Report

Lucas Heights Bioenergy Facility – Air Quality Assessment

LMS Energy Pty Ltd

Astute Environmental Consulting

Job: 25-176
Date: 2 October 2025

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EXECUTIVE SUMMARY

This assessment considered potential air quality impacts associated with the construction and operation of the Lucas Heights Bioenergy Facility (the Project).

Modelling has been performed in line with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022)[1]. A site-specific meteorological dataset that included weather data from the Cleanaway Automatic Weather Station was generated using TAPM and CALMET. The dispersion of the emissions from the proposed Caterpillar G3516 engines and other identified sources were predicted using CALPUFF.

The assessment incorporated background data from the Liverpool air quality monitoring station. Compliance was predicted at all receptors for all pollutants including NO_2 (using the Ozone Limiting Method) for the normal and worst case scenarios

Regarding the Project construction phase, particulate emissions are expected to be minor and readily managed via the construction environmental management plan (CEMP).

It is noted that the emissions associated with the Project effectively replace those from the existing generation facility. The emissions from each generator will be less due to the specification of modern low emission generation plant and continuous monitoring of operational performance.

Based on our assessment we recommend that the Project be approved, and stack emission monitoring be conducted post-commissioning to confirm the assumptions presented here.

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[1] “the Approved Methods”

1 INTRODUCTION

Astute Environmental Consulting Pty Ltd (Astute) was engaged by LMS Energy to perform an air quality assessment of Lucas Heights Bioenergy Facility within the Lucas Heights Resource Recovery Park (LHRRP) located off Little Forest Road, Lucas Heights in the Sutherland Local Government Area (LGA).

The LHRRP operates in accordance with SSD 6835, approved 2017 on land described as Lot 102 on DP1009354 (“the site”).

1.1 Background

The proposed bioenergy facility would be a like-for-like replacement of the existing power station, with improvements that comply with modern standards and regulations and forecast biogas generation capacity requirements. The Project ensures renewable energy generation would effectively continue through the remaining landfilling and post closure periods for the landfill.

Once commissioned, the Project will involve the operation of 20 Caterpillar 1.1 megawatt (MW) 3516 Gas Generators with each individual generator having its own stack. It should be noted that the New South Wales Environment Protection Authority (NSW EPA) currently regulates the existing power station under an Environment Protection Licence (EPL 6345) for electricity generation works with a scale of 0-250 gigawatt hours annual generating capacity.

The site layout is shown below in Figure 1-1 and the locality plan is shown as Figure 1-2. It is understood the existing gas generator power station to the west will be decommissioned following the commencement of the operational phase of the Project.

Figure 1-1: Site Layout (Source: LMS)

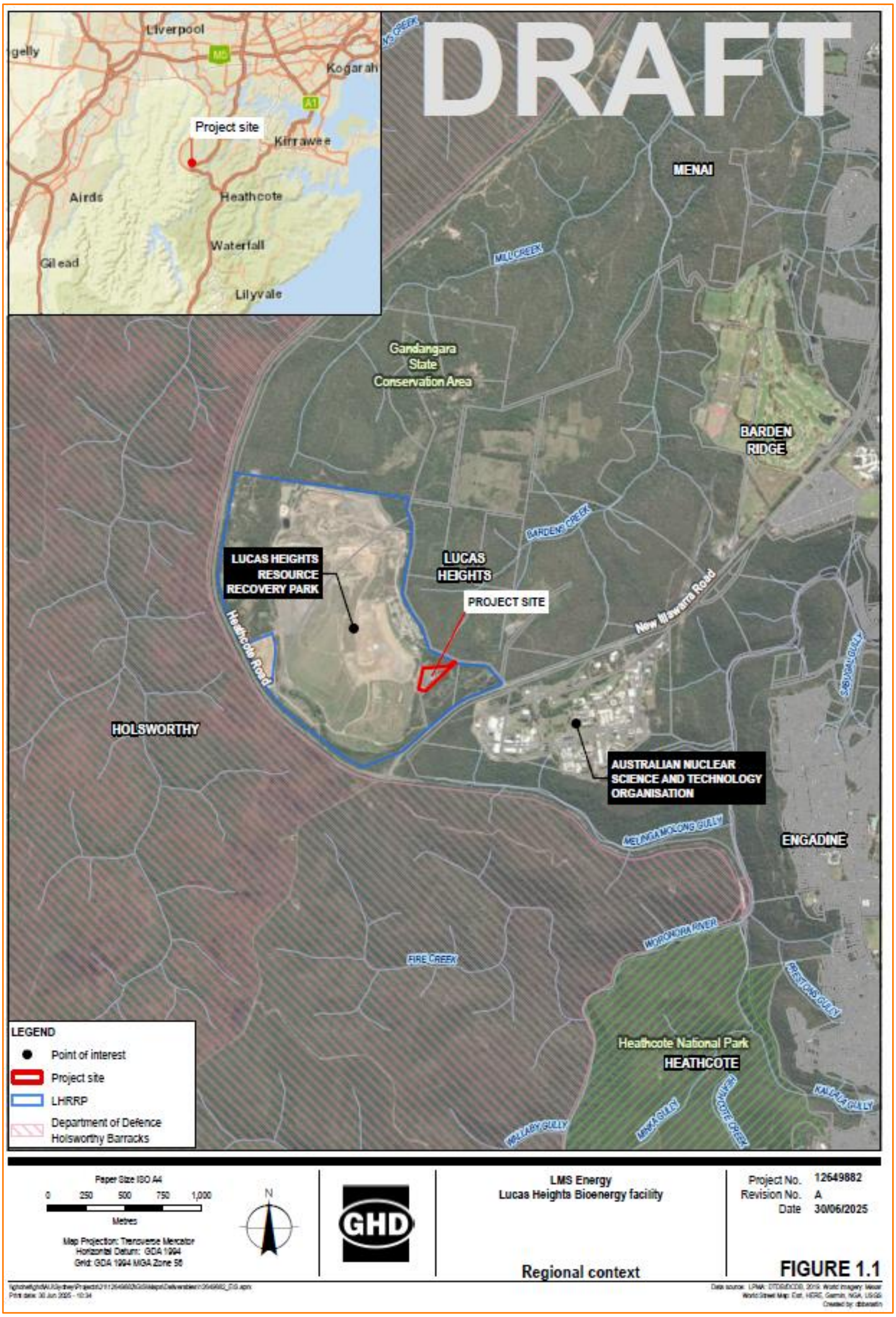

Figure 1-2: Locality Plan (Source: LMS)

1.2 Post Closure Landform

It is noted that the LHRRP is planned to be progressively rehabilitated and transformed into a community parkland following the cessation of landfill activities. The broad vision is to include 149 hectares of open space for passive recreation incorporating open grassed and treed areas with integrated cycling paths and vehicular access. The post closure landform for land owned by Cleanaway will be rehabilitated and transformed in accordance with an agreed outcome with Sutherland City Council. Where the land is leased, any post closure landform would be subject to ANSTO approval

The Project site is located within an operational area located to the east of the proposed parkland as shown in Figure 1-3 below. The final design and use of the parkland is to be determined closer to landfill closure in consultation with Sutherland Shire Council and ANSTO, although the use of the parkland immediately adjacent to the Project would be limited by the final landform slopes.

Figure 1-3: Post Closure Landform (Source: GHD)

1.3 Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements (SEARs) relevant to the Project are presented in Table 1-1, with references to where they are addressed in this report.

