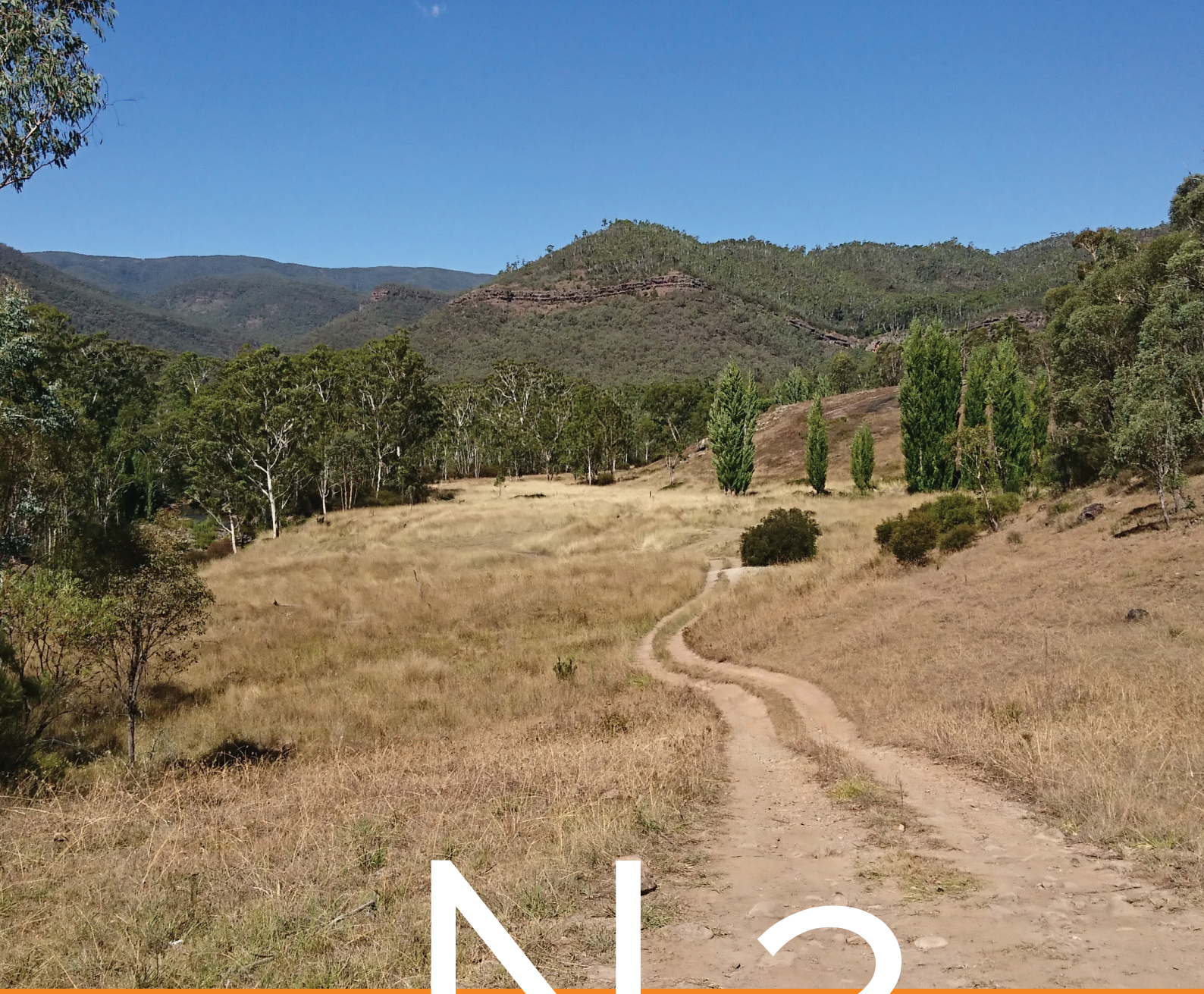


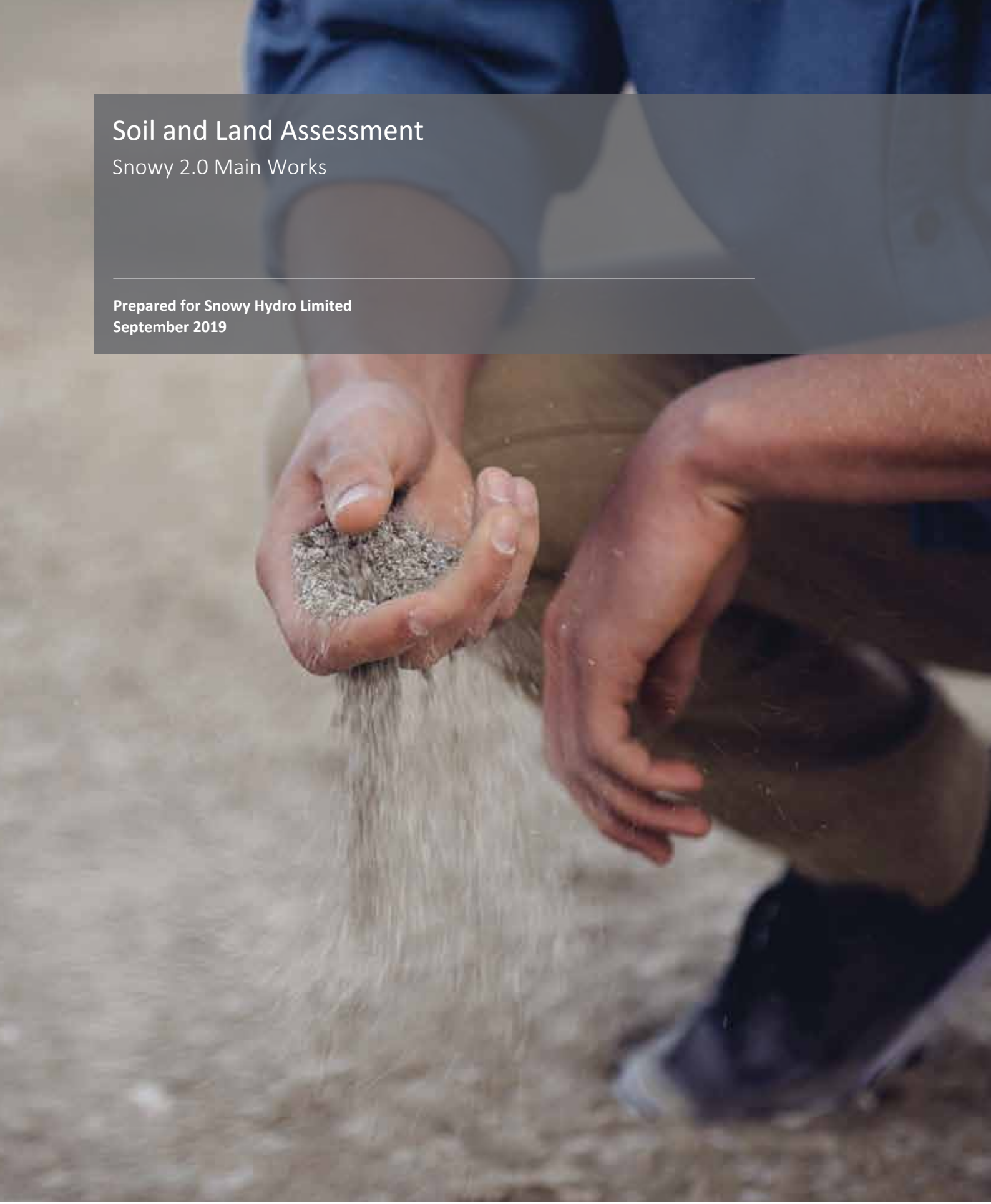
APPENDIX N.2

SOILS AND LAND ASSESSMENT

Soil and Land Assessment

Snowy 2.0 Main Works

Prepared for Snowy Hydro Limited
September 2019



EMM
creating opportunities

Soil and Land Assessment

Snowy 2.0 Main Works

Prepared for Snowy Hydro Limited
September 2019

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Soil and Land Assessment

Snowy 2.0 Main Works

Report Number

J17188 RP#95

Client

Snowy Hydro Limited

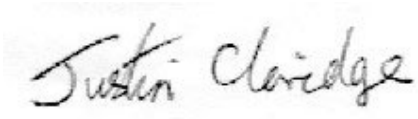
Date

13 September 2019

Version

v1 Draft

Prepared by



Justin Claridge
Principal Soil Scientist
13 September 2019

Approved by

Allan Reid
Associate Environmental Planner
13 September 2019

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1 Introduction

1.1 The project

Snowy Hydro Limited (Snowy Hydro) proposes to develop Snowy 2.0, a large-scale pumped hydro-electric storage and generation project which would increase hydro-electric capacity within the existing Snowy Mountains Hydro-electric Scheme (Snowy Scheme). Snowy 2.0 is the largest committed renewable energy project in Australia and is critical to underpinning system security and reliability as Australia transitions to a decarbonised economy. Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and a new hydro-electric power station will be built underground.

Snowy 2.0 has been declared to be State significant infrastructure (SSI) and critical State significant infrastructure (CSSI) by the former NSW Minister for Planning under Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and is defined as CSSI in clause 9 of Schedule 5 of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP). CSSI is infrastructure that is deemed by the NSW Minister to be essential for the State for economic, environmental or social reasons. An application for CSSI must be accompanied by an environmental impact statement (EIS).

Separate applications are being submitted by Snowy Hydro for different stages of Snowy 2.0 under Part 5, Division 5.2 of the EP&A Act. This includes the preceding first stage of Snowy 2.0, Exploratory Works for Snowy 2.0 (the Exploratory Works) and the stage subject of this current application, Snowy 2.0 Main Works (the Main Works). In addition, an application under Part 5, Division 5.2 of the EP&A Act is also being submitted by Snowy Hydro for a segment factory that will make tunnel segments for both the Exploratory Works and Main Works stages of Snowy 2.0.

The first stage of Snowy 2.0, the Exploratory Works, includes an exploratory tunnel and portal and other exploratory and construction activities primarily in the Lobs Hole area of the Kosciuszko National Park (KNP). The Exploratory Works were approved by the former NSW Minister for Planning on 7 February 2019 as a separate project application to DPIE (SSI 9208).

This Soil and Land Assessment has been prepared to accompany an application and supporting EIS for the **Snowy 2.0 Main Works**. As the title suggests, this stage of the project covers the major construction elements of Snowy 2.0, including permanent infrastructure (such as the underground power station, power waterways, access tunnels, chambers and shafts), temporary construction infrastructure (such as construction adits, construction compounds and accommodation), management and storage of excavated rock material and establishing supporting infrastructure (such as road upgrades and extensions, water and sewage treatment infrastructure, and the provision of construction power). Snowy 2.0 Main Works also includes the operation of Snowy 2.0.

Snowy 2.0 Main Works is shown in Figure 2.1. If approved, the Snowy 2.0 Main Works would commence before completion of Exploratory Works.

The Snowy 2.0 Main Works do not include the transmission works proposed by TransGrid (TransGrid 2018) that provide connection between the cableyard and the NEM. These transmission works will provide the ability for Snowy 2.0 (and other generators) to efficiently and reliably transmit additional renewable energy to major load centres during periods of peak demand, as well as enable a supply of renewable energy to pump water from Talbingo Reservoir to Tantangara Reservoir during periods of low demand. While the upgrade works to the wider transmission network and connection between the cableyard and the network form part of the CSSI declaration for Snowy 2.0 and Transmission Project, they do not form part of this application and will be subject to separate application and approval processes, managed by TransGrid. This project is known as the HumeLink and is part of AEMO's Integrated System Plan.

With respect to the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), on 30 October 2018 Snowy Hydro referred the Snowy 2.0 Main Works to the Commonwealth Department of the Environment and Energy (DEE) and, on a precautionary basis, nominated that Snowy 2.0 Main Works has potential to have a significant impact on MNES and the environment generally.

On 5 December 2018, Snowy 2.0 Main Works were deemed a controlled action by the Assistant Secretary of the DEE. It was also determined that potential impacts of the project will be assessed by accredited assessment under Part 5, Division 5.2 of the EP&A Act. This accredited process will enable the NSW Department of Planning, Industry and Environment (DPIE) to manage the assessment of Snowy 2.0 Main Works, including the issuing of the assessment requirements for the EIS. Once the assessment has been completed, the Commonwealth Minister for the Environment will make a determination under the EPBC Act.

1.2 Project location

Snowy 2.0 Main Works are within the Australian Alps, in southern NSW, about mid-way between Canberra and Albury. Snowy 2.0 Main Works is within both the Snowy Valleys and Snowy Monaro Regional local government areas (LGAs).

The nearest large towns to Snowy 2.0 Main Works are Cooma and Tumut. Cooma is located about 50 kilometres (km) south east of the project area (or 70 km by road from Providence Portal at the southern edge of the project area), and Tumut is located about 35 km north west of the project areas (or 45 km by road from Tumut 3 power station at the northern edge of the project area). Other townships near the project area include Talbingo, Cabramurra, Adaminaby and Tumbarumba. Talbingo and Cabramurra were built for the original Snowy Scheme workers and their families, while Adaminaby was relocated in 1957 to make way for the establishment of Lake Eucumbene.

The location of Snowy 2.0 Main Works with respect to the region is shown in Figure 1.1.

The pumped hydro-electric scheme elements of Snowy 2.0 Main Works are mostly underground between the southern ends of Tantangara and Talbingo reservoirs, a straight-line distance of 27 km. Surface works will also occur at locations on and between the two reservoirs. Key locations for surface works include:

- **Tantangara Reservoir** - at a full supply level (FSL) of about 1,229 metres (m) to Australian Height Datum (AHD), Tantangara Reservoir will be the upper reservoir for Snowy 2.0 and include the headrace tunnel and intake structure. The site will also be used for a temporary construction compound, accommodation camp and other temporary ancillary activities;

- **Marica** - this site will be used primarily for construction including construction of vertical shafts to the underground power station (ventilation shaft) and headrace tunnel (surge shaft), and a temporary accommodation camp;

- **Lobs Hole** - the site will be used primarily for construction but will also become the main entrance to the power station during operation. Lobs Hole will provide access to the Exploratory Works tunnel, which will be refitted to become the main access tunnel (MAT), as well as the location of the emergency egress, cable and ventilation tunnel (ECVT), portal, associated services and accommodation camp; and

- **Talbingo Reservoir** - at a FSL of about 546 m AHD, Talbingo Reservoir will be the lower reservoir for Snowy 2.0 and will include the tailrace tunnel and water intake structure. The site will also be used for temporary construction compounds and other temporary ancillary activities.

Works will also be required within the two reservoirs for the placement of excavated rock and surplus cut material. Supporting infrastructure will include establishing or upgrading access tracks and roads and electricity connections to construction sites.

Most of the proposed pumped hydro-electric and temporary construction elements and most of the supporting infrastructure for Snowy 2.0 Main Works are located within the boundaries of KNP, although the disturbance footprint for the project during construction is less than 0.25% of the total KNP area. Some of the supporting infrastructure and construction sites and activities (including sections of road upgrade, power and communications infrastructure) extends beyond the national park boundaries. These sections of infrastructure are primarily located to the east and south of Tantangara Reservoir. One temporary construction site is located beyond the national park along the Snowy Mountains Highway about 3 km east of Providence Portal (referred to as Rock Forest).

The project is described in more detail in Chapter 2.

1.2.1 Project area

The project area for Snowy 2.0 Main Works has been identified and includes all the elements of the project, including all construction and operational elements. The project area is shown on Figure 1.2. Key features of the project area are:

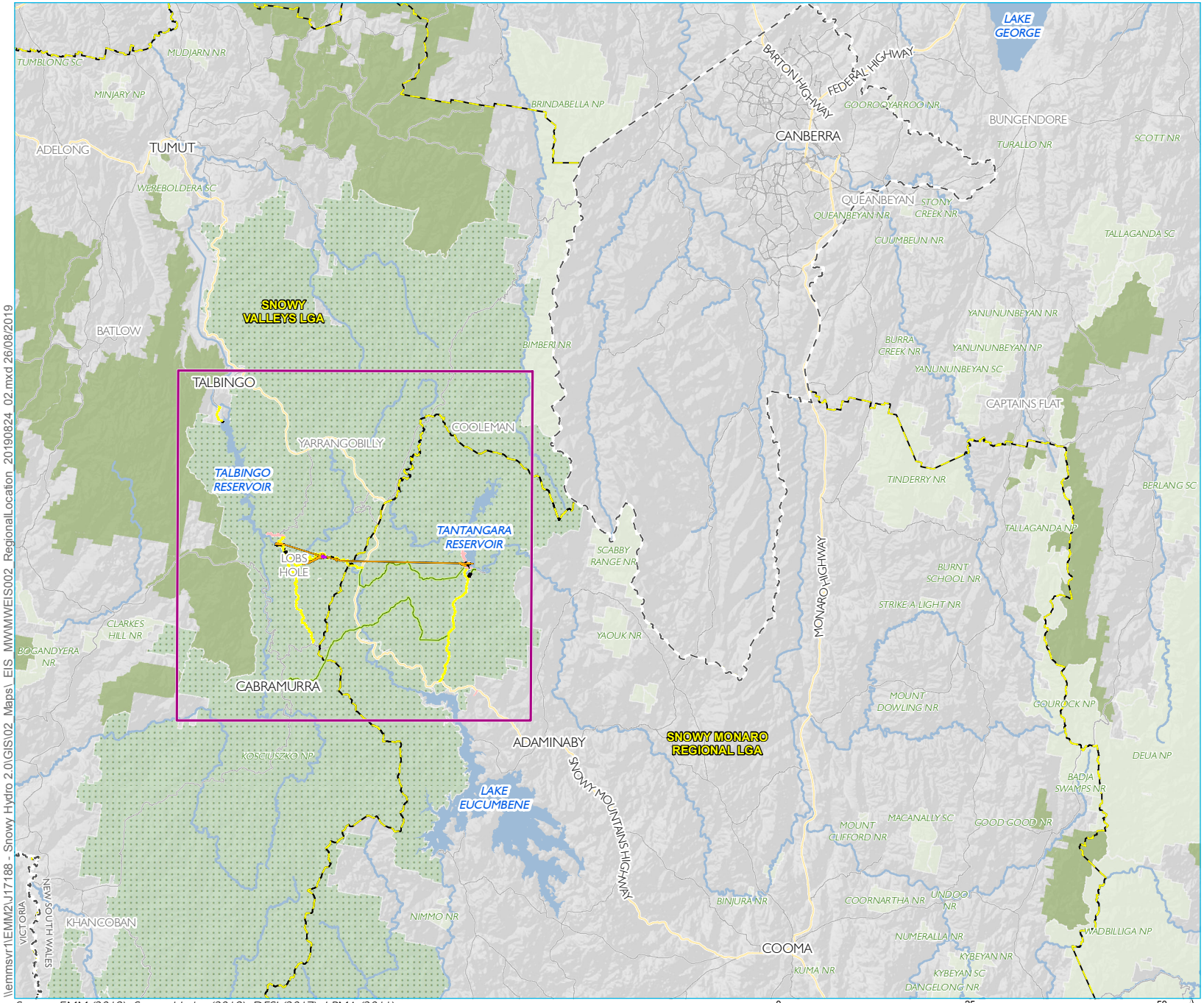
- the water bodies of Tantangara and Talbingo reservoirs, covering areas of 19.4 square kilometres (km^2) and 21.2 km^2 respectively. The reservoirs provide the water to be utilised in Snowy 2.0;

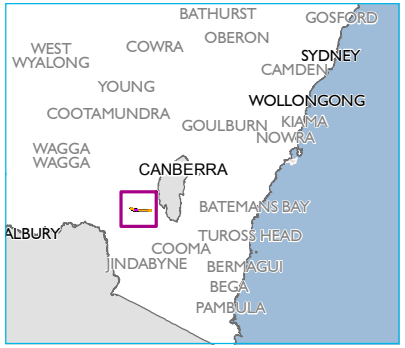
- major watercourses including the Yarrangobilly, Eucumbene and Murrumbidgee rivers and some of their tributaries;

- KNP, within which the majority of the project area is located. Within the project area, KNP is characterised by two key zones: upper slopes and inverted treelines in the west of the project area (referred to as the 'ravine') and associated subalpine treeless flats and valleys in the east of the project area (referred to as the 'plateau'); and

- farmland southeast of KNP at Rock Forest.

The project area is interspersed with built infrastructure including recreational sites and facilities, main roads as well as unsealed access tracks, hiking trails, farmland, electricity infrastructure, and infrastructure associated with the Snowy Scheme.





KEY

- Project area

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Kosciuszko National Park
- NPWS reserve
- State forest
- Local government area boundary
- State boundary

Regional setting

Snowy 2.0
Soils and land assessment
Main Works
Figure 1.1

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

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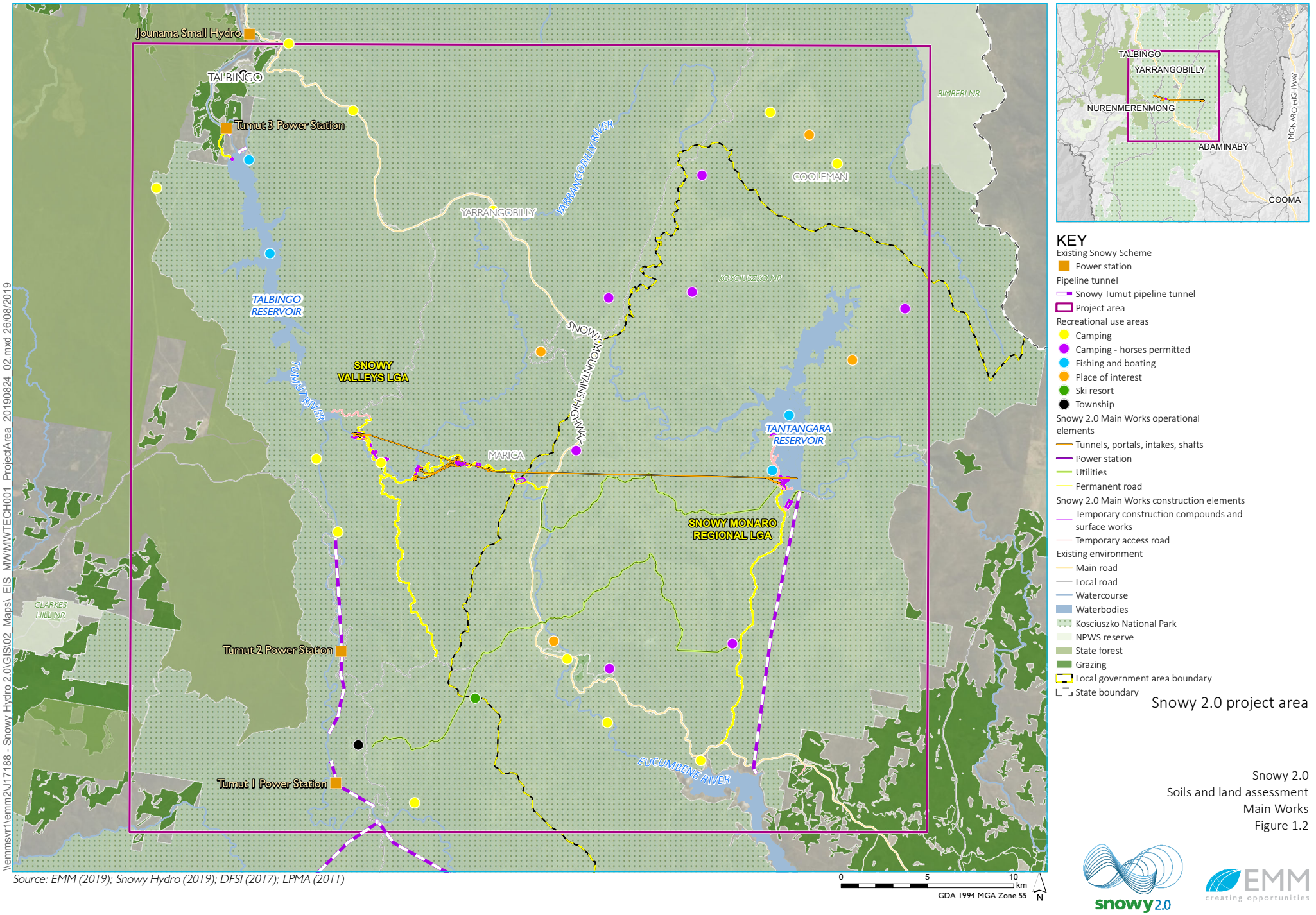

KEY

Existing Snowy Scheme
- Power station

Pipeline tunnel
- Snowy Tumut pipeline tunnel
- Project area

Recreational use areas
- Camping
- Camping - horses permitted
- Fishing and boating
- Place of interest
- Ski resort
- Township

Snowy 2.0 Main Works operational elements
- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements
- Temporary construction compounds and surface works
- Temporary access road

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies
- Kosciuszko National Park
- NPWS reserve
- State forest
- Grazing
- Local government area boundary
- State boundary

Snowy 2.0 project area

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

Snowy 2.0
Soils and land assessment
Main Works
Figure 1.2

snowy 2.0

EMM creating opportunities

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1.2.2 Soil and land assessment study area

The soil and land assessment study area is the land disturbance footprint of the EIS for the Snowy 2.0 Main Works and does not include the Talbingo and Tantangara Reservoirs. This study area is referred to as the soils assessment area for the purposes of this report and is presented in Figure 1.3.

1.3 Proponent

Snowy Hydro is the proponent for the Snowy 2.0 Main Works. Snowy Hydro is an integrated energy business – generating energy, providing price risk management products for wholesale customers and delivering energy to homes and businesses. Snowy Hydro is the fourth largest energy retailer in the NEM and is Australia's leading provider of peak, renewable energy.

1.4 Legislative Context

The key piece of legislation relating to the soil and land resources for the project is the *National Parks and Wildlife Act 1979* (NPW Act).

Under the NPW Act, the Director General of National Parks and Wildlife Service (NPWS) is responsible for the care, control and management of all national parks and various other categories of protected area. The primary responsibilities of NPWS under this legislation are the protection and maintenance of natural and cultural values, and the fostering of public appreciation, understanding and enjoyment of those values.

The KNP Plan of Management (PoM, DEC 2006) details management objectives for such features within the park such as native plants and animals, soils, karst, rivers, lakes etc. Management objectives follow those specified within the NPW Act and include:

- native plant species and communities are maintained and/or rehabilitated and include a representative range of successional stages and age classes;
- viable populations of all native animal species that currently occur in the park are maintained or restored;
- the diversity of native species found in the park is maximised at a regional scale; and
- research informs the management of the native animals of the park.

The requirements of the NPW Act and KNP PoM have been considered in this report.

Other relevant NSW legislation include:

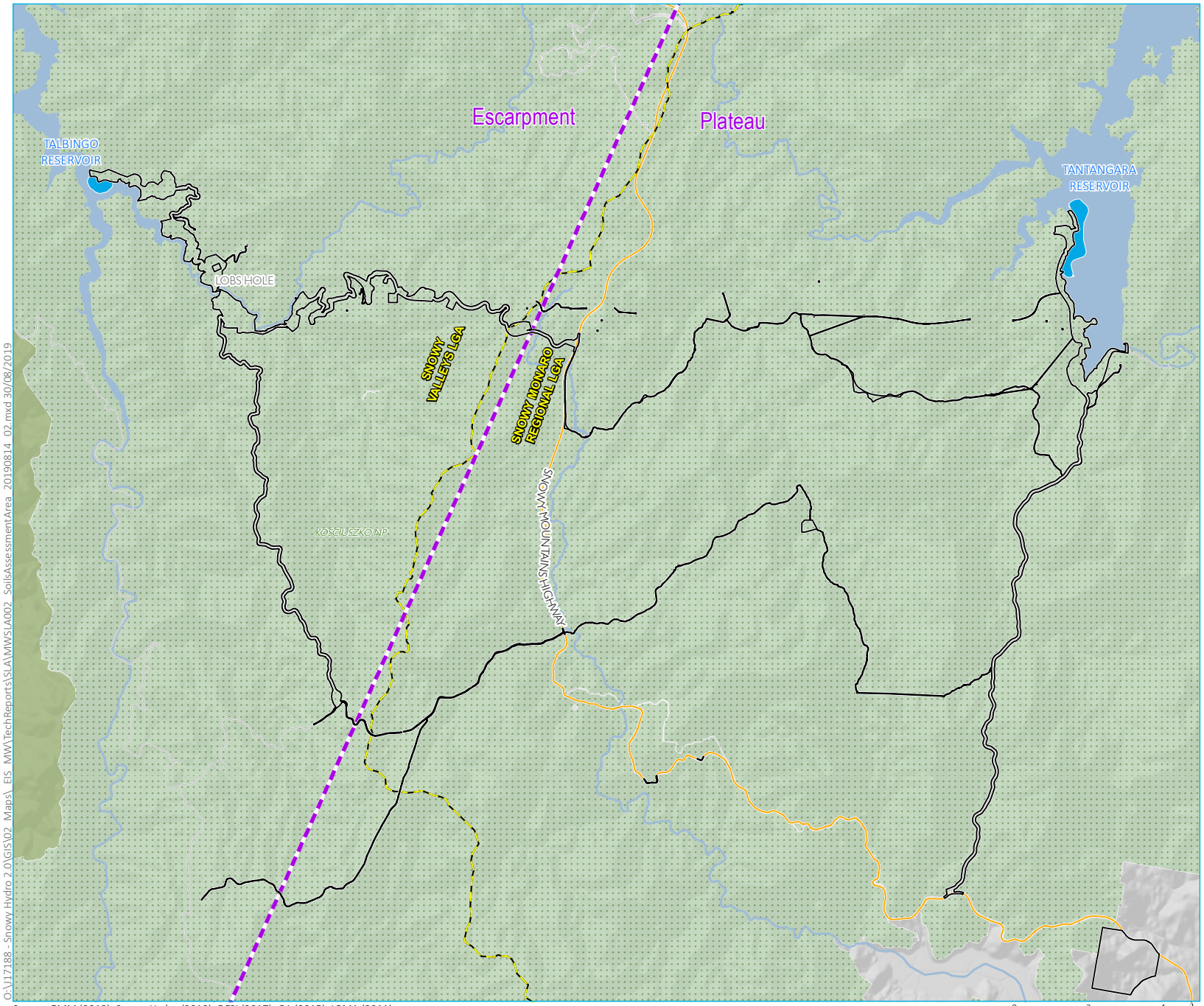
- *Protection of the Environment (Operations) Act 1997* (POEO Act);
- *Soil Conservation Act 1938* (SC Act);
- *Water Management Act 2000* (WM Act); and
- *Contaminated Land Management Act 1997* (CLM Act).

The object of the POEO Act is to achieve the protection, restoration and enhancement of the quality of the NSW environment. It enables the creation of explicit protection of the environment policies (PEPs) and provides a single licensing arrangement for environment protection licenses issued by the Environment Protection Authority (EPA).

The SC Act provides for the conservation of soil and farm water resources and for the mitigation of erosion.

The WM Act provides the statutory framework for managing water in NSW, recognising the need to allocate water for environmental flows and groundwater systems, while providing licence holders with secure access to water and opportunities to trade water through the separation of water licences from land. It specifically recognises that the management of water must be integrated with other natural resources such as vegetation, soils and land.

The CLM Act regulates seriously contaminated land in NSW and establishes a process for the EPA to identify, investigate and, where appropriate, order the remediation of land if the EPA considers the land to be significantly contaminated.



KEY

- Soils assessment area
- Indicative rock emplacement area
- Plateau escarpment boundary
- Main road
- Local road
- Watercourse
- Waterbody
- Kosciuszko National Park
- State forest
- State boundary
- Local government area boundary

Source: EMM (2018); Snowy Hydro (2018); DFSI (2017); GA (2015); LPMA (2011)

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Soils Assessment Area

Snowy 2.0
Soil and Land Assessment Report
Main Works
Figure 1.3

snowy 2.0

EMM creating opportunities

1.5 Purpose of this report

This soil and land assessment supports the EIS for the Snowy 2.0 Main Works. It documents the assessment methods and results, the initiatives built into the project design to avoid and minimise associated impacts to soil and land resources, and the mitigation and management measures proposed to address any residual impacts not able to be avoided.

The Secretary's Environmental Assessment Requirements (SEARs) requires "an assessment of impacts of the project on soils and land capability of the site". For the purposes of the approach adopted in the report, the assessment will examine the potential for project related activities to impact on the soil and land resource, to the extent that the capacity (of the soil and land resource) to support the land capability, uses and attributes for which the area is valued (including potential future uses) is diminished.

The scope of the Main Works soil and land assessment is to:

- address the SEARs and government agency assessment requirements relating to soil and land resources;
- incorporate the Exploratory Works soil assessment information into the Main Works assessment;
- describe, classify and map the soils within the Main Works soil assessment area;
- identify soil attributes of the soil map units that will inform appropriate management measures;
- identify appropriate soil management measures;
- identify any potentially problematic soils, such as acid sulfate soils, highly sodic, acidic or saline soils, that may require special management if disturbed during project activities; and
- assess the immediate and long-term impacts of the Main Works on the soil resources and land and soil capability.

1.5.1 Assessment guidelines and requirements

This Soil and Land Assessment has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for Snowy 2.0 Main Works, issued on 31 July 2019, as well as relevant government assessment requirements, guidelines and policies, and in consultation with the relevant government agencies.

The SEARs must be addressed in the EIS, with the bolded text in Table 1.1 listing the matters relevant to this assessment and where they are addressed in this report.

Table 1.1 Relevant matter raised in SEARs

Land Requirements	Section addressed
Land:	
• – an assessment of impacts of the project on:	
– **the soils and land capability of the site**, including potential impacts associated with the use of hydrocarbons and chemicals, dealing with the spoil generated by the project, disturbing land associated with previous mining activities and encountering any naturally occurring asbestos;	3, 4 and 5 of this report
– the topography of the site, including the creation of any new landforms;	
– the geotechnical stability of the site;	
– the geodiversity values of the site, including potential impacts on Karst systems, fossil beds and boulder streams;	
• – a strategy to manage the progressive rehabilitation of the land disturbed by the project and enhance any new landforms created;	3, 4 and 5 of this report

To inform preparation of the SEARs, the DPIE invited relevant government agencies to advise on matters to be addressed in the EIS. These matters were taken into account by the Secretary for DPIE when preparing the SEARs.

In addition, this assessment has been prepared following the appropriate guidelines, policies and industry requirements, and in consultation with relevant government agencies.

Guidelines and policies referenced are as follows:

- *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Land* (NSW Government 2013);
- *Soil and Landscape Issues in Environmental Impact Assessment* (DLWC 2000);
- *Acid Sulfate Soils Assessment Guidelines* (Ahern et al. 1998);
- *Guidelines for soil survey along linear features* (SSA 2015);
- *The land and soil capability assessment scheme (*OEH *2012);* and
- *Agfact AC25: Agricultural Land Classification* (NSW Agriculture, 2002).

1.6 Related projects

There are three other projects related to Snowy 2.0 Main Works, they are:

- Snowy 2.0 Exploratory Works (SSI-9208) – a Snowy Hydro project with Minister's approval;
- Snowy 2.0 Transmission Connect Project (SSI-9717) – a project proposed by TransGrid; and
- Snowy 2.0 – Segment Factory (SSI-10034) – a project proposed by Snowy Hydro.

While these projects form part of the CSSI declaration for Snowy 2.0 and Transmission Project, they do not form part of Snowy Hydro's application for Snowy 2.0 Main Works. These related projects are subject to separate application and approval processes. Staged submission and separate approval is appropriate for a project of this magnitude, due to its complexity and funding and procurement processes. However, cumulative impacts have been considered in this report where relevant.

1.7 Other relevant reports

This Soil and Land Assessment has been prepared with reference to other technical reports that were prepared as part of the Snowy 2.0 Main Works EIS. The other relevant reports referenced in this soil and land assessment report are listed below.

- Biodiversity development assessment (EMM 2019) – Appended to the EIS;
- Bushfire risk and hazard assessment (EcoLogical 2019) – Appended to the EIS;
- Cenozoic geodiversity report (Troedson 2019) – Appended to the EIS;
- Contamination assessment (EMM 2019) – Appended to the EIS;
- Groundwater assessment (EMM 2019) – Appended to the EIS;
- Paleozoic geodiversity report (Percival 2019) – Appended to the EIS;
- Rehabilitation strategy (SLR 2019) – Appended to the EIS; and
- Surface water assessment (EMM 2019) – Appended to the EIS.

The Main Works area encompasses the Exploratory Works area and the results of the initial exploratory works soil and land assessment have been incorporated into this assessment, where applicable. There have also been geotechnical and hydrogeological investigations for the project which have also been reviewed incorporated into this report where relevant. These investigations include:

- SMEC, 2017, *Snowy 2.0 Feasibility Study* | *Engineering Geology Assessment Report* | Prepared for Snowy Hydro Pty Ltd | S2-0600-REP-011506-0.
- SMEC, 2018a, *Feasibility Study; Geotechnical Factual Report* | Prepared for Snowy Hydro Pty Ltd | S2-0704-REP-012022-E.
- SMEC, 2018b, *Geotechnical Investigation Plan - Exploratory Works Roads* | Prepared for Snowy Hydro Pty Ltd | S2-4200-PLN-000001-C | May 2018.
- SMEC, 2018c, *Reference Design – Geological Reconnaissance Mapping Report* | Prepared for Snowy Hydro Pty Ltd | S2-1000-REP-000001-A | July 2018.
- SMEC, 2018d, *Reference Design – Geological Interpretive Report* | Prepared for Snowy Hydro Pty Ltd | S2-4100-REP-000012-B | November 2018.
- SMEC, 2019a, *Naturally Occurring Asbestos* | Snowy 2.0 Reference Design | Snowy Hydro Pty Ltd | S2-1707-TCN-016009-F.

- SMEC, 2019b, *Targeted Contamination Investigation on Mine Trail Ch 50-450*. S2-SHL-ENV-REP-000001.GDH 2018, Snowy Hydro Snowy 2.0 Geotechnical Investigation Manager | Geotechnical Factual Report R1 – Data Submission, May 2018, 2126928.
- GHD 2018, Snowy Hydro Snowy 2.0 Geotechnical Investigation Manager | *Geotechnical Factual Report R1 – Data Submission*, May 2018, 2126928.
- GHD 2019, Snowy Hydro Limited Snowy 2.0 Geotechnical Investigation Program Manager | *Geotechnical Factual Report*, 21-26928-GT-RPT-0003-R1, February 2019.

1.8 Limitations

The assessment of the soils and land resources in this report is based solely on desktop information. A field survey soil sampling program was not undertaken due to there being no available approval pathway to undertake soil sampling within the KNP during the EIS investigation phase.

Based on the locations of the existing soil site data and due to the limited sampling of certain pedo-geomorphic conditions, the confidence level of the soil type map and soil properties varies across the soils assessment area. there are sites with physical and chemical laboratory analysis data particularly for the soils on the plateau and the Tantangara area. The level of information contained in this report is considered appropriate for the EIS with relatively little value to be added with a EIS field soil survey program, recognising that targeted site specific soils assessment will be undertaken as required prior to construction to determine management measures such as, erosion and sediment control requirements and topsoil and subsoil stripping depths, based on the construction methodology and final design.

2 Description of the project

This chapter provides a summary of the Snowy 2.0 Main Works project. It outlines the functional infrastructure required to operate Snowy 2.0, as well as the key construction elements and activities required to build it. A more comprehensive detailed description of the project is provided in Chapter 2 (Project description) of the EIS, which has been relied upon for the basis of this technical assessment.

2.1 Overview of Snowy 2.0

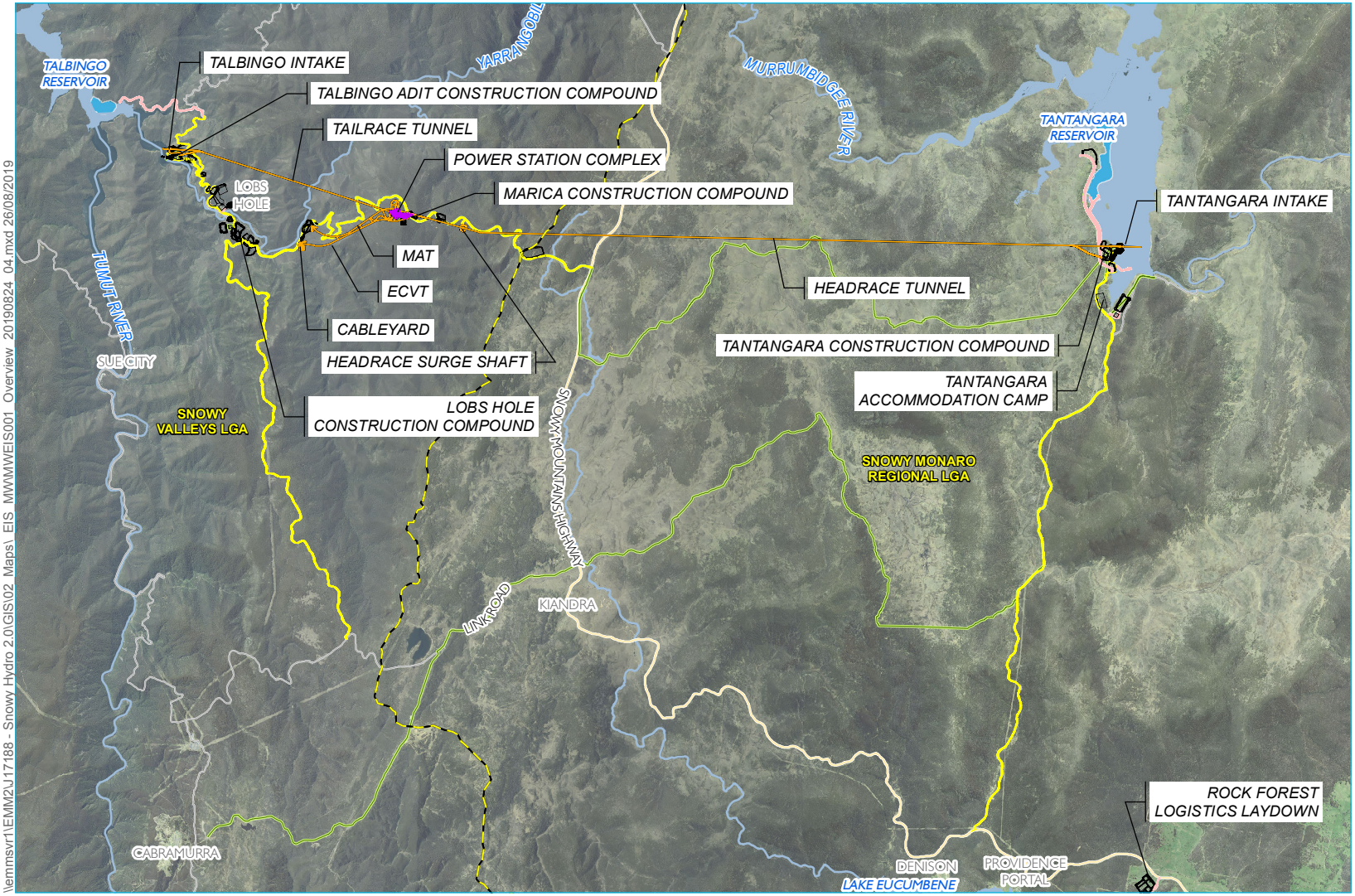
Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and a new hydro-electric power station will be built underground. An overview of Snowy 2.0 is shown on Figure 2.1, and the key project elements of Snowy 2.0 are summarised in Table 2.1.

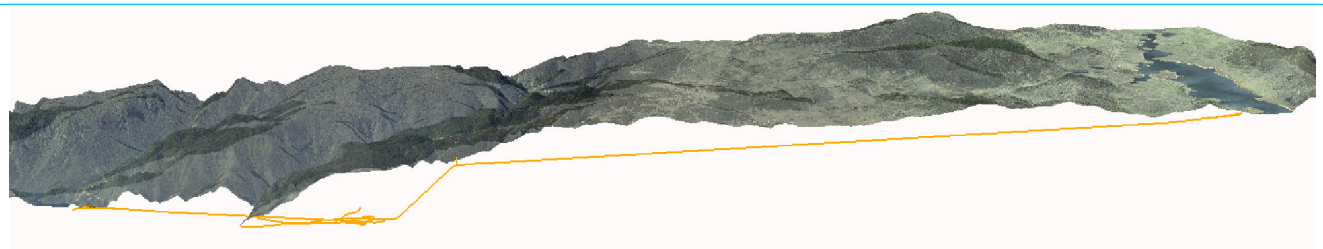
Table 2.1 Overview of Snowy 2.0 Main Works

Project element	Summary of the project
Project area	The project area is the broader region within which Snowy 2.0 will be built and operated, and the extent within which direct impacts from Snowy 2.0 Main Works are anticipated.
Permanent infrastructure	Snowy 2.0 infrastructure to be built and operated for the life of the assets include the: • intake and gate structures and surface buildings at Tantangara and Talbingo reservoirs; • power waterway tunnels primarily comprising the headrace tunnel, headrace surge structure, inclined pressure tunnel, pressure pipelines, tailrace surge tank and tailrace tunnel; • underground power station complex comprising the machine hall, transformer hall, ventilation shaft and minor connecting tunnels; • access tunnels (and tunnel portals) to the underground power station comprising the main access tunnel (MAT) and emergency egress, communication, and ventilation tunnel (ECVT); • establishment of a portal building and helipad at the MAT portal; • communication, water and power supply including the continued use of the Lobs Hole substation; • cable yard adjacent to the ECVT portal to facilitate the connection of Snowy 2.0 to the NEM; • access roads and permanent bridge structures needed for the operation and maintenance of Snowy 2.0 infrastructure; and • fish control structures on Tantangara Creek and near Tantangara Reservoir wall.
Temporary infrastructure	Temporary infrastructure required during the construction phase of Snowy 2.0 Main Works are: • construction compounds, laydown, ancillary facilities and helipads; • accommodation camps for construction workforce; • construction portals and adits to facilitate tunnelling activities; • barge launch ramps; • water and wastewater management infrastructure (treatment plants and pipelines); • communication and power supply; and • temporary access roads.
Disturbance area	The disturbance area is the extent of construction works required to build Snowy 2.0. The maximum disturbance area is about 1,680 hectares (ha), less than 0.25% of the total area of KNP. Parts of the disturbance area will be rehabilitated and landformed and other parts will be retained permanently for operation (operational footprint).

Table 2.1 Overview of Snowy 2.0 Main Works

Project element	Summary of the project
Operational footprint	The operational footprint is the area required for permanent infrastructure to operate Snowy 2.0. The maximum operational footprint is about 99 ha. This is 0.01% of the total area of KNP.
Tunnelling and excavation method	The primary tunnelling method for the power waterway is by tunnel boring machine (TBM), with portals and adits using drill and blast methods. Excavation for other underground caverns, chambers and shafts will be via combinations of drill and blast, blind sink, and/or raise bore techniques.
Excavated rock management	Excavated rock will be generated as a result of tunnelling activities and earthworks. The material produced through these activities will be stockpiled and either reused by the contractor (or NPWS), placed permanently within Tantangara or Talbingo reservoirs, used in final land forming and rehabilitation of construction pads in Lobs Hole, or transported offsite.
Construction water and wastewater management	Water supply for construction will be from the two existing reservoirs (Talbingo and Tantangara) and reticulated via buried pipelines (along access roads). Raw water will be treated as necessary wherever potable water is required (eg at accommodation camps). Water to be discharged (comprising process water, wastewater and stormwater) will be treated before discharge to the two existing reservoirs (Talbingo and Tantangara) as follows: • treated process water will be reused onsite where possible to reduce the amount of discharge to reservoirs, however excess treated water will be discharged to the reservoirs; • collected sewage will be treated at sewage treatment plants to meet the specified discharge limits before discharge and/or disposal; and • stormwater will be captured and reused as much as possible.
Rehabilitation	Rehabilitation of areas disturbed during construction including reshaping to natural appearing landforms or returning to pre-disturbance condition, as agreed with NPWS and determined by the rehabilitation strategy. This includes construction areas at Lobs Hole which comprise surplus cut materials that are required for the construction. Areas to be used by Snowy Hydro in the long-term may be re-shaped and rehabilitated to maintain access and operational capabilities (eg intakes and portal entrances).
Construction workforce	The construction workforce for the project is expected to peak at around 2,000 personnel.
Operational life	The operational life of the project is estimated to be 100 years.
Operational workforce	The operational workforce is expected to be 8-16 staff, with fluctuations of additional workforce required during major maintenance activities.
Hours of operation	Construction of Snowy 2.0 will be 24/7 and 365 days per year. Operation of Snowy 2.0 will be 24/7 and 365 days per year.
Capital investment value	Estimated to be $4.6 billion.





KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road
- Indicative rock emplacement area

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

0 2.5 5 km

GDA 1994 MGA Zone 55

N

Snowy 2.0 project elements

Snowy 2.0
Soils and land assessment
Main Works
Figure 2.1

snowy 2.0

EMM creating opportunities

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2.2 Construction of Snowy 2.0

A number of construction activities will be carried out concurrently, and across a number of different sites. Specific details on these activities as well as an indicative schedule of construction activities is provided in Chapter 2 (Project description) of the EIS. This section summarises the key construction elements of the project.

