Mount Buller Sustainable Water Security Project – Off-stream Storage

Hydrological and Ecological Monitoring and Adaptive Management Program

FINAL REPORT

Prepared for the Mount Buller and Mount Stirling Alpine Resort Management

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Biosis offices

AUSTRALIAN CAPITAL TERRITORY

Canberra
Phone: (02) 6102 1200
Email: canberra@biosis.com.au

NEW SOUTH WALES

Newcastle
Phone: (02) 4968 4901
Email: newcastle@biosis.com.au

Sydney
Phone: (02) 9101 8700
Email: sydney@biosis.com.au

Wollongong
Phone: (02) 4201 1090
Email: wollongong@biosis.com.au

QUEENSLAND

Brisbane
Phone: (07) 3831 7400
Email: brisbane@biosis.com.au

TASMANIA

Hobart
Phone: (03) 8686 4821
Email: hobart@biosis.com.au

VICTORIA

Ballarat
Phone: (03) 5304 4250
Email: ballarat@biosis.com.au

Melbourne (Head Office)
Phone: (03) 8686 4800
Fax: (03) 9646 9242
Email: melbourne@biosis.com.au

Wangaratta
Phone: (03) 5721 9453
Email: wangaratta@biosis.com.au

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Prepared by:	Michael Goddard Matthew Gibson Aaron Harvey Grant Jones Timothy Anderson Tim Wills Stephen Dahl
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- Ed Mahon (Buller Ski Lifts Pty Ltd)

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Glossary

Alpine Bogs	Both the EPBC Act threatened ecological community (Alpine Sphagnum Bogs and Associated Fens) and the FFG Act threatened community (Alpine Bog Community)
CBD	Central Business District
CMA	Catchment Management Authority
control sites	Twelve unaffected Alpine Bogs within the Mount Buller and Mount Stirling Alpine Resorts, nine of which are on the northern slopes of Mount Buller (Alpine Bogs 1, 2, 3, 4.1, 5, 7, 11.1, 14 and 15, comprising 1.097 hectares of Alpine Bog) and three of which are on Mount Stirling (of varying size, with a total combined area between 0.250 to 0.500 hectares)
DEE	Australian Government Department of the Environment and Energy
DELWP	Victorian Government Department of Environment, Land, Water and Planning
DGPS	Differential Global Positioning System
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EVC	Ecological Vegetation Class
FFG Act	Victorian *Flora and Fauna Guarantee Act 1988*
HEMAMP	Hydrological and Ecological Monitoring and Adaptive Management Program
impact sites	Eight indirectly affected Alpine Bogs downslope of the proposed water storage (Alpine Bogs 4.2, 6, 8, 9, 10, 11.2, 12 and 13, comprising 0.910 hectares)
PCF	Project Construction Footprint for the proposed Mount Buller Water Storage
project	The Mount Buller Sustainable Water Security Project, including the water storage and ancillary infrastructure
the resort	Mount Buller Alpine Resort
RMB	Mount Buller and Mount Stirling Alpine Resort Management Board
threatened	Species or ecological community listed as critically endangered, endangered or vulnerable under the EPBC Act, FFG Act or DELWP Advisory List
water storage	The proposed 100 megalitre water storage at Mount Buller

Summary

An off-stream water storage and ancillary infrastructure (the project) has been proposed for Mount Buller between the summit and the village. The project has potential to indirectly affect Alpine Bogs located downslope of the proposed water storage.

Objectives

This HEMAMP is designed to maintain the extent and condition of Alpine Bogs that are downslope of the proposed water storage. The overall objective of the HEMAMP is to limit the potential indirect loss of Alpine Bogs to no more than 0.090 hectares.

Additional objectives of the HEMAMP are to:

- Provide a detailed protocol for monitoring the hydrology and ecology of the Alpine Bogs.
- Specify performance criteria that will trigger adaptive management actions.
- Specify the duration and frequency of monitoring activities, reporting and review.

Performance criteria

The RMB's adaptive management will achieve outcomes that meet the following performance criteria, which aim to maintain the status quo within the Alpine Bogs at the impact sites, relative to the control sites:

- The '**extent**' criterion – no more than a 10% reduction in the total combined area of the affected Alpine Bogs, relative to control sites.
- The '**composition**' criterion – no more than a 10% reduction in the total 'bog-dependent' native flora species richness of the affected Alpine Bogs, relative to control sites.
- The **'encroachment'** criteria – no more than a 10% increase in the cover of 'non-bog-dependent' species within affected Alpine Bogs, relative to control sites, and weed cover will not exceed 5%.
- The '**structure**' criterion – no more than a 10% reduction in the average cover of sphagnum moss (*Sphagnum* spp.) within the affected Alpine Bogs, relative to control sites.

Adaptive management triggers

The RMB's adaptive management of impact sites will be triggered when monitoring indicates:

- A deterioration in Alpine Bog condition, such that the performance criteria have not been met or are unlikely to be met in the next 12 months.
- A demonstrated reduction/decline in surface water flows to Boggy Creek, over two consecutive years.
- A demonstrated reduction/decline in groundwater levels at bores within the Alpine Bogs, over two consecutive years.

All of the above changes relate to changes observed or measured at impact sites in relation to control sites.

1. Introduction

1.1 Project background

The Mount Buller and Mount Stirling Alpine Resort Management Board (the RMB) proposes to construct a 100 megalitre (ML) off-stream water storage and ancillary infrastructure (the project) on Mount Buller between the summit and the village. Around 2.149 hectares of Alpine Bog are found at Mount Buller, of which 2.007 hectares (93.4%) are downslope of the proposed Project Construction Footprint (PCF).

While the proposed PCF would avoid all direct impacts on Alpine Bogs, the project has the potential to affect the hydrology of 0.901 hectares of Alpine Bog downslope of the PCF (Biosis and GHD 2016). Working in collaboration and under the instruction of the RMB, Biosis Pty Ltd (Biosis) and GHD Pty Ltd (GHD) have prepared this document to mitigate indirect impacts on Alpine Bogs downslope of the PCF.

This document provides the details of a monitoring and adaptive management program to:

- Record existing site conditions and confirm the critical parameters to be monitored and assessed on an ongoing basis.
- Identify the nature and extent of any changes to site hydrology and hydrogeology as a result of implementing the project.
- Monitor the extent and condition of the Alpine Bogs in relation to any hydrological changes.
- Allow for early identification of potential impacts on Alpine Bogs.
- Enable implementation of measures to avoid and minimise impacts on Alpine Bogs.
- Document the effectiveness of any mitigation measures and inform future proactive and adaptive management activities.

This program is to be known as the Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP).

1.2 Location of the proposed water storage

The proposed water storage would be located within the Mount Buller Alpine Resort (the resort), approximately 150 kilometres northeast of Melbourne, Victoria. The proposed site (known as the 'Control Centre') is located on a gently to moderately sloping plateau, 700 metres east of the Mount Buller summit and 250 metres west of Mount Buller village (Figure 1).

The Project Construction Footprint (PCF) is north of the final section of the unsealed Mount Buller Summit Road and extends north down the hillside to the Summit Nature Walking Track (Figure 1). The PCF includes the proposed construction footprint of the water storage, roads, stockpile areas and extensions of variable shape and length for a range of ancillary infrastructure leading to and from the water storage. The PCF includes an area currently occupied by the Boggy Creek ski lift. It also includes a number of buildings (including the Control Centre building) and a section of the Mount Buller Summit Road.

The study area for this HEMAMP incorporates the broad 30-hectare area in and around the Project Construction Footprint (PCF). It extends beyond the PCF to encompass areas (such as Alpine Bogs) that may be indirectly affected by construction and operation of the proposed water (Figure 1).

The PCF is located on Crown land that is permanently reserved for the purpose of the Mount Buller Alpine Resort, known as Crown Allotment 5A, Section A (SPI 5A~A\PP2370), Parish of Changue East, County of Wonangatta. The RMB is the public land manager. The PCF is within the:

- Victorian Alps Bioregion.
- Goulburn River Basin.
- Management area of Goulburn Broken Catchment Management Authority.

1.3 Significance of the Mount Buller Alpine Bogs

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.

Alpine Bogs are groundwater dependent ecosystems with a scattered distribution in alpine, sub-alpine and montane environments across the Australian Alps, typically above the climatic treeline (DEWHA 2009; FFG Act Scientific Advisory Committee 2013). Alpine Bogs are restricted to wet sites and are generally characterised by the presence of sphagnum moss (*Sphagnum* spp.). They 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).

Alpine Bogs have an inherent ecological value. Not only are they rare ecosystems but they also provide habitat for threatened species, such as Alpine Bog Skink *Pseudemoia cryodroma*, Alpine Stonefly *Thaumatoperla flaveola* and Stonefly *Riekoperla isosceles*, all of which are listed as threatened under the FFG Act. Conservation and restoration of Alpine Bogs is also crucial to maintaining inland water resources because these systems issue water to major north and south flowing rivers from the Great Dividing Range (DEWHA 2009).

The present extent of Alpine Bogs is estimated to be approximately 8,000 hectares on mainland Australia, 4,500 hectares in Victoria and 61.5 hectares within the Goulburn Broken Catchment (TSSC 2008; Tolsma 2014). Around 2.149 hectares of Alpine Bog are found at Mount Buller, of which 2.023 hectares (94.1%) are within the broader study area and 2.007 hectares (93.4%) downslope of the PCF (Figure 2; Biosis and GHD 2016). Alpine Bogs therefore have a highly localised and restricted distribution at Mount Buller. They are synonymous with seven of Victoria's Ecological Vegetation Classes (EVCs), including Sub-alpine Wet Heathland (EVC 210) and Alpine Peaty Heathland (EVC 1011), both of which occur within the study area (Biosis and GHD 2016). Alpine Bogs located downslope of the proposed water storage (on the northern side of Mount Buller) may be indirectly affected by the project.

1.4 Existing investigations and monitoring

To support the concept design and associated planning documentation for the project, the study area has been subject to a series of detailed investigations since 2013. These investigations have resulted in detailed ecological mapping and the establishment of a network of groundwater monitoring bores to characterise site conditions.

In late 2014, the RMB commissioned GHD to establish a formal groundwater monitoring program at the site, including:

- Groundwater level and quality monitoring at various locations.
- Climate monitoring.
- Surface water (spring) flow monitoring and mapping (Boggy Creek Catchment).

The aim of this initial groundwater monitoring program was to characterise the seasonal behaviour of groundwater within the study area.

In early 2015, GHD conducted high resolution ground-truthed mapping of Alpine Bogs, which allowed for redesign of the water storage and ancillary infrastructure so that direct impacts on Alpine Bogs could be avoided. The PCF now avoids all direct impacts on Alpine Bogs and allows for a buffer area around Alpine Bogs. To further avoid and minimise the removal of native vegetation, preference has been given to siting material stockpiles, vehicle access, machinery storage etc. in existing areas of disturbed non-native vegetation rather than existing areas of native vegetation.

This HEMAMP builds upon the existing monitoring program and associated investigations.

1.5 Objectives of this HEMAMP

This HEMAMP is designed to maintain the extent and condition of Alpine Bogs that are downslope of the proposed water storage. Without implementation of the adaptive management actions outlined in this HEMAMP, around 0.901 hectares of Alpine Bog could be indirectly impacted as a result of changes to local hydrology from construction of the water storage. The overall objective of the HEMAMP (as specified in the performance criteria of Section 2.5) is to limit the potential indirect loss of Alpine Bogs to no more than 0.090 hectares.

Additional objectives of the HEMAMP are to:

- Provide a detailed protocol for monitoring the hydrology and ecology of the Alpine Bogs within the Mount Buller and Mount Stirling Alpine Resort, including sites downslope of the proposed water storage (affected Alpine Bogs or so-called "impact sites") and appropriate unaffected sites (control Alpine Bogs or so-called "control sites").
- Specify additional performance criteria that will trigger adaptive management actions.
- Specify the duration and frequency of monitoring activities, reporting and review.

1.6 Scope of this HEMAMP

The study area focusses on those Alpine Bogs identified on the northern face of the Mount Buller summit, topographically down-gradient of the proposed water storage. The hydrological monitoring and associated management arrangements presented in this HEMAMP do not consider the hydrological or hydrogeological impacts of ancillary structures such as delivery pipelines, power supply, pumping stations or roads. Much of this infrastructure is located away from the Alpine Bogs and the proposed mitigation measures will be adequate to address these impacts. This HEMAMP focuses on the water storage site and the potential impacts associated with its construction and operation.

1.7 Relationship with other protocols

The RMB has adopted or will adopt three other plans, with the general aim of avoiding, minimising or offsetting impacts of the project. These plans include:

- The Construction Environment Management Plan (CEMP), which specifies procedures for minimising environmental impacts during construction.
- The Ecological Rehabilitation Plan (ERP), which specifies procedures for re-establishing native vegetation within the PCF.
- An Offset Strategy and subsequent Offset Management Plan (OMP), which specify arrangements for offsetting impacts to native vegetation and threatened species habitat, as required under State and Commonwealth legislation.

