Mt Buller and Mt Stirling Alpine Resort Management Board

Mt Buller Sustainable Water Security Project

Off-Stream Storage

Options Summary

August 2016

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1. Introduction

This report for the Mt Buller Sustainable Water Security Project – Off-Stream Storage (the Project) documents the need for the proposed Off-Stream Storage, the alternatives considered, the assessment of potential storage sites, and the progressive development of a concept design for the preferred site.

1.1 Background

The Resort has significant constraints on its water supply. The water requirements of the Resort are determined by the need to service the resident and visitor populations, and to maintain the amenity and functionality of the Resort during winter for skiing and snow-play.

Investigations into the augmentation of existing water supply options and infrastructure, and potential water storage locations have been undertaken periodically by the RMB over the last two decades. A range of water supply options and potential sites for water supply storages have been assessed to varying degrees.

The RMB has established the Mt Buller Sustainable Water Security Project which encompasses a series of projects designed to assist it in meeting its obligation to provide a safe and reliable water supply to the Resort, both now and in the future. One component of the Mt Buller Sustainable Water Security Project is the development of an Off-Stream Storage and an associated upgrade of the Resort water supply infrastructure. Mt Buller is licenced to extract 700 ML of water a year from Boggy Creek. The water must be extracted between the months of May and October (inclusive). The current licence provides sufficient water to meet current and projected annual potable and snow making requirements. However, due to a lack of storage, the full water allocation cannot be realised, and in the past Mt Buller has been required to extract water during the summer months, outside its licence. This has impacts on the flows of Boggy Creek and is not sustainable or desirable in the longer term.

Based on a number of previous investigations and reviews, the RMB have determined that a 100 ML on mountain storage is required to assist it in meeting future potable and snow making water demands. A summary of water supply options is included in this document. In late 2013 GHD were commissioned by the RMB to undertake investigations into the siting and concept design of a 100 ML storage, and the ancillary infrastructure required to service this asset, with work continuing on this project. The proposed project is known as the Mt Buller Off-Stream Storage Project (hereafter referred to as the Project).

1.2 Purpose of this report

The purpose of this report is to document the process from the decision to develop an Off-Stream Storage through to the development of a revised concept design for the preferred site (August 2016). It will be used by the RMB to inform a number of project planning and approvals requirements.

Specifically, this report documents and summarises:

- The background and context of the Project (section 2)
- Water supply options considered for the augmentation of the Resorts' water supply (section 3)
- The methodology and framework for the Multi-Criteria Assessment (MCA) used to assess and select the preferred site for the Off-Stream Storage (section 4)

- Identification of sites and the evolution of concept designs for the Off-Stream Storage (section 5), and
- A summary of the results of the MCA and development of the revised concept design for the preferred site (post MCA) (section 6).

2. Project Overview & Context

This section of the report provides an overview of the current water supply system at the Mt Buller Resort, current and forecast demand for water and the strategic planning context of the proposed Project.

2.1 Mt Buller Alpine Resort Water Supply

The location of the Resort at high elevations and on sloping land near the summit of Mt Buller means that there is limited catchment nearby from which to collect or store water. The security of water supplies is not a new problem to the Resort, with investigations into potential water supply augmentation options being undertaken since the 1990's.

The water supply and treatment infrastructure at the Resort has developed over several decades in response to changes in the nature and scale of the activities being undertaken. Regulatory and policy requirements for drinking water and for the reuse of treated effluent have also influenced the development of water supply, treatment, storage and reuse infrastructure at the Resort.

A history of the development of the Mt Buller water supply infrastructure is provided in section 2.1 of GHD (2014a).

2.1.1 Current demand and supply arrangements

The Mt Buller water supply system receives water from two main sources; raw water diversions from Boggy Creek (and its tributaries), and Class A recycled water from the Mt Buller Wastewater Treatment Plant. A third source is obtained via a licensed extraction from a tributary of the Howqua River into the Sun Valley Reservoir. This is achieved via a temporary (20 ML/year) diversion licence to supplement demand for snow making purposes, with the infrastructure owned and operated by Buller Ski Lifts Pty Ltd (BSL).

A map showing the location of catchments and key infrastructure associated with the Mt Buller water supply is presented in Figure 1 of GHD (2014a). A schematic of the current water supply system is presented in Figure 1.

Current and estimated future average annual water demand figures, assuming a medium growth scenario are presented in Table 1. There is currently limited information on the annual variability in potable demand, so the 2013 figures shown in this table are approximate only.

Potable Water Demand and Supply

The current annual average potable water demand at Mt Buller is around 167 ML/yr and varies between 5 and 36 ML/month depending upon seasonal visitation. Over the longer term this demand is expected to increase to around 205 ML/yr in order to cater for increased visitation, including summertime activities such as mountain biking, consistent with the broad directions of *Alpine Resorts 2020 Strategy* and *Alpine Resorts Strategic Plan 2012*.

The potable water supply for the Resort is sourced from the Boggy Creek and its tributaries. A series of aqueducts and weirs within the Boggy Creek catchment collect and divert water to extraction points. Water is then either gravity fed or pumped into the Burnt Hut reservoir or a series of small tanks. The main storage facility at Burnt Hut reservoir has a capacity of 4.2 ML, and additional storage located within the supply system has a total capacity of approximately 1.6 ML[1]. Following storage it passes through one of two treatment plants prior to reticulation.

[1] GHD (2014b) Mt Buller Off-Stream Storage Water Supply Concept Design Investigations

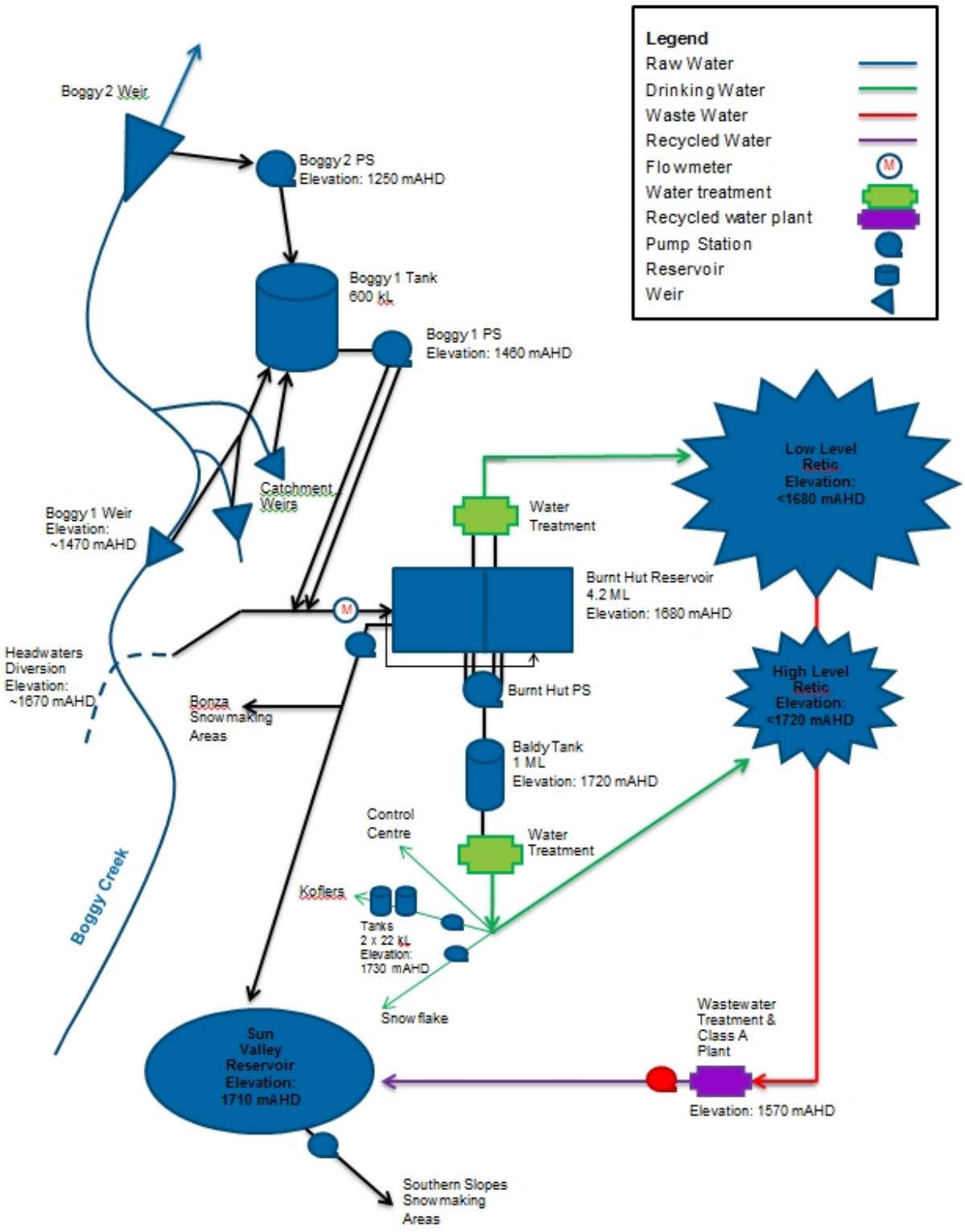


Figure 1 Mt Buller Water Supply System Schematic

Diversions from the Boggy Creek occur pursuant to the *Water Act 1989*. The RMB maintains a Section 51 Annual Diversion Licence issued by Goulburn-Murray Water (GMW). This licence permits up to 700 ML to be diverted each year between the months of May and October (inclusive) at a maximum diversion rate of 4 ML/day. The restriction of extraction to the months May – October is known as the 'winter fill requirement', which is a standard condition in accordance with current government policy, to provide for environmental flows over the 'summer' months.

Table 1 Current and estimated future annual average demand – medium growth scenario (in ML)

Type and Season	2013	2025 Estimate	2035 Estimate
Potable Demand			
May – October	134	161	161
November – April	33	44	44
Total	**167**	**205**	**205**
Snow Making Demand			
May – October	283	413	481
Total Demand (Winter + Summer)	**450**	**618**	**686**

Source: GHD (2014b) Mt Buller Off-stream Storage Water Supply Concept Design Investigations

Currently the demand for potable water between November and April ('summer' months) is estimated to be 33 ML per annum. As the existing storages (5.8 ML in total) provide just under 14% of the capacity currently required (excluding growth) to meet current potable demands for the 'summer' months, water is diverted from Boggy Creek during this time as part of a temporary exemption to the existing winter period diversion licence condition. However, this practice is not desirable as it reduces environmental flows to the Boggy Creek during the summer months. A new storage would allow adequate water to be diverted during the 'winter' months (May – October) to supply the Resort during the 'summer' months (November – April) in accordance with diversion licence conditions.

The reliability of the existing water supply system is low during low catchment inflow years as evidenced during the years of drought 2004-2010. Reliability is particularly problematic if low inflow years coincide with years where natural snow coverage is also poor, as this results in reduced recharge of the soil and groundwater systems from melted snow, which contribute to the storage and supply of water to the Boggy Creek.

The existing raw water treatment system complies with the current requirements of the Australian Drinking Water Guidelines. However, any future change in standards, together with the increased emphasis on multiple barrier approaches to water treatment, would require investment in the treatment system regardless of the Project.

Snowmaking Demand and Supply

Snowmaking activities on Mt Buller commenced in 1994. Raw water (untreated water from the Boggy Creek catchment) for snowmaking is sourced from the Burnt Hut reservoir (prior to potable treatment, and when excess is available) and the Class A Sewerage Treatment Plant (STP), which treats effluent received from the primary wastewater treatment facility to the Class A standard. Most snow making water is stored in the 70 ML capacity Sun Valley Reservoir. The current annual average snowmaking demand at Mt Buller is around 283 ML (May to October).

Snowmaking activities require significant volumes of water (at times in excess of 10 ML/day) to be supplied during a short period of time when conditions are optimal. However, under current

licence conditions, diversions from Boggy Creek are limited to 4 ML/day. This requirement, combined with the limited storage capacity of the Sun Valley Reservoir (70 ML) constrains water use in peak snow making periods. In addition, for public health purposes the Class A recycled water cannot be used to supply potable demand and cannot be reused for snowmaking on areas which fall within the potable water supply catchment area (i.e. the Boggy Creek and Delatite River catchments). The inability to reuse recycled water in the Boggy Creek and Delatite River catchment means that any expansion of snowmaking in new areas of the Resort must utilise raw water sourced from the waterways in the vicinity of the Resort (i.e. the Boggy Creek catchment).

Firefighting Demand and Supply

Water stored at the Mt Buller Resort is not only required to meet potable water consumption and snowmaking demands, but is also required in order for the RMB and other agencies to effectively respond to emergency situations such as structural fires or bushfires.

Currently there is a minimal supply of water for firefighting within the village, or for a larger bushfire response, stored at the Burnt Hut Reservoir. For much of the village this is not a gravity fed supply, so relies on pumping and therefore an electricity supply, which can fail during a fire.

The bushfires at Mt Buller in 2006 / 2007 highlighted bushfire risks to the Resort, and the importance of having an adequate water resource available for firefighting.

Additional water supply or storage capacity would improve the fire-fighting capability and bushfire event response across the Resort.

An appropriately located storage could supply water to the Resort via gravity, overcoming the issues associated with power supply failure, and may also allow helicopter access for fire suppression purposes.

