Mount Buller Water Storage Project

Hydrological and Ecological Monitoring and Adaptive Management Program

Impact Year 3 Monitoring

FINAL REPORT

Prepared for Mount Buller and Mount Stirling Alpine Resort Management Board

31 August 2022

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- Michael Goddard, Georgie Zacks, Sarah Hilliar and Jane Kenny (fieldwork, data analysis and/or reporting)
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Background

From October 2019 to May 2020, the Mount Buller and Mount Stirling Alpine Resort Management Board (the RMB) constructed a 100-megalitre off-stream water storage and ancillary infrastructure (the project) on Mount Buller, within a 10.347-hectare Project Construction Footprint (PCF) between the summit and the Mount Buller Village. As part of the project, the RMB is implementing an ongoing Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP), with an objective of maintaining the extent and condition of Alpine Bogs that are downslope of the water storage.

Two years of baseline ecological monitoring data (Baseline Years 1 and 2 or BY1 and BY2) were collected as part of the HEMAMP in 2018 and 2019. This was followed by ecological monitoring during construction in 2020 (Impact Year 1 or IY1) and post-construction ecological monitoring in 2021 and 2022 (Impact Years 2 and 3 or IY2 and IY3). This report summarises the results of ecological monitoring from Impact Year 3, compares the results with baseline data and provides an assessment of these results against the HEMAMP's performance criteria and ecological triggers for adaptive management.

The HEMAMP's performance criteria are as follows:

- The 'extent' criterion – there will be no more than a 10% reduction in the total combined area of the impact sites, determined by on-ground or remote (aerial) monitoring and taking into account natural variation based on extent observations averaged across control sites.
- The 'composition' criterion – there will be no more than a 10% reduction in the total 'bog-dependent' native flora species richness of the impact sites, taking into account natural variation based on species richness observations averaged across control sites.
- The 'encroachment' criteria:
  - Atypical species – there will be no more than a 10% increase in the cover of 'non-bog-dependent' species within the impact sites, taking into account natural variation based on observations averaged across control sites.
  - Weeds – the total cover of weeds (naturalised exotic flora species) within the impact sites will not exceed 5%.
- The 'structure' criterion – there will be no more than a 10% reduction in the average cover of Peat Moss *Sphagnum* spp. within the impact sites, taking into account natural variation based on Peat Moss cover averaged across control sites.

The HEMAMP's ecological triggers for adaptive management are directly related to the above performance criteria.

Results

Criterion	Parameter	Threshold	Result*	Compliant?	Action Req'd?	Comments
Extent	Area of Alpine Bogs	-10.0%	-6.9%	Yes	Yes	True relative reduction is likely to be closer to -2.0% because various factors, including the RMB's exceptional deer control works in IY2 and IY3, have disproportionately benefitted control sites. Continued sediment/ weed control and revegetation needed.
Composition	Bog-dependent species richness	-10.0%	-9.5%	Yes	Yes	One of the 11 baseline bog-dependent species (Silver Astelia) not detected at impact sites in IY3. Re-introduce Silver Astelia during autumn 2024 revegetation.
Encroachment by atypical species	Cover of non-bog-dependent native flora	+10.0%	+8.0%	Yes	Yes	No intervention until potential hydrological changes are better understood. The same hydrological changes may be leading to an increase in the area of impact sites.
Encroachment by weeds	Cover of weeds at impact sites	5%	8.8%	No	Yes	Weed cover was already non-compliant (5.4% and 6.3%) in baseline monitoring years. Intensive weed control was undertaken during and after IY3 monitoring. Improvements may take several years to materialise. Similar effort needed in future years.
Structure	Cover of Peat Moss	-10.0%	+5.1%	Yes	No	

*Note: The result for cover of weeds is expressed as an absolute percentage cover. All other results are expressed as a relative change from the Baseline Mean (BM) to Impact Year 2 (IY2).

Conclusion and recommendations

The following observations and conclusions were made from Impact Year 3 ecological monitoring:

- There was an exceptional effort from the RMB to undertake management actions that were recommended in previous monitoring reports and/or required by the new Ecological Rehabilitation Plan Addendum and associated management plans. Management actions included:
  - Installation and maintenance of more than 500 metres of sediment socks and 20 metres of sediment fence.
  - 1500 hours of weed control at Mount Buller, 850 hours of weed control at Mount Stirling and removal of over 2.5 tonnes of weed material.
  - Culling of 74 Sambar Deer from the Mount Buller and Mount Stirling resorts.
  - Planting of 725 tubestock in the Alpine Bogs.
- The effort involved to implement the above management actions should be commended. However, some management actions, such as deer control, are likely to have disproportionately benefitted control sites, rather than impact sites. This must be considered when interpreting monitoring results, particularly in relation to bog extent.
- Benefits of the above management actions are already apparent at impact sites. Bare ground attributed to sedimentation has declined from 3.4% in IY2 to 1.1% in IY3, indicating that the RMB has successfully controlled the entry of new sediment into the Alpine Bogs. Weed cover has declined at all impact sites, except for Bogs 6 and 12 (mid-slope impact sites), that impacts (e.g. existing sedimentation) are progressively moving downstream and upstream sites are recovering.
- While some benefits are already apparent at impact sites, it is too soon for the full range of expected benefits to be reflected in monitoring results at impact sites. In some cases, the management actions took place during or after IY3 monitoring. Improvements are expected to materialise in future monitoring years.

Recommendations of this monitoring report are as follows:

1. The deer control effort from IY2 and IY3 should continue in IY4 to ensure that deer activity remains low and to provide Alpine Bog vegetation with an opportunity to recover. The RMB's deer control works in IY2 and IY3 were exceptional, resulting in 126 deer being removed and much reduced deer activity in Alpine Bogs in IY3. However, some deer activity was still recorded in IY3 and Sambar Deer are likely to continue to move into the resorts from surrounding public and private land, replacing deer that have been culled.
2. For some ecological parameters, such as bog extent, it may be more appropriate for Mount Buller control sites to be used as the reference against which changes at Mount Buller impact sites are assessed, rather than control sites at both Mount Buller and Mount Stirling, because the RMB's recent deer control works are likely to have disproportionately benefitted Mount Stirling control sites.
3. The RMB must continue to closely monitor the effects of inadvertent artificial watering on eastern control sites at Mount Buller (Bogs 1, 2 and 11.1), especially as regular artificial watering ceased in November 2021.
4. Management actions, such as weed control and revegetation, must continue to focus on Bog 6 as a priority. Bog 6 is the only impact site that continued to decline in area in IY3.
5. In IY3, the RMB was successful in preventing further movement of sediment into impact sites. The RMB must continue to implement the Ecological Rehabilitation Plan (Biosis 2020a) and its Addendum (Biosis 2022a) to continue to prevent further movement of sediment from the PCF into Alpine Bogs.

6. The RMB must investigate the potential role that the environmental watering system is playing in the waterlogged soils that have been associated with dieback of native vegetation (non-bog-dependent flora) surrounding the Alpine Bogs. The investigation should focus on determining whether there is inadvertent discharge of water into the environmental watering system (e.g. via a leak that is bypassing the water meter) and/or whether the environmental watering system is intercepting groundwater flows (i.e. groundwater that would otherwise be delivered elsewhere). The investigation may require a detailed inspection of the environmental watering system. A detailed inspection would also allow for performance of the watering system to be checked and for maintenance to be carried out, so that the system can be called upon in the future (if required).
7. Locations of mortality of vegetation surrounding Alpine Bogs must continue to be re-visited in future years to investigate possible causes, to track vegetation recovery or succession and to plan any necessary management interventions.
8. The RMB must organise for the propagation of Silver Astelia from material of Mount Buller provenance. The resultant tubestock should be planted in Bogs 4.2 and/or 6 during the revegetation works that are planned for autumn 2024 (tubestock of this species will not be available earlier). Precise planting locations should be determined with reference to the location of any remaining Silver Astelia individuals in the vicinity.
9. The different weed control techniques used in Bog 6 in IY3 should be reviewed in IY4 to ascertain which techniques are most effective and efficient at reducing weed covers over large scales in Alpine Bogs.
10. The concerted weed control effort that occurred in IY3 must continue in IY4, with similar effort and intensity and following the weed control hierarchy outlined in the ERP Addendum (Biosis 2022a).

1. Introduction

1.1 Project background

Alpine Bogs are groundwater dependent ecosystems with a scattered distribution in alpine, sub-alpine and montane environments across the Australian Alps (DEWHA 2009; FFG Act Scientific Advisory Committee 2013). They are generally characterised by the presence of Peat Moss *Sphagnum* spp. and are particularly susceptible to climate change, given that they have a fragmented distribution and are already at their environmental tolerance limit (DEWHA 2009; Macdonald 2009). Approximately 3 hectares of Alpine Bog are known to exist at Mount Buller.

Alpine Bogs are listed as threatened ecological communities under Commonwealth and State legislation. The Alpine Sphagnum Bogs and Associated Fens (ASBAF) ecological community is listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Alpine Bog Community is listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act). Throughout this document, the term 'Alpine Bogs' refers to both ASBAF and the Alpine Bog Community.

In October 2019, the Mount Buller and Mount Stirling Alpine Resort Management Board (the RMB) started construction of a 100-megalitre off-stream water storage and ancillary infrastructure (the project) on Mount Buller between the summit and the Mt Buller Village. Construction of the project finished in May 2020, although there is ongoing rehabilitation of the Project Construction Footprint (PCF) and areas of unauthorised disturbance outside the PCF. The RMB continues to implement agreed compliance tasks to manage the impacts of the unauthorised disturbance outside the PCF, in consultation with and under supervision of the Victorian Government Department of Environment, Land, Water and Planning (DELWP) and the Australian Government Department of Climate Change, Environment, Energy and Water (DCCEEW).

Most of the known Alpine Bog community at Mount Buller is located downslope of the PCF and the project has the potential to affect the hydrology of these Alpine Bogs (Biosis and GHD 2016). In accordance with approvals for the project (EPBC Act Approval 2014/7303 and Planning Permit PA1600138), the RMB is implementing a Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP), with the objective of maintaining the extent and condition of Alpine Bogs that are downslope of the proposed water storage (Biosis 2019). Those Alpine Bogs with catchment areas affected by the water storage are known as impact sites and are monitored annually as part of the HEMAMP. The annual monitoring also includes control sites, which are Alpine Bogs with catchment areas that are unaffected by the water storage.

The HEMAMP aims to meet the following performance criteria:

- The 'extent' criterion – there will be no more than a 10% reduction in the total combined area of the impact sites, determined by on-ground or remote (aerial) monitoring and taking into account natural variation based on extent observations averaged across control sites.
- The 'composition' criterion – there will be no more than a 10% reduction in the total 'bog-dependent' native flora species richness of the impact sites, taking into account natural variation based on species richness observations averaged across control sites.
- The 'encroachment' criteria:
  - Atypical species – there will be no more than a 10% increase in the cover of 'non-bog-dependent' species within the impact sites, taking into account natural variation based on observations averaged across control sites.

    - Weeds – the total cover of weeds (naturalised exotic flora species) within the impact sites will not exceed 5%.

- The 'structure' criterion – there will be no more than a 10% reduction in the average cover of Peat Moss within the impact sites, taking into account natural variation based on Peat Moss cover averaged across control sites.

1.2 Scope of this report

The HEMAMP is a monitoring and management regime for selected Alpine Bogs on Mount Buller and Mount Stirling (Figure 1). The methods for this monitoring and management regime are outlined in the HEMAMP Protocol (Biosis 2022b). The Protocol is regularly updated and improved in consultation with DELWP and DCCEEW.

Between 2014 and 2018, the RMB, assisted by Biosis Pty Ltd (Biosis) and GHD Pty Ltd (GHD), established climatological and hydrological monitoring infrastructure and commenced collecting climate, groundwater and surface water observations as part of the HEMAMP. In January and February 2018, the RMB commissioned Biosis to establish the HEMAMP's ecological monitoring components and collect the first year of baseline ecological monitoring data. In total, two years of baseline (pre-construction) monitoring were undertaken (Baseline Years 1 and 2 or BY1 and BY2), one year of monitoring was completed during construction (Impact Year 1 or IY1) and two years of post-construction monitoring have been completed (Impact Years 2 and 3 or IY2 and IY3).

This monitoring report:

- Provides a summary of the ecological monitoring data collected in IY3.
- Compares ecological data collected in IY3 with the baseline data collected over BY1 and BY2.
- Provides an assessment of these results against the HEMAMP's performance criteria and so ecological triggers for adaptive management.
- Recommends appropriate management actions.

Throughout this report, recommendations are highlighted in text boxes as shown below.

Recommendations
All recommendations arising from IY3 monitoring are highlighted in this fashion throughout this monitoring report.

2. Methods

Monitoring methods followed the HEMAMP Protocol (Biosis 2022b), except where explicitly noted. Mount Buller and Mount Stirling monitoring sites are shown on Figure 2 and Figure 3 respectively.

2.1 Monitoring effort, frequency and timing

HEMAMP monitoring years run from the start of June (winter) to the end of May (autumn) each year. The ecological monitoring components of the HEMAMP were established in January and February 2018 (BY1). Since 2018, Biosis has conducted ecological monitoring, with assistance from the RMB, at six impact sites and seven control sites (Table 1). Each year, transect monitoring has been undertaken from late January until mid-February, while mapping has been undertaken from late January until mid-March (Table 2). The timing and completeness of the ecological datasets are further outlines in Appendix 1.

Slight differences in timing of ecological monitoring (particularly the monitoring end date) are generally associated with weather conditions and the need to maintain consistency in the quality of the data (e.g. mapping under clear skies to maximise spatial accuracy). Slight differences in the timing of ecological monitoring from year to year are unlikely to affect an assessment against the performance criteria or ecological triggers for adaptive management.

Table 1 Annual ecological monitoring effort as part of the HEMAMP

Monitoring effort	Impact sites	Control sites (Mt Buller:Mt Stirling)	Total
Number of sites* (Alpine Bogs)	6	7 (4 : 3)	13
Number of transects	24	23 (14 : 9)	47
Average length of transect (m)	18.5	21.6 (22.3 : 20.4)	20
Number of point intersections (20-cm intervals)	2196	2457 (1546 : 911)	4653
Number of quadrats	87	101 (64 : 37)	188
Number of photo points	48	46 (28 : 18)	94

*Note: The data presented in this table relate to the sites at which line and belt transects have been established. Additional sites are mapped but not subject to monitoring with line and belt transects.

Table 2 **Timing of ecological monitoring**

Monitoring year	Transect monitoring period	Mapping period
Baseline Year 1	26 Jan 2018 to 9 Feb 2018	26 Jan 2018 to 9 Feb 2018
Baseline Year 2	29 Jan 2019 to 14 Feb 2019	29 Jan 2019 to 23 Feb 2019
Impact Year 1	28 Jan 2020 to 20 Feb 2020	30 Jan 2020 to 14 Mar 2020
Impact Year 2	25 Jan 2021 to 4 Feb 2021	2 Feb 2021 to 26 Feb 2021
Impact Year 3	31 Jan 2022 to 9 Feb 2022	2 Feb 2022 to 22 Feb 2022

2.2 Monitoring parameters and data collection

The HEMAMP Protocol (Biosis 2022b) requires that the following ecological parameters are monitored annually:

- Bog extent
- Bog composition
- Encroachment by weeds and other atypical species
- Bog structure.

These parameters allow for the current extent and condition of the Alpine Bogs to be directly assessed against the performance criteria and triggers for adaptive management. Data relating to these ecological parameters are collected using established line transects, belt transects, photo points and on-ground mapping techniques. These data collection methods are outlined in detail in the Standard Operating Procedure (SOP) for ecological monitoring, which are appended to the HEMAMP Protocol (Biosis 2022b).

2.2.1 Bog extent

Bog extent refers to the area of the Alpine Bogs, which is calculated by mapping the boundary of each Alpine Bog on foot using a Differential Global Positioning System (DGPS). Until IY3, boundaries were mapped using a Samsung Galaxy Tab A6, which was paired with a Trimble R1 Global Navigation Satellite System (GNSS) receiver to provide DGPS functionality. In IY3, boundaries were mapped using newer DGPS technology, consisting of a Samsung Galaxy Tab S6 Lite paired with an Emlid Reach RS2 GNSS receiver.

Ongoing improvements to DGPS technology have allowed for more accurate mapping over the past 5 years. In BY1 and BY2, mapping was to an accuracy of 3 metres or better in most instances, but accuracy was reduced to up to 5 metres in some areas with an overhanging tree canopy, particularly at Mount Stirling. In IY1 and IY2, improvements to DGPS technology (e.g. satellite availability and satellite-delivered correction services) allowed for sub-2-metre accuracy in most instances (especially at Mount Buller sites) and generally no worse than 3-metre accuracy (e.g. at Mount Stirling sites with overhanging tree canopies). In IY3, use of the Emlid Reach RS2 GNSS receiver allowed for access to a greater number of satellites and sub-metre accuracy at all locations. DGPS accuracy was generally at 1 centimetre, but up to 15 centimetres below tree canopies at Mount Buller and up to 70 centimetres below tree canopies at Mount Stirling.

In addition to mapping the boundaries of Alpine Bogs, further analysis of bog extent is undertaken using data collected from the permanent monitoring transects. The dimensions of the Alpine Bogs are estimated by determining the start and end of Alpine Bog vegetation along the transects. The edge of the Alpine Bog vegetation is taken to be the point at which bog-dependent flora species richness is equal to non-bog-dependent flora species richness (similar to the on-ground boundary mapping, which records the boundary of the Alpine Bog at the point where bog-dependent flora transition from at least 50% of vegetative cover to less than 50% of vegetative cover). In addition, the transects allow for the cover and cause of bare ground to be analysed, which informs management actions (e.g. revegetation or pest animal control) that may be required to maintain bog extent.

2.2.2 Bog composition

Bog composition refers to the species richness of bog-dependent flora, which is determined using line transects (point intersection sampling) and belt transects (quadrat sampling) in accordance with the SOP for ecological monitoring (Biosis 2022b). The list of bog-dependent species is provided in Appendix 2 of this report and in the HEMAMP Protocol (Biosis 2022b).

The IY2 monitoring report documented the difficulty in distinguishing between Mountain Baeckea *Baeckea utilis s.s.* and Subalpine Baeckea *Baeckea latifolia*, which are two bog-dependent species that co-occur at Mount Buller and Mount Stirling and that are suspected of hybridising or forming intermediates (Biosis 2021). It is assumed that where one of these species has been recorded, both species and their intermediates are likely to exist. For this reason, while efforts were still made in the field to distinguish the two species, their records have been amalgamated for the purposes of assessing bog composition, in accordance with the HEMAMP Protocol (Biosis 2022b).

In addition to bog-dependent species richness, line transects also provide an estimate of the cover of bog-dependent flora. This analysis provides an indication of underlying trends in bog composition and allows for pre-emptive management actions to be taken, if needed.

2.2.3 Encroachment by weeds and other atypical species

Encroachment is assessed by estimating the cover of weeds and other atypical species, using line transects (point intersection sampling) in accordance with the SOP for ecological monitoring (Biosis 2022b).

It is important to note that weed cover is assessed as an absolute cover. This is unlike all other ecological monitoring parameters, which are assessed at impact sites relative to control sites. As noted in previous monitoring reports (e.g. Biosis 2019), weed cover is estimated across the entire length of the monitoring transects, not only within the Alpine Bogs themselves. The permanent monitoring transects were set up to pass through the Alpine Bogs, starting and ending 1.5-4 metres outside of the Alpine Bog boundary (when first established in BY1). This means that some weed cover may be attributable to areas immediately outside the Alpine Bogs.

In an effort to scale up weed management, the RMB and Biosis conducted some weed control concurrently with monitoring in IY3. Where we encountered isolated occurrences of a weed species, these isolated plants were removed by hand and placed in plastic bags for solarisation and disposal, immediately after recording any required monitoring data (e.g. point intersection or quadrat results). Where relevant, these plants will have contributed to weed cover results in IY3 but will not contribute to results in future years, assuming the immediate weed control actions have been effective. As always, a concerted effort was made to identify and map any novel weed species in the Alpine Bogs, whether encountered during mapping or transect monitoring.

2.2.4 Bog structure

Bog structure refers to the total cover of Peat Moss, whether dead or alive. The proportion of Peat Moss recorded as dead is also analysed to provide an indication of underlying trends in bog structure and pre-empt management actions that may be required (e.g. to avert the future loss of Peat Moss). The cover of Peat Moss, both alive and dead, is estimated using line transects (point intersection sampling) in accordance with the SOP for ecological monitoring (Biosis 2022b).

2.2.5 Other data collection considerations

In accordance with the SOP for ecological monitoring (Biosis 2022b), standardised photos were taken from the permanent photo points at the start and end of transects. These photos provide a visual documentation of gross vegetation changes, when compared with the same photos from previous monitoring years.

In addition, on-ground mapping provided an opportunity to inspect the full extent of the Alpine Bogs and to note any management issues that may not have been detected by transect monitoring (e.g. sedimentation, weed invasion or deer activity). Mapping data and notes from previous years were made available in the field for comparison, so that the cause of any changes could be investigated on the ground and past observations revisited.

2.3 Data management

The following ecological datasets are being maintained for monitoring consistency and repeatability in future years:

- Herbarium of plant samples.
- An electronic data collection spreadsheet for transect monitoring.
- A spreadsheet of all observations from all transect monitoring conducted to date.
- Spatial dataset of Alpine Bog boundaries from each year, photo point locations and transect locations.
- Database of all photo points taken to date.
- A collection of on-ground observations (e.g. potential management issues) made while walking the Alpine Bog boundaries.

As required by the HEMAMP Protocol (Biosis 2022b), the electronic datasets are stored on the RMB's servers and on a third-party cloud-based backup.

2.4 Data analysis

The ecological monitoring program follows a 'Beyond BACI' (Before-After-Control-Impact) design and data analysis has been set up accordingly (Underwood 1992 and 1994). Linear Mixed-effects Models (LMMs) and Analysis of Variance (ANOVA) were used to test the statistical significance of the effect of the period (before/after) and treatment (control/impact) on a given response variable (e.g. area of Alpine Bogs or cover of weeds).

LMMs were fitted using the 'lme4' package in the R statistical and graphical environment (R Development Core Team 2022) using the Restricted Maximum Likelihood (REML) method. The models were in the following form:

*Response ~ Period * Site Class + (1|Year) + (1|Sample)*

The various components of the models are explained as follows:

- Response:
  - The response variable is the ecological monitoring parameter of interest, such as the area of Alpine Bogs or cover of weeds, non-bog-dependent flora, bog-dependent flora or Peat Moss.

  - We are interested in detecting whether or not there has been a statistically significant change in the response variable at impact sites relative to control sites in the period after the impact commenced.

- Period and Site Class:
  - Period refers to the time before (i.e. BY1 and BY2) or after (i.e. IY1 and IY2) the potential impact commenced (i.e. before or after construction of the water storage started).
  - Site Class refers to the 'treatment' that the Alpine Bogs have received. The Alpine Bogs belong to one of two Site Classes – control sites or impact sites.
  - Period and Site Class are the fixed effects in the model. They are the BACI effect that we are monitoring.
  - Where relevant, a third fixed effect is added to the model to investigate differences between responses at Mount Buller and Mount Stirling. This fixed effect is known as Site, as opposed to Site Class.
- 1|Year and 1|Sample:
  - The model also includes Year (BY1, BY2, IY1 etc.) and Sample (Bog 1, Bog 2, Bog 4.1/5/7 etc.) as random effects (i.e. random temporal and spatial variables).
  - The Sample-to-Sample variation represents localised spatial variability within each Site Class (e.g. the variation between Bog 1 and Bog 2 represents some of the random effect within Control sites).
  - The Year-to-Year variation represents temporal variability that applies to all Samples, regardless of Site Class (i.e. the random temporal effect that applies equally to Control and Impact sites, causing the same fluctuations at both Site Classes from year-to-year).

We are interested in determining whether or not there is a statistically significant interaction between Period and Site Class (sometimes called a BA*CI interaction or BACI contrast). If the coefficient for the BA*CI interaction (i.e. the estimate of the BACI contrast) is statistically significant, it suggests that there is a significant difference in the response of control and impact sites to the impact. In other words, there is a statistically significant difference between the control and impact sites after the impact, compared with the control and impact sites before the impact.

The statistical significance of the BA*CI interaction (BACI contrast) was determined by two-way ANOVA using Type III Sums of Squares and the Kenward-Roger approximation for Degrees of Freedom (DF). Estimated Marginal Means (EMMs) provided an estimate of the BACI contrast and an indication of the variability or Standard Error (SE) in the dataset.

Examining SE is important and requires an ecological understanding of the dataset. If ANOVA suggests that the BA*CI interaction is not statistically significant, this may be because construction of the water storage has genuinely had no detectable effect on impact sites or it may be because the datasets are too variable (SE is too high) for an effect to be detectable.

Statistical tests were undertaken in the R statistical and graphical environment (R Development Core Team 2022) with a 5% statistical significance threshold ($\alpha = 0.05$). LMMs were fitted and ANOVA conducted using the 'lmerTest' package, while EMMs were computed and analysed using the 'emmeans' package.

3. Results

3.1 Bog extent

3.1.1 Area of Alpine Bogs

The area of each Alpine Bog was mapped using DGPS. The results of this mapping are summarised in Chart 1 and depicted in Figure 4 (raw results for each Alpine Bog are available in Appendix 5). The total combined area of all Alpine Bogs at impact sites was 1.3423 hectares in IY3, which is less than the baseline mean of 1.3666 hectares (a decrease of 0.0243 hectares or 1.8%). The total combined area of all Alpine Bogs at control sites was 2.1875 hectares in IY3, which is greater than the baseline mean of 2.0812 hectares (an increase of 0.1063 hectares or 5.1%). The relative change in the area of impact sites in IY3 was therefore a decrease of 6.9%, although this change was not statistically significant (BACI contrast = 0.0127; SE = 0.0087; F-statistic = 2.1184; numerator DF = 1; denominator DF = 47.1; P = 0.1522).

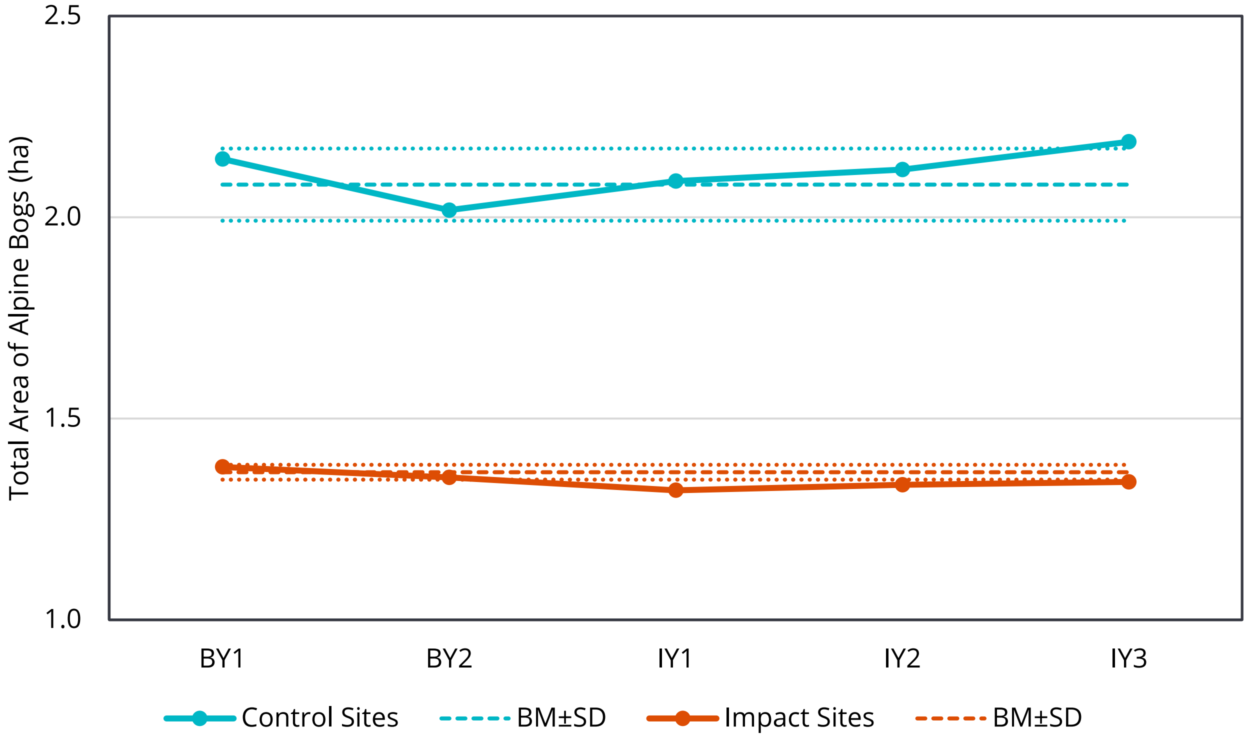

Chart 1 Total area (hectares) of Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)

3.1.2 Dimensions of Alpine Bogs

The dimensions of each Alpine Bog were estimated using line transects and the Diagnostic Key to Alpine Bogs (Appendix 3). The results of these estimates are presented in Chart 2 (raw results for each Alpine Bog are available in Appendix 5). The sum of dimensions at impact sites was 344.8 metres in IY3, which is less than the baseline mean of 354.7 metres (a decrease of 9.9 metres or 2.8%). The sum of dimensions at control sites was 438.8 metres in IY3, which is equal to the baseline mean. The relative change in the dimensions of the impact sites was therefore a decrease of 2.8%, although this change was not statistically significant (BACI contrast = -0.4130; SE = 0.6130; F-statistic = 0.4549; numerator DF = 1; denominator DF = 47.2; P = 0.5033).

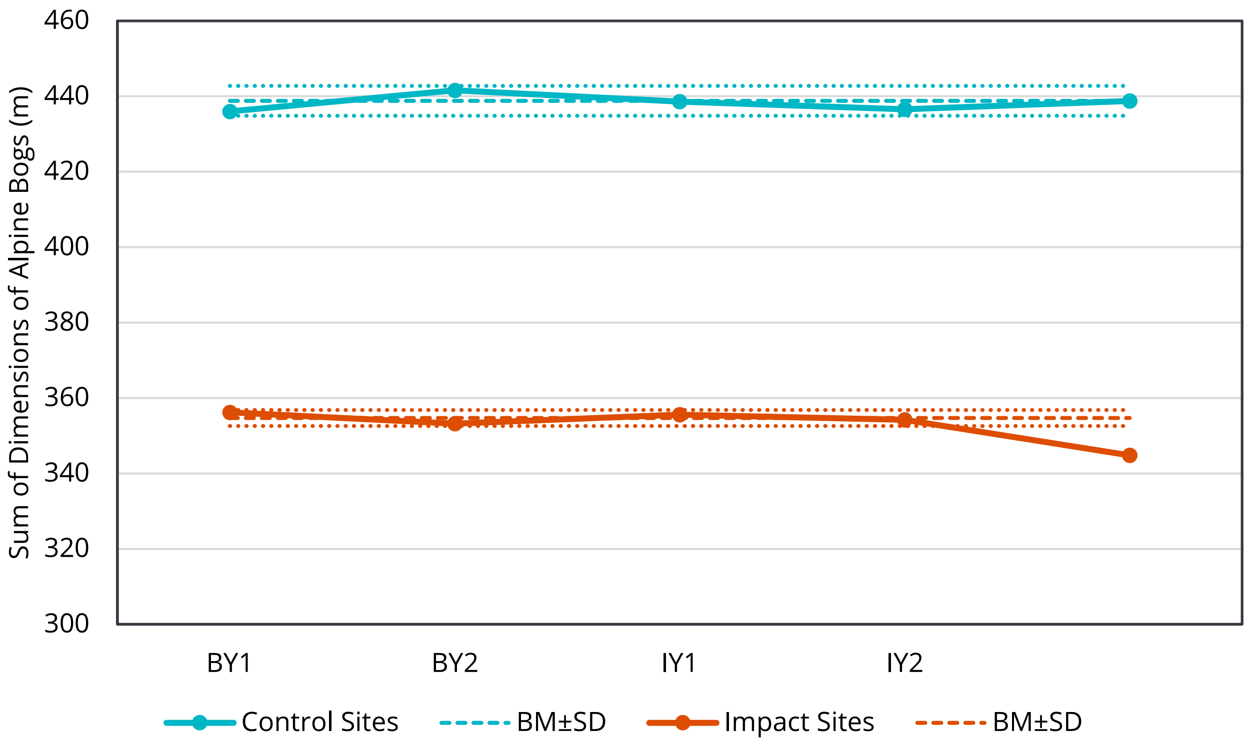

Chart 2 Sum of dimensions (metres) of Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)

3.1.3 Bare ground

Line transects (point intersections) were also used to estimate the cover of bare ground. These estimates are displayed in Chart 3 (raw results for each Alpine Bog are available in Appendix 5). The cover of bare ground was again elevated at impact sites and control sites in IY3 relative to the baseline mean. In IY3, the cover of bare ground was 3.6% at impact sites and 5.0% at control sites, compared with baseline mean covers of 1.0% and 0.5% respectively. The changes in bare ground at impact sites relative to control sites have not been statistically significant (BACI contrast = 0.0047; SE = 0.0154; F-statistic = 0.0947; numerator DF = 1; denominator DF = 47.2; P = 0.7597).

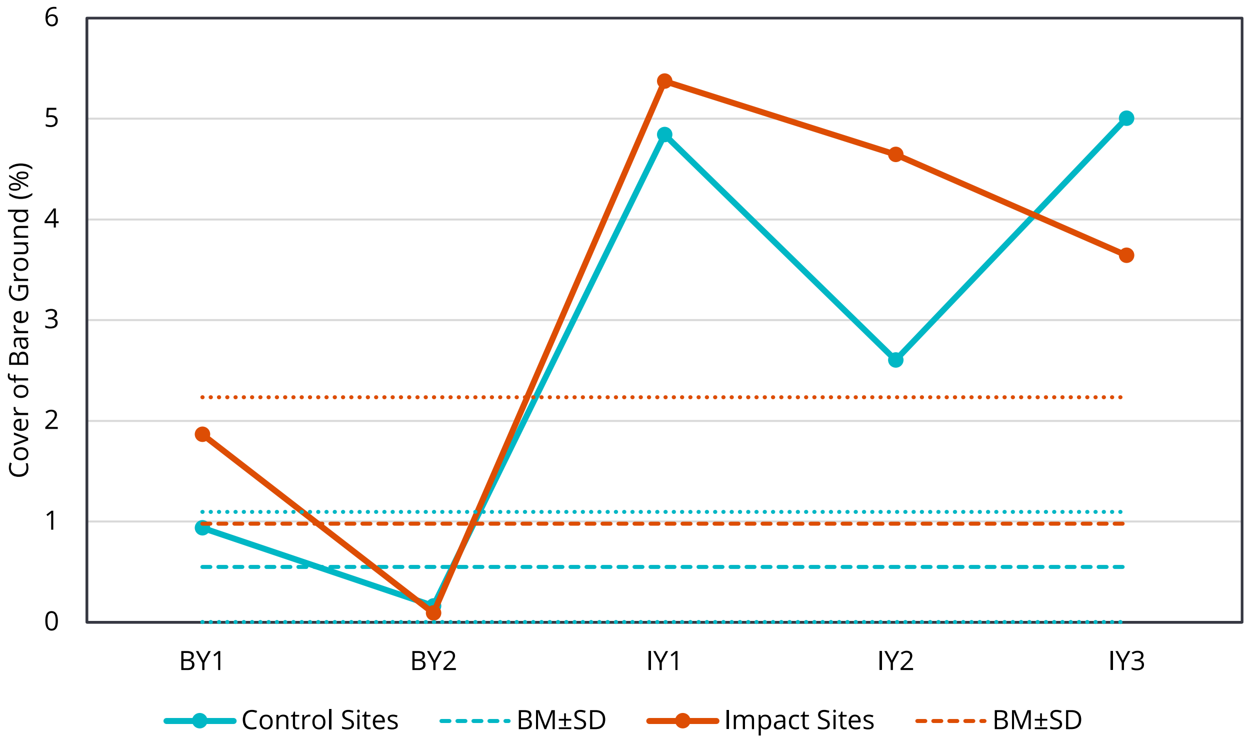

Chart 3 Percentage cover of total bare ground at Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)

The causes of bare ground differed at impact sites compared with control sites, as shown in Chart 4 (note that the cause or type of bare ground was not recorded prior to IY2). At impact sites, 30% of bare ground was attributed to sedimentation in IY3, down from 72.5% in IY2. The remainder of bare ground was considered natural (no bare ground was attributed to deer activity). At control sites, all bare ground was considered natural in IY3, with no bare ground attributed to deer or sedimentation. This was a change from IY2, when 67.2% of bare ground was considered natural and 32.8% was likely to have been caused by deer.

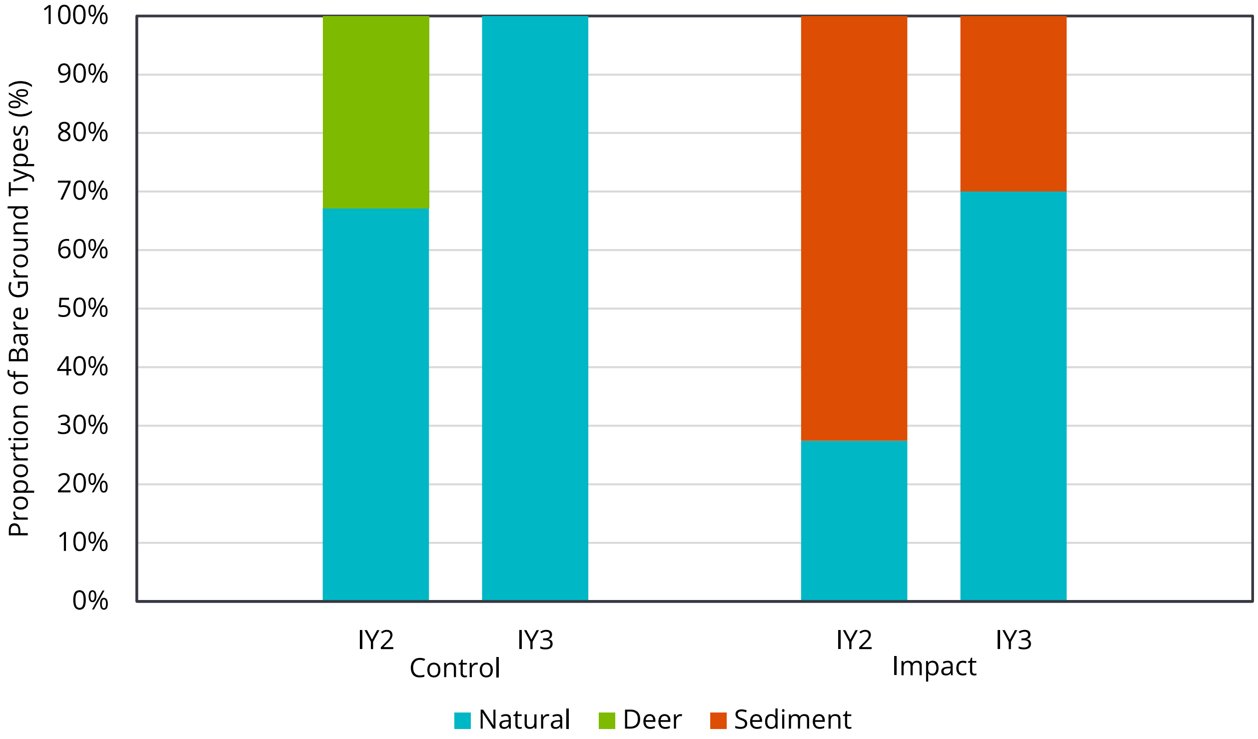

Chart 4 Types of bare ground recorded at control and impact sites as a proportion of all bare ground recorded at those sites

3.2 Bog composition

3.2.1 Species richness

Using line transects (point intersections) and belt transects (quadrats), a total of twelve bog-dependent flora species have been recorded at impact and control sites since monitoring started (Appendix 2; Appendix 5). Baseline monitoring detected 10-11 bog-dependent species across all impact sites and 10-11 bog-dependent species across all control sites (Chart 5). This means that the baseline mean bog-dependent species richness at impact sites and control sites was 10.5. In IY3, 10 bog-dependent flora species were recorded at impact sites (a 4.8% reduction in species richness from the baseline mean) and 11 bog-dependent flora species were recorded at control sites (a 4.8% increase in species richness from the baseline mean). The relative decrease in species richness at impact sites compared with control sites in IY3 was therefore 9.5%, although this change was not statistically significant (BACI contrast = -0.0160; SE = 0.0102; F-statistic = 0.0034; numerator DF = 1; denominator DF = 47.0; P = 0.9539).

