Koala Habitat Rehabilitation Monitoring Report ORU 4th Monitoring Period Yarrabilba

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Project Name: Yarrabilba
Proponent's ACN: 103 578 436
Prepared for: Lendlease
Prepared by: Dr M.N. Runkovski, K. Leopold & K. Richardt
Date: 15 January 2019
Proposed Action: To construct the Yarrabilba residential development and associated infrastructure approximately 40 kilometres south east of Brisbane, Queensland (see EPBC Act referral 3013/6791 and request to vary proposal dated 5 August 2013)

Natura Consulting – Document Control Sheet

Project	
Title:	**Habitat Rehabilitation Management Report – Offset Area 4th Monitoring Period**
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Revision History

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1 Executive summary

Natura Consulting has developed this *Habitat Rehabilitation Monitoring Report* as the 4th monitoring report after initial baseline surveys and 6 month plus 2nd and 3rd monitoring periods for rehabilitation within the Yarrabilba offset requirement areas as prescribed in the *Habitat Rehabilitation and Management Plan* (Natura Consulting, March 2015) and the Approval Conditions set out under the *Environmental Protection and Biodiversity Conservation Act 1999* dated 13 November 2014.

The intent of this plan is to provide monitoring information to direct the rehabilitation works associated with Koala habitat within the Fauna Corridor, Greenspace Corridor and Environmental Protection Zones of the Yarrabilba site. Pine tree removal and assisted natural regeneration commenced six months prior to the 2nd monitoring period and has been ongoing in response to successive monitoring reports. The areas to be rehabilitated are offset requirement areas, ensuring that Koala habitat is specifically maintained within the 195 ha offset area. This report provides the 4th monitoring period data for the rehabilitation of the offset areas, with 59 sites, down from 60 in the 3rd monitoring period (where 4 sites had issues surrounding monitoring due to land clearing and were removed previously (sites 48, 107 and 114) or in this monitoring period (site 101)) all monitored within an area of 198.2 ha in the Yarrabilba footprint. Each monitoring site is located within an offset area rehabilitation unit (ORU1 to ORU23) including road crossing rehabilitation units (CRU8, CRU11 and CU15), with the pre-clearing Regional Ecosystem (RE), management type and corridor type tabulated.

Each rehabilitation unit is to be rehabilitated to a vegetation structure and species composition that is in line with that of the appropriate pre-clearing RE. This is derived from the vegetation structure and species composition of the appropriate pre-clearing RE. The final benchmark for rehabilitation is derived from the definition of remnant vegetation under the *Vegetation Management Act 1999* (canopy is 70% of the height, 50% of the cover and similar species composition of the appropriate pre-clearing RE). Interim benchmarks are also provided whereby an assessment at regular intervals will be made on the progress of the rehabilitation / revegetation efforts towards achieving this plan's outcomes. For interim benchmark years 1 to 10, vegetation structure has been quantified from a cumulative growth curve (CGC). The reference benchmark, interim benchmarks and final benchmarks have been tabulated for each RE, with the relevant rehabilitation unit also identified.

Contingency measures and corrective actions have also been provided to account for instances of when interim benchmarks are not being met. 'As constructed' data and surveyed boundaries will also be provided for each rehabilitation unit to test and demonstrate compliance within the offset area (195 ha) requirement.

The monitoring methodology that is applied has been detailed, where a minimum of two monitoring sites per rehabilitation unit has been surveyed in order to document and assess rehabilitation through time. The final locations of the 59 monitoring sites have been mapped. Monitoring includes photo point monitoring and transect and quadrat monitoring to monitor changes in species richness, percentage foliage cover for the ground layer, shrub and canopy layers, canopy height, and weed prevalence.

An assessment of site species richness and structure was undertaken to determine the 4th monitoring period condition against the baseline and benchmark values. With five monitoring periods now undertaken, it will be possible to observe trends in the data, however, the analyses made within this report are relatively basic, to identify high priority areas and guide management recommendations for different ORU and CRU based on a number of variables and RE benchmark indicators. Regardless of results in this report, ongoing passive and active management, weed control and maintenance of fencing is required to ensure restoration practices are effective within the offset areas. Overall, compared to the 3rd monitoring period, general ecological health remained varied across offset sites.

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For example, maximum species richness values were much higher than previously recorded. There were also changes to height and cover in the different levels of strata, with T1 canopy tree cover and height also decreasing. In addition, T2-T3 small tree cover decreased while height remained relatively stable. There was an increase in shrub cover while shrub height decreased. Native ground cover also decreased, as did the proportion of weed cover in the ground-layer. Some of these effects are likely due to seasonal variation, recruitment of lower order structural layers into higher order structural layers (i.e. movement of shrubs into T3 layers) and management actions including exotic pine tree removal, off-target damage from weed management and decreased grazing due to adequate maintenance of exclusion fencing.

Of the 59 sites, a total of 24 sites meet a benchmark for T1 canopy tree cover, 30 sites meet a benchmark for T1 canopy tree height, 58 sites meet a benchmark for T2-T3 small tree cover, 57 sites meet a benchmark for T2-T3 small tree height, 42 sites meet a benchmark for shrub cover, 57 sites meet a benchmark for shrub height, 55 sites meet a benchmark for ground cover and 28 sites meet a benchmark for weed cover of the ground layer.

Overall, this assessment reveals that rehabilitation needs to continue prioritising weed control targeting graminoids such as *Setaria sphacelata* and *Andropogon virginicus,* herbs such as *Lantana camara* and exotic tree species *Pinus elliotti* to assist natural regeneration and prevent weed spread and incursion in areas adjacent to the Plunkett Conservation Reserve. Continued infill planting with appropriate species as discussed in previous rehabilitation monitoring reports and other rehabilitation efforts need to focus on assisted regeneration in sites that are in poorest condition, have made the least improvements or fail to meet the IMO-2 benchmark targets for this 2 year (4th) monitoring period (see Table 8). Where natural regeneration requires additional support, T1 canopy and shrub-layer species should be planted, and in some cases the removal of juvenile *Pinus elliotti* and dominating Acacia species such as *A. leiocalyx* and *A. disparrima* may improve species diversity over time by allowing emergence of new species from the local seed bank.

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2 Introduction

2.1 Background

The Yarrabilba development site is located on the eastern side of Waterford - Tamborine Road and to the south of Logan Village (refer to Figure 1). It is bounded by rural residential areas to the north, Plunkett Road to the south and the Plunkett Conservation Park to the east. The site consists of approximately 2,200 ha, of which 1,931 ha is controlled by Lendlease Communities (Yarrabilba) Pty Ltd. The land has been historically used for pine forestry, a military training camp in WWII and for livestock grazing, when first cleared. Yarrabilba is predominately vegetated with areas of regrowth native vegetation, regenerating pines and exotic grasslands. Some limited areas of native remnant and regrowth vegetation exist but they are mostly confined to creeks, drainage channels and wetlands.

The site is currently in the early stages of development with the growth of Yarrabilba projected to span approximately 30 years. The long-term master-planned development incorporates an extensive network of dedicated open space (in excess of 25% of the site). A significant component of the open space is dedicated to the conservation of habitat for Koalas (*Phascolarctos cinereus*).

Habitat rehabilitation is intended to improve Koala habitat quality within the site in order to significantly increase the site's carrying capacity in the medium to long term. In addition, the configuration of key elements of the open space system (Fauna Corridor, Greenspace Corridor and Environmental Protection Zone) will enhance the site's contribution to Koala movement opportunities within the context of larger areas of Koala habitat to the east and west of the site (Austecology 2012). Under the development of Yarrabilba, all existing fragments of remnant vegetation which have value for koalas will be retained (approximately 5.4% of the total site area) (Austecology 2012). The rehabilitation of the Fauna Corridor, Greenspace Corridor and Environmental Protection Zone will significantly expand on these values by providing additional Koala habitat (Natura Consulting 2011).

This report provides the 4th monitoring data for the rehabilitation of offset areas in the development site, with 59 sites monitored.

2.2 Objectives

The intent of this report is to provide data with which to assess the rehabilitation of Koala habitat within the Offset Requirement area, which includes Fauna Corridor, Greenspace Corridor and Environmental Protection Zone.

This report is consistent with the *Habitat Rehabilitation and Management Plan* (Natura Consulting 2015), *Offset Management Plan* (Austecology 2015), *Koala Management Plan* (Austecology 2012) and *Fauna Corridor Infrastructure Master Plan* (Natura Consulting 2011). In particular the objectives of this report are to:

- describe the rehabilitation areas and provide clear and concise rehabilitation outcomes and performance indicators against which achievement of the rehabilitation will be measured
- identify contingency measures and appropriate corrective actions that will be undertaken if the performance indicators or outcomes are not being met
- outline the monitoring methodology including monitoring site locations
- assess whether rehabilitation is on-track to meet the next interim performance indicator

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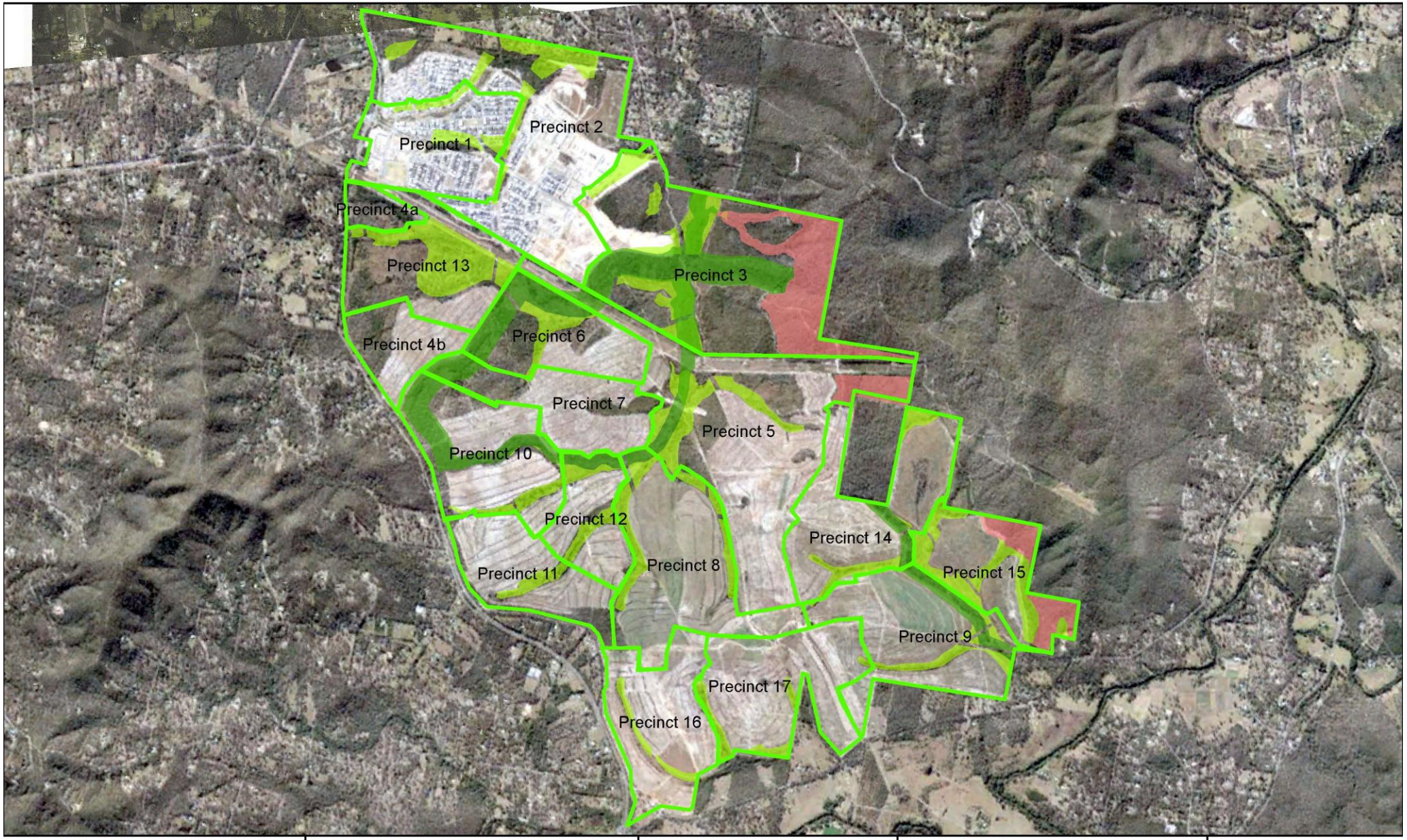

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Source: Corridor Areas/Conservation: Lend Lease 2016
Development Layout: Lend Lease 2016

Desclaimer: No warranty is given in relation the data (including accuracy, reliability, completeness, currency of suitability) and no liability is accepted (including without limitation liability in negligence) for any loss, damage or costs (including subsequent damage) relating to any use of the data. Data must not be used for direct marketing purposes or be used in breach of privacy laws.