1.8 Information sources

A range of information was reviewed during the development of this HEMAMP. Information included, but was not limited to:

- Mapping and assessment of Alpine Bogs in the Goulburn Broken Catchment (Tolsma 2014).
- Review of Alpine Bog ecology and hydrogeology (GHD 2015).
- Geotechnical investigations (GHD 2016b).
- Preliminary engineering design drawings and concept design summary report (GHD 2016a).
- Site Environment Management Plan (Meinhardt 2016).
- Snow gauge monitoring information compiled by Buller Ski Lifts.

1.9 Responsibilities and capabilities

The RMB is responsible for implementation of this HEMAMP and has the experience and resource capabilities to do so. The RMB has a history of conducting successful environmental monitoring and adaptive management programs, including:

- Management and ongoing monitoring of a population of endangered Mountain Pygmy-possum *Burramys parvus*.
- Long-standing management of water infrastructure (including wastewater treatment facilities) and monitoring of water quality as the local public "water supplier" under Victoria's *Safe Drinking Water Act 2003*.

Importantly, both the monitoring and the management components of this HEMAMP are straightforward and undemanding. The monitoring component follows a simple yet scientifically robust and repeatable design that has been refined in consultation with DELWP and DELWP's Arthur Rylah Institute. The management component has two essential components:

- Control of environmental weeds, which the RMB already conducts within the resorts.
- Environmental watering of Alpine Bogs, which will be achieved through a simple watering system and in priority to all other water demands within the resort.

The RMB has fully costed the program and is committed to its implementation.

2. Overview of the HEMAMP

2.1 Components of the HEMAMP

The HEMAMP specifies monitoring protocols and performance criteria for:

- Climate (Section 3).
- Surface water (Section 4).
- Groundwater (Section 5).
- Ecology (Section 6).

The HEMAMP also documents the proposed reporting and review processes (Section 7).

The focus of the monitoring is to enable early identification of potential changes to the hydrology, extent, structure and composition of the local Alpine Bogs throughout the lifetime of the water storage facility. This will enable proactive and adaptive management actions to be developed, implemented and assessed on an ongoing basis (Section 8).

2.2 Monitoring design

Monitoring will follow a Before-After-Control-Impact (BACI) design, incorporating:

- Twelve control sites.
- Eight impact sites.
- Minimum of one year of baseline (before impact) monitoring.
- Multiple years of post-impact monitoring for the lifetime of the water storage facility.

Although the intention of the development is to avoid impacts, the terms **impact** and **control** sites are used throughout this HEMAMP, in line with the BACI design. Ongoing post-impact monitoring is required (with scope for review) because potential impacts may occur over multiple years rather than a single, one-off impact that is typical of many BACI designs.

Alpine Bogs to be included in the monitoring program are (Figure 3):

- **Impact Sites** – the eight indirectly affected Alpine Bogs downslope of the proposed water storage (i.e. Bogs 4.2, 6, 8, 9, 10, 11.2, 12 and 13, comprising 0.910 hectares of Alpine Bog).
- **Control Sites** – twelve control bogs within the Mount Buller and Mount Stirling Alpine Resorts, nine of which will be on the northern slopes of Mount Buller (i.e. Bogs 1, 2, 3, 4.1, 5, 7, 11.1, 14 and 15, comprising 1.097 hectares of Alpine Bog) and three of which will be on Mount Stirling (i.e. three bogs of varying size, with a total combined area between 0.250 to 0.500 hectares).

Climate (meteorological) monitoring (Section 3) will make use of publicly available data from the Bureau of Meteorology (BoM) Mount Buller station and daily snow fall and snow depth information from Buller Ski Lifts sourced from gauges at Tirol Flat, Boggy Creek and Family Run (Figure 4).

Surface water monitoring (Section 4) is required to characterise the total yield from the Boggy Creek catchment and to confirm water use by the resort. Surface water monitoring will take place from two locations (Figure 5):

- Boggy Creek Weir 1: stage height (flow).
- Boggy Creek Weir 2: stage height (flow) and metering (flow) of raw water to the Burnt Hunt Reservoir.

During the operational and construction phase of the project, the relevant water storage related drainage waters (groundwater de-watering or groundwater flows under the water storage), which are proposed to be discharged to the aqueduct, will be added to the hydrological monitoring.

Groundwater monitoring (Section 5) relies on the existing groundwater bore monitoring network established at Mount Buller since 2014 (Figure 6). Automated monitoring of water levels, coupled with periodic manual measurements and water quality sampling is proposed.

Ecological monitoring (Section 6) will focus on the extent, structure and composition of the Alpine Bogs through transect monitoring methods at impact and control sites. These methods have been carefully designed to minimise the potential impacts that the monitoring procedures may have on Alpine Bogs (e.g. impacts from trampling).

2.3 Monitoring schedule

2.3.1 Climate, surface water and groundwater

Climate, surface water and groundwater monitoring will be a combination of automated and manual monitoring conducted twice yearly for the life of the storage (subject to review), as specified in Table 1.

Table 1 Schedule and summary of climate, surface water and groundwater monitoring

Project phase	Year	Parameter/Data	Description	Frequency
Pre-construction	0	Meteorological (BoM gauge)	Automated data from BoM Station 083024	Daily data downloaded for spring and autumn
	0	Meteorological (snow gauge)	Buller Ski Lifts snow gauge monitoring from three sites	Daily from mid-June to mid-October
	0	Surface water flow (stage height)	Boggy Creek Weir 1 Boggy Creek Weir 2	Daily (6 hourly)
	0	Surface water extraction (pumped metering)	Boggy Creek Weir 2	Daily (as pumped to Burnt Hut, part of Mt Buller Water Supply System)
	0	Surface water quality and inspection	Sampling, inspection, manual measurements and laboratory analysis of surface water	Twice yearly during the spring high flow period (mid-October to mid-November) and late summer or early autumn low flow period (February to March)
	0	Groundwater level	Automated water level logging	Daily (4 hourly)
	0	Groundwater quality and inspection	Sampling, inspection, manual measurements and laboratory analysis of groundwater	Twice yearly during the spring high flow period (mid-October to mid-November) and late summer or early autumn low flow period (February to March)

Project phase	Year	Parameter/Data	Description	Frequency
	0	Reporting	Annual monitoring report delivered to DELWP, DEE and published on website	One-off requirement in winter
	0	Review	Review of monitoring methodology and parameters	One-off task in winter
Construction	1	Meteorological (BoM gauge)	Automated data from BoM Station 083024	As per Pre-Construction
	1	Meteorological (snow gauge)	Buller Ski Lifts snow gauge monitoring from three sites	As per Pre-Construction
	1	Surface water flow (stage height)	Boggy Creek Weir 1 Boggy Creek Weir 2	As per Pre-Construction
	1	Surface water extraction (pumped metering)	Boggy Creek Weir 2	As per Pre-Construction
	1	Surface water quality and inspection	Sampling, inspection, manual measurements and laboratory analysis of surface water	As per Pre-Construction
	1	Groundwater level	Automated water level logging	As per Pre-Construction
	1	Groundwater quality and inspection	Sampling, inspection, manual measurements and laboratory analysis of groundwater	As per Pre-Construction
	1	Reporting	Annual monitoring report delivered to DELWP, DEE and published on website	One-off requirement in winter
	1	Review	Review of monitoring methodology and parameters	One-off task in winter
Post-construction (Operation)	2 and ongoing	Meteorological (BoM gauge)	Automated data from BoM Station 083024	As per Pre-Construction
	2 and ongoing	Meteorological (snow gauge)	Buller Ski Lifts snow gauge monitoring from three sites	As per Pre-Construction
	2 and ongoing	Surface water flow (stage height)	Boggy Creek Weir 1 Boggy Creek Weir 2	As per Pre-Construction
	2 and ongoing	Surface water extraction (pumped metering)	Boggy Creek Weir 2	As per Pre-Construction
	2	Surface water quality and inspection	Sampling, inspection, manual measurements and laboratory analysis of surface water	To be reviewed at end of Year 2
	2 and ongoing	Groundwater level	Automated water level logging	As per Pre-Construction
	2	Groundwater quality and inspection	Sampling, inspection, manual measurements and laboratory analysis of groundwater	To be reviewed at end of Year 2

Project phase	Year	Parameter/Data	Description	Frequency
	2 and ongoing	Reporting	Annual monitoring report delivered to DELWP, DEE and published on website	Annual requirement in winter
	2 and ongoing	Review	Review of monitoring methodology and frequencies	Once every three years in winter

2.3.2 Ecology

Ecological surveys will be conducted once (in summer) within the twelve months prior to construction of the water storage and annually thereafter (in summer) throughout the life of the facility (subject to review), as specified in Table 2. Summer monitoring will take place between mid-December and mid-February.

Table 2 Schedule and summary of ecological monitoring

Project phase	Year	Parameter/Data	Description	Frequency
Pre-construction	0	Control sites (unaffected Alpine Bogs)	Selection of control sites comprising Alpine Bogs with catchment areas outside the water storage footprint	One-off task in summer
	0	EVC mapping	Control and impact sites will be mapped and assigned to EVCs	One-off task in summer
	0	Floristics	A full combined flora species list for all control and impact sites and a list of flora species considered to be bog dependent	One-off task in summer
	0	Fixed transects	Establishment of 3-5 transects per Alpine Bog (dependent on the size of the Bog), for use as line and belt transects	One-off task in summer
	0	Fixed photo points	Establishment of photo point locations at both ends of each transect	One-off task in summer
	0	Photos	Recording of pre-construction photos from fixed photo points	Annual in summer
	0	Bog extent	Measurement of pre-construction extent (dimensions and area) of Alpine Bogs using line transects, on-ground mapping and aerial imaging	Annual in summer
	0	Bog composition	Measurement of the richness and cover of bog-dependent flora in control and impact sites using line and belt transects	Annual in summer
	0	Encroachment	Measurement of the cover of non-bog-dependent flora and weeds in control and impact sites using line and belt transects	Annual in summer

Project phase	Year	Parameter/Data	Description	Frequency
	0	Bog structure	Measurement of sphagnum cover in control and impact sites using line and belt transects	Annual in summer
	0	Reporting	Annual monitoring report delivered to DELWP, DEE and published on website	Annual in winter
	0	Review	Review of monitoring methodology, review of bog-dependent flora list and confirmation that control sites are suitably similar to impact sites so that valid post-construction comparisons can be made	One off task in winter
Construction	1	Photos	Recording of construction phase photos from fixed photo points	Annual in summer
	1	Bog extent	Measurement of construction phase extent (dimensions and area) of Alpine Bogs using line transects, on-ground mapping and aerial imaging	Annual in summer
	1	Bog composition	Measurement of the richness and cover of bog-dependent flora in control and impact sites using line and belt transects	Annual in summer
	1	Encroachment	Measurement of the cover of non-bog-dependent flora and weeds in control and impact sites using line and belt transects	Annual in summer
	1	Bog structure	Measurement of sphagnum cover in control and impact sites using line and belt transects	Annual in summer
	1	Reporting	Annual monitoring report delivered to DELWP, DEE and published on website	One-off requirement in winter
	1	Review	Review of monitoring methodology and frequencies	One-off task in winter
Post-construction (Operation)	2 and ongoing	Photos	Recording of post-construction photos from fixed photo points	Annual in summer
	2 and ongoing	Bog extent	Measurement of post-construction extent (dimensions and area) of Alpine Bogs using line transects, on-ground mapping and aerial imaging	Annual in summer

Project phase	Year	Parameter/Data	Description	Frequency
	2 and ongoing	Bog composition	Measurement of the richness and cover of bog-dependent flora in control and impact sites using line and belt transects	Annual in summer
	2 and ongoing	Encroachment	Measurement of the cover of non-bog-dependent flora and weeds in control and impact sites using line and belt transects	Annual in summer
	2 and ongoing	Bog structure	Measurement of sphagnum cover in control and impact sites using line and belt transects	Annual in summer
	2 and ongoing	Reporting	Annual monitoring report delivered to DELWP, DEE and published on website	Annual requirement in winter
	2 and ongoing	Review	Review of monitoring methodology and frequencies	Once every three years in winter

2.4 Reporting schedule

Annual monitoring reports will be completed each year by 30 June (refer to Section 7 for further details).

2.5 Performance criteria

While monitoring focusses on individual Alpine Bogs (at impacts sites and control sites), performance criteria are expressed in terms of all impact sites collectively, relative to all control sites collectively. Performance criteria for individual impact sites would be unrealistic, especially as smaller bogs at Mount Buller are marginal and already show signs of drying (Tolsma 2014; A Tolsma, pers. comm., July 2016).

The RMB's adaptive management will achieve outcomes that meet the following performance criteria, which aim to maintain the status quo within the Alpine Bogs at the impact sites, relative to the control sites:

- 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 sphagnum moss (*Sphagnum* spp.) within the impact sites, taking into account natural variation based on sphagnum moss cover averaged across control sites.

2.6 Data analysis overview

All data collected during the monitoring will be stored in digital format, in specifically designed databases either in Microsoft Excel or Microsoft Access format. The RMB will be responsible for ensuring monitoring data are maintained in a secure format suitable for data analysis.

