

Appendix C-1
Flora survey – Lethbridge & Andranangoo prospects

MATILDA MINERALS PTY LTD

TIWI ISLANDS PROJECT

FLORA SURVEY – LETHBRIDGE & ANDRANANGOO PROSPECTS



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Prepared for

URS

by

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MATILDA MINERALS – TIWI ISLANDS PROJECT

Flora Survey for Notice of Intent & EPBC Referral

EXECUTIVE SUMMARY

The Existing Environment

Lethbridge West Prospect:

- The 3 mineral resource deposits in the Lethbridge West lease area occur within a narrow coastal sand plain less than one kilometre wide. This sand plain is flanked on one side by the sea and on the other by brackish swamps and upland eucalypt open forest.
- Both the western and eastern deposits are approximately one kilometre long but less than 200m wide while a smaller, central deposit is less than 300m in extent.
- The sand plain comprises a system of low, parallel dunes and swales vegetated primarily by *Melaleuca* woodlands but also including patches of vine thicket.
- The strand vegetation on beaches includes narrow stands of *Casuarina equisetifolia*, interspersed with pockets of vine forest.
- Landward hinterland areas include Eucalypt-dominated open forests (*Eucalyptus miniata*/*E. tetradonta* and *Corymbia nesophila* dominant.) on the gentle slopes of a rising upland laterite plateau and brackish swamps. The proposed mining camp is situated in Eucalypt open forest habitat.

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Andranangoo West Prospect:

- Two narrow areas of mineralisation have been defined on the Andranangoo West mineral lease – the western area is approximately 3.5 km long, the eastern 1.5 km.
- The Andranangoo prospect is also located on a narrow coastal sand plain bordered by the sea on one side and by a rising upland laterite plateau and brackish swamps inland.
- The strand vegetation fringing the beach is backed by a system of well-developed dunes supporting patches of vine-thicket interspersed by large areas of bare sand.
- The vegetation associated with the mineral deposits is dominated by *Melaleuca* woodlands. Both deposits abut a large brackish swamp.

Flora

- The vegetation on the sand plains at both sites was relatively simple floristically. Paperbark trees (*Melaleuca spp.*) were the main canopy species with relatively few other co-dominant canopy species.
- 165 plant species were recorded during the field surveys at Lethbridge Bay and Andranangoo Creek on 18th and 19th January 2005
- Only two introduced plant species were recorded, *Tribulus cistiodes* and *Passiflora foetida*

Plant species and vegetation communities of conservation significance

- None of the vegetation communities within the Lethbridge or Andranangoo lease areas has declared conservation status.
- The Tiwi Islands are known for their high floristic diversity which includes an exceptional number of recognised rare and threatened species
- Twenty-five rare and threatened plant species listed under NT conservation legislation were identified as having potential to occur in environments affected by this mining proposal. However, none of these species are listed under the Federal Biodiversity Conservation Act.

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- During this survey only *Cycas armstrongii*, listed as Vulnerable (under NT Legislation), was recorded at the Andranangoo site.
 - A follow-up survey in the late wet season is needed to confirm the absence of other potential rare and threatened species on these sites.
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Environmental Assessment

- Overall the coastal sand plain habitat was relatively weed-free and in healthy condition. Weed species do not occur in high densities and habitat degradation was not observed.
 - The majority of upland vegetation had been burnt recently but much of the sand plains remained unburnt including relatively fire-sensitive monsoon vine-thicket vegetation.
 - Buffalo have caused localised damage to vegetation, including tracking, pugging and wallowing, particularly along the margins of swamps
 - Currently there is little evidence of land use by humans at either site, other than mining exploration disturbance and debris.
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Potential Impacts & Recommended Mitigation Measures

- Vegetation disturbance from mining will create favourable conditions for weed introductions and proliferation. Extreme care must be taken to avoid the introduction of exotic plant species to this relatively weed-free area.
 - The introduction of weeds can be avoided by the requirement to thoroughly wash down all machinery, vehicles and equipment prior to it reaching the site. Maintaining the Tiwi Islands as areas free of exotic species will become increasingly important for biodiversity conservation in the NT. (Similarly, gear should be checked to prevent the introduction of Cane Toads to the Island).
 - Monitoring of the site for the introduction of weed species should be maintained throughout the life of the project and weed control measures implemented rapidly in the event of an outbreak.
 - Where mining is proposed in areas immediately adjacent to swamps, an appropriate buffer zone should be left undisturbed to avoid impacts on the swamps and as a wildlife corridor. Wetland fringes are important wildlife habitats and altering the hydrological balance in these locations should be avoided.
 - The process of rehabilitation, particularly the respreading of topsoil over mined areas should occur as soon as possible after mining operations. If possible, this clearing and reinstatement of soil would ideally occur within one season, as the life of many seeds in the seed bank may be quite brief and storage of topsoil in piles is unlikely to be conducive to long-term viability of seeds.
 - The eastern resource area at Andranangoo is characterised by vegetation that indicates a relatively delicate hydrological balance exists in this area. Mining in this area, if it causes any significant lowering of the current ground level, may result in a different post-mining vegetation community or a shallow swamp. Careful reinstatement of ground levels and topsoil may facilitate more successful recovery of the vegetation in this area.
 - Erosion of tracks within the coastal sand plain habitat is unlikely to occur given the excellent drainage of the substrate. However, the sloping hinterland areas are subject to erosion and control measures will be necessary to maintain access tracks in these areas and to prevent habitat degradation
 - The method of access to the mining leases had not been determined at the time of writing (alternatives being a haul road or barge). If an access road is to be constructed to these sites, it will potentially involve significant impacts on the natural environment (including potential erosion, weed introduction and drainage issues). Adequate environmental assessment will need to be undertaken of any proposed access road alignment.
 - Similarly, if barge landing facilities are to be built at either location an environmental assessment of the site and the landing will need to be undertaken
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Above: The extensive brackish swamp to landward of the Andranangoo resource area.

Cover photo: The Lethbridge West prospect, viewed from east to west, showing mangroves in foreground and extensive brackish swamp behind the beach to the west.

MATILDA MINERALS – TIWI ISLANDS PROJECT**FLORA SURVEY & ENVIRONMENTAL ASSESSMENT for
NOTICE OF INTENT, JANUARY 2005**

1. INTRODUCTION

Matilda Minerals Pty Ltd is investigating the feasibility of extracting zircon and rutile from sand plains occurring on the northern coastline of Melville Island. As part of this process, a Notice of Intent and an EPBC referral is being prepared. This survey was commissioned to provide information on flora issues relevant to the compilation of these two documents.