Table 2.2 provides an overview of the construction elements, their purpose and location within the Project area.

Table 2.2 Snowy 2.0 construction elements

Construction element	Purpose	Location
Construction sites	Due to the remoteness of Snowy 2.0, construction sites are generally needed to: • Provide ancillary facilities such as concrete batching plants, mixing plants and on-site manufacturing; • Store machinery, equipment and materials to be used in construction; • Provide access to underground construction sites; and • Provide onsite accommodation for the construction workforce.	Each construction site needed for Snowy 2.0 is shown on Figures 2.2 to Figure 2.6.
Substations and power connection	One substation is required to provide permanent power to Snowy 2.0, at Lobs Hole. This substation is proposed as part of a modification to the Exploratory Works with a capacity of 80 mega volt amp (MVA). It will continue to be used for Main Works, however requires the establishment of further power supply cables to provide power to the work sites and TBM at Tantangara, as well as Talbingo, in particular to power the TBMs via the MAT, ECVT, Talbingo and Tantangara portals.	The supporting high voltage cable route mostly follows access roads to each of the work sites, using a combination of aerial and buried arrangements.
Communications system	Communications infrastructure will connect infrastructure at Tantangara and Talbingo reservoirs to the existing communications system at the Tumut 3 power station (via the submarine communications cable in Talbingo Reservoir established during Exploratory Works) and to Snowy Hydro's existing communications infrastructure at Cabramurra.	The cable will be trenched and buried in conduits within access roads. Crossing of watercourses and other environmentally sensitive areas will be carried out in a manner that minimises environmental impacts where possible, such as bridging or underboring.
Water and waste water servicing	Drinking water will be provided via water treatment plants located at accommodation camps. Water for treatment will be sourced from the nearest reservoir. There are three main wastewater streams that require some form of treatment before discharging to the environment, including: • Tunnel seepage and construction wastewater (process water); • Domestic sewer (wastewater); and • Construction site stormwater (stormwater).	Utility pipelines generally follow access roads. Water treatment plants (drinking water) will be needed for the accommodation camps and will be located in proximity. Wastewater treatment plants will similarly be located near accommodation camps. Process water treatment plants will be at construction compounds and adits where needed to manage tunnel seepage and water during construction.

Table 2.2 Snowy 2.0 construction elements

Construction element	Purpose	Location
Temporary and permanent access roads	Access road works are required to: • provide for the transport of excavated material between the tunnel portals and the excavated rock emplacement areas; • accommodate the transport of oversized loads as required; and • facilitate the safe movement of plant, equipment, materials and construction workers into and out of construction sites. The access road upgrades and establishment requirements are shown on Figure 2.2 to Figure 2.6. These roads will be used throughout construction including use of deliveries to and from site and the external road network. Some additional temporary roads will also be required within the footprint to reach excavation fronts such as various elevations of the intakes excavation or higher benches along the permanent roads.	The access road upgrades and establishment requirements are shown across the project area. Main access and haulage to site will be via Snowy Mountains Highway, Link Road and Lobs Hole Ravine Road (for access to Lobs Hole), and via Snowy Mountains Highway and Tantangara Road (for access to Tantangara Reservoir) (see Figure 2.1).
Excavated rock management	Approximately 9 million m^3 (unbulked) of excavated material will be generated by construction and require management. The strategy for management of excavated rock will aim to maximise beneficial reuse of materials for construction activities. Beneficial re-use of excavated material may include use for road base, construction pad establishment, selected fill and tunnel backfill and rock armour as part of site establishment for construction. Excess excavated material that cannot be re-used during construction will be disposed of within Talbingo and Tantangara reservoirs, used in permanent rehabilitation of construction pads to be left in situ in Lobs Hole, or transported for on-land disposal if required.	Placement areas are shown on Figure 2.2 and Figure 2.6.
Barge launch facilities	Barge launch facilities on Talbingo Reservoir will have already been established during Exploratory Works for the placement of the submarine communications cable and will continued to be used for Main Works for construction works associated with the Talbingo intake structure. The Main Works will require the establishment of barge launch facilities on Tantangara Reservoir to enable these similar works (removal of the intake plug).	Barge launch sites are shown on Figure 2.2 and Figure 2.6.
Construction workforce	The construction workforce will be accommodated entirely on site, typically with a FIFO/DIDO roster. Private vehicles will generally not be permitted and the workforce bused to and from site.	Access to site will be via Snowy Mountains Highway

The key areas of construction are shown on Figure 2.2 to Figure 2.6 and can be described across the following locations:

- Talbingo Reservoir – Talbingo Reservoir provides the lower reservoir for the pumped hydro-electric project and will include the tailrace tunnel and water intake structure. The site will also be used for temporary construction compounds and other temporary ancillary activities;

- Lobs Hole – this site will be used primarily for construction (including construction of the MAT and ECVT portals and tunnels to the underground power station and the headrace tunnel (and headrace tunnel surge shaft), underground tailrace surge shaft and a temporary accommodation camp);

- Marica – the site will be used primarily for construction to excavate the ventilation shaft to the underground power station as well as for the excavation and construction of the headrace surge shaft;

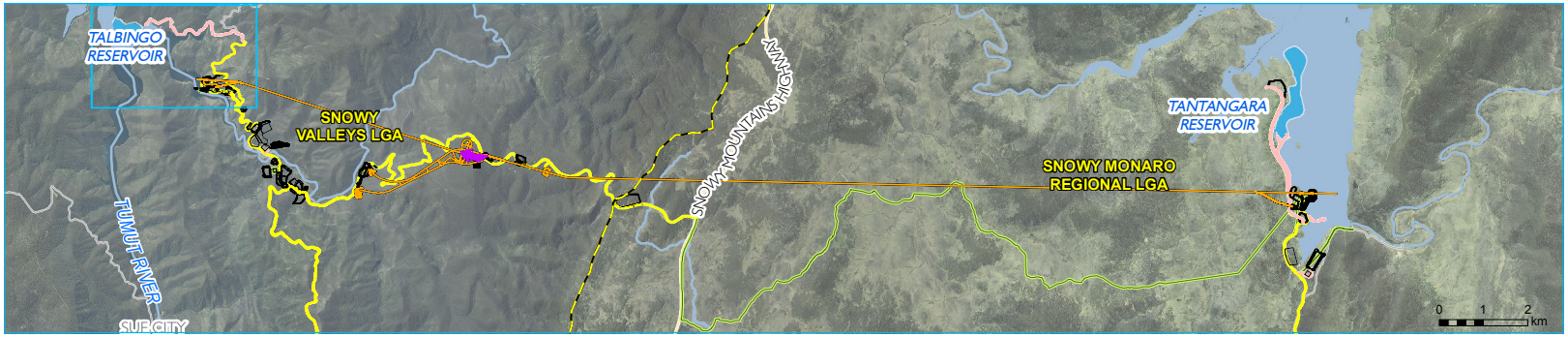
- Plateau – the land area between Snowy Mountains Highway and Tantangara Reservoir is referred to as the Plateau. The Plateau will be used to access and construct a utility corridor and construct a fish weir on Tantangara Creek;

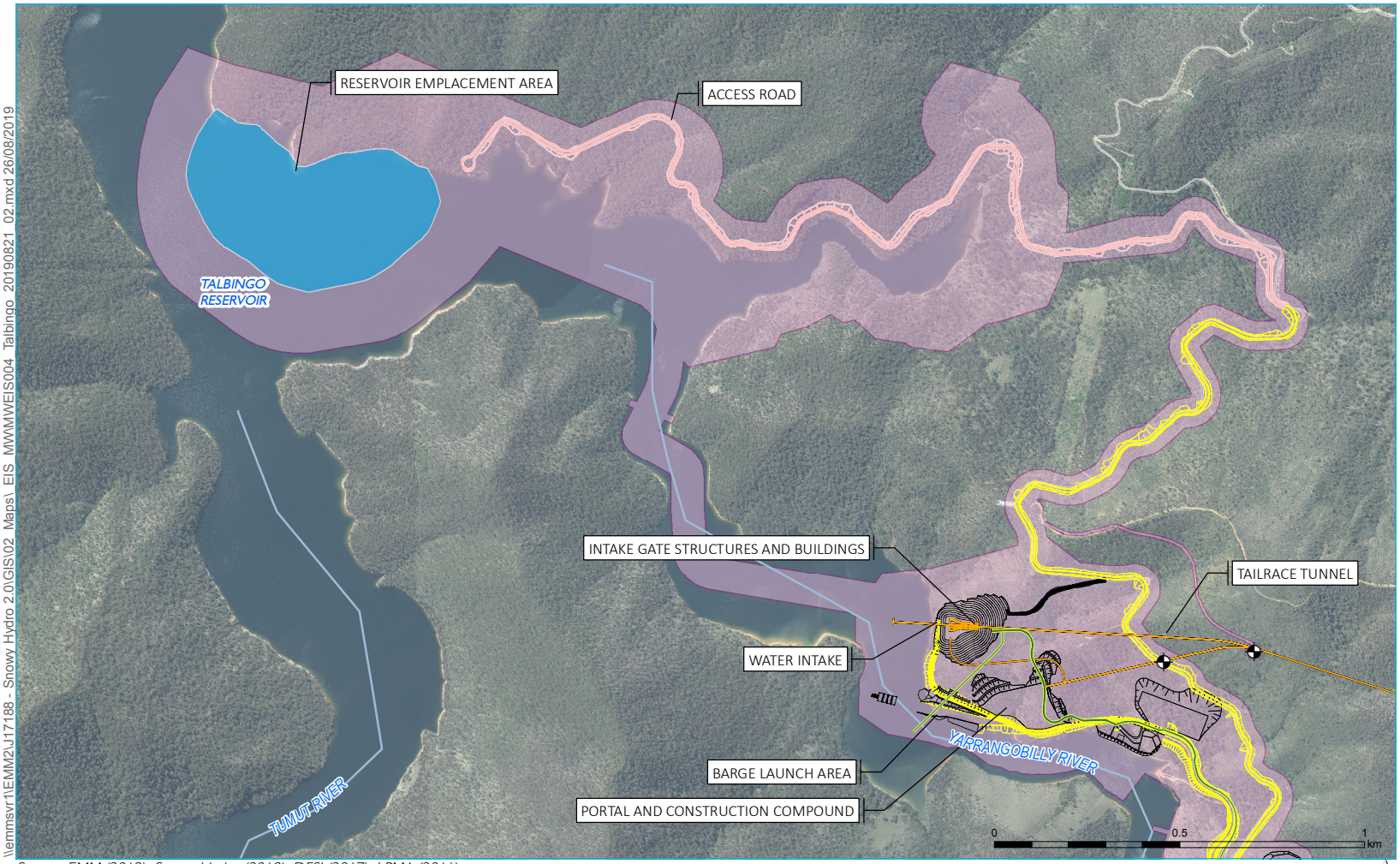
- Tantangara Reservoir – Tantangara Reservoir will be the upper reservoir for the pumped hydro project and include the headrace tunnel and intake structure. The site will also be used for a temporary construction compound, accommodation camp and other temporary ancillary activities; and

- Rock Forest – a site to be used temporarily for logistics and staging during construction. It is located beyond the KNP along the Snowy Mountains Highway about 3 km east of Providence Portal.

During the construction phase, all work sites will be restricted access and closed to the public. This includes existing road access to Lobs Hole via Lobs Hole Ravine Road. Restrictions to water-based access and activities will also be implemented for public safety and to allow safe construction of the intakes within the reservoirs. Access to Tantangara Reservoir via Tantangara Road will be strictly subject to compliance with the safety requirements established by the contractor.

A key construction element for the project is the excavation and tunnelling for underground infrastructure including the power station, power waterway (headrace and tailrace tunnels) and associated shafts. The primary methods of excavation are shown in Figure 2.8 with further detail on construction methods provided at Appendix D of the EIS.





KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Talbingo Reservoir - project elements, purpose and description

Snowy 2.0
Soils and land assessment
Main Works
Figure 2.2

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

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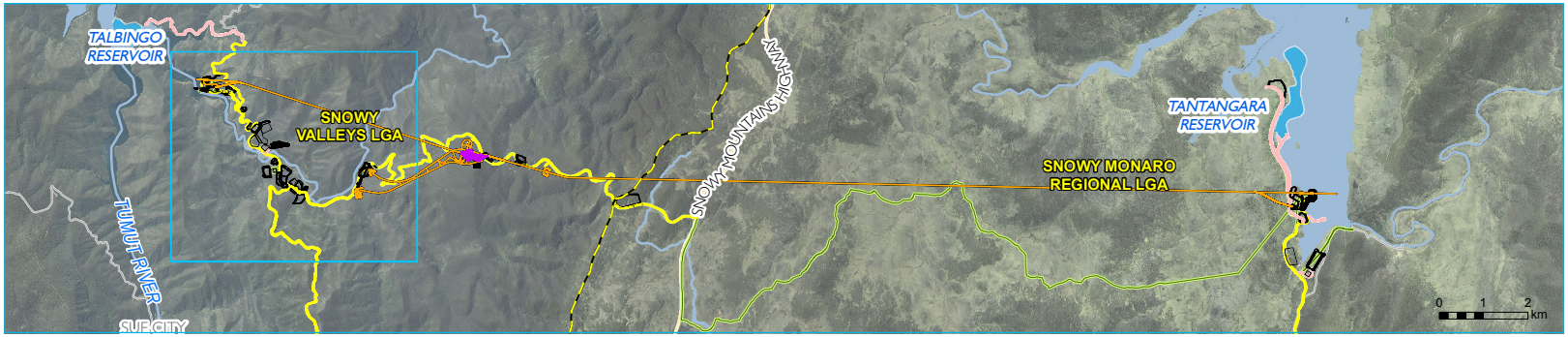

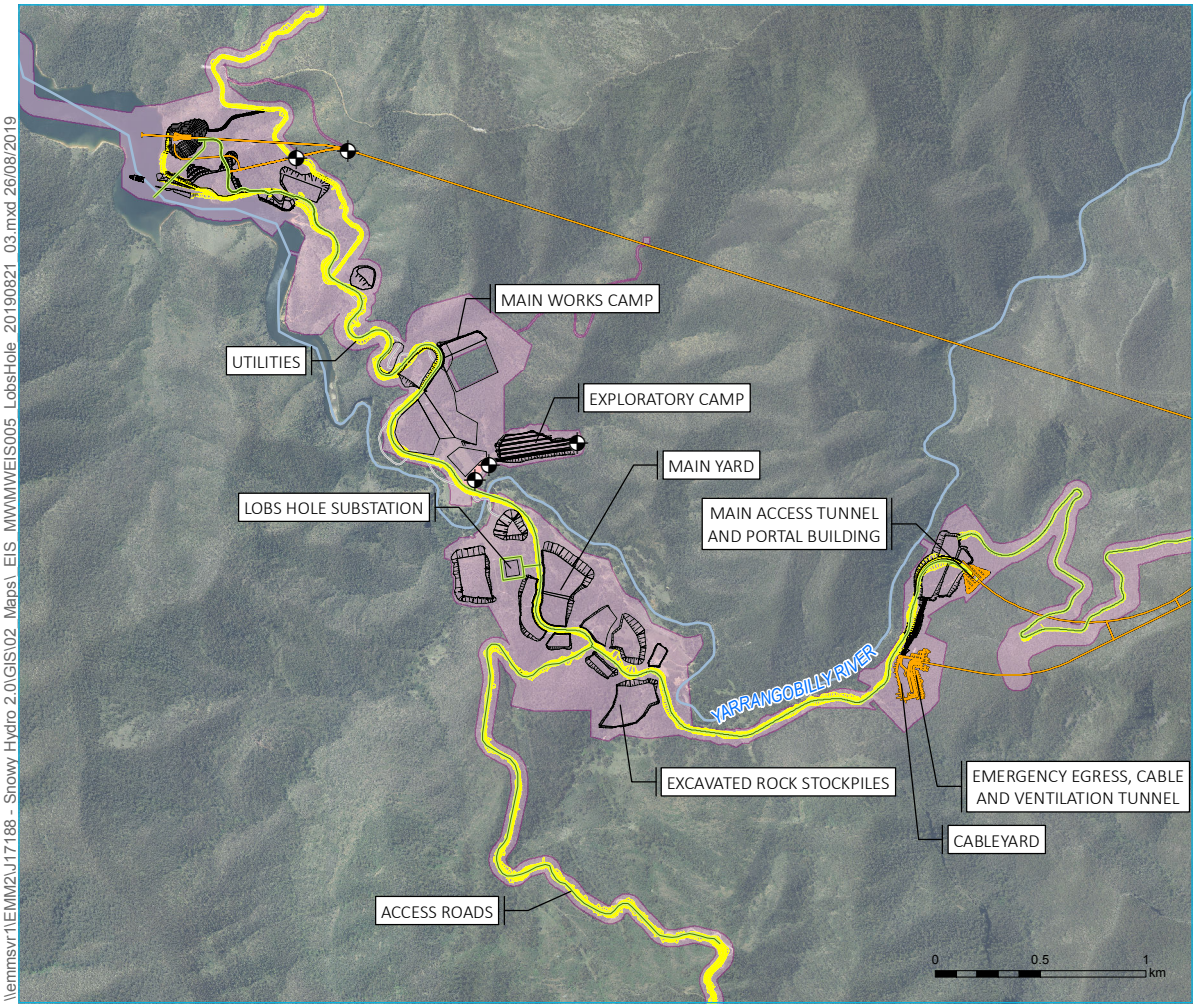

KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

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Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

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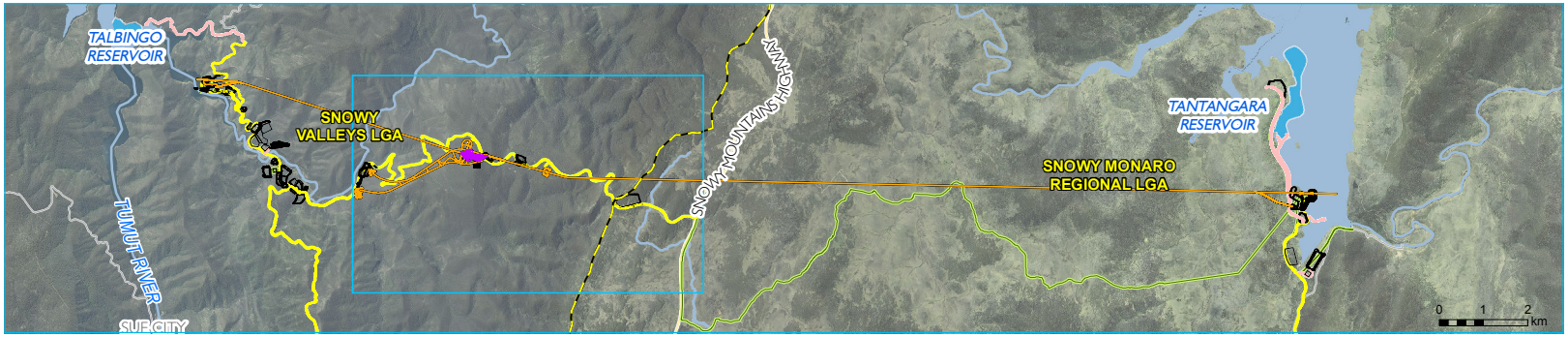
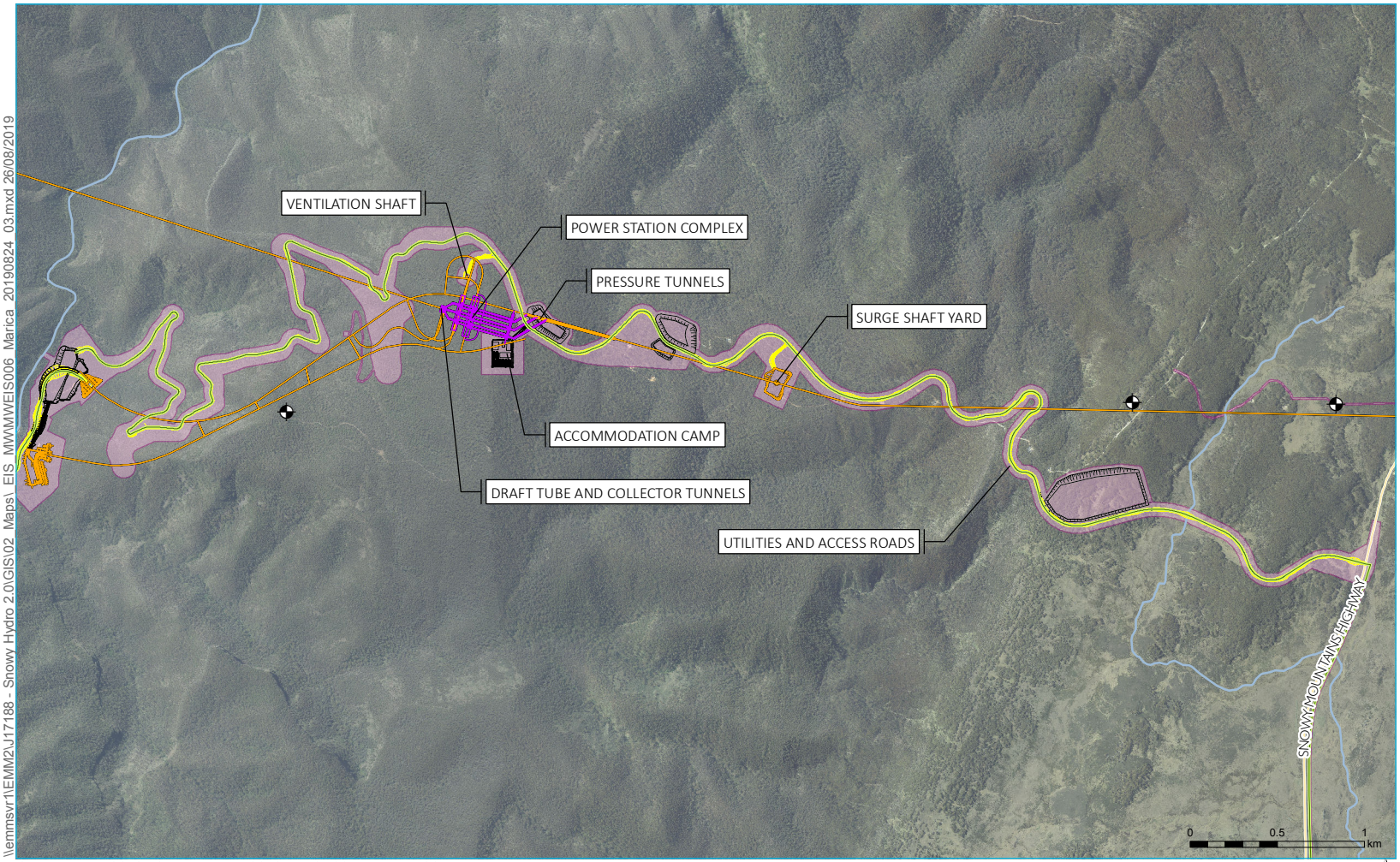
Lobs Hole - project elements, purpose and description

Snowy 2.0
Soils and land assessment
Main Works
Figure 2.3

snowy 2.0

EMM creating opportunities





KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Marica - project elements, purpose and description

Snowy 2.0
Soils and land assessment
Main Works
Figure 2.4

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

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snowy 2.0

EMM creating opportunities

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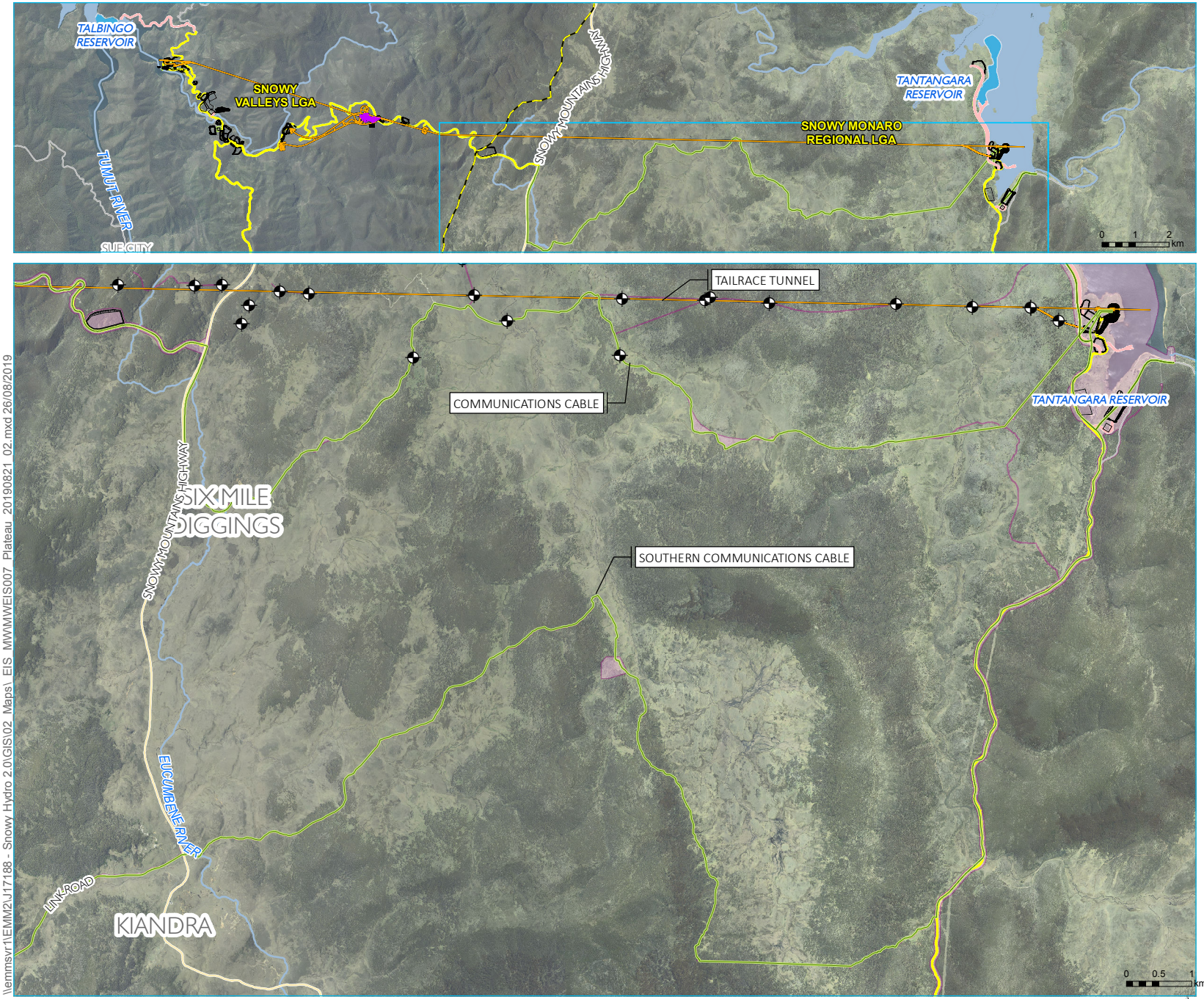

KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Plateau - project elements, purpose and description

Snowy 2.0
Soils and land assessment
Main Works
Figure 2.5

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

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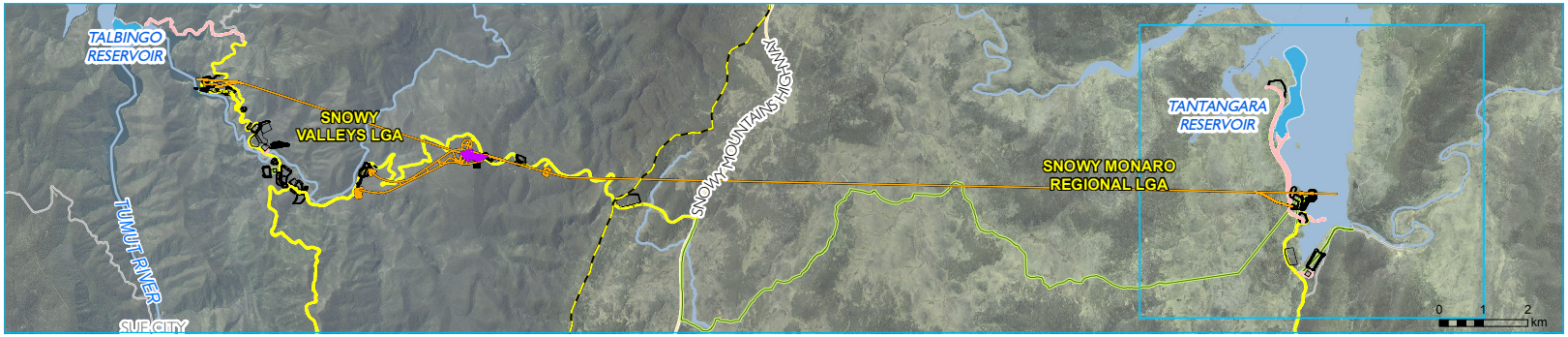

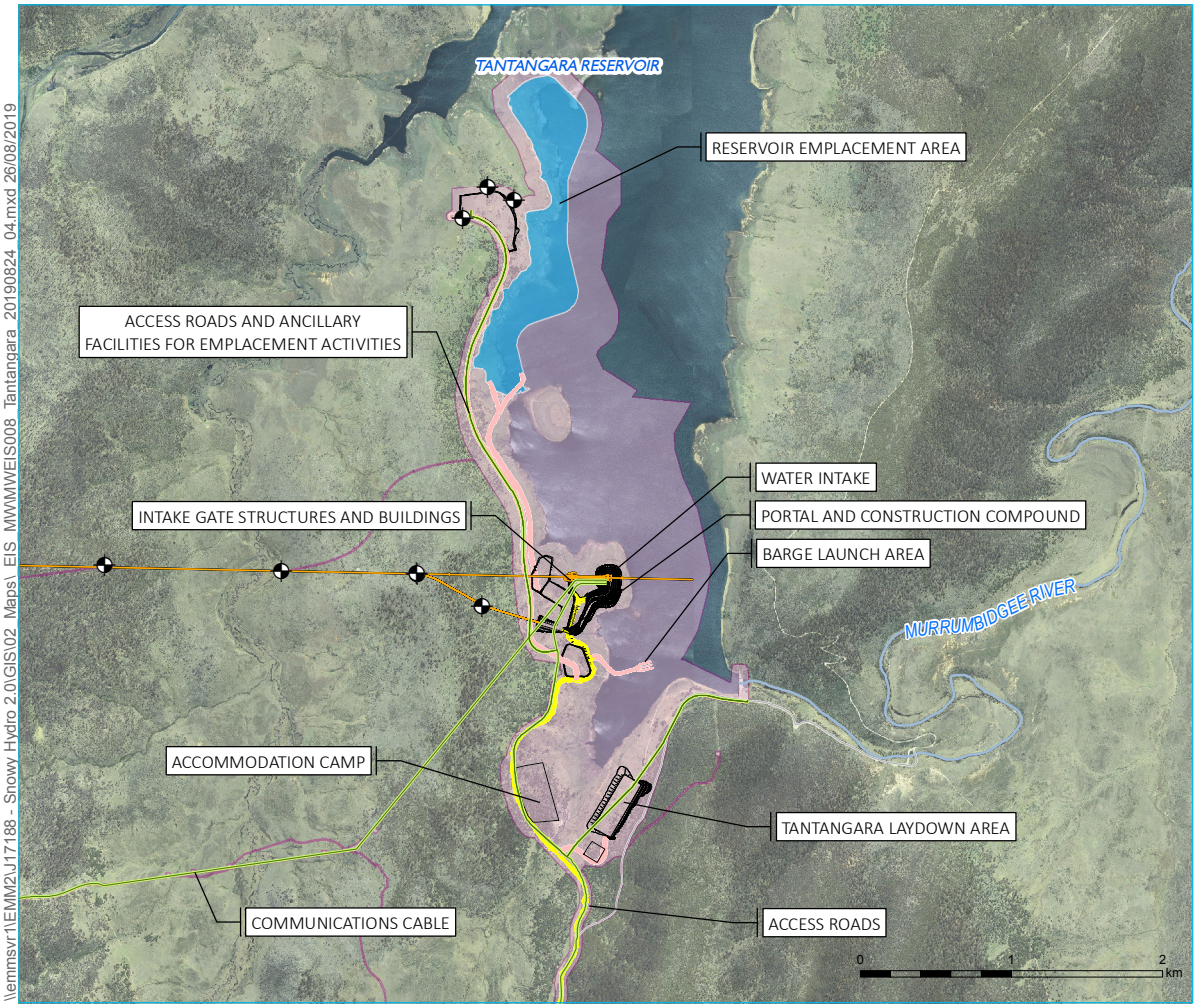

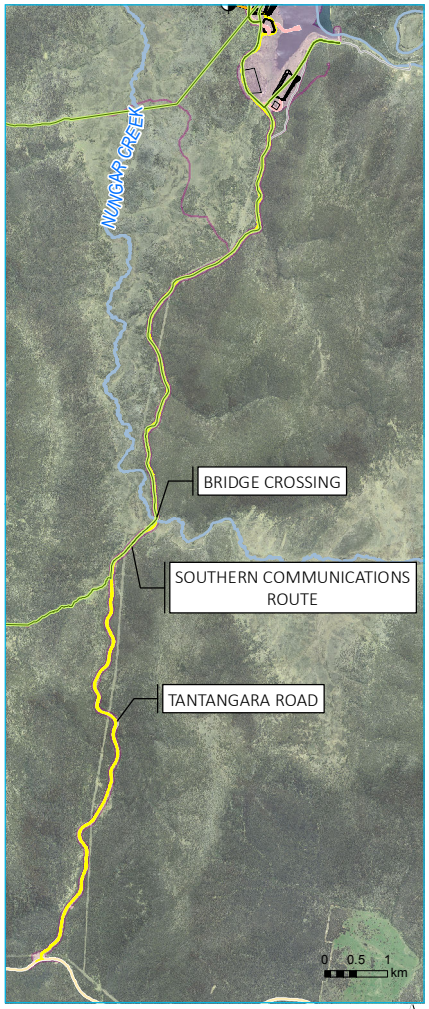

KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road

Snowy 2.0 Main Works construction elements

- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Indicative rock emplacement area
- Disturbance area*

Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

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Tantangara Reservoir - project elements, purpose and description

Snowy 2.0
Soils and land assessment
Main Works
Figure 2.6

snowy 2.0

EMM creating opportunities

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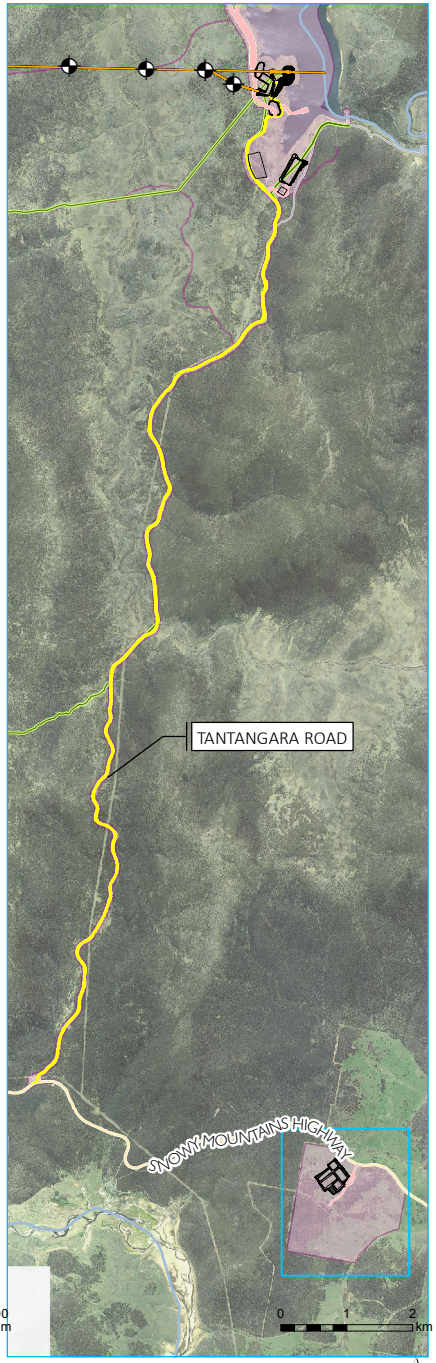

KEY

Existing environment
- Main road
- Local road
- Watercourse

Snowy 2.0 operational elements
- Tunnels, portals, intakes, shafts
- Utilities
- Permanent road

Snowy 2.0 contruction elements
- Temporary construction compounds and surface works
- Temporary access road
- Geotechnical investigation
- Disturbance area*

Note: the disturbance area is the extent of construction works required to build Snowy 2.0. It has been identified to allow an assessment of impacts for the EIS, and represents a defined maximum extent where construction works will be carried out. The area will be minimised as much as possible during detailed design.

Rock Forest - project elements, purpose and description

Snowy 2.0
Soils and land assessment
Main Works
Figure 2.7

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

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snowy 2.0

EMM creating opportunities

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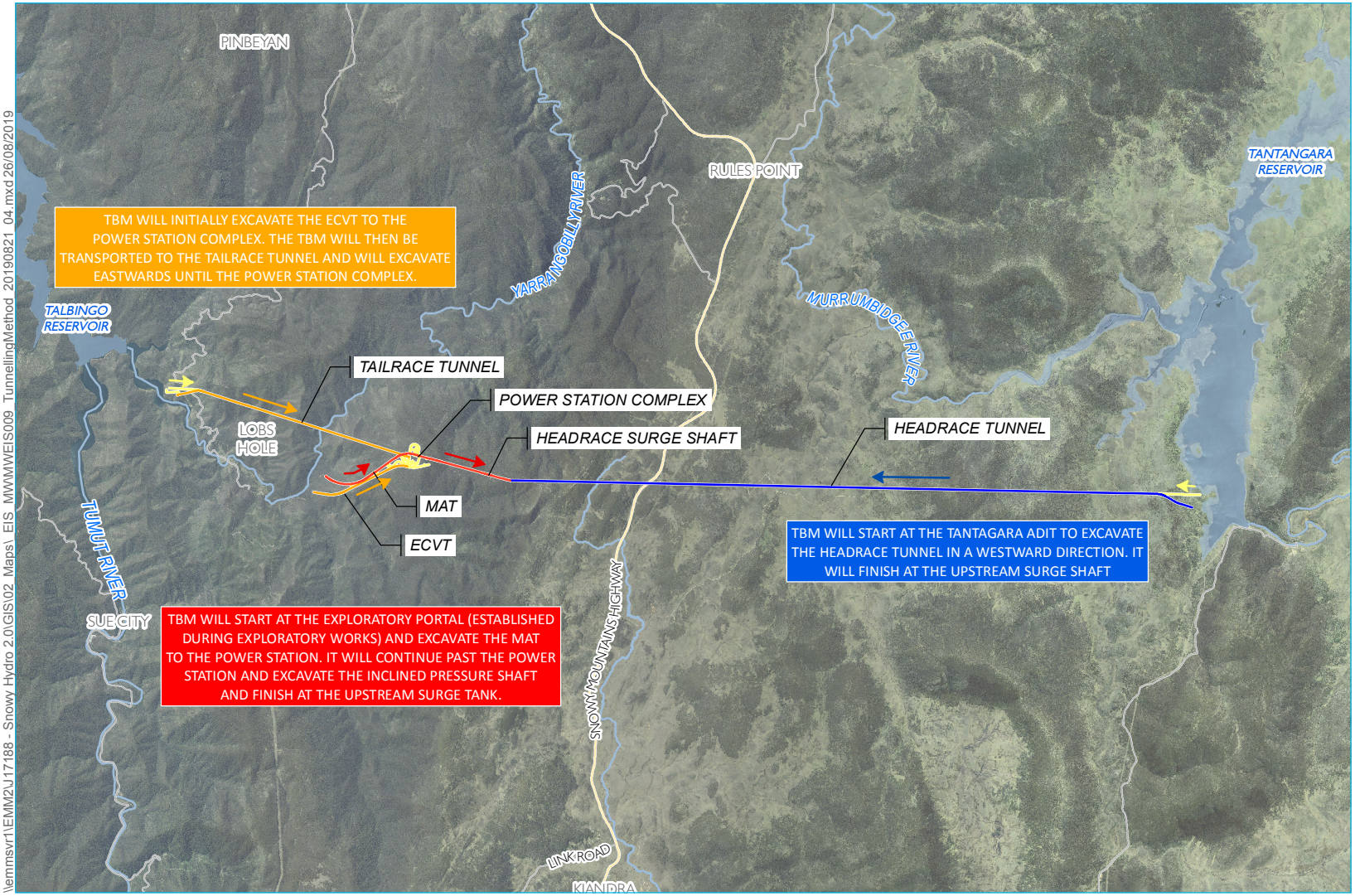
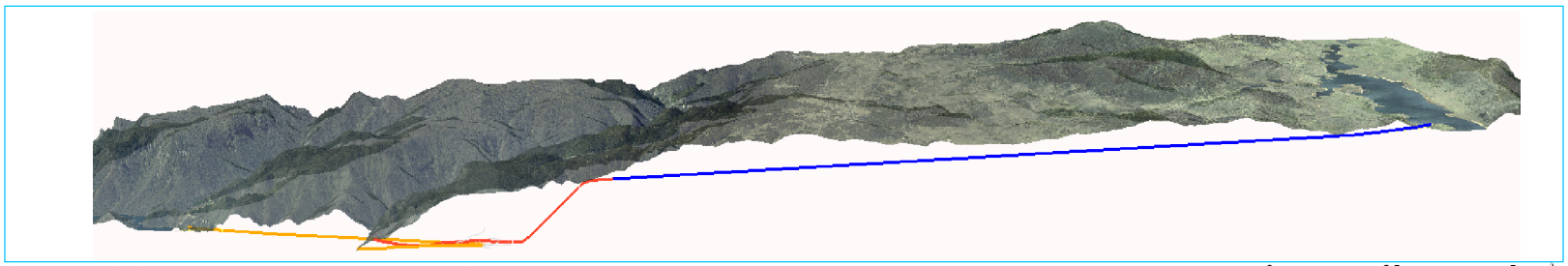


KEY

Tunnelling method
- Drill and blast
- TBM 1
- TBM 2
- TBM 3
- Tunnelling direction

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies



Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

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GDA 1994 MGA Zone 55

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Primary excavation methods – drill and blast and tunnel boring machine

Snowy 2.0
Soils and land assessment
Main Works
Figure 2.8

snowy 2.0

EMM creating opportunities

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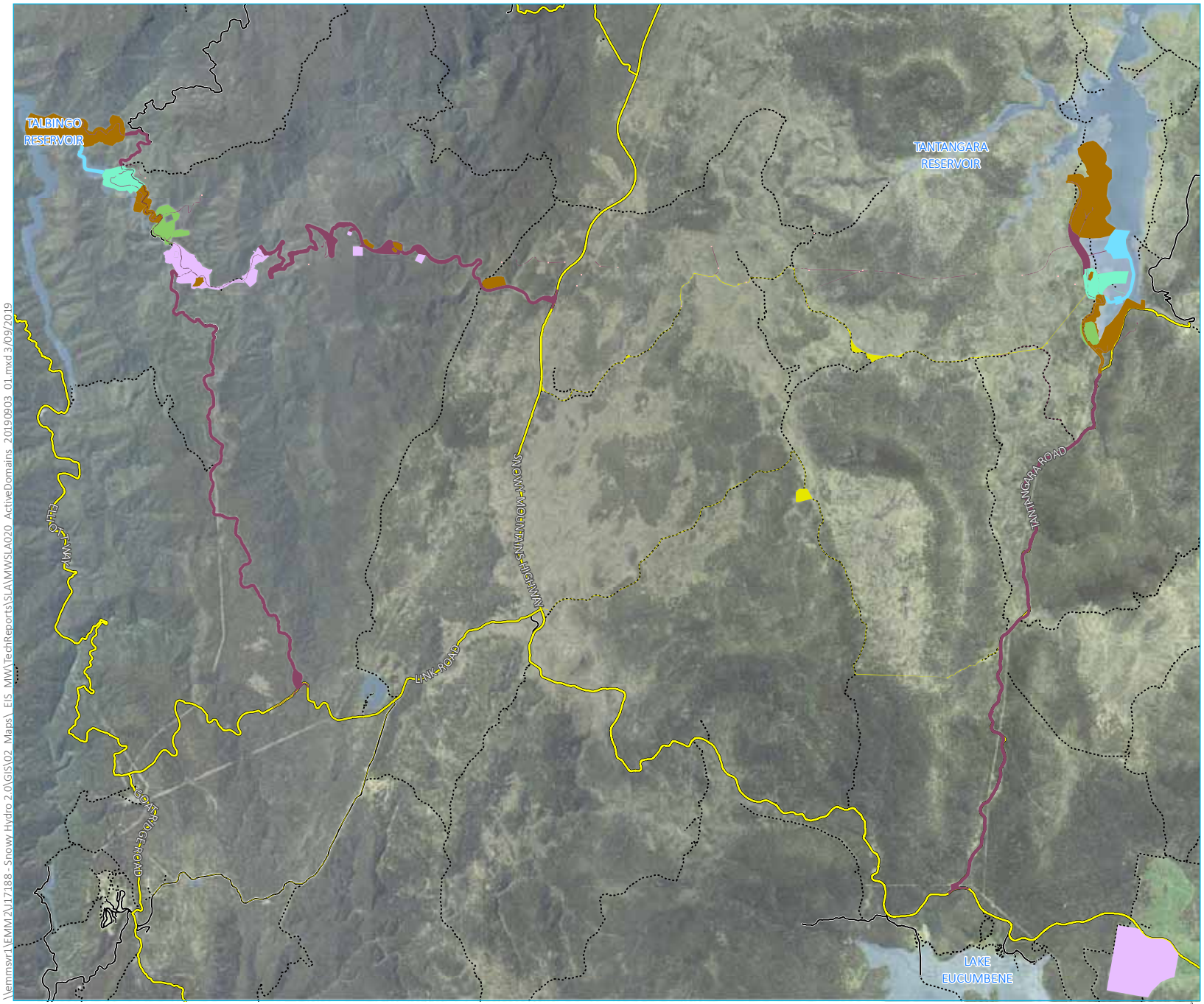

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Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); GA (2015); LPMA (2011)

Project active domains

Snowy 2.0
Soils and land assessment
Main Works
Figure 2.9

2.3 Operation of Snowy 2.0

2.3.1 Scheme operation and reservoir management

Snowy 2.0 would operate within the northern Snowy-Tumut Development, connecting the existing Tantangara and Talbingo reservoirs.

Tantangara Reservoir currently has the following operational functions within the Snowy Scheme:

- collects releases from the Murrumbidgee River and the Goodradigbee River Aqueduct,
- provides a means for storage and diversion of water to Lake Eucumbene via the Murrumbidgee-Eucumbene Tunnel, and
- provides environmental releases through the Tantangara Reservoir river outlet gates to the Murrumbidgee River.

Talbingo Reservoir currently has the following operational functions:

- collects releases from Tumut 2 power station,
- collects releases from the Yarrangobilly and Tumut rivers,
- acts as head storage for water pumped up from Jounama Pondage, and
- acts as head storage for generation at Tumut 3 power station.

Due to its historic relationship to both the upstream Tumut 2 power station and downstream Tumut 3 power station, Talbingo Reservoir has had more operational functions than Tantangara Reservoir in the current Snowy Scheme.

Following the commencement of the operation of Snowy 2.0, both Tantangara and Talbingo reservoirs will have increased operational functions. Tantangara Reservoir will have the additional operational functions of acting as a head storage for generation from the Snowy 2.0 power station and also acting as a storage for water pumped up from Talbingo Reservoir. Talbingo Reservoir will have the additional operational function of acting as a tail storage from Snowy 2.0 generation.

As a result of the operation of Snowy 2.0, the water level in Tantangara Reservoir will be more variable than historically. Notwithstanding this, operations will not affect release obligations under the Snowy Water Licence nor will it involve any change to the currently imposed Full Supply Levels (FSLs). No additional land will be affected by virtue of the inundation of the reservoirs through Snowy 2.0 operations. Water storages will continue to be held wholly within the footprint of the existing FSLs.

2.3.2 Permanent access

Permanent access to Snowy 2.0 infrastructure is required. During operation, a number of service roads established during construction will be used to access surface infrastructure including the power station's ventilation shaft, water intake structures and gates, and the headrace tunnel surge shaft. Permanent access tunnels (the MAT and ECVT) will be used to enter and exit the power station. For some roads, permanent access by Snowy Hydro will require restricted public access arrangements.

2.3.3 Maintenance requirements

Maintenance activities required for Snowy 2.0 will be integrated with the maintenance of the existing Snowy Scheme. Maintenance activities that will be required include:

- maintenance of equipment and systems within the power station complex, intake structures, gates and control buildings;
- maintenance of access roads (vegetation clearing, pavement works, snow clearing);
- dewatering of the tailrace and headrace tunnel (estimated at once every 15 to 50 years, or as required); and
- maintenance of electricity infrastructure (cables, cable yard, cable tunnel).

