Annex H

Air Quality And Greenhouse Gas Impact Assessment

Air Quality and Greenhouse Gas Assessment Report

Sancrox Quarry Expansion Project

Hanson Construction Materials Pty Ltd

August 2019

0418291 Final

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Air Quality and Greenhouse Gas Assessment Report

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EXECUTIVE SUMMARY

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by Hanson Construction Materials Pty Ltd (Hanson) to undertake specialist assessments to inform the Environmental Impact Statement (EIS) for the proposed Sancrox Quarry Extension Project (the 'Project').

The Project involves the following:

- *Extending the approved extraction boundary by approximately 52 hectares;*
- *Extending the quarry life by ten years (from 20 to 30 years);*
- *Increasing the production limit from 455,000 tonnes per annum (tpa) to 750,000 tpa;*
- *Constructing and operating a concrete batching plant producing 20,000m^3 per annum;*
- *Constructing and operating a concrete recycling facility processing 20,000 tpa;*
- *Increasing truck movements and equipment loading to 24 hours per day, 7 days per week;*
- *Increasing quarry operations to 24 hours per day, 7 days per week;*
- *Transporting material off-site via public roads; and*
- *Constructing and operating an asphalt plant producing 50,000 tpa.*

This Air Quality and GHG Assessment has been prepared in accordance with the latest version of Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an EIS for the Sancrox Quarry Extension Project (Department of Planning and Environment, 2017) *and forms the air quality assessment for the EIS to be submitted to the NSW Department of Planning and Environment (DP&E). The following scope of works has been undertaken:*

- *Assessment of potential for ambient air quality impacts and greenhouse gas emissions from construction and operation of the Proposed Project;*
- *Provision of mitigation measures to minimise impacts to the surrounding land use; and*
- *Recommendations for ambient monitoring to ensure compliance with legislation.*

It should be noted that the estimation of GHG emissions from the Project was limited to Scope 1 and Scope 2 emissions.

The Project has the potential for ambient air quality impacts and greenhouse gas emissions from the construction and operation of the following:

Quarry, including:	*Concrete Batching Plant, including:*	*Concrete Recycling Plant, including:*	*Asphalt Plant, including:*
• *Drilling;*	• *Dry product delivery;*	• *Product delivery;*	• *Bitumen delivery and storage;*
• *Blasting;*	• *Product storage;*	• *Product storage;*	• *High quality aggregate delivery and storage;*
• *Product handling;*	• *Product transfer;*	• *Product handling;*	• *Dryer emissions;*
• *Rock processing;*	• *Pneumatic unloading of moist product;*	• *Crushing, using primary crusher; and*	• *Truck load out; and*
• *Wheel generated dust; and*	• *Weight hopper and mixer unloading; and*	• *Wheel generated dust.*	• *Wheel generated dust.*
• *Wind generated dust.*	• *Wheel generated dust.*		

The primary emissions from the sources considered in this assessment are TSP, PM_{10}*,* $PM_{2.5}$ *and deposited dust. Concrete batching and asphalt plants however have the potential to emit additional species. All potential species emitted to atmosphere from these sources were identified through consideration of published emission factor databases for these sources.*

The criteria for all the emitted species were established through consideration of the following legislation and guidelines:

- *POEO Clean Air Regulation 2010* (New South Wales Government, 2017)*;*
- *Approved Methods for the Assessment of Air Pollutants in NSW* (State of NSW and Environment Protection Authority, 2016)*;*
- *National Environment Protection Measures* (Australian Government, 2016)*;*
- *Other international legislations:*
    - *Ontario Regulation 419/06: Air Pollution – Local Air Quality* (Government of Ontario, 2017)*;*
- *Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments* (NSW Government, 2018)*; and*
- *Protocol for Environmental Management: Mining and Extractive Industries* (Environment Protection Authority Victoria, 2007).

Initially, a screening assessment was undertaken for the species other than particulate matter, using the 'UK Air emissions risk assessment for your environmental permit' guidance (UK Guidance). The species that could not be screened out using the criteria provided in the UK Guidance were further considered through the use of atmospheric dispersion modelling.

Atmospheric dispersion modelling was undertaken using the California Puff (CALPUFF) dispersion model for the latest five year period (2012 to 2016 inclusive). The dispersion modelling was completed using site-specific meteorology predicted using a two-step process:

- *Prognostic modelling using TAPM (developed by CSIRO); and*
- *Diagnostic modelling using CALMET (the meteorological pre-processor for the CALPUFF dispersion model).*

The configuration of the emission sources within the CALPUFF dispersion model comprised a combination of volume, point and road sources.

The assessment of ambient air quality impacts identified that:

- *The cumulative annual mean concentrations of* PM_{10} *are below the Approved Methods criterion at all sensitive receptors;*
- *Contemporaneous analysis identified that the cumulative (background plus project contribution)* PM_{10} *24-hour average predicted concentrations indicate exceedances of the Approved Methods Criterion at 13 sensitive receptors.*
    - *Where exceedance of the Approved Methods Criterion occurs, a State Significant extractive development may be assessed against the criteria contained in the Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments* (NSW Government, 2018). *Impacts predicted for the Project demonstrate an acceptable level of* PM_{10} *24 hour concentrations under the Policy;*
- *The cumulative annual mean concentrations of* $PM_{2.5}$ *are below the Approved Methods criterion at all sensitive receptors;*
- *Contemporaneous analysis of the* $PM_{2.5}$ *24-hour average predicted concentrations are below the Approved Methods Criterion at all sensitive receptors;*
- *The predicted concentrations for all other species are below the adopted criteria at all sensitive receptor locations.*

The Project over its entire life cycle is estimated to release approximately 48.4 million tonnes of CO_2*-e into the atmosphere with scope 1 and scope 2 emissions accounting for 74% and 26% respectively of the total emissions. The main GHG emission sources over the life of the project representing 99% of all emissions are:*

- *Operations – Diesel for transport related purposes (38%)*

- *Operations – Electricity (26%)*
- *Operations – LNG (16%)*
- *Construction – Vegetation clearing (12%)*
- *Operations – Diesel for stationary energy purposes (6%)*

Peak Scope 1 and Scope 2 emissions from the Project (approximately 0.0054 Mt CO_2-e during Year 7/Year8) represent approximately 0.0010% of Australia's commitment for annual emissions under the Kyoto Protocol (550.2 Mt CO2-e/annum for 2016-17). In comparison to the 2015 GHG emissions in NSW, the project emissions account for approximately 0.0041%. When compared to the 2015 GHG emission levels from all Mining sources in Australia (74.5 Mt CO_2-e), the Project accounts to 0.0073%.

This air quality impact assessment considered all reasonable and feasible mitigation measures to minimise the emissions from the proposed activities at the site, including:

- *Roads, which are likely to remain unchanged throughout the Project stages and to be frequently used by machinery, will be sealed using asphalt and swept daily to minimise wheel-generated dust emissions;*
- *Full dust extraction system for drilling;*
- *Utilisation of water sprays during truck rear dumping;*
- *The use of mobile sprinkler systems during the operation of FELs;*
- *Dust suppression measures such as water sprays in place at the crushers and screeners;*
- *Water sprays used on all conveyor transfer points;*
- *The conveyor loading to be enclosed by a shroud;*
- *Level 2 watering (more than 2 litres/m^2/hour) applied to unsealed roads to minimise impact from hauling;*
- *Water sprays to be utilised to minimise wind erosion from stockpiles during wind speeds of over 5.4 metres per second;*
- *The dry product delivered to the concrete batching, concrete recycling and asphalt plants to be stored in aggregate storage bins enclosed on three sides. The walls to extend one metre above the height of the maximum quantity of raw material, and two metre beyond the front of the stockpile. The aggregate storage bins to be fitted with water sprays to keep the stored material damp at all times;*
- *Cement and cement supplement to be delivered to the concrete batching plant in the agitator trucks and pneumatically fed to the bottom-loaded silos;*

- *Concrete batching loading point to be totally enclosed with all particulate matter emissions generated by the facility captured by one bag filter located above the pan mixer;*

- *Concrete recycling facility outloading to be directly to processed material storage bins enclosed on three sides. The walls to extend one metre above the height of the maximum quantity of raw material, and two metre beyond the front of the stockpile. The recycled concrete storage bins to be fitted with water sprays to keep the stored material damp at all times;*

- *Vapour balancing system to be installed for the delivery of bitumen at the asphalt plant;*

- *Asphalt plant will be totally enclosed. All particulate matter emissions generated at the plant will be captured by one fabric filter associated with the natural-gas fired dryer; and*

- *Vapour recovery system to be employed for transfer of asphalt to trucks.*

It is recommended that the Site additionally employs real-time ambient air quality monitoring system. This will allow staff to identify when additional mitigation measures are to be implemented to minimise impact from the onsite activities on days when the background concentrations of PM_{10} and $PM_{2.5}$ exceed the criteria set by the Approved Methods.

1 INTRODUCTION

1.1 BACKGROUND

Environmental Resources Management Australia Pty Ltd (ERM) has been commissioned by Hanson Construction Materials Pty Ltd (Hanson) to undertake specialist assessments to inform the Environmental Impact Statement (EIS) for the proposed Sancrox Quarry Extension Project (the 'Proposed Project'). The site is located on Lot 2 DP 574308, Lot 353 DP 754434, Lot 1 DP 704890 and Lot 1 DP 720807, Sancrox Road, Sancrox, 8km west of Port Macquarie, within the Port Macquarie Hastings Council (PMHC) Local Government Area (LGA) on the Mid North Coast of New South Wales (NSW).

Current operations at the site primarily include the extraction and crushing of high quality aggregate materials (rhyolite) for concrete and asphalt, sealing aggregates, road bases and select fill to both the private and government sectors. Current extraction rate at the site is 455,000 tonnes per annum (tpa), which has been approved for a period of up to five years to service planned upgrades to the Pacific Highway.

The Project involves the following:

- Extending the approved extraction boundary by approximately 52 hectares;
- Extending the quarry life by ten years (from 20 to 30 years);
- Increasing the production limit from 455,000 tpa to 750,000 tpa;
- Constructing and operating a concrete batching plant producing 20,000m^3 per annum;
- Constructing and operating a concrete recycling facility processing 20,000 tpa;
- Increasing truck movements and equipment loading to 24 hours per day, 7 days per week;
- Increasing quarry operations to 24 hours per day, 7 days per week;
- Transporting material off-site via public roads; and
- Constructing and operating an asphalt plant producing 50,000 tpa.

This report forms the Air Quality and Greenhouse Gas (GHG) Assessment for the EIS to be submitted to the NSW Department of Planning and Environment (DP&E).

1.2 *SECRETARY ENVIRONMENTAL ASSESSMENT REQUIREMENTS (SEARS)*

This Air Quality and GHG Assessment has been prepared in accordance with the latest version of SEARs for the preparation of an EIS for the Sancrox Quarry Extension Project (Department of Planning and Environment, 2017). In relation to air quality the following has been required:

- *A detailed assessment of potential construction and operational impacts, in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (State of NSW and Environment Protection Authority, 2016)*, and with a particular focus on dust emissions including* $PM_{2.5}$ *and* PM_{10}*, and having regard to the Voluntary Land Acquisition and Mitigation Policy* (NSW Government, 2018)*;*

- *An assessment of potential dust and other emissions generated from processing, operational activities and transportation of quarry products;*

- *Reasonable and feasible mitigation measures to minimise dust and emissions; and*

- *Monitoring and management measures, in particular, real-time air quality monitoring.*

1.3 *SCOPE OF WORKS*

To address the SEARs for the preparation of an EIS for the Sancrox Quarry Extension Project (Department of Planning and Environment, 2017), ERM undertook the following scope of works:

The scope of works for the Air Quality Assessment is as follows:

- Assessment of potential for ambient air quality impacts and greenhouse gas emissions from construction and operation of the Proposed Project;

- Provision of mitigation measures to minimise impacts to the surrounding land use; and

- Recommendations for ambient monitoring to ensure compliance with legislations.

It should be noted that as the SEARs provide no specific guidance in relation to reporting of GHG emissions for EIS purposes, the estimation of GHG emissions from the Project was limited to Scope 1 (direct emissions) and Scope 2 (emissions associated with production of electricity consumed) emissions, in line with the requirements of National Greenhouse and Energy Reporting Act 2007 (Commonwealth of Australia, 2007) (please refer to *Section 5* of the Assessment for details).

2 SITE AND PROCESS DESCRIPTION

2.1 SITE LOCATION

The Proposed Project is located on Sancrox Road, Sancrox, approximately 8km west of Port Macquarie, within the PMHC LGA on the NSW Mid North Coast (refer *Figure 2.1*) (the site). Access to the site is gained via a sealed road which runs off Sancrox Road located to the southeast of the site. The total area of the Project is approximately 52 hectares. The closest residences to the site are located approximately 50m to the western boundary and 130 metres to the northern boundary of the Site.

2.1.1 *Site Layout*

The building west of the main access road serves as the site office and staff amenities block. A workshop and materials storage shed is located next to the site office. The weighbridge is also located on the access road near the site office.

The processing plant is proposed to be relocated approximately 300 metres south-west of the current location. A new stockpile area is proposed to be located to the west of the new processing plant location. A concrete recycling facility is proposed to be located immediately west of the new processing plant location and immediately east of the new stockpile area. Concrete batching facility is proposed to be located to the north of the old processing plant location, and asphalt plant is proposed to be located to the east of the new processing plant location.

It is proposed that roads, which are likely to remain unchanged throughout the stages of the Project and to be frequently used by machinery, are sealed using asphalt and swept daily to minimise wheel-generated dust emissions. *Figure 2.2* presents the site layout and outlines both sealed and unsealed roads.

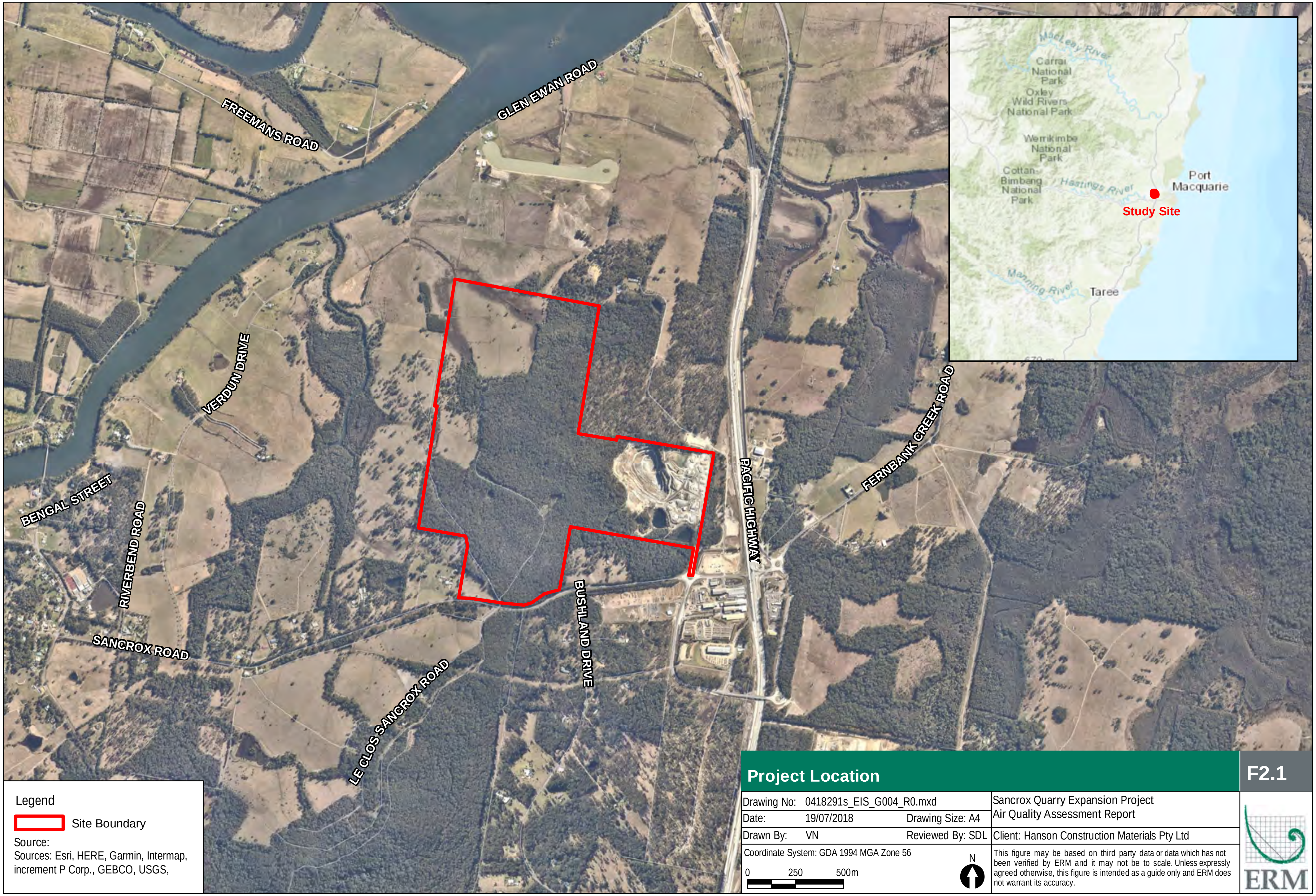
2.1.2 *Quarry Staging*

It is proposed that the quarry operations are expanded in five stages over a 10 year period. The five stages of the quarry expansion are provided in *Figure* 2.3, and may be described as follows:

- Stage 1 will involve the expansion of the western side of the quarry into the uncleared area, to a limit of RL-14.;
- Stage 2 will further expand the existing pit to the west to the previous extraction limit of RL-14;
- Stage 3 works include the widening and deepening of the benches towards the western extraction boundary. The quarry pit floor will be lowered from RL – 14 (AHD) to RL - 40m (AHD);

- Stage 4 works involve additional expansion of operations through the western side of the quarry to the approved boundary, and to the extraction depth proposed within Stage 3 works (i.e. RL-40); and

- Stage 5 will expand the quarry along the southern extraction boundary to a depth of RL-40.



Legend

Site Boundary

Source:
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS,

Project Location

F2.1

Drawing No: 0418291s_EIS_G004_R0.mxd		Sancrox Quarry Expansion Project Air Quality Assessment Report
Date: 19/07/2018	Drawing Size: A4	
Drawn By: VN	Reviewed By: SDL	Client: Hanson Construction Materials Pty Ltd
Coordinate System: GDA 1994 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

0 250 500m

N

ERM

Legend

Site Boundary

Final Pit (RL-40m)

Source: Near Map Dec 2017, DLPI

Site Layout

F 2.2

Drawing No: 0418291m_HRA_G001_R1.mxd		Sancrox Quarry Expansion Project
Date: 19/07/2018	Drawing Size: A4	
Drawn By: LT	Reviewed By: ME	Client: Hanson Construction Materials Pty Ltd
Coordinate System: GDA 1994 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

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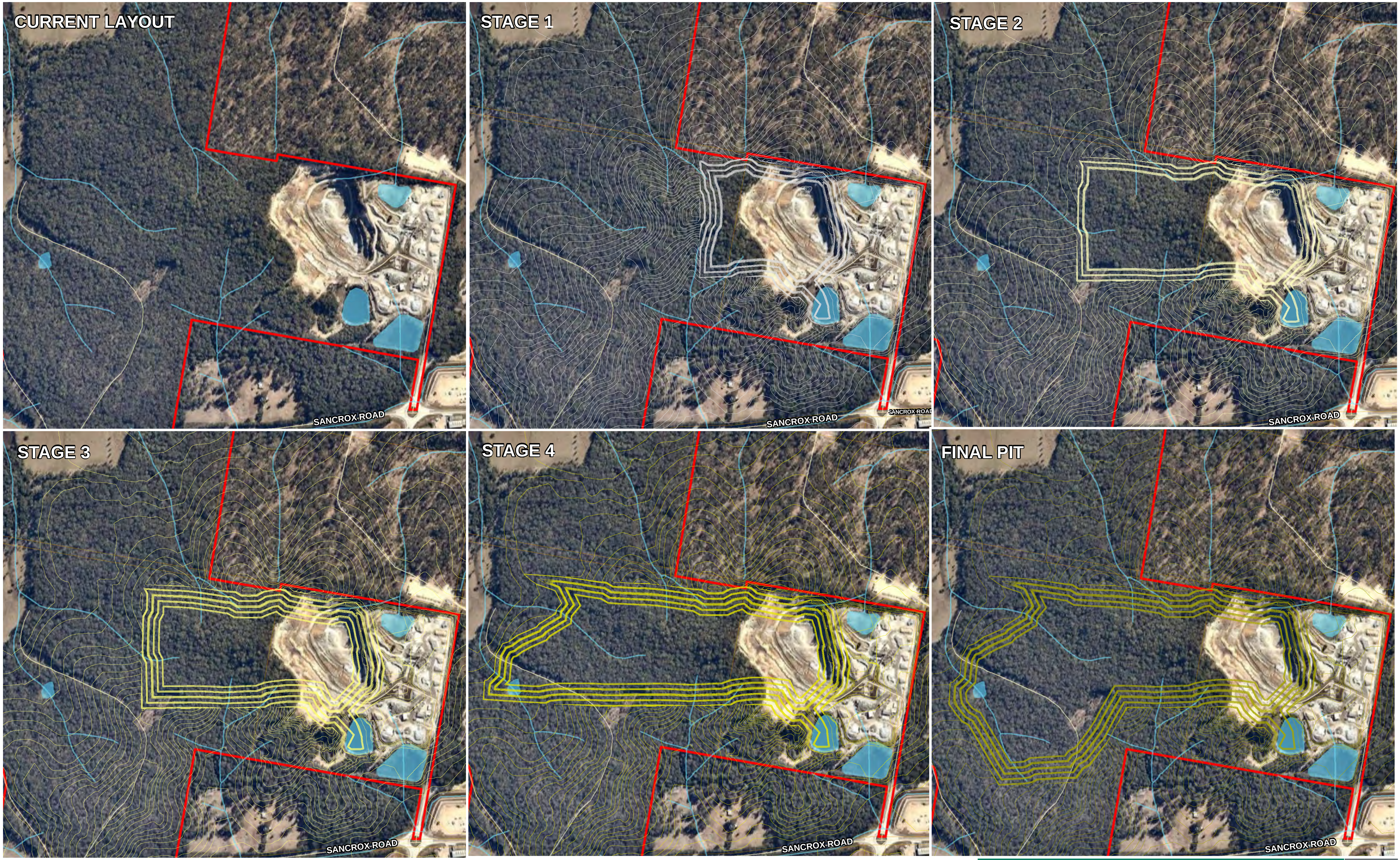

Legend

- Existing Property Ownership
- Lot Boundary
- Road Network
- Watercourses

Quarry Staging:

- Stage 1 (RL-14m)
- Stage 2 (RL-14m)
- Stage 3 (RL-40m)
- Stage 4 (RL-40m)
- Final Pit (RL-40m)

Source:
Spatial Data: DFSI DCDB, DTDB 2017
Imagery Data: nearmap August 2017

Quarry Staging

F2.3

Drawing No:	0418291s_AQA_G012_R0.mxd		
Date:	27/07/2018	Drawing Size: A4	
Drawn By:	LT	Reviewed By: ME	

Coordinate System: GDA 1994 MGA Zone 56

0 100 200m

N

Sancrox Quarry Expansion Project
Air Quality Assessment Report

Client: Hanson Construction Materials Pty Ltd

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2.1.3 *Sensitive Receptors*

Sensitive receptors are locations where the general population is likely to be exposed to the resultant ground level concentrations from the atmospheric emissions. The Approved Methods defines these as:

- *"A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area"* (State of NSW and Environment Protection Authority, 2016).

Forty five sensitive receptors have been identified on the basis of proximity to Site from all directions. In addition, the assessment has undertaken atmospheric dispersion modelling over a grid of 12 km by 12 km with a spatial resolution of 150 m. The results on the modelled grid are then interpolated and contoured to provide predicted concentrations for all other sensitive receptors not specifically included in the dispersion model, but within the modelled area. The locations of the specific sensitive receptors included in the model are provided *in Table 2-1* and *Figure 2.4*.

Table 2-1 Modelled specific sensitive receptors surrounding the Site (MGA Zone 55S)

Sensitive receptor	X (m)	Y (m)
1	482552	6520977
2	482404	6520969
3	482281	6521042
4	482236	6521212
5	481222	6521428
6	481371	6523402
7	483212	6522146
8	483289	6521515
9	483004	6521505
10	482775	6521355
11	482624	6523068
12	482382	6520901
13	482469	6521618
14	482535	6521234
15	482268	6521208
16	482420	6521099
17	482233	6521062
18	481521	6520908
19	481656	6521502
20	481477	6522042
21	480704	6522163
22	479872	6521891
23	480141	6522165
24	481146	6521405
25	480946	6521299
26	480251	6522566
27	480711	6522947
28	480906	6523185

Sensitive receptor	X (m)	Y (m)
29	481353	6523426
30	481795	6523669
31	481855	6523829
32	482524	6523013
33	483609	6523077
34	483701	6521979
35	483736	6521703
36	482434	6524144
37	484174	6522543
38	484191	6522511
39	484200	6522692
40	484189	6522599
41	482372	6520779
42	482234	6520814
43	482395	6520827
44	482960	6521383
45	483894	6521719

Sensitive Receptor Locations

F2.4

Drawing No: 0418291s_AQA_G001_R2.mxd		Sancrox Quarry Expansion Project Air Quality Assessment Report
Date: 27/07/2018	Drawing Size: A4	
Drawn By: VN	Reviewed By: EB	Client: Hanson Construction Materials Pty Ltd

Coordinate System: GDA 1994 MGA Zone 56

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2.2 PROCESS DESCRIPTION

2.2.1 *Quarry Operations*

Benches are developed by ripping, drilling and blasting. Ripped or blasted rock is loaded and then transported to either the processing plant located by the south-eastern boundary of the site, or transported directly off-site to market. The approximate split of material transported directly off-site is reportedly 10% with 90% transported to the processing area. The 90% of material to be taken to the processing plant is loaded to trucks using two excavators and hauled from the working face to the processing plant.

The processing plant reduces the size of feed rock by crushing. Screens are used to separate the material into various sizes and product types. Blending of materials will be undertaken to achieve required product specifications and quality control. It has been assumed by this Assessment that rock delivered to the processing plant is placed directly in to the feed hopper for processing. Conveyors transfer product from the screening area to stockpiles of various sizes.

The processed product is either loaded directly from stockpiles to delivery trucks by front-end loaders (FEL) or moved to a stockpile storage area to the west of the processing plant. It was considered that the proposed quantity of the material will require operation of two FELs around processing plant and stockpile area. The delivery trucks, loaded using FELs, leave the site via the weighbridge.

2.2.2 *Concrete Recycling Plant*

Concrete for recycling will be delivered from offsite using truck and dog type trucks to the aggregate storage bins located at the concrete recycling facility. The delivered concrete will be fed to a mobile primary crusher using one of the FELs in the vicinity of the processing plant and stockpile area. The concrete will be processed to the desired size and outloaded directly to the product storage bins prior to be taken offsite for the use as a recycled road base.

2.2.3 *Concrete Batching Plant*

Operations of the concrete batching plant require materials including coarse aggregate, sand, cement and cement supplement. The coarse aggregate component will be obtained from the rock processed at the processing plant, and will be delivered to the concrete batching plant from the stockpile area using the same trucks used to move material from the quarry floor. Sand will be delivered from offsite to the concrete batching plant using road truck and dogs. Cement and cement supplement will be delivered to the concrete batching plant in the agitator trucks and pneumatically fed to the bottom-loaded silos. The central mix concrete product will be pneumatically loaded to the agitator trucks, which will take the concrete offsite for application in residential houses, commercial structures, footpaths, sporting facilities etc. The concrete batching plant will be totally enclosed with one bag filter fitted above the pan mixer to mitigate particulate matter emissions from the facility.

2.2.4 *Asphalt Plant*

Operations of asphalt plant require high quality aggregate and bitumen. The aggregate for asphalt production will be obtained from the rock processed at the processing plant and will be delivered directly to the aggregate storage bins at the asphalt plant. The produced asphalt will be loaded in truck and dog-type trucks and taken offsite via the weighbridge. As part of asphalt plant, one fully enclosed pug mill will be located on site. It is understood that vapour balancing system will be installed for the delivery of bitumen on site and vapour recovery system will be employed for transfer of asphalt to trucks to minimise odour and dust emissions. Moreover, the asphalt plant will be totally enclosed and particulate matter emissions will be mitigated using one fabric filter associated with the natural-gas fired dryer.

3 LEGISLATION AND GUIDELINES

3.1 AIR QUALITY

Within New South Wales (NSW), the protection of local air quality standards is considered in the following policy documents:

- *Protection of the Environment Operations (Clean Air) Regulation 2010* (New South Wales Government, 2017);
- *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales* (State of NSW and Environment Protection Authority, 2016); and
- *Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments* (NSW Government, 2018).

In addition, NSW has committed to complying with the National Environment Protection (Ambient Air Quality) Measure (Australian Government, 2016).

3.1.1 POEO Clean Air Regulation 2010

The Protection of the Environment Operations (Clean Air) Regulation (2010) (the POEO Clean Air) (New South Wales Government, 2017) is the main legislative and regulatory instrument for air quality in NSW. With respect to industrial emissions, the POEO Clean Air defines:

- the meaning of a scheduled premises;
- groupings of activities and plant, based on commencement date of operation;
- allowable stack emission concentrations for a variety of industries based on the defined group; and
- requirements for the testing and assessment of emissions from existing and proposed industry.

The POEO Clean Air provides emission limits for point (stack) sources only. In relation to the proposed development, the concrete batching plant and the asphalt plant will have associated stacks. The remainder of operations at the facility will result in fugitive emissions not controlled under emission standards within the POEO Clean Air.

Table 3-1 provides the emission limits adopted in this assessment for the bag filter at the concrete batching plant.

Table 3-1 ***Emission limits for bag filters at the concrete batching plant adopted from the Schedule 3, POEO Clean Air Regulation (New South Wales Government, 2017)***

Emitted Species	Concentration	Reference conditions
Solid Particles	20 mg/m^3	Dry, 273 K, 101.3 kPa
Type 1 substances and Type 2 substances (in aggregate)	1 mg/m^3	Dry, 273 K, 101.3 kPa
Cadmium individually	0.2 mg/m^3	Dry, 273 K, 101.3 kPa
Note: Type 1 substance means the elements antimony, arsenic, cadmium, lead or mercury or any compound containing one or more of those elements. Type 2 substance means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium or any compound containing one or more of those elements.		