The objectives of the flora survey were to provide qualitative baseline information on the terrestrial vegetation within and immediately surrounding the Matilda Minerals resource areas (mineral deposits) at Lethbridge Bay and Andranangoo Creek (West). Particular attention was directed at areas of mineralisation for plant species or vegetation communities of conservation significance - as these locations will be progressively cleared during mining operations. The proposed locations for camps and access track alignments at both sites were also surveyed. Notes are provided on the anticipated environmental impacts of sand mining operations at both locations as well as recommendations for mitigating or reducing potential impacts on natural communities.

Surveys were designed to provide descriptions and information that will facilitate scientific impact assessment sufficient for the Notice of Intent and for an EPBC referral.

2. METHODOLOGY

Fieldwork at the Lethbridge Bay and Andranangoo sites was undertaken on the 18th and 19th of January 2005 respectively. The resource areas were located using GPS coordinates and satellite imagery provided by Matilda Minerals and traversed on foot. Complete plant species lists were compiled for each vegetation type on each resource area and these checklists should provide an inventory that may assist post-mining rehabilitation and revegetation. All plant community types were photographed and later mapped from satellite imagery.

A preliminary assessment of the potential impacts of mining on plant communities was also made whilst on site, based on the mining methods and scale of operations currently proposed by Matilda Minerals. Fieldwork and writing of the draft report was undertaken by Kristin Metcalfe (Consultant Environmental Scientist) and final report compilation by Julie Marris (URS Australia).

3. THE EXISTING ENVIRONMENT - FLORA

A total of 165 plant species were recorded during the field surveys of the Lethbridge and Andranangoo sites. Of these, seven are endemic to the Northern Territory. One listed threatened species, *Cycas armstrongii*, was recorded from the Andranangoo Prospect. This species is listed as Vulnerable under Northern Territory conservation Legislation but is not listed under the Federal Biodiversity Conservation Act (1999) (see Section 4). Only two exotic species (one naturalised) were recorded during the surveys.

The floristic data collected during the field surveys and subsequent analysis of satellite imagery have been collated to produce both general descriptions of the vegetation on the lease areas and more detailed descriptions of vegetation types on areas that will be directly affected by mining activities. The characteristics of vegetation communities within the lease areas are summarised in Section 3.1. Detailed descriptions of the vegetation on the Lethbridge and Andranangoo resource areas are described in Sections 3.2 and 3.3 respectively. Appendix 1 lists all the plant species present in each vegetation type on each resource area.

3.1. VEGETATION AND FLORA OF THE MINING LEASE AREAS

Seven (7) vegetation types have been mapped within the two project areas (Figures 1 and 2) indicating the distribution of the upland, lowland and coastal communities. The characteristics of these vegetation types are summarised in Table 1:

Table 1 : Summary table of the major vegetation types within & adjacent to the Lethbridge Bay and Andranangoo mining lease areas

MAP UNIT	VEGETATION COMMUNITY	KEY FEATURES
UPLAND COMMUNITIES		
1	Eucalypt Open Forest Woodland to open forest on low rounded hills and slopes	Typical of savanna woodland across the Top End with <i>Eucalyptus miniata</i> / <i>E. tetradonta</i> dominant tree species. <i>Eucalyptus nesophila</i> is often co-dominant on the Tiwi Islands.
LOWLAND COMMUNITIES		
2	Coastal vine thicket Areas of dense, closed canopy vegetation characterised by jungle species and abundant vines	Typical tree species include Peanut Tree (<i>Sterculia quadrifida</i>), Banyan (<i>Ficus virens</i>), <i>Pouteria sericea</i> , <i>Diospyros maritima</i> and <i>Mallotus nesophilus</i>
3	Melaleuca woodland Woodland to open forest with <i>Melaleuca</i> spp. the dominant canopy species.	Covers extensive areas of the coastal sand plain habitat. Species composition may be quite variable but <i>Melaleuca leucadendra</i> is ubiquitous with <i>Syzygium suborbicularis</i> , <i>Corymbia polycarpa</i> and <i>Acacia auriculiformis</i> locally common to co-dominant in some areas.
4	Brackish swamp Extensive swamps occur at the western end of the Lethbridge lease and east of Andranangoo	Typically fringed with a narrow band of mangrove species including <i>Rhizophora stylosa</i> and <i>Lumnitzera racemosa</i> . Dense stands of the sedge <i>Schoenoplectus littoralis</i> occur in the shallow sections of these brackish swamps.
COASTAL COMMUNITIES		
5	Strand (beach) Thin band of vegetation on the primary beach dunes, typically comprising sparse trees and grass	Narrow strip of vegetation on the main sand dune occurring at the back of the beach. Characterised by Sheoaks (<i>Casuarina equisetifolia</i>) and beach spinifex (<i>Spinifex longifolius</i>)
6	Dune vegetation Pockets of vine-thicket vegetation on tall dunes and swales, extends up to 100m inland from beach.	Patchy areas of vine-thicket tree species and abundant vines occurring on the 5m high dunes behind the beach at Andranangoo. Large expanses of bare sand are characteristic of this community
7	Mangrove & salt flats Dense mangrove forests within the lower intertidal zone and intermittent bare salt flats in the upper intertidal zone	Extensive mangroves occur in association with tidal creeks adjacent to both mining lease areas. <i>Rhizophora stylosa</i> typically occurs on the seaward fringe and <i>Ceriops australis</i> in the mid to upper mangrove zones. Salt flats occur in areas too saline for mangroves.

