APPENDIX U

AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

Snowy 2.0 Exploratory Works

Snowy Hydro Limited

Air Quality and Greenhouse Gas Assessment

Final | Revision 0

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Snowy 2.0 Exploratory Works

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Executive Summary

This report provides an assessment of the air quality and greenhouse gas impacts of exploratory works associated with Snowy 2.0 (Exploratory Works), a large scale pumped hydro-electric storage and generation project which would increase hydro-electric capacity within the existing Snowy Mountains Hydro-electric Scheme. The assessment has been carried out in accordance with the EPA's "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (EPA 2016).

The main air quality issue for the Exploratory Works was identified as airborne particulate matter (i.e. dust) from the handling and transport of excavated material. This issue was assessed by quantifying the potential impacts and identifying suitable air quality management measures, as appropriate, to minimise impacts.

A review of the existing environment was carried out. It was noted that no specific air quality monitoring has been carried out in the vicinity of the proposed site so existing air quality conditions had to be estimated or determined from the nearest known monitoring stations. The review also considered meteorological data from various locations. With this approach the review noted that:

- The prevailing winds are from the west-northwest and east-southeast.
- Particulate matter concentrations (TSP, PM_{10} and $PM_{2.5}$) and deposition levels are unlikely to exceed EPA criteria since the area is well removed from populated centres, industry and significant sources of air pollution.

The computer-based dispersion model known as CALPUFF was used to predict the potential air quality impacts of the Exploratory Works. The dispersion modelling accounted for meteorological conditions, land use and terrain information and used dust emission estimates to predict air quality impacts in the local area, including at the proposed location of the accommodation camp.

The model predictions showed that PM_{10}, $PM_{2.5}$, TSP and deposited dust levels would not exceed relevant EPA assessment criteria at the proposed accommodation camp, identified as the nearest sensitive receptor. The modelling did however show that there was a potential for the 24-hour average PM_{10} concentration to approach the criterion (50 µg/m^3) if the contribution from the works where high and the background levels were elevated on a particular day. The results were taken to be indicative of the potential impacts given that background levels were not known and necessarily had to be estimated.

It was concluded that the Exploratory Works can achieve acceptable air quality outcomes for the accommodation camp but was recommended that monitoring is carried out prior to and during the Exploratory Works to characterise the existing air quality environment and to inform the daily management of the proposed activities.

There will be greenhouse gas emissions as a result of the Exploratory Works. The estimated emissions reflect a small increase and total in the context of State and National emissions and no significant greenhouse gas emissions management is warranted. These emissions have been quantified with reference to State and National emission estimates.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to quantify the potential air quality and greenhouse gas impacts of Snowy 2.0 Exploratory Works in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

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). This would be achieved by establishing a new underground hydro-electric power station that would increase the generation capacity of the Snowy Scheme by almost 50%, providing an additional 2,000 megawatts (MW) generating capacity, and providing approximately 350,000 megawatt hours (MWh) of storage available to the National Electricity Market (NEM) at any one time, which is critical to ensuring system security as Australia transitions to a decarbonised NEM. Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and hydro-electric power station.

Snowy 2.0 has been declared to be State significant infrastructure and critical State significant infrastructure (CSSI) by the NSW Minister for Planning under the provisions of the NSW *Environmental P lanning and Assessment Act 1979* (EP&A Act) and is defined in Clause 9 of Schedule 5 of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP). Separate applications and environmental impact statements (EIS) for different phases of Snowy 2.0 are being submitted under Part 5, Division 5.2 of the EP&A Act. This technical assessment has been prepared to support an EIS for Exploratory Works to undertake investigative works to gather important technical and environmental information for the main Snowy 2.0 project. The main project will be subject of a separate application and EIS next year.

The purpose of Exploratory Works for Snowy 2.0 is primarily to gain a greater understanding of the conditions at the proposed location of the power station, approximately 850 metres (m) below ground level. Understanding factors such as rock conditions (such as stress conditions) and ground temperature is essential to inform decisions about the precise location of the power station cavern and confirm the cavern construction methods.

Exploratory Works comprises:

- an exploratory tunnel to the site of the underground power station for Snowy 2.0;
- horizontal and other test drilling, investigations and analysis in situ at the proposed cavern location and associated areas, and around the portal construction pad, access roads and excavated rock management areas all within the disturbance footprint;
- a portal construction pad for the exploratory tunnel;
- an accommodation camp for the Exploratory Works construction workforce;
- road works and upgrades providing access and haulage routes during Exploratory Works;
- barge access infrastructure, to enable access and transport by barge on Talbingo reservoir;
- excavated rock management, including subaqueous placement within Talbingo Reservoir;
- services infrastructure such as diesel-generated power, water and communications; and
- post-construction revegetation and rehabilitation, management and monitoring.

1.2 Purpose of this Report

This air quality and greenhouse gas assessment supports the EIS for Exploratory Works. It documents the assessment methods and results, the initiatives built into the project design to avoid and minimise associated impacts, and the mitigation and management measures proposed to address any residual impacts not able to be avoided.

1.3 Location of Exploratory Works

Snowy 2.0 and Exploratory Works are within the Australian Alps, in southern NSW. The regional location of Exploratory Works is shown on **Figure 1**.

Snowy 2.0 is within both the Snowy Valleys and Snowy Monaro Regional local government areas (LGAs), however Exploratory Works is entirely within the Snowy Valleys LGA. The majority of Snowy 2.0 and Exploratory Works are within Kosciuszko National Park (KNP). The area in which Exploratory Works will be undertaken is referred to herein as the project area, and includes all of the surface and subsurface elements further discussed in Section 2.

Exploratory Works is predominantly in the Ravine region of the KNP. This region is between Talbingo Reservoir to the north-west and the Snowy Mountains Highway to the east, which connects Adaminaby and Cooma in the south-east to Talbingo and Tumut to the north-west of the KNP. Talbingo Reservoir is an existing reservoir that forms part of the Snowy Scheme. The reservoir, approximately 50 kilometres (km) north-west of Adaminaby and approximately 30 km east-north-east of Tumbarumba, is popular for recreational activities such as boating, fishing, water skiing and canoeing.

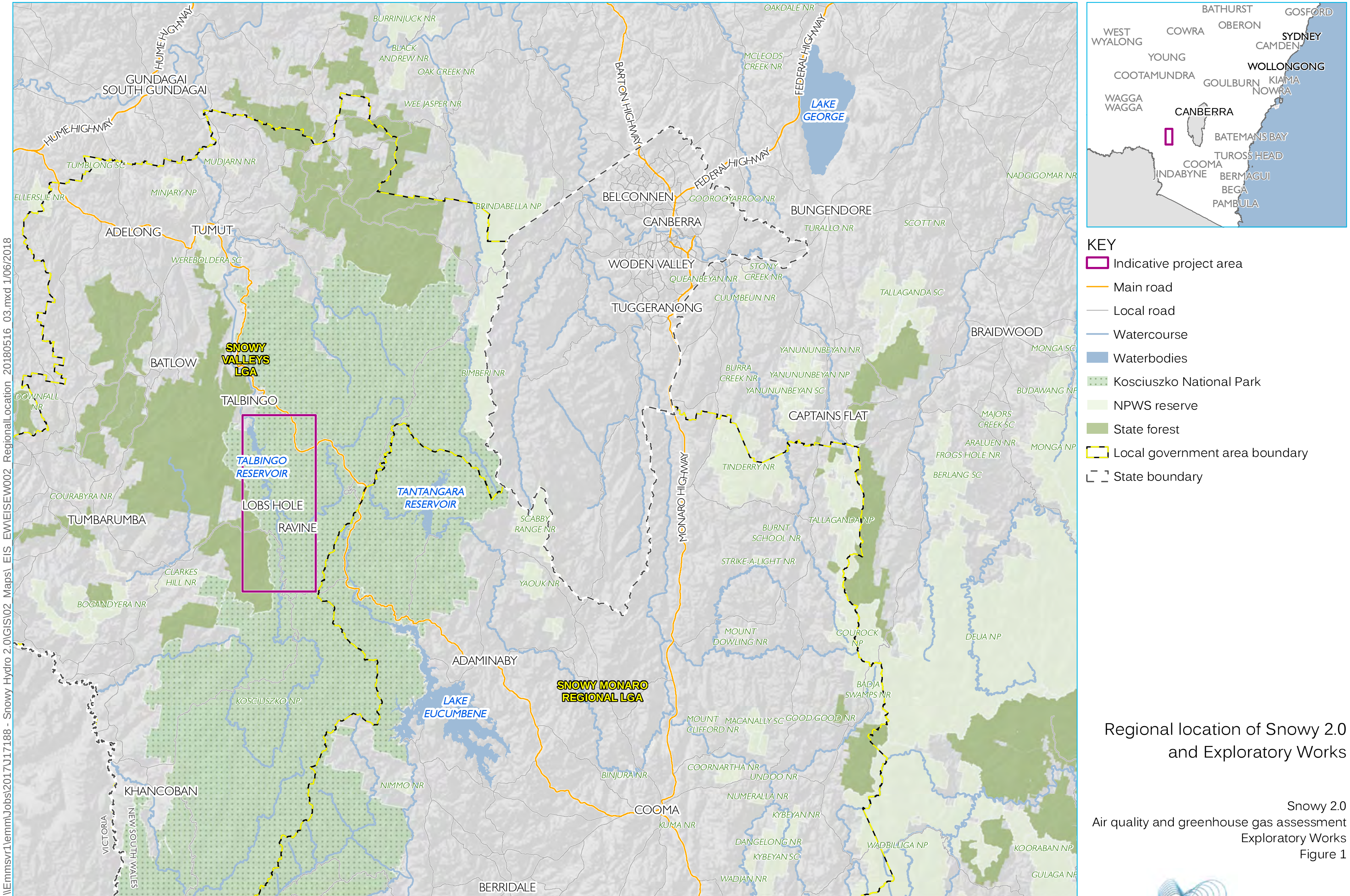
The nearest large towns to Exploratory Works are Cooma and Tumut. Cooma is approximately one hour and forty five minutes drive (95 km) south-east of Lobs Hole. Tumut is approximately half an hour (45 km) north of Talbingo. There are several communities and townships near the project area including Talbingo, Tumbarumba, Batlow, Cabramurra and Adaminaby. Talbingo and Cabramurra were built for the original Snowy Scheme workers and their families. Adaminaby was relocated to alongside the Snowy Mountains Highway from its original location (now known as Old Adaminaby) in 1957 due to the construction of Lake Eucumbene. Talbingo and Adaminaby provide a base for users of the Selwyn Snow Resort in winter. Cabramurra was modernised and rebuilt in the early 1970s and is owned and operated by Snowy Hydro. It is still used to accommodate Snowy Scheme employees and contractors. Properties within Talbingo are now predominantly privately owned. Snowy Hydro now only owns 21 properties within the town.

Other attractions and places of interest in the vicinity of the project area include Selwyn Snow Resort, the Yarrangobilly Caves complex and Kiandra. Kiandra has special significance as the first place in Australia where recreational skiing was undertaken and is also an old gold rush town.

The project area is shown on **Figure 1** and comprises:

- **Lobs Hole:** Lobs Hole will accommodate the excavated rock emplacement areas, an accommodation camp as well as associated infrastructure, roads and laydown areas close to the portal of the exploratory tunnel and portal construction pad at a site east of the Yarrangobilly River;
- **Talbingo Reservoir:** installation of barge access infrastructure near the existing Talbingo Spillway, at the northern end of the Talbingo Reservoir, and also at Middle Bay, at the southern end of the reservoir, near the Lobs Hole facilities, and installation of a submarine cable from the Tumut 3 power station to Middle Bay, providing communications to the portal construction pad and accommodation camp. A program of subaqueous rock placement is also proposed;
- **Mine Trail Road** will be upgraded and extended to allow the transport of excavated rock from the exploratory tunnel to sites at Lobs Hole that will be used to manage excavated material, as well as for the transport of machinery and construction equipment and for the use of general construction traffic; and
- several sections of **Lobs Hole Ravine Road** will be upgraded in a manner that protects the identified environmental constraints present near the current alignment.

The project is described in more detail in **Section 2.**



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

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Regional location of Snowy 2.0 and Exploratory Works

Snowy 2.0
Air quality and greenhouse gas assessment
Exploratory Works
Figure 1

1.4 Proponent

Snowy Hydro is the proponent for Exploratory 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.

1.5 Assessment Guidelines and Requirements

This assessment has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for Exploratory Works, first issued on 17 May 2018 and revised on 20 June 2018, as well as relevant governmental assessment requirements, guidelines and policies, and in consultation with the relevant government agencies.

The SEARs must be addressed in the EIS. **Table 1** lists the matters relevant to this assessment and where they are addressed in this report.

Table 1 Relevant matters raised in SEARs

Requirement	Section addressed
Air – including an assessment of the air quality impacts of the project;	This report, in particular **Section 7**

To inform preparation of the SEARs, the Department of Planning and Environment (DPE) invited relevant government agencies to advise on matters to be addressed in the EIS. These matters were taken into account by the Secretary for DPE when preparing the SEARs.

The air quality assessment has been carried out in accordance with the EPA's "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (EPA 2016).

The main objectives of this assessment were to:

- Characterise the existing meteorological and air quality environment;
- Identify potential air quality issues;
- Quantify the potential air quality impacts from Exploratory Works;
- Quantify the potential greenhouse gas emissions from Exploratory Works; and
- Identify suitable air quality and greenhouse gas management measures, as appropriate, to minimise impacts.

The assessment was based on the use of an air dispersion model, CALPUFF, to predict concentrations of substances emitted to air due to the Exploratory Works. Model predictions have been compared with air quality criteria referred to by the EPA in order to assess the effect that the Exploratory Works may have on the existing air quality environment.

In summary, the report provides information on the following:

- Proposed Exploratory Works (**Section 2**);
- Relevant air quality criteria (**Section 3**);
- Existing meteorological and air quality conditions (**Section 4**);
- Emissions to air from the proposed activities (**Section 5**);
- Methods used to predict air quality impacts (**Section 6**);
- Expected air quality impacts, as determined by a comparison of model results with air quality assessment criteria (**Section 7**); and
- Estimated greenhouse gas emissions (**Section 8**).

This assessment has been prepared with reference to other technical reports that were prepared as part of the Exploratory Works EIS. The other relevant reports referenced in this assessment are listed below.

- Barge access infrastructure (RHDHV 2018) – Appendix L of the EIS
- Dredging and dredging assessment (RHDHV 2018) – Appendix C of the Barge access infrastructure report (Appendix L of the EIS)
- Excavated rock emplacement areas assessment (SGME 2018) – Appendix K of the EIS
- Rehabilitation strategy (SMEC 2018) – Appendix E of the EIS
- Soils and land assessment (EMM 2018) – Appendix H of the EIS
- Traffic and Transport Assessment Report (SCT 2018) – Appendix Q of the EIS

2. Project Description

2.1 Overview

Exploratory Works comprises construction associated with geotechnical exploration for the underground power station for Snowy 2.0. The Exploratory Works elements are shown on **Figure 2** and involve:

- establishment of an exploratory tunnel to the site of the underground power station for Snowy 2.0;
- horizontal and other test drilling, investigations and analysis in situ at the proposed cavern location and associated areas, and around the portal construction pad, access roads and excavated rock management areas all within the disturbance footprint;
- establishment of a portal construction pad for the exploratory tunnel;
- establishment of an accommodation camp for the Exploratory Works construction workforce;
- road works and upgrades providing access and haulage routes during Exploratory Works;
- establishment of barge access infrastructure, to enable access and transport by barge on Talbingo reservoir;
- excavated rock management, including subaqueous placement within Talbingo Reservoir;
- establishment of services infrastructure such as diesel-generated power, water and communications; and
- post-construction revegetation and rehabilitation, management and monitoring.

2.2 Exploratory Tunnel

An exploratory tunnel of approximately 3.1 km is proposed to provide early access to the location of the largest cavern for the underground power station. This will enable exploratory drilling and help optimise the location of the cavern which, in turn, will optimise the design of Snowy 2.0.

The exploratory tunnel is proposed in the north-east section of Lobs Hole and will extend in an east-west direction with the portal construction pad to be outside the western end of the tunnel at a site east of the Yarrangobilly River, as shown on **Figure 2**.

The location of the proposed exploratory tunnel and portal construction pad is shown in **Figure 2**. The exploratory tunnel will be excavated by drill and blast methods and have an 8 x 8 m D-Shaped cross section.

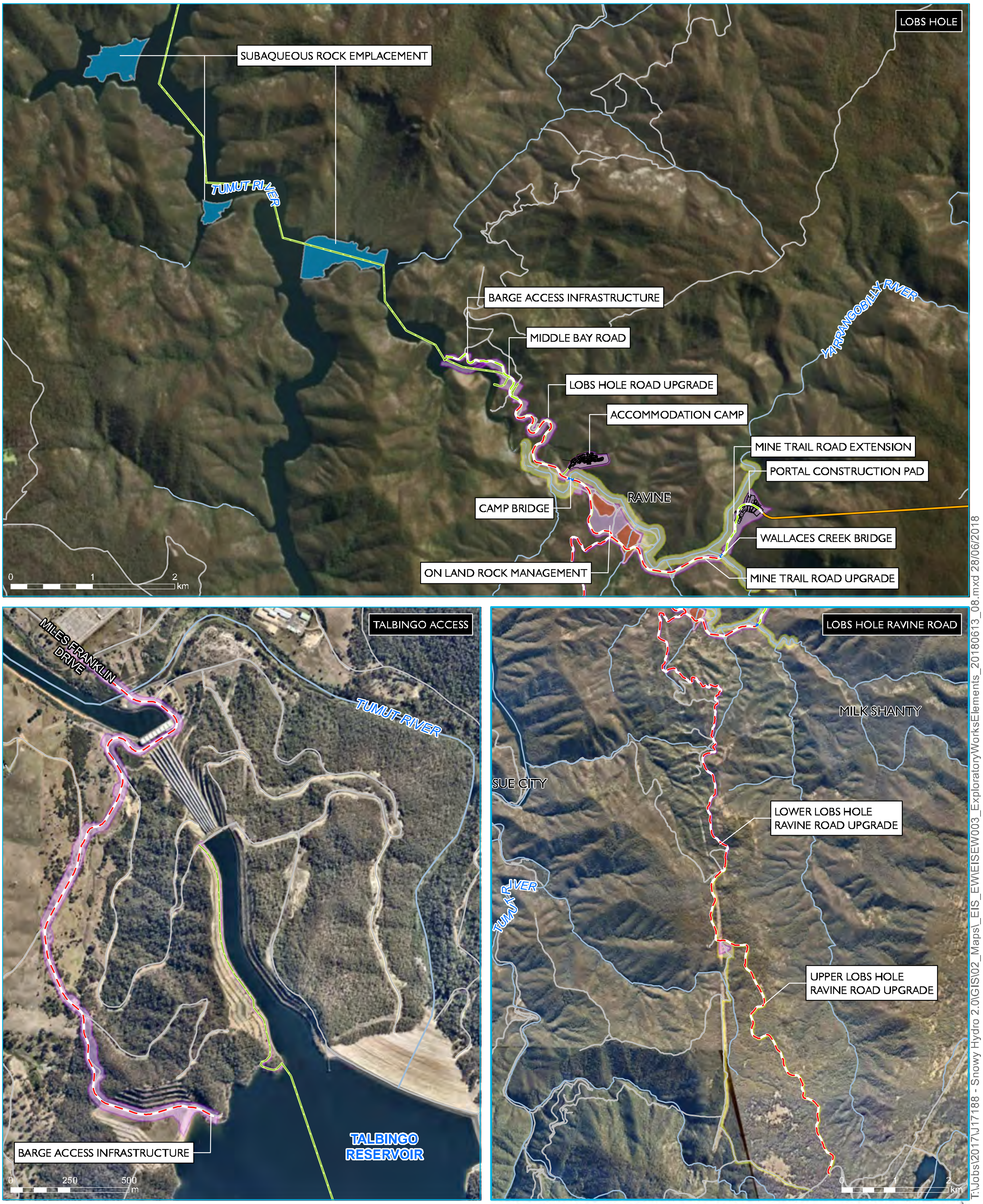
The drill and blast excavation process will be repeated cyclically throughout the tunnelling works, involving:

- marking up and drilling blast holes in a predetermined pattern in the working face of the tunnel;
- loading the blast holes with explosives, attaching detonators and connecting the holes into a blast sequence, and detonating the blast;
- ventilating the tunnel to remove blast fumes and dust;
- removing blasted rock;
- scaling and wash down of the tunnel roof and walls to remove loosened pieces of rock;
- geological mapping of the exposed rock faces and classification of the conditions to determine suitable ground support systems for installation;
- installing ground support; and
- advancing construction ventilation ducting and other utilities including power, water, compressed air and communications.