Table 1-1: SEARS Requirements

Description	Report Section
Identify all potential discharges of fugitive and point source emissions of pollutants and odour for all stages of the proposal. All processes that could result in air emission must be identified and described. Sufficient detail to accurately communicate the characteristics and quantity of all emissions must be provided.	Section 1, 3 and 4.5
Describe the receiving environment in detail. The proposal must be contextualised within the receiving environment (local, regional, and inter-regional as appropriate). The description must include but need not be limited to: a) meteorology and climate; b) topography; c) surrounding land-use; d) identified sensitive receptors; and e) ambient air quality.	Section 5
Identify comparable facilities within the airshed and consider the cumulative impact of air emissions from these facilities.	Section 4.5.5
Detail emission control techniques/practices, including emission sampling and monitoring, that will be employed by the proposal, and benchmark these techniques/practices against best practice emission control and management.	Section 7.3
Assess all risks to the environment, human health and amenity associated with emissions of air pollutants, including odour from all stages of the proposal	Section 6 and 7
Justify the level of assessment undertaken based on risk factors, including but not limited to: a) proposal location; b) characteristics of the receiving environment; and c) type and quantity of pollutants emitted.	Section 2
Include a consideration of 'worst case' emission scenarios and impacts at proposed emission limits.	Section 4.5.7 and 6.6
Account for cumulative impacts with existing emissions sources as well as any currently approved developments linked to the receiving environment.	Section 4.5, 5.3, and 6
Include air dispersion modelling conducted in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (EPA 2022)2. Consideration must be given to recent amendments to air pollutant standards contained in the National Environment Protection (Ambient Air Quality) Measure.	This report
Demonstrate the Proposal's ability to comply with the relevant regulatory framework, specifically the Environmental Planning and Assessment Act 1997 and the Protection of the Environment Operations (Clean Air) Regulation 2022.	This report

1.4 Scope of Work

The scope of work for this assessment included:

- Analysing regional weather data to select a representative year;
- Modelling meteorology for the area using TAPM/CALMET;
- Determine background air quality concentrations within the local airshed;
- Estimating combustion emissions from the Project;
- Predicting local air quality impacts using CALPUFF;
- Comparing the output of the dispersion modelling with the criteria in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022)[3];
- Assessing the modelled impacts of the Project;

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[2] "the Approved Methods"

[3] "the Approved Methods"

- Addressing the relevant SEARs; and
- Preparing a report.

The methodology used is summarised graphically in Figure 1-4.

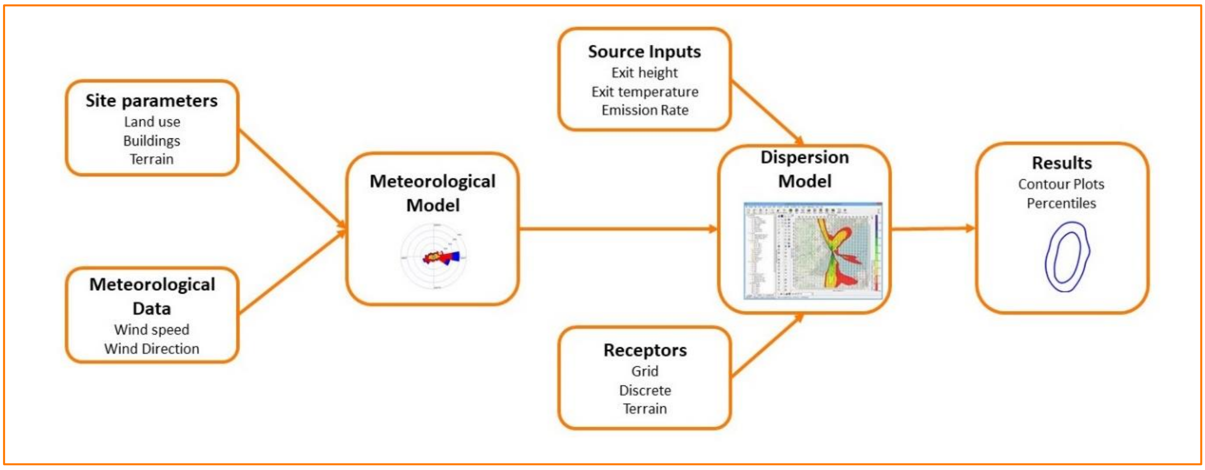

Figure 1-4: Modelling Methodology

2 ASSESSMENT METHODOLOGY

2.1 Legislative Requirements

The regulation of air pollution in New South Wales (NSW) is provided for in the Protection of the Environment (Operations) Act 1997 (POEO Act), which is supported by various regulatory tools that address air quality including:

- Protection of the Environment Operations (Clean Air) Regulation 2022 (Clean Air Regulation) which imposes operational requirements for activities and plant;
- Protection of the Environment Operations (General) Regulation 2022, Part 5.4 (Air pollution);
- Environmental Guidelines Solid Waste Landfills (Second Edition 2016); and
- Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2022).

The SEARs summarised in Table 1-1 above apply to the Project, which constitutes a State Significant Development (SSD) under the NSW Environmental Planning and Assessment Act (1979).

2.2 Dispersion Meteorology

A site-specific meteorological dataset was developed for this air quality assessment using the TAPM and CALMET models.

Observational data from the Cleanaway ultrasonic weather station has been assimilated into the CALMET model to better predict the near field atmospheric dispersion of pollutants. This method is considered an advanced model run since it combines the numerical prognostic model data from TAPM along with surface data.

The weather station data has been validated against the TAPM output, increasing the confidence in the meteorological dataset. The model setup is summarised in Sections 4 and the results of the validation of the dataset is summarised in Section 6.1 below.

2.3 Existing Environment

The Project and its surrounding environment are characterised by land use, terrain features, climatic conditions, meteorological data, existing air quality, and the location of sensitive receptors as summarised in Section 5.

Note a comprehensive description of the receiving environment (biodiversity, heritage etc.) is addressed in associated Project EIS documentation.

2.4 Emissions to Air

LMS has extensive experience in the construction and operation of biogas facilities and specifically the Caterpillar G3516 generators which are proposed here. The G3516 generators have been selected due to their reliability and low emission combustion technology that achieves the standards of concentration listed in the Protection of the Environment Operations (Clean Air) Regulation 2022.

The gas generators will be installed within individual modules with a single stack per module with stack diameter, exit velocity and exit temperatures consistent with the manufacturer’s datasheets.

The following air pollutants that have the potential to impact local air quality have been assessed:

- Oxides of nitrogen (NO_x) as nitrogen dioxide (NO_2);
- Carbon monoxide (CO);

- Total Volatile Organic Compounds (TVOC) and Benzene;
- Particulate Matter less than 10 microns (PM_{10});
- Particulate Matter less than 2.5 microns ($PM_{2.5}$); and
- Sulphur and associated compounds (e.g. Hydrogen sulfide (H_2S), Sulfuric acid mist (H_2SO_4).

Secondary impacts of ozone formed in the atmosphere from reactions of NO_x, CO and VOCs with sunlight have also been assessed through a level 1 screening ozone assessment. The level 1 assessment has been conducted following the report prepared on behalf of NSW EPA titled: *A Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources* (ENVIRON, 2011).

2.5 Predicted Air Quality Impacts

Predicted ground level concentrations from the CALPUFF model for all pollutants modelled have been presented in isolation and with background concentrations for a cumulative assessment. The results have been presented for each of the identified sensitive receptors as well as using isopleth plots. The results have been compared to the criteria in the Approved Methods.

3 POTENTIAL POLLUTANTS AND ASSESSMENT CRITERIA

3.1 Impact Assessment Criteria

This air quality assessment has been prepared following the Approved Methods which outline the approach to be applied for the modelling and assessment of air pollutants in NSW.