File/Date: Yarrabilba
Date: 21/09/2016

N

0 145 290 580 870 1,160 1,450
Meters

Coordinate System: WGS 1984 Zone 56S Projection: Transerve Mercator

Legend

- Ongoing Conservation Areas
- Ongoing Fauna Corridor
- Ongoing Greenspace Corridor
- Precinct Boundaries (as of 22.03.17)

Figure 1
Yarrabilba site location

3 Rehabilitation areas

3.1 Purpose of habitat rehabilitation

Koala habitat rehabilitation is to be undertaken within "Existing Assessable Koala Habitat to be protected and managed" and "Offset Areas" within Fauna Corridors, Greenspace Corridors and Environmental Protection Zones. This totals an area of 1,981,771 m^2 (198.2 ha) in the offset areas and an additional 754,657 m^2 (75.5 ha) within existing assessable Koala habitat areas outside of offset areas, comprising a combined area of 2,736,428 m^2 (273.6 ha) to be rehabilitated.

The Koala habitat rehabilitation area has been divided into offset rehabilitation and habitat rehabilitation units and crossing rehabilitation units. This report is relevant to the offset rehabilitation units only.

3.2 Offset rehabilitation units (ORU)

Koala habitat rehabilitation is to occur within offset rehabilitation units as shown in Figure 2. Each rehabilitation unit (ORU1 to ORU23) is a mapped polygon, where the polygon boundaries are the mapped Pre-Clearing Regional Ecosystems. The Regional Ecosystem (RE) code applicable to each unit was determined by overlapping Pre-Clearing Regional Ecosystem mapping (Queensland Government 2015b) with Offset Requirement area mapping within the Fauna Corridors, Greenspace Corridors and Environmental Protection Zones.

The Table 1 presents a summary of rehabilitation units attributes, including:

- the area of the rehabilitation unit in square metres
- the corridor within which the rehabilitation unit is located
- the RE code for pre-clearing vegetation within the rehabilitation unit and the landzone / geology of the rehabilitation unit

It is noted that the minimum rehabilitation unit size is ~2,500 m^2 to reflect the mapping limitation of the Pre-Clearing Regional Ecosystems mapping dataset (Queensland Government 2015a).

3.3 Crossing rehabilitation units (CRU)

Rehabilitation and monitoring will also be undertaken where road and infrastructure is proposed to traverse an Offset Requirement area. Crossing rehabilitation units have been identified by overlaying the proposed internal road network (currently under review) with the Pre-Clearing Regional Ecosystem mapping (Queensland Government 2015a) and Offset Requirement area mapping. Each crossing rehabilitation unit (CRU1 to CRU15) is a mapped polygon overlayed over offset rehabilitation units. It is noted that these locations are indicative and may change with the final alignment of roads. Table 2 presents a summary of the crossing rehabilitation units, which are subject to rehabilitation actions outlined in this report.

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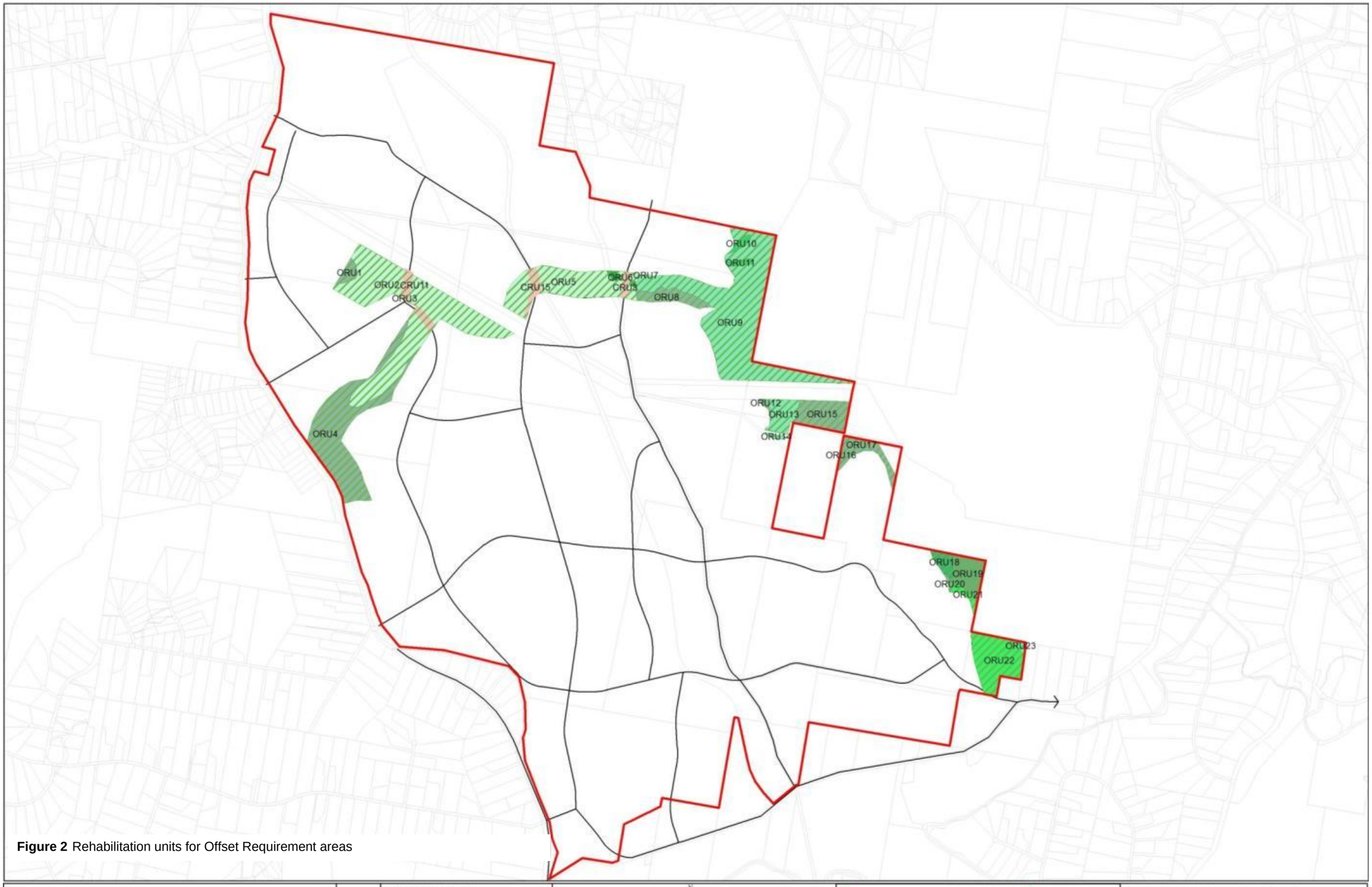

Figure 2 Rehabilitation units for Offset Requirement areas

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Table 1 Offset rehabilitation units (ORU) within the corridor network

Rehab. Unit	Area (m^2)	Corridor Type	RE Code(s)	Landzone / Geology
ORU1	16,933	Greenspace Corridor	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU2	439,297	Fauna Corridor / GreenSpace Corridor	12.3.11 / 12.3.6 / 12.3.7	Recent quaternary alluvial systems – alluvial river and creek flats
ORU3	1,451	Fauna Corridor	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks - undulating country on fine grained sedimentary rocks
ORU4	269,317	Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7 12.9-10.17 / 12.9-10.2	Recent quaternary alluvial systems – alluvial river and creek flats and Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU5	201,530	Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7	Recent quaternary alluvial systems – alluvial river and creek flats
ORU6	10,205	Fauna Corridor	12.3.11 / 12.3.7	Recent quaternary alluvial systems – alluvial river and creek flats
ORU7	7,264	Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7	Recent quaternary alluvial systems – alluvial river and creek flats
ORU8	46,711	Fauna Corridor	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU9	513,080	Environmental Protection / Fauna Corridor	12.9-10.17 / 12.9-10.19	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU10	8, 777	Environmental Protection	12.9-10.17	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU11	8,324	Environmental Protection	12.9-10.17	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU12	46,711	Environmental Protection	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU13	49,644	Environmental Protection	12.9-10.17 / 12.9-10.19 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU14	4,286	Environmental Protection	12.9-10.17 / 12.9-10.19 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU15	80,800	Environmental Protection	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks

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Rehab. Unit	Area (m^2)	Corridor Type	RE Code(s)	Landzone / Geology
ORU16	4,708	Environmental Protection	12.9-10.17 / 12.9-10.19	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU17	47,475	Environmental Protection	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU18	24,352	Environmental Protection	12.9-10.17	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU19	59,917	Environmental Protection	12.11.5 / 12.11.3	Recent quaternary alluvial systems – alluvial river and creek flats
ORU20	3,154	Environmental Protection	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks - undulating country on fine grained sedimentary rocks
ORU21	13,374	Environmental Protection	12.11.5 / 12.11.3	Recent quaternary alluvial systems – alluvial river and creek flats
ORU22	118,260	Environmental Protection	12.11.5 / 12.11.3	Recent quaternary alluvial systems – alluvial river and creek flats
ORU23	6,201	Environmental Protection	12.11.5	Recent quaternary alluvial systems – alluvial river and creek flats
Area	**1,981,771**			

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Table 2 Road and infrastructure crossing rehabilitation units (CRU) traversing offset rehabilitation units (ORU)

Crossing Rehab. Unit	Area (m^2)	Traversing ORU	Corridor Type	RE Code(s)	Landzone / Geology
CRU3	12,578	ORU5, ORU6, ORU7, ORU9	Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
CRU11	31,324	ORU2	Fauna Corridor	12.3.11 / 12.3.7	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
CRU15	22,138	ORU5	Greenspace Corridor / Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
Area	**66,040**				

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3.4 Pre-clearing Regional Ecosystems rehabilitation units

A short description of the pre-clearing Regional Ecosystems (RE) identified in the offset rehabilitation units and crossing rehabilitation units is provided in Table 3.

Table 3 Summary of pre-clearing Regional Ecosystems (RE) within offset rehabilitation units and crossing rehabilitation units

RE Code	RE short description (extract from Qld Herbarium RE Description Database)	*Vegetation Management Act* Class	Biodiversity Status
12.3.6	*Eucalyptus tereticornis, Casuarina cunninghamiana* subsp. *cunninghamiana* +/- *Melaleuca* spp. fringing woodland	Least concern	No concern at present
12.3.7	*Melaleuca quinquenervia* +/- *Eucalyptus tereticornis, Lophostemon suaveolens* open forest on coastal alluvial plains	Least concern	No concern at present
12.3.11	*Eucalyptus tereticornis* +/- *Eucalyptus siderophloia, Corymbia intermedia* open forest on alluvial plains	Of concern	Of concern
12.9-10.2	*Corymbia citriodora* subsp. *variegata* +/- *Eucalyptus crebra* open forest on sedimentary rocks	Least concern	No concern at present
12.9-10.4	*Eucalyptus racemosa* subsp. *racemosa* woodland on sedimentary rocks	Least concern	No concern at present
12.9-10.12	*Eucalyptus seeana, Corymbia intermedia, Angophora leiocarpa* woodland on sedimentary rocks	Endangered	Endangered
12.9-10.17	*Eucalyptus acmenoides, E. major, E. siderophloia* +/- *Corymbia citriodora* subsp. *variegata* woodland on sedimentary rocks	Least concern	No concern at present
12.9-10.19	*Eucalyptus fibrosa* subsp. *fibrosa* woodland on sedimentary rocks	Least concern	No concern at present
12.11.3	*Eucalyptus siderophloia, E. propinqua* +/- *E. microcorys, Lophostemon confertus, Corymbia intermedia, E. acmenoides* open forest on metamorphics +/- interbedded volcanics	Least concern	No concern at present
12.11.5	*Corymbia citriodora* subsp. *variegata, Eucalyptus siderophloia, E. major* open forest on metamorphics +/- interbedded volcanics	Least concern	No concern at present

(Source: QLD Government 2015a)

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4 Rehabilitation performance indicators

In accordance with the *EPBC Act 1999* decision notice, the Koala Habitat Rehabilitation Management Plan (Natura Consulting 2015) has been formulated reflecting the onsite rehabilitation requirements of Fauna and Green Space Corridors, Regional Ecosystems, drainage lines and post development fauna movement pathways within Offset Areas on the site. This plan identifies Koala habitat rehabilitation benchmarks and determines restoration actions to meet these benchmarks.

