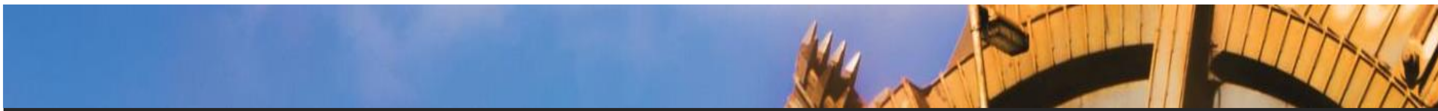

Koolyanobbing Iron Ore Project

MS1054 & 1133 ANNUAL COMPLIANCE ASSESSMENT REPORT 2020

Proponent:	Mineral Resources Ltd
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April 2021

Revision History

Revision Number	Issue Date	Prepared By	Reviewed By	Distribution
0	30/04/2020	A Vague	K Dennison	DWER

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1. INTRODUCTION

1.1 Project Overview

Mining has occurred at Koolyanobbing since the 1960's. Formally known as Portman Iron Ore, Cliffs Asia Pacific Iron Ore Pty Ltd (Cliffs) recommissioned the operations following closure by BHP Pty Ltd in the early 1980's and operated the mine from 1994 until 2018.

Cliffs ceased mining operations at Koolyanobbing in mid-2018 and entered into an Asset Sale Agreement with Mineral Resources Limited (MRL) on 12 June 2018. The transaction was completed in August 2018 and included the transfer of legal title in Cliffs mining tenements to MRL and ownership of all remaining iron ore, fixed plant, equipment and non-process infrastructure in the Yilgarn and at the Port of Esperance. All assets were transferred to the wholly owned MRL subsidiary Yilgarn Iron Pty Ltd (YIPL).

YIPL commenced mining at Koolyanobbing in September 2018. Iron ore is mined from a number of open pits, blended, crushed and screened to make products that meet export market specifications. The products are transported by rail from Koolyanobbing to Esperance Port.

Ore from the northern operations of Mt. Jackson, Windarling and Deception (located approximately 70, 100 and 120 km north of Koolyanobbing, respectively) is transported via a private haul road to Koolyanobbing or Carina where it is selectively blended with ore, crushed, and screened to meet market specifications.

The location of Mt Jackson, Windarling and Deception mines are shown **Figure 1**.

1.2 The Proponent

Following the Asset Sale Agreement and pursuant to section 38(6) and (7) of the *Environmental Protection Act 1986 (WA) (EP Act)*, YIPL was nominated as the person responsible for the Proposal (Yilgarn Operations, Koolyanobbing Range F Deposit; Assessment No. 2023; Statement No. 1054).

YIPL is a wholly owned subsidiary of MRL and became the beneficial holder of the mining tenements for the Koolyanobbing Iron Ore Project.

1.3 Approvals History

A Proposal was submitted by Cliffs for assessment to the Environmental Protection Authority (EPA) in July 2014 (Cliffs 2014). In September 2014, the EPA (2014) determined the Proposal should be subject to an Environmental Impact Assessment (EIA) at the level of Public Environmental Review (PER).

In October and November 2015, Cliffs' (2015) EIA-PER document was released for public review. The EIA-PER document outlined the location and infrastructure components of the Proposal, assessed the potential for environmental effects, and described Cliffs' proposed management actions to ensure such potential effects are minimised and controlled to an acceptable level.

In September 2016, the EPA (2016) assessment report to the Minister for Environment recommended the Proposal be approved, subject to environmental conditions. In January 2017, the Minister for Environment granted approval of the Proposal through the Statement 1054 approval in accordance with s45(5) of the Environmental Protection Act 1986 (WA).

On 6 February 2019, MRL formally requested that a section 46 (s 46) review of conditions 8, 9 and 10 of MS 1054 be initiated by the Minister. The amendment of Conditions 8, 9 and 10 was proposed to enable access to the Stage 2 mining area prior to the establishment of a new self-sustaining population of at least 313 (proposed to be amended to 261 to reflect the actual direct impact) T. erubescens individuals.

On 27 March 2019, the EPA advised that an inquiry into changing conditions of MS 1054 would be undertaken, pending provision of information from MRL in relation to the proposed amendments to conditions 8, 9 and 10. A s46 document was submitted on 18th of July 2019.

On the 06th of May 2020 approval of the s46 was granted and the agreed changes were outlined in Statement 1133. Amendments were granted for conditions 6, 8, 9 and 10 of MS 1054.

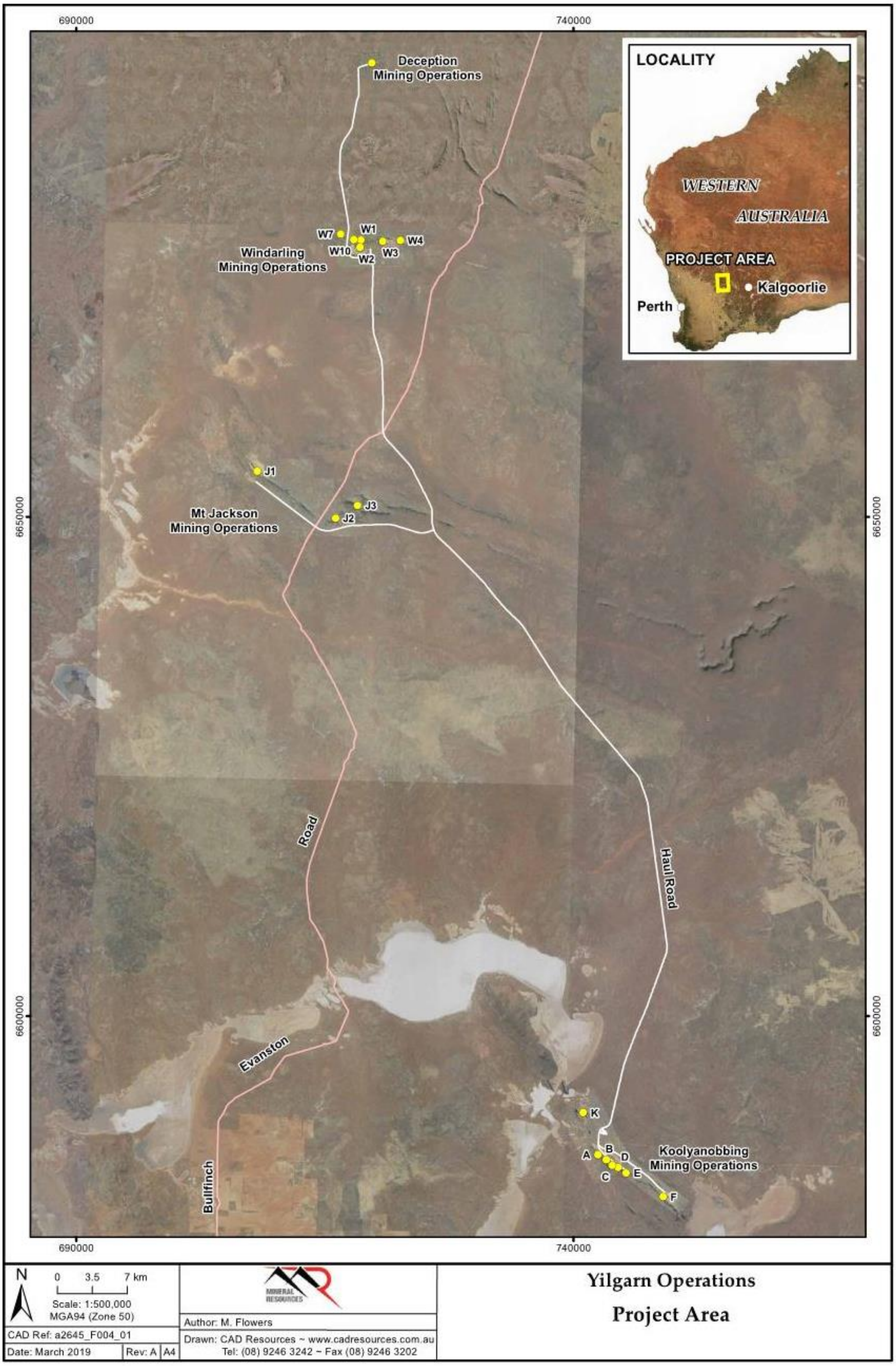

Figure 1: Location of YIPL Yilgarn Operations

1.4 Ministerial Statement MS1054

MS 1054 outlines the conditions regulating the mining of iron ore and construction of mine infrastructure at the F Deposit area, located on the southern Koolyanobbing Range, approximately 50 kilometres north-east of the town of Southern Cross. (See **Figure 1**).

Condition 4.6 of MS 1054 states:

The Proponent shall submit to the CEO a Compliance Assessment report by the 30th of April each year addressing compliance in the previous calendar year, or as agreed in writing by the CEO. The compliance assessment report shall:

1. *Be endorsed by the proponent's CEO or a person delegated to sign on the CEO's behalf;*
2. *Include a statement as to whether the proponent has complied with the conditions;*
3. *Identify all potential non-compliances and describe corrective and preventative actions taken;*
4. *Be made publicly available in accordance with the approved Compliance Assessment Plan; and*
5. *Indicate any proposed changes to the Compliance Assessment Plan required by condition 4-1*

This Annual Compliance Assessment Report was prepared in accordance with Condition 4-6 of MS1054 for the period between 1 January and 31 December 2020.

1.5 Ministerial Statement MS1133

On 6 February 2019, MRL formally requested that a section 46 (s 46) review of conditions 8, 9 and 10 of MS 1054 be initiated by the Minister. On 27 March 2019, the EPA advised that an inquiry into changing conditions of MS 1054 would be undertaken, pending provision of information from MRL in relation to the proposed amendments to conditions 8, 9 and 10.

On the 6th of May 2020, consistent with Section 46 of the *Environmental Protection Act 1986*, the Minister for Environment had consulted with other authorities and reached agreement that the implementation of conditions that apply to the s 46. The agreed changes were set out in Statement 1133.

MS 1133 outlines the changes to conditions to allow mining within the Stage 2 (F1 Pit) mining operations.

2. PROJECT STATUS

Operation continued in the F Deposit project area over the reporting period. Mining of F 2 & 3 deposits concluded in 2020. Active mining at F1 Deposit began in 2020 and is expected to continue for the next year.

3. COMPLIANCE

3.1 Non-compliances and Corrective Actions

No non-compliances were recorded during the 2020 reporting period.

3.2 Statement of Compliance

YIPL has complied with all conditions listed in Ministerial Statement 1054 for the 2020 reporting period. Refer to Attachment 1: 2020 Statement of Compliance MS1054.

4. DETAILS OF DECLARED COMPLIANCE STATUS

Assessment of Compliance – Ministerial Statement MS1054 Audit Table (**Attachment 2**) provides the compliance status of each implementation condition for the 2020 reporting period.

Attachment 1: 2020 Statement of Compliance MS1054

POST ASSESSMENT FORM 2

Statement of Compliance

1. Proposal and Proponent Details

Proposal Title	*Yilgarn Operations, Koolyanobbing Range F Deposit*
Statement Number	*MS1054*
Proponent Name	*Yilgarn Iron Pty Ltd. (nominated as person responsible under S38(6) and 38(7) of the EP Act)*
Proponent's Australian Company Number *(where relevant)*	ACN: 626 035 078

2. Statement of Compliance Details

Reporting Period	*1/01/20* to *31/12/20*

Implementation phase(s) during reporting period (please tick ✓ relevant phase(s))							
Pre-construction		Construction		Operation	✓	Decommissioning	

Audit Table for Statement addressed in this Statement of Compliance is provided at Attachment:	1
An audit table for the Statement addressed in this Statement of Compliance must be provided as Attachment 2 to this Statement of Compliance. The audit table must be prepared and maintained in accordance with the Department of Water and Environmental Regulation (DWER) *Post Assessment Guideline for Preparing an Audit Table*, as amended from time to time. The 'Status Column' of the audit table must accurately describe the compliance status of each implementation condition and/or procedure for the reporting period of this Statement of Compliance. The terms that may be used by the proponent in the 'Status Column' of the audit table are limited to the Compliance Status Terms listed and defined in Table 1 of Attachment 1.	

Were all implementation conditions and/or procedures of the Statement complied with within the reporting period? (please tick ✓ the appropriate box)			
No (please proceed to Section 3)		Yes (please proceed to Section 4)	✓

Each page (including Attachment 2) must be initialed by the person who signs Section 4 of this Statement of Compliance.
INITIALS: AM

POST ASSESSMENT FORM 2

3. Details of Non-compliance(s) and/or Potential Non-compliance(s)

The information required Section 3 must be provided for each non-compliance or potential non-compliance identified during the reporting period covered by this Statement of Compliance.

Non-compliance/potential non-compliance 3-1

Which implementation condition or procedure was non-compliant or potentially non-compliant?
Was the implementation condition or procedure non-compliant or potentially non-compliant?
On what date(s) did the non-compliance or potential non-compliance occur (if applicable)?

Was this non-compliance or potential non-compliance reported to the Chief Executive Officer, DWER?	
☐ Yes ☐ Reported to DWER verbally Date ___________ ☐ Reported to DWER in writing Date: ___________	☐ No

What are the details of the non-compliance or potential non-compliance and where relevant, the extent of and impacts associated with the non-compliance or potential non-compliance?
What is the precise location where the non-compliance or potential non-compliance occurred (if applicable)? (please provide this information as a map or GIS co-ordinates)
What was the cause(s) of the non-compliance or potential non-compliance?
What remedial and/or corrective action(s), if any, were taken or are proposed to be taken in response to the non-compliance or potential non-compliance?
What measures, if any, were in place to prevent the non-compliance or potential non-compliance before it occurred? What, if any, amendments have been made to those measures to prevent re-occurrence?
Please provide information/documentation collected and recorded in relation to this implementation condition or procedure: • in the reporting period addressed in this Statement of Compliance; and • as outlined in the approved Compliance Assessment Plan for the Statement addressed in this Statement of Compliance. (the above information may be provided as an attachment to this Statement of Compliance)

For additional non-compliance or potential non-compliance, please duplicate this page as required.

Each page (including Attachment 2) must be initialed by the person who signs Section 4 of this Statement of Compliance.
INITIALS: AM

4. Proponent Declaration

I, Aaron Maurer, General Manager, Yilgarn Operations declare that I am authorised on behalf of Yilgarn Iron Pty Ltd. *(being the person responsible for the proposal)* to submit this form and that the information contained in this form is true and not misleading.

Signature: A.Maurer Date: 14/04/2021

Please note that:

- it is an offence under section 112 of the *Environmental Protection Act 1986* for a person to give or cause to be given information that to his knowledge is false or misleading in a material particular; and
- the Chief Executive Officer of the DWER has powers under section 47(2) of the *Environmental Protection Act 1986* to require reports and information about implementation of the proposal to which the statement relates and compliance with the implementation conditions.

5. Submission of Statement of Compliance

One hard copy and one electronic copy (preferably PDF on CD or thumb drive) of the Statement of Compliance are required to be submitted to the Chief Executive Officer, DWER, marked to the attention of Manager, Compliance (Ministerial Statements).

Please note, the DWER has adopted a procedure of providing written acknowledgment of receipt of all Statements of Compliance submitted by the proponent, however, the DWER does not approve Statements of Compliance.

6. Contact Information

Queries regarding Statements of Compliance, or other issues of compliance relevant to a Statement may be directed to Compliance (Ministerial Statements), DWER:

Manager, Compliance (Ministerial Statements)

Department of Water and Environmental Regulation

Postal Address:	Locked Bag 33 Cloisters Square PERTH WA 6850
Phone:	(08) 6364 7000
Email:	compliance@dwer.wa.gov.au

7. Post Assessment Guidelines and Forms

Post assessment documents can be found at www.epa.wa.gov.au

Each page (including Attachment 2) must be initialed by the person who signs Section 4 of this Statement of Compliance.
INITIALS: AM

POST ASSESSMENT FORM 2

ATTACHMENT 1

Table 1 Compliance Status Terms

Compliance Status Terms	Abbrev	Definition	Notes
Compliant	C	Implementation of the proposal has been carried out in accordance with the requirements of the audit element.	This term applies to audit elements with: • ongoing requirements that have been met during the reporting period; and • requirements with a finite period of application that have been met during the reporting period, but whose status has not yet been classified as 'completed'.
Completed	CLD	A requirement with a finite period of application has been satisfactorily completed.	This term may only be used where: • audit elements have a finite period of application (e.g. construction activities, development of a document); • the action has been satisfactorily completed; and • the DWER has provided written acceptance of 'completed' status for the audit element.
Not required at this stage	NR	The requirements of the audit element were not triggered during the reporting period.	This should be consistent with the 'Phase' column of the audit table.
Potentially Non-compliant	PNC	Possible or likely failure to meet the requirements of the audit element.	This term may apply where during the reporting period the proponent has identified a potential non-compliance and has not yet finalized its investigations to determine whether non-compliance has occurred.
Non-compliant	NC	Implementation of the proposal has not been carried out in accordance with the requirements of the audit element.	This term applies where the requirements of the audit element are not "complete" have not been met during the reporting period.
In Process	IP	Where an audit element requires a management or monitoring plan be submitted to the DWER or another government agency for approval, that submission has been made and no further information or changes have been requested by the DWER or the other government agency and assessment by the DWER or other government agency for approval is still pending.	**The term 'In Process' may not be used for any purpose other than that stated in the Definition Column.** The term 'In Process' may not be used to describe the compliance status of an implementation condition and/or procedure that requires implementation throughout the life of the project (e.g. implementation of a management plan).

Each page (including Attachment 2) must be initialed by the person who signs Section 4 of this Statement of Compliance.
INITIALS: AM

Attachment 2: Assessment of Compliance MS1054 Audit Table

Yilgarn Operations – Koolyanobbing Range F Deposit (Statement 1054)

- Phases that apply in this table = Pre-Construction, Construction, Operation, Decommissioning, Overall (several phases).
- The Audit Table provides a summary interpretation of the condition requirements applying to the Proposal under the *Environmental Protection Act 1986* (WA). Please refer to the Statement approval issued for the Proposal for the agreed condition wording and abbreviations.
- Status: C = Compliant; CLD = Completed; Status: DEL = Deleted; NC = Non – compliant; NR = Not Required at this stage; NA = Not Audited; VR = Verification Required; IP = In Process.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
1054:M1-1	**Proposal Implementation**	When implementing the proposal, the proponent shall not exceed the authorised extent of the proposal as defined in Tables 2 and 3 in Schedule 1, unless amendments to the proposal and the authorised extent of the proposal have been approved under the EP Act.	Proposal implementation to be within authorised extent described in defined in Tables 2 and 3 in Schedule 1	Spatial mapping identifying the extent of the Proposal approved and extent of the Proposal as implemented	Overall	Ongoing	C	The proposal has been implemented to requirements described in Table 2 and Table 3 as described in MS 1054:1-1.
		Key Characteristic	**Description**					
	Proposal Implementation – Table 2 – Stage 1	Mine Pits (F2 and F3)	Clearing of no more than 24 hectares in the 203 hectares development envelope				C	To date, 21.87 hectares of land has been progressively cleared for mine pits (F2 and F3). See Attachment **4** Yilgarn Operations Koolyanobbing Range Mine operations 2020 Clearing.
	Proposal Implementation– Table 2- Stage 1	Waste Rock Dump	Clearing of no more than 73 hectares in the 203 hectares development envelope				C	To date, 51.94 hectares has been progressively cleared for the creation of a Waste Rock Landform. See Attachment **4** Yilgarn Operations Koolyanobbing Range Mine operations 2020 Clearing.
	Proposal Implementation– Table 2- Stage 1	Supporting Mine Infrastructure	Clearing of no more than 96 hectares in the 203 hectares development envelope				C	To date, 70.05 hectares of land has been progressively cleared for Supporting Mine Infrastructure. See Attachment **4** Yilgarn Operations Koolyanobbing Range Mine operations 2020 Clearing.
	Proposal Implementation - Table 3- Stage 2	Mine Pit (F1)	Clearing of no more than 9 hectares in the 203 hectares development envelope				C	To date, 21.87 hectares of land has been progressively cleared for Stage 2 Mine pit (F1). See Attachment **4** Yilgarn Operations Koolyanobbing Range Mine operations 2020 Clearing.
	Proposal Implementation – Table 3- Stage 2	Supporting Mine Infrastructure	Clearing of no more than 1 hectares in the 203 hectares development envelope				C	There has been no clearing for Stage 2 Supporting mine infrastructure. See Attachment **4** Yilgarn Operations Koolyanobbing Range Mine operations 2020 Clearing.
1054:M2-1	**Contact Details**	The proponent shall notify the CEO of any change of its name, physical address or postal address for the serving of notices or other correspondence within twenty-eight (28) days of such change. Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State.	Written notification to CEO of change	Written notification to CEO of change	Overall	Within 28 days of change	C	Cliffs entered into an asset sale agreement with Mineral Resources Limited Pty Ltd (MRL) in June 2018, which included the sale of all remaining iron ore at Yilgarn operations, fixed plant, equipment and non-process infrastructure. The asset sale transaction was completed in August 2018, with all assets transferred to the wholly owned MRL subsidiary Yilgarn Iron Pty Ltd (YIPL). Mining recommenced in September 2018. Pursuant to section 38(6) and (7) of the *Environmental Protection Act 1986*, Yilgarn Iron Pty Ltd was nominated as the person responsible for the Proposal on October 19th 2018, and contact details were updated accordingly.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
1054:M3-1	**Time Limit for Proposal Implementation**	The proponent shall not commence implementation of the proposal after five (5) years from the date on this Statement, and any commencement, prior to this date, must be substantial.	Proposal implementation to commence within 5 years of the date of this Statement, or to not commence after 5 years of the date of this Statement	Written notification to CEO of substantial commencement in accordance with Condition 3-2	Construction, Operation	5 years from the date of this Statement	C	Implementation of the proposal commenced 22 February 2017 with initiation of clearing work. Confirmation that the proposal has been substantially commenced is evidenced by the content of and submission of Annual Compliance Assessment Reports (ACAR) to the DWER.
1054:M3-2	**Time Limit for Proposal Implementation**	Any commencement of implementation of the proposal, on or before five (5) years from the date of this Statement, must be demonstrated as substantial by providing the CEO with written evidence, on or before the expiration of five (5) years from the date of this Statement.	Written notification to CEO of substantial commencement	Written notification to CEO of substantial commencement	Construction, Operation	5 years of the date of this Statement	C	The content and submission of the ACAR to the CEO provides evidence that the proposal had substantially commenced within 5 years of the date of the Statement.
1054:M4-1	**Compliance Reporting**	The proponent shall prepare, submit and maintain a Compliance Assessment Plan to the CEO at least three (3) months prior to the first Compliance Assessment Report required by condition 4-6, or prior to implementation, whichever is sooner.	Preparation and submission of Compliance Assessment Plan (CAP) to CEO	Preparation and submission of CAP to CEO	Pre-construction	Prior to implementation of Proposal	C	OEPA approved the CAP 21 February 2017 and determined that the CAP met the requirements of Conditions 4-1 and 4-2 of Statement 1054 (OEPA Ref: AC05-2017-007). YIPL updated the CAP to reflect changes to the proponent for MS1054 and the location of the publicly available reports in accordance with condition 4-6(4) of MS 1054 The update does not impact on any actions or requirements of the CAP that was approved by OEPA in 2017.
1054:M4-2	**Compliance Reporting**	The Compliance Assessment Plan shall indicate: (1) the frequency of compliance reporting; (2) the approach and timing of compliance assessments; (3) the retention of compliance assessments; (4) the method of reporting of potential non-compliances and corrective actions taken; (5) the table of contents of Compliance Assessment Reports; and (6) public availability of Compliance Assessment Reports.	Preparation and submission of CAP to CEO	Preparation and submission of CAP to CEO	Pre-construction	Prior to implementation of Proposal	C	OEPA approved the CAP 21 February 2017 and determined that the CAP met the requirements of Conditions 4-1 and 4-2 of Statement 1054 (OEPA Ref: AC05-2017-007). All YIPL's CARs are made available to the public through publication on MRL's website at http://www.mineralresources.com.au
1054:M4-3	**Compliance Reporting**	After receiving notice in writing from the CEO that the Compliance Assessment Plan satisfies the requirements of condition 4-2 the proponent shall assess compliance with conditions in accordance with the Compliance Assessment Plan required by condition 4-1.	Assess compliance in accordance with the CAP	CAR Reports prepared in accordance with the CAP	Overall	Ongoing	C	This 2020 annual Compliance Assessment Report (CAR) fulfils the requirement to assess compliance with the conditions of Statement 1054 for the period 1 January 2019 to 31 December 2020.
1054:M4-4	**Compliance Reporting**	The proponent shall retain reports of all compliance assessments described in the Compliance Assessment Plan required by condition 4-1 and shall make those reports available when requested by the CEO.	Retention of CAR as described in the CAP	Retention of CAR as described in the CAP	Overall	Ongoing	C	Annual CARs are retained within and made available on MRL's electronic network and have been submitted to the CEO/Director General – Department of Water and Environmental Regulation (DWER) in accordance with the Compliance Assessment Plan.
1054M:4-5	**Compliance Reporting**	The proponent shall advise the CEO of any potential non-compliance within seven (7) days of that non-compliance being known.	Written notification to CEO of any potential non-compliance	Written notification to CEO of any potential non-compliance	Overall	Ongoing	C	No non-compliances were recorded during the 2020 reporting period.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
1054:M4-6	**Compliance Reporting**	The proponent shall submit to the CEO a Compliance Assessment Report by 30 April each year addressing compliance in the previous calendar year, or as agreed in writing by the CEO. The first Compliance Assessment Report shall be submitted by 30 April 2017 addressing the compliance for the period from the date of issue of this Statement, notwithstanding that the first reporting period may be less than 12 months. The Compliance Assessment Report shall: (1) be endorsed by the proponent's CEO or a person delegated to sign on the CEO's behalf; (2) include a statement as to whether the proponent has complied with the conditions; (3) identify all potential non-compliances and describe corrective and preventative actions taken; (4) be made publicly available in accordance with the approved Compliance Assessment Plan; and (5) indicate any proposed changes to the Compliance Assessment Plan required by condition 4-1.	CAR submission to CEO	CAR submission to CEO	Overall	30th April, annually	C	The 2016 CAR was submitted in April 2017 in compliance with this condition. This 2020 CAR is the fifth to be submitted as required and covers the period 1 January 2020 to 31 December 2020. This CAR is endorsed by MRL's General Manager Mr Aaron Maurer.
1054:M5-1	**Public Availability of Data**	Subject to condition 5-2, within a reasonable time period approved by the CEO of the issue of this Statement and for the remainder of the life of the proposal the proponent shall make publicly available, in a manner approved by the CEO, all validated environmental data (including sampling design, sampling methodologies, empirical data and derived information products (e.g. maps, survey results, reports)) relevant to the assessment of this proposal and implementation of this Statement.	Public availability of Compliance Assessment Reports in as outlined within the Compliance Assessment Plan approved by the CEO		Overall	Ongoing	C	All YIPL's CAR's and supporting information required under this statement are made available to the public through prompt publication on the MRL website at http://www.mineralresources.com.au
1054:M5-2	**Public Availability of Data**	If any data referred to in condition 5-1 contains particulars of: (1) a secret formula or process; or (2) confidential commercially sensitive information; the proponent may submit a request for approval from the CEO to not make these data publicly available. In making such a request the proponent shall provide the CEO with an explanation and reasons why the data should not be made publicly available.	Written request to CEO		Overall	Ongoing	NR	YIPL does not request that any plans or reports or any sections of plans or reports not to be made publically available during the reporting period.
1054:M6-1	**Flora and Vegetation Management**	Prior to the commencement of any ground disturbing activities, or as otherwise agreed in writing by the CEO, the proponent shall prepare and submit a Condition Environmental Management Plan to the satisfaction of the CEO, on advice of the Department of Parks and Wildlife, to demonstrate that the following environmental outcomes will be met: (1) No adverse effects on native flora and vegetation outside the Stage 1 and 2 development envelopes as shown in Figure 2 in Schedule 1 and delineated by coordinates in Schedule 2 or within the Stage 2 development envelope until the requirements of condition 9 have been met; (2) No adverse effects on greater than 313 *Tetratheca erubescens* plants within the Stage 1 development envelope as shown in Figure 3 in Schedule 1 and delineated by coordinates in Schedule 2; and (3) No adverse effects on greater than 652 *Tetratheca erubescens* plants within the Stage 2 development envelope as shown in Figure 3 in Schedule 1 and delineated by coordinates in Schedule 2 once the requirements of condition 9 have been met.	Preparation and submission of a Condition Environmental Management Plan (Flora and Vegetation Management Plan) to the satisfaction of the CEO	Preparation and submission of a Condition Environmental Management Plan (Flora and Vegetation Management Plan) to the satisfaction of the CEO	Pre-construction	Prior to implementation of Proposal	DEL	OEPA provided approval (OEPA Ref: 17-012450) on 20 February 2017 for Cliffs to undertake early ground disturbing activities within the proposal area prior to the approval of the Flora and Vegetation Management Plan. The *Yilgarn Operations - Koolyanobbing Range F Deposit – Flora and Vegetation Management Plan* (Revision 0) was submitted to OEPA in November 2019. The Plan was approved by OEPA on 04 February 2020 (OEPA Ref: DWERA-000999). Condition 6-1 of Ministerial Statement is deleted And replaced with Condition 6-1 of MS 1133. See Audit Table 1133: M6-1 for additional information.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
1054:M6-2	**Flora and Vegetation Management**	The plan required by condition 6-1 shall include provisions required by condition 6-3 to address indirect impacts on native flora and vegetation (including *Tetratheca erubescens* and Priority flora species) and vegetation health and condition including from, but not limited to dust, weeds and fire as a result of implementation of the proposal. The plan shall be developed in consultation with an independent expert in the assessment and management of dust impacts on plants, to be endorsed in writing by the CEO.	Preparation and submission of a Condition Environmental Management Plan (Flora and Vegetation Management Plan) to the satisfaction of the CEO	Preparation and submission of a Condition Environmental Management Plan (Flora and Vegetation Management Plan) to the satisfaction of the CEO	Pre-construction	Prior to implementation of Proposal	C	OEPA provided approval (OEPA Ref: 17-012450) on 20 February 2017 for Cliffs to undertake early ground disturbing activities within the proposal area prior to the approval of the Flora and Vegetation Management Plan. The *Yilgarn Operations - Koolyanobbing Range F Deposit – Flora and Vegetation Management Plan* (Revision 0) was submitted to OEPA in November 2019. The Plan was approved by OEPA on 04 February 2020 (OEPA Ref: DWERA-000999). MRL is working in conjunction with Kings Park Science and Department of Biodiversity, Conservation and Attractions to develop Revision 2 of the Management Plan. See Audit Table 1133: M6-1 for additional information.
1054:M6-3	**Flora and Vegetation Management**	The Condition Environmental Management Plan shall: (1) include the results of a suitable, contemporary baseline flora and vegetation survey to determine flora and vegetation health and condition pre-ground disturbance; (2) specify trigger criteria that will trigger the implementation of trigger level actions if exceeded; (3) specify threshold criteria that: (a) provides a limit, which the proponent must not exceed, beyond which the environmental outcome identified in condition 6-1 is not achieved; and (b) will trigger the implementation of threshold contingency actions if exceeded. (4) specify monitoring and analysis to determine if trigger criteria and threshold criteria are exceeded; (5) specify trigger level actions to be implemented in the event that trigger criteria have been exceeded; (6) specify threshold contingency actions to be implemented in the event that threshold criteria are exceeded; (7) provide the format and timing for the reporting of monitoring results and analysis against threshold criteria to demonstrate that condition 6-1 has been met over the reporting period in the Compliance Assessment Report required by condition 4; and (8) provide for reporting of exceedances of the threshold criteria.	Preparation and submission of a Condition Environmental Management Plan (Flora and Vegetation Management Plan) to the satisfaction of the CEO	Preparation and submission of a Condition Environmental Management Plan (Flora and Vegetation Management Plan) to the satisfaction of the CEO	Pre-construction	Prior to implementation of Proposal	C	OEPA provided approval (OEPA Ref: 17-012450) on 20 February 2017 for Cliffs to undertake early ground disturbing activities within the proposal area prior to the approval of the Flora and Vegetation Management Plan. The *Yilgarn Operations - Koolyanobbing Range F Deposit – Flora and Vegetation Management Plan* (Revision 0) was submitted to OEPA in November 2019. The Plan was approved by OEPA on 04 February 2020 (OEPA Ref: DWERA-000999). See Audit Table 1133: M6-1 for additional information.
1054:M6-4	**Flora and Vegetation Management**	After receiving notice in writing from the CEO that the Condition Environmental Management Plan satisfies the requirements of condition 6-3 for condition 6-1, prior to the commencement of ground disturbing activities, unless otherwise agreed by the CEO, the proponent shall: (1) commence implementation of the provisions of the Condition Environmental Management Plan; (2) monitor the health and condition of the remaining *Tetratheca erubescens* plants at the Koolyanobbing Range. Parameters to be monitored include, but are not limited to, mortality, recruitment, vegetation health and reproductive health;	Implementation of a Condition Environmental Management Plan (Flora and Vegetation Management Plan) to the satisfaction of the CEO	Yilgarn Iron Ore Project *Tetratheca erubescens* Two Monthly Monitoring Summary Report 2020 (Revision 0) (See Attachment 5) Koolyanobbing F Deposit 2020 Annual Priority Flora and Vegetation Monitoring November 2020 Report (Revision 0) (See Attachment 6)	Construction, Operation	Ongoing	C	OEPA provided approval (OEPA Ref: 17-012450) on 20 February 2017 for Cliffs to undertake early ground disturbing activities within the proposal area prior to the approval of the Flora and Vegetation Management Plan. The *Yilgarn Operations - Koolyanobbing Range F Deposit – Flora and Vegetation Management Plan* (Revision 0) was submitted to OEPA in November 2019. The Plan was approved by OEPA on 04 February 2020 (OEPA Ref: DWERA-000999). MRL is working in conjunction with Kings Park Science and Department of Biodiversity, Conservation and Attractions to develop Revision 1 of the Management Plan.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
		(3) monitor the health and condition of Priority 1 flora species and native vegetation adjacent to the Development Envelope for Stages 1 and 2; and (4) continue to implement the Condition Environmental Management Plan until the CEO has confirmed by notice in writing that the proponent has demonstrated the outcome specified in condition 6-1 has been met.		Annual *Tetratheca erubescens* Monitoring November (Revision 0) (See Attachment 7)				See Audit Table 1133: M6-1 for additional information. Monitoring was undertaken at the frequency identified within the Plan following commencement of mining in May 2017. The results of this monitoring were compiled into two individual reports. These reports, being the; *Koolyanobbing Range Priority Flora and Vegetation Monitoring Report*, November 2017 and the *Koolyanobbing Range Two monthly Tetratheca erubescens Monitoring Report*, November 2017 were submitted to OEPA and the Department of Parks and Wildlife (DPaW) on 14 November 2017. Subsequent to these submissions, statistical analysis of the monitoring data was completed in 2018 to 2020 and the reports updated. Completion and submission of flora and vegetation monitoring reports as attachments to this CAR demonstrates implementation of the Flora and Vegetation Management Plan required by conditions 6-2 and 6-3. The Tetratheca erubescens Two-monthly Monitoring & F Deposit Annual Flora and Vegetation Report results indicate that no adverse effects to conservation significant flora and vegetation as a result of proposed actions.
1054:M6-5	**Flora and Vegetation Management**	In the event that monitoring indicates exceedance of threshold criteria specified in the Condition Environmental Management Plan, the proponent shall: (1) report the exceedance in writing within seven (7) days of the exceedance being identified; (2) immediately implement the threshold contingency actions specified in the Condition Environmental Management Plan and continue implementation of those actions until the trigger criteria are being met, or until the CEO has confirmed by notice in writing that it has been demonstrated that the environmental outcome in condition 6-1 is being met and implementation of the trigger level actions and/or threshold contingency actions are no longer required; (3) investigate to determine the cause of the threshold criteria being exceeded; (4) identify additional measures required to prevent the threshold criteria being exceeded in the future; (5) investigate to determine potential environmental harm or alteration of the environment that occurred due to threshold criteria being exceeded; and (6) provide a report to the CEO within ninety (90) days of the exceedance being reported. The report shall include: (a) details of threshold contingency actions implemented;	Written notification and report to CEO, and implementation of actions and measures and investigations, if required	Written notification and report to CEO, and implementation of actions and measures and investigations, if required	Construction, Operation	Following identification of monitoring indicating an exceedance, if required	NR	No exceedances of threshold criteria were recorded during the 2020 monitoring and reporting period, as outlined in the monitoring reports (See Attachments 5,6and 7).

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
		(b) the effectiveness of the threshold contingency actions implemented, monitored and measured against trigger criteria and threshold criteria; (c) the findings of the investigations required by condition 6-5(3) and 6-5(5); (d) additional measures to prevent the threshold criteria being exceeded in the future; and (e) measures to control or abate and mitigate the significant adverse environmental impacts which may have occurred.						
1054:M6-6	**Flora and Vegetation Management**	The proponent: (1) may review and revise the Condition Environmental Management Plan, or (2) shall immediately review and revise the Condition Environmental Management Plan if the environmental outcomes in condition 6-1 are not being met or as and when directed by the CEO.	Review and revision of the Condition Environmental Management Plan, if required	Review and revision of the Condition Environmental Management Plan, if required	Construction, Operation	Ongoing, if required	C	OEPA provided approval (OEPA Ref: 17-012450) on 20 February 2017 for Cliffs to undertake early ground disturbing activities within the proposal area prior to the approval of the Flora and Vegetation Management Plan. The *Yilgarn Operations - Koolyanobbing Range F Deposit – Flora and Vegetation Management Plan* (Revision 0) was submitted to OEPA in November 2019. The Plan was approved by OEPA on 04 February 2020 (OEPA Ref: DWERA-000999). See Audit Table 1133: M6-1 for additional information.
1054:M6-7	**Flora and Vegetation Management**	The proponent shall implement the latest revision of the Condition Environmental Management Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 6-3.	Implementation of the Condition Environmental Management Plan	Ongoing monitoring has been conducted since acquiring of the Koolyanobbing operations. Monitoring reports as per condition 6-2 are attached. Yilgarn Iron Ore Project *Tetratheca erubescens* Two Monthly Monitoring Summary Report 2020 (Revision 0) (See Attachment 5) Koolyanobbing F Deposit 2020 Annual Priority Flora and Vegetation Monitoring Report (Revision 0) (See attachment 6) Annual *Tetratheca erubescens* Monitoring November 2020 (Revision 0) (See Attachment 7)	Construction, Operation	Ongoing	C	OEPA provided approval (OEPA Ref: 17-012450) on 20 February 2017 for Cliffs to undertake early ground disturbing activities within the proposal area prior to the approval of the Flora and Vegetation Management Plan. The *Yilgarn Operations - Koolyanobbing Range F Deposit – Flora and Vegetation Management Plan* (Revision 0) was submitted to OEPA in November 2019. The Plan was approved by OEPA on 04 February 2020 (OEPA Ref: DWERA-000999). YILP are operating under 2017 Revision 0 Plan and will continue to do so until Revision 1 has received approval (the CEO has confirmed by notice in writing that the Plan satisfies the requirements of condition 6-3). The Plan has continued to be formally implemented since the remaining iron ore at the Yilgarn operations, fixed plant, equipment and non-process infrastructure assets were transferred to the wholly owned MRL subsidiary Yilgarn Iron Pty Ltd (YIPL) in August 2018.
1054:M7-1	**F3 Pit Wall Stability and Abandonment Bunding**	The proponent shall design and operate the F3 pit, as shown in Figure 3 in Schedule 1, to ensure stability of the southern pit wall during mining and post closure so that the *Tetratheca erubescens* plants adjacent to the southern pit wall, as shown in Figure 3 in Schedule 1, are not adversely impacted.	Design and operation of the F3 Pit southern wall to ensure stability	Southern pit wall is stable during mining and post closure with adjacent *Tetratheca erubescens* not adversely impacted	Construction, Operation, Decommissioning	Ongoing during mining and post mine closure of the F3 Pit	CL	The approved *Geotechnical Management Plan: F Pit Development* directs the design, operation and monitoring of F3 pit during mining and for post closure long term stability. In summary, investigations and assessment prior to and during mining have confirmed originally interpreted rock mass conditions including structural conditions (defect distributions), rock type, rock strength and hydrogeological conditions.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
								YIPL continued to operate the F3 pit according to the design identified in Figure 3 in Schedule 1, until closure in 2020, in order to ensure the stability of the southern pit wall and adjacent *Tetratheca erubescens* not adversely impacted. See Attachment 8: F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates
1054:M7-2	**F3 Pit Wall Stability and Abandonment Bunding**	The Factor of Safety for the final southern wall of the F3 pit, as shown in Figure 3 in Schedule 1, to be no less than 2.	Design of the F3 Pit southern wall to have Factor of Safety of 2	Design of the F3 Pit southern wall to have Factor of Safety of 2	Pre-construction, Construction, Operation	Ongoing during mining of the F3 Pit	C	In 2020, Peter O'Bryan & Associates were commissioned to undertake geotechnical re-assessment of the Yilgarn Operations. Assessment of the F3 pit wall identified that stability conditions are generally good and meet the requirements of condition 7-2. The report states "Stability conditions in F3 Pit walls are assessed to be good on average. The Factor of Safety against overall/rock mass failure of the highwall in >2.0." See Attachment 8: F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates
1054:M7-3	**F3 Pit Wall Stability and Abandonment Bunding**	The final separation distance between the edge of the southern wall of the F3 pit and the adjacent development envelope as shown in Figure 3 in Schedule 1, is to be a minimum of 20 metres.	Design of the F3 Pit southern wall to have a 20m separation distance	Design of the F3 Pit southern wall to have a 20m separation distance	Pre-construction, Construction, Operation	Ongoing during mining of the F3 Pit	C	The final separation distance between the southern wall edge of the F3 pit and the adjacent development envelope is greater than 20 metres along its length. See Attachment 9: Final separation distance F3.
1054:M7-4	**F3 Pit Wall Stability and Abandonment Bunding**	The final pit wall along the southern side of the F3 pit is to be established by means of a cut-back operation of a full 18 metre height batter along 150 metres of strike.	Development of the F3 Pit final southern wall by a cut-back of 18 metre height batter along 150 metres of strike	Development of the F3 Pit final southern wall by a cut-back of 18 metre height batter along 150 metres of strike	Construction, Operation	Ongoing during mining of the F3 Pit	C	The approved *Geotechnical Management Plan: F Pit Development* directs the design, operation and monitoring of F3 pit during mining and for post closure long term stability. See Attachment 8: F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates
1054:M7-5	**F3 Pit Wall Stability and Abandonment Bunding**	During operations rock strength parameters and geotechnical data to be obtained from a deep hole drilled in close proximity to the F3 pit wall. This data to be used to verify assumptions made relating to rock strength parameters, geotechnical data and early analysis, structural data and early analysis and results from the initial rock tests conducted.	Rock strength parameters and geotechnical data obtained from a deep hole drilled in close proximity to the F3 pit wall, geotechnical data and early analysis, structural data and early analysis and results from the initial rock tests conducted	Analysis of rock strength parameters and geotechnical data to verify assumptions made relating to rock strength parameters, geotechnical data and early analysis, structural data and early analysis and results from the initial rock tests conducted	Construction, Operation	Ongoing during mining of the F3 Pit	CL	Borehole P17GT001 was drilled in close proximity to the F3 pit wall. Data obtained from Borehole P17GT001 was interpreted and presented by Peter O'Bryan & Associates in *Technical Memorandum - F Deposit Pit 3 Additional Geotechnical Investigation Borehole P17GT001*. The information obtained from Borehole P17GT001 endorses interpretations and inferences made with respect to rock strength, rock mass strength and structural geological conditions derived from initial investigations. Mining of F3 Pit was completed in 2020.

<table>
<tr><th>Audit Code</th><th>Subject</th><th>Requirement</th><th>How</th><th>Evidence</th><th>Phase</th><th>Timeframe</th><th>Status</th><th>Further Information</th></tr>
<tr><td>1054:M7-6</td><td>F3 Pit Wall Stability and Abandonment Bunding</td><td>Prior to ground disturbing activities, prepare and submit a Stability Monitoring Program to the satisfaction of the DMP, and submit to the CEO. The Program shall include:
(1) routine geotechnical and geological mapping and data interpretation for each established batter along the southern F3 pit wall and continuous slope stability monitoring of the southern F3 pit wall; and
(2) vibration monitoring and measurements for each pit firing.</td><td>Prepare and submit a Stability Monitoring Program to the satisfaction of the DMP, and submit to the CEO</td><td>Stability Monitoring Program prepared and submitted to the satisfaction of the DMP, and submit to the CEO</td><td>Pre-construction</td><td>Prior to ground disturbing activities</td><td>CL</td><td>The Geotechnical Management Plan: F Pit Development (which includes the detail of the F3 pit wall Stability Monitoring Program) was submitted to and approved by the then Department of Mines and Petroleum (DMP) 17 February 2017.
The Plan was subsequently submitted to OEPA 17 February 2017. OEPA confirmed that they were satisfied that the Plan met the requirements of Condition 7-6 including the blast vibration limits.
The Plan has continued to be implemented since commencement of F Deposit mining activity. Ongoing collection of geotechnical and mapping data has been confirmed by the independent re-assessment undertaken by Peter O'Bryan & Associates
See Attachment 8: F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates
Mining of F3 Pit was completed in 2020.</td></tr>
<tr><td>1054:M7-7</td><td>F3 Pit Wall Stability and Abandonment Bunding</td><td>Ground vibrations along the southern edge of the F3 pit adjacent to the development envelope are not to exceed the following specifications in Table 1 and be included in the Stability Monitoring Program required by condition 7-6.
Table 1. Blast Vibration Limits<table><tr><th>Blast Frequency</th><th>Vibration PPV Limit</th></tr><tr><td>No blast greater than</td><td>No blast greater than 10 mm/sec</td></tr><tr><td>90% of the blasts per year</td><td>5 mm/sec</td></tr><tr><td>9 out of 10 consecutive blasts less than</td><td>5 mm/sec</td></tr></table></td><td>Management of blasting during mining operations to ensure blast vibration limits identified by Table 1 are achieved</td><td>Vibration monitoring results</td><td>Construction, Operation</td><td>Ongoing during mining of the F3 Pit</td><td>CL</td><td>A total of 64 blasts were conducted during the 2020 period, with results indicating:
• A total of two blasts registered a recording of between >5.0 - <10mm/sec.
• No blasts exceeded the 10mm/sec PPV limit.
• A total of 62 blasts registered less than 5mm/sec.
Based on the above, a total annual compliance of 97% was recorded for the 2020 reporting period.
Mining of F3 Pit was completed in 2020.</td></tr>
<tr><td>1054:M7-8</td><td>F3 Pit Wall Stability and Abandonment Bunding</td><td>Implement the Stability Monitoring Program required by condition 7-6.</td><td>Implement the Stability Monitoring Program</td><td>Geotechnical and geological mapping and data interpretation, slope stability monitoring results, vibration monitoring results</td><td>Construction, Operation</td><td>Ongoing during mining of the F3 Pit</td><td>CL</td><td>The Plan has continued to be implemented since commencement of F Deposit mining activity. Ongoing collection of geotechnical and mapping data has been confirmed by the independent re-assessment undertaken by Peter O'Bryan & Associates
See Attachment 8: F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates
Mining of F3 Pit was completed in 2020.</td></tr>
<tr><td>1054:M7-9</td><td>F3 Pit Wall Stability and Abandonment Bunding</td><td>Prepare and submit a Stability Monitoring Report in consultation with the DMP, and submit to the CEO with the Compliance Assessment Report required by condition 4-6.</td><td>Prepare and submit a Stability Monitoring Report in consultation with the DMP, and submit to the CEO</td><td>Stability Monitoring Report prepared in consultation with the DMP, and submitted to the CEO</td><td>Construction, Operation</td><td>30th April (annually) during mining of the F3 Pit</td><td>CL</td><td>Refer to section; Stability Conditions (p3) F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates
See Attachment 8: F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates
Mining of F3 Pit was completed in 2020.</td></tr>
<tr><td>1054:M7-10</td><td>F3 Pit Wall Stability and Abandonment Bunding</td><td>In the event that stability monitoring required by condition 7-7 and 7-8 and/or the report required by condition 7-9 indicates instability of the pit wall, the proponent shall immediately:
(1) investigate to determine the reason(s) for such findings;</td><td>Investigate pit wall instability findings, implement contingency actions</td><td>Investigate pit wall instability findings, implement contingency actions and report to CEO, if required</td><td>Construction, Operation</td><td>Ongoing during mining of the F3 Pit, if required, with reporting to</td><td>CL</td><td>In 2020, Peter O'Bryan & Associates were commissioned to undertake geotechnical re-assessment of the Yilgarn Operations. Assessment of the F3 pit wall identified that stability conditions are</td></tr>
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Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
		(2) implement contingency management actions and changes to proposal activities, on advice of the DMP; and (3) advise the CEO within seven (7) days.	and report to CEO, if required			the CEO within 7 days of instability being identified		generally good and meet the requirements of condition 7-8. Refer to section; *Stability Conditions* F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates See Attachment 8: F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates Mining of F3 Pit was completed in 2020.
1054:M7-11	**F3 Pit Wall Stability and Abandonment Bunding**	Post mining safety abandonment bunding and windrows to be installed at locations which ensure that the outcomes in condition 6-1 are met.	Design of abandonment bunding and/or windrows at each Mine Pit to not impact flora and vegetation beyond Proposal area	Design of abandonment bunding and windrows to not impact flora and vegetation beyond Proposal area	Operation, Decommissioning	During mining and post-mining of each Mine Pit.	NR	Abandonment bunding requirements and provisions are being progressively incorporated through mine closure planning and developed plans.
1054:M7-12	**F3 Pit Wall Stability and Abandonment Bunding**	Six (6) months prior to closure, the proponent shall prepare and submit an independent peer reviewed Close Out Report to the satisfaction of the CEO, on advice of the DMP, to demonstrate that condition 7-1 can be met. The Close Out Report is to be based on the analysis of Stability Monitoring Reports required by condition 7-9 and implementation of any contingency management actions and changes to proposal activities required by condition 7-10. In the event that the analysis indicates that condition 7-1 may not be met, identify additional contingency management actions and changes to proposal activities within the Close Out Report.	Prepare and submit an independent peer reviewed Close Out Report to the satisfaction of the CEO, on advice of the DMP	Close Out Report prepared and submitted to the satisfaction of the CEO, on advice of the DMP	Operation	6 months prior to mine closure	NR	
1054:M7-13	**F3 Pit Wall Stability and Abandonment Bunding**	The proponent shall implement any additional contingency management actions and changes to proposal activities identified in the Close Out Report required in condition 7-12, until the CEO has confirmed by notice in writing, satisfies the requirements of condition 7-1.	Implement actions or changes identified in the Close Out Report, if required	Actions or changes identified in the Close Out Report, if required, are implemented to the satisfaction of the CEO	Operation, Decommissioning	During mining and post-mining of the F3 Pit	NR	
1054:M8-1	**Stage 1 Offsets**	The proponent shall provide an offset to counterbalance the significant residual impact on *Tetratheca erubescens* as a result of implementation of Stage 1 of the proposal, as defined in Table 2 of Schedule 1 and delineated by coordinates in Schedule 2.	Provide an offset to counterbalance the effect to *Tetratheca erubescens* from Stage 1 mining in accordance with Condition 8-2	Provide an offset as outlined within the Stage 1 *Tetratheca erubescens* Offset Plan	Pre-construction	Prior to ground disturbing activities that impact *Tetratheca erubescens*	C	The *Koolyanobbing Range F Deposit, Stage 1* Tetratheca erubescens Offsets Plan, August 2017, (Revision 0) was approved on 16 August 2017 (Ref: AC05-2017-0006, DWERDA-003235). The *Koolyanobbing Range F Deposit, Stage 1* Tetratheca erubescens Offsets Plan, August 2017, (Revision 1) was submitted to DWER 07 September 2020 as per requirements of MS 1133 M8-2. See Audit Table 1133: M8-2 for additional information.
1054:M8-2	**Stage 1 Offsets**	Prior to commencement of any ground-disturbing activities that impact *Tetratheca erubescens*, or as unless otherwise agreed by the CEO, the proponent shall prepare and submit a Stage 1 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO on advice of Parks and Wildlife, as described in conditions 8-3 to the CEO. The objectives of the Stage 1 *Tetratheca erubescens* Offset Plan are to: (1) determine the methods to support translocation of *Tetratheca erubescens*; and (2) establish a new self-sustaining population of at least 313 mature individuals of *Tetratheca erubescens* on suitable landform that is suitable for the species.	Prepare and submit a Stage 1 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO	Stage 1 *Tetratheca erubescens* Offset Plan prepared and submitted to the satisfaction of the CEO	Pre-construction	Prior to ground disturbing activities that impact *Tetratheca erubescens*	DEL	The *Koolyanobbing Range F Deposit, Stage 1* Tetratheca erubescens Offsets Plan, August 2017, (Revision 0) was approved on 16 August 2017 (Ref: AC05-2017-0006, DWERDA-003235). Condition 8-2 of Ministerial Statement is deleted And replaced with Condition 8-2 of MS 1133. See Audit Table 1133: M8-2 for additional information.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
1054:M8-3	**Stage 1 Offsets**	The Stage 1 *Tetratheca erubescens* Offset Plan shall include, but not be limited to, the following: (1) develop a research program to identify methods to translocate and establish *Tetratheca erubescens* in the field. The outcomes of the research program are to be provided to the CEO and Parks and Wildlife; (2) detail the plant material to be used for translocation, to promote the viability of the species, on advice of Parks and Wildlife; (3) identify and map suitable translocation sites agreed to by Parks and Wildlife, and provide a scientifically robust analysis of the habitat requirements of the species; (4) identify the number of mature plants that each translocation site could support; (5) identify the area of translocation sites within which new plants will be established, in relation to the area of occupancy for the species impacted by implementation of the proposal; (6) describe the ongoing protection measures afforded to the translocated plants from threats including, but not limited to, fire, grazing and the proponent's future exploration and mining; (7) identify success criteria to demonstrate that the translocated plants have established, are in good health and reproducing, in consultation with Parks and Wildlife; (8) identify timeframes and responsibilities for implementation; (9) identify reporting procedures, including the content, format, timing and frequency for the reporting of monitoring data against the success criteria, in accordance with condition 8-3; (10) identify management and contingency measures should success criteria not be met, on advice of Parks and Wildlife; and (11) identify any ongoing management requirements for the translocation sites post completion of the plan.	Prepare and submit a Stage 1 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO	Stage 1 *Tetratheca erubescens* Offset Plan prepared and submitted to the satisfaction of the CEO	Pre-construction	Prior to ground disturbing activities	C	The *Koolyanobbing Range F Deposit, Stage 1* Tetratheca erubescens Offsets Plan, August 2017, (Revision 0) was approved on 16 August 2017 (Ref: AC05-2017-0006, DWERDA-003235). See Audit Table 1133: M8-2 for additional information. YILP are operating under 2017 Revision 0 Plan and will continue to do so until Revision 1 has received approval (the CEO has confirmed by notice in writing that the Plan satisfies the requirements of condition 8-4).
1054:M8-4	**Stage 1 Offsets**	After receiving notice in writing from the CEO that the Stage 1 *Tetratheca erubescens* Offset Plan satisfies the requirements of condition 8-3, prior to the commencement of ground disturbing activities that impact *Tetratheca erubescens*, unless otherwise agreed by the CEO, the proponent shall: (1) implement the Stage 1 *Tetratheca erubescens* Offset Plan; and (2) continue to implement the Stage 1 *Tetratheca erubescens* Offset Plan until the CEO, on advice of Parks and Wildlife, has confirmed by notice in writing that it has been demonstrated that the outcome in condition 8-1 has been met.	Implement the Stage 1 *Tetratheca erubescens* Offset Plan	Implement the Stage 1 *Tetratheca erubescens* Offset Plan	Construction, Operation, Decommissioning	Ongoing	C	The *Koolyanobbing Range F Deposit, Stage 1* Tetratheca erubescens *Offsets Plan,* August 2017, (Revision 0) was approved on 16 August 2017 (Ref: AC05-2017-0006, DWERDA-003235). YIPL will continue to implement this plan until it has met outcomes set out in condition 8.1 See Audit Table 1133: M8-2 for additional information. YILP are operating under 2017 Revision 0 Plan and will continue to do so until Revision 1 has received approval (the CEO has confirmed by notice in writing that the Plan satisfies the requirements of condition 8-4).
1054:M8-5	**Stage 1 Offsets**	The proponent shall monitor the success of implementation of the Stage 1 *Tetratheca erubescens* Offset Plan required by condition 8-2 and provide a written report, including monitoring data, to the CEO and Parks and Wildlife every twelve (12) months on the progress of this implementation of the Stage 1 *Tetratheca erubescens* Offset Plan until success criteria have been met. The	Monitor the outcomes of the Stage 1 *Tetratheca erubescens* Offset Plan and provide a written	Written report to the CEO and Parks and Wildlife	Construction, Operation, Decommissioning	Submit written report within 15 months of approval of the Stage 1 *Tetratheca erubescens* Offset	C	Cliffs and Botanic Gardens and Parks Authority have implemented the research and translocation trials as outlined in the Plan. YIPL has continued to implement this plan through its continued collaboration with Botanic Gardens and

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
		first report must be submitted within fifteen (15) months of receiving the notice under condition 8-4.	report to the CEO and Parks and Wildlife			Plan, then each 12 months after		Parks Authority. The Tetratheca erubescens Translocation Annual Research Report is submitted as evidence of implementation of this Plan and is in line with compliance reporting requirements. See Attachment 11 - Botanic Gardens and Parks Authority *Tetratheca erubescens Translocation Annual Research Report 2* (2021) (Revision O)
1054:M8-6	**Stage 1 Offsets**	Should the outcome of the Stage 1 *Tetratheca erubescens* Offset Plan required by condition 8-2 not be achieved within ten (10) years from the approval of the Stage 1 *Tetratheca erubescens* Offset Plan, the proponent shall submit a revised Stage 1 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO on advice of Parks and Wildlife, outlining management strategies to achieve the outcome specified in condition 8-2. The revised plan must be submitted within three months of the ten (10) year period lapsing.	Submit a revised Stage 1 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO, if required	Stage 1 *Tetratheca erubescens* Offset Plan submitted to the satisfaction of the CEO, if required	Construction, Operation, Decommissioning	Within 10 years after approval of the Stage 1 *Tetratheca erubescens* Offset Plan, if required	NR	
1054:M8-7	**Stage 1 Offsets**	The proponent: (1) may review and revise the Stage 1 *Tetratheca erubescens* Offset Plan, or (2) shall review and revise the Stage 1 *Tetratheca erubescens* Offset Plan as and when directed by the CEO.	Review and revise the Stage 1 *Tetratheca erubescens* Offset Plan, if required	Reviewed/revised Stage 1 *Tetratheca erubescens* Offset Plan submitted to the satisfaction of the CEO, if required	Construction, Operation, Decommissioning	Ongoing, as may be required	C	Revision 1 to the Plan was submitted to the CEO on 7th of September 2020. See Audit Table 1133: M8-2 for additional information.
1054:M8-8	**Stage 1 Offsets**	The proponent shall implement the latest revision of the Stage 1 *Tetratheca erubescens* Offset Plan, which the CEO, on advice of Parks and Wildlife, has confirmed by notice in writing, satisfies the requirements of condition 8-2.	Implement the Stage 1 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO	Stage 1 *Tetratheca erubescens* Offset Plan implemented to the satisfaction of the CEO	Construction, Operation, Decommissioning	Ongoing	C	The *Koolyanobbing Range F Deposit, Stage 1* Tetratheca erubescens Offsets Plan, August 2017, (Revision 0) was approved on 16 August 2017 (Ref: AC05-2017-0006, DWERDA-003235). YIPL has continued to implement the Plan. Revision 1 to the Plan was submitted to the CEO on 7th of September 2020. See Audit Table 1133: M8-2 for additional information.
1054:M9-1	**Access to Stage 2 Mining Area**	No ground disturbance may occur within the Stage 2 mining area as shown in Figure 3 in Schedule 1 and delineated by coordinates in Schedule 2 until: (1) the CEO on advice of Parks and Wildlife has confirmed by notice in writing that the proponent has demonstrated that the objectives in condition 8-2 have been met; and (2) the proponent has received notice in writing from the CEO that ground disturbance may occur within the Stage 2 mining area as shown in Figure 3 in Schedule 1 and delineated by coordinates in Schedule 2.	No ground disturbing activity within the Stage 2 mining area until Condition 8-2 has been met and the CEO has provided written notice that ground disturbance may occur	No ground disturbing activity within the Stage 2 mining area until Condition 8-2 has been met and the CEO has provided written notice that ground disturbance may occur	Construction, Operation	Ongoing	DEL	Condition 9-1 of Ministerial Statement is deleted as per MS 1133.
1054:M10-1	**Stage 2 Offsets**	The proponent shall provide an offset to counterbalance the significant residual impact on *Tetratheca erubescens* as a result of implementation of Stage 2 of the proposal, as defined by Table 3 in Schedule 1 and delineated by coordinates in Schedule 2.	Provide an offset to counterbalance the effect to *Tetratheca erubescens* from Stage 2 mining in accordance with Condition 10-2	Provide an offset as outlined within the Stage 2 *Tetratheca erubescens* Offset Plan	Pre-construction (of Stage 2 mining area)	Prior to ground disturbing activities that impact *Tetratheca erubescens* within the Stage 2 mining area	C	YIPL submitted the *Koolyanobbing Range F Deposit, Stage 2* Tetratheca erubescens Offsets Plan to the CEO on the 7th of September 2020.
1054:M10-2	**Stage 2 Offsets**	Prior to commencement of any ground-disturbing activities within the Stage 2 mining area as shown in Figure 3 in Schedule 1, the proponent shall prepare and submit a Stage 2 *Tetratheca erubescens* Offset Plan, using the research and findings from the Stage 1 *Tetratheca erubescens* Offset Plan required under	Prepare and submit a Stage 2 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO	Stage 2 *Tetratheca erubescens* Offset Plan prepared and submitted to the satisfaction of the CEO	Pre-construction (of Stage 2 mining area)	Prior to ground disturbing activities that impact *Tetratheca erubescens* within	DEL	Condition 10-2 of Ministerial Statement is deleted And replaced with Condition 10-2 of MS 1133. See Audit Table 1133: M10-2 for additional information.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
		condition 8-2, to the satisfaction of the CEO on advice of Parks and Wildlife, as described in condition 10-3 to the CEO. The objective of the Stage 2 *Tetratheca erubescens* Offset Plan as defined in Table 3 in Schedule 2 is to: (1) establish a new self-sustaining population of at least 652 mature individuals of *Tetratheca erubescens* on landform that is suitable for the species.				the Stage 2 mining area		YIPL is developing a Stage 2 Offsets plan in conjunction with Strategen.
1054:M10-3	**Stage 2 Offsets**	The Stage 2 *Tetratheca erubescens* Offset Plan shall specify the research and management actions to be undertaken to ensure the outcomes specified in condition 10-2 are met. The Stage 2 *Tetratheca erubescens* Offset Plan Shall include, but not be limited to, the following: (1) build on the research and findings from the Stage 1 *Tetratheca erubescens* Offset Plan; (2) detail the plant material to be used for translocation, to promote the viability of the species, on advice of Parks and Wildlife; (3) identify suitable translocation sites approved by the CEO on advice of Parks and Wildlife, and provide a scientifically robust analysis of the habitat requirements of the species; (4) identify the number of mature plants that each translocation site could support; (5) identify the area of translocation sites within which new plants will be established, in relation to the area of occupancy for the species impacted by implementation of the proposal; (6) describe the ongoing protection measures afforded to the translocated plants from threats including, but not limited to, fire, grazing and the proponent's future exploration and mining; (7) identify success criteria to demonstrate that the translocated plants have established, are in good health and reproducing, in consultation with Parks and Wildlife; (8) identify timeframes and responsibilities for implementation; (9) identify reporting procedures, including the content, format, timing and frequency for the reporting of monitoring data against the success criteria, in accordance with condition 10-3; (10) identify management and contingency measures should success criteria not be met, on advice of Parks and Wildlife; and (11) identify arrangements for the translocation sites post completion of the plan.	Prepare and submit a Stage 2 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO	Stage 2 *Tetratheca erubescens* Offset Plan prepared and submitted to the satisfaction of the CEO	Pre-construction (of Stage 2 mining area)	Prior to ground disturbing activities that impact *Tetratheca erubescens* within the Stage 2 mining area	C	YIPL submitted the *Koolyanobbing Range F Deposit, Stage 2* Tetratheca erubescens Offsets Plan to the CEO on the 7th of September 2020. YIPL is developing a Stage 2 Offsets plan in conjunction with Kings Park Science, Department of Biodiversity, Conservation and Attractions & Strategen.
1054:M10-4	**Stage 2 Offsets**	After receiving notice in writing from the CEO that the Stage 2 *Tetratheca erubescens* Offset Plan satisfies the requirements of condition 10-3, the proponent shall: (1) implement the research and management actions in accordance with the requirements of the Stage 2 *Tetratheca erubescens* Offset Plan; and (2) continue to implement the research and management actions in accordance with the requirements of the Stage 2 *Tetratheca erubescens* Offset Plan until the CEO on advice of Parks and Wildlife has confirmed by notice in writing that it has been demonstrated that the objective in condition 10-2 has been met.	Implement the Stage 2 *Tetratheca erubescens* Offset Plan	Implement the Stage 2 *Tetratheca erubescens* Offset Plan	Construction, Operation, Decommissioning	Ongoing	NR	Notice in writing from the CEO that the Stage 2 Tetratheca erubescens Offset Plan satisfies the requirements of condition 10-3, has not been granted.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
1054:M10-5	**Stage 2 Offsets**	The proponent shall monitor the success of implementation of the Stage 2 *Tetratheca erubescens* Offset Plan required by condition 10-2 and provide a written report, including monitoring data, to the CEO and Parks and Wildlife every twelve (12) months on the progress of this project until success criteria have been met. The first report must be submitted within fifteen (15) months of receiving the notice under condition 10-4.	Monitor the outcomes of the Stage 2 *Tetratheca erubescens* Offset Plan and provide a written report to the CEO and Parks and Wildlife	Written report to the CEO and Parks and Wildlife	Construction, Operation, Decommissioning	Submit written report within 15 months of approval of the Stage 2 *Tetratheca erubescens* Offset Plan, then each 12 months after	NR	Notice in writing from the CEO that the Stage 2 Tetratheca erubescens Offset Plan satisfies the requirements of condition 10-3, has not been granted
1054:M10-6	**Stage 2 Offsets**	Should the outcome of the Stage 2 *Tetratheca erubescens* Offset Plan required by condition 10-2 not be achieved within ten (10) years from implementation of the Plan, the proponent shall submit a revised Stage 2 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO on advice of Parks and Wildlife, outlining management strategies to achieve the outcome specified in condition 10-2. The revised plan must be submitted within three months of the ten (10) year period lapsing.	Submit a revised Stage 2 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO, if required	Stage 2 *Tetratheca erubescens* Offset Plan submitted to the satisfaction of the CEO, if required	Construction, Operation, Decommissioning	Within 10 years after approval of the Stage 2 *Tetratheca erubescens* Offset Plan, if required	NR	Notice in writing from the CEO that the Stage 2 Tetratheca erubescens Offset Plan satisfies the requirements of condition 10-3, has not been granted
1054:M10-7	**Stage 2 Offsets**	The proponent: (1) may review and revise the Stage 2 *Tetratheca erubescens* Offset Plan, or (2) shall review and revise the Stage 2 *Tetratheca erubescens* Offset Plan as and when directed by the CEO.	Review and revise the Stage 2 *Tetratheca erubescens* Offset Plan, if required	Reviewed/revised Stage 2 *Tetratheca erubescens* Offset Plan submitted to the satisfaction of the CEO, if required	Construction, Operation, Decommissioning	Ongoing, as may be required	NR	Notice in writing from the CEO that the Stage 2 Tetratheca erubescens Offset Plan satisfies the requirements of condition 10-3, has not been granted
1054:M10-8	**Stage 2 Offsets**	The proponent shall implement the latest revision of the Stage 2 *Tetratheca erubescens* Offset Plan, which the CEO, on advice of Parks and Wildlife, has confirmed by notice in writing, satisfies the requirements of condition 10-3.	Implement the Stage 2 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO	Stage 2 *Tetratheca erubescens* Offset Plan implemented to the satisfaction of the CEO	Construction, Operation, Decommissioning	Ongoing	NR	Notice in writing from the CEO that the Stage 2 Tetratheca erubescens Offset Plan satisfies the requirements of condition 10-3, has not been granted
1054:M11-1	**Staging of Plans**	Where a plan, program, report, survey, strategy or other document is required by these conditions to be prepared, submitted or endorsed by the CEO, prior to commencement of an activity, the plan, program, report, survey, strategy or other document may be prepared, submitted and endorsed by the CEO as per the relevant condition requirements, for a component of, or stage of the proposal or activity, provided the implementation of that component or stage of the proposal does not make the condition obsolete insofar as it applies to the remaining components or stages of the proposal or activity.	Prepare and submit documentation in a component/staged approach as may be required	Prepare and submit documentation in a component/staged approach as may be required	Pre-construction, Construction, Operation, Decommissioning	Ongoing, as may be required	C	Relevant plans and documentation have been prepared and submitted for approval in a component/ staged approach as outlined below. The *Geotechnical Management Plan: F Pit Development* was submitted to OEPA February 2017. The *Koolyanobbing Range F Deposit, Stage 1* Tetratheca erubescens Offsets Plan, August 2017, (Revision 0) was approved on 16 August 2017 (Ref: AC05-2017-0006, DWERDA-003235). The *Koolyanobbing Range F Deposit, Stage 1* Tetratheca erubescens *Offsets Plan,* August 2017 (Revision 1) was submitted to DWER September 2020. The *Koolyanobbing Range F Deposit, Stage 2* Tetratheca erubescens *Offsets Plan,* (Revision 1) was submitted to DWER September 2020. The *Koolyanobbing Range F Deposit, Flora and Vegetation Management Plan,* (Revision 1) was submitted to DWER September 2020 The development, submission and implementation of these plans prior to commencement of any proposal component as required by the conditions of MS 1054 has rendered existing conditions 6-1, 8-2, 9-1 & 10-2 obsolete insofar as they apply to the remaining components or stages of the proposal.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
								These have been deleted and amended under MS 1133. See Audit Table 1133 for more information.
1054:M11-2	**Staging of Plans**	Condition 11-1 does not apply to conditions relating to the submission of environmental baseline surveys or environmental baseline reports.	Prepare and submit documentation in a component/staged approach, as may be required	Prepare and submit documentation in a component/staged approach, as may be required	Pre-construction, Construction, Operation, Decommissioning	Ongoing, as may be required	C	Relevant plans and documentation have been prepared and submitted for approval in a component/ staged approach.

