Yarra Ranges Council

EES chapter 9 – Surface water, groundwater and geotechnical hazards

Warburton Mountain Bike Destination

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9.0 Surface water, groundwater and geotechnical hazards

This chapter assesses the potential surface water, groundwater and geotechnical hazards impacts associated with the construction and operation of the Warburton Mountain Bike Destination (the project). The information in this chapter is a summary of the impact assessment presented in **Technical Report B: Surface Water, Groundwater and Geotechnical Hazards** and describes the key potential impacts arising from the project.

9.1 Overview

Project construction activities and use of the trail network and supporting facilities have the potential to impact surface water, groundwater and present geotechnical hazards.

Understanding how the project would impact surface water, groundwater and geotechnical hazards is important to ensure that environmental values are protected and that effective mitigation measures are adopted where required. These mitigation measures align with the general environmental duty (GED) of the *Environment Protection Act 2017* to avoid the risk of environmental damage.

The key findings of the surface water, groundwater and geotechnical hazards impact assessment are as follows:

- Due to the construction methodology and design of elevated structures at designated waterways, the potential surface water, groundwater and geotechnical hazards impacts are assessed to be low and manageable. Under existing conditions, environmental values of surface water and groundwater are likely to be protected.
- The main potential impacts of the project were identified to be increased sedimentation of waterways during construction and changes to surface water hydrology during trail network construction and operation. Implementation of the proposed mitigation measures would minimise residual impacts to surface water so that significant impacts are not anticipated.
- A number of construction activities may cause increased sedimentation to waterways including, the clearing of vegetation, machinery disturbing the soil, removal of rocks and roots decreasing soil stability, compaction of trail surfaces increasing runoff and construction of trails without appropriate erosion controls in place.
- Following implementation of mitigation measures, residual impacts to surface water, groundwater and geotechnical hazards due to construction and operation activities would be minimised so that significant impacts are not anticipated. Where impacts do occur to surface water hydrology and flow, these would be localised and short term, for example, in the immediate vicinity of a waterway crossing point (days in duration).

In response to the EES evaluation objective, impacts of the project on surface water, groundwater and geotechnical hazards have been assessed and design solutions and mitigation measures have been identified to avoid and minimise adverse impacts.

9.2 EES evaluation objectives

The scoping requirements for the project set out the specific environmental matters to be investigated and documented in the project's EES in order to satisfy the Commonwealth and Victorian assessment and approval requirements.

The scoping requirements include a set of evaluation objectives that identify the desired outcomes to be achieved in managing the potential impacts of constructing and operating the project.

The following evaluation objective is relevant to the surface water, groundwater and geotechnical hazards study:

- **Surface Water, Groundwater and Geotechnical hazards** – maintain the functions and values of groundwater, surface water and floodplain environments and minimise effects on water quality and beneficial uses.

This chapter and **Technical Report B: Surface Water, Groundwater and Geotechnical Hazards** address the specific surface water, groundwater and geotechnical hazards related matters set out in the EES scoping requirements.

9.3 Applicable legislation and policy

Table 9-1 lists the key legislation, policies, guidelines and standards relevant to the surface water, groundwater and geotechnical hazards impact assessment.

Table 9-1 Surface water, groundwater and geotechnical hazards legislation, policy, guidelines and criteria

Type	Applicable legislation, policy and guidelines
Legislation and policy	• *Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)* ('EPBC Act') • *National Environment Protection Council Act 1994 (Commonwealth)* ('NEPC Act') • *Flora and Fauna Guarantee Act 1988 (Vic)* ('FFG Act') • *Water Act 1989 (Vic)* • *Environment Protection Act 2017 (Vic)* - Environment Protection Regulations 2021 (Vic) - Environment Reference Standard • *Heritage Rivers Act 1992 (Vic)* • *Yarra River Protection (Willip-gin Birrarung murron) Act 2017(Vic)* • *Safe Drinking Water Act 2003 (Vic)* • *Planning and Environment Act 1987* - Yarra Ranges Shire Planning Scheme
Guidelines and advisory documents	• Ministerial Guidelines for Groundwater Licensing and the Protection of High Value Groundwater Dependent Ecosystems 2015 • EPA Victoria 2006 Guidelines for Hydrogeological Assessments (Water Quality) • EPA Victoria 2014 The clean-up and management of polluted groundwater • EPA Victoria 1991 Construction techniques for sediment pollution control • EPA Victoria Publication 1834 2021 Civil construction, building and demolition guide • EPA Victoria Publication 1287 2009 Guidelines for risk assessment of wastewater discharges to waterways • Landslide Risk Management Guidelines 2007 – Australian Geomechanics Society, Vol. 42 No 1 March 2007 • Waterway Determination Guidelines (DNRE 2002)

9.4 Method

The purpose of the surface water, groundwater and geotechnical hazards impact assessment was to assess the potential impacts associated with the project and inform the preparation of the EES required for the project. This was achieved by undertaking the following:

- Establishing a study area which included all land within an approximate two-kilometre radius of the proposed trail network.
- An assessment of existing environmental conditions including desktop review of relevant datasets, review of literature, policies and legislation, and targeted site visits.
- A review of the project design and proposed activities in the context of existing environmental conditions to understand temporal and spatial distribution of project components and activities in relation to sensitive receptors.
- Use of a risk assessment as described in **Chapter 6: EES assessment framework** as a prioritisation tool to inform the impact assessment and development of mitigation measures.
- Assessment of potential direct and indirect surface water, groundwater and geotechnical hazard impacts of the construction and operation phases of the project, particularly in relation to the legislation, policy and guidelines listed in Section 9.3. This included an analysis of the spatial and temporal extent, magnitude and nature of the potential impacts, and gave consideration to the sensitivity and significance of affected receptors.
- Assessment of the alternative to Trail 1 shown in Figure 9-1 (the combination of Trail 45, Trail 46 and Trail 47) including describing existing conditions, assessment of impacts and a comparative analysis against Trail 1.
- Development of mitigation measures for the construction and operation of the project, based around the implementation of the mitigation hierarchy.

- Evaluation of the residual environmental impacts, which describe impacts once mitigation has been implemented.

9.5 Avoidance and minimisation through design

It is recognised that there are opportunities to avoid and minimise environmental impacts during the many stages of project development and has culminated in the preparation of a project description which is presented in Chapter 3 of this EES. During project inception and early design development stages of the project, decisions on the location of the project, its design and construction techniques have enabled impacts to be significantly avoided and minimised in accordance with the mitigation hierarchy described in **Chapter 6: EES assessment framework**.

For surface water, groundwater and geotechnical hazards, the key avoidance and minimisation measures that have been incorporated into the design include:

- Installation of waterway crossings that enable direct impact on waterways to be avoided
- No siting of trails within the Melbourne Water physical drinking water catchment (except for a 458 metre section of Trail 1 within the Coranderrk Creek drinking water catchment, which has had a risk assessment undertaken for it)
- Siting trails on existing formal and informal tracks and benches where possible
- Choice of shuttle bus routes that avoid the need for road widening
- Bridge over the Yarra River to fully span the river and not require works in the waterway
- Building trails to follow land contours avoiding the need for significant excavations.

After opportunities to avoid and minimise impact through design were exhausted, minimisation and rehabilitation measures were developed. These are described in the construction and operation impact assessment sections below.

9.6 Existing conditions

9.6.1 Surface water

Surface water provides a wide range of environmental values throughout the catchment. Environmental values are the uses, attributes and functions of water environments that should be protected which include:

- Water dependent ecosystems (aquatic ecosystems)
- Water for human consumption
- Water for agriculture, aquaculture and industry
- Water for recreation
- Water for cultural and spiritual values.

The environmental values considered relevant to the context of the project are waterways, stream flow and water quality, and the existing threats these values already face.

It is important to understand the existing surface water conditions of the region to establish a baseline for the impact assessment.

9.6.1.1 Potentially affected waterways

The project is set in a mountainous area with many waterways that may be impacted as a result of the installation of trail heads or trails. The spatial analysis of the area against the VicHydro stream network information identified 166 locations where trails may cross waterways. It should be noted that some of these crossing points do not hold permanent water and are therefore considered depressions or gullies. Of the 166 points identified, there are 42 points discussed in the impact assessment report where the new trail network crosses a waterway generally defined as follows:

- They are located on a named river, creek or stream, or
- They are located on unnamed tributaries with upstream catchment areas of 60 hectares or more.

This is in line with the criteria of what defines a ‘waterway’, as set out in the Victorian *Water Act 1989* and as defined under the *Waterway Determination Guideline* (DNRE, 2002).

The waterways and unnamed tributaries that are crossed by the project are listed in Table 9-2 and shown in Figure 9-1.

