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LIGHT WEIGHT AGGREGATE (LWA) PROJECT - BRICKWORKS, HORSLEY PARK, NSW

REVISED AIR QUALITY IMPACT ASSESSMENT – FEB 16028.1

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EXECUTIVE SUMMARY

McKenzie Group Pty Ltd (McKenzie Group), on behalf of Brickworks NSW Pty Ltd (Brickworks) – have commissioned Airlabs Environmental Pty Ltd (Airlabs) to undertake revised Air Quality Impact Assessment (AQIA) in relation to the proposed State Significant Development (SSD) Application pertaining to the Light Weight Aggregate (LWA) Project (the Project) which will be developed at the existing Plant 2 Brickworks Site at 780 Wallgrove Road, Horsley Park, NSW (the Project Site)

An initial AQIA was issued by Airlabs (Report No: JAN15015.4, dated: 2nd October 2015) accompanying the Environmental Impact Statement (EIS) for public exhibition. Since the public exhibition period, comments have been received from regulatory agencies. During recent discussions with Brickworks as a part of addressing the comments, Airlabs have been advised about the change in the type of fuels that would be used in the proposed LWA kilns. The original AQIA (JAN 15015.4) references the following fuel options – 100% natural gas, 90% Construction and Demolition (C&D) / Construction & Industrial (C&I) Timbers and 10% Natural Gas and 90% Refuse Derived Fuel (RDF) and 10% Natural Gas. Brickworks have since then advised Airlabs about the change of fuel options, which now comprises 100% natural gas and 100% pulverised coal and as-such, no waste fuels (i.e. C&D, C&I Timbers and RDF) are being proposed. This revised AQIA (FEB 16028.1) addresses the comments issued by the regulatory agencies as well as determining air quality impacts associated with the proposed change in fuel.

The Project is divided into two (2) stages – Stage 1 and Stage 2. Stage 1 of the Project comprises LWA production volumes of 300,000 tonnes per annum (tpa). An additional 300,000 tpa of LWA production is forecasted for Stage 2, which would potentially commence approximately five (5) years after commencement of Stage 1, therefore, the combined LWA production volumes for the Project comprising Stage 1 and Stage 2 operations would be 600,000 tpa. The rotary kiln for Stage 1 is designed to produce 300,000 tpa of LWA and as-such; a new rotary kiln in addition to the Stage 1 kiln would be commissioned during Stage 2 operations. Brickworks are also investigating the feasibility of using different types of fuels in the proposed rotary kilns and have identified two (2) specific fuel combinations, which include:

- 100% Natural Gas; and
- 100% Pulverised Coal

Regulatory requirements governing this Project include the following:

- Group 6 emission standards listed in the NSW-Environmental Protection Authority (NSW-EPA) Protection of the Environment Operations (POEO) Clean Air Regulation 2010;
- Ambient air quality limits in addition to meeting the Clean Air Regulation requirements

To determine air quality impacts associated with existing operations and the proposed LWA operations, air dispersion modelling has been undertaken for all pollutants associated with existing brick manufacturing operations and activities pertaining to LWA operations.

The AQIA has been prepared in accordance with the NSW – Department of Environment and Conservation (DEC) - *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, NSW (Approved Methods). As per the Approved Methods, the NSW – Environment Protection Authority (NSW-EPA) has stipulated minimum requirements regarding information contained within an AQIA, which are outlined below. The relevant sections in this AQIA, which provide details on the EPA's minimum requirements, are mentioned alongside.

- Site Plan – **Section 2**
- Activity Description - **Section 2**
- Emissions Inventory – **Section 6**

- Meteorological Data –**Section 7.2**
- Background Air Quality Data – **Section 5.3**
- Dispersion Modelling – **Section 7, Section 8**
- Bibliography – **Section 10**

As the Project is being assessed as a SSD, Secretary Environmental Assessment Requirements (SEARs) have been issued for the preparation of an Environmental Impact Statement (EIS). The SEARs issued for air quality and the relevant sections of this report, which address the SEARs, are mentioned alongside:

- A comprehensive air quality assessment of all potential point source and fugitive air emissions (including odour) and dust impacts from the development, including details of air quality impacts on private properties in accordance with relevant Environmental Protection Authority guidelines – **Section 6, Section 7,** and **Section 8**
- Details of mitigation, management and monitoring measures for preventing and/or minimising both point and fugitive emissions – **Section 6** to **Section 9**
- An assessment of the effectiveness of the proposed air quality mitigation measures - **Section 6** to **Section 9** and **Appendix B**

This revised assessment addresses the comments received from the regulatory agencies for the original assessment (JAN 15015.4, 2nd October 2015). Airlabs' responses to the comments are provided in **Section 1.**

Flue gas emissions and fugitive particulate emissions associated with existing brick manufacturing operations and proposed Stage 1 and Stage 2 LWA operations at Plant 2 were identified to be the key sources of air pollution.

In order to minimise flue gas emissions generated from the proposed LWA operations, Brickworks are proposing a suite of air pollution control measures for both Stage 1 and Stage 2 operations incorporating Best Available Technologies (BAT), which are in-line with best practice measures for LWA manufacturing facilities. Proposed control measures for both Stage 1 and Stage 2 operations include baghouse for controlling particulate emissions and metals, wet scrubber for reducing acid gas concentrations and Regenerative Thermal Oxidiser (RTO) for effectively minimising VOC and CO emissions. Brickworks are also proposing to implement wet scrubber control on Plant 2 during Stage 2 operations for effectively managing fluoride and acid gas emissions.

In order to determine the impacts associated with the Stage 1 and Stage 2 LWA operations for the proposed fuel sources, pollutant emission rates were estimated by using emission factors referenced from Emission Estimation Technique (EET) manuals.

Flue gas emissions were inventoried for Stage 1 and Stage 2 LWA operations for the two (2) fuel combustion options. Stack concentrations were estimated based on the inventoried emission rates and volumetric flow conditions (refer **Section 6.5**). Estimated stack concentrations for both Stage 1 and Stage 2 operations were then compared against Group 6 emission standards to assess for compliance. From the estimated emission rates and the subsequent determination of stack concentrations, it is observed that the flue gas concentrations for both Stage 1 and Stage 2 LWA operations comply with the Group 6 emission standards for both fuel options (i.e. 100% natural gas, 100% pulverised coal). For the existing operations at Plant 2, flue gas emissions were referenced from historical stack monitoring data.

For assessing fugitive dust impacts, Total Suspended Particulates (TSP), Particulate Matter with less than 10 microns equivalent diameter (PM_{10}) and Particulate Matter with less than 2.5 microns equivalent diameter ($PM_{2.5}$) emissions were inventoried for existing, Stage 1 and Stage 2 operations at Plant 2 using activity specific emission factors, activity details and control measures for dust mitigation. Background concentrations were referenced from the NSW-OEH Prospect monitoring station, which is the closest to the Project Site. Flue gas emissions, TSP, PM_{10} and $PM_{2.5}$ emissions from Plant 1, which is adjacent to the Project Site, have also been quantified and included in the assessment.

Dust impacts generated from construction activities are not considered significant when compared to operational activities, however, sources potentially generating dust emissions during construction activities and measures that would be implemented by Brickworks to mitigate dust emissions have been outlined in **Section 6.9**.

The CALMET/CALPUFF model system was utilised to predict incremental (Project related) and cumulative ground-level concentrations at identified sensitive receptors from existing and proposed operations.

From the modelled results, it is observed that the predicted incremental and cumulative concentrations for all pollutants comply with their respective assessment criteria for all the modelled scenarios at all identified sensitive residential receptors. However, exceedance of the annual average $PM_{2.5}$ is predicted at non-residential receptors corresponding to the infrastructure at Prospect reservoir for Stage 1 and Stage 2 operations. With respect to this exceedance, it is to be noted that the included annual average $PM_{2.5}$ background concentration of 7.6 $\mu g/m^3$ contributes to 90% of the cumulative impacts, whereas contribution from the Project is approximately 10% for all the modelled scenarios. Moreover, it is noted that Receptor DR6 & DR7 corresponds to non-residential receptors at Prospect Reservoir

Upon analysis of the predicted incremental and cumulative concentrations for each pollutant against their respective assessment criteria, the 90-day average and 24-hour average hydrogen fluoride (HF) impacts have been identified to be the significant pollutant across all modelled scenarios. The highest 90-day average HF concentration predicted across all receptors (residential and non-residential) for all scenarios is 0.47 $\mu g/m^3$, which complies with the assessment criteria of 0.5 $\mu g/m^3$. The highest 24-hour average HF concentration predicted across all receptors (residential and non-residential) for all scenarios is 2.1 $\mu g/m^3$, which complies with the assessment criteria of 2.9 $\mu g/m^3$.

Predicted ground level incremental impacts for individual air toxics at and beyond the Project site boundary are relatively low in comparison with their respective assessment criteria for all modelled scenarios.

For all the pollutants where cumulative concentrations have been determined, it is observed that the Project's contributions to the total concentrations are relatively minimal when compared with the corresponding background concentrations.

Based on implementation of air pollution control measures and achieving compliance with Group 6 emission standards and ambient air quality limits through dispersion modelling, it is observed that there would not be adverse air quality impacts associated with the existing and proposed operations on nearby residential receptors. Annual average $PM_{2.5}$ exceedances for Stage 1 and Stage 2 operations are predicted at non-residential receptors, but as mentioned earlier, background $PM_{2.5}$ concentrations account for 90% of the cumulative impacts, implying that the Project's contributions to these exceedances are comparatively minimal.

1. INTRODUCTION

McKenzie Group Pty Ltd (McKenzie Group), on behalf of Brickworks NSW Pty Ltd (Brickworks) – have commissioned Airlabs Environmental Pty Ltd (Airlabs) to undertake a revised Air Quality Impact Assessment (AQIA) in relation to the proposed State Significant Development (SSD) Application pertaining to the Light Weight Aggregate (LWA) Project (the Project) which will be developed at the existing Plant 2 Brickworks Site at 780 Wallgrove Road, Horsley Park, NSW (the Project Site)

An initial AQIA was issued by Airlabs (Report No: JAN15015.4, dated: 2nd October 2015) accompanying the Environmental Impact Statement (EIS) for public exhibition. Since the public exhibition period, comments have been received from regulatory agencies. During recent discussions with Brickworks as a part of addressing the comments, Airlabs have been advised about the change in the type of fuels that would be used in the proposed LWA kilns. The original AQIA (JAN 15015.4) references the following fuel options – 100% natural gas, 90% Construction and Demolition (C&D) / Construction & Industrial (C&I) Timbers and 10% Natural Gas and 90% Refuse Derived Fuel (RDF) and 10% Natural Gas. Brickworks have since then advised Airlabs about the change of fuel options, which now comprises 100% natural gas and 100% pulverised coal and as-such, no waste fuels (i.e. C&D, C&I Timbers and RDF) are being proposed. This revised AQIA (FEB 16028.1) addresses the comments issued by the regulatory agencies as well as determining air quality impacts associated with the proposed change in the fuel sources.

This revised AQIA has been prepared in accordance with the NSW – Department of Environment and Conservation (DEC) - *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, NSW (DEC, 2005) (hereafter The Approved Methods). As per Section 9 of the Approved Methods, the NSW – Environment Protection Authority (NSW-EPA) has stipulated minimum requirements regarding information contained within an AQIA, which are outlined below. The relevant sections in this revised AQIA, which provide details on the EPA's minimum requirements, are mentioned alongside.

- Site Plan – **Section 2**
- Project Description - **Section 2**
- Emissions Inventory – **Section 6**
- Meteorological Data – **Section 7.2**
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- Dispersion Modelling – **Section 7, Section 8**
- Bibliography – **Section 10**

As the Project is being assessed as a SSD, Secretary Environmental Assessment Requirements (SEARs) have been issued for the preparation of an EIS. The SEARs issued for air quality and the relevant sections of this report, which address the SEARs, are outlined in **Table 1**.

As mentioned earlier, this revised AQIA addresses the comments received from the regulatory agencies for the original assessment (JAN 15015.4). Airlabs' responses to the comments are tabulated in **Table 2**, **Table 3** and **Table 4**.

Table 1: Summary of Secretary Environmental Assessment Requirements (SEARs)

SEARs Issued	Sections of the revised AQIA addressing the SEARs
A comprehensive air quality assessment of all potential point source and fugitive air emissions (including odour) and dust impacts from the development, including details of air quality impacts on private properties in accordance with relevant Environmental Protection Authority guidelines	**6, 7 and 8**
Details of mitigation, management and monitoring measures for preventing and/or minimising both point and fugitive emissions; and	**6, 7, 8, 9**
An assessment of the effectiveness of the proposed air quality mitigation measures	**6, 7, 8, 9 and Appendix B**

Table 2: Airlabs Response to Comments issued by NSW – EPA (Energy from Waste)

NSW – EPA Comments (DOC15/485122)	Airlabs Response to Comments
Air Quality Impact Assessment (Energy from Waste)	
A review of Best Available Technologies (BAT), as they relate to thermal treatment or energy recovery of the proposed waste material. Whilst a review of BAT was undertaken on other LWA facilities, these were largely coal-powered and did not facilitate an assessment of BAT for mitigating potential emissions from the proposed waste feedstock material. The facility must demonstrate that the technology proposed is proven, well understood and capable of handling the expected variability and type of waste feedstock.	The revised fuel options proposed by Brickworks for LWA production comprise100 % natural gas and 100% pulverised coal only. Both the proposed fuel sources do not classify as waste fuels and as-such, the *NSW Energy from Waste Policy Statement* requirements would not be applicable.
Management of residues from the energy recovery process. This would include ash material as well as any air emissions.	
Emission factors were not available for C&D / C&I Timbers in the adopted EET manuals, and as a result emission factors relevant to saw dust were adopted. However given the inherent variability of C&D / C&I timbers and the potential for contamination, use of saw dust factors was not considered appropriate.	
Summarise any available trial data relevant to the site, which would support the use of the waste materials as an alternate fuel source, and the ability of the facility to adequately mitigate any potentially harmful emissions. In a meeting with Austral Bricks and the EPA on 20/10/15, they indicated that they had sampling and testing data of wood waste from C&D and C&I waste streams that they were going to propose as a sawdust substitute in the bricks.	
Implementation of all the technical criteria outlined in the Policy, some of which were reiterated in Section 4.2 of the AQIA. This includes the requirement for waste feed interlocks and continuous measurement for NOx, CO, particles (total), total organic compounds, HCl, HF, SO_2, temperature in the combustion chamber and oxygen, pressure and temperature in stack and water vapour content.	
Discussion of the thermal efficiency criteria, and whether the facility has the	

NSW – EPA Comments (DOC15/485122)	**Airlabs Response to Comments**
capacity to meet these.	
Provision of a plan to implement Proof of Performance trials to demonstrate compliance.	
Characterisation of the feedstock material including quality control measures. The waste feedstock were considered to comprise less than 1% halogenated organic substances, however there was no characterisation information to substantiate this. It must be noted that the gas resulting from the process would be required to be raised to 1100°C rather than 850°C.	
The description of the proposed fuel composition is broad and ambiguous. The EIS does not provide any information on the facilities from which the proposed alternate fuels will be sourced. The source of the material will have a major impact in the fuel composition and its likely contaminants. RDF, for example, can be derived from many types of facilities, including AWTs, MRFs and C&D recycling facilities. A more detailed description of the source and typical composition of alternate fuel sources should be provided along with its flow-on implications for modelling of emissions and residues.	
Undertake a Human Health Risk Screening Assessment for the facility.	

Table 3: Airlabs Response to Comments issued by NSW – EPA (Air Quality Impact Assessment)

NSW – EPA Comments (DOC15/485122)	Airlabs Response to Comments
Air Quality Impact Assessment (AQIA)	
Best Available Technology (BAT) Assessment The Best Available Technologies (BAT) assessment is largely qualitative and lacks detail. Specifically the BAT assessment: a. Is limited to a desktop review that references facilities without a detailed comparison of emission performances; b. Lists facilities with little contextual detail if these facilities utilise similar waste streams to the proposal. It is noted that some of the referenced facilities utilise coal as fuel; and c. References reports that would be considered outdated when considering Best Available Technologies (i.e. reports dated 1981 are referenced). *The EPA recommends that the proponent be requested to provide a more detailed BAT assessment.*	As the revised fuel options proposed by Brickworks comprise 100% natural gas and 100% pulverised coal only, it is noted that the *NSW Energy from Waste Policy Statement* and its requirements are not applicable for the Project, and consequently, the proposed facility is not required to demonstrate that the current international best practice techniques will be implemented. However, to demonstrate that Brickworks would be implementing best practice measures, a desktop review of BATs implemented by existing cement and LWA manufacturers is provided in **Section 6.2** of this revised AQIA.
Adoption of Emission Factors The assessment is based on the use of Emission Factors which are considered of limited value for this type of proposal. a. As per the Approved Methods for the Modelling and Assessment of Air Pollutants, Emission Factors are generally averages of available data and are used when emissions can reasonably be demonstrated to be negligible; b. Are not in line with the EfW expectations to reference fully operational plants; c. Are not demonstrated to adequately characterise the emissions from the proposed fuel sources. For example: • Emission factors for sawdust have been adopted for assessing emissions from	There are no emission factors corresponding to LWA manufacturing operations in Australia. Pollutant emission factors have been referenced from the closest available National Pollutant Inventory (NPI) Emission Estimation Technique (EET) manuals, which includes – Bricks, Ceramics and Clay Product Manufacturing. Emission factors have been provided for both fuel options (natural gas and pulverised coal) in the NPI *EET Manual for Bricks, Ceramics & Clay Product Manufacturing* As per the revised fuel options proposed by Brickworks, it is to be noted that C&D / C&I Timber or RDF will no longer be

NSW – EPA Comments (DOC15/485122)	**Airlabs Response to Comments**
C&D waste fuel; and • Emission factors for RDF have been adopted from emission estimation technique manuals for refuse combustion, which are for different process technologies than being proposed. *The EPA recommends that the proponent be requested to provide a revised AQIA based on manufacturer's specifications, emission guarantees and reference to similar fully operational plants using the same technologies and treating like waste streams.*	utilised as a source of fuel in the LWA operations, and consequently, the *NSW Energy from Waste Policy Statement* and its requirements will not be applicable Air emissions corresponding to the revised fuel sources (i.e. 100% natural gas and 100% pulverised coal) have been provided in **Section 6.5**.
Pollution Control Efficiencies The AQIA adopts a series of control efficiencies for key compounds, including: • An estimated control efficiency for dioxins associated with baghouses without any carbon injection of 30%. This is based on emission testing, however no supporting information (including test data) has been included; and • An estimated control efficiency of 20 % for vapour phase metals associated with the use of a baghouse & scrubber combination. The assessment outlines that no information is available with the regards to this control efficiency hence 20 % was applied as a conservative measures. *The EPA recommends that the AQIA include all necessary information to demonstrate the basis for adopted pollution control efficiencies. Where supporting data is not available no control should be assumed.*	Predicted incremental impacts for dioxins and vapour phase metals for all scenarios are very low in comparison with their respective criteria. Furthermore, adopted control efficiencies corresponding to dioxins and vapour phase metals have been removed in this revised assessment.
Meteorological Data a) Selection of 2014 meteorological data The assessment outlines that based on analysis of the meteorological data from 2010-2014 at the Bureau of Meteorology (BoM) Horsley Park Automatic Weather Station (AWS), 2014 was considered to be a representative year. However the analysis (provided as Appendix C of the AQIA) is limited to the compilation of wind roses without specific analysis or discussion. Windroses are considered one tool for determining the representative nature of a meteorological data set.	In this revised assessment, five (5) years of revised meteorological modelling (CALMET) has been conducted and inter-annual variability of the percentage of calm winds, wind roses, stability classes and mixing height have been analysed and presented. Based on the inter-annual analysis, 2014 was considered a representative year, as the data compares well with the previous years and no distinct anomalies have been identified. Furthermore, calendar year 2014 contained the highest percentage of calm wind conditions (18.6%), highest

NSW – EPA Comments (DOC15/485122)	Airlabs Response to Comments
The EPA recommends that the AQIA includes further analysis to demonstrate 2014 is considered a representative year for assessment purposes.	frequency (41%) of lower mixing heights below 60m and highest frequency (43%) of Pasquill-Gifford stability class F. Details of the inter-annual analysis are provided in **Section 7.3** and **Section 7.4**.
Meteorological Data b) Compilation of meteorological data used for dispersion modelling *The EPA recommends the AQIA include further validation of the meteorological data utilised for dispersion modelling purposes with a focus on the discrepancies between the quantity in calm conditions between the observation data and the CALMET generated data.*	In this revised assessment, five (5) years of revised meteorological modelling (CALMET) have been conducted using CALMET in Hybrid Mode (Prognostic Model Data + Observations). Surface observations from BoM were not directly assimilated into TAPM, rather, a SURF.DAT file was created from the BoM observations and used in CALMET. Additionally TAPM generated prognostic model output was used only above 1000m to give a larger bias to the BoM observations at surface level. Percentage calms predicted by the revised CALMET model now match closely to the BoM observations. Additional details are provided in **Section 7**.
Assessment of Air Toxics The AQIA provides predicted ground level concentrations for a number of pollutants at the nearest sensitive receptors for comparison against impact assessment criteria. The Approved Methods for Modelling and Assessment of Air Pollutants in NSW outlines that impact assessment criteria for individual toxic air pollutants applies at and beyond the boundary of the facility. *The EPA recommends that the AQIA be revised to include predicted ground level concentrations for air toxics at and beyond the boundary of the facility.*	For individual air toxic pollutants, impacts at and beyond the boundary of the facility have been predicted and compared against their respective criteria in this revised assessment.
Assessment of $PM_{2.5}$ Impacts The AQIA identifies TSP, PM_{10} & $PM_{2.5}$ as key fractions for airborne particulate matter. The report includes assessment against TSP and PM_{10}, however no assessment of $PM_{2.5}$ has been included. *The EPA recommends that the AQIA include an assessment of $PM_{2.5}$. The assessment should reference the NEPM advisory standards for $PM_{2.5}$, which include a 24-hour*	$PM_{2.5}$ impacts have been determined and assessed against the NEPM advisory standards in this revised assessment.

NSW – EPA Comments (DOC15/485122)	Airlabs Response to Comments
average criteria value of 25 $\mu g/m^3$, and an annual average criteria value of 8 μg /m^3.	
Predicted PM_{10} Concentrations The assessment includes predicted PM_{10} concentrations (on a cumulative basis) for each sensitive receptor, and scenario considered. Predicted PM_{10} concentrations over a 24-hour averaging period are approximately 27 $\mu g/m^3$ for the scenarios assessed on a cumulative basis. However Table 7 of the assessment outlines that the maximum PM_{10} concentration measured at Prospect in 2014 was 44 $\mu g/m^3$. The data from Prospect was utilised in the assessment for consideration of cumulative impacts. As per the Approved Methods for Modelling, assessment against the PM_{10} criteria must be reported as the 100th percentile (increment plus background), hence a predicted cumulative concentration below the 100th percentile background concentration would not be expected. *The EPA recommends that the predicted cumulative impacts be reviewed and revised where necessary.*	The contemporaneous assessment of PM_{10} impacts in this revised AQIA has been amended and the results have been updated to reflect the amendment.
Detailed Process Description The AQIA provides an overview of the Project, however no detailed description of the unit operations of the two kilns has been included. A process description is an important part of the assessment process, and aids in stakeholders of varying backgrounds to gain an appreciation of the technicalities of a process. The AQIA outlines two point source discharges for each kiln, those being the Product Combustion Stack and Cooling Air Stack. A detailed description of how these operate enables an appreciation for the pollutants that maybe associated with each point source. *The EPA recommends a process description of all processes and point source discharges be included. The description should be supported by process flow diagrams, and details on any air streams merging prior to discharge.* *The EPA recommends that the Proponent address the EfW Policy requirements prior to the revision of the AQIA, to allow for assessment of the AQIA based on the final proposal design that meets the EfW Policy to be presented.*	A revised process description has been included in **Section 6.1**. Additional process flow diagram has been included in **Section 6.1** which includes the following: • Material Flow Into and Out of the Kiln (Drawing BW-AGG-100-01); and • Gas Flow through the Kiln Exhaust and Grate Cooler Exhaust System (Drawing BW-AGG-100-02)

Table 4: Airlabs Response to Comments issued by Water NSW

Water NSW Comments (D2015/126797)	Airlabs Response to Comments
Water NSW's Prospect Reservoir and Upper Canal are located to the east of the site. The air quality impact assessment does not include the site as a sensitive receptor. We request assessment of the potential water quality impacts to the open Upper Canal water supply and Prospect Reservoir from kiln emissions.	Four (4) new receptors have been included in this revised assessment corresponding to the Prospect Reservoir and the Upper Canal. It is to be noted that although these new receptors have been included in the revised assessment, they have been classified as non-residential receptors. Assessment of water quality impacts to the open Upper Canal are outside the Scope of Works for an air quality assessment, however, air quality impacts have been determined at these receptors.

2. PROJECT OVERVIEW

2.1 Project Locality

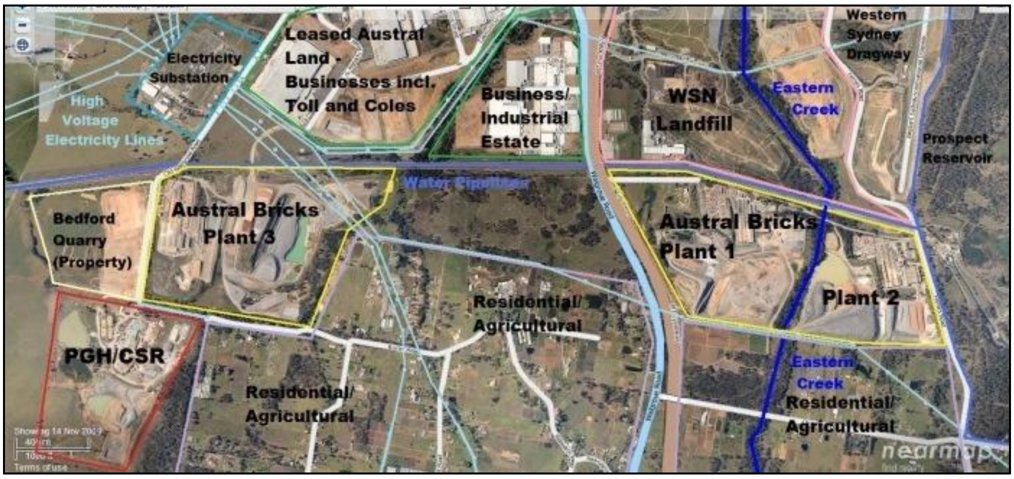
The Project Site is located at 780 Wallgrove Road, Horsley Park, NSW (Lot 7 in Deposited Plan 1059698) (**Figure 1**). The present condition of the Project Site is such that it contains existing stockpiles of clay and two facilities (Plant 1 and Plant 2) that are used for the purpose of brick manufacturing. The Project Site is currently used for the manufacture of bricks, tiles and pipe works.

Existing development at Plant 1 and Plant 2 are managed under the NSW – Environmental Protection Licence (NSW-EPL) 546, which also manages existing operations at Plant 3, which is located on Old Wallgrove Road, Horsley Park, NSW. Based on information provided by Brickworks and as per the proposal submitted by Austral Bricks (a 100% owned subsidiary of Brickworks) to the NSW – Department of Urban and Transport Planning (DUTP, 2003), it is understood that clay and shale extraction activities / operations are undertaken near Plant 3 and the extracted raw material is then supplied to Plant 1 and Plant 2. A spatial overview of Plant 1, Plant 2 and Plant 3 is shown in **Figure 2**.

Figure 1: Project Site Layout

Source: McKenzie Group, 2014

Figure 2: Spatial Overview of Brickworks – Plant 1, Plant 2 and Plant 3



Source: Pollution Incident Response Management Plant, (Austral Bricks, 2013)

2.2 Project Description

As per information provided by Brickworks, there exists a potential opportunity in Sydney to create a market for Lightweight Aggregates (LWA) with a strong and sustainable competitive advantage. Benefits of LWA include – lower dead loads when used in lightweight concrete, good fire resistance, superior acoustic properties and abrasion resistance.

The generic process for producing expanded shale LWA incorporates mining the raw material (clay/shale), crushing to appropriate sizes and storing in preparation for the process. Once prepared, the clay is extruded and then fed into a rotary kiln. After an initial drying phase, the clay enters a rapid heating zone (approximately 1250^{0}C at the point of combustion), where gases are evolved within the clay causing expansion and formation of voids. The cellular structure within the particles is developed by heating certain raw materials to incipient fusion (i.e. just below melting point). This structure is retained upon cooling. Final crushing and screening of sizes is generally required prior to stockpiling and delivery to customer. Additional details relating to the LWA production process is provided in **Section 6.1**.

With respect to the Project, the proposed development seeks to utilise a stockpile area on the existing property at Plant 2 to construct a new rotary kiln, screening plant, remove the existing stockpiles of material (to be used for manufacturing concrete aggregate) and ancillary site works. The development also proposes to use existing assets associated with Plant 2 including the primary crusher and extruder.

Key aspects of the Project comprise:

- **Clay Preparation System**: Existing facility at Plant 2 will be utilised for the Clay Preparation System, which will typically include existing clay / shale stockpiles, box feeders for clay and additives, rollers and extruders;
- **Rotary Kiln**: A rotary kiln will be constructed as a part of the Project. Specific details relating to the kiln and proposed air quality control systems to minimise flue gas emissions are provided in the later sections of this report;
- **Multi-fuel burner**: A multi-fuel burner would be installed, with the ability to potentially feed the following standard fuel source combinations:
  - **Option 1**: 100% Natural Gas;
  - **Option 2**: 100% Pulverised Coal
- **Solid Fuel Storage and Preparation Area**;
- **Crushing and Screening**: Crushing and screening infrastructure would be provided to produce size-varying graded stockpiles (e.g. 10mm, 15mm product). It is to be noted that the crushing activities associated with the Project will be relatively limited as the extrusion process itself will be providing sized products;
- **Storage and Stockpiling**: Fired material from the rotary kiln is stockpiled and conveyed to the crushing and screening system through underground reclamation. Post crushing and screening operations, graded products are stockpiled according to their size specifications;
- **Roadways and Truck Loading Facilities**: Material transport will be through the main entrance with separate in and out lanes and weighbridge. Internal roadways will allow for two (2) lanes of traffic and will contain truck-loading areas next to the graded product stockpiles. Loading will be undertaken by a front-end loader;
- **Staff Offices and Amenities**: Office provision for ten (10) people and amenities for twenty (20);

- **Mobile Plants / Equipment's**: Apart from the fixed plants associated with the Project (e.g. kiln, crusher, extruder etc.) mobile plants and equipment's that would have relevance with air quality impacts include a total of five (5) front end loaders (FELs) and haul-trucks for delivering material on and off the Project site.

Proposed layout plan for the Project showing existing and proposed operations is presented in **Figure 3.**

2.2.1 Project Stages and Production Volumes

The Project is divided into two (2) stages – Stage 1 and Stage 2. Stage 1 of the Project comprises LWA production volumes of 300,000 tonnes per annum (tpa). An additional 300,000 tpa of LWA production is forecasted for Stage 2, which would potentially commence approximately five (5) years after commencement of Stage 1, therefore, the combined LWA production volumes for the Project comprising Stage 1 and Stage 2 operations would be 600,000 tpa. The rotary kiln for Stage 1 is designed to produce 300,000 tpa of LWA and as-such; a new rotary kiln in addition to the Stage 1 kiln would be commissioned during Stage 2 operations. Air quality impacts associated with both Stage 1 and Stage 2 operations (which include Stage 1 operations) have been quantitatively determined as a part of this assessment. It is to be noted that all Stage 1 and Stage 2 operational activities will be undertaken at Plant 2.

2.3 Air Quality Complaints

Airlabs, at the time of preparing this revised AQIA are unaware of any official records of air-quality complaints (including odour) associated with existing operations.

3. PROJECT SETTING

3.1 Existing Land Use and Topography

The Project Site is located at 780 Wallgrove Road, Horsley Park, within the Fairfield Local Government Area (LGA). The Project Site is predominantly clear of vegetation, as the land has been historically used for quarrying and brick manufacturing operations. Adjoining the Project Site is the M7 Motorway, which links with the M2, M4 and M5 Motorways.

Development surrounding the Project Site predominantly comprises industrial facilities used for the purpose of warehousing and distribution and waste management / recovery facilities.

Industrial warehousing and distribution facilities are located to the north-west of the Project Site. The Eastern Creek Urban Resource – Reduction, Recovery and Recycling (UR-3R) Facility managed by Global Renewals is located due north of the Project Site and the Eastern Creek Resource Recovery Park managed by SITA Australia is located approximately 800m north of the Project Site. The Prospect Reservoir and its surrounding buffer area are located to the east, north-east of the Project Site.

The topography surrounding the Project Site varies with terrain elevations gradually increasing towards the west, south-west and south-east of the Project Site. Landforms to the north and south of the Project Site are relatively flat. Topographical features surrounding Project Site are illustrated in **Figure 4**.

Figure 3: Proposed Layout of the Project – Plant 2 – Existing and Proposed Operations

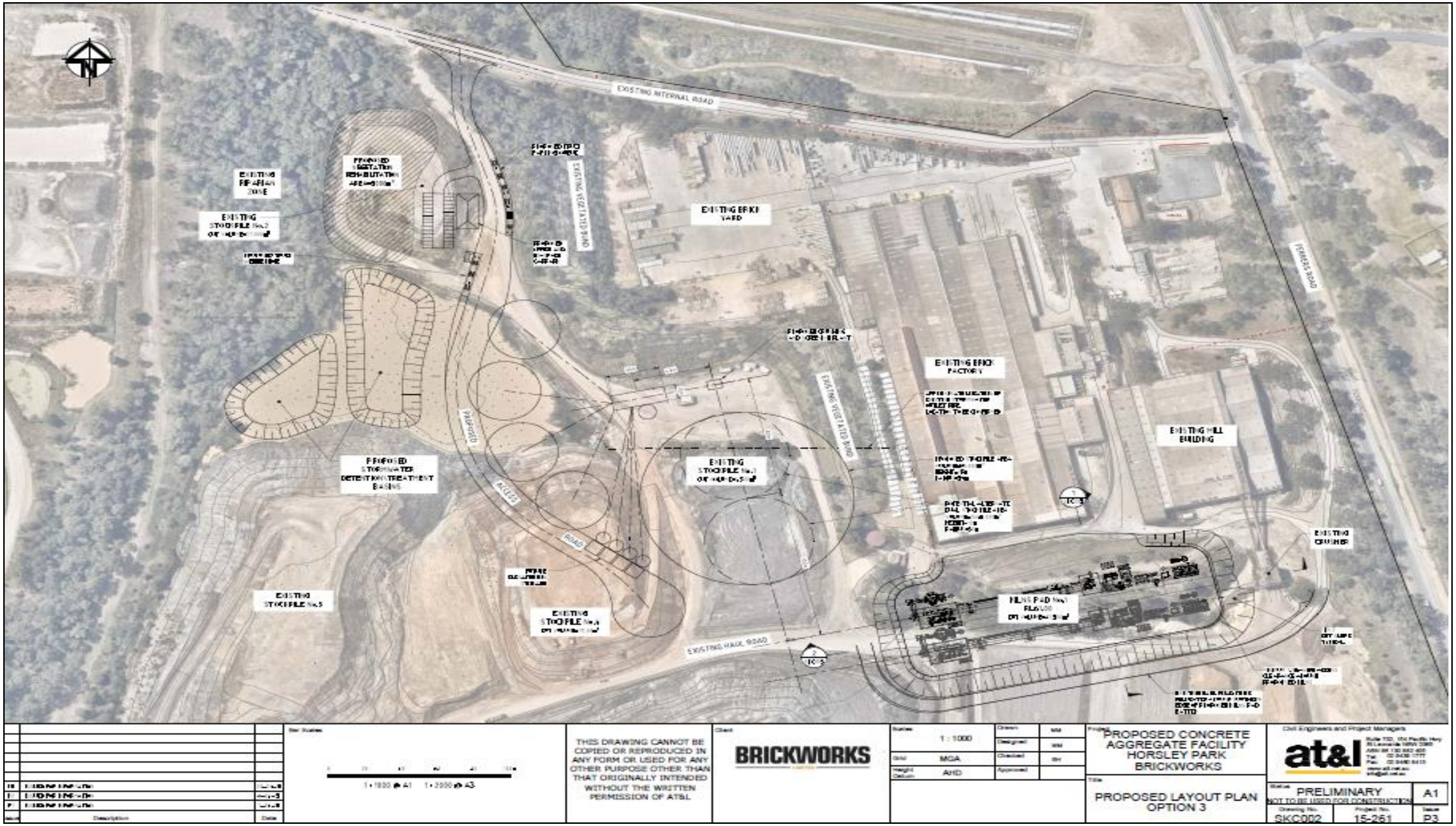
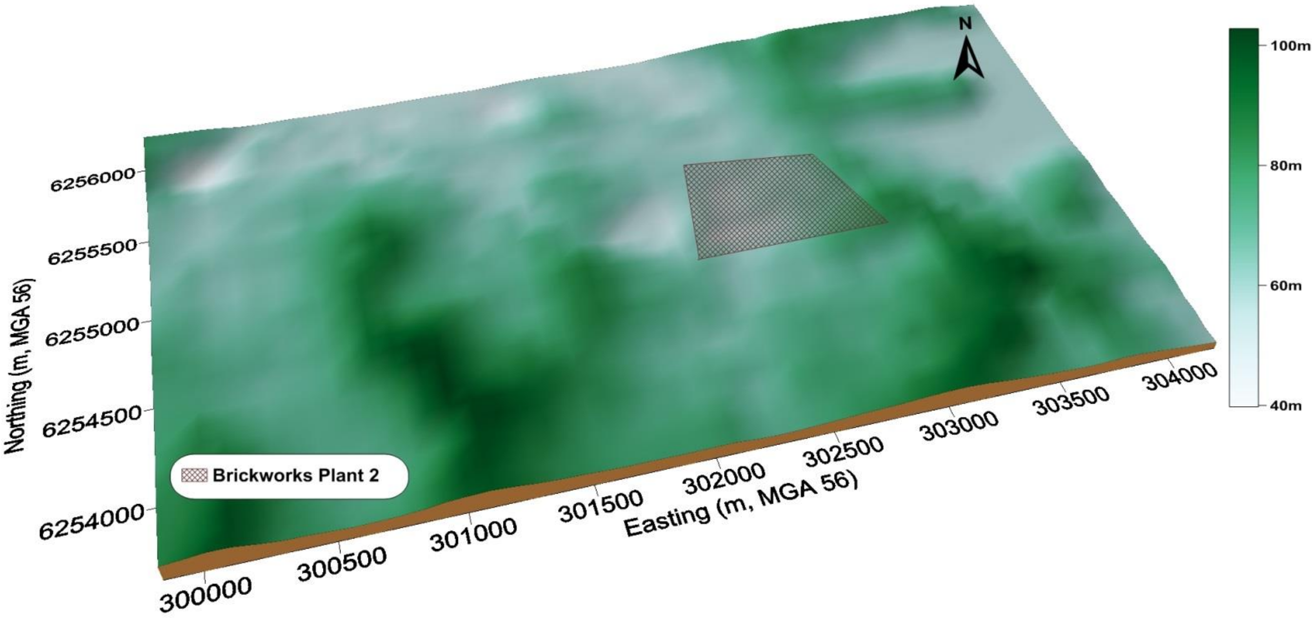


Figure 4: Topographical Features Surrounding Plant 2



3.2 Nearest Residential Receptors

Based on aerial imagery, it is observed that existing residential development surrounding the Project Site is characterised as rural – residential. Individual residential dwellings surrounding the Project Site have been identified and those residential dwellings closest to the Project Site have been considered as sensitive receptors (DR1 to DR5) for the purpose of this AQIA. The identified receptors are considered representative of the receiving environment.