The primary criteria pollutants from landfill gas-fired reciprocating engines are Oxides of Nitrogen (NO_x), Sulfur Compounds, Carbon Monoxide (CO) and Volatile Organic Compounds (VOCs). Particulate matter (PM) emissions including condensable particulate matter primarily result from volatised lubricating oil, engine wear, or from products of incomplete combustion and not because of the combustion of a solid fuel (USEPA, 2023). They have been modelled and presented here to enable a conservative assessment.

The following air pollutants that have the potential to impact local air quality have been assessed:

- Oxides of nitrogen (NO_x) as nitrogen dioxide (NO_2);
- Sulfur compounds;
- Carbon monoxide (CO);
- Total Volatile Organic Compounds;
- PM_{10} and $PM_{2.5}$; and
- Sulfur Dioxide (SO_2), Sulfuric Acid (H_2SO_4) and Hydrogen sulfide (H_2S).

The impact assessment criteria for assessing potential air quality impacts related to the Project are presented below in Table 3-1.

Table 3-1: Impact Assessment Criteria (Approved Methods)

Pollutant	Averaging Period	Percentile	Concentration (µg/m^3)
Hydrogen sulfide (H_2S)	1 sec	99th	2.07 (population 500)
Sulfuric acid mist (H_2SO_4)	1 hour	Maximum	18
Sulfur Dioxide (SO_2)	1 hour	Maximum	215
	24 hour	Maximum	57
Particulate matter less than 10 µm in aerodynamic equivalent diameter (PM10)	24 hours	Maximum	50
	Annual average	Average	25
Particulate matter less than 2.5 µm in aerodynamic equivalent diameter (PM2.5)	24 hours	Maximum	25
	Annual average	Average	8
Nitrogen Dioxide (NO2)	1 hour	Maximum	164
	Annual average	Average	31
Carbon Monoxide (CO)	15 minutes	Maximum	100,000
	1 hour	Maximum	30,000
	8 hours	Maximum	10,000
Volatile Organic Compounds (Benzene)	1 hour	Maximum	29

3.2 Concentration Limits

The maximum standards of concentration for generators are presented in Table 3-2 and have been sourced from the from the Clean Air and the *Environmental Guidelines: Solid Waste Landfills* (NSW EPA, 2016). All concentration standards are referenced to 273 K, 101.3 kPa and 7% Oxygen in line with the Clean Air Regulation.

Table 3-2: Gas Treatment Discharge Limits

Pollutant	Standard of Concentration (mg/m^3, dry STP @7% O_2)	Source
Hydrogen sulfide (H_2S)	5	*Protection of the Environment Operations (Clean Air) Regulation 2022*
NO_x (Oxides of nitrogen)	450	
Sulfuric acid mist (H_2SO_4)	100	
Volatile organic compounds as n-propane equivalent	40	

4 MODELLING METHODOLOGY

4.1 Representative year

The selection of a representative meteorological year for dispersion modelling is important. Typically, a single year of data is included in an assessment and therefore the year modelled needs to be consistent with typical conditions. Critical meteorological factors for air quality assessments include wind speed and temperature. These variables, therefore, need to be assessed against long-term data to determine which year is most like the average conditions rather than simply selecting a modelling year at random.

However, for sites where on-site data is used, the selection of a representative year is not considered as significant compared to a site where no on site data is available.

Here we have made use of weather data collected by a 10 m Environdata weather station on a neighbouring site which has an Environment Protection Licence requirement to measure in accordance with the Approved Methods. Data from September 2022 to August 2023 was used. This period was selected as there was a relatively complete, contiguous dataset for the site.

4.2 TAPM

The Air Pollution Model[4] (version 4), is a three-dimensional meteorological and air pollution model developed by CSIRO. TAPM is a prognostic model which uses synoptic-scale data to predict hourly meteorology in the area modelled. Details about the model can be found in the TAPM user manual (Hurley, 2008a) and details of the model development and underlying equations can be found in Hurley (2008b). Further information, including details of validation studies performed for TAPM are also available and include Hurley et. al. (2008c).

TAPM v4 predicts meteorological data including wind speed and direction in an area using a series of fluid dynamics and scalar transport equations (Hurley, 2008b) and it has both prognostic meteorological and air pollution (dispersion) components. The benefit of using TAPM is that key meteorological aspects including the influence of terrain induced flows are predicted both locally and regionally.

The TAPM default land use database was further refined to better define urban and commercial land uses as well as the bushland within the 300 m modelling domain. The default and adjusted land-use inputs are presented in Figure 4-1. The adjustment of the inner domain land use using the characteristics summarised in Table A.1 of Hurley (2008a) was warranted due to the coarseness and age of the TAPM default dataset.

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[4] TAPM

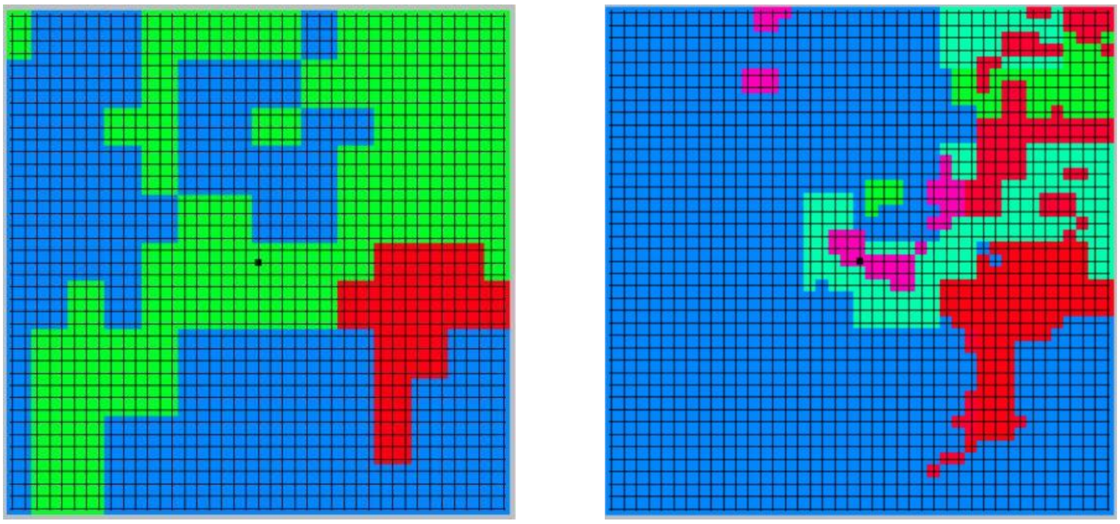

Figure 4-1: Default TAPM (left) and Adjusted Land use (right) for the Site

4.3 CALMET

CALMET is the meteorological pre-processor to CALPUFF and generates wind fields which include slope flows, terrain effects, and can incorporate factors including terrain blocking. CALMET uses meteorological inputs in combination with land use and terrain information for the modelling domain to predict a three-dimensional meteorological grid (which includes wind speed, direction, air temperature, relative humidity, mixing height, and other variables) for the area (domain) to be modelled in CALPUFF.

A 10 km x 10 km domain with a terrain resolution of 100 m was modelled with the centre of the domain. The centre of the domain was located just to the northeast of the site. A terrain resolution of 30 m was initially taken from the Shuttle Radar Topography Mission dataset using CALPUFF view. This was then converted to a 100 m grid for the model runs.

Land use was manually edited at 100 m resolution based on a recent aerial photograph of the area using Google Earth Pro and CALPUFF View.

