



## **Appendix G. Air Quality Assessment (Vipac Engineers & Scientist, 2021)**



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# **Vipac Engineers & Scientists**

Tonkin Consulting

**Buronga Landfill Expansion**

**Air Quality Assessment**

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## EXECUTIVE SUMMARY

Vipac Engineers and Scientists Ltd (Vipac) has been commissioned by Wentworth Shire Council to conduct an Air Quality Impact Assessment in support of the proposed landfill expansion at the Buronga Landfill situated at 258 Arumpo Rd Buronga (the Project). Due to the existing site approaching capacity, the expansion is expected to increase its capacity from 30,000 tonnes per annum to 100,000 tonnes per annum.

The overall approach to the assessment follows the guidance from *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* and the *Optimum CALPUFF modelling guidance for NSW* as follows:

- An emissions inventory of TSP, PM10, PM2.5, and deposited dust for the proposed Project was compiled using National Pollutant Inventory (NPI) and United States Environmental Protection Agency (USEPA) AP-42 emissions estimation methodology for the Project. Odour emissions from the landfill activities were conservatively derived from web-based research of measured data from similar facilities.
- Estimated emissions data was used as input for air dispersion modelling. The modelling techniques were based on a combination of The Air Pollution Model (TAPM) prognostic meteorological model (developed by CSIRO), and the CALMET model suite used to generate a three dimensional meteorological dataset for use in the CALPUFF dispersion model.
- The atmospheric dispersion modelling results were assessed against the air quality assessment criteria as part of the impact assessment. Air quality controls are applied to reduce emission rates where applicable.

As summarised in Table ES-1, the results of the modelling have shown that the odour, TSP and dust deposition predictions are below the relevant criteria for all averaging periods at all sensitive receptors. The annual average PM10 and PM2.5 predictions are also below criteria.

The 24 hour average PM10 and PM2.5 predictions are above the criteria. The exceedances are driven by the elevated background conservatively adopted for the assessment, which are already above the criteria. No additional exceedances of the criteria are predicted to occur as a result of the proposed Landfill expansion activities and that best management practices will be implemented to minimise emissions as far as is practical. As specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, under these circumstances no additional assessment is therefore required.

A greenhouse gas assessment has also been undertaken for the Project. This assessment determines the carbon dioxide equivalent (CO<sub>2</sub>-e) emissions from the Project according to international and Federal guidelines. The estimated annual operational phase emissions (161,680 tonnes CO<sub>2</sub>-e) represent approximately 0.03% of Australia's latest greenhouse inventory estimates of 532.5 MtCO<sub>2</sub>-E (2019).

It is therefore concluded that air quality should not be a constraint to proposed landfill expansion.

**Table ES-1 Summary of Results**

Pollutant	Averaging Period	Criteria	Maximum Prediction at Any Receptor		Compliant
			In isolation	Cumulative	
TSP	Annual	90 µg/m <sup>3</sup>	1.68 µg/m <sup>3</sup>	53.18 µg/m <sup>3</sup>	✓
PM10	24 Hour	50 µg/m <sup>3</sup>	13.12 µg/m <sup>3</sup>	114.7 µg/m <sup>3</sup>	✓
	Annual	25 µg/m <sup>3</sup>	0.62 µg/m <sup>3</sup>	21.22 µg/m <sup>3</sup>	✓
PM2.5	24 Hour	25 µg/m <sup>3</sup>	2.11 µg/m <sup>3</sup>	28.1 µg/m <sup>3</sup>	✓
	Annual	8 µg/m <sup>3</sup>	0.09 µg/m <sup>3</sup>	7.49 µg/m <sup>3</sup>	✓
Dust Deposition	Monthly Total	4 g/m <sup>2</sup> /month	0.36 g/m <sup>2</sup> /month	2.36 g/m <sup>2</sup> /month	✓
	Monthly Increase	2 g/m <sup>2</sup> /month	0.36 g/m <sup>2</sup> /month	0.36 g/m <sup>2</sup> /month	✓
Odour		7 OU	2.76 OU	2.76 OU	✓

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## 1 INTRODUCTION

Vipac Engineers and Scientists Ltd (Vipac) has been commissioned by Wentworth Shire Council (WSC) to prepare an Air Quality Impact Assessment in support of the proposed landfill expansion at the Buronga Landfill at 258 Arumpo Rd Buronga (the Project). Due to the existing site approaching capacity, the expansion is proposed to increase its capacity from 30,000 tonnes general waste per annum to 100,000 tonnes per annum.

The purpose of this assessment is to assess the potential impacts of air pollutants generated from the Project and to provide recommendations to mitigate any potential impacts that might have an effect on any sensitive receptors.

The assessment has been carried out in accordance with the NSW Environment Protection Authority's *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*.

## 2 PROJECT DESCRIPTION

### 2.1 OVERVIEW

The proposed expansion to the landfill will increase the total quantity of waste that WSC is licensed to landfill at the Buronga Landfill from 30,000 tonnes to 100,000 tonnes of general waste per annum. It will consist of the construction of multiple additional landfill cells over the next approximately 70 years comprising a volume of approximately 8.5 million m<sup>3</sup> over an area of approximately 395,000 m<sup>2</sup> (including the current active landfill cell). The proposed expansion is to occur on the same site as the existing facility, but beyond the footprint of the current landfill operation and will operate as a regional landfill facility. Additional sheds, hardstands and associated infrastructure are proposed as a part of the development to facilitate resource recovery, separate general public and commercial clients and capture stormwater.

The design of the landfill cells will be in accordance with current best practices using the layout provided in Figure 2-1, with all cells lined for acceptance of general waste. Detailed design of the landfill cells will occur as required over the lifetime of the site with the design of the first additional cell anticipated to begin after development approval is granted. These cells will be designed in accordance with the NSW Landfill Guidelines and other industry best practices to minimise the environmental impact of the landfill operation. Leachate and stormwater management infrastructure will be provided as a part of the development, including leachate and stormwater ponds. Closure and rehabilitation plans will be developed as required for the landfill cells and implemented as the cells reach end of life. The closure and rehabilitation process involves capping the landfill cells to prevent water ingress and revegetating the site.

Buronga Landfill currently accepts building and demolition waste, general exempted waste, waste mineral oils, tyres, asbestos and general solid waste (both putrescible and non-putrescible) as permitted under the NSW EPA Licence 20209. The facility is licenced to:

- Receive up to 10,000 tonnes/year (t/yr) and store a maximum of 20,000 tonnes recovered aggregate (building & demolition waste);
- store up to 4,000 litres of waste mineral oil;
- Store 50 tonnes of tyres at any one time; and
- Dispose of 500 t/yr tyres, 500 t/yr asbestos and 30,000 t/yr general solid waste.

It will continue to accept the same categories of waste as permitted in the NSW EPA Licence 20209 for the operation of the Buronga Landfill. The proposed development has the following objectives:

- Increase the landfill lifespan by staged construction of additional landfill cells on the current site over a footprint of approximately 40 ha of the 124 ha site;



delivery movements. The haulage route for truck traffic entering and leaving the waste facility will be Arumpo Road back to the Silver City Highway (and vice versa).

## 2.4 OPERATIONAL HOURS

The operating hours of the landfill are proposed to remain as currently licenced being:

- 6:00 am to 7:00 pm Monday to Friday; and
- 7:00 am to 6:00 pm Saturdays, Sundays and Public holidays.

## 2.5 PROPOSED EQUIPMENT

The proposed site equipment would include:

- 826 landfill compactor
- D7 dozer
- water truck (15kL)
- 20t excavator
- 30t tipper truck
- 12t loader
- tractor
- stormwater pump (diesel)
- leachate pumps (submersibles)
- 1 site vehicle
- weighbridge

## 3 POLLUTANTS OF CONCERN

The main emissions to air from landfill operations are caused by wind-borne dust, vehicle usage, materials handling and transfers. Fugitive air emissions can be estimated using emission factors combined with site-specific information such as the silt and moisture content of material being handled.

Dust is a generic term used to describe fine particles that are suspended in the atmosphere. The dust emissions considered in this report are particulate matter in various sizes:

- Total Suspended Particles (TSP) - Particulate matter with a diameter up to 50 microns;
- PM10 - Particulate matter less than 10 microns in size;
- PM2.5 - Particulate matter less than 2.5 microns in size; and
- Dust Deposition - deposited matter that falls out of the atmosphere.

As the landfill is proposed to accept general solid waste (both putrescible and non-putrescible), there is also potential for offsite odour impact. Odour is of particular concern and interest as a regulatory and community issue because of its ability to have direct sensory effects on people who are exposed to those emissions. This exposure can lead to nuisance and complaints, a situation that is often difficult to address in a purely quantitative manner.

## 4 REGULATORY FRAMEWORK

### 4.1 NATIONAL LEGISLATION

Australia's first national ambient air quality standards were outlined in 1998 as part of the National Environment Protection Measure for Ambient Air Quality (National Environment Protection Council, 1998).

The Ambient Air Measure (referred to as Air NEPM) sets national standards for the key air pollutants; carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, lead and particles (PM<sub>10</sub>). A revision to the Measure was issued in 2003 with the inclusion of advisory PM<sub>2.5</sub> standards. The Air NEPM requires the State's governments to monitor air quality and to identify potential air quality problems.

### 4.2 STATE LEGISLATION AND GUIDELINES

#### 4.2.1 NSW EPA PARTICULATE AIR QUALITY STANDARDS

The *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW Environment Protection Authority, 2016) detail both the assessment methodology and criteria for air quality assessments. Due to the type of industry and proximity to sensitive receptors, the requirements for a Level 2 assessment have been followed.