Table 9-2 Waterways and unnamed tributaries crossed by the project

Waterways	
• Anderson Creek	• McKenzie Creek
• Ballarat Gully	• Rocky Creek
• Calder Creek	• Scotchman's Creek
• Cemetery Creek	• Tugwell Creek
• Dirt Gully Creek	• Walkers Creek
• Four Mile Creek	• Ythan Creek
• Frenchman's Creek	• Yankee Jim Creek
• Harrison Creek	• Mann Creek
Unnamed tributaries of listed waterways	
• Backstairs Creek	• Frenchman's Creek
• Blue Nose Creek	• Scotchman's Creek
• Britannia Creek	• Stockdale's Creek
• Cemetery Creek	• Tugwell Creek
• Dee River	• Yankee Jim Creek
• Dirt Gully Creek	• Yarra Creek
• Don River	• Yarra River
• Edwardstown Creek	• Ythan Creek
• Four Mile Creek	

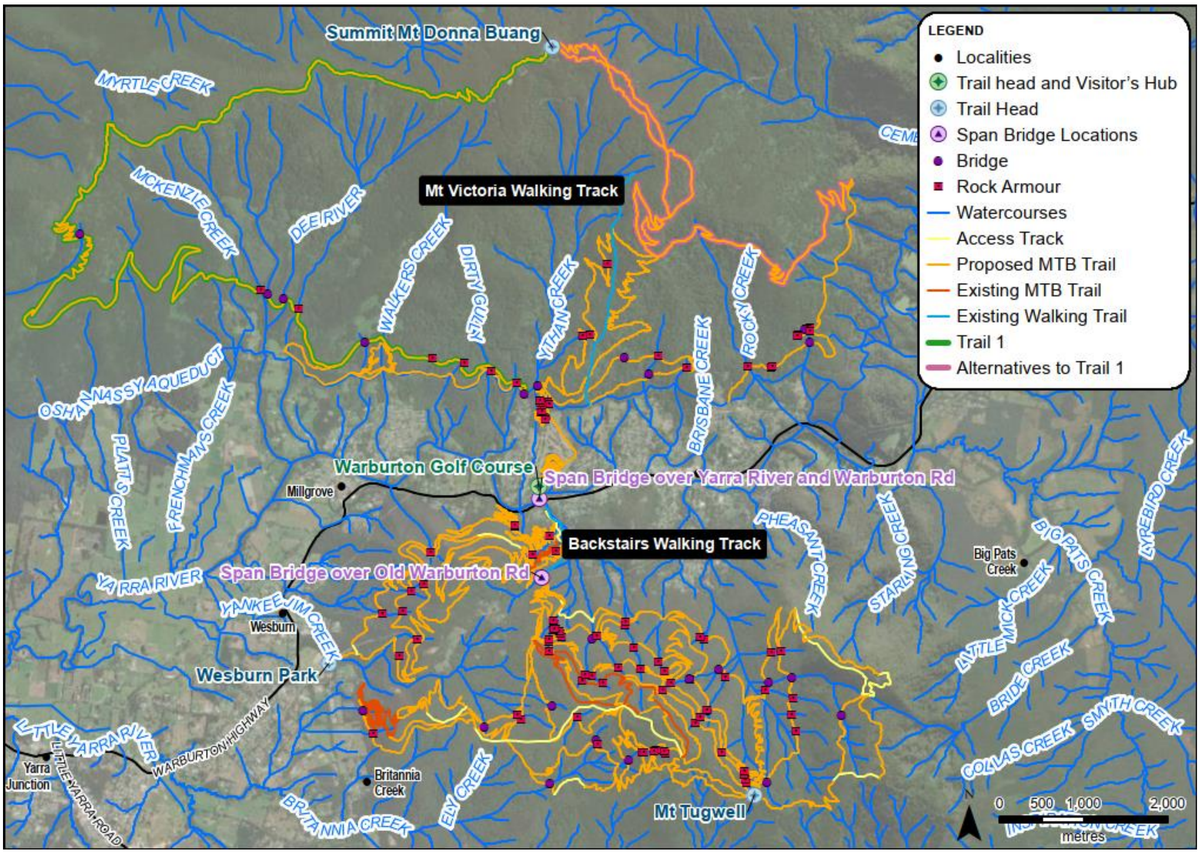

Figure 9-1 Overview of waterway crossings

Photographs of some of these waterways are included in Figure 9-2, Figure 9-3 and Figure 9-4.

Figure 9-2 Dirt Gully Creek

Figure 9-3 A tributary of Scotchman's Creek

Figure 9-4 An unnamed tributary of Yankee Jim Creek

9.6.1.2 Stream flow and water quality

The streams that are crossed by the trail network do not have any existing flow gauges which would monitor the water flow of and quality of waterways. Water quality conditions in the study area were inferred from data available from two nearby monitoring sites as follows:

- Yarra River at McKenzie-King Drive, Millgrove located approximately 2.5 kilometres downstream. Water quality at this site is affected by urban and agricultural runoff in the upstream catchment
- McMahons Creek at Woods Point Road located approximately 17 kilometres upstream, situated in a forested catchment where water quality conditions are likely to be similar to those at a number of the proposed stream crossings.

Approximately 7000 points of historical data was collated extending as far back as 1975 which are included in Appendix B of **Technical Report B: Surface Water, Groundwater and Geotechnical Hazards**.

These sites are considered representative of the identified crossing locations due to proximity within the catchment.

At each site water quality parameters (dissolved oxygen, turbidity, electrical conductivity (EC), pH, nutrients and metals) were compared to the environmental quality objectives listed to determine appropriate methods of surface water management.

Turbidity is the parameter most likely to be impacted by the proposed mountain bike trail construction and operation due to risk of erosion and consequential increased sediment load into waterways. Historic data indicates that turbidity complies with the new Environment Reference Standard (ERS) objective, that is, that the 75% percentile of the data must be below 15 Nephelometric Turbidity Units (NTU). However, occasionally turbidity is recorded above this threshold and there are instances where it has been recorded higher than 100 NTU at both sites. This is likely due to infrequent high flows arising from significant rainfall events resulting in a short-term increase of sediment load entering waterways.

Key parameters for environmental values (dissolved oxygen, EC, pH and nutrients) meet new ERS environmental quality objectives. However, copper and zinc are non-compliant with guideline values at both sites, and to a lesser extent phosphate, chromium and lead are also non-compliant.

Furthermore, macroinvertebrate data obtained from Melbourne Water for Cement Creek, Dee River and Yarra River indicates that sites in the vicinity of the project are high value ecosystems. These ecosystems support a diverse range of pollution sensitive taxa indicative of good to excellent water quality.

9.6.1.3 Existing threats to surface water values

There are a number of threats to surface water values which currently exist in and around the project area. These threats can create impacts to surface water quality, flow and hydrology through increased sediment loads, increased pathogen and pollutant load and alteration of hydrology. For the project area, the following existing threats are of most concern:

- Presence of deer and other feral animals – resulting in increased potential for soil erosion and increased pathogen loads in waterways
- Existing gravel and sealed roads – resulting in runoff of potential pollutants and sediment
- Cleared vegetation – resulting in alteration of hydrology, potential for erosion, runoff of nutrients including nitrogen and phosphorus from agricultural land and increased sedimentation
- Urbanisation – resulting in associated increased stormwater runoff carrying pollutants from impervious surfaces, larger volumes of runoff leading to scouring of waterways and increased risk of sewer system leakage releasing excess nutrients and pathogens into waterways.

With respect to presence of deer and other feral animals, as well as cleared vegetation; the project is unlikely to cause an increase in the threat of existing cleared vegetation and agricultural land to surface water values.

Whilst the project has the potential to increase traffic on some unsealed roads surrounding the track network (e.g. bike riders travelling by car to trail heads), it is the roads themselves rather than the traffic volume which is the threat to surface water values. No additional roads have been planned as part of this project.

The project is unlikely to cause an increase in the threat of existing urban areas to surface water values.

9.6.2 Geotechnical hazards

9.6.2.1 Geological setting

The project covers a large area with varying elevation (from 150 metres to 1,250 metres Australian Height Datum (AHD)) and associated terrain. The geological setting is underlain by marine deposited sedimentary rocks, deposited during the Silurian to Devonian periods.

During the Devonian period, these sedimentary rocks were intruded by igneous, granitic rock resulting in a large batholith present south of Warburton township. The intrusion of the igneous granitic rock also resulted in contact metamorphism, where due to heat the existing Silurian aged sedimentary rock changed composition to produce hornfels. The mountainous area north of Warburton was formed through large scale volcanic activity during the late Devonian, depositing igneous rock called rhyodacite. Weather and erosion of sedimentary rock between the late Devonian period through to the Cainozoic resulted in the deposition of Quaternary colluvium and alluvium in the lower lying areas.

The geological setting is not conducive for the presence of acid generation geological material. Therefore, there is an extremely low, to low probability of acid generating geological materials being present in the study area.

9.6.2.2 Previous records of landslides

The occurrence of landslides in the Yarra Ranges has been well documented. A review of previous landslides near Warburton provides and informs an understanding of land stability. A list of the significant past landslides recorded is included in Table 27-1, **Technical Report B: Surface Water, Groundwater and Geotechnical Hazards**. Based on this data, the following observations have been made:

- All known landslides occurred within the Donna Buang Rhyodacite, Felsic Dykes and colluvium geological units
- Previous landslides have generally occurred north of Warburton on the lower slopes and within the mountainous area
- There is no evidence that significant landslides are known to occur in the Warburton Granodiorite and Humevale Siltstone units south of Warburton

- Landslide movements are typically episodic with long periods of no apparent movement
- Heavy rainfall events have been known to trigger landslides
- Artificial concentrations of water such as irrigation of horticultural land and poor design of stormwater runoff are known to cause or contribute to landslides.