Each rehabilitation unit is to be rehabilitated to a vegetation structure and species composition that is in line with that of the appropriate pre-clearing RE (Table 4). The reference benchmark for rehabilitation of each rehabilitation unit is derived from the vegetation structure and species composition of the appropriate pre-clearing Regional Ecosystem (RE) (Table 4). These benchmarks quantify average canopy cover, shrub cover, ground cover, species richness and average height of the canopy and have been sourced from the Queensland Herbarium (Queensland Government 2015a). These technical descriptions are a compilation of data from multiple sites for canopy cover, shrub cover, and average stem density for each strata, groundcover and average species richness (Queensland Government 2015a). Through establishing these benchmarks, a reasonable comparison can be made between the floristic composition and vegetation structure of a given rehabilitation unit and the appropriate pre-clearing RE.

4.1 Performance indicators

The final benchmark for rehabilitation is derived from the definition of remnant vegetation under the *Vegetation Management Act 1999.* Vegetation can be mapped as remnant vegetation and associated essential habitat for Koalas if the canopy is 70% of the height, 50% of the cover and similar species composition of the appropriate pre-clearing RE (Queensland Government 2015a). Therefore, the final benchmark for rehabilitation is 70% of the reference benchmark cover (for canopy, shrub and ground-layer) and 50% of the reference benchmark height (for canopy and shrub layer) of the appropriate RE.

Six rehabilitation performance indicators were selected:

1 average canopy cover
2 average height of canopy
3 dominant canopy species
4 average shrub cover
5 average groundcover
6 species richness
7 weed cover

Weed cover needs to be considered for rehabilitation benchmarks for this site, particularly in the canopy where numerous exotic pine trees exist. Throughout the life of the development a weed cover of ≤5% is to be reached, and then maintained.

The reference and final benchmark vegetation structure and species composition for each of the pre-clearing RE's identified within the mapped rehabilitation units is identified in Table 4. Note that exotic species identified in Table 4 are to assist with identification purposes only and are to be controlled and managed, not planted or assisted.

Rehabilitation units are to be managed and restored until they reach the final benchmark condition as identified in Table 4 and objectives of the Habitat Rehabilitation and Management Plan. The objectives of this plan are long term and are likely to require more than 15 years to be achieved, within each rehabilitation unit, after commencement of implementation.

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Interim benchmarks are also provided whereby an assessment at regular intervals can be made on the progress of the rehabilitation / revegetation efforts towards achieving this plan's outcomes. Given this, adaptive management approaches can also be employed to redirect restoration approaches, in the event that interim benchmarks are not being met. Table 4 provides a summary of the timeframe to achieve the interim and final benchmarks.

For Interim Benchmark years 1 to 10, vegetation structure has been quantified from a cumulative growth curve (CGC), which for biological organisms including trees and shrubs, is sigmoidal. As the reference benchmarks applied for this report are at the Regional Ecosystem level and site data and long term tree and shrub growth curves are not available for Yarrabilba, we have derived general growth curves for each Regional Ecosystem. This is based on a sigmoidal growth curve, the average reference benchmark height of the stratum, the minimum height at which regrowth vegetation is considered to be of equivalent height as the RE (50% of reference benchmark height), and the average height of tubestock (20 cm) that is predominately used for revegetation in southeast Queensland.

The final benchmark at year 15 is 70% of the reference benchmark cover (for canopy, shrub and ground-layer) and 50% of the reference benchmark height (for canopy and shrub layer) of the appropriate pre-clearing RE.

4.2 Contingency measures and corrective actions

4.2.1 Meeting benchmarks

During the course of monitoring, if interim benchmarks are not being met, the timeframes to achieve the final benchmarks will be reviewed and extended, whereby Lendlease will continue to undertake rehabilitation works with continued monitoring until the final benchmarks are met. The review of the success of meeting interim benchmarks will be undertaken at each monitoring event and reported on. Where the extension of rehabilitation works is required for particular rehabilitation units, discussions will be undertaken with the Department of Environment, to ensure that any additional requirements are also highlighted and addressed.

4.2.2 As constructed data

Constructed data and surveyed boundaries will be provided for each rehabilitation unit, within three months of completion of earthworks. This will be undertaken to test and demonstrate compliance within the offset area (195 ha) requirement.

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Table 4 Reference, interim and final benchmark vegetation structure for each pre-clearing RE detailed for rehabilitation units (ORU and HRU) and crossing rehabilitation units (CRU)

Benchmark Condition (where rehabilitation units are treated individually, at least 70% of height and 50% of cover values to be attained within first 15 years of commencement of rehabilitation works)											
RE Code	**Name**	**Status (VMA)**	**Biodiversity Status**	**Habitat Rehabilitation Unit**				**Crossing Rehabilitation Unit**			
12.3.6	***Melaleuca quinquenervia* +/- *Eucalyptus tereticornis, Lophostemon suaveolens* open forest on coastal alluvial plains**	Least concern	No concern at present	ORU2, ORU4, ORU5, ORU7				CRU3, CRU15			
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				10.0	1.5			1.5	0.5	6.0	
Interim Benchmark by 2 years				14.0	3.0			2.0	0.8	10.0	
Interim Benchmark by 3 years				16.0	4.0			2.5	1.2	15.0	
Interim Benchmark by 5 years				22.0	6.0			3.0	1.4	20.0	
Interim Benchmark by 10 years				28.0	9.2			4.0	1.5	25.0	
Final Benchmark by 15 years				**30.5**	**10.7**			**4.5**	**1.6**	**29.2**	**-**
Reference Benchmark (Pre-Clearing RE)				**60.9**	**15.3**			**8.9**	**2.3**	**58.4**	**33.3 +/- 10.5**
12.3.7	***Eucalyptus tereticornis*, *Casuarina cunninghamiana* subsp. *cunninghamiana* +/- *Melaleuca* spp. fringing woodland**	Least concern	No concern at present	ORU2, ORU4, ORU5, ORU6, ORU7				CRU3, CRU11, CRU15			
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				5.5	1.6	2.0	0.8	2.5	0.5	6.0	
Interim Benchmark by 2 years				6.0	2.9	3.0	2.7	3.0	0.8	7.0	
Interim Benchmark by 3 years				7.0	4.1	4.0	3.7	3.5	1.2	8.0	
Interim Benchmark by 5 years				9.0	6.2	5.9	5.2	4.0	1.4	10.0	
Interim Benchmark by 10 years				12.0	10.1	9.3	7.3	6.0	1.5	12.0	
Final Benchmark by 15 years				**13.3**	**13.6**	**11.5**	**8.2**	**6.6**	**1.6**	**14.4**	**-**
Reference Benchmark (Pre-Clearing RE)				**26.6**	**19.4**	**15.3**	**9.0**	**13.2**	**2.3**	**28.7**	**52.8 +/- 7.5**

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Benchmark Condition (where rehabilitation units are treated individually, at least 70% of height and 50% of cover values to be attained within first 15 years of commencement of rehabilitation works)											
RE Code	**Name**	**Status (VMA)**	**Biodiversity Status**	**Habitat Rehabilitation Unit**				**Crossing Rehabilitation Unit**			
12.3.11	***Eucalyptus tereticornis* +/- *Eucalyptus siderophloia*, *Corymbia intermedia* open-forest on alluvial plains**	Of concern	Of concern	ORU2, ORU4, ORU5, ORU6, ORU7				CRU3, CRU11, CRU15			
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				7.0	1.6	2.0	0.8	2.0	0.4	1.5	
Interim Benchmark by 2 years				10.0	3.0	3.0	2.8	4.0	0.7	2.0	
Interim Benchmark by 3 years				12.0	4.2	4.2	3.8	5.0	1.1	3.0	
Interim Benchmark by 5 years				18.0	6.4	6.4	5.5	7.0	1.3	4.5	
Interim Benchmark by 10 years				22.0	10.7	10.7	8.2	9.0	1.5	7.0	
Final Benchmark by 15 years				**25.6**	**16.7**	**13.9**	**9.6**	**10.9**	**1.9**	**8.5**	**-**
Reference Benchmark (Pre-Clearing RE)				**51.1**	**23.8**	**23.9**	**11.3**	**21.7**	**2.7**	**17**	**40.6 +/- 8.5**
12.9-10.2	***Corymbia citriodora* subsp. *variegata* +/- *Eucalyptus crebra* open forest on sedimentary rocks**	Least concern	No concern at present	ORU1, ORU3, ORU4, ORU8, ORU12, ORU13, ORU14, ORU15, ORU17, ORU20							
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				6.0	1.6	2.0	0.8	6.0	0.4	6.0	3.0
Interim Benchmark by 2 years				10.0	2.9	2.9	2.8	6.5	0.7	7.0	4.0
Interim Benchmark by 3 years				12.0	4.2	4.0	3.8	7.0	1.1	12.0	5.0
Interim Benchmark by 5 years				18.0	6.3	6.0	5.3	8.5	1.3	18.0	7.0
Interim Benchmark by 10 years				22.0	10.5	9.6	7.7	11.4	1.5	22.0	9.0
Final Benchmark by 15 years				**26.8**	**15.5**	**11.9**	**8.9**	**15.1**	**1.8**	**23.6**	**10.8**
Reference Benchmark (Pre-Clearing RE)				**53.5**	**22.2**	**16.5**	**10.1**	**21.6**	**2.5**	**47.2**	**21.6**

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Benchmark Condition (where rehabilitation units are treated individually, at least 70% of height and 50% of cover values to be attained within first 15 years of commencement of rehabilitation works)												
RE Code	**Name**	**Status (VMA)**	**Biodiversity Status**	**Habitat Rehabilitation Unit**				**Crossing Rehabilitation Unit**				
12.9-10.17	***Eucalyptus acmenoides, Eucalyptus major, Eucalyptus siderophloia +/- Corymbia citriodora subsp. variegata* woodland on sedimentary rocks**	Least concern	No concern at present	ORU1, ORU3, ORU4, ORU8, ORU9, ORU10, ORU11, ORU12, ORU13, ORU14, ORU15, ORU16, ORU17, ORU18, ORU20								
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**	
Interim Benchmark by 1 year				6.0	1.6	2.0	0.8	6.0	0.6	10.0		
Interim Benchmark by 2 years				10.0	3.0	3.0	2.8	7.0	1.0	20.0		
Interim Benchmark by 3 years				12.0	4.2	4.3	3.9	10.0	1.5	25.0		
Interim Benchmark by 5 years				18.0	6.4	6.5	5.7	14.0	1.8	30.0		
Interim Benchmark by 10 years				22.0	10.9	11.3	8.9	16.0	2.2	35.0		
Final Benchmark by 15 years				**27.2**	**18.2**	**15.0**	**10.4**	**20.0**	**2.8**	**43.9**	-	
Reference Benchmark (Pre-Clearing RE)				**54.3**	**26.0**	**30.5**	**12.9**	**40.0**	**4.0**	**87.8**	**36.5 +/- 15.1**	

12.9-10.19	***Eucalyptus fibrosa subsp. fibrosa* woodland on sedimentary rocks**	Least concern	No concern at present	ORU9, ORU14, ORU16								
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**	
Interim Benchmark by 1 year				6.0	1.6	2.0	0.8	2.5	0.4	2.5		
Interim Benchmark by 2 years				7.0	3.0	2.9	2.7	4.0	0.7	3.0		
Interim Benchmark by 3 years				9.0	4.2	4.0	3.7	5.0	1.1	4.0		
Interim Benchmark by 5 years				12.0	6.3	6.0	5.2	7.0	1.3	6.0		
Interim Benchmark by 10 years				15.0	10.5	9.6	7.3	9.0	1.5	8.0		

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Benchmark Condition (where rehabilitation units are treated individually, at least 70% of height and 50% of cover values to be attained within first 15 years of commencement of rehabilitation works)											
RE Code	**Name**	**Status (VMA)**	**Biodiversity Status**	**Habitat Rehabilitation Unit**				**Crossing Rehabilitation Unit**			
Final Benchmark by 15 years				**20.9**	**15.8**	**11.9**	**8.2**	**9.6**	**1.7**	**8.2**	-
Reference Benchmark (Pre-Clearing RE)				**41.8**	**22.5**	**16.4**	**9.0**	**19.1**	**2.4**	**16.4**	**30.1 +/- 4.6**

12.11.3	***Eucalyptus siderophloia, E. propinqua* +/- *E. microcorys, Lophostemon confertus, Corymbia intermedia, E. acmenoides* open forest on metamorphics +/- interbedded volcanics**	Least concern	No concern at present	ORU19, ORU21, ORU22							
				Average T1 Canopy Cover (%)	**Average T1 Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				6.0	1.6	1.6	1.0	1.5	0.4	3.0	
Interim Benchmark by 2 years				10.0	3.0	3.0	2.7	2.0	0.7	5.0	
Interim Benchmark by 3 years				14.0	4.2	4.2	3.6	2.5	1.1	7.0	
Interim Benchmark by 5 years				20.0	6.4	6.5	4.9	4.0	1.3	10.0	
Interim Benchmark by 10 years				25.0	10.8	11.2	6.8	4.5	1.5	12.0	
Final Benchmark by 15 years				**31.1**	**17.6**	**14.9**	**7.5**	**5.3**	**1.7**	**15.4**	-
Reference Benchmark (Pre-Clearing RE)				**62.1**	**25.2**	**30.0**	**8.0**	**10.5**	**2.4**	**30.8**	**55.1 +/ 15.4**