The applicable criteria selected for this assessment are presented in *Table 4-1*.

*Table 4-1: Project Air Quality Goals*

Pollutant	Basis	Criteria	Averaging Time	Source
TSP	Human Health	90 µg/m <sup>3</sup>	Annual	Approved Methods
PM <sub>10</sub>	Human Health	50 µg/m <sup>3</sup>	24-hour	Approved Methods
	Human Health	25 µg/m <sup>3</sup>	Annual	Approved Methods
PM <sub>2.5</sub>	Human Health	25 µg/m <sup>3</sup>	24-hour	Approved Methods
	Human Health	8 µg/m <sup>3</sup>	Annual	Approved Methods
Dust deposition	Amenity	Maximum incremental increase of 2 g/m <sup>2</sup> /month	Annual	Approved Methods
	Amenity	Maximum total of 4 g/m <sup>2</sup> /month	Annual	Approved Methods

#### 4.2.2 NSW EPA ODOUR STANDARDS

##### 4.2.2.1 TECHNICAL OVERVIEW

In the context of environmental annoyance and nuisance, it is vital to address the response of individuals to the odour stimulus and the variance in this response across populations. Apart from the response to the physical characteristics of an odour if an individual believes that a specific odour has potential negative health implications, they are more likely to appraise that odour negatively.

The annoyance of an odour is a function of the FIDOL factors, which are Frequency, Intensity, Duration, Offensiveness and Location. The FIDOL factors can be used as a basic means of assessing the potential odour impact of proposed developments.

- Frequency indicates how often a person is exposed to an odour. Even an odour with pleasant hedonic tone can be perceived as a nuisance if exposure is too frequent. At low concentrations a rapidly fluctuating odour is more noticeable than a steady background odour; therefore a high frequency is an aggravating factor.

- Intensity indicates the strength of the odour; it is proportional to the  $\log_{10}$  of the odour concentration (Steven's law).
- Duration indicates the time length of an odour episode, i.e. how long the concentration remains consecutively above the odour threshold.
- Offensiveness is a mixture of odour character and hedonic tone at a given odour concentration. Some odours are universally considered offensive, such as decaying animal matter or rotten eggs. Other odours may be offensive only to those who suffer unwanted exposure, for example coffee roasting odour.
- Location indicates the type of land use and nature of human activities in the vicinity of an odour source. Particular attention must be paid to sensitive receptors, which include housing, schools, hospitals, commercial premises (such as restaurants, offices, shops etc.) and outdoor recreational space.

#### 4.2.2.2 ODOUR CRITERION

Odour performance goals are 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, 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. The *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* include odour assessment criteria as shown in Table 4-2.

Table 4-2: Assessment Criteria for Odour (1 Second Average, 99th Percentile)

Population of Affected Community	Assessment Criteria for Complex Mixtures of Odours (OU)
Urban (>2000) and/or schools and hospitals	2
.500	3
.125	4
.30	5
.10	6
Single rural residence (<2)	7

An odour assessment criterion of 7 OU (peak 1-second average, 99<sup>th</sup> percentile) would appropriately assess the odour performance of the proposed landfill activities.

## 5 EXISTING ENVIRONMENT

### 5.1 LOCAL SETTING

The surrounding environment is primarily industrial sites to the west and north-west and farmland to the south-west. Farmland lies approximately 300m to the South and South West of the site, and two industrial site (bentonite suppliers) approximately 400m to the West and Morello Gypsum 500 m to the North West. The closest residential dwellings are approximately 1km to the South and Lake Gol Gol is approximately 1.8 km to the East. The proposed extension does not move the landfill closer to the residential property or to Lake Gol Gol. Figure 5-1 shows the location of project site, the land zones, the nearest rural dwellings and surrounding developments.



Figure 5-1: Project Site and Surrounding Developments

### 5.2 SITE TOPOGRAPHY

The natural topography of the site generally slopes to the east from a peak of approximately RL48 in the north-west corner to RL35 at a lower area at the eastern toe of the landfill with the final landform to be a maximum of 59m AHD. The NSW 1:50 000 Topographic Map (Mildura 7329-N, 2017) shows site levels are around 40m AHD. Drainage generally follows the natural gradient through constructed drains to the east around the toe of the previous landfill area to a sediment pond located in the south eastern corner of the site.

The area around the site is generally quite flat, with levels increasing to RL50 on the Eastern side of Lake Gol Gol approximately 4 km away from the site. A gully runs North-East to South-West across the site.

### 5.3 DISPERSION METEOROLOGY

#### 5.3.1 REGIONAL METEOROLOGY

The nearest Bureau of Meteorology (BOM) station with long term data is at Mildura Airport (Site number 076031), located approximately 15 km southwest of the Project site. This monitoring station has recorded data since 1946 and a summary of the climate is presented in Table 5-1.

The long term mean temperature range is between 4°C and 33°C with the coldest month being July and the hottest months being December to March. Mean rainfall is consistent across the year but is typically higher in late winter to spring, rainfall in summer months typically occurs over a smaller number of higher intensity events, with the highest mean number of days of rain occurring in July. Rainfall reduces the dispersion of air emissions and therefore the potential impact on visual amenity and health.

Table 5-1: Long-term weather data for Mildura Airport [BOM]

Month	Temperature		Rainfall		9 am Conditions			3 pm Conditions		
	Max (°C)	Min (°C)	Mean Rain Days	No. of Days ≥ 1 mm	Temp (°C)	RH (%)	Wind Speed (km/h)	Temp (°C)	Mean RH (%)	Wind Speed (km/h)
Jan	32.5	16.8	22.2	2.5	21.7	52	15.7	30.5	27	16.9
Feb	31.8	16.5	21.2	2.1	20.9	56	14.5	29.9	30	16
Mar	28.5	13.9	19.2	2.4	18.5	61	13.4	27.1	33	15.6
Apr	23.7	10.2	19.5	2.8	14.9	68	11.6	22.7	40	15.4
May	19.1	7.4	25.1	4.1	10.8	81	9.5	18.3	50	15.1
Jun	16	5.1	21.8	4.5	7.8	88	9.4	15.3	56	15.6
Jul	15.5	4.3	24.5	5	7.1	86	10.4	14.6	54	17.3
Aug	17.3	5.2	25.4	5.1	9.1	78	12.8	16.4	47	19.3
Sep	20.6	7.4	26.5	4.3	12.7	67	15.7	19.4	40	19.7
Oct	24.2	9.9	28.7	4.4	16.1	57	17.4	22.6	34	19.7
Nov	27.7	12.6	25.6	3.6	18.4	53	16.6	25.9	30	18.4
Dec	30.4	15	25	2.8	20.5	50	16	28.4	27	18.1
<b>Annual</b>	<b>23.9</b>	<b>10.4</b>	<b>285.4</b>	<b>43.6</b>	<b>14.9</b>	<b>67</b>	<b>13.6</b>	<b>22.6</b>	<b>39</b>	<b>17.3</b>

A review of the number of rainfall days per year at Mildura shows that on average rainfall is recorded on 43.6 days per year.

The long term wind roses recorded daily at the Mildura Airport station at 9am and 3pm are provided in Figure 5-2. Winds are shown to be primarily from the south and southeast at 9am and from the south, southwest and west directions at 3pm. Stronger winds (>40km/hr or >11.1m/s) occur infrequently mostly from the west.

