattle) and *Grevillea* spp. The dominants in the grassy ground can include *Schizachyrium fragile* (firegrass), *Heteropogon contortus* (black speargrass) or *Themeda triandra* (kangaroo grass). Occurs predominantly on sandy shallow soils derived from granite on rolling low hills to hills. (BVG1M: 20a).
Special Values	None listed
VMA Status	Least Concern
Biodiversity Status	No Concern at Present

9.12.2	
Description	Mixed open-forest to occasionally low open-woodland including combinations of the species *Eucalyptus portuensis* (white mahogany), *Corymbia citriodora* (lemon-scented gum), *E. granitica* (granite ironbark) or *E. crebra* (narrow-leaved ironbark), *C. intermedia* (pink bloodwood) or *C. clarksoniana* (Clarkson's bloodwood) +/- *E. cloeziana* (Gympie messmate) +/- *Corymbia* spp. There is often an open to mid-dense sub-canopy containing canopy species +/- *Melaleuca viridiflora* (broad-leaved paperbark) +/- *Lophostemon suaveolens* (swamp mahogany) +/- *C. leichhardtii* (yellowjacket). The shrub layer varies from scattered shrubs to mid-dense and includes juvenile canopy species, *Acacia flavescens* (yellow wattle), *Callitris intratropica* (cypress pine), *L. suaveolens*, *Xanthorrhoea johnsonii* (grasstree) and *Petalostigma pubescens* (quinine). The dense grassy ground layer is generally dominated by *Themeda triandra* (kangaroo grass) +/- *Heteropogon triticeus* (giant speargrass) +/- *Mnesithea rottboellioides* (northern canegrass). In some areas, patches dominated by *E. moluccana* (gum-topped box) or *E. cloeziana* may occur. Occurs on rises, hill and ranges. (BVG1M: 9d).
Special Values	Old growth of this ecosystem is significant for a number of species including arboreal mammals. Habitat for vulnerable flora species including *Corymbia rhodops*.
VMA Status	Least Concern
Biodiversity Status	No Concern at Present

Regional Ecosystem 9.12.30a/9.12.20/9.12.4c (mixed polygon)

9.12.30a	
Description	Woodland to open-forest of *Corymbia leichhardtii* (yellowjacket) and *Eucalyptus cloeziana* (Gympie messmate) +/- E. portuensis (white mahogany) +/- *C. citriodora* (lemon-scented gum) +/- *E. cullenii* (Cullen's ironbark) +/- *Callitris intratropica* (cypress pine). Some canopy species can occur as emergents. The sparse to mid-dense shrub layer is dominated by juvenile canopy species, *Persoonia falcata*, *Grevillea glauca* (bushman's clothes peg) and *Allocasuarina inophloia* (stringybark sheoak) and a lower shrub with *Jacksonia thesioides* and *Xanthorrhoea johnsonii* (grass-tree) can occur. The sparse to mid-dense ground layer is dominated by *Themeda triandra* (kangaroo grass). Rocky rhyolite hills to steep hills. (BVG1M: 13a)
Special Values	The vulnerable species *Homoranthus porteri* is associated with this regional ecosystem.
VMA Status	Least Concern
Biodiversity Status	No Concern at Present

9.12.20	
Description	Woodland to low woodland of *Eucalyptus pachycalyx* (pumpkin gum) +/- *E. cloeziana* (Gympie messmate) +/- *Corymbia leichhardtii* (yellowjacket) +/- *Callitris intratropica* (cypress pine) +/- *E. portuensis* (white mahogany) +/- *E. cullenii* (Cullen's ironbark) or *E. atrata*. The mid-dense shrub layer includes juvenile canopy species, *Grevillea glauca* (bushman's clothes peg), *Persoonia falcata* and *Xanthorrhoea johnsonii* (grass-tree). The medium to dense grassy ground layer is mostly dominated by *Themeda triandra* (kangaroo grass). Occurs on steep rugged hills on acid volcanics. (BVG1M: 13a)
Special Values	This regional ecosystem contains a number of vulnerable species including *Corymbia rhodops*, *Grevillea glossadenia* and *Acacia purpureopetala*.
VMA Status	Least Concern
Biodiversity Status	No Concern at Present

9.12.4c	
Description	Low woodland to low open-woodland of *Callitris intratropica* (cypress pine) and *Eucalyptus shirleyi* (silver-leaved ironbark) and/or *E. melanophloia* (silver-leaved ironbark) +/- *Corymbia leichhardtii* (yellowjacket). The sparse mid layer can include juvenile canopy species, *Melaleuca* spp., *Dolichandrone heterophylla* (lemonwood), *Alphitonia pomaderroides*, *Petalostigma pubescens* (quinine), *Acacia bidwillii* (corkwood wattle) and *Grevillea* spp. The dominants in the grassy ground can include *Schizachyrium fragile* (firegrass), *Heteropogon contortus* (black speargrass) or *Themeda triandra* (kangaroo grass). Occurs predominantly on sandy shallow soils derived from granite on rolling low hills to hills. (BVG1M: 20a).
Special Values	None listed
VMA Status	Least Concern
Biodiversity Status	No Concern at Present

4.4 Aerial Photography Interpretation

Prior to field surveys, the aerial photography of the site was reviewed to identify a range of structural categories of vegetation. A stereoscope and stereo pairs of photographs were used for this purpose and later confirmed using digital imagery used in combination with a number of environmental layers (Geographical Information System - GIS). High resolution multi-band spectral imagery was also interpreted.

4.4.1 Development of Vegetation and Flora Survey Plan

A review was made of aerial photography and other digital imagery and layers to assist with developing a structured plan for sampling the vegetation and habitats likely to be intercepted by the proposal. The main focus of field investigations was along ridges and at proposed turbine sites, given that it was considered that these areas would receive the highest level of direct impact.

LiDAR was flown over the site and the mean height ranges of vegetation were derived through GIS. The following height classes were assigned to structural categories of vegetation across the site:

<1 m - Heathland with many areas of rock pavement and outcropping rock. Occurs above 900 m ASL and along exposed, windswept ridges. A majority of its representation is south of the transmission line. Characteristic species include: *Grevillea glossadenia*, *G. dryandri*, *Jacksonia thesioides*, *Pultenaea millarii*, *Acacia aulacocarpa*, *Eucalyptus lockyeri* subsp. *exuta* as isolated windswept specimens, *Gompholobium nitidum*, *Schizachyrium fragile*, *Cleistochloa subjuncea*, *Tripogon loliiformis*, *Eriachne humilis*, *E. mucronata*, *Panicum simile*, *Borya septentrionalis* (patches on scooped rock pavements), *Melaleuca uxorum*, *Cryptandra debilis* and *Melaleuca borealis*

1-2 m - Low woodland to shrubland with elements of heathland. Occurs primarily south of the transmission line and generally along ridges and exposed high points. Characteristic species include *Eucalyptus lockyeri* subsp. *exuta and Corymbia abergiana* as isolated windswept shrubs, *Homoranthus porteri*, *Acacia aulacocarpa*, *Allocasuarina littoralis*, *Corymbia abergiana*, *Grevillea glossadenia* and *Arundinella setosa*.

2- 10 m Low woodland and open woodland comprising trees, shrubs and a ground layer characterised by grasses, creepers, forbs and ferns. Many areas of exposed rock may be present, such as along ridges and rugged slopes. Also occurs on flatter land. Characteristic species include: *Corymbia abergiana (ridge tops)*, *Eucalyptus shirleyi* (mostly on flat land), *Eucalyptus lockyeri* subsp. *exuta*, *E. granitica*, *E. portuensis*, *Persoonia falcata*, *Grevillea mimosoides*, *Themeda triandra*, *Arundinella setosa*, *Hibbertia longifolia*, *Pseudopogonatherum contortum* and *Heteropogon triticeus.*

>10 m Mid-height woodland comprising trees, shrubs and a ground layer characterised by grasses, creepers, forbs and ferns. Exposed rocks may occur, but this category generally occurs on rolling hills, undulating land, gentle slopes and broad flay zones. Characteristic species include: *Corymbia citriodora*, *C. leichhardtii*, *Eucalyptus cloeziana*, *E. drepanophylla*, *E. portuensis*, *E. reducta*, *Pogonolobus reticulatus*, *Themeda triandra*, *Lepidosperma laterale* (wetter, well-developed woodlands), *Allocasuarina torulosa*, *Eucalyptus pachycalyx* (patchy distribution) and *Heteropogon triticeus.*

4.4.2 Identification of Habitats for R&Ts

Using the LiDAR described above, plus 8-band satellite imagery of the site, key habitats were identified on mapping. Given a majority of the habitats are associated with rocks, dissected ridges and high elevation areas, these habitats could be further assigned to the predicted presence of a number of conservation significant species, particularly *Homoranthus porteri*, *Grevillea glossadenia* and *Melaleuca uxorum.*

4.4.3 Identification of Conservation Significant Vegetation Types (REs)

The conservation significant vegetation types are associated with regional ecosystems 7.12.57c and 7.12.58 - both listed as Of Concern under the *Vegetation Management Act 1999*. Both these communities occur in the Wet Tropics bioregion section of the site, south of the transmission line on rocky landscapes. They are also associated with the presence of rare and threatened plants and a number of regionally restricted plant species (narrow endemics).

4.4.4 Identification of Significant Flora Diversity Areas

A key factor affecting the presence of the constrained plant species (conservation significant and narrow endemics species) is an approximate altitudinal demarcation of land which occurs above 900 m ASL. This is due to the exposure of the ridges in these zones and their inception of moisture from the cloud base (Ford and Hardesty, 2012). By applying the 900 m contour to mapping, a majority of the key biodiversity habitats were identified (**Appendix E**).

Mapping of rock outcrops and pavements also assisted in the identification fire-proof niches (**Appendix F**).

4.5 Database Searches

4.5.1 HERBRECS

HERBRECS is the Queensland Herbarium's (Department of Science, Information Technology, Innovation and the Arts) herbarium records management database. The herbarium is the repository for voucher collections of the Queensland flora. Records maintained in the HERBRECS data provide solid evidence of the presence of a species of plant at a particular location and at a given point in time. HERBRECS data and the specimen label information is therefore essential for mapping and predictive distribution modelling of plants of conservation interest and narrow endemic species. The HERBRECS data discussed in this report relates to voucher specimens of plants collected from within the area indicated in **Figure 2** and defined by the following coordinates (AMG Zone 55):

- Northwest corner: 307633 E, 8103872 S (480 m ASL) - approximately 8.5 km east of Dimbulah.
- Northeast corner: 341270 E, 8111535 S (504 m ASL) - approximately 10.5 km northeast of Walkamin, lower western slopes of Lamb Range.
- Southwest corner: 307945 E, 8070669 S (807 m ASL) - approximately 2 km southwest of Irvinebank.
- Southeast corner: 349529 E, 8073787 S (751 m ASL) - approximately 2.5 km northwest of Tarzali.

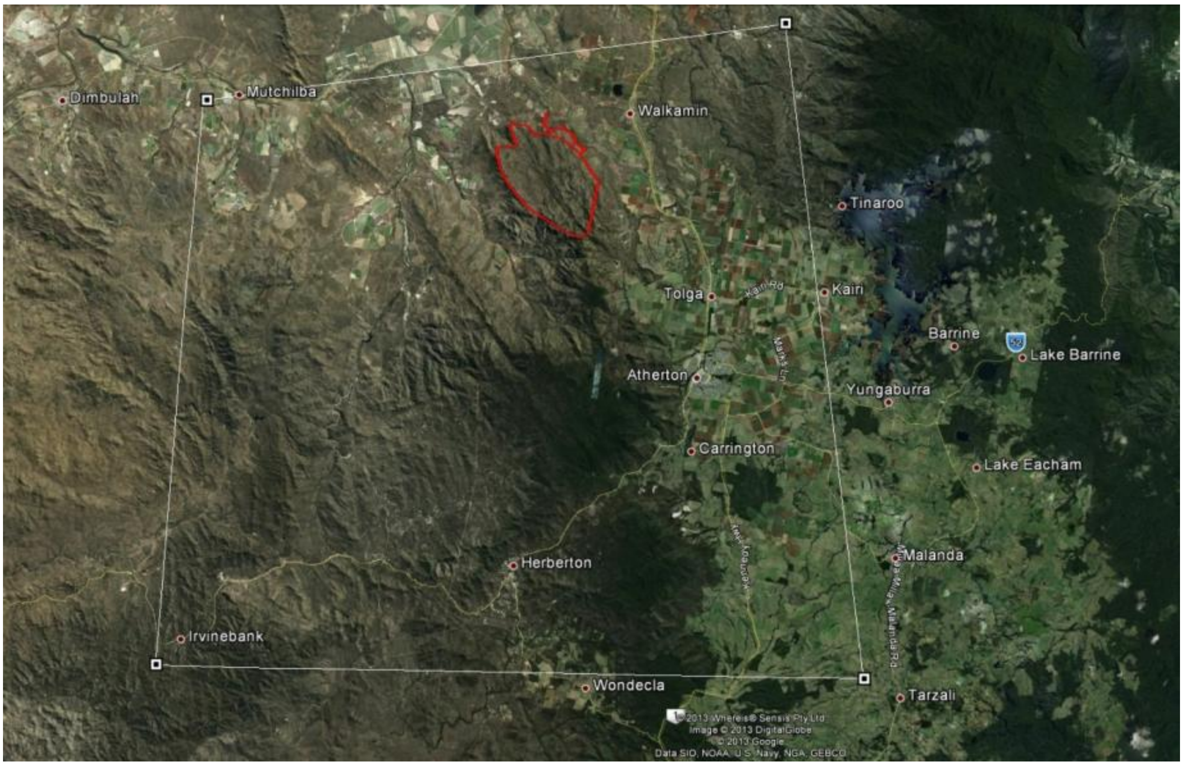

Figure 2 Queensland Herbarium HERBRECS search area (inside white line). The wind farm site is outlined in red.