The database will provide for storage of all monitoring data, including photos and other climatic, hydrological and ecological data. Two broad approaches will be used to examine the data with the aim of detecting change in the performance criteria:

- Statistical testing, using either Repeated Measures Analysis of Variance (ANOVA) or a Generalised Additive Mixed Model (GAMM).
- Graphical presentation of trends in criteria over time, separating control and impact sites, to determine if impact sites are responding differently to control sites. This analysis will also include correlation analysis with hydrological data (groundwater and surface water) and with climatic data.

3. Climate (meteorological) monitoring

3.1 Objective of climate monitoring

Climate monitoring will allow examination of the influence of the prevailing climate on the extent and condition of Alpine Bogs. Collection of climatic data will aim to assist in explaining some of the changes to Alpine Bogs that are not otherwise attributable to changes in hydrology. Climatic data will allow for more informed adaptive management actions to be taken.

3.2 Monitoring sites

3.2.1 Meteorological

The BoM maintains an active climate station at Mount Buller (Station Number 083024). This includes daily monitoring of temperature (highs and lows) and rainfall amongst other climate parameters. The automated station is located at Tirol Flat, approximately 500 metres from the site of the proposed water storage (Figure 4).

3.2.2 Snow cover

Buller Ski Lifts undertakes snow gauging at three locations across the resort (Tirol Flat, Boggy Creek and Family Run), which are considered to be within the general proximity to the study site (Figure 4). Buller Ski Lifts will supply monitoring data from these snow gauges to support the HEMAMP.

The three monitoring sites reflect different snow conditions across the resort, with the Tirol Flat and Boggy Creek gauges reflective of the conditions at the water storage site. The three monitoring locations are described below, based on historical records:

- **Tirol Flat** is located in the vicinity of the BoM automated weather station (083024). The monitoring site is located above the tree line and generally receives the least amount of snow. It has sunlight all day, is prone to scouring from wind effect and is the first to lose all its snow during the spring snowmelt (in line with it being on the north side of the mountain). It is not unusual for the Tirol Flat gauge to have no snow on it during a significant snowfall due to the effects of wind.
- **Boggy Creek** is located at the top of the Boggy Creek T-Bar. This gauge is above the tree line and receives sunlight all day. It experiences little or no wind affect and receives considerably more snow than the Tirol Flat gauge.
- **Family Run** is located on the southern side of the upper part of Family Run and is below the tree line. The site receives sunlight for most of the day and historically receives the most snow. It is the last gauge to lose its snow in spring.

All the snow gauging stations are marked and fenced. They are in locations that are not affected by snowmaking or wind deposition. All gauges are above the lowest skiable point (1,375 m) and are at a similar altitude (between 1,689 metres and 1,731 metres).

3.3 Frequency and parameters

3.3.1 Meteorological

Meteorological records for station 083024 will be downloaded twice yearly from BoM records and incorporated into the monitoring database prior to review of monitoring data.

3.3.2 Snowfall

Buller Ski Lifts has been recording the snow depths daily during the snow season since 1979 and the current gauge locations have been in use continuously since 1987. Buller Ski Lifts will undertake snow gauge monitoring as part of the existing Mount Buller Alpine Resort snow monitoring and associated Buller Ski Lifts programs. Buller Ski Lifts will provide the data to the RMB as part of the monitoring program.

At each location, a gauge has been installed to measure the depth of the snowpack. A 24-hour gauge sits on the snow surface and is recorded then cleaned off at about 5:30 am each day during the winter (or snow) season. The depths recorded are an average of the three snow gauging stations.

4. Surface water monitoring

4.1 Mount Buller water supply

Water requirements of Mount Buller Resort are determined by the need to serve potable demand and non-potable demands (such as snow making activities) across the resort. The annual demand for potable and non-potable water is strongly dependent upon the seasonal climatic conditions.

The Mount Buller water supply system receives water from two main sources:

- Licenced diversions from Boggy Creek (and its tributaries).
- Class A recycled water from the Mount Buller Wastewater Treatment Plant.

Boggy Creek is the only source of potable water for the village. In addition, the same supply is transferred to a raw water storage and used for snowmaking. Water from the wastewater treatment plant is also transferred to the raw water storage and used for snow making. A third source comprises a temporary diversion from the Howqua River into Sun Valley Reservoir.

Boggy Creek forms part of the Delatite River catchment, which is a tributary of the Goulburn River. The Boggy Creek catchment is located on the northern side of Mount Buller and is bound by two spur lines running north. The catchment is above 1,250 metres elevation and is mainly covered in snow during the winter period (mid-June to mid-September). The topography of the catchment is steep and vegetated, and lies in montane, sub-alpine and alpine areas.

The catchment is relatively inaccessible and is an area where vehicle access is controlled. In winter, the water sourced from the catchment is direct rainfall runoff, snowmelt or spring fed streamflow. In summer, the majority of the flow in the river is spring fed streamflow (i.e. groundwater seepage or baseflow).

Diversions from the Boggy Creek catchment occur at three locations (Figure 5). These are:

- The Headwaters of Boggy Creek, where a side hill trench across the northeast aspect of Mount Buller collects water that has originated from Alpine Bogs. This water can be gravity fed into Burnt Hut Reservoir.
- Two Catchment Weirs that collect water from a number of small gullies within the Boggy Creek catchment. This water is gravity fed into the Mount Buller system.
- Two Boggy Creek Weirs (Boggy Creek Weir 1 and Boggy Creek Weir 2) that divert water from Boggy Creek. Weir 1 gravity feeds into Boggy 1 Tank and Weir 2 requires water to be pumped from the creek into Boggy 1 Tank.

4.2 Objective of surface water monitoring

The objective of the surface water monitoring program is twofold:

- Characterise water use and quality.
- Quantify total flows generated by the Boggy Creek catchment.

4.3 Proposed surface water monitoring network

4.3.1 Existing infrastructure

There is currently one monitoring site for streamflow within Boggy Creek and its tributary streams. This infrastructure was installed at Boggy Creek Weir 2 during the 2014/15 summer period. Relying on one monitoring site places limitations on the assumptions that can be made regarding flow contributions from different parts of the Boggy Creek catchment. Additional monitoring locations are required.

4.3.2 Additional infrastructure

A network of surface water monitoring infrastructure will be installed to allow for more intricate modelling of surface water and groundwater contributions to surface water. Surface water monitoring will occur at three locations (Figure 5):

1. Boggy Creek Weir 1.
2. Boggy Creek Weir 2 (existing).
3. Discharge points of environmental watering system and water storage drainage system.

4.3.2.1 Boggy Creek Weir 1

Boggy Creek Weir 1 is located immediately downstream of the Alpine Bogs and provides a suitable location for gauging of surface water flows. Weir 1 is above the confluence of two sub-catchments and above gravity-fed off-takes for the Mount Buller water supply. Weir 1 is therefore subject to fewer external influences that may complicate surface water modelling. Combined with monitoring at Weir 2, monitoring at Weir 1 will allow more detailed breakdown of sub-catchment influence, better validation of the catchment model and confirmation of base-flow (groundwater) contributions within the Boggy Creek catchment.

4.3.2.2 Boggy Creek Weir 2

Boggy Creek Weir 2 is located immediately downstream of the confluence of two sub-catchments, one of which includes Weir 1. The installation of flow monitoring equipment at Weir 2 provides the ability to model base-flow responses in the adjacent catchment. This site also represents the licenced water supply diversion point which requires metering to enable the RMB to demonstrate compliance with its licence conditions.

4.3.2.3 Discharge points of watering and drainage systems

Boggy Creek is located north of the proposed off-stream storage. Directly north of the proposed storage is an aqueduct, referred to as the Headwaters Diversion. This aqueduct has a weir structure but is considered unsuitable for monitoring because:

- The existing weir structure is in poor condition (it is being bypassed in some areas).
- There is leakage from the unlined channel.
- The upstream catchment flows only partially cover the extent of the Alpine Bogs.

During the operational phase of the water storage, additional surface water related monitoring will be incorporated into the HEMAMP. Specifically, water quality monitoring at discharge points of the environmental watering system and monitoring of groundwater flows under the water storage will take place. A drainage system will be installed below the liner of the water storage. A flow meter will be installed at the discharge point of this drainage system to determine the flow contributions to the aqueduct. Specific monitoring details will be determined during the initial review of pre-construction monitoring data.

4.3.3 Gauging method

Stream gauging generally involves a four-step process:

1. Obtaining a continuous record of stage (i.e. the height of the water surface at a location along a stream).
2. Obtaining periodic measurements of discharge (i.e. the quantity of water passing a location along a stream).
3. Defining the natural, but often changing, relationship between the stage and discharge (i.e. rating of the gauge).
4. Using the stage-discharge relationship developed in step 3 to convert the continuously measured stage into estimates of streamflow or discharge.

4.4 Monitoring equipment

4.4.1 Stream gauge

Automated data loggers will be installed in the weir structures to enable automated water level monitoring. Such devices can measure water levels at frequencies varying from seconds through to months.

4.4.2 Water quality

Water quality sampling will be undertaken at each site in accordance with EPA Victoria's Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes (EPA 2000). In addition, water quality monitoring will be conducted at the discharge pits of the environmental watering system, to ensure that the quality of water delivered to downslope Alpine Bogs is not compromised.

4.4.3 Water storage discharge drainage

Water storage drainage infrastructure will be designed during the detailed design stage of the project and managed in accordance with the specific water storage operational manual and associated water storage safety guidelines (ANCOLD 2003). Monitoring will include installation of an automated flow meter.

4.5 Monitoring requirements

4.5.1 Parameters to be monitored

Surface water monitoring will include:

- Stage heights at the two gauging sites.
- Stream water quality at the two gauging sites.
- Asset condition (weir and flow meters) at the two gauging sites.
- Water storage drainage flows and water quality to the aqueduct during the operational phase of the water storage.

4.5.2 Monitoring frequencies

The monitoring frequency is a trade-off between resources and definition of information trends. The monitoring will be undertaken at greater frequencies during the first three years to build the knowledge base of the site behaviour.

The frequencies will be reviewed at the end of Year 2 with the objective of reducing monitoring to optimal frequencies (subject to agreement from DELWP and DEE). Monitoring reviews would also determine whether contingency actions are required.

4.5.2.1 Stage height

Surface water levels will be automatically recorded at the three surface water monitoring locations on a daily basis (e.g. at six hour frequency) using data loggers.

4.5.2.2 Surface water quality

Surface water quality will be analysed at the three surface water monitoring locations on a biannual basis. The frequency of surface water quality monitoring will be reviewed at the end of Year 2 during the annual review (Section 7.2).

Water samples will be tested for the following:

- Electrical conductivity (EC).
- Total Dissolved Solids (TDS).
- pH (field).
- Nutrients (Total P, N).
- Major ions (Ca, Mg, Na, K, Cl, SO4, HCO3, CO3 and NO3).
- Turbidity.
- Suspended Solids.

4.5.2.3 Weir and meter condition

Each site visit will involve an inspection of the weir structure. Monitoring equipment will be inspected, tested and calibrated every two years or as determined by the manufacturer's requirements.

4.6 Asset maintenance

4.6.1 Inventory

An asset inventory must be maintained for the long term operation of the monitoring network, particularly when maintenance works or expansion of the network is required. The documentation of assets facilitates purchasing, repairs, maintenance histories and performance specification. The asset inventory will include as a minimum:

- Metering records.
- Faults.
- Installed monitoring equipment specifications.
- Transducer/data logger type (make and model).

- Setting depth.
- Specifications for ordering.
- Range.
- Calibration details.

4.6.2 On-going maintenance

4.6.2.1 Weir

Deterioration of weir performance can be caused by a number of factors including:

- Vandalism.
- Blockages.
- Sedimentation.
- Structural collapse.

The RMB will be responsible for maintaining operational monitoring sites. This will include periodical inspection and repair or re-survey where required. Maintenance will be prompted from visual inspection and assessment during a site visit, but also where anomalous monitoring results (for example, no stream flow) are noted.

4.6.2.2 Monitoring equipment

The function of automated monitoring equipment will be checked periodically. During each water quality visit, the following will be completed:

- Confirmation of data storage capacity (depending upon logging frequencies, data loggers can store several months of data).
- Check of battery life.
- Check of communications cabling.
- Manual flow gauge measurement (to check for instrument drift).

5. Groundwater monitoring

5.1 Mount Buller groundwater

GHD (2016b) has conducted a number of subsurface investigations into the geology of the study area. These investigations confirmed that granite forms the basement rock throughout most of the study area. Granite closer to the surface has become weathered and formed granitic soils or 'grus'. In addition, the granite is capped in places with a relatively complex lithological profile comprising sediments and volcanics (including basalts). Also present are colluvium deposits, including cobbles and boulders of high-strength sandstone, and swamp deposits, including organic-rich carbonaceous clays and silts that have lithified to weak mudstones with minor coal seams.

When saturated, these lithologies represent aquifers to varying degrees. Both the granite and older volcanic basalt represent fractured rock aquifers where groundwater is stored and transmitted by fractures, joints and other discontinuities within the rockmass. Due to the nature of their emplacement, granites tend to be massive rock masses, with low fracture densities, compared to the extrusive older volcanic basalt, where fracture density is generally higher (GHD 2016b).