4.4 CALPUFF

CALPUFF (Exponent, 2011) is a US EPA regulatory dispersion model and is a non-steady state puff dispersion model that simulates the effects of varying meteorological conditions on the emission of pollutants. The model contains algorithms for near source effects including building downwash, partial plume penetration as well as long range effects such as chemical transformation and pollutant removal. CALPUFF is widely regarded as the leading model for air quality assessments due to its ability to incorporate light wind conditions and complex terrain effects more effectively than steady-state models like AERMOD. As a result, it is accepted as a regulatory model across Australia.

CALPUFF simulates complex effects including vertical wind shear, coastal winds including recirculation and katabatic drift. The model employs dispersion equations based on a Gaussian distribution of puffs released within the model run, and it considers variable effects between emission sources.

Table 4-1: TAPM, CALMET and CALPUFF Setup

Model	Parameter	Value
TAPM (v 4.0.5)	Number of grids (spacing)	30 km, 10 km, 3 km, 1 km, 0.3 km
	Number of grid points	41 x 41 x 25 (vertical)
	Year of analysis	01/09/2022 to 30/08/2023
	Centre of analysis	34°03.00' South (latitude), 150°58.50' East (longitude) X = 313,090 m; Y= 6,230,449 m
	Meteorological data assimilation	NA
CALMET (v 6.5.0)	Meteorological grid domain	10 km x 10 km
	Meteorological grid resolution	0.10 km
	South-west corner of domain	X = 308.000 km, Y = 6225.500 km
	Surface meteorological stations	Yes **Onsite Weather station** – Wind Speed, Wind Direction, Temperature, Relative Humidity **TAPM** – Missing data only **Holsworthy** – Barometric Pressure only
	Upper air meteorological data	N/A
	3D Windfield	m3D from TAPM (0.3 km) input as in initial guess in CALMET
	Year of analysis	01/09/2022 to 30/08/2023
	R1/R2	3.0/3.0
	R1 max / R2 max	5.0/5.05
	Terrad	0.5 km
	Cloud	4 - Gridded cloud cover from Prognostic Relative Humidity at all levels
CALPUFF (v 6.40)	Method used to compute dispersion coefficients	2 - dispersion coefficients using micrometeorological variables
	Building downwash included	Yes; Prime method
	Default settings	All other CALPUFF defaults have been used in line with OEH (2011).

4.5 Emissions Inventory

4.5.1 The Project

The emissions to air for the twenty gas generators have been presented in Table 4-2 below and are summarised as follows:

- The maximum allowable NO_x and TVOC concentrations in the Clean Air Regulation have been modelled[5];
- The percentage of Benzene has been taken from Table 59 of the NPI (NPI, 2008);
- PM_{10} and $PM_{2.5}$ emissions have been taken from Table 3.2-2 of the (USEPA, 2023) as it estimates both the filterable and condensable concentrations of particulate matter;
- SO_2 has been estimated from Table 59 of the NPI (2008) with a 10% conversion to SO_3 with a stoichiometric conversion to estimate ground level concentrations of H_2SO_4;

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[5] We note that the engine datasheets demonstrates that the NO_x limits can be met.

- Emissions of H_2S are based on a default H_2S biogas gas concentration of 36 ppm in US EPA (2008) with a combustion destruction efficiency of 99%;
- Temperature, load power, exhaust flow rate data and oxygen and carbon monoxide concentrations are based on the manufacturer's datasheet; and
- Exit velocity has been based on the stack diameter and calculated from the exhaust flow rate.

Table 4-2: Technical Data for Caterpillar 3516 LE

	Parameter	Value	Source/Comments
Equipment Specifications	Model type and number	G3516 LE	CAT 3516 LE Datasheet
	Number	20	
	Fuel type	Landfill Gas	
	100% Load power (kW)	1149	
Stack details	Release height (m)	10.235	Site plans
	Exhaust Diameter (m)	0.3	
	Temperature (°C)	503	CAT 3516 Datasheet
	Exhaust Flow Rate wet (Nm^3/bkW-/h)	4.23	
	Flow rate (m^3/s)	1.27	
	Flow rate (Nm^3/s @ 7% O_2)	1.20	Calculated
	Exit velocity (m/s)	50.0	
	Oxygen (O_2; %v/v)	7.8	CAT 3516 Datasheet
In-stack conc. (@ 7% O_2; mg/Nm^3)	NOx	450	Clean Air Regulation
	CO	1842	CAT 3516 specification
	TVOCs	40	Clean Air Regulation
	PM_{10}	1.6	Calculated based on USEPA (2023)
	$PM_{2.5}$	1.6	
	H_2S	0.55	Based on USEPA (2008) and combustion destruction efficiency of 99%.
	SO_2	47.8	Calculated from NPI (2008)
	SO_3 as H_2SO_4	4.8	10% conversion (Ma , et al., 2022)
Emission Rates (g/s)	NOx	0.54	Calculated from in-stack concentration and flow rate
	CO	2.20	
	TVOCs	0.048	
	PM_{10}	0.00204	
	$PM_{2.5}$	0.00204	
	H_2S	0.001	
	SO_2	0.061	
	SO_3 as H_2SO_4	0.0061	

4.5.2 Modelling of NOx Chemistry

During high-temperature combustion of gas, there will be the formation of oxides of nitrogen primarily in the form of nitric oxide (NO) and nitrogen dioxide (NO_2). In typical gas combustion, the NO will be approximately 90-95% of the total NOx with the residual percentage consisting of NO_2. However, ultimately all oxides of nitrogen emitted into the atmosphere are oxidised to NO_2 and then further to other higher oxides of nitrogen (Environment Agency, 2007).

The rate at which this oxidisation takes place depends on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as ozone. The rate of conversion is important for air quality studies and can vary from a few minutes to many hours.

As recommended by the Approved Methods, the oxidation of NO to NO_2 in the atmosphere can be assessed by several methods. The methods below range from the simple (Method 1) to more detailed (Method 3) as described below.

Method 1: 100% conversion of NO to NO_2

Method 1 assumes that 100% of the NOx emitted is converted to NO_2 and is considered a screening assessment or worst case estimation technique. If exceedances of the impact assessment criteria are predicted a more refined assessment should be undertaken.

Method 2: NO to NO_2 conversion limited by ambient ozone concentration (OLM)

The ozone limiting method assumes all the available ozone in the atmosphere will react with NO in the plume until either all the O_3 or the NO is consumed. This approach assumes the reaction is instant when the reaction actually takes place over many hours. The method, listed as Equation 8.1 in the Approved methods is reproduced below as Equation 1.

$$[NO_2]_{total} = \{0.1 \text{ x } [NO_x]_{pred}\} + \text{MIN}\{(0.9)\text{x}[NO_x]_{pred} \text{ or } (46/48) \text{ x } [O_3]_{bkgd}\} + [NO_2]_{bkgd} \qquad \text{Equation 1}$$

Where:

- $[NO_2]_{total}$ = the predicted concentration of NO_2 in µg/m^3;
- $[NO_x]_{pred}$ = the dispersion model prediction of the ground-level concentration of NO_x in µg/m^3;
- MIN = the minimum of the two quantities within the braces
- $[O_3]_{bkgd}$ = the background ambient O_3 concentration in µg/m^3;
- (46/48) = the molecular weight of NO_2 divided by the molecular weight of O_3; and
- $[NO_2]$ = the background ambient NO_2 concentration µg/m^3.

Method 3: NO to NO_2 conversion using empirical relationship

Janssen et al. (1988) developed an empirical equation for estimating the oxidation rate of NO in power plant plumes. The equation is dependent on distance downwind from the source and constants based on O_3 concentration, wind speed and season.

For this assessment, we have used Method 2.

