WEST NOWRA RECYCLING & WASTE FACILITY

Proposed Stage 4 Landfill Extension
Air Quality Impact Assessment

Prepared for:

Shoalhaven City Council

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PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
2 Lincoln Street
Lane Cove NSW 2066 Australia
(PO Box 176 Lane Cove NSW 1595 Australia)
T: +61 2 9427 8100
E: sydney@slrconsulting.com   www.slrconsulting.com

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1 Introduction

Shoalhaven City Council (SCC) is proposing to develop an extension to the existing landfill operation (the Proposal) at the West Nowra Recycling and Waste Facility (the Facility) at Flatrock Road, Mundamia. This Air Quality Impact Assessment (AQIA) has been prepared by SLR Consulting (Australia) Pty Ltd (SLR) to provide an assessment of potential air quality impacts associated with the Proposal as an input to the Environmental Impact Statement (EIS).

This report has been prepared with reference to the guideline document Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA, 2017) (hereafter Approved Methods).

For the assessment of potential odour emissions, this report also refers to the Technical Framework: Assessment and management of odour from stationary sources in NSW (NSW DEC, 2006a) (hereafter the Odour Framework) and the Technical Notes: Assessment and management of odour from stationary sources in NSW (NSW DEC, 2006b) (hereafter the Technical Notes).

The Approved Methods and the Odour Framework outline the parameters that need to be determined in any AQIA as follows:

- All potential emission sources - materials, equipment or activities (including transport, waste management and maintenance) (**Section 5.1** and **Section 8**);
- All nearby receptors potentially affected by odour emissions (**Section 3.4**);
- Operating hours and times when intermittent emission generating activities are likely to occur (**Section 4.3**);
- Site features that may affect pollutant propagation and dispersion, including topography, vegetation, buildings and surrounding land uses (**Section 3**);
- The pollutant assessment criteria that were used to assess the proposal under current and future circumstances (for example, where possibility of a change in land use exists) (**Section 5**);
- Weather conditions particular to the site (including prevailing wind directions and the likelihood of inversions or katabatic drift) (**Section 3.3**and **Section 7.5**); and
- Likely air quality impacts (**Section 9**).

2 Assessment Required

The Secretary's Environmental Assessment Requirements (SEARs) for the Proposal were originally issued on 19 August 2015, (SSD 15_7187), updated on 11 July 2017 and an extension of time for submission granted on 22 September 2017. This AQIA addresses the SEARs and other agency requirements for the Proposal relevant to air quality. These requirements are listed in **Table 1**, along with where they are addressed in this report.

Table 1 Secretary's Environmental Assessment Requirements and Agency Requirements (SSD 15_7187)

Assessment Requirements	Section Addressed
NSW Department of Planning and Environment	
A quantitative assessment of the potential air quality and odour impacts of the development on surrounding receivers, including impacts from construction, operation and transport.	This report
Details of the proposed mitigation, management and monitoring measures.	**Section 10**
NSW Environmental Protection Agency (EPA)	
Identify all sources of air emissions from the development. *Note: emissions can be classed as either: - point (e.g. emissions from stack or vent) or - fugitive (from wind erosion, leakages or spillages, associated with loading or unloading, conveyors, storage facilities, plant and yard operation, vehicle movements (dust from road, exhausts, loss from load), land clearing and construction works).*	**Section 5.1** & **Section 8**
Provide details of the project that are essential for predicting and assessing air impacts including: a) the quantities and physio-chemical parameters (e.g. concentration, moisture content, bulk density, particle sizes etc.) of materials to be used, transported, produced or stored b) an outline of procedures for handling, transport, production and storage c) the management of solid, liquid and gaseous waste streams with potential for significant air impacts.	**Section 4** & **Section 8**
Describe the topography and surrounding land uses. Provide details of the exact locations of dwellings, schools, hospitals and nearby businesses/offices. Where appropriate provide a perspective view of the study area such as the terrain file used in dispersion models.	**Section 3.2** & **Section 3.4**
Describe surrounding buildings that may affect plume dispersion.	**Section 7.7**
Provide and analyse site representative data on following meteorological parameters: a) temperature and humidity b) rainfall, evaporation and cloud cover c) wind speed and direction d) atmospheric stability class e) mixing height (the height that emissions will be ultimately mixed in the atmosphere) f) katabatic air drainage g) air re-circulation	**Section 3.3**
Provide a description of existing air quality and meteorology, using existing information and site representative ambient monitoring data.	**Section 6**, & **Section 7.5**
Identify all pollutants of concern and estimate emissions by quantity (and size for particles), source and discharge point.	**Section 5.1** & **Section 8**

Assessment Requirements	Section Addressed
Estimate the resulting ground level concentrations of all pollutants. Where necessary (e.g. potentially significant impacts and complex terrain effects), use an appropriate dispersion model to estimate ambient pollutant concentrations. Discuss choice of model and parameters with the EPA.	**Section 9**
Describe the effects and significance of pollutant concentration on the environment, human health, amenity and regional ambient air quality standards or goals.	**Section 9**
Describe the contribution that the development will make to regional and global pollution, particularly in sensitive locations.	**Section 9**
For potentially odorous emissions, provide the emission rates in terms of odour units (determined by techniques compatible with EPA procedures). Use sampling and analysis techniques for individual or complex odours and for point or diffuse sources, as appropriate. *Note: With dust and odour, it may be possible to use data from existing similar activities to generate emission rates*.	**Section 8**
Outline specifications of pollution control equipment (including manufacturer's performance guarantees where available) and management protocols for both point and fugitive emissions. Where possible, this should include cleaner production processes.	**Section 10**
Identify the extent that the receiving environment is already stressed by existing development and background levels of emissions to which this proposal will contribute.	**Section 6**
Assess the impact of the proposal against the long term air quality objectives for the area or region.	**Section 9**

3 Site Description

3.1 Site Location

The primary solid waste landfill that services the Shoalhaven Local Government Area is the West Nowra Recycling and Waste Facility (Facility), and it is located at 120 Flatrock Road, Mundamia, approximately 3.8 km west of Nowra. The Facility is operated by SCC. The Facility currently receives waste from nine waste transfer stations and a domestic waste collections service, as well as public and commercial drop-off direct to the Facility. The location of the Facility is shown in **Figure 1**.

The Facility is located on parcels of land owned by SCC and includes 14.5 ha of undeveloped land within the site boundary, part of which is proposed for the Stage 4 extension (the Proposal) of the existing landfill, as well as for environmental offsets. The proposed Stage 4 landfill extension area is on Lot 1 DP 1104402, which is to the east of Stages 2 (Lot 1 DP 847203) and 3 (Lot 1 DP 870268) as shown in **Figure 2**.

The Facility is located in close proximity to the Office of Environment and Heritage (OEH) Nowra Area Office and Depot, as well as the RSPCA Shoalhaven Animal Shelter[1]. A small number of rural residential properties are located south of the Facility and the Shoalhaven Campus of the University of Wollongong is located approximately 1 km to the east. The remaining land surrounding the Facility is undeveloped bushland – primarily the Bamarang Nature Reserve and/or land owned by the Nowra Local Aboriginal Land Council and the proponent. Sensitive receptors identified for this assessment are discussed in Section 3.4.

1 Note that the RSPCA Shoalhaven Animal Shelter has permanently closed since compilation of this report and hence this receptor is no longer considered relevant to the air quality assessment herein.

Figure 1 Facility Location

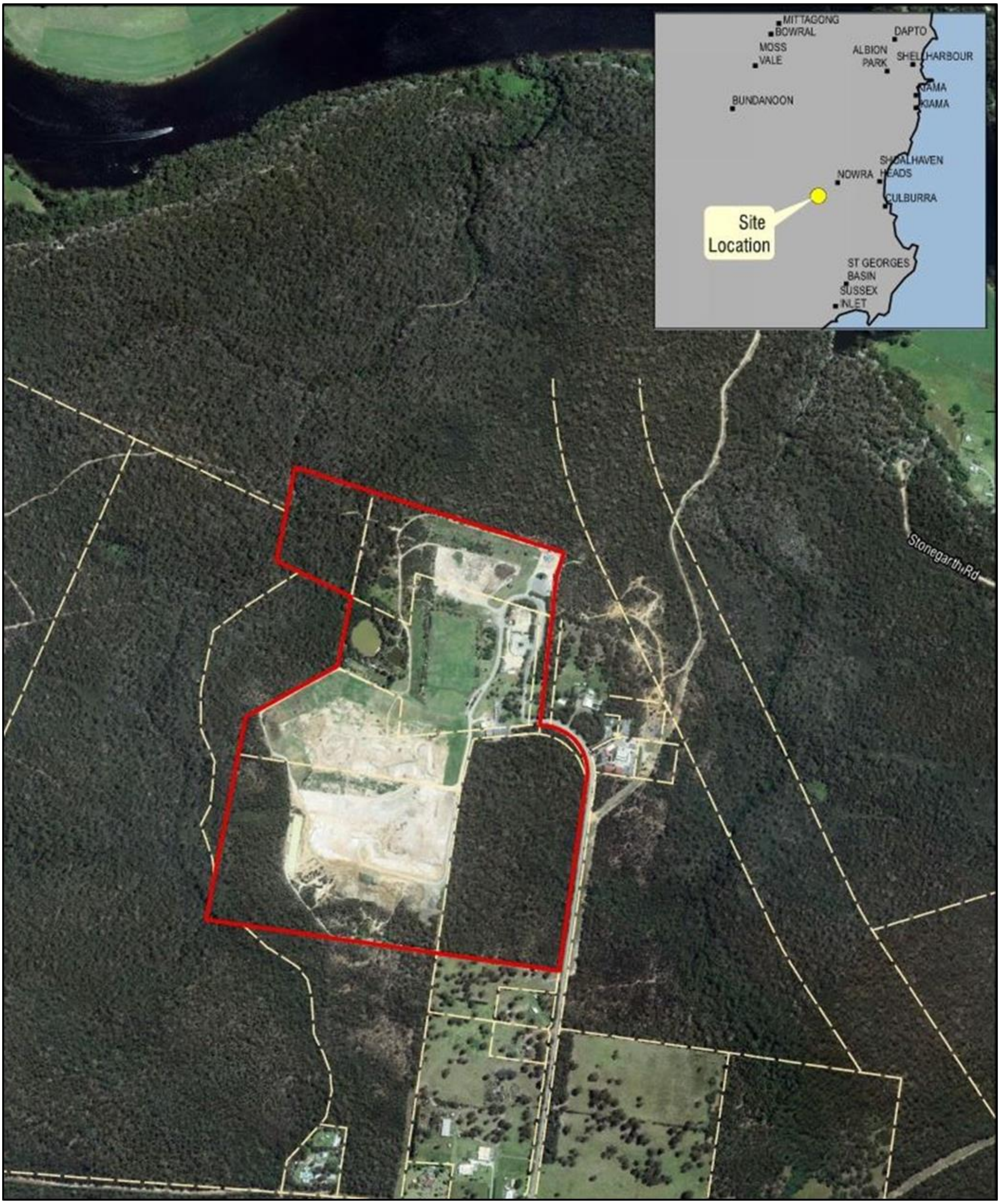
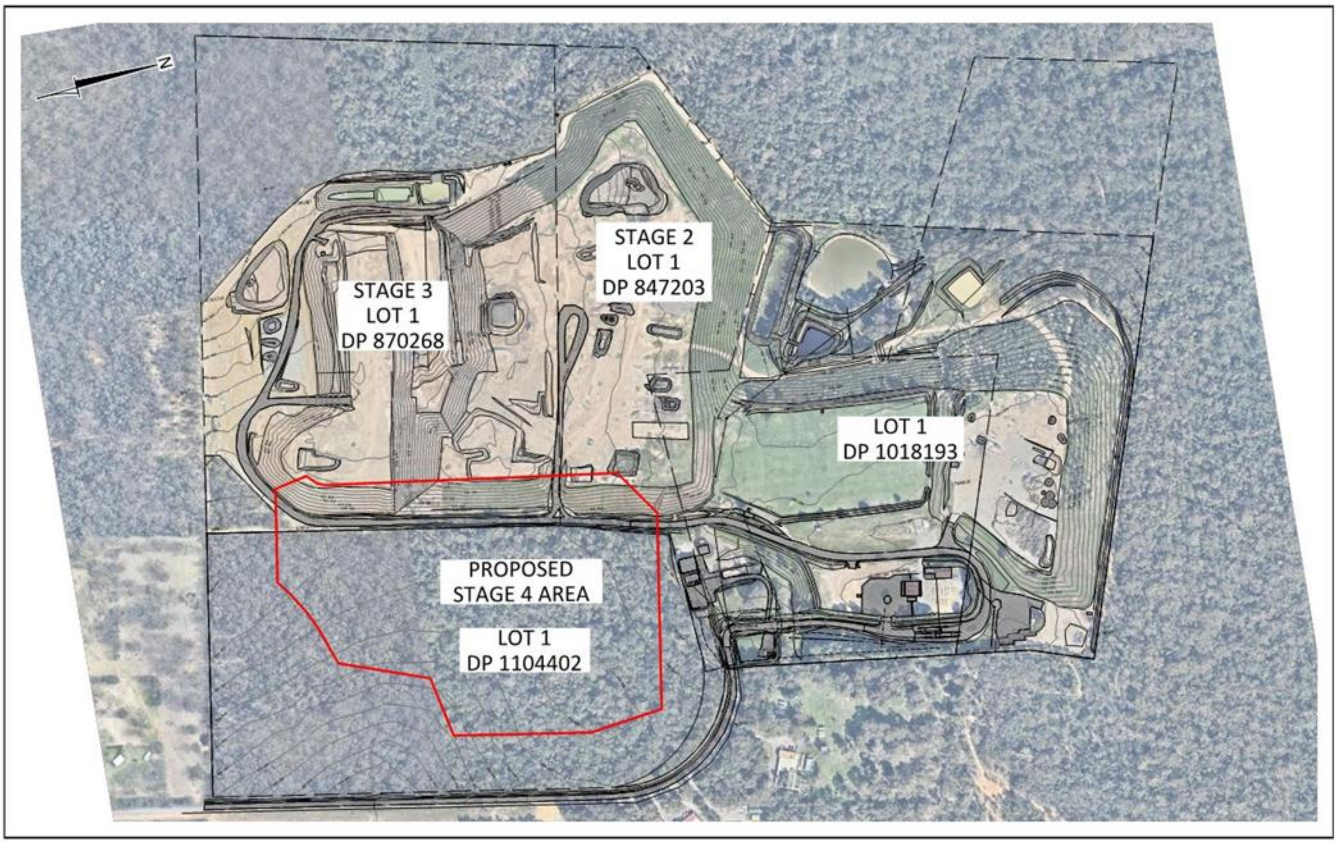


Figure 2 Overview of Proposed Stage 4 Landfill Extension Area



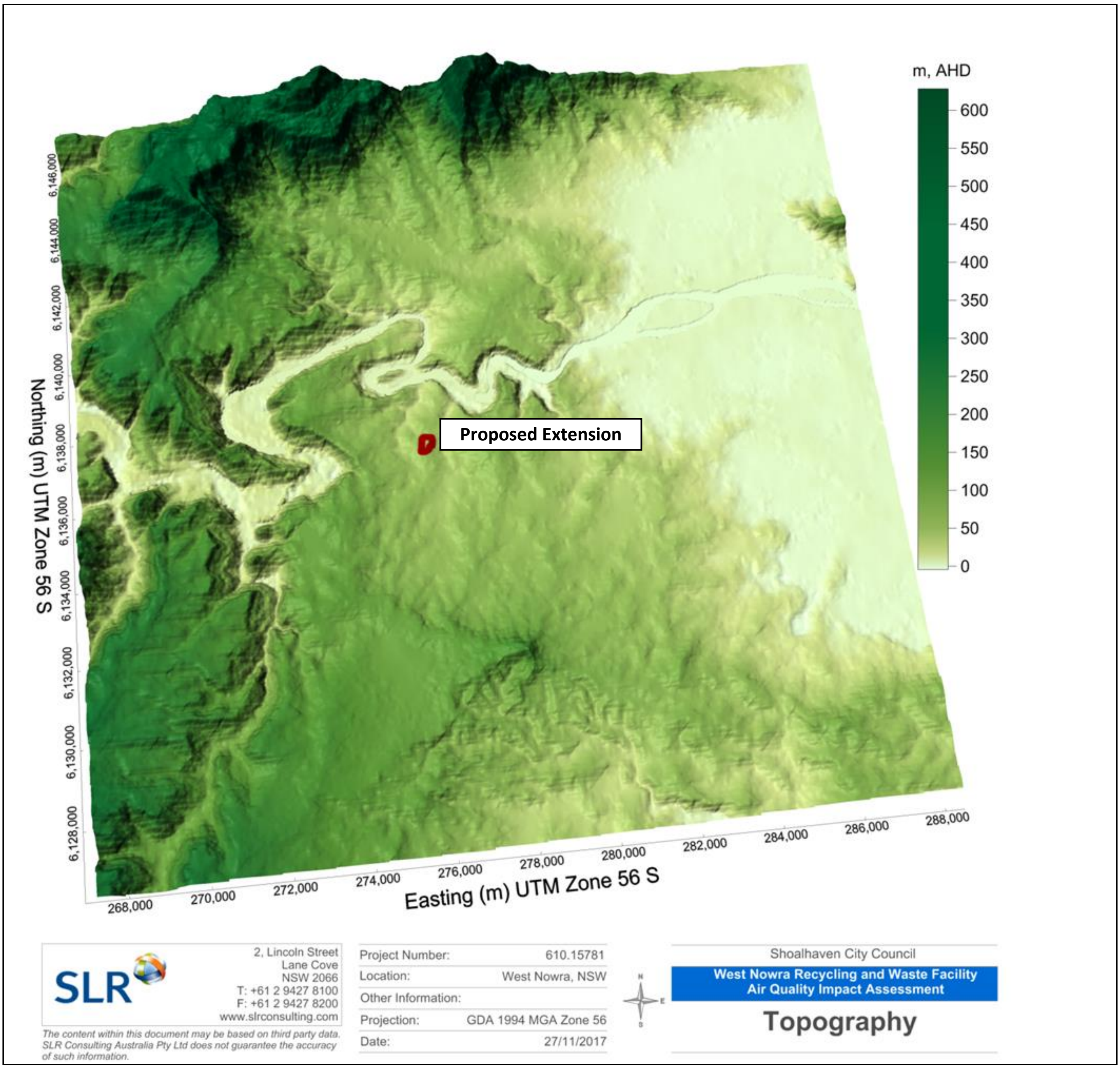
3.2 Local Topography

The Stage 4 landfill extension site is located approximately 1.5 km south and 2.5 km east of the Shoalhaven River. It is located on the eastern side of a ridge line, and is predominantly flat. There are several drainage features that border the extension site, with the area being predominantly drained by Cabbage Tree Creek, which flows northward to the Shoalhaven River.

The undisturbed site area that is being investigated for the Proposal is approximately an area of 14.52 ha (of which 9.94 ha is proposed to be disturbed). The lowest point of the site is approximately RL 41 m, and the highest point of the site approximately RL 50 m. The topography of the site is relatively flat with some undulatory variation.

The topography of the site and surrounds is illustrated in **Figure 3**.

Figure 3 Site Topography



3.3 Local Meteorology

The climate in the Nowra area is similar to that of the broader Wollongong region with warm to hot summers and cool to mild winters. The local climate at the West Nowra site is affected by broader regional patterns of synoptic pressure and wind with embedded weather systems. Synoptic features vary in intensity and location according to the season. For instance, during summer a high-pressure belt is usually found over or just to the south of Australia, bringing warm weather while the subtropical easterlies cover most of the continent. In winter, the subtropical high-pressure belt is usually located further north over the continent, allowing westerly winds and occasional to frequent strong cold fronts to affect southern Australia.

The nearest available automatic weather station (AWS) collecting data suitable for use in a quantitative air dispersion modelling study operated by the Bureau of Meteorology (BoM) is located at Nowra Airport, 6.7 km to the south-southwest. The Nowra RAN Air Station AWS (Station 68072, elevation 109 m), has data available from 2000 to 2017 for the following parameters:

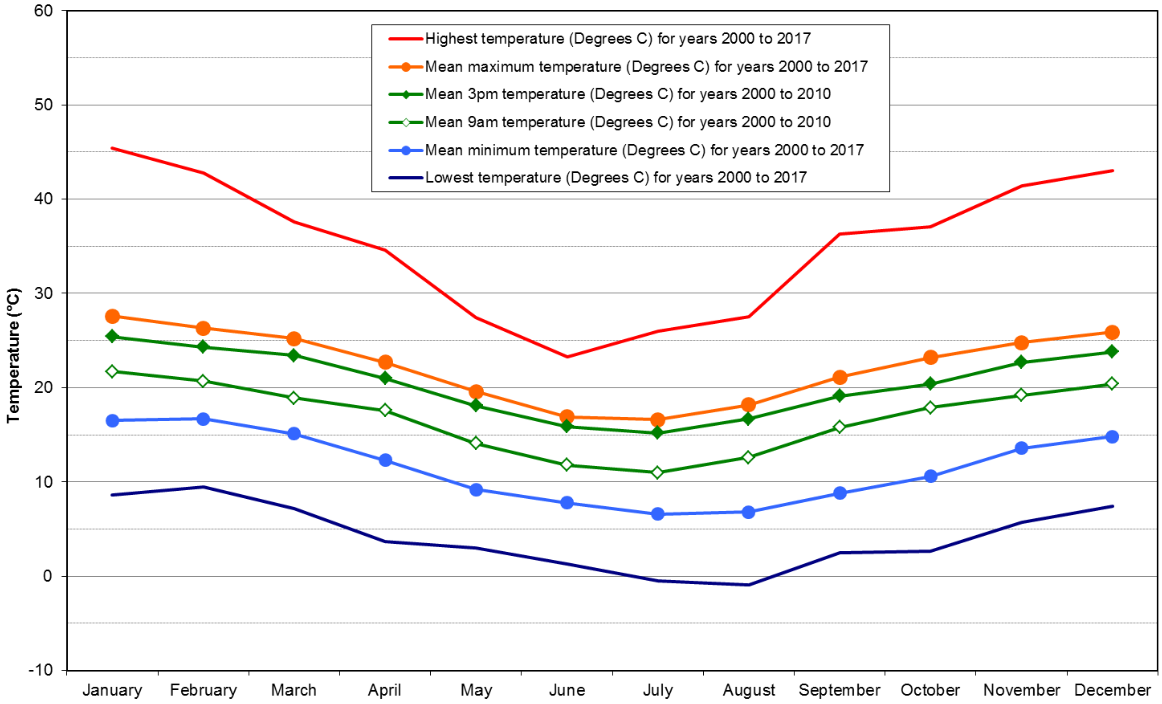
- Temperature (°C);
- Rainfall (mm);
- Relative humidity (%); and
- Wind speed (m/s) and wind direction (degrees).

A review of the long term data collected by this AWS is provided in the following sections

3.3.1 Temperature

Long-term temperature statistics for the Nowra RAN Air Station AWS are summarised in **Figure 4**. Mean maximum temperatures range from 16.0°C in winter to 27°C in summer, while mean minimum temperatures range from 6°C in winter to around 17°C in summer. Maximum temperatures above 45°C and minimum temperatures less than -5°C have been recorded.

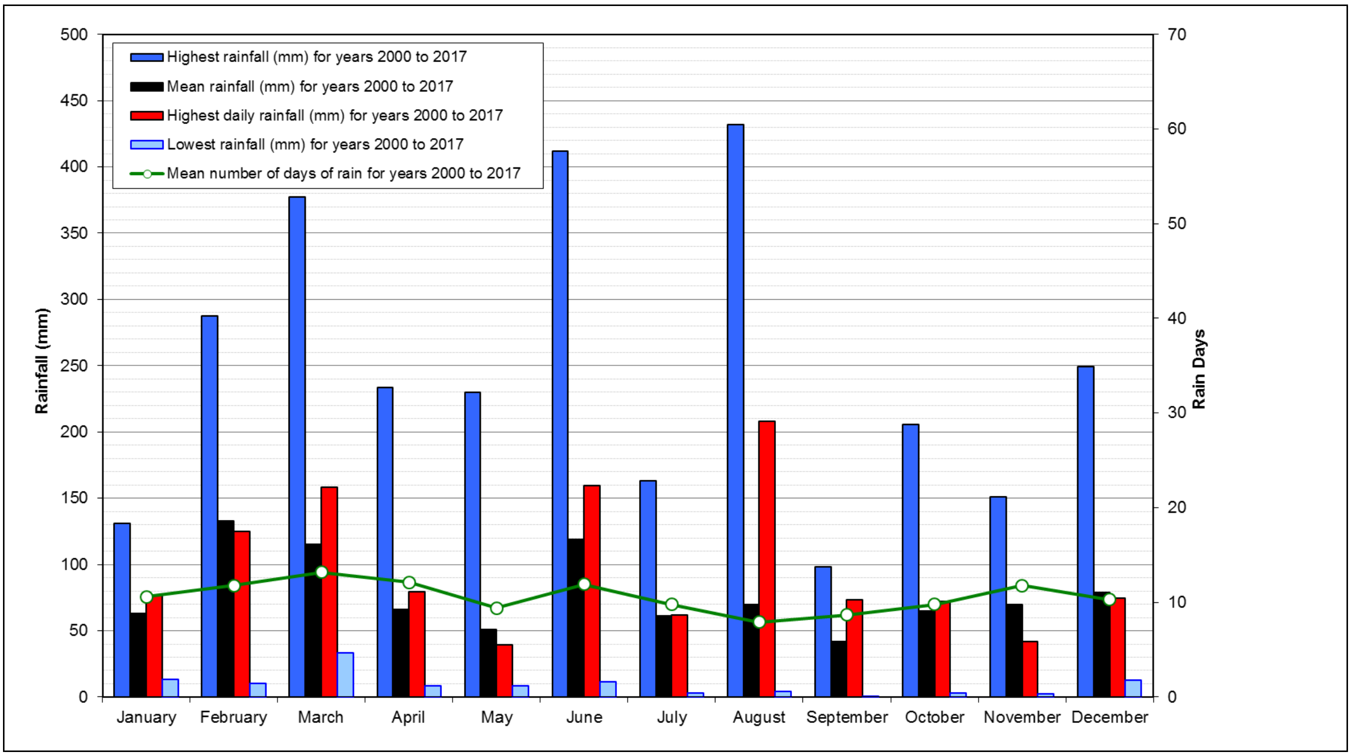
Figure 4 Long-Term Temperature Data for Nowra



3.3.2 Rainfall

Long-term rainfall statistics for the Nowra RAN Air Station AWS are summarised in **Figure 5.** The average annual rainfall in the region is 901.5 mm, with the average monthly rainfall ranging from 51 mm to 133 mm. The driest months are in late winter and spring, with the higher rainfalls experienced in the summer months.