The exploratory tunnel will be shotcrete-lined with permanent anchor support, and incorporate a groundwater management system. The exploratory tunnel shape and dimensions are designed to allow two-lane traffic for the removal of excavated material, along with additional space for ventilation and drainage of groundwater inflows. Groundwater intersected during tunnelling will be contained and transferred to the portal for treatment and management. Areas identified during forward probing with the potential for high groundwater flows may require management through a detailed grouting program or similar.

The tunnel portal will be established at the western end of the exploratory tunnel and provide access and utilities to the exploratory tunnel during construction. The portal will house power, communications, ventilation and water infrastructure. The portal will also provide a safe and stable entrance to the exploratory tunnel.

It is anticipated that the exploratory tunnel will be adapted for multiple functions during construction of the subsequent stages of the Snowy 2.0 project. The exploratory tunnel will also eventually be utilized to form the main access tunnel (MAT) to the underground power station during the operational phase of Snowy 2.0, should it proceed.



Source: EMM (2018); Snowy Hydro (2018); NearMap (2018); SMEC (2018); Robert Bird (2018); DFSI (2017); LPMA (2011)

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KEY

- Access road upgrade
- Access road extension
- Permanent bridge
- Portal construction pad and accommodation camp conceptual layout
- Communications cable and water services pipeline location
- Local road or track
- Watercourse
- Disturbance footprint
- Avoidance footprint
- On land rock management
- Subaqueous rock emplacement area

Exploratory Works elements

Snowy 2.0
Air Quality and Greenhouse Gas Impact Assessment
Exploratory Works
Figure 2

2.3 Portal Construction Pad

A portal construction pad for the exploratory tunnel will provide a secure area for construction activities. Infrastructure at the portal construction pad, shown in **Figure 3**, will primarily support tunnelling activities and include a concrete batching plant and associated stockpiles, site offices, maintenance workshops, construction support infrastructure, car parking, equipment laydown areas. Stockpile areas will allow for around two to three months' supply of concrete aggregate and sand for the concrete batching plant to ensure that the construction schedule for the proposed access road works do not interfere with the exploratory tunnel excavation schedule. A temporary excavated rock emplacement area is also required to emplace material excavated during tunnel construction prior to its transfer to the larger excavated material emplacement areas.

The portal construction pad will be at the western end of the exploratory tunnel. The portal construction pad will be excavated to provide a level construction area with a near vertical face for the construction of the portal and tunnelling. The layout of the portal construction pad is provided in **Figure 3**. The area required for the portal construction pad is approximately 100,000 m^2.

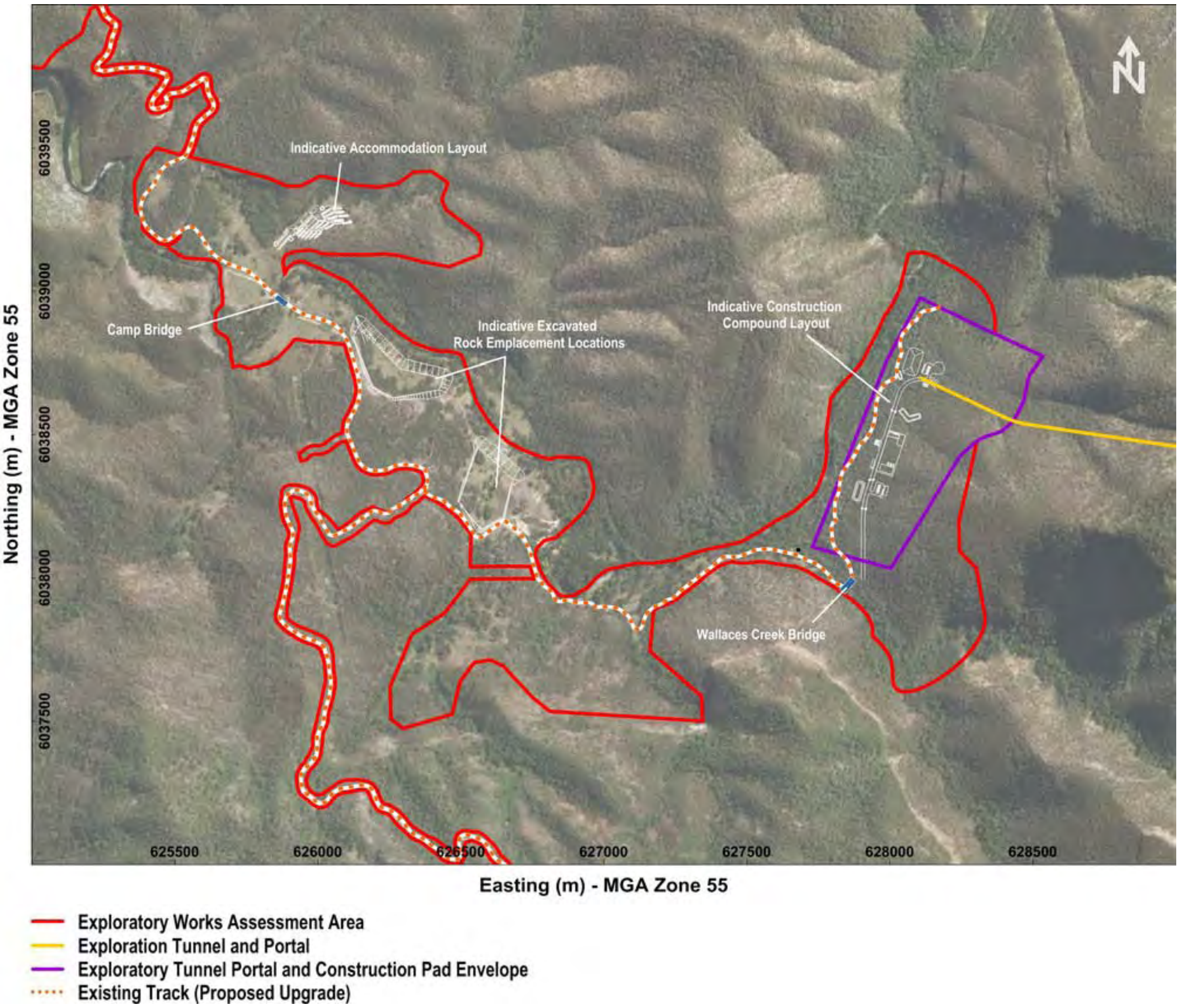


Figure 3 Conceptual layout of emplacement areas, camp, tunnel, portal and portal construction pad for Exploratory Works

2.4 Excavated Rock Management

It is estimated that approximately 750,000 m^3 of bulked materials will be excavated, mostly from the exploratory tunnel and portal construction pad with additional quantities from road upgrade works. Subject to geochemical testing of the rock material, excavated rock will be placed either on land or subaqueously within Talbingo Reservoir.

2.4.1 On Land Placement

Excavated materials will be placed in one of two rock emplacement areas at Lobs Hole as shown on **Figure 3**.

The strategy for excavated rock management is for excavated material to be emplaced at two areas with the final placement of excavated material to be determined at a later date.

Consultation with NPWS throughout the design process has identified an opportunity for the eastern emplacement area to form a permanent landform that enables greater recreational use of Lobs Hole following the completion of Snowy 2.0's construction. It is envisaged that the excavated rock emplacement area will provide, in the long-term, a relatively flat final landform suitable for camping and basic recreational facilities to be confirmed in consultation with NPWS.

The eastern emplacement area has a capacity of up to 600,000 m^3 of material. It will be approximately 25 m maximum depth and will be benched down to the northern edge of the emplacement which is setback 50 m from the Yarrangobilly River.

The western emplacement area will be used to store excavated material should it not be able to be placed within the eastern emplacement area. It is envisaged this emplacement area will be used to store excavated materials suitable for re-use within the construction of Exploratory Works or for use by NPWS in KNP maintenance activities. All remaining material placed in this emplacement area will be removed following the completion of Exploratory Works.

The guiding principles for the design, construction method and management of emplacement areas undertaken for Exploratory Works have been as follows:

- reducing potential for acid rock drainage from the excavated rock emplacement area entering the Yarrangobilly River or forming groundwater recharge;
- avoid known environmental constraints; and
- manage existing surface water flows from Lick Hole Gully.

The design and management of the emplacement areas have not yet been finalised due to the need for further investigations to determine the likely geochemical characteristics of the excavated material. Following further investigation and prior to construction of Exploratory Works a management plan will be prepared and implemented.

2.4.2 Subaqueous Placement

An initial program for the placement of excavated rock within Talbingo Reservoir also forms part of Exploratory Works. The program will be implemented in an appropriate section of Talbingo Reservoir in accordance with a detailed management plan based on an engineering method informed through the materials' geochemistry and reservoir's characteristics. The purpose of the program is to confirm the suitability of the emplacement method for future excavated rock material from the construction of Snowy 2.0, should it proceed.

The rock for subaqueous placement will be taken from the excavated rock emplacement areas as described above. Testing of the rock would be conducted during excavation to assess geochemical properties. Any rock assessed as unsuitable for subaqueous placement based on the prior geochemical and leachability testing would be separately stockpiled and not used in the program. Suitable (i.e. non-reactive material) would be transported and loaded to barge, for placement at the deposition area.

All placement within the reservoir would occur within silt curtains and would be subject to a detailed monitoring regime including survey monitoring of pre-placement and post-placement bathymetry, local and remote background water quality monitoring during placement with a structured management response to monitoring results in the event of an exceedance of established triggers. The management, mitigation and monitoring measures would be refined following the ongoing investigations.

2.5 Accommodation Camp

An accommodation camp is proposed to provide accommodation and supporting services for workers in close proximity to the exploratory tunnel. The accommodation camp layout includes ensuite rooms surrounding central facilities including a kitchen, tavern, gym, admin office, laundry, maintenance building, sewage and water treatment plants and parking that will service the Exploratory Works workforce. The accommodation camp access road will connect to the north side of Lobs Hole Road at Lobs Hole. The conceptual layout of the accommodation camp is shown on **Figure 3**.

2.6 Road and Access Provisions

Existing road and access will need to be upgraded to a suitable standard to:

- provide for the transport of excavated rock material between the exploratory tunnel 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 staff to the portal construction pad.

Given the topographic constraints of the area, the standard of the existing roads and the environmental values associated with KNP, the option of barging larger and oversized loads to the site is available. This is discussed further at **Section 2.7**.

2.6.1 Access Road Works

The access road upgrades will be designed based on access for a truck and dog trailer. The proposed road works are described in **Table 2**. It is expected that the majority of materials and equipment will travel along the Snowy Mountains Highway, Link Road and Lobs Hole Ravine Road, with some required to travel on Miles Franklin Drive via Talbingo to Talbingo Dam Wall and be transferred via a barge to site. Where existing roads are replaced by new access roads or road upgrades, the existing roads will be removed and rehabilitated in line with the rehabilitation strategy for Exploratory Works.

Table 2 Access road works summary

Roadwork area	Overview
Upper Lobs Hole Ravine Road upgrade	Minor upgrades to 7.5 km section of existing road. Only single lane access will be provided. No cut and fill earthworks or vegetation clearing will be undertaken.
Lower Lobs Hole Ravine Road upgrade	Upgrades to 6 km section of existing road involving cut and fill earthworks in some sections. Only single lane access will be provided.
Lobs Hole Road upgrade	Upgrade to 7.3 km section of existing road providing two-way access.
Mine Trail Road upgrade	Upgrade to 2.2 km section of existing track to two-way access.
Mine Trail Road extension	Establishment of a new two-way road providing access to the exploratory tunnel portal.
Middle Bay Road	Establishment of a new two-way road to the proposed Middle Bay barge ramp.
Spillway Road	Upgrade of a 3 km section of existing road to provide two-way access to the proposed Spillway barge ramp.

While no cut and fill earthworks or vegetation clearing is proposed along Upper Lobs Hole Ravine Road, a laydown area is proposed within and adjacent to the existing transmission line easement. This area will be used to store materials required for the road works to the lower section of Lobs Hole Ravine Road.

2.6.2 Watercourse Crossings

Bridge construction will be required at two locations as described in **Table 3**.

Table 3 Watercourse crossing summary

Bridge works area	Overview
Camp bridge	An existing crossing on Yarrangobilly River will be used as a temporary crossing while a new permanent bridge is built as part of Lobs Hole Road upgrade. The existing crossing will require the crossing level to be raised with rocks to facilitate vehicle passage. The rocks used to raise the crossing level will be removed and the crossing no longer used once the permanent bridge has been constructed. The new bridge (Camp Bridge) will be a permanent crossing and used for both Exploratory Works and Snowy 2.0 main works, should it proceed
Wallaces Creek bridge	Establishment of a new permanent bridge at Wallaces Creek as part of the Mine Trail Road extension. Establishment of this bridge will require an initial temporary pre-fabricated 'Bailey bridge' to be constructed, which will be removed before the end of Exploratory Works.

The design for permanent bridges at both crossings will consist of steel girders with a composite deck. This is the most common type of permanent bridge constructed in and around the existing Snowy Scheme. Lightweight steel girders are easy to transport and will therefore allow for efficiencies in the construction schedule and permit the use of smaller-scale lifting equipment at the construction site.

2.7 Barge Access Infrastructure

To provide an alternative to road access, a barge option is proposed, not only for bulky and heavy equipment but for materials and also in case of emergency. During Exploratory Works, barges will be loaded at the northern barge ramp (Talbingo barge ramp), travel about 18 km along Talbingo Reservoir and be unloaded at the southern barge ramp (Middle Bay barge ramp) before returning to the north. Some loads may also be transported in the reverse direction.

Barge access infrastructure will comprise two dedicated barge ramps at Middle Bay and Talbingo Spillway, with a slope of approximately 1 vertical to 10 horizontal (1V: 10H) at each location. A navigation channel is also required adjacent to the Middle Bay barge ramp. Construction will involve:

- geophysical and geotechnical investigation of the barge access area to inform detailed design;
- site establishment and excavation of barge access area;
- installation of precast concrete panels at the ramp location;
- installation of bollards for mooring lines;
- removal of trees and debris to establish a navigation channel allowing barge access; and
- minor dredging to allow barge access at the reservoir minimum operating level.

To facilitate construction, laydown areas are proposed adjacent to the Middle Bay barge ramp and adjacent to the water inlet pipeline. Laydown will also be used within the footprint of the Talbingo barge ramp.

Dredged material will be placed as part of the subaqueous placement program or within one of the designated on land rock emplacement areas.

2.8 Services and Infrastructure

Exploratory Works will require additional power and communication infrastructure. Water services are also needed and include a water services pipeline and water and waste water (sewage) treatment facilities. A summary of services required is provided at **Table 4**.

Table 4 Services and infrastructure

Services infrastructure	Description
Power	Power will be provided at the portal construction pad and accommodation camp by diesel generators, with fuel storage provided at the portal construction pad.
Communication	Communication will be provided via fibre optic link. The fibre optic service has been designed to incorporate a submarine cable from Tumut 3 power station across Talbingo Reservoir to Middle Bay, and then via a buried conduit within the access roads to the accommodation camp and the portal construction pad.
Water and waste water (sewage)	A water services pipeline is proposed for the supply and discharge of water for Exploratory Works which will pump water between Talbingo Reservoir and the exploratory tunnel portal, portal construction pad and accommodation camp.
	A package water treatment plant is proposed at the accommodation camp to provide potable water to the accommodation camp and portal construction pad facilities and will be treated to a standard that complies with the Australian Drinking Water Guidelines. The accommodation camp water supply will be pumped via the water pipeline from Talbingo Reservoir at Middle Bay.
	A package waste water (sewage) treatment plant (STP) is proposed at the accommodation camp for Exploratory Works waste water. The STP will produce effluent quality comparable to standard for inland treatment facilities in the region (e.g. Cabramurra). Following treatment waste water will be discharged to Talbingo reservoir via the water services pipeline connecting the accommodation camp to Talbingo Reservoir. Waste water from the exploratory tunnel and concrete batching plant will be either re-used on site or sent to the waste water treatment plant for treatment prior to discharge.

2.9 Construction and Schedule

2.9.1 Geotechnical Investigation

To assist the design development for the portal construction pad, accommodation camp, Middle Bay Road, Spillway Road, and Lobs Hole Ravine Road, further survey of ground conditions is required. A program of geotechnical investigations including geophysical survey, construction of test pits, and borehole drilling within the disturbance footprint, will be undertaken as part of construction activities. Excavation of test pits in areas where information on relatively shallow subsurface profiles is required, or where bulk sampling is required for laboratory testing. Borehole drilling is required to facilitate the detailed design of cuttings, bridge foundations, retaining wall foundations, and drainage structures.

2.9.2 Construction Activities

A disturbance footprint has been identified for Exploratory Works. Typical construction activities that will occur within the footprint are summarised in **Table 5**.

Table 5 Construction activities

Activity	Typical method
Geophysical and geotechnical investigation	Geophysical surveys will generally involve: • laying a geophone cable at the required location and establishing seismic holes; • blasting of explosives within seismic holes; and • in-reservoir geophysics surveys will use an air gun as the seismic source. Geotechnical surveys will generally involve: • establishing a drill pad including clearing and setup of environmental controls where required; • drilling a borehole to required depth using a tracked or truck mounted drill rig; and • installing piezometers where required for future monitoring program. • Geophysical and geotechnical investigation within Talbingo Reservoir will be carried out using barges and subject to environmental controls.
Site establishment for portal construction pad, accommodation camp, rock placement areas and laydown areas	Site establishment will generally involve: • identifying and flagging areas that are to be avoided during the Exploratory Works period; • clearing of vegetation within the disturbance footprint, typically using chainsaws, bulldozers and excavators; • civil earthworks to create a stable and level area suitable for establishment. This will involve a cut and fill approach where required to minimise the requirement for imported material; • installing site drainage, soil erosion and other permanent environmental controls where required; • surface finishing, compacting only existing material where possible, or importing additional material. Where suitable, this material will be sourced locally (e.g. from upgrade works to Lobs Hole Ravine Road); and • set up and commissioning of supporting infrastructure, including survey marks.
Road works	Upgrades of existing tracks (no widening) will generally involve: • identifying and flagging areas that are to be avoided during the Exploratory Works period; and • removing high points, infilling scours, levelling of rutting, and compacting surfaces. • Extension or widening of existing tracks will generally involve: • identifying and flagging areas that are to be avoided during the Exploratory Works period; • installing site drainage, soil erosion and other permanent environmental controls where required; • clearing and earthworks within the disturbance footprint; and • placing road pavement material on the roadway.
Bridge works	Establishment of permanent bridges will generally involve: • installing erosion and sedimentation controls around watercourses and installing scour protection as required; • establishing temporary diversions within the watercourse where required, including work to maintain fish passage; • establishing temporary bridges to facilitate permanent bridge construction; • constructing permanent bridges including piling, establishment of abutments and piers; and • removal and rehabilitation of temporary bridges and diversions.
Barge access works	Establishment of barge access infrastructure will generally involve: • installing sediment controls; • excavating and dredging of barge ramp area and navigation channel; • installing precast concrete planks and bollards; and • set up and commissioning of supporting infrastructure.