Supply constraints

The current combined annual average demand for potable and snowmaking water is around 450 ML/year. Under the existing licence, the total volume permitted to be diverted from Boggy Creek each year (700 ML/yr) is adequate to supply the current annual average potable and snowmaking demand (450 ML/yr), and forecast annual demand by 2,035 (686 ML/yr). However, the limited storage capacity in the current system and the maximum diversion rate per day (4 ML) constrain supply as summarised below:

- Adequate supply cannot be stored from winter diversions to supply the Resort during summer. Water is currently diverted during summer under a temporary exemption to the winter fill condition. This limits the ability to achieve environmental flows in Boggy Creek and is not a desirable or reliable long term solution, and
- Raw water use for snow making during peak periods is limited because of the maximum diversion rate from Boggy Creek (4 ML/day) and limited storage capacity in the Burnt Hut storage. Recycled water use for snowmaking is limited by the storage capacity of the Sun Valley Reservoir (70 ML). Furthermore, for public health reasons, recycled water cannot be used for snow making within the potable water supply catchment areas of the Resort.

Investigations and modelling undertaken for the Resort (Maunsell/AECOM, 2008 and AECOM, 2009) and the water supply demand strategy (GHD, 2013) indicate that a storage in the order of 100 ML is required to meet potable and snowmaking water demands throughout the year.

A number of different strategic solutions to these supply constraints, including development of a 100 ML storage, have been considered as described in section 3 of this report.

2.2 Benefits of addressing the identified supply constraints

Resolution of the supply constraints described previously would lead to a number of benefits, including (but not limited to) the following.

Improved environmental outcomes and licence compliance

- Additional storage capacity would enable RMB to divert water from the Boggy Creek during 'winter' months only, in accordance with licence conditions, and avoid impacting on environmental flows during 'summer' months.

Support for summer tourism

- The Government's Alpine Regions Strategic Plan (ARCC, 2012) and the Master Plan (2010) for the Mt Buller Mt Stirling Alpine Resort both propose an increase in total tourism numbers outside the peak period (i.e. during summer months), as well as during the peak winter period.
- Summer visitation is more likely to increase when there are activities and businesses within the Resort to attract visitors. A reliable and adequate supply of potable water is necessary to attract the operators and businesses that would provide these services in order to attract these visitors.
- Current potable water storage on the mountain is insufficient to provide adequate water supply to the current levels of tourism demand and so it is unlikely that there would be sufficient supply for any forecast or desired growth in tourist numbers over the summer period.
- Resolution of supply constraints would enable the growth of summer tourism which is considered important for diversity and resilience of the Resort.

Growth in winter recreation and overall visitation

- Access to a reliable supply of water would provide an improved level of certainty for any future investment in snow-making technology. Therefore, increased water storage capacity would facilitate an increase in snow making on existing areas, as well as provide for the potential expansion of snowmaking across the Resort. This is likely to result in increased economic benefits (such as those measured by the Gross State Product) from tourism and recreation.

Improved fire-fighting capability and bushfire event response

- Additional water supply or storage capacity would improve the fire-fighting capability and bushfire event response across the Resort.

3. Consideration of Water Supply Options

This section provides a description of water supply options for Mt Buller, including the 100 ML capacity on mountain off-stream water storage (the Project) and potential alternatives to it. The purpose of this section is to provide justification for selection of the proposed Project in the context of other potential options to address the water supply constraints identified.

3.1 Strategic options overview

A number of criteria were utilised as part of identifying and assessing the range of potential water supply options for the Resort. These criteria were established based upon criteria used in previous documentation and feasibility assessments, or in discussions with the RMB. They are as follows:

- *Compliance with winter fill extraction* – the preferred option should allow the RMB to comply with the winter fill extraction requirement of its existing water diversion licence (extraction between May and October inclusive)
- *Project footprint* – this criterion refers to the area of land likely to be affected by the project and includes ancillary infrastructure (for example roads, tracks, power lines and pipelines required to operate the option). Environmental (and particularly biodiversity) impacts can generally be avoided / minimised by minimising the project footprint and area disturbed for project construction
- *Requirement to meet peak potable water demand* – it is necessary for the option to be able to meet peak (winter time) potable water demand which is currently in the order of 1 ML/day (GHD, 2013)
- *Requirement to meet peak snowmaking water demand* – in order to contribute to 'on demand' snowmaking it is necessary for the option to be able to supply a large volume of water for snowmaking over a short period of time (nominally around 10 ML/day)
- *Assist with bushfire management* – an option which can supply water to the Resort via gravity (during power failure when no pumping is possible) or provide a water source for helicopter based suppression activities, is preferred over an option which is reliant upon electricity from the existing supply network, or a remote water source
- *Capital cost* – RMB seeks to minimise the capital investment associated with the water supply option and the associated ancillary infrastructure required to support it
- *Operating cost* – RMB seeks to minimise the costs associated with operating and maintaining the water supply option
- *Energy use and greenhouse gas emissions* – RMB seeks to minimise energy use and improve energy efficiency in its operations. RMB greenhouse gas emissions are principally associated with the use of electricity, and
- *Technical feasibility* – this criterion relates to the technical and / or regulatory issues expected to be encountered by the option (and to be addressed in order for the option to be successfully implemented).

The strategic options which have been assessed against these criteria are discussed in this section. For an option to be considered feasible it must meet *both* potable and snowmaking demands, be considered technically feasible, and satisfactorily resolve the identified supply constraints. Minimisation of capital and operating costs is also an important consideration. A summary of the review of each option against the criteria listed above is presented in Table 2.

3.1.1 Strategic Option 1: New on mountain off-stream storage

Option 1 involves construction of a new 100 ML capacity on mountain, off-stream water storage facility within the Resort (the proposed Project). This option would be consistent with the previous investigations undertaken at the Resort (which indicated that a storage of 100 ML was required), and would require the identification of an appropriate storage site.

This option would enable the RMB to divert water from Boggy Creek during winter in compliance with current licencing requirements, and to store sufficient water for the summer period. It would also enable the RMB to meet the peak water demands over winter months, and facilitate additional snowmaking. The option is considered to provide the greatest level of year round water security for the Resort and is considered feasible.

The option would require significant capital investment in new and ancillary infrastructure. It would be necessary to relocate a range of existing services on the mountain. A significant construction footprint would be necessary, and this would require the consideration and implementation of a range of impact mitigation measures.

If appropriately sited, the storage could provide a gravity fed supply of water for firefighting purposes, which is independent of electricity supply.

This option could resolve supply constraints and is technically feasible.

3.1.2 Strategic Option 2: Expand Sun Valley on mountain storage

This option would provide additional on mountain storage capacity by augmenting the current Sun Valley storage (70 ML capacity). The Sun Valley storage has a number of significant geotechnical constraints and has been recently remediated. Expansion of the storage would require a significant capital investment in ancillary infrastructure and the storage itself. Because of its design and location, it would not be feasible to achieve an additional 100 ML of capacity.

The storage contains Class A recycled water and is an important part of the Resort's strategy to recycle water and minimise extraction from waterways. Recycled water would not be suitable for potable purposes and would not be suitable for snow making use in the Boggy Creek and Delatite River catchments.

The option would not resolve supply constraints because:

- It could not store an additional 100 ML
- It does not assist with meeting peak potable water demands, and
- It is unlikely to meet all snowmaking demands because of geographic constraints on the use of recycled water.

3.1.3 Strategic Option 3: Demand management/water efficiency measures

This option would require a range of measures to manage and reduce consumption at the Resort. Measures would be expected to include:

- Improvements in the metering of flows throughout the Resort and the reconciliation of supply and demand in order to identify usage and potential losses within the water supply system
- Investigation followed by maintenance and repairs to any infrastructure identified as contributing to system losses (for example leaking supply pipework)
- Installation and retrofitting of water saving devices and more efficient technologies
- Restrictions on the use of potable water, and
- Public and Resort staff education programs.

This option may result in improvements in water use efficiency and contribute to a reduction in demand, however it is expected to be relatively expensive and time consuming to implement for the volume of water likely to be saved. The water savings which might be achieved are very unlikely to be large enough to avoid having to implement other measures. Assuming peak potable demand in winter is ~1 ML/day, savings associated with this measure would not assist in meeting peak potable or snow making demands.

It is considered very unlikely that the cumulative impact of this initiative would, on its own, provide an adequate solution. Unintended consequences of this approach would also need to be considered, as a reduction in potable water use may affect the operability of the recycled water plant and the volume of recycled water available for snowmaking.

The option would not resolve supply constraints primarily because it would not allow peak potable and snowmaking water demands to be met, but also because it would not assist in improving water supplies for bushfire management.

3.1.4 Strategic Option 4: Increase Boggy Creek surface water extractions

Option 4 assumes an increase in extractions from Boggy Creek by altering the licence extraction arrangements to allow summertime extraction, and extractions above the current licence limit of 4 ML/day.

No additional storage would be required, but the current extraction infrastructure (currently only capable of extracting at the rate of 2.5 ML/day) may require upgrading (new power supply, offtake and pumping equipment). If the licence were amended to allow routine diversion of water during the summer months, this could potentially improve the long term water reliability to summer residents, businesses and visitors especially in years where winter flows (and existing storages) are low.

This option would only be a partial solution for supply during ‘summer’ months (assuming adequate rainfall occurs) and during extended dry periods Boggy Creek yields may be insufficient. Catchment yields would not be able to meet peak demands during ‘winter’ months.

There may be significant ecological and hydrological impacts on the Boggy Creek in the vicinity of the extraction point and downstream, particularly during ‘summer’ months. Increased extractions during very high flow periods could be technically feasible and environmentally acceptable assuming the water was able to be stored.

The option is contradictory to current government policy (winter fill requirement) and so regulatory approval is considered unlikely.

Whist this option may not require significant changes in the infrastructure footprint (only an upgrade of existing infrastructure), it would not assist in improving water supplies for bushfire management.

The option would not resolve supply constraints, primarily because it does not meet peak snowmaking demand, and regulatory approval of extractions during ‘summer’ months is considered unlikely.

3.1.5 Strategic Option 5: Additional extraction from the Howqua/Delatite River without a storage

This option proposes additional surface water extraction and pumping from the Howqua or Delatite River catchments to increase the volume of water supplied to the Resort. These rivers would generally have sufficient flow to address the catchment yield issues associated with Boggy Creek. The option assumes that it is possible to obtain an appropriate water licence and allocation to facilitate this option. This option also assumes that no large storage is constructed.

In order to meet peak water demands it would be necessary to pump large quantities of water (up to 10 ML/day) a considerable distance and also a considerable elevation (up the mountain).

The temporary BSL licenced extraction from the Howqua River (20 ML/year) would not be adequate to meet the total Project water demand for this option. At best it could supplement snowmaking demand in winter, but would require new infrastructure in order to meet peak demand and potable supply requirements.

This option would require significant capital investment and impose substantial ongoing operating costs on the Resort. The footprint of the required infrastructure (break tanks, pipelines, pumps, power supply) would be relatively large when compared with the alternatives. The option would incur a number of technical challenges (for example geotechnical conditions), and the energy use associated with pumping would result in relatively high levels of greenhouse gas emissions.

This option may assist in improving water supplies for bushfire management, however it is contingent upon a reliable and uninterrupted supply of electricity (which cannot be guaranteed in a bushfire event).

The option could resolve supply constraints but is not preferred because of the very high capital and operating costs associated with meeting peak snowmaking demand.

3.1.6 Strategic Option 6: Alternative source – groundwater

Option 6 would see the continued use of the existing extraction licence and water storage facilities. It would then look to supplement the existing water supply with water from groundwater sources. This option assumes that a suitable groundwater resource would be available for exploitation, and that a large and extensive network of bores, pumps and pipelines could be constructed in order to transfer groundwater to the Resort.

Preliminary work suggests that the groundwater resource is likely to be connected to surface water systems and that the conjunctive management of these two water resources would be required, potentially resulting in restrictions on groundwater extraction/supply during the summer period. In addition, the fractured aquifer system may not yield the volumes required during the summer season. Because of this it is unlikely that the option is viable from a regulatory or technical perspective.

In order to meet peak flow demands associated with snowmaking, the option would require an extensive network of bores and ancillary infrastructure (pipes, pumps, valves, large storage tanks or a small reservoir, power supply). These flow demands would incur very high capital and operating costs. Footprint impacts and greenhouse gas emissions would also be significant when compared to other options.

This option may assist in improving water supplies for bushfire management, however it is contingent upon a reliable and uninterrupted supply of electricity (which cannot be guaranteed in a bushfire event).

The option would not address the supply constraints associated with peak snowmaking demands. It has a high degree of technical and regulatory uncertainty due to the volumes of water that would need to be extracted, and it would incur significant capital and operating costs.

3.1.7 Strategic Option 7: Alternative source – stormwater/rainwater harvesting

This option would involve harvesting rainwater and/or stormwater within and/or below the Resort. Although this approach would allow the maximum use of natural resources, the volumes able to be harvested would not meet the current or projected snowmaking water demands.

Rainwater harvesting would require buildings to be retrofitted with gutters, as well as collection and storage systems. There are practical issues associated with snow collecting on rooves and gutters and with the installation and operation of the collection system in an environment which freezes.

Stormwater could contribute to the snowmaking supply, but would be unsuitable for potable use without regulatory issues being addressed and significant investment in treatment and storage. Electricity costs may be moderate but would depend upon pumping and treatment requirements. Treatment costs (both capital and operating) would be significant.

The option relies on appropriate climatic conditions (adequate rainfall). Low rainfall periods would impact the viability of this option.

The small and dispersed harvesting and storage locations, as well as the uncertainty of supply during the bushfire season means that this option would be unlikely to assist in improving water supplies for firefighting.

This option would not resolve supply constraints due to the technical issues and costs associated with reliably meeting potable water quality requirements, and the inability to meet snowmaking volume demand.

3.1.8 Strategic Option 8: 'Off mountain' storage

A 100 ML 'off mountain' storage would potentially have the following advantages over an 'on-mountain' storage:

- Provide access to a larger and more reliable water supply catchment
- Allow dam construction on a site with 'simpler' geological and geotechnical characteristics
- Avoid development in sensitive alpine ecosystems containing rare or threatened flora and fauna species, and/or species with a naturally limited range
- Avoid or reduce visual impacts, and
- Avoid impacts upon ski resort utility.