Figure 5 Long-Term Monthly Rainfall Data for Nowra



3.3.3 Relative Humidity

Long-term humidity statistics (9 am and 3 pm monthly averages) for the Nowra RAN Air Station AWS are summarised in **Figure 6**. Morning humidity levels range from an average of around 75% in late summer to around 55% in late spring. Afternoon humidity levels are slightly lower, at around 63% in late summer and dropping to a low of 46% in late winter.

3.3.4 Wind Speed and Direction

Long term wind data (9 am and 3 pm) for the Nowra RAN Air Station AWS are presented as wind roses in **Figure 7**. The wind roses show winds from the northwest dominating during the morning while afternoon winds are more variable. Winds are also stronger in the afternoon than during the morning.

Figure 6 Long-Term Humidity Data for Nowra

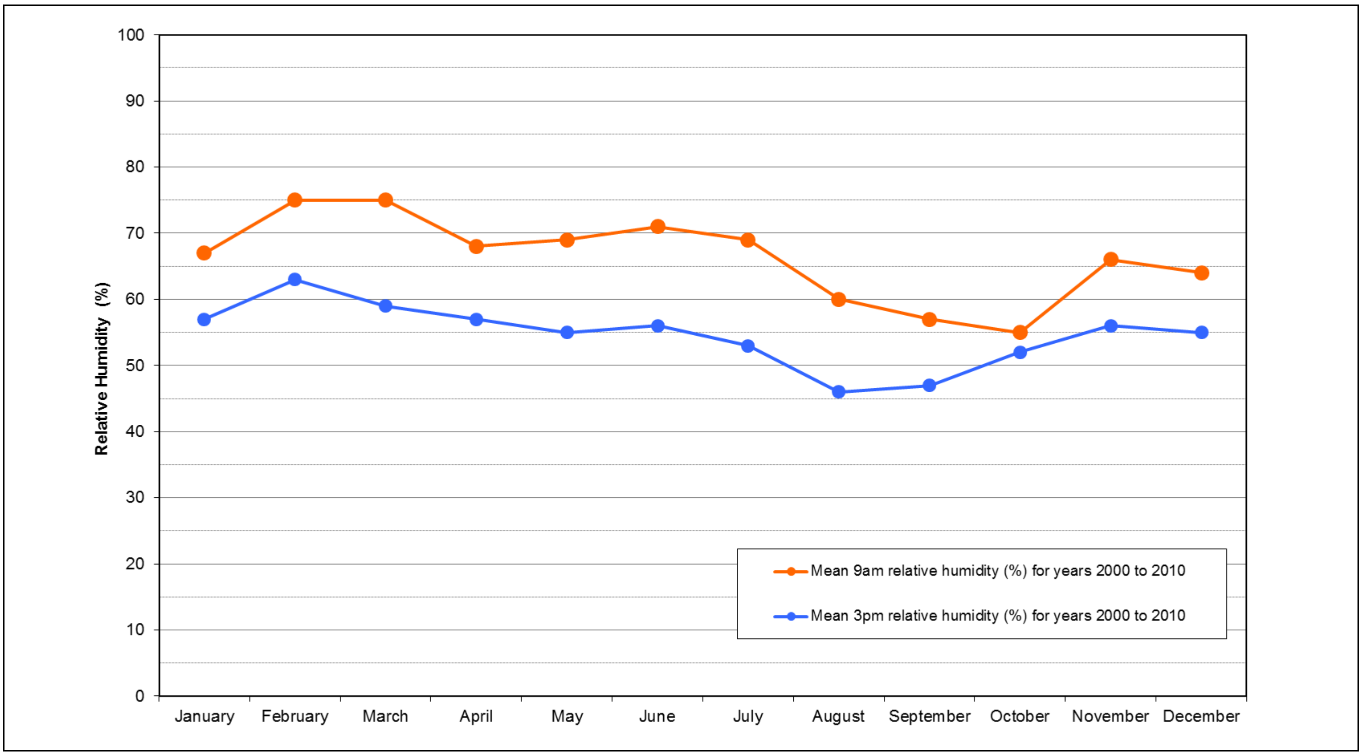
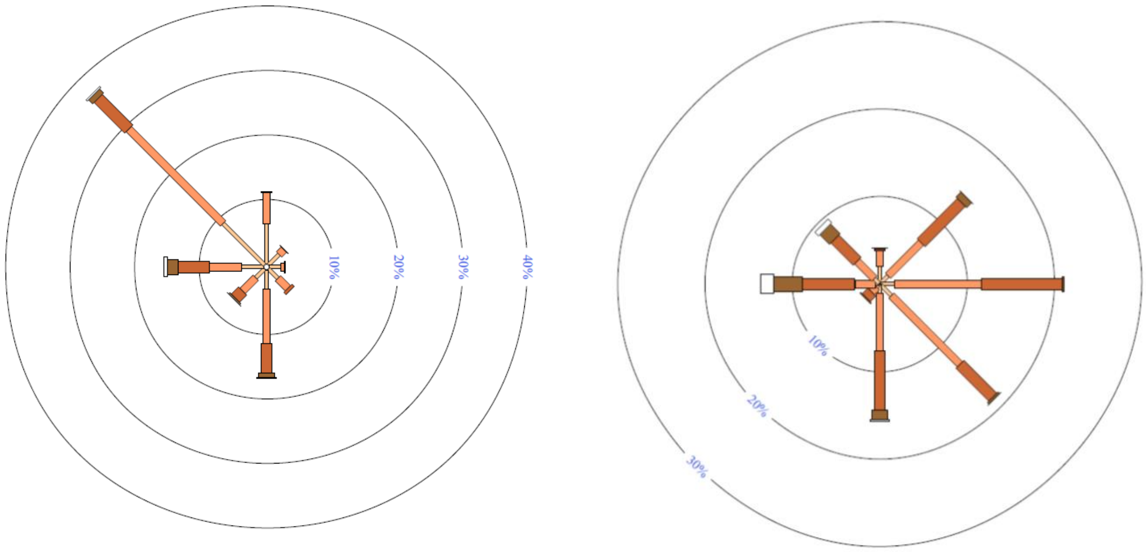
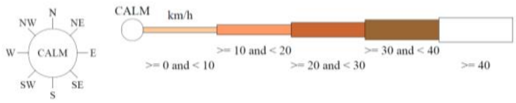


Figure 7 9am and 3pm Wind Roses - Nowra Airport AWS Wind Data (2000 - 2017)



9 am (6,006 total observations)
2.0% Calms

3 pm (6,010 total observations)
<0.5% Calms



3.4 Sensitive Receptors

A sensitive receptor is defined in the Odour Framework (NSW DEC, 2006a) as:

> *A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area.*

The nearest existing sensitive receptors to the Facility are shown in **Figure 8** and listed in **Table 2**. The closest residential receptor is located approximately 88 m to the south of the Proposal site.

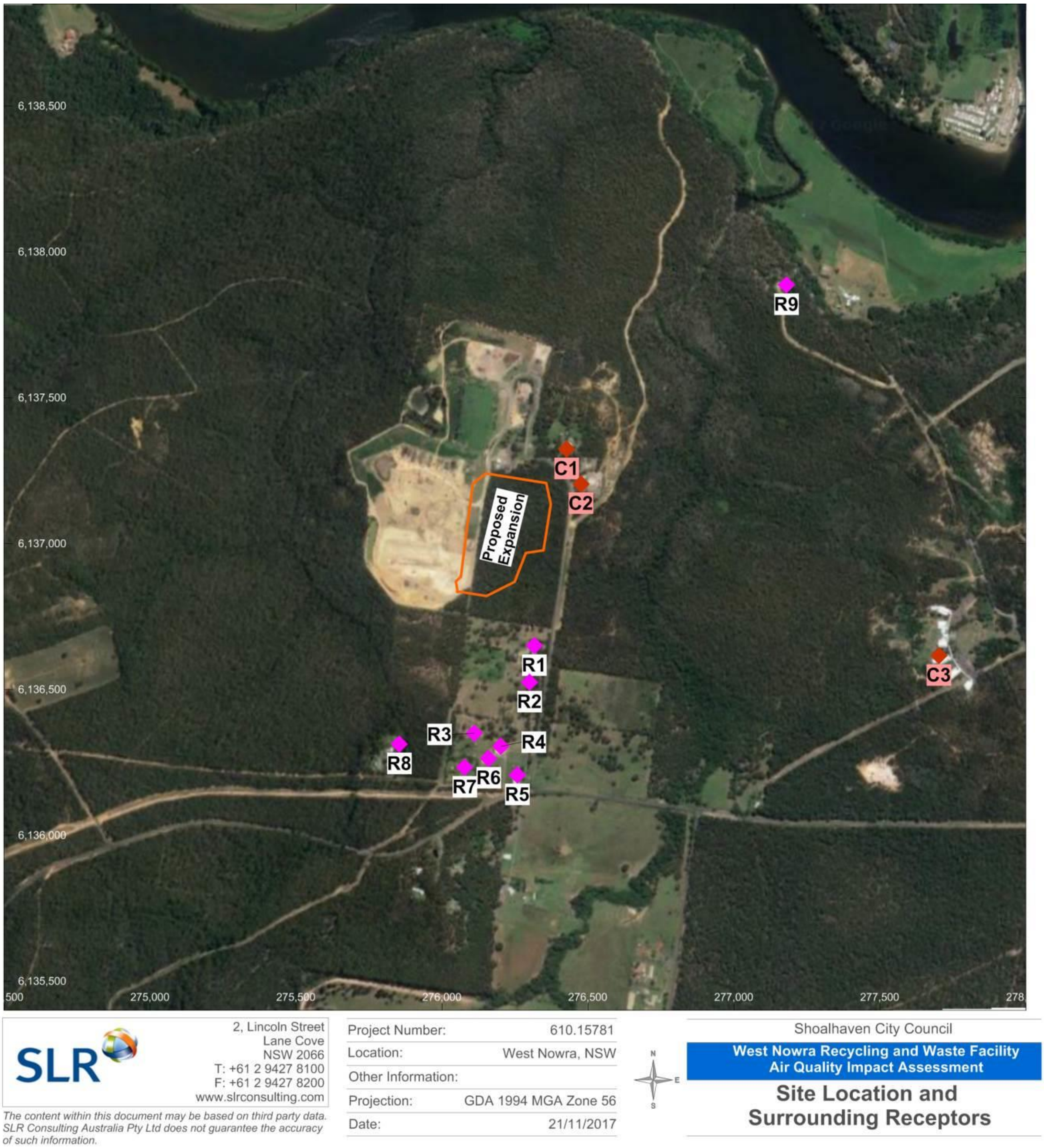
A number of non-residential receptors have also been included in the modelling. Of these, the University of Wollongong Shoalhaven Campus, as an educational institution, is considered to be the most likely to be sensitive to air quality impacts. The RSPCA Shoalhaven Animal Shelter (now closed) and OEH offices are located adjacent to the Facility, and it is considered reasonable that they would expect some minor amenity impacts such as intermittent odours and dust, given their close proximity. People will also not be present at these locations on a continuous basis, especially in the evening and at night when the highest off-site odour concentrations are most likely to occur.

Table 2 Nearest Sensitive Receptors and Land Uses

ID	Name	Co-ordinates (kmN, kmE)	Approximate Distance/Direction from the Stage 4 Extension
Residential			
R1 *	Residential dwelling, 43 Flatrock Road	(276,316, 6,136,650)	88 m south
R2	Residential dwelling, 41 Flatrock Road	(276,300, 6,136,525)	190 m south
R3	Residential dwelling/shed, 3 Flatrock Road	(276,110, 6,136,350)	375 m south
R4	Residential dwelling, 3 Flatrock Road	(276,202, 6,136,305)	420 m south
R5	Residential dwelling, 3 Flatrock Road	(276,258, 6,136,207)	513 m south
R6	Residential dwelling, 3 Flatrock Road	(276,160, 6,136,264)	466 m south
R7	Residential dwelling, 18 Bamarang Road	(276,078, 6,136,233)	511 m south
R8	Jim Da Silva Farm, 38A Old Bamarang Drive	(275,854, 6,136,313)	550 m southwest
R9	56 Stonegarth Road	(277,180, 6,137,887)	1.0 km northeast
Commercial/Educational			
C1	RSPCA Shoalhaven Animal Shelter	(276,427, 6,137,324)	85 m northeast
C2	OEH buildings	(276,476, 6,137,205)	55 m northeast
C3	University of Wollongong – Shoalhaven Campus	(277,702, 6,136,616)	1.3 km east

* This receptor location is based on the nearest legal dwelling on this property. It is noted that there is an illegal dwelling located on this property at approximately 65 m from the Stage 4 Extension site boundary, however as it is not a legal dwelling, it has not been included as a sensitive receptor.

Figure 8 Sensitive Receptor Locations



4 Current and Proposed Operations

The Facility commenced operation in 1979. The current landfill operations were approved in 1988 under Environment Protection Licence (EPL) number 5877. The landfill originally received domestic, industrial and commercial liquid and solid wastes. Additionally, it has also received hazardous wastes such as asbestos and oil; however, with the exception of asbestos waste, the disposal of these wastes has been prohibited since 1996.

Historically, the landfill practices have consisted of the excavation and filling of a series of trenches. The development of the landfill has been divided into stages, which are:

- Stage 1 - “old” landfill area, stockpile and irrigation areas, and landfill gas extraction;
- Stage 2 - recently completed landfill area, currently utilised for stockpiling and landfill gas extraction;
- Stage 3 - the active landfill disposal area(s) and wet weather tipping area; and
- Stage 4 - proposed Stage 4 landfill extension area.

4.1 Current Operations

Current activities at the Facility include:

- Landfilling of approximately 65,000 tonnes per annum (tpa) of general solid waste; and
- Composting of approximately 3,300 tpa of green waste.

The Facility includes the following:

- Site administration office and staff amenity building;
- Plant and equipment shed for equipment maintenance and storage, and additional storage sheds for equipment;
- Gatehouse / weighbridge office and two weighbridges (entry and exit);
- Transfer Station;
- Tyre collection;
- Non-ferrous collection area;
- Green waste stockpile and processing area;
- Steel waste stockpiles and processing area;
- Construction & demolition waste stockpile area;
- Virgin Excavated Natural Material (VENM) stockpile area;
- Pavement materials stockpile area;
- CRT Cell;
- Recycling sorting and collection area;
- Buyback area;
- Landfill gas management infrastructure (generator & flare);

- Site water management infrastructure (sediment, leachate collection and first flush capture dams); and
- Irrigation area.

The composition of and quantities of waste currently received at the Facility is summarised in **Table 3** (SLR, 2017a).

Table 3 Summary of Waste Types and Quantities for the 2015/2016 Financial Year

Waste Type	Quantity (tonnes)	
	Landfilled	**Recycled**
Construction and Demolition (C&D)	8,599	542
Commercial and Industrial (C&I)	19,287	1,079
Green waste	0	3,331
Domestic kerbside	28,020	0
Drop off domestic	8,376	328
Other landfill	1,307	0
Total	**65,589**	**5,280**

4.1.1 Landfilling

As noted above, the current input rate for landfilling of waste at the Facility is approximately 65,000 tpa (mixed waste - Class 1 and 2 (putrescible and non-putrescible)).

Materials delivered to the Facility are inspected and screened at the weighbridge, by SCC staff to ensure unacceptable loads of waste are not disposed at the Facility. In the event that unacceptable waste is identified in an incoming vehicle, the vehicle is refused entry, redirected to an appropriate disposal facility and details of the incident recorded. Inspection and screening of waste is also performed at active landfilling and stockpiling areas.

Waste, from heavy vehicles, accepted for landfilling is transported to the active landfilling area and unloaded. A dozer is then used to position the waste, and an articulated landfill compactor is used to compact the waste. VENM is used as a daily cover material at the end of the working day to suppress odour emissions and prevent litter being blown from the active landfilling area overnight. Recently, the NSW EPA approved the use of an Automated Tarp Deployment System (ATDS) at the Facility as an alternative to VENM for daily cover. Intermediate cover is used on landfill areas that have not been used for more than three months.

There is an existing landfill gas (LFG) extraction, cogeneration (generator) and treatment (flare) system operating at the Facility, which manages LFG generated from Stages 1 to 3. Between August 2013 and August 2014, the system generated approximately 6,403 megawatt hours (MWh) and the flare destroyed an amount of methane gas equivalent to 26,739 tonnes of carbon dioxide (SLR, 2017).

4.1.2 Green Waste Composting and Other Recycling Operations

The on-site composting operations produce a range of products suitable for mulch and compost applications. The green waste composting operations are located at the northeastern end of the Facility on rehabilitated areas of former landfilled areas. An overview of the activities performed as part of the composting operations is provided in **Table 4**.

In addition to the composting operation, the other recycling operations carried out on-site relevant to air emissions is the periodic processing of builders' waste (clean separated concrete, brick and tiles) received as part of the C&D waste. Concrete, bricks and tiles are stockpiled until there is a sufficient amount to be processed by a mobile crusher unit, with this activity only undertaken on an as-needs basis.

Table 4 Green Waste Composting Process

Stage	Activity	Duration
1	**Receival, decontamination and grinding/shredding** Incoming garden organics is delivered to the receival/ decontamination area and shredding area where gross contaminants are removed, and the organics ground and/or shredded.	1 to 4 weeks
2	**Static stockpile - watering and turning** The material is then stockpiled for approximately three months – some water may be added at this stage to maintain moisture levels. During this phase the compost may be turned (every two weeks or monthly) and watered. The temperature of the piles is monitored regularly.	3 months
3	**Windrows for maturation** After approximately three months the material is then formed into windrows for further maturation. The windrows are turned and watered as required. Turning generally occurs weekly. The temperature of the piles is monitored regularly.	3 months
4	**Matured product** At the completion of the maturation phase the matured compost is stored ready to be sold to commercial operators or given back to the community for free.	-

4.2 Proposed Operations

It is proposed to develop the Stage 4 landfill extension in six (6) landfill cell sub-stages, sequentially filled and moving from south (Landfill Cell 1) to north (Landfill Cell 6) with progressive side slope excavation and liner construction as required. The layout of the landfill cells sub-stages is shown in **Figure 9**. The final landfill capacity will be approximately 1,385,600 m^3 upon completion, at an approximate maximum elevation of RL 59 m at the top of the batter slope.

The base excavations will be performed in a staged manner with Landfill Cells 1 and 2 being excavated during the initial development phase, and Cells 3 to 6 progressively excavated during the life of Stage 4. As noted above, the waste landfilling sequence is to be developed from south to north. As each landfill cell stage is developed to nearing final waste filling design capacity, construction of an adjacent landfill cell stage will commence. Access to each landfill cell stage is proposed via access ramps from road infrastructure between Stages 2 and 3, and Stage 4. These access ramps will be maintained until construction of each landfill cell stage is completed.

It is proposed to divert Stage 4 leachate to the existing leachate collection dam. It is anticipated that the quality of the leachate generated from Stage 4 should be similar to that currently generated in the Stages 2 and 3 landfill cells as the wastes types disposed into Stage 4 will be similar to the types already disposed. As a result, the Facility proposes to manage leachate generated from Stage 4 using the existing leachate management infrastructure, which includes a collection system and leachate storage dam.

As per the existing landfill EPL 5877, the leachate currently collected in the leachate dam from Stages 1-3 may be irrigated over the following areas:

- Spraying over the "irrigation area"/"utilisation area" (EPA Identification No. 26 in EPL Number 5877), immediately north of Stage 2, and/or
- Irrigation at waste tipping faces.

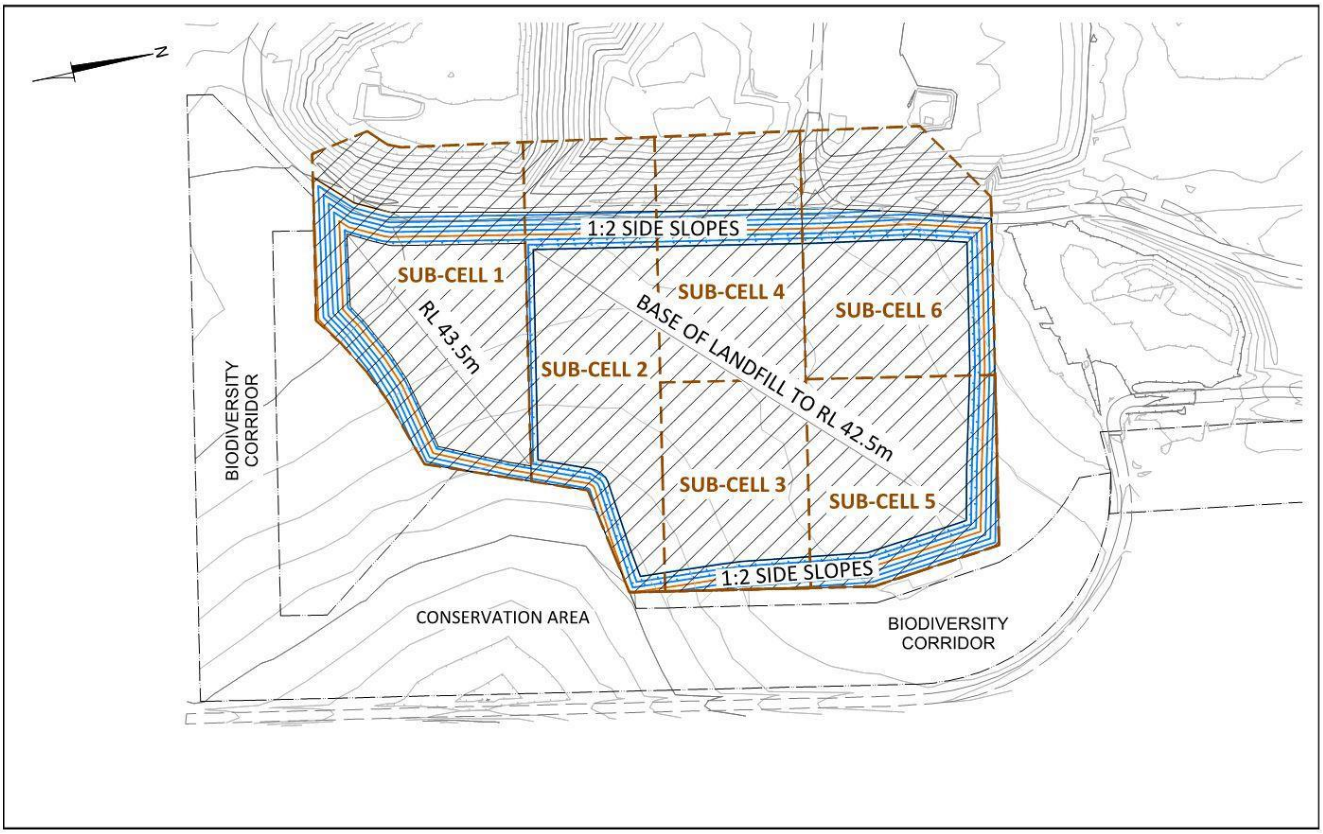
Due to the increase of leachate quantity from the Stage 4 extension and the potential for the existing irrigation area to result in the seepage of leachate off-site (due to it being located on a closed unlined landfill cell), a new irrigation area has been proposed. The new irrigation area will be a minimum of 14,000 m^2 in area, as determined by Hydrological Evaluation of Landfill Performance (HELP) modelling (SLR Leachate Management Memo, 2018). The proposed location for the new irrigation area will be on the surface of the existing lined Stage 2.

LFG generated from Stage 4 is also expected to be managed by the existing system. At this stage is has not been determined if the existing LFG extraction system has the ability and capacity to manage the additional LFG expected to be generated from Stage 4, or whether an upgrade will be required, and this will be assessed during the detailed design phase. This AQIA is based on the assumption that there will be no changes to the LFG extraction system that will significantly affect air emissions.

4.3 Operating Hours

The current operating hours for the Facility are 8 am - 5 pm Monday to Sunday and closed on public holidays, except Easter Monday.

Figure 9 Proposed Landfill Cell Sub-Stages Layout



5 Air Quality Criteria

5.1 Pollutants Assessed

The main air emissions associated with the current and proposed operations at the Facility are dust and odour emissions. The potential for these emissions to result in off-site air quality impacts have been assessed in a detailed atmospheric dispersion modelling study as described in the following sections.

There will also be emissions of diesel combustion products from the vehicles and mobile machinery working on the site, and gas combustion products from the burning of LFG in the on-site generator and flare. However these emissions do not have the potential to result in significant off-site air quality impacts and have not been considered further.

5.2 Impact Assessment Criteria

5.2.1 Odour

Impacts from odorous air contaminants are often nuisance-related rather than health-related. Odour performance goals guide decisions on odour management, but are generally not intended to achieve "no odour".

The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the *odour threshold* and defines one odour unit (ou). An odour goal of less than 1 ou would theoretically result in no odour impact being experienced.

In practice, the character of a particular odour can only be judged by the receiver's reaction to it, and preferably only compared to another odour under similar social and regional conditions. Based on the literature available, the level at which an odour is perceived to be a nuisance can range from 2 ou to 10 ou depending on a combination of the following factors:

- *Odour Quality*: whether an odour results from a pure compound or from a mixture of compounds. Pure compounds tend to have a higher threshold (lower offensiveness) than a mixture of compounds.
- *Population sensitivity:* any given population contains individuals with a range of sensitivities to odour. The larger a population, the greater the number of sensitive individuals it may contain.
- *Background level:* whether a given odour source, because of its location, is likely to contribute to a cumulative odour impact. In areas with more closely-located sources it may be necessary to apply a lower threshold to prevent offensive odour.
- *Public expectation:* whether a given community is tolerant of a particular type of odour and does not find it offensive, even at relatively high concentrations. For example, background agricultural odours may not be considered offensive until a higher threshold is reached than for odours from a landfill.
- *Source characteristics:* whether the odour is emitted from a fan box (point source) or from an area (diffuse source). Generally, the components of point source emissions can be identified and treated more easily than diffuse sources. Emissions from point sources can be more easily controlled using control equipment.

- *Health Effects:* whether a particular odour is perceived to potentially be associated with adverse health effects. In general, odours from agricultural activities are less likely to present a health risk than emissions from industrial facilities.

Experience gained through odour assessments in NSW indicates that an odour performance goal of 7 ou is likely to represent the level below which "offensive" odours should not occur (for an individual with a 'standard sensitivity' to odours). The NSW EPA recommends within the Odour Framework that, as a design goal, no individual be exposed to ambient odour levels of greater than 7 ou. This is expressed as the 99th percentile value, as a 'nose response time' average (approximately one second).

Odour performance goals need to be designed to take into account the range in sensitivities to odours within the community, and provide additional protection for individuals with a heightened response to odours. In NSW this is done using a statistical approach which depends on the size of the affected population. As the affected population size increases, the number of sensitive individuals is also likely to increase, which suggests that more stringent goals are necessary in these situations. In addition, the potential for cumulative odour impacts in relatively sparsely populated areas can be more easily defined and assessed than in highly populated urban areas. It is often not possible or practical to determine and assess the cumulative odour impacts of all odour sources that may impact on a receptor in an urban environment. Therefore, the proposed odour performance goals allow for population density, cumulative impacts, and anticipated odour levels during adverse meteorological conditions and community expectations of amenity.