Records of previous landslides suggest that there is potential for events ranging from rock falls to rapid debris flows to very slow moving large landslides incorporating whole hillsides to occur.

9.6.3 Groundwater

Groundwater provides a number of environmental values throughout the catchment which are defined in Section 9.6.1.

The environmental values of groundwater relevant to the context of the project are primarily from existing groundwater bores located in the vicinity of the project for the purposes of stock and domestic use, irrigation, or groundwater investigation or observation.

9.6.3.1 Depth and quality

A review of available groundwater bore information indicates that there is limited quantitative understanding of groundwater occurrence in the study area. The depth of groundwater has been interpreted based on the hydrogeological setting of the area and the following observations have been made:

- The direction of groundwater flow is generally from higher topographies towards lower topographies
- Groundwater depth is likely to be extremely variable particularly in the higher topographies where the depths could be over 50 metres. In the drainage lines and floodplains of waterways such as the Yarra River and Little Yarra River depth is likely to be less than 10 metres.
- The aquifers are unconfined and therefore groundwater levels would be influenced by prevailing climatic conditions
- Groundwater constitutes a high component of flow in the waterways in the region, as much as 50% to 60% of baseflow for some waterways in the Yarra Ranges
- Surface expressions of groundwater such as spring flow are relatively common in this terrain. The headwaters of many creeks and drainage lines can be traced back to spring origin points.
- Based on available regional groundwater information, the groundwater quality in the basement aquifer is expected to be high, with salinities ranging from less than 500 mg/L to 1,000 mg/L total dissolved solids (TDS). This range indicates that the groundwater may have a wide range of environmental values, including potable water supply, agricultural and irrigation use, water dependent ecosystems and species, cultural values, and industrial and commercial use. Groundwater with higher salinity (TDS) would have fewer environmental values.

9.6.3.2 Existing groundwater users

All existing groundwater bores identified in the vicinity of the project are located more than 500 metres from the trail network and were installed for the purposes of stock and domestic use, irrigation or groundwater investigation or observation.

The potential for groundwater to be contaminated is considered highly unlikely based on previous land uses within the National Park and State Forests.

9.7 Construction impact assessment

For surface water, groundwater and geotechnical hazards, a range of issues associated with project construction were examined. Further investigation through the impact assessment process identified that none of the impacts were considered to have significant environmental effects. The assessment of potential impacts described in this chapter include the following:

- Track construction results in increased turbidity and sedimentation in waterways
- Track being constructed crosses a defined waterway without a bridge or other appropriate infrastructure, resulting in sedimentation
- Changes to surface water hydrology during trail network construction.

Other matters assessed, but not presented within this chapter are set out in Table 9-3. None of these potential impacts are considered likely to be material when the proposed mitigation measures are implemented. Further information on these issues can be found in **Technical Report B: Surface Water, Groundwater and Geotechnical Hazards**.

Table 9-3 Other potential impacts assessed

Potential impact	Findings
Surface water	
Direct impact to waterways in the form of sedimentation as a result of not implementing appropriate waterway crossing infrastructure	To minimise any impacts from the selection of the wrong waterway crossing design solution, the project would implement Melbourne Water's crossing guidelines.
Spillage of hazardous construction material during construction resulting in degradation of surface water quality	Very small quantities of fuels and chemicals would be used. Implementation of procedures described in the Construction Environmental Management Plan (CEMP) would mean that spills during construction would be managed in accordance with relevant Australian Standards for storage, handling and transport of hazardous materials (refer to mitigation measure SWM10). As a result, residual impacts are not anticipated.
Toilets and amenities at trail heads that are not sewered – septic system results in nutrient loads to surface water and waterways	Appropriate design of systems would be implemented to cope with anticipated loads and implement frequent cleaning and de-sludging of septic tanks.
Disturbance of contaminated ground mobilises constituents and results in the degradation of surface water	The presence of contaminated ground is highly unlikely. Implementation of procedures in the CEMP, particularly in regard to soil, sediment and spill management would mean that residual impacts are not anticipated.
Yarra River Bridge crossing impacts hydrological regime	The Yarra River would be crossed using a bridge which would avoid impacts to the hydrological regime.
Trail construction causes impact on drinking water within Melbourne Water's Coranderrk Creek drinking water catchment	The potential for trail construction to impact on drinking water supply in terms of pathogens was assessed. The presence of works crews in the short 458-metre section of the catchment is unlikely to have a significant impact on water quality and any potential effects would be isolated and short-term. The Project has committed to measures that reduce the risk to drinking water catchments: i.e. within the CEMP in which educates track workers of the sensitive nature of the drinking water catchments and provision of proper toilet facilities, including hand washing stations, for the works crew (SWM02).
Groundwater	
Excavation of bench exposes spring and results in water flows emanating from the hillslope, creating water logging and/or erosion hazards downstream	Groundwater modelling indicates depths are varying across the project with deeper spring activity at higher elevations and shallower spring activity at lower elevations. While interception of groundwater may potentially occur at lower elevations, the very shallow nature of the excavations (using a mini-excavator) mean that exposure of a spring to the extent which results in water logging and/or erosion hazards is unlikely.
Spillage of hazardous materials during construction resulting in degradation of downstream groundwater	Implementation of procedures described in the CEMP would mean that spills during construction would be managed in accordance with relevant Australian Standards for storage, handling and transport of hazardous materials (refer to mitigation measure SWM10). As a result, residual impacts are not anticipated.
Intersection of contaminated groundwater resulting in risks to construction workers and potential project delays	The shallow nature of the excavations (using a mini-excavator) mean that intersection of contaminated groundwater is unlikely.

Potential impact	Findings
Excavation of existing crossing forms larger exposure of spring eye resulting in greater flow, creating water logging and/or erosion hazard downstream	Groundwater modelling indicates depths are varying across the project with deeper spring activity at higher elevations and shallower spring activity at lower elevations. While interception of groundwater may potentially occur at lower elevations, the very shallow nature of the excavations (using a mini-excavator) mean that exposure of a spring to the extent which results in water logging and/or erosion hazards is unlikely.
Toilets and amenities at trail heads are not sewered - septic systems results in nutrient and pathogen loads to groundwater and down-gradient receiving waterways	Appropriate design of systems would be implemented to cope with anticipated loads and implement frequent cleaning and de-sludging of septic tanks
Disturbance of contaminated soils due to excavation and stockpiling of such materials mobilises constituents and results in the degradation of groundwater	The potential for contaminated and acid sulfate soils in the project is low.
Geotechnical hazards	
Excavation works to form bench on steep slopes or within unstable soil results in over steepened upslope or downslope batters leading to localised failures or where excavated into unstable soil (e.g. debris flow material) cause reactivation or larger scale failures	The extent of excavation works is determined by the steepness of the natural slope and extensive excavation works are not anticipated to be required. Where excavation works are required on steep slopes, rock armouring would be installed. As such, it is unlikely that impacts as a result of excavations would occur. Regardless, measures would be implemented to manage this including • implementing the CEMP by introducing site by site assessments, appropriately stabilised batters, cease construction activity creating soil disturbance during extreme rainfall events and careful planning / staging of construction works. • Further to this, inspections of completed sections of the trail would be undertaken following heavy rainfall events to identify potential slow failures of newly formed batters. Should a large-scale failure occur, an inspection would be undertaken by a geotechnical specialist to assess the risk and remediation measures. With implementation of these measures, material residual impacts are not anticipated.
Removal of significant vegetation including large trees during track construction resulting in failures or erosion where ground once supported by vegetation becomes loose and/or unprotected	The project is committed to no removal of large trees unless they are unsafe and present a hazard either during construction or operation. Where vegetation removal is unavoidable, it will be limited to what is required within the construction corridor. Where unstable, soft soil is exposed through vegetation removal, protection measures to promote stability and limit erosion would be implemented through the installation of rock armouring.

9.7.1 Impacts to surface water quality

Erosion and sedimentation have the potential to increase sediment load into streams and increase turbidity. Elevated turbidity in freshwater systems can impact water quality.

The potential for the project to increase sediment load due to erosion and downstream turbidity levels was assessed. There are several ways the project may cause sedimentation:

- The clearing of the construction corridor of vegetation
- Workers and construction machinery accessing the site and associated soil disturbance
- The excavation of the path and associated soil disturbance

- Removal of rocks and roots from the path decreasing soil stability
- Compaction of the trail increasing runoff and causing erosion
- Construction of a trail over a defined or undefined watercourse without appropriate erosion controls in place (including construction of additional informal trails).

These impacts may potentially occur at the works waterway crossings listed in Section 9.6.1.1.