Attachment 3: Assessment of Compliance MS1133 Audit Table

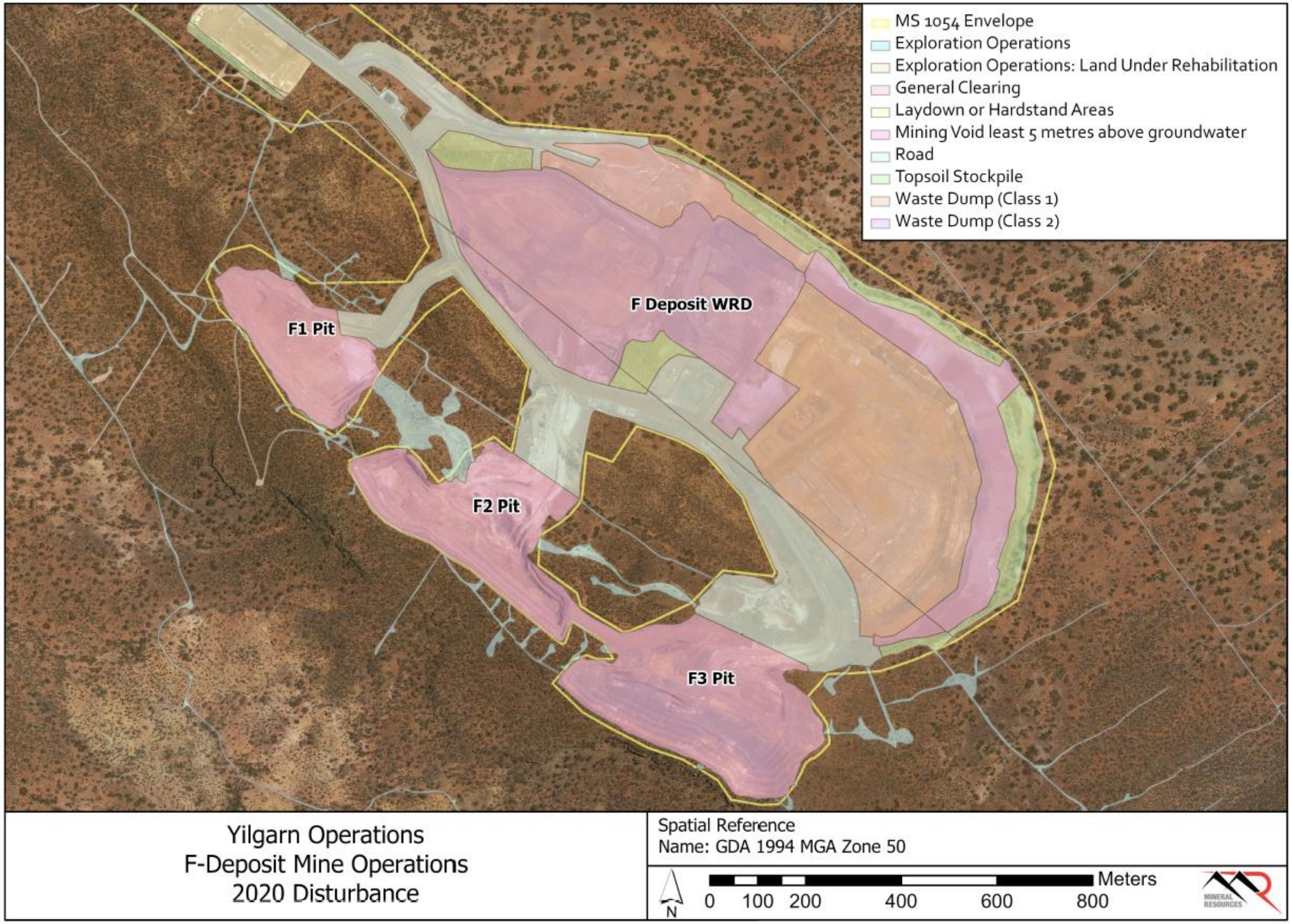
Yilgarn Operations – Koolyanobbing Range F Deposit (Statement 1054)

- Phases that apply in this table = Pre-Construction, Construction, Operation, Decommissioning, Overall (several phases).
- The Audit Table provides a summary interpretation of the condition requirements applying to the Proposal under the *Environmental Protection Act 1986* (WA). Please refer to the Statement approval issued for the Proposal for the agreed condition wording and abbreviations.
- Status: C = Compliant; CLD = Completed; DEL = Deleted; NC = Non – compliant; NR = Not Required at this stage; NA = Not Audited; VR = Verification Required; IP = In Process.

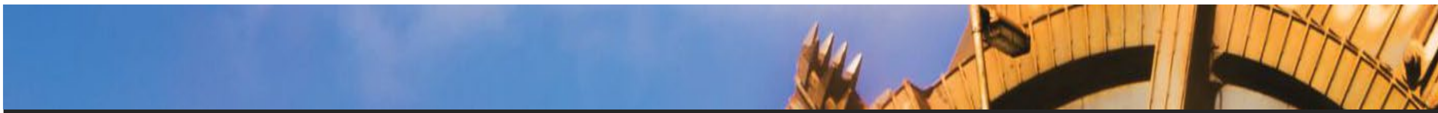
Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
1133:M6-1	**Flora and Vegetation Management**	Within three months of any ground disturbing activities within the Stage 2 mining area as shown in Figure 3 in Schedule 1 of Ministerial Statement 1054, the proponent shall update and submit a revised Condition Environmental Management Plan to the satisfaction of the CEO, on advice of the Department of Biodiversity, Conservation and Attractions, to demonstrate that the following environmental outcomes will be met: (1) No adverse effects on priority flora and vegetation outside the Stage 1 and 2 development envelopes attributable to the implementation of the proposal; (2) No adverse effects on greater than 261 *Tetratheca erubescens* plants attributable to the implementation of Stage 1; and (3) No adverse effects on greater than 652 *Tetratheca erubescens* plants attributable to the implementation of Stage 2.	Prepare and submit a revised Condition Environmental Management Plan (Flora and Vegetation Management Plan) to the satisfaction of the CEO	Preparation and submission of a Condition Environmental Management Plan (Flora and Vegetation Management Plan) to the satisfaction of the CEO	Construction	Within three months of any ground disturbing activities of the Stage 2 area	CLD	Ground disturbing activities commenced in June 2020. The *Koolyanobbing Range F Deposit, Flora and Vegetation Management Plan,* (Revision 1) was submitted to DWER September 2020.
1133:M8-2	**Stage 1 Offsets**	Within three months of any ground disturbing activities within the Stage 2 mining area as shown in Figure 3 in Schedule 1 of Ministerial Statement 1054, the proponent shall update and submit a revised Stage 1 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO on advice of Department of Biodiversity, Conservation and Attractions, as described in conditions 8-3 to the CEO. The objectives of the Stage 1 *Tetratheca erubescens* Offset Plan are to: (1) determine the methods to support translocation of *Tetratheca erubescens*; and (2) ensure a self-sustaining population of mature individuals of *Tetratheca erubescens* equivalent to those that have been impacted through implementation of Stage 1 on a landform that is suitable for the species.	Prepare and submit a revised Stage 1 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO	Stage 1 *Tetratheca erubescens* Offset Plan prepared and submitted to the satisfaction of the CEO	Pre-construction	Within three months of any ground disturbing activities of the Stage 2 area	CLD	Ground disturbing activities commenced in June 2020. The *Stage 1 Tetratheca erubescens Offset Plan,* (Revision 1) was submitted to DWER September 2020.
1133:M10-2	**Stage 2 Offsets**	Within three months of any ground disturbing activities within the Stage 2 mining area as shown in Figure 3 in Schedule 1 of Ministerial Statement 1054, the proponent shall update and submit a revised Stage 2 *Tetratheca erubescens* Offset Plan, using the research and findings from the Stage 1 *Tetratheca erubescens* Offset Plan required under condition 8-2, to the satisfaction of the CEO on advice of Department of Biodiversity, Conservation and Attractions, as described in condition 10-3 to the CEO. The objective of the Stage 2 *Tetratheca erubescens* Offset Plan as defined in Table 3 in Schedule 2 is to: (1) ensure a self-sustaining population of mature individuals of *Tetratheca erubescens* equivalent to those that have been impacted through implementation of Stage 2 on a landform that is suitable for the species.	Prepare and submit a Stage 2 *Tetratheca erubescens* Offset Plan to the satisfaction of the CEO	Stage 2 *Tetratheca erubescens* Offset Plan prepared and submitted to the satisfaction of the CEO	Pre-construction (of Stage 2 mining area)	Within three months of any ground disturbing activities of the Stage 2 area	CLD	Ground disturbing activities commenced in June 2020. The *Stage 2 Tetratheca erubescens Offset Plan,* (Revision 0) was submitted to DWER September 2020.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
1133:M12-1	**Offsets**	The proponent shall fund and undertake an offset for *Tetratheca erubescens* with the objective to maintain and protect the species from external threats as far as practicable. The amount of funding required shall be a minimum contribution of $500,000	Fund and undertake an offset for *Tetratheca erubescens*	ACAR Monitoring and Research Reports Invoices	Operation, Decommissioning	Ongoing, as may be required	NR	On approval of the *Tetratheca erubescens* Conservation Plan, funding can be released for the Monitoring and Research Projects
1133:M12-2	**Offsets**	Within twelve (12) months of the date of this Statement, or as otherwise agreed in writing by the CEO, the proponent shall prepare and submit to the CEO a *Tetratheca erubescens* Conservation Plan, for the offset required by condition 12-1, which identifies on-ground conservation projects and research project to be undertaken that contribute to long-term conservation outcomes for the species. The plan shall be to the satisfaction of the CEO on advice from the Department of Biodiversity, Conservation and Attractions.	Prepare and submit a *Tetratheca erubescens* Conservation Plan to the satisfaction of the CEO	*Tetratheca erubescens* Conservation Plan prepared and submitted to the satisfaction of the CEO	Operation, Decommissioning	Within twelve (12) months of the date of this Statement	NR	The *Tetratheca erubescens* Conservation Plan is to be submitted to the CEO by 06th of May 2021. YIPL is developing *Tetratheca erubescens* Conservation Plan in conjunction with Kings Park Science, Department of Biodiversity, Conservation and Attractions & Strategen.
1133:M12-3	**Offsets**	The *Tetratheca erubescens* Conservation Plan shall include, but not be limited to: (1) details on how the proposed on-ground conservation projects contribute to a long-term conservation outcome for *Tetratheca erubescens;* (2) details on how the proposed research projects contribute to a long-term conservation outcome for *Tetratheca erubescens* and more broadly to *Tetratheca* species in the Yilgarn region; (3) an outline of the agreed governance arrangements – including agreed stakeholder responsibilities for implementing the projects, and any contractual arrangements for third parties involved and legal obligations; and (4) details of the financial and financial auditing arrangements including project budget and recipients of funds if projects are being undertaken by any third parties.	Prepare and submit a *Tetratheca erubescens* Conservation Plan to the satisfaction of the CEO	*Tetratheca erubescens* Conservation Plan prepared and submitted to the satisfaction of the CEO	Operation, Decommissioning	Ongoing, as may be required	NR	YIPL is developing *Tetratheca erubescens* Conservation Plan in conjunction with Kings Park Science, Department of Biodiversity, Conservation and Attractions & Strategen.
1133:M12-4	**Offsets**	Within six (6) months of receiving notice in writing from the CEO that the *Tetratheca erubescens* Conservation Plan satisfies the requirements of conditions 12-1 to 12-3, the proponent shall commence the implementation of the conservation plan.	Implement *Tetratheca erubescens* Conservation Plan to the satisfaction of the CEO	*Tetratheca erubescens* Conservation Plan prepared and submitted to the satisfaction of the CEO. ACAR	Operation, Decommissioning	Ongoing, as may be required	NR	The *Tetratheca erubescens* Conservation Plan is to be submitted to the CEO by 06th of May 2021. YIPL is developing *Tetratheca erubescens* Conservation Plan in conjunction with Kings Park Science, Department of Biodiversity, Conservation and Attractions & Strategen.
1133:M12-5	**Offsets**	Any changes to the *Tetratheca erubescens* Conservation Plan must be approved by the CEO in writing.	Revisions of the *Tetratheca erubescens* Conservation Plan submitted to the CEO	Revisions of the *Tetratheca erubescens* Conservation Plan submitted to the CEO	Operation, Decommissioning	Ongoing, as may be required	NR	YIPL is developing revision 0 *Tetratheca erubescens* Conservation Plan in conjunction with Kings Park Science, Department of Biodiversity, Conservation and Attractions & Strategen.
1133:M12-6	**Offsets**	The proponent shall implement the latest revision of the *Tetratheca erubescens* Conservation Plan which the CEO has confirmed by notice in writing satisfies the requirements of conditions 12-1 to 12-3.	Implement approved revision of the *Tetratheca erubescens* Conservation Plan to the satisfaction of the CEO	Revisions of the *Tetratheca erubescens* Conservation Plan submitted to the CEO ACAR	Operation, Decommissioning	Ongoing, as may be required	NR	YIPL is developing revision 0 *Tetratheca erubescens* Conservation Plan in conjunction with Kings Park Science, Department of Biodiversity, Conservation and Attractions & Strategen.

Attachment 4: Yilgarn Operations Koolyanobbing Range Mine Operations 2020 Clearing



Attachment 5: MRL (2020) Yilgarn Iron Ore Project *Tetratheca erubescens* Two Monthly Monitoring Summary Report 2020 (Revision 0)



Yilgarn Iron Ore Project

Tetratheca erubescens TWO MONTHLY MONITORING SUMMARY REPORT 2020

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Report Reference: ENV-TS-RP-0281

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1 Introduction

In 2018 Mineral Resources Limited (MRL) acquired Cliffs Asia Pacific Iron Ore Pty Ltd.'s (Cliffs) Yilgarn Operations. This includes the mining of iron ore from open cut mines at the Koolyanobbing Range, Mt Jackson Range, Windarling Range and Deception, ore processing at Koolyanobbing, road and rail transport between these operations and the Port of Esperance where the processed ore is exported to international customers.

Tetratheca erubescens is a small shrub declared as threatened under the *Wildlife Conservation Act 1950* (WA) and only recorded at the southern Koolyanobbing Range. A census in 2013 estimated the population of *T. erubescens* within the Koolyanobbing Range at approximately 6,333 (6,202 live) individuals (Maia 2013). The current recorded distribution of *T. erubescens* is identified in **Figure 2.1**.

In January 2017, Cliffs received approval under the *Environmental Protection Act 1986* to implement the F deposit mine proposal (Minister for the Environment and Heritage 2017). Under this approval, Cliffs were required to develop and implement a Condition Environmental Management Plan, named the *F Deposit Flora and Vegetation Management Plan Revision 0* (FVMP) to the satisfaction of the CEO. This document was approved by the CEO in June 2017 (Cliffs 2017).

In February 2020 the Department of Water and Environmental Regulation approved Revision 1 of the FVMP. This was a re-branding of the plan into MRL templates. Approval for development of Koolyanobbing's F1 Pit was granted in 2020 under Ministerial Statement 1133. This triggered the requirement to update the FVMP. On the 25th of March 2021 Revision 2 of the FVMP was approved, bringing the plan in line with the requirements of Ministerial Statement 1133.

MRL continues to the implement the approved FVMP which includes a monitoring programme developed to assess the stability and condition of the *Tetratheca erubescens* population at defined monitoring plots along the southern Koolyanobbing Range.

The F Deposit Flora and Vegetation Management Plan outlines provisions to address indirect impacts on native flora and vegetation (including *Tetratheca erubescens*) including, but not limited to, dust, weeds and fire. The plan identifies trigger and threshold criteria that when exceeded will initiate the implementation of management actions to address any potential impacts on the population.

The FVMP states that for *Tetratheca erubescens*, the trigger criterion will be met when "Monitoring indicates a statistically significant relationship between condition (Index of Chlorophyll Fluorescence (ICF) and/or % live material) and dust deposition, distance from the proposal boundary or mine-related factor."

The threshold criteria for *Tetratheca erubescens* include:

- Monitoring of *Tetratheca erubescens* indicates a statistically significant relationship between mortality and dust deposition, distance from the proposal boundary or mine-related causal factor.
- Monitoring of *Tetratheca erubescens* indicates a statistically significant relationship between condition (ICF and/or % live material) and dust deposition, distance from the proposal boundary or mine-related causal factor for two consecutive two-monthly monitoring dates in year 1 or two consecutive quarterly monitoring dates in year 2.

- For dust deposition, the trigger criterion is "Dust deposition at any (non-reference) dust monitoring site exceeds 80g/m2/month (Sa) during the first 12 months from commencement of mining; 40g/m2/month (Sa) after 12 months from commencement of mining." There is no threshold criterion for dust deposition.

This report documents and discusses the results of monitoring from January to November 2020 and against data from monitoring that was conducted prior to ground disturbing activities in the F-Deposit area. The statistical tool is then used to compare these results against the trigger and threshold criteria.

2 Methodology

2.1 Monitoring Design

Cliffs, in consultation with the then Department of Parks and Wildlife (DPaW), Office of the Environmental Protection Authority (OEPA) and Data Analysis Australia (DAA), designed a monitoring program to identify any adverse effects to the *Tetratheca erubescens* population as a result of mining activities (including dust deposition).

2.2 Initial Monitoring

In October 2016, 15 *Tetratheca erubescens* individuals were randomly selected for monitoring in each of the 11 monitoring plots. Each plant was tagged with a unique identification number. The identification number was glued onto the rock surface as close as possible to the *T. erubescens* individual. The following information was recorded for each individual:

- Plot number
- Unique plant identification number
- Presence of flowers/fruits/buds
- Presence of soft tips (indicating new growth)
- Plant Status (Reproductive, Vegetative, Juvenile (1-3years old) or Seedling (<1-year-old)
- Condition Assessment (percentage of plant alive)
- Percentage of plant with dust (grouped into categories as shown in Table 2.1

Table 2.1: Dust categories and their description

Dust Category	Description
0	No visible dust
1	1-25% of plant covered with dust
2	25-50% of plant covered with dust
3	51-75% of plant covered with dust
4	76-100% of plant covered with dust

In November 2016, an additional plot (plot 26) including 15 *Tetratheca erubescens* individuals was added to the monitoring program. During the November 2016 monitoring, chlorophyll fluorescence (Fv/Fm) was also added as a monitoring parameter. Each individual had an index of chlorophyll fluorescence measurement taken using a plant efficiency analyser (pocket PEA) unit. Using information gained from fluorescence measurements, samples may be screened effectively for particular types of stress factors which limit the photosynthetic performance of the sample (Hansatech 2006). A clip was attached to a live stem of each *Tetratheca erubescens* individual, with the stem subsequently dark adapted. An index of chlorophyll fluorescence was then measured with the PEA unit and recorded on the data sheet.

A further plot (plot 13) including 15 *Tetratheca erubescens* individuals was included in the monitoring program from December 2016. Monitoring was conducted monthly from December 2016 to March 2017. Additional *Tetratheca erubescens* individuals were included in monitoring plots 7, 9, 11, 13 and 14 during May 2017.

Monitoring of Plot 26 ceased in July 2020 due to the plot being located under the F1 Pit footprint.

2.3 Current Monitoring

Since May 2017, a total of 251 individuals have been monitored on a two-monthly basis using the following parameters:

- Presence of flowers/fruits/buds
- Presence of soft tips (indicating new growth)
- Plant Status (Reproductive, Vegetative, Juvenile (1-3years old) or Seedling (<1-year-old)
- Condition Assessment (percentage of plant alive)
- Chlorophyll Fluorescence value (Fv/Fm)
- Percentage of plant with dust (grouped into categories as shown in **Table 2.1**)

Table 2.2 shows the number of individuals monitored per plot and their distance from the mine pit boundary, whilst the location of each monitoring plot in relation to F pit is shown in **Figure 2.1**.

The results from May 2017, therefore represent the first complete monitoring dataset and can be assumed to be natural results (as mining was commencing at the same time and indirect effects would not yet have occurred).

Table 2.2: Number of individuals monitored per plot and their distance from mine boundary

Distance from boundary	Plot Number													Total
	3	5	7	9	10	11	13	14	16	18	21	25	26	
<20m			19	13		14	21	15						82
20-50m			6	12		13	6	12						49
>50m	15	15			15				15	15	15	15	15	120
Plot totals	**15**	**15**	**25**	**25**	**15**	**27**	**27**	**27**	**15**	**15**	**15**	**15**	**15**	**251**

2.3.1 Dust Deposition Gauge Monitoring

Dust deposition gauges have been established at each monitoring plot and two control locations at F Deposit, as shown in **Figure 2.2**

2.3.2 Statistical Analysis

Data Analysis Australia (DAA) was engaged to design data analysis tools to test for significant changes in chlorophyll fluorescence, condition assessment and mortality for *Tetratheca erubescens.* The tool was finalised in January 2018 in accordance with the parameters outlined in the F Deposit Flora and Vegetation Management Plan (MRL 2020) to enable routine analysis of the monitoring data after each monitoring event.

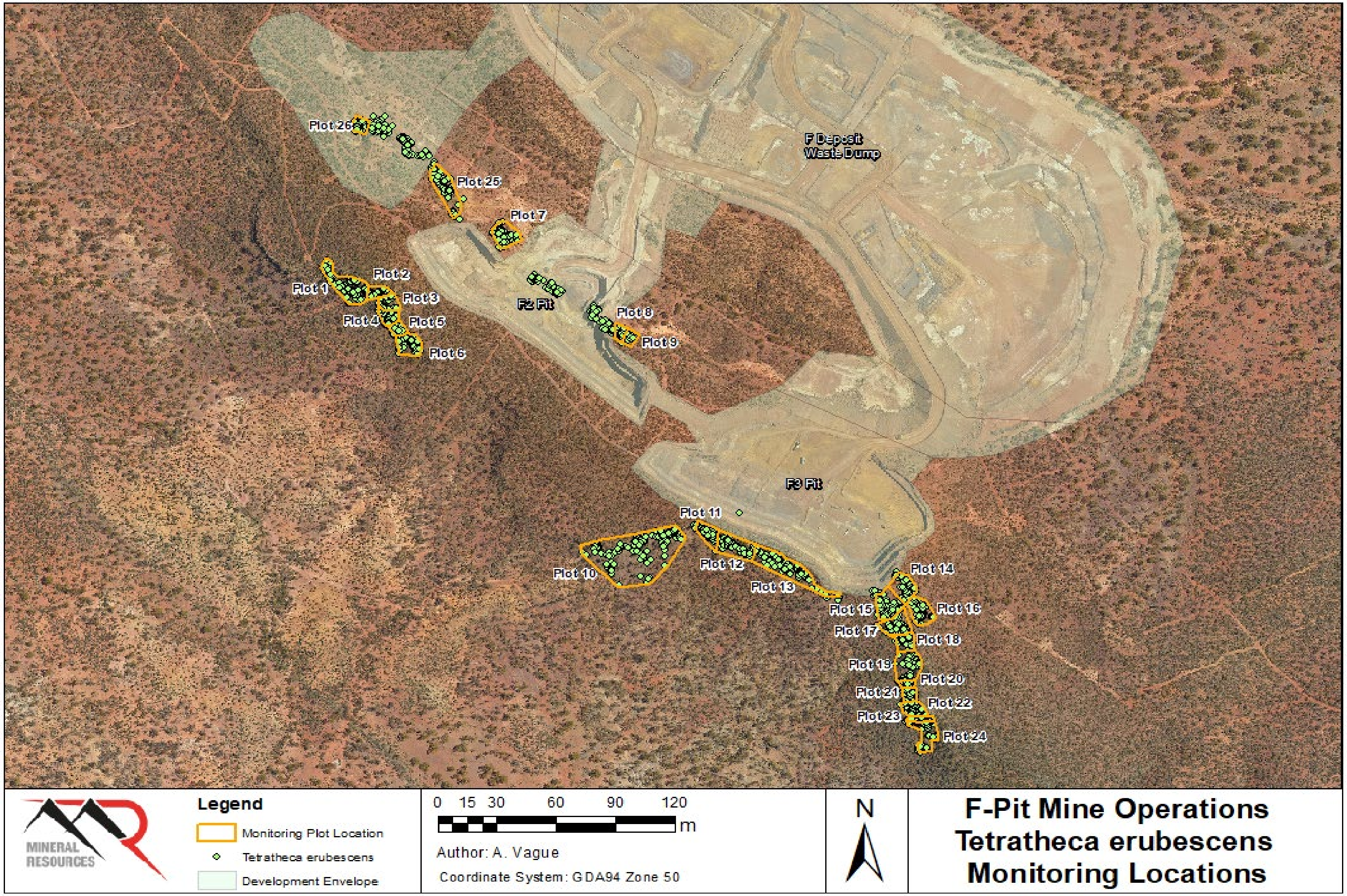


Figure 2.1: Location of Tetratheca erubescens and monitoring plots at Koolyanobbing. (The monitored plots are highlighted in orange.)

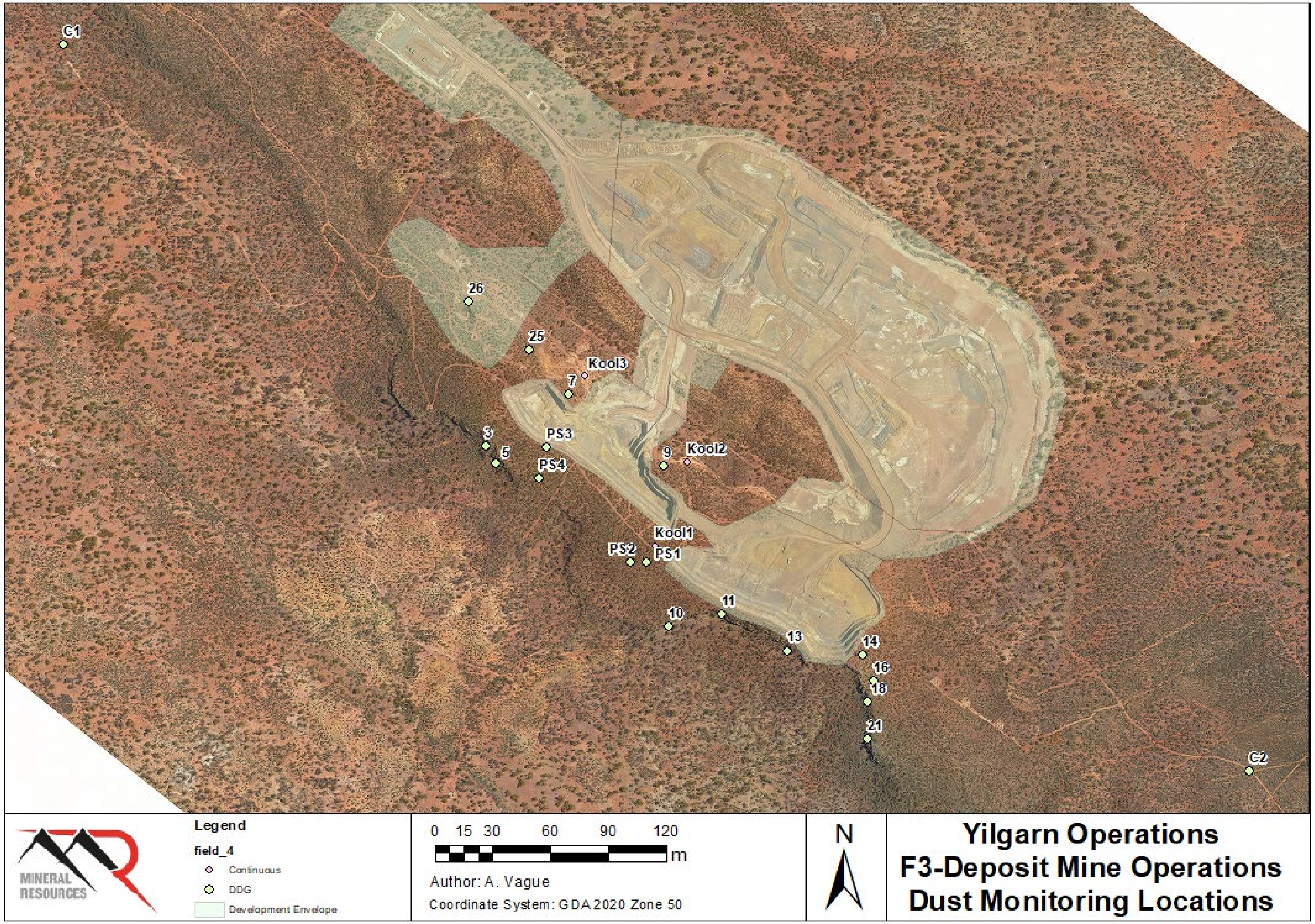


Figure 2.2 : Location of Dust Deposition Gauges

3 Results

January 2017 data has been used as a baseline as it would likely represent the lowest health/most stressed data available prior to commencement of mining (and therefore natural results).

3.1 Rainfall

The total monthly rainfall recorded at Koolyanobbing during 2018, 2019 and 2020 is shown in **Figure 3.1**, along with the long term average monthly rainfall (BoM 2020). A total of 274.7mm of rain fell in 2020 with a majority of this recorded during the summer months (35% of the annual total fell in February). In comparison, the 2019 reporting period recorded 212.5mm with a considerable reduction in summer rain with January and February receiving 4.4mm and 26.6mm respectively (BoM 2020). During 2020 below average rainfall was also recorded for the months of January, March, April, May, June, September, October and November.

In contrast, only an additional 62.3mm was recorded in 2020 (274.7mm) when compared to 2019 (212.5mm). 2020 also only received 12.4mm above the long term annual average. The months of February, August and November had the only above average monthly rainfalls (for the monitoring period) with 35% for February, 14% for August and 19% for November of the annual total. All other months had below average rainfall (**Figure 3.1**) (June was 0.1mm below).

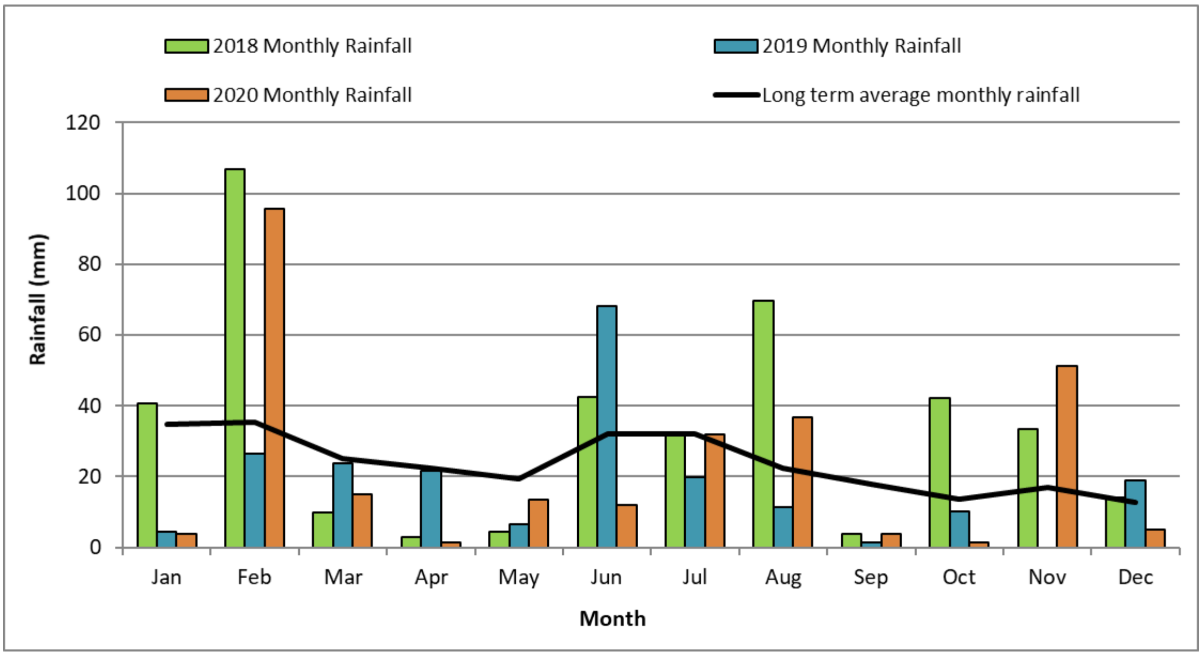


Figure 3.1: Monthly rainfall recorded at Koolyanobbing during 2018, 2019 and 2020 as well as the long term monthly average rainfall.

The total rainfall recorded in the two months prior to each monitoring event is shown in Table 3.1, along with the average maximum temperature during monitoring.

Table 3.1: Rainfall and average maximum temperatures recorded in the two months prior to each monitoring event during the 2020 monitoring.

Monitoring Dates	Rainfall recorded prior to monitoring (mm)	Average maximum temperature on monitoring dates (°C)
07 - 08 January 2020	22.6	42.5
14 - 16 March 2020	110.5	27.3
23 - 24 May 2020	15.0	21.2
19 - 21 July 2020	43.8	16.4
15 - 16 September 2020	44.1	29.8
13 -14 November 2020	52.5	25.4

3.2 Tetratheca erubescens

3.2.1 Reproductive Status

Figure 3.2 presents the percentage of plants that were reproductive per plot and distance from mining operations for each monitoring period. The September monitoring recorded the highest percentage of individuals reproductive, with a range between 68.4 (Plot 7, <20m from mining) and 100% (multiple plots), whilst in May the lowest percentage was scored, with a range between 0% (Plot 7, 20 - 50m from mining) and 53.3% (multiple plots) reproductive.

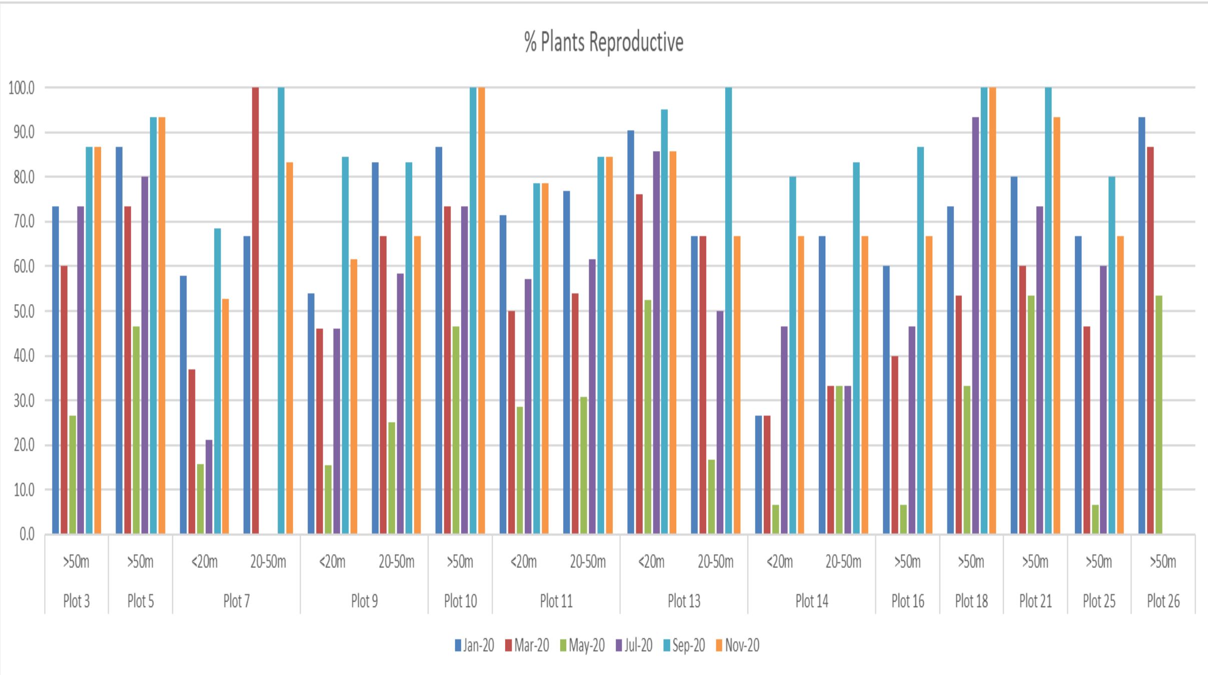


Figure 3.2: Percentage of plants reproductive per plot and monitoring event.

3.2.2 Condition Assessment

Figure 3.3 presents the average condition assessment (percentage of plant alive) per plot and distance from mining operations for each monitoring period. Average condition assessment varied between plots and between monitoring periods. The January 2020 monitoring found average condition ranged between 32.5% (Plot 7, 20-50m) and 54.3% (Plot 26, >50m before it was consumed by the development of F1 pit), whilst the November monitoring identified a range of 39.4% (Plot 7, <20m) to 65.7% (Plot 11, <20m). For the entire monitored population, average condition assessment was lowest during January (41.5%) and highest during March (55.5%). Condition Assessment results (± standard deviation) are also shown in table form in Appendix 1 Tabular results of chlorophyll fluorescence and average condition assessment ± standard deviation.

When direct comparison to 2019 average condition assessment there was an increase in the 2020 results. The 2020 monitoring period observed an average condition assessment of 50.7% while 2019 averaged 49.3%.

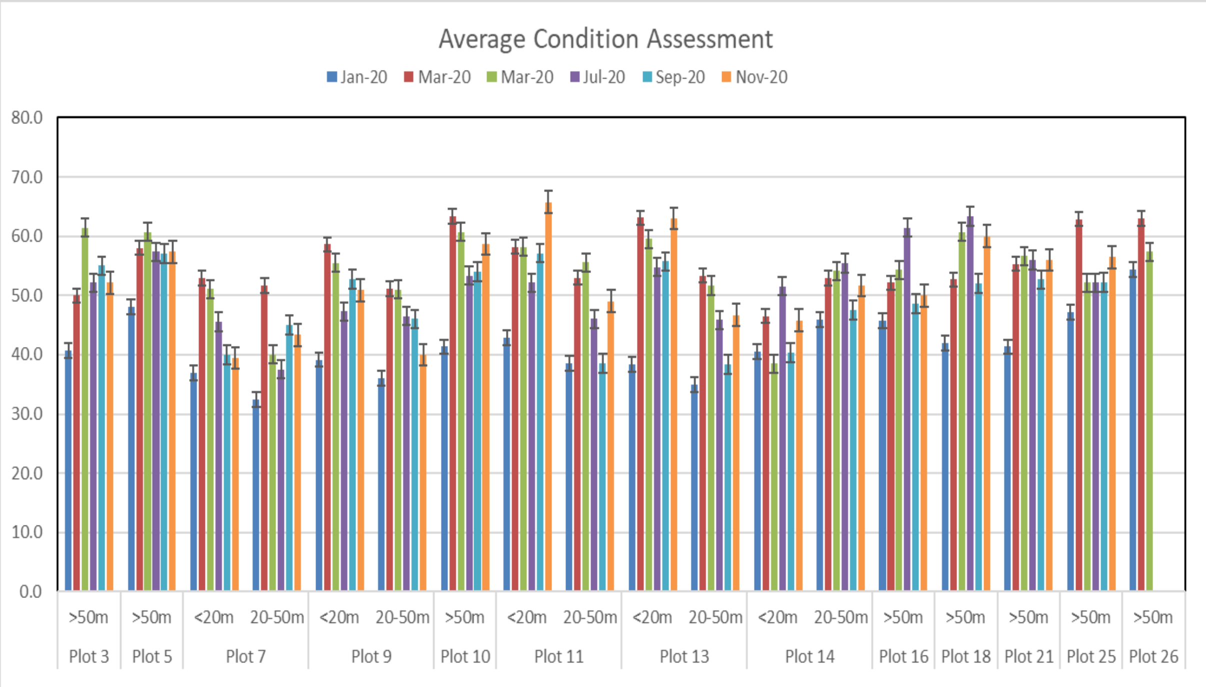


Figure 3.3: Average condition assessment (and standard deviation) per plot and monitoring event.

3.2.3 Chlorophyll Fluorescence (CF)

Figure 3.4 presents the Fv/Fm (index of chlorophyll fluorescence) monitoring results per plot and distance from mining for the monitoring period. The January 2020 monitoring recorded average chlorophyll fluorescence readings between 0.40 (Plot 5 >50m and Plot 7, <20m) and 0.67 (Plot 11, 20-50m), whilst the November monitoring recorded levels between 0.72 (Plot 7, <20m) and 0.78 (multiple plots). For the entire monitored population, average chlorophyll fluorescence was lowest during January (0.56) and highest in March (0.79).

Chlorophyll Fluorescence results (± standard deviation) are also shown in table form in Appendix 1 Tabular results of chlorophyll fluorescence and average condition assessment ± standard deviation.

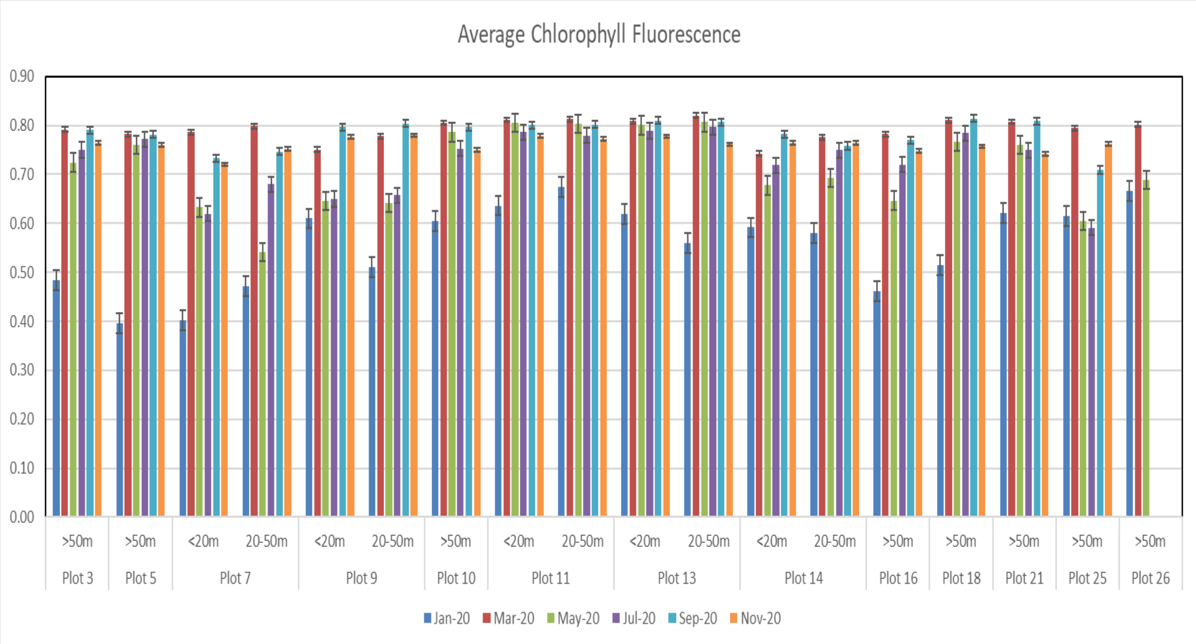


Figure 3.4: Average chlorophyll fluorescence (and standard deviation) per plot and monitoring event.

3.2.4 Soft Tips (new growth)

Figure 3.5 presents the percentage of plants with soft tips signifying new growth, per plot and distance from mining for each monitoring event. The January 2020 monitoring recorded between 0% (multiple plots) and 46.2% (Plot 9, 20-50m) of plants per plot with soft tips, whilst the November monitoring recorded between 25.0% (Plot 14, 20-50m) and 100% (multiple plots).

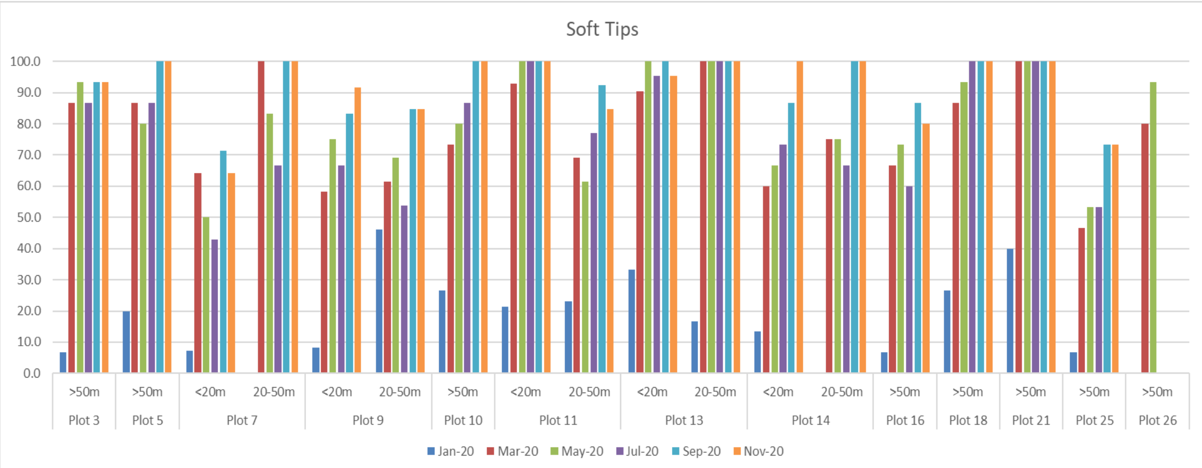


Figure 3.5 : Percentage of Plants with Soft Tips (New Growth)

3.2.5 Mortality

Five new individuals were identified as having no live tissue (NLT) during the 2020 monitoring period. Two individuals were identified as NLT in March, one in May and two in December. One individual was however identified as living again after being recorded as NLT since July 2018. The results of the statistical analysis for the November 2020 monitoring event are presented in Figure 3.6. The results confirm that the mortality does not appear to be attributable to any mine related factor.

Model Anova Results	Df	Sum Sq	Mean Sq	F value	p-value
BeforeOrAfterMining	1	0	0	0	0.995
Location	2	1.831	0.916	0.916	0.4
BeforeOrAfterMining:Location	2	0	0	0	1

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	0 (0,1)	0 (0,1)	0 (0,1)
After	0.02 (0,0.09)	0.01 (0,0.04)	0 (0,0.02)

No statistically significant association was found between mining activity and Mortality for Tetrathcea erubescens, p-value >= 0.1

Figure 3.6: Model ANOVA results for mining activity and mortality after allowing for Ash.

3.2.6 Leaf surface dust

Figure 3.7 illustrates the percentage of plants identified in each dust category vs. distribution per plot and distance from mining, for each monitoring event. Plot 25 (<50m) recorded the highest percentage of individuals within the 51 -75% dust category for the period September and the 76-100% dust cover category for November. Plot 25 was also located in close proximity to the F1 Pit which was developed in the second half of 2020.

Of note, however, is that the leaf dust does not correspond to depositional dust as highest readings were received at Plot 11 which is well away from Plot 25 which received the highest recording for leaf dust.

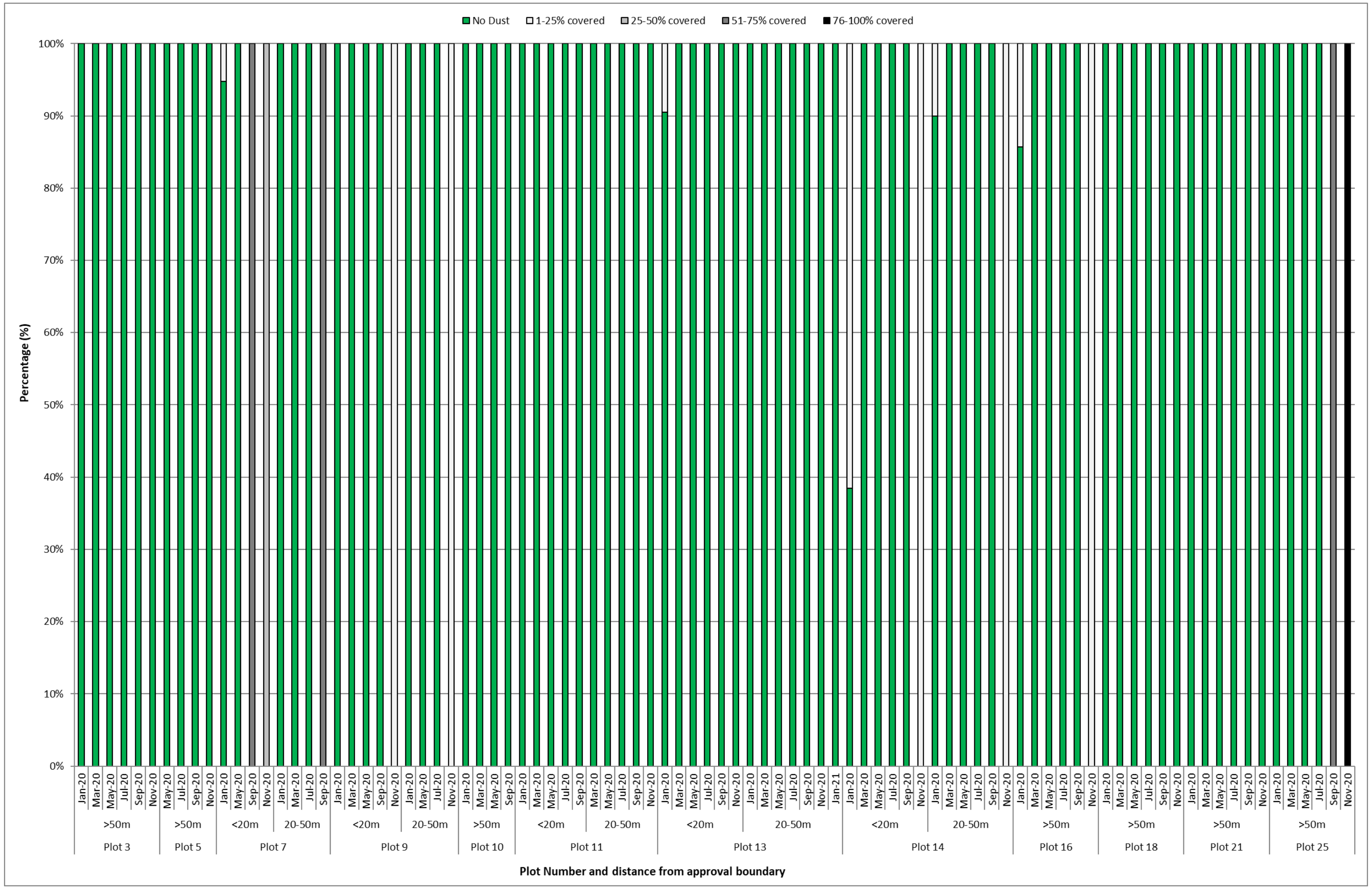


Figure 3.7 Percentage of monitored plants in each dust category per monitoring event. (Plots not shown are recorded as dust free in all monitoring events)

3.2.7 Dust Deposition

Figure 3.8 presents the results of the dust deposition gauge (DDG) monitoring at each plot for each monitoring event. As per the FMVP, the trigger criteria level of 40g/m^2/month was raised to 80g/m^2/month with the initiation of mining at F1 Pit. One dust exceedance was identified. Dust levels were low at most plots for all monitoring events, except plot 11 during the November monitoring period. DDG at PS3 and PS4 recorded elevated dust levels at the start of the year but declined later in the year. Dust at all other locations and monitoring events was low, with 85% of all monitoring events across all locations at less than 20g/m^2/month. There was one recorded dust deposition level above the trigger criteria level of 80g/m^2/month which occurred at Plot 11 (110g/m2/month during November) and an investigation was initiated and corrective actions implemented for this exceedance.

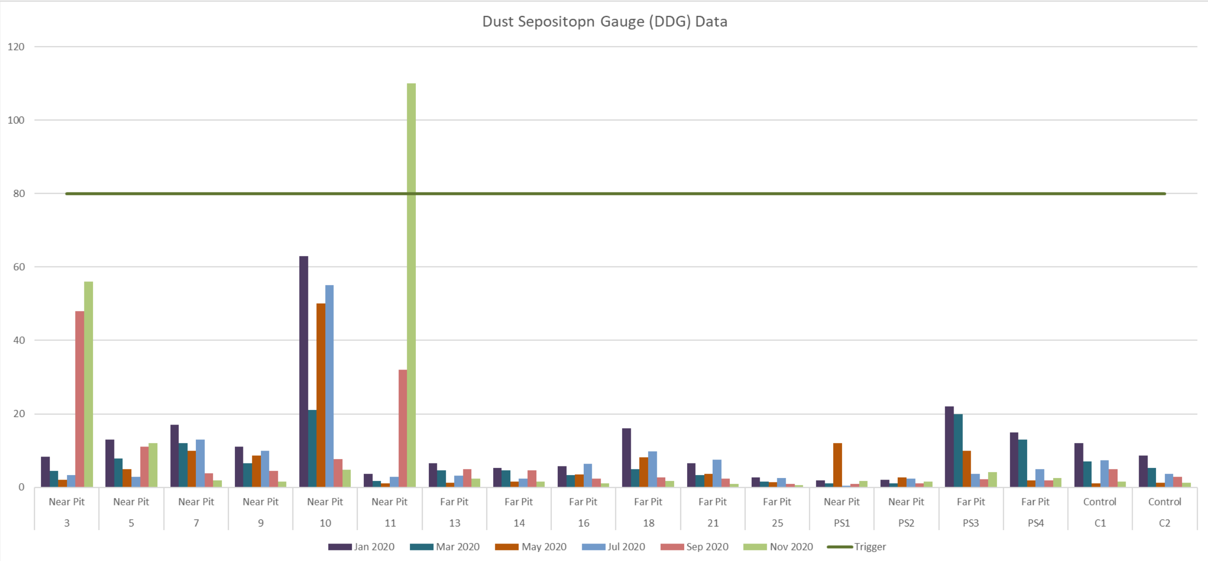


Figure 3.8: Mine related dust recorded in each plot during DDG monitoring

3.3 Statistical Analysis

No statistically significant relationship was found between mining activity and condition assessment, chlorophyll fluorescence or mortality of *Tetratheca erubescens* at a widely accepted 84% confidence interval (Figure 3.9). Appendix 2 Results of the statistical analysis, January - November 2020 presents the results of the statistical analysis from January to November 2020.

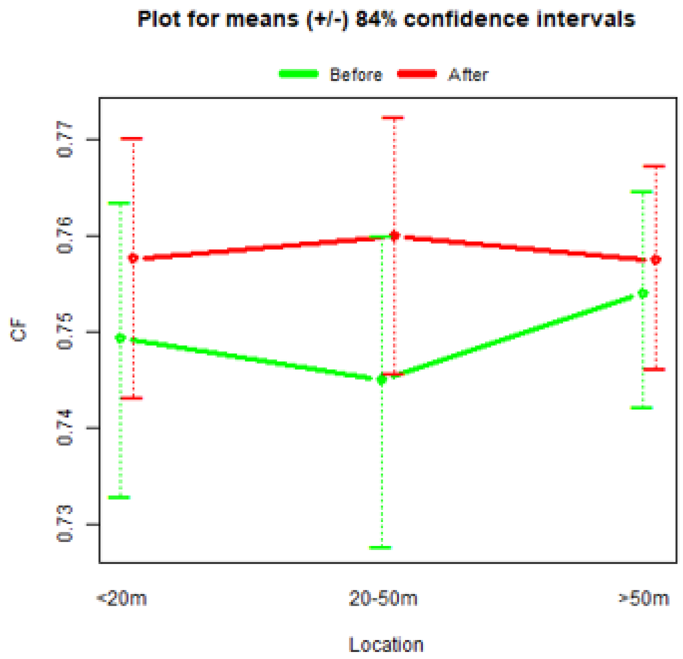


Figure 3.9: Chlorophyll Fluorescence readings on monitored plants before and after the commencement of mining.

4 Discussion and Conclusion

The monitoring suggests the *Tetratheca erubescens* plants are displaying some levels of recovery in condition, with a 1.4% increase in average condition assessment when compared to 2019. The period that showed the lowest condition rating was observed during the January monitoring period (41.5%). The contributing factor to the exhibited increase in condition could be attributed to the heavy rainfall events that occurred in late summer (February) and good follow up rains through the winter months, primarily July and August.

As expected, most plants (over 83%) were reproductive during the spring monitoring compared with 27% during the May monitoring. The majority of individuals (over 92%) recorded soft tips (new growth) in spring (September monitoring period), compared with just under 18% in summer (January).

Average chlorophyll fluorescence measurement is a more reliable indicator of plant health than condition assessment. The method directly measures physiological function and thus offers significant advantages over the more traditional measures of vegetation condition that use indirect indicators such as dead/live leaf material or leaf colour. Fv/Fm (index of chlorophyll fluorescence) has a normal range of 0.7 to 0.8 across a broad range of different vascular plant taxa. The ratio declines when plants experience stress. Various literatures (Ritchie 2006; Percival 2005) suggest values below 0.6 indicate plant stress. The January monitoring recorded low chlorophyll fluorescence values (average of 0.56), with individual plants recording values as low as 0.09. It is likely that the below average annual rainfall from 2019 and lower than average monthly rainfall in January contributed to the low chlorophyll fluorescence readings experienced over the monitoring periods compared to subsequent monitoring events recording higher chlorophyll fluorescence values. The March through December periods recorded values in the high 0.70's (0.79 in March) to the mid 70's (0.76 in December). These results suggest the monitored *Tetratheca erubescens* individuals are in a healthy condition.

The first mortality of the monitored individuals was recorded in July 2018, with 4 individuals recorded as no live tissue (NLT). 2020 recorded the same four individuals but also an additional five by the end of the year. It is also worthy of note that one individual recorded as NLT in 2018 was recorded as live in 2020.

The stems of the *Tetratheca erubescens* are quite brittle and the use of a clip in order to take a CF reading every two months often results in irreversible damage to the stem. Where individuals only have a few stems, the same stems are likely to be sampled repeatedly, resulting in potential damage to the individual and/or reducing its chance of survival. Due to this current monitoring practices avoid collecting CF measurements from those individuals with reduced number of live stems or those that are showing signs of stress due to physical disturbance from monitoring. CF measurement will recommence once the individuals have sufficiently recovered. Visual observations such as condition and dust assessments, reproductive status will still be collected until such a time that the individuals can withstand CF monitoring.

Dust deposition levels were relatively low at most plots however began to increase in some plots toward the later monitoring periods in the year. Plot 25 recorded the highest levels during the September and November monitoring periods followed by Plot 7 for the same monitoring periods. This is likely due to the development of the final, approved, F deposit pit. The high dust deposition value recorded at plot 11 during the November 2020 monitoring. The cause could not be determined as this is a plot that is far from the pit, historically low readings and faults with the monitoring equipment that collect daily data. It could be inferred that North Westerly winds have carried the dust to the location however this is not supported by the other depositional dust gauges that are found between the F1 pit and Plot 11.

4.1 Comparisons against trigger and threshold criteria

The F Deposit Flora and Vegetation Management Plan (MRL 2020) outlines trigger and threshold criteria that require further reporting and contingency actions. The following section compares the results of the monitoring against the relevant criterion.

4.1.1 Trigger criteria

1. <u>Monitoring of *Tetratheca erubescens* indicates a statistically significant relationship between condition (Index of Chlorophyll Fluorescence (ICF) and/or %live material) and dust deposition, distance from proposal boundary or mine related factor.</u>

   No statistically significant negative relationship was found between mining activity and condition assessment, chlorophyll fluorescence or mortality of *Tetratheca erubescens* as outlined in Section 3.4. Therefore, this trigger criterion has not been met.

2. <u>Dust deposition at any (non-reference) dust monitoring site exceeds 80g/m2/month (S_a) during the first 12 months from commencement of mining; 40g/m2/month (S_a) after 12 months from commencement of mining.</u>

   Elevated dust deposition levels (limit of 80g/m^2/month (S_a)) were observed at Plot 11 for the November monitoring event, as outlined in Section 3.2.7 and in Figure 3.8. Therefore, this trigger criterion has been met. As a result and following internal reporting processes an incident was raised and an investigation carried out however it was found that reporting equipment had malfunctioned and was now collecting data during this period. This has meant that detailed investigation has not been enabled but all faulty equipment has been sent to the manufacturer for repair and recalibration. Depositional monitoring has continued and subsequent monitoring has shown a reduction and will be presented in the 2021 report.

4.1.2 Threshold criteria

1. Monitoring of *Tetratheca erubescens* indicates a statistically significant relationship between mortality and dust deposition, distance from the proposal boundary or mine-related causal factor.

   The mortality of monitored *Tetratheca erubescens* individuals, recorded no statistically significant relationship with any mine-related causal factor, as outlined in Section 3.2.5. Therefore, this threshold criterion has not been met.

2. Monitoring of *Tetratheca erubescens* indicates a statistically significant relationship between condition (Index of Chlorophyll Fluorescence (ICF) and/or % live material) and dust deposition, distance from the proposal boundary or mine-related factor.

   No statistically significant negative relationship was found between mining activity and condition assessment, chlorophyll fluorescence or mortality of *Tetratheca erubescens*. As outlined in 3.3 Statistical Analysis. Therefore, this threshold criterion has not been met.

4.2 Review of monitoring data, methods and trigger levels

It is proposed to amend the trigger and threshold criteria to identify statistically significant *negative* relationships (i.e. high levels of dust coinciding with lower condition assessment or chlorophyll fluorescence), as opposed to also identifying and reporting on positive relationships such as those recorded during the 2018 monitoring (where dust was positively associated with condition assessment). A further review of the monitoring methods, data collected and appropriateness of trigger and threshold levels is proposed.

5 References

Bureau of Meteorology (2020) *Monthly Rainfall – Koolyanobbing.* BoM Station 12227. Accessed on 1st March 2020 from the Australian Bureau of Meteorology website at http://www.bom.gov.au.

MRL (2019) *Koolyanobbing Range F Deposit Flora and Vegetation Management Plan.* November 2019.

Hansatech (2006) *Handy PEA, Pocket PEA & PEA Plus Software.* Hansatech Instruments Ltd. Version 1.0, December 2006.

Maia (2013) *Southern Koolyanobbing Range Tetratheca erubescens Census.* Report prepared for Cliffs Natural Resources Pty Ltd., August 2013.

Minister for the Environment and Heritage (2017). *Statement 1054. Yilgarn Operations – Koolyanobbing Range F Deposit.* Statement that a proposal may be implemented (*Environmental Protection Act 1986*). January 2017, Perth Western Australia.