A summary of odour performance goals for various population densities, as referenced in the Technical Notes is shown in **Table 5**.

Table 5 Impact Assessment Criteria for Complex Mixtures of Odorous Air Pollutants

Population of Affected Community	Impact Assessment Criteria for Complex Mixtures of Odours (ou)
Urban area (≥ 2000)	2.0
~300	3.0
~125	4.0
~30	5.0
~10	6.0
Single residence (≤ 2)	7.0

Source: (NSW DEC, 2006a)

The Odour Framework states that the impact assessment criteria for complex mixtures of odorous air pollutants must be:

- Applied at the nearest existing or likely future off-site sensitive receptor(s); and
- The incremental impact (predicted impact due to the pollutant source alone) must be reported in units consistent with the impact assessment criteria (ou), as peak concentrations (i.e. approximately 1 second average) and as the 99th percentile of dispersion model predictions for Level 2 impact assessments.

Only nine residential dwellings have been identified in the area surrounding the Facility that have potential to be impacted by odour emissions from current and proposed operations. Based on this, the affected population is estimated to be in the region of 30 people. Considering the low population density and the rural nature of the area, a criterion of 5 ou is therefore considered to be appropriate for the rural residences located in the vicinity of the Facility. This is also consistent with an AQIA previously prepared for the Facility by GHD (GHD, 2015).

5.2.2 Suspended Particulate

Airborne contaminants that can be inhaled directly into the lungs can be classified on the basis of their physical properties as gases, vapours or particulate matter. In common usage, the terms “dust” and “particulates” are often used interchangeably. The term “particulate matter” refers to a category of airborne particles, typically less than 30 microns (µm) in diameter and ranging down to 0.1 µm and is termed total suspended particulate (TSP).

The annual goal for TSP recommended by the NSW EPA is 90 micrograms per cubic metre of air (µg/m^3). The TSP goal was developed before the more recent results of epidemiological studies which suggested a relationship between health impacts and exposure to concentrations of finer particulate matter.

Emissions of particulate matter less than 10 µm and 2.5 µm in diameter (referred to as PM_{10} and $PM_{2.5}$ respectively) are considered important pollutants due to their ability to penetrate into the respiratory system. In the case of the $PM_{2.5}$ category, recent health research has shown that this penetration can occur deep into the lungs. Potential adverse health impacts associated with exposure to PM_{10} and $PM_{2.5}$ include increased mortality from cardiovascular and respiratory diseases, chronic obstructive pulmonary disease and heart disease, and reduced lung capacity in asthmatic children.

The NSW EPA assessment goals for PM_{10} set out in the Approved Methods are a 24-hour maximum of 50 µg/m^3 and an annual average of 25 µg/m^3. The NSW EPA assessment goals for $PM_{2.5}$ are a 24-hour maximum of 25 µg/m^3 and an annual average of 8 µg/m^3.

A summary of the particulate guidelines is shown in **Table 6**.

Table 6 EPA Goals for Particulates

Pollutant	Averaging Time	Goal
TSP	Annual	90 µg/m^3
PM_{10}	24 Hours Annual	50 µg/m^3 25 µg/m^3
$PM_{2.5}$	24 Hours Annual	25 µg/m^3 8 µg/m^3

5.2.3 Deposited Particulate

The preceding section is concerned in large part with the health impacts of airborne particulate matter. Nuisance impacts also need to be considered, mainly in relation to deposited dust. In NSW, accepted practice regarding the nuisance impact of dust is that dust-related nuisance can be expected to impact on residential areas when annual average dust deposition levels exceed 4 grams per square metre per month (g/m^2/month).

Table 7 presents the impact assessment goals set out in the Approved Methods for dust deposition, showing the allowable increase in dust deposition level over the ambient (background) level to avoid dust nuisance.

Table 7 EPA Goals for Allowable Dust Deposition

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

Source: Approved Methods, NSW EPA 2017.

6 Background Air Quality

6.1 Particulate Matter

The NSW EPA used to operate an air quality station at the Nowra Sewage Treatment Plant however this station was decommissioned in December 2001. As the Approved Methods requires that the background dataset be contemporaneous with the meteorological year used in the modelling, alternative monitoring sites were reviewed. The nearest existing EPA air quality monitoring station is at Albion Park South in the Illawarra region approximately 40 km north of the Facility. This monitoring site is located in a more built up residential area than the facility and would potentially be more strongly impacted by vehicle emissions. The Bargo air quality monitoring station, located approximately 62 km north of the facility is located in a much more similar setting to the Facility, surrounded by rural residential properties, agricultural operations and national parks. Air quality data from the Bargo monitoring station was therefore reviewed for the last four years (2014 to 2017).

PM_{10} and $PM_{2.5}$ data available from the Bargo monitoring station are summarised in **Figure 10**. As shown in **Figure 10**, PM_{10} concentrations recorded over the four year period reviewed were generally well below the 24-hour average criterion aside from a small number of isolated events (one to three times per year), when elevated concentrations above the criterion were recorded.

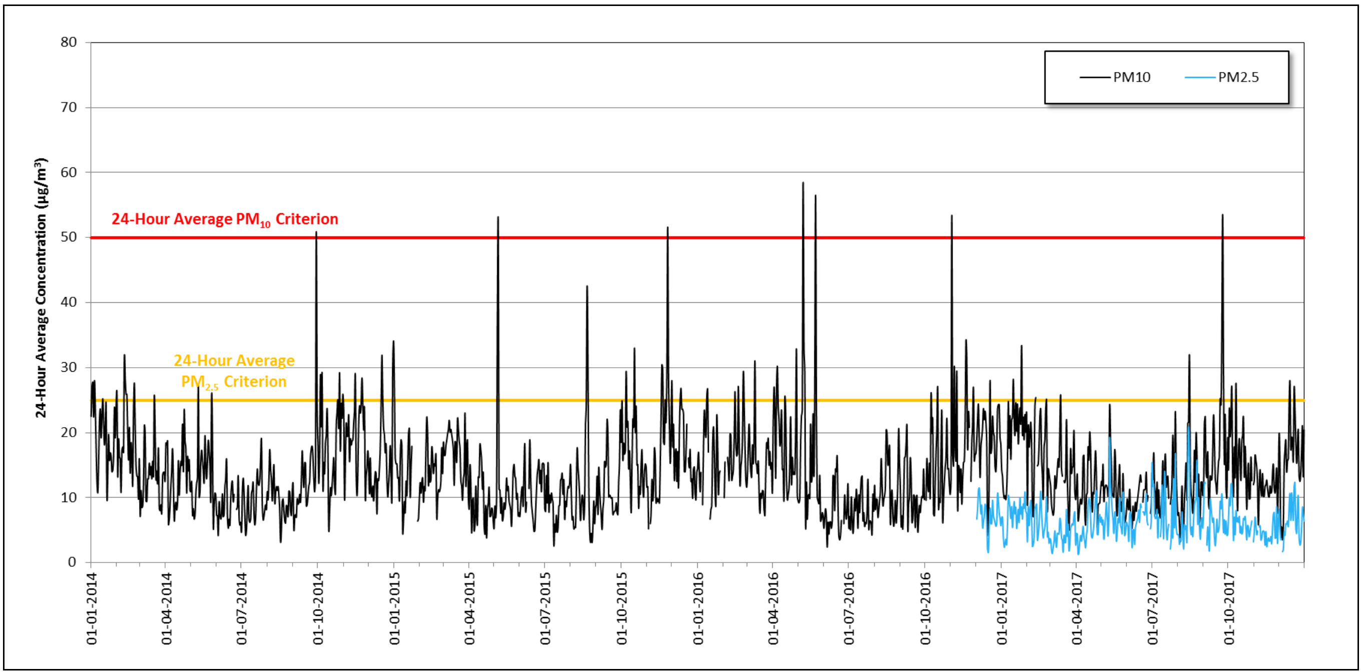
The annual average PM_{10} concentrations recorded were:

- 2013 = 14.1 µg/m^3;
- 2014 = 14.5 µg/m^3;
- 2015 = 13.4 µg/m^3; and
- 2016 = 14.4 µg/m^3.

In order to assess potential cumulative PM_{10} concentrations, the incremental 24-hour average PM_{10} concentrations predicted by the modelling for the Stage 4 landfill extension were added to the daily varying PM_{10} concentrations measured at Bargo over the same period as the meteorological data file (2014 calendar year).

It is noted that this background file includes one exceedance of the NSW EPA 24-hour average criterion for PM_{10} of 50 µg/m^3 (a reading of 50.8 µg/m^3 recorded on 29 September 2015). A review of NSW EPA monitoring reports and the NSW Rural Fire Service records did not identify any local bush/grass fires or regional dust events on this day that could have caused this elevated reading. It has therefore not been removed from the data file and has been incorporated into the cumulative impact analysis. Using the daily-varying background PM_{10} file, the potential for the Project to result in any *additional* exceedances of the 24-hour average criterion has been assessed. This is consistent with the Level 2 contemporaneous assessment methodology outlined in the Approved Methods (NSW EPA, 2017) for when there are elevated background concentrations.

Figure 10 PM_{10} and $PM_{2.5}$ Monitoring Data – Bargo Monitoring Station (2014 – 2017)



As shown in **Figure 10**, $PM_{2.5}$ data is available for this station from December 2016 onwards. The 24-hour average $PM_{2.5}$ concentrations recorded are consistently below the relevant NSW EPA criterion of 25 µg/m^3. The average $PM_{2.5}/PM_{10}$ ratio measured over the 13 months during which contemporaneous PM_{10} and $PM_{2.5}$ data are available was 0.46. As $PM_{2.5}$ monitoring data are not available for the 2014 calendar year, the daily PM_{10} data for 2014 were therefore scaled by a factor of 0.46 to provide estimates of background 24-hour average $PM_{2.5}$ concentrations. The background annual average $PM_{2.5}$ concentration for 2014 is estimated at 6.6 µg/m^3 based on this approach.

There is no TSP monitoring data available for the Facility or surrounding area. The ratio of PM_{10} to TSP in rural environments in Australia, where fine particle emissions from motor vehicles are not a major source, can generally be expected to be in the region of 0.5. For the purposes of this assessment it has therefore been assumed that the annual average TSP concentration is 29 µg/m^3, based on the annual average PM_{10} concentration recorded in 2014 of 14.5 µg/m^3.

No dust deposition monitoring data are available for the Facility or surrounding area. The modelling results have therefore been compared to the incremental guideline of 2 g/m^2/month.

A summary of the background TSP, PM_{10} and $PM_{2.5}$ data used in this assessment is provided in **Table 8**.

Table 8 Background Concentrations Assumed in this Assessment

Pollutant	Averaging Period	Background Concentration Assumed	Basis
TSP	Annual	29 µg/m^3	Annual average PM_{10} concentration recorded at Bargo in 2014 scaled by an estimated PM_{10}/TSP ratio of 0.5 for rural areas
PM_{10}	Annual	14.5 µg/m^3	Annual average PM_{10} concentration recorded in Bargo during 2014
	24-Hours	Daily varying	Daily varying PM_{10} concentrations recorded in Bargo during 2014
$PM_{2.5}$	Annual	6.6 µg/m^3	Annual average PM_{10} concentration recorded in Bargo during 2014 scaled by a $PM_{2.5}/PM_{10}$ ratio of 0.46 based on the average ratio of contemporaneous PM_{10} and $PM_{2.5}$ concentrations measured in Bargo during 2017
	24-Hours	Daily varying	Daily varying PM_{10} concentrations recorded in Bargo during 2014 scaled by a $PM_{2.5}/PM_{10}$ ratio of 0.46 based on the average ratio of contemporaneous PM_{10} and $PM_{2.5}$ concentrations measured in Bargo during 2017

6.2 Odour

Since commencement of operations, the Facility has received very few complaints regarding management of the facility (three complaints in the last 13 years). The few complaints received were related to odour and have been addressed through operational improvements and direct consultation with complainants and NSW EPA.

A summary of the environmental pollution complaints received by the Facility from 2006 to 2018 is provided in **Table 9**. As shown in the table, all odour events were identified as being associated with the storage of waste at the licenced wet weather tipping area and were resolved by relocation of the waste to the active landfilling area where it was covered.

The area surrounding the Facility is forested or rural in nature. The background odour environment is therefore expected to be dominated by natural odours generated by the surrounding vegetation, and potentially manure from grazing activities.

The modelling of odour emissions from the Proposal performed as part of this assessment includes odour emissions associated with existing odour sources at the Facility (e.g., leachate dam, composting activities, capped areas). As there are no other significant sources of odour in the surrounding area, it has been concluded that a cumulative odour impact assessment is not required and the incremental impact of odours from the Facility have been assessed in isolation.

Table 9 Summary of Odour Complaints (2006 – 2018)

Date of Complaint	Complaint Details	Actions
1 April 2014	Alleged odour complaint on 1 April 2014. Neighbouring resident confirmed that strong odours had been strong for three days.	Relocation of waste from licenced wet weather tipping area to active landfilling area - waste covered daily to reduce the likelihood of odours.
7 June 2013	Alleged odour complaint on 6 June 2013. Neighbouring resident confirmed that this was the first time in 7 years of living there that the odour had occurred.	Relocation of waste from licenced wet weather tipping area to active landfilling area - waste covered daily to reduce the likelihood of odours. Recent wet weather and low cloud cover over the last few days not assisting.
6 July 2010	Alleged odour complaint	Complaint investigated, and site inspection carried out. Due to wet weather, waste temporarily disposed at wet weather tip. Waste transferred from wet weather tipping area to the new landfill cell may have caused the alleged odour.

7 Assessment Methodology

The operation of a typical landfill waste facility involves a construction phase, such as the excavation of the landfill cell and installation of a synthetic lining system prior to the disposal of waste. This construction phase differs from typical industrial facilities where construction of the facility precedes operational activities. For the landfill, construction of the next cell occurs concurrently with the operation of the preceding cell, hence construction and operational activities are required to be assessed together.

This AQIA has been prepared based on a number of worst case assumptions including a high growth in waste volumes and assuming no resource recovery operations have been implemented. It is unlikely that this worst case will actually eventuate and the predicted off-site impacts are anticipated to be conservative estimates of actual impacts.

7.1 Scenarios Assessed

Construction and operational activities associated with the Proposal have been assessed based on the following worst case scenarios:

- **Odour Emissions**:
  - Stages 2 and 3 areas have reached waste capacity and are final capped;
  - The active landfill disposal face, where disposal of waste is occurring, is located at the southern end of landfill sub-cell 1 of Stage 4, which is located closest to the nearest sensitive receptors;
  - Recently disposed waste in landfill sub-cell 1 of Stage 4 adjacent to the active landfill disposal area covered daily, with the area assumed to be equivalent to twice the active landfill disposal area;
  - Remainder of landfill sub-cell 1 of Stage 4 assumed to be filled and capped with an appropriate final capping material;
  - Existing leachate dam to remain at the current size;
  - Irrigation of leachate over an area of 14,000 m^2 on the surface of the existing lined Stage 2;
  - Landfill sub-cells 2 - 6 of Stage 4 assumed to be filled and final capped – *Note this has been assumed to provide a worst case emissions scenario for use in the modelling and will not happen in reality as filling of sub-cells 2 – 6 will not occur until after sub-cell 1 is completed. This assumption has been included as a conservative approach to cover the end of life scenario where sub-cells 1 – 5 have been filled and sub-cell 6 is being filled, while keeping the most odorous source, the active landfill disposal face, closest to the nearest sensitive receptor*; and
  - Fresh green waste stockpile, composting windrows, mature compost stockpile and associated materials handling activities remain located in the existing Stage 1 area at the current sizes/activity rates.
- **Dust Emissions – Scenario 1** (concurrent operation of existing landfill and construction of Landfill sub-cell 1 in the proposed extension area):
  - Construction of landfill sub-cell 1 of Stage 4 and the drainage system completed over a 1 month period;
  - Excavated soils from landfill sub-cell 1 of Stage 4 loaded onto a truck;
  - Transport of excavated soils along internal unpaved road to landfill sub-cell 2 area;

- Unloading of excavated soils in landfill sub-cell 2 area;
- Transport of waste on internal paved and unpaved roads to existing Stage 3;
- Unloading of waste at the southern end of existing Stage 3;
- Landfill articulated compactor operating at active landfill disposal face in existing Stage 3; and
- Wind erosion from all unvegetated areas of existing Stages 2 and 3, and from composting area.

- **Dust Emissions – Scenario 2** (concurrent operation of landfilling in Landfill sub-cell 1 and construction of landfill sub-cell 2 in the Proposal area):
  - Construction of landfill sub-cell 2 of Stage 4 completed over a 1 month period;
  - Excavated soils from landfill sub-cell 2 of Stage 4 loaded onto a truck;
  - Transported of excavated soils along internal unpaved road to landfill sub-cell 1;
  - Unloading of excavated soils in landfill sub-cell 1;
  - Bulldozer or other appropriate machinery spreading/placing unloaded soil in landfill sub-cell 1;
  - Transport of waste on internal paved and unpaved roads to landfill sub-cell 2;
  - Disposing of waste at the southern end of landfill sub-cell 2;
  - Articulated landfill compactor operating at active waste disposal area in landfill sub-cell 2; and
  - Wind erosion from proposed sub-cell 1, existing Stages 2 and 3, and the composting area.

The locations of the key activities giving rise to odour and dust emissions assumed in the assessment are shown in **Figure 11** to **Figure 13**.

Figure 11 Source Locations Assumed for Assessing Potential Worst Case Odour Impacts

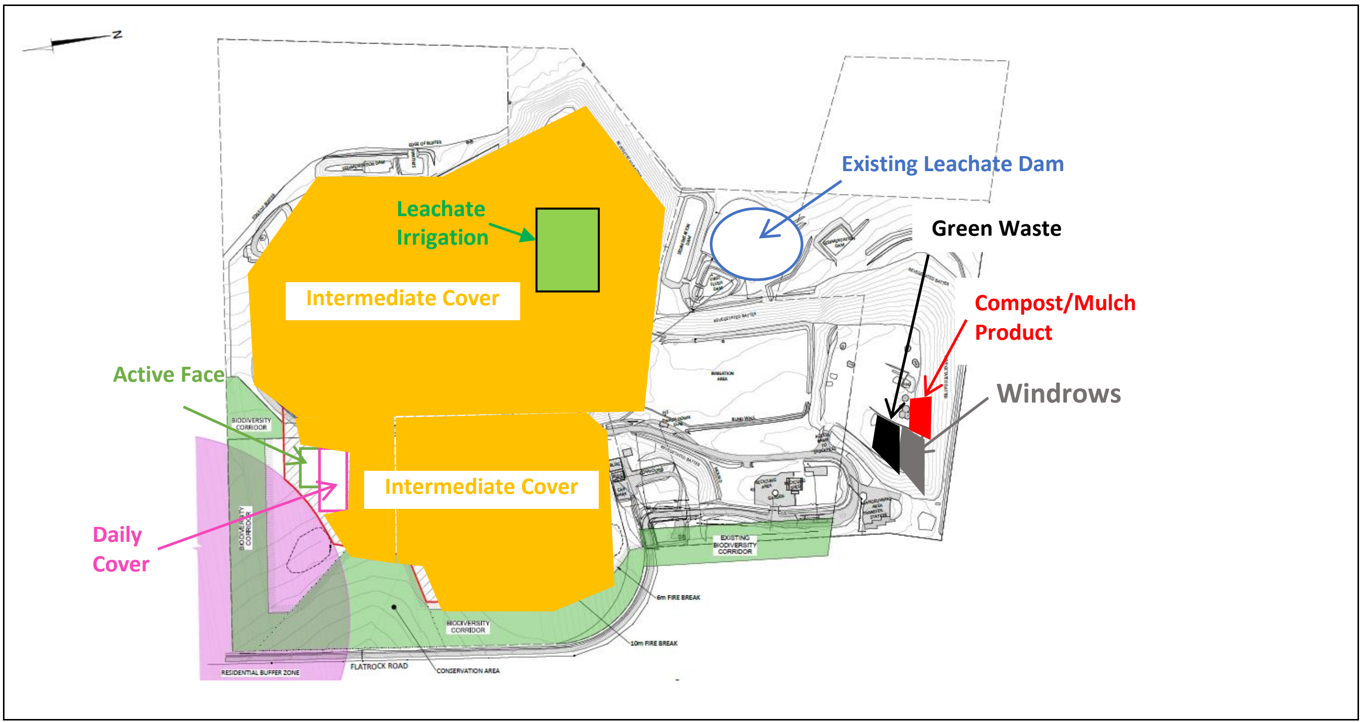


Figure 12 Source Locations Assumed for Assessing Potential Worst Case Dust Impacts – Scenario 1

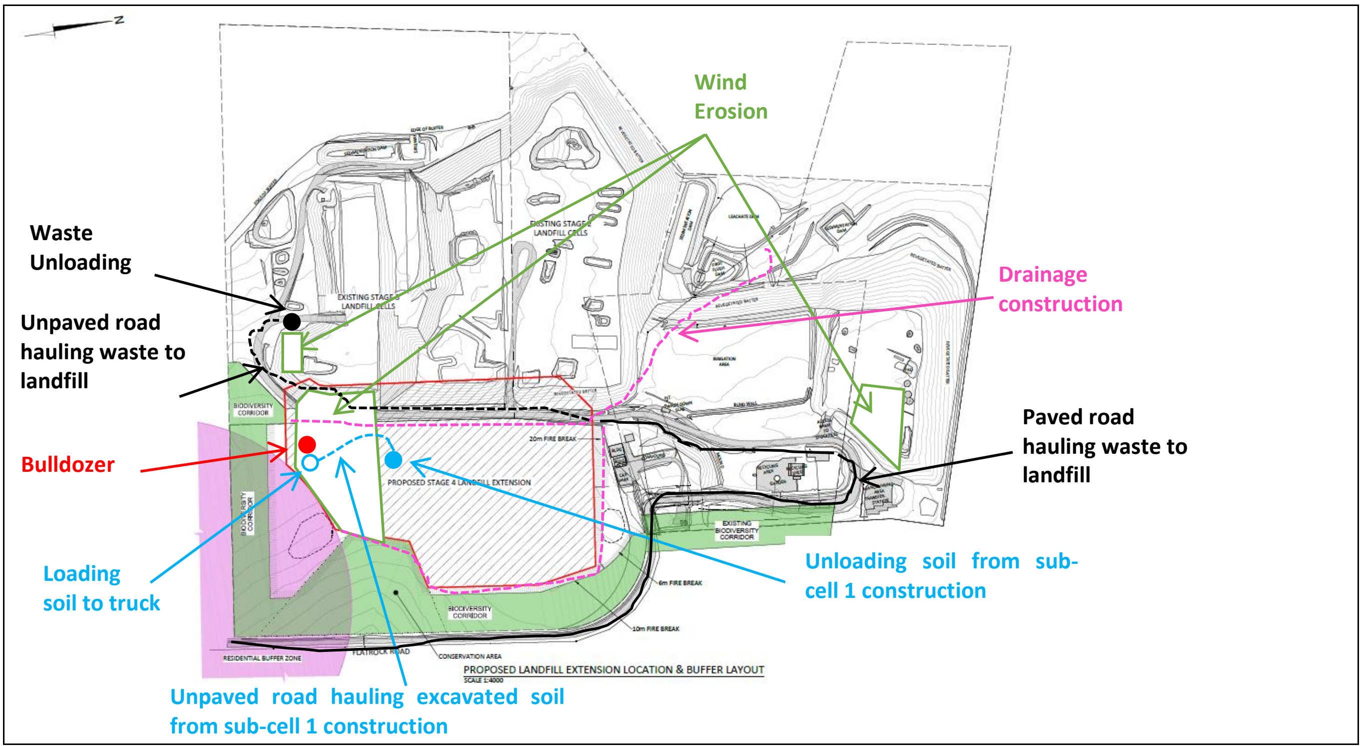
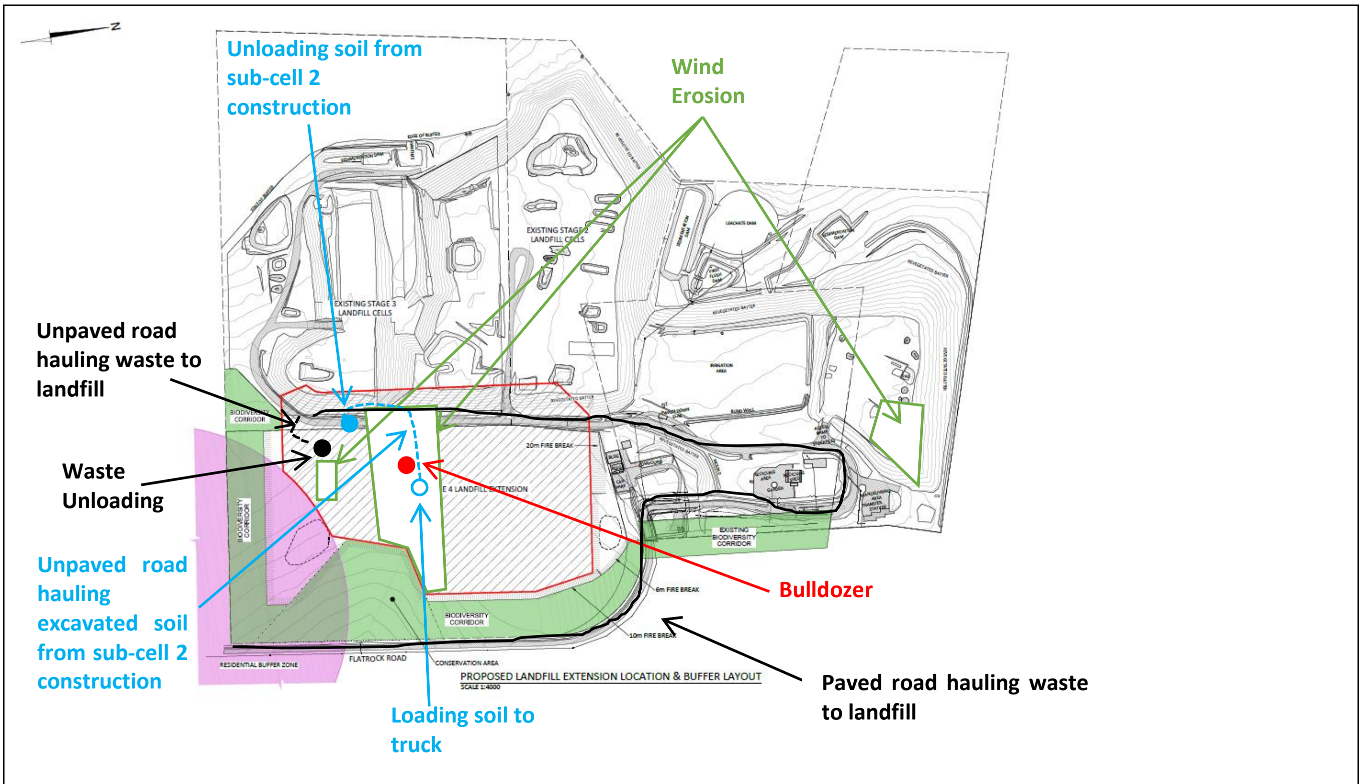


Figure 13 Source Locations Assumed for Assessing Potential Worst Case Dust Impacts – Scenario 2



7.2 Model Selection

Odour and particulate emissions from the Facility have been modelled using the US EPA's CALPUFF (Version 6) modelling system, as recommended by the NSW EPA. CALPUFF is a transport and dispersion model that ejects "puffs" of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so it typically uses the fields generated by a meteorological pre-processor CALMET, discussed further below. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentration or hourly deposition fluxes evaluated at selected receptor locations. The CALPOST post-processor is then used to process these files, producing tabulations that summarise results of the simulation for user-selected averaging periods.