No specific emission limits are set by the POEO Regulation for asphalt plants, therefore this assessment considered emission limits set in Schedule 4 for general activities and plant. *Table 3-2* provides the emission limits adopted in this assessment for the bag filter at the asphalt plant.

Table 3-2 ***Emission limits for asphalt plant adopted from the Schedule 4, POEO Clean Air Regulation (New South Wales Government, 2017)***

Emitted Species	Concentration	Reference conditions[1]
Solid Particles	20 mg/m^3	Dry, 273 K, 101.3 kPa, 3% O_2
NO_2	350 mg/m^3	Dry, 273 K, 101.3 kPa, 3% O_2
Type 1 substances and Type 2 substances (in aggregate)	1 mg/m^3	Dry, 273 K, 101.3 kPa, 3% O_2
Cadmium or mercury individually	0.2 mg/m^3	Dry, 273 K, 101.3 kPa, 3% O_2
Volatile organic compounds, as n-propane	40 mg/m^3 VOCs or 125 mg/m^3 CO	Dry, 273 K, 101.3 kPa, 3% O_2
1 Reference conditions are based on fuel burning equipment using gas Note: Type 1 substance means the elements antimony, arsenic, cadmium, lead or mercury or any compound containing one or more of those elements. Type 2 substance means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium or any compound containing one or more of those elements. Volatile organic compound (VOC) means any chemical compound that: (a) is based on carbon chains or rings, and (b) contains hydrogen, and (c) has a vapour pressure greater than 2mm of mercury (0.27 kPa) at 25°C and 101.3 kPa, and includes any such compound containing oxygen, nitrogen or other elements, but does not include methane, carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.		

3.1.2 Approved Methods for the Assessment of Air Pollutants in NSW

The *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales* (Approved Methods) (State of NSW and Environment Protection Authority, 2016) is referred to in Part 5 of the POEO Regulation 2010. The Approved Methods provides the statutory methods for modelling and assessing emissions to atmosphere from stationary sources in the state.

The regulation also provides ground level assessment criteria against which results of dispersion modelling are assessed. *Table 3-3* shows the criteria for particulate matter considered in this assessment.

Table 3-3 The Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Impact Assessment Criteria (State of NSW and Environment Protection Authority, 2016)

Species	Averaging Period	Criterion
TSP	Annual	90 µg/m³
PM_{10}	24 hour	50 µg/m³
	Annual	25 µg/m³
$PM_{2.5}$	24 hour	25 µg/m³
	Annual	8 µg/m³
Deposited Dust	Annual	2[1] g/m²/month
		4[2] g/m²/month

1. Maximum increase in deposited dust level
2. Maximum total deposited dust level

In addition to particulate matter the concrete batching plant emissions include metals as specified in AP-42 Section 11.12 (United States Environmental Protection Agency, 2006). Emissions from the dryer at the asphalt plant in addition to particulate matter emissions also include carbon monoxide (CO), Nitrogen dioxide (NO_2), sulfur dioxide (SO_2), organic species, metals and general odour (United States Environmental Protection Agency, 2004). *Table 3-4* presents the criteria for these additional species as contained in the Approved Methods.

Table 3-4 Approved methods criteria for other species considered in this assessment

Species	Averaging period	Criterion (µg/m³)
NO_2	1 hour	246
	Annual	62
CO	15 min	100,000
	1 hour	30,000
	8 hour	10,000
SO_2	10 min	712
	1 hour	570
	24 hour	228
	Annual	60
Benzene	1 hour	29
Ethylbenzene	1 hour	8,000
Formaldehyde	1 hour	20
n-Hexane	1 hour	3200
Methyl chloroform	1 hour	12,500
Polycyclic aromatic hydrocarbon (PAH) as benzo[a]pyrene	1 hour	0.4
Toluene	1 hour	360
Xylene	1 hour	190
n-Pentane	1 hour	33,000
Asphalt petroleum fumes	1 hour	90

Species	Averaging period	Criterion (µg/m³)
Antimony and compounds	1 hour	9
Arsenic and compounds	1 hour	0.09
Barium (soluble compound)	1 hour	9
Cadmium and cadmium compounds	1 hour	0.018
Chromium III compounds	1 hour	9
Copper fumes	1 hour	3.7
Chromium VI compounds	1 hour	0.09
Lead	Annual	0.5
Manganese and compounds	1 hour	18
Mercury organic	1 hour	0.18
Nickel and nickel compounds	1 hour	0.18
Silver soluble compounds (as Ag)	1 hour	0.18

For the assessment of complex mixtures of odours, the Approved Methods adopts a statistical approach, dependent on the population size. As the population increases the proportion of sensitive individuals is also likely to increase, indicating that more stringent criterion is required. The Approved Methods provide an equation to determine the appropriate impact assessment criterion for general odour.

Equation 3-1 ***Calculation of Impact Assessment Criterion for General Odour (State of NSW and Environment Protection Authority, 2016)***

$$IAC\ (OU) = \frac{(Log_{10}(Population) - 4.5)}{-0.6}$$

Where:
IAC (OU) is the Impact Assessment Criteria in Odour Units
Population is the number of people living within the model domain

The Approved Methods use *Equation 3-1* to provide a Table of acceptable criteria (*Table 3-5*).

Table 3-5 ***Acceptable Impact Assessment Criteria for Complex Mixtures of Air Pollutants (OU) for Various Population Sizes***

Population of Affected Community	Impact Assessment Criteria for Complex Mixtures of Air Pollutants (OU)
Urban (>2000) and/or schools and hospitals	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
~2 (Single Rural Residence)	7.0

1. (State of NSW and Environment Protection Authority, 2016)

The Approved Methods does not provide a definition as to the extent of area in which the population should be defined in order to use *Equation 3-1*. At the

2017 Clean Air Society Conference in Brisbane, EPA stated that the definition for the area of population of affected community is the extent of the 2 OU contour.

The number of residences within the 2 OU contour from the dispersion modelling result (Section *8.3*) is two. Given that *Table 3-5* identifies that a single rural residence has a population of 2, this indicates that two residences will have a population of 4. Using *Equation 3-1*, this provides an assessment criterion for general odour of **6.5 OU**.

3.1.3 Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments

The Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments (NSW Government, 2018) addresses particulate matter impacts from State significant mining, petroleum and extractive industry developments under Environmental Planning and Assessment Act 1979. The policy provides that where Approved Methods criteria are exceeded by the development, consideration should be given to the following criteria set out in the policy:

- Voluntary mitigation rights (*Table 3-6*); and
- Voluntary land acquisition rights (*Table 3-7*).

This Assessment has therefore considered the criteria provided in the Voluntary Land Acquisition and Mitigation Policy.

Table 3-6 Particulate matter mitigation criteria (NSW Government, 2018)

Species	Averaging Period	Criterion
$PM_{2.5}$	Annual	8 µg/m³*
	24 hour	25 µg/m³**
PM_{10}	Annual	25 µg/m³*
	24 hour	50 µg/m³**
TSP	Annual	90 µg/m³*
Deposited Dust	Annual	2[1] g/m²/month** 4[2] g/m²/month*

1. Maximum increase in deposited dust level
2. Maximum total deposited dust level

* Cumulative impact (i.e. increase in concentrations due to the development plus background concentrations due to all other sources)

** Incremental impact (i.e. increase in concentrations due to the development alone), with zero allowable exceedances of the criteria over the life of the development

The Policy provides that the particulate matter mitigation criteria provided in *Table 3-6* should be assessed at:

- At any residence on privately owned land; or

- At any workplace on privately owned land where the consequences of those exceedances in the opinion of the consent authority are unreasonably deleterious to worker health or the carrying out of busing at that workplace, including consideration of the following factors:
  - The nature of the workplace;
  - The potential for exposure of workers to elevated levels of particulate matter;
  - The likely period of exposure; and
  - The health and safety measures already employed in that workplace.

Table 3-7 Particulate matter acquisition criteria (NSW Government, 2018)

Species	Averaging Period	Criterion
$PM_{2.5}$	Annual	8 µg/m³*
	24 hour	25 µg/m³**
PM_{10}	Annual	25 µg/m³*
	24 hour	50 µg/m³**
TSP	Annual	90 µg/m³*
Deposited Dust	Annual	2[1] g/m²/month**
		4[2] g/m²/month*

1. Maximum increase in deposited dust level
2. Maximum total deposited dust level

* Cumulative impact (i.e. increase in concentrations due to the development plus background concentrations due to all other sources)

** Incremental impact (i.e. increase in concentrations due to the development alone), with up to five allowable exceedances of the criteria over the life of the development

The Policy provides that the particulate matter mitigation criteria provided in *Table 3-7* should be assessed at:

- At any residence on privately owned land; or
- At any workplace on privately owned land where the consequences of those exceedances in the opinion of the consent authority are unreasonably deleterious to worker health or the carrying out of busing at that workplace, including consideration of the following factors:
  - The nature of the workplace;
  - The potential for exposure of workers to elevated levels of particulate matter;
  - The likely period of exposure; and
  - The health and safety measures already employed in that workplace.

- On more than 25% of any privately-owned land where there is an existing dwelling or where a dwelling could be built under existing planning controls.

To assist with the decision-making process for particulate matter impacts, the Policy provides *Figure 3-1*. Following the directions of the chart (*Figure 3-1*), it is considered that where the mitigation criteria are not exceeded at the sensitive receptor locations considered in the assessment (*Section 2.1.3*), the Proposed Project is considered to be compliant. It is further considered that where compliance with the mitigation criteria cannot be guaranteed, the particulate matter impacts are to be considered against the acquisition criteria at the sensitive receptor locations, as well as at any privately-owned land where there is an existing dwelling or where a dwelling could be built under existing planning controls.

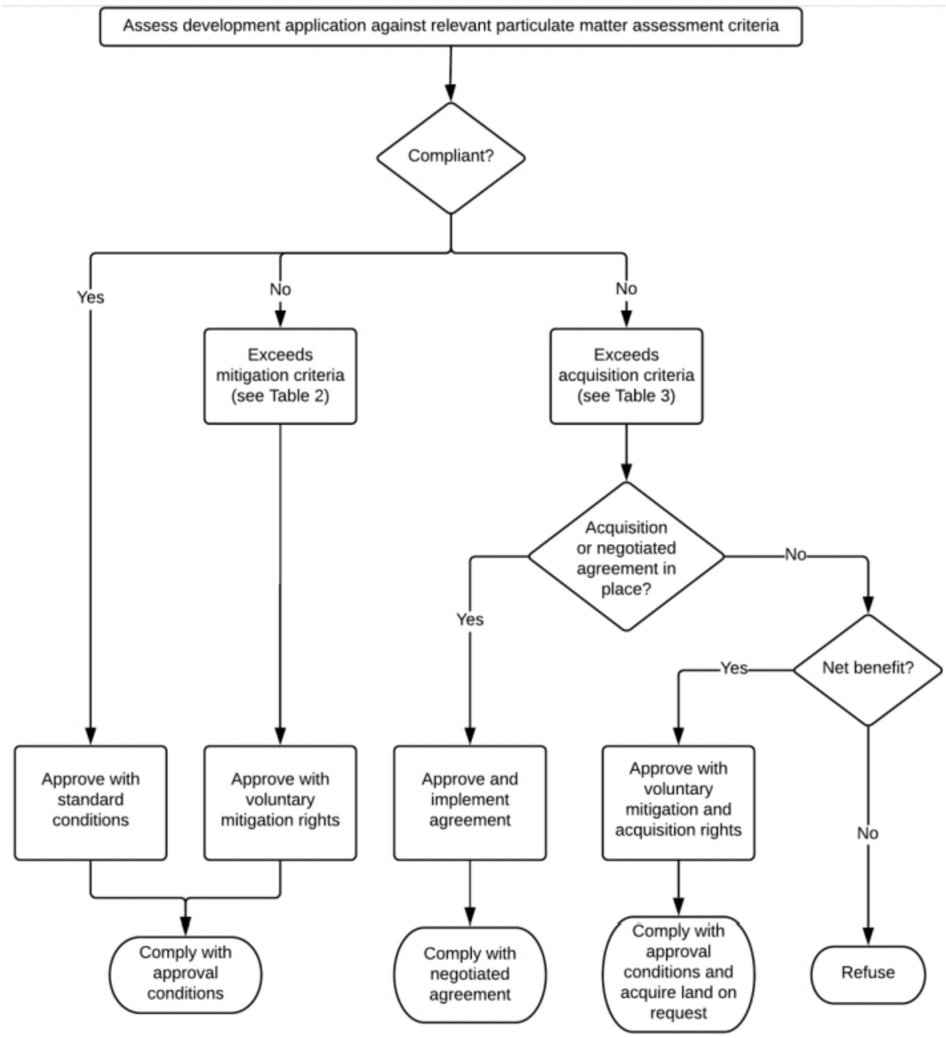


Figure 3-1 Decision-making process for particulate matter impacts (NSW Government, 2018)

3.1.4 *National Environment Protection Measure*

The National Environment Protection (Ambient Air Quality) Measure (NEPM) (Australian Government, 2016) is a Commonwealth Government initiative which sets uniform standards for ambient air quality for six major air species (carbon monoxide, nitrogen dioxide, photochemical oxidants (as ozone), sulfur dioxide, lead, particles as PM_{10} and $PM_{2.5}$.

All States and Territories including NSW have adopted the NEPM air quality standards for these species. The criteria relating to potential emissions from the Proposed Project are outlined in *Table 3-8*. The NEPM criteria have been incorporated into the NSW EPA impact assessment criteria.

Table 3-8 NEPM (Ambient Air Quality) Standards (Australian Government, 2016)

Species	Averaging Period	Maximum Concentration	Maximum Allowable Exceedances
CO	8 hours	9 ppm 11,243 μg/m³	1 day a year
NO_2	1 hour	0.12 ppm 246 μg/m³	1 day a year
	1 year	0.03 ppm 61 μg/m³	None
SO_2	1 hour	0.2 ppm 571 μg/m³	1 day a year
	1 day	0.08 ppm 228.4 μg/m³	1 day a year
	1 year	0.02 ppm 57 μg/m³	None
Lead	1 year	0.5 μg/m³	None
Particles as PM_{10}	24 hour	25 μg/m³	None
	Annual	50 μg/m³	None
	24 hour	25 μg/m³	None
Particles as $PM_{2.5}$	Annual	8 μg/m³	None

Measurements for determination of compliance against the NEPM criteria (*Table 3-8*) are completed at locations away from major roads and industry in locations where background air quality is representative of a population of 25,000 people. Consequently, it is not intended that the NEPM values indicate acceptable concentrations of ambient air quality adjacent to industry. Consequently, these standards have not been considered further in this assessment.

3.1.5 *Other Legislation*

For species considered in this Assessment and not included either in Approved Methods, the criteria were sourced from Ontario Regulation 419/06: Air Pollution – Local Air Quality (Government of Ontario, 2017) as provided in *Table 3-9*.

Table 3-9 Criteria sourced from Ontario Regulation 419/06 (Government of Ontario, 2017)

Species	Averaging period	Criterion (µg/m³)
n-Heptane	30 minutes	33,000
	24 hour	11,000
Zinc	30 minutes	100
	24 hour	120

3.1.6 Protocol for Environmental Management Mining and Extractive Industries

Ryolite is an igneous, volcanic rock, which is typically silica rich. During blasting, crushing and handling of material, there is potential that a portion of the particulate matter released will be comprised of crystalline silica. Crystaline silica has the potential to cause silicosis.

The Approved Methods does not contain standards for crystalline silica. ERM has therefore adopted the approach outlined by the Victorian Protocol for Environmental Management for the Mining and Extractive Industries (Mining PEM), which is an incorporated document to Victoria's State Environment Protection Policy for Air Quality Management.

The Mining PEM provides an assessment criterion for respirable crystalline silica (expressed as $PM_{2.5}$ of 3 µg/m³ as an annual average). This criterion was adopted in this assessment.

3.2 GREENHOUSE GAS

3.2.1 Federal Legislation

Federal parliament passed the National Greenhouse and Energy Reporting Act 2007 (the NGER Act) in September 2007 (Commonwealth of Australia, 2007). The NGER Act establishes a mandatory corporate reporting system for greenhouse gas emissions, energy consumption and production.

The NGER Act is one of a number of legislative instruments related to greenhouse reporting, which together form the National Greenhouse and Energy Reporting System (NGERs), as follows:

- The National Greenhouse and Energy Reporting Regulations 2008 (Commonwealth of Australia, 2017) includes the most recent amendments and provide the necessary details that allow compliance with, and administration of, the NGER Act.
- The National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Australian Government Department of the Environment and Energy, 2011) provides methods and criteria for calculating greenhouse gas emissions and energy data under the NGER Act.

- The National Greenhouse and Energy Reporting (Audit) Determination 2009 (Commonwealth of Australia, 2009) sets out the requirements for preparing, conducting and reporting on greenhouse and energy audits.

The NGER Act is seen as an important first step in the establishment of a domestic emissions trading scheme. This intention is stated in the objectives for the NGER Act, as follows:

- establish a baseline of emissions for participants in a future Australian emissions trading scheme;
- inform the Australian public;
- meet international reporting obligations; and
- assist policy formulation of all Australian governments while avoiding duplication of similar reporting requirements.

The NGER legislation sets corporate and facility reporting thresholds for greenhouse gas emissions and energy consumption or energy production beyond which corporations/ facilities are required to report (*Table 3-10)*. Based on the findings of this study, annual greenhouse gas emissions from the Sancrox will not exceed the NGERs facility threshold (refer to Section *5* for emission estimates). Therefore, Sancrox will not be required to report greenhouse gas emissions and energy consumption/production from the Project.

Table 3-10 NGER Reporting Threshold

Year	Corporate Threshold		Facility Threshold		
	Greenhouse gas emissions (kt CO_2-e)	Amount of energy produced (TJ)	Greenhouse Gas Emissions (kt CO_2-e)	Energy Consume d (TJ)	Energy Produced (TJ)
2008-2009	125	500			
2009-2010	87.5	350	25	100	100
2010-current	50	200			

3.2.2 *State Legislation*

Whilst no legislation exists in NSW mandating the reduction of GHG emissions, reference was made to the SEARs issued by the NSW Government for the Sancrox Quarry Extension Project (NSW Government Department of Planning & Environment , 2017).

The SEARs provide no specific guideline towards reporting greenhouse gas emissions for EIS purposes. Therefore emissions from the Project have been estimated in accordance to the NGER legislation (Australian Government Department of the Environment and Energy, 2011), which mandates facilities above the reporting threshold to report their annual Scope 1 and Scope 2 emissions. Scope 3 emissions are not reported under the NGER legislation and therefore not considered in this assessment.

4 EXISTING ENVIRONMENT

4.1 GENERAL METEOROLOGICAL CONDITIONS

Local meteorology plays a major role in determining the location and the degree of off-site impacts of activities proposed to be carried out at the site. Air dispersion modelling requires information about the dispersion characteristics of the area. In particular, data is required on wind direction, wind speed, temperature, atmospheric stability and mixing height. This meteorological data is outlined in the following Sections.

4.2 CLIMATE

Long-term climate data is available from the Bureau of Meteorology (BoM) weather station located in Port Macquarie (Airport), approximately 3.5 km east of the site. *Table 4-1* presents temperature, humidity and rainfall statistics from this weather station for the period 1995 to 2018, which consists of monthly average 9am and 3pm readings. Monthly averages of maximum and minimum temperatures are also presented. Rainfall data consists of mean monthly rainfall and the average number of rain days per month. Overall, the local area is characterised by:

- Annual average rainfall of 1,428.2 mm;
- Average maximum temperature of 27.7°C in January;
- Average minimum temperature of 6.4°C in July;
- Average maximum 9am humidity of 83% in March; and
- Average minimum 3pm humidity of 52% in August.

4.3 TYPICAL WIND CONDITIONS

Figure 4.1 provides the predicted wind roses (see Section *7.2*) showing the frequency of strength and direction of winds for five recent years (2012 to 2016 inclusive) at the Site. The data has been divided to show annual trends.

The wind roses indicate that typically winds at the subject Site are:

- Most frequently westerly, south-westerly and northerly;
- Occur moderately from the north-western and north-eastern directions;
- Low percentage of winds from the southern direction;
- Rarely from the east; and
- From approximately 6.7% to 11.4% calm conditions (less than 0.5 m/sec).

Table 4-1 Climate Data for Port Macquarie Station obtained from Bureau of Meteorology

Statistic Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Start Year	End Year
Mean maximum temperature (°C)	27.7	27.6	26.4	24.2	21.6	19.5	18.8	20.3	22.7	24.1	25.2	26.8	23.7	1995	2018
Mean minimum temperature (°C)	18.4	18.4	17.0	13.9	10.4	8.3	6.4	6.7	9.4	12.0	15.2	16.9	12.8	1995	2018
Mean rainfall (mm)	150.8	165.5	176.0	139.0	114.4	140.6	61.9	66.6	59.3	75.1	153.9	114.7	1428.2	1995	2018
Mean 9am temperature (°C)	23.3	22.6	20.8	19.5	16.1	13.3	12.3	14.0	17.7	20.1	20.7	22.6	18.6	1995	2010
Mean 9am relative humidity (%)	76	82	83	76	76	78	75	68	64	64	73	72	74	1995	2010
Mean 9am wind speed (km/h)	13.0	12.3	11.5	12.3	12.5	11.5	11.9	12.6	13.6	14.7	14.0	13.6	12.8	1995	2010
Mean 3pm temperature (° C)	26.1	26.0	24.9	22.5	20.1	18.2	17.5	18.7	20.5	21.9	23.1	24.9	26.1	1995	2010
Mean 3pm relative humidity (%)	65	66	65	64	61	60	55	52	56	59	65	64	61	1995	2010
Mean 3pm wind speed (km/h)	22.4	21.6	20.1	17.3	15.3	14.9	16.0	19.0	21.0	22.2	22.5	22.3	19.6	1995	2010

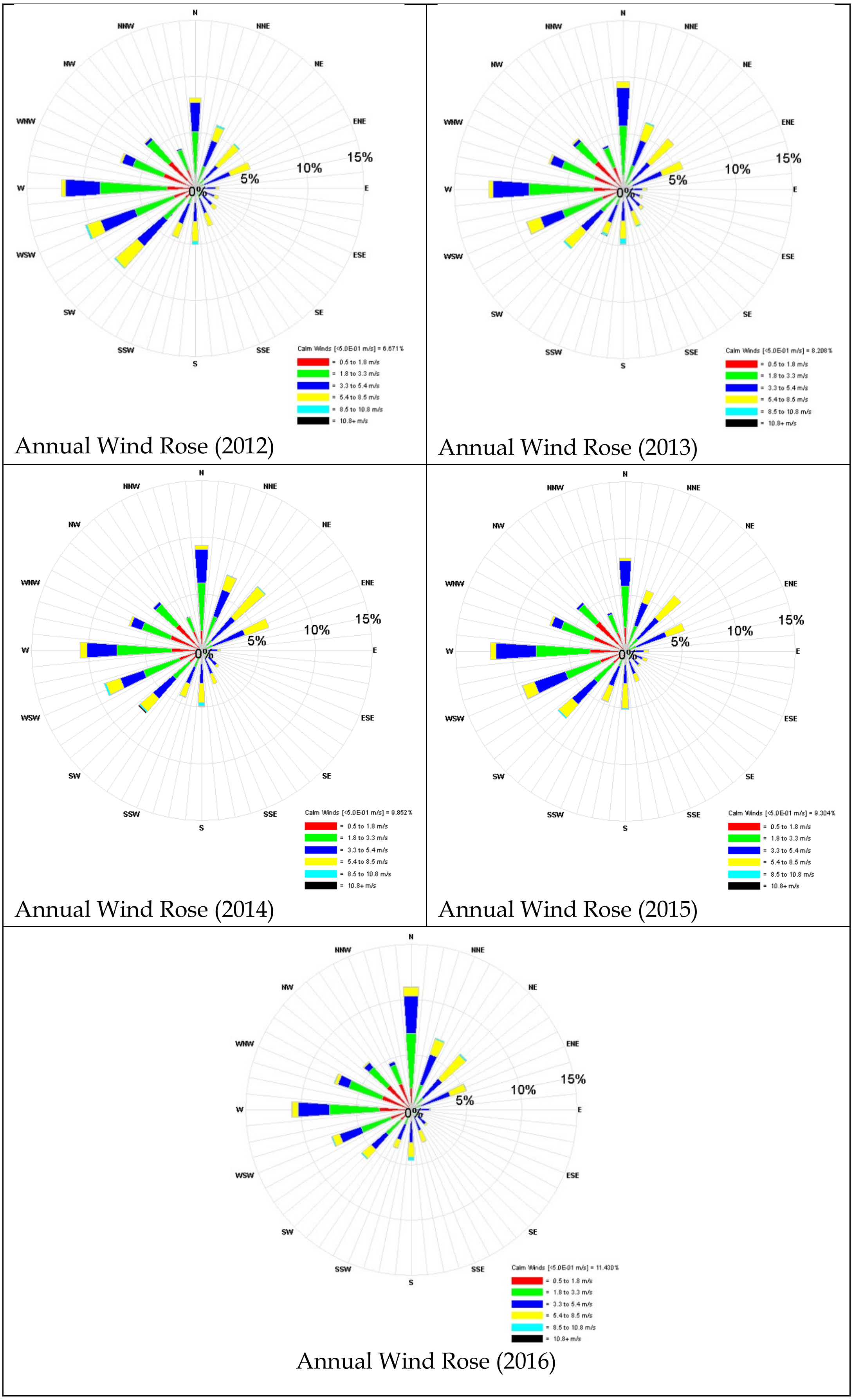


Figure 4-1 Site-Specific annual wind roses (2012-2016)

4.4 *ATMOSPHERIC STABILITY*

Atmospheric stability is one of the key parameters that effects dispersion and dilution of emissions away from source. In essence it describes the degree of thermal and mechanical mixing of the atmosphere that occurs due to wind and thermal heating. Higher stability of the atmosphere typically results in poor dispersion conditions and higher ground level concentrations, whilst unstable atmospheres typically have the opposite impact.

Atmospheric stability is described by the Pasquil-Gifford classification where:

- Category A describes a very unstable atmosphere;
- Category B describes an unstable atmosphere;
- Category C describe a moderately unstable atmosphere;
- Category D describes a neutral atmosphere;
- Category E describes a stable atmosphere;
- Category F describes a very stable atmosphere; and
- Category G describes a very very stable atmosphere.

Usually, categories F and G are combined when describing the frequency of these categories.

Typically, these atmospheric conditions occur under the following conditions:

- Category A – Very sunny and very windy conditions;
- Category B – Very sunny but less windy conditions;
- Category C – Moderately sunny and moderately windy conditions;
- Category D – The hours around sunrise and sunset in addition to overcast conditions;
- Category E, F and G – Mostly clear or clear night time conditions with decreasing wind speed.

Figure 4.2 shows the predicted frequency of stability categories at the Site. Stability categories have been predicted using the methodology outlined in Section *7.1*.

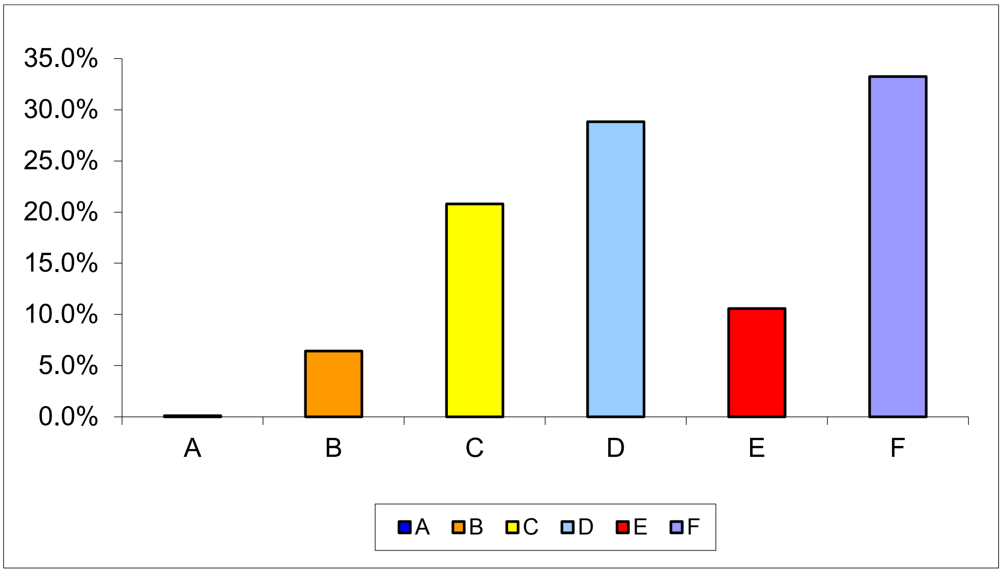


Figure 4-2 *Frequency of Atmospheric Stability Categories predicted for the Site*

The distribution of modelled stability categories based on five recent years of data (2012 to 2016 inclusive) indicates that there are:

- Relatively few windy days with high solar insolation (category A) (0.1%);
- A relatively low amount of sunny days with lighter winds (category B) (6.4%);
- A moderate amount of moderately sunny days with moderate wind conditions (category C) (20.8%);
- A higher percentage of category D, which represents atmospheric stability around dawn and dusk, as well as overcast days and nights (28.8%) ;
- A moderate amount of calm clear night time conditions (category E) (10.6%); and
- A higher percentage of very calm and clear night time conditions (category F) (33.3%).

4.5 *EXISTING AMBIENT AIR QUALITY*

Background air quality is a measure of the existing air quality in the absence of the project activity. The background air quality is due to sources (natural or man-made) other than the site. It is important to consider background air quality when considering cumulative impacts on sensitive receptors in the area.

A desktop review of the National Pollutant Inventory (NPI) of reported emissions from fixed and mobile sources in the vicinity of the site was also undertaken to obtain an indication of existing industries in the project area. There are no facilities within the Port Macquarie region reporting emissions of particulate matter under the NPI reporting scheme with the exception of this

Site. The proposed operation of this Site and proposed increase in activity is included in this air quality assessment.

A review of publications for the PMHC indicated that the Local Government Area has not undertaken any recent air monitoring.

