Rio Tinto Weipa

Rehabilitation Management Plan

April 2021

A plan prepared for submission to Queensland DES in compliance with the requirements of Environmental Authority (EA) No. EPML00562613

DOCUMENT CONTROL

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1.0	External submission	Holly Wallace, HSE Manager	QLD DEHP - Dean Sharpe	30 August 2013
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1. INTRODUCTION

This Rehabilitation Management Plan (RMP) has been prepared by Rio Tinto Weipa (RTW) for submission to the Queensland Department of Environment and Heritage Protection (DEHP) to demonstrate compliance with the requirements of the current Environmental Authority (EA) No EPML00562613 (Mining Activities). This EA applies to the ML 7031 mining lease.

1.1 REGULATORY REQUIREMENTS

Specifically, this RMP addresses Condition (C16) as follows:

Rehabilitation Management Plan

(C15) The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) by September 2015 and must include

(a) Schematic representation of final land form inclusive of drainage features;

(b) Slope and cover designs;

(c) Drainage design;

(d) Erosion controls proposed on reformed land;

(e) Revegetation methods inclusive of plant species selection, re-profiling, soil handling (including stockpiling), soil ameliorants/amendments, surface preparation and method of propagation;

(f) Materials balance including available topsoil and low permeability capping material;

(g) Geotechnical, geochemical and hydrological studies;

(h) Chemical, physical and biological properties of soil and water;

(i) Agreed post mining land and/or infrastructure use with the landowner/holder and the administering authority;

(j) rehabilitation goal, rehabilitation objective, indicators and measurable completion criteria for each agreed post mining land use within each domain that enables determination of rehabilitation success;

(k) Description of experimental design for monitoring of reference and rehabilitated areas inclusive of statistical design;

(l) A rehabilitation monitoring program based on a statistically sound, mutually agreed sampling design;

(m) Research program and associated milestones; and

(n) Programs for maintenance of rehabilitation as required to achieve the nominated rehabilitation objective.

In addition to Condition (C15), this RMP fulfils the requirements of the conditions listed below:

- **Condition (C3 (d)) Disturbance to Land (Topsoil management);**
- **Conditions (C9) and (C13) Rehabilitation Objectives; and**
- **Conditions (C14) and (C15) Topsoil.**

Full descriptions of these conditions and where they are addressed in the RMP is included in Appendix A. Other conditions in the ML7031 EA (EPML00562613) which relate to land use management have, in general, been addressed in the Land Use Management Plan (submitted to DES).

1.2 History of Rehabilitation at Rio Tinto Weipa Operations

Mine site rehabilitation has been undertaken progressively for over 40 years of operations at the Weipa Bauxite operations. During this time, rehabilitation requirements, expectations and techniques have changed. Over the life of the mine, the overall goal of the rehabilitation program has been to return the land to a post-mining land use that will be safe, stable, self-sustaining, requires minimal maintenance and protects downstream water quality. Returning a native ecosystem became the primary goal of rehabilitation during the 1970s, however pasture and forestry post mining land uses were also trialled in collaboration with the government and local stakeholders between the 1960s and mid-2000s. Whilst the Western Cape Communities Coexistence Agreement (WCCCA) and Ely Bauxite Mining Project Agreement (EBMPA) agreements provide for alternate post-mining land uses, the primary goal of rehabilitation prior to 2008 was “To establish self-sustaining vegetation comprising a variety of native plants, which in turn supports native fauna” (1991 EMOS & 2004 EMOS). Whereas following 2008 the goal shifted toward establishing a sustainable native ecosystem that is as similar to the pre-existing ecosystem as can be achieved within the limits of recognised good practice rehabilitation methods and the post-mining environment.

1.3 Mining and Rehabilitation Process Overview

RTW is an open-cut truck and loader operation which produces over 30 million tonnes of bauxite per annum. The operation consists of two bauxite mines at East Weipa and Andoom with a shared ship loader at Lorim Point and a third operation South of the Embley River, Amrun with export facilities located at CHITH export facility. While the rehabilitation strategy for Amrun is being developed, rehabilitation policy is detailed in an interim rehabilitation management plan. The mining leases total more than 365,000 hectares (ML7024/6024 and ML7031) and bauxite has been mined for more than 50 years. The potential remaining mine life is in excess of 50 years. Rehabilitation of mined land is undertaken progressively after mining activity has ceased in the specific location. Areas that are available for rehabilitation are identified in the Plan of Operations. A brief description of the key mining and rehabilitation phases is provided below and shown in **Figure 1**.

Mine Planning

Based on plans developed from the mine model, areas are nominated for mining at least three years ahead of planned disturbance. This lead time provides for the Traditional Owner consultation and comprehensive heritage and environmental surveys and investigations required to obtain internal disturbance approval.

Vegetation Clearing

Clearing is achieved on a marked up area using two large bulldozers towing a chain between them to bring about broad scale felling of eucalypt woodlands that consistently coincides with the bauxite ore body. The resultant biomass is raked clear of boundaries and burnt.

Soil Stripping

Topsoil and any additional overburden material is removed using a development fleet of front end loaders and rear tipper dump trucks. Soil removed is either directly placed to nearby mine floor for rehabilitation or stockpiled for later use. Overburden generally ranges between 0.3 to 2 metres deep.

Mining

Weipa bauxite ore is relatively loose and friable, therefore once the ore has been uncovered mining is undertaken using front end loaders to load long haul trucks for transporting the bauxite ore via the extensive haul road network to dump stations. The bauxite ore body typically ranges between 1 metre and 3-5 metres in thickness.

Processing & **Shipping**

From the dump stations, conveyors carry the ore to beneficiation plants where it is washed, crushed and sized. Waste products from beneficiation are oversize rocks (used for construction purposes) or tailings (stored in tailing storage facilities). Once beneficiated, the bauxite is transferred via conveyor or rail to the product stockpile at Lorim Point ready for loading onto bulk freight ships.

Rehabilitation

Topsoil placed on the mine floor is spread and ripped, prior to seeding via plane or tractor. Rehabilitation targets are focussed on ensuring that an area equivalent to that cleared is rehabilitated each year to minimise the disturbance footprint. Rehabilitated areas are monitored to evaluate progression towards completion criteria. Maintenance work including remediation activities, erosion, weed and fire control are conducted as required

Figure 1 Example of the Spatial Relationship between mining stages

2. THE WEIPA ENVIRONMENT

EA Condition:

(C15) The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) by September 2015 and must include:

(g) Geotechnical, geochemical and hydrological studies

(h) Chemical, physical and biological properties of soil and water

The Weipa operations are located on the west coast of Cape York Peninsula adjacent to the Weipa, Napranum, Mapoon and Aurukun communities, 810 km north-north-west of Cairns, Queensland. The RTA mineral leases extend to Palm Creek and Musgrave River in the north (north east of Mapoon and adjacent to the Skardon River) and almost to Aurukun in the south. A separate, small area of lease also exists south of Vrilya Point.

The area disturbed for mining is bordered to the north by the Pine and Wenlock Rivers, to the south by the Embley River and the Gulf of Carpentaria to the West (Figure 2 and Figure 3). The mining areas are referred to as the Weipa mining area, being that based on the Weipa Peninsula, and the Andoom mining area, being that to the north of the Mission River

2.1 CLIMATE

The Weipa region experiences a tropical monsoonal climate, dominated by distinct wet (summer) and dry (winter) seasons. The mean annual rainfall for Weipa is 2026 mm (Weipa Aero, BOM station #027045) and 1781 mm (Weipa Eastern Ave, BOM station #027042). Mean daily potential evaporation varies from 4.0 mm in February to 6.6 mm in October (Weipa Eastern Ave) and 5.0 to 9.0 mm (Weipa Aero). (BOM website, 6 June 2013)

Temperatures do not vary much throughout the year. Mean maximum temperatures range from 30.4˚C in July to 34.8˚C in October. Mean 9am relative humidity varies from 84 to 87% in January, February and March to 66 to 73% in August, September, and October (BOM website, 6 June 2013).

The onset of the wet season can vary, with approximately 97% of rain falling between November and April. High variability in monthly rainfall is evident from year to year, within years and over a range of sites in the local area.

The wet season rainfall patterns are affected by monsoonal activity and convective storms that often develop in the late afternoon. Cyclone season generally occurs from December to April with one cyclone, on average, expected to be formed in the gulf each year and 2 – 3 occurring in the Coral Sea (Dames and Moore, 1996).

2.2 SOILS

2.2.1 Soil types of the Weipa region

Biggs and Philip (1995) described seven soil landscapes on the Cape York Peninsula, which are based on distinctions in physiography and geology as well as elements of vegetation and current land use. These soil landscapes are useful for providing an overview of the soils and explaining their position in the landscape.

RTW leases are located entirely within the Batavia Landscape and situated on the Weipa plateau. The Batavia Landscape is associated with the lateritised Bulimba Formation and Rolling Downs Group (siltstone, labile glauconitic sandstone, and mudstone). The soils are largely related to the overlying Aurukun Surface, which is derived from lateritised sandstones of the Bulimba Formation. North of Weipa soil elements of the Heathlands Landscape exist. The Heathlands Landscape consists principally of soils, derived from sandstone that is vegetated with heaths and Eucalyptus tetrodonta woodlands.

On the Weipa plateau, the lateritic horizons are aluminous (bauxitic) in nature. These soils are infertile, with their moisture holding capacity restricted by their lighter texture and the presence of bauxite or ironstone segregations within the profile.

Red Kandosols occur in upper to mid landscape positions with smaller areas of Yellow Kandosols occasionally found in lower slope positions.

Weakly ferruginised Yellow Kandosol acid soils are associated with the footslopes of the lateritic remnants. They are derived from recent exposures of the underlying sediments of the Rolling Downs Group and are more acidic.

Redoxic Hydrosols (the Mapoon soil type of Biggs and Philip (1995)) occur in swamps common to the lower parts of this landscape. These soils have a clay subsoil texture in the swampy areas, but commonly have less developed gradational texture profiles (kandosolic) in the more common minor drainage lines. Redoxic Hydrosols are restricted to the Aurukun Surface. Biggs and Philip (1995) noted that the formation of these swamps is considered by some authors as a laterite-karst feature. Flooding and poor drainage are the over-riding restrictions on the use of these soils for agriculture.

Orthic Tenosols, Supratidal Hydrosols and Aquic or Grey Vertosols (the Caravan, Marina, George and Somerset soil types of Biggs and Philip (1995)) are associated with the Heathlands Landscape. Areas of beach ridge material and sand dunes (Orthic Tenosols) occur on the western coastal margin. In some areas, older beach ridge deposits may have a red colour which is a result of influence by the adjacent and underlying lateritic surface (Somerset soils). Minor occurrences of marine clays (Supratidal Hydrosols and Aquic or Grey Vertosols) occur on the coastal alluvial areas often associated with estuarine deposits (Intertidal Hydrosols) and mangroves (Rio Tinto 2011)

2.2.2 Chemical Properties

The chemical properties of Kandosol soils, the dominant soil type to be disturbed by mining at RTW, are detailed below:

- Slightly to moderately acidic with a pH range generally of 5.7 to 6.5;
- Low salinity and chloride levels;
- non-sodic (exchangeable sodium percentage);
- Low levels of calcium, magnesium and potassium;
- Extremely infertile and nutritionally deficient soils with low levels of Colwell extractable phosphorous and very low exchangeable potassium; and
- nutrients such as nitrogen, calcium and potassium present in the surface of soil, due to nutrient recycling in the litter layer. This layer represents the main nutrient storage capacity for tropical soils.

2.2.3 Physical properties

The Red Kandosols consistently have higher coarse and fine sand contents than clay reflecting the sandstone parent material. Red Kandosols with high fine sand contents appear to hardset when leaf

litter is removed and the soil surface is exposed; however, these appear to be uncommon. The Yellow Kandosol acid soils have significantly higher clay content, reflecting the lower landscape position. They also have higher silt content in the surface, which is consistent with their hardsetting nature.

2.2.4 Biological Properties

In nutritionally deficient soils, bacteria that colonise plant roots are particularly important for plant phosphorous and nitrogen uptake. Soils at Weipa were included in two Australian wide studies of mine site rehabilitation effects on symbiotic fungae and bacteria. Studies assessed the occurrence and infectivity of endo-mycorrhizae. These studies identified four to five different types of endo-mycorrhizae in soils at Weipa, although spores of the Glomus fasiculatus group were most prevalent. Both studies stressed the importance of the microbially-assisted adaptation of native plants to allow for the nutrient status of the Kandosol soils at Weipa (Schwenke 1996)

2.3 Water and Hydrology

2.3.1 Water Quality

An extensive Receiving Environment Monitoring Program (REMP) for surface waters is underway throughout the RTW operational areas (EA conditions (H14), (H15) and (H16)) with findings from this program due for submission in July 2014. This monitoring program (as accepted by DEHP in July 2012) includes monitoring locations up and downstream of mining activities and is aimed at determining indicators to assess the potential for impact from discharges form the mining areas. The program is based on the ANZECC guidelines, requiring the collection of 24 consecutive samples to create a statistically valid data set for investigation and assessment. Significant progress has been made towards achieving the required data set however insufficient information is yet available to accurately characterise the value ranges so far achieved. Interim values based on the data available are presented below however it is noted that significant temporal and seasonal variation has been observed within the data set collected to date. Therefore these results are considered preliminary and at best indicative and likely to change with the inclusion of more data.

The below values are based on the analysis of the REMP data collected from upstream freshwater streams monitoring locations:

- Slightly to moderately acidic pH (5.3 to 6.15, 20th to 80th percentile);
- Very low conductivity (17 to 27 µS/cm, 20th to 80th percentile);
- Generally very low concentrations of most trace elements, usually <1 µg/L;
- Relatively higher concentrations of aluminium (Al-F) (17.40 to 48.60 µg/L, 20th to 80th percentile), moderate levels of iron (Fe-F)(28.60 to 67.80 µg/L, 20th to 80th percentile); and Slightly elevated levels of turbidity (9.9 to 17.2, 20th to 80th percentile).

2.3.2 Biological Properties

The biological properties of the surface waters are determined by a number of factors:

- The duration of inundation during the seasonal cycle;
- The extent of connectivity to other water bodies, particularly for freshwater systems;
- Proximity to nutrient sources, particularly from seawater; and
- The extent of riparian or emergent vegetation and the amount of shading that affords.

The typically very clear waters tend to support diverse aquatic plant (macrophytes and algae) assemblages in the absence of strong shading. The seasonality of the inland habitats tends to

facilitate the prevalence of forms that have both aquatic and terrestrial forms, or tubers/seeds that can aestivate during the dry season (or in sediments that become saline in upper estuarine settings). However, the low nutrient status of the waters and sediments, despite supporting a diverse assemblage of aquatic plants, tends to limit the growth of some forms, resulting in a generally low abundance of epiphytic algae.

The freshwater faunal assemblages found on the bauxite plateau are depauperate compared to other regional water bodies where the underlying geology is non-lateritic. There are typically only 13 to 15 fish species per stream, and those species usually have low relative abundance. The macroinvertebrate assemblages are generally typical of those found in northern Australian intermittent waters, but lack molluscs and some crustacean groups are poorly represented (possibly due, at least in part, to the very low calcium concentrations making shell/exoskeleton deposition difficult). There is a high level of endemism among the decapod crustaceans, with an endemic crayfish and an endemic crab species in waters from the bauxite plateau. Reptiles are well represented while turtles only occur in tree swamps. Crocodiles are common, even in smaller streams, where they appear to primarily feed on terrestrial prey, such as pigs. Amphibians are relatively rare in streams, but more abundant in tree swamp margins.

2.3.3 Hydrology

A key characteristic of surface fresh waters in the bauxite plateau is that most are intermittent sensu stricto, in that they hold water during the wet season and for a period afterwards, but that most water bodies dry out before the end of the dry season. There are perennial to semi-perennial refugia within most catchments, but some may not have refugia in all years. There is typically strong connectivity between ground and surface waters, and stream flow and linear extent are ground water driven for most of the dry season, with only minor contributions from fluvial sediments and aquifers. Dry season persistence of tree swamps may be more driven by volume/evaporation relationships as these systems tend to have more impervious clay/silt sediments lining the depressions they occur in. Perennial lakes are apparently functionally ground water lenses and/or spring fed with few sufficiently deep to persist through the dry season without recharge.

2.4 GEOCHEMICAL DATA

The bauxite mining and beneficiation process generates tailings (coarse and fine) as a waste product and clean bauxite as a final product. The Ely Lease does not contain any tailings storage facilities

2.5 GEOTECHNICAL DATA

There are minimal geotechnical risks associated with bauxite mining in the Weipa area due to the slight grades that generally exist in the landscape (<10%) and the shallow nature of the mining activity. The only locations where steeper slopes occur are along coastal cliffs and dunes and along waterways which are not routinely impacted by the mining process. In terms of stream geomorphology and channel stability, streams and creeks in the area are stable, with very little active bed incision / deposition or major bank scour / failure occurring. In some locations there is localised movement of particularly erodible material, however all entire streams and creeks are generally stable. It is likely that stability is a consequence of a very old, inherently stable landscape with both lateral and vertical stability controlled to a large degree by the lateritic facies within which most of the stream channels sit. With implementation of the riparian vegetation buffer system most mine-related geomorphic impacts would be negligible, in terms of impacts on stream geomorphic integrity..

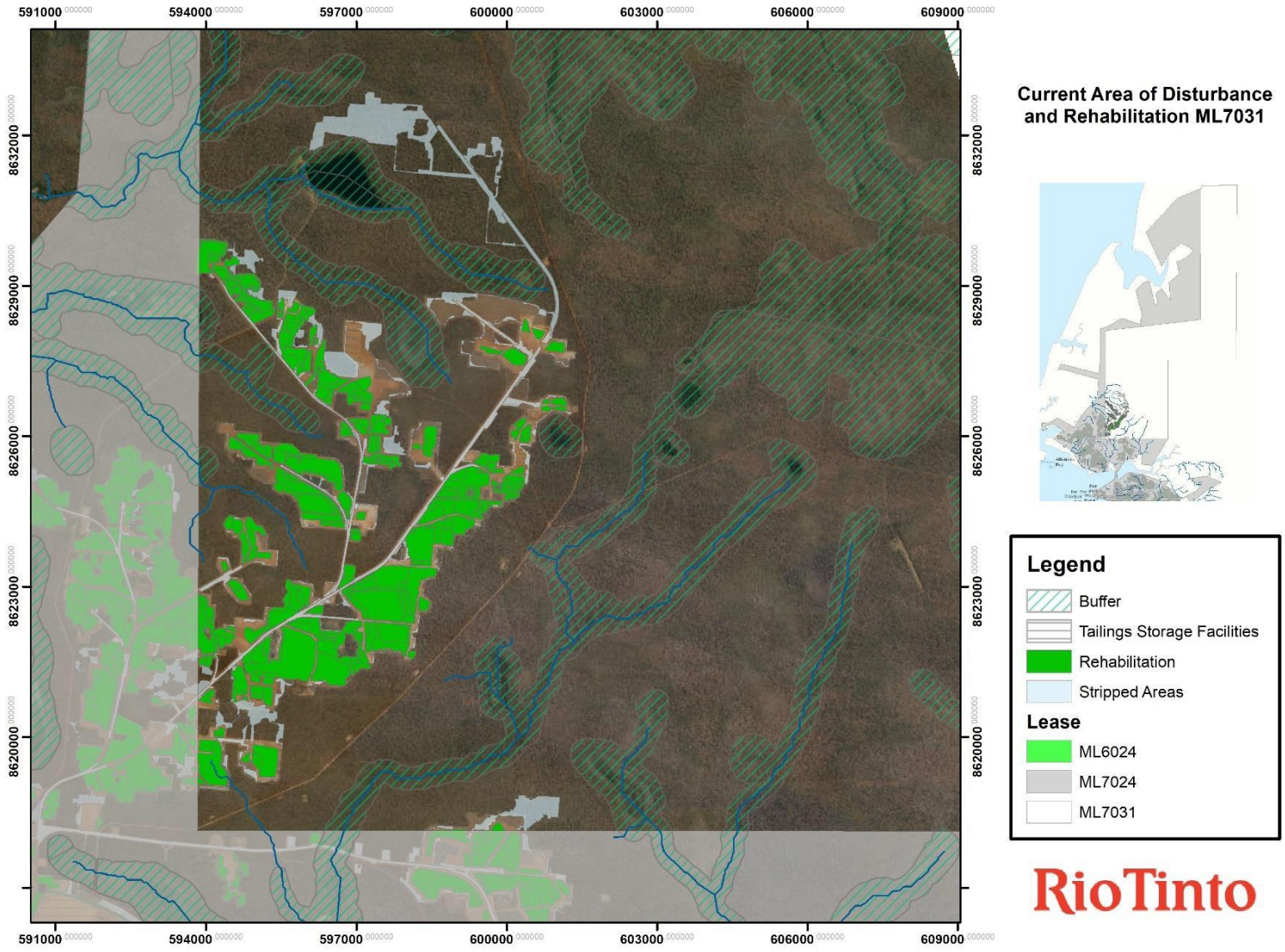

Figure 2Current Area of Operations and Disturbance 2019

3. FINAL LANDFORM.

EA Condition:

(C15) The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) by September 2015 and must include:

(a) Schematic representation of final land form inclusive of drainage features

(b) Slope and cover design

(c) Drainage design

(d) Erosion controls proposed on reformed land

3.1 SCHEMATIC REPRESENTATION OF FINAL LANDFORM

After overburden and soil are returned to mine floor following mining, the final rehabilitated land surface is at a lower elevation than the original land surface due to the removal of the bauxite, but the overall slope of the land form is generally similar. Where mined areas abut non mined areas batters are formed and these are contoured to a maximum slope of 25% (1 in 4, or approximately 13°). The final land form will not have any stockpiles of excavated topsoil but may contain some historic overburden stockpiles which will be battered down to a safe and stable slope, and rehabilitated. Tailings storage facilities will appear as elevated features in the post-mining landscape (in some cases reaching 40 RL) however these comprise a relatively minor proportion of the disturbance footprint. Given the changes to topography due to mining and infrastructure at a local scale are minor, there should be no significant changes to the broad scale topography of the area. The schematic representation of the final land form post-mining (Figure 4 and Figure 5) was created using the 2010 LiDAR ground surface data which consists of 0.25 m elevation contour lines of the site surveyed in November 2010 and as such reflects the mine surface level at that time. The data incorporates mine infrastructure such as haul roads, access roads and stockpiles on cleared land around the site. These are elevated structures above the ground surface and have not been modified to represent post-mining conditions; therefore they are artificial highpoints in the post-mining land form projection.

The LiDar data was used to create a DEM (digital elevation model) which was then modified to reflect to potential post-mining scenario (changed surface elevation) using the final elevation of the mine floor points (using the current RTW mine planning model of the bauxite ore ‘reserves’) and the topsoil thickness to be replaced as rehabilitation. The tailings dams surfaces were modified manually with final height specified as 40 m (as per EA Condition (D5)). The final DEM was used to create contours which were then smoothed to create a more natural visualisation of the final land form.

The final land form will be fully integrated within the broader landscape with little impact to the original topography. Mining-related features that do stand out include the tailings storage facilities, which take up only a minor proportion of the disturbed area, and some lower lying mine areas or borrow pits such as the ‘lakes’ to the west of the town area and the west Andoom mining area

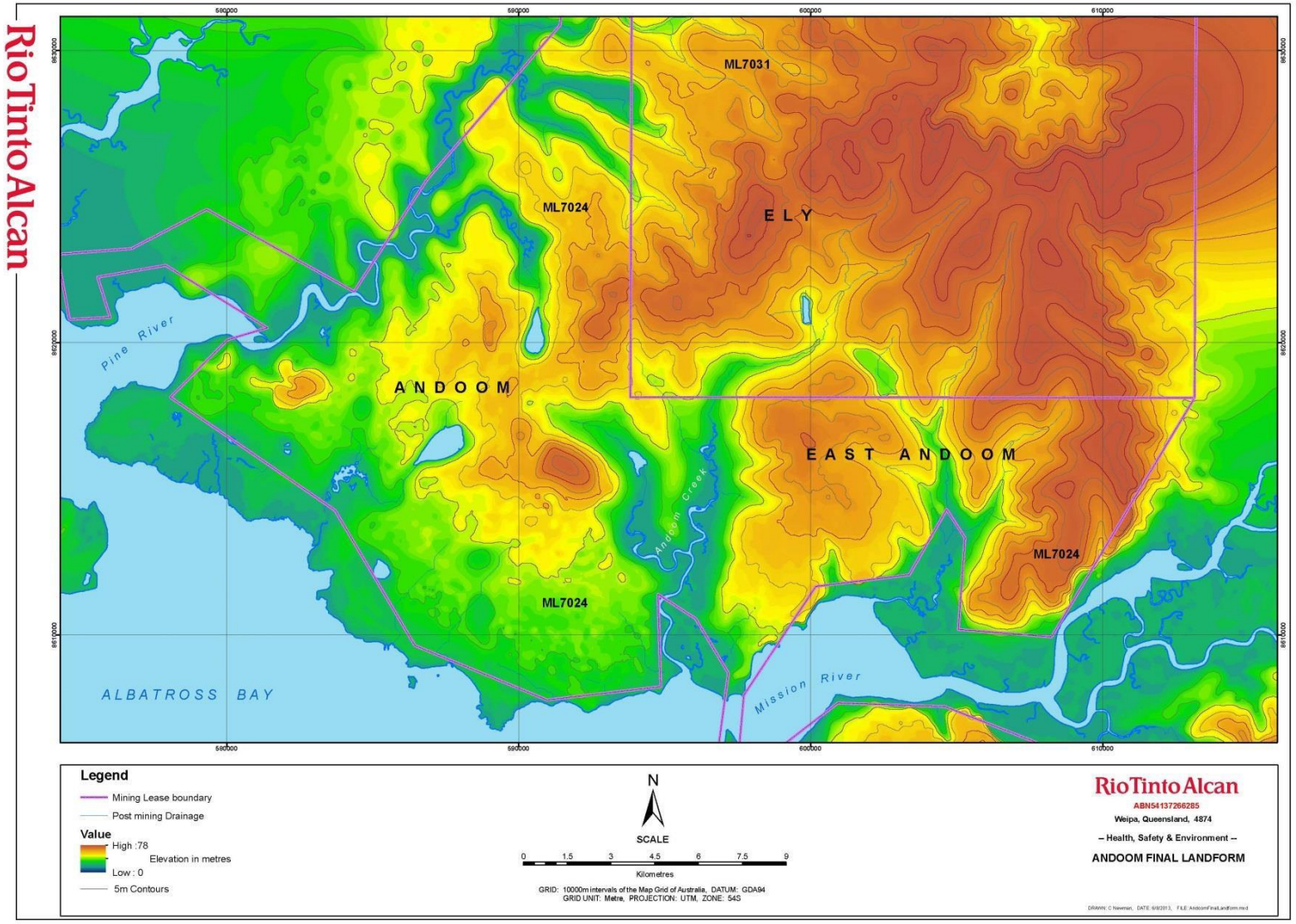

Figure 3Andoom Final Landform Schematic

3.2 DRAINAGE DESIGN, SLOPES AND EROSION

3.2.1 Drainage Design

The rehabilitated landscape (mine domain) at RTW is marginally lower than the surrounding areas in most locations. This means that most areas are internally draining, which, whilst in operational status, results in increased surface water ponding on the mine floor in some locations. However, once rehabilitated, in most areas surface water ponding and surface runoff is negligible, due to the mine floor being ripped to increase infiltration and evapotranspiration increasing with developing vegetation biomass (evapotranspiration can be as high as 43% of incident rainfall in similar undisturbed systems).

Above-ground features within the mine area domain, such as haul roads, stockpiles and so on will be land formed to ensure that the overall drainage of the area is not compromised. This may mean ripping the haul roads to remove compaction, or removing all or parts of a haul road to enable surface and/or subsurface water to move from one side to the other. (note: most haul roads are constructed along the highest points of the landscape for operational purposes, which also means that they generally do not impede any potential surface water flows across the landscape contours.)

The only rehabilitated areas where water ponding is significant are those which intersect the water table at the peak, saturated period of the wet season (Referred to as seasonally inundated 'Wetland' rehabilitation) which is recognised in this RTW RMP through the development of specifically rehabilitation goals and criteria for these areas. Mine planning processes, including replacement of waste and topsoil, aim to minimise the area subject to such inundation.

With this negligible site surface water runoff, and key controls in place, including undisturbed vegetation buffers around all natural drainage features, and soil handling, species selection and seeding rates aimed to ensure (among other things) that vegetation development is sufficient to reduce erosion from rehabilitated areas; there is a very low likelihood of the rehabilitated landscape having a negative impact on the downstream water quality of the surrounding ecosystems. Any operational or post-closure areas which do or are likely to result in surface run-off to natural ecosystems are managed under the REMP program (EA Condition (F13)).