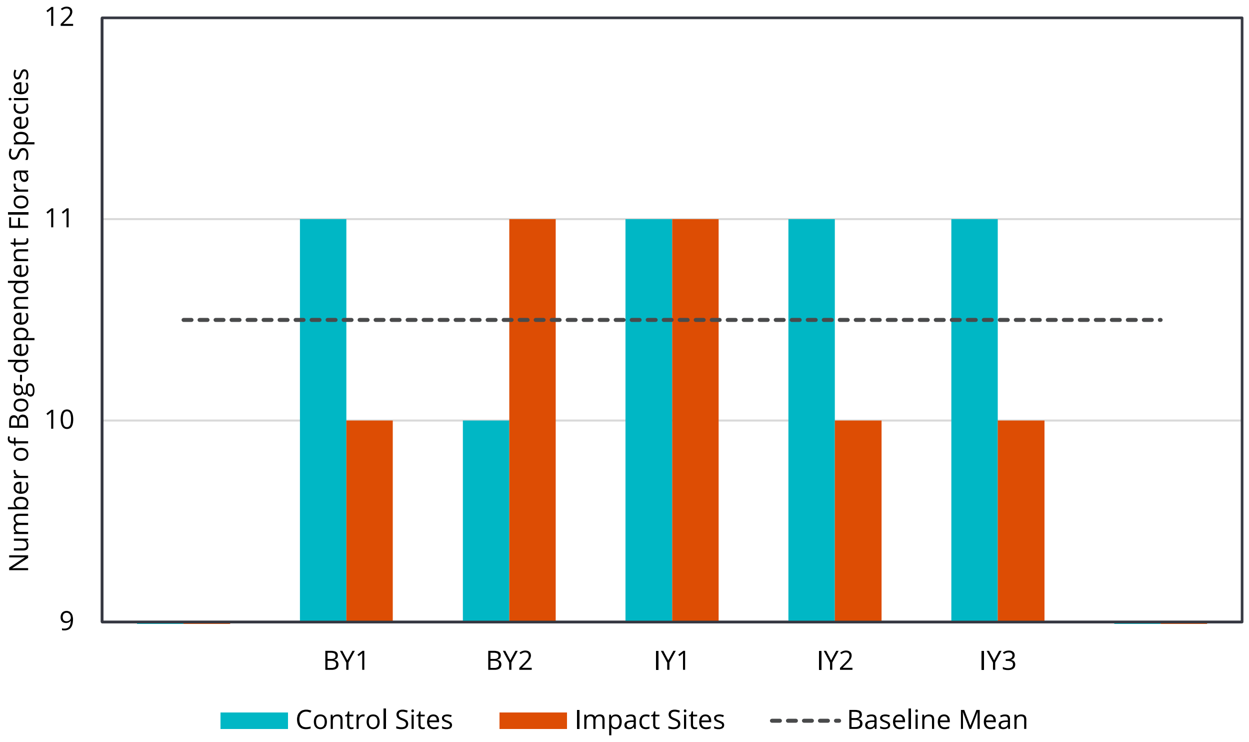

Chart 5 Bog-dependent flora species richness at control and impact sites relative to the baseline mean

3.2.2 Cover of bog-dependent flora

Line transects (point intersections) were also used to estimate the cover of bog-dependent flora species. Chart 6 shows these covers (raw results for each Alpine Bog are available in Appendix 5). The cover of bog-dependent flora species increased at impact sites from a baseline mean of 78.2% to 79.4% in IY3. The cover of bog-dependent flora species at control sites increased from a baseline mean of 87.9% to 89.1% in IY3. While the increase in cover of bog-dependent species was proportionally greater at impact sites relative to control sites, the increase was not statistically significant (BACI contrast = -0.0160; SE = 0.0102; F-statistic = 2.4592; numerator DF = 1; denominator DF = 47.1; P = 0.1235).

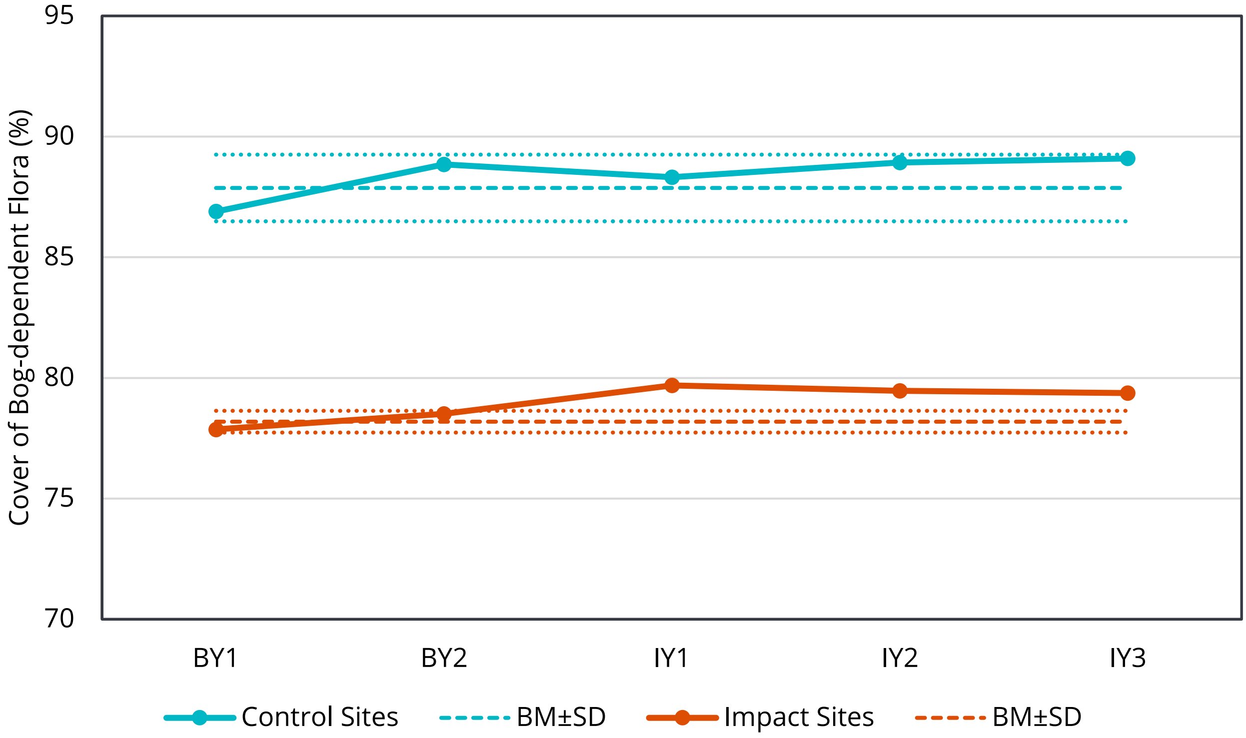

Chart 6 Percentage cover of bog-dependent flora at Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)

3.3 Encroachment by weeds and other atypical species

Line transects (point intersections) were used to estimate the covers of native non-bog-dependent flora species and introduced flora species (weeds) at each Alpine Bog (Appendix 5).

3.3.1 Cover of native non-bog-dependent flora

The cover of native non-bog-dependent flora species is shown in Chart 7. The cover of native non-bog-dependent flora increased at impact sites from a baseline mean of 45.2% to 48.5% in IY3 and decreased at control sites from a baseline mean of 45.1% to 44.8% in IY3. This represents a relative increase of 8.0% in the cover of native non-bog-dependent flora species at impact sites relative to control sites in IY3. This relative increase was statistically significant (BACI contrast = -0.0352; SE = 0.0125; F-statistic = 7.9248; numerator DF = 1; denominator DF = 47.1; P = 0.0071).

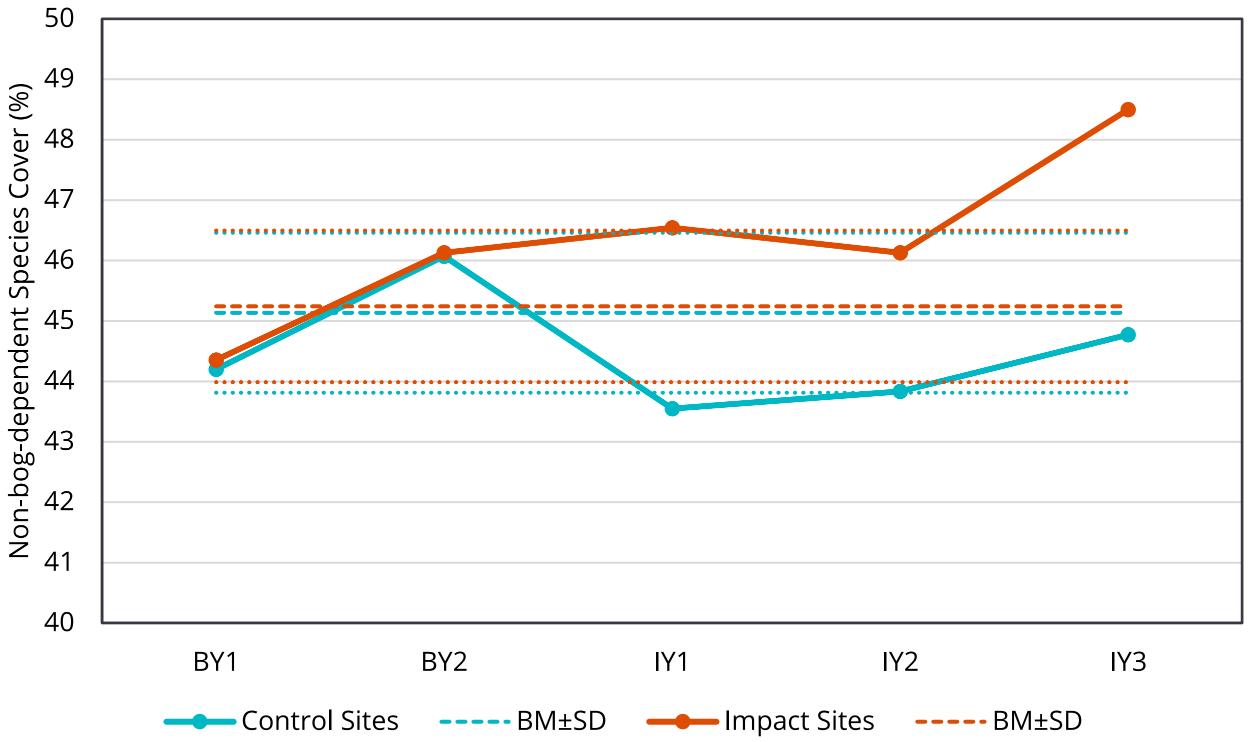

Chart 7 Percentage cover of native non-bog-dependent flora at Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)

3.3.2 Cover of weeds

The cover of weeds is shown in Chart 8. The cover of weeds increased at impact sites from a baseline mean of 5.9% to 8.8% in IY3 and increased at control sites from a baseline mean of 4.3% to 5.5% in IY3. The greater increase in weed cover at impact sites relative to control sites was statistically significant (BACI contrast = -0.0188; SE = 0.0092; F-statistic = 4.1713; numerator DF = 1; denominator DF = 47.1; P = 0.0467).

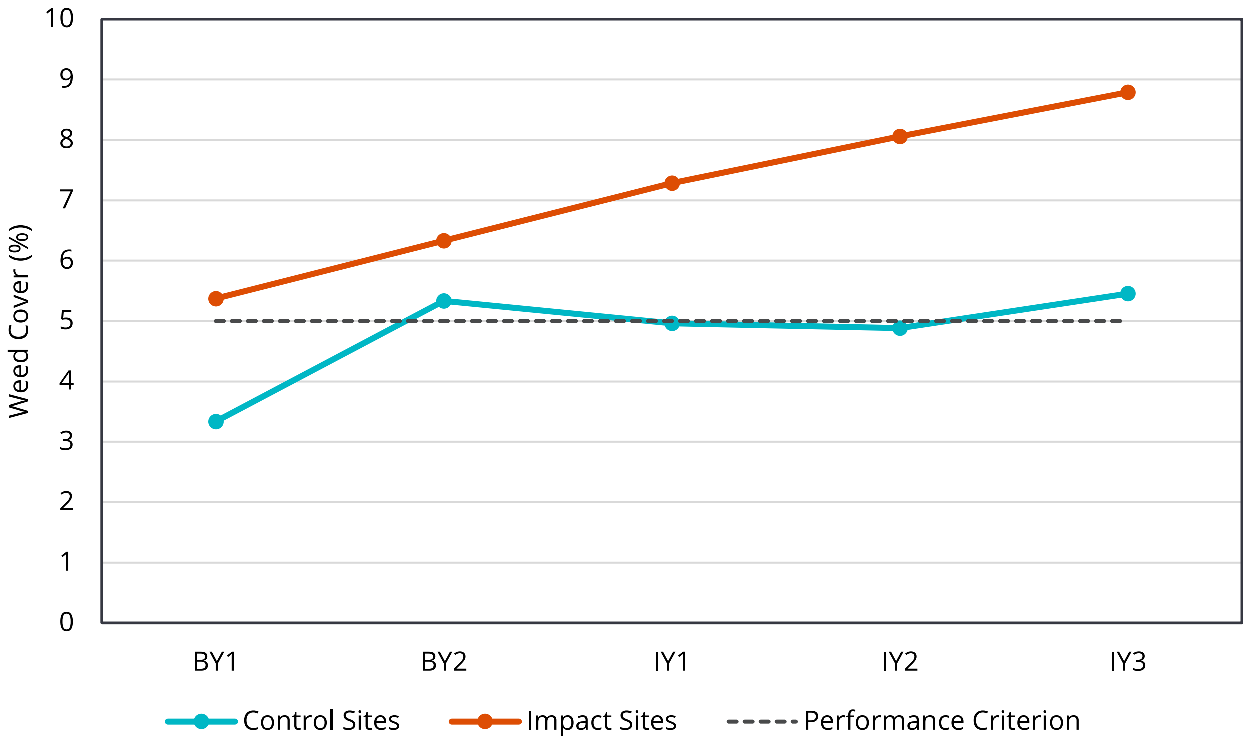

Chart 8 Percentage weed cover at Alpine Bogs over time relative to the 5% performance criterion

3.4 Bog structure

3.4.1 Cover of Peat Moss

Line transects (point intersections) were used to estimate the cover of Peat Moss *Sphagnum* spp. at impact sites and control sites. These estimates are displayed in Chart 9 (raw results for each Alpine Bog are available in Appendix 5). At impact sites, the cover of Peat Moss increased from a baseline mean cover of 5.4% to a cover of 5.9% in IY3, which represents a 9.3% increase. At control sites, the cover of Peat Moss increased from a baseline mean cover of 16.4% to a cover of 17.1% in IY3, which represents a 4.2% increase. In real terms, this means that Peat Moss cover increased by 5.1% at impact sites relative to control sites. However, the relative increase in Peat Moss cover at impact sites compared with control sites was not statistically significant (BACI contrast = -0.0115; SE = 0.0090; F-statistic = 1.6486; numerator DF = 1; denominator DF = 47.1; P = 0.2054).

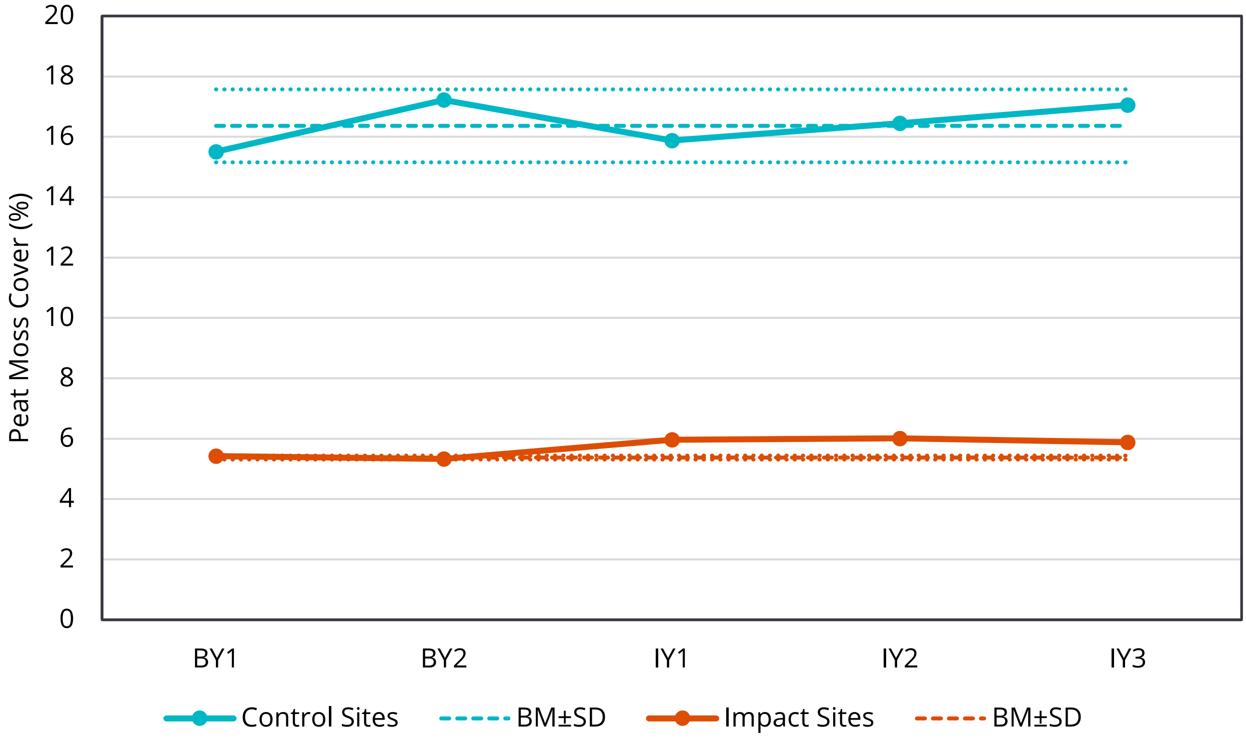

Chart 9 Percentage cover of Peat Moss at Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)

3.4.2 Dead Peat Moss

The proportion of dead Peat Moss at impact sites and control sites is shown in Chart 10. A substantial (albeit statistically insignificant) increase in dead Peat Moss was observed at impact sites in IY1, but the result has not been repeated since. At impact sites, the proportion of dead Peat Moss in IY3 was 0.8% and slightly lower than the baseline mean (although equal when rounded to the nearest tenth of a per cent). Changes in the proportion of dead Peat Moss at impact sites compared with control sites before and after construction have not been statistically significant (BACI contrast = -0.0011; SE = 0.0047; F-statistic = 0.0555; numerator DF = 1; denominator DF = 47.2; P = 0.8148).

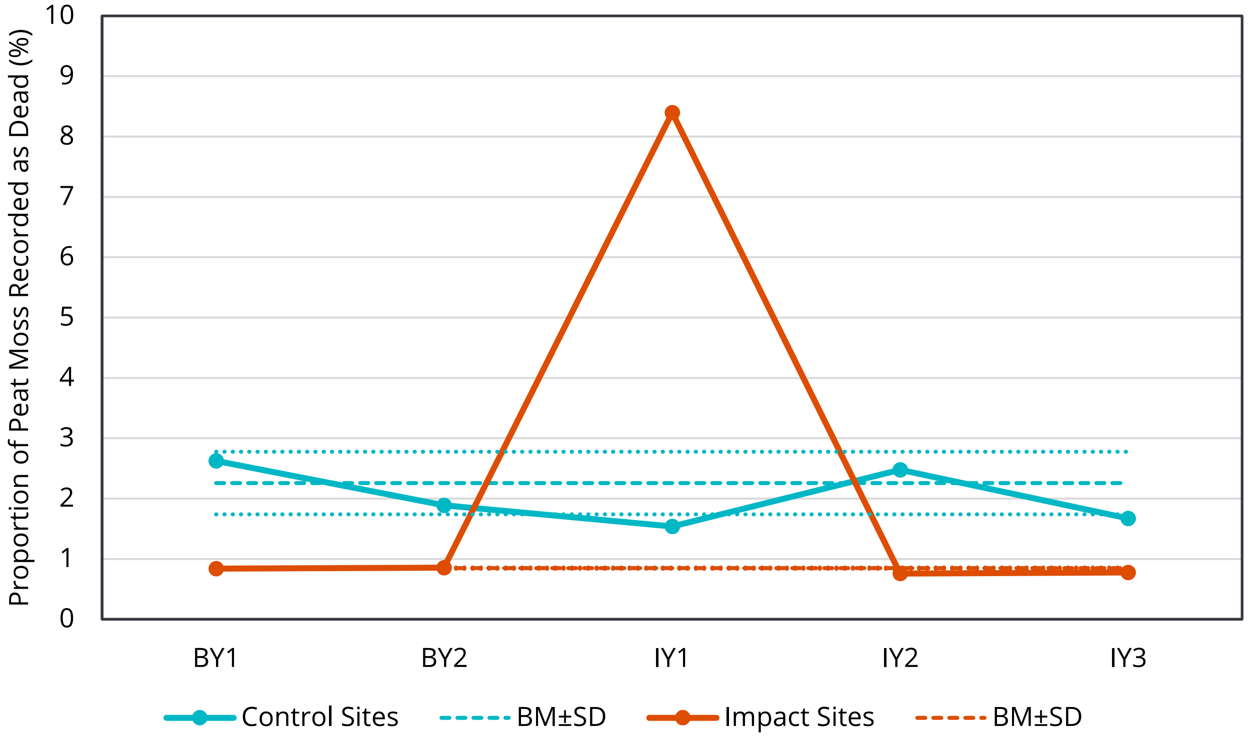

Chart 10 Proportion of Peat Moss recorded as dead relative to the baseline mean ± one standard deviation (BM±SD)

3.5 Summary of ecological monitoring results

Table 3 summarises the results of the HEMAMP IY3 monitoring in terms of the four performance criteria.

Table 3 Summary of ecological monitoring results in Impact Year 3

Parameter	Site	Baseline Mean (BM) ±Standard Deviation	IY3	Change (BM to IY3)	% Change (BM to IY3)
Extent					
Area (ha)	Impact sites	1.3667 ±0.0185	1.3423	-0.0243	-1.8%
	Control sites	2.0812 ±0.0897	2.1875	+0.1063	+5.1%
Sum of dimensions (m)	Impact sites	354.7 ±2.1	344.8	-9.9	-2.8%
	Control sites	438.8 ±4.0	438.8	0.0	+0.0%
Cover of bare ground (%)	Impact sites	1.0 ±1.3	3.6	+2.7	+272.1%
	Control sites	0.6 ±0.5	5.0	+4.5	+811.1%
Composition					
Bog-dependent species richness	Impact sites	10.5 ±0.7	10	-0.5	-4.8%
	Control sites	10.5 ±0.7	11	+0.5	+4.8%
Cover of bog-dependent flora (%)	Impact sites	78.2 ±0.4	79.4	+1.2	+1.5%
	Control sites	87.9 ±1.3	89.1	+1.2	+1.4%
Encroachment					
Cover of non-bog-dependent native flora (%)	Impact sites	45.2 ±1.2	48.5	+3.3	+7.3%
	Control sites	45.1 ±1.3	44.8	-0.3	-0.7%
Cover of weeds (%)	Impact sites	5.9 ±0.6	8.8	+2.9	+50.2%
	Control sites	4.3 ±1.4	5.5	+1.1	+25.8%
Structure					
Cover of Peat Moss (%)	Impact sites	5.4 ±0.1	5.9	+0.5	+9.3%
	Control sites	16.4 ±1.2	17.1	+0.7	+4.2%

4. Discussion

Construction of the water storage project started in October 2019 (midway through IY1) and finished in May 2020 (at the end of IY1). Monitoring in IY1 and IY2 detected that construction of the water storage and ancillary infrastructure had caused noticeable impacts on several downslope Alpine Bogs at Mount Buller, particularly Bogs 4.2, 6, 11.2 and 12 (all impact sites). Impacts on Alpine Bogs were documented in the IY1 and IY2 monitoring reports (Biosis 2020b and Biosis 2021) and included:

- Movement of sediment, large rocks and boulders into and through Alpine Bogs from the Project Construction Footprint (PCF) located upslope.
- Direct removal of approximately 8 square metres of Bog 4.2 along approximately 16 metres of its south-eastern boundary.
- Proliferation of weeds as a result of the above impacts, but particularly in areas affected by sedimentation.

In response to these impacts, the RMB prepared an Addendum to the Ecological Rehabilitation Plan (ERP; Biosis 2022a). The ERP Addendum aims to rehabilitate the Alpine Bogs through sediment control, weed management, pest animal control and revegetation. It was officially endorsed by DELWP and DCCEEW in March 2022. However, with consent from DELWP and DCCEEW (and after consultation with both departments), the RMB began early implementation of parts of the ERP Addendum in December 2021.

A range of management actions were undertaken in IY3 as part of the ERP Addendum and/or associated management plans. These management actions included the following (L. Perrin, RMB, pers. comm., 11 August 2022):

- Sediment control, involving:
  - Installation and maintenance of more than 500 metres of sediment socks.
  - Installation and maintenance of more than 20 metres of sediment fence, followed by disassembly before the declared snow season (end of IY3).
- Weed control, involving:
  - 1500 hours of weed control at Mount Buller and 850 hours of weed control at Mount Stirling, with up to 15 personnel from various organisations (RMB, Biosis, Graduate Gardeners and Taungurung Land and Waters Council).
  - Mostly manual weed removal, but with isolated herbicide treatment (e.g. for woody weeds).
  - Establishment of ongoing trials using a combination of methods, including manual removal, heat treatment and smothering (Photo 1, Photo 2 and Photo 3).
  - Removal of over 2.5 tonnes of weed material from Mount Buller and Mount Stirling (Photo 4).
- Pest animal control, including:
  - Deer control (shooting) from November 2021 to May 2022, involving the culling of 74 Sambar Deer *Cervus unicolor*.
  - European Rabbit *Oryctolagus cuniculus* deterrence from November 2021 to May 2022, involving three applications of blood and bone around revegetation sites after significant rain events.

  - Rabbit control (baiting) around Alpine Bogs in April 2022.
- Revegetation, involving:
  - Planting of 725 tubestock in April and May 2022.
  - Mass planting in the area of direct native vegetation removal.
  - Infill planting elsewhere, primarily areas affected by sedimentation.

Some of the above management actions started before IY3 ecological monitoring occurred in January and February 2022. This includes the deer control (shooting), which started in March and April 2021 (IY2) with the culling of 52 Sambar Deer and continued in IY3 with the culling of 74 Sambar Deer. This was the first meaningful deer cull permitted at Mount Buller or Mount Stirling in over 20 years. It is an exceptional effort and is likely to deliver lasting benefits for all native vegetation at Mount Buller and Mount Stirling. Some of the positive effects of these management actions are reflected in IY3 monitoring results and are discussed in the following sub-sections of this report.

Other management actions were implemented during or after IY3 ecological monitoring took place. The positive effects of these management actions are expected to be detected in IY4 or in later monitoring years. Furthermore, while construction-related impacts (e.g. sedimentation) have stabilised or been reversed in some instances, it is expected that the full effect of construction-related impacts will continue to materialise in coming years and necessitate adaptive management. The lagged nature of ecological responses to impacts and management actions should be considered when interpreting the IY3 monitoring results.

4.1 Bog extent

4.1.1 Reduction in the extent of impact sites

The performance criterion related to bog extent requires that there be no more than a 10% reduction in the total combined area of impact sites, relative to control sites. Further to this, Condition 2b of EPBC Act Approval 2014/7303 requires that there is no more than a 0.0900-hectare reduction in the total combined area of 'indirectly affected areas of Alpine Bog', relative to baseline monitoring and control sites. The approval defines 'indirectly affected areas of Alpine Bog' as Bogs 4.2, 6, 8, 9, 10, 11.2 and 12 (i.e. all impact sites except Bog 13).

As at IY3, neither of the performance thresholds (10% or 0.0900-hectare reduction) have been reached. There has been a 6.9% reduction in the total combined area of impact sites relative to control sites and the total combined area of 'indirectly affected areas of Alpine Bog' is 0.0243 hectares lower than the baseline mean. While these results represent compliance with conditions of approval for the project, the 6.9% relative decline in area of impact sites means that the 'amber' trigger level for adaptive management described in the HEMAMP Protocol (Biosis 2022b) has now technically been reached, necessitating that management actions be undertaken to reverse this decline. Management actions are discussed further in Sections 4.5 and 4.6 of this report.

It should be noted that the absolute area of impact sites, as opposed to their relative area (relative to control sites), is currently only 1.8% or 0.0243 hectares less than the baseline mean of 1.3666 hectares (Table 4). The absolute area of impact sites was at a low of 1.3217 hectares in IY1 (3.3% or 0.0450 hectares below the baseline mean), increased to 1.3353 hectares in IY2 (2.3% or 0.0313 hectares below the baseline mean) and increased again in IY3 to 1.3423 hectares (1.8% or 0.0243 hectares below the baseline mean).

While the absolute area of impact sites appears to be returning to baseline levels, there has been a 6.9% decline in the relative area of impact sites (as opposed to absolute area) and the relative area of impact sites appears to be on a downward trend, which started with construction of the water storage in IY1. The relative area of impact sites was 3.7% below the baseline mean in IY1, 4.1% below the baseline mean in IY2 and now 6.9% below the baseline mean in IY3. Although the relative changes in bog extent in impact years have not been statistically significant, the primary aim of monitoring is to assess results against the performance criteria (and over-reliance on statistical significance in the context of BACI monitoring should be avoided). The reduction in extent of impact sites from IY1 to IY3 points to potential protracted decline in bog extent at impact sites and future non-compliance, which is why an exploration of potential causes is outlined below.

4.1.2 Potential causes for a reduction in extent of impact sites

The relative decline in area of impact sites has been driven largely by an increase in the combined area of control sites (Table 4). The increase in area at control sites has mostly been at Mount Stirling, particularly Bogs S2 and S3. Mount Stirling control sites were 0.0909 hectares or 9.7% larger in IY3 compared with their baseline mean. Approximately half of this increase (0.0468 hectares or 4.7%) occurred from IY2 to IY3. The increase in area of Mount Stirling control sites in IY3 is at the limit of the range of variability recorded during baseline monitoring and is therefore notable (Table 4). In contrast, the area of control sites at Mount Buller in IY3 was only 0.0154 hectares (1.3%) greater than the baseline mean. This increase is well within the range of variability recorded during baseline monitoring (Table 4). The area of Mount Buller control sites has therefore remained relatively stable.

Table 4 Change in Alpine Bog area from baseline mean to Impact Year 3

Site	Area (ha)		
	Baseline Mean (BM) ±Standard Deviation	Impact Year 3	Change (BM to IY3)
All Impact Sites	**1.3666 ±0.0184**	**1.3423**	**-0.0243 (-1.8%)**
All Control Sites	**2.0812 ±0.0896**	**2.1875**	**+0.1063 (+5.1%)**
Mount Buller Control Sites	1.1403 ±0.0360	1.1556	+0.0154 (+1.3%)
Mount Stirling Control Sites	0.9410 ±0.0536	1.0319	+0.0909 (+9.7%)

Deer control, weed control and post-fire vegetation succession

The notable increase in the area of Mount Stirling control sites, which in turn has driven much of the relative decline in area of impact sites, has several probable causes, including the following:

- The RMB's successful deer control program, which commenced after IY2 monitoring in March 2021, is likely to have benefitted Mount Stirling control sites more than any other monitoring site. The results of IY2 monitoring suggested that Mount Stirling control sites were most affected by deer activity (Biosis 2021). All bare ground attributed to deer activity along transects in IY2 was at control sites (no bare ground was attributed to deer activity at impact sites) and 83.5% of this bare ground was recorded at Mount Stirling. In other words, ten times more bare ground attributable to deer activity was recorded along transects at Mount Stirling than at Mount Buller in IY2. This may be because Sambar Deer have a preference for more remote sites with less human activity. Regardless, Mount Stirling control sites are likely to have disproportionately benefitted from the unprecedented deer control works that the RMB has recently undertaken. More than 100 deer have been culled within the

Mount Buller and Mount Stirling Alpine Resorts since January and February 2021, when IY2 ecological monitoring took place. This exceptional effort should be commended. Some of the positive outcomes from the recent deer control are already evident (e.g. compare Photo 5, Photo 6 and Photo 7) and reflected in monitoring results but are expected to continue to materialise over coming years as vegetation progressively recovers.

- Mount Stirling sites may have disproportionately benefitted from the RMB's weed control works. Limited weed management occurred at the Alpine Bogs (Mount Stirling and Mount Buller) during BY1 and BY2 to allow for a robust and representative baseline dataset to be collected. Weed control and targeted revegetation efforts were increased following IY1 monitoring. However, during IY1 monitoring, some large and established weed infestations were controlled at Mount Stirling, particularly Blackberry *Rubus anglocandicans* and Musk Monkey-flower *Erythranthe moschata* at Bog S1. These weed control works, including photos, have been documented in previous monitoring reports (Biosis 2021). Although most of these infestations need to be re-treated, the IY1 weed control has resulted in a progressive recovery of Alpine Bog vegetation and consequent increase in bog extent in IY2 and IY3.
- The Mount Stirling monitoring sites are closer to the Mount Stirling offset site and are likely to have indirectly benefitted from the offset management actions conducted in and around the offset site. Offset management actions have been implemented at Mount Stirling since the offset site was secured in 2019. Offset management actions are above and beyond the conservation management actions required elsewhere in the resorts. They include weed and pest animal control, conducted within the offset area and, where relevant, beyond the offset area. Due to the proximity of the Mount Stirling monitoring sites to the offset site, offset management actions are likely to have disproportionately benefitted the Mount Stirling monitoring sites.
- Post-fire vegetation succession has involved recovery of Alpine Bog vegetation at Mount Stirling, more so than at Mount Buller. Many of the Alpine Bog monitoring sites, both a Mount Buller and Mount Stirling, were burnt during bushfires in 2007. At the boundaries of some sites, such as Bogs 6, S1 and S2, the vegetation is still in a state of succession. At Bogs 6 and S1, the vegetation succession has generally been associated with a small but noticeable loss of Alpine Bog extent as non-bog-dependent species, such as Snow Gum *Eucalyptus pauciflora* and Mountain Tea-tree *Leptospermum grandifolium*, continue to recover from the fire. However, recovery of Alpine Bog vegetation was noted across a relatively large area of Bog S2 (125.5 square metres) during on-ground mapping in IY3. Vigorous growth of bog-dependent species had resulted in otherwise scattered bog-dependent plants reaching a critical cover that was identifiable as Alpine Bog. This extent of post-fire recovery of Alpine Bog vegetation has never been recorded at Mount Buller (impact sites or control sites) since monitoring began.
- A combination of factors may have resulted in the unusually large increase in area of Mount Stirling control sites. For example, the removal of deer is likely to have removed herbivore pressures, thereby accelerating post-fire vegetation succession that was already in train and allowed for bog-dependent flora to fill the voids left from weed control works. The removal of deer is likely to have also removed one of the primary weed vectors in the Alpine Bogs.

While Mount Stirling sites are likely to have disproportionately benefitted from deer and weed control, it should be noted that Mount Buller monitoring sites have also benefitted from these works (albeit to a lesser extent). For example, reduced herbivory and trampling from deer was observed at Mount Buller sites during on-ground mapping in IY3 (e.g. Photo 8 and Photo 9).

It should also be noted that impacts from herbivores and weeds are still occurring at all sites. Despite the exceptional deer control efforts and overall reduced deer activity, there was still some deer activity recorded in IY3. Scats, tracks, vegetation trampling, herbivory and active deer wallows were all still observed during on-ground mapping. For example, deer tracks were still observed at the northern end of Bog S1 and appear to still be contributed to channelised water flows and a drying of the bog substrate. During IY3 transect monitoring, White Clover *Trifolium repens* var. *repens* was recorded for the first time in Bog S2, germinating from relatively fresh deer scats, suggesting that deer had been the vector for the introduction of this weed species (Photo 10). After being recorded, the White Clover germinant was immediately removed. These examples demonstrate that deer and weed impacts are still present and will require ongoing management.

Impact Year 3 – Recommendation 1

The deer control effort from IY2 and IY3 should continue in IY4 to ensure that deer activity remains low and to provide Alpine Bog vegetation with an opportunity to recover. The RMB's deer control works in IY2 and IY3 were exceptional, resulting in 126 deer being removed and much reduced deer activity in Alpine Bogs in IY3. However, some deer activity was still recorded in IY3 and Sambar Deer are likely to continue to move into the resorts from surrounding public and private land, replacing deer that have been culled.

Impact Year 3 – Recommendation 2

For some ecological parameters, such as bog extent, it may be more appropriate for Mount Buller control sites to be used as the reference against which changes at Mount Buller impact sites are assessed, rather than control sites at both Mount Buller and Mount Stirling, because the RMB's recent deer control works are likely to have disproportionately benefitted Mount Stirling control sites.

Construction-related impact and artificial watering

It is undeniable that Mount Stirling control sites will have also benefitted from a lack of construction-related impacts, but so too should have Mount Buller control sites, which remained relatively stable in area in IY3. Given that Mount Stirling control sites are likely to have disproportionately benefitted from deer control, weed control and post-fire vegetation succession, Mount Buller control sites may currently be a more reliable control than Mount Stirling control sites for assessing ecological impacts of the water storage project.

As at IY3, there has been a 3.1% decrease in the area of Mount Buller impact sites relative to Mount Buller control sites. This relative decline would be considered to be within the 'green' trigger level for management and require minimal intervention, beyond that which the RMB is already implementing (Biosis 2022b). The probable causes of this relative decline include the following:

- Construction-related impacts have resulted in a reduction in the total area of impact sites since baseline monitoring years.
  - Since IY1, the reduction in area at impact sites has been at Bogs 4.2, 6 and 11.2, which have reduced in area by 0.0063 hectares (1.6%), 0.0364 hectares (5.4%) and 0.0064 hectares (5.5%) respectively since baseline monitoring (i.e. compared with the baseline mean). These impact sites have been affected by construction-related impacts, particularly sedimentation, as documented in IY2 (Biosis 2021). All other impact sites have increased in area by a cumulative 0.0247 hectares (13.3%).

- Analysis of bog dimensions, which are assessed according to species presence along transects, allows for the locations of construction-related impacts to be objectively pinpointed. In IY3, some of the greatest reductions in bog dimensions occurred along Transects 4.2A, 4.2B, 4.2C, 4.2E, 6A, 6C and 6D. These transects are located along the Boggy Creek tributary where most sedimentation has been recorded.
- Effective rehabilitation actions have limited and started to reverse some of the construction-related impacts, such as sedimentation and weed cover. For example, Bogs 4.2 and 11.2 increased in area by 1.1% and 1.0% respectively from IY2 to IY3, although not enough to reverse the decline that has occurred since IY1.
- Construction-related impacts continued to materialise in IY3 and are likely to continue to materialise in future years. For example, despite there now being effective control of sediment movement into Alpine Bogs, sediment that is already present continues to move through the Alpine Bogs, providing opportunities for weeds to colonise (Photo 11). This is especially the case at Bog 6, which received a concentrated input of sediment due to its location relative to the aqueduct and Boggy Creek.
- As a result, Bog 6 was the only impact site that continued to decline in area in IY3, with a reduction of 1.8% from IY2. In addition, Bog 6 continues to become fragmented. It existed as one contiguous patch in BY1 and BY2, three patches in IY1 and IY2 and now four patches in IY3. Consequently, the perimeter-to-area ratio of Bog 6 has increased by almost 40% since baseline monitoring, which in turn makes Bog 6 more vulnerable to weed invasion if management actions are not taken.

- The 1.3% increase in the area of Mount Buller control sites has been driven by an increase in area at Mount Buller's eastern control sites (Bogs 1, 2 and 11.1), which may have benefitted from artificial watering.
  - In November 2021, it was discovered that water was being regularly discharged from Baldy Turret tank, from an overflow pipe near the eastern edge of Bog 1 and upslope of Bogs 2 and 11.1. The regular discharge was caused by an error in the automatic refilling of the water tank. Up until this time, it is estimated that approximately 10 kilolitres of water was being discharged at this location at each refilling of the water tank, which occurred twice per week in summer and three times per week in winter (i.e. up to 1.3 megalitres of water per annum).
  - It is unknown when the discharge error commenced but the additional water is likely to have benefitted Mount Buller's eastern control sites, namely Bogs 1, 2 and 11.1. While Bog 1 has not increased in area since baseline monitoring, it has consistently increased in area since IY1, when it declined in area by 12.3% relative to the baseline mean. During on-ground mapping in IY1, it was specifically noted that the substrate in the south-eastern corner of Bog 1 appeared to be drying. The drying appears to have been reversed, possibly by artificial water inputs.
  - The discharge error was rectified and regular discharges ceased in November 2021. As a result of the cessation of artificial watering in IY3, eastern control sites may contract in area in future years. For context, the area of the western control site (Bog 4.1/5/7) has remained consistently stable since baseline monitoring (0.2% larger in IY3 than its baseline mean area).