A review of the Office of Environment and Heritage (OEH) website for the NSW Air Quality Monitoring Network, indicates that ambient monitoring is completed for PM_{10}, $PM_{2.5}$ and NO_2 at the following locations for the Lower Hunter and Central Coast:

- Beresfield;
- Carrington;
- Mayfield;
- Newcastle;
- Stockton;
- Wallsend; and
- Wyong.

There are no ambient air quality measurements on the North Coast.

Of the available monitoring stations in the Lower Hunter and Central Coast, only the monitor at Wyong is both close to the coast and outside of the major urban area of Newcastle. Measurements from Wyong were therefore selected as representative background concentrations for the project area.

4.5.1 *Particulate Matter*

Table 4-2 provides the maximum measured 24 hour concentrations for PM_{10} and $PM_{2.5}$ as measured at Wyong for the modelled years.

Table 4-2 Maximum measured 24 hour average and annual mean concentrations (µg/m³) for PM_{10} and $PM_{2.5}$, as measured at Wyong for 2012 to 2016

Species	Averaging Period	Year 2012	2013	2014	2015	2016	Criterion
PM_{10}	24 Hour Mean	37.4	70.2	41.9	58.6	46	50
	Annual Mean	16.6	16.6	15.1	14.9	15.2	25
$PM_{2.5}$	24 Hour Mean	14.7	55.8	19.7	13.2	19.8	25
	Annual Mean	6.7	6.7	5.5	5.2	5.7	8

No measurements are taken at Wyong for Total Suspended Particulate (TSP). Consequently, for this assessment, the annual mean TSP concentration has conservatively been assumed to be double the annual mean PM_{10} concentration for each year.

The values in *Table 4-2* and the estimated values for TSP have been used in the level 1 assessment as outlined in Sections *8.1* and *8.2*.

As discussed in Sections *8.1* and *8.2*, a level 2 assessment was required for PM_{10} and $PM_{2.5}$. One hour average concentrations were downloaded from the Office of Environment and Heritage website, and added to the model results on an hour by hour basis as discussed in Section *7.6.4*.

4.5.2 *Dust Deposition*

There is no dust deposition monitoring program currently undertaken in the vicinity of the site. No public information regarding background dust deposition levels in the Sancrox region. In the absence of site specific monitoring data a cumulative assessment of dust deposition has not been undertaken.

Criteria for dust deposition, specified in the Approved Methods, allows an annual mean deposition rate of 4g/m²/month, no more than 2g/m²/month above background.

In the absence of site specific monitoring data, and as shown in *Table 3-3*, a criteria of an annual mean generated concentration of 2g/m²/month has been used to ensure the a cumulative impact from the site will remain below 2g/m²/month above background.

4.5.3 *Nitrogen Dioxide*

Table 4-3 provides the maximum measured 1 hour and annual mean concentrations for NO_2 as measured at Wyong for the modelled years. These values have been used in the Level 1 assessment as described in Section *8.3*.

Table 4-3 Maximum measured 1 hour average and annual mean NO_2 concentrations NO_2 as measured at Wyong for 2012 to 2016

Species	Averaging Period	Year					Criterion
		2012	2013	2014	2015	2016	
NO_2	1 Hour Mean	59.5	84.1	69.8	65.7	94.4	246
	Annual Mean	7.8	10.3	10.2	9.3	9.7	62

5 *GHG EMISSIONS INVENTORY*

GHG emissions from the Project have been estimated based on the methods outlined in the following documents:

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition ("the GHG Protocol") (World Business Council for Sustainable Development, World Resources Institute, 2015).
- The National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Australian Government Department of the Environment and Energy, 2011).
- The Australian Government Department of Environment and Energy National Greenhouse and Energy Reporting Scheme Measurement – Technical Guidelines for the estimation of emissions by facilities in Australia (Australian Government Department of the Environment and Energy, 2017a)
- The Australian Government Department of Environment and Energy National Greenhouse Accounts (NGA) Factors July 2017 (Australian Government Department of the Environment and Energy, 2017b).
- The Mining Association of Canada Towards Sustainable Mining – Energy and GHG Emissions Management Reference Guide (The Mining Association of Canada, 2014)
- Australia Transport Authorities Greenhouse Group, Greenhouse Gas Assessment Workbook for Road Projects (Transport Authorities Greenhouse Group Australia and New Zealand, 2013).

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Standard Organisation, endorsed by GHG initiatives (such as the Carbon Disclosure Proposal) and is compatible with existing GHG trading schemes.

Three 'scopes' of emissions (Scope 1, Scope 2 and Scope 3) are defined for GHG accounting and reporting purposes, as described below and summarised in *Figure 5.1*. This terminology has been adopted in Australian GHG reporting and measurement methods (Australian Government Department of the Environment and Energy, 2011) and has been employed in this assessment.

5.1.1 *Scope 1: Direct Greenhouse Gas Emissions*

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct GHG emissions are those emissions that are the result of the following types of activities undertaken by the entity (Sancrox Quarry, Concrete Batching, Concrete Recycling and Asphalt plants):

- Construction activities – these emissions result from the combustion of fuels in Hanson owned/ controlled industrial vehicles and equipment (e.g., excavators, graders, front-end loaders etc.), as well as clearing of land and sealing haul roads;

- Generation of electricity, heat or steam – the emissions result from the combustion of fuels in stationary sources;

- Physical or chemical processing – it is assumed that no emissions are emitted as by-product from the processing plant operations;

- Blasting – emissions that result from the use of explosives onsite e.g., ANFO; and

- Transportation of materials and products - these emissions result from the combustion of fuels in Hanson owned/controlled mobile combustion sources; e.g., haul trucks, product transport trucks, etc.

5.1.2 Scope 2: Energy Product Use – Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that account for GHG emissions from the generation of purchased energy products (principally, electricity and steam/heat) by the entity. Scope 2 in relation to the Project covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity.

5.1.3 Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of Scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

The GHG Protocol provides that reporting Scope 3 emissions is optional. In the Australian context, the NGER legislation does not require reporting for Scope 3 emissions from a facility.

In the absence of Project specific requirement under the SEARs and in line with the NGER legislation, scope 3 emissions have not been accounted for in this assessment.

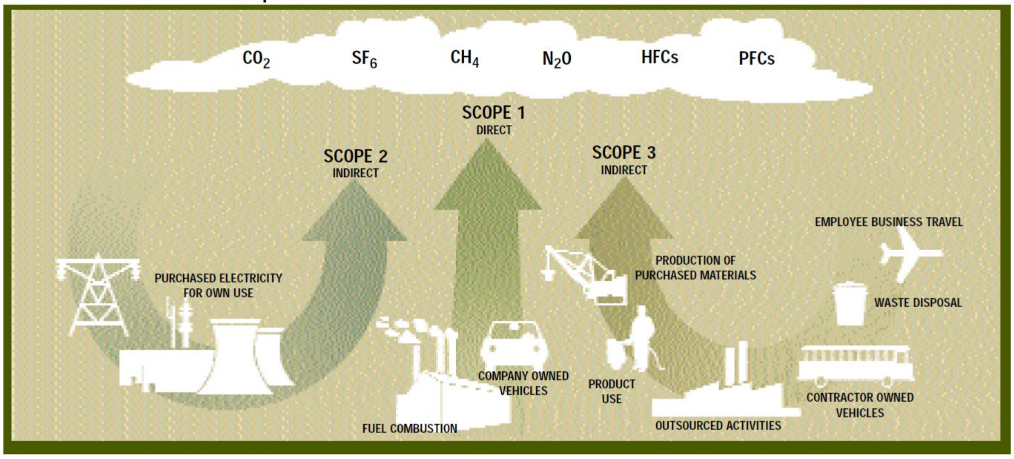


Figure 5-1 Overview of Scopes and Emissions across a Reporting Entity

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials), and emission factors take into account the global warming potentials of the gases created during combustion. The estimated emissions are referred to in terms of carbon dioxide equivalent, or CO_2-e, emissions by applying the relevant global warming potential. The GHG Assessment has been conducted using the documents referenced above.

5.2 CONSTRUCTION RELATED GHG EMISSIONS

Emissions from construction related activity including vegetation clearing were calculated based on Transport Authorities Greenhouse Group Workbook (Transport Authorities Greenhouse Group Australia and New Zealand, 2013).

GHG emissions from vegetation clearing accounts for the carbon that exists in the vegetation at the time of clearing and carbon that could have been sequestered in future if vegetation was not cleared. Vegetation clearing is proposed to be undertaken in six steps, provided *Table 5-1*, together with the corresponding Quarry stages. With the exception of Step 1, each step represent activities over a two-year period per step.

Table 5-1 Vegetation clearing steps

Step	Quarry Stage	Details	Area cleared in hectare (ha)
Step 1	Stage 1	Clearing for stockpiles and processing plant	6.07
Step 2		Clearing for mining purposes	4.87
Step 3	Stage 2	Clearing for mining purposes	9.29
Step 4	Stage 3	Clearing for mining purposes	No vegetation clearing required, quarry increasing in depth not lateral extent
Step 5	Stage 4	Clearing for mining purposes	11.94
Step 6	Stage 5	Clearing for mining purposes	8.50

GHG emissions from the construction phase of the Project involve combustion of liquid fuel used in land clearing and earthmoving machinery.

A summary of the construction related GHG emissions (including vegetation clearing) is provided in *Table 5-2*. Details on the methodology including emission factors used are provided in Appendix A.

Table 5-2 Summary of construction related GHG emissions (t CO_2-e) – Scope 1

Step	Vegetation Clearing[1]	Liquid fuel combustion[1]	Total
Step 1	862	244	1,106
Step 2	692	83	775
Step 3	1,319	101	1,420
Step 4	Not required	n/a	n/a
Step 5	1,696	129	1,825
Step 6	1,207	92	1,299

1. from clearing and grubbing of vegetated areas and earth moving equipment

For each step emissions from vegetation clearing account for at least 75% or more of the total construction related emissions from the Project. The largest construction related GHG emissions can be expected to occur during Stage 1 of the quarry development due to the GHG emissions from vegetation clearing for stockpile and processing plant, additional to vegetation clearing for mining purposes.

5.3 OPERATIONS RELATED GHG EMISSIONS

The operations related GHG emissions are associated with the use of different fuels (diesel, LNG and explosives) related to mining, processing and transporting product (Scope 1) and the purchase of electricity (Scope 2).

Information on the quantity of fuel and amount of electricity consumed were based on ERM's experience with projects of similar nature and are detailed in Appendix A together with the emission rates used.

A summary of the annual GHG emissions associated with the proposed operations at Sancrox quarry is provided in *Table 5-3*.

Table 5-3 Estimated annual total GHG emissions (t CO_2-e) from operations

Type of fuel	Scope 1	Scope 2	Total
Diesel – transport related	2,017	-	2,017
Diesel – stationary energy purpose	287	-	287
Blasting – ANFO	1	-	1
Electricity	-	1,348	1,348
LNG	864	-	864
Total	3,169	1,348	4,517

5.4 *GHG EMISSIONS SUMMARY*

A summary of the annualised GHG emissions from the Project over the 10-year life is presented in *Table 5-4* and plotted in *Figure 5.2*. The Project over its entire life cycle is estimated to release approximately 48.4 million tonnes of CO_2-e into the atmosphere with Scope 1 and Scope 2 emissions accounting for 74% and 26% respectively of the total emissions. The main GHG emission sources over the life of the project representing 99% of all emissions are:

- Operations – Diesel for transport related purposes (38%);
- Operations – Electricity (26%);
- Operations – LNG (16%);
- Construction – Vegetation clearing (12%); and
- Operations – Diesel for stationary energy purposes (6%).

Table 5-4 Summary of estimated annual average GHG emissions (t CO_2-e) from Project – Scope 1 and Scope 2

Year	Scope 1	Scope 2	Total
Year 1	2,185[1]	674[2]	2,843
Year 2	3,541	1,348	4,889
Year 3	3,879	1,348	5,227
Year 4	3,879	1,348	5,227
Year 5	3,169	1,348	4,517
Year 6	3,169	1,348	4,517
Year 7	4,082	1,348	5,429
Year 8	4,082	1,348	5,429
Year 9	3,818	1,348	5,166
Year 10	3,818	1,348	5,166

1.
   a. Assumes construction related activity related to Processing plant takes a year for completion ;
   b. assumes that diesel usage (for operations) is 20% of the nominal required for transportation purposes;
   c. there is no LNG usage associated with asphalt plant
   d. includes construction related to sealed roads
2. Assumes electricity requirements are 50% of the nominal consumption;

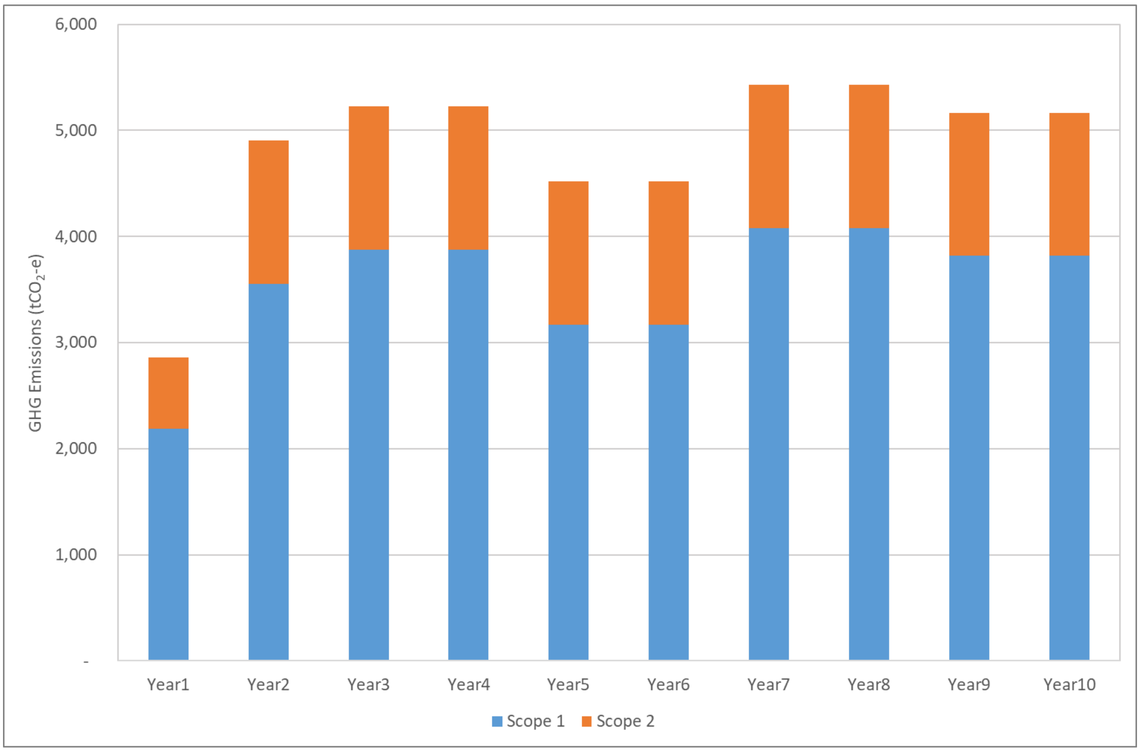


Figure 5-2 ***GHG Emissions Summary- Scope 1 and Scope 2 (Year 1 to Year 10)***

Scope 1 emissions from the Project split by emission sources is plotted in *Figure 5.3*. Relatively lower emissions are associated with Year 5 and Year 6 resulting from no proposed vegetation clearing during this time. The highest annual GHG emissions (4,082tCO_2-e) is expected to occur during Year 7 to Year 8 of operations.

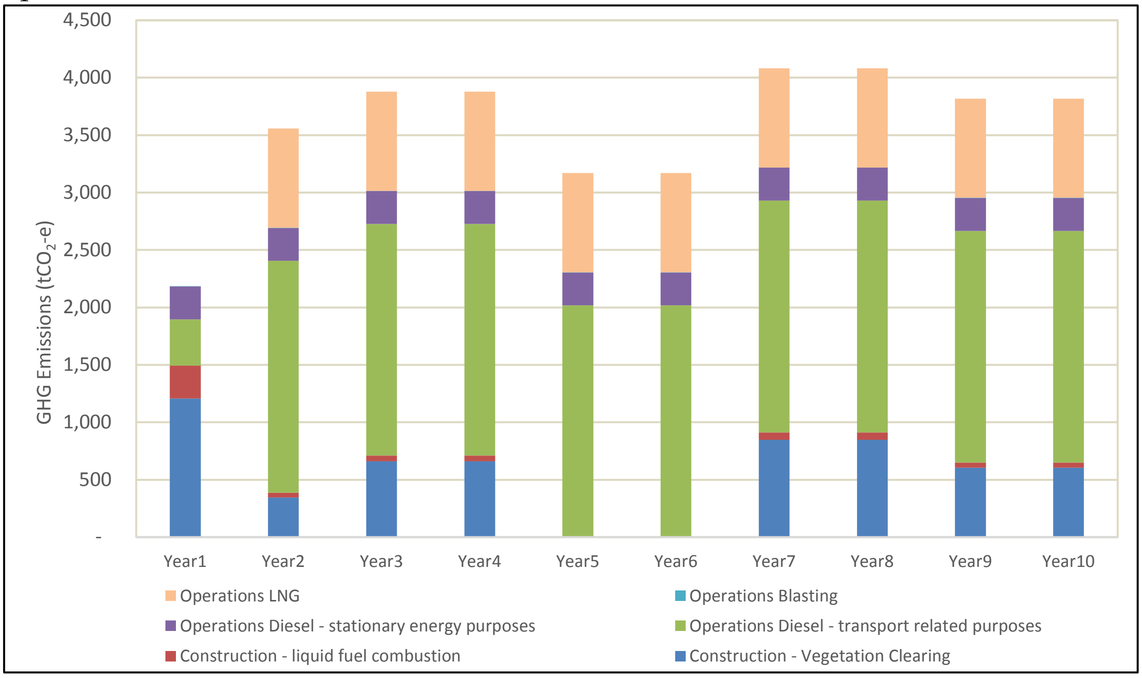


Figure 5-3 ***GHG Emissions Summary Scope 1 (Year 1 to Year 10)***

The Project's contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Peak Scope 1 and Scope 2 emissions from the Project (approximately 0.0054 Mt CO_2-e during Year 7/Year8) would represent approximately 0.0010% of Australia's commitment for annual emissions under the Kyoto Protocol (550.2 Mt CO2-e/annum for 2016-17). In comparison to the 2015 GHG emissions in NSW, the project emissions account for approximately 0.0041%. When compared to the 2015 GHG emission levels from all Mining sources in Australia (74.5 Mt CO_2-e), the Project accounts to 0.0073%.

6 *AIR QUALITY EMISSIONS INVENTORY*

Sections *6.1* to *6.4* discuss site operation, air emission sources and provide the summary of emission rates used in the dispersion modelling. The details of emission estimation are provided in *Annex B*.

6.1 *SITE OPERATIONS*

The proposed operating hours for the Project are 24 hours per day, seven days per week. Emissions from all the sources, except for some wheel-generated dust, have therefore been assumed to occur on every single hour of the year based on annual production. Wheel movements within the boundaries of the Site were assumed to spread evenly throughout 24 hours of operations. Wheel movements in and out of quarry within the dispersion model sought to represent the most likely traffic distribution scenario and therefore used typical market operational hours (6am to 6pm). It is expected that on rare occasions there may be additional movements outside of these adopted hours and impacts from these emission will be managed through real time monitoring at the boundaries of the Site to ensure there is no impact on the sensitive receptor locations (please refer to *Section 10*).

6.2 *QUARRY OPERATIONS*

Operations related to the quarry, will predominantly generate particulate matter from the following activities:

- Drilling;
- Blasting;
- Product handling, including:
    - Operation of excavators on quarry floor;
    - Rock truck-rear dumping at the processing plant; and
    - Operation of front-end-loaders (FEL) at the processing plant and stockpile area.
- Rock processing, including:
    - Crushing (primary, secondary and tertiary);
    - Screening; and
    - Conveying.
- Wheel generated dust from truck movements; and

- Wind generated dust from stockpiles and exposed areas.

Emissions have been estimated using the published emission factors from the following sources:

- Australian National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012); and
- Australian National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining and Processing of Non-Metallic Minerals Version 2.1 (Australian Government Department of the Environment, 2014).

6.2.1 *Drilling*

Drilling activities produce dust from the mechanical action of the drill. Drilling will take up to 20 hours in total in preparation for blasting a bench. The drill pattern will be determined by geological conditions on a shot by shot basis. A typical plan will be 3 x 3 metres (staggered) consisting of 125, 89mm diameter holes, with individual holes drilled up to a depth of approximately 11 metres. The drilling operations have a full dust extraction system and it is considered that dust emissions from this activity will be low.

Drilling will occur for 20 hours prior to blasting and emissions have been estimated for this time period accordingly (see *Section B.1.1* of Annex *B*).

6.2.2 *Blasting*

Hanson advised ERM that approximately 30 blasts per annum will be needed to yield the proposed 750,000 tonnes of rock. Area blasted in each blast will be 900 m^2 with the depth of blast holes of 11 metres. Blasting will occur over a short duration; however it will produce airborne particulate matter which has the potential to impact nearby receptors. Emissions per blast were estimated accordingly (see *Section 12B.1.2* of *Annex B*).

6.2.3 *Product handling*

Excavators on Quarry Floor

Blasting will reduce most of the in-situ rock to smaller fragments of less than one cubic metre in size. Each blast will yield approximately 25,740 tonnes of fragmented rock which will be sorted by one excavator at the quarry floor. Another excavator will load material into either rock trucks for transfer to the processing plant or truck-and-dog-type road trucks for direct delivery to market.

Emissions were estimated for the loading of trucks with the blasted material, occurring 24 hours a day (see Section *B.1.3* of Annex *B*).

Truck Rear Dumping

Fragmented rock delivered by rock trucks to the processing plant will be rear dumped directly to the feed hopper for processing, therefore one truck rear dumping emission source at the processing plant was included in the dispersion modelling. Water sprays will be used during truck rear dumping to minimise dust emissions.

Emissions were estimated for the rear dumping of rock, incorporating designed mitigation measures, at the process plant occurring 24 hours a day (see Section *B.1.3* of Annex *B*).

Front-End-Loaders

Processed rock at the processing facility will be stored in the stockpiles, from where the rock will be loaded to the trucks and taken either offsite, to the asphalt plant or to the concrete batching plant. Product will be loaded to the trucks using FELs. Operation of one FEL at the processing plant and one at stockpile area was included in the dispersion modelling. These FELs will also be used at the adjacent concrete recycling plant as needed. Mobile sprinkler systems will be used during the operation of FELs to minimise dust emissions.

Emissions were estimated for the use of FEL at the processing facility and the stockpile area occurring 24 hours a day (see Section *B.1.3* of Annex *B*).

6.2.4 Rock Processing

Crushing and Screening

The processing plant reduces the size of feed rock by crushing. Screens are used to separate the material into various sizes and product types. The dispersion modelling included primary, secondary and tertiary crushers and two screens. Dust suppression measures including water sprays will be in place and therefore this emission control was considered in the dispersion modelling.

Emissions were estimated for the crushing and screening at the processing facility incorporating designed mitigation occurring 24 hours a day (see Section *B.1.4* of Annex *B*).

Conveyor Transfer Points

Conveyors will transfer moist crushed product from the screening area to stockpiles of various sizes. Three conveyor transfer points and eight conveyor drop points have been included in the dispersion modelling assessment. Water sprays will be used on all conveyor transfer points.

Emissions were estimated for the conveyors incorporating designed mitigation occurring 24 hours a day (see Section *B.1.4* of Annex *B*).

6.2.5 *Wheel Generated Dust*

As previously discussed in Section *2.1.1*, the roads, which are likely to remain unchanged throughout the stages of the Project and to be frequently used by machinery, will be sealed using asphalt and swept daily to minimise wheel-generated dust emissions. The dispersion modelling therefore only considered dust emissions from unsealed roads.

It is estimated that 10% of broken rock will be loaded and hauled directly to market. ERM understands that the product will be taken offsite by truck and dog-type trucks. Given the volume of the material hauled (75,000 tpa) and the assumed capacity of the trucks (32.43 tonnes), it is estimated that an average of nine loaded haul movements would occur per day. Given the delivery statistics for the year 1.09.2016 to 31.08.2017 provided to ERM, the haul movements direct from quarry face to the market were assumed to occur during the busiest nine hours of the day – 7am to 4pm.

It is expected that approximately 90% of broken rock (675,000 tpa) will be taken to the processing facility. ERM understands that the site will utilise Caterpillar 769C trucks to haul the material from the working faces to the processing plant. Given the volume of the extracted material it is estimated that an average of 50 loaded haul movements per day will be required, which will occur 24 hours per day, every day of the year.

Operations at the concrete batching plant require coarse aggregate. Section 11.12 of AP-42 (United States Environmental Protection Agency, 2006) suggests that concrete mix requires approximately 46% of coarse aggregate (further discussed in Section *6.3.6*). It is therefore estimated that an average of two loaded haul trips from stockpile area to concrete batching plant will occur daily.

Operations at the asphalt plant will require high quality aggregate for production of asphalt. As asphalt plant is located next to the processing plant no additional haulage movements were included in the dispersion modelling.

All loaded haul movements, require empty trucks to return in the opposite direction. The movement of empty trucks was also included in the estimation of emissions.

Level 2 watering (more than 2 litres/m^2/hour) will be applied to unsealed roads to minimise impact from hauling.

Emissions were estimated for wheel generated dust incorporating designed mitigation (Level 2 watering). See Section *B.1.5* of Annex *B* for calculations.

6.2.6 *Wind Generated Dust*

Wind erosion is expected to generate particulate matter emissions from exposed areas and stockpiles. Wind erosion has been modelled occurring at wind speeds over 5.4 metres per second.

Stockpiles

Product will be continuously stockpiled around the processing plant. Wind erosion of stockpiles of unprocessed and processed material represents a potential emission source.

The approximate stockpile area of 11,695 m^2 for the current operations of 455,000 tpa was estimated using Nearmap imagery taken on 22 August 2017. It was considered that the growth of stockpile area will be proportional to the growth of output and therefore output of 750,000 tpa will require a stockpile area of approximately 35,665 m^2. Dispersion modelling has included 10 stockpiles of equal size to represent the required stockpile area. An additional nine stockpiles were included, located under conveyor drop points at the processing plant.

Water sprays will be utilised to minimise wind erosion from stockpiles during wind speeds of over 5.4 metres per second and therefore were considered in the dispersion modelling.

Emissions were estimated for wind generated dust from stockpiles, incorporating mitigation, to produce a time varying emission file that provides for emissions when wind speeds are elevated (see Section *B.1.6* of Annex *B*).

Exposed Areas

Wind erosion is expected to generate particulate matter emissions from exposed areas such as the pit floor (approximately 38.4 hectares). Emissions from this source only occur when the ground wind speed is predicted to be more than 5.4 m/sec. Ground level wind speeds predicted by meteorological modelling (discussed in Section *7.2*) however did not exceed 5.4 meter per second threshold on any hour of the five recent years of meteorology data used in the modelling. Wind generated emissions from exposed areas therefore were not included in the dispersion modelling.

6.3 CONCRETE RECYCLING PLANT

The proposed concrete recycling facility will process up to 20,000 tpa of concrete delivered at the Site. The potential sources of particulate matter emissions from central mix concrete batching plants generally include:

- Delivery of dry products to ground storage;
- Storage of dry products;
- Transfer of dry products using FELs;
- Conveyor transfer points;
- Concrete crushing using a mobile primary crusher; and
- Wheel generated dust from haul roads.

6.3.1 *Delivery of dry products*

Concrete for recycling will be delivered to site by the delivery trucks. The product will be dumped to the aggregate storage bins and therefore one rear dumping emission source at the concrete recycling facility was included in the dispersion modelling. Water sprays will be used during truck rear dumping to minimise dust emissions.

Emissions were estimated for the delivery of dry products, incorporating mitigation of water spray (see Section *B.2.1* of Annex *B*).

6.3.2 *Storage of dry products*

Concrete delivered on site will be stored in aggregate storage bins enclosed on three sides. The walls will extend one metre above the height of the maximum quantity of raw material, and extend two metre beyond the front of the stockpile. The aggregate storage bins will be fitted with water sprays to keep the stored material damp at all times. It is therefore considered that no wind-blown dust emissions will occur from the storage of product near the concrete batching plant, and have not been considered further in this assessment.

6.3.3 *Transfer of product*

The delivered concrete will be transferred from aggregate storage bins to conveyor belt using a FEL. As necessary, the concrete recycling facility will utilise one of the FELs in the vicinity of the processing plant and stockpile area. No additional FEL emission points have therefore been included in the dispersion modelling. Mobile sprinkler system will be used during the operation of FELs to minimise dust emissions.

6.3.4 *Conveyor transfer points*

ERM understands that the conveyor system at the facility will not include any uncovered conveyor transfer points and the loading point will be enclosed by a shroud. It is therefore considered that dust emissions from this source will be minimised and this source was not considered further in this assessment.

6.3.5 *Crusher*

The concrete recycling plant will include one mobile primary crusher fitted with water sprays. The details of emission estimation are presented in *Section B.2.2* of *Annex B*.

6.3.6 *Wheel Generated Dust from Haul Roads*

20,000 tpa of concrete for recycling will be delivered from offsite by road truck-and-dog-type trucks. It was estimated that approximately 2 haul trips per day will be required. Export of the recycled road base from the facility will also require approximately 2 haul trips per day and it was assumed that it will be exported using road truck-and-dog-type trucks. The hours of the deliveries on each day were randomised within 6am to 6pm as previously discussed in *Section 6.1*. Emissions were estimated for wheel based emissions associated with the concrete recycling facility, incorporating mitigation (see *Section B.2.4* of *Annex B*).

6.4 *CONCRETE BATCHING FACILITY*

The proposed concrete batching plant will produce 20,000 m^3 per annum of central mixed product. The concrete mix production requires dry products (aggregate and sand) and moist product (cement supplement and cement) (United States Environmental Protection Agency, 2006). The potential sources of particulate matter emissions from central mix concrete batching plants generally include:

- Delivery of dry products to ground storage;
- Storage of dry products;
- Transfer of dry products using FELs;
- Pneumatic unloading of moist products from delivery trucks to elevated storage silos;
- Weigh hopper loading;
- Mixer loading; and
- Wheel generated dust from haul roads.