Groundwater flow systems within the granite are likely to be complex. Flow within the slightly weathered to fresh granite would likely be dominated by secondary porosity mechanisms. With increased weathering, or reworking of extremely weathered granite (granitic soils), groundwater flow may be analogous to porous media flow (GHD 2016b).

The carbonaceous mudstone unit tends to be fine grained and therefore it is likely to act like an aquitard, forming either a perching bed or confining layer for the underlying saturated granite (granite rock and granitic soils). The colluvium is likely to behave as a porous media continuum when saturated (GHD 2016b).

Surface expression of groundwater (spring flow) occurs within the Alpine Bogs approximately 150 metres downslope of the proposed water storage (near bore location BH7; Figure 6).

5.2 Objective of groundwater monitoring

The objective of the groundwater monitoring component is to obtain sufficient data to identify relationships between the quantity and quality of groundwater and the groundwater system's response to climate, construction of the water storage and on-going operations. This enables the system's response to be related to the condition of downslope Alpine Bogs, thereby informing the implementation of management responses such as watering of Alpine Bogs to maintain or improve their condition.

The groundwater monitoring would have two phases:

- Phase 1 aims to characterise groundwater level behaviour and its relationship with vegetation condition. These data will inform the design of adaptive management if deemed necessary.
- Phase 2 focuses on characterising the long term condition of the site and the efficacy of any adaptive management that may occur.

Phase 1 of the groundwater monitoring component commenced in November 2014.

5.3 Proposed groundwater monitoring network

5.3.1 Groundwater monitoring method

Groundwater levels will be monitored using a series of boreholes or open standpipes already constructed at the site. These boreholes provide for both water sample collection and monitoring of groundwater levels.

5.3.2 Groundwater bore network

The location of the monitoring bores was determined in consultation with the various project specialists during the design stage of the project. The bore locations are summarised in Table 3 and shown in Figure 6.

Table 3 Summary of groundwater bore monitoring network

Bore ID	Zone 55 co-ordinates		Reduced Level (m AHD)[1]	Total Depth (m bgl)[2]	Screen (m bgl)[2]		
	Easting	Northing			Top	Bottom	Screened lithology
BH04	449,692.8	5,888,663	1,735	15.68	8.68	14.68	Carbonaceous mudstone (interbedded between basalt flows)
BH04A	449,692.6	5,888,663	1,735	2.56	1.56	2.56	Basalt (sandy clays, cobbles)
BH05	449,547.4	5,888,727	1,733	19.8	14	19.8	Granitic soils (zones of core loss)
BH05A	449,546.6	5,888,727	1,733	2.5	1.5	2.5	Colluvium (clayey sand, cobbles)
BH06[3]	449,429.0	5,888,787	1,727	9	6	9	Granite, weathered to sands with clay bands (water losses during coring)
BH07[3]	449,658.3	5,888,915	1,695	1	0	1	Bog/granitic soil
BH09[3]	449,611.8	5,888,835	1,714	6	3	6	Granite (sandy clay / clayey sands)
BH10[3]	449,679.9	5,888,856	1,712	9	6	9	Granite (EW-MW), with sand bands (core and water losses)
BH13[3]	449,580.0	5,888,729	1,733	9	6	9	Colluvium (sand, cobbles)
BH14	449,683.5	5,888,724	1,733	19.5	16.5	19.5	Granite (EW-MW)
BH14A[3]	449,683.9	5,888,725	1,733	15	12	15	Granite (EW) to soils
BH14B[3]	449,684.4	5,888,725	1,733	9.5	6.5	9.5	Granitic soils (clayey sands with core losses)

BH15	449,626.7	5,888,695	1,734	23	20	23	Granitic soils, clayey sands
BH15A	449,629.6	5,888,696	1,734	6	3	6	Colluvium, weathered basalt
BH16[3]	449,459.4	5,888,860.5	1,715	2.1	1.1	2.1	Clayey gravelly sand and silty gravel
BH17[3]	449,701.4	5,888,866.6	1,727	2.2	1.2	2.2	Clayey sand
BH18[3]	449,922.4	5,888,830.6	1,711	2.15	1.15	2.15	Clayey sand

Notes:

1. *Reduced Level derived from LiDAR data (not instrument surveyed) and measured in metres Australian Height Datum (m AHD)*
2. *Total Depth and Screen measured as metres below ground level (m bgl)*
3. *Installed with automated data loggers and currently being monitored*

5.3.3 Monitoring bore construction

The monitoring bores will be:

- Registered with Goulburn-Murray Water under the Victorian *Water Act 1989*.
- Constructed consistent with the NUDLC (2012) guidelines.
- 50 mm PVC cased bores, completed with appropriate seals.
- Completed with a secure, flush-mounted gatic™ cover which provides a safe, tamper-proof installation.
- Consistent with safety in design considerations.
- Maintained in operational condition.
- Kept secure from unauthorised access.
- Clearly identified on the bore casing or headworks.

5.4 Monitoring equipment

5.4.1 Groundwater level

Pressure transducers and data loggers have been installed in 10 monitoring bores since November 2014 to monitor water levels. The total number of automated logging sites will be reviewed following an initial 12-month review of data. Table 3 outlines the sites that are currently installed with automated loggers.

Groundwater levels will be manually measured at the remaining monitoring bores that are not installed with automatic loggers.

5.4.2 Groundwater quality

Sampling of groundwater quality will occur at bore locations BH6, BH7, BH9, BH16, BH17 and BH18.

The EPA (2000) provides specific guidance on the sampling of groundwater. Groundwater bores will be sampled using manual bailing methods.

5.5 Monitoring requirements

5.5.1 Parameters to be monitored

Groundwater monitoring will include monitoring of:

- Groundwater level.
- Groundwater quality.
- Asset condition.

5.5.2 Monitoring frequencies

The monitoring frequency is a trade-off between resources and definition of information trends. Groundwater monitoring will initially (at least until the Year 2 review) be undertaken at greater frequencies to build the knowledge base of the site behaviour.

The frequencies will be periodically reviewed (Section 7.2) with the objective of reducing to optimal frequencies. Monitoring reviews will also determine whether contingency actions are required (i.e. need for other groundwater monitoring sites).

5.5.2.1 Groundwater levels

Groundwater levels will be recorded on a daily basis (e.g. at six hour frequency) at automated monitoring sites. At manual monitoring sites, groundwater levels will be recorded twice per year during groundwater quality sampling.

5.5.2.2 Groundwater quality

Groundwater quality will be analysed twice per year. The frequency of groundwater quality monitoring will be reviewed in Year 2 during the annual review (Section 7.2). The frequency may be reduced to annual sampling if deemed appropriate (subject to agreement from DELWP and DEE).

During the pre-construction phase, groundwater sampling will analyse the following:

- Electrical conductivity (EC).
- Total Dissolved Solids (TDS).
- pH (field).
- Nutrients (Total P, N).
- Major ions (Ca, Mg, Na, K, Cl, SO4, HCO3, CO3 and NO3).

The Year 0 review will determine which of the above water quality measures are appropriate for analysis in Year 1 and beyond.

5.5.2.3 Groundwater bore condition

Each site visit will involve an inspection of the groundwater bores. Monitoring equipment will be inspected, tested and calibrated on a quarterly basis or as determined by the manufacturer's requirements.

5.6 Asset maintenance

5.6.1 Inventory

An asset inventory will be maintained for the long term operation of the monitoring network, particularly to track maintenance works or expansion of the network as required. The asset inventory will include as a minimum:

- Monitoring bore records.
- Lithological logs and bore construction details.
- Installed monitoring equipment specifications.
- Transducer/data logger type (make and model).
- Setting depth.
- Specifications for ordering.
- Range.
- Calibration.

5.6.2 On-going maintenance

5.6.2.1 Bore

Deterioration of monitoring bore performance can be caused by a number of factors including:

- Vandalism.
- Infestation by plant roots.
- Sedimentation.
- Structural collapse.

The RMB will be responsible for maintaining operational monitoring bores. This would include periodical inspection and repair or re-survey of monitoring bores where required. Maintenance would be prompted from visual inspection and assessment during a site visit, but also when anomalous monitoring results occur.

In general terms, periodical rust proofing of gatic™ covers and general bore access will be the main maintenance action.

5.6.2.2 Monitoring equipment

The function of automated monitoring equipment will be checked quarterly (or as site conditions allow). During each visit, the following will be completed:

- Confirmation of data storage capacity (depending upon logging frequencies, data loggers can store several months of data).
- Check of battery life.
- Calibration/'zeroing' in air.
- Check of suspending wires.
- Check of desiccants (if vented loggers are applied).
- Manual water level measurement (to check for instrument drift).

6. Ecological monitoring

6.1 Objective of ecological monitoring

The ecological monitoring component aims to assess the extent and condition of Alpine Bogs at impact sites relative to the extent and condition of Alpine Bogs at control sites. Ecological monitoring will focus on the extent of the bogs, their floristic composition, their structural health and encroachment of weeds and other atypical species. These parameters will be assessed with reference to specific performance criteria, which will set trigger points for adaptive management actions. Ultimately, the aim of ecological monitoring will be to inform the implementation of adaptive management measures to minimise the potential indirect impacts of the proposed water storage.

6.2 Monitoring requirements

6.2.1 Parameters to be monitored

Ecological monitoring will focus on the following parameters:

- Bog extent:
  - Area of Alpine Bogs.
- Bog composition:
  - Richness of bog-dependent flora.
  - Cover of bog-dependent flora.
- Encroachment by weeds and other atypical species:
  - Cover of weeds.
  - Cover of non-bog-dependent flora.
- Bog structure:
  - Sphagnum moss cover.

6.2.2 Monitoring frequency

As Alpine Bogs are highly sensitive ecosystems, it is essential that field methods are designed to avoid or minimise impacts that may result from the monitoring procedure itself. For this reason, ecological monitoring will take place annually, to avoid excessive trampling of the Alpine Bogs.

The methods specified in this HEMAMP use a combination of:

- Repeatable and systematic monitoring using belt transects and line transects.
- On-ground reference photo points.
- On-ground mapping of bog extent using differential GPS.
- High resolution aerial imagery.

Annual monitoring using these methods will be frequent enough to detect changes in Alpine Bogs and to inform adaptive management actions. Vegetative changes to Alpine Bogs, if they occur, would be slow and gradual enough for annual monitoring to be sufficient (A Tolsma, pers. comm., July 2016).

The frequency of ecological monitoring will be subject to reporting and review requirements (Section 7). If reviews reveal that annual monitoring is too frequent (e.g. because no changes are being detected and/or the monitoring procedure is itself impacting on the Alpine Bogs), the frequency of ecological monitoring may be reduced (subject to agreement from DELWP and DEE). Greater reliance may be placed on less intrusive monitoring methods, such as monitoring by way of aerial imagery.

6.3 Site selection and establishment

Identical methods and survey intensity will be conducted each year. However, some additional actions will be required to establish the sites in the initial monitoring visit. The first monitoring visit will involve:

- **Selection of control sites**. The monitoring program will include twelve Alpine Bogs with catchment areas that are entirely outside of the footprint of the proposed water storage and earth embankment. The control sites will include nine Alpine Bogs on the northern slopes of Mount Buller (i.e. Bogs 1, 2, 3, 4.1, 5, 7, 11.1, 14 and 15, comprising 1.097 hectares of Alpine Bog) and three Alpine Bogs of varying size on Mount Stirling (with a total combined area between 0.250 to 0.500 hectares). Alpine Bogs on Mount Stirling are far enough from the water storage and other infrastructure to ensure that resort activities (including construction and operation of the water storage) have no measurable impact on the extent or condition of the Alpine Bogs. Some areas of the Alpine Bogs on Mount Stirling are dominated by medium shrubs (greater than one metre tall). These shrub-dominated areas will be avoided to minimise the potential for damage from trampling during monitoring and to ensure that sites at Mount Stirling are comparable to sites at Mount Buller.
- **Full floristic assessment of all control and impact sites**. A comprehensive and combined species list will be collected for all Alpine Bogs included in the monitoring program.
- **Creation of bog-dependent flora species list**. From the full species list, a subset of species considered dependent on and characteristic of the Alpine Bogs will be determined and this list will be used in future assessments of the extent and composition criteria. The list of bog-dependent flora will be determined with reference to DELWPs EVC benchmarks and reviewed by an independent expert as part of the Year 0 review (i.e. prior to construction commencing in Year 1).
- **Mapping of control and impact sites**. Current mapping of the bogs will be verified and revised where necessary, with all areas of Alpine Bog assigned to EVCs and their boundaries accurately mapped using DGPS and aerial imagery.
- **Full aerial imaging of control and impact sites**. Aerial imaging of the Alpine Bogs and immediate surrounds will include red-green-blue (RGB), near infrared (NIR) and mid-infrared (mid-IR) imagery. A digital surface model (DSM) will be generated to determine changes in vegetation strata. The RMB will collect this aerial imagery (from satellite data and/or unmanned aerial vehicles) to verify that monitoring through aerial imaging is valid, in case reviews reveal that less intrusive monitoring methodology is required.
- **Establishment of fixed transects**. Permanent transects will be used to assess extent, composition, encroachment and structure for each Alpine Bog (at impact and control sites). The same transects will be used as line transects (for point intersection sampling), belt transects (for quadrat sampling) and photo points. Each Alpine Bog will have three to five transects, depending on the size of the Bog. To minimise trampling, transects will be aligned across the narrow dimensions of the Bog, rather than

across the longest dimension. Each transect will traverse the entire width of the Alpine Bog, starting 1.5-4 metres outside the Bog and ending 1.5-4 metres outside the Bog. The start and end point of transects will be recorded using DGPS and marked with small wooden pegs that do not protrude above the height of the vegetation, to avoid creating a risk to skiers and passers-by. Transect lengths (in metres) will be divisible by four to facilitate quadrat sampling at regular intervals.