12.11.5	***Corymbia citriodora* subsp. *variegata*, *Eucalyptus siderophloia*, *E. major* open forest on metamorphics +/- interbedded volcanics**	Least concern	No concern at present	ORU19, ORU21, ORU22, ORU23							
				Average T1 Canopy Cover (%)	**Average T1 Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				6.0	1.6	1.6	1.0	0.5	0.4	8.0	
Interim Benchmark by 2 years				9.0	3.0	2.8	2.7	1	0.7	10.0	
Interim Benchmark by 3 years				12.0	4.2	3.8	3.7	1.5	1.1	14.0	
Interim Benchmark by 5 years				15.0	6.4	5.4	5.3	2	1.3	18.0	
Interim Benchmark by 10 years				18.0	10.8	7.9	7.7	2.5	1.5	20.0	

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Benchmark Condition (where rehabilitation units are treated individually, at least 70% of height and 50% of cover values to be attained within first 15 years of commencement of rehabilitation works)											
RE Code	**Name**	**Status (VMA)**	**Biodiversity Status**	**Habitat Rehabilitation Unit**				**Crossing Rehabilitation Unit**			
Final Benchmark by 15 years				**21.8**	**15.8**	**9.2**	**8.7**	**2.9**	**1.6**	**23.0**	-
Reference Benchmark (Pre-Clearing RE)				**43.5**	**22.5**	**10.6**	**9.9**	**5.8**	**2.3**	**46.0**	**48.0 +/ 12.3**

Adapted from Queensland Government (2015a).* No pre-defined benchmarks for this RE are provided within the RE technical descriptions (Queensland Government 2015) and therefore, these numbers have been based on data collected in the field from previous assessments and reference sites within this RE type.

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5 Monitoring methodology

The following monitoring program was implemented to capture baseline data prior to rehabilitation treatments being applied. Adaptive management strategies will be used where a rehabilitation treatment does not produce the desired result. When this occurs, the treatment will be identified and/or modified.

For this monitoring program, a minimum of two monitoring sites per rehabilitation unit is sufficient to identify any major changes and to provide a 'snap shot' of ecological conditions. Monitoring in this way will allow the ongoing collection of information to demonstrate the effectiveness of habitat rehabilitation efforts, and the frequency of monitoring activities will enable management prescriptions to be adjusted to bring about any necessary changes and corrective actions (adaptive management).

5.1 Sites

Vegetation monitoring for the 4th monitoring period occurred in a network of 59 monitoring sites (refer to Table 1). The final location of each monitoring site within its representative rehabilitation unit was identified by GPS coordinates and direction (compass bearing). Monitoring site locations are identified in Figure 3.

Site locations have been permanently marked by two steel pickets with yellow safety caps placed approximately 50 m apart. Each picket is clearly labelled identifying the site number.

The following methodology will be applied to monitor at each site.

5.2 Photo point monitoring

For each site, a permanently marked photo point has been established at the first marker picket and photographing towards a second marker picket at 10 m along the relevant compass bearing. A yellow plastic picket cap was installed on starting point (0 m) star pickets, with the site number written in black permanent marker, to identify the site. All photos were taken such that the 0 m picket was located in the bottom left hand corner of the photo with the site number visible.

The photos were saved with the following information recorded for each file:

- site number
- survey (i.e. 4th mon.)
- date

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Figure 3 Offset Area monitoring locations

5.3 Transect and quadrat monitoring

Quantitative site data, including the attributes of species richness, percentage foliage cover for the ground layer, shrub and canopy layers, canopy height, and weed cover are to be collected from field transects and quadrats established at each of the monitoring sites:

- A 50 m transect was placed between the 0 m and 50 m metal pickets. Ten metre intervals were marked permanently with wooden stakes that had flagging tape attached for high visibility.

- Quadrats were placed along the transect:
  - 50 x 10 m plot positioned at the transect starting at 0 m on the right hand side of the transect
  - 1 x 1 m subplots positioned at staked intervals 0 m, 10 m, 20 m, 30 m and 40 m. Adjustments were made for each subplot if its positioning was placed over a trunk, fallen tree or roots. Installation of permanent stakes ensures consistent sampling and adequate replicaton for data collection in future monitoring periods.

Given the above, each monitoring site had the information collected, as detailed in (Table 5). This benchmark monitoring process has also been undertaken at 1 year, 18 months, 2 years (current monitoring period) and will continue at 2.5 years, 3 years, 4 years, 5 years, 10 years and 15 years. Reporting from each of the monitoring events shall be provided to the Department of Environment within 4 weeks of completion of monitoring.

Table 5 Data collected at monitoring sites

Method of collection	Data collected
50 m x 10 m quadrat (plot)	Species richness, tubestock survival, height of each canopy species
50 m transect	Canopy species cover and height, shrub cover
Five 1 x 1 m quadrats (subplot)	Percentage cover in ground layer (including regenerating native canopy cohorts)

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6 Results

6.1 Photo-point monitoring

Photo monitoring results for all surveyed sites, are reported in Table 6, indicating the variety of vegetation types and condition. This photo sample was considered representative of the entire transect in most cases, with the vegetation type and structure remaining fairly consistent throughout individual sites. In congruence with previous monitoring periods, the vegetation varies from mixed native grasses such as *Imperata cylindrica* and Bracken Fern (*Pteridium esculentum),* mixed with exotic grass pasture in the understorey with sparse regenerating shrubs and trees to established woodland eucalypt forest with intact structure and species composition. Note that a number of sites continue to show evidence of dense *Lantana camara* infestations, these sites are typically at an advanced state of natural regeneration with common canopy tree sized eucalypts and mixed acacia species. Felled and fallen trees can also be seen within many of the photo monitoring points. A number of these are exotic pine (*Pinus elliottii*) which have been hand felled as part of the ongoing weed management process. There are several sites also containing immature *Pinus elliottii* in the understorey and shrub layers.

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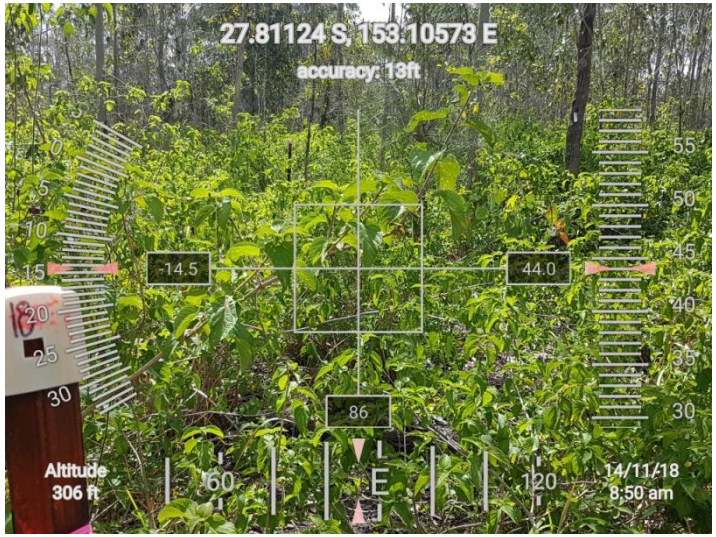
Table 6 Photo monitoring images

Site 18 – 14/11/2018



Site 19 – 14/11/2018

Site 23 – 7/11/2018

Site 24 – 23/11/2018

Site 25 – 14/11/2018

Site 26 – 7/11/2018

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Site 27 – 24/10/2018

Site 28 – 23/11/2018

Site 29 – 07/11/2018

Site 30 – 07/11/2018

Site 31 – 07/11/2018

Site 32 – 02/11/2018

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Site 33 – 02/11/2018

Site 44 – No site photo

Site 45 – 24/10/2018

Site 46 – 25/10/2018

Site 47 – 24/10/2018

Site 48 – No data, removed in 2nd monitoring period

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Site 49 – No site photo

Site 54 – 24/10/2018

Site 55 – 25/10/2018

Site 56 – 23/10/2018

Site 57 – 23/10/2018

Site 58 – 23/10/2018

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Site 59 – 24/10/2018

Site 60 – 24/10/2018

Site 61 – 25/10/2018

Site 62 – 01/11/2018

Site 63 – 30/10/2018

Site 64 – 31/10/2018

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Site 65 – 30/10/2018

Site 66 – 25/10/2018

Site 67 – 31/10/2018

Site 68 – 31/10/2018

Site 69 – 31/10/2018

Site 101 – Site removed due to clearing

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Site 102 – 01/11/2018

Site 103 – 01/11/2018 (Ignore “101” on post)

Site 104 – 01/11/2018

Site 107 – No data, removed in 2nd monitoring period

Site 109 – No site photo

Site 110 – 06/11/2018

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Site 111 – 01/11/2018

Site 112 – 06/11/2018

Site 113 – 02/11/2018

Site 114 – No data, removed in 3rd monitoring period

Site 115 – 06/11/2018

Site 123 – 16/11/2018

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Site 124 – 13/11/2018

Site 127 – 13/11/2018

Site 128 – 16/11/2018

Site 129 – 16/11/2018

Site 130 – 09/11/2018

Site 131 – 16/11/2018

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Site 132 – 09/11/2018

Site 133 – 30/11/2018

Site 134 – 09/11/2018

Site 135 – 08/11/2018

Site 136 – 21/11/2018

Site 137 – 21/11/2018

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Site 138 – 21/11/2018

Site 143 – 08/11/2018

Site 144 – 08/11/2018

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6.2 Transect and quadrat monitoring

6.2.1 Species richness

NB: During this monitoring period, site 101 was unable to be located in the field and therefore removed as a survey site. This may have been due to clearing or changes to the landscape that occurred after the porevious monitoring period. Original sites 48, 107, 114 and 144 had all been removed in previous monitoring period and were not reinstated. Site 48 had been removed as it was within 1 m of a vehicular passage way and was being damaged, and was not replaced as planned at the time of the previous monitoring report.

During the 4th monitoring period in October-November 2018, a total of 334 species were recorded within different strata at the 59 monitoring sites in the Offset Area. This is an increase of 44 species from the 3rd monitoring period.

Species richness within sites ranged from 16 to 69 native species (minus weeds), with 28.8 species per site observed on average. This is a 2.4% increase in average native species richness since the 3rd monitoring period.

Canopy tree species (T1 stratum) totalled 19 species (10 species less than 3rd monitoring period). Those most common across the offset area varied slightly from the 3rd monitoring period and included *Corymbia trachyphloia* (10 sites), *Eucalyptus siderophloia* and *E. fibrosa* (8 sites) and a number of species occurring at 4 of the offset sites, including *C. citriodora, E. acmenoides, E. planchoniana* and *E. resinifera*.

Small tree species (T2-T3) totalled 33 species (8 species more than 3rd monitoring period). Those common across the offset area varied slightly from the 3rd monitoring period and included *Lophostemon suaveolens, Eucalyptus siderophloia, L. Confertus, Corymbia intermedia, E. tereticornis* and *E. acmenoides* (from highest to lower abundance).

Shrub species (S1 stratum) totalled 57 species (11 species less than 3rd monitoring period). Those that were commonly observed across the offset area included *Acacia leiocalyx, Acacia disparrima, Acacia falcata, Alphitonia excelsa* and *Ozothamnus diosmifolius* (from highest to lower abundance).

Of all the species recorded, 53 were exotic (15.9% of total) (a non significant proportional decrease of 0.4% since 3rd monitoring period). This included one T2 species (*Pinus elliottii*), five shrub species including *Pinus ellioti, Cinnamomum camphora, Lantana camara, Ochna serrulata* and *Urena lobata* (from highest to lowest number of sites). The ground layer contained 47 species (89.2% of weed species recorded across sites), with 32 herbaceous species (6 more than 3rd monitoring period) and 11 graminoids (1 less than 3rd monitoring period). Ten of these were present at greater than 10 monitoring sites. This includes *Lantana camara* 48 sites (26 more than 3rd monitoring period), *Passiflora suberosa* (24 sites, 13 more than 3rd monitoring period), *Andropogon virginicus* (21 sites (4 more sites than 3rd monitoring period), *Ageratum houstonianum* (18 sites (7 more than 3rd monitoring period)), *Lantana montevidensis* (17 sites, same as 3rd monitoring period), *Digitaria didactyla* (17 sites), *Pinus elliotti* (16 sites), *Senecio madagascarensis* (15 sites), *Conyza bonariensis* (12 sites, 1 less than 3rd monitoring period) and *Emilia sonchifolia* (12 sites, 3 less than 3rd monitoring period).