The disadvantages of an 'off mountain' storage as compared to an 'on mountain' storage would be:

- Environmental impacts and capital costs of ancillary infrastructure required to transfer the water up the mountain (pumps, power supply, water pipeline, intermediate storages)
- Significant operating costs (and greenhouse gas emissions) associated with power supply and the operation of pumping equipment (particularly during periods of peak demand).

An appropriately sized storage could potentially meet peak snowmaking and potable water demand but it would be necessary to pump significant quantities of water (up to 10 ML/day) over a substantial elevation, in order to deliver it to the Resort.

This option may assist in improving water supplies for bushfire management, however it is contingent upon a reliable and uninterrupted supply of electricity (which cannot be guaranteed in a bushfire event).

This option could resolve supply constraints and is technically feasible, however it was considered inferior to Option 1 (the Project) due to the significant additional capital and operating costs associated with transferring stored water to the Resort.

3.1.9 Strategic Option 9: Do nothing

The 'do nothing' option assumes no new infrastructure or modifications to existing infrastructure, no demand reduction strategies, or changes to the current diversion licences.

This option would mean that:

- Water would need to be diverted during summer under an exemption or modification to the extraction licence, which limits environmental flows to Boggy Creek. This is not considered a desirable or reliable long term solution. This in turn limits the growth of summer tourism, the capacity to respond to bushfires, and overall reliability of the Resort water supply.
- Water use for snow making during peak periods would continue to be limited because of the maximum diversion rate and limited storage capacity. Increased snowmaking in current areas or expansion into new areas would not be possible. This would be expected to limit visitation and the development potential of winter tourism.

This option would not resolve the current water supply constraints. The constraints would persist and worsen as demand for water grows. The current water supply constraints for firefighting purposes would also remain in place.

3.1.10 Combination of options

As per the summary presented in Table 2, a number of options may potentially allow peak potable water demands to be met. However, only direct pumped extraction from the Howqua or Delatite River catchments, or a storage option would allow peak snowmaking demands to be met.

A storage option at an altitude above the Resort is required in order for fire-fighting requirements (gravity supply without reliance in electricity) to be met.

Demand management and water efficiency measures are always likely to have relevance in the management of the Resort water supplies, and should be implemented as part of good practice, and as part of any new development in the village.

From a supply perspective, some of the other options (for example groundwater supply or surface water extraction from other locations) may prove useful in augmenting water supplies and could potentially be used in combination with a storage. Given the peak water demands, cost and uncertainties with the reliability of supply for these options, it is unlikely that the use of these options in combination with a storage would significantly reduce the required (100 ML) storage volume.

3.2 Evaluation of strategic water supply options

A summary of the strategic water supply options considered, together with a high level assessment against the criteria described previously is presented in Table 2.

3.3 Recommended strategic option

Analysis indicates that Option 1 (a new 100 ML on mountain storage) is the most appropriate option as it provides the Resort with significant operational flexibility all year round, and allows it to balance raw water, potable and recycled water demands. A storage of this size would allow the RMB to divert water during 'winter' months only, in accordance with the condition of their extraction licence and would also provide an adequate, gravity fed (if appropriately sited) supply for firefighting. A storage is considered to be the best way to manage the inherent variability in climate and streamflow associated with the Mt Buller region.

A storage would enable the size of diversion (or extraction) infrastructure to be much smaller than that required to meet peak rates of demand. This avoids the need for capital expenditure on large capacity infrastructure which is operated below capacity or infrequently for much of the year. The provision of a large volume of on-site storage at Mt Buller would improve the cost effectiveness of any future water supply option, reducing the flow rate for water transferred and ultimately the cost of associated infrastructure.

The on mountain off-stream storage option is therefore considered to be an integral part of improving the security of water supplies to Mt Buller.

Table 2 Evaluation of strategic water supply options

Option No.	Strategic Option	Comply with 'winter fill' extraction arrangements?	Footprint	Meet peak potable demand?	Meet peak snowmaking demand?	Assist with bushfire management?	Capital cost	Operating cost	Energy use & greenhouse gas emissions	Technical feasibility
1	New 'On mountain' 100 ML storage	Yes	Significant when compared to some other options	Yes	Yes	Yes	High	Moderate	Moderate	Feasible based on geotechnical and concept design investigations undertaken
2	Expand Sun Valley for increased 'on mountain' storage and use of recycled water	Unlikely	Moderate	No	Partial (recycled water cannot be used in Delatite River. catchment)	Unlikely	Very High (geotechnical issues)	Moderate	Moderate	Significant geotechnical issues. Cannot achieve additional 100 ML storage capacity
3	Demand management & water efficiency measures	No	Low - Moderate	Unlikely (but may contribute)	No	No	High	Moderate	Low - Moderate	Retrofit, modify, replace. Small volumes.
4	Increase Boggy Creek surface water extraction (alter licence extraction limits or period – no additional storage)	Yes - assuming modification to licence	No change	Partial	No	No	Moderate	Moderate	Low	Regulatory issues, catchment yield, infrastructure constraints, potential aquatic impacts, security issues in low flow periods
5	Additional Howqua / Delatite River surface water extraction and pumping (no large storage)	Yes – assuming adequate supply available	Significant (new pipeline, pumps, power supply)	Yes	Possible	Unlikely (reliable power supply required)	Very High	Very High	Very High	Identify suitable site and alignments, supply infrastructure, geotechnical issues

Option No.	Strategic Option	Comply with 'winter fill' extraction arrangements?	Footprint	Meet peak potable demand?	Meet peak snowmaking demand?	Assist with bushfire management?	Capital cost	Operating cost	Energy use & greenhouse gas emissions	Technical feasibility
6	Alternative source - groundwater	Unlikely – conjunctive use?	Significant	Possible	No	Unlikely (reliable power supply required)	Very High	Very High	Very High (bore pumping)	Suitable aquifers? Regulatory issues? Large bore network required
7	Alternative source – rainwater / stormwater harvest	No	Moderate	Possible (flow) No (quality)	No	No	High (dam, pump, pipelines, treatment)	High	Moderate	Volumes inadequate Unlikely to be allowed for potable purposes. Reliant on rainfall
8	'Off mountain' Storage	Yes	Significant (dam site, new pipeline, pumps, power supply)	Yes	Yes	Unlikely (reliable power supply required)	Extremely high (if pump and pipeline capacity sized to meet snowmaking demand)	Very High	Very High	Identify suitable site and alignments, supply infrastructure, geotechnical issues
9	Do nothing	No	No change	No	No	No	Nil However, upgrade of existing water treatment plant and storage is required regardless	Nil However investment in water supply infrastructure would simplify system and reduce some operating costs	No change	Feasible, however investments in potable water supply and treatment are still required.

4. Multi- Criteria Assessment (MCA) Methodology

This section of the document summarises the Multi-Criteria Assessment *methodology* used to assess and compare potential sites for the Project, the information sources utilised, and the staging of the assessment.

It should be noted that further work has been undertaken to refine the project design and reduce the construction footprint since the original MCA and site selection process was undertaken. Where relevant, this additional work has been described elsewhere in this document as 'Stage 3'.

4.1 Multi Criteria Assessment (MCA) Framework and Objectives

A Multi-Criteria Assessment (MCA) approach was developed jointly by GHD / RMB and used to inform the selection of a suitable site for the off-stream storage. Initially, a MCA framework comprising objectives, criteria, measures and descriptors was developed, relevant to the Project and location. A number of the objectives in the MCA framework were based on relevant objectives from the:

- *Alpine Resorts Planning Scheme – Mt Buller Strategic Statement*, and the
- *Mt Buller and Mt Stirling Alpine Resort Management Board Strategic Management Plan* (2013-2018).

Other project-specific and complementary objectives were also developed and agreed between GHD and the RMB. These objectives were associated with technical, construction and operational aspects of the Project, and were intended to assist with site selection. Each of the MCA objectives is presented in Table 3 and the documents that informed each are indicated in the left-hand column. The link between strategic and project specific objectives, and the MCA framework and objectives is presented in Appendix A.

The MCA objectives cover a broad range of aspects that are relevant to the selection of a suitable site for the Project. These considerations can be categorised as:

- Land Use Planning
- Environment and Heritage
- Social
- Economic
- Ski Resort Utility
- Technical & Engineering
- Construction
- Operational, and
- Bushfire Management.

4.1.1 MCA Criteria and Descriptors

In order to assess the sites against each objective, a series of criteria and descriptors were developed for each objective. The criteria are more specific and measurable statements of the objective. Three descriptors were developed for each criterion to guide the rating of sites. A 'traffic light' approach (as opposed to a numerical/weighted approach) to the assessment of the sites for each criterion was adopted in order to simplify the assessment process, and because only a small number of storage siting options (three) were available for comparison. The MCA criteria and descriptors, together with explanatory notes where relevant are presented in Appendix A.

Whilst all the criteria were considered important and relevant to the Project and to the consideration of siting options, *key project criteria* representing key project drivers, were identified through the MCA process.

In some cases these key criteria stood out because they were considered to be critical to the feasibility of the Project. If such a criterion was rated poorly, then that option could be considered unfeasible or at best would require serious reconsideration. In contrast, other criteria in the same category were important, but not considered critical to the feasibility of an option.

In other cases one criterion was a surrogate (or partial surrogate) for other criteria. For example, the 'impact to native vegetation' criterion is also relevant to Mountain Pygmy Possum habitat, EPBC and FFG listed communities and species.

The key project criteria identified were:

- Impact to native vegetation;
- Geotechnical suitability and risk to achieving 100 ML storage volume;
- Impact to existing skiable terrain, connectivity and Resort functionality; and
- Storage construction cost.

4.2 Staged Approach

A staged and iterative process (two main stages) was used to assess the potential sites for an 'off stream' storage on the mountain.

4.2.1 Stage 1

In Stage 1, three sites were assessed using the MCA framework, based upon the initial storage concept designs and dam footprints as described in section 5. Whilst the level of information available for each of the potential storage sites differed, the information available was considered adequate to make an assessment against the MCA criteria. One of the sites had obvious disadvantages and was abandoned early.

The MCA assessment then focused on the key project criteria to identify a preferred site between the two remaining sites. The MCA was completed in December 2013 and a preferred site was selected pending further investigation of certain site aspects (principally geotechnical conditions and biodiversity constraints). The information gained from subsequent site investigations was used to revise dam design, ancillary infrastructure design and the construction footprint.

A summary of the outcomes of the MCA of the three sites is included in section 6 and the full MCA assessment is presented in Appendix A.

4.2.2 Stage 2

In January 2014 preliminary geotechnical testing of the preferred site was completed. The results indicated that sufficient rock would not be available for a full rock fill embankment to achieve the desired 100 ML volume. This was a significant change in project assumptions. The concept design of the preferred site was altered assuming a mixed rock and earthen fill embankment, resulting in a larger footprint.

Areas were also identified for ancillary infrastructure and for construction (primarily for temporary stockpiling of material) which would be required to construct the storage.

As a result of the change in embankment design (and the need for stockpiling of material), the overall footprint was much larger than had been assumed in the concept assessed for the MCA. Due to these changes, the team decided to reassess the revised concept designs of the final two sites against key project criteria from the MCA to check that the preferred site remained the preferred site.

The additional information sources available as a result of the stage 2 assessment included:

- Flora and fauna assessment of the revised footprints
- Geological mapping and hazard assessment completed by GHD for the geotechnical risk assessment of the preferred site and associated ancillary infrastructure, and
- Hydrogeological and hydrological information.

Table 3 MCA Objectives

Aspect / Informed by	MCA Objective
Land Use Planning	Minimise complexity of planning and environmental approvals and associated risks to project timeframes and costs
Environment & Heritage Informed by Alpine Resorts Planning Scheme (21.05).	Avoid / minimise impacts to native vegetation
	Avoid / minimise significant impacts to EPBC listed communities / species
	Avoid / minimise significant impacts to FFG listed communities/ species
	Avoid impacts on Mountain Pygmy Possum habitat (Type 1 and 2)
	Avoid / minimise potential impacts to waterways and aquatic habitat
	Protect water supply catchment area (Delatite catchment)
	Avoid / minimise potential impacts to indigenous cultural heritage
Social Informed by Alpine Resorts Planning Scheme (21.05).	Avoid / minimise significant impacts to areas of high scenic quality or visual sensitivity
	Storage dam design, construction and operation which minimises public and employee safety risks
Economic Informed by RMB Strategic Management Plan 2013-2018 *and* RMB - Project Specific Objectives.	Minimise dam construction cost
	Minimise ancillary infrastructure construction cost
	Minimise construction program
	Balance cut and fill in order to minimise construction cost and program, as well as other impacts (transport, amenity, environment)
	Minimise operational cost and complexity of infrastructure, and integrate storage efficiently into existing system
	Integrate new storage and water supply efficiently into snowmaking system in order to minimise capital and operating costs
	Maximise use of gravity to minimise electricity and operating costs. Minimise greenhouse gas emissions.
Ski Resort Utility Informed by Alpine Resorts Planning Scheme (21.05) *and* RMB Strategic Management Plan 2013-2018.	Avoid / minimise potential impacts to winter use terrain currently available to skiers, or potentially available for use in the future
	Avoid / minimise potential impacts to existing ski infrastructure
	Avoid / minimise impacts to core skiable areas currently supported by snowmaking
	Avoid / minimise impacts to future areas used for snowmaking
	Avoid / minimise impacts to areas identified for future recreational use in the Resort Master Plan

Aspect / Informed by	MCA Objective
Technical / Engineering Informed by Alpine Resorts Planning Scheme (21.05) *and* RMB - Project Specific Objectives.	Maximise site 'flexibility' in order to adjust design in line with geotechnical or footprint constraints, whilst still achieving required storage volume (reduce project risk)
	Minimise geotechnical risks through appropriate siting, design and construction
	Geotechnical risk to achieving 100 ML storage volume
	Minimise dam break risk and the potential to impact upon ski infrastructure, resort and road infrastructure, life and property
Construction Considerations Informed by RMB Draft Strategic Management Plan 2013-2018 *and* RMB - Project Specific Objectives.	Avoid impacts to potable water quality during construction phase
	Maintain continuity of Resort operations during construction - particularly for water treatment and supply
	Avoid / minimise the requirement for relocation of services or construction of new services - in order to minimise cost, environmental, business continuity impacts
Operational Considerations Informed by RMB - Project Specific Objectives.	Avoid / minimise potential impacts from planned or unplanned discharges - overtopping, storage maintenance, scouring
	Safe and efficient access to dam site and associated facilities
Bushfire Considerations Informed by Alpine Resorts Planning Scheme (21.05)	Ensure infrastructure enhances Resort fire preparedness and incident response

5. Identification of Sites and Concept Development

This section summarises the process undertaken to identify and shortlist potential sites for the Project, as well as the development of concept designs for each.