Percival (2005) *The use of Chlorophyll Fluorescence to Identify Chemical and Environmental Stress in Leaf Tissue of Three Oak (QUERCUS) Species.* Journal of Arboriculture 31 (5): September 2005. p215.

Ritchie (2006) *Chlorophyll Fluorescence: What is it and What do the Numbers Mean?* National Proceedings Forest and Conservation Nursery Associations – 2005. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 160p.

6 Appendix 1 Tabular results of chlorophyll fluorescence and average condition assessment ± standard deviation

A1 1: Average Chlorophyll Fluorescence per plot (± standard deviation)

Plot Number	Distance from pit	Jan-20		Mar-20		May-20		Jul-20		Sep-20		Nov-20	
		CF	SD	CF	SD	CF	SD	CF	SD	CF	SD	CF	SD
Plot 3	>50m	0.48	0.17	0.79	0.01	0.72	0.12	0.75	0.08	0.79	0.02	0.76	0.03
Plot 5	>50m	0.40	0.18	0.78	0.03	0.76	0.04	0.77	0.04	0.78	0.02	0.76	0.03
Plot 7	<20m	0.40	0.21	0.79	0.03	0.63	0.10	0.62	0.11	0.73	0.03	0.72	0.03
	20-50m	0.47	0.19	0.80	0.01	0.54	0.17	0.68	0.05	0.75	0.04	0.75	0.01
Plot 9	<20m	0.61	0.19	0.75	0.04	0.65	0.12	0.65	0.06	0.80	0.02	0.78	0.03
	20-50m	0.51	0.15	0.78	0.03	0.64	0.13	0.66	0.06	0.80	0.02	0.78	0.02
Plot 10	>50m	0.60	0.15	0.81	0.01	0.79	0.03	0.75	0.05	0.80	0.02	0.75	0.05
Plot 11	<20m	0.64	0.10	0.81	0.01	0.81	0.01	0.79	0.02	0.80	0.01	0.78	0.02
	20-50m	0.67	0.08	0.81	0.01	0.80	0.01	0.78	0.02	0.80	0.01	0.77	0.04
Plot 13	<20m	0.62	0.10	0.81	0.01	0.80	0.02	0.79	0.02	0.81	0.03	0.78	0.02
	20-50m	0.56	0.09	0.82	0.01	0.81	0.02	0.80	0.01	0.81	0.02	0.76	0.04
Plot 14	<20m	0.59	0.10	0.74	0.07	0.68	0.11	0.72	0.08	0.78	0.03	0.77	0.03
	20-50m	0.58	0.08	0.78	0.02	0.69	0.08	0.75	0.04	0.76	0.05	0.76	0.09
Plot 16	>50m	0.46	0.14	0.78	0.02	0.65	0.11	0.72	0.05	0.77	0.05	0.75	0.04
Plot 18	>50m	0.51	0.13	0.81	0.01	0.77	0.05	0.78	0.02	0.81	0.01	0.76	0.04
Plot 21	>50m	0.62	0.15	0.81	0.01	0.76	0.04	0.75	0.06	0.81	0.02	0.74	0.04
Plot 25	>50m	0.62	0.11	0.79	0.03	0.60	0.17	0.59	0.12	0.71	0.06	0.76	0.03
Plot 26	>50m	0.67	0.12	0.80	0.01	0.69	0.14						

A1 2: Average Condition Assessment per plot (± standard deviation)

Plot Number	Distance from pit	Jan-20		Mar-20		May-20		Jul-20		Sep-20		Nov-20	
		CA	SD	CA	SD	CA	SD	CA	SD	CA	SD	CA	SD
Plot 3	>50m	40.7	10.0	50.0	17.5	61.4	18.8	52.1	14.8	55.0	11.6	52.1	15.3
Plot 5	>50m	48.0	13.7	58.0	19.0	60.7	19.0	57.3	20.9	57.0	25.3	57.3	22.2
Plot 7	<20m	36.8	19.1	52.9	20.2	51.1	16.8	45.6	19.8	40.0	17.1	39.4	19.2
	20-50m	32.5	14.1	51.7	9.8	40.0	16.7	37.5	15.4	45.0	17.6	43.3	13.7
Plot 9	<20m	39.2	18.8	58.6	14.5	55.5	21.6	47.3	16.8	52.7	20.5	50.9	20.2
	20-50m	36.0	13.5	51.1	13.6	51.0	15.2	46.5	14.9	46.0	18.4	40.0	15.6
Plot 10	>50m	41.3	15.1	63.3	12.9	60.7	19.1	53.3	18.0	54.0	16.4	58.7	16.8
Plot 11	<20m	42.9	16.8	58.2	17.6	58.2	18.4	52.1	13.1	57.1	21.3	65.7	16.5
	20-50m	38.5	19.4	53.0	17.7	55.6	13.3	46.0	17.6	38.5	18.3	49.0	17.3
Plot 13	<20m	38.4	15.9	63.1	16.8	59.5	17.2	54.8	20.6	55.7	21.6	63.0	11.7
	20-50m	35.0	20.0	53.3	19.7	51.7	24.8	45.8	25.4	38.3	14.7	46.7	10.3
Plot 14	<20m	40.5	27.0	46.5	20.1	38.5	25.9	51.5	23.0	40.4	24.9	45.8	23.6
	20-50m	45.8	27.7	52.9	21.3	54.2	20.7	55.4	19.9	47.5	23.4	51.7	20.8
Plot 16	>50m	45.7	9.4	52.1	8.0	54.3	10.2	61.4	12.3	48.6	17.5	50.0	9.1
Plot 18	>50m	42.0	15.2	52.7	8.0	60.7	10.3	63.3	10.5	52.0	14.2	60.0	10.0
Plot 21	>50m	41.3	15.1	55.3	14.1	56.7	15.9	56.0	13.5	52.7	20.9	56.0	16.4
Plot 25	>50m	47.1	14.4	62.9	9.1	52.1	13.7	52.1	9.7	52.1	15.3	56.4	13.9
Plot 26	>50m	54.3	18.0	63.0	19.3	57.3	19.8						

7 Appendix 2 Results of the statistical analysis, January - November 2020

A2 1: Statistical analysis of Chlorophyll Fluorescence (excluding Ash)

Model for CF - excluding effect of Ash *Primary analysis (omitting outlier(s))*

transformed CF ~ BeforeOrAfterMining*Location + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	2.272	0.065	4898	35.158	0
BeforeOrAfterMining_After	-0.144	0.024	4898	-5.922	0
Location 20-50m	-0.095	0.108	236	-0.875	0.383
Location <20m	-0.107	0.106	236	-1.009	0.314
BeforeOrAfterMining_After:Location 20-50m	0.041	0.049	4898	0.831	0.406
BeforeOrAfterMining_After:Location <20m	0.048	0.044	4898	1.077	0.281

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	4898	1936.865	0
BeforeOrAfterMining	1	4898	46.528	0
Location	2	236	0.248	0.781
BeforeOrAfterMining:Location	2	4898	0.737	0.478

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	0.75 (0.73,0.77)	0.75 (0.73,0.77)	0.76 (0.75,0.77)
After	0.74 (0.72,0.76)	0.74 (0.72,0.76)	0.75 (0.73,0.76)

No statistically significant association was found between mining activity and Chlorophyll Fluorescence for Tetrathcea erubescens, p-value >= 0.1

January 2020

Model for CF - excluding effect of Ash *Primary analysis (omitting outlier(s))*

transformed CF ~ BeforeOrAfterMining*Location + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	2.272	0.065	5134	35.024	0
BeforeOrAfterMining_After	-0.109	0.024	5134	-4.474	0
Location 20-50m	-0.089	0.109	236	-0.824	0.411
Location <20m	-0.11	0.107	236	-1.03	0.304
BeforeOrAfterMining_After:Location 20-5	0.037	0.049	5134	0.764	0.445
BeforeOrAfterMining_After:Location <20	0.044	0.044	5134	0.999	0.318

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	5134	1969.792	0
BeforeOrAfterMining	1	5134	24.828	0
Location	2	236	0.342	0.711
BeforeOrAfterMining:Location	2	5134	0.631	0.532

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	0.75 (0.73,0.77)	0.75 (0.73,0.77)	0.76 (0.75,0.77)
After	0.74 (0.72,0.76)	0.74 (0.72,0.76)	0.75 (0.73,0.76)

No statistically significant association was found between mining activity and Chlorophyll Fluorescence for Tetrathcea erubescens, p-value >= 0.1

March 2020

Model for CF - excluding effect of Ash *Primary analysis (omitting outlier(s))*

transformed CF ~ BeforeOrAfterMining*Location + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	2.272	0.069	5371	32.81	0
BeforeOrAfterMining_After	-0.111	0.024	5371	-4.608	0
Location 20-50m	-0.089	0.115	236	-0.771	0.442
Location <20m	-0.11	0.114	236	-0.971	0.333
BeforeOrAfterMining_After:Location 20-50m	0.038	0.049	5371	0.788	0.431
BeforeOrAfterMining_After:Location <20m	0.05	0.044	5371	1.135	0.256

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	5371	1709.205	0
BeforeOrAfterMining	1	5371	25.583	0
Location	2	236	0.248	0.781
BeforeOrAfterMining:Location	2	5371	0.77	0.463

No statistically significant association was found between mining activity and Chlorophyll Fluorescence for Tetrathcea erubescens, p-value >= 0.1

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	0.75 (0.73,0.77)	0.75 (0.73,0.77)	0.76 (0.75,0.78)
After	0.74 (0.72,0.76)	0.74 (0.72,0.76)	0.75 (0.73,0.76)

May 2020

Model for CF - excluding effect of Ash *Primary analysis (omitting outlier(s))*

transformed CF ~ BeforeOrAfterMining*Location + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	2.272	0.072	5595	31.683	0
BeforeOrAfterMining_After	-0.111	0.024	5595	-4.672	0
Location 20-50m	-0.088	0.119	236	-0.736	0.462
Location <20m	-0.11	0.118	236	-0.939	0.349
BeforeOrAfterMining_After:Location 20-50m	0.038	0.048	5595	0.803	0.422
BeforeOrAfterMining_After:Location <20m	0.048	0.043	5595	1.115	0.265

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	5595	1583.312	0
BeforeOrAfterMining	1	5595	26.483	0
Location	2	236	0.268	0.766
BeforeOrAfterMining:Location	2	5595	0.758	**0.468**

No statistically significant association was found between mining activity and Chlorophyll Fluorescence for Tetrathcea erubescens, p-value >= 0.1

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	0.75 (0.73,0.77)	0.75 (0.73,0.77)	0.76 (0.75,0.78)
After	0.74 (0.72,0.76)	0.74 (0.72,0.76)	0.75 (0.73,0.76)

July 2020

Model for CF - excluding effect of Ash *Primary analysis (omitting outlier(s))*

transformed CF ~ BeforeOrAfterMining*Location + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	2.272	0.073	5819	31.256	0
BeforeOrAfterMining_After	-0.092	0.024	5819	-3.915	0
Location 20-50m	-0.089	0.121	236	-0.739	0.46
Location <20m	-0.108	0.119	236	-0.908	0.365
BeforeOrAfterMining_After:Location 20-50m	0.045	0.048	5819	0.934	0.35
BeforeOrAfterMining_After:Location <20m	0.052	0.043	5819	1.195	0.232

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	5819	1561.146	0
BeforeOrAfterMining	1	5819	16.227	0
Location	2	236	0.222	0.801
BeforeOrAfterMining:Location	2	5819	0.917	0.4

No statistically significant association was found between mining activity and Chlorophyll Fluorescence for Tetrathcea erubescens, p-value >= 0.1

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	0.75 (0.73,0.77)	0.75 (0.73,0.77)	0.76 (0.75,0.78)
After	0.74 (0.72,0.76)	0.75 (0.72,0.77)	0.75 (0.73,0.77)

September 2020

Model for CF - excluding effect of Ash *Primary analysis (omitting outlier(s))*

transformed CF ~ BeforeOrAfterMining*Location + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	2.272	0.071	6041	32.087	0
BeforeOrAfterMining_After	-0.09	0.023	6041	-3.865	0
Location 20-50m	-0.092	0.118	236	-0.779	0.437
Location <20m	-0.106	0.116	236	-0.913	0.362
BeforeOrAfterMining_After:Location 20-50m	0.055	0.047	6041	1.161	0.246
BeforeOrAfterMining_After:Location <20m	0.056	0.043	6041	1.311	0.19

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	6041	1655.898	0
BeforeOrAfterMining	1	6041	14.289	0
Location	2	236	0.205	0.815
BeforeOrAfterMining:Location	2	6041	1.212	0.298

No statistically significant association was found between mining activity and Chlorophyll Fluorescence for Tetrathcea erubescens, p-value >= 0.1

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	0.75 (0.73,0.77)	0.75 (0.73,0.77)	0.76 (0.75,0.78)
After	0.75 (0.72,0.76)	0.75 (0.73,0.77)	0.75 (0.74,0.77)

November 2020

A2 2: Statistical analysis of Condition Assessment (including Ash)

Model for CA - including effect of Ash *Extended analysis*

CA ~ BeforeOrAfterMining*Location + log(Ash) + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	48.179	1.788	2081	26.942	0
BeforeOrAfterMining_After	2.491	0.915	2081	2.722	0.007
Location 20-50m	-5.097	3.128	236	-1.63	0.105
Location <20m	3.282	2.854	236	1.15	0.251
ash_transformed	-1.566	0.321	2081	-4.882	0
BeforeOrAfterMining_After:Location 20-50r	1.188	1.482	2081	0.801	0.423
BeforeOrAfterMining_After:Location <20m	1.789	1.335	2081	1.34	0.18

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	2081	1515.171	0
BeforeOrAfterMining	1	2081	0.166	0.684
Location	2	236	5.301	0.006
ash_transformed	1	2081	22.236	0
BeforeOrAfterMining:Location	2	2081	0.978	0.376

No statistically significant association was found between mining activity and Condition Assessment for Tetrathcea erubescens after allowing for Ash, p-value >= 0.1

Ash was statistically significant associated with Condition Assessment for Tetrathcea erubescens, p-value < 0.05

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	51.46 (47,55.92)	43.08 (37.94,48.2	48.18 (44.67,51.68)
After	55.74 (51.29,60.19	46.76 (41.55,51.97	50.67 (47.16,54.18)

January 2020

Model for CA - including effect of Ash *Extended analysis*

CA ~ BeforeOrAfterMining*Location + log(Ash) + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	48.266	1.443	5186	33.44	0
BeforeOrAfterMining_After	4.114	0.663	5186	6.207	0
Location 20-50m	-4.387	2.661	236	-1.649	0.101
Location <20m	2.996	2.346	236	1.277	0.203
ash_transformed	-1.526	0.163	5186	-9.369	0
BeforeOrAfterMining_After:Location 20-50n	0.244	1.206	5186	0.202	0.84
BeforeOrAfterMining_After:Location <20m	-0.836	1.126	5186	-0.743	0.458

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	5186	2650.091	0
BeforeOrAfterMining	1	5186	0.655	0.418
Location	2	236	3.68	0.027
ash_transformed	1	5186	91.484	0
BeforeOrAfterMining:Location	2	5186	0.362	0.696

No statistically significant association was found between mining activity and Condition Assessment for Tetrathcea erubescens after allowing for Ash, p-value >= 0.1

Ash was statistically significant associated with Condition Assessment for Tetrathcea erubescens, p-value < 0.05

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	51.26 (47.6,54.92)	43.88 (39.46,48.29)	48.27 (45.44,51.09)
After	54.54 (51.18,57.89)	48.24 (44.05,52.42)	52.38 (49.67,55.09)

March 2020

Model for CA - including effect of Ash *Extended analysis*

CA ~ BeforeOrAfterMining*Location + log(Ash) + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	48.25	1.414	5424	34.13	0
BeforeOrAfterMining_After	4.501	0.659	5424	6.833	0
Location 20-50m	-4.282	2.617	236	-1.636	0.103
Location <20m	3.039	2.299	236	1.322	0.187
ash_transformed	-1.533	0.161	5424	-9.507	0
BeforeOrAfterMining_After:Location 20-50n	0.105	1.201	5424	0.088	0.93
BeforeOrAfterMining_After:Location <20m	-1.172	1.122	5424	-1.044	0.296

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	5424	2832.476	0
BeforeOrAfterMining	1	5424	1.949	0.163
Location	2	236	3.591	0.029
ash_transformed	1	5424	95.017	0
BeforeOrAfterMining:Location	2	5424	0.618	0.539

No statistically significant association was found between mining activity and Condition Assessment for Tetrathcea erubescens after allowing for Ash, p-value >= 0.1

Ash was statistically significant associated with Condition Assessment for Tetrathcea erubescens, p-value < 0.05

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	51.29 (47.7,54.87)	43.97 (39.62,48.32)	48.25 (45.48,51.02)
After	54.62 (51.35,57.89)	48.57 (44.46,52.68)	52.75 (50.1,55.4)

May-2020

Model for CA - including effect of Ash *Extended analysis*

CA ~ BeforeOrAfterMining*Location + log(Ash) + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	48.392	1.408	5649	34.357	0
BeforeOrAfterMining_After	4.568	0.654	5649	6.981	0
Location 20-50m	-4.26	2.607	236	-1.634	0.104
Location <20m	3.088	2.29	236	1.348	0.179
ash_transformed	-1.41	0.159	5649	-8.893	0
BeforeOrAfterMining_After:Location 20-5	-0.228	1.189	5649	-0.192	0.848
BeforeOrAfterMining_After:Location <20	-1.726	1.113	5649	-1.551	0.121

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	5649	2868.236	0
BeforeOrAfterMining	1	5649	2.948	0.086
Location	2	236	3.561	0.03
ash_transformed	1	5649	84.518	0
BeforeOrAfterMining:Location	2	5649	1.23	0.292

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	51.48 (47.91,55.05)	44.13 (39.8,48.46)	48.39 (45.63,51.15)
After	54.32 (51.07,57.58	48.47 (44.38,52.5	52.96 (50.32,55.6)

No statistically significant association was found between mining activity and Condition Assessment for Tetrathcea erubescens after allowing for Ash, p-value >= 0.1

Ash was statistically significant associated with Condition Assessment for Tetrathcea erubescens, p-value < 0.05

July 2020

Model for CA - including effect of Ash *Extended analysis*

CA ~ BeforeOrAfterMining*Location + log(Ash) + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	48.419	1.381	5874	35.069	0
BeforeOrAfterMining_After	4.623	0.653	5874	7.081	0
Location 20-50m	-4.213	2.566	236	-1.642	0.102
Location <20m	3.073	2.246	236	1.368	0.173
ash_transformed	-1.385	0.156	5874	-8.853	0
BeforeOrAfterMining_After:Location 20-50n	-0.51	1.185	5874	-0.43	0.667
BeforeOrAfterMining_After:Location <20m	-1.962	1.111	5874	-1.766	0.077

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	5874	3038.387	0
BeforeOrAfterMining	1	5874	2.839	0.092
Location	2	236	3.685	0.027
ash_transformed	1	5874	84.56	0
BeforeOrAfterMining:Location	2	5874	1.56	0.21

Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	51.49 (47.99,55)	44.21 (39.93,48.48)	48.42 (45.71,51.13)
After	54.15 (50.98,57.33)	48.32 (44.3,52.34)	53.04 (50.46,55.62)

No statistically significant association was found between mining activity and Condition Assessment for Tetrathcea erubescens after allowing for Ash, p-value >= 0.1

Ash was statistically significant associated with Condition Assessment for Tetrathcea erubescens, p-value < 0.05

September 2020

Model for CF - including effect of Ash *Secondary extended analysis*

transformed CF ~ BeforeOrAfterMining*Location + log(Ash) + Plot(Random) + Tag_num(Random)

Model Results	Value	Std.Error	DF	t-value	p-value
(Intercept)	2.199	0.072	5900	30.547	0
BeforeOrAfterMining_After	0.031	0.026	5900	1.16	0.246
Location 20-50m	-0.078	0.119	236	-0.658	0.511
Location <20m	-0.042	0.118	236	-0.355	0.723
ash_transformed	-0.054	0.006	5900	-9.144	0
BeforeOrAfterMining_After:Location 20-5	0.102	0.048	5900	2.127	0.033
BeforeOrAfterMining_After:Location <20	0.043	0.045	5900	0.975	0.33

Model Anova Results	numDF	denDF	F-value	p-value
(Intercept)	1	5900	1619.943	0
BeforeOrAfterMining	1	5900	17.084	0
Location	2	236	0.205	0.815
ash_transformed	1	5900	79.679	0
BeforeOrAfterMining:Location	2	5900	2.349	0.096

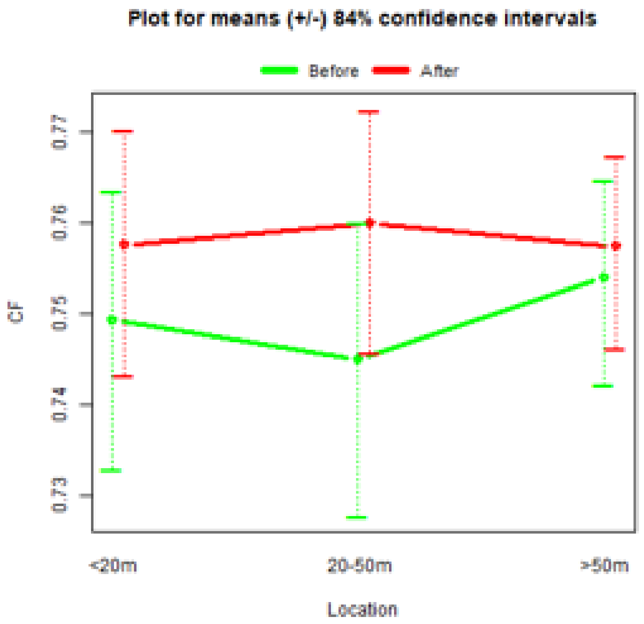
Mean (95% Confidence Interval)	<20m	20-50m	>50m
Before	0.75 (0.73,0.77)	0.74 (0.72,0.77)	0.75 (0.74,0.77)
After	0.76 (0.74,0.77)	0.76 (0.74,0.78)	0.76 (0.74,0.77)

While not statistically significant at the usually accepted 5% level, the result is suggestive of an association between mining activity and Chlorophyll Fluorescence for Tetrathcea

Ash was statistically significant associated with Chlorophyll Fluorescence for Tetrathcea erubescens, p-value < 0.05

November 20

Note; Ash was positively associated with Chlorophyll Fluorescence, as the figure below demonstrates (Mean CF Levels were higher after mining than before)



A2 3: Comparison of condition assessment results before and after mining (including effect of Ash)

Attachment 6: Ecotec (WA) Pty Ltd Koolyanobbing F Deposit 2020 Annual Priority Flora and Vegetation Monitoring (Revision 0)

Koolyanobbing F Deposit 2020 Annual Priority Flora and Vegetation Monitoring Report

September 2020

Revision A. 08-04-2021

Prepared by
Ecotec (WA) Pty Ltd for

Mineral Resources Ltd
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Koolyanobbing Operations

Environmental solutions for *MINING* *OIL & GAS* *CONSTRUCTION*

CONTENTS

FIGURES

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1.0 INTRODUCTION

Mineral Resources Limited (MRL) operations include iron ore mines at the Koolyanobbing Range, Mt Jackson Range and the Windarling Range in the Yilgarn; ore processing at Koolyanobbing, and road and rail transport between these operations and the Port of Esperance where the processed ore is exported to international customers.

The Koolyanobbing F Deposit mining proposal was approved in January 2017 under the Environmental Protection Act 1986 (Minister for the Environment and Heritage 2017). Under this approval, a Condition Environmental Management Plan was developed and implemented which outlines provisions to address indirect impacts on native flora and vegetation including, but not limited to, dust, weeds and fire (Cliffs 2017). As outlined in the Management Plan, a monitoring program was implemented in 2017 that covers defined monitoring plots along the Koolyanobbing Range in order to assess the condition of the native vegetation and Priority flora populations.

The plan identifies a trigger criterion that will initiate the implementation of actions if exceeded, which states:

> "*Monitoring of Priority species indicates a statistically significant relationship between condition (chlorophyll fluorescence and/or % live material) and dust deposition, distance from the proposal boundary or mine-related causal factor*."

and specifies a threshold criterion that must not be exceeded, which states:

> "*Monitoring of Priority species and/or native vegetation indicates a statistically significant relationship between mortality, dust deposition, distance from the proposal boundary or mine-related causal factor*."

Cliffs Asia Pacific Iron Ore (Cliffs) commenced mining at the southern Koolyanobbing Range (F Pit) during May 2017 and continued until April 2018. MRL recommenced mining at F Pit in January 2019 and continue to mine up to the present time.

This report outlines and discusses the results of the 2020 annual monitoring, conducted by Ecotec (WA) Pty Ltd in September 2020, and compares them against the trigger and threshold criteria.

2.0 METHODOLOGY

2.1 Monitoring Design and Plot Establishment

The monitoring program design was developed in consultation with the then Department of Parks and Wildlife (DPaW), Office of the Environmental Protection Authority (OEPA) and Data Analysis Australia (DAA) in order to identify any adverse effects to the native vegetation and Priority flora species adjacent to F Deposit mine pits as a result of mining activities.

In 2017, twelve 20m x 20m monitoring plots were established around the F Deposit mine pits. Each plot was marked with a metal fence dropper at each corner and a plot identification number attached to the fence dropper in the north-west corner. Six plots are located within 50m of a pit boundary (“near-pit”) and six plots are located further than 50m from a pit boundary (“far-pit”). Plot locations are identified in Figure 2.1.

The classification of Plot PS8 as a near- or far-pit plot will be changed as of the 2021 annual monitoring. It is currently considered a far-pit plot due to its distance from F2 pit boundary, however following development of F1 pit, which commenced in June 2020, it is now within 50m of the F1 pit boundary. As F1 development commenced in June 2020, the plot will remain classified as a far-pit for 2020.

At each plot the following information was recorded:

- Plot Number
- Monitoring Date
- GPS location (GDA94) taken from NW corner of plot
- Photographic record taken from NW corner of plot

The first monitoring event was conducted in September 2017 when each plot was visited and data recorded on the Priority flora and native vegetation, as outlined in the following sections.

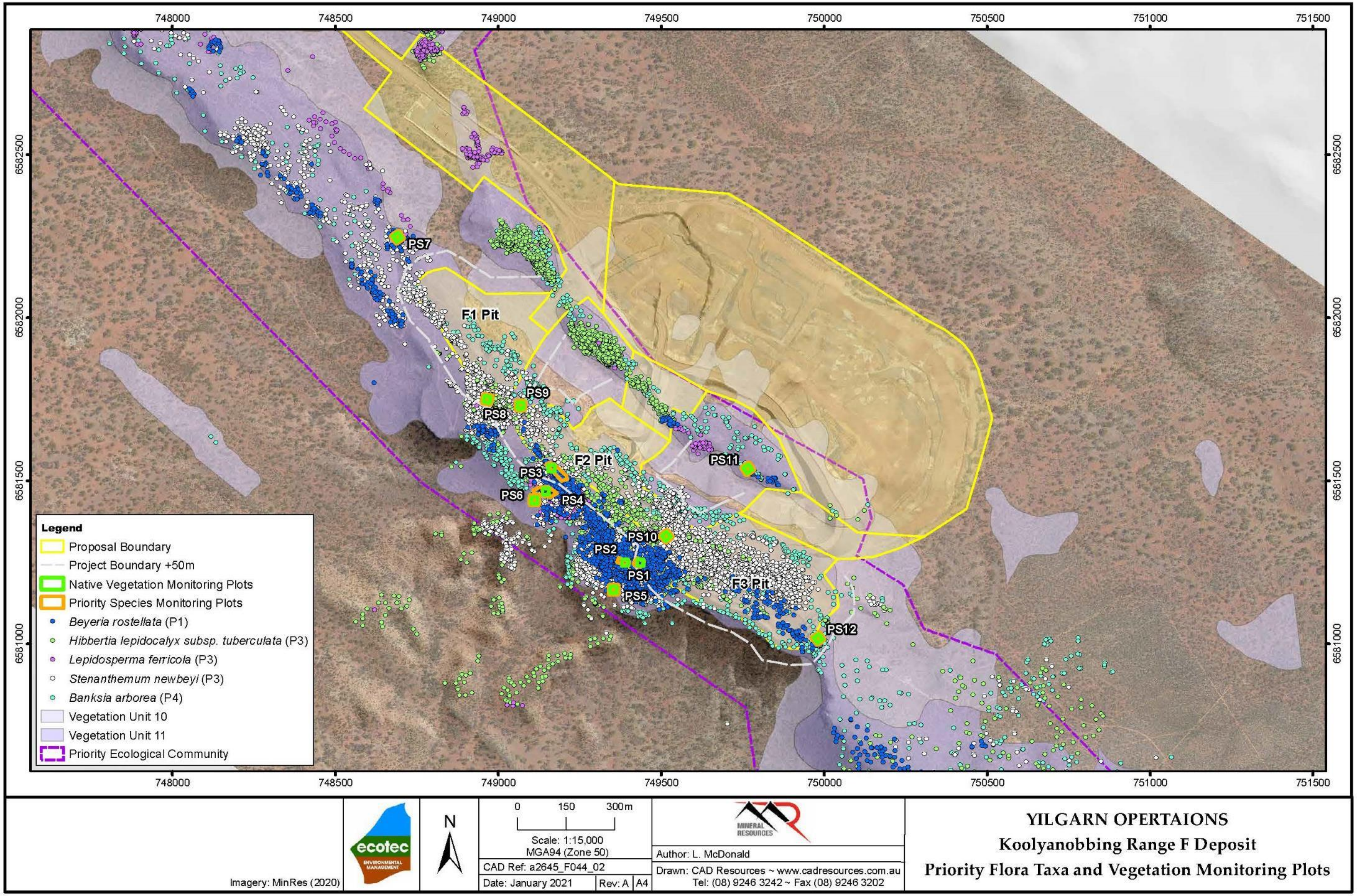

Figure 2.1: **Location of Priority flora and vegetation monitoring plots.**

2.2 Priority Flora Monitoring

To provide sufficient statistical power to detect changes in the health of Priority flora, a sample size of at least 15 individuals per species per plot is required. Ten of the 12 plots contain 15 individuals of the Priority flora species *Beyeria rostellata* (Br) (P1), *Stenanthemum newbeyi* (Sn) (P3), *Lepidosperma ferricola* (Lf) (P3) and/or *Hibbertia lepidocalyx* subsp. *tuberculata* (Hlt) (P3).

Table 2.1 outlines the Priority Flora species monitored in each of the 12 plots.

During each annual monitoring event, the following data is recorded for each individual:

- Reproductive status – vegetative, presence of buds, flowers and/or fruit
- Condition assessment - percentage of live material
- Leaf surface dust - visual estimate as outlined in Table 2.2
- Chlorophyll Fluorescence (Fv/Fm).

The 2020 Priority flora monitoring was carried out between 24 – 29 September.

The two plots that do not contain the 15 individuals required for statistical analysis are also visited and data collected from Priority species to provide additional information. These plots also contain *Banksia arborea* (P4) individuals which are monitored for reproductive status, condition assessment and a photographic record taken of each individual.

Table 2.1: Priority flora species monitoring in each plot.

Plot Number	Distance from Pit	*Beyeria rostellata*	*Stenanthemum newbeyi*	*Lepidosperma ferricola*	*Hibbertia lepidocalyx* subsp. *tuberculata*
PS1	<50m	✓	✓	✓	
PS2	>50m	✓	✓	✓	✓
PS3	<50m	✓	✓	✓	
PS4	>50m	✓	✓	✓	✓
PS5	>50m				
PS6	>50m			✓	
PS7	>50m	✓		✓	
PS8	<50m		✓		✓
PS9	<50m		✓		
PS10	<50m		✓		
PS11	>50m	✓			
PS12	<50m				

Table 2.2: Description of dust categories.

Dust Category	Description
0	No visible dust
1	1-25% of plant covered with dust
2	25-50% of plant covered with dust
3	51-75% of plant covered with dust
4	76-100% of plant covered with dust

The chlorophyll fluorescence reading taken is a ratio of Fv/Fm, where Fv is the variable chlorophyll fluorescence (Fm – Fo), Fm is the maximal chlorophyll fluorescence and Fo is the minimal chlorophyll fluorescence (Murchie and Lawson 2013; Percival 2005). This gives a measure of the optimal quantum yield of photosynthesis, an indicator of photosynthetic performance, thus enabling identification of plant stress (Hansatech 2006; Maxwell and Johnson 2000; Percival 2005). The index of chlorophyll fluorescence reading is taken using a 'Pocket PEA' portable chlorophyll fluorimeter. A special leaf clip is attached to a live leaf of each monitored individual and the sample allowed to become dark adapted. The chlorophyll fluorescence is then measured by the PEA unit and recorded.

2.3 Native Vegetation Monitoring

Since 2017, annual monitoring of the native vegetation is also conducted. The boundary of the plot is demarcated with measuring tape and further divided into manageable sections with measuring tape or flagging tape. Counts are then conducted a section at a time.

Within each plot the following information is recorded:

- Number of native species
- Number of individuals of each native species
- Number of weed species
- Number of individuals of each weed species
- Vegetation condition ranking using the Keighery (1994) scale (Table 2.3).

Table 2.3: The Keighery vegetation condition scale.

Condition Ranking	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered; obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as "parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

2.4 Statistical Analysis

Data analysis tools have been designed by Data Analysis Australia (DAA) to test for significant changes in chlorophyll fluorescence, condition assessment and mortality for Priority flora, and changes in number of species and number of individuals for native vegetation monitoring. The 2020 annual monitoring data will be incorporated into the post-mining data set and the data analysis tools utilised to assess post-mining data (September / October 2017 - 2020) against pre-mining data (November / December 2016 and May 2017), in accordance with parameters outlined in the Yilgarn Operations Koolyanobbing Range F Deposit Flora and Vegetation Management Plan (MRL 2019).

The 2020 Priority flora and vegetation monitoring data has not been analysed due to an unforeseen issue with the statistical analysis tool. The analysis will be run when the problem is resolved.

3.0 RESULTS

3.1 Priority Flora

In 2020 it became apparent that some individuals identified and labelled as *Hibbertia lepidocalyx* subsp. *tuberculata* were actually a similar looking species, *Hibbertia exasperata.* Both species were flowering in 2020 which enabled positive identification. The following six individuals had been incorrectly identified and were replaced by the correct species:

- Plot PS2: Hlt 17, Hlt 20, Hlt 22, Hlt 23, Hlt 24
- Plot PS4: Hlt 31

Photographic records, taken from the north west corner of each monitoring plot, are shown in Appendix 1.

Photographic records of the *Banksia arborea* (Ba) monitoring are shown in Appendix 2.

3.1.1 Reproductive Status

The percentage of monitored *Beyeria rostellata* individuals that were reproductive in 2020 ranged from 93% to 100%, as was the case in 2019, as shown in Figure 3.1. The percentage reproductive ranged from 87% - 100% in 2018 and 86% - 100% in 2017. In 2020 all plots except PS4 recorded 100% of individuals reproductive. Plot PS7 has recorded 100% of plants reproductive in all four years of monitoring.

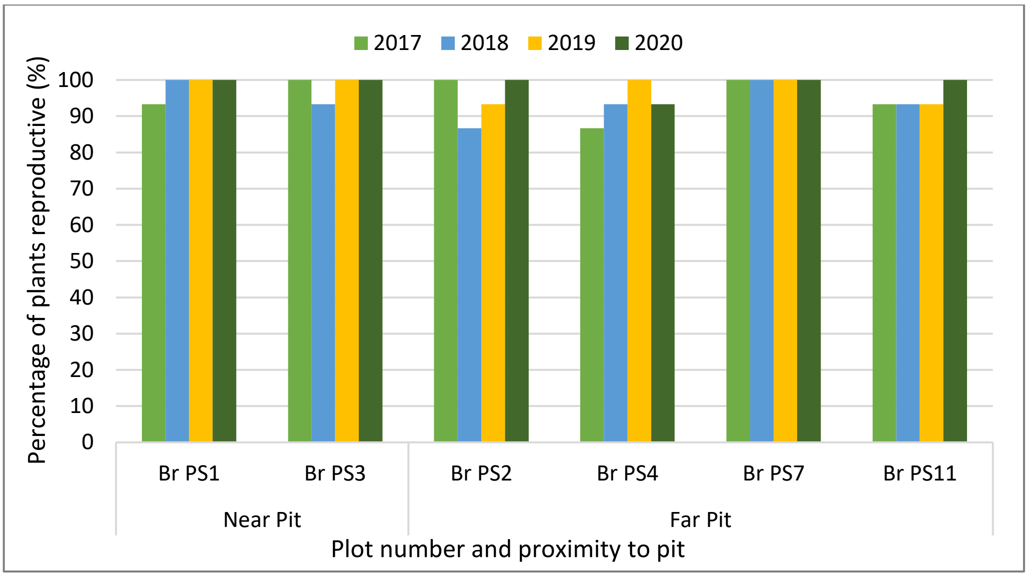

Figure 3.1: Percentage of *Beyeria rostellata* individuals recorded as reproductive 2017 – 2020.

The percentage of *Stenanthemum newbeyi* individuals recorded as reproductive in 2020 ranged from 83% to 100% and 80% to 100% in 2019. Two individuals in Plot PS3 were not found, including one which is assumed dead, and two individuals in Plot PS10 were dead. Dead individuals recorded prior to 2020 have not been included.

The percentage of reproductive *Stenanthemum newbeyi* individuals recorded each year in each plot is shown in Figure 3.2.

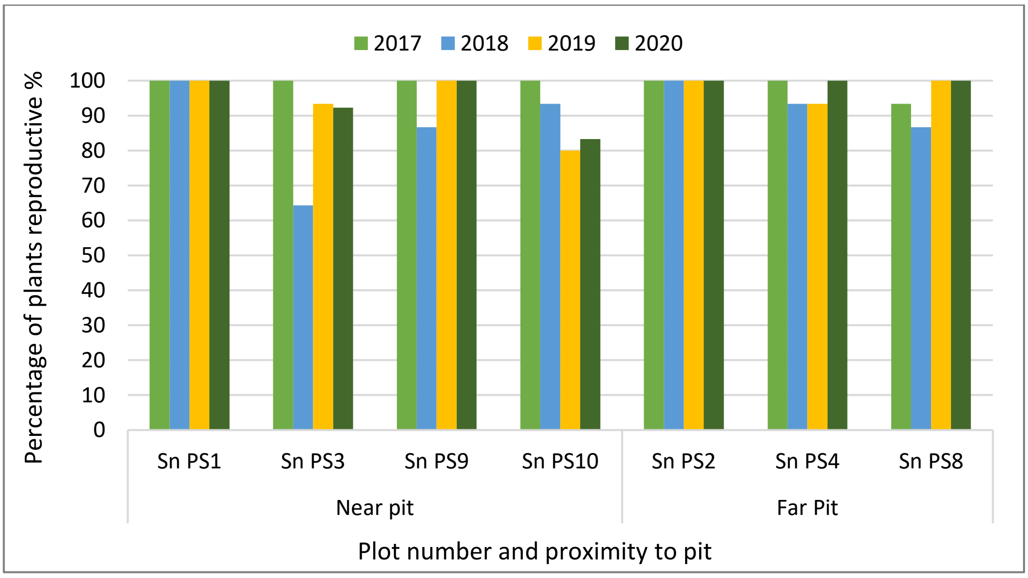

Figure 3.2: Percentage of *Stenanthemum newbeyi* individuals recorded as reproductive 2017 – 2020.

Figure 3.3 shows the percentage of monitored *Lepidosperma ferricola* individuals recorded as reproductive in each plot. All plots were recorded as 100% reproductive apart from Plot PS1 (93%) and Plot PS3 (73%). Plot PS3 (near-pit) has recorded the lowest proportion of reproductive individuals in all monitoring years.

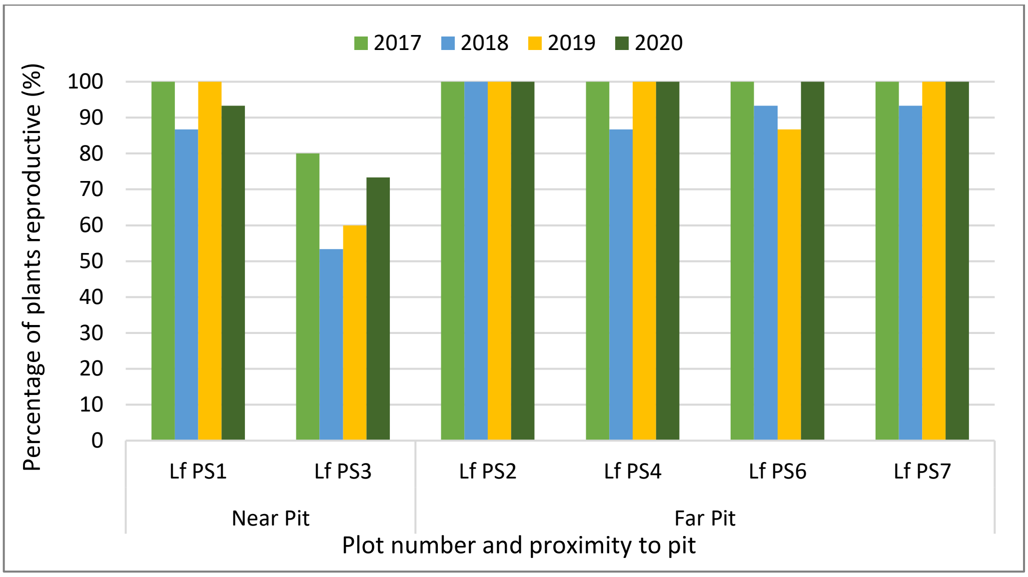

Figure 3.3: Percentage of *Lepidosperma ferricola* individuals recorded as reproductive 2017 – 2020.

All monitored *Hibbertia lepidocalyx* subsp. *tuberculata* individuals were reproductive in 2020, as shown in Figure 3.4.

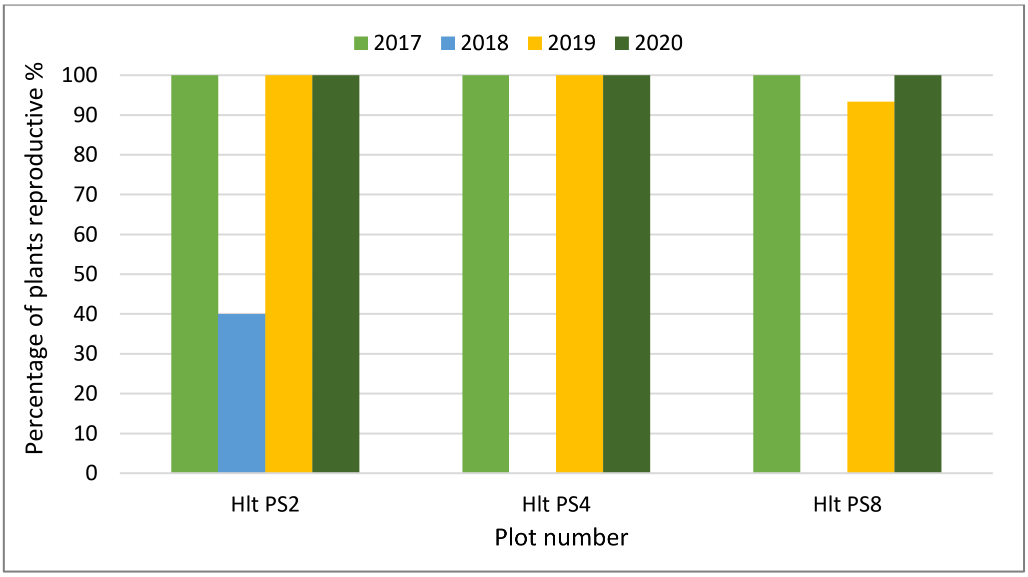

Figure 3.4: Percentage of *Hibbertia lepidocalyx* subsp. *tuberculata* individuals recorded as reproductive 2017 – 2020.

3.1.2 Condition Assessment

The average condition assessment (percentage of live growth) of *Beyeria rostellata* individuals ranged from 80% to 93% in 2020 and 84% to 91% in 2019, as shown in Figure 3.5. Plot PS3 (near-pit) has recorded the lowest average condition score across all years. All except two plots recorded a decrease in condition on 2019 results. Far-pit plots PS7 and PS11 recorded increased condition of approximately 2% compared to last year.

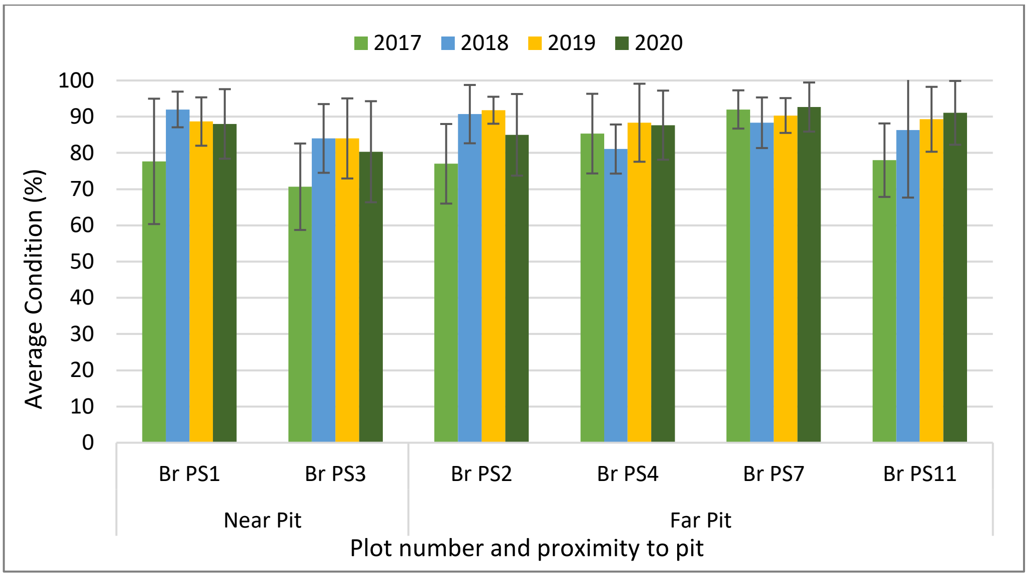

Figure 3.5: Average condition assessment with standard deviation of *Beyeria rostellata* in all plots 2017 - 2020.

Figure 3.6 presents the average condition assessment per plot for *Stenanthemum newbeyi*. Average condition ranged from 62% in Plot PS3 to 79% in Plot PS2. In 2019 average condition ranged from 64% in Plot PS1 to 81% in Plot PS8. Two plots, PS1 (near-pit) and PS2 (far-pit) recorded increased condition compared to 2019.

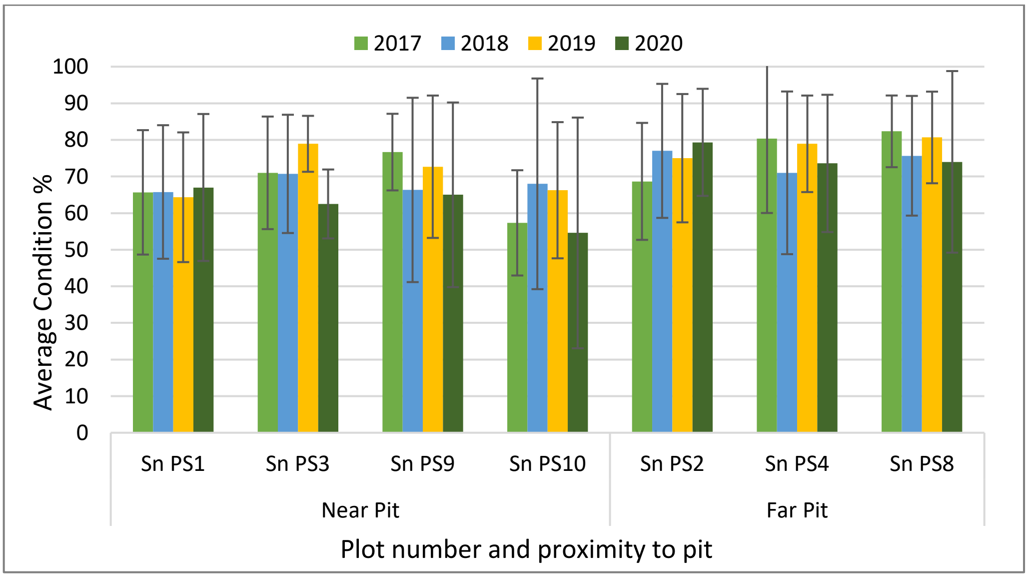

Figure 3.6: Average condition assessment with standard deviation of *Stenanthemum newbeyi* in all plots 2017 - 2020.

In 2020, average condition of *Lepidosperma ferricola* individuals was lower in all plots compared to 2019 as displayed in Figure 3.7. Average condition assessment scores ranged from 45% in Plot PS4 (far-pit) to 70% in Plot PS6 (far-pit) in 2020 and 50% in Plot PS4 to 78% in Plot PS6 in 2019. Plot PS4 has recorded the lowest average condition of *Lepidosperma ferricola* in all monitoring years.

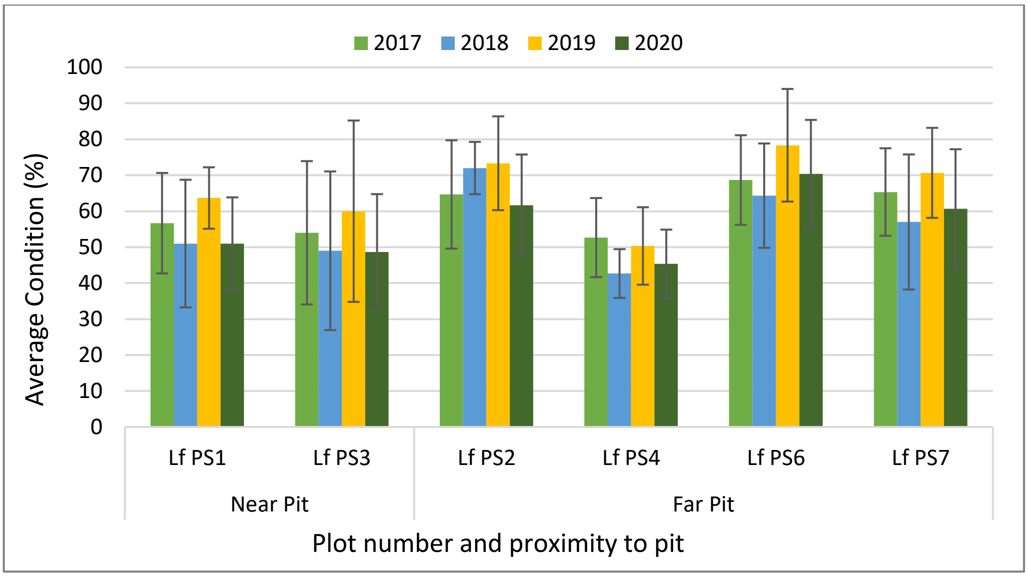

Figure 3.7: Average condition assessment with standard deviation of *Lepidosperma ferricola* in all plots 2017 - 2020.

The average condition of *Hibbertia lepidocalyx* subsp. *tuberculata* in 2020 ranged from 82% to 90% as shown in Figure 3.8. Two of the three plots recorded a marginal decrease in condition in 2020. Note that all *Hibbertia lepidocalyx* subsp. *tuberculata* plots are located far-pit.

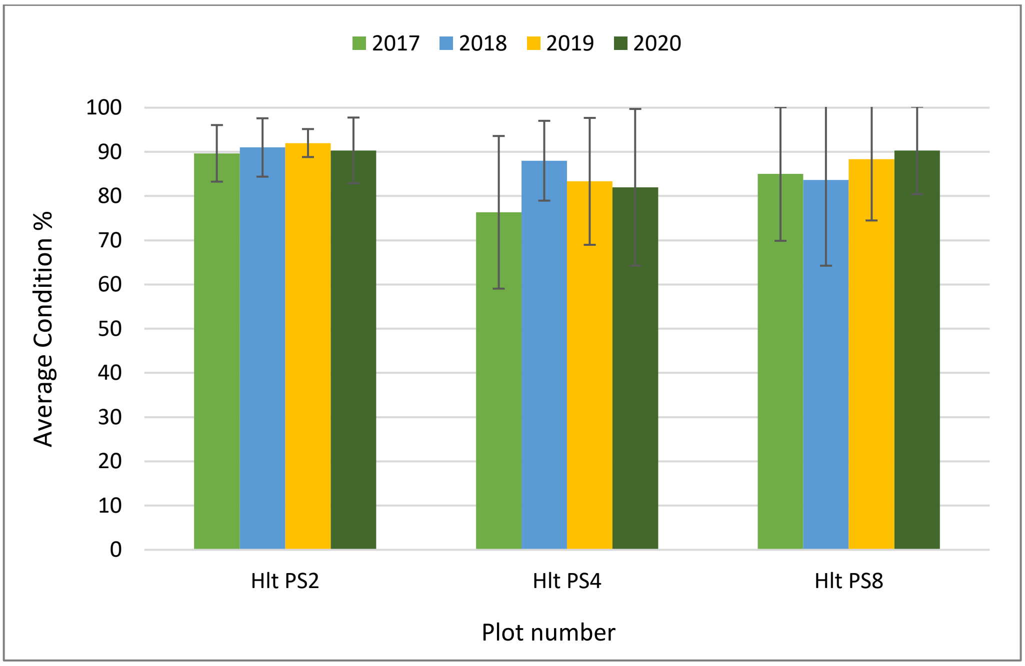

Figure 3.8: Average condition assessment with standard deviation of *Hibbertia lepidocalyx* subsp. *tuberculata* in all plots 2017 - 2020.

The average condition of the Priority species in near-pit plots and far-pit plots in 2019 and 2020 is displayed in Figure 3.9. *Banksia arborea* (Ba) individuals have been included although there are insufficient numbers of these individuals in each plot for statistical analysis.

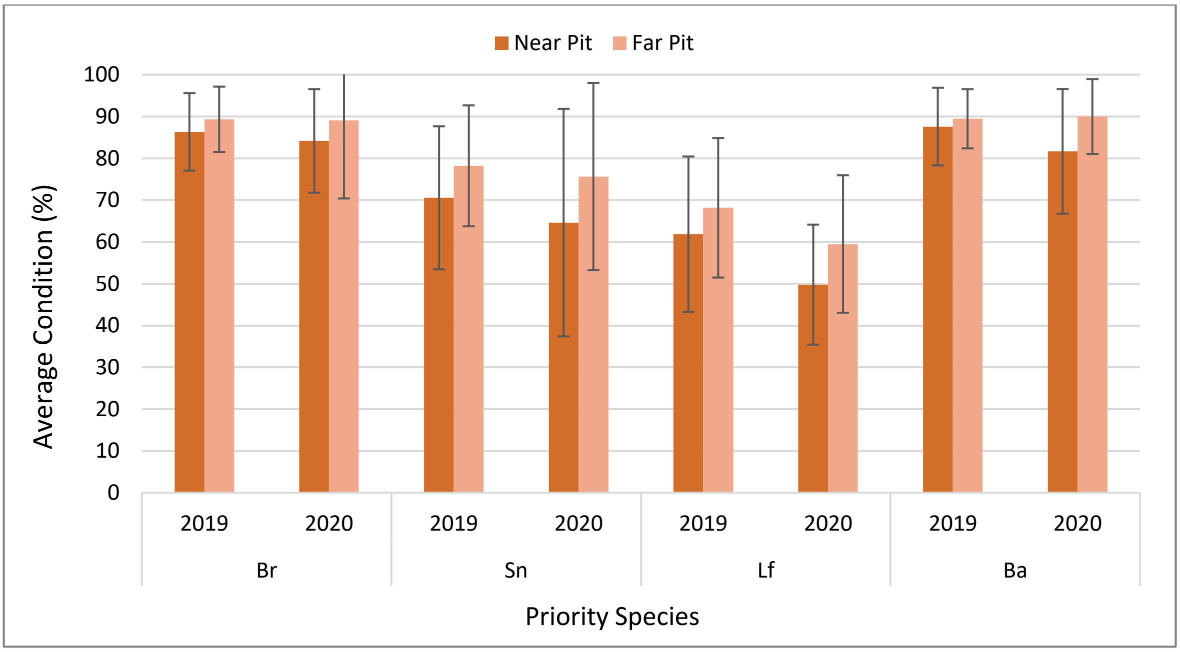

Figure 3.9: Average condition assessment with standard deviation of Priority species in near-pit and far-pit plots in 2019 and 2020.

3.1.3 Chlorophyll Fluorescence

Average chlorophyll fluorescence and standard deviation of *Beyeria rostellata* individuals in each plot for 2017 to 2020 is displayed in Figure 3.10. In 2020 average chlorophyll fluorescence ranged from 0.74 in Plot PS3 to 0.80 in Plot PS7. One plot, PS11 (far-pit), recorded lower chlorophyll fluorescence compared to the previous year.

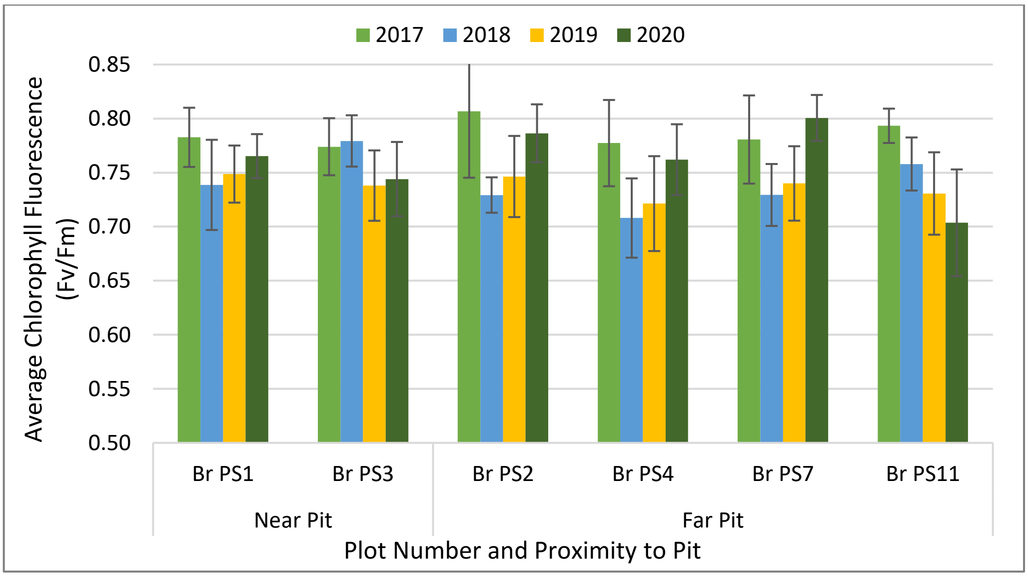

Figure 3.10: Average chlorophyll fluorescence with standard deviation of *Beyeria rostellata* in each plot 2017 – 2020.

Figure 3.11 shows the average chlorophyll fluorescence and standard deviation per plot for *Stenanthemum newbeyi* individuals for all monitoring years. There was little variation in average chlorophyll fluorescence across the plots in 2020. All plots recorded higher average chlorophyll fluorescence measurements than 2018 and 2019. The measurements in three near-pit plots showed marked increases compared to 2019. The readings in Plots PS3, PS9 and PS10 increased by 0.09 - 0.11.

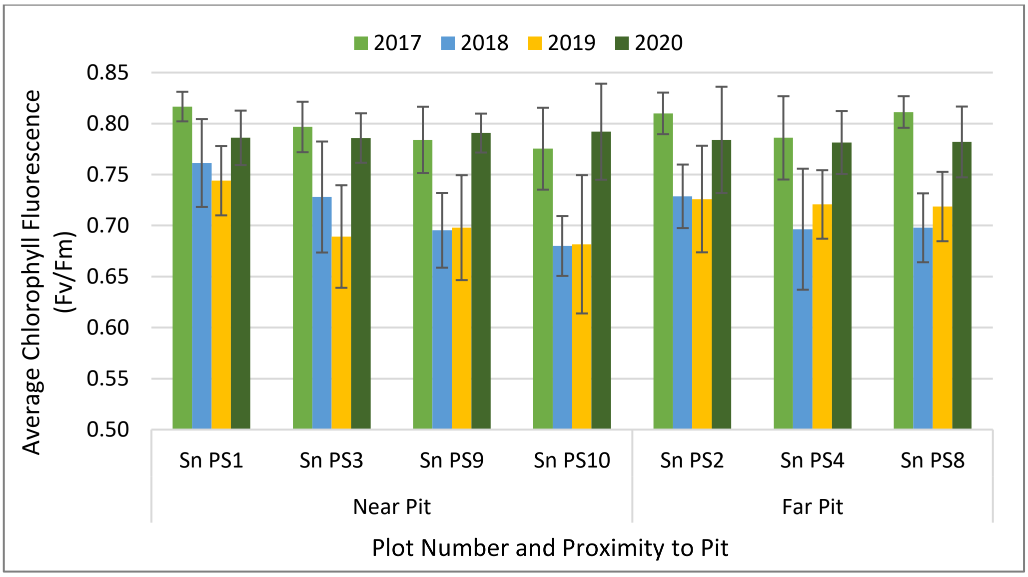

Figure 3.11: Average chlorophyll fluorescence with standard deviation of *Stenanthemum newbeyi* in each plot 2017 – 2020.

Average chlorophyll fluorescence for *Lepidosperma ferricola* individuals in all plots from 2017 to 2020 is displayed in Figure 3.12. Average chlorophyll fluorescence ranged from 0.75 to 0.78. All plots recorded higher average chlorophyll fluorescence than in 2018 and 2019.

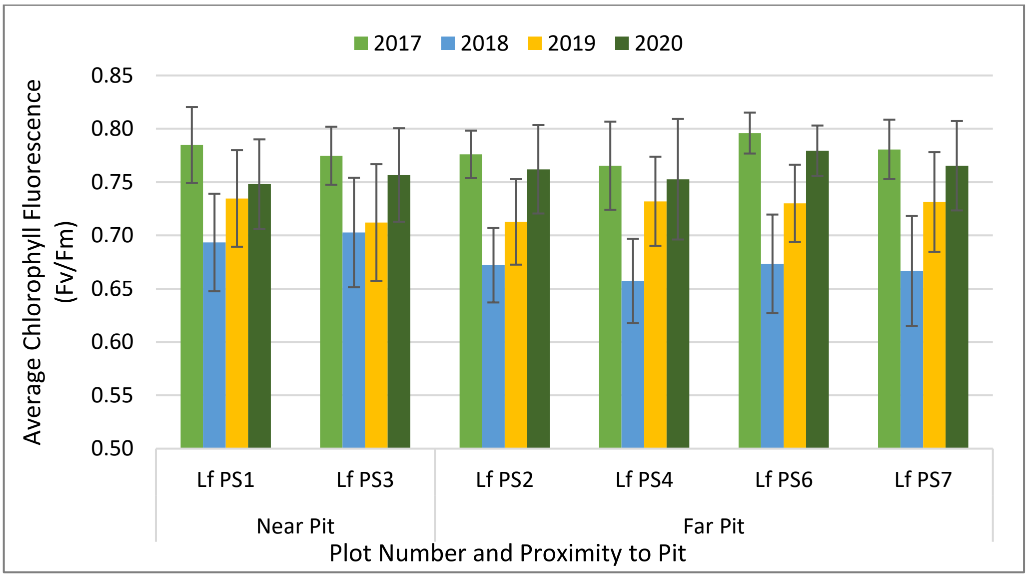

Figure 3.12: Average chlorophyll fluorescence with standard deviation of *Lepidosperma ferricola* in each plot 2017 – 2020.

Figure 3.13 shows the average chlorophyll fluorescence per plot for *Hibbertia lepidocalyx* subsp. *tuberculata* individuals. Average chlorophyll fluorescence values in 2020 ranged from 0.70 to 0.78 compared to a range of 0.68 to 0.72 in 2019. All plots recorded higher average readings than in 2019.

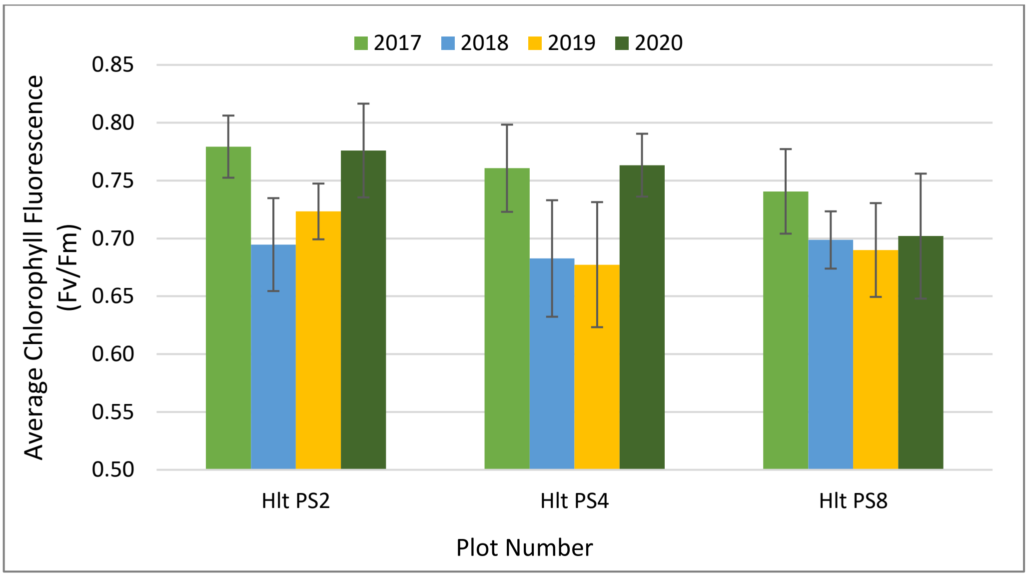

Figure 3.13: Average chlorophyll fluorescence with standard deviation of *Hibbertia lepidocalyx* subsp. *tuberculata* in each plot 2017 – 2020.

The average chlorophyll fluorescence of the Priority species in near-pit plots and far-pit plots is displayed in Figure 3.14. This shows an increase in chlorophyll fluorescence measurements for the three Priority species, *Beyeria rostellata, Stenanthemum newbeyi* and *Lepidosperma ferricola* in both near- and far-pit plots when compared to 2019 observations.

