25 October 2021

Gabrielle Allan
Principal Planning Officer
Planning and Assessment Group
Department of Planning, Industry and Environment
Submitted: NSW Major Project Portal
Dear Gabrielle,

SSD 5594 Springvale Mine
Trigger Investigation

Springvale Mine (Springvale) notified the Department of Planning, Industry and Environment (Department) on 1 September 2021 of an exceedance of floristic performance indicators outlined within the approved Swamp Monitoring Program.

The Autumn 2021 LW 424-427 Seasonal Swamp Monitoring report provided evidence of new triggers at Marrangaroo and Nine Mile Swamps for non-live vegetation cover at the swamp scale (SAVI<0.12). In addition, Pine Swamp exceeded the preliminary trigger for this metric and therefore was reported at this time.

A Trigger Investigation Report (Report) has been prepared by EcoResolve in accordance with the Swamp Monitoring Program TARP. The Report outlines the actions taken by Springvale in response to the trigger and details the investigation findings.

The Department of Agriculture, Water and Environment has been provided a copy of the Investigation Report produced by EcoResolve in accordance with EPBC 2013/6881.

This investigation has been undertaken in accordance with Schedule 3, Condition 10(h) of SSD 5594 associated with Longwall 424-427 Extraction Plan.

If you require any further information in regard to the above please contact Natalie Gardiner on 63501672 or email.

Yours sincerely

N. Gardiner

Natalie Gardiner

Environment and Community Superintendent

Attachment 1: Investigation Report

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Investigation Report

EcoResolve

Environment & Design

Trigger Investigation Report

Springvale LW 424 – 427: Autumn 2021

Prepared for: Natalie Gardiner – Environment and Community Coordinator @ Centennial
Prepared by: Arne Bishop – Ecology Director @ EcoResolve Pty Ltd
Date: 25 October 2021
Project no: ER027

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Document Control

Version - date	Purpose	Author	Reviewer	Approved by
V1 – 20/10/2021	Draft for Client review	Brea Heidke and Hugh James	Arne Bishop	Arne Bishop
V2 – 25/10/2021	Final for submission	Brea Heidke and Hugh James	Natalie Gardiner	Arne Bishop

1 Introduction

Development Consent SSD 5594 was granted on 21 September 2015, allowing the ongoing operations a Springvale Mine for a further 13 years. Current mining operations are undertaken in accordance with the Longwall 424–427 Extraction Plan. Flora monitoring is undertaken in accordance with the Swamp Monitoring Program (SMP).

Seasonal swamp monitoring for Autumn 2021 identified that two impact swamps exceeded the performance measure trigger levels within the Longwalls (LW) 424 – 427 Swamp Monitoring Program (SMP). Specifically, evidence was provided for new triggers at Marrangaroo, Nine Mile Swamps for non–live vegetation cover at the swamp scale (SAVI<0.12). In addition, Pine Swamp exceeded the preliminary trigger for this metric. In accordance with the mine approval conditions (SSD–5594 and EPBC 2013/6881), Centennial Springvale notified the Department on 1 September 2021 of the trigger level exceedance.

This Trigger Investigation Report has followed Chart 2 and 3 of the LW 424–427 SMP in response to the trigger level exceedances identified within the 'LW424–427 Seasonal Swamp Monitoring Report' for Autumn 2021 (RPS, 2021).

1.1 Purpose

The purpose of this report is to complete the investigation in accordance with the trigger action response plan in the 424–427 Swamp Monitoring Program. This includes

- Considering if there is a correlation between the flora trigger timing and a potential groundwater change.
- Considering the climate data and the influence it has this had on the species composition.
- Investigating potential correlations with the anthropogenic causes (e.g., swamps burning in 2013 and 2019/2020 and if there is a cumulative impact from repeated bushfire on recovery rates).
- Considering whether the impacts are mining related.

1.2 Preliminary Trigger and Trigger Values

Preliminary Trigger and Trigger values have been set to provide a framework for monitoring and managing THPSS that may be impacted by the secondary extraction of coal from the Springvale mine. Results reported for the Autumn2021 monitoring event are compared against these triggers. The monitoring area for the LW424–427 SMP is depicted in **Figure 1** and includes the location of both 'impact' and 'control' swamps.

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Figure 1. Springvale Impact and Control Swamps

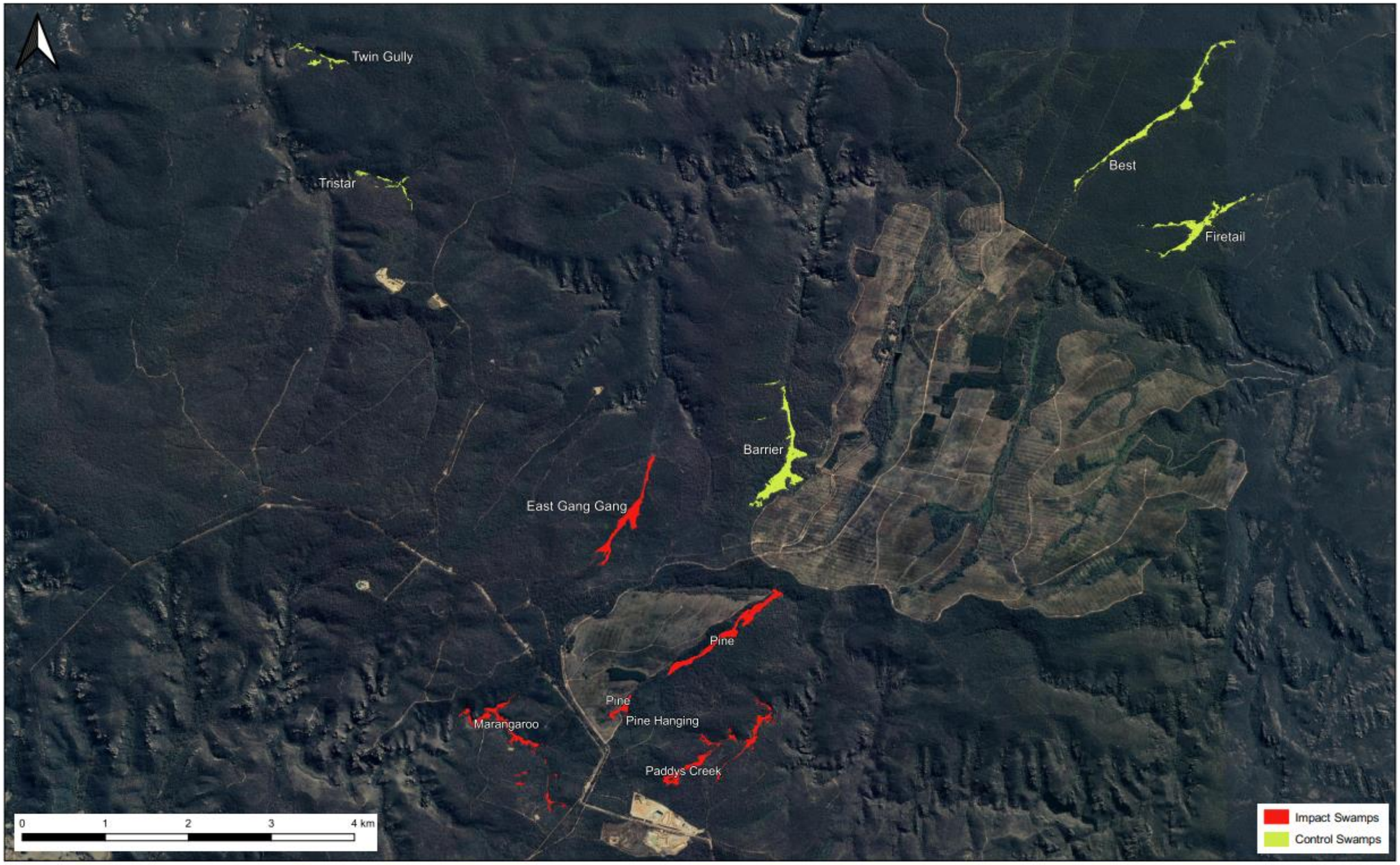

Figure 1: Springvale Impact and Control Swamps

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Author: Kazz Tokek
Date: 08.10.2021
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Coordinate Reference System: GDA 94 MGA Zone 56

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2 Assessment Methodology

The 'Flora monitoring methods for Newnes Plateau Shrub Swamps and Hanging Swamps' (Brownstein et al 2014) provides the methodology for the LW 424–427 SMP, which outlines specifications for the seasonal and annual surveys

The extent of the remotely sensed imagery used in the LW 424–427 monitoring program is depicted in **Figure 2**.

2.1 Seasonal Remote Sensing

Remote sensed imagery comprising Red–Green–Blue (RGB) and Near–Infrared (NI) bandwidths, with the near–infrared (NIR) bandwidth centred around 720 nm, was obtained by Aerometrex Pty Ltd using fixed wing aircraft on the 21st and 22nd of April 2021. Data collection and analysis methods used are consistent with those described in RPS (2019).

2.2 Ground Control Points

Ground control points (GCPs) provide a field–based validation of information generated from the analysis of remotely sensed imagery (e.g. presence of live plant material) and collect additional information on flora species (e.g. percent weed cover). A minimum of three GCPs were permanently established in each swamp, with each comprising a plot measuring 1 m^2 in area to directly measure the variables listed below:

- Percentage live vegetation (i.e. photosynthetically active plant material);
- Percentage non–vegetated area (i.e. bare ground, water, litter and standing dead biomass);
- Percentage cover of each exotic plant species; and
- Dominant and co–dominant species in the overstorey, mid–storey and groundcover strata.

Autumn 2021 GCP surveys were performed from 19 April to 29 April 2021. Data collection and analysis methods used were consistent with those described in RPS (2019).

2.3 Trigger Action Response Plan

A TARP forms part of the approved LW 424–427 SMP and sets out management measures for Centennial to undertake in the case of a Trigger exceedance. These management measures are outlined in Chart 2 (**Appendix 1**) and include the following investigations that are to be carried out within two months:

- Check for data inaccuracies (including; misreading, human error, instrument damage, instrument malfunction, data handling error, calculation error, and plotting error.)
- Similar triggers at reference sites (e.g. compare data from reference sites)

- Identify potential anthropogenic/natural impacts (including; forestry activity, erosion, swamp damage, bushfire, and vandalism.)
- Abnormal weather conditions
- Mining within 600m
- Evidence of possible mining impacts

Chart 3 (**Appendix 1**) has similar implications to Chart 2 with additional outcomes including some further recommendations as follows;

- Carry out additional field surveys
- Consider more frequent or additional monitoring
- Monitor if conditions worsen

3 Investigation

The TARP Chart 2 process was followed while investigating the Autumn Flora Exceedances. Triggers have been observed at both impact and control sites. Drought and fire are cofounding factors making it difficult to ascertain if impacts are related to mining alone.

3.1 Data Accuracy

To ensure human error such as incorrect calculation or other data handling errors had not contributed to the trigger exceedance, the reported results of RPS 2021 were compared with raw data to ensure there were no anomalies. The data sampled was found to be consistent. In addition, this data was compared with SAVI indicating human error in recording, calculating, or transcribing the data was unlikely a contributing factor to the measured trigger exceedance.

3.1.1 Seasonal Swamp Monitoring

Plant health monitoring results for each swamp are summarised in **Table 1** together with the baseline for LW 419 and LW420–422 against the preliminary trigger levels reported in RPS (2019).

Table 1 Mean Area (SAVI ≤ 0.12) ± SE (ha) and 5% and 10% Preliminary Trigger Level (Extracted from RPS, 2021)

Swamp	Mean Area (SAVI ≤ 0.12) ± SE (ha)	5% Preliminary Trigger Level (ha)	10% Preliminary Trigger Level (ha)	20% Trigger Level (ha)	Autumn 2021
424-427 Baseline Data					
Control Swamps (Shrub)					
Barrier	2.07 ± 0.976	3.198	3.350	3.655	0.640
Best	0.868 ± 0.447	1.381	1.447	1.578	0.513
Firetail	0.586 ± 0.274	0.899	0.942	1.028	0.668
Tristar	0.130 ± 0.077	0.217	0.228	0.248	0.167
Twin Gully	0.091 ± 0.065	0.164	0.172	0.187	0.094
Control Swamps (Hanging)					
Twin Gully Hanging	0.078 ± 0.034	0.118	0.123	0.134	0.082
Impact Swamps (Shrub)					
Marrangaroo	0.606 ± 0.291	0.942	0.987	1.076	1.307
Paddys Creek	0.286 ± 0.136	0.442	0.463	0.506	1.402
Pine	0.446 ± 0.272	0.755	0.791	0.862	0.826
Impact Swamps (Hanging)					
Pine Hanging	0.0012 ± 0.0007	0.002	0.002	0.0023	0.006
LW420-422 Baseline (Existing Data Set)					
Control Swamps (shrub)					
Barrier	1.928 ± 0.956	3.028	3.172	3.461	0.666
Best	0.848 ± 0.400	1.310	1.373	1.498	0.485
Firetail	0.585 ± 0.276	0.904	0.948	1.033	0.712
Tristar	0.151 ± 0.088	0.251	0.263	0.287	0.226
Twin Gully	0.108 ± 0.073	0.190	0.199	0.217	0.106
Control Swamps (hanging)					
Twin Gully Hanging	0.117 ± 0.040	0.165	0.172	0.188	0.124
Impact Swamp (shrub)					
Nine Mile	0.167 ± 0.076	0.256	0.268	0.292	0.301
LW419 Baseline (Existing Data Set)					
Control Swamps (shrub)					
Barrier	2.192 ± 0.583	2.914	3.053	3.330	1.056
Firetail	1.245 ± 0.297	1.619	1.696	1.850	1.225
Tristar	0.345 ± 0.079	0.445	0.466	0.509	0.733
Twin Gully	0.117 ± 0.036	0.161	0.168	0.184	0.175
Control Swamp (hanging)					
Twin Gully Hanging	0.218 ± 0.039	0.270	0.283	0.308	0.171
Impact Swamps (Shrub)					
East Gang Gang	0.506 ± 0.105	0.642	0.672	0.733	5.955

Results that exceed the corresponding baseline (i.e. SAVI is ≤ to 0.12) by >20% are coloured orange, which indicates:

- A trigger level exceedance for impact swamps; or
- Variation outside prior measured variation for control swamps.

Results that exceed the corresponding baseline (i.e. SAVI is ≤ to 0.12) by >10% are coloured grey, which indicates:

- A preliminary trigger level exceedance for impact swamps; or
- Variation outside prior measured variation for control swamps.

Statistical significance is included as a requisite indication of a trigger event.

The Key findings from the Autumn Monitoring Program are outlined below:

- Five impact swamps exceeded the trigger level for corresponding baseline (SAVI is ≤ to 0.12) by >20% (Marrangaroo, Paddy's Creek, Nine Mile, East Gang Gang and Pine Hanging). Of which, only Marangaroo and Nine Mile were new triggers, the rest were recurring triggers.

- Pine Swamp exceeded the preliminary trigger for corresponding baseline (SAVI is ≤ to 0.12) by >10%.

- Tristar Swamp exhibited variation outside prior measured variation for control swamps.

The swamps that experienced triggers are identified below on **Figure 2** and the SAVI classification and live versus non–live (SAVI <0.12) for the swamps which had preliminary triggers and triggers are depicted in **Figures 3–16**.

