PARKER RANGE IRON ORE PROJECT

MS 892

VEGETATION HEALTH AND WEED MONITORING AND MANAGEMENT PLAN

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Glossary of Terms

Term	Definition
Plant health	Score of plant health for individual plants utilising the Casson *et al.* (2009) health scale
Species richness	The number of different species present in the quadrat, a measure of the abundance of different species
Weediness index	Weediness scale of Loomes *et al.* (2008) provides a measure of the abundance of weed species, including annual species, that may be compared between monitoring events to identify the establishment and/or increase in weed abundance. Calculated using number of weed species and cover of weed species (where present): $\frac{\text{cover of weed species}}{\text{cover of native species}} + \frac{\text{number of weed species}}{\text{number of native species}}$
Canopy level: upper, mid and low	Upper represented by tree species, mid represented by shrubs >1m height, lower represented by shrubs, grasses and forbs <1m in height.
Vegetation cover	Visual assessment of the percentage of cover within a quadrat, a measure of the abundance of all plants or selected species within a given canopy level

Summary

This Vegetation Health and Weed Monitoring and Management Plan (VHWMMP) is prepared and implemented for the Parker Range Iron Ore Project (the Project) in accordance with Ministerial Statement No. 892, Condition 6 under the *Environmental Protection Act 1986* (EP Act). Table 1 presents the environmental objective that must be met through implementation of this VHWMMP.

Table 1: Purpose of the VHWMMP

Title of Project	Parker Range Iron Ore Project
Proponent	Mineral Resources Ltd
Ministerial Statement number	892 (EP Act)
Purpose of this VHWMMP	To fulfil the requirements of MS892 Condition 6
EPA's environmental objective for the key environmental factor	*Flora and Vegetation* To protect flora and vegetation so that biological diversity and ecological integrity are maintained
Objectives	1. To avoid a 25% or greater decline in health or abundance of vegetation at monitoring sites within a 250 m buffer around areas approved for disturbance as compared to the reference sites 2. To avoid the introduction of any new declared weed or environmental weed species or an increase in the abundance and distribution of existing weeds at monitoring sites within a 250 m buffer around areas approved for disturbance as compared to reference sites

This VHWMMP is designed to be adaptive and will be updated over the life of the Project (approximately six years) as required. This plan remains a working document with consultation with relevant departments as required.

1. CONTEXT, SCOPE AND RATIONALE

1.1 Project description

The Project is located approximately 15 km south-east of Marvel Loch and 45 km south-east of Southern Cross in the Goldfields region of Western Australia (Figure 1). The Project comprises open mine pits to extract approximately 30 million tonnes of iron ore and associated mining infrastructure.

The Project was assessed under the bilateral agreement between the Commonwealth and the Government of Western Australia. State approval of the Project was granted under Part IV of the EP Act by the Minister for the Environment on 12 April 2012 (Ministerial Statement (MS) No.892). Federal approval of the Project was granted under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 3 November 2011 (EPBC 2010/5435).

The proposed mine requires disturbance of approximately 350 hectares (ha) of native vegetation. Dewatering of pits below the watertable will also be required. The main characteristics of the Project, as outlined in MS 892, are summarised in Table 2; the approved project area is shown in Figure 2.

An upper haul road near Moorine Rock and rail siding (~4.1 ha), located 47 km from the mine site, was also approved under MS 892 and EPBC 2010/5435 but is not currently proposed for development as an alternative haul road alignment is under consideration. The scope of this VHWMMP is therefore currently limited to the mine site. In the event that Mineral Resources Limited (MRL) intend to develop the upper haul road and Moorine Rock rail siding, this VHWMMP will be updated to incorporate conditions relating to vegetation health and weed status for this additional area.

Table 2: Main characteristics of the Project

Element	Description (MS 892)
General	
Project life	7 to 10 years
Location	See Figure 1
Development envelope	929 ha[1]
Vegetation clearing	• Native vegetation clearing of up to 418.1 ha[1] comprising of: • Mine area – 414 ha • Upper haul road (near Moorine Rock) – 4.1 ha
Rehabilitation	Approximately 333 ha
Mining	
Mining method	Open cut
Pit	Up to 4 km long, 0.4 km wide and 135 m deep
Waste rock landform	Up to 2 km long, 0.5 km wide and 45 m high
Tailings storage facility	Up to 0.8 Mm^3 capacity, 400 m wide, 400 m long and 11 m high with five lifts
Water supply	Source: In pit and perimeter dewatering bores located along the open pit Maximum annual requirement: Mobile dry plant operations up to 321 ML/a Fixed wet plant operations up to 506L ML/a
Surplus dewater management	No requirement for surplus dewater management.

[1] Hydrogeological model to be updated based on empirical rate of aquifer drawdown to validate and monitor dewatering impacts.

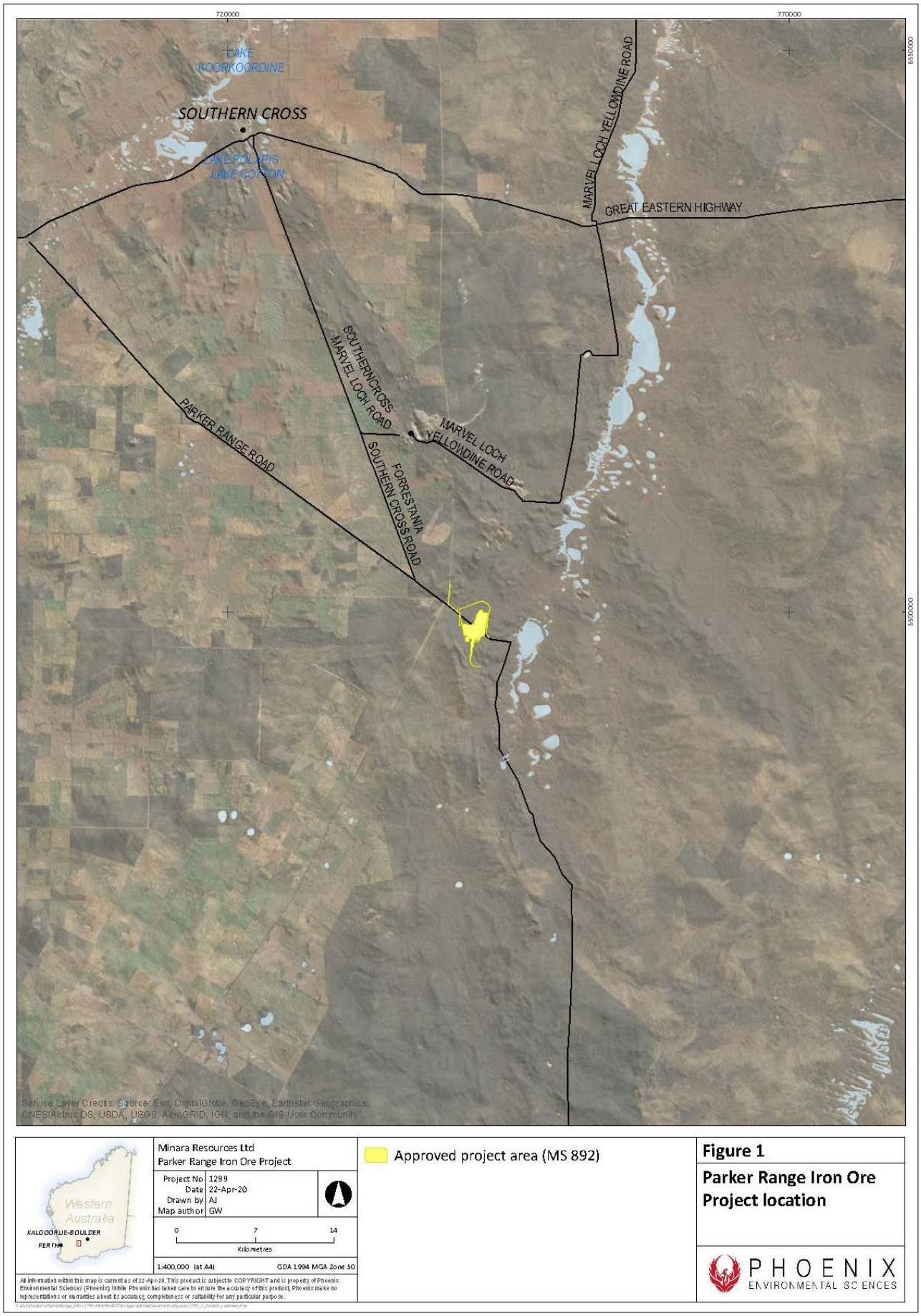

Figure 1: Parker Range Iron Ore Project location

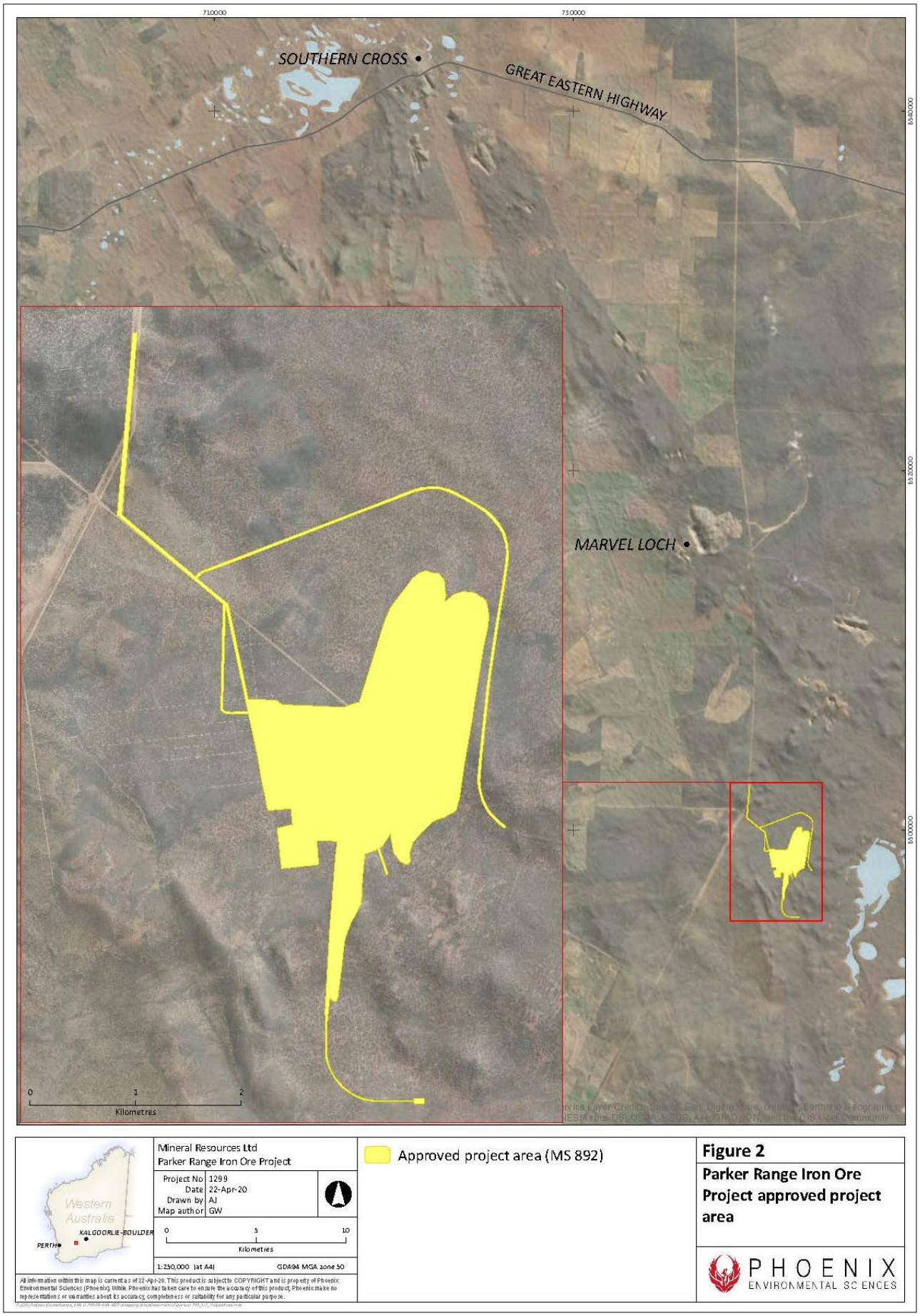

Figure 2: Parker Range Iron Ore Project approved project area

1.2 Key Environmental Factor: Flora and vegetation

As determined by the Environmental Protection Authority (EPA), 'Flora and vegetation' is considered a Key Environmental Factor for the Project for the following reasons (EPA 2011):

- The Project has potential to cause direct impacts to vegetation and flora through clearing of native vegetation within development envelope.
- The Project has potential to cause indirect impacts reducing vegetation health including edge effects such as:
    - dust deposition on vegetation preventing photosynthesis and plant respiration
    - competition from increased weeds.
- The Project will impact eight Priority flora.
- The Project has potential to cause indirect impacts to populations of the Threatened (T) species *Isopogon robustus* and the Priority (P) 1 species *Lepidosperma* sp. Mt Caudan[2].

Since the time of the assessment (EPA 2011), a further Priority species *Rinzia torquata* (P3) has been identified to occur within the development envelope with direct impact to this population.

All vegetation within the project area and 250 m buffer is mapped as part of the Priority 3 Parker Range Priority Ecological Community (PEC) by the Department of Biodiversity Conservation and Attractions (DBCA), the project area represents 0.74% of the mapped extent of the Parker Range PEC. Subsequently vegetation health monitoring is aimed at minimising indirect impacts to all vegetation types within the project area and 250 m buffer to minimise impacts to the PEC.

The EPA's objective for protection of flora and vegetation is to "To protect flora and vegetation so that biological diversity and ecological integrity are maintained (EPA 2016)". In the context of this objective, ecological integrity is the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements.

The key environmental factor, risk activities, botanical values and potential associated impacts are summarised in Table 3.

Table 3: Key environmental factors, risk activities, values and associated impacts

Key environmental factor	Risk activities	Botanical values	Impacts
Flora and vegetation	Clearing of native vegetation Mining activities Product haulage Vehicle movement	Vegetation health Threatened and Priority flora, with indicator species of concern: • *Isopogon robustus* (T) • *Chamelaucium* sp. Parker Range (P1) • *Lepidosperma* sp. Parker Range (P1) • *Lepidosperma* sp. Mt Caudan (P1) • *Acacia concolorans* (P2) • *Baeckea grandibracteata* subsp. Parker Range (P3) • *Hakea pendens* (P3) • *Cryptandra crispula* (P3) • *Rinzia torquata* (P3)	Direct impacts • clearing of native vegetation within the development envelope • clearing of populations of Priority flora Indirect impacts: • potential increased spread of introduced weeds • dust • habitat fragmentation • altered fire regimes • altered surface water flow

Key environmental factor	Risk activities	Botanical values	Impacts
		• *Banksia shanklandiorum* (P4)	

[2] The management of *Isopogon robustus* (T) and *Lepidosperma* sp. Mt Caudan (P1) will be addressed in a separate document, Significant Flora Monitoring and Management Plan.

1.3 Condition requirements

This VHWMMP is submitted in accordance with MS 892, Condition 6. The relevant conditions are outlined in Table 4 below.

Note, in this report, CEO refers to the CEO of the Department of Water and Environment Regulation (DWER).

Table 4: MS892 conditions relating to the VHWMMP

Condition number	Condition	VHWMMP section
6-1	The proponent shall undertake monitoring of the health and abundance of vegetation within a 250 metre buffer area around areas approved for disturbance at the mine site and within a 125 metre buffer around the upper haul road as illustrated in Figures 4 and 5 in Schedule 1.	Section 2.2
6-2	The monitoring required under condition 6-1 is to commence prior to ground disturbing activities required for the implementation and operation of the proposal and be carried out to the requirements of the CEO on advice of the DBCA (formerly Department of Environment and Conservation; DEC) and will include: the provision of baseline data; identification of baseline and control sites; definition of monitoring frequency, timing, intensity and replication; definition of health and abundance; identification of what and how parameters will be used to measure decline or rate of decline in health or abundance; and definition of management responses required should a 25 per cent (or greater) decline in health or abundance be recorded.	Section 2.2
6-3	Should the potential impact sites show a 25 per cent (or greater) decline in health or abundance as compared to the reference sites, the proponent shall provide a report to the CEO within 21 days of the decline being identified which: describes the decline; and provides information which allows determination of the likely root cause of the decline.	Section 2.2
6-4	If the decline in health or abundance identified in condition 6-3 is determined by the CEO to be caused by activities undertaken in implementing the proposal the proponent shall implement the actions identified in condition 62-6 and continue to implement such actions until the CEO determines that the remedial actions may cease.	Section 2.2
6-5	The proponent shall undertake weed management to ensure that: No new species of declared weeds and environmental weeds are introduced into the proposal area and that the abundance and distribution of existing weeds is not increased as a direct or indirect result of implementation of the proposal. Prior to ground disturbing activities the proponent shall undertake a baseline weed survey to determine the species and extent of declared weeds and environmental weeds present at weed monitoring sites within the project footprint including the mine area (schedule 1 Figure 2) and the upper haul road (schedule 1 Figure 3) and at least three	Section 2.2

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Condition number	Condition	VHWMMP section
	reference sites on nearby undisturbed land beyond 200 metres from the disturbance footprint in consultation with the DBCA. To determine whether changes in weed cover and type within the project footprint have occurred and are likely to have resulted from implementation of the proposal or broader regional changes, monitoring of baseline and reference sites surveyed as required by condition 6-5-2 shall commence within one year after initial ground disturbing activity required for the implementation of the proposal. These sites are to be monitored annually for two years during the time of year agreed to by the CEO on advice of the DBCA. Thereafter monitoring shall take place at least every two years at the time of year agreed above for the life of the proposal, with monitoring within a two year period to coincide with the year of any favourable rainfall events. If the results of monitoring under condition 6-5-3 indicate that adverse changes in weed cover and type within the project footprint are proposal attributable, the proponent shall report the monitoring findings to the CEO and DBCA within three months of completion of the monitoring and shall immediately undertake weed control and rehabilitation in the affected areas, where proposal attributable weed cover has adversely changed, using native flora species of local provenance. The proponent shall continue to implement the remedial measures required by condition 6-5-4 until approval is given by the CEO to cease.	

1.4 Rationale and approach

The objective of the VHWMMP is to identify vegetation management and monitoring measures to minimise the impact on vegetation health and weed status within the 250 m buffer of approved mine site project area. Consideration of the upper haul road has not been included in this plan as it not currently proposed for development. In the event that MRL intend to develop the upper haul road and Moorine Rock rail siding, this VHWMMP will be updated as per the detail included in section 2.2 below to incorporate conditions relating to vegetation health and weed status for this additional area.

1.5 Environmental Impact Assessment findings

The Project is located within two Interim Biogeographic Regionalisation for Australia (IBRA) subregions, the Southern Cross (COO2) subregion of the Coolgardie bioregion and Merredin subregion (AW1) of the Avon Wheatbelt bioregion. The Southern Cross subregion is recognised as a centre of endemism and diversity for flora. The Merredin subregion is recognised as a heavily cleared environment with little remaining remnant vegetation.