Activity	Typical method
Exploratory tunnel construction	The drill and blast excavation process will be repeated cyclically throughout the tunnelling works, involving: • marking up and drilling blast holes in a predetermined pattern in the working face of the tunnel; • loading the blast holes with explosives, attaching detonators and connecting the holes into a blast sequence, and detonating the blast; • ventilating the tunnel to remove blast fumes and dust; • removing blasted rock; • scaling and wash down of the tunnel roof and walls to remove loosened pieces of rock; • geological mapping of the exposed rock faces and classification of the conditions to determine suitable ground support systems for installation; • installing ground support; and • advancing construction ventilation ducting and other utilities including power, water, compressed air and communications.

2.9.3 Ancillary Construction Areas

Ancillary facilities and laydown areas have been identified within the conceptual layout for the portal construction pad and accommodation camp. A number of other indicative construction and laydown areas have also been identified to support Exploratory Works. A summary of these sites are:

- Upper Lobs Hole Ravine Road laydown area;
- rock emplacement area laydown, storage and ancillary uses;
- barge access infrastructure laydown areas at Talbingo and Middle Bay; and
- other minor laydown areas as needed during site establishment of watercourse crossings.

All laydown areas are within the disturbance footprint identified for Exploratory Works.

In addition, an area near Camp Bridge has been identified to be used for a plant nursery and organic stockpile area.

2.9.4 Construction Workforce Requirements

Staffing Levels

It is currently expected that workforce for Exploratory Works will be approximately 200 people in total at peak construction. Workers are anticipated to work a ‘swing’ shift, for example two weeks on and one week off. These workers will be accommodated within the accommodation camp at Lobs Hole when rostered on.

The majority of the workforce will work on a fly-in fly-out and drive-in drive-out basis. It is expected that the majority of workers will fly in and out of either Cooma Airport or Canberra Airport and then travel to site via bus.

During construction of the accommodation camp, workers will be accommodated at Cabramurra. Some workers may also be accommodated at Snowy Hydro existing accommodation units at Talbingo during construction of the Talbingo barge ramp. No accommodation will be required outside of Cabramurra, the construction accommodation camp or Talbingo for the Exploratory Works workforce.

Hours of Operation

It is expected that construction of the exploratory tunnel and haulage of rock material between the tunnel and excavated rock emplacement locations at Lobs Hole will be 24 hours a day, seven days a week for the duration of the tunnel drilling and blasting operation. Other construction activities, including the establishment works, road and infrastructure works, will normally work a 12 hour day, seven days a week.

The transport of materials along the haul route from Snowy Mountains Highway, Link Road and Upper Lobs Hole Ravine Road will only occur during day time hours (except during emergency), to avoid impacts to threatened species (Smoky Mouse). Transport by barge will be 24 hours a day, seven days a week.

2.9.5 Timing and Staging

Exploratory Works are expected to take about 34 months, with the exploratory tunnel expected to be completed by late 2021. It is expected that the construction works will be completed largely in parallel. However, road and access works are expected to be completed within the first six months from commencement. The proposed staging of construction activities are highlighted in **Table 6**.

Table 6 Indicative stage of construction

Construction works	2019				2020				2021			
Access roads												
Portal construction pad												
Accommodation camp												
Services infrastructure												
Barge access infrastructure												
Tunnelling												
Excavated rock management												

2.10 Site Rehabilitation

All Exploratory Works align with components of the main works for Snowy 2.0. However, should Snowy 2.0 not be approved or not progress, the project area will need to be rehabilitated, and project elements decommissioned in consultation with NPWS. Anticipated rehabilitation activities are summarised in **Table 7**.

Table 7 Planned Exploratory Works rehabilitation activities

Exploratory Works element	Indicative rehabilitation activities
Exploratory tunnel	Tunnel to remain open, and allowed to flood in lower portion provided groundwater impacts are negated.
Exploratory tunnel portal area	Permanent portal facade to be constructed, portal to be sealed from entry.
Portal construction pad and associated infrastructure	To be demobilised and all infrastructure removed. Site to be revegetated and returned to “original state”.
Excavated rock emplacement areas	Emplaced excavated rock in the western emplacement area to be removed offsite and area to be revegetated and returned to “original state”. The eastern emplacement area could remain in-situ and the landform rehabilitated as agreed with NPWS.
Accommodation camp	To be demobilised and all infrastructure removed. Site to be revegetated and returned to “original state”.
Road access works	No remediation required as works are to be designed to be permanent.
Barge access infrastructure	No remediation works required as wharf and loading ramps are designed as permanent. Wharf can be removed if desired.
Service and infrastructure	To be demolished and all infrastructure removed. Site to be revegetated and returned to “original state”.

2.11 Decommissioning

Should Snowy 2.0 not proceed following the commencement or completion of Exploratory Works, elements constructed are able to be decommissioned and areas rehabilitated. Given works are within KNP, Snow Hydro will liaise closely with NPWS to determine the extent of decommissioning and types of rehabilitation to be undertaken. This approach will be taken to ensure that decommissioning allows for integration with future planned recreational use of these areas and to maintain the values of KNP.

2.12 Key Aspects Relevant to Air Quality

Air quality issues can arise when emissions from an industry or activity lead to deterioration in the ambient air quality. Potential air quality issues have been identified from reviewing the proposed Exploratory Works and associated activities, in the context of emission source identification guidelines such as the “Emission Estimation Technique Manual for Mining” (NPI 2012). This identification process has considered the types of emissions to air and proximity of these emission sources to sensitive receptors.

Emissions to air are anticipated from all project elements, with a primary issue considered to be particulate matter generated during vegetation removal, material handling, material transport, emplacement, wind erosion, and blasting. These emissions would mainly comprise of particulate matter in the form of total suspended particulates (TSP), particulate matter with equivalent aerodynamic diameter of 10 microns or less (PM_{10}) and particulate matter with equivalent aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$).

The proposed Exploratory Work would also result in relatively minor emissions from machinery exhausts such as carbon monoxide (CO), oxides of nitrogen (NO_x) and particulate matter. Blasting can also lead to fume, as oxides of nitrogen (NO_x), in non-ideal explosive reactions. Greenhouse gas emissions are also anticipated due to diesel combustion, use of explosives and vegetation removal.

In summary, the potential air quality issue associated with the Exploratory Works has been identified as dust. That is, particulate matter in the form of TSP, deposited dust, PM_{10} or $PM_{2.5}$. This issue is the focus of the assessment.

3. Air Quality Criteria

Typically, air quality is quantified by the concentrations of air pollutants in the ambient air, where an air pollutant is a substance that is known to cause health, nuisance and/or environmental effects, when the concentration (or other measure of intensity) exceeds a certain level. With regard to human health and nuisance effects, the air pollutants most relevant to the Exploratory Works would be particulate matter emissions from excavation works and material handling, transport and emplacement activities, identified in **Section 2.11**.

There are various classifications of particulate matter with State regulatory authorities often providing standards, goals, objectives, criteria or targets for:

- Total suspended particulates (TSP), to protect against nuisance amenity impacts;
- Particulate matter with equivalent aerodynamic diameter less than or equal to 10 microns (PM_{10}), to protect against health impacts;
- Particulate matter with equivalent aerodynamic diameter less than or equal to 2.5 microns ($PM_{2.5}$), to protect against health impacts; and
- Deposited dust, to protect against nuisance amenity impacts.

The EPA has set air quality criteria for many air pollutants including those listed above. Most of the EPA criteria are drawn from national standards for air quality set by the National Environmental Protection Council of Australia (NEPC) as part of the National Environment Protection Measures (NEPM). To measure compliance with ambient air quality criteria, the Office of Environment and Heritage (OEH) has established a network of monitoring stations across the State and up-to-date records are published on the OEH website.

Air quality impacts from the Exploratory Works will be determined by the level of compliance with the air quality criteria set by the EPA as part of their “Approved Methods for the Modelling and Assessment of Air Pollutants in NSW” (EPA 2016). These criteria are outlined in **Table 8** and apply to existing and potential sensitive receptors such as such as residences, schools and hospitals.

The EPA air quality assessment criteria relate to the total concentration of air pollutant in the air (that is, cumulative) and not just the contribution from project-specific sources. Therefore, some consideration of background levels needs to be made when using these criteria to assess impacts. Further discussion of background levels in the study area is provided in **Section 4**.

Table 8 Relevant air quality assessment criteria

Substance	Averaging time	Criterion	Source
Particulate matter (PM_{10})	24-hour	50 µg/m^3	EPA / DoE (2016)
	Annual	25 µg/m^3	EPA / DoE (2016)
Particulate matter ($PM_{2.5}$)	24-hour	25 µg/m^3	EPA / DoE (2016)
	Annual	8 µg/m^3	EPA / DoE (2016)
Particulate matter (TSP)	Annual	90 µg/m^3	EPA / NHMRC (1996)
Deposited dust	Annual (maximum increase)	2 g/m^2/month	EPA / NERDDC (1998)
	Annual (maximum total)	4 g/m^2/month	EPA / NERDDC (1998)
Nitrogen dioxide (NO_2)	1-hour	246 µg/m^3	EPA / NEPC (1998)
	Annual	62 µg/m^3	EPA / NEPC (1998)

In December 2015 the Australian Government announced a National Clean Air Agreement (Agreement). This Agreement aims to reduce air pollution and improve air quality via the following main actions:

- The introduction of emission standards for new non-road spark ignition engines and equipment.
- Measures to reduce air pollution from wood heaters.

- Strengthened ambient air quality reporting standards for particle pollution. Specifically, and at the time, *"Taking into account the latest scientific evidence of health impacts, Ministers agreed to strengthen national ambient air quality reporting standards for airborne fine particles. Ministers agreed to adopt reporting standards for annual average and 24-hour $PM_{2.5}$ particles of 8 µg/m^3 and 25 µg/m^3 respectively, aiming to move to 7 µg/m^3 and 20 µg/m^3 respectively by 2025. Ministers also agreed to establish an annual average standard for PM_{10} particles of 25 µg/m^3. Victoria and the Australian Capital Territory will set, and South Australia will consider setting, a more stringent annual average PM_{10} standard of 20 µg/m^3 in the state, while ensuring nationally consistent monitoring and reporting against the agreed National Environment Protection Measure standards. The decision was also taken to review PM_{10} standards in 2018. The review will be co-led by the NSW and Victorian governments, in discussion with other jurisdictions."*

The strengthening of ambient air quality reporting standards for particle pollution is relevant to the Exploratory Works. On 25 February 2016 an amendment to the NEPM entered into force and introduced the new national air quality standards for PM_{10} and $PM_{2.5}$, as noted above. The NSW EPA subsequently revised their PM_{10} and $PM_{2.5}$ assessment criteria as part of an update to the "Approved Methods for the Modelling and Assessment of Air Pollutants NSW" (EPA 2016). These revised criteria are reflected in **Table 8**. There is currently no State legislation regarding the aim to move to more stringent $PM_{2.5}$ criteria by 2025.

4. Existing Environment

This section provides a description of the environmental characteristics in the area, including a review of the local meteorological and ambient air quality conditions. The review considers data collected from the nearest existing meteorological and air quality monitors. One of the objectives for reviewing these data was to identify any existing air quality issues as well as the meteorological conditions which typically influence the local air quality conditions.

4.1 Meteorological Conditions

Meteorological conditions are important for determining the direction and rate at which emissions from a source will disperse. The key meteorological requirements of air dispersion models are, typically, hourly records of wind speed, wind direction, temperature, atmospheric stability class and mixing layer height. For air quality assessments, a minimum one year of hourly data is usually required, which means that almost all possible meteorological conditions, including seasonal variations, are considered in the model simulations.

The nearest known meteorological station which collects data suitable for air quality purposes is located at Cabramurra, operated by the Bureau of Meteorology. This station (no. 72161) is located approximately 15 km to south of the proposed Exploratory Works and records a variety of meteorological parameters on a 10 m mast including temperature, wind speed, wind direction, rainfall and relative humidity. Snowy Hydro also operates meteorological stations at various other locations (including Talbingo, Tooma, Batlow, Eucumbene and Tantangara) however these data are collected on 2 m high masts and therefore do not meet the Australian Standard (AS/NZS 3580.14-2011) requirements for collecting data to be used for air quality purposes.

Meteorological data from the Cabramurra station for five recent years (2013 to 2017 inclusive) have been analysed in order to identify a representative year for the modelling. The procedure for identifying a representative meteorological year involved comparing wind patterns for the 2013 to 2017 calendar years.

Figure 4 shows the annual wind patterns at the Cabramurra station for 2013, 2014, 2015, 2016 and 2017. It can be seen from these wind-roses that the most common winds in the area are from the west-northwest and east-southeast. These wind patterns were similar in all of the past five years, except for 2015 which recorded more winds from the northwest than other years. This comparison suggests that wind patterns do not vary significantly from year to year, and potentially the data from any of the recent five years presented could be used as a representative year for modelling purposes.

The annual data statistics for the past five years have been examined to assist with identifying a representative meteorological year. **Table 9** shows the statistics.

Table 9 Annual statistics from meteorological data collected between 2013 and 2017

Statistic	2013	2014	2015	2016	2017
Percent complete (%)	100	100	100	100	100
Mean wind speed (m/s)	5.3	5.0	5.0	5.1	4.9
99^{th} percentile wind speed (m/s)	15.0	12.8	14.4	13.1	12.8
Percentage of calms (%)	2.8	2.9	3.7	4.4	4.1
Percentage of winds >6 m/s (%)	33.9	30.0	30.7	33.3	30.9

Over these five years, the mean speed has ranged from 4.9 to 5.3 m/s, and the percentage of calms has ranged from 2.8 to 4.4 per cent. For this assessment the 2017 calendar year has been selected as the meteorological modelling year since it as a recent year with high data capture rate and similar wind patterns to other years.

Methods used for incorporating the 2017 data into the meteorological modelling (CALMET) and air dispersion modelling (CALPUFF) are discussed in detail in **Section 6**. Seasonal wind-roses from data collected in 2017 are provided in **Appendix A**.

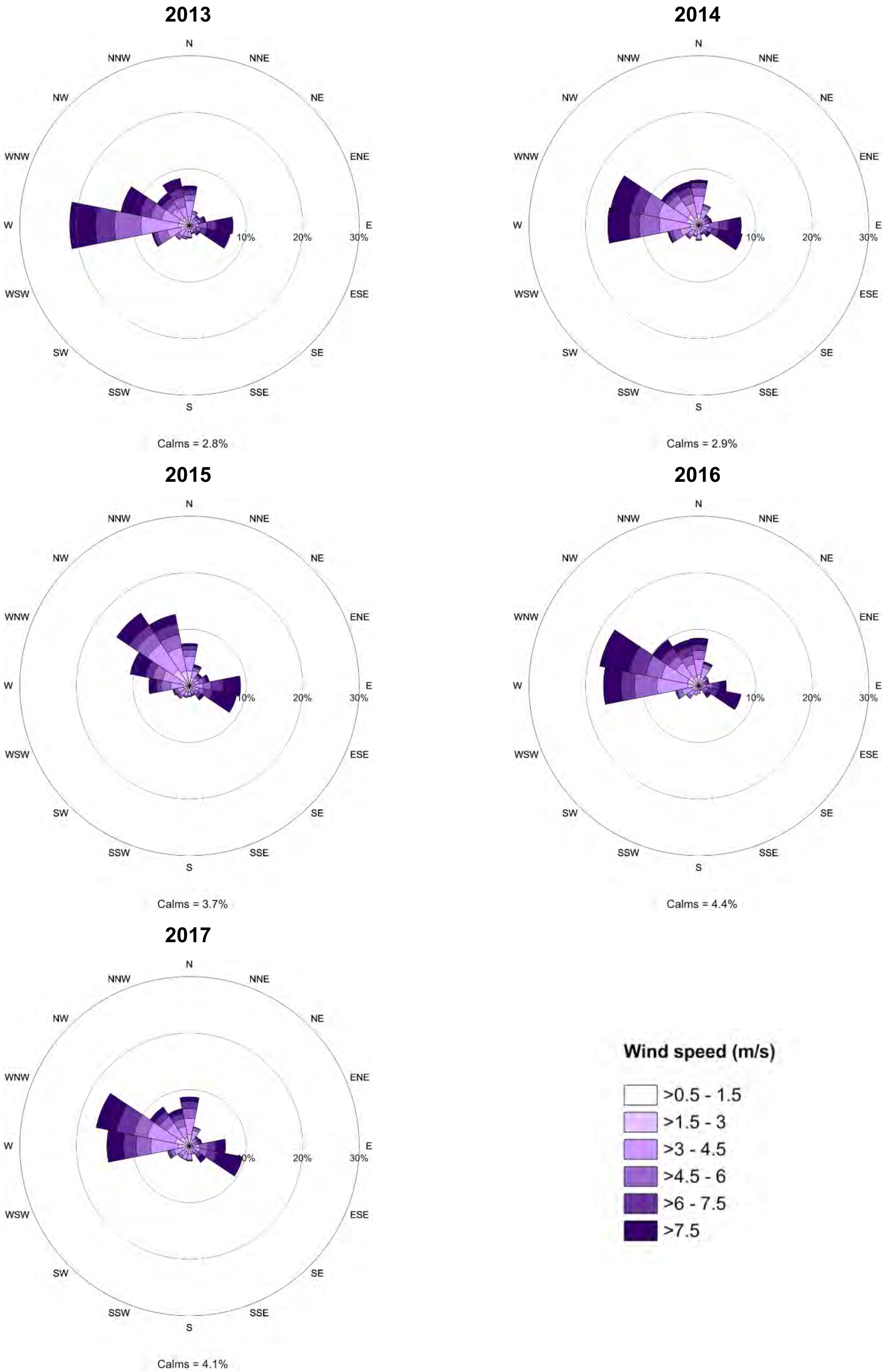


Figure 4 Annual wind-roses for data collected at Cabramurra meteorological station

4.2 Existing Air Quality Conditions

The EPA air quality criteria refer to levels of substances which generally include the project of interest and existing sources, not just the contribution from proposed activities. To fully assess impacts against all the relevant air quality criteria (see **Section 3**) it is necessary to have information or estimates of the existing air quality conditions. This section provides a review of the existing air quality.

No air quality monitoring has been carried out specifically for the proposed Exploratory Works. This is because there are no significant sources of air pollution in the region and no continuously populated locations. Such monitoring would include the measurement of the key issue substances; namely, airborne particulate matter in the form of TSP, PM_{10} and $PM_{2.5}$, as well as deposited dust. In the absence of project specific monitoring, the concentrations of these substances had to necessarily be estimated from existing data collected elsewhere in NSW.

The OEH has established a network of monitoring stations across the State and up-to-date records are published on the OEH website. However there are no OEH air quality monitoring stations in the alpine or National Park regions of NSW. The closest monitoring stations to the proposed Exploratory Works are located on the south-west slopes, at Albury and Wagga Wagga. These stations are located over 100 km from the area of interest, at elevations in the order of 200 m Australian Height Datum (AHD) and near rural townships. In contrast, the proposed Exploratory Works are in a National Park, well removed from industry and population centres, and at an elevation in the order of 600 m AHD. The absence of industry and human activities in the vicinity of the proposed Exploratory Works means that concentrations of substances in the local environment would likely approach baseline levels, that is, near the lowest concentrations that would be measured in NSW.

Table 10 and **Table 11** summarise the measured PM_{10} and $PM_{2.5}$ concentration data at the nearest OEH monitoring stations (Albury and Wagga Wagga). The inclusion of these data in this report is not intended to suggest that these levels are representative of air quality in the vicinity of the proposed Exploratory Works. Rather, the data are presented to show the types of statistics that are of interest for this assessment.

It should be noted that the measurement data represent the contributions from all sources that have at some stage been upwind of each monitor. In the case of particulate matter (as PM_{10}) for example, the background concentration may contain emissions from many sources such as from local activities, construction works, bushfires and 'burning off', industry, vehicles, roads, wind-blown dust from nearby and remote areas, fragments of pollens, moulds, and so on.

It can be seen from **Table 10** that average PM_{10} concentrations comply with the EPA's annual average criterion, however there is often one or more days each year when PM_{10} concentrations exceed the 24-hour average criterion. Similarly, for $PM_{2.5}$, **Table 11** shows compliance with the annual criterion but occasional exceedances of the 24-hour average criterion. These results reflect rural monitoring locations which are near populated areas and industries.