In addition to the identified residential receptors, four (4) non-residential receptors corresponding to the Prospect Reservoir and the Upper Canal have been added as per the request of Water NSW (refer **Table 4**)

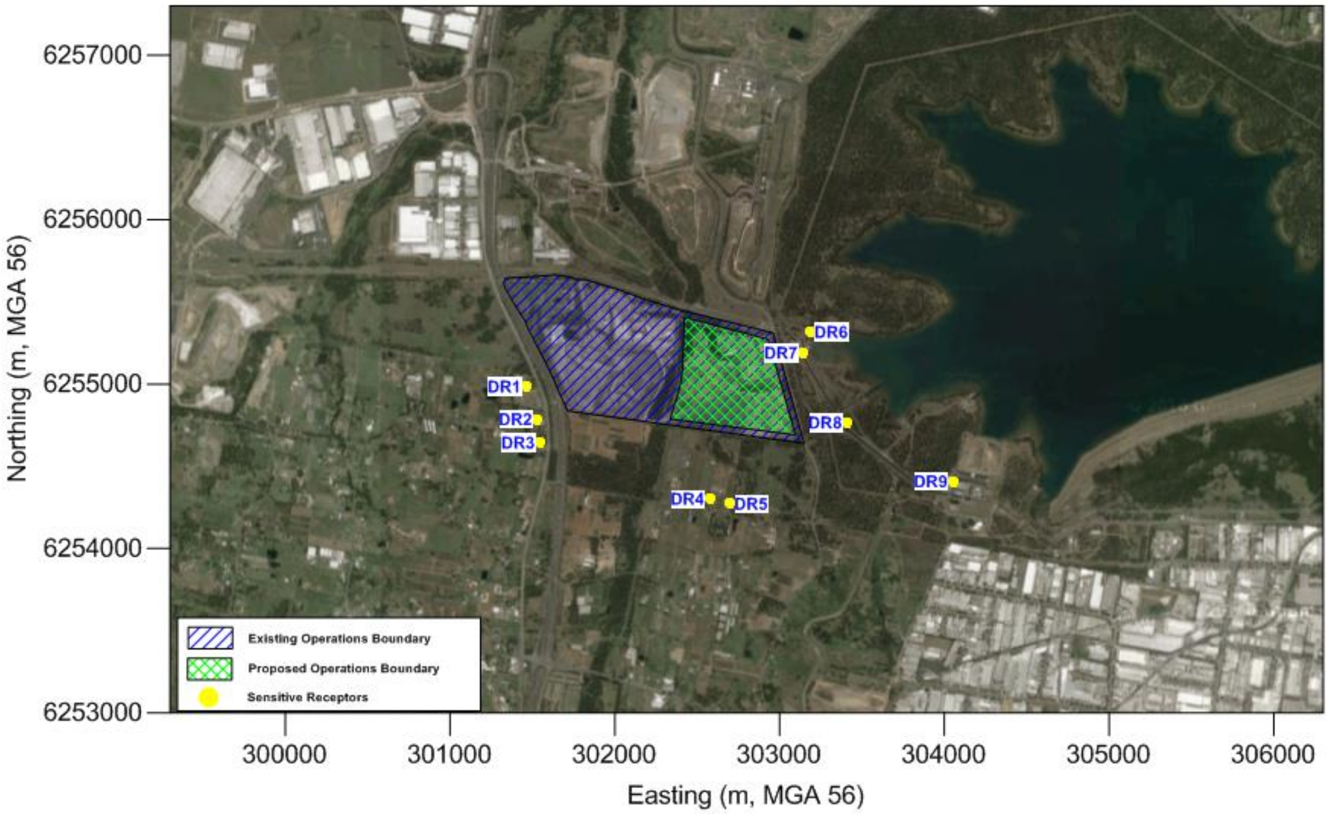
Details of the identified receptors are tabulated in **Table 5** and illustrated in **Figure 5**

Table 5: Details of Selected Sensitive Residential and Non-Residential Receptors

Discrete Receptor ID	Receptor Type	Address	Easting (m), MGA 56	Northing (m), MGA 56	Approximate Distance (km) to the Nearest Brickworks Boundary and Orientation
DR1	Residential	785-811 Wallgrove Road, Horsley Park	301464	6254982	1.4 km/W
DR2	Residential	763-783 Wallgrove Road, Horsley Park	301531	6254784	1.2km/WSW
DR3	Residential	749-761 Wallgrove Road Horsley Park	301547	6254641	1.2km/SW
DR4	Residential	168-174 Chandos Road, Horsley Park	302576	6254299	0.5km/S
DR5	Residential	150-154 Chandos Road, Horsley Park	302700	6254271	0.5km/S

Discrete Receptor ID	Receptor Type	Address	Easting (m), MGA 56	Northing (m), MGA 56	Approximate Distance (km) to the Nearest Brickworks Boundary and Orientation
DR6	Non residential	Prospect Reservoir / Upper Canal	303190	6255310	0.2km/E
DR7	Non residential		303140	6255190	0.15km/E
DR8	Non residential		303410	6254760	0.3km/E
DR9	Non residential		304050	6254410	1.0km/ESE

Figure 5: Aerial Imagery of Sensitive Receptors with respect to Project Site



4. REGULATORY REQUIREMENTS

Air pollutants discharged to air from clay/shale, brick manufacturing activities typically comprise:

- Particulate matter emissions released as product of combustion from process manufacturing and fugitive dust sources;
- Air pollutants released as products of combustion from process manufacturing, which include: oxides of sulfur dioxide(SO_2), oxides of nitrogen (NO_X), carbon monoxide (CO), acid gases such as hydrogen chloride (HCl), hydrogen fluoride (HF), polycyclic aromatic hydrocarbons (PAHs), polychlorinated dioxins and furans (PCDD/F), volatile organic compounds (VOC's) and heavy metals.

As mentioned in **Section 2.3**, at the time of preparation of this AQIA it is understood that no official odour complaints have been received for existing operations at Plant 1 and Plant 2. Additionally, a suite of air pollution control measures such as acid-gas scrubbers and regenerative thermal oxidisers (RTO) are being proposed for the kiln stack (refer **Section 6.4**). As-such, taking into consideration the non-putrescible nature of the raw materials, the proposed fuel sources; combustion processes and the proposed air pollution control measures, it is unlikely that there would be considerable odour impacts from the LWA process and have been excluded from this assessment.

Regulatory requirements applicable to this study are discussed in the following sections:

4.1 Emission Limits – POEO Clean Air Regulation 2010

The NSW-Environmental Protection Authority (NSW-EPA) Protection of the Environment Operations (POEO) Clean Air Regulation 2010 (the Clean Air Regulation) prescribes in-stack emission limits / concentration standards for industrial sources in NSW. As per the Clean Air Regulation, stack emissions corresponding to LWA operations would need to comply with Group 6 standards of concentration. As there are no specific concentration standards listed for LWA manufacturing in *Schedule 3 – Standards of concentration for scheduled premises: general activities and plants*, reference was made to ceramic works, which is considered to be the next closest to LWA manufacturing among all the activities and plants listed in Schedule 3. Concentration standards for the proposed LWA operations are outlined in **Table 6**.

Table 6: POEO Clean Air Regulation Standards of Concentration – Group 6

Pollutant	Standard of Concentration
Solid particles (total)	50 mg/m^3
Nitrogen dioxide (NO_2)	350 mg/m^3
Fluorine (F_2) or any compound containing fluorine as total fluoride (Hydrogen Fluoride - HF) equivalent	50 mg/m^3
Hydrogen chloride (HCl)	100 mg/m^3
Type 1 and Type 2 substances (in aggregate)	1 mg/m^3
Cadmium or Mercury (individually)	0.2 mg/m^3
Dioxins or furans	0.1 ng/m^3
Volatile organic compounds (VOC) as n-propane equivalent	40 mg/m^3

Reference conditions defined as dry, 273.15 K, 101.3kPa and 7%O_2, for all air impurities except for dioxins / furans where the required O_2 concentration is 11%

4.2 Ambient Air Quality Limits

In addition to meeting the Clean Air Regulation requirements, the proposed LWA operations would also need to satisfy the ambient air quality limits listed within the Approved Methods. Ambient air quality limits for the pollutants that will be assessed and their corresponding time-averaging periods are listed below:

4.2.1 Criteria for Airborne Particulate Matter

Airborne particulate matter, typically consist of particles of varying size fractions. The Approved Methods specifies air quality limits for Total Suspended Particulates (TSP) and Particulate Matter with less than 10 microns equivalent diameter (PM_{10}) for assessing impacts from dust-generating activities and operations. Although, TSP is defined as the total mass of all particles suspended in air, an effective upper limit of 30 microns aerodynamic diameter is assigned. Within the TSP matter, lie two sub-categories; particulate matter with an equivalent diameter of 10 microns (PM_{10}) and particulate matter with an equivalent diameter of 2.5 microns ($PM_{2.5}$). As particulates released from combustion process would be typically within the PM_{10} and smaller size ranges, focus is on assessing the PM_{10} and $PM_{2.5}$ impacts. As there would also be fugitive dust emissions released during operational activities, TSP emissions have also been quantified and subsequently modelled to predict impacts.

There are no assessment criteria for $PM_{2.5}$ in NSW; hence, reference is made to the National Environment Protection Measure (NEPM) advisory standards for $PM_{2.5}$. Air quality limits applicable to particulate matter referenced from the Approved Methods and NEPM advisory are summarised in **Table 7**.

Table 7: Air Quality Limits Applicable to Particulate Matter

Pollutant	Averaging Period	Concentration (μg/m^3)	Applicability
TSP	Annual	90	Sensitive receptors
PM_{10}	24-hour	50	Sensitive receptors
	Annual	30	Sensitive receptors
$PM_{2.5}$*	24-hour	25	Sensitive receptors
	Annual	8	Sensitive receptors

** NEPM advisory standards*

4.2.2 Criteria for Deposited Dust Levels

The NSW-DEC has prescribed maximum permissible dust deposition rates to regulate deposited dust levels. **Table 8** presents the limits for dust deposition, showing the allowable increase in deposited dust levels above ambient (background) levels which would be acceptable so that dust nuisance could be avoided.

Table 8: Air Quality Limits Applicable to Deposited Dust Levels

Averaging Period	Maximum Increase in Deposited Dust Level	Maximum Total Deposited Dust Level	Applicability
Annual	2 g/m^2/month	4 g/m^2/month	Sensitive receptors

4.2.3 Criteria for Other Air Pollutants

As mentioned earlier, a suite of other air pollutants in addition to particulate matter would be released as products of combustion from the various fuel combustion options. The pollutants that would be released and their applicable limits are summarised in **Table 9**.

Table 9: Air Quality Limits Applicable to Other Air Pollutants

Parameter	Assessment Criteria	Averaging Period	Applicability
Sulfur dioxide (SO_2)	712 µg/m³	10-minute	Sensitive receptors
	570 µg/m³	1-hour	Sensitive receptors
	228 µg/m³	24-hour	Sensitive receptors
	60 µg/m³	Annual	Sensitive receptors
Nitrogen dioxide (NO_2)	246 µg/m³	1-hour	Sensitive receptors
	62 µg/m³	Annual	Sensitive receptors
Carbon monoxide (CO)	100 mg/m³	15-minute	Sensitive receptors
	30 mg/m³	1-hour	Sensitive receptors
	10 mg/m³	8-hour	Sensitive receptors
Hydrogen fluoride (HF)	2.9 µg/m³ (a)	24-hour	Sensitive receptors
	1.7 µg/m³ (a)	7 days	Sensitive receptors
	0.84 µg/m³ (a)	30 days	Sensitive receptors
	0.5 µg/m³ (a)	90 days	Sensitive receptors
Hydrogen chloride (HCl)	0.14 mg/m³	1-hour	Outside Site Boundary
Acrylonitrile	0.008 mg/m³	1-hour	Outside Site Boundary
Acetone	22 mg/m³	1-hour	Outside Site Boundary
Benzene	0.029 mg/m³	1-hour	Outside Site Boundary
Carbon disulphide	0.07 mg/m³	1-hour	Outside Site Boundary
Chloroethane	48 mg/m³	1-hour	Outside Site Boundary
Chloroform (trichloromethane)	0.9 mg/m³	1-hour	Outside Site Boundary
Chloromethane	1.9 mg/m³	1-hour	Outside Site Boundary
Ethylbenzene	8.0 mg/m³	1-hour	Outside Site Boundary
Methylene Chloride (dichloromethane)	3.19 mg/m³	1-hour	Outside Site Boundary
Phenol	0.02 mg/m³	1-hour	Outside Site Boundary
Styrene	0.12 mg/m³	1-hour	Outside Site Boundary
Tetrachloroethylene	3.5 mg/m³	1-hour	Outside Site Boundary
Toluene	0.36 mg/m³	1-hour	Outside Site Boundary
Xylene	0.19 mg/m³	1-hour	Outside Site Boundary
1,1,1- Trichloroethane (methyl chloroform)	12.5 mg/m³	1-hour	Outside Site Boundary
Antimony	0.009 mg/m³	1-hour	Outside Site Boundary
Arsenic	0.00009 mg/m³	1-hour	Outside Site Boundary
Beryllium	0.000004 mg/m³	1-hour	Outside Site Boundary
Cadmium	0.000018 mg/m³	1-hour	Outside Site Boundary
Chromium (III)	0.009 mg/m³	1-hour	Outside Site Boundary

Parameter	Assessment Criteria	Averaging Period	Applicability
Chromium (VI)	0.00009 mg/m^3	1-hour	Outside Site Boundary
Copper dust	0.018 mg/m^3	1-hour	Outside Site Boundary
Lead	0.5 µg/m^3	Annual	Outside Site Boundary
Manganese	0.018 mg/m^3	1-hour	Outside Site Boundary
Mercury (inorganic)	0.0018 mg/m^3	1-hour	Outside Site Boundary
Nickel	0.00018 mg/m^3	1-hour	Outside Site Boundary
Polycyclic Aromatic Hydrocarbons (PAHs) – as benzo-a-pyrene	0.0004 mg/m^3	1-hour	Outside Site Boundary
Polychlorinated Dioxins and Furans (PCDD/F) – TEQ	2.0E-09 mg/m^3 (b)	1-hour	Outside Site Boundary

(a) Criteria applicable for general land-use, which includes all areas other than specialised land use

(b) Toxic Equivalent (TEQ) as defined in Clause 29 of the Regulation

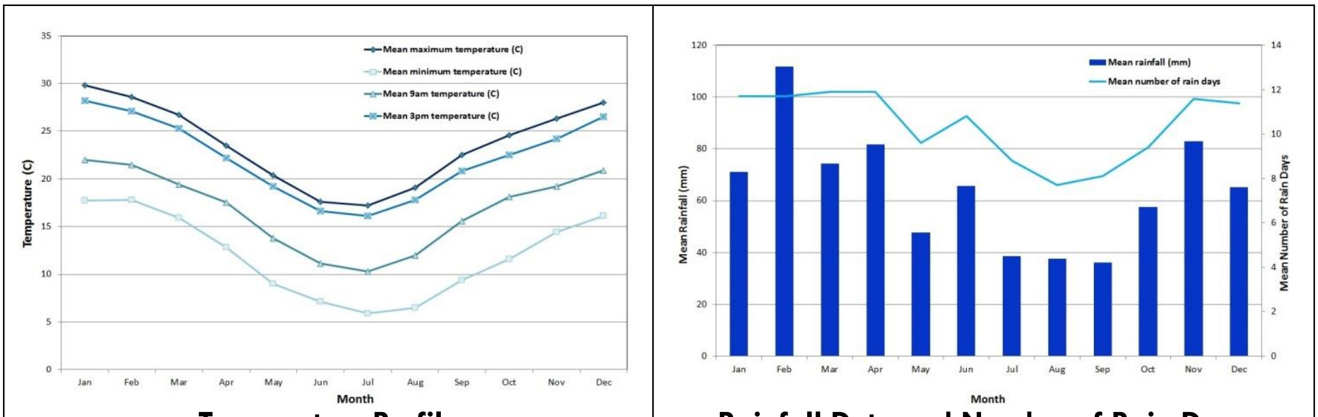
5. EXISTING ENVIRONMENT

This section characterises the long-term climatic conditions and key parameters characterising existing meteorological conditions such as stability class, mixing height and wind profile and existing air quality levels surrounding the Project Site.

5.1 Long Term Climate Statistics

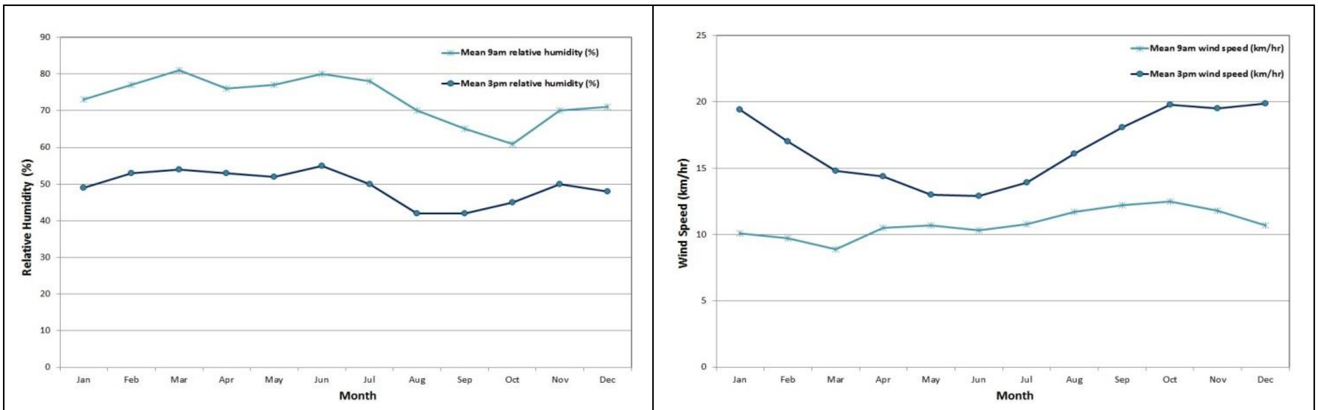
Long-term climatic data from the Bureau of Meteorology (BoM) Horsley Park Equestrian Centre Automatic Weather Station (AWS) (Station No: 067119) were analysed to characterise the local climatic conditions. The AWS is located approximately 2.5km south-south west of the Project Site. The key aspects that were analysed to understand the long-term climatic conditions were – mean minimum and maximum temperatures, mean 9AM and 3PM temperatures, rainfall data, mean 9AM and 3PM relative humidity (RH) levels and mean wind speeds. Analysed climate data is visually illustrated in **Figure 6**.

Figure 6: Climate Statistics – BoM Horsley Park AWS



Temperature Profile

Rainfall Data and Number of Rain Days



9AM and 3PM Relative Humidity (RH) Profile

9AM and 3PM Wind Speed Profile

From the data illustrated in **Figure 6**, the following observations can be made:

- Highest mean maximum temperatures are observed during January with a mean maximum temperature of 29.8°C;
- July is observed to be the coldest month of all the months, with a mean minimum temperature of 5.9°C;
- High rainfall is generally observed during summer seasons, with the highest rainfall levels observed during February;
- There is a clear distinction between Relative Humidity (RH) levels recorded at 9AM and 3PM. The 9AM RH levels vary between 61-81% and the 3PM RH levels vary between 42-55%;
- Similarly, a clear distinction can be observed between the 9AM and 3PM wind speeds. The mean 9AM wind speed averaged over all months is 10.8km/hr whereas the mean 3PM wind speed averaged over all months is 16.5km/hr.

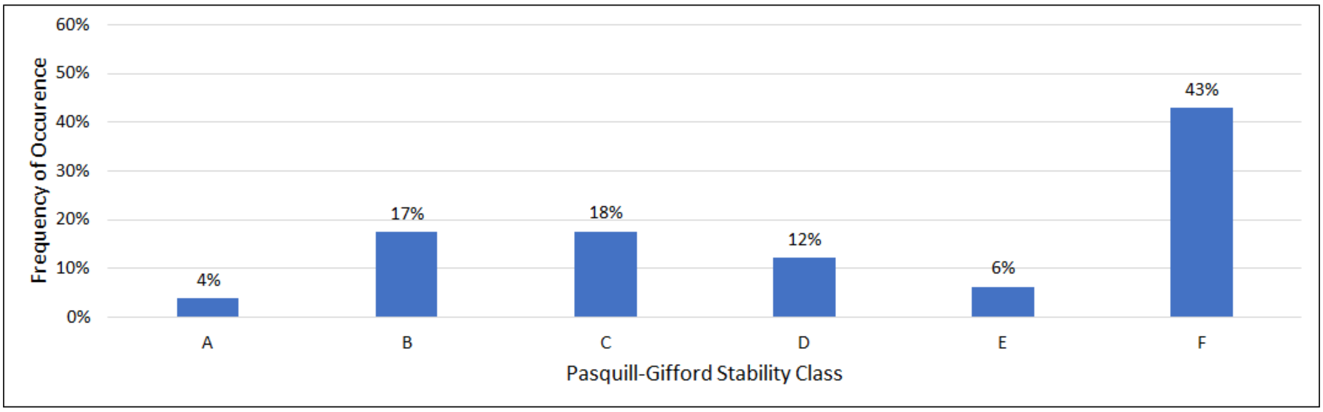
5.2 Stability Class, Mixing Height and Wind Profile

Stability of the atmosphere is determined by a combination of horizontal turbulence caused by the wind and vertical turbulence caused by the solar heating of the ground surface. Stability cannot be measured directly; instead, it must be inferred from available data, either measured or numerically simulated.

The Pasquill-Gifford scale defines stability on a scale from A to G, with stability class A being the least stable, occurring during strong daytime sun and stability class G being the most stable condition, occurring during low wind speeds at night. For any given wind speed, the stability category may be characterised by two or three categories depending on the time of day and the amount of cloud present. In meteorological models such as CALMET, the stability classes F and G are combined.

A summary of the numerically simulated hourly stability class data using CALMET with Bureau of Meteorology (BoM) surface observations for calendar year 2014 is presented in **Figure 7**. Stability class F is predicted to occur most frequently (43%), indicating that the dominant conditions are moderate to very stable, with very little lateral and vertical diffusion. Additional details regarding the CALMET modelling is presented in the later sections of this report.

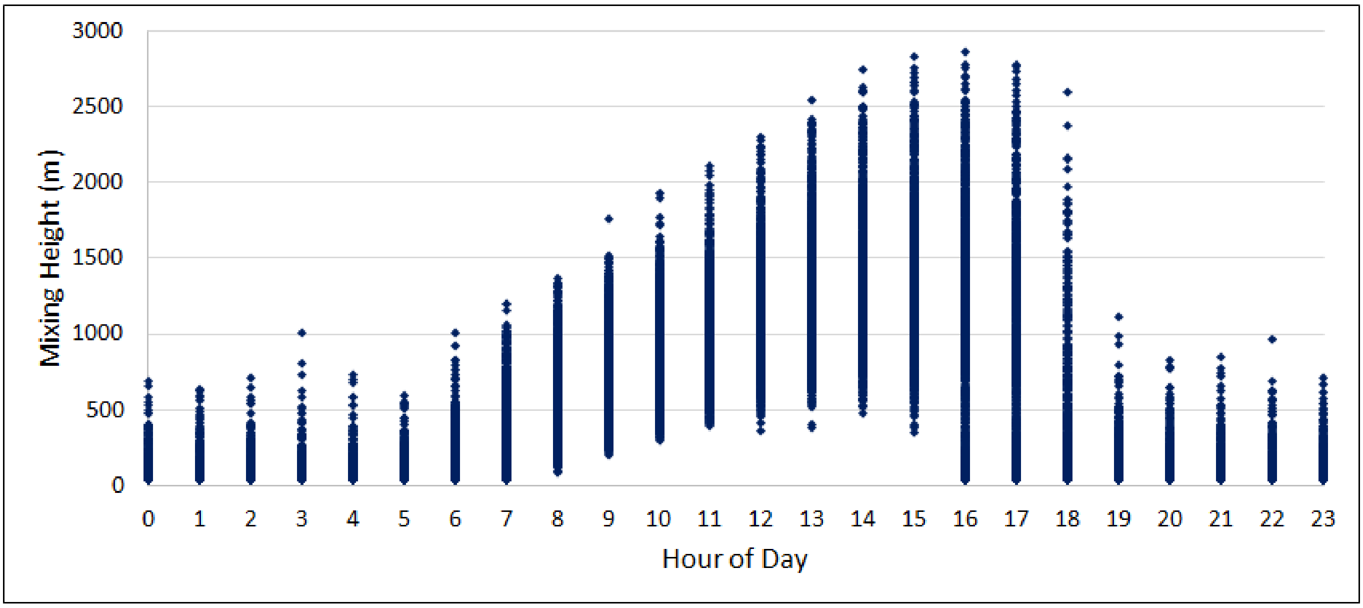
Figure 7: CALMET Predicted Frequency of Stability Class – 2014



The mixing height quantifies the vertical height of mixing in the atmosphere and is a modelled parameter that cannot be measured directly. Numerically simulated hourly mixing height data using CALMET for calendar year 2014 is presented in **Figure 8**.

Figure 8 shows the mixing height as a function of the hour of the day at the location of the Project Site. The graph represents the typical growth of the boundary layer, whereby the mixing height is generally lowest during the night and into the early morning and highest during the late afternoon. The mixing height decreases in the late afternoon, particularly after sunset, due to the change from surface heating from the sun to a net heat loss overnight. Low mixing heights typically translate to stagnant air with little vertical motion, while high mixing heights allow vertical mixing and good dispersion of pollutants.

Figure 8: CALMET Predicted Diurnal Variation in Mixing Heights – 2014



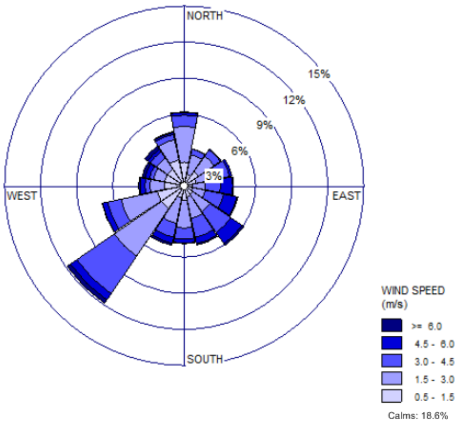
CALMET generated wind rose for the calendar year 2014 is presented in **Figure 9**.

From the wind roses illustrated in **Figure 9**, the following observations are made:

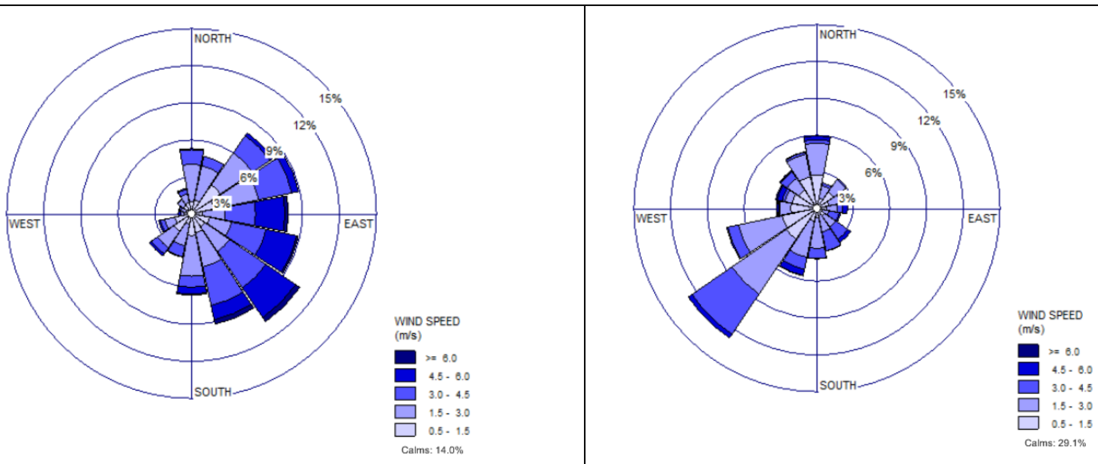
- Prevailing winds on an annual basis are predominantly from the west south western and south western sector, with these sectors cumulatively contributing to approximately 20% of the annual wind flow;
- Seasonal variation is observed in the wind patterns as majority of the winds during autumn and winter season are from the west south western and south-western sector, whereas during

summer, winds are prevalent from the eastern, north-eastern and south-eastern quadrants and during spring, wind distribution tends to be a lot more varied.

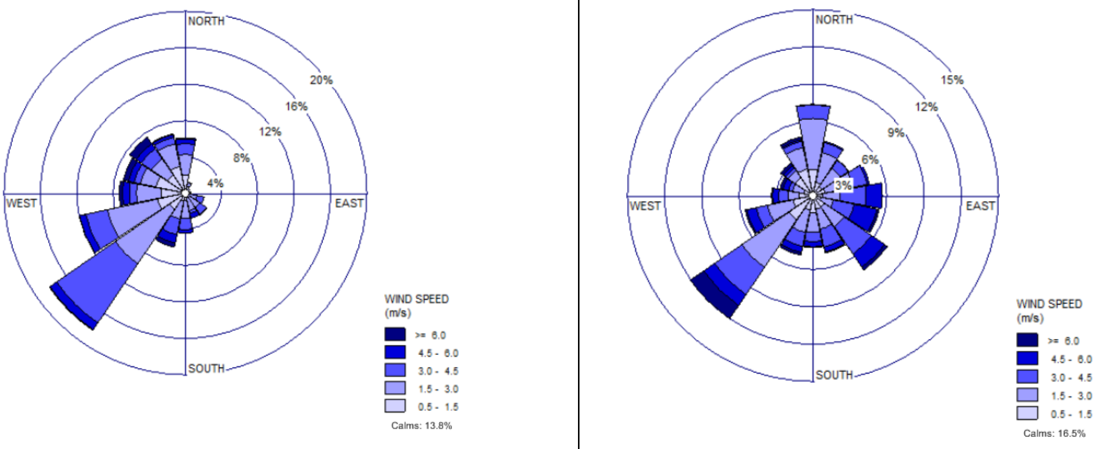
Figure 9: Annual and Seasonal Wind Roses for 2014 – CALMET Predictions



Annual



Summer **Autumn**



Winter **Spring**

5.3 Existing Air Quality

Characterising air quality levels surrounding the Project Site is a key factor, especially for determining cumulative pollutant concentrations.

No air-quality monitoring is undertaken at the Project Site, and as-such reference was drawn to the NSW-OEH ambient air quality monitoring station located at Prospect, NSW. The Prospect monitoring station is located approximately 5.3km north-east of the Project Site and records continuous concentrations of PM_{10}, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and ozone (O_3).

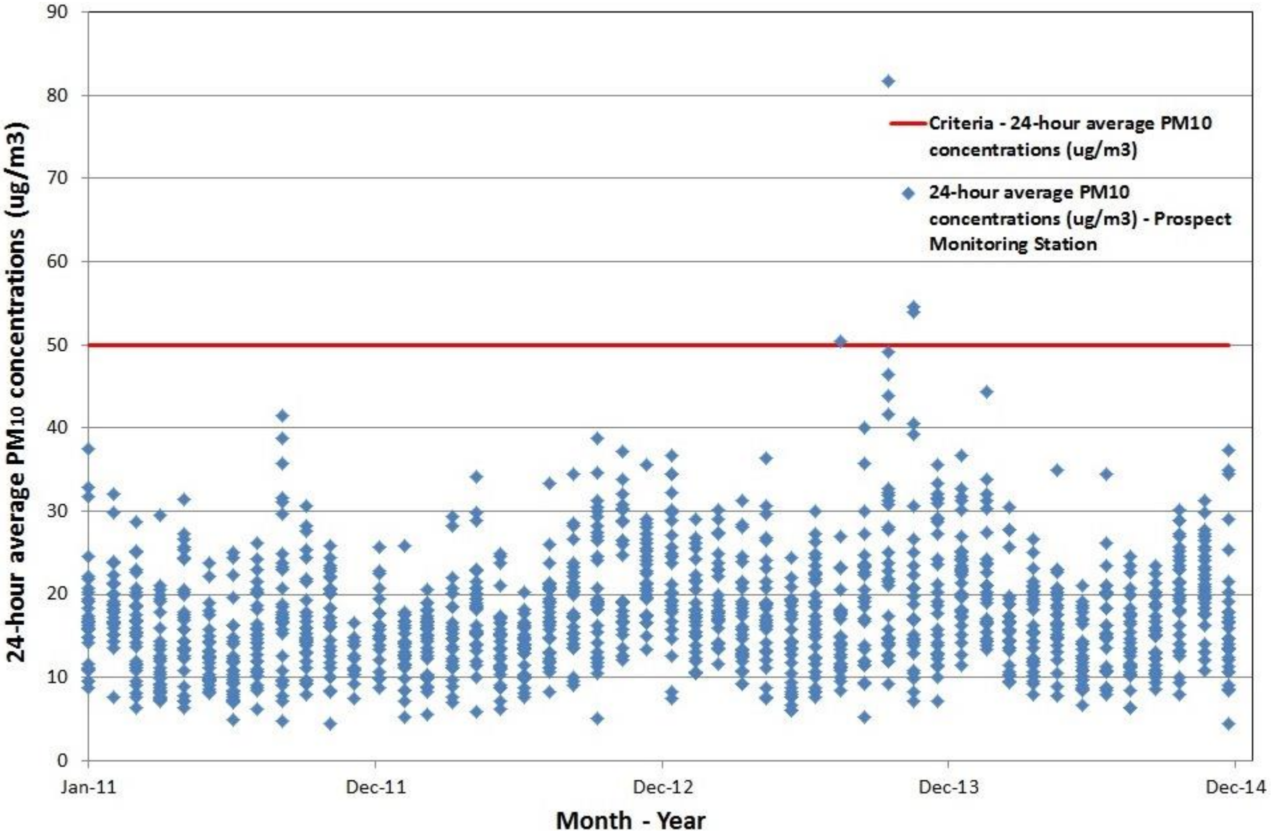
5.3.1 PM_{10} Concentrations

PM_{10} levels recorded at Prospect monitoring station from 2011-2014 were processed and are summarised in **Table 10** and illustrated in **Figure 10**.

Table 10: Measured PM_{10} Concentration Levels –Prospect Monitoring Station – 2011-14

Parameter	2011	2012	2013	2014
Minimum 24-hour average PM_{10} concentration (µg/m^3)	5	5	5	4
Maximum 24-hour average PM_{10} concentration (µg/m^3)	42	39	82	44
Average 24-hour average PM_{10} concentration (µg/m^3)	16	17	19	18
Number of days > 50 µg/m^3 (criteria)	0	0	3	0

Figure 10: 24-hour Average PM_{10} Concentrations – Prospect Monitoring Station – 2011-14



24-hour average PM_{10} concentration levels measured at Prospect monitoring station exceeded the criteria of 50 µg/m^3 on three (3) occasions in 2013. However, no such exceedances were observed in 2011, 2012 or 2014. For the purpose of assessing cumulative 24-hour PM_{10} impacts associated with the Project, daily varying PM_{10} concentrations from the 2014 dataset at the Prospect monitoring station was taken into consideration. The highest 24-hour average PM_{10} concentration model prediction at each of the identified sensitive receptors (**Table 5**) was added to the corresponding measured 24-hour average PM_{10} background concentration. For assessing annual average cumulative PM_{10} impacts, the annual average PM_{10} concentrations measured at the Prospect monitoring station for 2014 (18 $\mu g/m^3$) was considered to be the background concentration.

5.3.2 TSP Concentrations

TSP monitoring is not currently undertaken at the Prospect monitoring station. As no monitoring data is available, background TSP concentrations have been estimated based on a conservative assumption that 40% of TSP is PM_{10}, and as-such, based on that conservative assumption, the annual-average background TSP concentration for 2014 has been estimated to be 44 $\mu g/m^3$.

5.3.3 $PM_{2.5}$ Concentrations

$PM_{2.5}$ monitoring data was not available at the Prospect monitoring station for the calendar year 2014. Hence, in order to estimate ambient $PM_{2.5}$ concentrations, daily ratios of measured $PM_{2.5}$ to PM_{10} concentrations at nearby monitoring stations within the Sydney basin were calculated. Monitoring data from Liverpool, Chullora, Earlwood, Camden and Richmond recorded for the calendar year 2014 were used. The $PM_{2.5}$ to PM_{10} ratios were calculated for each day of the entire year across these monitoring stations and the daily averaged ratio (ranging from 0.18 to 1.12 with an average of 0.45) was applied to the measured daily PM_{10} concentration at Prospect for the year 2014.

Based on the above analysis, the maximum $PM_{2.5}$ 24-hour average concentration was calculated to be 21.9 $\mu g/m^3$ with an annual average concentration of 7.6 $\mu g/m^3$.

5.3.4 Deposited Dust Levels

No dust deposition monitoring is undertaken either at the Project Site or at the Prospect monitoring station. Based on similar projects undertaken by Airlabs personnel in the past, and taking into consideration the relationship between TSP levels and deposited dust levels, a conservative background value of 2.1 g/m^2/month has been applied to assess cumulative deposited dust levels.

5.3.5 Nitrogen Dioxide

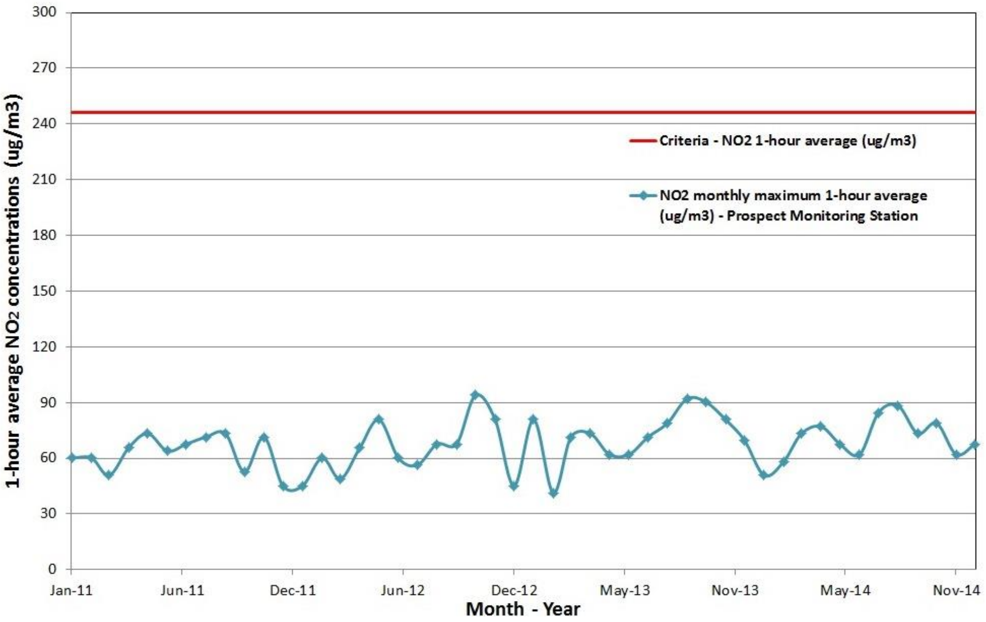
The monthly maximum 1-hour average NO_2 concentration levels measured at the Prospect monitoring station for 2014 are summarised in **Table 11** and the monthly maximum 1-hour average NO_2 concentration levels recorded from 2011-2014 are illustrated in **Figure 11**.

Table 11: Measured Monthly Maximum 1-Hour NO_2 Concentration Levels – Prospect Monitoring Station – 2014

Month	NO_2 Monthly Maximum 1-hour Average ($\mu g/m^3$)
January	51
February	58
March	73
April	77
May	68
June	62
July	85
August	88

Month	NO_2 Monthly Maximum 1-hour Average (µg/m^3)
September	73
October	79
November	62
December	68
Maximum in 2014	**88**

Figure 11: Monthly Maximum 1-Hour Average NO_2 Concentrations – Prospect Monitoring Station – 2011-14



The maximum monthly 1- hour average measured in 2014 (88 µg/m^3), was considered to be the background NO_2 level for assessing cumulative impacts.

5.3.6 Sulfur Dioxide

The monthly maximum 1-hour average SO_2 concentration levels measured at the Prospect monitoring station for calendar year 2014 are summarised in **Table 12.**

Table 12: Measured Monthly Maximum 1-Hour SO_2 Concentration Levels –Prospect Monitoring Station – 2014

Month	SO_2 Monthly Maximum 1-hour Average (µg/m^3)
January	31
February	34
March	39
April	26
May	21
June	16
July	31

Month	SO_2 Monthly Maximum 1-hour Average (μg/m^3)
August	10
September	50
October	21
November	21
December	37
Maximum in 2014	**50**

The maximum monthly 1- hour average measured in 2014 (50 μg/m^3), was considered to be the background SO_2 level for assessing cumulative impacts.

5.3.7 Carbon Monoxide

The background CO levels for this Project were estimated from the daily maximums derived from an 8-hour rolling average as measured by the Prospect monitoring station. The highest daily maximum value of 1.5 mg/m^3 based on an 8-hour rolling average (estimated to be 2.5 mg/m^3 based on a 1-hour average) measured across the 2014 dataset was considered to be the background CO concentration level for this assessment.