Figure 2 SAVI classification and live versus non-live (SAVI <0.12) Triggered Swamps

Figure 2: SAVI Trigger Swamps

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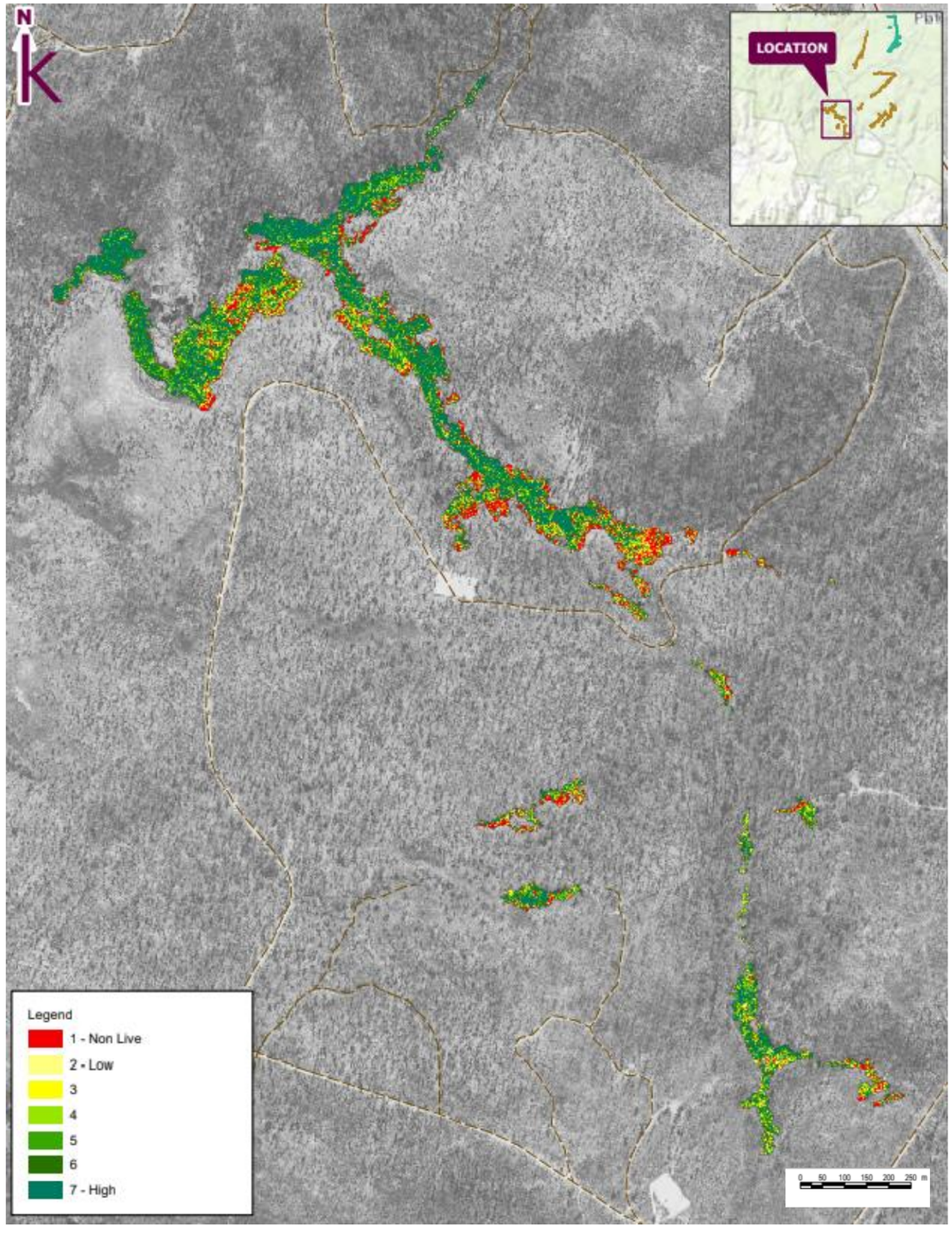
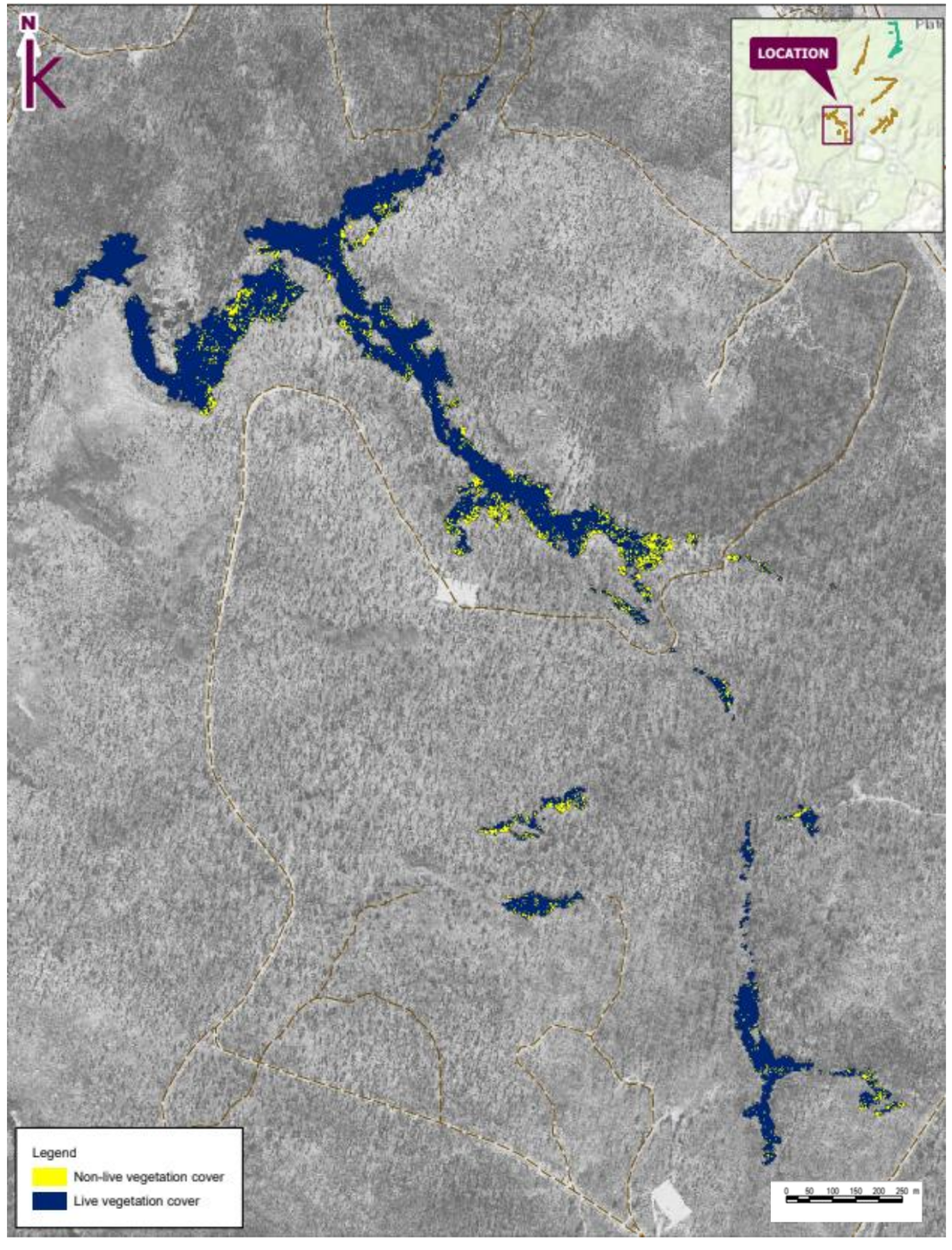
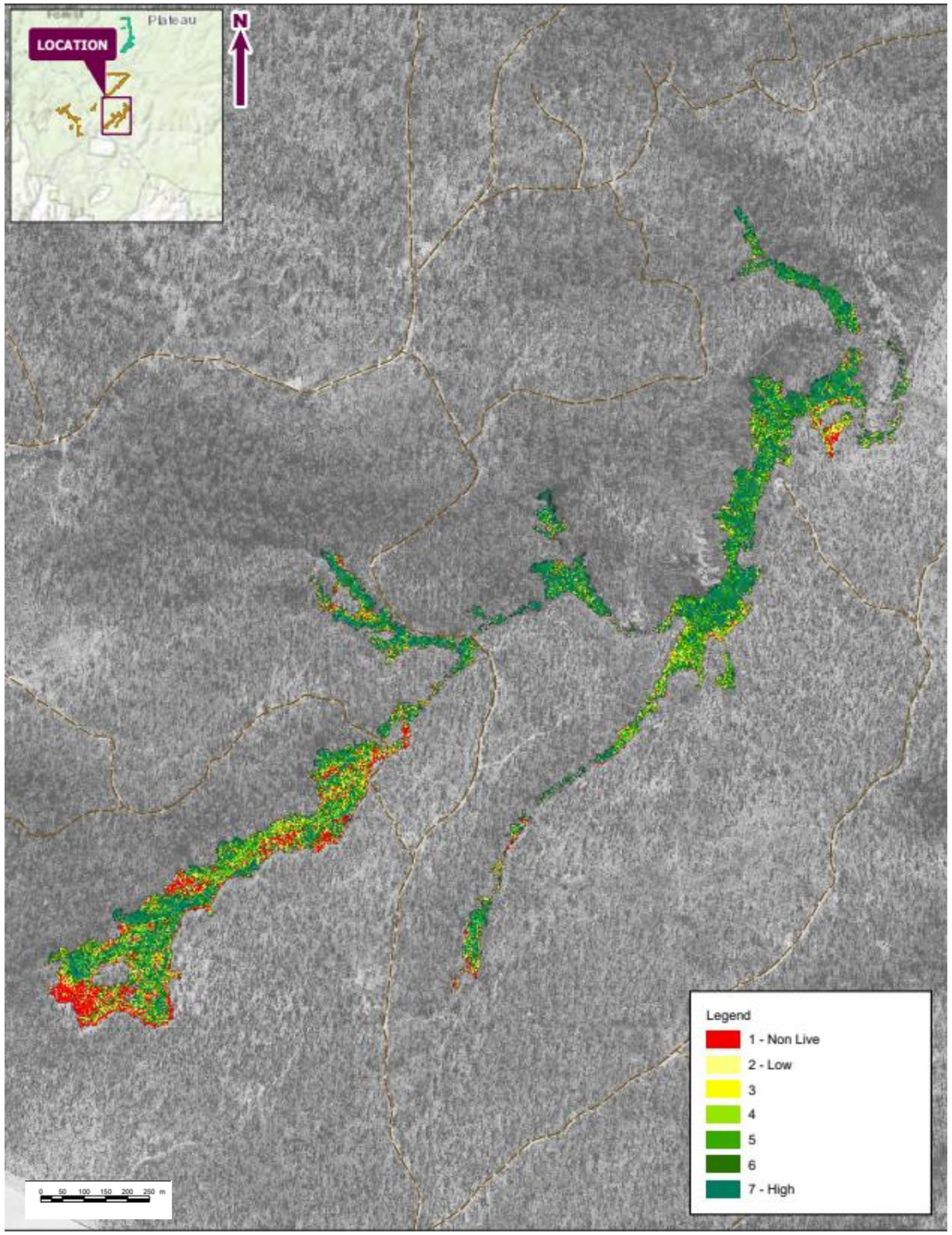
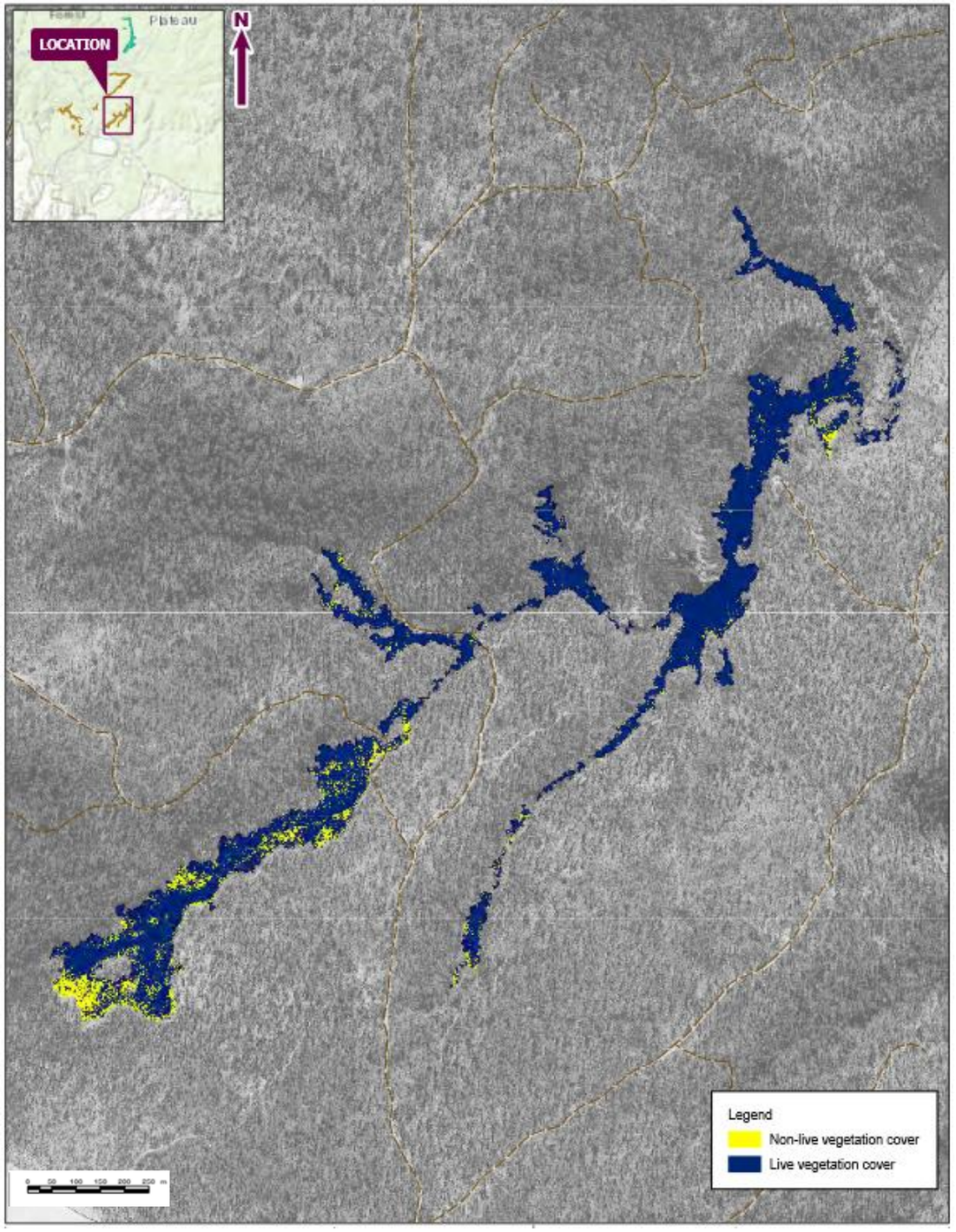