- **Establishment of fixed photo points**. A photo point location will be established at both ends of each fixed transect, providing 6-10 photo points per Alpine Bog.

6.4 Monitoring methods

6.4.1 Line transects (point intersections)

The fixed transects will be used as line transects, which will facilitate monitoring of extent, composition, encroachment and structure of Alpine Bogs, but particularly extent, encroachment and structure. At 10-centimetre intervals along each transect, a record will be taken of the plant species that intersect the transect. If no plant species is present at a particularly point intersection, the groundcover type (e.g. organic matter, rock or bare ground) will be recorded.

The types of species recorded (i.e. bog-dependent species or not) and the position at which they are recorded will provide an indication of the extent of the Alpine Bog. It will allow demarcation of the boundary of the Alpine Bog in at least six locations (if three transects are deployed) and in up to ten locations for larger Bogs (if five transects are deployed), thereby allowing approximate dimensions of the Alpine Bog to be determined.

The frequency at which species are recorded will provide an indication of the structure of the Alpine Bogs and any encroachment of atypical or weed species. It will allow for the 'cover' of bog-dependent species, non-bog-dependent species, weeds and sphagnum moss to be estimated. Estimating cover with point intersections is less subjective than simple visual estimates, which means that the data are less biased by an individual observer and more suited to vegetation monitoring for detection of change. This means that the data should be more accurate and the estimates of change over time more reliable. Assessing on a continuous scale as opposed to broad categories (as is the case for the widely used Braun-Blanquet or Domin scales) also increases the resolution of the data so that relatively smaller changes can be detected.

6.4.2 Belt transects (quadrats)

The fixed transects will be used as belt transects, which will facilitate monitoring of the composition of Alpine Bogs. More specifically, belt transects will allow for accurate estimation of the species richness of bog-dependent flora.

A 1x1 metre collapsible quadrat (Plate 1) will be placed at 4-metre intervals along each transect, starting and ending 4 metres from the ends of the transect. The centre of the quadrat will be placed at the 4-metre interval mark. All flora species within the quadrat will be recorded.

When combined with point intersection data, quadrat data will provide a measure of the species richness of bog-dependent flora. Point intersection data will capture the most dominant flora species. The inclusion of quadrat data increases the likelihood of detecting small or rare species, including any novel weed species that may need managing.

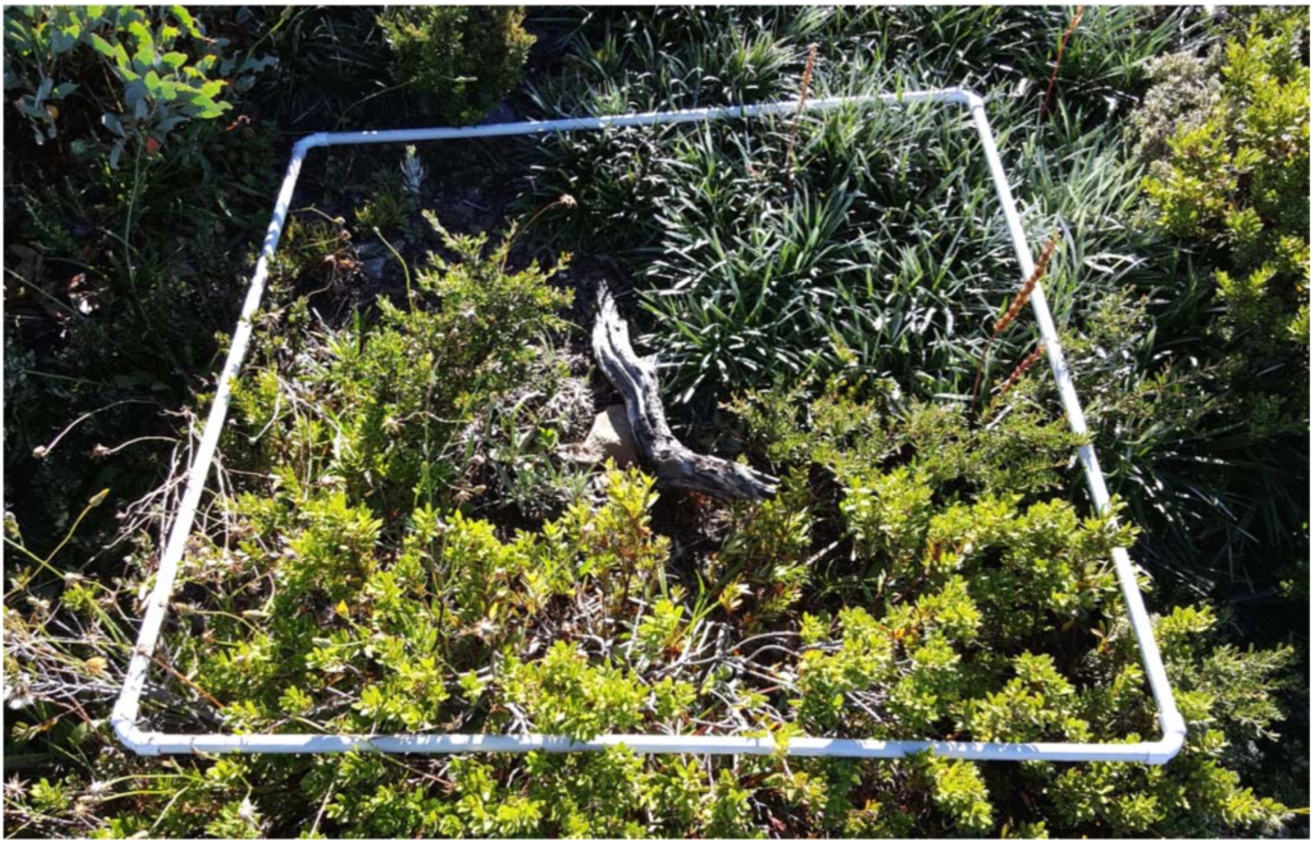

Plate 1 Example of the type of quadrat required for the belt transects (quadrat sampling).

6.4.3 Photo points

The ends of the fixed transects will be used as photo points, from which photos will be taken annually to allow for qualitative assessment of changes (if any) to the extent, composition, encroachment and structure of Alpine Bogs. A digital photograph will be taken from approximately 1.6 metres above the ground at the start and end of each permanent transect (from the wooden peg markers). The photo will show the length of the transect towards the other wooden peg. Each photo will be labelled with a photo board, be aligned in the centre of the field-of-view and positioned 4 metres along the transect from the photo point.

6.4.4 On-ground mapping

The boundary of each Alpine Bog (at impact and control sites) will be mapped on foot using a DGPS. The mapping will be conducted at a minimum resolution of 0.001 hectares (10 square metres) and at an ideal resolution of 0.0001 hectares (1 square metre) where possible. Across this given resolution, areas will be considered to be Alpine Bog if bog-dependent flora make up more than 50 per cent of vegetative cover.

Annual on-ground mapping will provide measures of the area of each Alpine Bog, which will enable changes to extent to be detected. Since on-ground mapping can be subjective and may cause excessive trampling of Alpine Bogs, on-ground mapping may be replaced by mapping using aerial imagery, if reviews show that it is valid (preliminary investigations suggest that aerial imagery will produce reliable data).

6.4.5 Aerial imaging

Aerial imaging will be conducted in Year 0 (pre-construction) to collect baseline data and to verify that monitoring through aerial imaging is valid. Assuming aerial imaging is found to be valid, it will provide an ecological monitoring contingency if reviews reveal that on-ground monitoring is disturbing the Alpine Bogs and less intrusive monitoring methods are required.

High resolution aerial imaging of the Alpine Bogs and immediate surrounds will include red-green-blue (RGB), near infrared (NIR) and mid-infrared (mid-IR) imagery. A digital surface model (DSM) will be generated to determine changes in vegetation strata. Aerial imagery will be collected using unmanned aerial vehicles (UAVs) flying approximately 120 metres above ground level and flying in accordance with Civil Aviation Safety Authority (CASA) regulations. Approximately one day of flight-time will be required to collect the necessary aerial imaging data, subject to weather conditions. Satellite imagery may also be used to supplement UAV imagery.

Post-collection analysis of these combined data will allow for estimation of:

- The extent (area) of Alpine Bogs (extent criterion).
- The cover of bog-dependent and non-bog-dependent flora species (composition and encroachment criteria).
- The cover of weeds (encroachment criterion).
- The cover of sphagnum moss (structure criterion).

6.5 Summary of ecological monitoring

A summary of the monitoring activities is provided in Table 4.

Table 4 Summary of ecological monitoring

<table>
<tr><th>Target criterion</th><th>Metric</th><th>Method</th><th>Sample size</th><th>Frequency</th></tr>
<tr><td>Extent</td><td>• Bog dimensions (m)
• Bog area (ha)</td><td>Line transects, on-ground mapping and aerial imaging</td><td>Three to five transects per Alpine Bog</td><td rowspan="4">Annual (summer)</td></tr>
<tr><td>Composition</td><td>• Richness of bog-dependent flora (# spp.)
• Cover of bog-dependent flora (% cov)</td><td rowspan="3">Line transects (point intersections) and belt transects (quadrats)</td><td rowspan="3">Three to five transects per Alpine Bog with point intersections at 10 cm intervals and quadrats at 4 m intervals</td></tr>
<tr><td>Encroachment</td><td>• Cover of non-bog-dependent flora (% cov)
• Cover of weeds (% cov)</td></tr>
<tr><td>Structure</td><td>• Sphagnum moss cover (% cov)</td></tr>
</table>

7. Reporting

7.1 Annual monitoring report

The RMB will prepare an annual report covering all elements of the HEMAMP, including the following:

- Details of compliance with the conditions of development approval.
- The results of the climatic, hydrological and ecological monitoring over the previous 12 months.
- A comparison of the results of the climatic, hydrological and ecological monitoring from the previous 12 months with all previous data, including the baseline data.
- A description of any long term trend in climatic, hydrological and ecological monitoring since the inception of the monitoring (i.e. since collection of baseline data commenced).
- Assessment of monitoring results against the defined performance criteria, whether adaptive management triggers have been reached and the consequences if they have.
- Strategic recommendations for proactive and adaptive management of the Alpine Bogs for the following 12 months and following 5 years.
- Recommendations for the ongoing monitoring of the Alpine Bogs under the HEMAMP, including any recommendations to adapt elements of the monitoring program as data are analysed and interpreted.

The annual report will be submitted to:

- The Victorian Department of Environment, Land, Water and Planning (DELWP).
- The Commonwealth Department of the Environment and Energy (DEE).

The RMB will provide the Departments with the report by 30 June each year and will publish the report on its website for public access. The Departments will review the annual report and may provide advice on the approach that the RMB should take for adaptive and proactive management of the Alpine Bogs.

7.2 Review

The first year of monitoring (deemed Year 0) will involve collection of baseline data. The HEMAMP will be reviewed at the end of Year 0 (pre-construction), end of Year 1 (construction), end of Year 2 (post-construction) and subsequently once every three years for the life of the water storage facility.

The purpose of the reviews will be to evaluate the effectiveness of the monitoring program, with consideration of the:

- Frequency and timing of field surveys.
- Sample size and selection of sample and control sites.
- Cost effectiveness of monitoring activities and assets.
- Survey methods, including whether or not survey methods are causing disturbance to Alpine Bogs.
- Data management and analysis procedures.
- Statistical power and sensitivity.
- Communication of findings to DELWP, DEE and the broader community.
- Utility of the monitoring procedures for triggering management responses.

The review will also specify the timing of the next review, if further review is considered necessary. Any recommended changes to the monitoring program will be subject to the RMB receiving approval from DELWP and DEE.

7.3 Quality assurance and quality control

The monitoring must include a quality assurance/quality control (QA/QC) program as part of its field procedures, based on relevant Australian Standards (Standards Australia 2005) and standard industry practice. The QA/QC program to be implemented will include the following:

- Implementation of standard procedures including sampling equipment decontamination between sampling points.
- Field measurement of groundwater quality parameters.
- Field equipment calibration records.
- Use of laboratories certified by the National Association of Testing Authorities (NATA).
- Transportation of samples with accompanying chain of custody (COC) documentation.
- Collection of blind and split duplicate samples and calculated review of Relative Percent Difference (RPDs).
- Comparison of field and analytical data.
- Compliance with sample holding times.
- Review of internal analysis of QC and laboratory duplicates.
- Use of suitably experienced field personnel (e.g. botanists) to undertake vegetation surveys.