Emissions have been estimated using published emission factors from the following source:

- United States Environment Protection Agency AP-42 Air Emissions Factors and Quantification, Chapter 11: Mineral Products Industry, Section 11.12 Concrete Batching (United States Environmental Protection Agency, 2006).

It should be noted that in addition to particulate matter emissions, emissions from the concrete batching plant include metals as specified in AP-42 Section 11.12 (United States Environmental Protection Agency, 2006). These metals were therefore also considered in this assessment (*Annex B*).

6.4.1 *Delivery of dry products*

Coarse aggregate and sand will be delivered to site by the delivery trucks. The product will be dumped to the aggregate storage bins and therefore one rear dumping emission source for all incoming dry material was included in the dispersion modelling. Water sprays will be used during truck rear dumping to minimise dust emissions.

Emissions were estimated for the delivery of dry products, incorporating mitigation of water spray (see *Section B.3*.1 of *Annex B*).

6.4.2 *Storage of dry products*

The product delivered on site will be stored in aggregate storage bins enclosed on three sides. The walls will extend one metre above the height of the maximum quantity of raw material, and extend two metre beyond the front of the stockpile. The aggregate storage bins will be fitted with water sprays to keep the stored material damp at all times. It is therefore considered that no wind-blown dust emissions will occur from the storage of product near the concrete batching plant, and have not been considered further in this assessment.

6.4.3 *Transfer of product*

The dry products will be transferred from aggregate storage bins to conveyor belt using one FEL. Mobile sprinkler system will be used during the operation of FELs to minimise dust emissions.

Emissions were estimated for the transfer of product, incorporating mobile sprinkler water application mitigation (see Section *B.3.*2 of Annex *B*).

6.4.4 *Pneumatic unloading of moist products*

Cement and cement supplement will be delivered to the concrete batching plant in the agitator trucks and pneumatically fed to the bottom-loaded silos. It is therefore considered that particulate matter emissions from this source are negligible, and have not been considered further in this assessment.

6.4.5 *Weigh Hopper and Mixer Loading*

Concrete batching plant will be totally enclosed. One bag filter will be fitted above the pan mixer to minimise particulate matter emissions from the facility.

Emissions were estimated from the bag filter based on the maximum allowable concentration for particulate emissions allowable under the POEO Regulation. Emissions of other identified species have also been estimated (see Section *B.3.*3 of Annex *B*).

6.4.6 *Wheel Generated Dust from Haul Roads*

The concrete mix production requires dry products (aggregate and sand) and moist product (cement supplement and cement). *Table 6-1* provides the estimated volumes of material required for the production of 20,000 m^3 of concrete.

Table 6-1 Concrete mix breakdown

Products	Fraction[1]	Volume (tpa)
Coarse aggregate	0.46	21,868
Sand	0.35	16,750
Cement	0.12	5,764
Cement supplement	0.02	853
Concrete	1	47,200[2]

1. Adopted from AP-42 Section 11.12 (United States Environmental Protection Agency, 2006)
2. Calculated using wet concrete density of the mix of 2,360 kg/m^3 (Edinburgh Napier University, n.d.)

Coarse aggregate will be delivered from the processing facility using Caterpillar 769C rock truck. As previously discussed in *Section 6.2.5*, it is estimated that an average of 2 haul trips from stockpile area to concrete batching plant will occur daily.

Sand will be delivered from offsite by road truck-and-dog-type trucks. Given the volume of material required (*Table 6-1*) and the adopted capacity of the trucks of 32.43 tonnes, it was estimated that approximately 1 haul trip per day will be required. The hours of the deliveries on each day were randomised within 6am to 6pm as previously discussed in *Section 6.1*.

Cement and cement supplement will be delivered to the concrete batching facility using agitator trucks. Given the volume of material required (*Table 6-1*) and the adopted capacity of the agitator trucks of 19.8 tonnes, it was estimated that approximately 1 haul trip per day will be required. The hours of the deliveries on each day were randomised within 6am to 6pm as previously discussed in *Section 6.1*.

Concrete mix will be taken from the site to the market by the agitator trucks and Hanson has advised ERM that approximately 11 deliveries of concrete mix per day will occur. Given the delivery statistics for the year 1.09.2016 to 31.08.2017 provided to ERM, the agitator trucks movements were assumed to occur during the busiest eleven hours of the day – 6am to 5pm.

Emissions were estimated for wheel based emissions associated with the concrete batching plant, incorporating mitigation (see Section *B.3*.4 of Annex).

6.5 ASPHALT PLANT

The proposed asphalt plant on site will produce up to 50,000 tonnes of asphalt per annum. The potential sources of particulate matter emissions from counter-flow drum mix asphalt plants generally include:

- Bitumen delivery and storage;
- High quality aggregate delivery and storage;

- Dryer emissions;
- Truck load out; and
- Wheel generated dust from haul roads.

Emissions have been estimated using published emission factors from the following source:

- United States Environment Protection Agency AP-42 Air Emissions Factors and Quantification, Chapter 11: Mineral Products Industry, Section 11.1 Hot Mix Asphalt Plants (United States Environmental Protection Agency, 2004).

6.5.1 Bitumen Delivery and Storage

Bitumen will be delivered from offsite. It is understood that vapour balancing system will be installed for the delivery of bitumen on site and therefore it is considered that odour and dust emissions from bitumen delivery on site will be negligible. Once delivered, bitumen will be stored in a 50 m^3 tank. It is considered that breathing losses from this tank will be negligible, and therefore were not considered further in this assessment.

6.5.2 High quality aggregate delivery and storage

High quality aggregate for asphalt production will be sourced from the onsite processing plant. One of the FELs located around the processing plant and stockpile area will be utilised to transfer the aggregate to the asphalt plant. No additional FEL emission points therefore were included in the dispersion model. The aggregate at the asphalt plant will be stored in aggregate storage bins enclosed on three sides. The walls will extend one metre above the height of the maximum quantity of raw material, and extend two metre beyond the front of the stockpile. The aggregate storage bins will be fitted with water sprays to keep the stored material damp at all times. It is therefore considered that no wind-blown dust emissions will occur from the storage of product near the asphalt plant.

6.5.3 Dryer Emissions

The asphalt plant will be totally enclosed. One fabric filter associated with the natural-gas fired dryer will be fitted to minimise particulate matter emissions from the facility. It should be noted that in addition to particulate matter emissions, emissions from the dryer include carbon monoxide (CO), oxides of Nitrogen (NOx), sulfur dioxide (SO_2), organic species, metals and odour (United States Environmental Protection Agency, 2004).

While POEO Regulation emission limits were considered, emission factors provided by the AP-42 resulted in much lower emission rates and therefore were adopted in this assessment (see Section *B.3.1* of Annex).

6.5.4 *Truck Load Out*

Vapour recovery system will be employed for transfer of asphalt to trucks and therefore it is considered that odour and dust emissions from this source will be negligible. Emissions from truck load out have therefore not been considered further in this assessment.

6.5.5 *Wheel Generated Dust from Haul Roads*

High quality aggregate constitutes over 92% by weight of the total mixture (46,000 tpa). Due to the proximity of the asphalt plant to the processing plant (approximately 50 metres) it is considered that the aggregate will be continuously transferred to the aggregate storage bins at the asphalt plant using one of the FELs located around processing plant/stockpile area. Therefore no additional haul roads were included in this assessment for the delivery of the aggregate. Bitumen (approximately 8% by weight of the total mixture – 4,000 tpa) will be delivered from offsite. Having considered the capacity of the trucks (assumed to be 19.8 tonnes) and the annual volume of the bitumen delivery, it was estimated that approximately 1 haul trip per day will be required. The hours of the deliveries on each day were randomised within 6am to 6pm as previously discussed in *Section 6.1*.

The asphalt plant will produce up to 50,000 tpa of asphalt. Having considered the capacity of the trucks taking asphalt to the market (assumed to be 20 tonnes), it was estimated that approximately 7 haul trips per day will be associated with export of asphalt offsite. Given the delivery statistics for the year 1.09.2016 to 31.08.2017 provided to ERM, the truck movements associated with asphalt export from the Site were assumed to occur during the busiest seven hours of the day – 9am to 4pm.

Emissions were estimated for wheel based emissions associated with the asphalt plant, incorporating mitigation (see Section *B.3.2* of Annex *B*).

6.6 *EMISSIONS SUMMARY*

Table 6-2 provides the summary of TSP and PM_{10} emission rates used in dispersion modelling. The detailed emission estimation is provided in *Annex B*. $PM_{2.5}$ emissions were derived by post-processing of the PM_{10} results and therefore are discussed in *Section 7.5*.

Table 6-2 TSP and PM_{10} emission rates used in dispersion modelling

Emission source	TSP Emission Rate	PM_{10} Emission Rate	Units	Source
Drilling	0.0001[1]	0.00005[1]	g/sec	Section 1.1.8, NPI Mining[2]
Blasting	3.71[3]	1.93	g/sec	Equation 18, NPI Mining[2]

Emission source	TSP Emission Rate	PM$_{10}$ Emission Rate	Units	Source
Excavators	Time-varying emission rate[4]		g/sec	Equations 10 and 11, NPI Mining[2]
Truck rear dumping	Time-varying emission rate[4]		g/sec	Equations 10, NPI Mining[2]
FELs	Time-varying emission rate[4]		g/sec	Equations 10 and 11, NPI Mining[2]
Primary Crusher	0.013[5]	0.00578[5]	g/sec	Table 17, Emission factor for tertiary controlled crushing[6]
Secondary Crusher	0.008[7]	0.004[7]	g/sec	
Tertiary Crusher	0.006[8]	0.003[8]	g/sec	
Primary Screening	0.023[5]	0.0079[5]	g/sec	Table 17, Emission factor for controlled screening[6]
Secondary Screening	0.015[7]	0.005[7]	g/sec	
Conveyor Drop Points	0.00019[9]	0.00006[9]	g/sec	Table 17, Emission factor for controlled conveyor transfer point
Conveyor Transfer Points	0.00019[9]	0.00006[9]	g/sec	
Wheel generated dust	Time-varying emission rate[10]		g/m/sec	Table 2, NPI Mining[2]
Wind erosion	Time-varying emission rate[10]		g/m/sec	Section 1.1.17 NPI Mining[2]
Mixer Loading with bag filter	0.00024[11]	0.0001[11]	g/sec	POEO Regulation[12]
Dryer with bag filter	0.026	0.003	g/sec	Section 11.1 AP-42[14]

1. Accounts for dust extraction system; Calculated for 125 holes as previously adopted (Environmental Resources Management Australia Pty Ltd, 2013)
2. (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012)
3. Estimated using area of blast of 900m^2 and depth of blast hole of 11 metres as provided by Hanson; and moisture content of the blasted material of 10% as previously adopted (Environmental Resources Management Australia Pty Ltd, 2013)
4. Calculated using moisture content of 9% (Environmental Resources Management Australia Pty Ltd, 2013) and hourly wind speed at the height of 2.5 metres above the ground, predicted in accordance with methodology outlined in *Section 7.1.*
5. Calculated for total tonnage of rock processed (675,000 tpa, averaged over the year)
6. (Australian Government Department of the Environment, 2014)
7. Calculated assuming that only 5/8 of the total rock processed will require secondary crushing
8. Calculated assuming that only 4/8 of the total rock processed will require tertiary crushing
9. Conveyor drop point to stockpiles, calculated assuming equal distribution to each of eight stockpiles (1/8th of the total rock processed)
10. Calculated using silt content of 7% as previously adopted (Environmental Resources Management Australia Pty Ltd, 2013).
11. Assumed volumetric flow for a similar type of facility (Environmental Resources Management Australia Pty Ltd, 2017)
12. Based on POEO regulation allowable solid particles discharge limit, Schedule 3 Cement or lime production or cement or lime handling, Group 6 (New South Wales Government, 2017)
13. Calculated for the total asphalt production of 50,000 tpa, averaged over the year
14. (United States Environmental Protection Agency, 2004) adopted as results in lower emission rate than emission rate required under POEO Regulation

As previously discussed, in addition to particulate matter, the concrete batching and asphalt plants emissions include metals as specified in AP-42 Section 11.1 and Section 11.12 (United States Environmental Protection Agency, 2006) (United States Environment Protection Agency, 2011). *Table 6-3* presents the emission rates considered in this assessment for these additional species.

Table 6-3 Emission rates for other species considered in this assessment

Species	Concrete Batching Plant Bag filter emission rate (g/sec)[1]	Asphalt dryer Bag Filter emission rate (g/sec unless specified otherwise)[2]
NO_x	-	0.02
CO	-	0.1
SO_2	-	0.003
Benzene	-	0.0003
Ethylbenzene	-	0.0002
Formaldehyde	-	0.002
Hexane	-	0.0007
Methyl chloroform	-	0.00004
Polycyclic aromatic hydrocarbon (PAH) as benzo[a]pyrene	-	0.00015
Toluene	-	0.0001
Xylene	-	0.0002
n-Heptane	-	0.007
n-Pentane	-	0.0002
Antimony and compounds	-	$1.4x10^{-7}$ **
Arsenic and compounds	$2.2x10^{-7}$ *	$4.4x10^{-7}$ **
Barium (soluble compound)	-	$4.6x10^{-7}$ **
Cadmium and cadmium compounds	$5.3x10^{-10}$ *	$3.2x10^{-7}$ **
Total Chromium	$9.4x10^{-8}$ *	$4.5x10^{-6}$ **
Copper fumes	-	$2.5x10^{-6}$ **
Chromium VI compounds	-	$2.6x10^{-7}$ **
Lead	$2.7x10^{-8}$ *	$4.9x10^{-7}$ **
Manganese and compounds	$2.8x10^{-6}$ *	$6.1x10^{-6}$ **
Mercury	-	$2.7x10^{-7}$ **
Nickel and nickel compounds	$1.8x10^{-7}$ *	0.00005
Silver soluble compounds (as Ag)	-	$3.8x10^{-7}$ **
Zinc	-	$4.8x10^{-5}$ **
Odour	-	43,333.3 (OU/sec)***

1. Calculated using emission factors obtained from AP-42 Section 11.12 (United States Environmental Protection Agency, 2006)
2. Calculated using emission factors obtained from Section 11.1 (United States Environmental Protection Agency, 2004).

* Calculated for the total concrete mix production of 20,000 m^3 (47,200 tpa), averaged over the year

** Calculated for the total asphalt production (50,000 tpa), averaged over the year

*** Calculated using odour emission rate of 1,040,000 OU m^3/min (GHD, 2008)

6.7 SCREENING ASSESSMENT

Prior to dispersion modelling, a screening assessment was undertaken to determine whether all emissions from the proposed operation were likely to result in material impact to ambient air quality.

It was considered that as the proposed development had multiple sources of particulate matter, these emissions should automatically be considered in the air quality assessment. The asphalt and concrete batching plants are the only potential onsite sources of metals, combustion products and organic species, and these emissions were therefore taken forward to screening.

The screening assessment adopted guidance published in the United Kingdom, '*Air emissions risk assessment for your environmental permit guidance*' (UK Department for Environment, Food and Rural Affairs Environment Agency, 2016). The approach uses conservative dispersion factors to determine the likely maximum contribution to ground level concentrations. Where the maximum concentration is below specific thresholds the species is excluded from further assessment. The details of the screening assessment are provided in *Annex C*. The following species could not be screened out and therefore were included, in addition to particulate matter, in the dispersion modelling:

- NOx;
- Formaldehyde;
- PAH;
- Nickel; and
- Odour.

Emission rates for these species used in dispersion modelling are provided in *Table 6-3*.

7 *DISPERSION MODELLING ASSESSMENT*

7.1 *MODELLING METHODOLOGY*

The Approved Methods states that:

"*Ausplume Version 6.0 is the approved dispersion model for most applications in New South Wales*" (State of NSW and Environment Protection Authority, 2016).

The Approved Methods further states that Ausplume:

"*…is not approved in some applications where other more advanced dispersion model, such as CALPUFF and TAPM, may be more appropriate*" (State of NSW and Environment Protection Authority, 2016).

Consideration of the local meteorology (*Figure 4.1*) demonstrated a relatively high occurrence (from 6.7 - 11.4%) of calm winds (less than 0.5m/sec). Gaussian plume models, such as Ausplume, are unable to account for wind speeds of less than 0.5 m/sec and therefore have the potential to under estimate impacts in locations with significant periods of calm winds. In addition, AUSPLUME is unable to model the effects of terrain on area and volume sources. This Assessment therefore used the CALPUFF dispersion model to model emissions from the proposed operations in accordance with the Approved Methods.

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on atmospheric pollution dispersion. The NSW EPA approves this model in their guidance document *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (State of NSW and Environment Protection Authority, 2016). CALPUFF is able to model the dispersion of emissions during calm wind events as it 'remembers' the position of historical emissions following dispersion until they have been removed from the modelled grid.

7.2 *METEOROLOGICAL MODELLING*

Meteorological modelling was completed for a recent five year period (2012 to 2016 inclusive). This was undertaken to provide sufficient data to the dispersion modelling to understand the inter-annual variation in predicted impacts as a result of inter-annual meteorology.

Meteorological modelling was undertaken through a two-step process:

- Prognostic modelling using TAPM (developed by CSIRO); and
- Diagnostic modelling using CALMET (the meteorological pre-processor for the CALPUFF dispersion model).

7.2.1 *TAPM*

Initially, the prognostic meteorological model TAPM was run to provide surface and upper air data either missing, or not collected, at the nearest Bureau of Meteorology Station (Port Macquarie Airport).

TAPM was run using the following parameters:

- Four nests of 30 km, 10 km, 3km, and 1 km;
- Grid centre of 31°26′ S, 152°49′ E (MGA Zone 55 482712mE, 6522001mS);
- Grid of 25 X 25 cells;
- Observation file for observations from Port Macquarie meteorological station with area of influence of 5 km with 4 layers of the atmosphere influenced by the readings; and
- 25 vertical levels (10 m, 25 m, 50 m, 100 m, 150 m, 200 m, 250 m, 300 m, 400 m, 500 m, 600 m, 750 m, 1000 m, 1250 m, 1500 m, 1750 m, 2000 m, 2500 m, 3000 m, 3500 m, 4000 m, 5000 m, 6000 m, 7000 m and 8000 m).

7.2.2 *CALMET*

The setup of CALMET was completed in accordance with published guidance using a combination of observational and prognostic data (Barclay & Scire, 2011).

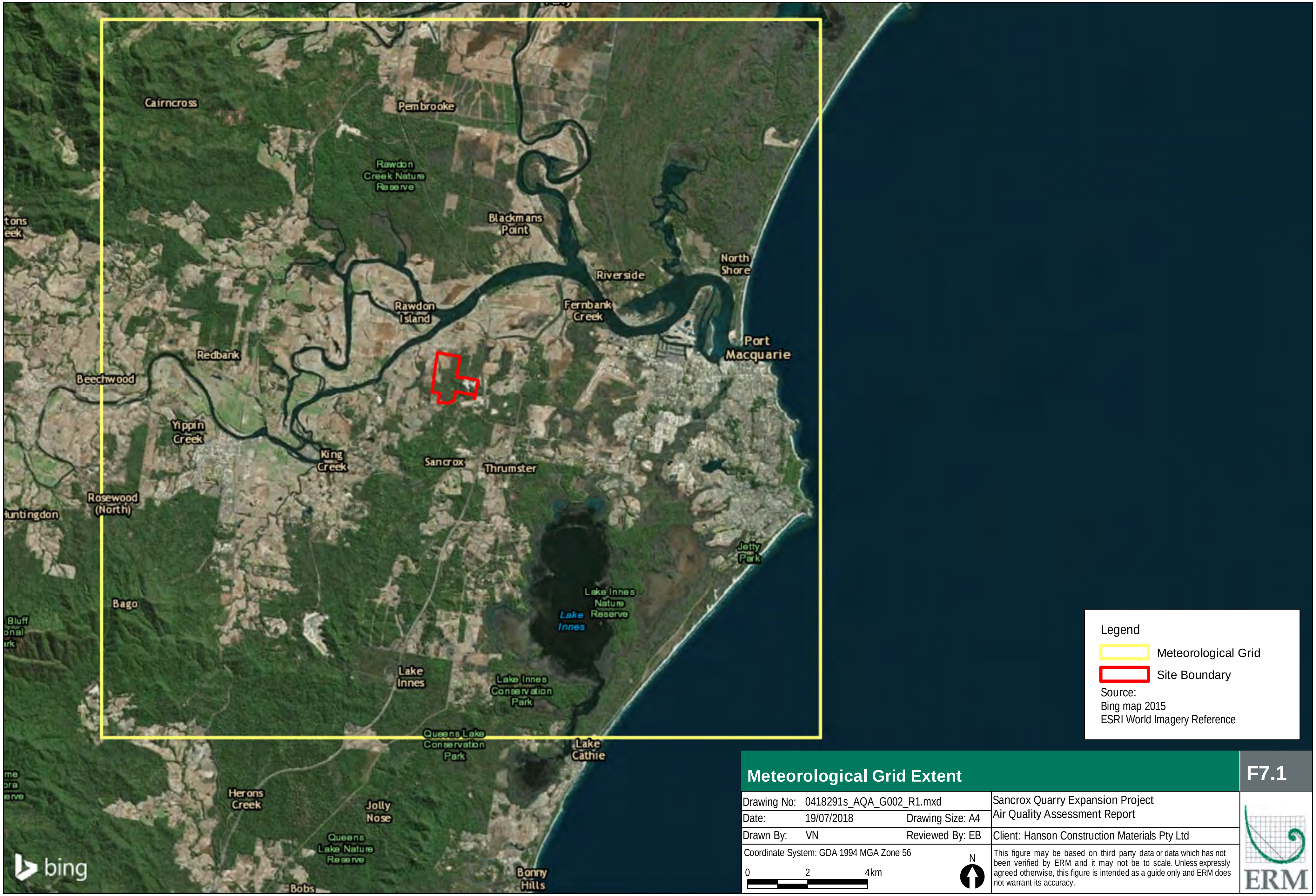
TAPM output was extracted at location 487712m E, 6533001m S (MGA Zone 55), and was used to generate a pseudo observation station for surface and upper air data within the modelled grid. For the surface data only where data was missing from Port Macquarie records for a particular hour was the data was included from the TAPM generated surface information file.

The CALMET model was set up using the system default settings with the exception of those shown in *Table 7-1*. *Figure 7.1* shows meteorological grid extent used in the dispersion modelling.

Table 7-1 Non-standard settings selected in CALMET

Parameter	Setting
Period Modelled	January 1 2012 to 31 December 2016 inclusive
UTM Zone	55 South
Grid south-west corner (MGA Zone 54)	470.483 km E, 6510.225 km N
Grid Spacing	150 m
Grid points	160 X 160
Cell face heights (m)	0, 20, 30, 40, 50, 70, 90, 100, 250, 500, 1000, 1500, 2000
Coriolis Frequency	7.5 X 10^{-5}
Bias adjustment for cell face heights	-1 , -1 , -.75 , -.75 , -.5 , -.25, 0 , 5 , 1 , 1 , 1 , 1
Terrad (km)[1]	0.5
RMAX 1 (km) [1]	7.5
RMAX2 (km) [1]	15.0
RMAX3 (km) [1]	30
RMIN (km) [1]	0.15
R1 (km) [1]	6.0
R2 (km) [1]	12.0
Surface Observation Station location	Port Macquarie (487.218km E, 6522.346km S),
Upper air observation (TAPM) location	487.712 km E, 6533.001 km S
Terrain data	ELVIS Elevation Information System (Australian Government Geoscience Australia, 2017)
Land use data	Catchment Scale Land Use of Australia (Department of Agriculture, 2016)

1. Selected in accordance with (Barclay & Scire, 2011)



Meteorological Grid Extent

F7.1

Drawing No: 0418291s_AQA_G002_R1.mxd		Sancrox Quarry Expansion Project Air Quality Assessment Report
Date: 19/07/2018	Drawing Size: A4	
Drawn By: VN	Reviewed By: EB	Client: Hanson Construction Materials Pty Ltd
Coordinate System: GDA 1994 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

ERM

7.3 *DISPERSION MODEL RECEPTORS*

A Cartesian grid was set-up with the south west corner positioned at 476408 m E, 6516150 m N and grid receptors at regularly spaced intervals of 150m, covering an area of 12 km by 12 km.

Discrete receptors were chosen to represent nearby sensitive receptors described in *Section 2.1.3.*

7.4 *EMISSION PARAMETERS*

The configuration of the emission sources within the CALPUFF dispersion model comprised a combination of volume, point and road sources.

Table 7-2 provides emission source parameters for volume and road sources included in the dispersion model. *Table 7-3* provides emission source parameters for point sources included in the dispersion model. Source positioning is presented in *Figure 7.2*

Table 7-2 Emission source parameters for volume and road sources used in the dispersion modelling

Source ID	X (m)	Y (m)	Base Elevation above sea level (m)	Height above Ground (m)	Sigma y	Sigma Z
			Drilling (Volume source)			
Drill1	482185	6521866	-12.2	15.00	0.01	0.01
Drill2	482169	6521840	-11.8	15.00	0.01	0.01
Drill3	482153	6521817	-9.8	15.00	0.01	0.01
Drill4	482137	6521796	-9.8	15.00	0.01	0.01
Drill5	482121	6521776	-9.1	15.00	0.01	0.01
Drill6	482097	6521771	-8.9	15.00	0.01	0.01
Drill7	482064	6521772	-10.1	15.00	0.01	0.01
Drill8	482034	6521767	-10.9	15.00	0.01	0.01
Drill9	481999	6521766	-10.4	15.00	0.01	0.01
Drill10	481961	6521757	-12.0	15.00	0.01	0.01
Drill11	481927	6521772	-14.4	15.00	0.01	0.01
Drill12	481915	6521804	-16.7	15.00	0.01	0.01
			Blasting (Volume source)			
Blast1	482185	6521866	-12.2	15.00	6.98	6.98
Blast2	482169	6521840	-11.8	15.00	6.98	6.98
Blast3	482153	6521817	-9.8	15.00	6.98	6.98
Blast4	482137	6521796	-9.8	15.00	6.98	6.98
Blast5	482121	6521776	-9.1	15.00	6.98	6.98
Blast6	482097	6521771	-8.9	15.00	6.98	6.98
Blast7	482064	6521772	-10.1	15.00	6.98	6.98
Blast8	482034	6521767	-10.9	15.00	6.98	6.98
Blast9	481999	6521766	-10.4	15.00	6.98	6.98
Blast10	481961	6521757	-12.0	15.00	6.98	6.98
Blast11	481927	6521772	-14.4	15.00	6.98	6.98
Blast12	481915	6521804	-16.7	15.00	6.98	6.98

Source ID	X (m)	Y (m)	Base Elevation above sea level (m)	Height above Ground (m)	Sigma y	Sigma Z
Crushing and Screening at the Processing Facility (Volume source)						
PRMCRSH	482572.10	6521900.31	41.25	3.00	0.50	0.70
SECCRSH	482536.54	6521866.65	38.25	3.00	0.50	0.70
TERCRSH	482575.59	6521827.92	37.05	3.00	0.50	0.70
SCR1	482554.95	6521884.60	40.39	3.00	0.50	0.70
SCR2	482557.39	6521842.76	37.05	3.00	0.50	0.70
Primary Crusher (Concrete Recycling Facility) (Volume source)						
PRMCRSH2	482489.11	6521868.77	37.40	3.00	0.50	0.70
Conveying (Volume source)						
CNVDP1	482516.45	6521893.63	40.01	3.00	0.25	0.70
CNVDP2	482515.15	6521838.11	35.54	3.00	0.25	0.70
CNVDP3	482562.14	6521863.84	38.93	3.00	0.25	0.70
CNVDP4	482553.75	6521836.45	37.05	3.00	0.25	0.70
CNVDP5	482584.91	6521846.74	35.73	3.00	0.25	0.70
CNVDP6	482561.16	6521814.46	34.96	3.00	0.25	0.70
CNVDP7	482583.29	6521795.96	34.96	3.00	0.25	0.70
CNVDP8	482597.26	6521815.79	33.66	3.00	0.25	0.70
CNVTSP1	482577.93	6521811.26	34.96	4.00	0.25	0.93
CNVTSP2	482522.02	6521853.33	38.25	4.00	0.25	0.93
CNVTSP3	482525.48	6521889.90	40.01	4.00	0.25	0.93
Product Handling (Volume source)						
FEL1	482405.55	6521821.17	26.66	1.50	0.70	0.35
FEL2	482553.40	6521803.73	35.25	1.50	0.70	0.35
EXC1	482071.11	6521807.41	-11.98	3.20	0.35	0.74
EXC2	482052.06	6521827.52	-12.55	3.20	0.35	0.74
TDP1	482583.56	6521912.19	41.25	1.50	0.70	0.35
FEL3	482892.00	6522098.00	28.14	1.50	0.70	0.35

Source ID	X (m)	Y (m)	Base Elevation above sea level (m)	Height above Ground (m)	Sigma y	Sigma Z
TDP2	482895.00	6522084.00	28.54	1.50	0.70	0.35
TDP3	482481.00	6521829.00	33.80	1.50	0.70	0.35
Wind erosion (Volume source)						
STP1	482446.7	6521860.0	32.9	2.5	15.7	1.16
STP2	482268.1	6521915.0	29.0	2.5	15.7	1.16
STP3	482336.0	6521913.9	32.5	2.5	15.7	1.16
STP4	482475.6	6521920.2	38.9	2.5	15.7	1.16
STP5	482248.4	6521828.7	26.1	2.5	15.7	1.16
STP6	482310.0	6521852.9	27.2	2.5	15.7	1.16
STP7	482378.9	6521796.5	24.9	2.5	15.7	1.16
STP8	482376.4	6521862.6	30.6	2.5	15.7	1.16
STP9	482409.5	6521917.3	31.3	2.5	15.7	1.16
STP10	482447.6	6521787.5	26.9	2.5	15.7	1.16
STP11	482515.2	6521838.1	35.5	1.5	5.1	0.70
STP12	482553.7	6521836.4	37.0	1.5	3.4	0.70
STP13	482587.1	6521845.6	35.7	1.5	4.5	0.70
STP14	482597.3	6521815.8	33.7	1.5	3.9	0.70
STP15	482587.0	6521799.3	33.7	1.5	4.1	0.70
STP16	482570.8	6521797.4	35.0	1.5	4.6	0.70
STP17	482561.2	6521814.5	35.0	1.5	3.7	0.70
STP18	482562.1	6521863.8	38.9	1.5	3.7	0.70
STP19	482516.2	6521896.3	40.0	1.5	6.7	0.70
Wheel generated (Road source)						
HR1	multiple	multiple	multiple	2.55[1]	5.16[2]	2.37[2]