Without mitigation, erosion and sedimentation may increase sediment loads into streams and increase turbidity. Elevated turbidity in freshwater systems can harm aquatic organisms directly. It can also have indirect impacts on aquatic organisms by increasing water temperature and decreasing dissolved oxygen levels. Further consideration of this impact is included in **Chapter 8: Biodiversity and habitats**.

Without mitigation, the spatial impacts from increased sediment load and downstream turbidity would be influenced by the type of channel. On waterways where water is present at the time of construction, an increase in erosion that leads to sediment washing into waterways could have impacts downstream from the sediment entry point. In headwaters or dry channels, the impacts would likely be confined to the point of entry.

Additionally, the construction of trail heads could lead to sedimentation of waterways in a similar way to that for the construction of trails. However, the footprint of the trail head sites are larger and may be closer to existing waterways. The Warburton Golf Course trail head is the key site identified for mitigation measures to reduce impacts due to the potential for impacts to surface water quality to the Yarra River resulting from works at this location. As such, specific mitigation measures were developed for this site, where stormwater runoff will have specific sediment treatment requirements to reduce sediment loads entering waterways.

The potential for the project to disturb the Mount Donna Buang Wingless Stonefly habitat was assessed based on sites where the species is known to occur. The proposed trail network has been designed as such to avoid crossing waterways where Mount Donna Buang Wingless Stonefly has been identified. Where the proposed trail network enters the Mount Donna Buang Wingless Stonefly habitat, further mitigation measures have been introduced to avoid any impacts to the habitat from erosion and sedimentation. This impact is discussed in greater detail in **Chapter 8: Biodiversity and habitats**.

The implementation of proposed mitigation measures outlined in Section 9.7.3 would mitigate the potential for impacts to surface water quality.

9.7.2 Impacts to surface water hydrology

Hydrology refers to the distribution and movement of water through a landscape. Changes to surface water hydrology, may cause increased runoff volume and velocity, divert water away from existing waterways and reduce flow, which in turn may lead to additional transport of sediments and soils, in-stream erosion and potentially affect aquatic biota in waterways. There are several ways the project may cause impacts on hydrology:

- The removal of vegetation in the construction corridor increasing runoff by a reduction in uptake of water from plants and from reduced interception of rainfall on plant leaves
- Compaction of the trail increasing runoff volumes and velocities
- Flow directed down the mountain bike trail increasing runoff and changing the flow regime, with higher peak flows
- Selection of inappropriate waterway crossing design.

The implementation of proposed mitigation measures outlined in Section 9.7.3 would mitigate the potential for impact on surface water hydrology.

9.7.3 Proposed mitigation measures

Implementation of the proposed mitigation measures would allow for a tiered approach to mitigate potential water quality impacts. The mitigation measures include allowing for design amendments to be made prior to construction, reducing the likelihood of sediment entering waterways using physical control barriers and work method practices and monitoring of water quality during construction to allow for adaptive management if monitoring indicates that water quality is being impacted.

To manage the impacts on waterways, bridges or boardwalks would be constructed over waterways that meet the definition outlined in Section 9.6.1.1. In addition, rock armour would be implemented for crossing over headwater channels and gullies that are not defined as a waterway. The trail network would also include additional bridges and boardwalks over points which are not mapped as waterways, for example, steep gullies or boggy ground, providing an additional level of protection at these points.

Proposed mitigation measures to reduce the likelihood of increased sediment load and downstream turbidity levels include the following:

- Undertake micro-sitting of trail network prior to construction (SWM01)
- Implement the CEMP (SWM02)
- Apply streamside buffer zones (SWM03)
- Avoid use of tracking machines across waterways (SWM04)
- Follow elevated crossing design recommendations (SWM05)
- Water quality monitoring of waterways (SWM06)
- Avoid water quality or hydrological changes to Stonefly habitat (SWM07)
- Design and construction of trail heads to avoid sedimentation impacts to surface water values (SWM08)
- Operation maintenance measures (SWM09).

The Warburton Golf Course trail head is the key site identified for mitigation measures to reduce impacts due to the potential for impacts to surface water quality to the Yarra River resulting from works at this location. As such, specific mitigation measures were developed for this site. Stormwater runoff would have specific sediment treatment requirements in accordance with EPA Publication – Construction techniques for sediment pollution control and EPA Publication 1893 – Erosion, sediment and dust.

Actual waterway crossing points would be determined during the construction phase as conditions on-site at the time of construction would dictate the exact placement of tracks within a 20-metre buffer zone. This would mitigate the potential impacts associated with the construction of tracks over an undefined waterway which later becomes a defined waterway due to the appearance of a spring.

9.7.4 Summary of residual impacts for construction

Due to the nature of the proposed construction methodology, particularly given the limited amount of plant, machinery and workforce required to deliver the project, impacts are considered to be manageable through a combination of design solutions and mitigation measures. Following the implementation of a carefully considered design approach to waterway management and mitigation measures, significant residual impacts (such as impacts to surface water quality and hydrology) due to works associated with construction are not anticipated. The effects of the project would be mitigated by:

- Implementing a design solution that ensures no direct interaction with waterways occurs by installing appropriate waterway crossing solutions across the project using bridges or rock armouring.
- Managing construction activities to minimise any erosion, sedimentation, and impacts to surface water flows and velocities by implementing a project CEMP and application of all relevant legislation, policies and standards.
- A water quality monitoring program would be developed in consultation with Melbourne Water to and implemented throughout the construction phase to ensure the effectiveness of the surface water mitigation measures.
- Ensuring no construction occurs within the Stonefly no-go zones.

Where impacts do occur to surface water quality, hydrology and flow these are anticipated to be localised, for example, in the immediate vicinity of a waterway crossing point and short-term, for example, a number of days in duration.

9.8 Operation impact assessment

For surface water, groundwater and geotechnical hazards, a range of issues associated with project operation were examined, however, none were assessed to have material impacts . Nevertheless, the following issue is of most interest to stakeholders and the community and therefore the assessment of this impact is described in this chapter:

- Increased sedimentation of waterways due to track use

Other matters assessed, but not presented within this chapter are set out in Table 9-4. None of these potential impacts are considered likely to be material when the proposed mitigation measures are implemented. Further information on these impacts can be found in **Technical Report B: Surface Water, Groundwater and Geotechnical Hazards**.

Table 9-4 Other potential impacts assessed

Potential impact	Findings
Surface water	
Changes to surface water hydrology as a result of installation of rock armouring	Appropriate selection of waterway crossing and monitoring of armoured crossings to observe conditions and amend structures if required. All waterway crossings will be designed in accordance with Melbourne Water's *Constructing Waterway Crossings* guidelines. All waterway crossings require a minimum deck height set 0.3 metres above the top of bank.
Water pollution from littering, illegal rubbish dumping and human waste	Adequate rubbish bins would be provided at the main trail head and Wesburn park trail head. Toilet facilities are proposed at trail heads, along with appropriate signage and therefore residual impacts are assessed to be very low.
Bike washing resulting in sediment load entering waterways	Bike washing facilities would be enclosed systems and with regular removal and disposal of sediment as part of maintenance, residual impacts to surface water are assessed to be very low
Use of trails during periods of snow and heavy rainfall	Yarra Ranges Council would proactively monitor trail conditions and close trails under adverse conditions to avoid damage and associated environmental impacts during these periods. Closures may be at a network scale or individual trail level.
Trail operation resulting in impacts to Melbourne Water's Coranderrk Creek drinking water catchments	The potential for trail operation to impact on drinking water with respect to pathogens and sediment was assessed. The anticipated number of cyclists per year using track 1 in the year 2031 is estimated to be 27,500. The final risk may potentially be considered to be between low and medium in the short section of the catchment, but key mitigating factors in place, means that the risk is probably closer to the 'low' rating. Mitigating factors include: proximity to existing toilet facilities (maximum of 1500 m to Mt Donna Buang toilets), large buffer zone to nearest tributary (200 m), relatively small trail distance inside the catchment boundary (458 m), 'track etiquette' signage will be in place, and riders would typically be transiting through the catchment for a relatively short time (estimated to be in the order of 90 seconds per rider) and unlikely to be stopping to rest due to the proximity to the start of the track. Monitoring of Trail 1 within the drinking water catchment boundary will allow for actual rider behaviour to be quantified (to confirm, or otherwise, that riders will typically be quickly transiting through the catchment, rather than stopping) (SWM16).
Groundwater	
Emergence of new springs as a result of mass wasting or landslides or wet weather events creating water logging and/or an erosion hazard	Periodic inspections are proposed of areas of landslide risk to ensure that trail drainage works do not exacerbate soil saturation conditions and to ensure where water-logged conditions occur trail treatments (e.g. armouring) are undertaken. Where springs are exposed due to mass wasting, the spring flow would be treated appropriately and therefore residual impacts are assessed to be very low.
Geotechnical hazards	
Poor trail formation which results in ineffective slope drainage can lead to unfavourable water flows conditions causing	Measures would be implemented as part of the CEMP such as rock armouring to protect areas from erosion and directing drainage water into vegetation. During operation, periodic inspections of the trail following heavy rainfall events would be

Potential impact	Findings
ongoing localised erosion effects and increased saturation of the trail. Long term stability of the slope could be reduced resulting in initiation or reactivation of slope failure.	undertaken to assess the effectiveness of trail drainage and undertake remediation where required. With implementation of these measures, material residual impacts are not anticipated.
Rockfall caused by dislodgement from soil matrix forming the upslope and downslope batters of the track or from exposed rock faces above the trail following heavy rainfall	Rockfall is most likely to occur where the trail is cut into weathered Warburton Granodiorite and Donna Buang Rhyodacite or where trails pass below exposed rock faces. Measures such as the removal of loose boulders from the batter face during construction and a geotechnical inspection of exposed rock faces with a height greater than 1.5 m to assess a need for permanent rockfall protection would be undertaken to ensure long-term stability of the slopes.
Build-up of debris material at waterway bridge crossings leading to failure of the bridge crossings creating a debris flow failure downslope of bridge	Measures would be implemented as part of the CEMP such as designing bridges to have a maximum span length of 3 m to span the majority of small streams encountered. This would ensure that bridge footings would not disrupt the defined waterway channel. Additionally, the periodic inspections of the bridge structure assess for potential build-up of debris, and removal of debris material would be undertaken. With implementation of these measures, material residual impacts are not anticipated.