A large proportion of the HERBRECS search area primarily east of the Kennedy Highway captures landforms supporting vine forest and mesic vegetation. The floristic composition of these communities is therefore of limited relevance to the sclerophyll woodlands and montane heathlands of the project site west of Walkamin. The broad zone of land and its rugged topography extending roughly southwest from the project site has noteworthy relevance however, and coincides with the geographical region encompassing the recognised floristically diverse areas of Baal Gammon, Stannary Hills, Irvinebank and Herberton. This region is a refuge for a large number of narrow endemic and conservation significant plants which are discussed in this report.

4.5.2 Naturalised Plants

The Queensland Herbarium defines naturalised plants as "non-native species that have successfully established and are reproducing without human intervention." In broad terms these are often considered to be weeds. Some species of naturalised plants have significant deleterious effects on the environment; whereas others can be relatively benign.

An examination of the Queensland Herbarium's current HERBRECS data indicates that 287 species of naturalised plants have been collected from region extending to south of Herberton, east to the Lamb Range and north to approximately Mareeba.

4.5.3 Wildlife Online

The Wildlife Online searches and discussion of species is given in RPS' report of 2011"Fauna, Vegetation & Flora Assessment - Proposed Mt Emerald Wind Farm" (RPS, 2011).

4.5.4 Protected Matters (EPBC)

The Protected Matters report of the EPBC Act 1999 and discussion of species is given in RPS' report of 2011"Fauna, Vegetation & Flora Assessment - Proposed Mt Emerald Wind Farm" (RPS, 2011).

4.6 Review of Conservation Significant and Important Flora

The following species of conservation significant plants were identified in searches of the EPBC Act's Protected Matters database, the Wildlife Online database and the Queensland's Herbarium database - HERBRECS. Because HERBRECS is based on validated and formally identified plants specimens held in the herbarium collection at Brisbane (BRI), they are considered the accurate and reliable account of what conservation significant plants are likely or do occur on the wind farm site. The species are summarised in **Table 1**.

Table 1 Summary of Conservation significant plant species confirmed to occur in region (HERBRECS data). Bolded species are confirmed to occur on the site. Vine forest taxa are excluded.

Family	Status	Botanical Name	Locality
Asteraceae	E	*Glossocardia orthochaeta* (F.Muell.) Veldkamp	STANNARY HILLS
Asteraceae	N	*Peripleura scabra* (DC.) G.L.Nesom	GREAT DIVIDING RANGE, C. 1.5KM NNW OF WALSH BLUFF, OFF CHANEL ROAD - SPRINGMOUNT ROAD.
Asteraceae	N	*Peripleura sericea* (N.T.Burb.) G.L.Nesom	STANNARY HILLS
Cycadaceae	V	*Cycas platyphylla* K.D.Hill	MUTCHILBA 17KM FROM RD TO IRVINEBANK VIA STANNARY HILLS
Euphorbiaceae	V	*Euphorbia carissoides* F.M.Bailey	STANNARY HILLS
Fabaceae	E	*Cajanus mareebensis* (S.T.Reynolds & Pedley) Maesen	PARADA NR DIMBULAH
Goodeniaceae	V	*Goodenia stirlingii* F.M.Bailey	GREAT DIVIDING RANGE, C. 200M NE OF WALSH BLUFF.
Lamiaceae	**V (NCA)**	***Plectranthus amoenus* P.I.Forst.**	**EX MT SPIDER TOP NR MAREEBA CULT THE GAP BRISBANE**
Lamiaceae	E	*Prostanthera clotteniana* (F.M.Bailey) A.R.Bean	NEAR BOUNDARY OF MT BALDY SF, WESTERN LOGGING AREA
Lamiaceae	E	*Prostanthera* sp. (Dinden P.I.Forster+ PIF17342)	TRIBUTARY OF OAKY CREEK OFF LEMONGRASS DRIVE C. 2KM WSW OF MT EMERALD
Mimosaceae	V	*Acacia guymeri* Tindale	SPRINGMOUNT ROAD, CA 2.3KM FROM CHISARI ROAD TOWARDS MAREEBA-DIMBULAH ROAD
Mimosaceae	N	*Acacia longipedunculata* Pedley	STANNARY HILLS
Mimosaceae	V	*Acacia purpureopetala* F.M.Bailey	NR MT EMERALD SW OF WALKAMIN (GPS 17 11 30 145 22 55)
Myrtaceae	V	*Corymbia rhodops* (D.J.Carr & S.G.M.Carr) K.D.Hill & L.A.S.Johnson	STANNARY HILLS, WNW OF HERBERTON
Myrtaceae	**V**	***Homoranthus porteri* (C.T.White) Craven & S.R.Jones**	**HERBERTON RANGE, NORTH-WEST OF TOLGA.**
Myrtaceae	E	*Melaleuca sylvana* Craven & A.J.Ford	HERBERTON RANGE, UPPER SLOPE OF MOUNT EMERALD, WEST OF TOLGA.
Myrtaceae	**E (NCA)**	***Melaleuca uxorum* Craven, G.Holmes & Sankowsky**	**HERBERTON RANGE, NEAR TOPO '967', NORTH-WEST OF TOLGA.**
Myrtaceae	E	*Micromyrtus delicata* A.R.Bean	BAAL GAMMON MINING LEASE
Orchidaceae	N	*Diuris oporina* D.L.Jones	W OF HERBERTON
Proteaceae	**V**	***Grevillea glossadenia* McGill.**	**WALSH BLUFF ON HEADWATERS OF GRANITE CK CA 4KM SSW OF WALKAMIN**
Rutaceae	V	*Zieria obovata* (C.T.White) J.A.Armstr.	STANNARY HILLS
Solanaceae	E	*Solanum angustum* Domin	STANNARY HILLS

4.7 Distribution of Conservation Significant Species

4.7.1 *Acacia purpureopetala*

A single collection has been made of this species on the south-western boundary of the project area. This collection represents the most northern and north-eastern distribution limit for *Acacia purpureopetala*. The population 'centres' (e.g. represented by the number of voucher specimens held in herbaria and plotted on mapping) are in the Irvinebank, Stannary Hills and the Silver Valley region to the south-west of the project area. A significant population has been confirmed on the scree slopes of Toy Creek (S. Gleed, pers. obs.). The species was not found during field surveys of the project area.

4.7.2 *Grevillea glossadenia*

Several collections and numerous sightings have been made from the project area of this distinctive species. It is also recorded from the Mt Emerald area immediately to the south of the project boundary. The species was frequently observed in the project area and across a range of habitats, including disturbed sites and vehicle track edges. In virtually all cases, it occurs on rocky ground. *Grevillea glossadenia* is the commonest occurring conservation significant species in the project area.

A single collection of *G. glossadenia* was taken from Abattoir Swamp between Mount Molloy and Julatten. This record represents the most northern distribution for the species and appears to be an outlier when plotted on mapping (i.e. mapping shows an obvious cluster of collections from the Irvinebank – Silver Valley region to the south the project area). Further, this is a single collection and details regarding the population size in this area are not known.

The most southern distribution of the species is from Ben Lomond mining lease west of the Harvey Range and west of Townsville. This collection also appears as an outlier and details regarding the population size are unknown.

4.7.3 *Homoranthus porteri*

This species was recorded at a number of sites within the project area growing directly on rock pavements in fissures, or on skeletal soils associated with shallow deposits on rock pavements. Occasionally it is found at the periphery of the rock pavement where rock gives way to deeper soils of a different landform. Where *H. porteri* grows in the project area, it forms monotypic thickets, but over a limited and relatively small area. The largest population observed on the site on the southwest ridge, formed a thicket approximately 6 x 6 m. Occasionally it is observed as scattered seedlings growing in rock crevices, and primarily in otherwise harsh environments in less than favourable growing conditions.

These observations are supported by a number of herbarium records from immediately south of the project area (Mt Emerald and surrounding slopes and ridges) where the same geology and similar vegetation formations are present.

A conspicuous population cluster appears on the mapping and from herbarium data to be around the Tumoulin-Archer Creek-Kaban region northwest of Ravenshoe.

A number of collections representing a population concentration have been made from the Baal Gammon Mine area between Watsonville and Herberton, and the species has been observed growing in association with *Acacia purpureopetala* on scree slopes above Toy Creek north of Baal Gammon.

The most northern distribution of the species is from the Mt Windsor region, assumed to be from 'dry' sclerophyll vegetation and from granite or rhyolite geology. This collection is represented by one herbarium specimen and the population size is not known.

The most southern distribution of the species is Puzzle Creek, Mt Zero – northwest of Townsville. This is represented by a single collection and no details are known regarding the population size in this area.

4.7.4 *Melaleuca uxorum*

Two populations are confirmed on the site. Listed as endangered under NCA, but not under EPBC Act. This species is considerably rare and at threat given the population centres are on the site and immediately south on Mt Emerald. It is a low-growing, scale-leaved shrub found on rocky ground in exposed, windswept situations along the southern ridge. One population had approximately 40-50 individuals, and the other at slightly lower elevation supported approximately 50 individuals. The species is confined to heath vegetation.

Populations of the species outside of the site are all found only a few hundred metres away on Mount Emerald. An outlier population occurs in the Silver Valley region.

4.8 Regional Endemic Species and Narrowly Distributed Plants

The following Queensland endemic plants (after Blake, 1954; Burbidge, 1960) have been recorded from the wind farm site (60 species):

Acacia bidwillii, *Acacia calyculata*, *Acacia flavescens*, *Acacia leptoloba*, *Acacia leptostachya*, *Acacia nesophila*, *Acacia whitei*, *Acrothamnus spathaceus*, *Astrotricha pterocarpa*, *Boronia bipinnata*, *Borya septentrionalis*, *Bursaria tenuifolia*, *Cajanus confertiflorus*?, *Capparis canescens*, *Cleistochloa subjuncea*, *Corymbia abergiana*, *Corymbia erythrophloia*, *Corymbia leichhardtii*, *Cryptandra debilis*, *Eriachne humilis*, *Eucalyptus cloeziana*, *Eucalyptus drepanophylla*, *Eucalyptus granitica*, *Eucalyptus lockyeri*, *Eucalyptus platyphylla*, *Eucalyptus portuensis*, *Eucalyptus reducta*, *Eucalyptus shirleyi*, *Gompholobium nitidum*, *Grevillea glossadenia*, *Hakea persiehana*, *Hakea plurinervia*, *Helichrysum newcastlianum*, *Helichrysum rupicola*, *Heliotropium tabuliplagae*, *Hibbertia longifolia*, *Hibbertia melhanioides*, *Homalium brachybotrys*, *Homoranthus porteri*, *Hovea nana*, *Indigofera bancroftii*, *Keraudrenia lanceolata*, *Larsenaikia ochreata*, *Leptospermum neglectum*, *Melaleuca borealis*, *Melaleuca monantha*, *Melaleuca uxorum*, *Notelaea punctata*, *Phyllanthus dallachyanus*?, *Phyllanthus simplex* var*. filicaulis*, *Pimelea sericostachya*, *Platysace valida*, *Plectranthus amoenus*, *Pseudanthus ligulatus*, *Pultenaea millarii*, *Stylidium confertum*?, *Stylidium eriorhizum*, *Trachymene bivestita*, *Velleia pubescens*?, *Xylomelum scottianum.*

Of the species listed above, the following have a particular habitat preference and are confined to ridges and rock pavements or a narrow band of fringing vegetation adjacent to this type of exposed, rocky topography on the site (23 species):

Acacia whitei, Astrotricha pterocarpa, Boronia bipinnata, Borya septentrionalis, Cleistochloa subjuncea, Corymbia abergiana, Cryptandra debilis, Eriachne humilis, Eucalyptus lockyeri subsp. exuta, Grevillea glossadenia, Heliotropium tabuliplagae?, Homoranthus porteri, Hovea nana, Indigofera bancroftii, Leptospermum neglectum, Melaleuca borealis, Melaleuca uxorum, Notelaea punctata?, Phyllanthus dallachyanus?, Plectranthus amoenus, Pseudanthus ligulatus, Pultenaea millarii, Stylidium eriorhizum.

Other species found on the site but not listed by Blake (1954) and Burbridge (1960) due to new species developments and taxonomic work could be present.

4.9 Regional Surveys

Ground surveys were completed of regional areas to gather information relating to the size of populations, their health and particular ecological characteristics that may be determinants of species presence on a certain landform or habitat type. Initially, surveys were completed of locations where the species are known to occur, and from where confirmed voucher collections have been made (e.g. herbarium records). Subsequently, surveys were carried out in habitats with similar physical attributes and characteristics as known sites, but where voucher collections have not been previously made.

Reference was made to population size estimates given in the SPRATS profiles for species where this data is available. In some instances, particularly *Acacia purpureopetala*, significant increases in population size (i.e. number of individuals) were recorded in the Silver Valley region south of Irvinebank (S. Gleed & S. De Ridder, pers. obs.). The Silver Valley populations of *A. purpureopetala* represent the most southern distribution of the species; and based on field observations in August 2012, one of the largest and most productive series of sub-populations.

Observations of several hundred seedlings of *A. purpureopetala* in skeletal, gravelly soils of granitic origin (Elizabeth Creek Granite) and with evidence of fire in the form of charcoal may indicate that the species responds to germination in a post-fire landscape.

A notable refuge and 'centre' for conservation significant plants, especially *A. purpureopetala*, was identified in a regional survey of Toy Creek, just north of the existing Baal Gammon mining lease near Watsonville.

5.0 Results

5.1 Description of Vegetation Communities

Eight vegetation communities were identified across the site. These are summarised below in **Table 2**, and profiles of each community provided in **Appendix G**.