The advantages of using CALPUFF (rather than using a steady state Gaussian dispersion model such as AERMOD) is its ability to handle calm wind speeds (<0.5 m/s), complicated terrain and cumulative pollution impacts. Steady state models assume that meteorology is unchanged by topography over the modelling domain and may result in significant over or under estimation of air quality impacts.

More advanced dispersion models (such as CALPUFF) are approved for use by many regulatory authorities in situations where these models may be more appropriate than use of steady-state models and assumptions.

7.3 Selection of Meteorological Year

In order to determine a representative meteorological year for use in dispersion modelling, five years of meteorological data (2012-2016) from the Nowra RAN Air Station AWS were analysed against the long term meteorological conditions. Specifically, the following parameters were analysed:

- Percentage of calm wind speed events (wind speed <0.5 m/s): Calm wind conditions are conducive to higher concentrations of air pollutants and odour due to poor dispersion of the plume;
- Wind speeds: Monthly average as well as hourly average observed at 9:00 am and 3:00 pm;
- Wind direction: Annual wind direction distribution; and
- Temperature: Monthly average as well as hourly average at 9:00 am and 3:00 pm.

Figure 14 and **Figure 15** present the average monthly temperatures and wind speeds for each year reviewed, compared to the 5-year average. **Figure 16** shows the frequency of low wind speeds recorded in each year compared to the 5-year average, while **Figure 17** presents the annual wind roses.

Figure 14 Nowra RAN Air Station AWS - Monthly Average Temperature Data, 2012-2016

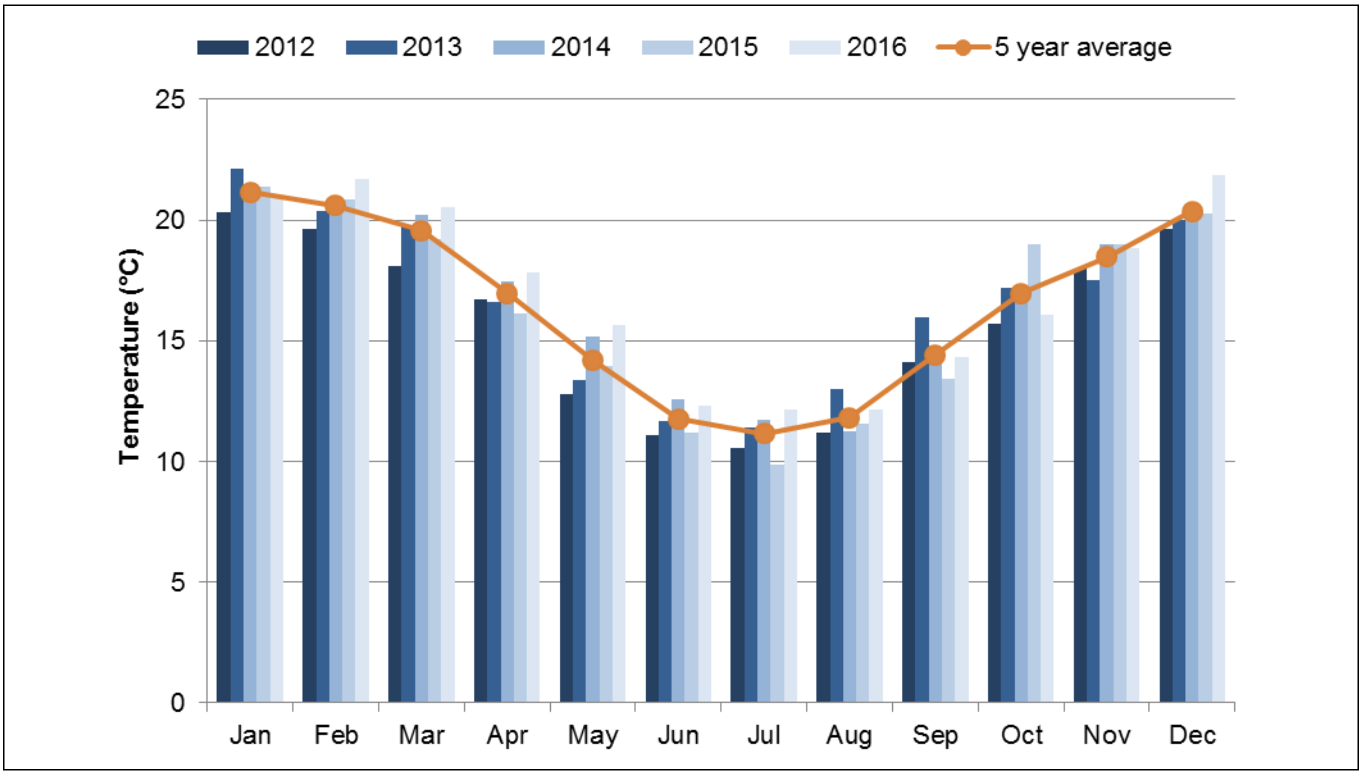


Figure 15 Nowra RAN Air Station AWS - Monthly Average Wind Speed Data, 2012-2016

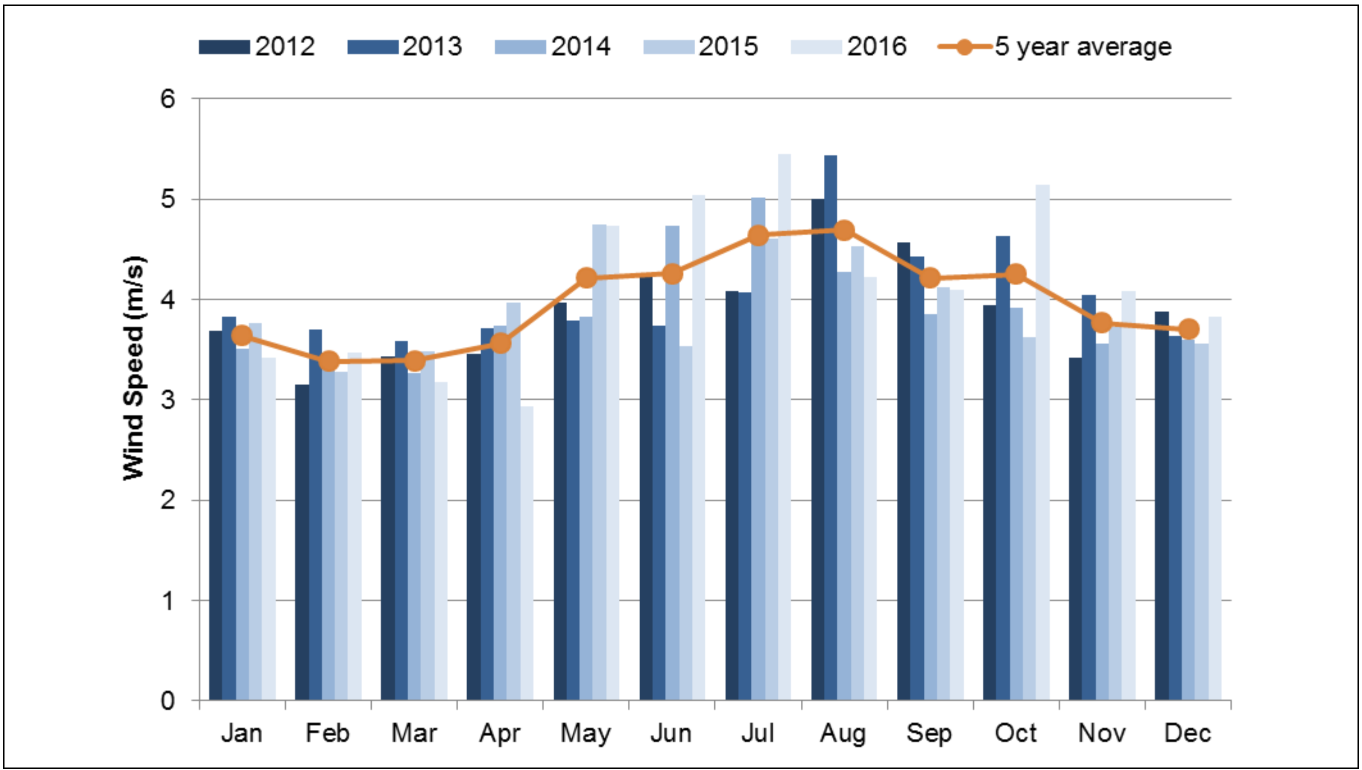


Figure 16 Nowra RAN Air Station AWS - Low Wind Speed Frequency Plot, 2012-2016

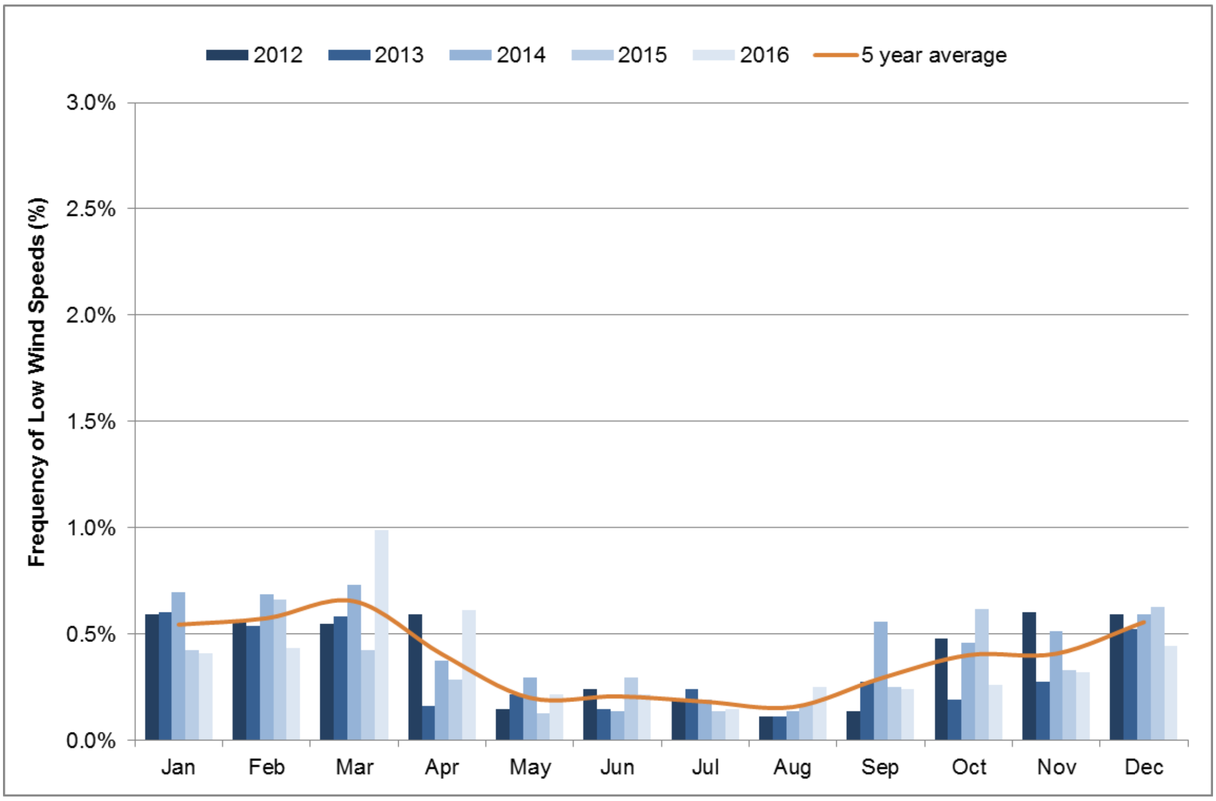
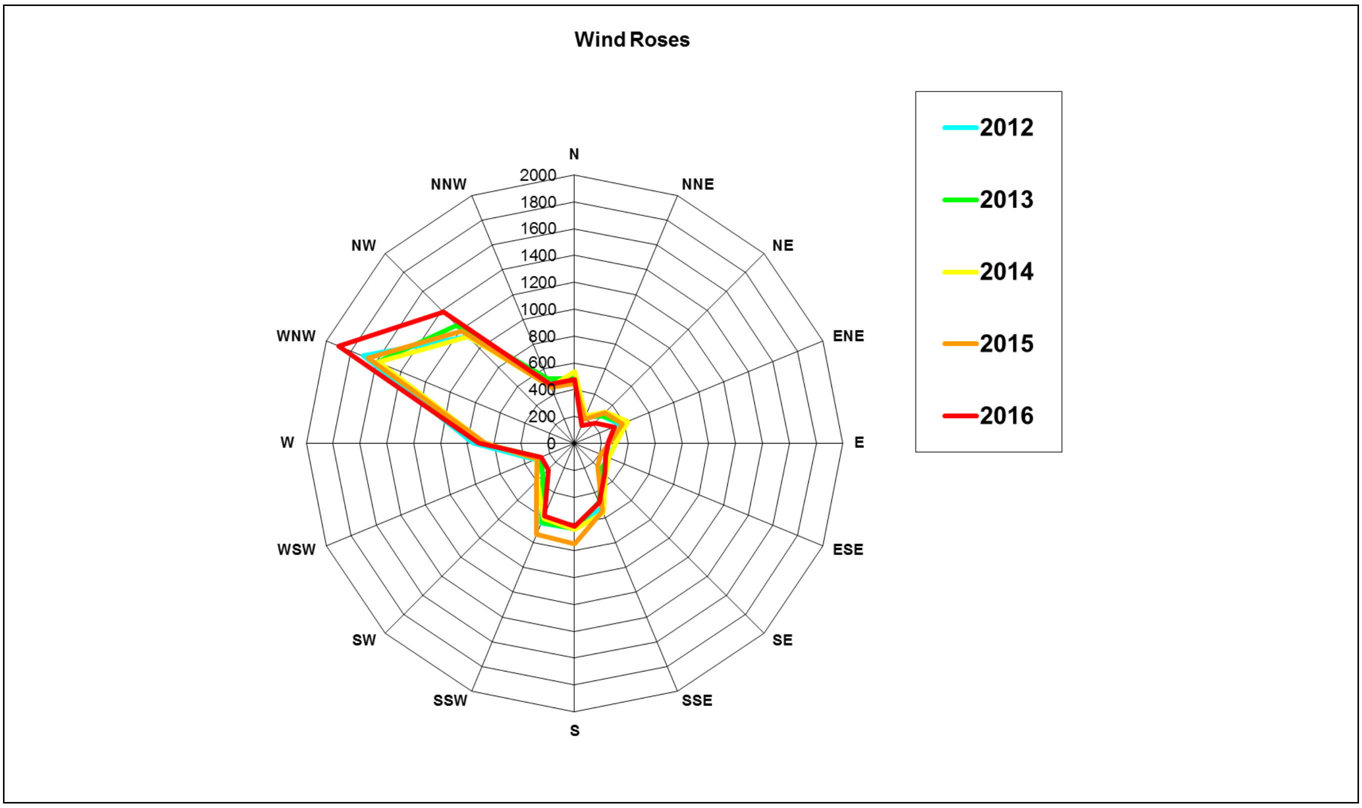


Figure 17 Nowra RAN Air Station AWS – Wind Direction Frequency Analysis, 2012-2016



The plots show that while the monthly average temperature data and annual wind patterns for the years analysed were generally similar, there is some inter-annual variability in the datasets, particularly in relation to wind speeds recorded during the winter months. **Figure 17** indicates that wind patterns during 2015 and 2016 varied the most from the 5-year average. The 2014 calendar year was the most recent year that showed consistency with typical wind conditions and was also reasonably representative of the 5-year average temperature records. Consequently, 2014 was selected as the representative year of meteorology for use in the modelling study.

7.4 Meteorological Modelling

7.4.1 TAPM

The TAPM prognostic model, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to generate the three-dimensional upper air data required for CALMET modelling (**Section 7.4.2**).

TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate one full year of hourly meteorological observations at user-defined levels within the atmosphere.

Table 10 Meteorological Parameters used for the AQIA – TAPM

TAPM (v 4.0.4)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km and 1 km)
Number of grid points	30 x 30 x 5
Year of analysis	1 January 2014 to 31 December 2014
Centre of analysis	276,173 m E 6,137,280 m S
Data assimilation	No observational data included (i.e., 'no obs mode')

7.4.2 CALMET

In the simplest terms, CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain that are required as inputs to the CALPUFF dispersion model. Associated two dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, sea breeze, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly varying wind field thus reflects the influences of local topography and land uses.

The CALMET domain (13.5 km × 13.5 km) was modelled with a horizontal grid spacing of 0.1 km. TAPM-generated three dimensional meteorological data was used as the initial guess wind field and the local topography and available surface weather observations in the area were used to refine the wind field predetermined by TAPM data. Hourly surface meteorological data from BoM's Nowra RAN Air Station located at Nowra Airport were incorporated in the domain modelling.

The gap filled and filtered (vegetation and obstacles removed) topographical data derived from the United States Geological Service's Shuttle Radar Topography Mission database data was obtained from Geo Science, Australia which has recorded topography across Australia with a 1 arc second (approximately 30 m) spacing. The land use data file was created using the latest publically available aerial imagery. **Table 11** details the parameters used in the CALMET meteorological modelling.

Table 11 Meteorological Parameters used for this Study – CALMET (v 6.42)

CALMET Domain	
Meteorological grid	13.5 km × 13.55 km
Meteorological grid resolution	0.1 km
Surface station data	Nowra RAN Air Station (BoM)
Initial guess filed	3D output from TAPM modelling

7.5 Meteorological Data Used in the Modelling Study

Wind Speed and Direction

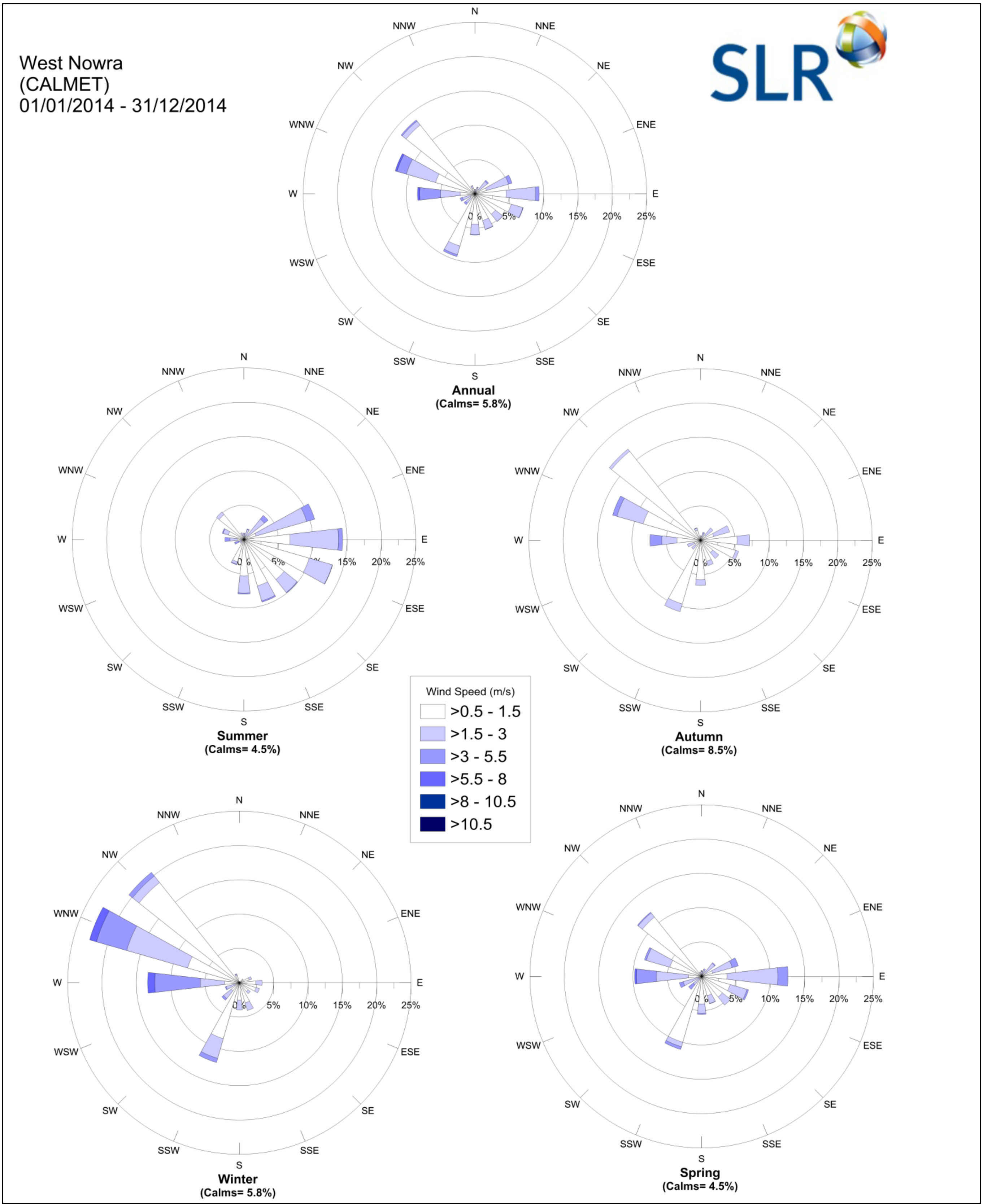
A summary of the annual wind behaviour predicted by CALMET for the Facility is presented as wind roses in **Figure 18**. **Figure 18** indicates that winds experienced in the study area are predominantly light (between 0.5 m/s and 3 m/s). Calm wind conditions (wind speed less than 0.5 m/s) were predicted to occur 5.8% of the time throughout the modelling period.

The seasonal wind roses indicate that typically:

- In summer, winds are light and are experienced predominantly from the east-northeast and the southeast quadrant. Calm winds were estimated to occur 4.5% of the time during summer;
- In autumn, wind speeds are lower and predominantly blow from the northwest, with few winds from the northeast and southeast. Calm winds were estimated to occur 8.5% of the time during autumn;
- In winter, winds are stronger and blew predominantly from the west-northwest, with very few winds from the northeast. Calm winds were estimated to occur 5.8% of the time during winter; and
- In spring, winds are light to moderate and more variable in direction compared to the other seasons. Calm winds were estimated to occur 4.5% of the time during spring.

The predicted wind data for the Facility shows a similar pattern to that recorded at Nowra Airport with a predominance of west northwesterly winds (see **Figure 17**) and stronger winds during winter. The wind speeds predicted by the modelling at the Facility appear to be slightly lower than those recorded at Nowra, which may be partly due to its lower elevation (40 – 50 m compared to 109 m for the Nowra RAN Air Station AWS).

Figure 18 Predicted Seasonal Wind Roses for the Facility (2014)



Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Turner assignment scheme identifies six Stability Classes, A to F, to categorise the degree of atmospheric stability as follows:

- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions
- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each Pasquill stability class are shown in **Table 12**.

Table 12 Meteorological Conditions Defining Pasquill Stability Classes

Surface Wind Speed (m/s)	Daytime Insolation			Night-Time Conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	<= 4/8 cloudiness
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

Source: (Pasquill, 1961)

Notes:

1. Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.
2. Night refers to the period from 1 hour before sunset to 1 hour after sunrise.
3. The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

The frequency of each stability class predicted by CALMET at the Facility during the modelling period is presented in **Figure 19**. The results indicate a high frequency of conditions typical to Stability Class F. Stability Class F is indicative of stable night time conditions with low wind speeds, which will inhibit pollutant dispersion and potentially result in higher predicted odour concentrations. During the daytime, Stability Classes B and C predominate, which are representative of moderately unstable and slightly unstable conditions when dispersion of odours and dust will occur more readily and off-site concentrations will be lower.

Mixing Heights

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Facility during the 2014 modelling period are illustrated in **Figure 20**. As would be expected, an increase in mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground based temperature inversions and growth of the convective mixing layer.