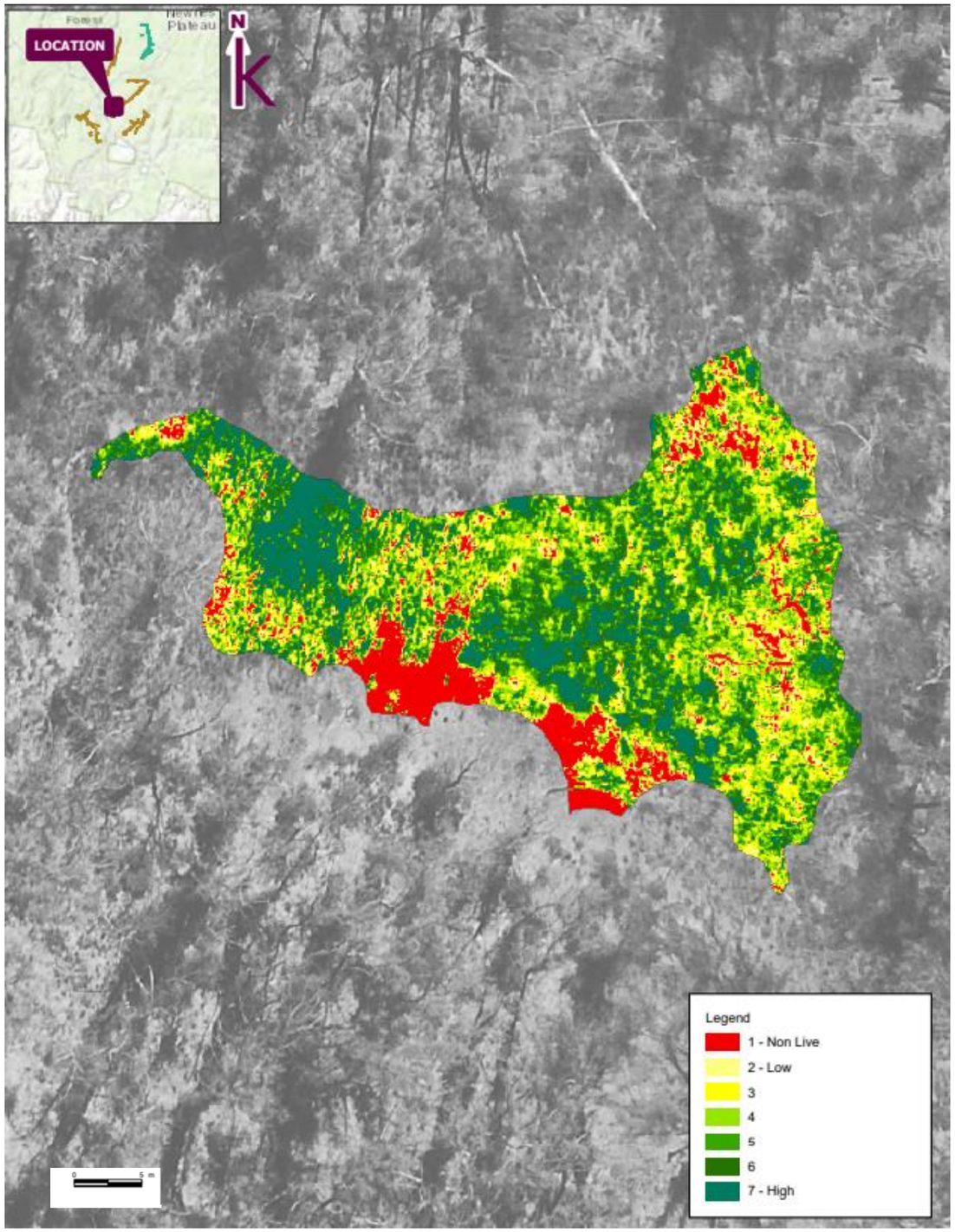


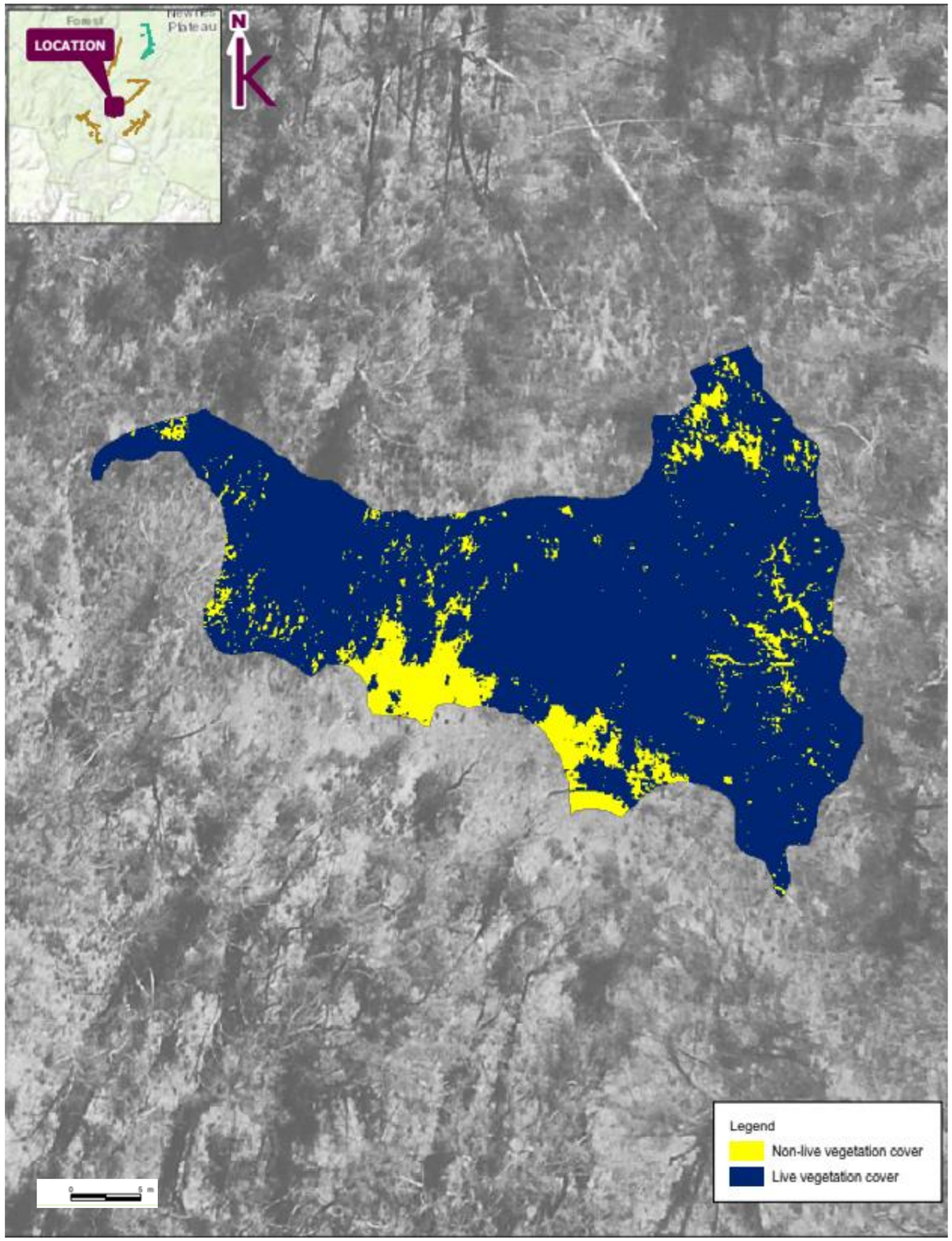
Figures 3 and 4 – SAVI classification and live versus non-live (SAVI <0.12) Marrangaroo Triggered (Extracted from RPS, 2021)



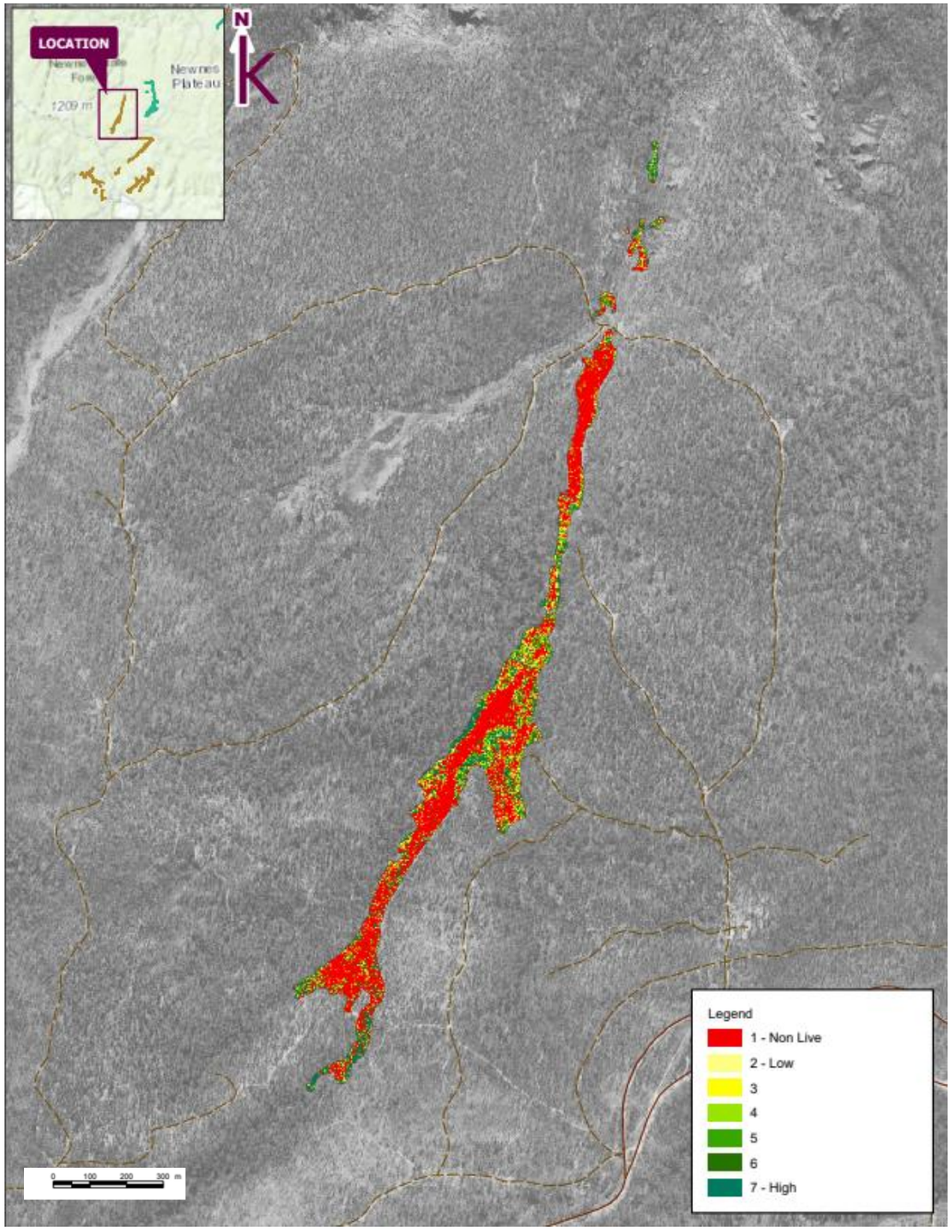


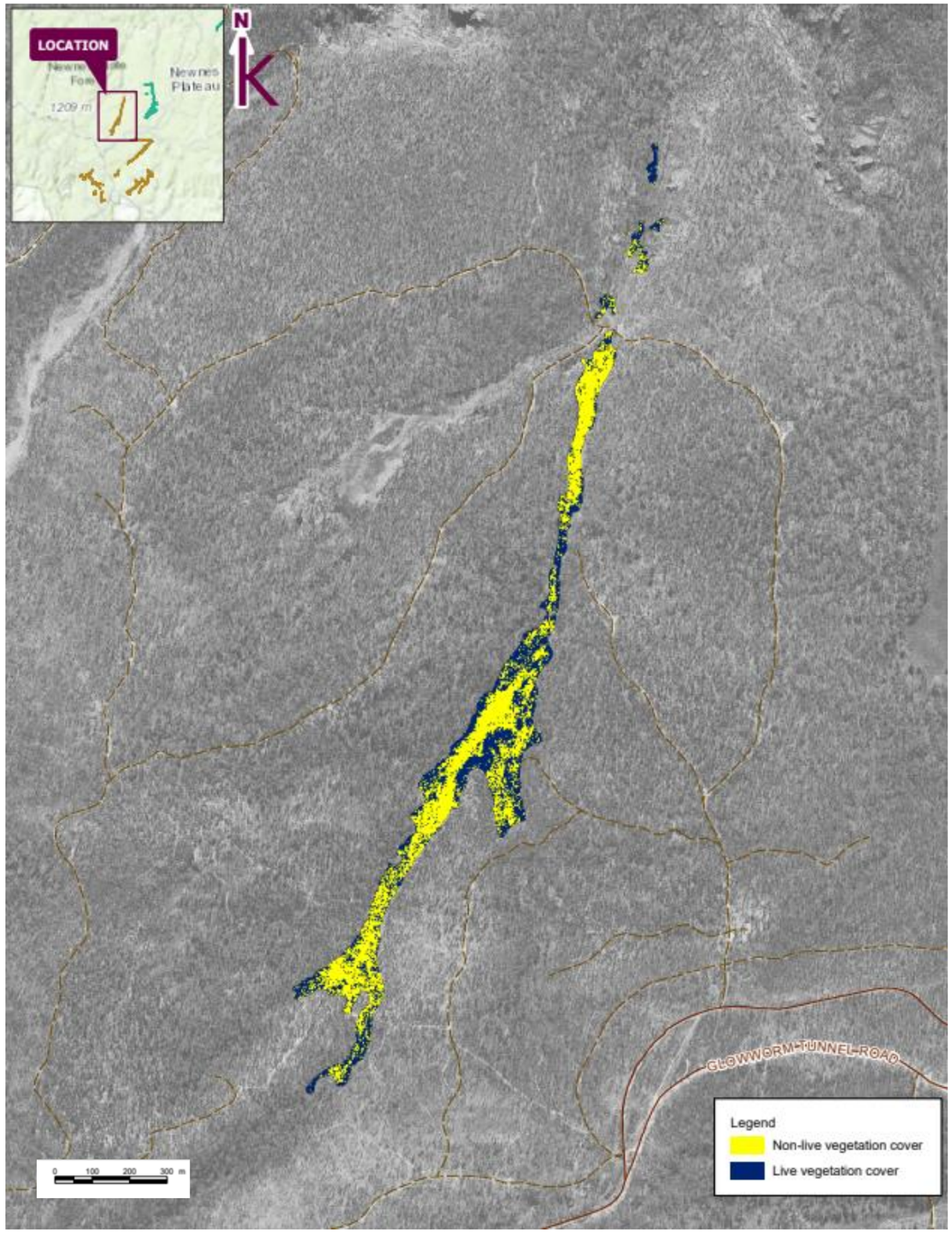
Figures 5 and 6 – SAVI classification and live versus non-live (SAVI <0.12) Paddys Creek Triggered (Extracted from RPS, 2021)