Bog 4.1/5/7 would appear to be the most reliable control site for comparison with impact sites, due to a range of external factors that are likely to have disproportionately benefitted other control sites. Even then, results must be interpreted with some context. For example, analysis of bog dimensions suggests that Bog 4.1/5/7 has also benefitted from the RMB's recent intensive pest animal control. The dimensions of Bog 4.1/5/7 have increased by 3.1 metres since baseline monitoring, which is almost double the increase recorded at any other monitoring site. Approximately two thirds of this increase occurred in IY3 along two transects: Transects 5A and 7A. Intense deer and/or rabbit activity, including wallowing, browsing and digging, was noted along these transects in previous years. A lack of deer activity but continued rabbit activity was noted in IY3. Recent deer control is likely to have promoted recovery of bog-dependent flora along Transects 5A and 7A, making these transects a possible example of sampling bias.

However, with respect to area of Alpine Bogs (which does not rely on transect monitoring), Bog 4.1/5/7 is likely to be the most suitable control site for comparison with impact sites in IY3. Bog 4.1/5/7 is very close to Bogs 4.2 and 6 and partially discharges into Bog 6, which is the only impact site that continued to decline in area in IY3. If Bog 4.1/5/7 were used as the reference against which impact sites were assessed, the relative decline in the area of impact sites from their baseline mean would be 2.0% as at IY3.

A relative decline in area of 2.0% is likely to be a more realistic assessment of the effect that the water storage project has had on the extent of impact sites. A relative decline of 2% would not meet the triggers for adaptive management. However, construction-related impacts are readily apparent on-ground and necessitate management intervention, which is already underway through implementation of the ERP Addendum. During and immediately after IY3 ecological monitoring (i.e. from February to May 2022), Bog 6 was targeted for concentrated management actions because it was evident that it was still worst affected by sedimentation and weed invasion. Management actions included weed control and revegetation, which are discussed in following sub-sections of this report. The benefits of these interventions and continued management actions are likely to materialise in future years.

Impact Year 3 – Recommendation 3

The RMB must continue to closely monitor the effects of inadvertent artificial watering on eastern control sites at Mount Buller (Bogs 1, 2 and 11.1), especially as regular artificial watering ceased in November 2021.

Impact Year 3 – Recommendation 4

Management actions, such as weed control and revegetation, must continue to focus on Bog 6 as a priority. Bog 6 is the only impact site that continued to decline in area in IY3.

4.1.3 Further considerations when assessing bog extent

Rime ice events

Severe rime ice events occurred at Mount Buller and Mount Stirling in the winter of 2022 i.e. in early IY3 (D. McCoombe and L. Perrin, RMB, pers. comm., 31 January 2022). The rime ice events resulted in many trees falling or losing branches. Trees that were affected included Snow Gums *Eucalyptus pauciflora* and Mountain Tea-tree *Leptospermum grandifolium*. Rime ice damage to trees that were overhanging Alpine Bogs was recorded in 13 locations during on-ground mapping in IY3.

So far, the effect of fallen trees and branches on Alpine Bog vegetation appears to have been negative at eight locations, neutral in four locations and positive in one location (Table 5). Negative effects have arisen where small areas of bog-dependent species have been smothered and their cover has been replaced by faster-growing non-bog dependent species, such as Alpine Shaggy-pea *Podolobium alpestre*, thereby resulting in a small loss of bog extent (less than 10 square metres in any given location; Photo 12). Neutral effects have arisen where Alpine Bog vegetation has been smothered but bog-dependent species are still dominant in their cover, resulting in no noticeable change in bog extent. In the one location where a positive effect was recorded (at Mount Stirling), the loss of a large Mountain Tea-tree has opened the canopy, resulting in vigorous growth of Peat Moss and Swamp Heath *Epacris paludosa* into the light-filled void.

The effect of rime ice events in IY3 has been relatively localised and spread evenly across monitoring sites. It is therefore unlikely that rime ice events have contributed to the decline in area of impacts sites relative to control sites.

Table 5 Number of locations of apparent rime ice damage to vegetation in Alpine Bogs in Impact Year 3 and their effect on Alpine Bog vegetation

Site	Impact		
	Negative	Neutral	Positive
All Impact Sites	**2**	**2**	**-**
All Control Sites	**6**	**2**	**1**
Mount Buller Control Sites	2	2	-
Mount Stirling Control Sites	4	-	1

Bare ground

The total cover of bare ground has been elevated at control sites and impact sites since IY1. This prompted the decision before IY2 monitoring to start attributing bare ground to one of three potential causes: natural causes, sedimentation or deer activity. It was thought that a better understanding of the potential causes of bare ground would assist in determining potential causes for decline in bog extent or other ecological parameters.

Total bare ground decreased at impact sites from 4.6% in IY2 to 3.6% in IY3. In contrast, total bare ground increased at control sites from 2.6% in IY2 to 5% in IY3. These values are still higher than the baseline mean of 1.0% at impact sites and 0.5% at control sites. In IY3, sedimentation was considered to be the cause of approximately one third of bare ground at impact sites, whereas all bare ground at control sites was considered to be natural.

There is no doubt that sedimentation is one of the construction-related impacts that has contributed to a reduction in the extent of impact sites, relative to control sites, since the baseline monitoring years. However, it is notable that the cover of bare ground attributable to sedimentation decreased from 3.4% in IY2 to 1.1% in IY3. All impact sites where bare ground had previously been attributed to sedimentation (Bogs 4.2, 6, 8/9/10 and 11.2) recorded a decrease in the cover of sedimentation along transects in IY3. This result supports the following observations made during transect monitoring and on-ground mapping in IY3:

- The RMB has effectively contained the movement of sediment into impact sites from the PCF. Sediment control has been achieved with sediment socks, sediment fences, mulch, natural regeneration and revegetation.

- Some sediment has been covered by a new humus or peat layer. This may explain why the cover of natural bare ground at impact sites doubled from 1.3% in IY2 to 2.6% in IY3. Unlike a layer of sediment, a layer of humus or peat is preferable because it appears to be less easily eroded and favours the re-establishment of bog-dependent flora rather than weeds.
- It is expected that sedimentation detected by transect monitoring may continue to fluctuate over coming years as some sediment that is already present within the impact sites continues to move downstream through the impact sites.

Impact Year 3 – Recommendation 5

In IY3, the RMB was successful in preventing further movement of sediment into impact sites. The RMB must continue to implement the Ecological Rehabilitation Plan (Biosis 2020a) and its Addendum (Biosis 2022a) to continue to prevent further movement of sediment from the PCF into Alpine Bogs.

As noted above, the increased cover of natural bare ground at impact sites may be partly due to sedimentation being covered by a new layer of humus or peat. In contrast, the increased cover of natural bare ground at control sites is likely to be partly due to rainfall washing away the organic litter layer and exposing the peat layer below. As shown in Chart 11, the elevated cover of bare ground since IY1 coincides with elevated rainfall at Mount Buller three days prior to transect monitoring taking place.

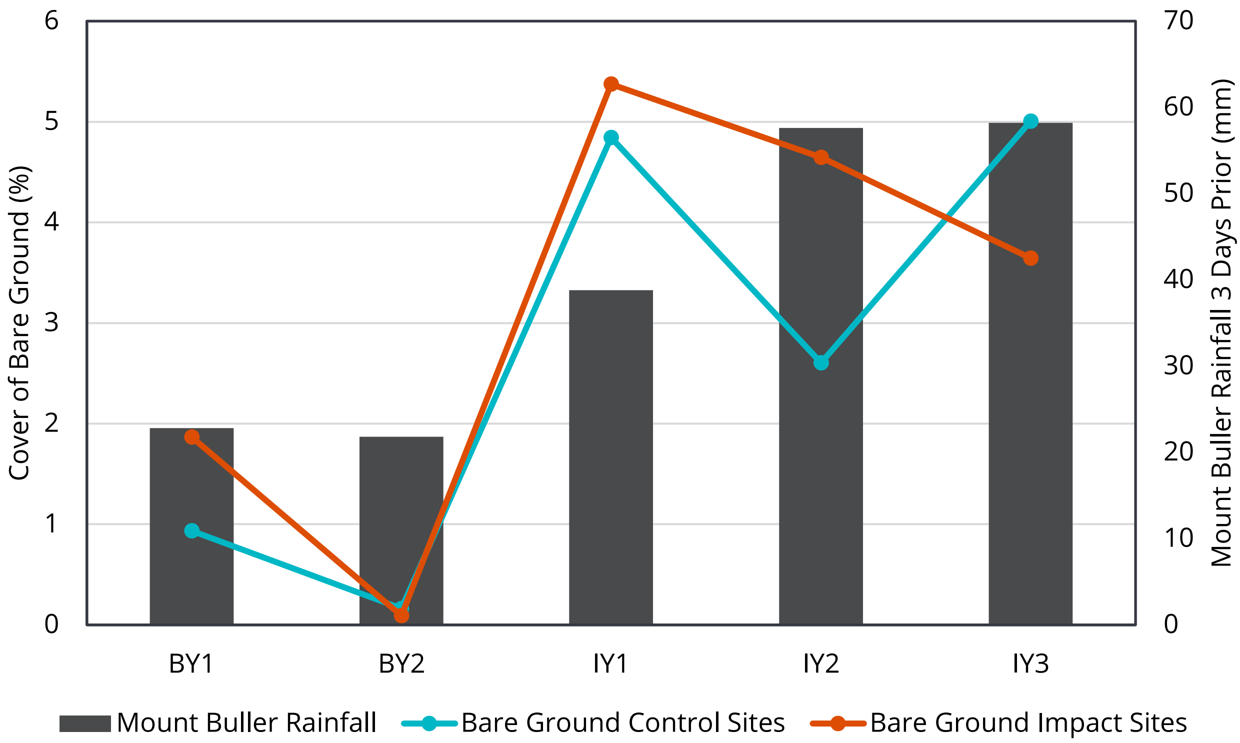

Chart 11 Percentage cover of total bare ground at Alpine Bogs over time relative total rainfall at Mount Buller three days prior to bare ground being recorded along transects

Localised hydrological changes

During IY2 monitoring, we observed localised mortality of small areas of Alpine Grassy Heathland downslope of the PCF, outside of Alpine Bogs but within 4 metres of Alpine Bog boundaries. Dieback of Alpine Rusty-pods *Hovea montana*, Alpine Leionema *Leionema phylicifolium* and Dusty Daisy-bush *Olearia phlogopappa* subsp. *flavescens* (all non-bog-dependent species) was observed at the following two locations:

- Location D1: Dieback of Alpine Rusty-pods, Alpine Leionema and Dusty Daisy-bush was noted at this location, approximately 4 metres west of Bog 11.2. The dieback of non-bog-dependent species was over approximately 20 square metres but was not homogeneous.
- Location D2: One mature Alpine Leionema (approximately 1 square metre) had died at this location approximately 3 metres south of Bog 10. It was visible in the photo point photo from the start of Transect 10A.

Following a recommendation made in the IY2 monitoring report (Biosis 2021), locations of mortality of vegetation surrounding Alpine Bogs were re-visited in IY3, possible causes were investigated and notes on vegetation recovery or succession were taken. During IY3 monitoring, we observed that the extent of dieback at D1 and D2 had increased and dieback of non-bog-dependent species at 14 new locations (denoted D3 to D17) had occurred. Most dieback of non-bog-dependent species has been observed near impact sites, with 11 of the 16 locations associated with impact sites and the remaining five locations associated with a control site (Bog 11.1). Observations from all 16 locations in IY3 are summarised in Table 6 and the 16 locations are shown in Figure 5.

Table 6 IY3 observations of dieback of non-bog-dependent species

Location	Observations in IY3	Approx. area (sq. m)	Likely cause	Proximity
D1 Photo 13	Dieback of non-bog dependent species, primarily Alpine Leionema. Increased from approx. 20 sq. m in IY2. Still not homogeneous but bog-dependent species, such as Swamp Heath, are beginning to fill void. Potentially future increase in area of Bog 11.2.	30	Sedimentation and/or waterlogging	Bog 11.2 (impact site)
D2	Dieback of Alpine Leionema. Increased from approx. 1 sq. m in IY2. Swamp Heath and Spreading Rope-rush *Empodisma minus* are persisting, resulting in an increase in the extent of Bog 10.	6	Sedimentation and/or waterlogging	Bog 10 (impact site)
D3	Dieback of Alpine Leionema and Alpine Pepper *Tasmannia xerophila* subsp. *xerophila*. Snow Gum canopy also appears sparse compared with previous years and surrounding areas. Swamp Heath and Tall Sedge *Carex appressa* are now dominant, resulting in increased extent of Bog 10.	20	Sedimentation and/or waterlogging	Bog 10 (impact site)
D4	Dieback of Alpine Shaggy-pea. No immediate change to bog extent, but location of possible future increase in bog extent.	1	Sedimentation and/or waterlogging	Bog 12 (impact site)

Location	Observations in IY3	Approx. area (sq. m)	Likely cause	Proximity
D5	Dieback of non-bog dependent species, mainly Alpine Leionema. Alpine Baeckea *Baeckea gunniana*, Mountain Daisy-bush *Olearia algida* and Tall Sedge are now dominant, resulting in increased extent of Bog 11.1.	4	Waterlogging	Bog 11.1 (control site)
D6	Dieback of Alpine Leionema and Alpine Shaggy-pea. Partly replaced by Subalpine Baeckea, resulting in increased area of Bog 11.1, but also by weeds, such as Soft Rush *Juncus effusus* and Monkey Musk *Erythranthe guttata*.	10	Waterlogging	Bog 11.1 (control site)
D7	Dieback of Alpine Leionema and Alpine Shaggy-pea. Nothing yet filling void, meaning no change to bog extent.	10	Waterlogging	Bog 11.1 (control site)
D8	Dieback of Alpine Leionema and Alpine Shaggy-pea. Alpine Baeckea and Carpet Sedge *Carex jackiana* filling void, resulting in increased extent of Bog 11.1. Waterlogging possibly due to reduced deer activity, which would otherwise channelise water flows.	3	Waterlogging	Bog 11.1 (control site)
D9	Dieback of Alpine Leionema and Alpine Shaggy-pea. Alpine Baeckea and Spreading Rope-rush filling void, resulting in increased extent of Bog 11.1. Waterlogging possibly due to reduced deer activity, which would otherwise channelise water flows.	2	Waterlogging	Bog 11.1 (control site)
D10	Dieback of Alpine Leionema, but not homogeneous. Baeckea *Baeckea* spp. and Swamp Heath are persisting, resulting in an increase in the extent of Bog 4.2.	4	Sedimentation and/or waterlogging	Bog 4.2 (impact site)
D11	Dieback of Alpine Leionema, but not homogeneous. Potential future increase in bog extent as Spreading Rope-rush and Candle Heath *Richea continentis* appear unaffected.	25	Sedimentation and/or waterlogging	Bog 4.2 (impact site)
D12	Dieback of Alpine Leionema, but not homogeneous. Bog-dependent species now dominant, resulting in increased extent of Bog 4.2.	6	Sedimentation and/or waterlogging	Bog 4.2 (impact site)

Location	Observations in IY3	Approx. area (sq. m)	Likely cause	Proximity
D13	Dieback of Alpine Leionema and Mountain Plum-pine *Podocarpus lawrencei*, but not homogeneous. Bog-dependent species appear unaffected, resulting in increased extent of Bog 4.2.	3	Sedimentation and/or waterlogging	Bog 4.2 (impact site)
D14	Dieback of Alpine Leionema and Alpine Pepper. No change to bog extent.	2	Waterlogging	Bog 4.2 (impact site)
D15 Photo 9	Dieback of Alpine Pepper, Mountain Plum-pine and, to a lesser extent, Kerosene Bush *Ozothamnus cupressoides*. Not homogeneous. Associated with dieback of bog-dependent species, such as Spreading Rope-rush, from sedimentation and deer trampling/browsing. Spreading Rope-rush is recovering but currently still a decline in bog extent.	15	Sedimentation and/or waterlogging	Bog 4.2 (impact site)
D16	Dieback of Alpine Leionema and Mountain Plum-pine, associated with sedimentation, proliferation of weeds and decline in bog extent.	3	Sedimentation	Bog 6 (impact site)

Most dieback of native vegetation surrounding the Alpine Bogs appears to have been caused by waterlogged soils. While sedimentation is often present and may have exacerbated the dieback, it does not appear to be the primary cause. For example, dieback of non-bog-dependent species around Bog 6 has been limited (only 3 square metres in one location), yet Bog 6 is one of the impact sites most severely affected by sedimentation. In addition, dieback has occurred at five locations in or near Bog 11.1, which is a control site that has not received bulk sediment loads from the PCF. Instead, the common element at most locations is the presence of a waterlogged substrate, which has likely to have been caused by localised hydrological changes and possibly exacerbated by sedimentation.

So far, most dieback of native vegetation surrounding the Alpine Bogs appears to be immediately downslope of the environmental watering system (Figure 5). The major exception to this is the dieback that has occurred near Bog 11.1. While most of the dieback at Bog 11.1 may not be near the environmental watering system, the dieback locations near Bog 11.1 may nevertheless be receiving supplementary water from the environmental watering system via the aqueduct, which discharges into part of Bog 11.1 (at its north-west extent). The environmental watering system may therefore be responsible for the waterlogged substrate that has been observed in dieback locations. The environmental watering system may be intercepting groundwater flows and distributing the water elsewhere. Alternatively, there may be unintended discharge or leakage into and from the environmental watering system from the water storage or its drainage infrastructure. The potential role of the environmental watering system in localised hydrological changes must be investigated further.

In general, the localised hydrological changes appear to have had a positive effect on Alpine Bog vegetation, mostly at impact sites. As non-bog-dependent species die back, they have been or are likely to be replaced by bog-dependent species and result in increases in bog extent. However, the mortality of non-bog-dependent species may also provide opportunities for weeds to colonise, which has already occurred at Locations D6 and D16. While this may not result in a direct loss of Alpine Bog extent, it is likely to place further weed pressures on nearby Alpine Bogs and should therefore continue to be monitored and treated, if necessary.

Impact Year 3 – Recommendation 6

The RMB must investigate the potential role that the environmental watering system is playing in the waterlogged soils that have been associated with dieback of native vegetation (non-bog-dependent flora) surrounding the Alpine Bogs. The investigation should focus on determining whether there is inadvertent discharge of water into the environmental watering system (e.g. via a leak that is bypassing the water meter) and/or whether the environmental watering system is intercepting groundwater flows (i.e. groundwater that would otherwise be delivered elsewhere). The investigation may require a detailed inspection of the environmental watering system. A detailed inspection would also allow for performance of the watering system to be checked and for maintenance to be carried out, so that the system can be called upon in the future (if required).

Impact Year 3 – Recommendation 7

Locations of mortality of vegetation surrounding Alpine Bogs must continue to be re-visited in future years to investigate possible causes, to track vegetation recovery or succession and to plan any necessary management interventions.

4.2 Bog composition

The performance criterion relating to the composition of the Alpine Bogs is expressed in terms of bog-dependent species richness (i.e. number of bog-dependent species). It requires that there be no more than a 10% reduction in the total bog-dependent native flora species richness of the impact sites, taking into account natural variation based on species richness observations averaged across control sites. The baseline mean bog-dependent species richness at impact sites and control sites was 10.5 species (10 to 11 bog-dependent species were recorded on average in the baseline monitoring years). This means that there would need to be a net loss of two bog-dependent species from impact sites relative to control sites for there to be greater than a 10% reduction in bog-dependent species richness.

In IY3, 10 bog-dependent species were recorded at impact sites and 11 bog-dependent species were recorded at control sites (all bog-dependent species recorded at impact sites were also recorded at control sites). The relative decrease in species richness at impact sites compared with control sites was therefore one species or 9.6%. This is close to the 10% threshold for non-compliance as specified in the performance criteria. The single bog-dependent species that was not detected at impact sites in IY3 was Silver Astelia *Astelia alpina* var. *novae-hollandiae*. This is the same result that occurred in IY2.

As explained in the IY2 monitoring report, Silver Astelia has not been recorded at control sites and has had a highly localised distribution at impact sites since monitoring began. It has only been previously detected in Bogs 4.2 and 6. The failure of transect monitoring to detect Silver Astelia may therefore be due to natural vegetation succession, seasonal conditions or observer error. Alternatively, localised construction-related impacts, such as sedimentation, may have resulted in the loss of this species. The failure to detect Silver Astelia in two consecutive years, so soon after construction occurred, suggests that construction-related impacts are more likely to be the cause.

Impact Year 3 – Recommendation 8

The RMB must organise for the propagation of Silver Astelia from material of Mount Buller provenance. The resultant tubestock should be planted in Bogs 4.2 and/or 6 during the revegetation works that are planned for autumn 2024 (tubestock of this species will not be available earlier). Precise planting locations should be determined with reference to the location of any remaining Silver Astelia individuals in the vicinity.

4.3 Encroachment by weeds and other atypical species

4.3.1 Encroachment by weeds

In 2013/2014, Mount Buller's Alpine Bogs were recorded as having low (less than 5%) weed cover (Biosis and GHD 2016). As a result, the HEMAMP's performance criteria require that the total weed cover at impact sites does not exceed 5% (Biosis 2022b). The total weed cover at impact sites has progressively increased from 5.4% in BY1 to 8.8% in IY3 (Chart 8). In contrast, after an initial increase from 3.3% in BY1 to 5.3% in BY2, total weed cover at control sites has remained relatively stable and was at 5.5% in IY3 (Chart 8). It should be noted that the HEMAMP's performance criterion for weed cover has never been met at impact sites, even during baseline monitoring. Weed cover was non-compliant before the project started.

The difference in weed cover at impact sites relative to control sites is statistically significant and has mostly taken place at Bog 6. From IY2 to IY3, weed cover declined at all impact sites except for Bogs 6 and 12. At Bog 6, weed cover has increased from a baseline mean of 5.7%, to 7.8% in IY1, 9.7% in IY2 and 14.5% in IY3. The increase in weed cover from IY2, when weeds were recorded at 46 transect points, to IY3, when weeds were recorded at 69 transect points, effectively accounts for all of the increase in weed cover recorded across impact sites collectively in IY3. Weed cover at Bog 12 has increased from a baseline mean of 0.2%, to 0.8% in IY1 and IY2 and 1.6% in IY3. In contrast, the increase in weed cover at Bog 12 was the result of weeds being recorded at two points along Bog 12 transects in IY1 and IY2, then four points along transects in IY3.

The substantial increase in weed cover at Bog 6 reflects mapping results, which have shown a fragmentation and reduction in the extent of Bog 6 as weeds proliferate. Increased weed cover was noticeable at Bog 6 as soon as mapping and transect monitoring commenced, even before monitoring results were known. For this reason, Bog 6 was the focus of a concerted and increased weed control effort in IY3, which commenced during IY3 monitoring and involved the following:

- When isolated or new weed infestations were observed during monitoring (whether transect monitoring or on-ground mapping), the weeds were removed by hand as soon as they were recorded. For example, we noticed during on-ground mapping that isolated Soft Rush *Juncus effusus* subsp. *effusus* and Sword Rush *Juncus ensifolius* individuals had started to colonise the middle of Bog 6, near Transect 6E, which had been affected by sedimentation. These isolated individuals were removed by hand immediately after being recorded.
- There was a focus on removing weeds and/or their propagules from drainage lines leading into Bog 6. Weed control took place from the headwaters of these drainage lines in Bogs 3, 4.2 and 4.1/5/7 into Bog 6. At a minimum, mature plants such as Soft Rush were 'de-seeded' by cutting off their flowering stems and placing them in plastic bags for solarisation and disposal. Where possible, mature plants were dug out and replaced with appropriate native tubestock (e.g. Tall Sedge) during revegetation in autumn. The aim of progressively moving down the drainage lines with weed control actions was to minimise the risk of weeds recolonising Bog 6 from upstream.

- Starting from the southern (upstream) end of Bog 6, where the aqueduct spills over into Bog 6 and where sedimentation had been previously concentrated, the following three weed control techniques were trialled and will be reviewed in future monitoring years:
  - Hand removal.
  - Hand removal, followed by smothering with jute mat.
  - Hand removal, followed by heat treatment, then smothering with jute mat.

Recovery of Alpine Bog vegetation was noted in some areas of Bog 6 during IY3 and resulted in localised increases in the extent of Bog 6. This recovery was probably as a result of targeted weed control and revegetation that occurred in IY2. However, improvements from the weed control efforts undertaken in IY3 may take several years to materialise. While some of the weeds that contributed to poor weed cover results in IY3 were removed immediately after being recorded, it is possible that weed cover results may increase further in Bog 6 before the improvements occur. For example, it is expected that sedimentation will continue to move downstream through Bog 6, creating opportunities for weeds to colonise. In addition, some areas of Bog 6 are likely to require several years of concerted weed control, similar in effort to weed control undertaken in IY3, for weed cover to be reduced to a level that allows for successful revegetation. It will also take several years for tubestock to establish and out-compete weeds. It should therefore not be surprising if the weed control and revegetation undertaken in IY3 does not result in an immediate decline in weed cover in Bog 6 in Impact Year 4 (IY4), as continued management will be required.

There is already some indication from monitoring results that construction-related impacts, such as sedimentation, are progressively moving downstream. For example, Bogs 6 and 12 were the only impact sites where weed cover increased from IY2 to IY3. Bogs 6 and 12 are further downstream from the PCF that most other impact sites. Downstream does not necessarily equate to directly downslope, as water and the weed propagules that is carries may move laterally within Alpine Bogs. Within Bog 6 itself, the first substantial increases in weed cover were noted along transects 6C and 6D in IY1 and IY2, probably because these transects are on the main drainage line running through Bog 6. In IY3, the notable increases in weed cover were along Transects 6A and 6E, which are across slope from the main drainage line. Weed management will therefore need to be adaptive and progressively move downstream through Bog 6. There will still need to be a focus on minimising weed propagule sources from upstream, whether upstream in Bog 6 or from the aqueduct and other Alpine Bogs upstream.

Impact Year 3 – Recommendation 9
The different weed control techniques used in Bog 6 in IY3 should be reviewed in IY4 to ascertain which techniques are most effective and efficient at reducing weed covers over large scales in Alpine Bogs.

Impact Year 3 – Recommendation 10
The concerted weed control effort that occurred in IY3 must continue in IY4, with similar effort and intensity and following the weed control hierarchy outlined in the ERP Addendum (Biosis 2022a).

4.3.2 Encroachment by native non-bog-dependent species

The performance criterion for atypical species requires that there be no more than a 10% increase in the cover of non-bog-dependent species at impact sites, relative to control sites. A divergence of impact sites from control sites with respect to cover of non-bog-dependent species was detected in IY1 and has persisted since then. In BY1, the cover of non-bog-dependent flora was 44.4% at impact sites and 44.2% at control sites. In BY2, the cover of non-bog-dependent flora was 46.1% at impact sites and control sites alike. In IY3, the cover of non-bog-dependent flora was 48.5% at impact sites and 44.8% at control sites (Chart 7). This represents a statistically significant 8.0% relative increase in the cover of non-bog-dependent species at impact sites in IY3 compared with the baseline mean.

A relatively large proportion of the increase in non-bog-dependent species cover at impact sites is attributable to Snow Gums. The cover of Snow Gums at impact sites has doubled from a baseline mean of 0.7% to 1.4% in IY3. Conversely, the cover of Snow Gums at control sites has halved from a baseline mean of 0.4% to 0.2% in IY3, with comparable results at Mount Buller and Mount Stirling control sites. Part of the increase in Snow Gum cover at impact sites may be due to the severe rime ice events that occurred in the winter of IY3, before monitoring took place. For example, Snow Gum cover along Transect 12A (an impact site) in IY3 was 6.7%, despite Snow Gums never previously being recorded along this transect. This is because numerous overhanging Snow Gum branches had cracked and fallen onto the transect but were still attached to the main tree and therefore recorded as the species being present. If the branches had been detached, as was the case at most other sites where Snow Gums had experienced rime ice damage, the branches either would not have been recorded or would have been recorded as organic litter.

However, IY3 results are representative of a trend in Snow Gum that has been occurring at impact sites since monitoring started in BY1. The trend has seen Snow Gum cover progressively increase at impact sites by approximately 0.2% each year, with the largest increase from 0.5% in BY1 to 0.9% in BY2. This trend is probably due to the growth of juvenile Snow Gums along some transects at impact sites but not control sites. For example, Transects 11.2C passes through juvenile Snow Gums, which are gradually increasing in size and therefore providing more understorey cover. Historically, these juvenile Snow Gum would have been removed during ski slope grooming but have remained in place since the adoption of a ski field vegetation management plan more than 10 years ago (Biosis Research 2011). These Snow Gums may eventually grow taller than the transect pin and therefore no longer be recorded as part of the understorey cover.

Other species that have contributed to the relative increase in cover of non-bog-dependent flora at impact sites since IY1 include the following shrubs and graminoids:

- Alpine Rusty-pods *Hovea montana*
- Alpine Leionema *Leionema phylicifolium*
- Kerosene Bush *Ozothamnus cupressoides*
- Alpine Podolobium *Podolobium alpestre*
- Alpine Pepper *Tasmannia xerophila* subsp. *xerophila*
- Snow Grasses *Poa* spp.

These species are typically found in vegetation surrounding Alpine Bogs, such as Alpine Grassy Heathland (EVC 1004) and Sub-alpine Woodland (EVC 32). Interestingly, most of these non-bog-dependent species have also been subject to dieback in native vegetation surrounding the Alpine Bogs (discussed in Section 4.1.3 of this report). In addition, the greatest increases in non-bog-dependent species cover appear to have been in Bogs 8/9/10 and 11.2, which is near where the most extensive dieback of surrounding vegetation has occurred. This suggests that the same localised hydrological changes that may have been responsible for the dieback of non-bog-dependent flora outside of impact sites may also be responsible for the increase in non-bog-dependent flora within impact sites.

4.4 Bog structure

The structure criterion requires that there be no more than a 10% reduction in the average cover of Peat Moss at impact sites, relative to control sites. The cover of Peat Moss has remained relatively stable at impact and control sites across monitoring years. The baseline mean cover of Peat Moss at impact sites and control sites was 5.4% and 16.4% respectively. As at IY3, the cover of Peat Moss at impact sites and control sites is 5.9% and 17.1% respectively. While this represents a 5.1% increase in the cover of Peat Moss at impact sites relative to control sites, it is not statistically significant.

Importantly, after a peak in the proportion of dead Peat Moss recorded along transects at impact sites in IY1, the proportion of dead Peat Moss returned to baseline levels at impact sites in IY2 and remained there in IY3 (Chart 10). This observation suggests that Peat Moss has recovered at impact sites after a disturbance event in IY1 and is supported by observations from on-ground mapping (compare Photo 14, Photo 15, Photo 16 and Photo 17, which show recovery of Peat Moss along the aqueduct after sedimentation in IY1). It appears that entry of new sediment into the Alpine Bogs is being controlled, allowing existing sediment to be washed out of Alpine Bogs and/or be covered by peat-forming species such as Peat Moss.

4.5 Triggers for adaptive management

The HEMAMP Protocol uses a 'traffic light' approach to adaptive management triggers, where the level of management intervention is escalated as the risk of adverse impacts on the ecological values of the impact sites increases, from 'green' to 'amber' to 'red' (Biosis 2022b).

The following ecological trigger levels have been reached:

- 'Green' trigger level, on the basis of the following criterion:
  - Bog structure – There has been a 5.1% increase in Peat Moss cover at impact sites, relative to control sites. No management actions are required to address this result, although HEMAMP monitoring, in-depth analysis and reporting must continue. Peat Moss cover would need to decline by more than 5% at impact sites relative to control sites for the 'amber' trigger level to apply.
- 'Amber' trigger level, on the basis of the following criteria:
  - Bog extent – There has been a 6.9% decrease in the extent of impact sites, relative to control sites. However, as explained in Section 4.1.2 of this report, this relative decrease may have been inflated by Mount Stirling control sites disproportionately benefitting from deer control, weed control and post-fire vegetation succession and from certain Mount Buller control sites benefitting from unintended artificial watering. A relative decline in area of 2.0% may be a more realistic assessment. In any case, management actions to address other criteria are likely to also reverse any decline in bog extent.
  - Bog composition – There has been a 9.5% decrease in bog-dependent species richness at impact sites, relative to control sites. This must be addressed through targeted revegetation to re-introduce Silver Astelia into Bogs 4.2 and/or 6 in autumn 2024.
  - Encroachment by atypical species – There has been an 8.0% increase in the cover of non-bog-dependent species at impact sites, relative to control sites. This increase may have been

caused by localised hydrological changes in and near impact sites, which may have conversely also resulted in dieback of non-bog-dependent species outside of impact sites. The impact sites are therefore in an unusual state of flux, which may actually culminate in an increase in the extent of the Alpine Bogs, despite the current increase in cover of non-bog-dependent species. Further investigation of potential hydrological changes and the possible role of the environmental watering system in these changes is required before more invasive management actions are undertaken.

- 'Red' trigger level, on the basis of the following criterion:
  - Encroachment by weeds – Weed cover at impact sites is currently at 8.8% and has been steadily increasing since monitoring started in BY1. It should be noted that baseline mean weed cover at impact sites was 5.9% and therefore already at the 'red' trigger level before construction started. Intensive weed control was undertaken in IY3, during and after ecological monitoring. The results of this concerted weed management are likely to materialise in future years, assuming that weed management of similar effort and intensity continues in accordance with the ERP Addendum (Biosis 2022a). Deer control, rabbit control, sediment control and revegetation are ongoing and will assist weed control efforts.

In response to the above triggers, intensive management actions commenced in IY3. The management actions include sediment control, weed control, pest animal (deer and rabbit) control and revegetation. In accordance with the HEMAMP Protocol (Biosis 2022b), if the criteria that are within the 'amber' trigger level do not return to the 'green' trigger level within 3 years (i.e. by IY6), management actions and effort will need to be increased. Similarly, if the weed criterion does not return to the 'amber' trigger level within 2 years (i.e. by IY5), weed control efforts will need to be increased further.

4.6 Key observations and required management actions at each monitoring site

Table 7 summarises the key observations made at each monitoring site in IY3 and indicates management actions that may be required.

Table 7 Observations made at monitoring sites in IY3 and management priorities

Bog	Observations in IY3	Priority
Impact Sites		
Bog 4.2	This impact site is showing signs of recovery from the effects of vegetation removal, sedimentation and rabbit activity, as a result of revegetation, sediment control and rabbit control that took place in IY2 and IY3. Dieback of native vegetation surrounding this impact site has occurred in six locations. Sediment control, weed control, rabbit control and revegetation must continue with a similar effort to that which occurred in IY3. In addition, the RMB must further investigate potential hydrological changes that may have occurred in and around this site and the possibility that the environmental watering system may have contributed to these changes.	High priority for weed control, rabbit control, revegetation and investigation of hydrological change (Recommendation 6).

Bog	Observations in IY3	Priority
Bog 6	Sedimentation is still evident in the south-west, west and centre of this site and appears to be moving downstream (including laterally). Weeds continue to proliferate, resulting in further fragmentation of the Alpine Bog. Deer control, weed control and revegetation undertaken in IY3 is likely to result in future improvements, assuming management efforts are maintained. Similar deer control, weed control and revegetation efforts must therefore be made in IY4. Weed control should include a focus on tributaries that enter Bog 6. In addition, the different weed control techniques used in IY3 should be reviewed determine which are most effective and efficient at reducing weed cover.	High priority for weed control, deer control, revegetation and review of different weed control techniques.
Bog 8/9/10	The area of this impact site has increased as bog-dependent species have filled the void left by the dieback of non-bog-dependent species, which has occurred at two locations. Conversely, the dimensions of this Alpine Bog complex along transects have decreased and the cover on non-bog-dependent species within the Alpine Bog complex has increased, suggesting that localised hydrological changes may be occurring at this site.	Moderate priority for weed control. High priority for investigation of hydrological change.
Bog 11.2 and 12	These bogs are immediately upslope/downslope of each other and have similar management issues. Bog 11.2 is showing signs of recovery from the effects of sedimentation, rocks and boulders, as a result of sediment control, weed control and revegetation. However, weeds continue to colonise sediment at both sites, including the area of Bog 11.2 damaged by a rock in IY1 (compare Photo 18, Photo 19 and Photo 20). Weed cover has consequently increased at Bog 12 (transects did not detect weeds in Bog 11.2, but they are present). Localised hydrological changes appear to have caused dieback of native vegetation surrounding these Alpine Bogs in two locations.	High priority for weed control and investigation of hydrological change (Recommendation 6).
Bog 13	Since BY1, this bog has been surrounded by predominantly introduced vegetation, particularly weedy grasses (e.g. Brown-top Bent and Sweet Vernal-grass). As at IY3, weed cover at this Alpine Bog appears to have stabilised but is still elevated compared to the baseline mean. This is likely to be due to the very small size of the Alpine Bog and its isolation, rather than any impacts from construction.	Moderate priority for weed control.
Control Sites		
Bog 1	The south-eastern corner of Bog 1 has been subject to unintended artificial watering from Baldy Turret tank for an unknown period of time. Regular discharges of water ceased in November 2021. The site should be monitored for drying and consequent incursion of weeds and/or non-bog-dependent species. Soft Rush is present along the northern boundary of this site, along the edge of the Summer Nature Walk. These plants were deseeded in IY3 but will ultimately need to be removed or killed. Given the location's proximity to the walking trail and sensitivity to erosion, herbicide treatment followed by revegetation may be the most appropriate method.	Moderate priority for weed control.

Bog	Observations in IY3	Priority
Bog 2	The eastern boundary of Bog 2, near Transect 2A, is subject to severe weed pressures due to historic disturbances to the east of this monitoring site. Weed cover has increased substantially along Transect 2A, from a baseline mean of 10.3% to 18.4% in IY3. Deer and rabbit control in IY3 is likely to assist in reducing weed covers but targeted weed control along the eastern boundary will be required. The extent of Bog 2 has increased, possibly due to inadvertent artificial watering from Baldy Turret tank.	Moderate priority for weed control.
Bog 4.1/5/7	This Alpine Bog complex has been fragmented by weed proliferation along the aqueduct and north of the aqueduct. The main weeds of concern remain Sword Rush, Musk Monkey-flower, Soft Rush and Apple, which were targeted for control in IY3, predominantly around the aqueduct because it discharges into Bog 6. Further weed control will be needed in IY4, particularly downstream of the aqueduct. Much reduced deer activity was noted at this control site in IY3, presumably as a result of recent deer control. However, rabbit browsing (particularly on Spreading Rope-rush and Carpet Sedge) appears to be worsening.	High priority for weed, deer and rabbit control.
Bog 11.1	Deer activity appears to have reduced at this control site. As a result, vigorous growth of bog-dependent species and an increase in the extent of this control site was noted in IY3, particularly along its two western branches, despite the westernmost branch still being fragmented by weeds (mainly Soft Rush). Localised hydrological changes appear to have caused dieback of non-bog-dependent species along the westernmost branch at five locations. This, along with possible artificial watering of the eastern side of Bog 11.1 from Baldy Turret tank, may have contributed to the increased area recorded in IY3.	Moderate priority for weed and deer control. High priority for investigation of hydrological change (Recommendation 6).
Bog S1	The north-western end of this Alpine Bog (near Transect S1A) remains dry, perhaps due to water flow becoming channelised by past deer and horse activity. The impact of deer is still evident but much reduced, presumably due to the exceptional deer control effort in IY2 and IY3. Impacts from horses are still present near Stirling Trail (Photo 21). Blocking of the main channel (e.g. with rice straw bales) may flood the dominant weeds and allow for recolonisation by bog-dependent species. Weeds, such as Musk Monkey-flower, were treated with heat in IY3 near the north-western end but further weed treatment will be needed. Near the mid-point of this Alpine Bog, the southern boundary remains dynamic as Mountain Tea-tree continue to regenerate following the 2006-2007 fires.	Moderate priority for weed control and flow management.