Figure 1: Draft vegetation map of Lethbridge West Prospect indicating areas of mineralisation and proposed infrastructure (approximate scale)

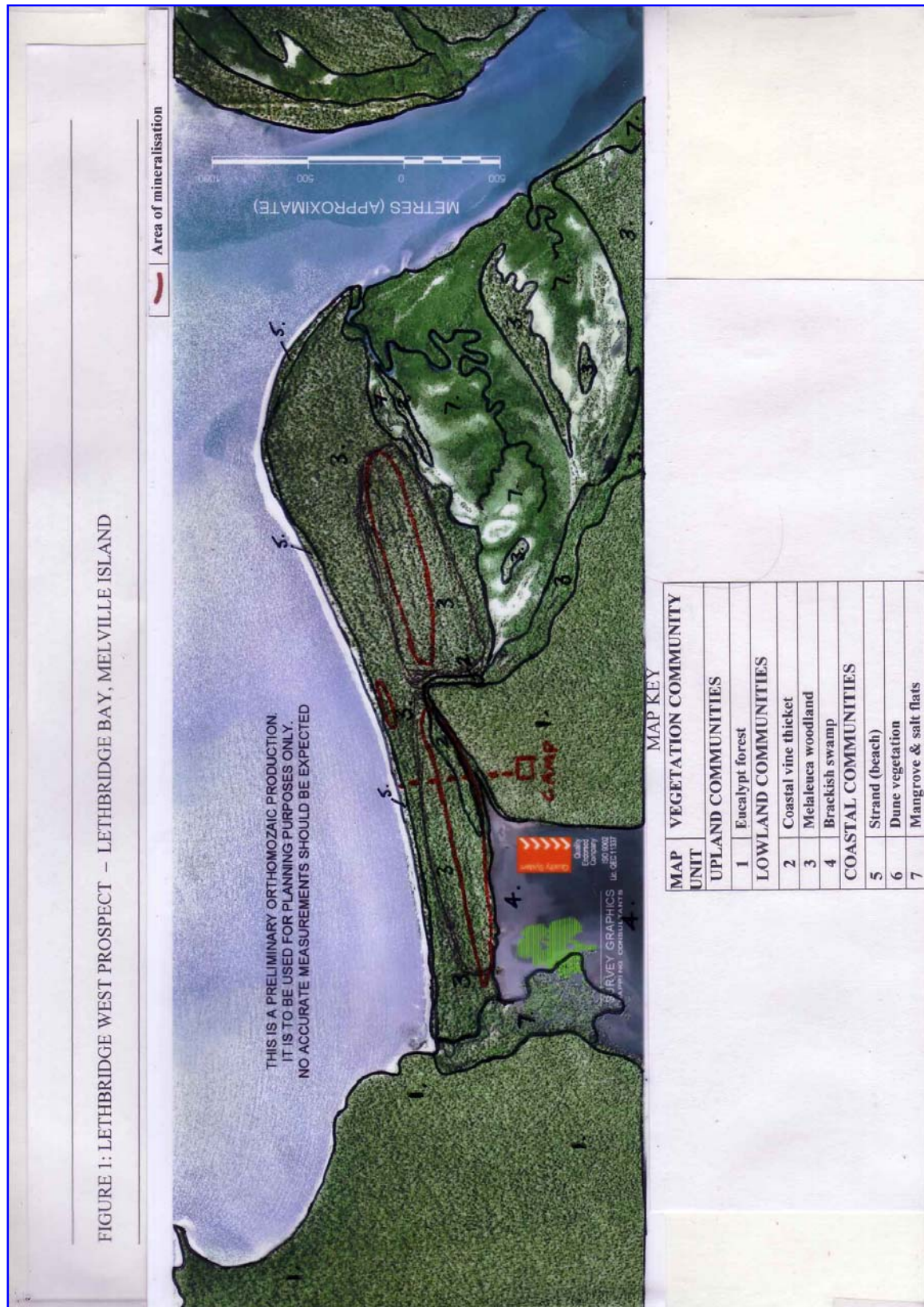


Figure 2: Draft vegetation map of Andranangoo West Prospect showing major vegetation types in relation to the areas of mineralisation and proposed infrastructure (approximate scale)



3.1.1. UPLAND COMMUNITIES

Upland vegetation comprising woodland to open forests dominated by *Eucalypts* spp. occupies the majority of hinterland areas. Typical of large areas across the Top End, these communities are common and have a widespread distribution. Small patches of monsoon vine forest occur infrequently in this community, particularly in peripheral areas at the base of the low escarpment and adjacent to swampy areas, but the vast majority of this vegetation type is characteristic Eucalyptus –dominated open forest.



Figure 3: Eucalyptus-dominated open forest characteristic of upland habitats

Eucalypt Forest (Map unit 1)

Eucalyptus miniata (Darwin Woollybutt) and *E. tetradonta* (Darwin Stringybark) are typically the dominant species with canopy height varying from 16 to 20 m (Figure 3). *Corymbia nesophila* (Melville Island Bloodwood) is dominant in some areas but usually occurs as a co-dominant with *E. miniata* or *E. tetradonta*. This community covers approximately 75% of the Tiwi Islands area (Woinarski et al., 2003). *Corymbia bleeseri* was also a common canopy forming species observed during the current survey, particularly on the rocky sideslopes fringing the access road alignment at Lethbridge Bay. The secondary trees, *Brachychiton diversifolius* and *Pouteria arnhemicus* are patchily distributed throughout the upland forests.

Mid-stratum species including *Acacia* spp., *Terminalia ferdinandiana*, *Buchanania obovata* and *Planchonia careya* formed a sparse to mid-dense understorey layer 6-8 m high. Other common mid-stratum species included the Sand Palm (*Livistona humilis*), *Acacia oncinocarpa* and the shrubs *Flueggia virosa*, *Acacia difficilis* and *Brachychiton megaphyllus*. Species dominance was observed to vary according to changes in local topography and drainage. For example *Pandanus spiralis* are characteristic species of seasonal waterlogging of low lying terrain, drainage lines and the freshwater seepage zone along the margins of the high ground adjacent to the mangrove communities.

A list of Eucalypt forest plant species was only compiled for the area identified for the camp and access tracks (Appendix 1); a complete inventory being outside the scope of this project.

3.1.2. LOWLAND COMMUNITIES

Coastal vine thicket (Map unit 2)

Vine-thicket was not extensive within the lease areas but a dense patch was identified at the eastern end of the Lethbridge West resource area. The community is characterised by closed-canopy forest of broad-leaved species including *Ficus virens*, *Sterculia quadrifida*

and *Diospyros maritima*. Black Wattle (*Acacia auriculiformis*) is a ubiquitous canopy species in vine-forest areas (Figure 4).

A distinct mid-stratum is seldom present but a number of common secondary trees including *Cupaniopsis anacardiodes*, *Drypetes lasiogyna*, *Mallotus nesophilus* and *Pouteria sericea* form a dense layer of foliage. Vine species are abundant and common species included *Adenia heterophylla*, *Abrus precatorius*, *Smilax australis*, *Cissus adnata* and *Cayratia maritima*. The ground stratum is often relatively sparse due to the low light conditions but often includes clumps of the woody vine *Opilia amentacea* and seedlings of canopy trees.