4.5.3 Odour Emissions

Trace compounds present in landfill gas are responsible for many of the odours associated with landfill operations. Uncontrolled landfill gas emissions can, under certain meteorological conditions, give rise to odours extending over the site boundary. Compounds found in landfill gas can include:

- hydrogen sulfide;
- organosulphur compounds, e.g. methanethiol and dimethyl sulphide;
- carboxylic acids, e.g. butanoic acid;
- aldehydes; and
- carbon disulphide.

The facility itself will not generate odours and management of gas from the landfill by the facility via the combustion of the gas will assist with odour management from the broader LHRRP. We have modelled the emission of H_2S from the engines.

4.5.4 Construction Dust Emissions

The key sources of air emissions associated with the construction of the biogas generator site are expected to include the following:

- wheel generated dust from the delivery of infrastructure from heavy equipment, employee light vehicles and smaller earthmoving vehicles;
- dust emissions from wind erosion of exposed areas; and
- dust emissions from infrastructure construction;

The dust emissions from these sources will be short term in nature and expected to be the coarser fraction associated with earthworks. This coarser fraction has localised impacts, as the particulate matter typically drops out close to the source. This means that any impacts will occur in the immediate area as opposed to receptors in the far field.

Dust associated with construction will be readily managed via the construction environmental management plan (CEMP) developed by LMS. Therefore, the residual risk for receptors following mitigation will be negligible.

4.5.5 Local Sources of Air Pollution

The Project is located within the Cleanaway LHRRP at Lucas Heights and is approximately 30 km south west of the Sydney central business district. It is surrounded by The Royal National Park. The Australian Nuclear Science and Technology Organisation’s (ANSTO) main operation is located to the south east and the Holsworthy Barracks are located approximately 5 km to the northwest. A small landscaping business (Menai Sand and Soil) is also located 2 km to the east and appears to service domestic scale customers.

Following the above review, an analysis of the NPI database was performed to locate any comparable facilities within a 10 km radius of the Project given the near field (local) impact of the gas generators. EDL Lucas Heights 1 (~ 3km north east see Figure 5-7 below) operates on landfill biogas for electricity generation (5 gas generators) and is surrounded by a golf course and sporting fields to the west and residential suburbs to the immediate east.

The emissions to air for the 2023 National Pollutant Inventory reporting year (DECCEEW, 2025) have been summarised for the pollutants of interest in Table 4-3 below.

Table 4-3: Relevant Emissions to Air for 2023 Reporting Year – 10 km radius

Facility Name	Location	NOx (kg/yr)	CO (kg/yr)	TVOCs (kg/yr)	PM_{10} (kg/yr)	$PM_{2.5}$ (kg/yr)
EDL Lucas Heights 1	3.3 km northeast	153,000	136,000	23,300	110	50.4

The Bioenergy facility is being developed to replace EDL Lucas Heights 2 which is proposed to be decommissioned following the commencement of operations. Therefore, the existing EDL Lucas Heights 2 site has not been modelled.

The emissions from the EDL Lucas Heights 1 has been assessed for a cumulative impact as it is a comparable industry with gas fired combustion from landfill gas.

4.5.6 Level 1 Ozone Assessment

The level 1 assessment has been conducted using the recognised method detailed in *A Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources* (ENVIRON, 2011) (Tiered Ozone Procedure).

4.5.7 Worst Case Emissions

In accordance with the SEARS (Table 1-1) a worst-case emissions scenario has also been modelled where six of the twenty engines are operating sub-optimally and emissions have increased by 50%. It should be noted that the Caterpillar G3516 is engineered and tuned to operate with optimum emissions characteristics for longevity and fuel usage. The hypothetical worst case assumption that six of the engines continually operate above the Clean Air Regulation limits is considered conservative as it is considered unlikely to occur. The results are discussed in Section 6 below.

4.5.8 Summary of Emissions Modelled

A summary of the emissions modelled and assessed are as follows;

- Combustion emissions from biogas from the Project (H_2S, NO_x, CO, TVOCs, PM_{10}, $PM_{2.5}$);
- Combustion emissions from biogas from EDL Lucas Heights 1 (NOx, CO, TVOCs, PM_{10}, $PM_{2.5}$); and
- A 50% increase in stack concentrations for all pollutants for six of the twenty generators has been assessed as a worst case scenario.

We note that dust emissions from the construction of the Project are negligible and routinely controlled with management methods and therefore modelling is not warranted.

5 EXISTING ENVIRONMENT

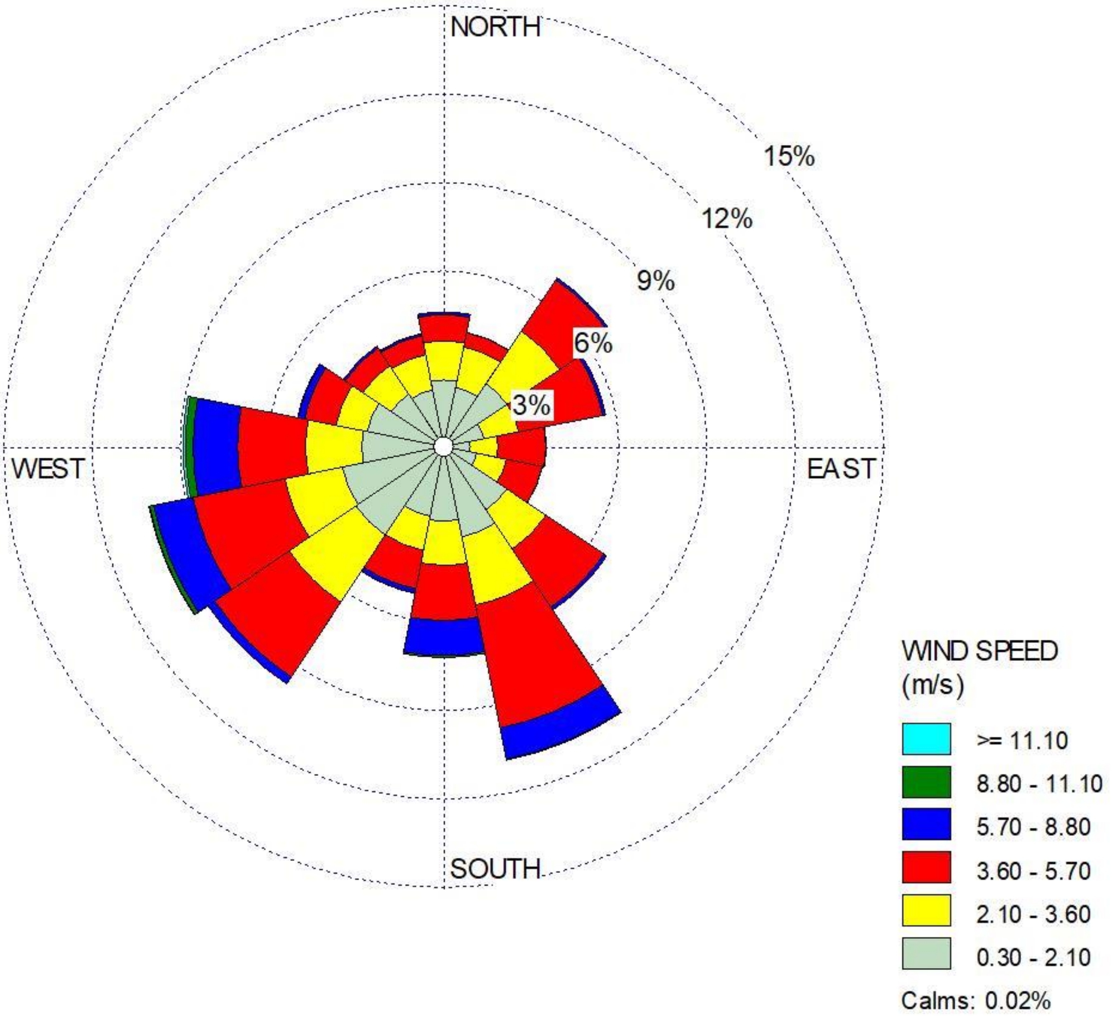
5.1 Meteorological Data

5.1.1 Wind Speed and Direction

Wind roses are used to show the frequency of winds by direction and strength. The bars show the compass points (north, north-north-east, north-east etc) from which the wind could blow. The length of each bar shows the frequency of winds from that direction and the different coloured sections within each bar show the wind speed categories and frequency of winds in those categories. In summary, wind roses are used to visually show winds over a defined period.