Other domains, such as tailings dams, which may have increased surface runoff once rehabilitated compared to the mine domain, will have specific drainage design considerations and criteria developed to ensure that there is no negative impact on downstream water quality. These design considerations and criteria will be developed on a case-by-case basis, generally at a time when the rehabilitation and/or decommissioning of the facility are being planned

3.2.2 Slopes and Erosion

The Kandosol soil types encountered in the area in mid to upper landscape positions have low potential to develop accelerated erosion when cleared of vegetation for mining or infrastructure development. The predominantly sandy surface soils together with the low slopes on the bauxite plateau facilitate infiltration and reduce the rate of runoff. Rainfall runoff is a very low proportion of total incident rainfall due to the very high infiltration rates of the bauxite plateau and the flat topography. The results of erosion monitoring of rehabilitated mined areas at RTW indicate that once soil profiles have settled (usually 3-5 years after topsoil has been respread) little active erosion is observed. The Hydrosol and Tenosol soil types in the drainage lines and coastal margins have a higher erosion potential. Any of these areas to be disturbed have a risk of erosion during the wet

season, however it should be noted that drainage line and coastal margins are not disturbed for mining.

A peak flow assessment has been undertaken to identify those areas in the post-mining landscape likely to be at risk of increased erosion due to run off from significant storm events (using the Time Area Unit Hydrograph as incorporated into the hydrological modelling software, XPSTORM). This assessment considered the catchments which are, or will be, disturbed during the life of the mine and enables the operation to ensure adequate controls are put in place to manage this risk.

A Stormwater, Erosion and Sediment Control Plan (SESCP) has been developed for RTW in accordance with the EA (Condition (F19)) and provides a management framework for preventing or minimising

- Erosion;
- Releases of contaminated stormwater to the environment;
- Uncontrolled release of sediment to receiving waters; and
- Uncontrolled release of stormwater to receiving waters.

The SESCP provides an overview of control strategies designed to manage erosion, sediment and drainage. Strategies are generally aligned with the Erosion and Sediment Controls Guidelines for QLD councils (LGAQ 2006). Erosion controls address methods for keeping soil on the mine site using an erosion resistant ground covers, sediment controls ensure that the flow velocity of water is reduced so that sediment can settle via gravity, and drainage controls cover movement of both clean and dirty water within stable channels.

The SESCP includes mostly operational controls however a number of the long-term controls are suited to rehabilitation and post-closure drainage and erosion control, for example:

- Land forming to reduce slopes, maximise infiltration and reduce risk of erosion resulting in sediment movement;
- Revegetation;
- Use of revetment and reno mattresses in lined channels; and
- Rock mulching on slopes to reduce raindrop impact and overland flow.
- Specific features of the post-mining landscape with slopes which are likely to require implementation of controls such as those listed above, include:
- Battered terminal mine boundaries

In most instances, erosion is controlled by limiting the maximum slope angle to 25% or 1:4. Slope construction is undertaken in a fashion that prevents, as much as possible, erosion from occurring. Erosion control measures include increasing surface roughness, tailored seed mixes with greater grass seed and breaking up slope length.

Tailings dam walls

Dam walls are seeded primarily with grasses to maintain a safe and stable slope. Maximum overall slope angles will be no more than 35°, with the exception of East Weipa Dams 1 and 2 which are rehabilitated with stable external slopes of up to 45°.

Stockpiles

Stockpiles are vegetated with a grass dominated seed mix to prevent erosion, provide competition for weed species, accumulate organic matter and establish a natural seed bank. Stockpiles that are

unable to be utilised elsewhere will be battered down to the maximum slope of 25% and integrated into the surrounding rehabilitated landscape prior to final revegetation.

Road drains and contours

This can be controlled by careful positioning of dump patterns and leaving drainage contours free, or by raising rehabilitation level with the road. In some instances, part or all of a haul road may be removed to reinstate any required surface water flow paths (Section 3.3.1).

3.3 COVER DESIGN

Generally at RTW, the materials being mined or stored in TSFs are benign and therefore cover materials are only required for erosion and revegetation purpose. Broadly speaking, the mined area domains at RTW are provided with a cover of topsoil material to ensure that the return and establishment of the target rehabilitation vegetation community is optimised. Other than the impacts of the handling process, this substrate is largely unchanged, however it is subsequently fertilised to enhance vegetation growth and development.

Once Tailings Storage Facilities (TSFs) have reached their capacity the surface and walls are revegetated and stabilised with a cover of trees, shrubs and grasses. There is no requirement to cap the TSFs prior to revegetation due to the non-hazardous nature of the bauxite tailings (Section 2.4 and Table 1). Some minor land form earthworks may be required. Also, some inoculation with fresh topsoil (to introduce local microbes and seeds) may be beneficial although this is not required for vegetation establishment and development. TSFs are regarded as permanent features in the post-mining landscape.

The only other instances of the use of a cover design and/or capping material due to mining activities at RTW may be in the remediation and rehabilitation of contaminated sites. These facilities are managed using methods developed on a case-by-case basis in accordance with DEHP's guidelines

4. POST MINING LAND USE

EA Conditions:

(C9) Land disturbed by mining activities as identified in Schedule K Plan 1 – Ely General Area Plan, must be rehabilitated in accordance with table C1 – Rehabilitation Requirements and the objectives of the Rehabilitation Management Plan required under Condition (C15).

Table C1 – Rehabilitation Requirements

Mine Domain	Mine Feature Name	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
TBD[1]	TBD[1]	All land subject to mining activities must be rehabilitated to meet the requirements of the administering authorities Guideline – Rehabilitation requirements for Mining Projects and will be defined in the Rehabilitation Management Plan	TBD[1]	TBD[1]	TBD[1]

[1] Post mine land use, rehabilitation indicators and completion criteria are to be nominated in accordance with Condition (C16).

(C11) Areas that are available for rehabilitation must be identified in the current Plan of Operations.

(C12) Rehabilitation must commence progressively as areas become available in accordance with the Plan of Operations.

(C15) The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) by September 2015 and must include:

(i) agreed post mining land and/or infrastructure use with the landowner/holder and the administering authority

(j) rehabilitation goal, rehabilitation objective, indicators and measureable completion criteria for each agreed post mining land use within each domain that enables determination of rehabilitation success

4.1 INTRODUCTION

Successful mine rehabilitation involves planning and implementation over the life of the mining operation, from prior to disturbance through to when an agreed, sustainable final land use has been established.

Elements critical to this process include:

- Agreed post-mining land use (PMLU);
- Rehabilitation goals and objectives; an Indicators and completion criteria (Refer Section 5).

4.2 CURRENT LAND USES

Through the identification of historical and current land uses in conjunction with environmental and social values, five separate land use zones that cover land owned, leased or managed by RTW have been defined. Land use zones have been established through the integration of regulatory requirements and tenure status with the physical, operational, environmental and social characteristics of the land. The land use zones for RTW are:

1. Weipa Township (WTA);
2. Mining Operations;
3. Mining Infrastructure;
4. Special Use; and
5. Restricted Use (including undisturbed areas).

Each land use zone has specific acceptable and prohibited activities (land uses). Further information on the land use zoning is provided in the Land Use Management Plan (submitted to DES).

More relevant to planning and management of mine site rehabilitation is the concept of 'domains': Categories of land disturbed due to mining and mining related activities which reflect the different activities that have or will be undertaken in those areas and, consequentially, the different post-mining land uses. Of relevance to this RMP, the domains recognised and utilised for planning and management purposes at RTW include:

- Mined area
- Tailing storage facilities (TSFs)
- Infrastructure – Final Voids and Rehabilitated Slots
- Infrastructure – Water
- Infrastructure – Plant
- Infrastructure – Civil

4.3 POST MINING LAND USE

The overall objective of the rehabilitation program is to return the land to a post-mining land use that will be stable, self-sustaining, requires minimal maintenance, and protects downstream water quality. For most domains this means the establishment of a self-sustaining vegetation community comprising local native tree, shrub and grass species which are appropriate to the given landform. The post-mining landform is considerably altered compared to the pre-existing bauxite plateau, and understanding the relationship between vegetation communities and key geomorphic features is essential in identifying sustainable and achievable vegetation communities for the final post-mining landform (Figure 6).

At Weipa, most mining disturbance impacts the relatively homogenous, vegetation type 2b tall Eucalyptus tetrodonta woodland on red earth soils (Godwin 1985) with some mining on 2c tall E. tetrodonta woodland on yellow earth soils (Gunness et al.1987). However, rehabilitation targets also consider alternate land units which are more likely to develop into sustainable vegetation communities given the constraints of the post-mining landform, such as those which occur on erosional slopes or lower lying drainage depressions. A full discussion of the plant species selected for rehabilitation operations can be found in Section 7.3.

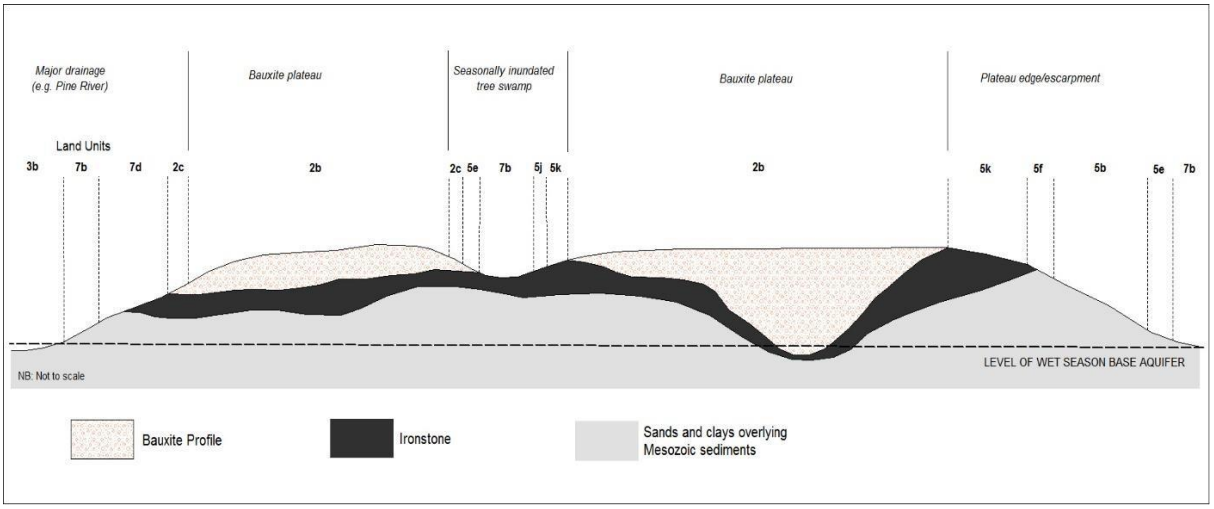

Figure 4 Schematic Representation of pre mining land units in relation to depth of wet season water table. Reddel & Hopkins (1994)

All mining equipment, infrastructure and plant will be removed and rehabilitated unless agreement is reached with relevant stakeholders and the administering authority for the relevant items to remain (as allowed for in Condition (C17) of the EA). Town infrastructure is likely to be required for the ongoing operation and development of the town. Subject to stakeholder engagement and the administering authority's agreement under Condition (C17), elements of town infrastructure will likely be transferred to a third party owner who will become responsible for ownership, liability and ongoing operations.

Under conditions of the Western Cape Communities Co-Existence Agreement (WCCCA), at the request of the Western Cape Communities Co-ordinating Committee (WCCCC), RTA may establish post-mining land use options other than those required by regulation, subject to obtaining all necessary government approvals. RTW also has commitments under the WCCCA to surrender parts of the mining lease after their rehabilitation. Such surrendering of parts of the mining lease would be undertaken where it is practical to do so, and would be subject to government approval

Table 1Domains and PMLU

Domain	Description	Post-Mining Land Use
Pre -2008 Mined area (Legacy)	Areas mined and rehabilitated prior to 2008.	• To establish self-sustaining vegetation comprising a variety of native plants, which in turn supports native fauna.
Post -2008 Mined area (benchmark)	Areas subject to mining activities - includes borrow pits and haul roads.	• A self-sustaining vegetation community comprising appropriate local native tree, shrub and grass species, which provides habitat to support local flora and fauna species, including culturally important species, and includes: ○ native dry woodland vegetation dominated by *Eucalypts*, *Corymbias*, *Erythrophleum* and other framework species; • native wetland community dominated by *Melaleuca* and/or *Lophostemon* species; or,
Tailings storage facilities	Above ground facilities holding tailings generated from the bauxite beneficiation process.	Self-sustaining landform and vegetation meeting criteria derived from monitoring and research of existing rehabilitation on TSFs.
Infrastructure – Final Voids	Below ground voids, generally resulting from material excavation and/or groundwater extraction.	Seasonally inundated, self-sustaining landform and vegetation meeting the nominated criteria
Infrastructure - Slots (rehabilitated)	Backfilled, contoured and revegetated below ground voids	Self-sustaining landform and vegetation meeting the nominated criteria
Infrastructure - Water	Includes water dams and other water infrastructure.	Subject to agreement with regulators and Traditional Owners some facilities may be left in place. Otherwise, RTW commitment is to remove structures at closure and rehabilitate as per the nominated criteria.
Infrastructure – Plant	Includes beneficiation plants, workshops, power station, product stockpiles and other hardstand areas, conveyors, and other fixed plant.	Subject to agreement with regulators and Traditional Owners some facilities may be left in place. Otherwise, RTW commitment is to remove structures at closure and rehabilitate as per the Mined area domain.

4.4 REHABILITATION GOALS AND OBJECTIVES

The rehabilitation strategy is aimed at achieving the designated post-mining land use for each domain within the mining leases.

The EA (Condition (C12)) states that rehabilitation can be considered successful when:

a) The site can be managed for its designated land-use (e.g. similar to that of surrounding undisturbed areas);

b) No greater management input than for other land in the area being used for a similar purpose is required and there is evidence that the rehabilitation has been successful;

c) the rehabilitation is carried out in accordance with the goals, objectives, indicators and completion criteria as specified in Table C1 – Rehabilitation Requirements (Table 6 in this document); and

d) Written agreement is obtained from the landowner/holder and administering authority.

In accordance with the Queensland Government Rehabilitation Requirements for Mining Projects Guideline (DES 2018), the general goals of the RTW rehabilitation program is to return the land to a post-mining land use that will be:

- Safe to humans and wildlife;
- Non-polluting;
- Stable landform(s); and
- Able to sustain an agreed post-mining land use

4.4.1 Mined Area Domain

RTW has conducted rehabilitation for over 40 years and during this time rehabilitation requirements, expectations and techniques have changed. Over the life of the mine, rehabilitation at RTW has strived to achieve a range of rehabilitation and post-mining land use goals. Returning a native ecosystem became the primary goal of rehabilitation during the 1970s, however pasture and forestry rehabilitation trials were also undertaken between the 1960s and mid-2000s in collaboration with the government and local stakeholders. The overall goal of the rehabilitation program is to return the land to a post-mining land use that will be safe, stable, self-sustaining, requires minimal maintenance, and protects downstream water quality.

In 2008, significant changes were made to the rehabilitation program and methods applied, including significant changes to species selection and soil handling techniques. This change necessitated a revision of the rehabilitation goals and associated objectives to reflect these improvements and a new set of goals and objectives were developed for Post-2008 rehabilitation. Rehabilitation established prior to 2008 is referred to as Pre-2008 rehabilitation. A full description of these existing and target rehabilitation vegetation types is provided in Appendix B.

The DES's Rehabilitation Requirements for Mining Projects Guideline DES (2018) includes some reference relating to the situation for existing, in this case Pre-2008, rehabilitation as follows: '*Historic rehabilitation must be evaluated against the rehabilitation requirements that were in place for the mining project at the time the rehabilitation was completed. This could lead to a matrix of different rehabilitation outcomes within a single domain. For example, over a period of time the species mix may have been changed in response to earlier experience or changing community expectations*'. The Guidelines also note that 'Where there is a clear intention for the rehabilitation to achieve a specified objective, the administering authority will consider applications for surrender or

progressive certification from the environmental authority holder on the basis of that objective. The application must show how the holder has rehabilitated the site to achieve the objective, and provide evidence to support the success of the rehabilitation

Table 2 Rehabilitation Goals and Objectives for the Mined Area Domain

Mine Domain	Rehabilitation Goal	Rehabilitation Objective/s
Mined area (Pre-2008)	Long-term safety	The site is safe for humans and animals, now and in the foreseeable future.
	Non-polluting	Surface water remains uncontaminated.
		Land is suitable for final land use
	Stable landform	Landform design achieves appropriate erosion rates.
	Native, self-sustaining dry woodland vegetation comprising a variety of plant species, which in turn supports native fauna	Soil health
		Self-sustaining dry woodland vegetation and fauna habitat established
		Local native mammals, birds, reptiles, amphibians& invertebrates using the site (or likely to)
	Self-sustaining wetland vegetation community that includes *Melaleucas* and other native plant species and supports native fauna	Soil health
		Self-sustaining wetland vegetation and fauna habitat established in seasonally inundated areas
		Local native mammals, birds, reptiles, amphibians & invertebrates using the site (or likely to)
	Forestry and pasture	TBD
Mined area (Post-2008)	Long-term safety	The site is safe for humans and animals, now and in the foreseeable future.
	Non-polluting	Surface water remains uncontaminated.
		Land is suitable for final land use
	Stable landform	Landform design achieves appropriate erosion rates.
	Self-sustaining native dry woodland vegetation dominated by *Eucalypts*, *Corymbias*, *Erythrophleum* and other framework species that meets criteria derived from dry woodland reference sites and trials	Soil health
		Self-sustaining dry woodland vegetation and fauna habitat established; management requirements comparable to those of unmined dry woodland
		Local native mammals, birds, reptiles, amphibians & invertebrates using the site (or likely to)
	Self-sustaining wetland vegetation community that includes *Melaleucas* and other native plant species and supports native fauna	As per Mined area (Pre-2008) self-sustaining wetland vegetation community

4.4.2 Infrastructure Domains

Infrastructure is a general term used to describe any built facilities resulting from the process of mining or associated activities. Due to the nature of the development of the mine over its 50-plus year history, this includes some infrastructure which is utilised, and in some cases depended on, by the broader community. This is recognised in the Environmental Authority (Condition (C17)) which allows for some facilities to be left in place, subject to agreement with regulators and Traditional Owners. Otherwise, the RTW commitment is to remove all structures at closure and rehabilitate as per appropriate criteria.

Table 3 Rehabilitation Goals and Objectives for other Infrastructure Domains

Mine Domain	Rehabilitation Goal	Rehabilitation Objective/s
Infrastructure - Final Voids	Long-term safety	The site is safe for humans and fauna, now and in the foreseeable future
	Non-polluting	As per Tailings Storage Facilities
	Stable landform	As per Tailings Storage Facilities (excluding max. slope)
	Sustainable Land Use	Establish specified water body with low risk of environmental harm
Infrastructure - Slots (rehabilitated)	Long-term safety	The site is safe for humans and fauna, now and in the foreseeable future
	Non-polluting	Surface water remain uncontaminated
		Soil remains uncontaminated
		Dust levels at sensitive human receptors meet EA conditions
	Stable landform	Landform design achieve appropriate erosion rates
		Vegetation cover to minimise erosion
	Sustainable land use	As per Tailings Storage Facilities
Infrastructure - Water (rehabilitated)	Long-term safety	The site is safe for humans and fauna, now and in the foreseeable future
	Non-polluting	As per Infrastructure – Slots (rehabilitated)
	Stable landform	As per Infrastructure – Slots (rehabilitated)
	Sustainable land use	As per Tailings Storage Facilities
Infrastructure - Water	Water infrastructure, such as the water supply dams, may be left in place.	Subject to agreement with regulators and Traditional Owners some facilities may be left in place. Otherwise, RTW commitment is to remove structures at closure and rehabilitate as per Infrastructure – Water (rehabilitated)

Mine Domain	Rehabilitation Goal	Rehabilitation Objective/s
Infrastructure – Plant	Some plant infrastructure may be left in place, otherwise rehabilitated as per Mined area domain.	Subject to agreement with regulators and Traditional Owners some facilities may be left in place. Otherwise, RTW commitment is to remove structures at closure and rehabilitate
Infrastructure – Civil	Some civil infrastructure is likely to be left in place, otherwise rehabilitate as per Mined area domain.	Subject to agreement with regulators and Traditional Owners some facilities will be left in place.

5. INDICATORS AND COMPLETION CRITERIA

EA Conditions:

(C9) Land disturbed by mining activities as identified in Schedule K Plan 1 – Ely General Area Plan, must be rehabilitated in accordance with table C1 – Rehabilitation Requirements and the objectives of the Rehabilitation Management Plan required under Condition (C15).

Table C1 – Rehabilitation Requirements

Mine Domain	Mine Feature Name	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
TBD[1]	TBD[1]	All land subject to mining activities must be rehabilitated to meet the requirements of the administering authorities Guideline – *Rehabilitation requirements for Mining Projects* and will be defined in the Rehabilitation Management Plan	TBD[1]	TBD[1]	TBD[1]

[1] Post mine land use, rehabilitation indicators and completion criteria are to be nominated in accordance with Condition (C15).

(C12) Rehabilitation can be considered successful when:

(a) the site can be managed for its designated land-use (e.g. similar to that of surrounding undisturbed areas);

(b) the level of ongoing management input required is no greater than for other land in the area being used for a similar purpose and there is evidence that rehabilitation has been successful;

(c) the rehabilitation is carried out in accordance with the goals, objectives, indicators and completion criteria as specified in Table C1 – Rehabilitation Requirements; and

(d) written agreement is obtained from the landowner/holder and administering authority.

(C15) The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan by 7 September 2015 and must include:

5.1 INTRODUCTION

Completion criteria are a set of objective standards against which the performance of rehabilitated areas can be assessed. They are used to demonstrate whether rehabilitation goals are being met and therefore whether rehabilitation is successful in achieving a sustainable post-mining ecosystem. As such, meeting completion criteria allows for mining operations with substantial lease areas to enter into a process of on-going relinquishment of rehabilitated lands. Prior to formal acceptance, a key phase of the completion criteria development process is ongoing refinement between the mining operation and the regulatory agency. Development of completion criteria for Rio Tinto Weipa (RTW) operations has been ongoing for over twenty years. During this time, research, traditional owner engagement, monitoring and operational learning has driven continual improvements in rehabilitation practices and outcomes for RTW.

This section addresses the following:

- Rehabilitation indicators; and
- Completion criteria

5.2 RATIONALE ON REHABILITATION INDICATORS

Rehabilitation indicators are parameters that can be measured and monitored to track the performance of rehabilitation against a given objective. DES (2018) defines indicators as 'something that can be measured and audited according to an established protocol and used to evaluate changes in a system'. A range of indicators can be chosen for completion criteria and rehabilitation monitoring. Given the vast range of indicators available as well as the financial and time constraints of most rehabilitation monitoring programs, only a selection of the indicators can actually be measured at any one mine. Dale and Beyeler (2001) suggest that indicators should meet a number of criteria in order for them to be effective. Firstly, the indicator must be easily measured. It must also be sensitive to stress on the system, and able to detect small changes should they occur. Further, it should be able to predict changes that can be averted by management actions, integrate several aspects of a system, have a known response to disturbances, change over time and have low variability in response. Where the target land use includes the establishment of native vegetation and ecosystem function; indicators toward rehabilitation goals must include composition, structure and function parameters derived from appropriate analogues to describe and evaluate success.

5.2.1 Methodology for determining closure criteria

The methodology used to obtain the quantitative completion criteria have been derived from distributions of rehabilitation indicators observed at analogue reference sites (Appendix G). The objective is to obtain benchmarks which are able to robustly discriminate between sites that have been successfully rehabilitated and those which require additional management interventions. A major challenge in doing this is the uncertainty associated with the reference data. This uncertainty is due to a range of factors including: 1) variation within a particular site, 2) variation between sites classified into a particular land unit, 3) the effects of recent environmental events prior to monitoring, and 4) measurement error. In order to mitigate the effects of these sources of uncertainty, rehabilitation benchmarks have been predominantly derived from data that contains a significant number of samples (N=65) obtained at range of locations (N=23 dry woodland and N= 21 wetland). Another difficulty in obtaining robust quantitative benchmarks is that equivalency between rehabilitated and analogue reference sites cannot be expected on the current timescale and historically this has not been the management objective. Rehabilitation benchmarks must therefore be considered individually based on the expected ecological relationship between

rehabilitated and analogue reference sites. This approach has been applied to obtain the proposed benchmarks for each indicator with specific reference to distributions of indicator values obtained from appropriate reference data. The rationale applied to determining appropriate closure criteria for rehabilitation at Weipa is discussed in detail in Appendix D.

Table 4 Completion Criteria for Legacy (Pre-2008) Mined Domain

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Methodology and notes
Stable landform	Landform design achieves appropriate erosion rates	Absence of soil erosion or present only at acceptable levels	No unacceptable soil erosion. Unacceptable erosion is defined as that which: • Appears likely to cause instability or degradation of the landform • Has the potential to compromise land use/objectives • Has the potential to deposit substantial alluvial sediment into receiving waters	Erosion is rarely observed to a degree likely to inhibit successful rehabilitation, given the internally draining, and low-relief landforms characterising Weipa's mine pits. Currently measured through Interim Assessment and Performance monitoring programs for Type (Gully, Rill, Sheet, None), Extent (Minor, Moderate, Severe) and Status (Active/Non Active) Unacceptable defined as Active, Moderate to Severe Erosion into receiving waters or Active, Severe Erosion onto rehabilitation.
Native, self-sustaining dry woodland vegetation comprising a variety of plant species, which in turn supports native fauna.	Soil Health	Development of soil A horizon and presence of leaf litter.	Development of soil A horizon and presence of leaf litter. .	Soil properties evidenced by excavations at 75% of 4, 25m intercepts along transect where excavations are undertaken to 300mm. The assessing ecologist will note the presence and breakdown of organics and formation of A horizon. Terminitaria presence should be recorded in transect.
		Soil formation processes underway	Presence of terminitaria and breakdown of organic matter in soil horizon..	Evidenced by excavations at 75% of 4, 25m intercepts along transect where excavations are undertaken to 300mm. The assessing ecologist will note the presence and breakdown of organics and formation of A horizon. Terminitaria presence should be recorded..

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Methodology and notes
Native, self-sustaining dry woodland vegetation comprising a variety of plant species, which in turn supports native fauna.	Soil Health	Ground Cover and leaf litter	Ground cover comprising leaf litter, grasses, or cryptograms to comprise 80% of intercepts for an assessment plot.	Currently measured through Performance Monitoring and Interim Assessment intercept component.
	Self-sustaining dry woodland vegetation and fauna habitat established	Tree density – total framework species >2m	≥140 stems per ha of Pre-2008 Dry Woodland framework species >2m.	Key metric measured through Performance and Interim Assessment monitoring.
		Canopy composition	Collective foliage projective cover of Acacia mangium, Acacia auriculiformis, Acacia torulosa., Grevillea pteridifolia and Grevillea heliosperma is less than 50% of all >1.5 m intercepts.	Currently measured through Performance and Interim Assessment monitoring.
		Vegetation health	The proportion of plants with significant health problems should not prevent any other criterion from being achieved and sustained.	In Performance monitoring methodology density data records health status of individual plants. Those species exhibiting poor health are to be discounted from any density calculations.
		Diversity	Reciprocal Simpson's index score for the site ≥1.6.	Data collected measured through Performance Monitoring and Interim Assessment intercept component.

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Methodology and notes
Native, self-sustaining dry woodland vegetation comprising a variety of plant species, which in turn supports native fauna.	Self-sustaining dry woodland vegetation and fauna habitat established	Presence of weeds	Weed species abundance (either individually or in aggregate) does not and is unlikely to prevent any other criterion being achieved or sustained. Ecosystem transformer weeds must be absent (i.e. Gamba Grass). If a site is treated to remove ecosystem transformer weeds, monitoring in the subsequent year/s must determine that the treatment has been successful.	Weed presence and relative density is recorded during interim assessment/performance monitoring methodology.
		Resilience to fire	Following a recent fire (within the previous five years), all other completion criteria must be shown to have been met, demonstrating recovery. If the site is long unburnt or has never been burnt, monitoring of structurally and floristically similar rehabilitation must demonstrate that attributes relevant to other completion criteria could be expected to recover following a wildfire.	Reformulate this criterion, if necessary, after fire research is complete, or, integrate the findings of the fire research into all other relevant criteria, and omit this 'resilience to fire' criterion.
		Development of habitat suitable for native fauna species that utilise dry woodland vegetation types in the area	The following habitat features must be present:One of more woody sub-canopy layers; Course woody debris (>1m), whether introduced or naturally-occurring; and An herbaceous layer inclusive of local perennial grasses.	Currently measured through Performance Monitoring and Interim Assessment intercept component.