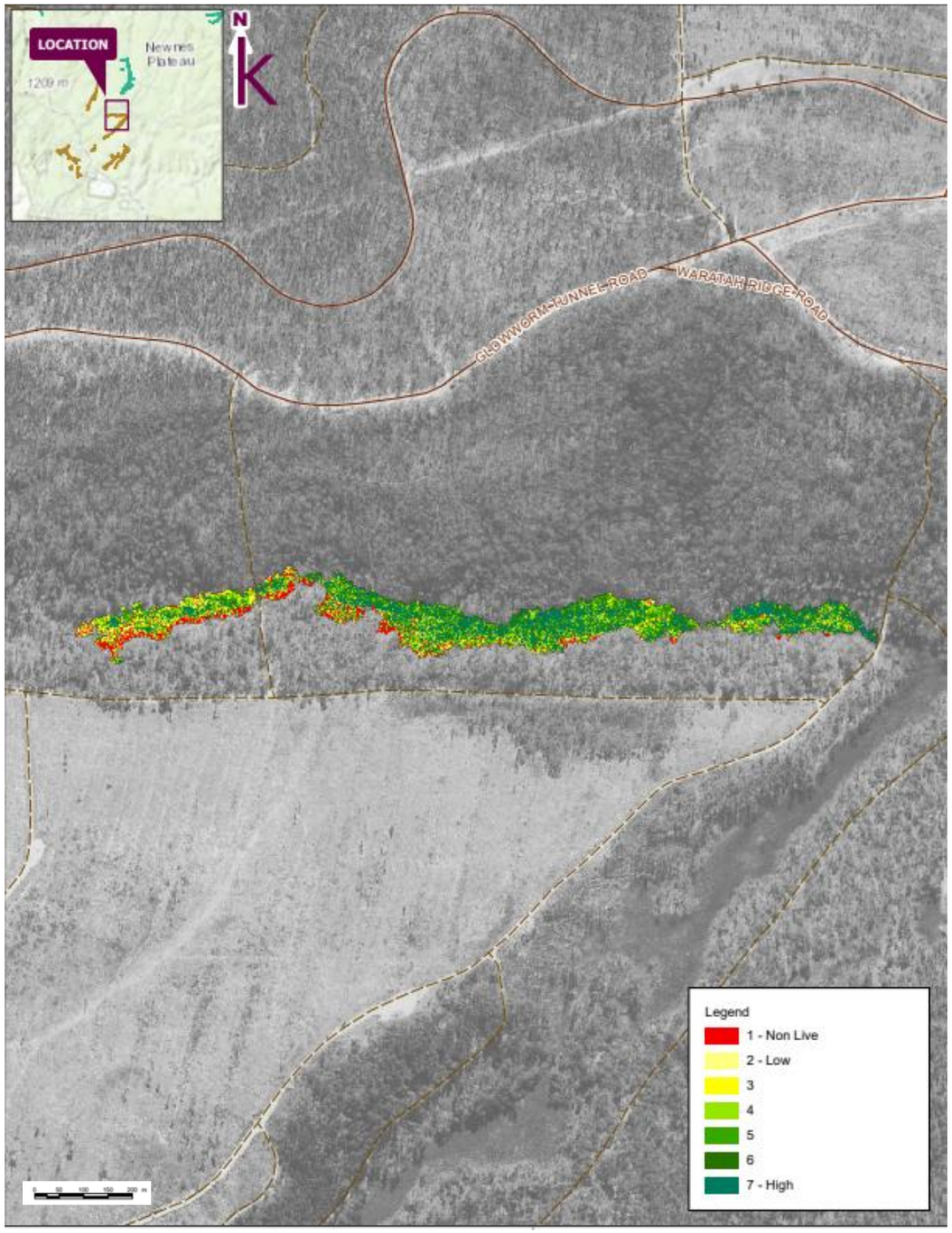


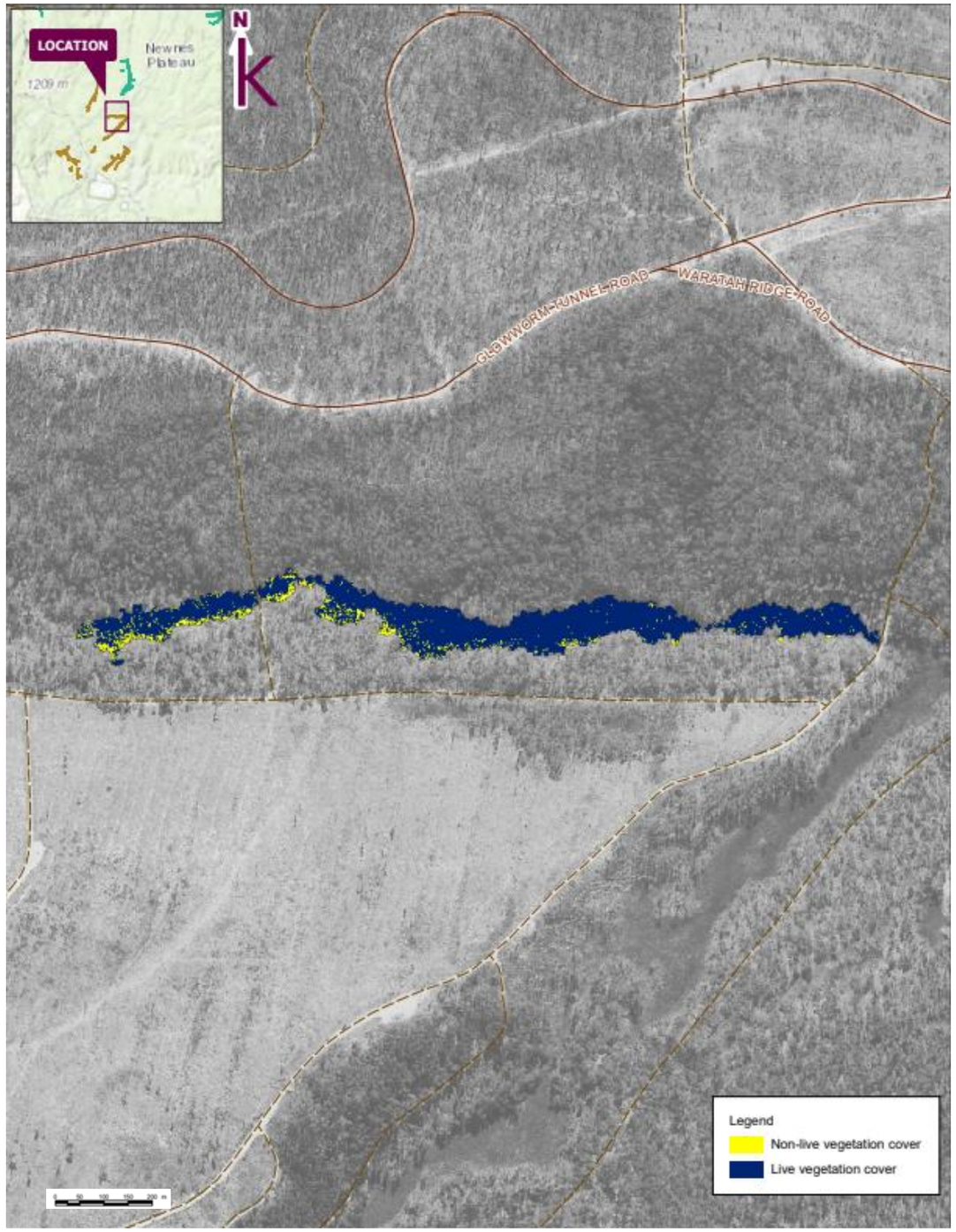
Figures 7 and 8 – SAVI classification and live versus non–live (SAVI <0.12) Pine Hanging Triggered (Extracted from RPS, 2021)



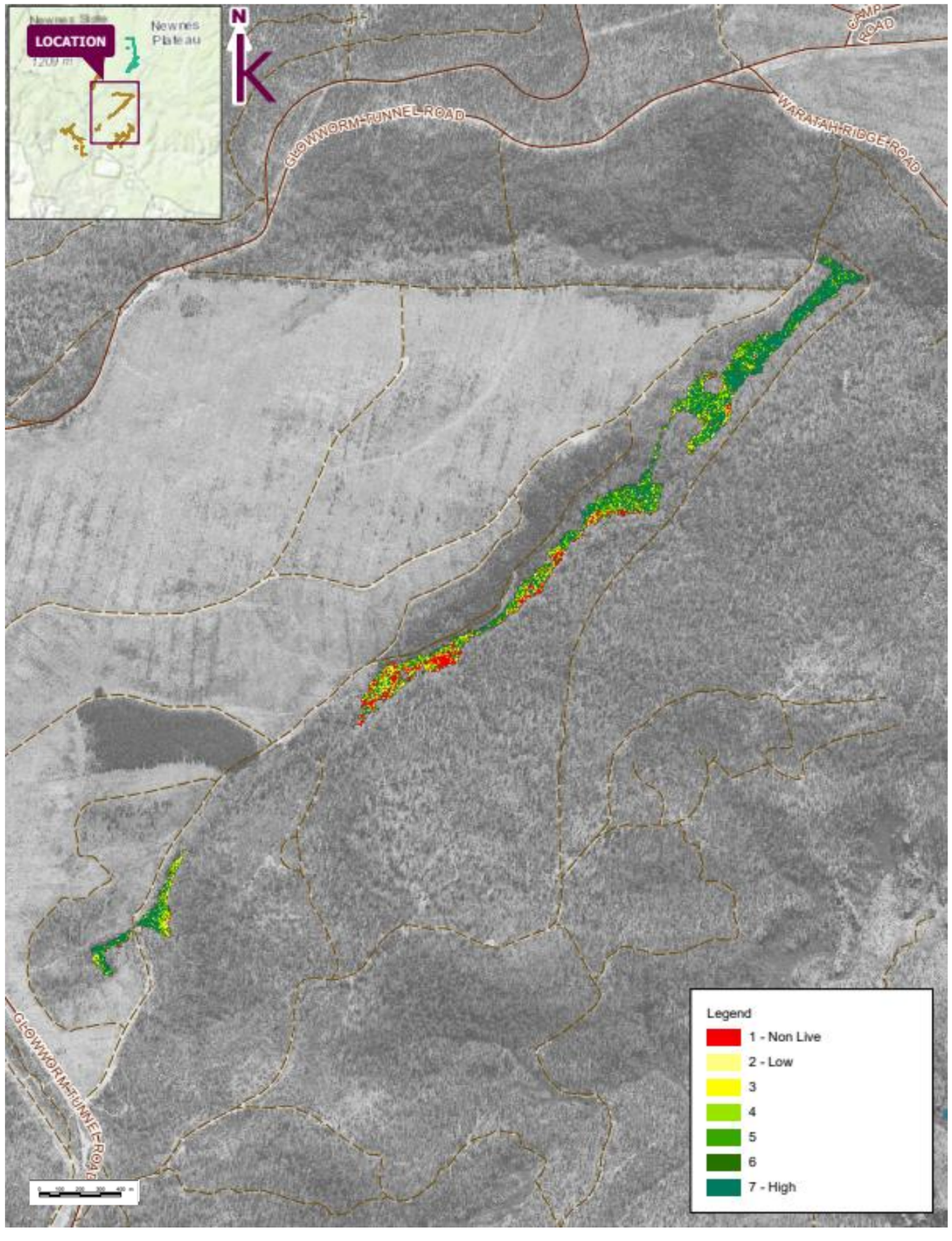


Figures 9 and 10 – SAVI classification and live versus non-live (SAVI <0.12) East Gang Gang Triggered (Extracted from RPS, 2021)





Figures 11 and 12 SAVI classification and live versus non-live (SAVI <0.12) Nine Mile Swamp Triggered (Extracted from RPS, 2021)



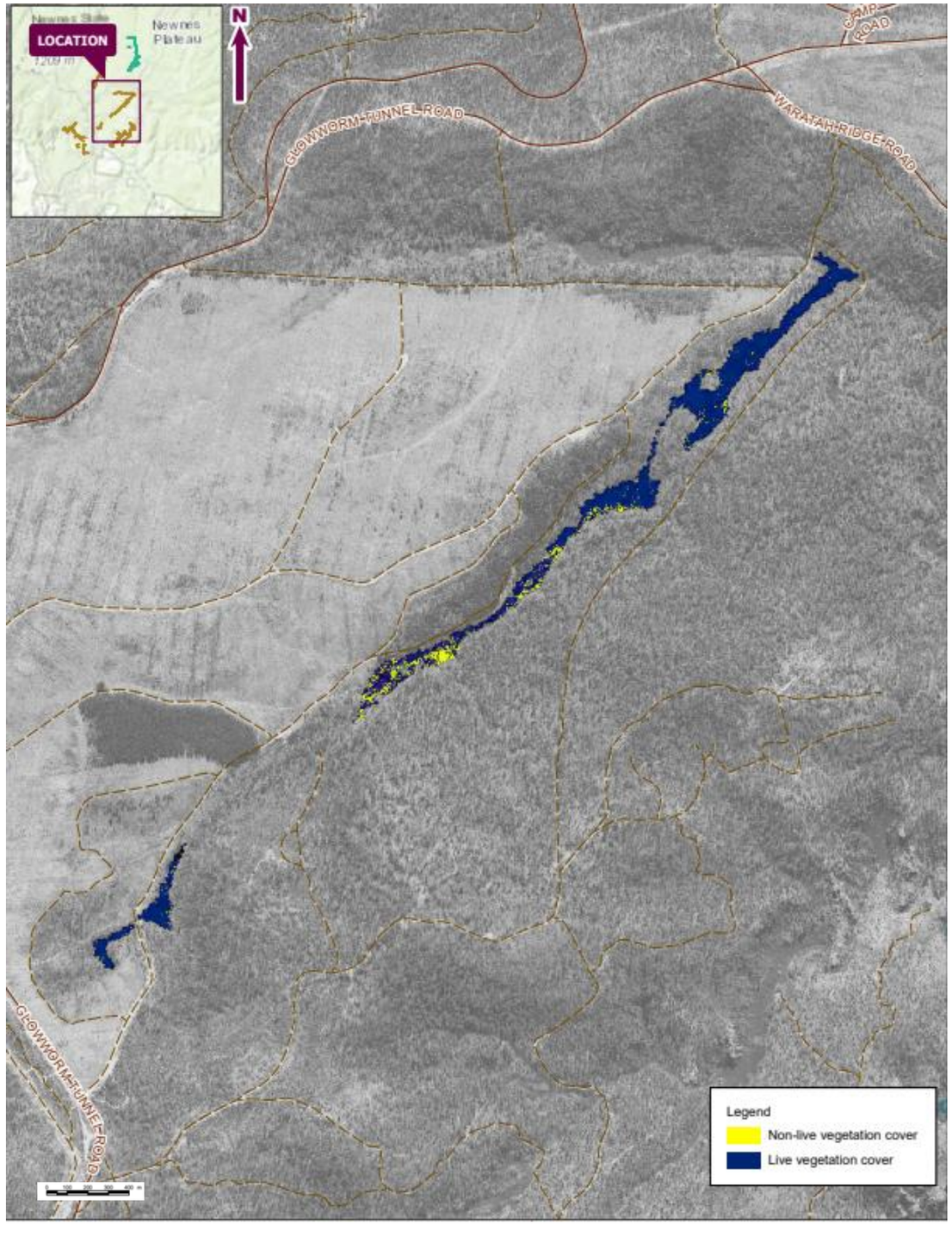
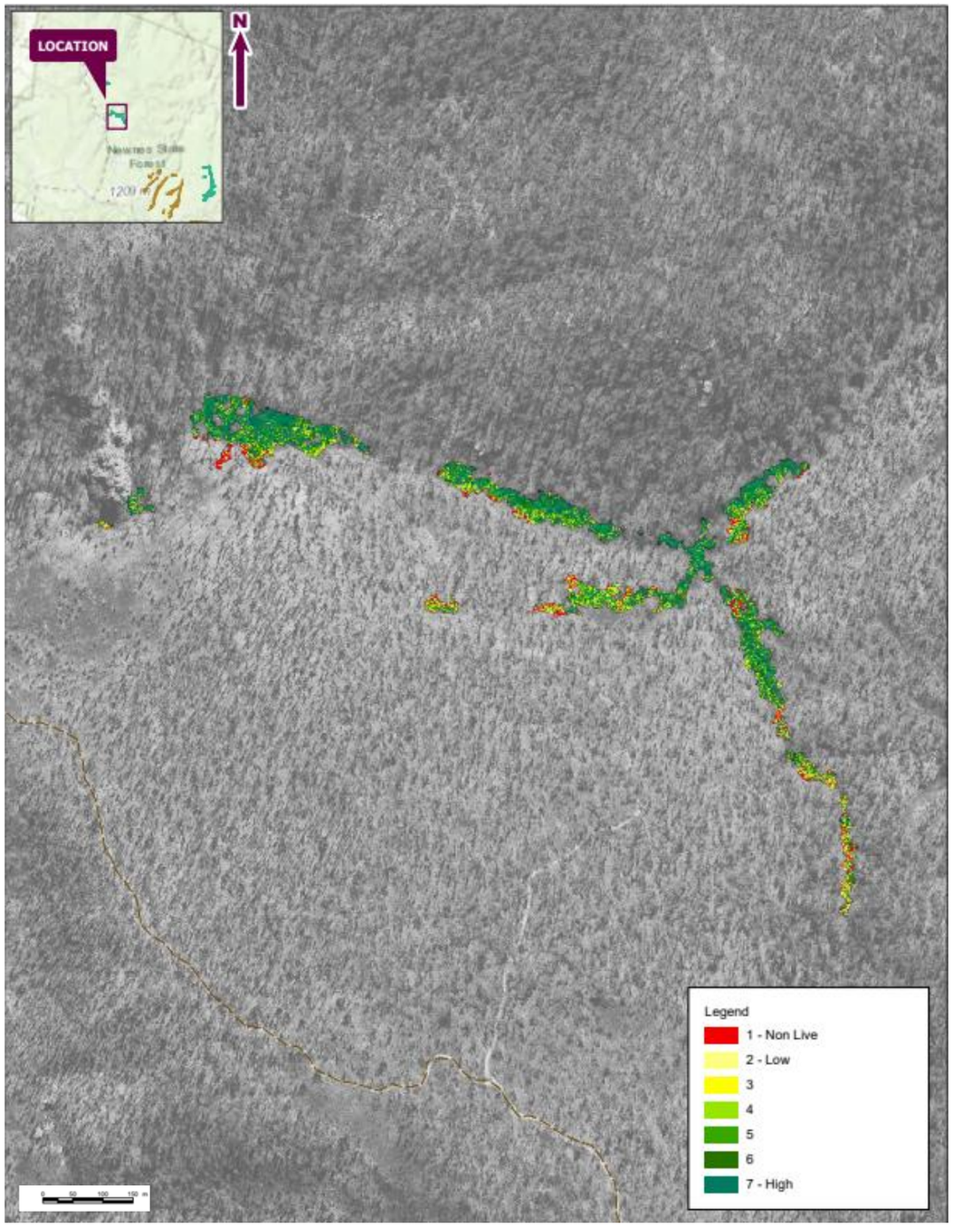
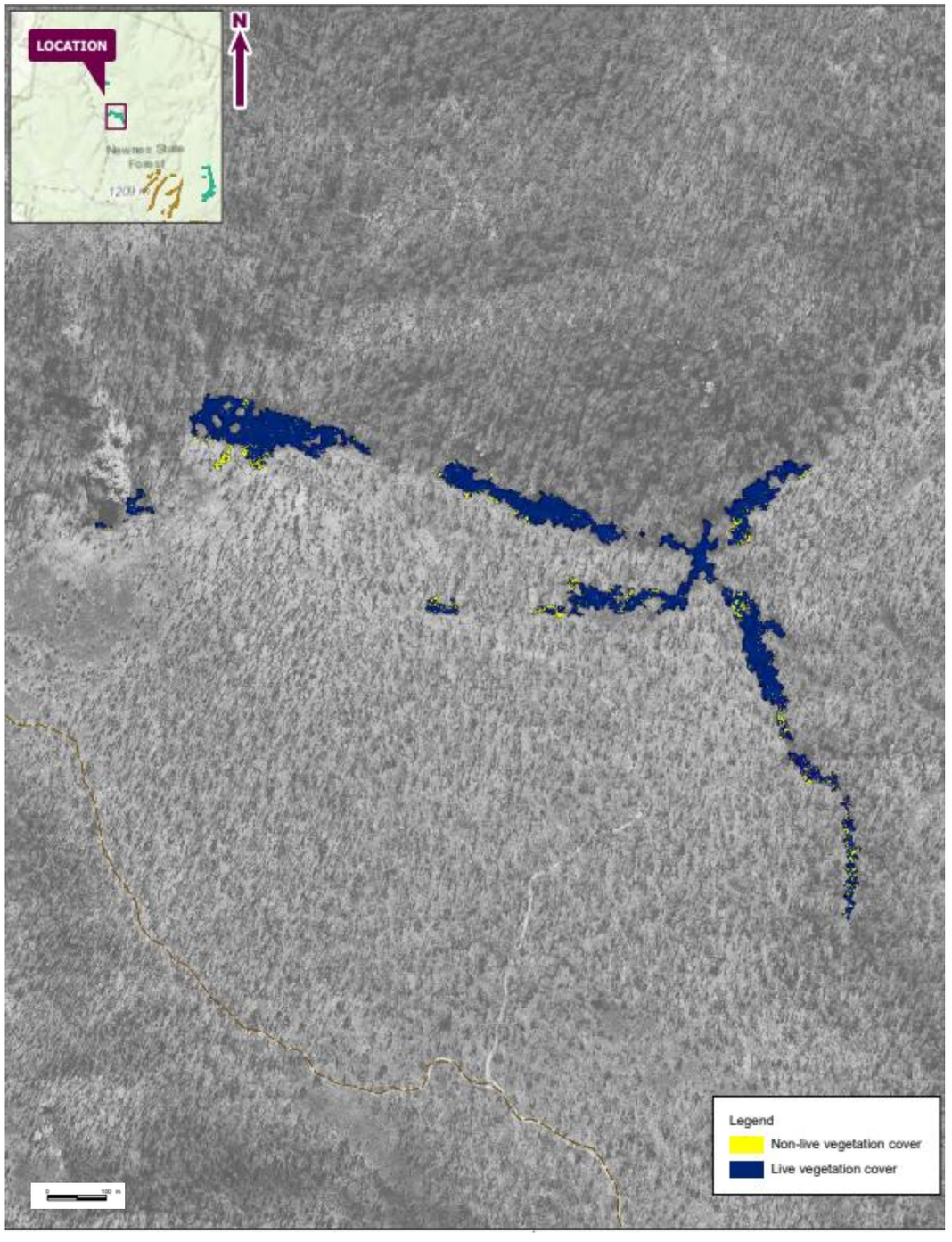