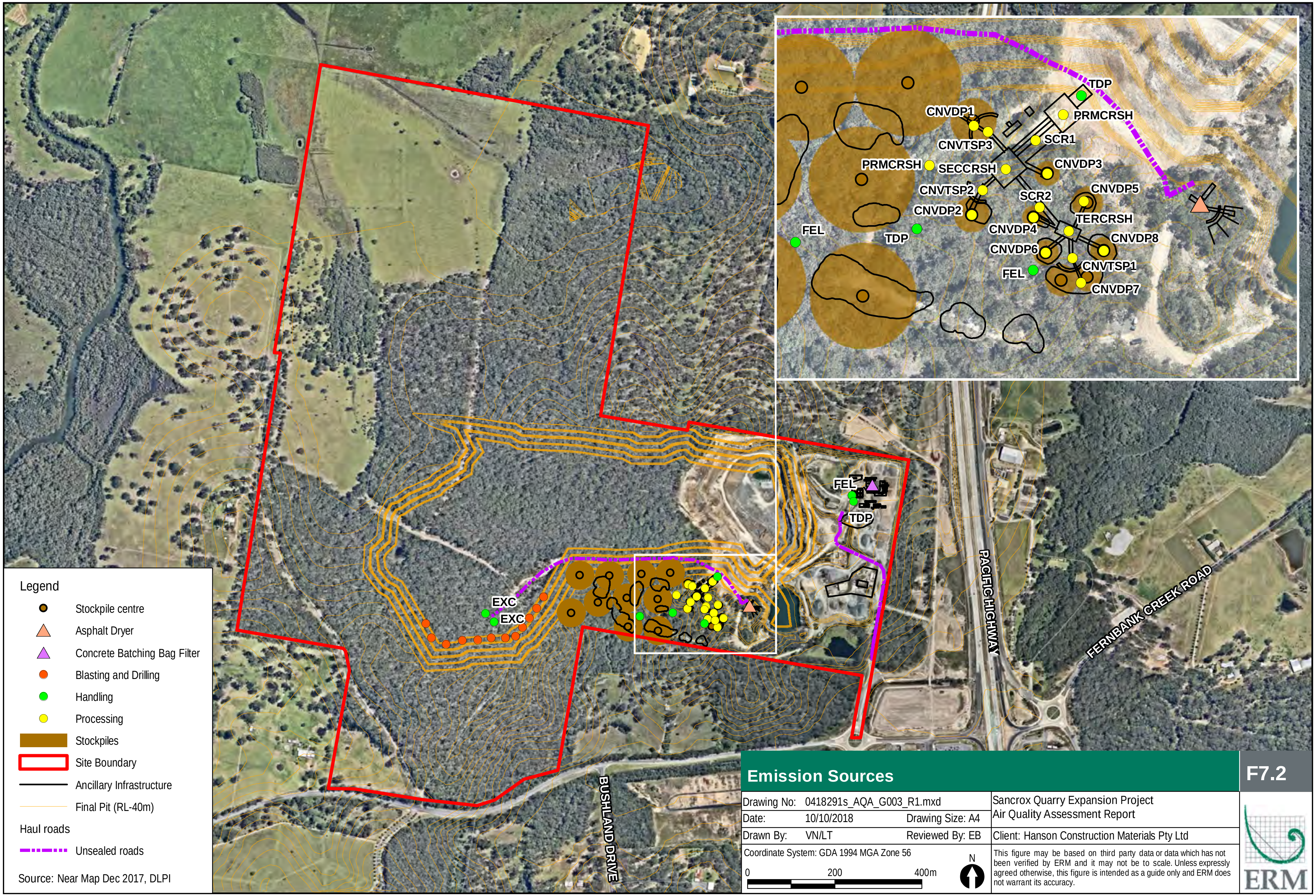
Source ID	X (m)	Y (m)	Base Elevation above sea level (m)	Height above Ground (m)	Sigma y	Sigma Z
HR4	multiple	multiple	multiple	2.55[1]	5.16[2]	2.37[2]
HR6	multiple	multiple	multiple	2.55[1]	5.16[2]	2.37[2]
HR7	multiple	multiple	multiple	2.55[1]	5.16[2]	2.37[2]
HR8	multiple	multiple	multiple	2.55[1]	5.16[2]	2.37[2]
HRA	multiple	multiple	multiple	2.55[1]	5.16[2]	2.37[2]

1. Volume release height as provided in the US EPA Haul Road Guidelines (United States Environmental Protection Agency, 2012)
2. Calculated in accordance with the modelling tip provided by Lakes Environmental (Lakes Environmental, 2016)

Table 7-3 Emission source parameters for point sources used in the dispersion modelling

Source Name	X (m)	Y (m)	Stack height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/sec)	Exit Temperature (deg. K)
ASPHALT	482657	6521845	5.0[2]	25.9	4.3[2]	0.85[2,3]	435.9[1]
C_BATCH	482938	6522122	5.0[4]	25.9	12.0[4]	0.025[4]	313.15[4]

1. Adopted from AP-42 Asphalt mix temperature (United States Environmental Protection Agency, 2004)
2. Adopted from technical data specification for Benninghoven Asphalt Mixing Plants (A Wirtgen Group Company, n.d.)
3. Converted from 28,000 Nm^3/hour, using temperature of 435.928 K and stack diameter of 4.3 metres.
4. Assumed, given information from a similar type of facility (Environmental Resources Management Australia Pty Ltd, 2017)



Emission Sources

F7.2

Drawing No: 0418291s_AQA_G003_R1.mxd
Date: 10/10/2018 Drawing Size: A4
Drawn By: VN/LT Reviewed By: EB
Coordinate System: GDA 1994 MGA Zone 56

Sancrox Quarry Expansion Project
Air Quality Assessment Report

Client: Hanson Construction Materials Pty Ltd

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7.5 PARTICLE SIZE DISTRIBUTION

Particle size distribution describes the range of particle sizes within a specific particle class and allows the dispersion model to estimate how they will behave in the atmosphere. The size distribution used in the dispersion modelling is presented in *Table 7-4*. Depletion due to wet and dry processes has been included in the model.

Table 7-4 Mean Particle Size Distribution

Emission Source	TSP		PM_{10}	
	Geometric mean (µm)	Standard Deviation (µm)	Geometric mean (µm)	Standard Deviation (µm)
All sources (except for asphalt plant dryer)[1]	9.88	3.31	4.11	2.7
Asphalt plant dryer[2]	14.15	1.00	7.53	0.20

1. Adopted from AP-42 Appendix B2, Table B2.2.2, Category 3 (United States Environmental Protection Agency, 1996)
2. Adopted from AP-42 Section 11.1, Table 11.1-4 (United States Environmental Protection Agency, 2004)

7.6 POST-PROCESSING

For each scenario, the dispersion model produced results for each modelled grid point and each sensitive receptor for the five years of meteorological data considered. Post processing has been used to take the hourly modelled results and process them to derive the relevant averaged values.

7.6.1 $PM_{2.5}$

$PM_{2.5}$ results for the sources were derived from the predicted PM_{10} concentrations using POSTUTIL post-processing tool of CALPUFF dispersion model. *Table 7-5* presents the $PM_{2.5}$ ratios at source obtained from the literature review for the sources included in the dispersion modelling. By the time PM_{10} emissions reach sensitive receptor locations, some of the particles will drop out and therefore the relative contribution of $PM_{2.5}$ to PM_{10} will increase. It was conservative assumed that at the sensitive receptor locations $PM_{2.5}$ will constitute 1.5 times its original contribution. *Table 7-5* presents $PM_{2.5}$ to PM_{10} ratios adopted in this assessment.

Table 7-5 *$PM_{2.5}$ to PM_{10} ratio*

Emission Source	**$PM_{2.5}$ to PM_{10} ratio at source**	**Adopted $PM_{2.5}$ to PM_{10} ratio at sensitive receptors[3]**
Load-in/Load-out	0.32[1]	0.48
Wheel generated dust	0.15[1]	0.23
Wind erosion	0.40[1]	0.60
Blasting and Drilling	0.06[1]	0.09
Concrete Batching	0.29[2]	0.44

1. Source: (SKM, 2005)
2. (United States Environment Protection Agency, 2011)
3. Conservatively assumed to be 1.5 times of the $PM_{2.5}$ to PM_{10} ratio at source

7.6.2 *Respirable Crystalline Silica*

Rhyolite is a fine-grained volcanic rock of granitic composition, which contains medium silica content (as compared to basalt and granite). Silica content of rhyolite was conservatively adopted in this dispersion modelling as 70% (Northern Arizona University, n.d.). The predicted annual average concentrations of respirable crystalline silica were derived from $PM_{2.5}$ annual average concentrations as required by adopted assessment criterion (see Section *3.1.5*).

7.6.3 *Odour*

Odour is generated from the asphalt plant. The structure of the asphalt plant has the potential to generate wake effect on the stack emissions. In accordance with the Approved Methods, the 1-hour average predicted odour concentration was converted to peak ground level concentration using factor 2.3 for wake-effected point source (State of NSW and Environment Protection Authority, 2016).

7.6.4 *Background Concentrations*

The Approved Methods requires that in analysing the results, initially a Level 1 assessment is completed. This involves use addition of the maximum background concentration with the maximum modelled concentration to determine if there is an exceedance of the standard. The values contained in Section *4.5* were used for the Level 1 assessment.

For species that result in cumulative concentrations in exceedance of the acceptable standards in a level 1 assessment are then taken forward to a Level 2 assessment. This involves the addition of background measurements on an hour by hour basis to determine whether the project is likely to result in additional exceedances of the acceptable standard.

Background measurements at Wyong indicate that in 2013 maximum measured 24 hour concentrations of both PM_{10} and $PM_{2.5}$ exceeded the assessment criterion, whilst in 2015 PM_{10} exceeded the assessment criterion. Addition of these values to the modelled concentration would therefore result in an exceedance of the assessment standard.

The background concentrations of PM_{10} and $PM_{2.5}$ for each hour of the modelled period (2012 to 2016) for Wyong were downloaded from the Office of Environment and Heritage Website. The hourly measurements for the days that had exceedances in the background data were removed from the analysis. The background concentrations were then combined with the results from the dispersion modelling in CALPOST on an hour by hour basis to provide a cumulative assessment.

8 MODELLING RESULTS

This section provides the dispersion model results and comparison to the assessment criteria.

8.1 PREDICTED PM_{10} CONCENTRATIONS

In relation to PM_{10} concentrations, the Approved Methods uses a staged approach to assessment using a Level 1 and Level 2 assessment, whereby:

- Level 1 comprises the sum of the maximum non-exceeding background concentration and the 100th percentile dispersion model predictions to obtain the potential maximum cumulative impact for each averaging period; and
- Level 2 comprises contemporaneous impact assessment of the PM_{10} 24-hour average predicted concentrations, where background data for the same time period is added to the model results to determine whether there is potential for additional exceedance of the standard given typical background and anticipated emissions.

A level 2 assessment is only completed where concentrations exceed the level 1 assessment, and is only completed for averaging periods of less than one year.

Table 8-1 provides the results of the Level 1 assessment of the PM_{10} predicted concentrations. The results of Level 1 assessment of the PM_{10} predicted concentrations indicates that the cumulative 24-hour concentrations are above the Approved Methods criterion at 43 sensitive receptors, while the cumulative annual mean concentrations are below the Approved Methods criterion at all sensitive receptors. It should be noted that the exceedances of PM_{10} 24-hour average criterion are mostly caused by the existence of elevated background levels within the measured values at Wyong.

Table 8-1 Level 1 Assessment of PM_{10} concentrations

	Predicted PM_{10} Concentrations ($\mu g/m^3$) Maximum impact (increment)	
Receptor ID	**24 Hour Average**	**Annual Mean**
1	**52.7 (3.4)**	17.4 (0.76)
2	**53.7 (4.2)**	17.4 (0.78)
3	**56.7 (7.2)**	17.5 (0.91)
4	**59.6 (10.1)**	18 (1.37)
5	**53.1 (3.6)**	16.8 (0.22)
6	**50.5 (1.2)**	16.7 (0.05)
7	**56.2 (6.7)**	17.5 (0.97)
8	**52.3 (3.7)**	17.1 (0.65)
9	**55.6 (6.1)**	17.5 (1.07)
10	**53.9 (4.4)**	17.5 (1)
11	**52.1 (3.5)**	16.8 (0.28)
12	**54.1 (4.6)**	17.3 (0.65)

Receptor ID	Predicted PM_{10} Concentrations ($\mu g/m^3$) Maximum impact (increment)	
	24 Hour Average	**Annual Mean**
13	**60.6 (16.8)**	20.2 (4)
14	**53 (3.8)**	17.6 (0.98)
15	**57.3 (7.8)**	17.9 (1.33)
16	**52.5 (3.3)**	17.4 (0.83)
17	**56.3 (6.8)**	17.6 (0.97)
18	**52.4 (3.6)**	16.9 (0.35)
19	**56.1 (14.5)**	17.4 (0.76)
20	**54.6 (7.3)**	16.8 (0.25)
21	**50.8 (2.2)**	16.7 (0.06)
22	49.97 (0.8)	16.6 (0.02)
23	49.98 (1.5)	16.6 (0.03)
24	**52.4 (2.9)**	16.8 (0.18)
25	**51.2 (1.8)**	16.7 (0.12)
26	**50.4 (1.4)**	16.6 (0.04)
27	**50.6 (1.8)**	16.6 (0.04)
28	**50.8 (1.8)**	16.6 (0.04)
29	**50.4 (1.2)**	16.7 (0.05)
30	**51 (1.5)**	16.7 (0.08)
31	**50.8 (1.3)**	16.7 (0.07)
32	**52.4 (3.7)**	16.9 (0.32)
33	**50.8 (1.6)**	16.8 (0.2)
34	**52.1 (3.5)**	17.2 (0.59)
35	**51.8 (2.6)**	17 (0.49)
36	**50.5 (1)**	16.7 (0.09)
37	**51.1 (1.7)**	16.8 (0.2)
38	**51 (1.7)**	16.8 (0.19)
39	**51.3 (1.8)**	16.8 (0.2)
40	**51.1 (1.6)**	16.8 (0.2)
41	**52.8 (3.3)**	17.1 (0.47)
42	**51.9 (2.9)**	17.1 (0.54)
43	**53.1 (3.6)**	17.1 (0.54)
44	**53.3 (4.4)**	17.4 (0.89)
45	**51.7 (2.3)**	17 (0.41)
Criterion	50[1]	25[1]

1. Source: (State of NSW and Environment Protection Authority, 2016)

Table 8-2 provides the results of Level 2 contemporaneous impact assessment of the PM_{10} 24-hour average predicted concentrations. The hourly background was added to the predicted concentrations, on an hour by hour basis for the five modelled years, to derive the maximum 24-hour average concentrations. The results of Level 2 contemporaneous impact assessment of the PM_{10} 24-hour average predicted concentrations indicate exceedances of the Approved Methods Criterion at 13 sensitive receptors.

The maximum site contribution to PM_{10} 24-hour average concentration at the sensitive receptor locations (incremental impact) is 16.8 µg/m³. This level of impact does not exceed particulate matter mitigation criteria contained in the Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments (NSW Government, 2018). Consequently, under this guidance, the level of impact to surrounding sensitive receptors is considered to be acceptable.

Table 8-2 Level 2 Assessment of PM_{10} 24-hour average concentrations

Receptor ID	Predicted 24 Hour PM_{10} Concentrations (µg/m³)	
	Maximum Cumulative impact	**Maximum Site Contribution (incremental impact)**
1	**50.1**	3.4
2	**50.1**	4.2
3	**51.0**	7.2
4	**51.7**	10.1
5	49.6	3.6
6	49.4	1.2
7	49.4	6.7
8	49.4	3.7
9	49.7	6.1
10	49.9	4.4
11	49.4	3.5
12	**50.1**	4.6
13	**56.5**	16.8
14	**50.6**	3.8
15	**51.5**	7.8
16	**50.4**	3.3
17	**51.3**	6.8
18	**50.4**	3.6
19	**50.5**	14.5
20	49.4	7.3
21	49.4	2.2
22	49.4	0.8
23	49.4	1.5
24	49.5	2.9
25	49.5	1.8
26	49.4	1.4
27	49.4	1.8
28	49.4	1.8
29	49.4	1.2
30	49.4	1.5
31	49.4	1.3
32	49.4	3.7
33	49.4	1.6
34	49.4	3.5
35	49.4	2.6
36	49.4	1.0
37	49.4	1.7

Receptor ID	Predicted 24 Hour PM_{10} Concentrations ($\mu g/m^3$)	
	Maximum Cumulative impact	**Maximum Site Contribution (incremental impact)**
38	49.4	1.7
39	49.4	1.8
40	49.4	1.6
41	49.99	3.3
42	**50.5**	2.9
43	49.98	3.6
44	49.6	4.4
45	49.4	2.3
Criteria	50[1]	50[2]

1. Source: (State of NSW and Environment Protection Authority, 2016)
2. Source: (NSW Government, 2018)

8.2 *PREDICTED $PM_{2.5}$ CONCENTRATIONS*

Table 8-3 provides the Level 1 assessment for $PM_{2.5}$ predicted concentrations. The results of Level 1 assessment of the $PM_{2.5}$ predicted concentrations indicates that the cumulative 24-hour concentrations are above the Approved Methods criterion at 16 sensitive receptors, the cumulative annual mean concentration is below the Approved Methods criterion at all sensitive receptors. It should be noted that the exceedances of $PM_{2.5}$ 24-hour average criterion are mostly caused by elevated background levels as measured at Wyong.

Table 8-3 Level 1 Assessment of $PM_{2.5}$ concentrations

	Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) Maximum impact (increment)	
Receptor ID	**24 Hour Average**	**Annual Mean**
1	**25.04 (0.9)**	6.9 (0.2)
2	**25.04 (0.9)**	6.9 (0.2)
3	**25.6 (2)**	6.9 (0.2)
4	**26.6 (4.2)**	7 (0.3)
5	24.7 (1.1)	6.8 (0.1)
6	24.3 (0.3)	6.7 (0)
7	**26 (2.6)**	6.9 (0.2)
8	24.9 (1.1)	6.8 (0.2)
9	**25.7 (2.3)**	6.9 (0.3)
10	**25.3 (1.1)**	6.9 (0.2)
11	**25.6 (2)**	6.8 (0.1)
12	24.99 (0.8)	6.9 (0.2)
13	**26.8 (3.1)**	7.6 (1)
14	24.96 (0.8)	6.9 (0.2)
15	**26.3 (3.7)**	7 (0.3)
16	24.95 (0.8)	6.9 (0.2)
17	**25.9 (2.9)**	6.9 (0.2)
18	24.97 (1)	6.8 (0.1)
19	**25.6 (2.3)**	6.9 (0.2)

Receptor ID	Predicted $PM_{2.5}$ Concentrations (µg/m³) Maximum impact (increment)	
	24 Hour Average	**Annual Mean**
20	**25.3 (1.8)**	6.8 (0.1)
21	24.5 (0.6)	6.7 (0)
22	24.3 (0.2)	6.7 (0)
23	24.4 (0.3)	6.7 (0)
24	24.6 (0.9)	6.7 (0)
25	24.5 (0.6)	6.7 (0)
26	24.4 (0.5)	6.7 (0)
27	24.4 (0.4)	6.7 (0)
28	24.3 (0.2)	6.7 (0)
29	24.3 (0.3)	6.7 (0)
30	24.9 (0.7)	6.7 (0)
31	24.9 (0.7)	6.7 (0)
32	**25.7 (2.1)**	6.8 (0.1)
33	24.8 (0.8)	6.8 (0.1)
34	24.9 (1.1)	6.8 (0.1)
35	24.8 (0.8)	6.8 (0.1)
36	24.6 (0.5)	6.7 (0)
37	24.6 (0.7)	6.8 (0.1)
38	24.6 (0.6)	6.8 (0.1)
39	24.6 (0.8)	6.8 (0.1)
40	24.6 (0.8)	6.8 (0.1)
41	24.8 (0.6)	6.8 (0.1)
42	**25.1 (1.3)**	6.8 (0.1)
43	24.8 (0.6)	6.8 (0.1)
44	**25.1 (1.4)**	6.9 (0.2)
45	24.8 (0.6)	6.8 (0.1)
Criterion	25[1]	8[1]

1. Source: (State of NSW and Environment Protection Authority, 2016)

Table 8-4 provides Level 2 contemporaneous impact assessment of the $PM_{2.5}$ 24-hour average predicted concentrations. The results of Level 2 contemporaneous impact assessment of the $PM_{2.5}$ 24-hour average predicted concentrations indicate no exceedances of the Approved Methods Criterion at any of the sensitive receptors. The maximum site contribution to $PM_{2.5}$ 24-hour average concentration at the sensitive receptor locations (incremental impact) is 4.2 µg/m³.

Table 8-4 Level 2 Assessment of $PM_{2.5}$ 24-hour average concentrations

Receptor ID	Predicted 24 Hour $PM_{2.5}$ Concentrations (µg/m³)	
	Maximum Cumulative impact	**Maximum Site Contribution (incremental impact)**
1	23.3	0.9
2	23.3	0.9
3	23.3	2.0
4	23.3	4.2
5	23.3	1.1

Receptor ID	Predicted 24 Hour $PM_{2.5}$ Concentrations (μg/m³)	
	Maximum Cumulative impact	**Maximum Site Contribution (incremental impact)**
6	23.3	0.3
7	23.3	2.6
8	23.3	1.1
9	23.3	2.3
10	23.3	1.1
11	23.6	2.0
12	23.3	0.8
13	23.4	3.1
14	23.3	0.8
15	23.3	3.7
16	23.3	0.8
17	23.3	2.9
18	23.3	1.0
19	23.3	2.3
20	23.3	1.8
21	23.3	0.6
22	23.3	0.2
23	23.3	0.3
24	23.3	0.9
25	23.3	0.6
26	23.3	0.5
27	23.3	0.4
28	23.3	0.2
29	23.3	0.3
30	23.3	0.7
31	23.3	0.7
32	23.8	2.1
33	23.3	0.8
34	23.3	1.1
35	23.3	0.8
36	23.5	0.5
37	23.3	0.7
38	23.3	0.6
39	23.3	0.8
40	23.3	0.8
41	23.3	0.6
42	23.3	1.3
43	23.3	0.6
44	23.3	1.4
45	23.3	0.6
Criteria	25[1]	-

1. Source: (State of NSW and Environment Protection Authority, 2016)

8.3 *PREDICTED CONCENTRATIONS FOR ALL OTHER SPECIES*

Table 8-5 provides the predicted concentrations for all species other than PM_{10} and $PM_{2.5}$ included in the dispersion modelling against the adopted criteria. The results for these species included in the dispersion modelling are below the adopted criteria at all sensitive receptor locations.

Table 8-5 Predicted concentrations for all species other than PM_{10} and $PM_{2.5}$ included in the dispersion modelling

Receptor ID	Predicted TSP Concentrations (µg/m³) Maximum impact (increment)	Predicted Silica Concentrations (µg/m³) Maximum impact	Predicted Dust Deposition (g/m²/month) Maximum impact (increment)	Predicted NO_2 (µg/m³) Maximum impact (increment)		Predicted Formaldehyde (µg/m³) Maximum impact	Predicted PAH (µg/m³) Maximum impact	Predicted Nickel (µg/m³) Maximum impact	Predicted Odour (OU/m³) Maximum impact
	Annual Mean	Annual Mean	Annual Mean	Annual Mean	1 Hour Mean	1 Hour Mean	1 Hour Mean	1 Hour Mean	Nose Response Time
1	30.6 (0.2)	0.14	0.0	10.3 (0.018)	95.2 (0.033)	0.0904	0.0055	0.0018	1.6
2	30.6 (0.2)	0.14	0.1	10.3 (0.012)	60.1 (0.039)	0.0718	0.0044	0.0015	1.2
3	30.8 (0.4)	0.16	0.1	10.3 (0.009)	70.2 (0.04)	0.0452	0.0028	0.0009	0.9
4	31.2 (0.8)	0.24	0.2	10.3 (0.009)	66.1 (0.047)	0.0470	0.0029	0.0010	1.1
5	30.5 (0.3)	0.04	0.1	10.3 (0.003)	70 (0.052)	0.0241	0.0015	0.0005	0.4
6	33.2 (0)	0.01	0.0	10.3 (0.001)	59.6 (0.067)	0.0142	0.0009	0.0003	0.2
7	33.9 (0.7)	0.17	0.2	10.3 (0.014)	66.1 (0.069)	0.0455	0.0028	0.0009	1.3
8	30.7 (0.3)	0.11	0.1	10.3 (0.007)	84.6 (0.069)	0.0510	0.0031	0.0010	0.9
9	31 (0.6)	0.19	0.2	10.3 (0.006)	94.8 (0.073)	0.0447	0.0027	0.0009	0.9
10	30.8 (0.4)	0.17	0.1	10.3 (0.007)	70.1 (0.062)	0.0354	0.0022	0.0007	0.9
11	30.1 (0.3)	0.07	0.1	10.3 (0.005)	59.8 (0.059)	0.0291	0.0018	0.0006	0.8
12	30.6 (0.2)	0.12	0.1	10.3 (0.011)	60 (0.059)	0.0624	0.0038	0.0013	1.1
13	34.2 (3.8)	0.68	0.8	10.3 (0.017)	95 (0.07)	0.0761	0.0047	0.0015	2.1
14	30.8 (0.4)	0.17	0.1	10.3 (0.013)	94.8 (0.081)	0.0412	0.0025	0.0008	1.1
15	31.1 (0.7)	0.23	0.2	10.3 (0.009)	84.5 (0.106)	0.0462	0.0028	0.0009	1.1
16	30.7 (0.3)	0.14	0.1	10.3 (0.012)	70.3 (0.117)	0.0624	0.0038	0.0013	1
17	30.9 (0.5)	0.17	0.1	10.3 (0.009)	59.9 (0.119)	0.0401	0.0025	0.0008	0.9
18	30.5 (0.3)	0.07	0.1	10.3 (0.007)	84.4 (0.145)	0.0293	0.0018	0.0006	0.7
19	31.1 (0.9)	0.14	0.3	10.3 (0.005)	66 (0.136)	0.0339	0.0021	0.0007	0.7
20	33.5 (0.3)	0.04	0.1	10.3 (0.003)	84.4 (0.135)	0.0320	0.0020	0.0007	0.5
21	33.3 (0.1)	0.01	0.0	10.3 (0.001)	84.3 (0.168)	0.0152	0.0009	0.0003	0.2
22	33.2 (0)	0.00	0.0	10.3 (0.001)	59.6 (0.189)	0.0107	0.0007	0.0002	0.1
23	33.2 (0)	0.01	0.0	10.3 (0.001)	59.6 (0.174)	0.0114	0.0007	0.0002	0.2
24	30.4 (0.2)	0.03	0.1	10.3 (0.002)	70 (0.193)	0.0225	0.0014	0.0005	0.3
25	30.3 (0.1)	0.02	0.0	10.3 (0.002)	69.9 (0.176)	0.0171	0.0010	0.0003	0.3
26	33.2 (0)	0.01	0.0	10.3 (0.001)	69.9 (0.158)	0.0119	0.0007	0.0002	0.2
27	33.2 (0)	0.01	0.0	10.3 (0.001)	65.8 (0.137)	0.0128	0.0008	0.0003	0.2
28	33.2 (0)	0.01	0.0	10.3 (0.001)	84.3 (0.147)	0.0134	0.0008	0.0003	0.1
29	33.2 (0)	0.01	0.0	10.3 (0.001)	59.6 (0.122)	0.0140	0.0009	0.0003	0.2
30	33.3 (0.1)	0.02	0.0	10.3 (0.002)	94.5 (0.104)	0.0152	0.0009	0.0003	0.2
31	33.3 (0.1)	0.02	0.0	10.3 (0.002)	69.9 (0.1)	0.0151	0.0009	0.0003	0.2
32	30.1 (0.3)	0.07	0.1	10.3 (0.005)	94.7 (0.099)	0.0294	0.0018	0.0006	0.8
33	33.3 (0.1)	0.04	0.0	10.3 (0.006)	70.1 (0.084)	0.0354	0.0022	0.0007	0.6
34	33.5 (0.3)	0.10	0.1	10.3 (0.009)	84.5 (0.09)	0.0467	0.0029	0.0009	0.9
35	30 (0.2)	0.09	0.1	10.3 (0.01)	70.4 (0.078)	0.0730	0.0045	0.0015	1.1
36	29.9 (0.1)	0.02	0.0	10.3 (0.002)	65.8 (0.094)	0.0138	0.0008	0.0003	0.3
37	33.3 (0.1)	0.04	0.0	10.3 (0.006)	59.8 (0.089)	0.0293	0.0018	0.0006	0.6
38	33.3 (0.1)	0.04	0.0	10.3 (0.006)	59.7 (0.067)	0.0273	0.0017	0.0006	0.6
39	33.3 (0.1)	0.04	0.0	10.3 (0.006)	94.7 (0.062)	0.0324	0.0020	0.0007	0.6

Receptor ID	Predicted TSP Concentrations (µg/m³) Maximum impact (increment)	Predicted Silica Concentrations (µg/m³) Maximum impact	Predicted Dust Deposition (g/m²/month) Maximum impact (increment)	Predicted NO_2 (µg/m³) Maximum impact (increment)		Predicted Formaldehyde (µg/m³) Maximum impact	Predicted PAH (µg/m³) Maximum impact	Predicted Nickel (µg/m³) Maximum impact	Predicted Odour (OU/m³) Maximum impact
40	33.3 (0.1)	0.04	0.0	10.3 (0.006)	59.8 (0.057)	0.0315	0.0019	0.0006	0.6
41	30.6 (0.2)	0.08	0.0	10.3 (0.01)	59.9 (0.053)	0.0509	0.0031	0.0010	1
42	30.6 (0.2)	0.09	0.1	10.3 (0.008)	59.9 (0.054)	0.0427	0.0026	0.0009	0.8
43	30.6 (0.2)	0.10	0.0	10.3 (0.011)	60 (0.051)	0.0552	0.0034	0.0011	1.1
44	30.8 (0.4)	0.16	0.1	10.3 (0.006)	94.7 (0.051)	0.0371	0.0023	0.0008	0.8
45	30 (0.2)	0.07	0.0	10.3 (0.009)	70.3 (0.054)	0.0673	0.0041	0.0014	1
Criteria	**90**	**3**	**2**	**62**	**246**	**20**	**0.4**	**0.18**	

9 MITIGATION MEASURES

This air quality impact assessment considered all reasonable and feasible mitigation measures to minimise the emissions from the proposed activities at the site. The mitigation measured considered in this assessment include:

- Roads, which are likely to remain unchanged throughout the Project stages and to be frequently used by machinery, will be sealed using asphalt and swept daily to minimise wheel-generated dust emissions;
- Full dust extraction system for drilling;
- Utilisation of water sprays during truck rear dumping;
- The use of mobile sprinkler systems during the operation of FELs;
- Dust suppression measures such as water sprays in place at the crushers and screeners;
- Water sprays used on all conveyor transfer points;
- The conveyor loading to be enclosed by a shroud;
- Level 2 watering (more than 2 litres/m^2/hour) applied to unsealed roads to minimise impact from hauling;
- Water sprays to be utilised to minimise wind erosion from stockpiles during wind speeds of over 5.4 metres per second;
- The dry product delivered to the concrete batching, concrete recycling and asphalt plants to be stored in aggregate storage bins enclosed on three sides. The walls to extend one metre above the height of the maximum quantity of raw material, and two metre beyond the front of the stockpile. The aggregate storage bins to be fitted with water sprays to keep the stored material damp at all times;
- Cement and cement supplement to be delivered to the concrete batching plant in the agitator trucks and pneumatically fed to the bottom-loaded silos;
- Concrete batching loading point to be totally enclosed with all particulate matter emissions generated by the facility captured by one bag filter located above the pan mixer;
- Concrete recycling facility outloading to be directly to processed material storage bins enclosed on three sides. The walls to extend one metre above the height of the maximum quantity of raw material, and two metre beyond the front of the stockpile. The recycled concrete storage bins to be fitted with water sprays to keep the stored material damp at all times;

- Vapour balancing system to be installed for the delivery of bitumen at the asphalt plant;
- Asphalt plant will be totally enclosed. All particulate matter emissions generated at the plant will be captured by one fabric filter associated with the natural-gas fired dryer; and
- Vapour recovery system to be employed for transfer of asphalt to trucks.