9.8.1 Increased sedimentation of waterways

The potential for the project to increase sediment load and downstream turbidity levels due to the use of trails was assessed. There are several ways the project may cause increased sedimentation:

- Use of trails during heavy rainfall
- Continued use of trails on damp south-facing slopes during winter (when tracks have not dried out)
- Inadequate on-going maintenance or appropriate protection infrastructure
- Inadequate management of surface water at Warburton Golf Course trail head.

The use of trails during heavy rainfall may lead to some parts of the track crossing water that is not a formally defined waterway and therefore, may not have appropriate crossing infrastructure.

During operation, the Warburton Golf Course trail head erosion/sediment treatment system will require on-going maintenance and management including the disposal of collected sediment to minimise impacts to waterways.

9.8.2 Proposed mitigation measures

Implementation of the recommended mitigation measures will allow for a tiered approach to mitigate potential impacts. Selection of appropriate crossing methods prior to operation, on-going maintenance or upgrades to elevated structure in the future, physical control barriers and ongoing monitoring during operation will be required to minimise impacts. Proposed mitigation measures to reduce the likelihood of increased sediment load and downstream turbidity levels include the following:

- Undertake micro-sitting of trail network prior to construction (SWM01)
- Follow elevated crossing design recommendations (SWM05)
- Water quality monitoring of waterways (SWM06)
- Design and construction of trail heads to avoid sedimentation impacts to surface water values (SWM08)
- Operation maintenance measures (SWM09)
- Gully erosion management and monitoring (SWM13)

Silt traps used near crossings during construction will be kept in place during the initial operational phase of the project to reduce risk of sedimentation of waterways (SWM02). The silt traps would be removed and hence impacts associated with their use is considered to be minimal and short-term. Additionally, proposed gully erosion management and monitoring (SWM13) and water quality monitoring (SWM06) should be appropriate to identify any necessary operational maintenance measures (SWM09).

Further consideration is given to areas of higher risk, that is areas with increased landslide, erosion or bogging susceptibility. Site inspections of higher risk sections of the track network and waterway crossing points after a rainfall event of a magnitude such as > 30 mm in 24 hours will determine if further mitigation work is required. Yarra Ranges Council would proactively monitor trail conditions and close trails under adverse conditions to avoid damage and associated environmental impacts during these periods. Closures may be at a network scale or individual trail level.

The stormwater treatment system at the Warburton Golf Course trail head will be required to meet Melbourne Water standards and those set out in EPA Publication 1893 (SWM08).

9.8.3 Summary of residual impacts for operation

The operation of mountain bike trails in this area is a relatively non-invasive activity with operational impacts considered to be manageable through design considerations and implementation of operational mitigation measures. Following the implementation of a carefully considered design approach to waterway management and mitigation measures, it is not anticipated that significant impacts (such as the impacts associated with the increased sedimentation of waterways) would occur. The effects of the project would be mitigated by:

- Ensuring waterway crossings are designed appropriately to respond to the context of each waterway. This includes the design and construction of bridges, boardwalks and rock armouring.
- Avoiding and minimising sedimentation impacts to surface water values through the design of the trail heads
- Implementing an ongoing water quality monitoring program (designed in consultation with Melbourne Water)
- Implementing ongoing erosion and flow monitoring

Following implementation of mitigation measures, residual impacts to surface water due to operational activities including the use of trails and trail heads are not anticipated. Where there are impacts to surface water quality, these would be localised (for example, within the vicinity of a waterway crossing point) and short-term (for example, days in duration).

9.9 Assessment of alternative to Trail 1

During the project development process, consideration was given to feasible trail alternatives for key trails where there is potential for significant environmental impact. Through a screening process that focussed on ecological, heritage and socioeconomic factors, the need to investigate alternative trail alignments was identified in order to ensure a network design that minimises the potential for significant environmental impact.

Trail 1 is approximately 23 kilometres in length and traverse the Yarra Ranges National Park from the summit of Mount Donna Buang travelling in a westerly direction through forested land alongside Road 2 before meandering generally south east through forested land towards the Warburton township, also intersecting Woiwurrung State Forest. The alternative to Trail 1 is a combination of Trails 45, 46 and 47. Trails 45 and 46 are within the Yarra Ranges National Park and commence at the summit of Mount Donna Buang, following a south easterly direction through forested land towards the Warburton township before tying into Trails 5 and 6. Trail 47, also within the Yarra Ranges National Park commences at Mount Donna Buang Road and travels east within the National Park to tie into Trail 8. The trails are respectively of length four kilometres (Trail 45), 5.5 kilometres (Trail 46) and 5.6 kilometres (Trail 47). Trail 1 and the alternative to Trail 1 are shown in Figure 9-1. The assessment and comparison of Trail 1 and the alternative to Trail 1 is based on the assessment described in **Technical Report B: Surface Water, Groundwater and Geotechnical Hazards**.

A comparison between Trail 1 and the alternative to Trail 1 found that waterways which are present in the vicinity of both alignments are located in similar environments. That is, both options are located in forested catchments under existing conditions. The main difference between the two alignments is that Trail 1 traverses a lower number of waterways (157 compared to 166) with slightly fewer crossings located on National Park land. With regards to a groundwater and geotechnical perspective, both alignments are located mostly on the same geology with similar water table depths anticipated. The comparison also did not identify any new impacts from the implementation of the alternative trail that had not already been considered for Trail 1.

The comparison is based on the residual impact of these options assuming effective implementation of the proposed mitigation and contingency measures described in the construction and operation impact assessment sections.

Overall, it was found that for both construction and operation, Trail 1 and the alternative would have similar residual impacts. The implementation of the mitigation (which includes using bridges or boardwalks will be constructed over identified waterways and rock armour to be implemented for crossing over headwater channels and gullies that are not identified as a waterway) are expected to the residual impacts are anticipated to be comparable.

9.10 Summary of mitigation and contingency measures

Table 9-5 summarises the mitigation measures developed to avoid and minimise the surface water, groundwater and geotechnical hazards impacts within the project area which are described in the construction and operation impact assessment sections above. Monitoring and contingency measures form part of the mitigation measures described below.

Table 9-5 Mitigation and contingency measures

Mitigation measure number	Project phase	Mitigation and contingency measures
Surface water		
SWM01	Design and construction	**Undertake micro-siting prior to construction** **Objective**: Appropriate selection of waterway crossing method to protect downstream values: • Avoid crossing if practical • Install an elevated structure (i.e. bridge or boardwalk) where *Water Act* definition of a waterway is met (defined bed and banks and/or natural channel fed by spring or absorbent soil). • Install rock armouring when gully is present but no other indication of waterway as per *Water Act* definition, or if there is signs of wet/unstable soil or changes to vegetation that signal higher water concentration that is likely to impact trail surface stability Review all crossing points identified by the Surface Water Impact Assessment which do not have a crossing type assigned. As required in sensitive areas, as per the CEMP, relevant appropriately qualified technical specialist staff would be used on site to undertake micro-siting. The existing conditions of the waterway at the crossing point would be fully documented as per *Water Act* definition. Geo-referenced photographs taken of crossings that intersect the VicHydro waterway layer (where no evidence of a waterway is observed at the crossing point). Melbourne Water can attend regular site inspections before, during and after construction to confirm that all waterways have been appropriately identified. Where multiple crossings are located within a small area, there may be risk of greater disturbance than for a single crossing – care must be taken to ensure the solution minimises the cumulative effects.
SWM02	Construction	**Implement the CEMP** **Objective:** To minimise erosion and sedimentation impacts to waterways Follow the EPA publications: • EPA publication 1894 Managing soil disturbance • EPA publication 1895 Managing stockpiles • EPA publication 1896 Working within or adjacent to waterways • EPA publication 1897 Managing truck and other vehicle movement Soil and Sediment Management: • Identify suitable locations for material stockpiles (if required prior to construction and ensure appropriate sediment controls are in place prior to stockpiling. • Stockpiles will be located away from waterways and protected from prevailing wind where necessary to prevent wind-blown particles from increasing sedimentation of waterways.