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Methodology and notes
Native, self-sustaining dry woodland vegetation comprising a variety of plant species, which in turn supports native fauna.	Local native mammals, birds, reptiles, amphibians & invertebrates using the site (or likely to)	An effective termite decomposer fauna has developed	Recent termite constructs (mounds, arboreal nests, earthen workings in litter, on wood and on tree stems) are present, and there is evidence of termite-mediated decomposition of woody and other plant materials including specific evidence of litter or soil-wood feeding termite activity.	Photography and sampling of termite activity in performance and interim assessment monitoring plots confirms presence of wood feeding or soil-wood feeding termites.
		Native fauna re-colonisation	Evidence of native fauna re-colonisation as demonstrated by fauna monitoring of representative Pre-2008 Dry Woodland rehabilitation	Targeted fauna surveys, carried out as part of Rio Tinto's monitoring program are essential to confirm the success of recolonization by fauna.
Native, Self-sustaining wetland vegetation community that includes Melaleucas and other native plant species and supports native fauna	Native Self-sustaining wetland vegetation and fauna habitat established in seasonally inundated areas	Framework species density	≥80 stems per ha of Pre-2008 Wetland framework species >2m	
		Diversity	Reciprocal Simpsons Index of ≥1.2	
		Canopy composition	Collective foliage projective cover of *Acacia*/*Grevillea*/*Dodonaea* species, other than those classified as key substrata species, is less than 50% of all >1.5 m intercepts.	Currently measured through interim assessment monitoring.
		Ground cover	Ground Cover and leaf litter Ground cover comprising leaf litter, grasses or cryptograms to comprise 65% of intercepts for an assessment plot.	Potentially subject to further refinement following fire study outcomes

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Methodology and notes
Native Self-sustaining wetland vegetation community that includes Melaleucas and other native plant species and supports native fauna	Native Self-sustaining wetland vegetation and fauna habitat established in seasonally inundated areas	Vegetation Health	The proportion of plants with significant health problems should not prevent any other criterion from being achieved and sustained. A significant health problem is one which is likely to substantially curtail the normal lifespan of the affected individual.	See comments for pre-2008 (Legacy Domain), Dry Woodlands
		Presence of weeds	Weed species abundance (either individually or in aggregate), does not, and is unlikely to prevent any other criterion being achieved or sustained. Ecosystem transformer weeds must be absent. If a site is treated to remove ecosystem transformer weeds, monitoring in the subsequent year must establish that the treatment has been successful.	See comments for pre-2008 (Legacy Domain), Dry Woodlands

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Methodology and notes
Native Self-sustaining wetland vegetation community that includes Melaleucas and other native plant species and supports native fauna	Local native mammals, birds, reptiles, amphibians & invertebrates using the site (or likely to)	Development of habitat suitable for native fauna species that utilise wetland vegetation types in the area	Vegetation monitoring shows wetland fauna habitat is developing including: • Suitable vegetation strata (overstory and/or shrubs and/or rushes and sedges); • local native plant species	

Table 5 Completion Criteria for Benchmark (Post 2008) Mined Area Domain

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Rationale, Notes
Stable landform	Landform design achieves appropriate erosion rates.	Absence of soil erosion or present only at acceptable levels.	No unacceptable soil erosion. Unacceptable erosion is defined as that which: Appears likely to cause instability or degradation of the landform Has the potential to compromise land use/objectives • Has the potential to deposit substantial alluvial sediment into receiving waters;	Erosion is rarely observed to a degree likely to inhibit successful rehabilitation, given the internally draining, and low-relief landforms characterising Weipa's mine pits. Currently measured through Interim Assessment and Performance monitoring programs for Type (Gully, Rill, Sheet, None), Extent (Minor, Moderate, Severe) and Status (Active/Non Active) Unacceptable defined as Active, Moderate to Severe Erosion into receiving waters or Active, Severe Erosion onto rehabilitation.
Self-sustaining native dry woodland vegetation dominated by framework species that meets criteria derived from dry woodland reference sites and trials.	Soil Health	Development of soil A horizon and presence of leaf litter.	Development of soil A horizon and presence of leaf litter. .	Soil properties evidenced by excavations at 75% of 4, 25m intercepts along transect where excavations are undertaken to 300mm. The assessing ecologist will note the presence and breakdown of organics and formation of A horizon. Terminitaria presence should be recorded in transect.
		Soil formation processes underway	Presence of terminitaria and breakdown of organic matter in soil horizon.	Evidenced by excavations at 75% of 4, 25m intercepts along transect where excavations are undertaken to 300mm. The assessing ecologist will note the presence and breakdown of organics and formation of A horizon. Terminitaria presence should be recorded..

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Rationale, Notes
Self-sustaining native dry woodland vegetation dominated by *Eucalypts, Corymbias, Erythrophleum* and other framework species that meets criteria derived from dry woodland reference sites and trials	Self-sustaining dry woodland vegetation and fauna habitat established; management requirements comparable to those of unmined dry woodland	Ground Cover and leaf litter	Ground cover comprising leaf litter, grasses, or cryptograms to comprise 80% of intercepts for an assessment plot.	Currently measured through Performance Monitoring and Interim Assessment intercept component.
		Tree density – total framework species >2m	≥200 stems per ha of Pre-2008 Dry Woodland framework species >2m.	Key metric measured through Performance and Interim Assessment monitoring.
		Diversity	Reciprocal Simpson's index scores for the site ≥3.	Data collected measured through Performance Monitoring and Interim Assessment intercept component.
		Presence of weeds	Weed species abundance (either individually or in aggregate), does not, and is unlikely to prevent any other criterion being achieved or sustained. Ecosystem transformer weeds must be absent. (Gamba grass). If a site is treated to remove ecosystem transformer weeds, monitoring in the subsequent year must establish that the treatment has been successful.	See comments for pre-2008 (Legacy Domain), Dry Woodlands
		Resilience to fire	Following a recent fire (within the previous five years), all other completion criteria must be shown to have been met, demonstrating recovery. If site is long unburnt or has never been never burnt, monitoring of structurally and floristically similar rehabilitation must demonstrate that attributes relevant to other completion criteria could be expected to recover following a wildfire.	Reformulate this criterion, if necessary, after fire research is complete, or, integrate the findings of the fire research into all other relevant criteria, and omit this 'resilience to fire' criterion.

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Rationale, Notes
Self-sustaining native dry woodland vegetation dominated by *Eucalypts, Corymbias, Erythrophleum* and other framework species that meets criteria derived from dry woodland reference sites and trials	Self-sustaining dry woodland vegetation and fauna habitat established; management requirements comparable to those of unmined dry woodland	Development of habitat suitable for native fauna species that utilise dry woodland vegetation types in the area	The following habitat features must be present: One of more woody sub-canopy layers; Course woody debris (>1m), whether introduced or naturally-occurring; and An herbaceous layer dominated by local perennial grasses.	Currently measured through Performance Monitoring and Interim Assessment intercept component.
	Local native mammals, birds, reptiles, amphibians & invertebrates using the site (or likely to)	An effective termite decomposer fauna has developed	Recent termite constructs (mounds, arboreal nests, earthen workings in litter, on wood and on tree stems) are present, and there is evidence of termite-mediated decomposition of woody and other plant materials.	Currently measured through Performance Monitoring and Interim Assessment intercept component.

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Rationale, Notes
Self-sustaining native dry woodland vegetation dominated by *Eucalypts, Corymbias, Erythrophleum* and other framework species that meets criteria derived from dry woodland reference sites and trials	Local native mammals, birds, reptiles, amphibians & invertebrates using the site (or likely to)	Development of habitat suitable for native fauna species that utilise dry woodland vegetation types in the area	The following habitat features must be present: One or more woody sub-canopy layers; Course woody debris (10 cm in diameter); and An herbaceous layer dominated by local perennial grasses.	Course woody debris can originate from the topsoil source, the rehabilitation itself, or be intentionally emplaced.
		Native fauna recolonization	Evidence of colonisation by fauna characteristic of Benchmark Domain Dry Woodland, as demonstrated by fauna monitoring of representative Transitional Domain Dry Woodland rehabilitation	See comments for pre-2008 (Legacy Domain).
Self-sustaining wetland vegetation community that includes Melaleucas, Lophostemon and wetland gums native plant species and supports native fauna	Self-sustaining wetland vegetation community that includes Melaleucas and other native plant species and supports native fauna	Framework species density	>140 stems per ha ofPost-2008 Wetland framework species >2m	Currently measured through Performance Monitoring and Interim Assessment intercept component.
		Diversity	Reciprocal Simpsons Index returns a value of >1.2	See diversity rationale for wetland sites;
		Ground cover	Ground Cover and leaf litter Ground cover comprising leaf litter, grasses, or cryptogram to comprise 65% of intercepts for an assessment plot.	

Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria	Rationale, Notes
Self-sustaining wetland vegetation community that includes Melaleucas, Lophostemon and wetland gums native plant species and supports native fauna	Self-sustaining wetland vegetation community that includes Melaleucas and other native plant species and supports native fauna	Vegetation Health	The proportion of plants with significant health problems should not prevent any other criterion from being achieved and sustained. A significant health problem is one which is likely to substantially curtail the normal lifespan of the affected individual.	See comments for pre-2008 (Legacy Domain), Dry Woodlands
		Presence of weeds	Weed species abundance (either individually or in aggregate), does not, and is unlikely to prevent any other criterion being achieved or sustained. Ecosystem transformer weeds must be absent. If a site is treated to remove ecosystem transformer weeds, monitoring in the subsequent year must establish that the treatment has been successful.	See comments for pre-2008 (Legacy Domain), Dry Woodlands
		Local native mammals, birds, reptiles, amphibians & invertebrates using the site (or likely to	Development of habitat suitable for native fauna species that utilise wetland vegetation types in the area	Vegetation monitoring shows wetland fauna habitat is developing including: • Surface water in some sites; •Suitable vegetation strata (overstory and/or shrubs and/or rushes and sedges); •local native plant species

Table 6 Infrastructure and TSF Closure Criteria

Mine Domain	Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria
Tailings Storage Facilities	Long-term safety	The site is safe for humans and fauna, now and in the foreseeable future	Tailings storage facilities are geotechnically stable	Evidence that storage facilities are physically stable
	Non-polluting	Surface water remain uncontaminated	Surface water monitoring	Evidence that surface water leaving rehabilitated site meets REMP requirements
		Dust levels at sensitive human receptors meet EA conditions	Dust monitoring in sensitive receptor areas	Evidence that dust levels do not exceed EA limits.
	Stable landform	Landform design achieve appropriate erosion rates	Soil erosion is acceptable	No unacceptable soil erosion. Unacceptable erosion is that which: • Causes instability or degradation of the landform • Will compromise land use/objectives
			Engineered structures to control water flow off outer batters	Evidence that required sustainable engineered structures are in place and functioning
		Slopes	Slope angles acceptable	Maximum overall slope angle of 35° (* with the exception of EW Dam 1&2)
		Vegetation cover to minimise erosion	Vegetation type and density	Evidence that vegetation is resilient, self-sustaining and appropriate to control erosion on the landform
		Very low probability of slope slippage with serious consequence in regards to environmental harm	Geotechnical and geochemical studies of existing structures	Evidence the appropriate risk assessment has been undertaken and the level of risk is acceptable.

Mine Domain	Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria
Tailings Storage Facilities	Sustainable land use	Establish specified self-sustaining natural vegetation	Presence of framework species	Minimum of two Dry Woodland framework species >2m present
			Presence of weed species	Weeds will be managed in accordance with the QLD Biosecurity Act (2014)
			Vegetation health	Evidence of good health (plants healthy, no significant disease or nutrient deficiency problems)
			Resilience of vegetation	Monitoring and/or research has shown that they regenerate after fire and meet presence of framework species criteria following a burn.
Infrastructure - Final Voids	Long-term safety	The site is safe for humans and fauna, now and in the foreseeable future	Safety assessment	Audit of the site to confirm stability and safety acceptability
	Non-polluting	As per Tailings Storage Facilities		
	Stable landform	As per Tailings Storage Facilities (excluding max. slope)		
	Sustainable Land Use	As per mined land (pre 2008 domain)	Hydrological studies to establish water levels and connectivity	Evidence the receiving environment is not adversely impacted by discharge from specified water body
			Water quality monitoring	Evidence that water quality meets relevant guidelines

Mine Domain	Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria
Infrastructure – Slots (rehabilitated)	Long-term safety	The site is safe for humans and fauna, now and in the foreseeable future	Safety assessment of contoured ground level	Fill material intact with acceptable settling and weathering
	Non-polluting	Surface water remain uncontaminated	Surface water monitoring	Reports confirm that surface water leaving rehabilitated site does not contain contaminant levels above relevant guidelines
		Soil remains uncontaminated	Soil quality monitoring	Reports confirm that soil in filled in areas does not contain contaminants above relevant guidelines
		Dust levels at sensitive human receptors meet EA conditions	Dust monitoring in sensitive receptor areas	Evidence that dust levels do not exceed EA limits.
	Stable landform	Landform design achieve appropriate erosion rates	Soil erosion is acceptable	No unacceptable soil erosion. Unacceptable erosion is that which: • Causes instability or degradation of the landform • Will compromise land use/objectives
		Vegetation cover to minimise erosion	Vegetation type and density	Evidence that vegetation is resilient, self-sustaining and appropriate to control erosion on the landform
	Sustainable land use	As per Tailings Storage Facilities		
Infrastructure - Water (rehabilitated)	Long-term safety	The site is safe for humans and fauna, now and in the foreseeable future	Safety assessment of contoured ground level	Fill material intact with acceptable settling and weathering
	Non-polluting	As per Infrastructure – Slots (rehabilitated)		

Mine Domain	Rehabilitation Goal	Rehabilitation Objective/s	Indicators	Completion Criteria
Infrastructure - Water (rehabilitated	Stable landform	As per Infrastructure – Slots (rehabilitated)		
	Sustainable land use	As per Tailings Storage Facilities		
Infrastructure - Water	Water infrastructure, such as the water supply dams, may be left in place.	Subject to agreement with regulators and Traditional Owners some facilities may be left in place. Otherwise, RTWO commitment is to remove structures at closure and rehabilitate as per Infrastructure – Water (rehabilitated)	NA	NA
Infrastructure – Plant	Some plant infrastructure may be left in place, otherwise rehabilitated as per Mined area domain.	Subject to agreement with regulators and Traditional Owners some facilities may be left in place. Otherwise, RTWO commitment is to remove structures at closure and rehabilitate	NA	NA
Infrastructure – Civil	Some civil infrastructure is likely to be left in place, otherwise rehabilitate as per Mined area domain.	Subject to agreement with regulators and Traditional Owners some facilities will be left in place.	NA	NA

6. REHABILITATION EARTHWORKS

EA Conditions:

(C3) When carrying out mining activities the holder of this environmental authority must:

(d) ensure that for land that is to be significantly disturbed by mining activities the topsoil layer is removed and handled in a manner that will minimise degradation of its biological, chemical and physical properties and is used for rehabilitation purposes (in accordance with Condition C12 & C13)

(C13) Top soil and subsoils must be stripped separately and replaced directly in an area awaiting rehabilitation or else be stockpiled and subsequently used in rehabilitation.

(C14) Topsoil must be managed in accordance with the rehabilitation management Plan and stockpiled in a manner that ensures stability. Measures must include:

(a) vegetating topsoil stockpiled during the months 1 November to 1 May;

(b) optimising the height and footprint of stockpiles; and

(c) re-using stockpiles as soon as possible.

(C15) The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) by September 2015 and must include:

(e) revegetation methods inclusive of plant species selection, re-profiling, soil handling (including stockpiling), soil ameliorants/amendments, surface preparation and method of propagation

6.1 INTRODUCTION

Prior to rehabilitation earthworks, pre-disturbance activities and vegetation clearing are undertaken at RTW. Vegetation clearing and pre-disturbance activities are described in detail in the RTW Land Use Management Plan (submitted to DEHP).

This section covers the following:

- Soil handling, including topsoil management and stockpiling;
- Re-profiling of the soil surface;
- Materials balance; and
- Surface preparation, including ripping.

Quality rehabilitation earthworks are the foundation of suitable and successful rehabilitation. Rehabilitation earthworks ensure quality topsoil is replaced after mining, in turn returning the soil seed bank and providing a suitable growing media for revegetation (Refer Section 7).

6.2 SOIL HANDLING

6.2.1 Topsoil at RTW

Topsoil is generally defined as the original surface layer of mineral soil containing material that is usually darker, more fertile and better structured than the underlying layers. Topsoils contain

practically all of the nutrients, seeds, and beneficial organisms found in the soil and at Weipa are very shallow. Topsoil nutrition, including organic matter, at Weipa is also very low due to the frequent fires and ancient nature of the soils.

While the topsoil seed bank is the primary source for many plant species to establish in the rehabilitation, studies in Weipa have shown that excessive grass competition inhibits framework species establishment (Schwenke 1996, Roberts 1994). Schwenke's study on soil organic dynamics concluded that "competition from volunteer grasses, not reduced quantity or quality of soil organic matter, was the key factor limiting establishment of sown-species" (Schwenke 1996).

For these reasons, 'topsoil' at RTW is handled as a 600mm layer (which includes some subsoil) as this dilutes the volume of grass seed at the soil surface available to germinate and compete with preferred rehabilitation species. This does, however, also dilute the other valuable topsoil attributes somewhat although some of these values can be artificially supplemented or replaced as part of the rehabilitation process (e.g. fertiliser application to increase soil fertility and seed application to replace the diluted seed store). This is considered a necessary compromise for the establishment of good numbers of healthy framework species in the rehabilitation.

It is important that soil handling is undertaken using appropriate and practical methods to ensure that rehabilitation areas benefit from the following:

- A suitable growing media with physical properties which optimise plant growth e.g. porosity and water holding capacity. This is managed by pit floor ripping and pre-seeding scarification;
- Optimal nutrition supplied by a combination of topsoil and fertiliser amendments;
- The soil seed bank of native plant species which supplement the applied rehabilitation seed mix; and
- •Symbiotic micro-organisms which form important associations with many native plant species used in rehabilitation. Soil microbes are primarily contained in fresh topsoil.

6.3 SOIL STRIPPING, PLACEMENT AND RE-PROFILING

Topsoil removal is conducted three to twelve months ahead of mining during the dry season when soil moisture is sufficiently low to minimise negative impacts on soil compaction. Wherever practical, topsoil and subsoil are stripped separately and returned directly to nearby areas of the mine floor. Topsoil and subsoil is replaced sequentially on mined areas available for rehabilitation and spread to depths similar to those that were stripped. A conceptual view of the soil profile before and after mining is shown in Figure 7.

Generally the overburden, subsoil and topsoil stripped from a new mining area are taken directly to an existing mined out area that is awaiting regeneration. Ideally, this material is respread, ripped and seeded within the same dry season. In circumstances when operational requirements prevent stripped material being directly re-located it is temporarily stockpiled

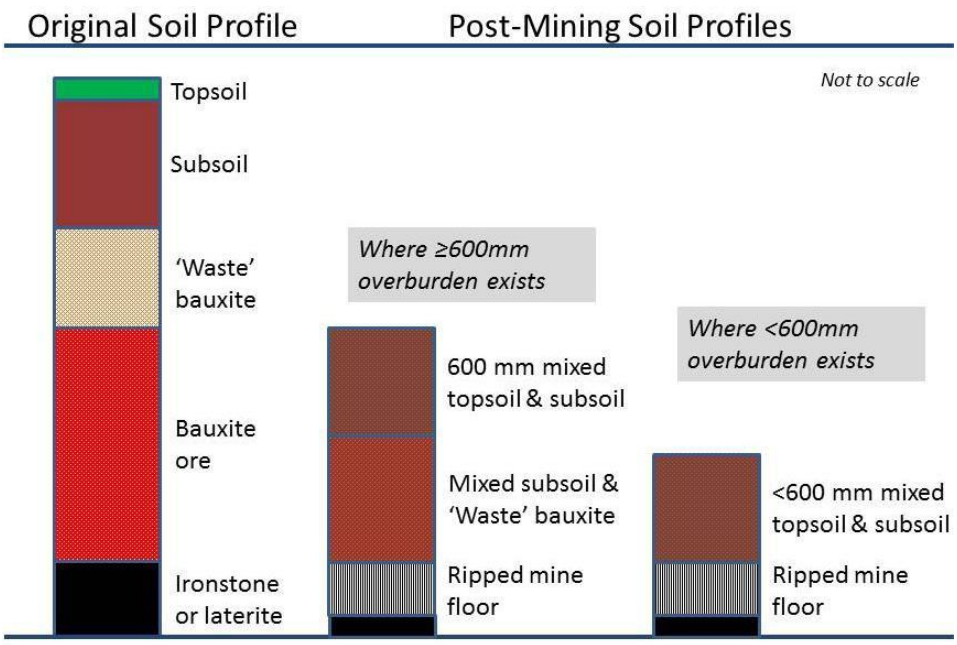

Figure 5 Conceptual pre/post mining soil profiles

6.4 STOCKPILING

Only when stripped topsoil cannot be directly returned to the mine floor will it be placed in a temporary stockpile. The mine planning process endeavours to use stockpiles as soon as possible. Wherever possible, stockpiles are located above areas subject to wet season inundation and are constructed to optimised footprints and heights. This optimisation means:

- That stockpile footprints are minimised, to reduce the need for additional clearing of native bushland or a reduction in the area of land rehabilitated, and
- Stockpile heights are maintained below 5 m (to minimise compaction and maximise the soil surface area to volume ratio and maintain as many valuable chemical, physical and biological properties as possible).

At Weipa, experience shows that topsoil stockpiles generally contain sufficient native seed (especially grass seed) that they naturally revegetate during the first wet season providing good erosion control and initiating recovery of some of the biological and chemical values in the outer layer of the topsoil. Any topsoil required to be stockpiled across a wet season (1 November to 1 May) is inspected for vegetation establishment and, if required, is sown with a seed mix dominated by grasses to control weeds and erosion.

Stockpile records are maintained which include the origin of the topsoil, stockpile volumes and location, erosion controls, and ongoing management information such as the status of revegetation, weed and erosion.

6.5 USING STOCKPILED SOIL

Rehabilitation areas receiving stockpiled material are sown with a special seed mix containing additional species to the standard seed mix, including seed of species that usually "volunteer" from natural seed store in freshly returned topsoil, such as grasses and Acacias.

Stockpiles can be a source of weeds for new rehabilitation areas. To prevent this, all stockpiles being used within a weed quarantine zone or shown to have Gamba grass present must be scalped prior to use. This process involves using a dozer, or similar machinery, to push all vegetation and soil, to a depth of 200-300mm, into a windrow. This material is then buried under replaced topsoil or other material to a minimum depth of 300mm. This process occurs within the weed quarantine zone prior to transporting the soil to the available mine floor for rehabilitation, ensuring that weed seeds are not spread to new areas

6.6 RIPPING

Ripping is the process of breaking up the mine floor, which is comprised of ironstone or compacted pisolitic material using a bulldozer with a tine attachment. The mine floor can be quite compacted after the bauxite has been mined from the traffic of haul trucks and other heavy earthmoving equipment. The purpose of ripping is to increase water infiltration rates thereby reducing the severity of erosion and maintaining water and air space. Ripping also encourages deep root penetration allowing greater anchorage and access to water, crucial for the growth and survival of larger trees and shrubs.

Ripping normally occurs immediately following the soil being respread on the mine floor. However, sometimes ripping is undertaken prior to the placement of soil for rehabilitation. In either case, the minimum ripping depth into the mine floor is approximately 500 mm. On slopes ripping is carried out along the contour (across the slope) to reduce sheet erosion. Ripped lines are spaced at approximately 3-4 metres apart

6.7 MATERIALS BALANCE

Most material movements are those associated with stripping topsoil and excess overburden (‘waste’) in preparation for mining the bauxite. This material is identified in the annual mine plan and specific locations for relocation are identified in the three month plan. Where no appropriate location can be found, topsoil is stockpiled for future use.

As described in Section 6.2, topsoil at RTW is managed as a 600mm cut (or less), so a considerable volume of material is relocated onto the mine floor and into topsoil stockpiles. The topsoil stockpiles contain a range of materials, including the valuable biological and chemical constituents found in the top layer (e.g. 10 cm) of the original soil surface. Thus, up to 80% of the volume of material in topsoil stockpiles could be considered more correctly as subsoil.

The 2018 EOY mine planning spatial data materials inventory for site shows a slight deficit of topsoil available for the current disturbance footprint at Andoom and a more significant deficit at East Weipa mine (Table 7). These calculations are based on a recent review of spatial data, including some historical data which contains some inaccuracies linked to the long history of the site and the variable operational and record keeping practices during this time. Current mine planning and development earthworks recording practices have recently been vastly improved, and now include a GIS-WENCO topsoil inventory tracking program

The topsoil deficit is likely due to historical practices including filling borrow pits and other voids with topsoil, respreading topsoil at depths thicker than stripped to elevate post-mining landscape, and the Pre-2008 sequencing method of dumping and spreading (which left topsoil sitting on the mine floor). The key strategy proposed to address the deficit is to look at returning the 600 mm topsoil material to the mine floor at a reduced thickness and increased surface area, with an option to also

utilise waste material below the returned topsoil layer to maintain depth. For example, if 600 mm topsoil is stripped from two hectares, it can be replaced at 300mm depth over four hectares, possibly also utilising 300 mm waste to make up for lost depth. It is believed that topsoil returned at anything over 5-10 cm thickness (over a suitable growth medium below) should provide the rehabilitated site with sufficient biological components (i.e. seed and microbes/mycorrhizae) to support good rehabilitation outcomes.

The positive kaolin balance will be addressed through closure activities including relocation of the remaining kaolin into a nearby pit. Relatively small volumes will be reserved for future utilisation including relining the Evans Landing landfill first flush ponds and various contaminated sites' management

Table 7 Inventory of Major Material Types

Material	Description ('000 BCM)	East Weipa	Andoom	Total
Topsoil	Stockpiled topsoil	11,452	11,120	22,572
	Volume required (to cover disturbed area (at average stripping depths – i.e. 600 mm at Weipa, 300/450 mm at Andoom)	14,541	11,496	26,037
	Variance	-3,090	-375	-3,465
Kaolin	Stockpiled kaolin	174	N/A	174
	Volume required (estimates identified for relining EVL landfill first flush ponds and misc. contaminated sites management)	0.175	N/A	0.175
	Variance	174	N/A	174

7. REVEGETATION PROCESS

EA Conditions:

(C16) The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) within two (2) years of the date of this environmental authority and must include:

(e) revegetation methods inclusive of plant species selection, re-profiling, soil handling (including stockpiling), soil ameliorants/amendments, surface preparation and method of propagation

7.1 INTRODUCTION

Progressive rehabilitation is undertaken at RTW as mined out areas become available. Progressive rehabilitation is undertaken during the operational phase of mining and is therefore completed before operations cease. Progressive rehabilitation maximises the benefits of reduced environmental impacts on disturbed land, reduces liabilities on the company and results in a geotechnically stable, revegetated landscape which has minimal impact on the surrounding environment. The aim at RTW is to annually rehabilitate an area of land equivalent to that cleared for mining.

Revegetation is the component of the rehabilitation process that involves rebuilding the soil of disturbed land, and establishing plants by seeding and/or planting.

This section covers the following:

- Surface preparation (i.e. scarification);
- Plant species selection;
- Direct seeding;
- Soil amelioration; and
- Propagation and seedling planting.

7.2 SCARIFICATION

The soil surface is scarified prior to seeding, except where the topsoil has been ripped immediately prior to seeding and the soil surface forms an appropriate seedbed. Pre-seeding scarification assists in providing suitable growing media properties to optimise plant growth (e.g. porosity and water holding capacity).

The soil at Weipa can form a thin surface crust even after light rainfall, creating an impenetrable layer for seedling establishment. Scarification breaks through any soil surface crust and creates small furrows of soft soil which allow seed to settle and germinate. Scarification maximises the chances of seed survival, germination and establishment by:

- increasing soil/seed surface contact; and
- allowing seed to lightly penetrate the soil surface providing protection from predation and harsh sun and wind conditions.

Similar to ripping, scarification on sloping ground typically occurs along the contour in order to minimise sheet or gully erosion. Scarification is carried out using various means, such as a tractor-

towed disc plough, a tractor-towed multi-tine scarifier, a grader with a scarifier or a dozer with a ripper beam attachment.

7.3 PLANT SPECIES SELECTION

Local, native species are selected for inclusion in the rehabilitation program primarily due to their likely suitability to the anticipated post-mining conditions of the area to be rehabilitated. The proximity of the post-mined landscape to the wet season water table is the key factor determining which native plant community is most appropriate for the post-mining landscape. Free-draining areas are most suited to establishment of Eucalypt dominated 'dry' woodlands with grassy understories – based largely on the vegetation found in the pre-mining woodlands (land units 2b and 2c) but also the surrounding slopes and scarps (Table 9 – 'Dry Woodland'). Post-mining landscapes likely to be less free draining and seasonally inundated are most suited to Melaleuca swamp and Melaleuca/Swamp mahogany vegetation communities (land units 3b and 7b among others) (Table 9 – 'Wetland').

Based on these target land units, a suite of 'framework' species has been developed representing the key species which need to be re-established to ensure that the rehabilitation develops into a mature ecosystem which is resilient to the local disturbance regimes and meets the goals and objectives of the rehabilitation.