Figure 19 Predicted Stability Class Frequencies at the Facility (2014)

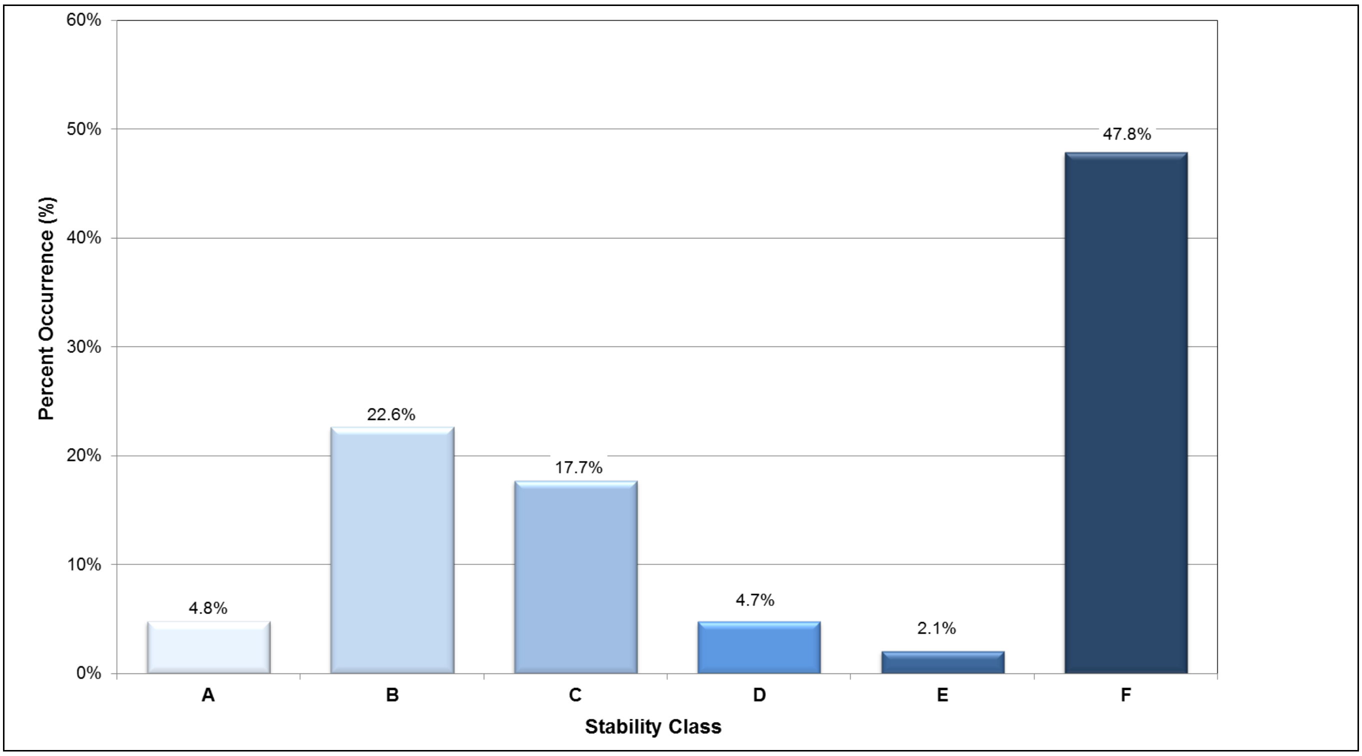
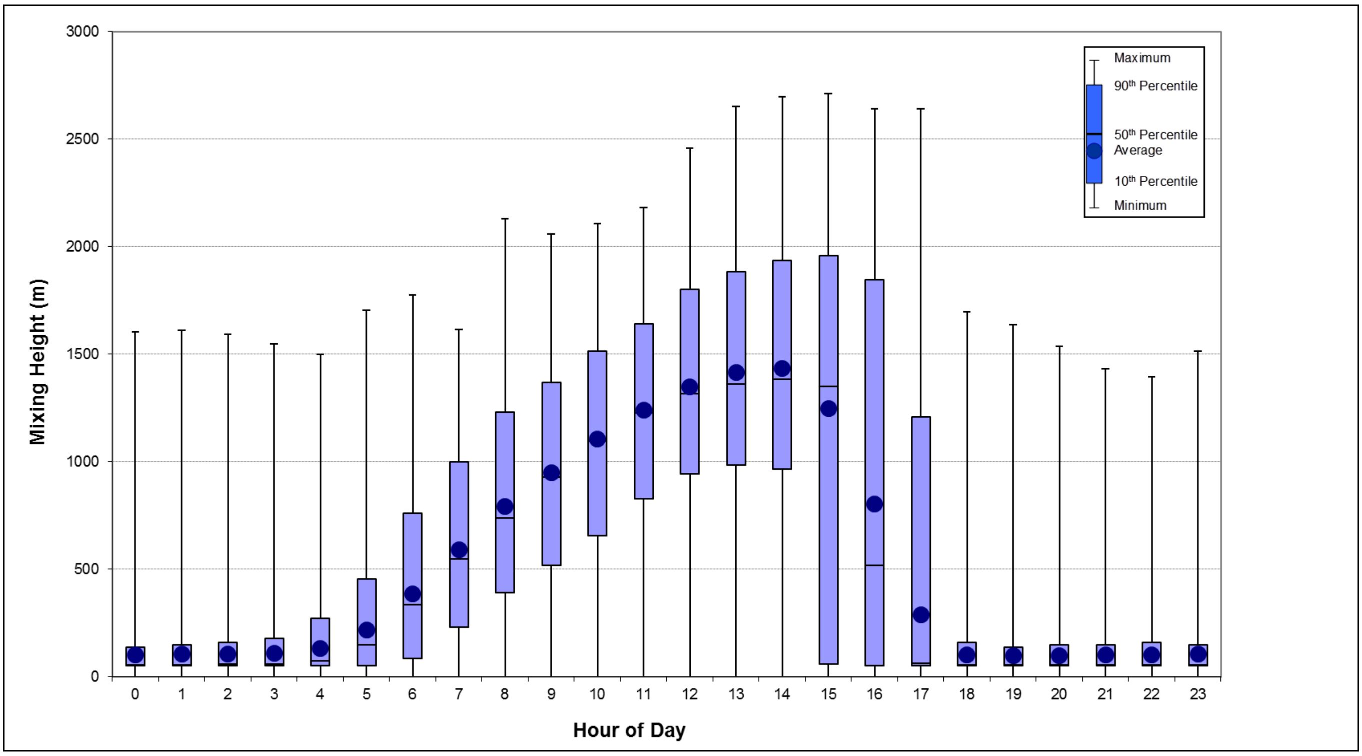


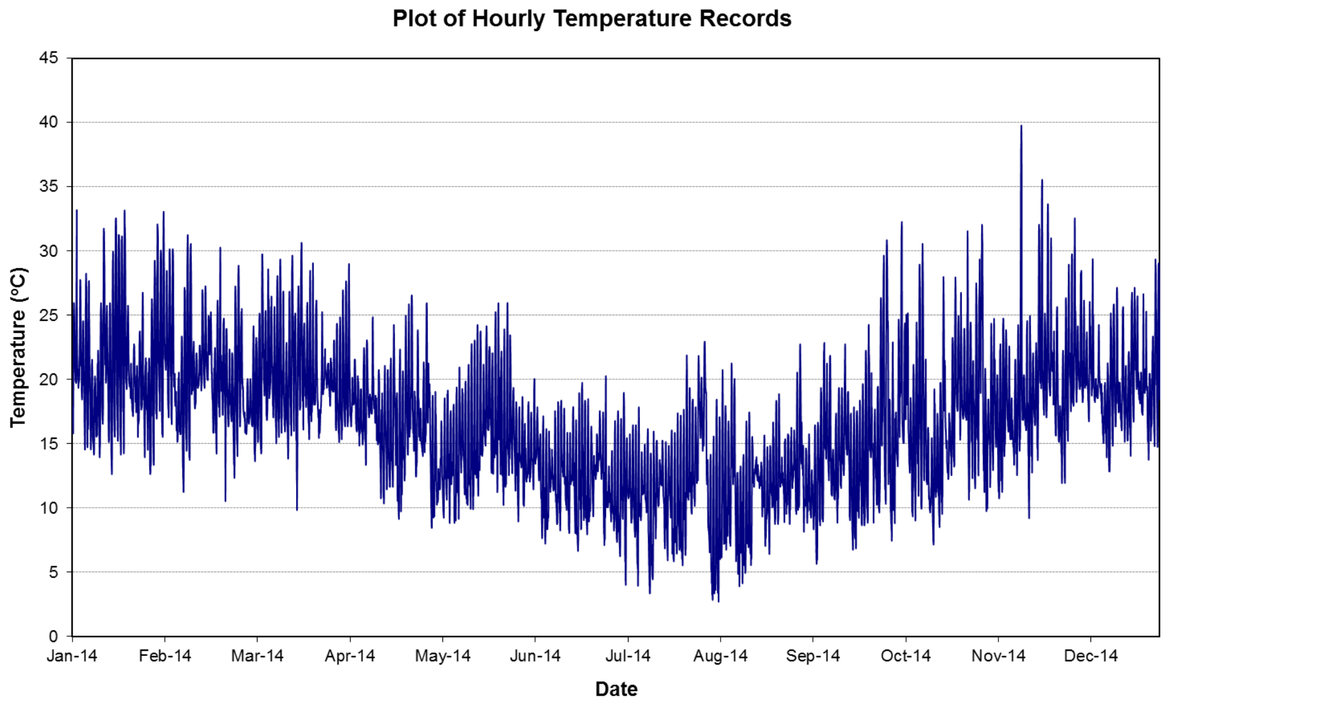
Figure 20 Predicted Mixing Heights at the Facility (2014)



Temperature

The modelled temperature variations as predicted at the Facility during the year 2014 are illustrated in **Figure 21**. The maximum temperature (39.8°C) was predicted on 14 November 2014 and the minimum temperature (2.8°C) was predicted on 5 August 2014.

Figure 21 Predicted Temperatures at the Facility (2014)



7.6 Odour Peak-to-Mean Ratios

The Approved Methods (NSW EPA, 2017) states that peak-to-mean ratios should be incorporated when conducting atmospheric dispersion modelling of odour.

It is commonly recognised that dispersion models such as CALPUFF need to be supplemented to accurately simulate atmospheric dispersion of odours. This is because the instantaneous perception of odours by the human nose typically occurs over a time scale of approximately one second but dispersion model predictions are typically valid for time scales equivalent to ten minutes to one hour averaging periods. To estimate the effects of plume meandering and concentration fluctuations perceived by the human nose, it is possible to multiply dispersion model predictions by a correction factor called a "peak-to-mean ratio". The peak-to-mean ratio (P/M60) is defined as the ratio of peak 1-second average concentrations to mean 1-hour average concentrations.

To estimate peak concentrations, this assessment has used data presented in Table 6.1 of the Odour Framework. Specifically, to establish a conservatively high estimate of peak odour concentrations, a P/M60 ratio of 2.3 has been applied to the emission rate for all sources. This P/M60 ratio is specified for wake-affected point sources and volume sources for all stability classes, and relates to near-field receptors.

7.7 Building Wake Effects

All emission sources at the Facility are fugitive ground levels emissions that are modelled as area and volume sources. No building wake effects were therefore included in the modelling.

7.8 Accuracy of Modelling

All atmospheric dispersion models, including CALPUFF, represent a simplification of the many complex processes involved in the dispersion of pollutants in the atmosphere. To obtain good quality results it is important that the most appropriate model is used and the quality of the input data (meteorological, terrain, source characteristics) is adequate.

The main sources of uncertainty in dispersion models, and their effects, are discussed below:

- **Oversimplification of physics:** This can lead to both under-prediction and over-prediction of ground level pollutant concentrations. Errors are greater in Gaussian plume models as they do not include the effects of non-steady-state meteorology (i.e., spatially- and temporally-varying meteorology).
- **Errors in emission rates:** Ground level concentrations are proportional to the pollutant emission rate. In addition, most modelling studies assume constant worst case emission levels or are based on the results of a small number of stack tests, however operations (and thus emissions) are often quite variable. Accurate measurement of emission rates and source parameters requires continuous monitoring.
- **Errors in source parameters:** Plume rise is affected by source dimensions, temperature and exit velocity. Inaccuracies in these values will contribute to errors in the predicted height of the plume centreline and thus ground level pollutant concentrations.
- **Errors in wind direction and wind speed**: Wind direction affects the direction of plume travel, while wind speed affects plume rise and dilution of plume. Errors in these parameters can result in errors in the predicted distance from the source of the plume impact, and magnitude of that impact. In addition, aloft wind directions commonly differ from surface wind directions. The preference to use rugged meteorological instruments to reduce maintenance requirements also means that light winds are often not well characterised.
- **Errors in mixing height:** If the plume elevation reaches 80% or more of the mixing height, more interaction will occur, and it becomes increasingly important to properly characterise the depth of the mixed layer as well as the strength of the upper air inversion.
- **Errors in temperature:** Ambient temperature affects plume buoyancy, so inaccuracies in the temperature data can result in potential errors in the predicted distance from the source of the plume impact, and magnitude of that impact.
- **Errors in stability estimates:** Gaussian plume models use estimates of stability class, and 3D models use explicit vertical profiles of temperature and wind (which are used directly or indirectly to estimate stability class for Gaussian models). In either case, errors in these parameters can cause either under-prediction or over-prediction of ground level concentrations. For example, if an error is made of one stability class, then the computed concentrations can be off by 50% or more.

The US EPA makes the following statement in its Modelling Guideline (US EPA, 2005) on the relative accuracy of models:

> *"Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ±10 to 40% are found to be typical, i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognised for these models. However estimates of concentrations that occur at a specific time and site are poorly correlated with actually observed concentrations and are much less reliable."*

This AQIA utilises the CALPUFF dispersion model in full 3D mode, incorporating 3D meteorological output from TAPM and CALMET. The meteorological dataset has been compiled using observations from a nearby automatic weather station and a five year period of meteorological data was reviewed to ensure that the year selected for use in the modelling is representative of long-term meteorological conditions. The use of the 99th percentile (88th highest) odour predictions given by the model in assessing off-site impacts (in accordance with the relevant odour impact assessment guideline) also means that uncertainties associated with the peak model predictions for rare or unusual meteorological conditions are removed.

8 Emissions Estimation

8.1 Odour Emissions

8.1.1 Landfill

Odour emissions from the Facility have been compiled using data sourced from a detailed emissions monitoring survey completed at the Eastern Creek Landfill in 2009 (PAE Holmes, 2010). This sampling programme consisted of direct measurement of odour emission rates from a range of sources at the Eastern Creek Waste and Recycling Centre landfill, including the following sources relevant to the current and proposed operations at the Facility:

- The active waste disposal area;
- Daily cover;
- Intermediate capped areas;
- Final capped areas;
- Leachate dam; and
- Green waste / compost stockpiles.

Odour samples from these sources were collected using an isolation flux hood and several samples were collected and analysed for the larger area sources to provide a spatially representative average emission rate. A summary of the odour concentrations and Surface Odour Emission Rates (SOERs) measured for each source type is provided in **Table 13**.

Table 13 Measured Odour Emission Rates at Eastern Creek Landfill

Source Type	Number of Samples	Sample Odour Concentration (ou.m^3)		Calculated Surface Odour Emission Rate (ou.m^3/m^2/s)	
		Range	Average	Range	Average
Active waste disposal area	3	630 – 6,210	3,390	0.36 – 3.65	1.97
Daily cover	3	2,350 – 3,440	2,830	1.48 – 2.16	1.78
Intermediate cover	1	-	59	-	0.04
Final capped areas	9	35 – 85	58	0.02 – 0.06	0.04
Leachate pond	2	59 - 304	182	0.11 – 0.19	0.15
Green waste / compost stockpiles	1	-	42	-	0.03

SOURCE: (PAE Holmes, 2010)

The sampling data presented in **Table 13** were used to estimate odour emission rates from each of the areas shown in **Figure 11** based on the following assumptions:

- The area of the active waste disposal area in landfill sub-cell 1 of Stage 4 was assumed to be 100 m^2 (data provided by SCC);
- An adjacent area twice the size of the active face (200 m^2) was assumed to represent recently disposed waste using the measured odour emission rate for daily cover;

- The SOER reported for final cover of 0.04 ou.m^3/m^2/s was assumed for all final covered areas. It is noted that this is the same as the average SOER measured across the intermediate cover areas at the Eastern Creek landfill;
- The maximum SOER reported for the active tipping area, daily cover and leachate pond was used for each respective area;
- Emissions from leachate irrigation area were conservatively estimated based on the SOER for the leachate pond; and
- During night-time hours (5pm – 8am), emissions from the active waste disposal area were reduced to reflect the placement of daily cover in this area.

The model was run with and without the emissions associated with leachate irrigation to provide information on its contribution to the total predicted off-site odour concentrations, as this will not be a constant activity.

Table 14 Odour Emission Rates Used in Dispersion Modelling for Landfilling Operations

Source	Area (m^2)	Assumed SOER (ou.m^3/m^2/s)	Odour Emission Rate (ou.m^3/s)
Stages 2 and 3: Final cover	189,200	0.04	7,568
Stage 4 landfill sub-cell 1: Active waste disposal area*	100	3.65	365
Stage 4 landfill sub-cell 1: Daily cover*	200	2.16	432
Stage 4 landfill sub-cell 1: Final cover	11,200	0.04	448
Stage 4 landfill sub-cells 2 - 6: Final cover	61,225	0.04	2,449
Leachate dam	6,500	0.19	1,235
TOTAL - LANDFILL			***12,497***
Leachate irrigation area	14,000	0.19	2,660
TOTAL – LANDFILL Plus LEACHATE IRRIGATION			***15,157***

*During night-time hours (5pm – 8am) emissions from the active waste disposal area were reduced to reflect the placement of daily cover in this area.

8.1.2 Composting

In order to predict the maximum potential cumulative odour impacts associated with operation of the existing Facility and the Proposal, emissions from the composting operation carried out at the northern end of the Facility were estimated based on odour emission data compiled by GHD as part of a previous odour modelling study for the Facility (GHD, 2015). This detailed odour emissions inventory for the composting operations was compiled based on odour monitoring programmes performed at a large number of other green waste composting operations and is summarised in **Table 13**.

Odour emissions during turning of windrows were estimated by GHD based on measurements performed during turning operations at another site, which indicated that odour emissions increased by a factor of around 100 compared to the undisturbed windrow.

Other assumptions used in characterising the odour emission rates for the composting operations were (GHD, 2015):

- 50% of the daily input of raw green waste (equivalent to 8 tonnes with an estimated emitting surface area of 50 m^2) sits at the receival area at any one time during operating hours (i.e. 8 hours/day, 7 days per week);
- Odour emissions from shedding of green waste were estimated by scaling the SOER measured from the screening of mature compost by a factor of 3, which was in turn derived from the ratio of SOER raw green waste stockpile / SOER undisturbed maturation windrows;
- The turning of static piles occurs for 6 hours a day, once every 2 weeks over 4 months for current operations;
- Odour emissions during the transfer of compost material were estimated by applying the SOER for turning of windrows to the exposed surface area;
- A 30% reduction was assumed in the mass of material at the maturation stage (i.e. after static phases due to evolution of moisture and VOCs during the composting process); and
- The bulk density of composting material during the static phases is assumed to be 0.33 tonnes/m^3, increasing to 0.6 tonnes/m^3 during the maturation phase.

Table 15 Odour Emission Inventory for Current Green Waste Composting Operations

Source	Surface Area (m^2)	Assumed SOER ($ou.m^3/m^2/s$)	Odour Emission Rate ($ou.m^3/s$)
OPERATING HOURS			
Green waste stockpile	53	4.0	212
Screening	-	-	4,960
Transfer operations (loader)	5 of 4 m^2	8.0	160
Unloading	5 of 4 m^2	5.3	106
Shredder	-	-	5,740
Static Windrows	1,306	3	3,918
Maturation windrows (with turning)	690	1.7	1,173
Matured stockpile	790	0.6	474
Total - Composting (operating hours)			***16,743***
NON-OPERATING HOURS			
Static Windrows	1,306	3	3,918
Maturation windrows (with turning)	690	1.7	1,173
Matured stockpile	790	0.6	474
Total - Composting (non-operating hours)			***5,565***

SOURCE: (GHD, 2015)

8.2 Dust Emissions

Fugitive emissions of TSP and PM_{10} were estimated using published emission factors from the US EPA's AP-42 Emission Factor Handbook and the National Pollutant Inventory Emission Estimation Technique Manual, as appropriate. The activity data used in the calculations are summarised in **Table 16**. Further details on assumptions used in estimating the fugitive particulate emissions are noted below.

- The amount of soil extracted during construction of Stage 4 landfill sub-cells 1 and 2 was estimated based on approximately one quarter of the total excavated volume for Stage 4 of 509,780 m^3 (SLR, 2017b) being extracted from each landfill sub-cell. A soil density of 1.83 tonnes/m^3 was used (based on the permeability and compaction test results from test pit excavations performed as part of the geotechnical study (Coffey, 2016) to give an estimated 233,225 tonnes per landfill sub-cell.
- Similarly, the tonnage of soil extracted during construction of the Stage 4 leachate drainage system was estimated at 32,587 tonnes based on the total excavated volume of 17,807 m^3 (SLR, 2017b) and a soil density of 1.83 tonnes/m^3. It was assumed that all this material is extracted during the one month construction period for landfill sub-cell 1.
- The payload of the trucks transporting the excavated soils out of the landfill sub-cell to the disposal area was assumed to be 30 tonnes. Assuming that the excavation works are completed in a one month period, and hauling of the material occurs from 8 am – 5 pm seven days per week, this gives 260 return trips per day and 29 return trips per hour.
- The bulldozer, scraper and excavator associated with the construction works were assumed to operate continuously from 8am – 5pm seven days per week.
- The total amount of waste transported to the active face was estimated based on the 2016/17 landfill waste quantity of 65,589 tpa (refer **Table 3**), increased to 150,331 tpa to reflect a worst case landfilling rate for 2034 (closure year), based on:
  - A 3% per annum waste generation medium-growth rate as advised by SCC based on estimates in the National Waste Report 2010 (DEE, 2010); and
  - An assumed 2% per annum population growth rate.

  It is noted that as filling of landfill sub-cell 1 of Stage 4 is anticipated to occur in 2025, use of waste generation rates projected for 2034 is a conservative assumption.
- The payload of trucks delivering waste to the site was assumed to be 9.5 tonnes. Based on waste deliveries occurring from 8am – 5 pm seven days per week, 52 weeks per year, this gives 43.4 deliveries per day, or 4.9 deliveries per hour (i.e., 9.6 return trips per hour).
- Haulage distances (total vehicle kilometres travelled (VKT)) on internal paved and unpaved roads (for both excavated soils and landfill waste) were estimated based on the length of each haul route shown in **Figure 12** and **Figure 13** and number of trips per day.
- A 50% control factor was applied to the wind erosion estimates based on an assumption that a minimum of Level 1 watering would be maintained during dry, windy conditions (2 L/m^2/hour).
- A 75% control factor was applied to the unpaved haul road estimates based on an assumption that a Level 2 watering would be maintained during dry, windy conditions (>2 L/m^2/hour).
- In the modelling, the wind erosion emission rate was varied hourly based on a cubic relationship with the wind speed data in the meteorological file to accurately simulate the increased dust generation at higher wind speeds.

The resulting emission inventories used in the dispersion modelling study are summarised in **Table 17** and **Table 18**, with details of the emission factors used provided in **Appendix A.**

Table 16 Dust Emission Estimation – Activity Data

Source/Activity	Value	Units	Source/Basis
Scraper	7,774	tonnes/day	233,225 t excavated over one month
Excavator in construction cell	7,774	tonnes/day	233,225 t excavated over one month
Excavator for leachate drainage works	1,086	tonnes/day	32,587 t excavated over one month
Bulldozer in construction cell	9	hrs/day	100% utilisation
Hauling excavated materials to stockpile	104	VKT/day	7,774 t moved, 30 t payload, 200 m haul road
Unloading excavated material onto stockpile	7,774	tonnes/day	233,225 t excavated over one month
Hauling waste to tipping face – unpaved road	17	VKT/day	150,331 tpa, 9.5 t payload, 200 m distance, 365 days/year
Hauling waste to tipping face – paved road	156	VKT/day	150,331 tpa, 9.5 t payload, 1.8 km distance, 365 days/year
Unloading waste at tipping face	412	tonnes/day	150,331 tpa, 365 days/year
Compactor on active face	9	hrs/day	100% utilisation
Wind erosion - active face	0.03	ha	Active landfilling and daily cover areas
Wind erosion - cell construction	2.4	ha	
Wind erosion - excavated materials stockpile	1.9	ha	
Wind erosion - composting stockpiles	0.9	ha	
Dust Mitigation Measures			
Watering on unpaved haul roads	75% control		Level 2 watering (> 2 L/m^2/hour)
Watering on all wind erosion sources	50% control		Level 1 watering (< 2 L/m^2/hour)

Table 17 Dust Emission Inventory – Scenario 1

Activity	Peak Daily Emission Rate (kg/day)		
	TSP	PM_{10}	$PM_{2.5}$
Scraper	225.45	56.75	5.68
Excavator – Landfill sub-cell 1	5.98	2.83	0.43
Excavator - Leachate drainage	0.84	0.40	0.06
Bulldozer – Landfill sub-cell 1	14.71	2.75	0.28
Hauling excavated materials to stockpile	22.80	6.74	0.67
Unloading excavated materials	5.98	2.83	0.43
Hauling waste to waste disposal area – Paved road	30.77	5.88	1.39
Hauling waste to tipping face – Unpaved road	3.81	1.13	0.11
Unloading waste at tipping face	0.32	0.15	0.02
Compactor on active face	14.71	2.75	0.28
Wind erosion - Tipping face	0.14	0.07	0.01
Wind erosion – Landfill sub-cell 1	11.28	5.64	0.56
Wind erosion - Composting area	4.32	2.16	0.22
Wind erosion - Stockpile	9.18	4.59	0.46
Total	**350**	**95**	**11**

Table 18 Dust Emission Inventory – Scenario 2

Activity	Peak Daily Emission Rate (kg/day)		
	TSP	PM_{10}	$PM_{2.5}$
Scraper	225.45	56.75	5.68
Excavator – Landfill sub-cell 2	5.98	2.83	0.43
Bulldozer – Landfill sub-cell 2	14.71	2.75	0.28
Hauling excavated materials to stockpile	34.20	10.11	1.01
Unloading excavated materials	5.98	2.83	0.43
Hauling waste to waste disposal area – Paved road	30.77	5.88	1.39
Hauling waste to tipping face – Unpaved road	3.81	1.13	0.11
Unloading waste at tipping face	0.32	0.15	0.02
Compactor on active face	14.71	2.75	0.28
Wind erosion - Tipping face	0.14	0.07	0.01
Wind erosion – Landfill sub-cell 2	11.28	5.64	0.56
Wind erosion - Composting area	4.32	2.16	0.22
Wind erosion - Stockpile	9.18	4.59	0.46
Total	**361**	**98**	**11**

9 Assessment of Impacts

9.1 Odour Impact Assessment

The 99th percentile (88th highest) nose-response odour concentrations predicted by the CALPUFF model at the surrounding sensitive receptors for the Proposal are presented in **Table 19**. These peak off-site impacts have been predicted using the peak-to-mean ratios discussed in **Section 7.6**.

The results presented in **Table 19** show that the incremental 99th percentile nose-response odour concentrations predicted as a result of proposed operations at the Facility comply with the adopted criterion at all of the residential receptors identified except for R1, which is located approximately 88 m south of the Proposal site. The 99th percentile odour concentration predicted at this receptor is 6.3 ou, slightly above the adopted criterion of 5 ou. A detailed review of the odour concentrations predicted at R1 showed that concentrations above 5 ou are only predicted to occur at this receptor during the hours of 5:00 pm to 5:00 am.

The results presented in **Table 19** also show that odour emissions from the proposed irrigation of leachate on an area of lined landfill Stage 2 are predicted to have a very minimal impact on the predicted cumulative off-site odour concentrations, even based on the very conservative assumption that odour emissions are occurring from the entire irrigation area (14,000 m^2) at the same rate as that assumed for the leachate dam itself (based on odour monitoring data from Eastern Creek Landfill).