The Project is located within five vegetation associations (8, 128, 552, 1068 and 1413) as described by Beard (1990). The mine area is located within the Priority 3 Parker Range PEC (EPA 2011); clearing will impact approximately 0.7% of this PEC.

Clearing for the Project will directly impact the following populations of Priority flora (EPA 2011):

- *Baeckea grandibracteata* subsp. Parker Range (P1)
- *Chamelaucium* sp. Parker Range (P1)
- *Lepidosperma* sp. Mt Caudan (P1)
- *Lepidosperma* sp. Parker Range (P1)
- *Westringia acifolia* (P1)
- *Acacia concolorans* (P2)

- *Hakea pendens* (P2)
- *Cryptandra crispula* (P3)
- *Rinzia torquata* (P3)
- *Banksia shanklandiorum* (P4).

Declines in vegetation health may indirectly impact these Priority flora species.

1.6 Baseline vegetation health and weed monitoring survey

A baseline vegetation health and weed survey conducted in spring 2019 (Appendix 1; Phoenix 2020) has informed this management plan, providing measurable parameters that will be used to monitor vegetation in the vicinity of the project area for potential impacts from Project activities. Surveys were conducted in established monitoring quadrats (Figure 3) that were established in a previous baseline survey (Botanica Consulting 2011) as these locations had been selected in consultation with the then DEC, now DBCA. A total of 28 quadrats were sampled (20 m x 20 m), comprising (Figure 4):

- 16 vegetation health quadrats within a 250 m buffer of the approved project area (impact sites)
- eight (8) vegetation health quadrats outside of the 250 m buffer (reference sites)
- four (4) weed monitoring quadrats adjacent to roads/vehicle access areas within the development envelope (weed impact sites).

A fifth weed quadrat, WQ5 (yet to be monitored) has been included (Figure 3). This quadrat is to be monitored in the event that the road and associated infrastructure does not extend as far south as what has been identified in the indicative site layout.

Parameters and methods for the monitoring program are to be consistent with those of the baseline survey and are described in Table 11.

The baseline survey determined the current status of vegetation health and weeds for the Project, in accordance with condition 6.1 and 6.2 of MS 892 (Phoenix 2020). Significant differences were identified in the species richness, canopy and dominant plant vegetation cover and average health of plants within and across vegetation health impact and reference quadrats in the baseline assessment (Appendix 1; Phoenix 2020).

Species richness and vegetation cover

The results of species richness and vegetation cover from the baseline monitoring survey in 2019 are summarized in the table below (Table 5).

Table 5: Species richness and vegetation cover for the vegetation health impact and reference quadrats surveyed in 2019

Quadrat no.	Species richness	Vegetation cover (%)		
		Upper	Mid	Low
Impact quadrats				
IQ1	24	60	20	40
IQ2	15	15	20	45
IQ3	20	10	50	60
IQ4	18	20	40	40
IQ5	13	20	45	10
IQ6	14	10	65	5

IQ7	9	20	60	60
IQ8	6	80	0	10
IQ9	17	40	40	15
IQ10	8	40	30	5
IQ11	11	10	1	10
IQ12	14	25	30	10
IQ13	16	20	15	35
IQ14	14	20	20	5
IQ15	15	10	70	30
IQ16	7	30	10	35
Reference quadrats				
RQ1	19	60	15	40
RQ2	15	10	10	10
RQ3	19	10	90	60
RQ4	18	25	30	40
RQ5	8	30	40	1
RQ6	19	20	20	10
RQ7	6	75	10	5
RQ8	4	25	2	10

Plant health and dust ratings

Health ratings for individual plants of dominant species varied within and between quadrats. Generally, most species showed signs of stress and were allocated a health rating of 3 (tips of branches stressed or dying).

No signs of dust build up were present for dominant plants within the impact and reference quadrats, with all dust ratings recorded as 0. A summary of the results for the spring 2019 vegetation monitoring is provided in Table 6.

Table 6: Vegetation health of impact and reference monitoring quadrats surveyed in spring 2019, mean values for dominant species health and dust ratings are provided

Canopy level	Cover (%)	No. of individuals	Species	Plant health			Mean dust rating
				Mean	Min	Max	
RQ1							
Upper	60	10	*Eucalyptus capillosa*	3.3	3	4	0
Lower	10	10	*Hibbertia exasperata*	3.3	3	4	0
RQ2							
Upper	10	10	*Eucalyptus salmonophloia*	3	3	3	0
Mid	3	10	*Eremophila oppositifolia*	3.4	1	4	0
Lower	5	10	*Scaevola spinescens*	2.8	1	4	0
RQ3							
Upper	70	10	*Allocasuarina corniculata*	3.1	1	4	0
Mid	20	10	*Melaleuca cordata*	3.3	3	4	0

Canopy level	Cover (%)	No. of individuals	Species	Plant health			Mean dust rating
				Mean	Min	Max	
RQ4							
Upper	25	5	*Eucalyptus capillosa*	2.6	1	4	0
Mid	20	10	*Allocasuarina acutivalvis* subsp. *acutivalvis*	1	1	1	0
Lower	20	10	*Melaleuca cordata*	2.6	1	4	0
RQ5							
Upper	10	1	*Eucalyptus salubris*	3	3	3	0
Upper	20	1	*Eucalyptus salmonophloia*	3	3	3	0
Mid	25	10	*Melaleuca laxiflora*	3.2	3	4	0
RQ6							
Upper	15	3	*Eucalyptus salmonophloia*	3.3	3	4	0
Mid	7	10	*Eremophila ionantha*	3.5	3	5	0
Lower	12	10	*Acacia merallii*	2.6	1	4	0
RQ7							
Upper	75	10	*Eucalyptus transcontinentalis*	3.2	3	4	0
Lower	5	5	*Olearia muelleri*	3.6	3	4	0
RQ8							
Lower	25	6	*Eucalyptus tephroclada*	2.7	1	4	0
Mid	10		*Melaleuca hamata*	1.3	1	3	0
IQ1							
Mid	30	10	*Allocasuarina spinosissima*	3.3	3	4	0
IQ2							
Mid	30	11	*Allocasuarina corniculata*	2.6	1	3	0
IQ3							
Upper	10	6	*Eucalyptus horistes*	2.7	1	4	0
Mid	35	10	*Allocasuarina corniculata*	3.2	3	4	0
IQ4							
Mid	25	10	*Allocasuarina corniculata*	2.7	1	4	0
IQ5							
Upper	20	10	*Eucalyptus eremophila*	2.7	1	4	0
Mid	20	10	*Melaleuca hamata*	3.1	3	4	0
IQ6							
Upper	10	9	*Eucalyptus capillosa*	2.3	1	3	0
Mid	35	10	*Melaleuca hamata*	3.5	3	4	0
IQ7							
Upper	20	5	*Acacia acuminata*	4	3	5	0
Mid	40	10	*Leptospermum roei*	1.6	1	3	0
Lower	35	10	*Hibbertia eatoniae*	3.5	3	4	0
IQ8							
Upper	75	10	*Eucalyptus transcontinentalis*	3.1	1	4	0

Canopy level	Cover (%)	No. of individuals	Species	Plant health			Mean dust rating
				Mean	Min	Max	
Lower	5	5	*Olearia muelleri*	3.2	1	4	0
IQ9							
Upper	40	7	*Eucalyptus capillosa*	3.7	2	4	0
Mid	20	10	*Melaleuca hamata*	3.7	3	4	0
Lower	15	10	*Phebalium tuberculosum*	3.3	3	4	0
IQ10							
Upper	40	9	*Eucalyptus transcontinentalis*	3	1	4	0
Mid	20	11	*Melaleuca hamata*	3.4	1	5	0
IQ11							
Upper	10	1	*Eucalyptus salmonophloia*	3	3	3	0
Lower	2	10	*Scaevola spinescens*	2.3	1	4	0
IQ12							
Upper	13	3	*Eucalyptus transcontinentalis*	2.3	1	3	0
Upper	12	3	*Eucalyptus salmonophloia*	2.3	1	3	0
Mid	20	10	*Melaleuca pauperiflora*	2.8	1	3	0
Lower	6	10	*Microcybe multiflora*	2	1	3	0
IQ13							
Upper	20	3	*Eucalyptus salmonophloia*	2.7	1	4	0
Mid	12	10	*Eucalyptus salubris*	1.3	0	3	0
Lower	10	10	*Scaevola spinescens*	2.2	1	4	0
IQ14							
Upper	20	2	*Eucalyptus salmonophloia*	3.4	3	3	0
Mid	20	10	*Melaleuca pauperiflora*	3.4	3	4	0
Lower	5	10	*Eremophila oppositifolia*	3.1	1	4	0
IQ15							
Upper	10	1	*Eucalyptus livida*	3	3	3	0
Mid	30	10	*Allocasuarina acutivalvis*	1.2	1	3	0
Lower	50	10	*Acacia beauverdiana*	1.2	1	3	0
IQ16							
Upper	5	1	*Eucalyptus salubris*	2	2	2	0
Upper	30	5	*Eucalyptus salmonophloia*	3	3	3	0
Mid	10	10	*Melaleuca pauperiflora*	2.7	1	4	0
Lower	10	10	*Acacia enervia* subsp. *enervia*	2.7	1	4	0

[3] Upper represented by tree species, mid represented by shrubs >1m height, lower represented by shrubs, grasses and forbs <1m in height.

Weed monitoring

A desktop review of relevant databases and previous survey reports preceded the field survey to identify weed species that may potentially occur in the approved mine site project area and 250 m buffer, and determine the locations of previously recorded weed species (Table 7). The desktop assessment determined

the potential for at least sixteen weed species to occur, including two Declared Pests, **Chrysanthemoides monilifera* and **Moraea miniata*. Four weed species, **Bromus rubens*, **Lysimachia arvensis*, **Sonchus oleraceus* and **Ursinia anthemoides*, have been recorded within the approved mine site project area (Botanica Consulting 2010; KLA 2010).

One weed species, **Centaurea melitensis*, was found within a vegetation monitoring quadrat and is the first record of this species for the Project (Table 7; Figure 4; Appendix 1). No weed species were recorded in the weed monitoring quadrats during the current survey (

Table 8).

Table 7: Weed species recorded within a 20 km radius of the development envelope

Species	DBCA (2019b)	Botanica Consulting (2011)	Baseline survey (Phoenix 2020)
**Arctotheca calendula*		*	
**Centaurea melitensis*	*		*
**Chrysanthemoides monilifera*		*	
**Hypochaeris glabra*	*	*	
**Sonchus oleraceus*	*	*	
**Ursinia anthemoides*	*	*	
**Carrichtera annua*		*	
**Medicago minima*	*		
**Moraea miniata*		*	
**Aira cupaniana*	*	*	
**Bromus rubens*		*	
**Cenchrus ciliaris*		*	
**Pentameris airoides*	*	*	
**Vulpia bromoides*		*	
**Vulpia myuros*		*	
**Lysimachia arvensis*	*	*	

Table 8: Weed and native vegetation cover for weed monitoring quadrats surveyed in 2019

Quadrat	Weed cover (%)	Native vegetation cover (%)
W1	0	85
W2	0	75
W3	0	35
W4	0	45

Priority flora

The baseline survey also identified the presence of three Priority species, *Westringia acifolia* (P1), *Acacia concolorans* (P2), *Banksia shanklandiorum* (P4) and one undescribed species a *Microcorys* sp. in monitoring quadrats (Appendix 1; Phoenix 2020).

1. *Westringia acifolia* (P1) was recorded in one impact monitoring quadrat within the buffer area. *Westringia acifolia* is a shrub, 0.3 m in height. Only one population of this species has been previously recorded, approximately 60 km west of the development envelope within the Avon Wheatbelt bioregion (DBCA 2019a).
2. *Acacia concolorans* (P2) was recorded in two impact monitoring quadrats and in one weed monitoring quadrat within the buffer area. *Acacia concolorans* is an intricate, sprawling or compact, pungent shrub, 0.1-0.5 m high with yellow flowers from July to August. The species grows in red/brown loam and clay and occurs on low lateritic hills and flats. *Acacia concolorans* occurs in the Avon Wheatbelt, Mallee and Coolgardie bioregions (DBCA 2019a).
3. *Banksia shanklandiorum* (P4) was recorded in one health monitoring quadrat. *Banksia shanklandiorum,* is an upright, non-lignotuberous shrub, 0.4-2.5 m in height and up to 3 m wide. This species flowers June to August and occurs in white/yellow sand with lateritic gravel. *Banksia shanklandiorum* is distributed within the Avon Wheatbelt bioregion (DBCA 2019a).

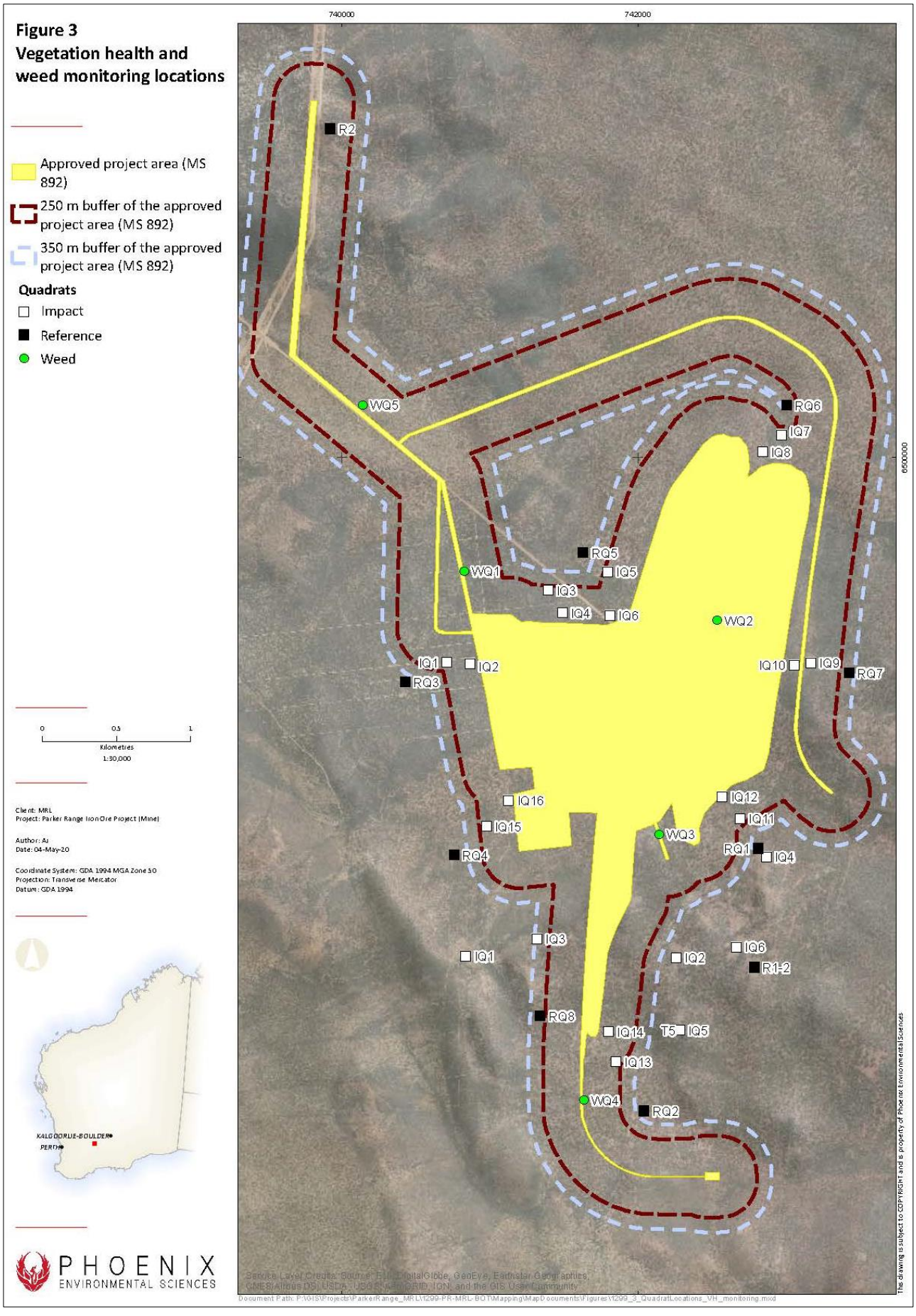

Figure 3: Quadrat locations

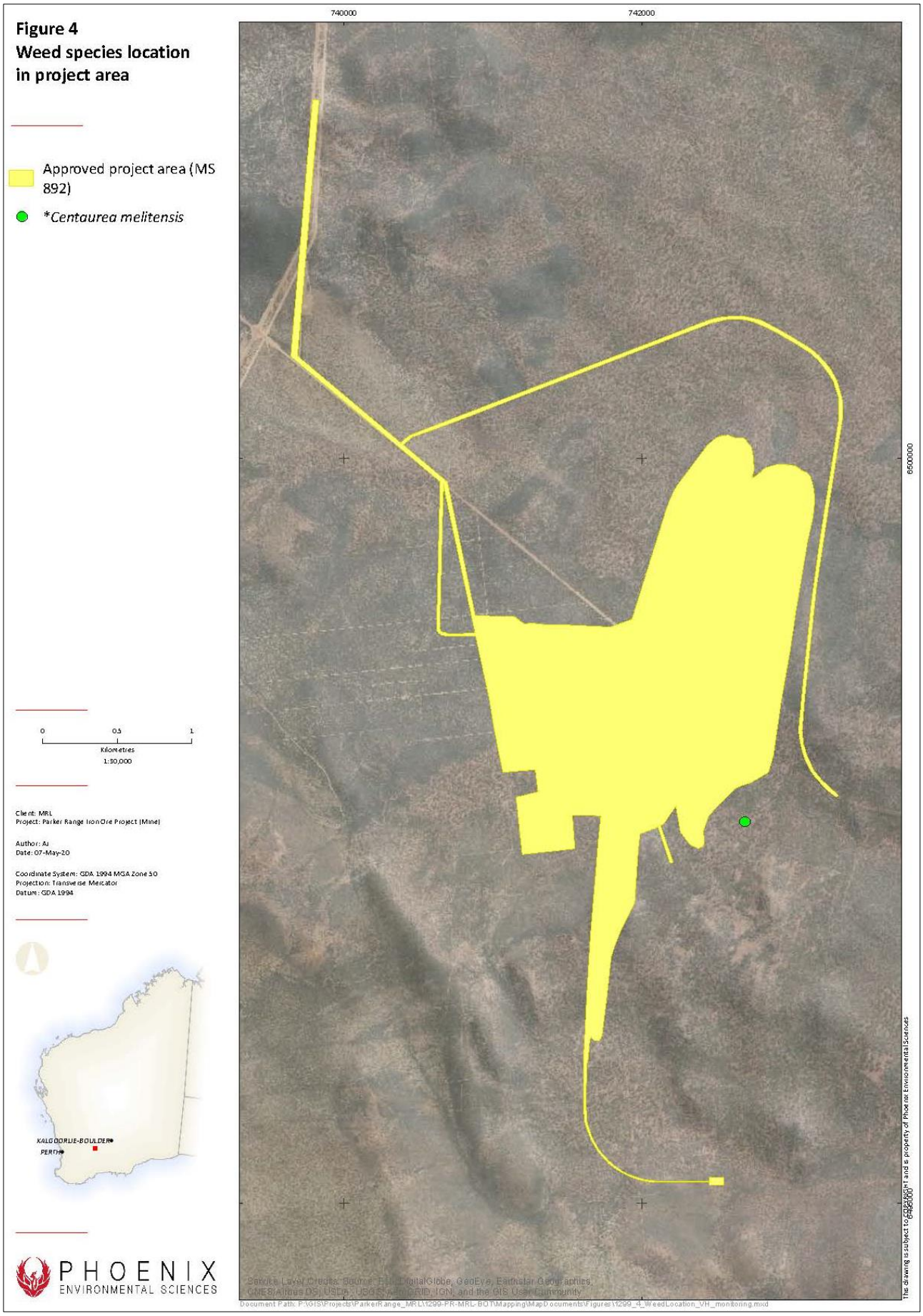

Figure 4: Weed species location in project area

1.7 Key assumptions and uncertainties

Key assumptions:

- Surveys have adequately characterised the environmental values of the project area.
- Flora surveys were completed in compliance with EPA and Department of the Environment and Energy (DoEE) requirements at the time.
- Monitoring quadrats are adequate to identify impacts to vegetation health and introduction/spread of weeds.
- The current baseline vegetation health and weed survey has adequately determined the current status of vegetation health and the current status of weeds within 250m buffer of the approved mine site project area.
- No species is restricted to the approved mine site project area.
- Dust deposition on plant foliage will impact on vegetation health.
- Only one weed species currently occurs within the 250 m buffer of the approved mine site project area.