6.2.2 Tree canopy cover and height (T1)

Of the sites with canopy trees present (T1 stratum), tree canopy cover varied from 2% to 56.5% overlapping cover, with average total canopy cover of 22.6%, 2.2% more than 3rd monitoring period (Table 7). Canopy species with high canopy cover were *Eucalyptus fibrosa* (a number of *E.*

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siderophloia were reidenified as *E. fibrosa* in this monitoring period), *Corymbia trachyphloia, E. planchoniana and E. siderophloia* (in order of highest to lower).

Twenty seven of the sites (45.7%) did not have any canopy trees present, including sites 23, 24, 25, 26, 27, 28, 32, 33, 44, 47, 49, 54, 56, 57, 58, 59, 60, 61, 110, 112, 113, 129, 130, 132, 134, 138 and 144.

Of the sites with canopy trees present within the T1 stratum, tree height varied from 12 m to 22 m, with the average tree height 16.5 m, which was 0.7 m higher than average tree height during the 3rd monitoring period (Table 7). Canopy species with high average canopy height were *Corymbia trachyphloia, Eucalyptus fibrosa, E. siderophloia, Corymbia intermedia* and *Eucalyptus planchoniana* (in order of highest to lower).

Total weed crown cover (largely *Pinus elliottii* and *Cinnamomum camphora* in the 1st monitoring period) remained at 0% from 2nd monitoring period, following management activities. For the 3rd and 4th (current) monitoring periods, this has remained at 0%.

6.2.3 Small tree cover and height (T2-T3)

Of the sites with small trees present (T2 – T3 stratum), cover varied from 0.5% to 85.5% overlapping cover, with average total canopy cover of 26.7%, which was 2.9% lower than in the 3rd monitoring period. Small tree species with high average cover were *Acacia disparrima, Lophostemon confertus, Eucalyptus acmenoides, L. Suaveolens* and *E. siderophloia* (from highest to lower).

Of the sites surveyed, only one (site 115) did not have any small trees (T2-T3 strata) present. This is one site less than during the 3rd monitoring period. Sites 101 and 110, which had no small trees present in the 3rd monitoring period, had improved, with cover recorded at 2.5% and 32% in this monitoring period and average height being 11 m and 7 m respectively.

Of the sites with small trees present within the T2-T3 stratum, tree height varied from 5 m to 14.1 m, with the average tree height 9.0 m, which was 0.5 m lower than average tree height during the 3rd monitoring period (Table 7). Canopy species with high average canopy height were *Eucalyptus siderophloia, E. acmenoides, Corymbia trachyphloia, Lophostemon suaveolens* and *L. confertus* (in order of highest to lower).

6.2.4 Shrub cover and height (S1)

Of the sites with shrubs present, shrub cover varied from 0.2% to 44.5% overlapping cover, with average total canopy cover of 11.2% (1.3% less average cover than 3rd monitoring period). Shrub height varied from 1.5 m to 4.9 m with an average height of 2.5 m, down by 0.1 m since the 3rd monitoring period. Shrub species with high cover within sites were *Acacia leiocalyx, Lantana camara, A. disparrima, Alphitonia excels* and *Lophostemon confertus* (in order of highest to lower average cover).

98% of sites (58 out of 59 sites) during this monitoring period contained shrub cover, a decrease of 2% since the 3rd monitoring period. Site 132 was the only site where ground cover was absent this monitoring period.

6.2.5 Ground cover (G1)

Consistent with the 2nd and 3rd monitoring periods as well as the baseline study, all sites had living ground cover layer. Ground-layer cover ranged from 2.8 to 99.8%, which was higher than the

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previous monitoring period. The increase was also reflected in the average living ground-layer cover, which was 48.9%, 14.9% higher than in the 3rd monitoring period. The weed grasss *Andropogon virginicus* maintained the highest amount of cover in the ground layer and was present at 35% of sites. Other ground cover species with high cover within sites included the native grasses *Imperata cylindrica* and *Entolasia stricta,* the weed shrub *Lantana camara* and a diversity of other native species - *Pteridium esculentum, Lomandra longifolia* and *Cymbopogon refractus* (in order of highest to lower average cover). A lower proportion of ground-layer species were weeds 13.7% (2.5% less than the 3rd monitoring period), indicating a continued decline since the 2nd monitoring period.

6.2.6 Weed incursion

Weeds in the ground layer were present at 47 sites (79%, a 1% decrease in the number of sites containing weeds since the 3rd monitoring period) with an average weed cover of 13.7% showing a 2.5% decrease in weed cover since the 3rd monitoring period. There was a decrease in maximum average cover from 52.4% to 45.6% at site 61 (6.8% less maximum cover). For sites that contained weeds in the ground layer, weed cover varied from 0.4% (site 127). Overall, weed cover in the ground layer had increased at 21 sites (35.5%, sites 18, 19, 20, 27, 30, 31, 32, 33, 44, 46, 56, 57, 61, 66, 109, 129, 130, 135, 136, 137 and 144) and decreased at 25 sites (42.3%) since the 3rd monitoring period. Sites with highest weed cover include sites 18 (31.6%, 15.6% more than 3rd monitoring period), 26 which also had high cover in 3rd monitoring period (39.6, 12.8% less than 3rd monitoring period), 57 (39.6%, 0.8% increase since 3rd monitoring period), 60 (41.2%, 3.2% less than 3rd monitoring period), 61 (45.6%, 1.6% more than in 3rd monitoring period), 111 which also had high cover in 3rd monitoring period (32.4%, 18.8% less than 3rd monitoring period) and 112 which also had high cover in 3rd monitoring period (35.6%, 7.6% less than 3rd monitoring period). These sites are located in either within the Precinct 3 Fauna Corridor area (sites 57, 60, 61) or within the Greenspace Corridors in Precinct 4 (site 18), Precinct 5 (site 26 and 111) and Precinct 13 (site 112).

Weed species in the ground layer with highest cover were similar to that of the 3rd monitoring period, comprising *Andropogon virginicus* (approximately 2-fold more abundant than any other weed), *Lantana camara*, immature *Pinus elliotti, Passiflora suberosa* and *Setaria sphacelata* (in order of highest to lower abundance).

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Table 7 4th monitoring period species richness, average canopy height within the canopy (T1), sub-canopy (T2-T3) and shrub layer (S1) and average total cover within the canopy (T1), sub-canopy (T2-T3), shrub layer (S1) and ground layer (G1). Purple shading indicates removed sites.

Site	Species Richness (incl. weeds)					Height (m)			Overlapping Crown Cover (%)					Av. Ground Cover (%)	
	Canopy (T1)	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	Ground Layer (G1)	Total (excl. weeds)	*Canopy (T1)*	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	*Canopy (T1)*	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	*Total Weed Crown Cover*	*Total Crown Cover*	*Total Ground Layer*	*Total Weed Ground Layer*
18	0	2	1	37	28	15.5	5.9	2.6	27	8.9	25.1	0	61.0	55.2	31.6
19	2	1	2	38	32	15.5	6.9	2.5	26	8.2	11	0	45.2	28.8	6.8
23	0	2	3	36	32	0	6.8	2.6	0	11	7.4	0	18.4	66.4	3.2
24	0	2	1	37	26	0	8.1	10.5	0	22.5	2.3	0	24.8	61.2	42
25	0	3	2	31	30	0	10.9	2.5	0	44.5	5.9	0	50.4	29.6	2
26	0	5	3	45	40	0	11.0	2.5	0	10	7.2	0	17.2	64.4	39.6
27	0	5	6	22	25	0	5.5	2.8	0	21	38.8	0	59.8	18.4	6
28	0	1	5	37	33	0	5.0	2.7	0	3.5	3.4	0	6.9	58.8	10.4
29	0	4	0	36	26	14.0	8.9	2.0	6	19.5	2.9	0	28.4	38.8	18
30	4	2	1	62	50	16.6	10.9	2.0	45	14	0.2	0	59.2	38.8	4
31	0	1	3	25	22	14.0	9.9	2.1	2	23.2	2.3	0	27.5	8.8	1.2
32	0	6	3	9	14	0	7.8	3.1	0	61.3	8.5	0	69.8	9.2	5.6
33	0	5	1	18	18	0	7.8	3.0	0	16	26.1	0	42.1	15.2	6
44	0	2	1	15	14	0	5.3	2.9	0	9	44.5	0	53.5	26.4	12.8
45	1	4	3	26	24	20.0	11.2	2.0	10	30.5	4.5	0	45.0	40.8	8.8
46	1	3	6	34	33	20.0	14.1	2.3	4	44.5	2.3	0	50.8	39.2	11.2
47	0	3	0	13	11	0	6.9	2.4	0	4.3	20.4	0	24.7	31.2	5.6
48															
49	0	8	1	27	28	0	8.2	2.0	0	8	20	0	28.0	43.6	4.4
54	0	4	4	21	23	0	9.0	2.6	0	0.5	8.8	0	9.3	50.8	6
55	3	7	4	31	40	22.0	11.2	2.9	16	46.5	10.8	0	73.3	23.6	3.2
56	0	8	5	25	34	0	7.8	2.4	0	20	9.7	0	29.7	33.6	3.6
57	0	5	2	32	34	0	6.6	3.3	0	11.5	21	0	32.5	51.6	39.6
58	0	4	4	22	28	0	9.1	2.7	0	12.5	21.7	0	34.2	36.4	14
59	0	2	3	22	20	0	8.3	2.8	0	9.5	3.2	0	12.7	50.8	19.6
60	0	4	1	20	21	0	5.7	3.7	0	8.5	4.9	0	13.4	51.2	41.2
61	0	2	3	33	29	0	6.1	2.9	0	16.5	11.5	0	28.0	52.8	45.6
62	1	5	4	14	24	13.3	8.3	1.7	21	18	9.5	0	48.5	17.6	0
63	4	0	6	14	24	17.5	6.6	2.6	37	11	16	0	64.0	31.2	0
64	1	3	3	24	31	16.3	9.8	1.8	14	19	4.2	0	64.0	19.2	0
65	0	0	7	28	35	17.2	10.6	2.8	39	28.5	13.5	0	37.2	36.4	0
66	1	5	7	29	37	16.0	8.2	2.4	14	28.5	25.2	0	81.0	34	1.2
67	1	4	6	38	44	16.6	8.1	2.5	32	24	9.6	0	67.7	31.2	1.2
68	1	3	4	24	32	16.0	8.9	2.3	8	31.5	3	0	65.6	38	0
69	2	2	2	15	21	15.9	12.2	1.5	18.5	8.2	1	0	42.5	26.8	0
101															
102	2	3	2	11	17	13.2	8.3	2.3	56.5	19.2	2.8	0	78.5	4.4	0
103	5	1	1	29	33	17.4	11.4	1.5	28.5	9.5	3.5	0	41.5	18.8	0
104	3	3	5	13	23	15.9	9.5	1.6	22	14.5	3.3	0	39.8	26.4	0
107															
109	4	1	2	27	30	16.1	7.9	2.6	23	12.5	3.5	0	39.0	9.2	0.8

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Site	Species Richness (incl. weeds)					Height (m)			Overlapping Crown Cover (%)					Av. Ground Cover (%)	
	Canopy (T1)	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	Ground Layer (G1)	Total (excl. weeds)	*Canopy (T1)*	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	*Canopy (T1)*	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	*Total Weed Crown Cover*	*Total Crown Cover*	*Total Ground Layer*	*Total Weed Ground Layer*
110	0	4	2	21	18	0	11.0	3.5	0	2.5	0.3	0	2.8	54	14
111	2	3	1	21	22	2.0	7.0	2.2	12	32	124.2	0	168.2	43.6	32.4
112	0	5	0	42	34	0	6.1	3.8	0	23.7	10.5	0	34.2	70.4	35.6
113	0	8	2	28	31	0	7.0	2.8	0	3	6.3	0	9.3	59.2	26.4
114															
115	1	1	2	25	21	13.0	0	2.4	3	0	7.6	0	10.6	55.6	18.4
123	3	0	5	17	25	15.9	8.9	2.0	29	28	3.2	0	60.2	16.8	0
124	3	3	1	20	26	14.6	7.8	2.8	47	16.5	8	0	71.5	18.4	0
127	3	1	2	33	32	14.5	9.4	1.8	31.5	14.5	1.3	0	47.3	18.8	0.4
128	7	2	3	40	44	17.4	9.1	2.8	53.5	16.5	8.2	0	78.2	33.2	7.2
129	0	7	4	42	42	0	6.2	2.4	0	54	19.7	0	73.7	38	20.4
130	0	9	5	27	38	0	12.4	2.7	0	63	6.5	0	69.5	14.4	7.2
131	1	8	1	30	36	22.5	12.2	2.3	9	49.5	5.8	0	64.3	18.4	0.8
132	0	7	0	14	17	0	10.9	0	0	30.5	0	0	30.5	19.6	4.4
133	2	8	1	20	28	22.3	11.1	4.9	6	62.5	16	0	84.5	18.4	4
134	0	4	3	17	22	0	8.4	2.7	0	73	5.5	0	78.5	14	0
135	0	10	1	39	40	0	10.1	2.5	0	66	10.5	0	76.5	38.8	15.6
136	0	8	4	27	33	0	10.0	2.8	0	85.5	14.3	0	99.8	12.4	2.4
137	0	8	1	41	43	0	12.9	2.4	0	47.3	30.5	0	77.8	43.6	30.8
138	0	8	1	31	33	0	13.3	2.9	0	64	24.2	0	88.2	34	15.6
143	0	5	4	13	21	16.9	10.2	1.5	25	49.5	10.2	0	84.7	31.2	9.6
144	0	0	0	0	0	16.0	11.1	1.6	0	55.5	7.2	0	62.7	40.4	3.2
*	**2.4 (-1.7)**	**4.3 (+2.6)**	**3.0 (-2.0)**	**27.0 (+5.7)**	**28.8 (+2.4)**	**16.1 (+0.3)****	**9.0 (-0.5)**	**2.7 (+0.1)****	**22.9 (+2.5)**	**26.7 (+2.9)**	**12.8 (+0.3)****	**0 (0)****	**50.6 (+16.6)**	**34.1 (+1.1)**	**13.7 (-2.5)**

* Note: values in parentheses indicate the percent or actual change in averages since 3rd monitoring period
** Within the margin of error (+/- 4%) for this type of assessment and is otherwise identified as 'no change' between two subsequent monitoring periods. Analysis of results from additional monitoring periods will provide a basis for more accurate conclusions.