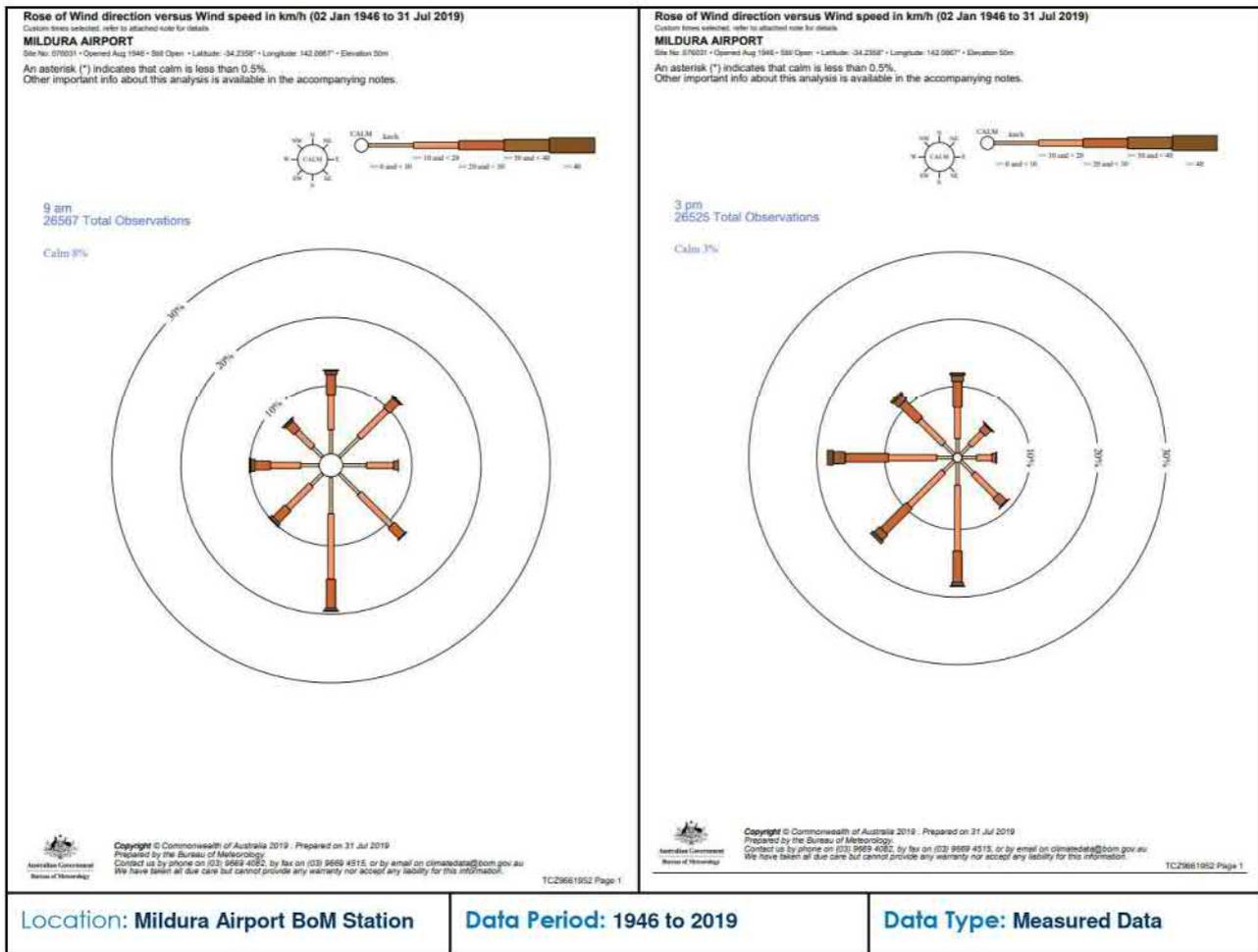


Figure 5-2: Annual wind roses for Mildura Airport Weather Station (1946 to 2019)

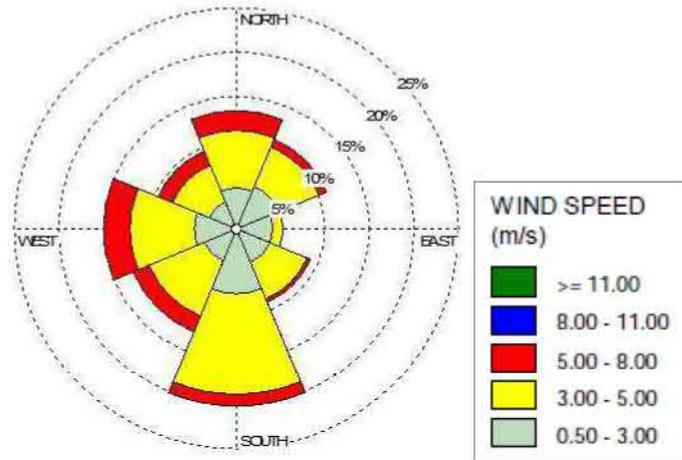
### 5.3.2 LOCAL METEOROLOGY

#### 5.3.2.1 INTRODUCTION

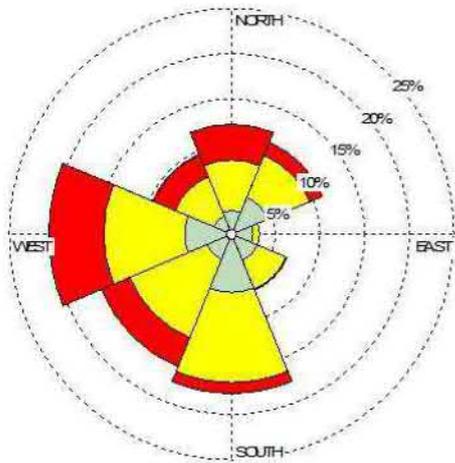
A three dimensional meteorological field was required for the air dispersion modelling that includes a wind field generator accounting for slope flows, terrain effects and terrain blocking effects. The Air Pollution Model, or TAPM, is a three-dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research and can be used as a precursor to CALMET which produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables for each hour of the modelling period. The TAPM-CALMET derived dataset for 12 continuous months of hourly data from the year 2016 and approximately centred at the proposed Project has been used to provide further information on the local meteorological influences. Details of the modelling approach are provided in Section 6.4.

#### 5.3.2.2 WIND SPEED AND DIRECTION

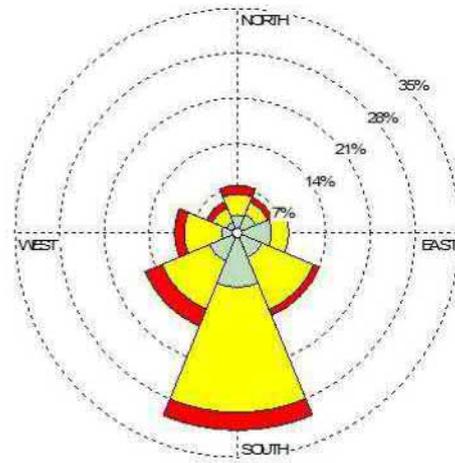
The wind roses from the TAPM-CALMET derived dataset for the year 2016 are presented in Figure 5-3 and Figure 5-4 for the Project site. Figure 5-3 shows that the dominant wind direction is from W during spring, S during the summer and autumn months. In winter, the winds are primarily from the N and W direction. Overall, winds from the E are infrequent.



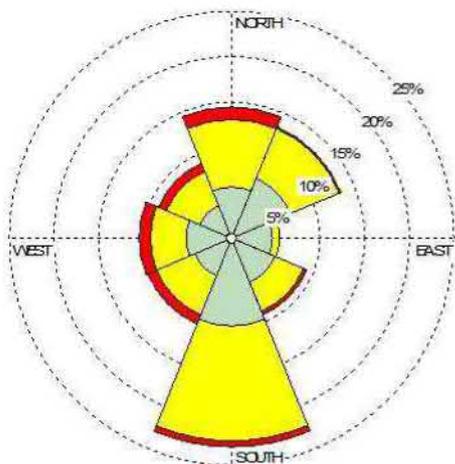
Annual (Calm – 4.1 %)



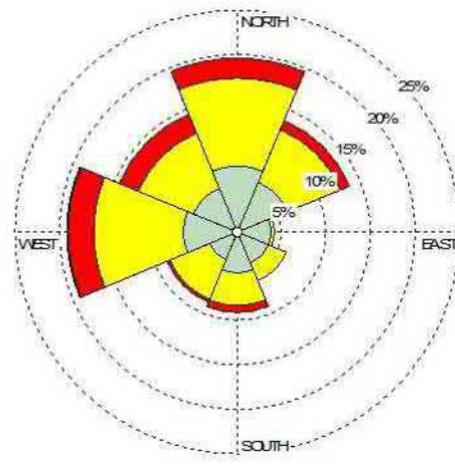
Spring (Calm – 2.6 %)



Summer (Calm – 2.5 %)



Autumn (Calm – 5.2 %)



Winter (Calm – 5.4 %)

Figure 5-3: Site-specific wind roses by season for the TAPM-CALMET derived dataset, 2016

Figure 5-4 shows the wind roses for the time of day during the year for 2016. It can be seen that there are more frequent winds from the west during the afternoon periods.

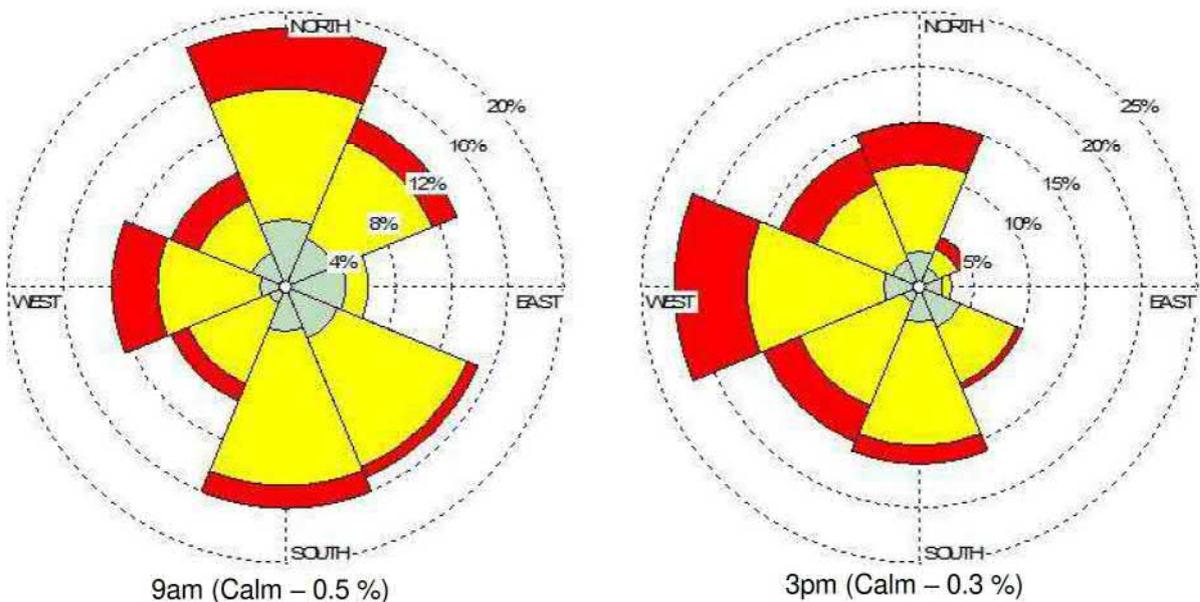


Figure 5-4: Site-specific wind roses by time of day for the TAPM-CALMET derived dataset, 2016

A comparison of the wind roses at 9am and 3pm hours for the TAPM-CALMET derived dataset (Figure 5-4) at the Project site was also undertaken with the BOM long-term wind roses at Mildura (Figure 5-2). There are similarities between the wind roses from BOM and derived dataset, most notably the dominance of winds from the N and S in the morning and W in the afternoon.