Bog	Observations in IY3	Priority
Bog S2	Until IY3, no weeds had ever been recorded by line (point) or belt (quadrat) transects at this monitoring site. However, White Clover was recorded within a quadrat in IY3, germinating from deer scats (Photo 10). Incidental observations also suggest that Musk Monkey-flower may be increasing in cover, particularly at the north-western (upstream) end. Deer activity has reduced in the Montane Riparian Thicket surrounding the Alpine Bog and post-fire vegetation succession has resulted in recovery of Alpine Bog vegetation and an increase in the extent of this monitoring site.	Moderate priority for weed and deer control.
Bog S3	Peat Moss at this control site appears very healthy, especially along the western boundary, despite disturbance caused by monitoring activity and falling Snow Gums. In IY2, new and expanded deer wallows were noted outside the northern boundary of Bog S3 and more than 20% of bare ground recorded within Bog S3 was attributed to deer activity. Deer activity was conspicuously absent in IY3, with very little sign of deer activity in established wallows and no bare ground attributed to deer activity. The RMB's recent deer control efforts will need to be repeated to ensure that deer activity remains low.	Moderate priority for deer control.
Other Sites		
Bog 3	Soft Rush and Musk Monkey-flower are still present in Bog 3, particularly along its western side, resulting in the current size of the Alpine Bog still being less than its baseline mean. Bog 3 is at the headwaters of drainage line that ultimately enters Bog 6, which is why Bog 3 was targeted for weed control in IY3. Further weed control will be needed in IY4.	High priority for weed control.

5. Conclusion and recommendations

Five years of ecological monitoring, including two years of baseline monitoring, have now been completed. The monitoring results allow for an assessment against the HEMAMP's performance criteria. Table 8 presents the results of the compliance assessment as at IY3. It should be noted that there was an exceptional effort from the RMB to undertake management actions in IY3 (e.g. weed, deer and sediment control) and that the full benefits of these management actions on impact sites will not yet be reflected in monitoring results (partly because some management actions took place during and after monitoring).

Table 8 Compliance with the HEMAMP performance criteria

Performance criterion	Compliant?	Action required?	Comments
Extent			
No more than a 10% reduction in the total combined area of impact sites, relative to control sites.	Yes	Yes	Potential for future non-compliance. Total combined area of impact sites, relative to control sites, has decreased by 6.9% (although true value is likely to be closer to 2.0%). Sediment/weed control and revegetation are still needed, especially at Bog 6.
Composition			
No more than a 10% reduction in the total 'bog-dependent' native flora species richness of impact sites, relative to control sites.	Yes	Yes	Potential for future non-compliance. One bog-dependent species, Silver Astelia, was not detected at impact sites in IY3. Re-introduce Silver Astelia through revegetation in IY5 (autumn 2024).
Encroachment			
No more than a 10% increase in the cover of 'non-bog-dependent' species within impact sites, relative to control sites.	Yes	Yes	Potential for future non-compliance with a relative 8.0% increase in cover of non-bog-dependent species at impact sites. Investigate possible hydrological changes. No intervention until better understood.
Weed cover not to exceed 5% (noting that baseline mean was already 5.9%).	No	Yes	Weed cover at impact sites is 8.8% and increasing but does not include benefits from concerted IY3 weed control effort. Control sediment, weeds and deer and revegetate.
Structure			
No more than a 10% reduction in the average cover of Peat Moss within impact sites, relative to control sites.	Yes	No	Peat Moss cover has increased by 5.1% at impact sites relative to control sites. Overall, Peat Moss cover and health is good.

The recommendations of this monitoring report are as follows:

1. The deer control effort from IY2 and IY3 should continue in IY4 to ensure that deer activity remains low and to provide Alpine Bog vegetation with an opportunity to recover. The RMB's deer control works in IY2 and IY3 were exceptional, resulting in 126 deer being removed and much reduced deer activity in Alpine Bogs in IY3. However, some deer activity was still recorded in IY3 and Sambar Deer are likely to continue to move into the resorts from surrounding public and private land, replacing deer that have been culled.
2. For some ecological parameters, such as bog extent, it may be more appropriate for Mount Buller control sites to be used as the reference against which changes at Mount Buller impact sites are assessed, rather than control sites at both Mount Buller and Mount Stirling, because the RMB's recent deer control works are likely to have disproportionately benefitted Mount Stirling control sites.
3. The RMB must continue to closely monitor the effects of inadvertent artificial watering on eastern control sites at Mount Buller (Bogs 1, 2 and 11.1), especially as regular artificial watering ceased in November 2021.
4. Management actions, such as weed control and revegetation, must continue to focus on Bog 6 as a priority. Bog 6 is the only impact site that continued to decline in area in IY3.
5. In IY3, the RMB was successful in preventing further movement of sediment into impact sites. The RMB must continue to implement the Ecological Rehabilitation Plan (Biosis 2020a) and its Addendum (Biosis 2022a) to continue to prevent further movement of sediment from the PCF into Alpine Bogs.
6. The RMB must investigate the potential role that the environmental watering system is playing in the waterlogged soils that have been associated with dieback of native vegetation (non-bog-dependent flora) surrounding the Alpine Bogs. The investigation should focus on determining whether there is inadvertent discharge of water into the environmental watering system (e.g. via a leak that is bypassing the water meter) and/or whether the environmental watering system is intercepting groundwater flows (i.e. groundwater that would otherwise be delivered elsewhere). The investigation may require a detailed inspection of the environmental watering system. A detailed inspection would also allow for performance of the watering system to be checked and for maintenance to be carried out, so that the system can be called upon in the future (if required).
7. Locations of mortality of vegetation surrounding Alpine Bogs must continue to be re-visited in future years to investigate possible causes, to track vegetation recovery or succession and to plan any necessary management interventions.
8. The RMB must organise for the propagation of Silver Astelia from material of Mount Buller provenance. The resultant tubestock should be planted in Bogs 4.2 and/or 6 during the revegetation works that are planned for autumn 2024 (tubestock of this species will not be available earlier). Precise planting locations should be determined with reference to the location of any remaining Silver Astelia individuals in the vicinity.
9. The different weed control techniques used in Bog 6 in IY3 should be reviewed in IY4 to ascertain which techniques are most effective and efficient at reducing weed covers over large scales in Alpine Bogs.
10. The concerted weed control effort that occurred in IY3 must continue in IY4, with similar effort and intensity and following the weed control hierarchy outlined in the ERP Addendum (Biosis 2022a).

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Figures

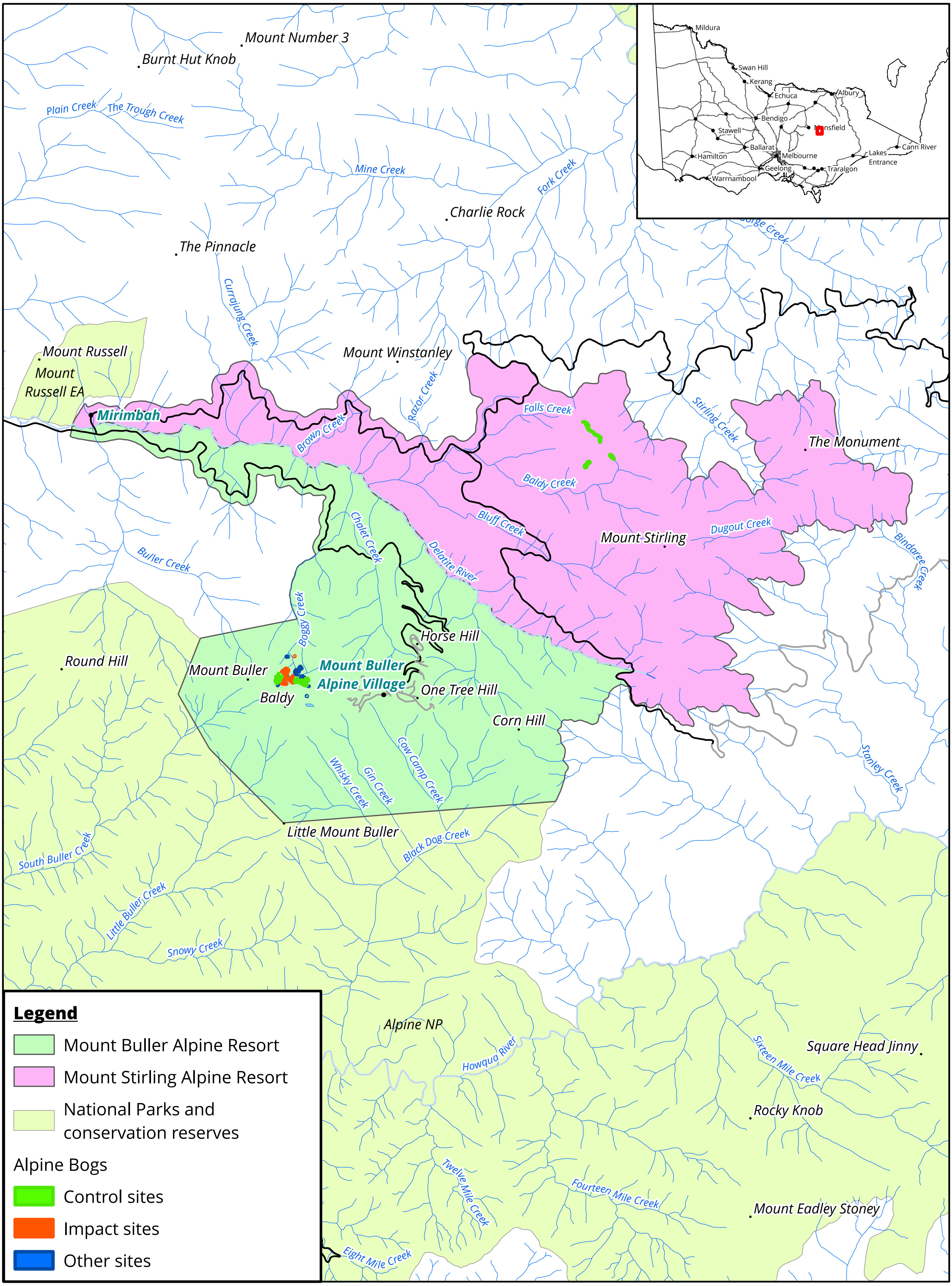

Figure 1 Location of the Mount Buller and Mount Stirling Alpine Resorts, Victoria

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Acknowledgement: VicMap Data ©State of Victoria

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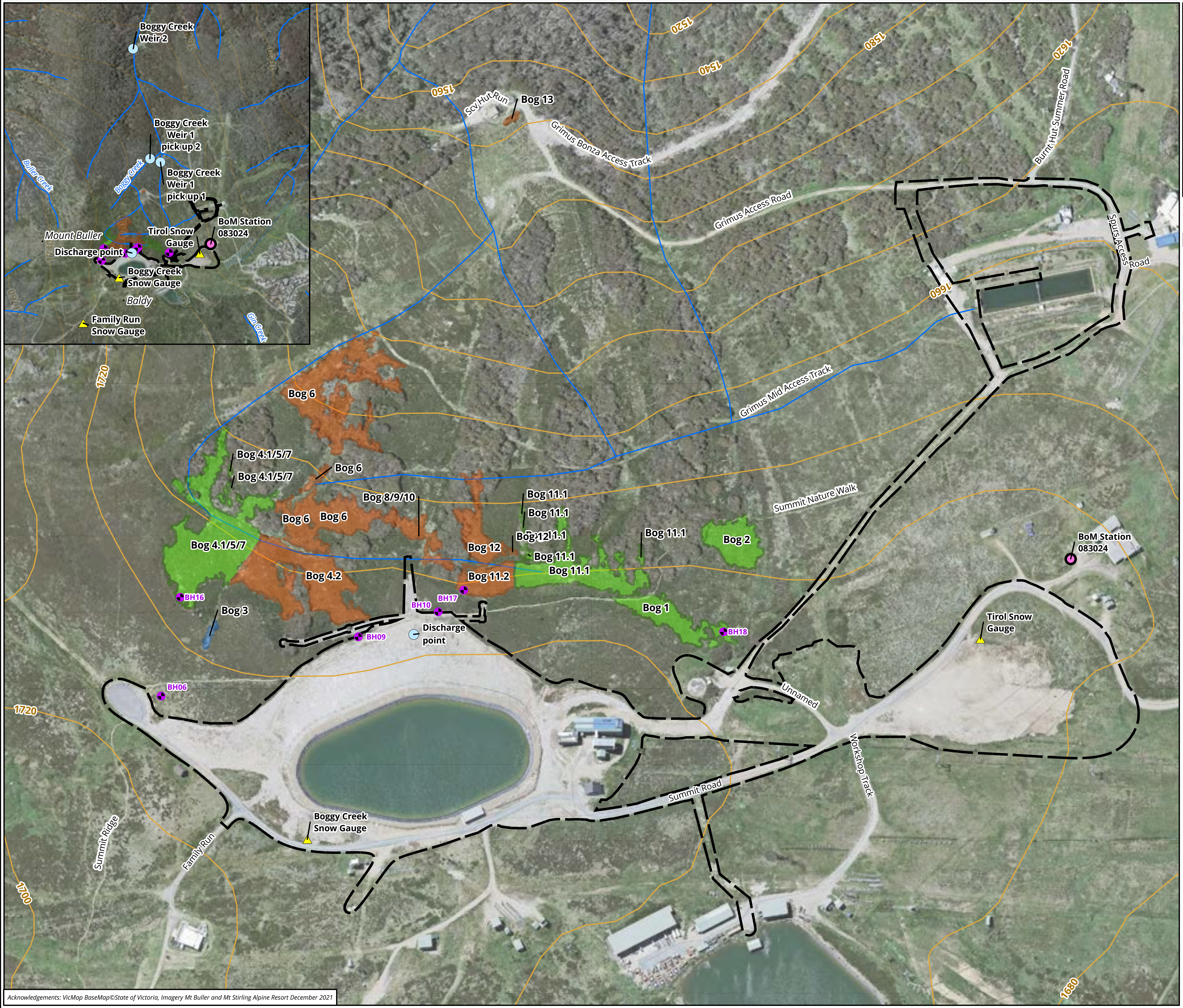

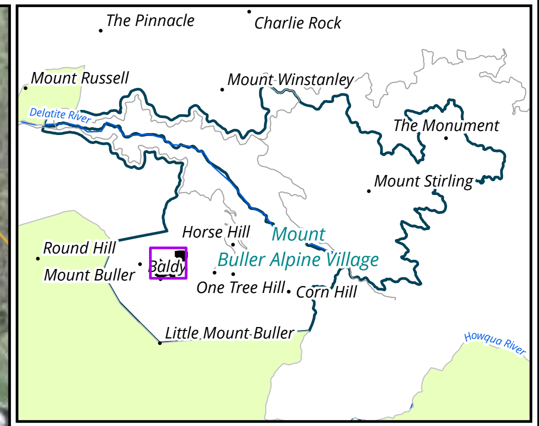

Legend

Project Construction Footprint (PCF)

Ecological monitoring (Alpine Bogs)

Control site (2022)

Impact site (2022)

Other site (2022)

Climatological monitoring

Snow gauge

Weather station

Hydrological monitoring

Groundwater bore

Surface water monitoring location

Figure 2 Location of Alpine Bogs subject to monitoring at Mount Buller Alpine Resort

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Metres

Scale: 1:3,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

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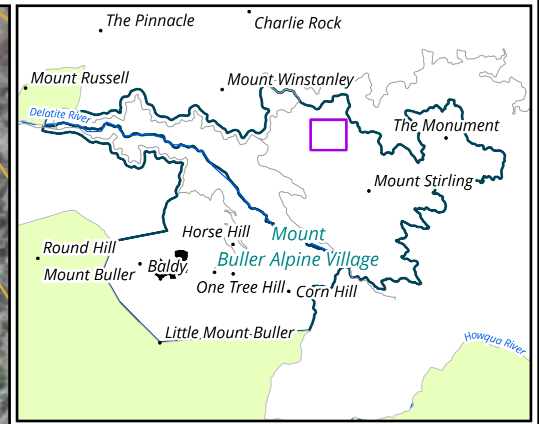

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Ecological monitoring (Alpine Bogs)

Control site (2022)

Climatological monitoring

Weather station

Figure 3 Location of Alpine Bogs subject to monitoring at Mount Stirling Alpine Resort

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Metres

Scale: 1:3,000 @ A3

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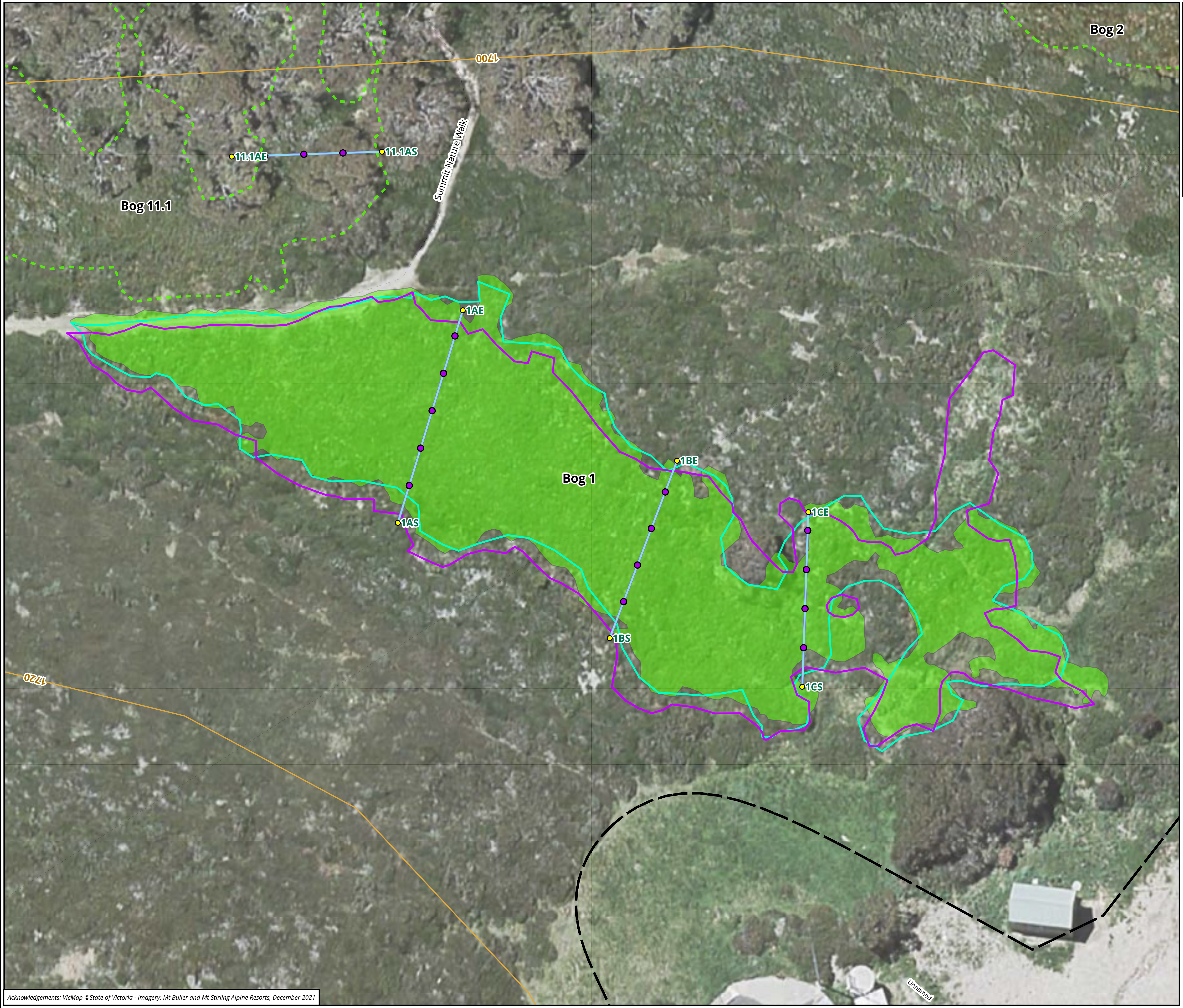

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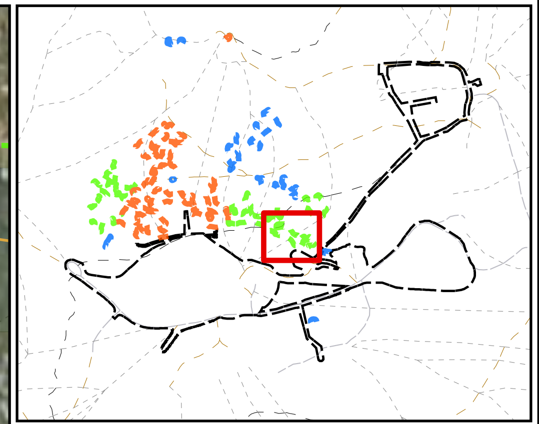

Legend

- Project Construction Footprint
- Transects
- Quadrats
- Photo points
- Control site (2022)
- Baseline year 1
- Baseline year 2

Figure 4a Bog 1 (control site)

0 2.5 5 7.5 10 12.5

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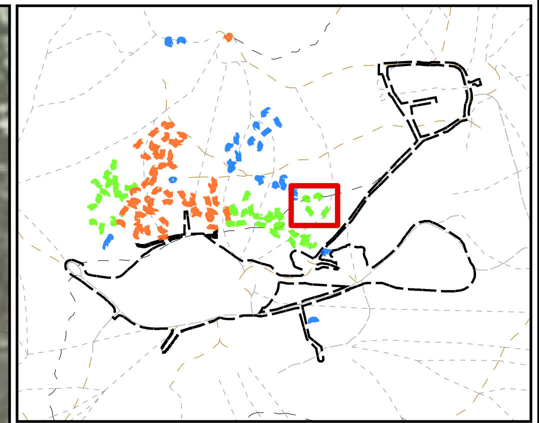

Figure 4b Bog 2 (control site)

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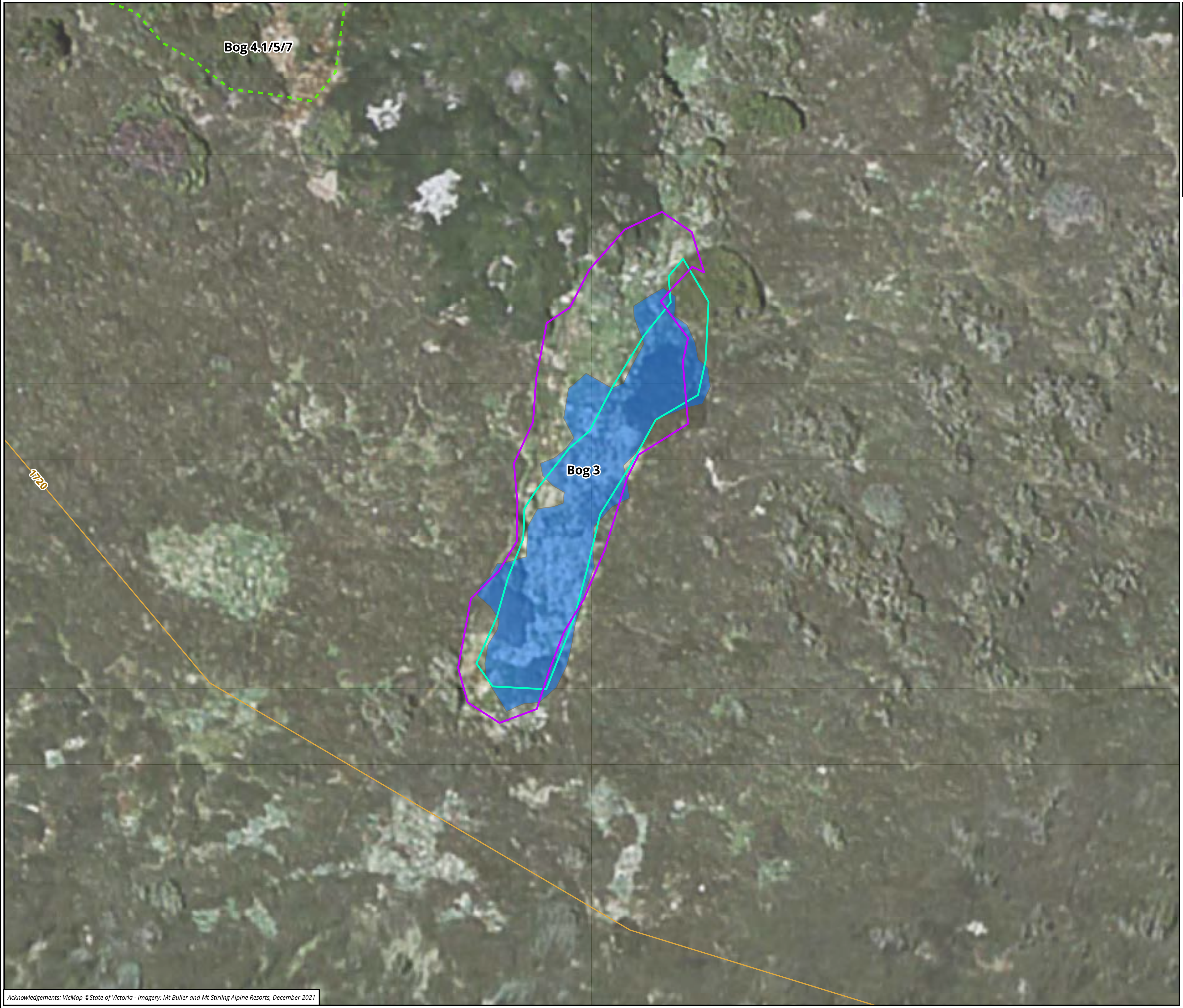

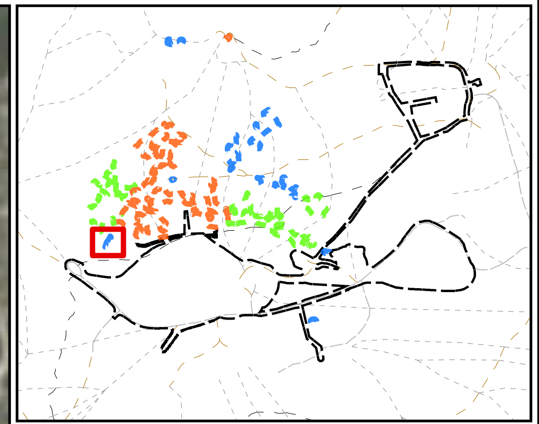

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- Photo points
- Other site (2022)
- Baseline year 1
- Baseline year 2

Figure 4c Bog 3 (other site)

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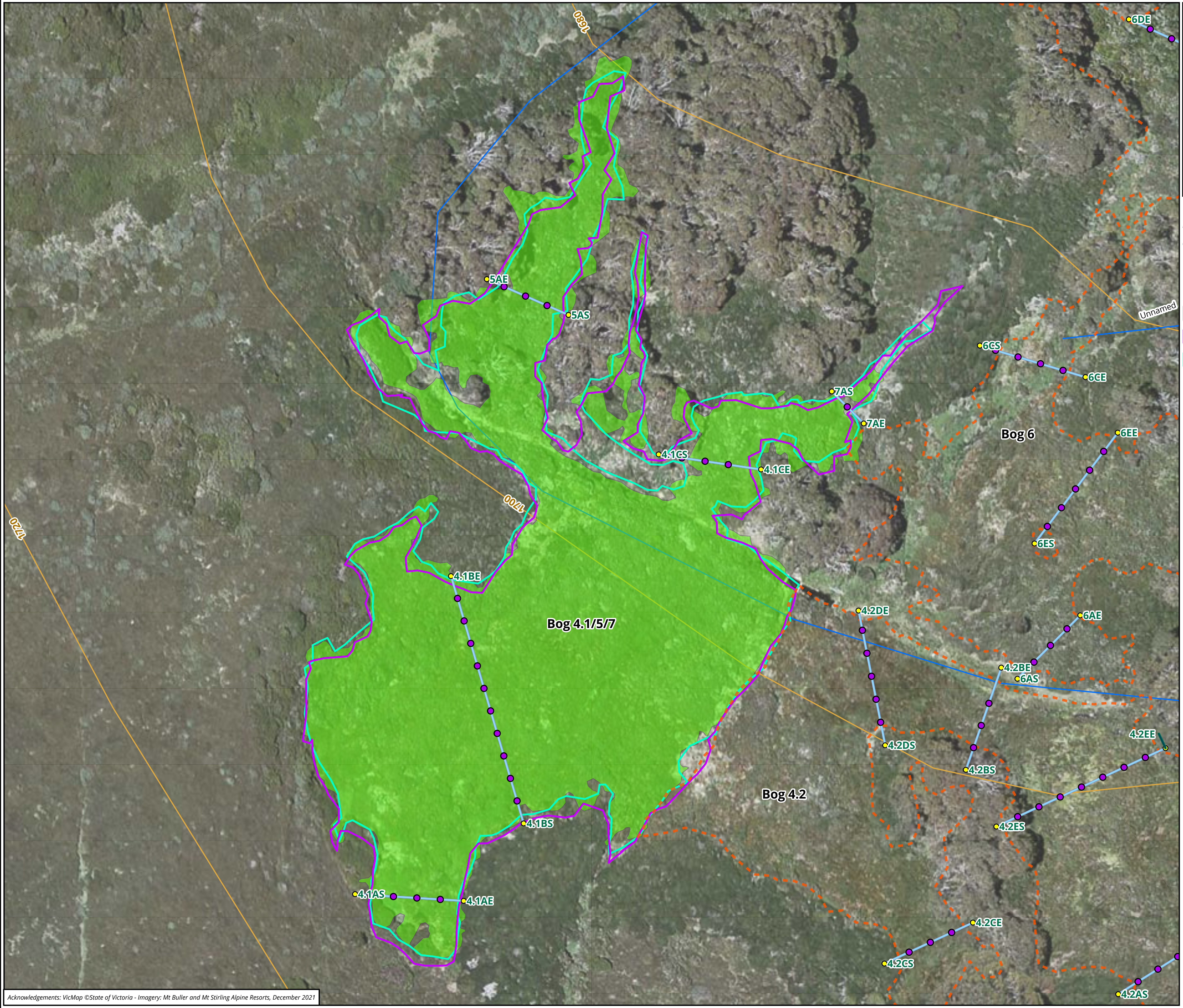

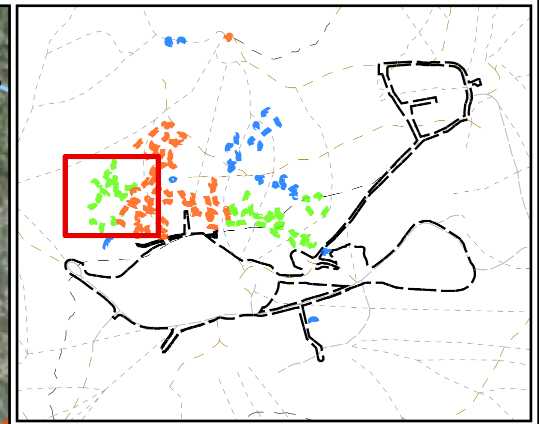

Legend

- Transects
- Quadrats
- Photo points
- Control site (2022)
- Baseline year 1
- Baseline year 2

Figure 4d Bog 4.1/5/7 (control site)

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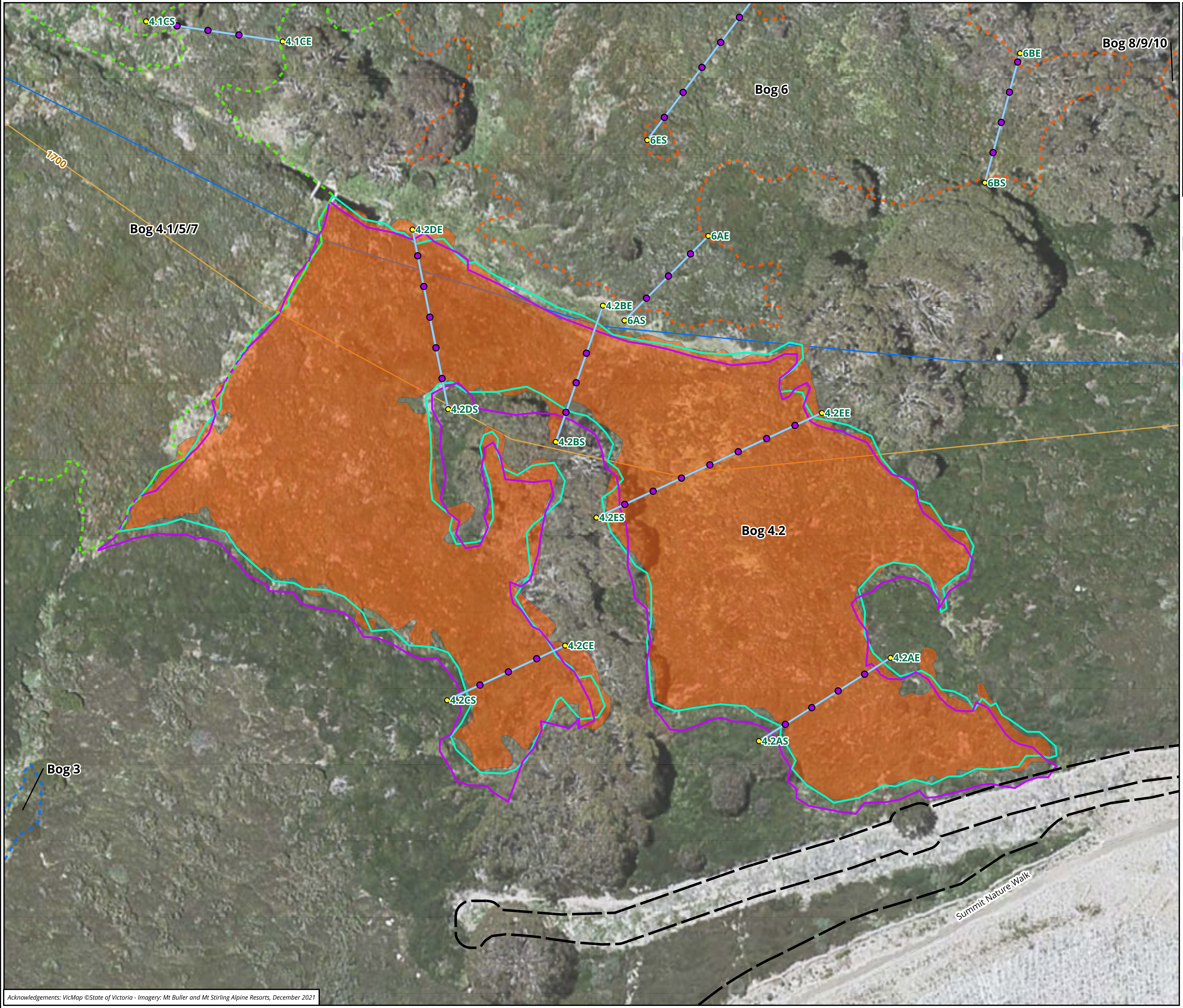
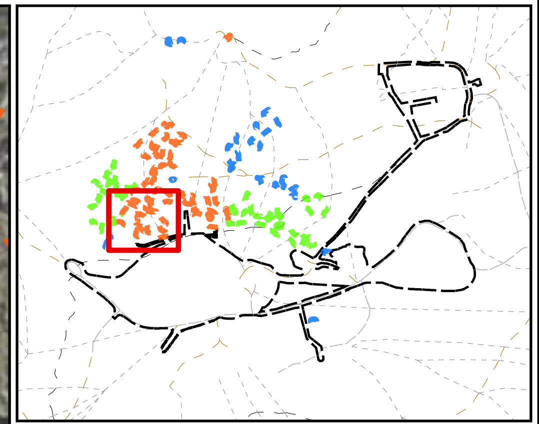
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Impact area
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx



Acknowledgements: VicMap ©State of Victoria - Imagery: Mt Buller and Mt Stirling Alpine Resorts, December 2021



Legend

- Project Construction Footprint
- Transects
- Quadrats
- Photo points
- Impact site (2022)
- Baseline year 1
- Baseline year 2

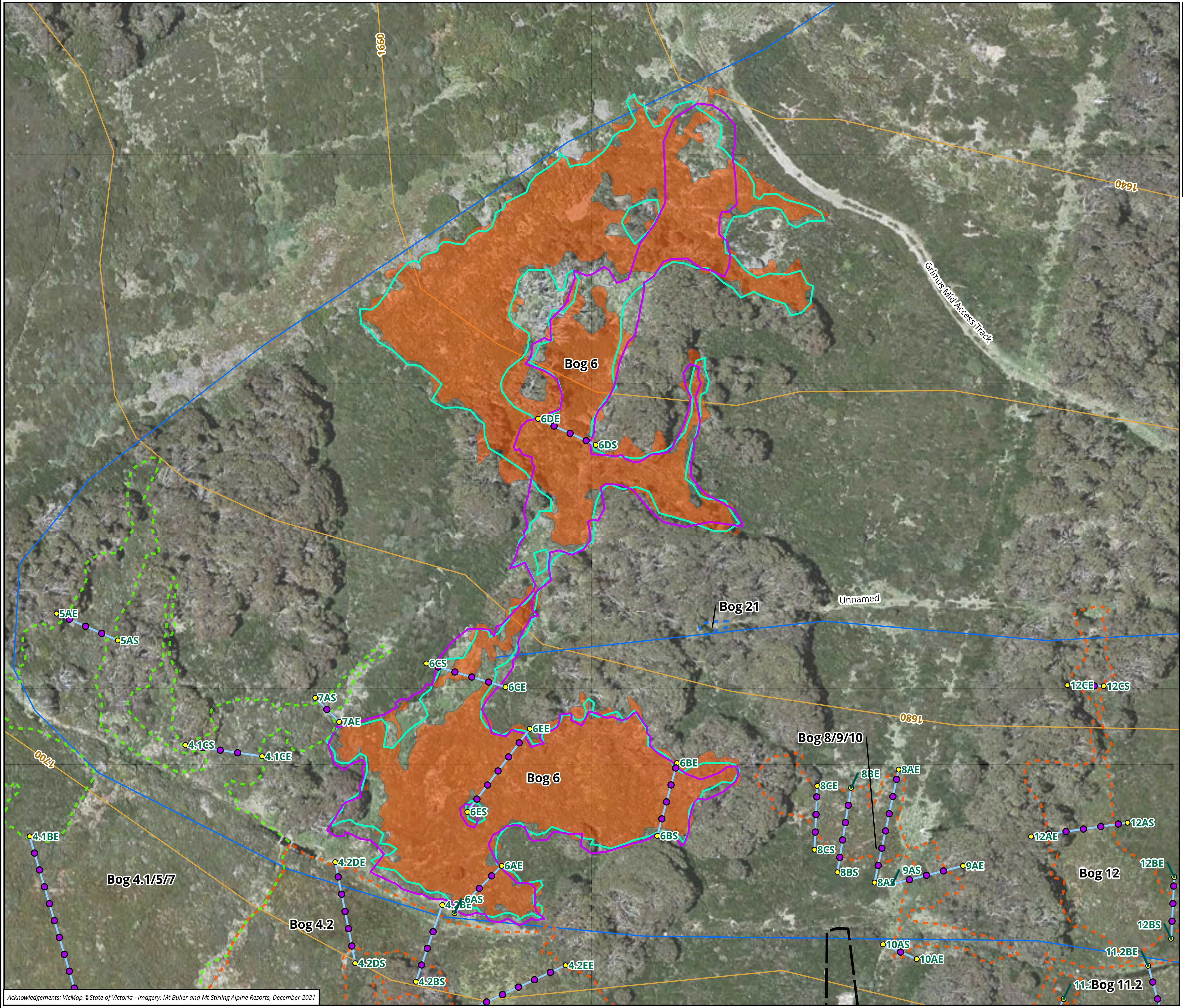
Figure 4e Bog 4.2 (impact site)

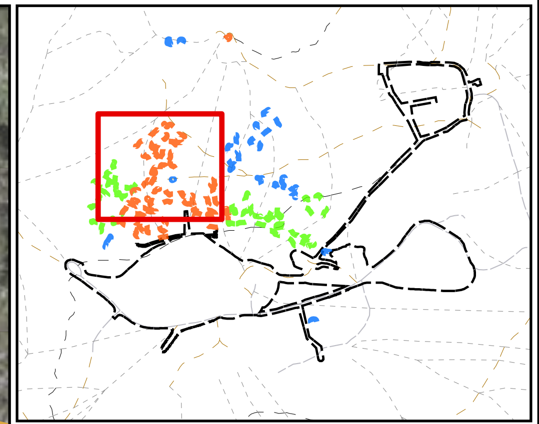
0 3.5 7 10.5 14 17.5
Metres
Scale: 1:450 @ A3
Coordinate System: GDA 1994 MGA Zone 55

N

biosis

Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Impact area
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx





Legend

- Project Construction Footprint
- Transects
- Quadrats
- Photo points
- Impact site (2022)
- Baseline year 1
- Baseline year 2

Figure 4f Bog 6 (impact site)