5.3.8 Hydrogen Fluoride

It is to be noted that no HF monitoring is undertaken at the Prospect monitoring station. However, taking into consideration the location of the Project Site and the nearby surroundings, it is unlikely that there would be other major contributors of HF emissions in the nearby vicinity than the existing Plant 1 and Plant 2 operations.

5.3.9 Contribution of Plant 1 Emissions

The current Scope of Work for the AQIA does not include determining air quality impacts for Plant 1 as the objective is to determine impacts associated with existing operations and the LWA Project (Stage 1 and Stage 2) at Plant 2. However, as no air quality monitoring is undertaken by Brickworks and taking into consideration that Plant 1 is located adjacent to Plant 2, emission rates have been quantified for Plant 1 in order to comprehensively determine cumulative air quality impacts within the near-field region. It is to be noted that the Prospect monitoring station will incorporate contribution from both Plant 1 and existing operations at Plant 2 and quantifying emissions from Plant 1 and Plant 2 and adding their respective contribution to the background air quality data is considered a conservative approach. Details regarding estimating pollutant emission rates from Plant 1 are mentioned in **Section 6.8**

6. EMISSION ESTIMATION

Based on the understanding of the Project, pollutant emission rates have been determined for the following:

- Flue gas emissions from the proposed LWA rotary kiln stack for the two (2) fuel combustion options for both Stage 1 and Stage 2 operations;
- Fugitive particulate matter emissions corresponding to Stage 1 and Stage 2 LWA operations;
- Emissions released to air from existing brick making operations at Plant 2, which include flue gas emissions from the existing brick-kiln stack and associated fugitive particulate matter emissions; and
- Flue gas emissions from the existing brick-kiln stack at Plant 1 and corresponding fugitive particulate matter emissions.

As mentioned in **Section 2.2.1,** Stage 1 of the Project comprises LWA production volumes of 300,000 tonnes per annum (tpa) and a total of 600,000 tpa of LWA production is forecasted for Stage 2 (including 300,000 tpa of LWA from Stage 1), which would potentially commence approximately five (5) years after commencement of Stage 1. The rotary kiln for Stage 1 is designed to produce 300,000 tpa of LWA and as-such; a new rotary kiln in addition to the existing kiln would be commissioned during Stage 2 operations.

Dust impacts generated from Stage 1 and Stage 2 construction activities are not considered significant when compared with operational activities, however, sources generating dust emissions during construction activities and mitigation measures that would be implemented by Brickworks are summarised in **Section 6.9**.

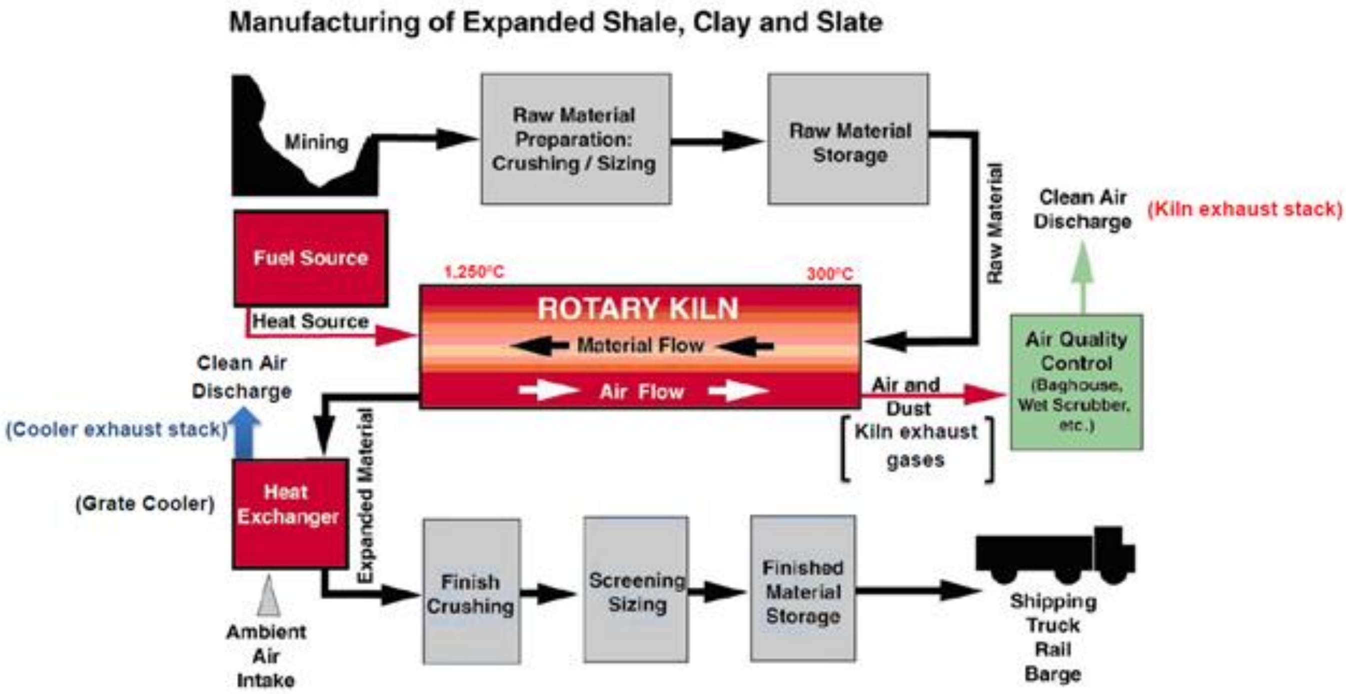
6.1 Process Description

The LWA production process involves feeding the material to a rotary kiln, which is fired with natural gas / pulverised coal to temperatures of about 1,250°C. From the kiln, the hot aggregate is transferred to a grate cooler where it is cooled by air, forming a porous material. After cooling, the LWA is screened for size, crushed if necessary, stockpiled, and shipped. The key steps involving kiln operations include:

- The material and gas flow in the rotary kiln is a counter flow principle – where the solids and gases are flowing in opposite directions;
- The raw material enters the kiln at the “exhaust” end, whereas the heat input from the burner is at the product discharge end;
- The combustion gases “scrub” the raw material as they flow in opposite directions along the kiln, such that the combustion gases preheat the material prior to entering the burner zone. This is a vital part of the process for preparing the raw material for firing, as well as significantly improving fuel efficiency;
- The products of combustion gases then exit the kiln (at approximately 300°C) at the material inlet end and then pass through the exhaust treatment process. The clean gases are then discharged through the kiln exhaust stack or the product combustion stack (PCS);
- The hot aggregate exits the kiln at the burner zone at approximately 1,250°C and passes through a grate cooler (heat exchanger) where it is cooled with ambient air to less than 100°C. The exhaust air from the grate cooler passes through a bag filter and is then discharged through the cooler exhaust stack or the cooling air (CA) stack at a temperature of approximately 150°C.

A flowchart outlining the LWA production process for both Stage 1 and Stage 2 operations has been provided by Brickworks and is illustrated in **Figure 12**.

Figure 12: Flowchart Illustrating LWA Production Process – Stage 1 and Stage 2 Operations

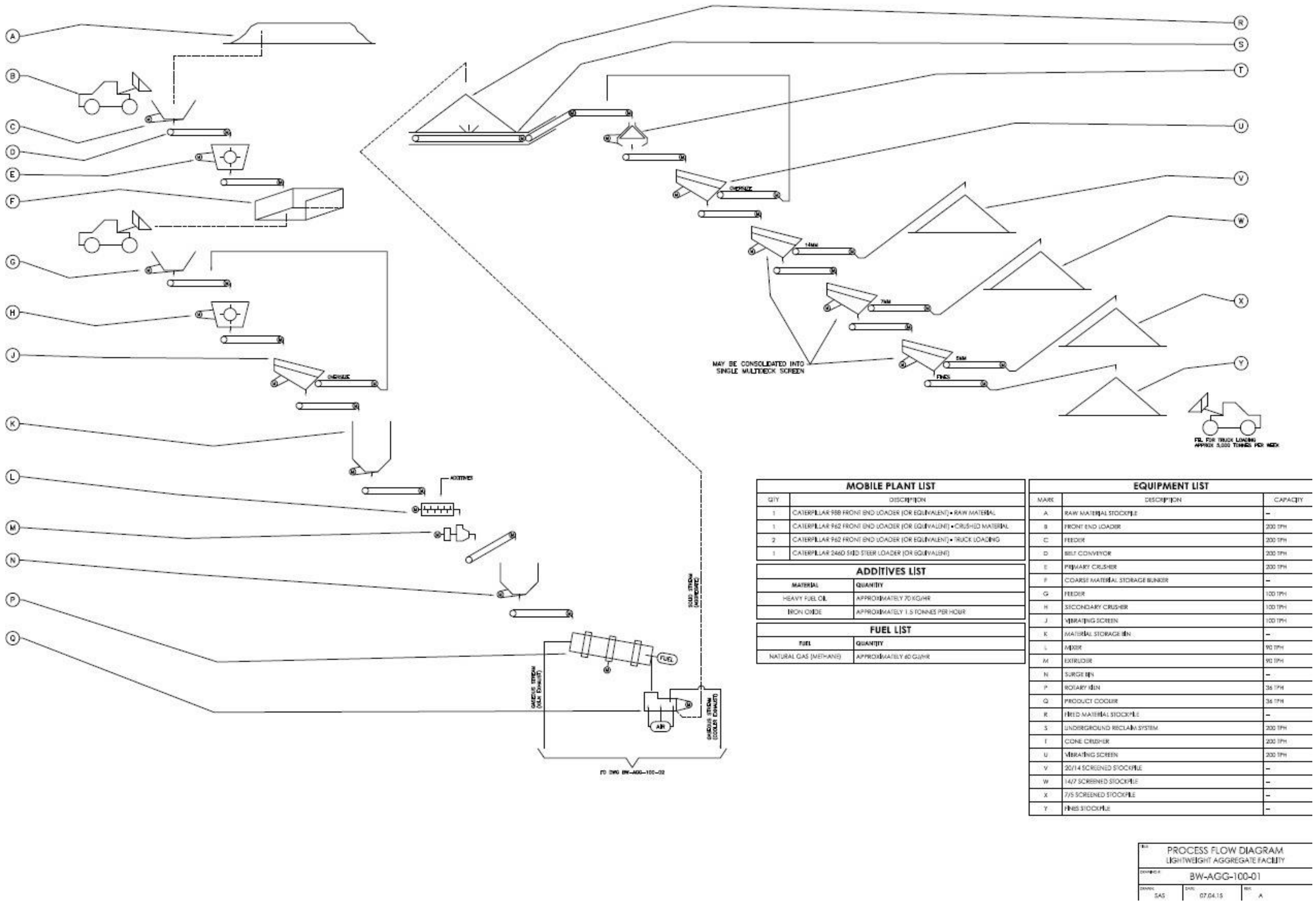


A flowchart outlining the material flow into and out of the kiln during the LWA production process is illustrated in **Figure 13.**

A flowchart outlining the gas flow through the kiln exhaust and grate cooler exhaust system for the LWA production process is illustrated in **Figure 14.**

A schematic layout of the proposed air quality control measures to be installed is illustrated in **Figure 15.**

Figure 13: Flowchart Illustrating LWA Production Process – Material Flow Into and Out of the Kiln



MOBILE PLANT LIST

QTY	DESCRIPTION
1	CATERPILLAR 988 FRONT END LOADER (OR EQUIVALENT) • RAW MATERIAL
1	CATERPILLAR 962 FRONT END LOADER (OR EQUIVALENT) • CRUSHED MATERIAL
2	CATERPILLAR 962 FRONT END LOADER (OR EQUIVALENT) • TRUCK LOADING
1	CATERPILLAR 246D SKID STEER LOADER (OR EQUIVALENT)

ADDITIVES LIST

MATERIAL	QUANTITY
HEAVY FUEL OIL	APPROXIMATELY 70 KG/HR
IRON OXIDE	APPROXIMATELY 1.5 TONNES PER HOUR

FUEL LIST

FUEL	QUANTITY
NATURAL GAS (METHANE)	APPROXIMATELY 60 GJ/HR

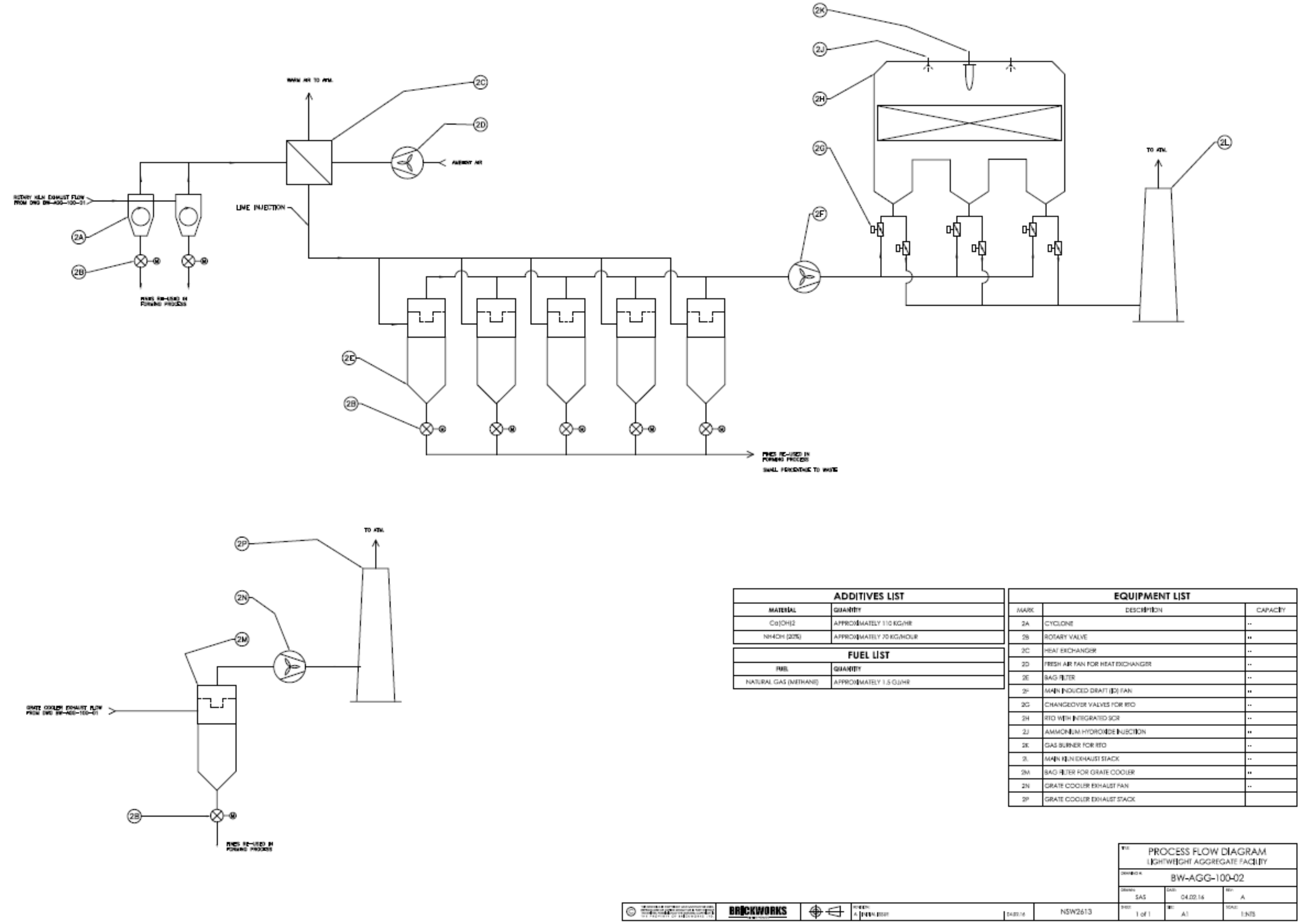
EQUIPMENT LIST

MARK	DESCRIPTION	CAPACITY
A	RAW MATERIAL STOCKPILE	–
B	FRONT END LOADER	200 TPH
C	FEEDER	200 TPH
D	BELT CONVEYOR	200 TPH
E	PRIMARY CRUSHER	200 TPH
F	COARSE MATERIAL STORAGE BUNKER	–
G	FEEDER	100 TPH
H	SECONDARY CRUSHER	100 TPH
J	VIBRATING SCREEN	100 TPH
K	MATERIAL STORAGE BIN	–
L	MIXER	90 TPH
M	EXTRUDER	90 TPH
N	SURGE BIN	–
P	ROTARY KILN	36 TPH
Q	PRODUCT COOLER	36 TPH
R	FIRED MATERIAL STOCKPILE	–
S	UNDERGROUND RECLAIM SYSTEM	200 TPH
T	CONE CRUSHER	200 TPH
U	VIBRATING SCREEN	200 TPH
V	20/14 SCREENED STOCKPILE	–
W	14/7 SCREENED STOCKPILE	–
X	7/5 SCREENED STOCKPILE	–
Y	FINES STOCKPILE	–

PROCESS FLOW DIAGRAM
LIGHTWEIGHT AGGREGATE FACILITY
BW-AGG-100-01
SAS 07.04.15 A

Note: See Appendix D (Drawing: BW-AGG-100-01) for a higher resolution imagery

Figure 14: Flowchart Illustrating LWA Production Process – Gas Flow through the Kiln Exhaust and Grate Cooler Exhaust System



ADDITIVES LIST

MATERIAL	QUANTITY
Ca(OH)2	APPROXIMATELY 110 KG/HR
NH4OH (20%)	APPROXIMATELY 70 KG/HOUR

FUEL LIST

FUEL	QUANTITY
NATURAL GAS (METHANE)	APPROXIMATELY 1.5 GJ/HR

EQUIPMENT LIST

MARK	DESCRIPTION	CAPACITY
2A	CYCLONE	--
2B	ROTARY VALVE	--
2C	HEAT EXCHANGER	--
2D	FRESH AIR FAN FOR HEAT EXCHANGER	--
2E	BAG FILTER	--
2F	MAIN INDUCED DRAFT (ID) FAN	--
2G	CHANGEOVER VALVES FOR RTO	--
2H	RTO WITH INTEGRATED SCR	--
2J	AMMONIUM HYDROXIDE INJECTION	--
2K	GAS BURNER FOR RTO	--
2L	MAIN KILN EXHAUST STACK	--
2M	BAG FILTER FOR GRATE COOLER	--
2N	GRATE COOLER EXHAUST FAN	--
2P	GRATE COOLER EXHAUST STACK	

TITLE: PROCESS FLOW DIAGRAM LIGHTWEIGHT AGGREGATE FACILITY		
DRAWING N: BW-AGG-100-02		
DRAWN: SAS	DATE: 04.02.16	REV: A
SHEET: 1 of 1	SIZE: A1	SCALE: 1:NTS

REVISION: A INITIAL ISSUE 04.02.16

Note: See Appendix D Drawing BW-AGG-100-02 for a higher resolution imagery

6.2 Best Available Technologies (BAT)

A desktop review of BATs implemented by existing LWA manufacturing facilities for minimising flue gas emissions has been undertaken and their findings are presented below. It is to be noted that at the time of preparing this assessment, limited information was available on public domain pertaining to LWA manufacturing and associated emissions and their controls. Additionally, as the revised fuel options proposed by Brickworks include 100% natural gas and 100% pulverised coal only, it is noted that the *NSW Energy from Waste Policy Statement* and its requirements are not applicable for the Project, and consequently, the proposed facility is not required to demonstrate that the current international best practice techniques will be implemented. However, to demonstrate that Brickworks would be implementing best practice measures, a desktop review of BATs implemented by existing cement and LWA manufacturers is provided below:

- *Berrima Cement Works, Boral* – This plant uses the following air pollution control measures - electrostatic precipitator and a bag filter for solid particulate and heavy metals, conditioning towers for dioxins and furans, low NOx technology for minimising NOx emissions, precalciner technology for PAH's, PCB, Greenhouse Gas (GHG) emissions, acid gases and VOC's (Berrima, 2011);
- *Minergy Corporation, Oak Creek, Wisconsin* – This LWA manufacturing facility uses baghouse for dust and particulate emissions and scrubbing system for cleaning acid gases released in the process (Minergy, 2011);
- *Texas Industries, Clodine, Texas* – This coal-fired LWA manufacturing plant uses wet scrubbers, dry cyclones and fabric filters for emissions control (US-EPA, 1981a);
- *Arkansas LWA Corporation, West Memphis, Arkansas* – This coal-fired LWA manufacturing plant uses wet scrubber and dry cyclones for emissions control (US-EPA, 1981b);
- Section 2.4 of the US-Environmental Protection Agency (US-EPA) *AP-42 Emission Factor Documentation for AP-42 Section 11.20 – Lightweight Aggregate Manufacturing* states that emissions from rotary kilns generally are controlled by wet scrubbers. However, fabric filters (baghouse) and electrostatic precipitators (ESP) are also used to control kiln emissions.

Based on a review of the publicly available information pertaining to minimising flue gas emissions generated from LWA rotary kilns, it is observed that baghouses and scrubbers are largely used as BATs for minimising particulate and acid gas (HF, HCl, SO_2 etc.) emissions.

6.3 LWA Flue Gas Emissions

Based on the review of the LWA manufacturing process, flue gas emission sources and the corresponding pollutants for both Stage 1 and Stage 2 LWA operations are outlined in **Table 13**. It is to be noted that the only difference between Stage 1 and Stage 2 operations would be the increase in the LWA production volumes from 300,000 tpa during Stage 1 to a total of 600,000 tpa during Stage 2 (which includes Stage 1) operations and commissioning of two new stacks – PCS2 and CA2. The operational process for Stage 1 and Stage 2 operations would remain the same.

Table 13: LWA Flue Gas Sources and Pollutants - Stage 1 and Stage 2 Operations

Source	Type	Associated Pollutants
Product Combustion Stack 1 (PCS 1) – Stage 1 Operations	Stack Emissions (Point Source)	Particulates, NO_2, SO_2, CO, HF, HCl, Acid Gases, Volatile Organic Compounds (VOCs), Metals, PAHs, Dioxins and Furans
Cooling Air Stack 1 (CA1) – Stage 1 Operations	Stack Emissions (Point Source)	Particulates
Product Combustion Stack	Stack Emissions (Point	Particulates, NO_2, SO_2, CO, HF, HCl, Acid

Source	Type	Associated Pollutants
2 (PCS 2) – Stage 2 Operations	Source)	Gases, Volatile Organic Compounds (VOCs), Metals, PAHs, Dioxins and Furans
Cooling Air Stack 1 (CA2) – Stage 2 Operations	Stack Emissions (Point Source)	Particulates

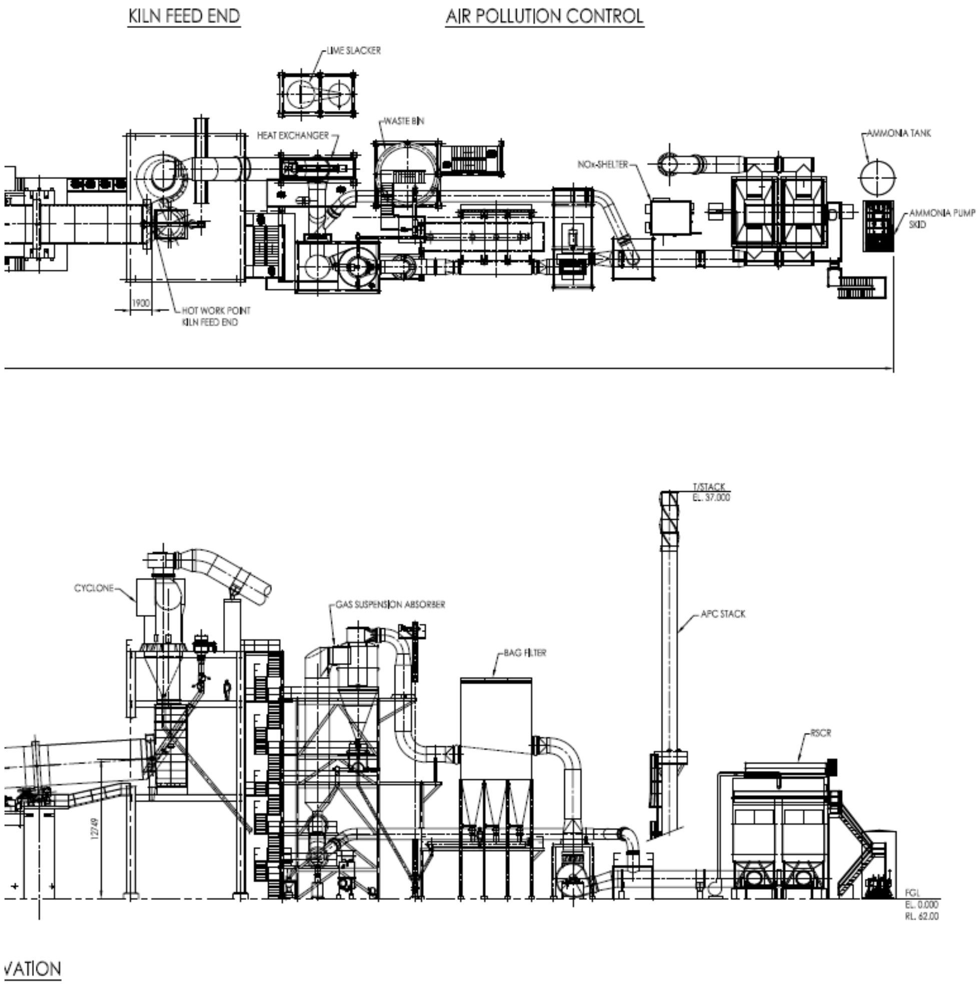
6.4 Proposed Air Pollution Control Measures

In order to minimise flue gas emissions generated from LWA operations, Brickworks are proposing a set of air pollution control measures for both Stage 1 and Stage 2 operations incorporating BATs for LWA manufacturing. The proposed measures, their objectives and their estimated control efficiencies (%) are summarised in **Table 14** and a layout of the proposed air quality control measures to be installed is illustrated in **Figure 15** and **Figure 16.**

Table 14: Proposed Air Pollution Control Measures for Flue Gas Emissions – Stage 1 and Stage 2

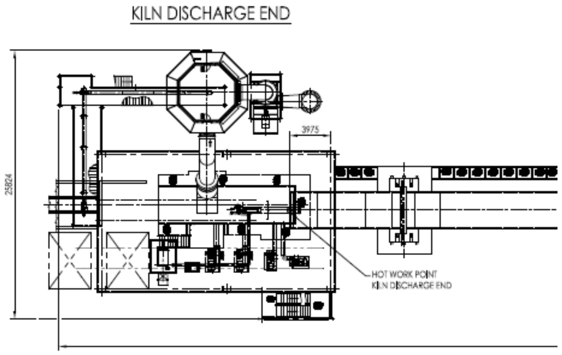
Operational Stage and Source	Proposed Air Pollution Control Systems	Pollution Control System Objective	Estimated Control Efficiency (%)	Control Efficiency Reference Source
Product Combustion Stack (PCS 1 – Stage 1) & (PCS 2 – Stage 2)	Baghouse Filtration	For effectively controlling particulate emissions and metals	99% for particulate and metals (in particulate phase)	Control efficiency obtained from NPI – Combustion in Boilers (2011) – fabric filters (baghouses) for new equipment
	Lime / Water Scrubbing System – (Wet Scrubber)	For effectively controlling acid gases (e.g. HF, HCl, SO_2)	95%	US-EPA Air Pollution Control Technology Factsheet for wet scrubbers and NPI – Combustion in Boilers (2011) – wet scrubber
	Regenerative Thermal Oxidisers (RTO)	For effectively controlling VOC's and Carbon monoxide emissions	95%	Firmin and Lipke, ASME 1996
Cooling Air Stack (CA1 – Stage 1) & (CA2 – Stage 2)	Baghouse Filtration	For effectively controlling particulate emissions	99%	Control efficiency obtained from NPI – Combustion in Boilers (2011) – fabric filters (baghouses) for new equipment

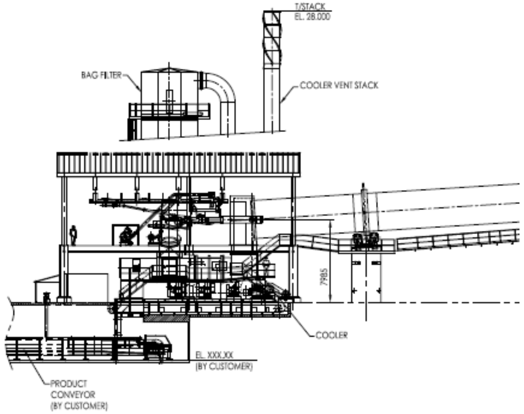
Figure 15: Layout of the Proposed Air Pollution Control Systems for the Production Combustion Stack



Source: Brickworks Drawing 9232500831-0200-40-46-1050.pdf

Figure 16: Layout of the Proposed Air Pollution Control Systems for the Cooling Air Stack





Source: Brickworks Drawing 9232500831-0200-40-46-1050.pdf

By comparing the proposed air pollution control measures outlined in **Table 14** with measures implemented by other LWA manufacturing facilities, it is observed that the measures proposed by Brickworks are in-line with best practices for minimising flue gas emissions generated from LWA manufacturing operations. Additionally, as per information provided to Airlabs by Brickworks, the rotary kiln system and air pollution control measures will be designed to ensure compliance with the Group 6 emission standards requirements.

6.5 Estimating LWA Flue Gas Emissions

As discussed in **Section 2.2**, Brickworks are investigating two (2) fuel sources for LWA production, which include 100% natural gas and 100% pulverised coal. In order to understand the emissions profile and subsequent impacts associated with each fuel source type, pollutant emission rates have been quantified for each of the following fuel combustion options for both Stage 1 (300,000 tpa) and Stage 2 (total 600,000 tpa – including 300,000 tpa from Stage 1) operations:

- **Option 1**: 100% Natural Gas;
- **Option 2**: 100% Pulverised Coal.

Pollutant emission rates for each of the aforementioned fuel combustion options were estimated using emission factors, referenced from Emission Estimation Technique (EET) manuals. It is to be noted that, there are no emission factors corresponding to LWA manufacturing operations in Australia. Pollutant emission factors have been referenced from the following EET manuals:

- National Pollutant Inventory (NPI) , *Emission Estimation Technique Manual for Bricks, Ceramics & Clay Product Manufacturing*, Environment Australia, August 1998;
- National Pollutant Inventory (NPI) , *Emission Estimation Technique Manual for Combustion in Boilers*, Version 3.6, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, December 2011;
- AP-42 Emission Factors, *Chapter 11.3 Brick and Structural Clay Product Manufacturing* United States Environmental Protection Agency (US-EPA 1997); and
- Sources of Dioxins and Furans in Australia, Air Emissions – Revised Edition, (Environment Australia, 2002).

Among the referenced EET's flue gas emission factors were mainly determined from the Bricks, Ceramics & Clay Product Manufacturing EET because of the comparable similarities between raw materials associated with brick, clay and LWA manufacturing. Moreover, the EET also has specific emission factors pertaining to different types of fuel used (i.e. natural gas and coal) for product manufacturing. Other manuals were referenced, when no information could be obtained from the Bricks, Ceramics & Clay Product Manufacturing EET manual.

Based on emission factors (kg of pollutant released/tonne of LWA produced) published in the aforementioned EET manuals, tonnage of LWA material produced for Stage 1 (300,000 tpa) and Stage 2 operations (600,000 tpa – Stage 1 included), amounts of fuel used, proposed air pollution control measures and their corresponding control efficiencies (**Table 14**), emission estimates have been quantified. Pollutant emission factors utilised for developing emission rates are presented in **Appendix A**.

Flue gas emissions inventory for Stage 1 and Stage 2 operations for the two (2) fuel combustion options are presented in **Table 15**. Additionally, stack concentrations were calculated based on the estimated emission rates and volumetric flow conditions for the PCS and CA stack for both Stage 1 and Stage 2 operations (as provided by Brickworks) and subsequently compared against Group 6 emission standards (**Table 6**) to assess for compliance with the Clean Air Regulations. Estimated stack concentrations for both Stage 1 and Stage 2 operations are well below the Group 6 emission standards and as-such, comply with the Clean Air Regulation standards.

Table 15: Stack Emissions Inventory – LWA Stage 1 and Stage 2

Pollutant	**Controlled Estimated Emission Rates (g/sec)**			
	Stage 1 (100% Natural Gas) (1 x PCS Stack, 1 x CA Stack)	**Stage 1 (100% Pulverised Coal) (1 x PCS Stack, 1 x CA Stack)**	**Stage 2 (100% Natural Gas) (2 x PCS Stacks, 2 x CA Stacks)**	**Stage 2 (100% Pulverised Coal) (2 x PCS Stacks, 2 x CA Stacks)**
Product Combustion Stack (PCS) – Estimated Emission Rate per PCS Stack				
Particulate Matter PM$_{2.5}$	2.18E-02	3.50E-02	2.18E-02	3.50E-02
Particulate Matter PM$_{10}$	4.14E-02	6.66E-02	4.14E-02	6.66E-02
Total Solid Particulates (TSP)	4.35E-02	7.01E-02	4.35E-02	7.01E-02
Sulfur dioxide (SO_2)	7.42E-01	1.14E+00	7.42E-01	1.14E+00
Oxides of Nitrogen (NO_X)	1.66E+00	2.43E+00	1.66E+00	2.43E+00
Carbon Monoxide (CO)	2.85E-01	1.90E-01	2.85E-01	1.90E-01
Hydrogen Fluoride (HF)	1.40E-01	4.04E-02	1.40E-01	4.04E-02
Hydrogen Chloride (HCl)	4.04E-02	4.04E-02	4.04E-02	4.04E-02
Acetone	8.08E-03	3.23E-03	8.08E-03	3.23E-03
Benzene	1.38E-02	1.38E-03	1.38E-02	1.38E-03
Carbon disulphide	2.04E-04	1.09E-05	2.04E-04	1.09E-05
Chloroethane	2.23E-03	5.23E-05	2.23E-03	5.23E-05
Chloroform (trichloromethane)	n/a	4.76E-07	n/a	4.76E-07
Ethylbenzene	2.09E-04	9.99E-05	2.09E-04	9.99E-05
Xylene	5.94E-04	8.42E-04	5.94E-04	8.42E-04
Phenol	4.09E-04	1.66E-04	4.09E-04	1.66E-04
Styrene	9.51E-05	4.76E-07	9.51E-05	4.76E-07
Tetrachloroethane	1.33E-05	4.76E-07	1.33E-05	4.76E-07
Trichloroethane	n/a	4.76E-07	n/a	4.76E-07
Toluene	7.61E-03	1.19E-03	7.61E-03	1.19E-03

Pollutant	**Controlled Estimated Emission Rates (g/sec)**			
	Stage 1 (100% Natural Gas) (1 x PCS Stack, 1 x CA Stack)	**Stage 1 (100% Pulverised Coal) (1 x PCS Stack, 1 x CA Stack)**	**Stage 2 (100% Natural Gas) (2 x PCS Stacks, 2 x CA Stacks)**	**Stage 2 (100% Pulverised Coal) (2 x PCS Stacks, 2 x CA Stacks)**
Polycyclic Aromatic Hydrocarbons (PAHs) – as benzo-a-pyrene	6.20E-06	4.27E-06	6.20E-06	4.27E-06
Polychlorinated Dioxins and Furans (PCDD/F) – TEQ	4.81E-11	1.33E-10	4.81E-11	1.33E-10
Arsenic	1.47E-05	6.18E-05	1.47E-05	6.18E-05
Beryllium	2.00E-07	7.61E-06	2.00E-07	7.61E-06
Cadmium	1.07E-05	1.15E-05	1.07E-05	1.15E-05
Chromium (III)	1.36E-06	5.84E-06	1.36E-06	5.84E-06
Chromium (VI)	n/a	1.78E-06	n/a	1.78E-06
Copper dust	8.27E-07	2.21E-05	8.27E-07	2.21E-05
Manganese	1.38E-04	1.38E-05	1.38E-04	1.38E-05
Mercury (inorganic)	3.57E-05	4.56E-04	3.57E-05	4.56E-04
Lead	4.85E-07	9.44E-06	4.85E-07	9.44E-06
Nickel	2.04E-06	6.29E-06	2.04E-06	6.29E-06
Cooling Air (CA) Stack – Estimated Emission Rate per CA Stack				
Particulate Matter $PM_{2.5}$	2.18E-02	3.50E-02	2.18E-02	3.50E-02
Particulate Matter PM_{10}	4.14E-02	6.66E-02	4.14E-02	6.66E-02
Total Solid Particulates (TSP)	4.35E-02	7.01E-02	4.35E-02	7.01E-02

n/a indicates that the specific pollutant is not released during the combustion process

Table 16: Comparison of Estimated LWA Stage 1 and Stage 2 Flue Gas Concentrations with POEO Emission Standards

Pollutant and corresponding POEO Group 6 Emission Standards	**Estimated LWA Flue Gas Concentrations**			
	Stage 1 (100% Natural Gas) **(1 x PCS Stack, 1 x CA Stack)**	**Stage 1 (100% Pulverised Coal)** **(1 x PCS Stack, 1 x CA Stack)**	**Stage 2 (100% Natural Gas)** **(2 x PCS Stacks, 2 x CA Stacks)**	**Stage 2 (100% Pulverised Coal)** **(2 x PCS Stacks, 2 x CA Stacks)**
Product Combustion Stack (PCS) – Estimated Gas Concentration per PCS Stack				
Total Particulates (50 mg/m^3)	2.5	4.0	2.5	4.0
Oxides of Nitrogen (NO$_X$) (350 mg/m^3)	94	137	94	137
Sulfur dioxide (SO$_2$) (n.a.)	42	65	42	65
Carbon Monoxide (CO) (125 mg/m^3)	16	11	16	11
Hydrogen Fluoride (HF) (50 mg/m^3)	8	2	8	2
Hydrogen Chloride (HCl) (100 mg/m^3)	2	2	2	2
Total VOCs (40 mg/m^3)	1.6	0.2	1.6	0.2
Polychlorinated Dioxins and Furans (PCDD/F) – TEQ (0.1 ng/m^3)	0.003	0.012	0.003	0.012
Type 1 and Type 2 substances (in aggregate) (1 mg/m^3)	0.01	0.04	0.01	0.04
Cadmium (0.2 mg/m^3)	0.0006	0.0010	0.0006	0.0010
Mercury (0.2 mg/m^3)	0.002	0.026	0.002	0.026
Cooling Air (CA) Stack) – Estimated Gas Concentration per CA Stack				
Total Particulates (50 mg/m^3)	2.18E-02	3.50E-02	2.18E-02	3.50E-02

(1) Reference conditions defined as dry, 273.15K, 101.3kPa and 7% O$_2$ and 11% O$_2$ for dioxins and furans

6.6 LWA Fugitive Particulate Emissions

Fugitive particulate emission sources corresponding to Stage 1 and Stage 2 LWA operations are listed below. Sources contributing to fugitive particulate emissions have been identified and are listed below. Sources have been determined based on the process description details provided to Airlabs by Brickworks (refer **Figure 13**)

- Loading and Unloading Operations via Front End Loader (FEL);
- Material Handling / Conveying Activities;
- Loading Fired Material Stockpiles from the Rotary Kiln;
- Crushing and Grinding Operations;
- Loading Product Stockpiles;
- FEL loading Product Stockpiles to Trucks;
- Heavy Vehicle Haulage on Gravel Surfaces; and
- Wind Erosion from Raw and Product Stockpiles.

Based on discussions with Brickworks, it is understood that the pulverised coal that would be used as a fuel in the LWA production would be fed directly into the rotary kiln through enclosed pipework system. No stockpiles of pulverised coal would be stored on-site and as-such; it is expected that no fugitive particulate emissions would be generated. To quantify TSP and PM_{10} emissions from the aforementioned sources, reference was drawn to the following EET's:

- National Pollutant Inventory (NPI) , *Emission Estimation Technique Manual for Bricks, Ceramics & Clay Product Manufacturing*, Environment Australia, August 1998;
- National Pollutant Inventory (NPI) , *Emission Estimation Technique Manual for Mining*, Version 3.1, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, January 2012;
- AP-42 Emission Factors, *Chapter 11.3 Bricks and Structural Clay Product Manufacturing*, United States Environmental Protection Agency (US-EPA 1997);
- AP-42 Emission Factors, *Chapter 11.19.2 Crushed Stone Processing and Pulverised Mineral Processing*, United States Environmental Protection Agency (US-EPA 2004);
- AP-42 Emission Factors, *Chapter 13.2.2 Unpaved Roads*, United States Environmental Protection Agency (US-EPA 2006a); and
- AP-42 Emission Factors, *Chapter 13.2.4 Aggregate Handling and Storage Piles*, United States Environmental Protection Agency (US-EPA 2006b)

TSP and PM_{10} emissions associated with Stage 1 and Stage 2 operations are summarised in **Table 17** and **Table 18**. Emission rates have been quantified based on emission factors corresponding to specific activity, activity details (e.g. amount of materials handled, vehicle kilometres travelled, stockpile footprint areas etc.) and control measures for dust mitigation (refer **Appendix A** for further details). It is to be noted that the moisture content of the raw material (clay/shale) for existing and proposed LWA operations would be approximately 13%, which would considerably limit the potential for airborne fugitive dust emissions. For fugitive emissions, $PM_{2.5}$ emission rates were assumed to be 50% of PM_{10}.