In addition, as specified in the Approved Methods (2016), a comparison of the modelled data wind rose generated for 2016 is provided with the most recent five years of available measured data at the BoM monitoring station site. As shown in Figure 5-5, the modelled data is consistent with the measured data for the past five years.

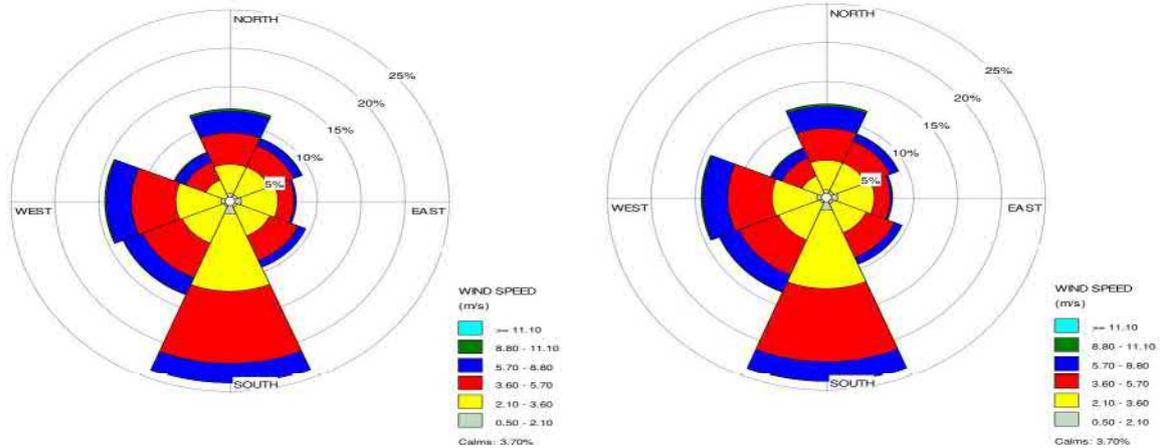


Figure 5-5: Wind roses comparison of modelled 2016 data (left) with Mildura measured data (right)

### 5.3.2.3 ATMOSPHERIC STABILITY

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion of pollutants. The Pasquill-Turner assignment scheme identifies six Stability Classes (Stability Classes A to F) to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions and are used in various air dispersion models. The frequency of occurrence for each stability class for 2016 is shown in Figure 5-6.

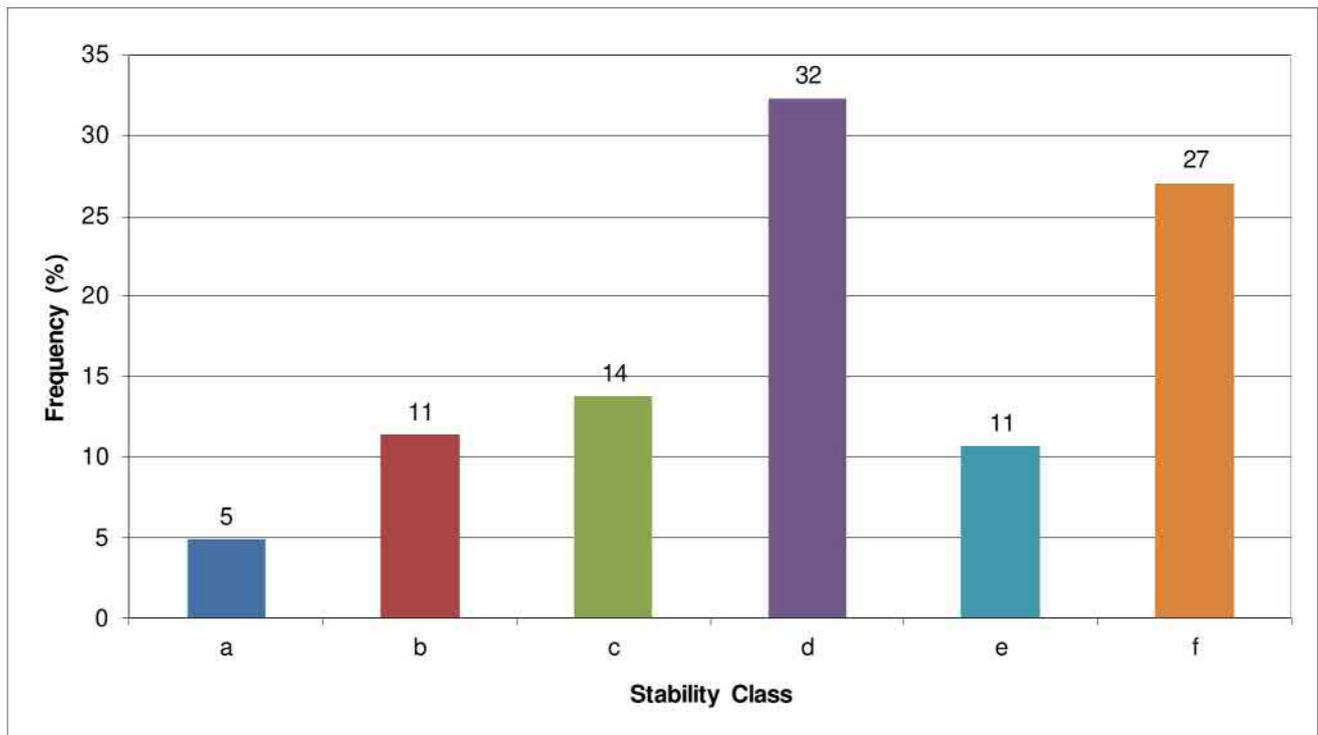


Figure 5-6: Stability class frequency for the TAPM-CALMET derived dataset, 2016

### 5.3.2.4 MIXING HEIGHT

Mixing height refers to the height above ground within which particulates or other pollutants released at or near ground can mix with ambient air. During stable atmospheric conditions, the mixing height is often quite low and particulate dispersion is limited to within this layer.

Diurnal variations in mixing depths are illustrated in Figure 5-7. As would be expected, an increase in the 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 the growth of convective mixing layer.