2.4 Rehabilitation and final land use

A rehabilitation strategy has been prepared for Snowy 2.0 Main Works and appended to the EIS.

It is proposed that all areas not retained for permanent infrastructure will be revegetated and rehabilitated. At Lobs Hole, final landform design and planning has been undertaken to identify opportunities for the reuse of excavated material in rehabilitation to provide landforms which complement the surrounding topography in the KNP.

Given that most of Snowy 2.0 Main Works is within the boundaries of the KNP, Snowy Hydro will liaise closely with NPWS to determine the extent of decommissioning of temporary construction facilities and rehabilitation activities to be undertaken following the construction of Snowy 2.0 Main Works.

2.5 Main Works active domains

The footprint of areas disturbed for project related activities are identified in active domains. This report uses the domains identified in the rehabilitation strategy defined as the set of discrete areas that have a particular operational or functional purpose and therefore have similar soil management and rehabilitation requirements. The footprint of each active domain is shown in Figure 2.9. The active domains are:

1. Infrastructure

Infrastructure is split into two sub-domains as follows:

1.1 Accommodation camps

This domain includes the proposed Lobs Hole accommodation camp for the Exploratory Works. For Main Works additional accommodation camps are proposed at Lobs Hole and Tantangara. Accommodation camps will provide accommodation and supporting services for the construction workforce.

1.2 Construction portals and yards

This includes the proposed construction yards on which construction facilities will be placed. Construction yards will typically be in the vicinity of construction portals where tunnelling is taking place within KNP and outside the national park boundaries at Rock Forest.

3. Access roads

This includes all proposed access roads either existing, upgraded or new roads associated with the project. The number of utilised and upgraded access roads will increase during the construction phase.

4. Intakes

This domain includes the proposed permanent intake structures situated on the banks of the Reservoirs which includes intake structures, tunnel boring machine (TBM) launching adits and gatehouses at the Talbingo and Tantangara reservoirs.

5. Stockpiles

This domain includes the temporary land emplacement areas (stockpiles) utilised for excavated material management.

6. Utilities

This domain includes the proposed disturbance corridors associated with the installation of the supporting utilities to service the project. This will include:

- power;
- water;
- sewage and process water treatment facilities; and
- communications.

It is noted that a number of utilities will be installed within existing access road corridors; in this case these areas are included in the Access Roads Domain.

7. Water Management

This domain includes the disturbance areas for the Talbingo and Middle Bay barge ramps and associated Middle Bay navigation channel. Works in these areas will include the construction of barge infrastructure and dredging to establish the navigation channel.

3 Soil assessment methodology

3.1 Overview of the assessment process

A field survey soil sampling program was not undertaken due to there being no available approval pathway to undertake soil sampling within the KNP during the EIS investigation phase. This soils and land assessment therefore relies on existing data both publicly available and collected through earlier phases of the project.

The soil assessment comprised the following steps:

- a desktop review of existing information including studies and surveys from previous phases of the project including geological and geotechnical investigations, preliminary soils and contamination investigations (incorporated into Section 4);
- a soils assessment using desktop information, including site and laboratory data and relevant reports, and enhanced resource assessment methodologies to identify soil types and their characteristics of the soils assessment area (Section 4);
- identification of the vulnerability of soils and land resources in the project area, which includes but is not limited to a soil erosion hazard assessment (Section 4 and Section 5); and
- an assessment of potential impacts on soil resources and proposed management and mitigation methods (Section 5 and Section 6).

The approach in this report concentrates on determining the vulnerability of soil types (or soil landscape units) to potential impacts and therefore focuses on recommending appropriate management measures intended to avoid/mitigate potential impacts. Although the management measures are not highly specific for different construction workspaces at this stage, their principles and requirements should be carried through to site-based management plans required for construction.

3.2 Desktop review

Existing information on soils and soil environments for the assessment area was sourced from regional mapping published by government departments and Snowy Hydro. The soils assessment area has a relative paucity of existing soils information due to its remoteness and/or difficult access and due to most of the Snowy 2.0 Main works being located within a national park. There have been a range of geotechnical and hydrogeological investigations for the project (refer to Section 0)which were also reviewed and soils information was incorporated into this report where relevant. The most relevant information was found in the following:

- *Soil profile attribute data environment (eSPADE) online database (OEH 2018g);*
- *Soils of the Australian Alps Factsheet* (Mason 2014);
- *Independent Scientific Committee; an assessment of the values of Kosciuszko National Park* (NPWS 2004);
- *Soil and land assessment Snowy 2.0 Exploratory works* (EMM 2018); and
- *Snowy 2.0 Feasibility Study* (SHL 2017).

Other broad scale studies and mapping reviewed includes:

- *Wagga Wagga 1:250,000 geological sheet* (Adamson & Loudon 1966);
- *Canberra 1:250,000 geological sheet* (Best et al. 1964);
- *Australian soil classification (ASC) soil type map of NSW* (OEH 2018a);
- *Great soil group soil type mapping of NSW* (OEH 2018b);
- *Hydrological soil group mapping* (OEH 2018c);
- *Inherent soil fertility mapping* (OEH 2018d);
- *Land and soil capability classes mapping* (OEH 2018e);
- *Atlas of Australian Acid Sulfate Soils* (Fitzpatrick et al. 2011);
- *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries)* 2007 (Mining SEPP) - *Strategic Agricultural Land Map of NSW* (DP&I 2013); and
- *NSW soil and land information system* (SALIS) (OEH 2018f).

The relevant information for this soils assessment report has been summarised and presented in Section 3.

3.3 Soils assessment

A review of resolution and quality of the existing soils mapping was undertaken using available site data for the project area. Existing mapping products such as the Atlas of Australian Soils, Digital Soil Mapping (DSMs) and the NSW state-wide soil type mapping (e.g. state-wide ASC and GSG mapping) all have significant limitations due to the source of their underlying data and the fact that they are broad scale studies which naturally are unable to provide any real focus on the soils assessment area which is the subject of this study.

Based on the limitation of the existing soils mapping referred to above, a desktop soils assessment was undertaken to identify and map the soils of the assessment area using an enhanced resource assessment approach with methodologies adopted from the *Guidelines for surveying soil and land resources* (McKenzie et al 2008). This approach uses the best available information, environmental correlation and expert interpretation to identify and map the different soil types and their characteristics.

The following is a description of the methodology used in the development of the soils map.

A range of datasets are available over the soils assessment area, which provide information or have correlations with pedogenic factors and processes. Data used to develop the new soils mapping included:

- soil sites from exploratory works and eSPADE (Soil reports included in Annexure A).
    - there was a total of 88 profiles in close proximity to or with similar geomorphic conditions as the soils assessment area. A total of 27 sites were used from the exploratory works survey;
- Exploratory works soils mapping (EMM 2018);
- Project geology and geotechnical reports (SMEC 2017, SMEC 2018a, SMEC 2018b, SMEC 2018c and SMEC 2018d);

- Soils of the Australian Alps fact sheet (Mason 2004) (https://theaustralianalps.files.wordpress.com/2013/11/soils.pdf);
- The NSW *NPWS Independent Scientific Committee; an assessment of the values of Kosciuszko National Park* (NPWS 2004);
- geology mapping at a scale of 1:250,000 (Wyborn *et al.* 1990);
- the vegetation of the Kosciuszko NP (SHL 2017);
- a digital elevation model from lidar data flown for the project (SHL 2017), with a pixel resolution of 1 m slope and contour data;
- aerial imagery (SHL 2018); and
- NSW state-wide mapping including the ASC layer (OEH 2018a).

The process used to develop the soils map involved the following steps:

1. The soil site data from the exploratory works phase and available profiles in eSPADE were converted into a spatial coverage with key attributes attached.
2. A spatial join was used to append the rock unit information from the regional geological mapping to each site.
3. A pivot table was used to interrogate the soil site and geology mapping to generate a list of the unique geology map codes and a list and count of the soil sites ASCs.
4. The geology coverage was clipped using the soil assessment area as the starting point for the new soils mapping layer.
5. The list of geology map codes and the soil site ASCs were joined back into the geology clip layer or what is now the new soils map. A summary of the tabular data is presented in Annexure B.
6. The exploratory work soils map was used where it overlapped with the main works area and extrapolated into nearby areas where there were similar geomorphic environments. Extrapolation was undertaken using the geology mapping, slope data, vegetation mapping and aerial imagery.
7. Areas outside the exploratory works mapping were refined where there were consistent clear differences in landform and / or vegetation.
8. Interpretation of the existing information to inform final map units ASC's and short description.
9. Identification of areas with Alpine Humus Soils or Peat Bog soils. This process used elevation and soils site data that identified fabric, hemic or sapric peat layers and information in the Independent Scientific committee assessment (NPWS 2004).

Based on the locations of the existing soil site data and limited laboratory analysis in some areas, with certain pedo-geomorphic conditions, are poorly represented and have been populated using expert interpretation of environmental variables. Therefore, the confidence level of the soil type map and soil properties vary across the assessment area.

The results of the soils assessment and mapping are presented in Section 4.6.2.

3.4 Framework for soil erosion hazard assessment

The soil erosion hazard can be assessed in a variety of ways from inherent soil erodibility to landscape processes, land management and the ability of land to recover.

For water erosion, soil erodibility is the susceptibility of the soil to detachment and transport by water and is primarily influenced by soil texture, aggregate stability and soil coherence. Soil erodibility classes based on soil morphology are presented in Table 3.1.

Table 3.1 Soil erodibility classes based on soil morphology (Hazelton and Murphy 2007, p52)

Erodibility	Topsoil	Subsoil
Low†	High organic matter (>3%) (soils have a dark colour and feel greasy when textured). High coarse sand.	Cemented layers including iron, manganese and silicon pans such as laterite, silcrete and ortstein. High coarse sand.
Moderate	Moderate organic matter (2–3%). Moderate fine sand and silt, such as hard, pedal red duplex soils. Well-structured clay loams and clays that slake in water to particles less than 2 mm in diameter (Emerson Aggregate Classes 3–6), such as black earths and cracking clays (Ug5.1, Ug5.2 and Ug5.3 soils or Vertosols).	Stable, non-dispersible loams and clay loams (Dr2 soils or Red Chromosols) such as red and yellow massive earths (Gn2.1 and Gn2.2 soils or Yellow Kandosols). Non-dispersible or slightly dispersible clays with particles that slake to finer than 2 mm diameter (Emerson Aggregate Classes 3–6), such as non-sodic, red and yellow soils (Dr, Db and Dy soils or Chromosols).
High	Low (1–2%) to very low (<1%) organic matter, such as soils with bleached A2 horizons. High to very high silt and fine sand (>65%).	Dispersible clays (Emerson Aggregate Classes 1 and 2) such as sodic, yellow and red soils (Dy3.4, Dr3.4, Dr2.3 soils or Sodosols). Unstable, dispersible clayey sands and sandy clays, such as yellow and grey massive earths formed on sandstone and some granites (Gn2.3, Gn2.8, Gn2.9, Dy5.8 soils or Yellow and Grey Kandosols). Unstable materials high in silt and fine sand, such as unconsolidated sediments and alluvial materials.

Notes: †Well-structured, non-dispersible clay loams and clays having aggregates that do not slake in water to particles less than 2 mm diameter (Emerson Aggregate Classes 4, 6, 7 and 8) such as red, smooth and rough-ped earths (Gn3, Gn4 soils or Dermosols), some cracking clays (Ug5.1, Ug5.2, Ug5.3 soils or Vertosols), some structured loams (Um6.1 soils, Dermosols) and friable duplex soils (Dr4, Db3 soils or Dermosols).

A soils potential to disperse is an important characteristic in assessing a soils erodilility as presented in Table 3.1. A dispersion hazard rating as an indicator of dispersion potential based on a range of soil parameters is presented in Table 3.2. The most commonly used parameters are Exchangeable Sodium Percentage (ESP) and Emerson class number.

Table 3.2 Clay dispersion hazard (IECA 2008)

Dispersion hazard rating	Emerson class number	ESP (%)	Ca:Mg ratio	Typical clay content (%)	Cation:clay ratio
Low	4-8	<6	>0.5	<10	<0.2
Moderate	3	6-15	0.5	10-30	>0.2
High	1-2	>15	<0.5	>30	>0.2

The inherent soil erodibility is only one factor influencing erosion hazard and there can be significant hazards from landscape processes with areas of steep slopes, long slope lengths, low surface cover and large disturbance activities. The sensitivity of the site to change and the ability to achieve a stabilized condition are also important considerations. A classification system for the overall degree of erosion hazard is presented in Table 3.3. Erosion hazard can also be assessed on individual factors and three commonly used factors and their associated hazard are presented in Table 3.4.

Table 3.3 Degrees of erosion hazard (Hazelton and Murphy 2007, p50)

Class of erosion hazard	Description of classes
Slight	The combination of slope, runoff/runon and erodibility is such that no appreciable erosion damage will take place.
Moderate	Significant short-term erosion will occur as a result of the combination of slope, soil erodibility, and runoff/runon factors. Control can be obtained with structural works, topsoiling, vegetative techniques and by phasing development.
High	Major erosion, and in some cases long-term erosion, can be expected to take place. Control of this erosion will require the adoption of intensive soil conservation works.
Very high	Major short-term and long-term erosion losses can be expected with this land. The combination of slope, soil erodibility and runoff/runon ratings make intensive soil conservation works necessary.
Extreme	Even with intensive short-term and long-term soil conservation works, significant erosion and soil loss would occur from this class of land.

Table 3.4 Erosion hazard parameters and recommended ratings (IECA 2008)

Site conditions during soil disturbance	Erosion hazard rating				
	Very low	Low	Moderate	High	Extreme
Average slope of disturbed area (%)	<3	>3 & ≤5	>5 & ≤10	>10 & ≤15	>15
Clay dispersion hazard[1]	Low	Low	Moderate	Moderate	High
Average monthly rainfall depth (mm)[2]	0-30	31-45	46-100	101-225	>225

Notes: 1. The clay dispersion hazard rating is based on Table 3-2
2. The average monthly rainfall depth (mm) should be determined as an average of the months during which soil disturbance is occurring, or scheduled to occur, whenever this time period is known; otherwise the annual average value shall be adopted.

Regolith erodibility is also a relevant aspect for the project given that much of the area is forest. Regolith is defined as weathered in situ and transported material overlying unweathered bedrock. Murphy et al. (1998) developed an estimate of regolith erodibility for NSW as a basis for predicting erosion and potential pollution of stream systems associated with forestry operations. The conceptual framework for regolith stability is presented in Table 3.5 whereby materials with the highest erodibility are those with low coherence and high potential for sediment delivery.

Table 3.5 Conceptual framework of regolith stability class (Hazelton and Murphy 2007, p54)

	Low sediment delivery	High sediment delivery
High coherence	R1 high ferro-magnesium regolith (basalt and dolerite) fine-grained argillaceous soil regolith with high gravel content (siltstones, metasediments) highly organic soil regolith (peats)	R3 fine-grained argillaceous (clay) soil regolith with low/no gravel content fine-grained massive soil regolith
Low coherence	R2 unconsolidated sands medium to coarse-grained feldspathic quartzose soil regolith (ademillite, quartz sandstone)	R4 unconsolidated deposits of silt and clay unconsolidated fine-grained weathered soil regolith (saprolite)

4 Existing environment

The project area is largely within the KNP which has Plan of Management (DEC 2006) for the management of the reserve to protect the values of the park. KNP is a conservation reserve with an overarching objective of protecting and conserving the broad range of values, many of national and international significance, that are contained in the park. The Plan of Management also recognises the existence and continued operation of, the Snowy Scheme.

Soils are an important part of most ecosystems and are the medium through which many conservation management measures operate.

The soil and land resources have a significant role in contributing to these park values directly as unique and significant soils and landform features and indirectly through the provision of a range of ecosystem services including provision of clean water and flow attenuation, suitable habitats for insect fauna and substrate for significant ecological communities.

Soils have a role in providing a supply of clean water for a wide range of downstream uses including, recreation, domestic and industrial uses, irrigation and hydroelectric power. The upland soils that process snow melt in particular receive, store, process and supply a large quantity of high-quality water as do the soils of the surrounding mountain forests (NPWS 2004).

Soils have an ability to absorb nutrients and sediment to the benefit of catchment water supply, but it does not necessarily benefit other park values. Nutrients in human urine and faeces, especially phosphorus, can persist for years in recipient soils, which may be colonised by weeds (NPWS 2004).

Surface soil conditions, including cover, are necessary for non-erosive infiltration of precipitation and prevention of erosive surface run-off.

The soil conditions in the subalpine areas promote abundant insect fauna in KNP (some 850 recorded species) (NPWS 2004).

4.1 Climate

Long term climatic data for the site was obtained from the Bureau of Meteorology (BoM) weather stations at Tumbarumba Post Office (645 m Australian Height Datum (AHD)) (Station no. 72043) and Cabramurra SMHEA AWS (1482 m AHD) (Station no. 72161) (BoM 2018) and used to characterise the local climate. The two stations were used to capture the variation in elevation at the site and are approximately 37.2 km apart. Figure 4-1 and Figure 4-2 shows the mean rainfall and maximum and minimum temperatures recorded in Tumbarumba Post Office (645 m AHD) and Cabramurra SMHEA AWS (1482 m AHD) respectively. Mean maximum temperatures range from 28.9°C (645 m AHD) to 21.5°C (1482 m AHD) in January. Mean minimum temperatures range from -0.1°C (645 m AHD) to -0.9°C (1482 m AHD) in July.

Rainfall is winter dominant with the wettest winter month resulting in approximately double the rainfall of the driest summer month. With a winter dominant rainfall, soils will be at their wettest over winter until they dry out in the spring with the drier conditions and warmer temperatures. Both stations have approximately the same relative monthly rainfall distribution, but Cabramurra receives approximately 200 mm more rainfall each year. Even though Cabramurra receives a higher annual rainfall this rainfall is less intense based on the 2016 Intensity-Frequency-Duration (IFDs) design rainfall events. The amount of rainfall and its intensity has a significant effect on the risk of soil erosion. Lobs Hole does not receive much snow and it is not persistent.

The snow season typically ranges from June to October and with falls most persistent above elevations of around 1,400 m AHD (Snowy Hydro Limited 2017). In these areas much of the annual rainfall is in the form of snow. In spring snow melt will run into creeks and rivers, with soils, particularly the peats and bogs, having an important role in the storage and attenuation of water flows.

The most common winds on an annual basis are from the north, north-west and west directions. Wind speeds during the warmer months have a similar spread between the reported 9 am and 3 pm conditions when compared to the colder months (Table 4-1). Higher elevation areas tend to have higher wind speeds throughout the year by approximately 9 kilometres per hour (km/hr). At 1482 m AHD, mean 9 am wind speeds range from an average low of 14.8 km/hr in February and average high of 18 km/hr in October while mean 3 pm winds range from 15.4 km/hr in May to 21.7 km/hr in October.

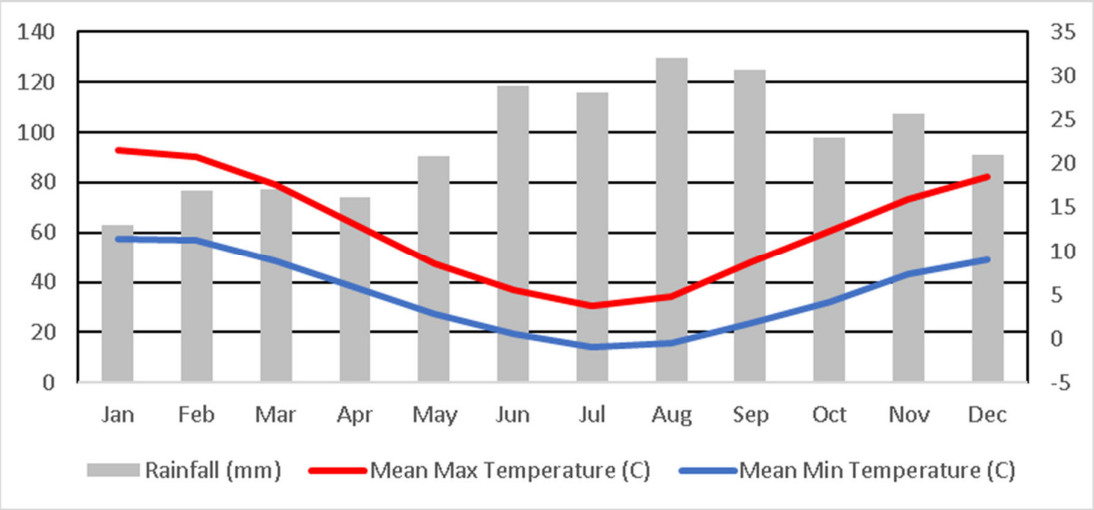


Figure 4.1 Mean rainfall and temperature in Cabramurra SMHEA AWS (Station 72161) 1996 to 2018

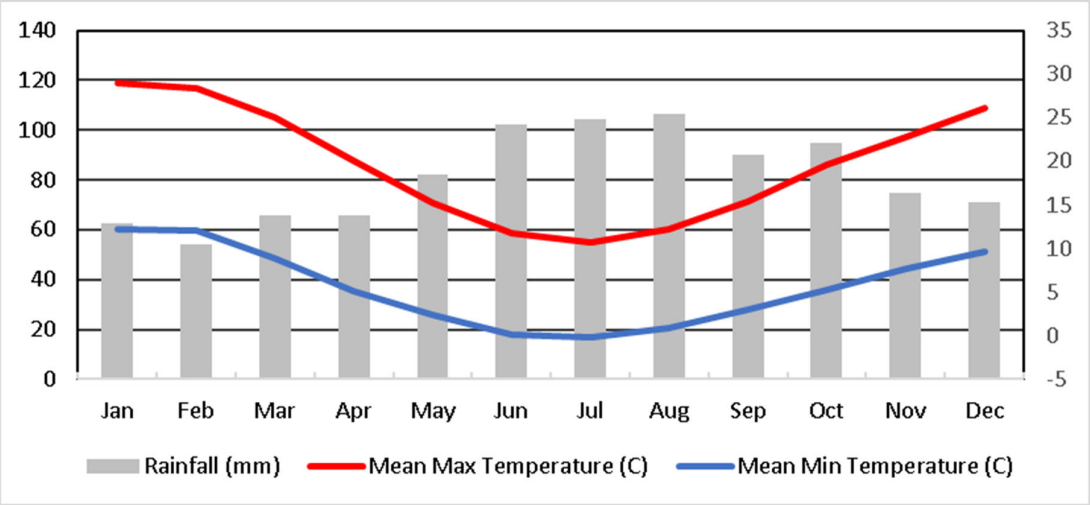


Figure 4.2 **Mean rainfall and temperature in Tumbarumba (Station 72043) 1885 to 2018**

Table 4.1 **Wind speed data**

	072161 CABRAMURRA SMHEA AWS (Mean wind speed (km/h) for years 1996 to 2010)		072043 TUMBARUMBA POST OFFICE (Mean wind speed (km/h) for years 1965 to 2010)	
	9am	3pm	9am	3pm
January	15.3	18.9	6.9	9.6
February	14.8	17.8	5.9	9
March	15.4	17.9	5.6	8.4
April	15.3	16	5.4	7.1
May	15.6	15.4	4.7	6.4
June	17	15.8	4.5	7
July	16.5	16.2	5.2	7.9
August	16.8	18.3	6.5	9.2
September	17.7	20.6	7.5	10.4
October	18	21.7	8	10.2
November	16.7	19.5	7.5	10.3
December	15.2	19.8	7.4	9.8

4.2 Topography and hydrology

Elevation across the soil assessment area ranges from about 550-1450 m AHD. The topography of the area is shown in Figure 4.3 and the slopes of the area are shown in Figure 4.4. Slope and slope length are major factors affecting the risk of soil erosion and although the majority of works sites are gently sloping the steep slopes (>15%) in some areas of the project result in an extreme soil erosion hazard rating (Table 3.4). Through the design process, infrastructure has been positioned on flatter areas within the topographic constraints of the Main Works sites.

The soil assessment area is located within two markedly different terrains; the Kiandra Tablelands (the plateau) and the Ravine area (Lobs Hole, Marica and Talbingo Reservoir project areas). The Kiandra Tablelands are represented by mature undulating tablelands in the central and eastern portion of the Project Area. The Ravine area consists of steep valleys and ravines of the Yarrangobilly River and tributaries primarily in the western portion of the Project Area (SMEC 2018a).

These two main terrains are separated by an escarpment that trends north-northeast, perpendicular to the tunnel alignment. This escarpment is coincident with the mapped trace of the Long Plain Fault and is accepted as marking the surface trace, as documents on published geological mapping (Wyborn *et al* 1990).

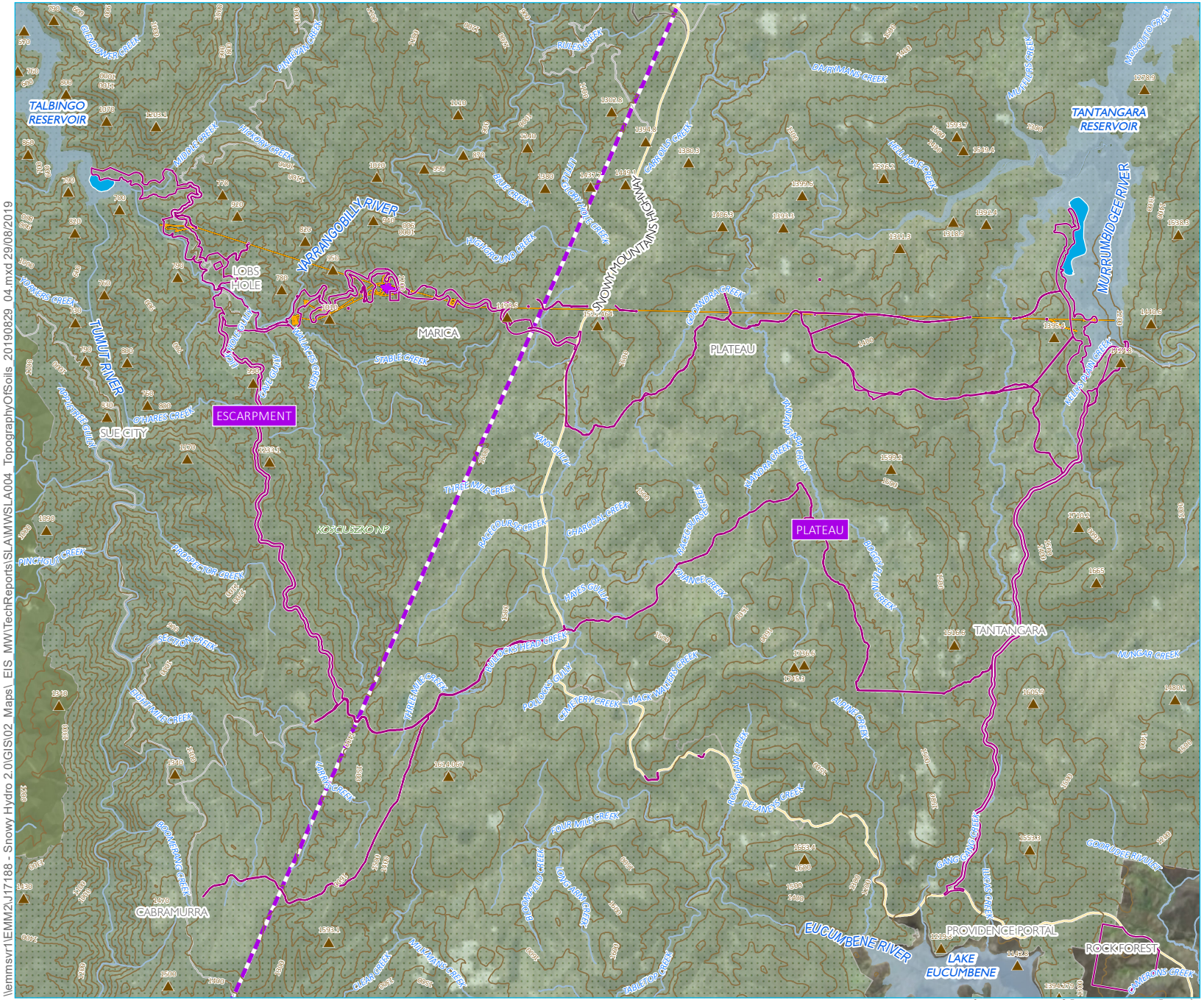
The soil assessment area is bisected by the Snowy Mountains Highway, which connects Adaminaby and Cooma in the south-east to Talbingo and Tumut to the north-west. The project also spans the NSW Western Slopes, South Eastern Highlands and Australian Alps Interim Biogeographic Regionalisation for Australia (IBRA) regions.

The Lobs Hole and Marica project areas are within a steeply incised ravine and along the western fringe of the Long Plains fault escarpment. Most of this area is characterised by deep gorges and steep sloping ridges, the product of incision from watercourse flow and glaciations, with localised areas of lower grade, such as ridgelines, saddles, benches, and alluvium beside watercourses.

The central and eastern part of the soils assessment area (generally east of the Snowy Mountains Highway) are drained by creeks flowing into the Murrumbidgee River (Gooandra Creek, Tantangara Creek and Nungar Creek). The Eucumbene River drains a narrow region of the Project Alignment between Wallaces Creek Fire Trail and the Snowy Mountains Highway (SMEC 2018a). The subalpine plateau that includes the Tantangara project area has had a complex geomorphic history resulting in a landscape of disrupted drainage patterns, swampy basins and erosion surfaces. The Rock Forest site, situated outside the boundary of KNP, is located on relatively gentle slopes.

The majority of Snowy 2.0 project is located between the Tantangara and Talbingo Reservoirs, within the catchments of the Yarrangobilly, Eucumbene and Murrumbidgee rivers. Receiving waters include the Yarrangobilly, Eucumbene, Tumut and Murrumbidgee Rivers and some of their tributaries, and the Talbingo and Tantangara Reservoirs.

The rivers and their tributaries include a variety of watercourse typologies, including ephemeral bogs and fens, minor watercourses and major regional rivers.



KEY

- Spot height - trig station (all elevations in mAHD)
- Soils assessment area

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Indicative rock emplacement

Existing environment

- Main road
- Local road
- Watercourse
- Contour (100 m)
- Waterbodies
- Indicative Plateau escarpment boundary
- Kosciuszko National
- State forest

Source: EMM (2019); Snowy Hydro (2019); FGJV (2019); DFSI (2017); LPMA (2011)

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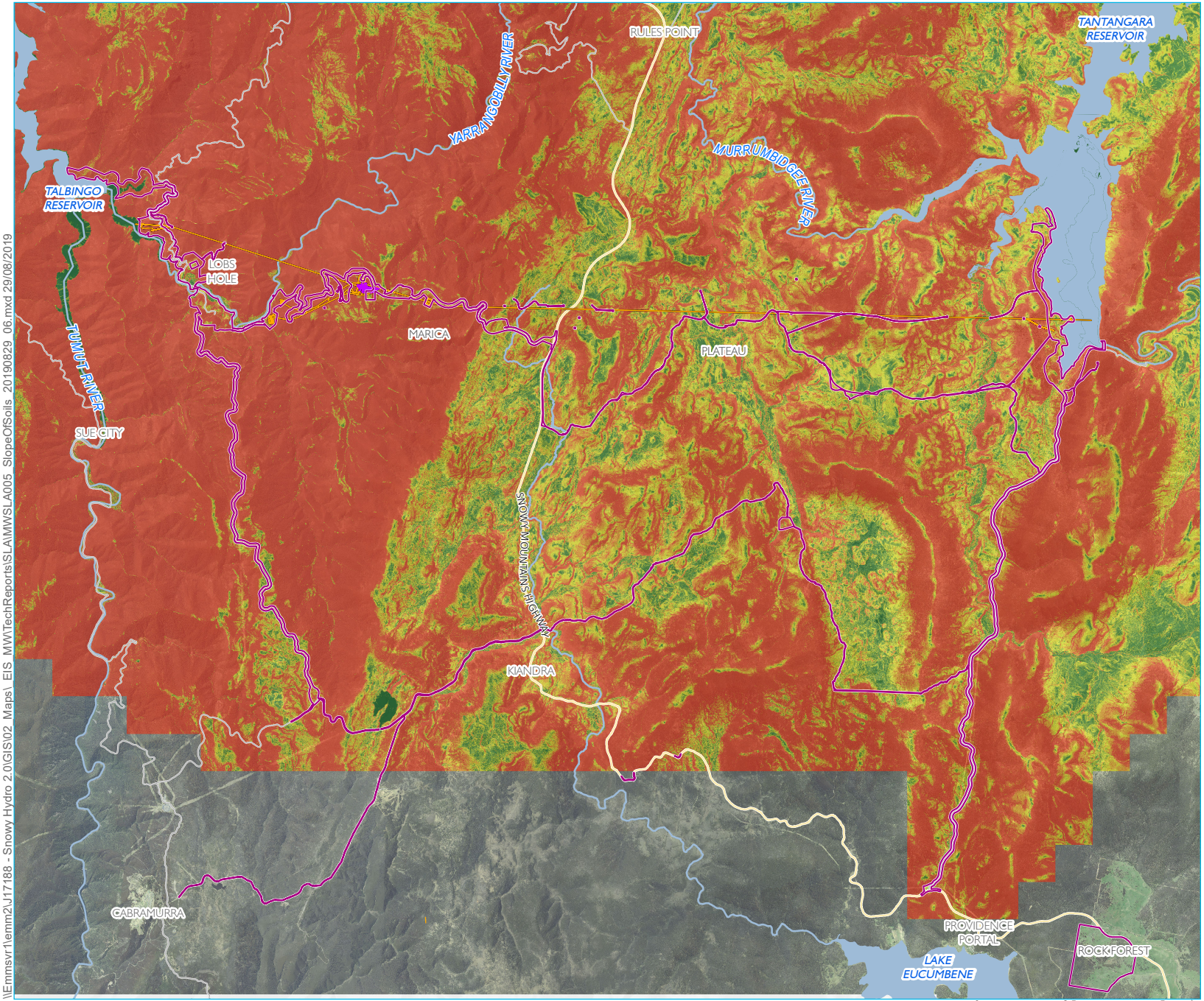
Topography of the soils assessment area

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.3

snowy 2.0

EMM creating opportunities



KEY

- Soils assessment area

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station

Slope percent (erosion risk)

- 0-3 %
- 3-5 %
- 5-10 %
- 10-15 %
- >15 %

\\Emmsvr1\emm2\J17188 - Snowy Hydro 2.0\GIS\02 Maps\ EIS MWTechReports\SLA\MWSLA005 SlopeOfSoils 20190829 06.mxd 29/08/2019

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

Slope of the soils assessment area

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.4

snowy 2.0

EMM creating opportunities

4.3 Land use and vegetation

The soil assessment area is located mostly within the KNP, which encompasses 6,735 km^2 and is the largest national park in NSW. The park is approximately 150 km in length, running from the Victorian border to the Australian Capital Territory border west of Namadgi National Park. The soils assessment area is mapped as Back Country in the KNP Plan of Management (DEC 2006). Most of Snowy Mountains Hydro-electric Scheme operational infrastructure is located within the Back Country Zone (DEC 2006). It includes parts of the park that have limited public vehicular access and not included in declared wilderness areas which contain vehicular trails that are retained for management purposes. The remaining construction sites are within existing major and minor road corridors.

The nearest large towns to the Main Works are Cooma and Tumut. Cooma is approximately 95 km south-east of Talbingo Reservoir. Tumut is approximately 45 km north of Talbingo. There are several communities and townships near the soil assessment area including Talbingo, Cabramurra, Adaminaby and Tumbarumba.

Previous land uses and impacts within KNP began with thousands of years of active use of the area by Aboriginal peoples. The early explorer-settlers arriving in the 1820s and have included activities undertaken under snow leases/permissive occupancies, mining, former engineering operations of the Snowy Mountains Hydro-Electric Authority (SMHEA) and recreational use. Lobs Hole has been used since the early 1800s for grazing, settlement, agriculture, copper mining and recreation. Bushfire has had the most widespread pressure on the soils in KNP, as it can destroy or reduce the protective ground cover leading to erosion (NPWS 2004). A bushfire risk and hazard assessment is appended to the EIS. Introduced animals such as wild horses, rabbits, pigs and deer also heavily impact some areas where their numbers are concentrated and by the trampling of fragile landscapes.

Mining activities have been undertaken in the assessment area since gold discovery in 1859, in the Kiandra area. The ensuing gold rush saw over 10,000 miners flock to the region however, the alluvial deposits and associated leads were quickly exhausted and mining of any significant volume ceased in the area by 1937 (SMEC 2017).

Historical copper mines at Lobs Hole and Blue Creek are indicated in the Kosciuszko National Park Geology Sheet Wyborn et al. 1990). Blue Creek Copper Mine opened in 1910, following a copper-rich lode into the hillside for an unverified distance of 800 feet. The mine is situated within a deep gorge adjacent to the Yarrangobilly River, about 3.5 km north of the Project Alignment. The last record of production was in 1949 (unknown source). The former Lobs Hole Copper Mine is within Lobs Hole and southwest of the proposed MAT and ECVT, and is understood to have also yielded silver and gold. Unverified records indicate that the mine was operational between 1874 and 1916, producing 1,600 tonnes of copper in the on-site smelter. Numerous shafts are visible in the surrounding area. At its peak, the Lobs Hole area housed up to 500 people (Moreton and England, 2012).

The vegetation communities across the soils assessment area are strongly related to elevation, landform and geology. The western side of the assessment area down into Lobs Hole and Talbingo Reservoir consists of montane tableland forests and dry grass/shrub forests and ash eucalypt forests near the top of the western escarpment. On the Plateau and Tantangara Reservoir there is a mix of sub-alpine grasslands and sub-alpine low forests, with small pockets of montane table forests and montane/sub-alpine sedge swamps in some of the major drainage systems.

4.4 Geology

The geology of the soils assessment area consists of a wide range of rock types from sediments, metamorphosed sediments and intrusive and extrusive volcanics. The geology is shown in Figure 4.5 and a description of the mapped geological units is presented in Table 4.2. Comprehensive geological and geotechnical information for the project area is presented in the *Engineering Geology Assessment Report* prepared by SMEC (2017).

The SMEC (2017) geology assessment reported that the soils assessment area is:

> ”within the south-eastern portion of the Lachlan Orogen (Fold Belt) (Stuart Smith, 1991), which comprises a suite of Ordovician age (485 Million years to Devonian 359 Million years) sedimentary, igneous and metamorphic rocks that have developed during several orogenic periods associated with extensive faulting forming major geotectonic structures through the area (Owen and Wyborn, 1979a; Wyborn et al, 1990). During the Cenozoic Era, basaltic volcanism and faulting resulted in differential uplift which affected the development of the drainage system and geomorphology throughout the region (Sharp, 2004).”

The geology of the plateau area comprises granites that have formed faulted, stepped ranges at the point where the South Eastern Highlands in NSW turn west into Victoria (NPWS 2003). The South Eastern Highlands are part of the Lachlan Fold Belt that runs through the eastern states as a complex series of metamorphosed Ordovician to Devonian sandstones, shales and volcanic rocks intruded by numerous granite bodies and deformed by four episodes of folding, faulting and uplift. The general structural trend in this bioregion is north-south and the topography strongly reflects this (NPWS 2003). The area between Talbingo and Tantangara reservoirs is structurally deformed, with numerous folds and several major faults associated with the north-south trending Long Plain Fault. Long Plain Fault – forms the western boundary of the Tantangara Block and the plateau. The fault trends in a north-northeast direction over a distance of more than 200 km, from the Upper Murray River to west of the Brindabella Ranges near Canberra.

Overlying the older Ordovician to Devonian units, a regionally extensive weathered zone is assumed to exist consisting of a mixture of colluviums, regolith and weathered basement rocks. More recent Tertiary volcanic activity produced basaltic flows that are mostly reflected in the current landscape as residual caps on ridgelines.

In the Pleistocene Era the cold climate superimposed glacial features on the landscape. The Australian Alps bioregion was the only part of the mainland to have been affected by Pleistocene glaciation and contains a variety of unique glacial and periglacial landforms above 1,000 m AHD (NPWS 2004). Landform features include frost-shattered bedrock, boulder fields, solifluction deposits, stone streams, stone-banked lobes, non-sorted steps and nivation features. Solifluction often produces smooth slopes through the downslope movement of unconsolidated rock debris by freeze-thaw processes, interstitial ice and snow melt. Nivation are complex land-forming processes found in and around long-lasting snow patches, particularly where the ground surface is bare (NSWP 2004).

The geology of the ravine area consists mostly of marine deposits of shale, slate, greywacke, siltstone, limestone and conglomerate of the Ravine Beds, Byron Range Groups and Yarrangobilly Limestone. These are overlain by the Devonian Boraig (rhyolite), Gooandra Volcanics (Ordivician basalts) and Tertiary basalts at the top of Ravine Road. As part of the Tumut Trough, moderate folding and some faulting of the beds leads to relatively short-range outcropping of different lithologies. The Yarrangobilly Limestone is present as massive karstic limestone beds along the eastern limit of the Ravine Group (SMEC 2017). The *Kosciuszko National Park Plan of Management* (DEC 2006) outlines a geodiversity (non-living component of the park) conservation strategy aimed at protecting all rocks, landforms and soils at risk of degradation. The plan identifies scree slopes, which occur along the Lobs Hole Ravine Road, as having geodiversity value for KNP.

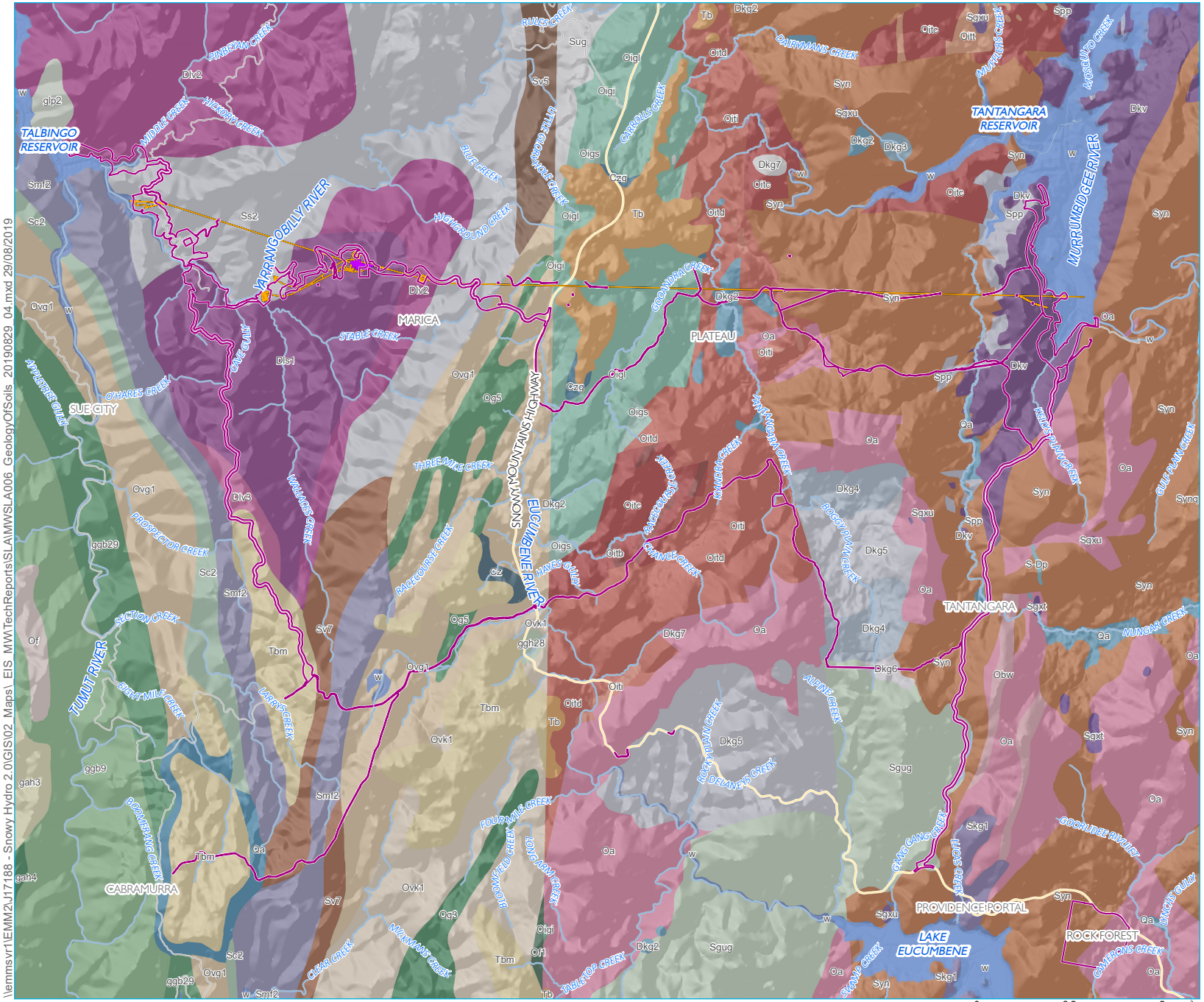
The *Wagga Wagga 1:250,000 geological sheet* (Adamson & Loudon 1966) and *Canberra 1:250,000 geological sheet* (Best et al. 1964) outline surface geological units found within the soil assessment area. Surficial geology and its contribution as the parent material is usually the dominant factor in soil formation in Australia.

Table 4.2 Geological units intersected by the soils assessment area

Symbol	Unit name or Group	Age (Period)	Dominant lithology	Description
Dkg2	Boggy Plain Suite	Devonian	granodiorite, gabbro	I-type granitoids; even grained texture, mostly granodiorites and quartz monzogabbros
Dkg4	Hell Hole Creek Adamellite	Devonian	granodiorite	Granodiorite, minor quartz gabbro
Dkg5	Boggy Plain Adamellite	Devonian	adamellite	Phase 2: Adamellite
Dkg6	Boggy Plain Adamellite	Devonian	gabbro	Phase 3: Gabbro, quartz gabbro, minor granodiorite
Dkv	Kellys Plain Volcanics	Devonian	ignimbrite, tuff, agglomerate, rhyolite	Dacite ignimbrite, rhyodacite ignimbrite, tuff, agglomerate, rhyolite
Dls1	Byron Range Group	Devonian	conglomerate, sandstone, shale & nodular limestone	conglomerate, sandstone, shale & nodular limestone
Dlv2	Boraig Group	Devonian	rhyolite, tuff, sandstone, granophyre	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre
Dlv3	Mountain Creek Volcanics	Devonian	rhyolite, tuff, sandstone, granophyre	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre
Oa	Adaminaby Group	Ordovician	sandstone, mudstone, shale, quartzite, phyllite, slate	Turbiditic sequence; sandstone, mudstone, shale; quartzite, quartz phyllite, phyllite, slate
Og5	Shaw Hill Gabbro	Ordovician	gabbro, diorite, basic intrusive, pyroxenite	Gabbro, diorite, metabasic intrusives, pyroxenite
Oigl	Gooandra Volcanics	Ordovician	basalt, breccia, lava, rhyolite, shale	aphyric and feldsparphyric basalt, lava breccia, pillow lava, rhyolite, shale
Oitb	Temperance Formation	Ordovician	agglomerate	Agglomerate, minor tuff and chert
Oitc	Temperance Formation	Ordovician	chert	Bedded chert, minor basaltic tuff
Oitd	Temperance Formation	Ordovician	tuff, chert, arenite	Interbedded basaltic tuff, chert, and feldspathic arenite, minor agglomerate
Oiti	Temperance Formation	Ordovician	monzonite, hornblendite, lamprophyre, monzonite	Monzonite, hornblendite, lamprophyre, quartz monzonite
Ovg1	Gooandra Volcanics	Ordovician	basalt, amphibolite, schist, sandstone	Metabasalt, basalt breccia, pillow lavas, amphibolite, chloritic schists, feldspathic sandstone
Ovk1	Kiandra Group	Ordovician	basalt, agglomerate, sandstone, chert	Basaltic lavas, agglomerate, sandstone and chert

Table 4.2 Geological units intersected by the soils assessment area

Symbol	Unit name or Group	Age (Period)	Dominant lithology	Description
Qa	undifferentiated	Quaternary	alluvium, gravel, sand, silt, clay	Alluvium, fluvial deposits: gravel, sand, silt and clay
Sgug	Gang Adamellite	Silurian	adamellite, leucogranite	Biotite-muscovite adamellite, sodic leucogranite
Smf2	Jackalass Slate	Silurian	sandstone, siltstone, shale	Sandstone, siltstone and shale (turbiditic)
Spp	Peppercorn Formation	Silurian	conglomerate, arenite, siltstone, shale	Basal conglomerate, overlain by arenite, siltstone and cleaved shale, with minor limestone lenses
Ss2	Ravine Beds/Yarrangobilly Limestone	Silurian	limestone, sandstone, siltstone, shale	Limestone, sandstone, siltstone and shale
Sv7	Kings Cross Formation	Silurian	dacite, ignimbrite	Porphyritic dacite and rhyodacite ignimbrite, rare dacite lava, tuff and agglomerate
Syn	Tantangara Formation	Silurian	sandstone, siltstone, shale	Coarse to fine quartz sandstone, siltstone and shale, grading from proximal flysch in west to distal flysch in east
Tbm	unnamed	Tertiary	basalt	Basalt



Source: EMM (2019); Snowy Hydro (2019); FGJV (2019); DFSI (2017); LPMA (2011)

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Geology of the soils assessment area

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.5

snowy 2.0

EMM
creating opportunities

4.5 Salinity

Surface waters within the KNP waterways have typically low salinities (NPWS 2004). Samples from the exploratory works soil survey found that the salt levels in all soils was very low (DERM 2011), with chloride below the limit of reporting. No salt affected land was mapped within Snowy River Shire by DNR including during their salinity mapping program within NSW, between 2000 and 2005 (http://reports.envcomm.act.gov.au/SoE2004/SnowyRiver/landdegradation.htm).