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6.3 Normalised Difference Vegetation Index (NDVI) monitoring

During the 4th monitoring period an additional assessment was undertaken to determine the health and condition of native vegetation within “Existing Assessable Koala Habitat to be protected and managed” and “Offset Areas” within Fauna Corridors, Greenspace Corridors and Environmental Protection Zones. This assessment was called Normalised Difference Vegetation Index (NDVI) imaging and was conducted as part of aerial mapping of the offset areas using a Phantom 4 DJI remote-piloted aircraft (drone) with an affixed Parrot Sequoia multispectral NDVI camera. NDVI imagery determines percent foliar cover and photosynthetic health of the vegetation (Figure 4). This method calculates the ratio of ingoing absorbed visible light (wavelengths 0.4 – 0.7 µm) against reflected / outgoing near-infrared light to determine photosynthetic health of foliar cover. The higher the values of visible light / near-infrared light per point, the higher the NDVI value (scale -1 to 1), and therefore the healthier the foliage, and vice versa.

Three series of 3 x 1 ha sampling tiles were assessed using the drone and NDVI camera. These were placed at selected random monitoring sites across the development area (Figure 5). All aerial imagery for all of the sampling tiles series were 'stitched' together and uploaded to Pix4D for processing of NDVI-indexed images (Figure 4). Quantification of total percent foliar cover using NDVI, was carried out using ArcMap Version 10.5.1. For calculating descriptive statistics of photosynthetic health, firstly a complete 'stitched' NDVI image of each sampling tile was uploaded to ArcMap as a .tiff file and geolocated to the site location. Within this area, the image was clipped to the 1ha quadrangle. Following this, the raster data set that comprises the NDVI image, was converted into a grid of points (average size circ. 2.6 million points per series) with each point bearing the NDVI value of the underlapping pixel. These points were then analysed for mean average (+/- standard deviation), minimum and maximum values (Table 8).

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Table 8 Results of NDVI imaging values for each sampling tile per series

Series	Sampling Tile	# NDVI sampling points	Mean NDVI (µm) +/- SD	Minimum NDVI (µm)	Maximum NDVI (µm)	Overall NDVI health
Eastern	1	902,075	0.37 +/- 0.15	-0.44	0.74	Moderate
	2	902,075	0.4 +/- 0.23	-0.28	0.8	Moderate
	3	900,475	0.41 +/- 0.17	-0.24	0.76	Moderate
		2,704,625	0.39 +/- 0.18	-0.32	0.77	Moderate
Northern	1	912,071	0.63 +/- 0.11	0.05	0.9	Moderate
	2	912,073	0.62 +/- 0.1	0.22	0.9	Moderate
	3	911,223	0.59 +/- 0.12	0	0.88	Moderate
		2,735,367	0.61 +/- 0.11	0.14	0.89	Moderate
Southern	1	837,251	0.64 +/- 0.11	0.14	0.9	Moderate
	2	837,250	0.61 +/- 0.13	0.11	0.87	Moderate
	3	837,253	0.6 +/- 0.12	0.17	0.88	Moderate
		2,511,754	0.62 +/- 0.12	0.14	0.88	Moderate
		7,951,746	0.54 +/- 0.14	-0.01	0.85	Moderate

Key

	NDVI values 0.8 - 1	Excellent health with high photosynthetic activity/chlorophyll content
	NDVI values 0.3 – 0.79	Moderate health with moderate photosynthetic activity/chlorophyll content
	NDVI values 0.1 – 0.29	Poor health with low photosynthetic activity/chlorophyll content
	NDVI values -1 – 0	Dead/no photosynthetic activity/chlorophyll content

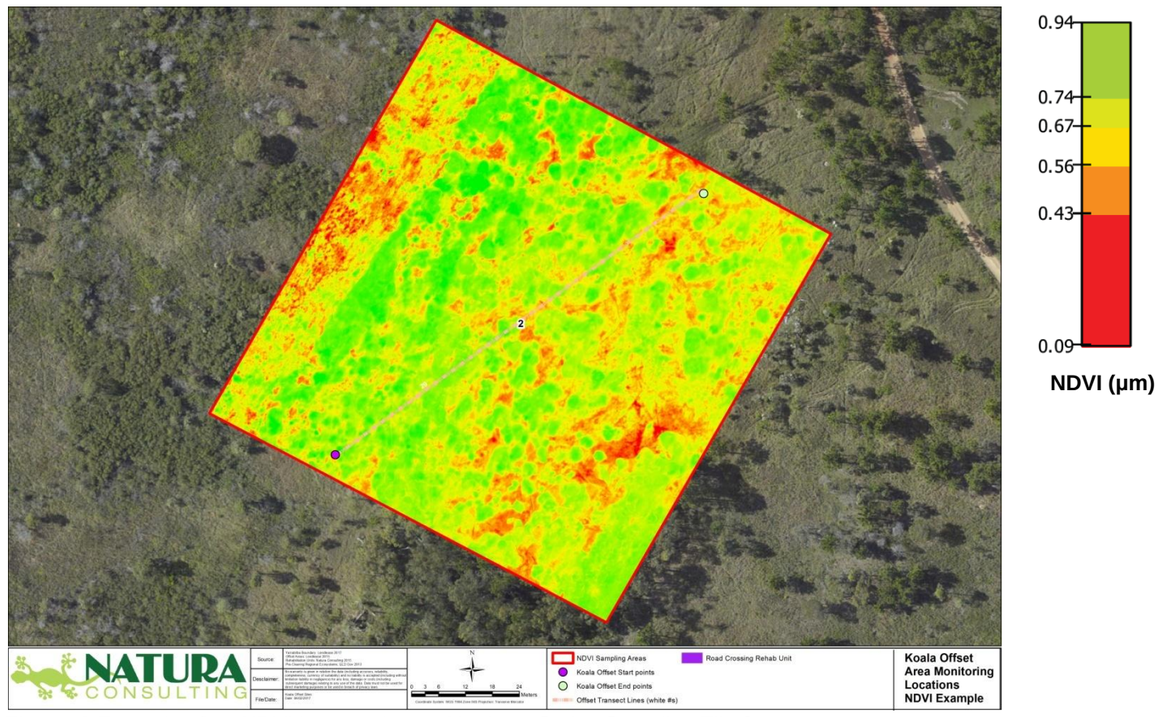

Figure 4 Example of an NDVI image taken at Northern Series Sampling Tile 2

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Figure 5 Locations of NDVI imaging across the three series of 3 x 1ha sampling tiles across the total Koala offset management area

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7 Discussion

An assessment of site species richness and structure was undertaken to determine the 4th monitoring period condition against the 3rd monitoring period and to measure them against target benchmark parameters (Table 9). An increasing number of sites already meet the final benchmark for some individual parameters. This is a good result, indicating that a number of sites are already close to or approaching the goal of reaching their original RE conditions and are recovering naturally, with very little active management required. The 4th monitoring period represents the 2nd year of monitoring, therefore, ideally, sites will have attained a minimum of IMO-2 for the benchmark variables. Due to the vaired complexity and condition of sites, however, this is not consistent across all variables at every site and it can be seen that individual sites are at different stages of recovery, but generally trending towards improvement.

When compared to the 3rd monitoring period, there was an overall trend of increase or no change in benchmark values for species richness, cover and height in most strata, with the exception of cover in the shrub (S1) layer, which saw an overall trend of decrease. The trend of increase or no change remained consistent throughout strata at 12 (20%) sites, which were site 18 (ORU1), 28 (ORU2), 30 (ORU4), 49 (CRU15), 55 (ORU6), 56 (CRU3), 66 (ORU9), 102 (ORU13), 123 (ORU18), 128 (ORU20), 143 (CRU8) and 144 (CRU8). This is a decrease of 6%, compared to 16 sites in the 3rd monitoring period. Despite an overall trend of increase, 44 sites (74% of sites) saw a decrease in at least one of the benchmark variables (excluding weed cover). The variable that had decreased at the least number of sites was ground cover, with 7 sites decreasing. The variable that had decreased at the most amount of sites was shrub cover, with 20 sites decreasing. Some sites saw a decrease in a number of variables, including species richness, canopy height, small tree height, small tree cover, shrub height and ground cover for sites in RE12.9-10.17 (sites 60-63, 65, 67-69, 104-115, 124, 127) and a decrease in canopy cover, canopy height, small tree height, shrub cover and shrub height for sites in RE12.11.5 (129, 130, 132, 134-138).

In general, there was a trend of decrease for the number of sites improved within variables since the 3rd monitoring period, with a lower number of sites improving in benchmark variables canopy height, small tree height, shrub cover and shrub height. This may be explained by the significant amount of improvement observed in the 3rd monitoring period, rendering fewer sites to improve. It may also represent seasonal fluctuations in growth and reflect amendments to methodological discrepancies. A significant increase was observed for the number of sites improving for species richness (13 sites this monitoring period, compared to 5 sites improving in the 3rd monitoring period), as well as canopy cover (14 sites this monitoring period, compared to 6 sites improving in the 3rd monitoring period) and ground cover (16 sites this monitoring period, compared to 5 sites improving in the 3rd monitoring period), indicating new growth in the ground layer and also new recruitment into the T1 canopy layer at a number of sites. Recruitment of trees in the T2 and shrub layers into successively higher strata is an expected outcome of seasonal growth and may concurrently explain some of the perceived declines in the T2 and shrub layers.

Regarding weed cover, the overall trend was of no change, with 51 sites remaining the same since the 3rd monitoring period. A total of 28 sites met a benchmark for weedcover compared to 30 in the 3rd monitoring period, with two sites improving. This was a small improvement when compared to the 3rd monitoring period, which saw 18 sites improving (evidencing reduced weed cover). It would be ideal to **further investigate sites that have not met the benchmark or made improvements and prioritise weed management tasks within these ORU's, ORU1 (site 18 and 19), CRU11 (site 24), ORU2 (sites 26 and 28), ORU4 (site 29 and 32), ORU5 (sites 44-47), ORU6 (site 54), CRU3 (site 57), ORU7 (sites 58-59), ORU8 (sites 60-61), ORU15 (site 111), ORU16 (sites 112-113), ORU17 (site 115), ORU20 (site 128), ORU21 (site 129), ORU22 (site 135), ORU23 (sites 137 and 138) and CRU8 (site 143).**

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Table 7 contains the average results for variables within each site and also the overall average for each variable, indicating the variation since the previous (3rd) monitoring period. In the 4th monitoring period, the overall native species richness (excluding weeds) increased to 28.8 (by 2.4% since the 3rd monitoring period). This corresponded to higher species richness in the small tree layer (4.3%, an increase of 2.6% since 3rd monitoring period). The site with the lowest species richness recorded in the current monitoring period was site 47 (consistent with the 3rd monitoring period), with 11 species recorded (excluding weeds), which were predominantly ground cover species with a dominance of *Acacia leocalyx* in the S1 shrub layer. Again, there were no canopy (T1) species recorded within the site. **To improve species richness at site 47, strategic removal of acacia trees in the shrub layer is recommended, with in-fill planting of a variety of local native plants in alignment with recommended native species.**

The site with the highest species richness in this monitoring period was site 30, with 50 species recorded (excluding weeds). Over 86% of the native species recorded at site 30 were ground cover species. The high species richness recorded in the 3rd monitoring period at site 65 decreased significantly during the 4th monitoring period, from 41 to 35 and no weed species were recorded within the site. A total of 29 sites now meet a benchmark for species richness, as opposed to 28 during the 3rd monitoring period.