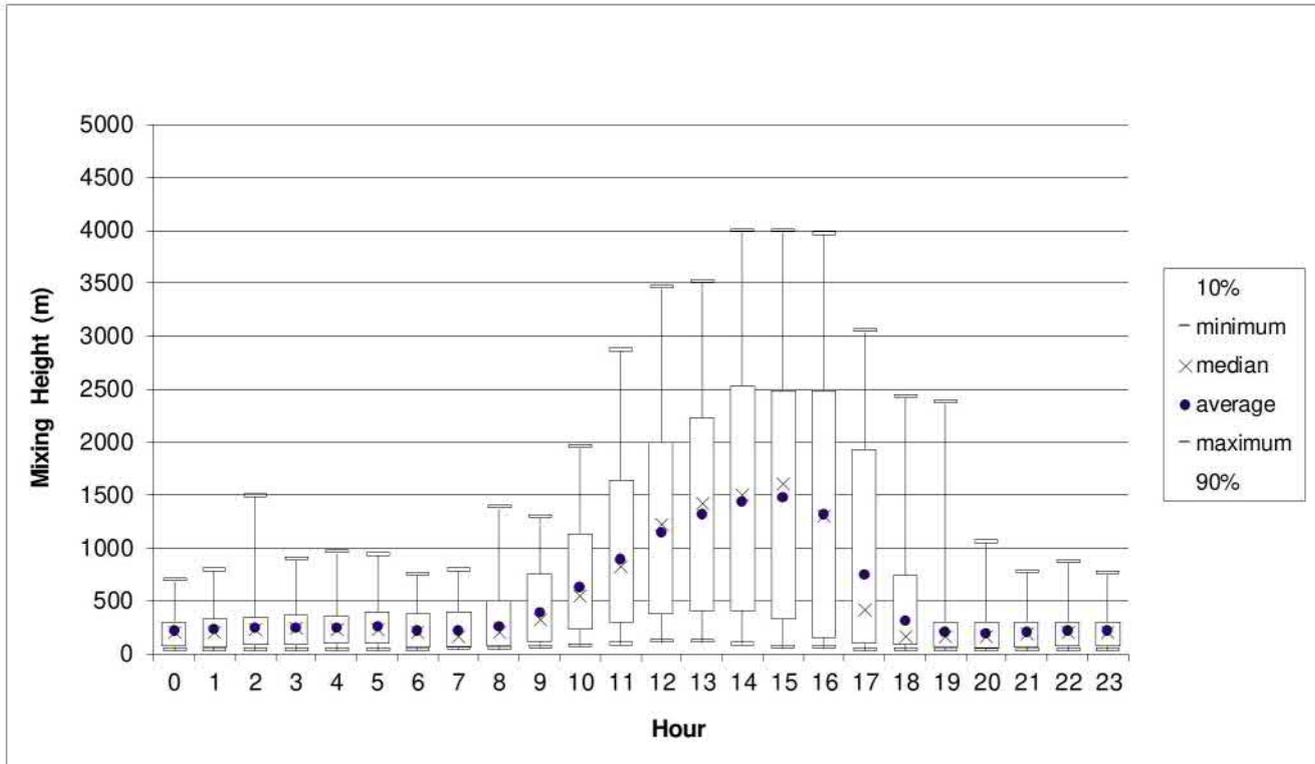


Figure 5-7: Mixing height for the TAPM-CALMET derived dataset, 2016

## 5.4 EXISTING AIR QUALITY

An extensive network of NATA-accredited air quality monitoring stations which use Standards Australia methods, where available is operated by the NSW EPA. The closest monitoring site to the Project site is at Wagga Wagga North, approximately 500 km to the east. The Wagga Wagga North air quality monitoring site is located near the tennis courts in the Wagga Wagga racecourse adjacent to Beckwith Street in Wagga Wagga. While it is noted that this station is a considerable distance from the Project site, it is also a regional site with similar rural sources of air emissions (e.g. primarily dust from farming activities or wind-borne). Of the pollutants of interest, PM<sub>10</sub> and PM<sub>2.5</sub> are measured at the Tamworth site. Where available, the maximum 24 hour average data collected at this site for 2016 is outlined in Table 5-2 as specified in the Approved Methods (2016). Individual 24-hour average predicted PM<sub>10</sub> and PM<sub>2.5</sub> concentrations paired in time with the corresponding 24-hour concentration within the adopted 2016 monitoring dataset to obtain total impact at each receptor is provided for a Level 2 Assessment. In addition, annual average concentration data are adopted for the background levels of pollutants requiring assessment for these periods (e.g. PM<sub>2.5</sub> and PM<sub>10</sub>).

Where unavailable, a conservative assumption is adopted. For example, annual TSP background is derived as 2.5 x measured PM10 based on data collected around Australian mines (ACARP, 1999). No dust deposition data is available, however the results of dust deposition monitoring undertaken at similar locations in central Queensland have been utilised. The average dust deposition from monitoring at these locations is 33 mg/m<sup>2</sup>/day. This is likely to be typical of annual average dust fallout in rural regions although higher levels may exist in the vicinity of local sources. Therefore, the average background deposition rate for the air quality impact assessment in relation to the Project has been assumed to be double the nominated monitoring result, that is 2.0 g/m<sup>2</sup>/month (67 mg/m<sup>2</sup>/day). This methodology is consistent with the Approved Methods, which specifies criteria of 2 g/m<sup>2</sup>/month without background and 4 g/m<sup>2</sup>/month including background.

As shown in Table 5-2, the maximum measured 24 hour average PM<sub>10</sub> is already above the relevant criteria of 50 µg/m<sup>3</sup>.

Table 5-2: Assigned Background Concentrations

Parameter	Air Quality Criteria	Period	Maximum Measured	Adopted Background	Comments
TSP	90 µg/m <sup>3</sup>	Annual	51.5 µg/m <sup>3</sup>	51.5 µg/m <sup>3</sup>	Conservative assumption
PM <sub>10</sub>	50 µg/m <sup>3</sup>	24 Hour	114 µg/m <sup>3</sup>	Varies	NSW EPA Measurement
	25 µg/m <sup>3</sup>	Annual	20.6 µg/m <sup>3</sup>	20.6 µg/m <sup>3</sup>	
PM <sub>2.5</sub>	25 µg/m <sup>3</sup>	24 Hour	28.1 µg/m <sup>3</sup>	Varies	NSW EPA Measurement
	8 µg/m <sup>3</sup>	Annual	7.4 µg/m <sup>3</sup>	7.4 µg/m <sup>3</sup>	
Dust Deposition	4 g/m <sup>2</sup> /month	Month	2 g/m <sup>2</sup> /month	2 g/m <sup>2</sup> /month	Conservative assumption

## 6 METHODOLOGY

The overall approach to the assessment follows the guidance from *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Department of Environment & Conservation, 2016) and the *Optimum CALPUFF modelling guidance for NSW* (Barclay & Scire, 2011).

The air quality impact assessment has been carried out as follows:

- An emissions inventory of TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, and deposited dust for the Project activities was derived using National Pollutant Inventory (NPI) and United States Environmental Protection Agency (USEPA) AP-42 emissions estimation methodology. Odour emissions from the landfill activities were conservatively derived from web-based research of measured data from similar facilities.
- Estimated emissions data was used as input for air dispersion modelling. The modelling techniques were based on a combination of The Air Pollution Model (TAPM) prognostic meteorological model (developed by CSIRO), and the CALMET model suite used to generate a three dimensional meteorological dataset for use in the CALPUFF dispersion model (see Figure 6-1).
- The atmospheric dispersion modelling results were assessed against the air quality assessment criteria described in Section 4 as part of the impact assessment.

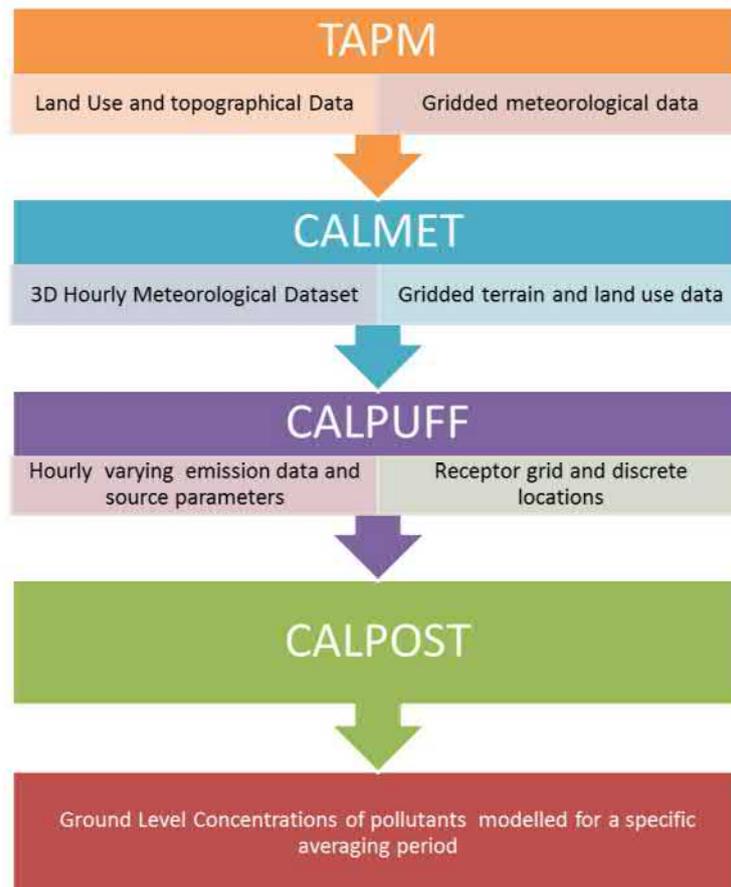


Figure 6-1: Overview of Modelling Process

## 6.1 EMISSIONS INVENTORY

### 6.1.1 PARTICULATE MATTER EMISSIONS

The air quality assessment takes into account dust generating activities from landfill activities and disturbed surfaces within the site boundaries. The main emissions to air from the proposed landfill activities are dust and particulate matter generated by the onsite activities which primarily occur as a result of the following activities:

- unloading of trucks
- front end loader and excavator operations
- wind erosion from disturbed areas and stockpiles
- materials handling
- vehicle movements

Estimated emissions were estimated based on anticipated maximum activity for the sources including controls and are summarised in Table 6-1. Further details of the emissions estimation methodology may be found in Appendix A.

Table 6-1: Emissions Input Data Adopted for the Modelling

Activity	Emission Rate (g/s)			Control applied
	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	
<b>Active Landfill Area</b>				
Excavator/FEL on waste	0.486	0.233	0.051	-
Trucks dumping waste	0.233	0.084	0.025	-
<b>Wind Erosion</b>				
WE – Active landfill	0.311	0.156	0.033	Watering and windbreaks
WE – Inactive landfill	0.036	0.018	0.004	Revegetation
WE – Historical landfill	0.021	0.011	0.002	
<b>Hauling</b>				
Wheel generated dust – Heavy Vehicles	3.290	0.972	0.056	Watering and limiting vehicle speeds < 50km/h
Wheel generated dust – Light Vehicles	0.183	0.064	0.007	
<b>Total</b>	<b>4.56</b>	<b>1.54</b>	<b>0.18</b>	

### 6.1.2 ODOUR EMISSIONS

It is noted that the landfill is proposed to accept both putrescible and non-putrescible waste material. Odour emissions from any non-putrescible waste material being deposited at the landfill site are not likely to be significant. Measurement of odour generated by waste materials can often be limited to more odorous materials and therefore, emission factors adopted to support this Air Quality Impact Assessment represent putrescible waste sources, which would significantly over-estimate the predicted odour impacts of the non-putrescible portion.

Emission factors adopted here have been adopted from site specific source sampling performed to support the Melbourne Regional Landfill (MRL) Air Quality Assessment (PEL, 2016), which are associated with putrescible waste operations and therefore represent a conservative approximation of likely odour emissions resulting from the landfill. This is also the approach adopted for the Proposed Bangus Quarry Landfill – Tumblong NSW (Northstar, 2017).

Measured odour emission rates at the MRL active tip face were 3.3 OU/m<sup>2</sup>/s with odour on interim covered waste at the MRL measured to be 0.16 OU/m<sup>2</sup>/s.