Table 10 Summary of measured PM_{10} concentrations at the nearest OEH monitoring stations

Year	Albury	Wagga Wagga North	Criterion
Maximum 24-hour average in µg/m^3			
2013	59	111	50
2014	160	88	
2015	93	145	
2016	51	115	
2017	49	172	
Number of days above 24-hour average criteria			
2013	2	15	-
2014	5	13	

Year	Albury	Wagga Wagga North	Criterion
2015	2	7	
2016	1	16	
2017	0	10	
Annual average in µg/m^3			
2013	16	22	
2014	16	21	
2015	15	20	25
2016	15	21	
2017	16	21	

Table 11 Summary of measured $PM_{2.5}$ concentrations at the nearest OEH monitoring stations

Year	Albury	Wagga Wagga	Criterion
Maximum 24-hour average in µg/m^3			
2013	-	30	
2014	-	28	
2015	-	24	25
2016	-	28	
2017	19	33	
Number of days above 24-hour average criteria			
2013	-	3	
2014	-	2	
2015	-	0	-
2016	-	2	
2017	0	4	
Annual average in µg/m^3			
2013	-	8	
2014	-	8	
2015	-	8	8
2016	-	7	
2017	7.3	8	

4.3 Summary of the Existing Environment

The following conclusions have been made from the review of local meteorological and ambient air quality monitoring data:

- The prevailing winds are from the west-northwest and east-southeast.
- Particulate matter concentrations (TSP, PM_{10} and $PM_{2.5}$) and deposition levels are unlikely to exceed EPA criteria since the area is well removed from populated centres, industry and significant sources of air pollution.

4.4 Assumed Background Levels

One of the objectives for reviewing the air quality monitoring data was to determine appropriate background levels to be added to model predictions for the assessment of potential cumulative impacts, that is, project contribution plus existing air quality. The estimated background levels that apply at the location of the proposed Exploratory Works are shown below in **Table 12**. These levels represent estimates based on experience with reviewing air quality monitoring data collected at various locations across Australia and over long periods of time. The estimated levels have been added to the model predictions in order to determine the potential cumulative impacts. Given the absence of any significant nearby sources of air pollution, the assumed levels below are almost certainly higher than what would be expected in the area. This means that the assessment will be conservative.

Table 12 Assumed non-modelled background levels

Substance	Averaging time	Assumed background level
Particulate matter (PM_{10})	24-hour	30 µg/m^3
	Annual	10 µg/m^3
Particulate matter ($PM_{2.5}$)	24-hour	15 µg/m^3
	Annual	5 µg/m^3
Particulate matter (TSP)	Annual	25 µg/m^3
Deposited dust	Annual	1 g/m^2/month

5. Emissions to Air

The most significant emission to air from the Exploratory Works will be dust (particulate matter) due to material handling, material transport, processing, wind erosion, and blasting. Estimates of these emissions are required by the dispersion model. Total dust emissions have been estimated by analysing the material handling schedule, equipment listing and layout plans and identifying the location and intensity of dust generating activities. Operations have been combined with emissions factors developed both locally and by the US EPA.

The emission factors used for this assessment have been drawn largely from the following sources:

- *Emission Estimation Technique Manual for Mining* (NPI, 2012);
- AP 42 (US EPA, 1985 and updates); and
- ACARP Project C22027 (ACARP 2015).

Dust emission inventories for TSP, PM_{10} and $PM_{2.5}$ have been developed for the proposed Exploratory Works. These inventories were informed most significantly by the material handling quantities provided by Snowy Hydro. Key inputs to the emission inventories included:

- Movement of a total 286,454 m^3 of spoil for the tunnel portal and tunnel construction works;
- Movement of a total 436,000 m^3 of spoil for the access road construction works; and
- Delivery and handling of 79,356 tonnes of cement, aggregate and sand for concrete and shotcrete production.

Table 13 shows the estimated annual TSP, PM_{10} and $PM_{2.5}$ emissions due to the proposed Exploratory Works. **Appendix B** provides details of the dust emission calculations, including assumptions, emission controls and allocation of emissions to modelled locations.

It should be noted that the main intent of the inventories is to capture the most significant emission sources that may affect off-site air quality, and for the most intense period of construction. Not every source will be captured but the activities listed below are expected to be the most significant in terms of influencing the local air quality.

Table 13 Estimated TSP, PM_{10} and $PM_{2.5}$ emissions due to the Exploratory Works

Activity	Estimated annual emissions (kg/y)		
	TSP	PM_{10}	$PM_{2.5}$
Hauling spoil from portal to construction pad	4,421	1,306	221
Unloading spoil to construction pad	10,610	3,802	530
Loading spoil from construction pad to trucks	3,210	1,518	160
Hauling spoil from construction pad to disposal area	110,520	32,659	5,526
Unloading spoil to disposal area	10,610	3,802	530
Hauling spoil for access road construction	479,600	141,726	23,980
Dozers shaping overburden	64,264	15,645	6,748
Wind erosion from construction pad	5,694	2,847	427
Wind erosion from spoil disposal area	8,595	4,297	645
Concrete batch plant – deliveries	19,839	5,863	992
Concrete batch plant - unloading to ground bins	288	136	14
Concrete batch plant - loading to hoppers by FEL	288	136	14
Concrete batch plant - unloading to storage bins	288	136	14
Concrete batch plant - unloading from bins to trucks	288	136	14
Concrete batch plant – dispatch	2,645	782	132
Total	**721,160**	**214,792**	**39,950**

6. Approach to Assessment

6.1 Overview

This assessment has followed the EPA's "Approved Methods of the Modelling and Assessment of Air Pollutants in New South Wales" (EPA, 2016), which specifies how assessments based on the use of air dispersion models should be undertaken. The "Approved Methods" include guidelines for the preparation of meteorological data, reporting requirements and air quality assessment criteria to assess the significance of dispersion model predictions. Background air quality levels are also relevant to the assessment, where levels are measured in accordance with the "Approved Methods for Sampling and Analysis of Air Pollutants in NSW" (DEC 2007).

The CALPUFF computer-based air dispersion model has been used to predict ground-level concentrations and deposition levels due to the identified emission sources, and the model predictions have been compared with relevant air quality criteria. The choice of model has considered the expected transport distances for the emissions, as well as the potential for temporally and spatially varying flow fields due to influences of the locally complex terrain, non-uniform land use, and potential for stagnation conditions characterised by calm or very low wind speeds with variable wind directions.

The CALPUFF model, through the CALMET meteorological pre-processor, simulates complex meteorological patterns that exist in a particular region. The effects of local topography and changes in land surface characteristics are accounted for by this model. The model comprises meteorological modelling as well as dispersion modelling, both of which are described below.

6.2 Meteorological Modelling

The air dispersion model used for this assessment, CALPUFF, requires information on the meteorological conditions in the modelled region. This information is typically generated by the meteorological pre-processor, CALMET, using surface observation data from local weather stations and upper air data from radio-sondes or numerical models, such as the CSIRO's prognostic model known as TAPM (The Air Pollution Model). CALMET also requires information on the local land-use and terrain. The result of a CALMET simulation is a year-long, three-dimensional output of meteorological conditions that can be used as input to the CALPUFF air dispersion model.

As noted in **Section 4.1** the Bureau of Meteorology operates a meteorological station at Cabramurra however there are no known meteorological stations in the vicinity of the proposed Exploratory Works that collect suitable upper air data for CALMET. The necessary upper air data were therefore generated by TAPM, using influence from the surface observations at the Cabramurra meteorological station. CALMET was then set up with one surface observations station and one upper air station, based on TAPM output for the Cabramurra meteorological station. The meteorological modelling followed the guidance of TRC (2011) and adopted the "observations" mode.

Key model settings for TAPM are shown below in **Table 14**.

Table 14 Model settings and inputs for TAPM

Parameter	Value(s)
Model version	4.0.5
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	35 x 35 x 25
Year(s) of analysis	2017
Centre of analysis	Proposed Exploratory Works (35°47.5' S, 148°24' E)
Terrain data source	Shuttle Research Topography Mission (SRTM)
Land use data source	Default
Meteorological data assimilation	Cabramurra meteorological station. Radius of influence = 10 km. Number of vertical levels for assimilation = 4

Table 15 lists the model settings and input data for CALMET. This information has been provided so that the user can reproduce the results if required.

Table 15 Model settings and inputs for CALMET

Parameter	Value(s)
Model version	6.334
Terrain data source(s)	SRTM
Land-use data source(s)	Digitized from aerial imagery
Meteorological grid domain	10 km x 10 km
Meteorological grid resolution	0.1 km
Meteorological grid dimensions	100 x 100 x 9
Meteorological grid origin	622000 mE, 6033000 mN. MGA Zone 55
Surface meteorological stations	Cabramurra (Observations of wind speed, wind direction, temperature and relative humidity. TAPM for ceiling height, cloud cover, and air pressure)
Upper air meteorological stations	Upper air data file for the location of Cabramurra met station derived by TAPM Biased towards surface observations (-1, -0.8, -0.6, -0.4, -0.2, 0, 0, 0, 0)
Simulation length	8760 hours (1 Jan 2017 to 31 Dec 2017)
R1, R2	0.5, 1
RMAX1, RMAX2	5, 20
TERRAD	5

Terrain information was extracted from the NASA Shuttle Research Topography Mission database which has global coverage at approximately 30 metre resolution. Land use data were extracted from aerial imagery. **Figure 5** shows the model grid, land-use and terrain information, as used by CALMET.

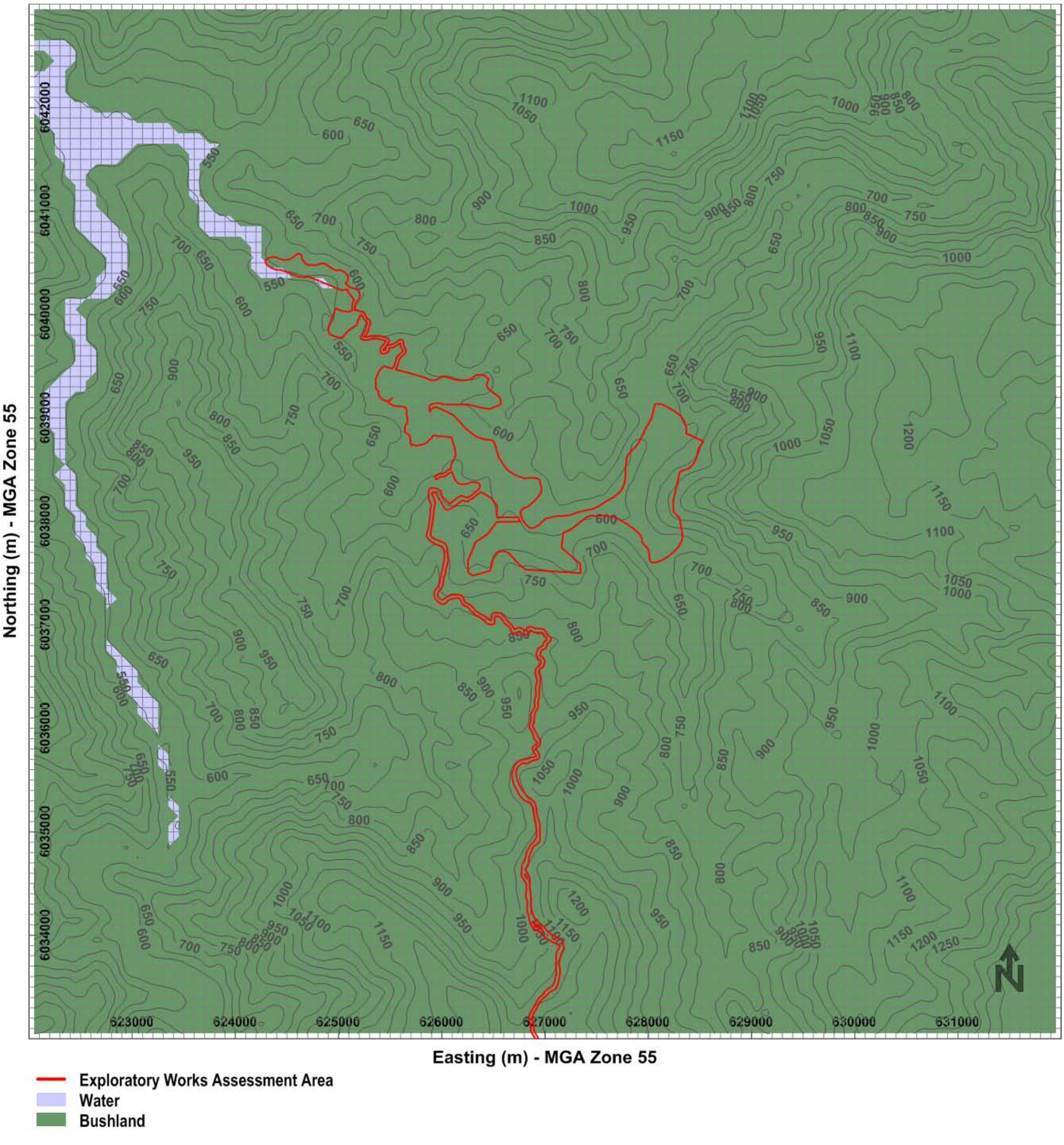


Figure 5 Model grid, land-use and terrain information

Figure 6 shows a snapshot of winds at 10 metres above ground-level as simulated by the CALMET model under stable conditions. This plot shows the effect of the topography on local winds (for this particular hour), and highlights the non-uniform wind patterns in the area, which further supports the use of a non-steady-state model such as CALPUFF.

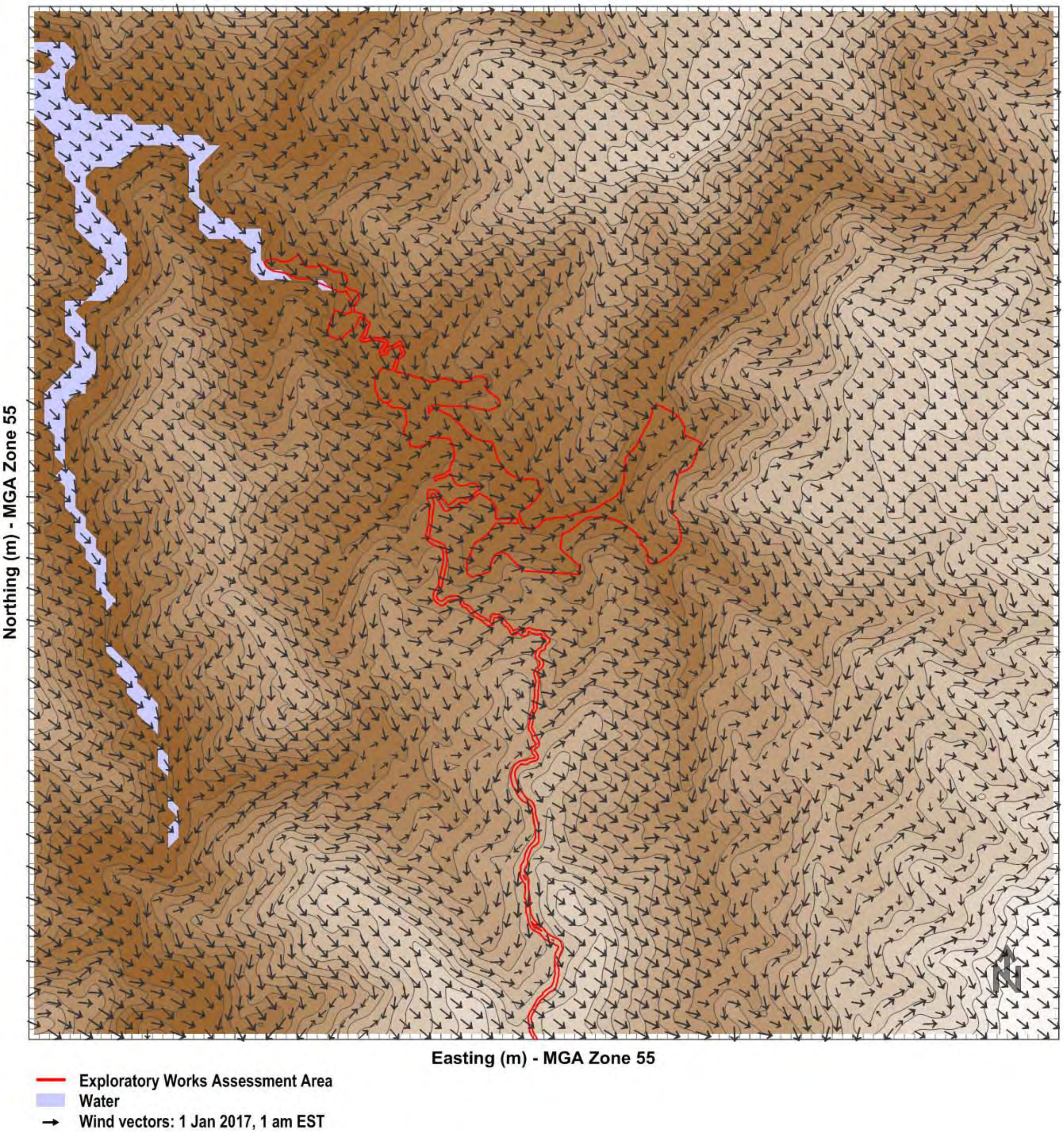


Figure 6 Example of CALMET simulated ground-level wind flows

6.3 Dispersion Modelling

Ground-level concentration and deposition levels due to the identified emission sources have been predicted using the air dispersion model known as CALPUFF (Version 6.42). CALPUFF is a Lagrangian dispersion model that simulates the dispersion of pollutants within a turbulent atmosphere by representing emissions as a series of puffs emitted sequentially. Provided the rate at which the puffs are emitted is sufficiently rapid, the puffs overlap and the serial release is representative of a continuous release.

The CALPUFF model differs from traditional Gaussian plume models (such as AUSPLUME and ISCST3) in that it can model spatially varying wind and turbulence fields that are important in complex terrain, long-range transport and near calm conditions. It is the preferred model of the United States Environmental Protection Agency for the long-range transport of pollutants and for complex terrain (TRC 2007). CALPUFF has the ability to model the effect of emissions entrained into the thermal internal boundary layer that forms over land, both through fumigation and plume trapping. CALPUFF is an air dispersion model which has been approved by the EPA for these types of assessments (EPA 2016).

The modelling was performed using the emission estimates from **Section 5** and using the meteorological information provided by the CALMET model, described in **Section 6.2**. Predictions were made at 787 discrete receptors (including at the location of the accommodation camp) to allow for contouring of results. The locations of the model receptors are shown in **Appendix C**.

Exploratory Works activities were represented by a series of volume sources located according to the location of activities for each modelled scenario. **Figure 7** shows the location of the modelled sources where the emissions from the dust generating activities summarised in **Table 13** were assigned to one or more of these source locations (refer to **Appendix B** for details of the allocations).

Dust emissions for all modelled sources have been considered to fit in one of three categories, as follows:

- Wind insensitive sources, where emissions are relatively insensitive to wind speed (for example, dozers).
- Wind sensitive sources, where emissions vary with the hourly wind speed, raised to the power of 1.3, a generic relationship published by the US EPA (1987). This relationship has been applied to sources such as loading and unloading of rock to/from trucks and results in increased emissions with increased wind speed.
- Wind sensitive sources, where emissions also vary with the hourly wind speed, but raised to the power of 3, a generic relationship published by Skidmore (1998). This relationship has been applied to sources including wind erosion from stockpiles or exposed areas, and results in increased emissions with increased wind speed.

Emissions from each volume source were developed on an hourly time step, taking into account the level of activity at that location and, in some cases, the hourly wind speed. This approach ensured that light winds corresponded with lower dust generation and higher winds, with higher dust generation.

The works associated with construction of the access roads were modelled for 12 hours per day (6 am to 6 pm). All other activities and associated emissions were modelled for 24 hours per day, for every day of the year.