Figure 4: Coastal vine-thicket at Lethbridge- central section of the western resource area

Melaleuca woodland (Map unit 3)

Melaleuca woodland (to open forest) communities dominate the coastal sand plains that comprise the majority of the mining lease areas. Several Paperbark species occur including *Melaleuca leucadendra*, *Melaleuca nervosa* and *Melaleuca viridiflora* often forming mixed communities in association with Long-fruited Bloodwood (*Corymbia polycarpa*), Bush Apple (*Syzygium suborbiculare* f.coastal) and Black Wattle (*Acacia auriculiformis*). Stands were typically between 12 and 18m high with forests of *Melaleuca nervosa* of low stature occurring on infertile, extensive sand sheets and taller *Melaleuca leucadendra* in drainage ways and on the fringes of brackish swamps. The most common co-dominant species was the Pink Bush Apple *Syzygium suborbiculare* (f.coastal) which typically occurs on the low dunes of the extensive coastal sand plains while *Melaleuca* spp. occur in the swales, or minor depressions.



Figure 5: *Melaleuca* woodland community at Lethbridge, at western limit of resource area

The understorey layer is extremely variable and commonly comprised pockets of vine-thicket species including abundant vines. The seasonal lily *Crinum angustifolium*, sedges (*Cyperus javanicus*, *Bulbostylis barbata*) and herbs (*Hypoestes floribunda*, *Glinus oppositifolius*) grew in drainage depressions beneath Melaleuca forest (Figure 5).

Brackish swamp (Map unit 4)

Extensive brackish swamps occur at both mining leases, typically less than 1 km from the coast. A thin border of mangrove species typically lines the shore of these slightly saline swamps (Figure 6) which appear to connect to the sea via tidal mangrove systems. Mangrove species observed fringing these swamps include *Lumnitzera racemosa*, *Avicennia marina* at Lethbridge Bay and *Rhizophora stylosa* and mangrove associates *Acrostichum speciosum* (Mangrove Fern) and *Diospyros maritima*.

The shallow sections of the swamp typically have a dense growth of sedge (*Schoenoplectus littoralis*) and occasionally water lilies (*Nymphaea violacea*).



Figure 6 : A thin border of mangroves typically lines the shoreline of brackish swamps

3.1.3. COASTAL COMMUNITIES

Strand (Map unit 5)

A distinctive band of coastal vegetation mapped as the strand community occurs on the primary beach dune immediately behind the beach at both Lethbridge and Andranangoo prospects. The upper stratum is almost exclusively *Casuarina equisetifolia* (Coastal Sheoak) and the mid- and ground layers are often sparse.



Figure 7: Strand vegetation on the primary beach dune at Andranangoo

Large areas of bare sand are common and where present, the ground layer is likely to comprise Beach Spinifex (*Spinifex longifolius*) and *Fimbristylis sericea*. Scattered shrubs include *Scaveola taccada* and coastal vines such as *Ipomoea pes-caprae* and *Carnivalia rosea* may be locally common.

Dune vegetation (Map unit 6)

Landward of the strand vegetation at Andranangoo Beach is a system of well developed sand dunes (from 2 to 6 m) that support pockets of vegetation, particularly in the swales (Figure 8). Tree species are typically mixed and include *Melaleuca leucadendra*, *Acacia auriculiformis*, *Pousteria sericea*, *Syzygium suborbiculare* and *Corymbia polycarpa*.



Figure 8: High dunes occur behind the beach at Andranangoo with patchy vine-thicket

Overall the species are characteristic of vine-thicket communities but grow in disjunct patches separated by large areas of bare, relatively steep sand dunes. Vines are particularly common and include *Tinospora smilacina*, *Marsdenia glandulifera* and *Cayratia maritima*.

The pattern of distribution of coastal communities at Andranangoo is shown in Figure 9.

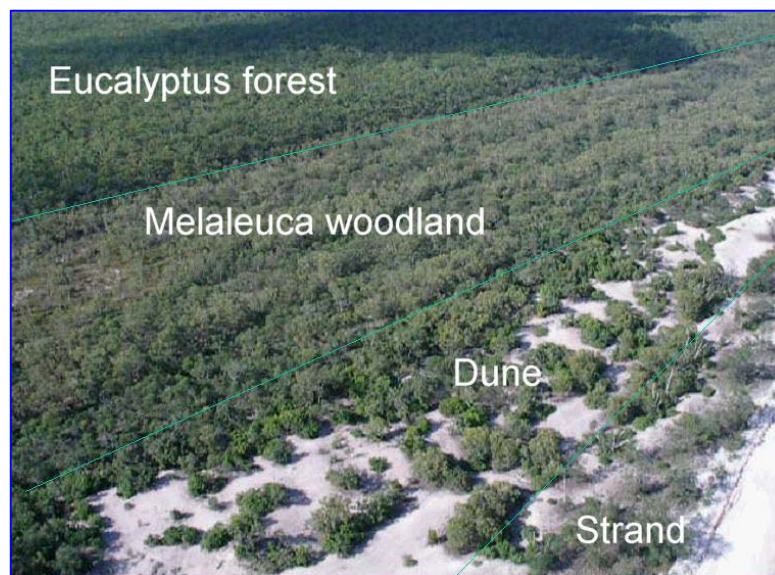


Figure 9:
Vegetation
communities
on the coastal
sand plains,
Andranangoo
prospect

Mangroves and salt flats (Map Unit 7)

Both mining leases include mangrove and salt flat environments where they intersect tidal creeks systems and sheltered embayments on their eastern sides. The Lethbridge West lease includes the most extensive stands.

Table 2 : Mangrove species recorded within Andranangoo & Lethbridge mining lease areas

MANGROVE SPECIES
<i>Bruguiera exaristata</i>
<i>Ceriops australis</i>
<i>Avicennia marina</i>
<i>Lumnitzera racemosa</i>
<i>Excoecaria ovalis</i>
<i>Scyphiphora hydrophyllacea</i>
<i>Rhizophora stylosa</i>
<i>Acrostichum speciosum</i>

Rhizophora stylosa is dominant to seaward and fringing tidal creeks while *Ceriops australis* forms dense monospecific stands in the mid- to upper tidal flat. The diverse band of mangroves fringing the hinterland included *Lumnitzera racemosa* and *Avicennia marina*. Eight mangrove and salt flat species were recorded from mangroves within and adjacent to the mining lease areas during this survey (Table 2).