Table 2 Vegetation communities of the wind farm site

Community Description	
Rustyjacket Woodland Woodland to open woodland of *Corymbia leichhardtii*, *Callitris intratropica* with *Eucalyptus shirleyi* and *Eucalyptus granitica* to 8 - 12 m. Occurs mainly the centre of the site in the EU bioregion section.	
Silver-leaf Ironbark Woodland Woodland to low open woodland of *Eucalyptus shirleyi* to 4 m with emergent *Callitris intratropica* (12 m). Best representation is near the centre of the site close in the EU and WT bioregion sections.	
Yellow Stringybark Woodland Grassy woodland of *Eucalyptus portuensis* with *Corymbia citriodora* to 7-12 m. Occurs on slopes of WT and EU bioregion sections.	

Community Description	
White Stringybark Woodland Tall, grassy woodland of *Eucalyptus reducta* with *Eucalyptus portuensis* and occasional *Corymbia citriodora* and *Eucalyptus drepanophylla* (sens. lat.) to 12-18 m. Occurs mainly in the WT bioregion section on slopes.	
Range Bloodwood Woodland and Shrubland Low, windswept woodland to open woodland and shrubland of *Corymbia abergiana* to 4 m on exposed ridges. Mainly occurs in the WT bioregion section close to ridge tops and edges.	
Montane Heathland Low heathland with scattered shrubs or isolated, wind-sheared and stunted trees of *Corymbia abergiana* and *Eucalyptus lockyeri* subsp. *exuta*. Includes patches of rock pavements and outcropping rock. Occurs above 900 m in the WT bioregion section.	

Community Description	
Narrow-leaf Ironbark and Lemon-scented Gum Woodland Woodland of *Eucalyptus drepanophylla* (sens. lat.) and *Corymbia citriodora* to 15 m. Occurs in northern aspects of the site mainly in the EU bioregion section.	
Dead Finish Woodland Grassy woodland to 8-10 m of *Eucalyptus cloeziana*, *Corymbia citriodora* and *E. portuensis*. Occurs mainly around the boundary junction of the WT and EU bioregion sections.	
WT - Wet Tropics, EU - Einasleigh Uplands	

5.2 Flora Composition

Over the period of study of the wind farm and investigations of more than 140 sites since May 2010, a voucher collection, photographic records and observations of the flora have been compiled. The checklist of vascular plants currently represents 279 species (see **Appendix H**) and has been validated by the Queensland Herbarium (**Appendix H1**).

The key findings of the flora surveys are the confirmed presence of the following conservation significant plants on the site: *Grevillea glossadenia*, *Homoranthus porteri*, *Plectranthus amoenus* and *Melaleuca uxorum*.

The cumulative checklist still has gaps given that surveys have not been completed every month of the year, and certain taxonomic groups are underrepresented (for example, ephemeral, short-lived taxa and herbs that may only be present during a particular month and under special climatic conditions.

5.2.1 Naturalised Plants - Weeds

From the HERBRECS data and observations, 43 weed species have been identified on the site, with a majority occurring along Kippen Drive (see **Table 3**).

Table 3 Naturalised plants recorded from the site (44 spp.)

Family Name	Botanical Name
Asteraceae	*Ageratum conyzoides* L. subsp. *conyzoides*
Asteraceae	*Bidens bipinnata* L.
Asteraceae	*Bidens pilosa* L.
Asteraceae	*Crassocephalum crepidioides* (Benth.) S.Moore
Asteraceae	*Emilia sonchifolia* (L.) DC.
Asteraceae	*Praxelis clematidea* R.M.King & H.Rob.
Asteraceae	*Synedrella nodiflora* (L.) Gaertn.
Asteraceae	*Tridax procumbens* L.
Caesalpiniaceae	*Chamaecrista rotundifolia* (Pers.) Greene var. *rotundifolia*
Caesalpiniaceae	*Senna occidentalis* (L.) Link
Caesalpiniaceae	*Senna pendula* var. *glabrata* (Vogel) H.S.Irwin & Barneby
Convolvulaceae	*Ipomoea hederifolia* L.
Fabaceae	*Centrosema molle* Mart. ex Benth.
Fabaceae	*Desmodium tortuosum* (Sw.) DC.
Fabaceae	*Macroptilium atropurpureum* (DC.) Urb.
Fabaceae	*Stylosanthes humilis* Kunth
Fabaceae	*Stylosanthes scabra* Vogel
Lamiaceae	*Hyptis suaveolens* (L.) Poit.
Malvaceae	*Sida cordifolia* L.
Malvaceae	*Sida rhombifolia* L.
Malvaceae	*Urena lobata* L.
Mimosaceae	*Mimosa pudica* var. *unijuga* (Walp. & Duchass.) Griseb.
Passifloraceae	*Passiflora foetida* L.
Poaceae	*Chloris virgata* Sw.
Poaceae	*Cynodon dactylon* (L.) Pers. var. *dactylon*
Poaceae	*Dactyloctenium aegyptium* (L.) Willd.
Poaceae	*Eleusine indica* (L.) Gaertn.
Poaceae	*Hyparrhenia rufa* subsp. *altissima* (Stapf) B.K.Simon
Poaceae	*Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs var. *maximus*
Poaceae	*Melinis minutiflora* P.Beauv.
Poaceae	*Melinis repens* (Willd.) Zizka
Poaceae	*Setaria pumila* (Poir.) Roem. & Schult. subsp. *pumila*
Poaceae	*Sporobolus jacquemontii* Kunth
Poaceae	*Sporobolus pyramidalis* P.Beauv.
Poaceae	*Themeda quadrivalvis* (L.) Kuntze
Poaceae	*Urochloa decumbens* (Stapf) R.D.Webster
Polygalaceae	*Polygala paniculata* L.
Rubiaceae	*Mitracarpus hirtus* (L.) DC.
Rubiaceae	*Richardia brasiliensis* Gomes
Sparrmanniaceae	*Triumfetta rhomboidea* Jacq.
Verbenaceae	*Lantana camara* L.
Verbenaceae	*Stachytarpheta australis* Moldenke
Verbenaceae	*Stachytarpheta cayennensis* (Rich.) Vahl
Verbenaceae	*Stachytarpheta jamaicensis* (L.) Vahl

5.3 Description of Specialist Habitats

The flora of the rock pavements and ridges within the wind farm site have special and unique qualities. Many of the plant species found in these harsh montane environments do not occur in other habitats and are almost entirely restricted to ridges and rocky ground with skeletal soil.

The simplest expression of plant niche utilisation can be determined from basic presence/absence observations, where for example, the conservation significant shrub *Homoranthus porteri* is rarely, if ever, encountered in woodlands where a grass layer of *Themeda triandra* is present, but is always found on rock pavements, ledges or rocky ridges with the barest of soil cover.

Repeated field surveys, plant collections and species mapping confirm that the rock-dominant habitat outlined here is the unique environment in which a majority of the conservation significant and narrow endemic species are found.

5.3.1 Rock Pavements

Description: These features are characterised by an expanse of rhyolite in a near horizontal plain. The surface is relatively unbroken (cf. ridges). They are variously referred to as rock plates, rock platforms and rock shelves.

The florisitics structure and composition of vegetation of rock pavements is sparse and typically supports relatively few species of plants. A reason for this is the absence or very limited development of soil and growth media, which congregates in fissures, crevices, settles in hollows or is captured by woody debris and in surface irregularities.

Soil: Soil formation is slow and dependent in the early stages on the presence of foliose lichens, mosses and small plants that are able to establish in rock cracks and fissures. The soil veneer is thin but can have a very high organic content which is subsequently rich in humus. When not integrated with sand or clay, it has a loamy, peat-like structure with good water-holding capacity. These peaty soils (**Plate 6**) are derived from foliose and crustose lichens, mosses, and decomposing leaf litter from shrubs with microphyll leaves such as *Homoranthus porteri*, *Polycarpaea spirostylis* and *Borya septemtrionalis*. The roots of herbaceous plants and grasses and the rock ferns *Cheilanthes nitida* and *C. nudiuscula* play an important soil-contributing role, where the fronds die-back in the driest times, remaining dormant through underground rhizomes until new foliage regenerates during more favourable growing periods.

Plate 7 Humus rich soil associated with rock pavements is derived from mosses, lichens and decaying plant matter.

Floristic composition: *Acacia humifusa*, *Polycarpaea corymbosa*, *Pseudanthus ligulatus* subsp. *ligulatus*, *Borya septentrionalis*, *Tripogon loliiformis*, *Eriachne humilis*, *E. mucronata*, *Schizachyrium fragile*, *Aristida superpendens*, *Sedopsis* sp. (Bulimba Station P.I.Forster+ PIF14742), *Cheilanthes nitida*, *C. nudiuscula*. Stunted trees and shrubs are infrequent, and are usually widely spaced and grow in crevices or between larger rocks and can include *Acacia aulacocarpa* (forming dominant thickets), *Maytenus disperma*, *Homoranthus porteri*, *Grevillea glossadenia* and *Eucalyptus lockyeri* subsp. *exuta*, and occasionally *Corymbia abergiana*. Representatives of the genus *Plectranthus* are usually represented on rock pavements and includes the species *P. amoenus* and *P. graveolens*.

In some instances, wattles (*Acacia* spp.) dominate a rock pavement, where they form tangled thickets typically comprising a single species. For example, *Acacia aulacocarpa* forms dense, woody thickets to 1.8 m tall on high altitude rock pavements in the southwest of the site. At slightly lower elevation, and often in association with surrounding low open woodland of *Eucalyptus shirleyi*, *A. humifusa* forms a layer to 40 cm on more fractured rock pavements. *Acacia umbellata* may also form dominant stands in this zone. North of the transmission line A*. leptostachya* grows as a dense shrubland to 3 m usually at the periphery of the rock pavement. Where the rock pavement grades into the ridge (see below), two species of wattle become more frequent: *A. calyculata* and *A. whitei*.

Ecological values: Rock pavements and their perimeters are the unique habitat environment for conservation significant plants including *Homoranthus porteri*, *Melaleuca uxorum* and *Plectranthus amoenus*. These species rely on the soil-deficient surfaces and are not found in adjacent woodlands where soil conditions are improved.

Because of the near-absence of flammable plant material on rock pavements, fires are more or less excluded; and hence this habitat has refugial qualities because of the fire-proof niche.

When disturbed, rock pavements are prone to invasion by wind dispersed Asteraceae weeds (daisies); particularly the environmental weed *Praxelis clematidea*.

Distribution: The most floristically diverse rock pavements occur south of the transmission line at elevations above 900 m, where cloud stripping for moisture is a driver of montane heath vegetation communities. Less diverse features are found north of the transmission line and support significantly fewer regionally restricted species.

5.3.2 Ridges

Description: Ridges and large areas of outcropping rhyolite are separate as a topographical unit from the more uniform surfaces of rock pavements. Stony ridges are characterised by sections of outcropping rock and large angular boulders. Some of these ridges give way abruptly to precipitous drop-offs, the faces of which are sometimes broken by a series of rock shelves and narrow terraces. Some sections of the ridges south of the transmission line are narrow and not much wider than 20 m.

The presence of taller woodlands usually comprising *E. reducta* and *E. drepanophylla* with *Allocasuarina torulosa* in the lower tree layer on west-facing slopes or sheltered valleys signifies a change in landform and the presence of improved soil conditions and more sheltered aspects.

Floristic composition: Typical trees on ridges include *E. lockyeri* subsp. *exuta*, *Corymbia abergiana*, *C. intermedia* and *Maytenus disperma*. *Allocasuarina littoralis* and *E. portuensis* may also be present. Shrubs include *Homoranthus porteri* (south of transmission line), *Xanthorrhoea johnsonii*, *A. calyculata* and *A. whitei*. A secondary shrub layer can be dominated by *Jacksonia thesioides*, *Gompholobium nitidum*, *Grevillea dryandri* subsp. *dryandri*, as well as younger generation plants of *G. glossadenia*. Less frequently low heath-type plants are present including *Boronia bipinnata*, *Zieria minutiflora*, *Cryptandra debilis*, *Pultenaea millarii*, *Mirbelia pungens*, *M. speciosa* subsp. *ringrosei*, *Sannantha angusta*, *Melaleuca borealis* and *Jacksonia thesioides*. The grasses *Cleistochloa subjuncea*, *Arundinella setosa*, *Eriachne mucronata* and *Themeda triandra* are relatively common.

Ecological values: Ridges south of the transmission line are narrow and accordingly host narrowly distributed plant communities. They are also key habitat for *Homoranthus porteri* and *Grevillea glossadenia*, as well as the narrow endemic species similarly found on rock pavements. One of the populations of *Melaleuca uxorum* found on the site, occurs on a windswept ridge.

Because of the narrow definition of ridges, they act as important conduits and pathways for genetic flow between plants that are restricted to them.

Above 900 m ASL and south of the transmission line, ridges are the main environment of the montane heath vegetation type.

Distribution: The most floristically diverse ridges occur south of the transmission line. North of the transmission line, ridges become wider and less dissected and rocky. Here, more widespread woodland types occupy ridges and notably fewer conservation significant plants are found.

5.4 Population Viability

Population viability refers to a species' capacity to retain a persistent and viable local population in the wild (i.e. within the location and habitat where each population occurs). A definition of *viable* in reference to population viability analysis and conservation planning is given by Akçakaya and Sjögren-Gulve (2000) as: "Viability of a species in a given geographic region is often expressed as its risk of extinction or decline, expected time to extinction, or chance of recovery."

The viability of a plant population relies on a number of factors, including but not limited to:

- population size (number of individuals);
- specificity of habitat (reliance on certain habitat attributes); and
- area and ordination of habitat (linear features are prone to change and external influence).

Negative consequences for the viability of a population of plants can occur as a result of habitat fragmentation and isolation (Klank, *et al*. 2010). These effects are obviously more profound for species of plants that grow in spatially constrained environments (e.g. ridges, rock pavements, fringes of wetlands).