In summary, priority is placed on local, native species from the target land unit vegetation communities, including those which are either:

- Framework species,
- Able to reliably colonise from freshly replaced topsoil;
- Suited to establishment from broadcast seed;
- Able to be collected within our Indigenous Community Seed Collection Program or commercial seed collections contracts; and/or
- Of cultural significance to Traditional Owners.

Resulting from the above considerations, a comprehensive set of seed mixes is currently used at RTW specifically tailored to establish rehabilitation with a high likelihood of achieving the rehabilitation goals and objectives for each disturbed area (Appendix C). These seed mixes are used routinely each year as part of the progressive rehabilitation program. Additional seed mixes are developed to meet other requirements, such as to establish vegetation to control dust on the tailings dams, or to reduce erosion on steep slopes through use of a 'high grass' seed mix

Table 8 Analogue Land Units for Determination of Closure Targets

Land Unit	Description
Dry Woodland	
2b	Bauxite or laterite plateau; red earths; excessively drained. Tall Darwin stringybark woodland with Melville Island bloodwood, Cooktown iron-wood, nonda plum, Roth`s wattle, tall perennial grasses and annual grasses and herbs.
2c	Bauxite plateau; mottled yellow earths; slightly impeded drainage. Darwin stringybark woodland with Melville Island bloodwood, nonda plum, Roth`s wattle, perennial and annual grasses and herbs.
5b	Undulating plains and erosional slopes on bauxite and sandstone; lateritic yellow and red earths with hard setting surfaces; slow to medium drainage. Ironbark grassy woodland with Cooktown ironwood, quinine bush, beefwood and medicine bush.
5e	Colluvial deposites in upper reaches of broad drainage basins; bleached yellow podzolics; poorly drained with waterlogging for short periods in the wet season. Mixed woodland with long-fruited bloodwood, Cape York red gum, nonda plum, swamp mahogany, pandanus and bushman`s peg. Banksia and Melville Island bloodwood are absent.
5f	Eroding slopes and scarps on colluvium from bauxite plateau; yellow podzolic and bleached gleyed podzolics with hard setting surfaces. Run-off rates are moderate but infiltration and drainage rates are slow. Broad-leaved carbeen and Darwin stringybark woodland with long-fruited bloodwood, Cooktown ironwood, Molloy red box, broad-leaved paperbark, beefwood, bushman`s peg, boot-lace oak and spear grass.
5k	Eroding gentle laterite slopes; shallow gravelly reddish brown loams with outcropping ironstone; medium drainage but run-off is excessive. Grassy woodland with Melville Island bloodwood, Darwin stringybark, variable barked bloodwood, Roth`s wattle, cocky apple, nonda plum, woody pear and giant spear grass.
Wetland	
7d	Colluvial deposites on footslopes or along the margins of drainage lines; yellow or gleyed podzolics; poorly drained, some waterlogging. Broad-leaved paperbark woodland with bladey grass, sometimes with long-fruited bloodwood, Cape York red gum and ghost gum.
7b	Outer margins of sink holes and internal drainage depressions; gleyed or yellow podzolics; poorly drained, waterlogged for long periods. Broad-leaved paperbark - swamp mahogany woodland with false casuarina and mixed paperbark species and sparse grass or sedge ground layer.
5j	Upper parts of broard basins and colluvial foot slopes; soils range from loams to sands with an `A` horizon present; drainage impeded at depth and waterlogged during the wet season. Long-fruited bloodwood-banksia woodland with swamp mahogany, wattles and buskman`s peg.
3b	Fringe zones at most consistant waterlevel in swamps (permanently saturated); bleached yellow podzolics and gleyed podzolics. Paperbark forest, sometimes of single species and often with distinct zonation. Weeping paper-bark, broad-leaved paperbark and cajuput tree.

Table 9 Framework Species for Dry Woodland and Wetland Vegetation types

Dry woodland	Wetland
Corymbia clarksoniana	Corymbia novoguinensis
Corymbia nesophila	Eucalyptus brassiana
Corymbia polycarpa	Eucalyptus alba
Corymbia spp.	Lophostemon grandiflorus
Corymbia stockeri	Lophostemon suaveolens
Erythrophleum chlorostachys	Melaleuca cajuputi
Eucalyptus alba	Melaleuca dealbata
Eucalyptus brassiana	Melaleuca leucadendra
Eucalyptus cullenii	Melaleuca nervosa
Eucalyptus leptophleba	Melaleuca saligna
Eucalyptus spp.	Melaleuca spp.
Eucalyptus tetrodonta	Melaleuca stenostachya
	Melaleuca symphyocarpa
	Melaleuca viridiflora

7.3.1 Culturally Important Species

A significant consultative program was undertaken in 2010 and again 2012 to work with Traditional Owners to identify species which were considered 'culturally important' and which might be appropriate to incorporate into the rehabilitation program (Fell, 2012). Thirty-seven plant species were identified by Traditional Owners as a priority for re-establishment within the rehabilitation. Twenty-eight of these occur naturally within Eucalyptus tetrodonta woodlands and are considered suitable for drier rehabilitation areas. An additional 15 plant species, from other, non-woodland vegetation communities, were recognised as priority plants for incorporation in low lying, seasonally inundated, areas that occur within the post-mined landscape.

The current seed mix already includes 27 of these species (when available). In addition, analysis of older rehabilitation shows that 32 of the 37 species have established in rehabilitated areas. This compares favourably with undisturbed sites of the target land units (Table 8) where 31 of the 37 species have been recorded.

Culturally important species which have not been seen in the rehabilitation to date are included in the 'target' list for ongoing development of our species diversity under the R&D program - Seed Biology (Section 11.2.1).

7.4 Propagation Methods

7.4.1 Direct Seeding

Direct seeding has been found to be the best method for establishing desired plant species, especially considering the scale of the progressive rehabilitation program at Weipa. Direct seeding is

undertaken using a seed mix of locally occurring native species at a density and richness to facilitate establishment of the self-sustaining local native ecosystem.

Direct seeding is generally undertaken using either a belt spreader towed behind a tractor, or via aerial seeding. Aerial seeding allows for large areas to be seeded over relatively short periods of time, e.g. over 1000 hectares in approximately two weeks; reducing the risks associated with failed establishment following germination from early, isolated rainfall events. Tractor seeding is required on areas that are not practical for the aeroplane due to their size, shape and/or location. Using a combination of these techniques enables RTW to achieve the large rehabilitation targets necessary to minimise the operation's disturbance footprint.

Seeding typically occurs between November and January of each year to help ensure the soil moisture and follow-up rainfall is favourable to seedling establishment. Large seed, such as that of Pandanus spiralis and Parinari nonda, are too large to be spread using the aeroplane or tractor spreaders. As a result these seeds are hand sown. Due to the extensive area of rehabilitation, modified 4WD vehicles are used to deliver these large seeds. This operation typically occurs early in the wet-season immediately following tractor seeding operations (i.e. January).

7.4.2 Seedlings

At Weipa, planting of seedlings can be used as a remediation technique to correct substandard rehabilitation, rather than an initial rehabilitation establishment method (see Section 9). Seedling planting can be advantageous in that there is a higher likelihood of the individual plants surviving the first dry season (than germinants from broadcast seed), the planted seedlings will be more resilient to fire earlier, and as a mode of reintroducing particular species not suited to establishment from broadcast seed. Areas intended for seedling planting may include:

- Recently rehabilitated areas which have failed to establish only a few key species;
- Areas which are targeted for 'accelerated' rehabilitation, e.g. wildlife corridors;
- Areas where species struggle to establish (e.g. inundated areas); or
- Areas at risk of fire or competition from weeds where accelerated establishment and growth of framework species is desirable

7.5 SOIL AMELIORATION

The red Kandosol soils used in rehabilitation at Weipa are extremely infertile and nutritionally deficient (see Section 2.2.2). However, they are perfectly suited to supporting the establishment and growth of the native species found in the region, and used in the rehabilitation program. Most physical and chemical parameters are not significantly altered by the mining soil handling processes.

There is some reduction in macro- and micro-nutrients due mostly to dilution of the topsoil through the handling process. This is largely addressed through provision of fertiliser at the time of seeding, with an aim to provide sufficient nutrients to maximise initial establishment and plant growth during the first wet season. The type and rate of fertiliser application is determined by the nature of the rehabilitated soils and plant species being re-established. Generally, superphosphate is applied at a rate of 200 kilograms per hectare (kg/ha) using a tractor-towed belt spreader or via aerial seeding

8. MONITORING PROGRAM

EA Conditions:

(C15) The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) by September 2015 and must include:

(k) description of experimental design for monitoring of reference and rehabilitated areas inclusive of statistical design

(l) a rehabilitation monitoring program based on a statistically sound, mutually agreed sampling design

8.1 INTRODUCTION

Monitoring is an integral part of the rehabilitation process. RTW has designed and implemented a rigorous and scientifically-based monitoring program to assess rehabilitation performance. The monitoring program aims to:

- Assess rehabilitation progress towards the desired post-mining land uses;
- Identify areas that require remediation; and
- Demonstrate compliance against relevant completion criteria.
- More specifically, monitoring at RTW is used to assess:

• Species diversity and composition;

- Health and growth;
- Structural development;
- Ecological function; and
- Sustainability.

The rehabilitation monitoring program consists of a number of individual components, including:

- Vegetation monitoring; and
    - Early Assessment vegetation and erosion monitoring
    - Monitoring rehabilitation development
    - Completion criteria development
- Fauna monitoring.

These are discussed in more detail in the following sections;

8.2 VEGETATION MONITORING

There is very strong evidence that initial floristic composition, established by the end of the first dry season, has a profound influence on the long-term prospects and likely developmental trajectories of rehabilitation (Reddell *et al.* 1993) and the likelihood that future management interventions will be required. Rehabilitation efforts at RTW focus on the initial establishment of floristic composition dominated by framework species derived from reference site monitoring at analogous land units (Table 9). Framework species dominance ensures maximum opportunity for establishment, effective competition, and the capture of site nutrient and plant-available water resources. These species give the revegetation its longer term stability, predictability and fire resistance. It is therefore desirable to establish a diverse range of these taxa and to also establish a diversity of taxa that are characteristic of different strata (canopy, mid and ground layers).

Conversely, if the initial floristic composition of the revegetation is strongly dominated by grasses, acacias or other woody shrubs, and has low densities of framework species, the possibilities of the site developing into a stable woodland ecosystem are less predictable and likely to be remote in the medium term (30 to 50 years) without active, and potentially costly, management intervention. Active management is therefore required for areas where framework species are absent at the end of the first dry season to ensure long-term rehabilitation success.

It is therefore important to monitor relevant aspects of rehabilitation at the establishment stage, and follow up with monitoring of rehabilitation development over time. Monitoring identifies rehabilitation issues requiring remediation, ensuring rehabilitation remains on a trajectory towards meeting end point goals and objectives..

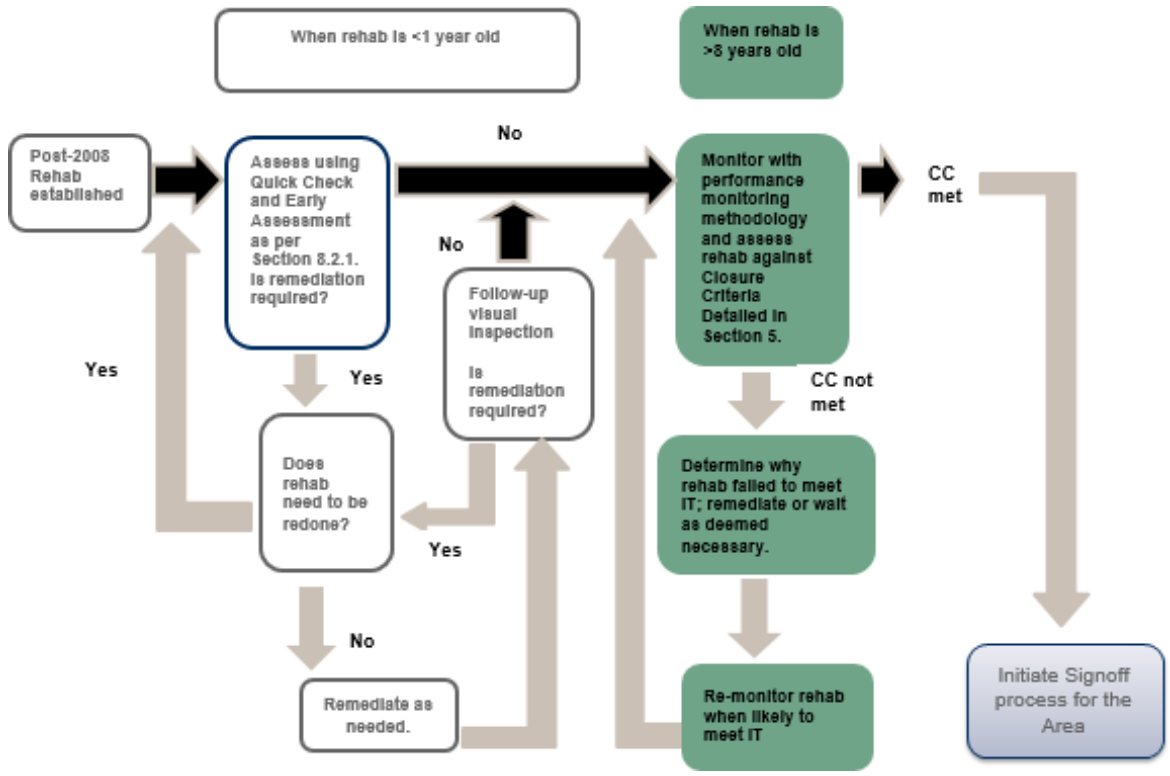

Figure 6Rehabilitation Monitoring Flowchart

8.2.1 Early Assessment Monitoring

In the wet-dry tropics, a major focus of monitoring is on assessing species composition and density within the first 2 to 3 years after establishment. For this early assessment, a range of standard vegetation survey techniques (e.g. belt transects) are generally employed (e.g. Morton 1983). Data collected from this monitoring is used to refine establishment practices, or where potential problems are identified, to implement remediation if required such as enrichment plantings or other management interventions. In effect, Early Assessment serves as a useful Quality Assessment tool to confirm that rehabilitation has been carried out as per agreed procedures, and is establishing satisfactorily.

When assessing initial rehabilitation establishment success, RTW has used – and will continue to use – two procedures:

- The Quick Check survey is conducted in May and is designed to continuously improve the understanding of rehabilitation techniques, soil types and the influence of climatic events on early rehabilitation establishment. The method is a simple site inspection that involves walking into each rehabilitated area at least 20m from the edge, and recording observations. General site details recorded include presence of key tree, shrub, grass and weed species, and vegetation ground cover. Any problems that may require remediation, such as developing erosion, are also noted
- Early Assessment monitoring is conducted in August. It aims to quantify the establishment of native species, confirming which rehabilitated areas are successful, and those that require remediation work. Monitoring plots 100m x 5m are established and used to record ground cover, species richness, density of framework species, other native species and woody weeds, as well as additional observations on erosion, weed dominance and soil condition.

These have been used in most rehabilitated areas for over 30 years and provide a valuable record of rehabilitation establishment. Using data from Early Assessment, RTW has developed internal establishment targets and used these both to assess whether rehabilitation establishment has been satisfactory.

8.3 Monitoring Rehabilitation Development

Considerable monitoring has been undertaken to help understand the development of rehabilitation over time. This has included:

- Repeat monitoring of long-term transects conducted three times in the 1990s and again in 2008/09 in conjunction with University of Queensland; and
- Additional monitoring conducted in 2009, 2010, 2011 and 2012 focussed on development of completion criteria.

8.4 Development of the Current Monitoring Program

From 2009-2012 monitoring was conducted to provide a detailed understanding of the rehabilitation development, and help with the development of the current monitoring program and rehabilitation completion criteria. A total of 175 rehabilitated and 44 reference sites (Appendix G) were monitored over that time, some of these on several occasions to help understand trends over time. The

rehabilitated sites were mostly in Pre-2008 rehabilitation but also included some Post-2008 rehabilitation. The Pre-2008 sites were selected to encompass a range of rehabilitation ages and developing vegetation types, viz. Dry Woodland and Wetland. Post-2008 sites were all comparatively young and included both Dry Woodland and Wetland. Reference sites selected included those typical of areas mined, and those for which it was thought that rehabilitated sites might resemble to some extent (Table 9).

The monitoring procedure used 50m x 10m plots, with 10m x 10m sub-plots. Parameters measured included density of individual framework species, combined density of framework species >2m and <2m, total species richness, ground cover, total foliage projective cover (FPC) >1.5m, height and DBH of trees >2m. Analysis of this data was used to develop completion criteria (Section 5).

8.5 The Current Monitoring Program

Future monitoring to assess the progress of rehabilitation towards meeting long-term goals and objectives will take place as illustrated in Figure 7. The Performance Monitoring methodology, is based on 500m2 Rehabilitation Monitoring plots sampled at a rate of 1 per 20 ha. This plot size was found to be suitable for the purposes of monitoring rehabilitation development when used to assess rehabilitation from 2009-2012. Neldner et al. (2012) state that the Queensland Herbarium has adopted a 10m × 50m plot as the standard for secondary and tertiary monitoring sites (which is approximately the level of detail generally used in rehabilitation monitoring). They add that this plot size is widely accepted internationally and is often used in surveys in Australia; and for Queensland vegetation apart from rainforests, a comprehensively surveyed 500 m² plot captures the majority of the vascular plant diversity at a site. For sampling intensity for assessment of rehabilitation against completion criteria, a rate of one Rehabilitation Monitoring plot per 20ha is used. The subsequent data is used to assess the following;

Ground Cover - Direct measurement of vegetation-graminoid, litter and cryptogam

Framework Species Presence - Identification of tree and tall shrub framework species

Framework Species Density - Counting numbers of each framework species and calculating their density in the Rehabilitation Monitoring plots

Species Richness – The total number of native plant species recorded in each Rehabilitation Monitoring plot

Species Diversity- Species diversity consists of three components: species richness, taxonomic diversity and species evenness. Species richness is a simple count of species, diversity is the genetic relationship between different groups of species, whereas species evenness quantifies how equal the abundances of the species are.

Structural Composition – Assessed by framework species density and ground cover

Native Species Recruitment - Assessed by the presence of framework species <2m in older Rehabilitation Monitoring plots

Weed Species - Assessed through compliance with weed management procedures in accordance with the Land Protection (Pest & Stock Route Management) Act 2002

Health and Resilience to Disturbance - Measured by assessing the recovery of key parameters following fire

Fauna - Assessed using fauna surveys conducted in representative rehabilitated and reference sites including the presence of terminitaria

Course Woody Debris- Assessed during Performance monitoring survey work.

Soil horizon development- Assessed by excavations at 25m intervals along transect to assess leaf litter breakdown and soil formation processes.

Canopy Composition- Assessed during cover intercept assessment.

8.6 Fauna Monitoring

Fauna monitoring of rehabilitation and unmined reference areas is used to investigate trends in fauna communities and factors potentially affecting fauna occurrence in rehabilitated habitats including comparison of different mine areas, effect of rehabilitation age, seasonal variation in fauna species occurrence, effect of distance from undisturbed habitat on fauna diversity, and relative colonisation of rehabilitation compared to the regional fauna community. Previous fauna monitoring has been conducted over three decades, specifically in 1981, 1996 and 2008/09, using generally similar survey techniques.

The potential benefits of adding fauna habitat features to rehabilitation were reviewed in 2012 and a trial was initiated to assess the practicality of adding log piles to new rehabilitation. These trials will subsequently be monitored to assess the performance of the log piles with respect to enhanced habitat opportunities that may be reflected by differences in the density and occurrence of ground fauna species that are likely to respond to the availability of such habitat features. The current RTW Land Use Management Plan includes provision for assessment of the potential for habitat enhancement works to be effectively applied in strategic rehabilitation areas such as adjacent to key habitat corridor opportunities or very high value environmental areas.

Vegetation monitoring, provides considerable useful information on the development of fauna habitat including species composition, tree density, ground cover, vegetation structure, health, resilience, and other aspects of fauna habitat development. Evidence of the utilisation of rehabilitation by fauna is also collected during vegetation monitoring. Together with fauna survey data, this is important in determining whether fauna completion criteria have been met.

9. REMEDIATION

9.1 INTRODUCTION

The rehabilitation monitoring program (Section 8) ensures that rehabilitation is assessed at important stages in its development against a series of relevant targets and completion criteria. Rehabilitation which is identified as not achieving particular targets is flagged for management through the remediation program. For some sites, this may simply mean waiting for several years until the failing corrects itself and the target is met. For others, active focus through the weed and/or fire management program may be required, while some sites may require active intervention, as discussed later.

The aim is to apply the most cost effective remediation methods at the correct time for the optimal improvement of the rehabilitation so that it can once again be managed as 'successful rehabilitation' and removed from the remediation program (noting however that it will still be subject to the default maintenance programs as per all rehabilitation).

9.2 REMEDIATION PROGRAM OVERVIEW

Remediation may be required at any of the following stages: rehabilitation operations, establishment, and development. Sites needing remediation are identified through the monitoring process described in Section 8, as illustrated within the overall rehabilitation monitoring context in Figure. With specific reference to remediation, the process is illustrated in Figure below.

Figure 7 The monitoring and remediation cycle

One of the key elements of successful remediation is understanding the causes of why rehabilitation has failed to meet its defined target(s). These causes can vary widely, and include specific site factors, operational procedures, weather (e.g. timing and/or amount of rainfall), variation in successional trends, fire regimes, and combinations of these and other factors. Addressing the causes will vary depending on the stage of rehabilitation, and can include simply waiting for particular parameters to change (e.g. ground cover to increase), conducting routine management (e.g. weed and fire management), and more active management aimed at remediating specific problems so that substandard rehabilitation areas can be directed back towards the desired successional state or trajectory.

There exists a range of opportunities to impose post-establishment management techniques to, for example, remove dominant undesirable species, increase overall species richness or reduce the risk of damage due to uncontrolled fire. However it should be noted that some of the earliest management activities, such as soil selection and handling, can be the most influential on the ultimate trajectory of the vegetation development.

It is important that remediation efforts focus on ensuring the rehabilitation's progression through the developmental (seral) stages, as well as controlling the direction of this progression to ensure it moves toward the desired end point targets (e.g. meeting completion criteria).

However, active management takes time and effort and is contrary to the overall final rehabilitation target of a 'sustainable' system, requiring no more inputs (e.g. management) than similar natural systems. The gradual removal of management activities, e.g. weed control, should be strategically planned, then implemented and carefully monitored.

Nevertheless, there are situations where active management is required. These may include situations where:

- Rehabilitation has failed (e.g. young trees killed when burnt, vegetation susceptible to harsh winds/heat/lack of water infiltration);
- Certain key framework species have failed while other species have developed satisfactorily (thus total re-establishment of the area is not warranted); and/or
- There is lack of colonisation by non-seeded species.

Just as there is an array of rehabilitation scenarios that may warrant management intervention, there are a wide range of available options for the rehabilitation practitioner to employ. Management options available to potentially influence rehabilitation development and improve the quality of rehabilitation are generally focussed on three key process stages:

- Landform establishment, soil profile reconstruction and topsoil handling;
- Vegetation establishment; and
- On-going management, such as weed and fire control.

Of the many activities with the potential to impact on rehabilitation success, some may be expected to have a greater influence than others, or provide good outcomes for relatively little effort or cost, and thus may be more suited to any efforts at improving techniques. Given the variability between mine sites and even within single blocks of rehabilitation, site-specific investigations are required to identify the most appropriate remediation methods and thereby produce the best outcomes.

9.3 Substandard Rehabilitation

Rehabilitation at RTW can 'fail' for a variety of reasons. Monitoring data can be used to show that 'failed' rehabilitation can typically be classified into one of several states requiring remediation. These can then be linked to an appropriate remediation methodology, which is then further tailored to address the specific issues of each area of rehabilitation. Sites requiring remediation include those with:

- Open grasslands lacking framework species;
- Introduced eucalypt species and limited regeneration of framework species;
- Open canopy dominated by short-lived Acacia, Grevillea and Dodonaea species;
- Closed canopy dominated by long-lived Acacia, Grevillea and Dodonaea species with suppressed framework species;
- Ecosystem altered by weeds such as Gamba grass (Andropogon gayanus);
- Bare earth with limited establishment of vegetation;
- Bare earth caused by extended seasonal inundation; and/or
- Significantly eroded surfaces and slopes.

Understanding the drivers behind why these states require remediation is a key component of rehabilitation improvement works undertaken at RTW. Factors known to contribute to rehabilitation failure include:

- Poor seed quality;
- Inappropriate seed mix used;
- Seeding methods;
- Insufficient topsoil preparation;
- •Poor weed hygiene;
- Lack of fire management and exclusion from young rehabilitation;
- Topsoil handling and quality; and
- Below average wet season rainfall or sporadic rainfall during establishment.

As well as enabling effective remediation to be implemented, understanding the causes of problems can be used to avoid them occurring in future rehabilitation. Adopting this approach helps RTW achieve ongoing improvements in rehabilitation standards.

9.4 Remediation Options

The remediation process begins when sites are identified as requiring remediation. Most commonly, this is due to poor vegetation establishment or a lack or framework species, and to date, the majority of remediation has focussed on these two aspects.

For young rehabilitation (generally aged 1-2 years), a remediation strategy is developed using Early Assessment data, or site inspection, to complete the RTW rehabilitation remediation inspection form in the field by a rehabilitation officer. Where needed, this strategy involves additional ploughing and seeding of selected areas during the follow rehabilitation season. Good initial establishment is critical if good outcomes are to be achieved. This may require a number of remediation procedures, such as supplementary seeding of particular key framework species, and/or application of additional seed mix where numbers of all species are low (e.g. when follow up rains are poor). With young rehabilitation, the key aim is to ensure that it is on a trajectory that will enable it to meet any internal interim targets developed, and eventually, completion criteria. For older rehabilitation (e.g. more than 3-4 years), remediation requirements can vary widely depending on the problems

identified. Some examples are listed in Section 9.3. In some instances, waiting for 1-2 years might be all that is required. For example, in time, trees will grow (resulting in higher densities of trees >2m), new species will establish through wind or birds spreading seed (resulting in higher species richness), and ground cover will establish and leaf litter increase in the absence of fire.

Other remediation may require weed management. Depending on the species, weeds can have a significant impact on the development of native ecosystem rehabilitation, by outcompeting native plants for light, water and nutrients. Weeds can include both grass weeds and woody weeds, such as non-local native acacias, which were established in some Pre-2008 rehabilitated areas. Each needs to be managed according to the weed species present, its risk to the developing rehabilitation (e.g. some weeds disappear when the rehabilitation canopy closes), and the most appropriate methods for controlling it, where required.

Fire can have both a positive impact on rehabilitation, e.g. by reducing competition of some species and promoting seed germination; and a negative effect, by killing young trees and promoting densities of some weed and acacia species. Overall, fire is a significant determinant of ecosystem structure and composition in the natural ecosystems at Weipa. Generally, sites need to be protected from fire for at least 5-8 years, however in time, burning is inevitable and sites will need to be sustainable in the presence of the post-mining fire regimes. Further information is needed on the responses of different rehabilitation ages and types to fire, and any requirements in relation to remediation. Active remediation can also include planting particular key framework species where these are found to be missing or in very low numbers. Remedial earthworks include areas where erosion is found to be significant and active. Where there is deemed to be a risk to safety, stability and the achievement of required rehabilitation outcomes, appropriate remediation procedures must be developed and implemented.

It should be noted that it is difficult to be specific about remediation requirements and options as these will vary according to the specific issues identified, site characteristics, and other aspects. It is therefore important that remediation requirements are developed on a specific site by site basis. As completion criteria and interim targets are adopted, remediation research will be required to develop the most cost effective methods of addressing any problems identified during monitoring.

9.5 Remediation Monitoring

Following the implementation of remediation options, it is important that monitoring of the site is carried out to ensure that the operations have addressed the problem and the site has returned towards the desired trajectory. This may be as simple as a visual inspection and photographic monitoring, or may require more detailed assessment of plots to show that parameters such as framework species and/or species richness have reached the required targets. Once this is done, the remediation process is complete and it is anticipated that rehabilitation at the site should continue to develop as normal.

10. MAINTENANCE PROGRAM

EA Conditions:

(C16) **The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) by September 2015 and must include:**:

(n) programs for maintenance of rehabilitation as required to achieve the nominated rehabilitation objective

Rehabilitated areas would be regularly monitored to identify any areas in need of maintenance at an early stage. Rehabilitation maintenance activities are likely to include:

- A fire management program aimed at excluding wildfires from rehabilitated land through construction and maintenance of fire access tracks and a prescribed burning program. The burning program would include areas adjacent to new rehabilitation. Prescribed burning is conducted early in the burning season, when fuel flammability is sufficient to carry a fire but low enough to maintain a relatively cool, low intensity burn;
- Weed monitoring and management; and
- Erosion monitoring and control.