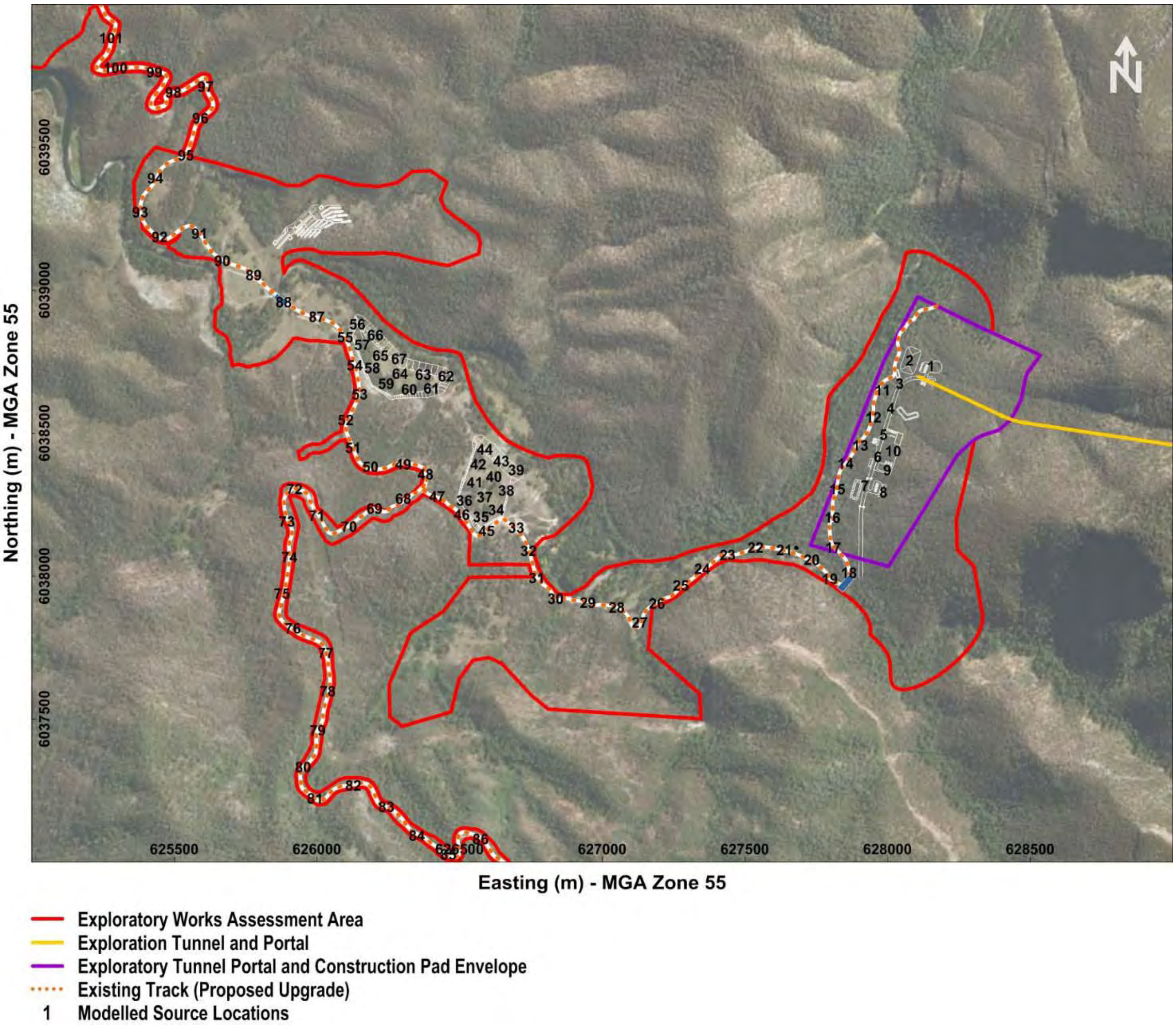


Figure 7 Location of modelled sources

Key model settings and inputs for CALPUFF are provided in **Table 16**.

Table 16 Model settings and inputs for CALPUFF

Parameter	Value(s)
Model version	6.42
Computational grid domain	100 x 100
Chemical transformation	None
Dry deposition	Yes
Wind speed profile	ISC rural
Puff element	Puff
Dispersion option	Turbulence from micrometeorology
Time step	3600 seconds (1 hour)
Terrain adjustment	Partial plume path
Number of volume sources	101. See Figure 7. Height = 2m, SY = 10 m, SZ = 5 m
Number of discrete receptors	787. See **Appendix C**.

Finally, the model predictions at identified sensitive receptors were then compared with the EPA air quality criteria, previously discussed in **Section 3**. Contour plots have also been created to show the spatial distribution of model predictions.

Prediction of the potential air quality impacts has been based on the following key assumptions:

- Excavation and handling of 76,214 m^3 of spoil for the tunnel portal and 210,240 m^3 for the tunnel;
- Excavation and handling of 436,000 m^3 of spoil for the access road;
- Cement usage for concrete production of 16,344 t;
- Aggregate for concrete and shotcrete production of 57,451 t;
- Sand for concrete and shotcrete production of 5,561 t;
- Tunnel excavation works over 26 months;
- Excavation work would occur for 24 hours a day, seven days a week

7. Assessment of Impacts

This section provides an assessment of the key air quality issues associated with the Exploratory Works, primarily based on model predictions and comparisons to air quality criteria.

7.1 Particulate Matter (as PM_{10})

Figure 8 shows the predicted maximum 24-hour average PM_{10} concentrations due to the proposed Exploratory Works. Background concentrations are not included in these plots. It can be seen from **Figure 8** that the maximum 24-hour PM_{10} concentration at the accommodation camp is predicted to be in the order of 18 µg/m^3. Adding an estimated maximum background level of 30 µg/m^3 indicates that the proposed works would comply with, but have the potential to approach, the EPA's 50 µg/m^3 assessment criterion. This approach of adding maximum predicted concentrations to maximum background concentrations is conservative as it assumes that the maximum predicted concentrations and maximum background concentrations would occur on the same day which, over the course of the year, is unlikely to be the case.

Nevertheless, with the conservative approach, the modelling suggests that compliance with the 24-hour average PM_{10} criterion of 50 µg/m^3 will be achieved at the accommodation camp. These results are indicative of the potential impacts given that background levels were not known and necessarily had to be estimated. Therefore it would be appropriate for monitoring to be carried out prior to and during the Exploratory Works to characterise the existing air quality environment and to inform the daily management of proposed activities.

Figure 9 shows the predicted annual average PM_{10} concentrations due to the Exploratory Works. The contribution of the works is predicted to be less than 3 µg/m^3 at the accommodation camp. With background levels in the order of 10 µg/m^3, the works are unlikely to cause exceedances of the EPA's 25 µg/m^3 criterion.

Table 17 shows the predicted PM_{10} concentrations at the accommodation camp, for both 24-hour and annual averages. From the results below and discussion above it is therefore concluded that the Exploratory Works would not cause adverse air quality impacts with respect to PM_{10}.

Table 17 Predicted PM_{10} concentrations at the accommodation camp

Statistic	Predicted contribution from Exploratory Works	Estimated background	Cumulative	Criterion
Maximum 24-hour average PM_{10} (µg/m^3)	18	30	48	50
Annual average PM_{10} (µg/m^3)	2.4	10	12	25

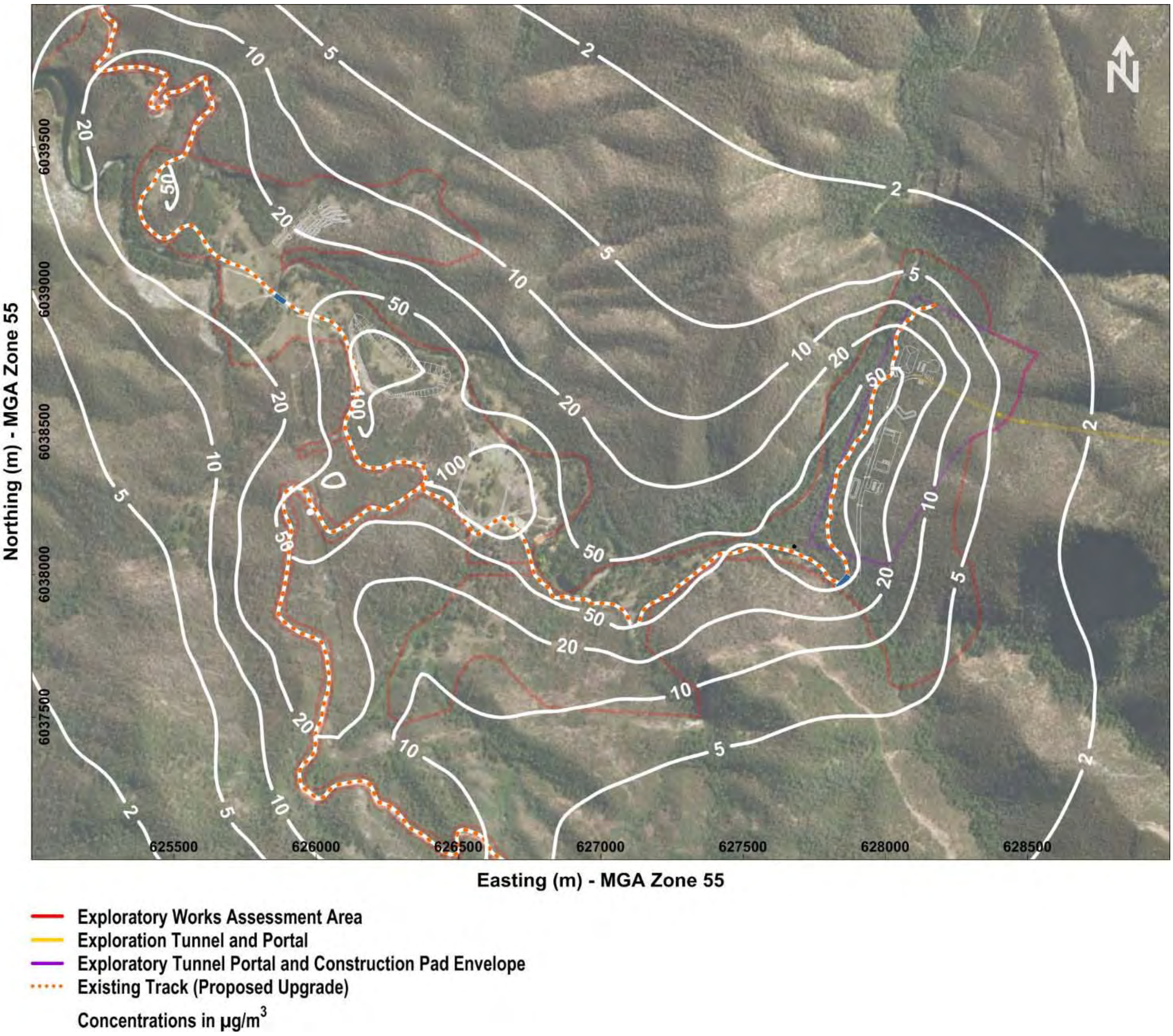


Figure 8 Predicted maximum 24-hour average PM_{10} concentrations due to Exploratory Works

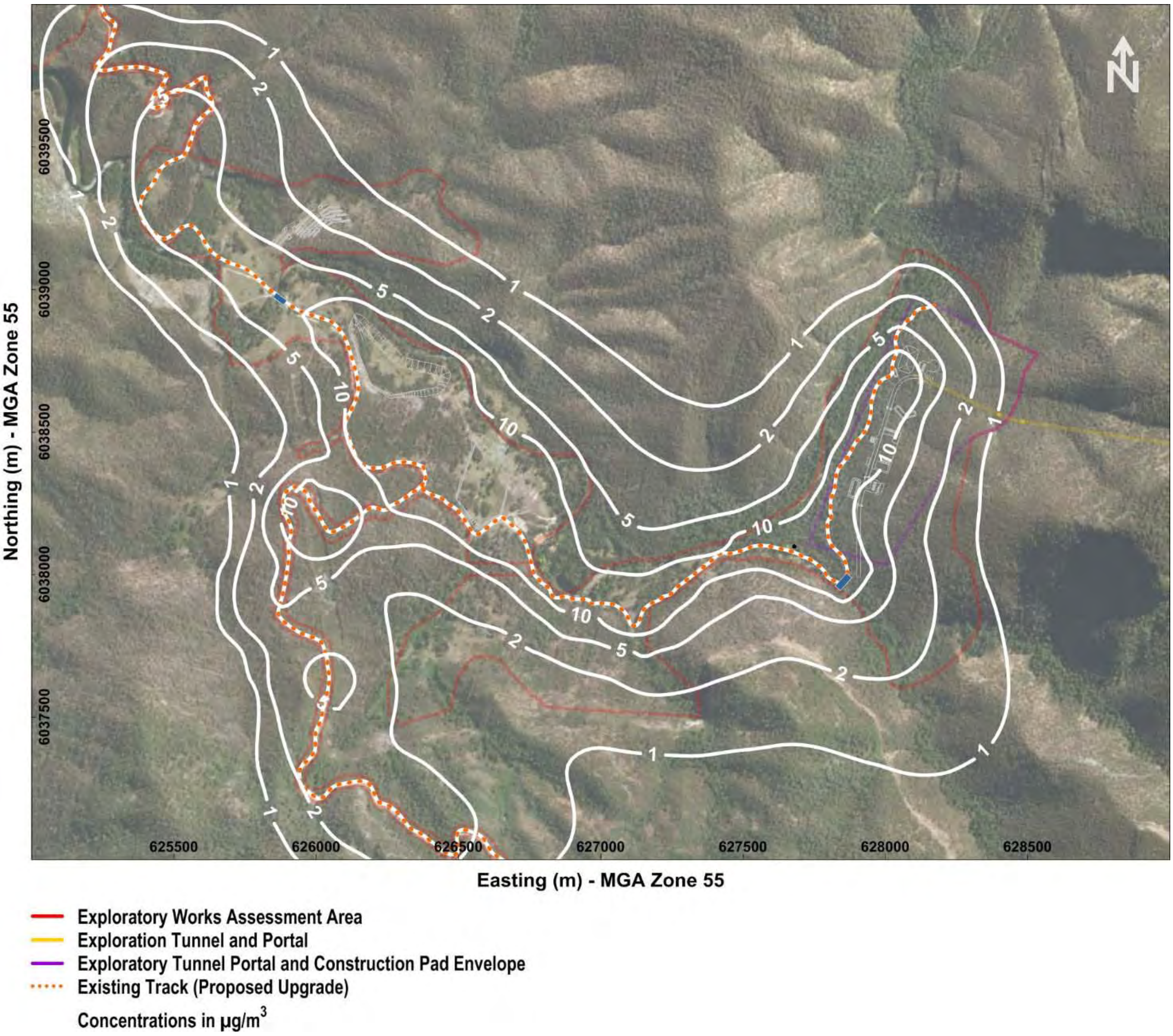


Figure 9 Predicted annual average PM_{10} concentrations due to Exploratory Works

7.2 Particulate Matter (as $PM_{2.5}$)

Figure 10 shows the predicted maximum 24-hour average $PM_{2.5}$ concentrations due to the Exploratory Works. Background concentrations are not included in these plots. It can be seen from this figure that the maximum 24-hour $PM_{2.5}$ concentrations due to the Exploratory Works are predicted to be in the order of 5 µg/m^3 at the accommodation camp. Adding the estimated maximum background level of 15 µg/m^3 would still demonstrate compliance with the EPA's 25 µg/m^3 assessment criterion.

Figure 11 shows the predicted annual average $PM_{2.5}$ concentrations due to the Exploratory Works. The contribution of the works is predicted to be less than 1 µg/m^3 at the accommodation camp. With background levels in the order of 5 µg/m^3, the proposed works are not predicted to cause exceedances of the EPA's 8 µg/m^3 criterion.

Table 18 shows the predicted $PM_{2.5}$ concentrations at the accommodation camp. These results show that the cumulative concentrations would not exceed relevant $PM_{2.5}$ assessment criteria. It is therefore concluded that the Exploratory Works would not cause adverse air quality impacts with respect to $PM_{2.5}$.

Table 18 Predicted $PM_{2.5}$ concentrations at the accommodation camp

Statistic	Predicted contribution from Exploratory Works	Estimated background	Cumulative	Criterion
Maximum 24-hour average $PM_{2.5}$ (µg/m^3)	4.9	15	20	25
Annual average $PM_{2.5}$ (µg/m^3)	0.6	5.0	5.6	8

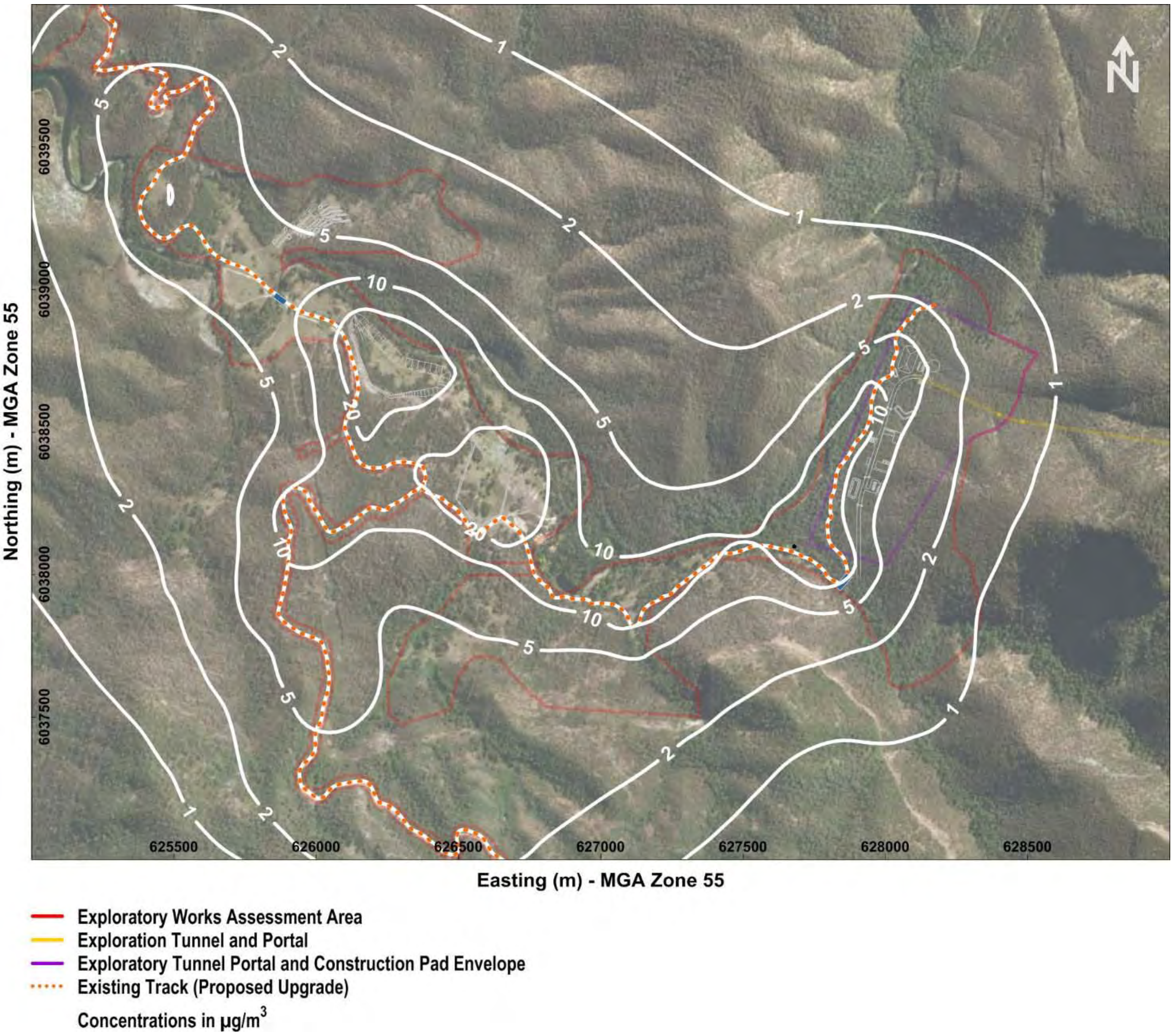


Figure 10 Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to Exploratory Works