Networks of bare hypersaline salt flats, which are clearly visible on the imagery, are scattered throughout the mangroves surrounding the lease areas at elevations that receive infrequent tidal inundation (Figure 10).



Figure 10:
Extensive mangroves with bare salt flats in the upper intertidal zone about the eastern end of the Lethbridge mineral lease

3.2. LETHBRIDGE BAY WEST

The Lethbridge Bay prospect comprises a quaternary strand plain approximately 500m in width with two zones of mineralisation. The western deposit lies between the beach bordering Lethbridge Bay to the north and an extensive brackish water swamp to the south (Figure 1). The strand plain comprises a system of low sand dunes running parallel to the shoreline that supports predominantly *Melaleuca* (Paperbark) communities. Paperbark forests are characteristic of sandy drainage depressions that typically experience several months of seasonal inundation waterlogging. An upland spur of the Tertiary plateau divides the eastern and western zones of mineralisation at Lethbridge Bay and is the proposed location of the mining camp and access track. Extensive mangroves occur just to the south of the eastern resource area associated with the mouth of Jessie Creek.

Figure 1 indicates the 6 main vegetation communities, including 1 upland community, 3 lowland and 2 coastal habitats distinguished within the wider survey area (the mineral lease boundary). Four of these communities are potentially affected by the proposed development. *Melaleuca* woodland (Map unit 3) and Coastal Vine-thicket (Map unit 2) overlies the two Lethbridge resource areas and the mining camp will be located in upland Eucalypt- dominated woodland (Map unit 1). The proposed access road crosses the sand plain from the beach to the proposed mining camp and will therefore traverse four communities including a small area of vine-thicket (Figure 11) and Eucalyptus woodland.



Figure 11: The central section of the western Lethbridge resource area is densely vegetated with vine-thicket species

At the western end of the western deposit (Site 3, Matilda Minerals Mining Lease Application map), dominant upper stratum trees include *Melaleuca leucadendra* (16 to 18m) and *Acacia auriculiformis* (8 to 14m) in a woodland to open forest formation with a mid-dense to sparse understorey layer. The mid-stratum includes immature canopy trees and shrubs such as *Flueggia virosa*, *Allophylus cobbe* and *Mallotus nesophilus*. Vines (*Cayratia trifoliata*, *Gymnanthera oblonga*, *Cissus adnata*, *Tinospora smilacina*, *Tylophora flexuosa*) are abundant in the ground stratum and trail up into the lower canopy. Dense patches of the herb *Hypoestes floribunda* occur on the ground amongst extensive areas of bare ground. Some of the swales appear to hold water regularly and some shallow pools were observed closer to the swamp. The only weed species observed was *Passiflora foetida*.

The majority of the western Lethbridge resource area comprises similar *Melaleuca* woodland and open forest with substantial areas with dense vine-forest or vine-thicket understorey. Centrally, an area of dense vine-forest occurs with large Banyans (*Ficus virens*), Peanut Trees (*Sterculia quadrifida*) and Black Wattle (*Acacia auriculiformis*), 16 to 18m high. Dense vines and shrubs are characteristic of the understorey layer. Other vine-thicket species (4 to 6m high) in this area include *Ixora timorensis*, *Glochidium apodogynum*, *Bridelia tomentosa* and *Diospyros maritima*, which may be dense and locally common.

The eastern Lethbridge resource area differs from the western deposit area in being more open in structure and having no dense vine-thicket areas (Figure 12). Largely comprising *Melaleuca leucadendra* open woodland, 16 to 18m high with a sparse understorey of young *Melaleucas* and *Acacia auriculiformis*. Mid-stratum species typically includes shrubby *Allophylus cobbe* and *Flueggia virosa*. A similar complement of vine species as described for the western deposit occurs in the east and patches of the lily *Crinum angustifolium* were observed throughout. Extensive areas of bare sandy ground with a thin layer of leaf litter, occurs throughout the open forest.



Figure 12: Melaleuca woodland associated with eastern Lethbridge resource area

The central Lethbridge deposit is associated with similar *Melaleuca leucadendra* woodland to open woodland 14-16m high, located just behind the beach. Common canopy species in this area include *Acacia auriculiformis*, *Sterculia quadrifida* and *Syzygium suborbiculare*. Common vines include *Jasminum didymum*, *Tylophora flexuosa*, *Opilia amentacea* and *Smilax australis*. The edge of the central deposit (delineated by Sites 5 and 6 on Mining Lease Application map), intergrades with the open, sandy strand habitat at the back of the main beach (Figure 13)



Figure 13: The small, central resource area at the Lethbridge prospects adjoins the strand community, characterised by sparse Sheoaks (*Casuarina equisetifolia*)

3.3. ANDRANANGOO CREEK WEST

The Andranangoo Creek West prospect also occurs on a Quaternary strand plain, less than 1 km in width that abuts a low Tertiary Plateau. A discrete mangrove swamp borders the plain to the west and a very extensive brackish swamp lies to the east. A narrow fringe of high sand dunes (3-5 m high) borders the main beach but dissipates in height to the north where the extensive mangroves of the Jessie Creek system commences. The main resource area occurs at the base of hinterland plateau and extends northwards along a sandy peninsula bordered by swamp.

The eastern mineralisation is a linear section of the sub-coastal sand sheet between the mangrove lined creek to the north and the brackish swamp to the south (Figure 2). Similar to Lethbridge Bay, the predominant vegetation associated with the mineral-bearing sand sheets is Paperbark forest (*Melaleuca* spp.), the composition and structure of this and the other vegetation communities mapped in Figure 2 are described below.

Close to the western tip of the east Andranangoo deposit, sandy dunes typically support *Melaleuca* spp. in swales and depressions with *Syzygium suborbiculare* on the upper dunes (Figure 14). Mid-stratum species in dune areas include *Calytrix extstipulata*, *Verticordia cunninghamii* and *Jacksonia dilatata*. The grasses *Thaumastochloa major*, *Eriachne trisetata*, *Ectrosia leporina* and the tiny sedge *Bulbostylis barbata* are common in this area.