10 MONITORING AND MANAGEMENT MEASURES

It is recommended that in addition to management measures described in Section *9*, the Site employs real-time ambient air quality monitoring system. This will allow staff to identify when additional mitigation measures are to be implemented to minimise impact from the onsite activities on the days when the background concentrations of PM_{10} and $PM_{2.5}$ exceed the criteria set by the Approved Methods. Given the proximity of Receptor 13 to the site boundary and moderate occurrence of winds from the north-western and north-eastern directions (*Figure 4.1*), it is recommended that one real-time monitor is placed along the southern boundary of the Site to capture the Site emissions and another monitor is placed along the northern boundary to obtain background concentrations when the winds are blowing from offsite.

Table 10-1 provides recommendations for the environmental management to ensure minimisation of air quality impact to the surrounding land use as a result of construction activities.

Table 10-1 Recommendations for the environmental management plan

Item	Mitigation/ Management/Control Measure	Trigger/Timing	Responsibility
Clearing, Site Preparation and Excavation			
1	Modify working practices by limiting clearing, stripping and spoil handling during periods of adverse weather (hot, dry and windy conditions) and when dust is seen leaving the site.	When visible dust is being generated	Supervisors, Construction Manager
2	Limit the extent of clearing of vegetation and topsoil to the designated footprint required for construction and appropriate staging of any clearing.	During construction works planning stage	Construction Manager
3	All disturbed areas where trees and other vegetation are removed are to be stabilised and or revegetated/ rehabilitated in accordance with the contractual requirements as soon as practical following final land shaping	After final land shaping	Supervisors, Construction Manager
4	Minimise the exposure of fill and excavated material to active work fronts.	Ongoing	Supervisors
5	Use water sprays as a suppressant during road construction, when movement of materials generates visible dust.	When visible dust is being generated.	Supervisors, Construction Manager
6	Minimise drop heights for material transport to prevent dust dispersal.	Ongoing	Supervisors
7	Maintain all construction equipment, machinery and vehicles to ensure optimal performance which would minimise exhaust emissions.	Ongoing	Supervisors
8	Minimise idling of construction equipment, machinery and vehicles to no more than 5 minutes to minimise exhaust emissions.	Ongoing	Supervisors
9	Plan construction methodology to ensure capacity of construction equipment, machinery and vehicles is fully utilised.	During construction works planning stage	Construction Manager
Haulage and Heavy Plant and Equipment Movements			
10	Modifying work practices during periods of high winds and/or dry conditions by limiting scraper/ grader activity.	Ongoing	Supervisors
11	All vehicles on-site will be confined to a designated route with a speed limit of 30 km/hr enforced.	Ongoing	Supervisors
12	Trips and trip distances will be controlled and reduced where possible, for example by coordinating delivery and removal of materials to avoid unnecessary trips.	Ongoing	Supervisors, Construction Manager
13	All trucks delivering fill or leaving the site with spoil material will have their load covered.	Ongoing	Supervisors

Item	Mitigation/ Management/Control Measure	Trigger/Timing	Responsibility
14	No idling of vehicles unless power is required for unloading or cooling for the occupant of vehicle on days of high temperature.	Ongoing	Supervisors
Wind Erosion			
15	Wind erosion from exposed ground will be limited by avoiding unnecessary vegetation and topsoil clearing and limiting to the minimum footprint required.	Ongoing	Supervisors, Construction Manager
16	Wind erosion from temporary stockpiles will be limited by minimising the number of work faces on stockpiles, minimising the number of stockpiles and through covering or temporary stabilisation (compaction of surface, water sprays, seeding, veneering) of the stockpiles.	Ongoing	Supervisors, Construction Manager
Dust monitoring			
17	Visual checks for excessive dust generation will be undertaken daily during construction	Ongoing	Supervisors, Construction Manager

11 *CONCLUSIONS*

ERM was engaged by Hanson to undertake specialist assessments to inform the EIS for the proposed Sancrox Quarry Extension Project. This assessment addresses the Secretary's Requirements for the preparation of an EIS for the Sancrox Quarry Extension Project (Department of Planning and Environment, 2017) and undertook the following scope of works:

- Assessment of potential for ambient air quality impacts and greenhouse gas emissions from construction and operation of the Project;
- Provision of mitigation measures to minimise impacts to the surrounding land use; and
- Recommendations for ambient monitoring to ensure compliance with legislation.

The assessment of ambient air quality impacts identified that:

- The cumulative annual mean concentrations of PM_{10} are below the Approved Methods criterion at all sensitive receptors;
- Contemporaneous analysis identified that the cumulative (background plus Site contributions) PM_{10} 24-hour average predicted concentrations indicate exceedances of the Approved Methods Criterion at 13 sensitive receptors. The maximum incremental impact, however, does not exceed particulate matter mitigation criteria contained within the Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments (NSW Government, 2018) and consequently under this guidance the level of impact to surrounding land use is considered to be acceptable;
- The cumulative annual mean concentrations of $PM_{2.5}$ are below the Approved Methods criterion at all sensitive receptors;
- The results of Level 2 contemporaneous impact assessment of the $PM_{2.5}$ 24-hour average predicted concentrations are below the Approved Methods Criterion at all sensitive receptors; and
- The predicted concentrations for all other species are below the adopted criteria at all sensitive receptor locations.

The Project over its entire life cycle is estimated to release approximately 48.4 million tonnes of CO_2-e into the atmosphere with scope 1 and scope 2 emissions accounting for 74% and 26% respectively of the total emissions. The main GHG emission sources over the life of the project representing 99% of all emissions are:

- Operations – Diesel for transport related purposes (38%);

- Operations – Electricity (26%);
- Operations – LNG (16%);
- Construction – Vegetation clearing (12%); and
- Operations – Diesel for stationary energy purposes (6%).

Peak Scope 1 and Scope 2 emissions from the Project (approximately 0.0054 Mt CO_2-e during Year 7/Year8) represent approximately 0.0010% of Australia's commitment for annual emissions under the Kyoto Protocol (550.2 Mt CO2-e/annum for 2016-17). In comparison to the 2015 GHG emissions in NSW, the project emissions account for approximately 0.0041%. When compared to the 2015 GHG emission levels from all Mining sources in Australia (74.5 Mt CO_2-e), the Project accounts to 0.0073%.

This assessment considered all reasonable and feasible mitigation measures to minimise the emissions from the proposed activities at the site and provided recommendations for ambient monitoring to ensure compliance with legislation.

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Annex A

GHG Emission Estimation

A.1 GHG EMISSION CALCULATIONS

A.1.1 Construction GHG Emissions

Vegetation Clearing

Greenhouse gas (GHG) emissions from vegetation clearing was estimated using the following equation:

Equation 1:

$$E_{CO_2-e} = A\ X\ EF$$

where:

E_{CO2-e}	Emissions of GHG due to loss in carbon sink from vegetation clearing	(t CO_2-e)
A	Estimated extent of vegetation clearing	(hectare)
EF	Emission factor for vegetation clearing	(t CO_2-e/ha)

The emissions factor was sourced from Transport Authorities Greenhouse Group Workbook (Transport Authorities Greenhouse Group Australia and New Zealand, 2013) and is detailed in *Table A-2*.

Table A-2 GHG Emission Rate – Vegetation clearing

Activity	**Emission Factor**	**Unit**
Vegetation Clearing	142	t CO_2–eq /ha

Note:

1. Reference: Table 11, Supporting Document for Greenhouse Gas Assessment Workbook for Road Projects (Transport Authorities Greenhouse Group of Australia & New Zealand, 2013b).
2. Applicable for maximum biomass class 4 (150 - 250 tonnes dry matter/ha) & Vegetation Class 'C' (Open Forest).
3. Relates to emissions resulting from lost carbon sequestration associated with vegetation clearance.

The extent of cleared land is provided in *Table 5-1*. Soil removal depth of 100cm was used to estimate the volume of material moved.

Diesel combustion

The quantity of fuel used during construction was estimated using the following equation.

Equation 2:

$$Q = \frac{Q_r \times A}{1000}$$

where:

Q	Quantity of fuel used during construction	(kL)
Q_r	Fuel usage rate	(kL/ha or kL/m^3)
A	Extent of disturbance	(ha or m^3)

The fuel usage rate was sourced from Transport Authorities Greenhouse Group Workbook (Transport Authorities Greenhouse Group Australia and New Zealand, 2013) and is detailed in *Table A-3*.

Table A-3 Fuel usage rate –associated with vegetation clearing and construction

Activity	Emission Rate	Unit	Assumptions
Liquid Fuel combustion - clearing and grubbing of vegetated areas	2.8	kL / ha	Applicable for High shrubs and medium dense trees < 10m, assumed to be equivalent to woodland with a vegetation mass of 210t/ha of cleared area
Liquid Fuel combustion - earthmoving equipment	0.0012	kL/ m^3	Assumes earthwork using conventional method (graders and dozers)
Liquid Fuel combustion – sealing of haul roads	0.00169	kL/m^2	Tale 5-8, Default Quantity Factors for Pavements for Full Depth Asphalt

Note:

1. Reference: Table 5-6, Greenhouse Gas Assessment Workbook for Road Projects, Transport Authorities Greenhouse Group, February 2013 (Transport Authorities Greenhouse Group Australia and New Zealand, 2013).

The resulting quantity of fuel used during construction is presented in *Table A-4*.

Table A-4 Estimated quantity of fuel used in construction

Stage	Quantity of fuel – clearing and grubbing of vegetated areas (kL)	Quantity of fuel – earthmoving equipment (kL)	Quantity of fuel – sealing haul roads
Stage 1	17.0	72.9	0
Stage 2	13.6	5.8	11.3
Stage 3	26.0	11.1	0
Stage 4	0.0	0.0	0
Stage 5	33.4	14.3	0
Stage 6	23.8	10.2	0

Greenhouse gas (GHG) emissions from diesel consumption during construction was estimated using the following equation:

Equation 3:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

$E_{CO2\text{-}e}$	Emissions of GHG from diesel combustion	(t CO2-e)[1]
Q	Estimated combustion of diesel	(GJ)[2]
EF	Emission factor for diesel combustion	(kg CO2-e/GJ)[3]

[1] tCO2-e = tonnes of carbon dioxide equivalent

[2] GJ = gigajoules

[3] kg CO2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

The quantity of diesel consumed in GJ is calculated using an energy content factor for diesel of 38.6 gigajoules per kilolitre (GJ/kL) (Australian Government Department of the Environment and Energy, 2017a). The emission factor for diesel combustion for stationary energy purpose is 70.2 kg CO_2 eq/GJ (Australian Government Department of the Environment and Energy, 2017a).

A.1.2 Operational GHG Emissions

At Sancrox quarry, it is assumed that diesel will be used for the following operational purposes:

- Fuel in trucks for haulage of materials onsite;
- Fuel in trucks for haulage of finished product to offsite client premises; and
- Fuel to operate machinery including but not limited to excavators, front end loaders and dozers.

Diesel Oil – Onsite Operations

Greenhouse gas (GHG) emissions from diesel consumption were estimated using Equation 3.

The annual quantity of diesel consumed (Q) was based on ERM's experience in projects of similar nature in Australia. The following assumptions were made:

- Assumed 80% of diesel oil during operations is associated with the operation of haul trucks for transporting ore and waste onsite; and
- Assumed 20% of the diesel oil during operational phase of the project is from stationary energy sources including excavators, front-end loaders and other mining equipment.

The estimated quantity of diesel oil used for operations onsite is presented in *Table A-5*.

Table A-5 ***Quantity of Diesel oil – operations onsite***

Items	Quantity of fuel (kL)
Diesel – transport related	424
Diesel – stationary energy purpose	106

Diesel Oil – offsite transport

Greenhouse gas (GHG) emissions from diesel consumption were estimated using Equation 3.

The following assumptions were made to estimate the quantity of diesel oil used for transporting pre-mix concrete, quarried material and products to client facilities:

- Average fuel use of 40 litres/100km was assumed;
- Assumed trucks travel on average 30km (including return) to deliver products to client premises; and
- Assumed all haul truck fleet for delivering product is 100% owned/leased by Sancrox (i.e., Scope 1).

The quantity of diesel oil used for transporting products offsite is presented in *Table A-6*.

Table A-6 ***Diesel oil – transportation of products offsite***

Items	Pre-mix concrete	Quarried material	Other Product
No. of truck trips – one way	4015[1]	2313	20,140
Distance travelled for return trip (km/year)	120,450	69,390	604,200
Diesel oil usage (litres/year)	48,180	27,756	241,680

Note:

1. An average day involves 11 pre-mix deliveries (information provided by Sancrox)

Operational Emissions – Diesel

The quantity of diesel consumed in GJ is calculated using an energy content factor for diesel of 38.6 gigajoules per kilolitre (GJ/kL).

- The Scope 1 emission factor for diesel combustion for stationary energy purpose is 70.2 kg CO2 e/GJ (Australian Government Department of the Environment and Energy, 2017a); and

- The Scope 1 emission factor for diesel combustion for transport energy for Euro III compliant trucks is 70.5 kg CO2 e/GJ (Australian Government Department of the Environment and Energy, 2017a).

The estimated annual average GHG emissions from diesel usage are presented in the *Table A-7*.

Table A-7 Estimated Scope 1 emissions from diesel consumption (tCO_2-e)

Fuel	Fuel usage (kL)	Emissions (tCO_2 –eq)
Diesel oil – stationary energy purpose	106	287
Diesel oil – transport energy purpose - onsite	424	1,153
Diesel oil – transport energy purpose – offsite	318	864
Total		**2,304**

ANFO

Ammonium Nitrate/ Fuel Oil (ANFO) is used as a fuel for blasting. GHG emissions from explosives usage were estimated using the following equation:

Equation 2:

$$E_{co2-e} = Q \times EF$$

where:

E_{CO2-e}	Emissions of GHG from explosives	(t CO2-e)
Q	Estimated quantity of explosives	(t)
EF	Emission factor (Scope 1) for explosive combustion	(kg CO2-e/kg of explosive)[3]

The amount of ANFO used is based on ERM's experience in similar projects and is presented in *Table A-8*, together with the emission factor used.

Table A-8 Blasting - quantity of fuel and emission rate

Item	Value	Unit
Quantity of ANFO	4.12	Tonnes
Blasting emission factor	0.189[1]	kg of CO_2-e / kg of fuel

[1] Appendix D, Towards Sustainable Mining, Energy and GHG Emissions Management Reference Guide published by The Mining Association of Canada, June 2014 (The Mining Association of Canada, 2014)

LNG

Liquefied Natural Gas (LNG) is used as fuel in the proposed asphalt plant. The amount of LNG used was derived based on work undertaken by (Wojciech Grabowski, 2010). The GHG emissions was calculated based on Equation 3. The quantity of LNG consumed in GJ is calculated using an energy content factor for LNG of 25.3 gigajoules per kilolitre (GJ/kL). The Scope 1 emission factor for LNG combustion is 51.53 kg CO_2 e/GJ (Australian Government Department of the Environment and Energy, 2017a). The LNG emission factor and quantity of fuels is provided in *Table A-9*.

Table A-9 LNG - quantity of fuel and emission factor

Item	Value	Unit
Fuel input rate	13[1]	Litres per tonnes of hot mix asphalt
Asphalt production rate	50,000[2]	Tonnes per annum

[1] Derived from Table 2 and Table 3, Issues of Energy Consumption during Hot Mix Asphalt (HMA) production, paper presented at the 10th International Conference on Modern Building materials, structures and techniques (Wojciech Grabowski, 2010)

[2] supplied by Sancrox

Electricity

GHG emissions from electricity consumption was estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E_{CO2-e}	Emissions of GHG from electricity usage	(t CO2-e)[1]
Q	Estimated electricity use	(kWh/annum)[2]
EF	Emission factor (Scope 1) for electricity usage	(kg CO2-e/kWh)[3]

[1] tCO2-e = tonnes of carbon dioxide equivalent

[2] kWh = kilo-watt-hour

[3] kg CO2-e/GJ = kilograms of carbon dioxide equivalents per kWh

The quantity of electricity used (Q) per annum is based on ERM's experience with projects of similar nature and is presented in *Table A-10* together with the Scope 2 emission factor used.

Table A-10 Electricity – amount and emission rate

Item	Value	Unit	Comments
Operations - electricity	1,623,786	kWh	Includes electricity used for office, workshop and asphalt plant operations
Operations – concrete batching plant	11.73	kWh	Electricity for concrete batching plant
GHG Emission Rate	0.83[1]	kg of CO_2-e / kWh	Applicable for NSW, Table 7.2, NGER Technical Guidelines, 2017-18 (Australian Government Department of the Environment and Energy, 2017a)

Annex B

Air Quality Emission Estimation

The following sections provide an outline of activities on site which are expected to generate particulate emissions.

B.1 *QUARRY OPERATIONS*

B.1.1 *Drilling*

Section 1.1.8 of NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012) provides default emission factor of:

- 0.59 kg/hole of TSP; and
- 0.31 kg/hole of PM_{10}.

The drill pattern will be determined by geological conditions on a shot by shot basis with typical plan consisting 125 holes. Drilling will take up to 20 hours in total in preparation for blasting a bench and will have a full dust extraction system, which will achieve 99% emission control (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012).

Emission estimation for emissions from drilling were therefore calculated using *Equation B-1*. The calculated emission rates of 0.0001 g/sec and 0.00005 g/sec for TSP and PM_{10} respectively were adopted in the dispersion modelling.

Equation B-1 Emission estimation for drilling

$$ER_i = \frac{EF_i \times N}{20 \times 3{,}600} \times \left(\frac{100 - C}{100}\right)$$

Where
ER_i is emission rate for TSP/PM_{10} (g/sec)
EF_i is emission factor for TSP/PM_{10} (kg/hole)
N is number of holes
C is control factor

B.1.2 *Blasting*

NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012) provides *Equation B-2* for calculating TSP emissions factor for blasting. The emission factor of 13.35 kg of TSP per blast was calculated, using *Equation B-2* and site-specific information provided to ERM (*Table B-1*).

NPI manual indicates that for blasting PM_{10} constitutes 52% of the TSP. The emission factor of 6.94 kg of PM_{10} per blast was therefore calculated in accordance with the manual.

Equation B-2 Emission factor for blasting estimation (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012)

$$EF_{TSP} = \frac{344 \times A^{0.8}}{M^{1.9} \times D^{1.8}}$$

Where
EF_{TSP} is emission factor for TSP (kg/blast)
A is area blasted (m^2)
M is moisture content in percent
D is depth of the blast hole (m)

Table B-1 Site-specific parameters used for estimation of emission factors for blasting

Site-specific parameters	Value	Units
Area blasted	900[1]	m^2
Moisture of blasted material	10[2]	percent
Depth of blast hole	11[1]	meters

1. Provided by Hanson
2. As previously adopted (Environmental Resources Management Australia Pty Ltd, 2013)

Emissions from blasting occurs instantaneously, however the emission rate in terms of grams per second input to the dispersion model will apply for each second of that hour. Input of the actual instantaneous emission rate to the model would therefore result in a significant over estimate of emissions and impact. The instantaneous emission rate is therefore averaged over the hour in order that the total emissions over the modelled hour are equal to the total emissions within the instantaneous blast. To achieve this, *Equation B-3* was used to estimate TSP and PM_{10} emission rates for blasting. The calculated emission rates of 3.71 g/sec and 1.93 g/sec for TSP and PM_{10} respectively were adopted in the dispersion modelling.

Equation B-3 Blasting emission rate estimation

$$ER = EF \times \frac{1,000}{3,600}$$

Where:
ER is emission rate (g/sec)
EF is emission factor (kg/blast)

B.1.3 *Product Handling*

Excavators on Quarry Floor

NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012) provides *Equation B-4* for calculating TSP and PM_{10} emissions factors for excavation. Time-varying emission factors were estimated using hourly wind speed at the height of 2.5 metres above the ground (approximately the height of loading of trucks), predicted in accordance with methodology outlines in Section *7.2* and moisture content of 9% as previously adopted (Environmental Resources Management Australia Pty Ltd, 2013).

Equation B-4 Emission factor for excavators (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012)

$$EF = k \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where:
EF is emission factor (kg of pollutant/tonne of material)
k is a constant equal to 0.74 for particles less than 30 µm aerodynamic diameter and 0.35 for particles less than 10 µm aerodynamic diameter
U is mean wind speed in m/sec
M is moisture content (9% by weight was adopted)

Equation B-5 was then used to estimate TSP and PM_{10} emission rates for excavation. The calculation adopted volume of material of 750,000 tpa (the proposed throughput) shared between two excavators.

Equation B-5 Excavators emission rate estimation

$$ER = EF \times \frac{Q}{N} \times \frac{1,000}{365 \times 24 \times 3,600}$$

Where:
ER is emission rate (g/sec)
EF is emission factor (kg/tonne)
Q is quantity of material (tpa)
N is number of excavators at the quarry floor

Truck Rear Dumping

NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012) provides *Equation B-4* for calculating TSP and PM_{10} emissions factors for loading and unloading trucks (rear dumping). Time-varying emission factors were estimated using hourly wind speed at the height of 2.5 metres above the ground (approximately the height of release from the dumping activity), predicted in accordance with methodology outlines in Section *7.2* and moisture content of 9% as previously adopted (Environmental Resources Management Australia Pty Ltd, 2013).

As previously discussed in Section *6.2.3*, one rear dumping emission point at the feed hopper at the processing plant was included in the dispersion modelling. Time-varying emission rates for this source were further calculated using *Equation B-6* for total volume of material to be processed at the processing plant of 675,000 tpa (90% of the total throughput). The derived emission rates were further reduced by 70% to account for the use of water sprays.

Equation B-6 Emission rates factor calculation for truck rear dumping

$$ER = EF \times \frac{Q \times 1{,}000}{365 \times 24 \times 3{,}600}$$

Where:
ER is emission rate in g/sec
EF is emission factor (kg of pollutant/tonne of material)
Q is quantity of material delivered on site (tpa)

FELs

The NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012) provides *Equation B-4* for calculating TSP and PM_{10} emissions factors for operation of FELs. Time-varying emission factors were estimated using hourly wind speed at the height of 2.5 metres above the ground, predicted in accordance with methodology outlines in Section *7.2* and moisture content of 9% as previously adopted (Environmental Resources Management Australia Pty Ltd, 2013).

Equation B-5 was then used to estimate TSP and PM_{10} emission rates for operations of FELs. The calculation adopted the total volume of material of 695,000 tpa (675,000 tpa - 90% of the proposed throughput of the quarry, and 20,000 tpa of road base output from the nearby concrete recycling facility) shared between two FELs working around the processing plant area. The derived emission rates were further reduced by half to account for mitigation factor of 50% associated with the use of mobile sprinkler systems.

B.1.4 Rock Processing

Crushing

The NPI Emission Estimation Technique Manual for Mining and Processing of Non-Metallic Minerals Version 2.1 (Australian Government Department of the Environment, 2014) provides emission factors for tertiary crushing of 0.0006 kg of TSP and 0.00027 kg of PM_{10} per tonne of material crushed, using wet suppression. As no emission factors are provided by the manual for primary and secondary crushing, the tertiary crushing emission factors were conservatively adopted for primary, secondary and tertiary crushing.

Equation B-6 was then used to calculate emission rates in grams per second. The emission estimation for primary crushing adopted the quantity of material of 675,000 tpa (total expected throughput at the processing plant). The emission rate for secondary crushing adopted the quantity of material of 421,875 tpa, assuming that only 62.5% of the total material processed will require secondary crushing. Emission rate for tertiary crushing adopted the quantity of material of 337,500 tpa, assuming that 50% of the total material processed will require tertiary crushing. *Table B-2* presents emission rates adopted in the dispersion modelling for primary, secondary and tertiary crushing.

Table B-2 ***Emission rates for primary, secondary and tertiary crushing adopted in the dispersion modelling***

Emission source	TSP emission rate (g/sec)	PM_{10} emission rate (g/sec)
Primary crushing	0.013	0.006
Secondary crushing	0.008	0.004
Tertiary crushing	0.006	0.003

Screening

The NPI Emission Estimation Technique Manual for Mining and Processing of Non-Metallic Minerals Version 2.1 (Australian Government Department of the Environment, 2014) provides emission factors for screening of 0.0011 kg of TSP and 0.00037 kg of PM_{10} per tonne of material screened, using wet suppression. These emission factors were adopted for both primary and secondary screening at the processing plant.

Equation B-6 was then used to calculate emission rates in grams per second. The emission estimation for primary screening adopted the quantity of material of 675,000 tpa (total expected throughput at the processing plant). Emission rate for secondary screening adopted the quantity of material of 421,875 tpa, assuming that only 5/8 of the total material processed will require secondary crushing. *Table B-3* presents emission rates adopted in the dispersion modelling for primary and secondary screening.

Table B-3 ***Emission rates for primary and secondary screening adopted in the dispersion modelling***

Emission source	TSP emission rate (g/sec)	PM_{10} emission rate (g/sec)
Primary screening	0.024	0.008
Secondary screening	0.015	0.005

Conveyor Transfer Points

As discussed in Section *6.2.4* two conveyor transfer points and eight conveyor drop points have been included in the dispersion modelling assessment. The NPI Emission Estimation Technique Manual for Mining and Processing of Non-Metallic Minerals Version 2.1 (Australian Government Department of the Environment, 2014) provides emission factors for conveyor transfer points of 0.00007 kg of TSP and 0.000023 kg of PM_{10} per tonne of material transferred, using wet suppression. These emission factors were adopted for conveyor transfer and drop points at the processing plant.

Equation B-6 was then used to calculate emission rates in grams per second. The emission estimation assumed equal distribution of the processed material to each of eight stockpiles and therefore adopted the quantity of material of 84,375 tpa (12.5 % of the total expected throughput at the processing plant) for each emission point. Emission rates of 0.00019 g/sec of TSP and 0.000062 g/sec of PM_{10} were adopted for each of conveyor transfer points included in the dispersion modelling.

B.1.5 Wheel Generated Dust

The NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012) provides *Equation B-7* for calculating emissions factor for wheel generated dust emissions from unpaved roads at industrial sites.

Equation B-7 Wheel generated dust emission factor (kg/vehicle km travelled) (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012)

$$EF = \frac{0.4536}{1.6093} \times k \times \left(\frac{S}{12}\right)^{a} \times \left(\frac{W \times 1.1023}{3}\right)^{b}$$

Where:
EF is emission factor (kg/vehicle kilometre travelled)
k is value equal to 4.9 for TSP and 1.5 for PM_{10}
S is silt content of material (%)
W is vehicle mass (t)
a is an empirical constant equal to 0.7 for TSP and 0.9 for PM_{10}
b is an empirical constant equal to 0.45

Wheel dust from unpaved roads at the quarry is generated by the following types of trucks:

- Caterpillar 769C rock trucks, used for haulage within the site; and
- Truck and dog-type trucks, used for haulage offsite;

Table B-5 presents emission factors calculated for the types of trucks used at the quarry, using *Equation B-7* and site-specific information provided in *Table B-4*.

Table B-4 Site-specific parameters used for estimation of emission factors for wheel generated emissions

Site-specific parameters	Value	Units
Silt content of overburden	7[1]	percent
Loaded weight of a rock truck	67.586[2]	tonnes
Unloaded weight of a rock truck	30.675[2]	tonnes
Loaded weight of a truck and dog	42.5[3]	tonnes
Unloaded weight of a truck and dog	10.07[4]	tonnes

1. As previously adopted (Environmental Resources Management Australia Pty Ltd, 2013)
2. (RitchieSpecs, 2018)
3. (National Heavy Vehicle Regulator, 2017)
4. Assuming truck capacity of 34.43 tonnes

Table B-5 Emission factors estimated for wheel generated dust from unpaved roads by trucks at the quarry

Truck type	TSP (kg/VKT[1])	PM_{10} kg/VKT)
Unloaded rock truck	2.82	0.77
Loaded rock truck	4.02	1.10
Unloaded truck and dog-type truck	1.71	0.47
Loaded truck and dog-type truck	3.26	0.9

1. VKT stands for Vehicle Kilometre Travelled

TSP and PM_{10} emission rates in grams per second per meter were then calculated using *Equation B-8*.