Table 17: Fugitive TSP, PM_{10} and $PM_{2.5}$ Emissions Inventory – Stage 1 Operations

Activity	TSP Emissions (kg/year)	PM_{10} Emissions (kg/year)	$PM_{2.5}$ Emissions (kg/year)
Truck Dumping Raw Material	6	3	1.5
Front End Loader (FEL) Loading Raw Material to Feeder	39	19	9.5
Conveying to Primary Crusher	12	6	3
Primary Crushing	174	77	38.5
Conveying to Mill Building	12	6	3
Mill Building Operations – Grinding, Front End Loader (FEL) and Storage Operations	806	74	37
Material Conveyed to New Extruder Facility	8	4	2
Material Handling Operations Inside New Extruder Facility	405	162	81
Conveying Fired Stockpiles from Kilns	27	13	6.5
Loading Fired Stockpiles	27	13	6.5
Crushing and Screening Operations	122	54	27
Loading Product Stockpile – 1	7	3	1.5
Loading Product Stockpile – 2	7	3	1.5
Loading Product Stockpile – 3	7	3	1.5
Loading Product Stockpile – 4	7	3	1.5
Front End Loader (FEL) Loading Product Stockpiles to Truck	27	13	6.5
Heavy Vehicle Haulage on Gravel Surfaces	3,267	922	461
Wind Erosion – Existing Stockpile – 1	677	338	169
Wind Erosion – Existing Stockpile – 2	170	85	42.5
Wind Erosion – Existing Stockpile – 3	612	306	153
Wind Erosion – Fired Stockpile	521	260	130
Wind Erosion – Product Stockpile – 1	130	65	32.5
Wind Erosion – Product Stockpile – 2	130	65	32.5
Wind Erosion – Product Stockpile – 3	130	65	32.5
Wind Erosion – Product Stockpile – 4	130	65	32.5
Total Emissions	**7,460**	**2,628**	**1,314**

Table 18: Fugitive TSP, PM_{10} and $PM_{2.5}$ Emissions Inventory – Stage 2 Operations

Activity	TSP Emissions (kg/year)	PM_{10} Emissions (kg/year)	$PM_{2.5}$ Emissions (kg/year)
Truck Dumping Raw Material	6	3	1.5
Front End Loader (FEL) Loading Raw Material to Feeder	67	32	16
Conveying to Primary Crusher	20	9	4.5
Primary Crushing	296	131	65.5
Conveying to Mill Building	20	9	4.5
Mill Building Operations – Grinding, Front End Loader (FEL) and Storage Operations	1,369	126	63
Material Conveyed to New Extruder Facility	16	8	4
Material Handling Operations Inside New Extruder Facility	810	324	162
Conveying Fired Stockpiles from Kilns	55	26	13
Loading Fired Stockpiles	55	26	13
Crushing and Screening Operations	243	108	54
Loading Product Stockpile – 1	14	6	3
Loading Product Stockpile – 2	14	6	3
Loading Product Stockpile – 3	14	6	3
Loading Product Stockpile – 4	14	6	3
Front End Loader (FEL) Loading Product Stockpiles to Truck	55	26	13
Heavy Vehicle Haulage on Gravel Surfaces	4,298	1,213	606.5
Wind Erosion – Existing Stockpile – 1	677	338	169
Wind Erosion – Existing Stockpile – 2	170	85	42.5
Wind Erosion – Existing Stockpile – 3	612	306	153
Wind Erosion – Fired Stockpile	521	260	130
Wind Erosion – Product Stockpile – 1	130	65	32.5
Wind Erosion – Product Stockpile – 2	130	65	32.5
Wind Erosion – Product Stockpile – 3	130	65	32.5
Wind Erosion – Product Stockpile – 4	130	65	32.5
Total Emissions	**9,864**	**3,317**	**1,657**

6.7 Plant 2 – Existing Operations, Stage 1 Operations and Stage 2 Operations

Emissions from existing brick making operations at Plant 2 include the following:

- Flue gas emissions from the existing brick kiln stack; and
- Fugitive particulate emissions with respect to existing Plant 2 operations.

Existing sources of air pollution associated with Plant 2 operations are listed in **Table 19**

Table 19: Sources and Pollutants Associated with Existing Plant 2 Operations

Source	Type	Associated Pollutants
Plant 2 Brick Kiln Stack	Stack Emissions (Point Source)	Particulates, NO_2, SO_2, CO, HF, HCl, Volatile Organic Compounds (VOCs), Metals
Trucks Unloading Raw Material	Fugitive Emissions	Particulates
Loading and Unloading Operations via Front End Loader (FEL)	Fugitive Emissions	Particulates
Material Handling / Conveying Activities	Fugitive Emissions	Particulates
Crushing and Grinding Operations	Fugitive Emissions	Particulates
Heavy Vehicle Haulage on Gravel Surfaces	Fugitive Emissions	Particulates
Wind Erosion from Raw and Product Stockpiles	Fugitive Emissions	Particulates

It is to be noted that brick making operations at Plant 2 have been non-functional since 2007, however, operations have re-commenced in 2015. As no recent stack emissions monitoring data from Plant 2 is available, reference has been made to stack emissions data from the adjacent Plant 1 kiln stack. Airlabs undertake regular stack emission testing at Plant 1 and emissions data and stack parameters from the most recent testing undertaken by Airlabs in June 2015 has been used to estimate Plant 2 stack emissions. Emission rates from Plant 1 were scaled based on the ratio of 0.55 (daily production rate of Plant 2/ daily production rate of Plant 1). Plant 2 brick kiln stack emissions are presented in **Table 20**. It is to be noted that during Stage 2 operations, wet scrubber control will be applied to Plant 2 operations and as-such, emission rates for particulates, fluorides, HCl and SO_2 have been scaled appropriately.

Table 20: Plant 2 Brick Kiln Stack Emissions Inventory

Pollutant	Emission Rate (g/sec) (1)		
	Existing Operations Uncontrolled	Stage 1 Operations Uncontrolled	Stage 2 Operations Wet Scrubber
Total particulates as TSP	0.21	0.21	0.10
PM_{10}	0.17	0.17	0.09
$PM_{2.5}$	0.10	0.10	0.05
NO_2	0.40	0.40	0.40
Total Fluoride	0.35	0.35	0.01735
H_2S	0.02	0.02	0.02
HCl	0.47	0.47	0.023
SO_2	1.55	1.55	0.310
Total VOC (expressed as n-propane)	0.01	0.01	0.01
Benzene	0.004	0.004	0.004
Toluene	0.001	0.001	0.001
Xylene (m, p and o isomers)	0.002	0.002	0.002
Antimony (Type 1)	9E-07	9E-07	9E-07
Arsenic (Type 1)	5E-06	5E-06	5E-06
Beryllium (Type 2)	4E-06	4E-06	4E-06
Cadmium (Type 1)	9E-07	9E-07	9E-07
Chromium (Type 2)	7E-05	7E-05	7E-05
Cobalt (Type 2)	2E-05	2E-05	2E-05
Lead (Type 1)	3E-05	3E-05	3E-05
Manganese (Type 2)	0.001	0.001	0.001
Mercury (Type 1)	0.0002	0.0002	0.0002
Nickel (Type 2)	0.0003	0.0003	0.0003
Selenium (Type 2)	2E-05	2E-05	2E-05
Tin (Type 2)	0.0002	0.0002	0.0002
Vanadium (Type 2)	4E-05	4E-05	4E-05

(1) Emission rates referenced from Airlabs (December 2015) scaled by 0.55 to account for lower production rate of Plant 2

Fugitive particulate emissions have been estimated based on existing activity details at Plant 2, production capacities and the EET manuals as listed in **Section 6.6.** Fugitive $PM_{2.5}$ emissions have been assumed to be 50% of PM_{10} emissions. Plant 2 fugitive emissions presented in **Table 21**.

Table 21: TSP, PM_{10} and $PM_{2.5}$ Emissions Inventory – Plant 2

Activity	**TSP Emissions (kg/year)**	**PM_{10} Emissions (kg/year)**	**$PM_{2.5}$ Emissions (kg/year)**
Truck Dumping Raw Material	6	3	1.5
Front End Loader (FFL) Loading Raw Material to Feeder	12	6	3
Conveying to Primary Crusher	4	2	1
Primary Crushing	53	23	11.5
Conveying to Mill Building	4	2	1
Mill Building Operations – Grinding, Front End Loader (FEL) and Storage Operations	244	22	11
Heavy Vehicle Haulage on Gravel Surfaces	2,235	631	315.5
Wind Erosion – Existing Stockpile – 1	677	338	169
Wind Erosion – Existing Stockpile – 2	170	85	42.5
Wind Erosion – Existing Stockpile – 3	612	306	153
Wind Erosion – Existing Stockpile – 4	290	145	72.5
Wind Erosion – Existing Stockpile – 5	193	97	48.5
Total Emissions	**4,499**	**1,660**	**830**

6.8 Plant 1 – Existing Operations, Stage 1 Operations and Stage 2 Operations

The current Scope of Work for this assessment excludes assessing impacts from Plant 1. However, as no air quality monitoring is undertaken by Brickworks and taking into consideration that Plant 1 is located adjacent the proposed operations, emission rates have been quantified for Plant 1 in order to comprehensively determine cumulative air quality impacts within the near-field region.

Emissions from existing brick making operations at Plant 1 include the following:

- Flue gas emissions from the existing brick kiln stack; and
- Fugitive particulate emissions with respect to existing Plant 1 operations.

Airlabs undertake regular stack emission testing at Plant 1. Stack emissions data and stack parameters from the most recent testing undertaken by Airlabs in June 2015 (Airlabs, December 2015) have been used and are summarised in **Table 22**.

Table 22: Plant 1 Brick Kiln Stack Emissions Inventory

Pollutant	**Emission Rate (g/sec)**		
	Existing Operations Uncontrolled	**Stage 1 Operations Uncontrolled**	**Stage 2 Operations Uncontrolled**
Total particulates as TSP	0.38	0.38	0.38
PM_{10}	0.32	0.32	0.32
$PM_{2.5}$	0.19	0.19	0.19
NO_2	0.73	0.73	0.73
Total Fluoride	0.63	0.63	0.63
H_2S	0.05	0.05	0.05
HCl	0.85	0.85	0.85

Pollutant	**Emission Rate (g/sec)**		
	Existing Operations Uncontrolled	**Stage 1 Operations Uncontrolled**	**Stage 2 Operations Uncontrolled**
SO_2	2.8	2.8	2.8
Total VOC (expressed as n-propane)	0.02	0.02	0.02
Benzene	0.01	0.01	0.01
Toluene	0.002	0.002	0.002
Xylene (m, p and o isomers)	0.003	0.003	0.003
Antimony (Type 1)	2E-06	2E-06	2E-06
Arsenic (Type 1)	1E-05	1E-05	1E-05
Beryllium (Type 2)	7E-06	7E-06	7E-06
Cadmium (Type 1)	2E-06	2E-06	2E-06
Chromium (Type 2)	1E-04	1E-04	1E-04
Cobalt (Type 2)	4E-05	4E-05	4E-05
Lead (Type 1)	5E-05	5E-05	5E-05
Manganese (Type 2)	0.003	0.003	0.003
Mercury (Type 1)	0.0003	0.0003	0.0003
Nickel (Type 2)	0.001	0.001	0.001
Selenium (Type 2)	5E-05	5E-05	5E-05
Tin (Type 2)	0.0003	0.0003	0.0003
Vanadium (Type 2)	0.0001	0.0001	0.0001

No information on fugitive particulate matter emissions corresponding to Plant 1 is available. As-such, Airlabs have assumed that the fugitive particulate matter emissions for Plant 1 will be similar to Plant 2 (refer **Table 21**).

6.9 Construction Emissions

Construction activities for the Project will be undertaken in a staged approach as shown below:

- *Construction Stage 1*: Dewatering of the existing dam. The water will be treated prior to discharge into Eastern Creek;
- *Construction Stage 2*: Excavation and treatment of saturated material at the base of the dam which is unsuitable for subgrade of the proposed basins;
- *Construction Stage 3*: Construction of new basin embankments using compacted fill from Stockpile No.2. The basins will then be operational for use as sediment control measures during bulk earthworks on the wider site;
- *Construction Stage 4*: Excavation of the existing bund south of the existing factory for use as fill across the site;
- *Construction Stage 5*: Controlled filling of the crusher/screener pad, main stockpile pad and access road; and
- *Construction Stage 6*: Controlled filling of the crusher/screener pad, main stockpile pad and access road

Construction Stages 1 to 4 comprise site preparation activities, which primarily include cut, fill and drainage works. Earthworking / construction activities pertaining to Stage 5 correspond to Production Stage 1 (300,000 tpa) and Stage 6 activities correspond to Production Stage 2 (300,000 tpa in addition to Stage 1)

Construction based activities, which have a potential to generate dust emissions include:

- Earthwork operations such as excavation and topsoil stripping;
- Handling of spoil and structural fill material;
- Wind erosion from exposed areas and stockpiles;
- Wheel generated dust from haulage on paved roads, unpaved roads or other work areas.

Based on information provided by Brickworks, equipment likely to generate dust emissions during specific stages of construction are identified and presented in **Table 23**.

Table 23: Construction Stages and Associated Sources of Dust Generation

Construction Stages	Associated Equipment
Stage 1 to Stage 4 - Site preparation (Cut, Fill and Drainage works)	1 x Excavators 1 x Back Hoe 1 x Dump truck 1 x Roller 1 x Dozer 1 x Scraper 1 x Grader 1 x Trencher 1 x Water truck
Stage 5 – Production Stage 1	1 x Concrete truck 1 x Articulated truck 1 x Dump truck 1 x Water truck
Stage 6 – Production Stage 2	Same as Stage 5

Given that construction activities are progressive in nature and considering the proximity of the nearest residential receptor (0.5km from the facility boundary), the potential for these activities to adversely impact local air quality is unlikely. Additionally dust emissions during construction activities would take place sporadically over a larger area and this would significantly limit the potential for any adverse off-site impacts. Though, it is unlikely that there would be any significant off-site dust impacts arising from construction activities for Production Stage 1 and Production Stage 2, Brickworks are proposing the following dust mitigation measures.

Table 24: Construction Dust Mitigation Measures

Source of Dust	Mitigation Measure	Timing
General	Identify dust-generating activities and inform site personnel about location of nearby sensitive receptors.	Throughout construction
	Identify adverse weather conditions (dry and high wind blowing from dust source to sensitive receptors) and halt dust emitting activities if visible dust impacts are identified at sensitive receptors.	Throughout construction
Handling of spoil and structural fill material	Minimise drop height for material handling equipment.	Throughout construction
Wind generated dust from stockpiles and exposed areas	Apply watering through water trucks or sprinklers.	As required
	Progressive staging of dust generating activities throughout the day to avoid concurrent dust emissions.	Throughout construction
	Minimise exposed area if possible.	Throughout construction
	Minimise amount of material stockpiled if possible.	Throughout construction
Wheel generated dust during hauling	Restrict vehicle movement to haul routes that are watered regularly.	Throughout construction
	Watering of unpaved haul roads.	As required
	Cleaning of haul roads.	As required
	Speed restrictions	Throughout construction

Combustion of diesel or petrol fuels (from vehicle movements and mobile machinery) could generate emissions of particulate matter, CO, SO_2, NO_X and VOCs. Based on the relatively small amount of fuel burning during the construction phase, emissions from vehicle exhaust and mobile machinery are not likely to cause adverse impacts on surrounding sensitive receptors.

7. DISPERSION MODELLING METHODOLOGY

7.1 Modelling Overview

In order to predict impacts at the identified sensitive receptors (**Table 5**) from the emissions inventoried in **Section 6**, air dispersion modelling was undertaken using the combination of the following mathematical models TAPM and CALMET / CALPUFF.

- **TAPM:** The Air Pollution Model (TAPM) is a prognostic meteorological model that generates three-dimensional (3D) meteorological data and air pollution concentrations;
- **CALMET:** CALMET is the meteorological pre-processor for the dispersion model CALPUFF, Using geophysical information and observed/simulated surface and upper air data as inputs, hourly wind fields and temperature fields are generated on a three-dimensional (3-D)

gridded modelling domain. Associated two-dimensional (2-D) fields such as mixing height, surface characteristics, and dispersion properties are also included in the field produced by CALMET (SRC, 2000);

- **CALPUFF**: CALPUFF is the dispersion model that calculates the dispersion of plumes within the three-dimensional (3D) meteorological field calculated by CALMET. CALPUFF is a non-steady state US-EPA approved dispersion model, which "advects" puffs of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so, it typically uses the wind fields generated by CALMET. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period (SRC, 2011)

7.2 Dispersion Meteorology

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. The local meteorology at the site plays a significant role in understanding the pollutant transport and dispersion mechanisms, and in order to adequately characterise the local meteorological conditions, information is needed on key parameters such as prevailing wind regime, mixing depth, atmospheric stability, ambient temperatures, rainfall and relative humidity. The following sections outline the methodology for characterising the local meteorological conditions at the Project Site.

7.2.1 TAPM

For this assessment, the meteorological model 'The Air Pollution Model (TAPM) (Version 4.0.5)' was used to generate the prognostic output. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model, which is used to predict three-dimensional meteorological data and air pollution concentrations. TAPM allows users to generate synthetic observations by referencing in-built databases (e.g. terrain information, synoptic scale meteorological observations, vegetation and soil type etc.) which are subsequently used in generating site-specific hourly meteorological data.

TAPM includes the option to assimilate local observations (of wind speed and wind direction) in order to nudge the predicted solution towards the observed records. Local observations 2.5 km south southwest (SSW) of the Project Site were available from the Bureau of Meteorology (BoM) Automatic Weather Station (BoM –AWS), which is the Horsley Park Equestrian Centre AWS (Station No: 067119). However, as only the upper air data of TAPM will be used in CALMET, the data assimilation functionality of TAPM was not used. Instead, the surface observations from Horsley Park Equestrian Centre AWS were used in the next step of meteorological modelling (CALMET). Technical details of the model equations, parameterisations and numerical methods are described in Hurley (2008)

For the Project, TAPM simulation was run for five calendar year 2010 through to 2014 and was setup using four (4) nested 25 x 25 grids, (30km, 10km, 3km and 1km) centred on latitude 33°, 49.5' south, longitude 150°, 52' east, which is within the Project Site. Thirty (30) vertical levels were used with the lowest level being 10m and the highest level being 8km.

7.2.2 CALMET

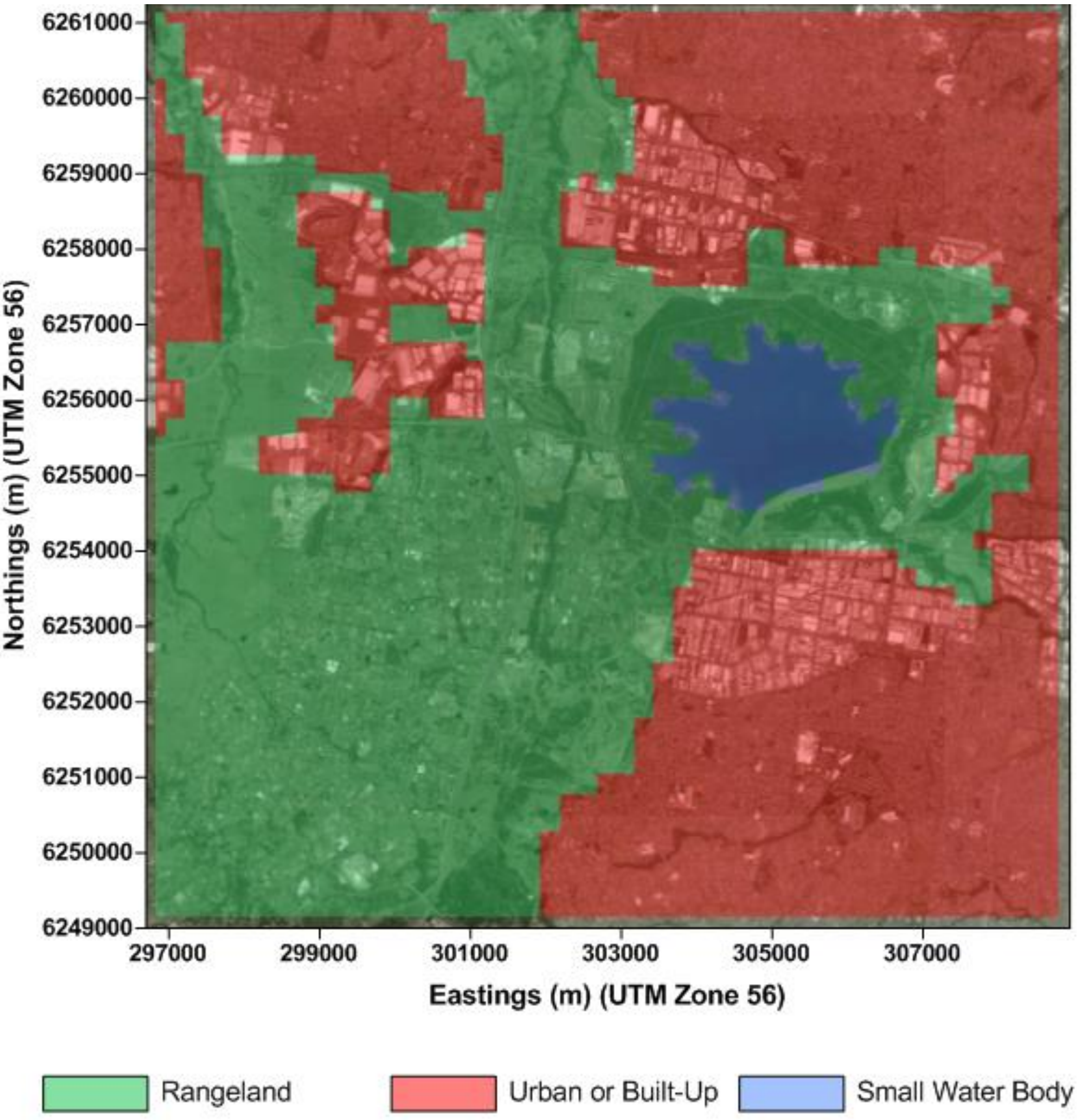
CALMET is a diagnostic three-dimensional meteorological pre-processor for the CALPUFF modelling system (developed by Earth Tech, Inc.). CALMET was run in Hybrid Mode (Prognostic Model Data + Observations) The meteorological modelling domain for CALMET for the calendar years 2010 through to 2014 consisted of a grid extending 20km east-west and 20km north-south, with a grid spacing of 250m. The meteorological grid domain was located in the centre of the Plant 2 facility, bearing Easting coordinates 302824m and Northing coordinates 6255126m, located in the Universal Transverse Mercator (UTM) Zone 56.

For the upper air data, prognostic output from TAPM for the five (5) years was converted to 3D.DAT using the CALTAPM utility program.

Surface observations from the BoM Horsley Park Equestrian Centre AWS (Station No: 067119) were collated for year 2010 through to 2014 and used as input in CALMET. Assimilation of surface observations in CALMET requires that at least one station has a non-missing value for wind speed and wind direction for each hour of simulation. Values of wind speed and wind direction from the TAPM generated surface station location were only used in the absence of observational data from the Horsley Park Equestrian Centre AWS.

The Geophysical dataset for CALMET contains terrain and land use information for the modelling domain. For this assessment, terrain for the CALMET grid was extracted from 1- arc second (30m) spaced elevation data obtained via NASA's Shuttle Radar Topography Mission (SRTM) in 2000 (Downloaded from USGS website). The land use or land cover data for the modelling domain as shown in figure below was manually generated based on aerial images from Google Earth and NSW SIX Maps. The geotechnical parameters for the land use classification were adopted from the default CALMET corresponding land use categories.

Figure 17: CALMET Land Use



Using geophysical datasets, prognostic and surface observational data, CALMET then develops the higher resolution flow fields to include (in general) the kinematic effects of terrain, slope flows, blocking effects and 3-dimensional divergence minimisation as well as differential heating and surface roughness associated with variations in land use categories across the modelling domain.

The CALMET model settings were in accordance with the '*Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia*' (OEH, 2011).

7.3 Inter-Annual Variability in CALMET Generated Meteorological Dataset

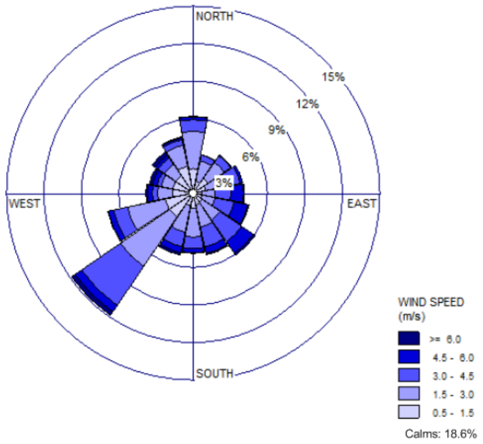
CALMET output was extracted at the centre of Project area for the five (5) years, and was analysed to compare the inter-annual variability in winds, stability classes and mixing height.

Inter-annual comparison of CALMET Wind rose is presented in **Figure 18**. Inter-annual comparison of percentage calm wind speeds, frequency of stability class and frequency of mixing heights is presented in **Figure 19, Figure 20** and **Figure 21** respectively.

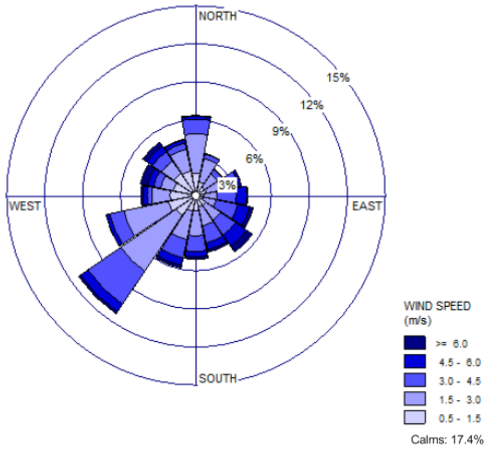
Based on the analysis, 2014 was considered a representative year, as the data compares well with the previous years and no distinct anomalies have been identified for the 2014 dataset and as-such, meteorological data from the 2014 calendar year was considered for the modelling.

It is also noted that, of the five years of CALMET meteorological dataset, year 2014 contained highest percentage of calm wind conditions (18.6%), highest frequency (41%) of lower mixing heights below 60 m and highest frequency (43%) of Pasquill-Gifford stability class F.

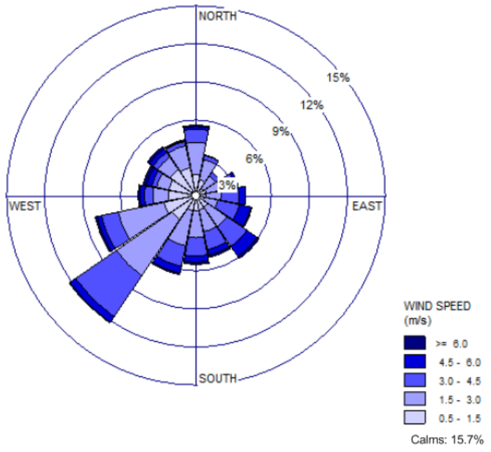
Figure 18: CALMET 2010 to 2014 – Comparison of Annual Wind Rose



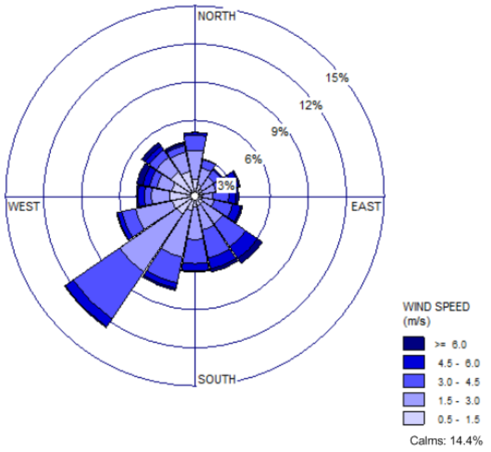
2014



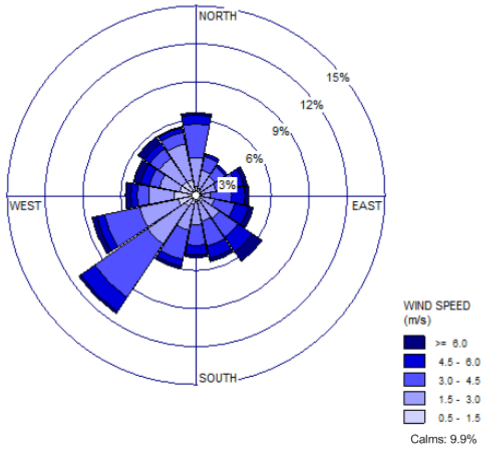
2013



2012



2011



2010

Figure 19: CALMET 2010 to 2014 – Comparison of Percentage of Calms

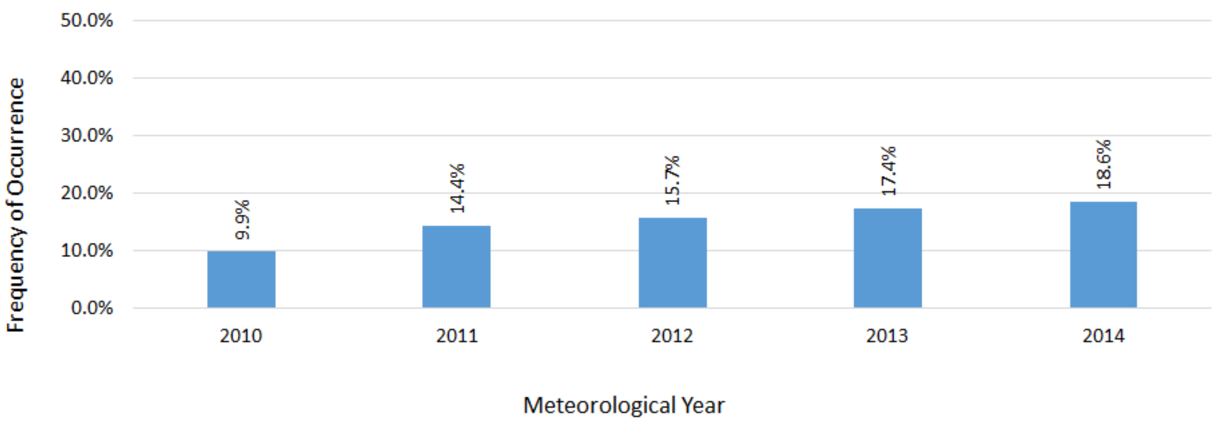


Figure 20: CALMET 2010 to 2014 – Comparison of Frequency of Pasquill-Gifford Stability Class

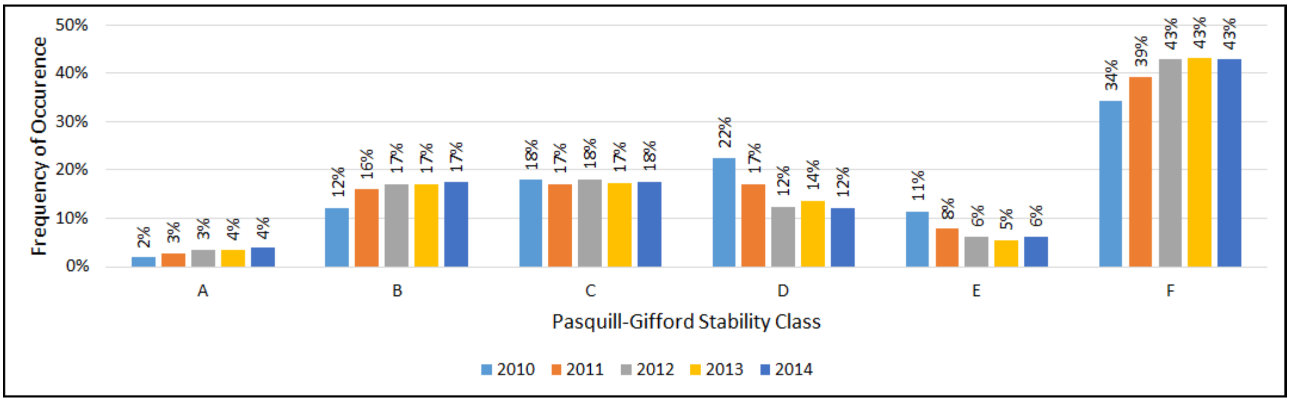
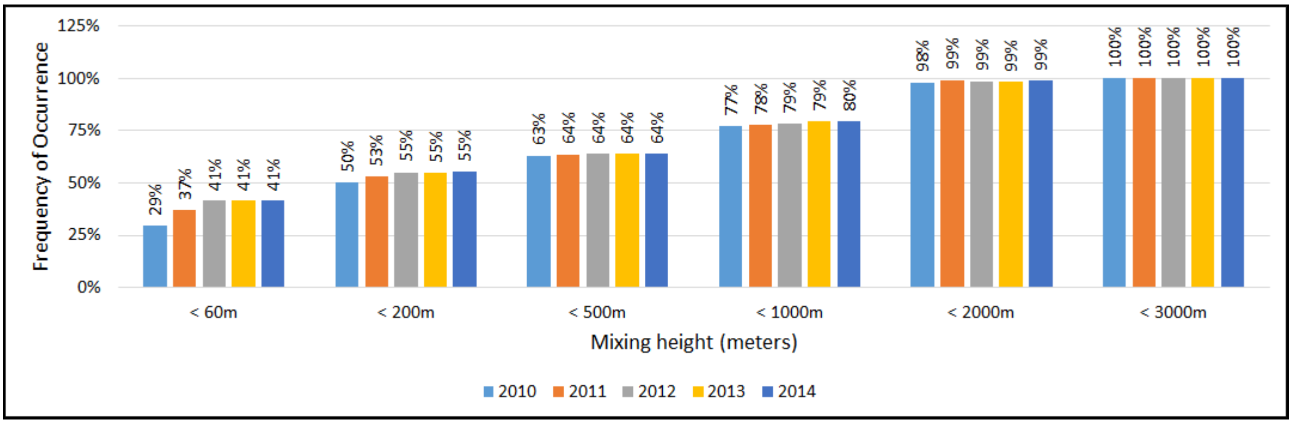


Figure 21: CALMET 2010 to 2014 – Comparison of Frequency of Mixing Heights



7.4 Comparison of Observed BoM (Horsley Park AWS) and CALMET Data - 2014

Comparison was made between the simulated data from CALMET and observed meteorological data at BoM operated Horsley Park AWS for the calendar year 2014 and is shown in **Table 25**. Approximately 3% of meteorological data was missing from the Horsley Park AWS 2014 yearly dataset (*10 days of data, between 9th September 2014 to 29th September 2014*).

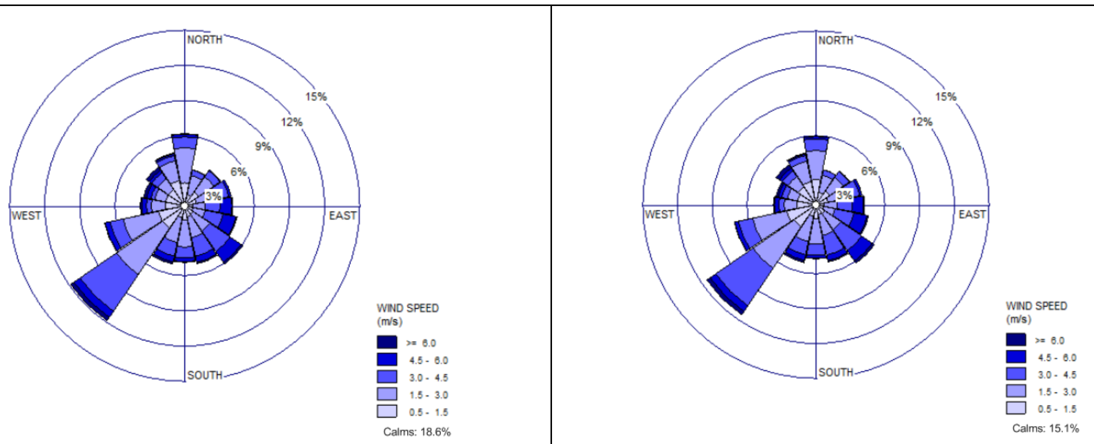
Percentage of calms (wind speed <0.5 m/s) in CALMET simulated dataset for year 2014 matches closely to that of observed data with the exception of spring season which can be attributed to the 10 days of missing data at Horsley Park AWS. Additionally, it is noted that the percentage of calms is generally slightly higher in simulated CALMET dataset compared to the observed data at BoM Horsley park AWS.