Plant populations on the wind farm site of species such as *Homoranthus porteri* and *Melaleuca uxorum*, which both grow in specific, poorly represented habitats associated with ridges and rock pavements could be adversely threatened by clearing for tracks and the turbine footprint (assuming the respective species grows within the disturbance footprint). Falk (1991) suggests that these types of species could be considered as *edaphic specialists*: relying on a particular geology and soil environment and consequently may be prone to population demise at the micro-scale.

Grevillea glossadenia exhibits greater plasticity in its preference for habitat, and is found in a variety of environments ranging from ridges, to track edges and infrequently, in woodland adjoining ridges. Given this species' propensity for greater habitat tolerance, plus its capability of forming significantly larger and spatially diffuse populations, it is likely to be more resilient to the effects of habitat modification. This shrub is often encountered as seed-derived plants growing in rock spoil and even in stockpiled road base material. It is also one of the descendants of the horticultural Grevillea 'Orange Marmalade' - recognised by the nursery trade and growers alike to be an exceptionally hardy plant resilient to even errant encounters with lawnmowers.

The approximate population sizes for conservation significant plants are summarised in **Table 4**, and are based on observations made during walking traverses of ridges and the proposed routes of the access and cabling tracks linking each turbine.

Table 4 Approximate population size and descriptions of conservation significant and narrow endemic plants

Species	Status	Distribution within site	Distribution regional	Population estimate overall site	Population estimate impacted zone	Habitat	Notes
Cryptandra debilis	-	Restricted to ridges and rocky ground dominated by heath vegetation, but occasionally in sparse open woodland. Greatest representation in Wet Tropics bioregion, with isolated individuals found on ridge approaching Walsh Bluff.	Narrow - found in rocky country extending SW through Baal Gammon to Silver Valley and along Herberton Range.	?	<200 individuals	Confined to rocky substrates, ridges and more exposed situations. Found in montane heath and sparse open woodland.	Narrow endemic to region.
Grevillea glossadenia	V	Widespread in rocky habitat of the Wet Tropics bioregion section of site. Relatively common along ridges above 900 m, but rarely found under woodland cover.	Found in Herberton Range and south to Ravenshoe. Mt Garnet Road, Silver Valley, Irvinebank.	>500	300-400	Most common on exposed ridges, but also found on track edges and very well-lit woodlands close to ridges and almost exclusive to Wet Tropics bioregion section of site. Responds to ground disturbance of rocky sites and will regenerate in rock spoil.	With Grevillea dryandri, this species is the commonest Grevillea on the site in the southern portion.
Homoranthus porteri	V	More or less confined to SW ridges of the Wet Tropics bioregion section, with isolated populations (x2) in Einasleigh Uplands bioregion section.	?	>400	300-350	When mature, forms thickets on rock pavements or their edges, and along exposed rocky ridges. Not found in woodland on slopes.	Can be common in patches on exposed ridges and frequently on rock pavements or their edges.
Hovea nana	-	Generally found south of the transmission line on woodland edges but in association with surface rocks.	?	?	<100	Edges of woodlands and along ridges.	Narrow endemic to region.
Indigofera bancroftii	-	Primarily south of the transmission line and along ridges at altitude ~ above 850 m.	In the Irvinebank-Herberton-Watsonville region.	?	<100	Rocky ground on ridges and edges of woodlands.	Narrow endemic to region.

Species	Status	Distribution - within site	Distribution - regional	Population estimate - overall site	Population estimate - impacted zone	Habitat	Notes
Melaleuca uxorum	E	Very limited and narrow distribution on southern part of ridge in SW portion of site. Two separate populations confirmed.	Restricted to Mt Emerald, the site and an outlier population in the Silver Valley region.	~120+	<120	Very restricted on windswept east-facing rock pavement/ridge complex.	Highly restricted and exceptionally rare - only two populations found in site, although extreme SW corner not surveyed.
Mirbelia pungens	-	Very uncommon plant found only along windswept ridge of SW portion of site in one location.	?	<100	<100	Narrow - on exposed ridge with outcropping rock and small rock pavements - with *Corymbia abergiana*.	Narrow endemic to region. Restricted to exposed ridges in SW sector of site.
Mirbelia speciosa subsp. *ringrosei*	-	Uncommon plant found only along windswept ridge of SW portion of site in one location.	Irvinebank, Watsonville region.	<200	<100	Narrow - on exposed ridge with outcropping rock and small rock pavements - with *Corymbia abergiana*.	Narrow endemic to region. Restricted to exposed ridges in SW sector of site.
Plectranthus amoenus	V	Recorded from near Turbine 66, but possibly found on rock pavements of SW portion of site. Species identification difficult and may intergrade with other species of *Plectranthus*.	?	?	<50	Confined to rock pavements with no tree cover on ridges or pavements at lower elevation interspersed in woodland with *Callitris intratropica* and *Corymbia leichhardtii*.	Difficult taxon to identify in field, but *Plectranthus* favours rock pavements and very rocky ground. Rarely found under woodland cover.

6.0 Constraints and Opportunities

An assessment of the environmental constraints and opportunities relative to the wind farm project area can help inform decisions on the positioning of turbines and access tracks. This section identifies and describes the environmental limitations and prospects for practical options aimed at precluding and restricting impacts to environmentally sensitive matters such as conservation significant plants and unique vegetation types.

6.1 Constraints - Vegetation and Flora

The south-west section of the project area and a majority of the land south of the 275 kV transmission line possesses the highest status in regard to the landscape condition, vegetation integrity, floristic composition of conservation significant and restricted plant species, and near-absence of weeds.

The elevation increase to 900 m and greater, plus the degree to which the land is dissected by ravines, rocky bluffs, rock shelves and narrow ridges gives rise to unusual and poorly represented montane heath vegetation along the southwest ridge of the project site. Proposed turbines (as shown in **Appendix A**) 35 to 42 are situated in this area. Other turbines located above outliers of the 900 m contour include 43, 44, 45, and 46.

6.2 Opportunities - Vegetation and Flora

The least constrained aspects of the project area are found to the north of the 275 kV transmission line and across the east-facing slopes of the eastern section of the property. With the exception of the most south-eastern section of the site (i.e. the land that approaches Mt Emerald), these zones have lower diversity in relation to the presence of plants of interest to conservation, and also support less diverse vegetation types.

Across the broad areas of the site described above, mixed woodlands occur. These typically comprise combinations of trees such as lemon-scented gum (*Corymbia citriodora*), rusty jacket (*C. leichhardtii*), *Eucalyptus lockyeri* subsp. *exuta* (no common name), narrow-leaf ironbark (*E. drepanophylla* sens. lat.), granite ironbark (*E. granitica*), yellow stringybark (*E. portuensis*) silver-leaved ironbark (*Eucalyptus shirleyi*) and cypress pine (*Callitris intratropica*). The ground layer of these woodlands is nearly always dominated by kangaroo grass (*Themeda triandra*) and broombush (*Jacksonia thesioides*).

The dominance of kangaroo grass is an indicator of better soil conditions; whereas, the presence of the tufted grass *Cleistochloa subjuncea* usually indicates harder, less fertile ground conditions. Kangaroo grass, when the dominant species, is generally found on wetter, gentle slopes, valleys and flat areas. It is also found on ridges, where it is noticeably less abundant and generally replaced by *C. subjuncea*.

Two plant species of interest to conservation were observed in low abundance in the woodlands described above: *Grevillea glossadenia* and the ground orchid *Habenaria elongata*. The latter species was observed in a sheltered valley in the centre of the southern portion of the site and represent a new southern distribution limit of some 100 km from its previously known southern limit. It is not listed under conservation legislation; however, the record highlights the significance of the southern portion of the site. Given its presence in a valley, the population of this orchid is unlikely to be affected by the proposal.

Weedy grasses also feature more prominently north of the 275 kV transmission line and in the eastern sector of the site. Molasses grass (*Melinis minutiflora*) forms dense patches on wet, eastern slopes closer to the Kennedy Highway side of the site. A number of these high points which are suited to turbine placement are topographically constrained by steep gradients and longer access approaches. They nevertheless, hold the lowest vegetation-ground layer floristic integrity because of the presence of modifying weedy grasses. Unfortunately, strategic repositioning of turbines from this area (as shown on early project layouts) because of visual amenity may result in significant impacts to environmental values in other areas of the site where biodiversity integrity is highest.

The comparatively lower vegetation and flora values associated with the land described above provide the best opportunities for limiting and greatly decreasing the level of impact on matters of National Environmental Significance, as well as reducing the impact on the unique montane heath vegetation community, which commensurately supports the highest numbers and most significant populations of conservation significant plants.

6.3 Constraints - Geological and Landform

Although a detailed geological investigation is not included in the scope of this report, rock type and characterisation and the position in the landscape are important determinants of unique vegetation communities, notably the montane heath vegetation which is restricted to windswept, exposed ridges above 900 m ASL.

The series of ridges south of the 275 kV transmission line are narrowest, and in some instances not much wider than 15 m with eastern-facing precipitous drop-offs. The ridge tops between proposed turbines 36 and 41 (and possibly 42, which has not been investigated) form the niche environment for montane heath communities and the specific habitat for the most significant populations of *Homoranthus porteri*, plus two critically important populations of the endangered *Melaleuca uxorum*.

Sections of ridge between proposed turbines 43 and 48 are also narrow with steep sides. Between this section though, conservation significant plant species are less abundant, but include populations of *Homoranthus porteri* and more commonly, *Grevillea glossadenia*.

Access tracks and cabling to a constructed cleared width of 10 m, and 20 m wide (minimum) at turbine pads will effectively remove major components of populations of *Homoranthus porteri*, with the greatest impact expected along the narrowest ridges between proposed turbines 36 and 42 (see **Appendix A**). More concerning, would be the loss of one of only two populations of the endangered *Melaleuca uxorum* found in the vicinity of turbine 38. Another population of *M. uxorum* is encountered between turbine 37 and 38

The population density of conservation significant plants, and the presence of a noteworthy number of narrow endemic plant species between proposed turbines 36 and 42 render this section of the project site highly constrained.

6.4 Opportunities - Geological and Landform

The undulating and more moderate landform characteristic of the northern section of the project area beyond the 275 kV transmission line affords a number of construction and turbine placement opportunities. These include greatly improved access; less rugged terrain; comparatively low abundance of conservation significant plants; limited availability of niche habitats for narrow endemic and rare and threatened plants; a majority of the land is below the crucial 900 m contour associated with unique and important vegetation types; and the land has a higher level of pre-disturbance than the land south of the transmission line.

6.5 Constraints and Opportunities Mapping

Mapping showing the environmentally constrained zones of the project area is provided in **Appendix I**. The mapping shows environmentally sensitive features such as watercourses; highlights the importance of the land south of the 275 kV transmission line; delineates key plant habitat areas; identifies pre-existing disturbance zones such as tracks; shows the proposed turbine footprints and interconnecting tracks; and demarcates quarantine areas of high ecological significance.

The mapping is based on the confirmed presence of significant environmental features that are not found elsewhere in the project area, and in some instances, are poorly represented at a regional scale. It is derived from a combination of a range of results gathered from field investigations over three years, plus observations made of *ex situ* populations of plants.

The balance of the project area shown on the mapping (i.e. land not included in the mapping as constrained) is considered to be relatively unconstrained. On the condition that the highest level of impact avoidance and mitigation is practiced during the construction and operation of the wind farm, losses to environmental values could be manageable.

7.0 Assessments of Impacts

The assessment of impacts is based on the layout provided by the proponent in July 2012 and further more June 2013. Classifying and determining the severity of potential impacts is important in order to formulate the most appropriate mitigation strategies, measures and site specific management practices to preclude or offset the impacts.

This report has described and highlighted the significant ecological zones of the project site, with an emphasis on identifying priority vegetation and flora areas. The report also identifies parts of the site with lower environmental values and fewer constraints. A key part of the assessment is to determine what areas are likely to be prone to irreversible or difficult to manage impacts. Avoidance of the impact is the first line of sustainable environmental practice, and because of the sensitivity of certain parts of the site, this report strongly recommends that avoidance is practiced as the foremost priority.

Construction of the wind farm however, will result in a range of unavoidable impacts. These will range in severity from low to relatively high. Direct impacts will occur primarily as a result of vegetation cover clearing and consequently from disturbance and alteration of the soil and ground features.

Less prominent, indirect impacts could become evident over time after the project's construction and when the frequency of machinery and surface disturbance reduces or is finalised. Due to the unknown nature and subtlety of these indirect impacts, a number of predictions have been made and based on the most landscape-relevant information available. Some of these predictions were derived from regional surveys of similar landforms with floristic affinities to the project site; and where these surveys did not yield sufficient information, some predictions were derived from an interpretation of pertinent literature.

7.1 Project Description

The project proposes to establish 63 wind turbines each with a construction pad measuring a minimum of 40 x 30 m. In real terms (i.e. the area of land modified beyond its natural condition) this equates to 6 ha of land being cleared, levelled and prepared with a range of imported or introduced materials including road base, concrete, sand and other construction materials. Areas given in this report are minimum, and it is expected that larger areas of clearing will be required for certain construction aspects of the project.

Based on the project layout supplied by the proponent (**Appendix A**), the network of tracks that will be created between each turbine for access and underground cabling will a proposed construction width of 10 m. This network of tracks will require 51 ha of land to be cleared and modified as described above, with the main modification being trenching to accommodate underground cabling. The depth of the trenching is unknown.

Other clearing and construction modifications that could impact on the environmental values of the site include the construction of the associated substation, and the separately proposed concept of the Asia Pacific Energy Innovation Centre (APEIC), which is understood to be planned at the northern end of the project site.

7.2 Impacting Processes

7.2.1 Habitat Loss and Landform Modification

Loss of rock pavements south of the transmission line could have a higher level of impact significance, given that these features are represented by small areas, and that access tracks are likely to traverse or intersect them. Therefore the probability of direct impacts to specific plant habitats represented as rock pavements is reasonably high.