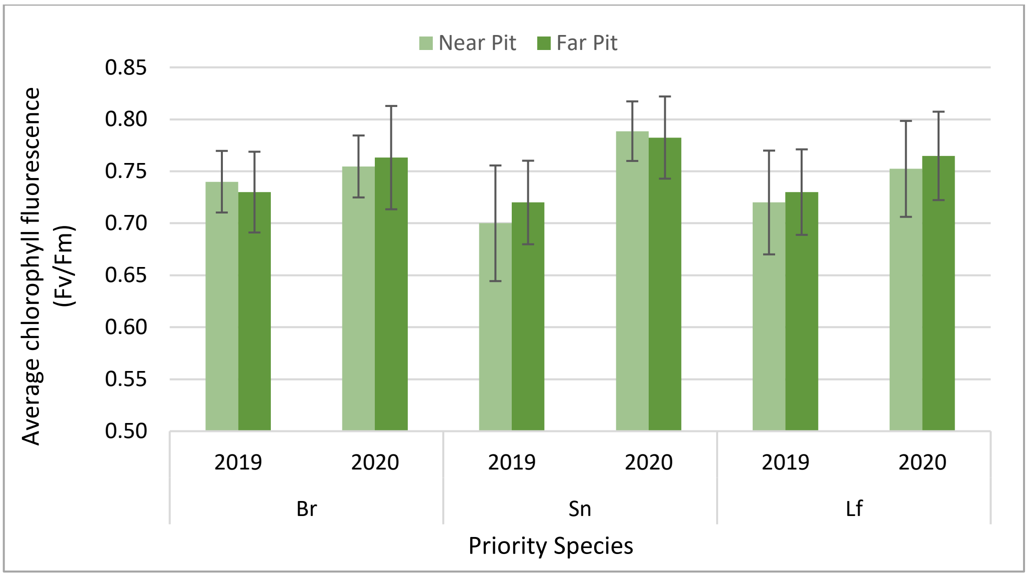

Figure 3.14: Average chlorophyll fluorescence with standard deviation of Priority species in near-pit and far-pit plots in 2019 and 2020.

3.1.4 Leaf Surface Dust

In 2020, leaf surface dust was recorded in all *Stenanthemum newbeyi* plots. Two far-pit plots, Plot PS2 and PS4, contained some individuals with no visible leaf surface dust. Plot PS9 (near-pit) recorded 100% of individuals with the highest cover of leaf surface dust, Dust Category 4 (76 - 100% covered). Plot PS8 (far-pit) recorded 40% of individuals with Dust Category 4 and 60% of individuals with Dust Category 3 (51 - 75% covered). Figure 3.15 displays the proportion of *S. newbeyi* individuals with leaf surface dust recorded in each plot and the dust category (as defined in Table 2.2) in 2019 and 2020.

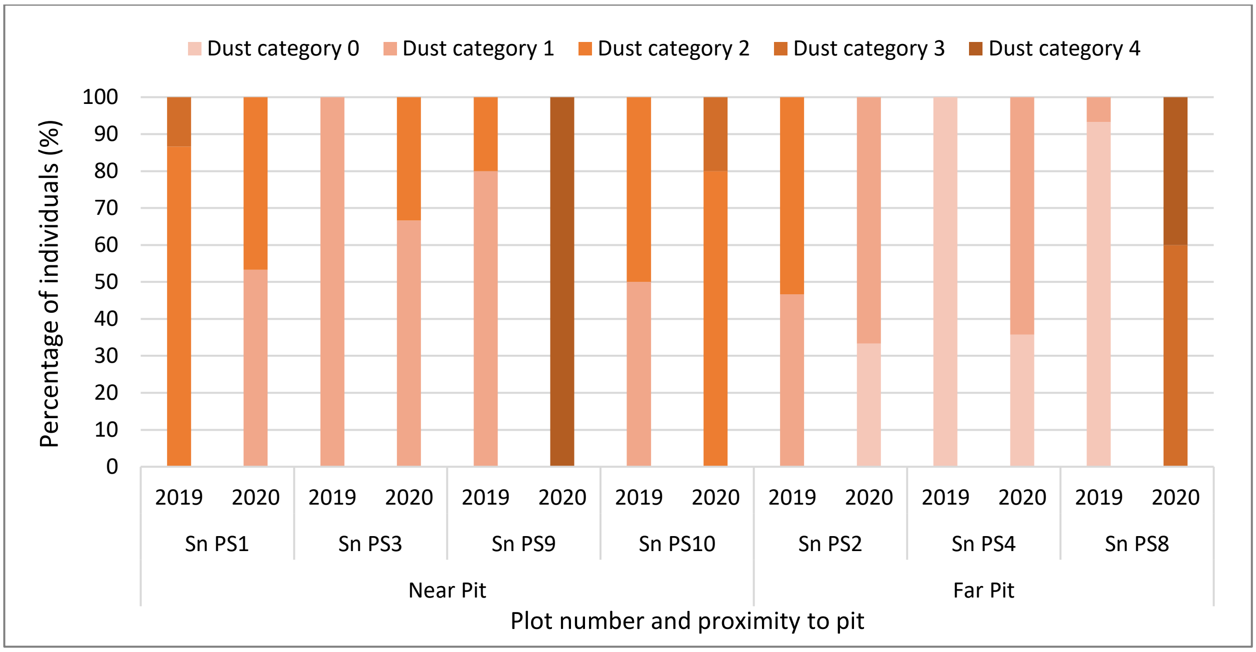

Figure 3.15: Leaf surface dust on *Stenanthemum newbeyi* in each plot in 2019 and 2020.

In 2020, leaf surface dust was recorded in all *Beyeria rostellata* monitoring plots with the exception of far-pit Plots PS2 and PS4. Plot PS11 (far-pit) recorded 14.3% of individuals with leaf surface Dust Category 2 (26 – 50% covered) and 85.7% of individuals with Dust Category 1 (1 – 25% covered). Plot PS4 recorded no visible leaf surface dust in 2020 or 2019, as displayed in Figure 3.16.

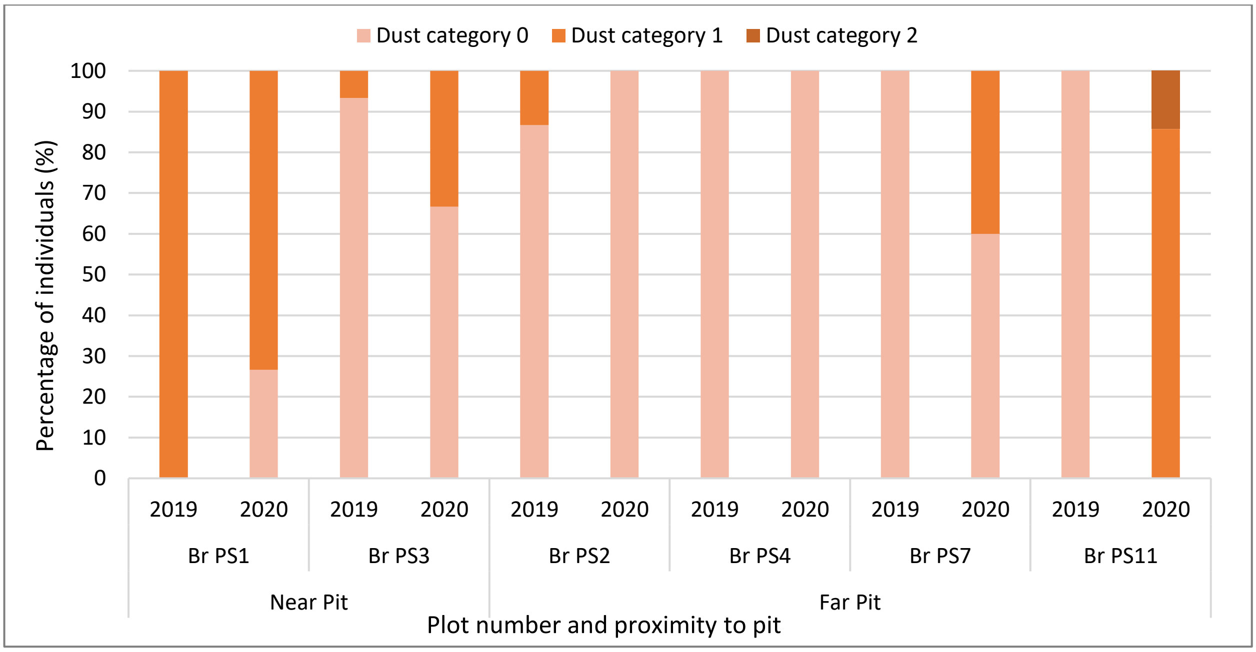

Figure 3.16: Leaf surface dust on *Beyeria rostellata* in each plot in 2019 and 2020.

No visible leaf surface dust was recorded on any of the *Lepidosperma ferricola* in 2020. In 2019 no visible leaf surface dust was recorded on any *Lepidosperma ferricola* or *Hibbertia lepidocalyx* subsp. *tuberculata* individuals in any plot and in 2018 no visible leaf surface dust was recorded on any individuals in any plot.

3.1.5 Mortality

A total of 18 dead individuals were recorded in eight plots in 2020, as shown in Figure 3.17. Of these, four *Stenanthemum newbeyi* (Sn) were recorded as dead in 2020. The remaining *S. newbeyi*, *Beyeria rostellata* (Br) and *Banksia arborea* (Ba) individuals were recorded as being dead in 2018 and 2019. Plot PS10 has the highest total number of dead individuals, with five dead *S. newbeyi*. Note that Plots PS5 and PS12 are not included in the statistical analysis data but contain *B. arborea* individuals.

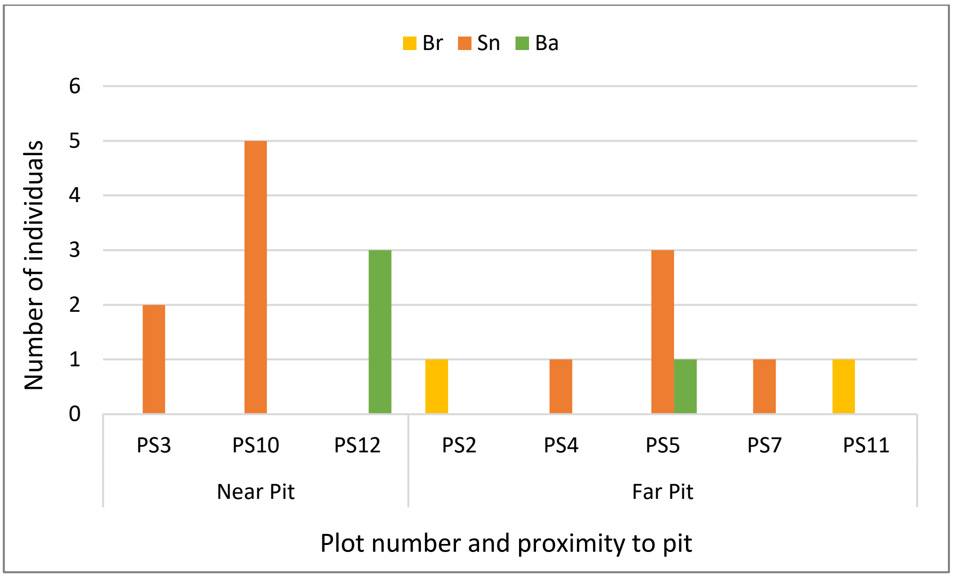

Figure 3.17: Number of dead individuals recorded in monitoring plots in 2020.

3.1.6 Statistical Analysis

Statistical analysis has not yet been run on the 2020 Priority flora monitoring data due to an error in the data analysis tool. The analysis will be conducted when the tool has been repaired by DAA and the updated results will be reported in the 2021 annual monitoring report. .

3.2 Native Vegetation

3.2.1 Vegetation Condition

Table 3.1: Vegetation condition in each plot.Table 3.1 presents the results of the vegetation condition monitoring for all years of monitoring. In 2020 the monitoring plots were ranked from ‘Poor’ to ‘Excellent’, as defined by Keighery (1994). Vegetation condition in Plot PS3 has declined from a ranking of Excellent in 2017 to Poor in 2020. Plot PS9 and PS12 have also recorded a decline from Excellent in 2017 to Good in 2020.

Table 3.1: Vegetation condition in each plot.

Plot Number	Proximity to Pit	2017	2018	2019	2020
PS1	Near pit	Excellent	Excellent	Excellent	Excellent
PS2	Far pit	Excellent	Excellent	Excellent	Very good
PS3	Near pit	Excellent	Good	Good	Poor
PS4	Far pit	Excellent	Excellent	Excellent	Excellent
PS5	Far pit	Excellent	Very good	Excellent	Good – very good
PS6	Far pit	Excellent	Excellent	Excellent	Excellent
PS7	Far pit	Excellent	Very good	Excellent	Excellent
PS8	Far pit	Very good	Very good	Very good	Very good
PS9	Near pit	Excellent	Very good	Very good	Good
PS10	Near pit	Very good	Very good	Very good	Very good
PS11	Far pit	Excellent	Very good	Excellent	Very good
PS12	Near pit	Excellent	Very good	Good	Good

3.2.2 Species Richness and Abundance

Total species richness in each plot (number of species per plot) from 2017 to 2020 is shown in Figure 3.18.

Species richness in 2020 ranged from 20 species in Plots PS5 (far-pit) and PS9 (near-pit) to 41 species in Plot PS12 (near-pit). In 2019 the minimum and maximum number of species was slightly higher, ranging from 24 species in Plot PS9 to 44 species in Plot PS12. Plot PS9 continues to record the lowest species richness, with an average of 19 species over four years while Plot PS12 has the highest species richness in all years, recording an average of 36 species. Plot PS3 recorded the largest decline in species richness, from 38 species in 2019 to 24 species in 2020. Compared to 2019 species richness decreased in eight plots, increased in three plots and remained the same in one plot. In 2020 a total of 10 native annual species were recorded.

Figure 3.19 displays the average species richness of combined near-pit and far-pit plots from 2017 – 2020. Overall the plots nearer the pits have a slightly higher species richness compared to plots further from the pits.

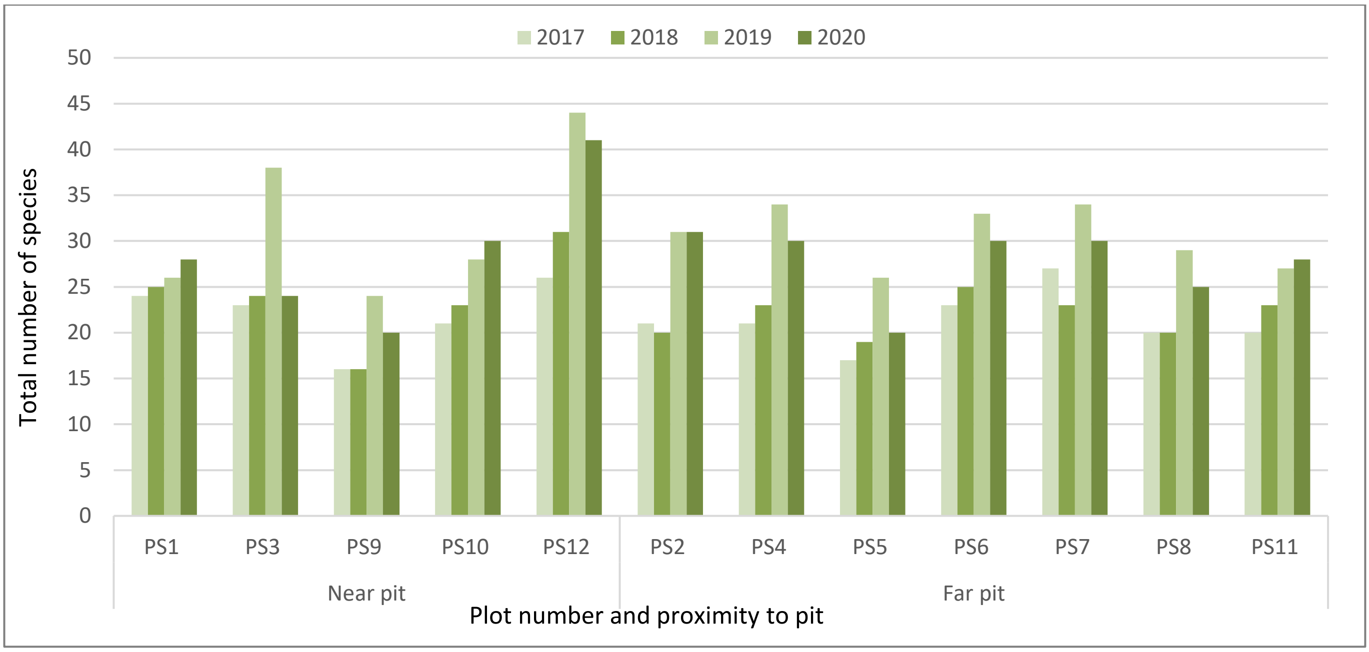

Figure 3.18: Total species richness per plot 2017 - 2020.

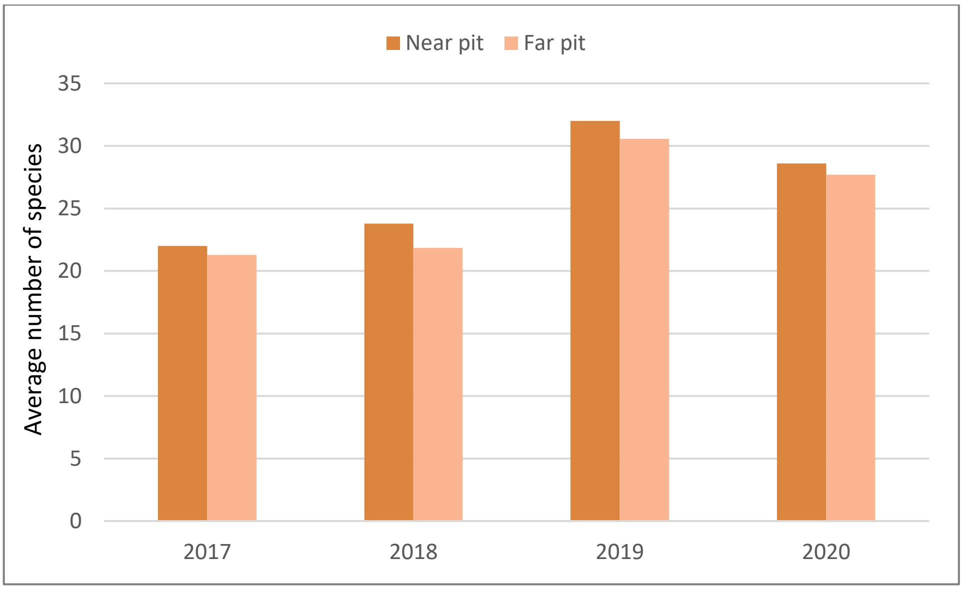

Figure 3.19: Average species richness in near- and far-pit plots 2017 – 2020.

The average number of live adult individuals in 2020 ranged from 8.8 in Plot PS5 (far-pit) to 41.3 in Plot PS12 (near-pit), as shown in Figure 3.20. There was a decrease in the average number of individuals in seven of the plots compared to 2019 results. Plot PS5 has recorded the lowest number of individuals in all years of monitoring.

The average number of live adults in combined near-pit plots was marginally higher than far-pit plots from 2017 – 2019 as displayed in Figure 3.21. In 2020 the number of live adults was virtually the same in both near and far-pit plots.

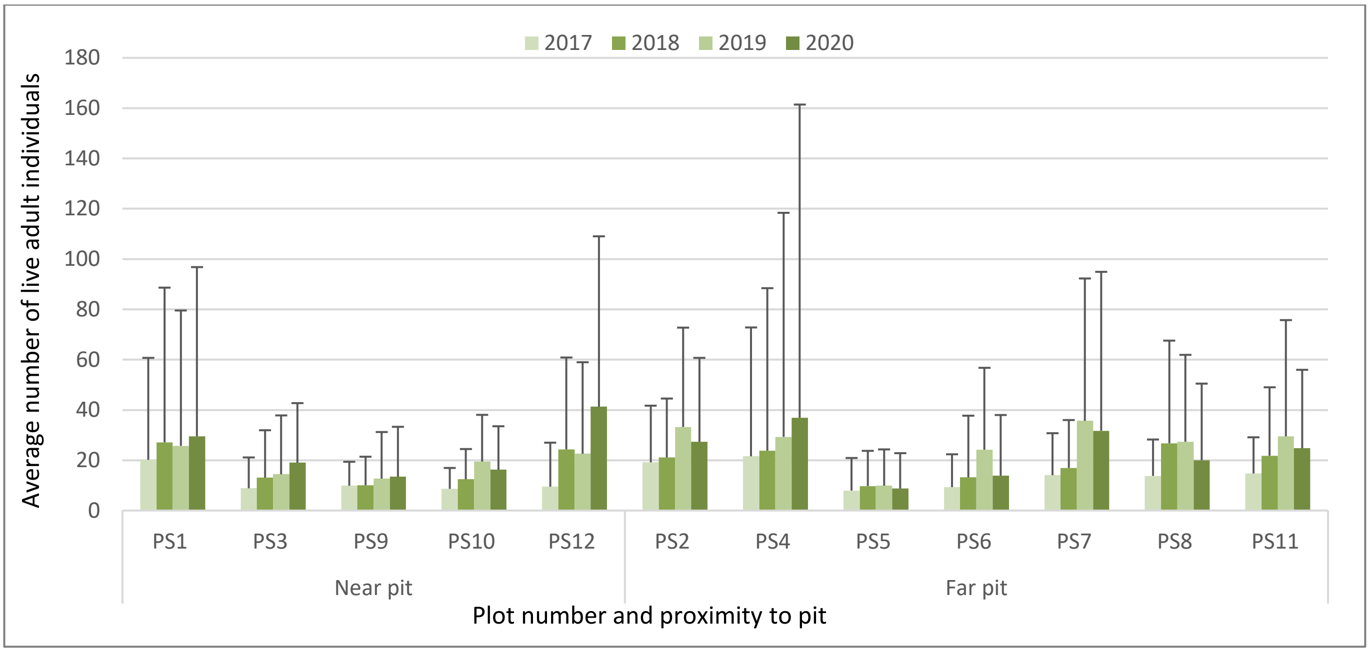

Figure 3.20: Average number of live adult plants per plot, with standard deviation, 2017 – 2020.

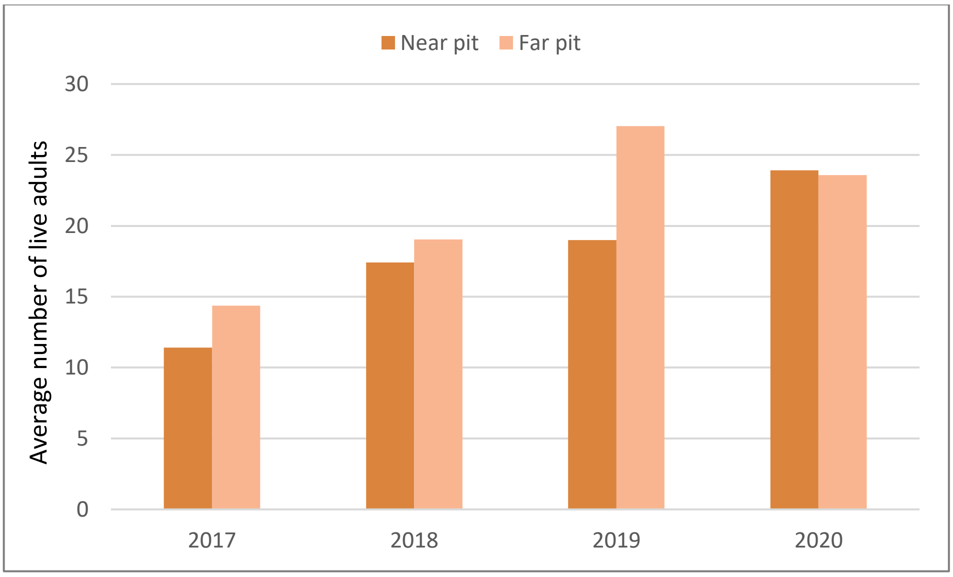

Figure 3.21: Average number of live adult individuals in near- and far-pit plots 2017 – 2020.

3.2.3 Recruitment and Mortality

The number of seedlings recorded during the native vegetation monitoring in 2020 ranged from four seedlings in Plot PS9 (near-pit) to 357 seedlings in Plot PS12 (near-pit). Two hundred and eighty-six (286) of the seedlings in Plot PS12 were *Ptilotus obovatus* and 45 were *Rhagodia drummondii.* Plot PS9 has recorded the lowest number of seedlings for all monitoring years. The number of seedlings recorded in each plot in 2017 to 2020 is displayed in Figure 3.22.

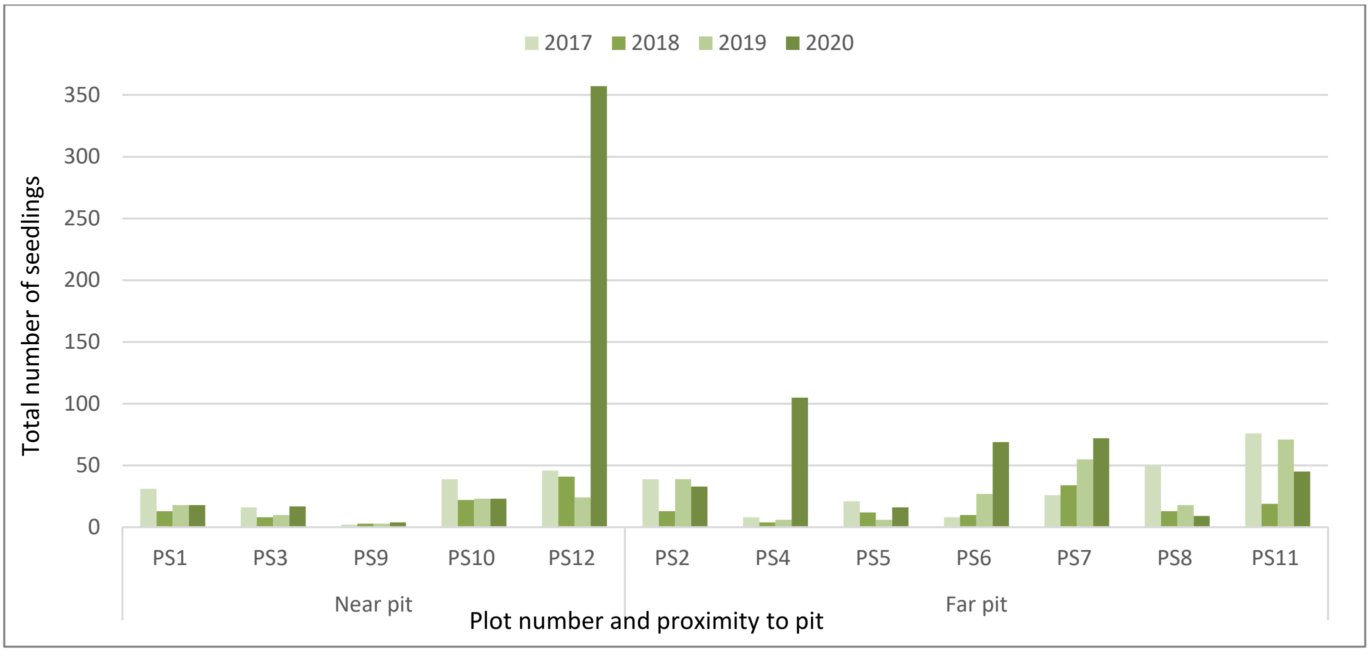

Figure 3.22: Total number of seedlings in each native vegetation monitoring plot 2017 – 2020.

In 2020, the native vegetation monitoring plots with the highest number of dead individuals were Plot PS7 (far-pit) which recorded 325 dead individuals and Plot PS11 (far-pit) which recorded 265 dead individuals. The large number of dead individuals in these plots is mainly attributable to the annual species *Drosera macrantha.*

Figure 3.23 displays the numbers of dead individuals recorded in each native vegetation plot in 2017 to 2020.

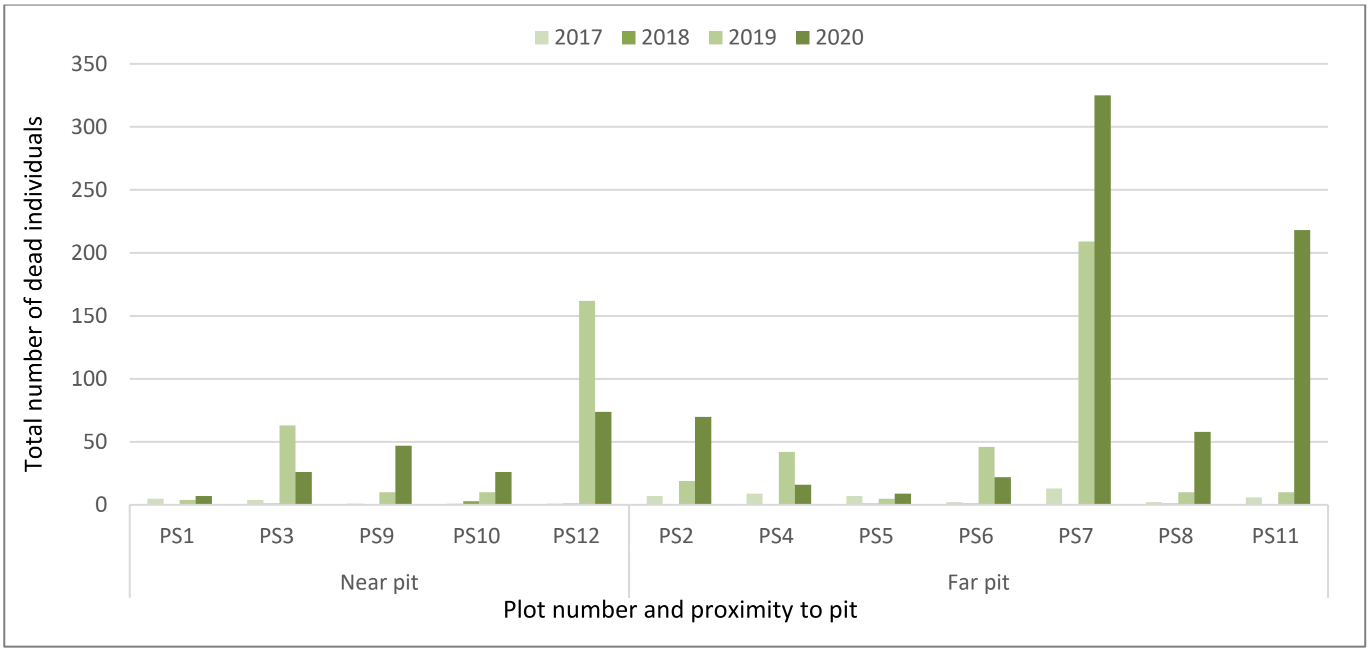

Figure 3.23: Total number of dead individuals in each plot 2017 – 2020.

3.2.4 Weeds

Five weed species, *Carrichtera annua* (Wards weed), ?*Hordeum glaucum* (Northern barley grass), *Monoculus monstrosus* (Stinking Roger), *Sonchus oleraceus* (Common sow thistle) and ?*Ursinia anthemoides* were recorded in 2020. All five weed species were recorded in Plot PS12 and one *Carrichtera annua* seedling was recorded in Plot PS6.

3.2.5 Statistical Analysis

Statistical analysis has not been run on the 2020 native vegetation monitoring data due to an error in the data analysis tool. The analysis will be conducted when the tool has been repaired by DAA and the updated results will be reported in the 2021 annual monitoring report.

3.3 Rainfall

In the 12 months prior to the 2020 monitoring (October 2019 – September 2020), Koolyanobbing recorded 242.8 mm of rain. The 2001-2020 average annual rainfall for Koolyanobbing is 271.6 mm (BoM 2020).

Figure 3.24 shows the total monthly rainfall received at Koolyanobbing in 2020 and the three previous years, as well as the 2001-2020 monthly average. Below average rainfall was recorded during nine months of 2019-2020 monitoring period with above average rainfall occurring in February, July and August.

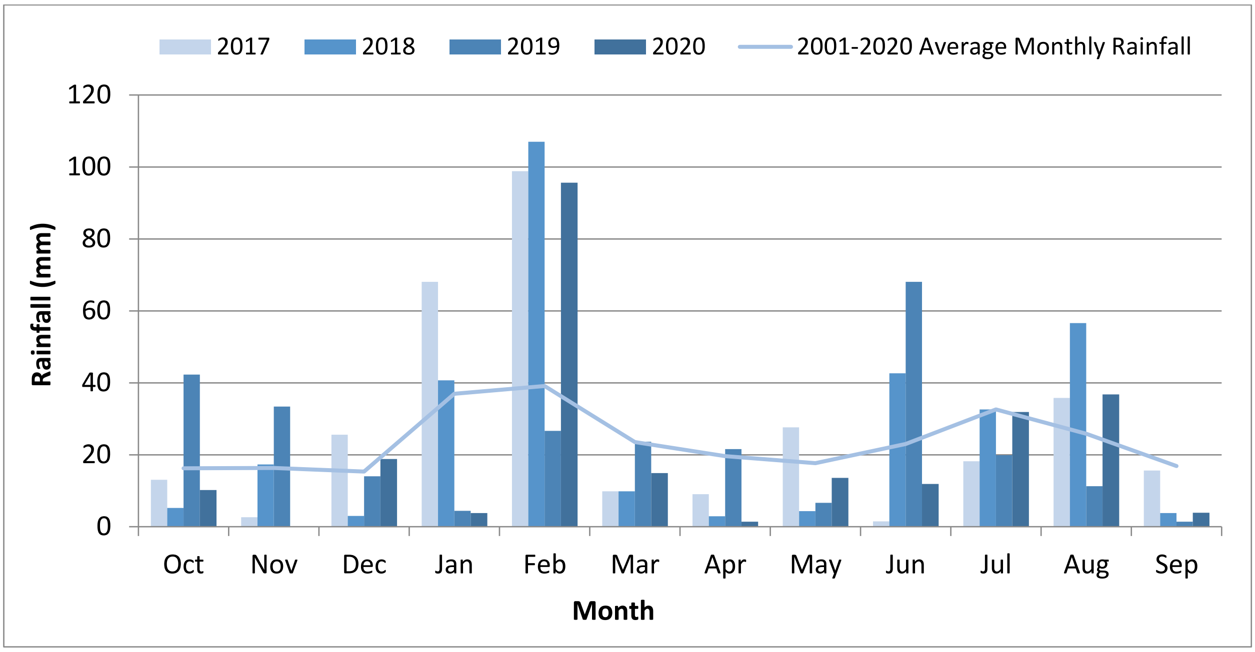

Figure 3.24: Monthly rainfall 2017 – 2020 and 2001 – 2020 monthly average rainfall at Koolyanobbing.

4.0 DISCUSSION AND CONCLUSION

The 2020 monitoring is the fourth year of monitoring the Priority flora and vegetation at F deposit. Mining activities commenced at F pit in May 2017 and ceased in April 2018. Mining resumed in early December 2018. Overall, the results of the 2020 monitoring indicate that the Priority flora and native vegetation populations in the F pit area are maintaining their condition. However, some patterns may be emerging that indicate potential impacts to flora and vegetation in some plots.

The majority of monitored Priority flora were found to be reproductive in 2020. All monitored *Stenanthemum newbeyi* individuals were reproductive. There were four new *S. newbeyi* deaths recorded in 2020. All *Beyeria rostellata* were recorded as reproductive except one individual in far-pit plot PS4. Of the *Lepidosperma ferricola* plots, near-pit plot PS3 has recorded the lowest percentage of reproductive individuals in all monitoring years. A recovery was demonstrated in 2020 with 73% recorded as reproductive following 60% in 2019 and 53% in 2018. The *Hibbertia lepidocalyx* subsp. *tuberculata* plots displayed good reproductive results, with 100% of individuals fruiting.

Following the observation during monitoring last year that at least one *Hibbertia lepidocalyx* subsp. *tuberculata* individual was actually another very similar species, *Hibbertia exasperata* (Hlt 31 in Plot PS4) all tagged *Hibbertia* individuals were checked for correct identification. Identification of the two species is difficult when not flowering however most were flowering in 2020. Six *Hibbertia exasperata* individuals were found to have been incorrectly identified as *H. lepidocalyx* subsp. *tuberculata* and were subsequently replaced by individuals of the correct priority species.

Overall, the average condition assessment for Priority flora species in 2020 decreased compared to 2019. The 2020 average condition assessment in all plots located less than 50m from the pit show consistent lower condition compared to the plots further than 50m from the pit for *Beyeria rostellata, Stenanthemum newbeyi* and *Lepidosperma ferricola* as well as *Banksia arborea* (Figure 3.9).

Average condition assessment results of *Beyeria rostellata* measured over 80% live material. Plot PS3, located near the pit, has recorded the lowest condition for all monitoring years. All plots except two far-pit plots (Plots PS7 and PS11) recorded decreased condition compared to 2019.

The average condition of *Stenanthemum newbeyi* varied from 54.6% in Plot PS10 (near-pit) to 79.3% PS2 (far-pit). All *Stenanthemum newbeyi* plots had decreased condition compared to 2019 except one near-pit plot (Plot PS1) and one far-pit plot (Plot PS2). In 2020, near-pit plots had lower average condition compared to far-pit plots, as has been the case all years since 2017.

The average condition of *Lepidosperma ferricola* ranged from 45.3% to 70.3% in 2020. Average condition in all *Lepidosperma ferricola* plots was lower than in 2019. *Hibbertia lepidocalyx* subsp. *tuberculata* individuals recorded good average condition in all plots, ranging from 82% – 90%. Two plots had marginally lower condition and one plot marginally higher condition in 2020 compared to 2019.

The average chlorophyll fluorescence across all Priority flora plots in 2020 was higher compared to the two previous years. The average reading for all Priority individuals was 0.77 in 2020, 0.72 in 2019 and 0.71 in 2018. The average recorded in 2017 was 0.78. Average chlorophyll fluorescence results for all species in all plots with the exception of one plot, were higher in 2020 than in 2019. The average chlorophyll fluorescence of *Beyeria rostellata* in Plot PS11, a far-pit plot, decreased compared to all previous years and is the lowest average chlorophyll fluorescence recorded for *B. rostellata* across all plots and all years. The average chlorophyll fluorescence of *Stenanthemum newbeyi* and *Lepidosperma ferricola* in all plots was higher than in 2018 and 2019 but marginally lower than in 2017.

After four years of monitoring, there is no apparent pattern between chlorophyll fluorescence and proximity to pits. Higher average chlorophyll fluorescence readings have been recorded in far-pit plots for *S. newbeyi* in 2017 and 2019, *B. rostellata* in 2017 and 2020 and *L. ferricola* in 2019 and 2020. The reverse was true in the other years.

Various literature indicates that optimal chlorophyll fluorescence (Fv/Fm) readings, associated with healthy non-stressed plants, can range from around 0.75 to 0.84, and values around 0.6 are indicative of severe plant stress (Maxwell and Johnson 2000; Percival 2005; Ritchie 2006). These values can vary across different species however, the 2017 results, with average chlorophyll fluorescence ranging from 0.74 – 0.82, reflect the potential if not optimal results for these species. Lower results were recorded in 2018 and 2019 but there was improvement in 2020.

Leaf surface dust monitoring indicates that those plots with the highest recorded levels of observed leaf surface dust are from *S. newbeyi* in Plot PS9, in which 100% of individuals displayed dust levels of Category 4. Plot PS8 displayed 40% of dust Category 4 and 60% Category 3. Plot PS10 recorded Category 2 and 3 dust levels. Leaf surface dust was recorded in all *S. newbeyi* plots and Category 1 and 2 dust levels were recorded on *B. rostellata* in plot PS11. No visible leaf surface dust was recorded on any of the *Lepidosperma ferricola* in 2020.

Observations of dust levels in the field indicate that Plots PS3, PS8, PS9, PS10, PS11 and PS12 were visibly dusty. Plot PS8 was recorded as "very dusty" and PS9 "covered in dust". For the purposes of comparison, Plot PS8 is considered a far pit plot in 2020. However, development of F1 pit commenced in June 2020 and Plot PS8 is now within 50 m of the F1 pit boundary. As such there were approximately four months (June to September) prior to the annual monitoring event where it was near the F1 pit boundary, which is likely to account for the high observed dust levels in this plot.

Overall, the 2020 native vegetation monitoring found the vegetation around F pit to be in a generally healthy condition, with most plots ranked 'Good' to 'Excellent' as defined by Keighery (1994). Four plots, Plots PS2, PS3, PS5 and PS9 had a reduced condition ranking compared to 2019. The near-pit plot, PS3, was ranked 'Poor' in 2020 and has displayed a decline from 'Excellent' in 2017. Observations recorded during the monitoring event indicate that Plot PS3 was dusty, contained fly rock and damaged vegetation. These observations have been noted in previous years for this plot and near-pit plot PS12 which recorded a vegetation condition of 'Good" in 2020 which is consistent with 2019 but reduced from 2017. These plots are close to mining activity and monitoring suggests a trend of dusty conditions and vegetation damage.

Compared to 2019, species richness decreased in eight plots and remained the same in one plot. Plot PS3 recorded the largest decline in species richness, from 38 species in 2019 to 24 species in 2020. This is mainly due to the presence of more annual and short lived species in 2019. There were 10 native annual species in 2020, compared to 16 in 2019. The number of annuals is likely to be closely related to the timing and amount of rainfall. In seven plots there was a decrease in the number of live adults compared to 2019.

A large portion of the dead individuals recorded in 2020 are the species, *Cheilanthes sieberi* subsp. *sieberi* (24 dead in Plot PS7; 55 dead in Plot PS12) and *Drosera macrantha* (285 dead recorded in Plot PS7; 200 dead in Plot PS11). *Cheilanthes sieberi* subsp. *sieberi* is a rhizomatous herb or fern and *Drosera macrantha* is a tuberous perennial herb or climber, both species are known to die off in dry conditions. Apart from annuals or short-lived species, the most notable number of deaths was 21 dead recorded for *Allocasuarina acutivalvis* subsp. *acutivalvis* in Plot PS2. This plot also contains 80 live adult *Allocasuarina* individuals and six seedlings so the mortality recorded may be due to natural "thinning out" of the population.

Most of the data suggests that the Priority and vegetation populations in the F pit area are relatively healthy. There is no apparent pattern between chlorophyll fluorescence and proximity to pits and average chlorophyll fluorescence is within a healthy range. However, condition assessment, on average, has displayed a decline in 2020 and plots nearer the pits have a lower average condition than those plots further from the pits. Further conclusions will be reached when the statistical analysis is conducted on the Priority flora and native vegetation monitoring data.

4.1 Comparisons against trigger and threshold criteria

The Yilgarn Operations Koolyanobbing Range F Deposit Flora and Vegetation Management Plan (MRL 2019) outlines trigger and threshold criteria that require further reporting and contingency actions. The following section compares the results of the monitoring against the relevant criterion.

4.1.1 Trigger Criteria

Monitoring of Priority species indicates a statistically significant relationship between condition (chlorophyll fluorescence and/or % live material) and dust deposition, distance from the proposal boundary or mine related causal factor.

Statistical analysis of the Priority flora data is yet to be conducted. The analysis will be run when the statistical analysis tool is repaired and findings reporting in the 2021 annual monitoring report.

4.1.2 Threshold Criteria

Monitoring of Priority species and/or native vegetation indicates a statistically significant relationship between mortality, dust deposition, distance from the proposal boundary or mine related causal factor.

Statistical analysis of the Priority flora and native vegetation data is yet to be conducted. The analysis will be run when the statistical analysis tool is repaired and findings reporting in the 2021 annual monitoring report.

4.2 Recommendations and requirements for 2021 monitoring

Vegetation monitoring plot design

The large size of the vegetation monitoring plots and the requirement to count all individuals in the plot contains inherent errors and is difficult to maintain consistency year on year. A more effective monitoring design would be to divide the plot into more manageable transects or subplots. This method can be implemented in 2021 if approved by MRL.

Selection of individuals for statistical analysis

In order for there to be sufficient numbers for statical analyses, more individuals need to be selected to replace those that have died. The numbers will be reviewed prior to the 2021 monitoring but a preliminary count suggests the following additional individuals need to be selected and tagged:

Plot PS3 - Sn x3

Plot PS4 - Sn x1

Plot PS10 - Sn x5

Plot PS2 - Br x1

Plot PS11 - Br x1

5.0 REFERENCES

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Attachment 7: Ecotec (WA) Pty Ltd Annual *Tetratheca erubescens* Monitoring 2020 (Revision 0)

2020 Annual *Tetratheca erubescens* Monitoring Report

September 2020

Revision A. 08-04-2021

Prepared by
Ecotec (WA) Pty Ltd for

Mineral Resources Ltd
1 Sleat Rd, Applecross, WA 6153
Koolyanobbing Operations.

Environmental solutions for MINING OIL & GAS CONSTRUCTION

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APPENDICES

1.0 INTRODUCTION

Mineral Resources Ltd (MRL) operations include iron ore mines at the Koolyanobbing Range, Mt Jackson Range and Windarling Range in the Yilgarn region, ore processing at Koolyanobbing, and road and rail transport between these operations and the Port of Esperance where the processed ore is exported to international customers. These operations were acquired by MRL from Cliffs Asia Pacific Iron Ore Pty Ltd (Cliffs) in 2018.

Tetratheca erubescens is a small shrub growing to approximately 0.5m tall that grows on banded ironstone ridges and cliffs on the southern Koolyanobbing range. The only recorded population of the species occurs at the Koolyanobbing Range. *T. erubescens* is declared as Threatened Flora under the Western Australian Biodiversity Conservation Act 2016. The population of *T. erubescens* at the Koolyanobbing Range prior to mining was approximately 6321 individuals (Maia 2013) and was estimated at approximately 6222 after commencement of mining.

The F Deposit mining operation was approved in January 2017 under the Environmental Protection Act 1986 (Minister for the Environment and Heritage 2017). Under this approval, a Condition Environmental Management Plan was developed and implemented. This EMP outlines provisions to address indirect impacts of factors including, but not limited to, dust, weeds and fire on native flora and vegetation (including *Tetratheca erubescens*) (MRL 2019). Cliffs commenced mining at the southern Koolyanobbing Range (F Pit) during May 2017 and continued until April 2018. MRL recommenced mining at F Pit in January 2019 and continue to mine up to the present time.

A monitoring program to evaluate defined monitoring plots along the Koolyanobbing Range, in order to assess the stability and condition of the *Tetratheca erubescens* population, was implemented in 2017. Annual monitoring has been conducted by Ecotec (WA) Pty Ltd (Ecotec) in 2018, 2019 and 2020. This report documents and discusses the results of the 2020 monitoring, the fourth annual monitoring event since mining commenced.

2.0 METHODOLOGY

2.1 Monitoring Design

The monitoring design utilised by MRL has been adopted from that previously developed by Cliffs in consultation with Data Analysis Australia (DAA), with the aim of capturing changes in population dynamics (DAA 2015).

2.2 Initial Monitoring

Following the recommended design outlined by DAA, 10 plots (3, 5, 7, 9, 10, 11, 14, 16, 18 and 21) were monitored along the Koolyanobbing Range in 2015. These plots were randomly selected following the process outlined by DAA (2015). Figure 2.1 displays the plot locations and the recorded distribution of *T. erubescens* along the Koolyanobbing Ridge.

At each plot, all accessible *T. erubescens* occurring within the area were tagged with a unique identification number. The identification number was glued onto the rock surface as close as possible to the *T. erubescens* individual. The following information was recorded for each individual:

- Plot number
- Unique plant identification number
- Presence of flowers/fruits/buds
- Plant Status - Reproductive, Vegetative, Dead (no live tissue), Juvenile (1-3 years old) or Seedling (<1 year old).

Additionally, a number of individuals were randomly selected for a condition assessment (percentage of total plant alive). The random selection of individuals was chosen based on a method developed by DAA (DAA 2015).

Monitoring in 2016 followed the same methodology as used in the 2015 monitoring. All *T. erubescens* individuals recorded during the 2015 monitoring were revisited and re-assessed. Any new seedlings encountered were also tagged and assessed using the same methodology. During November and December 2016, three additional monitoring plots (13, 25 and 26) were established. The establishment of these additional plots followed the same methodology used in the previous monitoring, including the selection of additional individuals for condition assessment monitoring. The location of these additional monitoring plots is shown in Figure 2.1. Plots located less than 50m from a pit boundary are considered "near-pit" plots while those greater than 50m from a pit boundary are considered "far-pit" plots.

In 2016, individuals monitored for condition assessment also had an index of chlorophyll fluorescence reading taken using a pocket PEA unit. The measurement taken is a ratio of Fv/Fm, where Fv is the variable chlorophyll fluorescence (Fm – Fo), Fm is the maximal chlorophyll fluorescence and Fo is the minimal chlorophyll fluorescence (Murchie and Lawson 2013; Percival 2005). This gives a measure of the optimal quantum yield of photosynthesis, an indicator of photosynthetic performance, thus enabling identification of plant stress (Hansatech 2006; Maxwell and Johnson 2000; Percival 2005).

Chlorophyll fluorescence measurements are taken by attaching a clip to a live stem of the *T. erubescens* individual, with the stem subsequently dark adapted. The index of chlorophyll fluorescence (Fv/Fm) is then measured with the PEA unit and recorded. As this monitoring involves physical access to the plants (to attach clips) as opposed to visually estimating the condition, some of the plants selected for condition monitoring in 2015 were replaced with the nearest accessible plant.

2.3 2020 Monitoring

The 2020 monitoring was conducted from 23-25 September by Ecotec. The 2020 monitoring followed the same methodology as used in previous years. All *T. erubescens* individuals recorded during the 2019 monitoring were revisited and re-assessed for status and presence of buds, flowers and/or fruits. Any new individuals encountered within the plots were tagged and assessed using the same method described in Section 2.2. Plot 26, which contained 104 individuals, is no longer part of the annual monitoring due to the development of F1 pit.

A total of 235 individuals were monitored for condition in 2020. Plot 26 contained 15 condition assessment individuals.

Chlorophyll fluorescence measurements were carried out on 224 individuals by the MRL Environmental Advisor at a separate monitoring event from 15 – 20 September.

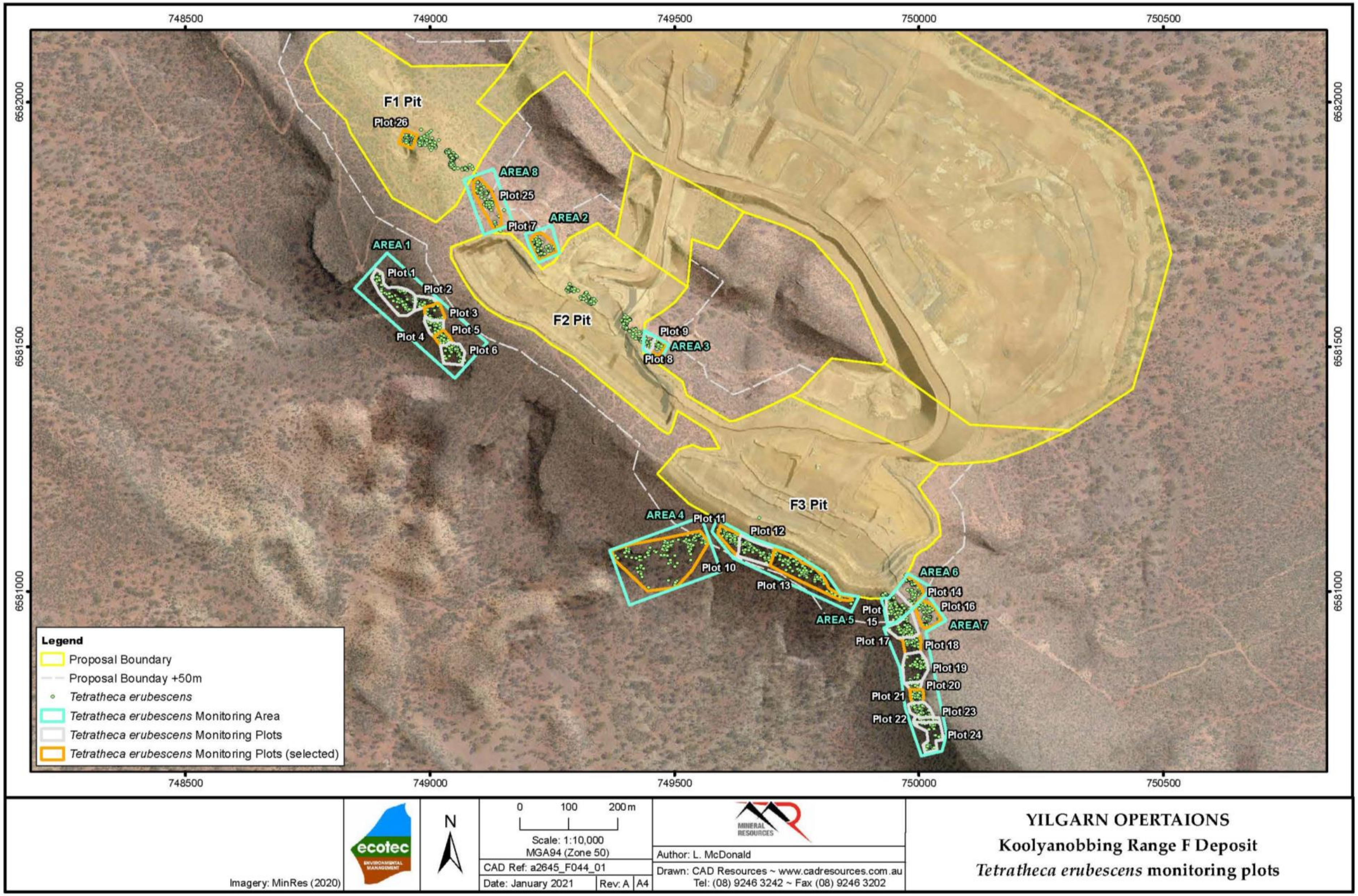

Figure 2.1: Distribution of *Tetratheca erubescens* and location of annual monitoring plots.

3.0 RESULTS

Table 3.1 presents a summary of results from all monitoring years since 2016. The 2016 monitoring is considered baseline (initial) data as it includes all 13 plots monitored prior to the commencement of mining.

Plot 26, containing 104 individuals, is no longer monitored due to the development of F1 pit. For comparison purposes, Plot 26 data from all years of monitoring have been excluded from the results in this report.

In 2020, 1593 *T. erubescens* individuals were recorded, of which seven were seedlings (0.4% of population), 23 were juveniles (1.4% of population), 226 were dead (14% of population), 1154 were reproductive (72% of population) and 174 were vegetative (11% of population). Nine individuals were not monitored as they could not be located or were unsafe to access.

Eleven individuals recorded as dead during 2019 had re-sprouted and recorded as alive in 2020.

Thirteen new plants were recorded and tagged in 2020. Seven were seedlings, three juvenile and three reproductive. Seedlings recorded in 2019 were considered juveniles in 2020, unless found to be reproductive (therefore considered adults).

Table 3.1: Summary of results from 2016 - 2020 annual monitoring.

Plant Status / Category	2016	2017	2018	2019	2020
Dead	128	135	149	184	226
Seedling	3	18	24	18	7
Juvenile	2	3	11	15	23
Vegetative	166	113	80	131	174
Reproductive	1196	1264	1279	1220	1154
Not located	1	0	16	8	9
Total Alive	**1367**	**1398**	**1394**	**1384**	**1358**
Total Population	**1496**	**1533**	**1559**	**1576**	**1593**

Figure 3.1 presents a summary of the results from 2016 - 2020, showing the proportion of the population in each category.

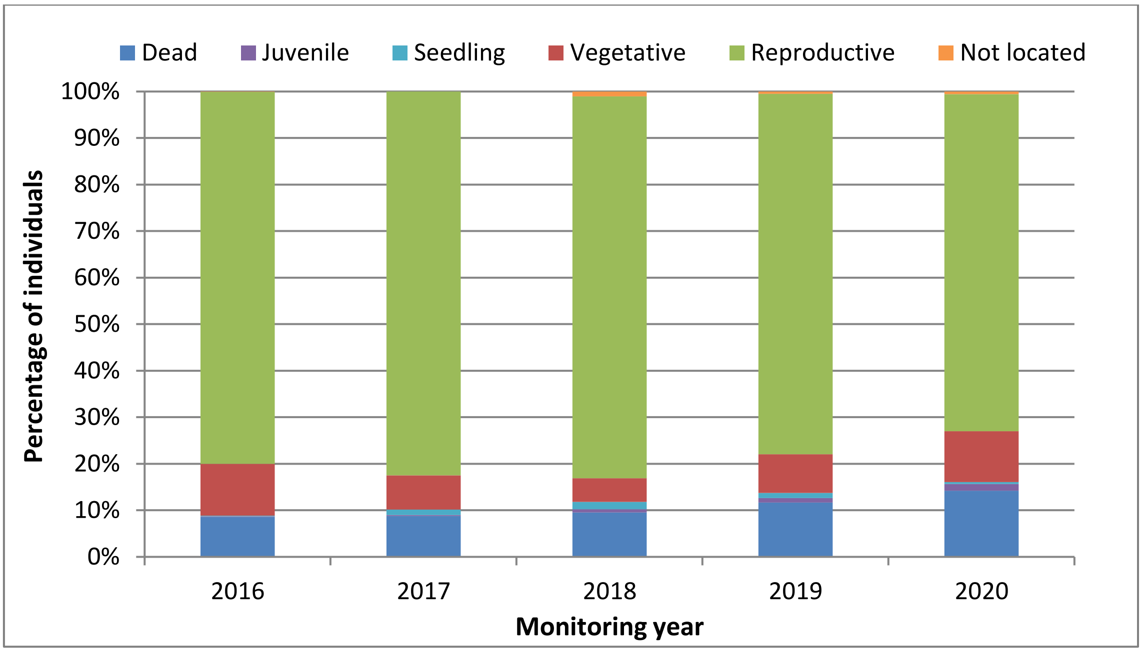

Figure 3.1: Percentage of *Tetratheca erubescens* population in each life stage, 2016 -2020.

3.1 Health Assessment

3.1.1 Condition Assessment

During the 2020 monitoring, 235 individuals were assessed for condition. Of these individuals seven have been dead or gone for two or more years and will be removed from the list of condition assessment individuals. Five of the condition assessment individuals were newly dead (0% alive) in 2020. The percentage of foliage alive ranged from 5% – 90%.

Figure 3.2 displays the condition assessment for individuals ranked in percentage foliage alive categories for 2016 to 2020.

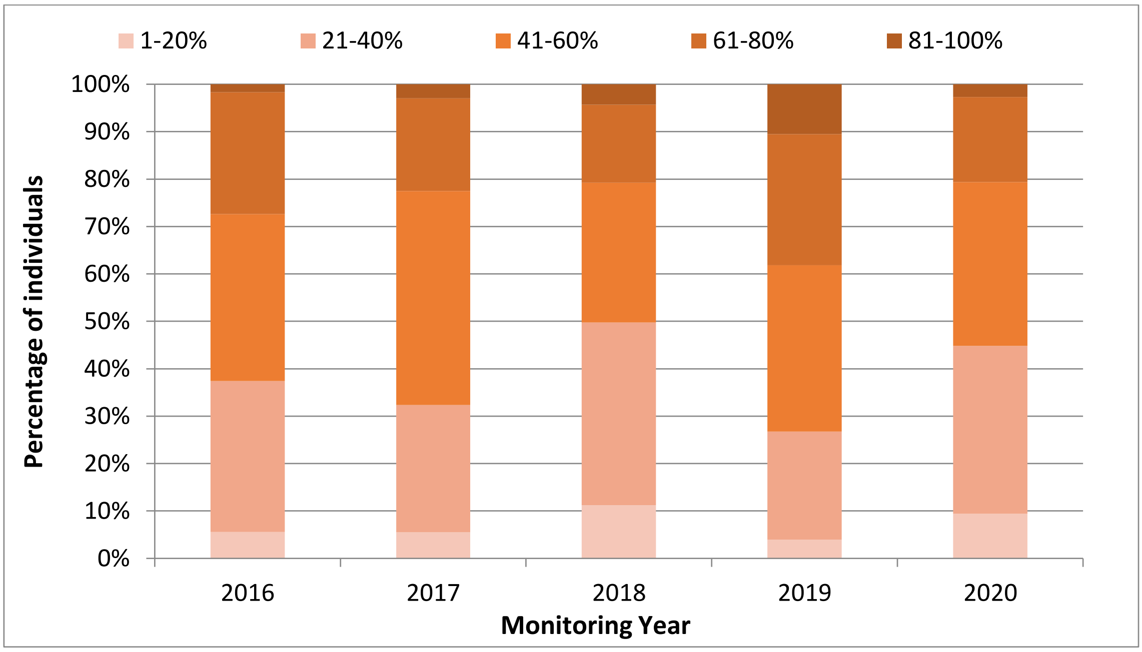

Figure 3.2: Condition assessment rankings for 2016 - 2020.

The average overall condition was lower in 2020 compared 2016, 2017 and 2019. The average condition in 2020 was 46% compared to 57% in 2019, 45% in 2018, 52% in 2017 and 53% in 2016. In 2020 all plots recorded a decrease in average condition compared to 2019 except Plot 5 which recorded a 10% increase in condition. In 2020 average condition ranged from 40% in Plot 3 to 57% in Plot 5. In 2019 average condition ranged from 47% in Plot 5 to 68% in Plot 10.

Table 3.2 lists the average condition assessment results and standard deviation for each plot in relation to distance from the pit.

Table 3.2: Average condition assessment and standard deviation for each plot in 2020.

Distance from pit	Plot number	Average condition assessment (%)	Standard Deviation
>50m from pit boundary	**3**	40.3	15.3
	5	56.7	24.5
	10	44.6	19.3
	16	56.1	17.6
	18	48.3	12.9
	21	43.3	20.6
<50m from pit boundary	**7**	42.8	22.7
	9	43.2	25.5
	11	44.0	19.9
	13	41.7	21.0
	14	45.4	24.9
	25	51.0	19.8

Figure 3.3 compares the average condition assessment (including standard deviation) for *T. erubescens* plants in each monitoring plot and in relation to proximity to the pit boundary, for the current year (2020) and previous years (2016 - 2019). Average condition recorded in near-pit plots (less than 50m from the pit boundary) in 2020 was 45% and in far-pit plots was 48%, compared to 56% and 58% in 2019.

Appendix 2 displays the average condition assessment for each plot in relation to pit location.

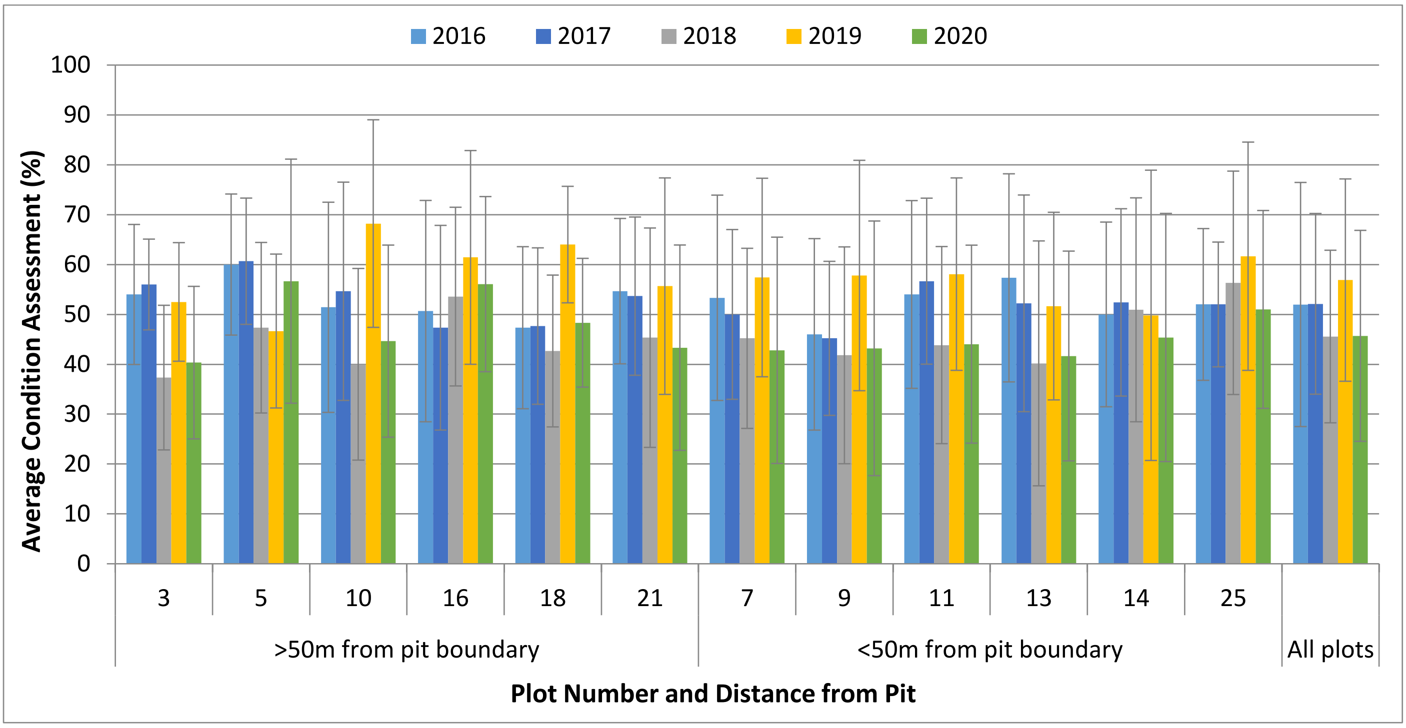

Figure 3.3: Average condition assessment with standard deviation for each plot 2016 - 2020.

3.1.2 Chlorophyll Fluorescence Assessment

The individuals assessed for condition also had chlorophyll fluorescence measurements taken. Chlorophyll fluorescence readings were conducted from 15 - 20 September 2020, separately to the annual status and condition assessment monitoring.

In 2020, the overall average chlorophyll fluorescence reading of 0.78 was the same as 2019 and higher than in all previous years. Average chlorophyll fluorescence ranged from 0.71 in Plot 25 (less than 50m from pit boundary) to 0.81 in Plots 18 and 21 (greater than 50m from pit boundary) and Plot 13 (less than 50m from pit boundary).

There were no large variations in average chlorophyll fluorescence readings between 2019 and 2020. The greatest change was a 0.04 decrease in Plot 25 and a 0.04 increase in Plot 9.

The average chlorophyll fluorescence readings with standard deviation are listed in Table 3.3 and presented in Figure 3.4.

Table 3.3: Average chlorophyll fluorescence and standard deviation for all monitoring plots in 2020.