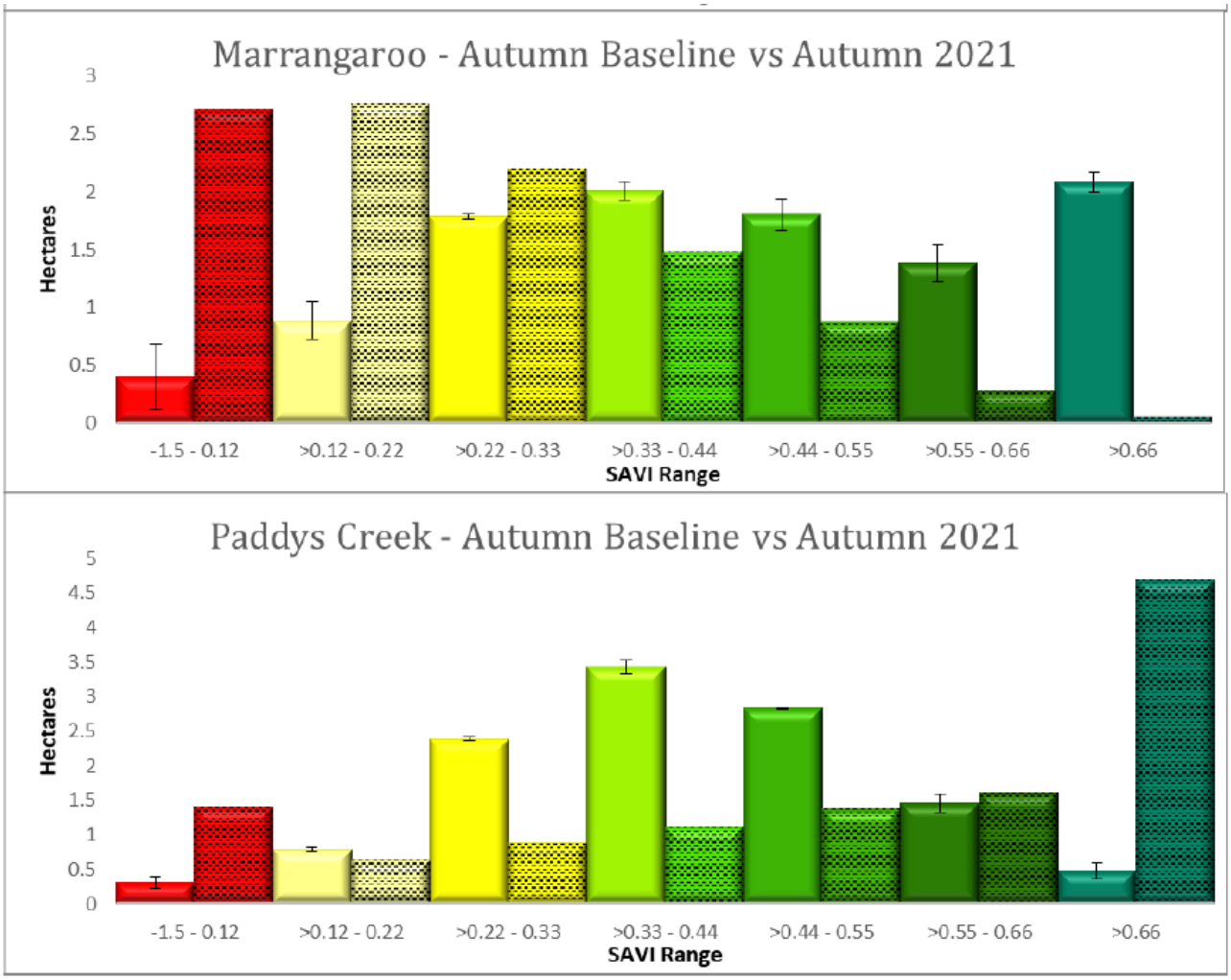
Figure 13 and 14 SAVI CLASSIFICATION AND LIVE VERSUS NON-LIVE (SAVI <0.12) Pine Swamp Preliminary Trigger (EXTRACTED FROM RPS, 2021)

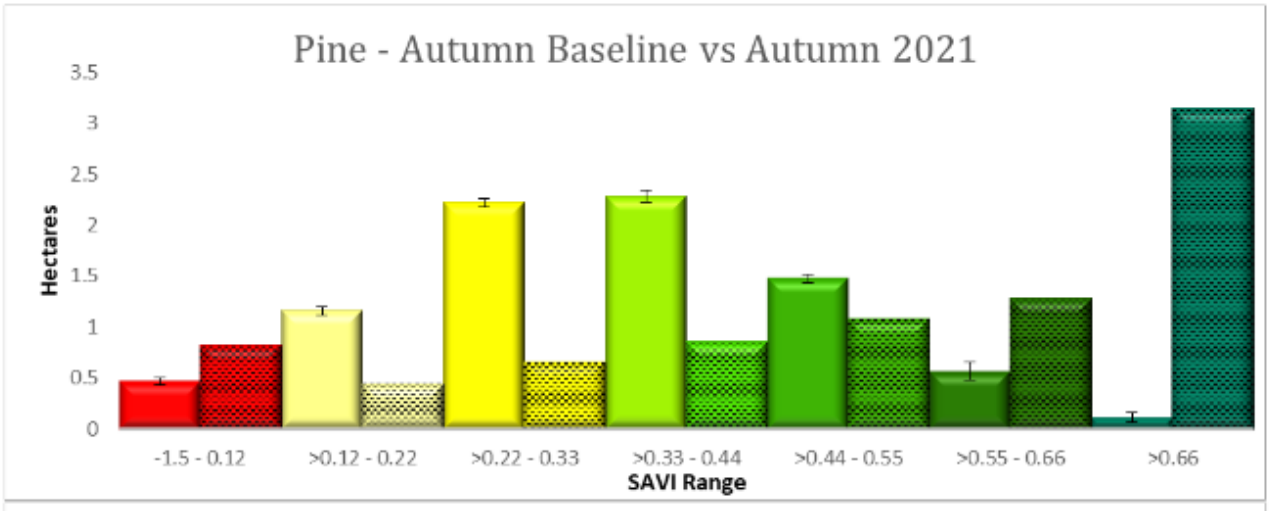


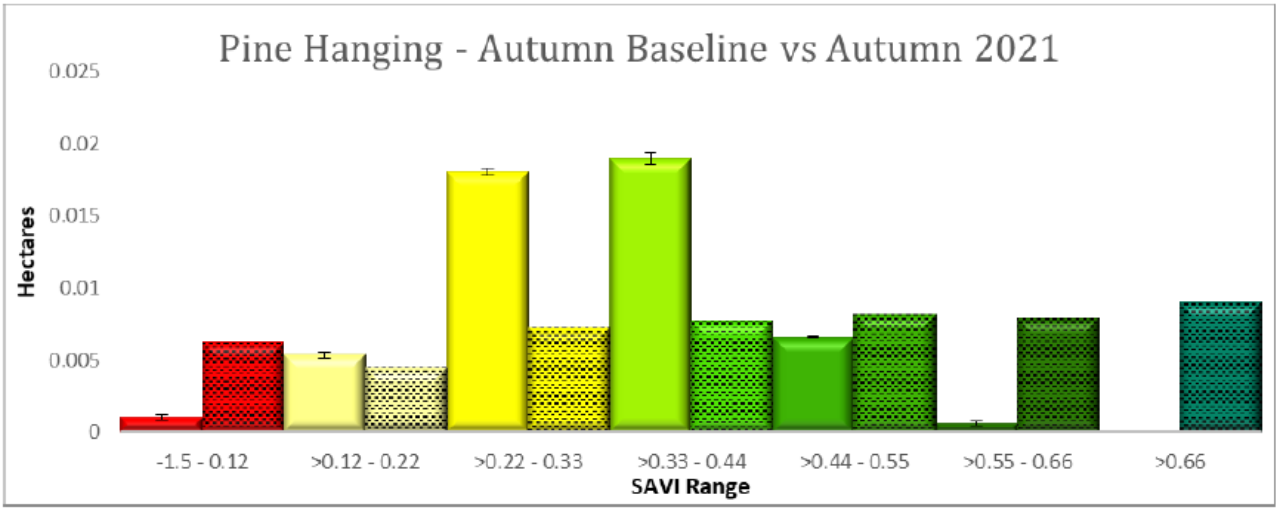


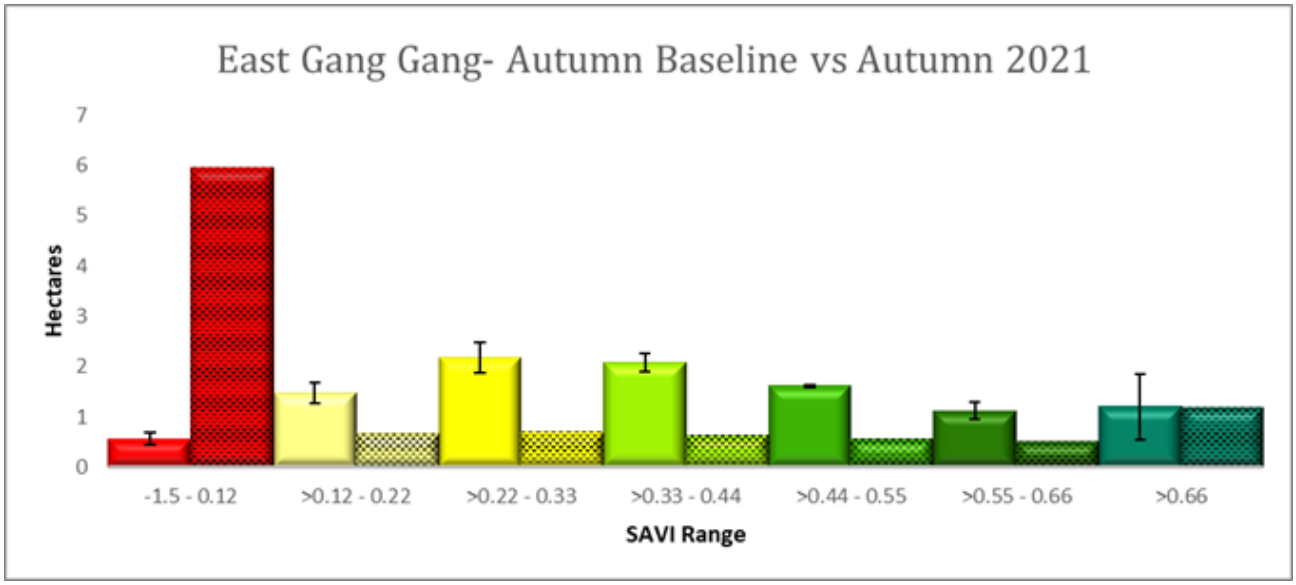
Figures 15 and 16 – SAVI classification and live versus non-live (SAVI <0.12) Tristar Swamp Triggered (Extracted from RPS, 2021

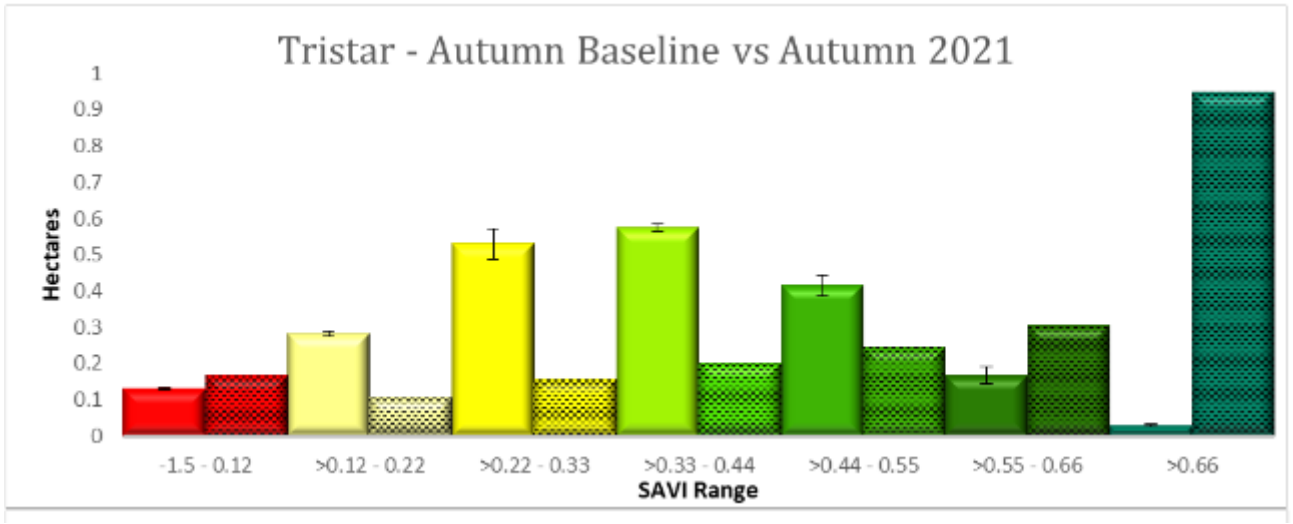
Graph 1 – Seasonal Histograms – SAVI classification and live versus non-live (SAVI <0.12) Triggered (Extracted from RPS, 2021)




Pine - Autumn Baseline vs Autumn 2021
Hectares
3.5
3
2.5
2
1.5
1
0.5
0
-1.5 - 0.12
>0.12 - 0.22
>0.22 - 0.33
>0.33 - 0.44
>0.44 - 0.55
>0.55 - 0.66
>0.66
SAVI Range


Pine Hanging - Autumn Baseline vs Autumn 2021
Hectares
0.025
0.02
0.015
0.01
0.005
0
-1.5 - 0.12
>0.12 - 0.22
>0.22 - 0.33
>0.33 - 0.44
>0.44 - 0.55
>0.55 - 0.66
>0.66
SAVI Range





3.1.2 Ground Control Points

Results obtained from GCP reconnaissance performed in the Autumn 2021 monitoring event are summarised below.