Comparison of CALMET and Horsley Park AWS wind rose shows similar wind patterns for all seasons as shown in **Figure 22.**

Table 25: Comparison of Calm Conditions -Observed BoM Horsley Park AWS and CALMET 2014

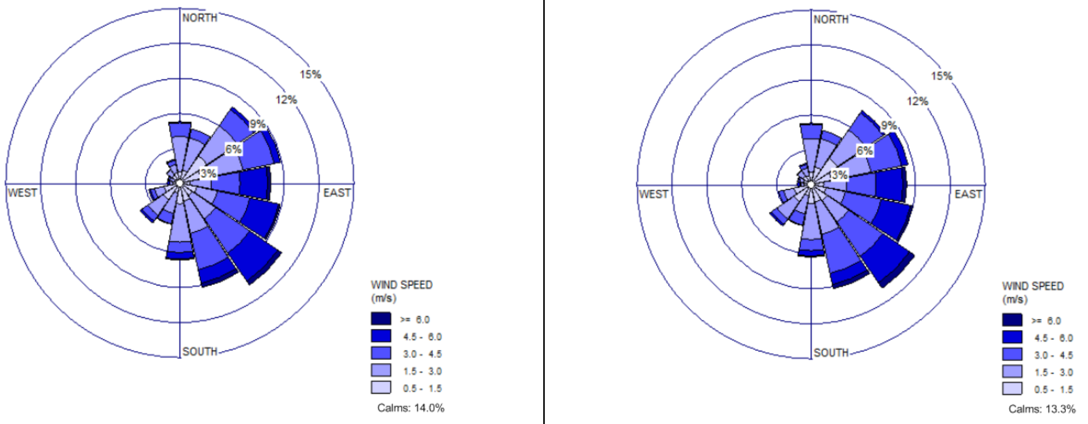
Period	**% Missing**		**% Calms**		**% Non-Calms**		**% Total**	
	BoM	**CALMET**	**BoM**	**CALMET**	**BoM**	**CALMET**	**BoM**	**CALMET**
Annual	2.9%	0.0%	15.1%	18.6%	82.0%	81.4%	100%	100%
Summer	0.0%	0.0%	13.3%	14.0%	86.7%	86.0%	100%	100%
Autumn	0.1%	0.0%	29.1%	29.0%	70.8%	71.0%	100%	100%
Winter	0.0%	0.0%	13.7%	13.8%	86.3%	86.2%	100%	100%
Spring	11.6%	0.0%	4.0%	16.5%	84.4%	83.5%	100%	100%

Figure 22: Comparison of Wind Rose -Observed BoM Horsley Park AWS and CALMET 2014



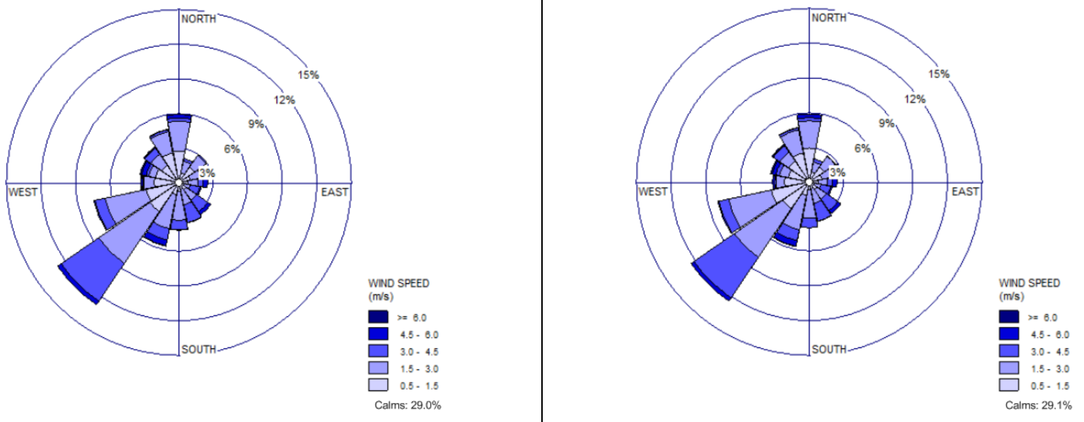
CALMET – Annual 2014

BoM – Annual 2014



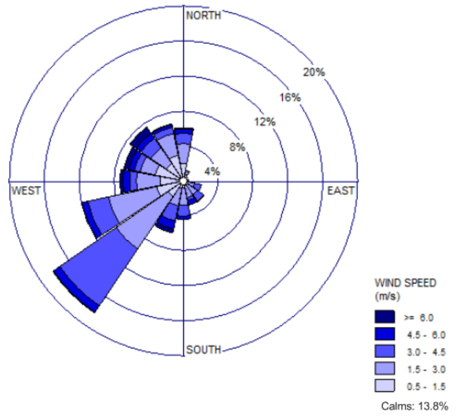
CALMET – Summer 2014

BoM – Summer 2014

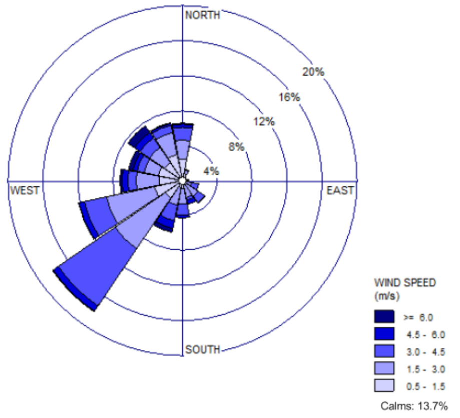


CALMET – Autumn 2014

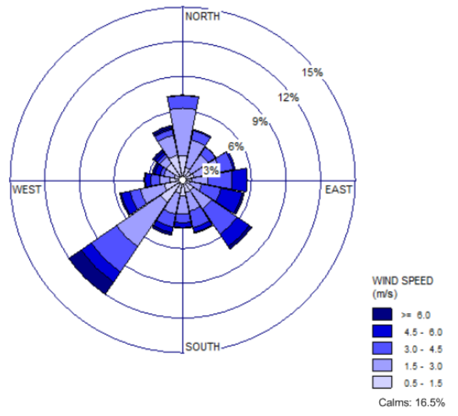
BoM – Autumn 2014



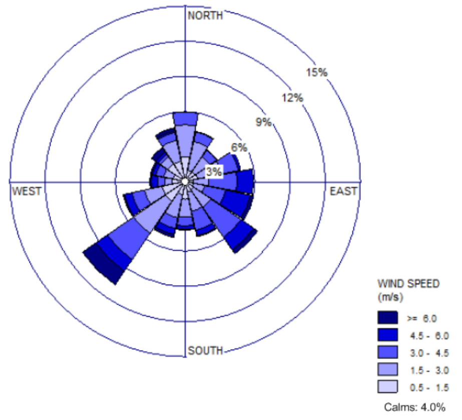
CALMET – Winter 2014



BoM – Winter 2014



CALMET – Spring 2014



BoM – Spring 2014

7.5 CALPUFF Model Configuration

The CALPUFF model domain was set as a sub-set of the CALMET model domain, with the sampling grid extending 7 km east-west and 7 km north-south with a grid spacing of 125m (using a nesting factor of 2 on 250m CALMET resolution). Additionally, ground level concentrations have also been predicted at identified sensitive receptors (**Table 5**).

Buildings in the vicinity of the sources play a major role in pollutant dispersion as they may create zones of strong turbulence and enhance downward mixing resulting in higher ground-level concentrations. For the Project, the building downwash effects were determined using the US Building Input Program – Plume Rise Model Enhancements (BPIP -PRIME). The wind direction-specific building dimensions calculated by BPIP for the stack sources were then entered into the CALPUFF model.

All other CALPUFF model settings were referenced from the Generic *Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia*' (OEH, 2011)

7.6 Source Parameters

Sources associated with existing and proposed operations have been categorised as either stack emissions or fugitive emissions. Stack parameters for existing and proposed operations that have been incorporated into the CALPUFF model are summarised in **Table 26**.

Table 26: Stack Parameters – Existing and Proposed Operations

Stack Parameters	**Existing Plant 1 Kiln Stack**	**Existing Plant 2 Kiln Stack**	**Proposed Product Combustion Stack 1 (PCS 1) – Stage 1**	**Proposed Cooling Air Stack (CA 1) – Stage 1**	**Proposed Product Combustion Stack 2 (PCS 2) – Stage 2**	**Proposed Cooling Air Stack (CA 2) – Stage 2**
Coordinates – Easting (m)	302023	302801	302944	302819	302944	302819
Coordinates – Northing (m)	6255241	6255028	6255005	6255005	6254985	6254985
Height (m)	30	16	37	28	37	28
Diameter (m)	1.6	1.4	1.43	1.47	1.43	1.47
Temperature (C/K)	161/434	161/434	95/368	145/418	95/368	145/418
Exit Velocity (m/sec)	11.7(a)	11.7	14.9 (b)	13.2 (c)	14.9 (b)	13.2 (c)
Rate of Release	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous

(a) Exit velocity referenced from Airlabs Environmental, December 2015

(b) Exit velocity determined from stack diameter of 1.43m and a volumetric flow rate of 86,316 m3/hour (actual flow) (information provided by Brickworks)

(c) Exit velocity determined from stack diameter of 1.47m and a volumetric flow rate of 80,942 m3/hour (actual flow) (information provided by Brickworks)

For modelling fugitive dust sources, each dust generating activity (refer **Table 17**, **Table 18**, **Table 21**) was represented by a series of volume sources which would be active from 6AM to 6PM seven (7) days of the week, except for wind erosion sources (e.g. wind erosion from stockpiles) which were assigned a continuous rate of release.

It is to be noted that Brickworks typically operate on a five (5) day working-week cycle, however, in order to account for unscheduled weekend activities, which could generate fugitive particulate emissions; it was conservatively assumed that particulate matter emissions corresponding to all fugitive dust sources would be generated seven (7) days of the week across the entire year. For Plant 1, as no information is available about specific operations, fugitive particulate emissions for Plant 1 (similar to Plant 2, refer **Table 21**) were modelled as a single volume source. As mentioned earlier, accounting for emissions from Plant 1 might be a conservative option as the Prospect monitoring station will incorporate contribution from Plant 1 and subsequently the contribution from Plant 1 will be added to the background air quality data to predict cumulative concentrations.

7.7 Modelled Scenarios

To comprehensively determine air quality impacts associated with existing and proposed operations at the Project Site, the following modelling scenarios were developed:

- **Existing Operations** – Plant 1 and Plant 2 – stack emissions and fugitive particulate emissions;
- **Stage 1 Operation** – Existing operations and Stage 1 stack emissions (PCS 1 and CA 1) and fugitive particulate emissions. Furthermore, in order to determine impacts from the different fuel combustion options, Stage 1 operations were sub-divided into the following:
    - **Stage 1 Option 1**: Combustion of 100% Natural Gas;

  - **Stage 1 Option 2**: Combustion of 100% Pulverised Coal;

- **Stage 2 Operations** – Existing and Stage 1 operations and Stage 2 stack emissions (PCS 2 and CA 2) and fugitive particulate emissions. Furthermore, in order to determine impacts from the different fuel combustion options, Stage 2 operations were sub-divided into the following:
  - **Stage 2 Option 1**: Combustion of 100% Natural Gas;
  - **Stage 2 Option 2**: Combustion of 100% Pulverised Coal;

As mentioned earlier, it is to be noted that wet scrubber control will be applied to Plant 2 during Stage 2 operations.

8. RESULTS AND DISCUSSION

Ground level incremental (Project related) and cumulative pollutant concentrations predicted at each of the identified sensitive receptors (**Table 5**) for all the modelled scenarios (**Section 7.7**) are presented in this section. The 100th percentile value of the predicted impacts has been reported for all averaging periods and all pollutants. Concentration isopleths for key pollutants (where predicted cumulative impact at any identified receptor was greater than 75% of the criteria) are presented in **Appendix B**.

Predicted concentrations for some of individual air toxic pollutants (Acetone, Chloroform, Chromium (III) compounds, Copper dust, Manganese and compounds, Phenol, Styrene, Tetrachloroethane, Trichloroethane, Carbon disulphide, Chloroethane and Ethylbenzene) were very low (generally less than 5% of their respective criteria) and hence results for these pollutants have not been presented.

Predicted concentrations for some of the pollutants have been reported using scientific notation, where justified. A few examples of scientific notation are shown below:

0.001	1E-03	0.01	1E-02
0.1	1E-01	1	1E+00

Based on the results presented in **Table 28** to **Table 37** and the concentration isopleths in **Appendix B**, the following observations are made:

- Predicted ground level incremental (Project related) and cumulative concentrations for all pollutants comply with their respective assessment criteria for all the modelled scenarios at all identified sensitive residential receptors. However, exceedance of the annual average $PM_{2.5}$ is predicted at non-residential receptors corresponding to the infrastructure at Prospect Reservoir for Stage 1 and Stage 2 operations. With respect to this exceedance, it is to be noted that the included annual average $PM_{2.5}$ background concentration of 7.6 µg/m^3 contributes to 90% of the cumulative impacts, whereas the contribution from the Project is approximately 10% for all the modelled scenarios. Moreover, it is noted that Receptor DR6 & DR7 corresponds to non-residential receptors at Prospect Reservoir. A summary of annual $PM_{2.5}$ cumulative impacts at identified receptors is presented in **Table 27**;

- Upon analysis of the predicted incremental and cumulative concentrations for each pollutant against their respective assessment criteria, the 90-day average and 24-hour average hydrogen fluoride (HF) impacts have been identified to be the significant pollutant across all modelled scenarios. The highest 90-day average HF concentration predicted across all receptors (residential and non-residential) for all scenarios is 0.47 µg/m^3, which complies with the assessment criteria of 0.5 µg/m^3. The highest 24-hour average HF concentration predicted across all receptors (residential and non-residential) for all scenarios is 2.1 µg/m^3, which complies with the assessment criteria of 2.9 µg/m^3;

- Incremental impacts – especially for polycyclic aromatic hydrocarbons (PAHs) (expressed as benzo(a)pyrene), dioxins and furans (PCDD/F) – TEQ, speciated volatile organic compounds (VOCs) and metals predicted at and beyond the Project site boundary are relatively low in comparison with their respective assessment criteria for all modelled scenarios;
- For pollutants where cumulative concentrations have been determined (e.g. TSP, PM_{10}, $PM_{2.5}$, NO_2, SO_2 etc.) it is observed that the Project's contributions (incremental concentrations) to the total concentrations (cumulative concentrations) are relatively minimal when compared with the corresponding background concentrations;
- With regards to predicted NO_2 concentrations, it was conservatively assumed that 100% of the NO_X emissions released would be converted to $NO_{2;}$
- Based on the modelling results, it is observed that there would not be any adverse air quality impacts associated with the existing and proposed operations at the Project Site on nearby residential receptors. However, it is to be noted that exceedance of the annual average $PM_{2.5}$ impacts is predicted for Stage 1 and Stage 2 operations at non-residential receptors i.e. infrastructure of Prospect Reservoir, but as mentioned earlier, the background concentrations contribute to 90% of the total concentrations and the Project's contributions to this exceedance for all the modelled scenarios is approximately 10%.

Table 27: Summary of Annual $PM_{2.5}$ Cumulative Impacts at Identified Receptors – All Scenarios – All Fuel Combustion Options

Modelled Scenario	**Criteria (µg/m3)**	**Included Background Conc. (µg/m3)**	**Predicted Cumulative Concentrations (µg/m3)**								
			DR1	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**
			Residential Receptors					**Non-Residential Receptors**			
Existing Operations	8.0	7.6	7.7	7.7	7.7	7.9	7.8	7.9	8.0	7.8	7.7
Existing and Stage 1 Operations (300,000 tpa) – Option 1 (100% Natural Gas)	8.0	7.6	7.7	7.7	7.7	7.9	7.9	**8.1**	**8.3**	7.9	7.7
Existing and Stage 1 Operations (300,000 tpa) – Option 2 (100% Pulverised Coal)	8.0	7.6	7.7	7.7	7.7	7.9	7.9	**8.1**	**8.3**	7.9	7.7
Existing and Stage 2 Operations (600,000 tpa - includes 300,000 tpa of Stage 1 Operations) – Option 1 (100% Natural Gas)	8.0	7.6	7.7	7.8	7.8	8.0	8.0	**8.2**	**8.5**	8.0	7.7
Existing and Stage 2 Operations (600,000 tpa - includes 300,000 tpa of Stage 1 Operations) – Option 2 (100% Pulverised Coal)	8.0	7.6	7.7	7.8	7.8	8.0	8.0	**8.2**	**8.5**	8.0	7.7

Table 28: Predicted Incremental and Cumulative Ground Level Concentrations at Receptors – Existing Operations

Pollutant	**Criteria (µg/m^3)**	**Bkg. Conc. (µg/m^3)**	**Av. Period**	**Predicted Incremental Concentrations (µg/m^3)**									**Predicted Cumulative Concentrations (µg/m^3)**								
				DR1	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**	**DR1**	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**
HF	2.90	N.A.	24-Hr	1.22	0.92	1.03	0.62	0.71	1.38	1.89	0.85	0.47	1.22	0.92	1.03	0.62	0.71	1.38	1.89	0.85	0.47
	1.70	N.A.	7-Days	0.39	0.32	0.30	0.26	0.29	0.41	0.42	0.38	0.21	0.39	0.32	0.30	0.26	0.29	0.41	0.42	0.38	0.21
	0.84	N.A.	30-Days	0.31	0.28	0.21	0.21	0.22	0.32	0.35	0.23	0.12	0.31	0.28	0.21	0.21	0.22	0.32	0.35	0.23	0.12
	0.50	N.A.	90-Days	0.22	0.20	0.16	0.17	0.17	0.27	0.26	0.17	0.08	0.22	0.20	0.16	0.17	0.17	0.27	0.26	0.17	0.08
NO$_2$	246	88	1-Hr	4.9	5.1	3.9	7.7	6.7	9.6	12.8	15.1	7.7	93.3	93.4	92.3	96.0	95.0	98.0	101.1	103.4	96.1
	62	19	Annual	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	18.9	18.9	18.9	19.0	19.0	19.0	19.0	18.9	18.9
SO$_2$	570	50	1-Hr	18.9	19.5	15.3	29.6	25.7	37.3	49.4	58.2	29.8	68.7	69.3	65.0	79.4	75.5	87.0	99.2	107.9	79.5
	228	13	24-Hr	5.5	4.1	4.6	2.8	3.2	6.2	8.5	3.8	2.1	18.6	17.2	17.7	15.9	16.3	19.3	21.6	16.9	15.2
	60	3	Annual	0.5	0.5	0.5	0.6	0.6	0.8	0.8	0.5	0.2	3.1	3.1	3.1	3.2	3.2	3.4	3.4	3.1	2.8
CO	30000	2500	1-Hr	0	0	0	0	0	0	0	0	0	2500	2500	2500	2500	2500	2500	2500	2500	2500
	10000	1495	8-Hr	3	3	2	2	2	3	4	2	1	1498	1498	1497	1497	1497	1498	1499	1497	1496
PM$_{10}$	50	Varying	24-Hr	0.7	0.8	0.8	2.1	1.9	1.8	2.6	1.7	0.6	44.32	44.30	44.30	44.30	44.30	44.31	44.31	44.30	44.30
	30	17.6	Annual	0.1	0.2	0.2	0.4	0.4	0.6	0.7	0.3	0.1	17.7	17.8	17.8	18.0	18.0	18.2	18.3	17.9	17.7
PM$_{2.5}$	25	Varying	24-Hr	0.4	0.5	0.6	1.3	1.2	1.2	1.5	1.1	0.4	21.9	22.0	22.0	22.5	22.5	22.7	23.1	23.0	22.2
	8	7.6	Annual	0.1	0.1	0.1	0.3	0.2	0.3	0.4	0.2	0.1	7.7	7.7	7.7	7.9	7.8	7.9	8.0	7.8	7.7
TSP	90	44	Annual	0.2	0.2	0.2	0.5	0.4	0.7	1.1	0.3	0.1	44.2	44.2	44.2	44.5	44.4	44.7	45.1	44.3	44.1
DDG	4	2.1	Annual	0.01	0.01	0.01	0.03	0.03	0.03	0.06	0.02	0.00	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.1	2.1

Table 29: Predicted Incremental and Cumulative Ground Level Concentrations outside Project Site Boundary – Existing Operations

Pollutant	Criteria (µg/m³)	Av. Period	Predicted Incremental Concentrations (µg/m³)
			Maximum Outside Site Boundary
Arsenic	0.09	1-Hr	0.0003
Cadmium	0.018	1-Hr	0.00006
Chromium (VI)	0.09	1-Hr	0.004
HCl	140	1-Hr	29.8
Mercury	1.8	1-Hr	0.011
Nickel	0.18	1-Hr	0.019
Lead	0.5	1-Hr	0.0018
Benzene	29	1-Hr	0.25
Toluene	360	1-Hr	0.08
Xylene	190	1-Hr	0.10

Table 30: Predicted Incremental and Cumulative Ground Level Concentrations at Receptors – Stage 1 Operations (100% Pulverised Coal)

Pollutant	**Criteria (µg/m^3)**	**Bkg. Conc. (µg/m^3)**	**Av. Period**	**Predicted Incremental Concentrations (µg/m^3)**									**Predicted Cumulative Concentrations (µg/m^3)**								
				DR1	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**	**DR1**	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**
HF	2.90	N.A.	24-Hr	1.22	0.93	1.03	0.65	1.08	1.72	1.78	1.50	0.71	1.22	0.93	1.03	0.65	1.08	1.72	1.78	1.50	0.71
	1.70	N.A.	7-Days	0.39	0.33	0.30	0.29	0.33	0.59	0.48	0.46	0.23	0.39	0.33	0.30	0.29	0.33	0.59	0.48	0.46	0.23
	0.84	N.A.	30-Days	0.32	0.29	0.22	0.23	0.25	0.42	0.38	0.27	0.13	0.32	0.29	0.22	0.23	0.25	0.42	0.38	0.27	0.13
	0.50	N.A.	90-Days	0.22	0.20	0.17	0.19	0.20	0.36	0.32	0.21	0.10	0.22	0.20	0.17	0.19	0.20	0.36	0.32	0.21	0.10
NO_2	246	88	1-Hr	14.1	15.2	17.1	38.6	79.6	41.5	46.1	60.0	33.8	102.4	103.6	105.5	127.0	167.9	129.9	134.5	148.4	122.1
	62	19	Annual	0.3	0.3	0.3	0.6	0.7	1.8	1.6	0.9	0.3	19.1	19.1	19.1	19.4	19.5	20.6	20.4	19.7	19.1
SO_2	570	50	1-Hr	18.9	19.5	17.5	29.6	42.2	41.4	51.3	79.3	37.7	68.7	69.3	67.2	79.4	92.0	91.2	101.0	129.1	87.4
	228	13	24-Hr	5.6	4.3	4.7	4.7	5.3	12.4	10.0	10.6	4.6	18.7	17.4	17.8	17.8	18.4	25.5	23.1	23.7	17.7
	60	3	Annual	0.6	0.6	0.5	0.8	0.9	1.6	1.5	0.9	0.4	3.2	3.2	3.2	3.5	3.5	4.2	4.1	3.6	3.0
CO	30000	2500	1-Hr	1	1	1	3	6	3	3	4	2	2501	2501	2501	2503	2506	2503	2503	2504	2502
	10000	1495	8-Hr	3	3	2	2	2	5	4	3	1	1498	1498	1497	1497	1497	1500	1499	1498	1496
PM_{10}	50	Varying	24-Hr	0.89	1.17	1.24	2.84	2.78	3.14	4.76	2.94	0.95	44.33	44.31	44.30	44.30	44.30	44.32	44.33	44.30	44.30
	30	17.6	Annual	0.2	0.2	0.2	0.5	0.5	0.9	1.3	0.5	0.1	17.8	17.8	17.8	18.1	18.1	18.5	18.9	18.1	17.7
$PM_{2.5}$	25	Varying	24-Hr	0.6	0.8	0.8	1.7	1.7	1.9	2.7	1.9	0.6	22.0	22.0	22.1	22.7	22.7	23.1	24.1	23.7	22.4
	8	7.6	Annual	0.1	0.1	0.1	0.3	0.3	0.5	0.7	0.3	0.1	7.7	7.7	7.7	7.9	7.9	**8.1**	**8.3**	7.9	7.7
TSP	90	44	Annual	0.2	0.3	0.3	0.7	0.6	1.3	2.2	0.6	0.1	44.2	44.3	44.3	44.7	44.6	45.3	46.2	44.6	44.1
DDG	4	2.1	Annual	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.1	2.1

Table 31: Predicted Incremental Ground Level Concentrations outside Project Site Boundary – Stage 1 Operations (100% Pulverised Coal)

Pollutant	Criteria (µg/m^3)	Av. Period	Predicted Incremental Concentrations (µg/m^3)
			Maximum Outside Site Boundary
Arsenic	0.09	1-Hr	0.0037
Cadmium	0.018	1-Hr	0.00068
Chromium (VI)	0.09	1-Hr	0.004
HCl	140	1-Hr	29.8
Mercury	1.8	1-Hr	0.027
Nickel	0.18	1-Hr	0.019
Lead	0.5	1-Hr	0.0018
Benzene	29	1-Hr	0.246
Toluene	360	1-Hr	0.107
Xylene	190	1-Hr	0.110
PAH	0.4	1-Hr	2.5E-04
PCDD/F	2.0E-06	1-Hr	7.9E-09

Table 32: Predicted Incremental and Cumulative Ground Level Concentrations at Receptors – Stage 1 Operations (100% Natural Gas)

Pollutant	Criteria (µg/m^3)	Bkg. Conc. (µg/m^3)	Av. Period	Predicted Incremental Concentrations (µg/m^3)									Predicted Cumulative Concentrations (µg/m^3)								
				DR1	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**	**DR1**	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**
HF	2.90	N.A.	24-Hr	1.23	0.94	1.04	0.83	1.13	2.10	1.94	1.88	0.86	1.23	0.94	1.04	0.83	1.13	2.10	1.94	1.88	0.86
	1.70	N.A.	7-Days	0.40	0.34	0.33	0.33	0.38	0.86	0.58	0.59	0.27	0.40	0.34	0.33	0.33	0.38	0.86	0.58	0.59	0.27
	0.84	N.A.	30-Days	0.34	0.30	0.24	0.26	0.29	0.57	0.45	0.33	0.15	0.34	0.30	0.24	0.26	0.29	0.57	0.45	0.33	0.15
	0.50	N.A.	90-Days	0.23	0.22	0.18	0.22	0.23	0.47	0.40	0.27	0.12	0.23	0.22	0.18	0.22	0.23	0.47	0.40	0.27	0.12
NO_2	246	88	1-Hr	10.3	11.0	12.6	27.1	55.1	30.5	33.7	45.9	25.2	98.6	99.4	101.0	115.4	143.4	118.9	122.0	134.3	113.5
	62	19	Annual	0.2	0.2	0.2	0.5	0.6	1.3	1.2	0.7	0.2	19.0	19.0	19.0	19.3	19.4	20.1	20.0	19.5	19.0
SO_2	570	50	1-Hr	18.9	19.5	15.3	29.6	29.3	40.9	50.6	71.9	33.2	68.7	69.3	65.1	79.4	79.1	90.7	100.4	121.7	82.9
	228	13	24-Hr	5.5	4.2	4.7	3.9	5.1	9.8	8.8	8.9	4.0	18.6	17.3	17.8	17.0	18.2	22.9	21.9	22.0	17.1
	60	3	Annual	0.6	0.6	0.5	0.8	0.8	1.4	1.3	0.8	0.3	3.2	3.2	3.1	3.4	3.4	4.0	3.9	3.4	2.9
CO	30000	2500	1-Hr	1	2	2	4	9	5	5	5	3	2501	2502	2502	2504	2509	2505	2505	2505	2503
	10000	1495	8-Hr	3	3	2	2	2	5	4	3	2	1498	1498	1497	1497	1497	1500	1499	1498	1497
PM_{10}	50	Varying	24-Hr	0.88	1.17	1.24	2.82	2.75	3.09	4.70	2.89	0.93	44.33	44.31	44.30	44.30	44.30	44.32	44.33	44.30	44.30
	30	17.6	Annual	0.2	0.2	0.2	0.5	0.5	0.9	1.2	0.5	0.1	17.8	17.8	17.8	18.1	18.1	18.5	18.8	18.1	17.7
$PM_{2.5}$	25	Varying	24-Hr	0.6	0.8	0.8	1.7	1.7	1.9	2.7	1.9	0.6	22.0	22.0	22.1	22.7	22.7	23.1	24.1	23.7	22.4
	8	7.6	Annual	0.1	0.1	0.1	0.3	0.3	0.5	0.7	0.3	0.1	7.7	7.7	7.7	7.9	7.9	**8.1**	**8.3**	7.9	7.7
TSP	90	44	Annual	0.2	0.3	0.3	0.7	0.6	1.3	2.2	0.6	0.1	44.2	44.3	44.3	44.7	44.6	45.3	46.2	44.6	44.1
DDG	4	2.1	Annual	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.1	2.1

Table 33: Predicted Incremental Ground Level Concentrations outside Project Site Boundary – Stage 1 Operations (100% Natural Gas)

Pollutant	Criteria (µg/m³)	Av. Period	Predicted Incremental Concentrations (µg/m³)
			Maximum Outside Site Boundary
Arsenic	0.09	1-Hr	0.0009
Cadmium	0.018	1-Hr	0.00064
Chromium (VI)	0.09	1-Hr	0.004
HCl	140	1-Hr	29.8
Mercury	1.8	1-Hr	0.011
Nickel	0.18	1-Hr	0.019
Lead	0.5	1-Hr	0.0018
Benzene	29	1-Hr	0.824
Toluene	360	1-Hr	0.454
Xylene	190	1-Hr	0.102
PAH	0.4	1-Hr	3.7E-04
PCDD/F	2.0E-06	1-Hr	2.9E-09

Table 34: Predicted Incremental and Cumulative Ground Level Concentrations at Receptors – Stage 2 Operations (100% Pulverised Coal)

Pollutant	**Criteria (µg/m^3)**	**Bkg. Conc. (µg/m^3)**	**Av. Period**	**Predicted Incremental Concentrations (µg/m^3)**									**Predicted Cumulative Concentrations (µg/m^3)**								
				DR1	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**	**DR1**	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**
HF	2.90	N.A.	24-Hr	1.19	0.87	1.00	0.53	0.50	0.61	0.63	0.59	0.33	1.19	0.87	1.00	0.53	0.50	0.61	0.63	0.59	0.33
	1.70	N.A.	7-Days	0.36	0.29	0.26	0.19	0.19	0.26	0.23	0.27	0.15	0.36	0.29	0.26	0.19	0.19	0.26	0.23	0.27	0.15
	0.84	N.A.	30-Days	0.27	0.23	0.17	0.14	0.14	0.18	0.16	0.16	0.08	0.27	0.23	0.17	0.14	0.14	0.18	0.16	0.16	0.08
	0.50	N.A.	90-Days	0.19	0.17	0.14	0.11	0.10	0.16	0.15	0.11	0.06	0.19	0.17	0.14	0.11	0.10	0.16	0.15	0.11	0.06
NO_2	246	88	1-Hr	27.4	37.9	34.3	49.8	85.9	74.8	94.7	99.6	59.9	115.8	126.2	122.6	138.1	174.2	163.2	183.1	188.0	148.2
	62	19	Annual	0.5	0.5	0.4	1.1	1.3	3.3	3.1	1.7	0.6	19.3	19.3	19.2	19.9	20.1	22.1	21.9	20.5	19.4
SO_2	570	50	1-Hr	18.9	19.5	16.1	29.6	40.4	37.3	46.5	67.9	37.5	68.7	69.3	65.9	79.4	90.2	87.0	96.3	117.7	87.3
	228	13	24-Hr	5.5	4.2	4.7	4.5	6.2	15.2	14.4	10.2	4.7	18.6	17.3	17.8	17.6	19.3	28.3	27.5	23.3	17.8
	60	3	Annual	0.6	0.6	0.5	0.8	0.9	1.8	1.7	1.0	0.4	3.2	3.2	3.2	3.4	3.5	4.4	4.3	3.6	3.0
CO	30000	2500	1-Hr	2	3	3	4	7	5	7	7	4	2502	2503	2503	2504	2507	2505	2507	2507	2504
	10000	1495	8-Hr	2	3	2	1	1	2	2	2	1	1497	1498	1497	1496	1496	1497	1497	1497	1496
PM_{10}	50	Varying	24-Hr	1.16	1.54	1.58	3.43	3.38	4.30	6.45	3.79	1.21	44.34	44.32	44.31	44.30	44.30	44.33	44.34	44.30	44.30
	30	17.6	Annual	0.2	0.3	0.3	0.6	0.6	1.1	1.6	0.7	0.2	17.8	17.9	17.9	18.2	18.2	18.7	19.2	18.3	17.8
$PM_{2.5}$	25	Varying	24-Hr	0.8	1.1	1.1	2.1	2.1	2.5	3.6	2.4	0.8	22.0	22.1	22.1	22.9	22.9	23.4	24.7	24.3	22.5
	8	7.6	Annual	0.1	0.2	0.2	0.4	0.4	0.6	0.9	0.4	0.1	7.7	7.8	7.8	8.0	8.0	**8.2**	**8.5**	8.0	7.7
TSP	90	44	Annual	0.2	0.3	0.3	0.8	0.8	1.7	3.1	0.8	0.1	44.2	44.3	44.3	44.8	44.8	45.7	47.1	44.8	44.1
DDG	4	2.1	Annual	0.0	0.0	0.0	0.1	0.0	0.1	0.2	0.0	0.0	2.1	2.1	2.1	2.2	2.1	2.2	2.3	2.1	2.1

Table 35: Predicted Incremental Ground Level Concentrations outside Project Site Boundary – Stage 2 Operations (100% Pulverised Coal)

Pollutant	Criteria (µg/m^3)	Av. Period	Predicted Incremental Concentrations (µg/m^3)
			Maximum Outside Site Boundary
Arsenic	0.09	1-Hr	0.0053
Cadmium	0.018	1-Hr	0.00099
Chromium (VI)	0.09	1-Hr	0.004
HCl	140	1-Hr	26.6
Mercury	1.8	1-Hr	0.042
Nickel	0.18	1-Hr	0.019
Lead	0.5	1-Hr	0.0020
Benzene	29	1-Hr	0.290
Toluene	360	1-Hr	0.148
Xylene	190	1-Hr	0.140
PAH	0.4	1-Hr	3.6E-04
PCDD/F	2.0E-06	1-Hr	1.1E-08

Table 36: Predicted Incremental and Cumulative Ground Level Concentrations at Receptors – Stage 2 Operations (100% Natural Gas)

Pollutant	**Criteria (µg/m^3)**	**Bkg. Conc. (µg/m^3)**	**Av. Period**	**Predicted Incremental Concentrations (µg/m^3)**									**Predicted Cumulative Concentrations (µg/m^3)**								
				DR1	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**	**DR1**	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**	**DR7**	**DR8**	**DR9**
HF	2.90	N.A.	24-Hr	1.20	0.90	1.02	0.61	0.76	1.82	1.75	1.23	0.59	1.20	0.90	1.02	0.61	0.76	1.82	1.75	1.23	0.59
	1.70	N.A.	7-Days	0.38	0.31	0.29	0.25	0.32	0.82	0.63	0.45	0.23	0.38	0.31	0.29	0.25	0.32	0.82	0.63	0.45	0.23
	0.84	N.A.	30-Days	0.30	0.27	0.20	0.19	0.22	0.49	0.44	0.27	0.12	0.30	0.27	0.20	0.19	0.22	0.49	0.44	0.27	0.12
	0.50	N.A.	90-Days	0.21	0.19	0.16	0.16	0.18	0.37	0.34	0.21	0.09	0.21	0.19	0.16	0.16	0.18	0.37	0.34	0.21	0.09
NO$_2$	246	88	1-Hr	19.4	26.1	23.5	34.2	58.9	53.0	67.0	73.1	43.1	107.8	114.5	111.9	122.5	147.3	141.4	155.4	161.4	131.5
	62	19	Annual	0.4	0.4	0.3	0.8	1.0	2.3	2.2	1.2	0.4	19.2	19.2	19.1	19.6	19.8	21.1	21.0	20.0	19.2
SO$_2$	570	50	1-Hr	18.9	19.5	15.3	29.6	26.3	37.3	34.5	54.0	28.7	68.7	69.3	65.0	79.4	76.0	87.0	84.2	103.8	78.5
	228	13	24-Hr	5.4	4.1	4.6	3.1	4.2	10.1	9.4	7.1	3.4	18.5	17.2	17.7	16.2	17.3	23.2	22.5	20.2	16.5
	60	3	Annual	0.5	0.5	0.5	0.6	0.7	1.3	1.2	0.7	0.3	3.2	3.2	3.1	3.3	3.3	3.9	3.9	3.3	2.9
CO	30000	2500	1-Hr	3	4	4	6	10	8	10	10	6	2503	2504	2504	2506	2510	2508	2510	2510	2506
	10000	1495	8-Hr	2	3	2	1	1	3	4	3	1	1497	1498	1497	1496	1496	1498	1499	1498	1496
PM$_{10}$	50	Varying	24-Hr	1.15	1.52	1.58	3.38	3.31	4.17	6.34	3.73	1.17	44.34	44.31	44.31	44.30	44.30	44.33	44.34	44.30	44.30
	30	17.6	Annual	0.2	0.3	0.3	0.6	0.6	1.0	1.6	0.6	0.1	17.8	17.9	17.9	18.2	18.2	18.6	19.2	18.2	17.7
PM$_{2.5}$	25	Varying	24-Hr	0.8	1.1	1.1	2.1	2.0	2.5	3.6	2.4	0.8	22.0	22.1	22.1	22.9	22.9	23.4	24.7	24.3	22.5
	8	7.6	Annual	0.1	0.2	0.2	0.4	0.4	0.6	0.9	0.4	0.1	7.7	7.8	7.8	8.0	8.0	**8.2**	**8.5**	8.0	7.7
TSP	90	44	Annual	0.2	0.3	0.3	0.8	0.7	1.6	3.1	0.8	0.1	44.2	44.3	44.3	44.8	44.7	45.6	47.1	44.8	44.1
DDG	4	2.1	Annual	0.0	0.0	0.0	0.1	0.0	0.1	0.2	0.0	0.0	2.1	2.1	2.1	2.2	2.1	2.2	2.3	2.1	2.1

Table 37: Predicted Incremental Ground Level Concentrations outside Project Site Boundary – Stage 2 Operations (100% Natural Gas)

Pollutant	Criteria (µg/m^3)	Av. Period	Predicted Incremental Concentrations (µg/m^3)
			Maximum Outside Site Boundary
Arsenic	0.09	1-Hr	0.0014
Cadmium	0.018	1-Hr	0.00092
Chromium (VI)	0.09	1-Hr	0.004
HCl	140	1-Hr	26.6
Mercury	1.8	1-Hr	0.011
Nickel	0.18	1-Hr	0.019
Lead	0.5	1-Hr	0.0018
Benzene	29	1-Hr	1.253
Toluene	360	1-Hr	0.672
Xylene	190	1-Hr	0.122
PAH	0.4	1-Hr	5.2E-04
PCDD/F	2.0E-06	1-Hr	4.1E-09

9. RECOMMENDATIONS

Results from the dispersion modelling demonstrate that compliance would be achieved for all pollutants from existing operations at Plant 1 and Plant 2 and the proposed LWA manufacturing operations at all identified sensitive residential receptors. Exceedance of the $PM_{2.5}$ annual average concentration is observed in the immediate vicinity of the Project site boundary at non-residential receptors DR6 & DR7 corresponding to Prospect reservoir, but as mentioned earlier, it is observed that the $PM_{2.5}$ background concentrations contributes to 90% of the cumulative impacts . However, in order to effectively manage air emissions from all sources, the following recommendations are made:

- Air pollution control measures proposed by Brickworks for reducing flue gas emissions generated from LWA manufacturing include – baghouse for controlling particulate emissions and metals, wet scrubber for reducing acid gas concentrations and RTO for effectively minimising VOC and CO emissions. These proposed control measures are to be designed and managed / maintained effectively to ensure that the estimated control efficiencies (**Table 14**) are achieved at all times and that the emission levels comply with the Group 6 emission standards;
- Air pollution control measures proposed by Brickworks for reducing flue gas emissions generated from the existing Plant 2 operations during Stage 2 operations comprise wet scrubber for reducing fluoride and acid gas concentrations. These proposed control measures are to be designed and managed / maintained effectively to ensure that the estimated control efficiencies (**Table 14**) are achieved at all times.

Control measures for reducing fugitive particulate emissions from existing and proposed operations include:

- *Watering of unpaved / gravel surfaces* – currently implemented and will be undertaken for proposed Stage 1 and Stage 2 LWA operations;
- *Speed restriction* – Speed restrictions are implemented (40 km/hour), especially on unpaved, gravel surfaces to minimise wheel-generated dust for existing and proposed Stage 1 and Stage 2 LWA operations;
- *Water sprays* – currently implemented for stockpiles and crushing / grinding operations and will be undertaken for proposed Stage 1 and Stage 2 operations; and
- *Enclosed infrastructures* – Existing material handling infrastructure near the Primary Crusher area and Mill Building area is currently enclosed.