7.2.2 Erosion and Sedimentation

Following track and pad construction, an increased potential for soil erosion will be present. Different sections of the site have different soil textures and structures, and therefore, the potential for erosion is varied. Slope and rainfall intensity will also affect the rate and severity of soil erosion.

No sodic soils have been observed on the site, and therefore, deep erosion comprising tunnelling and gullies is not expected on moderately inclined landforms. The track ascending into the site however, is steeply inclined, and it is expected that erosion and soil movement will be at its greatest along this section of the track. Interconnecting sections of track between turbines will also be affected differently by erosion - again, dependent on the degree of slope and severity of rainfall events.

7.2.3 Weed Incursion

Weeds pose a great threat to the integrity and function of the vegetation of all aspects of the wind farm site. Some weeds have established in the site in recent times, and most probably as a result of construction of transmission line and its associated track network.

Some zones of the site have probably suffered longer term weed incursions possibly as a result of grazing at lower elevation. The most significant manifestation of weed invasion can be seen adjacent to both sides of the main access road into the site along Kippen Drive. In this section, loss of native woodlands through prior land clearing, plus road verge maintenance have resulted in large areas being infested and dominated by weedy grasses and shrubs including grader grass (*Themeda quadrivalvis*), stylo (*Stylosanthes scabra* and other species), Hyptis (*Hyptis suaveolens*) and stinking passion flower (*Passiflora foetida*).

Higher on the site, where traffic and human movement is lower and less frequent, weed presence is found wherever land has been cleared and modified. Weeds observed on the site at higher elevation include Praxelis (*Praxelis clematidea*), molasses grass (*Melinis minutiflora*), guinea grass (*Megathyrsus maximus* var. *maximus*), thatch grass (*Hyparrhenia rufa*) and pigeon grass (*Setaria pumila*). Isolated occurrences of a tall rat's tail grass (*Sporobolus* sp.) and Lantana (*Lantana camara*) can be found around transmission line tower pads.

Weed incursion results in loss of vegetation and landscape integrity. Weeds affect vegetation function, alter the floristic composition, impede or stop natural regeneration and can have a profound effect on the fire ecology of a region.

Species of weeds that have a high potential to enter the site through construction will be those found along the access road edges; those which are already present at higher elevation; and a range of other deleterious species generally found in drier landscapes. An indicative list is provided below, but is by no means exhaustive.

Grasses: Rat's tail grasses (*Sporobolus pyramidalis*, *S. natalensis*, *S. jacquemontii*), thatch grass (*Hyparrhenia rufa* and *H. hirta*), graders grass (*Themeda quadrivalvis*), pigeon grasses (*Setaria pumila* and other weedy *Setaria* species), fountain grasses (*Pennisetum setaceum* and other weedy *Pennisetum* species), molasses grass (*Melinis minutiflora*), guinea grass (*Megathyrsus maximus*), red natal grass (*Melinis repens*), signal grass (*Urochloa decumbens*). **Potential other species:** gamba grass (*Andropogon gayanus*), buffel grass (*Cenchrus ciliaris*).

Vines: scarlet morning glory (*Ipomoea hederifolia*), black-eyed Susan (*Thunbergia alata*), rubber vine (*Cryptostegia grandiflora*), siratro (*Macroptilium atropurpureum*), stinking passion flower (*Passiflora foetida*), glycine (*Neonotonia wightii*), climbing Asparagus (*Asparagus plumosus*)

Creepers/ground layer forbs - Praxelis (*Praxelis clematidea*), blue top (*Ageratum conyzoides*), thickhead (*Crassocephalum crepidioides*), cobbler's pegs (*Bidens pilosa* and *B. bipinnata*), Tridax daisy (*Tridax procumbens*), snakeweed (Stachytarpheta jamaicensis, S. cayennensis), wynn cassia (*Chamaecrista rotundifolia*), Singapore daisy (*Sphagneticola trilobata*), white eye (*Mitracarpus hirtus*), Mexican clover (*Richardia brasiliensis*).

Succulents: sisal and century plant (*Agave sisalana* and *A. vivipara*), mother-of-millions (*Bryophyllum* species). **Potential other species:** Parthenium (*Parthenium hysterophorus*), cactus (horticultural species and others).

Shrubs: Hyptis (*Hyptis suaveolens*), stylo (*Stylosanthes scabra* and other species), Japanese sunflower (*Tithonia diversifolia*), Cinderella weed (*Synedrella nodiflora*), Lantana (*Lantana camara*), sicklepods (*Senna* spp.), Urena burr (*Urena lobata*), flannel weed (*Sida cordifolia*)

7.2.4 Loss of Vegetation Integrity

Loss of species and structural integrity of the original vegetation cover will occur as a result of land clearing. Large-class trees are generally found on sheltered slopes and in valleys, and rarely along ridges and high points. Nevertheless, larger trees form the framework of woodlands and also provide numerous habitat niches for fauna.

Vegetation integrity of the shrub layer and ground layer of heath and shrublands along ridges is at most risk of being impacted. These communities are unlikely to recover to their original floristic or structural composition, and the most likely scenario is a species poor community dominated by wattles (*Acacia* spp), and the heath plant *Jacksonia thesioides*.

The introduction and potential replacement of native floristic elements by weeds is a probability. The daisy weed Praxelis (*Praxelis clematidea*) will invade disturbed rocky areas and could preclude the establishment of native species.

7.2.5 Slow Vegetation Succession

Colonisation of cleared track edges by native plants could be slow and result in disclimax communities of wattles or grasses, with limited representation of the original floristic component. This could be further exacerbated by opportunistic weed establishment.

7.2.6 Altered Fire Ecology

The introduction of weedy grasses with tall growth habits and bulk dry material could promote unnatural fire dynamics, which has many follow-on negative effects for both flora and fauna ecology.

7.3 Identification of Impacted Areas

7.3.1 Description of Construction Zones

Based on the current information available, construction zones for the wind farm project are understood to comprise two main features: turbine construction pads and interconnecting tracks, which will also serve as the routes for underground electrical cabling. An electrical substation will also need to be incorporated into the project.

The turbine construction pads are proposed to be of a minimum area of 40 x 30 m, with the longest side orientated with the direction of the ridge (if applicable).

The interconnecting tracks are proposed to be cleared to an initial minimum width of 10 m; however, wider tracks will need to be constructed to allow for long, heavy machinery and trailers to negotiate bends and switchbacks when bringing the infrastructure into the site from lower elevations.

The depth of cabling (trenching) to be installed in the approximate centre of the interconnecting tracks is not known, but is expected to be a minimum of 1 m below the finished ground surface for safety reasons.

A number of vehicle (trucks and heavy machinery) turnaround areas will need to be incorporated into the "disturbance footprint". The location and size of these is not known.

The substation will occupy an area 200m x 200m and is situated along the current transmission line (**Appendix A**).

Other zones of potential impact which will be required include workers and site management facilities and depots; concrete batching plant/s, and possibly sources of roadbase and other construction materials. It is not known where or what size these facilities will be.

7.3.2 Area of Impact

The areas identified to be directly impacted by construction of the wind farm are shown on the mapping in **Appendix A Site layout.** Impacted land shown on the mapping is only applicable to the known construction zones outlined above.

From the current information available the total area of new impacts (i.e. new tracks and construction pads) is estimated to be 51 ha.

7.4 Impacted Conservation Significant Plant Species & Habitats

7.4.1 Known Species and Habitats to be Cleared

The conservation significant plant species that will be impacted by construction of the wind farm are *Grevillea glossadenia*, *Homoranthus porteri* and *Plectranthus amoenus* - all of which occur along ridges and on rock pavements.

It is not possible to calculate the exact numbers of individuals that will be impacted due to the uncertainties surrounding the precise turbine construction zones and the configuration of the interconnecting track network.

7.4.2 Potentially Affected Habitats

Habitats most at risk are those which are restricted to ridges. South of the transmission line is where the greatest representation of key habitats for montane heath communities and conservation significant plants occur. More precisely, the critical habitat zone is above the 900 m contour.

7.5 Impacts on Ecological Function

7.5.1 Vegetation Integrity

The integrity of the composition and structure of vegetation is likely to be compromised wherever vegetation clearing and surface disturbance will occur. One of the drivers of these changes will be the plant community that replaces the original community. Shifts in integrity can be structural and / or floristic. For example, wattles (*Acacia* spp.) are recognised as a group, for their capacity to recolonise and reshape the floristic composition of plant communities that they succeed. Examples of this can be seen across a range of edge-affected woodland types on the site. The shrubby wattle *Acacia umbellata* for example, readily forms mono-specific thickets over cleared tracks edges adjacent to existing transmission line access tracks (S. Gleed, pers. obs.).

Acacia- dominated thickets have no structural or floristic resemblance to the original woodland, which in the example given above, was characterised by a tree layer to 6 m of *Corymbia leichhardtii* with scattered *Callitris intratropica*. The ground layer originally comprised the grass *Themeda triandra* with the heath *Jacksonia thesioides*, overtopped by a secondary shrub layer of the grass tree *Xanthorrhoea johnsonii*. Effectively, thickets of *A. umbellata* preclude the regeneration of the original floristic composition; and therefore the integrity of the vegetation is compromised, and may never attain the original status and composition prior to its clearing. This type of scenario has implications for plant communities which possess high numbers of endemic and conservation significant species.

7.5.2 Connectivity

Linear clearing for tracks that are required between the turbine arrays will contribute to breaks and disjunctions of vegetation connectivity. Vegetation connectivity with high levels of structural and floristic integrity (described above) is important for the gene flow and the persistence of vegetation communities; and populations of plants - particularly those species which are narrow endemics; have limited distribution and habitat tolerance; and/or are important to conservation. The importance of connectivity therefore becomes even more crucial for species and communities that exhibit contracted habitat and edaphic ranges: plants with limited tolerance for differentiation in their growth environment.

Removal of the surface soil medium from ridges has the potential to have the most deleterious impacts, since plants that grow in this spatially narrow environment tend to be highly constrained to the particular depauperate soil qualities. Montane heath communities along narrow and exposed ridges will be most at risk because of the limited surface area available as habitat.

Woodland vegetation with taller stature, higher structural characteristics, and greater regional representation, is by contrast to the ridge-top vegetation, less prone to long-term and irreversible impacts. The configuration of this structural unit across slopes, valleys and undulating land renders it less susceptible to adverse impacts associated with breaks in connectivity and displacement of gene flow. This is one of the primary reasons why the section of the project site north of the 275 kV transmission line is least constrained in terms of environmental impacts associated with vegetation and flora species of interest to conservation, because of the decrease in presence of ridges and narrowly defined plant communities.

7.5.3 Refugia

Refugia could be defined as special habitats: niches and protected places where plants and discrete vegetation communities can survive and persist beyond the perturbations of extreme environmental events such as fire, flood, desiccation, drought or even predation.

A range of refugial plant habitats are present within the project site and include riparian fringes affording longer-term moisture and denser vegetation; rock outcrops with deep fissures and pockets of peat-like soils which retain moisture to sustain plant growth in otherwise desiccated environments; rock pavements , with naturally fireproof or fire-protecting qualities because of the minimalist presence of flammable material and low fire-bearing vegetation; ridges which by virtue of their steeply inclined sides have narrow surface area and support special plant communities.

The limited spatial representation of refugia adds to their conservation significance (for example, heath communities above 900 m). The most profound impacts that could be expected to these specialist habitats are likely to be associated with clearing of ridges for interconnecting tracks and the turbine construction pads in these areas. Due to the narrowness of ridges, notably south of the 275 kV transmission line, there are limited opportunities to avoid the impact of clearing, except on the widest ridge crests.

7.5.4 Critical Habitats

Critical habitats are mostly associated with the presence of conservation significant plants - notably those species found in narrowly represented habitats found south of the transmission line and mostly above the 900 m contour. These habitats support the montane heath community where species such as *Homoranthus porteri*, *Grevillea glossadenia and Melaleuca uxorum* are found. Several narrow endemic, and regionally restricted plants are also found in this high elevation, exposed plant communities.

Given that these critical habitats occur primarily south of the 275 kV transmission line, construction of turbines and access tracks along the ridges in this part could have significant impacts on populations of conservation significant plants. In some cases, surface modification of the ridge top will result in loss of complete habitat niches, and particularly disrupt connectivity and the capacity for these populations to regenerate.

Significant habitat and populations of conservation significant plants are present at and between turbines 38 to 42. Turbines 43 to 46 also occur in areas of significant high quality habitat (as shown in **Appendix A**).

7.5.5 Botanical Values

Parts of the project site associated with habitats between 36 and 46 have significant botanical values. The concentration of conservation significant and narrow endemic species in this region renders their populations sensitive to disturbance.

The primary disturbance factors are ridge clearing and surface modification, loss of soil and a growth medium, and colonisation by weeds. The introduced daisy Praxelis (*Praxelis clematidea*) has been observed to quickly colonise disturbed rocky sites south of the transmission line between turbines 48 and 49 at the 80 m wind monitoring tower. This weed exhibits allelopathic traits which preclude or retard the establishment and recovery of land by native species.

Mapping showing the core botanical zone and corresponding habitats is given in **Appendix E**.

7.6 Threatening Processes

A number of threatening processes, impacts and landscape modifications will result from construction and maintenance of the proposed wind farm. Some of these impacts will be direct and require immediate mitigation. Others will be more subtle and indirect and may occur over a period of time - possibly months or even years after the project has been constructed.

Direct impacts include vegetation clearing and surface levelling for road and turbine construction. Whilst this is considered to be the largest impact requiring a commensurate level of mitigation, the area impacted represents approximately 2.1% of the site.

Indirect impacts include the introduction of weeds and pathogens into once weed-free and healthy vegetation zones.