0 6 12 18 24 30

Metres

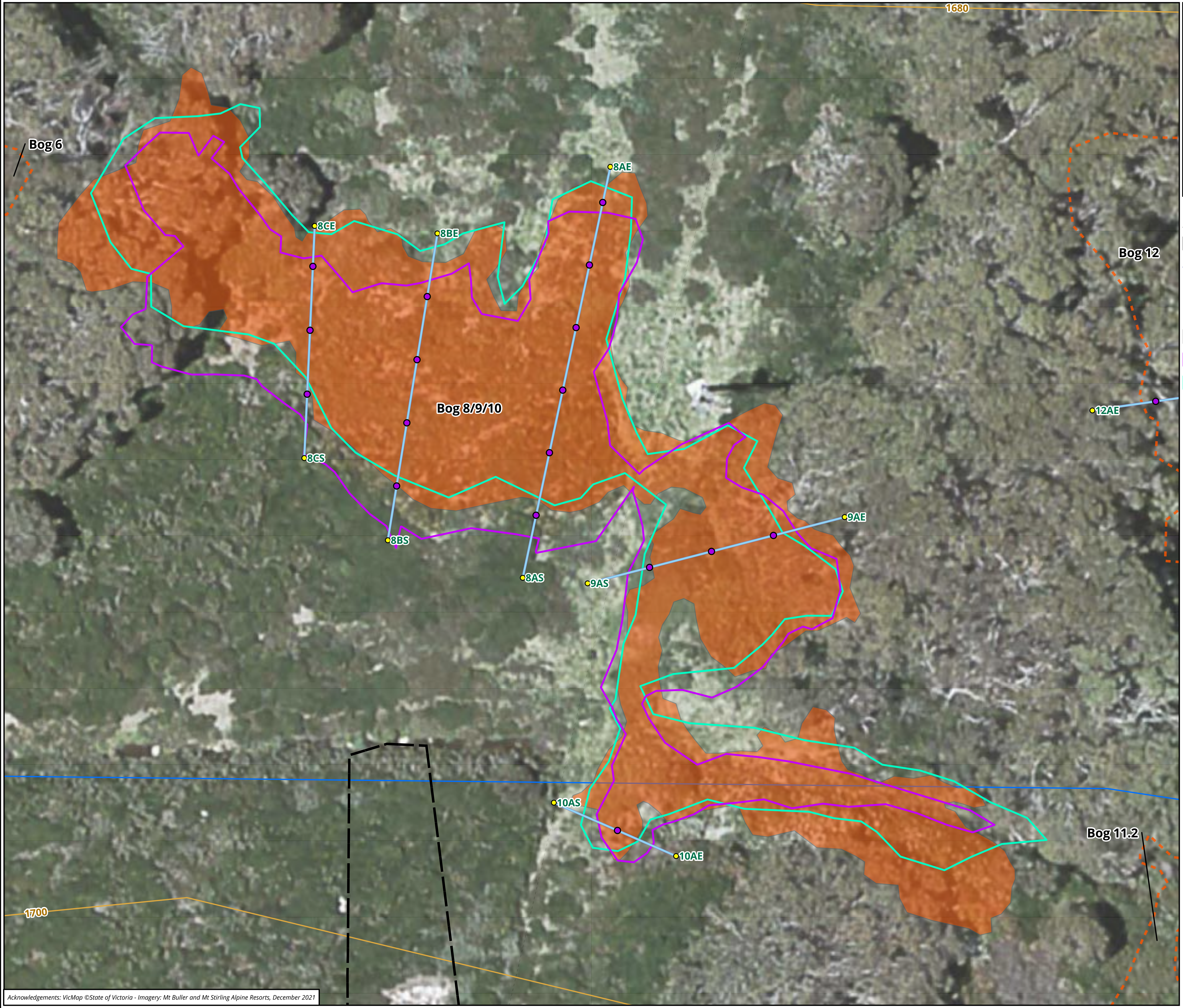
Scale: 1:800 @ A3

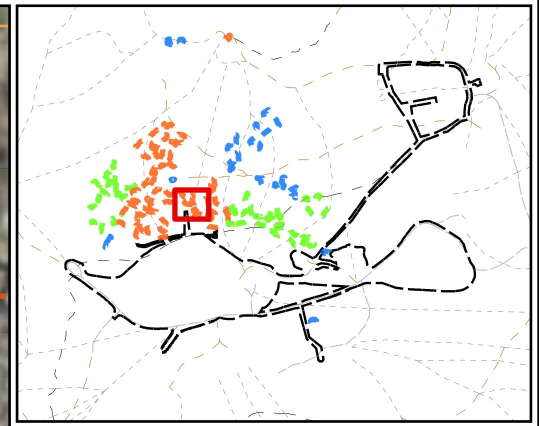
Coordinate System: GDA 1994 MGA Zone 55

N

biosis

Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Impact area
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx





Legend

- Project Construction Footprint
- Transects
- Quadrats
- Photo points
- Impact site (2022)
- Baseline year 1
- Baseline year 2

Figure 4g Bog 8/9/10 (impact site)

0 1.5 3 4.5 6 7.5
Metres
N

Scale: 1:220 @ A3
Coordinate System: GDA 1994 MGA Zone 55

biosis

Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Impact area
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx

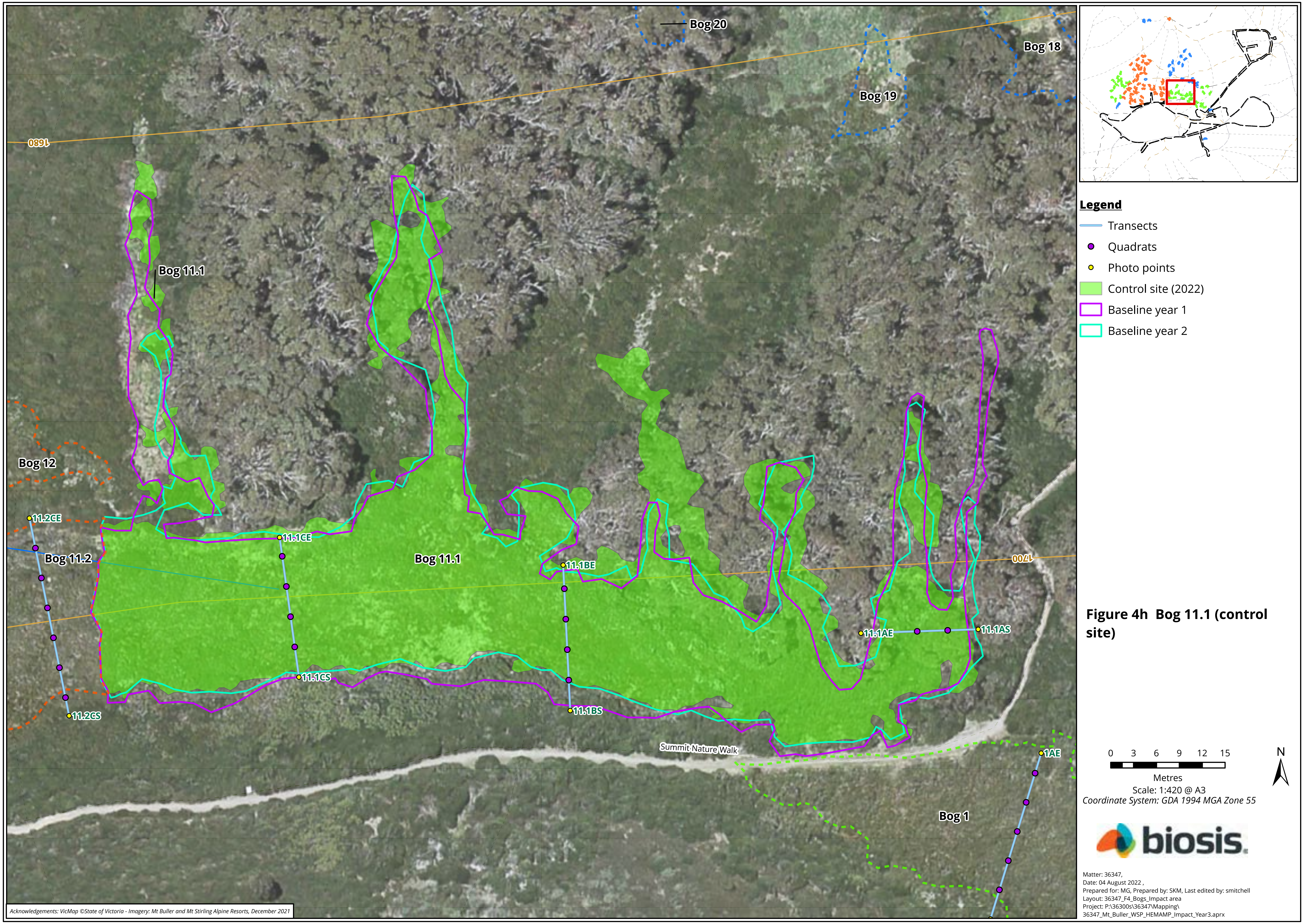
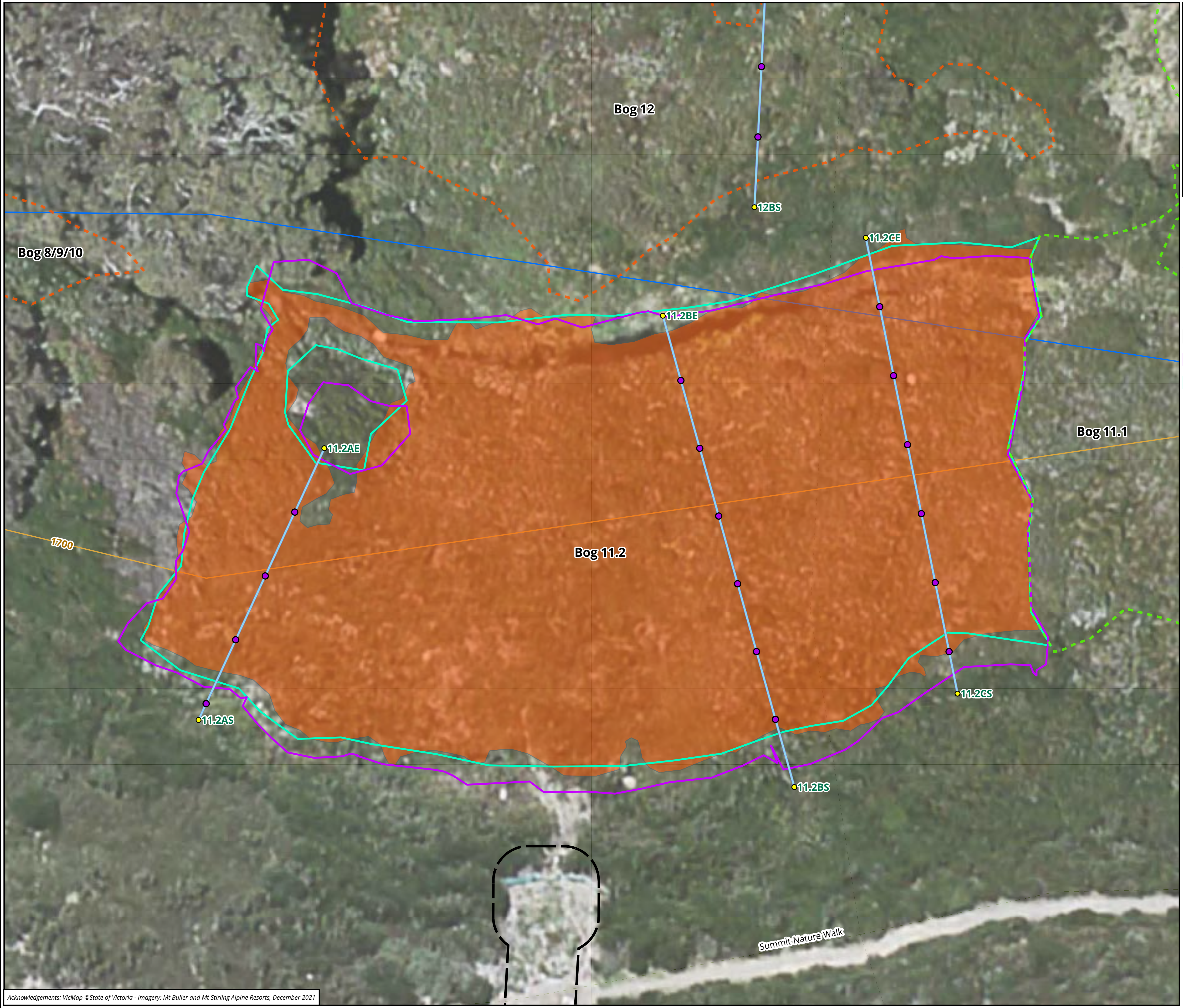
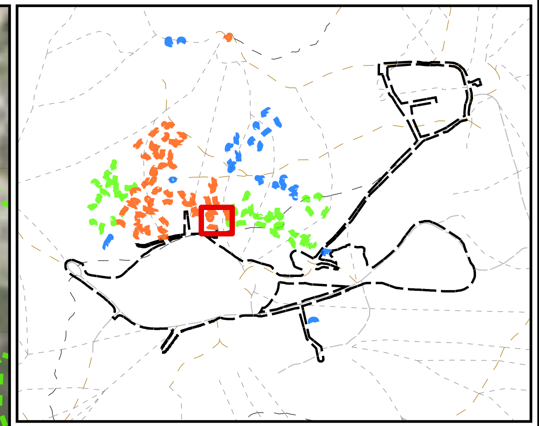


Figure 4h Bog 11.1 (control site)

Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Impact area
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx





Legend

- Project Construction Footprint
- Transects
- Quadrats
- Photo points
- Impact site (2022)
- Baseline year 1
- Baseline year 2

Figure 4i Bog 11.2 (impact site)

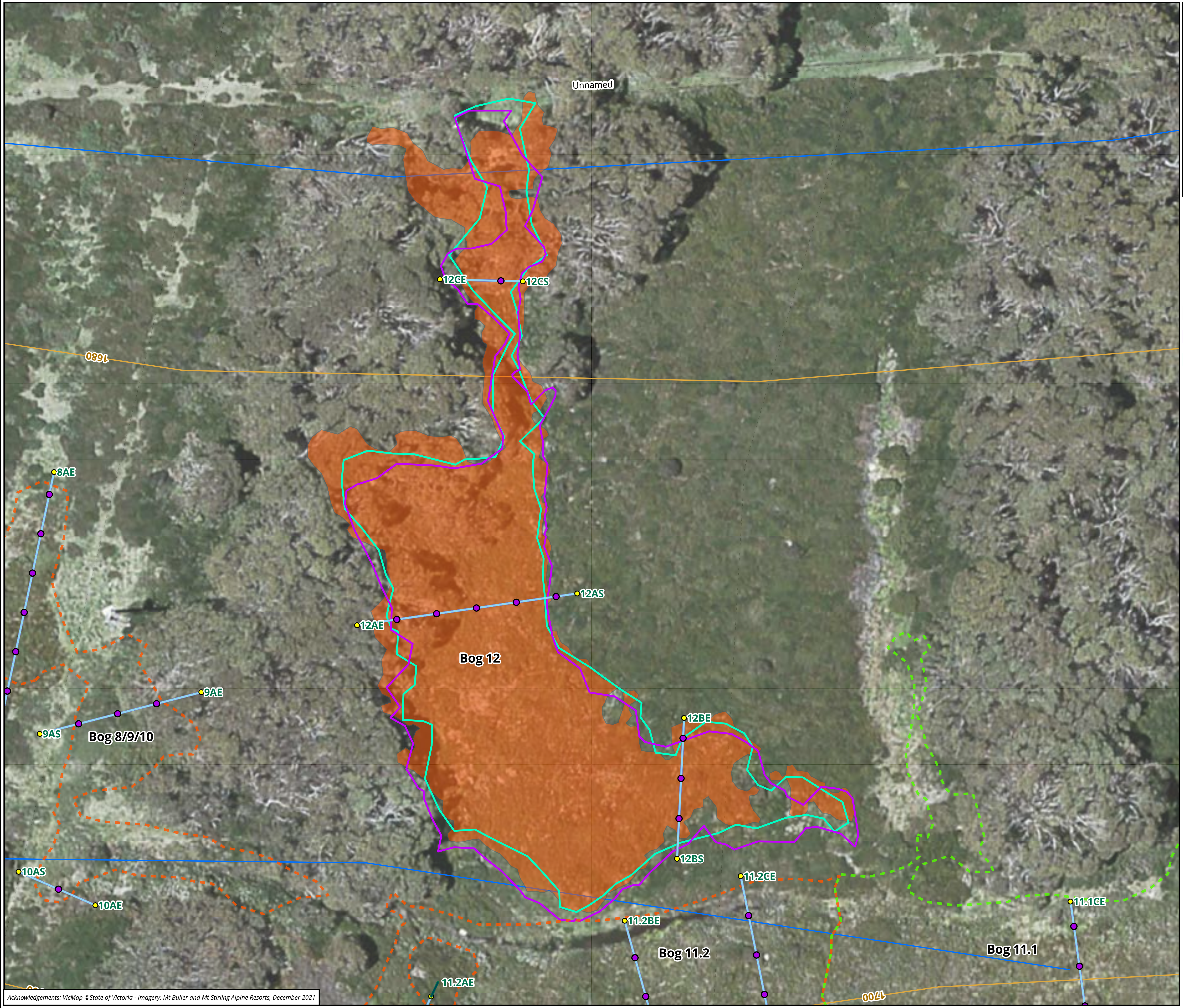
0 1.5 3 4.5 6 7.5
Metres
N

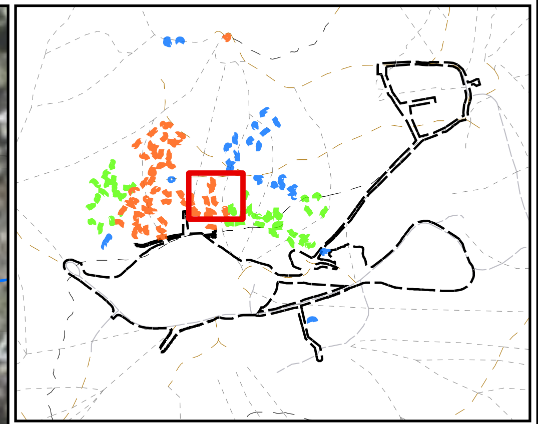
Scale: 1:200 @ A3

Coordinate System: GDA 1994 MGA Zone 55

biosis

Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Impact area
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx





Legend

- Transects
- Quadrats
- Photo points
- Impact site (2022)
- Baseline year 1
- Baseline year 2

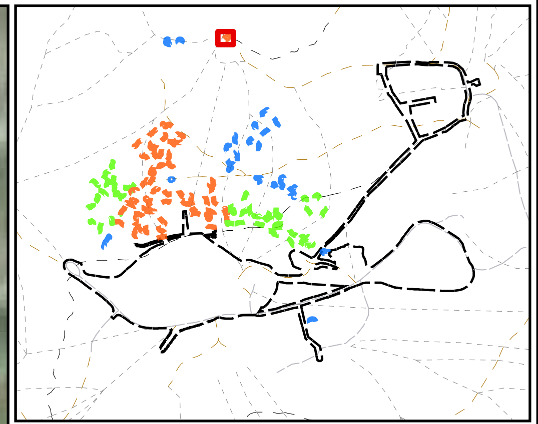
Figure 4j Bog 12 (impact site)

0 2.5 5 7.5 10 12.5
Metres
Scale: 1:350 @ A3
Coordinate System: GDA 1994 MGA Zone 55

N

biosis

Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Impact area
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx



Legend

- Transects
- Quadrats
- Photo points
- Impact site (2022)
- Baseline year 1
- Baseline year 2

Figure 4k Bog 13 (impact site)

0 0.8 1.6 2.4 3.2 4

Metres

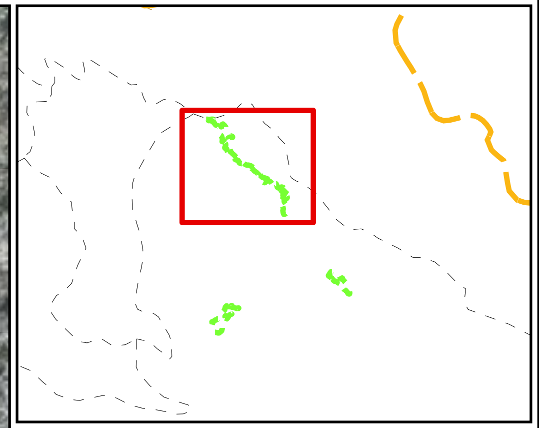
N

Scale: 1:100 @ A3

Coordinate System: GDA 1994 MGA Zone 55

biosis.

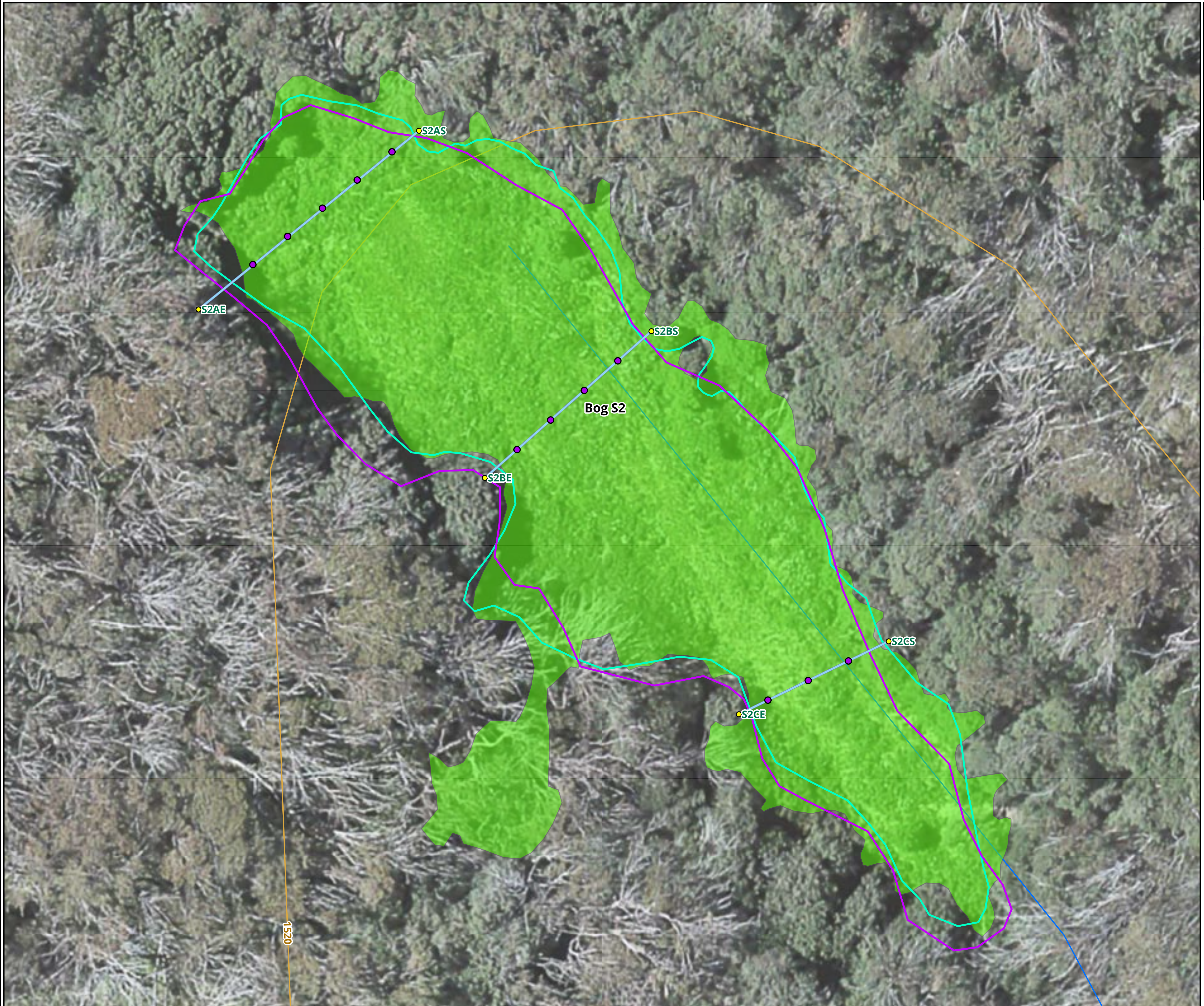
Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Impact area
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx



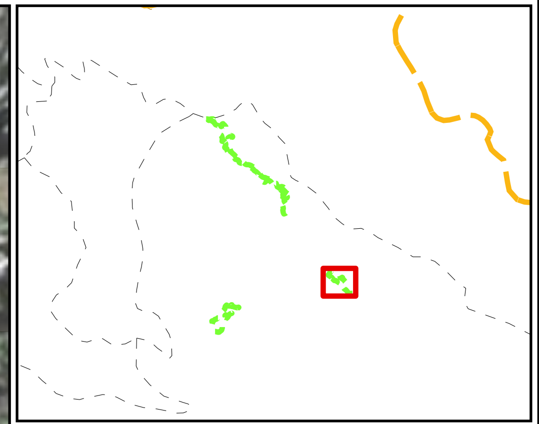
Legend

Figure 4l Bog S1 (control site)

Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Stirling
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx



Acknowledgements: VicMap ©State of Victoria - Imagery: Mt Buller and Mt Stirling Alpine Resorts, December 2021



Legend

- Transects
- Quadrats
- Photo points
- Control site (2022)
- Baseline year 1
- Baseline year 2

Figure 4m Bog S2 (control site)

0 2.5 5 7.5 10 12.5

Metres

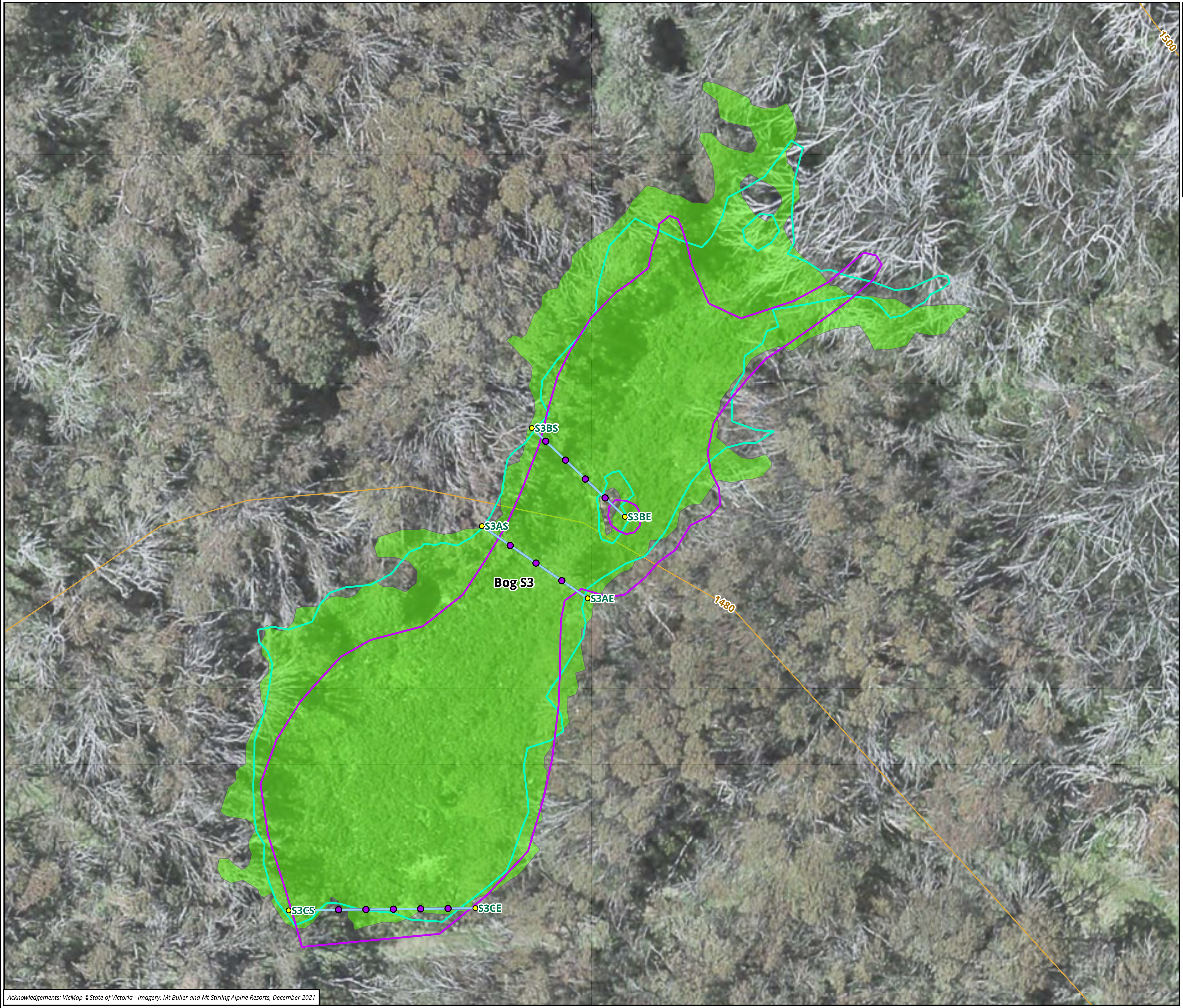
N

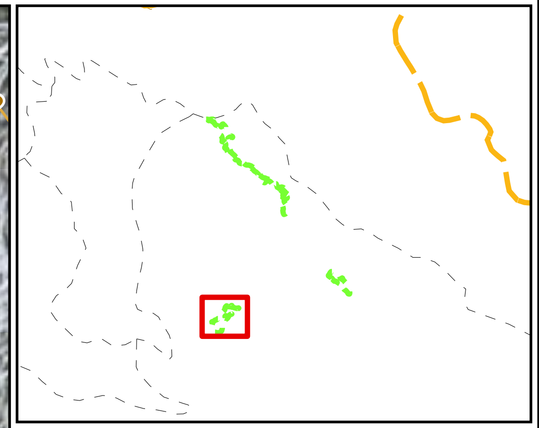
Scale: 1:320 @ A3

Coordinate System: GDA 1994 MGA Zone 55

biosis

Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Stirling
Project: P:\36300s\36347\Mapping\
36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx





Legend

- Transects
- Quadrats
- Photo points
- Control site (2022)
- Baseline year 1
- Baseline year 2

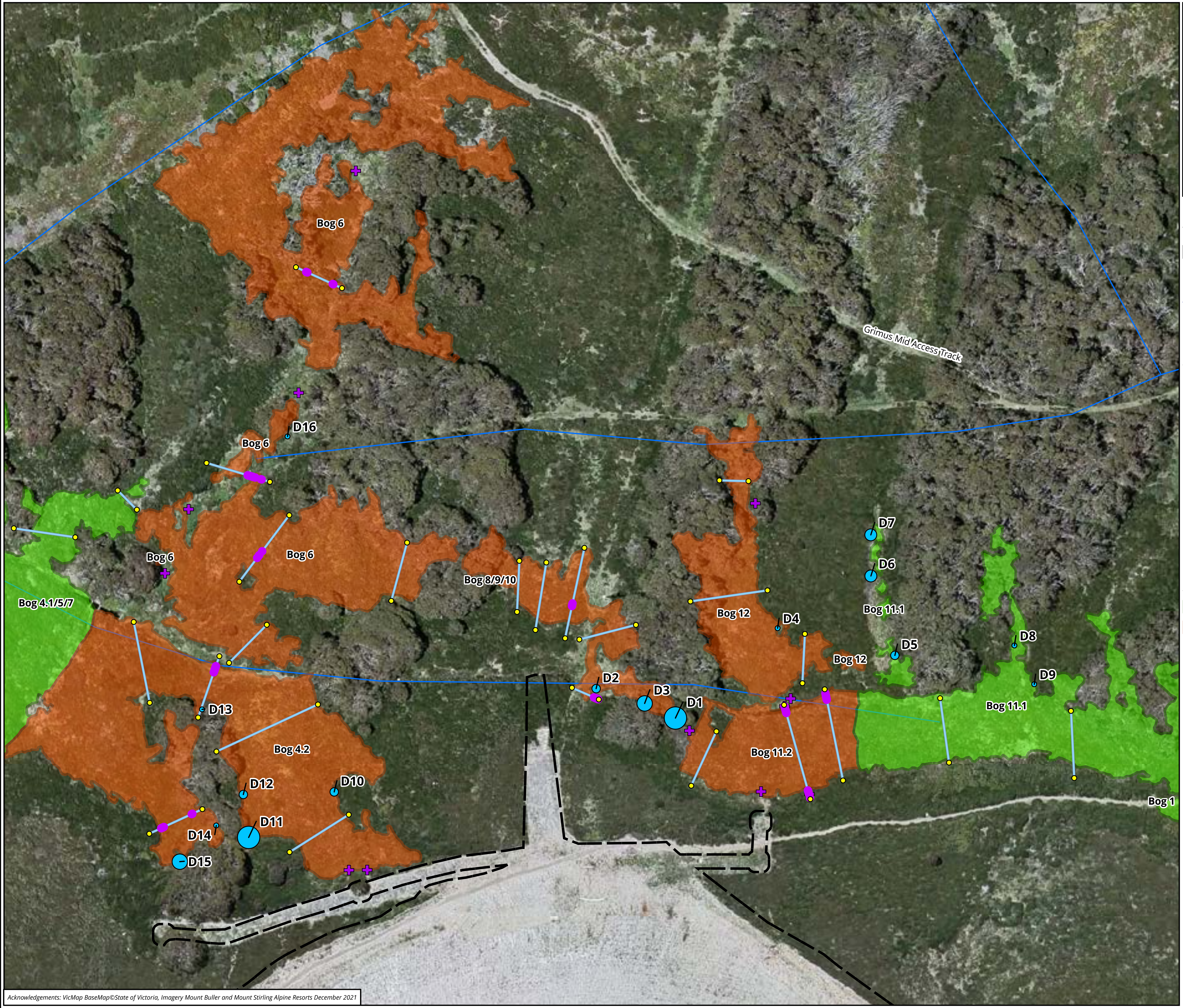
Figure 4n Bog S3 (control site)

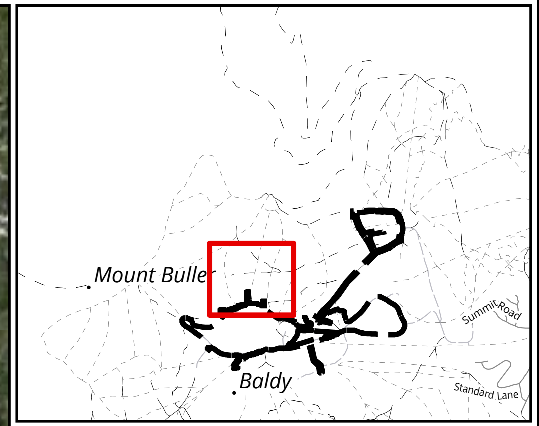
0 3.5 7 10.5 14 17.5
Metres
Scale: 1:450 @ A3
Coordinate System: GDA 1994 MGA Zone 55

N

biosis.

Matter: 36347,
Date: 04 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 36347_F4_Bogs_Stirling
Project: P:\36300s\36347\Mapping\36347_Mt_Buller_WSP_HEMAMP_Impact_Year3.aprx





Legend

- Project Construction Footprint (PCF)
- Photo points
- Transects

Dieback of non-bog-dependent flora (2022)

Approximate area sq.m

- 1 - 3
- 4 - 6
- 7 - 10
- 11 - 20
- 21 - 30

Impact

- Sediment recorded by transect monitoring (2021)
- Sediment recorded during on-ground mapping (2021)

Alpine Bogs

- Control sites (2022)
- Impact sites (2022)

Figure 5 Locations of dieback of Alpine Grassy Heathland and Sub-alpine Woodland (non-bog-dependent flora) surrounding Alpine Bog vegetation in Impact Year 3

0 10 20 30 40 50
Metres
N

Scale: 1:1,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

Matter: 33202,
Date: 31 August 2022 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 33202_F5_Dieback_IY3
Project: P:\33200s\33202\Mapping\33202_WSP_Offset.aprx

Photos

Photo 1 Former area of Bog 6, approximately 30 metres downstream from aqueduct, now dominated by grassy and herbaceous weeds (IY3; 9 February 2022; compare with Photo 2 and Photo 3).

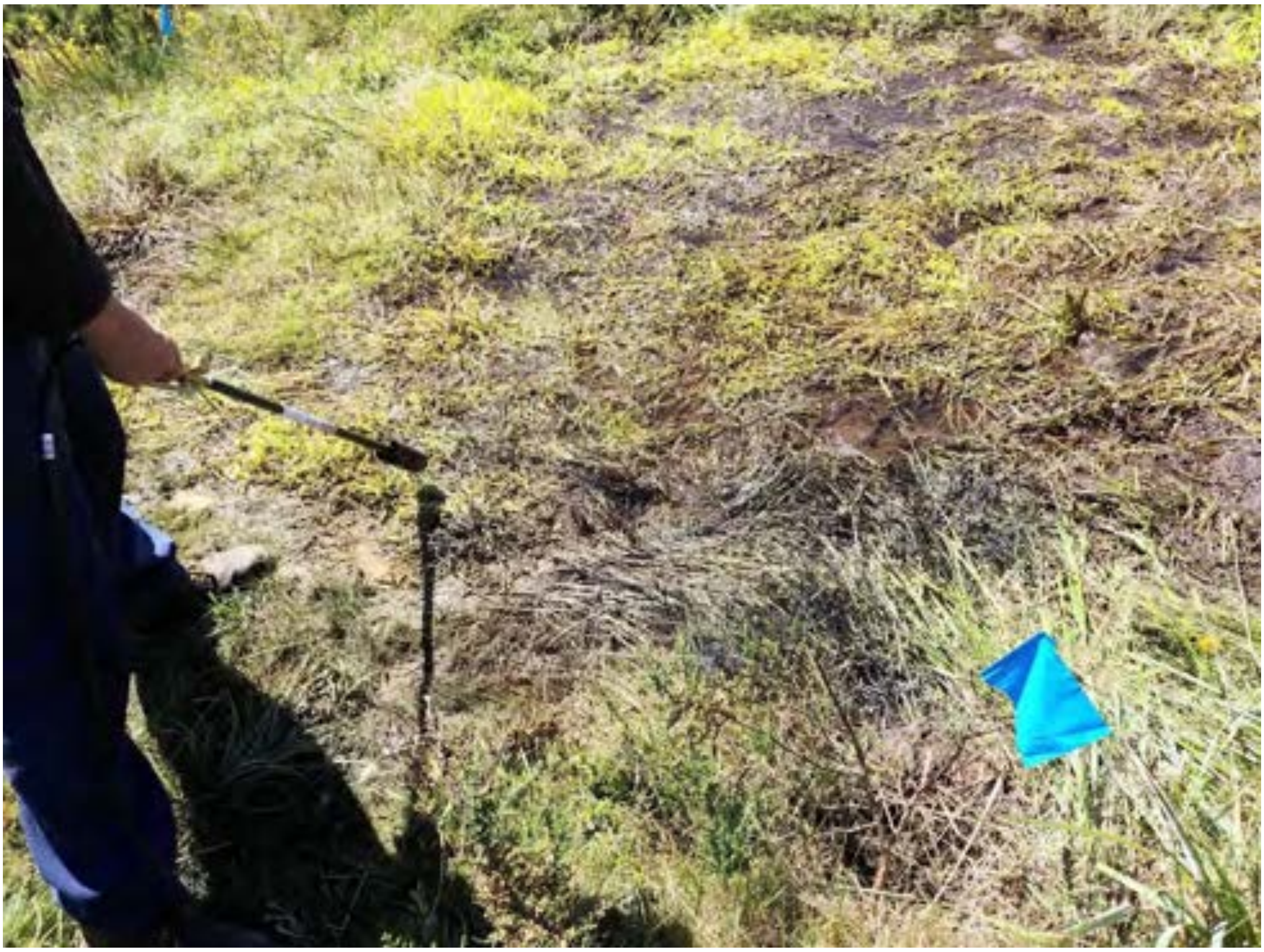


Photo 2 **Heat treatment of grassy and herbaceous weeds in former area of Bog 6, approximately 30 metres downstream from aqueduct (IY3; 17 February 2022; compare with Photo 1 and Photo 3).**

Photo 3 **Former area of Bog 6, approximately 30 metres downstream from aqueduct, after heat treatement and during application of jute mat for smothering grassy and herbaceous weeds (IY3; 17 February 2022; compare with Photo 1 and Photo 2).**

Photo 4 Examples of bags of weed material collected from Mount Buller Alpine Bogs in IY3, ready for solarisation and disposal.