10.1 FIRE MANAGEMENT

An annual inspection of the fire break network is undertaken in March/April in preparation for identification of resourcing requirements. New rehabilitation areas from the previous season are identified and if their placement is alongside the terminal boundary of the mine the fire break network is extended to protect these areas from the ingress of wildfires.

The Fire Management Areas (FMAs) within active mining areas relate directly to protection & ongoing maintenance of rehabilitation efforts and are listed by fire break name derived from mine blocks which determine the start and end point for each FMA. Fire regimes (frequency, season, intensity), recent history, FMA objectives, traditional owner group and resourcing are covered for rehabilitation, and cultural heritage assets. The proposed burning times are flexible as conditions relating to weather (rain, wind, relative humidity, temperature) and fuel cure rates are highly variable between and within seasons. The annual control burn program of rehabilitation is carried out from late July through to mid-August.

10.2 WEED MANAGEMENT

Routine weed management activities are conducted to control the spread of invasive weeds into rehabilitated areas. As detailed in the RTW Land Use Management Plan (submitted to DEHP), the weed management strategy is achieved through the application of a number of control methodologies. Depending on the area within the lease and its priority, a different application of the controls will be applied. The hierarchy of controls include prevention, eradication, control and contain, monitor and research & development. Rehabilitation and how it relates to the broader landscape will govern which treatment methodology it receives, for example prevention or eradication.

Ongoing prevention into rehabilitated areas is achieved through the routine and repeated patrolling of clean areas. In the instance that a priority weed is found in the prevention zone it is immediately destroyed. The key maintenance activities are determined and governed by the results of the rehabilitation monitoring program, principally the results of "Quick Check". Through the early identification of weed incursions the weed management program can be tailored to target the priority weed species. In the event that Quick Check data shows that a priority weed has established in an eradication zone then the weed control program will be adjusted to include these areas into the annual list of activities.

10.3 Erosion Management

Rehabilitated areas usually comprise of relatively long, low-gradient slopes that are generally not subject to erosion. In the event of erosion potential impacts may include;

- Loss of topsoil,
- Damage to flow control structures,
- Creation of unsafe areas within rehabilitated sites, and
- Loss of vegetation sustainability.

The probability of erosion occurring is greatest in newly rehabilitated areas, before adequate vegetation cover is established. To address this, erosion is routinely monitored in conjunction with the rehabilitation flora monitoring program at the end of the wet-season.

Where erosion is detected in rehabilitation, the erosion is monitored during succeeding wet-seasons until either the erosion stabilises (usually resulting from successful vegetation establishment and development) or a decision is made to undertake remedial works. In general, if gully or rill erosion remains active at the end of the second wet-season consideration is given to its remediation. If, instead, the erosion shows evidence of stabilising, then observations are continued for a short amount of time to confirm that stability has been achieved.

11. RESEARCH PROGRAM

(C16) The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) by September 2015 and must include:

(m) research program and associated milestones.

11.1 INTRODUCTION

Research is a key component of rehabilitation practice at RTW, ensuring continuous improvements are made to rehabilitation techniques and outcomes throughout the life of the mine.

A rehabilitation advisory panel was established in 2013, bringing together internal and external experts in the rehabilitation and environmental field to discuss the key rehabilitation issues at RTW. An important role of this panel is to support operational staff to identify, scope, execute, evaluate and ultimately implement improvements to the rehabilitation program based on sound research.

- The RTW Research Program presented below is based on the current mine plan and budget cycle. It consists of a number of projects that have been developed to address needs and opportunities identified through mine and rehabilitation planning, monitoring, risk assessment and stakeholder consultation.
- Key themes of the research program include:
- Rehabilitation Establishment;
- Rehabilitation Development;
- Resilience and Sustainability;
- Remediation; and
- Management of Spatial Data

Proposed research projects described in the following sections have been identified as research needs or opportunities at RTW.

11.2 THEME 1 REHABILITATION ESTABLISHMENT

Successful establishment of framework species as well as key understorey and ground cover species is a key requirement if rehabilitation is to meet agreed completion criteria. Species establish from a number of sources including topsoil, seeding, and natural recolonisation. For many species, seeding is the most effective and in some cases the only method of establishing them in the desired numbers.

The overall objective of this research program is to understand and develop methods to ensure the ongoing reliability and predictability for establishing key frameworks species in the post-mining landscape. Other non-framework species may also be identified from monitoring programs, lists of culturally significant species etc. and, where needed, investigations will be conducted into whether their cost-effective establishment is possible using seeding. Understanding key dynamics around soil seed life, the soil seed bank in the pre and post-mining landscapes and key elements involved in seed collection to storage will be the central driver for this program.

Key milestones for this project are:

- Identifying priority species for research

- Prioritisation of species for investigation;
- Determining what factors might be limiting their establishment success through seeding;
- Developing recommendations to improve the cost effectiveness of the seeding program.

11.3 Theme 2 Rehabilitation Development

11.3.1 Project; Improving Rehabilitation Monitoring

In recent years, considerable work has focussed on rehabilitation monitoring methods. This has provided much valuable information on rehabilitation development, and enabled RTW to develop completion criteria. However, it is recognised that there may be opportunities to further improve monitoring methods, particularly in relation to broadscale assessment of rehabilitation quality, long term trends in areas that currently do not meet the criteria for dry woodland and wetland rehabilitation (referred to as 'other', e.g. areas with very dense Acacias and Grevilleas), and the identification of small, patchy areas where rehabilitation quality is lower.

It is therefore proposed that current work investigating a number of monitoring procedures continues and, if applicable, the findings be incorporated into monitoring as noted in Section 0. Procedures being investigated include the use of BioCondition, strip transects, and other remote sensing procedures including spectral analysis (see also Project 11.6.1). Other investigations will focus on aspects such as whether trends in DBH/density of framework species >2m in height adequately reflect the growth of rehabilitated areas.

Key milestones for this project are:

- Completing the current project investigating the use of BioCondition, strip transects and other monitoring methods;
- Developing projects to investigate other methods or parameters if required to improve the cost effectiveness of monitoring for assessing rehabilitation development and completion criteria;

11.3.2 Project: Improving Understanding Fauna use of Rehabilitation

With the definition of the dry woodland and wetland rehabilitation vegetation types, and associated completion criteria, there is a need for ongoing work to further understand fauna utilisation of these habitats, and how fauna recolonisation can be increased. As noted in Section 9.3, a considerable amount of fauna monitoring and research has been carried out and this has given RTW a relatively good understanding of which species utilise rehabilitation, and in what numbers.

Further monitoring and research are underway to investigate trends in fauna re-colonisation of dry woodland and wetland rehabilitation. This work is aimed at investigating trends in fauna communities and factors potentially affecting fauna occurrence in rehabilitated habitats. They will assess fauna colonisation and utilisation of different mine areas (including variable rehabilitation quality), effect of rehabilitation age (including links between vegetation development and fauna habitat), seasonal variation in fauna species occurrence, and relative colonisation of rehabilitation compared to the regional fauna community.

A trial to assess the practicality of adding log piles to rehabilitation is underway determine the value of log-course wood debris return to rehabilitation in relation to enhancing fauna habitat value for ground dwelling fauna species. If other practical opportunities for enhancing fauna return to rehabilitation are identified through monitoring, these too may be investigated through appropriate research trials.

Together, the findings from this monitoring and research will provide a better understanding of the extent of fauna recolonisation and how this can be increased, as well as help determine whether fauna monitoring criteria are being met.

Key milestones for this project are:

- Conducting monitoring and research, conducted in 2015.
- Completing the evaluation of the log pile trial.

11.4 Theme 3: Resilience and Sustainability

11.4.1 Project: Understanding the role of fire

Fire is an integral component of the native ecosystems occurring in RTW's bauxite mining leases. Fire can have a range of impacts on native woodland and shrubland ecosystems. It can alter plant species composition and abundance by stimulating germination of some species, whilst killing seedlings of others. It can affect nutrient cycling processes by volatilizing nitrogen, mobilizing other elements (from vegetation to soil), affecting litter breakdown processes, and altering the abundance of N-fixing legumes. Fire can also alter vegetation structure, with impacts on fauna habitat, aesthetics and other functions such as erosion protection. All of these are important aspects of the development, function and sustainability of native ecosystems, and for this reason it is important that the role of fire in rehabilitation is well understood.

The overall objective of the fire research project is to assist RTW in the ongoing development of a fire strategy to ensure that the post-mining landscape is resilient and self-sustaining. The research program will assess the positive and negative impacts that are associated from alternative fire regimes on key functions of a system, for example species resilience and ongoing recruitment. The key aim of the program will be to understand and identify the most appropriate fire management practices to deliver and maximise rehabilitation success in light of current and predicted fire regimes.

Key milestones for this project are:

- Production of a report that summarises the pattern, frequency and effects of fires in rehabilitation on vegetation, fauna and soils.
- Designing and implementing trial burns to investigate key elements of fire ecology such as fire frequency, patchiness, timing and intensity, and their impacts on rehabilitation development and values.

The key deliverable of this project would be a fire management plan that will help ensure that rehabilitated ecosystems are resilient to fire and likely to be self-sustainable.

11.5 Theme 4: Remediation

11.5.1 Developing Effective Remediation Methods

One of the key purposes of rehabilitation monitoring is to identify areas that are not developing along a trajectory that will result in them meeting agreed objectives and completion criteria. Once identified, such areas need to be investigated to determine whether they are likely to return to the required trajectory (e.g. following the next fire, or given more time), or if not, whether they may require remediation.

The overall objective of this research program is to identify, develop, trial and analyse a range of remediation options for areas of sub-standard mine rehabilitation. The key focus of this program will be the identification of a range of management techniques and their associated timing for intervention to deliver rehabilitation success. Through the development of key inputs to a range of sub-standard conditions, the remediation program will improve rehabilitated areas so that they return to the desired developmental trajectory.

Key milestones for this project are:

- Implementation of trials to investigate the cost-effectiveness of proposed remediation methods; and
- Production of a report based on the findings of these trials, that describes remediation procedures required to address particular problems detected in rehabilitation

11.6 Theme 5: Management of Spatial Data

11.6.1 Project: Management of spatial data.

The overall objective of this project is to use remote sensing in a cost effective manner to assess key aspects related to localised conditions, vegetation health, composition and development. The method identified must be suitable for application over the large areas of rehabilitation and potentially unmined vegetation within the lease. This program will help RTW to identify and minimise impacts on surrounding areas and meet key rehabilitation objectives.

Key milestones for this project are:

• Depending on the outcomes, either the development or implementation of a cost-effective remote sensing method, or if this is not possible, then understanding why not.

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APPENDIX A REHABILITATION CONDITIONS UNDER SCHEDULE C OF THE ENVIRONMENTAL AUTHORITY FOR ML7031

<table>
<tr><th>EA Theme/Topic</th><th>EA Condition</th><th>EA Condition</th><th>PoOps Stated Action</th><th>Covered in Section …</th></tr>
<tr><td>Disturbance to Land</td><td>C3</td><td>When carrying out mining activities the holder of this environmental authority must:
(d) ensure that for land that is to be significantly disturbed by mining activities the topsoil layer is removed and handled in a manner that will minimise degradation of its biological, chemical and physical properties and is used for rehabilitation purposes (in accordance with Condition C12 & C13)</td><td>RTAW ensures compliance with these conditions through the internal application of a Community Heritage Environment (CHE) Permit Process. This process is used to assess, permit and control all land disturbance activities. This process is used to prevent unauthorised clearing of sensitive areas identified through the pre-clearance surveys and to ensure only approved activities are carried out. Issues listed under Condition C3 are specifically addressed within this process.</td><td>Section 6

Also addressed in the LUMP</td></tr>
<tr><td>Rehabilitation Objectives</td><td>C9</td><td>Land disturbed by mining activities as identified in Schedule K Plan 1 – Ely General Area Plan, must be rehabilitated in accordance with table C1 – Rehabilitation Requirements and the objectives of the Rehabilitation Management Plan required under Condition (C15).
Table C1 – Rehabilitation Requirements
<table>
<tr><th>Mine Domain</th><th>Mine Feature Name</th><th>Rehabilitation Goal</th><th>Rehabilitation Objectives</th><th>Indicators</th><th>Completion Criteria</th></tr>
<tr><td>TBD[1]</td><td>TBD[1]</td><td>All land subject to mining activities must be rehabilitated to meet the requirements of the</td><td>TBD[1]</td><td>TBD[1]</td><td>TBD[1]</td></tr>
</table></td><td>Rehabilitation of disturbed areas will be undertaken as described in the Rehabilitation Management Plan to meet the requirements of the EA.
The Rehabilitation Management Plan will be submitted in accordance with the time frame stipulated in Condition C16 of the EA.</td><td>Section 4 & Section 5</td></tr>
</table>

EA Theme/Topic	EA Condition	EA Condition	PoOps Stated Action	Covered in Section …
		administering authorities Guideline – Rehabilitation requirements for Mining Projects and will be defined in the Rehabilitation Management Plan [1] Post mine land use, rehabilitation indicators and completion criteria are to be nominated in accordance with Condition (C16).		
Rehabilitation Objectives	C11	Areas that are available for rehabilitation must be identified in the current Plan of Operations.	Areas that are available for rehabilitation are identified in the PoOps. A current land balance and a progressive regeneration schedule is included in Section 4 of the PoOps. Areas available for regeneration are detailed in the figures appended to the PoOps. Future disturbance within the terms of the PoOps will take place within the area indicated in the figures appended to the PoOps.	Section 4
Rehabilitation Objectives	C12	Rehabilitation must commence progressively as areas become available in accordance with the Plan of Operations.	Rehabilitation of mined land is undertaken progressively after mining activity has ceased in the specific location.	Section 4

EA Theme/Topic	EA Condition	EA Condition	PoOps Stated Action	Covered in Section …
Rehabilitation Objectives	C12	Rehabilitation can be considered successful when: (a) the site can be managed for its designated land-use (e.g. similar to that of surrounding undisturbed areas); (b) no greater management input than for other land in the area being used for a similar purpose is required and there is evidence that the rehabilitation has been successful; (c) the rehabilitation is carried out in accordance with the goals, objectives, indicators and completion criteria as specified in Table C1 – Rehabilitation Requirements; and (d) written agreement is obtained from the landowner/holder and administering authority.	Rehabilitation success criteria are included in the Rehabilitation Management Plan. Disturbed land is not considered to be successfully rehabilitated until all criteria are met.	Section 4 & Section 5
Topsoil	C13	Top soil and subsoils must be stripped separately and replaced directly in an area awaiting rehabilitation or else be stockpiled and subsequently used in rehabilitation.	Soil will be stripped separately and directly placed on mined out areas in readiness for regeneration, however, if required soil will be stockpiled.	Section 6
Topsoil	C14	Topsoil must be managed in accordance with the rehabilitation management Plan and stockpiled in a manner that ensures stability. Measures must include: (a) vegetating topsoil stockpiled during the months 1 November to 1 May; (b) optimising the height and footprint of stockpiles; and (c) re-using stockpiles as soon as possible.	Topsoils stockpiles are sown with a native local seed mix to control weeds and erosion. All stockpile volumes and locations will be recorded. Practices relating to stockpile management will be implemented from the "*Technical Guidelines for Environmental Management for Exploration and Mining in QLD*".	Section 6
Rehabilitation Management Plan	C15	The holder of this environmental authority must develop, implement and submit to the administering authority a Rehabilitation Management Plan (RMP) by September 2015 and must include:	A Rehabilitation Management Plan (RMP) will be developed and implemented on site as approved by the administering authority by 31	Rehabilitation Management Plan, submitted August 2013

EA Theme/Topic	EA Condition	EA Condition	PoOps Stated Action	Covered in Section …
			September 2015 as per the requirements of the EA. The content of the RMP will be in accordance with the requirements of the EA.	
		(a) schematic representation of final land form inclusive of drainage features		Section 3
		(b) slope and cover design		Section 3
		(c) drainage design		Section 3
		(d) erosion controls proposed on reformed land		Section 3
		(e) revegetation methods inclusive of plant species selection, re-profiling, soil handling (including stockpiling), soil ameliorants/amendments, surface preparation and method of propagation		Section 6 & Section 7
		(f) materials balance including available topsoil and low permeability capping material		Section 6
		(g) geotechnical, geochemical and hydrological studies		Section 2
		(h) chemical, physical and biological properties of soil and water		Section 2
		(i) agreed post mining land and/or infrastructure use with the landowner/holder and the administering authority		Section 4

EA Theme/Topic	EA Condition	EA Condition	PoOps Stated Action	Covered in Section …
		(j) rehabilitation goal, rehabilitation objective, indicators and measureable completion criteria for each agreed post mining land use within each domain that enables determination of rehabilitation success		Section 4 & Section 5
		(k) description of experimental design for monitoring of reference and rehabilitated areas inclusive of statistical design		Section 8
		(l) a rehabilitation monitoring program based on a statistically sound, mutually agreed sampling design		Section 8
		(m) research program and associated milestones		Section 11
		(n) programs for maintenance of rehabilitation as required to achieve the nominated rehabilitation objective		Section 10

APPENDIX B- DESCRIPTION OF CURRENT AND TARGET REHABILITATION VEGETATION COMMUNITIES

Pre-2008 Dry woodland

Pre-2008 Dry Woodland rehabilitation is characterised by the presence of a Eucalyptus/Corymbia dominated tree canopy over a grassy ground layer with or without a well-developed shrub layer. The structural characteristics of Dry Woodland are determined to a large extent by rehabilitation age (more so than for the Wetland rehabilitation type) as canopy height and density continues to develop over many years. Using the vegetation classification of Walker and Hopkins (1990) the typical structural composition of Dry Woodland comprises a mid-high to tall open woodland with a tall to extremely tall sparse to closed shrubland understorey over a sparse to closed grassland. The structural composition of Dry Woodland rehabilitation generally resembles that of natural woodland types observed in the Weipa region including both grassy open woodland (e.g. grassy woodlands on eroding slopes and scarps on colluvium from bauxite plateau (land unit 5f)) and shrubby woodlands (e.g. shrubby occurrences of land unit 5e and 2c).

Table 10Contributing Land Units for 'Dry Woodland' Rehabilitation Vegetation Type

Land Unit	Description
2b	Bauxite or laterite plateau; red earths; excessively drained. Tall Darwin stringybark woodland with Melville Island bloodwood, Cooktown iron-wood, nonda plum, Roth`s wattle, tall perennial grasses and annual grasses and herbs.
2c	Bauxite plateau; mottled yellow earths; slightly impeded drainage. Darwin stringybark woodland with Melville Island bloodwood, nonda plum, Roth`s wattle, perennial and annual grasses and herbs.
5b	Undulating plains and erosional slopes on bauxite and sandstone; lateritic yellow and red earths with hard setting surfaces; slow to medium drainage. Ironbark grassy woodland with Cooktown ironwood, quinine bush, beefwood and medicine bush.
5e	Colluvial deposites in upper reaches of broad drainage basins; bleached yellow podzolics; poorly drained with waterlogging for short periods in the wet season. Mixed woodland with long-fruited bloodwood, Cape York red gum, nonda plum, swamp mahogany, pandanus and bushman`s peg. Banksia and Melville Island bloodwood are absent.
5f	Eroding slopes and scarps on colluvium from bauxite plateau; yellow podzolic and bleached gleyed podzolics with hard setting surfaces. Run-off rates are moderate but infiltration and drainage rates are slow. Broad-leaved carbeen and Darwin stringybark woodland with long-fruited bloodwood, Cooktown ironwood, Molloy red box, broad-leaved paperbark, beefwood, bushman`s peg, boot-lace oak and spear grass.
5k	Eroding gentle laterite slopes; shallow gravelly reddish brown loams with outcropping ironstone; medium drainage but run-off is excessive. Grassy woodland with Melville Island bloodwood, Darwin stringybark, variable barked bloodwood, Roth`s wattle, cocky apple, nonda plum, woody pear and giant spear grass.

Darwin stringybark (Eucalyptus tetrodonta) frequently occurs in more recent rehabilitation blocks and may dominate the canopy, and bloodwoods (Corymbia spp.) are common in all age woodlands. Framework species frequently encountered in Dry Woodland include Eucalyptus tetrodonta, Corymbia polycarpa/clarksoniana, Erythrophleum chlorostachys, Eucalyptus brassiana, and Eucalyptus alba/platyphylla.

Pre-2008 Dry Woodland framework species include:

Corymbia clarksoniana	*Eucalyptus alba*
Corymbia nesophila	*Eucalyptus brassiana*
Corymbia polycarpa	*Eucalyptus cullenii*
Corymbia spp.	*Eucalyptus leptophleba*
Corymbia stockeri	*Eucalyptus spp.*
Erythrophleum chlorostachys	*Eucalyptus tetrodonta*

The shrub understorey can be floristically very diverse in denser occurrences or contain only a few species in more open woodland examples. Frequently occurring shrub species include Grevillea pteridifolia, Grevillea parallela, Melaleuca viridiflora, Syzygium suborbiculare, Ficus opposita, Acacia rothii and Alphitonia excelsa.

The structural and floristic composition of the ground cover vegetation is also quite variable reflecting the density of overlying canopy and shrub layers and surface drainage characteristics. In more mature woodlands, a tall grassland occurs that is very similar to the Heteropogon triticeus dominated grassland of Darwin stringybark woodland. In shrubbier woodlands the ground cover is patchy and sparse and includes extensive areas of leaf litter interspersed with softer grasses such as Alloteropsis semialata and Schizachyrium fragile.

The fauna habitat values of the Dry Woodland are characterised by the seasonal availability of food resources for fauna, and emerging arboreal habitat features. This seasonal aspect underpins the natural woodlands of the region, as the cyclical rainfall patterns and relatively low diversity of canopy and understorey species (compared for example to vine forest or riparian gallery forest) combine to produce peaks in habitat productivity aligned with wet season rainfall and discrete flowering events of canopy and understorey species. Fauna monitoring has consistently confirmed the significant seasonal utilisation of Dry Woodland by nectar feeding birds, especially large flocks of rainbow lorikeets, and little friarbird, noisy friarbird and brown honeyeater.

Arboreal habitat opportunities in the Dry Woodland are still developing. Tree hollows and spouts take many years to develop with smaller fauna accommodated initially by cavities formed in younger smaller branches, and larger fauna subsequently accommodated as canopy trees mature and start to senesce. Smaller spouts exist in more advanced woodlands and provide habitat for microbats, treefrogs and arboreal reptiles such as geckos, frill-necked lizards and spotted pythons.

As with natural woodlands, the availability of microhabitat for ground fauna is constrained by the low density of canopy tress and therefore a limited availability of fallen branches and shed bark which provide additional shelter opportunities and feeding substrates for small ground fauna including small reptiles and invertebrates.

Post-2008 Dry Woodland

As Post-2008 rehabilitation is still young (5-6 years old) there are no sites available to illustrate the appearance and key characteristics of mature vegetation. However, it is possible to get an indication

of how it might develop by taking into account rehabilitation methods, the assessment of older Pre-2008 Dry Woodland rehabilitation, and some early monitoring results for Post-2008 rehabilitation.

Species seeded include Eucalyptus tetrodonta, Erythrophleum chlorostachys and Corymbia nesophila, but do not include the non-local species such as Eucalyptus camaldulensis and E. miniata and high seeding rates of Acacias used in the Pre-2008 seed mixes. Due to this, it is expected that the resultant rehabilitation is likely to resemble the target local, woodland vegetation communities than the Pre-2008 rehabilitation.

It is likely that, when mature, Post-2008 Dry Woodland rehabilitation will be characterised by the presence of a Eucalyptus/Corymbia dominated tree canopy over a grassy ground layer with a developed shrub layer also present. Specific structural characteristics will depend on rehabilitation age as canopy height and tree density continue to develop over many years. Using the vegetation classification of Walker and Hopkins (1990) the typical structural composition of Dry Woodland rehabilitation is likely to comprises a mid-high to tall open woodland with a tall sparse to closed shrubland understorey over a sparse to closed grassland. The structural composition is likely to resemble that of unmined Dry Woodland vegetation types in the Weipa region including both grassy open woodland (e.g. grassy woodlands on eroding slopes and scarps on colluvium from bauxite plateau (land unit 5f)) and shrubby woodlands (e.g. shrubby occurrences of land unit 5e and 2c) (as per Table above).

Based on the seed mix described earlier, Post-2008 Dry Woodland vegetation will include a number of tall Eucalypt and Corymbia framework species as listed above. Canopy height is likely to vary with rehabilitation age and site characteristics such as soil depth and fertility and substrate moisture regime, with canopy heights reaching 20m or more in advanced areas. In the early successional stages, tree density is likely to be higher, then as sites age, canopy density will tend to become more open, and more closely reflect that of a natural Dry Woodland in the region. Darwin stringybark (Eucalyptus tetrodonta) is likely to dominate the canopy in many areas, with bloodwoods (Corymbia spp.) also common. Framework species are likely to be similar to those in the list of Pre-2008 Dry Woodland framework species, and include Eucalyptus tetrodonta, Corymbia polycarpa/clarksoniana, Erythrophleum chlorostachys, Eucalyptus brassiana, and Eucalyptus alba/platyphylla.

The density of the shrubby understorey is expected to reflect the variability found in unmined Dry Woodland reference sites. Based on the seed mix, topsoil handling procedures and early monitoring results, the floristic diversity of Post-2008 rehabilitation is likely to be higher than that of Pre-2008 rehabilitation, and the species composition more similar to that of the reference sites. More common shrub species present are likely to include Grevillea pteridifolia, Grevillea parallela, Melaleuca viridiflora, Syzygium suborbiculare, Ficus opposita, Acacia rothii and Alphitonia excelsa.

The structural and floristic composition of the ground cover vegetation in Post-2008 rehabilitation is also likely to vary depending on the density of overlying canopy and shrub layers and surface drainage characteristics. Results for Pre-2008 Dry Woodland rehabilitation suggest that in more mature Post-2008 rehabilitation, a tall grassland may be present in some areas that is very similar to the Heteropogon triticeus dominated grassland of Darwin stringybark woodland. In Dry Woodland rehabilitation where more shrubs are present, the ground cover may be more patchy and as well as a number of shrub species, might include extensive areas of leaf litter interspersed with softer grasses such as Alloteropsis semialata and Schizachyrium fragile. Monitoring results for Pre-2008 Dry Woodland rehabilitation, and early results for Post-2008 rehabilitation suggest that values for combined litter and ground cover vegetation are likely to be high.

The fauna habitat values of Post-2008 Dry Woodland rehabilitation are likely to be similar to those of Pre-2008 Dry Woodland rehabilitation as described in Section 0, although due to the expected greater similarity of the vegetation to that of Dry Woodland reference sites, fauna habitat values for some species are also likely to be higher.

Also, as with Pre-2008 Dry Woodland rehabilitation, it is expected that arboreal habitat opportunities will develop over a longer period, with tree hollows and spouts taking many years and smaller fauna accommodated initially by cavities formed in younger smaller branches, and larger fauna subsequently accommodated as canopy trees mature and start to senesce. By 20-30 years smaller spouts are likely to exist in more advanced woodlands and provide habitat for microbats, treefrogs and arboreal reptiles such as geckos, frill-necked lizards and spotted pythons. Termite species will recolonise rehabilitation and commence the process of developing hollows in trees and logs, and creating termite nests in trees that can be used by fauna such as some kingfisher species for nesting.

The development of the litter layer and, in time, fallen branches and shed bark will add to ground fauna habitat diversity, together with the establishment of herbs, shrubs and grasses. Some patchiness in rehabilitation such as variation in species composition and tree density, due perhaps to fire or soil moisture availability, is likely to provide habitat for a greater range of fauna over the whole rehabilitated area. Fauna monitoring results for Pre-2008 rehabilitation suggest that the level of fauna colonisation in Post-2008 Dry Woodland rehabilitation is likely to be high.

Wetland

Wetland vegetation typically comprises seasonally inundated areas supporting swamp forest or woodland with limited shrub and ground vegetation development. The Wetland vegetation is generally very similar to the natural land units 3b, 5j, 7b and 7d. This is because the seasonally inundated conditions can only be tolerated by wetland specialist species. Thus, floristic and structural composition of the Wetland areas exhibits only limited variability from site to site, and is determined by the initial seed mix and prevailing site specific drainage conditions and topography.

According to the vegetation classification of Walker and Hopkins (1990) the typical structural composition of Wetland areas comprises a mid-high to tall open woodland to closed forest of wetland tree species with minimal understorey and ground vegetation development. The understorey is typically limited to recruiting individuals of the canopy species.

Wetland vegetation is typically dominated by Melaleuca spp. and/or Lophostemon suaveolens. Melaleucas include species naturally occurring in the Weipa area such as M. viridiflora, M. leucadendra and M. quinquenervia/cajuputi, all of which, together with L. suaveolens are wetland framework species. At the margins of wetland areas or on slightly higher ground within wetlands, eucalypt species that are tolerant of saturated substrate conditions often occur including Eucalyptus brassiana and Eucalyptus alba/platyphylla.