Distance from pit	Plot number	Average chlorophyll fluorescence (Fv/Fm)	Standard Deviation
>50m from pit boundary	**3**	0.79	0.02
	5	0.78	0.02
	10	0.80	0.02
	16	0.77	0.05
	18	0.81	0.01
	21	0.81	0.02
<50m from pit boundary	**7**	0.74	0.03
	9	0.80	0.02
	11	0.80	0.01
	13	0.81	0.03
	14	0.77	0.04
	25	0.71	0.06

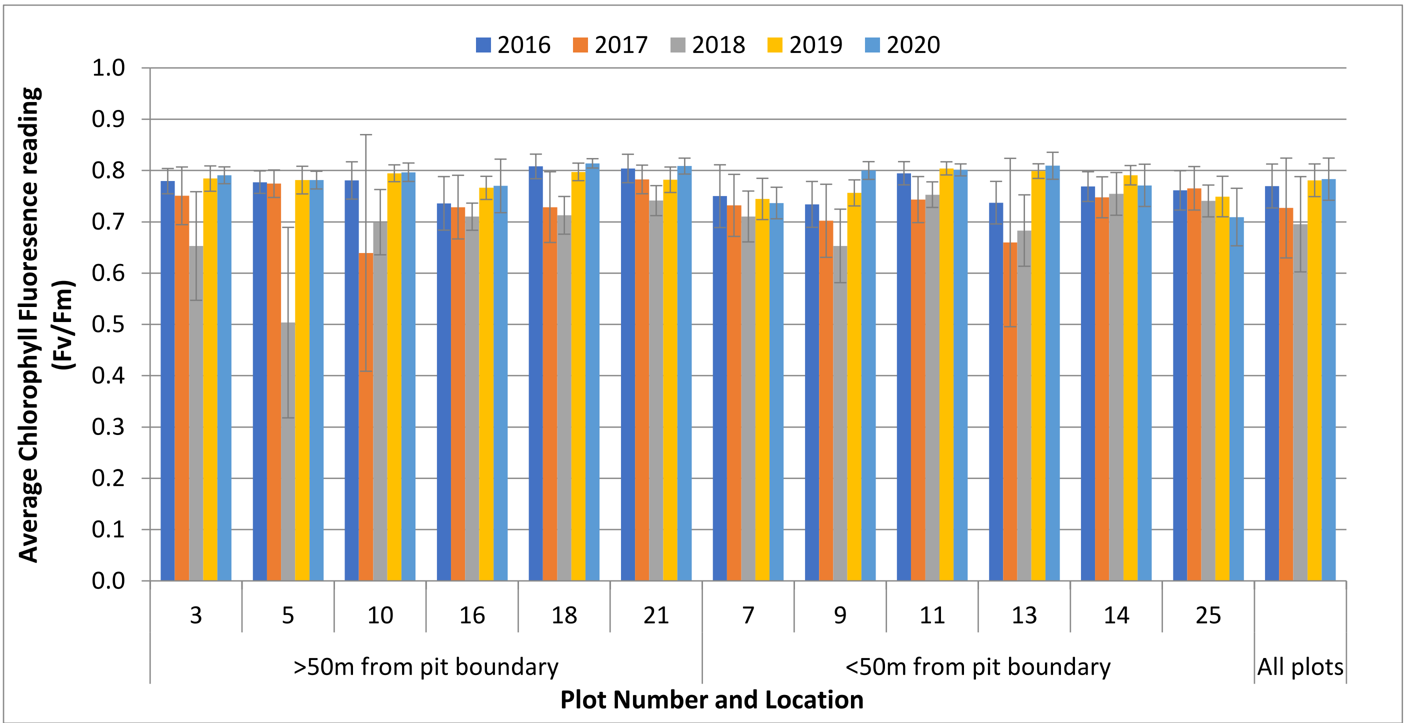

Figure 3.4: Average chlorophyll fluorescence with standard deviation for all plots 2016 -2020.

3.2 Reproductive Status

The 2020 monitoring recorded 87% of the live adult *T. erubescens* population as reproductive, compared with approximately 90% in 2019, 94% in 2018, 92% in 2017 and 88% in 2016.

Figure 3.5 displays the proportion of the live adult population that was reproductive in 2019 and 2020 for each plot. In 2020 the near-pit plots had an average of 81% reproductive individuals whilst the far-pit plots had an average of 93% reproductive individuals. In 2019 the average percentage of reproductive individuals was 86% in near-pit plots and 95% in far-pit plots.

Figure 3.5: Percentage of live adult population reproductive in each plot in relation to proximity to pit.

Figure 3.6 displays the percentage of the reproductive population that displayed buds, flowers and/or fruits during the 2019 and 2020 monitoring.

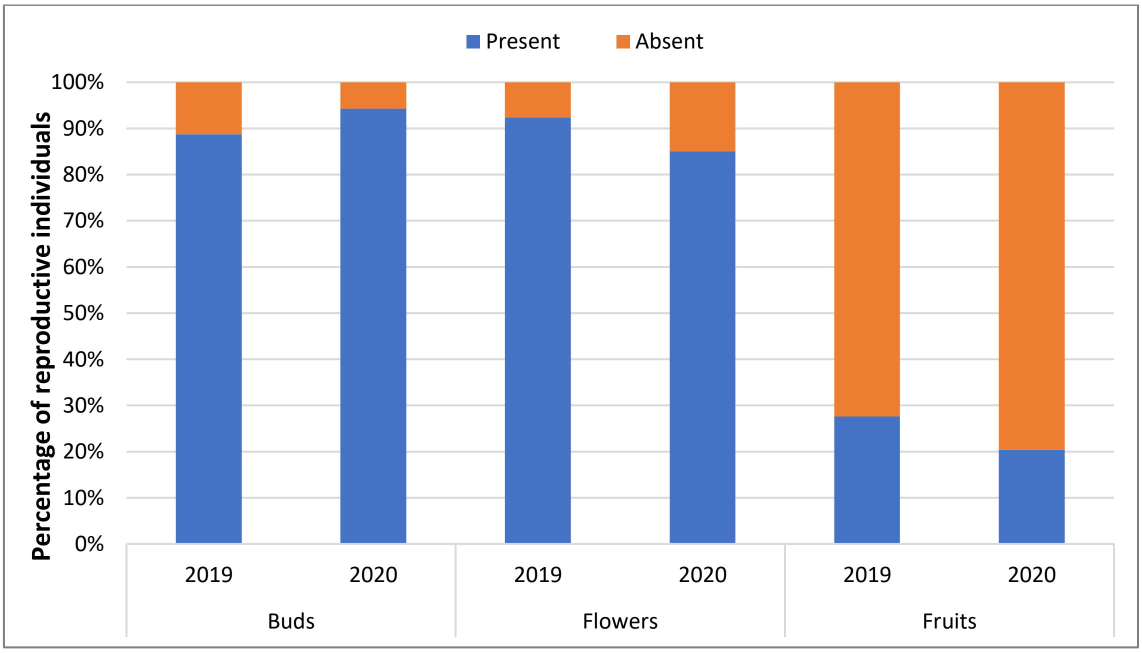

Figure 3.6: Proportion of reproductive individuals displaying buds, flowers and/or fruits 2019 - 2020.

3.3 Life Stage, Mortality and Seedling Recruitment

Figure 3.7 shows the percentage of the monitored *T. erubescens* population in each life stage (dead, reproductive, vegetative, juvenile or seedling) for the 2019 and 2020 monitoring.

Of the total 226 deaths recorded, 50 individuals were recorded as “new” deaths (recorded as alive in 2019) during the 2020 monitoring. Six of these were recorded as looking unhealthy or almost dead during the 2019 monitoring. No new deaths were recorded in Plots 5, 10 and 11. All other plots recorded at least one new death with the highest number of deaths recorded in Plots 7, 9 and 14 (near-pit), each recording 10 dead. Seventy six percent (76%) of all deaths recorded in 2020 were attributed to plots located less than 50m from pit boundary, similar to the 77% recorded in 2019.

Figure 3.8 provides a comparison of the number of dead individuals recorded in each plot during 2017 – 2020 annual monitoring events.

Eleven individuals recorded as dead in 2019 were recorded as alive during the 2020 monitoring. Thirteen new plants were recorded and tagged in 2020. Seven were seedlings, three juvenile and three reproductive. Twenty seedlings were recorded in 2019 and 25 recorded in 2018. Seedlings were recorded in Plots 10, 11 and 14.

Appendix 1 displays the mortality and recruitment per plot in relation to proximity to mining.

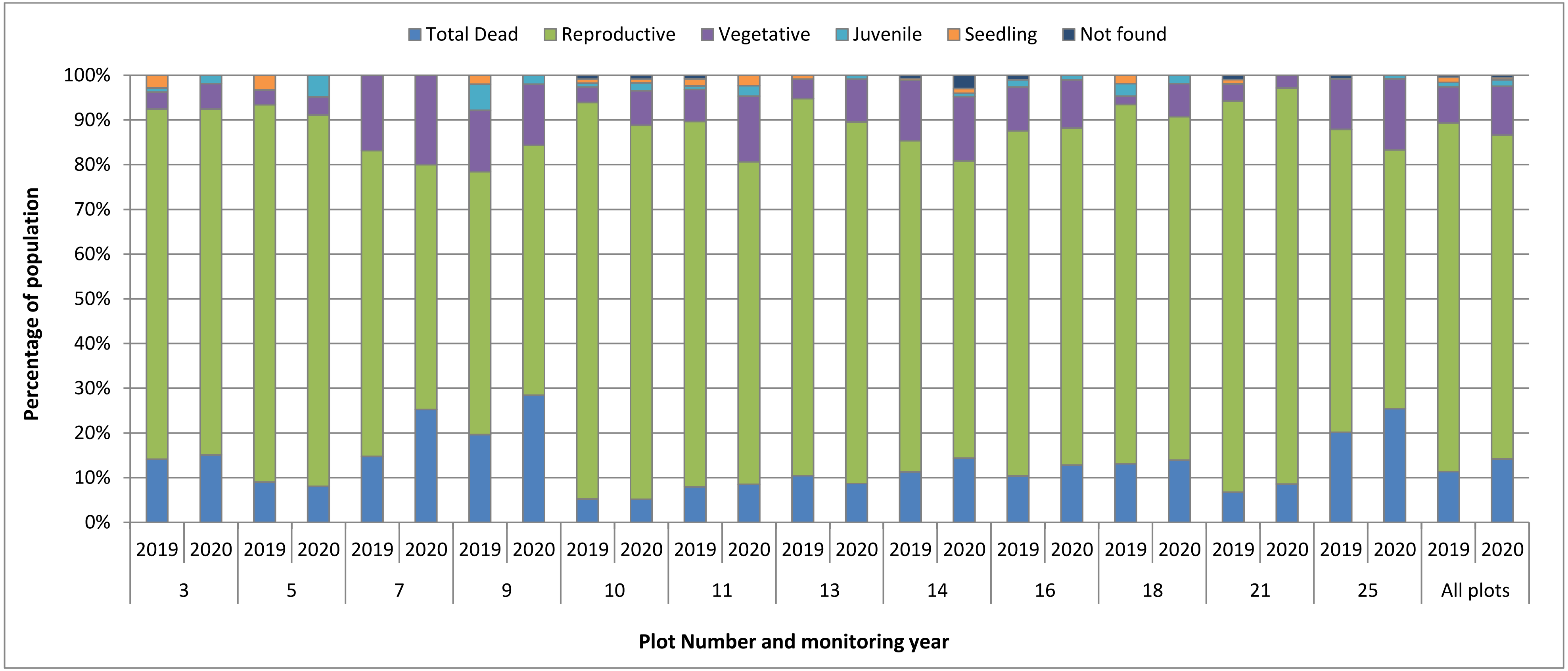

Figure 3.7: Percentage of *T. erubescens* in each life stage during previous year (2019) and current year (2020) monitoring.

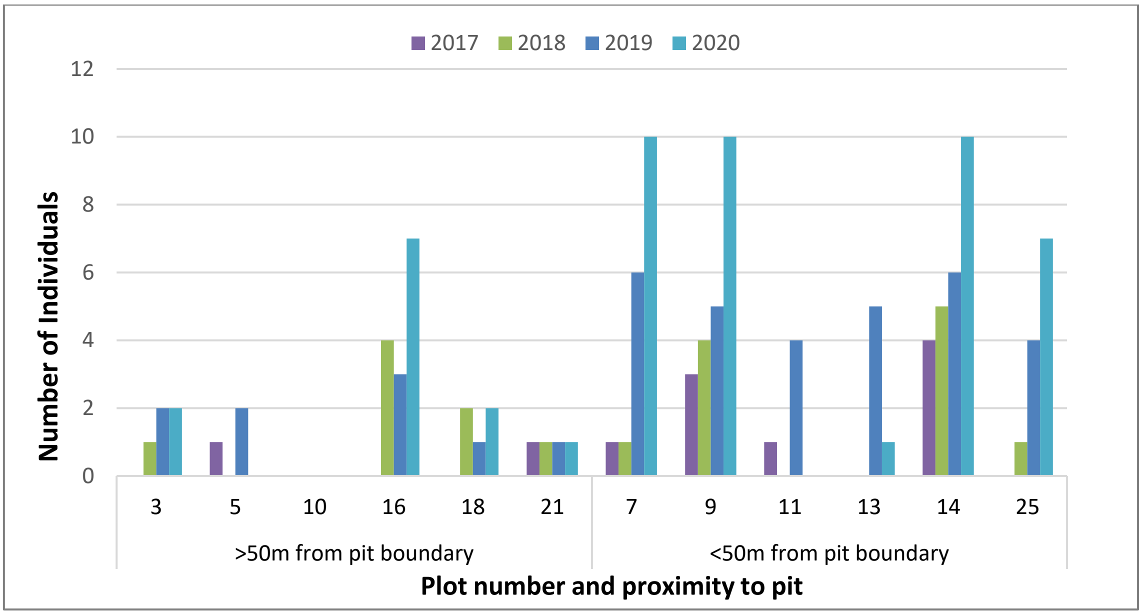

Figure 3.8: Number of dead individuals recorded per plot in relation to proximity to pit, 2017 – 2020.

Figure 3.9 provides a comparison of the percentage mortality (new deaths per previous live population) in near-pit and far-pit plots from 2017 to 2020.

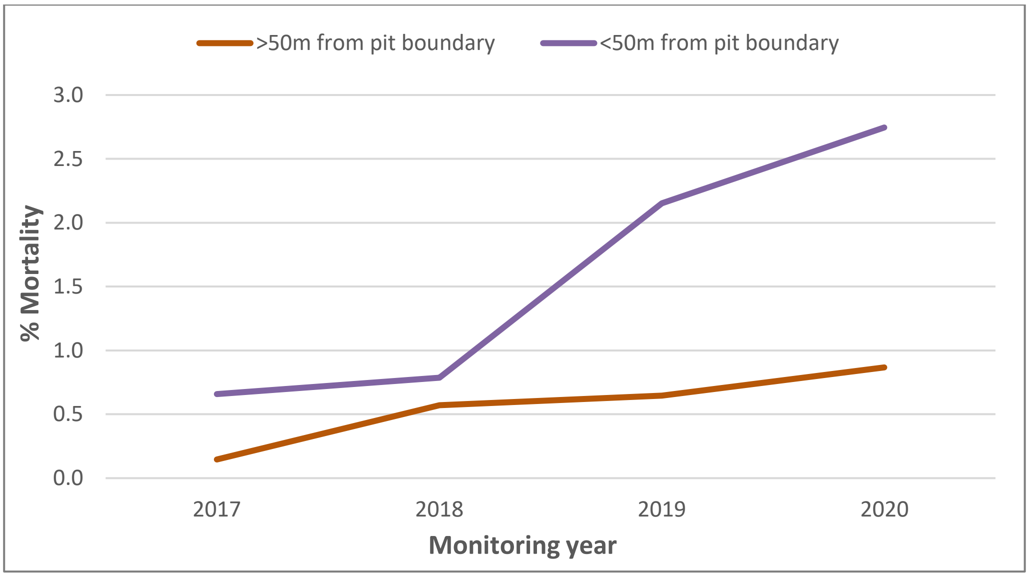

Figure 3.9: Mortality in relation to proximity to pit, 2017 – 2020.

3.4 Dust

Figure 3.10 displays the results of bimonthly dust monitoring for each plot, in relation to proximity to the pits. Overall, Plot 14 displayed the highest dust levels in the period. There were spikes in dust levels in Plot 7 in November 2019 and September 2020 and Plot 25 in September 2020.

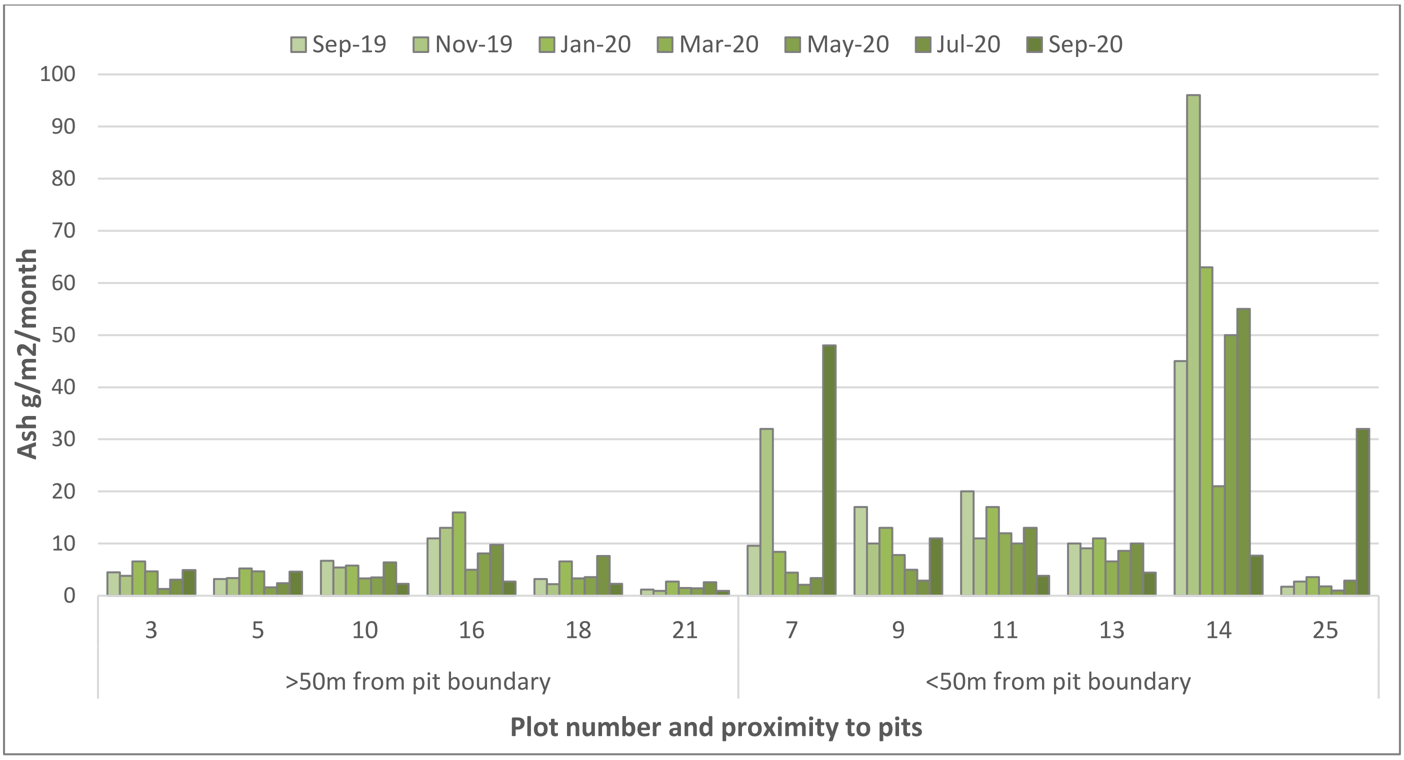

Figure 3.10: Bimonthly dust monitoring results in relation to proximity to pits, September 2019 – September 2020.

3.5 Rainfall

In the 12 months prior to the 2020 monitoring (October 2019 – September 2020), Koolyanobbing recorded 242.8 mm of rain. The 2001-2020 average rainfall for Koolyanobbing is 271.6 mm (BoM 2020).

Figure 3.11 shows the total monthly rainfall received at Koolyanobbing prior to the current and previous monitoring events, as well as the 2001-2020 monthly average. July and August 2020 received average and above average rainfall while many other months experienced lower than average falls.

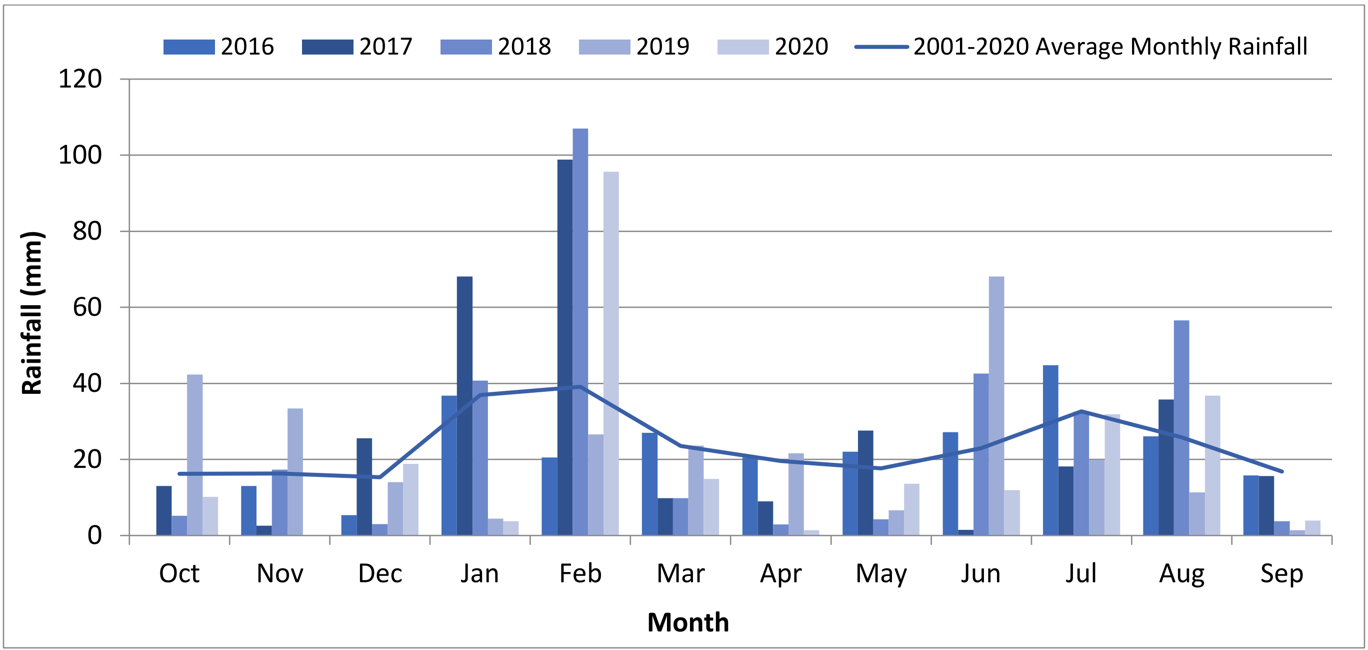

Figure 3.11: Monthly rainfall and average monthly rainfall at Koolyanobbing 2016 -2020.

Figure 3.12 shows the annual rainfall for each monitoring year since 2015, the annual period being the period between monitoring events, October to September in 2020. The annual rainfall in 2020 for this period is the lowest since 2015.

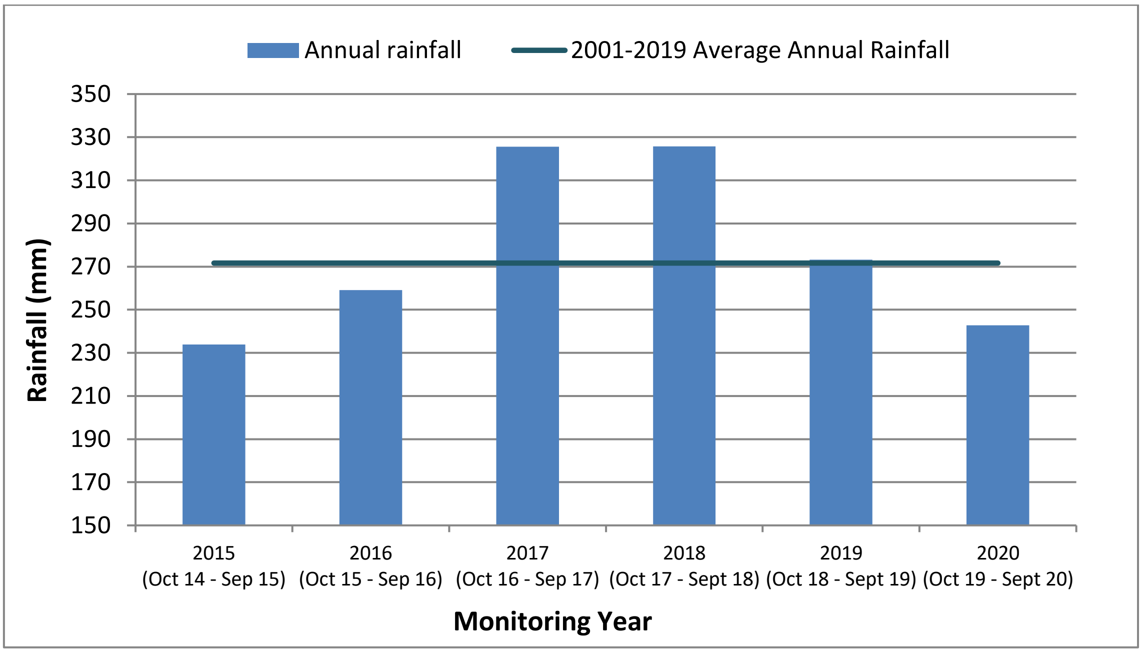

Figure 3.12: Annual rainfall October to September 2015 – 2020.

4.0 DISCUSSION AND CONCLUSION

The results from the 2020 annual *T. erubescens* monitoring demonstrate that 85% of monitored individuals were alive and approximately 87% of the live population was reproductive at the time of monitoring. The live population is approximately 2.6% smaller than 2019 and the proportion of the population that is reproductive is 3.4% less than in 2019. Recruitment is lower and mortality higher than recorded since 2016. Of the nine individuals that were not located, seven individuals in Plot 14, were not accessible due to unstable rock making the area unsafe.

The 2020 monitoring is the fourth year of monitoring since commencement of mining activities at F deposit. Approximately 12 months of mining activity occurred from May 2017 – April 2018, then mining temporarily ceased during acquisition of the project by MRL. Mining recommenced in January 2019 and continues to the present time. Mining has ceased in F2 pit and development of F1 pit commenced in June 2020.

In 2020, the overall average chlorophyll fluorescence (Fv/Fm) reading of 0.78 was comparable to 2019 and higher than in all previous years. The theoretical optimal value of Fv/Fm is around 0.83 for most plants (Maxwell and Johnson 2013; Murchie and Lawson 2013; Richie 2006). Although the literature does vary, measurements between 0.78 – 0.83 generally indicate healthy, non-stressed plants (Maxwell and Johnson 2013; Percival 2005; Richie 2006). A range of approximately 0.7 – 0.8 is considered normal and readings below 0.6 are indicative of plant stress (Ritchie 2006; Percival 2005). The lowest individual chlorophyll fluorescence reading recorded in September 2020 was 0.61, taken from three individuals (one in Plot 16, two in Plot 25) suggesting that the majority of individuals assessed were not stressed at the time.

Average chlorophyll fluorescence was marginally lower in plots less than 50m from a pit boundary (0.77) compared to those further than 50m from a pit boundary (0.79), as was the case in 2019. However, the reverse was the case in 2018. There was little variation in average chlorophyll fluorescence readings across all plots between 2019 and 2020.

The average condition assessment of the entire population was 45.7% in 2020. This represents an 10.8% decrease in condition on 2019 average results of 56.5%. A similar condition score was recorded in 2018 (45.2%). Although a subjective indicator, the comparison year on year suggests a decrease in the health of the monitored individuals in 2020. A higher proportion of individuals (45%) assessed for condition in 2020 had lower foliar alive scores, in the 1 – 40% range, compared to 2019 (27%), and a lower proportion (21%) had high scores in the 61 – 100% range in 2020 compared to 2019 (38%).

Average condition assessment in 2020 was higher for those plots located further from a pit (48.2%) than those close to a pit (44.7%). This was also the case in 2019 (58.1% and 56.1%) and 2017 (53.0% and 51.4%). Conversely, plots further from a pit recorded marginally lower condition in 2018 (44.4% and 46.4%).

Condition assessment can be a deceptive indicator of plant health as *T. erubescens* individuals retain much of their dead material for long periods of time. Most individuals have dead leaves/material attached to very healthy and reproducing live material with older plants having very large 'skirts' of dead material. Dust deposited on the leaf surface may also hinder assessment of condition as it is difficult to distinguish dead material from dusty leaves. Therefore, the condition assessment results should be considered in combination with other factors such as reproduction, recruitment and mortality to assess the health of the population.

Thirteen new individuals were located and tagged during the 2020 monitoring. Of these, seven were seedlings, three were juveniles and three were reproductive. The reproductive individuals could also be considered juveniles since they appear to be young plants less than two years old, however they were displaying buds and/or flowers. New germinants may not have been recorded the previous year due to being of insufficient size to be positively identified as *T. erubescens*.

Recruitment was lower in 2020 than has been recorded since 2016. From 2017 – 2019 the number of seedlings recorded was 18, 24 and 18 individuals, approximately 1.3% - 1.7% of the live population, compared to 7 seedlings in 2020, which is 0.5% of the live population. The population was reproductive and if the fruits develop and produce viable seed, there is likely to be seed available to germinate when conditions are favourable. Lower annual rainfall prior to the 2020 monitoring may have contributed to reduced germination, although there were good falls in July and August. The disturbed and dusty conditions observed in some of the near-pit plots may also reduce recruitment, either through disruption of seed establishment or new germinants being affected by dust deposition.

The number of newly dead individuals recorded in 2020 was 50, the highest since the first monitoring event in 2015 when 102 individuals were recorded as dead. Of those dead in 2020, three were juveniles and six were recorded as unhealthy or almost dead in 2019. There is some correlation between mortality and proximity to the pits. The majority of deaths (76%) occurred in plots less than 50m from a pit boundary. This was similar to 2019 which recorded 77% of deaths in the near-pit plots. In 2020, three near-pit plots (Plots 7, 9 and 14) each recorded 10 deaths. Plots closer to the pit boundaries have recorded greater mortality than plots further from the pit boundaries from 2017 – 2020. The lower condition of *T. erubescens* individuals, lower recruitment and higher mortality overall, and in particular in the plots closer to the pits may be indicators of impacts from mining activities.

The bimonthly dust results from September 2019 to September 2020 indicate that elevated dust levels have occurred in some plots closer to the pits (Figure 3.10). Elevated dust levels in Plot 7 and Plot 25 in September 2020 coincide with the development of F1 pit. Plot 14, located near the F3 pit, recorded dust levels above 40g/m2/month in all bimonthly monitoring events during this period except March and September 2020.

Dust deposition on the surface of leaves is considered to affect photosynthesis through leaf shading, increasing leaf temperature and blocking stomata (Hirano *et al* 1990). As such it is expected that chlorophyll fluorescence measurements would be reduced by dust deposition on the leaf surface. Plots 7 and 25, which recorded the highest dust levels in September, recorded marginally lower (0.046 and 0.074 respectively) chlorophyll fluorescence than the overall average. Although average measurements in plots closer to the pits are slightly lower (0.02) than plots further from the pits, overall, the Fv/Fm measurements are within the “normal” range across all plots.

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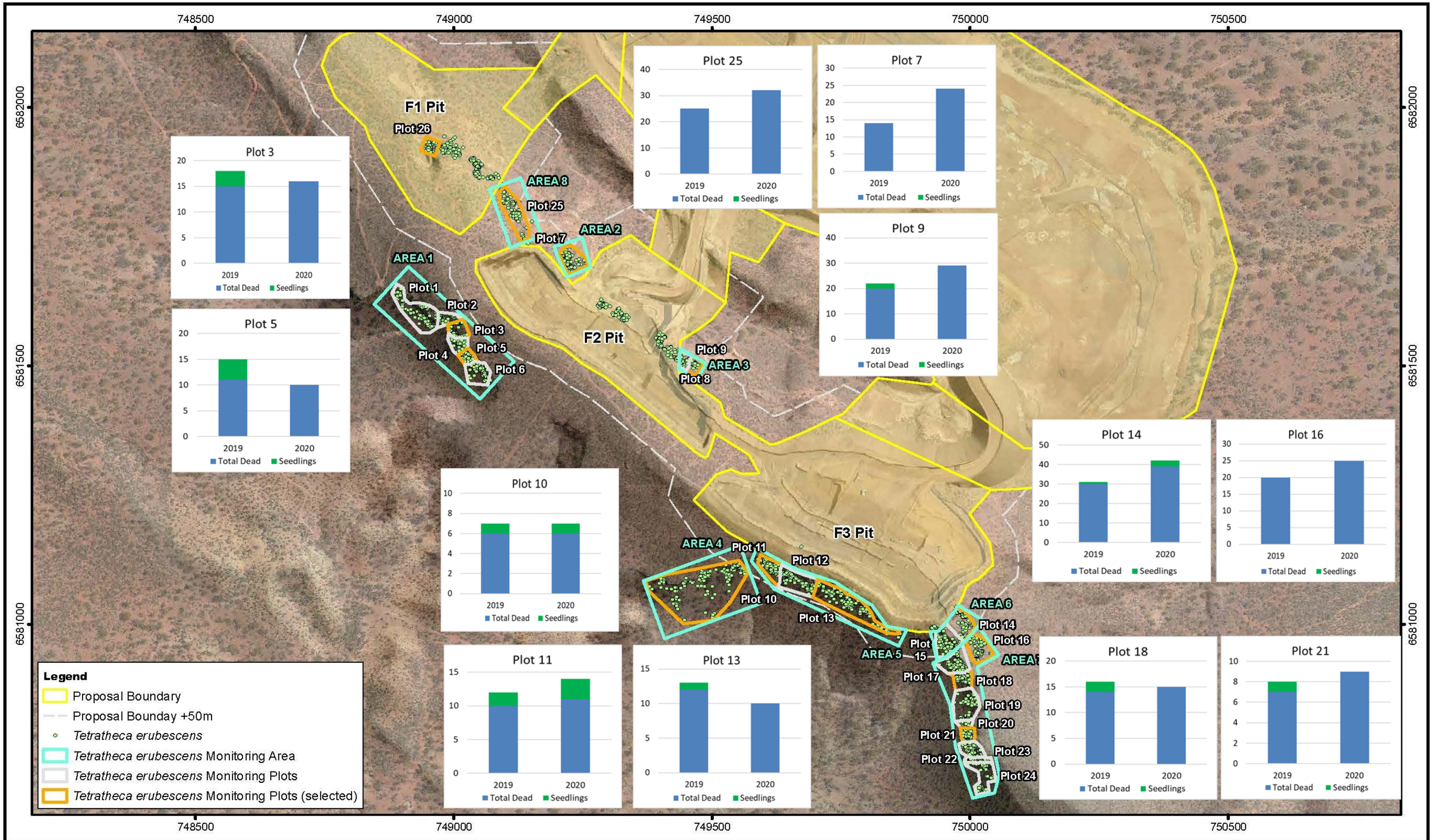
Appendix 1

Mortality and recruitment per plot in relation to proximity to mining



Imagery: MinRes (2020)

ecotec ENVIRONMENTAL MANAGEMENT

N

0 100 200 m

Scale: 1:10,000
MGA94 (Zone 50)

CAD Ref: a2645_F044_01

Date: January 2021 | Rev: A | A4

MINERAL RESOURCES

Author: L. McDonald

Drawn: CAD Resources ~ www.cadresources.com.au
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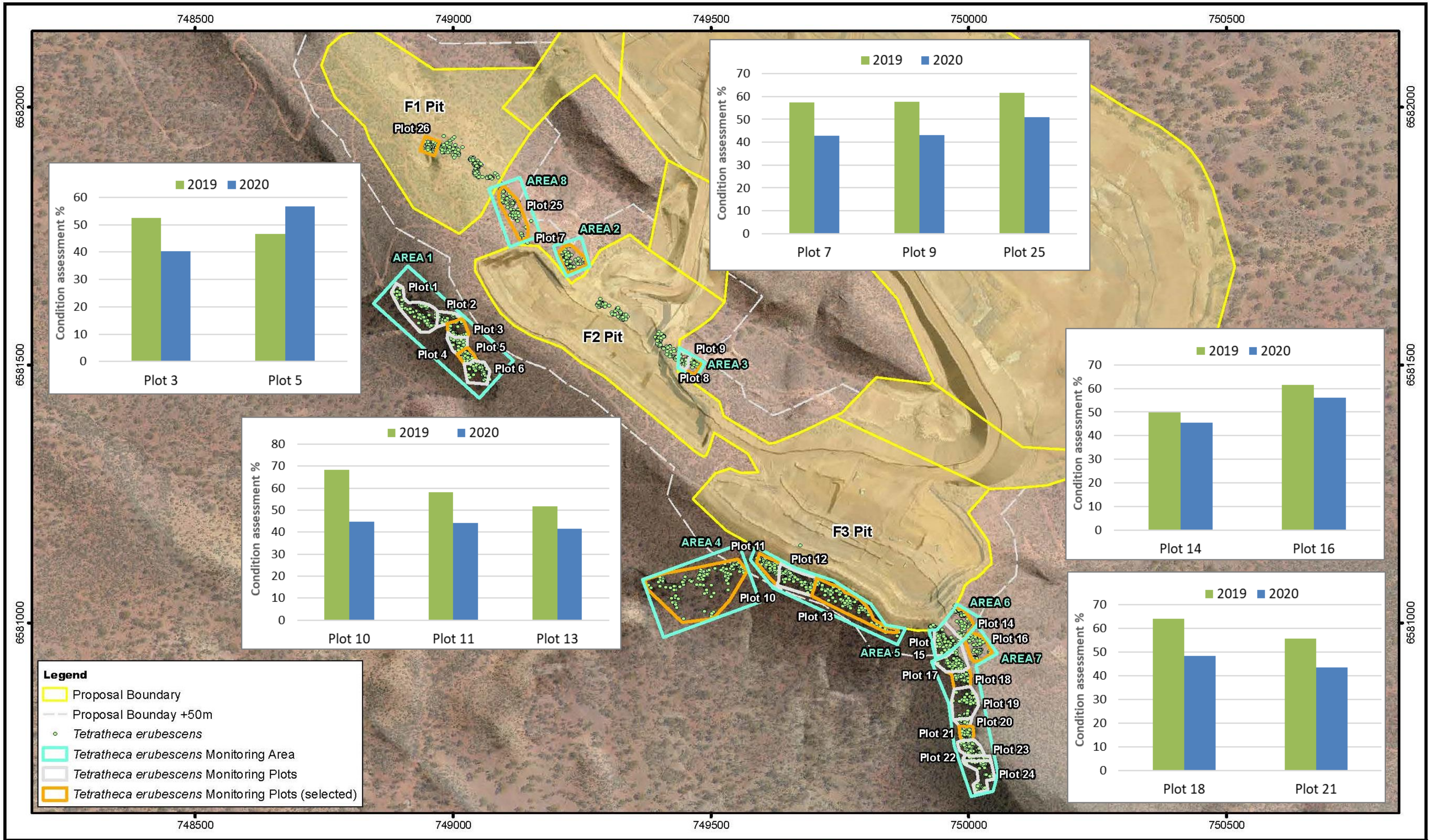
YILGARN OPERTAIONS
Koolyanobbing Range F Deposit
***Tetratheca erubescens* monitoring plots**

Appendix 2

Average condition assessment per plot in relation to proximity to mining



Imagery: MinRes (2020)

N

0 100 200 m

Scale: 1:10,000
MGA94 (Zone 50)

CAD Ref: a2645_F044_01

Date: January 2021 | Rev: A | A4

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YILGARN OPERTAIONS

Koolyanobbing Range F Deposit

***Tetratheca erubescens* monitoring plots**

Attachment 8: F3 Open Pit Wall & Natural Scarp Stability Geotechnical Review, 2020. Peter O'Brian and Associates.

TECHNICAL MEMORANDUM

Mineral Resources Limited
Iron Resources Pty Ltd
Koolyanobbing Iron Ore Operations

20081
21 January 2021

F DEPOSIT
F3 OPEN PIT WALLS & NATURAL SCARP STABILITY GEOTECHNICAL REVIEW NOVEMBER 2020

Attention: Anne-Louise VAGUE

Introduction

This memorandum summarises the findings of geotechnical review of general wall stability conditions in the now completed F3 Pit, and stability conditions along the natural scarp located to the south of the F3 Pit highwall.

Open pit mining at F Deposit forms part of the Koolyanobbing Iron Ore Operations, owned and operated by Mineral Resources Limited (MRL) / Iron Resources Pty Ltd.

The review was performed at the request of Anne-Louise Vague, Senior Environmental Advisor of CSI Mining Services/ Mineral Resources Limited (MRL).

Background Information

F Deposit is located within a south-easterly trending ridgeline of the Koolyanobbing Range, ~ 6 km south-east of the Koolyanobbing A, B, C, D and E Pits and ~ 15 km south-east of K Pit.

The ridgeline which hosts F Deposit also hosts a population of *Tetratheca erubescens*, a protected flora which inhabits iron-rich outcrops. The October 2020 EOM as-mined configurations of the F Deposit pits and the pre-mining distribution of *T. erubescens* along the F Deposit ridgeline are shown in Figure 1.

T. erubescens are concentrated on and adjacent to scarps in banded iron formation (BIF) rocks along the flanks of the ridge. The BIF scarps are formed by natural, ongoing degradation, and as such are at the active edge of natural wastage processes which occur variously via erosion; rock weathering; near-surface relaxation; and mechanical partial disintegration as rock blocks collapse from the scarp.

Removal of some portions of the F Deposit *T. erubescens* population during development and mining was permitted by relevant State authorities, with attendant obligation to protect and monitor the condition of all remaining *T. erubescens*, located mainly within monitoring plots (Figure 2).

The potentials for disturbance/ damage to vegetation (of any type) in such locations are associated with impact from fallrock and possibly uprooting caused by block impact and/ or block movement.

Blasting vibrations from mining activity adjacent to these habitats increase potential for disturbance, though the typical separation distances between blasts and *T. erubescens* habitats is such that conventional open pit blasts could be expected to dislodge only rock blocks which are already disturbed, requiring only minor perturbation to be destabilised.

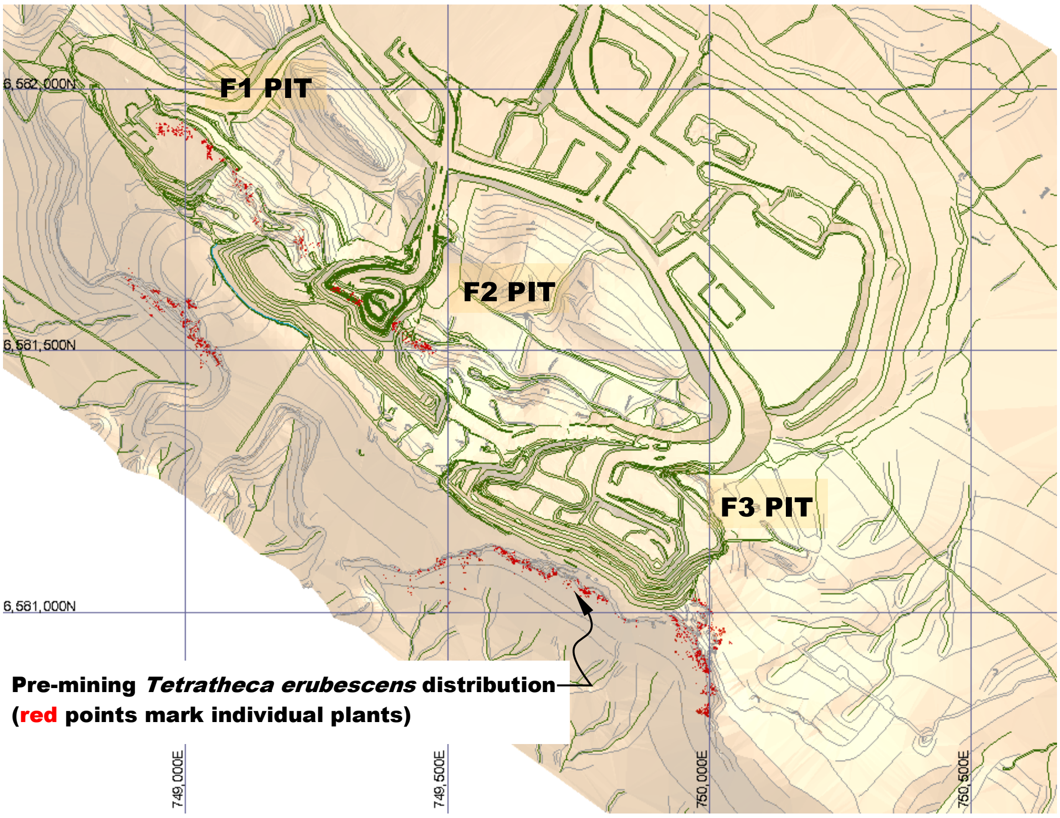


Figure 1 **F1, F2 & F3 Pits as-mined October 2020 EOM**

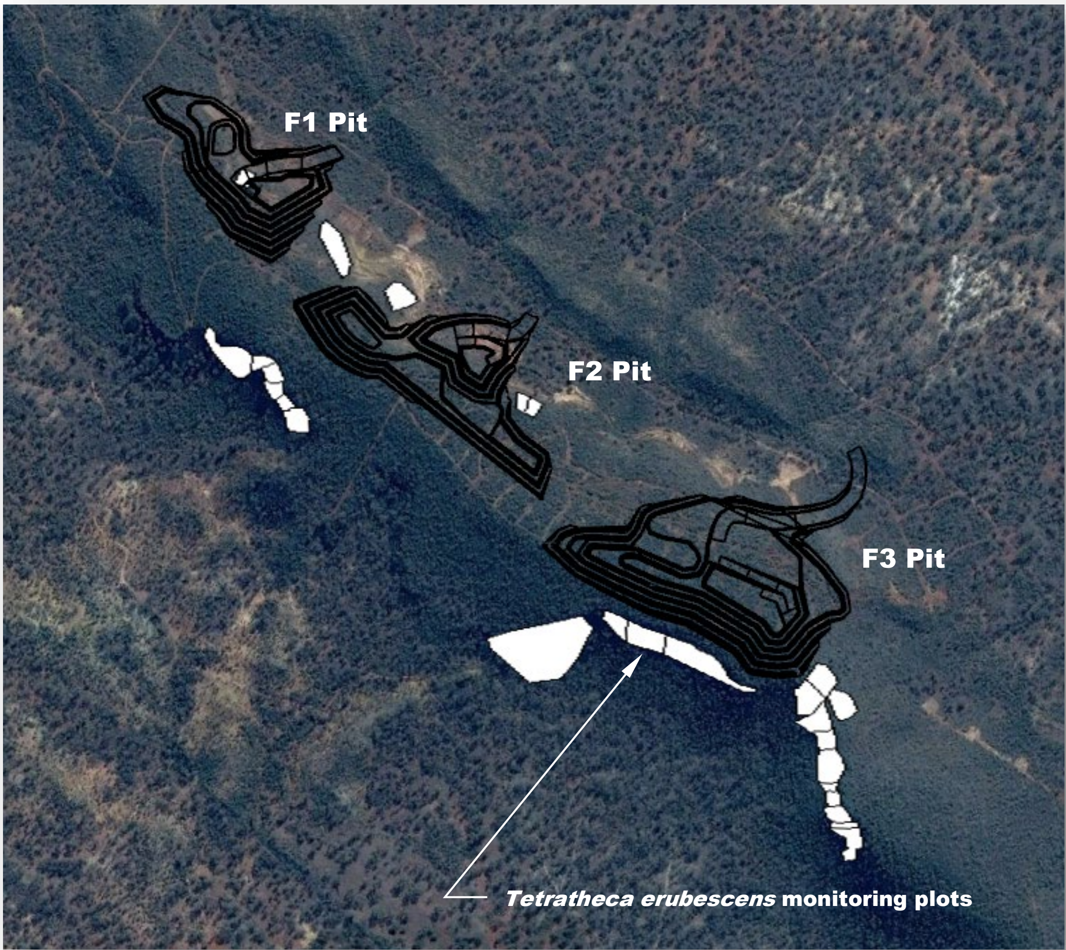


Figure 2 ***Tetratheca erubescens* monitoring plots** (image from Google Earth)

Current Status

Mining at the F Deposit pits commenced in 2017 and is expected to be completed in 2021.

⇨ F2 Pit commenced in Q3 2017 and was completed in late 2019.

⇨ F3 Pit pioneering work was commenced in Q3 2017 (concurrent with F2 mining)

⇨ F3 Pit production in Q1 2018 and was completed in August 2020.

⇨ F1 Pit commenced production in April 2020 and is anticipated to be completed in mid-2021.

The configurations of completed and current mining at F Deposit are shown in Figure 1.

Figure 3 shows the configuration of the F3 Pit at completion.

Pit Wall & Natural Slope Inspections

Inspections of the F3 Pit and environs were made within the following areas/ locations:

⇨ Crest of the (northern) low wall

⇨ Lower ramp to the south-eastern sector of the pit

⇨ Pit floor at the south-eastern end of the pit (deepest pit sector)

⇨ Along the length of the highwall crest

⇨ Natural scarp and scree slope south of the highwall crest, inspecting ground conditions in *T. erubescens* Monitoring Plots 10 through 15 (Figure 4)

Stability Conditions

F3 Pit Walls

Wall stability conditions in the now completed F3 Pit are assessed to be *good* [#] on average and overall slope stability is expected to be maintained in the very long term. Results from limit equilibrium analysis of the tallest portion of the highwall are presented in Figure 5.

The maximum height of the F3 highwall is ~ 112m (at the merger with the eastern endwall); and the maximum highwall overall angle is ~ 54°. The average overall angle is estimated to be ~ 52 to 53°.

For interested readers, the average Rock Mass Rating (RMR_{89}) for highwall rocks is ~ 80 (which is classifies the mass as 'good' quality rock) [1]. This estimate is based on geotechnically mapped rock mass conditions in the F2 and F3 Pits. Local minimum RMR_{89} values, some ≤ 50, are associated with limonitic units in/ around bedding-parallel structures. These zones of poorer rock mass quality have no discernible influence on overall wall stability.

Final development of the upper highwall was carried out in stages; mining an interim southern wall to 472mRL, ~ 35m depth below the highwall crest, followed by cut-back mining incorporating allowance for limits blasting methods to be applied when forming final batters. Figure 6 shows the configuration of the F3 Pit (in early 2018), with lower interim wall in place, the cut-back area and the final limits/ perimeter blast zone. Current wall conditions attest the success of the practice.

Overviews of the as-mined highwall are provided as Plates 1 and 2.

Wall Stability Conditions Descriptors

Good:	The rock/rock mass is apparently competent (in relation to the height and angle of slope being formed). No failures are evident and there is no real sign of potential for failure.
Fair:	Stability and safety (against wall related hazards) are adequate for mining purposes. Minor, localised failures may exist, and there may be potential for (further) such events. There are no obvious signs of impending or possible major wall failure. Local minor design adjustments may be necessary to improve stability conditions.
Poor:	Potential for failure is clear, and future failure is expected (if some instability has not already occurred). It is likely that failure will be of large scale and/or that a substantial proportion of the wall (or sector of wall in question) would be adversely affected by such. Failure(s) may be averted by remedial work and/or significant design adjustments.
Very poor:	There is usually already some degree of collapse, with progressive collapse expected, or future failure is highly likely. Failure is not likely to be averted.

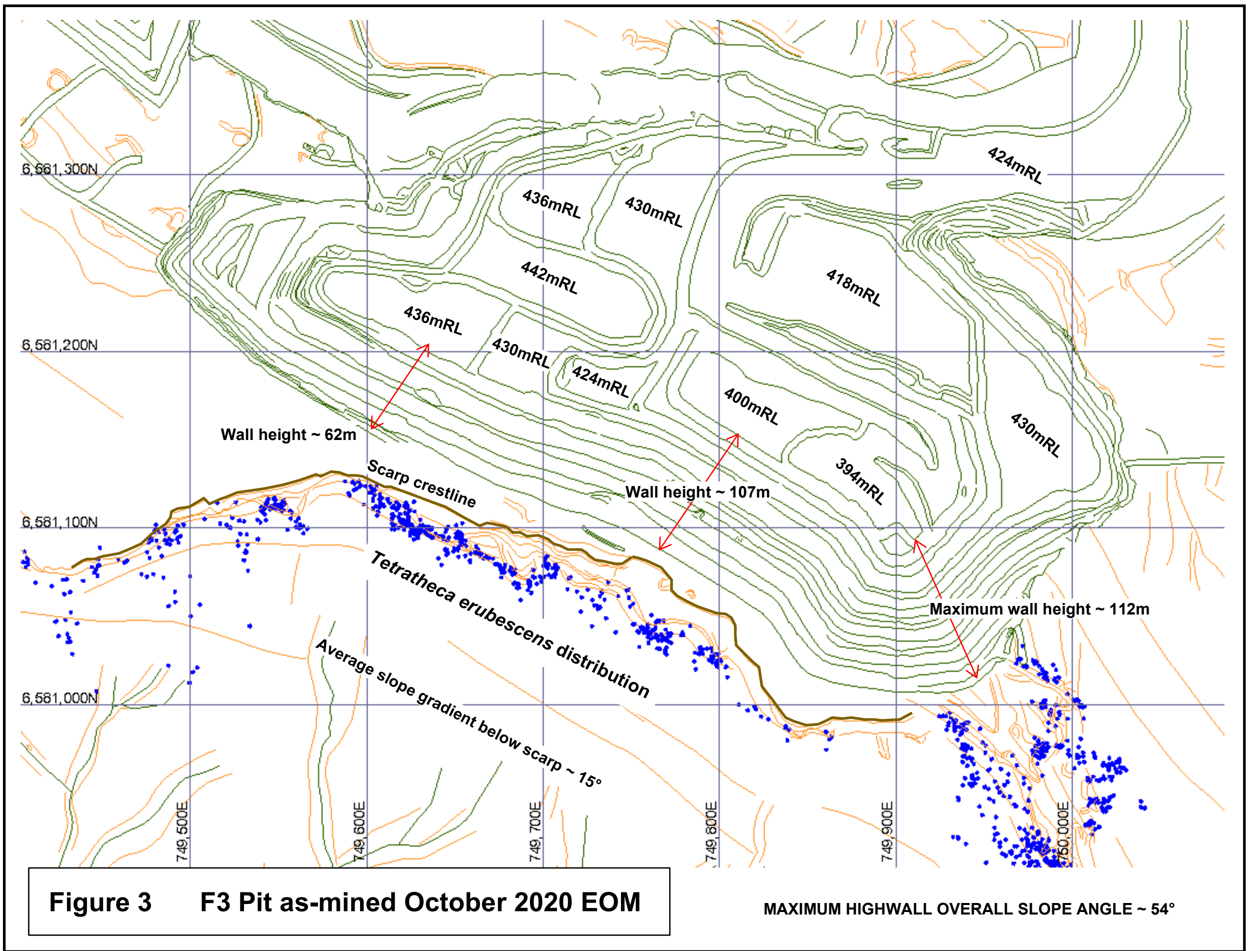


Figure 3 F3 Pit as-mined October 2020 EOM

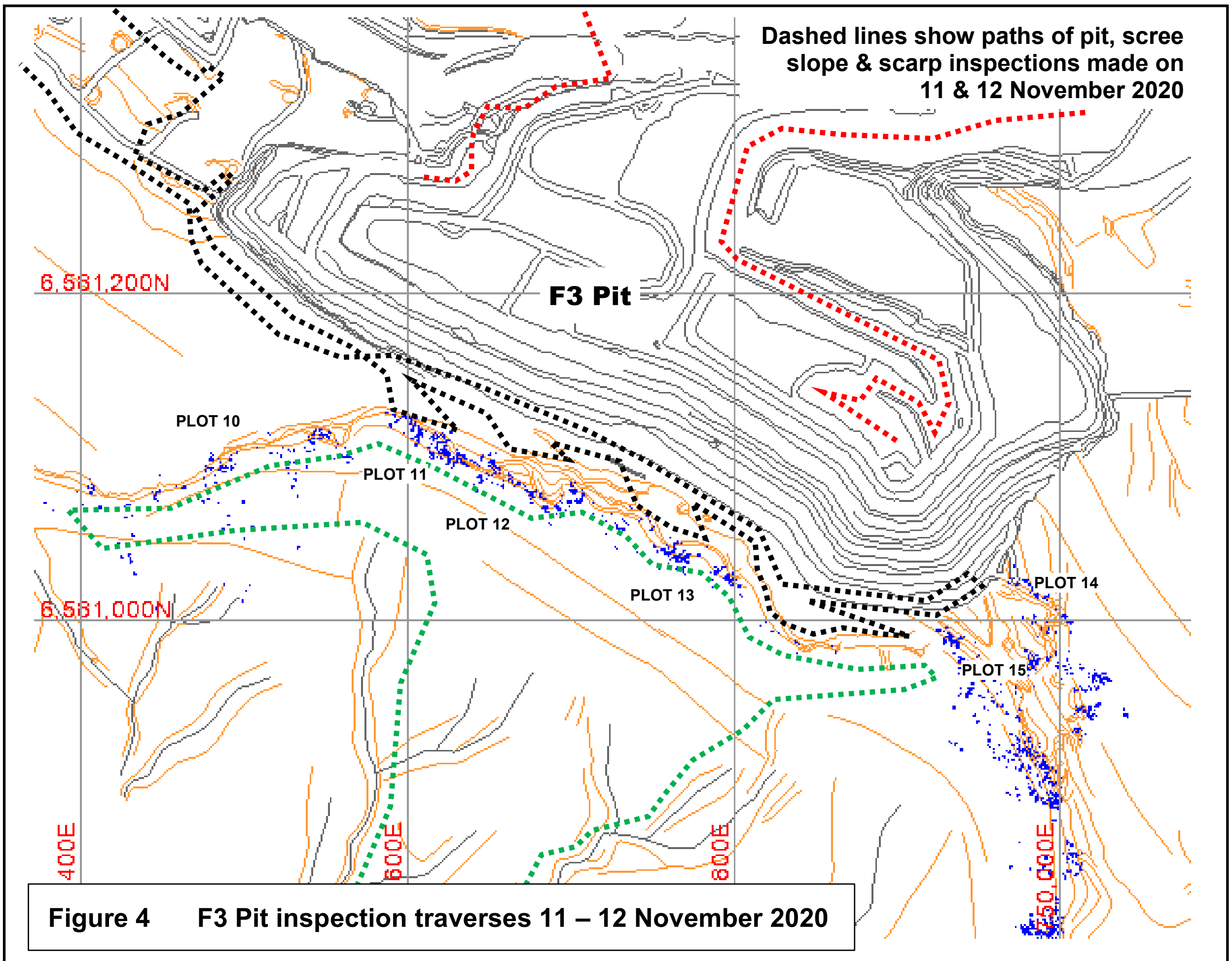


Figure 4 F3 Pit inspection traverses 11 – 12 November 2020

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Anisotropic Function	Water Surface	Ru
BIF		32	Anisotropic function			F3BIF	None	0
Transitional BIF		30	Anisotropic function			F3BIFtrx	None	0
Duricrust		30	Mohr-Coulomb	200	35		None	0

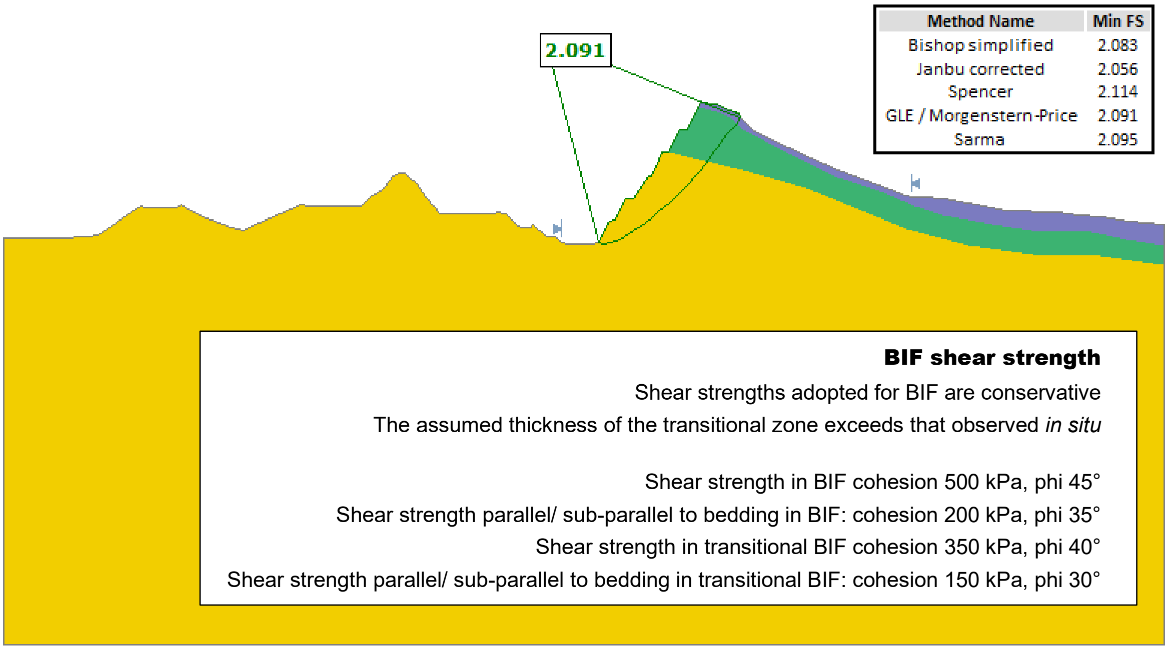


Figure 5 **F3 Pit highwall limit equilibrium analysis**

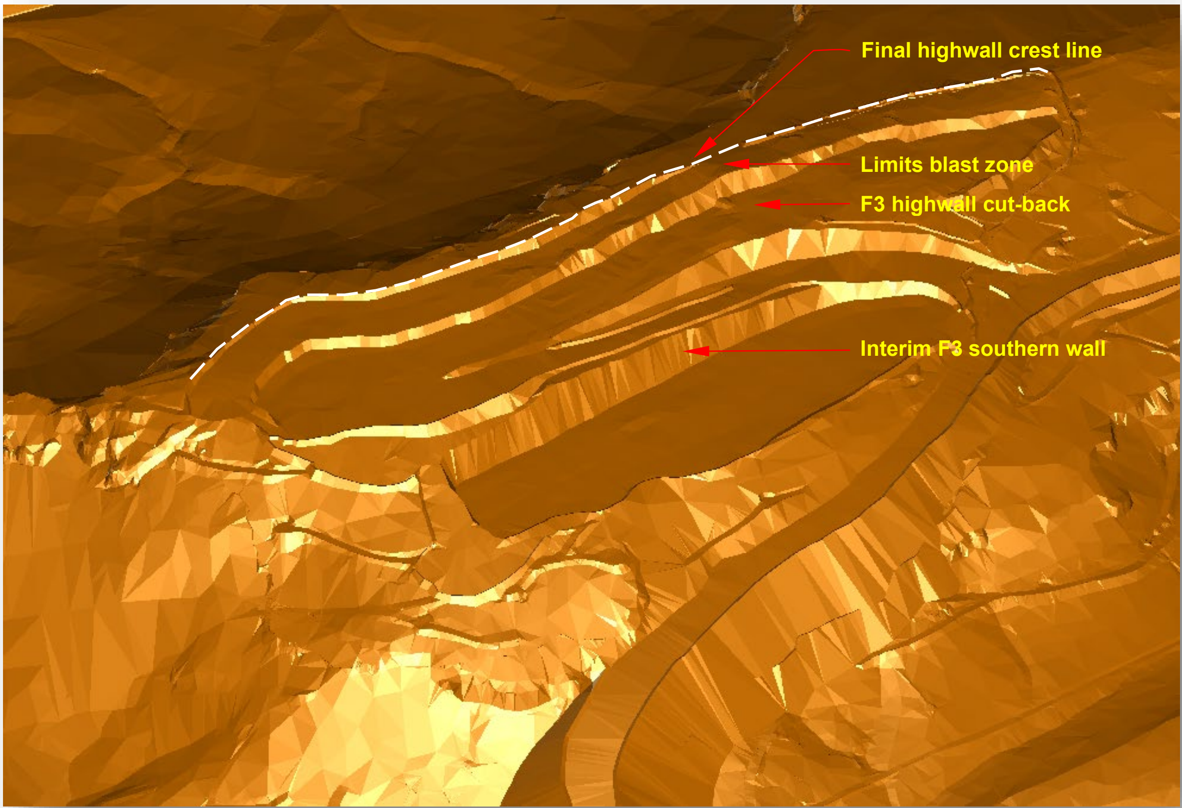


Figure 6 **F3 Pit highwall, cut-back & final batter development (March 2018)**

Plate 1 F3 Pit highwall & eastern endwall (12 November 2020)

Plate 2 F3 Pit upper highwall (11 November 2020)

Instances of minor fretting on the F3 highwall are variously related to local cavities, rock structure (cross-cutting faulting and bedding faults) and associated penetrative weathering (typically presence of limonitic materials). The more significant, yet benign, features are highlighted in Figure 7.

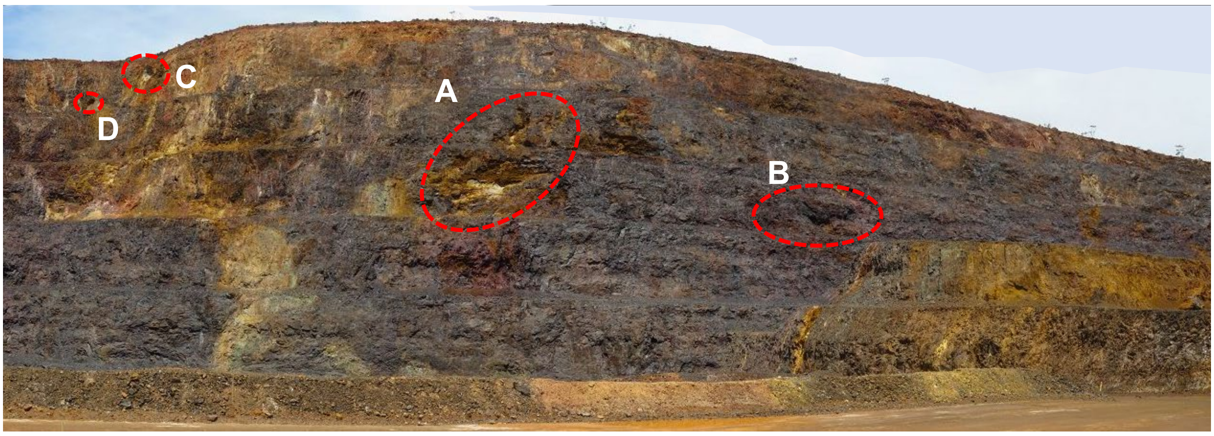


Figure 7 F3 Pit upper highwall zones of localised fretting (11 November 2020)

At Location A, Figure 7, fretting of limonitic material associated with fluid flow along bedding-parallel faults/ shears. The area is shown and described in Figures 8 and 9. Fretting has occurred where the weak limonite is exposed in the batter; however, continued deterioration is extremely slow, with material deeper into the face being well-confined by adjacent strong BIF rocks, which also provide a framework to support the batter face.