Key uncertainties:

- Likely responses of individual species to an increase in foliar dust load. Plant health will be monitored over time and results from impact quadrats will be compared to reference quadrats. This will identify any adverse impacts to plant health and any correlations with dust build up on plant foliage.
- Plant numbers within the approved mine site project area is not known with certainty for some species of Priority flora:
    - *Acacia concolorans* (P2)
    - *Baeckea grandibracteata* subsp. Parker Range (P3)
    - *Hakea pendens* (P3)
    - *Cryptandra crispula* (P3)
    - *Rinzia torquata* (P3)
    - *Banksia shanklandiorum* (P4)
- Number of weed species occurring within the 250 m buffer of the approved mine site project area
- Vegetation health and weed status of the upper haul road.

1.8 Management approach

The Project will have a small footprint over a long life of mine with priority use of existing disturbed areas and progressive rehabilitation, including rehabilitation of historic exploration disturbance. Management and mitigation measures have been designed for the proposed 6-year life of mine, and as such, may require adaptive solutions in subsequent revisions. MRL will manage potential impacts on vegetation, through implementing the mitigation hierarchy: avoid, minimise and rehabilitate. Management actions specific to minimisation of impacts are provided in Table 9.

Table 9: Management actions to minimise impacts to vegetation health and introduction/spread of weeds

Potential impacts	Management actions to minimise impacts	Performance indicator	Timing
Direct impacts: Clearing of populations of Priority flora	• Limit vegetation clearing to the minimum necessary for the construction and operation of the Project. • Identify and demarcate of significant vegetation and flora populations (identified in baseline surveys and targeted searches) prior to disturbance. • Clearly demarcate areas to be cleared to avoid over-clearing.	Disturbance footprint modified to avoid botanical values (identified in baseline surveys and targeted searches) 100% compliance with Site Disturbance Permit and Land Clearing Procedure	Prior to disturbance activities

Indirect impacts:
 	
Increased spread of weeds
	• Implement weed hygiene procedures for all mining machinery and vehicles entering the project area. A Weed Hygiene Certificate will be required when there is a medium to high risk, including:
	  ○ movement of equipment that has been operating in borrow pits or in topsoil stockpiling or recovery operations.
	  ○ light vehicles and drill rigs operating in an area with known weed occurrences.
	  ○ any off-road earthmoving or heavy equipment moving from one mine site to another.
	• Identify the extent and distribution of weed infestations occurring within the project area through annual weed monitoring.
	• Undertake regular inspections of weed monitoring quadrats and areas susceptible to weed infestation (i.e. cleared areas and tracks, previously recorded weed locations).
	• Undertake suitable control methods for identified weed species that are recommended in the Department of Primary Industries and Regional Development and DBCA guidelines, including the Declared Plant Control Handbook (DPIRD 2020).
	• Separately store topsoil from areas of known weed occurrence from other topsoil stockpiles.
		Compliance with weed hygiene procedures including completion of a weed hygiene certificate for all vehicles/machinery where there is a medium to high risk of weed establishment/ infestation
		
		Annual weed monitoring to identify the presence of new weed species and the extent of weed cover
		
		Reporting of weed management in AER
			All phases
			
			Weed monitoring to occur during spring, within 6-8 weeks of winter rainfall
			
			Control activities to be conducted within one month of detection of weeds

Potential impacts	Management actions to minimise impacts	Performance indicator	Timing
Dust	• Restrict vehicle speeds to 40 km/hr along gravel/unsealed roads. • Manage dust prone areas through water sprays and progressive rehabilitation. • Monitor dust levels in consultation with DWER – installation and operation of monitoring stations to measure dust deposition at each vegetation monitoring quadrat.	Compliance with vehicle speed restrictions Dust deposition readings at impact sites comparable to those at reference sites and/or below 20 g/ m2 /month (Sa)	All phases Monthly during all phases of operation

1.9 Rationale for choice of provisions

The outcome-based approach of this VHWMMP is informed by results of the spring 2019 baseline vegetation health and weed monitoring survey (Phoenix 2020) and the characteristics of the Project. Land clearing to establish the mine will unavoidably result in losses of vegetation and some priority flora. Once land clearing has been undertaken, mining and related activities will be undertaken in close proximity to uncleared vegetation.

The capacity to quantitatively monitor floristic parameters allows for outcome-based monitoring to establish whether proportionate trigger values specified in MS 892, i.e. 10% decline, have been exceeded. Monitoring for trigger value exceedances will initiate management actions to remediate impacts from the Project. Floristic parameters that will be quantitatively assessed in the proposed monitoring program comprise:

- plant health of dominant plant species
- changes to species richness in monitoring quadrats
- changes to total plant foliage cover
- changes to foliage cover of dominant species in canopy stratum
- vegetation weediness index
- dust deposition on plant foliage

Management measures will be implemented to reduce the potential for indirect impacts on uncleared vegetation due to dust, the introduction or spread of weeds and other potential risks, e.g. increased fire frequency.

Outcome-based actions have been identified to address potential impacts identified for flora and vegetation. The actions focus on all key project activities identified as potentially having an adverse impact on vegetation health and weed status, as well as addressing specific conditions in MS 892. They also incorporate proponent commitments for the Project outlined in the Project PER (Cazaly Resources Limited 2010).

The Project will have a small footprint over a long life of mine with priority use of existing disturbed areas and progressive rehabilitation, including rehabilitation of historic exploration disturbance. Management and mitigation measures have been designed for the long-term 6-year life of mine, and as such, may require adaptive solutions in subsequent revisions.

The environmental criteria proposed to be used for trigger and threshold criteria are relevant measures of dust deposition and vegetation health and abundance.

1.9.1 Trigger criteria

Dust deposition was selected as a trigger criterion as it was identified by the EPA as a potential impact to flora and vegetation health. Dust will be measured monthly using dust deposition gauges AS_NZS_3580.10.1 (Standards Australia 2016) within each vegetation monitoring site (impact and reference).

Trigger levels for dust have been selected based on results from the Yilgarn operations at Koolyanobbing Range F deposit located within 90 km of the Parker Range Iron Ore mine (Mineral Resources 2019). Over four years of monthly dust deposition has been measured using monitoring gauges located at sites surrounding the mining operation. Dust monitoring gauges within 50 m of mining operations recorded peak dust levels of 96 g/ m^2 /month during early stages of mining (Mineral Resources 2019).

Vegetation monitoring sites at Parker Range operations are located within 50 – 250 m of mining operations and so dust values are expected to be vary for each site, some will be similar to, and some much lower, than those within 50 m of operations at the Koolyanobing mine site. To be conservative the dust trigger value proposed is 40 g/ m^2/month (Sa), this value is lower than peak dust levels reached at Koolyanobing mine site. This trigger value will be revised and reassessed as necessary, dependant on dust deposition values at reference sites and vegetation health values recorded for monitoring sites.

Vegetation health is expected to naturally fluctuate due to environmental conditions, therefore vegetation abundance and mean plant health within impact sites will be monitored against reference sites and baseline data.

Trigger criterion 1: a dust deposition reading of 40 g/ m^2/month (Sa) after commencement of mining. This trigger will act as an early warning sign to assess vegetation health outside of the yearly monitoring periods and will instigate investigation into whether elevated dust deposition is due to mining activities and subsequent review of control dust measures where elevated levels are detected.

Trigger criterion 2: A 10% (or greater) decline in vegetation abundance or mean health within impact sites compared to baseline monitoring values and reference sites, correlated with a dust deposition reading of 40 g/m^2/month (Sa) after commencement of mining. This trigger will identify early declines (if any) in vegetation abundance or mean health due to increased dust deposition from mining activities and instigate contingency responses and increased monitoring.

1.9.2 Threshold criteria

The threshold criteria are intended to detect if a negative effect on flora and vegetation outside the project area has occurred as a result of mining activities associated with the Project. The threshold criterion is a 25% (or greater) decline in abundance or mean health in impact monitoring sites, compared to baseline monitoring values and reference sites, correlated with leaf surface dust and/or a dust deposition reading of 40 g/ m^2/ month (Sa). If this threshold is reached it will trigger management actions (Table 9).

2. VHWMMP PROVISIONS

This section identifies the outcome-based provisions that MRL will implement to ensure protection of flora and vegetation health and the prevention of weed status. It states the performance-based objectives for flora and vegetation health and weed status, project specific triggers and contingency actions.

2.1 Provisions table

The management provisions are outlined in Table 10.

Table 10: Vegetation health and weed monitoring provisions to meet legal requirements of Condition 6 of MS 892

EPA factor and objective: Flora and vegetation. To protect flora and vegetation so that biological diversity and ecological integrity are maintained					
Outcome/s: 1. To avoid a 25% or greater decline in health or abundance of vegetation at monitoring sites within a 250 m buffer around areas approved for disturbance as compared to the reference sites 2. To avoid the introduction of any new weed species or an increase in weediness at monitoring sites within a 250 m buffer around areas approved for disturbance as compared to reference sites					
Key environmental values: Vegetation health, Priority flora					
Key impacts and risks: Clearing of native vegetation, dust, introduction and spread of weeds, and altered fire regimes					
OUTCOME-BASED PROVISIONS					
Environmental criteria	**Management actions**	**Performance indicator**	**Monitoring**	**Reporting**	**Responsible personnel**
Condition 6-1 The proponent shall undertake monitoring of the health and abundance of vegetation within a 250 m buffer area around areas approved for disturbance at the mine site					

Trigger criteria
1. A dust deposition reading of 40 g/m^2/month (Sa)[4] after commencement of mining
	Trigger level actions
	• Undertake an investigation to determine whether dust readings at the impact sites are comparable to the those at the reference sites
	• For areas and activities identified as the main sources of dust emissions.
	  ○ Re-examine dust control measures and implement an increase in dust control treatments
	  ○ Adjust locations and/or timing of mining activities should conditions at scheduled mining locations and/or times be unfavourable in terms of wind and weather conditions
		Dust deposition readings higher at impact sites in comparison to reference sites	Monthly	Monthly dust monitoring report	Environmental Advisor

2. A 10% (or greater) decline in vegetation abundance or mean health within impact	• Implement contingency measures within 24 hours of the exceedance being identified (see section 3.1)	Dust deposition readings higher at impact sites in	Annual monitoring or quarterly	Annual vegetation health and	Environmental Advisor

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sites compared to baseline monitoring values and reference sites, correlated with a dust deposition reading of 40 g/ m^2/ month (Sa) after commencement of mining	• Increase vegetation monitoring frequency to a three-month cycle at impact sites where trigger criteria was exceeded with no comparable observation in the reference sites • If after the two consecutive monitoring events, a threshold exceedance has not been identified, resume standard monitoring frequency. • Re-examine applied monitoring parameters to confirm they are operating within management levels and implement changes where necessary	comparison to reference sites Change in abundance or mean health at impact site/s in comparison to reference sites	monitoring in the advent monitoring indicates potential impact	weed monitoring report AER	Environmental Manager
Threshold criteria A 25% (or greater) decline in abundance or mean health in impact monitoring sites compared to baseline monitoring values, correlated with leaf surface dust and/or a dust deposition reading of 40 g/ m^2/ month (Sa)	**Trigger level actions** • Implement contingency responses within 24 hours of the exceedance being identified (see section 3.1). • Report the threshold exceedance to the CEO of DWER within 7 days of the exceedance being identified. • Provide evidence to the satisfaction of the CEO of DWER which allows determination of the cause of the exceedance within 21 days of the exceedance being identified. • Implement corrective actions, as appropriate to prevent recurrence. • Continue to implement remedial actions until approval to cease has been given by the CEO of DWER.	Dust deposition readings higher at impact sites in comparison to reference sites Change in abundance or mean health at impact site in comparison to reference sites	Annual monitoring or quarterly monitoring in the advent monitoring indicates potential impact	Annual vegetation health and weed monitoring reporting AER Report of exceedance of trigger criteria to CEO of DWER Receipt of approval to cease remedial activities from CEO of DWER	Environmental Advisor Environmental Manager Environmental Manager Environmental Manager
Condition 6-5 The proponent shall undertake weed management to ensure that: 1. No new species of declared weeds and environmental weeds are introduced into the proposal area and that the abundance and distribution of existing weeds is not increased as a direct or indirect result of implementation of the proposal.					

Trigger criteria
1. The introduction of any new declared weeds or environmental weed species
2. An increase in weediness index at impact sites
	Trigger level actions
	• If new declared weeds or environmental weeds are identified, undertake an investigation to determine the source of the introduction and whether weed hygiene procedures need to be amended.
	• In the event an increase in weediness index occurs, undertake an investigation to determine whether the changes observed in the impact sites are comparable to the observations in the reference sites
	  ◦ where it was not caused by construction, operation or decommissioning activities, resume standard monitoring frequency.
	• Where the increase in weediness is caused by construction, operation or decommissioning activities:
	  ◦ implement contingency measures within 24 hours of the exceedance being identified (see Section 3.1);
	  ◦ submit a report to the CEO of DWER with actions within 3 months of the determination being made; and
	  ◦ provide evidence to the satisfaction of the CEO of DWER which allows determination of the cause of the exceedance within 21 days of the exceedance being identified.
	• Immediately undertake weed control and rehabilitation in the affected areas, where proposal attributable weed cover has adversely changed, using native flora species of local provenance.
	• Continue to implement remedial measures until approval to cease has been given by the CEO of
		Identification of new weed species within the Project area
		
		Increase in weediness index at impact sites comparative to reference sites
			Annual monitoring (for the first two years, thereafter, every two years) or quarterly monitoring in the advent monitoring indicates potential impact	Annual vegetation health and weed monitoring report
				AER
				
				Report of exceedance of trigger criteria to CEO of DWER
				
				Receipt of approval to cease remedial activities from CEO of DWER
					Environmental Advisor
					
					Environmental Manager

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	DWER re-examine applied monitoring parameters to confirm they are operating within management levels and implement changes where necessary. • Increase weed monitoring frequency to a three-month cycle at impact sites where trigger criteria was exceeded with no comparable observation in the reference sites. • After the two consecutive monitoring events, determine if trigger criteria have been exceeded and a management response is required. If after the two consecutive monitoring events, a threshold exceedance has not been identified, resume standard monitoring frequency.				

[4] Sa = mass deposition rate of ash, in grams per square metre per month

2.2 Vegetation health and weed monitoring program

A vegetation health and weed monitoring program is required to measure the effectiveness of the management actions outlined above. The outcomes of the monitoring program will inform whether the environmental objective is being achieved and when management actions will need to be reviewed and revised.

This baseline vegetation health and weed monitoring program is designed in accordance with MS 892, Condition 6 (Section 1.3).

Condition 6-1, MS 892, states that the proponent shall undertake monitoring of the health and abundance of vegetation within a 250 metre buffer area around areas approved for disturbance at the mine site and within a 125 metre buffer around the upper haul road as illustrated in Figures 4 and 5 in Schedule 1.

The monitoring required under Condition 6-1 is to commence prior to ground disturbing activities required for the implementation and operation of the proposal and be carried out to the requirements of the CEO on advice of the DBCA and will include:

1. The provision of baseline data.
2. Identification of baseline and control sites.
3. Definition of monitoring frequency, timing, intensity and replication.
4. Definition of health and abundance.
5. Identification of what and how parameters will be used to measure decline or rate of decline in health or abundance.
6. Definition of management responses required should a 10% (or greater) decline in health or abundance be recorded.

In the event that MRL intend to develop the upper haul road and Moorine Rock rail siding (Appendix 2), this VHWMMP will be updated to incorporate conditions relating to vegetation health and weed status for this additional area.

A baseline vegetation health and weed survey will be conducted in monitoring quadrats established in consultation with DBCA in a previous baseline survey (Botanica Consulting 2011) involving:

- 2 reference sites (outside the 125 m buffer)
- 4 impact sites (within the 125 m buffer)
- 2 weed quadrats .

Field work will be undertaken in spring, with methods following those established for the monitoring of vegetation health and weed status of the project area (Appendix 1; Phoenix 2020). The management of vegetation health and weed status for the haul road will be incorporated into this plan following the same management provisions and actions outlined in this VHWMMP.

Monitoring parameters and methods

Dust monitoring

Dust deposition monitoring will be undertaken monthly using standard dust deposition gauges located within each vegetation monitoring plot (Figure 3).

Vegetation health and weed monitoring

Annual monitoring of all sites sampled in the baseline vegetation health and weed survey (Appendix 1; Phoenix 2020) will be undertaken in spring. A set of monitoring parameters and methods have been selected

to align with the conditions of MS 892 and are consistent with the baseline survey. Monitoring parameters and methods are described in Table 11.

Vegetation health

Due to the significant differences observed in the average health of plants within and across monitoring sites (section 1.6, Appendix 1), to monitor for changes to vegetation health over time, the proportional change in metrics (mean health score, abundance and dust rating) within each monitoring quadrat will be determined and then compared between quadrats.

Declines in abundance or mean health scores (including changes in range, i.e. min and max health scores) identified in vegetation impact quadrats will be compared with those of reference quadrats to assess whether declines are a result of climatic conditions (i.e. drought, cyclones) or impacts from the development and/or operations of the mine. Should any decline in a vegetation impact quadrat not be reflected in a reference quadrat then investigations will be conducted to determine the cause of the decline. Data may be correlated to changes in the dust deposition scale to indicate whether the change may be related to mine site operations. In addition, site photos and field notes would be reviewed to detect other possible causes for the change.

Weed status

Baseline data has been collected on the weed status of four weed impact sites and eight reference sites (200m outside the development envelope (Figure 3). Results from future monitoring will be compared to baseline data to detect the presence of new weed species or increases in weed cover (weediness index). The presence of new weed species or increases in weed cover (weediness index) identified in weed impact quadrats will also be compared with those of reference quadrats to assess whether changes are a result of impacts from the development and/or operations of the mine or broader regional changes (i.e. rainfall, cyclones). Should any new weed species or increases in weed cover identified in a weed impact quadrat not be reflected in a reference quadrat then investigations will be conducted to determine the cause of the introduction or increase in cover.