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11. GLOSSARY

ANZECC	Australian and New Zealand Environment Council
Airlabs	Airlabs Environmental Pty Ltd
Approved Methods	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
ASME	American Society of Mechanical Engineers
AQIA	Air Quality Impact Assessment
AWS	Automatic Weather Station
BaP	Benzo (a) Pyrene
BAT	Best Available Technology
BoM	Bureau of Meteorology
BPM	Best Practice Measures
CA	Cooling Air Stack
CALMET	Meteorological processor of the CALPUFF model
CALPUFF	Non-steady state US-EPA approved air dispersion model
C&D	Construction and Demolition
C&I	Construction and Industrial
CO	Carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEC	Department of Environment and Conservation
DUTP	Department of Urban and Transport Planning
DR	Discrete Receptor
EET	Emission Estimation Technique
EIS	Environmental Impact Statement
EPA	Environmental Protection Authority
EPL	Environmental Protection Licence
FEL	Front End Loader
HF	Hydrogen fluoride
HCl	Hydrogen chloride
LGA	Local Government Area
LOI	Loss on Ignition
LWA	Light Weight Aggregate
MGA	Map Grid of Australia
mg/m^3	Milligram per cubic metre (concentration units)
ng/m^3	Nanogram per cubic metre (concentration units)
NO_X	Oxides of Nitrogen

NO_2	Nitrogen dioxide
NPI	National Pollutant Inventory
NSW	New South Wales
O_3	Ozone
PAHs	Polycyclic Aromatic Hydrocarbons
POEO	Protection of the Environment Operations
POP	Proof of Performance
PCDD/F	Polychlorinated Dioxins and Furans
PCS	Product Combustion Stack
$PM_{2.5}$	Particulate matter less than 2.5 microns in diameter
PM_{10}	Particulate matter less than 10 microns in diameter
RDF	Refuse Derived Fuel
RH	Relative Humidity
RTO	Regenerative Thermal Oxidiser
SEAR	Secretary Environmental Assessment Requirements
SO_2	Sulfur dioxide
SPCC	State Pollution Control Commission
SRC	Sigma Research Corporation
SSD	State Significant Development
SW	South West
TERRAD	The Radius of Influence of Terrain
TEQ	Toxic Equivalent
TOC	Total Organic Carbon
Project	Brickworks, Light Weight Aggregate Project
Project Site	Plant 2, Brickworks, Horsley Park, NSW
tpa	Tonnes per annum
TSP	Total Suspended Particulates
UTM	Universal Transverse Mercator
US-EPA	United States – Environmental Protection Agency
VOCs	Volatile Organic Compounds
WSW	West South West
μ	Micrometre / Microns
$\mu g/m^3$	Microgram per cubic metre (concentration units)

APPENDIX A – EMISSION ESTIMATION DETAILS

Proposed Product Combustion Stack (PCS) and Cooling Air (CA) Stack

Emission Factors for Natural Gas Combustion

List of Pollutants	Emission Factor (kg/tonne)	Reference Source
Total Particulates	0.458	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Sulfur dioxide (SO_2)	0.39 *(based on low sulfur content)*	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Oxides of Nitrogen (NO_X)	0.175	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Carbon Monoxide (CO)	0.6	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Hydrogen Fluoride (HF)	0.295	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Hydrogen Chloride (HCl)	0.085	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Acetone	0.00085	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Benzene	0.00145	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Carbon disulphide	2.15E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Chloroethane	0.000235	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Ethylbenzene	2.20E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Xylene	6.25E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Phenol	4.30E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Styrene	1.00E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Tetrachloroethylene	1.40E-06	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Toluene	0.0008	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Polycyclic Aromatic Hydrocarbons (PAHs) - *kg/tonne of fuel combusted*	1.38E-05	NPI - EET, Combustion in Boilers, December 2011

List of Pollutants	**Emission Factor (kg/tonne)**	**Reference Source**
Polychlorinated Dioxins and Furans (PCDD/F) - TEQ - *kg/tonne of fuel combusted*	1.07E-10	NPI - EET, Combustion in Boilers, December 2011
Arsenic	1.55E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Beryllium	2.10E-07	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Cadmium - *kg/tonne of fuel combusted*	2.38E-05	NPI - EET, Combustion in Boilers, December 2011
Chromium (III) - *kg/tonne of fuel combusted*	3.03E-05	NPI - EET, Combustion in Boilers, December 2011
Copper dust - *kg/tonne of fuel combusted*	1.84E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Manganese	1.45E-04	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Mercury	3.75E-06	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Lead - *kg/tonne of fuel combusted*	1.08E-05	NPI - EET, Combustion in Boilers, December 2011
Nickel - *kg/tonne of fuel combusted*	4.54E-05	NPI - EET, Combustion in Boilers, December 2011

Emission Factors for Pulverised Coal Combustion

List of Pollutants	Emission Factor (kg/tonne)	Reference Source
Total Particulates	0.737	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Sulfur dioxide (SO_2)	0.6	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Oxides of Nitrogen (NO_X)	0.255	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Carbon Monoxide (CO)	0.4	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Hydrogen Fluoride (HF)	0.085	US EPA AP-42, Chapter 11.3 - Brick and Structural Clay Product Manufacturing
Hydrogen Chloride (HCl)	0.085	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Acetone	0.00034	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Benzene	0.00145	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Carbon disulphide	1.15E-06	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Chloroethane	5.50E-06	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Ethylbenzene	1.05E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Xylene	8.85E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Phenol	1.75E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Styrene	5.00E-08	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Tetrachloroethane	5.00E-08	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Trichloroethane	5.00E-08	
Toluene	1.25E-04	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Polycyclic Aromatic Hydrocarbons (PAHs) - *kg/tonne of fuel combusted*	9.49E-06	NPI - EET, Combustion in Boilers, December 2011

List of Pollutants	Emission Factor (kg/tonne)	Reference Source
Polychlorinated Dioxins and Furans (PCDD/F) - TEQ - *kg/tonne of fuel combusted*	2.97E-10	NPI - EET, Combustion in Boilers, December 2011
Arsenic	6.50E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Beryllium	8.00E-06	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Cadmium - *kg/tonne of fuel combusted*	2.55E-05	NPI - EET, Combustion in Boilers, December 2011
Chromium (III) - *kg/tonne of fuel combusted*	1.30E-04	NPI - EET, Combustion in Boilers, December 2011
Chromium (VI) - *kg/tonne of fuel combusted*	3.95E-05	NPI - EET, Combustion in Boilers, December 2011
Copper dust - *kg/tonne of fuel combusted*	4.92E-04	NPI - EET, Combustion in Boilers, December 2011
Manganese	1.45E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Mercury	4.80E-05	NPI-EET - Bricks, Ceramics and Clay Product Manufacturing, June 1998
Lead - *kg/tonne of fuel combusted*	2.10E-04	NPI - EET, Combustion in Boilers, December 2011
Nickel - *kg/tonne of fuel combusted*	1.40E-04	NPI - EET, Combustion in Boilers, December 2011

Fugitive Emission Estimation Details

For quantifying TSP and PM_{10} emissions from fugitive dust sources, reference was drawn to the following EET's for determining particulate emission factors:

- National Pollutant Inventory (NPI) , *Emission Estimation Technique Manual for Bricks, Ceramics & Clay Product Manufacturing*, Environment Australia, August 1998;
- National Pollutant Inventory (NPI) , *Emission Estimation Technique Manual for Mining*, Version 3.1, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, January 2012;
- AP-42 Emission Factors, *Chapter 11.3 Bricks and Structural Clay Product Manufacturing*, United States Environmental Protection Agency (US-EPA 1997);
- AP-42 Emission Factors, *Chapter 11.19.2 Crushed Stone Processing and Pulverised Mineral Processing*, United States Environmental Protection Agency (US-EPA 2004);
- AP-42 Emission Factors, *Chapter 13.2.2 Unpaved Roads*, United States Environmental Protection Agency (US-EPA 2006a); and
- AP-42 Emission Factors, *Chapter 13.2.4 Aggregate Handling and Storage Piles*, United States Environmental Protection Agency (US-EPA 2006b)

TSP and PM_{10} Emission Factor Equations

Activity	Emission Factor Equations	Variables	Control Efficiency	Source
Front End Loader (FEL)	**EF** = k x 0.0016 x $((U/2.2^{1.8})/(M/2)^{1.4})$ kg/tonne	$k_{TSP} = 0.74$, $k_{PM10} = 0.35$, U = wind speed (m/s), M = moisture content (%)	no controls applied	US-EPA AP-42, 13.2.4
Truck Loading/Unloading material	**EF** = k x 0.0016 x $((U/2.2^{1.8})/(M/2)^{1.4})$ kg/tonne	$k_{TSP} = 0.74$, $k_{PM10} = 0.35$, U = wind speed (m/s), M = moisture content (%)	no controls applied	US-EPA AP-42, 13.2.4
Crushing Operations	$\mathbf{EF}_{TSP}$ = 0.0027 kg/tonne, $\mathbf{EF}_{PM10}$ = 0.0012 kg/tonne		enclosed facilities 70% water sprays 50%	US-EPA, AP-42, 11.19.2
Grinding and Screening Operations	$\mathbf{EF}_{TSP}$ = 0.0125 kg/tonne, $\mathbf{EF}_{PM10}$ = 0.00115 kg/tonne		enclosed facilities 70% water sprays 50%	US-EPA, AP-42, 11.3

Activity	Emission Factor Equations	Variables	Control Efficiency	Source
Haulage on Unpaved Roads	**EF** = k x $(s/12)^{0.7}$ * $(W/3)^{0.45}$ x 0.2819 x (365-p/365) kg/vkt	k_{TSP} = 4.9, k_{PM10} = 1.5, s = silt content (%) W = Vehicle Gross Mass p = number of days in a year with rainfall greater than 0.25mm	watering twice a day 55% 40km/hour speed restriction 40%	US-EPA AP-42, 13.2.2
Material Handling / Conveying / Loading-Unloading Operations	**EF** = k x 0.0016 x $((U/2.2^{1.8})/(M/2)^{1.4})$ kg/tonne	k_{TSP} = 0.74, k_{PM10} = 0.35, U = wind speed (m/s), M = moisture content (%)	enclosed conveyors 70% water sprays 50%	NPI, Mining V3.1
Wind Erosion	**EF** = 1.9 x (s/1.5) x 365 x (365-p/235) x (f/15) kg/ha/year	s = silt content (%) p = number of days in a year with rainfall greater than 0.25mm f = % of time wind speed is greater than 5.4m/sec	wind breaks – 30% watering stockpiles – 50% existing Stockpile 1 and 2 have a thick crust on them , have a high moisture content (~10%) and are not that actively disturbed – 95% (NSW EPA, 2011)	NPI, Mining V3.1

APPENDIX B – CONCENTRATION ISOPLETHS

Figure B-1: Existing Operations – Predicted Incremental HF 90-Day Average Concentrations (µg/m³) (Criteria: 0.5 µg/m³)

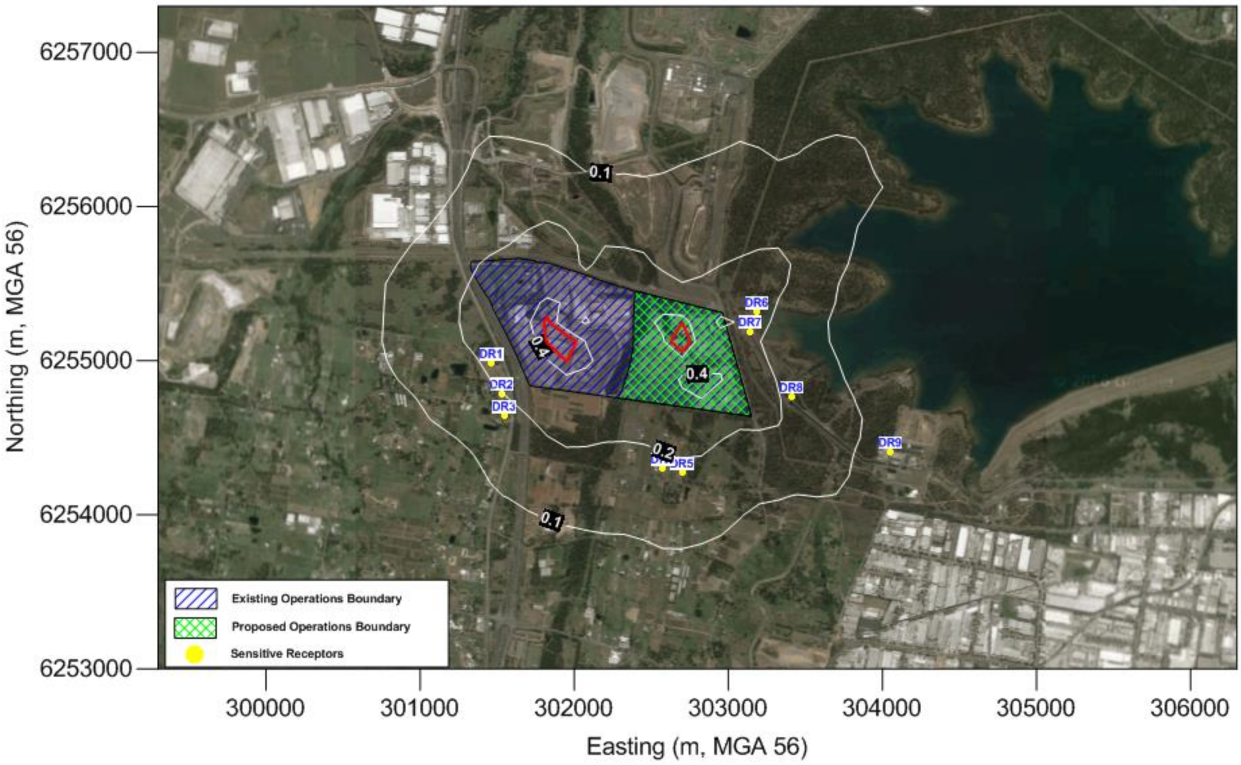


Figure B-2: Stage 1 (Coal) Operations – Predicted Incremental HF 90-Day Average Concentrations (µg/m³) (Criteria: 0.5 µg/m³)

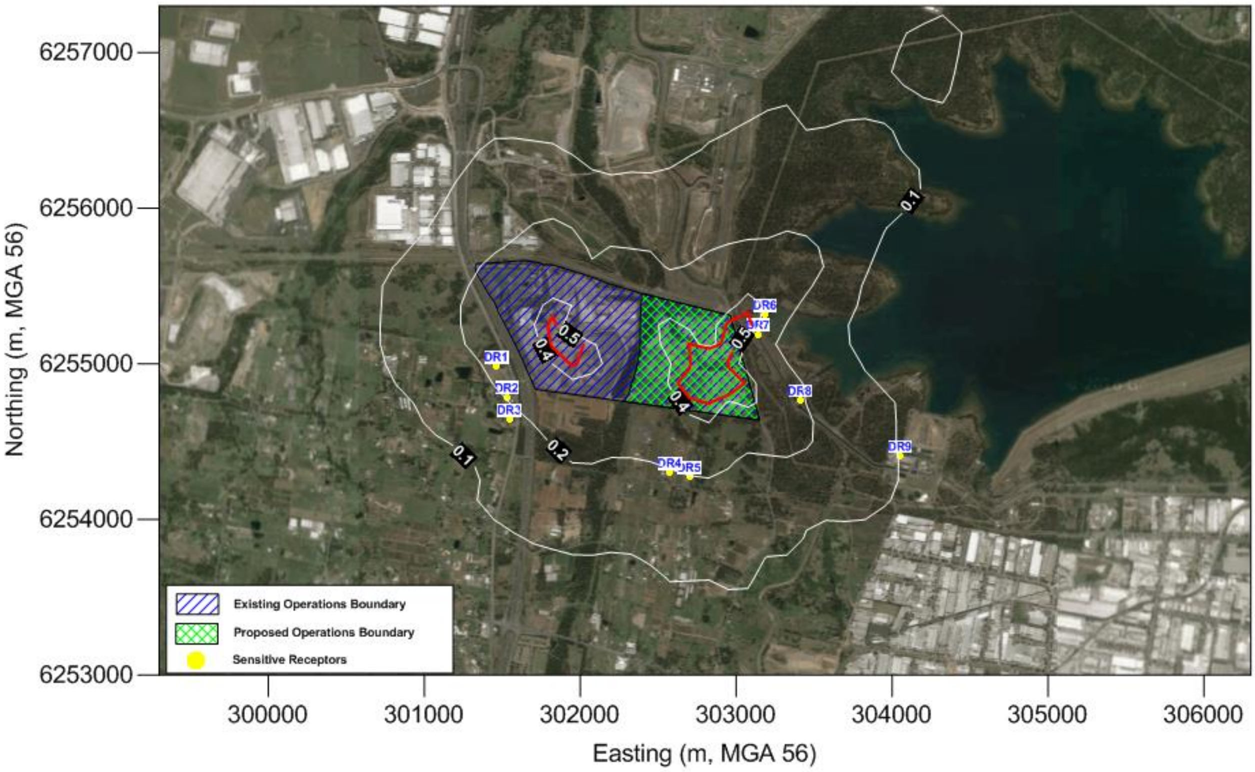


Figure B-3: Stage 1 (Natural Gas) Operations – Predicted Incremental HF 90-Day Average Concentrations (µg/m³) (Criteria: 0.5 µg/m³)

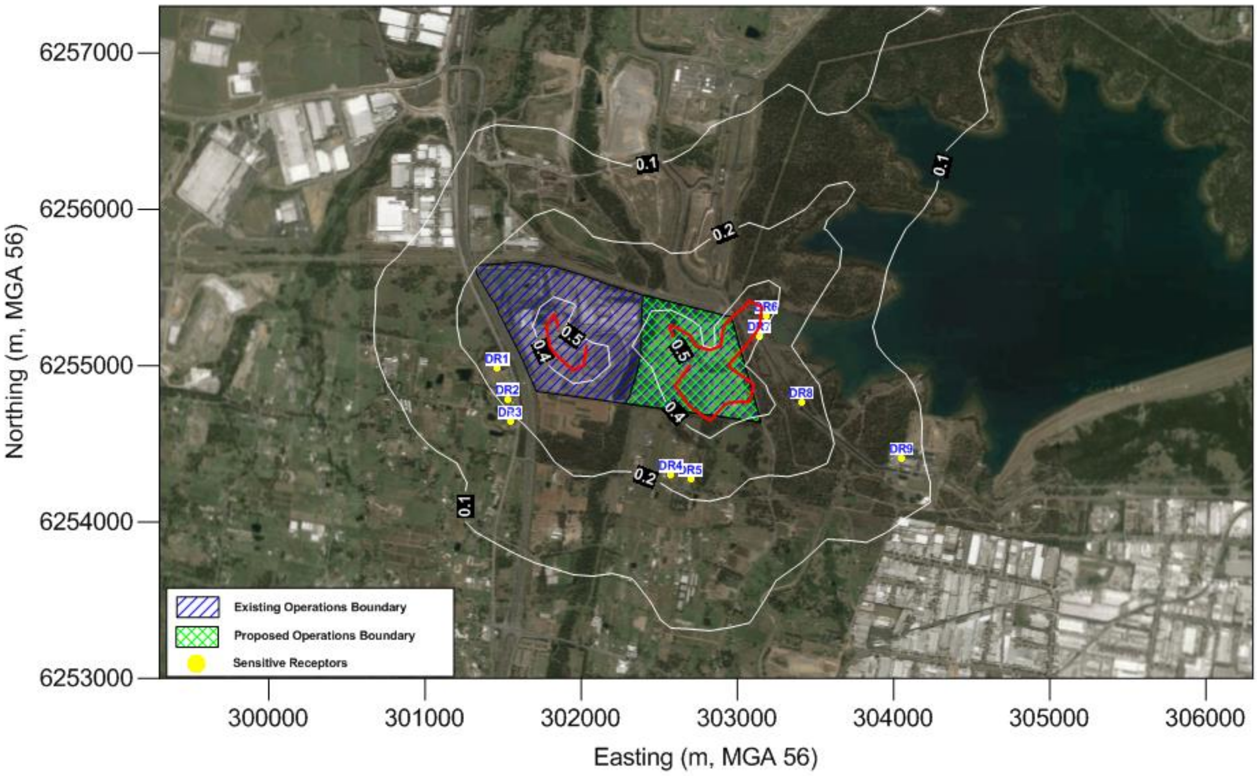


Figure B-4: Stage 2 (Coal) Operations – Predicted Incremental HF 90-Day Average Concentrations (µg/m³) (Criteria: 0.5 µg/m³)

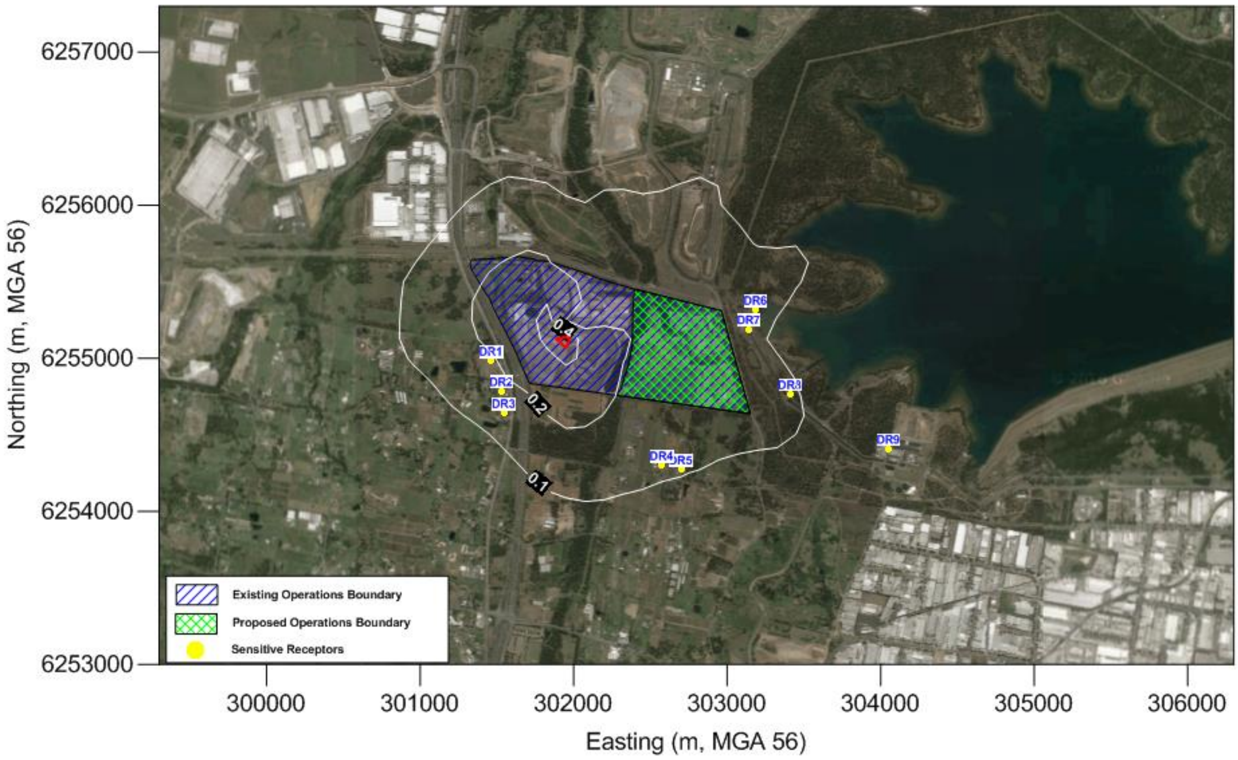


Figure B-5: Stage 2 (Natural Gas) Operations – Predicted Incremental HF 90-Day Average Concentrations (µg/m3) (Criteria: 0.5 µg/m3)

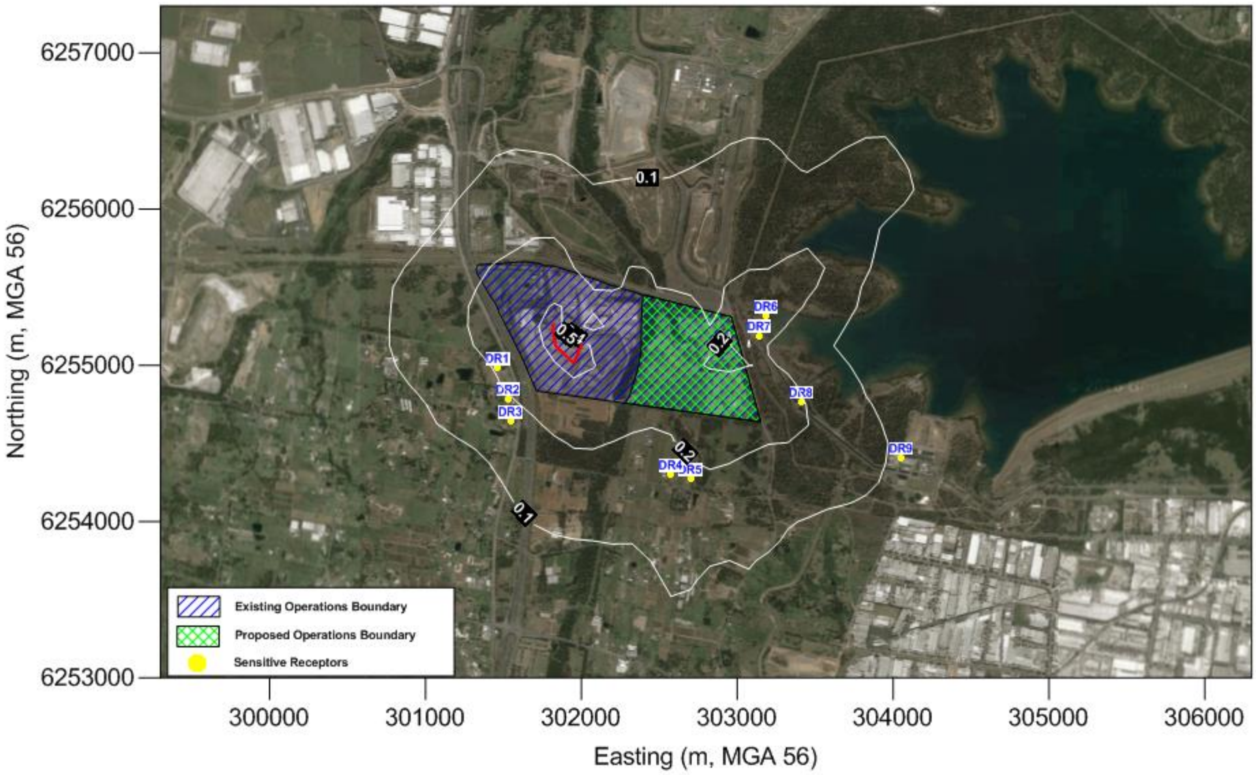


Figure B-6: Existing Operations – Predicted Incremental HF 24-Hour Average Concentrations (µg/m^3) (Criteria: 2.9 µg/m^3)

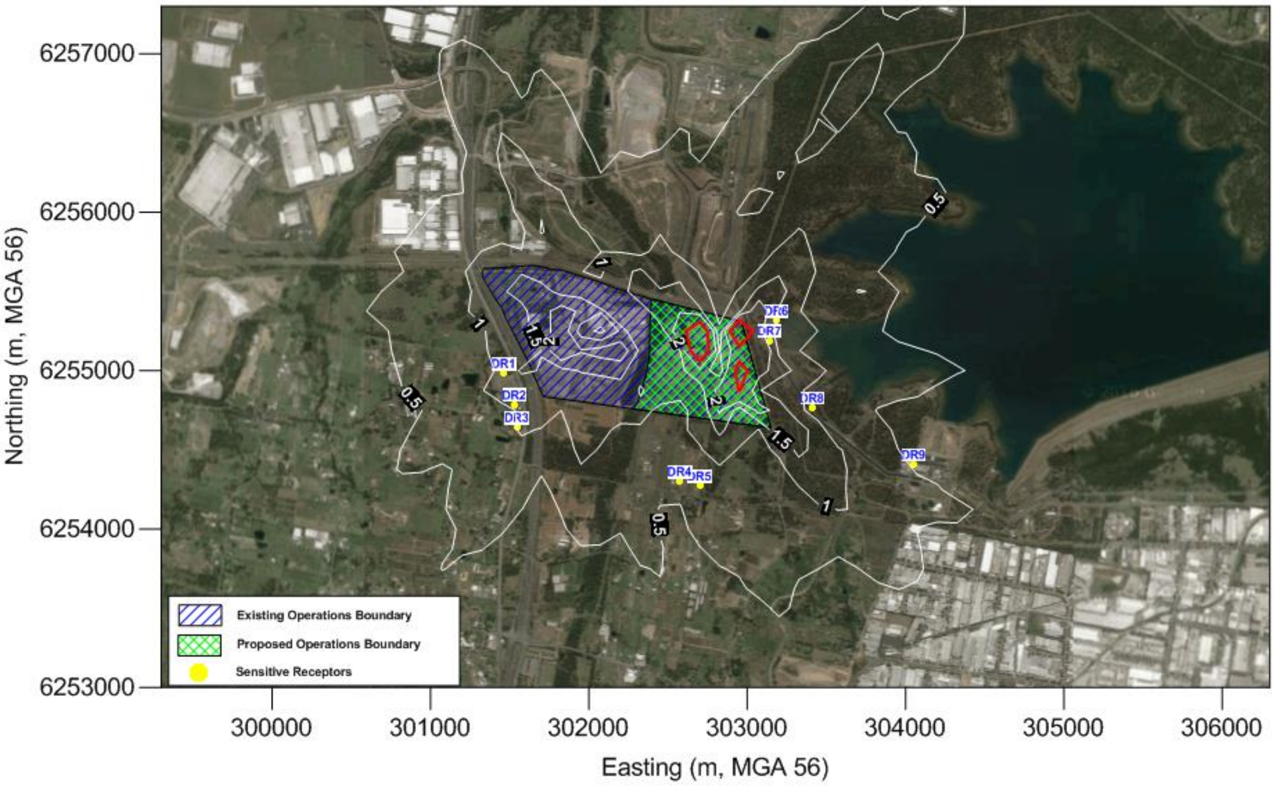


Figure B-7: Stage 1 (Coal) Operations – Predicted Incremental HF 24-Hour Average Concentrations (µg/m³) (Criteria: 2.9 µg/m³)

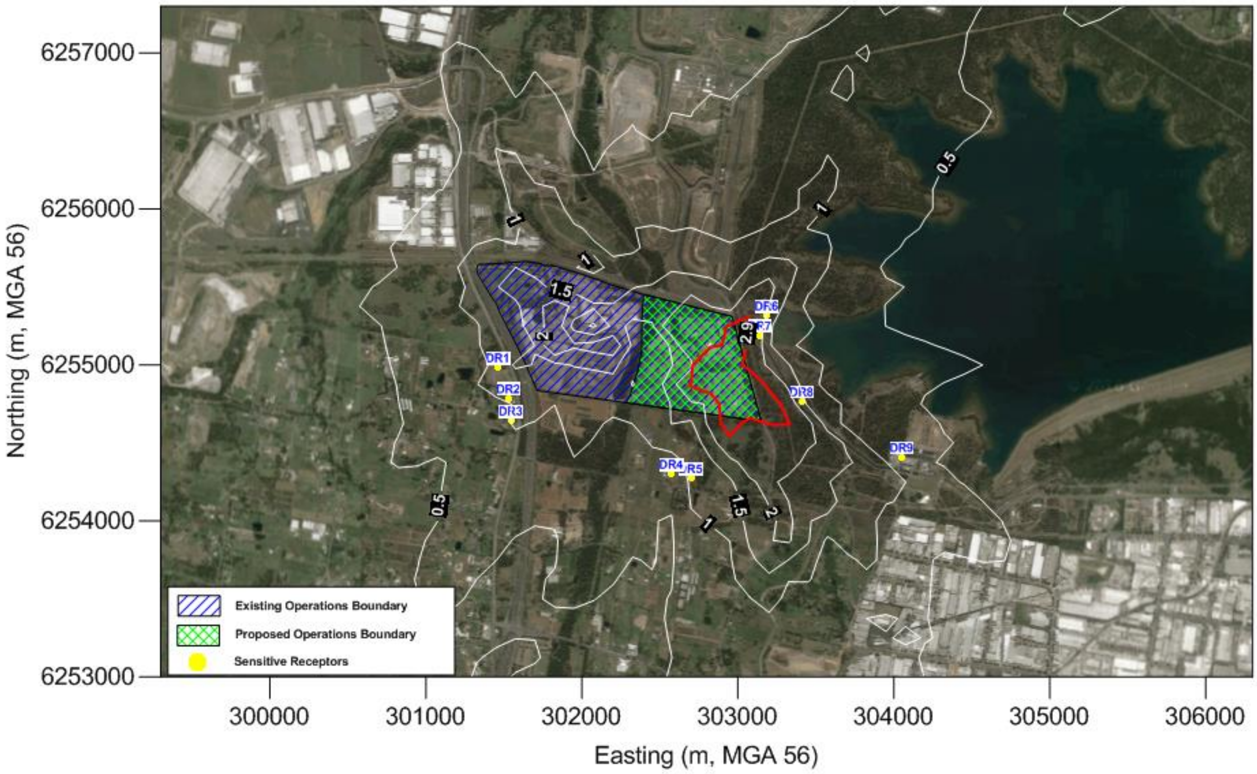


Figure B-8: Stage 1 (Natural Gas) Operations – Predicted Incremental HF 24-Hour Average Concentrations (µg/m³) (Criteria: 2.9 µg/m³)

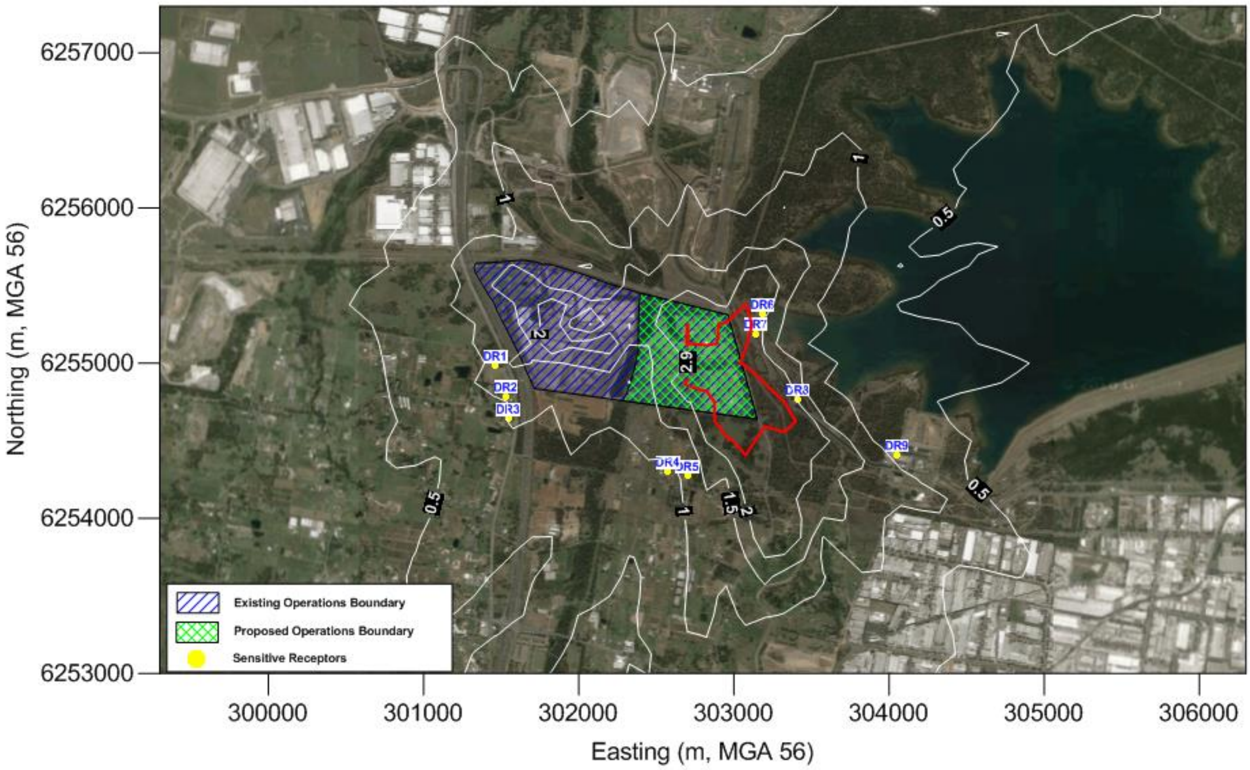


Figure B-9: Stage 2 (Coal) Operations – Predicted Incremental HF 24-Hour Average Concentrations (µg/m³) (Criteria: 2.9 µg/m³)

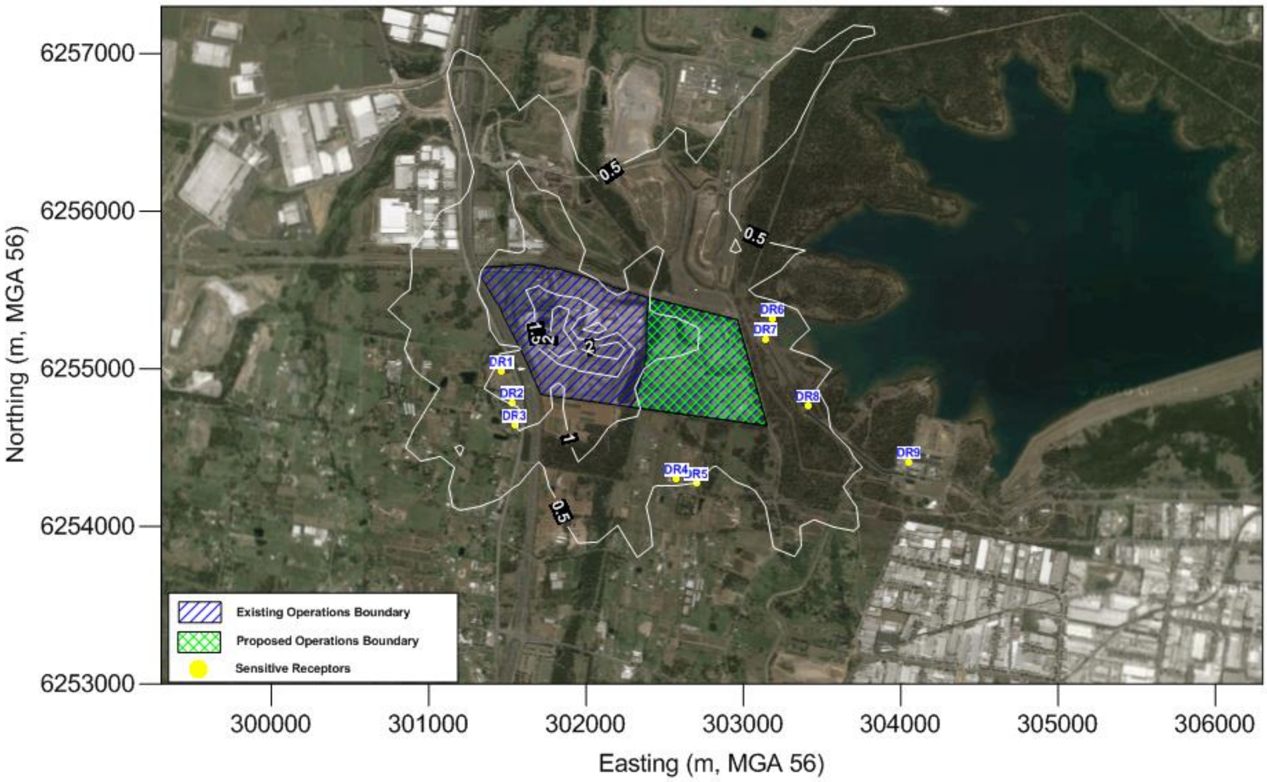


Figure B-10: Stage 2 (Natural Gas) Operations – Predicted Incremental HF 24-Hour Average Concentrations (µg/m³) (Criteria: 2.9 µg/m³)

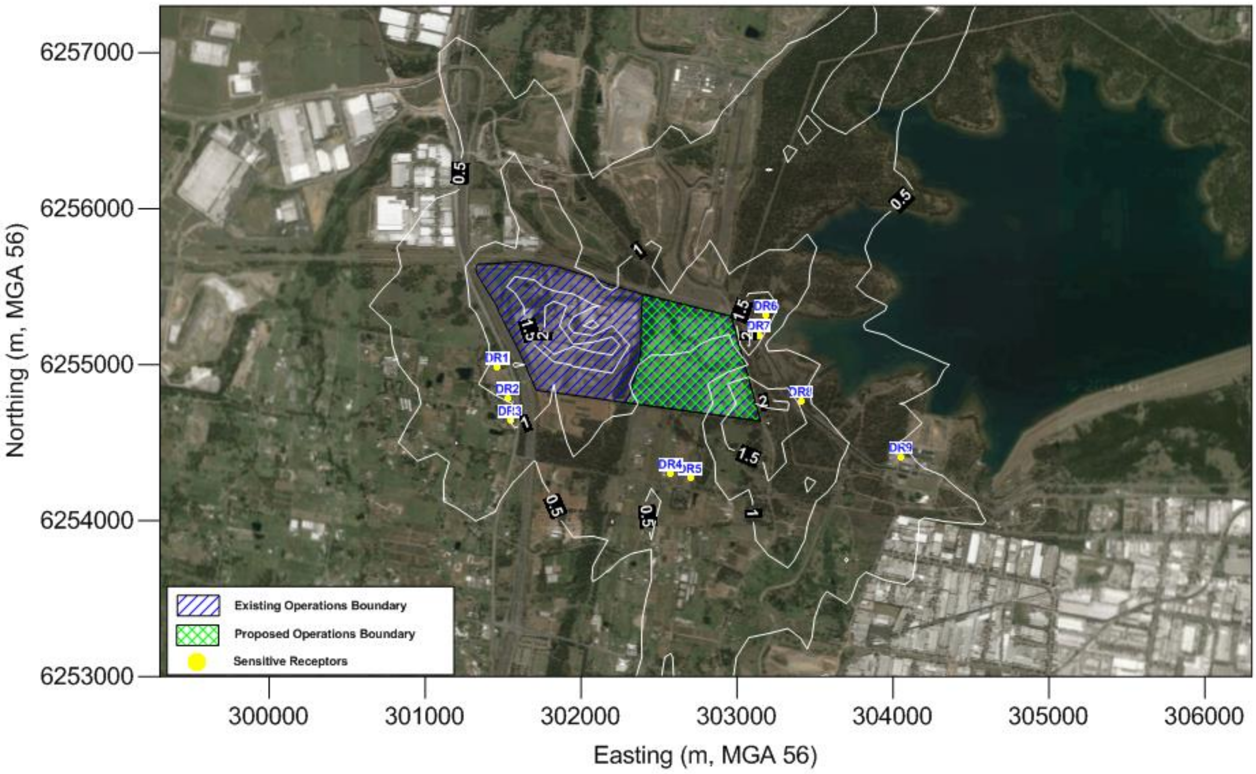


Figure B-11: Existing Operations – Predicted Cumulative PM_{10} 24-Hour Average Concentrations (µg/m³) (Criteria: 50 µg/m³)