7.6.1 Phytophthora

One of the insidious and potentially harmful indirect impacts could be the introduction of the Phytophthora plant pathogen (*Phytophthora cinnamomi*). The negative effects this disease has had on discrete plant communities in Western Australia is documented by Barrett (2000), where it is was identified that *P. cinnamomi* was the most serious threat to montane heath vegetation above 900 m ASL in the Stirling Ranges. At the taxon level Barrett (1996) reports the disease *P. cinnamomi* significantly impacts Proteaceous and Epacrid plants. Therefore, there is potential for the disease, if introduced to the wind farm site to affect conservation significant species such as *Grevillea glossadenia* (Proteaceae) plus a number of regionally restricted endemic species in the family Ericaceae (formerly referred to Epacridaceae). Phytophthora is a soil borne pathogen and would need to be managed through rigorous attention to equipment and machinery cleanliness (i.e. wash downs guarantees of no imported soil or plant material from diseased areas).

7.6.2 Myrtle Rust

Another recently described fungal plant pathogen myrtle rust (*Puccinia psidii* syn. *Uredo rangelii*) also poses a threat to plants in the family Myrtaceae. Myrtle rust spreads by microscopic spores and is readily dispersed by wind. It can also be spread by any vector that is able to carry the spores; therefore, vehicle movements, water, soil, on equipment and machinery and even plant nursery stock imported into the site have the potential to mobilise the pathogen.

Because of the significance of the Myrtaceae in the Australian environment (i.e. eucalypts, bloodwoods, bottlebrushes, tea-trees and paperbarks, etc), myrtle rust has been identified as a high to extreme risk biosecurity threat (Pegg, *et al.*, 2012).

7.6.3 Surface Clearing and Scraping

Ground surface clearing and increased levels of substrate disturbance will occur as a result of establishing a series of tracks and construction pads for wind turbines. Due to the topography and the preferred location for wind turbines on the highest elevation points on the site, clearing will mostly affect the ridges connecting these high points.

Ridges and rock pavements form the geomorphologic habitat basis for montane heath vegetation (Ford and Hardesty, 2012). Slopes falling away from the ridges generally support a taller woodland of different physiognomic structure and floristic composition (S. Gleed, pers. obs., J. Kemp, unpublished data) and are unlikely to receive similar levels of disturbance as the ridges.

Clearing of vegetation and modification of the ground layer along ridges for the construction of tracks (proposed initial width of 10 m) and turbine pads (proposed minimum width of 30 m) is predicted to result in the following impacts:

- Transportation and relocation of the upper soil horizon.
- Modification of the underlying geology and edaphic conditions.
- Relocation and re-stratification of the soil seed bank.
- Potential exposure and desiccation of plant propagules including roots, rhizomes and seed.
- Alteration of soil drainage, water retention and rates of evaporation.
- Complete removal of vegetation cover and loss of habitat-obligated species.
- Initiate plant succession with the potential for species replacement and exclusion (e.g. *Acacia* replacing habitat specific plants such as *Homoranthus porteri*, *Melaleuca uxorum*, *Cryptandra debilis* and many

others).

- Potential introduction of weeds and pathogens.

Observations were made on the site's western boundary of a recently cleared 3.5 m wide track through similar country as what is found on higher ridges (**Plate 8**). The track passes over the same rhyolite-derived soil and geology to that found along ridges south of the 275 kV transmission line. Plant regeneration at this site on road spoil was primarily by the wattle *Acacia leptostachya*, forming low, species-limited thickets.

Plate 8 Recently cleared track 3.5 m wide close to ridge country on western boundary of site. Track is estimated to have been cleared in 2012. Person on right of picture is standing 10 m from left-hand side of track, which represents the proposed clearing width of tracks between turbines.

Following Clarke (2002), parallels could be drawn between the effects of fire on species composition in heathlands and the capacity for regeneration of floristic components of the original montane heath flora following disturbance. For example, if fire is seen to be a significant disturbance factor and determinant of floristic composition of vegetation on ridges and rock pavements (Clarke, 2002), then species composition after disturbance such as clearing could be influenced by the ratio of obligate seeders (species that are killed by fire) and sprouters (species that resprout after fire) present in the original flora (Clarke, 2002; Bond and Midgley, 2001; Ford and Hardesty, 2012).

For species that recuperate by reshooting after disturbance (sprouters), there must be at the very least some functional primary root matter or vegetative propagule for the plant to recover. Track clearing and trenching will remove roots and stems of shallow-rooted shrubby species, and any successional vegetation will probably comprise mainly obligate seeders (i.e. species able to germinate from the soil seed bank). Obligate seeders are only able to recuperate if there is some semblance of the original seed carrying soil remaining *in situ*, such as in rock crevices. Therefore, increased or deeper removal of soil and substrate will result in lower species recovery rates and potential reduced species diversity.

Williams *et al*. (2005) identified that 97% of the montane heath species found on Bishop's Peak in the Wet Tropics bioregion are sprouters, with only one species being an obligate seeder (*Banksia plagiocarpa*). Based on these figures specifically relating to montane heath vegetation in the Wet Tropics bioregion, it is reasonable to expect that the floristic composition of ridges and rock pavements will significantly change following construction work.

7.6.4 Inter-turbine Cabling

Inter-turbine cabling is expected to be underground and buried to a depth that meets Australian Standards and any Queensland standards for safety. At a minimum, it is expected that cabling will need to be buried to a depth below the formed ground surface of 1 m. Based on the design provided by the proponent (**Appendix A**), the route for this cabling is assumed to follow the access tracks and aligned with the centre of these tracks.

Construction of the cabling trenches will require methods that employ the use of heavy earth-moving and trenching machinery. Additionally, it is possible that explosive blasting of solid rock substrates will be necessary in some areas. Solid rock is associated with many sections and linear stretches along ridges - sometimes in excess of 400 m. Fracturing of this geological landform may result in the total loss or significant modification of vegetation communities constrained to ridge formations.

7.7 Post-construction Environmental Responses

7.7.1 Vegetation Recovery After Disturbance

Fire has had a profound effect on the survival of certain plant species and the species that have recovered over the site. Ford and Hardesty (2012) record a fire event in the Mount Emerald location as taking place in late December 2007. Initial observations of the vegetation for the wind farm project began in May 2010. During this time access was gained to the most easterly ridges and the southwest and western ridges. Vegetation had been particularly affected in some locations, whereas some zones, mostly ridges and rock pavements, had remained relatively unscathed - reinforcing the fire-proof niche concept of these features (Clarke, 2002). Elsewhere, trees such as *Callitris intratropica* have not since recovered. By 2013, some eucalypts and bloodwoods showed some signs of recovery through the development of epicormic shoots. Judging by observations of vegetation recovery over successive field visits, it appears that the ridge vegetation recovers from gross disturbance and modifying events very slowly. Taller woodlands on slopes and in valleys on the other hand show signs of more rapid recovery.

The wattle *Acacia umbellata* is one of the commonest shrubs to regenerate after fire. This species forms monotonous low thickets, sometimes interspersed with a secondary shrub layer of grass trees (*Xanthorrhoea johnsonii*) and a low, uniform layer of the heath-like shrub *Jacksonia thesioides* (**Plate 9**). In places (mainly woodlands), the hemi-parasitic *Exocarpos cupressiformis* has emerged as a response to fire. The presence of these post-disturbance species, plus the suite of successional plants established in the existing powerline corridor give an insight into the possible species composition that could develop following construction of the tracks and turbine pads.

Plate 9 Regeneration of the wattle *Acacia umbellata* and the resultant allelopathic community following a severe fire event.

Observations of the floristic composition of various successional stages of plant communities on the site confirm that wattles (*Acacia* spp.) are the predominant group to take effect on disturbed ground. Few species of wattle tolerate fire and generally recover from germination of seed stored in the soil. The commonest species of Acacia occupying rocky ground and amongst rock pavement mosaics include *A. aulacocarpa* (rock pavements), *A. calyculata* (ridges), *A. humifusa* (ridges and rock pavements), *A. umbellata* (ridges, rock pavements and edge of tracks - **Plate 8**) and *A. whitei* (ridges).

The ability for some conservation significant species and narrow endemics to re-establish after track clearing may be limited - possibly because of displacement and allelopathic soil conditions created by wattles. As a group, narrow endemic plants are reported to have a reduced capacity for colonization than widespread congeners (Lavergne *et al.* 2004). This further explains why a majority of the conservation significant plants (with the exception of *Grevillea glossadenia*), plus a great proportion of the narrow endemic species encountered, are restricted to a poorly represented habitat unit of montane heath found along ridges (see also Thompson *et al*. 2005).

Interestingly, the conservation significant shrub *Grevillea glossadenia*, despite being a narrow endemic, favours disturbance and appears to be an obligate seeder. Evidence of this species' capacity to regenerate *en masse* following ground perturbation can be seen around the 80 m wind monitoring tower between proposed turbines 48 and 49 (**Plate 10**). The shrub also survives healthily on and around stockpiled road base material near the Stannary Hills turnoff road to the south-west of the site (S. Gleed, pers.obs.).

Plate 10 The shrub *Grevillea glossadenia* regenerating from seed around the 70 m wind monitoring tower on the site.

For obligate seeders, if the soil seed bank is displaced, translocated or physically altered beyond a state whereby its regenerative germination capacity is diminished there is likely to be a corresponding decrease in the number of species represented in the original floristic complement consequently surviving. Similarly, for those species that are sprouters, complete loss of their vegetative parts will result in a loss of individuals from the disturbance footprint. This is particularly important to a number of locally endemic plants with contracted distribution ranges, including the shrubs *Melaleuca uxorum* (endangered), *Cryptandra debilis*, *Melaleuca borealis* and *Hovea nana*, *Indigofera bancroftii* plus others that are not found in woodlands on slopes, but are restricted to ridge environments on the site. Other examples of niche-specific plants that could be affected by clearing include *Borya septentrionalis*, *Mirbelia pungens*, *M. speciosa* subsp. *ringrosei*, *Sannantha angusta* and at least two species of unidentified orchid lithophytes.

The species described above exhibit minimal tolerance for habitat types and are constrained to depauperate rocky surfaces. Ford and Hardesty (2012) recorded their regeneration capacity as resprouting from the base of stems and from epicormic buds on branches and stems; and therefore, the probability that this group of plants will recover to form viable populations following major ground modification is low, unless they can be replanted or successfully propagated.

However, pads around turbines will be a mixture of scalped and pushed rock debris, which if respread in close proximity to its origin should have some capacity to supply surrogate habitats. Some regeneration of the original floristic component may occur from the soil seed bank, remains of roots, corms, rhizomes and tubers. Given the predicted limited success rate of tube stock planting as a rehabilitation method for the wind farm site, long-term observations and records of regeneration provide a sound opportunity for an ongoing research project.

7.7.2 Impacts on Soil Formation

The formation of soil on the surfaces of rock pavements and along skeletal zones of ridges is slow and results in the barest of growing medium in which higher order plants can later establish. Soil development from rhyolite is reliant on basic seral stages in vegetation succession, where a bare impervious surface is gradually colonised by lower order plants: foliose and crustose lichens, mosses and later by ferns (*Cheilanthes* spp.) and then by sparsely distributed short grasses such as *Eriachne humilis* and *Tripogon loliiformis*. The so-called resurrection plant *Borya septentrionalis* forms a patchwork cover over some rock pavement surfaces: usually in hollows and scoops, attaining a thickness of 15 cm; where the vestiges of roots and decomposing foliage provide the main constituent of the underlying humus rich, peat-like soil medium (**Plate 11**).

Plate 11 The resurrection plant *Borya septentrionalis* is an important contributor to the formation of skeletal peat-like soils on some rock pavements. Decaying root matter and spent leaves blend with exfoliating rock particles to form the medium that is capable of retaining water on an otherwise impervious rock surface.

Ramsey and Cairns (2004) recognise the importance of lower order plants, particularly bryophytes (mosses), in the development of soil and other physiological factors such as water harvesting, storage and slow release on rock pavements (**Plate 12**). Due to the depauperate nature of rock-derived lithosols, the retention and development of lower order plants in the primary successional phases as well as later stages is critical. These types of montane soils are uniquely associated with rock pavement floristics and are intrinsically linked to the presence of montane heath vegetation.

Plate 12 Mosses and lichens are crucial to the early development of a growing medium for higher order plants on rock pavements and subsequently are a key contribution to the montane heath environment.

Woodlands on the site are found mainly on deeper, more well-developed soils and grow almost exclusively on the slopes and in valleys between ridges. The depth, structure and profiles of the soils supporting taller vegetation types in markedly different from the skeletal soils of ridges and associated rock pavements. Greater soil depth and improved structure contribute to vegetation of different stature and physiognomy, where for example, the tallest and most developed woodlands occur on the west-facing slopes in the south-western quadrant of the site. Here, large-class trees of *Eucalyptus reducta* over a lower tree layer of *Allocasuarina torulosa* reach their best development (**Plate 13**). Many trees have significant hollows giving evidence to their age and longevity in the landscape. The ground layer is markedly different from the ridges, where there are fewer shrubs and sub-shrubs, and the ubiquitous kangaroo grass (*Themeda triandra*) is invariably dominant.

Plate 13 Woodland of *Eucalyptus reducta* is found on sheltered parts of the southern section of the site. These woodlands exhibit the best structural development of all vegetation types in the project area, and evidenced by the size classes of trees, may also be the oldest.

7.7.3 EPBC Act Significant Impact Criteria

The significant impact criteria of the EPBC Act is applied to the three EPBC Act listed species known to occur on the site and in very close proximity (*Acacia purpureopetala*), and summarised in **Table 5**.