Mitigation measure number	Project phase	Mitigation and contingency measures

		• Plan construction works to provide for the progressive and timely stabilisation and rehabilitation of disturbed areas as required
		• Balanced cut and fill construction is to be used wherever possible. No spoil is to be spread down slope, minimising damage to adjacent vegetation below the trail.
		• Where the trail runs alongside a waterway, excavated spoil material would not be placed such that it enters the waterway or impedes natural drainage.
		• No borrow pits to be established within 50 m of a waterway or any areas of significant vegetation.
		• Rock armouring shall be used on the entry and exit to any low-level bridges or boardwalks and on some steep sections of trail chutes and may be used on sections of boggy ground.
		• Topsoil would be retained in stockpiles on any cleared areas not required for construction of the trail tread or batter slopes. Materials would be reused on the site where possible.
		• In areas of high erodibility soils cut batters must be near vertical, and where possible retained by logs or rock facing. Site by site assessment on the requirement for retaining walls would be required. Batters would be stabilised appropriately to reduce potential slippage and erosion. Appropriate silt control mechanisms would be applied where necessary to control and minimize scour and silt movement.
		• Cut batters to be less than 2 m in vertical height.
		• Upon achieving practical completion of a trail, the trail is to remain closed for a period of 4-12 weeks (depending on weather, time of year and other variables) to allow for 'curing' of the trail surface. All sediment control measures (i.e. silt fences) to remain in place during this curing period.
		• Silt fences to be installed on all grade reversal outlets within 50 m of a waterway where access allows.
		• All trails to be consistent with International Mountain Bicycling Association trail construction guidelines, especially:
		  ○ Use the 'half rule' to guide track alignment: A track's grade should never exceed half the grade of the sidehill it is located on. Grade is the elevation gained divided by the distance of the segment of the track (expressed as a percentage). A track across a side slope of 20% should not exceed 10%.
		  ○ Follow the 'ten per cent average' guideline for sustainable grade: The average track grade is the slope of the track for an entire uphill section. Generally, an average grade of 10% or less is most sustainable.
		  ○ Maximum sustainable grade: typically, the maximum sustainable track grade is about 15% for a short distance, but it is site-specific and varies with track alignment, use of the half rule, soil type, annual rainfall, vegetation, use of grade reversals, type of users, number of users and level of difficulty.
		  ○ Grade reversals: most tracks benefit from grade reversals every 6–16 metres. A grade reversal is a spot at which a track drops subtly and rises again, which forces water to drain off the track.
		  ○ Outslope: most tracks should be built with a 5% outslope. An outslope is a tilt on the downhill or outer edge of the track, which encourages water to sheet across and off the track in a gentle manner instead of funnelling down the track's centre.
		• Maintain all erosion and sediment controls in effective working order as required throughout the construction period.
		• Vehicle entry and exits would be via designated areas only.
		• Identify all designated 'no go zones' on the plans.
		• Construction activities creating any soil disturbance to cease during extreme rainfall events (i.e. greater than 25 mm in 24 hours).

Mitigation measure number	Project phase	Mitigation and contingency measures
		(continued below)

- Materials stockpiled on-site would be stored in a designated storage location, with silt fencing on down slope areas where the stockpiles are within 30 m of a waterway.
- Coir logs or silt fences would be maintained on slopes below bare soil areas at drainage flow path outlets, where it is within 30 m of a waterway.
- Ensure all temporary erosion and sediment controls are removed and relevant rehabilitation undertaken at the completion of works or when sufficient ground cover for stabilisation is achieved.

Waterway Crossings

- Where waterway crossing is required, identify the narrowest practicable location.
- Low level bridges must be designed to cope with peak flows for the catchment they are located in and must not impede flow in any way.
- Low level bridges must be Building Code of Australia (BCA) compliant.
- Approaches to waterway crossings would as much as possible be at right angles to the waterway and minimise the length of track within the immediate riparian zone.
- Rock armouring should be used as appropriate on either side of ridge/boardwalks to prevent soil being carried onto the bridge/boardwalk.
- Works near waterways would be scheduled appropriately. For example, works would be timed to coincide with periods of low flow and completed quickly. Works would be stopped if conditions are not suitable, such as during and after heavy rain.
- Any removal of fallen timber within the waterway must be to the minimum extent necessary and any material removed must be retained on-site, downstream from the crossing point.

Drainage

- If areas of high erodible soils are found in trail surface, the area must be armoured with rock, gravel or low erodibility soils.
- Drainage must be installed on approaches to waterway crossings so that where possible a 30 m buffer of vegetation is achieved to act as a filter strip.
- All drainage must direct water onto vegetation and not exposed fill material.
- Unless the trail tread is out-sloped (i.e. it drains to the lower side of the track) and no table drain is required on the upper side, cross drains/water bars/grade reversals must be installed at no greater distance apart than shown below:

1-5%	70 m
6-10%	40 m
11-20%	30 m
>20%	20 m

Monitoring of trails under active construction:

- Daily visual inspections of works site and all erosion and sediment control devices.
- Inspection of all erosion and sediment control devices following significant rainfall events.

Corrective actions to control erosion:

- Repair/maintain existing drainage, erosion and sediment control devices.
- Clean up or rehabilitate any impacts and exposed areas.
- Install additional erosion and sediment control devices where issues have been identified.
- Consider the deployment of alternative erosion and sediment control devices where issues have been identified with the existing devices.

Mitigation measure number	Project phase	Mitigation and contingency measures
		• Ensure all personnel involved in the deployment and maintenance of erosion and sediment control measures are appropriately trained in their use and deployment. • Communicate changes with all relevant staff. Drinking Water Catchments • Ensure adequate portable toilets are available to construction crews, particularly in drinking water catchments, and that these toilets are maintained appropriately • Daily pre-start risk assessment and education of construction crew about works in a drinking water catchment.
SWM03	Design	**Streamside buffers** **Objective**: To provide adequate buffer to minimise sedimentation of waterways • Apply a 20 m streamside buffer to minor waterways running parallel to track (<60 ha catchment) • Apply a 30 m streamside buffer for larger waterways running parallel to track (>60 ha catchment)
SWM04	Construction	**Use of tracking machines** **Objective**: Avoid direct and downstream impacts to waterways during construction • Follow EPA publication 1897 Managing truck and other vehicle movement • Works would be scheduled to avoid tracking machines through waterways which contain water at all times. • Temporary bridges would be used during construction to traverse waterways, so that there is no need to take the machines through the waterway itself.
SWM05	Construction	**Elevated crossing design** **Objective**: Appropriate crossing design to protect downstream values • A 'Works on Waterways Permit' / 'Consent for Minor Waterway Work' would be obtained from Melbourne Water as appropriate. • The minimum deck height of crossings would be set above the top of bank by at least 0.3 m. The final deck heights at each location would be determined based on hydraulic assessment and design in accordance with the stated SWM02 mitigation measures. • The typical elevation indicates minimum raising of the profile at either side of the channel and encroachment within the channel of supports and rock retaining wall. Bridge abutments would be positioned beyond the channel shoulder and there would be no restriction in channel cross section. • If required by Melbourne Water, rock work protection is to extend underneath, upstream and downstream of the bridge to protect the waterway. Protection upstream and downstream would be proportionate to scale of impact. Minimum 0.5 m either side of deck profile. • Drawings would consider Melbourne Water crossing guidelines and specify rock beaching and erosion protection requirements on the crossing drawings. Minimum rock sizes would be determined based on hydraulic flow conditions and shear forces expected to be encountered at these sites.
SWM06	Construction and operation	**Water quality monitoring of waterways** **Objective**: To monitor effectiveness of mitigation measures A waterway monitoring program would be developed in consultation with Melbourne Water. The key potential stressor to waterways for the project is sedimentation and therefore turbidity is the key metric of interest. In addition, monitoring of macroinvertebrates would provide evidence of any longer-term project effects. Subject to consultation outcomes with Melbourne Water, the monitoring program would have the following key features: • Monitoring scopes in alignment with the ANZG (2018) guidelines for water quality monitoring (covering such aspects as spatial extent, parameter selection, scale, duration, frequency, cost effectiveness of the monitoring program)