Where T1 canopy trees were present in the 3rd monitoring period they are on average slightly taller than during the 3rd monitoring period, however there is no statistical difference in T1 canopy height (0.3% increase, within +/- 4% margin of error). Weed canopy cover remained at 0% cover across all sites. A total of 24 sites meet a benchmark for T1 canopy cover (40.6%, 2.4% decrease since 3rd monitoring period), whilst 30 sites (50.8%, 4.8% increase since 3rd monitoring period) meet the benchmark for T1 canopy height.

T2-T3 small tree cover increased to 26.7% (+2.9% since 3rd monitoring period) across sites. Where T2-T3 small trees do occur at sites in the 4th monitoring period, they are 9 metres high on average (0.5% decrease since the 3rd monitoring period). In contrast to the 3rd monitoring period, where the T1 And T2 layer was absent at site 110, all sites now contained data for for height and cover for either the T1 or T2 strata or both. The site may have improved through assisted regeneration or natural progression of shrub layer trees into the T2 layer. Overall, total canopy crown cover (T1-T3) has increased by 16.6% to 50.6% total crown cover (excluding weed canopy).

Shrub cover has increased slightly to 12.8% (by 0.3% on average, therefore not statistically different). This indicates that shrub cover across sites has remained stable following a significant increase in the result for shrub cover in the 2nd monitoring period, where shrub cover was only recorded at 34% of sites. Despite the increase in average cover, the total number of sites meeting a benchmark decreased since the 3rd monitoring period, with 42 sites (71% of sites) meeting a benchmark (compared to 50 sites or 83% in the 3rd monitoring period). A total of 57 sites meet the benchmark for for shrub height which is also relatively consistent with results from the 3rd monitoring period, with a slight decrease (3% decrease since 3rd monitoring period). This decrease may be attributed to migration of plants in the shrub layer to successive layers of strata, or potentially also variation or error between different field staff, though is not considered significantly different (with the +/- 4% margin of error).

The abundance of ground layer weeds has been seen to decrease by 2.5% since the 3rd monitoring period, likely attributable to ongoing weed control efforts in offset management areas, such as exotic pine removal from the ground and shrub layers to allow natural emergence of native species, off target herbicide application during weed control and also continuing to limit stock access. Successful implementation of management actions following the 2nd and 3rd monitoring periods may explain the

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overall decrease in weed presence, especially in the eastern Precincts adjacent to the Plunkett Conservation Reserve.

Overall, the number of variables meeting benchmarks within sites had improved since the 3rd monitoring period, with all sites meeting at least 4 benchmarks across variables and 45 sites (76% of sites) reaching IMO-2 or greater for at least 4 variables, where benchmarks had been met. A number of sites (14 sites, 24% of sites) were **still at IMO-1 benchmark level** for the variables canopy cover (site 29, ORU4), small tree cover (site110, ORU15), shrub cover (sites 24 (CRU11), 28 (ORU2), 59 (ORU7) and 113 (ORU16)) and ground cover (sites 33 (ORU4), 62 (ORU9), 64 (ORU11), 103 (ORU13), (123 and 124 (ORU18) and site 127 (ORU20)). 50% of these sites (sites 24, 28, 29, 33, 59, 110 and 113) also failed to meet the benchmark for weed cover, **indicating additional areas for rehabilitation, focusing on weed control and planting of appropriate species to bring the site into alignment with the approaching IMO-3 targets.** Site photos and Table 9 data show that the remaining IMO-1 sites were characterised by a sparse understorey with a high litter density and a tall canopy benchmark value of IMO-5 or greater.

Sites that had the **poorest conditions** overall in the 3rd monitoring period (failing to meet at least 4 benchmarks across the parameters), including sites 32 (ORU4), 54 (ORU6), 101 (ORU12) and 110 (ORU15), generally improved, having a higher number of variables meeting benchmark parameters in the current monitoring period, with the exception of site 101 which was removed due to land clearing. Of these, the two sites with the least improvement were sites 32 and 54. Site 32 had improvements in shrub cover from IMO-1 to IMO-2, with a total of four variables meeting benchmarks (10% decrease). Site 54 also had improvements in shrub cover from IMO-3 to IMO-5 and four variables meeting a benchmark (same as 3rd monitoring period, weed cover declined to non benchmark value). These sites are mostly characterised by a sparse understorey or contain dense *Imperata cylindrica* in association with *Pteridium esculentum*, and occasional *Pinus elliotti* +/- *Andropogon virginicus, Ageratum houstonianum, Conyza bonariense, Lantana camara, Lantana montevidensis* and *Setaria sphacelata.*

In this monitoring period, the number of sites that failed to meet at least four benchmarks across the variables **(therefore considered to be in poorest condition)** increased from 4 sites in the 3rd monitoring period to 6 sites, including site 32 (ORU4), site 54 (ORU6), site 60 (ORU8), site 110 (ORU15), site 115 (ORU17) and site 132 (ORU19). This may be attributed to the focus of rehabilitation and weed control being placed on improving the conditions of other low benchmark areas determined in the 3rd monitoring report. **These sites will need to be included amongst those prioritised for rehabilitation within the next 6 months. It is recommended that rehabilitation efforts are adjusted to prioritise sites that have the poorest condition overall, through continued weed management including removal of *Pinus elliotti* trees and juveniles where necessary (predominantly sites 54, 60, 110, 115 and 132).**

The sites that were considered to have the **least improvement** were sites that had 4 or less benchmarks achieved across variables, with the lowest number of variables improving. Of these low benchmark sites, there were four considered to have made the least improvement, as they had only improved benchmark value in one of the variables. All these sites were also rated as 'poorest condition sites as discussed above. This includes sites 32 (ORU4) and 54 (ORU6) for shrub cover, site 60 (ORU8) for small tree cover (T2) and site 132 (ORU19) for native ground cover. Three of these sites consistently failed to meet the benchmark for native species richness, T1 canopy cover and T1 canopy height and weed cover (sites 32, 54 and 60). Whilst the other site did meet the final benchmark for weed cover, it also failed to meet the benchmark for native species richness, T1 canopy cover and T1 canopy height as well as for shrub cover and shrub height. **It is recommended that rehabilitation efforts within these ORU's are focussed on weed management in the ground layer, with assisted natural regeneration of the ground and shrub layers and potential planting**

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of T1 canopy species where possible at all four sites. The most common weeds within these sites include *Lantana camara, Lantana montevidensis* and *Pinus elliotti*, with a significantly high abundance of *Andropogon virginicus* recorded throughout site 60.

Overall condition of sites taken from a random sample of 9 x 1 ha NDVI sampling tiles across 3 series showed that **photosynthetic health of the vegetation within these areas is currently 'moderate'**. This is indicated by the middle-range NDVI values on the scale (overall average = 0.54) indicating overall moderate health. Individually all sampling tiles showed moderate health as well. This could be explained by the high presence of bare ground that occurs naturally within the types of REs found in these sites. Bare ground reflects very low NDVI values as it does not constitute photosynthetically-active tissues and chlorophyll compounds. Thus when a 1 ha sampling tile contains a large amount of bare ground, the overall NDVI value is inherently reduced. Long-term monitoring of the NDVI values of these sampling tiles over time will indicate whether these baseline values remain constant or improve with increasing regeneration and management of the offset areas.

Overall, this assessment reveals that rehabilitation efforts have resulted in improvements to vegetation condition in many of the targeted offset rehabilitation areas. Despite this, there are still a large number of sites (31 sites - 52%, a non significant 2% increase since 3rd monitoring period) that fail to meet the ≤5% benchmark for total weed ground layer and a number of sites (6 sites) that fail to meet at least 4 benchmark parameters. Looking forward, the results indicate that **rehabilitation should continue to prioritise management of weed control in sensitive areas, particularly those within Precincts 3 (ORU6 and ORU8), 5 (ORU15) and 17 (ORU19), with the addition of precinct 13 (ORU17)**, which are adjacent to the Plunkett Conservation reserve, to minimise infiltration of weeds into the conservation area, where weed abundance is minimal or even absent in some areas. There are a total of 46 sites in these areas, 24 (52%) of which already meet the ≤5% benchmark for weed cover.

High priority weed control and rehabilitation areas include sites adjacent to the Plunkett Conservation reserve that do not yet meet the benchmark, comprising sites 44-47 (ORU5), 54 (ORU6), 57 (CRU3), 58-59 (ORU7), 60-61 (ORU8), 110-111 (ORU15), 112-113 (ORU16), 115 (ORU17), 128 (ORU20), 129-130 (ORU21), 135 (ORU22), 137-138 (ORU23) and 143 (CRU8). **Rehabilitation efforts also need to continue prioritising ongoing maintenance of stock exclusion fencing, and planting of canopy species specific to the pre-clearing RE type,** as an integrated measure for reducing weed cover to below the 5% benchmark for all sites, in the shortest time frame possible. **Furthermore, continued strategic rehabilitation of the shrub layer may be required in these areas** to continue boosting the layer to meet or improve benchmarks, and also to help ensure that weeds are outcompeted and shaded out, thereby reducing the need for reactive management over time.

In conclusion, according to results for benchmark indicators and weed cover**, there are 4 Rehabilitation Units to be considered highest priority action, including ORU4, ORU6, ORU8 and ORU19,** which have a combination of ≤4 parameters meeting benchmarks and also a high weed prevalence of >5%. **An additional 8 Rehabilitation Units which need to be prioritised for weed control and benchmark improvements include ORU2, CRU11, ORU15, ORU16, CRU3, ORU19 and ORU17 and ORU7 in order from highest to lowest priority,** determined by cross assessment of highest % total ground weed cover, poorest conditions (sites which meet <4 benchmarks), least improved sites and failure to meet benchmark IMO-2 for one or more of the variables in sites.

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Table 9 4th monitoring period species richness, canopy height within the canopy (T1), sub-canopy (T2-T3) and shrub layer (S1) and cover within the canopy (T1), sub-canopy (T2-T3), shrub layer (S1) and ground layer (G1). Purple shading indicates removed sites.