Table 11: Vegetation health monitoring parameters and methods

Monitoring parameter	Method
Health and abundance quadrats	
Plant health	Visual assessment of health based on the Casson *et al.* (2009) health scale (Table 13)
Species richness	List and count of plant species in the quadrat, annual and perennial
Percentage vegetation cover of the dominant species in each canopy level	Visual assessment of percentage cover, site photos will be utilised to compare canopy covers between monitoring periods to assist in determining changes.
Weed species present	Visual assessment of any weed species present, collections taken to confirm identity of any plants thought to be introduced Visual assessment of percentage cover of weeds present, site photos will be utilised to compare canopy covers between monitoring periods to assist in determining changes.
Dominant species (up to 10 individuals) within each canopy level (upper[4], mid, low)	Visual assessment of percentage of vegetation cover Visual assessment of height of each plant Dust level rating (Table 12) A health score using a scale from Casson *et al.* (2009) (Table 13)
Weed quadrats	

Monitoring parameter	Method
Species richness of weed species	List and count of weed species present
Weed species cover	Visual assessment of percentage vegetation cover of all weed species present, site photos will be utilised to compare canopy covers between monitoring periods to assist in determining changes.
Weediness index	'Weediness index' (Loomes *et al.* 2008) calculated using number of weed species and cover of weed species (where present): $\frac{\text{cover of weed species}}{\text{cover of native species}} + \frac{\text{number of weed species}}{\text{number of native species}}$
Species richness of native species	List and count of native species present
Native species cover	Visual assessment of percentage vegetation cover of native species, site photos will be utilised to compare canopy covers between monitoring periods to assist in determining changes.

[5] Upper represented by tree species, mid represented by shrubs >1m height, lower represented by shrubs, grasses and forbs <1m in height.

Table 12: Dust deposition scale

Dust Rating	Description
0	no evidence of dust deposition
1	evidence of dust deposition (minor discolouration indicating fine dust particles on surface of leaves)
2	minor, dust build up visible on surface of some leaves
3	moderate, dust build up with more than 50% of leaves covered
4	heavy, dust build up covers entire surface of all leaves

Table 13: Plant health scale (Casson et al. 2009)

Health rating	Description
0	healthy, no dead leaves
1	occasional dead leaves
2	epicormic shoots (therefore stressed)
3	tips of branches stressed or dying
4	entire or whole branches dying or dead (nb some lower branches excluded from this assessment)
5	more than half tree/shrub dead
6	tree dead

2.3 Reporting

MRL is required to report against its compliance with this VHWMMP in an annual compliance assessment report (CAR), prepared in accordance with condition 4-6 of MS 892. The CAR is required to be submitted to the CEO of the DWER within three months following each 12-month reporting period (12 April–11 April of the following year).

In accordance with condition 6-3 of MS 892, if the potential impact sites show a 25% (or greater) decline in health or abundance as compared to the baseline data or comparison to reference sites, written notice is to be provided to the CEO, on advice of DBCA, within 21 days of the decline being identified which:

1. describes the decline
2. provides information which allows determination of the likely root cause of the decline.

In accordance with condition 6-5 of MS 892, if the results of weed monitoring indicate an increase in weediness index within weed monitoring quadrats are proposal attributable, the proponent shall report the monitoring findings to the CEO and DBCA within three months of completion of the monitoring.

3. ADAPTIVE MANAGEMENT AND REVIEW OF THE VHWMMP

Adaptive management practices that will be assessed for the vegetation health monitoring and management program as part of this approach may include:

- Evaluation of the monitoring program.
- If monitoring results indicate that management objectives are not being achieved.
- If new information is discovered during construction, operations or closure.
- Where any significant changes to project design or operation have occurred, and
- Where it has been longer than 12 months since the last revision.
- Evaluation of the monitoring program, data and comparison to baseline data and reference sites on an annual basis to verify whether responses to project activities are the same or similar to predictions.
- Evaluation of assumptions and uncertainties of the vegetation health management and monitoring program.
- Review and implementation of contingency actions in the event management targets indicate these are required.
- Review of data and information gathered over the review period that has increased understanding of site environment in the context of the regional ecosystem.
- Review of management actions as the project matures and new management measures and technologies become available that may be more effective for vegetation health management.
- Assessment of changes which are outside the control of the project and the management measures identified (i.e. a new project within the area or region; regional change affecting vegetation health management).
- Review of the VHWMMP will be undertaken annually and updated, if required, based on review outcomes.

3.1 Contingency measures

The specific actions to be undertaken by MRL in response to trigger events would be dependent on the particular causal factors found to be contributing to trigger events. However, the management response is likely to include the modification of practices, or potentially the suspension or relocation of particular operational activities if found to be contributing to the trigger event. Contingency measures are identified below for potential key impacts to vegetation health and weed status. This list is not exhaustive and additional contingency actions may be identified following investigation into any incidents relating to vegetation health and weed status.

Loss of Priority flora

- Any works being undertaken directly or indirectly leading to the loss of Priority flora species, will be temporarily ceased (where possible) or modified to prevent further risk/loss of Priority flora.
- An investigation will be undertaken to identify the cause of the unauthorised clearing and corrective actions to prevent any further unauthorised clearing of Priority flora.
- Corrective actions will be implemented.
- Notification of loss of Priority flora will be provided to regulatory bodies.

If the loss of Priority flora is due to onsite activities, the loss will be recorded and the relevant authorities notified (CEO, DBCA).

Indirect impact

Reduction in vegetation health:

- Any works being undertaken directly (or indirectly) leading to the reduction in vegetation health will be temporarily halted.
- An investigation of work practices will be undertaken to identify corrective actions to reduce risk of further reduction in vegetation health.
- Corrective actions will be implemented
- Where dust levels are correlated with declines in health or abundance
    - re-examine dust control measures and implement an increase in dust control treatments
    - adjust locations and/or timing of mining activities should conditions at scheduled mining locations and/or times be unfavourable in terms of wind and weather conditions

Introduction of weeds or increase in weed cover:

- Any works being undertaken directly (or indirectly) leading to the introduction of weeds or the increase in weed cover will be temporarily halted
- An investigation of work practices will be undertaken to identify corrective actions to reduce risk of further introduction of weeds or the increase in weed cover
- Corrective actions will be implemented

Monitoring indicates an adverse impact to vegetation health:

- Contingency actions, in the event monitoring indicates an adverse impact to vegetation health, are to be identified through an investigation into the cause of the decline, in consultation with DBCA.

4. STAKEHOLDER CONSULTATION

Stakeholder consultation will be undertaken with DBCA as the VHWMMP is implemented and it is therefore likely that revisions will be made to the VHWMMP if further guidance is provided by these stakeholders.

Table 14: Stakeholder consultation

Stakeholder	Date	Type of consultation	Persons involved	Comments received
EPA services	12/11/2019	Email response	Jessica Allen, Les Purves	Parameters being measured for vegetation health should be clarified: • definition of health and abundance • identification of what and how parameters will be used to measure decline or rate of decline in health or abundance • definition of management responses required should a 25% (or greater) decline in health or abundance be recorded. There is a lack of information on what data will be collected for weeds Utilise a health scale that does not use flowering as an indicator of health

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Appendix 1: Baseline health assessment of vegetation and weed monitoring report

PHOENIX
ENVIRONMENTAL SCIENCES

Baseline health assessment of vegetation and weed monitoring for the Parker Range Iron Ore Project

Prepared for Mineral Resources Ltd

February 2020

Final Report

Baseline health assessment of vegetation and weed monitoring for the Parker Range Iron Ore Project.

Final Report

Prepared for Mineral Resources Ltd

Version history

Authors	Reviewer/s	Version	Version number	Date submitted	Submitted to
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EXECUTIVE SUMMARY

Mineral Resources Limited (MRL) are proceeding to implement the Parker Range Iron Ore Project (the Project), located approximately 45 km south-east of Southern Cross.The Project was approved under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC 2010/5435) on 3 November 2011 via the bilateral agreement between the Commonwealth and WA. The Project was approved under Part IV of *the Environmental Protection Act 1986* (EP Act) on 12 April 2012, subject to conditions and procedures outlined in ministerial statement (MS) 892.

Condition 6 of MS 892 requires development of a monitoring plan for vegetation health and weed status.

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by MRL to undertake a baseline survey to assess vegetation health and weed establishment for the Project.

A previous baseline survey was undertaken for the Project by Botanica Consulting in 2011. Advice from Environmental Protection Authority (EPA) on the outcomes and methodology of the previous survey capacity to meet the conditions of MS 892 resulted in changes to the parameters to be measured for the baseline survey. The EPA advice required:

- identification of what and how parameters will be used to measure decline in plant health and abundance
- definition of plant health and abundance
- use of a plant health scale that does not use flowering as a measure of health
- identification of what data will be collected to monitor for weeds
- clarification of how any observed decline in health or abundance may be attributable to mining operations.

A desktop review of relevant databases and previous survey reports preceded the field survey to identify weed species that may potentially occur in the Project and determine the locations of previously recorded weed species. The desktop assessment determined the potential for at least sixteen weed species to occur, including two Declared Pests, **Chrysanthemoides monilifera* and **Moraea miniata*. However, no weed species had been recorded in the weed monitoring quadrats or in any of the vegetation health impact quadrats from pervious surveys. During the current survey one weed species, **Centaurea melitensis*, was found within an impact quadrat and is the first record of this species for the Project. However, no weed species were recorded within the weed monitoring quadrats.

Advice from the EPA recommended the use of a different plant health scale for the current survey than used previously, that did not use flowering as a measure of plant health. The desktop assessment identified a suitable plant health scale developed by DEC (now DBCA) which was applied for the current survey.

Field work involved sampling of 28 quadrats; 16 impact quadrats, eight reference quadrats, and four weed monitoring quadrats. The following metrics were recorded for each vegetation health impact monitoring quadrat:

- list of each species present
- species richness, i.e. number of plant species in the quadrat, annual and perennial
- percentage vegetation cover within each canopy level (upper, mid, low)
- percentage vegetation cover of the dominant species in each canopy level

- species identitification of any weeds present
- percentage vegetation cover of all weeds present
- photographs of vegetation from all four corners of the quadrat.

The following metrics were recorded for each weed monitoring quadrat:

- list of each species present
- number of native species present
- percentage vegetation cover of native species
- number of weed species present
- percentage vegetation cover of all weed species present.

In addition, plant health was recorded for up to 10 plants of the dominant species for each canopy level represented in the quadrat vegetation (upper, mid and low). A scale of dust accumulation on the plant's foliage was also recorded to provide an indication of potential impacts on plants from the mining operations.

The species richness, canopy and dominant species vegetation cover, average health and dust measures of the dominant species for each canopy layer will be used to measure decline or rate of decline in health or abundance in future monitoring. Data collected for weeds will be used to calculate a weediness index that will be used to monitor for weed infestations.

Significant differences were identified in the species richness, canopy and dominant plant vegetation cover and average health of plants within and across vegetation health impact and reference quadrats. Subsequently, to monitor for changes to vegetation health over time, the proportional change in metrics within each quadrat will be determined and then compared between quadrats.

Declines in abundance or mean health scores identified in vegetation impact monitoring quadrats would be compared with those of reference quadrats to assess whether declines are a result of climatic conditions (i.e. drought, cyclones) or impacts from the development and/or operations of the mine. Should any decline in a vegetation impact monitoring quadrat not be reflected in reference quadrats then investigations will be conducted to determine the cause of the decline. Data may be correlated to changes in the dust deposition scale to indicate whether the change may be related to mine site operations. In addition, site photos and field notes would be reviewed to detect other possible causes for the change.

There were a number of notable differences in the results of the current survey when compared with the previous survey:

- three priority species were found within impact quadrats in the current survey, only one priority species had been previously recorded
- species richness of the majority of quadrats for the current survey was higher than in the prior survey
- long-lived perennial species recorded in high numbers in the quadrats in the previous survey were not present during the current survey and were not evident in the site photos of the previous survey.

In addition, there were inconsistencies in species lists in the previous survey report and some monitoring quadrats had not been permanently marked with posts. It is therefore suggested that the most recent survey data be used as the new baseline health assessment of vegetation and weed monitoring for the Project.

1. INTRODUCTION

Mineral Resources Limited (MRL) are proceeding to implement the Parker Range Iron Ore Project (the Project). The Project was approved under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (EPBC 2010/5435; DSEWPaC 2011) on 3 November 2011 via the bilateral agreement between the Commonwealth and Western Australia (WA). The Project was approved under Part IV of *the Environmental Protection Act 1986* (EP Act) on 12 April 2012, subject to conditions and procedures outlined in ministerial statement (MS) 892 (Minister for Environment; Water 2012).

The Project is located 55 km southeast of Southern Cross, in the Goldfields region of Western Australia (Figure 1-1). The approved project area under MS 892 and EPBC 2010/5435 is 418.1 ha including the upper haul road (4.1 ha) (Figure 1-1). MRL are seeking a minor amendment to the approved project area (referred to in this report as the development envelope), which is 418.9 ha, excluding the upper haul road (Figure 1-1). This report adopts the revised development envelope in place of the approved project area.

Condition 6 of MS 892 relates to the management and monitoring of vegetation and weeds, as outlined below.

1.1 STATE APPROVAL REQUIREMENTS

Although not explicitly stated, condition 6 of MS 892 requires development of a monitoring plan for vegetation health and weed status, including the provision of baseline data, prior to ground disturbing activities. Full details of Condition 6 as stated in Minister for Environment; Water (2012) are provided below.

6 Flora and vegetation

6-1 The proponent shall undertake monitoring of the health and abundance of vegetation within a 250 m buffer area around areas approved for disturbance at the mine site and within a 125 m buffer around the upper haul road[1] as illustrated in Figures 4 and 5 in schedule 1.

6-2 The monitoring required under condition 6-1 is to commence prior to ground disturbing activities required for the implementation and operation of the proposal and be carried out to the requirements of the CEO on advice of the Department of Environment and Conservation (DEC) and will include:

1. the provision of baseline data;
2. identification of baseline and control sites;
3. definition of monitoring frequency, timing, intensity and replication;
4. definition of health and abundance;
5. identification of what and how parameters will be used to measure decline or rate of decline in health or abundance; and
6. definition of management responses required should a 25% (or greater) decline in health or abundance be recorded.

[1] The upper haul road near Moorine Rock and rail siding approved under MS 892 is not currently proposed for development and has been excluded from this baseline survey.

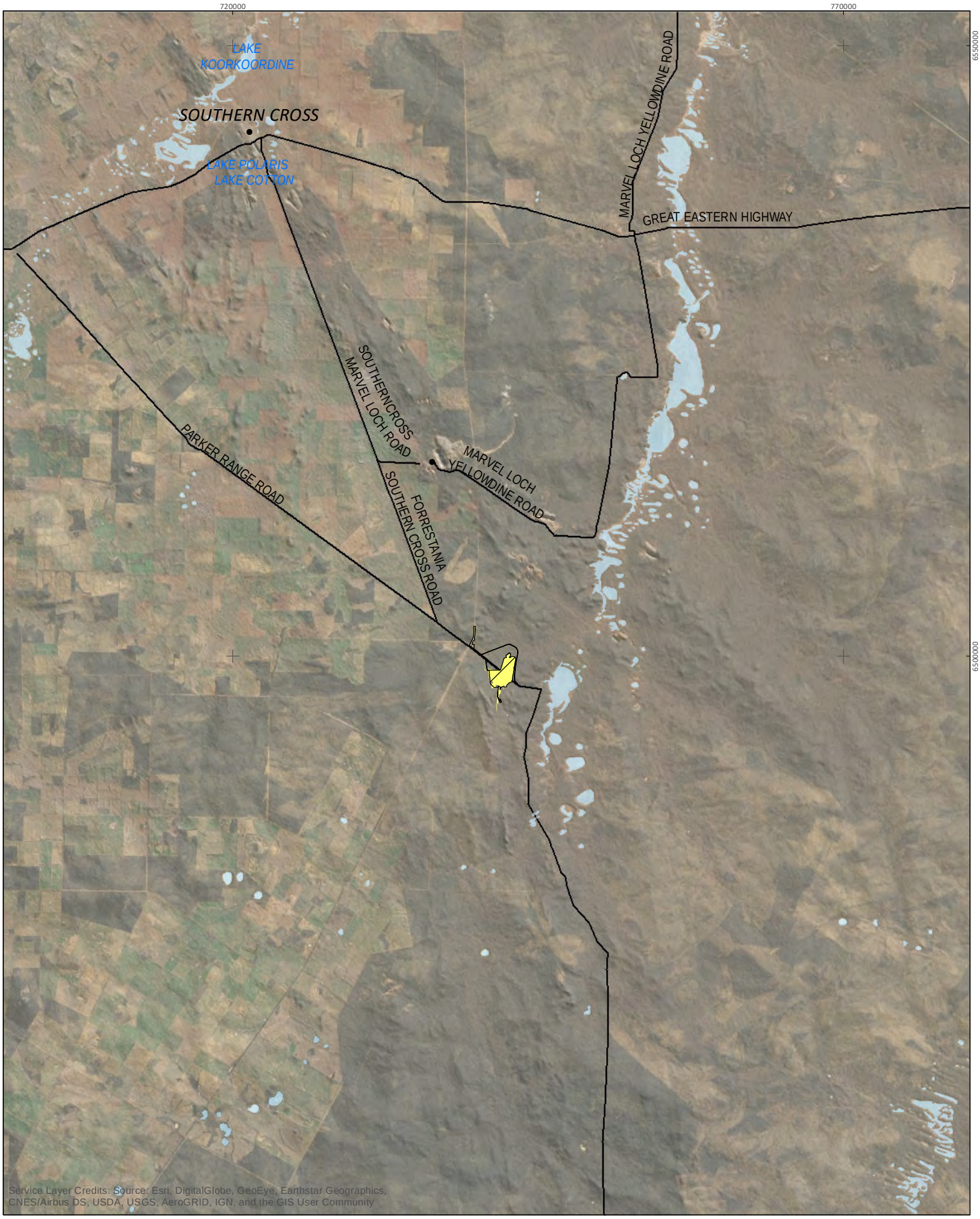
6-3 Should the potential impact sites show a 25% (or greater) decline in health or abundance as compared to the reference sites, the proponent shall provide a report to the CEO within 21 days of the decline being identified which:

1. describes the decline; and
2. provides information which allows determination of the likely root cause of the decline.

6-4 If the decline in health or abundance identified in condition 6-3 is determined by the CEO to be caused by activities undertaken in implementing the proposal the proponent shall implement the actions identified in condition 6-2-6 and continue to implement such actions until the CEO determines that the remedial actions may cease.