Odour resulting from storage of leachate has been calculated using odour emission rates cited in the Northstar document as measured at the leachate dam within the Woodlawn Bioreactor facility at Tarago, NSW. The odour emission rate associated with leachate storage at that facility was 0.459 OU/m<sup>2</sup>/s. The leachate generated at the Woodlawn site is associated with putrescible waste, and the leachate collected as part of the Proposal is likely to be significantly less odorous. Table 6-2 outlines the odour emission rates adopted for the modelling.

**Table 6-2: Odour emission rates**

Source	Area (m <sup>2</sup> )	Specific odour emission rate (OU/m <sup>2</sup> /s)	Peak to mean <sup>1</sup>	Modelled odour emission rate (OU/m <sup>2</sup> /s)
Active tipface	600	3.3	2.5	4950
Interim cover	400,000	0.16	2.5	55760
Leachate pond	12,828	0.459	2.5	1205

1. The peak to mean ratio (P/M60) of 2.5 has been adopted in stability classes A to F (i.e. all stability classes) to provide a conservatively high estimate of peak odour concentrations from an area source.

## 6.2 EMISSION CONTROLS

A number of emissions controls were adopted in the modelling assessment to mitigate emissions of particulate matter and odour.

### 6.2.1 PARTICULATE MATTER

Particulate matter emissions controls adopted include:

- Watering and windbreaks for the active landfill cell resulting in emissions reductions of 50% and 30%, respectively;
- Revegetation of inactive landfill cells resulting in emissions reductions of 99%
- Watering of unsealed roads resulting in emissions reductions of 75%; and
- Limiting vehicle speeds on unsealed roads to 50km/h resulting in emissions reductions of 44%.

### 6.2.2 ODOUR

Emissions will be managed through the adoption of industry best practice as outlined in the NSW Landfill Guidelines (NSW EPA, 2016), including:

- Restriction of the active tip face to 600 m<sup>2</sup>;
- Placement of daily cover on the active tip face at a depth of 150 mm at the close of business each day;
- The use of intermediate cover on areas awaiting final capping;
- Placement of waste in thin layers to maximise compaction;
- Immediate covering of malodorous wastes; and
- Minimising disturbance of previously filled areas.

## 6.3 SOURCE EMISSION LOCATIONS

Sources associated with the landfill dust and odour emissions were modelled at the locations shown in Figure 2-1. A worst-case scenario was modelled such that the active tipface sources were in the southwestern corner of the proposed expansion nearest to the residential sensitive receptor.

## 6.4 AIR DISPERSION MODELLING

### 6.4.1 TAPM

A 3-dimensional dispersion wind field model, CALPUFF, has been used to simulate the impacts from the Project. CALPUFF is an advanced non-steady-state meteorological and air quality modelling system developed and distributed by Earth Tech, Inc. The model has been approved for use in the 'Guideline on Air Quality Models' (Barclay and Scire, 2011) as a preferred model for assessing applications involving complex meteorological conditions such as calm conditions.

To generate the broad scale meteorological inputs to run CALPUFF, this study has used the model The Air Pollution Model (TAPM), which is a 3-dimensional prognostic model developed and verified for air pollution studies by the CSIRO.

TAPM was configured as follows:-

- Centre coordinates – 34° 8.0 S, 142° 12.0 E;
- Dates modelled – 30th December 2015 to 31st December 2016 (2 start-up days);
- Four nested grid domains of 30 km, 10 km, 3 km and 1 km;
- 41 x 41 grid points for all modelling domains;
- 25 vertical levels from 10 m to an altitude of 8000 m above sea level;
- Data assimilation using measured meteorological data from the Bureau of Meteorology Station at Mildura Airport; and
- The default TAPM databases for terrain, land use and meteorology were used in the model;

### 6.4.2 CALMET

CALMET is an advanced non-steady-state diagnostic three-dimensional meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF modelling system.

The CALMET simulation was run as No-Obs simulation with the gridded TAPM three-dimensional wind field data from the innermost grid. CALMET then adjusts the prognostic data for the kinematic effects of terrain, slope flows, blocking effects and three-dimensional divergence minimisation.

### 6.4.3 CALPUFF

CALPUFF is a non-steady-state Lagrangian Gaussian puff model. CALPUFF employs the three-dimensional meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal.

Emission sources can be characterised as arbitrarily-varying point, area, volume and lines or any combination of those sources within the modelling domain.

The radius of influence of terrain features was set at 20 km while the minimum radius of influence was set as 0.1 km. The terrain data incorporated into the model had a resolution of 1 arc-second (approximately 30 m) in accordance with the *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'*.

## 6.4.4 OTHER MODELLING INPUT PARAMETERS

### 6.4.4.1 PARTICLE SIZE DISTRIBUTION

CALPUFF requires particle distribution data (geometric mass mean diameter, standard deviation) to compute the dispersion of particulates (Table 6-3).

Table 6-3: Particle size distribution data

Particle size	Mean particle diameter (µm)	Geometric standard deviation (µm)
TSP	15	2
PM10	4.88	1
PM2.5	0.89	1

### 6.4.4.2 SENSITIVE RECEPTORS

As discussed in Section 5.1, the nearest sensitive receptors are approximately 1km to the South and Lake Gol Gol is approximately 1.8 km to the East.. Figure 6-2 shows the locations of the four sensitive receptors adopted for the modelling assessment.

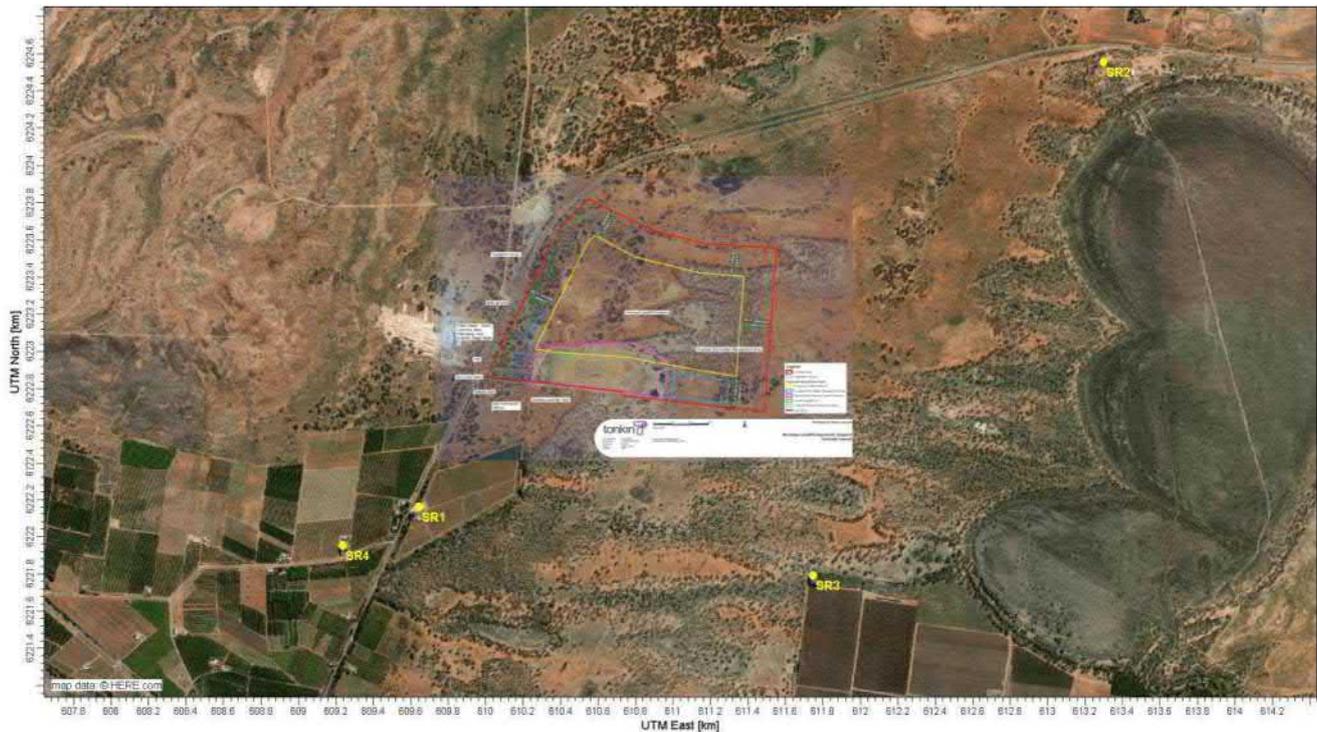


Figure 6-2: Sensitive Receptor Locations

## 7 ASSESSMENT OF IMPACTS

This section presents the results of the air quality impact assessment for predicted ground level concentrations of TSP, PM10 and PM2.5, dust deposition and odour for the proposed operation of the landfill.

The results of the dispersion modelling include individual sensitive receptor and contour plots that are indicative of ground-level concentrations and deposition. This Level 2 impact assessment requires the predictions to be presented as follows:

- The incremental impact of each pollutant as per the criterion units and time periods;
- The cumulative impact (incremental plus background) for the 100<sup>th</sup> percentile (i.e. maximum value) in units as per the criterion and time periods.

### 7.1 TSP

The predicted annual average TSP with and without background (51.5  $\mu\text{g}/\text{m}^3$ ) are presented in **Table 7-1**.

The model predictions for TSP are well below the criteria of 90  $\mu\text{g}/\text{m}^3$ . TSP emissions from the proposed Project are not predicted to adversely impact upon the sensitive receptors. A contour plot is presented in **Appendix B**.