Photo 5 **Deer wallow at the north-eastern edge of Bog S3, when first discovered (IY1; 14 March 2020; compare with Photo 6 and Photo 7).**

Photo 6 **Deer wallow at the north-eastern edge of Bog S3, one year after discovery, showing worsening impacts from deer activity (IY2; 3 February 2021; compare with Photo 5 and Photo 7).**

Photo 7 **Deer wallow at the north-eastern edge of Bog S3, two years after discovery and less than one year after culling of more than 50 deer, showing much reduced deer activity (IY3; 2 February 2022; compare with Photo 5 and Photo 6).**

Photo 8 **Deer resting site at Bog 4.2 in IY2, facing south with arrow pointing eastwards at future dieback location (Location D15; IY2; 25 February 2021; compare with Photo 9).**

Photo 9 **Deer resting site at Bog 4.2 in IY3, facing east with arrow pointing eastwards at dieback location (Location D15; IY3; 9 February 2022; compare with Photo 8).**

Photo 10 White Clover (arrow) germinating from deer scats in Bog S2 in IY3.

Photo 11 Continued sediment discharge from Bog 11.2 into the aqueduct (IY3; 15 February 2021).

Photo 12 Example of rime ice damage to Snow Gum in IY3, resulting in fallen branch smothering Alpine Bog vegetation at Bog 4.2 (IY3; 9 February 2022).

Photo 13 Dieback of non-bog-dependent flora at western boundary of Bog 11.2 (Location D1; IY3; 1 February 2022).

Photo 14 Aqueduct between Bog 11.2 (right) and Bog 12 (left), facing east (BY1; 27 January 2018, before construction).

Photo 15 **Aqueduct between Bog 11.2 (right) and Bog 12 (left), facing east (IY1; 6 February 2020, during construction).**

Photo 16 **Aqueduct between Bog 11.2 (right) and Bog 12 (left), facing east (IY2; 25 February 2021, after construction).**

Photo 17 Aqueduct between Bog 11.2 (right) and Bog 12 (left), facing east (IY3; 15 February 2022, after construction).

Photo 18 A rock that entered Bog 11.2 from the PCF in IY1 (IY2; 18 February 2020).

Photo 19 The rock in Bog 11.2 in IY2, with death of surrounding vegetation (IY2; 24 February 2021).

Photo 20 The rock in Bog 11.2 in IY3, with some recovery of bog-dependent flora but also coloinsation by weeds (IY3; 17 February 2022).

Photo 21 Pugging by horses at Bog S1 near Stirling Trail in IY3, with weeds now dominating the vegetative cover of the disturbed ground (IY3; 16 February 2022).

Appendices

Appendix 1 HEMAMP monitoring calendar

Table A1.1 summarises the frequency and timing of the ecological monitoring and highlights where datasets may be incomplete. The following codes are used in Table A1.1:

Code	Meaning
Yes	Complete dataset for given month
Part	Partially complete dataset for given month
No	Missing dataset for given month
(C)	Data relevant to control sites
(I)	Data relevant to impact sites
(C/I)	Data relevant to control and impact sites

Table A1.1 Timing, frequency and completeness of the HEMAMP's ecological datasets

			Baseline Year 1											
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
						2017						2018		
Ecology	Transect monitoring	Control sites									Yes			
		Impact sites								Yes	Yes			
	Mapping	Control sites								Yes	Yes			
		Impact sites								Yes	Yes			

			Baseline Year 2											
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
						2018						2019		
Ecology	Transect monitoring	Control sites								Yes	Yes			
		Impact sites								Yes	Yes			
	Mapping	Control sites									Yes			
		Impact sites									Yes			

			Impact Year 1											
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
						2018						2019		
Ecology	Transect monitoring	Control sites								Yes	Yes			
		Impact sites									Yes			
	Mapping	Control sites								Yes	Yes	Yes		
		Impact sites								Yes	Yes	Yes		

			Impact Year 2											
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
			2018							2019				
Ecology	Transect monitoring	Control sites								Yes	Yes			
		Impact sites								Yes	Yes			
	Mapping	Control sites									Yes			
		Impact sites									Yes			

			Impact Year 3											
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
			2018							2019				
Ecology	Transect monitoring	Control sites								Yes	Yes			
		Impact sites								Yes	Yes			
	Mapping	Control sites									Yes			
		Impact sites									Yes			

Appendix 2 Flora species lists

The following status codes are used in this Appendix:

Code	Meaning	Notes
National significance		
CR	Critically endangered	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
EN	Endangered	
VU	Vulnerable	
State significance		
cr	Critically endangered	Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act)
e	Endangered	
v	Vulnerable	
P	Protected species (public land only)	
Noxious weed status		
SP	State prohibited species	Victorian *Catchment and Land Protection Act 1994* (CaLP Act) statuses within the Goulburn Broken/North East catchments
RP	Regionally prohibited species	
RC	Regionally controlled species	
R	Restricted species	
Other		
#	Native species outside its natural range	Assessed using VBA (DELWP 2021) and VicFlora (RBGV 2021)
^	Bog-dependent species	Refer to Diagnostic Key to Alpine Bogs (Appendix 3)

Table A2.1 Flora species list for all Alpine Bogs

Status	Scientific Name	Common Name
Indigenous species		
	Acaena novae-zelandiae	Bidgee-widgee
	Achrophyllum dentatum	Toothed Mitre-moss
e P	*Aciphylla glacialis*	Snow Aciphyll
e P	*Acrothamnus montanus*	Snow Beard-heath
	Agrostis parviflora s.s.	Hair Bent
	Anthosachne scabra s.s.	Common Wheat-grass
e P	*Argyrotegium poliochlorum*	Grey-green Cudweed
P	*Asperula conferta*	Common Woodruff
P	*Asperula gunnii*	Mountain Woodruff
^	*Astelia alpina* var. *novae-hollandiae*	Silver Astelia
P ^	*Baeckea gunniana*	Alpine Baeckea
e P ^	*Baeckea latifolia*	Subalpine Baeckea
P ^	*Baeckea utilis s.s.*	Mountain Baeckea
	Bartramia robusta	Common Apple-moss
P	*Blechnum penna-marina* subsp. *alpina*	Alpine Water-fern
P	*Brachyscome scapigera*	Tufted Daisy
P	*Brachyscome spathulata*	Spoon Daisy
	Brachythecium paradoxum	Feather Moss
	Brachythecium rutabulum	Rough-stalked Feather-moss
	Brachythecium salebrosum	Smooth-stalk Feather-moss
	Brachythecium spp.	Feather Moss
^	*Callistemon pityoides*	Alpine Bottlebrush
	Campylopus introflexus	Heath Star Moss
	Carex appressa	Tall Sedge
	Carex austroflaccida	Mountain Hook-sedge
	Carex breviculmis	Common Grass-sedge
	Carex hebes	Mountain Sedge
e ^	*Carex jackiana*	Carpet Sedge
	Carex spp.	Sedge
	Catagonium nitens subsp. *nitens*	Feather-tail Moss
e P	*Celmisia latifolia*	Victorian Snow-daisy
P	*Celmisia* spp.	Snow Daisy
v P	*Celmisia tomentella*	Silver Snow-daisy
P	*Chiloglottis cornuta*	Green Bird-orchid
P	*Chiloglottis* spp.	Bird Orchid
	Chiloscyphus semiteres var. *semiteres*	Common Crestwort
	Chiloscyphus trialatus (syn. *Chiloscyphus pallidus*)	Greasy Crestwort
	Clematis aristata	Mountain Clematis
P	*Coronidium monticola*	Mountain Everlasting
P	*Cotula alpina*	Alpine Cotula
e P	*Craspedia adenophora*	Sticky Billy-buttons
P	*Craspedia aurantia s.l.*	Orange/Green Billy-buttons

Status	Scientific Name	Common Name
e P	*Craspedia lamicola*	Bog Billy-buttons
P	*Craspedia* spp.	Billy Buttons
e P	*Craspedia sylvestris*	Mountain Forest Billy-buttons
^	*Empodisma minus*	Spreading Rope-rush
P ^	*Epacris paludosa*	Swamp Heath
	Epilobium billardiereanum subsp. *billardiereanum*	Smooth Willow-herb
	Epilobium billardiereanum subsp. *hydrophilum*	Robust Willow-herb
v	*Epilobium sarmentaceum*	Mountain Willow-herb
	Epilobium spp.	Willow Herb
	Eucalyptus pauciflora	Snow Gum
P	*Euchiton involucratus s.s.*	Star Cudweed
P	*Euchiton sphaericus*	Annual Cudweed
P	*Euchiton* spp.	Cudweed
	Exocarpos nanus	Alpine Ballart
	Gemmabryum sauteri	Sauter's Thread-moss
	Gentianella cunninghamii subsp. *major*	Tall Snow-gentian
v	*Gentianella muelleriana* subsp. *willisiana*	Mt Buller Snow-gentian
	Geranium potentilloides var. 1	Soft Crane's-bill
	Geranium sp. 7	Alpine Swamp Crane's-bill
	Gonocarpus micranthus	Creeping Raspwort
	Gonocarpus montanus	Mat Raspwort
	Gonocarpus tetragynus	Common Raspwort
	Goodenia hederacea	Ivy Goodenia
P	*Grevillea australis*	Alpine Grevillea
	Grimmia pulvinata var. *africana*	Blunt-beak Grimmia
^	*Hierochloe redolens*	Sweet Holy-grass
	Hovea montana	Alpine Rusty-pods
e P	*Huperzia australiana*	Fir Clubmoss
	Hydrocotyle hirta	Hairy Pennywort
	Hydrocotyle spp.	Pennywort
	Hygrolembidium acrocladum	Fingerwort
	Hymenodontopsis mnioides (syn. *Pyrrhobryum mnioides*)	Woolly-stem Thyme-moss
	Hypericum japonicum	Matted St John's Wort
	Isolepis aucklandica	New Zealand Club-sedge
	Isolepis habra	Wispy Club-sedge
e	*Isolepis montivaga*	Fog Club-sedge
	Isolepis spp.	Club Sedge
	Isolepis subtilissima	Mountain Club-sedge
P	*Lagenophora montana*	Mountain Bottle-daisy
P	*Lagenophora stipitata s.s.*	Blue Bottle-daisy
	Leionema phylicifolium	Alpine Leionema
	Leptospermum grandifolium	Mountain Tea-tree
	Libertia pulchella	Pretty Grass-flag
	Luzula modesta	Southern Woodrush

Status	Scientific Name	Common Name
	Luzula spp.	Woodrush
P	*Lycopodium fastigiatum*	Mountain Clubmoss
cr P	*Lycopodium scariosum*	Spreading Clubmoss
	Marchantia berteroana	Common Marchantia
	Melicytus sp. aff. *dentatus* (snowfields variant)	Alpine Shrub-violet
	Mentha laxiflora	Forest Mint
P	*Microseris lanceolata*	Alpine Yam-daisy
P ^	*Olearia algida*	Mountain Daisy-bush
e P	*Olearia phlogopappa* subsp. *flavescens*	Dusty Daisy-bush
	Oreobolus distichus	Fan Tuft-rush
	Oreomyrrhis eriopoda	Australian Caraway
	Orites lancifolius	Alpine Orites
	Orthodontium lineare	Cape Thread-moss
P	*Ozothamnus cupressoides*	Kerosene Bush
e	*Phebalium squamulosum* subsp. *alpinum*	Alpine Phebalium
P	*Picris angustifolia* subsp. *merxmuelleri*	Highland Picris
	Pimelea alpina	Alpine Rice-flower
	Pimelea ligustrina	Tall Rice-flower
	Pimelea spp.	Rice Flower
	Plantago euryphylla	Broad Plantain
	Poa costiniana	Bog Snow-grass
	Poa ensiformis	Sword Tussock-grass
	Poa fawcettiae	Horny Snow-grass
	Poa hiemata	Soft Snow-grass
	Poa hothamensis	Ledge Grass
	Poaceae spp.	Grass
	Podocarpus lawrencei	Mountain Plum-pine
P	*Podolepis robusta*	Alpine Podolepis
P	*Podolepis* spp.	Podolepis
	Podolobium alpestre	Alpine Podolobium
P	*Polystichum proliferum*	Mother Shield-fern
	Polytrichum commune	Common Haircap
	Polytrichum spp.	Haircap
P	*Prasophyllum alpestre*	Mauve Leek-orchid
P	*Prasophyllum* spp.	Leek Orchid
	Ptychostomum pseudotriquetrum	Bog Bryum
	Ranunculus graniticola	Granite Buttercup
e	*Ranunculus gunnianus*	Gunn's Alpine Buttercup
	Ranunculus lappaceus	Australian Buttercup
	Ranunculus pimpinellifolius	Bog Buttercup
	Ranunculus scapiger	Hairy Buttercup
	Ranunculus spp.	Buttercup
	Rhaphidorrhynchium amoenum	Common Signal-moss
P ^	*Richea continentis*	Candle Heath
	Rosulabryum capillare	Capillary Thread-moss

Status	Scientific Name	Common Name
	Rubus parvifolius	Small-leaf Bramble
	Rumex brownii	Slender Dock
	Rytidosperma nudiflorum	Alpine Wallaby-grass
	Rytidosperma penicillatum	Weeping Wallaby-grass
	Rytidosperma spp.	Wallaby Grass
	Sanionia uncinata	Sickle-leaved Hook-moss
	Schoenus calyptratus	Alpine Bog-sedge
e	*Scleranthus brockiei*	Brock Knawel
P	*Senecio gunnii*	Mountain Fireweed
e P	*Senecio pinnatifolius* var. *alpinus*	Snowfield Groundsel
P ^	*Sphagnum cristatum*	Peat Moss
	Stellaria pungens	Prickly Starwort
P	*Stylidium armeria* subsp. *armeria*	Common Triggerplant
e P	*Stylidium montanum*	Alpine Triggerplant
P	*Stylidium* spp.	Trigger Plant
	Tasmannia xerophila subsp. *xerophila*	Alpine Pepper
P	*Thelymitra* spp.	Sun Orchid
e P	*Trochocarpa clarkei*	Lilac Berry
	Veronica serpyllifolia	Thyme Speedwell
	Viola betonicifolia	Showy Violet
	Wahlenbergia ceracea	Waxy Bluebell
	Wahlenbergia gloriosa	Royal Bluebell
P	*Xerochrysum subundulatum*	Orange Everlasting
	Zoopsis leitgebiana	Glass Centipede
Introduced species		
	Acetosella vulgaris	Sheep Sorrel
	Achillea millefolium	Milfoil
	Agrostis capillaris	Brown-top Bent
	Anthoxanthum odoratum	Sweet Vernal-grass
	Cerastium glomeratum s.s.	Sticky Mouse-ear Chickweed
	Cerastium spp.	Mouse-ear Chickweed
	Cerastium vulgare	Common Mouse-ear Chickweed
R/RC	*Cirsium vulgare*	Spear Thistle
	Dactylis glomerata	Cocksfoot
	Erythranthe guttata	Monkey Musk
	Erythranthe moschata	Musk Monkey-flower
	Festuca rubra s.s.	Creeping Fescue
	Glyceria declinata	Manna Grass
	Holcus lanatus	Yorkshire Fog
	Hypochaeris radicata	Flatweed
	Juncus articulatus subsp. *articulatus*	Jointed Rush
	Juncus effusus subsp. *effusus*	Soft Rush
	Juncus ensifolius	Sword Rush
	Malus pumila	Apple

Status	Scientific Name	Common Name
	Phleum pratense	Timothy Grass
	Ranunculus repens	Creeping Buttercup
RC	*Rubus anglocandicans*	Common Blackberry
	Rumex conglomeratus	Clustered Dock
	Sonchus asper s.s.	Rough Sow-thistle
	Taraxacum officinale spp. agg.	Garden Dandelion
	Trifolium repens var. *repens*	White Clover
	Viola arvensis	Field Pansy

Table A2.2 Bog-dependent flora species list

Status	Scientific Name	Common Name
^	*Astelia alpina* var. *novae-hollandiae*	Silver Astelia
P ^	*Baeckea gunniana*	Alpine Baeckea
e P ^	*Baeckea latifolia*	Subalpine Baeckea
P ^	*Baeckea utilis s.s.*	Mountain Baeckea
^	*Callistemon pityoides*	Alpine Bottlebrush
e ^	*Carex jackiana*	Carpet Sedge
^	*Empodisma minus*	Spreading Rope-rush
P ^	*Epacris paludosa*	Swamp Heath
^	*Hierochloe redolens*	Sweet Holy-grass
P ^	*Olearia algida*	Mountain Daisy-bush
P ^	*Richea continentis*	Candle Heath
P ^	*Sphagnum cristatum*	Peat Moss

Table A2.3 Differences between Mountain Baeckea and Subalpine Baeckea

Feature	Mountain Baeckea *Baeckea utilis s.s.*	Subalpine Baeckea *Baeckea latifolia*	Reference
Plant height	Up to 4 m (1–3 m)	Up to 1.5 m (1–3 m)	Bean 1997 (VicFlora 2021)
Branchlets	Yellowish to grey; oil glands absent	Pink to grey; oil glands present	Bean 1997
Leaf shape	Narrowly obovate to elliptical (Oblanceolate to elliptic)	Broadly elliptical (Elliptic or obovate)	Bean 1997 (VicFlora 2021)
Leaf keel	Keeled or not keeled (Keeled)	Not keeled (Not distinctly keeled)	Bean 1997 (VicFlora 2021)
Leaf cross-section	Triangular, concavo-convex (More or less flat above)	Flat (More or less flat)	Bean 1997 (VicFlora 2021)
Leaf length	3.4–7.0 mm (4.0–10.0 mm)	6.4–9.0 mm (6.0–9.0 mm)	Bean 1997 (VicFlora 2021)
Leaf width	0.9–2.3 mm (1.0–3.0 mm)	2.3–5.3 mm (2.0–6.0 mm)	Bean 1997 (VicFlora 2021)
Petiole length	0.5–0.8 mm	1.2–1.5 mm	Bean 1997
Pedicel length	1.6–2.5 mm	3.0–3.3 mm	Bean 1997 and VicFlora 2021
Stamens	8–10 (8–10, usually 8)	6–8 (6–8, usually 8)	Bean 1997 (VicFlora 2021)

Appendix 3 Diagnostic Key to Alpine Bogs

This diagnostic key has been reproduced from the key to the EPBC Act listed Alpine Sphagnum Bogs and Associated Fens ecological community on the Australian mainland, prepared by the Australian Government Department of the Environment (DoE 2013). The key appeared in early draft versions of the National Recovery Plan but does not appear in the final version, although the final version does make reference to the key (DoE 2015; A. Tolsma, ARI, pers. comm., February 2019).

Key to the listed Alpine *Sphagnum* bogs and Associated Fens ecological community on the Australian mainland

The listed ecological community comprises two main components, *Sphagnum* bogs and their associated fens. Fens, or fen pools, are species-poor communities typically linked to bogs. They are dominated by sedges and frequently inundated. The bogs which surround or link to fens generally display greater species diversity, and it is this diversity which in part guides the following key.

1. Are you above 1000m in elevation and in the Australian Alps bioregion?
Yes – go to 2 | No – Unlikely to be the listed community

2. Is live, hummock-forming *Sphagnum* present and abundant, or if burnt[1], can abundant pre-fire *Sphagnum* be inferred from burnt remnants?
Yes – Is the listed community | No, *Sphagnum* is minor or absent – go to 3

3. Does the site have a peat substrate evident?
Yes, or unsure – go to 4 | No – Unlikely to be the listed community

4. Is *Sphagnum* present?
Yes – go to 5 | No – go to 6

5. Is most of the non-*Sphagnum* vegetation cover composed of two or more of the diagnostic species listed below?
Yes – Is the listed community. | No – Not the listed community, but may be transitional or a degraded version[2]

6. Is most of the vegetation cover composed of 3 or more of the diagnostic species?
Yes – Is the listed community, possibly degraded. | No – Not the listed community, but may be transitional or a degraded version[2]

<u>Diagnostic species other than *Sphagnum*</u>:

- *Empodisma minus*
- *Epacris* spp (usually *E. paludosa, E. glacialis, E. celata or E. breviflora*)
- *Richea* spp (*R. continentis or R. victoriana*)
- *Baeckea* spp (usually *B. gunniana, B. latifolia or B.utilis*)
- *Astelia alpina*
- *Carpha nivicola*
- *Baloskion australe*
- *Carex gaudichaudiana*
- *Callistemon pityoides*
- *Hakea microcarpa*
- *Carex jackiana*[3]
- *Hierochloe redolens*[3]
- *Olearia algida*[3]

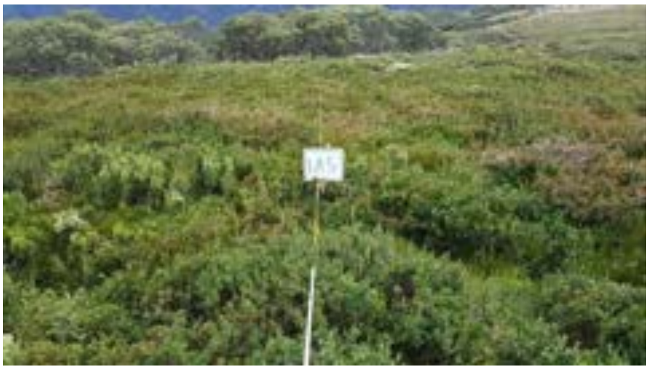
[1] If a site has been recently and severely burnt, *Sphagnum* and other key diagnostic species may be temporarily absent (live hummock-forming *Sphagnum* would normally comprise at least 20-30% cover).In this case, assessment of the site for the listed community should be delayed for at least 24 months. However, the presence of burnt hummocks over peat indicates the community is present.

[2] Clarification: no need to refer.

[3] This key originally appeared in a draft version of the National Recovery Plan for the Alpine Sphagnum Bogs and Associated Fens. The key has been left unchanged except for the addition of these three species and this footnote. These species have been added by Biosis for the purposes of monitoring Alpine Bogs at Mount Buller and Mount Stirling, Victoria. At these locations, Carex jackiana, Hierochloe redolens and Olearia algida are restricted to Alpine Bogs and are therefore amongst the diagnostic species.

Appendix 4 Photo points

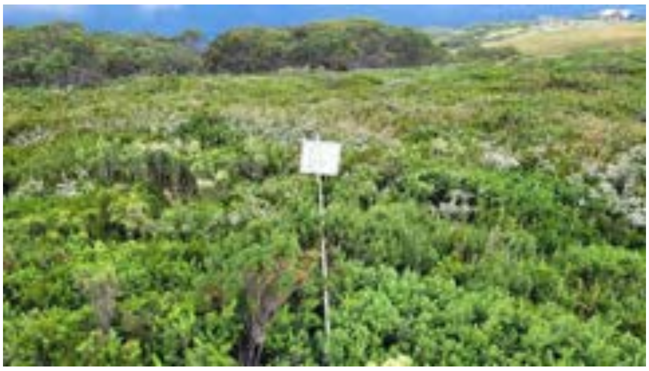
Bog 1 (Control Site), Photo Point 1AS


Baseline Year 1, 9 February 2018


Baseline Year 2, 31 January 2019

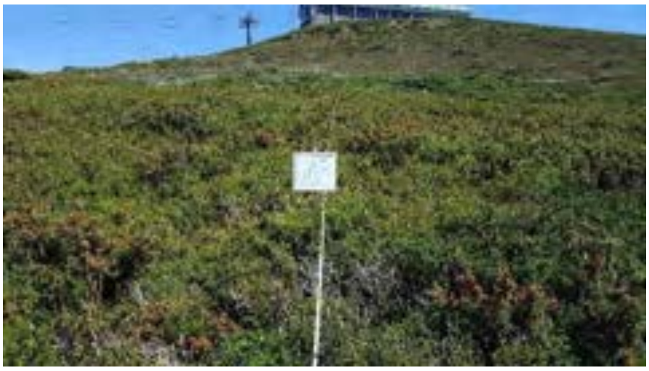

Impact Year 1, 31 January 2020


Impact Year 2, 2 February 2021


Impact Year 3, 31 January 2022

Bog 1 (Control Site), Photo Point 1AE

Baseline Year 1, 9 February 2018



Baseline Year 2, 31 January 2019

Impact Year 1, 31 January 2020

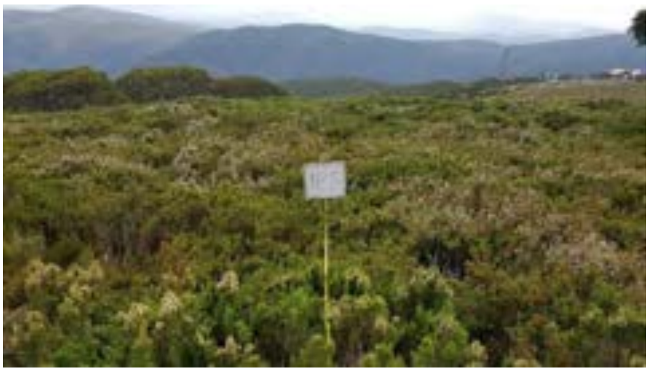
Impact Year 2, 2 February 2021

Impact Year 3, 31 January 2022

Bog 1 (Control Site), Photo Point 1BS

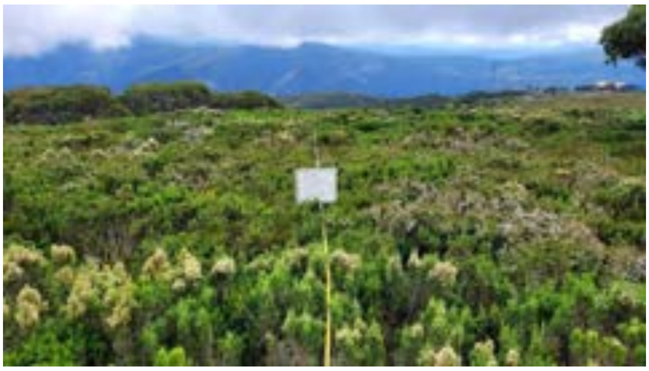
Baseline Year 1, 9 February 2018

Baseline Year 2, 31 January 2019



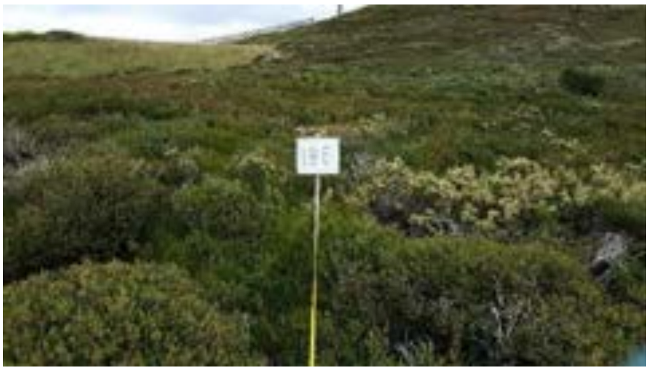
Impact Year 1, 31 January 2020

Impact Year 2, 2 February 2021



Impact Year 3, 31 January 2022

Bog 1 (Control Site), Photo Point 1BE



Baseline Year 1, 9 February 2018

Baseline Year 2, 31 January 2019

Impact Year 1, 31 January 2020

Impact Year 2, 2 February 2021

Impact Year 3, 31 January 2022

Bog 1 (Control Site), Photo Point 1CS


Baseline Year 1, 9 February 2018


Baseline Year 2, 31 January 2019


Impact Year 1, 31 January 2020


Impact Year 2, 2 February 2021


Impact Year 3, 31 January 2022

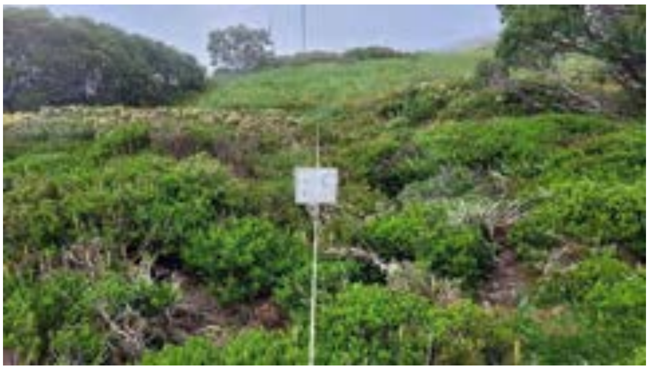
Bog 1 (Control Site), Photo Point 1CE

Baseline Year 1, 9 February 2018

Baseline Year 2, 31 January 2019

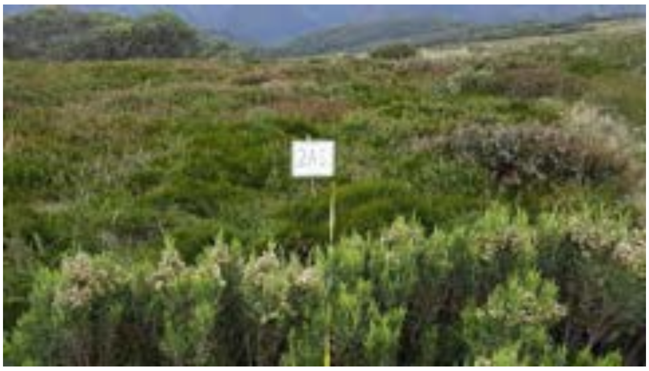
Impact Year 1, 31 January 2020

Impact Year 2, 2 February 2021



Impact Year 3, 31 January 2022

Bog 2 (Control Site), Photo Point 2AS



Baseline Year 1, 9 February 2018

Baseline Year 2, 31 January 2019

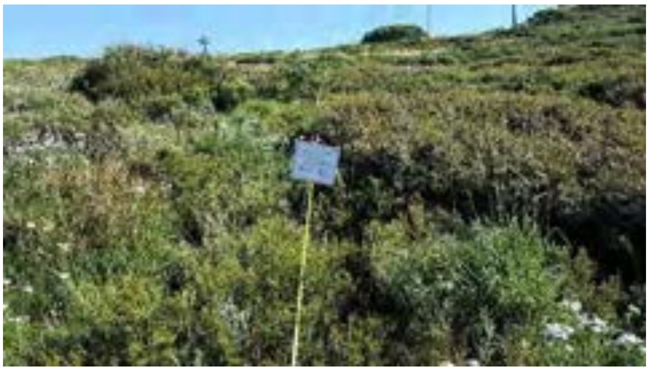
Impact Year 1, 3 February 2020

Impact Year 2, 26 January 2021

Impact Year 3, 31 January 2022

Bog 2 (Control Site), Photo Point 2AE


Baseline Year 1, 9 February 2018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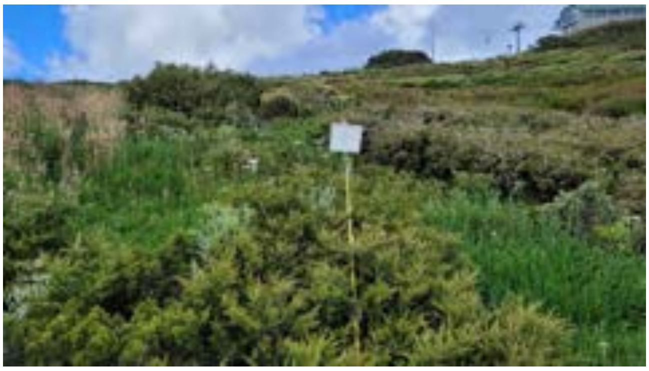
Impact Year 1, 3 February 2020


Impact Year 2, 26 January 2021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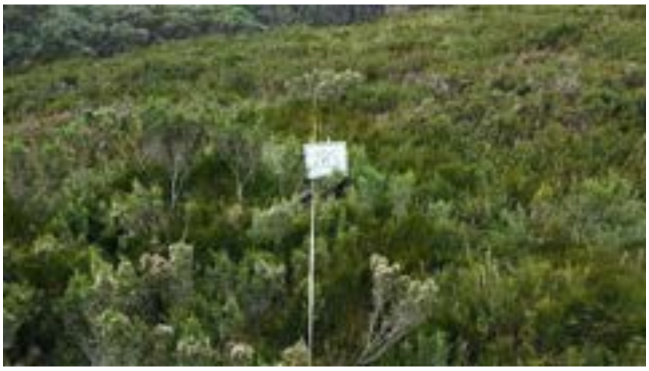
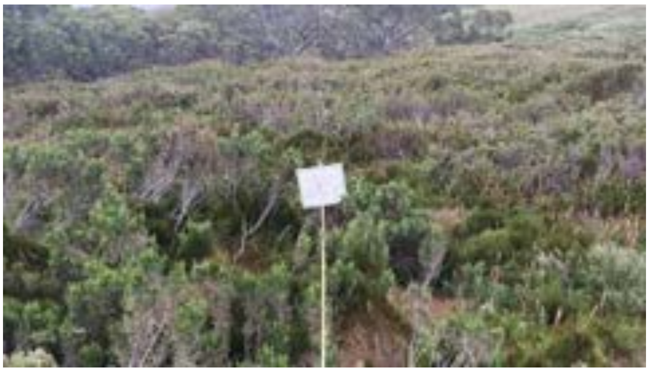
Bog 2 (Control Site), Photo Point 2BS


Baseline Year 1, 9 February 2018


Baseline Year 2, 1 February 2019


Impact Year 1, 3 February 2020


Impact Year 2, 25 January 2021


Impact Year 3, 31 January 2022

Bog 2 (Control Site), Photo Point 2BE

Baseline Year 1, 9 February 2018

Baseline Year 2, 1 February 2019

Impact Year 1, 3 February 2020

Impact Year 2, 25 January 2021

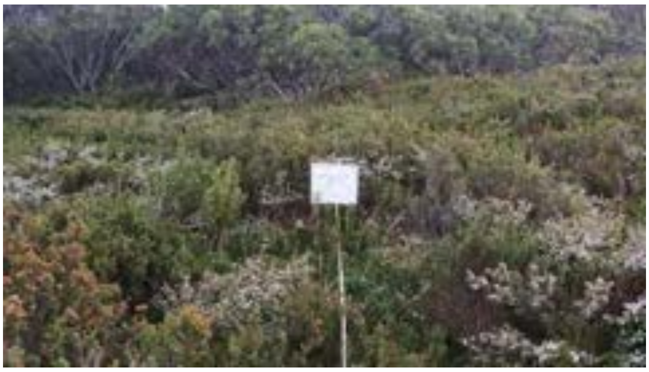
Impact Year 3, 31 January 2022

Bog 2 (Control Site), Photo Point 2CS

Baseline Year 1, 9 February 2018

Baseline Year 2, 1 February 2019

Impact Year 1, 3 February 2020



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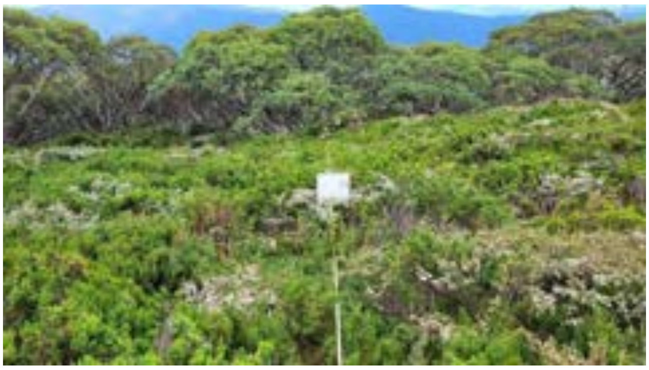


Impact Year 3, 31 January 2022

Bog 2 (Control Site), Photo Point 2CE


Baseline Year 1, 9 February 2018

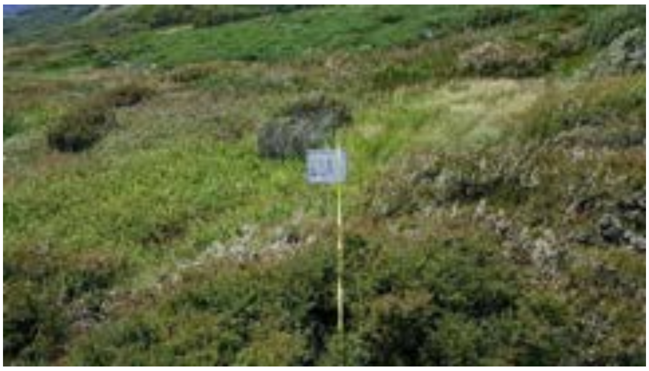

Baseline Year 2, 1 February 2019


Impact Year 1, 3 February 2020


Impact Year 2, 26 January 2021

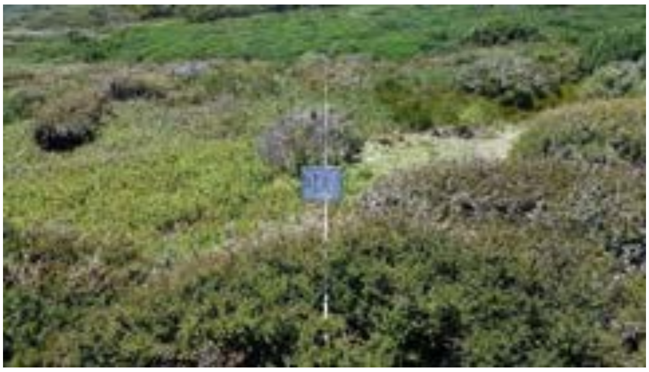

Impact Year 3, 31 January 2022

Bog 4.1/5/7 (Control Site), Photo Point 4.1AS


Baseline Year 1, 8 February 2018

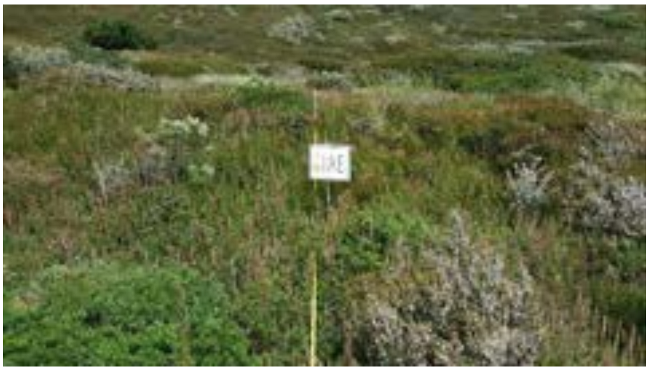

Baseline Year 2, 14 February 2019


Impact Year 1, 4 February 2020

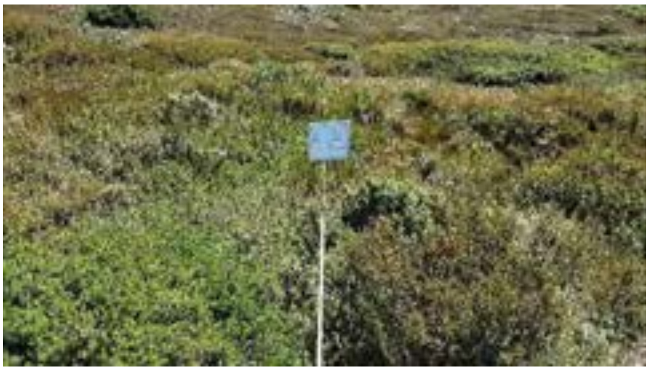

Impact Year 2, 2 February 2021


Impact Year 3, 9 February 2022

Bog 4.1/5/7 (Control Site), Photo Point 4.1AE



Baseline Year 1, 8 February 2018



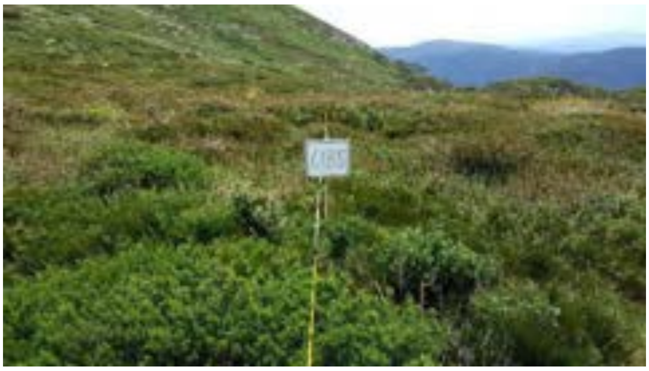
Baseline Year 2, 14 February 2019

Impact Year 1, 4 February 2020

Impact Year 2, 2 February 2021

Impact Year 3, 9 February 2022

Bog 4.1/5/7 (Control Site), Photo Point 4.1BS


Baseline Year 1, 8 February 2018

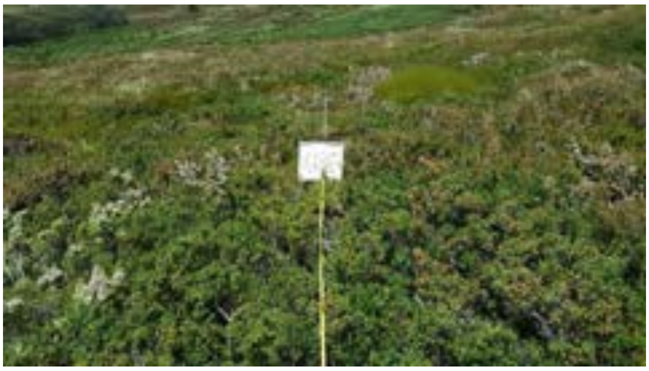

Baseline Year 2, 14 February 2019


Impact Year 1, 4 February 2020


Impact Year 2, 1 February 2021


Impact Year 3, 8 February 2022

Bog 4.1/5/7 (Control Site), Photo Point 4.1BE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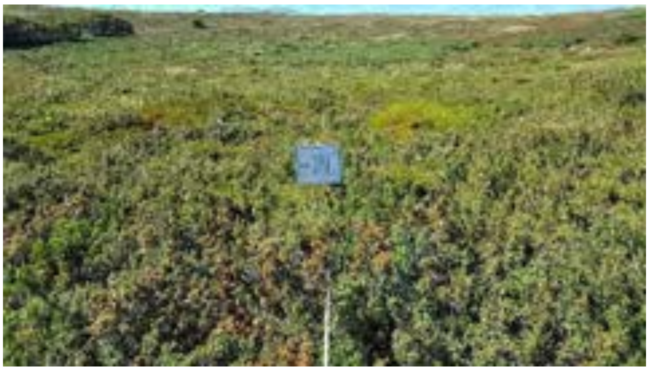
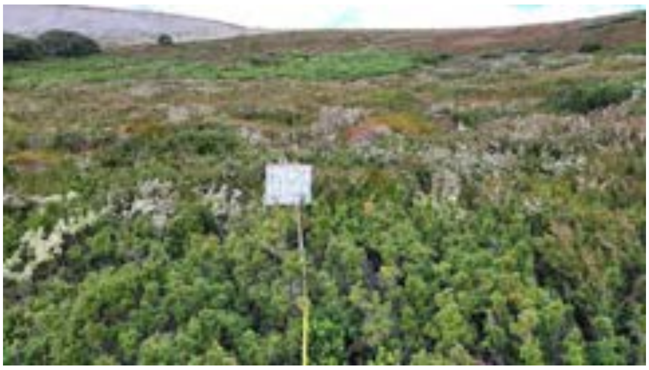