A summary for shrub swamps is provided as follows:

- Percent live vegetation cover below the baseline range was recorded for 71 of 82 (87%) of impact swamp GCPs.
- Percent live vegetation cover below the baseline range was recorded for 55 of 77 (71%) of control swamp GCPs.

A summary for hanging swamps is provided as follows:

- Percent live vegetation cover below the baseline range was recorded for 4 of 6 (66%) of impact hanging swamp GCPs.

- Percent live vegetation cover below the baseline range was recorded for 0 of 1 (0%) of control hanging swamp GCPs.

3.2 Reference Swamp Comparison

The reference swamps Barrier, Central Carne, Best, Firetail, Twin Gully, Twin Gully Hanging, and Tristar were spatially analysed with reference to the baseline report RPS (2018). These results were then compared against the trigger levels applied to impact swamps.

The reference (control) site comparison as part of the BACI designed swamp monitoring program identified that one reference swamp (Tristar) triggered against the SAVI metric (SAVI<0.12).

The GCP results reported above suggest that a high proportion of both reference and impact swamps are experiencing higher than expected percentages of non–live vegetation, and that this might be more exaggerated (exceeding trigger levels) in impact sites due to the confounding factors such as prolonged dry and hot conditions and bushfire recovery rates.

3.3 Potential anthropogenic/natural impacts

The examination of aerial imagery identified that there has been no significant forestry activity, erosion events or swamp damage due to vandalism located within the catchments or swamp boundaries of triggered swamps.

3.3.1 Bushfire

The bushfires of the summer of 2019–2020 burnt through approximately 853,977 ha of the Greater Blue Mountains World Heritage Area, (Department of Agriculture Water and the Environment, 2020) and adjacent areas, including those above Centennial's Springvale Coal mining operation. The Newnes Plateau was severely affected (K. A. Fryirs et al., 2021).

In the Newnes Plateau area, the effect of the fires was severe. Almost all the swamp area was affected (93%) and 96% of swamps were either partially or completely burnt. Of these, 97% experienced a high to very high burn severity. Follow up field observations of the Newnes Plateau swamps showed that swamp grasses were burnt to ground level. In most of the affected swamps, the surface organic matter was lost, while in the most severe cases, the upper peat layer (the alternating organic sands (AOS) (K. Fryirs, Freidman, B., Williams, R., Jacobsen, G., 2014) were also burnt. Post fire, heavy rainfall has led to surface erosion and rill and gully formation. There has been, in some places, significant ash transport. While further surveys have not yet been undertaken, K. A. Fryirs et al. (2021) propose that swamps with greater soil moisture were burnt less severely.

The recent 2019–2020 bushfires caused immense damage to the Newnes Plateau THPSS swamps. Recovery of swamp vegetation is occurring, particularly in wetter swamps with long term water supply. In swamps that have been undermined and dried to some degree prior to the fire, it appears that vegetation recovery is hampered and vegetation structure has changed.

Graph 2 presents the mean GCP live vegetation cover within 50cm (%) per swamp over time. Data is grouped by impact swamps (orange) and control/ reference swamps (green).

Graph 2 Mean GCP live vegetation cover within 50cm (%) per swamp over time.

Graph 3 presents the average ratio of GCP live vegetation cover within 50 cm (%) to the corresponding baseline value for the respective GCP. Impact swamps are plotted in orange, control swamps are plotted in green. Baseline data remains a constant of 1 and is represented by the red horizontal axis.

Graph 3 average ratio of GCP live vegetation cover within 50 cm (%)to the corresponding baseline value for the respective GCP

Although the recovery rates for swamps post fire are lower for Swamps that triggered for the SAVI metric (SAVI<0.12), it is evident in the graphs above that all swamps are on a recovery trajectory post fire and it is unclear at this stage whether all swamps will make a full recovery back to within the pre-fire baseline natural variance.

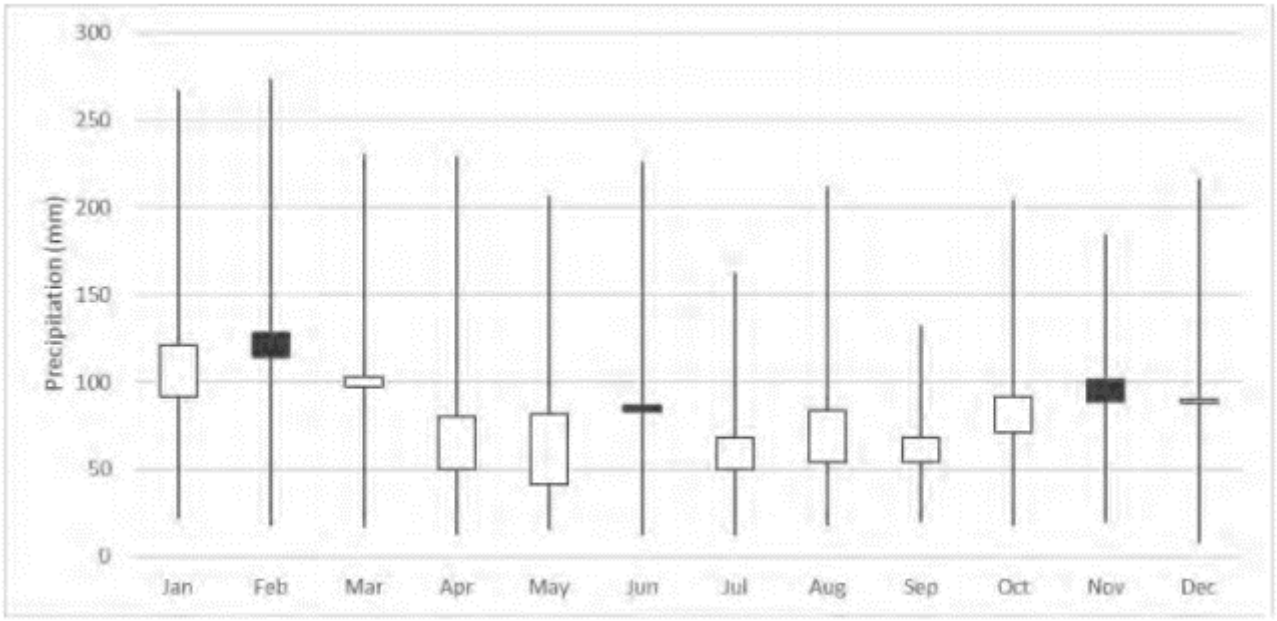
3.3.2 Abnormal weather conditions

Potential impacts with regards to weather events such as above or below average rainfall period, storm events, lightning and drought conditions have been assessed through investigating BOM weather records over that period.

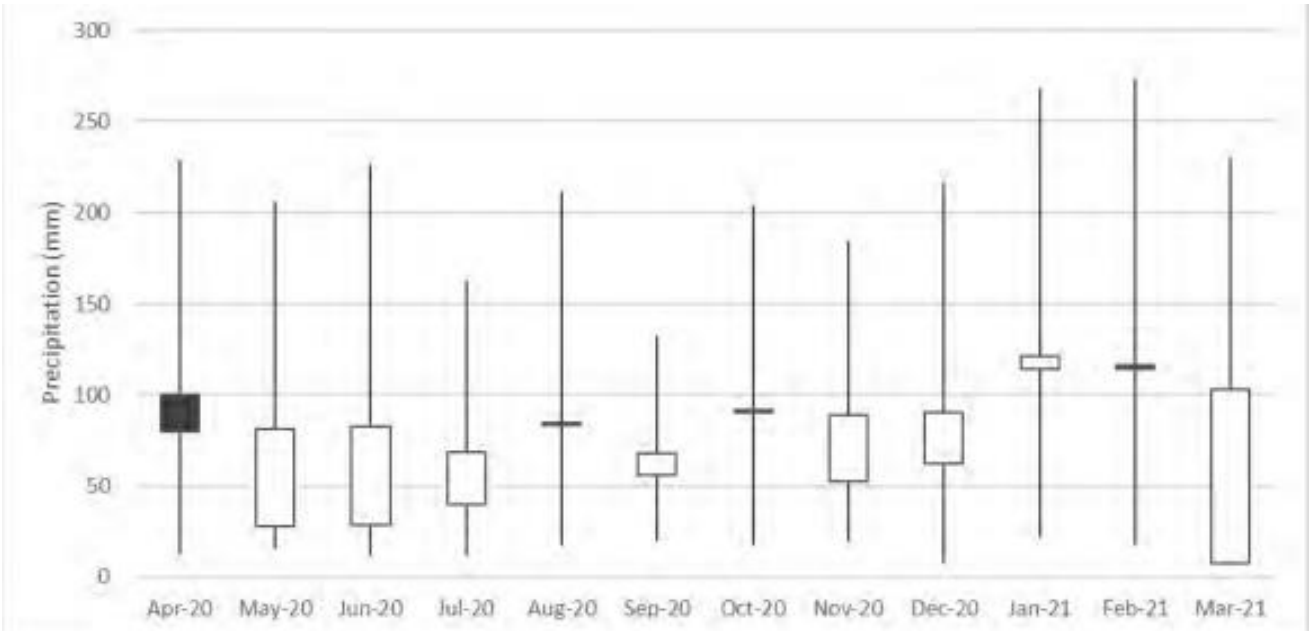
Weather conditions associated with the monitoring period were compared with historical datasets to aid interpretation of monitoring results. A summary of mean weather data is provided in the following sections.

3.3.2.1 Rainfall

Mean monthly rainfall totals for February, June and November (ALS 2002–2021) exceed the corresponding historical monthly means reported at the Newnes Forest Centre 63062 (1938–1999) (BOM 2021a) as shown by closed candles in **Graph 4**. Mean monthly rainfall (ALS 2002–2021) for the remaining calendar months were substantially lower than the long-term mean (1938–1999) (BOM 2021a).



Graph 4 Mean monthly rainfall for Newnes Forest Centre 36062 (1938–1999) (BOM2021a) and ALS Newnes Plateau (June 2003 – March 2021)

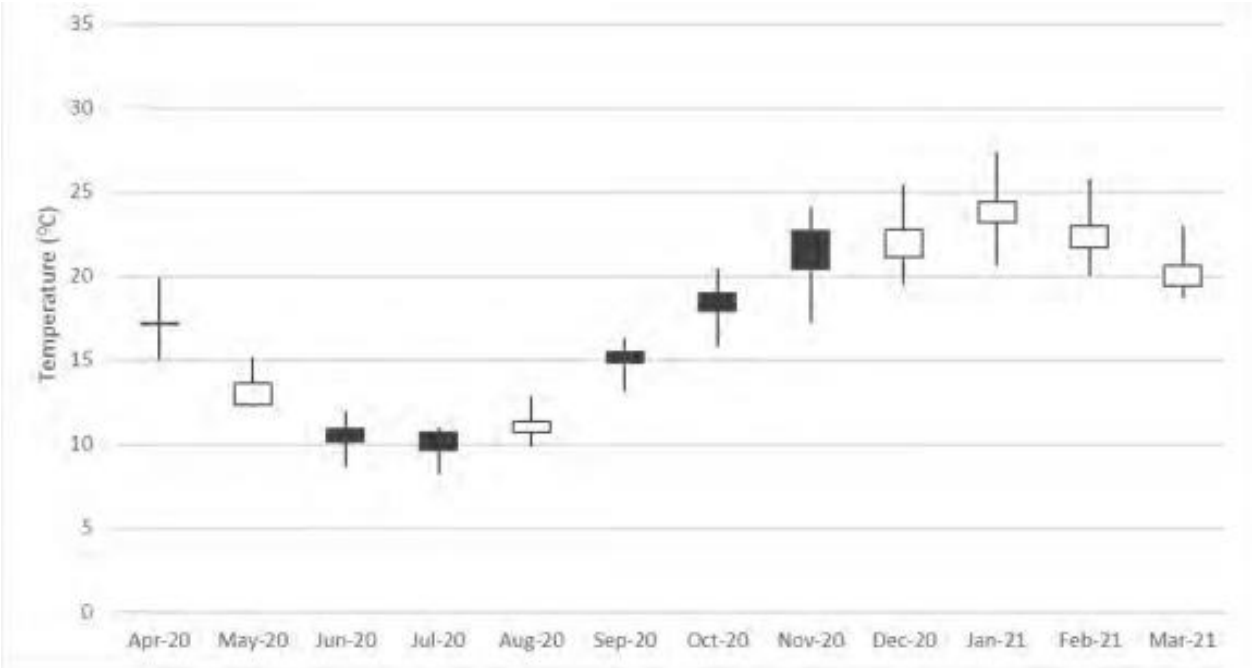


Graph 5 Monthly precipitation for April 2020 to March 2021 compared to mean monthly rainfall for the Newnes Forest Centre 63062 (1938–1999) (BOM 2021a)

Low rainfall was observed for eight of the twelve months prior to the April 2021 sampling period (**Graph 5**). February, March, April and August all experienced rainfall that exceeded historical means for the area. Remaining months comprised of rainfall which remained below the historical mean for the area.