Table 11Contributing Land Units for the 'Wetland' Rehabilitation Vegetation Type

Land Unit	Description
7d	Colluvial deposites on footslopes or along the margins of drainage lines; yellow or gleyed podzolics; poorly drained, some waterlogging. Broad-leaved paperbark woodland with bladey grass, sometimes with long-fruited bloodwood, Cape York red gum and ghost gum.
7b	Outer margins of sink holes and internal drainage depressions; gleyed or yellow podzolics; poorly drained, waterlogged for long periods. Broad-leaved paperbark - swamp mahogany woodland with false casuarina and mixed paperbark species and sparse grass or sedge ground layer.
5j	Upper parts of broard basins and colluvial foot slopes; soils range from loams to sands with an `A` horizon present; drainage impeded at depth and waterlogged during the wet season. Long-fruited bloodwood-banksia woodland with swamp mahogany, wattles and buskman`s peg.
3b	Fringe zones at most consistant waterlevel in swamps (permanently saturated); bleached yellow podzolics and gleyed podzolics. Paperbark forest, sometimes of single species and often with distinct zonation. Weeping paper-bark, broad-leaved paperbark and cajuput tree.

There is generally no permanent ground cover in Wetland areas that experience seasonal inundation. However, very minimal establishment of aquatic macrophytes may occur during inundation and on the saturated substrate at the margin of receding waters following the wet season. Species include sedges, Eriocaulon spp. and Ludwigia octovalvis. The fauna habitat values of Wetland vegetation are distinctly seasonal in occurrence and limited by the low species diversity of the canopy and the absence of substantial understorey and ground cover vegetation. Nevertheless habitat values are substantial for certain fauna groups, especially frogs and nectar feeding birds and bats. Wetland areas provide substantial breeding habitat for native frogs including arboreal species and those that breed in still waters, formed following the initial rains of the wet season. Wetland habitats typically do not provide extensive aquatic habitat for fish or waterbirds but this is similar to natural tree swamps of the Weipa area which exhibit only minimal annual colonisation by freshwater fish and macroinvertebrates, and limited utilisation by waterfowl.

Seasonal flowering of canopy species provides a significant feeding resource for nectar and insect feeding fauna. Melaleucas in particular have very high nectar producing capacity which in turn hosts large insect populations during flowering time. Flowering events attract intensive feeding activity by nectar feeding birds such as lorikeets and honeyeaters, as well as flying-foxes. They are also likely to support the feeding activity of microbats and arboreal mammals such as the sugar glider. Significantly, Melaleuca often flower during the dry season providing important feeding resources at this time of the year when other feeding resources may be scarce.

APPENDIX C-CURRENT RTAW SEED MIXES FOR REHABILITATION.

Species	Dry	Wet	Stockpiles / Slopes
	g/ha	g/ha	g/ha
Framework			
Corymbia clarksoniana	50	10	0
Corymbia nesophila	200	10	0
Corymbia stockeri	50	10	0
Erythrophleum chlorostachys	300	20	0
Eucalyptus alba	50	20	0
Eucalyptus brassiana	40	40	0
Eucalyptus cullenii	50	10	0
Eucalyptus leptophleba	50	10	0
Eucalyptus tetrodonta	400	50	0
Lophostemon suaveolens	5	10	0
Melaleuca leucadendra	5	5	0
Melaleuca stenostachya	0	5	0
Melaleuca symphyocarpa	0	5	0
Melaleuca viridiflora	5	5	5
Midstorey / Understorey			
Abrus precatorius	5	0	5
Acacia aulacocarpa	5	2	0
Acacia auriculiformis	5	2	0
Acacia crassicarpa	10	5	0
Acacia leptocarpa	5	5	5
Acacia platycarpa	5	5	5
Acacia rothii	10	10	10
Adenanthera pavonina	10	5	0
Alphitonia excelsa	20	10	0
Alstonia actinophylla	0.5	0.2	0
Alstonia spectabilis	0.5	0.2	0
Antidesma parviflorum	5	2	5
Atalaya varifolia	4	0	2
Brachychiton garrawayae	5	2	0
Breynia cernua	5	2	5
Cassytha filiformis	4	0	4
Cayratia trifolia	4	0	4
Clerodendron floribundum	20	2	2
Cochlospermum gillivraei	10	2	2
Elaeocarpus spp	5	2	0

Species	Dry	Wet	Stockpiles / Slopes
Ficus opposita	20	0	10
Grevillea glauca	10	2	2
Grevillea parallela	10	2	2
Grevillea striata	10	2	2
Livistona muelleri	50	10	0
Petalostigma pubescens	10	5	0
Planchonia careya	10	5	0
Sterculia quadrifida	10	5	0
Xylomelum scottianum	5	2	0
Dioscorea transversa	4	0	0
Erythrina vespertillio	5	0	0
Grewia retusifolia	10	0	0
Morinda reticulata	10	0	0
Siphonodon pendulus	10	0	0
Ampelocissus acetosa	4	0	0
Canarium australianum	5	0	0
Large seed			
Pandanus spiralis	500	500	0
Parinari nonda	75	75	0
Grass seed			
Aristida holathera	10	0	120
Ectrosia leporina	20	10	150
Eriachne armittii	5	0	75
Eriachne burkittii	5	0	75
Heteropogon contortus	20	10	150
Heteropogon triticeus	20	0	150
Imperata cylindrica	20	10	120
Sorghum plumosum	20	0	150

APPENDIX D- REFINED CLOSURE CRITERIA FOR RTW

An addendum to Rehabilitation Management Plans for Environmental Authorities; EPML00526613 and EPML0072513 (Abridged)

Refined Completion Criteria for Rio Tinto Weipa

Completion criteria are a set of objective standards against which the performance of rehabilitated areas can be assessed. They are used to demonstrate whether rehabilitation goals are being met and therefore whether rehabilitation is successful in achieving a sustainable post-mining ecosystem. As such, meeting completion criteria allows for mining operations with substantial lease areas to enter into a process of on-going relinquishment of rehabilitated lands. Prior to formal acceptance, a key phase of the completion criteria development process is ongoing refinement between the mining operation and the regulatory agency. Development of completion criteria for Rio Tinto Weipa (RTW) operations has been ongoing for over twenty years. During this time, research, traditional owner engagement, monitoring and operational learning has driven continual improvements in rehabilitation practices and outcomes for RTW. The Rehabilitation Management Plan (RMP) for ML6024/7024 was developed and submitted to the Queensland Department of Environment and Heritage Protection (DEHP) in 2013 fulfilling condition C23 of the Environmental Authority (EA) EPML0072511. A component of this submission was a supporting data document RMP- Supporting Data and Analyses (RTW, 2013) which provides summary data and analyses outlining the rationale used to select appropriate completion criteria to achieve land rehabilitation that is safe, stable, non-polluting, and comprises self-sustaining native vegetation. Following the submission of the RMP, the requirement to provide further detail for components of the proposed completion criteria has led to further analysis of RTW's existing data sets. This work has led to the refined set of measurable and validated completion criteria provided herein.

Domains

RTW has conducted minesite rehabilitation for over 40 years and during this time rehabilitation requirements, expectations and techniques have changed. Over the life of the mine, the overall goal of the rehabilitation program has been to return the land to a post-mining land use that will be safe, stable, self-sustaining, requires minimal maintenance and protects downstream water quality. Returning a native ecosystem became the primary goal of rehabilitation during the 1970s, however pasture and forestry post mining land uses were also trialled in collaboration with the government and local stakeholders between the 1960s and mid-2000s. Whilst the WCCCA and EBMPA agreements provide for alternate post mining land uses, the primary goal of rehabilitation prior to 2008 was "To establish self-sustaining vegetation comprising a variety of native plants, which in turn supports native fauna" (1991 EMOS & 2004 EMOS). Whereas following 2008 the goal shifted toward "establishing a sustainable native ecosystem that is as similar to the pre-existing ecosystem as can be achieved within the limits of recognised good practice rehabilitation methods and the post-mining environment". (2008 Rehabilitation Strategy). The DEHP's Rehabilitation Requirements for Mining Projects Guideline Section 8.1 (DEHP 2014) includes reference relating to the situation for existing (Pre-2008) rehabilitation as follows: 'Historic rehabilitation must be evaluated against the rehabilitation requirements that were in place for the mining project at the time the rehabilitation was completed. This could lead to a matrix of different rehabilitation outcomes within a single domain. For example, over a period of time the species mix may have been changed in response to earlier experience or changing community expectations'. In consideration of this, RTW proposed in 2013 that for the mined areas at Weipa, two domains with similar goals but differing criteria be

adopted for rehabilitation completion criteria on the basis of the age where contemporary practices were implemented and the definition of post mining land uses changed at the time.

Legacy Mined Area Domain (pre-2008)

Much of the pre-2008 rehabilitation areas at Weipa (especially those within the Dry Woodland objective) are essentially novel ecosystems due to varied historical rehabilitation methodology being applied. As discussed, rehabilitation requirements at the time of establishment were not defined by comparison with analogue reference sites, moreover the stated goal was the establishment of unspecified native ecosystems which are stable, self-sustaining and able to support native fauna. As a result, whilst key criteria for this domain rely on metrics provided from the analogue reference sites — for example density of framework species (indicator for resilience and stability) and groundcover (indictor for soil health and ecosystem function) — direct comparisons with function and structure of undisturbed sites are inappropriate. The objective of refined completion criteria for this legacy domain (both current and proposed formulations) is to bring this era of rehabilitation up to the standard of a hybrid ecosystem which is both resilient and sustainable. This will allow Legacy rehabilitation to better integrate with the surrounding landscape (benchmark rehabilitation and natural savannah woodland). In the instances where out of date rehabilitation practices have been used, strict adherence to targets derived from reference sites would be an unreasonable expectation. Fundamentally, the Legacy Domain is not about achieving similarity with local reference sites. The core objectives for rehabilitation from this era are: not spreading weeds; fire tolerance and a self-sustaining demography of native species which in turn provides functional amenity to native fauna.

Benchmark Mined Area Domain (2008 onwards)

Rehabilitation vegetation communities can vary depending on post-mining landform aspects, and it is not possible to accurately predict what vegetation type will develop at a specific site. These variations in emergent vegetative composition include the presence or absence of locally occurring species, changes in relative abundance of these species and varying levels of structural variation. (White & Walker, 1997). In fact, mine rehabilitation elsewhere indicates that rehabilitation can often have characteristics of several pre-mining vegetation types and this is also likely to be the case at Weipa. Thus, it is not appropriate to use only one particular vegetation type (land unit) when selecting reference sites for developing completion criteria nor monitoring progress towards them. Rather, a range of vegetation types which are biogeographically representative should be selected into which land rehabilitation can hybridise into.

Completion criteria for the post-2008 domain therefore have been derived from analogue reference data obtained from a combination of different local land units within either Wetland or Dry Woodland land units described in Gunness et al (1987) and included as **Appendix 1**. Given the geophysical constraints and variability within the post mining landform, development of similar composition and structure through reference to key descriptors common to reference land units, facilitates the establishment of rehabilitated areas which are able to provide function and structure similar to the post mining environment. That is, the proposed completion criteria facilitates the establishment of land rehabilitation that is as close as possible to local ecosystems, but allows for a combination of attributes from different vegetation communities.

Tailings Storage Facilities

Rehabilitation of tailings storage facilities will be conducted progressively as these features become non-operational and available for rehabilitation. Final landform design of these areas is subject to

ongoing studies (East Weipa 1 & East Weipa 2). RTW's Rehabilitation Management Plan (RMP) provides a list of Post-Mining Land Uses for all domains; the land use for the TSF domain is listed as "Self-sustaining landform and vegetation meeting criteria derived from monitoring and research of existing rehabilitation on TSFs". As such, and in consideration of constraints on conducting rehabilitation on fundamentally different landforms and with the definition of post mining land use prescribed at time of TSF construction; Completion criteria for the legacy domain apply to these areas. It is likely however that following closure studies, additional refinements in relation to erosion and landform stability will be included.

Mine Infrastructure Areas

This domain includes water infrastructure areas, beneficiation plants, workshops, product stockpiles and other hardstand areas, conveyors and other fixed plant. Closure for this domain will involve decommissioning, demolition and removal of infrastructure. Subsequently, the surface of the disturbed land will be rehabilitated in accordance with objectives for general mine rehabilitation, that is back to a native ecosystem as defined for the benchmark domain. The demolition analysis has assumed that concrete foundations and other sub-terrain benign materials will be removed to a depth of 300mm below the surface, with an additional breaking-up of remaining materials by a further 500mm. Whilst this would potential result in a lower amount of growth medium for rehabilitation compared to the surrounding areas, this would still be considered sufficient to establish adequate revegetation to relinquishment standard.. All mining equipment, infrastructure and plant will be removed and rehabilitated unless agreement is reached with relevant stakeholders and the administering authority for the relevant items to remain (as allowed for in Condition (C16) of the EA).

Reference Monitoring Data

The use of reference data is important in the context of rehabilitation at Weipa as it facilitates determination of conditions under which restored ecosystems are likely to be self-sustaining and therefore likely to have low management costs. (White & Walker, 1997) The reference data is utilised through the use of quantiles, statistical significance or similarity indices in order to benchmark against conditions in the natural environment. It should be noted that the reference data used for determining appropriate rehabilitation has been collected from a range of local analogue reference ecosystems which vary according to topography, access to groundwater and soil type. As detailed in Gunness et al. (1987), depth to groundwater is a key regulating factor for ecosystem development at Weipa. As such, the removal of the bauxite strata limits the ability to recreate the tall Darwin Stringybark *E. tetrodonta* dominated forest of the lateritic plateau given the resultant decrease in topographical relief and therefore depth to groundwater. Recognition of this fact has long been key to the rehabilitation approach at Weipa where the application of seed mixes contain canopy species from across the mining lease area including those found in landforms such as eroding slopes, broad basins, clay flats, older terraces and seasonally inundated areas; all of which are more analogous to the post rather than pre mining landscape. The rationale being that, whilst constrained in the ability to replicate undisturbed sites, rehabilitation can reach a state where there is establishment of self-sustaining, resilient "framework" canopy tree species with distinctive mid-story and herbaceous layers. The resultant post-mining landscape can thus provide similar ecosystem and cultural function as found in the pre-mining landscape. Local framework species (e.g. *Eucalyptus*, *Corymbia & Erythrophleum sp. for*dry vegetation community areas and *Melaleuca* & *Lophostemon sp.* for wet vegetation community areas) are characterised by **(a)** relatively long lifespans **(b)** high resistance to fire or inundation (i.e. wet species) **(c)** vegetative regeneration strategies (from root

suckers, lignotubers, etc) in response to stresses and disturbance, and **(d)** high predictability of growth performance and developmental stages.

With this rationale applied, the use of aggregated reference data from a variety of analogous land units has provided realistic targets which represent the establishment of key ecosystem features. This data, used in *RMP- Supporting Data and Analyses* (RTW, 2013) is provided as an appendix to this submission at the request of the Department of Environment and Science (DES). For setting post-2008 completion criteria, analogue reference data has been used, whereas in pre-2008 due to earlier, more broadly defined post mining land uses, both rehabilitation monitoring data and analogue reference monitoring has been analysed to provide the benchmarks included in the proposed completion criteria.

Traditional Owner Aspirations and Post Mining Land Uses

Rehabilitation at Andoom and East Weipa is undertaken on lands represented by four traditional owner groups Thanikwith, Algnith, Peppan and Wathayn. The description of post mining land use as 'native, self-sustaining woodland vegetation comprising a variety of species, which in turn supports native fauna' reflect those explicitly stated in the EMOS (2004) and agreed to under section 8.1.1 of the WCCCA Agreement. Should other viable post mining land uses be identified as stated in section 8.2.1, agreement may be sought by Comalco or the relevant Traditional Owner groups provided necessary government approvals are obtained. Through extensive on country consultation (e.g. Fell & McIntyre-Tamwoy, 2013 & Wrigley, 2010), the Traditional Owners assessed rehabilitated areas as well as natural undisturbed areas in order to identify features which are considered important to ensuring ongoing cultural utility of the land. From this work a list of species considered important across all groups was developed and has since informed the composition of RTW's seed and direct planting mixes (Appendix 2). Whilst in some circumstances the species selected may not co-occur within the immediate native ecosystem, the use of a local, generalised species mix is consistent with establishing a hybrid ecosystem defined by the presence of local dry or wetland plant species from local analogue reference sites.

Rationale on Indicators

Dale and Beyeler (2001) suggest that indicators should meet a number of criteria in order for them to be effective. Firstly, the indicator must be easily measured, be sensitive to stress on the system and able to detect small changes should they occur. Further, it should be able to predict changes that can be averted by management actions, integrate several aspects of a system, have a known response to disturbances, change over time and have low variability in response. The suite of indicators should also be representative of the structure, function and composition of the ecological system. Together, these reflect three key elements a good indicator must have:

- Sensitivity/change over time;
- Predictability/repeatability; and
- Representativeness.

Stable Landform (soil erosion is acceptable)

Erosion is rarely observed to a degree likely to inhibit successful rehabilitation given the internally draining and low-relief landforms characterising Weipa's mine pits (Landloch, 2012). This metric is currently measured through Interim Assessment (IA) and Performance Monitoring (PM) rehabilitation monitoring programs for erosion type (Gully, Rill, Sheet, None), Extent (Minor,

Moderate, Severe) and Status (Active/Non Active). Unacceptable erosion is defined as Active, Moderate to Severe Erosion into receiving waters or Active, Severe Erosion onto rehabilitation.

Soil Physical, Chemical and Biological Properties (Including leaf litter and ground cover)

Based on RTW's current soil handling and nutrient application practices which are informed by targeted research into these dynamics (e.g. Bell et al 1991, Schwenke, 1996, Landline 2012 & Landloch 2013), changes in soil chemical characteristics during the rehabilitation process are not considered key limiting factors to sustained growth of framework species at Weipa. When comparing the effect of various soil disturbance regimes (dual stripping and bulk or mixed rill stripping) on nutrient dynamics at Weipa, Schwenke (1996) concluded that competition from volunteer grasses not reduced quantity or quality of soil organic matter from mixed rill stripping was the key factor limiting establishment of sown-species. In setting completion criteria for mined areas at Weipa, Landline (2012) undertook detailed soil chemical analysis was undertaken (see **Appendix 5)**. When comparing these results to representative geochemical profiles described by Landloch, (2013), it was concluded that the process of mining and soil replacement was non-limiting for vegetation establishment and growth from a geochemical perspective. Furthermore, in considering available indicators for soil health relating to its chemical properties, it is not considered practicable to undertake direct chemical analysis of soils across rehabilitation given the number of representative samples required to meet density guidelines for site characterisation at the appropriate scale (McKenzie et al 2008). However, on the basis of observed or suspected nutrient deficiency within an assessment site, soil geochemical analysis can be undertaken for comparison with the unmined nutrient profile. This measure, although not a specific completion criterion, provides an effective tool for informing any required management manipulation relating to soil chemical properties (Landline 2012).

Surrogates for direct measurement of soil chemical profiles can also assist in determining the services and functions being undertaken in a landscape. For example, increasing amounts of litter and associated litter breakdown contribute positively to the soil surface condition; this has been demonstrated to correlate with increasing soil stability, infiltration rates and nutrient cycling (Tongway & Hindley, 2003). As the majority of available soil nutrients at Weipa are bound within soil organic matter, the presence of leaf litter at appropriate coverage (determined through reference to analogue reference monitoring), presence of fungal hyphae and a decomposing vegetative layer as well as a developing A horizon are deemed an appropriate, practical indicators of these underlying processes.

Termites and Ants

Other key indicators for the development of nutrient cycling, soil formation and habitat development processes include the presence and activity of soil invertebrates. The importance of soil invertebrates in facilitating soil aeration, drainage, and litter decomposition, nutrient cycling, pollination, seed dispersal and acting as a source of food for vertebrate predators is described in Spain & Anderson (1998). The study found the suite of termite species found within rehabilitation areas at Weipa changed as vegetation developed reflecting increasing capacity to cycle nutrients over time (majority of which are locked in organic matter). Earthen mounds containing litter feeders typically appear within two years of rehabilitation establishment whereas soil-wood feeders typically appeared at five years. As such, the presence of active, function specific termitaria (Table 3.3) within rehabilitation alongside other landscape function indicators such as a developing leaf litter layer and decomposing activity is nominated as indicators for good soil health. Soil-wood feeding termite activity has also been shown to be a required and important precursor for development of habitat

features such as hollow bearing trees and logs. This is highly important for a number of hollow using reptiles, birds and mammals including threatened species whose presence has been confirmed within the RTW's operational footprints such as the Black-footed Tree-rat *Mesembriomys gouldii* (Pittman 2003 & Rankmore 2006) and Palm Cockatoo *Probosciger aterrimus* (Murphy 2007).

Table 3.3 Terminitaria function categories at Weipa from Spain and Anderson (1998)

Ecological Category	Function-Indicator	Species examples
Litter feeding species	Early colonisers, break down of grass biomass, soil development	*Amitermes laurensis*- Low conical mounds in well drained areas and elongate wedge shaped mounds where drainage is impeded.
Wood feeding species	Breakdown of woody material including fallen timber formation of hollows in living trees	*Coptotermes acinacifomis*- Mounds to 2.5m at the base of trees-sometimes incircling- Key for hollow development in E. tetrodonta. *Nasutitermes graveolus*- Arboreal nesting termite, hollow development and piping.
Soil wood feeding species	Nutrient and mineral cycling	Termes-Capritermes- Ephelotermes cheeli. Dark, carton mound

Framework Species Density

Long-lived woody trees and shrubs that dominate the biomass, and often canopy, of the forests and woodlands of the Weipa region have been referred to as 'framework' species. (Reddell & Hopkins, 1994) Framework species () control most of the nutrient and water resources, provide core habitat values for other plants and animals, and contribute substantially to the overall function and long-term sustainability of the plant communities. Framework species density provides an indicator of the degree to which resilient canopy species have been established at a given rehabilitation site. The early establishment of these framework species on the post-mining landform is essential to the development of successful rehabilitation in a predictable manner. Framework species density >2m in height provides an indicator of the degree to which resilient canopy species have been established at a given site. As discussed in Cook et al (2012), growth beyond an escape height is a crucial stage of development and survivorship for key framework species found at Weipa. This height signals the likely transition toward resilient canopy species reaching sexual maturity. It is for this reason that on the basis of a comparative analysis, framework species density is used as benchmark criteria for rehabilitation success. For the pre-2008 (Legacy) domain, some of which includes areas with an absence of framework species, reference monitoring data will provide completion criteria to work towards within the natural range of densities found in the natural environment. Benchmarking against natural reference sites provides for resilience of post-mining ecosystems to threatening processes such as fire and also allows for continuity of structure between legacy and benchmark rehabilitation domains. The areas with lower than target or an absence of framework species density will require management intervention (See Section 6 of the RTW operational rehabilitation plan, 2018).

Recruitment

Natural recruitment is a key indicator of a self-sustaining ecosystem. It is however a dynamic process which can fluctuate within natural systems markedly on the basis of environmental factors. For

dominant overstory (framework) species at Weipa (e.g. *E. tetrodonta*, *C. nesophila* and *C. clarksoniana*) flowering events are also highly variable with a number of seasonal factors including fire, rainfall and wind as well as spatial factors such as topography and aspect being observed as likely impacting seed production (Bellairs, 2013; Setterfield & Williams, 1996). In Weipa, procuring *E tetrodonta* seed has proven to be highly variable with over seven years between seed fall events. Observations made by RTW Environment Staff and professional seed collectors can attest to the high levels of spatial and temporal variation of flowering events among key over storey species. Seed production in framework species can vary strongly between years in the absence of fire (Setterfield & Williams 1996 & Williams et al 1999). This coupled with the proposed age of rehabilitation assessment against completion criteria (8 years for post 2008 and 10 years for pre 2008) is likely to greatly inhibit RTW's ability to have areas signed off if tied to a flowering or seed production metric. The highly variable nature of recruitment in analogue reference sites in response to varied disturbance and seasonal dynamics is also evidenced in analysis of annually repeated monitoring at a subset of analogue reference sites. The mean standard deviation for the density of framework species < 2m at 9 analogue reference dry woodland sites was found to be 380 stems/ha, and for repeat measurements at 4 analogue reference wetland sites the mean standard deviation was 2680 stems/ha. Furthermore, while the development of framework species to sexual maturity is often constrained through competition from grasses, insect and mammal herbivory and fire (Werner and Franklin, 2010), through Early Development monitoring (annual repeat site monitoring), rehabilitation at Weipa in the post-2008 era has shown to exhibit sustained growth and stable densities for framework species over time **(Figure 3.5 & Figure 3.6)** On the basis of the reproductive physiology of *Eucalypt* and *Corymbia* framework species, it is considered that development of framework species past this escape threshold (2m in height) in densities comparable to analogue reference sites is an appropriate indicator of a self-sustaining, resilience ecosystem.

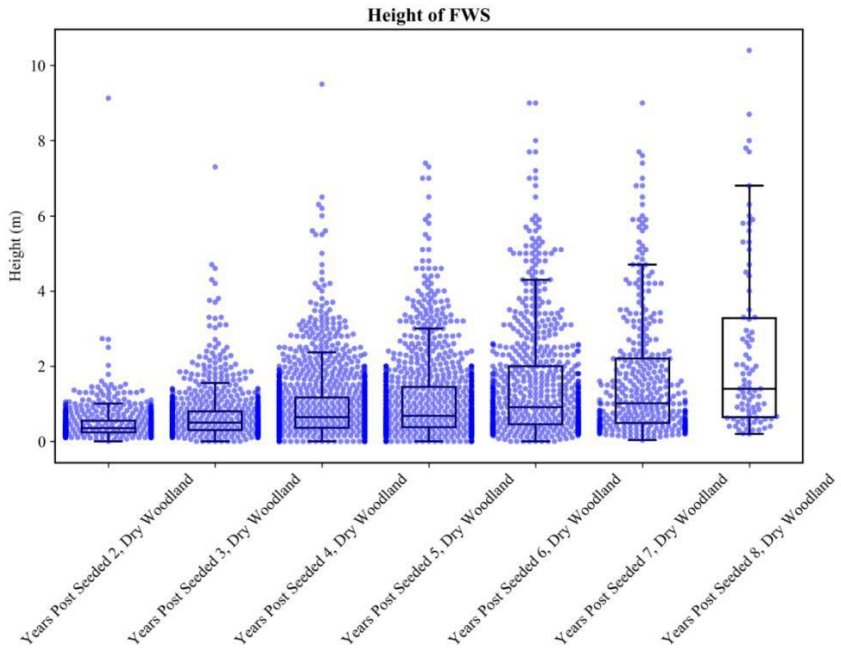

Figure 3.5 Average heights of Framework Species by year of development for Dry Woodland rehabilitation type.

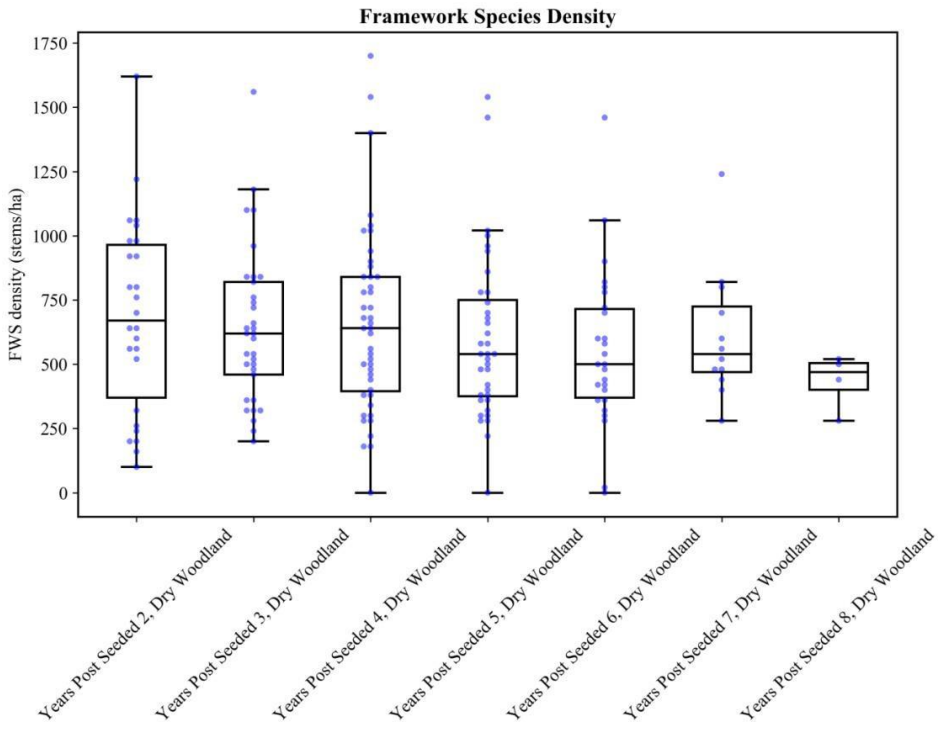

Figure 3.6 Framework species density for dry woodland rehabilitation over time monitored through early development methodology.