6-5 The proponent shall undertake weed management to ensure that:

1. No new species of declared weeds and environmental weeds are introduced into the proposal area and that the abundance and distribution of existing weeds is not increased as a direct or indirect result of implementation of the proposal.
2. Prior to ground disturbing activities the proponent shall undertake a baseline weed survey to determine the species and extent of declared weeds and environmental weeds present at weed monitoring sites within the project footprint including the mine area (schedule 1 Figure 2) and the upper haul road[1] (schedule 1 Figure 3) and at least three reference sites on nearby undisturbed land beyond 200 metres from the disturbance footprint in consultation with the DEC.
3. To determine whether changes in weed cover and type within the project footprint have occurred and are likely to have resulted from implementation of the proposal or broader regional changes, monitoring of baseline and reference sites surveyed as required by condition 6-5-2 shall commence within one year after initial ground disturbing activity required for the implementation of the proposal. These sites are to be monitored annually for two years during the time of year agreed to by the CEO on advice of the DEC. Thereafter monitoring shall take place at least every two years at the time of year agreed above for the life of the proposal, with monitoring within a two year period to coincide with the year of any favourable rainfall events.
4. If the results of monitoring under condition 6-5-3 indicate that adverse changes in weed cover and type within the project footprint are proposal attributable, the proponent shall report the monitoring findings to the CEO and DEC within three months of completion of the monitoring and shall immediately undertake weed control and rehabilitation in the affected areas, where proposal attributable weed cover has adversely changed, using native flora species of local provenance.
5. The proponent shall continue to implement the remedial measures required by condition 6-5-4 until approval is given by the CEO to cease.



Mineral Resources Ltd Parker Range Iron Ore Project

Project No	1299
Date	19-Feb-20
Drawn by	AJ
Map author	KC

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Kilometres

1:400,000 (at A4) GDA 1994 MGA Zone 50

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Approved project area (MS 892)

New development envelope

Figure 1-1

Parker Range Iron Ore Project location

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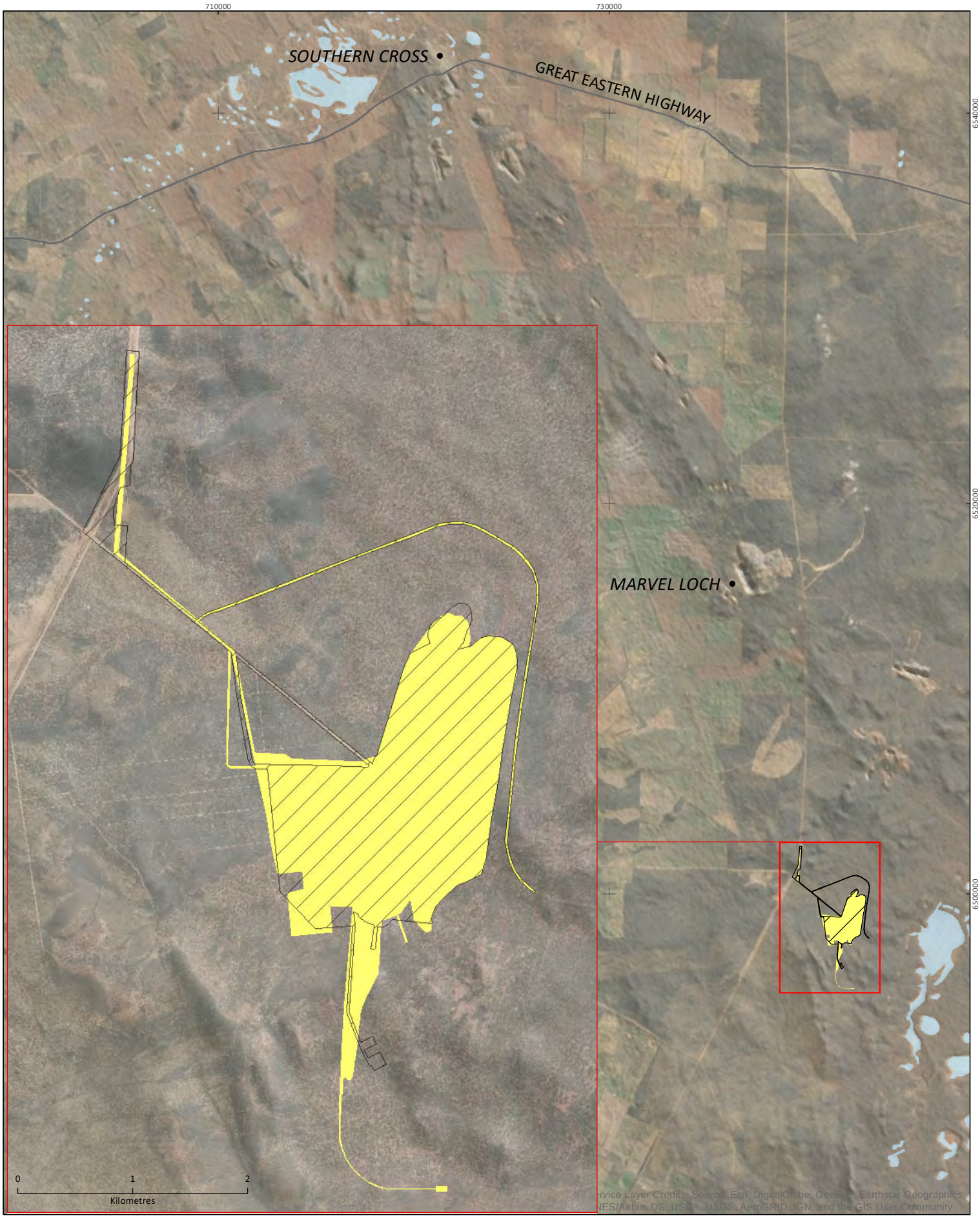

Mineral Resources Ltd
Parker Range Iron Ore Project

Project No	1299
Date	19-Feb-20
Drawn by	AJ
Map author	GW

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Approved project area (MS 892)

New development envelope

Figure 1-2

Parker Range Iron Ore Project approved project area and new development envelope

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1.2 PREVIOUS SURVEY

A baseline survey to assess vegetation health and weed establishment was previously undertaken for the Project in 2011 (Botanica Consulting 2011b). A total of 28 20 m x 20 m quadrats were installed (Figure 1-3; Appendix 1):

- 16 quadrats within a 250 m buffer of the development envelope (impact sites)
- Eight quadrats outside of the 250 m buffer (reference)
- four weed monitoring quadrats adjacent to roads/vehicle access areas within the development envelope (weed sites).

The location of the reference sites was selected in conjunction with the Department of Environment and Conservation (Botanica Consulting 2011b), now the Department of Biodiversity, Conservation and Attractions (DBCA).

The previous baseline assessment recorded several metrics:

- species richness in the quadrat
- total plant abundance
- plant density (m^2)
- total percentage vegetation cover
- percentage vegetation cover for each canopy layer
- species identitification of any weeds present
- percentage cover of weeds.

In addition, the vegetation in the quadrat was assigned a health score according to the scale provided in Table 1-1.

Table 1-1 Vegetation health rating scale

Health rating	Health description	Definition
5	Excellent	Plants are highly vigorous (healthy, strong and growing well), leaves are lush (very green and healthy). Plants are in flower and producing fruit. New growth is present.
4	Very Good	Plants are moderately vigorous, leaves are lush. Plants have no flowers/dry
3	Good	Plants are not vigorous, leaves are not lush. Plants have no flowers and no fruit. No new growth is present flowers and no fruit. New growth is present.
2	Poor	Plants are not vigorous, leaves are not lush. Plants have no flowers and no fruit. No new growth is present flowers and no fruit. New growth is present.
1	Dead	Plants are dead

Figure 1-3
Vegetation health and weed monitoring locations

Approved project area (MS 892)

New development envelope

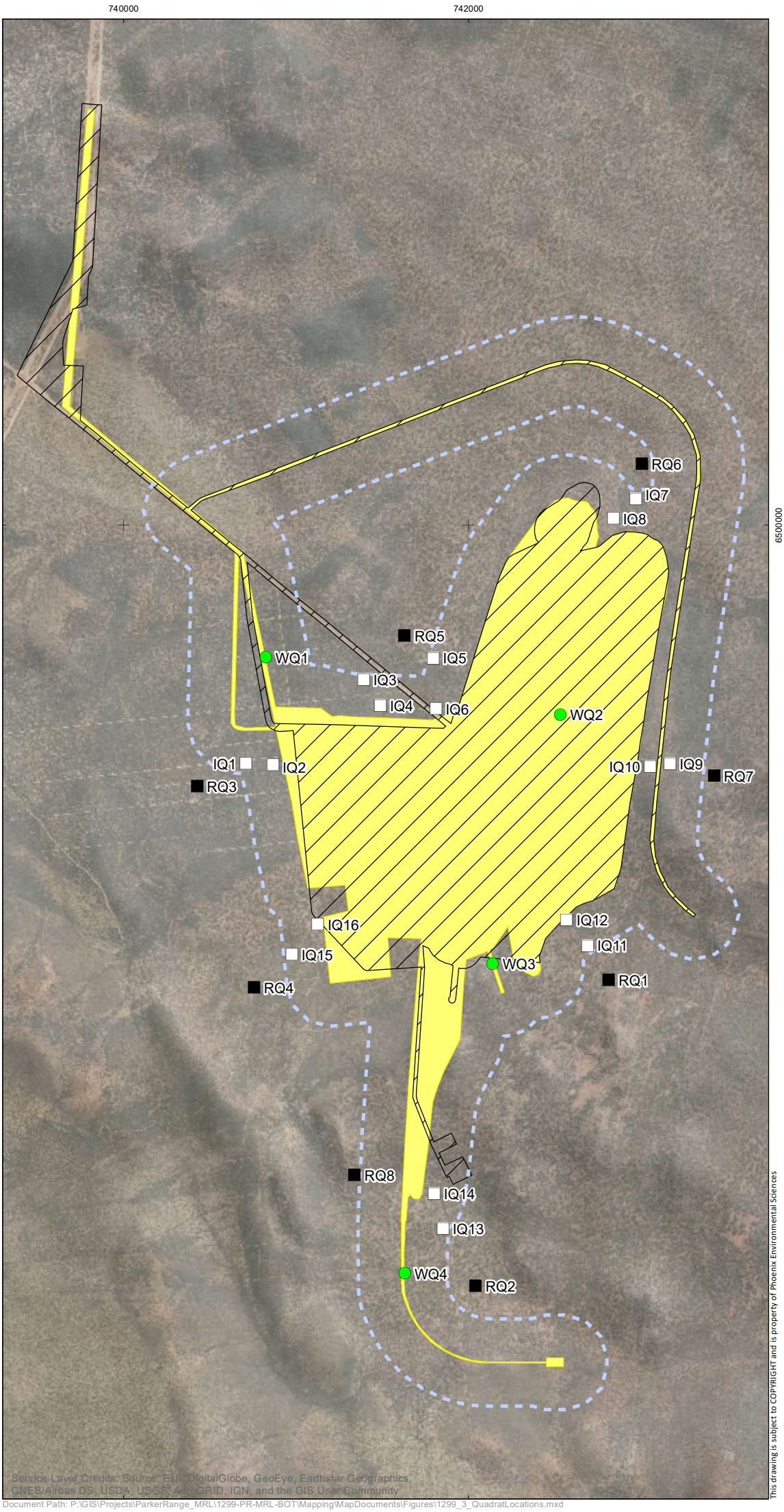
250 m buffer of the development envelope

Quadrats

Impact

Reference

Weed



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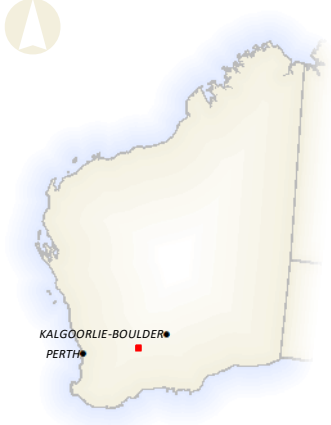
Kilometres

1:30,000

Client: MRL
Project: Parker Range Iron Ore Project (Mine)

Author: AJ
Date: 24-Feb-20

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994



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1.3 REQUIREMENTS FOR THE CURRENT BASELINE ASSESSMENT

Advice from EPA Services (Jessica Allen pers. com. via email to Les Purves of MRL 12 November 2019) on the outcomes and methodology of the previous survey capacity to meet the conditions of Ministerial Statement 892 were reviewed and changes to the parameters to be measured were implemented for the current baseline survey. Further detail is provided in section 1.4.

1.4 PURPOSE AND SCOPE OF THIS REPORT

The purpose of this report is to provide the baseline data (including data required in conditions 6-2(1) and 6-5(2)) to inform a vegetation health and weed monitoring and management plan for the Project.

The scope of work in relation to conditions of MS 892 was as follows:

- undertake a baseline vegetation health survey of impact[2] quadrats within a 250 m buffer of the development envelope, as well as reference sites to determine current status of vegetation health accordance with condition 6.1 and 6.2 of MS 892
- undertake a baseline weed survey of quadrats within a 250 m buffer of the development envelope, as well as reference sites, to determine current status of weeds in accordance with condition 6.5 of MS 892.

Further to these requirements, the scope of works for the current baseline assessment was to:

- provide an alternative health measure that does not include flowering
- demonstrate how the health measure and other metrics may be used to assess the 25% trigger value
- provide a measure to link potential impacts on plants to the mining operations if applicable.

An assessment of vegetation health and weed status of the 125 m buffer of the upper haul road was not completed as part of the monitoring program. MRL have indicated that they have no intention of utilising the upper haul road as part of the Project operations. Should MRL seek to utilise the upper haul road, further monitoring will be completed prior to disturbance to confirm baseline data.

[2] Impact quadrat refers to sites within 250 m of the development envelope that could be potentially impacted due to moining activities

2. METHODS

2.1 LITERATURE REVIEW

Prior to conducting the field survey, a review of a vegetation condition monitoring manual (Casson *et al.* 2009) was undertaken to identify an alternative vegetation health scale.

Previous vegetation and flora assessments for the Project were reviewed to identify weed species previously recorded and provide a list of species recorded in monitoring quadrats to facilitate identification during the field survey. In addition, a search of NatureMap (DBCA 2019b) was conducted to identify weed species recorded within 20 km of the development envelope.

The Bureau of Meteorology website (BoM 2019) was interrogated to identify the closest active weather station to the development envelope to provide long term monthly rainfall and temperature averages for comparison to monthly total just prior to the field surveys.

2.2 FIELD SURVEY

The field survey was conducted by Dr Grant Wells and Shenade Findlay from 13-23 November 2019.

As the previous monitoring quadrats had been selected in consultation with the DBCA (then DEC) (Botanica Consulting 2011b), these quadrats were revisited (Figure 1-3). This was also undertaken to provide baseline data from two monitoring periods.

A single GPS location had been recorded for each of the monitoring plots (Botanica Consulting 2011b) requiring some searching for quadrat marker posts in denser vegetation. To facilitate locating marker posts for future surveys a GPS location for each post was recorded during the current field survey. In addition, some of the previous plots had no or just two permanent marker posts. In these instances, steel fence droppers were used to mark out new quadrats.

The following metrics were recorded for each vegetation health monitoring quadrat:

- list of each species present
- species richness, i.e. number of plant species in the quadrat, annual and perennial
- percentage vegetation cover within each canopy level (upper[2], mid, low)
- percentage vegetation cover of the dominant species in each canopy level
- height (m) of each of the dominant species in each canopy level (up to 10 individuals)
- identity of any weed species present
- percentage vegetation cover of all weeds present.

The dominant species in each canopy level (up to 10 individuals), were tagged, numbered (1 to 10) and their GPS location recorded. In addition, each plant was allocated a dust level rating (Table 2-1) and health score, using a scale from Casson *et al.* (2009) (Table 2-2). Where less than ten individuals occurred in the quadrat (e.g. large *Eucalyptus* spp.), the health and dust rating were recorded for each of the individuals present. Where no dominant species were present, no recording was taken for that canopy layer.

[2] Upper represented by tree species, mid represented by shrubs >1m height, lower represented by shrubs, grasses and forbs <1m in height.

The following metrics were recorded for each weed monitoring quadrat:

- list of each species present
- number of native species present
- percentage vegetation cover of native species
- number of weed species present
- percentage vegetation cover of all weed species present.

The number of weed species and cover of weed species (where present) was utilised to calculate the 'weediness index' (Loomes *et al.* 2008):

$$\frac{\text{cover of weed species}}{\text{cover of native species}} + \frac{\text{number of weed species}}{\text{number of native species}}$$

Table 2-1 Dust deposition scale

Dust Rating	Description
0	No evidence of dust deposition
1	Evidence of dust deposition (minor discolouration indicating fine dust particles on surface of leaves)
2	Minor, dust build up visible on surface of some leaves
3	Moderate, dust build up with more than 50% of leaves covered
4	Heavy, dust build up covers entire surface of all leaves

Table 2-2 Plant health scale (Casson et al. 2009)

Health rating	Description
0	Healthy, no dead leaves
1	Occasional dead leaves
2	Epicormic shoots (therefore stressed)
3	Tips of branches stressed or dying
4	Entire or whole branches dying or dead (NB some lower branches excluded from this assessment)
5	More than half tree/shrub dead
6	Tree dead

3. RESULTS

3.1 LITERATURE REVIEW

3.1.1 Weeds

A desktop assessment (Botanica Consulting 2011b) determined that records of 14 weeds occurred within a 10 km radius of the development envelope (Table 3-1). This included two Declared Pests, **Chrysanthemoides monilifera* and **Moraea miniata*. **Chrysanthemoides monilifera* is also listed as a Weed of National Significance (WoNS) (DoEE 2019).

Interrogation of the NatureMap database (DBCA 2019b) identified records for eight weed species within a 20 km radius of the development envelope, none of which were a Declared Pest or WoNS, and included two species not identified in the previous desktop assessment (Table 3-1). The combined results from the two assessments indicate potential for at least 16 weed species to occur in the development envelope and buffer.

No weed species were previously recorded in the weed monitoring quadrats or in any of the vegetation health monitoring quadrats (Botanica Consulting 2011a, b). Four weed species, **Bromus rubens*, **Lysimachia arvensis*, **Sonchus oleraceus* and **Ursinia anthemoides* have been recorded within the development envelope (Botanica Consulting 2010; KLA 2010).

Table 3-1 List of weed species/declared weeds recorded within a 20 km radius of the development envelope (DBCA 2019b)

Species		Source	
Family	**Species**	**Botanica Consulting (2011b)**	**DBCA (2019b)**
Asteraceae	**Arctotheca calendula*	*	
Asteraceae	**Centaurea melitensis*		*
Asteraceae	**Chrysanthemoides monilifera*	*	
Asteraceae	**Hypochaeris glabra*	*	*
Asteraceae	**Sonchus oleraceus*	*	*
Asteraceae	**Ursinia anthemoides*	*	*
Brassicaceae	**Carrichtera annua*	*	
Fabaceae	**Medicago minima*		*
Iridaceae	**Moraea miniata*	*	
Poaceae	**Aira cupaniana*	*	*
Poaceae	**Bromus rubens*	*	
Poaceae	**Cenchrus ciliaris*	*	
Poaceae	**Pentameris airoides*	*	*
Poaceae	**Vulpia bromoides*	*	
Poaceae	**Vulpia myuros*	*	
Primulaceae	**Lysimachia arvensis*	*	*

3.1.2 Weather

The nearest Bureau of Meteorology (BoM) weather station with comprehensive data collection and historic climate data is located at Southern Cross (No. 012320, Latitude: 31.25°S Longitude: 119.34°E) approximately 45 km northwest of the development envelope. Southern Cross records the highest maximum mean monthly temperature in January (36.2°C), and the lowest minimum mean in July (3.8°C) (BoM 2019) (Figure 3-1). The average annual rainfall is 306.0 mm with January, March and July recording the highest monthly averages (31.3 mm, 36.1 mm and 35.1 mm respectively).