5.1 Identification of potential storage dam sites

The process of identifying and shortlisting potential sites for a 100 ML capacity water storage involved:

- Review of previous investigation reports commissioned by RMB for potential water storage sites
- Consultation and discussions with RMB and BSL to identify and confirm potential sites and likely issues or constraints, and
- Site inspections by GHD dams engineers, geotechnical, planning and environmental personnel to confirm and develop a shortlist of potential sites.

The above process resulted in the identification of three potential sites within the vicinity of the Resort. The potential sites are known as 'Tirol', 'Koflers' and 'Control Centre'. A series of site photos are presented in Figure 2, Figure 3, and Figure 4. The location of the sites is presented in Figure 5.

5.2 Development of storage dam concepts

5.2.1 Stage 1 – Preliminary concept designs

Once the three potential storage sites were identified, preliminary 100 ML concept designs were developed in order to understand how a storage would fit on each site. This provided information on footprint, embankment dimensions, excavation quantities and depth, as well as potential visual and ecological impacts. Other issues such as potential impacts on Resort users and existing infrastructure could also be identified.

There were a number of iterations of the concept designs for each site during Stage 1. The MCA assessed the final Stage 1 concepts (Tirol v3, Koflers v2, Control Centre v3) as presented in Figure 5.

5.2.2 Stage 2 – Concept designs

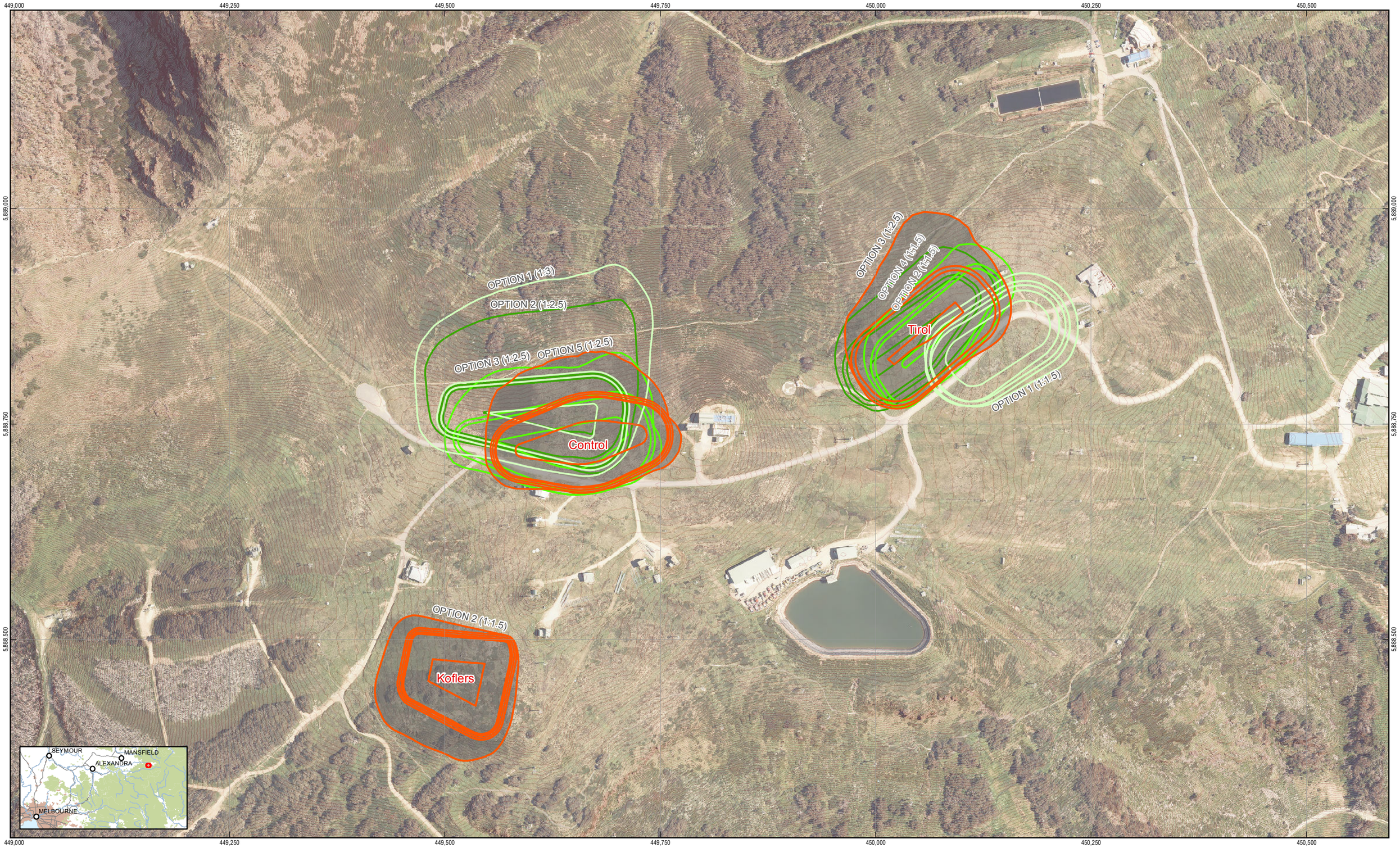
Stage 2 Concept designs for two sites continued to develop following further site investigations (hydrology, hydrogeology, geotechnical stability, flora and fauna, ancillary infrastructure, Resort utility and operational considerations). As indicated in section 4.2.2, a key result from the investigations was that there was insufficient rock available on either site to construct a rock fill embankment (as had been previously assumed). The requirement for an earthern embankment altered project footprints and construction methodologies. Engineering and water supply / ancillary infrastructure considerations were also used to define a revised project footprint for each potential site, and inform a MCA review process. The design and location of ancillary infrastructure took account of previously disturbed areas, and utilised these areas in preference to undisturbed areas.

Stage 2 Concept designs for the Tirol and Control Centre site are presented in Figure 6 and Figure 7.

Figure 2 Views of the Tirol site

Figure 3 Views of the Koflers site

Figure 4 Views of the Control Centre site



Paper Size A3

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Final Option
- Third Option
- Second Option
- First Option
- Contours 1m

Mt Buller & Mt Stirling Resort Management
Mt Buller Sustainable Water Security Project

Storage Options General Arrangements

Job Number	31-30733
Revision	A
Date	04 Jul 2014

Figure 5

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Data source: DEPI, Vicmap, 2013. Created by:mjahanshahi

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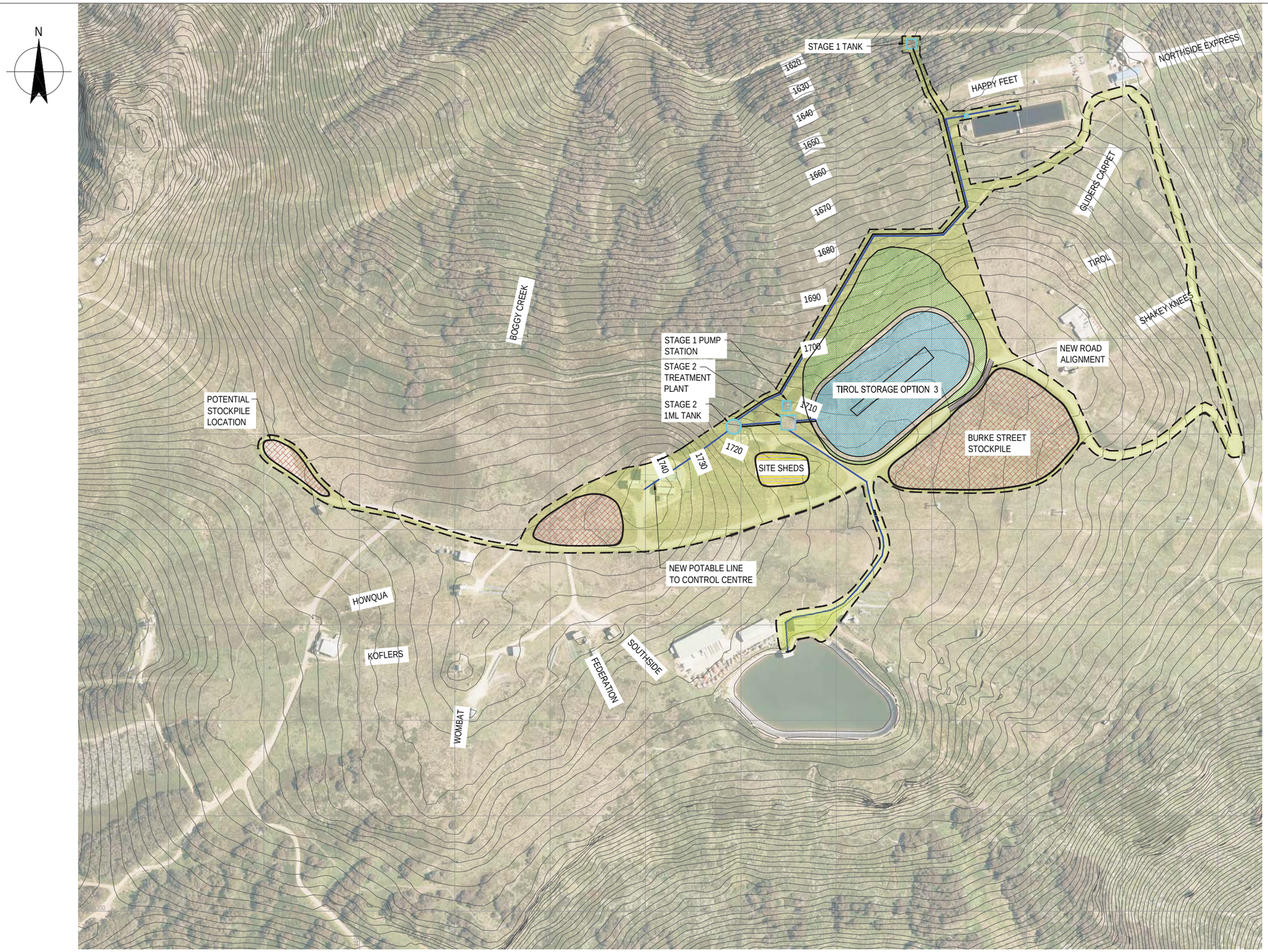

LEGEND:

- PROJECT DISTURBED AREAS
- MATERIAL STOCKPILES
- PIPELINE ALIGNMENTS

PRELIMINARY

No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Job Manager	Project Director	Date
A	PRELIMINARY		RMS			

0 20 40 60 80 100m

SCALE 1:2000 AT ORIGINAL SIZE

GHD

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E melmail@ghd.com.au **W** www.ghd.com

DO NOT SCALE

Drawn	R.SLARKS	Designer	G. JONES
Drafting Check		Design Check	
Approved (Project Director)			
Date			
Scale	1:1000	This Drawing must not be used for Construction unless signed as Approved	

Client **MOUNT BULLER RESORT**

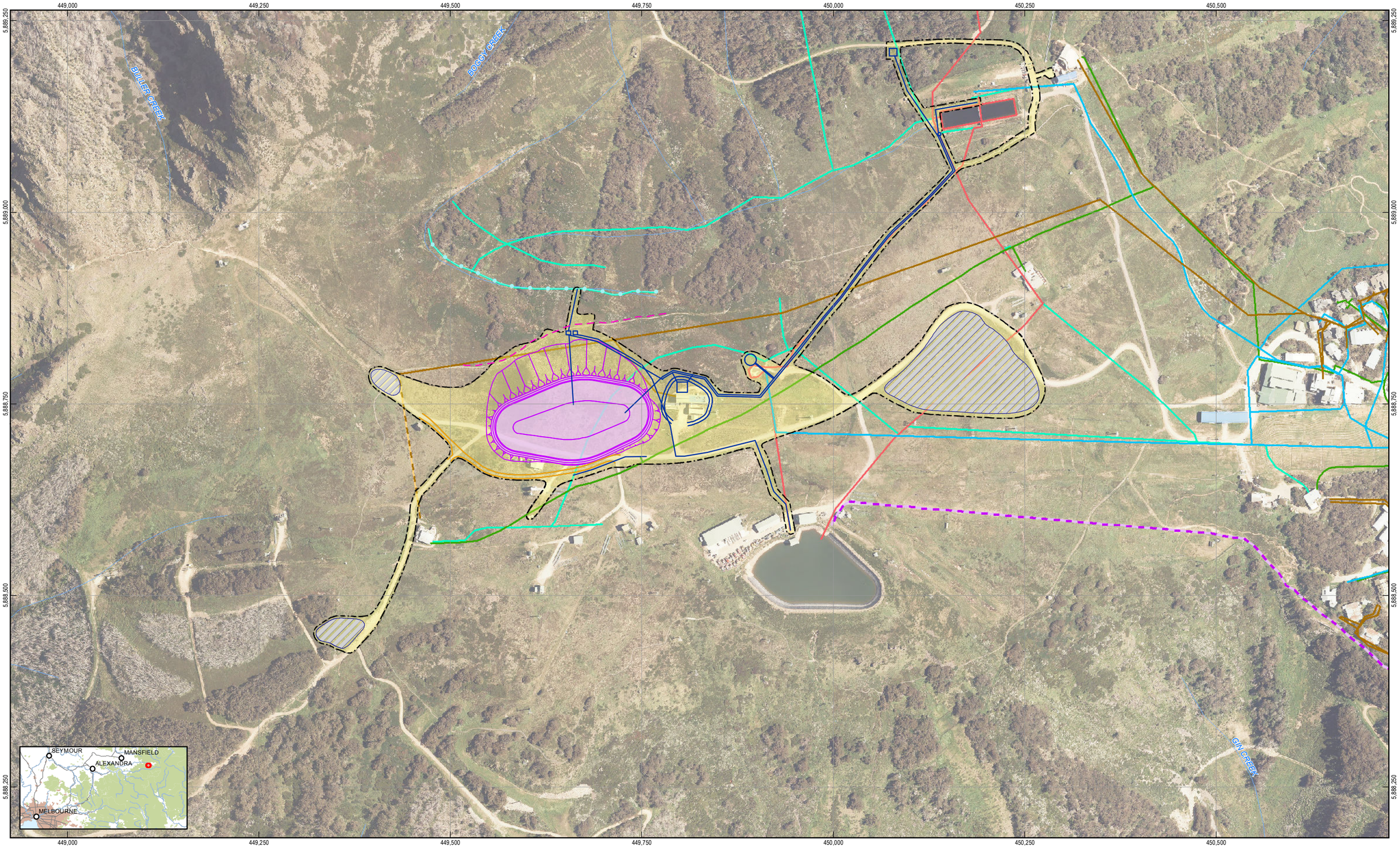
Project **MOUNT BULLER STORAGE OPTIONS**