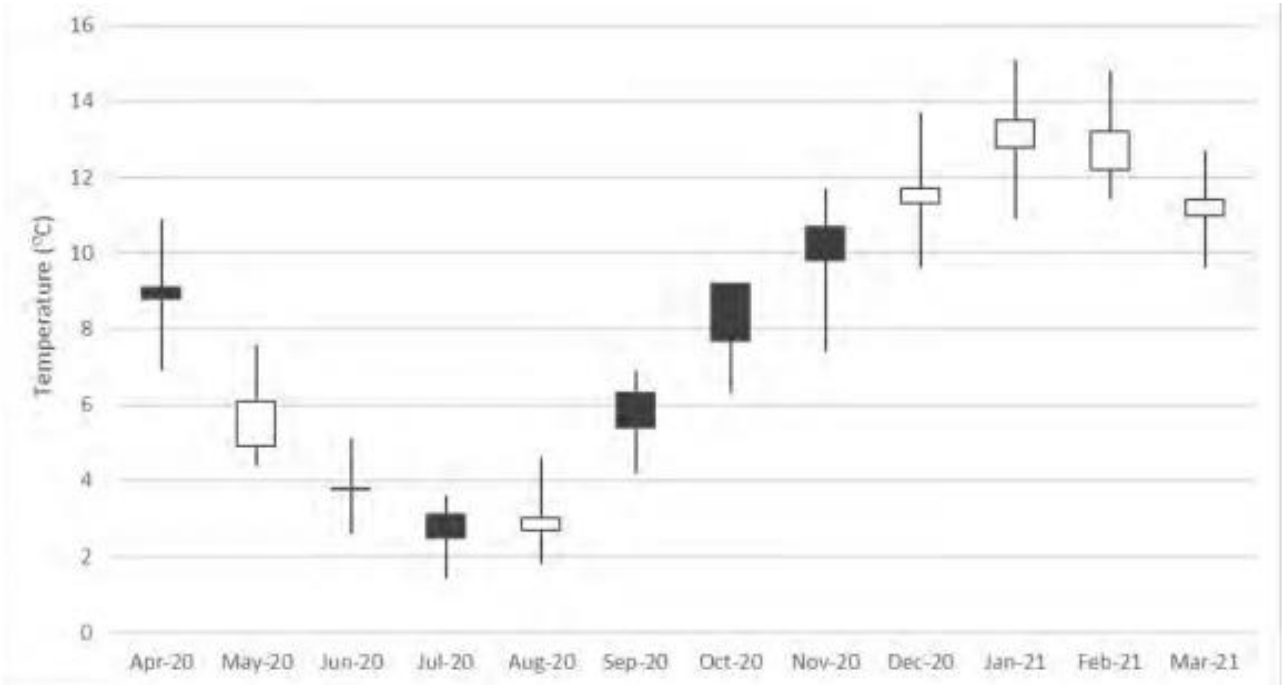
3.3.2.2 Temperature

The mean maximum monthly temperatures at Mount Boyce (station number 063292) (BOM 2021b) during the three months (January 2021to March 2021) prior to the summer 2021 sampling (i.e. April 2021) were all below the historical average (1989–2017), with all three months prior to the Autumn 2021 survey effort recording mean maximum monthly temperatures between the 5th and 95th percentiles. Six of the twelve months prior to the survey recorded mean maximum monthly temperatures greater than, or equal to, the historic average (**Graph 6**).



Graph 6 Mean monthly maximum temperatures at Mount Boyce (April 2020 – March 2021) compared with long term mean (1991–2021; BOM 2021b)

Mean minimum monthly temperature were lower than the historical average throughout the same corresponding three–month period (January 2021 to March 2021) prior to the Autumn 2021 sampling. Two months (December and January) had a mean minimum average temperature which was lower than the historical average, all three months were still located within the 5th and 95th percentile (**Graph 7**).



Graph 7 Mean monthly minimum temperatures at Mount Boyce (April 2020 – March 2021) compared with the long–term mean (1991–2021; BOM 2021b)

3.4 Mining within 600m

Mining within the Trigger Investigation Area (TIA, i.e. 600m) is a possible indicator of whether mining is related to the impact or not. At the time of the reporting trigger mining was being conducted in Longwall 427. All triggered impact Swamps have been within the 600m TIA however no groundwater change was been observed at Marrangaroo Swamp.

3.5 Evidence of possible mining impacts

Given the confounding factor of the recent bushfires and the variance in intensity it is difficult to ascertain if the impacts are primarily mining related and if they are likely to recover at a reduced rate due to their resilience being hampered from mining practices. However, additional detailed investigations are being conducted with pre–fire and post fire data to ascertain if the observed impacts are deemed to be mining related (refer to **Section 6**).

3.6 Carry out additional field surveys and/or consider more frequent or additional monitoring.

Further field surveys or increased monitoring are not considered warranted at this stage, because although the anomalous conditions are inconclusive, the ongoing monitoring program is considered sufficient for monitoring the post bushfire recovery rates in the swamps. However, as aforementioned additional detailed investigations into the existing monitoring data are being undertaken (refer to **Section 6**).

3.7 Monitor for if conditions worsen

In accordance with Chart 3, recommendations include that further monitoring is conducted and reassessed to confirm if conditions worsen or stabilise within the next 6 months.

The flora monitoring program established will continue to be undertaken to ensure ongoing condition monitoring.

4 Discussion

The Swamp Monitoring Program (SMP) for Longwalls (LW) 424 – 427, requires Centennial to monitor THPSS to ensure that potential impacts from mining are avoided, minimised or, where necessary, mitigated or offset. The SMP sets agreed trigger values for each monitoring program (Subsidence, Flora, Fauna, Groundwater and Surface water) to ensure necessary action is taken in response to changes in the monitored values, beyond the trigger values. Where a trigger event occurs, an investigation will be conducted to assess the origin of the impact (whether it is mining related) and take appropriate steps to continue to monitor and report on the issue or implement adaptive management in consultation with relevant agencies to mitigate, remediate or offset the impact.

Impacts have occurred at Marrangaroo, Nine Mile, Paddy's Creek, Pine Swamp and East Gang Gang Shrub Swamps and Pine Hanging Swamp with all six swamps triggered for non–live vegetation

cover at swamp scale (SAVI<0.12). Reference swamp Tristar exhibited a trigger level exceedance which is located a significant distance from the TIA. This trigger event in a control site highlights the fact that there are multiple potentially confounding factors that can impact the health of these swamps.

Previous groundwater triggers have been reported for East Gang Gang, Paddy's Creek, Pine and Nine Mile Swamp. A trigger was reported by Centennial at Marrangaroo but continuous logging data demonstrates an operator error during a manual dip monitoring event (EMM, 2021).

Confounding factors associated with the 'lineament theory', drought conditions and the Gospers Mountain Fire limit the ability to measure these impacts or state whether conditions have stabilised relative to reference sites.

In Summer 2019/2020 the Gospers Mountain bushfires caused immense damage to all the impact and reference swamps and all swamps triggered except one reference (Barrier). Recovery of swamp vegetation is occurring, particularly in wetter reference swamps with more consistent water supply. In impact swamps which have been undermined and dried to some degree prior to the fire, it appears that vegetation recovery is hampered, and vegetation structure has changed. Ongoing monitoring is required to measure the recovery trajectory and intervention through remediation investigations would be of benefit.

5 Conclusion

The steps that must be followed when preparing a Trigger investigation such as this report are outlined Chart 1, 2 and 3 within the Appendices. This investigation report has been in accordance with the TARP process.

The Trigger exceedance of non–live vegetation cover has been demonstrated not to be attributable to human error or data inaccuracies. A comparison of measures across both control and impact swamps has indicated that although comparable, the non–live vegetation cover increase is notably greater in the impact swamps. However, a trigger has been observed in one reference site (Tristar). The confounding factors of drought conditions lowering the groundwater and surface water levels combined with repeated fire (most recently catastrophic) make it difficult to attribute the decline in THPSS to undermining impacts alone. Rather it is likely that the undermining may have reduced the THPSS resilience or increased its susceptibility to these environmental factors.

Further field surveys or increased monitoring are not considered warranted at this stage, because the ongoing monitoring program is undertaken seasonally.

6 Recommendations

Centennial Coal has committed to conducting more detailed investigations of historical monitoring datasets to analyse swamp impacts post longwall mining through time in relation to the

Development Consent (SSD_5594). These investigations analyse surface water, groundwater, and flora data together in a series of swamp-by-swamp reports for a more targeted and holistic evaluation of impact causation and effect. The objective is to focus on ascertaining when performance indicator exceedances were first observed in groundwater or surface water monitoring programs as the primary indicators and whether they can be correlated with a flora trigger as secondary indicators.

The scope of works associated with the preparation of the swamp impact analysis reports is summarised as follows:

- Review the applicable datasets from previous monitoring investigations undertaken both pre- and post-bushfire.
- Consider the confounding factors such as bushfire, the lineament theory and climatic variation.
- Collation of desktop research data from surface water, groundwater, and flora monitoring programs into one report for comparative analysis.
- Assess performance criteria to identify if:
    - Impacts are mining related (or not)?
    - Is the impact beyond negligible?
    - Have the impacts stabilised for more than 12 months?

The impact analysis report series will provide the basis for determining the next phase of works which will aim to identify areas which can be targeted for remediation research and devise a strategy for securing the offsets for residual impacts to swamps. Swamps that are determined to be impacted by mining during extraction of LW418–432 beyond the negligible performance criteria and impacts have stabilised (i.e., not recovered) for more than 12 months will be offset accordingly.

7 References

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8 Appendix 1: Trigger Action Response Plan (TARP) Charts 1-3.

Chart 1: Trigger Action Response Plan – Overview

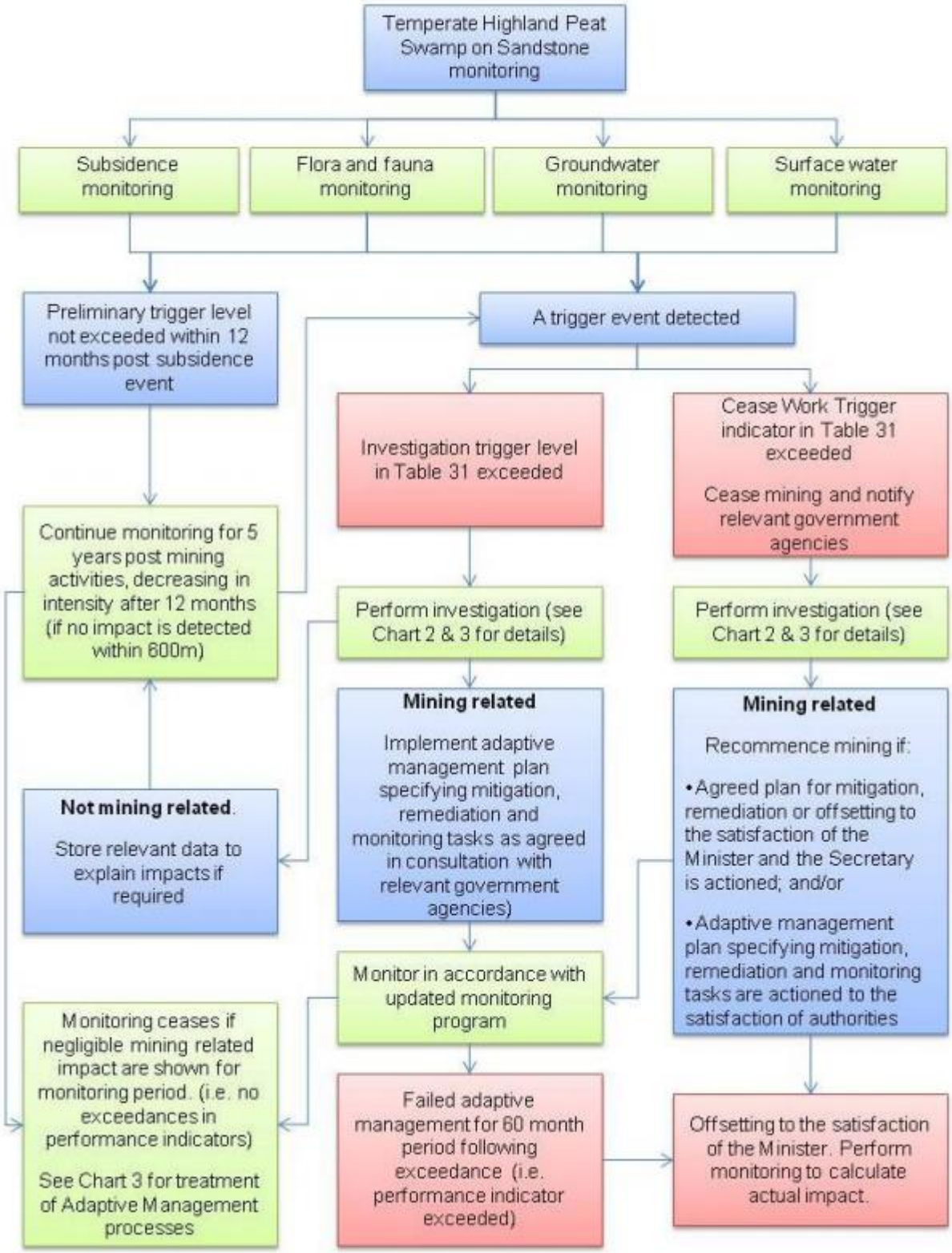


Chart 2: Trigger Action Response Plan – Management Measures

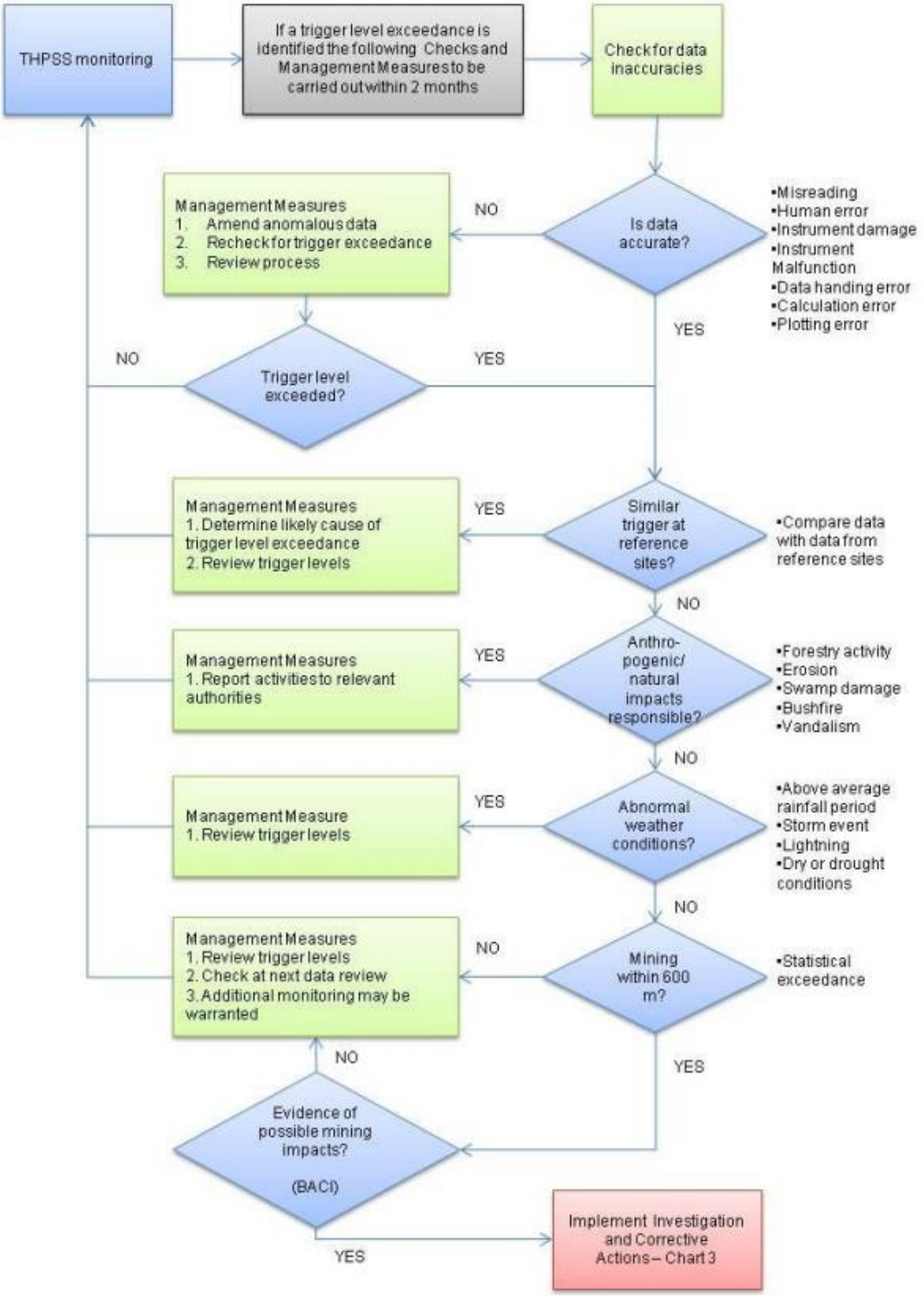
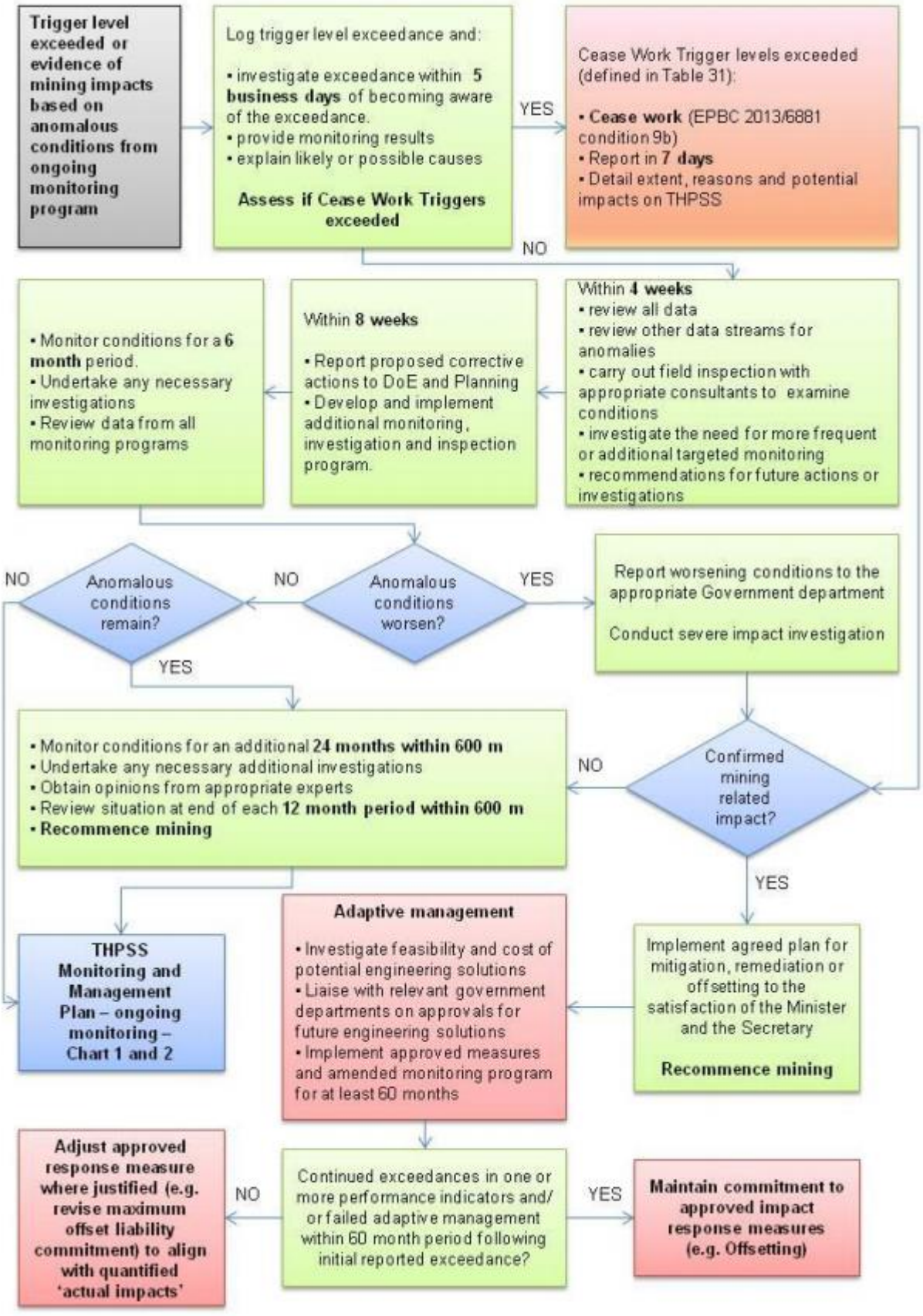