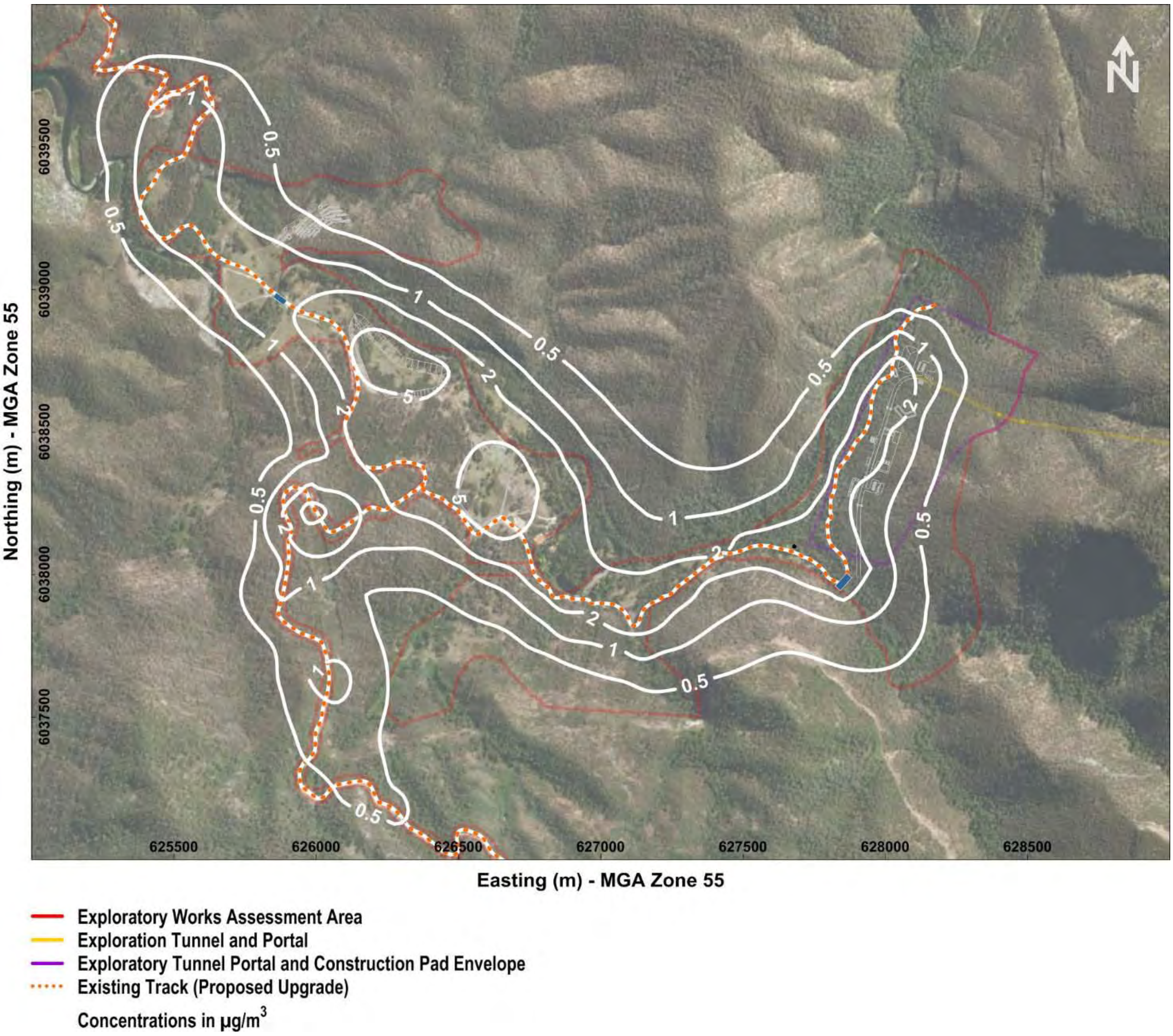


Figure 11 Predicted annual average $PM_{2.5}$ concentrations due to Exploratory Works

7.3 Particulate Matter (as TSP)

Figure 12 shows the predicted annual average TSP concentrations. The concentrations are predicted to be in the order of 5 µg/m^3 at the accommodation camp. **Table 19** shows the specific predictions. These results show that the Exploratory Works would not cause exceedances of TSP criteria, including with estimated background levels.

Table 19 Predicted TSP concentrations at the accommodation camp

Statistic	Predicted contribution from Exploratory Works	Estimated background	Cumulative	Criterion
Annual average TSP (µg/m^3)	5.2	25	30	90

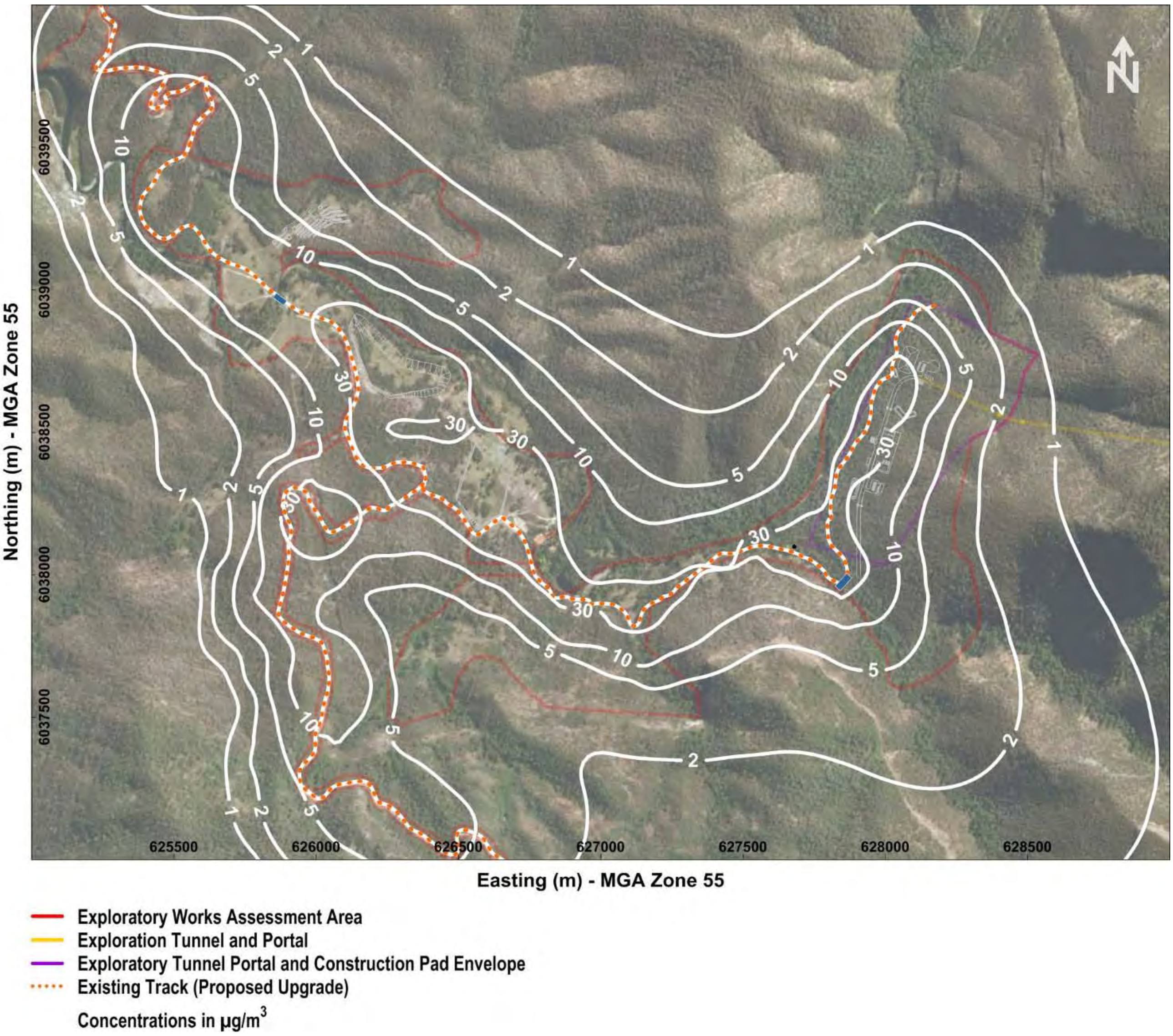


Figure 12 Predicted annual average TSP concentrations due to Exploratory Works

7.4 Deposited Dust

Figure 13 shows the predicted annual average dust deposition. The deposition rate is predicted to be in the order of 1.2 µg/m^3 at the accommodation camp. **Table 20** shows the specific predictions. These results show that the Exploratory Works would not cause exceedances of dust deposition criteria, including with estimated background levels.

Table 20 Predicted dust deposition at the accommodation camp

Statistic	Predicted contribution from Exploratory Works	Estimated background	Cumulative	Criterion
Annual average dust deposition (g/m^2/month)	1.2	1.0	2.2	4

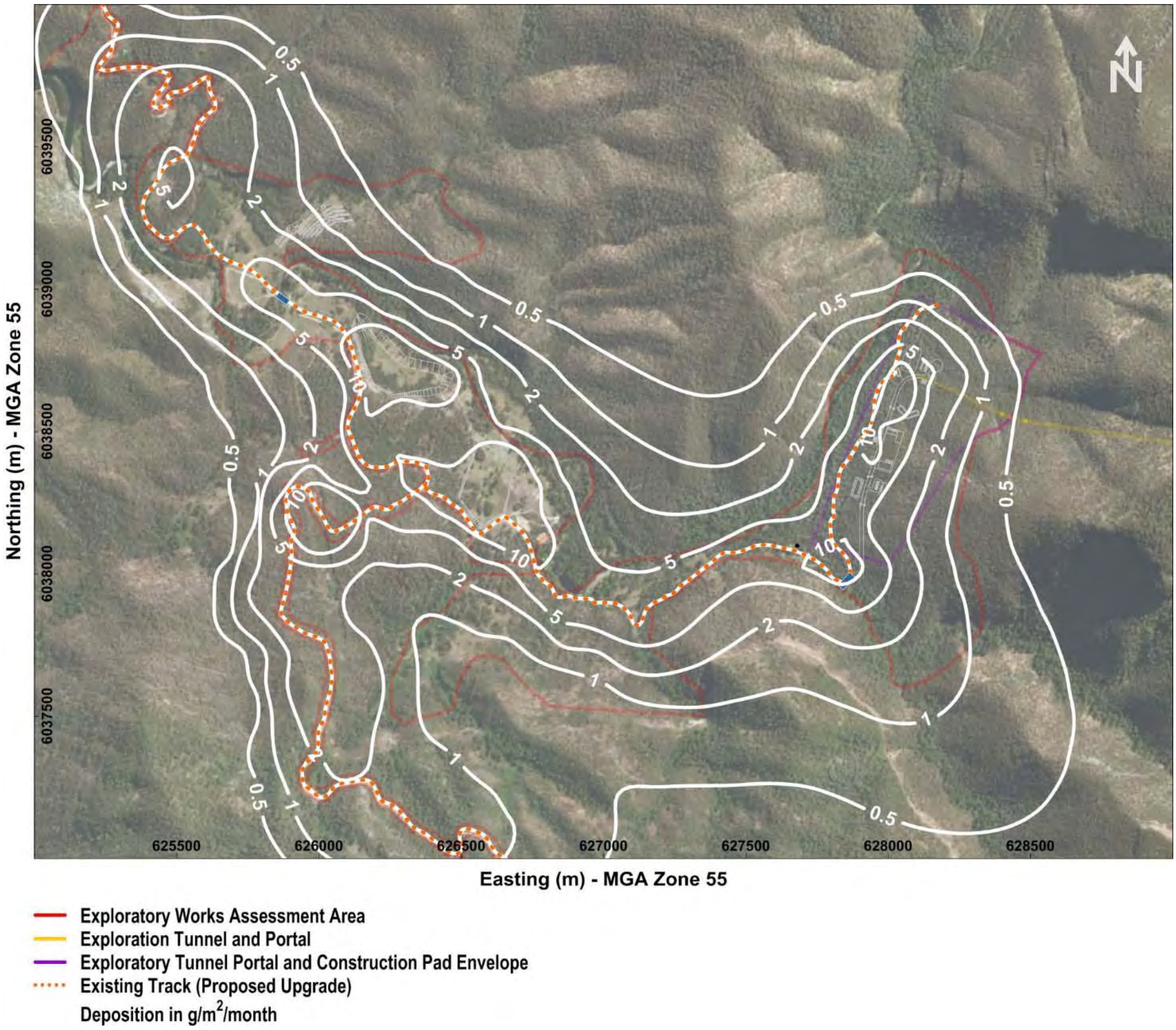


Figure 13 Predicted annual average dust deposition due to Exploratory Works

7.5 Management Measures

Air quality management procedures to cover the proposed Exploratory Works will be developed in an Air Quality Management Plan (AQMP) prior to commencement. It is anticipated that the management procedures will include those listed in **Table 21** below as well as engineering solutions (such as shielding of sources to prevent emissions) and design features such as minimising haul distances. Also included in this table is the assumed emission control for each activity, as used in the modelling.

Table 21 Emission management measures

Impact	Ref	Activity	Environmental management measures	Assumed emission control (%) (NPI 2012, Donnelly et el 2011)
Potential air quality impacts on the camp	AQ01	Hauling spoil on unsealed roads	Watering of haul routes Maintenance of haul routes Restricting vehicle speeds Clearly marked routes Prompt clean-up of any material spillage	75 (2 litres/m^2/h)
		Loading and unloading of spoil	Minimisation of fall distances during unloading and loading Planning of dump locations based on weather conditions Ceasing operations during adverse dust conditions	0
		Dozer shaping spoil disposal areas	Minimisation during dry, dusty conditions Reduced travel speed during dry, dusty conditions	0
		Spoil disposal areas	Disturbance of the minimum areas practicable Reshaping and rehabilitating as soon as practicable	0
		Machinery exhausts and plant and equipment	Servicing all machinery in accordance with maintenance contracts and adopting original equipment manufacturer recommendations for maintenance.	0

8. Greenhouse Gas Emissions

8.1 Background

Greenhouse gases (GHGs) is a collective term for a range of gases that are known to trap radiation in the upper atmosphere, where they have the potential to contribute to the greenhouse effect (global warming). Creating an inventory of the likely GHG emissions associated with a project has the benefit of determining the scale of the emissions and providing a baseline from which to develop and deliver GHG reduction options. Greenhouse gases include:

- Carbon dioxide (CO_2)– by far the most abundant, primarily released during fuel combustion
- Methane (CH_4) – from the anaerobic decomposition of carbon based material (including enteric fermentation and waste disposal in landfills)
- Nitrous oxide (N_2O)– from industrial activity, fertiliser use and production
- Hydrofluorocarbons (HFCs) – commonly used as refrigerant gases in cooling systems
- Perfluorocarbons (PFCs) – used in a range of applications including solvents, medical treatments and insulators
- Sulphur hexafluoride (SF_6) – used as a cover gas in magnesium smelting and as an insulator in electrical switch gear and power transformers.

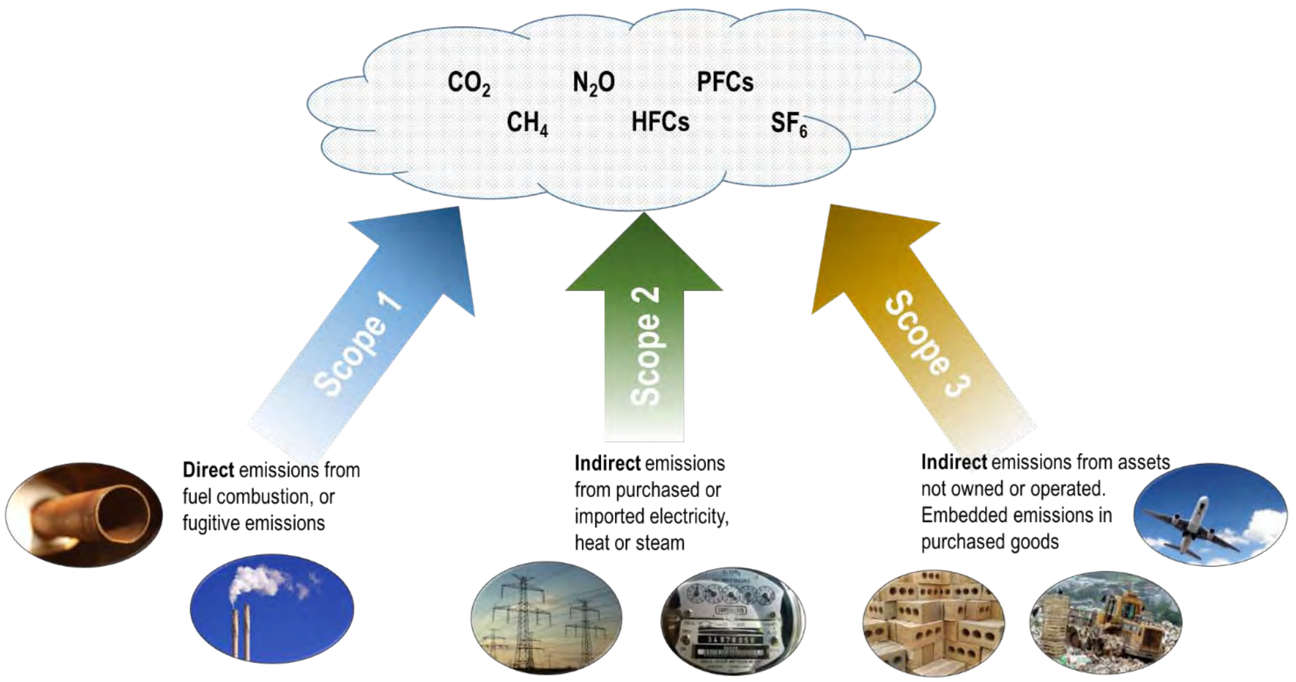
It is common practice to aggregate the emissions of these gases to the equivalent emission of carbon dioxide. This provides a simple figure for comparison of emissions against targets. Aggregation is based on the potential of each gas to contribute to global warming relative to carbon dioxide and is known as the global warming potential (GWP). The resulting number is expressed as carbon dioxide *equivalents* (or CO_2e).

The GHG inventory in this document is calculated in accordance with the principles of the Greenhouse Gas Protocol (GHG Protocol)[1]. The GHG emissions that form the inventory can be split into three categories known as 'Scopes'. Scopes 1, 2 and 3 are defined by the GHG Protocol are shown in **Figure 14** and can be summarised as follows:

- **Scope 1** – Direct emissions from sources that are owned or operated by a reporting organisation (*examples – combustion of diesel in company owned vehicles or used in on-site generators*)
- **Scope 2** – Indirect emissions associated with the import of energy from another source (*examples – import of electricity or heat*)
- **Scope 3** – Other indirect emissions (other than Scope 2 energy imports) which are a direct result of the operations of the organisation but from sources not owned or operated by them (*examples i nclude business travel (by air or rail) and product usage*)

The initial action for a greenhouse gas inventory is to determine the sources of greenhouse gas emissions, assess their likely significance, and set a provisional boundary for the study.

[1] The Greenhouse Gas Protocol is collaboration between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The Protocol provides guidance on the calculation and reporting of carbon footprints.



Adapted from: World Business Council for Sustainable Development – Greenhouse Gas Protocol

Figure 14 Sources of greenhouse gases

The results of this study are presented in terms of the above-listed 'Scopes' to help understand the direct and indirect impacts of the project.

The GHG Protocol (and many other reporting schemes) dictates that reporting Scope 1 and 2 sources is mandatory, whilst reporting Scope 3 sources is optional. Reporting *significant* Scope 3 sources is recommended. Within this inventory, assessment has been made of all (Scopes 1, 2 and 3) sources of GHG deemed significant to the implementation of the proposal.

8.2 Policy Context

This section contains background information relating to greenhouse gases and climate change, and introduces the policy context from federal government and state government perspectives and from Transport for New South Wales perspective.