Title **PIPELINE ALIGNMENTS AND DISTURBED AREAS GENERAL ARRANGEMENT**

Original Size **A1**

Drawing No: **31-30733-FIGURE 6**

Rev: **A**



Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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LEGEND

- Irrigation Line
- Proposed Pipelines
- New Road Alignment
- Stockpiles
- Project Disturbed Areas
- Dam Option
- Recycled Water Main
- Sewerage Main
- Sewerage Rising Main
- Water Main
- Gas Main
- Sewerage Main
- Water Infrastructure
- Potable Water Pipeline
- Stream
- Aqueduct

Mt Buller & Mt Stirling Resort Management
Mt Buller Sustainable Water Security Project

Job Number 31-30733
Revision A
Date 22 Jul 2014

Control Centre Stage 2 Concept Design

Figure 7

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Data source: DEPI, Vicmap, 2013. Created by:mjahanshahi

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5.2.3 Stage 3 Concept design refinement

Project investigations and additional studies continued beyond the Stage 2 concept design and associated site selection phase. In particular, the investigations focused on:

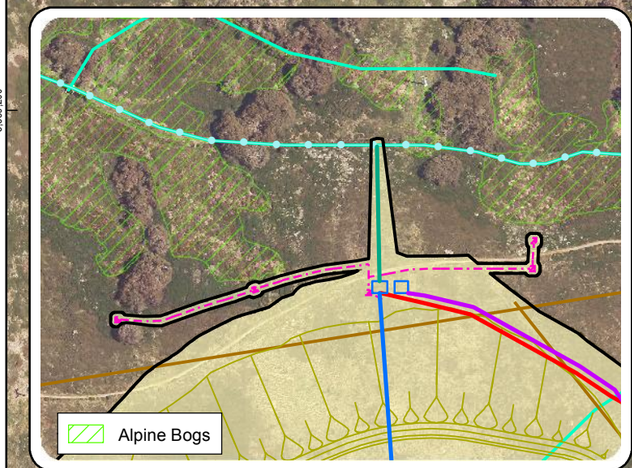
- Detailed mapping of the alpine bog distribution and associated site hydrology and hydrogeology downslope of the proposed storage (GHD, 2015)
- Development of a groundwater monitoring program
- Development of a project specific Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP).

Key refinements in the concept design post the Stage 2 siting and design were based on the outcomes of these additional investigations and have included:

- Reducing the width and undertaking micro-alignment changes for the water supply transfer pipeline from Burnt Hut to the proposed Control Centre storage to avoid as much as possible, mapped native vegetation. This reduced the pipeline corridor width from 10 m to 5 m in sections of the alignment
- A minor adjustment to the alignment of the storage discharge pipeline to the aqueduct based on refined Alpine Bog mapping in order to avoid all direct impacts to the *Alpine Sphagnum Bog and Associated Fens community*
- The design of an environmental watering system downslope of the storage, which would allow water from the storage and/or internal storage drainage water to be distributed across the contour above the Alpine bog community. The watering regime and associated monitoring activities would be undertaken in accordance with a project specific Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP). Conceptual details of the environmental watering system are provided in the summary of the project concept design (GHD 2016)
- The rationalisation of the construction footprint to reduce the area of native vegetation potentially impacted by the construction phase impacts (rather than permanent infrastructure), and
- The review of stockpile requirements and rationalisation of the stockpile area and associated reuse of material.

The above investigations and design have resulted in the further refinement of the Stage 2 concept design. The project construction footprint has been reduced from 11.28 ha to 10.35 ha.

The current design concept is presented in Figure 8.



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5,889,200 5,889,000 5,888,800 5,888,600

1 2 3 4 5 6 7 8 9 10 11 12 12A 12B

Paper Size A3

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Metres

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

New Infrastructure

- Construction footprint
- Proposed stockpiles(12)
- Dam Option (1)
- Buller Irrigation Pipeline(11)
- New Road Alignments (8,9)
- Kofflers Water Supply Pipeline(10)
- Outlet Pipeline(2)
- Storage Tank(6)
- Sun Valley Water Supply Pipeline(4)
- Treatment Supply Pipeline(5)
- Water Supply Pipeline(7)
- Water Supply Pump(3)
- Aqueduct

Exisiting Water Infrastructure (approximate location)

- Water main
- Sewerage Main
- Sewerage Rising Main
- Recycled Water Main
- Gas Main
- Sewerage Main
- Water Infrastructure
- Potable Water Pipeline

Mt Buller & Mt Stirling Resort Management
Mt Buller Sustainable Water Security Project

Job Number 31-30733
Revision A
Date 28 Jul 2016

Project Concept Design

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Data source: Mt Buller & Mt Stirling Resort Management, Aerial imagery, 2011; ARI, bog mapping. Created by:tworth

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6. Siting Options Assessment

This section summarises the results of the MCA assessment based on the Stage 1 and Stage 2 concept designs discussed in section 5.

6.1 Stage 1 Results – Comparison of Storage Options

The results (December 2013) of the 'traffic light' methodology applied to the storage sites presented in Figure 5 are shown in Table 4 and Appendix A. Performance criteria which rated well are shown in green, whilst relatively poor performance against criteria is shown in red. 'Key' project criteria are also highlighted in the table.

All sites had relative advantages and disadvantages when assessed against individual criteria and against each other. The Koflers site was inferior for a range of criteria and was eliminated as a siting option.

6.1.1 Preferred site

After a consideration of the range of criteria (both the 'general' and the 'key' project criteria), the RMB and GHD concluded that the Control Centre site had sufficient merit to be considered the preferred site, but that confirmation of its 'preferred' status would not be possible until additional information was obtained on the:

- Site geotechnical risks (and associated construction costs), and
- Potential for indirect (offsite) impacts on the downslope alpine bog vegetation communities as a result of the storage construction and the alteration of surface and groundwater flow, and the ability to mitigate these impacts.

Table 4 MCA Stage 1 results (December 2013)

Aspect	Criteria	Key Criteria	Tirol	Koflers	Control Centre
Land Use Planning	Complexity of planning and environmental approvals				
Environment & Heritage	Impact to native vegetation	✓			
	Impact to EPBC listed communities or species				
	Impact to FFG listed communities or species				
	Proximity to Mountain Pygmy Possum habitat				
	Impact to water quality and / or hydrology				
	Protect water supply catchment area (Delatite catchment)				
	Potential for Aboriginal cultural heritage impacts				
Social	Impact on visual amenity				
	Public safety & associated controls				
Economic	Dam Construction Cost - embankment material availability	✓			
	Dam Construction Cost - ripping and blasting required for rock cut	✓			
	Dam Construction Cost - minimise earthworks volume	✓			
	Ancillary Infrastructure Construction Cost				
	Construction program duration				
	Quantity of material to be imported or exported				

Aspect	Criteria	Key Criteria	Tirol	Koflers	Control Centre
	Excess material can be reused on site in landscaping				
	Ability to integrate storage, simplify & rationalise long term, reduce operating / management costs				
	Ability to integrate storage / water supply into existing snowmaking infrastructure				
	Operating cost (energy use) (operating head)				
Ski Resort Utility	Impact to existing skiable terrain, connectivity and Resort functionality	✓			
	Impact to existing ski infrastructure				
	Impact to existing snow making areas				
	Impact to future snow making areas				
	Impact to Master Plan and proposed future recreational areas				
Technical / Engineering	Capacity to adjust dimensions of the footprint during detailed design and construction				
	Geotechnical suitability	✓			
	Geotechnical risk to achieving 100 ML storage volume	✓			
	Dam Break Consequence Category				
Construction Considerations	Dust impacts to Burnt Hut water storage quality during construction				
	Impacts to continuity of existing water supply				
	Relocation of services, construction of new services				
Operational Considerations	Discharge location / treatment				
	Ease of site access throughout the year				
Bushfire Considerations	Water supply to Resort can be maintained during power failure				
	Storage and associated infrastructure is defendable, location in the landscape minimises risk				

6.2 Stage 2 Results

As described in section 4.2, a series of investigations were undertaken in conjunction with the concept design development process in order to obtain additional information to inform design work, construction methodology and costs, and confirm the feasibility of the Project. The investigations allowed siting options to be assessed in more detail.

A review of the revised concept designs incorporating a construction footprint for the Tirol and Control Centre sites against key project criteria, and other relevant criteria was undertaken in Stage 2. The review concluded that:

- Potential native vegetation impacts (area) (key criterion) were similar between storage sites [note that these were subsequently reduced in the Stage 3 design]
- Impact mitigation measures and operational controls to avoid and minimise impacts on water quality and hydrology were expected to be similar between sites [note that these have been further developed through the HEMAMP and concept design development processes]
- Dam construction costs (key criterion) were expected to be lower at the Control Centre site
- Whilst the Control Centre storage would require the decommissioning and removal of the existing Boggy Creek T-bar, this infrastructure was proposed to be decommissioned in the longer term (in the current Resort Master Plan (Mt Buller Mt Stirling Alpine Resort

Management Board (2010)). The Tirol site design would continue to have an impact on existing Resort ski infrastructure, would require relocation of the Tirol T-Bar load/unload area, and would continue to affect ski-field connectivity and functionality (key criterion)

- Geotechnical suitability and risk for the Control Centre site was considered to be lower than Tirol following site specific geotechnical investigations (key criteria)
- The management of any discharges from either storage would be treated similarly and managed through design and operational measures.

Based on the investigations undertaken and the consideration of project criteria (both key project and other relevant project criteria), it was concluded that the Control Centre site was the preferred site for the location of the 100 ML off-stream storage dam proposed by RMB.

The Stage 3 refinement of the concept design (as described in 5.2.3) has supported this finding.

7. Summary

This report for the Mt Buller Sustainable Water Security Project – Off-Stream Storage (the Project) documents and summarises the need for the proposed 100 ML Off-Stream Storage, the alternative water supply options considered, the identification and assessment of potential storage sites, and the progressive development of a concept design for the preferred site.

7.1 Water supply constraints and options

Background and contextual information on the Project (section 2) highlights the importance of a safe and reliable water supply to the achievement of the RMB performance obligations and strategic objectives, and for the ongoing economic viability of the Resort. The factors influencing water demand and supply and the existing constraints have also been presented. From this it may be seen that the Resort water supplies (for both potable and snowmaking use) are significantly constrained, and likely to come under increasing pressure as strategies to increase summertime visitation are implemented. The requirement for a 100 ML storage is identified in order to address the constraints. The benefits of addressing these constraints include:

- *Licence compliance and improved environmental outcomes* by avoiding water extraction during the drier periods of the year (maintaining and improving environmental flows)
- *Sustained summer tourism growth*, which improves the economic viability of the Resort
- *Growth in winter recreation and overall visitation*, due to the capability to increase snowmaking on existing areas, or expand snowmaking onto new areas
- *Improved fire-fighting capability and bushfire event response*, through the provision of an on mountain water supply to the Resort capable of supporting fire suppression activities.

Section 3 documents the range of water supply options and alternatives to an on mountain off-stream storage which have been considered. The options that were evaluated against a range of criteria were:

- The proposed option (on mountain off-stream storage)
- Expansion of the Sun Valley reservoir
- Demand management and water efficiency measures
- Increased surface water extraction or extraction from other catchments
- Alternative sources – groundwater and rainwater/stormwater harvesting
- Off mountain storage, and
- Do nothing.

The results of the evaluation indicate that a new 100 ML on mountain storage is the most appropriate option as it:

- Allows peak potable and snowmaking water demands to be met
- Facilitates compliance with the winter fill criteria
- May provide a gravity fed supply and assist with fire preparedness and suppression
- Would have relatively lower capital, operating costs, energy use and greenhouse gas emissions, and
- Is considered technically feasible.

A range of water supply and demand management measures may still need to be implemented by the RMB over the longer term.

7.2 Off-stream storage site options assessment

Section 4 of this report describes the multi criteria assessment (MCA) methodology adopted for the assessment of potential storage sites. This MCA utilised a range of considerations associated with land use planning, environment, heritage, social, economic, ski resort utility, technical and engineering, construction, operation and bushfire management considerations.