Groundwater across the soils assessment area consists of shallow systems in peats/bogs and other localised unconsolidated materials and deeper groundwater associated with deeper fractured rock (i.e. Ravine Beds). Salinity levels are expected to be low in shallow groundwater areas where the groundwater is readily recharged via rainfall and snow melt.

In the deeper groundwater systems, located within a variety of fractured rocks that are part of the Lachlan Fold Belt, the water quality results are reasonably comparable between the different target formations across the soils assessment area. Salinity varies from fresher (201 µS/cm) to the east of Long Plain Fault across the plateau area and marginal (780 µS/cm) west of the fault, within the Ravine Beds and the soils assessment area.

There is no evidence to suggest that salinity is an issue within the soils assessment area.

4.6 Soils

4.6.1 Published Regional Soils Data

Existing published soils information used in this assessment has been summarised below including, information from the NPWS (broad soil types and a factsheet Soils of the Australian Alps), eSPADE soil profiles and NSW state-wide mapping series. and. The state-wide maps produced by OEH that include dominant soil types (Australian Soil Classification (ASC) and Great Soil Group (GSG)), dominant Land and Soil Capability (LSC), dominant Inherent Soil Fertility and Hydrologic Soil Group.

The different sources of information can be used to build up a picture on the nature and distribution of soils in the project area and therefore potential project impacts or risks. The most accurate local soils data (not withstanding the competency of the surveyor) is from soil sites and this was a key data set in the desktop soils mapping. The various datasets are presented below.

i Soils KNP data

a KNP Great Soil Groups

The Independent Scientific committee assessment (NPWS 2004) includes a map of GSGs for KNP that was prepared by NSW NPWS in 2002. Based on this mapping the main soils types of the major project work areas are brown podzolic soils for Talbingo Reservoir and Lobs Hole, red loams for Marica, red loams, transitional alpine humus soils and alpine humus soils across the plateau and alpine humus soils at the Tantangara Reservoir.

b Soils of the Australian Alps factsheet

The Australian Alps National Parks Co-operative Management program published a factsheet which outlines soil types found in the Australian Alps as well as the characteristics of these soil types (Mason 2014). These are summarised in Table 4.3.

Table 4.3 Soil types within the Australian Alps National Parks (Mason 2014)

Soil type	Duplex	Friable gradational loams and brownish gradational loams	Alpine humus loams	Peats	Lithosols
ASC equivalents	Chromosols, Kurosols	Dermosols, Kandosols	Kandosols, Tenosols	Organosols	Tenosols, Rudosols
Description	Two distinct horizons: a sandy loam or hard-setting loam overlaying a heavy clay horizon. They are found on the lower slopes and tableland areas adjacent to the Australian Alps.	Lower Montane: loams gradually merging into clay with depth. Upper Montane: deep friable loams. Highly porous and friable, these soils are found on the steep slopes of the montane zone.	Shallow, very friable loams. The most extensive soil type found in the subalpine and alpine zones, occurring on relatively sheltered, gentle, well-drained slopes. The surface is highly organic with strong plant root development. Highly porous and friable.	Found in basins and depressions where water collects all year round. They are highly organic and contain undecomposed and partially decomposed plant remains.	Very shallow loams found in pockets on high exposed ridges and elevated stony slopes. They have a lower organic content than alpine humus loams and are highly porous.
Surface colour	Yellow to grey-brown	Brown to grey-brown	Dark brown	Black	Light brown
Organic content (A horizon)	Medium	Medium high	High	Extremely high	Medium high
Clay content	Low in A horizon. High in B horizon.	Low in A horizon. Medium in B horizon.	Low	Low	Low
Depth	Medium	Deep	Medium	Medium	Shallow
Coarse fragments	Very few	Few	Many	Many	Many
pH	6-7	5-6	4-5	4	4-5
Origin	In situ weathering of parent materials with some deposition of soils above.	Weathering of bedrock, some deposition of soils from above and the breakdown of plant remains. Wetter and cooler conditions produce deeper soils and a greater accumulation of organic material.	Weathering of bedrock and intense biological cycling in the upper layers.	An accumulation of undecomposed and decomposed plant remains. Water-logged environment and low temperatures restrict decomposition of organic matter.	Weathering of bedrock under extremes of cold, heat, wind and precipitation.
Associated vegetation communities	Open woodlands, mixed eucalypt forest.	Tall open forests (wet), open forests (dry).	Tussock grasslands, alpine herbfields, Snow gum woodlands.	Sphagnum bogs.	Shrubby heathland, herbfield feldmark.

ii eSPADE soil profiles

The eSPADE soil profile database search identifies information on soil profiles surveyed in the region and submitted to the SALIS database (OEH 2018f). There are 61 profiles that occur in proximity to the soils assessment area with similar pedogenic conditions. The soil reports for these eSPADE soil profiles are presented in **Annexure A**. The sites are described in detail, but no laboratory data is available. Key information for each site is also tabulated in **Annexure B**.

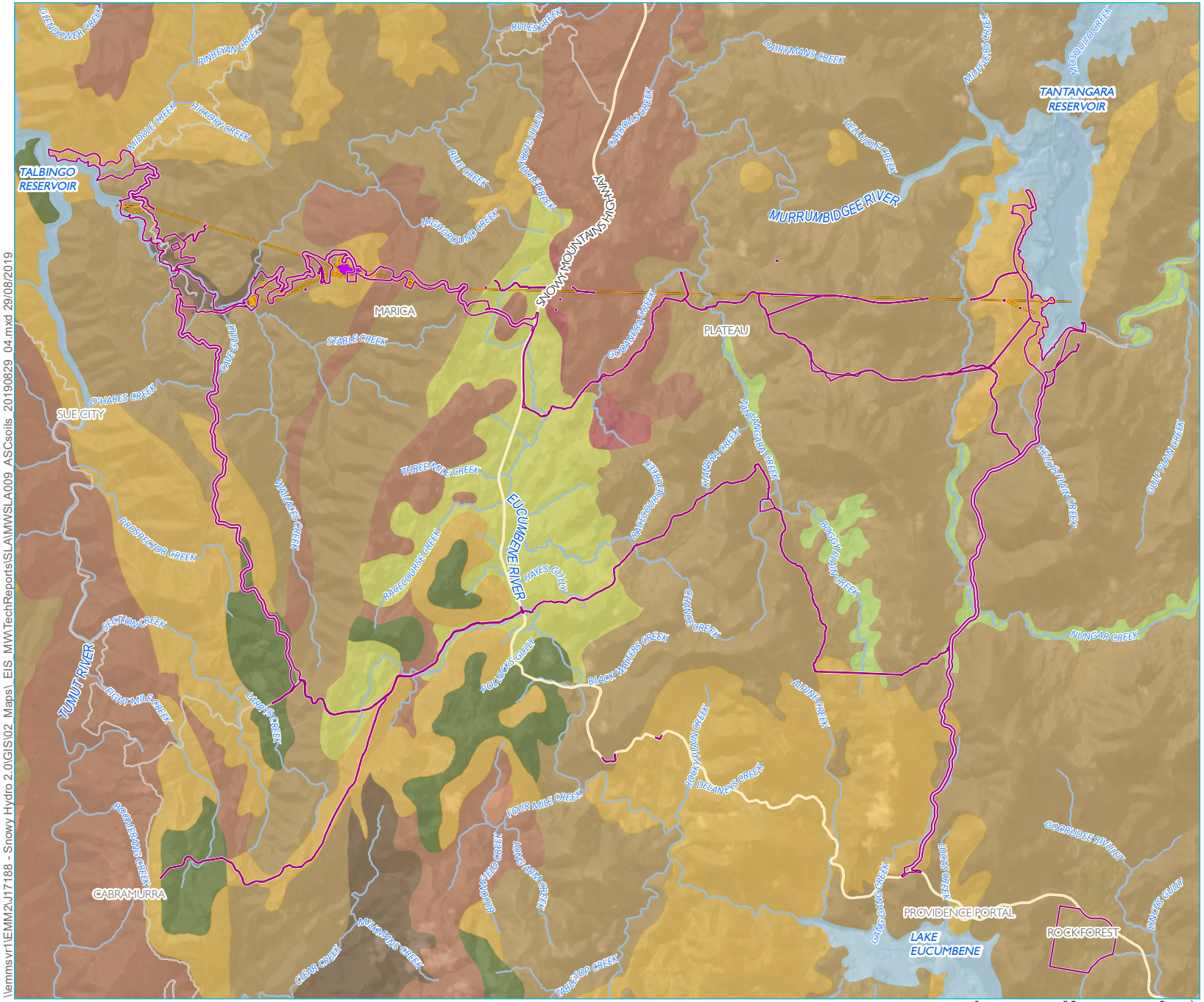
iii Australian Soil Classification mapping

The Australian Soil Classification (ASC) scheme (Isbell 2016) is a multi-category scheme with soil classes defined on the basis of diagnostic horizons and their arrangement in vertical sequence as seen in an exposed soil profile. The soil units of the assessment area can be classed within the current Australian soil classification (Isbell 2016).

Historic soil mapping identified from NSW government mapping (OEH 2018a) indicated that seven soil types (ASC) are mapped in the soils assessment area (Table 4.4 and Figure 4.6). Kurosols, which are texture contrast soils with a strongly acid subsoil, are the dominant soils mapped in the soils assessment area. Tenosols and Rudosols are the next most dominant unit and are associated with steep slopes, high exposed ridges and elevated stony slopes. Dermosols have been mapped in some of the basic volcanic and granodiorite areas. There are minor occurrences of alluvial Rudosols on major drainage features. Organosols are found in basins and depressions in valley floors where water collects all year round.

Table 4.4 Statewide soil mapping – ASC distribution (%) in the soils assessment area

Soil type - ASC	GSG equivalent	Area (ha)	%
Inside KNP			
Dermosols	Brown Earths, Red Earths - more fertile (volcanics and granodiorites), Red Podzolic Soils - more fertile (volcanics and granodiorites)	54	5.5%
Kurosols	Brown Podzolic Soils, Red Podzolic Soils - less fertile (granites and metasediments)	455	46.8%
Kurosols, Natric	Soloths	40	4.1%
Organosols	Neutral to Alkaline Peats	37	3.8%
Rudosols (Alluvial)	Alluvial Soils - Light Sandy Textured (Sands to Sandy Loams)	12	1.3%
Rudosols and Tenosols	Lithosols	257	26.4%
Tenosols	Alpine Humus soils	116	11.9%
Total area inside KNP		**972**	**100%**
Outside KNP			
Kurosols	Red Podzolic Soils - less fertile (granites and metasediments)	229	98.6%
Kurosols, Natric	Soloths	3	1.1%
Rudosols and Tenosols	Lithosols	1	0.2%
Total area outside KNP		**233**	**100%**



KEY

- Soils assessment area

Australian soil classification - order

- Dermosols
- Ferrosols
- Kandosols
- Kurosols
- Kurosols, Natric
- Organosols
- Rudosols (Alluvial)
- Rudosols and Tenosols
- Tenosols
- Water

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station

Existing environment

- Main road
- Local road
- Watercourse

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Source: EMM (2019); EOH (2018a) Snowy Hydro (2019); FGJV (2019); DFSI (2017); LPMA (2011)

0 2.5 5 km

GDA 1994 MGA Zone 55

N

ASC mapping

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.6

snowy 2.0

EMM creating opportunities

iv Inherent soil fertility

The inherent soil fertility is typically expressed as the ability of the soil to be used for different agricultural uses and the inputs which are required to maintain that use. This type of soil fertility is presented in this section and related to the ASC soil types found within the soils assessment area.

However, this traditional concept of soil fertility is not particularly useful in KNP where the soil fertility is combined with the other soil characteristics (acidity, PAWC, rockiness) and their ability to support the current or natural vegetation communities and other ecosystem services that the soils perform.

The inherent fertility is based on GSG mapping of the assessment area from which a fertility value was derived using a lookup table modified from Charman (1978). The fertility rankings are defined by OEH (2018d) as follows:

- **Moderately high (4):** includes soils with high fertility in their virgin state but fertility can be significantly reduced after a few years of cultivation and amendments and fertilisers are required.
- **Moderate (3):** soils have low to moderate fertilities and usually require fertiliser and/or have some physical restriction for arable use.
- **Moderately low (2):** Includes soils with low fertilities, such that, generally, only plants suited to grazing can be supported. Large inputs of fertiliser are required to make the soils useable for arable purposes.
- **Low (1):** Includes soils which due to their poor physical and/or chemical status only support plant growth. The maximum agricultural use of these soils is low intensity grazing.

The mapping identifies soils within the soils assessment area as ranging from Low (1) soil fertility through to Moderately High (4).

A majority (45%) of the soils assessment area was mapped as moderate (associated with Kurosols) and low fertility land (associated with Rudosols, Tenosols and Organosols), being 27% of the soils assessment area. Small pockets of moderately high (associated with Dermosols, 15%) and moderately low (associated with Natric Kurosols, 11%) fertility land make up the remainder (Table 4.4).

Table 4.5 Summary of regional soil mapping by OEH within the soils assessment area

Soil type - ASC	Inherent soil fertility	Hydrologic soil group	Area (ha)
Inside KNP			
Dermosols	Moderate – Moderately High	B and C	54
Kurosols	Moderate	C	455
Kurosols, Natric	Moderately Low	D	40
Organosols	Low	D	37
Rudosols (Alluvial)	Moderately Low	A	12
Rudosols and Tenosols	Low	B	257
Tenosols	Low	D	116
Total area inside KNP			**972**
Outside KNP			
Kurosols	Moderate	C	229
Kurosols, Natric	Moderately Low	D	3
Rudosols and Tenosols	Low	B	1
Total area outside KNP			**233**

v Hydrologic soils group

The hydrologic soils group (OEH 2018c) present in the soil assessment area is comprised predominantly group B and C – moderate and slow infiltration respectively. There are areas of group D (16%) associated with the organic rich soils (Organosols) and Kurosols (natric) and very small pockets of group A (1%) soils associated with sandy alluvial areas. These are defined as follows:

- **A:** soils having high infiltration rates, even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.
- **B:** soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
- **C:** soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
- **D:** soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent highwater table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

vi Land and soil capability classes

The LSC assessment scheme is a broad-scale scheme for low intensity agricultural land use. The LSC classes distinguish between the inherent physical capacity of the land to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water resources. It emphasises risks and hazards rather than productivity.

It is acknowledged that land and soil capability classes and their reference to agricultural land uses are not necessarily relevant in KNP where the land use is conservation. However, the framework still has merit as often land with lower capability is often more easily degraded when disturbed and maybe difficult to return to its original status. Additionally, within the conservation objectives of KNP there will also be other landscape characteristic and functional thresholds which may be important for maintaining or restoring ecological characteristics and functioning back to their pre-disturbance condition.

OEH has produced LSC mapping for most of NSW at a very broad scale in the compilation of "The land and soil capability assessment scheme – second approximation", OEH 2012. Figure 4-7 shows the current LSC mapping.

The LSC assessment scheme uses soil and landscape attributes that describe the biophysical features of the land including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil hazards. These hazards include water erosion, wind erosion, soil structure decline, soil acidification, salinity, waterlogging, shallow soils and mass movement OEH 2012).

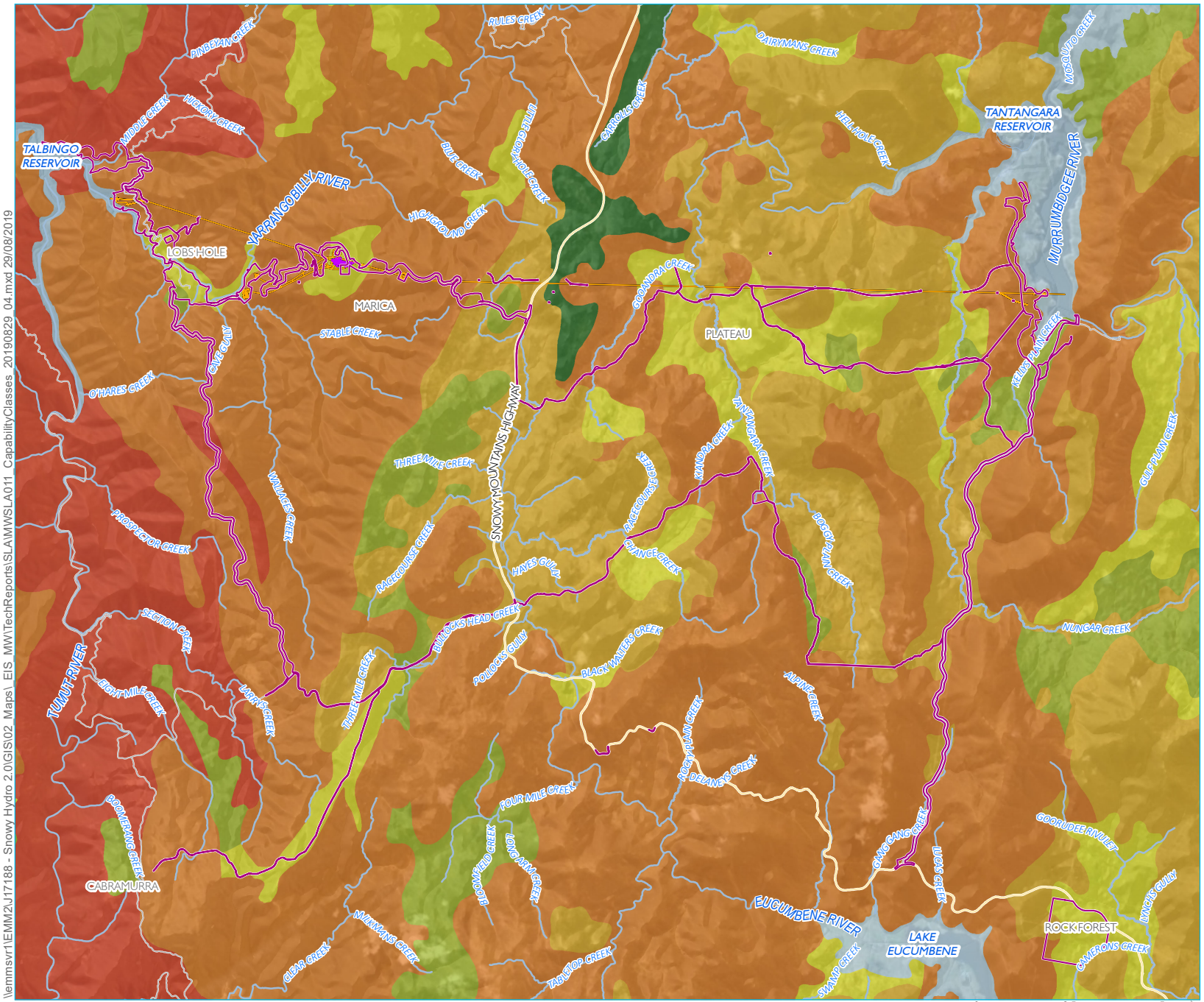
The soil assessment area is currently mapped as Class 4 to Class 8 meaning that there are moderate to severe limitations to cropping. The majority of the soil assessment area is low capability land (classes 6, 7 and 8) with small sections of classes 4 and 5 in Lobs Hole, the southern end of Tantangara reservoir isolated areas on the plateau. Agricultural land uses will be restricted to grazing, forestry, and nature conservation. There are few land management practices available to overcome these limitations. The relevant LSC classes for the soil assessment area are detailed in Table 4.6.

Table 4.6 Relevant land and soil capability classes

LSC class	Associated ASC classes	Description	Area (Ha)	%
Inside KNP				
3	Dermosols	**High capability land:** Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.	1	0.1%
4	Dermosols, Kurosols	**Moderate capability land:** Moderate to high limitations for high-impact land uses. It will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture; and the limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.	84	8.7%
5	Kurosols, Rudosols and Tenosols, Tenosols	**Moderate-low capability land:** High limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.	171	17.6%
6	Kurosols, Kurosols (Natric), Rudosols (Alluvial)	**Low capability land:** Very high limitations for high-impact land uses and is generally suitable for limited land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.	121	12.4%
7	Dermosols, Kurosols, Organosols, Rudosols and Tenosols	**Very low capability land:** Severe limitations that restrict most land uses and generally cannot be overcome. Generally suitable only for selective forestry and nature conservation.	537	55.2%

Table 4.6 Relevant land and soil capability classes

LSC class	Associated ASC classes	Description	Area (Ha)	%
8	Tenosols	**Extremely low capability land:** Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.	61	6.9%
Outside KNP				
5	Kurosols	**Moderate-low capability land:** High limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.	191	82.4%
6	Kurosols, Kurosols (Natric)	**Low capability land:** Very high limitations for high-impact land uses and is generally suitable for limited land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.	23	10.1%
7	Kurosols	**Very low capability land:** Severe limitations that restrict most land uses and generally cannot be overcome. Generally suitable only for selective forestry and nature conservation.	18	7.6%



KEY

- Soils assessment area

Land and soil

- 3 - Moderate limitations
- 4 - Moderate to severe limitations
- 5 - Severe limitations
- 6 - Very severe limitations
- 7 - Extremely severe limitations
- 8 - Extreme limitations
- Water

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station

Existing environment

- Main road
- Local road
- Watercourse

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Source: EMM (2019); EOH (2018); Snowy Hydro (2019); FGJV (2019); DFSI (2017); LPMA (2011)

Land and soil capability classes

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.7

snowy 2.0

EMM creating opportunities

a Biophysical strategic agricultural land

The NSW Government has mapped biophysical strategic agricultural land (BSAL) across the whole of NSW, based on a desktop study. The resultant maps accompany the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*. The BSAL shown on the maps comprises land which meets criteria described in the Interim Protocol: access to a reliable water supply; and falls under soil fertility classes 'high' or 'moderately high' under the NSW OEH *Draft Inherent General Fertility of NSW,* where it is also present with land capability classes I, II or III under OEH's *Land and Soil Capability Mapping of NSW;* or falls under soil fertility classes 'moderate' under OEH's *Draft Inherent General Fertility of NSW,* where it is also present with land capability classes I or II under OEH's *Land and Soil Capability Mapping of NSW*.

The Strategic Agricultural Land Map prepared by OEH and presented in the Interim Protocol, indicates that there is no BSAL in the soil assessment area.

4.6.2 Soils mapping Main Works

A new soils map has been prepared for this soils assessment methodology in accordance with the methodology presented in Section 3.3. The new soils map is presented in Figure 4-8.

During the soil mapping process, it was identified that the subalpine plateau areas had a different combination of dominant pedogenic processes and the decision was made to map these areas separately. The Independent Scientific committee assessment (NPWS 2004) noted the dominance of the alpine and subalpine climate on soil formation seen in the development of the alpine humus soils, on all parent materials (e.g. volcanics, sediments and metamorphics). This contrasts to the increasing dominance of parent material on soil formation on the western escarpment and Lobs Hole. The topographic factor through erosion and drainage is also still expressed in the alpine-subalpine environment with Tenosols and Rudosols in upper-catenary positions often with surface rock or rock outcrops, mid-lower catenary soils exhibiting deeper profiles (often Tenosols or Kandosols) and with Organosols and Hydrosols at the bottom of catenas.

Following the separation of the plateau and western escarpment areas the soils mapping legend was developed by grouping similar geologies into separate groups and these groupings were divided into units with different landform/vegetation where there was a change in the dominant ASC. A description of the soil mapping units is presented in Table 4-7.

The plateau area consists of a wide range of rock types due to the complex geology leading to potentially a wide range of soil types. However, climate in these alpine and subalpine areas have a more dominant role in soil formation than the ravine area as seen in the development of one soil group, the alpine humus soil, across all parent materials (e.g. volcanic, sediment and metamorphic) (NPWS 2004). Based on site data, Rudosols / Tenosols are the second most common soil type and are most likely to be Alpine Humus Soils with high organic or peaty layers in the profile. Kandosols are the most common soil type from the site data, forming on a range of geologies. Dermosols (on a range of geologies) and Chromosols (on granites and sediments) were also relatively common. Other soil types also include Ferrosols (on basic igneous geologies), Hydrosols and Organosols (in drainage depressions or alluvial areas).

Whilst the Main Works will largely avoid ground disturbance to upland subalpine areas, some construction on the Plateau and near Tantangara Reservoir have potential to impact upland soils. Upland soils with very high organic layers such as the Alpine Humus Soils (most commonly Tenosols) and bog and fen peats (usually Organosols) are fragile soils that are difficult to return to their natural state once disturbed. The soil structure and porosity are degraded when these soils are disturbed and there is an accelerated rate of organic matter loss. They are fragile due in part to the restricted growing season of the alpine and subalpine regions, but also due to the very fragile nature of some systems, particularly alpine snowpatch vegetation and the Alpine Sphagnum Bogs and Associated Fens ecological community (Ashton and Williams 1989).

Alpine Humus Soils were identified as most likely to occur over approximately 1400 m AHD which is a higher elevation than the majority of the Main Works construction areas. Alpine Sphagnum Bogs and Associated Fens Ecological Community mapping was also used to identify bogs and fens (OEH 2018g). EMM ecological field surveys have verified and mapped bogs and fens within the project area (Biodiversity development assessment report). The bog soils are generally more acidic and have less phosphorus, nitrogen and potassium than those of the fens, although the two types of wetland are often juxtaposed. A map of bogs and fens and areas where Alpine Humus Soils are likely to occur is presented in Figure 4-9.

There is evidence of periglacial conditions, most extreme during the Pleistocene, which can be found in most areas above 1000 m AHD and possibly as low as 600 m. The evidence of periglacial conditions includes observation of features such as frost-shattered bedrock, boulder fields, solifluction deposits, stone streams, stone-banked lobes, non-sorted steps and nivation features (NPWS 2004).

Fossil soil features are suspected to occur within the soils assessment area due to the relatively undissected uplifted paleoplain and periglacial conditions. Fossil topsoils (sometimes buried), solifluction terraces and non-sorted steps are examples with international significance (NPWS 2004).

Project impacts to geodiversity, which includes periglacial features have been assessed in Palaeozoic geodiversity features within the Snowy 2.0 Main Works project area (EMM 2019) and Cenozoic geodiversity features within the Snowy 2.0 Main Works project area (EMM 2019).

The western escarpment soils were developed on two main types of geology, fine grained acid volcanics and sediments with limestone, which formed similar soils due to the strong influence of topographic factors in their development. These soils are generally sandy or silty clay loams that are neutral to strongly acid depending on the parent material. The main soil types have been mapped mainly on their topographic position with very shallow to shallow and rocky soils on steep slopes or crest/upper slope positions and shallow to moderate depth soils on flatter and lower slope positions. Occasionally the lithology of individual layers in the sediments may result in different soils (e.g. Dermosols in more clay rich layers), but they have generally not been mapped out due to the limited distribution of sample sites.

There are relatively minor areas of clayey alluvium of Dermosols and Vertosols associated with the Yarrangobilly River. There are also deeper Kandosol and Ferrosol soils on more gently sloping basic and intermediate volcanics towards the top of Ravine Road.

Rock Forest is located on lower to mid slopes of gently undulating to undulating rises on sandstones. The soils are likely to be Kandosols and Dermosols that are moderately deep gradational profiles of clay loam over light clays.

Table 4.7 Soil mapping units

Geological group	Slope class	ASC	Soil map unit description
Subalpine/Alpine units			
Alluvial	Low	HY, OR	Sedge swamps with peat soils or other soils which are seasonally or permanently wet. Grouped into this alluvial unit are residual soils with bogs or fens.
Acid igneous	NA	KA/DE, TE/RU	Very shallow to moderately deep clay loam sandy to light medium clay over fine grained acid volcanic and metamorphics. pH is slightly acid to strongly acid. Peaty horizons occur in some profiles.
	NA	CH/KA, TE/RU	Sandy texture contrast soils and uniform sandy soils on granite. Shallow rocky soils on steeper slopes and crests.

Table 4.7 Soil mapping units

Geological group	Slope class	ASC	Soil map unit description
Acid volcanic fine grained	Low	DE, TE/RU	Shallow to moderately deep soils on mid to lower slopes on fine grained acid volcanics with Dermosols likely on gentle slopes and lower slope positions and Tenosols/Rudosols in steeper areas. Slightly to strongly acid profiles.
	High	TE/RU	Very shallow to shallow soil on steep slopes of fine-grained acid volcanics. High organic contents in soils which may have a fibric/hemic peat layer on the surface or a sapric peat horizon.
Basic and intermediate volcanics	High	TE/RU, KA	Very shallow to shallow clay loam to silty clay overlying rock. High organic contents in soils which may have a fibric/hemic peat layer on the surface or a sapric peat horizon. Surface rock and outcrops likely on steeper slopes and upper slopes. Peaty horizons occur in some profiles.
	Low	KA, CH/DE, RU	Shallow to moderately deep clay loam sandy to light medium clay. Some soils may have more than weak structure in the subsoil (DE) and texture contrast soils may develop on the intermediate volcanics. Peaty horizons occur in some profiles.
Sediments quartzose	Low	KA, CH, DE	Undulating rises on sediments including quartzose sandstone forming Kandosols and Chromosols with Dermosols in lower slope positions or in finer more labile sediments.
	Mod - High	TE/RU, CH/KA	Shallow sandy clay loam and sandy clay soils on quartzose sediments and metamorphics. Peaty horizons present in some soils and rock/outcrop occurs on upper slopes and crests.
Sediments fine-grained	Low	DE	Undulating rises on fine-grained sediments forming Dermosols.
	High	TE/RU, KA, DE	Shallow clay loam and clay soils on fine-grained sediments and metamorphics. Peaty horizons present in some soils and rock/outcrop occurs on upper slopes and crests.
Western Escarpment, Lobs Hole and Talbingo			
Alluvial	Low	DE	Alluvial deposits associated with Yarrangobilly River and local tributaries with clay soils (DE) on terraces and backplains (VE). Gravelly and/or sandy soils are likely near channel or on levees. Older terraces grade into colluvium and likely shallower.
Acid volcanic fine grained	Low	KA, TE/RU	Undulating to moderately steep hills on fine grained acid volcanics, clay loam over rock or grading to light clay and moderately acid to strongly acid throughout.
	High	TE/RU, KA	Shallow rocky soils on steep slopes of fine-grained acid volcanics.
Basic and intermediate volcanics	Low-moderate	KA, FE, DE	Deep silty clay loams on basalt.
Sediments and limestone	NA	DE, RU	Gently sloping ridges and side slopes with red clays.
	Moderate	KA, TE/RU	Shallow loam to clay loam textured soils with a slightly acid to neutral pH. Soils >1m in places.
	High	TE/RU, KA	Very shallow to shallow rocky soils on steep slopes with sandy clay loam to silty clay loam textures and a slightly acid to neutral pH.

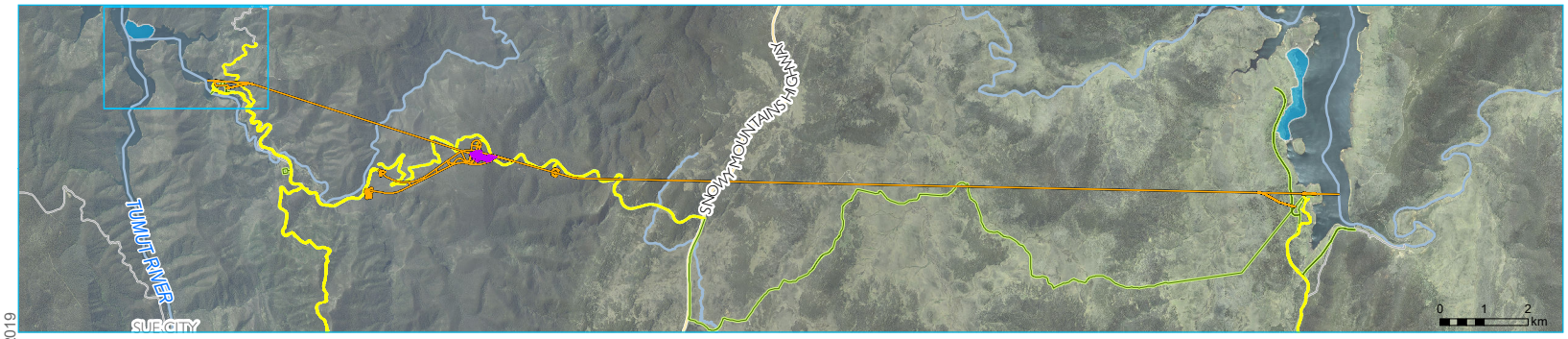
The mapped soil types have a range of different soil attributes which can be favourable for construction and rehabilitation or pose constraints or risks on these processes. These soil attributes will inform the use of management measures to avoid or minimise project impacts on the soil and land resource. Potential impacts and appropriate mitigation and management measures are discussed in Section 5.

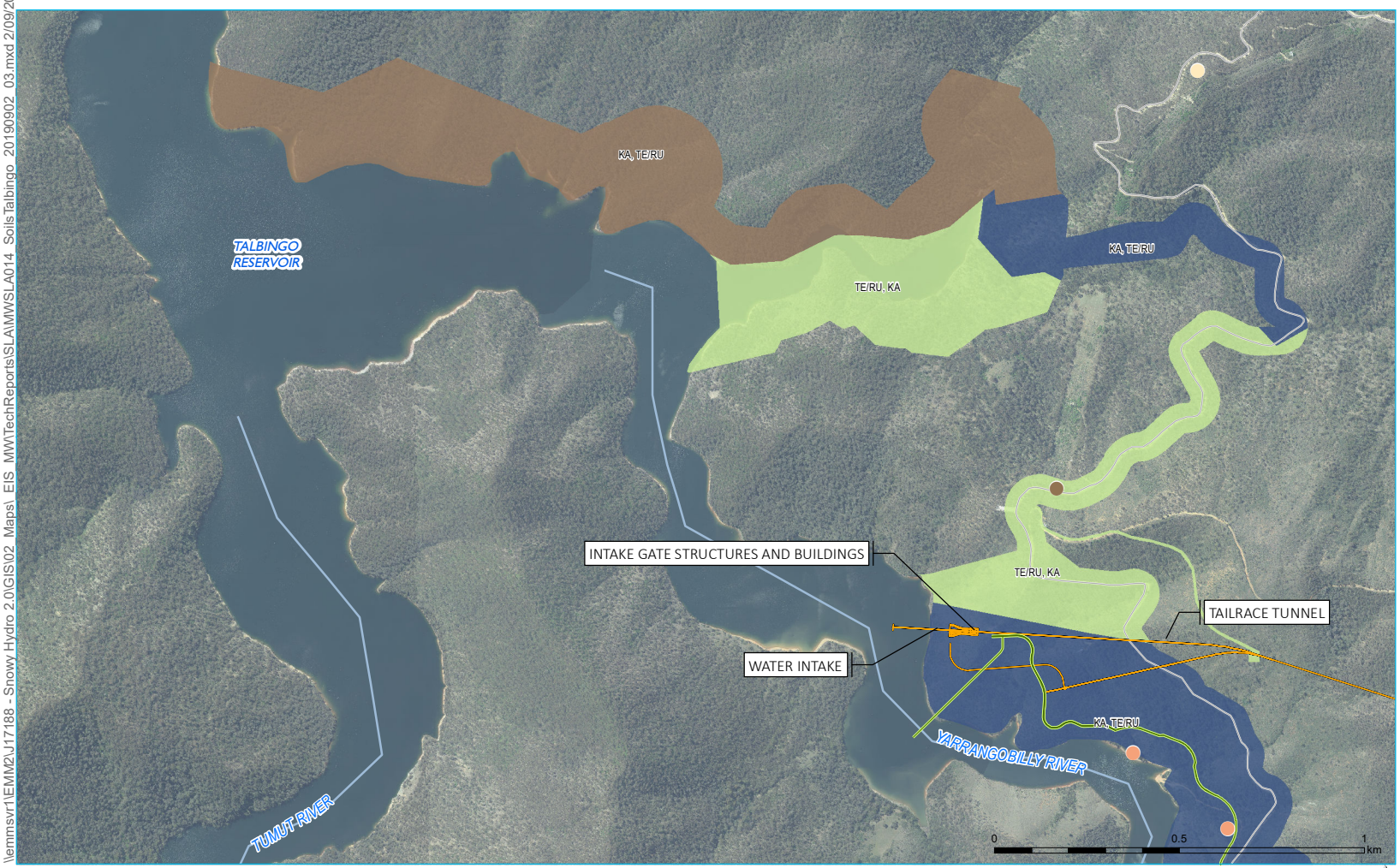
Soil and land attributes and their mapped occurrence that can be used to inform management measures include:

- organic carbon content;
    - high organic carbon levels can be quickly degraded following disturbance and these areas are vulnerable areas for low potential rehabilitation – most likely on the plateau (e.g. Kandosols, Tenosols/Rudosols) and in the bogs / fens (Organosols).
- fertility;
    - fertility will depend on the parent material and to an extent on organic carbon content.
    - high fertility soils will generally be easier to re-establish vegetation cover – these are usually the basic volcanics and alluvial soils. Some of the sedimentary sequences are also likely to have good fertility.
    - soils with low fertility are likely to occur in areas of acid igneous, fine grained acid volcanics and some sedimentary/metamorphic geologies.
- rockiness and rock outcrops;
    - the abundance and size of rock can be difficult to handle and reinstate to original conditions. Rock and rock outcrop can reduce the volume of soil and limit the soil's ability to supply water and nutrients. Rockiness and rock outcrops are most likely on steep and elevated areas / slopes of Tenosols/Rudosols.
- slope;
    - soils on steep slopes have an increased erosion risk – moderate and steep mapped units are more at risk.
- soil depth including reserves of topsoil and subsoil;
    - topsoils can be a constraint to rehabilitation where they are thin or non-existent – most likely on steep slopes of Tenosols/Rudosols.
- soil texture;
    - soils with higher clay contents are more likely to be susceptible to compaction – these are the Dermosols and subsoils of Chromosols and some Kandosols.
    - soils with high silt content are often more susceptible to wind erosion when disturbed / trafficked – high silt contents are more likely on the plateau and the fine-grained acid volcanics.
- soil structure and coherence; and
    - soils with weak structure and low coherence are more susceptible following disturbance – the sandier soils including Kandosols and Tenosols/Rudosols are likely to have this characteristic.
- acidity.

- Acid soil can increase the impact of toxic elements and decrease the availability of essential nutrients. The effect on plants will depend on their sensitivity to acid soils. It can be difficult to establish a cover crop on highly acid soils. Acidity may only be in the subsoil. Soils with strong acidity are more likely to occur in soils with a very high organic carbon content (e.g. organic peats) and soils on the fine-grained acid volcanics.

A limitation of the existing soils information is the lack of chemical data particularly for the soils on the Plateau and near Tantangara Reservoir. Laboratory data is available for the analysed sites in the exploratory works soil survey that covers Ravine Road and Lobs Hole. For a copy of the full laboratory results refer to the soil and land assessment report for the exploratory works (EMM 2018).





KEY

Existing environment
- Main road
- Local road
- Watercourse

Snowy 2.0 Main Works operational elements
- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road
- Indicative rock emplacement area

Australian soils classification order level
- Kandosol
- Rudosol
- Tenosol

Soil type
- Western escarpment | Acid volcanic fine grained | Low | KA, TE/RU
- Western escarpment | Sediments and limestone | High | TE/RU, KA
- Western escarpment | Sediments and limestone | Moderate | KA, TE/RU

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Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

GDA 1994 MGA Zone 55

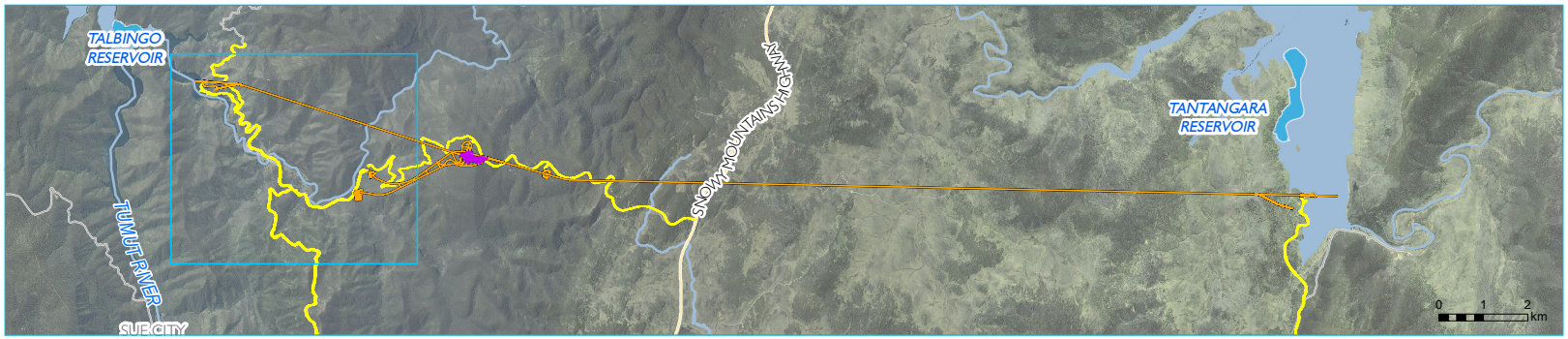
N

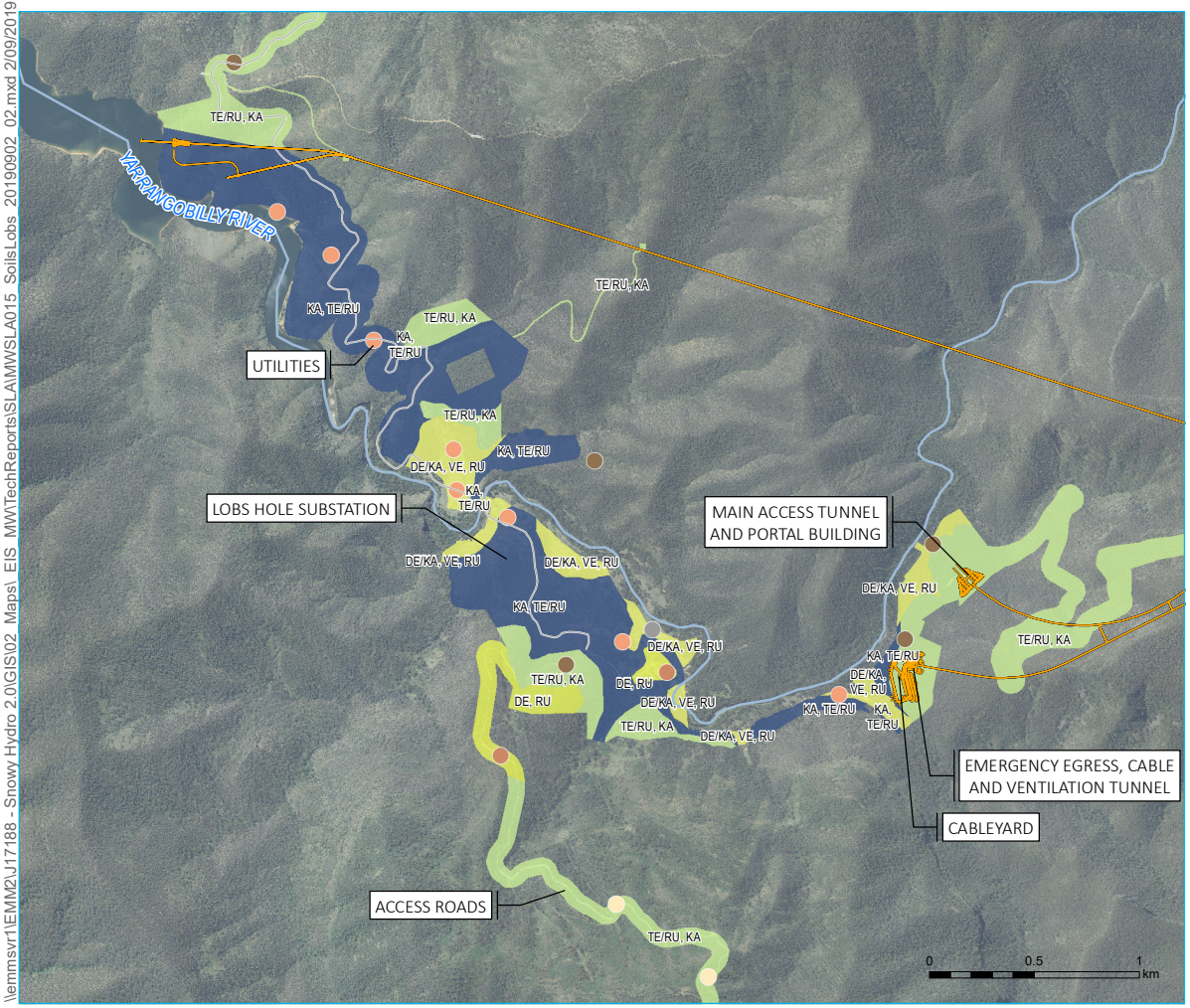
Talbingo Reservoir - soils

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.8a

snowy 2.0

EMM creating opportunities





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Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

N

KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Permanent road
- Indicative rock emplacement area

Australian soils classification order level

- Dermosol
- Ferrosol
- Kandosol
- Rudosol
- Tenosol
- Vertosol

Soil type

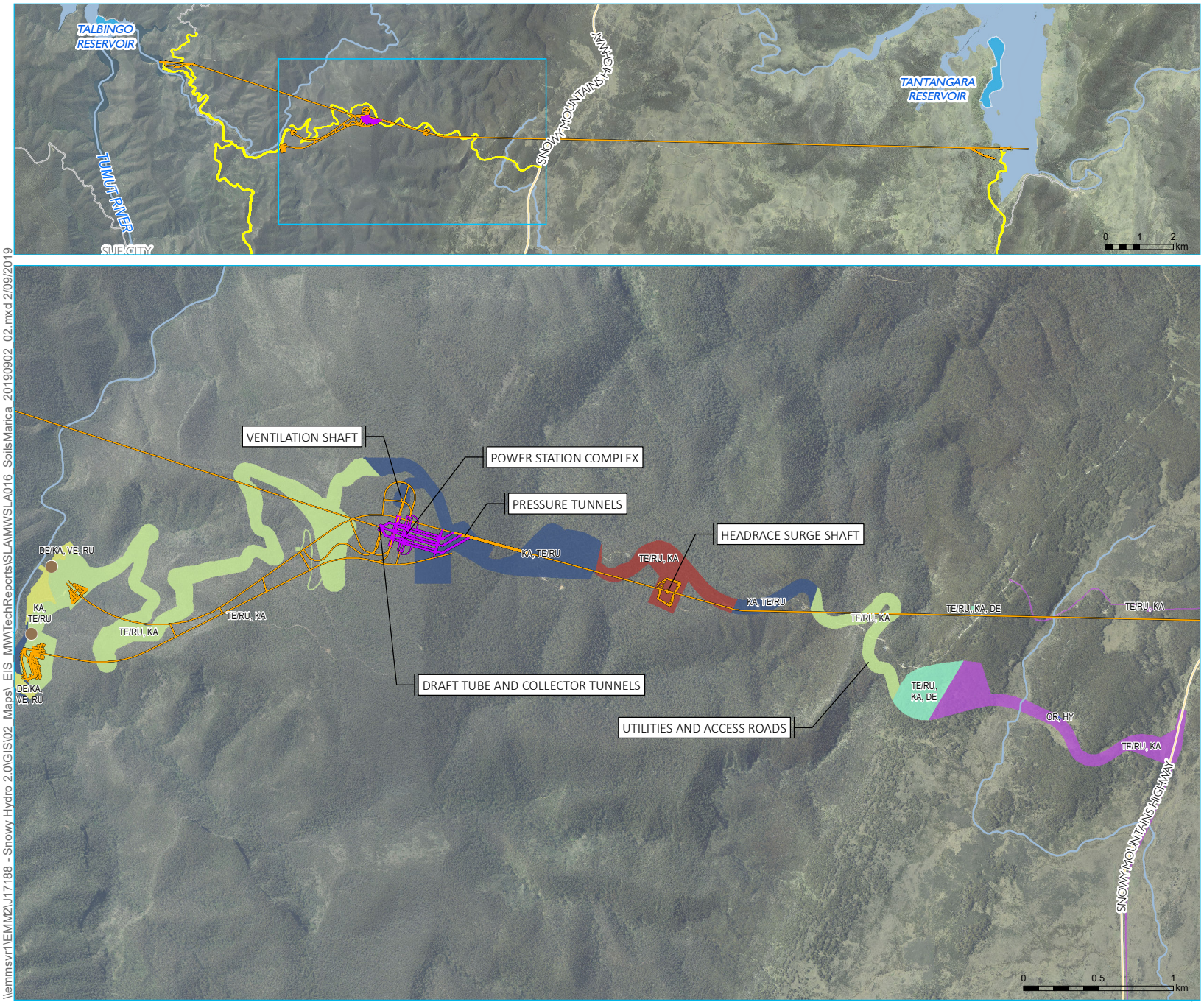
- Alpine | Acid volcanic fine grained | High | TE/RU
- Alpine | Sediments fine-grained | Low | DE
- Western escarpment | Acid volcanic fine grained | High | TE/RU, KA
- Western escarpment | Acid volcanic fine grained | Low | KA, TE/RU
- Western escarpment | Alluvial | DE/KA, VE, RU
- Western escarpment | Basic and intermediate volcanics | Low to moderate | KA, FE, DE
- Western escarpment | Sediments and limestone | DE, RU
- Western escarpment | Sediments and limestone | High | TE/RU, KA
- Western escarpment | Sediments and limestone | Moderate | KA, TE/RU