The wind roses below were created from data extracted from CALMET and are presented in Figure 5-1 and Figure 5-2 The annual wind rose (Figure 5-1) shows that the site is dominated by winds from the west and south east.

The wind roses show a low frequency of calm winds (<0.1%) with light winds over the year (up to 3 m/s) occurring ~56% of the time. The wind speed frequencies are summarised graphically in Figure 5-3 and show a high frequency of southerly through westerly winds.



Location:	*Year:*	*Data Source:*
X: 313,000 m; Y: 6,230,500 m	01/09/2022 to 30/08/2023	CALMET extract
Calm winds:	*Average wind speed:*	*Creator:*
<0.1 %	3.1 m/s	W. Shillito

Figure 5-1: Annual Wind Rose for Centre of Domain[6]

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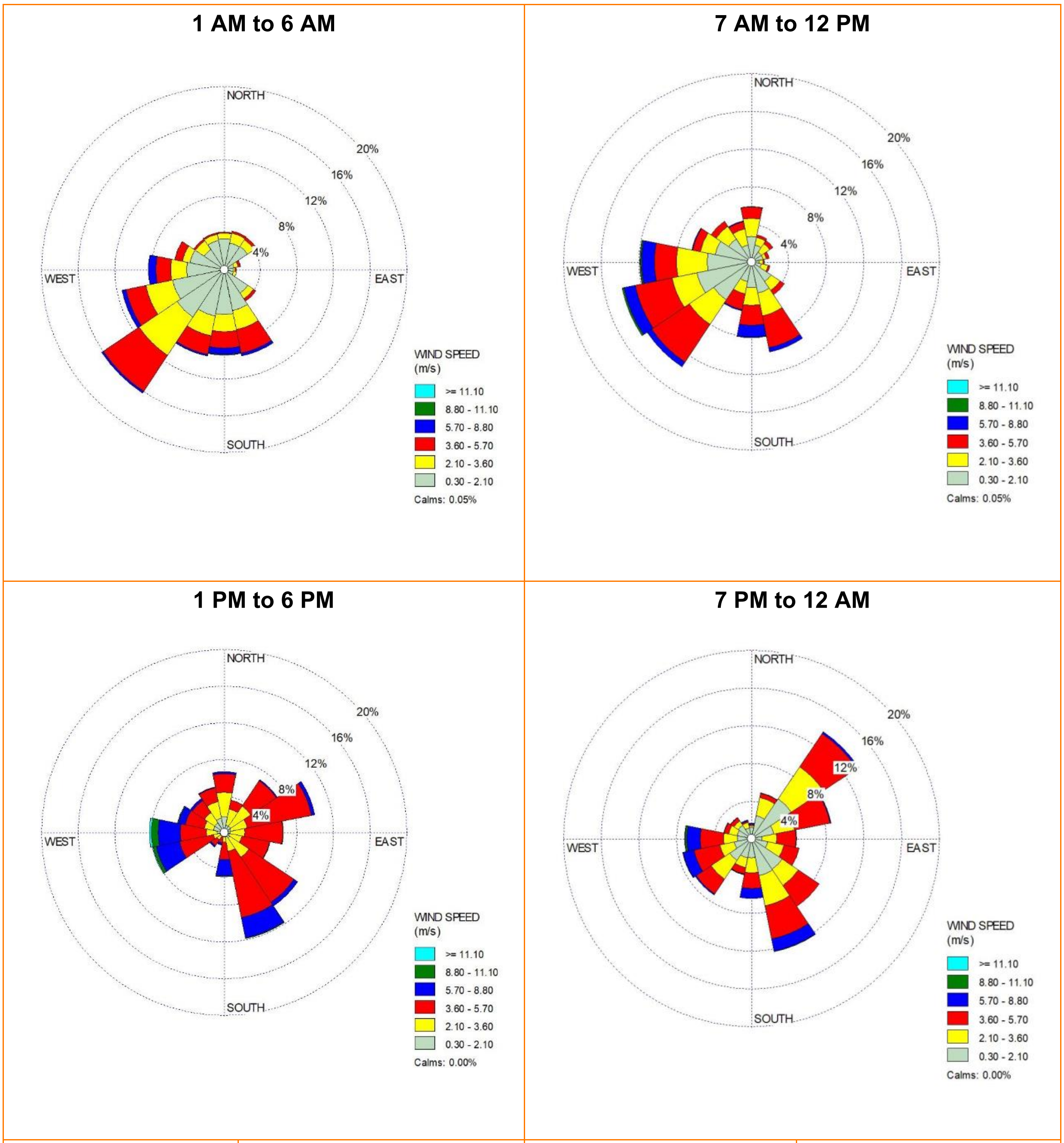
[6] Approximately 2 km east of weather station location



Period	*Average wind speed (m/s)*	*Calm winds %*	WIND SPEED (m/s) 🟦 >= 11.10 🟩 8.80 - 11.10 🟦 5.70 - 8.80 🟥 3.60 - 5.70 🟨 2.10 - 3.60 🟩 0.30 - 2.10
1 AM to 6 AM	2.5 m/s	0.1%	
7 AM to 12 PM	2.9 m/s	0.15%	
1 PM to 6 PM	4.1 m/s	0.0%	
7 PM to 12 AM	3.1 m/s	0.0%	
Location: X: 313,000 m; Y: 6,230,500 m	*Year:* 01/09/2022 to 30/08/2023	*Data Source:* CALMET extract	*Creator:* W. Shillito