A series of detailed assessment criteria and descriptors for the MCA were developed in conjunction with the RMB, based on relevant planning and strategy documents, and from RMB organisation specific objectives. Key criteria for the Project were identified as:

- Impact to native vegetation
- Geotechnical suitability and risk to achieving 100 ML storage volume
- Impact to existing skiable terrain, connectivity and Resort functionality, and
- Storage construction cost.

Section 5 of the report describes the process of storage site identification and the development of storage dam concepts. A two stage process was implemented. Three sites (called 'Tirol', 'Koflers' and 'Control Centre') were identified for evaluation.

Section 6 of the report describes the results of the options assessment process and the comparison of storage options against the MCA criteria. A two stage site options assessment process was undertaken to identify and evaluate potentially suitable sites for an on mountain storage.

The first stage of the process evaluated three sites (Tirol, Koflers and Control Centre), and was informed from prior investigations, as well as limited site specific geotechnical and ecological investigations. This stage utilised the MCA. One site (Koflers) was considered to be inferior and was eliminated early. The Control Centre site was considered to have sufficient merit to be the preferred site, but additional information was required in order for this to be confirmed.

The second stage of the site selection process was undertaken following a series of more detailed geotechnical, hydrogeological and ecological investigations, in conjunction with a preliminary concept design process. This concept design considered a larger footprint than the first stage in order to take account of storage construction methodology, and the need to install and relocate ancillary infrastructure. Following these investigations, the MCA was reviewed to ensure that the preferred site remained preferred in light of the additional information which had been gained.

The concept design has been refined and updated (stage three) based on the need to avoid, minimise and mitigate potential impacts associated with hydrological changes and vegetation removal. The refined concept design is consistent with the stage 2 MCA finding.

7.3 Preferred site

The Control Centre site has been determined as the preferred site for the 100 ML off-stream storage. A comparison of the Control centre with the Tirol site using the key project criteria (and taking into account the investigations and design refinements undertaken since July 2014) indicates that:

- The area of direct impact to native vegetation was previously estimated to be similar between sites. A rationalisation of the construction footprint has resulted in a reduction in the area of vegetation likely to be directly impacted by the project. There is potential for

the construction of the Control Centre storage to result in indirect (hydrology related) impacts to the downslope alpine bog vegetation. A range of mitigation measures including an environmental watering system to be operated in conjunction with a Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP) has been designed to address the indirect impacts. The monitoring and management plan would integrate groundwater and ecological information, and facilitate adaptive management of site and the mitigation of impacts.

- There is significant geotechnical complexity associated with both sites, however the geotechnical risks, and the risks associated with failure to achieve a 100 ML storage during the construction phase are considered to be lower at the Control Centre site
- The potential impacts on skiable terrain, connectivity and Resort functionality are significantly lower at the Control Centre site. Construction at the site would require decommissioning of the Boggy Creek T bar (something which has been proposed in the Resort Master Plan), and
- The construction costs associated with the Control Centre site are expected to be lower than Tirol due to the smaller quantities of rock to be handled and processed.

The review and assessment processes undertaken as part of the options assessment have identified a range of risks which would need to be addressed in the project planning, design, construction and operational phases of the project.

8. References

AECOM (2009) *Mt Buller Water Storage Concept Design Report*. Report for the Mt Buller and Mt Stirling Alpine Resort Management Board.

Alpine Resorts Coordinating Council (2012) *Alpine Resorts Strategic Plan 2012*

DELWP *Alpine Resorts Planning Scheme*

DSE (2004) *Alpine Resorts 2020 Strategy*.

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9. Limitations

This report is an updated summary of a previous GHD report for the Project (Options Assessment Report, Report #6974, 11 July 2014) (GHD,2014a).

This report has been prepared by GHD for Mt Buller and Mt Stirling Alpine Resort Management Board and may only be used and relied on by Mt Buller and Mt Stirling Alpine Resort Management Board for the purpose agreed between GHD and the Mt Buller and Mt Stirling Alpine Resort Management Board as set out in this section of the report.

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The assessment information presented, whilst considering a range of potential impacts, is not in itself a detailed assessment of any particular impact.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

Appendices

Appendix A – MCA objectives and Stage 1 Assessment

Alpine Resorts Planning Scheme (21.05) - Relevant Objectives

Planning Scheme - Strategic Objectives	Planning Scheme - Objectives	MCA Ref No.	MCA Objective
Environmental and Landscape values. To conserve and protect the natural environmental systems and landscape values within and adjacent to the Mt Buller Alpine Resort so as to minimise disturbance to flora and fauna communities and to areas of high scenic quality or visual sensitivity	To maintain, preserve and enhance the natural environmental features of the Resort	2.1	Avoid / minimise impacts to native vegetation
	To maintain, preserve and enhance the habitat of threatened species and communities within the Resort	2.2	Avoid / minimise significant impacts to EPBC listed communities / species
		2.3	Avoid / minimise significant impacts to FFG listed communities/ species
		2.4	Avoid impacts to Mountain Pygmy Possum habitat (Type 1 and 2)
	To ensure that use and development minimises environmental impact through sensitive siting and implementation of sound construction and management techniques	2.5	Avoid / minimise potential impacts to waterways and aquatic habitat
		3.1	Avoid / minimise significant impacts to areas of high scenic quality or visual sensitivity
Natural Resource Management To ensure that use and development within the Mt Buller Alpine Resort is undertaken in an ecologically sustainable manner	To protect the quality and integrity of natural water systems and aquatic ecosystems		*Refer Reference No. 2.5*
		2.6	Protect water supply catchment area (Delatite catchment)
Infrastructure To optimise the snow user capacity of the skifields and ensure provision of appropriate infrastructure to meet current and future needs of the Resort taking into account environmental constraints.	To ensure that service and infrastructure is provided in a manner that minimises impacts on existing natural built, cultural and environmental values of the Resort	5.1	Avoid / minimise potential impacts to winter use terrain currently available to skiers, or potentially available for use in the future
		5.2	Avoid / minimise potential impacts to existing ski infrastructure
To achieve a high level of performance and safety for all development and service infrastructure for all users.		3.2	Storage dam design, construction and operation which minimises public and employee safety risks
	To minimise the impact of stormwater and other discharges on the water quality of the Howqua and Delatite Rivers		*Refer Reference No. 2.5*
Environmental Risks	To take proper account of geotechnical stability considerations	6.2	Minimise geotechnical risks through appropriate siting, design and construction
	To ensure the safety of the Resort from bushfire	9.1	Ensure infrastructure enhances Resort fire preparedness and incident response
		9.2	Minimise potential for bushfire damage to storage and associated infrastructure
Built Environment and Heritage	To protect and improve identified and potential places, sites and objects of Aboriginal and European cultural, historical and architectural significance.	2.6	Avoid / minimise potential impacts to indigenous cultural heritage.
	To ensure protection of significant vegetation on development sites		*Refer Reference No. 2.1, 2.2, 2.3*

RMB Strategic Management Plan 2013-2018 - Relevant Objectives

Strategic Management Plan Objective	5 Year Commitments	MCA Ref No.	MCA Objective
Our Services Provide safe and reliable water and wastewater, and waste removal facilities and services	Continue investment in upgrade and modernisation of plant and systems to improve assets management and resilience of systems	4.5	Minimise operational cost and complexity of infrastructure, and integrate storage efficiently into existing system
		7.1	Avoid impacts to potable water quality during construction phase
		7.2	Maintain continuity of Resort operations during construction - particularly for water treatment and supply
	Implement water supply demand strategy to facilitate appropriate and sustainable supply of water		
Develop initiatives to further snow-making capabilities	Provide ongoing commitment to support infrastructure and best practice in snow making technology	5.3	Avoid / minimise impacts to core skiable areas currently supported by snowmaking
		5.4	Avoid / minimise impacts to future areas used for snowmaking
Maximise asset performance by striving for best use, and improving asset efficiency....	Develop and maintain long-term asset management and investment plan		
Our Environment Manage the endemic alpine flora and fauna communities within the Resorts	Enhance habitat and protection of Mountain Pygmy possum to improve sustainability of the population		*Refer Reference No. 2.4*
	Monitor and manage threats to listed flora and fauna species and communities		*Refer Reference No. 2.2, 2.3, 2.4*
Reduce the Resorts' environmental footprint by developing and promoting sustainable practices and programs	Implement programs and projects to improve Resort resources and efficiencies	4.7	Maximise use of gravity to minimise electricity and operating costs. Minimise greenhouse gas emissions.
Our Community Develop and enhance village and community centres	Continue with the implementation and investment in the Mt Buller Resort Master Plan	5.5	Avoid / minimise impacts to areas identified for future recreational use in the Resort Master Plan
Acknowledge the cultural heritage of our region and celebrating our community's history	Continue to work with local arts, culture and heritage based groups....		*Refer Reference No. 2.7*
Facilitate essential and emergency services required by the community	Continue to ensure that the RMB is skilled and capable of managing and coordinating our response to emergency situations, including bushfires and structural fires		*Refer Reference No. 9.1, 9.2*

RMB - Other Relevant Project Specific Objectives

	Economic, Technical & Operational Objectives	4.1	Minimise dam construction cost
		4.2	Minimise ancillary infrastucture construction cost
		4.3	Minimise construction program
		4.4	Balance cut and fill in order to minimise construction cost and program, as well as other impacts (transport, amenity, environment)
		4.6	Integrate new storage and water supply efficiently into snowmaking system in order to minimise capital and operating costs
		6.1	Maximise site 'flexibility' in order to adjust design in line with geotechnical or footprint constraints, whilst still achieving required storage volume (reduce project risk)
		6.3	Minimise dam break risk and the potential to impact upon ski infrastructure, resort and road infrastructure, life and property
		7.3	Avoid / minimise the requirement for relocation of services / construction of new services in order to minimise cost, environmental, business continuity impacts
		8.1	Avoid / minimise potential impacts from planned or unplanned discharges - overtopping, storage maintenance, scouring
		8.2	Safe and efficient access to dam site and associated facilities

MT BULLER OFF STREAM STORAGE - MCA CRITERIA

Aspect	Ref No.	MCA Objectives	Criteria	Descriptor	Rating	Explanatory Notes
Land Use Planning	1	Minimise complexity of planning and environmental approvals and associated risks to project timeframes and costs	Complexity of planning and environmental approvals	Planning permit under existing planning scheme provisions		
				More complex approval eg. planning scheme amendment, EPBC Act referral likely to be required		
				Environment Effects Statement and EPBC referral required		
Environment & Heritage	2.1	Avoid / minimise impacts to native vegetation	Impact to native vegetation	Low proportion (<50 %) of dam footprint is covered by intact/undisturbed native vegetation, low likelihood of threatened species / community impact		Utilisation of previously disturbed sites in order to avoid / minimise impacts. Note - dam footprint only at this stage
				Med. proportion (50-75 %) of dam footprint is covered by intact/undisturbed native vegetation, mod. likelihood of threatened species / community impact		
				High proportion (>75 %) of dam footprint is covered by intact/undisturbed native vegetation, high likelihood of threatened species / community impact		
	2.2	Avoid / minimise significant impacts to EPBC listed communities / species	Impact to EPBC listed communities or species	No direct or indirect impact considered likely		EPBC listed species may be different to FFG listed species and trigger different approvals - therefore separated from FFG (below)
				Potential direct or indirect impact		
				Certain direct or indirect impact		
	2.3	Avoid / minimise significant impacts to FFG listed communities/ species	Impact to FFG listed communities or species	No direct or indirect impact considered likely		
				Potential direct or indirect impact		
				Certain direct or indirect impact		
	2.4	Avoid impacts on Mountain Pygmy Possum habitat (Type 1 and 2)	Proximity to Mountain Pygmy Possum habitat	Footprint > 100m from mapped habitat		Potential risk of direct / indirect impacts from construction (vibration, sediment etc) or operation. Distance from mapped habitat used as descriptor - assumes risk of impact reduces with increased distance. 30m buffer to habitat also applies.
				Footprint between 50m and 100m from mapped habitat		
				Footprint < 50m from mapped habitat, potential for direct or indirect impacts during construction or operation		
	2.5	Avoid / minimise potential impacts to waterways and aquatic habitat	Impact to water quality and / or hydrology	Storage dam unlikely to significantly alter site hydrology or create water quality issues		Assumes construction mitigation measures can be successfully applied. Consideration to be given to potential aquatic impacts associated with both construction and operation.
				Storage dam may result in minor changes to site hydrology and / or create water quality issues		
				Storage dam will significantly alter surrounding hydrology and / or create water quality issues		
	2.6	Protect water supply catchment area (Delatite catchment)	Minimise risks to drinking water through segregation of snowmaking water supplies (potable and recycled). Avoid use of recycled water in Delatite catchment.	Allows full segregation of water sources by catchment area		Use of recycled water for snowmaking in water supply catchment introduces risks. Risks will be reflected in new treatment plant design. There are also best practice / regulatory considerations.
				Requires minor augmentation to segregate water sources		
				Difficult to segregate, requires significant new infrastructure to achieve segregation		
	2.7	Avoid / minimise potential impacts to indigenous cultural heritage.	Potential for Aboriginal cultural heritage impacts	Footprint outside any area of cultural heritage sensitivity		No VHR or VAHR sites are present on Mt Buller Resort ski area. Areas of sensitivity (where there is potential for as yet unknown cultural heritage to occur) based on Vic Govt cultural heritage sensitivity mapping have been used.
				Footprint partially within an area of cultural heritage sensitivity		
				Footprint wholly within an area of cultural heritage sensitivity		
Social	3.1	Avoid / minimise significant impacts to areas of high scenic quality or visual sensitivity	Impact on visual amenity	Storage not visible from main vantage points near Resort or access roads		
				Storage partially visible from vantage points near Resort and access roads		
				Storage easily visible from Resort and access roads. Significant feature in the landscape.		
	3.2	Storage dam design, construction and operation which minimises public and employee safety risks	Public safety and associated controls	Location avoids main thoroughfare, public access can be restricted and monitored, storage not traversed by ski lift		
				Located near main thoroughfare, public access can be restricted but difficult to monitor, storage not traversed by ski lift		
				Located on main thoroughfare, public access difficult to restrict and monitor, storage close to ski lift		
Economic	4.1	Minimise dam construction cost	Availability of embankment construction material	Extensive amount of material available from cut for embankment		
				Moderate amount of material available from cut for embankment		
				Limited amount of material available from cut for embankment		
			Ripping and blasting required for rock cut	Limited amount of ripping or blasting likely to be required		
				Moderate amount of ripping or blasting likely to be required		
				Extensive amount of ripping or blasting likely to be required		
			Minimise earthworks volume and handling	Relatively low earthworks volume for required storage <35,000 m3. No double handling of materials.		
				Moderate earthworks volume for required storage 35,000 - 75, 000 m3. Some double handling of materials.		
				Relatively high earthworks volume >75,000 m3. Significant double handling of materials.		
	4.2	Minimise ancillary infrastructure construction cost	Ancillary infrastructure (pipelines, power, road) construction cost	Infrastructure cost relatively low		Influenced by distances, connection and control points. Relocation of existing services and access roads.
				Infrastructure cost moderate		
				Infrastructure cost relatively high		
	4.3	Minimise construction program	Construction program duration	Can commence early works at the end summer 2013/14 (subject to planning approvals)		
				Can be constructed over a single summer		
				May require two summer construction periods		
	4.4	Balance cut and fill in order to minimise construction cost and program, as well as other impacts (transport, amenity, environment)	Quantity of material to be imported / exported	Cut / fill quantities are balanced (+/- 10% of total quantity)		
				Cut / fill quantities unbalanced (+/- 20% of total quantity to be imported / exported)		
				Cut / fill quantities unbalanced (+/- 30% of total quantity to be imported / exported)		
			Excess material can be reused on site in landscaping	All excess material can be reused on site		Excess material can potentially be used for landscaping the storage embankment in order to minimise visual amenity impact
				Majority of excess material can be reused on site		
				No excess material can be reused on site - must be exported		
	4.5	Minimise operational cost and complexity of infrastructure, and integrate storage efficiently into existing system	Ability to integrate storage into existing infrastructure, simplify and rationalise infrastructure long term, reduce operational / management costs	Infrastructure integrates with existing system and allows simplification / rationalisation long term, provides operational cost savings		Requires consideration of distances, existing infrastructure, potential to redesign
				Infrastructure partially integrates with existing system, operating cost neutral		
				Infrastructure does not easily integrate, duplicates or increases complexity long term, increases operational costs		
	4.6	Integrate new storage and water supply efficiently into snowmaking system in order to minimise capital and operating costs	Ability to integrate storage / water supply into existing snowmaking infrastructure	Infrastructure integrates with existing system		
				Infrastructure partially integrates with existing system requiring minor additional infrastructure		
				Infrastructure does not easily integrate requiring significant additional infrastructure		
	4.7	Maximise use of gravity to minimise electricity and operating costs. Minimise greenhouse gas emissions.	Operating cost (energy use / pumping duty)	Storage location and conveyance infrastructure can utilise gravity to a large extent, short pipeline length		Operating head and pipeline length used to determine relative differences in energy use
				Storage location and conveyance infrastructure can partially utilise gravity feed but additional pumping will be required, mod. pipeline length		
				Storage location and conveyance infrastructure require significant additional pumping, long pipeline length		