Table 19 Predicted 99th Percentile Nose-Response Odour Concentrations (ou)

ID	Name	Odour Concentration (ou, nose response time)	
		Without Leachate Irrigation	With Leachate Irrigation
Residential			
R1	Residential dwelling, 43 Flatrock Road	**6.3**	**6.3**
R2	Residential dwelling, 41 Flatrock Road	4.1	4.2
R3	Residential dwelling/shed, 3 Flatrock Road	3.6	3.7
R4	Residential dwelling, 3 Flatrock Road	2.7	2.8
R5	Residential dwelling, 3 Flatrock Road	2.0	2.0
R6	Residential dwelling, 3 Flatrock Road	2.6	2.6
R7	Residential dwelling, 18 Bamarang Road	2.6	2.6
R8	Jim Da Silva Farm, 38A Old Bamarang Drive	3.2	3.3
R9	56 Stonegarth Road	1.8	1.9
Commercial/Educational			
C1	RSPCA Shoalhaven Shelter	**12.6**	**12.7**
C2	OEH buildings	**12.6**	**12.7**
C3	University of Wollongong – Shoalhaven Campus	1.0	1.1
CRITERION		**5.0**	

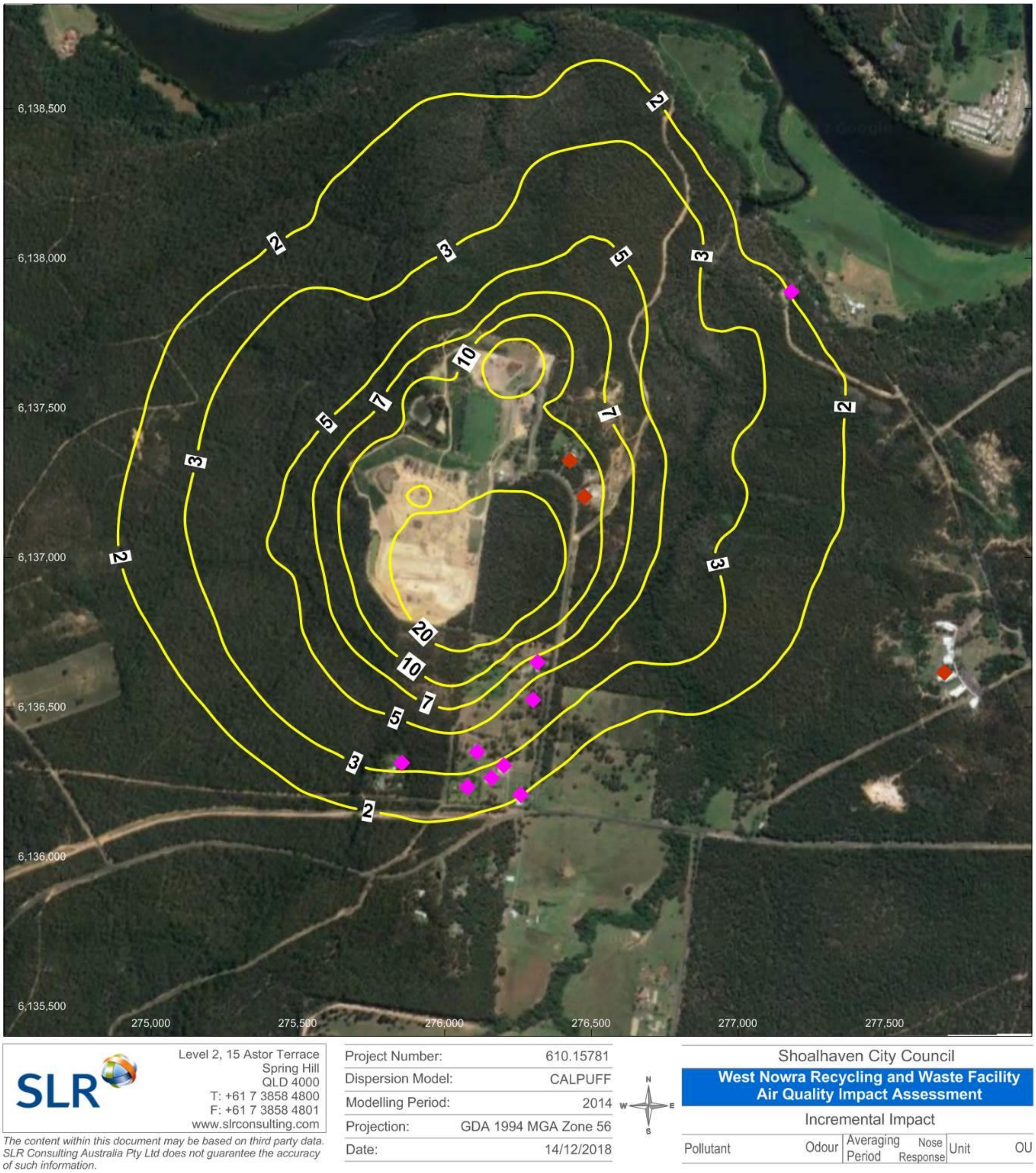
Concentrations above the sensitive receptor criterion are also predicted at the old RSPCA Shoalhaven Animal Shelter site and the OEH buildings. These receptors would not be considered to be particularly sensitive to odour impacts, given that they are located adjacent to the landfill in an area where some periods of detectable odours would be expected to occur. People will only be present at these locations during work hours, especially not in the evening and at night when the highest off-site odour concentrations are most likely to occur. A detailed review of the odour concentrations predicted at C1 and C2 showed that concentrations above 5 ou are only predicted to occur at these receptors during the hours of 4:00 pm to 7:00 am.

It should also be noted that the predicted odour concentrations are based on a number of conservative assumptions, including an assumption that landfill sub-cells 2 - 6 of Stage 4 are assumed to be filled and final capped. This assumption was included as a conservative approach to cover the end of life scenario where landfill sub-cells 1 – 5 have been filled and capped, and landfill sub-cell 6 is being filled, while keeping the most odorous source, the active waste disposal area, closest to the nearest residential receptor. Given this, the predicted nose response odour concentrations presented in **Table 19** are expected to represent conservative worst case impacts at surrounding sensitive receptors, and the actual odour concentrations at surrounding receptors due to the Proposal operations should be lower than the predicted odour concentrations presented in **Table 19**.

Nonetheless, the modelling does indicate that odours have potential to be detected at Receptor R1 at levels above the adopted nuisance-based assessment criterion for sensitive receptors. Appropriate mitigation measures should be implemented to minimise the potential for off-site odour impacts (see **Section 10.1.1**).

The predicted 99^{th} percentile odour concentrations (nose-response time, 1-second average) are presented as a contour plot in **Figure 22**. It is noted that the odour contour plot does not reflect odour concentrations occurring at any particular instant in time, but rather illustrates a compilation of the 99^{th} percentile odour concentrations predicted at all locations downwind, taking into account all combinations of meteorological conditions modelled across the entire year.

Figure 22 Predicted 99th Percentile Nose-Response Odour Concentrations (Includes Leachate Irrigation)



9.2 Particulate Matter

9.2.1 TSP and Deposited Dust

The incremental and cumulative annual average TSP concentrations and maximum monthly incremental dust deposition rates predicted at surrounding sensitive receptors for Scenario 1 and 2 are presented in **Table 20**. The estimated background TSP concentration of 29 µg/m^3 (refer **Section 6.1**) has been used to calculate the cumulative TSP impacts at each sensitive receptor. The dust deposition rate predictions are shown as incremental impacts only and are compared to the incremental criterion of 2 g/m^2/month.

The modelling results presented in **Table 20** show that the cumulative TSP concentrations and incremental dust deposition rates predicted at each surrounding sensitive receptor comply with the relevant ambient air quality criteria outlined in **Section 5.2**.

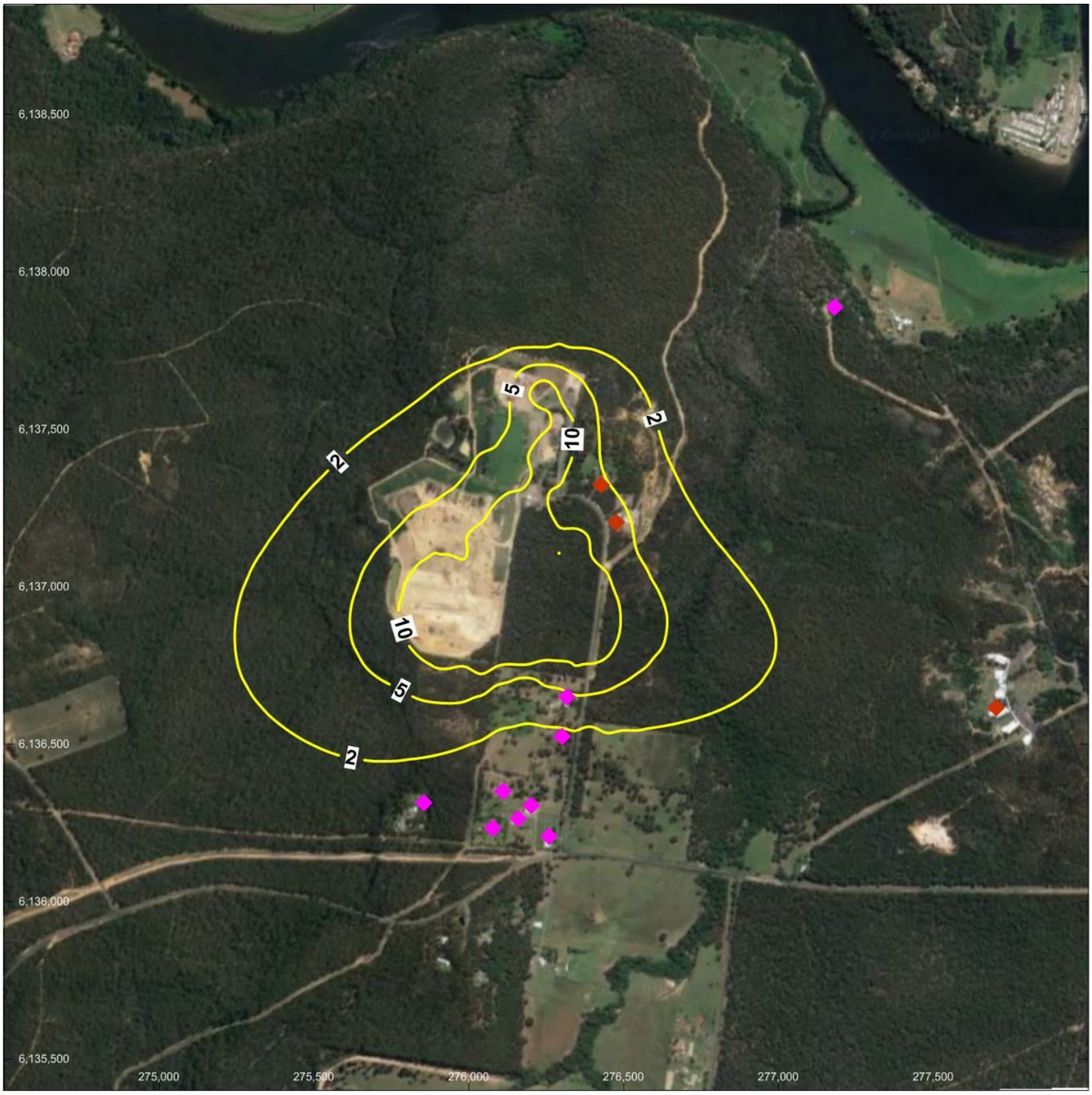
Contour plots showing the incremental TSP concentrations and dust deposition rates predicted for each scenario are presented in **Figure 23** to **Figure 26**.

Table 20 Predicted TSP Concentrations and Dust Deposition Rates – Scenarios 1 and 2

Receptor ID	Annual Average Incremental TSP Concentrations (µg/m³)		Annual Average Cumulative TSP Concentrations * (µg/m³)		Maximum Monthly Incremental Dust Deposition Rates (g/m²/month)	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Residential						
R1	4.6	3.0	34	32	0.5	0.3
R2	1.8	1.4	31	30	0.2	0.1
R3	0.9	0.8	30	30	0.1	0.1
R4	0.7	0.6	30	30	0.1	0.1
R5	0.5	0.5	30	29	<0.1	<0.1
R6	0.6	0.6	30	30	0.1	<0.1
R7	0.6	0.6	30	30	0.1	0.1
R8	1.1	1.0	30	30	0.1	0.1
R9	0.4	0.5	29	29	<0.1	<0.1
Commercial						
C1	5.6	6.6	35	36	0.5	0.6
C2	7.2	9.3	36	38	0.8	1.0
C3	0.7	0.7	30	30	0.1	0.1
Criteria	**-**	**-**	**90**	**90**	**2.0**	**2.0**

* Includes an assumed annual average TSP background value of 29 µg/m^3 (see **Section 6.1**)

Figure 23 Predicted Annual Average Incremental TSP Concentrations – Scenario 1



SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	610.15781
Dispersion Model:	CALPUFF
Modelling Period:	2014
Projection:	GDA 1994 MGA Zone 56
Date:	14/12/2018

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Air Quality Impact Assessment
Incremental Impact - Scenario 1

Pollutant	TSP	Averaging Period	Annual	Unit	µg/m³

Figure 24 Predicted Annual Average Incremental TSP Concentrations – Scenario 2

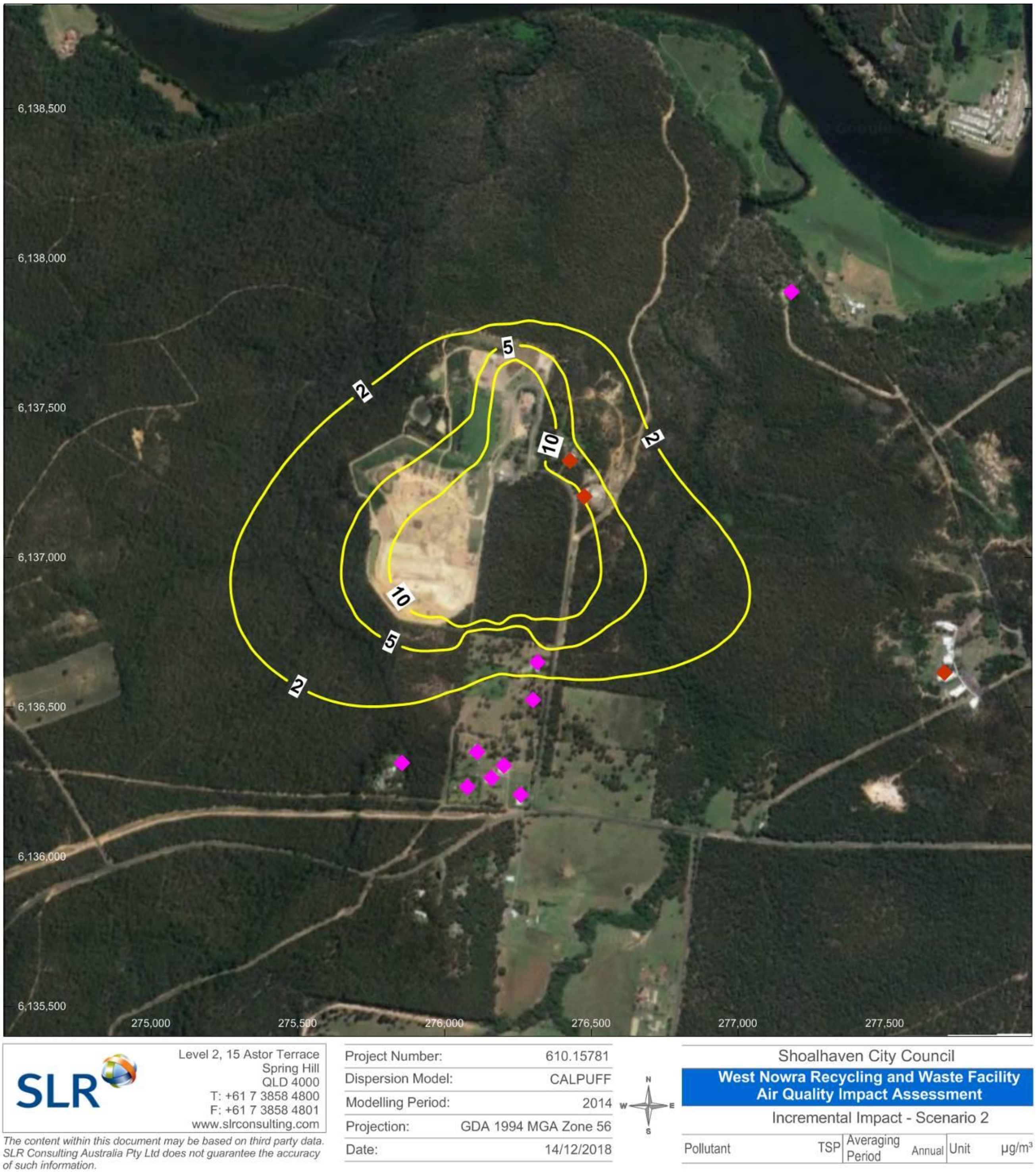
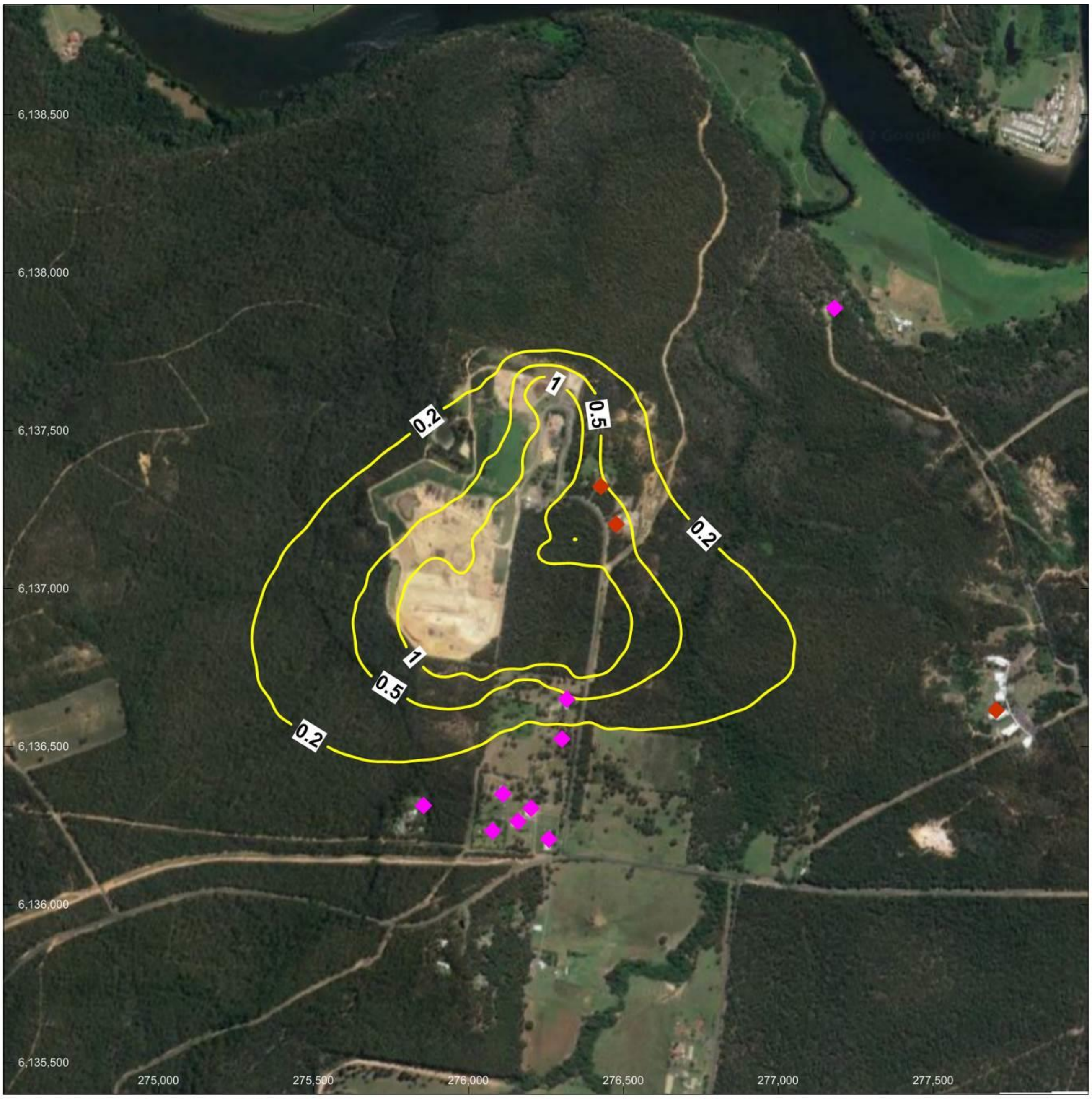


Figure 25 Predicted Maximum Monthly Incremental Dust Deposition Rates – Scenario 1



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Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

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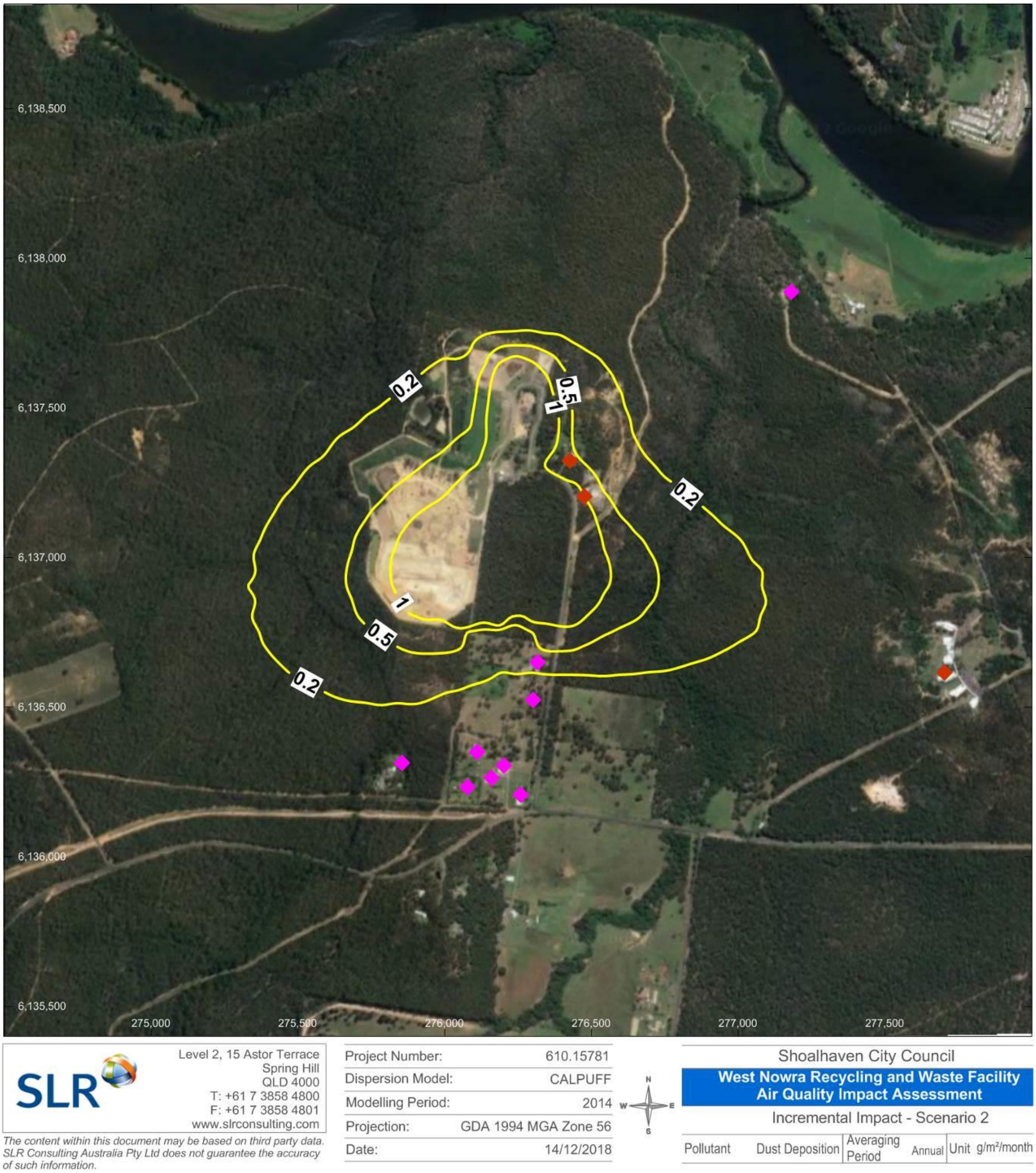
Pollutant	Dust Deposition	Averaging Period	Annual	Unit	g/m²/month

Figure 26 Predicted Maximum Monthly Incremental Dust Deposition Rates – Scenario 2



9.2.2 PM_{10}

The incremental and cumulative annual average and 24-hour average PM_{10} concentrations predicted at surrounding sensitive receptors for Scenario 1 and 2 are presented in **Table 21**. Daily varying background PM_{10} data recorded at Bargo in 2014 (concurrent with the meteorological data) have been used to calculate the cumulative impacts (refer **Section 6.1**). The number in brackets in the cumulative 24-hour average column indicates the number of days per annum predicted to exceed the NSW EPA criterion of 50 µg/m^3. It is noted that there is already one day in the background data file with a 24-hour average concentration above 50 µg/m^3.

Contour plots showing the incremental 24-hour and annual average PM_{10} concentrations predicted for each scenario are presented in **Figure 27** and **Figure 28** (maximum 24-hour averages) and **Figure 29** and **Figure 30** (annual averages). These plots show the maximum downwind PM_{10} concentrations predicted in the area surrounding the Facility due to emissions from the proposed operations, exclusive of local background PM_{10} concentrations.

Table 21 Predicted PM_{10} Concentrations – Scenarios 1 and 2

Receptor ID	24-Hour Average PM_{10} Concentrations (µg/m³) [1]				Annual Average PM_{10} Concentrations (µg/m³) [2]			
	Incremental		Cumulative [3]		Incremental		Cumulative	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Residential								
R1	26.7	21.3	54.5 (1)	52.7 (1)	1.7	1.1	16.1	15.6
R2	16.4	11.5	52.0 (1)	51.6 (1)	0.7	0.5	15.2	15.0
R3	5.0	4.7	51.2 (1)	51.2 (1)	0.4	0.3	14.8	14.8
R4	4.3	3.8	51.2 (1)	51.2 (1)	0.3	0.3	14.7	14.7
R5	4.2	3.2	51.2 (1)	51.1 (1)	0.2	0.2	14.7	14.6
R6	4.0	3.6	51.2 (1)	51.1 (1)	0.3	0.2	14.7	14.7
R7	4.0	3.8	51.1 (1)	51.1 (1)	0.3	0.2	14.7	14.7
R8	8.4	7.5	51.1 (1)	51.0 (1)	0.5	0.4	14.9	14.9
R9	3.1	3.5	50.9 (1)	50.9 (1)	0.2	0.2	14.6	14.7
Commercial								
C1	21.4	26.1	51.8 (1)	51.8 (1)	1.9	2.3	16.3	16.7
C2	24.1	31.0	53.3 (1)	54.1 (1)	2.3	3.0	16.7	17.5
C3	3.7	3.6	51.7 (1)	51.8 (1)	0.3	0.3	14.8	14.8
Criteria	-		**50.0**		-		**25.0**	

1 Includes daily varying background PM_{10} concentrations based on data from Bargo (see **Section 6.1**)

2 Includes an assumed annual average PM_{10} background value of 14.5 µg/m^3 (see **Section 6.1**)

3 There is already one day in the background data file with a 24-hour average concentration above 50 µg/m^3, hence only *additional* exceedances are considered to represent non-compliances.