Figure 5-2: Time of Day Wind Rose for the site

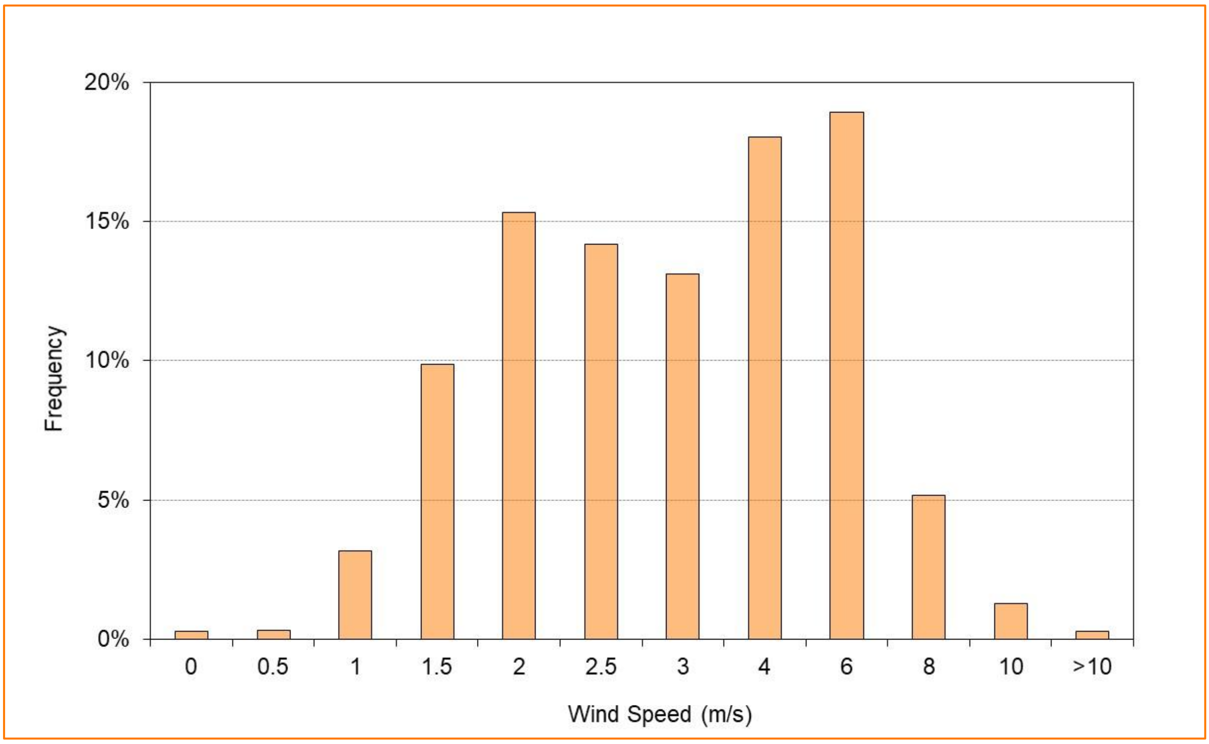


Figure 5-3: Wind Speed Frequency

5.1.2 Atmospheric Stability

Atmospheric stability is a key factor in dispersion modelling and is used to describe turbulence in the atmosphere. Turbulence is an important factor in plume dispersion. Turbulence increases the width of a plume due to random motion within the plume. This changes the plume cross-sectional area (width and height of the plume), thus diluting or spreading the plume. As turbulence increases, the rate at which this occurs also increases. Limited or weak turbulence, therefore, does not dilute or diffuse the plume as much as strong turbulence and leads to high downwind concentrations. This is often associated with low wind speeds (<0.3 m/s).

The Pasquill-Gifford stability scheme has been in use for many years to define turbulence in the atmosphere. The scheme uses stability classes from A to F[7]. Class A is highly unstable and at the other end of the scheme are class F conditions, which are very stable conditions that commonly occur at night and in the early morning. As noted above, under stable conditions, plumes do not disperse as well as during the day (unstable conditions) and these conditions can lead to impacts, especially for ground-level sources.

Between Class A and Class F are stability classes which range from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are most often associated with clear skies, class D is linked to sunset and sunrise, or cloudy and/or windy daytime conditions. Unstable conditions most often occur during the daytime and stable conditions are most common at night.

The stability classes predicted by CALMET for the Development Site are summarised in Figure 5-4. The data shows that E and F class stability occurs ~31% of the time. The frequency of D class

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[7] Note that CALPUFF uses a more accurate micrometeorological scheme for turbulence.

stability (~50%) is commonly seen in areas with winds above 2.5 m/s at night or site with a high frequency of cloudy days.

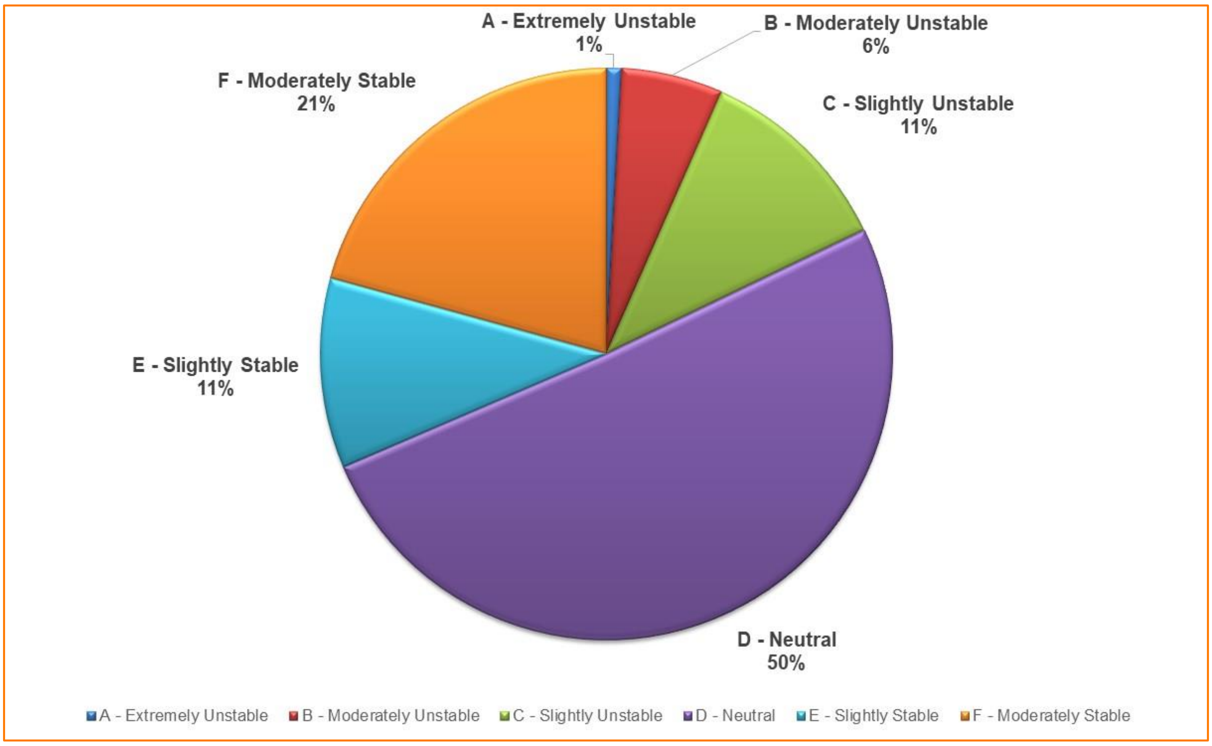

Figure 5-4: Atmospheric Stability

5.1.3 Atmospheric Mixing Height

The mixing height is the height of vertical mixing of air and suspended gases or particles above the ground. This height can be measured by the observation of the atmospheric temperature profile. A parcel of air rising from the surface of the Earth will rise at a given rate (called the dry-adiabatic lapse rate). If the parcel of air is warmer than the ambient temperature, it will continue to rise. However, once it becomes colder than the temperature of the environment, it will slow down and eventually stop (University of Michigan , 2004).

The mixing height is commonly referred to as an inversion layer. It is an important parameter when assessing air emissions as it defines the vertical mixing of a plume. This is because the air below the layer has restricted dispersion vertically and therefore the higher the mixing height, the more potential for dispersion.

The estimated variation of mixing height over time predicted at the site by CALMET is shown in Figure 5-5. The diurnal cycle is clear in this figure whereby at night the mixing height is normally relatively low and after sunrise, it increases because of heat associated with the sun on the Earth’s surface. Overall, the estimated mixing height shown below is as expected.