Daily mean temperatures and rainfall for Southern Cross in the 12 months preceding the survey (November 2018–October 2019) were only slightly variable to annual long-term averages (Figure 3-1). Mean maximum temperatures were approximately average to slightly above average while mean minimum temperatures were mostly equal to average. Rainfall was variable against long term annual averages with total annual rainfall (226.4 mm) lower than the average annual rainfall (306.0 mm). The three months prior to the survey in November 2019 experienced below average rainfall (BoM 2019).

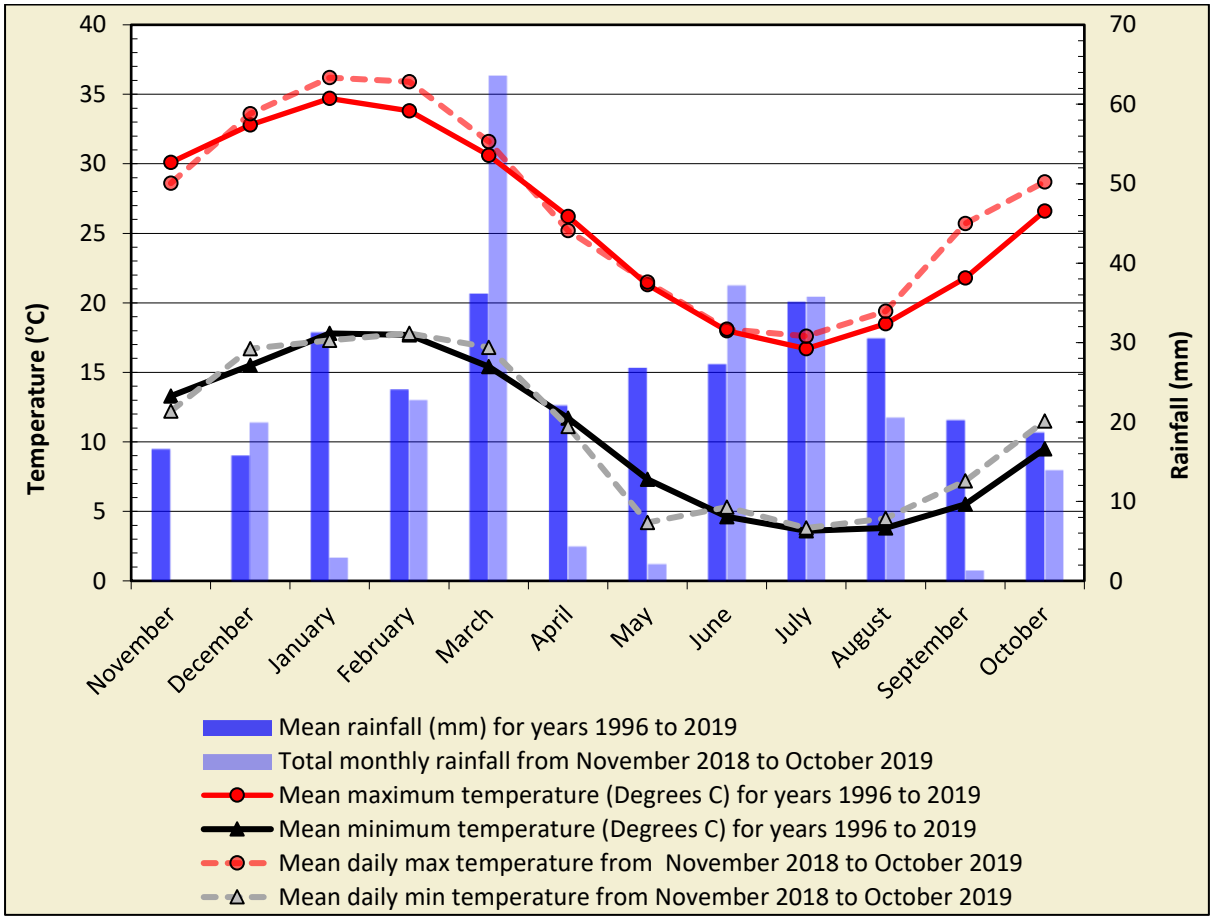

Figure 3-1 **Annual climate and weather data for Southern Cross (no. 012320) (BoM 2019) and mean monthly data for the 12 months preceding the field survey**

3.2 VEGETATION HEALTH

3.2.1 Vegetation health quadrats

3.2.1.1 Species richness and vegetation cover

A total of 116 species were recorded in the impact quadrats (Appendix 2). Species richness varied substantially between quadrats (Table 3-2; Appendix 3), ranging from 4-19 species in the reference quadrats and 6-24 in the impact quadrats. Average species richness for impact and reference quadrats was ca.14 species per quadrat. Similarly, there were large disparities between cover values of the different canopy levels between quadrats.

Table 3-2 Species richness and vegetation cover for the vegetation health impact and reference quadrats surveyed in 2019

Quadrat no.	Species richness	Vegetation cover (%)		
		Upper	Mid	Low
Impact quadrats				
IQ1	24	60	20	40
IQ2	15	15	20	45
IQ3	20	10	50	60
IQ4	18	20	40	40
IQ5	13	20	45	10
IQ6	14	10	65	5
IQ7	9	20	60	60
IQ8	6	80	0	10
IQ9	17	40	40	15
IQ10	8	40	30	5
IQ11	11	10	1	10
IQ12	14	25	30	10
IQ13	16	20	15	35
IQ14	14	20	20	5
IQ15	15	10	70	30
IQ16	7	30	10	35
Reference quadrats				
RQ1	19	60	15	40
RQ2	15	10	10	10
RQ3	19	10	90	60
RQ4	18	25	30	40
RQ5	8	30	40	1
RQ6	19	20	20	10
RQ7	6	75	10	5
RQ8	4	25	2	10

3.2.1.2 Plant health and dust ratings

Health ratings for individual plants of dominant species varied within and between quadrats (Table 3-3; Appendix 4). Generally, most species showed signs of stress and were allocated a health rating of 3 (tips of branches stressed or dying).

Plants in two impact quadrats and one reference quadrat, IQ13, IQ15 and RQ8, contained at least one dominant species with an average health score of 1, indicating healthy plants with only occasional dead leaves. Similarly, plants with a health rating of 5, more than half tree/shrub dead, occurred in both impact quadrats (IQ7 and IQ10) and an reference quadrat (RQ6). No dominant species were allocated a rating of 6 (plant dead).

No signs of dust build up were present for dominant plants within the impact and reference quadrats, with all dust ratings recorded as 0. A summary of the results for the spring 2019 vegetation monitoring is provided in Table 3-3.

Table 3-3 Vegetation health of impact and reference monitoring quadrats surveyed in spring 2019, mean values for dominant species health and dust ratings are provided

Canopy level	Cover (%)	No. of individuals	Species	Mean plant health	Mean dust rating
RQ1					
Upper	60	10	*Eucalyptus capillosa*	3.3	0
Lower	10	10	*Hibbertia exasperata*	3.3	0
RQ2					
Upper	10	10	*Eucalyptus salmonophloia*	3	0
Mid	3	10	*Eremophila oppositifolia*	3.4	0
Lower	5	10	*Scaevola spinescens*	2.8	0
RQ3					
Upper	70	10	*Allocasuarina corniculata*	3.1	0
Mid	20	10	*Melaleuca cordata*	3.3	0
RQ4					
Upper	25	5	*Eucalyptus capillosa*	2.6	0
Mid	20	10	*Allocasuarina acutivalvis* subsp. *acutivalvis*	1	0
Lower	20	10	*Melaleuca cordata*	2.6	0
RQ5					
Upper	10	1	*Eucalyptus salubris*	3	0
Upper	20	1	*Eucalyptus salmonophloia*	3	0
Mid	25	10	*Melaleuca laxiflora*	3.2	0
RQ6					
Upper	15	3	*Eucalyptus salmonophloia*	3.3	0
Mid	7	10	*Eremophila ionantha*	3.5	0
Lower	12	10	*Acacia merallii*	2.6	0
RQ7					
Upper	75	10	*Eucalyptus transcontinentalis*	3.2	0

Canopy level	Cover (%)	No. of individuals	Species	Mean plant health	Mean dust rating
Lower	5	5	*Olearia muelleri*	3.6	0
RQ8					
Lower	25	6	*Eucalyptus tephroclada*	2.7	0
Mid	10		*Melaleuca hamata*	1.3	0
IQ1					
Mid	30	10	*Allocasuarina spinosissima*	3.3	0
IQ2					
Mid	30	11	*Allocasuarina corniculata*	2.6	0
IQ3					
Upper	10	6	*Eucalyptus horistes*	2.7	0
Mid	35	10	*Allocasuarina corniculata*	3.2	0
IQ4					
Mid	25	10	*Allocasuarina corniculata*	2.7	0
IQ5					
Upper	20	10	*Eucalyptus eremophila*	2.7	0
Mid	20	10	*Melaleuca hamata*	3.1	0
IQ6					
Upper	10	9	*Eucalyptus capillosa*	2.3	0
Mid	35	10	*Melaleuca hamata*	3.5	0
IQ7					
Upper	20	5	*Acacia acuminata*	4	0
Mid	40	10	*Leptospermum roei*	1.6	0
Lower	35	10	*Hibbertia eatoniae*	3.5	0
IQ8					
Upper	75	10	*Eucalyptus transcontinentalis*	3.1	0
Lower	5	5	*Olearia muelleri*	3.2	0
IQ9					
Upper	40	7	*Eucalyptus capillosa*	3.7	0
Mid	20	10	*Melaleuca hamata*	3.7	0
Lower	15	10	*Phebalium tuberculosum*	3.3	0
IQ10					
Upper	40	9	*Eucalyptus transcontinentalis*	3	0
Mid	20	11	*Melaleuca hamata*	3.4	0
IQ11					
Upper	10	1	*Eucalyptus salmonophloia*	3	0
Lower	2	10	*Scaevola spinescens*	2.3	0
IQ12					
Upper	13	3	*Eucalyptus transcontinentalis*	2.3	0

Canopy level	Cover (%)	No. of individuals	Species	Mean plant health	Mean dust rating
Upper	12	3	*Eucalyptus salmonophloia*	2.3	0
Mid	20	10	*Melaleuca pauperiflora*	2.8	0
Lower	6	10	*Microcybe multiflora*	2	0
IQ13					
Upper	20	3	*Eucalyptus salmonophloia*	2.7	0
Mid	12	10	*Eucalyptus salubris*	1.3	0
Lower	10	10	*Scaevola spinescens*	2.2	0
IQ14					
Upper	20	2	*Eucalyptus salmonophloia*	3.4	0
Mid	20	10	*Melaleuca pauperiflora*	3.4	0
Lower	5	10	*Eremophila oppositifolia*	3.1	0
IQ15					
Upper	10	1	*Eucalyptus livida*	3	0
Mid	30	10	*Allocasuarina acutivalvis*	1.2	0
Lower	50	10	*Acacia beauverdiana*	1.2	0
IQ16					
Upper	5	1	*Eucalyptus salubris*	2	0
Upper	30	5	*Eucalyptus salmonophloia*	3	0
Mid	10	10	*Melaleuca pauperiflora*	2.7	0
Lower	10	10	*Acacia enervia* subsp. *enervia*	2.7	0

3.2.2 Weed monitoring quadrats

No weed or alien species were recorded within the four weed monitoring quadrats. The native vegetation cover varied among the four quadrats from 85% in WQ1 to 35% in WQ3 (Table 3-4).

One weed species, **Centaurea melitensis*, was found outside of the weed quadrats, in a vegetation monitoring quadrat (VMQ11). The calculated weediness index for this quadrat was 0.12.

Table 3-4 Vegetation cover for weed monitoring quadrats surveyed in 2019

Quadrat	Weed cover (%)	Native vegetation cover (%)
W1	0	85
W2	0	75
W3	0	35
W4	0	45

3.2.3 Priority species

A Priority 1, a Priority 2 and a Priority 4 species were recorded within the impact monitoring quadrats during the spring 2019 survey.

The Priority 1 species, *Westringia acifolia* was found at a single location in the impact monitoring quadrat IQ3. *Westringia acifolia* is a shrub, 0.3 m in height. Only one population of this species has been previously recorded, approximately 60 km west of the development envelope within the Avon Wheatbelt bioregion (DBCA 2019a).

The Priority 2 species *Acacia concolorans* was recorded quadrats IQ14, WQ3 and WQ4. *Acacia concolorans* is an intricate, sprawling or compact, pungent shrub, 0.1-0.5 m high with yellow flowers from July to August. The species grows in red/brown loam and clay and occurs on low lateritic hills and flats. *Acacia concolorans* occurs in the Avon Wheatbelt, Mallee and Coolgardie bioregions (DBCA 2019a).

The Priority 4 species, *Banksia shanklandiorum* was found in the impact monitoring quadrat IQ1. *Banksia shanklandiorum,* is an upright, non-lignotuberous shrub, 0.4-2.5 m in height and up to 3 m wide. This species flowers June to August and occurs in white/yellow sand with lateritic gravel. *Banksia shanklandiorum* is distributed within the Avon Wheatbelt bioregion (DBCA 2019a).

Additional targeted searches for *Westringia acifolia* (P1) and *Microcorys* sp. nov will be conducted from the 11th to the 14th of Feburary 2020. Subsequent updates will be made to this Baseline report proceeding these searches.

4. DISCUSSION

This vegetation health and weed survey provides baseline measurable parameters that will be used to monitor vegetation in the vicinity of the development envelope for potential impacts from Project activities. Amendments to the monitoring methods and parameters from the previous baseline assessment (Botanica Consulting 2011b) have been made to address advice from EPA Services (Jessica Allen pers. com. via email to Les Purves of MRL 12 November 2019) on the outcomes and methodology of the previous survey capacity to meet the conditions of MS 892. These included:

- use of the Casson *et al.* (2009) plant health scale which does not include flowering as a measure of plant health
- plant health ratings were recorded for a minimum of 10 plants (dominant in at least one canopy level) per quadrat and up to 30 plants (10 from each canopy level) to generate a mean value of plant health that may be compared between monitoring seasons and impact and reference quadrats. This replaces the single measure of plant health for the entire quadrat provided in the prior survey (Botanica Consulting 2011b)
- species richness (number of different species present in the quadrat) was recorded and provides a measure of the abundance of different species
- visual estimates of vegetation cover for the vegetation canopy levels, upper (trees) mid (mid (>1 m) to tall (>2 m)) and low (shrubs, grasses, forbs <1 m) and vegetative cover of the dominant species in each stratum provide measures of plant abundance
- use of the weediness scale of Loomes *et al.* (2008) provides a measure of the abundance of weed species, including annual species, that may be compared between monitoring events to identify the establishment and/or increase in weed abundance
- a scale of dust deposition on plant foliage has been included to provide an indication of whether mine construction and/or operations may be impacting vegetation health. Any identified decline in vegetation health parameters may be correlated with any change in dust deposition to identify potential impacts from operations requiring further investigation. In addition, site photos from all four permanently marked (and GPS recorded) corners of the quadrats (Appendix 5) may be used to identify other forms of disturbance or impact that may have contributed to vegetation health decline, for example, fire damage, machinery impacts e.g. clearing or flooding.

The current survey identified substantial differences in species richness, the composition of species, vegetation cover of canopy levels and the average health of plants within and between reference and impact quadrats. Subsequently, to monitor for changes to vegetation health over time, the proportional change in metrics within each quadrat will be determined and then compared between quadrats. For example, any increase or decrease in species richness within a quadrat will be determined by dividing the species recorded in the current monitoring period to that of the previous monitoring period and the baseline data obtained from the current survey to quantify proportionate (percentage of) change. This value would then be compared between impact quadrats and reference quadrats to determine whether there is a similar trend across quadrats or whether it is restricted to one or few quadrats. Should any change be recorded this may be correlated to changes in the dust deposition scale to indicate whether the change may be related to mine site operations. Site photos and field notes would also be reviewed to detect other possible causes for the change.

Levels of dust build-up on plants was not assessed in the previous survey (Botanica Consulting 2011b), and during the spring 2019 survey, no dust build-up was recorded for any species across both the vegetation impact and reference quadrats. Monitoring the level of dust build-up on individual plants

will aid as a further indicator of the impact of mining development and/or operations. Changes in dust levels will be correlated with health scores and other changes observed such as fire and mining operations.

There were a number of notable differences in the results of the current survey with that of the Botanica Consulting (2011b) survey:

- Three priority species were found within impact monitoring quadrats in the current survey; *Westringia acifolia* (P1), *Acacia concolorans* (P2) and *Banksia shanklandiorum* (P4) and a potentially new species, belonging to the *Microcorys* genus, was also recorded within two of the impact monitoring quadrats. Only one priority species, *Banksia shanklandiorum* (P4), had been previously recorded in the impact monitoring quadrats (Botanica Consulting 2011b).
- Species richness of the majority of quadrats for the current survey was higher than in the prior survey, for example, five more species were recorded in quadrats VMQ13, VMQ15 and AQ4.
- Long-lived perennial species recorded in high numbers in the previous survey, e.g. *Melaleuca pauperiflora* in VMQ3 (40 plants), VMQ4 (21 plants) and AQ8 (20 plants) were not present during the current survey.

As the previous survey was conducted nine years ago and there is disparity with the recently collected data, it is suggested that the most recent survey data (spring 2019) be used as the new baseline health assessment of vegetation and weed monitoring for the Project.