Table 5 Significant impact criteria of the EPBC Act as it applies to the three most relevant species on or adjacent to the site

EPBC Significant Impact Criteria	*Acacia purpureopetala* Presence not confirmed in project area	*Grevillea glossadenia* Confirmed presence in project area	*Homoranthus porteri* Confirmed presence in project area
Lead to a long-term decrease in the size of an important population of a species	Unlikely – most collections of the species are from Irvinebank and Stannary hills – possible limited habitat on south-western boundary of project area.	Unlikely due to relative high abundance and ability to tolerate a wide range of ecological conditions.	Possible if not managed appropriately – need to identify important sub-populations within the site and conserve areas of rock pavement south of transmission line.
Reduce the area of occupancy of an important population	Unlikely – most records of the species are from Irvinebank/Stannary Hills region to the south-west of the project area. One collection from the south-west of the project area. Major population in Toy Creek (off-site).	Unlikely – a widespread species across the southern half of the project area. Disturbance triggers growth responses/seed germination.	Possible given that the species occupies a naturally small niche around rock pavements and on rocky ridges.
Fragment an existing important population into two or more populations	Unlikely – see comments above.	Unlikely due to evenness of distribution.	Unlikely, as the species is represented elsewhere on the site where wind turbines are not proposed to be constructed.
Adversely affect habitat critical to the survival of a species	Unlikely – more significant populations mapped over the Irvinebank/Stannary Hills region –lower rainfall and possibly more preferential habitat. Evidence indicates that the species is adapted to disturbed environments (road edges, mine sites).	Unlikely due to wide tolerance by the species of habitat types –even on disturbed land.	Some possibility - the species has a comparatively narrow ecological tolerance.
Disrupt the breeding cycle of an important population	Unlikely – important population not identified on the site.	Unlikely due to capacity for mass germination – assuming soil seed bank is left intact.	Low probability if turbines are appropriately micro-sited.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely – drier, and possibly more preferential habitat in the Irvinebank/Stannary Hills region.	Unlikely – habit for the species is well represented across the southern half of the project area.	Yes – see comments below for weeds. Also, rock pavements, which are the preferred habitat for this species, occupy small areas mostly associated with ridges and points of highest or exposed elevation.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely - important populations not identified on the site.	Possible – introduction of deleterious weeds such as sicklepod, grader grass, molasses grass, and a range of other naturalised plants that could outcompete the species and preclude successful regeneration.	Possible – introduction of deleterious weeds such as sicklepod, grader grass, molasses grass, and a range of other naturalised plants that could outcompete the species and preclude successful regeneration. The weed *Praxelis clematidea* poses a threat to disturbed rocky ground.

EPBC Significant Impact Criteria	*Acacia purpureopetala* Presence not confirmed in project area	*Grevillea glossadenia* Confirmed presence in project area	*Homoranthus porteri* Confirmed presence in project area
Introduce disease that may cause the species to decline, or	Unlikely - important populations not identified on the site.	Possible if appropriate weed hygiene and other protocols for the management of pathogens are not implemented and maintained throughout the duration of the wind farm. Phytophthora could be deleterious.	Possible if appropriate weed hygiene and other protocols for the management of pathogens are not implemented and maintained throughout the duration of the wind farm. Myrtle Rust and Phytophthora could be deleterious.
Interfere substantially with the recovery of the species.	There is no recovery plan in place for this species.	There is no recovery plan in place for this species.	There is no recovery plan in place for this species.

7.7.4 Likelihood of Recovery after Disturbance

In the event that a particular site and corresponding habitat is modified or drastically changed from its natural state, the following notes have been compiled regarding the predicted (but not guaranteed) potential for a particular EPBC listed plant species to recover at the site. The notes are based on observations and label data (i.e. HERBRECS) of the responses of the species to modified environments in other areas with similar geological and broad vegetation characteristics.

Acacia purpureopetala – likely, but not able to quantify. Evidence of regeneration at mine sites on benches where no other plants are able to establish. Known recovery and observations of regeneration on scraped road verges at the Stannary Hills road turnoff near Irvinebank (S. Gleed, pers. obs.)

Grevillea glossadenia – highly probable this species will recover and populations will not be adversely impacted. Observational evidence at several sites within the project area of recovery following ground disturbance and modification of habitat. Mass germination of seed following fire events (note: recent fires may have destroyed these new populations before they had time to mature and set seed. The species appears to have a wide tolerance of a range of edaphic conditions – providing the base geology is rhyolite.

Homoranthus porteri – little evidence of recovery after disturbance because habitats have yet to be grossly modified. Possible resilience to fire, but not fully understood. The species has been observed to have survived in patches where ridge trees have otherwise been affected by fire. The species is thicket-forming and is likely to set high quantities of seed. Seed is probably small (not observed). This species has a relatively small ecological tolerance, and is strongly reliant on rock-pavement surfaces and the skeletal soil environment of rocky ridges.

8.0 Mitigation of Impacts

8.1 Alternatives to the Proposed Layout

A notable reduction in impacts can be gained by careful locating of each turbine with stringent consideration given to avoiding key habitats, zones of high concentrations of conservation significant plants, and essential habitat areas. In this regard, the most significant area of the project sites is south of the 275 kV transmission line. The primary habitat for important populations of many narrow endemic plants is found in this area. By not establishing tracks and turbine footprints in this zone, a considerable proportion of high value environment could be preserved. This zone is shown in **Appendix I**.

8.2 Mitigation Measures

A range of mitigation measures will need to be negotiated with the proponent, designed and implemented prior to construction. Some of these measures will be required throughout the operation of the wind farm.

8.2.1 Mitigation of Impacts on Vegetation Communities

The aims of the mitigation strategies are to maintain to the highest level the following vegetation-related matters: ecological function, vegetation integrity, connectivity, refugia and critical habitats.

The most prudent mitigation measure with respect to maintaining integrity to vegetation communities is to not clear the vegetation or modify the landscape beyond the current condition; the exception to this being the control and management of weeds that have existed on the site prior to the wind farm development. Based on this principle, any clearing should be undertaken according to a prescribed route and clearly defined turbine footprints, and kept to the absolute minimum necessary. Therefore, the layout of the turbine arrays and track network should be carefully and thoughtfully designed and clearly articulated on survey accurate plans.

Mechanical clearing of sensitive communities should be avoided as the only means of establishing the turbine construction pads and track network. Selective hand clearing of vegetation is preferred, and with qualified environmental advisors on hand to provide guidance to the least impacting methods of site preparation.

Maintaining the structure of the vegetation by not entirely clearing all trees and altering the architecture and framework of the community is important. Therefore, larger-class trees, hollow-bearing trees and shrubs should not be cleared if not necessary. Notwithstanding that, the highest representation of large-class trees tends to be in sheltered valleys, gorges and in the south of the site on west-facing slopes; and such specimens should be protected. Trees with a stem diameter at breast height of 30 cm or greater fit into this category.

Maintaining the floristic integrity of the ground layer is equally as important, as this stratum is the most diverse in terms of flora species in sclerophyll communities. This is particularly pertinent for any vegetation communities occurring along narrow ridges or bands of land where the community is not widespread.

Heath vegetation on ridges south of the transmission line will be prone to loss of floristic and structural integrity if cleared; therefore, it is critical that turbine construction pads are carefully planned and situated in the least susceptible vegetation types. Vegetation and track clearing will need to be constrained to the absolute minimum in these circumstances; and in some situations avoided altogether (see **Appendix I** for proposed conservation area).

Linear and broad-scale clearing are notable impacts that affect ecological function. With clearing, the potential for weed invasion is substantially increased - another major contributing factor to the disruption of ecological function.

Sensitive zones of vegetation (riparian, heath vegetation and key habitats for rare and threatened plants) should be defined and clearly marked on the ground. These areas should be quarantined from machinery activity, materials storage and other potentially impacting factors.

The management and control of weeds is critical and of the highest importance. A dedicated weed management plan will need to be prepared and implemented prior to construction. Any new incidences of weeds in formerly "clean" areas should be dealt with immediately, and a record kept of the incidence for future reference and monitoring.

Weeds, pathogens, machinery and land modification are all interrelated. Therefore an integrated approach to construction is essential. Machinery and vehicles should pass through a washdown bay and be regularly cleaned at a designated point outside of the wind farm project construction zone (i.e. in the vicinity of Kippen Drive).

Unplanned fires and burn-offs should be avoided. A dedicated and strategic fire management plan should be developed and integrated into an overarching Environmental Management Plan. Therefore, burning as a means of clearing and cleaning-up a site should not be permitted. Similarly, burning windrowed vegetation should not occur.

8.2.2 Mitigation of Impacts on Plant Species of Conservation Significance

All plants of conservation significance should be clearly identified prior to clearing and construction activities progressing. Important populations of such species should be protected from impacts and identified on mapping. On the ground, these populations should be marked with fluorescent flagging tape, and where practicable, be allocated a buffer zone of at least 10 m in which no vegetation disturbance should occur.

Protection of supporting habitat for rare and threatened plants should be afforded where identified on mapping and in a similar fashion to that described above for vegetation communities. Again, weed management and control, is critical.

To assist with identification, plant guides, which describe important species and have good photographs of their characteristics should be compiled and issued to contractors.

Plants of interest to conservation that are to be cleared or damaged (i.e. in the construction footprint) will need to be recorded: noting the numbers to be cleared, the health of the population and other relevant information. Advice should be sought from a botanist prior to contractors undertaking work where rare and threatened plants are located.

A translocation plan will need to be developed in accordance with the EPBC Act guidelines and following the associated technical advice reported in Vallee, *et al*. (2004). Suitable recipient translocation sites should be identified and opportunities for relocating the conservation plants to these sites undertaken.

8.2.3 Mitigation of Impacts on Refugia and Critical Habitats

Refugial, protected zones for plants are often expressed in sheltered places: amongst larger rock outcrops, remote rock pavements, riparian niches and fireproof habitats, with minimal soil development, sparse vegetation and usually a dominance of rock on the surface. On the site these refugia area found adjacent to streams and ephemeral drainage lines, along ridges, in gorges, and in the remote section of the site south of the transmission line - particularly in the region of the most western ridge.

The mapping in **Appendix I** shows the section of the site with the highest proportion of important plant habitats and consequently, refugia. Also, the rock pavement and outcrop mapping in **Appendix F** provides a spatial indication of micro-habitats for plants and could assist with the design of construction and placement of roads and turbine pads.

All key refugia should be identified and clearly demarcated prior to construction.

The refugial habitats summarised above should not be modified or have the vegetation cleared. This is most relevant to the ridge and heath vegetation found south of the transmission line.

Preservation of the ground surface is an important mitigation strategy in these sensitive habitats and notably for the heath vegetation. Here, any soil removal should be kept to an absolute minimum. Soil and rock spoil should be stockpiled immediately adjacent to where it will be excavated. It should then be returned and respread over the disturbed site as soon as possible.

Under no circumstances should weed-infested soil be introduced into these environments. Any imported road base and fill material will need to be sourced from local supplies and be certified weed-free.

For riparian niches, minimal clearing can be achieved by using existing tracks and stream crossings. Upgrading and installing culverts where necessary is advised. Weed control is required at some stream crossings.

8.3 Environmental Offsets

A number of impacts will occur as a result of construction of the wind farm. Some of these impacts may not be able to be avoided in their entirety, and therefore, the application of environmental offsets will be required. The main triggers for initiating offsets include:

- Clearing remnant vegetation listed as Of Concern under the *Vegetation Management Act 1999;*
- Clearing of species of plants listed under the *Environment Protection and Biodiversity Conservation Act 1999;* and
- Clearing of species of plants listed under the *Nature Conservation Act 1992*

Other matters that can trigger interest with respect to environmental offsets include the loss of habitat that is critical to sustaining populations of plants listed under the EPBC Act and the NCA.

8.3.1 The Need for Offsets

If impacts cannot be avoided, then consideration might be given to providing conservation area offsets – this process is complex and the preferred option is clearly to avoid the impact by repositioning turbine construction pads and re-routing tracks.

In real terms, environmental offsets are the least preferred option for impact mitigation. It is far more ecologically sustainable to avoid creating the impact rather than environmental trade-offs such as land swaps, rehabilitation, monetary offsets and so on. Nevertheless, where the impact is unavoidable, such as in situations where plants of conservation significance occur in the disturbance/clearing footprint, then environmental offsets to supplement practical mitigation measures will need to be negotiated with respective government departments and administering authorities.

8.3.2 Types of Offsets

This report does not outline the range of environmental offsets in practice in Australia. This aspect should be considered as a separate component to this report, and focus on strategic approaches which could incorporate:

- Rehabilitation initiatives: for example, identifying *ex situ* land with an important landscape position, where the conservation values could be enhanced and improved through a long-term rehabilitation programme.
- Land swaps and purchases: acquisition of land with important values (similar to above), with the intention of maintaining the land in perpetuity as a conservation area.
- Designating *in situ* conservation zones: the land to the south of the transmission line is identified as having significant conservation value. This land could be considered as a key conservation zone (see mapping in **Appendix I**).
- Financial offsets: a complex area; nevertheless, monetary negotiations should be directed at achieving a net conservation benefit.
- Instigating research initiatives: research initiatives and concepts are discussed in the following section in this report, and could be supported through grants or bursaries issued by the proponent.

8.4 Concepts for Environmental Offsets and Conservation-based Initiatives

8.4.1 Plant Translocation Plan

There is a requirement under the EPBC Act to identify and confirm opportunities for the translocation of wild plants if they are to be cleared from the construction footprint. A translocation plan based on the criteria and guidelines detailed in Vallee, *et al*. (2004) should be developed with site specific objectives clearly outlined.

Recipient and target translocation sites across the project area should be described and mapped and integrated into the plan accordingly.

8.4.2 Literature and Interpretive Material

Affiliated with offsets could be a series of interpretive literature and associated material which describes and recognises the importance of the project site from a range of perspectives. For example, the northern Quoll (*Dasyurus hallucatus*), noted for its conservation status, is relatively widespread in the project area and worthy of documenting. Such documentation would include photographs of the species including infra-red photographs taken during the population survey of the species in the project area; as well as its habitat requirements, feeding needs and notes on its natural history. Similar short communications could be developed for other species of fauna of interest to conservation.