8. Adaptive management actions

The footprints of the water storage and earth embankment will reduce the catchment areas of Bogs 4.2, 6, 8, 9, 10, 11.2, 12 and 13, thereby potentially causing these Alpine Bogs to dry (Figure 3). Adaptive management actions therefore focus on returning water to these bogs through the design and management considerations outlined below. Priority will be given to those bogs (priority Alpine Bogs) that are likely to experience the greatest reductions in catchment area (Bogs 4.2, 6, 8, 9, 10, 11.2 and 12). Additional management responses are also considered below.

8.1 Design considerations

In consultation with Biosis and under instruction from the RMB, GHD has designed the water storage facility and ancillary infrastructure to avoid all direct impacts on Alpine Bogs. The RMB has succeeded in avoiding direct loss of Alpine Bogs. No areas of Alpine Bog occurs within the Project Construction Footprint (PCF) and no area of Alpine Bog will be directly lost by construction of the water storage or ancillary infrastructure.

In addition, design of the water storage has incorporated considerations for drainage and a watering system to avoid, minimise and mitigate impacts to the Alpine Bogs and to facilitate adaptive management if required. These features will be maintained throughout the life of the water storage.

8.1.1 Drainage

Drainage and landscaping around the periphery of the storage and access tracks will be constructed to direct water runoff along the natural flow paths towards downslope Alpine Bogs. Overflow and perimeter drains will also divert water towards the Alpine Bogs (incorporating appropriate sediment protection).

The water storage and earth embankment will incorporate an internal drainage system to control groundwater pressure. Groundwater seepage under the footprint of the water storage will be collected to a centralised point and redistributed through a drainage outlet pipe under natural groundwater pressure to the aqueduct that runs through the downslope Alpine Bogs (Figures 7 and 8). The drainage outlet pipe will also be connected to the watering system to provide contributions to environmental watering of the Alpine Bogs, if required.

8.1.2 Watering system

A watering system will be installed during the construction phase to allow for environmental watering of priority Alpine Bogs (Bogs 4.2, 6, 8, 9, 10, 11.2 and 12). The watering system incorporates a distribution pipeline and several discharge pits (Figures 7 and 8). Importantly, environmental watering will not take place in close proximity to (within 20 metres of) the water storage earth embankment so as not to compromise the geotechnical stability of the embankment. Installation of the watering system will be above ground or by horizontal directional drilling, so that it is non-invasive and avoids disturbance to the Alpine Bogs. Pipeline alignments and construction depths will be located sensitively to avoid or minimise the potential for interception or redirection of groundwater.

The watering system has been designed so that the method of delivery of water to Alpine bogs mimics the natural groundwater seepage and baseflow discharge patterns. While the precise frequency or timing of delivery of water may not match the natural system, collection of hydrological data over time, particularly baseline data in Year 0, will allow for the timing of watering to be continually refined to best mimic natural hydrology.

The environmental watering system has been designed with valves (Figure 8), which will control the volume of water being delivered by each discharge pit. If necessary, the valves will allow water to be delivered to Alpine Bogs in volumes proportional to the area of Alpine Bog catchment that is affected by the water storage. Ultimately, however, the volume of water delivered to each affected Alpine Bog will depend on observed impacts on those Bogs.

The watering system includes filtration mechanisms to ensure that environmental water delivered to downslope Alpine Bogs is of high quality, with low sediment load and no weed propagules. The surface water monitoring program includes monitoring of water quality at discharge pits of the watering system, to ensure that the quality of water delivered to downslope Alpine Bogs is maintained.

8.2 Adaptive management actions and responses

The RMB is committed to the project meeting environmental needs, as a first priority. This means that demands for environmental water for Alpine Bogs will take priority over other demands, such as demands for snowmaking or potable water, for the lifetime of the water storage facility. The RMB cannot guarantee that there will always be a minimum volume of water present in the dam for environmental watering purposes because the volume of water that is present will ultimately depend on increasingly variable environmental (climatic) conditions. Nevertheless, when there is water available, the RMB is committed to environmental watering taking precedence over other water uses. Triggers for adaptive management

Triggers for management responses are required to enable intervention to maintain the status quo of the Alpine Bogs at the impact sites, relative to the extent and condition of the Alpine Bogs at the control sites. The RMB's adaptive management of impact sites will be triggered when monitoring indicates:

- A deterioration in Alpine Bog condition (extent, composition, structure and encroachment of weeds/atypical species), such that the performance criteria outlined in Section 2.5 have not been met or are unlikely to be met in the next 12 months.
- A demonstrated reduction/decline in surface water flows to Boggy Creek, over two consecutive years. The percentage reduction will be determined at the end of Year 0 based on pre-construction monitoring data because no flow data has currently been collated on Boggy Creek.
- A demonstrated reduction/decline in groundwater levels at bores within the Alpine Bogs, over two consecutive years. The percentage reduction will be determined at the end of Year 0 based on pre-construction monitoring data because limited seasonal groundwater level data has been collated within the Alpine Bogs.

All of the above triggers relate to changes observed or measured at impact sites in relation to control sites. These are changes that are most likely to be caused by construction and operation of the water storage. Broad landscape scale changes, such as those brought about by a drying and warming climate, are unlikely to trigger adaptive management if they affect impact and control sites similarly.

There may be scope for environmental watering to protect Alpine Bogs at impact sites from the effects of a changing climate. However, it would be unrealistic for the RMB to commit to protecting Alpine Bogs against the effects of climate change for the lifetime of the water storage, given that these effects are unlikely to be purely hydrologic in nature and unlikely to be entirely avoidable through environmental watering. The RMB's commitment to environmental watering will nevertheless ensure that Alpine Bogs at impact sites retain their resilience to landscape scale environmental change.

If monitoring reveals that one or more triggers for adaptive management have been met and environmental watering is required, environmental water held within the water storage will be re-directed (under pressure) to the watering system via the drainage discharge pipe. The HEMAMP and its triggers for environmental watering have been designed to be reactive in some instances and pre-emptive in others because of the inherent variability associated with climatological, hydrological and ecological systems and because of the uncertainty around precisely how impacts on downslope Alpine Bogs will materialise.

Hydrological triggers for environmental watering (reductions in surface water flows or groundwater levels) will have a lag of two years to account for the inherent variability that can occur in hydrological systems over relatively short time scales. Thus, reductions in these hydrological parameters at impact sites relative to control sites will need to occur over two consecutive years before environmental watering occurs. In this respect, management responses to hydrological triggers will be reactive.

Ecological triggers for environmental watering will be immediate and in some cases pre-emptive. Ecological changes to Alpine Bogs (e.g. changes to extent, species composition or encroachment of weeds) are likely to be slow and manifest themselves over a timescale of many years. It will therefore be important to begin reversing these ecological changes (through environmental watering and weeding) as soon as they are detected or if they are predicted to occur in the next 12 months.

Importantly, environmental watering will be adaptive and change according to the latest monitoring results. Over time, as more site-specific climatological, hydrological and ecological data are collected, there will be greater scope to pre-empt ecological changes and prevent them from occurring.

8.2.1 Pre-construction and construction phases

The approach to the adaptive management during the design and construction stage will be as follows:

- Implementation of the critical design considerations as outlined in Section 8.1.
- At the end of Year 0 (i.e. prior to construction), groundwater and surface water monitoring results will be interpreted to develop and calibrate a water balance model which will predict the hydraulic relationships between the Alpine Bogs and the storage construction under varying climate conditions. The water balance model will predict seasonal estimates of:
    - Groundwater levels/flows.
    - Surface water flows in Boggy Creek.
    - Direct rainfall and evaporation.
- Based on Year 0 (pre-construction) monitoring and the water balance model, the operation of the environmental watering system will be refined.

8.2.2 Post-construction (operation) phase

Adaptive management will comprise a tiered approach, with the level of intervention increasing with the risk of adverse impact to the site's ecological values.

Post-construction, the RMB will reserve the necessary amount of environmental water for the priority Alpine Bogs (Bogs 4.2, 6, 8, 9, 10, 11.2 and 12) as a first priority management consideration above all other demands for water. The provision of environmental water to these Alpine Bogs will be a critical feature of the plan to mitigate potential drying impacts.

If the water balance model detects a trend towards drying of the Alpine Bogs in excess of natural seasonal fluctuations, an assessment will be undertaken to ascertain the source and magnitude of the risk and recommendations will be developed to mitigate the environmental risks.

If the triggers for adaptive management are reached, the RMB will immediately implement the adaptive management actions outlined in Table 5.

Table 5 **Triggers and responses for adaptive management of Alpine Bogs at impact sites**

Trigger	Response
1a. Deterioration in Alpine Bog condition. Reduction in extent (area) of Alpine Bogs by 10% or more.	Environmental watering.
1b. Deterioration in Alpine Bog condition. Reduction in total bog-dependent native flora species richness by 10% or more.	Environmental watering. Consider further investigations (see below).
1c. Deterioration in Alpine Bog condition. Cover of non-bog-dependent species exceeds 10% or weed cover exceeds 5%.	Weed management. Environmental watering if accompanied by Triggers 2 and/or 3.
1d. Deterioration in Alpine Bog condition. Reduction in cover of sphagnum moss by 10% or more.	Environmental watering. Consider further investigations (see below).
2. Demonstrated reduction/decline in surface water flows to Boggy Creek.	Environmental watering.
3. Demonstrated reduction/decline in groundwater levels at bores within Alpine Bogs.	Environmental watering.

Further investigations will be required as a response to some triggers, especially if existing adaptive management responses have had no effect in addressing triggers. Further investigations would include: re-testing or repeat monitoring as a QA/QC check and increased monitoring frequency to further investigate changes or to gauge effectiveness of the adaptive management actions.

9. Conclusion

This HEMAMP is designed to protect and maintain the extent and condition of Alpine Bogs that are downslope of the proposed water storage. The HEMAMP adopts a BACI design to monitor climate, hydrology and ecology of Alpine Bogs at impact sites and control sites.

The focus of the monitoring is to enable early identification of potential changes to the hydrology, extent, structure and composition of the local Alpine Bogs throughout the lifetime of the water storage facility. This will enable proactive and adaptive management actions to be developed, implemented and reviewed on an ongoing basis.

The RMB has the experience and resource capabilities required to implement the HEMAMP and has a successful history of implementing other large-scale environmental monitoring and adaptive management programs. The RMB is committed to the performance criteria specified in this HEMAMP and will prioritise the environmental demands of the project over all other demands.

Successful implementation of this HEMAMP will maintain the status quo among the Alpine Bogs on the northern slopes of Mount Buller for the lifetime of the water storage facility.

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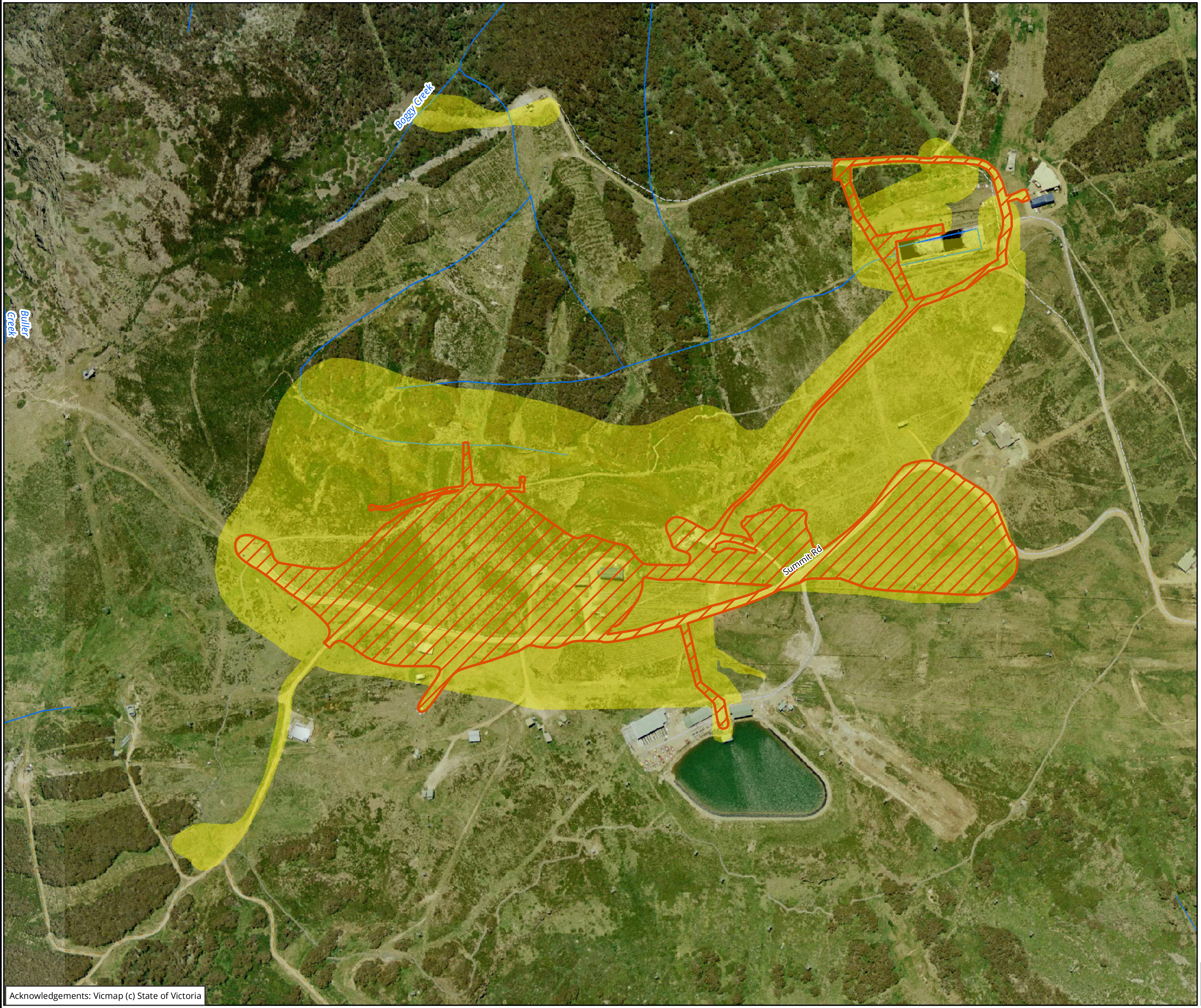
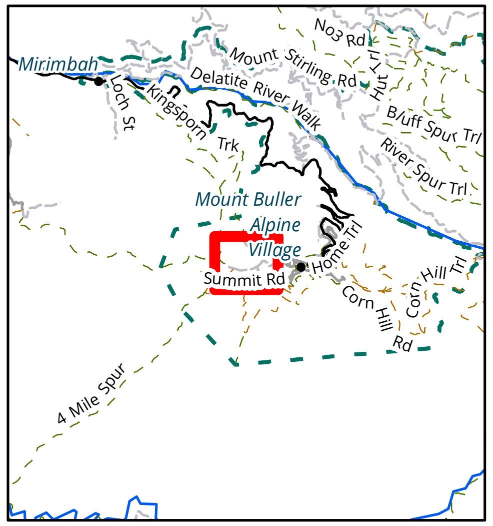
Figures