The modelling results presented in **Table 21** show that the predicted annual average PM_{10} concentrations are below the NSW EPA criterion at all sensitive receptor locations.

The maximum 24-hour average cumulative PM_{10} concentrations predicted at the nearest sensitive receptors exceed the relevant ambient air quality criterion set by NSW EPA (refer **Table 6**) of 50 µg/m^3 at all receptors for both scenarios. This is as expected as the background PM_{10} dataset used in the modelling already contains one exceedance of 50.8 µg/m^3 (refer **Section 6.1**). None of the receptors are predicted to experience any additional exceedances due to emissions from the Proposal.

Figure 27 Predicted Maximum 24-Hour Average Incremental PM_{10} Concentrations – Scenario 1

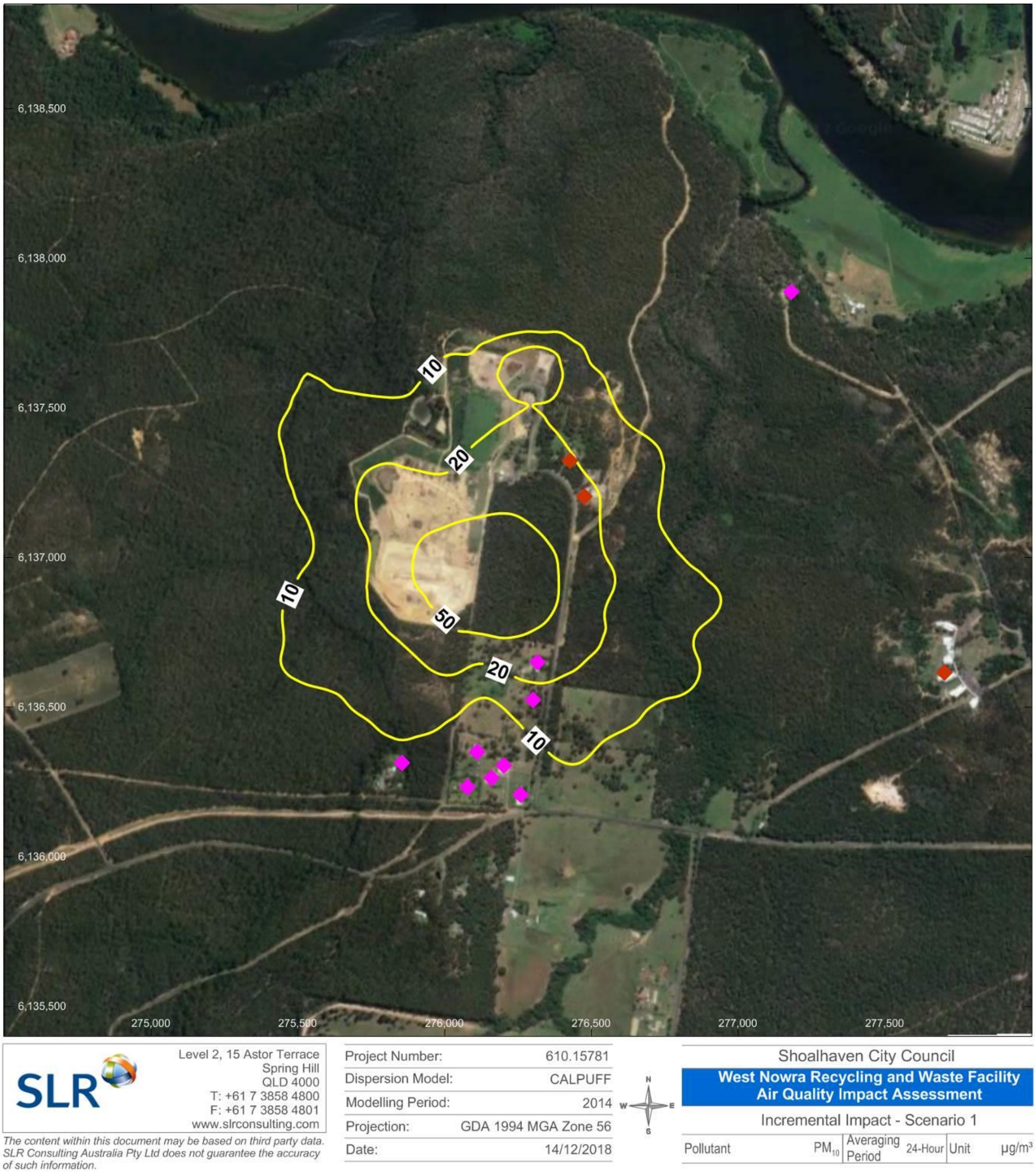


Figure 28 Predicted Maximum 24-Hour Average Incremental PM_{10} Concentrations – Scenario 2

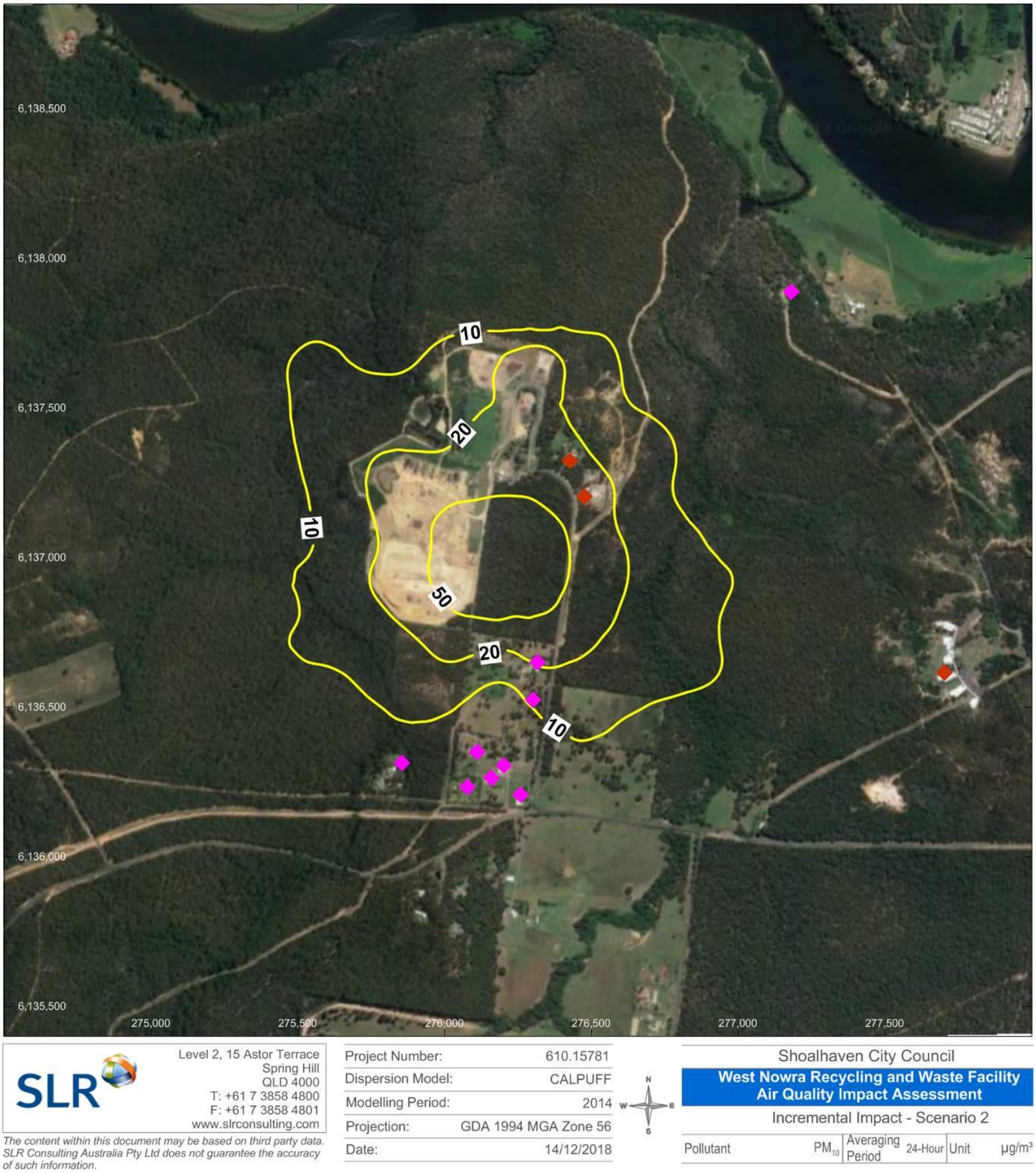


Figure 29 Predicted Annual Average Incremental PM_{10} Concentrations – Scenario 1

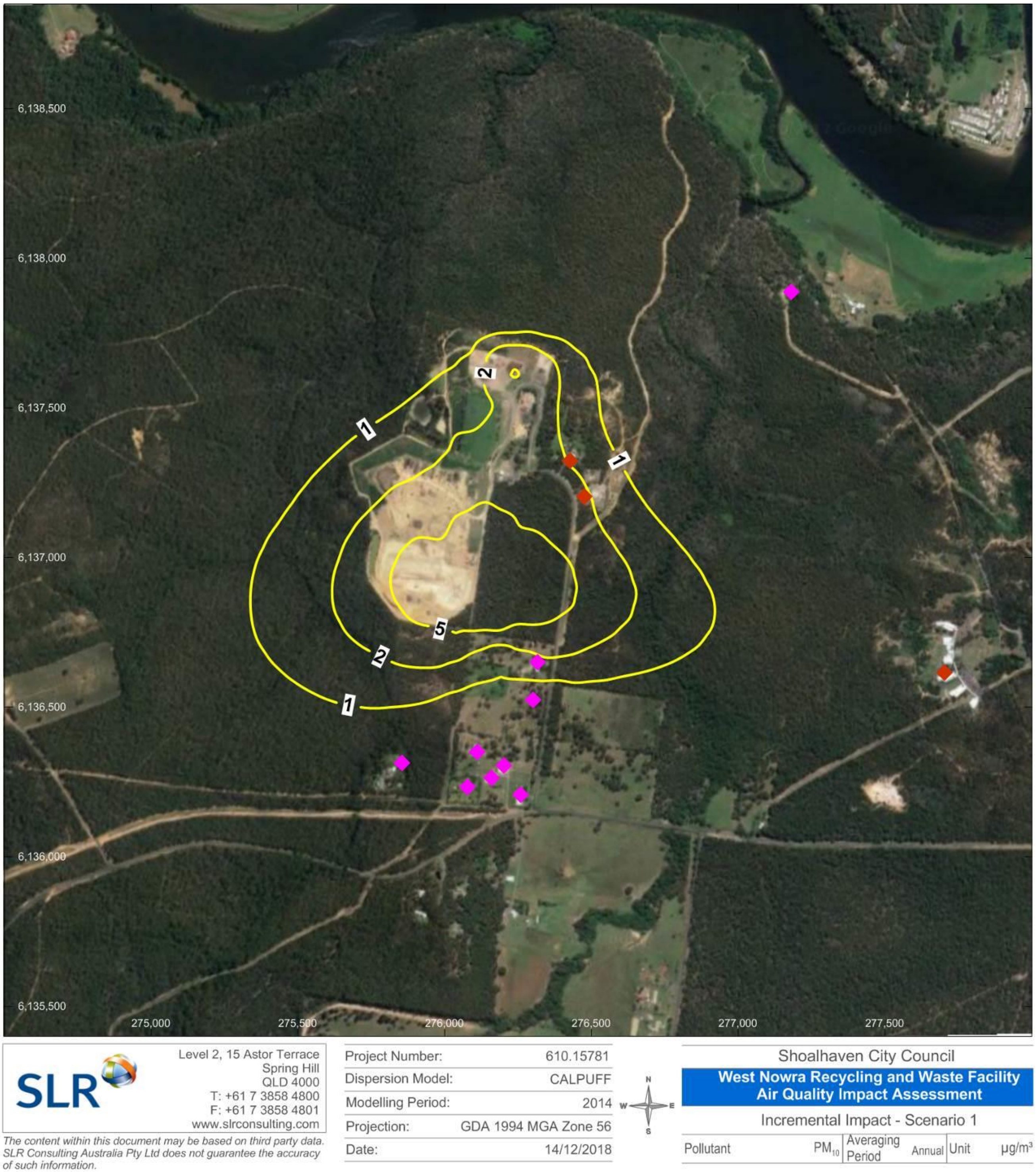
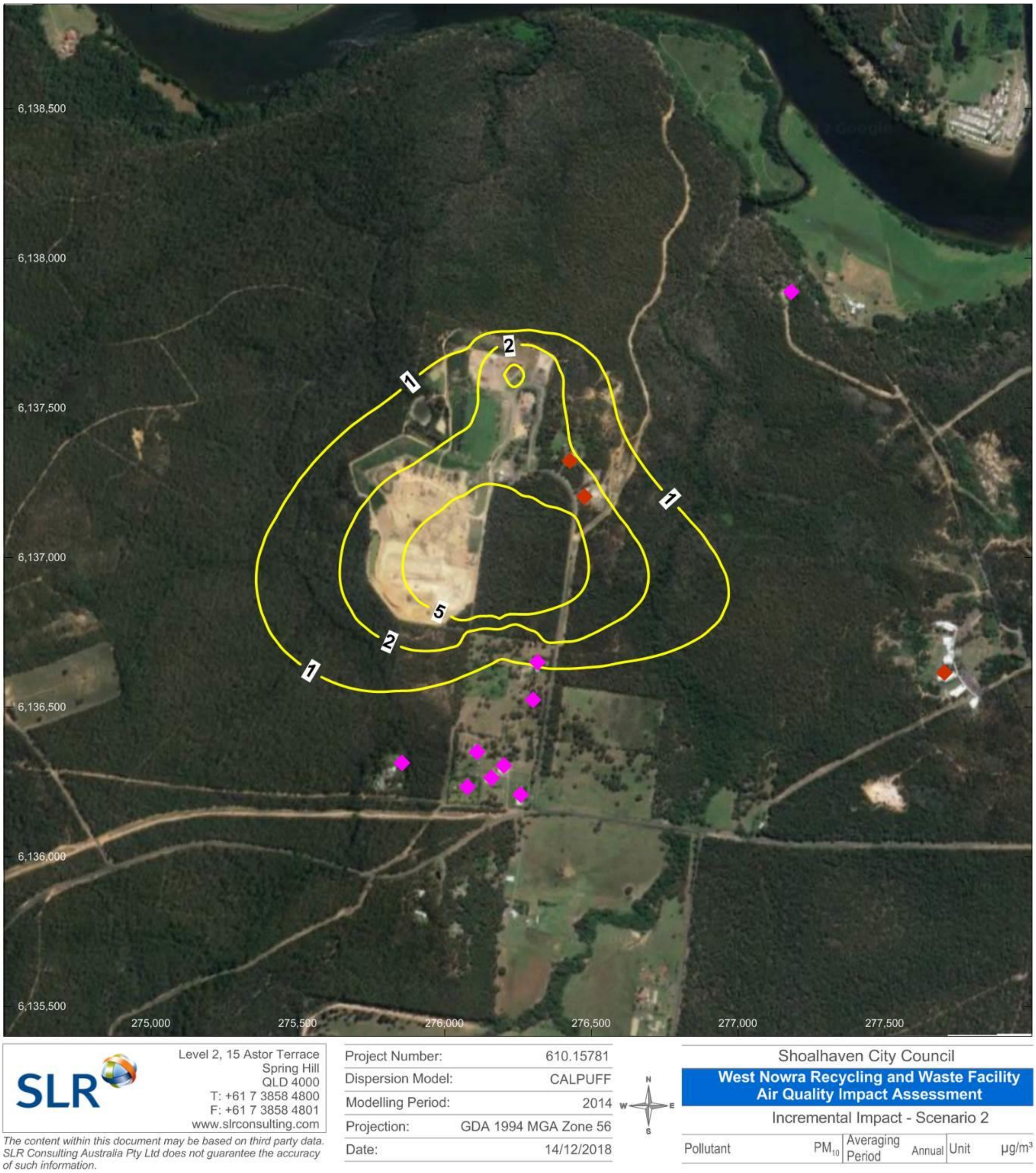


Figure 30 Predicted Annual Average Incremental PM_{10} Concentrations – Scenario 2



9.2.3 $PM_{2.5}$

The cumulative annual average and 24-hour average $PM_{2.5}$ concentrations predicted at surrounding sensitive receptors for Scenario 1 and 2 are presented in **Table 22**. Daily varying background PM_{10} data recorded at Bargo in 2014 (concurrent with the meteorological data) have been scaled by a ratio of 0.46 to provide estimates of background $PM_{2.5}$ concentrations to enable an assessment of potential cumulative impacts (refer to **Section 6.1**).

Contour plots showing the incremental 24-hour and annual average $PM_{2.5}$ concentrations predicted for each scenario are presented in **Figure 31** and **Figure 32** (maximum 24-hour averages) and in **Figure 33** and **Figure 34** (annual averages). These plots show the maximum downwind $PM_{2.5}$ concentrations predicted in the area surrounding the Facility due to emissions from the proposed operations, exclusive of local background $PM_{2.5}$ concentrations.

The modelling results presented in **Table 22** show that the maximum 24-hour average cumulative $PM_{2.5}$ concentrations predicted at the nearest residential receptors are below the relevant criterion of 25 µg/m^3. The annual average cumulative $PM_{2.5}$ concentrations predicted at the nearest sensitive receptors are also below the relevant NSW EPA criterion of 8 µg/m^3.

Table 22 Predicted $PM_{2.5}$ Concentrations – Scenarios 1 and 2

Receptor ID	24-Hour Average $PM_{2.5}$ Concentrations (µg/m³) [1]				Annual Average $PM_{2.5}$ Concentrations (µg/m³) [2]			
	Incremental		Cumulative		Incremental		Cumulative	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Residential								
R1	2.8	2.3	23.8	23.6	0.2	0.1	6.8	6.8
R2	1.8	1.2	23.5	23.5	0.1	0.1	6.7	6.7
R3	0.6	0.5	23.4	23.4	<0.1	<0.1	6.7	6.7
R4	0.5	0.4	23.4	23.4	<0.1	<0.1	6.7	6.7
R5	0.5	0.4	23.4	23.4	<0.1	<0.1	6.7	6.7
R6	0.4	0.4	23.4	23.4	<0.1	<0.1	6.7	6.7
R7	0.5	0.4	23.4	23.4	<0.1	<0.1	6.7	6.7
R8	0.9	0.8	23.4	23.4	0.1	<0.1	6.7	6.7
R9	0.4	0.4	23.4	23.4	<0.1	<0.1	6.7	6.7
Commercial								
C1	9.8	12.5	23.6	23.6	0.3	0.3	6.9	7.0
C2	10.7	14.4	23.8	23.9	0.3	0.4	7.0	7.1
C3	1.9	2.0	23.5	23.5	<0.1	<0.1	6.7	6.7
Criteria	-		25.0		-		8.0	

1 Includes estimated daily varying background $PM_{2.5}$ concentrations based on PM_{10} data recorded at Bargo and a $PM_{2.5}/PM_{10}$ ratio of 0.46 (see **Section 6.1**).

2 Includes an assumed annual average $PM_{2.5}$ background value of 6.6 µg/m³ based on PM_{10} data recorded at Bargo and a $PM_{2.5}/PM_{10}$ ratio of 0.46 (see **Section 6.1**).

Figure 31 Predicted Maximum 24-Hour Average Incremental $PM_{2.5}$ Concentrations – Scenario 1

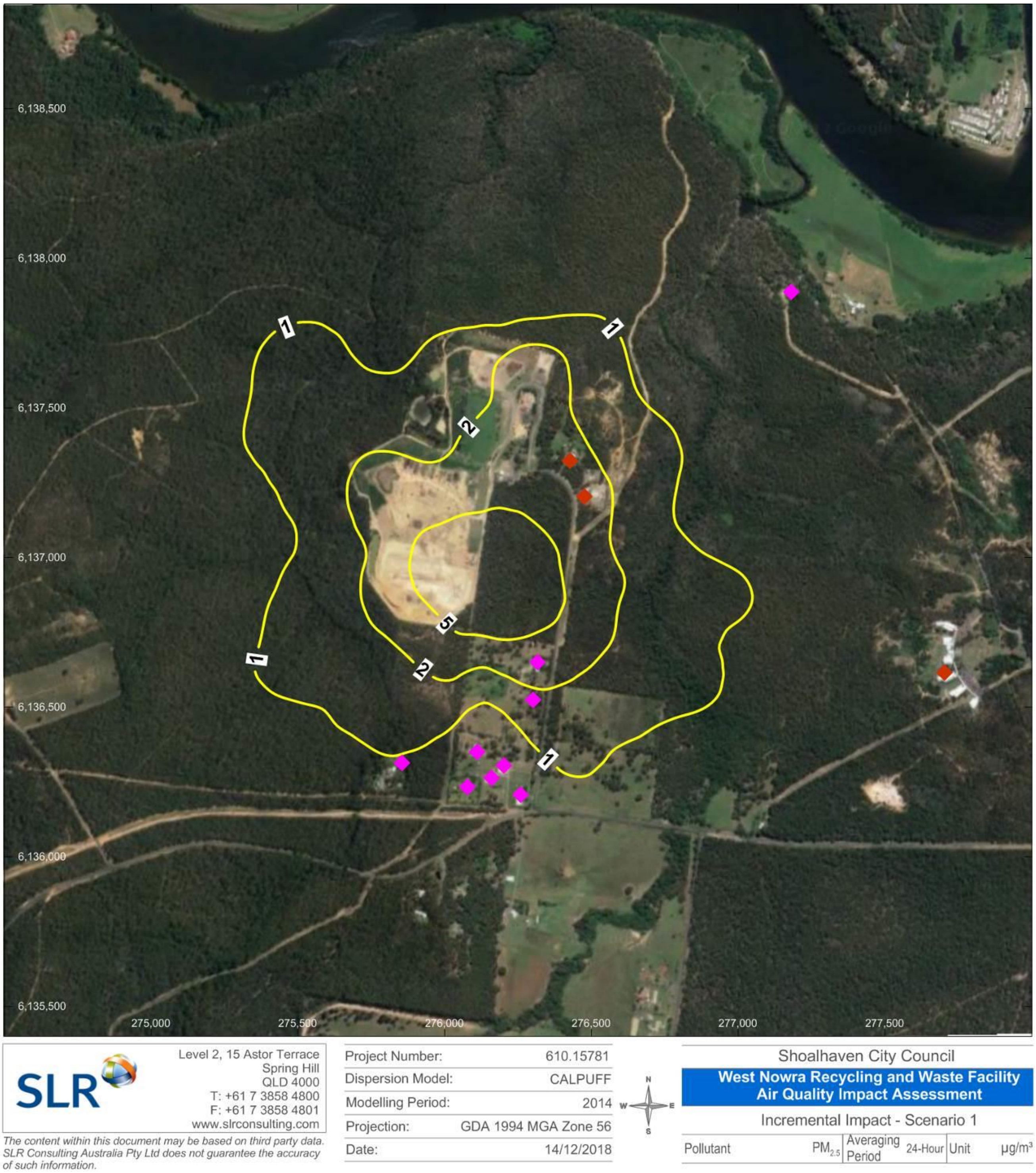
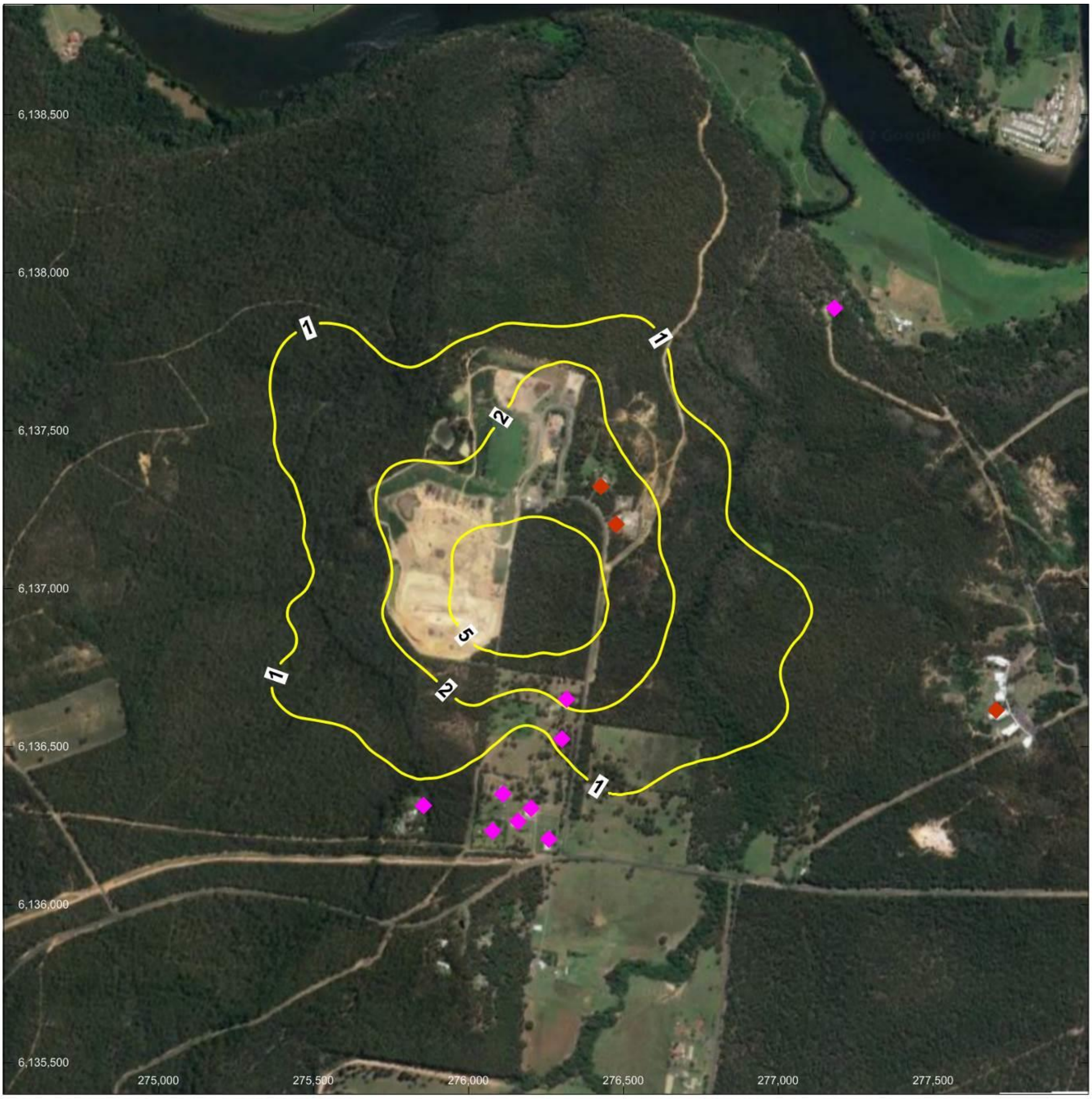