Equation B-8 Wheel generated dust emission rate estimation (g/m/sec)

$$\boldsymbol{ER} = \frac{\boldsymbol{EF \times 1,000 \times L}}{\boldsymbol{T}} \times \frac{\boldsymbol{T}}{\boldsymbol{3,600}} \times \frac{\boldsymbol{N}}{\boldsymbol{L \times 1,000}} \times \boldsymbol{C}$$

Where:
ER is emission rate (g/m/sec)
EF is emission factor (kg/vehicle kilometre travelled)
L is road length (km)
T is time it takes for one trip assuming speed of 20 km/hr (sec)
N is number of trips per day
C is activity control level (75% due to level 2 watering as per NPI guidance)

B.1.6 *Wind Generated Dust*

Wind erosion is expected to generate particulate matter emissions from exposed areas and stockpiles. As discussed in Section *6.2.6*, wind erosion from exposed areas was not included in the dispersion modelling and therefore is not discussed in this section. Dispersion modelling of wind erosion from stockpiles included 10 stockpiles of equal size located in the stockpile area and eight stockpiles under the conveyor drop points

The NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012) provides *Equation B-9* for calculating TSP emission factors for wind erosion from the stockpiles. For each year assessed, *Equation B-9* and site-specific information (*Table B-6*) were used to estimate the total TSP content.

Equation B-9 Wind erosion from stockpiles and exposed conveyors

$$EF_{TSP} = 1.9 \times (\frac{S}{1.5}) \times 365 \times (\frac{365 - p}{235}) \times (\frac{f}{15})$$

Where:
EF_{TSP} is emission factor of TSP (kg/ha/y)
S is the silt content
p is the number of days per year when rainfall is greater than 0.25mm
f is the percentage of time that wind speed is greater than 5.4 m/s at the mean height of the stockpile

Table B-6 Site-specific parameters used for wind erosion emission factors calculation

Site-specific parameters	Year	Value	Units
Silt content of product[1]	All	7	percent
Rainy days (>0.25mm)[2]	2012	122	days
	2013	114	
	2014	115	
	2015	120	
	2016	106	
Time when wind speed is >5.4 m/sec at the mean height of the stockpile[2]	2012	16.55	percent
	2013	16.54	
	2014	16.21	
	2015	14.77	
	2016	13.89	
Number of hours when rainfall < 0.25mm and wind speed is >5.4 m/sec[2]	2012	567	hours
	2013	576	
	2014	657	
	2015	486	
	2016	459	

1. As previously adopted (Environmental Resources Management Australia Pty Ltd, 2013)
2. Calculated based on the predicted meteorology for the Site

Taking into account wind erosion based particulate matter size distribution between PM_{10} and PM_{30}, a factor of 0.5 was used to calculate the emission factor for PM_{10} emissions from wind erosion (SKM, 2005). *Table B-7* presents the calculated emission factors for TSP and PM_{10} for wind erosion.

Table B-7 Estimated emission factors for TSP and PM_{10} emissions as a result of wind erosion

Species	2012	2013	2014	2015	2016
TSP (kg/ha/year)	3692.94	3811.82	3720.65	3322.69	3302.641
PM_{10} (kg/ha/year)	1846.47	1905.91	1860.32	1661.35	1651.321

This total emission per year was divided between the number of hours where both the wind speed and rainfall conditions contained in *Equation B-9* were met (*Table B-6*) and converted to grams per second using *Equation B-10*.

Equation B-10Wind erosion emission rate estimation

$$ER = \frac{A \times EF \times C}{Hr} \times \frac{1{,}000}{3{,}600}$$

Where:
ER is emission rate (g/sec)
EF is emission factor (kg/ha/y)
Hr is number of hours where wind speed is greater than 5.4 m/s and the rainfall average of the last 24 hours is less than 0.25mm
A is the area of the stockpile (ha)
C is activity control level (50% for use of water sprays)

Table B-8 presents stockpile areas for each stockpile modelled used in the emission estimation and the derived emission rates for TSP and PM_{10} used in dispersion modelling.

Table B-8 Stockpile areas and emission rates used in dispersion modelling

		2012		2013		2014		2015		2016	
Source Name	Area (ha)	TSP (g/sec)	PM_{10} (g/sec)	TSP (g/sec)	PM_{10} (g/sec)	TSP (g/sec)	PM_{10} (g/sec)	TSP (g/sec)	PM_{10} (g/sec)	TSP (g/sec)	PM_{10} (g/sec)
STP1	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP2	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP3	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP4	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP5	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP6	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP7	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP8	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP9	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP10	0.36	0.32	0.16	0.33	0.16	0.14	0.28	0.17	0.34	0.36	0.18
STP11	0.04	0.03	0.02	0.04	0.02	0.03	0.01	0.02	0.01	0.04	0.02
STP12	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.03	0.01	0.02	0.01
STP13	0.03	0.03	0.01	0.03	0.01	0.02	0.01	0.02	0.01	0.03	0.01
STP14	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01
STP15	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.03	0.01	0.02	0.01
STP16	0.03	0.03	0.01	0.03	0.01	0.02	0.01	0.02	0.01	0.03	0.02
STP17	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01
STP18	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01
STP19	0.06	0.06	0.03	0.06	0.03	0.05	0.03	0.06	0.03	0.06	0.03

B.2 CONCRETE RECYCLING PLANT

The following sections describe the emission estimation for sources included in the dispersion modelling.

B.2.1 Delivery of Dry Products

As discussed in Section *6.3.1*, one truck rear dumping point was included in the dispersion modelling. Time-varying emission factors were estimated using:

- *Equation B-4* provided by the NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012);
- Hourly wind speed at the height of 2.5 metres above the ground, predicted in accordance with methodology outlines in Section *7.2;* and
- Assumed moisture content of 9%.

Time-varying emission rates for this source were further calculated using *Equation B-6* for 20,000 tpa of concrete delivered on site for recycling. The derived emission rates were further reduced by 70% to account for the use of water sprays for mitigation.

B.2.2 Crushing

The NPI Emission Estimation Technique Manual for Mining and Processing of Non-Metallic Minerals Version 2.1 (Australian Government Department of the Environment, 2014) provides emission factors for tertiary crushing of 0.0006 kg of TSP and 0.00027 kg of PM_{10} per tonne of material crushed, using wet suppression. As no emission factors are provided by the manual for primary crushing, the tertiary crushing emission factors were conservatively adopted for crushing at the concrete recycling facility.

Equation B-6 was then used to calculate emission rates in grams per second. The emission estimation for crushing was based on the quantity of material to be delivered at the facility of 20,000 tpa. *Table B-2* presents emission rates adopted in the dispersion modelling for primary, secondary and tertiary crushing.

Table B-9 Emission rates for primary, secondary and tertiary crushing adopted in the dispersion modelling

Emission source	TSP emission rate (g/sec)	PM_{10} emission rate (g/sec)
Crushing	3.81×10^{-4}	1.71×10^{-4}

B.2.3 Wheel Generated Dust from Haul Roads

Wheel dust from unpaved roads at the concrete recycling facility is associated with:

- The delivery of concrete for recycling to the facility; and
- The delivery of recycled road base output from the facility.

The emission factors for wheel generated dust emissions were calculated using *Equation B-7* provided by NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012).

Table B-13 presents emission factors calculated for the types of trucks used at the concrete recycling plant, using *Equation B-7* and site-specific information provided in *Table B-12*.

Table B-10 Site-specific parameters used for estimation of emission factors for wheel generated emissions

Site-specific parameters	Value	Units
Adopted silt content	7	percent
Loaded weight of a truck and dog	42.5[1]	tonnes

1. (National Heavy Vehicle Regulator, 2017)

Table B-11 Emission factors estimated for wheel generated dust from unpaved roads by trucks at the quarry

Truck type	TSP (kg/VKT[1])	PM_{10} kg/VKT)
Loaded truck and dog-type truck	3.26	0.9

1. VKT stands for Vehicle Kilometre Travelled

TSP and PM_{10} emission rates in grams per second per meter were then calculated using *Equation B-8*.

B.3 CONCRETE BATCHING PLANT

The following sections describe the emission estimation for sources included in the dispersion modelling.

B.3.1 Delivery of Dry Products

As discussed in Section *6.2.3*, one truck rear dumping point was included in the dispersion modelling. Time-varying emission factors were estimated using:

- *Equation B-4* provided by the NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012);
- Hourly wind speed at the height of 2.5 metres above the ground, predicted in accordance with methodology outlines in Section *7.2;* and
- Assumed moisture content of 9%.

Time-varying emission rates for this source were further calculated using *Equation B-6* for the total volume of dry material dumped at the concrete batching plant (21,868 tpa of coarse aggregate delivered from the processing area and 16,750 tpa of sand delivered from offsite as provided in *Table 6-1*). The derived emission rates were further reduced by 70% to account for the use of water sprays for mitigation.

B.3.2 Transfer of Product

As discussed in Section *6.2.3*, one FEL operating at the concrete batching plant was included in the dispersion modelling. Time-varying emission factors were estimated using:

- *Equation B-4* provided by NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012);
- Hourly wind speed at the height of 2.5 metres above the ground, predicted in accordance with methodology outlines in Section *7.2*; and
- Assumed moisture content of 9%.

TSP and PM_{10} emission rates were further calculated using *Equation B-5* for the total volume of dry material delivered to the facility (21,868 tpa of coarse aggregate delivered from the processing area and 16,750 tpa of sand delivered from offsite as provided in *Table 6-1*).

B.3.3 Weigh Hopper and Mixer Loading

The concrete batching plant will be totally enclosed. All particulate matter emissions generated by the facility will be captured by one bag filter located above the pan mixer.

TSP emission rate from the bag filter was calculated in accordance with the POEO Clean Air Regulations discharge limit of 20 mg/Nm^3 for solid particles, contained in Schedule 3 for cement or lime production or cement or lime handling (New South Wales Government, 2017). *Equation B-11* presents the equation used to calculate TSP emission rate. It should be noted that whilst the United States Environment Protection Agency AP-42 Air Emissions Factors and Quantification, Chapter 11: Mineral Products Industry, Section 11.12 Concrete Batching (United States Environmental Protection Agency, 2006) provides emission factor for TSP emissions from these type of facilities, the emission rate calculated using POEO Regulation was estimated to be more stringent and therefore was adopted in this assessment.

Equation B-11 Concrete batching plant bag filter TSP emission rate estimation

$$ER = \frac{DL \times VF}{1{,}000 \times 3{,}600}$$

Where:
ER is emission rate (g/sec)
DL is POEO discharge limit of 20 mg/Nm^3
VF is volumetric flow of 42.9 Nm^3/hour adopted from a similar facility (Environmental Resources Management Australia Pty Ltd, 2017)

PM_{10} emission rate from the bag filter was estimated using particle size distribution adopted from AP-42 Appendix B.2 Generalised Particle Size Distribution for concrete batching of 51% (United States Environmental Protection Agency, 1996). *Table B-9* presents emission rates for TSP and PM_{10} adopted in the dispersion modelling.

Table B-12 TSP, PM_{10} and $PM_{2.5}$ emission rates for bag filter at the concrete batching plant adopted in the assessment

Source	TSP emission rate (g/sec)	PM_{10} emission rate (g/sec)
Bag filter	0.00024	0.000122

In addition to particulate matter, United States Environment Protection Agency AP-42 Air Emissions Factors and Quantification, Chapter 11: Mineral Products Industry, Section 11.12 Concrete Batching (United States Environmental Protection Agency, 2006) provide emission rates for the following metals:

- Arsenic;
- Cadmium;
- Total Chromium;
- Lead;
- Manganese;
- Nickel; and
- Total Phosphorus.

No criteria exist for Total Phosphorus (*Section 3*) and therefore this species was not considered further in this assessment.

Table B-10 presents metal emission factors as provided in United States Environment Protection Agency AP-42 Air Emissions Factors and Quantification, Chapter 11: Mineral Products Industry, Section 11.12 Concrete Batching (United States Environmental Protection Agency, 2006).

Table B-13 Emission factors for metals emitted from concrete batching plants (United States Environmental Protection Agency, 2006)

Source	Emission factor (kg/tonne of material loaded)					
	Arsenic	Cadmium	Total Chromium	Lead	Manganese	Nickel
Central Mix Batching with Fabric Filter	1.48×10^{-7}	3.55×10^{-10}	6.34×10^{-8}	1.83×10^{-8}	1.89×10^{-6}	1.24×10^{-7}

Table B-11 provides the calculated emission rates for metals adopted in this assessment, calculated using *Equation B-12*.

Equation B-12 Concrete batching plant bag filter TSP emission rate estimation

$$ER = \frac{EF \times Q \times 1{,}000}{365 \times 24 \times 3{,}600}$$

Where:
ER is emission rate (g/sec)
EF is emission factor (kg pollutant per tonne of material loaded)
Q is total material loaded (47,200 tpa as provided in *Table 6-1*)

Table B-14 Emission factors for metals emitted from concrete batching plants (United States Environmental Protection Agency, 2006)

Source	Emission factor (kg/tonne of material loaded)					
	Arsenic	Cadmium	Total Chromium	Lead	Manganese	Nickel
Central Mix Batching with Fabric Filter	2.2×10^{-7}	5.3×10^{-10}	9.4×10^{-8}	2.7×10^{-8}	2.8×10^{-6}	1.9×10^{-7}

B.3.4 Wheel Generated Dust from Haul Roads

Wheel dust from unpaved roads at the concrete batching plant is associated with:

- The delivery of coarse aggregate from the processing plant using rock trucks;

- The delivery of sand and concrete for recycling using road truck-and-dog-type trucks from offsite;
- The delivery of cement and cement supplement using agitator trucks from offsite; and
- The delivery of cement mix from the site to the market using the agitator trucks.

The delivery of coarse aggregate has been considered as part of quarry operations (Section *B.1.5*) and therefore is not discussed further in this section. The emission factors for wheel generated dust emissions from other sources were calculate using equation *Equation B-7* provided by NPI Emission Estimation Technique Manual for Mining Version 3.1 (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012).

Table B-13 presents emission factors calculated for the types of trucks used at the concrete batching plant, using *Equation B-7* and site-specific information provided in *Table B-12*.

Table B-15 ***Site-specific parameters used for estimation of emission factors for wheel generated emissions***

Site-specific parameters	Value	Units
Adopted silt content	7	percent
Loaded weight of a truck and dog	42.5[1]	tonnes
Unloaded weight of a truck and dog	10.07[2]	tonnes
Loaded weight of an agitator truck	32[3]	tonnes
Unloaded weight of an agitator truck	12.2[3]	tonnes

2. (National Heavy Vehicle Regulator, 2017)
3. Assuming truck capacity of 34.43 tonnes
4. (Excel Concrete Pty Ltd, 2011)

Table B-16 ***Emission factors estimated for wheel generated dust from unpaved roads by trucks at the quarry***

Truck type	TSP (kg/VKT[1])	PM_{10} kg/VKT)
Unloaded truck and dog-type truck	1.71	0.47
Loaded truck and dog-type truck	3.26	0.9
Unloaded agitator truck	1.86	0.51
Loaded agitator truck	2.87	0.79

1. VKT stands for Vehicle Kilometre Travelled

TSP and PM_{10} emission rates in grams per second per meter were then calculated using *Equation B-8*.

B.4 *ASPHALT PLANT*

The following sections describe the emission estimation for sources included in the dispersion modelling for the asphalt plant.

B.4.1 *Dryer Emissions*

Emissions have been estimated using published emission factors from the United States Environment Protection Agency AP-42 Air Emissions Factors and Quantification, Chapter 11: Mineral Products Industry, Section 11.1 Hot Mix Asphalt Plants (United States Environmental Protection Agency, 2004). The source provides emission rates for a wide range of species, however no criteria exist for all the species (*Section 3*) and therefore only species included in *Table B-14* were considered further in this assessment. In addition to species presented provided by Chapter 11, the asphalt plant will emit odour and therefore the potential for odour impact was also considered in this assessment.

Table B-14 presents emission factors and the associated emission rates calculated using *Equation B-13*, with exception of odour. The odour emission rate was sourced from a similar study and adapted to site-throughput using *Equation B-14* (GHD, 2008).

Table B-17 Emission factors and rates for species associated with the asphalt plant

Species	Emission factor (kg/tonne asphalt produced)[1]	Asphalt dryer Bag Filter emission rate (g/sec unless specified otherwise)[2]
TSP	0.033	0.026
PM_{10}	0.0042	0.003
NO_x	0.026	0.02
CO	0.13	0.1
SO_2	0.0034	0.003
Benzene	0.00039	0.0003
Ethylbenzene	0.00024	0.0002
Formaldehyde	0.0031	0.002
Hexane	0.00092	0.0007
Methyl chloroform	0.000048	0.00004
Polycyclic aromatic hydrocarbon (PAH) as benzo[a]pyrene	0.00019	0.00015
Toluene	0.00015	0.0001
Xylene	0.0002	0.0002
n-Heptane	0.0094	0.007
n-Pentane	0.00021	0.0002
Antimony and compounds	0.00000018	1.4×10^{-7}
Arsenic and compounds	0.00000056	4.4×10^{-7}
Barium (soluble compound)	0.0000058	4.6×10^{-7}
Cadmium and cadmium compounds	0.00000041	3.2×10^{-7}
Total Chromium	0.0000055	4.5×10^{-6}
Copper fumes	0.0000031	2.5×10^{-6}
Chromium VI compounds	0.00000045	2.6×10^{-7}
Lead	0.00000062	4.9×10^{-7}
Manganese and compounds	0.0000077	6.1×10^{-6}
Mercury	0.000000336	2.7×10^{-7}
Nickel and nickel compounds	0.000032	0.00005
Silver soluble compounds (as Ag)	0.00000048	3.8×10^{-7}
Zinc	0.000061	4.8×10^{-5}
Odour[3]	-	43,333.3 (OU/sec)

1. (United States Environmental Protection Agency, 2004).
2. Calculated for the total asphalt production (50,000 tpa), averaged over the year
3. Calculated from odour emission rate of 1,040,000 OUm^3/min (GHD, 2008)

Equation B-13Concrete batching plant bag filter TSP emission rate estimation

$$ER = \frac{EF \times Q \times 1{,}000}{365 \times 24 \times 3{,}600}$$

Where:
ER is emission rate (g/sec)
EF is emission factor (kg pollutant per tonne of asphalt produced)
Q is total quantity of asphalt produced (50,000 tpa)

Equation B-14Concrete batching plant bag filter TSP emission rate estimation

$$ER_{Site} = \frac{ER_{GHD} \times 50{,}000}{20{,}000 \times 60}$$

Where:
ER_{Site} is site emission rate (g/sec)
ER_{GHD} is emission rate provided in GHD assessment (GHD, 2008)

B.4.2 Wheel Generated Dust from Haul Roads

Wheel dust from unpaved roads at the asphalt plant is associated with:

- The delivery of bitumen using agitator trucks from offsite; and
- The delivery of asphalt from the site to market using road truck-and-dog-type trucks.

The emission factors calculated for the types of trucks used at the asphalt plant are provided in *Table B-13*. TSP and PM_{10} emission rates in grams per second per meter were then calculated using *Equation B-8*.

Annex C

Screening Assessment

There are a number of species of metals, combustion related emissions and organic compounds that have the potential to be released from both the concrete batching and asphalt plants. The emissions from these sources are small, and therefore a screening assessment was completed to determine which sources and species should be taken forward to dispersion modelling. It should be noted that particulate matter from these sources was not subject to the screening method, as it was considered that given the contribution from other sources at the Site, additional emissions from these sources should be included in the cumulative assessment.

The screening assessment for the concrete batching and asphalt plants was undertaken in accordance with UK '*Air emissions risk assessment for your environmental permit guidance*' (UK Department for Environment, Food and Rural Affairs Environment Agency, 2016) using emission rates provided in *Table 6-3*. The Guidance provides dispersion factors expressed as µg/m³/g/sec for a variety of release heights and averaging periods (*Table C-1*) (UK Department for Environment, Food and Rural Affairs Environment Agency, 2016).

Table C-18 Dispersion factors provided in the Air Emissions Risk Assessment for your Environmental Permit Guidance (UK Department for Environment, Food and Rural Affairs Environment Agency, 2016)

Effective height of release in metres	Annual dispersion factor	Monthly dispersion factor	Hourly dispersion factor
0	148	529	3900
10	32	33.7	580
20	4.6	6.2	161
30	1.7	2.3	77
50	0.52	0.68	31
70	0.24	0.31	16
100	0.11	0.13	8.6
150	0.048	0.052	4
200	0.023	0.026	2.3

The release height of bag filter at the concrete batching facility was assumed to be 5 metres based on the information from a similar type of facility (Environmental Resources Management Australia Pty Ltd, 2017). The release height of the point source at the asphalt plant of 5 metres was adopted based on the technical data specification for Benninghoven Asphalt Mixing Plants (A Wirtgen Group Company, n.d.).

A linear interpolation method was used to derive the dispersion factor for the height of 5 metres using the dispersion factors in *Table C-1 (Equation C-1*). The relevant dispersion factors are provided in *Table C-2*.

Equation C-1 Linear interpolation of dispersion factors provided in the Air Emissions Risk Assessment for your Environmental Permit Guidance (UK Department for Environment, Food and Rural Affairs Environment Agency, 2016)

$$\mathrm{DF}_{n+1} = \frac{(H_{n+1} - H_n)(DF_{n+2} - DF_n)}{(H_{n+2} - H_n)} + DF_n$$

Where:
DF_n and DF_{n+2} are dispersion factors provided in the Guidance in µg/m³/g/sec
DF_{n+1} is the dispersion factor required in µg/m³/g/sec
H_n and H_{n+2} are the associated effective heights of release in metres; and
H_{n+1} is the required release height in metres.

Table C-19 Dispersion factors adopted in the assessment

Averaging period	Dispersion factor (µg/m³/g/sec)[1]
10 minute	2,375[5]
15 minute	2,224[3]
30 minute	1,907[5]
1 hour	1,660
8 hour	1,162[4]
24 hour	979[2]
Annual	58

1. The dispersion factors presented in Table are subject to interpolation of the dispersion factors provided in the Guidance;
2. 24 hour dispersion factor was derived from the hourly dispersion factor using factor of 0.59 as recommended in the Guidance;
3. 15 minute dispersion factor was derived from the hourly dispersion factor using factor of 1.34 as recommended in the Guidance;
4. 8 hour dispersion factor was derived from the hourly dispersion factor using factor of 0.7 as recommended in the Guidance;
5. Conversion of 1 hour model results to 10 minute and 30 minute averages has been undertaken using the peak to mean ratio as described in Victorian EPA Publication 1551 (Environment Protection Authority Victoria, 2013).

Equation C-2, contained within the Guidance, was used to combine the emission rates in *Table 6-3* with the dispersion factors in *Table C-2* to provide the estimated maximum short-term and long-term ground level concentrations attributed to each source.

Equation C-2 Estimation environmental concentrations for the species

$$EC = ER \times DF$$

Where:
EC is the environmental concentration of the species in micrograms per cubic meter
ER is emission rate in gram per second
DF is dispersion factor in micrograms per cubic metre per gram per second

Table C-3 provides short-term and long-term environmental concentrations for species emitted from concrete batching plant.

Table C-3 ***Short-term and long-term contribution to environmental concentrations for species emitted from concrete batching plant***

	Concentration (ug/m³)	Criterion (ug/m³)	Percent (%)
Arsenic	0.0004	0.09	0.4
Cadmium	8.8×10^{-7}	0.018	0.0
Chromium	0.0002	0.09	0.2
Lead	1.6×10^{-6}	0.5	0.0
Manganese	0.005	18	0.0
Nickel	0.0003	0.18	0.2

The Guidance outlines that the following criteria must be met in order to screen out species that result in an insignificant contribution to ambient air quality and for which no further assessment is required (UK Department for Environment, Food and Rural Affairs Environment Agency, 2016):

- The estimated short-term environmental concentration is less than 10% of the short-term environmental standard; and
- The estimated long-term environmental concentration is less than 1% of the long-term environmental standard.

Table C-3 indicates that the total short-term environmental concentrations related to the batching plant are below 10 percent of the relevant criteria for all species and the total long-term environmental concentrations are below one percent of the relevant criteria for all species. It is therefore considered that emissions from the concrete batching facility are not likely to be significant contributors to ambient air quality concentrations and no further assessment is required. It should be also considered that dispersion factors in the Guidance result in a very conservative assessment and the environmental concentrations for the species in reality will be much lower than presented in *Table C-3*.

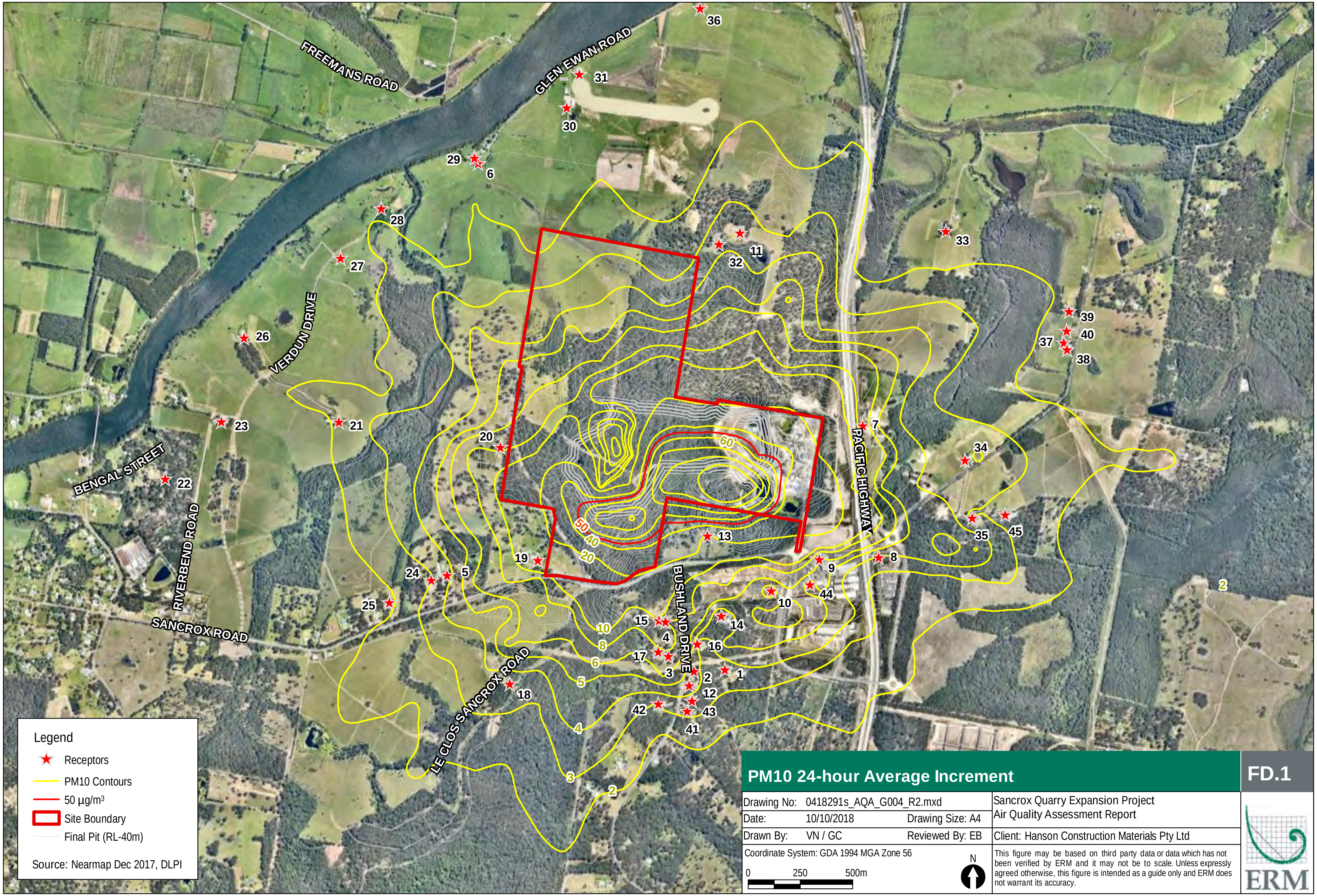
Table C- 4 provides short-term and long-term environmental concentrations for species emitted from asphalt plant. *Table C- 4* indicates that the total short-term environmental concentrations are below 10 percent of the relevant criteria for all species, except for NO_2, formaldehyde, PAH and nickel, and the total long-term environmental concentrations are below one percent of the relevant criteria for all species, except for NO_2. Only NO_2, formaldehyde, PAH and nickel were included in the dispersion modelling and no further assessment was required for any other species contained in *Table C-4* It should be also considered that dispersion factors in the Guidance result in a very conservative assessment and the environmental concentrations for the species in reality will be much lower than presented in *Table C- 4*

Table C-20 Short-term and long-term contribution to environmental concentrations for species emitted from asphalt plant

Species	Averaging period	Concentration (ug/m³)	Criterion (ug/m³)	Percent (%)
NO_2	1 hour	34.2	246	**13.91**
	Annual	1.2	62	**1.93**
Formaldehyde	1 hour	4.1	20	**20.40**
PAH	1 hour	0.3	0.4	**62.51**
Nickel	1 hour	0.1	0.18	**46.06**
CO	15 min	229.2	100000	0.23
	1 hour	171.1	30000	0.57
	8 hour	119.7	10000	1.20
SO2	10 min	6.4	712	0.90
	1 hour	4.5	570	0.78
	24 hour	2.6	228	1.16
	Annual	0.2	60	0.26
Benzene	1 hour	0.5	29	1.77
Ethylbenzene	1 hour	0.3	8000	0.00
Hexane	1 hour	1.2	3200	0.04
Methyl chloroform	1 hour	0.1	12500	0.00
Toluene	1 hour	0.2	360	0.05
Xylene	1 hour	0.3	190	0.14
Heptane	30 min	16.6	33000	0.05
n-Pentane	1 hour	0.3	33000	0.00
Antimony	1 hour	0.0002	9	0.00
Arsenic	1 hour	0.0007	0.09	0.82
Barium	1 hour	0.008	9	0.08
Cadmium	1 hour	0.0005	0.018	3.00
Chromium	1 hour	0.007	9	0.08
Copper	1 hour	0.004	3.7	0.11
Hexavalent Chromium	1 hour	0.0006	0.09	0.66
Lead	Annual	0.00003	0.5	0.01
Manganese	1 hour	0.0101	18	0.06
Mercury	1 hour	0.0004	0.18	0.25
Silver	1 hour	0.0006	0.18	0.35
Zinc	30 min	0.09	100	0.09
	24 hour	0.05	120	0.04
Asphalt petroleum fumes	1 hour	6.9	90	7.66