Mitigation measure number	Project phase	Mitigation and contingency measures
		● Macroinvertebrate monitoring in selected waterways to provide evidence of any longer-term effects. The monitoring program would cover the construction and operations phases of the project, and be 'adaptive' – i.e. be responsive to the results to optimise the monitoring effort. During construction and operation, the following principal activities would be undertaken, subject to consultation with Melbourne Water. Specific details of surface water monitoring would be incorporated into the CEMP and OEMP. Construction: Twice daily monitoring would be undertaken upstream and downstream of waterway crossing construction where water is present at the time of construction. This monitoring would include visual observation and measurements using a handheld turbidity meter. Observations and measurements would be recorded. Should monitoring indicate that corrective or remedial actions are required at a construction site, actions would be undertaken by the construction crew or Yarra Ranges Council (e.g., installation of hay bales, coir logs or star pickets to minimise sediment movement). The corrective actions would be recorded, including the location of the actions taken. Macroinvertebrate monitoring would be undertaken in accordance with EPA Publication 604.2 Guideline for Environmental Management: Rapid bioassessment methodology for rivers and streams prior to and during the construction phase (and then in the early stages of the operations phase). The monitoring event prior to construction commencement would establish background conditions. Monitoring would be undertaken at sites in the Yarra River upstream and downstream of tributaries which may be impacted by the project and in selected tributaries which have the highest risk of impact (tributaries with a high number of crossings: Britannia, Four Mile and Scotchmans Creeks). Operation: Periodic monitoring of turbidity would be undertaken in the Yarra River and tributaries with a high number of crossings: Britannia, Four Mile and Scotchmans Creeks) using a turbidity meter, to identify any increases in turbidity. Monitoring would commence prior to operation. Macroinvertebrate monitoring would be undertaken in accordance with EPA Publication 604.2 Guideline for Environmental Management: Rapid bioassessment methodology for rivers and streams in the early stages of the operations phase, as outlined in the construction section above. Where monitoring detects impacts due to the project, contingency measures would be implemented such as remedial actions listed in EPA publication 1834 Civil construction, building and demolition guide. Modifications to waterway crossing structures would also be considered where appropriate. Any corrective actions taken would be recorded including the location of actions taken.
SWM07	Construction and operation	**Adhere to Stonefly no-go zones** **Objective**: To avoid water quality or hydrological changes to Stonefly habitat ● No track to be placed in the identified stonefly no-go zones ● Establish no-go zones in the vicinity of Sites WP1 and WP2 (as identified by Tsyrlin, 2019) ● Decrease the sediment generated from Donna Buang Rd, especially near sites WP1 and WP2 (the location of these sites is described in Tsyrlin (2019)) by installing sediment traps and other appropriate measures.
SWM08	Construction	**Design and construction of trail heads** **Objective**: To avoid sedimentation impacts to surface water values Follow EPA publication 1834 and 1893 (particularly for trail head at golf course) to reduce erosion risk to Yarra River.
SWM09	Operation	**Operational maintenance measures** **Objective**: To monitor effectiveness of mitigation measures Inspection of the trails would be undertaken for the identification of new spring activity or other changes to catchment in which a channel becomes a 'waterway'.

Mitigation measure number	Project phase	Mitigation and contingency measures
		Where identified, trail treatments, e.g. armouring or an elevated structure, may be required to control erosion. ● Undertake a site inspection of all water crossings and high-risk sections of track after a rainfall event (e.g. >25 mm in 24 hours). ● Implement measures to rectify if crossings become erosion risk after heavy rainfall. ● A crossing agreement would be required to be entered into with Melbourne Water, outlining ongoing ownership and maintenance responsibilities. ● If a spring is detected: - Document the spring activity and location (following GWM01, which also covers the identification of springs and establishes appropriate treatments to protect groundwater and the down-gradient discharging environment) - Review the trail design in this localised area and consider opportunities for micro-siting (SWM01) - Implement the CEMP and requirements stipulated in SWM02 - Implement a trail control to ensure that spring flow is not dammed, and that downstream water quality and erosion hazards are minimised. This would require the installation of drained berms, rock armouring, or in extreme cases of high flow, bridging structures. - Confirm the acceptability of the control through monitoring / inspection during operation, as per SWM09 and GWM01. Although springs can occur any time, there is likely to be a correlation with recent rainfall. Inspections for springs would occur after rainfall events (trigger to inspect 3 -7 days after > 10 mm rainfall in 24 hours). Undertake this four times per year and adapt the monitoring program and adjust the frequency once sufficient data is gathered with regards to spring activity. Record the inspection in a form or by another measure and also list corrective actions to be undertaken as a result of the monitoring and act on those.
SWM10	Construction and operation	**Spill management** **Objective**: Minimise the likelihood and impact of a spillage and establishing controls to contain and clean-up Follow EPA publication 1698 Liquid storage and handling guidelines. Implement the CEMP to prevent and manage chemical spills and leaks: ● Australian Standard AS 1940- Storage and handling of flammable and combustible liquids to be adhered to. ● All storage and transport of chemicals will be undertaken in accordance with the relevant Australian standards. ● Current safety data sheets (SDS) will be kept on-site wherever hazardous materials are being stored. ● A register of all chemicals and SDS for these chemicals will be held on-site. ● Spill kits would be present on-site during these works. ● All personnel would be trained in spill response procedures and in the use of spill kits. ● If a spill occurs works would stop immediately, and emergency procedures enacted if required. ● All regulated and hazardous waste would be stored in a bunded area as far as practical from the waterways. ● The quantity of materials being stored on-site would be minimised. ● Machinery would be used and serviced as per manufacturer's instructions. ● Vehicles would not be washed down on-site. ● Plant shall not undergo maintenance or cleaning where contaminants could be released to any waters. ● Machinery would be refuelled at locations where the risk of environmental harm in the event of a spill is minimised, as specified in the refuelling protocol. ● Refuelling of machinery shall conform with the following:

Mitigation measure number	Project phase	Mitigation and contingency measures
		- Occur away from waterways (at least 10 metres) - Fuelling activity to be supervised at all times ● Machinery shall be maintained to minimise the leakage of oil, fuel, hydraulic and other fluids. During the servicing of machinery, the Contractor shall use management measures to capture and contain oils, fuels, hydraulic and other fluids so as to minimise contamination of the servicing area. ● Surface coating treatments would be undertaken in a manner that avoids or minimises release of chemicals to the environment and contact with the public. Unless otherwise stated in the contract, no pre-coating of aggregates shall be conducted on-site. ● Toilet facilities utilised would be the existing park facilities. An additional port-a-loo facility would be maintained and used on-site, with the amenity maintained, transported and used on-site in accordance with manufacturers' and suppliers' specifications. ● All waste material would be removed from the site before removing any erosion and sediment control measures. ● All hazardous materials would be removed from site and disposed of appropriately.
SWM11	Construction	**Design of septic systems** **Objective**: Minimise the likelihood and impact of elevated nutrient and pathogen loading to surface water Septic systems must be designed consistent with Yarra Ranges Council / land manager codes.
SWM12	Operation	**Operation of trail heads** **Objective**: Minimise the likelihood and impact of human waste, littering and illegal rubbish dumping impacting surface water Ensure trailhead facilities have adequate toilets that cater for the expected number of users. Bins would be provided at Wesburn park and the main trail head. Facilities must be appropriately maintained and cleaned. Signage or 'track etiquette' rules may be appropriate. The OEMP will include procedures and additional details for the inspection and maintenance of the trail network including the trail heads. Compliance will be independently audited and verified using the OEMP's environmental management framework.
SWM13	Operation	**Gully erosion management and monitoring** **Objective**: To monitor effectiveness of mitigation measures Follow EPA publication 1894 Managing soil disturbance Erosion monitoring: Photo-point monitoring of selected gully crossing points to identify gully erosion. Flow monitoring: Place field cameras or appropriate flow monitoring equipment at selected gully crossing points (i.e. three or four of the most used or highest risk sites) to identify rainfall events which will cause water to flow in gullies or rock armouring to be overtopped. Sediment and debris observations will be made at other gully crossings during post rainfall assessments. Adaptive management can then allow for a decision to temporarily close tracks based on forecast rainfall events, if required. Undertaken periodical inspection of trails to assess condition and need for maintenance or additional trail treatments, particularly after severe weather events. Mitigation selection may depend upon the size of the affected area. Inspections of trail conditions for waterways with the highest number of crossings would be undertaken in parallel with the spring monitoring activities listed above (i.e. an all encompassing track inspection regime, to check for track condition, spring emergence, soil erosion, bogginess, litter, vandalism etc). As per the spring monitoring, it is likely best undertaken after rainfall (e.g. 1 -7 days after > 10 mm rainfall in 24 hours) at a minimum 4 times per year, but adapt the frequency of the monitoring program once data has been gathered to make