Chart 3: Trigger Action Response Plan – Corrective Actions



9 Appendix 2: Performance and Trigger Values

Table 3 Performance Measures, Performance Indicator, Preliminary Trigger (drying) and Triggers for THPSS for SMP LW 424–427

Performance measure	Performance Indicator	Preliminary trigger	Trigger
Negligible change to the shallow groundwater regime when compared with control swamps	Groundwater levels remain within 95th percentile of pre-mining groundwater depth for more than 7 consecutive days.	Evidence of a reduction in water table depth or stability, due to underground mining, from piezometers located in impact sites.	Groundwater depth in any piezometer exceeds the 95th percentile pre-mining groundwater depth for more than 7 consecutive days.
		A statistically significant[1] reduction in the abundance of native wetland species in an impacted swamp relative to the previous survey[7].	A statistically significant[1] reduction in the abundance of native wetland species in an impacted swamp when compared to control swamps.
		Increased establishment of eucalypt and/or pine seedlings (≤1m in height)[2]	30% increase in frequency of eucalypt and/or pine seedlings (≤1m in height)[2]
Negligible erosion of the surface of the swamp	Evidence of natural recruitment comprising characteristic swamp plant species within patches of nonvegetative cover. Characteristic swamp species are defined as terrestrial damp habitat (Tda) or amphibious (A) species[3]	Signs of ponding, surface deformation and/ or scouring with corresponding loss of vegetation cover.	20% increase in the extent of non-vegetated area (excluding areas covered by standing water)
		10% increase[2] in the extent of non-vegetated area (excluding areas covered by standing water) relative to the previous survey[7].	A single patch of non-vegetative cover greater than 400 m² doubles in size compared to baseline data[2]
Negligible change in the size of the swamp	Swamp boundaries remain within the variation observed throughout the baseline monitoring period The live green vegetated area within a swamp boundary remains within the variation observed throughout the baseline monitoring period for the corresponding season.	Physical contraction in swamp boundary of 5% or more in any reportable monitoring and/ or Plant health[4] of characteristic swamp species reduces in an impact swamp by >5% relative to the same season in the previous year (i.e. 5% or more increase in SANDVI[5] scores below 0.15)	Significant[1] contraction in swamp boundary when compared to baseline conditions and variance observed in control swamps and/ or Significant[1] loss in photosynthetic activity at a swamp scale compared with baseline conditions
Negligible change in the ecosystem functionality of the swamp	The population size and/ or spatial occurrence of key swamp obligate species[6] remains stable at the swamp scale	A statistically significant[1] reduction in population size and/ or spatial occurrence of a key swamp obligate species in an impacted swamp relative to the previous survey[7].	A statistically significant[1] reduction in population size and/ or spatial occurrence of a key swamp obligate species in an impacted swamp relative to control swamps.
	The population size and/ or spatial occurrence of key swamp obligate species[6] remains stable at the swamp scale	Increased establishment of eucalypt and/or pine seedlings (≤1m in height)[2]	30% increase in frequency of eucalypt and/or pine seedlings (≤1m in height)[2]
		A 10% increase in terrestrial dry habitat (Tdr) vegetation as a proportion of total vegetation cover[2] in an impacted swamp relative to the previous survey[7]	Statistically significant[1] increase in terrestrial dry habitat (Tdr) vegetation as a proportion of total vegetation cover in an impacted swamp relative to control swamps.
Negligible change to the composition or distribution of species within the swamp	The proportion of amphibious (A) vegetation remains within the variability measured during the baseline period	A 10% decrease in amphibious (A) species over as a proportion of total vegetation cover[2] in an impact swamp relative to the previous survey[7]	Statistically significant[1] decrease in amphibious (A) species cover as a proportion of total vegetation

Performance measure	Performance Indicator	Preliminary trigger	Trigger
			cover in an impacted swamp relative to control swamps.
	The proportion of terrestrial damp habitat (Tda) vegetation remains within the variability measured during the baseline period	A 10% change in terrestrial damp habitat (Tda) species cover as a proportion of total vegetation cover[2] in an impact swamp relative to the previous survey[7]	Statistically significant[1] change (increase or decrease) in Tda vegetation as a proportion of total vegetation in an impacted swamp relative to control swamps.
	The proportion of terrestrial dry habitat (Tdr) vegetation remains within the variability measured during the baseline period	A 10% increase in terrestrial dry habitat (Tdr) vegetation as a proportion of total vegetation cover[2] in an impacted swamp relative to the previous survey[7]	Statistically significant[1] increase in terrestrial dry habitat (Tdr) vegetation as a proportion of total vegetation in an impacted swamp relative to control swamps.
	No increase in exotic vegetation cover	10% increase[2] in the extent of exotic vegetation cover relative to the previous survey[7]	statistically significant[1] increase exotic vegetation as a proportion of total vegetation cover for an impact swamp compared to control swamp
	No increased establishment of eucalypt and/or pine seedlings (≤1m in height)	10% increase in the establishment of eucalypt and/or pine seedlings (≤1m in height)[2] relative to the previous survey[7]	30% increase in frequency of eucalypt and/or pine seedlings (≤1m in height)[2]
Negligible change to the structural integrity of the bedrock base or any controlling rockbar/s of the swamp	Measured subsidence does not exceed predictions. No visual cracking or peat slumping that was not present prior to mining.	Measured subsidence exceeds predictions. Visual cracking or peat slumping notable (not present prior to mining)	Measured subsidence in excess of predictions (>125% of predicted levels) Visual cracking >50mm in width and 10m in length (not present prior to mining) Peat slumping >0.5m depth and >20m² relative to adjacent swamp surface (not present prior to mining)

[1] Statistically significant is taken to mean a p value <0.05

[2] Taken from Brownstein et al (2014) and are referred to as 'preliminary'. Subject to change

[3] See Brownstein et al (2014) for list of amphibious (A), terrestrial dry habitat (Tdr) and terrestrial damp habitat (Tda)

[4] Photosynthetic activity as measured by remote sensing using the Soil Adjusted Normalised Difference Vegetation Index (SANDVI)

[5] SANDVI = Soil Adjusted Normalised Difference Vegetation Index

[6] Key swamp obligate species include Blue Mountains Water Skink, Giant Dragonfly, Boronia deanei, amphibious vegetation (see Brownstein et al 2014)

[7] For the purpose of this report, "previous survey" is taken to mean baseline or before dataset (i.e. data collected in winter 2017 to autumn 2019)

10 Appendix 3: Groundwater Monitoring triggers

Table 4 LW424–427 Groundwater Monitoring Summary

Bore ID	Swamp	Monitoring	Impact / Reference Site	600m Longwall Proximity	Monitoring Frequency
Swamp Water Level and Soil Moisture Monitoring					
GG1	Gang Gang East	Swamp Water Level	Impact	427 / Lineament	Weekly / Monthly
GG2 SM	Gang Gang East	Soil Moisture Monitoring	Impact	427 / Lineament	Monthly
GG2	Gang Gang East	Swamp Water Level	Impact	427 / Lineament	Weekly / Monthly
GG2 SM	Gang Gang East	Soil Moisture Monitoring	Impact	427 / Lineament	Monthly
GG3	Gang Gang East	Swamp Water Level	Impact	427 / Lineament	Weekly / Monthly
GG3 SM	Gang Gang East	Soil Moisture Monitoring	Impact	427 / Lineament	Monthly
BS1	Pine	Swamp Water Level	Impact	422	Weekly / Monthly
BS1 SM proposed	Pine	Soil Moisture Monitoring	Impact	422	Monthly
BS2	Pine	Swamp Water Level	Impact	424	Weekly / Monthly
BS2 SM Proposed	Pine	Soil Moisture Monitoring	Impact	424	Monthly
BS3	Pine/ Nine Mile	Swamp Water Level	Impact	424 / Lineament	Weekly / Monthly
BS3 SM proposed	Pine/ Nine Mile	Soil Moisture Monitoring	Impact	424 / Lineament	Monthly
BS4 (PSS) Proposed	Pine	Swamp Water Level	Impact	424	Weekly / Monthly
BS4 (PSS) SM Proposed	Pine	Soil Moisture Monitoring	Impact	424	Monthly

Bore ID	Swamp	Monitoring	Impact / Reference Site	600m Longwall Proximity	Monitoring Frequency
BS5 (NMSS) Proposed	Nine Mile	Swamp Water Level	Impact	422	Weekly / Monthly
BS5 (NMSS) SM Proposed	Nine Mile	Soil Moisture Monitoring	Impact	422	Monthly
PC1	Paddy's Creek	Swamp Water Level	Impact	424 - 426	Weekly / Monthly
PC1 SM Proposed	Paddy's Creek	Soil Moisture Monitoring	Impact	424 - 426	Monthly
PC2	Paddy's Creek	Swamp Water Level	Impact	424 - 426	Weekly / Monthly
PC2 SM Proposed	Paddy's Creek	Soil Moisture Monitoring	Impact	424 - 426	Monthly
MS1	Marrangaroo	Swamp Water Level	Impact	427 / Lineament	Weekly / Monthly
MS1 SM proposed	Marrangaroo	Soil Moisture Monitoring	Impact	427 / Lineament	Monthly
MS2	Marrangaroo	Swamp Water Level	Impact	427 / Lineament	Weekly / Monthly
MS2 SM proposed	Marrangaroo	Soil Moisture Monitoring	Impact	427 / Lineament	Monthly
CC1	Carne Central	Swamp Water Level	Reference	N/A	Monthly
CC1 SM proposed	Carne Central	Soil Moisture Monitoring	Reference	N/A	Monthly
CC2	Carne Central	Swamp Water Level	Reference	N/A	Monthly
CC2 SM proposed	Carne Central	Soil Moisture Monitoring	Reference	N/A	Monthly
BA1	Barrier	Swamp Water Level	Reference	N/A	Monthly
BA1 SM Proposed	Barrier	Soil Moisture Monitoring	Reference	N/A	Monthly
BA2	Barrier	Swamp Water Level	Reference	N/A	Monthly
BA3 SM Proposed	Barrier	Soil Moisture Monitoring	Reference	N/A	Monthly
BA3	Barrier	Swamp Water Level	Reference	N/A	Monthly
BA3 SM Proposed	Barrier	Soil Moisture Monitoring	Reference	N/A	Monthly
TG1	Twin Gully Swamp	Swamp Groundwater Level	Reference	N/A	Monthly

Bore ID	Swamp	Monitoring	Impact / Reference Site	600m Longwall Proximity	Monitoring Frequency
TG1 SM proposed	Twin Gully Swamp	Soil Moisture Monitoring	Reference	N/A	Monthly
TG2	Twin Gully Swamp	Swamp Groundwater Level	Reference	N/A	Monthly
TG2 SM proposed	Twin Gully Swamp	Soil Moisture Monitoring	Reference	N/A	Monthly
TS1	Tristar Swamp	Swamp Water Level	Reference	N/A	Monthly
TS2	Tristar Swamp	Swamp Water Level	Reference	N/A	Monthly
TS2 SM proposed	Tristar Swamp	Soil Moisture Monitoring	Reference	N/A	Monthly
TS3	Tristar Swamp	Swamp Water Level	Reference	N/A	Monthly
TS3 SM proposed	Tristar Swamp	Soil Moisture Monitoring	Reference	N/A	Monthly
FS1	Firetail Swamp	Swamp Water Level	Reference	N/A	Monthly
FS1 SM proposed	Firetail Swamp	Soil Moisture Monitoring	Reference	N/A	Monthly
FS2	Firetail Swamp	Swamp Water Level	Reference	N/A	Monthly
FS2 SM proposed	Firetail Swamp	Soil Moisture Monitoring	Reference	N/A	Monthly
BE1	Best Swamp	Swamp Water Level	Reference	N/A	Monthly
BE1 SM proposed	Best Swamp	Soil Moisture Monitoring	Reference	N/A	Monthly
BE2	Best Swamp	Swamp Water Level	Reference	N/A	Monthly
BE2 SM Proposed	Best Swamp	Soil Moisture Monitoring	Reference	N/A	Monthly
Shallow Groundwater Monitoring Adjacent to Swamps					
SPR1603	Gang Gang East	Shallow Perched Groundwater Monitoring	Impact	427 / Lineament	Monthly
SPR1604	Carne Central	Shallow Perched Groundwater Monitoring	Reference	N/A	Monthly
SPR1605	Nine Mile / Pine	Shallow Perched Groundwater Monitoring	Impact	424 / Lineament	Monthly
SPR1606	Paddy's Creek	Shallow Perched Groundwater Monitoring	Impact	424 - 420	Monthly
SPR1607	Marrangaroo	Shallow Perched Groundwater Monitoring	Impact	427	Monthly
SPR1608	Barrier	Shallow Perched Groundwater Monitoring	Reference	N/A	Monthly