Annex D

Contour Plots

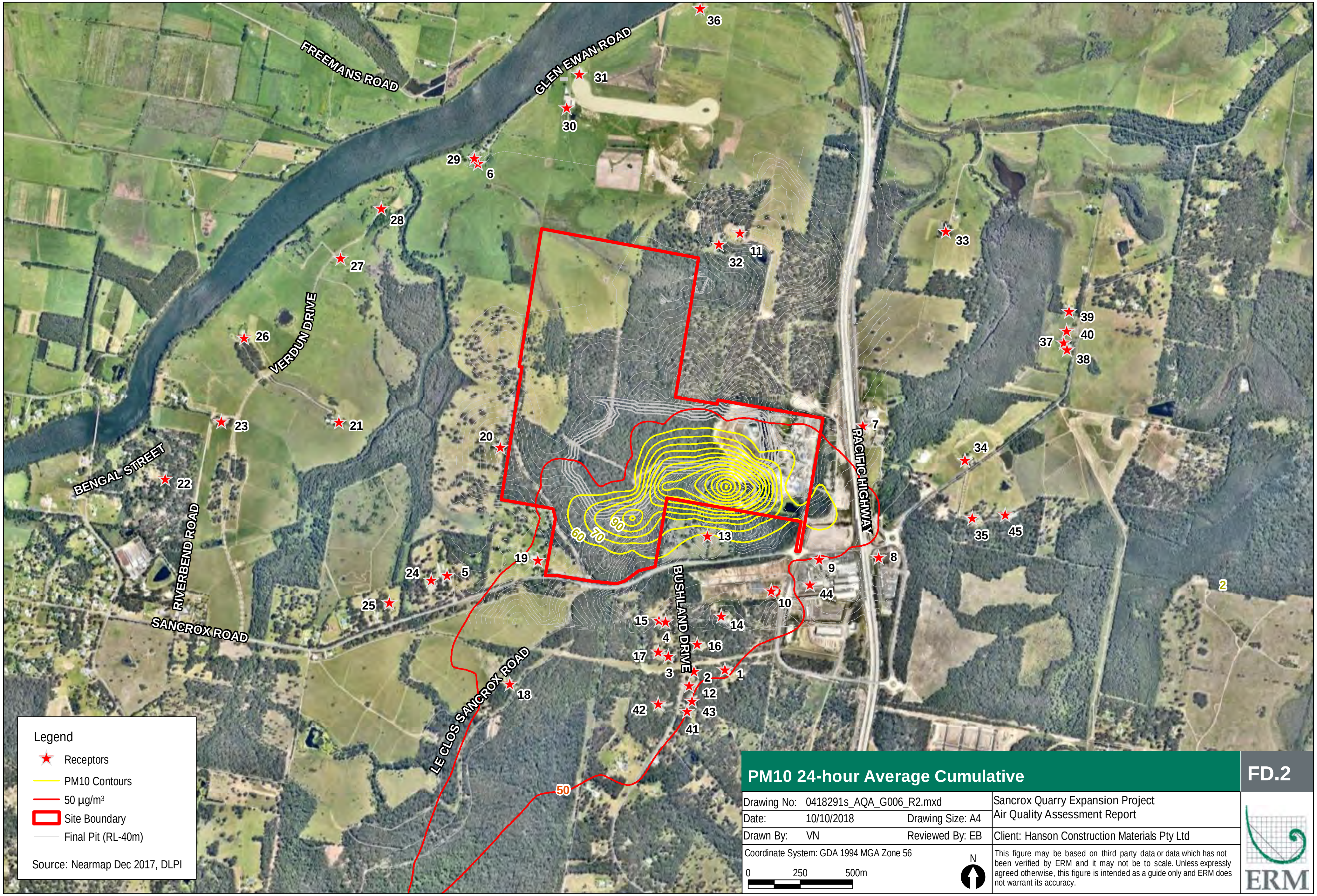


PM10 24-hour Average Increment

FD.1

Drawing No: 0418291s_AQA_G004_R2.mxd		Sancrox Quarry Expansion Project Air Quality Assessment Report
Date: 10/10/2018	Drawing Size: A4	
Drawn By: VN / GC	Reviewed By: EB	Client: Hanson Construction Materials Pty Ltd
Coordinate System: GDA 1994 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

ERM



PM10 24-hour Average Cumulative

FD.2

Drawing No: 0418291s_AQA_G006_R2.mxd		Sancrox Quarry Expansion Project Air Quality Assessment Report
Date: 10/10/2018	Drawing Size: A4	
Drawn By: VN	Reviewed By: EB	Client: Hanson Construction Materials Pty Ltd

Coordinate System: GDA 1994 MGA Zone 56

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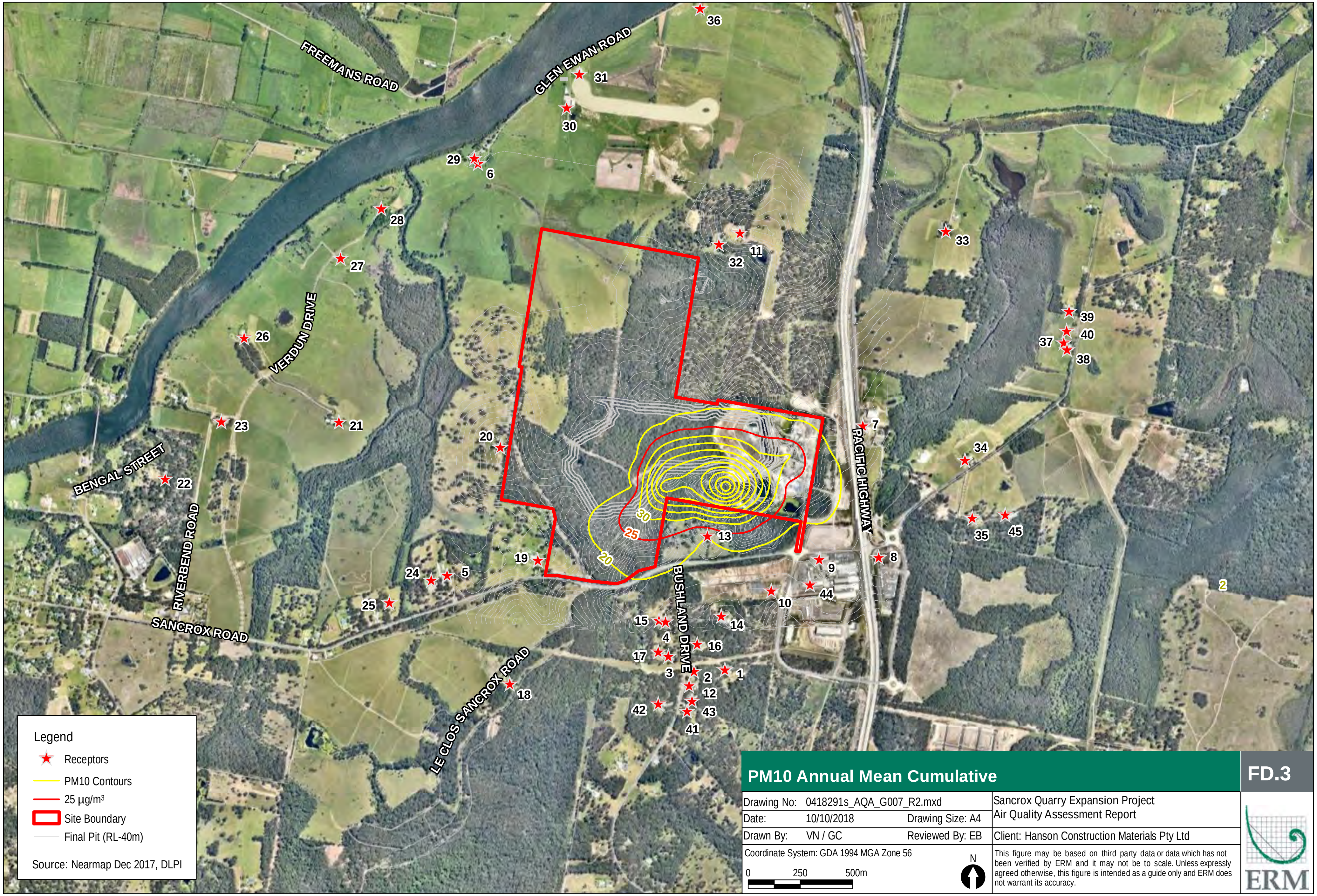
ERM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GLEN EWAN ROAD
VERDUN DRIVE
BENGAL STREET
RIVERBEND ROAD
SANCROX ROAD
LE CLOS SANCROX ROAD
BUSHLAND DRIVE
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Legend
Receptors
PM10 Contours
25 µg/m³
Site Boundary
Final Pit (RL-40m)
Source: Nearmap Dec 2017, DLPI
PM10 Annual Mean Cumulative
FD.3
Drawing No: 0418291s_AQA_G007_R2.mxd
Date: 10/10/2018
Drawing Size: A4
Drawn By: VN / GC
Reviewed By: EB
Coordinate System: GDA 1994 MGA Zone 56
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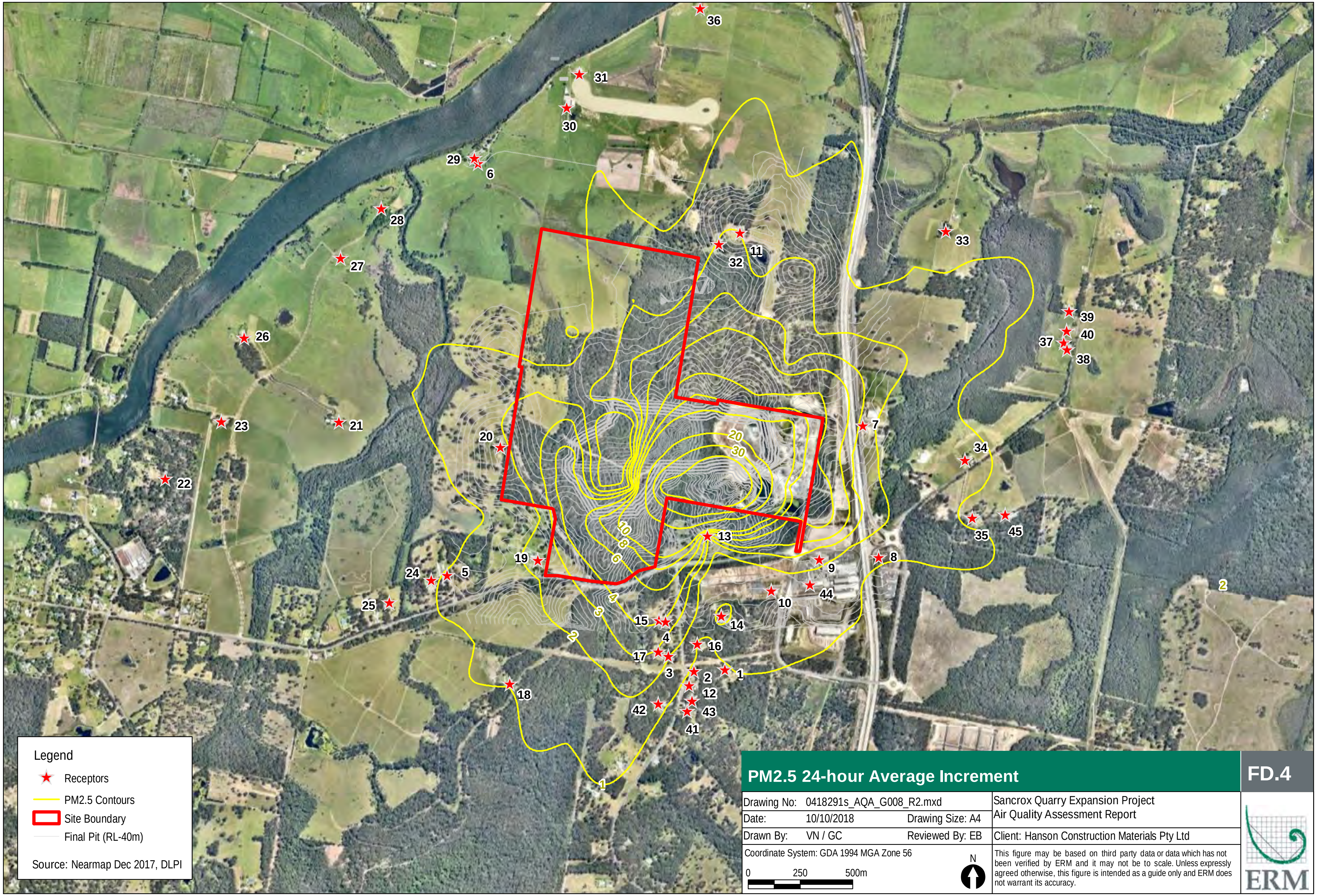
Sancrox Quarry Expansion Project
Air Quality Assessment Report
Client: Hanson Construction Materials Pty Ltd
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
ERM



PM2.5 24-hour Average Increment

FD.4

Drawing No:	0418291s_AQA_G008_R2.mxd		Sancrox Quarry Expansion Project Air Quality Assessment Report
Date:	10/10/2018	Drawing Size: A4	
Drawn By:	VN / GC	Reviewed By: EB	Client: Hanson Construction Materials Pty Ltd

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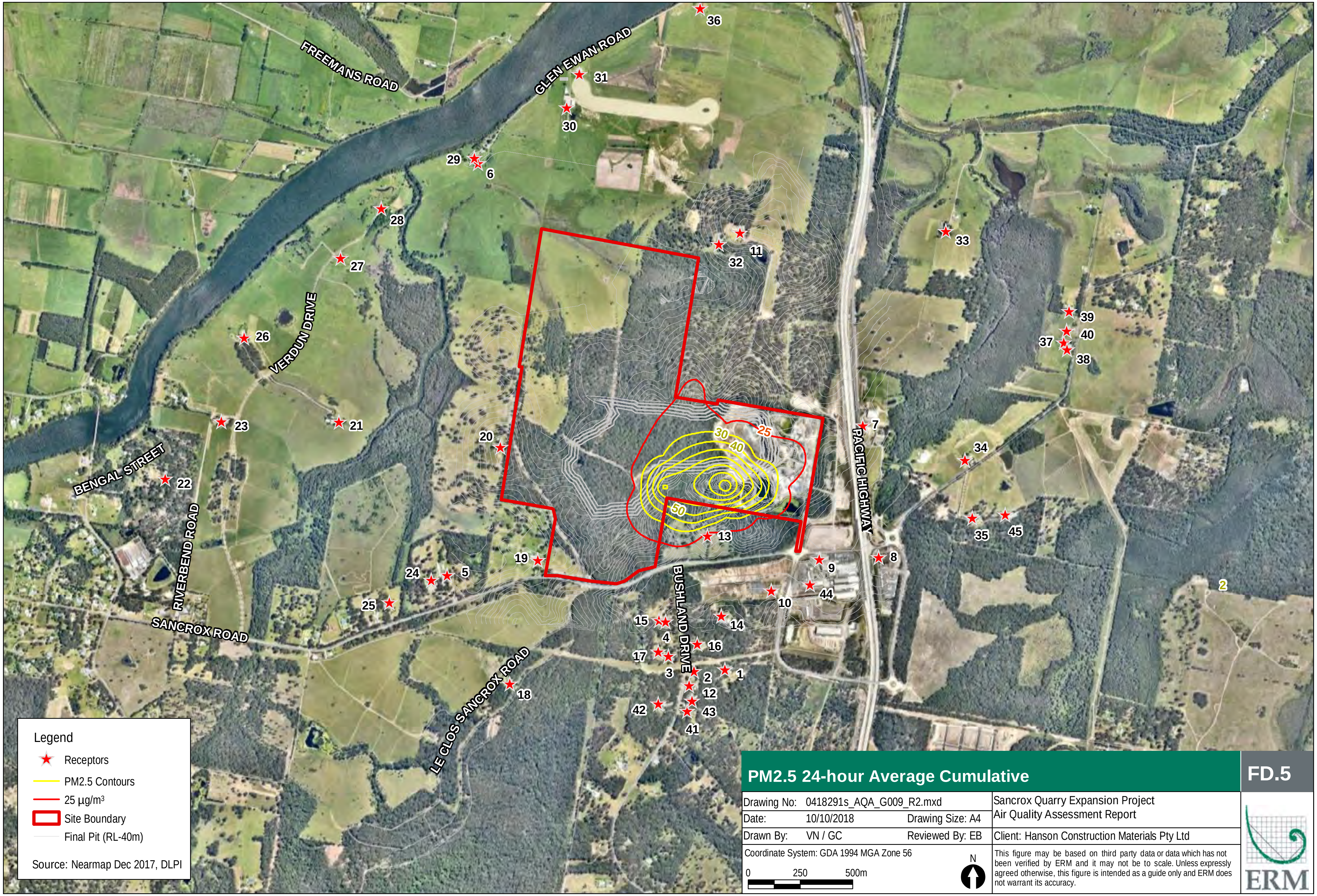
ERM



PM2.5 24-hour Average Cumulative

FD.5

Drawing No: 0418291s_AQA_G009_R2.mxd		Sancrox Quarry Expansion Project Air Quality Assessment Report
Date: 10/10/2018	Drawing Size: A4	
Drawn By: VN / GC	Reviewed By: EB	Client: Hanson Construction Materials Pty Ltd
Coordinate System: GDA 1994 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

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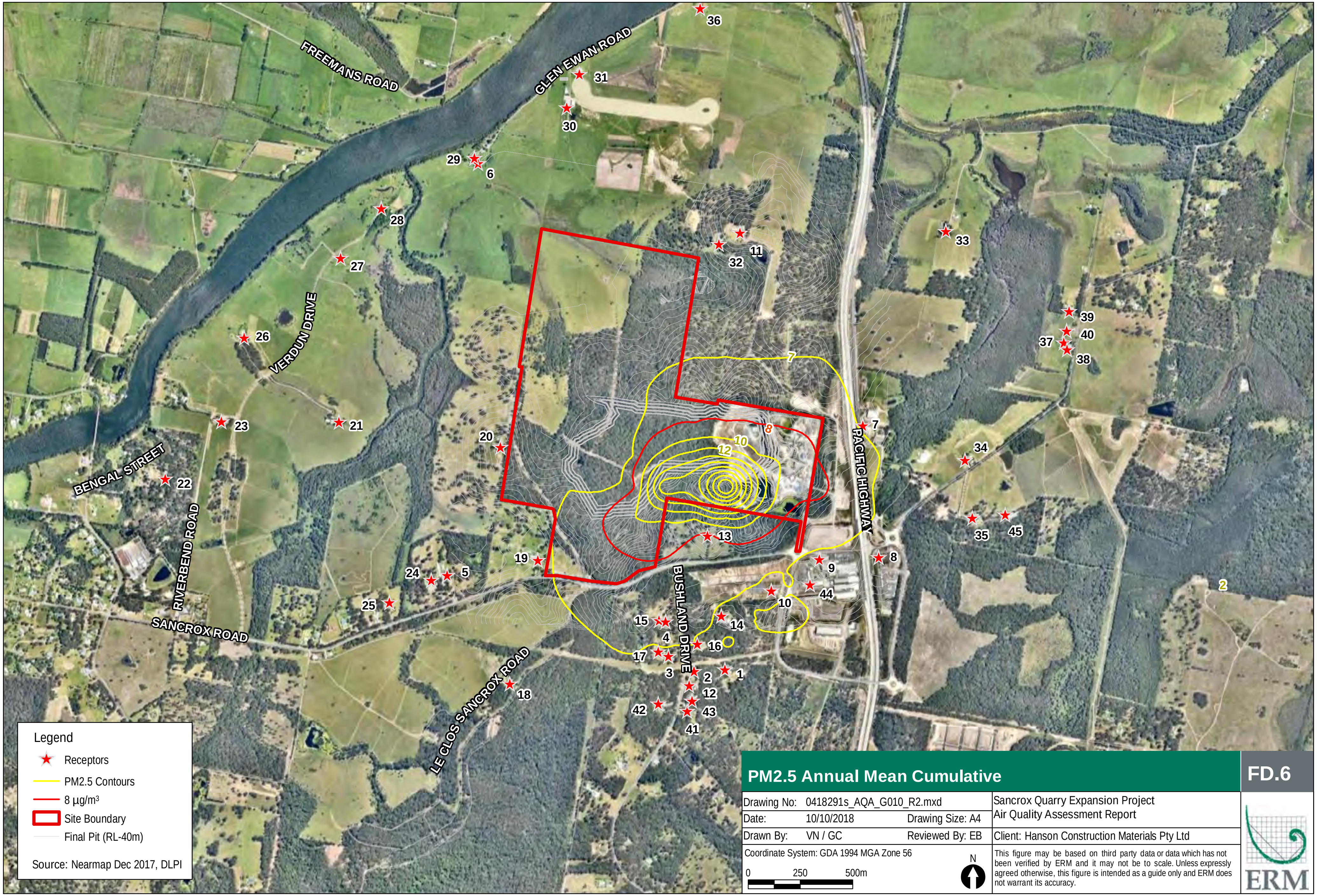
ERM



PM2.5 Annual Mean Cumulative

FD.6

Drawing No: 0418291s_AQA_G010_R2.mxd

Date: 10/10/2018 Drawing Size: A4

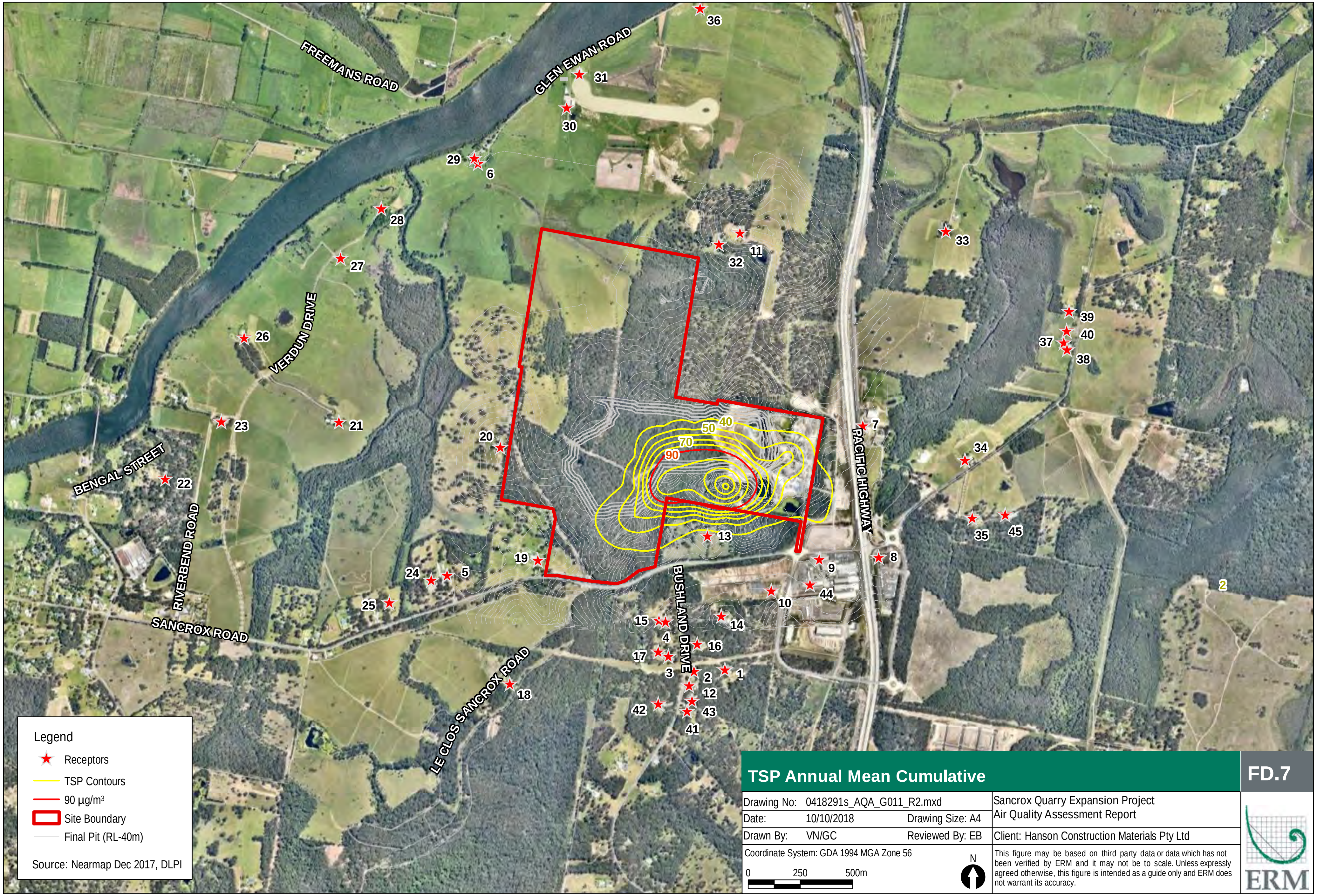
Drawn By: VN / GC Reviewed By: EB

Coordinate System: GDA 1994 MGA Zone 56

Sancrox Quarry Expansion Project
Air Quality Assessment Report

Client: Hanson Construction Materials Pty Ltd

ERM



FREEMANS ROAD
GLEN EWAN ROAD
VERDUN DRIVE
BENGAL STREET
RIVERBEND ROAD
SANCROX ROAD
LE CLOS SANCROX ROAD
BUSHLAND DRIVE
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Legend
Receptors
TSP Contours
90 µg/m³
Site Boundary
Final Pit (RL-40m)
Source: Nearmap Dec 2017, DLPI
TSP Annual Mean Cumulative
FD.7
Drawing No: 0418291s_AQA_G011_R2.mxd
Date: 10/10/2018
Drawing Size: A4
Drawn By: VN/GC
Reviewed By: EB
Sancrox Quarry Expansion Project
Air Quality Assessment Report
Client: Hanson Construction Materials Pty Ltd
Coordinate System: GDA 1994 MGA Zone 56
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500m
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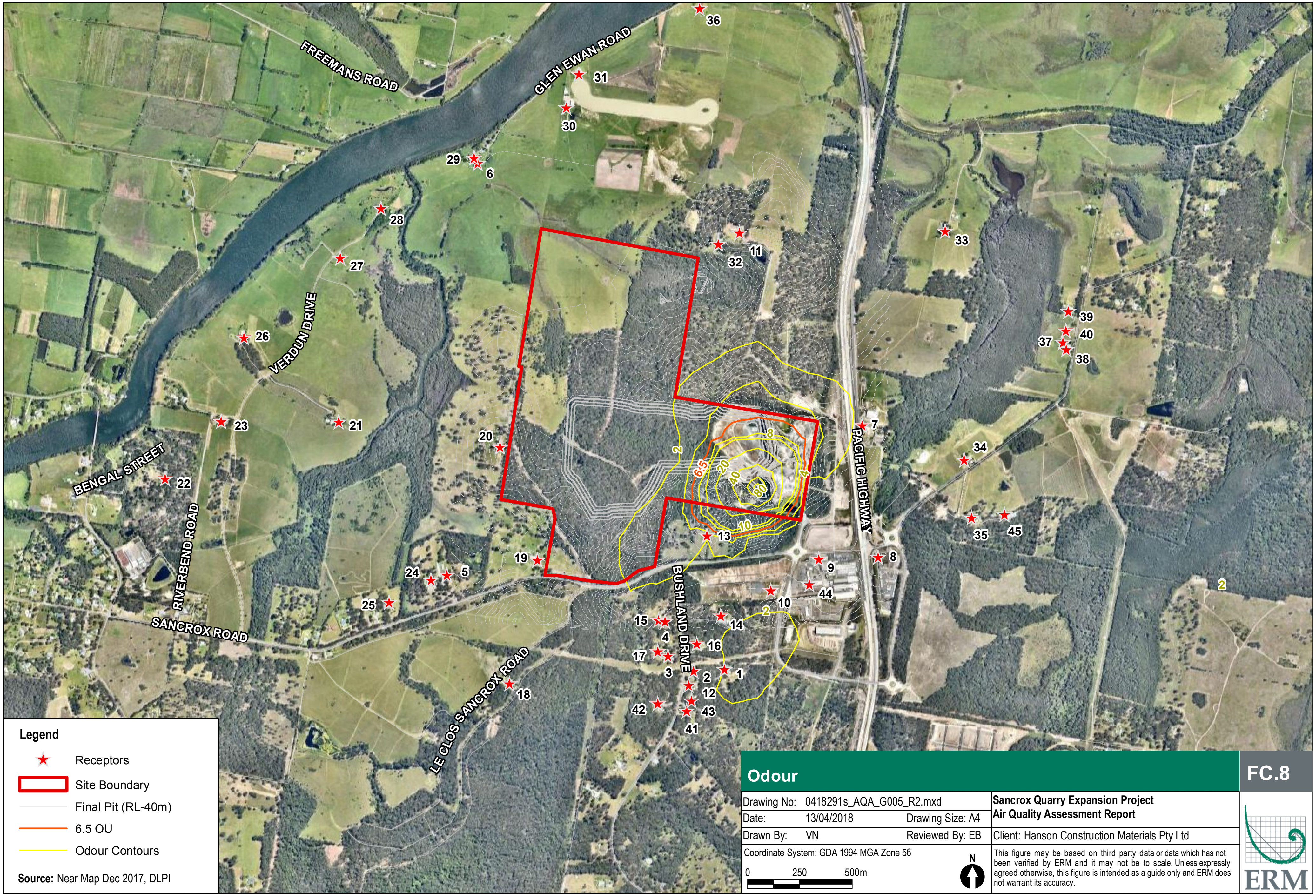
ERM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GLEN EWAN ROAD
VERDUN DRIVE
BENGAL STREET
RIVERBEND ROAD
SANCROX ROAD
LE CLOS SANCROX ROAD
BUSHLAND DRIVE
PACIFIC HIGHWAY
Legend
Receptors
Site Boundary
Final Pit (RL-40m)
6.5 OU
Odour Contours
Source: Near Map Dec 2017, DLPI
Odour
FC.8
Drawing No: 0418291s_AQA_G005_R2.mxd
Date: 13/04/2018
Drawing Size: A4
Drawn By: VN
Reviewed By: EB
Sancrox Quarry Expansion Project
Air Quality Assessment Report
Client: Hanson Construction Materials Pty Ltd
Coordinate System: GDA 1994 MGA Zone 56
0 250 500m
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