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Appendix 1 Site locations

Site	Location Coordinates
RQ1	119.56013, -31.63331
RQ2	119.55243, -31.64945
RQ3	119.53471, -31.62367
RQ4	119.53848, -31.63413
RQ5	119.54717, -31.61557
RQ6	119.56142, -31.60631
RQ7	119.56627, -31.62249
RQ8	119.54489, -31.64381
IQ1	119.53949, -31.64029
IQ2	119.55447, -31.64008
IQ3	119.54453, -31.63912
IQ4	119.56068, -31.63381
IQ5	119.54896, -31.61669
IQ6	119.56142, -31.60631
IQ7	119.56108, -31.60811
IQ8	119.55975, -31.60918
IQ9	119.56355, -31.62193
IQ10	119.56236, -31.62208
IQ11	119.55879, -31.63152
IQ12	119.55747, -31.63020
IQ13	119.55037, -31.64650
IQ14	119.54977, -31.64468
IQ15	119.54073, -31.63236
IQ16	119.54228, -31.63074
WQ1	119.53874, -31.61687
WQ2	119.55680, -31.61949
WQ3	119.55302, -31.63259
WQ4	119.54808, -31.64889

Appendix 2 List of species occurring in the impact and reference health monitoring quadrats, spring survey 2019

Family	Species
Apocynaceae	*Alyxia buxifolia*
Asparagaceae	*Lomandra effusa*
Asteraceae	**Centaurea melitensis*
Asteraceae	*Olearia axillaris*
Asteraceae	*Olearia dampiera* subsp. *eremicola*
Asteraceae	*Olearia muelleri*
Casuarinaceae	*Allocasuarina acutivalvis*
Casuarinaceae	*Allocasuarina campestris*
Casuarinaceae	*Allocasuarina carincinus*
Casuarinaceae	*Allocasuarina corniculata*
Casuarinaceae	*Allocasuarina helmsii*
Casuarinaceae	*Allocasuarina spinosissima*
Chenopodiaceae	*Sclerolaena diacantha*
Chenopodiaceae	*Rhagodia drummondii*
Chenopodiaceae	*Maireana georgei*
Cupressaceae	*Callitris preissii*
Dilleniaceae	*Hibbertia ancistrophylla*
Dilleniaceae	*Hibbertia exasperata*
Dilleniaceae	*Hibbertia pungens*
Dilleniaceae	*Hibberita eatoniae*
Dilleniaceae	*Hibbertia nutans*
Eriaceae	*Leucopogon* sp. Outer Wheatbelt
Eriaceae	*Acrotriche lancifolia*
Euphorbiaceae	*Bertya dimerostigma*
Euphorbiaceae	*Beyearia sulcata var. sulcata*
Fabaceae	*Acacia accuminata*
Fabaceae	*Acacia beauverdiana*
Fabaceae	*Acacia camptoclada*
Fabaceae	*Acacia colletoides*
Fabaceae	*Acacia conclurens* (P2)
Fabaceae	*Acacia enervia* subsp. *enervia*

Family	Species
Fabaceae	*Acacia erinacea*
Fabaceae	*Acacia hemiteles*
Fabaceae	*Acacia heteroneura* var. *petila*
Fabaceae	*Acacia merrallii*
Fabaceae	*Acacia nigripilosa* subsp. *nigripilosa*
Fabaceae	*Acacia steedmanii*
Fabaceae	*Acacia synchronicia*
Fabaceae	*Acacia yorkakinensis*
Fabaceae	*Daviesia argillaceae*
Fabaceae	*Daviesia nematophylla*
Fabaceae	*Gastrolobium spinosum*
Goodeniaceae	*Scaevola spinescens*
Laminaceae	*Microcorys* sp.
Laminaceae	*Westringia acifolia* (P1)
Laminaceae	*Westringia cephalantha*
Lauraceae	*Cassytha melantha*
Lauraceae	*Cassytha nodiflora*
Myrtaceae	*Baeckea grandibracteata*
Myrtaceae	*Banksia shanklandiorum* (P4)
Myrtaceae	*Beaufortia calyptoides*
Myrtaceae	*Beaufortia interstans*
Myrtaceae	*Beaufortia orbifolia*
Myrtaceae	*Beaufortia puberula*
Myrtaceae	*Calytrix leschenaultii*
Myrtaceae	*Chamelaucium pauciflorum*
Myrtaceae	*Eucalyptus burracoppinensis*
Myrtaceae	*Eucalyptus calycogona*
Myrtaceae	*Eucalyptus capillosa*
Myrtaceae	*Eucalyptus eremophila*
Myrtaceae	*Eucalyptus incrassata*
Myrtaceae	*Eucalyptus horistes*
Myrtaceae	*Eucalyptus livida*
Myrtaceae	*Eucalyptus salmonophloia*

Family	Species
Myrtaceae	*Eucalyptus salubris*
Myrtaceae	*Eucalyptus tephroclada*
Myrtaceae	*Eucalyptus transcontinentalis*
Myrtaceae	*Euromyrtus maidenii*
Myrtaceae	*Leptospermum erubescens*
Myrtaceae	*Leptospermum roei*
Myrtaceae	*Leptospermum spinescens*
Myrtaceae	*Melaleuca cordata*
Myrtaceae	*Melaleuca eleuterostachya*
Myrtaceae	*Melaleuca hamata*
Myrtaceae	*Melaleuca lateriflora*
Myrtaceae	*Melaleuca laxiflora*
Myrtaceae	*Melaleuca pauperiflora*
Myrtaceae	*Thryptomene australis* subsp. *brachyandra*
Myrtaceae	*Thryptomene kochii*
Myrtaceae	*Verticordia aeriosaphala*
Myrtaceae	*Verticordia brachypoda*
Myrtaceae	*Verticordia chrysantha*
Myrtaceae	*Verticordia insignis* subsp. *compta*
Myrtaceae	*Verticordia roei* subsp. *roei*
Myrtaceae	*Verticordia stenopetala*
Myrtaceae	*Micromyrtus racemosa*
Rutaceae	*Drummondita hassellii*
Poaceae	*Austrostipa elegantissima*
Proteaceae	*Grevillea acacioides*
Proteaceae	*Grevillea acuaria*
Proteaceae	*Grevillea didymobotrya* subsp. *didymobotrya*
Proteaceae	*Grevillea huegelii*
Proteaceae	*Grevillea oncogyne*
Proteaceae	*Grevillea paradoxa*
Proteaceae	*Hakea chordophylla*
Proteaceae	*Hakea erecta*
Proteaceae	*Hakea minyma*

Family	Species
Proteaceae	*Hakea multilineata*
Proteaceae	*Hakea scoparia*
Proteaceae	*Hakea subsulcata*
Proteaceae	*Isopogon scabriusculus* subsp. *stenophyllus*
Proteaceae	*Persoonia coriacea*
Proteaceae	*Petrophile ericifolia*
Rutaceae	*Phebalium filifolium*
Rutaceae	*Phebalium tuberculosum*
Rutaceae	*Microcybe multiflora* subsp. *multiflora*
Santalaceae	*Exocarpos aphyllus*
Santalaceae	*Leptomeria preissiana*
Santalaceae	*Santalum acuminatum*
Sapidaceae	*Dodonaea bursarifolia*
Scrophulariaceae	*Eremophila decipiens*
Scrophulariaceae	*Eremophila drummondii*
Scrophulariaceae	*Eremophila ionantha*
Scrophulariaceae	*Eremophila maidenii*
Scrophulariaceae	*Eremophila oppositifolia*
Scrophulariaceae	*Eremophila scoparia*
Solanaceae	*Solanum hoplopetalum*

Appendix 3 Vegetation impact and reference quadrat descriptions, spring 2019 vegetation monitoring

IQ1		
Vegetation cover (%)		
Upper: 60	**Mid:** 20	**Lower:** 40
Species in quadrat		
Acacia heteroneura var. *petila*		
Acacia nigripilosa subsp. *nigripilosa*		
Allocasuarina spinoissima		
Allocasurina campestris		
Banksia shanklandiorum (P4)		
Beaufortia calyptoides		
Beaufortia puberula		
Cassytha melantha		
Chamelaucium pauciflorum		
Drummondita hassellii		
Microcorys sp.		
Eucalyptus burracoppinensis		
Eucalyptus incrassata		
Grevillia didymobotrya subsp. *didymobotrya*		
Hakea erecta		
Isopgon scabriusculus subsp. *stenophyllus*		
Leptospermum spinescens		
Melaleuca cordata		
Micromyrtus racemosa		
Persoonia coriacea		
Petrophile ericifolia		
Phebalium filifolium		
Verticordia aereiflora		
Verticordia chrysantha		
Verticordia roei subsp. *roei*		
Verticordia stenopetala		
IQ2		
Vegetation cover (%)		
Upper: 15	**Mid:** 20	**Lower:** 45

Species in quadrat
Acacia enervia subsp. *enervia*
Allocasuarina corniculata
Beaufortia puberula
Drummondita hassellii
Eucalyptus burracoppinensis
Eucalyptus horistes
Euromyrtus maidenii
Grevillea acuaria
Grevillea oncogyne
Grevillia didymobotrya subsp. *didymobotrya*
Isopogon scabriusculus subsp. *stenophyllus*
Melaleuca calyptroides
Melaleuca cordata
Phebalium filifolium
Thryptomene kochii

IQ3		
Vegetation cover (%)		
Upper: 10	**Mid: 5**0	**Lower:** 60
Species in quadrat		
Allocasurina corniculata		
Banksia shanklandiorum		
Beaufortia puberula		
Bertya dimerostigma		
Beyeria sulcata		
Calitris prissii		
Daviesia nematophylla		
Drummondita hassellii		
Eucalyptus horistes		
Euromyrtus maidenii		
Grevillea oncogyne		
Grevillia didymobotrya subsp. *didymobotrya*		
Hakea scoparia		
Isopogon scabriusculus subsp. *stenophyllus*		
Lomandra effusa		

Melaleuca calyptroides
Melaleuca hamata
Micromyrtus racemosa
Westringia acifolia (P1)
Thryptomene kochii

IQ4		
Vegetation cover (%)		
Upper: 20	**Mid:** 40	**Lower:** 40
Species in quadrat		
Acacia nigripilosa subsp. *nigripilosa*		
Allocasuarina corniculata		
Baeckea grandibracteata		
Banksia shanklandiorum (P4)		
Beaufortia interstans		
Beaufortia orbifolia		
Bertya dimerostigma		
Beyaeria sulcata var. *sulcata*		
Callitris preissii		
Drummondita hasellii		
Eucalyptus horistes		
Eucalyptus incrassata		
Grevillia didymobotrya subsp. *didymobotrya*		
Hakea scoparia		
Micromyrtus racemosa		
Thryptomene kochii		
Verticordia brachypoda		
Verticordia insignis subsp. *compta*		
IQ5		
Vegetation cover (%)		
Upper: 20	**Mid:** 45	**Lower:** 10
Species in quadrat		
Acacia colletoides		
Beryta dimerostigma		
Deviesia argillacea		

Eucalyptus eremophila		
Grevillea huegelii		
Grevillea oncogyne		
Lomandra effusa		
Melaleuca eleuterostachya		
Melaleuca hamata		
Melaluca laxiflora		
Olearia dampiera subsp. *eremicola*		
Santalum acuminatum		
Scaevola spinescens		
IQ6		
Vegetation cover (%)		
Upper: 10	**Mid:** 65	**Lower:** 5
Species in quadrat		
Bertya dimerostigma		
Beyearia sulcata		
Callitris preissii		
Davesia argillaceae		
Dodonaea bursariifolia		
Eucalyptus capillosa		
Grevillia huegelii		
Hibbertia pungens		
Leptospermum erubescens		
Melaleuca eleuterostachya		
Melaleuca hamata		
Melaleuca laxiflora		
Micromyrtus racemoso		
Olearia axillaris		
IQ7		
Vegetation cover (%)		
Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Acacia accuminata		
Allocasuarina corniculata		
Allocasuarina helmsii		

Amphipogam carincinus		
Euryomyrtus maidenii		
Hakea minyma		
Hibertia eatoniae		
Leptospermum roei		
Thryptomene kochii		
IQ8		
Vegetation cover (%)		
Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Acacia merrallii		
Austrostipa elegantissima		
Eucalyptus salmonophloia		
Eucalyptus transcontinentalis		
Olearia muelleri		
Westringia cephalantha		
IQ9		
Vegetation cover (%)		
Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Acacia colletoides		
Acacia hemiteles		
Allocasuarina acutivalvis		
Allocasuarina campestris		
Alyxia buxifolia		
Beyaria sulcata var. *sulcata*		
Eucalyptus capillosa		
Grevillia acacioides		
Hibertia eatoniae		
Melaluca eleuterostachya		
Melaluca hamata		
Melaluca laxiflora		
Micromyrtus racemosa		
Olearia muelleri		
Phebalium tuberculosum		

Phebalium filifolium		
Santalum acuminatum		
IQ10		
Vegetation cover (%)		
Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Acacia hemiteles		
Alyxia buxifolia		
Daviesia argillacea		
Eucalyptus transcontinentalis		
Melaleuca lateriflora		
Melaluca hamata		
Phebalium tuberculosum		
Santalum acuminatum		

IQ11		
Vegetation cover (%)		
Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Acacia erinacea		
Acacia hemiteles		
**Centaurea melitensis*		
Eremophila decipiens		
Eremophila scoparia		
Eucalyptus salmonophloia		
Exocarpos aphyllus		
Maireana georgei		
Scaevola spinescens		
Sclerolaena diacantha		
Senna cardiosperma		
IQ12		
Vegetation cover (%)		
Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Alyxia buxifolia		

Austrostypa elogantisima		
Eremophila decipiens		
Eremophila oppositifolia		
Eremophila scoparia		
Eucalyptus salmonophloia		
Eucalyptus transcontinentalis		
Exocarpus aphyllus		
Grevillea acuaria		
Melaleuca pauperiflora		
Micrcybe multiflora subsp. *multiflora*		
Oleara muelleria		
Rhagodia drummondii		
Scaevola spinescens		
IQ13		
Vegetation cover (%)		
Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Acacia camptoclada		
Acacia colletoides		
Acacia conclurens (P2)		
Acacia erinacea		
Acacia synchronicia		
Alyxia buxifolia		
Austrostipa elegantissima		
Eremophila drummondii		
Eremophila ionantha		
Eremophila oppositifolia		
Eucalyptus salmonophloia		
Eucalyptus salubris		
Exocarpos aphyllus		
Melaleuca pauperiflora		
Olearia muelleri		
Scaevola spinescens		
IQ14		
Vegetation cover (%)		

Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Acacia camptoclada		
Acacia colletoides		
Acacia conclurrens (P2)		
Acacia erinacea		
Alyxia buxifolia		
Austrostipa elegantissima		
Eremophila ionantha		
Eremophila oppositifolia		
Eucalyptus salmonophloia		
Exocarpos aphyllus		
Melaleuca pauperiflora		
Olearia muelleri		
Scaevola spinescens		
IQ15		
Vegetation cover (%)		
Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Acacia beauverdiana		
Acacia nigripilosa subsp. *nigripilosa*		
Acacia steedmanii		
Acacia yorkakinensis		
Allocasaurina acutivalvis		
Microcybe multiflora		
Leucopogon sp. Outer Wheatbelt		
Eucalyptus livida		
Grevillea acacioides		
Grevillia paradoxa		
Hakia multilineata		
Hibertia nutans		
Melaleuca hamata		
Micromyrtus racemosa		
Thryptomene australia subsp. *brachyandra*		
IQ16		

Vegetation cover (%)		
Upper: 20	**Mid:** 60	**Lower:** 60
Species in quadrat		
Acacia camptoclada		
Acacia enervia subsp *enervia*		
Acacia erinacea		
Eucalyptus salmonophloia		
Eucalyptus salubris		
Melaleuca pauperiflora		
Scaevola spinescens		
RQ1		
Vegetation cover (%)		
Upper: 60	**Mid:** 15	**Lower:** 40
Species in quadrat		
Acacia erinacea		
Acrotriche lancifolia		
Allocasuarina corniculata		
Austrostipa elegantissima		
Alyxia buxifolia		
Dodonaea caespitosa		
Eremophila oppositifolia		
Eucalyptus capillosa		
Exocarpos aphyllus		
Grevillea acuaria		
Hibbertia exasperata		
Lepidospermum sp. Mount Caudan		
Melaleuca hamata		
Micromyrtus racemosa		
Olearia muelleri		
Phebalium tuberculosum		
Santalum acuminatum		
Scaevola spinescens		
Westringia cephalantha		
RQ2		
Vegetation cover (%)		

Upper: 10	**Mid:** 10	**Lower:** 10
Species in quadrat		
Acacia colletoides		
Acacia camptoclada		
Acacia erinacea		
Acacia synchronicia		
Alyixia buxifolia		
Austrostipa elegantissima		
Eremophila decipiens		
Eremophila ionantha		
Eremophila oppositifolia		
Eucalyptus salmonophloia		
Exocarpos aphyllus		
Melaleuca pauperiflora		
Olearia muelleri		
Scaevola spinesens		
RQ3		
Vegetation cover (%)		
Upper: 10	**Mid:** 90	**Lower:** 60
Species in quadrat		
Allocasuarina spinosissima		
Beaufortia puberula		
Callitris preissii		
Calytrix leschenaultii		
Cassytha melantha		
Eucalyptus burracoppinensis		
Eucalyptus capillosa		
Drummondita hassellii		
Euryomyrtus maidenii		
Grevillea paradoxya		
Hakea chordophylla		
Hakea erecta		
Isopgon scabriusculus subsp. *pubifloris*		
Melaleuca calyptroides		
Melaleuca cordata		

Micromyrtus racemosa		
Phebalium filifolium		
Thryptomene kochii		
Verticordia insignis subsp. *compta*		
RQ4		
Vegetation cover (%)		
Canopy: 25	**Mid:** 30	**Lower:** 40
Species in quadrat		
Acacia hemiteles		
Acacia neurophylla		
Acacia nigripilosa subsp. *nigripilosa*		
Acacia steedmanii		
Allocasuarina accutivelvus subsp. *accutivelvus*		
Beaufortia intersans		
Cassytha nodiflora		
Leucopogon sp. Outer Wheatbelt		
Eucalyptus capillosa		
Grevillia acacioides		
Grevillia paradoxa		
Hibertia eatoniae		
Melaleuca cordata		
Melaluca hamata		
Microcybe multiflora subsp. *multiflora*		
Micromyrtus racemosa		
Westringia cephalantha		
RQ5		
Vegetation cover (%)		
Upper: 30	**Mid:** 40	**Lower**:0.1
Species in quadrat		
Eucalyptus salmonophloia		
Eucalyptus salubris		
Exocarpos aphyllus		
Melaleuca hamata		
Melaleuca laxiflora		
Melaleuca pauperiflora		

Santalum acuminatum		
RQ6		
Vegetation cover (%)		
Upper: 20	**Mid:** 20	**Lower:** 10
Species in quadrat		
Acacia enervia subsp*. enervia*		
Acacia erinacea		
Acacia hemiteles		
Acacia merellii		
Alyxia buxifolia		
Austrostipa elegantissima		
Eremophila decipiens		
Eremophila ionantha		
Eremophila scoparia		
Eucalyptus salmonophloia		
Eucalyptus sp.		
Exocarpus aphyllus		
Grevillea acuaria		
Olearia muelleri		
Olearia sp.		
Rhagodia drummondii		
Santalum acuminatum		
Scaevola spinescens		
Solanum hoplopetalum		
RQ7		
Vegetation cover (%)		
Upper: 75	**Mid:** 10	**Lower:** 5
Species in quadrat		
Acacia hemiteles		
Eucalyptus transcontinentalis		
Melaluca pauperiflora		
Olearia muelleri		
Santalum acuminatum		
Scaevola spinescens		
RQ8		

Vegetation cover (%)		
Upper: 25	**Mid:** 2	**Lower:** 10
Species in quadrat		
Acrotriche lancifolia		
Eucalyptus calycogona		
Hakea scoparia		
Melaluca hamata		
WQ1		
Species in quadrat	**Native veg cover (%):** 85	
Acacia heteroneura var. *petila*		
Acacia nigriplosa		
Allocasuarina corniculata		
Beaufortia puberula		
Beaufortia calyptoides		
Beyearia sulcata var. *sulcata*		
Callitris preissii		
Cassytha nodiflora		
Drumondita hassillii		
Microcorys sp.		
Eucalyptus horistes		
Gastrolobium spinosum		
Hakea subsulcata		
Hibbertia ancistrophylla		
Isopogan scabriusculus subsp. *pubifloris*		
Leptomeria preissiana		
Melaleuca cordata		
Micromyrtus racemosa		
Persoonia coriacea		
Stenanthemum stipulosum		
Verticordia eriocephata		
Verticordia mitoides		
Verticordia roei subsp. *roei*		
WQ2		
Species in quadrat	**Native veg cover (%):** 75	
Acacia erinacea		