**Table 7-1: Predicted Annual Average TSP Concentrations**

ID	Predicted Annual Average TSP Concentrations ( $\mu\text{g}/\text{m}^3$ )	
	Incremental	Cumulative
R1	1.68	53.18
R2	0.09	51.59
R3	0.25	51.75
R4	0.55	52.05
<b>Criteria</b>	<b>90</b>	

### 7.2 PM10

The maximum predicted 24 hour (including maximum measured background of 114.7  $\mu\text{g}/\text{m}^3$ ) and annual average (including measured annual background of 20.6  $\mu\text{g}/\text{m}^3$ ) PM10 are presented in **Table 7-2**.

The model predictions for annual average PM10 are below the criteria of 25  $\mu\text{g}/\text{m}^3$ . The model predictions for cumulative 24 hour average PM10 are above the criteria of 50  $\mu\text{g}/\text{m}^3$ . As noted in Section 5.4, the measured 24 hour background PM10 of 114.7  $\mu\text{g}/\text{m}^3$  is already above the criteria of 50  $\mu\text{g}/\text{m}^3$ . Further investigation of the contemporaneous measured background and predicted data is therefore undertaken. **Table 7-3** provides the maximum cumulative concentrations at each receptor including contemporaneous background concentrations and associated number of exceedances of the criteria for the modelled year. As shown in **Table 7-3**, 16 exceedances of the 24 hour average PM10 criteria (50  $\mu\text{g}/\text{m}^3$ ) are predicted at each of the receptors modelled. This exceedance corresponds to the dates of the elevated measured background above the 50  $\mu\text{g}/\text{m}^3$  criterion. Furthermore, the maximum contribution of the landfill emissions to the cumulative PM10 is negligible (0.81  $\mu\text{g}/\text{m}^3$ ) on those days and does not contribute to any additional exceedances of the relevant criteria. As specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, under these circumstances no additional assessment is therefore required.

The 24 hour and annual average PM10 emissions from the proposed Project are not predicted to adversely impact upon the sensitive receptors. Contour plots are provided in **Appendix B**.

**Table 7-2: Predicted 24 Hour and Annual Average PM10 Concentrations**

ID	Predicted 24 Hour Average PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )		Predicted Annual Average PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )	
	Incremental	Cumulative	Incremental	Cumulative
R1	13.12	127.12	0.62	21.22
R2	0.51	114.51	0.04	20.64
R3	1.09	115.09	0.10	20.70
R4	4.08	118.08	0.21	20.81
<b>Criteria</b>	<b>50</b>		<b>25</b>	

**Table 7-3: Predicted Cumulative 24 Hour Average PM10 Concentrations and Number of Exceedances**

ID	Predicted Cumulative 24 Hour Average PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )	Number of Exceedances
R1	114.7	16
R2	114.7	16
R3	114.7	16
R4	114.7	16
<b>Criteria</b>	<b>50</b>	

### 7.3 PM2.5

The maximum predicted 24 hour (including maximum measured background of  $28.1 \mu\text{g}/\text{m}^3$ ) and annual average (including measured annual background of  $7.4 \mu\text{g}/\text{m}^3$ ) PM2.5 are presented in **Table 7-4**.

The model predictions for annual average PM2.5 are below the criteria of  $8 \mu\text{g}/\text{m}^3$ . The model predictions for cumulative 24 hour average PM2.5 are above the criteria of  $25 \mu\text{g}/\text{m}^3$ . As noted in Section 5.4, the measured 24 hour background PM2.5 of  $28.1 \mu\text{g}/\text{m}^3$  is already above the criteria of  $25 \mu\text{g}/\text{m}^3$ . Further investigation of the contemporaneous measured background and predicted data is therefore undertaken. **Table 7-5** provides the maximum cumulative concentrations at each receptor including contemporaneous background concentrations and associated number of exceedances of the criteria for the modelled year. As shown in **Table 7-3**, two exceedances of the 24 hour average PM2.5 criteria ( $25 \mu\text{g}/\text{m}^3$ ) are predicted at each of the receptors modelled. This exceedance corresponds to the dates of the elevated measured background above the  $25 \mu\text{g}/\text{m}^3$  criterion. Furthermore, the maximum contribution of the landfill emissions to the cumulative PM2.5 is  $0 \mu\text{g}/\text{m}^3$  on those days and does not contribute to any additional exceedances of the relevant criteria. As specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, under these circumstances no additional assessment is therefore required.

The 24 hour and annual average PM2.5 emissions from the proposed Project are not predicted to adversely impact upon the sensitive receptors. Contour plots are provided in **Appendix B**.

**Table 7-4: Predicted 24 Hour and Annual Average PM2.5 Concentrations**

ID	Predicted 24 Hour Average PM2.5 Concentrations ( $\mu\text{g}/\text{m}^3$ )		Predicted Annual Average PM2.5 Concentrations ( $\mu\text{g}/\text{m}^3$ )	
	Incremental	Cumulative	Incremental	Cumulative
R1	2.11	30.21	0.09	7.49
R2	0.09	28.19	0.01	7.41
R3	0.30	28.40	0.02	7.42
R4	0.70	28.80	0.04	7.44
<b>Criteria</b>	<b>25</b>		<b>8</b>	

**Table 7-5: Predicted Cumulative 24 Hour Average PM2.5 Concentrations and Number of Exceedances**

ID	Predicted Cumulative 24 Hour Average PM2.5 Concentrations ( $\mu\text{g}/\text{m}^3$ )	Number of Exceedances
R1	28.1	2
R2	28.1	2
R3	28.1	2
R4	28.1	2
<b>Criteria</b>	<b>25</b>	

#### 7.4 DUST DEPOSITION

The maximum predicted monthly average dust deposition are presented in **Table 7-6**.

The model predictions for incremental and cumulative monthly average dust deposition are well below the criteria of  $2 \text{ g}/\text{m}^2/\text{month}$  and  $4 \text{ g}/\text{m}^2/\text{month}$ . Dust deposition from the proposed Project is not predicted to adversely impact upon the sensitive receptors. Contour plots are provided in **Appendix B**.

**Table 7-6: Predicted Monthly Average Dust Deposition**

ID	Predicted Monthly Average Dust Deposition ( $\text{g}/\text{m}^2/\text{month}$ )	
	Incremental	Cumulative
R1	0.36	2.36
R2	0.02	2.02
R3	0.04	2.04
R4	0.10	2.10
<b>Criteria</b>	<b>2</b>	<b>4</b>

#### 7.5 ODOUR

The predicted 1-second nose response time 99th percentile odour concentrations (OU) resulting from the operation of the proposed landfill are presented in **Table 7-7**. As discussed, these impacts represent the placement and storage of putrescible wastes, where the landfill would only accept non-putrescible wastes which would be significantly less odorous. The results can therefore be viewed as highly conservative.

Despite the conservatism, the predicted 99th percentile odour concentrations are below the 70OU criterion at all sensitive receptors.

**Table 7-7: Predicted 99th Percentile Odour**

ID	Predicted 1-Second Odour (OU)
	Incremental
R1	2.76
R2	0.43
R3	1.11
R4	1.45
<b>Criteria</b>	<b>7</b>

## 8 GREENHOUSE GAS

### 8.1 INTRODUCTION

This assessment determines the carbon dioxide equivalent (CO<sub>2</sub>-e) emissions from the Project according to international and Federal guidelines.

### 8.2 BACKGROUND

Greenhouse gases are a natural part of the atmosphere; they absorb and re-radiate the sun's warmth, and maintain the Earth's surface temperature at a level necessary to support life. Human actions, particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing, are increasing the concentrations of the greenhouse gases. This is the enhanced greenhouse effect, which is contributing to warming of the Earth.

Greenhouse gases include water vapour, carbon dioxide (CO<sub>2</sub>), methane, nitrous oxide and some artificial chemicals such as chlorofluorocarbons (CFCs). Water vapour is the most abundant greenhouse gas. These gases vary in effect and longevity in the atmosphere, but scientists have developed a system called Global Warming Potential to allow them to be described in equivalent terms to CO<sub>2</sub> (the most prevalent greenhouse gas) called equivalent carbon dioxide emissions (CO<sub>2</sub>-e). A unit of one tonne of CO<sub>2</sub>-e (t CO<sub>2</sub>-e) is the basic unit used in carbon accounting. An emissions inventory, or 'carbon footprint', is calculated as the sum of the emission rate of each greenhouse gas multiplied by the global warming potential.

### 8.3 LEGISLATION OVERVIEW

The *Commonwealth National Greenhouse and Energy Reporting Act 2007* (NGER Act) established a national framework for corporations to report greenhouse gas emissions and energy consumption. The NGER Act requires corporations to submit an annual report in energy consumption, energy production and greenhouse gas emissions, if any of the following thresholds are met:

- The facility consumes more than 100 terajoules of energy in a financial year or emits greenhouse gases above 25,000 tonnes CO<sub>2</sub>-e (facility threshold); and
- All Australian facilities collectively consume more than 200 terajoules of energy in a financial year or emit greenhouse gases above 50,000 tonnes CO<sub>2</sub>-e (corporate threshold).

A facility is defined as an activity, or a series of activities (including ancillary activities), if it involves the production of greenhouse gas emissions, the production of energy or the consumption of energy; and forms a single undertaking or enterprise and meets the requirements of the regulations.