8.2.1 Federal Greenhouse Gas Policy

Paris Climate Conference COP21

The Paris COP reached an agreement 'to achieve a balance between anthropogenic (human induced) emissions by sources and removals by sinks of greenhouse in the second half of this century'. Following COP21, international agreements were made to:

- Keep global warming well below 2.0 degrees Celsius, with an aspirational goal of 1.5 degrees Celsius (based on temperature pre-industrial levels)
- From 2018, countries are to submit revised emission reduction targets every 5 years, with the first being effective from 2020, and goals set to 2050
- Define a pathway to improve transparency and disclosure of emissions
- Make provisions for financing the commitments beyond 2020.

In response to this challenge – Australia has committed to reduce emissions to 26-28 per cent on 2005 levels by 2030.

National Greenhouse and Energy Reporting Act 2007

The Federal Government uses the National Greenhouse Gas and Energy Reporting (NGER) legislation for the measurement, reporting and verification of Australian GHG emissions. This legislation is used for a range of purposes, including being used for international GHG reporting purposes. Corporations which meet the thresholds for reporting under NGER must register and report their GHG emissions.

Under the NGER Act, constitutional corporations in Australia which exceed thresholds for GHG emissions or energy production or consumption are required to measure and report data to the Clean Energy Regulator on an annual basis. The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* identifies a number of methodologies to account for GHGs from specific sources relevant to the proposal. This includes emissions of GHGs from direct fuel combustion (fuels for transport energy purposes), emissions associated with consumption of power from direct combustion of fuel (e.g. diesel generators used during construction), and from consumption of electricity from the grid.

Emissions Reduction Fund (ERF)

Previous legislation passed by the Australian Government to reduce carbon emissions was the *Clean Energy Act 2011*. This legislation established an Emissions Trading Scheme (ETS), also referred to as a carbon price. Under this ETS, approximately 370 companies were required to purchase a permit for every tonne of carbon equivalent they emit.

The *Clean Energy Legislation (Carbon Tax Repeal) Act 2014* repealed the *Clean Energy Act 2011*. This abolished the carbon pricing mechanism from 1 July 2014, and is replaced with the Australian Government's Direct Action Plan, which aims to focus on sourcing low cost emission reductions. The Direct Action Plan includes an Emissions Reduction Fund (ERF); legislation to implement the ERF came into effect on 13 December 2014, and is now considered to be the centrepiece of the Australian Government's policy suite to reduce emissions.

Emissions reduction and sequestration methodologies are available under the ERF which could provide Exploratory Works with the opportunity to earn carbon credits as a result of emissions reduction activities.

8.2.2 State Greenhouse Gas Policy

NSW Climate Change Policy Statement

In response to national GHG reduction commitments, the NSW government has developed the NSW Climate Change Policy Statement which sets the objective of achieving net-zero emissions by 2050. It intends to achieve this through a combination of policy development, leading by example and advocacy. Energy generation and transport emissions form a significant part of the NSW emissions inventory, and as such this project will be set into the context of state and national emissions to determine its contribution.

8.3 Methodology

8.3.1 Scope and Boundary

The assessment boundary defines the scope of greenhouse gas emissions and the activities to be included in the assessment. **Table 22** summarises the emissions sources and activities considered within the project's assessment boundary for construction, according to scope. Note that some emissions sources are split into more than one scope. This is typically the case where there are direct emissions (e.g. combustion of fuel in a vehicle operated as part of the project) as well as indirect emissions (such as the extraction and processing of fuel before it is used).

Table 22 Emission sources included in the construction GHG assessment

Emission source	Scope 1	Scope 2	Scope 3
Diesel Combustion - Plant and equipment (stationary)	✓		✓
Diesel Combustion - Plant and equipment (mobile)	✓		✓
Diesel Combustion - Light vehicles	✓		✓
Diesel Combustion - Transport of diesel fuel to site			✓
Diesel Combustion - Transport of construction materials to site			✓
Use of Explosives	✓		
Vegetation removal	✓		

8.3.2 Other Emission Sources

Sources of GHG emissions which are not presented in **Table 22** are addressed below

Electricity Consumption

Power for construction activities will be powered by 45 kVa 3 phase, 56 amp per phase diesel generators. It is therefore assumed that power will not be purchased from the electricity grid for this project. The assessment of GHG emissions from the combustion of diesel fuel by the generators are captured in this assessment by 'Diesel Combustion - Plant and equipment (stationary)'. This includes the power used by site offices, lighting, and requirements for ancillary compounds, water treatment plants and the concrete batch plant.

Transport of Materials by Barge

Material will be transported by barge when access via Snowy Mountains Highway is restricted due to weather conditions. Bulky and heavy equipment would also be transported by barge. The barge would be loaded from Talbingo Dam wall and travel to Middle Bay, near Lobs Hole, approximately 20 km south. The number of barge movements is dependent on weather and access. The transport of material from its source by road to Talbingo Dam has a substantially larger impact than the movement of the barges, with a larger uses and a significantly larger fuel use. Transport of materials by barge has therefore not been assessed.

Employee Commuting

The majority of the workforce will be fly-in / fly-out (FIFO) with only local subcontractors on short term work assignments travelling to site on a daily basis. FIFO works will stay at the construction camp, and hence commuting will be limited. This source has therefore been excluded.

8.3.3 Tools Used

The calculation of greenhouse gas emissions for this assessment was facilitated through the use multiple tools. These are presented in **Table 23**. The tools were used to determine the emissions associated with discrete components of the assessment, but do not represent the tools used for the whole assessment. In addition to the tools presented in **Table 23**, bespoke calculations were carried out (as described in later sections) for a large some parts of this assessment. All tools source a variety of emissions factors, but preference was taken for the National Greenhouse Accounts (NGA) factors (2017) where required.

Table 23 Tools for assessment of greenhouse gas emissions

Greenhouse Gas Assessment Tool	Description	Application
Carbon Gauge	• Framework for assessing GHG emissions from road construction projects • Automates calculations, assumptions and greenhouse gas emission factors presented in Greenhouse Gas Assessment Workbook for Road Projects • GHG emission profile built through used inputs of, areas of vegetation and other accessible data.	• Some elements of GHG emissions within construction (veg removal) • Review of calculations conducted using different methods
Infrastructure Sustainability Materials Calculator (ISMC)	• Developed by the Infrastructure Sustainability Council of Australia (ISCA), which evaluates environmental impacts in relation to the use of materials on infrastructure projects, including the transport of materials to and from project sites • Emissions profile is built by inserting material quantities, concrete strengths, aggregate, plastic and steel types, as well as transport types into the model	• Assessment of emissions from manufacture of construction materials. • Emissions from transport of materials to and from project sites

8.3.4 Construction Input Data

This section presents the methodology used to estimate greenhouse gas emissions associated with construction of the project.

Diesel Combustion from Stationary and Mobile Construction Plant and Equipment and Light Vehicles

Stationary plant and equipment include all those which operate wholly within the construction site. Mobile plant and equipment include those which would leave the site area (typically those which travel on roads such as haul trucks).

For the purpose of this assessment, total diesel fuel consumption by plant and equipment during construction has been projected by quantity surveyors, and has been split equally to be used by stationary and mobile equipment (as no greater level of detail was available).

As diesel fuel consumption by light vehicles has been individually specified by the project, the predicted GHG emissions from light vehicles has been assessed separately.

The method to calculate the greenhouse gas emissions resulting from fuel combustion by construction equipment and plant is outlined as follows:

- Identification of the total quantity of diesel fuel required for trucks, plant and equipment.
- Total predicted fuel use was split equally to represent mobile and stationary equipment.
- To calculate the Scope 1 greenhouse gas emissions from the combustion of fuel by construction equipment and plant, the following formula was used, sourced from the National Greenhouse Accounts (NGA) Factors, 2017.

$$\text{Greenhouse Gas Emissions (t } CO_2e) = ((Q \times ECF)/1000) \times (EF_{CO2} + EF_{CH4} + EF_{N2O})$$

Where:

- Q is Quantity of fuel (kL)
- ECF is the relevant energy content factor (in GJ/kL)
- EF_{CO2} is the relevant carbon dioxide emission factor (kg CO_2e/GJ)
- EF_{CH4} is the relevant methane emission factor (kg CO_2e/GJ)
- EF_{N2O} is the relevant nitrous oxide emission factor (kg CO_2e/GJ)

To calculate the Scope 3 greenhouse gas emissions from the combustion of fuel by construction equipment and plant, the following formula was used, as per NGA Factors 2017.

$$\text{Greenhouse Gas Emissions (t } CO_2e) = (Q \times ECF \times EF_{Scope\ 3})/1000$$

Where:

- Q is the quantity of fuel (kL)
- ECF is the relevant energy content factor (GJ/kL)
- $EF_{Scope\ 3}$ is the relevant emission factor (kg CO_2e/GJ)

Table 24 presents the energy content factors (ECF) and the emission factors from NGA (2017) which apply to the above equations, emphasising the different emission factors applied between stationary and mobile plant and equipment. Note that the emission factors for mobile vehicles would apply (100%) to the light vehicle diesel usage. The above equations were applied assuming that all equipment and plant (including barges) to be used would operate on diesel fuel, and are 'post 2004' vehicles.

Table 24 Diesel Fuel Emissions Factors

Fuel	Energy content factor (GJ per kL)	Scope 1 emission factor (kg CO_2e/GJ)			Scope 3 emission factor (kg CO_2e/GJ)	Emissions per unit quantity (t CO_2e per kL	
		CO_2	CH_4	N_2O		Scope 1	Scope 3
Diesel (stationary fuel use)	38.6	69.9	0.1	0.2	3.6	2.7097	0.1390
Diesel (Mobile/transport fuel use)	38.6	69.9	0.01	0.6	3.6	2.7217	0.1390

Construction Materials

Greenhouse gas emissions associated with construction materials have been determined using the emission factors provided by the Infrastructure Sustainability Materials Calculator (ISMC), developed by the ISCA. This calculator evaluates environmental impacts in relation to the use of materials on infrastructure projects and assets. To determine the greenhouse gas emissions from construction materials, the following steps were undertaken:

- Material quantity estimates were determined by cost estimators, in the form of a Bill of Quantities for major construction materials.
- The Bill of Quantities was filtered to include only significant construction materials, determined by quantity.
- The Bill of Quantities was refined to provide greater detail as required. This included tasks such as translating data where quantities were provided as a number, into one which could be directly applied to a relevant emissions factor (such as volume or weight). This involved researching applicable conversion factors for specific materials.

The quantities of construction materials determined for each project is shown in **Table 25**. These quantities were multiplied against corresponding emission factors as provided in the ISMC for individual materials to determine the resulting Scope 3 greenhouse gas emissions. All emission factors for materials in **Table 25** came from the ISMC, apart from the emission factor for explosives, which was derived from the TAGG Greenhouse Gas Assessment Workbook for Road Projects (2013) which provides an emissions factor for tunnelling for roads and mines.

Table 25 Construction materials input volumes

Material	Quantity (t)
Dense graded asphalt	3,704
Cement (for batch plant)	16,344
Precast concrete* (slabs, beams, culverts, headwalls)	502
Precast concrete* (pipes)	12,016
HD PVC conduit	14
Reinforcing steel bars	163
Wiring and cabling (as copper)	1,191
Steel rock bolts	38
Geotextiles (incl. fabric mesh)	90
Aggregates – crushed rock and gravel	2,532
Aggregates – sand	5,657
Explosives (emulsion)	348

**Precast concrete has been assumed to have a grade strength of 40 mPA.*

Diesel Combustion from the Transport of Diesel Fuel and Materials to Site

Power for construction activities will be powered by 45 kVa 3 phase, 56 amp per phase diesel generators. To limit long distance movements for mobile equipment and other onsite vehicles, diesel fuel is proposed to be delivered by 11,000 litre fuel trucks to a 66,000 litre self-bunded storage facility on site.

To determine the greenhouse gas emissions resulting from the transport of diesel fuel and also construction materials to the construction sites, the quantity and type of fuel and material, the distance for individual materials to be transported and the modes of transport were determined.

Using the emission factors in the ISCA calculator for the transport of materials by specific modes of transport, the following formula was used:

$$\text{Greenhouse Gas Emissions (t } CO_2e) = Q \times EF \times D$$

Where:

- Q is the quantity to be transported in tonnes
- EF is the relevant emission factor (kg CO_2e/unit)
- D is the distance the material is required to be transported (km)

The above equation was applied to all road transport proposed to import material to the project site by land. It has been assumed that the mode of transport for all materials would be a rigid truck of between 3.5 and 16 tonnes.

Table 26 presents the emission factors from ISCA used to determine the greenhouse gas emissions resulting from a rigid truck during transit. **Table 27** presents the inputs for calculating the greenhouse gas emissions resulting from the transport of materials to construction sites.

Table 26 Emission factors for modes of transport

Mode of transport	Emission factor (kg CO_2e / tonne.)
Rigid truck	0.216

Table 27 Material and fuel transport emissions

Material	Quantity (t)	Anticipated sources	Assumed distance (km)	Assumed mode of transport
Fuel Delivery	7,211	Canberra	240	Rigid truck
Asphalt	3,704	NSW (Assumed Sydney)	500	Rigid truck
Concrete	16,344	NSW (Assumed Sydney)	500	Rigid truck
Precast Concrete - slabs, beams, culverts, headwalls	502	Canberra	240	Rigid truck
Precast concrete – Piping	12,016	Canberra	240	Rigid truck
HD PVC conduit	14	Canberra	240	Rigid truck
Reo steel	163	Canberra	240	Rigid truck
Wire and Cable (as copper - inorganic material)	1,191	Sydney	500	Rigid truck
Geotextiles (incl. fabric mesh)	90	Newcastle	650	Rigid truck
Rock bolts (steel)	38	Canberra	240	Rigid truck
Aggregates- Crushed rock and gravel	2,532	Various NSW (Assumed Sydney)	500	Rigid truck
Aggregates- Sand	5,657	Various NSW (Assumed Sydney)	500	Rigid truck
Explosives	348	Newcastle	650	Rigid truck

Use of Explosives

The controlled use of explosives would be required for tunnelling as part of the proposed exploratory works. The proposed type of explosives materials to be used and its quantity are summarised in **Table 28**.

Table 28 Proposed explosive type and quantity

Purpose	Product	Quantity (kg)
Tertiary (Emulsion)	Civec control 1	31,130
	Civec control 1	23,980
	Civec control 1	293,260
	Total – Civec Control	**348,370**

The emission factor used to derive the greenhouse gas emission resulting from the proposed use of the explosives outlined above has been sourced from the Civec Control Technical Data Sheet provided by the manufacturer. The scope 1 emission factor for the use of explosives is presented in **Table 29**.

Table 29 Scope 1 emission factor for the use of proposed explosives

Explosives Product	Scope 1 Emissions Factor (t CO_2-e/t)
Civec Control	0.188

Vegetation Removal

The TAGG Workbook (2013) outlines the method for estimating greenhouse gas emissions as a result of carbon loss associated with the removal of vegetation. This assessment employs vegetation data used by the Department of Climate Change and Energy Efficiency (DCCEE) to estimate greenhouse gas emissions for Australia's international reporting requirements under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

This methodology can be considered conservative, in that there is an assumption that all carbon pools are removed, and all carbon that is removed is converted to carbon dioxide and released to the atmosphere. It is also assumed that sequestration from revegetation of the project site is not included.

The methodology for estimating the loss of carbon dioxide equivalent sequestration potential from vegetation during road construction involves the following steps.

1. Determine the 'Maxbio' class, by determining the location of the project area on a colour coded map presenting the maximum potential biomass class for all areas of Australia (provided in the TAGG 2013 workbook);

2. Identify the vegetation classes within the project area, and the area of each class to be cleared;

3. Using default emission factors provided for Maxbio values against vegetation classes, determine the potential greenhouse gas emissions by multiplying the area to be cleared by the relevant emissions factor.

The identified vegetation species to be cleared were categorised into the required vegetation classes for this assessment. This data and the area to be cleared per class are presented below in **Table 30**. The Maxbio class for the project areas were determined to be Class 3, which represents areas which have approximately 100-150 tonnes of dry matter per hectare, as per the TAGG Greenhouse Gas Assessment Workbook.

Vegetation do be cleared as 'road/rail/track'' have been classified as 'grassland (classification I), as per guidance in the TAGG Supporting Document for the Greenhouse Gas Assessment Workbook. Unmapped vegetated areas to be cleared and vegetation described as 'water' has been included in **Table 30** to present areas of land clearing, however do not have a greenhouse gas impact.

Table 30 Vegetation input data

Identified plant community type	Vegetation class (VIS database*)	Description	Area to be cleared (ha)
N/A	I	Cleared, road/trail/track	16.4
PCT 1191	D	Snow Gum - Candle Bark woodland on broad valley flats of the tablelands and slopes, South Eastern Highlands Bioregion	0.2
PCT 1196	D	Snow Gum - Mountain Gum shrubby open forest of montane areas, South Eastern Highlands Bioregion and Australian Alps Bioregion	3.0
PCT 285	F	Broad-leaved Sally grass - sedge woodland on valley flats and swamps in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion	5.4
PCT 296	B	Brittle Gum - peppermint open forest of the Woomargama to Tumut region, NSW South Western Slopes Bioregion	47.5
PCT 300	G	Ribbon Gum - Narrow-leaved (Robertsons) Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW South Western Slopes Bioregion and western Kosciuszko escarpment	6.8
PCT 302	D	Riparian Blakely's Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland wetland of the NSW South Western Slopes Bioregion and South	9.8

Identified plant community type	Vegetation class (VIS database*)	Description	Area to be cleared (ha)
		Eastern Highlands Bioregion	
PCT 311	G	Red Stringybark - Broad-leaved Peppermint - Nortons Box heath open forest of the upper slopes subregion in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion	7.1
PCT 643	G	Alpine shrubland on scree, blockstreams and rocky sites of high altitude areas of Kosciuszko National Park, Australian Alps Bioregion	0.1
PCT 729	F	Broad-leaved Peppermint - Candlebark shrubby open forest of montane areas, southern South Eastern Highlands Bioregion and South East Corner Bioregion	17.0
PCT 953	G	Mountain Gum - Snow Gum - Broad-leaved Peppermint shrubby open forest of montane ranges, South Eastern Highlands Bioregion and Australian Alps Bioregion	0.0
PCT 999	G	Norton's Box - Broad-leaved Peppermint open forest on footslopes, central and southern South Eastern Highlands Bioregion	0.5
N/A	N/A	Water	0.2
		Total	**114**

** Vegetation Information System*

8.4 Estimated Emissions

8.4.1 Diesel Combustion from Stationary and Mobile Construction Plant and Equipment and Light Vehicles

The projected greenhouse gas emissions from fuel consumption during the construction of the project is presented in **Table 31**. Stationary and mobile on-site equipment are predicted to produce approximately 25kt CO_2e of GHG emissions during the exploratory works.

Table 31 Projected greenhouse gas emissions from diesel fuel consumption during construction

Source	Total fuel consumption (kL)	Greenhouse gas emissions (t CO_2e)		
		Scope 1	Scope 3	Total
Stationary construction plant and equipment	4,333	11,740	602	12,342
Mobile construction plant and equipment	4,333	11,792	602	12,394
Light vehicles	23	62	3	65
Total	**8,688**	**23,594**	**1,207**	**24,801**

8.4.2 Construction Materials

The projected greenhouse gas emissions resulting from individual construction materials for specific construction stages are presented in **Table 32**. The table shows that cement production for the batch plant is projected to have the highest contribution to the total emissions from materials, due to the large quantity, and the high emission factor for cement. Other contributing materials to greenhouse gas emissions include precast concrete piping, due to the quantity. These contributions can be directly related to the quantity required, as well as the higher energy required to produce concrete.