It is inferred that in the very long term fretting and/ or erosion of the limonite may occur, though the effects are expected to be surficial. The worst case envisaged would entail fretting/ failure back to the southern contact of the limonite zone, but upslope collapse would not progress beyond the immediate overlying berm. Overall highwall stability would not be compromised.

Minor fretting from narrow limonite zones is evident further west along the highwall. Further fretting from friable zones may be possible, however, such events would be inconsequential.

A small cavity has been exposed by mining at Location B, Figure 7, (evident in the lower right corner of the larger image in Figure 8). Further fretting, if any, is expected to be minimal. The surrounding formation is sufficiently strong to maintain stability around the void.

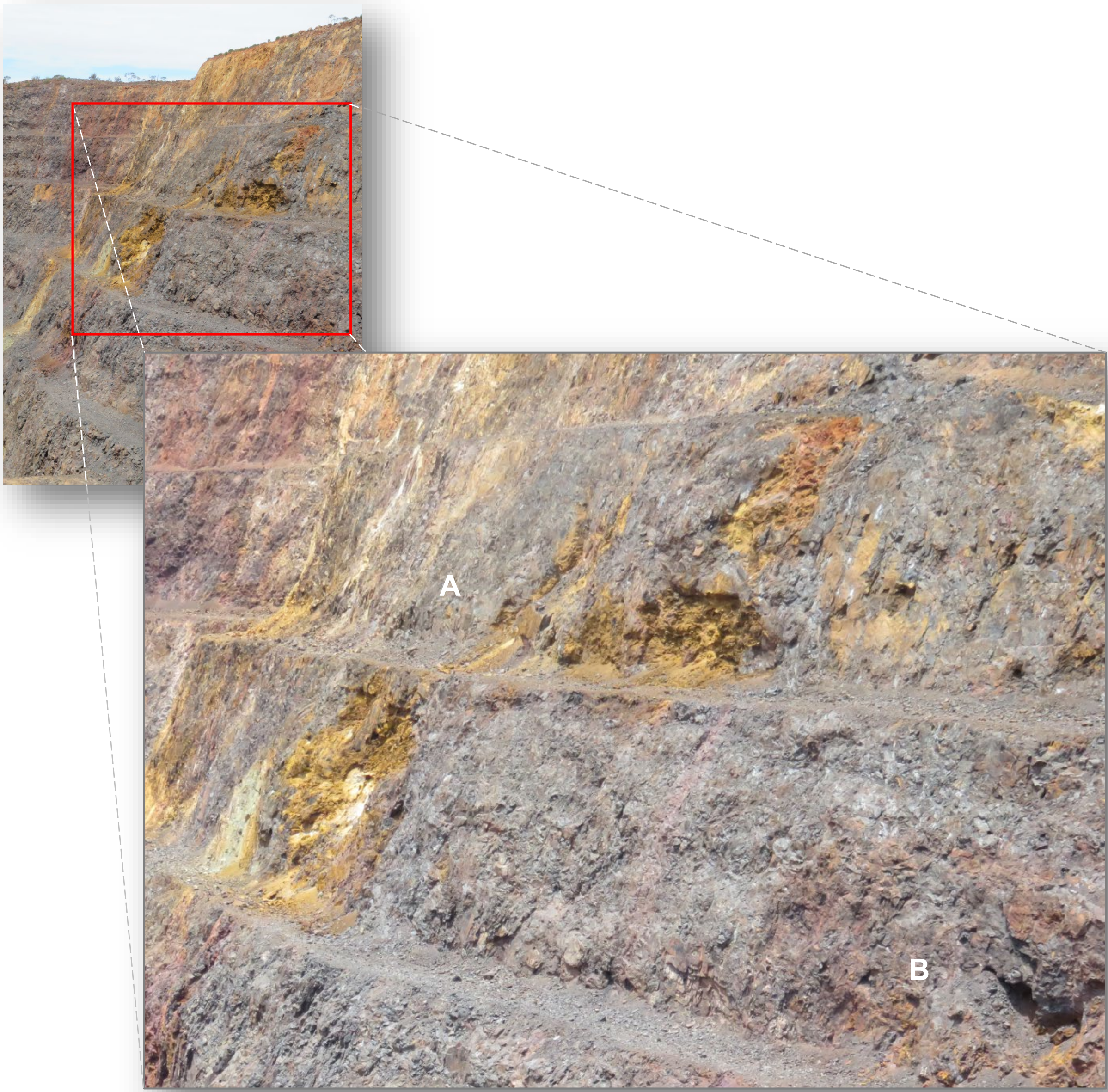


Figure 8 F3 Pit Locations A & B, (Figure 5)

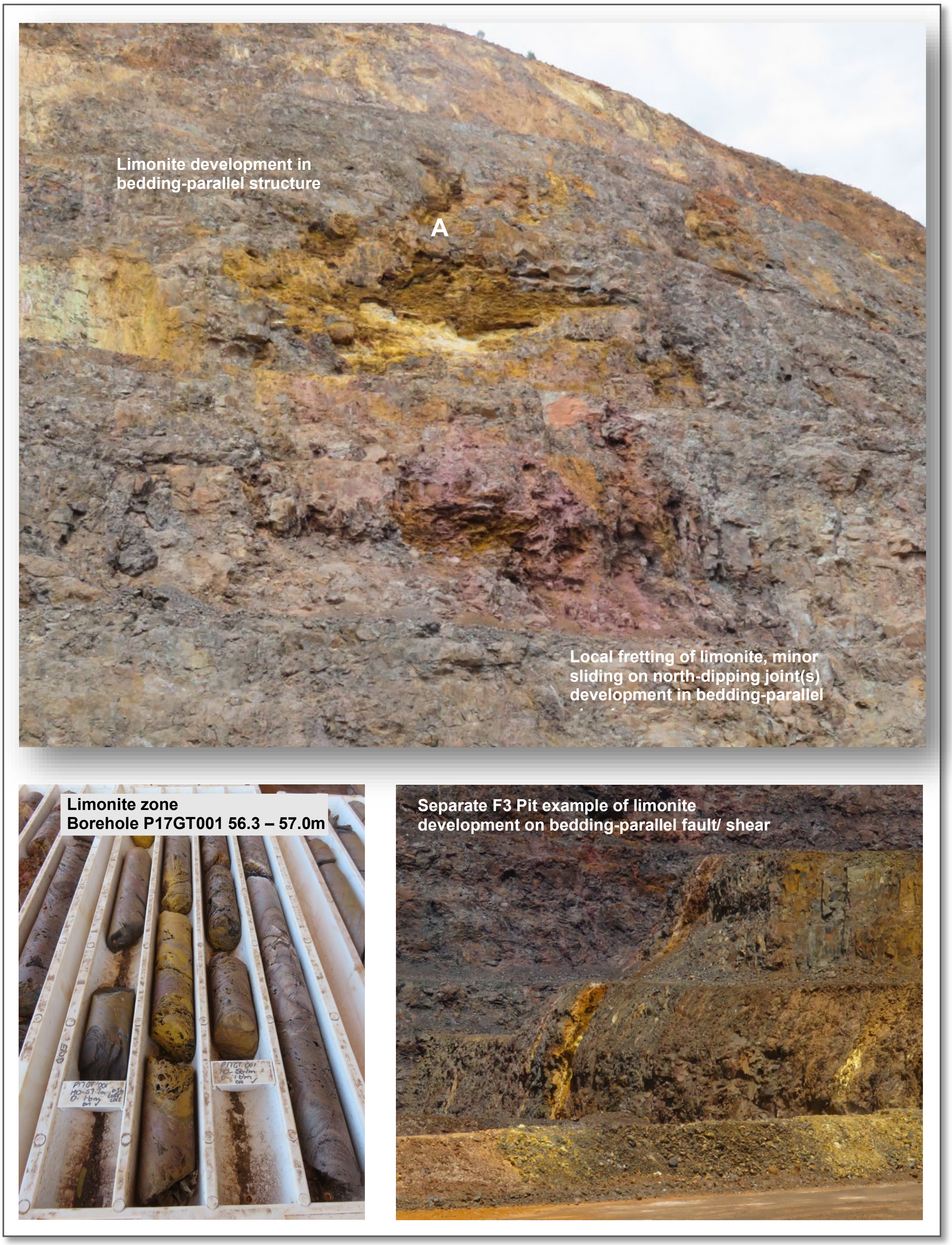


Figure 9 F3 Pit Location A, limonite in core & a separate similar limonite structure in F3 Pit

At Location C, Figure 7 fretting from a limonitic zone has occurred ~ 2m below the crest of the pit, Plate 3. The undercut is ~ 1.5m deep × ~ 3m along str. At present the back of the undercut is stable, but it is possible that fretting could, in the very long term, break through to surface. Should such a situation eventuate, expected crest retreat would be ≤ 3m along strike. Subsequent fretting would be limited and run-off erosion would not be an issue as the ground slopes at ≥ 10° to the south.

At this location the distance between the pit crest and the southern scarp crest is ~ 22m, with the nearest *T. erubescens* a further ~ 8m horizontally and ~ 5m vertically from the scarp crest.

Plate 3 F3 Pit, undercut near crest at eastern end of the highwall (Location C, Figure 5)

At Location D, Figure 7 a small, structurally-defined block drop-out has undercut the batter. The undercut is ≤ 2m × 2m and ≤ 2m deep. The opening formed by the structures (inferred joints) is stable. Any future deterioration would have negligible influence on overall wall stability.

Other

Access into F3 via the north wall ramp should be re-aligned, away from an undercut (circled in Plate 4) and a bund constructed to contain possible debris from rockfall or fretting (as shown in Plate 4).

Plate 4 F3 Pit, recommended rockfall protection on north wall ramp

Natural Slope South of F3 Pit

The natural scarp south of the F3 Pit, where mining activity most closely approached protected *T. erubescens* habitats, remains stable in an overall sense. No discernible evidence of recent rockfall (since January 2020) was detected during the November 2020 inspections.

Inevitably natural deterioration will continue over time, albeit at an extremely slow average rate.

Numerous falls of ground are evident on the scree slope, resulting from the natural process of degradation and collapse. The debris from rockfalls overwhelmingly pre-date mining at F Deposit. The scarp has retreated over millennia and this process will continue with progressive relaxation, loosening and fall of blocks from the surface of the scarp.

Two significant falls of ground occurred from the southern scarp during the mining of the F3 Pit; however, the cause of the falls cannot be conclusively or exclusively be ascribed to ground disturbance related to mining:

1) **Fall of ground # 1**

   Occurred at some unknown date and time between 13 November 2018 and 14 January 2019.

   Fallrock impacted two (2) individual *T. erubescens* along the line of the fall. Both survived.

   This fall event area was inspected by Peter O'Bryan & Associates on 31 January 2019 and reported on in February 2019 (Memorandum 19001B to Mineral Resources Limited / Iron Resources Pty Ltd, dated 22 February 2019).

   No changes in conditions were noted during the November 2020 inspection in the area around the original position of the fallrocks.

2) **Fall of ground # 2**

   Occurred at some unknown date and time between 25 June and 24 August 2019.

   Fallrock impacted three (3) individual *T. erubescens*.

   Debris from the fall comprises a large slab (≥ 2m × 0.6m × 0.6 to 1.2m, with long sides/ contacts (when previously *in situ*) inclined at angles between ~ 55° and 70°) and several blocks which are inferred to have been broken from the slab due to impacts during the fall.

   This fall of ground was inspected by Peter O'Bryan & Associates on 29 and 30 January 2020 and reported on in February 2020 (Memorandum 20009 to Mineral Resources Limited / Iron Resources Pty Ltd, dated 21 February 2019).

   No change was noted in the slope around the original *in situ* position of this fallrock.
   No obvious change in slope stability conditions was detected.
   No change in fallrock block positions or conditions is evident in comparison of photographs of the area taken in January and November 2020.

An example of the steadiness in slope stability conditions is provided in Plates 5 and 6, where a naturally developed undercut in the scarp shows no visibly detectable change between the January and November 2020 inspections.

Deterioration of the surface and near-surface blocks will continue, though at any given time most blocks will remain stable. However, the degree of stability of individual blocks is difficult to ascertain visually, and the ruggedness of the terrain and presence of vegetation preclude more detailed assessment in limited periods.

Several apparently tenuously stable blocks of diverse sizes remain evident along the scarp, and it is possible that more similarly metastable but unnoticed blocks are present. It is pertinent to note, however, that in many (most?) cases apparently loose blocks in seemingly dilated ground are in fact well-constrained by interlocking and/ or friction and are unlikely to detach without further significant rock mass relaxation/ loosening.

Plate 5 Plot 13 natural undercut 11 November 2020

Plate 6 Plot 13 natural undercut 30 January 2020

While these blocks are stable, ongoing time-related deterioration or dilation (creep under gravity or general rock mass relaxation) and/ or some external disturbance (water and/ or wind erosion, disturbance by plant roots can cause a fall or falls.

There is at least one (1) area along the southern scarp (around the mid-strike point of the F3 highwall) where relaxation under gravity has caused significant lateral block displacement ≥ 1m (Plate 7). The block displacement clearly pre-dates development and mining activities at the deposit.

Imminent collapse is unlikely, rather it is anticipated that collapse will not occur until well into the future; however, it is probable that the collapse event will occur 'suddenly'. The volume of rock involved is expected to be large (≥ 100 tonnes to several hundred tonnes).

Plate 7 Naturally occurring block displacement (above western end of Plot 13)

The main mechanism of future falls is expected to be block sliding, instigated by time-related degradation of the shear strength of the defects defining the blocks (fundamentally the friction between abutting blocks) and/ or degradation of key blocks under load. Potential for block toppling exists locally and could also develop if block sliding causes local undercutting.

It is not possible to identify the rate of degradation; hence prediction of time of failure/ fall is similarly impossible. The only available evidence indicates approximately one (~ 1) fall of ground per year, which may or may not be representative of occurrences over a longer term.

Flyrock

Numerous pieces of flyrock were noted during inspection of the southern scarp and underlying slope. The estimated mass of flyrock ranged from << 1 kilogram to a few kilograms. Plates 8A and 8B show examples. The probability of flyrock striking *T. erubescens* is/ was very low and is now considered to be negligible given the distance (≥ 850m) between blasting in F1 and the monitoring plot on the slope south of F3.

Plate 8 Examples of flyrock on southern slope

Conclusion

Stability conditions in F3 Pit walls are assessed to be *good* on average. The Factor of Safety against overall/ rock mass failure of the highwall is > 2.0.

Mining in the F3 Pit has been completed hence potential for mining-induced disturbance to the scarp and slope to the south of the F3 highwall has been essentially removed.

The influence of vibrations from blasting in the F1 pit, ≥ 850m from the *T. erubescens* monitoring plots adjacent to the F3 Pit, is expected to be negligible.

Despite local appearances which may intuitively lead to contrary inference, the southern scarp is inferred to be fundamentally stable.

While there are a few localised signs of natural deterioration which must be monitored closely, no evidence for imminent falls of ground was noted.

Closure

We trust that the information provided meets your immediate needs.

Please contact the undersigned if there is any need for clarification or further discussion.

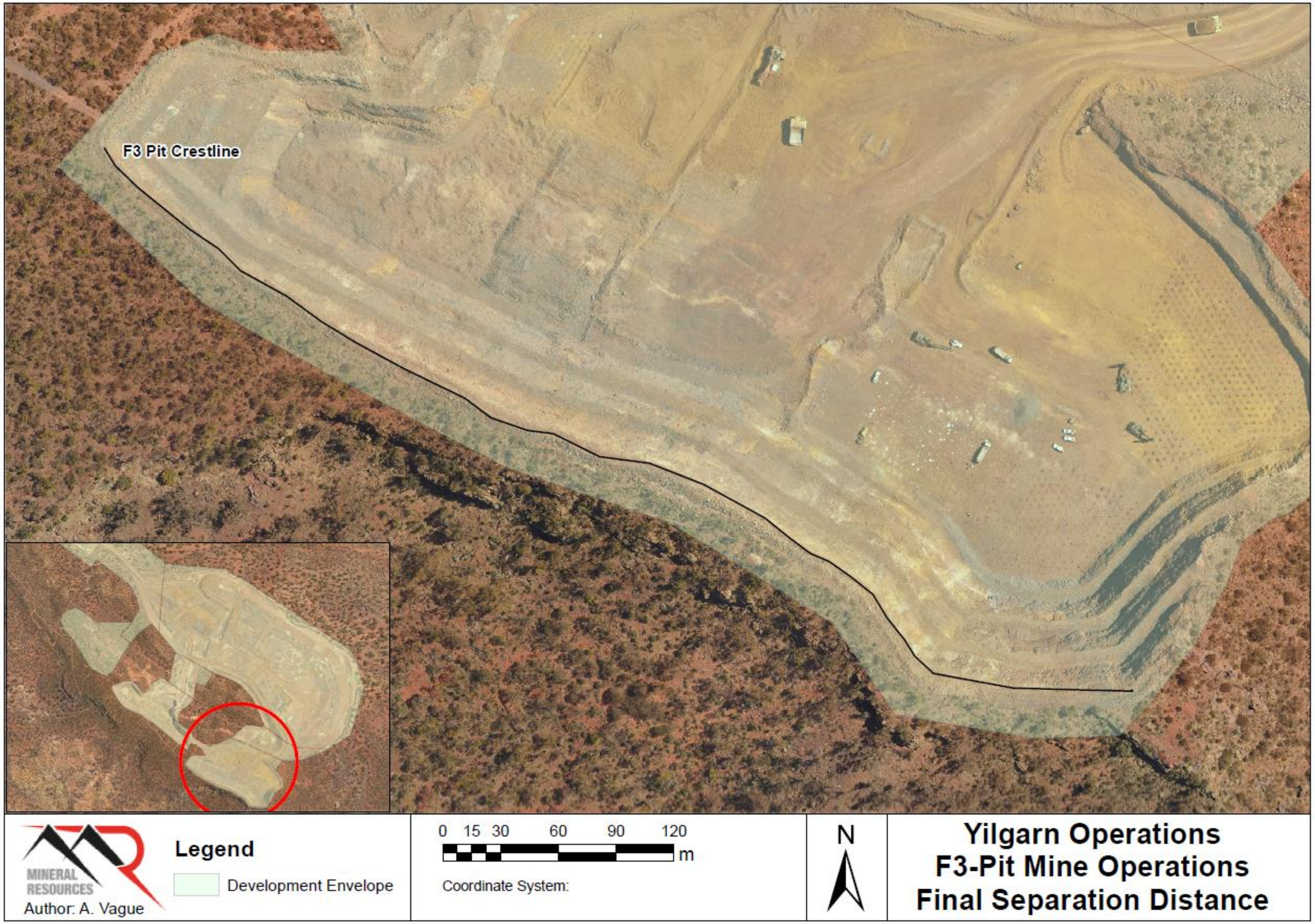
PETER O'BRYAN *& Associates*

Peter O'Bryan

BE (Mining) MEngSc MAusIMM (CP)

Principal

Attachment 9: Final Separation Distances F3 Pit



Attachment 10: MRL Vibration Monitoring Report 2020 (Revision 0)

Koolyanobbing Iron Ore Project

2020 F-DEPOSIT VIBRATION MONITORING REPORT

Proponent:	Yilgarn Iron Pty Ltd
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31 March 2021

Report Reference: ENV-TS-RP-0266

Revision History

Revision Number	Issue Date	Prepared By	Reviewed By	Approved By	Document Purpose
0	31/03/2020	A Vague		A Maurer	MS 1054 Reporting

CONTENTS

TABLES

FIGURES

ATTACHMENTS

1. INTRODUCTION

The Yilgarn Iron Ore Operations (Yilgarn Operations) are located north east of Southern Cross, Western Australia, with these operations comprising of mining operations at the Koolyanobbing Range, Mt Jackson Range and Windarling Range; ore processing at Koolyanobbing prior to railing to the Port of Esperance for export.

In January 2017, Cliffs Asia Pacific Iron Ore Pty Ltd (Cliffs) received approval under the *Environmental Protection Act 1986* to implement the F deposit mining proposal (Minister for the Environment and Heritage 2017). Under Ministerial Statement 1054 (MS 1054), Cliffs were required to develop and implement a Stability Monitoring Program to ensure the stability of the southern pit (F3 Pit) wall during mining and post closure so that the Tetratheca erubescens plants adjacent to the southern pit wall are not adversely impacted. Condition 7-6(2) of MS 1054 required the Stability Monitoring Program to include vibration monitoring and measurements for each firing of the southern F3 pit.

In August 2018, Cliffs completed an asset sale transaction with Mineral resources Limited (MRL), with the new proponent of the Yilgarn Operations being Yilgarn Iron Pty Ltd (YIPL). As the proponent of the Yilgarn Operations, YIPL assumed all responsibilities under MS 1054, including the monitoring and recording of vibration measurements for the Project's F3 pit. Specifically, Condition 7-7 required that ground vibrations along the southern edge of the F3 pit adjacent to the development envelope were not to exceed the specifications in **Table 1** (below).

Final blasting was completed on the 4th of August 2020. Mining of F3 pit concluded August 2020.

TABLE 1: BLAST VIBRATION LIMITS

Blast Frequency	Vibration PPV Limit
No blast greater than	10mm/sec
90% of blaster per year	5mm/sec
9 out of 10 consecutive blaster less than	5mm/sec

This Report presents F3 pit blast vibration results for 2020 period (1 January – 31 December 2020).

2. METHODOLOGY

Vibration monitoring was established at the F Deposit F3 Pit as per the Stability Monitoring Program (Geotechnical Management Plan: F Pit Development, Cliffs 2017), approved by the Department of Mines, Industry, Regulation and Safety (DMIRS)/ Environmental Protection Authority (EPA) under Condition 7-6(2) in February 2017.

To establish site specific empirical relationships for calculation of blast induced vibration parameters including peak particle velocity (PPV) and site and rock properties, a series of five (5) test blasts where carried out within the boundaries of F3 pit shell to develop site laws to ensure compliance with site conditions. These tests were concluded on contour at the top of the ridge of F deposit.

To monitor the ground vibration, two standard tri-axial geophones were installed along the southern ridge of F Deposit, one at F3 and one at F2. The geophones use a suspended mass between two magnets to convert the ground vibrations into voltage deflections. During a seismic activity, this mass moves relative to the magnets thus producing a voltage which can be measured, recorded and analysed at a later stage.

Vibration predictions were made before each blast using the equation: $V=[R/\sqrt{Q}]^{-\beta}$

Where:

- V is the peak particle velocity (PPV) in mm/sec.
- R is the distance between the blast and the point of measurement in meters.
- Q is the maximum instantaneous charge in kilograms.
- K & β are constants related to site and rock mass properties.

3. RESULTS

Blasting continued in F3 pit during 2020. **Figure 1** presents the vibration monitoring results from January to December 2020. The raw data is included in **Attachment 1.**

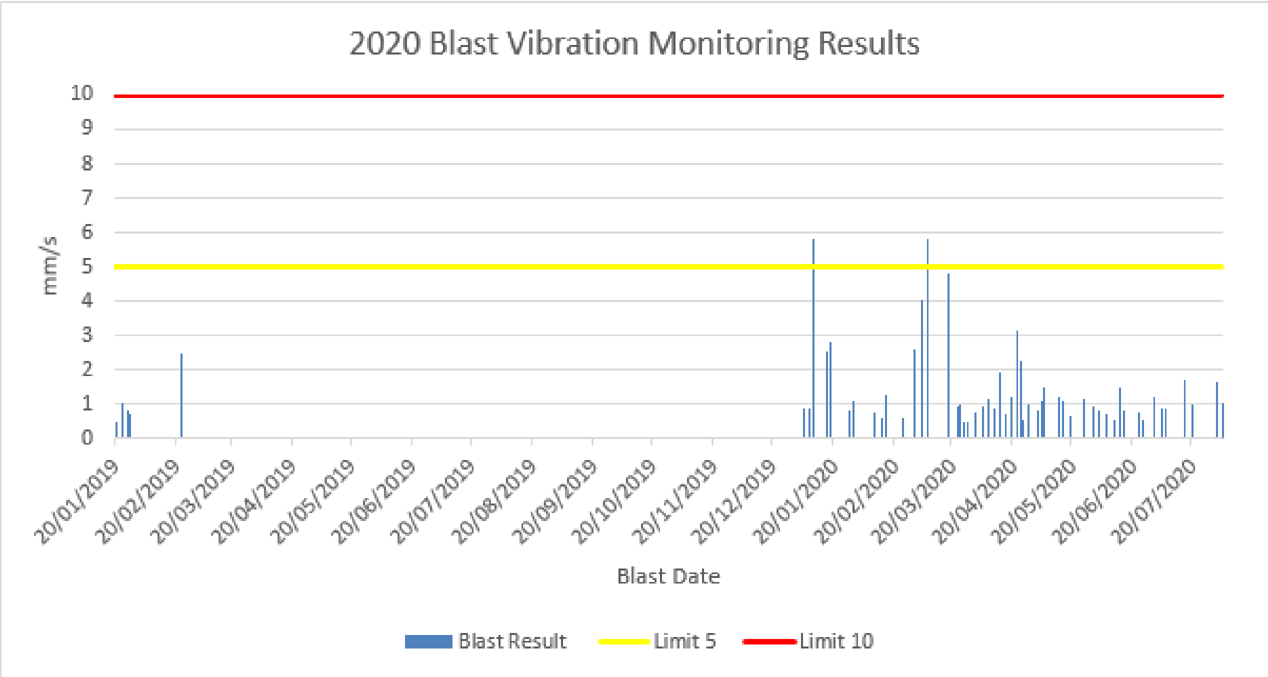

FIGURE 1: BLAST VIBRATION MONITORING RESULTS

A total of 64 blasts were conducted during the 2020 period, with results indicating:

- A total of two blasts registered a recording of between >5.0 - <10mm/sec.
- No blasts exceeded the 10mm/sec PPV limit.
- A total of 62 blasts registered less than 5mm/sec.

Based on the above, a total annual compliance of 97% was recorded for the 2020 reporting period.

3.1 Exceedance Summary

No blast vibrations exceeding the allowable vibration limits for F3 pit, as specified in Condition 7-7 were recorded.

4. DISCUSSION AND CONCLUSIONS

4.1 Environmental Impacts

An assessment of the F3 pit following the recorded exceedances has found no evidence of pit wall instability and/or signs of potential development of pit wall instability. These observations provide a high level of confidence in the Project's geotechnical stability predictions.

To date, the recorded vibration exceedances have not resulted in any observed adverse impacts to *Tetratheca erubescens* plants and/ or other environmental values located on the scarp of the southern wall of the F3 pit. In addition, no detrimental stability impacts to the rock mass on which *Tetratheca erubescens* plants are located has been recorded.

4.2 Ongoing Stability Monitoring

Implementation of the approved Stability Monitoring Program continued during 2020. An independent aeromechanical consultant (Peter O'Bryan &Associates 2020) was engaged to provide a geotechnical assessment of the F3 pit and mining operation, specifically to review the ground conditions exposed during active mining. This assessment was used to compare findings with predictions, based on drill hole data obtained and used for pre-mining pit wall stability assessment.

The monitoring program confirms the stability of the southern wall of F3 Pit and the scarp of the southern Koolyanobbing Range has not been impacted. The report, found wall conditions in F3 Pit to be good, with no obvious signs of potential for development of significant wall instability.

To date, YIPL has been in full compliance with blast vibration Conditions of Ministerial Statement 1054 since the implementation of the corrective actions.

ATTACHMENT 1: RAW PPV DATA – 2020

Date	Blast Result
4/01/2020	0.85
7/01/2020	0.8
7/01/2020	0.85
9/01/2020	5.81
16/01/2020	2.51
18/01/2020	2.8
20/01/2020	0.5
23/01/2020	1.02
26/01/2020	0.83
27/01/2020	0.68
28/01/2020	0.8
30/01/2020	1.08
3/02/2020	0
7/02/2020	0
9/02/2020	0.75
13/02/2020	0.6
15/02/2020	1.26
22/02/2020	2.48
24/02/2020	0.615
1/03/2020	2.57
4/03/2020	4.04
7/03/2020	5.78
18/03/2020	4.79
20/03/2020	0
23/03/2020	0.91
24/03/2020	0.98
26/03/2020	0.5
28/03/2020	0.47
31/03/2020	0.78
4/04/2020	0.93
7/04/2020	1.16
10/04/2020	0.88

Date	Blast Result
13/04/2020	1.92
16/04/2020	0.68
19/04/2020	1.22
20/04/2020	0
22/04/2020	3.14
24/04/2020	2.23
25/04/2020	0.54
28/04/2020	1
2/05/2020	0.84
4/05/2020	1.07
5/05/2020	1.49
13/05/2020	1.21
15/05/2020	1.11
19/05/2020	0.67
21/05/2020	0
24/05/2020	0
26/05/2020	1.17
30/05/2020	0.92
2/06/2020	0.83
6/06/2020	0.68
10/06/2020	0.56
13/06/2020	1.47
15/06/2020	0.83
23/06/2020	0.73
25/06/2020	0.52
30/06/2020	1.21
4/07/2020	0.85
6/07/2020	0.89
16/07/2020	1.71
20/07/2020	0.97
1/08/2020	1.66
4/08/2020	1.04

Attachment 11: BGPA *Tetratheca erubescens* Translocation Annual Research Report 2020 (Revision 0)

Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

Biodiversity and Conservation Science

BOTANIC GARDENS & PARKS AUTHORITY

KINGS PARK SCIENCE

ABN 30 706 225 320

Tetratheca erubescens Translocation Annual Research Report 4

for Mineral Resources Limited March 2020 to March 2021

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EXECUTIVE SUMMARY

Kings Park Science's "*Tetratheca erubescens* Translocation Research Program" commenced in June 2017 and has been active for <4 years. The broad research objectives of the Program were to (i) develop methods to support translocation and restoration of *T. erubescens;* (ii) provide technical and scientific support for a five-year research program of field translocation; and (iii) to assess functional attributes within restored / translocated populations to determine their long-term sustainability compared with natural populations.

This report highlights new research findings (March 2020 – March 2021) and summarises ongoing research since project commencement (June 2017). The following has been achieved:

- Program 1: Seed Biology
  - Completed priming approaches to enhance germination speed under controlled conditions.
  - Completed investigation into seed enhancement design (using priming and pelleting technology).
- Program 2: Translocation and monitoring
  - Conducted ongoing monitoring events of seedling emergence and greenstock survival in five translocation sites that were established in 2017 and replanted in 2018 and 2019.
  - Established five translocation trial sites in 2020 that involved *in situ* placement of 900 seed and 720 nursery propagated greenstock.
  - Monitored natural demographic sites four times to assess plant growth, health, ecophysiology and fecundity of adults, juveniles and seedlings.
- Program 3: Plant function, habitat and substrate interactions
  - Continued ecophysiological measurements of plant function in natural populations (four sites) with a focus on *Tetratheca erubescens* and co-occurring BIF species.
  - Compared plant function in natural and translocation sites with a focus on slope aspect of populations.
  - Continued storage of soils for molecular analysis to understand niche level microbial processes underpinning ecosystem function.
  - Continued soil temperature and moisture data collection in three natural and two translocation sites to monitor environmental conditions.

BACKGROUND

Cliffs Asia Pacific Iron Ore (Cliffs) received conditional approval to develop a new mining area at F deposit in the southern Koolyanobbing Range (Ministerial Statement 1054). The development at F deposit involves the removal of individuals of the Declared Rare Flora species *Tetratheca erubescens*. The Ministerial Statement includes a requirement for a program of research and restoration as part of the Stage 1 *Tetratheca erubescens* Offsets Plan. Cliffs originally engaged with the Botanic Gardens and Parks Authority (BGPA, or 'Kings Park Science') and formed a partnership to deliver a translocation research program for *Tetratheca erubescens* that supports the Offsets Plan. In 2018, Mineral Resources Limited took over operation of the F Deposit project area and implementation of the Translocation Research Program (with Kings Park Science, a science program under Biodiversity and Conservation Science in the Department of Biodiversity, Conservation and Attractions).

Tetratheca erubescens occurs in the Koolyanobbing area, in the Coolgardie IBRA (Interim Biogeographic Regionalisation for Australia) bioregion of Western Australia. This species has Threatened flora status under the *Biodiversity Conservation Act* (WA) 2016 with a very narrow distribution associated with a single banded iron formation (BIF) range where it grows in rock fissures on cliff faces. This extreme habitat provides a number of specific challenges for restoration and translocation of populations. Effective, sustainable translocation of plant individuals and populations requires understanding of attributes of the species and its habitat, including population processes and interactions with the environment, as well as appropriate propagation and translocation techniques.

This translocation research program aims to:

- Develop methods to support the translocation and restoration of *T. erubescens.*
- Provide technical and scientific support for a five-year research program of field translocations of *T. erubescens*. MRL's objective is to establish a new self-sustaining population of at least 313 mature individuals of *Tetratheca erubescens* on suitable landform that is suitable for the species.
- Assess functional attributes within restored/translocated populations to determine their long-term sustainability through a comparison with natural populations.

This document outlines the progress and outcomes of the scientific approach from March 2020-March 2021 that aims to:

- Develop practical, effective and sustainable restoration of *Tetratheca erubescens.* This will be achieved through understanding and optimising their establishment ecology and environmental requirements.
- Determine how these can be effectively utilised or recreated in restored systems. Thus ensuring the long term persistence of the species and viability of disturbed populations.

The Kings Park Science research program addresses the science required to underpin and inform translocation efforts by MRL. Occurring concurrently is an Offset Plan, derived and agreed upon by MRL and relevant regulatory authorities. Although Kings Park Science was not involved in developing the Offset Plan and associated milestones *per se,* it is understood that the Kings Park Science program will assist MRL in the science investigations relevant to the Offset Plan.

RESEARCH PROGRAM

The translocation of species whose habitat is confined to narrow cracks in rock outcrops is a challenge that significantly exceeds the complexities of a normal translocation program. The general principles of effective and sustainable translocation involve:

1. Understanding a) the interactions between plants and the environment in their natural habitat and b) the ecological, genetic and demographic population processes that enable self-sustained growth and persistence of natural populations.
2. Selecting, modifying or creating an appropriate translocation site given 1a.
3. Selecting plant material and developing translocation techniques that will enable the number of individuals required given likely attrition rates, with the appropriate level of population genetic diversity and representation given 1b.
4. Implementing, maintaining and monitoring the translocation.
5. Typically, translocation research and translocation programs involve an iterative learning/adaptive management approach and a scaling-up from experimental to implementation phases.

We have adopted these principles and executed a research program to support practical, effective and sustainable restoration of *Tetratheca erubescens* through investigation in three key disciplines: seed biology and enhancement (Program 1); translocation and demographic studies (Program 2) and plant-substrate interactions (Program 3).

RESEARCH RESULTS

Program 1. Seed biology

1.1 *Dormancy and germination.*

1.1.1 Assess the sensitivity of seeds to constant and alternating incubation temperatures under differing light regimes.

Research outcomes:

- Optimal temperature for germination was between 15 - 20°C (even after breaking dormancy through warm stratification).
- Alternating temperatures (e.g. 20/10°C, or 25/15°C) did not support germination.
- There is no difference between alternating light/dark and constant dark conditions for seed germination.
- Details of research are in Annual Research Reports 1-3 respectively (Elliott *et al.* 2018; Elliott *et al.* 2019; Elliott *et al.* 2020).

1.1.2 Profile the sensitivity of seeds to water stress during germination.

Research outcomes:

- Seeds require at least 14 days of optimal water availability (0 to -0.25 MPa) for germination.
- At higher water stress conditions (close to the permanent plant wilting point e.g. -1.0 to -1.5 MPa), germination capacity decreased and seeds took >24 days to germinate.
- Germination sensitivity to water stress changed between dormant and non-dormant seed batches. Stratifying seeds (as outlined in Elliott *et al.* 2019), and pre-treating with KAR_1 increased germination (its range into water stress; germination speed).
- Details of research are in Annual Research Report 3 (Elliott *et al.* 2020).

1.1.3 Identify the optimal conditions required for promoting dormancy loss focussing on after-ripening, wet/dry cycling and stratification.

Research outcomes:

- Highest germination was achieved by stratifying seeds for 6 weeks.
- Application of a germination stimulant (KAR_1) further increased germination responses by 10-15%.
- Application of stratification treatment to water stress experiments demonstrate an increased capacity for seeds to germinate at lower water availabilities.
- Details of research are in Annual Research Reports 1 and 2 respectively (Elliott *et al.* 2018; Elliott *et al.* 2019).

1.1.4 Define the role of germination stimulants in promoting germination.

Research outcomes:

- The smoke related germination stimulant karrikinolide (KAR_1) significantly improves germination at temperatures between 10-20°C in fresh seeds and during dormancy loss following stratification, after-ripening and wet/dry cycling.
- KAR_1 increases the capacity for seeds to germinate into water stress (Section 1.1.2).
- Details of research are in Annual Research Reports 1 and 2 respectively (Elliott *et al.* 2018; Elliott *et al.* 2019).

1.2 *Seed enhancement to improve seedling establishment.*

1.2.1 Assess the potential of seed priming to enhance germination and seedling establishment in the field.

Current research outcomes:

- Hydro- and osmo-priming seeds for 8 days increases germination speed compared to fresh seeds; fastest germination was recorded after 16.6 and 17.3 day respectively.
- Osmopriming after 8 days demonstrated highest germination of up to 80%.
- Despite increasing germination speed, there was no advantage for optimally hydro- and osmo-primed seeds under water stress conditions, when compared to stratified seeds.

Priming involves hydrating seeds sufficiently to advance the metabolism involved in germination without the seed germinating, followed by drying of the seed (Hardegree and Emmerich 1992; Bewley *et al.* 2013). Primed seeds generally demonstrate a more synchronous and faster germination than non-primed seeds. To determine the effects of priming, two methodologies were tested on dormancy alleviated seeds (through a 6-week stratification period, as determined in Section 1.1.1; see Elliott *et al.* 2018); using 1) hydropriming and 2) osmopriming methodologies. Hydropriming involves hydrating seeds in water for different periods of time, while osmopriming, involves hydrating seeds in solutions containing different water potentials to regulate maximum water uptake. A water potential of -1.0 MPa was selected as the water potential threshold in the osmotic solution (as determined from experiments conducted in Section 1.1.2; Elliott *et al.* 2020), and prepared by dissolving polyethylene-glycol (PEG-8000, Sigma-Aldrich Pty. Ltd., Sydney, NSW, Australia) in water following the methodologies outlined in Michel (1983). For both methodologies, a priming time experiment was conducted that tested different hydration time durations. The hydration period for both methodologies was 0 (control), 4, 8 and 12 days. We did not test for longer periods, as we have previously observed germination in dormancy alleviated seeds after 14 days (see Section 1.3.3; Elliott *et al.* 2020) and thus risk germinating seeds during the priming process.

The seed treatments tested were untreated seeds that were freshly collected (Control – fresh), dormancy alleviated seeds that were stratified (Control - stratified), and dormancy alleviated seeds (through stratification) that were either hydroprimed, or osmoprimed at the

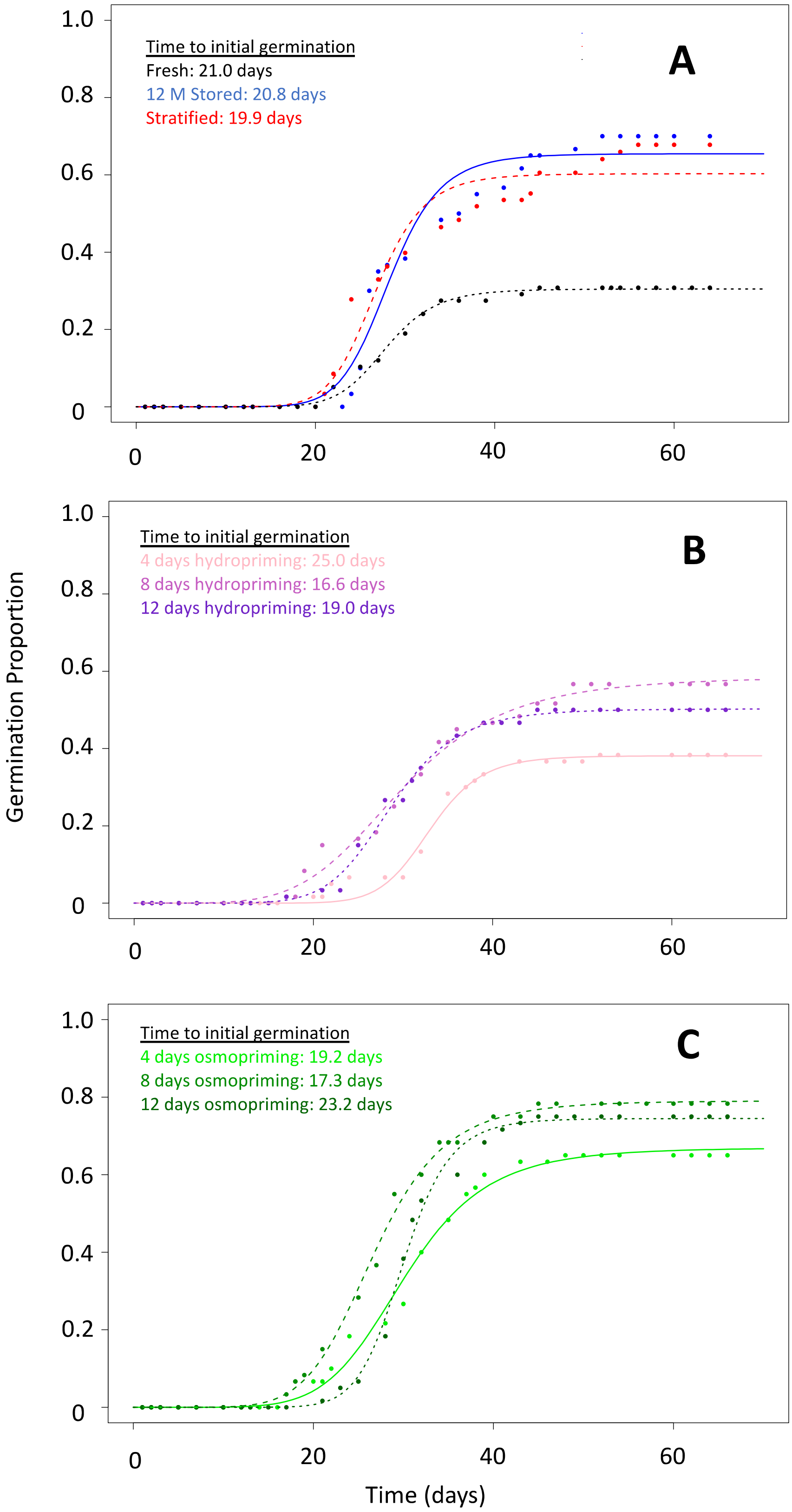


Figure 1.2.1a. Proportion of seeds to germinate over 65 days for A) Control: fresh, 12 months stored or stratified seeds; B) hydroprimed seeds; and C) osmoprimed seeds. The two priming treatments occurred over a period of 4, 8 and 12 days.

different hydration times. We also included a comparison against seeds that were stored for 12 months at 15% relative humidity and at constant 15°C (Control – 12M stored).

Initial germination was recorded after 21 days from fresh seeds with maximum germination proportions that never exceeded 30% (Figure 1.2.1a). Seeds that were stratified or stored for 12 M, germinated to higher proportions (60-65%, respectively), and marginally quicker for initial germination responses (Figure 1.2.1a.a). Hydro- and osmo-primed seeds demonstrated an increase in germination speed as the hydration period increased from 4-8 days, while treatment of seeds for 12 days generally slowed germination (Figure 1.2.1b.c). Fastest germination was recorded after 16.6 and 17.3 days, in hydro- and osmo-primed seeds that were hydrated for 8 days, respectively (Figure 1.2.1b.c). Despite increasing germination speed after 8 days of treatment, the hydroprimed seeds only germinated to 60%, while the osmoprimed seeds germinated to 80%.

Hydro- and osmopriming treatments after 8 days represented the optimal priming treatments and their germination responses were compared on a water stress gradient against the control treatments (e.g. Control: fresh, 12M stored and stratified seeds). A water stress gradient was created by using thermally corrected polyethylene-glycol solutions (PEG-8000, Sigma-Aldrich Pty. Ltd., Sydney, NSW, Australia) following the methodologies outlined in Michel (1983). The seed treatments were incubated in the different osmotic solutions for 60 days. Along a water stress gradient 0 MPa represents freely available water and is usually associated with optimal and non-limiting moisture conditions, while at -1.5 MPa seeds are exposed to conditions representing water limited conditions and the permanent plant wilting point (Bewley *et al*. 2013; Bradford 2002).

Germination decreased under higher water availabilities for both hydro- and osmo-priming treatments (Figure 1.2.1b; Table 1.2.1a). The sensitivity thresholds limiting germination were consistently higher for both priming treatments, when compared to the fresh, 12M stored, and stratified seeds. This response could be explained by priming inducing conditional dormancy, whereby seeds would have a high response under narrow optimal conditions, however, decrease rapidly into limiting environmental conditions (Baskin and Baskin, 2014). Interestingly, despite germinating at lower proportions, the dormant fresh seeds were demonstrating wider germination thresholds into water stress than either of the priming treatments. The wide germination thresholds for the 12M stored and stratified seeds were likely as result of the seeds being in a lower dormancy condition because of the prolonged storage period for the 12M stored seeds, or the 6-week stratification treatment. For all treatments, cut-testing seeds and tetrazolium staining indicated that seeds were still viable at the completion of the water stress-experiment.

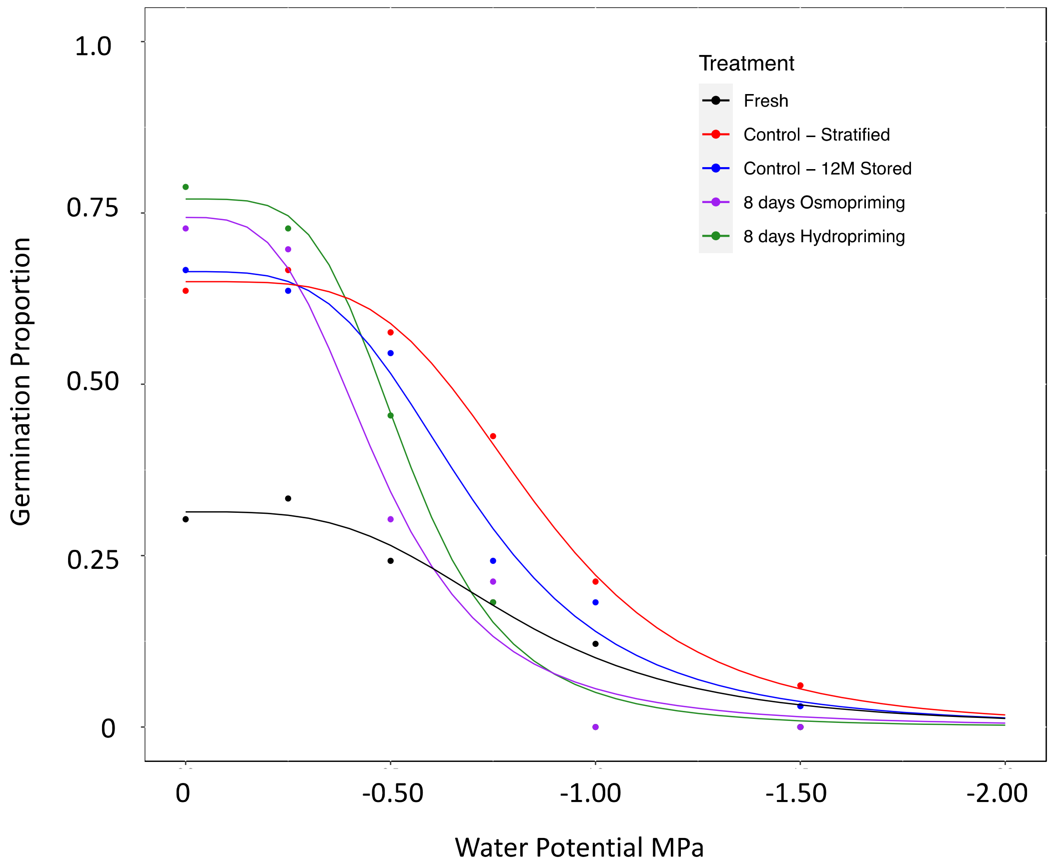


Figure 1.2.1b. Germination responses to water stress after 60 days from fresh, stratified, 12 M stored, osmoprimed and hydroprimed. The seeds were incubated on a water potential gradient mimicking freely available water (e.g. 0 MPa) and high-water stress (e.g. -1.5 MPa).

Table 1.2.1a. Water stress thresholds limiting germination at the median response, and at the 90th percentile response. The median represents the thresholds reducing germination by 50%, while at the 90th percentile, germination responses are close to zero, representing the tail-end of the response curve.

Treatment	Ψb50 [MPa]	Ψb90 [MPa]
Control - Fresh	-0.69 ± 0.04	-1.26 ± 0.12
Control -12 M stored	-0.85 ± 0.04	-1.44 ± 0.16
Control - Stratified	-0.81 ± 0.12	-1.51 ± .0.33
Osmopriming for 8 days	-0.47 ± 0.03	-0.91 ± 0.08
Hydropriming for 8 days	-0.54 ± 0.03	-0.90 ± 0.07

Applications:

- While priming increases maximum germination and speed responses, there is no apparent benefit under water stress conditions that is a limiting factor under field conditions.
- As the current tested priming-methodology is likely to induce conditional dormancy (e.g. high germination under narrow optimal conditions) for *T. erubescens* seeds, we do not recommend this treatment for field sowing or translocation trials.

1.2.2 Investigate seed coating and seed pelleting approaches for improving seed germination and establishment in the field.

Research outcomes:

- The pelleting techniques were not suitable for *T. erubescens*, due to loss of seed during the process of producing small pellets and the impracticality of finding suitably sized cracks to accommodate a larger pellet.
- Details of research are in Annual Research Reports 2 and 3 respectively (Elliott *et al.* 2019; Elliott *et al.* 2020).
- A 'slurry' matrix was considered more practical to employ in the field rather than pellets, as its application into an artificial propagation structure was successful.
- Emergence was observed from the 'slurry' soil matrix, but the response was very low and the enhanced treatment performed the same as the control treatment.
- The tested 'slurry' soil matrix did not improve emergence responses of *T. erubescens*.

As pelleting was previously reported to impede seedling emergence, we tested a 'slurry' soil matrix, which also had the capacity to deliver the beneficial microbes, nutrient and growth factors (e.g. increased water holding capacity) to promote *in situ* germination, emergence and seedling establishment. We constructed a brick, gravel and topsoil substrate as our artificial propagation structure under controlled conditions (cool room at 20°C with daily watering of 6ml) and used *T. erubescens*, *Acacia hilliana* and *Androcalva perlaria* seed to test a 'slurry' soil matrix (Figure 1.2.2a). Emergence of two species (*T. erubescens*, *A. hilliana*) occurred in both the control (topsoil only) and enhanced (topsoil, water holding crystals) soil matrices. Emergence started 25 days (*A. hilliana*) post-sowing and the final emergence was observed at 80 days (*T. erubescens*; experiment terminated at 22 weeks). Emergence was 3.3-5%, for *T. erubescens* and *A. hilliana* respectively, and was inconclusive regarding the enhanced soil matrix. All seedlings survived the construct and 'slurry' environment until termination. Seedlings were harvested at the end of the experiment and rooting structure was found to reach the base of the artificial construct under both soil matrices.

The 'slurry' settled into a hard setting substrate for both the control and enhanced soil matrices, potentially impacting on emergence. This has been observed in similar studies and alterations to the mix to include a sand or loam substrate into the recipe improved overall emergence (Stock et. al. 2020). Altering the soil matrix to include a sand or loam would be the next stage of testing the 'slurry' efficacy. During the course of the experiment, we observed a salt build up on the surface of the bricks that may have affected the later part of the experiment. The artificial construct was suitable to test the effect of a 'slurry' matrix, but the materials used need to be examined for secondary compounds like salt exudate.

The feasibility of applying a 'slurry' soil matrix using an artificial propagation structure was positive, however, the slow and low levels of emergence of *T. erubescens* and *A. hilliana* do not support the use of this approach in the field. The emergence from the 'slurry' soil matrix indicates this approach does not improve responses beyond that observed in *in situ* translocation direct sowing (0.2-3.5% under ambient conditions; Elliott *et al.* 2019 and Elliott *et al.* 2020) or under *ex situ* germination conditions (50-80% under optimal laboratory conditions; see Section 1.2.1) and is not a recommended approach at this stage.

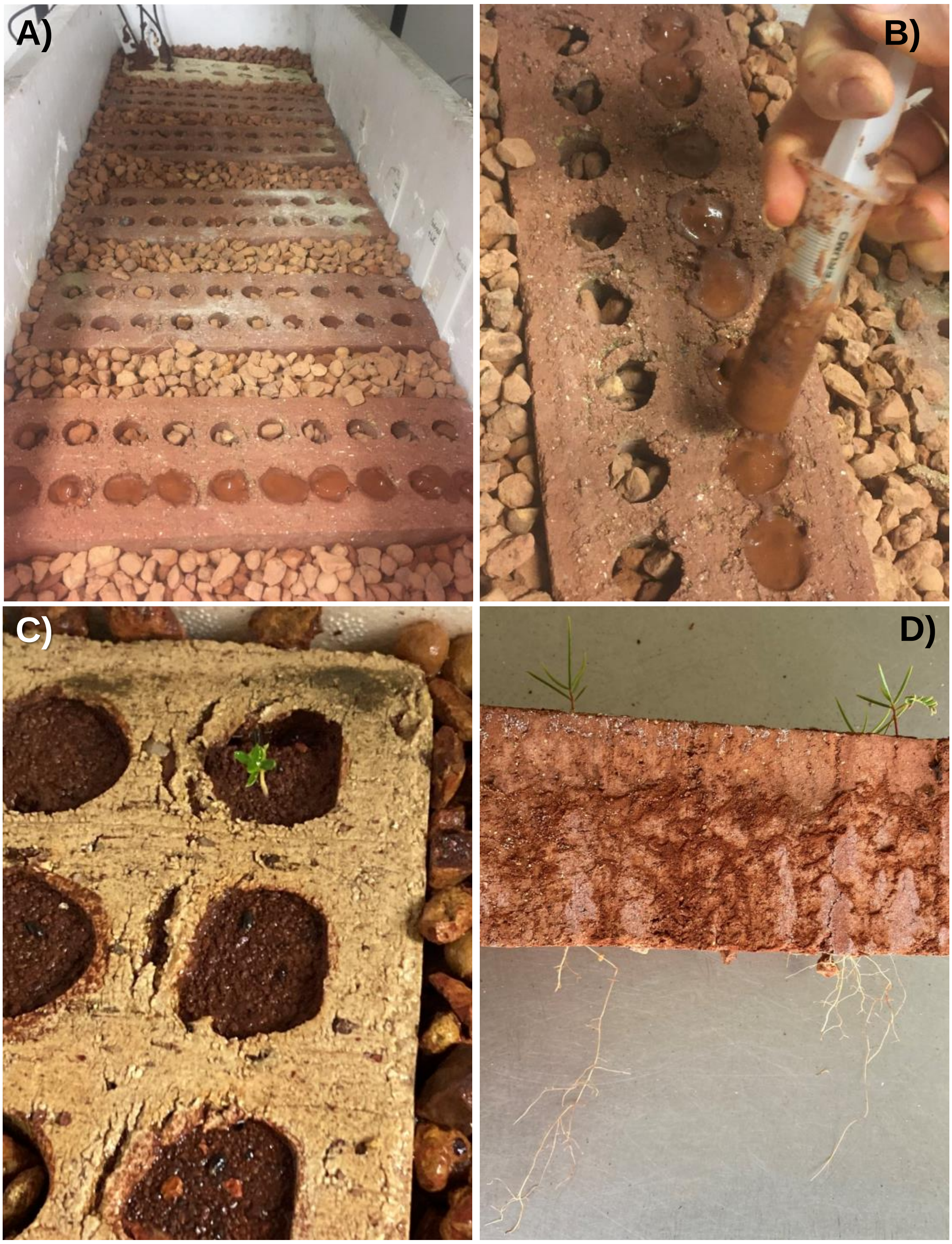


Figure 1.2.2a. 'Slurry' soil matrix trial: A) artificial propagation structure used to test treatments; B) application of 'slurry' soil matrix into structure; C) *T. erubescens* seedling that emerged in 'slurry'; and D) size of *A. hilliana* seedlings at harvest. Images A. Ritchie.

Program 2. Translocation and monitoring

2.1 *Optimising translocation approaches*

2.1.1 Assess the effectiveness of treated *in situ* sown seeds for undertaking translocations.

Current research outcomes:

- Seedling emergence was observed in August 2020 (total of 14 seedlings).
- This emergence was lesser than August 2018 (29 seedlings) or 2019 (72 seedlings); possibly due to the average June and July rainfall in 2020.
- There was no seedling survival after the summer period (2020/2021); possibly due to average, but late, climate conditions in spring and summer.
- Only the oldest two seedlings, recruited in 2018 and 2019, were still alive after the 2020/2021 summer.
- No collection of fresh seed occurred due to low levels of flowering and fruiting.

Translocations – 2017-2020

The habitat characteristics and results from the 2017-2020 translocation sites are summarised in Table 2.1.1a. In late 2017, the immediate area of T19 became unstable and the presence of mining activities close to and above the T19 area presented unsafe conditions for personnel to conduct ongoing monitoring (monitoring February 2018 incomplete). An additional translocation site (T24) was approved for use as a translocation site in 2018-2020 (Table 2.1.1a).

Details of these locations and the overall numbers of seed and greenstock trialled at each location for the 2020 translocation is summarised in Table 2.1.1b. Further details of the treatment design for the direct seeding are in Table 2.1.1g and for the greenstock planting are in Table 2.1.1h. Details of the 2017-2019 translocation trials are in Annual Research Reports 1-3 respectively (Elliott *et al.* 2018; Elliott *et al.* 2019; Elliott *et al.* 2020).

Table 2.1.1a. Summary of specific habitat details for each translocation site.

Site	Latitude	Longitude	Geology	Translocation potential (no. plants)	Distance to extant plants	Model strength (BGPA 2015)*
T6	-30.87245	119.60269	Canga/weathered haematite	<300	<0.1km	<0.3
T18	-30.88656	119.61919	BIF (high iron)	<200	0.7km	0.45-0.5
T19	-30.87145	119.60642	-	50	<0.1km	<0.3
T21	-30.87394	119.60513	BIF (20% iron)	75	<0.1km	0.55-0.6
T23	-30.87150	119.60637	BIF (20% iron)	150	<0.1km	<0.3
T24	-30.87417	119.61111	Canga	150	0.18km	0.3-0.5

* the higher the number the higher the predicted likelihood of habitat matching by the model for *Tetratheca erubescens* (Miller 2015)

Table 2.1.1b. Summary of the number of seed sown and greenstock planted for each translocation site (2020).

Site	Latitude	Longitude	Seed sown	Greenstock
T6	-30.87245	119.60269	300	160
T18	-30.88656	119.61919	300	290
T21	-30.87394	119.60513	-	90
T23	-30.87150	119.60637	-	50
T24	-30.87417	119.61111	300	130
Total			900	720

Monitoring schedule for 2017-2020 translocations were as follows:

Table 2.1.1c. Summary of installation and monitoring periods for each translocation site (Translocation 2017). Translocation site T19 only had the first monitoring assessment and none afterwards (see above).

		Monitoring											
Site	**Installed**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**
T6	9-16th	18-25th	8-15th	16-23rd	21-28th	12-20th	22-30th	30-7th	14-26th	11-20th	14-21st	23-28th	22-2
T18	Aug 2017	October	February	August	October	February	August	November	February	May	August	October	February
T19		2017	2018	2018	2018	2019	2019	2019	2020	2020	2020	2020	2021
T21	Late												
T23	Winter	9 wks	25 wks	51 wks	61 wks	77 wks	97 wks	107 wks	121 wks	133 wks	149 wks	158 wks	175 wks

Table 2.1.1d. Summary of installation and monitoring periods for each translocation site (Translocation 2018).

		Monitoring									
Site	**Installed**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**
T6	14-21st	16-23rd	21-28th	12-20th	22-30th	30-7th	14-26th	11-20th	14-21st	23-28th	22-2
T18	June	August	October	February	August	November	February	May	August	October	February
T21	2018	2018	2018	2019	2019	2019	2020	2020	2020	2020	2021
T23											
T24	Early Winter	8 weeks	18 weeks	34 weeks	54 weeks	64 weeks	78 weeks	90 weeks	106 wks	115 wks	132 wks

Table 2.1.1e. Summary of installation and monitoring periods for each translocation site (Translocation 2019).

		Monitoring						
Site	**Installed**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
T6 T18 T21 T23 T24	13-23rd Jun 2019 Early Winter	22-30th Aug 2019 8 weeks	30-7th Nov 2019 18 weeks	14-26th Feb 2020 32 weeks	11-20th May 2020 44 weeks	14-21st Aug 2020 60 weeks	23-28th Oct 2020 69 weeks	22-2 Feb 2021 86 weeks

Table 2.1.1f. Summary of installation and monitoring periods for each translocation site (Translocation 2020).

				Monitoring		
Site	**Latitude**	**Longitude**	**Installed**	**1st**	**2nd**	**3rd**
T6	-30.87245	119.60269	16-24th June 2020 Early Winter	14-21st August 2020 7 weeks	23-28th October 2020 18 weeks	22-2 February 2021 35 weeks
T18	-30.88656	119.61919				
T21	-30.87394	119.60513				
T23	-30.87150	119.60637				
T24	-30.87417	119.61111				

Table 2.1.1g. Summary of the 2020 translocation site, source of seed, treatment tested, location of seed line, number of seeds sown and the total number of seedlings emerged over the monitoring period (at 18 weeks; see Table 2.1.1f).

Site	Latitude	Longitude	Source of seed	Treatment tested	Seeding location	Number of seeds sown	Number of emergents
T6	-30.87245	119.60269	2017/2018	Stratified	Drill hole	160	0
					Fissure/crack	140	0
T18	-30.88656	119.61919	2017/2018	Stratified	Drill hole	130	0
					Fissure/crack	170	0
T24	-30.87150	119.60637	2017/2018	Stratified	Drill hole	160	0
					Fissure/crack	140	2
Total						**900**	**2**

Table 2.1.1h. Summary of the 2020 translocation site, source of greenstock and the total number of planted at each site.

Site	Latitude	Longitude	Greenstock source	Number planted June 2020
T6	-30.87245	119.60269	Cutting	80
			Seedling	80
T18	-30.88656	119.61919	Cutting	145
			Seedling	145
T21	-30.87394	119.60513	Cutting	45
			Seedling	45
T23	-30.87150	119.60637	Cutting	25
			Seedling	25
T24	-30.87417	119.61111	Cutting	65
			Seedling	65
Total				**720**

Direct seed sowing in 2017-2020 translocations

Seeds collected from natural plants in 2016/2017 (Elliott *et al.* 2017) were used in the direct seeding experiments in the 2017 and 2018 translocation trials. Due to limited seed availability from this initial collection, seeds for the 2019 and 2020 translocation trials were sourced from the 2017/2018 collection. The development and implementation of the translocation design for the *in situ* sown seeds, including the seed treatments, the number of replicates implemented, and the number of emergents counted within each translocation site, are summarised in Table 2.1.1g for the 2020 translocation.

Seeds that were sown in the 2020 translocation were placed within available natural cracks within the site and covered with topsoil (0.5-1cm) or drill holes, by placing topsoil halfway up the drill hole, sowing seeds and covering seeds with a layer of topsoil (~1cm). Each sowing location was visually inspected, and photos were taken when the locations were considered to have significantly changed due to disturbance (e.g. wash-out, run-off, or burial by vegetation) or when seedling status had changed. The seeding lines showed no evidence of washout 18 weeks after sowing. This indicated that natural rainfall during this period was not flushing soil from the 2020 seeding line locations.

Seedling emergence from our direct sowing lines was detected in August and October 2020, for all four years of direct seeding (2017: 1 seedling; 2018: 3 seedlings; 2019: 8 seedlings; 2020: 2 seedlings; for a total of 14 seedlings). This was a poorer emergence response than 2018 (29 seedlings in total; Elliott *et al.* 2019) or 2019 (72 seedlings in total; Elliott *et al.* 2020). Winter 2019 received 88.5mm of rainfall (1 June to 10 August), whereas the 2020 winter only received 68.8mm of rainfall over the same period, suggesting that the higher rainfall during the 2019 winter stimulated a greater germination response in all translocation trials. The continued emergence from seed that had been sown in previous years, despite a low recruitment pulse, demonstrates the persistence of seed in the soil seedbank after three years.

However, seedling survival after the summer period (2020/2021) for the 2020 recruitment was zero and there were further declines in survival of the previous year's recruitment events (recruitment in 2018: 1 seedling surviving three summers and 2019: 1 seedling surviving two summers; both at T21). Rainfall over summer 2020/2021 was 14% above average (1 Dec 2018 - 28 Feb 2021) however, the late summer rain on 27 Feb may have been too late for most seedlings (excluding this equates to 58% below average rain for 1 Dec – 26 Feb 2021; BOM, 2021). In addition to understanding that summer rains may be an important part of sustaining seedling survival from the 2018 emergence data, it is now apparent that the timing of these rainfall events is also critical to seedling survival in their first year, as the oldest seedlings (from 2018 and 2019) are still alive.

Future research:
Given the low survival from emergence lines, future research will aim to understand if the low survival is a result of the growth environment, or possibly a natural occurrence in the system. In order to address this issue, habitat characteristics will be measured on seedlings recruiting and surviving in natural sites, and compared with seedlings recruiting and surviving in translocation sites. A broad species comparison was undertaken during the 2019 translocation trial at T18, whereby a range of BIF species were sown into rock and ground strata. Data are currently being analysed and responses will be compared to *T. erubescens* germination and emergence results. Findings will be reported in the next annual report.