Lobs Hole - soils

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.8b

snowy 2.0

EMM creating opportunities



KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies

Snowy 2.0 operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Permanent road
- Indicative rock emplacement area

Australian soils classification order level

- Tenosol

Soil type

- Alpine | Alluvial | OR, HY
- Alpine | Basic and intermediate volcanics | High | TE/RU, KA
- Alpine | Sediments fine-grained | High | TE/RU, KA, DE
- Western escarpment | Acid volcanic fine grained | High | TE/RU, KA
- Western escarpment | Alluvial | DE/KA, VE, RU
- Western escarpment | Sediments and limestone | High | TE/RU, KA
- Western escarpment | Sediments and limestone | Moderate | KA, TE/RU

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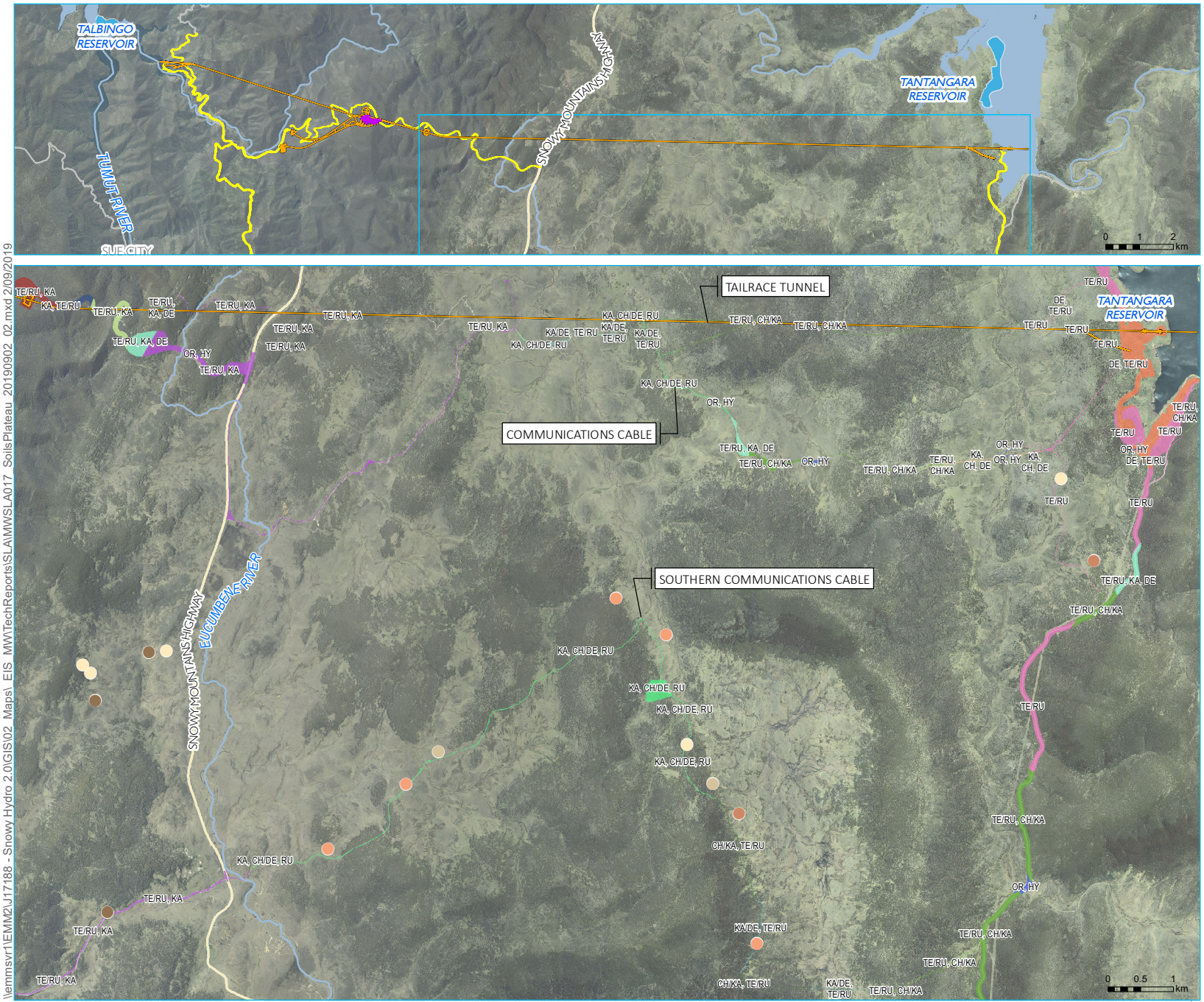
Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

Marica - soils

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.8c

snowy 2.0

EMM creating opportunities



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KEY

Existing environment
- Main road
- Local road
- Watercourse
- Waterbodies

Snowy 2.0 operational elements
- Tunnels, portals, intakes, shafts
- Power station
- Permanent road
- Indicative rock emplacement area

Australian soils classification order level
- Chromosol
- Dermosol
- Kandosol
- Rudosol
- Tenosol

Soil type
- Alpine | Acid igneous | CH/KA, TE/RU
- Alpine | Acid igneous | KA/DE, TE/RU
- Alpine | Acid volcanic fine grained | High | TE/RU
- Alpine | Acid volcanic fine grained | Low | DE, TE/RU
- Alpine | Alluvial | OR, HY
- Alpine | Basic and intermediate volcanics | High | TE/RU, KA
- Alpine | Basic and intermediate volcanics | Low | KA, CH/DE, RU
- Alpine | Sediments fine-grained | High | TE/RU, KA, DE
- Alpine | Sediments quartzose | High | TE/RU, CH/KA
- Alpine | Sediments quartzose | Low | KA, CH, DE
- Western escarpment | Acid volcanic fine grained | High | TE/RU, KA
- Western escarpment | Sediments and limestone | High | TE/RU, KA
- Western escarpment | Sediments and limestone | Moderate | KA, TE/RU

Plateau - soils

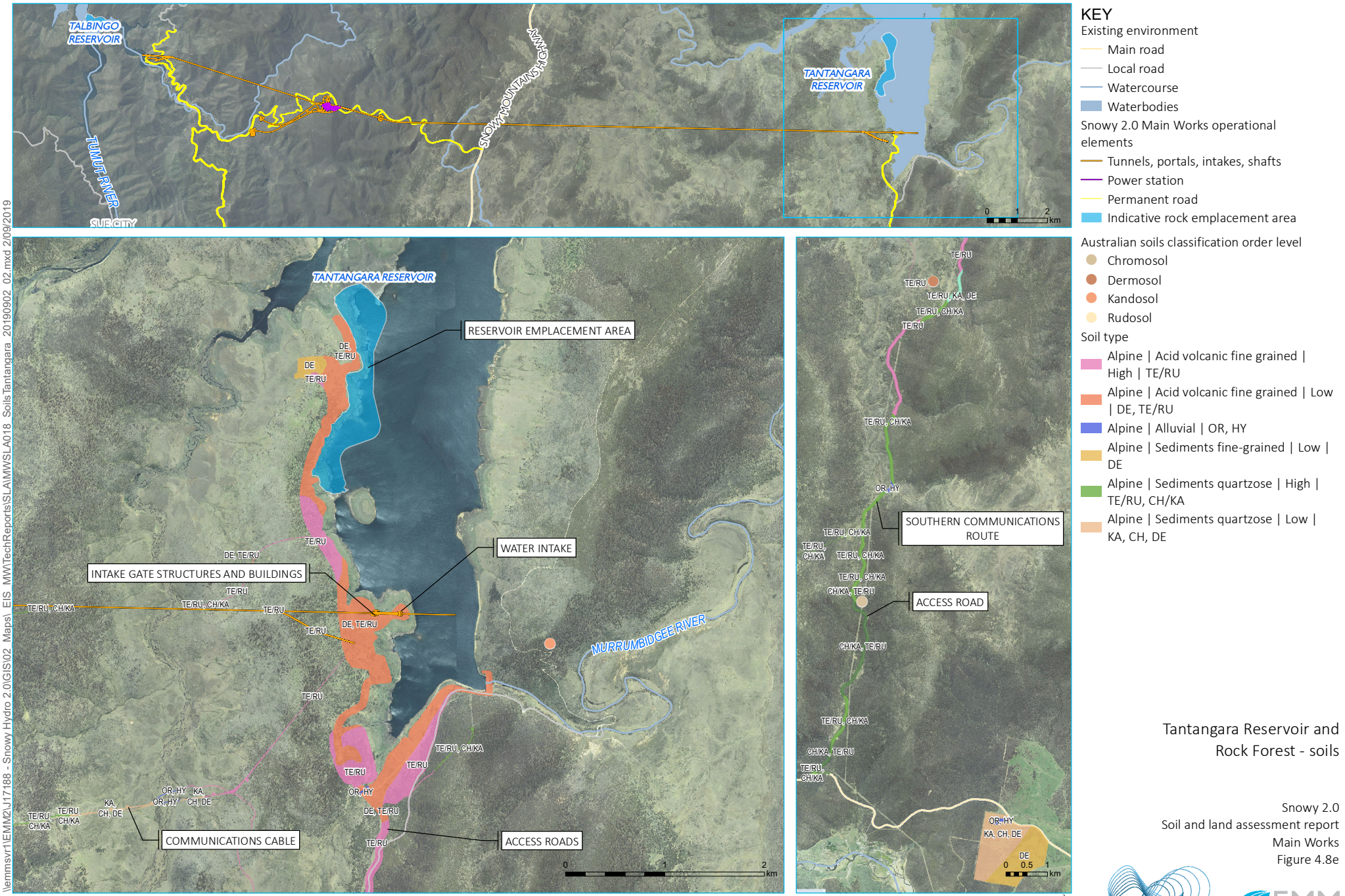
Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

GDA 1994 MGA Zone 55

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.8d

snowy 2.0

EMM creating opportunities



KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Permanent road
- Indicative rock emplacement area

Australian soils classification order level

- Chromosol
- Dermosol
- Kandosol
- Rudosol

Soil type

- Alpine | Acid volcanic fine grained | High | TE/RU
- Alpine | Acid volcanic fine grained | Low | DE, TE/RU
- Alpine | Alluvial | OR, HY
- Alpine | Sediments fine-grained | Low | DE
- Alpine | Sediments quartzose | High | TE/RU, CH/KA
- Alpine | Sediments quartzose | Low | KA, CH, DE

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

GDA 1994 MGA Zone 55

N

Tantangara Reservoir and Rock Forest - soils

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.8e

snowy 2.0

EMM creating opportunities

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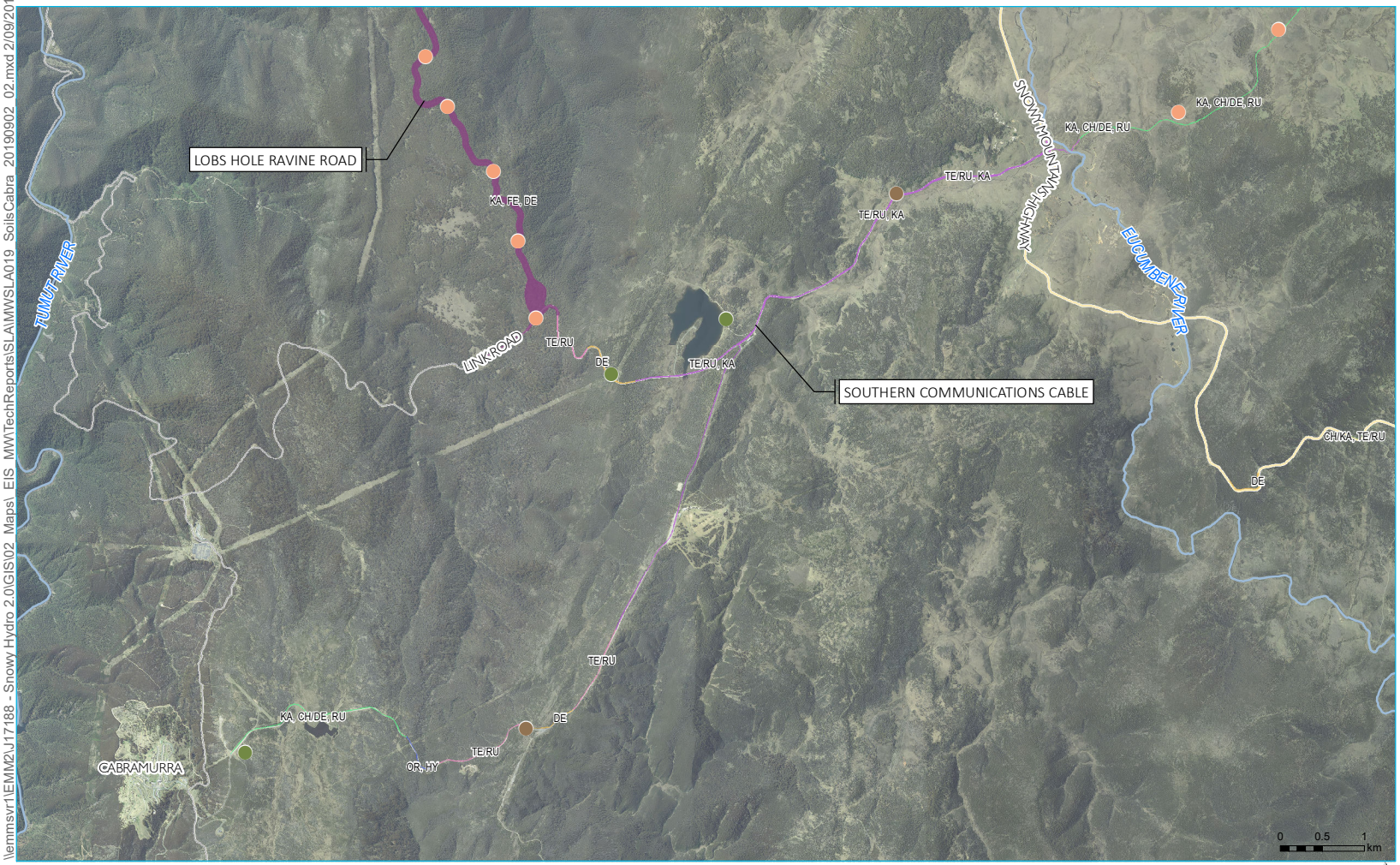

KEY

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies

Snowy 2.0 Main Works operational elements

- Permanent road

Australian soils classification order level

- Kandosol
- Organosol
- Tenosol

Soil type

- Alpine | Acid igneous | CH/KA, TE/RU
- Alpine | Acid volcanic fine grained | High | TE/RU
- Alpine | Alluvial | OR, HY
- Alpine | Basic and intermediate volcanics | High | TE/RU, KA
- Alpine | Basic and intermediate volcanics | Low | KA, CH/DE, RU
- Alpine | Sediments fine-grained | Low | DE
- Western escarpment | Basic and intermediate volcanics | Low to moderate | KA, FE, DE

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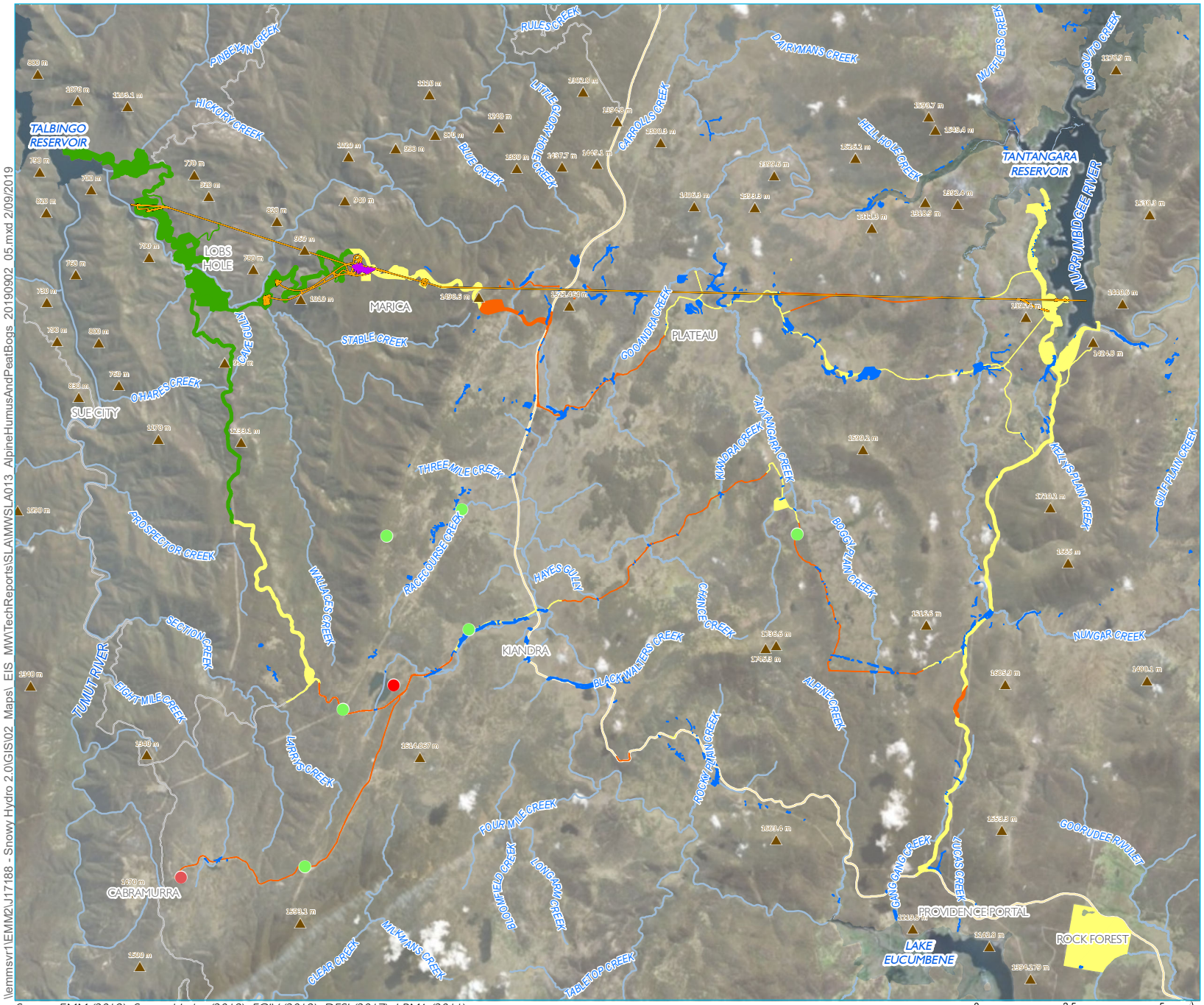
Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

Southern communications route to Cabramurra - soils

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.8f

snowy 2.0

EMM creating opportunities



KEY

- Spot height - trig station (all heights in mAHD)
- Acid Peat Soil
- Alpine Humus Soil
- Neutral Peat Soil
- Surveyed bogs and fens
- Unlikely alpine humus soil
- Possible alpine humus soil
- Possible alpine humus soil (>1400m)

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station

Existing environment

- Main road
- Local road
- Watercourse

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Source: EMM (2019); Snowy Hydro (2019); FGJV (2019); DFSI (2017); LPMA (2011)

0 2.5 5 km

GDA 1994 MGA Zone 55

N

Distribution of alpine humus soils, bogs and fens

Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.9

snowy 2.0

EMM creating opportunities

4.7 Soil erosion

Early development and grazing within the KNP led to widespread catchment erosion, especially in the alpine and subalpine areas. This was documented by the Soil Conservation Service of NSW in the 1940s and 1950s and attributed to the destruction of soil cover by bushfires and grazing (Costin 1954; Durham 1956; Morland 1949, 1951, 1958ab, 1959, 1960; Newman 1953, 1954abc, 1955abc; Taylor 1956, 1957, 1958ab; NPWS 2004).

The protection of the park from these practices through improved fire management and progressive removal of grazing has resulted in the natural stabilisation of most soils in the park. Measurements over 20 years have shown an improvement in soil cover and other soil properties such as organic matter and reduction in bulk density (NPWS 2004).

In the 2004 NPWS independent scientific committee report on the assessment of the values within KNP, it is reported that in general, the recovery trend of the last 40–50 years has reached a plateau of relative stability, but not always in the original condition. Near-original conditions have been achieved where sufficient organomineral topsoil remained, but not where topsoil loss proceeded to the residual stony erosion–pavement stage.

Subsequent to the initial development in KNP, localised soil damage has occurred due to the construction of the original Snowy Hydro Scheme, roads and management tracks, horse riding route pads and walking tracks; and transmission lines. While most of the disturbances are stable, on-going maintenance work is required.

The incising and eroding peats and other groundwater soils show continuing erosion of streambank and stream-bed profiles in some subalpine valleys, even though the initial disturbing agents are no longer present (NPWS 2004).

On-going soil disturbance and erosion is also caused by feral animals including deer, rabbits, pigs and a large population of wild horses. Rooting by pigs opens ground to erosive forces and facilitates weed invasion. The horses selectively frequent mountain valleys that are sensitive to trampling because meadow soils and bog peats are easily incised and gullied (NPWS 2004).

Road cuttings appear quite stable with no significant erosion including the absence of rilling and gullies. A few examples of road cuttings are shown in Plate 4-1 to Plate 4-4.

Plate 4.1 **Cutting on Tantangara Road**

Plate 4.2 **Schofields Trail**

Plate 4.3 **Cutting on Ravine Road**

Plate 4.4 **Cutting on Ravine Road**

4.8 Soil erosion hazard assessment

The risk of soil erosion and associated impacts is a key issue for management during all surface works construction activities. Therefore, it is important to understand the soil erosion hazard factors to identify and implement appropriate management practices and controls. Consideration of all erosion hazard factors including disturbance to surface cover and the design of drainage works, will need to be undertaken on a site by site basis.

The project is to consider erosion hazard during construction activities as well as the long-term stability of the final landform and land use. Understanding of erosion hazard requires suitable site planning and review of all relevant erosion risk factors which include but are not limited to the slope and landform, existing cover and land use, the receiving environment, soil constraints (e.g. erodibility, sodicity, dispersibility, texture, pH, depth, fertility), landscape constraints (e.g. mass movement, flood hazard) and climate factors (e.g. rainfall volume and intensity, frost heave).

The topography of the soils assessment area is discussed in Section 4.2 and a slope map is presented in Figure 4.4which can be used as an indicator of erosion risk by using the slope classes in Table 3.4. The report sections on climate (Section 4.1) and land use and vegetation (Section 4.3) can also be used to understand soil hazard in the soil assessment area.

A recently developed spatial dataset of soil erodibility identified as part of this soils assessment was a study by Yang *et al.* in 2018, which digitally mapped soil erodibility for water erosion in NSW. This study developed a validated K-factor[1] map and other Revised Universal Soil Loss Equation (RUSLE) factors to assess soil loss for preventing and managing soil erosion. All other factors being equal, the higher the K value, the greater the susceptibility of the soil to rill and sheet erosion by rainfall. Generally, the K-factor ranges from 0.005 (very low) to 0.075 (very high). A map of the K-factor for the soils assessment area is presented in Figure 4-10.

Soils with weak to massive structure and high silt contents are the most at risk of wind erosion, due to increased likelihood of forming dust sized soil particles when disturbed. High wind, silty soils with high traffic loads resulting in the pulverisation of soil all increase the likelihood of wind erosion.

A framework for the assessment of soil water erosion hazard is presented in Section 3.4 and is used to discuss the project areas in the Section 4.8.1 to Section 4.8.3.

4.8.1 Plateau area

The plateau soils are likely to have high organic matter contents and are generally moderately to strongly acidic likely to reflect a highly leached environment. Soils are not likely to be sodic or magnesic. Their topsoil erodibility is likely to be low to moderate depending on the organic matter content. The subsoils are generally non-dispersible ranging from loams to clays. Some subsoils are likely to have relatively low coherence particularly for lighter textures (e.g. loams) or coarser sandy soils.

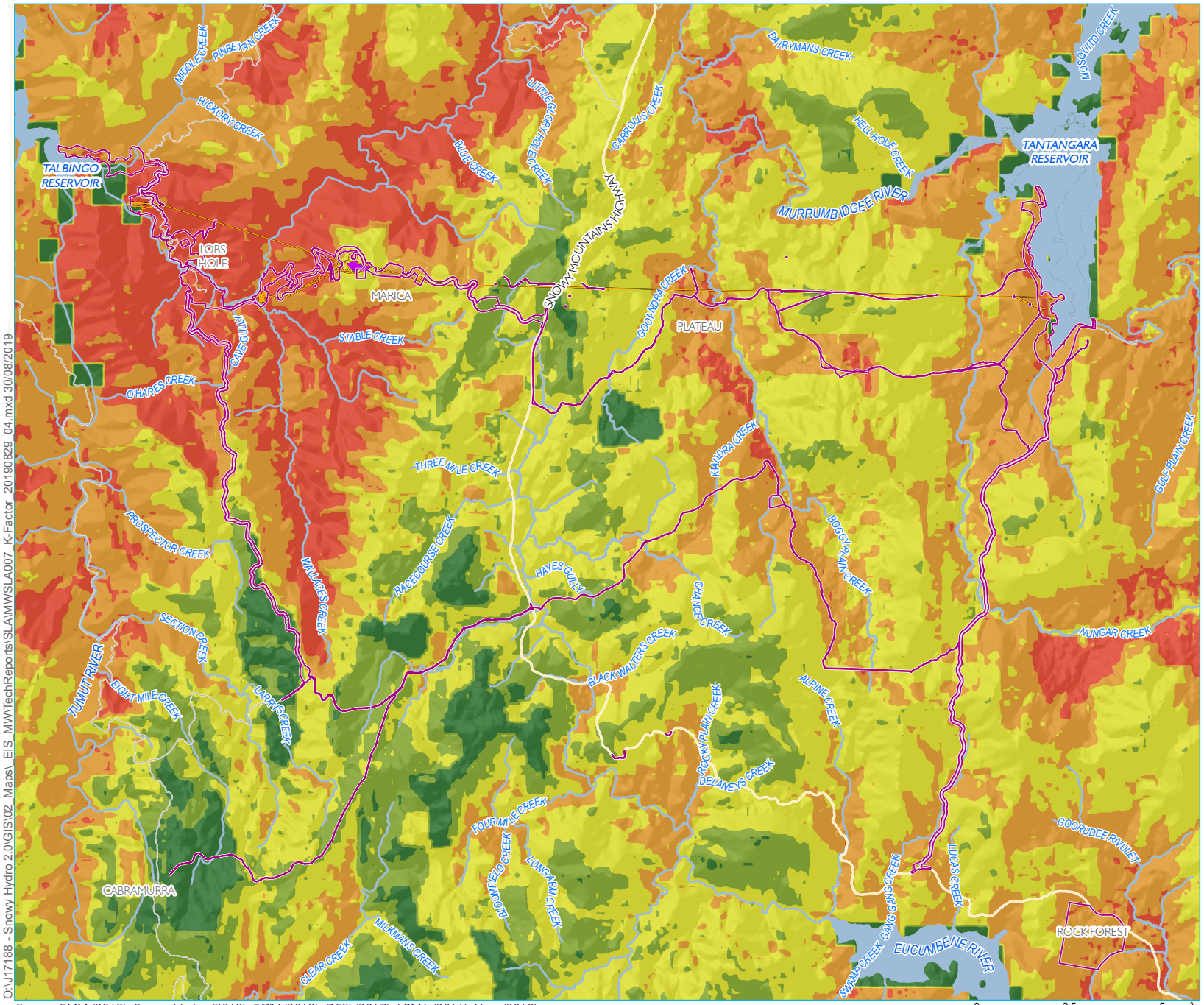
Soil erosion processes in a subalpine area lead to periglacial phenomenon such as needle-ice erosion, and frost heave. Understanding and managing these forms of erosion will be important in the subalpine areas of the project.

The erosion hazard of the soils in this area is moderate to very high with the effects of cold climate, shallow soils, highly organic soils, deep solifluction deposits and steep slopes increasing the erosion hazard of the soils.

Whilst the Main Works will largely avoid ground disturbance to upland subalpine areas, some construction -on the Plateau and near Tantangara Reservoir have potential to impact upland soils. Upland soils with very high organic layers such as the Alpine Humus Soils (most commonly Tenosols) and bog and fen peats (usually Organosols) are fragile soils that are difficult to return to their natural state once disturbed. They are fragile due in part to the restricted growing season of the alpine and subalpine regions, but also due to the very fragile nature of some systems, particularly alpine snowpatch vegetation and the Alpine Sphagnum Bogs and Associated Fens ecological community (Ashton and Williams 1989).

Regolith erodibility of the available site data indicated a regolith stability class of mostly either R1 on the very shallow Rudosols and Tenosols and Organosols or R3 on the deeper Kandosols, Dermosols and Chromosols.

[1] K factor is soil erodibility factor, which represents both susceptibility of soil to erosion and the rate of runoff, as measured under the standard unit plot condition.



KEY

Soils assessment area

K-factor

- 0.01-0.02
- 0.02-0.03
- 0.03-0.04
- 0.04-0.05
- >0.05

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies

Soil erodibility K-factor

Source: EMM (2019); Snowy Hydro (2019); FGJV (2019); DFSI (2017); LPMA (2011); Yang (2018)

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Snowy 2.0
Soil and land assessment report
Main Works
Figure 4.10

snowy 2.0

EMM creating opportunities

4.8.2 Ravine area

The topsoils generally have moderate to low erodibility with moderate to high organic matter contents and an Emerson class of 4 to 8 where tested. The subsoils have a moderate erodibility with non-dispersible to some dispersion following remoulding loams to light clays with an Emerson class of 3 to 4 where tested.

The soils analysed from the exploratory works soil survey did not contain any samples that were sodic or magnesic. In the OEH site data there was one dispersive soil (Sodosol - Yarrangobilly survey site 81) 2.3 km to the north west of the footprint on rhyolite in a drainage depression. There are 7 other sites in the same geology which are Tenosols or Kandosols. Based on the landforms of the project footprint with this geology, Sodosols may potentially occur, but are unlikely or minor occurrence.

The majority of the soils have only weak structure and low coherence.

The other factors affecting erosion hazard such as steep long slopes and shallow soils have a moderate to very high class of erosion hazard.

Regolith erodibility of the available site data indicated a regolith stability class of mostly R3 with some R2 and R1 sites.

4.8.3 Rock Forest

The topsoils generally have moderate to low erodibility with possible highly organic layers. The subsoils have a moderate erodibility. The Kandosols have massive to weak structure throughout and are likely to have low coherence. The Dermosols do not have low coherence in the subsoil and are likely to be slightly less erodible due to their better structure. The soils are moderately to strongly acidic likely to reflect a highly leached environment. Soils are not likely to be sodic or magnesic.

The erosion hazard is moderate to high due to the climatic conditions of the area (snow and limited growing season), the possible highly organic topsoils, low coherence of Kandosols and the gently undulating to undulating slopes.

Regolith erodibility of the available site data indicated a regolith stability class of mostly R3 with some R2 and R1 sites.

4.9 Acid sulfate soils

The combination of the acid sulfate soils mapping and the geomorphic features in the project disturbance areas suggest that there is a low potential for the occurrence of acid sulfate soils in the Main Works area.

There is no local scale acid sulfate soils (ASS) mapping for the Main Works soils assessment area. Although usually associated with coastal environments, acid sulfate soils can also occur at higher elevations inland, associated with anaerobic conditions along river and lake beds and in saline seepage areas where there are organic-rich deposits. A review of the national Atlas of Australian Acid Sulfate Soils (Fitzpatrick *et al.* 2011) shows that the proposed project footprint intersects three areas mapped as having a high probability of ASS:

1. Talbingo Reservoir ($Aq(p4)^1$) - works below the mapped dam full supply level;
2. Tantangara Reservoir (Aq(p4)) – on the western side, works below the mapped dam full supply level; and
3. East of Eucumbene Reservoir ($Ak(p4)^2$) – southern portion of Rock Forest.

1. **A** High Probability of occurrence (>70% chance of occurrence in mapping unit); **q** ASS1 generally within upper 1 m in wet / riparian areas with Kandosols, Ferrosols, Tenosols, Rudosols and Podosols (Isbell 1996); **p** Potential ASS (PASS); **4** No necessary analytical data are available and classifier has little knowledge or experience with ASS, hence classification is provisional
2. **A** High Probability of occurrence (>70% chance of occurrence in mapping unit); **k** Subaqueous material in lakes - ASS material and/or monosulfidic black ooze (organic ooze enriched by iron monosulfides; **p** Potential ASS (PASS); **4** No necessary analytical data are available and classifier has little knowledge or experience with ASS, hence classification is provisional)

However, this is at a map scale of 1:2 Million and with the lowest mapped confidence of 4 (i.e. polygons with a rated Confidence of 4 that are provisional classifications inferred from surrogate data with no on ground verification). Investigations in the exploration area concluded that the likelihood of ASS being present in the Middle Bay barge ramp was low (EMM 2018).

The risk factors listed in the *National Acid Sulfate Soils guidance: National acid sulfate soils sampling and identification methods manual* (Sulllivan et al 2018a; Stone et al. 1998) were reviewed in conjunction with a site assessment at the Talbingo Reservoir during the exploratory works soil survey. It was concluded that there was a low potential for the occurrence of acid sulfate soils.

The geomorphic conditions at the Tantangara Reservoir are also not conducive to the formation of acid sulfate soils, with the Tantangara project area being located on Kellys Plain Volcanics (Dacite) and on side slopes of a man-made impoundment where there are no significant drainage inflows with alluvium or bog swamps present (i.e. not at the distal end of the reservoir). Soils encountered during the exploratory works soil survey also support this conclusion with no soil features or local geomorphic conditions conducive to the presence of ASS.

The ASS mapping at Rock Forest is located on the southern portion of the lot. The unit is mapped as 'Ak(p4)' which is subaqueous material in lakes. This mapped area consists of low to moderate slopes with a couple of unnamed drainage features draining to the east. The geomorphic conditions based on the desktop review do not support the provisional ASS mapping. Other considerations which would mean that ASS is unlikely to be encountered are that the site is proposed to be used as laydown and storage areas which will avoid waterlogged areas and the current design footprint is not located in the ASS mapping.

The combination of the acid sulfate soils mapping and the geomorphic features in the project disturbance areas suggest that there is a low potential for the occurrence of acid sulfate soils in the Main Works area. This is supported by observations from the geomorphology, geology and hydrogeology field survey teams of who did not identify or map any ASS within the project area.

5 Impact assessment, management and recommendations

The impact of the project on the soils and land resources is related to the nature of the disturbance activity, the environmental values and their sensitivity to change.

Potential impacts of the project on the soils and land resources in the study area will result in land degradation and off-site impacts unless there is implementation of appropriate and effective management and mitigation measures. The soil and land resource will vary in its vulnerability to potential impacts depending on the characteristics and values at a site.

The potential impacts may result in direct impacts to the soil resource or indirect/offsite impacts. Direct impacts could include erosion (water and wind) and sedimentation, soil compaction, reduced soil quality (e.g. through the mixing of the soil profile) and fertility decline (e.g. loss of topsoil and organic carbon). Indirect impacts could include soil and land conditions which may limit rehabilitation outcomes and future land uses, inability to support significant ecological communities and provision of ecosystem services such as water quality and flow moderation. Assessment of the ecological values and ecosystem services for the project are also discussed in the following technical reports, which are appended to the EIS:

- Aquatic ecology assessment (Cardno 2019);
- Biodiversity development assessment (EMM 2019);
- Cenozoic geodiversity report (Troedson 2019);
- Groundwater assessment (EMM 2019);
- Paleozoic geodiversity report (Percival 2019); and
- Surface water assessment (EMM 2019).

The traditional concepts of soil fertility and the use of land and soil capability classes and their reference to agriculture are not particularly useful in KNP. Instead it is the land and soil characteristics in their entirety which affect their ability to support the natural vegetation communities and other ecosystem services that the land/soils perform. However, the traditional frameworks still have some merit as methods to characterise land and soil through the integration of a wide range of factors to easily understood concepts.

The alternative is to attempt to breakdown and rate the individual soil and land characteristics that are important for each ecological community, conservation value and ecosystem function. Clearly an extremely complex task if even achievable. Instead, the projects goal of impact avoidance, minimisation and mitigation in relation to the land and soil in the project area are to examine the vulnerability of the soil and land resource to potential impacts.

The vulnerability of the soil and land resource to potential impacts could be grouped into the following impact issues:

- Soil erosion hazard (e.g. K factor, slope, Emerson class);
- Soil degradation potential (e.g. compaction, fertility decline, topsoil reserves);

- Rehabilitation potential (e.g. low potential Alpine Humus);
- Supporting significant ecological communities (e.g. Alpine Peat/Fens); and
- Other ecosystem services and land use (e.g. water quality and flow moderation from alpine humus soils / bogs and recreation use).

Identification of these different impact issues can assist in giving specific attention to appropriate management measures that will be important in vulnerable areas.

Many of potential impacts are interrelated and have flow-on effects, for example, road construction in areas with alpine humus soils or bogs could reduce groundcover and initiate erosion which could deplete the organic rich topsoil base, reduce capacity of the area to support the unique vegetation communities relying on the rich organic soil and water holding capacity of the soils and reduce the capacity of the system to provide water quality and flow moderation outcomes. Whilst the Main Works will largely avoid ground disturbance to upland subalpine areas, some construction on the Plateau and near Tantangara Reservoir have potential to impact upland soils.

The final land uses following the project have been broken into five domains, as outlined in the rehabilitation strategy and these final land use domains will be referred to in this section and the activity-based management recommendations section (Section 2). The final land use domains are listed below and presented in Figure 5-1.

1. Retained infrastructure;
2. Upgraded roads;
3. Recreation sites;
4. Native vegetation; and
5. Water management.

These final land use domains reflect the temporary construction impacts and the permanent infrastructure/facilities which are part of the Snowy 2.0 scheme. The project temporary construction impact areas include temporary camps and construction yards and permanent impacts include upgraded roads and infrastructure facilities such as the Tantangara intake and tunnel portals.

Areas in the Native Vegetation final land use domain will be revegetated and returned to a native vegetation final land use. The species used for each area will be commensurate with that present prior to disturbance as per the Plant Community Type (PCT) mapped for the area. Appropriate soil management will be particularly important in this domain to achieve successful rehabilitation outcomes.

There are a number of active project domains (refer to Figure 5.1) that refer to different project activities or infrastructure areas and are discussed with more specific management and recommendations in Section 6.

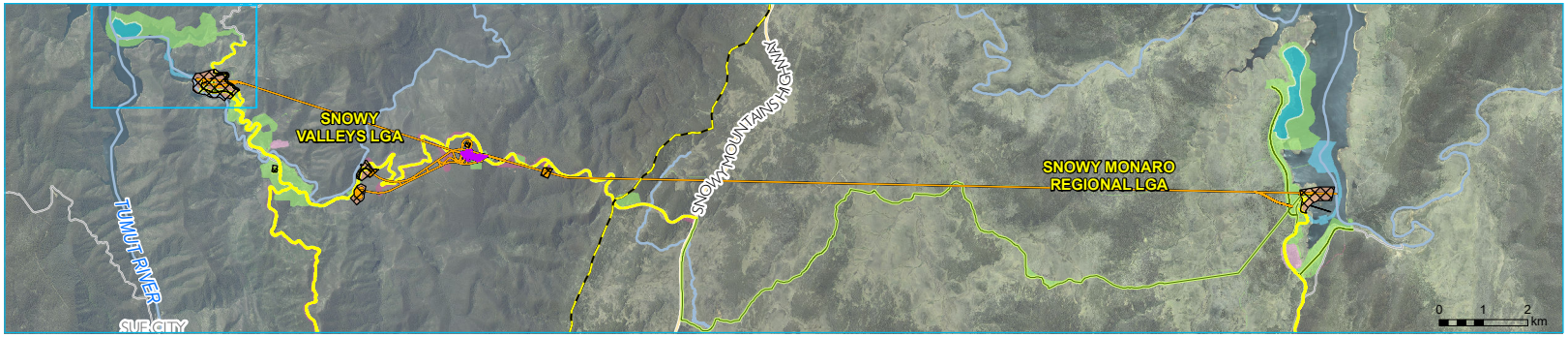
The different project construction activities in the active domains often require similar construction, maintenance and rehabilitation techniques, although the scale may vary, the general management measures are presented in this section. The project active domains that have site specific management and recommendations are presented in Section 6.

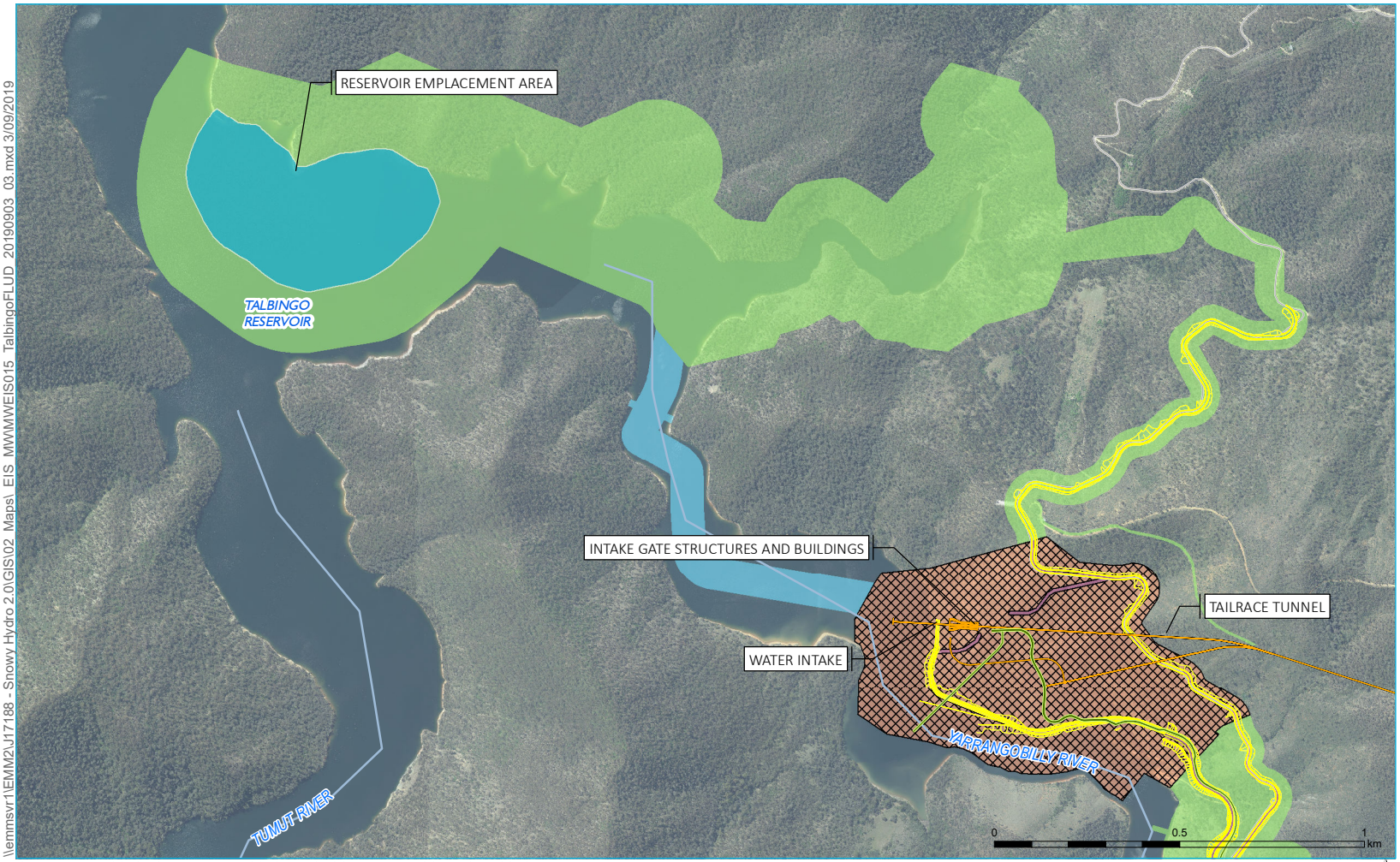
A rehabilitation strategy has been prepared for the project and outlines the approach to rehabilitation and decommissioning and has been prepared to demonstrate the understanding of, and commitment to, the protection and rehabilitation of KNP throughout all Snowy 2.0 works. A rehabilitation management plan will be prepared to provide further resolution to rehabilitation methodologies.

It is recommended that targeted soil site investigations be undertaken prior to construction at each site to confirm the soil characteristics at a site construction level so that the soil resource can be appropriately managed.

Site specific information, collected using the guidelines listed below, will need to be included in a rehabilitation management plan and implemented for surface disturbance construction work.

- *Guidelines for Soil Survey along Linear Features* (SSA 2015);
- *Guidelines for surveying soil and land resources* (McKenzie et al. 2008);
- *Australian Soil and Land Survey Field Handbook* (NCST 2009);
- *Australian Soil Classification* (Isbell 2016); and
- Si*te investigations for urban salinity (*DLWC 2002).