Canopy Composition

The Legacy Domain is the primary focus of the proposed canopy composition criterion, specifically addressing the issue of shading or dominance by aggressive pioneer species. It is proposed that a limit be placed on the foliage projective cover of problem Acacia/Grevillea/Dodonaea species encountered in some rehabilitation areas. Whilst *Acacia rothii* can occur in high densities, its open canopy habitat means that it does not appear to out-compete framework species in the longer term. This is in contrast to shading species such as *Acacia mangium*, *Acacia auriculiformis* or the competitive *Acacia torulosa*. Deviated grevillea-dominated rehabilitation areas consist primarily of *Grevillea pteridifolia* and *Grevillea heliosperma*.

Health of Vegetation

Vegetation health is considered to be demonstrated in the absence of any evidence of dieback or disease that prevents any other criterion from being achieved and sustained. Standard in Performance Monitoring and Interim Assessment methodologies is the requirement for assessors (suitably qualified ecologists/botanists) to provide detail on vegetation health for each individual recorded in density counts (woody vegetation). For the purposes of this indicator, a significant health problem is one which is likely to substantially curtail the normal lifespan of the affected individual; for example; possibly nutrient deficiencies, evidence of insect attack or dieback). In assessing health of the area, those individual trees or shrubs with poor health are not included as contributing to other key indicators such as density or richness. Where signs of nutrient deficiency are seen during assessment, comparison with geochemical analysis from unmined soil profiles (Landloch 2012) and appropriate management action can be taken.

Species Diversity

Diversity is an important property to examine in the context of overall sustainability of rehabilitation. Diversity depends on both the numbers of species and the evenness or relative

abundance of each species within a sampled area. It provides an indicator which can be directly measured against the range of diversity in reference sites to illustrate developing composition similar to that of the pre-mining environments. It is also important to note that, despite the functional importance of framework species for long-term sustainability and stability, they are not necessarily the major components of species diversity within the reference land systems. Annual and perennial grasses and forbs in the ground-layer often dominate total plant species diversity. However, these components can be very ephemeral in their nature, resulting in considerable year-to-year variation in both species diversity and composition, even at a single natural woodland site (Fenshaw 1990; Williams et al. 2003a). Nevertheless, they are considered important in relation to the assessment of rehabilitation development. For example, as indicators of the re-establishment of structure for dryland rehabilitation types. For these reasons calculating diversity indices for use as benchmarks, the strata included is limited to mid-story and canopy species. Furthermore, it should be noted that within natural wetland systems, analogue reference monitoring indicates that land units 7d and 3b (detail provided in **Appendix 1**) may exhibit total dominance of *Melaleuca viridiflora* with minor occurrences of *Acacia leptocarpa* in the midstory. In some instances (e.g. AN35 and AN28), pure stands of *M viridiflora* are recorded as described in mapping in Gunness et al. (1987). For this reason, diversity criteria for wetland rehabilitated areas are lower than dryland sites reflecting this natural variation.

Weed Presence

This indicator has been specifically formulated to address the threat of ecosystem transforming weed species. Richardson et al. (2000) defines transformer weeds as invasive species which change the character, condition, form or nature of ecosystems over a substantial area relative to the extent. Weeds found at Weipa which have demonstrated this definition comprise Gamba Grass *Andropogon gayanus*.

Resilience to Fire

The landscapes found across Australia's tropical savannah are largely a product of the various fire regimes produced by climatic dynamics in these regions i.e. distinct wet and dry seasons. This includes the surrounding landscape of the mining project area at Weipa. Fire resilience and associated physiological adaptations are key characteristics of most dominant canopy species in land units overlying or adjacent to the bauxite deposits at Weipa (Russel Smith et al. 2003; Prior, 1997). At Alcoa, Grant et al. (2007) found that primary eucalypt species found on site were resilient to fire after the age of 10 years. Resilience was also demonstrated through key composition and density metrics being sustained within natural range following fire. Fire research at RTW aims to determine an appropriate age where fire may be introduced into rehabilitation and therefore prescribe the physical characteristics at which upon reaching, rehabilitation can deemed likely resilient to fire. At Weipa, the proposed criteria follows a similar rationale in that the presence of framework species within rehabilitation at a density comparable to unmined sites being an indicator for resilience to fire for both pre-2008 and post-2008 rehabilitation. This is addressed in both domains where the presence and persistence of fire resistant species within natural range for density and diversity following a wildfire is proposed as criteria for this indicator. RTW are also currently undertaking a review of the fire ecology of rehabilitation at Weipa, the work aims to determine the age at which grouped (through multivariate analysis) rehabilitation types exhibit resilience to natural wildfire including providing further detail on fuel load dynamics within rehabilitated systems. These ages, with consideration to fuel loads, (should other criteria be met) will then be used as surrogates for this indicator.

Fauna in Rehabilitation

In setting criteria relating to the development of fauna habitat at Weipa, identification of the ecological services provided within analogue reference sites can provide a benchmark on which rehabilitation can be measured **(Appendix 1).** The development of species composition and structure similar to local analogues is considered to be indicative of the provision (or future provision) of these services. The rehabilitation objective for fauna re-colonisation is the development of native ecosystems comprising species and habitat analogous to the surrounding landscape. The structural features of these ecosystems provide habitat based indicators to facilitate native fauna re-colonisation; these include a developing herbaceous layer, emergent framework species, seasonally inundated areas dominated by wet framework species and species diversity indices. There are also more functional indicators to support fauna re-colonisation such as the presence of soil invertebrates (Spain and Anderson, 1998), sufficient grass cover and a developing canopy dominated by framework species are all considered important pre-cursors for fauna re-colonisation.

In assessing the biodiversity values provided by rehabilitation, the hybrid and varied nature of rehabilitation across the mine can be viewed as supplementing the natural environment. That is, the inherent variability in rehabilitated systems returns varied and seasonal opportunities for biodiversity values across faunal groups. Reeders & Morton (1993) found forest species return to be 73% in rehabilitation with 55% of mammals, 73% of birds, 86% of lizards, 64% of snakes and 94% of frogs to recolonise or use rehabilitation in the study period. Studies of fauna use in rehabilitation are however difficult due to temporal and site variations. Within the timescale proposed for assessment it is not considered practical to conduct targeted presence/absence faunal surveys, however RTW is actively conducting research into faunal habitat within rehabilitation. This work is aimed at further understanding how native vegetation buffers are supplemented by the features of the rehabilitated landscape from a biodiversity and ecosystem function perspective. Of particular note is work underway to better understand the use of rehabilitation by Black-footed Tree-rat *Mesembriomys gouldi* so as to ensure the services provided by existing rehabilitation can be retained to ensure continued use by this threatened species.

Methodology for Determining Criteria

The methodology used to obtain the quantitative benchmarks within the proposed completion criteria have been derived from distributions of rehabilitation indicators observed at analogue reference sites. The objective is to obtain benchmarks which are able to robustly discriminate between sites that have been successfully rehabilitated and those which require additional management interventions. A major challenge in doing this is the uncertainty associated with the reference data. This uncertainty is due to a range of factors including: 1) variation within a particular site, 2) variation between sites classified into a particular land unit, 3) the effects of recent environmental events prior to monitoring, and 4) measurement error. In order to mitigate the effects of these sources of uncertainty, rehabilitation benchmarks have been predominantly derived from data that contains a significant number of samples (N=65) obtained at range of locations (N=23 dry woodland and N= 21 wetland). Another difficulty in obtaining robust quantitative benchmarks is that equivalency between rehabilitated and analogue reference sites cannot be expected on the current timescale and historically this has not been the management objective. Rehabilitation benchmarks must therefore be considered individually based on the expected ecological relationship

between rehabilitated and analogue reference sites. This approach has been applied to obtain the proposed benchmarks for each indicator with specific reference to distributions of indicator values obtained from appropriate reference data.

Litter and Ground Cover

In satisfying rehabilitation requirements with regards to ground cover as an indicator for developing soil health, analogue reference sites were used to provide comparable benchmarks. **Figure 4.1** shows the distribution of ground cover comprising vegetation, graminoid, leaf litter and cryptogram in reference sites. In acknowledgement of the inherent variability within this metric and the developing status and age of rehabilitation, the 10th percentile of natural sites has been used to calculate appropriate criteria.

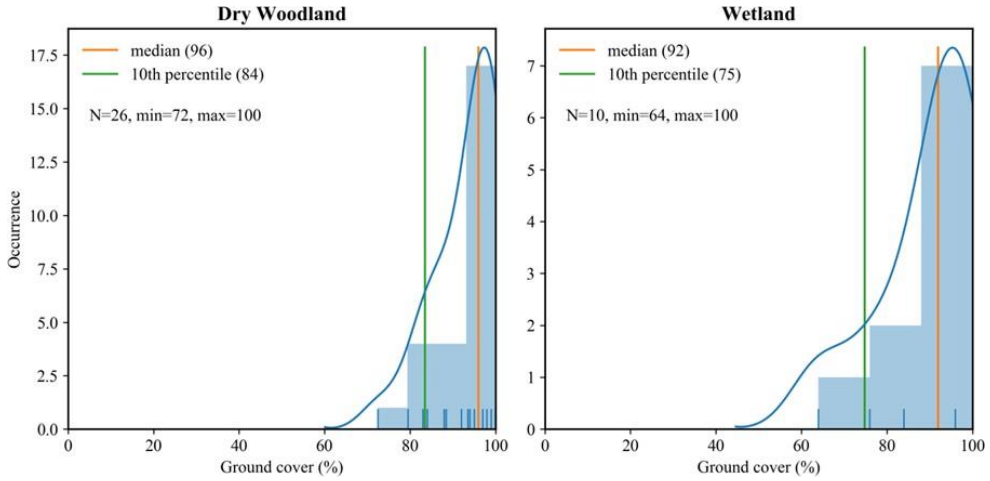

Figure 4.1 Distribution of ground cover values from analogue reference sites.

Density of Framework Species

Criteria relating to this indicator have been determined through comparison with the distribution of data from analogue reference sites. As shown in Figure 4.2, for pre-2008 domain criteria, the minimum framework species density >2m for reference sites (dry or wet) has been used to set appropriate targets on the basis of rationale presented in section 3. For post-2008 domain criteria, the 20th percentile of framework species density >2m for reference sites (dry or wet) has been used to set appropriate targets; reflecting the stated goals and rationale in 3.2.

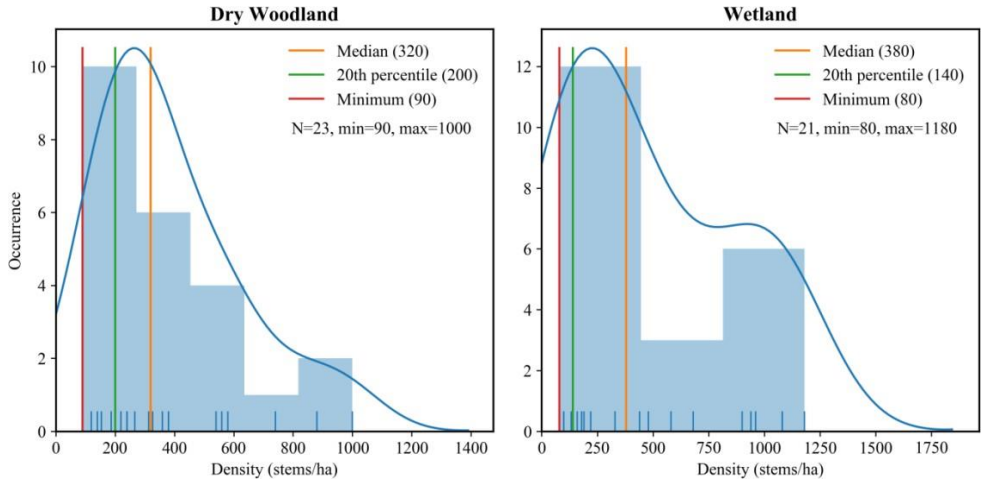

Figure 4.2 Distribution of Framework Species Density >2m for analogue reference sites showing 10th and 20th percentile.

Canopy Composition

In recognising the potential risk of limited resilience in select areas of pre-2008 rehabilitation, this criteria has been introduced to address distinct problem age cohorts dominated by pioneer species. RTW proposes a limit of 50% be placed on the foliage projected cover from these pioneer species which are comprised of the *Acacia/Grevillea/Dodonaea* genus. These species include *Grevillea pteridifolia*, *Grevillea heliosperma*, *Dodonaea platyptera*, *Acacia torulosa*, *Acacia mangium, Acacia auriculiformis* and other *Dodonaea sp*.

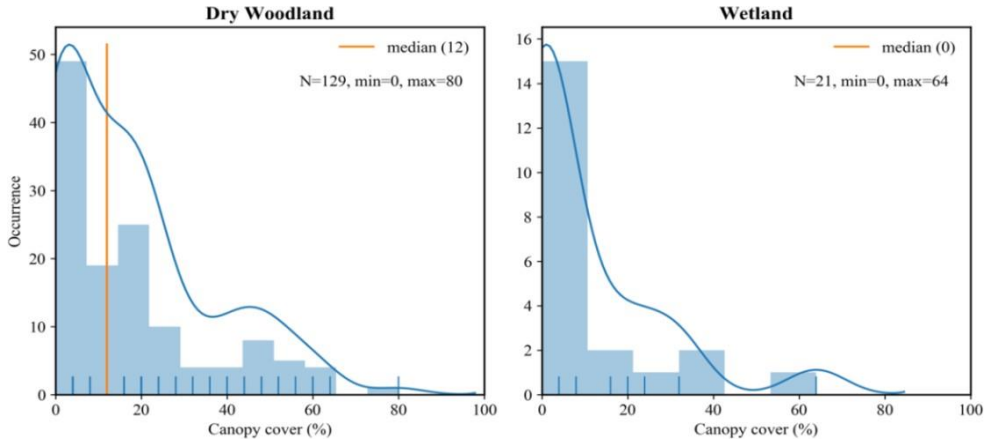

Figure 4.3 Distribution of Canopy Cover comprised by aggressive Dodonea/Grevillea/Acacias for pre-2008 (legacy) sites

Diversity

The 2D diversity index quantified the degree of species diversity exhibited within a sample from the inverse of the proportional abundance of each species squared (Eq. 1).(Tuomisto, 2010) The 2D diversity index is equivalent to the reciprocal of the commonly used Simpson's Index (□) with the advantage of being conceptually easier to relate to species richness: a sample with N species in equal abundance has a 2D diversity index of N, however if the sample of N species has unequal abundance the 2D diversity index will be <N approaching a lower limit of 1 for samples which are dominated by a single species.

$$^2D = \frac{1}{\sum_{i=1}^{R} p_i^2} = \frac{1}{\lambda} \quad (1)$$

Within the natural range of reference sites, mid-story and canopy species have been used to determine an appropriate 2D diversity index to benchmark against for rehabilitation. The minimum value which can be recorded using this index is 1. This value would represent a community containing only one species.

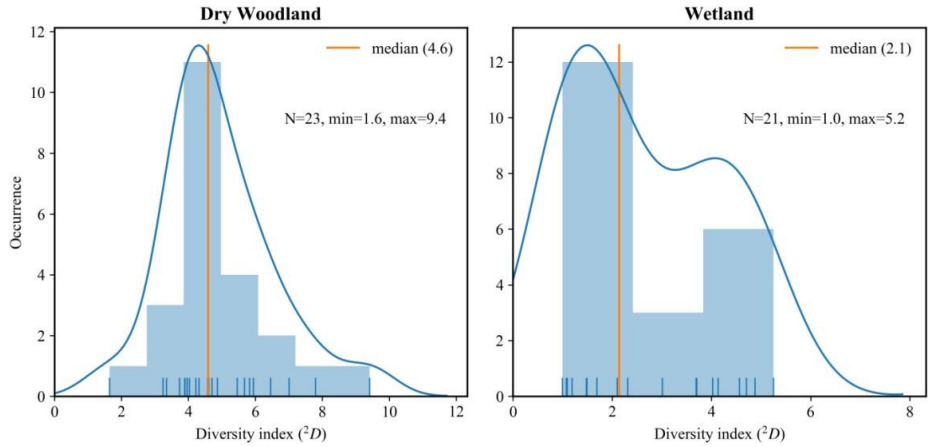

Figure 4.4 Reciprocal Diversity Indices analogue reference sites showing median benchmark.

For Pre-2008 Dry woodland, a value of 1.6 has been applied to ensure a comparable level of diversity is achieved within the bounds of the stated goal for this domain. For post-2008 where the rehabilitation goals include higher expectations around diversity within sites, a value of 3 is proposed. For wet sites for both pre-2008 and post -2008 a value of 1.2 is used on the basis of naturally low canopy and mid-story diversity characteristic of wet analogue reference sites.

APPENDIX E LAND UNIT FUNCTION DESCRIPTIONS

Land unit	Description	Framework species typically present	Habitat features
2b	**Stringybark woodland on red earth soils** *Physical:* Excessively drained red earths overlying the bauxite or laterite plateau. *Structure:* Tall to very tall woodland to open forest of Darwin stringybark with Melville Island bloodwood +/- a mid-high to tall shrub understorey dominated by Cooktown iron-wood, nonda plum, Roth`s wattle, over a tall tussock grassland. *Other:* Occurs as extensive tracts on the bauxite plateau.	*Corymbia nesophila* *Corymbia stockeri* *Erythrophleum chlorostachys* *Eucalyptus tetrodonta*	• Provides seasonally fluctuating productivity for nectar and insect feeding fauna. • Contains high availability of tree hollows and spouts for small to large fauna. • Supports relatively diverse and numerous reptile communities. • Potential foraging and breeding habitat for threatened fauna including red goshawk, palm cockatoo, chestnut dunnart, Papuan Sheathtail bat
2c	**Stringybark and bloodwood woodland on yellow earth soils** *Physical:* Mottled yellow earths with slightly impeded drainage occurring on the lower scarp of the bauxite plateau close to the seasonal ground water level or over shallow sub-surface ironstone layers. *Structure:* Tall to very tall woodland to open forest of Darwin stringybark with Melville Island bloodwood and a mid-high to tall shrub understorey dominated by Cooktown iron-wood, nonda plum, Roth`s wattle, broad-leaved tea tree over a tall tussock grassland.	*Corymbia nesophila* *Corymbia stockeri* *Erythrophleum chlorostachys* *Eucalyptus tetrodonta*	• Provides seasonally fluctuating productivity for nectar and insect feeding fauna. Productivity may be higher in 2c than 2b due to the prevalence of Corymbia. • Contains high availability of tree hollows and spouts for small to large fauna. • Supports relatively diverse and numerous reptile communities. • Overall utilisation by fauna may be higher than 2b due to the typical proximity to riparian habitats.

Land unit	Description	Framework species typically present	Habitat features
	Other: Melville Island bloodwood is more common than in 2b and often dominates the canopy. The ground layer is usually dominated by Cockatoo grass (*Alloteropsis semialata*) reflecting the seasonal saturation of the substrate.		• Potential foraging and breeding habitat for threatened fauna including red goshawk, palm cockatoo, chestnut dunnart, Papuan Sheathtail bat
3b	**Melaleuca swamp zone at the most consistent water level** *Physical:* Bleached yellow podzolics and greyed podzolics associated with freshwater or estuarine sediments, alluvium and colluvium. Occurs on the fringe of the permanently saturated zone of swamps. *Structure:* Mid-high to tall woodland to closed forest dominated by *Melaleuca* spp. +/- swamp mahogany with little understorey development and ground vegetation. Small areas of floating (e.g. water lilies) or emergent macrophytes may be present during the wet season. *Other:* May comprise monospecific stands or distinct zones of different species and/or structure.	*Lophostemon suaveolens* *Melaleuca cajuputi* *Melaleuca leucadendra* *Melaleuca viridiflora*	• Provides seasonal inundated habitat for aquatic flora and fauna including small fish, freshwater crabs, water snakes and waterbirds. • Seasonally productive habitat for nectar and insect feeding species aligned with flowering events of canopy trees. • May provide important feeding habitat (Melaleuca flowering events) for local fauna during the dry season when adjoining eucalypt woodlands have lower productivity. • Potential habitat for threatened flora and fauna including chocolate tea-tree orchid, red goshawk, rufous owl, palm cockatoo.
5b	**Grassy ironbark woodland on undulating plains and erosional slopes** *Physical:* Lateritic yellow and red earths with hard setting surfaces and slow to medium drainage.	*Corymbia clarksoniana* *Eucalyptus culleni*	• Provides seasonally fluctuating productivity for nectar and insect feeding fauna. • Contains moderate availability of tree hollows and spouts for small to medium fauna.

Land unit	Description	Framework species typically present	Habitat features
	Occurs on undulating plains and erosional slopes on bauxite and sandstone. *Structure:* Tall grassy open woodland dominated by Cullen's ironbark and Cooktown ironwood with very sparse understorey of quinine bush, beefwood and medicine bush. *Other:* Infiltration rates are slow leading to surface run off. Often occurs as a patchy mosaic on the eroding plateau edge with land unit 5f.	*Eucalyptus tetrodonta* *Erythrophleum chlorostachys* *Lophostemon suaveolens* *Melaleuca stenostachya*	• May include small springs, gullies and gorges which provide broken rocky habitat not found on the bauxite plateau. • Typically occurs in a patchy mosaic with land unit 5f on the edge of the plateau between the extensive stringybark woodlands and riparian or marine plain vegetation downslope. Consequently is part of a fairly diverse habitat mosaic occurring at the plateau edge. • Provides potential habitat for northern quoll.
5e	**Bloodwood woodland on colluvial upper reaches of broad drainage basins** *Physical:* Bleached yellow podzolics which are poorly drained. Occupies colluvial deposits in upper reaches of broad drainage basins that dissect the bauxite plateau. *Structure:* Tall open woodland to woodland (less common) dominated by Clarkson's bloodwood, Cape York red gum and nonda plum with layered understorey containing swamp mahogany, pandanus and bushman`s peg, often with a sub-canopy of broad-leaved tea-tree. Ground cover is grassy typically of Cockatoo grass reflecting the seasonal saturation of the substrate.	*Corymbia clarksoniana* *Eucalyptus brassiana* *Eucalyptus tetrodonta* *Lophostemon suaveolens* *Melaleuca stenostachya* *Melaleuca viridiflora*	• Due to the presence of bloodwood broad-leaved tea-tree and bushman's pegs, provides peaky productivity for nectar and insect feeding fauna. • One of the few land units where the sugar glider is still recorded from time to time. • Contains moderate availability of tree hollows and spouts for small to medium fauna. • Seasonal inundation provides moist substrate into the dry season that may be exploited by ground mammals and reptiles. • Occurs on the upper limit of riparian/colluvial corridors that provide key seasonal feeding habitats for mobile woodland fauna that occupy

Land unit	Description	Framework species typically present	Habitat features
	Other: Banksia and Melville Island bloodwood* are absent (*distinguishing feature from 2c which typically occurs on adjacent slightly higher topography). Flooding and waterlogging occurs for short periods during the wet season.		the extensive stringybark woodlands (land unit 2b) on the bauxite plateau. • Provides potential nesting habitat for estuarine crocodile.
5f	**Grassy broad-leaved carbeen woodland on eroding slopes on colluvium** *Physical:* Yellow podzolic and bleached greyed podzolics with hard setting surfaces. Run-off rates are moderate but infiltration and drainage rates are slow. Occurs on eroding slopes and scarps on colluvium from bauxite plateau. *Structure:* Tall to very tall grassy open woodland dominated by broad-leaved carbeen and Darwin stringybark with Clarkson's bloodwood, Cooktown ironwood, and Molloy red box; with a very sparse understorey of broad-leaved paperbark, beefwood, bushman`s peg and boot-lace oak. Ground cover is dominated by giant spear grass. *Other:* Often occurs as a patchy mosaic on the eroding plateau edge with land unit 5b.	*Corymbia clarksoniana* *Eucalyptus tetrodonta* *Eucalyptus leptophleba* *Erythrophleum chlorostachys* *Melaleuca viridiflora*	• Provides seasonally fluctuating productivity for nectar and insect feeding fauna. • Contains moderate availability of tree hollows and spouts for small to medium fauna. • May include small springs, gullies and gorges which provide broken rocky habitat not found on the bauxite plateau. • Typically occurs in a patchy mosaic with land unit 5b on the edge of the plateau between the extensive stringybark woodlands and riparian or marine plain vegetation downslope. Consequently is part of a fairly diverse habitat mosaic occurring at the plateau edge. • Provides potential habitat for northern quoll.
5j	**Bloodwood-Banksia woodland on colluvium in upper parts of broad basins** *Physical:* Soils range from loams to sands with an `A` horizon present. Drainage is impeded by an ironstone or clay layer located not far below the surface leading to waterlogging during the wet season. Occurs in the upper parts of broad basins and as a marginal band on	*Corymbia clarksoniana* *Lophostemon suaveolens* *Melaleuca*	• Due to the presence of bloodwood banksia and bushman's peg, provides peaky productivity for nectar and insect feeding fauna. • One of the few land units where the sugar glider is still recorded from time to time.

Land unit	Description	Framework species typically present	Habitat features
	colluvial foot slopes along drainage corridors. *Structure:* Mid-high to tall open woodland dominated by Clarkson's bloodwood with a variable very sparse to mid-dense understorey characterised by banksia with swamp mahogany, wattles and bushman's peg. The ground cover reflects the seasonally inundated and mesic nature of the substrate and includes cockatoo grass, sedges, sundews, and pipe wort. *Other:* The presence of banksia distinguishes this land unit from 5e. Seasonal springs and seepages occur at the upper margin of this land unit (typically adjacent to land unit 2c on the base of the plateau). This area often includes low surface outcrop of ironstone.	*stenostachya* *Melaleuca viridiflora*	• Contains low availability of tree hollows and spouts for small fauna. • Seasonal inundation provides moist substrate into the dry season that may be exploited by ground mammals and reptiles. • As a result of substantial lateral seepage and overbank flows from nearby streams, these areas become seasonal wetlands that may be colonised by aquatic fauna including small fish and crustaceans. • Occurs on the upper limit of riparian/colluvial corridors that provide key seasonal feeding habitats for mobile woodland fauna that occupy the extensive stringybark woodlands (land unit 2b) on the bauxite plateau. • Provides potential nesting habitat for estuarine crocodile.
5k	**Bloodwood and Stringybark woodland on gravelly ironstone soils** *Physical:* Shallow gravelly reddish brown loams with outcropping ironstone. Medium drainage but run-off is excessive. Occurs on eroding gentle laterite slopes or ironstone ridges. *Structure:* Tall to very tall woodland to open forest of Melville Island bloodwood, Darwin	*Corymbia nesophila* *Corymbia stockeri* *Erythrophleum chlorostachys* *Eucalyptus*	• Provides seasonally fluctuating productivity for nectar and insect feeding fauna. Productivity may be higher in 2c than 2b due to the prevalence of Corymbia. • Contains high availability of tree hollows and spouts for small to large fauna. • Low rocky outcrops may be present and enhance

Land unit	Description	Framework species typically present	Habitat features
	stringybark and variable barked bloodwood with a mid-high to tall shrub understorey dominated by Roth`s wattle, cocky apple, nonda plum, woody pear and giant spear grass. *Other:* May occur as bands along the upper part of scarps at the plateau edge or isolated patches within extensive areas of land unit 2b.	*tetrodonta*	ground habitat diversity. • Potential foraging and breeding habitat for threatened fauna including red goshawk, palm cockatoo, chestnut dunnart, Papuan Sheathtail bat.
7b	**Melaleuca-swamp mahogany on the outer margins of drainage depressions** *Physical:* Greyed or yellow podzolics that are poorly drained and waterlogged for long periods. Occurs on the outer margins of sink hole tree swamps and internal drainage depressions. *Structure:* This is a highly variable land unit that often displays internal zonation determined by microtopography and inundation depth and periodicity. Typically a canopy of broad-leaved tea-tree and swamp mahogany is present ranging from a low to tall, woodland to open woodland. A dense understorey of liniment tree and false casuarina is often present that may become the dominant stratum where Melaleuca and swamp mahogany stem density diminishes. Water lilies may be present whilst inundated and following recession of the water a sparse covering of pipe wort is common. *Other:* Seasonal inundation is the main determinant of this land unit as it occurs on a range of parent material.	*Lophostemon suaveolens* *Melaleuca stenostachya* *Melaleuca viridiflora*	• Provides seasonally fluctuating productivity for nectar and insect feeding fauna with peaks associated with synchronous flowering events of melaleuca and swamp mahogany. • May provide important feeding habitat (Melaleuca flowering events) for local fauna during the dry season when adjoining eucalypt woodlands have lower productivity. • Low availability of tree hollows and spouts for small to medium fauna. • Provides seasonal inundated habitat for aquatic flora and fauna including small fish, freshwater crabs, water snakes and waterbirds. • Potential habitat for threatened flora and fauna including chocolate tea-tree orchid, red goshawk, rufous owl, masked owl and palm cockatoo.