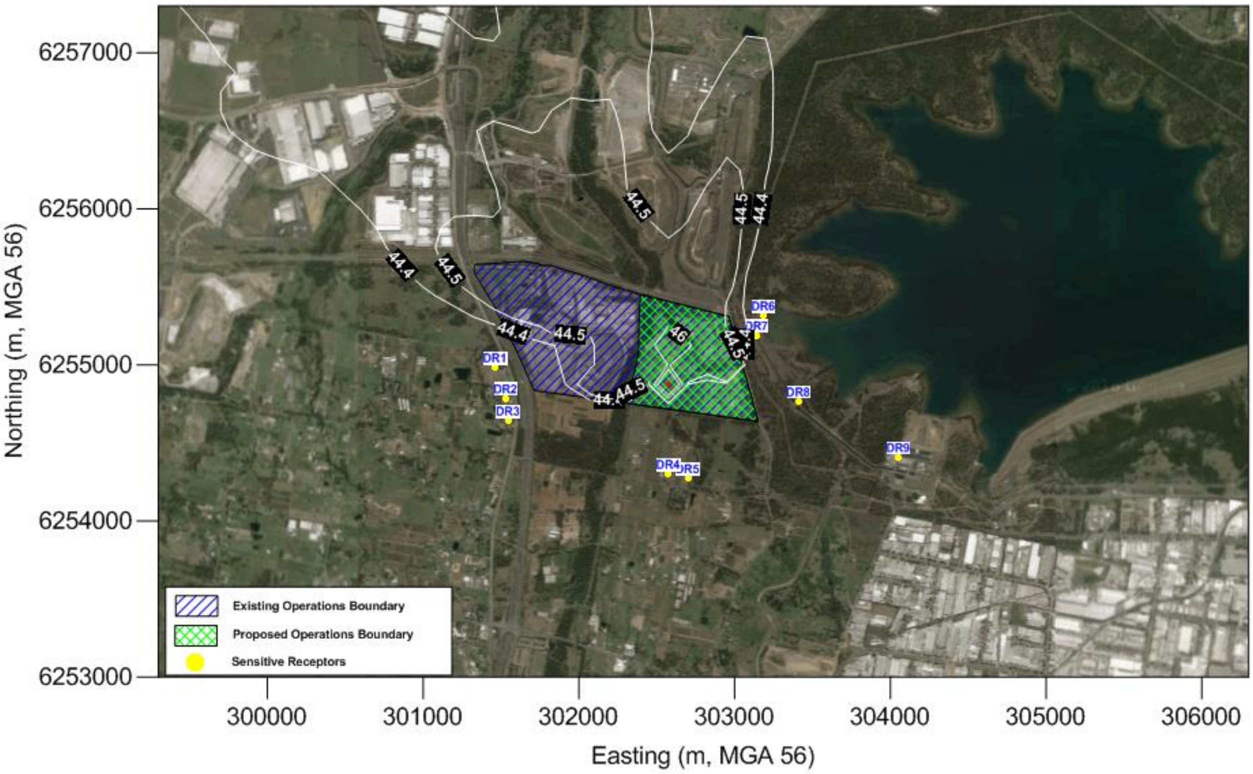


Figure B-12: Stage 1 (Coal) Operations – Predicted Cumulative PM_{10} 24-Hour Average Concentrations (µg/m³) (Criteria: 50 µg/m³)

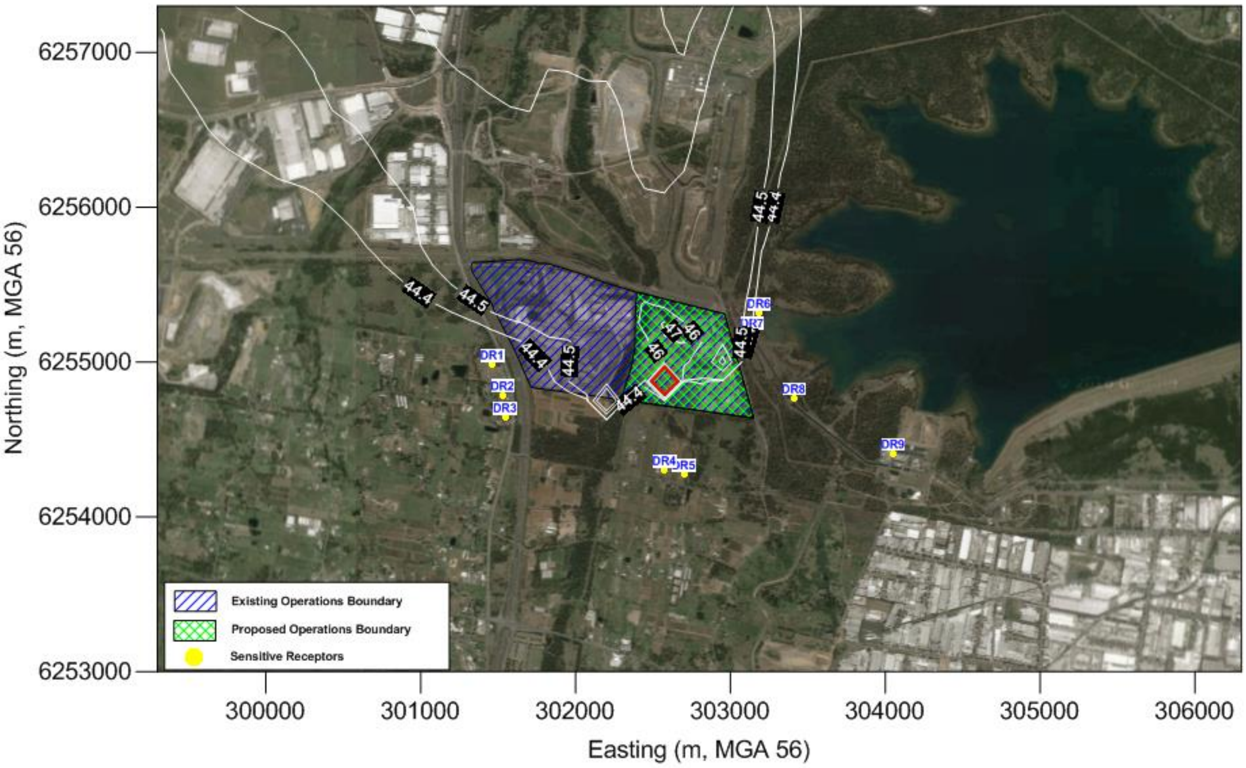


Figure B-13: Stage 1 (Natural Gas) Operations – Predicted Cumulative PM_{10} 24-Hour Average Concentrations (µg/m³) (Criteria: 50 µg/m³)

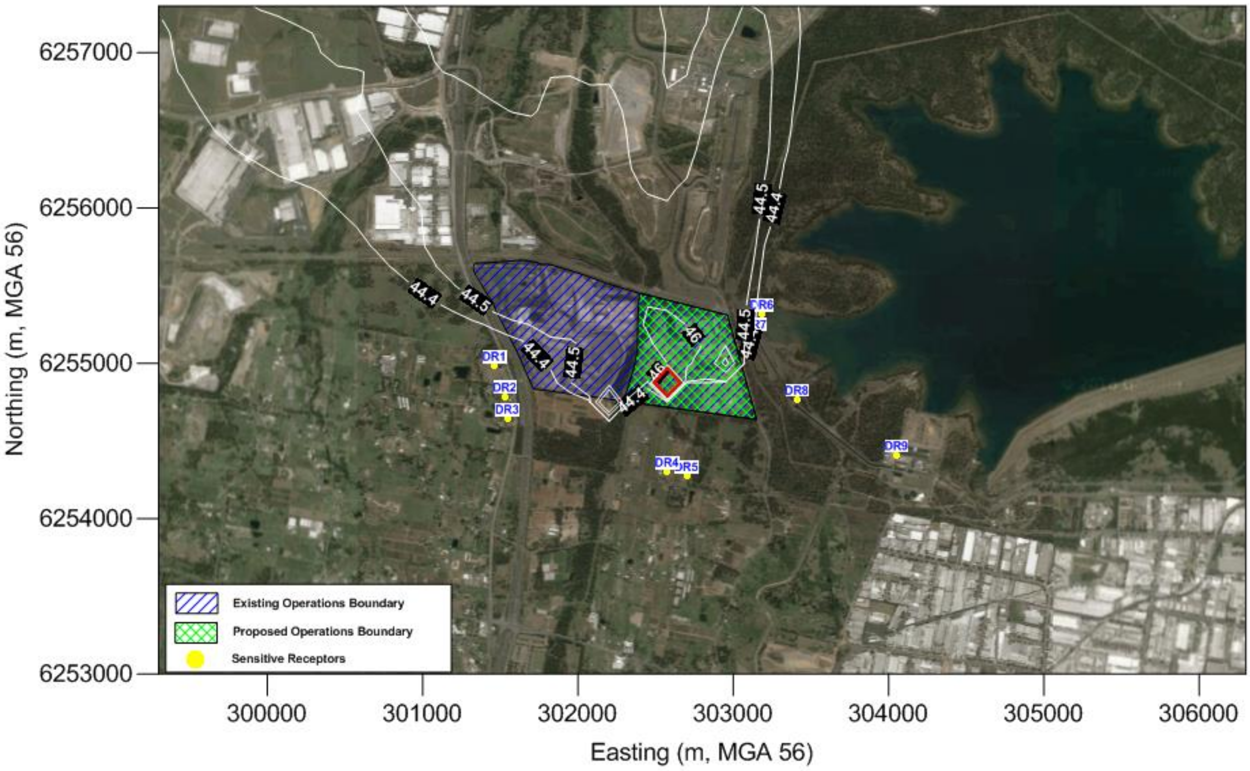


Figure B-14: Stage 2 (Coal) Operations – Predicted Cumulative PM_{10} 24-Hour Average Concentrations (µg/m³) (Criteria: 50 µg/m³)

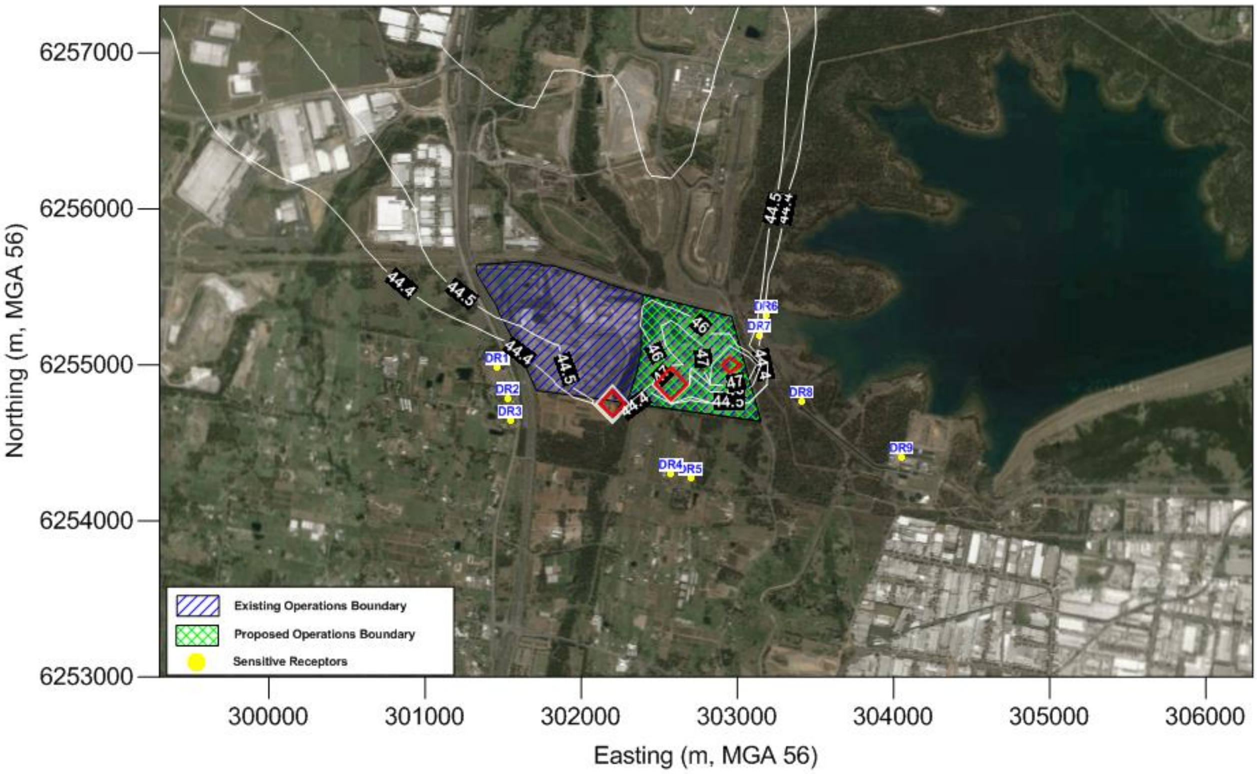


Figure B-15: Stage 2 (Natural Gas) Operations – Predicted Cumulative PM_{10} 24-Hour Average Concentrations (µg/m^3) (Criteria: 50 µg/m^3)

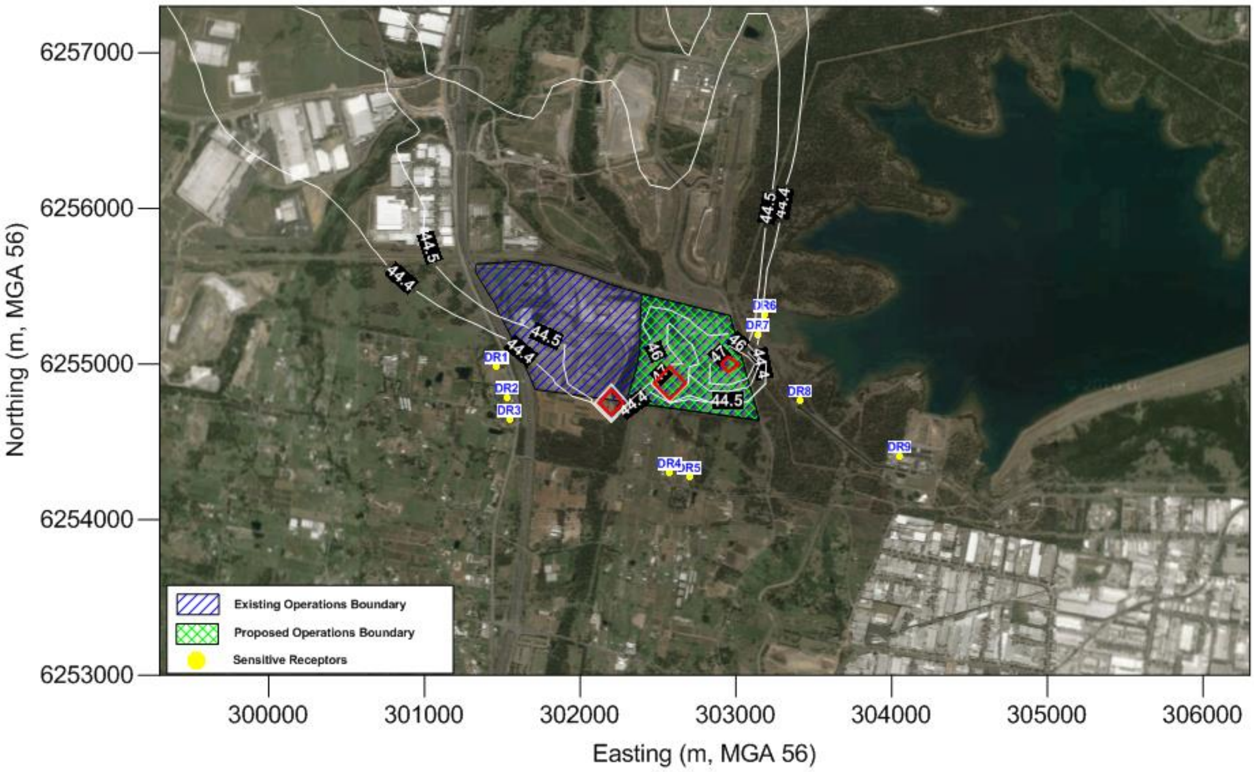


Figure B-16: Existing Operations – Predicted Cumulative $PM_{2.5}$ 24-Hour Average Concentrations (µg/m^3) (Criteria: 25 µg/m^3)

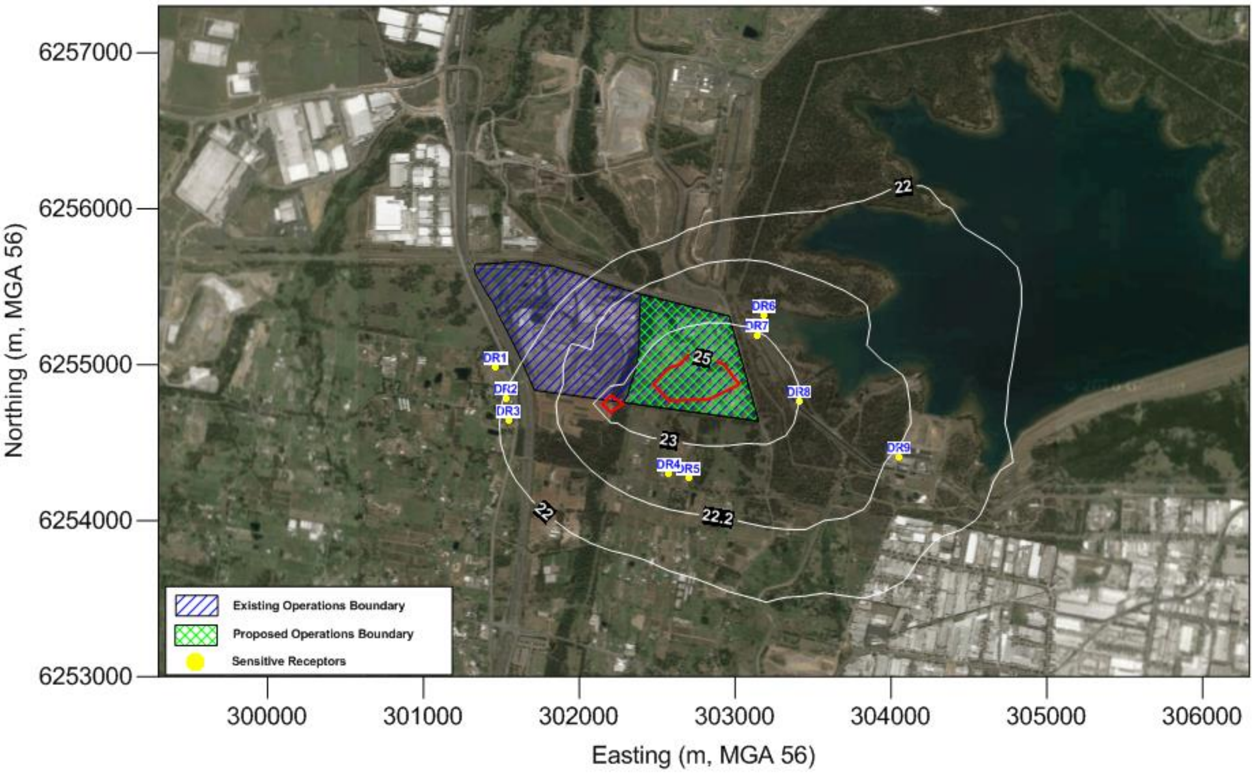


Figure B-17: Stage 1 (Coal) Operations – Predicted Cumulative $PM_{2.5}$ 24-Hour Average Concentrations (µg/m³) (Criteria: 25 µg/m³)

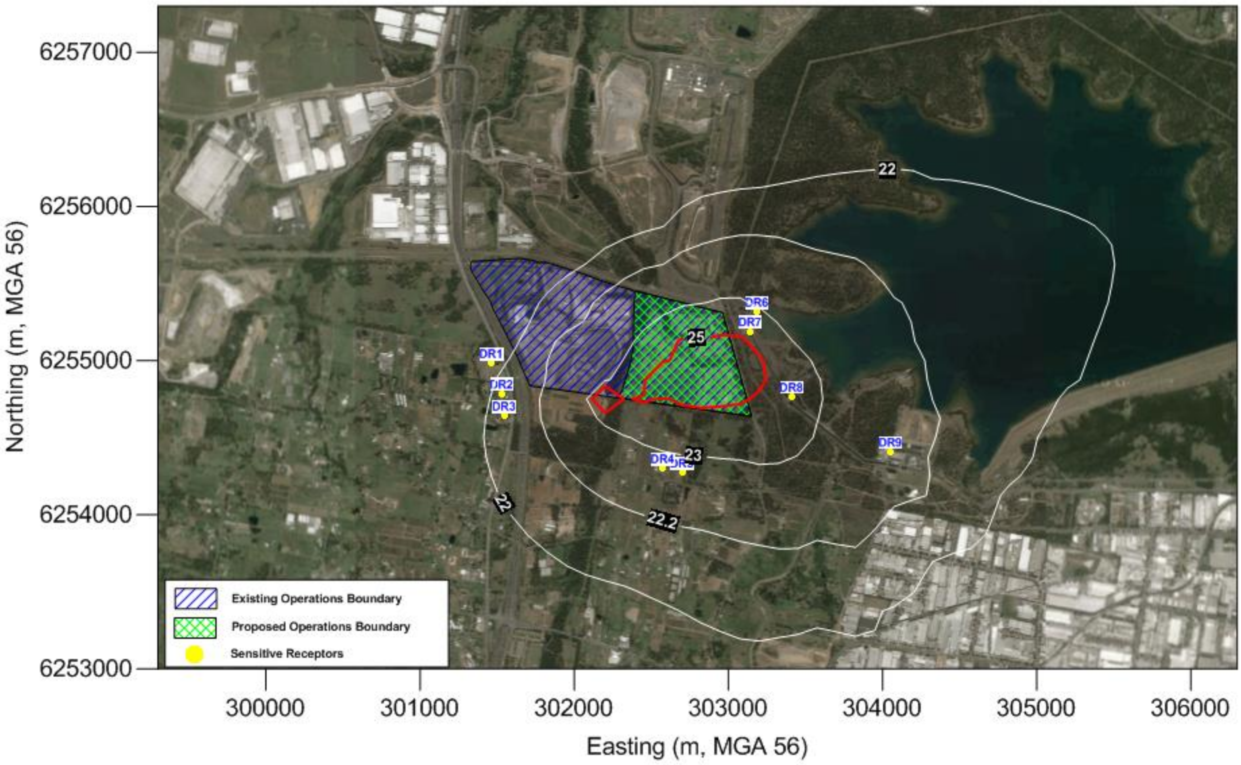


Figure B-18: Stage 1 (Natural Gas) Operations – Predicted Cumulative $PM_{2.5}$ 24-Hour Average Concentrations (µg/m³) (Criteria: 25 µg/m³)

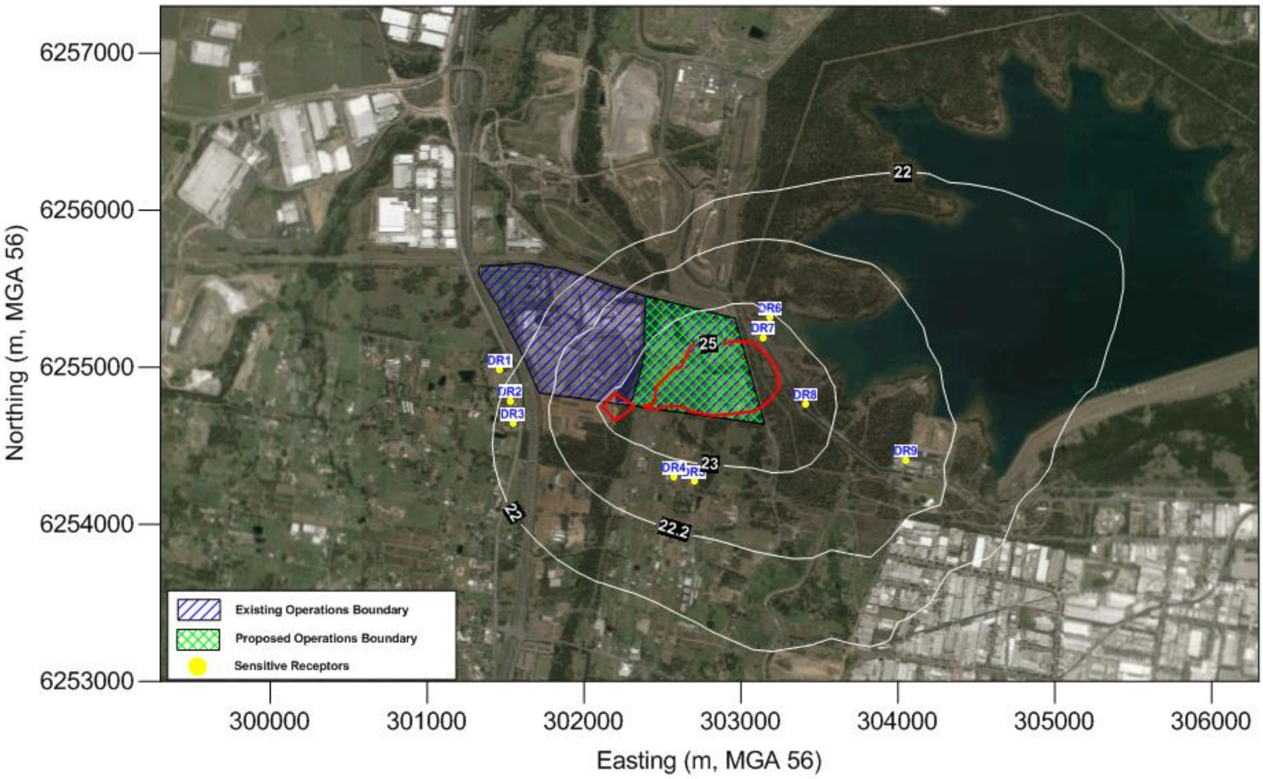


Figure B-19: Stage 2 (Coal) Operations – Predicted Cumulative $PM_{2.5}$ 24-Hour Average Concentrations (µg/m³) (Criteria: 25 µg/m³)

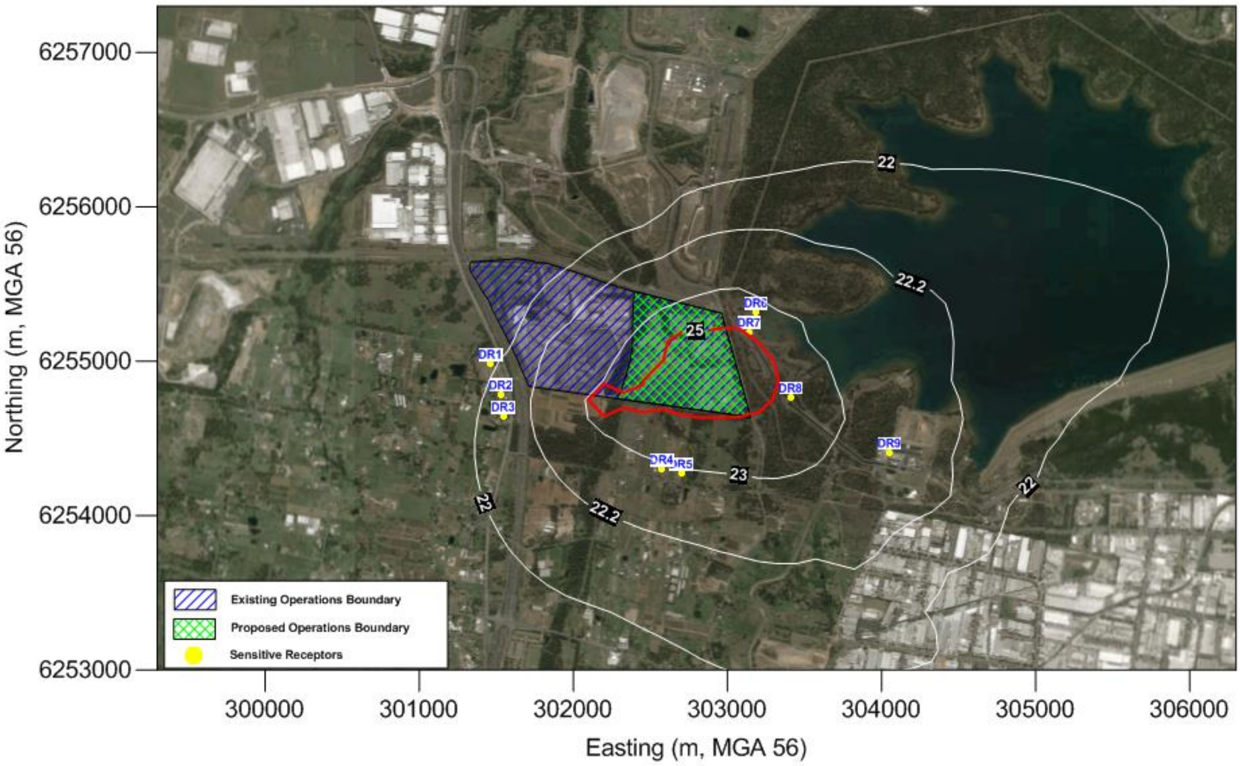


Figure B-20: Stage 2 (Natural Gas) Operations – Predicted Cumulative $PM_{2.5}$ 24-Hour Average Concentrations (µg/m³) (Criteria: 25 µg/m³)

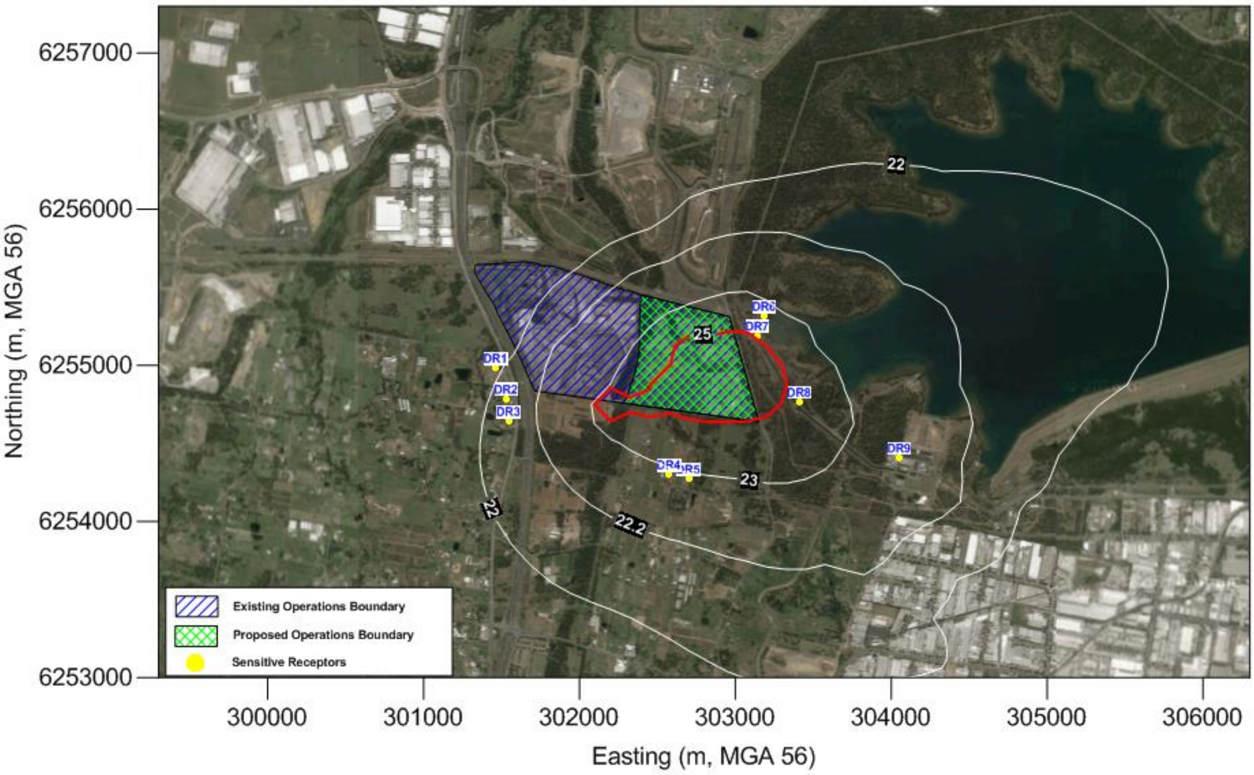


Figure B-21: Existing Operations – Predicted Cumulative $PM_{2.5}$ Annual Average Concentrations (µg/m³) (Criteria: 8 µg/m³)

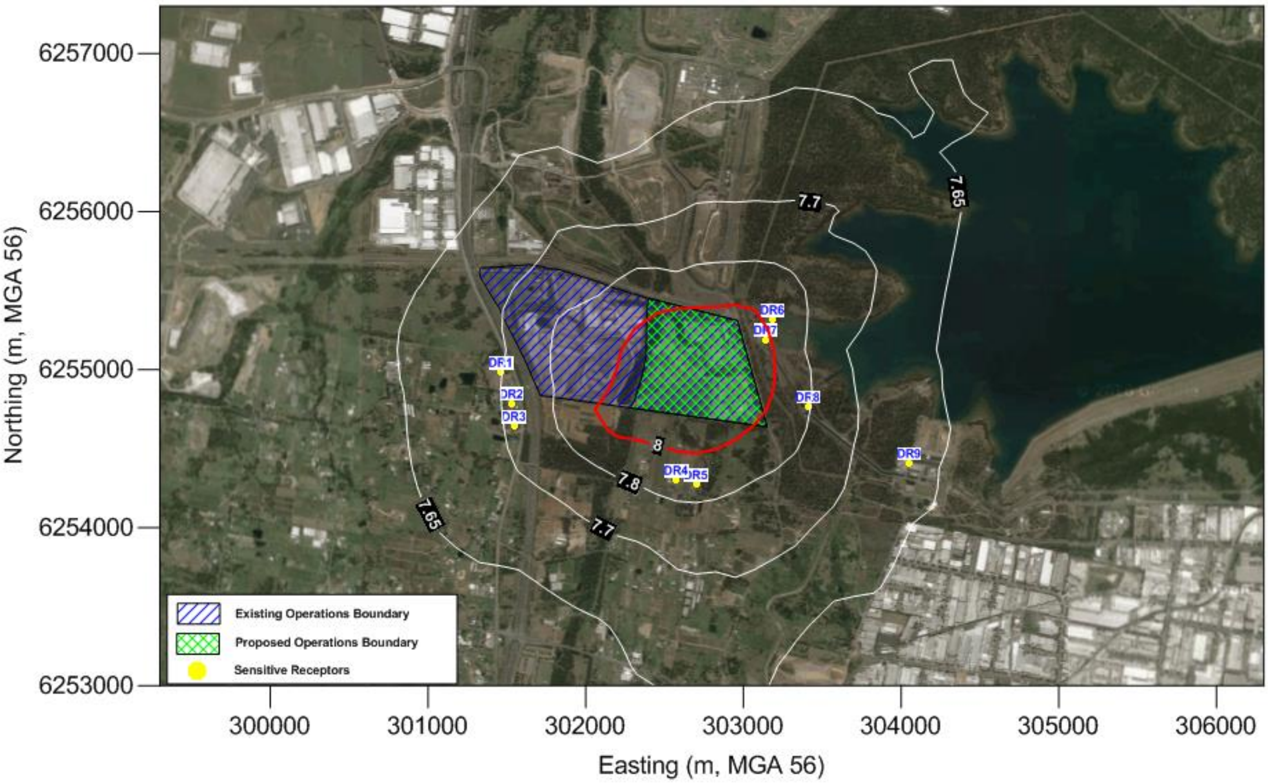


Figure B-22: Stage 1 (Coal) Operations – Predicted Cumulative $PM_{2.5}$ Annual Average Concentrations (µg/m³) (Criteria: 8 µg/m³)

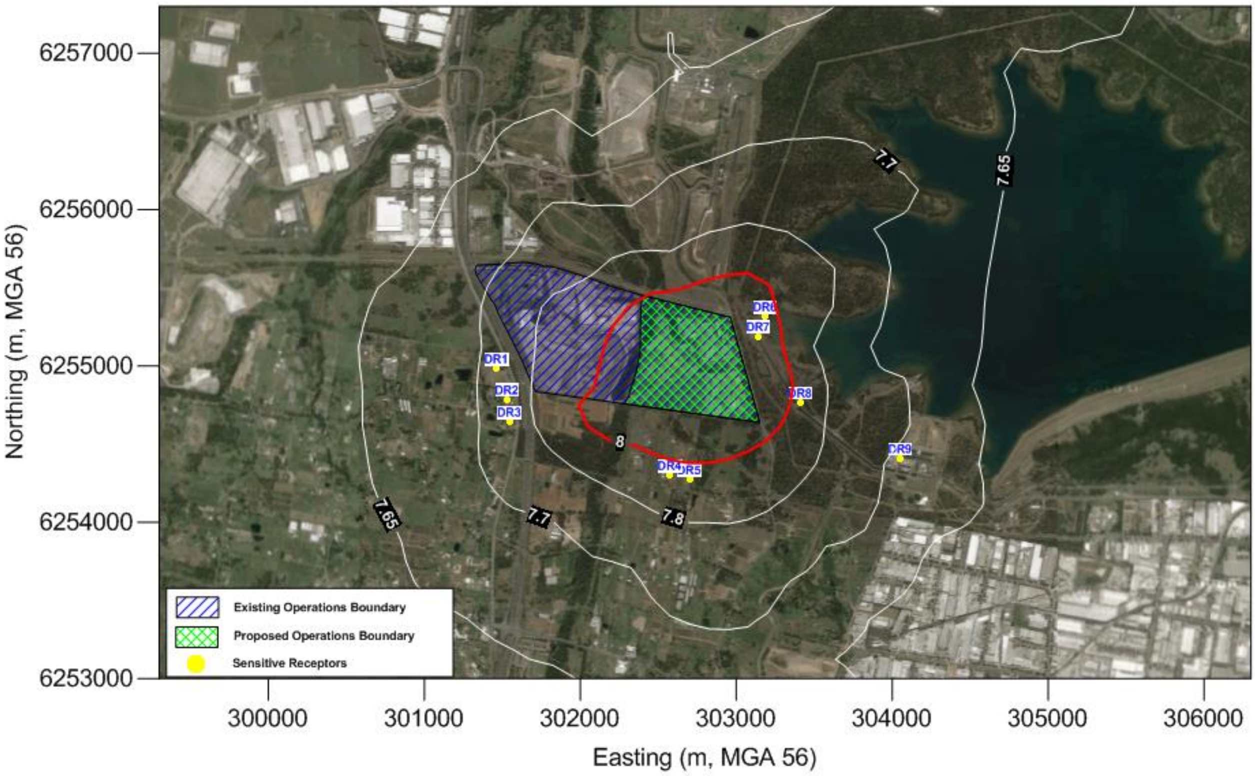


Figure B-23: Stage 1 (Natural Gas) Operations – Predicted Cumulative $PM_{2.5}$ Annual Average Concentrations (µg/m³) (Criteria: 8 µg/m³)