KEY

- Operational footprint

Final land use domain

- A - Retained infrastructure
- B - Upgraded roads
- C - Recreation sites
- D - Native vegetation
- E - Water management

Existing environment

- Main road
- Local road
- Watercourse
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road
- Indicative rock emplacement area

Talbingo Reservoir - final land use domains

Snowy 2.0
Soils and land assessment
Main Works
Figure 5.1

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

GDA 1994 MGA Zone 55

N

snowy 2.0

EMM creating opportunities

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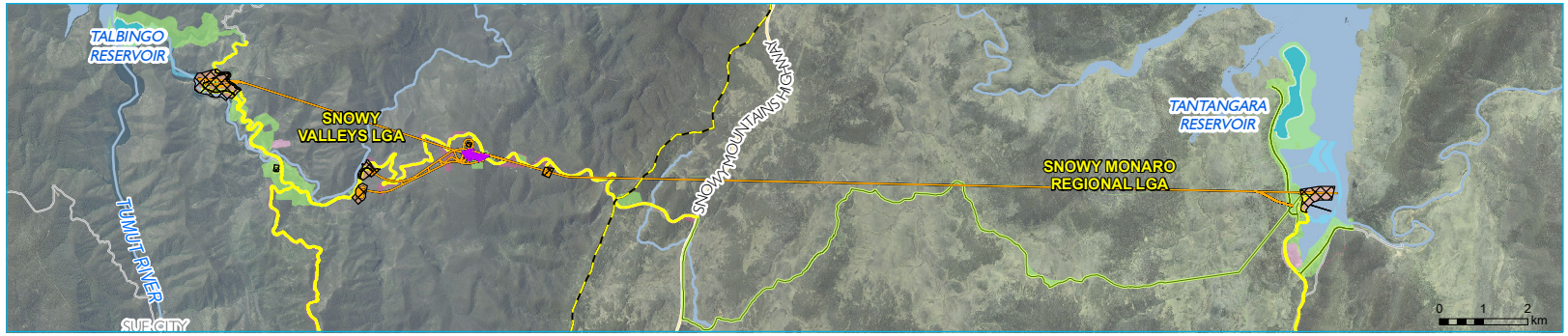

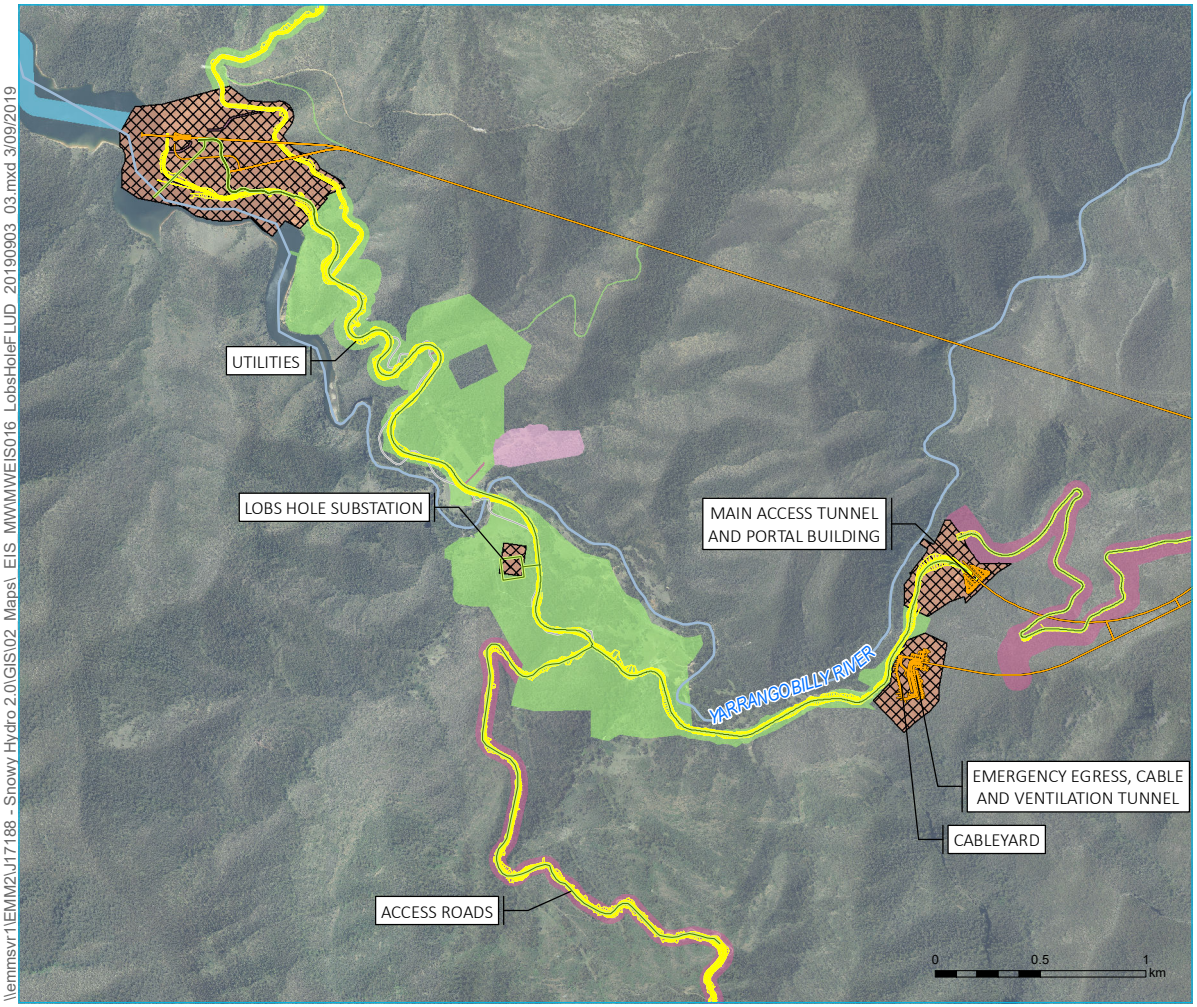

KEY

- Operational footprint

Final land use domain

- A - Retained infrastructure
- B - Upgraded roads
- C - Recreation sites
- D - Native vegetation
- E - Water management

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road
- Indicative rock emplacement area

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Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

GDA 1994 MGA Zone 55

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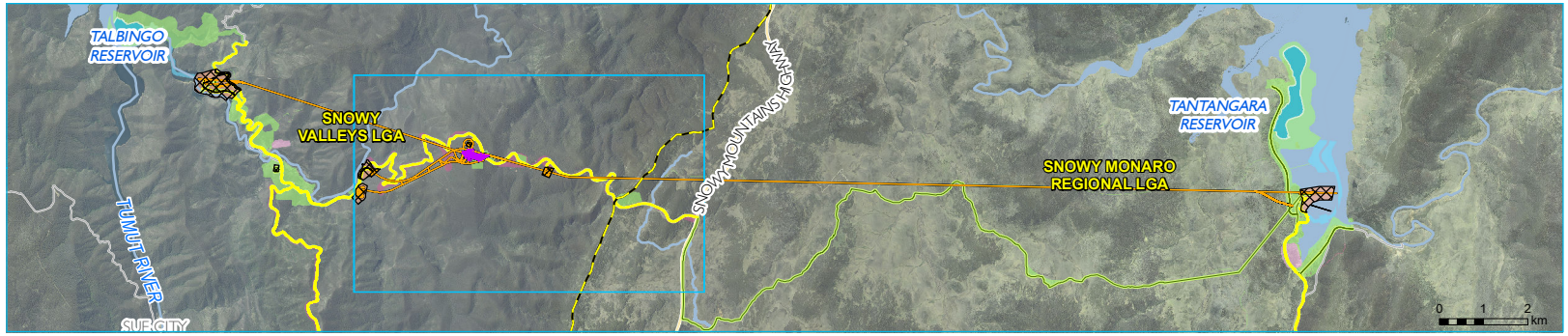
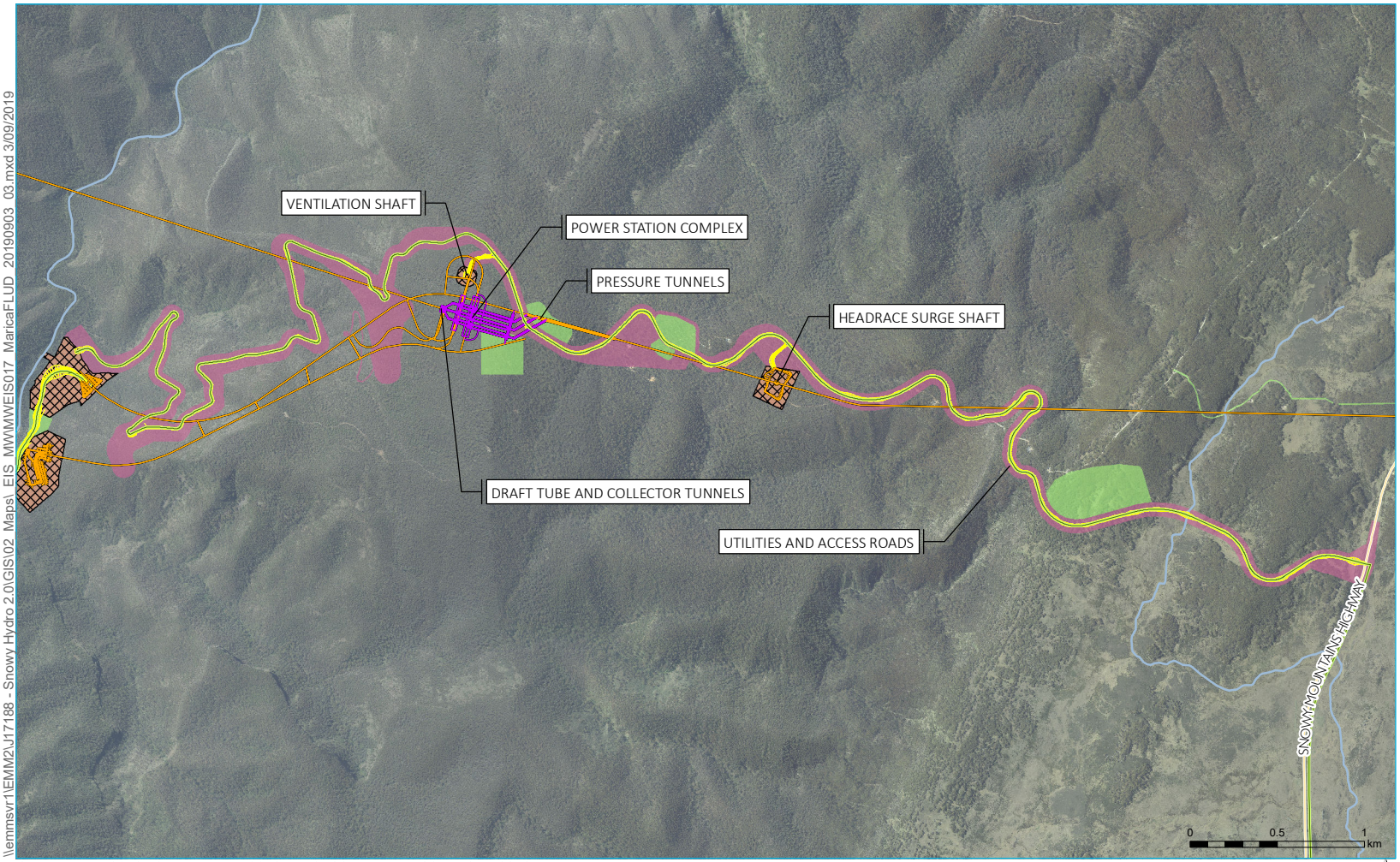
Lobs Hole - final land use domains

Snowy 2.0
Soils and land assessment
Main Works
Figure 5.2

snowy 2.0

EMM creating opportunities





KEY

Operational footprint

Final land use domain

- A - Retained infrastructure
- B - Upgraded roads
- C - Recreation sites
- D - Native vegetation
- E - Water management

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road
- Indicative rock emplacement area

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Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

GDA 1994 MGA Zone 55

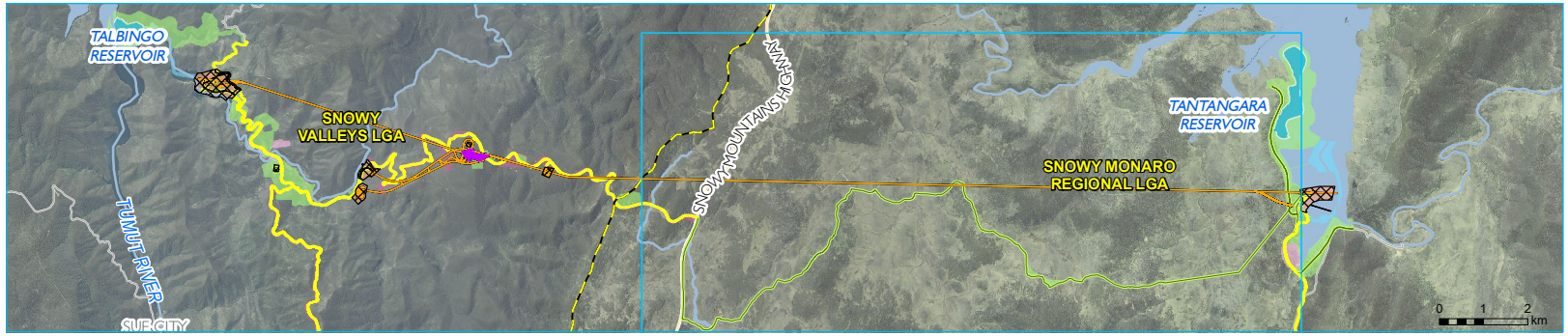
N

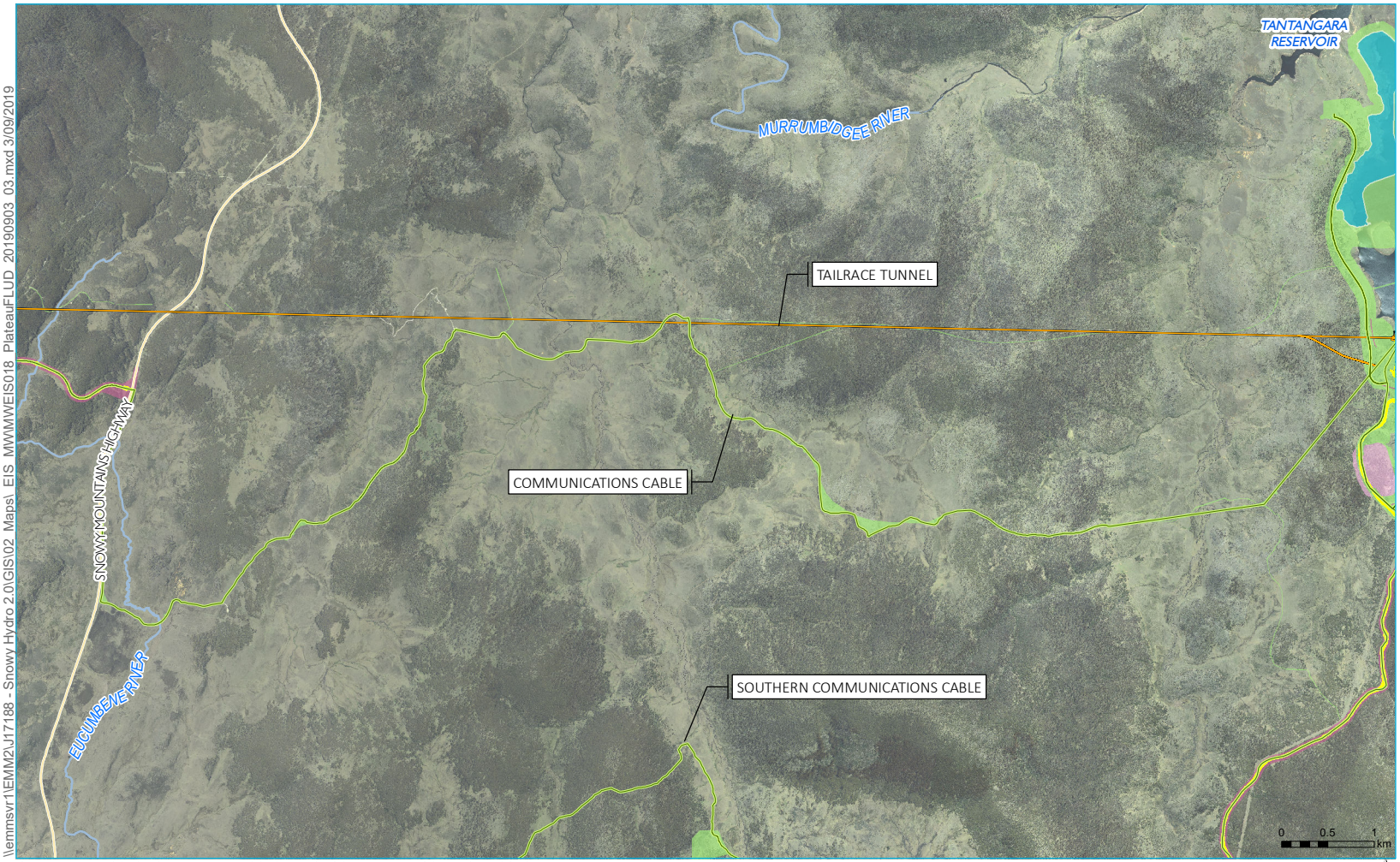
Marica - final land use domains

Snowy 2.0
Soils and land assessment
Main Works
Figure 5.3

snowy 2.0

EMM creating opportunities





KEY

Operational footprint

Final land use domain

- A - Retained infrastructure
- B - Upgraded roads
- C - Recreation sites
- D - Native vegetation
- E - Water management

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road
- Indicative rock emplacement area

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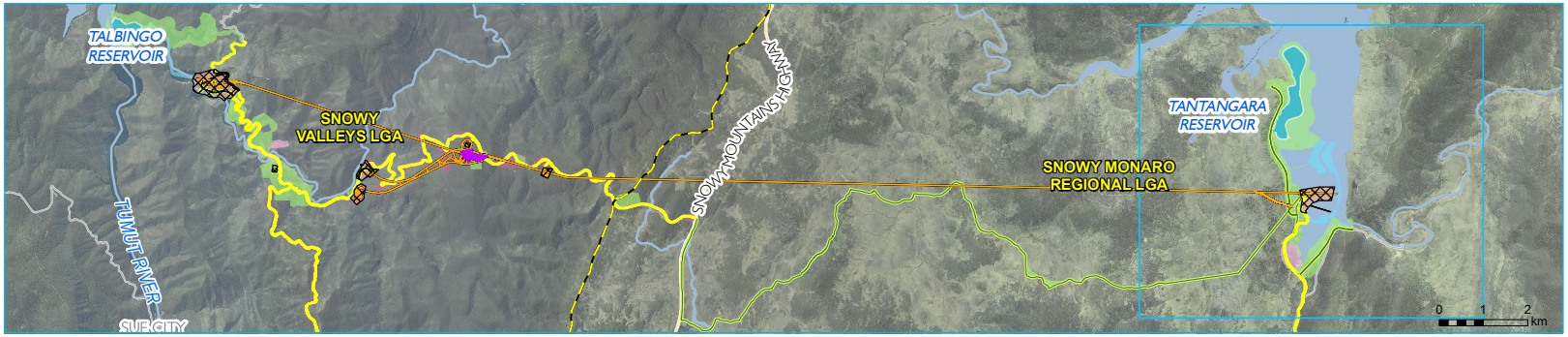
Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

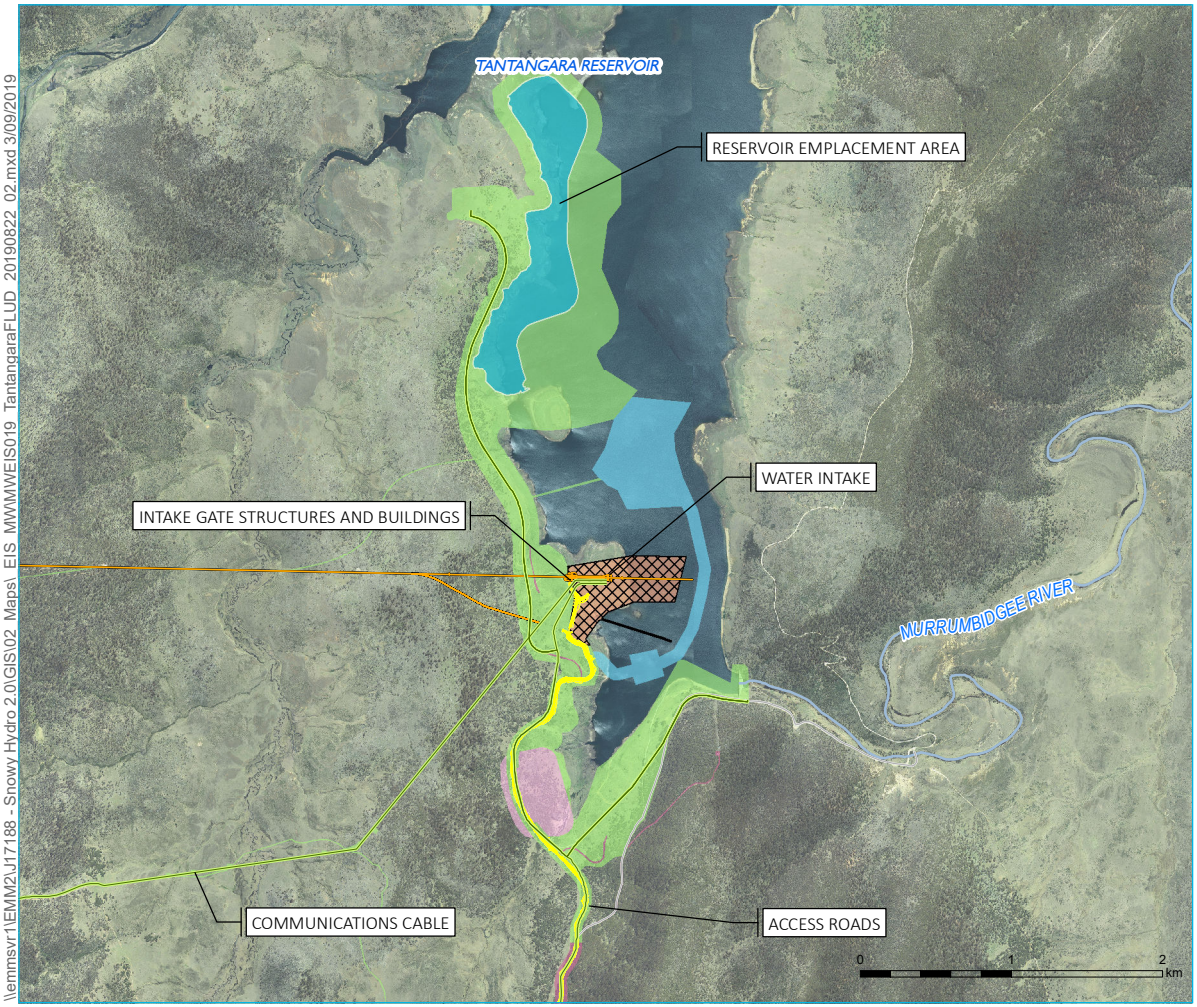
Plateau - final land use domains

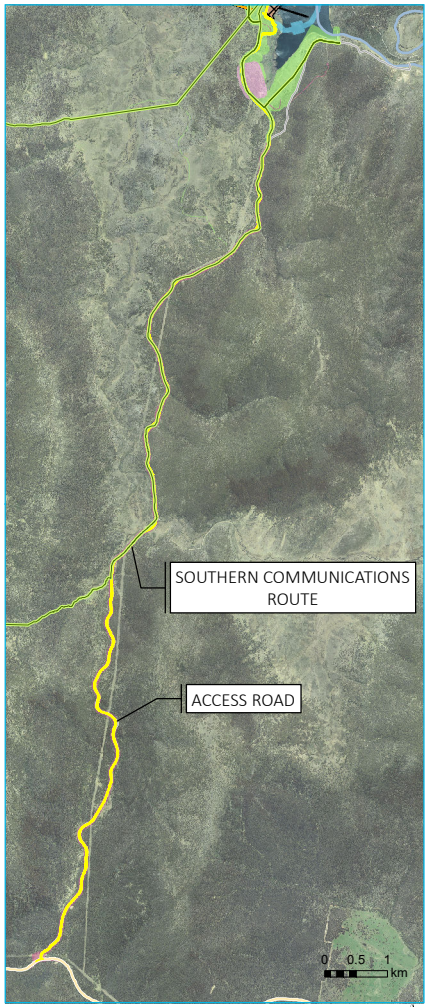
Snowy 2.0
Soils and land assessment
Main Works
Figure 5.4

snowy 2.0

EMM creating opportunities







KEY

- Operational footprint

Final land use domain

- A - Retained infrastructure
- B - Upgraded roads
- C - Recreation sites
- D - Native vegetation
- E - Water management

Existing environment

- Main road
- Local road
- Watercourse
- Waterbodies
- Local government area boundary

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Power station
- Utilities
- Permanent road
- Indicative rock emplacement area

GDA 1994 MGA Zone 55

N

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011); SLR (2019)

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Tantangara Reservoir - final land use domains

Snowy 2.0
Soils and land assessment
Main Works
Figure 5.5

snowy 2.0

EMM creating opportunities

KEY

Operational footprint

Final land use domain

- A - Retained infrastructure
- B - Upgraded roads
- C - Recreation sites
- D - Native vegetation
- E - Water management

Existing environment

- Main road
- Local road
- Watercourse

Snowy 2.0 Main Works operational elements

- Tunnels, portals, intakes, shafts
- Utilities
- Permanent road

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Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

GDA 1994 MGA Zone 55

N

Rock Forest - construction areas, purpose and description

Snowy 2.0
Soils and land assessment
Main Works
Figure 5.6

snowy 2.0

EMM creating opportunities

5.1 Changes to landform and hydrology

5.1.1 Potential impacts

Localised changes to landform, where site disturbance works require cut and fill within the current landscape, will be unavoidable in the construction of this project. Some of these changes will be temporary, for example at construction camps which will be reinstated (as close as practicable back to the original landform) at the completion of the project, and some permanent impacts where roads have been upgraded but will remain in use following the completion of construction. As a result, in some areas, the final contours after construction will differ from the original landform.

Changes to landforms are likely to be most significant where facilities are located on steep slopes and where roads grades require cuttings or traverse steep slopes. Permanent alterations to landform will also occur at the Talbingo and Tantangara intakes and portals.

Landsliding could occur within the study area as a result of cut / fill operations and changes to the hydrology without appropriate management. Potential landsliding and slope destabilisation may be caused by the removal of material at the base of the slope or addition of material at the head, removal of vegetation or alteration of drainage.

Landform and hydrology are closely connected and will be affected to varying degrees depending on the magnitude and location of the project site works. There is a high likelihood that drainage, including groundwater infiltration, sheet flow and creeks / streams will be altered to varying degrees as a result of this project. This has the potential to result in impacts on downstream aquatic ecosystems where there are changes in runoff, water quality and potential sedimentation resulting from mitigation measures not being implemented during construction and site operation.

Potential impacts to the hydrology have been assessed and reported in the surface water assessment (EMM 2019).

5.1.2 Management and recommendations

Final landform design and planning has been undertaken to identify opportunities for the reuse of excavated material in rehabilitation and in the construction of final landforms which complement the surrounding topography in the KNP. In consultation with NPWS, it is proposed that the final landform will be constructed from excavated material to create a safe and stable landform, commensurate with the surrounding topography of the area.

Project works requiring permanent modifications to landforms (e.g. upgraded roads, intakes and portals) will seek to minimise visual impacts.

During the landform establishment phase, activities will include slope stabilisation and the construction of permanent water management and erosion and sediment controls. This includes monitoring for and rectification of any defects that may arise, such as subsidence on trenches or erosion before the rehabilitation completion criteria are met.

The risk of potential landsliding will be addressed through geotechnical investigation, engineering design and construction monitoring as well as measures identified in the rehabilitation strategy.

Management and recommendations for erosion and sedimentation is covered in Section 5.6.

5.2 Salinity

5.2.1 Potential impacts

Based on the minimal salinity in this landscape (soils and groundwater), the moderate winter dominant rainfall and relatively minor changes to the surface hydrology there is a low risk that the project will result in salinity issues through the mobilisation of salt due to the changes in the water balance. However, it should be noted that due to the very low levels of salinity in the surface waters only a relatively small change in salinity could be significant.

5.2.2 Management and recommendations

In order to minimise changes to the hydrology which could potentially mobilise salt, vegetation clearing will be minimised where practical.

5.3 Alpine humus soils and peat bogs

5.3.1 Potential impacts

The alpine humus soils (often Tenosols) and peat bogs (usually Organosols or Hydrosols) are a feature of the upland environment of the project area and are significant due to their limited distribution and ecological significance. A map of their likely distribution is presented in Figure 4-9, which is likely to include the higher elevations of Marica works areas and Ravine Road as well as across the plateau and at the Tantangara and Rock forest work areas. They are also very fragile and difficult to rehabilitate when disturbed due to the fact organic carbon is easily lost during disturbance and not easily replaced due to slow and seasonal vegetation growth and periglacial processes that increase the risk of erosion. They are fragile due in part to the restricted growing season of the alpine and subalpine regions, but also due to the very fragile nature of some systems, particularly alpine snowpatch vegetation and the Alpine Sphagnum Bogs and Associated Fens ecological community (Ashton and Williams 1989).

Where damage has occurred to bogs, the recovery of structure and function of ecological communities is likely to take several decades (McDougall 2007).

Acid bogs support shrub dominants with Sphagnum hummocks, while permanently wet fens are dominated by sedges. These wet areas grade into alpine herbfields with improving soil drainage and transition from Organosols / Hydrosols possibly to Kandosols where there are deeper soils or Tenosols.

Alpine humus soils and peat bogs are vulnerable to disturbance, soil erosion, weed invasion, sedimentation and alteration of hydrology.

Potential impacts incorporate loss of soil quality including the loss of organic matter and compaction / compression of the soil and an inability to re-establish cover leading to erosion.

A loss of highly organic topsoils can result in the reduction in the competitive ability of native species (DECC 2007) and the loss of sustaining ecological communities.

5.3.2 Management and recommendations

Management and recommendations to minimise impacts to Alpine humus soils and peat bogs are:

- to minimise the disturbance area as much as possible;

- optimising the use of sods in an effective way when reinstating these areas; and
- avoid all unnecessary disturbance including any traffic by foot, vehicle and other plant.

5.4 Loss of soil resource

5.4.1 Potential impacts

Any soil disturbance has the potential to result in the loss of the soil resource if not managed appropriately. The soil resource includes topsoil and subsoil reserves that supply water and nutrients for plant growth. Where soil is lost there is a risk that it will impact on soil capability and rehabilitation outcomes. Soil loss can be both physical loss and loss through contamination with unsuitable materials.

Some soil is always lost during handling (i.e. stripping, stockpiling and spreading), and poor site selection for stockpiles may further decrease the available soil, particularly if the stockpile has to be relocated. Soil erosion is covered in more detail in Section 5.6.

Contamination can occur through mixing of topsoils and subsoils and the mixing of soil with other materials including, strongly acid soils, sodic soils, highly rocky material or deeper regolith material which reduce the suitability of the soil resource. Soil quality is covered in more detail in Section 5.5.

It is important to protect and reinstate the organomineral topsoil resource where practical to ensure the effectiveness of rehabilitation.

The soils most at risk are those listed below:

- soils with very thin topsoils, particularly where topsoils overlie rock or subsoils with significant constraints; and
- soils with a very high organic carbon content, such as the alpine humus soils and peats (refer to Section 5.3).

5.4.2 Management and recommendations

To enable sufficient soil available for use in rehabilitation works, soil requirements will be accurately determined before construction works begin. The volume of soil required for rehabilitation can be calculated using the area estimated for rehabilitation multiplied by the depth of soil required. If any alterations to the plans are made, or if site conditions are different than expected (e.g. shallow soil in places) the required volume of soil for rehabilitation can then be re-calculated.

An inventory of soil stripped should be prepared, so that if any significant deficit is identified, additional material can be sourced prior to rehabilitation. The recommendations made in the topsoil stripping procedure and the stockpiling procedure in **Section 5.5.2** address these measures to prevent loss of soil resource.

A suitably experienced Contractor Site Environmental Advisor or operator is to determine, topsoil and subsoil stripping depths for each site. The depth should be recorded and conveyed clearly to the earth moving plant operators.

5.5 Soil capability class and rehabilitation

5.5.1 Potential impacts

Degradation of soil resources can reduce the capability of the affected land to support the intended vegetation and/or land use. This section covers other mechanisms by which soil degradation can occur leading to a reduction in soil capability and rehabilitation outcomes. Loss of the soil resource and erosion impacts are covered in Sections 5.4 and 5.6, respectively.

Loss of organic matter and nutrient decline can reduce soil capability and rehabilitation outcomes. Loss of organic matter can occur through soil disturbance (resulting in increased breakdown rates of organic matter) and removal of vegetation as a source of new organic matter. Volatilisation and leaching of nutrients can lead to decline in nutrient levels. A loss of organic matter can affect soil properties such as soil water storage, soil structure and cation exchange capacity.

A decline in organic matter and nutrient levels is likely to occur while the soil is stored in stockpiles. This would decrease fertility and may mean the rehabilitated land using the returned soil would support less plant growth and would reduce the potential of the land. Highly organic topsoils are also important for revegetation with native species, particularly in the alpine environment. A loss of highly organic topsoils can result in the reduction in the competitive ability of native species (DECC 2007).

Soil structural decline through the compaction of soils through the breakdown of soil aggregates and loss of pore space will also reduce a soils capability. Structural decline of the soil refers to the breakdown of the aggregates (or peds), resulting in soil particles becoming more randomly and closely packed together with little pore space compared to the original structure (Keipert 2005). Structural decline can be caused by compaction by heavy vehicles and machinery when trafficked or during the removal, stockpiling and re-spreading process. Drainage of highly organic soils can also increase a soils bulk density with the loss of pore water and breakdown of organic matter. As a result, soil permeability, water-holding capacity, aeration and microfauna presence decreases, and the affected soils are less favourable for plant growth. Therefore, management practices need to minimise the risk of compaction wherever practicable. Impacts from compaction can last for a long time in some of these soils. Alpine humus soils are an example where pore space in soils is related to many years of previous soil development (NPWS 2004) and compaction is not easily reversed.

A loss of soil capability may result in limitations in establishing stabilising cover and rehabilitation, and in some cases the vegetation community originally on-site may not be able to be sustained following reinstatement. This may be a temporary impact until soil properties improve or in some cases it could be permanent if critical thresholds are exceeded.

5.5.2 Management and recommendations

The overall aim of rehabilitation works undertaken will be to leave a legacy that enables the Project to co-exist within KNP and maintain its values. Most disturbed areas, not retained by Main Works will be returned to land uses generally consistent with their pre-disturbance use, subject to ongoing consultation with NPWS (as detailed in the rehabilitation strategy. The management measures should ensure that long-term site management is not required outside operational areas for the Snowy 2.0 project.

To minimise structural decline of soil, the amount of compaction of soils during stripping and stockpiling will be minimised. This will be achieved by using suitable machinery, appropriate timing of stripping where possible and stockpile development techniques.

In KNP no fertilisers are to be used, to prevent unintended environmental impacts such as nutrient leaching or the potential to modify existing soils in a manner that alters the competitive ability of native vegetation to achieve the rehabilitation outcomes. Nutrient decline will occur during stockpiling of soils but can be minimised by suitable stockpile management methods. Any nutrient decline in areas outside KNP can be amended at the time of rehabilitation by utilising fertilisers and amendment techniques (eg gypsum, organic matter or lime application), if appropriate. The recommendations made in the topsoil stripping procedure and the stockpiling procedure below address risks to soil degradation.

The loss of organic matter and nutrient decline can be partially offset by use of fertilisers during the rehabilitation process outside of KNP. On long-term stockpiles (>12 months), vegetative cover should be established to maintain some biological cycling. In highly organic soils, multiple topsoil layers should be stripped and stockpiled separately where practical.

In some highly organic soils and in alpine or subalpine environments the use of sodding should be used, where practicable, not only to preserve the organotopsoils, but also to assist in the rehabilitation of the site following disturbance (DECC 2007).

i Topsoil management

Effective management of topsoil and subsoil also addresses the impacts of loss of soil resource, compaction and salinity/sodicity. The objective of topsoil management is to:

- preserve as much uncontaminated topsoil as possible;
- ensure topsoil is not degraded or compacted during construction and following reinstatement; and
- ensure topsoil is not mixed with unsuitable soil and spoil materials.

Topsoil management will be based on a risk management approach. By applying a risk-based approach to topsoil stripping the level of disturbance, and therefore rehabilitation required, can be minimised. High risk activities such as trenching or creation of cut and fill batter slopes can be stripped to the largest depth of topsoil available where practicable, to maintain the quality of the topsoil. More minor activities such as some access tracks may not require topsoil to be stripped to their full depth and should, where possible, avoid the disturbance of subsoils.

Prior to construction works stripping depths will be confirmed to accommodate any differences in depths encountered at specific sites.

ii Topsoil stripping

A topsoil stripping procedure will be implemented consistent with leading practice and incorporate the full range of reasonable and feasible mitigation methods for soil stripping, such as:

- where available and stripping is required, topsoil will be stripped to a minimum depth of 100 mm but may extend to deeper if suitable reserves are available;
- care will be taken during stripping, stockpiling and/or re-spreading to ensure that structural degradation/compaction of the soil is minimised;
- handling and rehandling of stripped topsoil will be minimised as far as practicable by progressively stripping vegetation and soil only as needed for development activities;

- for minor works in sensitive areas geotextile may be placed under soil stockpiles to protect underlying vegetation/soil; and
- collection and storage of indigenous/native seed and alpine sods for propagation in accordance with a seed collection and propagation program.

a Topsoil stockpiling

A topsoil stockpiling procedure will be implemented consistent with leading practice and incorporate reasonable and feasible management methods for soil stockpiling such as:

- stripped topsoil will be stockpiled separately from woody material and subsoil stockpiles;
- topsoil stockpile heights will not exceed 2.5 m, to minimise the risk of compaction and to maintain the viability of the soil seed bank;
- topsoils will be stockpiled using methods and machinery that limit the amount of compaction so as to minimise soil structural decline;
- stockpiles will be placed away from water discharge zones; topsoil should not be stockpiled against fences or vegetation and should be retained separately from mulch (apart from a surface layer);
- topsoils to be maintained for an extended period of time should have the surface left in a rough state and monitored for weed management;
- topsoil stockpiles will be clearly signposted; and
- inspections for dispersion and erosion of topsoil stockpiles will be undertaken, particularly on moderately dispersive soils. Suitable measures will be applied to reduce erosion potential as required.

iii Subsoil management

Subsoil should only be disturbed during construction bulk earthworks or trenching activities. The objective of subsoil management is to:

- prevent contamination of topsoil;
- prevent degradation of the subsoil structure;
- avoid or ameliorate subsoil constraints immediately below topsoils; and
- ensure reinstatement of soil horizons in the correct order and depths.

Subsoil will be managed in accordance with best practice including the following techniques:

- subsoil should be removed and stockpiled separately from topsoil;
- areas will be compacted to an appropriate density following backfilling with subsoil;
- excess displaced subsoil (e.g. on trenches) will be prevented from mixing with topsoil;
- excess subsoil will be stockpiled separately for disposal/re-use by appropriate methods. This may include burial in voids, or, if tested and found suitable, as fill; and

- inspections for dispersion and erosion of subsoil stockpiles will be undertaken, particularly on moderately dispersive soils. Suitable measures will be applied to reduce erosion potential as required.

iv Topsoil application procedure and rehabilitation

The rehabilitation objectives will be identified in a rehabilitation management plan, based on the final land use identified in the rehabilitation strategy. The permanent infrastructure / facilities will be rehabilitated in a manner that they can be managed and operated by Snowy Hydro in a way that avoids or minimises environmental impacts. Temporary infrastructure, required for construction works, will be rehabilitated by reinstating the typical pre-disturbance landform, to the extent as is reasonable and feasible, and meeting the final land use rehabilitation success criteria before being handed back to National Parks. Areas to be returned to native vegetation final land use will be revegetated using species commensurate with those present prior to disturbance as per the PCT mapped for the area.

In order to rehabilitate temporary disturbance areas to their final land use at completion of the project, topsoils and subsoils will need to be reinstated appropriately and sites stabilised so that they can be rehabilitated. A rehabilitation management plan will be prepared for the project, which will contain site specific information on soil management and how different project areas will be rehabilitated.

Soil will be applied to landforms once they are re-shaped and drainage works are complete. This may include contour or diversion banks with stable discharge points if required to manage runoff and ripping of compacted zones under infrastructure and other hardstand areas.

The topsoil application procedure will essentially be the reverse of the stripping procedure. It will be designed to minimise any degradation of soil characteristics, consistent with industry leading practice. Soils horizons will be reinstated in the correct order and depth to allow for rehabilitation.

Stabilisation of disturbed surfaces is to occur as soon as possible throughout all project phases and progressive rehabilitation will be undertaken to reduce the risk of erosion and assist in achieving the final rehabilitation acceptance criteria sooner.

The following measures are designed to minimise the loss of soil during respreading on rehabilitated areas and promote successful vegetation establishment:

- a soil balance will be prepared and included in the rehabilitation management plan before the topsoil is spread, which shows the depths and volume of soils to be reapplied in particular areas. The plan will take account of the relative erodibility of the soils, with more erodible material being placed on flatter areas to minimise the potential for erosion (where practicable and this does not conflict with the final land use);

- soil will be respread in even layers at a thickness appropriate for the land capability of the area to be rehabilitated and the soil resources available;

- topsoil will be compacted firmly but not excessively and left slightly rough (light cultivation after reinstatement may be required) to provide a suitable seed bed for revegetation, which will be undertaken as soon as practicable after topsoil re-spreading;

- where works have removed subsoil or deeper regolith, the area to be rehabilitated may need to be re-profiled and/or deep ripped, before the subsoil is respread onto the site (or all at once if not stripped and stored separately), followed by the topsoil;

- soils will be lightly scarified on the contour to encourage rainfall infiltration and minimise run-off;

- as soon as practicable after respreading, a sterile cover crop (or other form of cover if a cover crop is unsuitable) should be established to limit erosion and soil loss. A cover crop will also provide good mulch for native plant establishment;

- where vegetative cover has not been established the use of other cover may include mulching (organics or rocks), geofabrics (e.g. jute matting) or soil binding agent until suitable cover is achieved. This will be particularly important for sites with high erosion risk and where season / plant growth conditions are not optimal;

- long term erosion and sediment controls will be implemented where deemed necessary prior to vegetation;

- in areas likely to experience frost heave, additional measures such as jute mesh, sod revegetation or similar to be used to minimise the risk of erosion;

- where required, collection of indigenous/native seed and sods for propagation will be undertaken. Where sods were collected prior to construction they are to be used immediately following reinstatement; and

- A rehabilitation management plan will be prepared to guide the long-term rehabilitation of the site including establishment of native plant species. Rehabilitation goals and objectives for the domains of the project area will be determined through the final land use, which is identified in the rehabilitation strategy.

A Rehabilitation Monitoring Program will be prepared to ensure that the rehabilitated areas are managed towards the nominated completion criteria and the ultimate completion of rehabilitation and handover back to NPWS. Regular rehabilitation monitoring will be undertaken to identify any defects, such as slumping, erosion or poor vegetation establishment, so that they can be rectified.

5.6 Soil erosion and sediment transport

5.6.1 Potential impacts

Construction of the proposed infrastructure will require vegetation clearing and soil disturbance which has potential to destabilise soils and leave them exposed to erosion processes unless managed appropriately. In addition to the usual erosion processes, erosion of exposed soil can be exacerbated by freeze thaw cycles. Soil erosion will result in the loss of soil from project sites which can reduce the effectiveness of rehabilitation outcomes, particularly where topsoil is lost. Off-site impacts can be caused by sedimentation of land and waterways (e.g. streams, rivers, and lakes), as well as a decrease in water quality of these surface water features.

The receiving environments in KNP range from slightly disturbed to pristine condition. Therefore, the erosion and sediment control measures should be undertaken to the highest standard practicable.

The Main Works area also covers a large range of climate, topography, soil types and plant communities, all of which affect soil erosion processes. This wide variation in conditions means soil erosion measures will not be standard across the project but tailored to specific sites.

5.6.2 Management and recommendations

Site-based progressive Erosion and Sediment Control Plans (ESCPs) will be prepared for the construction works with controls addressing the sensitivity and the proximity of the receiving environment and attention will be given to areas where there is an increased risk of erosion, such as, dispersive soils, upland soils and steep slopes.

Stormwater management measures to be implemented for the proposed works are detailed in the surface water assessment (EMM 2019).

Erosion and sediment control measures will be designed, constructed and implemented in accordance with the following guidelines:

- Managing Urban Stormwater, Volume 1 (Blue Book) (Landcom 2004);
- Managing Urban Stormwater, Volume 2A Installation of Services (DECC 2007); and
- Managing Urban Stormwater, Volume 2C Unsealed roads (DECC 2008).

Typical erosion and sediment control management measures to be applied include:

- staging of construction and progressive rehabilitation to limit the total area of land at risk from increased erosion risk;
- installation of erosion and sediment controls at the start of construction including any required clean water diversions, dirty water catch banks and sedimentation basins or other sediment capture devices for constrained areas;
- where practicable dirty water will be directed from disturbed areas to sediment basins or to areas with adequate controls to trap and/or filter coarse sediment before it leaves the site;
- erosion and sediment controls will be inspected regularly during construction;
- temporary erosion and sediment controls will be regularly maintained and promptly rectified following rain events;
- the use of a soil binder agent to provide cover on any areas at risk of erosion until they have been stabilised or achieved rehabilitation cover targets;
- exposed soils in the more elevated sections of the Main Works area are subjected to frost-heave, necessitating rapid stabilisation and rehabilitation of disturbed areas (DEC 2006);
- where practicable above ground excavation activities should be undertaken when soils are not saturated and during periods of lower rainfall to reduce the risk of erosion;
- use of weather forecasting will be used to manage site operations when there is the risk of high intensity rainfall in storms;
- dust control, such as the use of water trucks should be implemented where appropriate with attention given to construction activities that have the potential to create dust on at risk soils and during windy conditions (detailed in Section 4.1);
- soil stockpiles will be managed to minimise impacts from wind erosion where required;
- stockpiles will be located where they are not exposed to overland or flood flow; and
- soil stockpiles will have clean water diversions installed upslope and sediment controls installed downslope.

5.7 Soil contamination

5.7.1 Potential impacts

Soil contamination associated with proposed construction activities may occur as a result of spills or unplanned releases of potentially contaminating materials. This can include potential spills of fuels or hazardous chemicals, such as petrol, oil and lubricant (POL) and other chemicals (eg herbicides) at storage locations, use locations, or during transport. Earthworks and other disturbance activities can also disturb unidentified sites of contamination, for example old mine sites, tailings and historic building structures potentially containing hazardous materials such as asbestos or metals.

The Lobs Hole area was the site of a copper mine in the late nineteenth century through to 1916. A summary of the findings of previous contamination investigations undertaken in the vicinity of Lobs Hole are provided in Preliminary Site Investigation – Contamination report for the project (EMM 2019).

Naturally occurring asbestos (NOA) and potentially acid forming (PAF) rock may be encountered or impacted during the construction of the project. Disturbance of NOA could potentially result in the exposure of project workers and other human receptors to asbestos contamination. Impacts associated with the presence of PAF rock potentially includes the generation of contaminated surface water runoff which could discharge to waterways and/or surrounding land.

5.7.2 Management and recommendations

Specific measures for the management of potential contamination resulting from project construction activities will be detailed in a Construction Environmental Management Plan (CEMP) and associated plans developed to inform the management of NOA and PAF rock, which would be prepared post project approval. These site-specific management plans will aim to minimise project construction related contamination risks to both human health and environment. The CEMP will address environmental issues and risks associated with project construction, and will encompass all areas where physical construction activities will occur.

The Preliminary Site Investigation - Contamination report (EMM 2019) assesses the risk and management requirements for NOA and PAF rock that may be encountered or impacted during the construction of the project. The report includes management and mitigation recommendations including the development of an Excavated Material Management Plan to be implemented during all phases of the Project lifecycle.

5.8 Acid sulfate soils

5.8.1 Potential impacts

Acid sulfate soils, when undisturbed, do not present a risk to the environment. When disturbed, the iron sulfides the soils contain react with oxygen in the air to create sulfuric acid. In turn, the sulfuric acid can release metals in the soil and damage waterways, aquatic and terrestrial flora and fauna and infrastructure.

The desktop review and field survey revealed that the assessment area is unlikely to contain acid sulfate soils.

5.8.2 Management and recommendations

No specific management measures are required unless acid sulfate soils are encountered during works and these will be managed as per the unexpected find procedure in the CEMP.

5.9 Importing of construction materials

5.9.1 Potential impacts

Sourcing of construction materials for the project can have both on-site and off-site potential impacts.

Importing construction materials could introduce weeds and diseases (e.g. Phytophthora) to the project area. If construction materials contain elevated levels of salt it could adversely affect water quality if leaching occurs.

5.9.2 Management and recommendations

Any soil material brought onto site will need certification that it does not contain waste or pose a biosecurity risk. This will be managed in accordance with procedures to be outlined in the rehabilitation management plan.

Water management measures will be applied to minimise the potential for water quality impacts arising from construction activities including storage and use of construction materials. Potential for impacts to water quality and relevant management measures are provided in the surface water assessment (EMM 2019).

6 Project active domain management recommendations

This section provides recommendations for management of construction works in project active domains, which are additional to the general measures outlined in Section 5. Details of the construction activities occurring in the project active domains are presented in Section 2 and the location of these domains are shown in Figure 5.1 The project active domains with land and soil management are:

1. Infrastructure;
    a) Accommodation Camps;
    b) Construction portals and yards;
2. Access roads;
3. Intakes;
4. Stockpiles; and
5. Utilities

6.1 Accommodation camps

The temporary accommodation camps for the construction phase for the project are:

- Exploratory camp;
- Marica camp;
- Main camp; and
- Tantangara camp.

The construction of these camps is likely to involve bulk earthworks to achieve slopes suitable for camp use. All camp areas will be returned to a native vegetation final land use and revegetated using species commensurate with those present prior to disturbance as per the PCT mapped for the area. Based on this final land use it will be important to manage and preserve the condition of the soil resource to ensure that it can be reinstated to closely resemble the original soil profile.

It will be important to preserve and reinstate adequate depths of topsoil and subsoil over less weathered rock / substrate. Topsoil and subsoil should be stripped and managed separately and where practicable, be reinstated at similar pre-disturbance depths. Where described topsoil is very shallow (<0.2 m) and there is subsoil material without significant soil constraints (i.e. not very strongly acidic, sodic, salty, etc) in the horizon below then a topsoil depth of up to 0.3 m should be stripped to assist in final rehabilitation.

No soil amelioration/soil amendments (eg lime or gypsum) or fertilisers are to be used within KNP due to potential impacts to the native vegetation communities and other KNP ecosystem values.

Impacts on the soils and land resources from the projects accommodation camps should managed through the implementation of the management and recommendations from Section 5 with a focus on sections 5.4.2, 5.5.2 and 5.6.2.

Site specific soils information for the camps is presented in Table 6-1.

6.2 Construction portals and pads

This domain includes the temporary construction yards and permanent and temporary project portals established during the construction phase for the project as follows:

- Talbingo portal (temporary);
- Main yard (temporary);
- ECVT portal (permanent);
- MAT portal (permanent);
- Marica portal (permanent);
- Tantangara adit (temporary); and
- Rock Forest yard (temporary).

The construction pads on which construction facilities will be placed. Construction pads will typically be in the vicinity of construction portals where tunnelling is taking place.

6.2.1 Permanent portals

The construction of the portals will include the excavation of a significant amount of spoil with a permanent impact and the loss of land in the excavated footprint. All slope cuts and structures will be designed by a geotechnical engineer taking into account issues of global stability, local stability and rock fall.

All spoil will either be reused as site construction material or disposed of at an appropriate location.