Fresh seed collections (2020/2021)
Tetratheca erubescens plants had a low level of fecundity during the 2020 flowering season and therefore, a seed collection event was not carried out for this season.

Future research:
Further investigation will be conducted on these seed collections to determine if there are additional environmental variables, such as genetic groups (as determined in Krauss and Anthony 2019), NE- and SW-facing aspects, or on a plot level to understand the variation in seed quality among locations on the ridge, in different years.

2.1.2 Assess the feasibility of using greenstock derived from different sources (seeds, vs cuttings) for establishing new plants *in situ*.

Research outcomes:

- It is feasible to derive greenstock from cuttings or seeds to establish plants in the field, based on the 2019 and 2020 translocations.
- Survival was similar between the two types of greenstock (2020 translocation).

Greenstock for the 2020 translocation trial that were derived from cutting material were sourced from stock plants (propagated in 2017) and maintained under controlled glasshouse conditions. Greenstock derived from seedlings were sourced from seedlings generated from laboratory trials or the 2018 seed collection. Cuttings and seedlings grown in biodegradable pots that were 8 months old at planting, both had well-developed stem biomass and visible root growth at the time of planting (Figure 2.1.2a). We planted 360 greenstock of each source type (seed or cutting derived) in the 2020 translocation across the five sites (Table 2.1.1h). Seedlings were able to be planted in the field and overall, we had similar survival of seedling derived greenstock as cutting derived greenstock in the early stages of the translocation, as rainfall was average (2% above) for the calendar year (see Section 2.2).

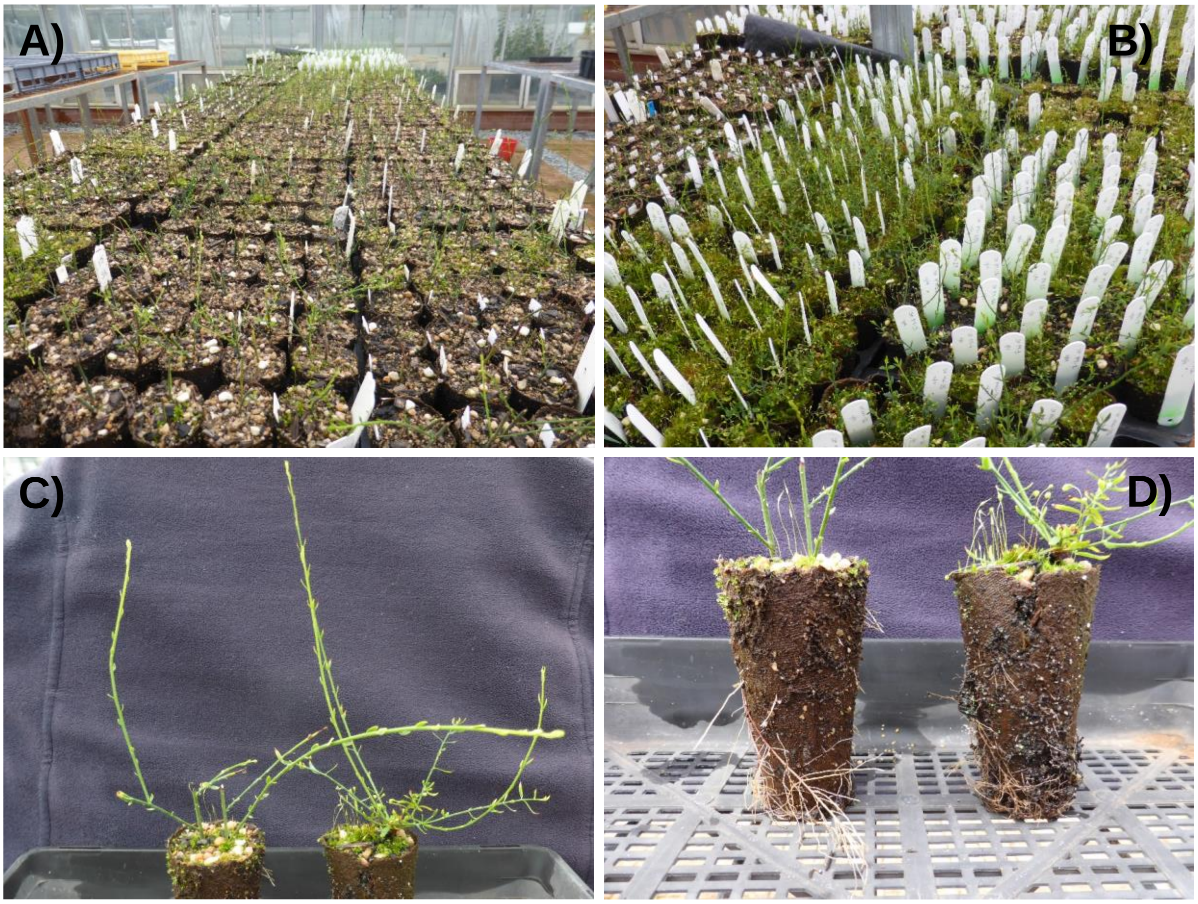


Figure 2.1.2a. Greenstock used in the 2020 translocation. A) seedling and cutting derived greenstock in biodegradable pots; B) seedling collection in glasshouse used in translocation; C) size of seedling (left) and cutting (right) greenstock in June 2020; and D) rooting status of seedling (left) and cutting (right) greenstock in June 2020. Images C. Elliott.

2.1.3 Determine the environmental requirements (crack attributes, aspect, temperature and moisture) for establishing plants *in situ*.

Current research outcomes:

- Greenstock locations were considered water capturing slope types and their survival was less variable in these water capturing locations.
- Preliminary review suggests that greenstock planting locations reflect the locations of natural plants (on local geomorphologic features and local slope type only).
- Natural recruitment and survival of seedlings was greatest in water capturing locations.
- Details of research are in Annual Research Reports 2 and 3 respectively (Elliott *et al.* 2019; Elliott *et al.* 2020).
- Peak soil temperatures were >60°C in summer 2017/2018, and <60°C in 2018/2019, 2019/2020, and 2020/2021 summers.
- The hot summers in 2019/2020 and 2020/2021 were matched by prolonged periods without moisture recharge from rainfall.
- Rainfall was approximately average in 2020 (2% above average).

Habitat characteristics

Review of planting locations

The choice of greenstock locations in the translocation sites reflected the breath of habitat characteristics where adult plants of *T. erubescens* occur (Miller 2015). The majority of greenstock were planted in water capturing locations (see Elliott *et al.* 2020), where naturally occurring plants were 2.4 times more likely to occur (Miller 2015).

Future research:

Kings Park Science will measure these habitat characteristics on individual seeding line locations within translocation sites in 2021 and any additional seedlings that emerge from recruitment events in the natural population, to determine if patterns of survival and growth can be better predicted by fine-scale assessment of individual sowing locations across multiple years.

Soil characteristics

Soil moisture and temperature loggers were installed in five sites (two translocation sites: T6 and T18; three natural sites: P5, P7 and P25) across northeast (NE) and southwest (SW) slope aspects (see Section 2.1.3 in Elliott *et al.* 2020 for installation details). Composite soil samples were collected from 0-5 cm depth at each site and used to determine soil water retention curves. The retention curves will help describe seed and plant available water calculations and site environmental effects on plant establishment and function in Programs 1, 2 and 3. Additionally, the retention curves help to described soil moisture availability ranging between field capacity (e.g. 100% = -0.01 MPa) and dry soil (e.g. 0 % < -10 MPa).

Across all sites, natural rainfall events of 5 mm were correlated with raising the soil water content to ~50% field capacity (Figure 2.1.3a), while rainfall events of 10 mm elevates the soil moisture content to >75% field capacity, though soil type, particle size and underlying substrate will influence moisture retention following rainfall. Higher soil moisture content was generally related to cooler periods (August- September), with higher soil temperature related with quicker soil drying events (e.g. November - January). During the warmer months, soil water content depleted to drier ranges 0-7% field-capacity (Figure 2.1.3a). The rainfall events that occurred in March 2021 (24 mm and 46mm on the 3rd and 4th respectively) raised the soil moisture to 68% field capacity and the moisture was retained in the soil profiles for up to 5 days.

A moisture window was consistently evident during autumn, winter and spring months (May - November) – where soil moisture levels were elevated (5-80%) and never completely dried (e.g. 0%). The increased moisture availability in winter was a likely result of lower evaporation rates evident from the soil profile due to cooler soil temperatures. Due to the lower total rainfall in 2019 and 2020 (212-271 mm, compared to >300 mm in 2017 and 2018), soil moisture availability was consistently lower across all sites during this period (Figure 2.1.3a and Figure 2.1.3b). For both translocation trials, planting and sowing seeds during this period coincided with the period of highest moisture availability. The spring period in 2019 and 2020 were both considered dry (see rainfall Figure 2.1.3b), with recently planted seeds, seedlings and cuttings exposed to prolonged periods without moisture recharge from rainfall. Interestingly, soil moisture peaks were higher in the translocation sites when compared to natural sites, however the moisture windows (the time moisture is available) were similar between the sites. A possible driver for the variation in the peaks could be the particle size composition of the substrate, surrounding vegetation shading the site and availability of hydrological zones in the BIF that may be retaining greater moisture than zones that are exposed.

There was a general cooling trend observed in some sites during summer (e.g. SW-aspect: Plot 5; NE-aspect: Plot 7 and 25; Translocation site: T18), with the soil temperatures quantified in 2017 (max temperature 56-67°C) consistently hotter compared to 2018, 2019 and 2020 (max temperatures 43-63°C). Despite the slight cooling trend, the sites were overall drier due to the decreasing rainfall trend. Natural populations with NE-facing aspects (P7 and P25) were consistently hotter (max temperatures: 55-65°C, Figure 2.1.3b) than SW-facing aspects (e.g. P5, max temperatures: 48-56°C; Figure 2.1.3b) between 2017 and 2021. In the translocation sites, T6 was consistently wetter than T18 (see Figure 2.1.3a), which is due to the majority of the site being shaded during the morning and having a SW-facing aspect. Despite having higher wetting profiles, T6 measured the highest soil temperatures during summer (65°C).

Future research:
Soil moisture and temperature logging will continue throughout the project to determine environmental requirements for natural and translocated *T. erubescens* populations. The data will also be correlated against ecophysiological measures. A full breakdown of moisture and temperature summary statistics will be available in the final report.

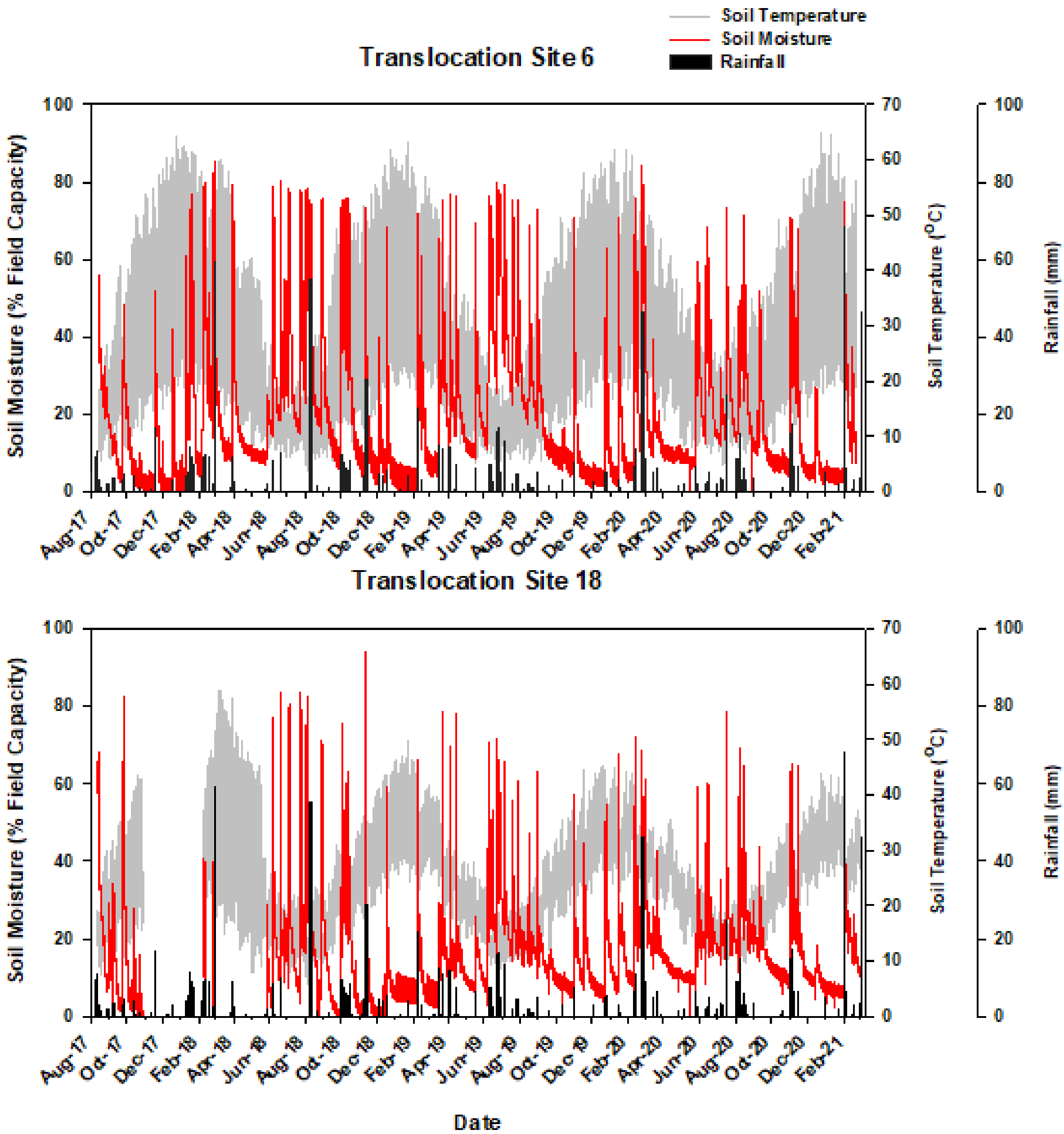


Figure 2.1.3a. Soil moisture, soil temperature and total daily rainfall for translocation sites T6 and T18 from August 2017 to February 2021. Soil moisture is shown as % Field capacity, with 100% indicating field capacity = -0.01 MPa, and dry 0% < -10 MPa. Rainfall data available from BOM, 2021 - Koolyanobbing, Site 12227.

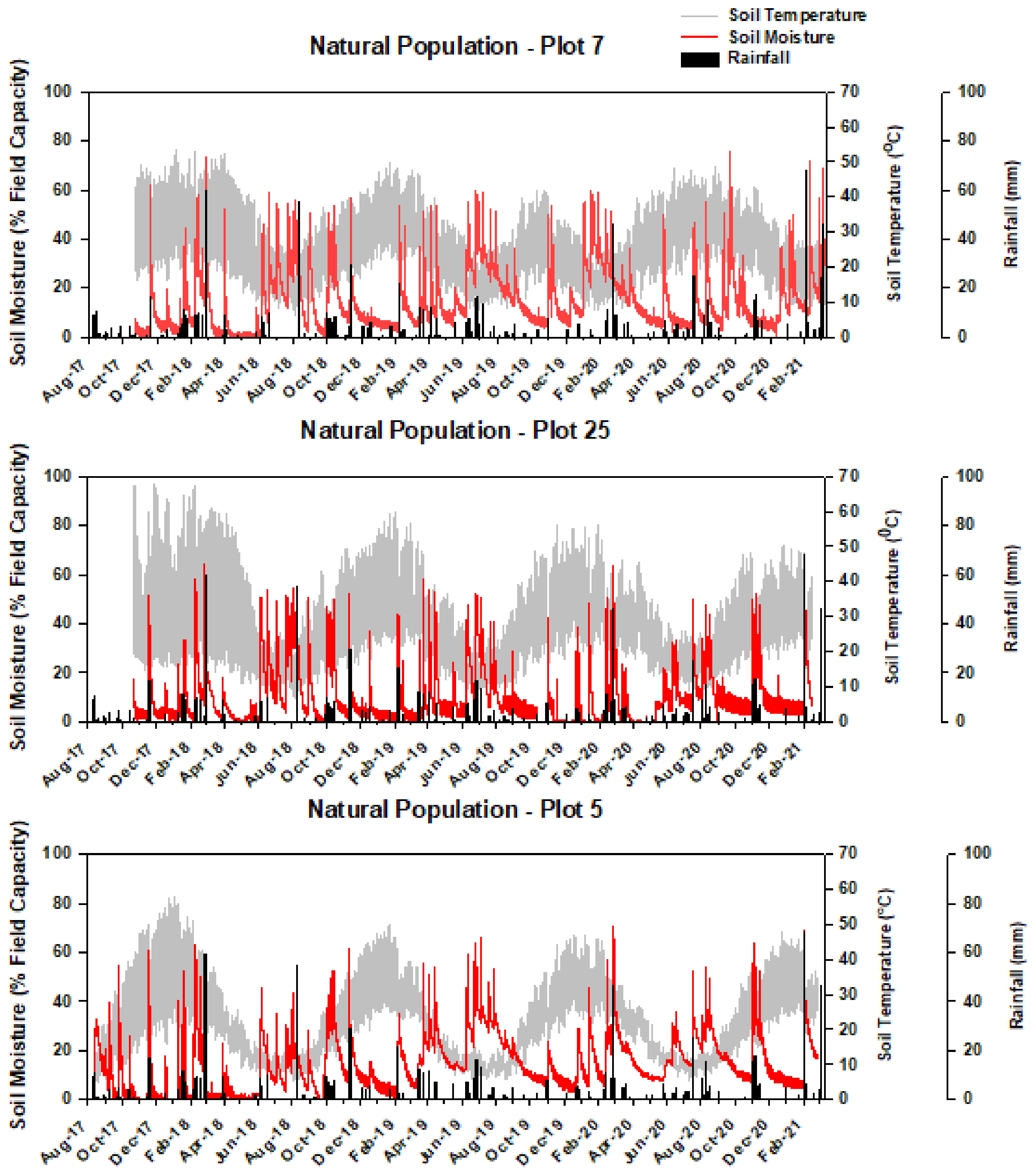


Figure 2.1.3a continued. Soil moisture, soil temperature and total daily rainfall for plots 5, 7 and 25 from August 2017 to February 2021.

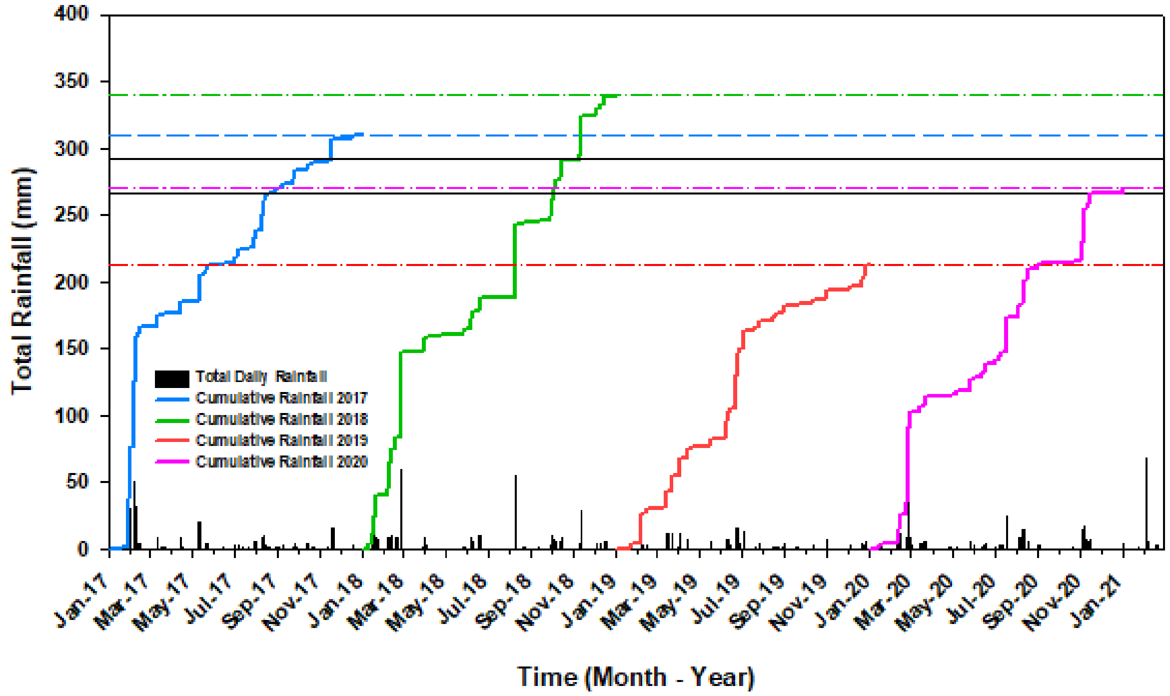


Figure 2.1.3b Cumulative rainfall for 2017 (blue line), 2018 (green line), 2019 (red line) and 2020 (purple line) between January 2017 and February 2021. The dashed horizontal lines indicate total yearly rainfall (2017: dashed blue line; 2018: dashed green line; 2019: dashed red line; and 2020: dashed purple line). Total rainfall over a period of 365 days is reported in Figure 2.1.3b. Rainfall data available from BOM, 2021 – Koolyanobbing, Site 12227, with the average total mean (bottom line) and medium (top line) rainfall for Koolyanobbing represented as the black lines.

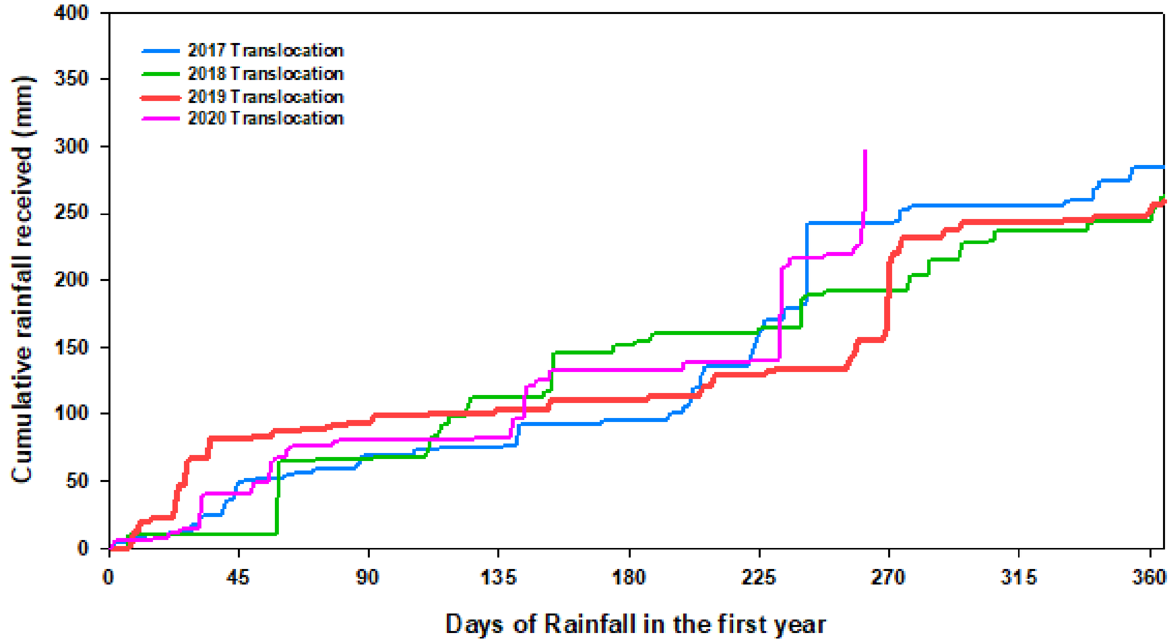


Figure 2.1.3c. Cumulative rainfall within the first year for each translocation trial. The time scale has been standardized to demonstrate how much rainfall the site received after planting for each translocation year (2017-2020). The first 90 days generally coincide with winter conditions, while the last 90 days (270-360 days) were summer conditions.

2.1.4 Compare the responses of plants when placed *in situ* into different locations including within, adjacent and outside of known *T. erubescens* populations, and into artificial sites created as a consequence of mining.

Current research outcomes:

- Plant responses (i.e. survival) to *in situ* locations were similar among most translocation sites, except one located adjacent to natural populations on the northern side of the ridge where survival was noticeably higher (T23).
- Pre-planting performance of greenstock were similar in height but seedlings had on average one more stem than cuttings.
- Baseline (*ex situ*) plant function responses to drought declined after three days and plants significantly deteriorate after ten days.
- Details of research are in Annual Research Report 3 (Elliott *et al.* 2020).

Greenstock survival was similar among most translocation sites in the initial stages at all three translocation sites (Elliott *et al*. 2018; Elliott *et al*. 2019; Table 2.1.4a), but the survival over multiple summers has showed a varied temporal response among sites. Despite the low survival, the best performing site was an adjacent site (T23) in all four translocation years (See Section 2.2 for further details).

Table 2.1.4a. Summary of greenstock survival for each trial in each translocation site and their spatial location. Table represents cumulative survival of greenstock that are 3.4 years (2017), 2.5 years (2018), 1.6 years (2019) and 8 months (2020) of age as of February 2020. Location was classed according to distance to the natural population (Elliott *et al*. 2018).

Site	Latitude	Longitude	Location class	Distance to population	Greenstock survival			
					2017	2018	2019	2020
T6	-30.87245	119.60269	Outside	<0.1km	0.4%	3.4%	0%	2.5%
T18	-30.88656	119.61919	Outside	0.7km	1.9%	4.5%	0.8%	3.8%
T19	-30.87145	119.60642	Artificial	<0.05km	0%	na	na	na
T21	-30.87394	119.60513	Adjacent	<0.01km	na	1.9%	0%	1.1%
T23	-30.87150	119.60637	Adjacent	<0.02km	4.4%	9.6%	0%	8%
T24	-30.87417	119.61111	Outside	<0.1km	na	3.7%	0%	1.6%

na = not applicable due to no greenstock planted at location

Plants were translocated into five locations with different underlying substrate and context (i.e. distance to nearest *Tetratheca* population; Table 2.1.1a). The pre-planting performance of greenstock was measured to provide a baseline to compare the future growth of translocated plants (average height, stem count).

Growth assessment

The baseline results show that the average height of greenstock was similar between cuttings and seedlings. On average, seedling greenstock had one more stem than cutting greenstock (Figure 2.1.4a). This indicated that seedling greenstock had more aboveground biomass than cutting greenstock of similar age. Both were ~8 months old at planting, which was a similar age to the seedlings planted in the 2019 translocation (greenstock was ~20 months old in the 2019 translocation).

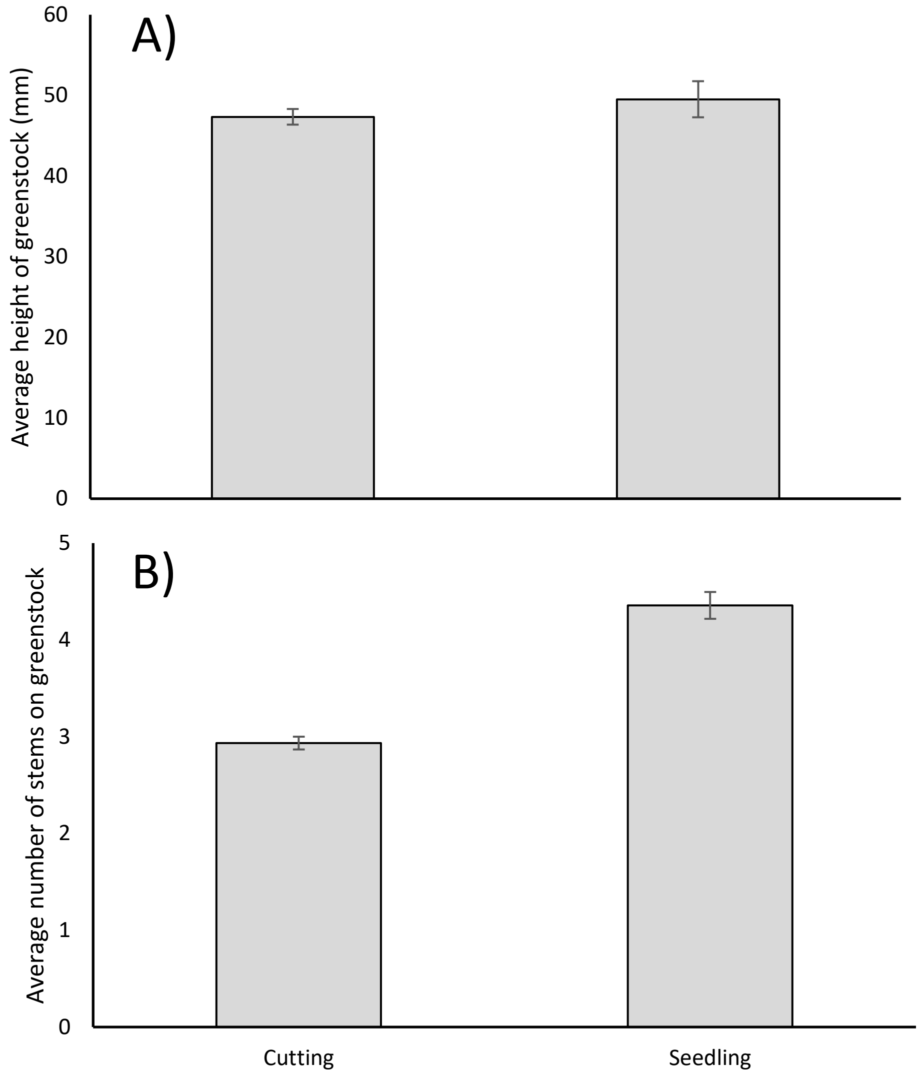


Figure 2.1.4a. Growth performance of greenstock planted in 2020: A) average plant height (mm) and B) average number of live stems per plant. Figure represents mean ± standard error.

2.2 *Survival, growth and reproduction in restored and natural populations.*

2.2.1 Develop baseline data on the growth, survival, flowering and seed production of seedlings, juveniles and mature plants.

Natural population

Current research outcomes:

- Adult plant mortality was recorded (two plants).
- Floral and fruiting phenology differed to previous seasons for adult plants.
- Growth rates of adult plants on the northern side were similar, relative to their size, in comparison to plants on the southern side.
- Growth rates in 2020 were <30% and this was lower than 2018 or 2019.
- Natural recruitment (20 seedlings) was lower than 2018 (121 seedlings) or 2019 (252 seedlings) recruitment events.
- Survival of naturally recruited seedlings was only 10% post-summer 2020/2021.

Translocated populations

Current research outcomes:

- 2017 translocation greenstock survival (derived from cuttings) overall was 1.8% after four summers (13 greenstock plants).
- 2018 translocation greenstock survival (derived from cuttings) overall was 4.3% after three summers (46 greenstock plants).
- 2019 translocation greenstock (derived from cuttings and seed) overall was 0.4% after two summers (2 plants).
- 2020 translocation greenstock (derived from cuttings and seed) overall was 3.1% after one summer (22 plants)
- 2020/2021 summer declines of *in situ* greenstock were greater in young greenstock (i.e. 8 months established) than older greenstock (i.e. 42 months established).
- Greenstock survival patterns were similar amongst all translocation sites (within the same year).
- See Section 2.1.1 for current research outcomes for direct seed sowing.

Natural population

In October 2017, mature plants were initially tagged and measured for ongoing reproductive monitoring (plant size, plant health, flower production, fruit production). Table 2.2.1a summarises the number of adult plants tagged for survival, growth and reproductive monitoring and the number that are also being measured for ecophysiology parameters. We recorded no above-ground green foliage for two plants (P9) for 12 and 24 months (Feb 2019 – Feb 2021), and suspect these plants have died. Monitoring should continue to determine if this species can recover after this period of no photosynthetic material, given future rainfall conditions in 2021. This will also assess if below-ground tissues are still viable and capable of regenerating new shoots after this length of time.

Table 2.2.1a. Summary of the number of mature plants in the natural population that were tagged for monitoring in each plot.

Site	General Easting	General Northing	Location on range	No. of plants for demography	No. of plants for ecophysiology
Plot 3	749028	6581554	South	20	4-6
Plot 5	749048	6581507	South	21	4-6
Plot 7	749260	6581695	North	20	4-6
Plot 9	749433	6581518	North	20	-
Plot 10	749531	6581119	South	20	-
Plot 11	749628	6581109	South	20	-
Plot 13	749702	6581074	South	20	-
Plot 16	750011	6580924	North	20	-
Plot 25	749117	6581805	North	20	4-6
Total				**181**	**16-24**

Table 2.2.1b. Summary of set-up and monitoring periods for tagged plants in each plot in the natural population at Koolyanobbing Range.

		Monitoring											
Site	**Set-up**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**
P3 P5 P7 P9 P10 P11 P13 P16 P25	18-25th Oct 2017 Mid Spring	18-21st May 2018	16-23rd Aug 2018	21-28th Oct 2018 1 year	12-20th Feb 2019	7-16th May 2019	22-30th Aug 2019	30-7th Nov 2019 2 years	14-26th Feb 2020	11-20th May 2020	14-21st Aug 2020	23-28th Oct 2020 3 years	22-2nd Mar 2021

Floral and fruiting phenology

The average number of floral units (e.g. buds + flowers + fruit) was much lower in 2020 than 2018 or 2019 (Figure 2.2.1a), and corresponds to the pattern of late falling and average rainfall that occurred (Figure 2.2.1j). The stage of floral development showed that the phenology of bud, flower or fruit production had similar responses between the years (i.e. skewed in one direction, and different between the northern and southern sides; Figure 2.2.1a). However, unlike 2018 or 2019 there was not an increase in floral units in October as expected for spring peak flowering, perhaps due to the late falling average rainfall that may not have started or sustained the flowering season for plants in 2020.

The peak production of buds in 2020 was similar on the northern side of the range and occurred during late winter (Figure 2.2.1b.i) and by mid-spring plants had a combination of buds (e.g. late flowering) or flowers, but mainly had fruits (e.g. early flowering). The mid-spring pattern of reproductive phenology was similar to 2019 patterns, with being lower in quantity and the amount of buds and flowers were similar on both sides of the ridge (Figure 2.2.1b.j). In summary, this data indicates that floral phenology for 2020 was similar between the northern and southern sides of the range, which is different to patterns in 2018 and 2019, perhaps due to a different reproductive response to differing environmental conditions (e.g. temperature, moisture) than previous years.

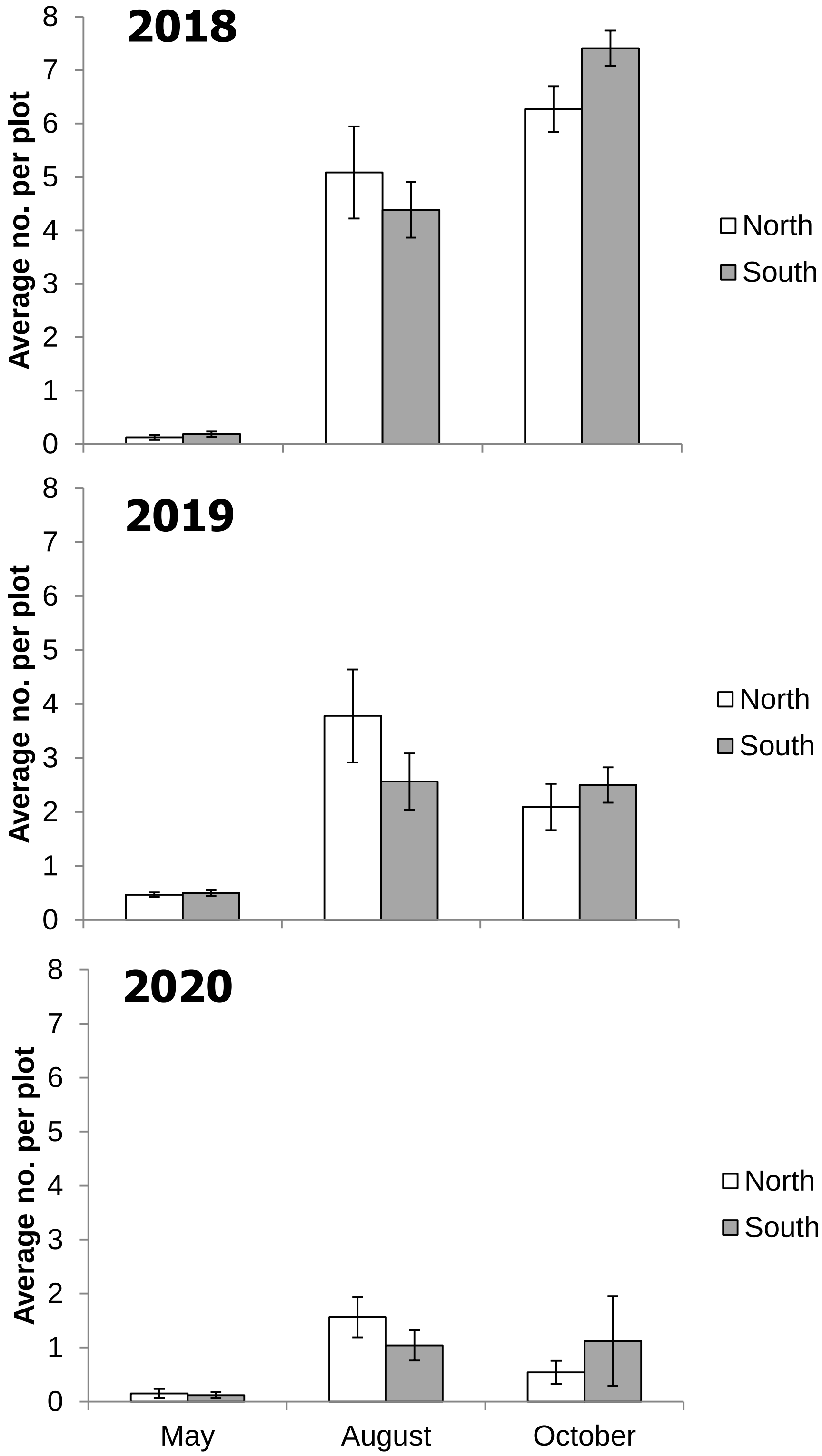


Figure 2.2.1a. Reproductive phenology (mean ± standard error) of plants (n = 20 per plot; Table 2.2.1a) in the natural population located on the northern or the southern side of the Koolyanobbing Range. Reproductive phenology represents the average number of floral units (e.g. buds + flowers + fruit) recorded for each month (average number of floral units per branch). Top chart is the 2018 flowering season (Elliott *et al.* 2018); middle chart is the 2019 season (Elliott *et al.* 2020) and the bottom chart is the 2020 flowering season.

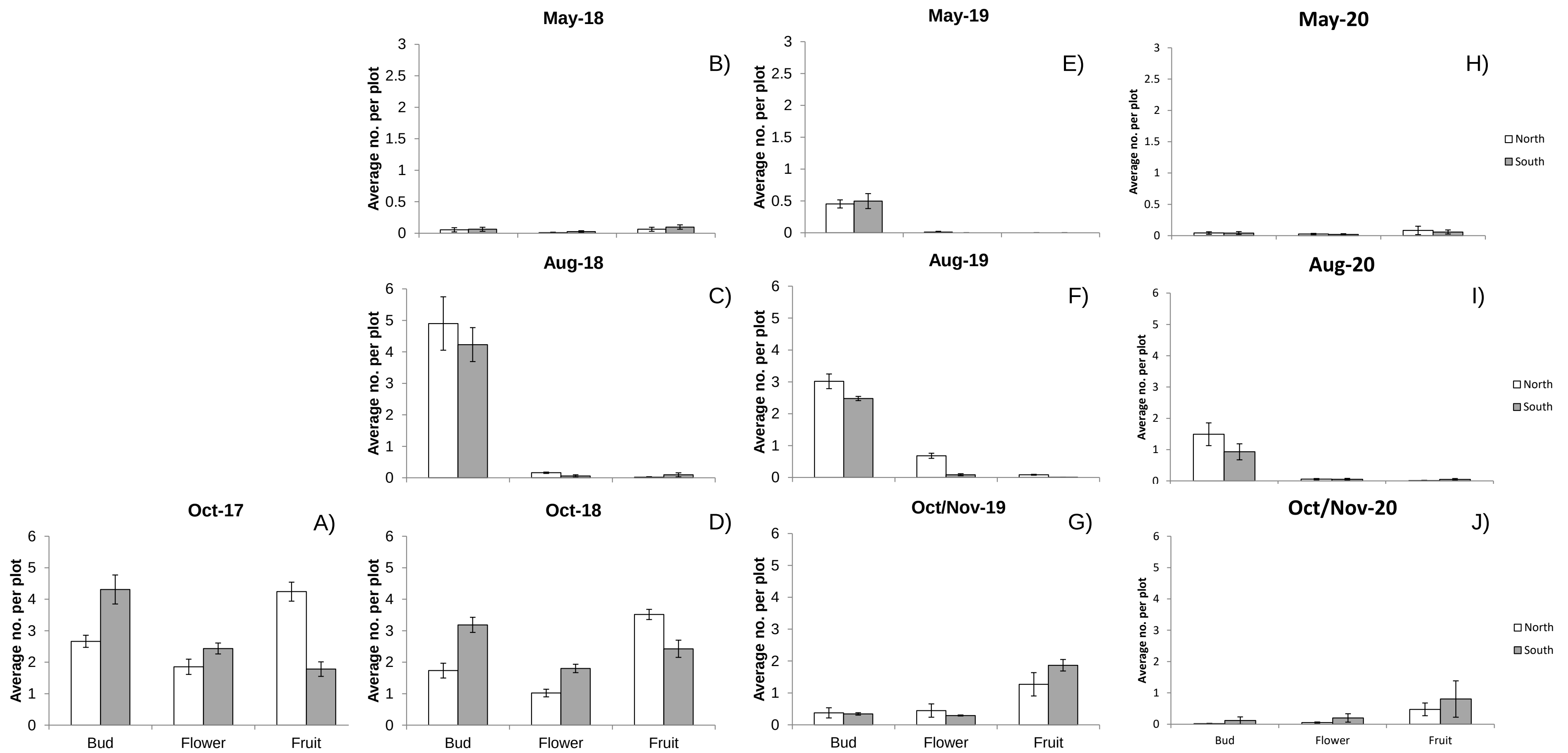


Figure 2.2.1b. Floral and fruiting phenology (mean ± standard error) of plants (*n* = 20 per plot; Table 2.2.1a) located on the northern side (white) or the southern (grey) side of Koolyanobbing Range. The average number of buds, flowers or fruit on plants during A) October 2017; B) May 2018; C) August 2018; D) October 2018; E) May 2019; F) August 2019; G) October/November 2019; H) May 2020; I) August 2020; J) October/November 2020 (average number of floral units per branch).

Plant size and growth

The plant sizes and growth of adult plants in the natural population were assessed to establish the baseline physical attributes of plants. Adult plants on the northern side were smaller on average than those on the southern side (see Elliott *et al*. 2019 for details). New plant growth (new stems) of monitored plants occurred mainly between May and August (Figure 2.2.1c). Unlike 2019 patterns, plants on the southern side produced higher amounts of new growth, relative to their size, in comparison to plants on the northern side (Figure 2.2.1c.a). Each plot performed similarly, with a greater proportion of new growth occurring in May before it reached either a plateau or declined in August (Figure 2.2.1c.b). This pattern of reduced growth during winter leading into spring is different to all previous years, except for observations in one plot in 2019 (P9; Elliott *et al*. 2020). This pattern of reduced growth corresponds to a pattern of decreased plant condition observed over the same period (see Figure 3.1.1b). That is, there was an overall decline in plant growth (i.e. number of new stems) of 2-6% between the May and August growing period (Figure 2.2.1c) and a decline in plant condition (i.e. proportion of the plant that is dead) of 6-7% during the same period (Figure 3.1.1b). In addition, the amount of flowering during this period was also lower than previous years (Figure 2.2.1b)

Overall plant growth in 2020 was 22-30% compared to 35-40% in 2019 and 60-70% in 2018 (Elliott *et al*. 2019; Elliott *et al*. 2020). Differences observed between these growing seasons may be partly explained by environmental conditions (rainfall, temperature). For example, in 2020, there was late summer rains (above average February) that may have triggered this level of plant growth in late autumn (May; similar response observed in 2018, see Elliott *et al*. 2019). However, below average monthly rainfall during March to June may have limited continuation of this new growth, whereas in previous years, at least one or more of these months received its monthly average. Recovery of plants from a limited or premature growth season will be important to monitor in subsequent seasons.

Natural population recruitment

In August 2020, recruitment of *T. erubescens* seedlings occurred in some of the established monitoring plots in the natural population. These seedlings or existing juveniles were tagged and monitored to establish baseline survivorships of this age cohort in the population. At the time of measurements, seedlings and some juvenile plants were sensitive to assessments due to their low abundance, location accessibility and very small size, therefore, a limited number of measurements were taken to minimise any impact to their survival.

In six of nine monitoring plots (Table 2.2.1a; excluding P7, P25, P9), seedlings were observed in plots, ranging from 1-11 seedlings per plot. In total, 20 seedlings were monitored for growth and survival, which was lower than 2018 or 2019 natural recruitment. Monitoring in February 2021 (post-summer) found that only 10% of these new seedlings had survived (i.e. 2 seedlings). These seedlings emerged and died across a broad range of habitat types, including cliff cracks, rock benches, under adult plants (or not) and deeper soils at the cliff foot-slope. The survival of the 2018 recruits after three summers was 6.6%, and for 2019 recruits was 3.7% after their second summer, both further declines on the previous year.

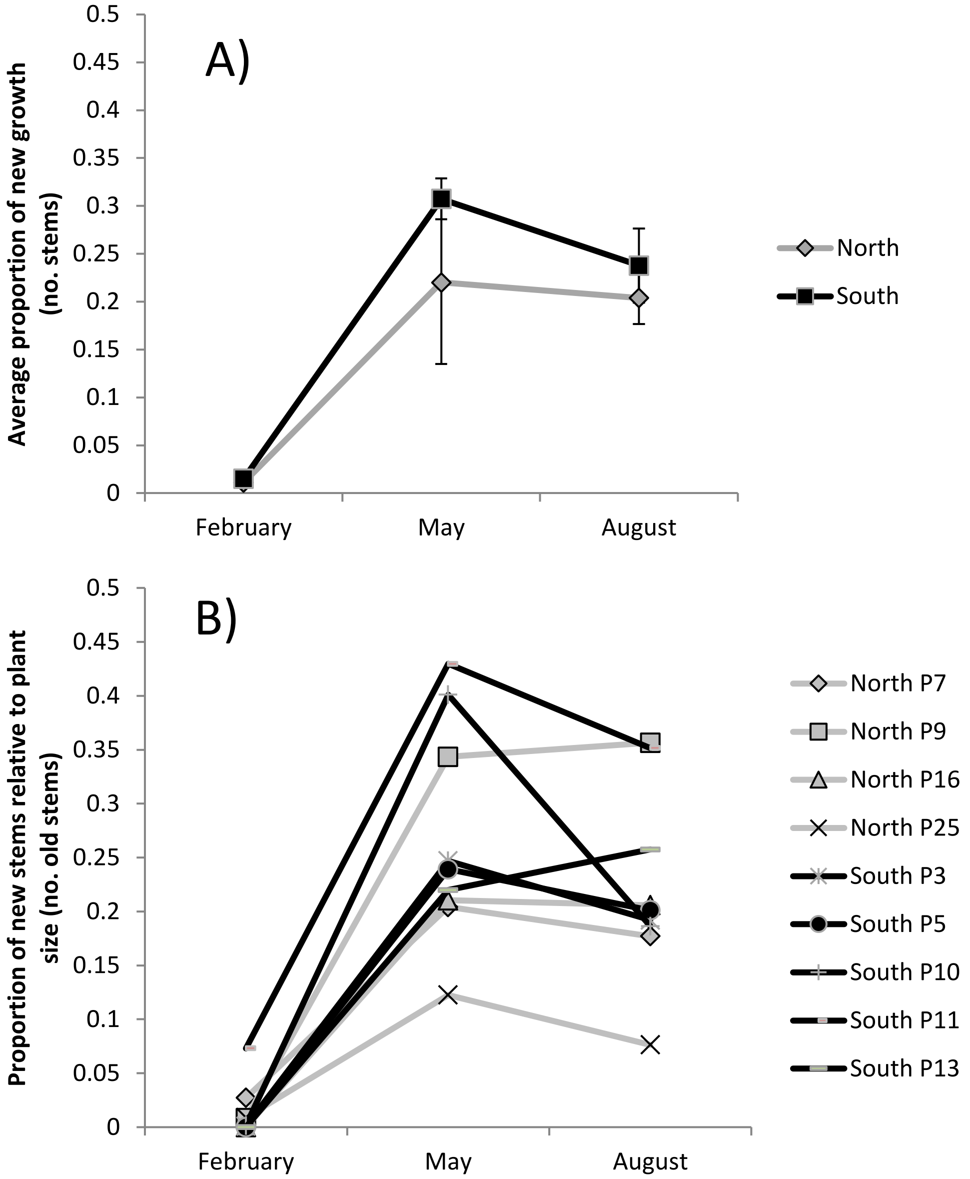


Figure 2.2.1c. Growth of adult plants in the natural population (*n* = 20 plants per plot; Table 2.2.1a), as measured by the number of new stems relative to the number of old stems on each plant over time (February – August 2020). A) overall plant growth (mean ± standard error) for the northern or southern side and B) growth rates (mean ± standard error) within each individual plot, on the northern or southern side.

Translocated populations

See section 2.1.1 for details on translocation site details, including location, characteristics, number of seed sown per translocation and number of greenstock planted per translocation. Details on direct seeding responses and survival is also summarised in this section.

Greenstock planting in 2017 translocation

The survival of greenstock (i.e. at least one cutting per planting unit still alive) declined only in one site after their fourth summer (T18), while the other two held steady (T6 and T23; Figure 2.2.1f). Survival after 3.5 years ranged from 0.4 – 4.4% per site, of the original planting (overall = 1.8% or 13 plants).

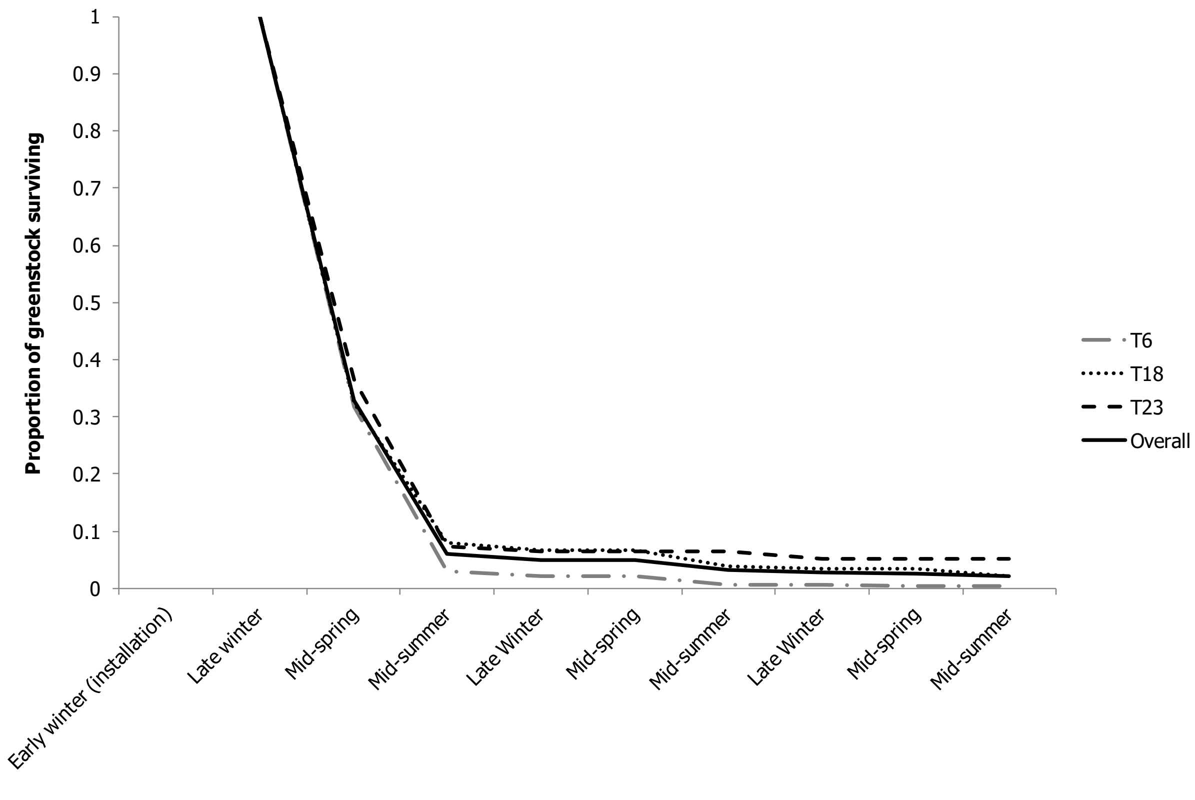


Figure 2.2.1f. Survival of 2017 translocation greenstock from installation (August 2017) to their fourth summer of monitoring (February 2021). Data represents the three translocation sites (T6, T18 and T23) and a combined overall survival rate.

Greenstock planting in 2018 translocation

The survival of greenstock (i.e. at least one cutting per planting unit still alive) declined again after their third summer in two sites (T6 and T23), while the other three held steady (T18, T21 and T24; (Figure 2.2.1g). Survival after 22 months ranged from 1.9 – 9.6% per site, of the original planting (overall = 4.3% or 46 plants).

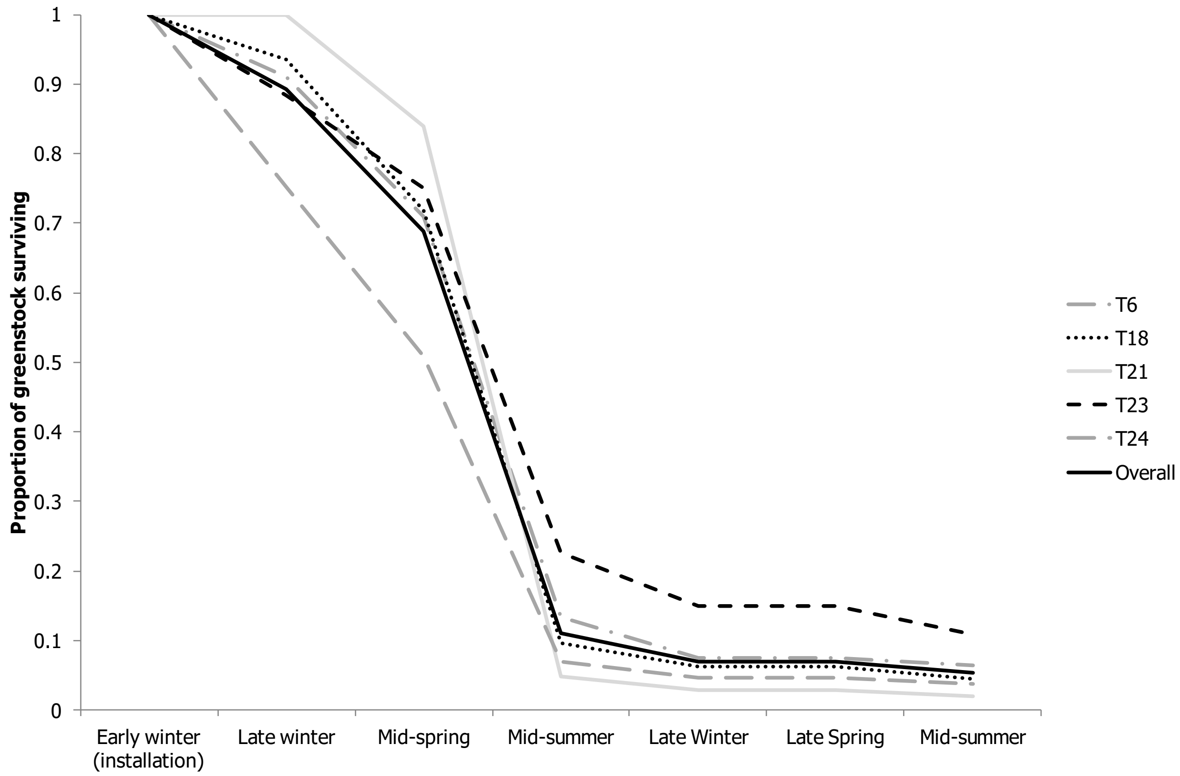


Figure 2.2.1g. Survival of 2018 translocation greenstock from installation (June 2018) to their third summer of monitoring (February 2021). Data represents the five translocation sites (T6, T18, T21, T23 and T24) and a combined overall survival rate.

Greenstock planting in 2019 translocation

The survival of greenstock (i.e. at least one cutting per planting unit still alive) declined significantly by 60% after their second summer (Figure 2.2.1h), with only 2 plants surviving from the previous summer (overall = 0.4% or 2 plants).

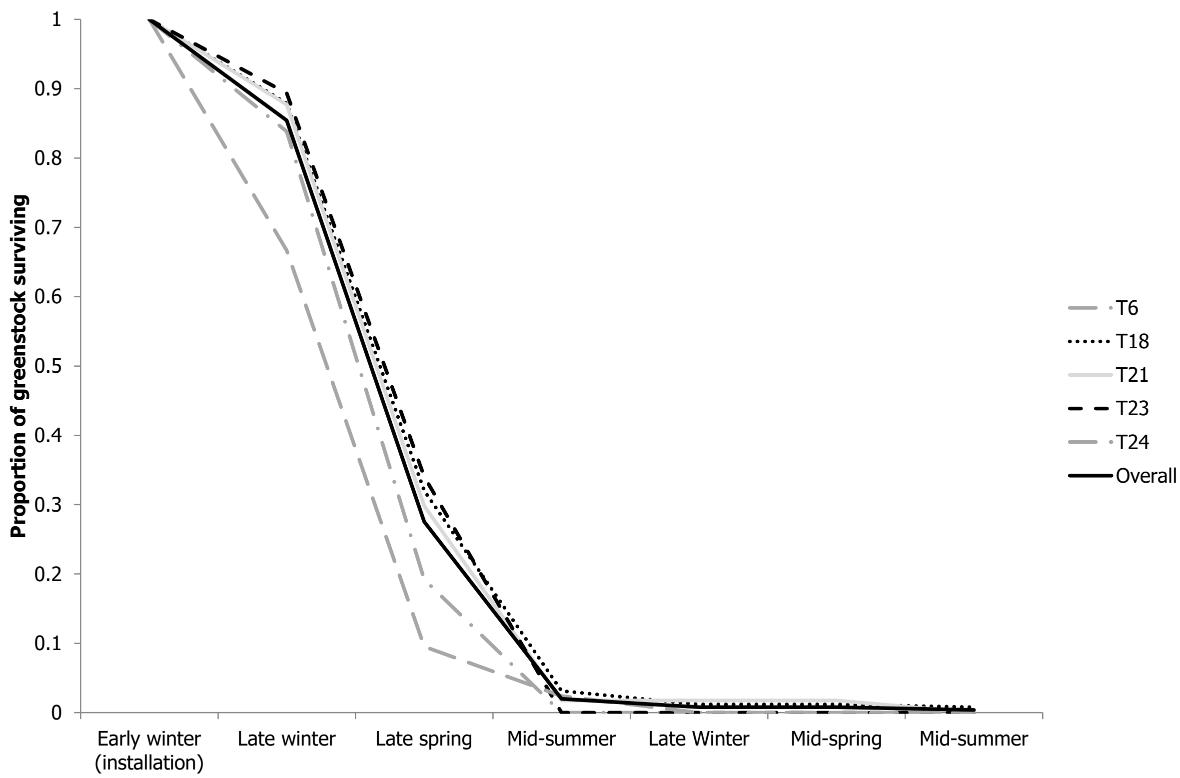


Figure 2.2.1h. Survival of 2019 translocation greenstock from installation (June 2019) to their second summer of monitoring (February 2021). Data represents the five translocation sites (T6, T18, T21, T23 and T24) and a combined overall survival rate.

Greenstock planting in 2020 translocation

Seedlings were germinated and cuttings were collected from stock plants held in the *ex situ* collection at Kings Park in October 2020, propagated and were planted in the five translocation sites in 2020 (Table 2.1.1b; Figure 2.2.1k). Each planting unit had one seedling or 1-4 cuttings as previously outlined for the 2017 translocation (Elliott *et al*. 2018). The treatments tested on the planted greenstock and the number of replicates implemented within each translocation site are summarised in Table 2.1.1h.

The survival of greenstock (i.e. at least one cutting per planting unit still alive) declined significantly after their first summer (Figure 2.2.1i), consistent with the previous 2017-2019 translocation responses. Survival after 8 months ranged from 1.1 – 8.0% per site, of the original planting (overall = 3.1% or 22 plants).

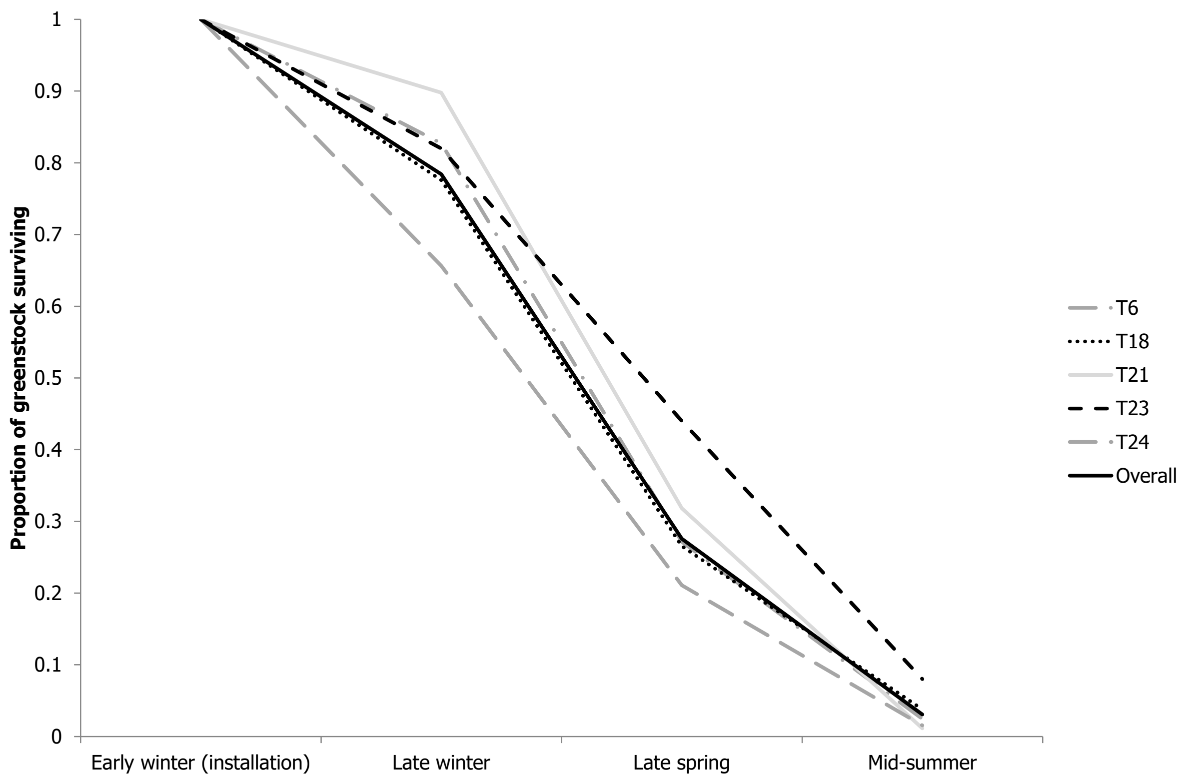
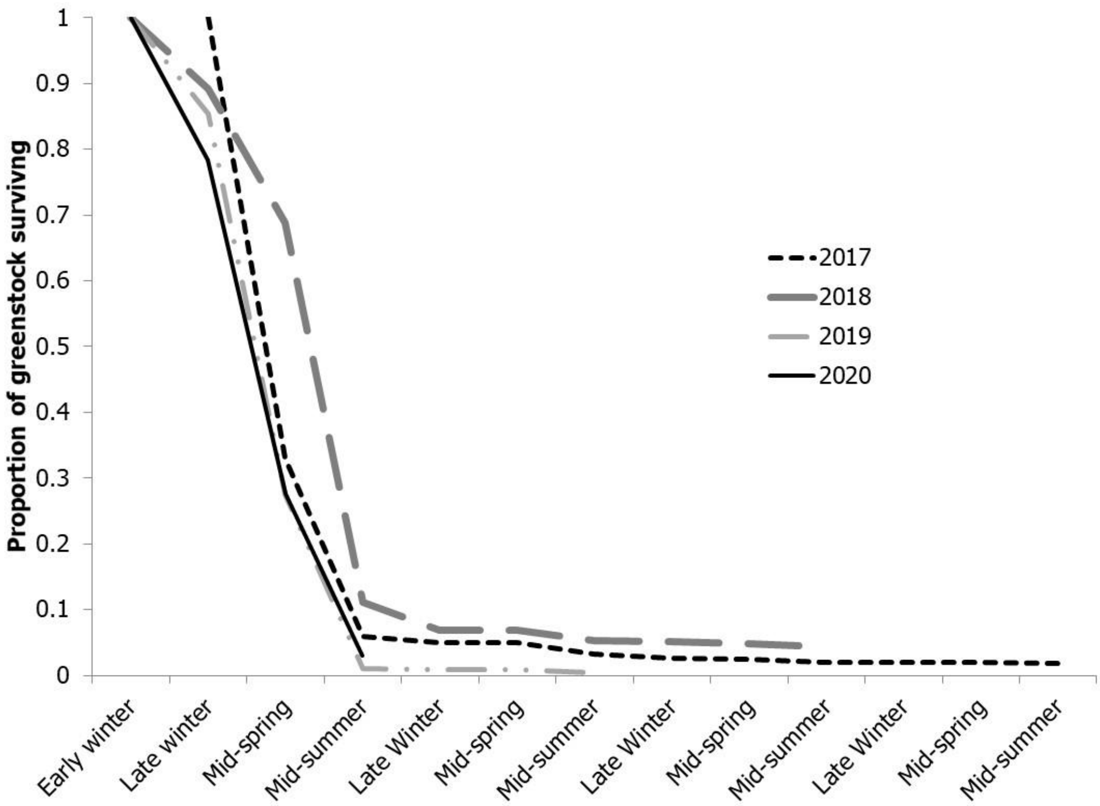


Figure 2.2.1i. Survival of 2020 translocation greenstock from installation (June 2020), late winter (7 weeks; August 2020), mid-spring (18 weeks; October 2020) and after their first summer of monitoring (35 weeks; February 2021). Data represents the five translocation sites (T6, T18, T21, T23 and T24) and a combined overall survival rate.