Figure 32 Predicted Maximum 24-Hour Average Incremental $PM_{2.5}$ Concentrations – Scenario 2



SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

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Project Number:	610.15781
Dispersion Model:	CALPUFF
Modelling Period:	2014
Projection:	GDA 1994 MGA Zone 56
Date:	14/12/2018

N W E S

Shoalhaven City Council
West Nowra Recycling and Waste Facility
Air Quality Impact Assessment
Incremental Impact - Scenario 2

Pollutant	$PM_{2.5}$	Averaging Period	24-Hour	Unit	µg/m³

Figure 33 Predicted Annual Average Incremental $PM_{2.5}$ Concentrations – Scenario 1

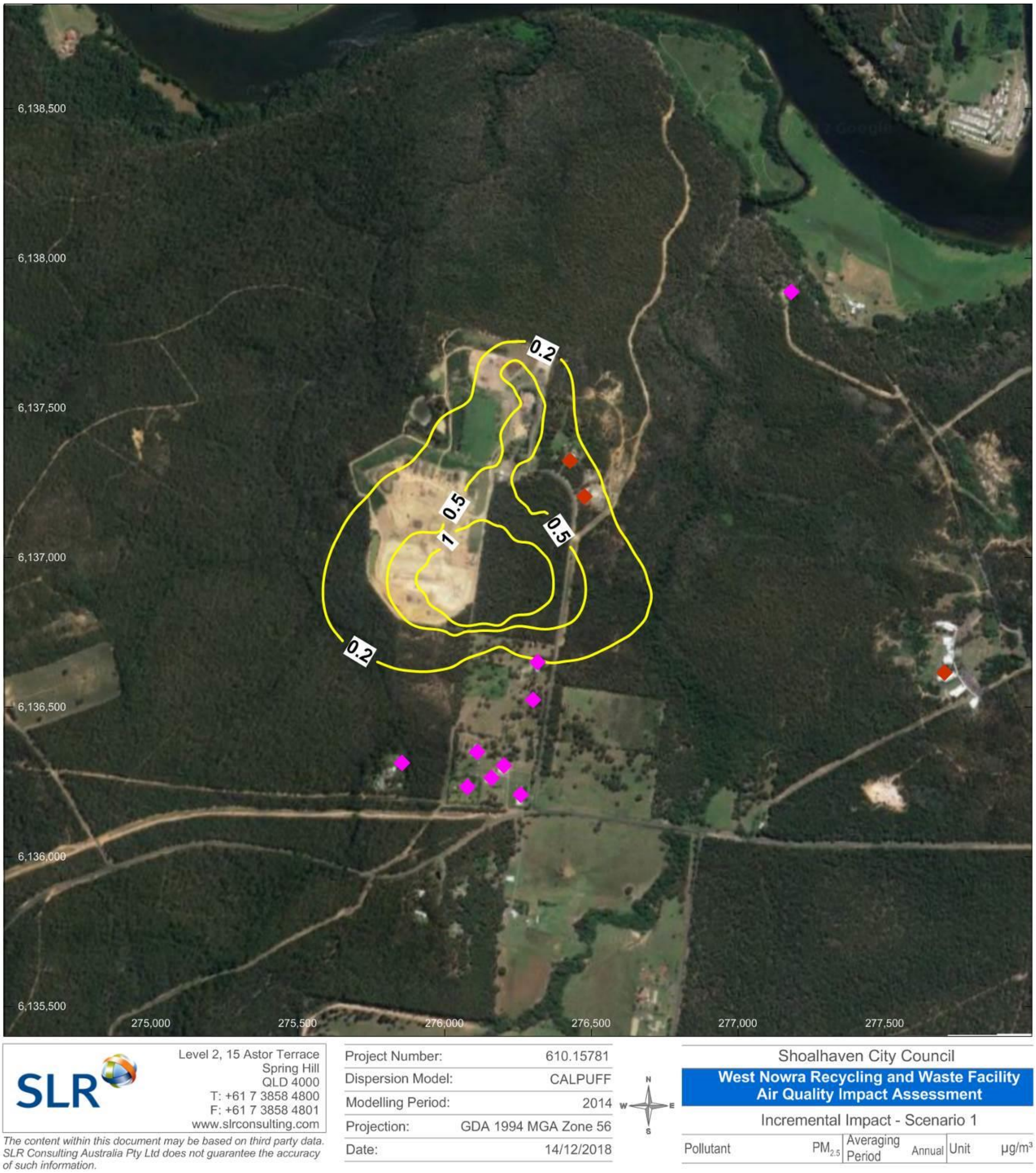
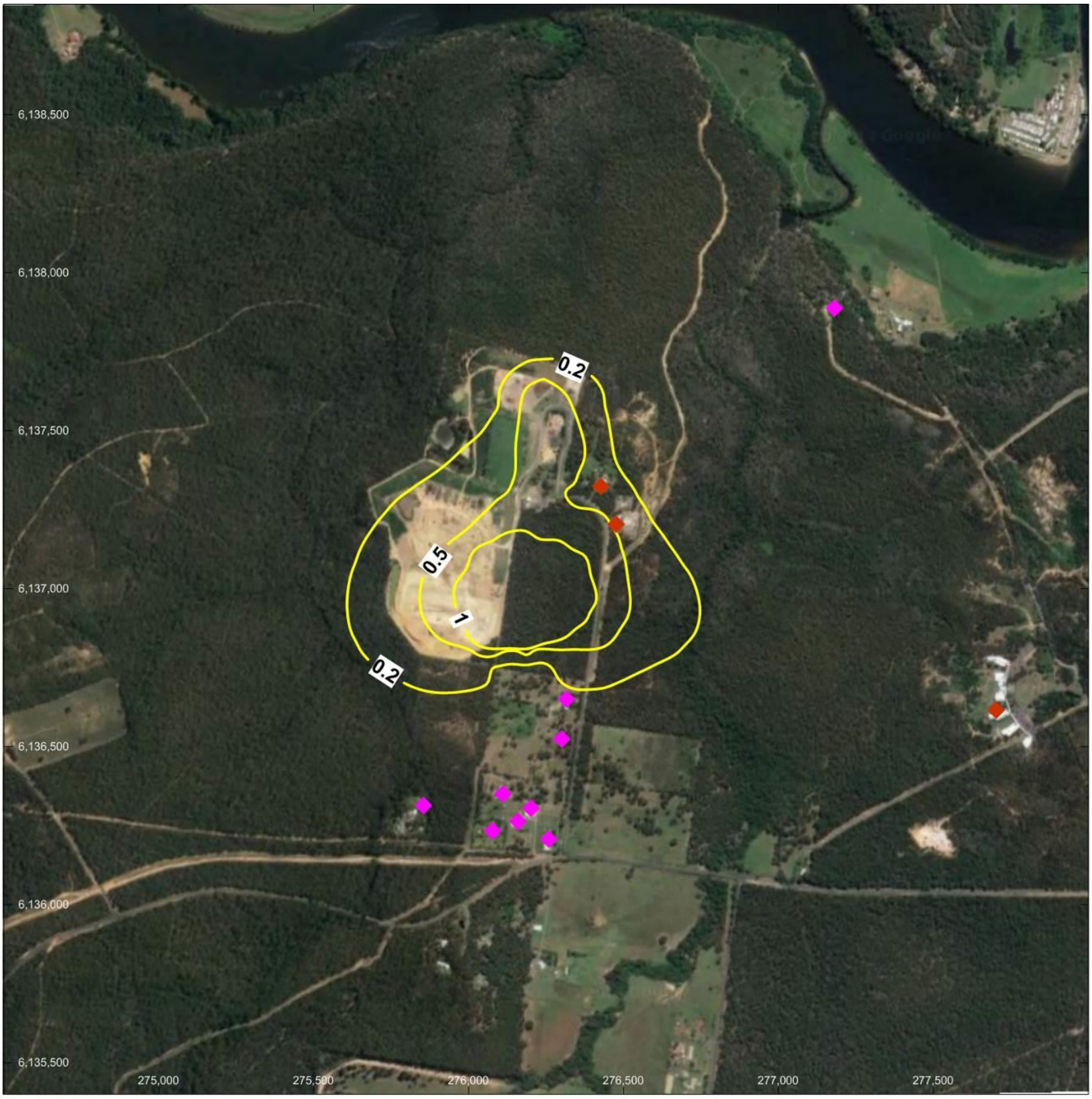


Figure 34 Predicted Annual Average Incremental $PM_{2.5}$ Concentrations – Scenario 2



SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
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Shoalhaven City Council
West Nowra Recycling and Waste Facility
Air Quality Impact Assessment
Incremental Impact - Scenario 2

Pollutant	$PM_{2.5}$	Averaging Period	Annual	Unit	µg/m³

SLR

10 Mitigation and Monitoring

10.1 Mitigation Measures

10.1.1 Odour

The results of the odour modelling indicate that off-site odour impacts from the Proposal would comply with the relevant guideline at all sensitive residential receptors except at the nearest residential receptor, R1. This dwelling is located approximately 88 m from the boundary of the Proposal site, and about 250 m from the nearest waste tipping area. Regular consultation and communication with this receptor is recommended to ensure that odours from the Facility are being managed to acceptable levels.

Management practices recommended to prevent and manage odours from the proposed landfilling operations are provided below.

- Include methods for management of odour emissions into site inductions, training and daily toolbox meetings.
- Perform daily odour checks along the Facility boundary to identify whether odours are detectable off-site and where the main sources of odours are so that action can be taken to mitigate any impacts.
- Regularly audit waste receipt procedures to confirm that appropriate actions are taken by on-site staff in the event that unacceptable and highly odorous wastes are delivered to site.
- Minimise the active landfill waste disposal area and apply appropriate daily and intermediate cover material to minimise odour generating areas in the active landfill cell.
- Implement and regularly review traffic management procedures to co-ordinate delivery schedules and avoid queueing of incoming or outgoing trucks at the Facility for extended periods of time.
- Retain as much vegetative screening between the Proposal and the nearest sensitive receptors as possible.
- Develop and implement spill management procedures to ensure immediate clean-up of any spills from incoming or outgoing vehicles.
- Ensure all utes, trailers and trucks entering and leaving the site are covered.
- Train staff to ensure that any particularly odorous loads are quickly covered to prevent significant odour emissions.
- Manage stockpiles and composting windrows to facilitate natural ventilation and prevent the development of anaerobic zones.
- Maintain an odour complaint logbook/register that records:
  - The time and date the complaint was received (and the time date the odours were observed if the event occurred prior to the complaint being submitted, for example, the night before);
  - The location where odours were observed;
  - A description of the odours including the intensity, duration and frequency as well as a description of the character of the odour;

    - Any information the complainant can provide on the meteorological conditions at the time of the complaint;
    - Contact details for the complainant; and
    - The feedback provided to the complainant once the event has been investigated.
- In the event of an odour complaint being received, investigate whether the odours are originating from the Facility based on a review of operations and local meteorological conditions, and (where on-site sources are identified) take appropriate actions to minimise/eliminate them.

10.1.2 Dust

The results of the fugitive dust modelling indicate that off-site $PM_{2.5}$, PM_{10} and TSP concentrations, and dust deposition rates would comply with the relevant guidelines at the nearest sensitive receptors.

Management practices recommended to minimise dust emissions from the landfill cell construction activities and landfilling operations include the following:

- Include methods for the management of dust emissions in site inductions, training and daily toolbox meetings;
- Perform daily inspections of visible dust emissions along the site boundary of the Proposal to identify whether dust is travelling off-site and where the main sources of dust are so that action can be taken to mitigate any impacts (i.e. additional watering etc.);
- Site staff should determine the frequency of water cart passes required, based on the following:
    - weather conditions;
    - volume of traffic on exposed or dusty surfaces;
    - extent of stripped area; and
    - extent of unprotected areas;
- Reduce dust production on site by scheduling work into stages to minimise land disturbance in the planning and design stage, including scheduling installation of control measures for dust prevention, while having regard for seasonal dryness;
- Retain as much vegetative screening between the Proposal and the nearest sensitive receptors as possible;
- Limit vehicle movements to designated sealed entries and exits, haulage routes and parking areas;
- Use cattle/shaker grids and wheel wash in order to reduce the tracking of mud off-site onto public roads;
- Regularly water access roads to ensure material is not tracked onto the roads around the site;
- Keep the areas of land cleared to a minimum, and the period of time areas remain cleared to a minimum;
- Define haul routes to be used wherever it is necessary for vehicles to traverse unsealed roads;
- Rehabilitate cleared areas promptly;
- Locate stockpiles in areas that are protected from wind where possible and/or away from sensitive receptors; and

- Ensure appropriate use and management of temporary erosion control with fabrics or plastics (short-term only), vegetation or polymers (long term controls).

10.1.3 Other Air Pollutants

To control emissions of products of fuel combustion from the Facility (including fine particulate matter), ensure plant and machinery is regularly checked and maintained in a proper and efficient condition.

Plant and machinery should be turned off when not in use and be fitted with emission control devices complying with Australian Design Standards.

10.2 Monitoring

The emission estimation and dispersion modelling study performed as part of this AQIA indicates that even based on conservative estimates regarding future waste volumes only minor off-site impacts are predicted at the nearest sensitive receptors. The nearest sensitive receptor R1 is predicted to experience 99th percentile odour concentrations slightly above the adopted odour criterion. However the TSP, PM_{10} and $PM_{2.5}$ concentrations, and monthly dust deposition rates predicted at this receptor all comply with the relevant criteria. The modelling results for all other sensitive receptors comply with the relevant air quality criteria.

Given the above, and the very small number of complaints regarding air emissions from the current Facility operations, no instrument-based air quality monitoring programs are recommended. It is recommended however that a programme of regular odour surveys be implemented at the site, prior to (for baseline) and during waste disposal in Stage 4. A procedure should be developed for performing these surveys that ensures:

- The surveys are performed along an agreed route (focussing on the southern boundary) with all observations recorded on suitable field sheets, which are then retained on-site to be made available for review and analysis as required in the future;
- Observations recorded include:
  - Date and time of day;
  - Weather conditions (wind speed, wind direction, temperature, recent rainfall); and
  - Odour intensity and odour character (landfill odours or other odours) at each survey point;
- The personnel performing the surveys have been tested in a dynamic dilution odour laboratory to confirm they meet the sensitivity requirement for odour panellists as set out in AS 4323.3:2001 *Determination of odour concentration by dynamic olfactometry*;
- The personnel performing the surveys have been appropriately trained in performing odour observations and documenting their observations as required;
- The odour intensity observations are recorded using a suitable intensity scale that will provide information on the relative strength of any odours detected along the boundary before and after landfilling commences in Stage 4;
- The odour surveys are performed on a regular basis (eg fortnightly) and include observations during early morning and in the evening to cover the time period when the modelling indicates that worst-case odour impacts are most likely to occur; and

- If personnel from the Facility perform the surveys, that they have been off-site for a suitable period of time before undertaking this task to minimise the risk that they are desensitised to the odours from the landfill (eg. perform them at the start of the shift).

The main objective of the odour surveys would be to provide information on existing (baseline) odour levels along the site boundary that can then be compared to observations made as the landfilling activities move into the Stage 4 Extension, to assess whether any significant change in the strength or frequency of any odours can be detected. In the event that significant landfill-related odours are detected during a survey, the source of the odours at the Facility should also be investigated at that time, so that remedial action can be taken.

Regular inspections of visible dust emissions from the Proposal should also be performed by site personnel to ensure that mitigation measures are being appropriately implemented.

11 Conclusions

SCC is proposing to develop an extension to the existing landfill operation at the West Nowra Recycling and Waste Facility at Flatrock Road, Mundamia. This Air Quality Impact Assessment (AQIA) has been prepared to provide an assessment of potential air quality impacts associated with the proposed extension (the Proposal) as an input to the Environmental Impact Statement.

This AQIA has been prepared based on a number of worst case scenario assumptions including a high growth in waste volumes and assuming no resource recovery operations have been implemented. It is unlikely that this worst case scenario will actually eventuate and the predicted off-site impacts are anticipated to be overestimates of actual impacts.

The results of the odour and dust modelling study performed for the Proposal activities are summarised below.

- The incremental 99th percentile nose-response odour concentrations predicted as a result of the Proposal comply with the adopted criterion all of the residential receptors identified except for R1, which is located approximately 88 m south of the Proposal. The 99th percentile odour concentration predicted at this receptor is 6.4 ou, slightly above the adopted criterion of 5 ou.
- Odour concentrations above the sensitive receptor criterion are also predicted at the (now closed) RSPCA Shoalhaven Animal Shelter site and the OEH buildings. These receptors would not be considered to be particularly sensitive to odour impacts. People will only be present at these locations during work hours, especially not in the evening and at night when the highest off-site odour concentrations are most likely to occur. They are also located adjacent to the landfill in an area where some periods of detectable odours would be expected to occur.
- The annual average TSP concentrations and maximum monthly dust deposition rates predicted at all sensitive receptor locations are below the relevant assessment criteria. No nuisance dust impacts would therefore be expected as a result of fugitive dust emissions from the Proposal.
- The maximum 24-hour average and annual average cumulative PM_{10} concentrations predicted at the nearest sensitive receptors comply with the relevant ambient air quality criteria.
- The maximum 24-hour average and annual average cumulative $PM_{2.5}$ concentrations predicted at the nearest sensitive receptors are below the relevant ambient air quality criteria.

Given the uncertainty associated with the estimation and modelling of odour emissions from landfills, conservative assumptions have been used in the assessment so that the results should be a conservative over-estimate of actual impacts. It is noted that there is no history of significant numbers of complaints regarding odour emissions from the current landfilling operations. Nonetheless, the results of the modelling indicate that there is potential for some minor odour impacts at the nearest sensitive receptor R1 as the landfilling operations move further south on the site. Regular consultation and communication with this landowner is therefore recommended to ensure that odour from the Facility is being managed to acceptable levels. Odour surveys are also recommended to be performed prior to (for baseline) and during waste disposal in Stage 4.

Regular inspections of visible dust emissions from the Proposal should also be performed by site personnel to ensure that mitigation measures are being appropriately implemented. Any complaints received regarding air quality issues should be appropriately addressed and documented.

12 References

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APPENDIX A

Particulate Emission Factors and Emission Calculations

Scenario 1

Activity	Emission Factor				Intensity		Peak Daily Emission Rate (kg/day)			Peak Emission rate (kg/annum)			Mitigation Measure	Control Efficiency
	TSP	PM_{10}	$PM_{2.5}$	Unit	Value	Unit	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$		
Scrapers	0.029	0.0073	0.00073	kg/t	7,774	tonnes/day	225.45	56.75	5.68	82,289	20,714	2,071		
Excavator - Cell 1 *	0.00077	0.000364	5.51×10^{-5}	kg/t	7,774	tonnes/day	5.98	2.83	0.43	2,184	1,033	156		
Excavator - leachate drainage *	0.00077	0.000364	5.51×10^{-5}	kg/t	1,086	tonnes/day	0.84	0.40	0.06	305	144	22		
Dozers on Cell 1 *	1.63	0.305	0.031	kg/hr	9	hrs/day	14.71	2.75	0.28	5,369	1,004	100		
Hauling excavated materials to stockpile	0.88	0.26	0.026	kg/VKT	104	VKT/day	22.80	6.74	0.67	8,322	2,459	246	Level 1 watering	75%
Unloading excavated materials	0.00077	0.000364	5.51E-05	kg/t	7,774	tonnes/day	5.98	2.83	0.43	2,184	1,033	156		
Hauling waste to tipping face - unpaved road	0.88	0.26	0.026	kg/VKT	17	VKT/day	3.81	1.13	0.11	1,392	411	41	Level 1 watering	75%
Hauling waste to tipping face - paved road	0.20	0.04	0.01	kg/VKT	156	VKT/day	30.77	5.88	1.39	11,231	2,147	508		
Unloading waste at tipping face	0.00077	0.000364	5.51E-05	kg/t	412	tonnes/day	0.32	0.15	0.02	116	55	8		
Compactor on active face	1.63	0.305	0.031	kg/hr	9	hrs/day	14.71	2.75	0.28	5,369	1,004	100		
Wind erosion - tipping face	0.4	0.2	0.02	kg/ha/hr	0.03	ha	0.14	0.07	0.01	53	26	3	Level 1 watering	50%
Wind erosion - Cell 1	0.4	0.2	0.02	kg/ha/hr	2.4	ha	11.28	5.64	0.56	4,119	2,059	206	Level 1 watering	50%
Wind erosion - Composting area	0.4	0.2	0.02	kg/ha/hr	0.9	ha	4.32	2.16	0.22	1,577	788	79	Level 1 watering	50%
Wind erosion - Stockpile	0.4	0.2	0.02	kg/ha/hr	1.9	ha	9.18	4.59	0.46	3,352	1,676	168	Level 1 watering	50%
Total							**350**	**95**	**11**	**127,862**	**34,553**	**3,864**		

* The duration of construction assumed to be one month

Total amount of landfilled waste - current	65,589	tpa	2016/17 weighbridge records
Projected waste increase	3	% pa	From National Waste Report 2010
Projected population increase	2	% pa	
Total amount of landfilled waste 2034	150,331	tpa	in 2034 (closure year)
Total amount of soil excavated for Stage 4	509,780	m3	Concept Design report
Soil density	1.83	t/m3	Geotech study (Coffey, 2016)
Moisture content of soil	8.5	%	Average measurement from test pits
Silt content of soil	6.9	%	Average value given in AP-42 for overburden
Total amount of soil excavated for Stage 4	932,897	tonnes	
Total amount of soil excavated for drainage	17,807	m3	
Total amount of soil excavated for drainage	32,587	tonnes	
Distance travelled - excavated soils	0.2	km	
Distance travelled - waste trucks - paved	1.8	km	
Distance travelled - waste trucks - unpaved	0.2		
Payload of dump trucks for construction	30	tonnes	
Payload of waste trucks	9.5	tonnes	
GVM waste truck	15.0	t	https://jjrichards.com.au/wp-content/uploads/2014/06/4x2-hino-side-loading-garbage-truck.pdf
Deliveries per day	43.4		
Deliveries per hour	4.8		
Return Trips	9.6		

Scenario 2

Activity	Emission Factor			Unit	Intensity		Peak Daily Emission Rate (kg/day)			Peak Emission rate (kg/annum)			Mitigation Measure	Control Efficiency
	TSP	PM_{10}	$PM_{2.5}$		Value	Unit	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$		
Scrapers	0.029	0.0073	0.00073	kg/t	7,774	tonnes/day	225.45	56.75	5.68	82,289	20,714	2,071		
Excavator - Cell 2 *	0.00077	0.000364	5.51×10^{-5}	kg/t	7,774	tonnes/day	5.98	2.83	0.43	2,184	1,033	156		
Dozers on Cell 2 *	1.63	0.305	0.031	kg/hr	9	hrs/day	14.71	2.75	0.28	5,369	1,004	100		
Hauling excavated materials to stockpile	0.88	0.26	0.026	kg/VKT	155	VKT/day	34.20	10.11	1.01	12,483	3,689	369	Level 1 watering	75%
Unloading excavated materials	0.00077	0.000364	5.51E-05	kg/t	7,774	tonnes/day	5.98	2.83	0.43	2,184	1,033	156		
Hauling waste to tipping face - unpaved road	0.88	0.26	0.026	kg/VKT	17	VKT/day	3.81	1.13	0.11	1,392	411	41	Level 1 watering	75%
Hauling waste to tipping face - paved road	0.20	0.04	0.01	kg/VKT	156	VKT/day	30.77	5.88	1.39	11,231	2,147	508		
Unloading waste at tipping face	0.00077	0.000364	5.51E-05	kg/t	412	tonnes/day	0.32	0.15	0.02	116	55	8		
Compactor on active face	1.63	0.305	0.031	kg/hr	9	hrs/day	14.71	2.75	0.28	5,369	1,004	100		
Wind erosion - tipping face	0.4	0.2	0.02	kg/ha/hr	0.03	ha	0.14	0.07	0.01	53	26	3	Level 1 watering	50%
Wind erosion - Cell 1	0.4	0.2	0.02	kg/ha/hr	2.4	ha	11.28	5.64	0.56	4,119	2,059	206	Level 1 watering	50%
Wind erosion - Composting area	0.4	0.2	0.02	kg/ha/hr	0.9	ha	4.32	2.16	0.22	1,577	788	79	Level 1 watering	50%
Wind erosion - Stockpile	0.4	0.2	0.02	kg/ha/hr	1.9	ha	9.18	4.59	0.46	3,352	1,676	168	Level 1 watering	50%
Total							**361**	**98**	**11**	**131,718**	**35,639**	**3,965**		

* The duration of construction assumed to be one month

Total amount of landfilled waste - current	65,589	tpa	2016/17 weighbridge records
Projected waste increase	3	% pa	From National Waste Report 2010
Projected population increase	2	% pa	
Total amount of landfilled waste 2034	150,331	tpa	in 2034 (closure year)
Total amount of soil excavated for Stage 4	509,780	m3	Concept Design report
Soil density	1.83	t/m3	Geotech study (Coffey, 2016)
Moisture content of soil	8.5	%	Average measurement from test pits
Silt content of soil	6.9	%	Average value given in AP-42 for overburden
Total amount of soil excavated for Stage 4	932,897	tonnes	
Total amount of soil excavated for drainage	17,807	m3	
Total amount of soil excavated for drainage	32,587	tonnes	
Distance travelled - excavated soils	0.3	km	
Distance travelled - waste trucks - paved	1.8	km	
Distance travelled - waste trucks - unpaved	0.2		
Payload of dump trucks for construction	30	tonnes	
Payload of waste trucks	9.5	tonnes	
GVM waste truck	15.0	t	https://jjrichards.com.au/wp-content/uploads/2014/06/4x2-hino-side-loading-garbage-truck.pdf
Deliveries per day	43.4		
Deliveries per hour	4.8		
Return Trips	9.6		

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

GOLD COAST
Ground Floor, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

ROCKHAMPTON
rockhampton@slrconsulting.com
M: +61 407 810 417

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TAMWORTH
PO Box 11034
Tamworth NSW 2340
Australia
M: +61 408 474 248
F: +61 2 9427 8200

TOWNSVILLE
Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

NELSON
5 Duncan Street
Port Nelson 7010
New Zealand
T: +64 274 898 628

NEW PLYMOUTH
Level 2, 10 Devon Street East
New Plymouth 4310
New Zealand
T: +64 0800 757 695