A rehabilitation management plan will be prepared for the revegetation of these areas based on the final land use objectives and operational requirements. A sufficient quantity of topsoil is to be stripped for the revegetation as part of the landscaping works.

6.2.2 Temporary construction portals and yards

The construction of these portals and yards will involve bulk earthworks in some locations to achieve suitable slopes. All temporary construction areas will be returned to a native vegetation final land use and revegetated using species commensurate with those present prior to disturbance as per the PCT mapped for the area. Based on this final land use it will be important to manage and preserve the condition of the soil resource so that it can be reinstated to closely resemble the original soil profile.

It will be important to preserve and reinstate adequate depths of topsoil and subsoil over less weathered rock/substrate. Topsoil and subsoil should be stripped and managed separately so that they can be reinstated at similar pre-disturbance depths. Where described topsoil is very shallow (<0.2 m) and there is subsoil material without significant soil constraints (i.e. not very strongly acidic, sodic, salty, etc) in the horizon below then a topsoil depth of up to 0.3 m should be stripped to assist in final rehabilitation.

No soil amelioration/soil amendments (e.g. lime or gypsum) or fertilisers are to be used within KNP. Outside KNP amelioration should only be used if soil constraints are likely to occur higher in the reinstated soil profile due to the soil handling/mixing during works. Likewise, light fertiliser applications can be applied to areas outside KNP during establishment of initial cover in the stabilisation and to address any deficiencies identified compared to the original soil fertility.

Impacts on the soils and land resources from the projects temporary construction portals and yards should managed through the implementation of the recommendations from Section 5 with a focus on sections 5.4.2, 5.5.2 and 5.6.2.

Site specific soils information for the construction portals and yards is presented in Table 6-1.

6.3 Access roads

Some new access roads or those which are upgraded, widened and sealed will be retained with agreement from NPWS. During operation, a number of service roads established during construction will be used to access surface infrastructure including the power station's ventilation shaft, intake structures and gates, and the headrace tunnel surge shaft.

Temporary roads will be used to serve construction yards, accommodation camps, construction areas of the intakes and geotechnical investigation areas and environmental monitoring points. These roads will be returned to a native vegetation final land use and revegetated using species commensurate with those present prior to disturbance as per the PCT mapped for the area.

The project involves the design of the access roads connecting the existing, public roads with the construction areas and accommodation camps associated with the Snowy 2.0 project. In total, there will be approximately 70 km of access roads constructed as part of the Main Works. Road design will minimise the impact of stormwater on downslope areas by avoiding having large outlets and releases onto less stable areas. Progressive rehabilitation and detailed planning and implementation of erosion and sediment control will be critical for managing erosion.

Impacts on the soils and land resources from the construction and use of access roads should managed through the implementation of recommendations from Section 5 with a focus on sections 5.4.2, 5.5.2 and 5.6.2.

6.4 Intakes

The project has two intake structures. The Talbingo intake is located at the lower reservoir at the tailrace tunnel and the Tantangara intake is located at the higher ground of the headrace tunnel.

The construction of both intakes will include the excavation of a significant amount of spoil with permanent impact and the loss of land in the excavated footprint. All slope cuts and structure will be designed by a geotechnical engineer and address global stability, local stability and rock fall.

All spoil will either be reused as site construction material or disposed of at an appropriate location according to the CEMP and the Excavated Material Management Plan.

A rehabilitation management plan will be prepared for the revegetation of these areas based on the final land use objectives and operational requirements.

Topsoil is to be stripped to supply quantities sufficient for the revegetation as part of the landscaping works.

Impacts on the soils and land resources from the construction and operation of the intakes should managed through the implementation of the recommendations presented in Section 5, with a focus on the management measures identified in sections 5.4.2, 5.5.2 and 5.6.2.

Site specific soils information for the intakes is presented in Table 6-1.

6.5 Spoil stockpiles

This domain includes the temporary land emplacement areas (stockpiles) utilised for excavated material management during the project. The main temporary stockpiles will be the excavated rock stockpiles at Lobs Hole; however, numerous additional stockpiles will be used throughout the project.

Material from the stockpiles will be either reused within construction works or as road base material; or it will be disposed of at the end of the project. For Main Works, it is proposed to place excavated material in-reservoir, where possible, in Talbingo and Tantangara Reservoirs. Details of the proposed in-reservoir placement are provided in the Main Works EIS and the Reservoir Assessment Overview (Appendix N).

The Preliminary Site Investigation - Contamination report (EMM 2019) includes recommendations for the management of potentially impacted NOA and PAF rock/spoil.

An Excavated Material Management Plan will be prepared for the project, which will address:

- clean excavated material;
- PAF material;
- NOA/hazardous mineral fibre/silica rich material;
- contaminated material, e.g. from Lobs Hole mining waste; and
- dredged material.

To limit the potential for any groundwater infiltration, when stockpiling spoil, a geotextile/geomembrane will be used and drainage cells will be directed to drainage pipes on the site.

All stockpiles will be designed and managed implementing principles of erosion and sediment control, which will include the preparation of a specific ESCP for each stockpile area, in accordance with the Soil Management Plan and Surface Water Management Plan. This will consider:

- planning (e.g. preparation of a series of progressive plans and environmental work method statements);
- minimum disturbance to existing vegetation (e.g. 'no go' barriers);
- topsoil management for revegetation/rehabilitation (e.g. stripping and stockpiling);
- runoff control (e.g. onto, through/around and off the sites; separation of 'clean' and 'dirty' flows);
- erosion control (i.e. retaining soil at its place of origin);
- sediment control (i.e. final line of defence such as sediment basins, fences and traps); and
- progressive revegetation/rehabilitation (e.g. temporary on some stockpiles).

Ripping of the ground under the stockpiles will be undertaken to relieve any compaction prior to the respreading of topsoil.

Impacts on the soils and land resources from the temporary spoil stockpiles should managed through the implementation of the recommendations presented in Section 5, with a focus on the management measures identified in sections 5.4.2, 5.5.2 and 5.6.2.

Site specific soils information for the spoil stockpiles is presented in Table 6-1.

6.6 Utilities

This domain will include disturbance corridors associated with the installation of the supporting utilities to service the project. This will include:

- power;
- water;
- sewage and process water treatment facilities; and
- communications.

A number of utilities will be installed within existing access road corridors; these areas are included in Domain 2.

Utilities that will be installed on new access roads will have cable trenches cut to the required depth, following the clear and grade road construction activities. Where required, bedding sand will be laid, and the conduit placed, before the trench is backfilled and compacted with the excavated material. The trenches will be controlled and only opened when absolutely required to reduce the distance of open trench.

A significant portion of the construction power infrastructure will form permanent infrastructure. All infrastructure that is not required for permanent power will be removed from site in an appropriate manner and all underground cabling/conduits will be pulled up and recycled or appropriately disposed of. To assist in this process, wherever it is safe to do so, temporary electrical infrastructure will be installed above ground.

Communications cable routes for the main works includes the following:

- the remaining communications cable route from the Main Access Tunnel to Tantangara Intake;
- Tantangara Intake to Lake Eucumbene;
- Lake Eucumbene to Cabramurra via Three Mile Dam; and
- re-routing of the cableway (which bypassed the Talbingo intake structure site during exploratory works) to the Talbingo intake structure once constructed.

Progressive ESCPs will be applied during construction of the utilities. Where vegetation clearing has occurred during site works the use of site sourced mulch is suggested to provide cover of sufficient depth to protect soils from erosion. Use of organic mulch and/or vegetation (branches placed on the contour) may be appropriate in some areas.

In addition to the general soil management measures described previously, trenching activities should:

- minimise the disturbed area;
- minimise length of open trench;

- strip topsoil and subsoil separately;
- include the use of temporary erosion and sediment controls as required (e.g. diversion drains, sediment traps);
- implement erosion and sediment controls on maintenance tracks;
- involve temporary stabilisation such as soil binding agent, sods or geotextile;
- progressive rehabilitation with permanent species;
- consider the use of sods for peat soils and where revegetation maybe difficult due to environmental conditions;
- avoid altering the surface drainage;
- avoid driving on revegetated areas; and
- monitor and rectify any subsidence or other defects promptly.

All excess spoil generated from the installation of utilities will either be reused by the contractor (or NPWS), placed permanently within Tantangara or Talbingo reservoirs, used in final land forming and rehabilitation of construction pads in Lobs Hole, or transported offsite.

Table 6.1 Soil and land characteristics1 at project infrastructure locations

Infrastructure	Geology	Slope	Vegetation	ASC	Soil description	Soil erodibility	Strip depth	Organic / peat layers
Camps								
Exploratory camp	Ravine Beds/ Yarrangobilly Limestone (ss2). Limestone with sediments	Generally >15%	Montane Mountain Gum-Snow Gum Forests	KA, TE/RU	Sandy clay loam to clay loam over rock at 0.5m. pH slightly acid to neutral. Surface rock boulders. Topsoil depth 0.05m	K-factor 0.049-0.053 Massive to weak structure likely to have low coherence when disturbed Not dispersive High erodibility	Topsoil 0.2m Subsoil 0.5m (depth of clay loam)	Not highly organic
Main camp	Ravine Beds/ Yarrangobilly Limestone (ss2). Limestone with sediments	Broad ridge – flat to moderately steep. 0-10%	Montane NL Peppermint Grass/Shrub Forests	KA, TE/RU	Sandy clay loam to clay loam over rock at 0.5m. pH slightly acid to neutral. Surface rock boulders. Topsoil depth 0.05m	K-factor 0.049-0.053 Massive to weak structure likely to have low coherence when disturbed Not dispersive High erodibility	Topsoil 0.2m Subsoil 0.5m (depth of clay loam)	Not highly organic
Tantangara camp	Kellys plain Volcanics (Dkv). Fine grained Peppercorn Formation (Spp). Quartzose sediments	Mid-slope and low saddle. Low to moderate steep. 0-15%	Sub-alpine Dry Herb-Grassland	DE, TE/RU	Shallow to moderately deep soils on mid to lower slopes on fine grained acid volcanics and quartzose sediments. Dermosols likely on gentle slopes and lower slope positions and Tenosols/Rudosols in steeper areas. Slightly to strongly acid profiles.	K-factor 0.039-0.051 Massive to moderate structure likely to have low coherence apart from Dermosols High erodibility	Topsoil 0.3m Subsoil to rock or 1m	Possible highly organic surface layer (possible alpine humus soil)

Table 6.1 Soil and land characteristics1 at project infrastructure locations

Infrastructure	Geology	Slope	Vegetation	ASC	Soil description	Soil erodibility	Strip depth	Organic / peat layers
Rock Forest laydown	Tantangara Formation (Syn) and Adaminaby Group (Oa) Quartzose sediments	Lower to mid slopes draining to the north east or draining to the south east	Cleared pasture Montane Mountain Gum-Snow Gum Forests A carex fen is mapped in the north-west of the area	KA/CH west DE eastern side	Moderately deep soils on lower to mid slopes of gently undulating to undulating rises on sandstones. Gradational soils of clay loam over light clays. Slightly to strongly acid profiles.	K-factor 0.038-0.051 Massive to moderate structure likely to have low coherence apart from Dermosols High erodibility	Topsoil 0.3m Subsoil to rock or 1 m	Not highly organic, apart from drainage features and a carex fen mapped the north-west

Notes: 1. Soil and land characteristics are based on expert interpretation of closest available site descriptions from the exploratory works soils survey and profiles from eSPADE (OEH 2018g). No field survey was undertaken as part of this study due to land access not being granted within KNP.

7 Summary of management measures and recommendations

This section contains a summary of the mitigation measures that will be implemented for the project to avoid and minimise impacts to the soil and land resources. Table 7.1 focuses on impacts / risks to the soil and land resources and associated management measures. It is important to note that there is close link between mitigation measures and the soil and land values, with the same general management measures required across multiple impacts.

Table 7.1 Summary of mitigations measures

Impact/risk	Timing (of measure)	Management measures / recommendations
Safe and stable landform, commensurate with the surrounding topography of the area	Pre-construction /construction	Measures outlined in the rehabilitation strategy will be implemented to provide a safe and stable landform, commensurate with the surrounding topography of the area
Alpine humus soils and peat bogs/fens are vulnerable to disturbance, soil erosion, weed invasion, sedimentation and alteration of hydrology. Alpine humus soils and peat bogs/fens - A loss of highly organic topsoils can result in the reduction in the competitive ability of native species (DECC 2007) and the loss of sustaining ecological communities.	Pre-construction /construction/operations	The following mitigations will be implemented to minimise impacts to Alpine humus soils and peat bogs/fens: • to minimise the disturbance area as much as possible; • optimising the use of sods in an effective way when reinstating these areas; and • avoid all unnecessary disturbance including any traffic by foot, vehicle and other plant to avoid compaction / compression of soil.
Salinity	Construction	Vegetation clearing will be minimised where practical.
Loss of soil resource, both physical loss and loss through contamination with unsuitable materials	Pre-construction /construction	Preservation of the soil resource including quantity and quality to be managed through the implementation of soil management measures incorporated within the rehabilitation management plan which includes: • inventory of soils to be stripped, including depths and volumes • a topsoil stripping and stockpiling procedure • subsoil management measures • a soil reinstatement methodology which includes a topsoil application procedure.

Table 7.1 Summary of mitigations measures

Impact/risk	Timing (of measure)	Management measures / recommendations
Impacts to soil capability class leading reduced rehabilitation outcomes due to: • loss of soil • loss of organic matter and nutrient decline • soil structural decline • compaction	Pre-construction /construction/operations	Soil management measures to minimise impacts to the soil capability class will be developed within the rehabilitation management plan which includes: • soil handling procedures including topsoil stripping and stockpiling • subsoil management measures • a soil reinstatement methodology which includes a topsoil application procedure to promote successful vegetation establishment • a Rehabilitation Monitoring Program will be prepared to ensure that the rehabilitated areas are managed towards the nominated completion criteria and the ultimate completion of rehabilitation and handover back to NPWS.
Soil erosion and sedimentation	Pre-construction /construction/operations	Site-based Erosion and Sediment Control Plans (ESCPs) will be prepared by a Certified Professional in Erosion and Sediment Control (CPESC) for the construction works with controls addressing the sensitivity and the proximity of the receiving environment and attention will be given to areas where there is an increased risk of erosion, such as, dispersive soils and steep slopes and subalpine landscapes.
Soil contamination – spills and unplanned releases	Construction	Procedures and resources outlined in a management plan.
Soil contamination – disturbance of existing contamination (eg Lobs Hole mine)	Construction	Management measures for potential contamination resulting from project construction will be detailed in a Contamination Management Plan to be prepared post approval.
Soil contamination - Naturally occurring asbestos (NOA) and potentially acid forming (PAF) rock	Construction	Excavated Material Management Plan will contain project management measures.
Acid sulfate soils	Construction	No specific management measures are required unless acid sulfate soils are encountered during works and these will be managed as per the unexpected find procedure in the CEMP.
Importing construction material – weeds and disease	Construction	Any soil material brought onto site will need certification that it does not contain waste or pose a biosecurity risk. This will be managed in accordance with procedures to be outlined in the rehabilitation management plan

8 Residual impact assessment

There will be minimal residual impacts on soils and land from the project in the form of the permanent infrastructure. These impacts include the loss of land capability associated with road upgrades/realignments, the intake structures and project portals.

Permanent infrastructure provides the potential for ongoing risks associated with operational use and these areas will likely need ongoing maintenance both from an operational perspective and for protection of environmental values. The length of road and spatial extent through a range of landscapes present an elevated risk profile. To minimise these risks best practice design and construction techniques will be implemented as well as implementation of effective soil management measures in stabilisation works and rehabilitation / revegetation of project areas.

The degree or significance of residual impacts from the project will be minimised by the implementation of management measures. Minimal residual erosion and sedimentation, contamination, rehabilitation issues, loss of soil resource and soil degradation is expected during construction or operation if the management and recommendations listed in the above section are implemented.

9 Conclusions

Snowy 2.0 is located mostly within the KNP and covers a diverse range of environmental conditions from the Lobs Hole ravine (~550 m AHD) to the Plateau region (~1400 m AHD). Soil and land resources have a significant role in contributing to KNP values directly as unique and significant soils and landform features and indirectly through the provision of a range of ecosystem services including providing clean water and flow attenuation, suitable habitats for insect fauna, and substrate for significant ecological communities.

The soils of the Snowy 2.0 project area were mapped using an enhanced resource assessment approach, with key datasets consisting of the existing soil site data and geological mapping, as there was no available approval pathway to undertake additional soil sampling within the KNP during the EIS investigation phase. The soils mapping legend was developed with the separation of the plateau and western escarpment areas, then map units were grouped into similar geologies before being divided into map units with different landform/vegetation where there was a change in the dominant ASC. Based on topographic position soils tend to be shallower and rocky on steep slopes or crest/upper slope positions with shallow to moderate depth on flatter and lower slope positions. Upland soils are likely to contain peat layers and due to their characteristics and location are generally fragile soils which are difficult to return to their natural state once disturbed.

This soils and land assessment considered the project's goal of impact avoidance, minimisation and mitigation in relation to the land and soil in the project area to examine the vulnerability of the soil and land resource to potential impacts.

The vulnerability of the soil and land resource to potential impacts from the Main Works was assessed with reference to the following impact issues:

- soil erodibility (e.g. K factor, slope, Emerson class);
- soil degradation potential (e.g. compaction, fertility decline, topsoil and subsoil reserves);
- rehabilitation potential (e.g. low potential Alpine Humus Soils and shallow depth soils);
- supporting significant ecological communities (e.g. Alpine Peat/Fens); and
- other ecosystem services and land use (e.g. water quality and flow moderation from alpine humus soils / bogs and recreation use).

Identification of these different impact issues gives specific attention to appropriate management measures that will be important in vulnerable areas.

With the implementation of appropriate and effective management and mitigation measures potential impacts of the project on the soils and land resources in the study area, including land degradation, off-site impacts and a reduction in the ability to provide ecosystem services, will be minimised. Mitigation measures will be implemented to limit the potential for erosion and sedimentation, soil compaction, creation of dust and reduced soil quality, which will assist in improving rehabilitation outcomes and future land use. Preservation of the soil resource including quantity and quality will be managed through the implementation of soil management measures incorporated within the rehabilitation management plan.

Many of the impacts identified are interrelated and will require suitable management with consideration of multiple environmental values. For example construction activities, without suitable mitigation measures, in areas vulnerable to soil impacts have potential to reduce groundcover and initiate erosion which could deplete the organic rich topsoil base, reduce capacity of the area to support the unique vegetation communities relying on the rich organic soil and water holding capacity of the soils and reduce the capacity of the system to provide water quality and flow moderation outcomes.

The key potential project risks to soil and land resources are soil erosion and impacts to land and soil capability. These project risks require additional mitigation measures in vulnerable areas such as steep slopes, shallow topsoils, highly organic soils and climatic conditions in higher elevation environments. The development and implementation of construction-based management plans, using site specific soils information, and the adoption of the recommended management measures in this report will assist to mitigate impacts on the soil and land resources. It is expected that through the detailed design and management measures proposed the Main Works will effectively minimise impacts to soils and land will maintain or return the soil to a condition that achieves the land use and rehabilitation objectives.

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Annexure A

Soil sites from the NSW SALIS database

NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	Profile 9
Map Reference:	MGA Grid Reference: Zone 55, 653089E, 6012901N. 8625 BERRIDALE (1:100000) map sheet.
Profile Details:	OBSCRAS - BERRIDALE Survey (1003643), Profile 9, collected by Mr Dermot McKane on 02 March, 1999
Physiography:	hillslope under woodland grass understorey on sandstone-quartz lithology and used for volun./native pasture. Slope 6% (measured), aspect north west. Surface condition is soft, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Red Kandosol (ASC), Red Podzolic Soil (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	cmz5hsrllow. R1

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.08 m A1 Horizon	colour not recorded clay loam with massive structure (earthy), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 2

0.08 - 0.55 m BC Horizon	colour not recorded light clay with massive structure (earthy), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	Caves exit road - 1.3km from Hwy
Map Reference:	MGA Grid Reference: Zone 55, 636844E, 6044183N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	MSBP - Tantangara Soils Benchmarking Project Survey (1004562), Profile 194, collected by Mr Wayne Cook on 19 October, 2005
Physiography:	swamp under swamp complex on organic material, alluvium lithology and used for National/State Parks. Slope 4% (measured), local relief very low (9-30 m), elevation 1307.0 m, aspect north west. Surface condition is soft, profile drainage is very poorly drained, erosion hazard is moderate, and no salting evident
Soil Type:	Kandosolic Oxyaquic Hydrosol (ASC)
Base of observation:	soil continues
Profile Field Notes:	Heathland community, swamp. ovg1 = Gooandra Volcanics underlie swamp.

SOIL DESCRIPTION

Layer 1

0.00 - 0.50 m A Horizon	brown (dull yellowish brown) (10YR 4/3) [moist] light fibric peat with massive structure (earthy), abundant (>100/10x10cm) roots (<1mm), abundant (>100/10x10cm) roots (1-2mm), field pH is 5.0. Coarse fragments are not evident. Layer notes are: Fibric Peat texture (LCIP: as per Australian Soil and Land Survey, 1990).; not evident boundary to ...

Layer 99

LABORATORY TESTS

Sample Code	Upper Bnd.	Lower Bnd.	% Clay 517.99_CL	USCS 550.02	pH 4A1	EC 3A1	OC 6A1	Bray Phos 9E1	Phos Sorb 9I1	Exch Al 15F2_AL	Exch Ca 15F1_CA	Exch K 15F1_K	Exch Mg 15F1_MG	Exch Na 15F1_NA
WEL/05/4/507(1)	0.00	0.50			5.8	0.03								

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	Caves Exit Road
Map Reference:	MGA Grid Reference: Zone 55, 636648E, 6044542N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	MSBP - Tantangara Soils Benchmarking Project Survey (1004562), Profile 193, collected by Mr Wayne Cook on 01 September, 2005
Physiography:	hillslope under dry sclerophyll forest on shale, siltstone/mudstone lithology and used for National/State Parks. Slope 10% (measured), local relief very low (9-30 m), elevation 1315.0 m, aspect south west. Surface condition is soft, erosion hazard is slight, and no salting evident
Soil Type:	Acidic Petrocalcic Brown Dermosol (ASC)
Base of observation:	bedrock reached
Profile Field Notes:	sv5 = Gaobragondra Volcanics. Shaley massive volcanic sediments, 1:250K (Geol of Kasi, not Park). Under snow at time of sampling. 5cm O horizon - Eucalyptus layer.

SOIL DESCRIPTION

Layer 1

0.00 - 0.03 m A1 Horizon	brown (7.5YR 4/3) [moist] fine sandy clay loam with weak pedality (polyhedral, 10 - 20 mm), abundant (>100/10x10cm) roots (<1mm), few (1-10/10x10cm) roots (1-2mm), field pH is 6.0. Coarse fragments are common (10-20%), as parent material, fine gravel (2-6 mm), gravel (6-20 mm). Layer notes are: Thin A1 (1-3cm). Very high percentage of fungal mychoriza.; smooth sharp (<5 mm) boundary to ...

Layer 2

0.03 - 0.22 m B2 Horizon	reddish brown (dull reddish brown) (5YR 4/4) [moist] light medium clay with strong pedality (rough-faced peds), many (25-100/10x10cm) roots (<1mm), few (1-10/10x10cm) roots (1-2mm), field pH is 5.0. Coarse fragments are common (10-20%), as parent material, fine gravel (2-6 mm), gravel (6-20 mm), coarse gravel (20-60 mm). Layer notes are: Sub - plastic.

Layer 99

LABORATORY TESTS

Sample Code	Upper Bnd.	Lower Bnd.	% Clay 517.99_CL	USCS 550.02	pH 4A1	EC 3A1	OC 6A1	Bray Phos 9E1	Phos Sorb 9I1	Exch Al 15F2_AL	Exch Ca 15F1_CA	Exch K 15F1_K	Exch Mg 15F1_MG	Exch Na 15F1_NA
WEL/05/4/505(1)	0.00	0.03			6.4	0.05								
WEL/05/4/506(1)	0.03	0.22			5.9	0.03								

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	Crest above Jersey Cave carpark
Map Reference:	MGA Grid Reference: Zone 55, 634534E, 6045757N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	MSBP - Yarrangobilly Soils Benchmarking Project Survey (1004565), Profile 188, collected by Mr Wayne Cook on 30 August, 2005
Physiography:	hillcrest under dry sclerophyll forest on limestone lithology and used for National/State Parks. Slope 0% (estimated), local relief high (90-300 m), elevation 1051.0 m. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Haplic Brown Kurosol (ASC)
Base of observation:	equipment/auger refusal
Profile Field Notes:	Yarrangobilly limestone. Geo code from 'Kasi not Park, Geology of' 1:250K.

SOIL DESCRIPTION

Layer 0

Coarse fragments are abundant (50-90%), as rock outcrop, cobbles (60-200 mm), stones (200-600 mm), boulders (> 600 mm)

Layer 1

0.00 - 0.12 m
A1 Horizon

brown (greyish brown) (7.5YR 4/2) [moist] light clay loam with weak pedality (polyhedral, 5 - 10 mm, rough-faced peds), many (25-100/10x10cm) roots (<1mm), common (10-25/10x10cm) roots (1-2mm), field pH is 5.5. Coarse fragments are common (10-20%), as parent material, fine gravel (2-6 mm); irregular clear (20-50 mm) boundary to ...

Layer 2

0.12 - 0.21 m
B2 Horizon

reddish brown (dull reddish brown) (5YR 4/3) [moist] light medium clay with strong pedality (polyhedral, 10 - 20 mm, smooth-faced peds), many (25-100/10x10cm) roots (<1mm), common (10-25/10x10cm) roots (1-2mm), field pH is 5.5. Coarse fragments are common (10-20%), as parent material, fine gravel (2-6 mm), gravel (6-20 mm)

Layer 99

LABORATORY TESTS

Sample Code	Upper Bnd.	Lower Bnd.	% Clay 517.99_CL	USCS 550.02	pH 4A1	EC 3A1	OC 6A1	Bray Phos 9E1	Phos Sorb 9I1	Exch Al 15F2_AL	Exch Ca 15F1_CA	Exch K 15F1_K	Exch Mg 15F1_MG	Exch Na 15F1_NA
WEL/05/4/494(1)	0.00	0.12			6.7	0.1								
WEL/05/4/495(1)	0.12	0.21			6.8	0.13								

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	Jersey Cave Carepark
Map Reference:	MGA Grid Reference: Zone 55, 634548E, 6045702N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	MSBP - Yarrangobilly Soils Benchmarking Project Survey (1004565), Profile 187, collected by Mr Wayne Cook on 30 August, 2005
Physiography:	hillslope under dry sclerophyll forest on limestone lithology and used for National/State Parks. Slope 22% (measured), local relief high (90-300 m), elevation 1029.0 m, aspect south. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Acidic Pedaric Red Dermosol (ASC)
Base of observation:	equipment/auger refusal
Profile Field Notes:	Geo code Kasi region 250K Yarrangobilly limestone.

SOIL DESCRIPTION

Layer 1

0.00 - 0.15 m A Horizon	reddish brown (dull reddish brown) (5YR 4/3) [moist] clay loam with weak pedality (polyhedral, 2 - 5 mm, rough-faced peds), abundant (>100/10x10cm) roots (<1mm), many (25-100/10x10cm) roots (1-2mm), field pH is 4.5. Coarse fragments are few (2-10%), as parent material, fine gravel (2-6 mm); smooth sharp (<5 mm) boundary to ...

Layer 2

0.15 - 1.00 m B Horizon	red (reddish brown) (2.5YR 4/6) [moist] clay with moderate pedality (polyhedral, 5 - 10 mm, smooth-faced peds), common (10-25/10x10cm) roots (<1mm), few (1-10/10x10cm) roots (1-2mm), field pH is 5.0. Coarse fragments are very few (< 2%), as parent material, fine gravel (2-6 mm)

Layer 99

LABORATORY TESTS

Sample Code	Upper Bnd.	Lower Bnd.	% Clay 517.99_CL	USCS 550.02	pH 4A1	EC 3A1	OC 6A1	Bray Phos 9E1	Phos Sorb 9I1	Exch Al 15F2_AL	Exch Ca 15F1_CA	Exch K 15F1_K	Exch Mg 15F1_MG	Exch Na 15F1_NA
WEL/05/4/492(1)	0.00	0.15			5.6	0.04								
WEL/05/4/493(1)	0.15	1.00			5.7	0.02								

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	CAVES EXIT ROAD
Map Reference:	MGA Grid Reference: Zone 55, 634533E, 6045304N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 109, collected by Ms Janet Wild on 17 March, 1999
Physiography:	hillslope under dry sclerophyll forest on limestone lithology and used for National/State Parks. Slope 23% (not recorded), aspect west. Surface condition is soft, profile drainage is well drained, erosion hazard is slight, and no salting evident
Soil Type:	Terra Rossa Soil (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3. Exit rd between rd to thermal pool carpark and rd to rangers house.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.15 m A Horizon	colour not recorded clay loam with moderate pedality (granular, 5 - 10 mm, smooth-faced peds), field pH is 7.0; clear (20-50 mm) boundary to ...

Layer 2

0.15 - 0.57 m B Horizon	colour not recorded light clay with strong pedality (angular blocky, 100 - 200 mm, smooth-faced peds), field pH is 7.0. Layer notes are: Few manganese and ped coatings.; clear (20-50 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	NEAR THERMAL POOL CARPARK
Map Reference:	MGA Grid Reference: Zone 55, 634313E, 6045144N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 108, collected by Ms Janet Wild on 17 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, shale, metamorphic lithology and used for National/State Parks. Slope 50% (measured), aspect west. Surface condition is hard set, water repellent, profile drainage is imperfectly drained, erosion hazard is high, and no salting evident
Soil Type:	Red Chromosol (ASC), Red Podzolic Soil (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. 5lsshhilmrz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.07 m A Horizon	colour not recorded fine sandy clay loam with weak pedality (crumb, 5 - 10 mm, rough-faced peds), field pH is 6.0. Layer notes are: Hydrophobic; clear (20-50 mm) boundary to ...

Layer 2

0.07 - 0.45 m A2e Horizon	colour not recorded sandy clay loam with massive structure (earthy), field pH is 5.5. Layer notes are: Pale red-brown; clear (20-50 mm) boundary to ...

Layer 3

0.45 - 0.65 m B Horizon	colour not recorded clay loam with moderate pedality (sub-angular blocky, 5 - 10 mm, rough-faced peds), field pH is 5.0; clear (20-50 mm) boundary to ...

Layer 4

0.65 - 1.10 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	EXIT ROAD B/W THERMAL POOL AND CARPARK
Map Reference:	MGA Grid Reference: Zone 55, 634393E, 6044484N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 107, collected by Ms Janet Wild on 17 March, 1999
Physiography:	hillslope under dry sclerophyll forest on limestone lithology and used for National/State Parks. Slope 70% (measured), aspect south. Surface condition is loose, profile drainage is well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Leptic Rudosol (ASC), Lithosol (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3. As limestone increases dominance as proprtion of parent material, soil increases in structure and red colour.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.22 m A Horizon	colour not recorded silty clay with moderate pedality (crumb, 5 - 10 mm), field pH is 7.0; gradual (50-100 mm) boundary to ...

Layer 2

0.22 - 0.55 m AC Horizon	colour not recorded clay loam with strong pedality (sub-angular blocky, 2 - 5 mm, rough-faced peds), field pH is 8.0; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	GLORY FARM TRAIL (NEAR THERMAL POOL)
Map Reference:	MGA Grid Reference: Zone 55, 634313E, 6044884N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 106, collected by Ms Janet Wild on 17 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, shale, metamorphic lithology and used for National/State Parks. Slope 70% (measured), aspect west. Surface condition is loose, water repellent, profile drainage is rapidly drained, erosion hazard is high, and no salting evident
Soil Type:	Leptic Rudosol (ASC), Lithosol (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R2. 5lsshhilmrz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.15 m AC Horizon	colour not recorded loamy peat with weak pedality (crumb, < 2 mm, rough-faced peds), field pH is 6.5. Layer notes are: Hydrophobic.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	CAVES TO POOL VIA RIVER
Map Reference:	MGA Grid Reference: Zone 55, 634203E, 6045134N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 105, collected by Ms Janet Wild on 17 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, shale, metamorphic lithology and used for National/State Parks. Slope 80% (not recorded), aspect west. Surface condition is soft, profile drainage is well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Leptic Rudosol (ASC), Lithosol (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. Yarrangobilly Caves, River walk to thermal pool. 5lsshhilmrz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.33 m A Horizon	colour not recorded sandy clay loam with weak pedality (crumb, < 2 mm, rough-faced peds), field pH is 6.5. Layer notes are: Slightly hydrophobic; gradual (50-100 mm) boundary to ...

Layer 2

0.33 - 0.90 m AC Horizon	colour not recorded coarse sandy clay loam with single grained (sandy), field pH is 6.0. Layer notes are: Reddish-brown.; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	RIVER WALK TO THERMAL POOL (AT Y-CAVE)
Map Reference:	MGA Grid Reference: Zone 55, 634413E, 6045554N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 104, collected by Ms Janet Wild on 17 March, 1999
Physiography:	hillslope under dry sclerophyll forest on limestone lithology and used for National/State Parks. Slope 50% (not recorded), aspect south west. Surface condition is loose, profile drainage is well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Leptic Rudosol (ASC), Lithosol (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.25 m A Horizon	colour not recorded light clay loam with moderate pedality (angular blocky, 10 - 20 mm, rough-faced peds), field pH is 7.0

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	JERSEY CAVE CARPARK - N
Map Reference:	MGA Grid Reference: Zone 55, 634533E, 6045734N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 101, collected by Ms Janet Wild on 17 March, 1999
Physiography:	hillslope under dry sclerophyll forest and used for National/State Parks. Slope 30% (measured), aspect south east. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Red Ferrosol (ASC), Krasnozem (GSG)
Base of observation:	layer continues
Profile Field Notes:	R1. ~20m N of profile number 100. Deeper profile than typical.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A Horizon	colour not recorded light clay with strong pedality (granular, 2 - 5 mm, smooth-faced peds), field pH is 7.0; gradual (50-100 mm) boundary to ...

Layer 2

0.20 - 0.70 m B Horizon	colour not recorded light clay with strong pedality (granular, 50 - 100 mm, smooth-faced peds), field pH is 8.0; gradual (50-100 mm) boundary to ...

Layer 3

0.70 - 1.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	JERSEY CAVE CARPARK - NE
Map Reference:	MGA Grid Reference: Zone 55, 634513E, 6045714N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 100, collected by Ms Janet Wild on 17 March, 1999
Physiography:	hillslope under dry sclerophyll forest on shale, limestone, metamorphic lithology and used for National/State Parks. Slope 30% (not recorded), aspect south west. Surface condition is firm, profile drainage is well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Red Ferrosol (ASC), Krasnozem (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. In drainage lines. Deeper profile than is typical. More sheltered site.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A Horizon	colour not recorded clay loam with weak pedality (crumb, 10 - 20 mm, rough-faced peds), field pH is 4.5. Layer notes are: Slightly hydrophobic; gradual (50-100 mm) boundary to ...

Layer 2

0.20 - 0.65 m B Horizon	colour not recorded clay loam with moderate pedality (sub-angular blocky, 50 - 100 mm, rough-faced peds), field pH is 6.0; gradual (50-100 mm) boundary to ...

Layer 3

0.65 - 1.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	SHAW HILL (ABOVE GIBSONS PLAINS)
Map Reference:	MGA Grid Reference: Zone 55, 632973E, 6033064N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 99, collected by Ms Janet Wild on 16 March, 1999
Physiography:	hillslope under woodland shrub understorey on metamorphic lithology and used for National/State Parks. Slope 34% (not recorded), aspect east. Surface condition is loose, soft, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Leptic Rudosol (ASC), Lithosol (GSG)
Base of observation:	
Profile Field Notes:	R1. Lithology mapped as "me" - va. 5vauhlowpiz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A Horizon	colour not recorded sapric peat with weak pedality (granular, 2 - 5 mm, rough-faced peds). Layer notes are: Marginally hydrophobic

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	GIBSONS PLAINS
Map Reference:	MGA Grid Reference: Zone 55, 633093E, 6032944N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 98, collected by Ms Janet Wild on 16 March, 1999
Physiography:	hillslope under woodland grass understorey on metamorphic lithology and used for National/State Parks. Slope 27% (measured), aspect east. Surface condition is soft, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Leptic Rudosol (ASC), Lithosol (GSG)
Base of observation:	layer continues
Profile Field Notes:	R1. Lithology mapped as "me" - va. 5vauhlowliz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.25 m A Horizon	colour not recorded silty clay loam with moderate pedality (crumb, 5 - 10 mm, rough-faced peds), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 2

0.25 - 0.70 m AC Horizon	colour not recorded silty clay with massive structure (earthy), field pH is 5.5. Layer notes are: Coarse frags concentrated in this layer.; clear (20-50 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	GIBSONS PLAIN
Map Reference:	MGA Grid Reference: Zone 55, 633163E, 6032524N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 97, collected by Ms Janet Wild on 16 March, 1999
Physiography:	footslope under grassland/herbland on sedimentary, igneous lithology and used for National/State Parks. Slope 2% (not recorded), aspect east. Surface condition is loose, soft, profile drainage is poorly drained, erosion hazard is slight, and no salting evident
Soil Type:	Peaty Chernic Tenosol (ASC), Alpine Humus Soil (GSG)
Base of observation:	layer continues
Profile Field Notes:	R1. Extended seasonal waterlogging. 5vaulfootlz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.03 m O Horizon	colour not recorded hemic peat with weak pedality (granular, 2 - 5 mm, rough-faced peds), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 2

0.03 - 0.35 m A1 Horizon	colour not recorded silty clay with massive structure (earthy), field pH is 6.0. Layer notes are: Iron stains in fine root channels.; clear (20-50 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	GIBSONS PLAINS (OFF SNOWY MTNS HWY)
Map Reference:	MGA Grid Reference: Zone 55, 633983E, 6033264N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 96, collected by Ms Janet Wild on 16 March, 1999
Physiography:	footslope under grassland/herbland on sedimentary, igneous lithology and used for National/State Parks. Slope 3% (measured), aspect north east. Surface condition is loose, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Paralithic Leptic Tenosol (ASC), Lithosol (GSG)
Base of observation:	
Profile Field Notes:	R1. 200m west of profile 95. 5vaulfootlz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded silty clay loam with moderate pedality (granular, 2 - 5 mm, rough-faced peds), field pH is 6.0; gradual (50-100 mm) boundary to ...

Layer 2

0.20 - 0.46 m A2 Horizon	colour not recorded light clay loam, field pH is 6.0. Layer notes are: Not bleached. Light brown in colour.; gradual (50-100 mm) boundary to ...

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	GIBSONS PLAIN (OFF SNOWY MTNS HWY)
Map Reference:	MGA Grid Reference: Zone 55, 634253E, 6033284N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 95, collected by Ms Janet Wild on 16 March, 1999
Physiography:	footslope under grassland/herbland on sedimentary, igneous lithology and used for National/State Parks. Slope 6% (measured), aspect north east. Surface condition is loose, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Leptic Rudosol (ASC), Lithosol (GSG)
Base of observation:	
Profile Field Notes:	R1. 5vaulfootlz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.30 m Horizon	colour not recorded silty clay loam with strong pedality (granular, 5 - 10 mm, rough-faced peds), field pH is 5.5. Layer notes are: Underlain by C-horizon. Overlaid by 3cm fibric peat (brown)

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	LINK ROAD-2KM FROM SNOWY MTNS HWY
Map Reference:	MGA Grid Reference: Zone 55, 633353E, 6029284N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 94, collected by Ms Janet Wild on 16 March, 1999
Physiography:	footslope under grassland/herbland on sedimentary, igneous lithology and used for National/State Parks. Slope 17% (measured), aspect south west. Surface condition is loose, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Peaty Chernic Tenosol (ASC), Alpine Humus Soil (GSG)
Base of observation:	layer continues
Profile Field Notes:	R1. Possible previous mining in area. 5vaulfootlz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.14 m O Horizon	colour not recorded sapric peat with single grained (sandy), field pH is 6.0. Layer notes are: No coarse frags in this layer.; gradual (50-100 mm) boundary to ...

Layer 2

0.14 - 0.80 m AC Horizon	colour not recorded silty clay with massive structure (earthy), field pH is 5.5. Layer notes are: Underlain by substrate which consists of both shale/basalt.; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	WALLACES CREEK FIRE TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 631133E, 6031804N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 93, collected by Ms Janet Wild on 16 March, 1999
Physiography:	hillslope under woodland grass understorey on sedimentary, metamorphic, igneous lithology and used for National/State Parks. Slope 6% (not recorded), aspect south. Surface condition is loose, water repellent, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Peaty Chernic Tenosol (ASC), Alpine Humus Soil (GSG)
Base of observation:	
Profile Field Notes:	R1. Lithology mapped as 'me' - va

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.13 m A Horizon	colour not recorded sapric peat with weak pedality (granular, 5 - 10 mm, rough-faced peds), field pH is 5.5. Layer notes are: Hydrophobic (moderatley); gradual (50-100 mm) boundary to ...

Layer 2

0.13 - 0.33 m BC Horizon	colour not recorded loam with massive structure (earthy), field pH is 6.0. Layer notes are: Coarse frags quartz shale.; gradual (50-100 mm) boundary to ...

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	THREE MILE DAM (EAST EDGE)
Map Reference:	MGA Grid Reference: Zone 55, 631323E, 6027784N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 92, collected by Ms Janet Wild on 16 March, 1999
Physiography:	footslope under grassland/herbland on sedimentary, igneous lithology and used for National/State Parks. Slope 3% (estimated), aspect north. Surface condition is loose, profile drainage is very poorly drained, erosion hazard is slight, and no salting evident
Soil Type:	Basic Sapric Organosol (ASC), Acid Peat Soil (GSG)
Base of observation:	layer continues
Profile Field Notes:	R1. 5vaulfootlz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.40 m O Horizon	colour not recorded loamy peat with weak pedality (granular, 2 - 5 mm, rough-faced peds), field pH is 4.5; clear (20-50 mm) boundary to ...

Layer 2

0.40 - 0.47 m B Horizon	colour not recorded silty clay with massive structure (earthy), field pH is 5.5; clear (20-50 mm) boundary to ...

Layer 3

0.47 - 0.60 m C1 Horizon	colour not recorded silty clay loam with massive structure (earthy), field pH is 5.5. Layer notes are: Bright yellow.; wavy abrupt (5-20 mm) boundary to ...

Layer 4

0.60 - 0.93 m C2 Horizon	colour not recorded silty clay loam with massive structure (earthy), field pH is 6.0. Layer notes are: Bright red.; wavy abrupt (5-20 mm) boundary to ...

Layer 5

0.93 - 1.50 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	QUARRY ON KINGS CROSS ROAD
Map Reference:	MGA Grid Reference: Zone 55, 628933E, 6022904N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 91, collected by Ms Janet Wild on 16 March, 1999
Physiography:	hillslope under grassland/herbland on sedimentary, shale, metamorphic lithology and used for quarry/mining. Slope 23% (measured), aspect north. Surface condition is loose, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Paralithic Chernic Tenosol (ASC), Alpine Humus Soil (GSG), Um1.43 (PPF)
Base of observation:	soil continues
Profile Field Notes:	R1. 5lsullowslz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.12 m A Horizon	colour not recorded sapric peat with weak pedality (granular, 2 - 5 mm, rough-faced peds), field pH is 6.0. Layer notes are: Underlain by C-horizon of highly fractured shale/slate.; abrupt (5-20 mm) boundary to ...

Layer 2

0.12 - 0.25 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	KINGS CROSS ROAD - DRY DAM
Map Reference:	MGA Grid Reference: Zone 55, 625583E, 6022614N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 90, collected by Ms Janet Wild on 16 March, 1999
Physiography:	plain under grassland/herbland on basalt lithology and used for National/State Parks. Slope 1% (estimated). Surface condition is soft, profile drainage is poorly drained, erosion hazard is slight, and no salting evident
Soil Type:	Paralithic Basic Sapric Organosol (ASC), Neutral Peat Soil (GSG)
Base of observation:	
Profile Field Notes:	R1. Slight erosion hazard assumes no cattle grazing. Elevated plateau surface. Dry dam near Cabramurra. Snow grass plain with snow gum and black sally.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.30 m O Horizon	colour not recorded sapric peat with massive structure (earthy), field pH is 7.0. Layer notes are: Very faint Bh and Bfe at 0.12m; gradual (50-100 mm) boundary to ...

Layer 2

0.30 - 0.44 m AC Horizon	colour not recorded loamy peat with massive structure (earthy), field pH is 7.0. Layer notes are: Coarse frags = 70%, coarse gravel, rounded and sub rounded basalt.; gradual (50-100 mm) boundary to ...

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	LINK ROAD - UNDER POWERLINE
Map Reference:	MGA Grid Reference: Zone 55, 629953E, 6027124N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 89, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, igneous lithology. Slope 8% (measured), aspect south west. Surface condition is soft, profile drainage is mod. well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Sapric Organosol (ASC), Alpine Humus Soil (GSG)
Base of observation:	layer continues
Profile Field Notes:	R1. 5vauhlowliz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.34 m A Horizon	colour not recorded sapric peat with moderate pedality (granular, 10 - 20 mm, rough-faced peds), field pH is 6.0

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	RAVINE ROAD (700M SE OF O'HARE HILL)
Map Reference:	MGA Grid Reference: Zone 55, 627163E, 6032244N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 88, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on basalt lithology and used for National/State Parks. Slope 10% (not recorded), aspect south west. Surface condition is soft, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Haplic Red Ferrosol (ASC), Krasnozem (GSG)
Base of observation:	soil continues
Profile Field Notes:	Small area of knz in ruz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.35 m A Horizon	colour not recorded silty clay with moderate pedality (crumb, 10 - 20 mm, rough-faced peds), field pH is 6.0; gradual (50-100 mm) boundary to ...

Layer 2

0.35 - 0.85 m B Horizon	colour not recorded clay loam with moderate pedality (sub-angular blocky, 50 - 100 mm, rough-faced peds), field pH is 6.0. Layer notes are: Gradual boundary to C-horizon.; gradual (50-100 mm) boundary to ...

Layer 3

0.85 - 1.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	RAVINE ROAD
Map Reference:	MGA Grid Reference: Zone 55, 626863E, 6034514N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 87, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, igneous lithology and used for National/State Parks. Slope 62% (measured), aspect south west. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Leptic Tenosol (ASC), Lithosol (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.24 m A Horizon	colour not recorded silty clay loam with weak pedality (crumb, 10 - 20 mm), field pH is 6.0; gradual (50-100 mm) boundary to ...

Layer 2

0.24 - 1.20 m BC Horizon	colour not recorded coarse sandy loam with massive structure (earthy), field pH is 6.5; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	RAVINE ROAD
Map Reference:	MGA Grid Reference: Zone 55, 626923E, 6036324N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 86, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on shale lithology and used for National/State Parks. Slope 50% (measured), aspect east. Surface condition is hard set, profile drainage is imperfectly drained, erosion hazard is moderate, and no salting evident
Soil Type:	Bleached-Leptic Tenosol (ASC), Lithosol (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3. 5hsshhilrma

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.14 m A1 Horizon	colour not recorded sandy clay loam with weak pedality (crumb, 10 - 20 mm, rough-faced peds), field pH is 7.0; clear (20-50 mm) boundary to ...

Layer 2

0.14 - 0.25 m A2h Horizon	colour not recorded clay loam with massive structure (earthy), field pH is 6.5; clear (20-50 mm) boundary to ...

Layer 3

0.25 - 0.50 m C Horizon	colour not recorded clay loam with massive structure (earthy), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	RAVING ROAD
Map Reference:	MGA Grid Reference: Zone 55, 626953E, 6036744N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 85, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillcrest under dry sclerophyll forest and used for National/State Parks. Slope 65% (measured), aspect east. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Paralithic Leptic Rudosol (ASC), Lithosol (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3. Blackberries abundant. 5hsshhilrma

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.18 m A Horizon	colour not recorded light clay loam with weak pedality (crumb, 5 - 10 mm, rough-faced peds), field pH is 7.0; gradual (50-100 mm) boundary to ...

Layer 2

0.18 - 0.80 m AC Horizon	colour not recorded medium clay loam with massive structure (earthy), field pH is 6.0; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	RAVINE ROAD - UPPER LICKHOLE GULLY
Map Reference:	MGA Grid Reference: Zone 55, 626513E, 6037094N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 84, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on limestone lithology and used for National/State Parks. Slope 37% (measured), aspect north west. Surface condition is firm, hard set, profile drainage is mod. well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Paralithic Leptic Rudosol (ASC), Lithosol (GSG), Um5.51 (PPF)
Base of observation:	bedrock reached
Profile Field Notes:	R3. Abundant blackberries

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m AC Horizon	colour not recorded sandy clay loam, field pH is 7.0; gradual (50-100 mm) boundary to ...