Mitigation measure number	Project phase	Mitigation and contingency measures
		informed changes. Record the condition in a form or report, list the corrective actions and then act on them. Reviews of photo-point flow monitoring data would be completed under the same frequency, with emphasis placed on assessment of flow conditions during and following rainfall events (>10 mm in 24 hours). The key metric for monitoring would be to select the waterways with the highest number of crossings and then to locate a single monitoring point for that waterway below the lowest crossing in its sub-catchment. The waterways with the highest number of crossings are: Four Mile Creek (37 crossings), Scotchmans Creek (30 crossings) and Britannia Creek (20 crossings) and Yankee Jim Creek (12 crossings). The crossings with the highest anticipated usage would be included in the monitoring program. Initially these are assumed to be located nearest to the trail heads, but this may be adapted if trail usage data shows other tracks being more frequently used.
SWM14	Operation	**Bike wash system** **Objective**: Minimise the likelihood and impact of grey water impacting surface water Ensure the bike wash system and water recycling unit is functioning as designed. Plan required for removal and reuse of trapped sediment. The OEMP will include procedures and additional details for the inspection and maintenance of the trail network including the operation of bike wash systems. Compliance will be independently audited and verified using the OEMP's environmental management framework.
SWM15	Operation	**Track closure during periods of snow or high rainfall** **Objective:** Minimise impacts of erosion and turbidity during periods of snow or high rainfall Yarra Ranges Council would proactively monitor trail conditions and close trails under adverse conditions to avoid damage and associated environmental impacts during these periods. Closures could be at a network scale or individual trail level. These decisions would be made by Yarra Ranges Council based on: ● A trigger of 25 mm of rain in the preceding 24 hours for a network closure, or ● Observations of staff indicating sustained wet/snow conditions likely to impact trails (could be individual trails, areas, or complete network) Trail closures would be communicated to mountain bikers by: ● Active social media and electronic communications ● Signage at trail heads and strategic locations around the network ● Signage at start of trail for individual trail closures
SWM16	Operation	**Monitoring of rider usage** **Objective:** To monitor rider behaviour within drinking water catchment Yarra Ranges Council would monitor rider behaviour along the section of trail network within the Coranderrk Creek catchment (for off trail activities and toileting) to verify absence of significant risk to drinking water quality.
Groundwater		
GWM01	Construction and operation	**Objective**: Identify springs and establish appropriate treatments to protect groundwater and down-gradient discharging environment. Spring mapping would be undertaken prior to construction. Evidence of spring activity, location, quantification of flow and quality (if possible), photographic record etc, to establish a baseline in spring activity. Daily inspection of the trails and current work area would be undertaken during construction for the identification of new spring activity, which may have resulted from bench excavations that exposed new spring eyes, or springs that weren't flowing due to prevailing climate conditions. Where identified the springs need to

Mitigation measure number	Project phase	Mitigation and contingency measures
		be documented and characterised. Periodical inspections during the operation phase are required to assess for the presence of new springs and seeps. Where identified, trail micro-siting, or trail treatments, e.g. armouring, may be required to control erosion. Treatments documented in CEMP and SWM01, SWM02 and SWM09. Where a new spring has emerged as a result of the excavations, or unexpectedly through climate variation, an assessment would be made regarding: ● Potential treatments to control sedimentation and erosion ● Impact to behaviour of nearby springs, and need for treatment, e.g. diversion of discharge to the same area. When treated, inspection and maintenance are undertaken during the remainder of the construction phase, and periodically during the operation phase to assess effectiveness of the treatment. Although springs can occur any time, there is likely to be a correlation with recent rainfall. Inspections for springs would occur after rainfall events (trigger to inspect 3-7 days after > 10 mm rainfall in 24 hours). Inspections would also be undertaken at a minimum of 4 times per year and the frequency of inspection would be adjusted once sufficient data is gathered with regards to spring activity. Record the inspection in a form or by another measure and also list corrective actions to be undertaken as a result of the monitoring and act on those.
GWM02	Construction	**Objective**: Minimise the likelihood and impact of a spillage and establish controls to contain and clean-up. Implement a Construction Environmental Management Plan to manage risks associated with storage and handling of hazardous substances and spill / control / clean-up measures. As per SWM10.
GWM03	Construction	**Objective**: Minimise the likelihood and impact of elevated nutrient and pathogen loading to groundwater. New septic facilities would be sited and designed consistent with Yarra Ranges Council / land manager codes and SWM11.
GWM04	Construction	**Objective: To identify (and manage) contamination prior to its disturbance by construction.** A Phase 1 Environmental Site Assessment would be undertaken for those areas where a potentially contaminating land use (existing or historical) has been identified, and where structures require excavations greater than 2 m below the surface. In the unlikely event that the Phase 1 Environmental Site Assessment identifies that the project will intersect with potentially contaminating materials, a Phase 2 Detailed Site Investigation would be undertaken to manage any contaminated materials.
Geotechnical hazards		
GTM01	Construction	**Objective**: Reduce and manage the occurrence of slope instability during excavation works for trail construction. ● Plan construction works to provide for the progressive and timely stabilisation and rehabilitation of disturbed areas as required. ● Rock armouring shall be used on some steep sections of trails. ● Site by site assessment on the requirement for retaining walls would be required. Batters would be stabilised appropriately to reduce potential slippage and erosion. ● Cut batters to be less than 2 m in vertical height. ● Construction activities creating any soil disturbance to cease during extreme rainfall events. ● Works near waterways would be scheduled appropriately. For example, works would be timed to coincide with periods of low flow and completed quickly. Works would be stopped if conditions are not suitable, such as during and after heavy rain.

Mitigation measure number	Project phase	Mitigation and contingency measures
		● Avoid excessive excavation when working near waterways or gully systems. ● Inspection of completed sections of the trail would be undertaken following heavy rainfall events to observe potential slope failures of newly formed batters. If a large-scale failure has occurred which has resulted in significant damage to the trail and natural landform, an inspection would be undertaken by a geotechnical specialist to assess the risk and remediation measures.
GTM02	Construction	**Objective**: Reduce and manage the occurrence of unstable soil and erosion caused by vegetation removal. ● Vegetation removal would be limited to what is required within the construction corridor ● The trail route would be designed to avoid large trees so that removal is not necessary. Where unstable, soft soil is exposed through vegetation removal, rock armouring can be used to promote stability and limit erosion.
GTM03	Construction	**Objective**: Reduce and manage this risk of poor trail formation resulting in ineffective drainage leading to instability and erosion ● Ensure trail tread is compact ● Use rock armouring to protect areas of the trail subject to erosion ● Use of raised embankments to promote effective drainage where the trail is flat ● Preferred method of drainage from the trail is grade reversal and out sloping trail head but culverts and water bars may be used from time to time ● All drainage must direct water onto vegetation and not exposed fill material ● Trail design and construction is to minimise any changes to surface water flows Periodic inspections of the trail following heavy rainfall events to assess the effectiveness of the trail drainage and observe areas subject to erosion or unfavourable water flow downslope of the trail. Remediation to prevent further impact would be required.
GTM04	Construction and operation	**Objective**: Reduce and manage the risk of rockfalls below or above the trails ● Removal of loose boulders from the batter face during construction. These can be used as rock armouring at the base of the batter slope; ● Loose material would be removed from any expose rock faces adjacent to the trail during construction ● A geotechnical inspection of exposed rock faces with a height >2 m to assess the need for permanent rockfall protection such as rockfall mesh; Ensure that boulders placed on the out slope as part of the construction process are secure and not likely to roll down the slope.
GTM05	Operation	**Objective:** Manage the build-up of debris material at the location of bridge structures to reduce the risk of debris flows • Periodical inspections of the bridge structure, particularly following heavy rainfall events to assess potential build-up of debris material • Removal of debris material from bridge structure. Where possible, debris material would be placed downstream from the bridge structure.

9.11 Conclusion

The assessment has shown that the construction and operation phases of the project can be managed such that the objective of minimising potential adverse impacts to surface water, groundwater and geotechnical hazards at local and regional scales can be achieved.

During construction, impacts are anticipated to surface water quality (from sedimentation and erosion) and surface water hydrology (through clearance of vegetation and compaction of trails). In the first instance, these impacts would be avoided by designing the project in such a way to avoid these impacts through the introduction of elevated water crossing design solutions. This includes bridges or boardwalks to be constructed over identified waterways and rock armour will be implemented for crossing over headwater channels and gullies that are not identified as a waterway. The trail network also includes additional bridges and boardwalks over points which are not mapped as waterways, for example, steep gullies or boggy ground, providing an additional level of protection at these points. To further avoid and minimise these impacts, construction mitigation measures would be implemented including a CEMP and regular monitoring programs for water quality and hydrology.

Operational impacts were assessed, the most material of which was an increase in sedimentation impacting waterways due to the use of the trails. The findings of the assessment concluded that through the application of design solutions to avoid and minimise sedimentation entering waterways and the implementation of water quality, erosion and flow monitoring programs would result in minimal residual impacts which would be localised and short term. Impacts to groundwater and geotechnical hazards during construction and operation were not considered extensive or material.

Additionally, Trail 1 is situated within the Coranderrk Creek catchment boundary for approximately 458 metres. It is anticipated that with mitigating factors including adequate provision of proper toilet facilities, buffer zones to the nearest tributary (200 m) and education during construction and operation, the impact to drinking water supply would be overall low.

Following implementation of mitigation measures outlined in Section 9.10, residual impacts to surface water due to construction and operational activities are not anticipated to be significant. Where there are impacts to surface water quality and hydrology, these would be localised (for example, within the vicinity of a waterway crossing point) and short-term (for example, days in duration). Nevertheless, it is proposed to undertake monitoring during project construction and operation to detect any unforeseen impacts.

In response to the EES evaluation objective described at the beginning of this chapter, impacts of the project on surface water, groundwater and geotechnical hazards have been assessed and mitigation measures have been identified to avoid and minimise adverse impacts.