Legend

- Study Area
- Project Construction Footprint (PCF)

Figure 1: The project construction footprint and broader study area within the Mount Buller Alpine Resort, Victoria.

0 40 80 120 160 200
Metres
Scale: 1:4,000 @ A3
Coordinate System: GDA 1994 MGA Zone 55

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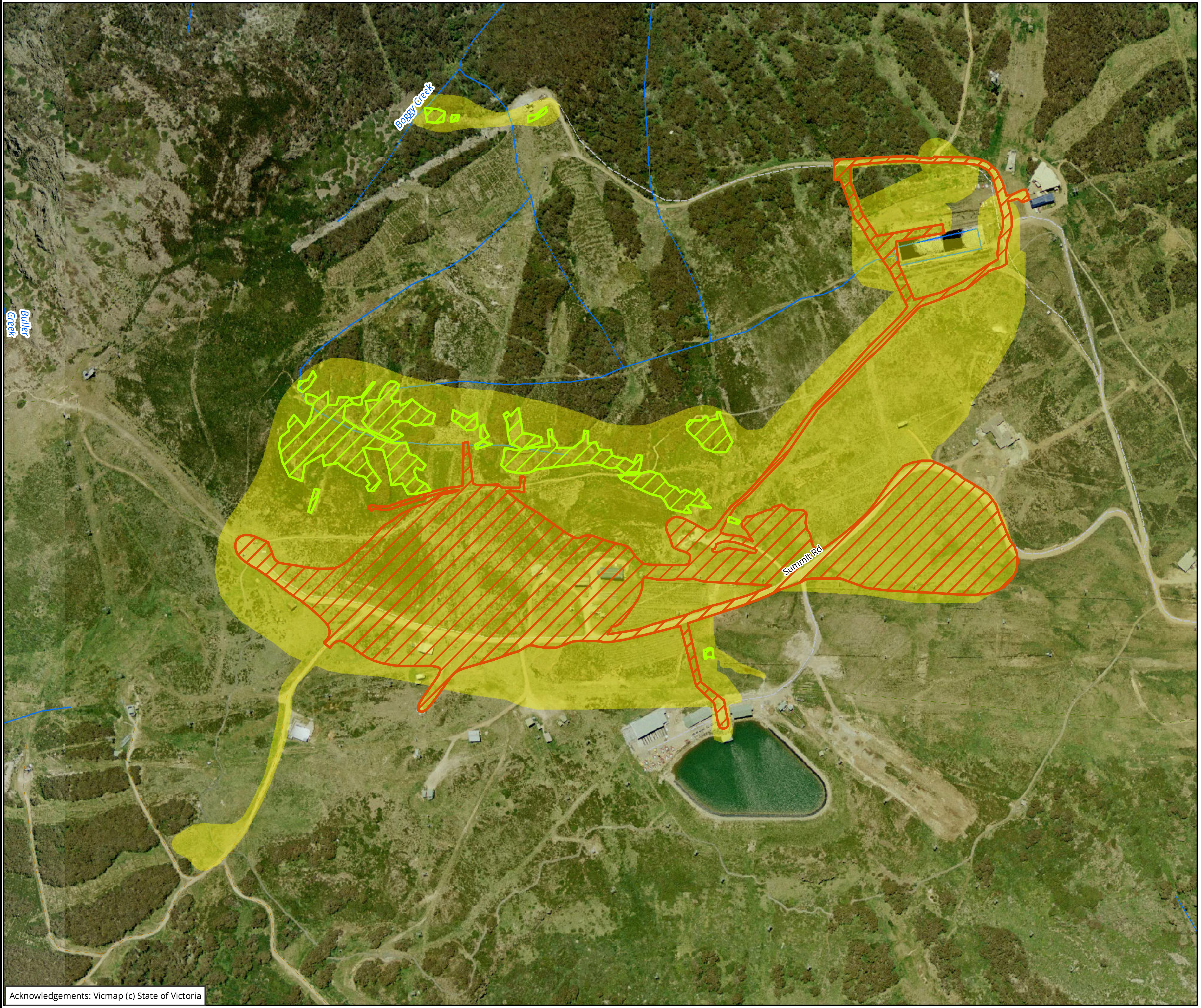

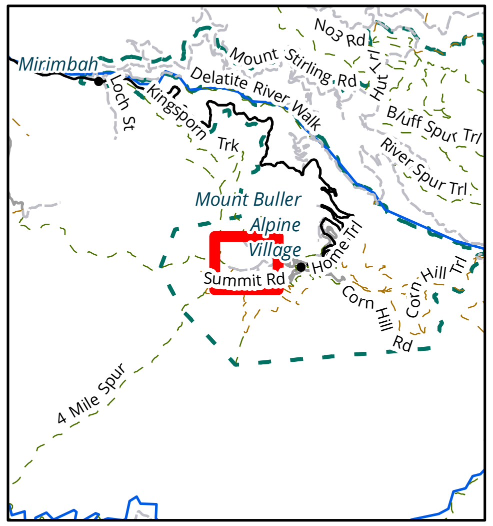

Legend

- Study Area
- Project Construction Footprint (PCF)
- Alpine Bogs

Figure 2: Distribution of Alpine Bogs within the study area, Mount Buller, Victoria.

0 40 80 120 160 200

Metres

Scale: 1:4,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

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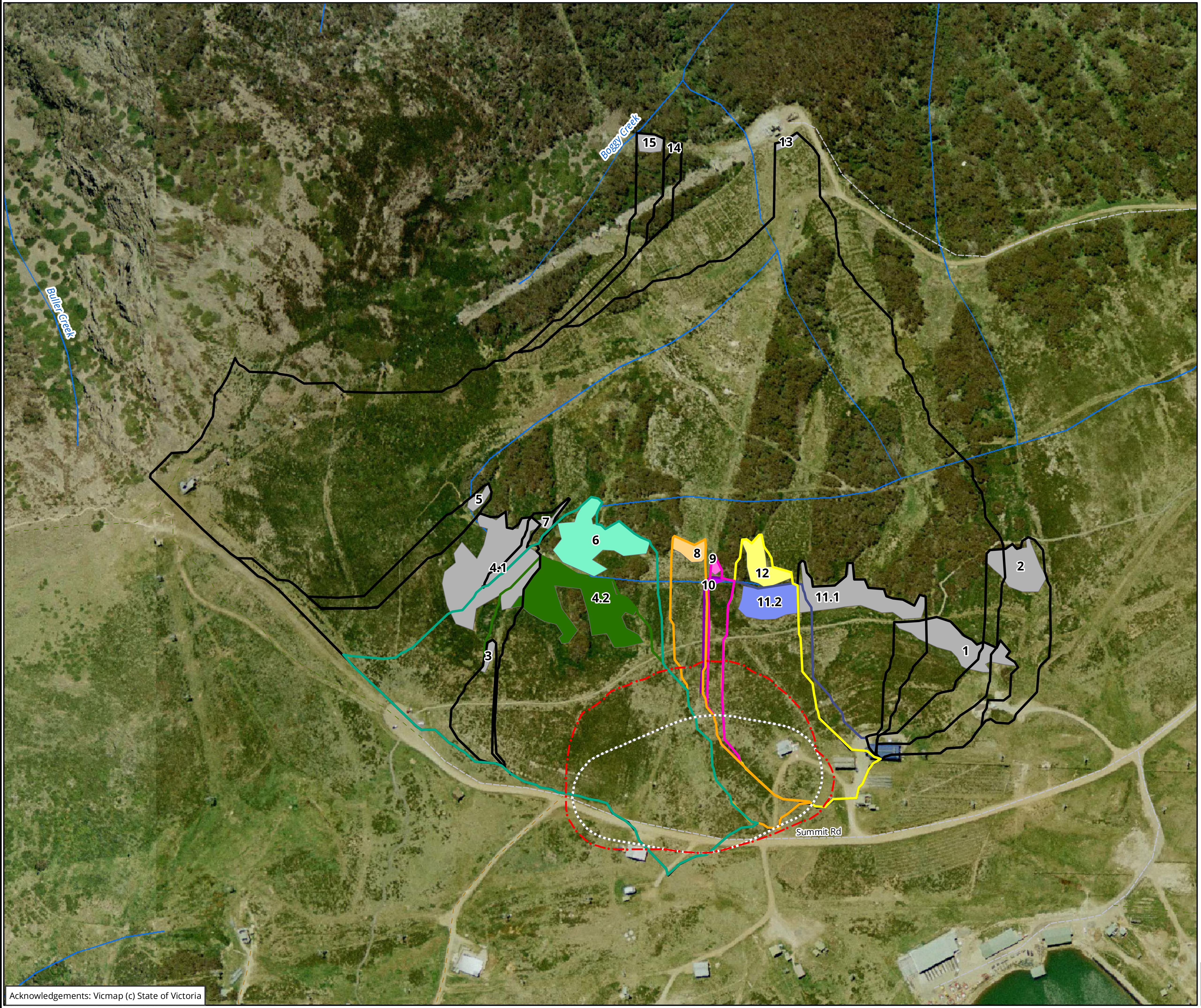

Legend

Water Storage Footprint

Earth Embankment Footprint

Alpine Bogs and Alpine Bog Catchment Areas (GHD)

Indirectly Affected – Potentially Significant Impact

4.2

6

8

9

10

11.2

12

Indirectly Affected – Insignificant Impact

13

Unaffected

1

2

3

4.1

5

7

11.1

14

15

Figure 3: Catchment areas of Alpine Bogs in and around the study area, Mount Buller, Victoria.