Table 32 Projected greenhouse gas emissions from construction material manufacture

Material	Quantity (t)	Scope 3 greenhouse gas emissions (t CO_2e)
Dense graded asphalt	3,704	240

Material	Quantity (t)	Scope 3 greenhouse gas emissions (t CO_2e)
Cement (for batch plant)	16,344	16,245
Precast concrete* (slabs, beams, culverts, headwalls	502	100
Precast concrete* (pipes)	12,016	2,403
HD PVC conduit	14	35
Reinforcing steel bars	163	201
Wiring and cabling (as copper)	1,191	(inorganic material – no impact)
Steel rock bolts	38	47
Geotextiles (incl. fabric mesh)	90	162
Aggregates – crushed rock and gravel	2,532	27
Aggregates – sand	5,657	24
Explosives (emulsion)	348	59
TOTAL	**-**	**19,545**

8.4.3 Diesel Combustion from the Transport of Diesel Fuel and Materials to Site

Table 33 presents projected greenhouse gas emissions from the transport of materials to the project, based on volumes of materials, assumed travel distances and mode of transport. It is projected that the transport of ready concrete, precast concrete piping and sand would generate the most greenhouse gas emissions, due to the volume of material required to be transported, and the distance of transporting these materials.

Table 33 Projected greenhouse gas emissions from the transport of materials to the construction site

Material	Anticipated sources	Scope 3 greenhouse gas emissions (t CO_2e)
Fuel Delivery	Canberra	375
Asphalt	NSW (Assumed Sydney)	401
Cement	NSW (Assumed Sydney)	1,769
Precast Concrete - slabs, beams, culverts, headwalls	Canberra	26
Precast concrete – Piping	Canberra	624
HD PVC conduit	Canberra	1
Reo steel	Canberra	8
Wire and Cable (as copper - inorganic material)	Sydney	129
Geotextiles (incl. fabric mesh)	Newcastle	13
Rock bolts (steel)	Canberra	2
Aggregates- Crushed rock and gravel	Various NSW (Assumed Sydney)	274
Aggregates- Sand	Various NSW (Assumed Sydney)	612
Explosives	Newcastle	
TOTAL		**4,234**

8.4.4 Use of Explosives

The projected greenhouse gas emissions from the use of explosives is presented in **Table 34.**

Table 34 Projected greenhouse gas emissions from the use of explosives

Purpose	Product	Quantity (kg)	Scope 1 Greenhouse gas emissions (t CO_2e)
Tertiary (Emulsion)	Civec control 1	31,130	6
	Civec control 1	23,980	5
	Civec control 1	293,260	55
	Total – Civec Control	348,370	65

8.4.5 Vegetation Removal

The projected greenhouse gas emissions from the removal of vegetation as a loss of a carbon sink, is presented in **Table 35**.

There are certain areas of vegetation proposed to be removed which are classified as cleared road, track rail areas. These have been classified as grassland for the purpose of this assessment as per guidance in the TAGG Supporting Document for the Greenhouse Gas Assessment Workbook.

Those vegetation types which are predicted to have no greenhouse gas impacts are shrub land, which do not have corresponding emissions to the relative vegetation bio class in the project area.

Table 35 Projected greenhouse gas emissions during resulting from vegetation removal during construction

Identified Plant Community Type	Description	Area to be cleared (ha)	Scope 1 Greenhouse gas emissions (t CO_2e)
N/A	Cleared, road/trail/track	14.6	1,608
PCT 1191	Snow Gum - Candle Bark woodland on broad valley flats of the tablelands and slopes, South Eastern Highlands Bioregion	0.3	107
PCT 1196	Snow Gum - Mountain Gum shrubby open forest of montane areas, South Eastern Highlands Bioregion and Australian Alps Bioregion	0.5	156
PCT 285	Broad-leaved Sally grass - sedge woodland on valley flats and swamps in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion	5.4	-
PCT 296	Brittle Gum - peppermint open forest of the Woomargama to Tumut region, NSW South Western Slopes Bioregion	44.9	10,640
PCT 299	Riparian Ribbon Gum-Robertsons Peppermint-Apple Box riverine very tall open forest of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	0.9	220
PCT 300	Ribbon Gum - Narrow-leaved (Robertsons) Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW South Western Slopes Bioregion and western Kosciuszko escarpment	7.2	-
PCT 302	Riparian Blakely's Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland wetland of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	12.7	3,887
PCT 311	Red Stringybark - Broad-leaved Peppermint - Nortons Box heath open forest of the upper slopes subregion in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion	4.3	-
PCT 643	Alpine shrubland on scree, blockstreams and rocky sites of high altitude areas of Kosciuszko National Park, Australian Alps Bioregion	0.1	-
PCT 729	Broad-leaved Peppermint - Candlebark shrubby open forest of montane areas, southern South Eastern Highlands Bioregion and South East Corner	19.2	-

Identified Plant Community Type	Description	Area to be cleared (ha)	Scope 1 Greenhouse gas emissions (t CO_2e)
	Bioregion		
PCT 953	Mountain Gum - Snow Gum - Broad-leaved Peppermint shrubby open forest of montane ranges, South Eastern Highlands Bioregion and Australian Alps Bioregion	0.0	-
PCT 999	Norton's Box - Broad-leaved Peppermint open forest on footslopes, central and southern South Eastern Highlands Bioregion	0.5	-
N/A	Unmapped - verification required	2.9	-
N/A	Water	0.4	-
	Total	**114.1**	**16,618**

8.5 Summary

Table 36 summarises the greenhouse gas emissions in tonnes of CO_2-e, for the Exploratory Works, including all of the above emission sources and scopes. It is estimated that the Exploratory Works will result in emissions of 65,313 t of CO_2e (65 kt CO_2e) - total of Scope 1, 2 and 3).

The construction emissions are set in the context of state and national greenhouse gas inventories to determine their potential contribution. Based on the latest dataset available (2015) from the Australian Greenhouse Emissions Information System (AEGIS) the NSW state and National emissions inventories were:

- 537,851 kt CO_2e (Australian emissions); and
- 133,426 kt CO_2e (NSW state emissions)

The estimated emissions reflect a small increase and total in the context of State and National emissions and no significant greenhouse gas emissions management is warranted.

Table 36 Estimated total greenhouse gas emissions for Exploratory Works

Construction – sources of greenhouse gas emissions	Emissions (ktCO_2e)			
	Scope 1	Scope 2	Scope 3	Total
Diesel combustion – plant and equipment (stationary)	11.740	-	0.602	12,342
Diesel combustion – plant and equipment (mobile)	11.792	-	0.602	12,394
Diesel combustion – light vehicles	0.062	-	0.003	0.065
Diesel combustion – transport of diesel fuel to site	-	-	0.375	0.375
Diesel combustion – transport of construction material to site	-	-	3.859	3.859
Use of explosives	0.065	-	-	0.065
Vegetation removal	16.618	-	-	16.618
Construction materials	-	-	19.545	19.545
Total	**40.278**	**-**	**25.035**	**65.313**

8.6 Mitigation Measures

The following potential mitigation and management measures have been identified.

Table 37 Greenhouse gas emission management measures

Impact	Ref	Environmental management measures
Emissions of greenhouse gases	GG01	• Energy efficiency can be considered during the design of mechanical and electrical systems such as the tunnel ventilation system and tunnel lighting. Energy efficient systems can be installed where reasonable and practicable. • Options for the installation of renewable energy generation (small scale wind or solar photovoltaics) to power electronic equipment associated with ancillary and support facilities (e.g. communications locations, outlying works) can be considered. • Opportunities to use low emission construction materials, such as use of bio-fuels or bio-fuel blends in construction plant and equipment, recycled aggregates in road pavement and surfacing, steel with recycled content, and cement replacement materials, can be investigated and incorporated where feasible and cost effective. • Construction plant and equipment can be operated and maintained to maximise efficiency and reduce emissions, with construction planning used to minimise vehicle wait times and idling onsite and machinery turned off when not in use. • Locally produced goods and services can be procured where feasible and cost effective to reduce transport fuel emissions. • Cut and fill balances for earthworks can be reviewed to make sure that material is transported the least possible distances.

9. Conclusions

This report has assessed the potential air quality impacts of exploratory works associated with Snowy 2.0. The main potential air quality issue was identified as dust, that is, particulate matter in the form of TSP, PM_{10} and $PM_{2.5}$.

A review of the existing environment was carried out. It was noted that no specific air quality monitoring has been carried out in the vicinity of the proposed site so existing air quality conditions had to be estimated or determined from the nearest known monitoring stations. The review also considered meteorological data from various locations. With this approach the review noted that:

- The prevailing winds are from the west-northwest and east-southeast.
- Particulate matter concentrations (TSP, PM_{10} and $PM_{2.5}$) and deposition levels are unlikely to exceed EPA criteria since the area is well removed from populated centres, industry and significant sources of air pollution.

The computer-based dispersion model known as CALPUFF was used to predict the potential air quality impacts of the Exploratory Works. The dispersion modelling accounted for meteorological conditions, land use and terrain information and used dust emission estimates to predict air quality impacts in the local area, including at the proposed location of the accommodation camp.

The model predictions showed that PM_{10}, $PM_{2.5}$, TSP and deposited dust levels would not exceed relevant EPA assessment criteria at the nearest sensitive receptor (that is, the accommodation camp). The modelling did however show that there was a potential for the 24-hour average PM_{10} concentration to approach the criterion (50 $\mu g/m^3$) if the contribution from the works where high and the background levels were elevated on a particular day. The results were taken to be indicative of the potential impacts given that background levels were not known and necessarily had to be estimated.

It is concluded that the Exploratory Works can achieve acceptable air quality outcomes for the nearest sensitive receptor (that is, the accommodation camp) but it is recommended that monitoring is carried out prior to and during the Exploratory Works to characterise the existing air quality environment and to inform the daily management of the proposed activities.

The greenhouse gas assessment identified vegetation removal, stationary and mobile construction plant and equipment and the production of construction materials for the project as the main sources of greenhouse gas emissions. Concrete and cement based materials were the main sources of emissions with regards to the production of materials, with over 70% of emissions coming from these sources. However, the total estimated emissions reflect a small increase and total in the context of State and National emissions and no significant greenhouse gas emissions management is warranted.

10. References

ACARP (2015) "Development of Australia-specific PM_{10} emission factors for coal mines". Published by the Australian Coal Association Research Program (ACARP), 21/9/2015.

AGO (2006) "AGO Factors and Methods Workbook", December 2006, published by the Australian Greenhouse Office.

AEGIS, 2015 - Australian Greenhouse Emissions Information System – http://ageis.climatechange.gov.au/ - Accessed March 2018.

Carbon Gauge (2013) – Carbon Gauge GHG Calculator for Road Projects - version 01.130612, 2013, VicRoads

DoE (2016) *National Environment Protection (Ambient Air Quality) Measure – as amended*, Federal Register of Legislative Instruments F2016C00215, Department of the Environment, Canberra.

DEC (2007) "Approved Methods for Sampling and Analysis of Air Pollutants in NSW". Department of Environment and Conservation, January 2007.

DEE (2015) "National Inventory Report 2015", Volume 1, Department of the Environment and Energy, May 2017.

DEE (2017) "National Greenhouse Accounts Factors", Department of the Environment and Energy, July 2017.

EPA (2016) "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW".

GHG Protocol - A Corporate Accounting and Reporting Standard (Revised Edition), World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI). http://www.ghgprotocol.org/sites/default/files/ghgp/standards/ghg-protocol-revised.pdf

National Pollutant Inventory (2012) "Emission Estimation Technique Manual for Mining". Version 3.1, January 2012.

NEPC (1998) "Ambient Air – National Environment Protection Measure for Ambient Air Quality", National Environment Protection Council, Canberra.

NERDDC (1988) "Air Pollution from Surface Coal Mining: Measurement, Modelling and Community Perception", Project No. 921, National Energy Research Development and Demonstration Council, Canberra.

NGA 2017 – National Greenhouse Accounts (NGA) Factors July 2017, Australian Government Department of the Environment and Energy

NHMRC (1996) "Ambient Air Quality Goals Recommended by the National Health and Medical Research Council, National Health and Medical Research Council", Canberra.

NSW Mineral Council (2000) "Particulate Matter and Mining Interim Report", Technical Paper.

Skidmore, E.L. (1998) "Wind Erosion Processes". USDA-ARS Wind Erosion Research Unit, Kansas State University. Wind Erosion in Africa and West Asia: Problems and Control Strategies. Proceedings of the expert group meeting 22-25 April 1997, Cairo, Egypt.

SPCC (1986) "Particle size distributions in dust from open cut coal mines in the Hunter Valley". Report number 10636-002-71. Prepared for the State Pollution Control Commission of NSW (now EPA) by Dames and Moore.

TRC (2007) CALPUFF model web-site http://www.src.com/calpuff/regstat.htm.

TRC (2011) “Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the ‘Approved Methods for the Modelling and Assessments of Air Pollutants in NSW’”. Prepared for the Office of Environment and Heritage by TRC, March 2011.

US EPA (1985 and updates) “Compilation of Air Pollutant Emission Factors”, AP-42, Fourth Edition United States Environmental Protection Agency, Office of Air and Radiation Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711. Now a web-based document.

US EPA (1987) Update of fugitive dust emission factors in AP-42 Section 11.2, EPA Contract No. 68-02-3891, Midwest Research Institute, Kansas City, MO, July 1987.

US EPA (1995) “User’s Guide for the Industrial Source Complex (ISC3) Dispersion Models - Volume 1 User’s Instructions” and “Volume 2 Description of Model Algorithms” US Environmental Protection Agency, Office of Air Quality Planning and Standards Emissions, Monitoring and Analysis Division, Research Triangle Park, North Carolina 27711.

US EPA (2005) “Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule”. Environmental Protection Agency.

Appendix A. Annual and Seasonal Wind-roses

Figure A1 Annual and seasonal wind-roses for Cabramurra meteorological station for 2017

Appendix B. Emissions Calculations

Emission calculations																		
Snowy 2.0 Exploratory Works																		
	Annual emissions (kg/y)						TSP		PM10		PM2.5		Variables					
Activity	TSP	PM10	PM2.5	Control (%)	Intensity	Units	Factor	Units	Factor	Units	Factor	Units	(ws/2.2)^1.3	Moisture (%)	kg/VKT	t/truck	km/trip	Silt (%)
Hauling spoil from portal to construction pad	4421	1306	221	75	884158	t/y	0.02000	kg/t	0.00591	kg/t	0.001	kg/t	-	-	4.0	40	0.2	-
Unloading spoil to construction pad	10610	3802	530	0	884158	t/y	0.01200	kg/t	0.0043	kg/t	0.001	kg/t	-	-	-	-	-	-
Loading spoil from construction pad to trucks	3210	1518	160	0	884158	t/y	0.00363	kg/t	0.001717	kg/t	0.000	kg/t	3.07	2	-	-	-	-
Hauling spoil from construction pad to disposal area	110520	32659	5526	75	884158	t/y	0.50000	kg/t	0.147754	kg/t	0.025	kg/t	-	-	4.0	40	5	-
Unloading spoil to disposal area	10610	3802	530	0	884158	t/y	0.01200	kg/t	0.0043	kg/t	0.001	kg/t	-	-	-	-	-	-
Hauling spoil for access road construction	479600	141726	23980	75	1918400	t/y	1.00000	kg/t	0.295508	kg/t	0.050	kg/t	-	-	4.0	40	10	-
Dozers shaping overburden	64264	15645	6748	0	3840	h/y	16.7	kg/h	4.074149	kg/h	1.757	kg/h	-	2	-	-	-	10
Wind erosion from construction pad	5694	2847	427	0	7	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	-	-	-	-	-	-
Wind erosion from spoil disposal area	8595	4297	645	0	10	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	-	-	-	-	-	-
Concrete batch plant - deliveries	19839	5863	992	75	79356	t/y	1.00000	kg/t	0.295508	kg/t	0.050	kg/t	-	-	4.0	40	10	-
Concrete batch plant - unloading to ground bins	288	136	14	0	79356	t/y	0.00363	kg/t	0.001717	kg/t	0.000	kg/t	3.07	2	-	-	-	-
Concrete batch plant - loading to hoppers by FEL	288	136	14	0	79356	t/y	0.00363	kg/t	0.001717	kg/t	0.000	kg/t	3.07	2	-	-	-	-
Concrete batch plant - unloading to storage bins	288	136	14	0	79356	t/y	0.00363	kg/t	0.001717	kg/t	0.000	kg/t	3.07	2	-	-	-	-
Concrete batch plant - unloading from bins to trucks	288	136	14	0	79356	t/y	0.00363	kg/t	0.001717	kg/t	0.000	kg/t	3.07	2	-	-	-	-
Concrete batch plant - dispatch	2645	782	132	75	79356	t/y	0.13333	kg/t	0.039401	kg/t	0.007	kg/t	-	-	4.0	6	0.2	-
	721160	214792	39950															

Source allocations

```
-------------------------------      07-May-2018 11:15
  DUST EMISSION CALCULATIONS XL1
 -------------------------------

 Output emissions file  : C:\Users\slakmaker\Projects\IA180600_Snowy\calpuff\emiss.vol
 Meteorological file    : NA
 Number of dust sources : 101
 Number of activities   : 15

  -----ACTIVITY SUMMARY-----
 ACTIVITY NAME : Hauling spoil from portal to construction pad
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 4421 kg/y TSP  1306 kg/y PM10   221 kg/y PM2.5
 FROM SOURCES  : 3
1 2 3
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Unloading spoil to construction pad
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 10610 kg/y TSP  3802 kg/y PM10  530 kg/y PM2.5
 FROM SOURCES  : 2
2 3
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Loading spoil from construction pad to trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 3210 kg/y TSP  1518 kg/y PM10  160 kg/y PM2.5
 FROM SOURCES  : 2
2 3
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Hauling spoil from construction pad to disposal area
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 110520 kg/y TSP  32659 kg/y PM10  5526 kg/y PM2.5
 FROM SOURCES  : 60
2 3 4 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Unloading spoil to disposal area
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 10610 kg/y TSP  3802 kg/y PM10  530 kg/y PM2.5
 FROM SOURCES  : 23
34 35 36 37 38 39 40 41 42 43 44 56 57 58 59 60 61 62 63 64 65 66 67
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Hauling spoil for access road construction
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 479600 kg/y TSP  141726 kg/y PM10  23980 kg/y PM2.5
```

```
 FROM SOURCES  : 68
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 45 46 47 48 49 50 51 52 53 54 55 68 69 70 71 72
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101
 HOURS OF DAY  :
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Dozers shaping overburden
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 64264 kg/y TSP  15645 kg/y PM10  6748 kg/y PM2.5
 FROM SOURCES  : 23
34 35 36 37 38 39 40 41 42 43 44 56 57 58 59 60 61 62 63 64 65 66 67
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Wind erosion from construction pad
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 5694 kg/y TSP  2847 kg/y PM10  427 kg/y PM2.5
 FROM SOURCES  : 9
2 3 4 5 6 7 8 9 10
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Wind erosion from spoil disposal area
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 8595 kg/y TSP  4297 kg/y PM10  645 kg/y PM2.5
 FROM SOURCES  : 23
34 35 36 37 38 39 40 41 42 43 44 56 57 58 59 60 61 62 63 64 65 66 67
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Concrete batch plant - deliveries
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 19839 kg/y TSP  5863 kg/y PM10  992 kg/y PM2.5
 FROM SOURCES  : 54
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 45 46 47 68 69 70 71 72 73 74
75 76 77 78 79 80 81 82 83 84 85 86
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Concrete batch plant - unloading to ground bins
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 288 kg/y TSP  136 kg/y PM10  14 kg/y PM2.5
 FROM SOURCES  : 3
8 9 10
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Concrete batch plant - loading to hoppers by FEL
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 288 kg/y TSP  136 kg/y PM10  14 kg/y PM2.5
 FROM SOURCES  : 3
8 9 10
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Concrete batch plant - unloading to storage bins
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 288 kg/y TSP  136 kg/y PM10  14 kg/y PM2.5
 FROM SOURCES  : 3
8 9 10
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Concrete batch plant - unloading from bins to trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 288 kg/y TSP  136 kg/y PM10  14 kg/y PM2.5
 FROM SOURCES  : 3
8 9 10
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Concrete batch plant - dispatch
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 2645 kg/y TSP  782 kg/y PM10  132 kg/y PM2.5
 FROM SOURCES  : 9
2 3 4 5 6 7 8 9 10
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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Appendix C. Model Receptors