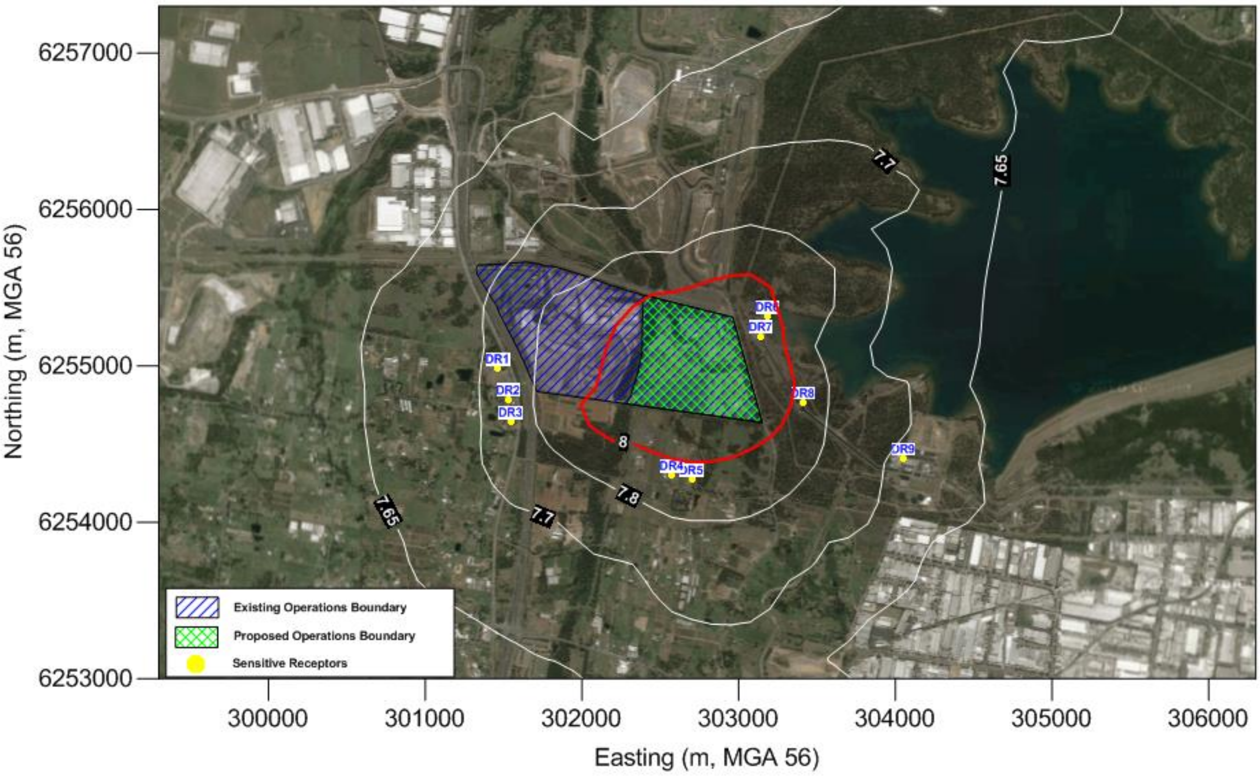


Figure B-24: Stage 2 (Coal) Operations – Predicted Cumulative $PM_{2.5}$ Annual Average Concentrations (µg/m³) (Criteria: 8 µg/m³)

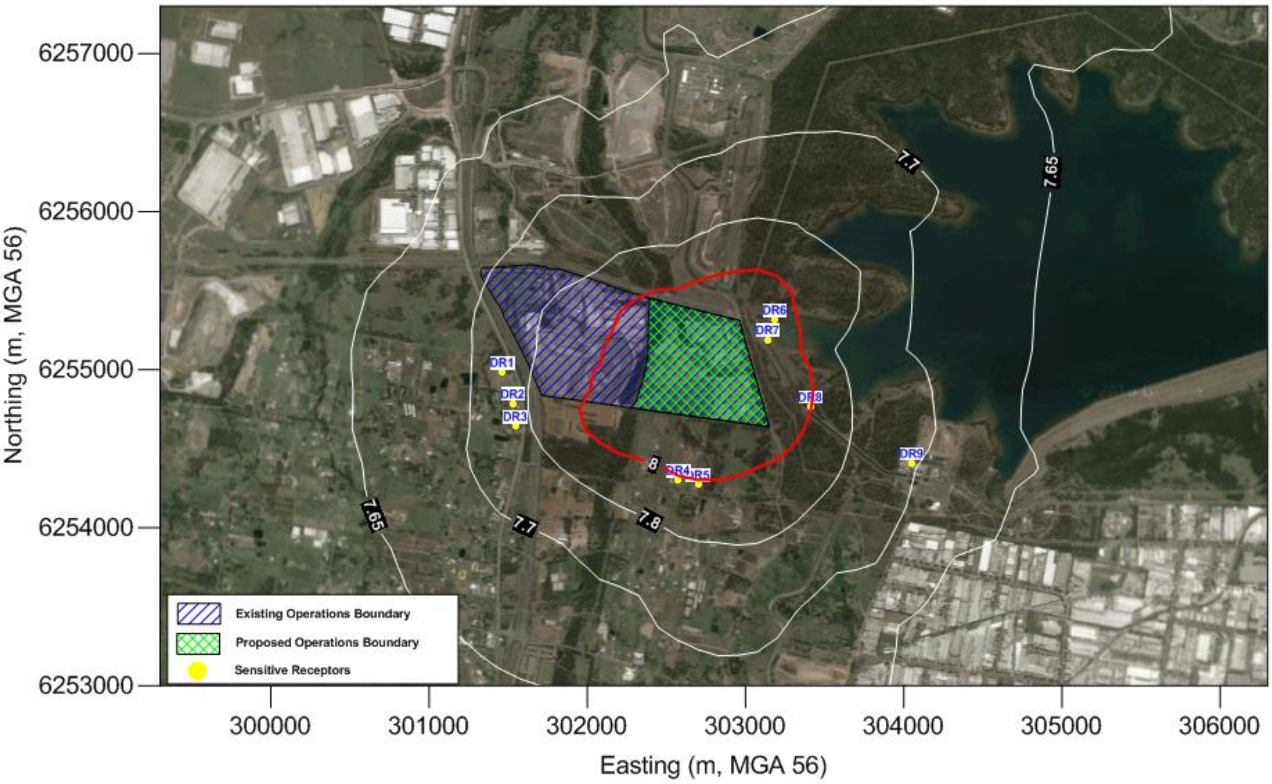


Figure B-25: Stage 2 (Natural Gas) Operations – Predicted Cumulative $PM_{2.5}$ Annual Average Concentrations (µg/m³) (Criteria: 8 µg/m³)

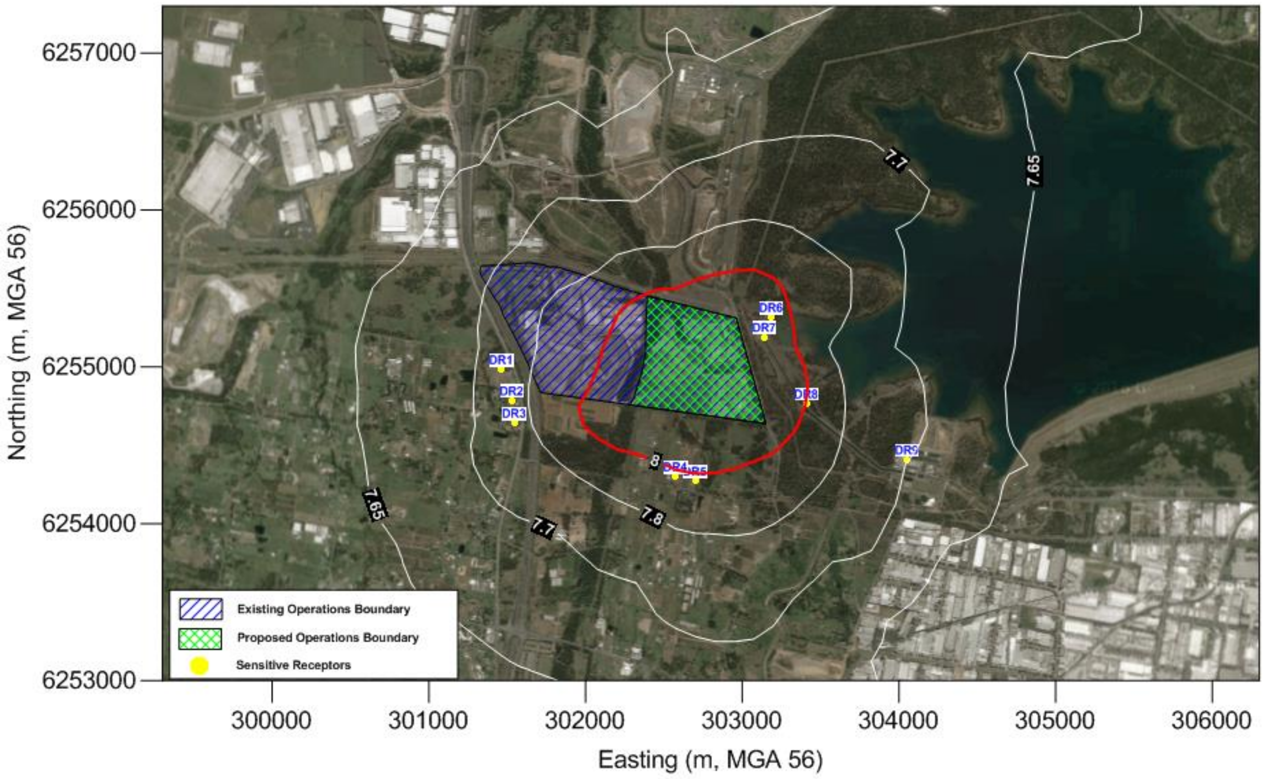


Figure B-26: Existing Operations – Predicted Cumulative NO_2 1-Hour Average Concentrations (µg/m³) (Criteria: 246 µg/m³)

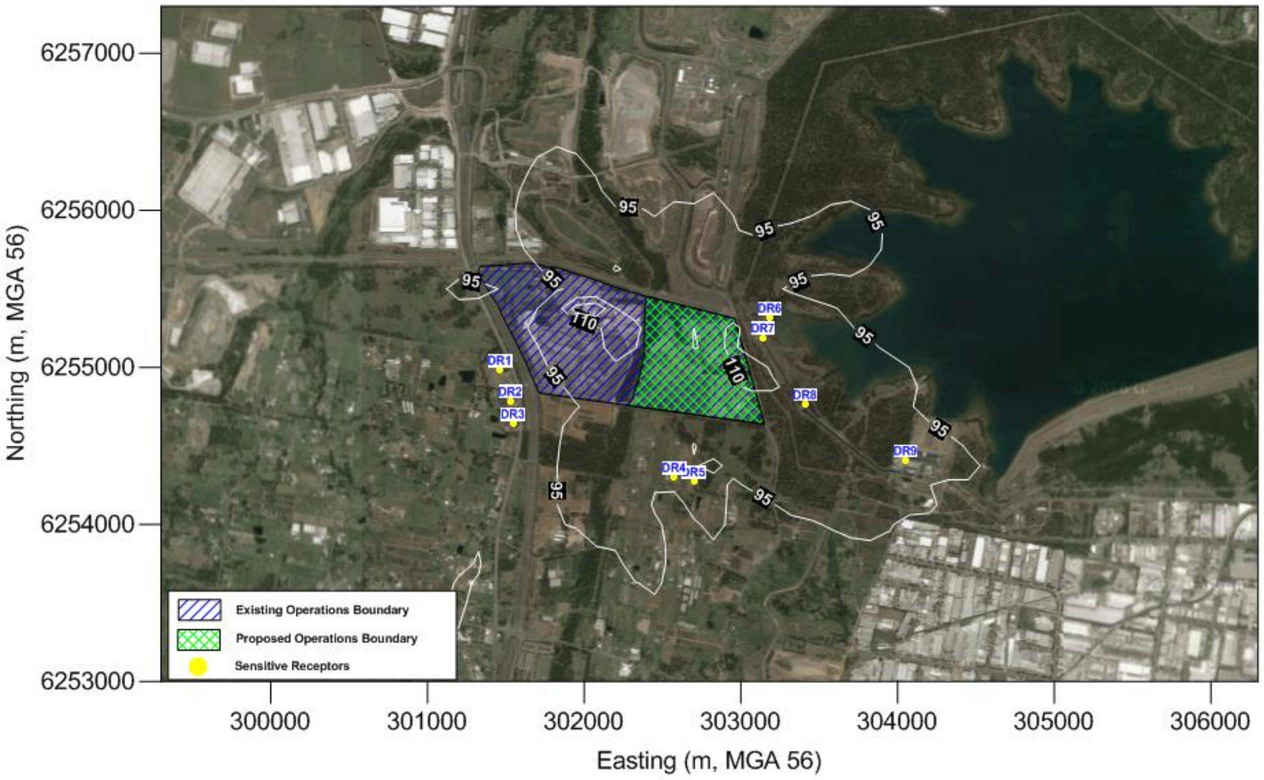


Figure B-27: Stage 1 (Coal) Operations – Predicted Cumulative NO_2 1-Hour Average Concentrations (µg/m³) (Criteria: 246 µg/m³)

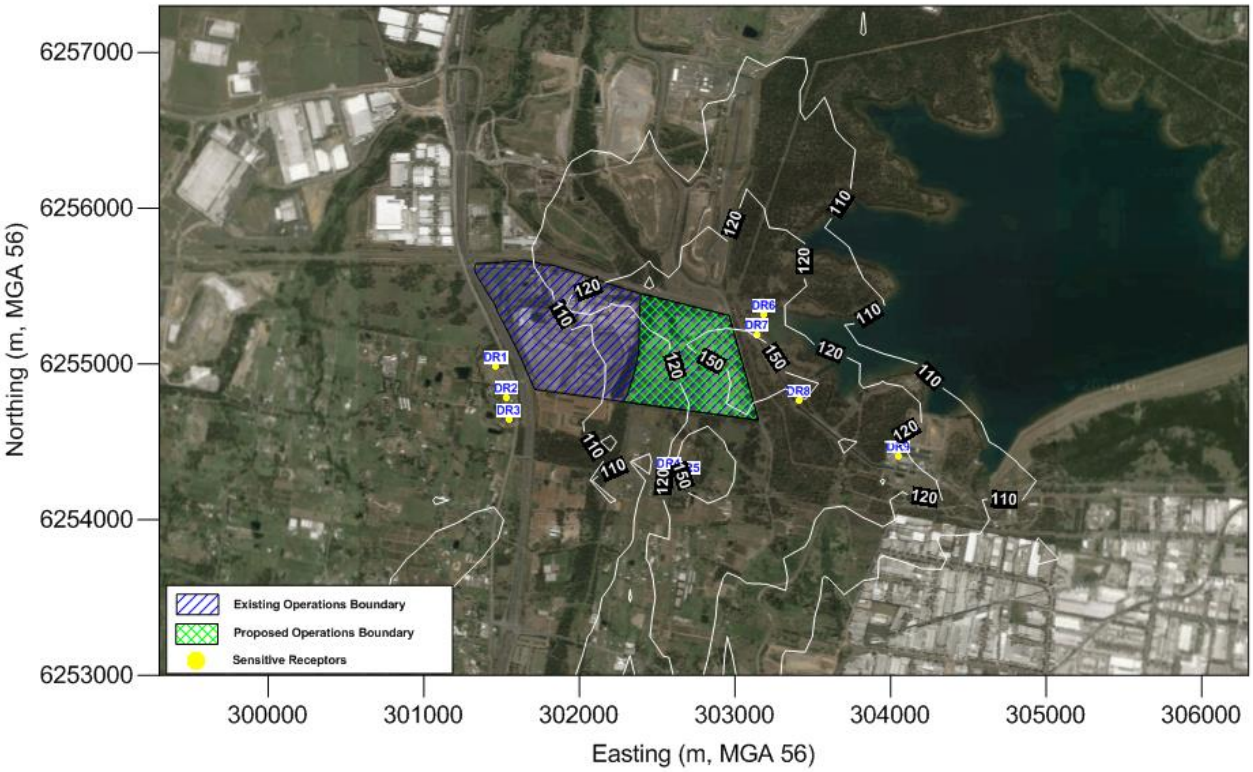


Figure B-28: Stage 1 (Natural Gas) Operations – Predicted Cumulative NO_2 1-Hour Average Concentrations (µg/m³) (Criteria: 246 µg/m³)

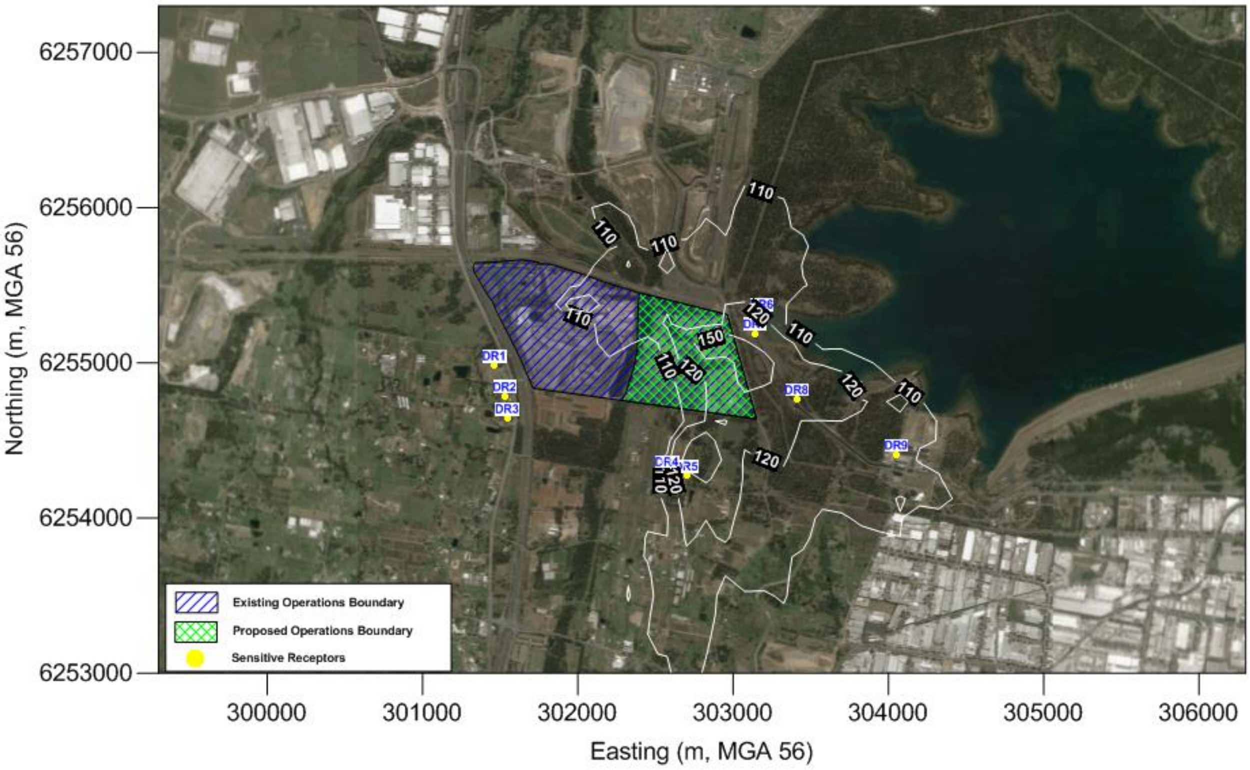


Figure B-29: Stage 2 (Coal) Operations – Predicted Cumulative NO_2 1-Hour Average Concentrations ($\mu g/m^3$) (Criteria: 246 $\mu g/m^3$)

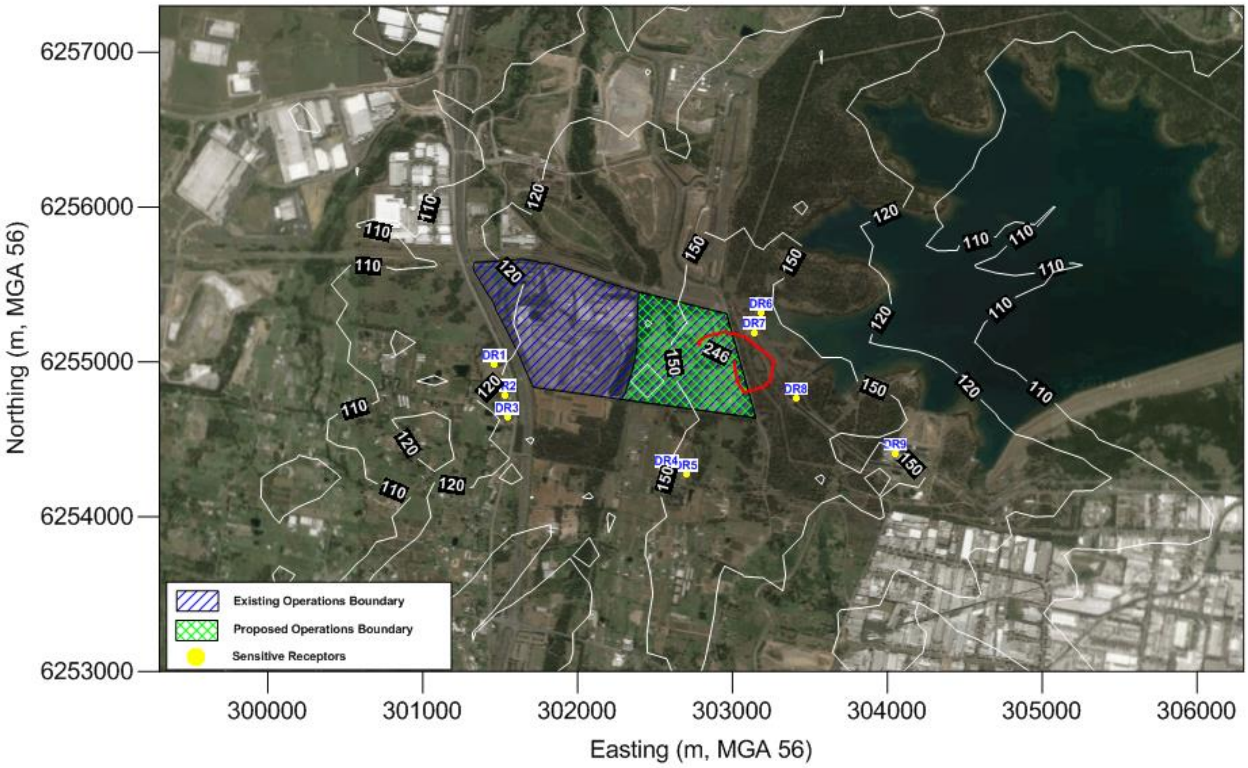
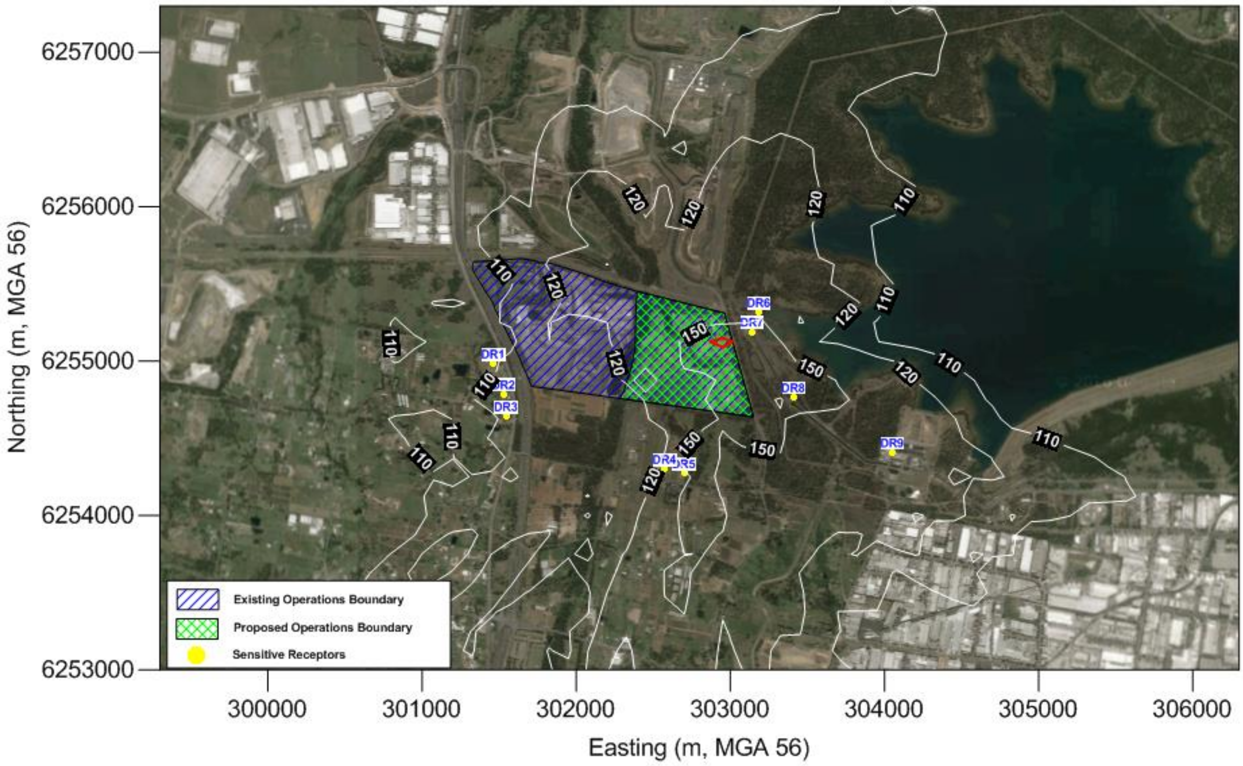


Figure B-30: Stage 2 (Natural Gas) Operations – Predicted Cumulative NO_2 1-Hour Average Concentrations ($\mu g/m^3$) (Criteria: 246 $\mu g/m^3$)

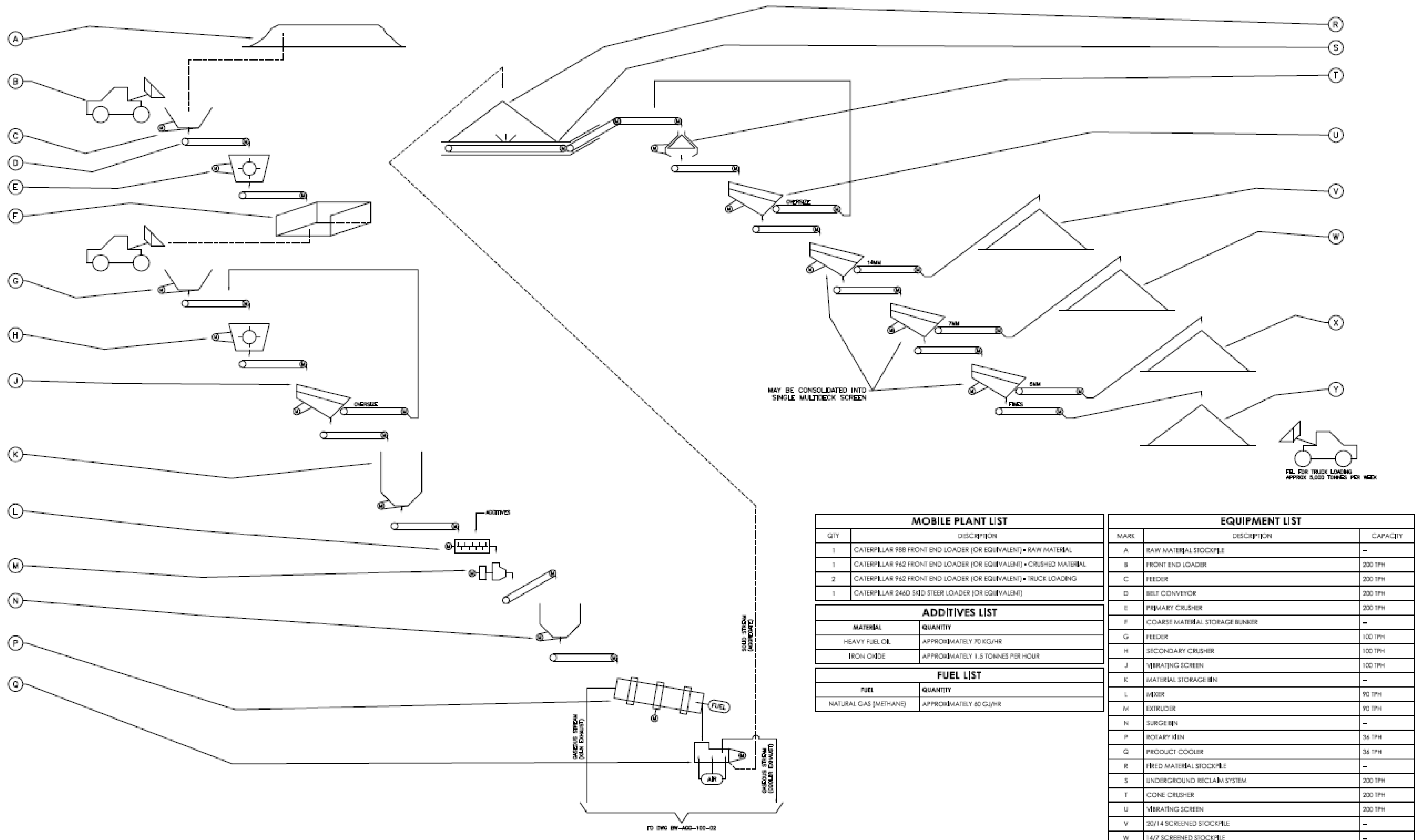


APPENDIX C – AIRLABS ENVIRONMENTAL CORRESPONDENCE WITH NSW-EPA

On the 12th of August, 2015, Mr. Abhilash Aitharaju (Abhi), Principal Air Quality Consultant from Airlabs Environmental Pty Ltd contacted Ms. Jacqueline Roberts – Operations Officer – Sydney Industry Section, NSW-EPA to discuss the Lightweight Aggregate (LWA) Air Quality Impact Assessment (AQIA). The aim of this exercise was to brief NSW-EPA about the methodology and the findings of the LWA-AQIA before a submission was made. During the telephone conversation, Ms. Jacqueline advised the Consultant that any discussion pertaining to the AQIA would be initiated post submission, and as-such, Airlabs are submitting the AQIA for Public Exhibition.

On the 1st of March, 2016, Mr. Abhilash Aitharaju (Abhi), Principal Air Quality Consultant from Airlabs Environmental Pty Ltd emailed Ms. Jacqueline Roberts – Operations Officer – Sydney Industry Section, NSW-EPA to inform that that Brickworks have decided on a change of fuel and as-such the only fuels that will be used for the LWA production are natural gas and pulverised coal. Abhilash informed Ms Jacqueline that the revised assessment will be prepared and will address the comments issued by the various regulatory agencies.

APPENDIX D – LWA - PROCESS FLOW DIAGRAMS



MOBILE PLANT LIST

QTY	DESCRIPTION
1	CATERPILLAR 988 FRONT END LOADER (OR EQUIVALENT) • RAW MATERIAL
1	CATERPILLAR 962 FRONT END LOADER (OR EQUIVALENT) • CRUSHED MATERIAL
2	CATERPILLAR 962 FRONT END LOADER (OR EQUIVALENT) • TRUCK LOADING
1	CATERPILLAR 246D SKID STEER LOADER (OR EQUIVALENT)

ADDITIVES LIST

MATERIAL	QUANTITY
HEAVY FUEL OIL	APPROXIMATELY 70 KG/HR
IRON OXIDE	APPROXIMATELY 1.5 TONNES PER HOUR

FUEL LIST

FUEL	QUANTITY
NATURAL GAS (METHANE)	APPROXIMATELY 60 GJ/HR

EQUIPMENT LIST

MARK	DESCRIPTION	CAPACITY
A	RAW MATERIAL STOCKPILE	–
B	FRONT END LOADER	200 TPH
C	FEEDER	200 TPH
D	BELT CONVEYOR	200 TPH
E	PRIMARY CRUSHER	200 TPH
F	COARSE MATERIAL STORAGE BUNKER	–
G	FEEDER	100 TPH
H	SECONDARY CRUSHER	100 TPH
J	VIBRATING SCREEN	100 TPH
K	MATERIAL STORAGE BIN	–
L	MIXER	90 TPH
M	EXTRUDER	90 TPH
N	SURGE BIN	–
P	ROTARY KILN	36 TPH
Q	PRODUCT COOLER	36 TPH
R	FIRED MATERIAL STOCKPILE	–
S	UNDERGROUND RECLAIM SYSTEM	200 TPH
T	CONE CRUSHER	200 TPH
U	VIBRATING SCREEN	200 TPH
V	20/14 SCREENED STOCKPILE	–
W	14/7 SCREENED STOCKPILE	–
X	7/5 SCREENED STOCKPILE	–
Y	FINES STOCKPILE	–

TITLE
PROCESS FLOW DIAGRAM
LIGHTWEIGHT AGGREGATE FACILITY

DRAWING NO:
BW-AGG-100-01

DRAWN:	DATE:	REV:
SAS	07.04.15	A

MOBILE PLANT LIST

QTY	DESCRIPTION
1	CATERPILLAR 988 FRONT END LOADER (OR EQUIVALENT) - RAW MATERIAL
1	CATERPILLAR 962 FRONT END LOADER (OR EQUIVALENT) - CRUSHED MATERIAL
2	CATERPILLAR 962 FRONT END LOADER (OR EQUIVALENT) - TRUCK LOADING
1	CATERPILLAR 246D SKID STEER LOADER (OR EQUIVALENT)

ADDITIVES LIST

MATERIAL	QUANTITY
HEAVY FUEL OIL	APPROXIMATELY 70 KG/HR
IRON OXIDE	APPROXIMATELY 1.5 TONNES PER HOUR

FUEL LIST

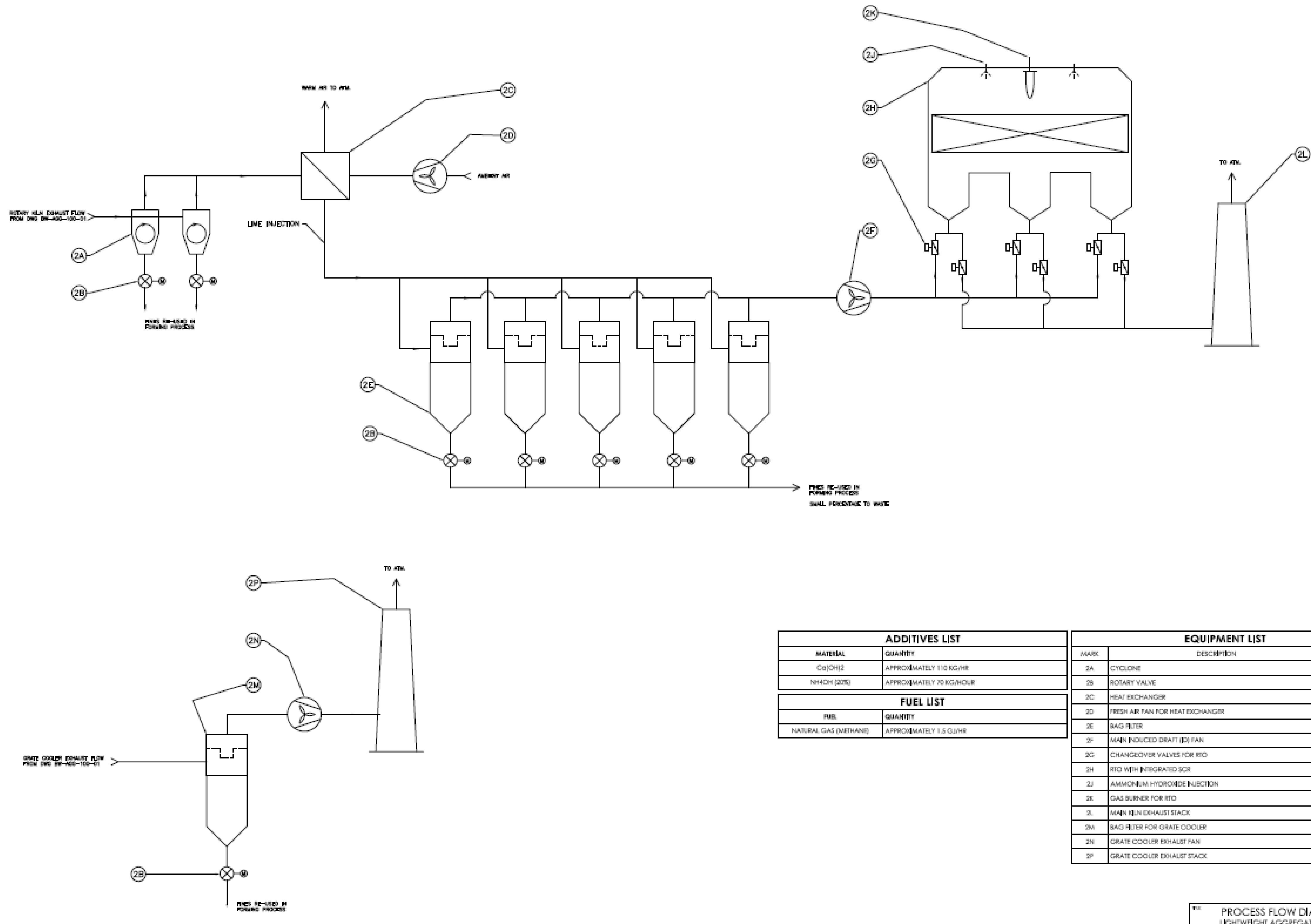
FUEL	QUANTITY
NATURAL GAS (METHANE)	APPROXIMATELY 60 GJ/HR

EQUIPMENT LIST

MARK	DESCRIPTION	CAPACITY
A	RAW MATERIAL STOCKPILE	–
B	FRONT END LOADER	200 TPH
C	FEEDER	200 TPH
D	BELT CONVEYOR	200 TPH
E	PRIMARY CRUSHER	200 TPH
F	COARSE MATERIAL STORAGE BUNKER	–
G	FEEDER	100 TPH
H	SECONDARY CRUSHER	100 TPH
J	VIBRATING SCREEN	100 TPH
K	MATERIAL STORAGE BIN	–
L	MIXER	90 TPH
M	EXTRUDER	90 TPH
N	SURGE BIN	–
P	ROTARY KILN	36 TPH
Q	PRODUCT COOLER	36 TPH
R	FIRED MATERIAL STOCKPILE	–
S	UNDERGROUND RECLAIM SYSTEM	200 TPH
T	CONE CRUSHER	200 TPH
U	VIBRATING SCREEN	200 TPH
V	20/14 SCREENED STOCKPILE	–
W	14/7 SCREENED STOCKPILE	–
X	7/5 SCREENED STOCKPILE	–
Y	FINES STOCKPILE	–

TITLE: PROCESS FLOW DIAGRAM
LIGHTWEIGHT AGGREGATE FACILITY
DRAWING #: BW-AGG-100-01
DRAWN: SAS
DATE: 07.04.15
REV: A
SHEET: 1 of 1
SIZE: A1
SCALE: 1:NTS

BRICKWORKS
REVISION: 1 ADDED AIR FLOW DATA 04.02.16
NSW2613



ADDITIVES LIST

MATERIAL	QUANTITY
Ca(OH)2	APPROXIMATELY 110 KG/HR
NH4OH (20%)	APPROXIMATELY 70 KG/HOUR

FUEL LIST

FUEL	QUANTITY
NATURAL GAS (METHANE)	APPROXIMATELY 1.5 GJ/HR

EQUIPMENT LIST

MARK	DESCRIPTION	CAPACITY
2A	CYCLONE	..
2B	ROTARY VALVE	..
2C	HEAT EXCHANGER	..
2D	FRESH AIR FAN FOR HEAT EXCHANGER	..
2E	BAG FILTER	..
2F	MAIN INDUCED DRAFT (ID) FAN	..
2G	CHANGEOVER VALVES FOR RTO	..
2H	RTO WITH INTEGRATED SCR	..
2J	AMMONIUM HYDROXIDE INJECTION	..
2K	GAS BURNER FOR RTO	..
2L	MAIN KILN EXHAUST STACK	..
2M	BAG FILTER FOR GRATE COOLER	..
2N	GRATE COOLER EXHAUST FAN	..
2P	GRATE COOLER EXHAUST STACK	

TITLE PROCESS FLOW DIAGRAM
LIGHTWEIGHT AGGREGATE FACILITY
DRAWING NO. BW-AGG-100-02

ADDITIVES LIST

MATERIAL	QUANTITY
$Ca(OH)_2$	APPROXIMATELY 110 KG/HR
NH_4OH (20%)	APPROXIMATELY 70 KG/HOUR

FUEL LIST

FUEL	QUANTITY
NATURAL GAS (METHANE)	APPROXIMATELY 1.5 GJ/HR

EQUIPMENT LIST

MARK	DESCRIPTION	CAPACITY
2A	CYCLONE	–
2B	ROTARY VALVE	–
2C	HEAT EXCHANGER	–
2D	FRESH AIR FAN FOR HEAT EXCHANGER	–
2E	BAG FILTER	–
2F	MAIN INDUCED DRAFT (ID) FAN	–
2G	CHANGEOVER VALVES FOR RTO	–
2H	RTO WITH INTEGRATED SCR	–
2J	AMMONIUM HYDROXIDE INJECTION	–
2K	GAS BURNER FOR RTO	–
2L	MAIN KILN EXHAUST STACK	–
2M	BAG FILTER FOR GRATE COOLER	–
2N	GRATE COOLER EXHAUST FAN	–
2P	GRATE COOLER EXHAUST STACK	

TITLE:
PROCESS FLOW DIAGRAM
LIGHTWEIGHT AGGREGATE FACILITY

DRAWING #:
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