### 8.4 METHODOLOGY

The Department of Industry, Science, Energy and Resources (formerly Department of the Environment and Energy (DotEE)) monitors and compiles databases on anthropogenic activities that produce greenhouse gases in Australia. The DotEE has published greenhouse gas emission factors for a range of anthropogenic activities. The DotEE methodology for calculating greenhouse gas emissions is published in the National Greenhouse Accounts (NGA) Factors workbook (DotEE, 2019). This workbook is updated regularly to reflect current compositions in fuel mixes and evolving information on emission sources.

The scope that emissions are reported, as defined by the NGA Factors Workbook is determined by whether the activity is within the organisation's boundary (Scope 1 – Direct Emissions) or outside the organisation's boundary (Scopes 2 and 3 – Indirect Emissions). The scopes are described as follows:

- Scope 1 Emissions: Direct (or point-source) emission factors give the kilograms of carbon dioxide equivalent (CO<sub>2</sub>-e) emitted per unit of activity at the point of emission release (i.e. fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal, etc.);

- Scope 2 Emissions: Indirect emissions from the generation of the electricity purchased and consumed by an organisation as kilograms of CO<sub>2</sub>-e per unit of electricity consumed; and
- Scope 3 Emissions: Indirect emissions for organisations that:
  - a. Burn fossil fuels: to estimate their indirect emissions attributable to the extraction, production and transport of those fuels; or
  - b. Consume purchased electricity: to estimate their indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the transmission and distribution network.

Scope 1 emissions include those from fuel use by onsite equipment, methane emissions from landfills. Scope 2 emissions are from any purchased electricity. Scope 3 emissions are from the emissions resulting from the energy required to manufacture products such as diesel and equipment.

The definition, methodologies and application of Scope 3 emission factors are currently subject to international discussions and have the potential to cause much confusion. Large uncertainty exists in the accurate quantification of these emissions.

Emission factors used in this assessment have been derived from either the DotEE, site-specific information or from operational details obtained from similar emission sources.

The majority of the emission factors used in this report have been sourced from the NGA Factors Workbook (DotEE, 2020) as indicated in Table 8-1.

*Table 8-1: Emission Factors*

Scope	Emission Source	Emission Factor	Source
1	Combustion for transport (general)	2.69 t CO <sub>2</sub> -e / kWh	NGA Factors Workbook, 2020
1	Municipal solid waste disposal	1.6 t CO <sub>2</sub> -e / t waste	NGA Factors Workbook, 2020

The following emission sources were not included in this assessment:

- Emissions arising from the leachate;
- Emissions arising from waste transport to site; and
- Use of electricity from the grid.

### 8.5 QUANTIFICATION OF EMISSIONS

Table 8-2 outlines the estimated greenhouse gas emissions for the operational phase of the Project. The following assumptions have been made for this assessment:

- The operational equipment list is in accordance with that specified in Section 2.5;
- It is estimated that heavy vehicle hauling activities of 40 laden and unladen trips per day; and
- Electricity purchased from the grid would be minimal.

*Table 8-2: Estimated Greenhouse Gas Emissions (CO<sub>2</sub>-e tonnes)*

Emission Source	Scope	Annual Emissions (t CO <sub>2</sub> -e)
		Operation
Waste	1 (direct)	160,000
Equipment	1 (direct)	1,664
Onsite haulage	1 (direct)	16
		<b>161,680</b>

### 8.6 SUMMARY AND CONCLUSION

The results of the assessment of greenhouse gas emissions from the Project may be summarised as follows:

- During a potential maximum operational phase whereby 100,000 t waste/annum are received, the annual emissions are projected to be 161,680 tonnes CO<sub>2</sub>-e; and
- The estimated annual operational phase emissions (161,680 tonnes CO<sub>2</sub>-e) represents approximately 0.03% of Australia’s latest greenhouse inventory estimates of 532.5 MtCO<sub>2</sub>-E (2019).

## 9 CONCLUSION

An Air Quality and Greenhouse Gas Assessment in support of the proposed expansion to the Buronga landfill from 30,000 tonnes to 100,000 tonnes of general waste per annum has been undertaken to assess the potential impacts of air pollutants and to provide recommendations to mitigate any potential impacts that might have an effect on any sensitive receptors.

The assessment has been carried out in accordance with the NSW Environment Protection Authority's *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*.

As summarised in **Table 9-1**, the results of the modelling have shown that the odour, TSP and dust deposition predictions are below the relevant criteria for all averaging periods at all sensitive receptors. The annual average PM10 and PM2.5 predictions are also below criteria.

The 24 hour average PM10 and PM2.5 predictions are as above. The exceedances are driven by the elevated background conservatively adopted for the assessment, which are already above the criteria. No additional exceedances of the criteria are predicted to occur as a result of the proposed waste facility activities and that best management practices will be implemented to minimise emissions as far as is practical. As specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, under these circumstances no additional assessment is therefore required.

A greenhouse gas assessment has also been undertaken for the Project. This assessment determines the carbon dioxide equivalent (CO<sub>2</sub>-e) emissions from the Project according to international and Federal guidelines. The estimated annual operational phase emissions (161,680 tonnes CO<sub>2</sub>-e) represent approximately 0.03% of Australia's latest greenhouse inventory estimates of 532.5 MtCO<sub>2</sub>-E (2019).

It is therefore concluded that air quality should not be a constraint to proposed landfill expansion.

**Table 9-1: Summary of Results**

Pollutant	Averaging Period	Criteria	Maximum Prediction at Any Receptor		Compliant
			In isolation	Cumulative	
TSP	Annual	90 µg/m <sup>3</sup>	1.68 µg/m <sup>3</sup>	53.18 µg/m <sup>3</sup>	✓
PM10	24 Hour	50 µg/m <sup>3</sup>	13.12 µg/m <sup>3</sup>	114.7 µg/m <sup>3</sup>	✓
	Annual	25 µg/m <sup>3</sup>	0.62 µg/m <sup>3</sup>	21.22 µg/m <sup>3</sup>	✓
PM2.5	24 Hour	25 µg/m <sup>3</sup>	2.11 µg/m <sup>3</sup>	28.1 µg/m <sup>3</sup>	✓
	Annual	8 µg/m <sup>3</sup>	0.09 µg/m <sup>3</sup>	7.49 µg/m <sup>3</sup>	✓
Dust Deposition	Monthly Total	4 g/m <sup>2</sup> /month	0.36 g/m <sup>2</sup> /month	2.36 g/m <sup>2</sup> /month	✓
	Monthly Increase	2 g/m <sup>2</sup> /month	0.36 g/m <sup>2</sup> /month	0.36 g/m <sup>2</sup> /month	✓
Odour	1-second	7 OU	2.76 OU	2.76 OU	✓

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## Appendix A EMISSIONS ESTIMATION METHODOLOGY

The major air emission from the landfill activities is fugitive dust. Emission factors can be used to estimate emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> to the air from various sources. Emission factors relate the quantity of a substance emitted from a source to some measure of activity associated with the source. Common measures of activity include distance travelled, quantity of material handled, or the duration of the activity.

The National Pollutant Inventory Emission Estimation Technique Manual for Mining (January 2012) provides the equations and emission factors to determine the emissions of TSP and PM<sub>10</sub> from mining activities. These emission factors incorporate emission factors published by the USEPA in their AP-42 documentation.

PM<sub>2.5</sub> emission factors were derived from the ratio of PM<sub>2.5</sub> to TSP published in the relevant US AP42 Chapter tables. Table A-1 summarises the PM<sub>2.5</sub> to TSP ratio adopted for the emissions estimations.

*Table A-1: Ratio of PM<sub>2.5</sub> to TSP ratio adopted for the emissions estimations*

Source	Ratio PM <sub>2.5</sub> /TSP
Crushing	0.022
Truck loading	0.105
Front End Loaders	0.105
Wheel generated dust	0.017
Wind erosion	0.105

In the absence of measured physical parameters such as moisture and silt content, the default emission factors for all of the various operations as specified in Table 2 of the National Pollutant Inventory Emission Estimation Technique Manual for Mining (January 2012) have been conservatively adopted (Table A-2). Table A-3 outlines the activity data applied in the emissions estimation.

*Table A-2: Source type Emission Factors applied*

Source type	TSP Emission factor	PM <sub>10</sub> /TSP ratio	Units
<b>Wind erosion:</b>			
stockpiles/ exposed areas	0.4	0.5	kg/ha/h
<b>Handling:</b>			
FEL on waste	0.025	0.48	kg/t
Trucks dumping waste	0.012	0.35	kg/t
<b>Wheel generated dust:</b>			
HDV	4.23	0.3	kg/VKT
LDV	0.94	0.35	kg/VKT

Table A-3: Parameters applied in emissions estimation

Parameter ID	Value	Units	Description	Data source
Hours	87	hours/week	Hours of operation	client supplied
Days	365	Days/year	Hours of operation	client supplied
W	46	t	Truck capacity	client supplied
Waste received	100,000	t/y	Waste received	client supplied
Maximum waste received/handled	910	t/day	Waste received/handled	estimated
Haul	10	VKT/hr	HDV Hauling	estimated
Haul	5	VKT/hr	LDV Hauling	estimated

## Appendix B CONTOUR PLOTS

The contour plots are created from the predicted ground-level concentrations at the network of gridded receptors within the modelling domain at frequent intervals. These gridded values are converted into contours using triangulation interpolation in the CALPOST post-processing software within the CALPUFF View software (Version 7.2 - June 2014).

Contour plots illustrate the spatial distribution of ground-level concentrations across the modelling domain for each time period of concern. However, this process of interpolation causes a smoothing of the base data that can lead to minor differences between the contours and discrete model predictions.