Land unit	Description	Framework species typically present	Habitat features
7d	**Grassland with broad-leaved paperbark on the seepage zone along foot slopes or outer margin of drainage lines.** *Physical:* Colluvial deposits on foot slopes or along the margins of drainage lines. Water logging and seasonal flooding from groundwater seepage and surface flows are characteristic. *Structure:* Comprises a tall to very-tall closed grassland of blady grass or vetiver grass with scattered low to mid-high trees including broad-leaved tea-tree, Clarkson's bloodwood, Cape York red gum, pandanus and acacia; or, a sparse low understorey of broad-leaved paperbark. The ground cover is of low species diversity and usually comprises monospecific swards of the native grasses. *Other:* Groundwater seepage and seasonal saturation of the substrate is a feature of this land unit.	*Corymbia clarksoniana* *Eucalyptus brassiana* *Melaleuca viridiflora*	• Habitat values are limited by the low floristic and structural diversity of the vegetation. • Flowering events of broad-leaved tea-tree will attract mobile nectar and insect feeders including honeyeaters and microbats. • Seasonal inundation provides habitat for breeding terrestrial frogs. • Overall residential fauna community is likely to be minimal.

APPENDIX F- CULTURALLY SIGNIFICANT SPECIES

Family	Species Name (Bostock & Holland 2010)	Common Name (use common name of TO's first followed by other common names)	Life Form	Habitat[1]	Thaynakwith Name (1 Fletcher 2007, 2 Wharton 1998, 3 Hiddins, 4 Roth, 5 Barkely)	Thaynakwith	Thaynakwithi	Wathayn	Peppan	Alngith	Part Used	Food Use	Material Use	Medicinal use	Art use	Ceremony uses	Indicator Species	Aesthetic Values
Malvaceae	*Abelmoschus moschatus* subsp. *tuberosus*	wild turnip, creeping hibiscus	Low Shrub	1	Ayawurr (1)	1	1	0	0	0	roots	1	0	0	0	0	0	1
Fabaceae	*Abrus precatorius*	gidee gidee, crabs eye	Vine	5, 2, 1	Njulnjul (1)	1	1	1	1	1	seeds	0	1	0	1	1	0	1
Mimosaceae	*Acacia crassicarpa*	black wattle, brown salwood, thick-podded; thick-podded salwood	Tree	2, 1	Thurru (1)	1	1	0	0	1	bark	0	1	0	0	0	1	1
Mimosaceae	*Acacia rothii*	spoon tree, roth's wattle	Tall Shrub	1, 6	La (1, 2, 5)	1	1	1	1	1	timber	0	1	0	0	0	1	1
Fabaceae	*acia* sp.	black wattle	shrub/ tree	2	Thanakupi, Thurru (1)	1	1	0	0	1	flower, bark	0	1	0	0	0	1	0

[1] Habitats in order of primary occurrence: 1 stringybark woodlands; 2 coastal dunes; 3 mangroves; 4 swamp forests; 5 vine forests & thickets; 6 riparian forests & woodlands; 7 other woodlands; 8 wetlands; 9 cultivated.

Family	Species Name (Bostock & Holland 2010)	Common Name (use common name of TO's first followed by other common names)	Life Form	Habitat[1]	Thaynakwith Name (1 Fletcher 2007, 2 Wharton 1998, 3 Hiddins, 4 Roth, 5 Barkely)	Thaynakwith	Thaynakwithi	Wathayn	Peppan	Alngith	Part Used	Food Use	Material Use	Medicinal use	Art use	Ceremony uses	Indicator Species	Aesthetic Values
Mimosaceae	*Acacia torulosa*	black wattle	Tree	2	Thanakupi (1)	1	1	0	0	1	flowers	0	0	0	0	0	0	0
Poypodiaceae	*Acrostichum speciosum*	mangrove fern	Fern (terrestrial)	3, 4	Ngong (1)	0	0	0	0	0	root	1	0	0	0	0	0	0
Rhamnaceae	*Alphitonia excelsa*	shampoo tree	tree	1, 2, 5, 6, 7	Arrarr (1), Arar (2)	1	1	1	1	1	leaves, flowers, fruit, seeds	0	1	0	0	1	1	0
Apocynaceae	*Alstonia actinopylla*	milky pine, milkwood	tree or shrub	1, 5, 2	Wanj (1)	1	1	1	1	1	flowers, bark	0	0	0	0	1	1	0
Apocynaceae	*Alstonia spectabilis*	milkwood	Tree	5, 2	Chal (1)	1	0	0	0	0	unknown	0	0	1	0	1	0	0
Araceae	*Amorphophallus* sp.	ground lily	Geophyte	5	Thilim (1)	1	0	0	0	0	plant whole	0	0	0	0	1	0	0
Vitaceae	*Ampelocissus acetosa*	wild grape	Vine	1, 2, 5, 6, 7	Mbown (1, 2)	1	1	1	1	1	fruit	1	1	0	1	0	0	0
Phyllanthaceae	*Antidesma bunius*	black currant tree	small tree	5	thanjirri (1)	1	1	0	0	0	fruit	1	1	0	0	0	0	1
Phyllanthaceae	*Antidesma ghaesambila*	black currant tree	shrub	1, 2, 5	thanjirri (1)	1	1	1	1	1	fruit	1	0	0	0	0	0	0

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Acanthaceae	*Avicennia marina*	white mangrove, grey mangrove	tree marine intertidal	3	Njer (1, 2)	1	1	0	0	0	seeds	1	0	0	0	0	0	0
Bombacaceae	*Bombax ceiba* var. *leiocarpum*	canoe tree	tree	5	Kinuwa (1), Kinwa (2)	1	1	1	0	1	trunk	0	1	0	0	0	1	0
Sterculiaceae	*Brachychiton paradoxus*	kurrajong tree	tree	1, 6	Alakanam (1)	1	1	1	1	0	leaves, roots, nuts	1	1	1	0	1	0	0
Fabaceae	*Eriosema chinense*	wild turnip	plant	1, 2	Mru' (1)	1	0	0	0	0	root	1	0	0	0	0	0	0
Rhizophoraceae	*Bruguiera gymnorrhiza*	black mangrove	Tree marine	3	Nhomb (1, 2)	1	1	0	0	1	pods, trunks, buttress	1	1	0	0	1	0	0
Clusiaceae	*Calophyllum bicolor*	springwood	slender single stemmed shrub and small tree	5, 4	Orrambin (1)	1	1	1	1	1	shafts	0	1	0	0	0	0	0
Burseraceae	*Canarium australianum*	Turpentine tree, gum	tree	5, 1, 2, 6	Kechen the' "resin for binding" (1)	1	1	1	1	1	gum	0	1	0	0	0	1	0

Family	Species Name (Bostock & Holland 2010)	Common Name (use common name of TO's first followed by other common names)	Life Form	Habitat[1]	Thaynakwith Name (1 Fletcher 2007, 2 Wharton 1998, 3 Hiddins, 4 Roth, 5 Barkely)	Thaynakwith	Thaynakwithi	Wathayn	Peppan	Alngith	Part Used	Food Use	Material Use	Medicinal use	Art use	Ceremony uses	Indicator Species	Aesthetic Values
		tree																
Rhizophoraceae	*Carallia brachiata*	corkwood	tree	5, 6	Lorr (1)	1	1	0	0	1	fruit	1	0	0	0	0	0	0
Lauraceae	*Cassytha filiformis*	beach vine, dodder laurel	vine	2, 1, 5, 6	Thimith, Thimidh (1, 2)	1	1	1	1	1	fruit, vine	1	0	1	0	0	0	0
Casuarinaceae	*Casuarina equisetifolia*	she-oak	tree	2	Rrunggu (1, 2)	1	1	0	0	1	leaves	0	1	0	0	0	0	1
Rhizophoraceae	*Ceriops tagal*	yellow mangrove	tree	3	Alandhal (1)	1	0	0	0	0	trunks, buttresses	0	1	0	0	0	0	0
Lamiaceae	*Clerodendrum floribundum*	lolly bush	Low Shrub	2, 5, 1	Muth arrak (1)	1	1	0	0	0	branches	0	1	0	0	0	0	0
Myrtaceae	*Corymbia nesophila*	melville island bloodwood	Tree	1, 7	Thughuth (1)	1	1	1	1	1	tree	0	1	0	0	0	0	0
Araceae	*Crinum* sp.	white lily	Geophyte	6, 1	Mapthawan (1)	1	0	0	0	0	flower	0	0	0	0	0	0	1
Zingiberaceae	*Curcuma australasica*	cape york lilly, wild ginger, land	Herb	5, 6	Peminam (1, 2)	1	0	0	0	0	roots	1	0	0	0	0	0	1

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		lily or native ginger																
Bignoniaceae	*Deplanchea tetraphylla*	golden bouquet tree	Tree	6, 5	Thawethe (1)	1	1	0	0	0	flowers	0	0	0	0	0	0	1
Dioscoreaceae	*Dioscorea transversa*	long yam	Vine	2, 5, 1, 6	Kwi'ith (1, 2)	1	1	1	1	1	tuber	1	0	0	0	0	0	0
Dioscoreaceae	*Dioscores bulbifera*	yam, cheeky yam	vine	2, 5, 1	Ndhay (1), Ndhaygh (2)	1	1	0	0	1	tuber	1	0	0	0	0	0	0
Orchidaceae	*Dipodium elegantulum*	wild ground orchid	plant	1	Chika (1)	1	1	0	0	1	bulb	1	0	0	0	0	0	1
Cyperaceae	*Eleocharis dulcis*	water chestnut, paarnja	aquatic plant	8	Ngganj (1, 2)	1	1	1	1	1	corms	1	0	0	0	0	0	0
Mimosaceae	*Entada phaseoloides*	matchbox bean	Vine	5, 6	Ndhapal (1)	1	1	1	1	1	seeds	1	1	0	0	1	0	0
Fabaceae	*Erythrina vespertilio*	bats wing coral tree	tree	1, 7	Mbyugh nam (1)	1	1	1	1	1	flower, seeds	0	0	0	0	0	1	0

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Caesalpiniaceae	*Erythrophleum chlorostachys*	cooktown ironwood	Tree	1	Nom wegh (1), Nom weegh (2)	1	1	1	1	1	flowers, timber, leaves	0	1	0	0	1	1	0
Myrtaceae	*Corymbia (check species) (syn. Eucalyptus papuana (Fletcher has Eucalyptus papuana as sp.)*	ghost gum	tree	1, 7	Thunddughur (1)	1	1	1	1	1	Timber, bloodwood gall, leaves	1	1	0	0	0	0	0
Myrtaceae	*Eucalyptus tetrodonta*	Messmate tree	tree	1	Thoy (1, 2, 5), Thundthoy (1) (Thund general meaning of tree and Thoy messmate tree) Nggen (canoe made from messmate bark), Ndhigh or Ndhi skin canoe made from messmate bark)	1	1	1	1	1	bark	0	1	1	1	1	1	0

Family	Species Name (Bostock & Holland 2010)	Common Name (use common name of TO's first followed by other common names)	Life Form	Habitat[1]	Thaynakwith Name (1 Fletcher 2007, 2 Wharton 1998, 3 Hiddins, 4 Roth, 5 Barkely)	Thaynakwith	Thaynakwithi	Wathayn	Peppan	Alngith	Part Used	Food Use	Material Use	Medicinal use	Art use	Ceremony uses	Indicator Species	Aesthetic Values
Euphorbiaceae	*Euphorbia bifida*	baby flower	Herb	1	Irri malong (1)	1	0	0	0	0	whole plant	0	0	1	0	0	0	0
Santalaceae	*Exocarpos latifolius*	small red fruit	small tree	2, 5, 1, 6	mbambam (1)	1	1	1	1	1	fruit	1	0	0	0	0	0	0
Moraceae	*Ficus benjamina*	jail tree	tree	5	Mbinhi (1)	0	0	0	0	0	bark, fruit	1	1	0	0	0	0	0
Moraceae	*Ficus opposita*	sandpaper fig	shrub, small tree	2, 1, 5, 6	Alonggu (1), Aloongu (2)	1	1	1	1	1	fruit, leaves	1	1	1	0	0	0	0
Moraceae	*Ficus virens*	wild fig tree, banyan tree, and wattle tree	tree	5	Thuth (basket) (1)	1	1	0	0	1	root	1	1	0	1	0	0	0
Moraceae	*Ficus virens*	strangler fig	tree	5	Ndhenhathiy (2)	1	1	0	0	1	tree	0	1	0	0	0	0	0
Flagellariaceae	*Flagellaria indica*	lawyer cane vine	vine	5, 6	lindhi (1, 2)	1	1	1	1	1	vine	1	1	0	0	0	0	0
Phyllanthaceae	*Flueggea virosa* subsp. *melanthesoides*	white currant, white fruit bush	low shrub	1, 2, 7	Wari (1)	1	1	1	1	1	roots, fruit	1	0	1	0	0	0	0

Family	Species Name (Bostock & Holland 2010)	Common Name (use common name of TO's first followed by other common names)	Life Form	Habitat[1]	Thaynakwith Name (1 Fletcher 2007, 2 Wharton 1998, 3 Hiddins, 4 Roth, 5 Barkely)	Thaynakwith	Thaynakwithi	Wathayn	Peppan	Alngith	Part Used	Food Use	Material Use	Medicinal use	Art use	Ceremony uses	Indicator Species	Aesthetic Values
Proteaceae	*Grevillea parallela*	beefwood	small tree	1		1	1	0	0	1	Wood ash	0	1	1	0	0	0	0
Malvaceae	*Grewia retusifolia*	cough' plant	low shrub	1, 2, 7	Wina malong (1)	1	1	1	1	1	root	1	0	1	0	0	0	0
Haemodoraceae	*Haemodorum coccineum*	kutini plant	low shrub	1, 2	Nggang thanh (1)	1	1	0	0	0	root	0	1	0	0	1	0	0
Malvaceae	*Hibiscus tiliceus*	coastal hibiscus tree	tree	2, 3	Kwambranh (1)	1	1	1	1	1	shaft	0	1	0	0	0	0	0
Convolvulaceae	*Ipomoea pes-capre* subsp. *brasiliensis*	goats foot convolvulus, skipping rope vine	vine	2	Fri' 1 , 2, 5	1	1	1	1	1	leaves, vine stems	0	1	1	0	0	0	0
Aracaceae	*Livistona muelleri*	cabbage palm, dwarf fan palm	palm	1, 6	Ndrre mbri (1), Ndre mbri (2)	1	1	1	1	1	Palm heart, leaves	1	1	1	0	0	0	0
Laxmaniaceae	*Lomandra longifolia*	spike rush	grass	6, 5, 1	Walam (1, 5, 7)	1	1	1	1	1	leaves	0	1	0	0	0	0	0
Myrtaceae	*Lophostemon suaveolens*	red barked tea tree, swamp box	tree	4, 1	Trelen ndigh (1, 5)	1	1	1	1	1	bark	0	1	1	0	0	0	0

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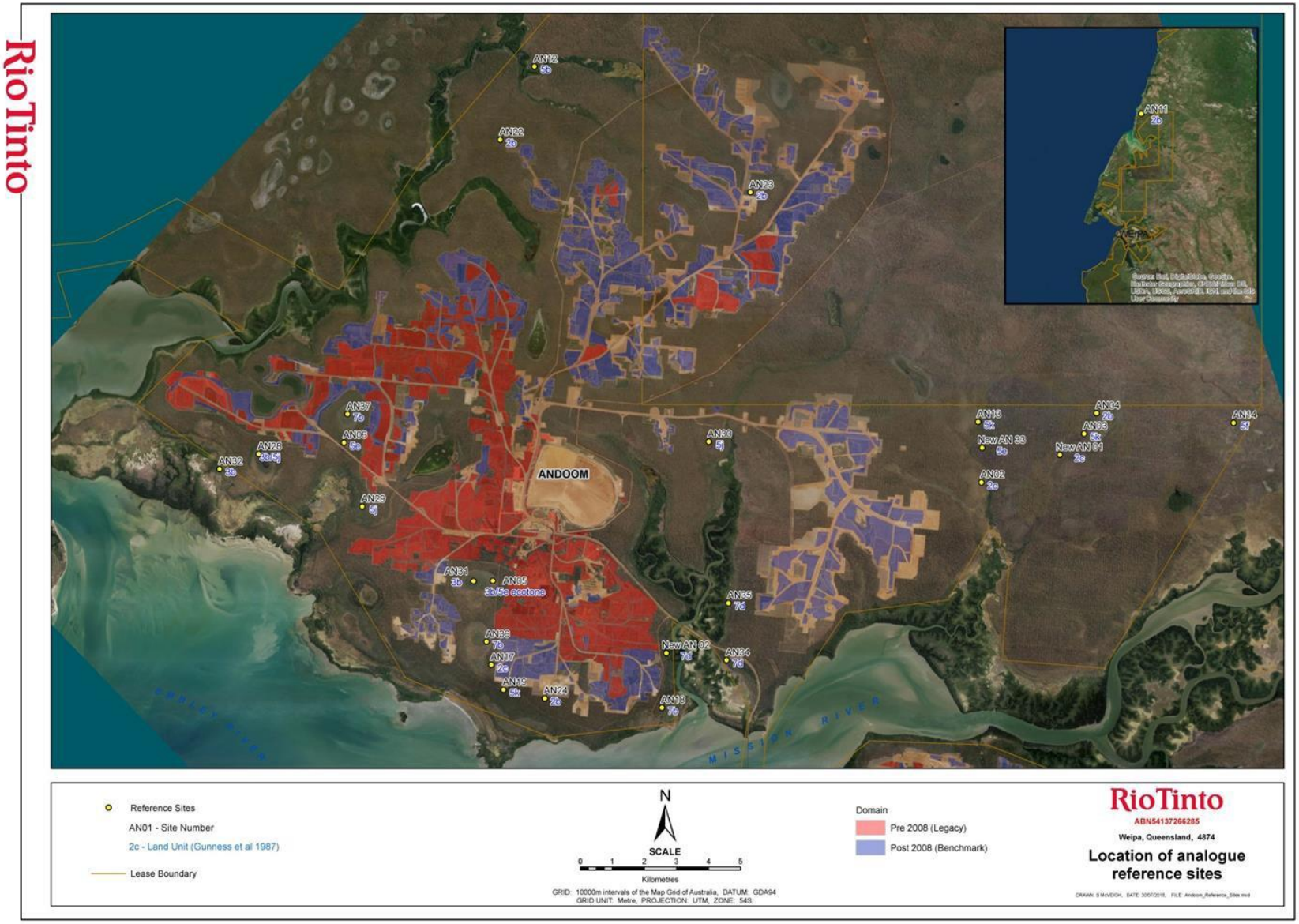
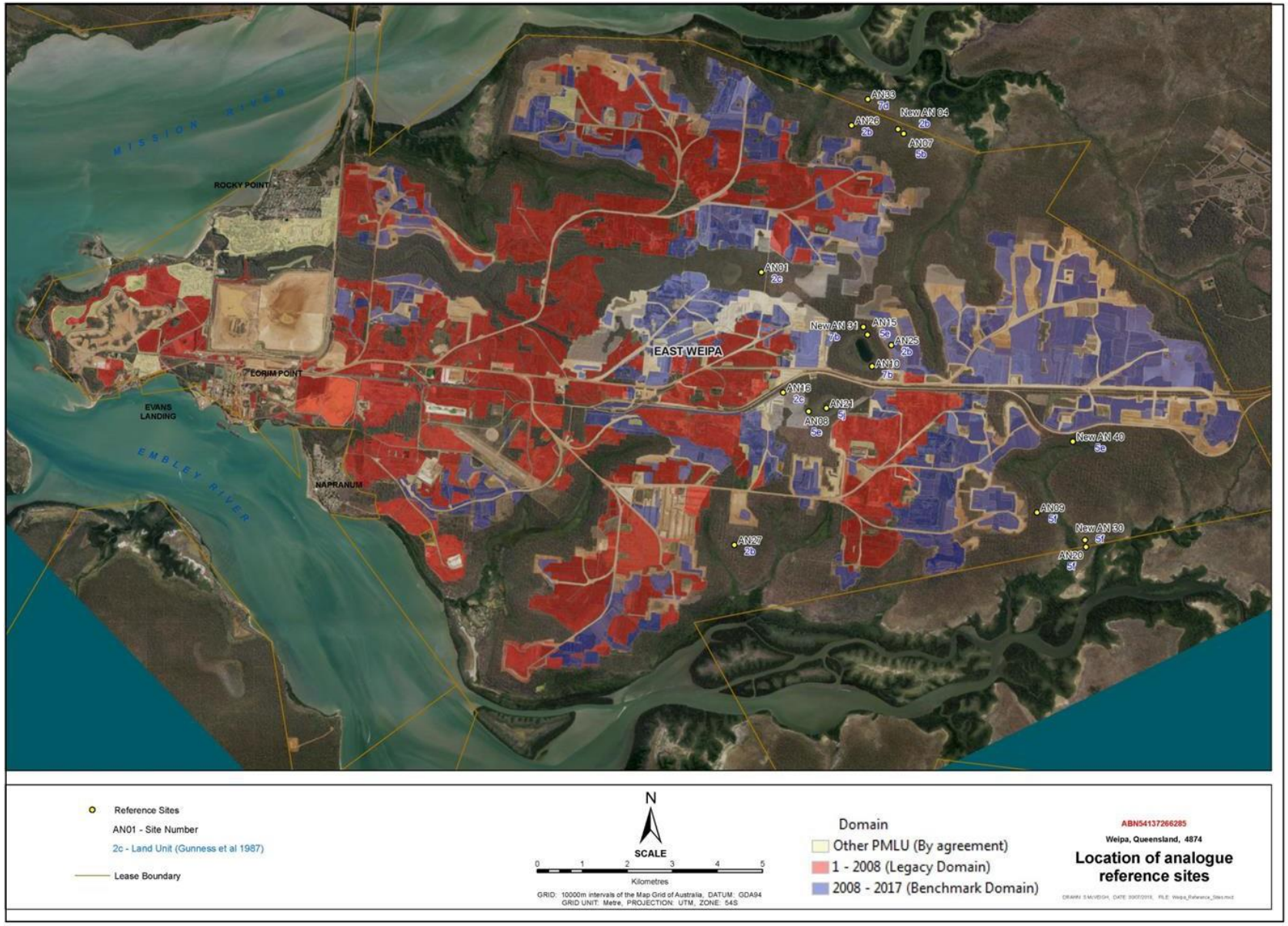
Sapotaceae	*Manilkara kauki*	black fruit, Wongai	tree	2, 5	Wongai (1, 6, 7)	1	1	0	0	1	fruit	1	1	0	0	0	0	0
Myrtaceae	*Melaleuca dealbata*	blue leaf tea tree, ti-trer	tree	6, 4	Ndhigh (1), Ndhi (2)	1	1	1	1	1	bark	0	1	1	0	0	0	0
Myrtaceae	*Melaleuca leucadendra*	tea tree, ti-tree, Paperbark tree	tree	6, 4	Ndhigh (1), Ndhi (2)	1	1	1	1	1	bark	0	1	1	0	0	0	0
Myrtaceae	*Melaleuca viridflora*	tea tree, ti-tree, Paperbark tree	tree	6, 4	Ndhigh (1), Ndhi (2)	1	1	1	1	1	bark	0	1	1	0	0	0	0
Melastomataceae	*Melastoma affine*	jamfruit	low shrub	4, 6	Kumbu (1, 5)	1	1	0	1	1	fruit	1	0	0	0	0	0	1
Rubiaceae	*Morinda citrifolia*	cheese/dog-fruit tree	tree	6, 4, 5	Wa malong (1, 5)	1	1	1	1	1	fruit	0	0	1	0	0	0	0
Rubiaceae	*Morinda reticulata*	oyster plant	low Shrub	1, 2	Kandhak (1, 5)	1	1	1	1	1	roots	0	1	0	0	0	1	0

Family	Species Name (Bostock & Holland 2010)	Common Name (use common name of TO's first followed by other common names)	Life Form	Habitat[1]	Thaynakwith Name (1 Fletcher 2007, 2 Wharton 1998, 3 Hiddins, 4 Roth, 5 Barkely)	Thaynakwith	Thaynakwithi	Wathayn	Peppan	Alngith	Part Used	Food Use	Material Use	Medicinal use	Art use	Ceremony uses	Indicator Species	Aesthetic Values
Nymphaeaceae	*Nymphaee violacea*	blue water lily	aquatic macrophyte	8	Atakani (1, 5)	1	1	0	0	1	stems, seed pod and bulbs	1	0	0	0	0	0	0
Poaceae	*Oplismenus aemulus*	long grass	grass	5, 6	Walam, 'Wamgan "basket"	0	0	0	0	0	whole	0	1	0	0	0	0	0
Pandanaceae	*Pandanus spiralis*	screw palm	palm	1, 2, 4, 6	Agharr, Aykil	1	1	1	1	1	nuts, leaves	1	1	1	0	0	0	0
Poaceae	*Panicum* sp.	native panic	grass	1, 2, 7	Ludh (1)	1	1	0	1	1	seeds	1	0	0	0	1	1	0
Chrysobalancaceae	*Parinari nonda*	nonda plum	tree	1, 2, 6	Ngguluk (1, 2)	1	1	1	1	1	bark, honey, fruit, nuts	1	1	1	0	0	0	0
Lecythidaceae	*Planchonia careya*	jellyfish tree, wild mango, cocky apple	shrub, small tree	1, 2, 6, 7	Layndhi (1, 5)	1	1	1	1	1	bark	0	1	1	1	1	1	0
Rhizophoraceae	*Rhizophora* spp. (Includes *R. apiculata, R. mucronata, R. stylosa)*	Stilted mangrove	tree	3	thayniy (1)	1	1	1	1	1		1	1	0	0		0	0

Family	Species Name (Bostock & Holland 2010)	Common Name (use common name of TO's first followed by other common names)	Life Form	Habitat[1]	Thaynakwith Name (1 Fletcher 2007, 2 Wharton 1998, 3 Hiddins, 4 Roth, 5 Barkely)	Thaynakwith	Thaynakwithi	Wathayn	Peppan	Alngith	Part Used	Food Use	Material Use	Medicinal use	Art use	Ceremony uses	Indicator Species	Aesthetic Values
Smilacaceae	*Smilax australis*	barb wire vine	vine	5, 6	Ndrwal mbuy (1, 2)	1	0	0	0	0	nil	0	0	0	0	0	0	0
Sterculiaceae	*Sterculia quadrifida*	peanut tree	tree	2, 5, 1	Mbiya (1, 6), Mbe (2)	1	1	1	1	1	nut	1	0	0	0	0	0	0
Myrtaceae	*Syzygium aquem*	bell fruit	shrub, small tree	9	Bell fruit	0	0	0	0	1	fruit	1	0	0	0	0	0	0
Myrtaceae	*Syzygium branderhorstii*	Lockerbie satinash	tree	9	sorbi	0	0	0	0	1	fruit	1	0	0	0	0	0	0
Myrtaceae	*Syzygium forte* subsp. *potamophilum*	white apple	tree	6	Iwagh (1)	1	1	0	0	1	fruit	1	0	0	0	1	0	0
Myrtaceae	*Syzygium suborbiculare*	lady apple	tree	2, 1	Thigh parach (1), Thiigh parach (2)	1	1	1	1	1	fruit	1	0	0	0	0	0	0
Taccaceae	*Tacca leontopetaloides*	arrowroot	geophyte	2, 5	anj (1), Aanj (2)	1	1	0	0	1	tuber	1	0	0	0	0	0	0
Combretaceae	*Terminalia muelleri*	crowfruit	tree	5, 2	Rer (1)	1	1	1	1	1	fruit	1	0	0	0	0	0	0
Malvaceae	*Thespesia populnea*	indian tulip tree	tree	3, 2	Kwambranh (6)	1	1	1	1	1	trunk, branches	0	1	0	0	0	0	0

APPENDIX G -REFERENCE (ANALOGUE) MONITORING LOCATIONS




MISSION RIVER
ROCKY POINT
EORIM POINT
EVANS LANDING
EMBLEY RIVER
NAPRANUM
EAST WEIPA
AN33 7d
New AN 04 2b
AN26 2b
AN07 5b
AN01 2c
New AN 01 7b
AN15 5e
AN25 2b
AN10 7b
AN16 2c
AN21 5f
AN08 5e
New AN 40 5e
AN09 5f
New AN 39 5f
AN20 5f
AN27 2b
Reference Sites
AN01 - Site Number
2c - Land Unit (Gunness et al 1987)
Lease Boundary
N
SCALE
0 1 2 3 4 5
Kilometres
GRID: 10000m intervals of the Map Grid of Australia, DATUM: GDA94
GRID UNIT: Metre, PROJECTION: UTM, ZONE: 54S
Domain
Other PMLU (By agreement)
1 - 2008 (Legacy Domain)
2008 - 2017 (Benchmark Domain)
ABN54137266285
Weipa, Queensland, 4874
Location of analogue reference sites