Aspect	Ref No.	MCA Objectives	Criteria	Descriptor	Rating	Explanatory Notes
Ski Resort Utility	5.1	Avoid / minimise potential impacts to winter use terrain currently available to skiers, or potentially available for use in the future	Impact to existing skiable terrain, connectivity and Resort functionality	No impact on skiable terrain or existing ski runs. Connectivity and functionality of runs/lifts unaffected.		Includes skiable terrain available for use (based on BSL mapping). Connectivity to maintain efficient skier movement is important. Note: Additional criteria for snowmaking areas (below) provided due to importance during poor seasons.
				Reduction in skiable terrain which requires minor modification of existing ski runs in order to maintain connectivity and Resort functionality		
				Significant reduction in skiable terrain, requires major modification of existing ski runs to retain connectivity and Resort functionality		
	5.2	Avoid / minimise potential impacts to existing ski infrastructure	Impact to existing ski infrastructure	No impact to existing infrastructure		
				Minimal impact to existing infrastructure - modification or relocation required		
				Major impact to existing infrastructure - requires decommissioning or major modification to one or more lifts		
	5.3	Avoid / minimise impacts to core skiable areas currently supported by snowmaking	Impact to existing snow making areas	No impact on existing snow making areas or infrastructure		Based on BSL mapping of current snowmaking areas.
				Minimal impact on existing snow making areas or infrastructure		
				Significant impact on existing snow making areas requiring modification of infrastructure and runs		
	5.4	Avoid / minimise impacts to future areas used for snowmaking	Impact to future snow making areas	No impact on future snow making areas		Based on BSL mapping of future snowmaking areas
				Minimal impact on future snow making areas		
				Significant impact on future snow making areas requiring modification of infrastructure and runs		
	5.5	Avoid / minimise impacts to areas identified for future recreational use in the Resort Master Plan	Impact to Master Plan and proposed future recreational areas	No impact		Based on Mt Buller Master Plan Report October 2010
				Minimal impact		
				Significant impact requiring modification of plans		
Technical & Engineering	6.1	Maximise site 'flexibility' in order to adjust design in line with geotechnical or footprint constraints, whilst still achieving required storage volume (reduce project risk)	Capacity to adjust dimensions of the footprint during detailed design and construction	No significant footprint constraints for the required volume.		Additional geotechnical information being obtained. Flexibility of dam footprint is highly desirable to minimise project construction risks & ensure target storage volume can be achieved.
				Project footprint is constrained, but has some flexibility for adjustment.		
				Project footprint is heavily constrained. No flexibility.		
	6.2	Minimise geotechnical risks through appropriate siting, design and construction	Geotechnical suitability	Geotechnical conditions predictable and uniform		
				Geotechnical conditions have potential areas of complexity, likely to require specific engineering measures		
				Geotechnical conditions complex, require detailed investigation and testing throughout project, specific additional engineering measures		
			Geotechnical Risk to achieving 100 ML volume (based on current information)	Geotechnical info provides sufficient confidence of achieving 100 ML objective		No geotechnical info for Koflers. Potential to compromise 100ML storage requirement. Assumptions made about rock/geotechnical conditions based on site inspection.
				Limited geotechnical info - uncertainty of achieving 100 ML objective		
				Only surface assessment of geological conditions - potential to significantly compromise 100 ML storage objective		
	6.3	Minimise dam break risk and the potential to impact upon ski infrastructure, resort and road infrastructure, life and property	Dam Break Consequence Category (ANCOLD)	Minimal potential to impact upon the built environment, life and property. (Very Low to Low consequence category)		Ratings determined by ANCOLD Guidelines
				Potential for localised impacts on the built environment, life or property. (Significant to High (C) consequence category)		
				Potential for significant impacts on the built environment, life or property. (High (B) to Extreme consequence category)		
Construction Considerations	7.1	Avoid impacts to potable water quality during construction phase	Dust impacts to Burnt Hut water storage quality	No potential dust impact on water quality in Burnt Hut storage		Burnt Hut storage is open to the air and potentially impacted upon by airborne contaminants mobilised during construction
				Some potential dust impact on water quality within Burnt Hut storage requiring additional treatment to maintain potable standard		
				Significant potential dust impact on water quality within Burnt Hut storage compromising ability to meet potable water standard		
	7.2	Maintain continuity of Resort operations during construction - particularly for water treatment and supply	Impacts to continuity of existing water supply	Can be constructed with no / minimal impact to existing water supply, treatment and conveyance systems		
				Construction will result in periodic but manageable interruptions to water supply, treatment and conveyance systems		
				Construction will result in significant interruption to existing water supply / treatment / conveyance and complex 'work arounds'		
	7.3	Avoid / minimise the requirement for relocation of services or construction of new services - in order to minimise cost, environmental, business continuity impacts	Relocation of services, construction of new services	Requires minimal relocation of existing services, new services all within previously distrubed areas		
				Requires relocation of services and construction of new services, primarily within previously disturbed areas		
				Requires significant relocation of existing services and/or construction of new services in undisturbed areas.		
Operational Considerations	8.1	Avoid / minimise potential impacts from planned or unplanned discharges - overtopping, storage maintenance, scouring	Discharge location / treatment	Discharges from storage can be easily directed to least sensitive environments and/or treatment systems		
				Discharges from storage will require significant engineering to direct to least sensitive environments and/or treatment systems		
				Discharges from storage have potential to enter identified sensitive environments eg. boulder fields, MPP habitat, bogs		
	8.2	Safe and efficient access to dam site and associated facilities	Ease of site access throughout the year	Site easily accessible all year round		
				Site generally accessible all year round		
				Site potentially inaccessible at times		
Bushfire Management	9.1	Ensure infrastructure enhances Resort fire preparedness and incident response	Water supply to Resort can be maintained during power failure	Water can gravity feed to the Resort in the event of power failure, multiple supply options / redundancy possible		
				Water can gravity feed to the Resort in the event of power failure		
				Water cannot gravity feed in the event of power failure		
	9.2	Minimise potential for bushfire damage to storage and associated infrastructure	Storage and associated infrastructure is defendable, location in the landscape minimises risk	Storage location is defendable, adjoining vegetation provides low fuel load		Storage will be lined with a membrane which is susceptible to fire.
				Storage location is defendable, adjoining vegetation provides moderate fuel load		
				Storage location is not easily defendable, adjoining vegetation provides high fuel load		

EVALUATION

Land Use Planning

Option	1.0 Complexity of planning and environmental approvals		Potential to manage/reduce impact or risk?
	Rating	Comments	
Tirol		Planning permit with EPBC referral likely to be required (potential for *direct & indirect* impact on Alpine bog community)	Partial - direct impact on small area, design to avoid/mitigate hydrology impacts
Koflers		Planning permit with EPBC referral likely to be required (potential to impact on Pygmy Possum)	No - footprint constrained
Control Centre		Planning permit with EPBC referral likely to be required (potential for *indirect* impact on Alpine bog community (via groundwater). Note: requires assessment of indirect impacts (hydrogeo & geotech investigations)	Yes - design solution to avoid direct impact to sub alpine wet heath / bog communities. Potential for management and monitoring to support mitigation of hydrology impacts.

Environment & Heritage

Option	2.1 Impact to native vegetation		
	Rating	Comments	
Tirol		~80% of dam footprint estimated to be intact, remainder disturbed or degraded	
Koflers		~100% of dam footprint estimated to be intact. Footprint includes a variety of EVCs	No - dam footprint limited flexibility
Control Centre		~70% of dam footprint estimated to be intact, remainder disturbed or degraded.	
	2.2 Impact to EPBC listed communities or species		
	Rating	Comments	
Tirol		Footprint avoids EPBC listed vegetation community. Potential for direct / indirect impacts associated with construction activities or changes in hydrology.	
Koflers		Small area of listed vegetation community, close proximity to MPP habitat. Referral may be required.	
Control Centre		No EPBC listed veg communities on site. Significant potential for local hydrology changes and indirect impact to EPBC listed communities below dam site. Referral likely to be required. Requires further investigation	
	2.3 Impact to FFG listed communities or species		
	Rating	Comments	
Tirol		Footprint avoids listed veg. community, a number of listed flora and fauna species likely to occur. FFG listed community (Sub alpine wet heathland) adjacent and downslope.	Yes - optimise footprint to avoid FFG listed wet heathland community
Koflers		Small area of listed veg. community impacted, a number of listed flora and fauna species likely to occur	No - dam footprint limited flexibility
Control Centre		No listed veg communities on site. Significant potential for local hydrology changes and indirect impact to FFG listed communities below dam site. A number of listed flora and fauna species likely to occur.	Yes - optimise footprint to avoid FFG listed wet heathland community
	2.4 Proximity to Mountain Pygmy Possum habitat		
	Rating	Comments	
Tirol		Outside Revised Management Area. Dam footprint approx 360 m from Habitat 2 and 550 m from Habitat 1 (excludes 30 m buffer)	
Koflers		Part of footprint within Revised Management Area. Dam footprint approx 50 m from Habitat 2, 130 m from Habitat 1. Small patch of potential habitat present within the footprint (excludes 30 m buffer).	No - dam footprint limited flexibility
Control Centre		Outside Revised Management Area. Dam footprint approx 300 m from Habitat 2 and 340 m from Habitat 1 (excludes 30 m buffer)	
	2.5 Impact to water quality and / or hydrology		
	Rating	Comments	
Tirol		Localised impact on hydrology likely. Assumes erosion mitigation measures can be successfully applied.	
Koflers		Localised impact on hydrology likely. Assumes erosion mitigation measures can be successfully applied.	
Control Centre		Significant potential for localised impact on hydrology. Assumes erosion mitigation measures can be successfully applied. Level of impact on hydrology and catchment yield to be investigated.	Yes - requires investigation and development of mitigation measures
	2.6 Protect water supply catchment area (Delatite catchment)		
	Rating	Comments	
Tirol		Segregation achieved though valving and new snow making pump	
Koflers		Segregation difficult / costly to achieve	
Control Centre		Segregation achieved though valving and new snow making pump	
	2.7 Potential for Aboriginal cultural heritage impacts		
	Rating	Comments	
Tirol		Wholly within ACHS due to 'high plains' regulation. Large part of footprint previously surveyed with no heritage identified.	Yes - undertake CHMP
Koflers		Footprint partially within ACHS due to proximity (within 200m) of waterway.	Yes - undertake CHMP
Control Centre		Footprint partially within ACHS due to 'high plains' regulation. Part of footprint previously surveyed with no heritage identified.	Yes - undertake CHMP