Figure 14: Bush Apple (*Syzygium suborbiculare* f. coastal) occurs on low dunes with *Melaleuca* spp. in swales, eastern Andranangoo mineralisation area

Sites 8 and 9 (Matilda Minerals Mining Lease Application map) delineate the extent of the 1.5 km long eastern Andranangoo resource. A rather uniform, floristically simple community of *Melaleuca leucadendra* and *M. nervosa* (10- 16m) occurs on the low sand plain associated with this deposit, with an almost monospecific ground cover of the sedge *Dapsilanthus spathaceus* (Figure 15). These species indicate seasonal waterlogging in this area. The habitat is characterised by low species diversity, a sparse understorey layer to 2m and areas of bare ground. The few mid-stratum species present (*Acacia leptocarpa* and *Jacksonia dilatata*) form a sparse shrubby layer.



Figure 15: *Melaleuca nervosa* with *Dapsilanthus spathaceus* ground cover

The grass *Eriachne trisetata* is found in areas of slightly higher ground with *Acacia* spp.

The most eastern point of the eastern Andranangoo deposit lies close to the tip of a peninsula largely surrounded by mangroves (Site 9, Matilda Minerals Lease Application Map). The area is vegetated with *Melaleuca leucadendra* woodland with vine-thicket species becoming more abundant close to the mangrove and brackish swamp margins. A ‘parkland’ of mixed species including *Canarium australianum*, *Syzygium suborbiculare*, *Polyalthia nitidissima* and *Pouteria sericea* fringes the wetland area (Figure 16) and intergrades with surrounding *Melaleuca*-dominated woodlands.



Figure 16: Littoral woodland fringing the brackish swamp, eastern Andranangoo deposit

A thin strip of mangroves and mangrove associates (<10m wide) including the Mangrove Fern *Acrostichum speciosum*, Native Ebony (*Diospyros littorea*) and *Rhizophora stylosa* lines the swamp separating the east and west Andranangoo deposits (Figure 17). Dense sedge growth (*Eleocharis sp.*) was observed in the shallow water between the two peninsulas.



Figure 17: A narrow strip of mangroves including *Rhizophora stylosa* fringes the Andranangoo swamp with dense sedge (*Eleocharis sp.*)

The eastern section of the west Andranangoo mineral deposit (Site 7) lies on a sandy peninsula surrounded by swamp. The vegetation is *Melaleuca leucadendra* woodland (to 16m) with abundant Bush Apple trees (*Syzygium suborbiculare* f. coastal). The long-fruited Bloodwood (*Corymbia polycarpa*) is also locally abundant to dominant in this area (Figure 18). Cycads (*Cycas armstrongii*) were observed approximately 700m west of Site 7.

Vine-thicket species (*Litsea glutinosa*, *Psydrax odorata*, *Drypetes lasiogyne*, *Opilia amentacea*) are scattered throughout the understorey with abundant vines (*Ipomoea abrupta*, *Cissus adnata*, *Smilax australis*, *Abrus precatorius*, *Protoasparagus racemosus* and *Ampelocissus acetosa*). Lillies

(*Crinum angustifolius*) and the grass *Eriachne trisetata* were recorded from the ground stratum.

The east Andranangoo deposit extends along the base of a low hinterland escarpment for several kilometres and the vegetation of this strip consistently remains *Melaleuca* woodland, with local abundance of different canopy species including *Corymbia polycarpa*, *Syzygium suborbiculare*, *Melaleuca viridiflora* and *Acacia* spp.



Figure 18: The Long-fruited Bloodwood (*Corymbia polycarpa*) is locally common to dominant in areas associated with the east Andranangoo area of mineralisation

A freshwater swamp, probably fed by springs occurs mid-way along the resource area, at the base of the hinterland escarpment (Figure 19). Several species associated with freshwater were recorded from this spot including *Melastoma malabathricum*, the fern *Dicranopteris linearis*, water lillies (*Nymphaea* sp.) and the fern ally *Lycopodiella cernua*. These species are typically associated with perennial water. In the vicinity of Site 6, marking the western tip of the resource area, *Corymbia polycarpa* is co-dominant with *Acacia* spp. and *Syzygium* common secondary tree species.



Figure 19: A freshwater swamp occurs mid-way along the Andranangoo west mineralised area, at the base of the low hinterland escarpment

4. PLANT SPECIES AND VEGETATION COMMUNITIES OF CONSERVATION SIGNIFICANCE

Plant species conservation significance was determined by reference to threat listings under NT (*Territory Parks and Wildlife Conservation Act 2000*) and Federal (*Environment Protection and Biodiversity Conservation Act 1999*) conservation legislation. Although species threat ratings on the two lists currently differ it is expected that the most recent threat classifications determined by NT Government authorities, using Federal criteria, will eventually be adopted at that level.

The Tiwi Islands are known for their high floristic diversity which includes an exceptional number of recognised rare and threatened species (Woinarski et al., 2003). Twenty plant taxa are listed as Endangered or Vulnerable under NT Conservation legislation while a further 44 are listed as Data Deficient; a category generally synonymous with rarity. Furthermore a high proportion of the rare and threatened species are also endemic to the Tiwi Islands in the NT. Overall, the most significant habitat for rare and endangered species on the Tiwi Islands is rainforest but rare and threatened plants have been recorded from most other habitat types.

The main plant communities to be affected by mineral sands mining at Lethbridge Bay and West Andranangoo will be Melaleuca woodland / open forest, coastal vine thicket and minor areas of strand communities on coastal dunes. Some areas of Eucalypt open forest will also be disturbed or cleared for camp areas, access tracks and haul roads. There are 25 rare and endangered plant species listed under NT legislation that are known from these environments on the Tiwi Islands (Table 3) though none of them are currently listed under the Federal Biodiversity Conservation Act (1999).

Only one threatened species (NT Legislation), *Cycas armstrongii* (Figure 20) was recorded during this survey (at the eastern end of the Andranangoo site) but at present it would be premature to suggest that other threatened species do not occur in the operations areas. This survey was conducted in the early part of the wet season. The sites were still quite dry and the majority of the threatened species listed in Table 3 are herbaceous and if present, may not yet have germinated or grown to recognisable proportions. In general this survey recorded low numbers of herbaceous species with most being identified from very young sterile growth. We are reasonably certain that *Crinum venosum* is not in the operations areas but a follow-up survey near the end of the wet season is needed to confirm the absence of other threatened taxa.