Site	Rehab Unit	Pre-Clearing Regional Ecosystem	Species Richness (native)	Canopy Cover (T1)	Canopy Height (T1)	Small Tree Height (T2-T3)	Small Tree Cover (T2-T3)	Shrub Cover (S1)	Shrub Height (S1)	Ground Cover (G1)	Weed Cover (<5%?)
18	ORU1	12.9-10.17/12.9-10.2	FINAL (S)	IMO-10 (S)	IMO-10 (S)	IMO-5 (S)	IMO-5 (S)	FMO-15 (I)	IMO-10 (D)	FMO-15 (I)	X (S)
19	ORU1	12.9-10.17/12.9-10.2	FINAL (S)	IMO-10 (I)	IMO-10 (I)	IMO-5 (S)	IMO-5 (S)	IMO-3 (S)	IMO-10 (S)	IMO-3 (S)	X (S)
23	CRU11	12.3.11/12.3.6/12.3.7	FINAL (S)	X (S)	X (S)	IMO-5 (S)	IMO-10 (I)	IMO-5 (D)	FMO-15 (S)	FINAL (S)	FINAL (S)
24	CRU11	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-10 (I)	FMO-15 (S)	IMO-1 (D)	FINAL (S)	FINAL (S)	X (S)
25	ORU2	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	FINAL (S)	FINAL (S)	IMO-3 (D)	FMO-15 (D)	FINAL (S)	FINAL (S)
26	ORU2	12.3.11/12.3.6/12.3.7	FINAL (S)	X (S)	X (S)	FINAL (S)	IMO-5 (D)	IMO-5 (D)	FMO-15 (S)	FINAL (S)	X (S)
27	ORU2	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-5 (S)	FMO-15 (S)	FINAL (S)	FINAL (I)	FINAL (D)	X (D)
28	ORU2	12.3.11/12.3.6/12.3.7	FINAL (I)	X (S)	X (S)	IMO-3 (S)	IMO-2 (S)	IMO-1 (S)	FINAL (I)	FINAL (S)	X (S)
29	ORU4	12.9-10.17/12.9-10.2	X (D)	IMO-1 (I)	IMO-10 (I)	IMO-10 (D)	FMO-15 (S)	X (D)	IMO-5 (D)	IMO-10 (D)	X (S)
30	ORU4	12.9-10.17/12.9-10.2	FINAL (S)	FMO-15 (S)	IMO-10 (S)	FMO-15 (I)	IMO-10 (I)	X (S)	IMO-5 (I)	IMO-10 (I)	FINAL (S)
31	ORU4	12.9-10.17/12.9-10.2	X (S)	X (S)	IMO-10 (I)	IMO-10 (S)	FMO-15 (S)	X (S)	IMO-10 (I)	X (D)	FINAL (S)
32	ORU4	12.9-10.17/12.9-10.2	X (D)	X (S)	X (S)	IMO-5 (S)	FINAL (S)	IMO-2 (I)	FMO-15 (S)	X (S)	X (S)
33	ORU4	12.9-10.17/12.9-10.2	X (S)	X (S)	X (S)	IMO-5 (S)	FMO-15 (I)	FMO-15 (S)	FMO-15 (I)	IMO-1 (I)	X (D)
44	ORU5	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-3 (D)	IMO-5 (I)	FINAL (S)	FINAL (S)	FINAL (S)	X (S)
45	ORU5	12.3.11/12.3.6/12.3.7	FINAL (I)	IMO-2 (I)	FMO-15 (I)	FMO-15 (S)	FINAL (S)	X (D)	FMO-15 (S)	IMO-10 (D)	X (S)
46	ORU5	12.3.11/12.3.6/12.3.7	FINAL (I)	X (S)	FMO-15 (I)	FINAL (S)	FINAL (S)	X (S)	FMO-15 (D)	IMO-10 (D)	X (S)
47	ORU5	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-5 (S)	IMO-3 (I)	FMO-15 (D)	FMO-15 (D)	FINAL (S)	X (S)
48	CRU15	12.3.11/12.3.6/12.3.7									
49	CRU15	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-10 (I)	IMO-5 (S)	FMO-15 (S)	FMO-15 (S)	FINAL (S)	FINAL (I)
54	ORU6	12.3.11/12.3.7	X (S)	X (S)	X (S)	IMO-10 (S)	X (S)	IMO-5 (I)	FMO-15 (D)	FINAL (S)	X (S)
55	ORU6	12.3.11/12.3.7	FINAL (S)	IMO-3 (I)	FMO-15 (S)	FINAL (S)	FINAL (S)	IMO-10 (I)	FINAL (S)	FINAL (S)	FINAL (I)
56	CRU3	12.3.11/12.3.7	FINAL (I)	X (S)	X (S)	IMO-5 (S)	FMO-15 (S)	IMO-10 (S)	FMO-15 (S)	FINAL (I)	FINAL (S)
57	CRU3	12.3.11/12.3.6/12.3.7	FINAL (I)	X (S)	X (S)	IMO-5 (S)	IMO-10 (I)	FMO-15 (D)	FINAL (S)	FINAL (S)	X (S)
58	ORU7	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-10 (D)	IMO-10 (I)	FINAL (S)	FINAL (S)	FINAL (S)	X (S)
59	ORU7	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-10 (S)	IMO-5 (S)	IMO-1 (D)	FINAL (S)	FINAL (S)	X (S)

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Site	Rehab Unit	Pre-Clearing Regional Ecosystem	Species Richness (native)	Canopy Cover (T1)	Canopy Height (T1)	Small Tree Height (T2-T3)	Small Tree Cover (T2-T3)	Shrub Cover (S1)	Shrub Height (S1)	Ground Cover (G1)	Weed Cover (<5%?)
60	ORU8	12.9-10.17/12.9-10.2	X (D)	X (S)	X (S)	IMO-5 (S)	IMO-5 (I)	X (D)	FMO-15 (S)	FMO-15 (S)	X (S)
61	ORU8	12.9-10.17/12.9-10.2	X (D)	X (S)	X (S)	IMO-5 (S)	FMO-15 (I)	IMO-3 (D)	FMO-15 (I)	FMO-15 (S)	X (S)
62	ORU9	12.9-10.17/12.9-10.19	X (D)	IMO-5 (I)	IMO-10 (I)	IMO-5 (D)	FMO-15 (D)	IMO-2 (S)	IMO-3 (D)	IMO-1 (S)	FINAL (S)
63	ORU10	12.9-10.17	X (D)	FMO-15 (S)	IMO-10 (D)	IMO-5 (S)	IMO-5 (D)	IMO-10 (D)	IMO-10 (D)	IMO-5 (I)	FINAL (S)
64	ORU11	12.9-10.17	X (D)	IMO-3 (I)	IMO-10 (S)	IMO-10 (S)	FMO-15 (I)	X (S)	IMO-5 (S)	IMO-1 (S)	FINAL (S)
65	ORU10	12.9-10.17	FINAL (S)	FMO-15 (I)	IMO-10 (S)	FMO-15 (S)	FMO-15 (D)	IMO-3 (D)	FMO-15 (S)	IMO-10 (I)	FINAL (S)
66	ORU9	12.9-10.17/12.9-10.19	FINAL (S)	IMO-3 (S)	IMO-10 (S)	IMO-5 (S)	FMO-15 (S)	FMO-15 (S)	IMO-10 (S)	IMO-5 (I)	FINAL (S)
67	ORU9	12.9-10.17/12.9-10.19	FINAL (S)	FMO-15 (S)	IMO-10 (S)	IMO-5 (D)	FMO-15 (I)	IMO-2 (D)	IMO-10 (D)	IMO-5 (I)	FINAL (S)
68	ORU9	12.9-10.17/12.9-10.19	X (D)	IMO-1 (I)	IMO-10 (I)	IMO-10 (D)	FINAL (S)	X (D)	IMO-10 (S)	IMO-10 (I)	FINAL (S)
69	ORU9	12.9-10.17/12.9-10.19	X (D)	IMO-5 (I)	IMO-10 (I)	FMO-15 (D)	IMO-5 (D)	X (S)	IMO-3 (S)	IMO-3 (I)	FINAL (S)
101	ORU12	12.9-10.17/12.9-10.2									
102	ORU13	12.9-10.17/12.9-10.19	X (S)	FINAL (I)	IMO-10 (S)	IMO-5 (S)	FMO-15 (S)	X (S)	IMO-10 (S)	X (S)	FINAL (S)
103	ORU13	12.9-10.17/12.9-10.19	FINAL (S)	FMO-15 (I)	IMO-10 (S)	FMO-15 (S)	IMO-5 (D)	X (S)	IMO-3 (I)	IMO-1 (I)	FINAL (S)
104	ORU13	12.9-10.17/12.9-10.19	X (D)	IMO-10 (S)	IMO-10 (S)	IMO-10 (D)	IMO-10 (D)	X (S)	IMO-3 (S)	IMO-3 (I)	FINAL (S)
107	ORU14	12.9-10.17/12.9-10.19									
109	ORU15	12.9-10.17/12.9-10.2	X (S)	IMO-10 (I)	IMO-10 (S)	IMO-5 (S)	IMO-10 (D)	X (D)	IMO-10 (S)	X (S)	FINAL (S)
110	ORU15	12.9-10.17/12.9-10.2	X (D)	X (S)	X (S)	FMO-15 (I)	IMO-1 (I)	X (S)	FMO-15 (I)	FMO-15 (S)	X (D)
111	ORU15	12.9-10.17/12.9-10.2	X (S)	IMO-3 (I)	IMO-1 (I)	IMO-5 (S)	FINAL (S)	FINAL (I)	IMO-10 (D)	IMO-10 (D)	X (S)
112	ORU16	12.9-10.17/12.9-10.19	FINAL (S)	X (S)	X (D)	IMO-5 (I)	FMO-15 (I)	IMO-3 (D)	FMO-15 (D)	FMO-15 (S)	X (S)
113	ORU16	12.9-10.17/12.9-10.19	X (D)	X (S)	X (S)	IMO-5 (S)	IMO-2 (S)	IMO-1 (D)	FMO-15 (S)	FMO-15 (S)	X (S)
114	ORU17	12.9-10.17/12.9-10.2									
115	ORU17	12.9-10.17/12.9-10.2	X (D)	X (S)	IMO-10 (I)	X (D)	X (D)	IMO-2 (S)	IMO-10 (I)	FMO-15 (S)	X (S)
123	ORU18	12.9-10.17	FINAL (S)	FMO-15 (S)	IMO-10 (S)	IMO-10 (S)	FMO-15 (S)	X (S)	IMO-5 (S)	IMO-1 (I)	FINAL (S)
124	ORU18	12.9-10.17	FINAL (S)	FMO-15 (S)	IMO-10 (S)	IMO-5 (D)	FMO-15 (S)	IMO-2 (S)	IMO-10 (D)	IMO-1 (S)	FINAL (S)
127	ORU20	12.9-10.17/12.9-10.2	FINAL (S)	FMO-15 (S)	IMO-10 (S)	IMO-10 (S)	IMO-10 (D)	X (D)	IMO-5 (D)	IMO-1 (S)	FINAL (S)
128	ORU20	12.9-10.17/12.9-10.2	FINAL (S)	FMO-15 (S)	IMO-10 (S)	IMO-10 (S)	FMO-15 (S)	IMO-2 (I)	IMO-10 (S)	IMO-5 (S)	X (S)
129	ORU21	12.11.5/12.11.3	FINAL (S)	X (D)	X (D)	IMO-5 (D)	FINAL (I)	FINAL (I)	FINAL (I)	FMO-15 (S)	X (S)

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Site	Rehab Unit	Pre-Clearing Regional Ecosystem	Species Richness (native)	Canopy Cover (T1)	Canopy Height (T1)	Small Tree Height (T2-T3)	Small Tree Cover (T2-T3)	Shrub Cover (S1)	Shrub Height (S1)	Ground Cover (G1)	Weed Cover (<5%?)
130	ORU21	12.11.5/12.11.3	FINAL (I)	X (D)	X (D)	FINAL (S)	FINAL (S)	FINAL (I)	FINAL (S)	IMO-3 (I)	X (D)
131	ORU19	12.11.5/12.11.3	FINAL (I)	IMO-2 (D)	FINAL (I)	FINAL (S)	FINAL (S)	FINAL (I)	FINAL (S)	IMO-5 (S)	FINAL (S)
132	ORU19	12.11.5/12.11.3	X (S)	X (S)	X (D)	FINAL (S)	FINAL (S)	X (D)	X (D)	IMO-5 (I)	FINAL (S)
133	ORU19	12.11.5/12.11.3	FINAL (I)	X (D)	FMO-15 (S)	FINAL (I)	FINAL (S)	FINAL (S)	FINAL (S)	IMO-5 (I)	FINAL (S)
134	ORU22	12.11.5/12.11.3	FINAL (I)	X (D)	X (D)	IMO-10 (I)	FINAL (S)	FMO-15 (D)	FINAL (S)	IMO-3 (S)	FINAL (S)
135	ORU22	12.11.5/12.11.3	FINAL (I)	X (D)	X (D)	FINAL (I)	FINAL (S)	FINAL (S)	FINAL (S)	FMO-15 (S)	X (S)
136	ORU22	12.11.5/12.11.3	FINAL (I)	X (D)	X (D)	FINAL (S)	FINAL (S)	FINAL (S)	FINAL (S)	IMO-2 (S)	FINAL (S)
137	ORU23	12.11.5	FINAL (I)	X (D)	X (D)	FINAL (I)	FINAL (S)	FINAL (S)	FINAL (S)	FMO-15 (S)	X (S)
138	ORU23	12.11.5	FINAL (I)	X (D)	X (D)	FINAL (S)	FINAL (S)	FINAL (S)	FINAL (S)	FMO-15 (S)	X (S)
143	CRU8	12.11.5/12.11.3	X (S)	FMO-15 (I)	FMO-15 (I)	FINAL (S)	FINAL (S)	FINAL (I)	IMO-10 (I)	FMO-15 (S)	X (S)
144	CRU8	12.11.5/12.11.3	X (S)	X (S)	FMO-15 (I)	FINAL (S)	FINAL (S)	FINAL (I)	IMO-10 (I)	FMO-15 (S)	FINAL (S)
Total meeting a benchmark			**29**	**24**	**30**	**57**	**58**	**42**	**57**	**55**	**28**
Total meeting a benchmark (3rd monitor. period)			**28**	**26**	**28**	**58**	**57**	**50**	**60**	**57**	**30**
Total improving (since 3rd monitor.)			**13**	**14**	**13**	**9**	**14**	**11**	**12**	**16**	**2**
Total declining (since 3rd monitor.)			**13**	**9**	**10**	**11**	**10**	**21**	**13**	**6**	**4**
Total same (since 3rd monitor.)			**32**	**35**	**35**	**37**	**34**	**26**	**32**	**36**	**51**
Overall trend			**=**	**≥**	**=**	**=**	**≥**	**≤**	**=**	**≥**	**=**
Total sites (excl. removed) = 59											

Note: the site meets the following benchmarks: IMO - 1 year; IMO – 2 year, IMO – 3 year, IMO- 4 year, IMO – 5 year, IMO – 10 year, FMO – 15 year, FINAL Benchmark condition, and X – does not meet any benchmark.

* D = Decrease, S = Same, I = Increase in all values

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