Baseline Year 2, 14 February 2019


Impact Year 1, 4 February 2020


Impact Year 2, 1 February 2021


Impact Year 3, 8 February 2022

Bog 4.1/5/7 (Control Site), Photo Point 4.1CS


Baseline Year 1, 8 February 2018


Baseline Year 2, 14 February 2019


Impact Year 1, 5 February 2020


Impact Year 2, 28 January 2021

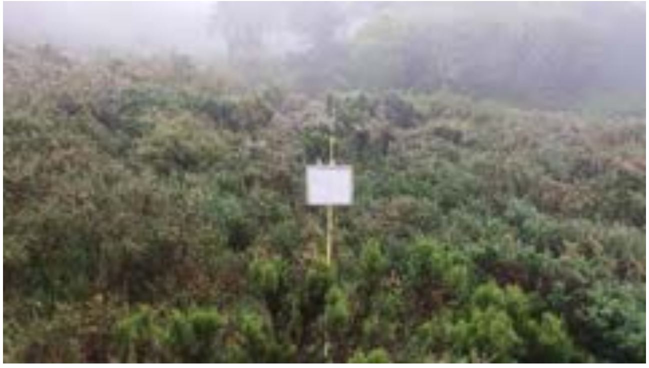

Impact Year 3, 8 February 2022

Bog 4.1/5/7 (Control Site), Photo Point 4.1CE


Baseline Year 1, 8 February 2018


Baseline Year 2, 14 February 2019


Impact Year 1, 5 February 2020


Impact Year 2, 28 January 2021


Impact Year 3, 8 February 2022

Bog 4.1/5/7 (Control Site), Photo Point 5AS


Baseline Year 1, 8 February 2018


Baseline Year 2, 14 February 2019

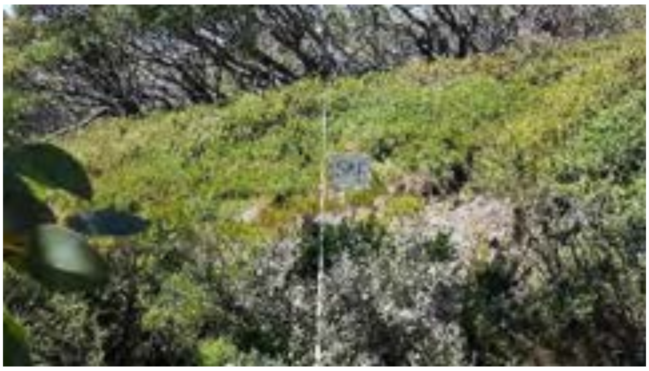

Impact Year 1, 6 February 2020


Impact Year 2, 1 February 2021


Impact Year 3, 8 February 2022

Bog 4.1/5/7 (Control Site), Photo Point 5AE


Baseline Year 1, 8 February 2018


Baseline Year 2, 14 February 2019


Impact Year 1, 6 February 2020


Impact Year 2, 1 February 2021

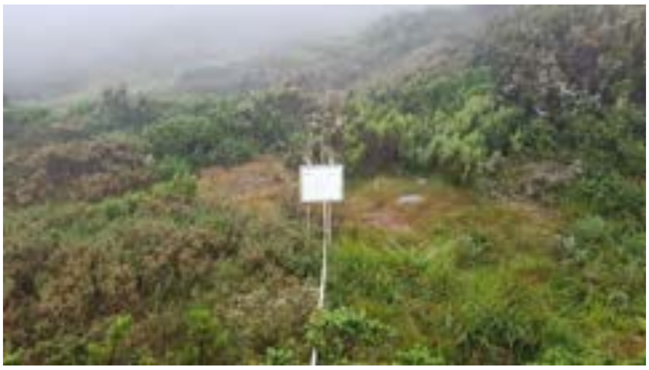

Impact Year 3, 8 February 2022

Bog 4.1/5/7 (Control Site), Photo Point 7AS


Baseline Year 1, 1 February 2018


Baseline Year 2, 11 February 2019


Impact Year 1, 5 February 2020


Impact Year 2, 28 January 2021


Impact Year 3, 8 February 2022

Bog 4.1/5/7 (Control Site), Photo Point 7AE

Baseline Year 1, 1 February 2018

Baseline Year 2, 11 February 2019

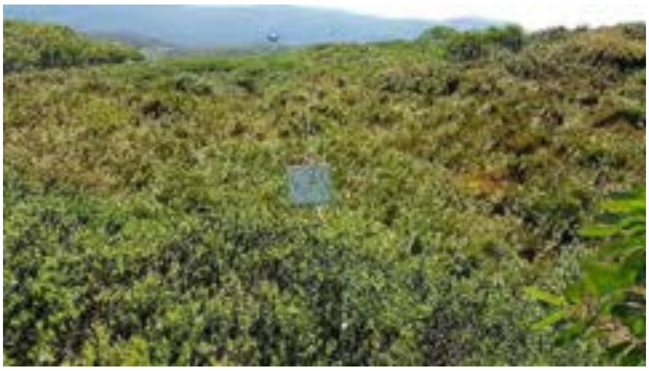
Impact Year 1, 5 February 2020

Impact Year 2, 28 January 2021

Impact Year 3, 8 February 2022

Bog 4.2 (Impact Site), Photo Point 4.2AS


Baseline Year 1, 30 January 2018

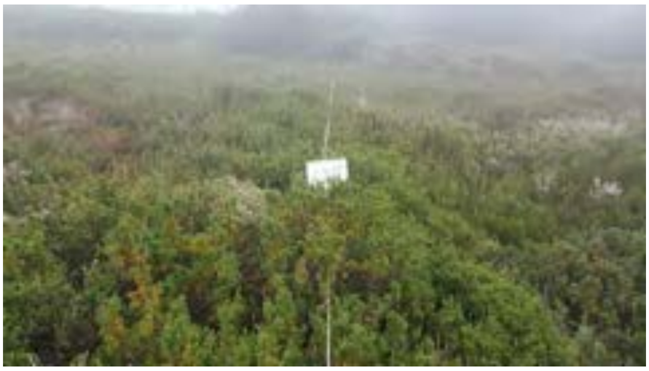

Baseline Year 2, 1 February 2019


Impact Year 1, 5 February 2020

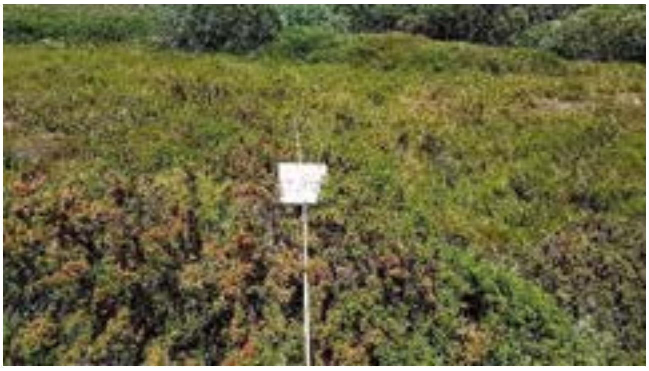

Impact Year 2, 1 February 2021


Impact Year 3, 8 February 2022

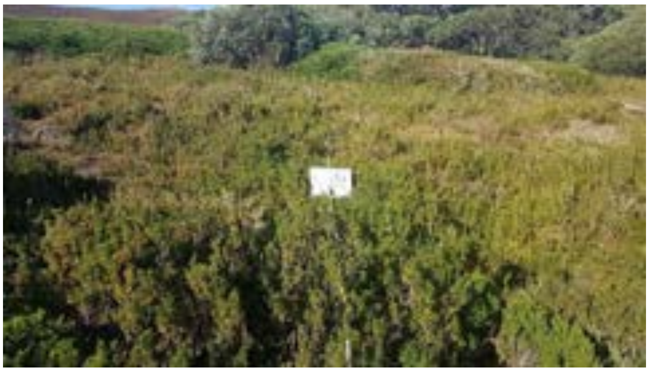
Bog 4.2 (Impact Site), Photo Point 4.2AE



Baseline Year 1, 30 January 2018



Baseline Year 2, 1 February 2019



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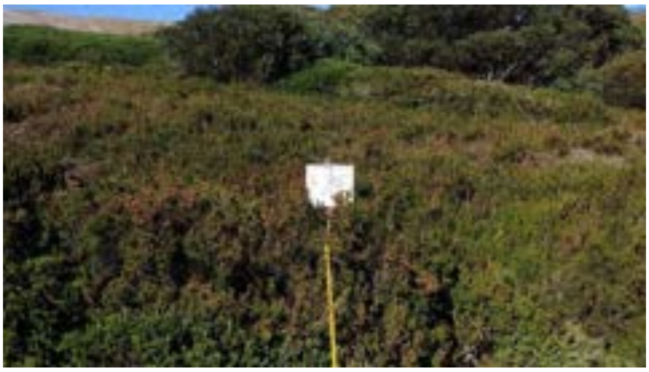


Impact Year 2, 1 February 2021

Impact Year 3, 8 February 2022

Bog 4.2 (Impact Site), Photo Point 4.2BS


Baseline Year 1, 30 January 2018


Baseline Year 2, 1 February 2019


Impact Year 1, 4 February 2020


Impact Year 2, 1 February 2021


Impact Year 3, 8 February 2022

Bog 4.2 (Impact Site), Photo Point 4.2BE

Baseline Year 1, 30 January 2018

Baseline Year 2, 1 February 2019

Impact Year 1, 4 February 2020

Impact Year 2, 1 February 2021

Impact Year 3, 8 February 2022

Bog 4.2 (Impact Site), Photo Point 4.2CS

Baseline Year 1, 31 January 2018

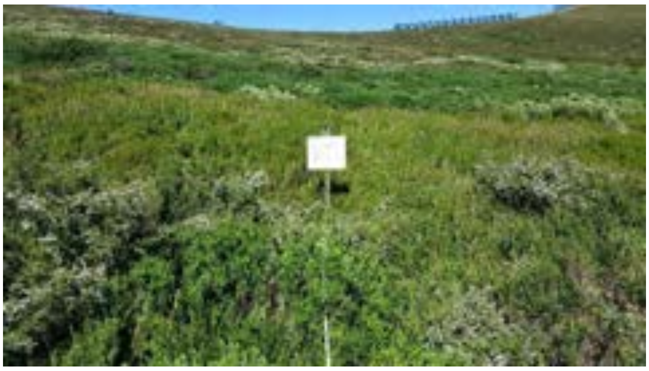
Baseline Year 2, 1 February 2019

Impact Year 1, 4 February 2020

Impact Year 2, 2 February 2021

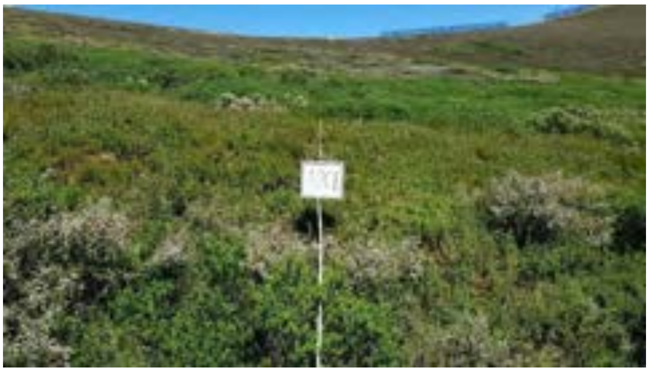
Impact Year 3, 8 February 2022

Bog 4.2 (Impact Site), Photo Point 4.2CE

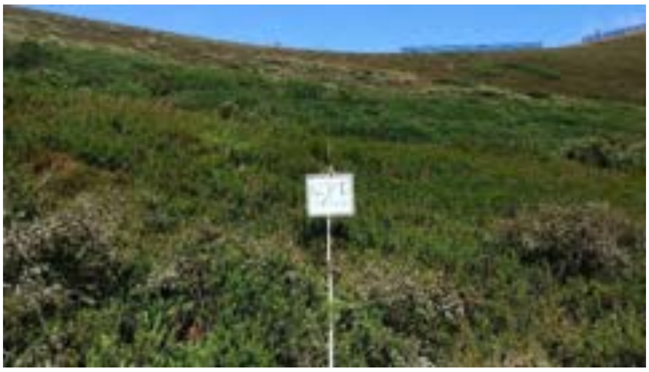


Baseline Year 1, 31 January 2018

Baseline Year 2, 1 February 2019



Impact Year 1, 4 February 2020



Impact Year 2, 2 February 2021

Impact Year 3, 8 February 2022

Bog 4.2 (Impact Site), Photo Point 4.2DS


Baseline Year 1, 31 January 2018


Baseline Year 2, 1 February 2019


Impact Year 1, 4 February 2020


Impact Year 2, 1 February 2021


Impact Year 3, 8 February 2022

Bog 4.2 (Impact Site), Photo Point 4.2DE

Baseline Year 1, 31 January 2018

Baseline Year 2, 1 February 2019

Impact Year 1, 4 February 2020

Impact Year 2, 1 February 2021

Impact Year 3, 8 February 2022

Bog 4.2 (Impact Site), Photo Point 4.2ES


Baseline Year 1, 31 January 2018


Baseline Year 2, 1 February 2019


Impact Year 1, 4 February 2020


Impact Year 2, 2 February 2021


Impact Year 3, 8 February 2022

Bog 4.2 (Impact Site), Photo Point 4.2EE


Baseline Year 1, 31 January 2018


Baseline Year 2, 1 February 2019


Impact Year 1, 4 February 2020


Impact Year 2, 2 February 2021


Impact Year 3, 8 February 2022

Bog 6 (Impact Site), Photo Point 6AS

Baseline Year 1, 31 January 2018

Baseline Year 2, 1 February 2019

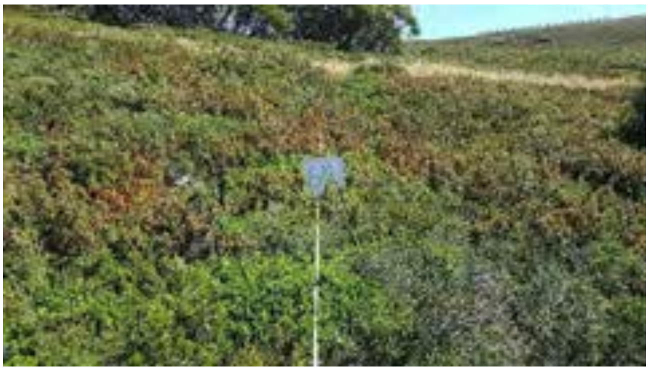
Impact Year 1, 5 February 2020

Impact Year 2, 28 January 2021

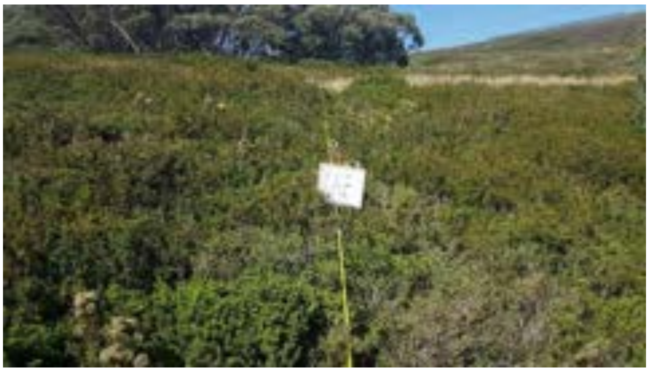
Impact Year 3, 7 February 2022

Bog 6 (Impact Site), Photo Point 6AE

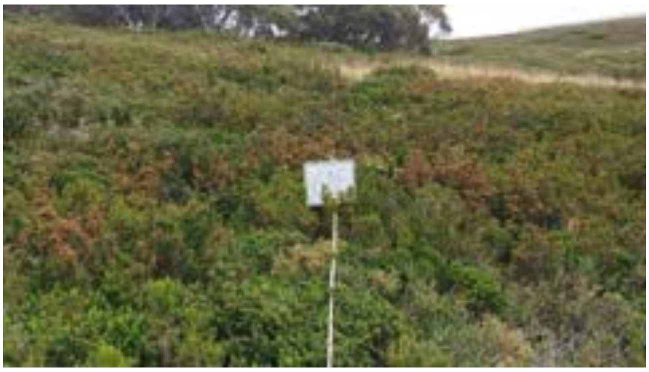
Baseline Year 1, 31 January 2018



Baseline Year 2, 1 February 2019



Impact Year 1, 5 February 2020



Impact Year 2, 28 January 2021

Impact Year 3, 7 February 2022

Bog 6 (Impact Site), Photo Point 6BS

Baseline Year 1, 31 January 2018

Baseline Year 2, 14 February 2019

Impact Year 1, 5 February 2020

Impact Year 2, 27 January 2021

Impact Year 3, 7 February 2022

Bog 6 (Impact Site), Photo Point 6BE

Baseline Year 1, 31 January 2018


Baseline Year 2, 14 February 2019


Impact Year 1, 5 February 2020


Impact Year 2, 27 January 2021


Impact Year 3, 7 February 2022

Bog 6 (Impact Site), Photo Point 6CS


Baseline Year 1, 1 February 2018


Baseline Year 2, 11 February 2019


Impact Year 1, 5 February 2020


Impact Year 2, 28 January 2021


Impact Year 3, 7 February 2022

Bog 6 (Impact Site), Photo Point 6CE


Baseline Year 1, 1 February 2018


Baseline Year 2, 11 February 2019


Impact Year 1, 5 February 2020


Impact Year 2, 28 January 2021


Impact Year 3, 7 February 2022

Bog 6 (Impact Site), Photo Point 6DS

Baseline Year 1, 1 February 2018

Baseline Year 2, 11 February 2019

Impact Year 1, 5 February 2020

Impact Year 2, 28 January 2021

Impact Year 3, 7 February 2022

Bog 6 (Impact Site), Photo Point 6DE

Baseline Year 1, 1 February 2018

Baseline Year 2, 11 February 2019

Impact Year 1, 5 February 2020

Impact Year 2, 28 January 2021

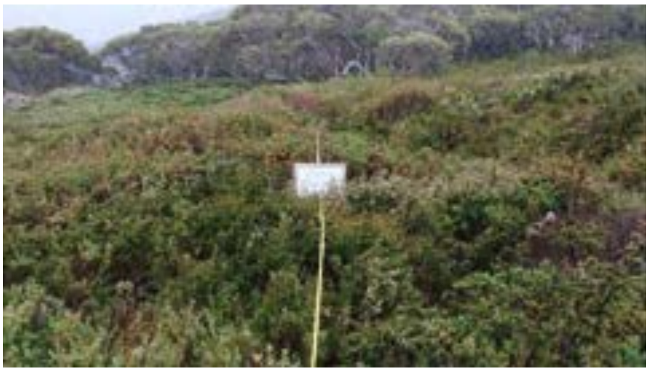
Impact Year 3, 7 February 2022

Bog 6 (Impact Site), Photo Point 6ES


Baseline Year 1, 1 February 2018


Baseline Year 2, 11 February 2019


Impact Year 1, 5 February 2020

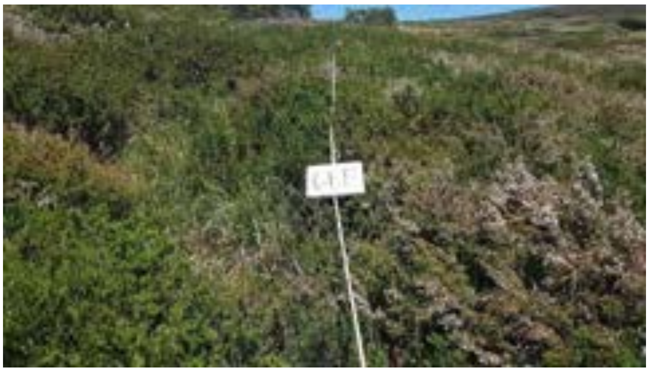

Impact Year 2, 28 January 2021


Impact Year 3, 7 February 2022

Bog 6 (Impact Site), Photo Point 6EE

Baseline Year 1, 1 February 2018

Baseline Year 2, 11 February 2019



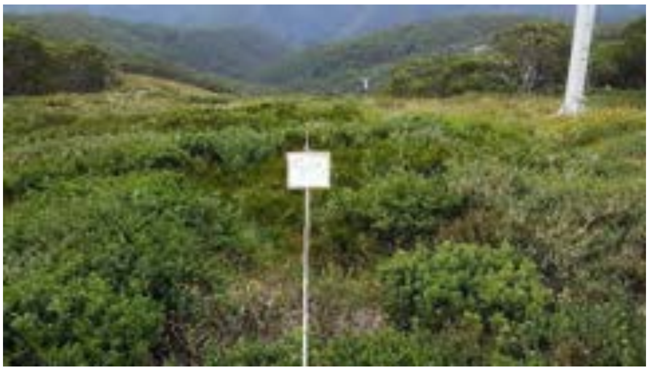
Impact Year 1, 5 February 2020

Impact Year 2, 28 January 2021

Impact Year 3, 7 February 2022

Bog 8/9/01 (Impact Site), Photo Point 8AS

Baseline Year 1, 26 January 2018



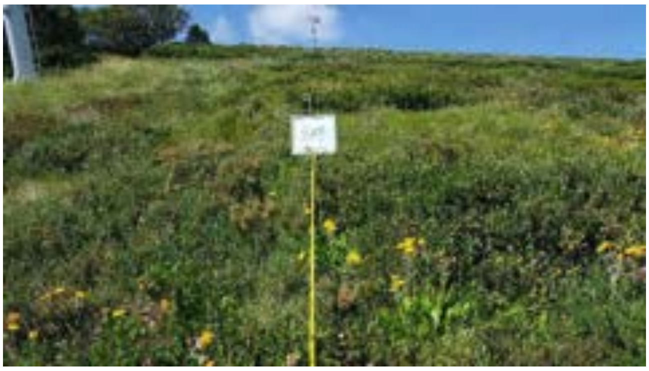
Baseline Year 2, 29 January 2019

Impact Year 1, 18 February 2020

Impact Year 2, 27 January 2021

Impact Year 3, 1 February 2022

Bog 8/9/01 (Impact Site), Photo Point 8AE



Baseline Year 1, 26 January 2018

Baseline Year 2, 29 January 2019

Impact Year 1, 18 February 2020

Impact Year 2, 27 January 2021

Impact Year 3, 1 February 2022

Bog 8/9/01 (Impact Site), Photo Point 8BS


Baseline Year 1, 26 January 2018


Baseline Year 2, 29 January 2019


Impact Year 1, 18 February 2020

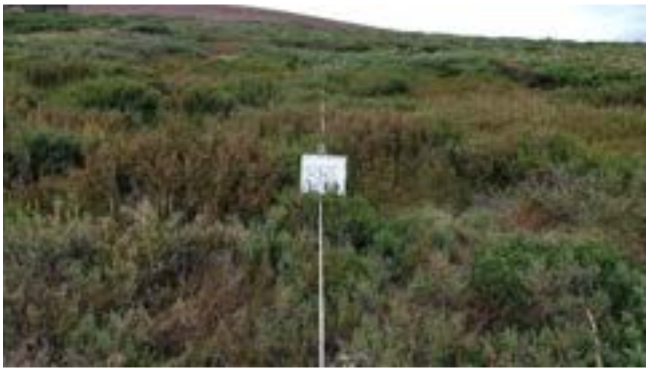

Impact Year 2, 27 January 2021


Impact Year 3, 1 February 2022

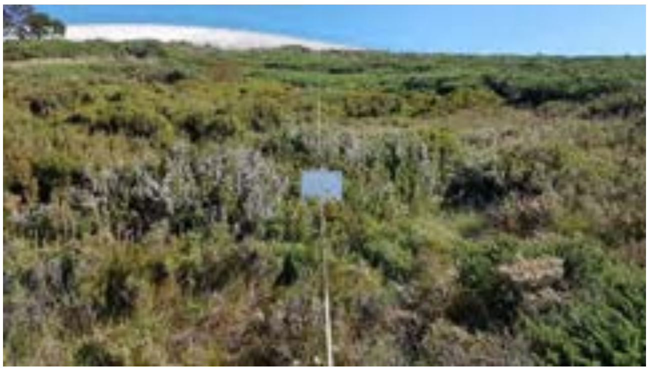
Bog 8/9/01 (Impact Site), Photo Point 8BE

Baseline Year 1, 26 January 2018

Baseline Year 2, 29 January 2019



Impact Year 1, 18 February 2020

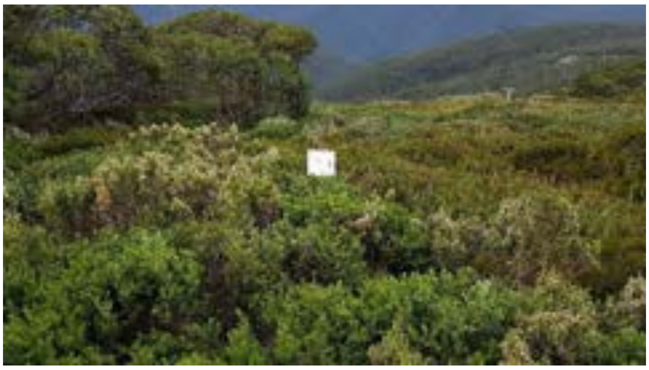


Impact Year 2, 27 January 2021

Impact Year 3, 1 February 2022

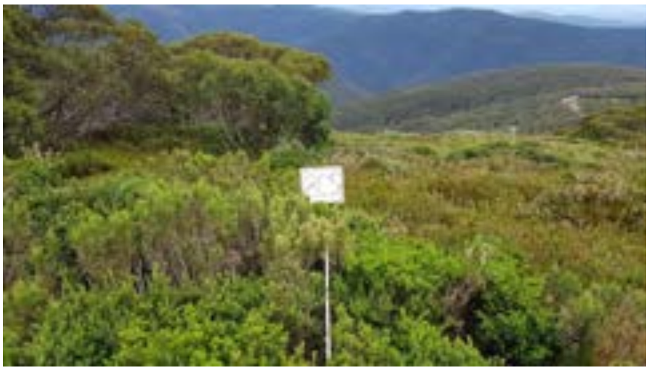
Bog 8/9/01 (Impact Site), Photo Point 8CS

Baseline Year 1, 26 January 2018



Baseline Year 2, 30 January 2019

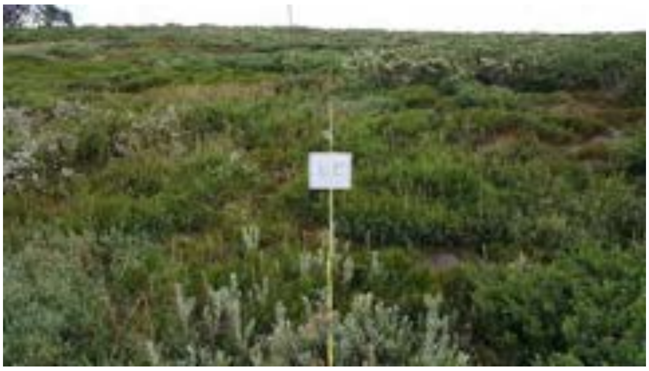
Impact Year 1, 20 February 2020

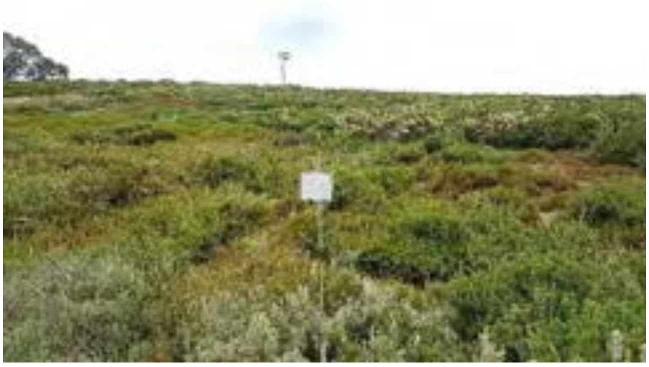


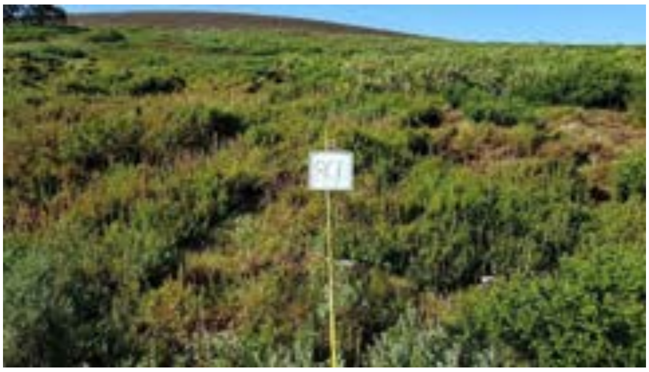
Impact Year 2, 28 January 2021

Impact Year 3, 3 February 2022

Bog 8/9/01 (Impact Site), Photo Point 8CE


Baseline Year 1, 26 January 2018


Baseline Year 2, 30 January 2019


Impact Year 1, 20 February 2020


Impact Year 2, 28 January 2021


Impact Year 3, 3 February 2022

Bog 8/9/01 (Impact Site), Photo Point 9AS


Baseline Year 1, 27 January 2018

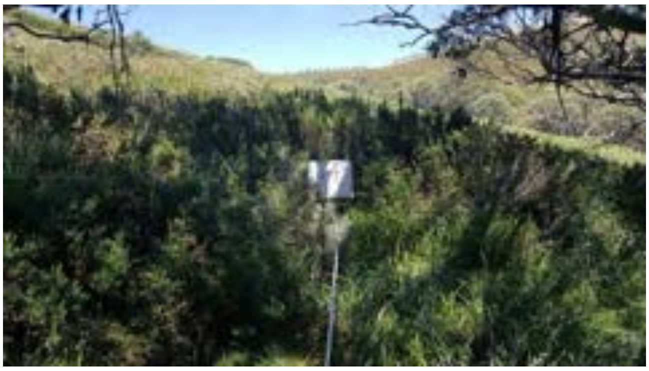

Baseline Year 2, 30 January 2019


Impact Year 1, 7 February 2020


Impact Year 2, 27 January 2021


Impact Year 3, 1 February 2022

Bog 8/9/01 (Impact Site), Photo Point 9AE



Baseline Year 1, 27 January 2018

Baseline Year 2, 30 January 2019

Impact Year 1, 7 February 2020

Impact Year 2, 27 January 2021

Impact Year 3, 1 February 2022

Bog 8/9/01 (Impact Site), Photo Point 10AS

Baseline Year 1, 27 January 2018

Baseline Year 2, 30 January 2019

Impact Year 1, 7 February 2020

Impact Year 2, 28 January 2021

Impact Year 3, 3 February 2022

Bog 8/9/01 (Impact Site), Photo Point 10AE

Baseline Year 1, 27 January 2018

Baseline Year 2, 30 January 2019

Impact Year 1, 7 February 2020

Impact Year 2, 28 January 2021

Impact Year 3, 3 February 2022

Bog 11.1 (Control Site), Photo Point 11.1AS

Baseline Year 1, 8 February 2018

Baseline Year 2, 31 January 2019

Impact Year 1, 3 February 2020

Impact Year 2, 25 January 2021

Impact Year 3, 31 January 2022

Bog 11.1 (Control Site), Photo Point 11.1AE


Baseline Year 1, 8 February 2018


Baseline Year 2, 31 January 2019


Impact Year 1, 3 February 2020


Impact Year 2, 25 January 2021

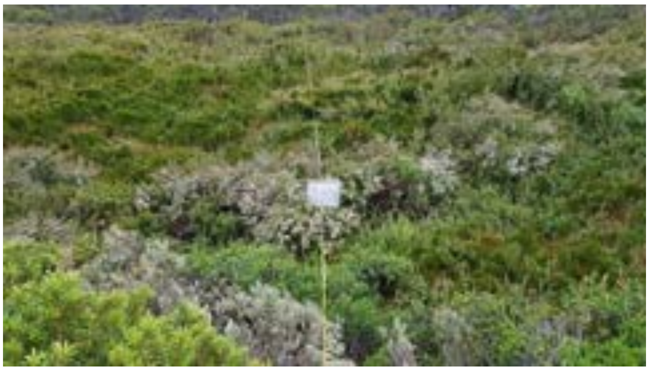

Impact Year 3, 31 January 2022

Bog 11.1 (Control Site), Photo Point 11.1BS


Baseline Year 1, 8 February 2018


Baseline Year 2, 31 January 2019


Impact Year 1, 3 February 2020


Impact Year 2, 25 January 2021


Impact Year 3, 31 January 2022

Bog 11.1 (Control Site), Photo Point 11.1BE

Baseline Year 1, 8 February 2018

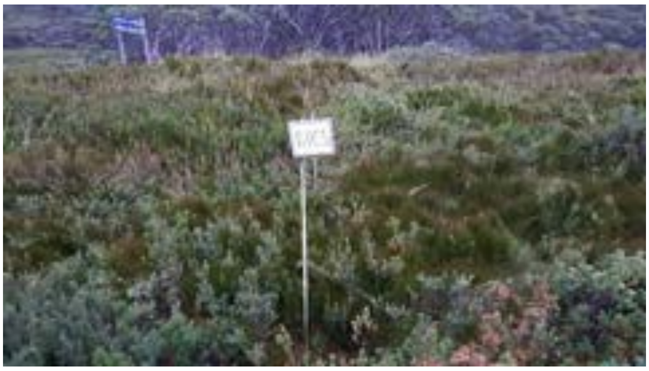
Baseline Year 2, 31 January 2019

Impact Year 1, 3 February 2020

Impact Year 2, 25 January 2021

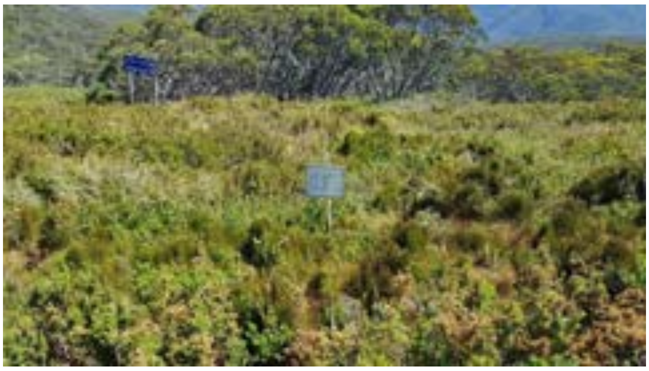
Impact Year 3, 31 January 2022

Bog 11.1 (Control Site), Photo Point 11.1CS


Baseline Year 1, 8 February 2018


Baseline Year 2, 31 January 2019


Impact Year 1, 4 February 2020

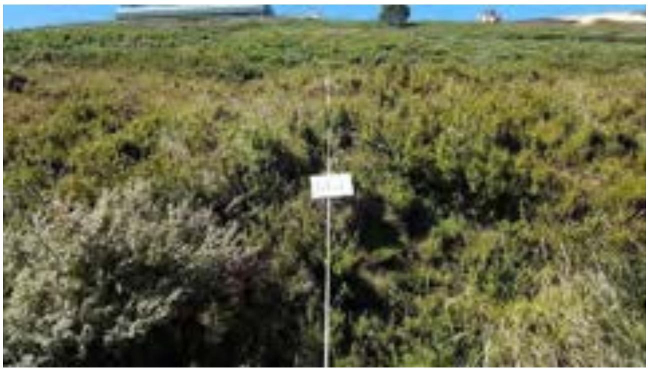

Impact Year 2, 25 January 2021


Impact Year 3, 31 January 2022

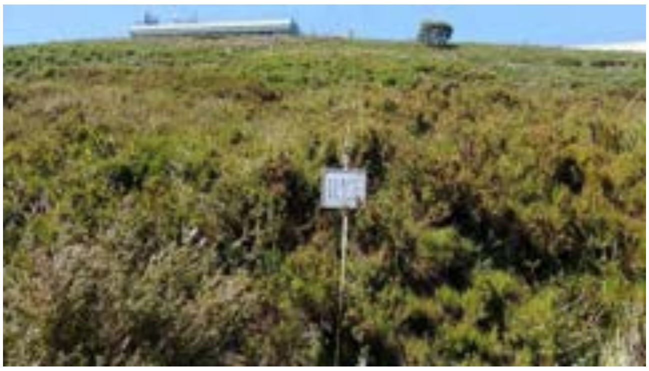
Bog 11.1 (Control Site), Photo Point 11.1CE