Acacia hemiteles
Allocasuarina corniculata
Alyxia buxifolia
Austrostipa elegantissima
Eremophila oppositifolia
Eucalyptus salmonophloia
Exocarpos aphyllus
Grevillia aquaria
Melaleuca pauperiflora
Olearia muelleri
Phebalium tuberuculosum
Scaevola spinescens

WQ3	
Species in quadrat	**Native veg cover (%):** 35
Acacia conclurens	
Alyxia buxifolia	
Cryptandra nutans	
Daviesia argillacea	
Eremophila granitica	
Grevillea acuaria	
Melaleuca lateriflora	
Melaleuca pauperiflora	
Microcybe multiflora subsp*. multiflora*	
Olearia muelleri	

WQ4	
Species in quadrat	**Native veg cover (%):** 45
Acacia conclumens	
Austrostipa elegantissima	
Eremophila ionantha	
Eremophila oppositifolia	
Eucalyptus salmonophloia	
Melaleuca pauperiflora	
Olearia muelleri	
Scaevola spinescens	

Appendix 4 Plant health and dust ratings

Canopy level	Cover (%)	Species	Height (m)	Health rating	Dust rating
RQ1					
Upper	60	*Eucalyptus capillosa*	12.0	3	0
			10.0	3	0
			12.0	3	0
			10.0	3	0
			7.0	3	0
			9.0	4	0
			9.0	4	0
			8.0	3	0
			9.0	4	0
			10.0	3	0
Lower	10	*Hibbertia exasperata*	0.5	3	0
			0.6	3	0
			0.5	3	0
			0.7	3	0
			0.5	3	0
			0.7	4	0
			0.6	3	0
			0.6	4	0
			0.5	4	0
			0.7	3	0
RQ2					
Upper	10	*Eucalyptus salmonophloia*	15.0	3	0
			9.0	3	0
Mid	30	*Eremophila oppositifolia*	4.5	4	0
			3.0	4	0
			3.0	4	0
			2.8	4	0
			0.7	4	0
			1.3	3	0
			2.1	3	0
			1.2	1	0
			2.1	4	0
			1.9	3	0
Lower	5	*Scaevola spinescens*	1.1	3	0
			0.8	3	0
			0.5	1	0
			0.6	3	0

Canopy level	Cover (%)	Species	Height (m)	Health rating	Dust rating
			1.1	3	0
			1.3	4	0
			0.5	3	0
			1.0	3	0
			0.5	2	0
			0.8	3	0
RQ3					
Upper	70	*Allocasuarina corniculata*	1.8	3	0
			2.5	4	0
			2.0	4	0
			2.2	3	0
			2.5	4	0
			2.1	3	0
			1.7	3	0
			2.0	3	0
			2.0	3	0
			2.5	1	0
Mid	20	*Melaleuca cordata*	1.5	3	0
			1.3	3	0
			0.7	4	0
			1.5	4	0
			1.3	3	0
			1.5	3	0
			1.7	3	0
			1.6	3	0
			1.4	3	0
			1.5	4	0
RQ4					
Upper	25	*Eucalyptus capillosa*	6.0	4	0
			3.5	2	0
			8.0	1	0
			8.0	3	0
			12.0	3	0
Mid	20	*Allocasuarina acutivalvis* subsp. *acutivalvis*	1.1	1	0
			1.5	1	0
			1.1	1	0
			1.5	1	0
			1.6	1	0
			1.8	1	0

Canopy level	Cover (%)	Species	Height (m)	Health rating	Dust rating
			1.4	1	0
			2.0	1	0
			1.4	1	0
			1.5	1	0
Lower	20	*Melaleuca cordata*	3.0	1	0
			0.7	3	0
			1.0	3	0
			1.0	3	0
			2.0	1.1	0
			1.2	3	0
			1.3	3	0
			1.0	4	0
			0.7	3	0
			0.5	2	0
RQ5					
Upper	10	*Eucalyptus salubris*	8.0	3	0
Upper	20	*Eucalyptus salmonophloia*	12.0	3	0
Mid	25	*Melaleuca laxiflora*	2.5	3	0
			2.1	3	0
			2.5	3	0
			1.8	3	0
			2.2	4	0
			2.5	3	0
			2.6	3	0
			2.4	3	0
			2.5	3	0
			2.6	4	0
RQ6					
Upper	15	*Eucalyptus salmonophloia*	11.0	3	0
			12.0	3	0
			10.0	4	0
Mid	7	*Eremophila ionantha*	0.8	3	0
			1.2	5	0
			1.3	3	0
			1.5	3	0
			1.0	3	0
			0.7	3	0
			1.2	3	0
			1.6	4	0

Canopy level	Cover (%)	Species	Height (m)	Health rating	Dust rating
			1.0	4	0
			1.0	4	0
Lower	12	*Acacia merallii*	0.2	3	0
			0.2	3	0
			0.2	1	0
			0.2	4	0
			0.3	4	0
			0.2	3	0
			0.4	3	0
			0.2	3	0
			0.1	1	0
			0.2	1	0
RQ7					
Upper	75	*Eucalyptus transcontinentalis*	6.0	3	0
			4.0	3	0
			6.0	3	0
			7.0	4	0
			8.0	3	0
			7.0	4	0
			8.0	3	0
			6.0	3	0
			9.0	3	0
			6.0	3	0
Lower	5	*Olearia muelleri*	0.2	3	0
			0.4	3	0
			0.4	4	0
			0.5	4	0
			0.6	4	0
RQ8					
Upper	25	*Eucalyptus tephroclada*	8.0	3	0
			6.0	1	0
			6.0	1	0
			6.0	4	0
			6.0	3	0
			9.0	4	0
Mid	10	*Melaleuca hamata*	1.0	1	0
			1.5	1	0
			1.5	1	0
			1.5	1	0

Canopy level	Cover (%)	Species	Height (m)	Health rating	Dust rating
			1.1	3	0
			0.8	1	0
			1.0	1	0
			1.2	1	0
			0.7	2	0
			2.0	1	0
IQ1					
Mid	30	*Allocasuarina spinosissima*	3.0	3	0
			2.1	4	0
			3.0	3	0
			2.0	3	0
			3.0	3	0
			3.0	4	0
			2.2	3	0
			3.0	4	0
			2.5	3	0
			2.5	3	0
IQ2					
Mid	30	*Allocasuarina corniculata*	2.5	3	0
			2.6	3	0
			3.0	3	0
			3.1	1	0
			2.6	3	0
			2.8	1	0
			2.6	3	0
			2.5	3	0
			2.5	3	0
			3.0	3	0
IQ3					
Upper	10	*Eucalyptus horistes*	3.0	4	0
			4.0	4	0
			4.0	3	0
			2.0	1	0
			2.1	1	0
			4.0	3	0
Mid	35	*Allocasuarina corniculata*	2.5	3	0

			2.0	3	0
			2.5	3	0
			3.0	4	0
			2.5	3	0
			2.5	3	0
			3.0	4	0
			2.5	3	0
			2.7	3	0
			3.0	3	0
IQ4					
Mid	25	*Allocasuarina corniculata*	2.0	3	0
			2.0	4	0
			2.0	3	0
			3.0	3	0
			1.5	3	0
			2.0	3	0
			2.0	3	0
			2.0	1	0
			3.0	1	0
			2.5	3	0
IQ5					
Upper	20	*Eucalyptus eremophila*	5.0	1	0
			7.0	3	0
			9.0	4	0
			6.0	3	0
			6.0	1	0
			5.0	3	0
			9.0	3	0
			10.0	3	0
			8.0	3	0
			5.0	3	0
Mid	20	*Melaleuca hamata*	3.0	3	0
			2.5	3	0
			2.5	3	0
			3.0	3	0
			3.0	3	0
			2.7	4	0

			2.9	3	0
			2.5	3	0
			3.2	3	0
			3.0	3	0
IQ6					
Upper	10	*Eucalyptus capillosa*	1.5	1	0
			6.0	1	0
			6.0	1	0
			5.0	3	0
			8.0	3	0
			7.0	3	0
			5.0	3	0
			5.0	3	0
			8.0	3	0
Mid	35	*Melaleuca hamata*	2.2	3	0
			4.0	3	0
			3.0	4	0
			2.5	4	0
			2.6	4	0
			2.2	4	0
			3.0	3	0
			3.0	3	0
			2.0	4	0
			2.4	3	0
IQ7					
Upper	20	*Acacia acuminata*	7.0	4	0
			7.0	5	0
			8.0	3	0
			7.0	3	0
			8.0	5	0
Mid	40	*Leptospermum roei*	2.0	1	0
			2.0	3	0
			1.5	3	0
			2.1	1	0
			2.2	3	0
			2.3	1	0
			1.7	1	0

			2.0	1	0
			1.6	1	0
			1.5	1	0
Lower	35	*Hibbertia eatoniae*	0.6	4	0
			0.7	3	0
			0.6	4	0
			0.6	4	0
			0.6	3	0
			0.7	3	0
			0.7	4	0
			0.7	4	0
			0.8	3	0
			0.7	3	0
IQ8					
Upper	75	*Eucalyptus transcontinentalis*	14.0	3	0
			9.0	1	0
			12.0	3	0
			14.0	3	0
			8.0	4	0
			9.0	4	0
			10.0	3	0
			10.0	4	0
			10.0	4	0
			13.0	2	0
Lower	5	*Olearia muelleri*	0.3	4	0
			0.3	4	0
			0.5	4	0
			0.3	3	0
			0.3	1	0
IQ9					
Upper	40	*Eucalyptus capillosa*	7.0	3	0
			8.0	3	0
			4.0	3	0
			6.0	4	0
			6.0	2	0
			9.0	4	0
			9.0	3	0

Mid	20	*Melaleuca hamata*	3.5	4	0
			3.5	3	0
			2.5	4	0
			3.0	4	0
			3.0	4	0
			5.0	4	0
			3.0	3	0
			5.0	4	0
			3.5	4	0
			3.5	4	0
Lower	15	*Phebalium tuberculosum*	1.4	4	0
			1.6	3	0
			0.9	4	0
			1.0	4	0
			1.2	3	0
			1.4	3	0
			1.0	3	0
			1.3	3	0
			1.6	3	0
			1.4	3	0
IQ10					
Upper	40	*Eucalyptus transcontinentalis*	6	3	0
			8	3	0
			10	3	0
			12	3	0
			8	3	0
			7	3	0
			4.5	1	0
			6	3	0
			7	4	0
Mid	20	*Melaleuca hamata*	6	4	0
			3 5	3	0
			3.5	4	0
			4	5	0
			2.5	1	0
			3	1	0
			5	5	0

			5	4	0
			5	4	0
			6	3	0
			4	4	0
IQ11					
Upper	10	*Eucalyptus salmonophloia*	10.0	3	0
Lower	2	*Scaevola spinescens*	0.5	3	0
			0.6	4	0
			0.7	4	0
			1.1	3	0
			0.3	1	0
			0.4	1	0
			1.2	4	0
			0.5	1	0
			0.6	1	0
			0.6	1	0
IQ12					
Upper	13	*Eucalyptus transcontinentalis*	12	3	0
			11	3	0
			12	1	0
Upper	12	*Eucalyptus salmonophloia*	12	3	0
			14	3	0
			14	1	0
Mid	20	*Melaleuca pauperiflora*	3.7	3	0
			2.4	3	0
			3	3	0
			3	3	0
			3	3	0
			3.1	1	0
			3.5	3	0
			4	3	0
			5	3	0
			3	3	0
Lower	6	*Microcybe multiflora*	1	3	0
			1.2	2	0
			1.2	2	0
			1	2	0

			0.8	2	0
			1.2	2	0
			0.9	1	0
			1	2	0
			1	2	0
			1.3	2	0
IQ13					
Upper	20	*Eucalyptus salmonophloia*	10	3	0
			11	1	0
			11	4	0
Mid	12	*Eucalyptus salubris*	2	0	0
			2.5	1	0
			2	1	0
			2	3	0
			2.5	1	0
			3.1	1	0
			3	1	0
			3.3	1	0
			2.2	1	0
			2.3	3	0
Lower	10	*Scaevola spinescens*	0.5	1	0
			0.8	1	0
			0.5	3	0
			0.5	1	0
			0.4	1	0
			0.6	1	0
			1.3	4	0
			1	3	0
			1	3	0
			1.3	4	0
IQ14					
Upper	20	*Eucalyptus salmonophloia*	12.0	3	0
			12.0	3	0
Mid	20	*Melaleuca pauperiflora*	3.8	3	0
			4	4	0
			4	4	0
			4	3	0

			3.9	3	0
			4.2	3	0
			4.5	4	0
			4.2	4	0
			4.6	3	0
			4.5	3	0
Lower	5	*Eremophila oppositifolia*	1.5	3	0
			1.4	3	0
			2.3	3	0
			2.5	4	0
			2.7	4	0
			0.6	1	0
			1.5	3	0
			2.3	4	0
			2	3	0
			1.5	3	0
IQ15					
Upper	10	*Eucalyptus livida*	5.0	3	0
Mid	30	*Allocasuarina acutivalvis* subsp. *acutivalvis*	1.7	1	0
			2.1	1	0
			2	1	0
			2.2	1	0
			1.8	1	0
			1.5	3	0
			1.8	1	0
			1.7	1	0
			2	1	0
			1.5	1	0
Lower	50	*Acacia beauverdiana*	2	1	0
			2	1	0
			2	1	0
			2	3	0
			2.5	1	0
			2.1	1	0
			2.5	1	0
			2	1	0
			1.5	1	0

			2	1	0
IQ16					
Upper	5	*Eucalyptus salubris*	4.0	2	0
Upper	30	*Eucalyptus salmonophloia*	10	3	0
			12	3	0
			12	3	0
			12	3	0
			8	3	0
Mid	10	*Melaleuca pauperiflora*	3.5	1	0
			2.2	3	0
			3.5	3	0
			2.2	3	0
			2.5	3	0
			4	4	0
			2.4	1	0
			2.5	3	0
			2.1	3	0
			2.6	3	0
Lower	10	*Acacia enervia* subsp. *enervia*	0.4	4	0
			0.4	3	0
			0.6	4	0
			0.5	1	0
			0.5	3	0
			0.6	3	0
			0.5	3	0
			0.4	3	0
			0.7	1	0
			0.5	3	0

Appendix 5 Quadrat site photos

Reference sites RQ1 **Quadrat site photographs**

NW

NE

SW

SE

RQ2

NW

NE

SW

SE

RQ3

NW

NE

SW

SE

RQ4

NW

NE

SW

SE

RQ5

NW

NE

SW

SE

RQ6

NW

NE

SW

SE

RQ7

NW

NE

SW

SE

RQ8

NW

NE

SW

SE

Impact sites
Q1

NW

NE

SW

SE

Q2

NW

NE

SW

SE

Q3

NW

NE

SW

SE

Q4

NW

NE

SW

SE

Q5

NW

NE

SW

SE

Q6

NW

NE

SW

SE

Q7

NW

NE

SW

SE

Q8

NW

NE

SW

SE

Q9

NE

SW

SE

Q10

NW

NE

SW

SE

Q11

NW

NE

SW

SE

Q12

NW

NE

SW

SE

Q13

NW

NE

SW

SE

Q14

NW

NE

SW

SE

Q15

NW

NE

SW

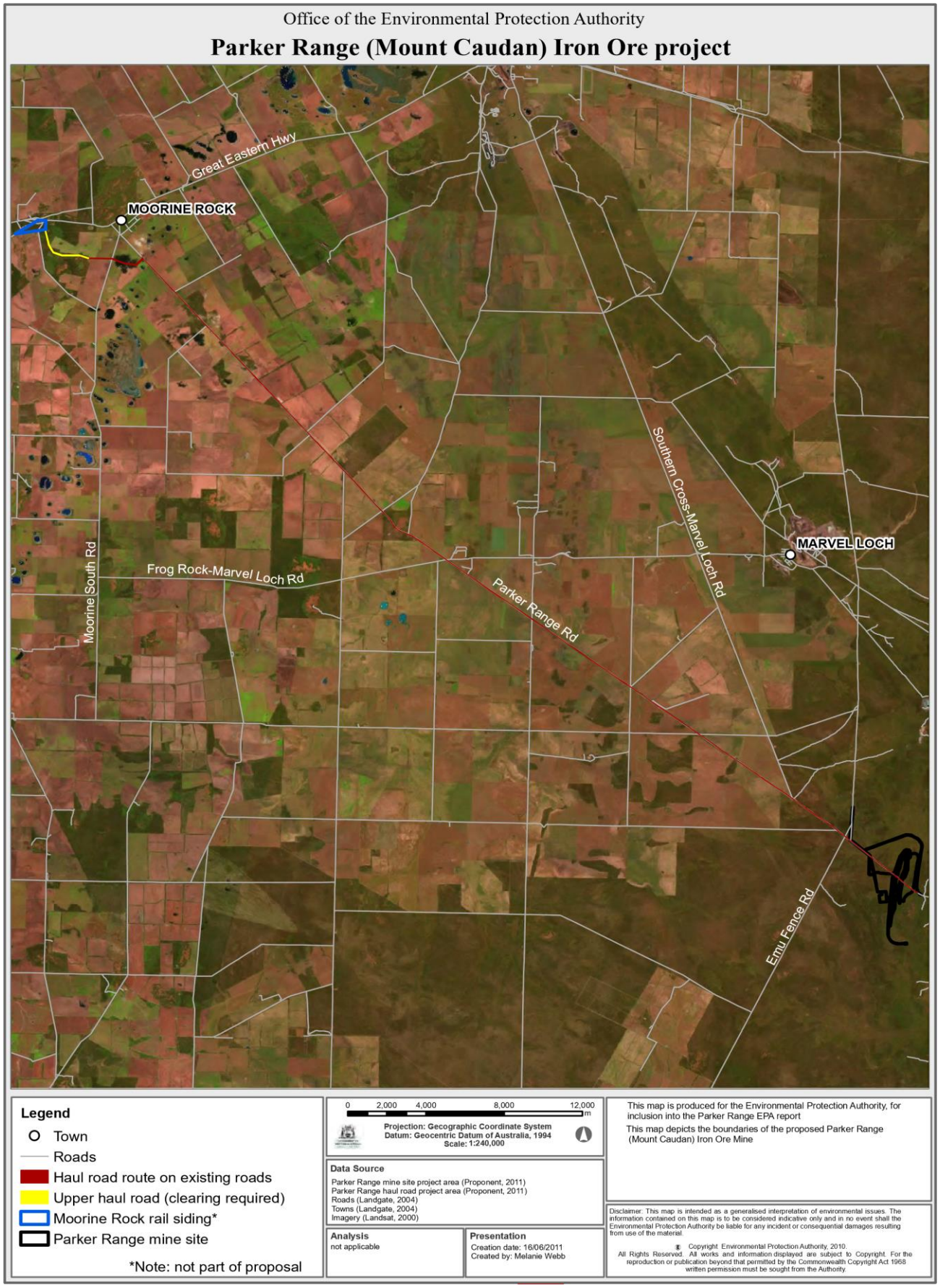
SE

Q16

NW

NE

SW

SE

Appendix 2: Parker Range upper haul road