Layer 2

0.20 - 0.75 m C Horizon	colour not recorded light clay, field pH is 6.0. Layer notes are: Limestone coarse fragments >90% coarse gravels and cobbles.; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	LOBS HOLE POWERMINE ROAD
Map Reference:	MGA Grid Reference: Zone 55, 624693E, 6041104N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 83, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, metamorphic lithology and used for National/State Parks. Slope 55% (measured), aspect north. Surface condition is firm, hard set, profile drainage is mod. well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Paralithic Orthic Tenosol (ASC), Red Earth (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. Under powerline. Banksia sp.. 5lsshhilmrz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.25 m A Horizon	colour not recorded sandy clay loam with moderate pedality (crumb, 10 - 20 mm, rough-faced peds), field pH is 6.5; gradual (50-100 mm) boundary to ...

Layer 2

0.25 - 1.30 m BC Horizon	colour not recorded clay loam with massive structure (earthy), field pH is 7.0; gradual (50-100 mm) boundary to ...

Layer 3

1.30 - 1.80 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	LOBS HOLE POWERLINE ROAD
Map Reference:	MGA Grid Reference: Zone 55, 625073E, 6042234N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 82, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, igneous lithology and used for National/State Parks. Slope 52% (measured), aspect north west. Surface condition is hard set, water repellent, profile drainage is mod. well drained, erosion hazard is high, and no salting evident
Soil Type:	Arenaceous Leptic Rudosol (ASC), Lithosol (GSG)
Base of observation:	soil continues
Profile Field Notes:	R2

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.29 m AC Horizon	colour not recorded sandy clay loam with massive structure (earthy), field pH is 5.5. Layer notes are: Underlain by C-horizon. Hydrophobic; wavy clear (20-50 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	LOBS HOLE POWERLINE RD
Map Reference:	MGA Grid Reference: Zone 55, 626353E, 6042974N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 81, collected by Ms Janet Wild on 15 March, 1999
Physiography:	drainage depression under dry sclerophyll forest on sedimentary, igneous lithology and used for National/State Parks. Slope 59% (measured), aspect north west. Surface condition is firm, hard set, profile drainage is poorly drained, erosion hazard is very high, and no salting evident
Soil Type:	Brown Sodosol (ASC), Yellow Podzolic Soil (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R4. 0.5km w of hickory gully.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded fine sandy clay loam with weak pedality (crumb, 5 - 10 mm, rough-faced peds), field pH is 6.5; gradual (50-100 mm) boundary to ...

Layer 2

0.20 - 0.44 m A2h Horizon	colour not recorded fine sandy loam with massive structure (earthy), field pH is 6.5; clear (20-50 mm) boundary to ...

Layer 3

0.44 - 1.30 m B Horizon	colour not recorded light clay, field pH is 6.5. Layer notes are: Disperable; clear (20-50 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	LOBS HOLE POWERLINE ROAD (E SIDE OF RD
Map Reference:	MGA Grid Reference: Zone 55, 627843E, 6044684N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 80, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, igneous lithology and used for National/State Parks. Slope 56% (measured), aspect west. Surface condition is firm, water repellent, profile drainage is mod. well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Paralithic Orthic Tenosol (ASC), Lithosol (GSG), Um5.41 (PPF)
Base of observation:	bedrock reached
Profile Field Notes:	R2

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A Horizon	colour not recorded fine sandy clay loam with weak pedality (crumb, 5 - 10 mm, rough-faced peds), field pH is 5.5. Layer notes are: Hydrophobic; gradual (50-100 mm) boundary to ...

Layer 2

0.20 - 0.65 m BC Horizon	colour not recorded light clay loam with massive structure (earthy), field pH is 5.5; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	LOBS HOLE POWERLINE RD
Map Reference:	MGA Grid Reference: Zone 55, 628083E, 6045584N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 79, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, metamorphic lithology and used for National/State Parks. Slope 50% (measured), aspect south west. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Paralithic Orthic Tenosol (ASC), Lithosol (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3. 100m NW of Pinbeyan Ck. 5lsshhilmrz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.15 m A Horizon	colour not recorded fine sandy clay loam, field pH is 6.0; gradual (50-100 mm) boundary to ...

Layer 2

0.15 - 0.60 m BC Horizon	colour not recorded clay loam, field pH is 6.0. Layer notes are: Underlain by substrate of cemented, rounded cobbles and coarse gravels.; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	LOBS HOLE POWERLINE ROAD
Map Reference:	MGA Grid Reference: Zone 55, 628217E, 6047524N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 78, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, metamorphic lithology and used for National/State Parks. Slope 31% (measured), aspect east. Surface condition is loose, firm, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Paralithic Orthic Tenosol (ASC), Red Earth (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. W side of road. 5lsshhilmrz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.16 m A Horizon	colour not recorded light clay loam, field pH is 6.0. Layer notes are: Overlaid by 1-2cm dead plant material; gradual (50-100 mm) boundary to ...

Layer 2

0.16 - 1.30 m BC Horizon	colour not recorded silty clay with moderate pedality (sub-angular blocky, 2 - 5 mm, rough-faced peds), field pH is 5.5; gradual (50-100 mm) boundary to ...

Layer 3

1.30 - 1.70 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	LOBS HOLE POWERLINE ROAD
Map Reference:	MGA Grid Reference: Zone 55, 628193E, 6047624N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 77, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, metamorphic lithology and used for National/State Parks. Slope 23% (measured), aspect east. Surface condition is loose, profile drainage is imperfectly drained, erosion hazard is moderate, and no salting evident
Soil Type:	Paralithic Chernic Tenosol (ASC), Alpine Humus Soil (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. West side of road. 5lsshhilmrz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.15 m O Horizon	colour not recorded sapric peat with moderate pedality (granular, 5 - 10 mm, rough-faced peds), field pH is 6.0; gradual (50-100 mm) boundary to ...

Layer 2

0.15 - 0.33 m A1h Horizon	colour not recorded fine sandy loam, field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 3

0.33 - 0.52 m A2 Horizon	colour not recorded fine sandy loam, field pH is 6.0; gradual (50-100 mm) boundary to ...

Layer 4

0.52 - 1.60 m BC Horizon	colour not recorded sandy clay loam, field pH is 6.5; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	LOBS HOLE POWERLINE ROAD
Map Reference:	MGA Grid Reference: Zone 55, 628623E, 6048344N. 8526 YARRANGOBILLY (1:100000) map sheet.
Profile Details:	OBSCRAS - YARRANGOBILLY Survey (1003656), Profile 76, collected by Ms Janet Wild on 15 March, 1999
Physiography:	hillslope under dry sclerophyll forest on sedimentary, metamorphic lithology and used for National/State Parks. Slope 18% (measured), aspect south east. Surface condition is soft, profile drainage is mod. well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Paralithic Chernic Tenosol (ASC), Alpine Humus Soil (GSG), Um5.41 (PPF)
Base of observation:	layer continues
Profile Field Notes:	R3. Under powerline. (Profile more typical of lbz). 5lsullowslz

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.12 m A Horizon	colour not recorded loamy peat with weak pedality (granular, 5 - 10 mm, rough-faced peds), field pH is 7.0; gradual (50-100 mm) boundary to ...

Layer 2

0.12 - 0.95 m BC Horizon	colour not recorded silty clay loam with massive structure (earthy), field pH is 5.5; gradual (50-100 mm) boundary to ...

Layer 3

0.95 - 1.80 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	SNOWY MTHNS HWY
Map Reference:	MGA Grid Reference: Zone 55, 638311E, 6045339N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 57, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	hillslope under woodland shrub understorey on basalt lithology and used for National/State Parks. Slope 35% (measured), aspect south east. Surface condition is firm, profile drainage is well drained, erosion hazard is moderate
Soil Type:	Brown Dermosol (ASC), Krasnozem (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R1(3). 5vbrhhilsmz1

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.15 m A1 Horizon	colour not recorded fine clay loam sandy with massive structure (earthy), field pH is 6.0; abrupt (5-20 mm) boundary to ...

Layer 2

0.15 - 0.60 m B2 Horizon	colour not recorded light medium clay with strong pedality (polyhedral, 2 - 5 mm, rough-faced peds), field pH is 6.0. Layer notes are: Some fine sand; clear (20-50 mm) boundary to ...

Layer 3

0.60 - 1.30 m B3 Horizon	colour not recorded light medium clay with weak pedality (sub-angular blocky, 10 - 20 mm, rough-faced peds), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 4

1.30 - 3.00 m BC Horizon	colour not recorded coarse sandy clay with massive structure (earthy), field pH is 5.5; clear (20-50 mm) boundary to ...

Layer 5

3.00 - 5.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	NUNGAR CREEK TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 636715E, 6030257N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 53, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	hillslope under woodland shrub understorey on chert lithology and used for National/State Parks. Slope 30% (measured), aspect north west. Surface condition is soft, profile drainage is well drained, erosion hazard is moderate
Soil Type:	Brown Kandosol (ASC), Brown Earth (GSG), Gn2.41 (PPF)
Base of observation:	bedrock reached
Profile Field Notes:	5lsrhhilgoz1

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.05 m O Horizon	colour not recorded loamy peat with massive structure (earthy), field pH is 5.5; clear (20-50 mm) boundary to ...

Layer 2

0.05 - 0.20 m A1 Horizon	colour not recorded fine clay loam sandy with massive structure (earthy), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 3

0.20 - 0.90 m BC Horizon	colour not recorded sandy clay with massive structure (earthy), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 4

0.90 - 1.50 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	NUNGAR CREEK FIRE TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 637908E, 6031242N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 52, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	plain under woodland shrub understorey on chert lithology and used for National/State Parks. Slope 4% (measured), aspect north west. Surface condition is hard set, water repellent, profile drainage is poorly drained, erosion hazard is high, and no salting evident
Soil Type:	Brown Kandosol (ASC), Brown Podzolic Soil (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. 5lsullowgoa1

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.10 m A1 Horizon	colour not recorded sandy clay loam with massive structure (earthy), field pH is 5.5; clear (20-50 mm) boundary to ...

Layer 2

0.10 - 0.25 m A12 Horizon	colour not recorded clay loam sandy with strong pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 5.0; abrupt (5-20 mm) boundary to ...

Layer 3

0.25 - 0.70 m B2 Horizon	colour not recorded light medium clay with weak pedality (polyhedral, 20 - 50 mm, rough-faced peds), field pH is 5.0; abrupt (5-20 mm) boundary to ...

Layer 4

0.70 - 3.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	ABOVE WILD HORSE PLAIN
Map Reference:	MGA Grid Reference: Zone 55, 638402E, 6031743N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 51, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	hillslope under woodland shrub understorey on chert lithology and used for National/State Parks. Slope 8% (not recorded), aspect south. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is high, and no salting evident
Soil Type:	Brown Chromosol (ASC), Brown Podzolic Soil (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3. 5lsullowgoa1

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.15 m A1 Horizon	colour not recorded fine clay loam sandy with strong pedality (polyhedral, 2 - 5 mm, rough-faced peds), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 2

0.15 - 0.50 m B2 Horizon	colour not recorded medium clay with strong pedality (polyhedral, 20 - 50 mm, smooth-faced peds), field pH is 5.0; clear (20-50 mm) boundary to ...

Layer 3

0.50 - 0.80 m B22 Horizon	colour not recorded medium clay, field pH is 5.5. Layer notes are: Yellow mottles.; clear (20-50 mm) boundary to ...

Layer 4

0.80 - 1.30 m C Horizon	colour not recorded sandy clay, field pH is 5.5; clear (20-50 mm) boundary to ...

Layer 5

1.30 - 3.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	ALPINE CREEK TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 641113E, 6034084N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 50, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	plain under grassland/herbland on alluvium lithology and used for National/State Parks. Slope 1% (estimated). Surface condition is cracked, profile drainage is very poorly drained, erosion hazard is slight, and no salting evident
Soil Type:	Brown Kandosol (ASC), Grey Clay (GSG)
Base of observation:	
Profile Field Notes:	R3

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded light clay with weak pedality (sub-angular blocky, 10 - 20 mm, rough-faced peds), field pH is 5.5; abrupt (5-20 mm) boundary to ...

Layer 2

0.20 - 0.60 m B2 Horizon	colour not recorded light medium clay with weak pedality (sub-angular blocky, 20 - 50 mm, rough-faced peds), field pH is 5.0. Layer notes are: Gley mottles. BC?; abrupt (5-20 mm) boundary to ...

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	ALPINE CREEK TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 641880E, 6033527N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 49, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	hillslope under woodland shrub understorey on chert lithology and used for National/State Parks. Slope 10% (not recorded), aspect east. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is slight, and no salting evident
Soil Type:	Brown Kandosol (ASC), Brown Earth (GSG), Gn2.41 (PPF)
Base of observation:	layer continues
Profile Field Notes:	R3. 5lsullowgoa1

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded fine clay loam sandy with moderate pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 5.5; gradual (50-100 mm) boundary to ...

Layer 2

0.20 - 0.50 m B2 Horizon	colour not recorded light clay with massive structure (earthy), field pH is 5.0; gradual (50-100 mm) boundary to ...

Layer 3

0.50 - 3.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	ALPINE CREEK TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 642200E, 6031850N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 48, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	hillcrest under woodland shrub understorey on chert lithology and used for National/State Parks. Surface condition is soft, water repellent, profile drainage is well drained, erosion hazard is slight
Soil Type:	Rudosol (ASC), Alpine Humus Soil (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	5lsrhhilgoz1. Minimal alpine humus soil.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m colour not recorded fibric peat, field pH is 5.5
O Horizon

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	ALPINE CREEK TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 642592E, 6031255N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 47, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	hillslope under woodland shrub understorey on chert lithology and used for National/State Parks. Slope 25% (measured), aspect north east. Surface condition is firm, water repellent, profile drainage is mod. well drained, erosion hazard is moderate
Soil Type:	Brown Chromosol (ASC), Brown Podzolic Soil (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. Lots of regrowth timber. 5lsrhhilgoz1

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.10 m A1 Horizon	colour not recorded coarse clay loam sandy with massive structure (earthy), field pH is 6.5; abrupt (5-20 mm) boundary to ...

Layer 2

0.10 - 0.60 m B2 Horizon	colour not recorded light medium clay with moderate pedality (prismatic, 50 - 100 mm, rough-faced peds), field pH is 6.5. Layer notes are: Some 1-2cm polyhedral peds. Some coarse sand.; clear (20-50 mm) boundary to ...

Layer 3

0.60 - 0.90 m B3 Horizon	colour not recorded coarse sandy clay with weak pedality (granular, 10 - 20 mm, rough-faced peds), field pH is 6.5; clear (20-50 mm) boundary to ...

Layer 4

0.90 - 3.50 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	BOGGY PLAIN
Map Reference:	MGA Grid Reference: Zone 55, 642993E, 6030795N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 46, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	footslope under woodland shrub understorey on other lithology and used for National/State Parks. Slope 4% (measured), aspect north east. Surface condition is soft, erosion hazard is moderate
Soil Type:	Brown Dermosol (ASC), Brown Podzolic Soil (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	Quartz arenite. R3

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded fine clay loam sandy with moderate pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 6.5; abrupt (5-20 mm) boundary to ...

Layer 2

0.20 - 0.50 m B2 Horizon	colour not recorded light clay with moderate pedality (prismatic, 20 - 50 mm, rough-faced peds), field pH is 6.5. Layer notes are: Some fine sand; abrupt (5-20 mm) boundary to ...

Layer 3

0.50 - 0.70 m C Horizon	colour not recorded coarse sandy clay with massive structure (earthy), field pH is 5.5; abrupt (5-20 mm) boundary to ...

Layer 4

0.70 - 3.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	ALPINE CREEK FIRE TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 643268E, 6028816N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 45, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	footslope under woodland shrub understorey on other lithology and used for National/State Parks. Slope 5% (not recorded), aspect east. Surface condition is soft, water repellent, profile drainage is well drained, erosion hazard is slight
Soil Type:	Brown Kandosol (ASC), Brown Earth (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. Arenite.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.10 m O Horizon	colour not recorded fine sandy peat with massive structure (earthy), field pH is 7.0; abrupt (5-20 mm) boundary to ...

Layer 2

0.10 - 0.30 m A1 Horizon	colour not recorded fine clay loam sandy with moderate pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 6.5. Layer notes are: Lots of organic matter, some fine sand.; clear (20-50 mm) boundary to ...

Layer 3

0.30 - 0.50 m B2 Horizon	colour not recorded light clay with weak pedality (granular, 10 - 20 mm, rough-faced peds), field pH is 6.5. Layer notes are: Some fine sand.; clear (20-50 mm) boundary to ...

Layer 4

0.50 - 3.50 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	ALPINE CREEK FIRE TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 643163E, 6025747N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 44, collected by Ms Sally McInnes-Clarke on 16 March, 1999
Physiography:	hillslope under dry sclerophyll forest on adamellite lithology and used for National/State Parks. Slope 15% (not recorded), aspect east. Surface condition is firm, water repellent, profile drainage is mod. well drained, erosion hazard is high
Soil Type:	Brown Chromosol (ASC), Brown Earth (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded coarse loamy sand with weak pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 6.5

Layer 2

0.20 - 0.90 m B2 Horizon	colour not recorded coarse sandy clay with weak pedality (sub-angular blocky, 10 - 20 mm, rough-faced peds), field pH is 6.0

Layer 3

0.90 - 1.30 m C Horizon	colour not recorded coarse sandy clay, field pH is 6.0

Layer 4

1.30 - 4.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	TANTANGARA DAM FIRE TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 647912E, 6035915N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 42, collected by Ms Sally McInnes-Clarke on 12 March, 1999
Physiography:	hillcrest on other lithology and used for National/State Parks. Slope 2% (not recorded), aspect south west. Surface condition is firm, profile drainage is well drained, erosion hazard is moderate
Soil Type:	Rudosol (ASC), Lithosol (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R1. Ignembrite

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.07 m A1 Horizon	colour not recorded coarse sandy clay loam with weak pedality (granular, 5 - 10 mm, rough-faced peds), field pH is 6.0

Layer 2

0.07 - 0.75 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	TANTANGARA DAM FIRE TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 648409E, 6034660N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 41, collected by Ms Sally McInnes-Clarke on 12 March, 1999
Physiography:	hillslope under woodland grass understorey on other lithology and used for National/State Parks. Slope 6% (measured), aspect west. Surface condition is firm, profile drainage is poorly drained, erosion hazard is moderate
Soil Type:	Grey Dermosol (ASC), Grey Clay (GSG)
Base of observation:	
Profile Field Notes:	R3. Low hills/drainage plains. Ignembrite.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded light clay with strong pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 5.0; gradual (50-100 mm) boundary to ...

Layer 2

0.20 - 0.60 m B2 Horizon	colour not recorded medium clay with moderate pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 5.5; gradual (50-100 mm) boundary to ...

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	TANTANGARA ROAD
Map Reference:	MGA Grid Reference: Zone 55, 646690E, 6026919N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 40, collected by Ms Sally McInnes-Clarke on 12 March, 1999
Physiography:	hillslope under dry sclerophyll forest on other lithology and used for National/State Parks. Slope 25% (estimated), aspect east. Surface condition is soft, profile drainage is well drained, erosion hazard is moderate, and no salting evident
Soil Type:	Brown Chromosol (ASC), Brown Earth (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3(2). leucogranite.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded sandy clay loam with weak pedality (granular, 10 - 20 mm, rough-faced peds), field pH is 6.0; abrupt (5-20 mm) boundary to ...

Layer 2

0.20 - 0.40 m B2 Horizon	colour not recorded sandy clay with weak pedality (granular, 2 - 5 mm, rough-faced peds), field pH is 6.5. Layer notes are: Water repellant; abrupt (5-20 mm) boundary to ...

Layer 3

0.40 - 2.00 m C Horizon	colour not recorded medium sandy clay, field pH is 5.5; abrupt (5-20 mm) boundary to ...

Layer 4

2.00 - 4.50 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	PORT PHILLIP TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 648585E, 6046443N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 38, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	hillslope under woodland shrub understorey on chert lithology and used for National/State Parks. Slope 10% (measured), aspect south east. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is slight
Soil Type:	Red Dermosol (ASC), Krasnozem (GSG)
Base of observation:	layer continues
Profile Field Notes:	R1. 5lsrhhilgoz1

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.10 m A1 Horizon	colour not recorded clay loam with strong pedality (polyhedral, 10 - 20 mm, rough-faced peds), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 2

0.10 - 0.50 m B2 Horizon	colour not recorded light clay with strong pedality (polyhedral, 20 - 50 mm, rough-faced peds), field pH is 6.5; gradual (50-100 mm) boundary to ...

Layer 3

0.50 - 1.40 m B22 Horizon	colour not recorded light medium clay with strong pedality (polyhedral, 20 - 50 mm, rough-faced peds), field pH is 6.5; gradual (50-100 mm) boundary to ...

Layer 4

1.40 - 4.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	PORT PHILLIP FIRE TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 648887E, 6046146N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 37, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	hillslope under woodland shrub understorey on chert lithology and used for National/State Parks. Slope 12% (not recorded), aspect north east. Surface condition is hard set, profile drainage is well drained, erosion hazard is moderate
Soil Type:	Brown Kandosol (ASC), Brown Earth (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R2. Stony. 5lsrhhilgoz1

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded clay loam with moderate pedality (polyhedral, 5 - 10 mm, smooth-faced peds), field pH is 6.0; abrupt (5-20 mm) boundary to ...

Layer 2

0.20 - 0.40 m BC Horizon	colour not recorded light clay with massive structure (earthy), field pH is 7.0; abrupt (5-20 mm) boundary to ...

Layer 3

0.40 - 2.50 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	TANTANGARA DAM
Map Reference:	MGA Grid Reference: Zone 55, 651092E, 6045453N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 36, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	hillslope on other lithology and used for National/State Parks. Slope 5% (measured), aspect east. Surface condition is soft, water repellent, profile drainage is well drained, erosion hazard is moderate
Soil Type:	Brown Kandosol (ASC), Brown Earth (GSG), Gn4.31 (PPF)
Base of observation:	bedrock reached
Profile Field Notes:	R2. Ignembrite. Low rise

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.25 m A1 Horizon	colour not recorded clay loam with strong pedality (< 2 mm, rough-faced peds), field pH is 6.0. Layer notes are: Very fine structure? Can't decide if it is massive or strongly structured <2mm. Some sand

Layer 2

0.25 - 0.50 m B2 Horizon	colour not recorded light clay with weak pedality (granular, 5 - 10 mm, rough-faced peds), field pH is 6.0

Layer 3

- m Horizon	colour not recorded . Layer notes are: Clayey gravels.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	PORT PHILLIP FIRE TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 653638E, 6044250N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 35, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	hillslope under woodland grass understorey on other lithology and used for National/State Parks. Slope 5% (not recorded), aspect north. Surface condition is hard set, profile drainage is imperfectly drained, erosion hazard is slight
Soil Type:	Red Dermosol (ASC), Red Podzolic Soil (GSG)
Base of observation:	layer continues
Profile Field Notes:	Ignembrite. R3

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded fine clay loam sandy with moderate pedality (granular, 5 - 10 mm, rough-faced peds), field pH is 7.0; abrupt (5-20 mm) boundary to ...

Layer 2

0.20 - 0.30 m B1 Horizon	colour not recorded light clay with moderate pedality (polyhedral, 10 - 20 mm, rough-faced peds), field pH is 6.5. Layer notes are: Some fine sand.; gradual (50-100 mm) boundary to ...

Layer 3

0.30 - 0.50 m B2 Horizon	colour not recorded medium clay with moderate pedality (polyhedral, 20 - 50 mm, rough-faced peds), field pH is 6.5. Layer notes are: Some fine sand.; gradual (50-100 mm) boundary to ...

Layer 4

0.50 - 2.50 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	Profile 34
Map Reference:	MGA Grid Reference: Zone 55, 650935E, 6037856N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 34, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	hillslope under dry sclerophyll forest on other lithology and used for National/State Parks. Slope 40% (measured), aspect south east. Surface condition is water repellent, profile drainage is well drained, erosion hazard is high
Soil Type:	Brown Kandosol (ASC), Brown Earth (GSG)
Base of observation:	bedrock reached
Profile Field Notes:	R3(2). Arenite

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.10 m A1 Horizon	colour not recorded clay loam sandy with weak pedality (granular, 5 - 10 mm, rough-faced peds), field pH is 5.0; clear (20-50 mm) boundary to ...

Layer 2

0.10 - 0.30 m B2 Horizon	colour not recorded light clay with massive structure (earthy), field pH is 5.5; clear (20-50 mm) boundary to ...

Layer 3

0.30 - 3.00 m C Horizon	colour not recorded . Layer notes are: Rock.

Layer 4

3.00 - 4.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	CICUIT HUT TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 651959E, 6032459N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 33, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	hillslope under woodland grass understorey on other lithology and used for National/State Parks. Slope 32% (not recorded), aspect south east. Surface condition is firm, water repellent, profile drainage is well drained, erosion hazard is moderate
Soil Type:	Red Kandosol (ASC), Red Earth (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3. Arenite.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.15 m A1 Horizon	colour not recorded clay loam with weak pedality (polyhedral, 2 - 5 mm, rough-faced peds), field pH is 5.5. Layer notes are: Some fine sand.; clear (20-50 mm) boundary to ...

Layer 2

0.15 - 0.70 m B2 Horizon	colour not recorded light clay with weak pedality (sub-angular blocky, 10 - 20 mm, rough-faced peds), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 3

0.70 - 1.50 m B22 Horizon	colour not recorded light clay with weak pedality (sub-angular blocky, 20 - 50 mm, rough-faced peds), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 4

1.50 - 3.50 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	NUNGAR CREEK - CIRCUITS HUT TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 652715E, 6029813N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 32, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	plain under grassland/herbland on alluvium lithology and used for timber/scrub/unused. Slope 2% (estimated). Surface condition is firm, profile drainage is very poorly drained, erosion hazard is high
Soil Type:	Grey Hydrosol (ASC), Grey Clay (GSG)
Base of observation:	layer continues
Profile Field Notes:	R3

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.10 m Horizon	colour not recorded fine sandy clay loam with moderate pedality (polyhedral, 2 - 5 mm, rough-faced peds), field pH is 6.0. Layer notes are: High organic content. No layer depths supplied, layer depths given here are nominal.

Layer 2

0.10 - 0.20 m Horizon	colour not recorded medium clay with moderate pedality (polyhedral, 10 - 20 mm, rough-faced peds), field pH is 4.5. Layer notes are: No layer depths supplied, layer depths given here are nominal.

Layer 3

0.20 - 0.30 m Horizon	colour not recorded medium clay with weak pedality (earthy), field pH is 4.5. Layer notes are: Massive when wet. No layer depths supplied, layer depths given here are nominal.

Layer 99

Layer notes are: No layer depths supplied, layer depths given here are nominal.

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	CIRCUITS HUT TRAIL - NUNGAR PLAIN
Map Reference:	MGA Grid Reference: Zone 55, 652713E, 6028847N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 31, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	footslope under grassland/herbland on other lithology and used for National/State Parks. Slope 3% (measured), aspect north. Surface condition is firm, profile drainage is imperfectly drained, erosion hazard is slight
Soil Type:	Brown Dermosol (ASC), Chocolate Soil (GSG)
Base of observation:	
Profile Field Notes:	Arenite. R3

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded clay loam with moderate pedality (polyhedral, < 2 mm, rough-faced peds), field pH is 5.5

Layer 2

0.20 - 0.50 m B2 Horizon	colour not recorded light clay with moderate pedality (granular, 5 - 10 mm, rough-faced peds), field pH is 6.0

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	CIRCUITS HUT TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 653308E, 6026921N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 30, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	hillslope under woodland grass understorey on other lithology and used for National/State Parks. Slope 7% (estimated), aspect north east. Surface condition is firm, water repellent, profile drainage is imperfectly drained, erosion hazard is moderate
Soil Type:	Brown Dermosol (ASC), Brown Earth (GSG)
Base of observation:	
Profile Field Notes:	Andesite. R3

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.05 m A1 Horizon	colour not recorded clay loam with massive structure (earthy), field pH is 5.5. Layer notes are: Lots of organic matter; clear (20-50 mm) boundary to ...

Layer 2

0.05 - 0.15 m B1 Horizon	colour not recorded clay loam with moderate pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 3

0.15 - 0.50 m B Horizon	colour not recorded light medium clay with moderate pedality (polyhedral, 10 - 20 mm, rough-faced peds), field pH is 6.5; clear (20-50 mm) boundary to ...

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	CIRCUITS HUT TRAIL
Map Reference:	MGA Grid Reference: Zone 55, 654265E, 6026016N. 8626 TANTANGARA (1:100000) map sheet.
Profile Details:	OBSCRAS - TANTANGARA Survey (1003653), Profile 29, collected by Ms Sally McInnes-Clarke on 11 March, 1999
Physiography:	hillslope on other lithology and used for National/State Parks. Slope 23% (measured), aspect south west. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is high
Soil Type:	Red Kandosol (ASC), Brown Earth (GSG)
Base of observation:	layer continues
Profile Field Notes:	R2. Arenite

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.20 m A1 Horizon	colour not recorded clay loam with massive structure (earthy), field pH is 6.5. Layer notes are: Some sand.; clear (20-50 mm) boundary to ...

Layer 2

0.20 - 0.40 m B1 Horizon	colour not recorded clay loam with weak pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 6.0. Layer notes are: Some sand; clear (20-50 mm) boundary to ...

Layer 3

0.40 - 0.70 m B Horizon	colour not recorded light clay with weak pedality (polyhedral, 5 - 10 mm, rough-faced peds), field pH is 6.0; clear (20-50 mm) boundary to ...

Layer 4

0.70 - 4.00 m Horizon	colour not recorded . Layer notes are: Unknown layer(s) - created due to gap in layer depths; adjusted subsequent layer numbers to be sequential.

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Annexure B

Soil site and geology relationships

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Yarrangobilly 99	55	632973	6033064	weak granular rough faced	Sapric peat	Rudosol	Leptic	Lithosol	0	0.2	metamorphic	Og5	Shaw Hill Gabbro	unknown	Ordovician	Gabbro, diorite, metabasic intrusives, pyroxenite
Yarrangobilly 98	55	633093	6032944	moderate crumb	Silty clay loam	Rudosol	Leptic	Lithosol	6	0.25	metamorphic	Og5	Shaw Hill Gabbro	unknown	Ordovician	Gabbro, diorite, metabasic intrusives, pyroxenite
Yarrangobilly 97	55	633163	6032524	weak granular rough faced	Hemic peat	Tenosol	Peaty Chernic	Alpine Humus soil	6	0.35+	sedimentary igneous	Ovg1	Gooandra Volcanics	unknown	Ordovician	Metabasalt, basalt breccia, pillow lavas, amphibolite, chloritic schists, feldspathic sandstone
Yarrangobilly 96	55	633983	6033264	moderate granular	Silty clay loam	Tenosol	Paralithic Leptic	Lithosol	6	0.46	sedimentary igneous	Ovg1	Gooandra Volcanics	unknown	Ordovician	Metabasalt, basalt breccia, pillow lavas, amphibolite, chloritic schists, feldspathic sandstone
Yarrangobilly 95	55	634253	6033284	strong granular	Silty clay loam	Rudosol	Leptic	Lithosol	5.5	0.3	sedimentary igneous	Ovg1	Gooandra Volcanics	unknown	Ordovician	Metabasalt, basalt breccia, pillow lavas, amphibolite, chloritic schists, feldspathic sandstone

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Yarrangobilly 94	55	633353	6029284	massive earthy	Sapric peat	Tenosol	Peaty Chernic	Alpine Humus soil	6	0.14	sedimentary igneous metamorphic	Og5	Shaw Hill Gabbro	unknown	Ordovician	Gabbro, diorite, metabasic intrusives, pyroxenite
Yarrangobilly 93	55	631133	6031804	weak granular rough faced	Sapric peat	Tenosol	Peaty Chernic	Alpine humus soil	5.5	0.13	sedimentary igneous metamorphic	Sv7	Kings Cross Formation	unknown	Silurian	Porphyritic dacite and rhyodacite ignimbrite, rare dacite lava, tuff and agglomerate
Yarrangobilly 92	55	631323	6027784	weak granular rough faced	Loamy peat	Organosol	Sapric	Acid Peat Soil	4.5	0.47	sedimentary igneous metamorphic	Ovg1	Gooandra Volcanics	unknown	Ordovician	Metabasalt, basalt breccia, pillow lavas, amphibolite, chloritic schists, feldspathic sandstone
Yarrangobilly 91	55	628933	6022904	weak granular rough faced	Sapric peat	Tenosol	Paralithic Chernic	Alpine Humus soil	6	0.12	shale	Sv7	Kings Cross Formation	unknown	Silurian	Porphyritic dacite and rhyodacite ignimbrite, rare dacite lava, tuff and agglomerate
Yarrangobilly 90	55	625583	6022614	massive earthy	Sapric peat	Organosol	Sapric	Neutral Peat soil	7	0.3	Basalt	Tbm	unnamed	unknown	Tertiary	Basalt
Yarrangobilly 89	55	629953	6027124	moderate granular	Sapric peat	Organosol	Sapric	Alpine Humus soil	6	0.34+	sedimentary igneous	Smf2	Jackalass Slate	unknown	Silurian	Sandstone, siltstone and shale (turbiditic)
Yarrangobilly 88	55	627163	6032244	moderate crumb	Silty clay	Ferrosol	Red	Krasnozem	6	0.85+	basalt	Tbm	unnamed	unknown	Tertiary	Basalt

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Yarrangobilly 87	55	626863	6034514	weak crumb	Silty clay loam	Tenosol	Leptic	Lithosol	6	0.24	sedimentary igneous	Dls1	undifferentiated	BYRON RANGE GROUP	Devonian	conglomerate, sandstone, shale & nodular limestone
Yarrangobilly 86	55	626923	6036324	weak crumb	Sandy clay loam	Tenosol	Bleached-Leptic	Lithosol	7	0.25	shale	Dls1	undifferentiated	BYRON RANGE GROUP	Devonian	conglomerate, sandstone, shale & nodular limestone
Yarrangobilly 85	55	626953	6036744	weak crumb	Light clay loam	Rudosol	Paralithic Leptic	Lithosol	7	0.18		Dls1	undifferentiated	BYRON RANGE GROUP	Devonian	conglomerate, sandstone, shale & nodular limestone
Yarrangobilly 84	55	626513	6037094		Sandy clay loam	Rudosol	Paralithic Leptic	Lithosol	7	0.2	limestone	Dls1	undifferentiated	BYRON RANGE GROUP	Devonian	conglomerate, sandstone, shale & nodular limestone
Yarrangobilly 83	55	624693	6041104	moderate crumb	Sandy clay loam	Tenosol	Paralithic Orthic	Red Earth	6.5	0.25	metamorphic	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Yarrangobilly 82	55	625073	6042234	massive earthy	sandy clay loam	Rudosol	Arenaceous Leptic	Lithosol	5.5	0.29	sedimentary igneous	Dlv2	unnamed	Boraig Group	Devonian	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Yarrangobilly 81	55	626353	6042974	weak crumb	fine sandy loam	Sodosol	Brown	Yellow Podzolic Soil	6.5	1.3	sedimentary igneous	Dlv2	unnamed	Boraig Group	Devonian	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre
Yarrangobilly 80	55	627843	6044684	weak crumb	fine sandy loam	Tenosol	Paralithi c Orthic	Lithosol	5.5	0.2	sedimentary igneous	Dlv2	unnamed	Boraig Group	Devonian	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre
Yarrangobilly 79	55	628083	6045584		fine sandy loam	Tenosol	Paralithi c Orthic	Lithosol	6	0.15	metamorphic	Dlv2	unnamed	Boraig Group	Devonian	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre
Yarrangobilly 78	55	628217	6047524		Light clay loam	Tenosol	Paralithi c Orthic	Red Earth	6	0.16	metamorphic	Dlv2	unnamed	Boraig Group	Devonian	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre
Yarrangobilly 77	55	628193	6047624	moderate granular	Sapric peat / fine sandy loam	Tenosol	Paralithi c Chernic	Alpine humus soil	6	0.52	metamorphic	Dlv2	unnamed	Boraig Group	Devonian	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Yarrangobilly 76	55	628623	6048344	weak granular rough faced	Loamy peat	Tenosol	Paralithic Chernic	Alpine humus soil	7	0.12	metamorphic	Dlv2	unnamed	Boraig Group	Devonian	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre
Yarrangobilly 194	55	636844	6044183	massive earthy	light fibric peat	Hydrosol			5	0.5+	alluvium	Oigl	Gooandra Volcanics	unknown	Ordovician	aphyric and feldsparphyric basalt, lava breccia, pillow lava, rhyolite, shale
Yarrangobilly 193	55	636648	6044542	weak polyhedral	fine sandy clay loam	Dermosol	Brown		6	0.22+	siltstone/mudstone	Oigl	Gooandra Volcanics	unknown	Ordovician	aphyric and feldsparphyric basalt, lava breccia, pillow lava, rhyolite, shale
Yarrangobilly 188	55	634534	6045757	weak polyhedral	Light clay loam	Kurosol	Brown		5.5	0.21	limestone	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Yarrangobilly 187	55	634548	6045702	weak polyhedral	clay loam	Dermosol	Red		4.5	1	limestone	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Yarrangobilly 109	55	634533	6045304	moderate granular	clay loam	Dermosol		Terra Rossa Soil	7	0.57	limestone	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Yarrangobilly 108	55	634313	6045144	weak crumb	fine sandy clay loam	Chromosol	Red	Red Podzolic soil	6	0.65+	shale	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Yarrangobilly 107	55	634393	6044484	moderate crumb	silty clay	Rudosol	Leptic	Lithosol	7	0.22	limestone	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Yarrangobilly 106	55	634313	6044884	weak crumb	Loamy peat	Rudosol	Leptic	Lithosol	6.5	0.15	shale	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Yarrangobilly 105	55	634203	6045134	weak crumb	sandy clay loam	Rudosol	Leptic	Lithosol	6.5	0.39	shale	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Yarrangobilly 104	55	634413	6045554	moderate angular blocky	Light clay loam	Rudosol	Leptic	Lithosol	7	0.25	limestone	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Yarrangobilly 101	55	634533	6045734	strong granular	light clay	Ferrosol	Red	Krasnozem	7	0.7+		Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Yarrangobilly 100	55	634513	6045714	weak crumb	clay loam	Ferrosol	Red	Krasnozem	4.5	0.65	shale, limestone, metamorphic	Ss2	Ravine Beds/Yarrangobilly Limestone	Bredbo Group	Silurian	Limestone, sandstone, siltstone and shale
Tantangara 57	55	638311	6045339	massive earthy	Fine clay loam sandy	Dermosol	Brown	Krasnozem	6	1.3	Basalt	Oigl	Gooandra Volcanics	unknown	Ordovician	aphyric and feldsparphyric basalt, lava breccia, pillow lava, rhyolite, shale

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Tantangara 53	55	636715	6030257	massive earthy	Loamy peat	Kandosol	Brown	Brown Earth	5.5	0.2	Chert	Oitd	Temperance Formation		Ordovician	Interbedded basaltic tuff, chert, and feldspathic arenite, minor agglomerate
Tantangara 52	55	637908	6031242	massive earthy	Sandy Clay Loam	Kandosol	Brown	Brown Podzolic soil	5.5	0.7	chert	Oitb	Temperance Formation		Ordovician	Agglomerate, minor tuff and chert
Tantangara 51	55	638402	6031743	strong polyhedral	Fine clay loam sandy	Chromosol	Brown	Brown Podzolic soil	6	0.8	Chert	Oitc	Temperance Formation		Ordovician	Bedded chert, minor basaltic tuff
Tantangara 50	55	641113	6034084	weak sub-angular blocky	Light clay	Kandosol	Brown	Grey Clay	5.5	0.6	alluvium	Oitd	Temperance Formation		Ordovician	Interbedded basaltic tuff, chert, and feldspathic arenite, minor agglomerate
Tantangara 49	55	641880	6033527	moderate polyhedral	Fine clay loam sandy	Kandosol	Brown	Grey Clay	5.5	0.5+	Chert	Oitd	Temperance Formation		Ordovician	Interbedded basaltic tuff, chert, and feldspathic arenite, minor agglomerate
Tantangara 48	55	642200	6031850	fibric	Fabric peat	Rudosol		Alpine humus soil	5.5	0.2	chert	Oitd	Temperance Formation		Ordovician	Interbedded basaltic tuff, chert, and feldspathic arenite, minor agglomerate
Tantangara 47	55	642592	6031255	massive earthy	Coarse clay loam sandy	Chromosol	Brown	Brown podzolic soil	6.5	0.9+	Chert	Dkg5	Boggy Plain Adamellite		Devonian	Phase 2: Adamellite

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Tantangara 46	55	642993	6030795	moderate polyhedral	Fine clay loam sandy	Dermosol	Brown	Brown Podzolic soil	6.5	0.5	Quartz arenite	Dkg5	Boggy Plain Adamellite		Devonian	Phase 2: Adamellite
Tantangara 45	55	643268	6028816	massive earthy	Fine sandy peat	Kandosol	Brown	Brown Earth	7	0.5+	Arenite	Dkg4	Hell Hole Creek Adamellite		Devonian	Granodiorite, minor quartz gabbro
Tantangara 44	55	643163	6025747	weak polyhedral	Coarse loam sandy	Chromosol	Brown	Brown Earth	6.5	0.9	Adamellite	Dkg5	Boggy Plain Adamellite		Devonian	Phase 2: Adamellite
Tantangara 42	55	647912	6035915	weak granular rough faced	Coarse sandy clay loam	Rudosol		Lithosol	6	0.07	Ignembrite.	Dkv	Kellys Plain Volcanics		Devonian	Dacite ignimbrite, rhyodacite ignimbrite, tuff, agglomerate, rhyolite
Tantangara 41	55	648409	6034660	strong polyhedral	Light clay	Dermosol	Grey	Grey Clay	5	0.6	Ignembrite.	Dkv	Kellys Plain Volcanics		Devonian	Dacite ignimbrite, rhyodacite ignimbrite, tuff, agglomerate, rhyolite
Tantangara 40	55	646690	6026919	weak granular rough faced	Sandy Clay Loam	Chromosol	Brown	Brown Earth	6	0.4	leucogranite	Syn	Tantangara Formation		Silurian	Coarse to fine quartz sandstone, siltstone and shale, grading from proximal flysch in west to distal flysch in east
Tantangara 38	55	648585	6046443	strong polyhedral	clay loam	Dermosol	Red	Krasnozem	6	1.4+	Chert	Oitc	Temperance Formation		Ordovician	Bedded chert, minor basaltic tuff

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Tantangara 37	55	648887	6046146	moderate polyhedral	clay loam	Kandosol	Brown	Brown Earth	6	0.4		Oitc	Temperance Formation		Ordovician	Bedded chert, minor basaltic tuff
Tantangara 36	55	651092	6045453	strong structure	clay loam	Kandosol	Brown	Brown Earth	6	0.5	Ignembrite.	Dkv	Kellys Plain Volcanics		Devonian	Dacite ignimbrite, rhyodacite ignimbrite, tuff, agglomerate, rhyolite
Tantangara 35	55	653638	6044250	moderate granular	Fine clay loam sandy	Dermosol	Red	Red Podzolic soil	7	0.5+	Ignembrite.	Dkv	Kellys Plain Volcanics		Devonian	Dacite ignimbrite, rhyodacite ignimbrite, tuff, agglomerate, rhyolite
Tantangara 34	55	650935	6037856	weak granular rough faced	Clay loam sandy	Kandosol	Brown	Brown Earth	5	0.3	Arenite	Syn	Tantangara Formation		Silurian	Coarse to fine quartz sandstone, siltstone and shale, grading from proximal flysch in west to distal flysch in east
Tantangara 33	55	651959	6032459	weak polyhedral	Clay loam	Kandosol	Red	Red Earth	5.5	1.5+	Arenite	Syn	Tantangara Formation		Silurian	Coarse to fine quartz sandstone, siltstone and shale, grading from proximal flysch in west to distal flysch in east

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
Tantangara 32	55	652715	6029813	moderate polyhedral	Sandy clay loam	Hydrosol	Grey	Grey Clay	6			Qa	undifferentiated		Quaternary	Alluvium, fluvial deposits: gravel, sand, silt and clay
Tantangara 31	55	652713	6028847	moderate polyhedral	Clay loam	Dermosol	Brown	Chocolate Soil	5.5	0.5+	Arenite	Syn	Tantangara Formation		Silurian	Coarse to fine quartz sandstone, siltstone and shale, grading from proximal flysch in west to distal flysch in east
Tantangara 30	55	653308	6026921	massive earthy	Clay loam	Dermosol	Brown	Brown Earth	5.5	0.5+	Andesite	Oa	Adaminaby Group		Ordovician	Turbiditic sequence; sandstone, mudstone, shale; quartzite, quartz phyllite, phyllite, slate
Tantangara 29	55	654265	6026016		Clay loam	Kandosol	Red	Brown Earth	6.5	0.7+	Arenite	Syn	Tantangara Formation		Silurian	Coarse to fine quartz sandstone, siltstone and shale, grading from proximal flysch in west to distal flysch in east
EW 58	55	625754	6039064		silty loam	Kandosol	Grey		5.7			Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
EW 53	55	624900	6040389		clay loam	Kandosol	Red		5.5			w	water		Quaternary	Water
EW 52	55	626756	6038196		clay loam	Dermosol	Red		4.7			Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone
EW 51	55	626687	6038400		clay	Vertosol	Black		8			Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone
EW 5	55	628540	6029554		silty loam	Kandosol	Brown					Tbm	unnamed		Tertiary	Basalt
EW 48	55	616694	6057180		silty loam	Kandosol	Red		5.4			Dlv2	unnamed		Devonian	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre
EW 44	55	625155	6040184		sandy clay loam	Kandosol	Red		5.1			Ss2	Ravine Beds/Yarrangobilly Limestone		Silurian	Limestone, sandstone, siltstone and shale
EW 43	55	626275	6038232		sandy clay loam	Tenosol	Brown-Orthic		5.7			Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone
EW 42	55	627575	6038092		silty clay loam	Kandosol	Grey		5.7			Ss2	Ravine Beds/Yarrangobilly Limestone		Silurian	Limestone, sandstone, siltstone and shale

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
EW 41	55	627890	6038355		silty loam	Tenosol	Brown-Orthic					Ss2	Ravine Beds/Yarrangobilly Limestone		Silurian	Limestone, sandstone, siltstone and shale
EW 40	55	628024	6038806		loamy sand	Tenosol	Brown-Orthic		6			Ss2	Ravine Beds/Yarrangobilly Limestone		Silurian	Limestone, sandstone, siltstone and shale
EW 4	55	628834	6028719		silty loam	Kandosol	Brown		5.3			Tbm	unnamed		Tertiary	Basalt
EW 38	55	626544	6038341		silty loam	Kandosol	Red		5.9			Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone
EW 37	55	625997	6038935		clay loam	Kandosol	Red		6			Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone
EW 36	55	626412	6039204		sandy clay loam	Tenosol	Brown-Orthic					Ss2	Ravine Beds/Yarrangobilly Limestone		Silurian	Limestone, sandstone, siltstone and shale
EW 35	55	625740	6039257		clay loam	Kandosol	Grey		6.5			Ss2	Ravine Beds/Yarrangobilly Limestone		Silurian	Limestone, sandstone, siltstone and shale
EW 33	55	625359	6039779		loam	Kandosol	Red					Ss2	Ravine Beds/Yarrangobilly Limestone		Silurian	Limestone, sandstone, siltstone and shale

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
EW 26	55	625962	6037793		clay loam	Dermosol	Red		6.1			Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone
EW 25	55	626286	6037150		clay loam				5.7			Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone
EW 23	55	626917	6035923		clay loam	Kandosol	Brown		5.8			Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone
EW 21	55	626872	6034160		silty clay loam	Kandosol	Brown					Dls1	undifferentiated		Devonian	conglomerate, sandstone, shale & nodular limestone
EW 20	55	626924	6033340		clay loam	Kandosol	Brown		5.6			Dlv3	Mountain Creek Volcanics		Devonian	Rhyolite, rhyodacite, tuff, lapilli tuff, feldspathic sandstone, granophyre
EW 19	55	627142	6032037		silty clay loam	Kandosol	Brown		5.3			Tbm	unnamed		Tertiary	Basalt
EW 18	55	627497	6031792		silty loam							Tbm	unnamed		Tertiary	Basalt
EW 17	55	627734	6030922		silty loam	Kandosol	Brown		6			Tbm	unnamed		Tertiary	Basalt
EW 16	55	627998	6030324		silty loam	Kandosol	Brown		5.6			Tbm	unnamed		Tertiary	Basalt

Table B.1 Soil site data and geology

Site number	Zone	Easting	Northing	Surface structure	Surface texture	ASC Order	ASC Sub-Order	GSG	pH	Soil depth (m)	Lithology from soil site	Geology code	Geology unit name	Geology group	Period	Description
EW 13	55	629051	6027797		silty loam	Kandosol	Brown		5.5			Tbm	unnamed		Tertiary	Basalt
Berridale 9	55	653089	6012901	massive earthy	clay loam	Kandosol	Red	Red Podzolic soil	6	0.55		Syn	Tantangara Formation		Silurian	Coarse to fine quartz sandstone, siltstone and shale, grading from proximal flysch in west to distal flysch in east