Baseline Year 1, 8 February 2018

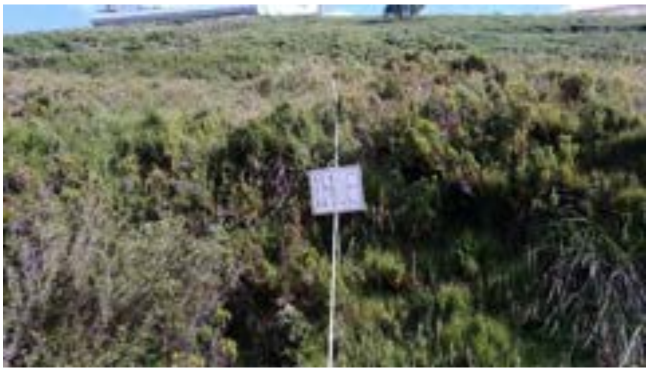
Baseline Year 2, 31 January 2019



Impact Year 1, 4 February 2020



Impact Year 2, 25 January 2021

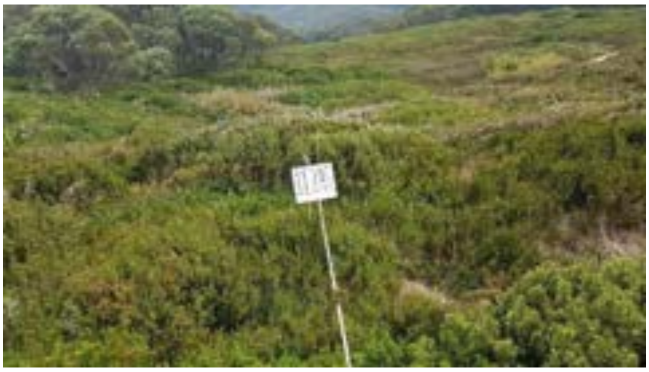


Impact Year 3, 31 January 2022

Bog 11.2 (Impact Site), Photo Point 11.2AS


Baseline Year 1, 28 January 2018

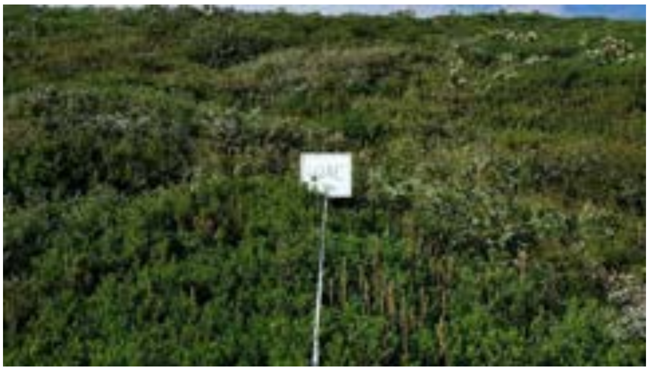

Baseline Year 2, 31 January 2019


Impact Year 1, 7 February 2020

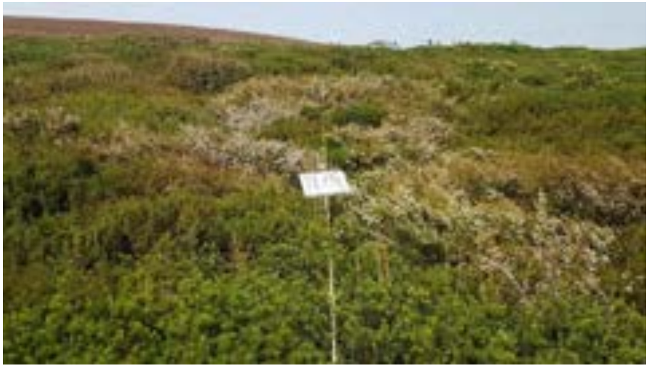

Impact Year 2, 26 January 2021


Impact Year 3, 1 February 2022

Bog 11.2 (Impact Site), Photo Point 11.2AE


Baseline Year 1, 28 January 2018

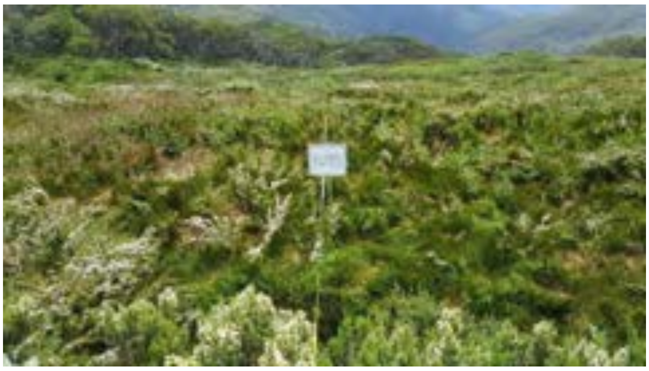

Baseline Year 2, 31 January 2019


Impact Year 1, 7 February 2020


Impact Year 2, 26 January 2021


Impact Year 3, 1 February 2022

Bog 11.2 (Impact Site), Photo Point 11.2BS


Baseline Year 1, 28 January 2018

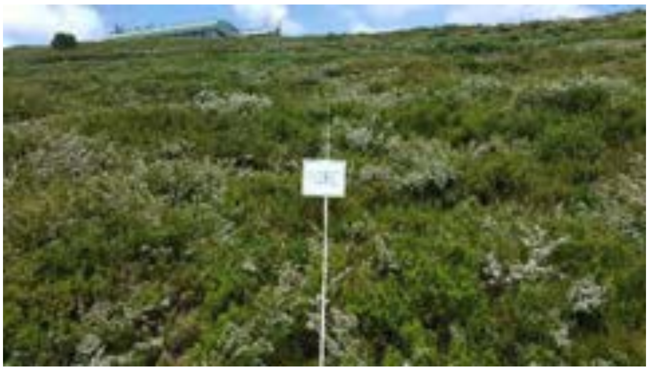

Baseline Year 2, 31 January 2019

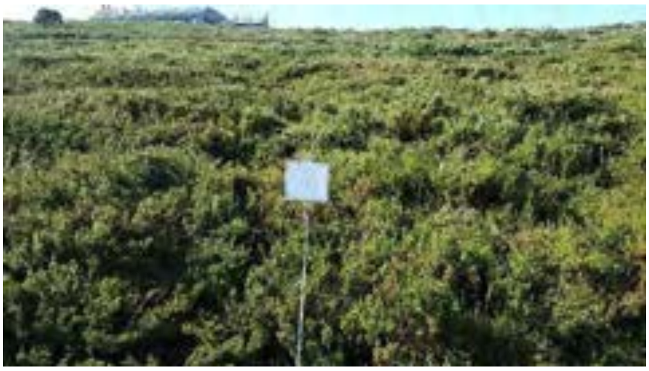

Impact Year 1, 20 February 2020

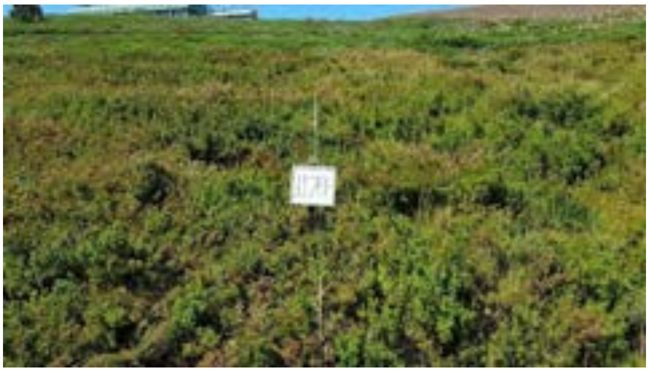

Impact Year 2, 26 January 2021

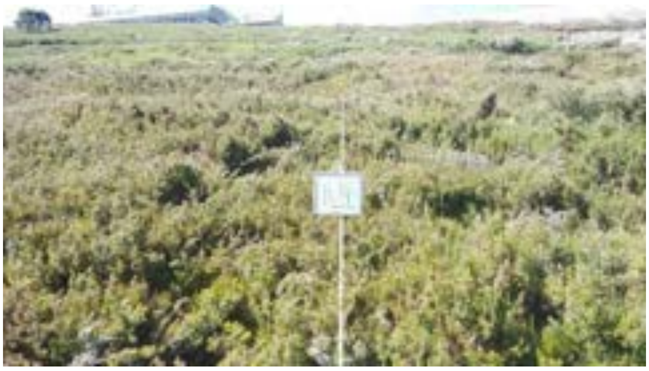

Impact Year 3, 1 February 2022

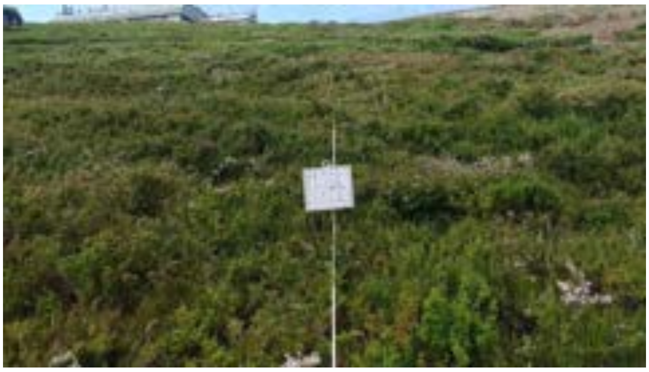
Bog 11.2 (Impact Site), Photo Point 11.2BE


Baseline Year 1, 28 January 2018

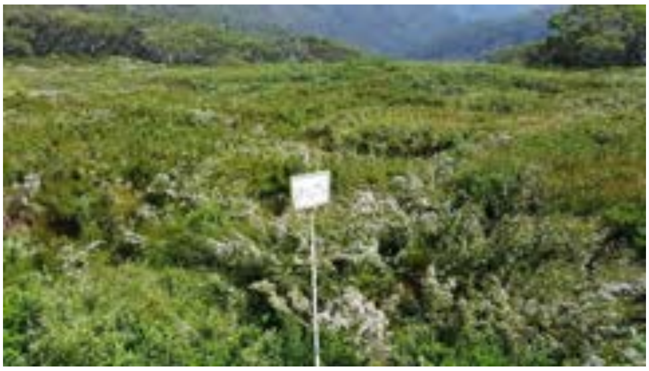

Baseline Year 2, 31 January 2019


Impact Year 1, 20 February 2020

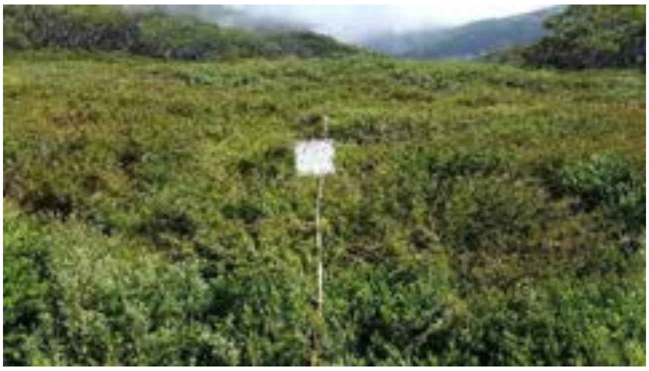

Impact Year 2, 26 January 2021


Impact Year 3, 1 February 2022

Bog 11.2 (Impact Site), Photo Point 11.2CS

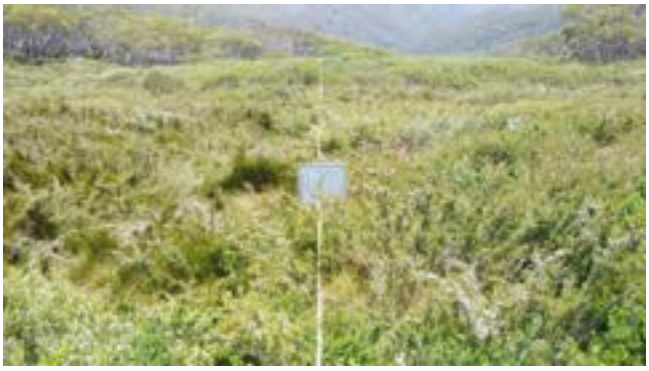


Baseline Year 1, 28 January 2018



Baseline Year 2, 31 January 2019

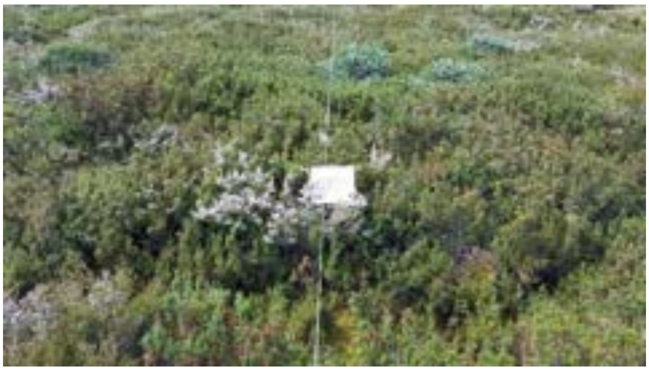
Impact Year 1, 6 February 2020



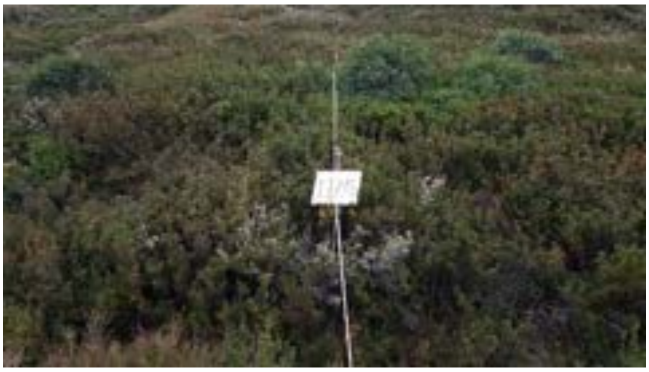
Impact Year 2, 27 January 2021

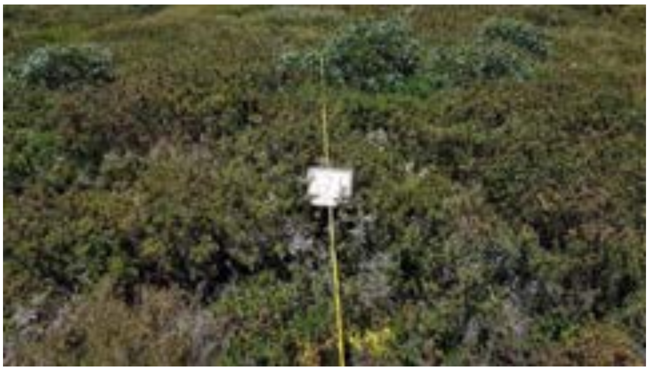
Impact Year 3, 1 February 2022

Bog 11.2 (Impact Site), Photo Point 11.2CE


Baseline Year 1, 28 January 2018


Baseline Year 2, 31 January 2019


Impact Year 1, 6 February 2020

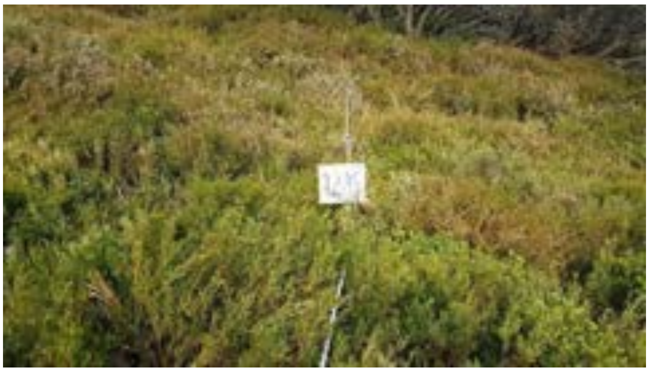

Impact Year 2, 27 January 2021


Impact Year 3, 1 February 2022

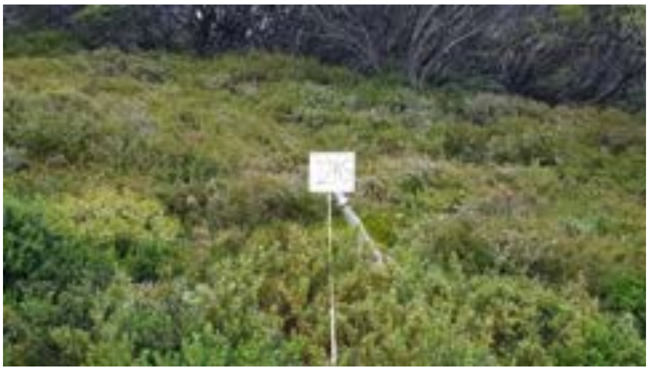
Bog 12 (Impact Site), Photo Point 12AS

Baseline Year 1, 27 January 2018

Baseline Year 2, 30 January 2019



Impact Year 1, 7 February 2020



Impact Year 2, 27 January 2021

Impact Year 3, 3 February 2022

Bog 12 (Impact Site), Photo Point 12AE

Baseline Year 1, 27 January 2018

Baseline Year 2, 30 January 2019

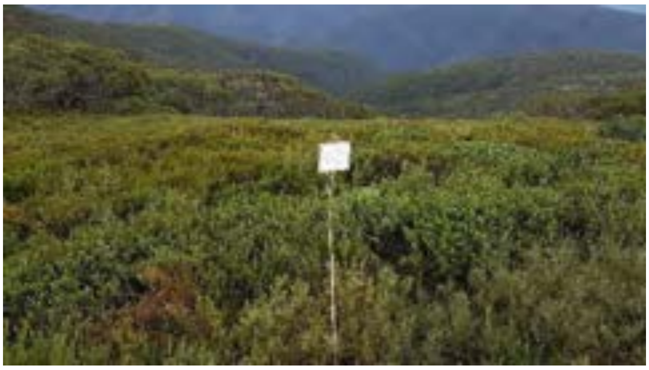
Impact Year 1, 7 February 2020

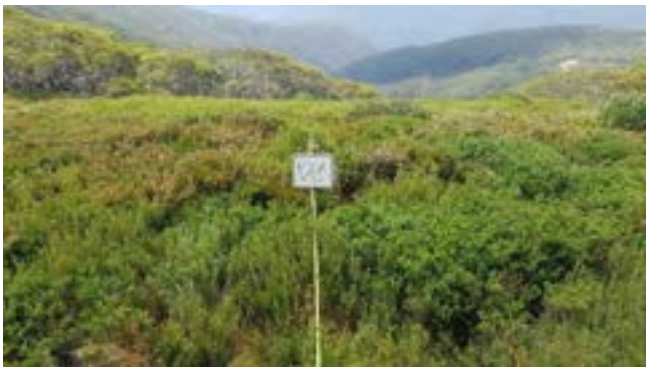
Impact Year 2, 27 January 2021

Impact Year 3, 3 February 2022

Bog 12 (Impact Site), Photo Point 12BS


Baseline Year 1, 29 January 2018


Baseline Year 2, 30 January 2019


Impact Year 1, 6 February 2020


Impact Year 2, 27 January 2021


Impact Year 3, 1 February 2022

Bog 12 (Impact Site), Photo Point 12BE


Baseline Year 1, 29 January 2018


Baseline Year 2, 30 January 2019


Impact Year 1, 6 February 2020


Impact Year 2, 27 January 2021


Impact Year 3, 1 February 2022

Bog 12 (Impact Site), Photo Point 12CS

Baseline Year 1, 29 January 2018

Baseline Year 2, 30 January 2019

Impact Year 1, 7 February 2020

Impact Year 2, 27 January 2021

Impact Year 3, 3 February 2022

Bog 12 (Impact Site), Photo Point 12CE

Baseline Year 1, 29 January 2018

Baseline Year 2, 30 January 2019

Impact Year 1, 7 February 2020

Impact Year 2, 27 January 2021

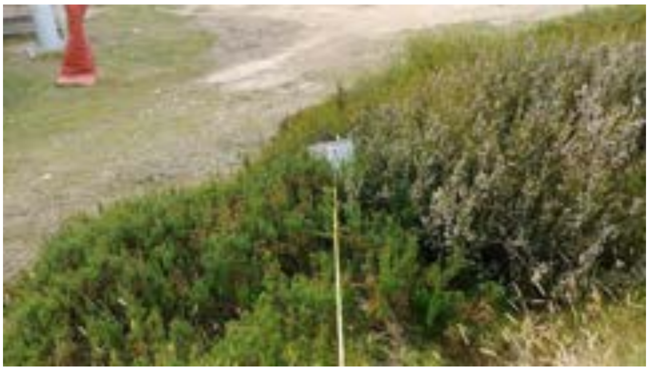
Impact Year 3, 3 February 2022

Bog 13 (Impact Site), Photo Point 13AS

Baseline Year 1, 2 February 2018

Baseline Year 2, 14 February 2019

Impact Year 1, 31 January 2020



Impact Year 2, 4 February 2021

Impact Year 3, 9 February 2022

Bog 13 (Impact Site), Photo Point 13AE

Baseline Year 1, 2 February 2018

Baseline Year 2, 14 February 2019

Impact Year 1, 31 January 2020

Impact Year 2, 4 February 2021

Impact Year 3, 9 February 2022

Bog 13 (Impact Site), Photo Point 13BS

Baseline Year 1, 2 February 2018

Baseline Year 2, 14 February 2019

Impact Year 1, 31 January 2020

Impact Year 2, 4 February 2021

Impact Year 3, 9 February 2022

Bog 13 (Impact Site), Photo Point 13BE

Baseline Year 1, 2 February 2018

Baseline Year 2, 14 February 2019

Impact Year 1, 31 January 2020

Impact Year 2, 4 February 2021

Impact Year 3, 9 February 2022

Bog 13 (Impact Site), Photo Point 13CS


Baseline Year 1, 2 February 2018


Baseline Year 2, 14 February 2019


Impact Year 1, 31 January 2020


Impact Year 2, 4 February 2021


Impact Year 3, 9 February 2022

Bog 13 (Impact Site), Photo Point 13CE


Baseline Year 1, 2 February 2018


Baseline Year 2, 14 February 2019


Impact Year 1, 31 January 2020


Impact Year 2, 4 February 2021


Impact Year 3, 9 February 2022

Bog S1 (Control Site), Photo Point S1AS

Baseline Year 1, 6 February 2018

Baseline Year 2, 13 February 2019

Impact Year 1, 28 January 2020

Impact Year 2, 4 February 2021

Impact Year 3, 2 February 2022

Bog S1 (Control Site), Photo Point S1AE


Baseline Year 1, 6 February 2018


Baseline Year 2, 13 February 2019


Impact Year 1, 28 January 2020


Impact Year 2, 4 February 2021


Impact Year 3, 2 February 2022

Bog S1 (Control Site), Photo Point S1BS

Baseline Year 1, 6 February 2018

Baseline Year 2, 13 February 2019

Impact Year 1, 28 January 2020

Impact Year 2, 4 February 2021

Impact Year 3, 2 February 2022

Bog S1 (Control Site), Photo Point S1BE

Baseline Year 1, 6 February 2018

Baseline Year 2, 13 February 2019

Impact Year 1, 28 January 2020

Impact Year 2, 4 February 2021

Impact Year 3, 2 February 2022

Bog S1 (Control Site), Photo Point S1CS

Baseline Year 1, 6 February 2018

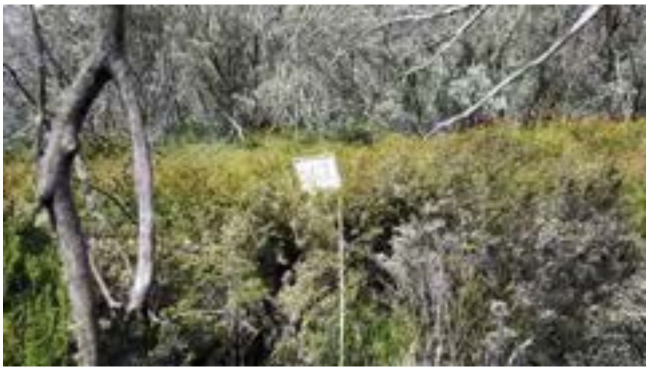
Baseline Year 2, 13 February 2019

Impact Year 1, 28 January 2020

Impact Year 2, 4 February 2021

Impact Year 3, 2 February 2022

Bog S1 (Control Site), Photo Point S1CE



Baseline Year 1, 6 February 2018

Baseline Year 2, 13 February 2019

Impact Year 1, 28 January 2020

Impact Year 2, 4 February 2021

Impact Year 3, 2 February 2022

Bog S2 (Control Site), Photo Point S2AS

Baseline Year 1, 6 February 2018

Baseline Year 2, 13 February 2019

Impact Year 1, 29 January 2020

Impact Year 2, 3 February 2021

Impact Year 3, 3 February 2022

Bog S2 (Control Site), Photo Point S2AE

Baseline Year 1, 6 February 2018

Baseline Year 2, 13 February 2019

Impact Year 1, 29 January 2020

Impact Year 2, 3 February 2021

Impact Year 3, 3 February 2022

Bog S2 (Control Site), Photo Point S2BS


Baseline Year 1, 7 February 2018


Baseline Year 2, 13 February 2019


Impact Year 1, 29 January 2020


Impact Year 2, 3 February 2021


Impact Year 3, 3 February 2022

Bog S2 (Control Site), Photo Point S2BE


Baseline Year 1, 7 February 2018


Baseline Year 2, 13 February 2019


Impact Year 1, 29 January 2020


Impact Year 2, 3 February 2021


Impact Year 3, 3 February 2022

Bog S2 (Control Site), Photo Point S2CS

Baseline Year 1, 7 February 2018

Baseline Year 2, 13 February 2019

Impact Year 1, 30 January 2020

Impact Year 2, 3 February 2021

Impact Year 3, 3 February 2022

Bog S2 (Control Site), Photo Point S2CE


Baseline Year 1, 7 February 2018


Baseline Year 2, 13 February 2019


Impact Year 1, 30 January 2020


Impact Year 2, 3 February 2021


Impact Year 3, 3 February 2022

Bog S3 (Control Site), Photo Point S3AS

Baseline Year 1, 7 February 2018

Baseline Year 2, 12 February 2019

Impact Year 1, 29 January 2020

Impact Year 2, 3 February 2021

Impact Year 3, 3 February 2022

Bog S3 (Control Site), Photo Point S3AE

Baseline Year 1, 7 February 2018

Baseline Year 2, 12 February 2019

Impact Year 1, 29 January 2020

Impact Year 2, 3 February 2021

Impact Year 3, 3 February 2022

Bog S3 (Control Site), Photo Point S3BS

Baseline Year 1, 7 February 2018

Baseline Year 2, 12 February 2019

Impact Year 1, 29 January 2020

Impact Year 2, 3 February 2021

Impact Year 3, 3 February 2022

Bog S3 (Control Site), Photo Point S3BE

Baseline Year 1, 7 February 2018

Baseline Year 2, 12 February 2019

Impact Year 1, 29 January 2020

Impact Year 2, 3 February 2021

Impact Year 3, 3 February 2022

Bog S3 (Control Site), Photo Point S3CS

Baseline Year 1, 7 February 2018

Baseline Year 2, 12 February 2019

Impact Year 1, 29 January 2020

Impact Year 2, 3 February 2021

Impact Year 3, 2 February 2022

Bog S3 (Control Site), Photo Point S3CE

Baseline Year 1, 7 February 2018

Baseline Year 2, 12 February 2019

Impact Year 1, 29 January 2020

Impact Year 2, 3 February 2021

Impact Year 3, 2 February 2022

Appendix 5 Ecology data

Table A5.1 Area of Alpine Bogs as determined by DGPS mapping

Site	Area (ha)					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**1.3797***	**1.3536**	**1.3666**	**1.3217**	**1.3353**	**1.3423**
Bog 4.2	0.4014	0.3842	0.3928	0.3912	0.3823	0.3866
Bog 6	0.4914*	0.6723	0.6723*	0.6380	0.6473	0.6359
Bog 8/9/10	0.0667	0.0718	0.0692	0.0704	0.0762	0.0798
Bog 11.2	0.1195	0.1120	0.1157	0.1094	0.1083	0.1094
Bog 12	0.1145	0.1071	0.1108	0.1076	0.1157	0.1249
Bog 13	0.0051	0.0063	0.0057	0.0051	0.0055	0.0058
All control sites	**2.1446**	**2.0178**	**2.0812**	**2.0902**	**2.1183**	**2.1875**
Bog 1	0.1781	0.1620	0.1700	0.1491	0.1595	0.1626
Bog 2	0.1516	0.1481	0.1499	0.1459	0.1464	0.1521
Bog 4.1/5/7	0.5562	0.5457	0.5509	0.5480	0.5597	0.5519
Bog 11.1	0.2798	0.2590	0.2694	0.2571	0.2676	0.2890
Bog S1	0.5712	0.4584	0.5148	0.5126	0.4992	0.5009
Bog S2	0.1805	0.1778	0.1791	0.1785	0.1846	0.2108
Bog S3	0.2271	0.2669	0.2470	0.2989	0.3013	0.3201

*Note: As discussed in the IY1 monitoring report, mapping of Bog 6 in BY1 is unlikely to have captured the full extent of the Bog 6 entity as recognised in subsequent years and is therefore unreliable. The BY2 area for Bog 6 has therefore been used as the baseline mean and BY1 total for all impact sites.

Table A5.2 Dimensions of Alpine Bogs as estimated by line transects

Site	Sum of dimensions (m)					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**356.2**	**353.2**	**354.7**	**355.6**	**354.2**	**344.8**
Bog 4.2	92.2	92.6	92.4	92.2	92.6	89.8
Bog 6	79.6	75.8	77.7	77.4	78.2	74.2
Bog 8/9/10	66.4	67.8	67.1	65.2	65	61.4
Bog 11.2	67.2	66.4	66.8	66.8	67.2	67.2
Bog 12	40.6	41.0	40.8	41.4	40.6	40.6
Bog 13	10.2	9.6	9.9	12.6	10.6	11.6
All control sites	**436.0**	**441.6**	**438.8**	**438.6**	**436.6**	**438.8**
Bog 1	55.8	57.2	56.5	57.0	56.6	55.8
Bog 2	78.8	79.6	79.2	77.2	79	79.4
Bog 4.1/5/7	81.6	84.2	82.9	85.2	83.8	86
Bog 11.1	48.6	48.4	48.5	48.0	47.4	47.6
Bog S1	52.6	52.4	52.5	52.0	51.2	50.8
Bog S2	57.4	58.2	57.8	58.2	57	57
Bog S3	61.2	61.6	61.4	61.0	61.6	62.2

Table A5.3 Cover of all bare ground as estimated by line transects

Site	Cover of all bare ground					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**1.9%**	**0.1%**	**1.0%**	**5.4%**	**4.6%***	**3.6%***
Bog 4.2	3.4%	0.0%	1.7%	5.8%	5.2%	1.9%
Bog 6	3.8%	0.0%	1.9%	8.2%	5.3%	4.0%
Bog 8/9/10	0.7%	0.0%	0.3%	6.0%	3.7%	2.8%
Bog 11.2	0.0%	0.0%	0.0%	3.7%	8.0%	5.6%
Bog 12	0.8%	0.8%	0.8%	3.1%	0.4%	5.4%
Bog 13	0.0%	0.0%	0.0%	0.0%	1.7%	3.4%
All control sites	**0.9%**	**0.2%**	**0.5%**	**4.8%**	**2.6%***	**5.0%***
Bog 1	0.6%	0.0%	0.3%	3.5%	0.3%	1.9%
Bog 2	1.1%	0.0%	0.6%	10.3%	0.7%	2.7%
Bog 4.1/5/7	0.4%	0.0%	0.2%	0.8%	0.6%	0.6%
Bog 11.1	0.7%	0.4%	0.5%	3.6%	0.0%	3.2%
Bog S1	3.0%	0.3%	1.7%	2.4%	7.1%	4.7%
Bog S2	0.0%	0.0%	0.0%	5.7%	0.7%	1.0%
Bog S3	0.9%	0.9%	0.8%	7.9%	10.7%	24.0%

*Note: In IY2 and IY3, the type of bare ground was also recorded. Results presented here are for all bare ground, regardless of type.

Table A5.4 Cover of bare ground attributed to natural causes as estimated by line transects

Site	Cover of bare ground attributed to natural causes					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**-**	**-**	**-**	**-**	**1.3%**	**2.6%**
Bog 4.2	-	-	-	-	2.2%	1.7%
Bog 6	-	-	-	-	1.1%	3.4%
Bog 8/9/10	-	-	-	-	1.1%	2.3%
Bog 11.2	-	-	-	-	0.8%	0.8%
Bog 12	-	-	-	-	0.4%	5.4%
Bog 13	-	-	-	-	1.7%	3.4%
All control sites	**-**	**-**	**-**	**-**	**1.8%**	**5.0%**
Bog 1	-	-	-	-	0.3%	1.9%
Bog 2	-	-	-	-	0.7%	2.7%
Bog 4.1/5/7	-	-	-	-	0.0%	0.6%
Bog 11.1	-	-	-	-	0.0%	3.2%
Bog S1	-	-	-	-	3.4%	4.7%
Bog S2	-	-	-	-	0.7%	1.0%
Bog S3	-	-	-	-	8.5%	24.0%

Table A5.5 Cover of bare ground attributed to deer activity as estimated by line transects

Site	Cover of bare ground attributed to deer activity					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**-**	**-**	**-**	**-**	**0.0%**	**0.0%**
Bog 4.2	-	-	-	-	0.0%	0.0%
Bog 6	-	-	-	-	0.0%	0.0%
Bog 8/9/10	-	-	-	-	0.0%	0.0%
Bog 11.2	-	-	-	-	0.0%	0.0%
Bog 12	-	-	-	-	0.0%	0.0%
Bog 13	-	-	-	-	0.0%	0.0%
All control sites	**-**	**-**	**-**	**-**	**0.9%**	**0.0%**
Bog 1	-	-	-	-	0.0%	0.0%
Bog 2	-	-	-	-	0.0%	0.0%
Bog 4.1/5/7	-	-	-	-	0.6%	0.0%
Bog 11.1	-	-	-	-	0.0%	0.0%
Bog S1	-	-	-	-	3.7%	0.0%
Bog S2	-	-	-	-	0.0%	0.0%
Bog S3	-	-	-	-	2.2%	0.0%

Table A5.6 Cover of bare ground attributed to sedimentation as estimated by line transects

Site	Cover of bare ground attributed to sedimentation					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**-**	**-**	**-**	**-**	**3.4%**	**1.1%**
Bog 4.2	-	-	-	-	3.0%	0.2%
Bog 6	-	-	-	-	4.2%	0.6%
Bog 8/9/10	-	-	-	-	2.5%	0.5%
Bog 11.2	-	-	-	-	7.2%	4.8%
Bog 12	-	-	-	-	0.0%	0.0%
Bog 13	-	-	-	-	0.0%	0.0%
All control sites	**-**	**-**	**-**	**-**	**0.0%**	**0.0%**
Bog 1	-	-	-	-	0.0%	0.0%
Bog 2	-	-	-	-	0.0%	0.0%
Bog 4.1/5/7	-	-	-	-	0.0%	0.0%
Bog 11.1	-	-	-	-	0.0%	0.0%
Bog S1	-	-	-	-	0.0%	0.0%
Bog S2	-	-	-	-	0.0%	0.0%
Bog S3	-	-	-	-	0.0%	0.0%

Table A5.7 Bog-dependent flora species richness as determined by line and belt transects

Site	Number of bog-dependent flora species					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**10**	**11**	**10.5**	**11**	**10**	**10**
Bog 4.2	8	9	8.5	8	8	8
Bog 6	8	8	8	9	8	8
Bog 8/9/10	9	5	7	8	7	7
Bog 11.2	6	6	6	6	5	6
Bog 12	7	7	7	6	6	6
Bog 13	3	5	4	6	4	5
All control sites	**11**	**10**	**10.5**	**11**	**11**	**11**
Bog 1	5	5	5	5	6	6
Bog 2	6	6	6	5	5	6
Bog 4.1/5/7	8	8	8	7	9	8
Bog 11.1	8	7	7.5	8	8	8
Bog S1	6	6	6	7	7	6
Bog S2	6	6	6	6	7	5
Bog S3	7	8	7.5	9	8	8

Table A5.8 Cover of bog-dependent flora species as estimated by line transects

Site	Cover of bog-dependent flora species					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**77.9%**	**78.5%**	**78.2%**	**79.7%**	**79.5%**	**79.4%**
Bog 4.2	87.5%	87.3%	87.4%	87.3%	87.7%	86.0%
Bog 6	72.2%	72.4%	72.3%	72.6%	74.1%	74.3%
Bog 8/9/10	75.6%	75.6%	75.6%	77.5%	74.9%	77.5%
Bog 11.2	88.1%	90.5%	89.3%	91.0%	91.0%	88.9%
Bog 12	72.8%	72.4%	72.6%	73.5%	75.1%	73.9%
Bog 13	43.6%	48.7%	46.2%	59.0%	53.0%	58.1%
All control sites	**86.9%**	**88.8%**	**87.9%**	**88.3%**	**88.9%**	**89.1%**
Bog 1	88.0%	90.5%	89.3%	90.2%	90.2%	88.6%
Bog 2	89.0%	91.1%	90.0%	91.3%	90.4%	91.5%
Bog 4.1/5/7	81.2%	83.9%	82.5%	83.7%	83.7%	81.7%
Bog 11.1	87.4%	87.7%	87.5%	88.1%	88.4%	88.4%
Bog S1	84.8%	86.9%	85.9%	86.9%	89.2%	88.2%
Bog S2	97.0%	99.3%	98.1%	98.0%	98.7%	98.3%
Bog S3	84.2%	85.2%	84.7%	82.3%	85.2%	90.9%

Table A5.9 Cover of native non-bog-dependent flora species as estimated by line transects

Site	Cover of native non-bog-dependent flora species					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**44.4%**	**46.1%**	**45.2%**	**46.5%**	**46.1%**	**48.5%**
Bog 4.2	24.7%	26.9%	25.8%	27.1%	29.5%	27.5%
Bog 6	62.5%	65.7%	64.1%	61.5%	65.7%	66.9%
Bog 8/9/10	49.4%	51.7%	50.6%	53.3%	50.6%	56.1%
Bog 11.2	24.9%	23.6%	24.3%	25.7%	24.7%	27.6%
Bog 12	61.5%	61.5%	61.5%	63.4%	56.4%	62.6%
Bog 13	66.7%	72.6%	69.7%	79.5%	72.6%	77.8%
All control sites	**44.2%**	**46.1%**	**45.1%**	**43.5%**	**43.8%**	**44.8%**
Bog 1	42.9%	44.2%	43.5%	45.4%	44.8%	49.2%
Bog 2	41.6%	41.4%	41.5%	41.2%	40.5%	42.1%
Bog 4.1/5/7	39.2%	42.3%	40.8%	39.8%	39.0%	40.2%
Bog 11.1	41.2%	44.4%	42.8%	40.4%	43.0%	44.0%
Bog S1	54.5%	57.9%	56.2%	46.8%	47.1%	44.4%
Bog S2	32.3%	32.3%	32.3%	33.0%	34.7%	34.3%
Bog S3	61.2%	63.7%	62.5%	60.6%	61.5%	62.1%

Table A5.10 Cover of weed species as estimated by line transects

Site	Cover of weed species					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**5.4%**	**6.3%**	**5.9%**	**7.3%**	**8.1%**	**8.8%**
Bog 4.2	4.5%	4.7%	4.6%	4.3%	4.5%	4.3%
Bog 6	4.4%	6.9%	5.7%	7.8%	9.7%	14.5%
Bog 8/9/10	6.0%	9.0%	7.5%	11.0%	11.5%	10.3%
Bog 11.2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 12	0.0%	0.4%	0.2%	0.8%	0.8%	1.6%
Bog 13	40.2%	35.0%	37.6%	42.7%	47.0%	44.4%
All control sites	**3.3%**	**5.3%**	**4.3%**	**5.0%**	**4.9%**	**5.5%**
Bog 1	3.2%	3.5%	3.3%	3.5%	3.8%	3.8%
Bog 2	3.9%	4.6%	4.2%	5.5%	4.8%	7.8%
Bog 4.1/5/7	4.9%	7.6%	6.2%	5.4%	5.0%	6.0%
Bog 11.1	1.4%	3.2%	2.3%	4.3%	2.9%	2.2%
Bog S1	6.4%	7.4%	6.9%	6.7%	9.8%	6.7%
Bog S2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog S3	2.2%	9.5%	5.8%	8.5%	7.6%	9.8%

Table A5.11 Cover of Peat Moss *Sphagnum* spp. as estimated by line transects

Site	Cover of Peat Moss *Sphagnum* spp.					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**5.4%**	**5.3%**	**5.4%**	**6.0%**	**6.0%**	**5.9%**
Bog 4.2	15.9%	15.1%	15.5%	15.1%	16.8%	16.8%
Bog 6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 8/9/10	0.0%	0.0%	0.0%	2.1%	0.0%	0.0%
Bog 11.2	3.2%	2.7%	2.9%	2.1%	2.9%	2.1%
Bog 12	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 13	18.8%	22.2%	20.5%	28.2%	26.5%	26.5%
All control sites	**15.5%**	**17.2%**	**16.4%**	**15.9%**	**16.4%**	**17.1%**
Bog 1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 2	3.4%	3.0%	3.2%	2.1%	3.4%	2.5%
Bog 4.1/5/7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 11.1	5.4%	11.9%	8.7%	7.6%	6.1%	4.7%
Bog S1	33.7%	39.4%	36.5%	38.7%	37.7%	40.7%
Bog S2	62.0%	65.0%	63.5%	59.3%	61.6%	65.0%
Bog S3	21.1%	21.1%	21.1%	21.8%	24.3%	25.6%

Table A5.12 Proportion of Peat Moss *Sphagnum* spp. recorded as dead along line transects

Site	Cover of Peat Moss *Sphagnum* spp.					
	Baseline Year 1	Baseline Year 2	Baseline Mean	Impact Year 1	Impact Year 2	Impact Year 3
All impact sites	**0.8%**	**0.9%**	**0.8%**	**8.4%**	**0.8%**	**0.8%**
Bog 4.2	1.2%	1.2%	1.2%	2.5%	1.1%	1.1%
Bog 6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 8/9/10	0.0%	0.0%	0.0%	66.7%	0.0%	0.0%
Bog 11.2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 12	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 13	0.0%	0.0%	0.0%	9.1%	0.0%	0.0%
All control sites	**2.6%**	**1.9%**	**2.2%**	**1.5%**	**2.5%**	**1.7%**
Bog 1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 4.1/5/7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bog 11.1	0.0%	15.2%	10.4%	0.0%	0.0%	0.0%
Bog S1	7.0%	0.0%	3.2%	1.7%	5.4%	0.8%
Bog S2	1.6%	1.6%	1.6%	2.3%	0.5%	0.5%
Bog S3	0.0%	0.0%	0.0%	0.0%	3.9%	6.2%