The rare and threatened plants found in the project area lend themselves to interpretation both through literature and as design elements in an arboretum for example, and in revegetation. Given the static nature of plants they are readily photographed and described. The ecology of plant species can also be easily interpreted. Interestingly, the flora of the project area is poorly represented in the current literature, apart from occasional taxonomic work (Craven, *et al*. 2003; Craven and Ford, 2004; Ford and Hardesty, 2012). These forms of documentation generally have a narrow audience, and arguably have limited effect in informing wider, more generalist audiences; therefore, there are reasonable opportunities to interpret the local flora and unique vegetation types in the form of plant guides, booklets and so on.

Of importance in this regard, is the need for contractors and managers to be able to identify the plants that are the subject of this report, and which form a basis for the site's distinctive environmental qualities. Accordingly, a plant guide should be developed as a matter of course.

8.4.3 Revegetation

Rehabilitation and replacement of weeds with native plants along both sides of the existing road verges from the Granite Creek crossing to the base of the project area is essential, and would increase visual amenity into the site, and more importantly will increase the capacity to slow down the establishment of invasive weeds such as grader grass and molasses grass amongst many others. This section of the road poses a significant risk to weed invasion higher into the project area.

Other revegetation activities should be undertaken around and in the vicinity of each turbine. These sites also afford opportunities to study the effects of weed establishment and native plant regeneration in rocky landscapes.

8.4.4 Research Opportunities

Several areas have been identified where information gaps in relation to the project's construction and operation exist. The summaries below do not constitute a comprehensive assessment of the information gaps; however, research into these areas would greatly benefit an understanding of the special environmental qualities of the project site.

Vegetation succession: Comparatively limited understanding of how mountain vegetation (montane heath) responds and recovers after disturbance and clearing.

Weeds: Unknown effects of potential ecological "modifier" weeds such as Praxelis (*Praxelis clematidea*) as well as others - particularly tall grass weeds such as thatch grass (*Hyparrhenia rufa*). Early observations indicate that *P. clematidea* hinders the establishment and possibly precludes secondary and climax phase montane heath plants.

Fire ecology: Insufficient understanding of fire ecology and its role or impact on montane heath communities. This important facet of ecology is critical to understand in greater depth given that it may have bearing on vegetation succession and the ability for populations of conservation significant plants to survive and perpetuate future, viable generations that maintain the current level of genetic diversity. Similarly, maintenance of the level of high endemism could be influenced by the local fire ecology.

Floristic inventory: Over 140 sites have been surveyed to elucidate the flora of the project site. Ground surveys are moderated by the degree of accessibility, availability of time and resources, and obvious safety factors. The final survey that was undertaken on the site located the exceptionally uncommon (endangered) shrub *Melaleuca uxorum* along the southern-most ridge. Opportunistic sightings of the ground orchid *Habenaria elongata* confirmed a new southern distribution limit of approximately 100 km from its previously known location in southern Cape York Peninsula. One-off sightings and chance encounters such as these highlight the need to undertake monthly flora monitoring and recording surveys to compile a more complete and seasonal floristic inventory.

Plant endemism: The site sits at the northern end and terminus of the Herberton Range. This geographical feature at this location holds a concentration of narrow endemic plant species and species with restricted distribution ranges. The determinants of this endemic focus for the montane heath flora is not fully understood and is poorly represented in the scientific and taxonomic literature.

Population viability: The population viability of key conservation significant plants could not be ascertained because of time and resource constraints to complete detailed studies. The results of a Population Viability Analysis investigation would be beneficial to inform a range of mitigation measures for clearing vegetation along ridges, and also to determine acceptable levels of clearing in order not to adversely affect the population dynamics of certain plant species, mainly *Homoranthus porteri* and *Melaleuca uxorum*.

Landscape rehabilitation: The wet tropics region is well regarded for its attention to tropical restoration and rehabilitation. These efforts however, have primarily focussed on rain forest (vine forest) vegetation types and land that formerly supported vegetation communities dominated by mesic plant species. Broad methods, typically tube-stock planting and direct-seeding have been used with varying levels of success; nevertheless, very little is known or has been practiced in sclerophyll-dominant vegetation other than mine site rehabilitation and direct-seeding efforts associated with recovering borrow pits and road verges.

***Horticulture of specialist plants*:** A rehabilitation programme and strategy for the Mt Emerald Wind Farm project could include the use of plants sourced from the horticulture industry (plant nurseries). As with many aspects of tropical montane heath vegetation, which is common along the ridges of the southern half of the project area, there is a small body of information pertaining to the propagation of the plants that typify this community. Generally much is understood regarding the nursery production of eucalypts and bloodwoods (*Eucalyptus* and *Corymbia* spp.), as well as a range of common northern woodland plants such as wattles (*Acacia* spp.); the heath plants however, are not so well recognised in horticulture.

There are a number of species which are found in the project site which have been propagated by a local, commercial plant nursery with some success, and include *Homoranthus porteri* and "*Baeckea* sp. Herberton Range", which could refer to *Sannantha angusta* - a local endemic. Given the high proportion of endemic plants and the uniqueness of the site's flora, any plant stock used in rehabilitation should be derived from material whose provenance is from the site or the immediate region from the same rhyolite geology and vegetation type. More information is required about the species hardiness and resilience to being transplanted into the natural environment with no post-human intervention or assistance.

***Soil-seed bank dynamics*:** The soil-seed bank of the montane heath community is not completely understood and research could consider transplanting sub-sets of topsoil from different site locations and monitoring germination. Research efforts would ideally be performed in a controlled plant nursery setting. Basic data to collect would include species, categorising plant functional groups, species names and number of individuals germinating per unit area. Seedlings germinated from the trials could be used in site-specific rehabilitation and landscaping.

8.5 Monitoring of Impacts

A strategic approach to monitoring environmental impacts in relation to flora is required. A monitoring programme should be developed and be integrated into an overarching Environmental Management Plan for the project. The result of the monitoring may have to be submitted to SEWPaC for compliance.

The purpose of the monitoring programme will be to record and document the impacts to conservation significant plant species and their habitats. The monitoring should not be limited to those species listed under the EPBC Act, as there are considerably rarer and more poorly represented species present on the site that require an increased level of conservation in order to maintain viable populations.

The monitoring programme must be designed with the intent of recording and measuring the impacts (predicted and non-predicted), and should include the following information:

- Impacts to ecosystems and specialist vegetation types: changes in floristic composition, structure and integrity. To be recorded twice each year according to most marked seasonal changes (i.e. wet and dry season).
- Reproductive phenology: flowering and fruiting times, events and frequency; production of viable seed or propagules, and germination / recruitment of new individuals (seedlings). Baseline data required (i.e. flowering and fruiting phenology). Possible recording period of each month.
- Stability of plant populations (conservation significant): reductions or increases in population size - number of individuals. To be recorded according to baseline data. Probable recording period of once each year per taxon.

- Strategic monitoring component for rehabilitation and any associated environmental offsets that may have been negotiated.
- The level (severity) of effect caused by predicted and actual impacts and a categorisation of these impacts.
- Weed monitoring: records of new weed incidences; new weed species; dates of establishment; proposed control measures; efficacy of control; follow-up weed management practices and events.

Concurrent with the monitoring programme, a series of key performance indicators will need to be developed. These may include predetermined rates of vegetation succession, measures of abundance; records of species composition; ratios of pioneer/successional communities to original vegetation composition/type; spatial measurements of land recovery/vegetation establishment - particularly adjacent to tracks and turbine construction pads.

Information gained from the monitoring programme will be used to gauge and assess the effectiveness of the mitigation measures proposed; and also inform new or adapted mitigation strategies that may develop as the project progresses. For example, unforeseen impacts may become evident when the wind farm is operational.

9.0 Conclusion

The Mt Emerald wind farm site is a unique area, hosting interesting vegetation types and habitats - some of which are poorly represented on a regional scale because of the mountainous topography.

The project site, located at the northern end of the Herberton Range, a mountainous feature of rhyolite geology, takes in sections of the Wet Tropics and the Einasleigh Uplands bioregions. The Wet Tropics bioregion section is characterised by rugged and broken topography of narrow ridges and steep slopes. The Einasleigh Uplands section has gentler landforms of less dissected character and also takes in the prominent landscape feature of Walsh Bluff at the most northern end. The southern section of the site comprises undisturbed land which is contiguous with Mount Emerald (proper).

Sixty three wind turbines are proposed to be constructed across the project site on cleared and levelled pads, each measuring a minimum of 30 x 40 m. Wind turbines are to be interconnected by an unsealed track which will also incorporate the underground electrical cabling network. These tracks are proposed to be cleared to an initial width of 10 m. In places the tracks will necessitate wider clearing to allow for bends and machinery manoeuvring space.

Four plant species of conservation interest have been positively confirmed to occur in the wind farm project site, and in areas identified to be impacted (cleared) for turbine construction pads or tracks. These are *Homoranthus porteri* (listed as vulnerable under the EPBC Act and NCA), *Grevillea glossadenia* (listed as vulnerable under the EPBC Act and NCA), *Plectranthus amoenus* (listed as vulnerable under the NCA) and *Melaleuca uxorum* (listed as endangered under the NCA).

In order of rarity (number of individuals observed on the site, plus comparison with regional populations), *Melaleuca uxorum* is exceptionally rare and only occurs in two isolated populations on the site with a total of approximately 100 individuals in the Wet Tropics bioregion section.

Plectranthus amoenus is poorly represented on rock pavements in the Wet Tropics and Einasleigh Uplands sections (total numbers unknown).

Homoranthus porteri populations are centred in the Wet Tropic bioregion section only high elevation ridges, with two outlier populations in the Einasleigh Uplands section. The number of individuals could not be accurately determined; however, the species is confined mostly to exposed, narrow ridges. The wind farm site represents an important population centre for the species because of its relatively narrow habitat tolerance and the possible northern distribution limit of significant populations.

The most frequently occurring of the conservation significant species is *Grevillea glossadenia*, which is widespread in the Wet Tropics section with individuals also found on disturbed track edges in the Einasleigh Uplands section. Of the conservation significant plants described here, this species has the widest habitat tolerance and appears to favour disturbance to some extent (disturbed rock spoil may trigger germination of seed). The numbers of individuals of this species extend into the hundreds.

The montane heath community, reliant on elevation separation and cloud stripping of moisture above 900 m, is a rare and narrowly defined vegetation type, which hosts a major proportion of conservation significant plants and narrow endemic species. This community is largely confined to the Wet Tropics bioregion section of the project site. It supports considerable floristic diversity, which on a regional scale is only found locally and is an extension of the Mount Emerald environment.

Floristic diversity and structural uniqueness (vegetation) decrease in the northern half of the site, which coincides with the Einasleigh Upland bioregion section. The landform here is markedly less rugged and dissected and a majority of it sits lower than 900 m ASL. Because of this, vegetation types are more broadly represented on a regional scale, and hold less intrinsic value. Most areas are however, in very good condition with few signs of modification and weed incursion. Nevertheless, conservation significant plants are rarely found in the northern section, even on the most rocky, exposed ridges or points.

The key impacts identified which will influence the recovery of the landscape post-construction are those associated with clearing and removing the thin veneer of rocky soil. Along narrow ridges in the Wet Tropics section, a return of the vegetation to its natural floristic composition is unlikely within approximately 15 years, when compared with disturbance events on similar landforms (e.g. existing tracks). This is evidenced by the cleared tracks associated with the transmission line infrastructure, which was commissioned in 2002. The most probable scenario for plant succession is colonisation by low, shrubby wattles. *Grevillea glossadenia* will probably respond in some areas favourably by germinating *en masse* in rocky spoil adjacent to tracks. No evidence was found to indicate that *Homoranthus porteri* will respond to disturbance in a similar, positive manner. *Melaleuca uxorum* is by virtue of its rarity and exceptionally limited distribution on a regional scale, a montane heath specialist species that is at risk of decline if the populations are disturbed or influenced by edaphic changes and altered hydrological regimes (runoff and drainage). *Plectranthus amoenus* is restricted to rock pavements and it is not understood from observations how this species will respond to disturbance. The genus is however, known to be easily propagated in horticulture.

Weed colonisation will be inevitable after ground disturbance of the site. Praxelis (*Praxelis clematidea*) poses a risk to communities on rocky ground such as along ridges, and it is expected that this species will be one of the first to establish on newly cleared land. Later incursions by weedy grasses such as thatch grass (*Hyparrhenia rufa*), grader grass (*Themeda quadrivalvis*) and signal grass (*Urochloa decumbens*) are possible if stringent, long-term weed control protocols are not followed. Other weeds noted for their 'roadside' colonisation traits include Hyptis (*Hyptis suaveolens*), Sida (*Sida* spp.) and stinking passionflower (*Passiflora foetida*). The list is not inclusive, and the project site is considered vulnerable to the deleterious effects of weeds. Of concern would be the import of a range of introduced legumes in construction material, such as sicklepods (*Senna* spp.), Wynn cassia (*Chamaecrista rotundifolia*), sensitive weeds (*Mimosa* spp.), siratro (*Macroptilium atropurpureum*), rattlepods (*Crotalaria* spp.) and many other species.

Because of the sensitive nature of the environment of the project site, impact mitigation strategies and measures will need to be carefully thought out and be focussed on the unique qualities and challenges posed by the elevated, mountainous aspect. This report recommends demarcating specific zones of the site and quarantining them from construction and disturbance activities. Of special relevance in this context is the rugged country to the south of the transmission line in the Wet Tropics section. This land clearly holds the highest and most significant environmental values and modification of the landform will most probably result in irreversible changes to rare and unique vegetation communities, floristic composition and ecological function.

The best construction opportunities for the wind farm are to be found in the Einasleigh Uplands section north of the transmission line. The more undulating and level landform holds lower environmental value, does not support poorly represented vegetation communities, and conservation significant plants are found is considerably lower abundance. From a feasibility perspective, the limited presence of precipitous drop-offs and steeply inclined slopes in the northern section offers easier construction prospects, whereby environmental impacts to the landscape values appear, at this stage, to be more practicably manageable and reversible.

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