Figure 20: *Cycas armstrongii* at Andranangoo prospect. This plant was the only declared species of conservation significance recorded within both mining leases- listed as vulnerable under NT Legislation

Table 3 : List of rare and threatened plant species within coastal dune, *Melaleuca* woodland and *Eucalyptus* open forest environments on the Tiwi Island (Woinarski et al., 2003)

FAMILY	SPECIES	HABITAT	STATUS (NT Legis)
RUBIACEAE	<i>Spermacoce omissa</i>	Coastal dunes	Data Deficient
TILIACEAE	<i>Triumfetta aquila</i>	Coastal Dunes	Data Deficient
TILIACEAE	<i>Triumfetta repens</i>	Coastal dunes	Data Deficient
CYPERACEAE	<i>Cyperus compactus</i>	Melaleuca woodland	Data Deficient
CYPERACEAE	<i>Eleocharis nuda</i>	Melaleuca woodland	Data Deficient
CYPERACEAE	<i>Fimbristylis bisumbellata</i>	Melaleuca woodland	Data Deficient
CYPERACEAE	<i>Scleria biflora</i>	Melaleuca woodland	Data Deficient
LENTIBULARIA CEAE	<i>Utricularia subulata</i>	Melaleuca woodland	Endangered
LILIACEAE	<i>Crinum venosum</i>	Melaleuca Woodland	Data Deficient
LOGANIACEAE	<i>Mitrasacme stellata</i>	Melaleuca woodland	Data Deficient
ORCHIDACEAE	<i>Calochilus caeruleus</i>	Melaleuca woodland	Vulnerable
ORCHIDACEAE	<i>Dendrobium tritamellatum</i>	Melaleuca woodland	Data Deficient
ORCHIDACEAE	<i>Habenaria ferdinandi</i>	Melaleuca woodland	Data Deficient
ORCHIDACEAE	<i>Liparis habenaria</i>	Melaleuca woodland	Data Deficient
ORCHIDACEAE	<i>Malaxis acuminata</i>	Melaleuca woodand	Data Deficient
POACEAE	<i>Eragrostis concinna</i>	Melaleuca woodland	Data Deficient
STYLIDIACEAE	<i>Stylidium nominatum</i>	Melaleuca woodland	Data Deficient
XYRIDACEAE	<i>Xyris pusilla</i>	Melaleuca woodland	Data Deficient
ARACEAE	<i>Typhonium jonesii</i>	Eucalypt open forest	Endangered
ARACEAE	<i>Typhonium mirabile</i>	Eucalypt open forest	Endangered
ARACEAE	<i>Typhonium russell-smithii</i>	Eucalypt open forest	Data Deficient
CYCADACEAE	<i>Cycas armstrongii</i>	Eucalypt open forest	Vulnerable
ORCHIDACEAE	<i>Calochilus holtzei</i>	Eucalypt open forest	Data Deficient
ORCHIDACEAE	<i>Habenaria triplonema</i>	Eucalypt open forest	Data Deficient
ORCHIDACEAE	<i>Nervilia peltata</i>	Eucalypt open forest	Data Deficient

5. ENVIRONMENTAL IMPACT ASSESSMENT -NOTES

It is anticipated that any impacts arising from the development will be relatively localised in extent. However, due to the proximity of mining operations to several swamps, any potential pollutants used in the mineral concentration process (including minerals concentrated to biologically toxic levels) will need to be carefully contained to prevent contamination of adjacent water bodies. It is recommended that where mining occurs adjacent to swamps that a buffer zone of at least 50m be maintained as a fauna corridor and to prevent any potentially negative impacts of mining (eg mineral rich slurry, fuel or chemical spills etc) from affecting the swamp habitat.

The dry slot mining process as described by Director of Operations, Bruce Maluish is a relatively small scale, closely contained operation that incorporates progressive rehabilitation of recently mined areas. The small scale of works should facilitate environmental protection measures. The retention of topsoil will greatly facilitate the revegetation of mined sites. Ideally the clearing and reinstatement of soil would occur as soon as possible, and within one season, as the life of many seeds in the seed bank may be quite brief and storage of topsoil in piles is unlikely to be conducive to long-term viability of seeds.

5.1. ACCESS ROAD – LETHBRIDGE WEST PROSPECT

The access road starts within the strand community on the sand dunes at the back of the beach and runs perpendicular to the beach for approximately 900m to the proposed mining camp. The access road traverses Melaleuca woodland and vine-thicket and after crossing the northern tip of the swamp continues up a low hill through Eucalyptus forest (Figure 1). Potential impacts from access road construction include clearing of a linear tract of vegetation. Erosion of the track could occur in the sideslopes leading to the camp area (Figure 21) and erosion control measures need to be installed to prevent this. The access road crosses a small drainage line at the base of the low escarpment (Figure 22) and pipes should be installed beneath the track at this location so that natural drainage is not impeded in this area.

Erosion of the access track in the beach dune area may lead to localised habitat degradation and the alignment and construction of the track through beach dunes requires adequate planning and stabilisation respectively.



Figure 21: The access track to the proposed Lethbridge mining camp



Figure 22: The Lethbridge prospect access road where it crosses the northern tip of the brackish swamp

5.2. ACCESS ROAD – ANDRANANGOO WEST PROSPECT

The alignment of the access road to the mining camp at Andranangoo follows a very similar course as that at Lethbridge and traverses similar communities. The Andranangoo access track does not, however pass through vine-forest but its current alignment does intersect some high sand dunes behind the beach (see dune vegetation, Figure 2). Relatively steep slopes occur where the access road drops down into the Melaleuca woodland and also where it grades up into the Eucalypt woodland habitat. Erosion of the access track may lead to habitat degradation if not prevented and erosion control measures need to be implemented in these areas. The majority of the access track alignment is relatively flat and sandy (Figure 23), two factors reducing the potential for erosion.

The method of access to the mining leases has not been determined at the time of writing (alternatives being a haul road or barge). If an access road is to be constructed to these sites, it will potentially involve quite significant impacts on the natural environment (including potential erosion, altered drainage and weed introduction issues). Adequate environmental assessment will need to be undertaken of any proposed access road alignment. Similarly, if barge landing facilities are to be built at either location an environmental assessment of the site and the landing will need to be undertaken



Figure 23: The access track to the mining camp at Andranangoo traverses mainly well-drained Eucalypt forest and a minor area of *Melaleuca* woodland (above)

5.3. MINING CAMPS

Both sites selected for mining camp locations are relatively flat, well-drained upland areas amongst quite dense Eucalypt forest (Figure 24). Camp construction will probably require that the forest be cleared around the perimeter of the camp as a firebreak, leading to some loss of habitat. However, the size of the camps is relatively small (approximately 6 caravans) and thus the area of clearing will not be large.