Social

Option	3.1 Impact on visual amenity		
	Rating	Comments	
Tirol		Visible from a number of vantage points and access roads. Significant 'presence'.	Partial - minimise through landscape treatment / design
Koflers		Visible from a some vantage points and access roads	
Control Centre		Visible from a some vantage points and access roads. Any excess fill can potentially assist with landscaping.	
	3.2 Public Safety & associated controls		
	Rating	Comments	
Tirol		Located near thoroughfare, can restrict public access but limited ability to monitor, fencing potentially a safety issue due to skier traffic near Summit Road	
Koflers		Located near thoroughfare, can restrict public access but limited ability to monitor.	
Control Centre		Located near thoroughfare, can restrict public access. Can be monitored more closely from control centre building	

Economic

Option	4.1 (a) Dam construction cost - Availability of embankment construction material		
	Rating	Comments	
Tirol		Known to be available but to limited depth (encounter XW granite at depth). Earthen embankment or combination rock / earthen likely to be required.	
Koflers		Bedrock at surface level however depth is unknown. No geotech info available.	
Control Centre		Material available but will be an earthen embankment. Additional geotech info required in order to complete design.	
	4.1 (b) Dam construction cost - Ripping and blasting required for rock cut		
	Rating	Comments	
Tirol		Moderate amount of ripping and blasting expected	
Koflers		Significant deep cut required (and therefore significant ripping and blasting likely to be required)	No - dam design dictates significant depth 30m+
Control Centre		Limited amount of ripping and blasting expected. Based on preliminary geotech - boulders / floaters expected but cannot be defined at this stage	
	4.1 (c) Dam construction cost - Minimise earthworks volume and handling		
	Rating	Comments	
Tirol		Cut 71,000 m3 and fill 73,000 m3 modelled (14/11/13). Some double handling of material expected including rock crushing.	
Koflers		Cut 93,000 m3 and fill 40,000 m3 modelled (4/10/13)	No - dam design dictates significant depth
Control Centre		Cut 73,000 m3 and fill 50,000 m3 modelled (13/11/13). Some double handling of material expected for moisture conditioning.	
	4.2 Ancillary infrastructure (pipelines, power, road) construction cost		
	Rating	Comments	
Tirol		Road relocation required, gas pipeline relocation likely, other services to be relocated	
Koflers		New and duplicated services required, greater distances increase capital cost (estim 2 x Tirol), access road upgrade	No - distance is determined by location
Control Centre		Road relocation required, other services including sewer, water and comms to be relocated. Marginal increase in pipeline distances when compared with Tirol	No - distance is determined by location
	4.3 Construction program duration		
	Rating	Comments	
Tirol		Can be constructed in a single summer	
Koflers		Can be constructed in a single summer	
Control Centre		Can be constructed in a single summer	
	4.4 (a) Quantity of material to be imported or exported		
	Rating	Comments	
Tirol		Current storage design balances cut / fill with a high level of confidence	
Koflers		Current storage design balances cut / fill, however geotech conditions unknown, no ability to alter footprint.	
Control Centre		Current storage design balances cut / fill however geotech conditions highly variable. Site footprint provides some flexibility to assist with balance. Some import of sand or stabilising material likely to be required.	
	4.4 (b) Excess material can be reused on site in landscaping		
	Rating	Comments	
Tirol		A number of options available to utilise excess material on uphill side of storage. No reuse possible on toe of storage	
Koflers		Footprint and slope constraints - no capacity to utilise excess material in landscaping	No - dam design / site constraints
Control Centre		A number of options available to utilise excess material around dam site.	
	4.5 Ability to integrate storage, simplify & rationalise long term, reduce operating / management costs		
	Rating	Comments	
Tirol		Preliminary assessment indicates integration and longer term efficiencies possible. Requires further evaluation and decisions on system preferences.	
Koflers		Relative remoteness makes integration, rationalisation more difficult.	
Control Centre		Preliminary assessment indicates integration and longer term efficiencies possible. Requires further evaluation and decisions on system preferences. Potentially offers greater operational efficiencies than Tirol.	

		4.6 Ability to integrate storage / water supply into existing snowmaking infrastructure	
	Rating	Comments	
Tirol		Preliminary assessment indicates integration and longer term efficiencies possible. Requires further evaluation and decisions on system preferences.	
Koflers		More difficult to integrate because of location, potential duplication of pipelines	
Control Centre		Preliminary assessment indicates integration and longer term efficiencies possible. Requires further evaluation and decisions on system preferences.	
		4.7 Operating cost (energy use / pumping duty)	
	Rating	Comments	
Tirol		Closer proximity to pumping / treatment plant, gravity feed to village	
Koflers		Greater distances to convey water, possibly larger diameter pipes / pump capacity required	No - dam distance from supply is fixed
Control Centre		Greater distances to convey water, however gravity feed option to village with greater pressure	

Ski Resort Utility

Option		5.1 Impact to existing skiable terrain, connectivity and Resort functionality	
	Rating	Comments	
Tirol		Dam site footprint partially within mapped skiable terrain. Includes an existing ski run important for connectivity and functionality (particularly for beginners).	Partial - through dam footprint & new ski run alignment
Koflers		Dam site footprint occurs wholly within mapped skiable terrain (excluding tree patches). However terrain not generally utilised - minimal impact	
Control Centre		Dam site footprint wholly within mapped skiable terrain, but not a high use area / thoroughfare, potential connectivity issues along Summit Road and Howqua lift can be managed including via landscaping	
		5.2 Impact to existing ski infrastructure	
	Rating	Comments	
Tirol		Requirement to relocate (shorten) the Tirol T-Bar unload station in order to avoid conflicts with embankment. Relocation of existing run to the north of the storage required	
Koflers		No impact identified	
Control Centre		Will require decommissioning of Boggy Ck T-Bar. Note that this is planned for in the Resort Master Plan	No - impact not reduced but decommissioing has been previously proposed / planned
		5.3 Impact to existing snow making areas	
	Rating	Comments	
Tirol		Current dam footprint avoids snowmaking areas	
Koflers		Current dam footprint avoids snowmaking areas	
Control Centre		Current dam footprint avoids snowmaking areas (small area potentially impacted)	
		5.4 Impact to future snow making areas	
	Rating	Comments	
Tirol		Current dam footprint includes a proposed snowmaking area	
Koflers		Current dam footprint avoids proposed snowmaking areas	
Control Centre		Current dam footprint avoids proposed snowmaking areas	
		5.5 Impact to Master Plan and proposed future recreational areas	
	Rating	Comments	
Tirol		Master Plan identifies a proposed sporting oval - impacted by proposed dam footprint.	Possible - relocate proposed sports oval to Burnt Hut site?
Koflers		No impact on proposed future recreational areas in the Master Plan	
Control Centre		No impact on proposed future recreational areas in the Master Plan. Triggers removal of Boggy Creek T-Bar which is consistent with Master Plan.	

Technical & Engineering

Option		6.1 Capacity to adjust dimensions of the footprint during detailed design and construction	
	Rating	Comments	
Tirol		Site constrained. Current footprint determined via negotiation with BSL. Limited potential to adjust dimensions or to investigate earthfill if rock fill availability is a problem.	
Koflers		Site heavily constrained. Rock fill embankment only (no room for earthfill due to steepening natural slope to north)	No - dam footprint limited flexibility
Control Centre		Site constrained. Some potential to adjust dimensions, but limited by significant environmental constraints/values down slope.	
		6.2 (a) Geotechnical suitability	
	Rating	Comments	
Tirol		Existing investigations indicate site is suitable. Some parts of footprint and specific areas require further investigation. Geotechnical risk considered to be medium.	Yes - geotech investigations to understand risk / implement measures
Koflers		No geotechnical information currently available other than limited surface assessment. Assumed to be suitable. Geotechnical risk considered to be medium.	Yes - geotech investigations to understand risk / implement measures
Control Centre		Existing investigations indicate material is suitable but highly variable. Slope stability risk is considered high to very high based upon field observation of former large adjoining landslides. Additional detailed investigations of site, adjoining landslides and groundwater required to determine whether site is appropriate or has a level of risk acceptable for the storage. Groundwater control measures required.	Yes - geotech investigations to understand risk / implement measures
		6.2 (b) Geotechnical risk to achieving 100 ML storage volume (based on current info)	
	Rating	Comments	
Tirol		High level of confidence of achieving 100 ML volume , but footprint potentially constrained by Resort activities	
Koflers		Potential for 100 ML volume to be compromised - no geotech info and no site flexibility to adjust design based on future geotech info	Yes - detailed geotech investigation to understand / reduce risks
Control Centre		High level of confidence of achieving 100 ML volume but significant footprint constraints associated with native vegetation	
		6.3 Dam Break Consequence category	
	Rating	Comments	
Tirol		Potential for localised impacts on the built environment, life or property. Significant to High (C) consequence category likely	
Koflers		Potential for localised impacts on the built environment, life or property. Significant to High (C) consequence category likely	
Control Centre		Potential for localised impacts on the built environment, life or property. Significant to High (C) consequence category likely	

Construction Considerations

Option		7.1 Dust impacts to Burnt Hut water storage quality during construction	
	Rating	Comments	
Tirol		Footprint close to Burnt Hut - dust impacts likely	Yes - cover storage, additional treatment/monitoring
Koflers		Footprint further from Burnt Hut - minimal dust impacts expected	
Control Centre		Footprint further from Burnt Hut - minimal dust impacts expected	
		7.2 Impacts to continuity of existing water supply	
	Rating	Comments	
Tirol		Periodic impacts during construction which can be managed	
Koflers		Periodic impacts during construction which can be managed	
Control Centre		Periodic impacts during construction which can be managed	
		7.3 Relocation of services, construction of new services	
	Rating	Comments	
Tirol		Relocation of existing services required (gas, sewer, water, snowmaking) primarily within previously disturbed areas	
Koflers		New services to be constructed, some within undisturbed areas	
Control Centre		Relocation of sewer, minor comms and water. New services to be constructed, some within undisturbed areas	

Operational Considerations

Option		8.1 Discharge location / treatment	
	Rating	Comments	
Tirol		Less sensitive receiving environment - still some potential to impact alpine bog	Yes - through design and operation
Koflers		Potential discharge to Mountain Pygmy Possum habitat	No (difficult)- determined by location
Control Centre		Potential discharge to alpine bog EVC's	Yes - through design and operation
		8.2 Ease of site access throughout the year	
	Rating	Comments	
Tirol		Site easily accessible throughout the year	
Koflers		Upgrade of access road required. Pump station below dam may be difficult to access	Partial - upgrade of access road
Control Centre		Site generally accessible. Upgrade and deviation of main access road required.	

Bushfire Management

		9.1 Water supply to Resort can be maintained during power failure	
	Rating	Comments	
Tirol		Need to review / confirm supply options & redundancy. Gravity feed possible	
Koflers		Gravity feed not possible	
Control Centre		Need to review / confirm supply options & redundancy. Gravity feed possible	
		9.2 Storage and associated infrastructure is defendable, location in the landscape minimises risk	
	Rating	Comments	
Tirol		Bushfire risk to infrastructure considered to be medium due to adjoining vegetation fuel load/structure	
Koflers		Bushfire risk to infrastructure considered to be high due to adjoining vegetation fuel load/structure	
Control Centre		Bushfire risk to infrastructure considered to be medium due to adjoining vegetation fuel load/structure	

SUMMARY

Aspect	Ref No.	Criteria	Key Project Driver or Criteria?	Tirol	Koflers	Control Centre
Land Use Planning	1	Complexity of planning and environmental approvals				
Environment & Heritage	2.1	Impact to native vegetation				
	2.2	Impact to EPBC listed communities or species				
	2.3	Impact to FFG listed communities or species				
	2.4	Proximity to Mountain Pygmy Possum habitat				
	2.5	Impact to water quality and / or hydrology				
	2.6	Protect water supply catchment area (Delatite catchment)				
	2.7	Potential for Aboriginal cultural heritage impacts				
Social	3.1	Impact on visual amenity				
	3.2	Public safety & associated controls				
Economic	4.1 (a)	Dam Construction Cost - embankment material availability				
	4.1 (b)	Dam Construction Cost - ripping and blasting required for rock cut				
	4.1 (c)	Dam Construction Cost - minimise earthworks volume				
	4.2	Ancillary Infrastructure Construction Cost				
	4.3	Construction program duration				
	4.4 (b)	Quantity of material to be imported or exported				
	4.4 (a)	Excess material can be reused on site in landscaping				
	4.5	Ability to integrate storage, simplify & rationalise long term, reduce operating / management costs				
	4.6	Ability to integrate storage / water supply into existing snowmaking infrastructure				
	4.7	Operating cost (energy use) (operating head)				
Ski Resort Utility	5.1	Impact to existing skiable terrain, connectivity and Resort functionality				
	5.2	Impact to existing ski infrastructure				
	5.3	Impact to existing snow making areas				
	5.4	Impact to future snow making areas				
	5.5	Impact to Masterplan and proposed future recreational areas				
Technical / Engineering	6.1	Capacity to adjust dimensions of the footprint during detailed design and construction				
	6.2 (a)	Geotechnical suitability				
	6.2 (b)	Geotechnical risk to achieveing 100 ML storage volume				
	6.3	Dam Break Consequence Category				
Construction Considerations	7.1	Dust impacts to Burnt Hut water storage quality during construction				
	7.2	Impacts to continuity of existing water supply				
	7.3	Relocation of services, construction of new services				
Operational Considerations	8.1	Discharge location / treatment				
	8.2	Ease of site access throughout the year				
Bushfire Considerations	9.1	Water supply to Resort can be maintained during power failure				
	9.2	Storage and associated infrastructure is defendable, location in the landscape minimises risk				

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