<u>Year to year comparison</u>

In summary:

- Late winter planting with below average winter rainfall can result in poorer survival, particularly after summer (i.e. 2017 vs 2018).
- Above average winter rainfall but below average spring rainfall (78%) can result in poorer survival, equivalent to a "late winter planting with below average winter rainfall" response in survival (i.e. 2017 vs 2019).
- Below average or average spring rainfall coupled with late summer rains (Feb rain event of >45mm) may have affect greenstock survival. In addition, most rainfall events 6 months post-planting were between 1-10mm (<20 events; >10mm = 3-4 events) that may have also contributed to extremely limited survival (2019 and 2020; Figure 2.1.3c).
- 2019/2020 and 2020/2021 summer declines of greenstock were greater in young greenstock (i.e. planted in 2019 or 2020 and 8 months established) than older greenstock (i.e. planted in 2017 and 42 months established).



29%	29%	85%*	3%	48%	45%	31%	78%	45%*	3%*	5%*	14%*		2017
3%	48%	45%	31%	78%	45%*	3%*	5%*	14%*					2018
31%	78%	45%*	3%*	5%*	14%*								2019
3%*	5%*	14%*								*Late rains			2020

Figure 2.2.1j. Overall survival of greenstock planted (2017-2020 translocations) from installation, late winter, mid-spring and summer. Data represents five translocation sites (T6, T18, T21, T23 and T24) in a combined overall survival rate. Table presents the amount of above (blue) or below (red) average rainfall for that specific period of season (BOM, 2021).

Future research:

Natural population and translocated populations

Ongoing development of baseline data on the growth, survival, flowering and seed production of seedlings, juveniles and mature plants in natural and translocated sites will occur to quantify spatiotemporal variation (and any treatment effects). Characterisation of habitat types where these seedlings emerged and survived (or did not) will occur to determine what role it plays in the ongoing survival of seedlings under natural conditions (See Section 2.1.3).

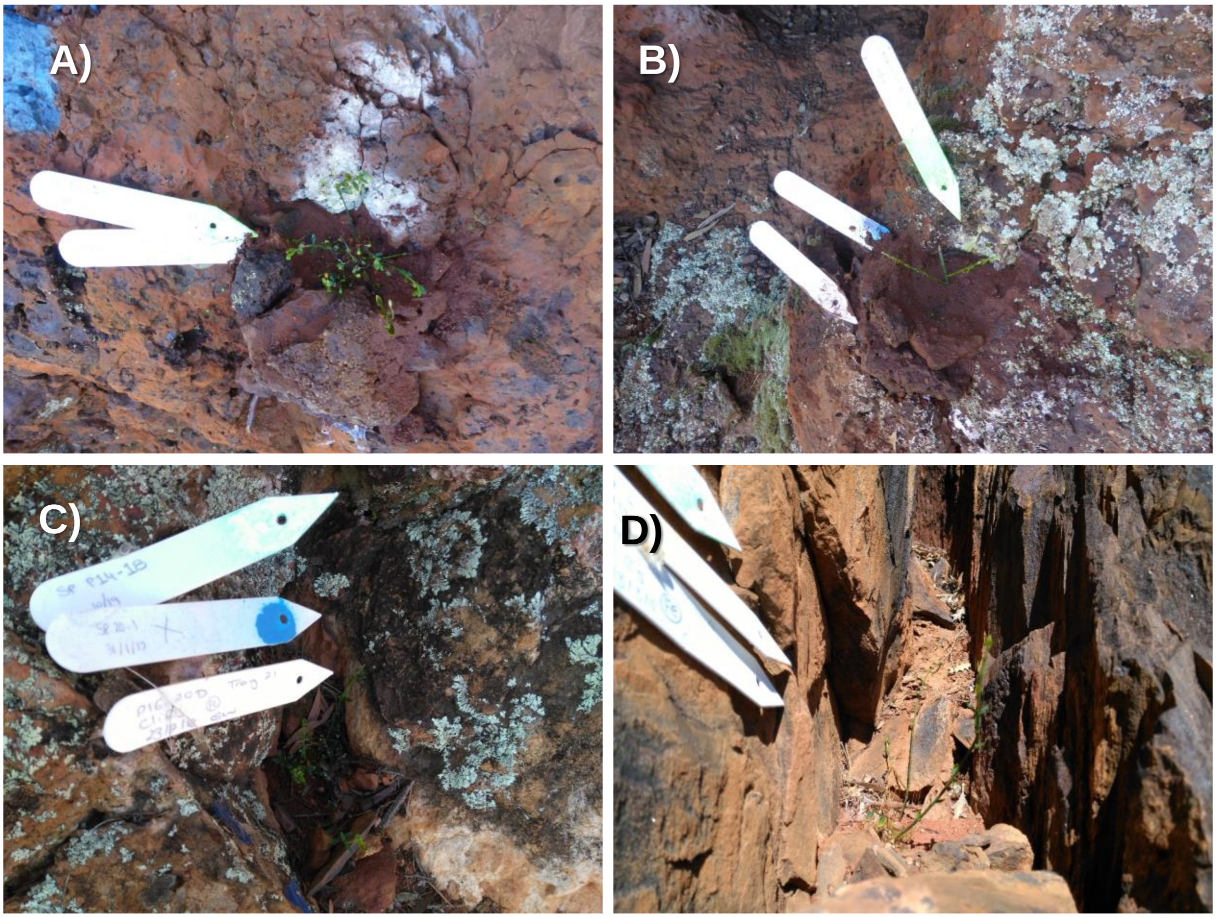


Figure 2.2.1k. Images of the 2020 translocation of greenstock. A) T6 locations of seedling derived greenstock at planting (June); B) T6 location of cutting derived greenstock at planting (June); C) T18 location of seedling derived greenstock in late winter (August); and D) T18 location of cutting derived greenstock in late winter (August). Images A&B C. Elliott and C&D S. Whiteley.

2.2.2 Develop understanding of the importance of spatiotemporal environmental factors that drive variation in these population parameters.

Seasonal monitoring will continue across sites and will be paired with environmental data gathered from data loggers (currently at five translocation sites). Kings Park Science will also be using accurate rainfall, wind and temperature data provided by MRL from their weather stations on the top of Koolyanobbing Range. Multiple seasons are required to determine spatiotemporal variation and will be concluded at the end of the project. We anticipate reporting findings following the 2021 data collection.

2.2.3 Model the dynamics of *T. erubescens* populations to increase understanding of parameters such as expected longevity and time to maturity.

Data are being collected from demographic studies outlined in 2.2 for demographic modelling. This modelling is scheduled for summer 2022.

2.2.4 Compare performance of plants (growth, survival, flowering and seed production) in natural and translocated sites.

Current research outcomes:

- Survival of translocated greenstock (0.4 - 4.3%) was lower than the survival of monitored adult plants in the natural population (99%; two plants dead in P9).
- The quantity of flowering and seeding of greenstock plants (8-42 months old) was lower than natural adult plants.
- There was no seedling survival from emergents in translocations and low seedling survival from natural recruitment (10% survival; August 2020 – February 2021).

The comparative performance of adult plants in the natural population to the greenstock of the 2017 (3.4 years), 2018 (2.5 years), 2019 (1.6 years) or 2020 (8 months) translocation plants was difficult to make for some measures due to the young age and poor survival of greenstock. For example, survival or growth of adults was not a realistic comparison to make to greenstock, as almost all monitored natural plants remained alive for the duration of the monitoring unlike the translocated greenstock, where significant mortality was recorded (see Section 2.1.4 and 2.2.1). Flowering and seed production was quantifiable for oldest translocated plants only. Although not comparable to adults in the natural population (i.e. size, maturity etc.), greenstock plants produced 1-33 flowers per greenstock plant (of those that flowered). Developing fruits were observed, but were immature at the time and could not be collected and the plants too fragile to place organza bags on them. Maturity and ongoing survival of greenstock plants will ensure comparative performance measures can occur in future seasons. Emergence of seedlings from direct seeding lines in the translocations (see Section 2.1.1) or the natural population (see Section 2.2.1) was poorer in 2020 than previous years and their survival (limited) was only detected in the natural population (10%) after the 2020/2021 summer.

Observations of an undefined type of disturbance (e.g. possibly herbivory) were noted, as fresh mammal scats were observed at translocation sites and there was a large increase in the number of greenstock plants that had no aboveground biomass (alive or dead) to measure, in comparison to previous years. It is suggested that cameras are placed at translocation sites post-planting and over the first summer to confirm and identify the type disturbance.

Future research:

Ongoing comparative performance between plants in natural and translocated sites will occur to quantify spatiotemporal variation for natural adult plants across seasons, greenstock across seasons, as greenstock matures in translocations and comparisons between both groups (and any treatment effects). Ongoing monitoring of plants impacted by disturbance events is necessary to determine survival/recovery outcomes and/or initiate management actions to ensure survival.

Program 3. Plant function, habitat and substrate interactions

3.1 *Plant function, condition and water usage*

3.1.1 Develop baseline data on the physiology and function of *T. erubescens* plants at seedling, juvenile and adult stages in natural populations.

Current research outcomes:

- Ecophysiological performance was similar between juvenile and adult plants in the natural population.
- Plant condition of those in the natural population, as measured by the proportion of a plant that had recently died, was at its lowest during the peak growing season (May-Aug) and highest during summer (Feb). This has been consistent across years (2018-2020).
- Relative plant condition changed between February 2020 and February 2021, with a 19.7-25.8% decline in plant condition (i.e. greater proportion of the plant had died) in 2021 over its relative condition in 2020.
- Each plot responded similarly to 2020 conditions, with increases in the proportion of a plant that was dead from May through to February 2021, indicating declines in relative plant condition (on both sides of the ridge).

Plant health, measured by assessing chlorophyll fluorescence (Fv/Fm) on dark adapted leaves on plants in the natural population during late winter (August 2020) and mid spring (October 2020) showed that juvenile plants performed to a similar or higher level as that of adult plants (i.e. on the same side of the range; Figure 3.1.1a). This was consistent with the performance of juveniles and adults in 2018 and 2019 (Elliott *et al.* 2019; Elliott *et al.* 2020).

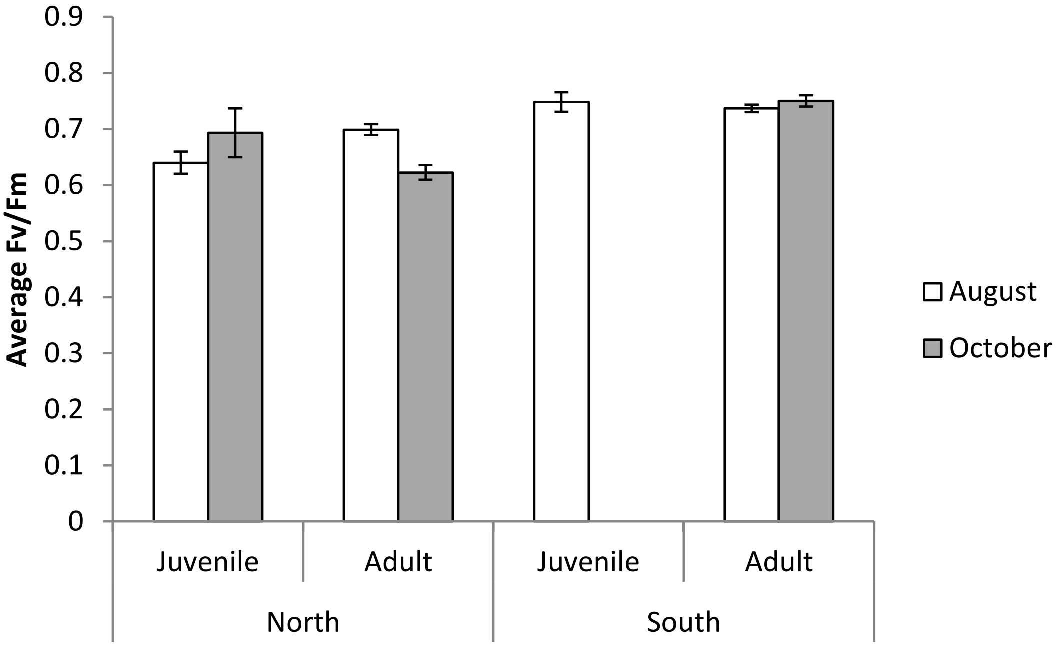


Figure 3.1.1a. Average Fv/Fm measurements of adult plants (*n* = 26-61 plants) and juveniles (*n* = 2-6 plants) in the natural population during two periods in 2020.

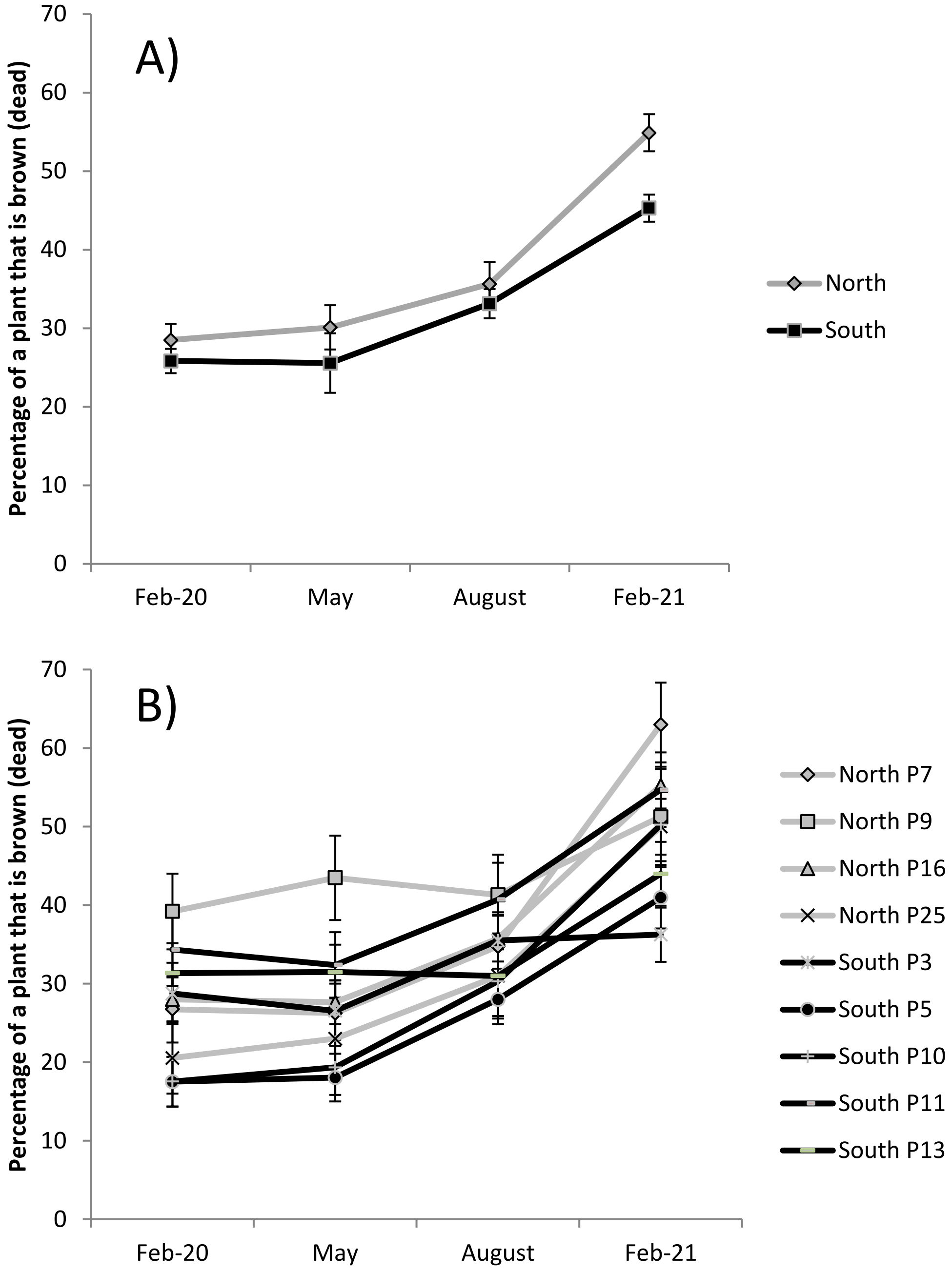


Figure 3.1.1b. Condition (mean ± standard error) of adult plants (*n* = 20 per plot; Table 2.2.1a) in the natural population, as measured by the proportion of an adult plant that is brown (i.e. newly dead plant tissue less than six months is a rich brown, not faded grey/white) over this time period (February 2019 – February 2020). A) overall plant condition averages (% plant brown) for the northern or southern side and B) average condition of plants within each individual plot, on the northern or southern side.

The peak condition of monitored plants (i.e. majority of the plant was green) occurred mainly during May in 2018 (see Elliott *et al*. 2019), but in 2019 there was no apparent peak overall, as plant condition showed a steady and stable decrease in health from summer to summer (see Elliott *et al*. 2020). In 2020, there was also no apparent peak in plant condition, despite plants putting on new stems (see Figure 2.2.1c). In 2020, there was a steady decline in relative plant condition (i.e. proportion of the plant that was brown) from summer, through the growing season (May-Aug) and into the following summer. This pattern was similar for the northern and southern sides of the ridge (Figure 3.1.1b.a). Unlike the pattern in 2019, each individual plot had a similar response to the 2020 conditions (Figure 3.1.1b.b).

Plant condition of those monitored in the natural population, as measured by the proportion of the plant biomass that had recently died (% brown), had changed when comparing February 2020 with February 2021 (Figure 3.1.1b.b). There was an overall decline in plant condition in summer 2021, where a greater proportion of the plant had died that was 19.7-25.8% over and above their relative condition at the same time the previous year (2020). Unlike the previous three summers, where less than 1% of monitored plants had an observed plant condition of >90% brown biomass, in 2021 this increased to 5.5% of monitored plants with a recorded plant condition of >90% brown biomass. Such a change in relative plant condition between years has not been previously observed and is cause for concern.

Previous trials assessing the drought responses under glasshouse conditions (see Section 2.1.4 in Elliott *et al.* 2020) indicated that plant health declined significantly after prolonged periods of low soil water potentials (-0.91 to -1.34 MPa). These soil water potentials occurred after withholding water from potted plants for 13-14 days. There is a possibility that the plants have reached this threshold that has caused reduced plant condition, but further modelling would need to investigate the soil moisture dynamics on performance windows (both condition and function) based on plant-water interactions. Controlled drought trials would inform against the patterns observed in the field and should be considered for identifying optimal watering treatments in any future translocation planning.

Future research:
To understand plant function at different ages, plants will need to be propagated from seed and grown to seedling, juvenile and adult plant stages, as these life stages may represent different tolerances to stress. The source material can be generated from seed experiment methods outlined in Program 1. Germinated seeds should be propagated into large pots and grown to different stages over two years. At each growth stage, a subset of plants (8-16 samples/treatment) should be used to understand drought-response, gas exchange (photosynthesis, transpiration and stomatal conductance) and chlorophyll fluorescence. Plant function and condition of those tagged in the natural population should continue to be monitored to determine the magnitude of variation in their responses to seasonal changes.

3.1.2 Assess the impact of spatiotemporal variation in the environment (years, seasons, sites, habitat characteristics) on plant function

Current research outcomes:

- Stomatal conductance varied among seasons and between aspects, most likely driven by soil water availability and temperature/site exposure.

- Summer measurements for 2017 and 2018 were on average the lowest for all species, which coincided with elevated leaf temperatures and a decrease in chlorophyll fluorescence.
- Summer measurements for stomatal conductance in 2020 and 2021 were elevated due to measurements coinciding with rainfall events.
- The measurements in spring in 2020 coincided with increased leaf temperatures and decreased stomatal conductance, which were a result of the decreased number of rainfall events in spring.
- *Tetratheca erubescens* plants on NE-facing aspects have consistently lower performance during autumn, winter and spring, but slightly elevated responses during summer than plants on SW-facing aspects.
- Leaf temperatures were higher in NE-facing sites indicating hotter site temperatures.
- Chlorophyll fluorescence declined between spring and summer periods and recovered between autumn and winter periods. Further corroborating stomatal conductance and leaf temperature measurements, NE-facing sites are generally showing lower Fv/Fm ratios suggesting an increased stress risk to environmental conditions.

Methods and Results

Previous ecophysiological assessments were quantified using a LI-COR 6400XT gas exchange system. While providing high quality data, measurements were constrained by the mobility of device, accessibility to plants on rocky locations and measurement durations. As an alternative to the LI-COR 6400XT, porometer measurements (SC-1 Leaf Porometer, Decagon Devices Inc. Pullman) were conducted to increase the sample size and the spatial resolution of plants measured across sites. While only providing measurements for stomatal conductance and leaf temperature, the porometer is more mobile across the landscape and measurements are more rapid, thus increasing the sample size. Measurements were conducted in four natural *T. erubescens* populations (NE Plots: 7 and 25; SW Plots: 3 and 5) in spring, summer, autumn and winter seasons in 2018-2020, and the summer of 2021 on 8-12 adult *T. erubescens* plants per plot (*n* =16-24 plants per NE and SW aspect) on green new/fully developed phyllodes. All measurements were conducted in the morning between 0700-1130am. Leaf temperature was quantified simultaneously with stomatal conductance measurements to determine how effective plants were regulating their stomata relative to the environment. Chlorophyll fluorescence was measured after dark adapting the same leaf for 10 minutes. These measurements were conducted on 4-6 *Banksia arborea* and *Eremophila decipiens* plants per plot (*n* = 8-12 plants per NE and SW aspect) that co-occur with *T. erubescens*, to quantify environmental variation on a species-level across natural populations. In total, thirteen measurement blocks have been completed since summer, 2017.

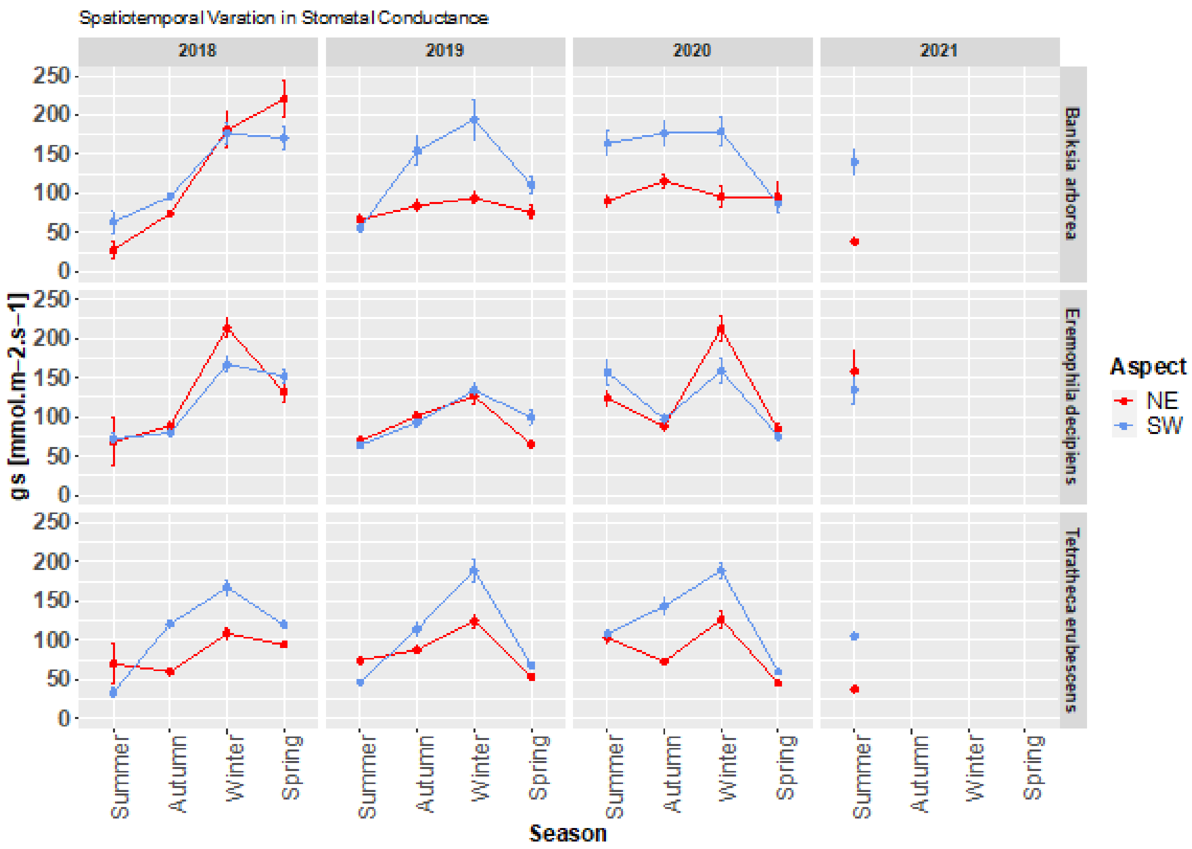


Figure 3.1.2a. Stomatal conductance (mean ± standard error) of *Tetratheca erubescens* (*n* = 16-24) and two common BIF species (*Banksia arborea* and *Eremophila decipiens*; *n* = 8-12) in NE-facing sites (P7 and P25) and SW-facing sites (P3 and P5).

There was seasonal variation in stomatal conductance between NE- (P7 and P25) and SW-facing (P3 and P5) sites (Figure 3.1.2a). As demonstrated by winter measurements that were always characterised by highest plant performance, and summer characterised by lowest plant performance (with exception to the summer period of 2020 and 2021 as measurements coincided with rainfall events occurring prior to the measurement window). For T. *erubescens,* there was consistently lower stomatal conductance in NE-facing sites compared to SW-facing sites. Compared to the other two species, measurements in 2019 for *T. erubescens* were consistent with measurements from 2018. Both *Banksia arborea* and *Eremophila decipiens* demonstrated higher performance values in 2018 compared to 2019. This response is likely a result of lower rainfall observed in 2019 (see Figure 2.1.3b). For *T. erubescens,* despite the SW-facing sites having higher stomatal conductance responses across autumn, winter and spring seasons, both summer 2018 and 2019 measurement points were lower than NE-facing sites. The summer measurements in 2020 and 2021 on average demonstrated much higher responses compared to previous summers on SW-sites, due to greater plant available water in the BIF substrate following rainfall during the measurement period. The NE-sites demonstrated the lowest performance for stomatal conductance. For all species there were increases in stomatal conductance compared to the previous spring measurement.

Leaf temperatures were consistently higher for all species in NE-plots than in SW-plots (Figure 3.1.2b). Higher leaf temperatures were matched by lower stomatal conductance – indicating summer to be periods of decreased water-use and ecophysiological function for all species. For all species, leaf temperatures in spring 2019 were similar to leaf temperatures measured in the previous two summer periods, indicating a hot and dry spring period in 2019, had elicited a summer response in plants. These conditions are likely contributing to the decreased stomatal conductance measurements reported in spring 2019 (Figure 3.1.2a). The spring 2020 leaf temperature measurements were elevated for all species compared to the previous years and varied between 30-34°C. For all species, the elevated leaf temperatures in spring were matched by the leaf temperatures in the recent 2021 summer measurements. Taken together, these values indicate that measured plants were experiencing a prolonged period of heat across the landscape.

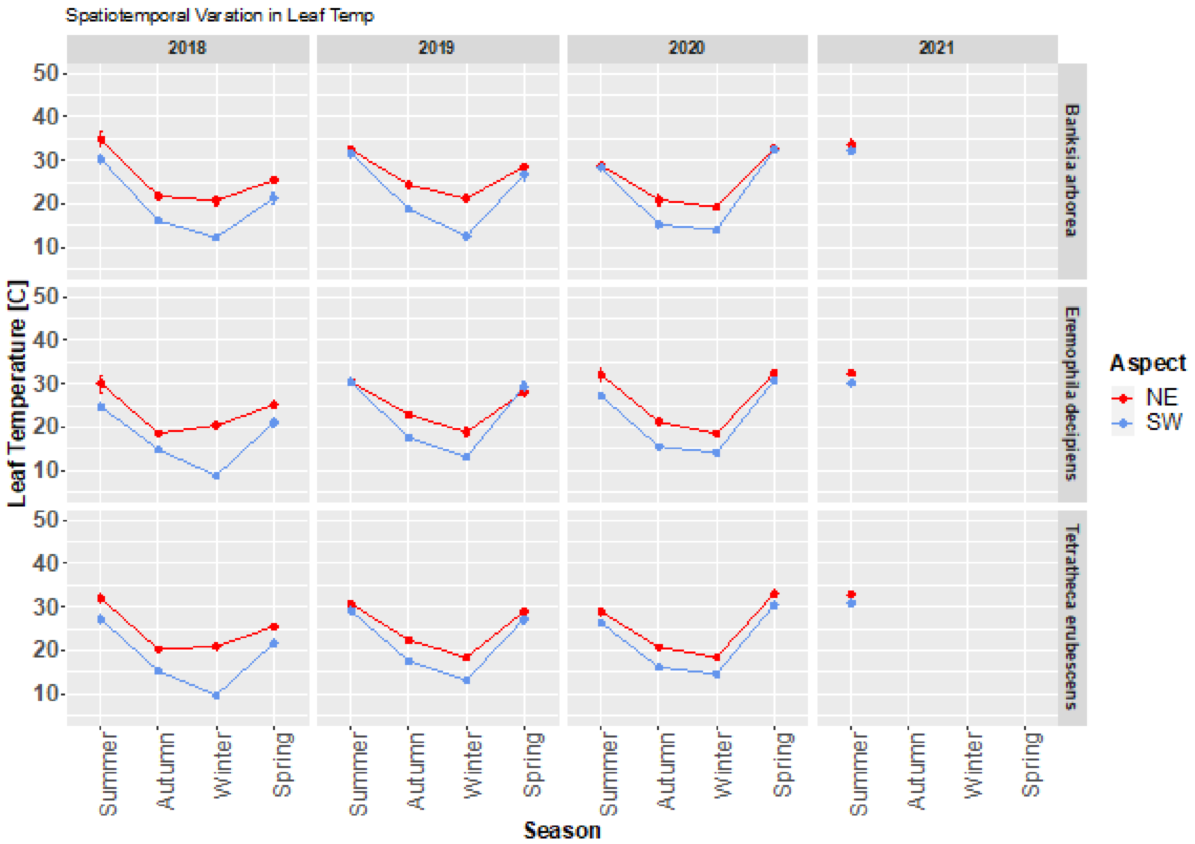


Figure 3.1.2b. Leaf temperatures (mean ± standard error) of *Tetratheca erubescens* (*n* = 16-24) and two common BIF species (*Banksia arborea* and *Eremophila decipiens*; *n* = 8-12) in NE-facing sites (P7 and P25) and SW-facing (P3 and P5) sites.

Chlorophyll fluorescence generally declined between spring and summer periods, with recovery observed between autumn and winter. For all species, lower chlorophyll fluorescence coincided with higher leaf temperatures in NE-facing plots (Figure 3.1.2c). Further corroborating the low stomatal conductance and high leaf temperatures measures during summer, low chlorophyll fluorescence values during summer indicate declines in stem health. The autumn 2020 measurements for *T. erubescens* were lowest on the NE-aspect (FV/FM < 0.6). These measures coincided with decreased stomatal conductance, which could have been driven by the decreased soil moisture available between March and May

2020 (see Figure 2.1.3a; P7 and P25). The increased chlorophyll fluorescence measurements in summer 2020 and 2021, demonstrate recovery following the spring senescence.

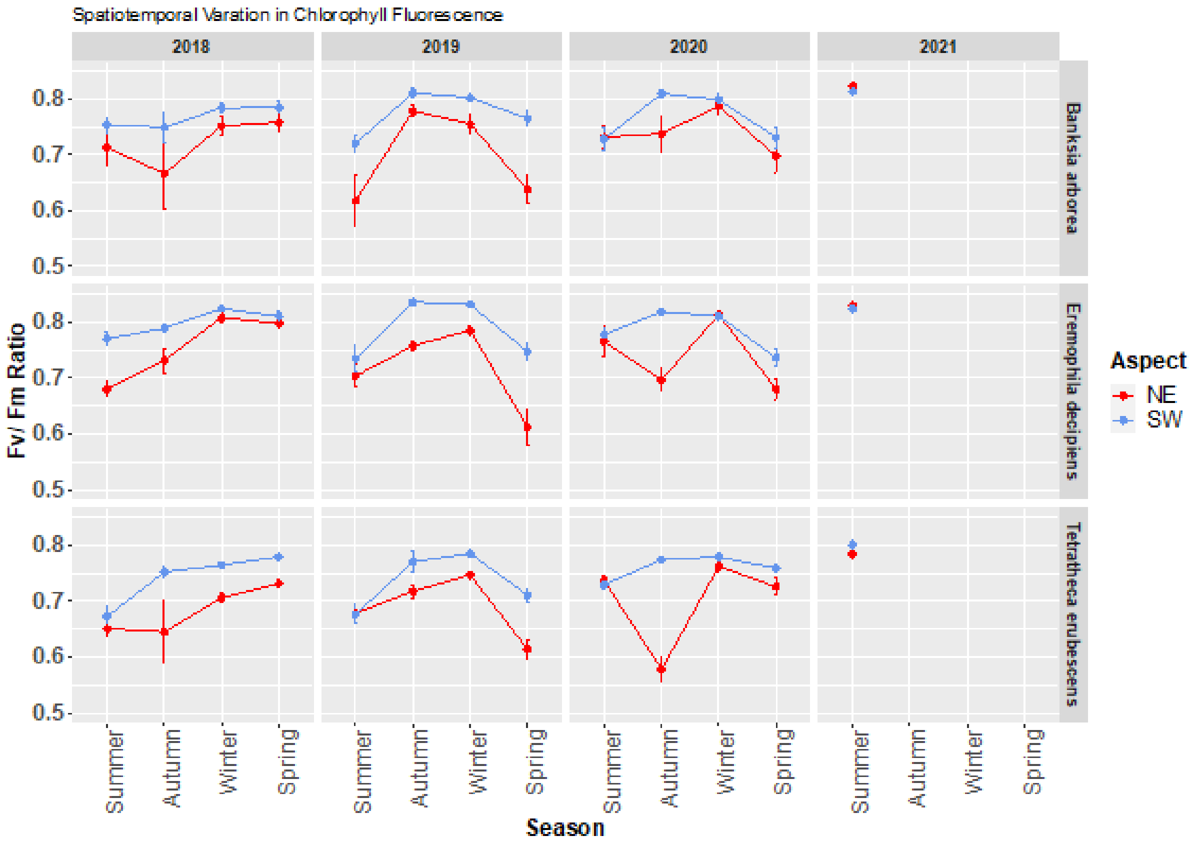


Figure 3.1.2c. Chlorophyll fluorescence (mean ± standard error) of *Tetratheca erubescens* (*n* = 16-24) and two common BIF species (*Banksia arborea* and *Eremophila decipiens*; *n* = 8-12) in NE-facing sites (P7 and P25) and SW-facing (P3 and P5) sites.

Applications

- The data demonstrate seasonal changes in plant performance between summer and winter periods – these conform to the active plant growth and senescence cycles (reported in Section 2.2).
- The common species, *B. arborea* and *E. decipiens*, demonstrate similar patterns, with reduced plant performance observed during summer. The ridge aspect showed strongest variation, with NE-facing sites generally more exposed to direct sun-light and thus hotter leaf temperatures, lower stomatal conductance and chlorophyll fluorescence compared to the shaded SW-facing sites.
- In summary, plants (*T. erubescens, B. arborea* and *E. decipiens*) growing in NE-facing sites appeared functionally more stressed. This may have implications for future translocation designs, as NE-facing sites may expose cuttings to greater environmental stress.
- The rainfall that coincided with the measurements in summer 2020 and 2021 increased soil water availability, which increased plant performance in the SW-facing aspect, but not always in the NE-facing aspect (compare 2020 summer, with 2021 summer measurements for stomatal conductance).

Future research:
Ongoing measurements will occur over the next year to quantify spatiotemporal variation for plants of *Tetratheca erubescens* (and the two common species) to confirm that plant function is responding differently than other more common species in the same habitat, during the same season.

3.1.3 Identify the ecophysiological strategies employed by plants that enable them to survive and grow in rock fissures in a semi-arid environment

Current research outcomes:

- Rock strata contain potential pockets of accessible moisture for roots (as outlined in Elliott et al 2019).

Ongoing analysis of the materials collected for this objective is required before an identification of the ecophysiological strategies employed by plants on banded ironstone ranges can be reasonably made. Additional sampling may be required to improve the resolution of the analysis, should the opportunity occur to collect more samples.

3.1.4 Develop understanding of the environmental factors that underpin variation in plant function

Investigations in Sections 3.1.1 and 3.1.2 are currently in progress and will contribute towards underpinning variation in plant function. Kings Park Science will report findings following the 2021 data collection. Current investigations for environmental factors include leaf temperature, ambient temperature, soil temperature, evaporation, rainfall and aspect.

3.1.5 Compare plant function (chlorophyll fluorometry, leaf gas exchange, and plant water status) of plants growing in natural and translocated sites.

Current research outcomes:

- There is variation in plant performance between natural and translocation sites, and populations in planted facing northeast and southwest aspects.
- As cuttings establish over time, they perform similarly to plants in natural reference sites.
- Lowest performance indicators are measured from more recent translocation trials, as populations are experiencing highest mortality rates.

Natural vs translocation performance
Ecophysiological assessments were conducted on cuttings that were planted in 2017-2020 translocation trials with the aim to compare plant function from establishing plants with plants in natural sites. Measurements were quantified using the same approach as outlined in Section 3.1.2. As there was a strong difference between the aspects in natural sites for ecophysiological functioning measurements were conducted in translocation sites T23 and T6 and compared against natural/ reference sites on the same aspect.

Plants in natural reference sites demonstrated increased stomatal conductance (Figure 3.1.5a) and lower leaf temperatures (Figure 3.1.5b) at the commencement of measurements compared to the cuttings in translocation sites. In 2019, older and more established cuttings generally demonstrated higher ecophysiological functioning (e.g. 2017 and 2018; increased stomatal conductance and chlorophyll fluorescence) compared to cuttings from the 2019 translocation trial. The increased ecophysiological functioning was likely explained by the cuttings having established and survived in their planting locations, and their roots likely accessing moisture resources in the rock profile. The cuttings from the 2019 translocation were also exposed to increased environmental stress after planting, due to the low rainfall in 2019, which resulted in highly reduced ecophysiological functioning (e.g. stomatal conductance < 50 $mmol.m^{-2}.s^{-1}$; Fv/Fm < 0.1; Figures 3.1.5a,b) and increased mortality rates in spring 2019 and summer 2019/20.

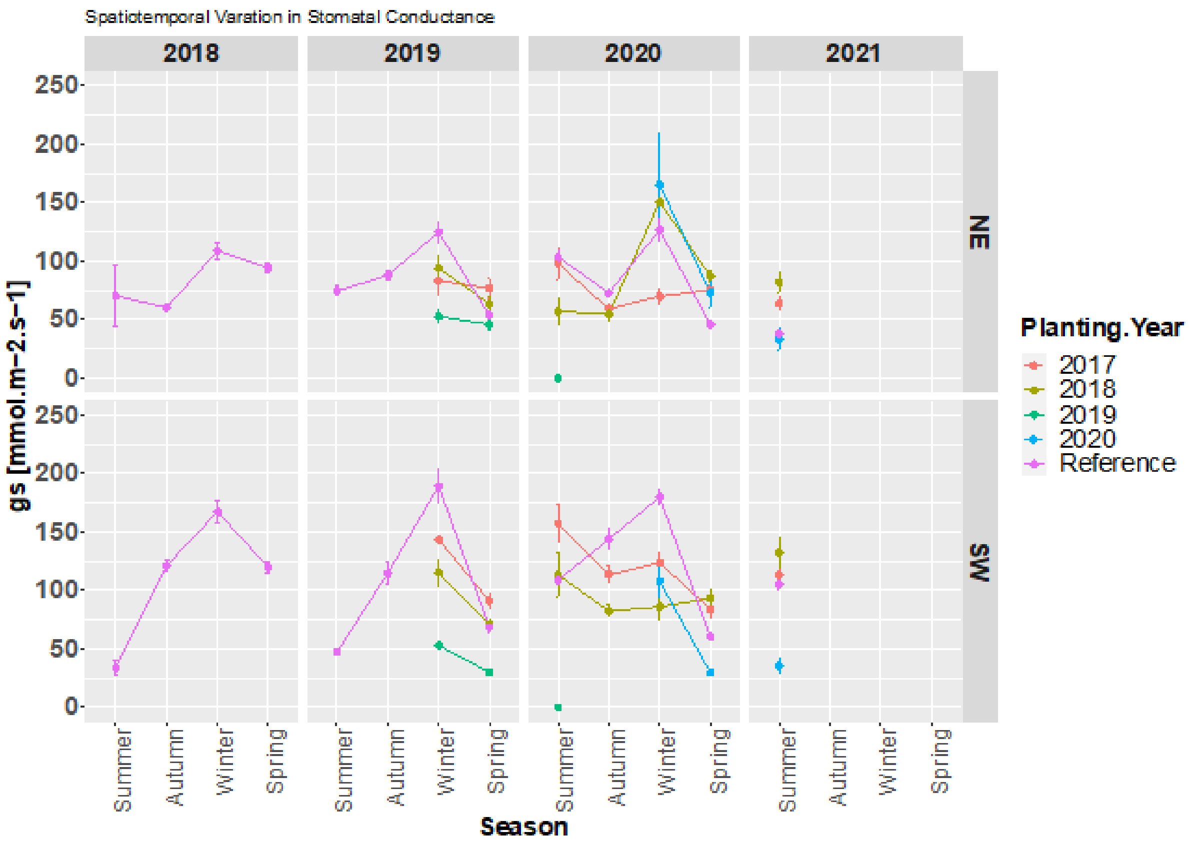


Figure 3.1.5a. Stomatal conductance (mean ± standard error) of *Tetratheca erubescens* in natural/ reference sites (NE-aspect plots: P7 and P25; SW-aspect plots: P3 and P5), and cuttings that were planted in translocation sites (NE-aspect: T23; SW-aspect: T6. The translocation sites contained cuttings that were planted in 2017, 2018, 2019 and 2020 Ecophysiological assessments in translocation sites commenced in the winter season of 2019 for cuttings that were planted in 2017-2019, and assessments commenced in the winter season of 2020 for the 2020 translocations.

There were elevated performance values from the 2017 cuttings in the SW-aspect compared to natural plants and 2018 cuttings in the summer of 2020. These measurements coincided with rainfall events of >20 mm that are believed to have saturated the drill holes into which the cuttings were planted. The performance in the summer 2020 for cuttings in the NE-facing aspect was generally either same for natural plants and cuttings from the 2017 translocation, or reduced for cuttings from the 2018 translocation year. The lower performance could be attributed to the plants being of smaller size or still establishing in their niche compared to the 2017 cuttings.

From the 2018 and 2020 translocations, ecophysiological functioning decreased strongly in NE-aspects from winter into spring and were like the performance from naturally occurring plants, while there was reduced/ conservative performance from the 2017 cuttings between the seasons (Figure 3.1.5a). In the SW-aspect, all cuttings were performing lower compared to natural plants in winter, while in summer there was no difference between natural plants and older planting years (e.g. 2017 and 2018). The cuttings that were recently planted in the winter of 2020 all demonstrated a strong reduction in ecophysiological functioning, with lowest performance measured in the 2021 summer period.

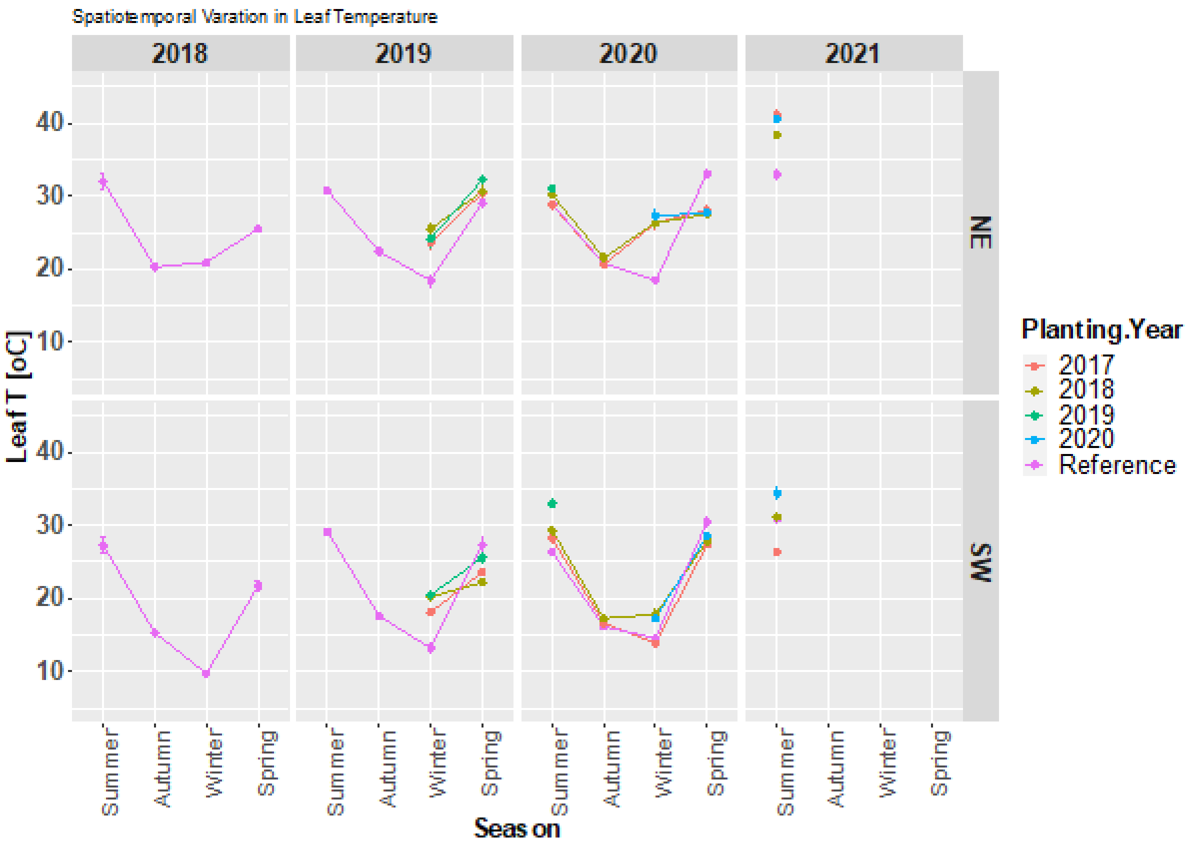


Figure 3.1.5b. Leaf temperatures (mean ± standard error) of *Tetratheca erubescens* in natural/ reference sites (NE-aspect plots:P7 and P25; SW-aspect plots: P3 and P5), and cuttings that were planted in translocation sites (NE-aspect: T23; SW-aspect: T6). The translocation sites contained cuttings that were planted in 2017, 2018, 2019 and 2020 Ecophysiological assessments in translocation sites commenced in the winter season of 2019 for cuttings that were planted in 2017-2019, and assessments commenced in the winter season of 2020 for the 2020 translocations.

The leaf temperatures were relatively similar between natural/ reference sites and translocated plants, except for measurements occurring in the winter, 2020 season where all translocated cuttings in the NE-aspect were demonstrated elevated leaf temperatures compared to natural plants (Figure 3.1.5b). The recent summer in 2021 demonstrated the highest leaf temperatures.

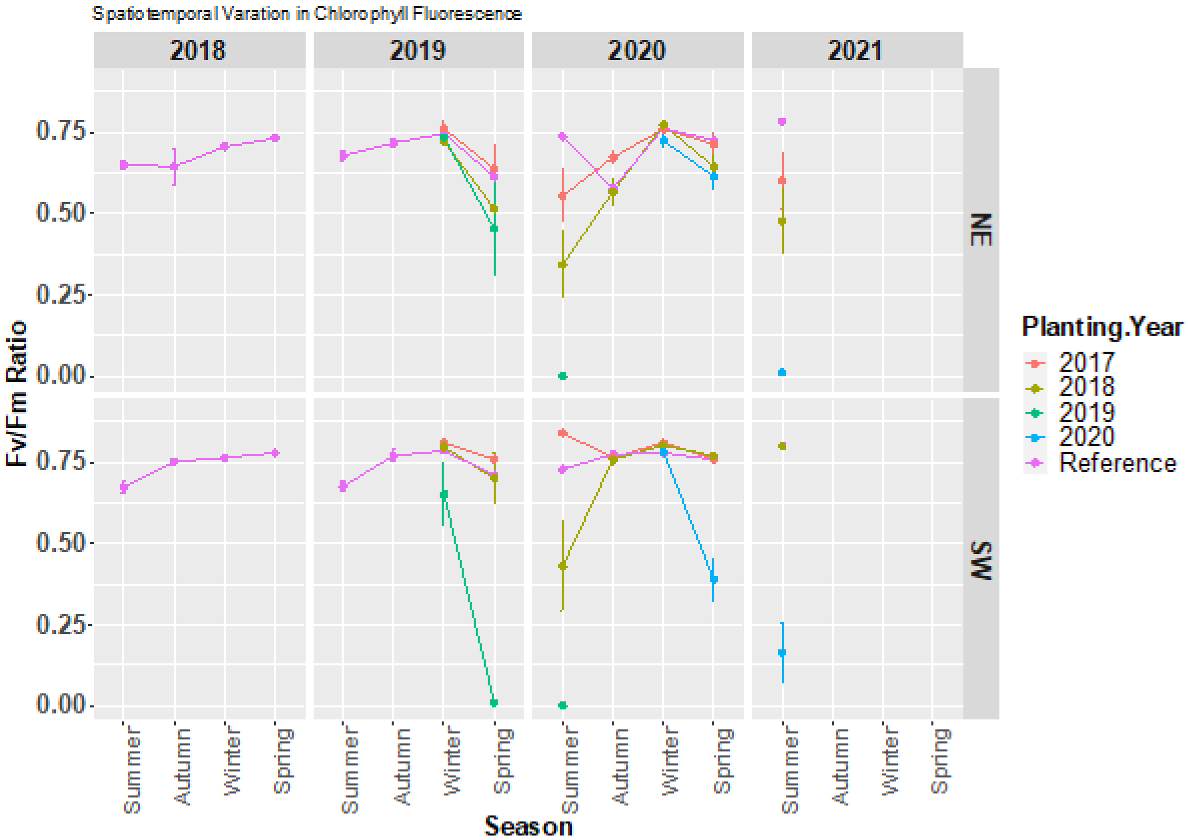


Figure 3.1.5c. Chlorophyll fluorescence (mean Fv/Fm ratio ± standard error) of *Tetratheca erubescens* in natural/ reference sites (NE-aspect plots:P7 and P25; SW-aspect plots: P3 and P5), and cuttings that were planted in translocation sites (NE-aspect: T23; SW-aspect: T6). The translocation sites contained cuttings that were planted in 2017, 2018, 2019 and 2020 Ecophysiological assessments in translocation sites commenced in the winter season of 2019 for cuttings that were planted in 2017, 2018 and 2019, and assessments commenced in the winter season of 2020 for the 2020 translocations.

Winter consistently represents the period of highest plant health across all sites, while spring and summer represent the periods of highest stress (Figure 3.1.5c). This is supported by elevated leaf temperatures and lower chlorophyll fluorescence during this period. For 2019 and 2020 plantings, reduced ecophysiological functioning also coincided with increased mortality rates during this period.

Future research:
Ecophysiological assessments were also conducted on seedling derived greenstock that were planting in the 2019 and 2020 translocation – future analyses will determine the variation in performance of these propagules.

3.2 *Soil - nutrient acquisition interactions*

3.2.1 Assess the chemical and physical properties of soils from within natural *T. erubescens* populations.

Research outcomes:

- Assessment of soil chemical and physical composition analyses show similar physical structure, but dissimilar chemical composition among locations.
- Ridge top soils were generally associated with higher calcium (Ca) and magnesium (Mg) cations and nutrients, while BIF soils sampled underneath and adjacent to *T. erubescens* plants were associated with higher iron (Fe) and boron (B) concentrations.
- Investigations are based on low resolution of samples, and thus only present limited assessments of underlying soil chemical and physical composition.
- Details of research are in Annual Research Report 3 (Elliott *et al*. 2020).

3.2.2 Develop understanding of the importance of varying soil properties on plant survival and growth

Research outcomes:

- Lower total N, P, K and Ca composition in leaves of *T. erubescens* and *B. arborea* compared to other species.
- Based on the sampling, there was separation of species sampled from the ridge top and slope locations, with BIF classified as overlapping due to sharing similar leaf tissue composition traits with both the ridge top and slope locations.
- Investigations are based on low resolution of samples, and thus only present limited assessments of underlying plant leaf tissue composition.
- Details of research are in Annual Research Report 3 (Elliott *et al*. 2020).

3.2.3 Provide data to support soil treatments aiming to improve the establishment and growth of plants in translocated sites.

Research outcomes:

- Soil treatments (as outlined in Elliott et al 2018, 2019), did not show improved establishment due to poor survival rates observed in Summer 2018 or Summer 2019.
- Two types of iron fertilizer were tested as soil treatments (2017 translocation: iron chelate supplement; 2018 translocation: Fetrilon Combi2).
- Details of research are in Annual Research Reports 1 and 2 respectively (Elliott *et al.* 2018; Elliott *et al.* 2019).

3.3 *Soil biological function in natural and translocation sites.*

3.3.1 Assess biological communities of soils where *T. erubescens* grow

Soils were sampled in July 2017 and October 2017 from three locations and have been stored for assessment. Unforeseen circumstances have delayed the timeline for analysis, while an alternate service provider and their requirements for sample submission are confirmed. The continuation of this objective has been delayed and the revised timeline for analysis is Autumn 2021 (see Elliott *et al*. 2019 for details).

3.3.2 Assess the frequency and type of mycorrhizal associations of *T. erubescens*

Soils were sampled in July 2017 and stored for assessment (as described in Elliott *et al*. 2019). The continuation of this objective has been delayed and the revised timeline for analysis is in Spring 2021.

3.3.3 Compare soil biological diversity and function between natural and translocated sites.

Soils have only been collected from natural sites (as described in Elliott *et al*. 2019) and stored for assessment. The collection of soils from translocated sites will occur later in the project as translocations mature (see Table 4 of the Program Schedule).

3.3.4 Provide data to support soil inoculation aiming to improve the establishment and growth of plants in translocated sites.

Research outcomes:

- Initial soil inoculation trials in the 2017 translocation experiment did not support improved establishment and growth of planted cuttings in the different translocation sites.
- Details of research are in Annual Research Report 1 (Elliott *et al*. 2018).

PROGRAM SCHEDULE

Project management schedule

A five-year project is underway, with components varying in start date and period as described in Table 4. Translocation and monitoring, and plant function analysis are proposed for each year, with seed biology concentrated in the first years and soil nutrition and biological function studies both at the start and towards the end – reflecting their focus on initial conditions and on conditions in developing translocated populations.

Table 4 Program schedule.

	2017/18				2018/19				2019/20				2020/21				2021/22			
	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A
Pr.1 Seed biology																				
1.1 Dormancy and germination																				
		test 'best bet' dormancy mode & germination																		
						Refine tests: wet/dry cycling														
								temperature and water potential tests												
1.2 Seed enhancement																				
				Priming																
					develop pellet design															
							preliminary pelleting field trials													
									refine pellet design											
											test pelleting in field									
Pr.2 Translocation and monitoring																				
2.1 Optimising translocation approaches																				
		establish initial translocation sites																		
				collect seed and propagate material for Y2																
					develop sites for Y2 trial															
						2nd year translocation														
							preliminary pelleting field trials													
											3rd year translocation: test pelleting in field									
															4th year translocation					
			Monitor				translocation													
2.2 Survival, growth and reproduction																				
			Demographic				survey													
														demographic modelling						
Pr.3 Plant function, habitat and substrate interactions																				
3.1 Plant function, condition and water use																				
			regular plant function monitoring: in natural systems																	
											in translocation									
3.2 Soil - nutrient acquisition interactions																				
				collect and analyse soils: in natural sites																
											in translocation									
3.3 Soil biological function																				
		collect materials and undertake molecular analysis: in natural system																		
														in translocation						
								mycorrhizal assessment												

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APPENDIX 1

Items for Stage 1 Offset Plan

Table S1.1. Items from the Stage 1 *Tetratheca erubescens* Offsets Plan August 2017, Cliffs Asia Pacific Iron Ore.

Table 3-9 Stage 1 *Tetratheca erubescens* Offsets Plan implementation schedule.

YEAR	TIMING	ACTION	DELIVERY	PURPOSE/OUTCOME		
2016	November (completed)	Seed collections (soil vacuuming, placement of collection nets beneath plants and bags on developing fruit clusters).	BGPA	Soil-stored seed collection from Stage 1 area approved for mining. For use in research and/or field translocations.		
	November (completed)	Cuttings collections and establishment of greenstock.	BGPA	Potted greenstock for use in field translocations.		
	September – March 2017	Review relevant Tetratheca restoration knowledge.	Cliffs/BGPA	Incorporation learnings into the design of the *Tetratheca erubescens* research program and translocation design.	Completed (2017 report)	
	December – January 2017	Field assessments of potential translocation sites and selection of preferred sites.	BGPA/Cliffs	Assessment and suitability ranking of potential translocation sites.	Completed (2017 report)	
2017	January	Retrieval of seed collection nets and bags and seed cleaning.	BGPA	Seed collections from locations across the geographic range of *Tetratheca erubescens*.	Completed (2017 report)	
	January - February	Seed viability assessments.	BGPA	Determine the seed resource available for 2017 research and translocations.	Completed (2017 report)	
	January - June	Maintenance and potting-on of greenstock.	BGPA and Natural Area Holdings Pty Ltd	Establishment of greenstock into narrow pots suitable for planting out.	Completed (2017 report)	
	March	Detailed design of 2017 field translocations.	BGPA/Cliffs	2017 translocation design.	Completed	
	March - April	Apply treatments to seed.	BGPA	Treated seed of adequate numbers as required by the field translocation design.	Completed (2017 report)	
	May	Prepare tubestock planting niches at translocation sites	Cliffs/BGPA	Adequate numbers of planting niches as per translocation design.	Completed (2017 report)	
	June	Transfer tubestock from NAM Perth to Koolyanobbing and maintain 2-3 weeks for hardening-off.	Cliffs/NAM	Adequate numbers of hardened-off tubestock held on site as per translocation design.		
	July-August	Implementation of 2017 field translocations.	BGPA/Cliffs	Translocations established as per translocation design.	Completed (2018 report)	
	July 2017 – March 2018	Maintenance of 2017 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*. Supplemental watering treatments applied initially as per 2017 translocation design.	Completed (2018 report)	
	July - August	Molecular analysis of soils within *Tetratheca erubescens* occupied sites.	BGPA	Soil biota characterisation within natural populations.	In progress (Collected only)	Section 3 pp. 54
	September 2017 - March 2018	Research and testing of seed priming and pelleting.	BGPA	Development of techniques for potential application in 2018 translocations.	Complete (2017 report)	
	October - November	Monitoring of 2017 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*.	Completed (2018 report)	

	October - November	Population demographic survey	BGPA	Obtain annual population demographic information for *Tetrathec* *erubescens*	Completed (2018 report)	
	October 2017 - January 2018	Seed and cuttings collections.	BGPA	Obtain adequate viable seed and cuttings for 2018 research and translocations.	Completed (2018 report)	
	October 2017 - February 2018	Root rhizosphere soil investigations and *Tetratheca erubescens* tissue analysis.	BGPA	Information on soil characteristics and *Tetratheca erubescens* nutri acquisition strategies within natural populations.	Completed (2020 report)	
	December 2017 - December 2021	Monitoring of plant physiology and function in natural and restored populations	BGPA/Cliffs	Build a profile of physiological functioning across life stages of *Tetratheca erubescens* and compare with translocated individuals	In progress (2021 report)	Section 3 pp. 42-52
2018	January 2018 – May 2019	Development and testing of seed priming, coating and pelleting methods.	BGPA/Cliffs	Determine suitable methods and complete laboratory/greenhous testing.	Complete (2021 report)	Section 1 pp. 7-12
	February	Review and report results.	Cliffs/BGPA	Report describing results to date and assessing results against succ criteria.	Complete	
	February-March	Consult with technical specialists, OEPA and DBCA regarding results and 2018 research and translocation plans.	Cliffs	Recommendations regarding 2018 program.		
	February - March	Evaluate potential translocation sites for 2018 translocations.	BGPA/Cliffs	Preferred translocation sites for 2018.	Complete	
	February - May	Follow-up research and testing of methods to refine direct seeding and/or greenstock translocation methods.	BGPA/Cliffs	Refined translocation methods available for application in 2018.	Complete (2019 report)	
	March - April	Detailed design of 2018 field translocations.	BGPA/Cliffs	Approved translocation proposal for 2018 translocations.	Complete	
	April-May	Monitoring of 2017 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*.	Complete (2019 report)	
	April	Annual reporting	Cliffs	Report to OEPA and DBCA on results and progress against plan.		
	May - June	Implementation of 2018 field translocations.	BGPA/Cliffs	Translocations established as per translocation design.	Complete (2019 report)	
	June 2018 – March 2019	Maintenance of 2018 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*. Supplemental watering treatments applied initially as per 2017 translocation design.	Part complete (2019 report)	
	June - November	Preliminary field testing of pelleting methods.	BGPA	Determine if pelleting is likely to be suitable for field applications.	Complete	
	October - November	Monitoring of 2017 and 2018 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*.	Complete (2019 report)	
	October - November	Population demographic survey	BGPA	Obtain annual population demographic information for *Tetrathec* *erubescens*	Complete (2019 report)	
	October – January 2019	Seed temperature and water potential testing.	BGPA	Information to refine optimal seed pre-treatments.	Complete (2020 report)	
	October – January 2019	Seed and cuttings collections.	BGPA	Obtain seed and cuttings for 2019 translocations.	Complete (2020 report)	

	October – January 2019	Mycorrhizal assessment of *Tetratheca erubescens* roots	BGPA		Incomplete	Section 3 pp. 54
	December - February 2018	Refine seed pellet design.	BGPA/Cliffs	Pellet design suitable for scaled-up application in 2019 translocations	Complete (2021 report)	Section 1 pp. 11-12
2019	March - April	Review and report results.	Cliffs (BGPA/CMSR)	Report describing results to date and assessing results against succes criteria.	Complete	
	March - April	If success criteria not yet achieved, consult with OEPA and DBCA, review, revise and extend Stage 1 Offsets Plan. Seek approval of revised Stage 1 Offsets Plan.	Cliffs	Approval of revised Stage 1 Offsets Plan.		
	March - April	Detailed design of 2019 field translocations, including the testing of pelleting.	BGPA/Cliffs	Approved translocation proposal for 2019 translocations.	Complete	
	April - May	Monitoring of 2018 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*.	Complete (2020 report)	
	April	Annual reporting	Cliffs	Report to OEPA and DBCA on results and progress against plan.		
	May - June	Implementation of 2019 field translocations.	BGPA/Cliffs	Translocations established as per translocation design.	Complete (2020 report)	
	June 2019 – March 2020	Maintenance of 2019 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*. Supplemental watering treatments applied initially as per 2017 translocation design.	Part complete (2020 report)	
	October - November	Monitoring of 2017, 2018 and 2019 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*.	Complete (2020 report)	
	October - November	Population demographic survey	BGPA	Obtain annual population demographic information for *Tetratheca erubescens*.	Complete (2020 report)	
2020	March - April	Detailed design of 2020 field translocations.	BGPA/Cliffs	Approved translocation proposal for 2018 translocations.	Complete	
	April	Annual reporting	Cliffs	Report to OEPA and DBCA on results and progress against plan.		
	April - May	Monitoring of 2019 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*.	Complete (2021 report)	Section 2 pp. 13-19
	May - June	Implementation of 2020 field translocations.	BGPA/Cliffs	Translocations established as per translocation design.	Complete (2021 report)	Section 2 pp. 13-19
	June 2020 – March 2021	Maintenance of 2020 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*.	Complete (2021 report)	Section 2 pp. 35-39
	October 2020 - February 2021	Root rhizosphere soil investigations and *Tetratheca erubescens* tissue analysis.	BGPA	Information on soil characteristics and *Tetratheca erubescens* nutrier acquisition strategies within translocation populations.	In progress	Section 3 pp. 53-54
	October – November	Monitoring of 2017, 2018, 2019 and 2020 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens*.	Complete (2021 report)	Section 2 pp. 13-19

	October - November	Population demographic survey	BGPA	Obtain annual population demographic information for *Tetratheca erubescens.*	Complete (2021 report)	Section 2 pp. 28-34
2021	April	Annual reporting	Cliffs	Report to OEPA and DBCA on results and progress against plan.		
	April - May	Monitoring of 2020 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens.*		
	July - August	Molecular analysis of soils within *Tetratheca erubescens* translocation sites.	BGPA	Soil biota characterisation within translocation populations and comparison with the population in natural sites.		
	October - November	Monitoring of 2017, 2018, 2019 and 2020 field translocations.	Cliffs/BGPA	Information obtained on the germination, survival and growth of translocated *Tetratheca erubescens.*		
	October - November	Population demographic survey	BGPA	Obtain annual population demographic information for *Tetratheca erubescens.*		
	November - December	Complete population demographic modelling.	BGPA	Long-term population demographic model for *Tetratheca erubescens.*		
2022	April	Prepare and submit a final report providing the results and outcomes of the Stage 1 *Tetratheca erubescens* Offsets Plan.	Cliffs/BGPA	Summary report capturing the results and outcomes of the five-year offsets plan.		
	April - May	Undertake a review of the offsets plan in consultation with OEPA and DBCA and prepare and submit a revised offsets plan, if required.	Cliffs	Results of the five-year offsets plan considered in detail and decisions made around the needs and content of a revised offsets plan. A revised offsets plan developed and submitted to OEPA for approval, if required.		

APPENDIX 2

Publications, conferences, workshops, requested reports or project publicity associated with the research program.

Table S2.1. Date, type of activity and details of activity that relates to the publicity of the *Tetratheca* research program.

Date	**Activity**	**Details**
June/July 2020	Presentation: Project updates	Update on the status of the *Tetratheca erubescens* project provided to MRL and Strategen Environmental.
July 2020	Presentation: for Goldfields Threatened Species Recovery Team	Update on the monitoring of *Tetratheca erubescens* and *Ricinocarpos brevis* translocations provided to Goldfields Threatened Species Recovery Team meeting with MRL