Figure 24: Proposed locations for mining camps at Lethbridge (left) and Andranangoo (right) prospects. Both camps are situated in well drained upland areas with Eucalypt-dominated open forests

No weed species were observed at either of the proposed locations for mining camps and environmental management of the sites should aim to maintain these sites in this condition.

5.4. AREAS OF MINERALISATION - LETHBRIDGE WEST PROSPECT

Lethbridge west. The western deposit at Lethbridge Bay (bounded by sites 3 and 4) will involve clearing of approximately x ha of vegetation including x ha of Melaleuca woodland and x ha of dense vine-thicket. The vine-thicket vegetation tends to be quite species-rich and the community is relatively restricted in distribution throughout the region, containing a high proportion of fire-sensitive species. Clearing in the Lethbridge west area should be kept to the minimum necessary for the mining operation and a buffer zone of vegetation, including the thin strip of mangroves lining the brackish swamp should be maintained as a sediment/pollutant trap and a fauna corridor.

Lethbridge central. The central deposit at Lethbridge (delineated by sites 5 and 6) is situated close to the beach and includes strand and Melaleuca woodland communities on deep sandy substrates. The main impact of mining at this location is expected to be clearing of vegetation and depending on how much of the beach dune is mined, destabilisation of the dunes may occur. Successful revegetation and rehabilitation in this area will be essential to prevent habitat degradation. The coastal dune environment is considered a more fragile habitat than more landward communities due to the potential for erosion by storms, king tides and strong winds and the sparse nature of existing vegetation.

Lethbridge east. The eastern deposit at Lethbridge is located in Melaleuca woodland habitat with low parallel dunes and shallow swales. It is sandy, relatively flat, internally drained and would appear to present no real potential for erosion. The major potential impacts anticipated in this area are temporary loss of habitat from vegetation clearing. As at all sites to be mined, there is

potential for the introduction and spread of weeds in disturbed ground and all machinery to be used on site will need to be thoroughly washed down to prevent the introduction of weed species into this weed-free area.

Erosion of tracks within the coastal sand plain habitat is unlikely to occur given the excellent drainage of the substrate. However, the sloping hinterland areas are subject to erosion and control measures will be necessary to maintain access tracks in these areas and to prevent habitat degradation

5.5. AREAS OF MINERALISATION - ANDRANANGOO WEST PROSPECT

Andranangoo west deposit. The western resource area at the Andranangoo prospect is quite extensive (approximately 3.5 km long) and although largely flat and well drained, includes a small drainage line leading from a freshwater swamp. Mining in these areas should avoid these drainage features where possible and rehabilitation be undertaken in a way that reinstates the previous natural pattern of drainage. The freshwater swamp is probably fed by springs and is likely to represent an important water resource for local fauna. Plant species including *Melastoma*., *Lycopodiella cernua* and *Dicranopteris linearis* were only recorded from this location. The major impact on flora from mining operations is anticipated to be loss of habitat from clearing, including some areas of tall, substantial trees (eg. *Corymbia polycarpa*, *Melaleuca leucadendra*) in the eastern section of this deposit. The one species listed as Vulnerable on Northern Territory listing of Rare and Endangered Plants, *Cycas armstrongii*, was also recorded from this area.

Andranangoo east deposit. The vegetation community overlying the eastern Andranangoo deposit is relatively simple floristically (Figure 25) comprising almost monospecific stands of *Melaleuca* spp. with an understorey of several common shrubs and sedges (see section 3.3 for description). Thus the clearing of this vegetation, which is also locally widespread and common is not of particular concern. However, the hydrological balance in these areas appears to be quite delicate. *Acacia* species only occur on slightly raised (and therefore better drained) ground and there are extensive areas of bare ground between the trees.

The area to be mined is clearly low-lying and subject to periods of prolonged inundation. Thus if mining results in any considerable lowering of the ground surface, for example by up to 50cm (B Maluish pers com.), it is probable that a different plant community will reestablish in this area. Alternatively, if the water table is particularly shallow, a permanent swamp may result.



Figure 25: *Melaleuca* woodland at Andranangoo prospect, a relatively simple floristic community with a potentially delicate hydrological balance

Currently, the low species diversity is a reflection of soil infertility and seasonal inundation, and slow recovery of rehabilitated land may occur in this area. The existing low species diversity may contribute to topsoil from this area not containing a particularly robust seed bank which could further contribute to slow recovery times.

6. REFERENCES

- Wightman, G.M., 1989. Mangroves of the Northern Territory, Northern Territory Botanical Bulletin No. 7. Conservation Commission of the Northern Territory, Palmerston.
- Woinarski, J., Brennan, K., Cowie, I.D., Kerrigan, R. and Hempel, C., 2003. Biodiversity Conservation on the Tiwi Islands, Northern Territory, Department of Infrastructure, Planning and Environment, Northern Territory Government, Darwin, NT.

APPENDICES

APPENDIX 1: FLORA SPECIES LIST

KEY

EXPLANATION OF ABBREVIATIONS IN PLANT SPECIES LIST

LIFEFORMS					
	lifeform	explanation			
	fn	Fern			
	fo	Forb (herbaceous, not a grass or sedge)			
	gr	Grass			
	pm	Palm			
	se	Sedge			
	sh	Shrub			
	sh.fo	Subshrub			
	sh.vnw	Shrubby vine			
	tr	Tree			
	tr.sh	Tree or shrub			
	vn	Vine			
	vnh	Herbaceous vine			
	vnh.pr	Herbaceous vine, root parasite			
	vnw	Woody vine			
		LIFE CYCLE			
	r	annual aerial parts, root perennial			
	a	true annual			
	a.r	'a' or 'r'			
	p	perennial aerial parts, evergreen			
	p.r	'p' or 'r'			
	a.p	'a' or 'p'			
	o	obligate deciduous			
	f	falcultative deciduous			
CONSERVATION STATUS					
	lc	least concern			
	v	vulnerable			
	ne	not evaluated			
	UPPER CASE =		endemic		