0 30 60 90 120 150

Metres

Scale: 1:3,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

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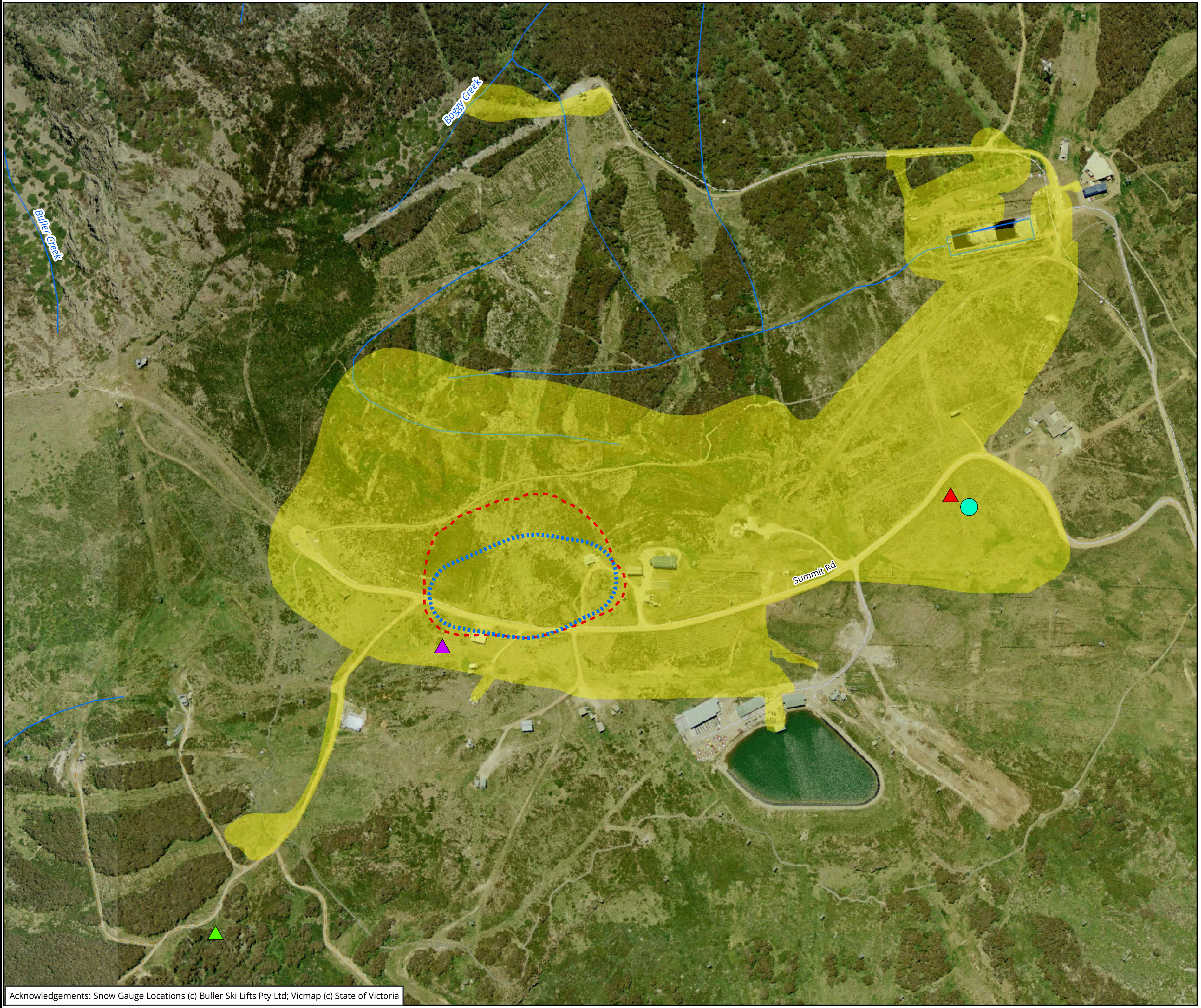

Legend

- BoM Station 083024
- Boggy Creek Snow Gauge
- Family Run Snow Gauge
- Tirol Snow Gauge
- Water Storage Footprint
- Earth Embankment Footprint
- Study Area

Figure 4: Location of snow gauges and the Bureau of Meteorology (BoM) station in and around the study area.

0 40 80 120 160 200

Metres

Scale: 1:4,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

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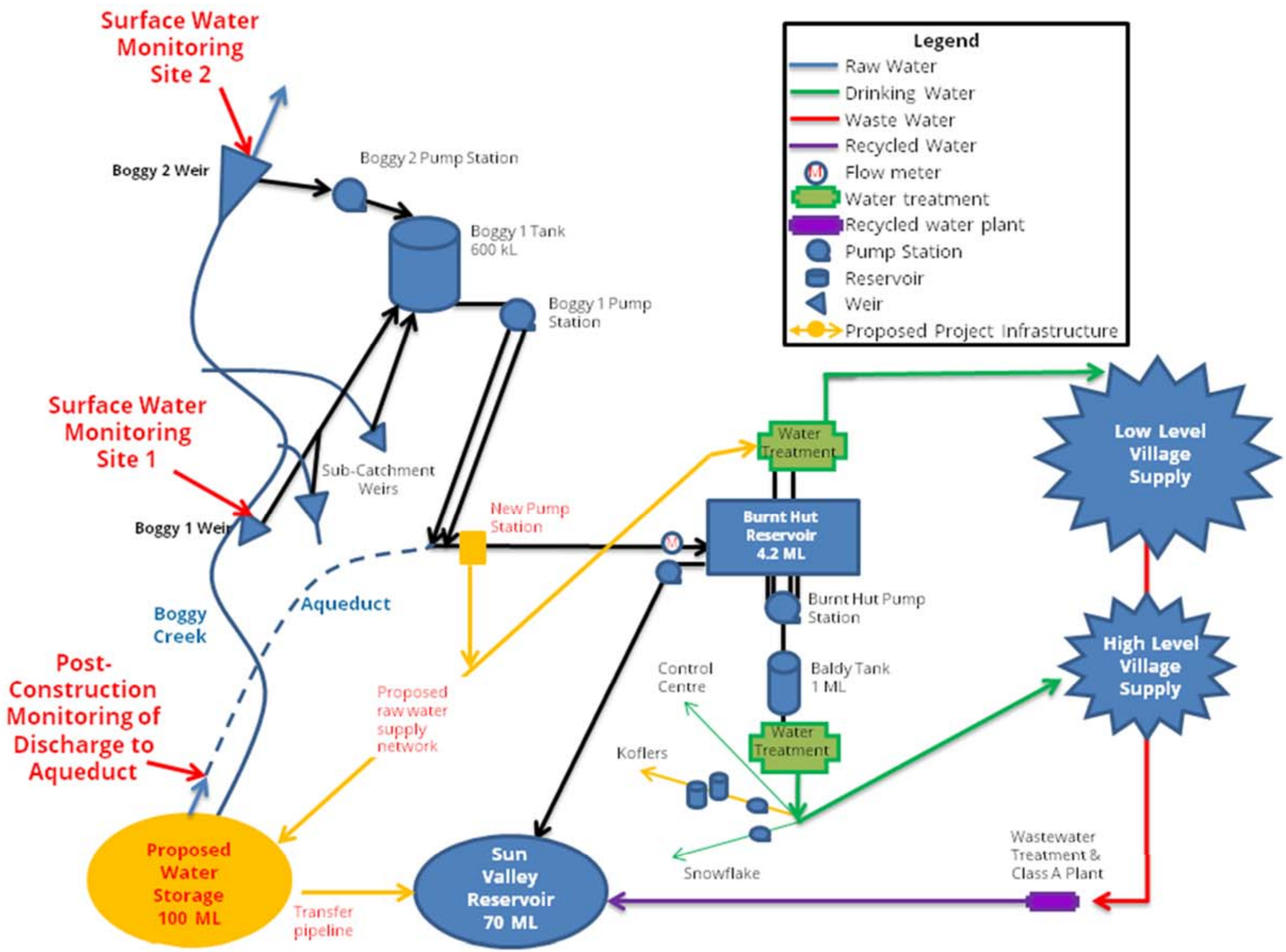
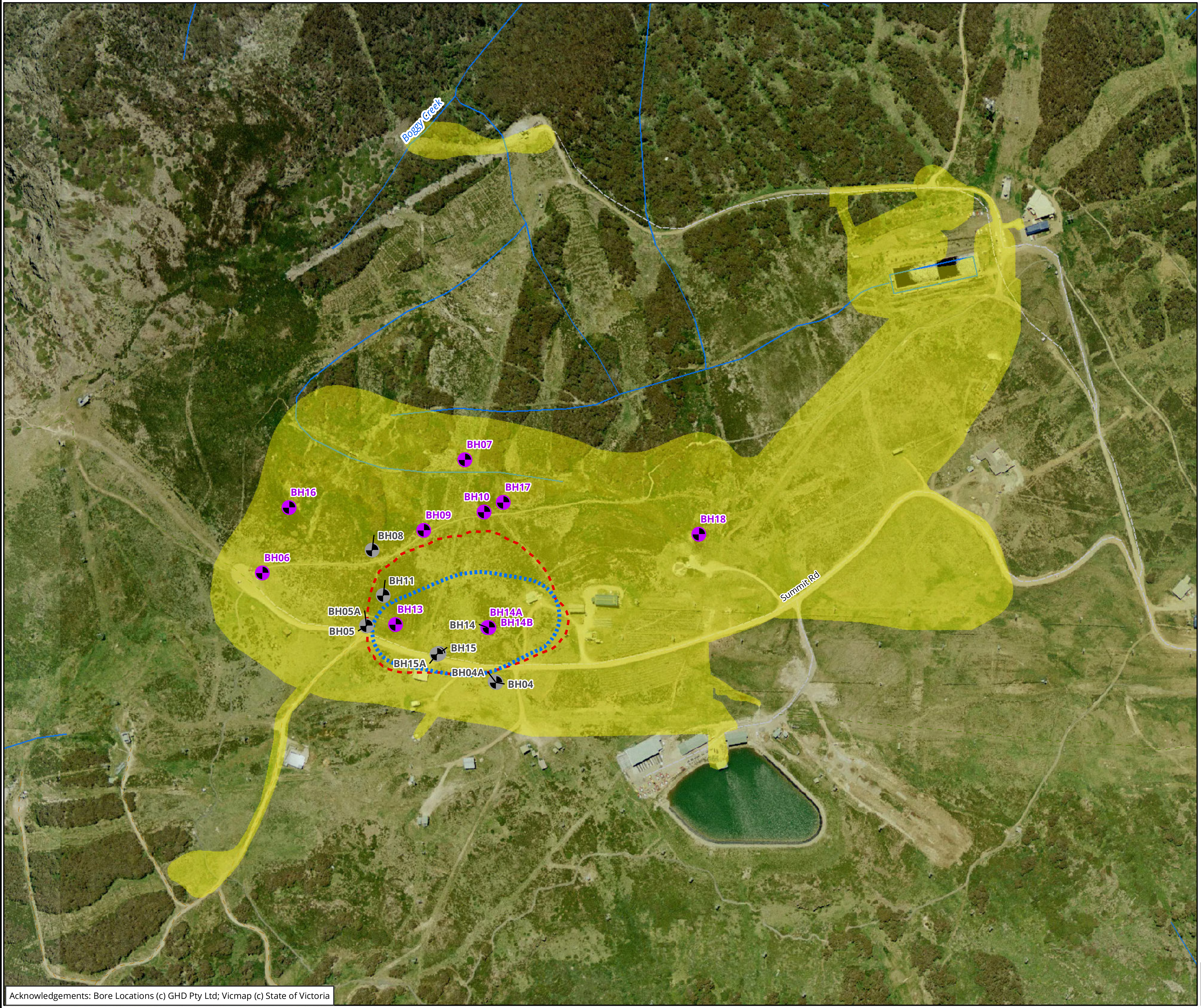
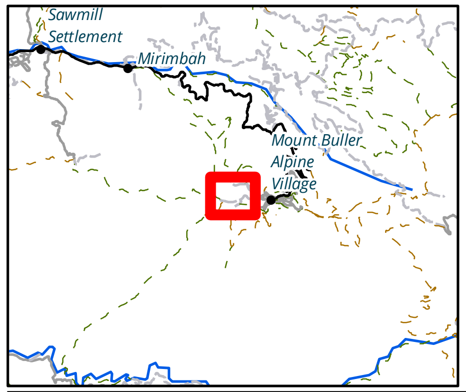


Figure 5 Location of surface water monitoring sites around the study area





Legend

- Bore Location
- Bore Location - Monitored in 2015
- Water Storage Footprint
- Earth Embankment Footprint
- Study Area

Figure 6: Location of the groundwater bore monitoring network in and around the study area.

0 40 80 120 160 200

Metres

Scale: 1:4,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

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No	Revision	Drawn	Job Manager	Project Director	Date
C	IRRIGATION PIPELINE ADDED	RMS	GJ*	PB*	16.09.15
B	PRELIMINARY RE-ISSUE	RMS	GJ*	GJ*	22.07.15
A	PRELIMINARY	RMS	GJ*	GJ*	24.07.14

Note: * indicates signatures on original issue of drawing or last revision of drawing

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SCALE 1:500 AT ORIGINAL SIZE

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Level 2, 45 Brougham Street Geelong VIC 3220 Australia
T 61 3 5273 1800 F 61 3 5273 1801
E gexmail@ghd.com.au W www.ghd.com.au

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Drawn R. SLARKS
Designer P. BUCHANAN
Drafting Check
Design Check
Approved (Project Director)
Date
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Client **MT BULLER & MT STIRLING ALPINE RESORT MGMT BOARD**
Project **MT BULLER SUSTAINABLE WATER SECURITY PROJECT**
Title **CONTROL CENTRE OFF STREAM STORAGE LAYOUT OF ENVIRONMENTAL WATERING SYSTEM**

Original Size A1 Drawing No: **FIGURE 7** Rev: C

Plot Date: 2 August 2016 - 11:44 AM Plotted by: Rob Slarks Cad File No: N:\AU\Melbourne\Projects\31\30733\CADD\Drawings\FIGURE 7.dwg

No	Revision	Drawn	Job Manager	Project Director	Date
A	PRELIMINARY	RMS	GJ*	PB*	16.09.15

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Client **MT BULLER & MT STIRLING ALPINE RESORT MGMT BOARD**
Project **MT BULLER SUSTAINABLE WATER SECURITY PROJECT**
Title **CONTROL CENTRE OFF STREAM STORAGE DESIGN OF ENVIRONMENTAL WATERING SYSTEM**

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