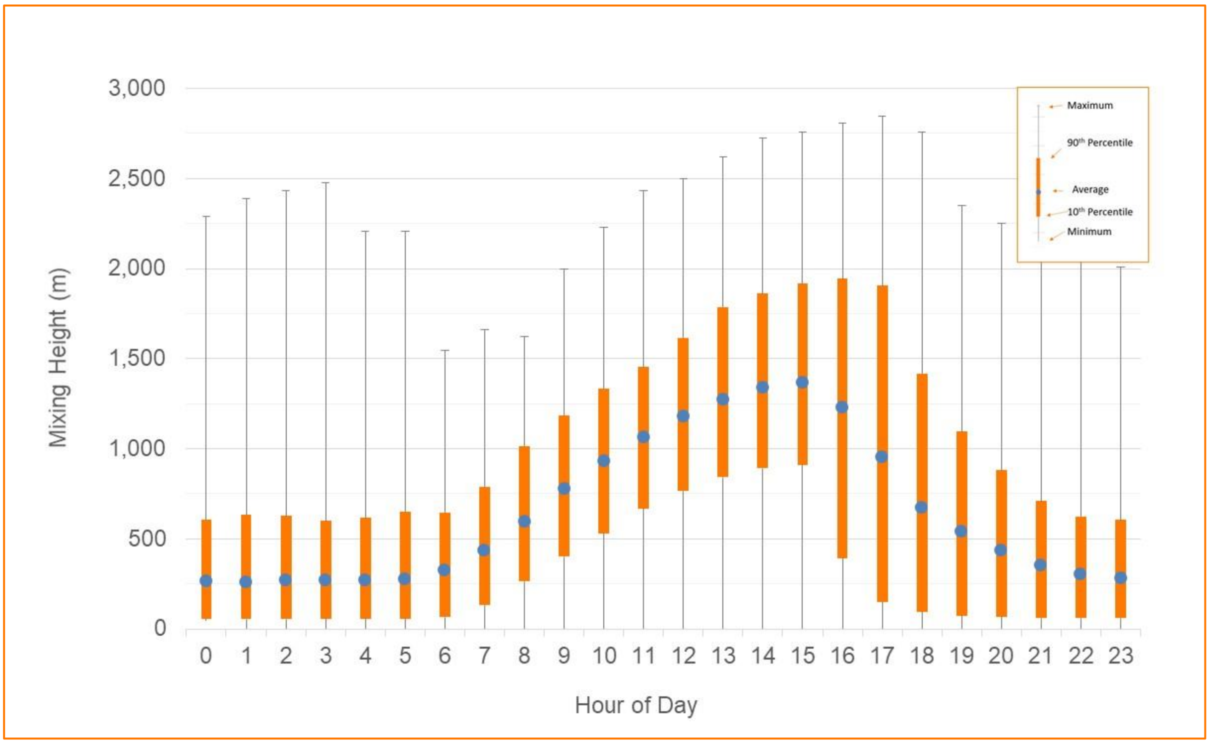

Figure 5-5: Atmospheric Mixing Height

5.2 Local Topography

The local topography within the modelling domain is show in Figure 5-6. The site can be characterised as being situated on a gently undulating plateau with some slopes that drop away along narrow valleys.

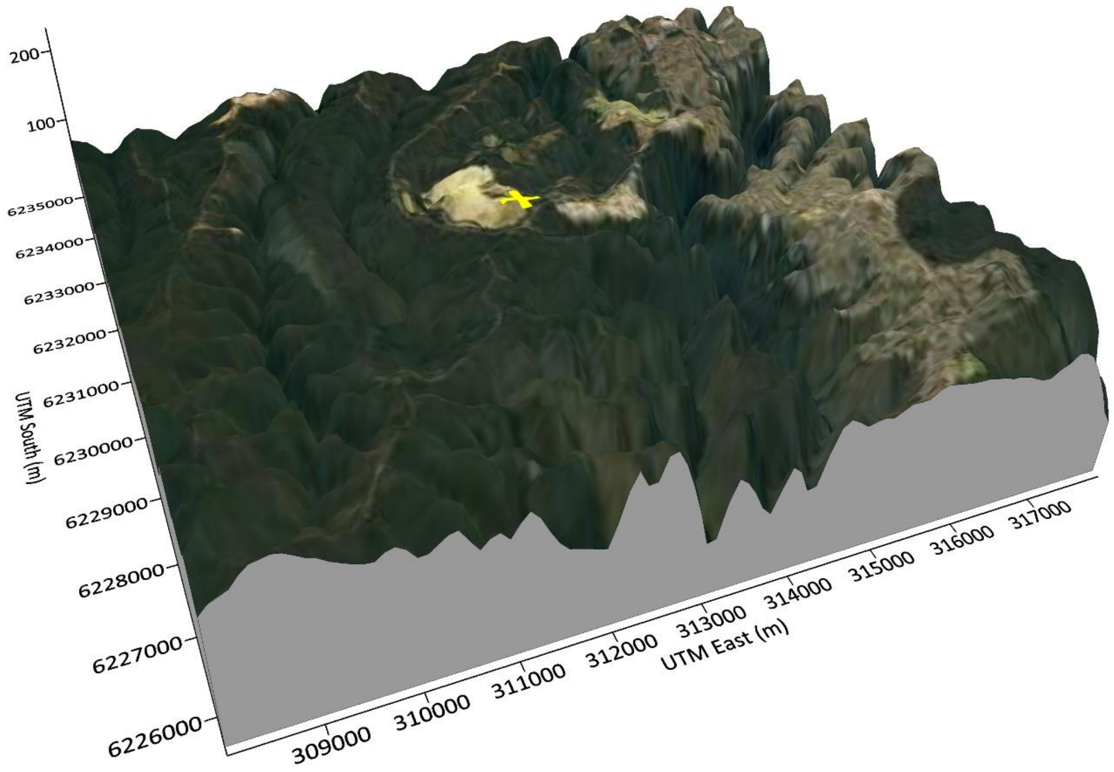

Figure 5-6: Local Terrain (exaggerated)

5.3 Background Air Quality Data

The NSW Air Quality Monitoring Network measures ambient air quality at numerous locations throughout New South Wales. The closest monitoring station is Liverpool, which is located 14 km to the northwest.

The Liverpool air quality monitoring station is located at the Council depot, off Rose Street in Liverpool. It is situated in the centre of the larger Sydney basin in a mixed residential and commercial area.

The following relevant air pollutants and meteorological variables are currently measured at Liverpool:

- Sulfur Dioxide (SO_2);
- Carbon monoxide (CO);
- Fine particles as PM_{10} and $PM_{2.5}$;
- Oxides of nitrogen (NO, NO_2);
- Ozone (O_3);
- Visibility using nephelometry; and
- Ambient temperature, relative humidity, wind speed and direction.

The dataset for the meteorological year had approximately 94% data completion for the required meteorological inputs. The missing data was filled using linear interpolation in line with standard methods.

In accordance with the Approved Methods, the impact assessment criteria are applied for the criteria pollutants (NO_2 and CO) where the predicted concentrations are added to the background concentrations. The adopted background concentrations for the modelling year are presented in Table 5-1.

Table 5-1: Adopted Background Air Quality Data from Liverpool

Pollutant	Averaging Period	Statistic	Value ($\mu g/m^3$)
SO_2	1 hour	Maximum	68.6
	24 hour	Average	12.1
NO_2	1 hour	Maximum	76
	Annual	Average	18
CO	15 minutes	Maximum	2,639
	1 hour	Maximum	2,000
	8 hours	Maximum	1,691
PM_{10}	24 hour	Maximum	43.4
	Annual	Average	17.2
$PM_{2.5}$	24 hour	Maximum	22.1
	Annual	Average	6.7
O_3	1 hour	Maximum	205
	Annual	Average	30

5.4 Receptors

The nearest sensitive receptors to the Project were identified using the definitions in the Approved Methods and selected using aerial photography. They are presented below in Table 5-2 and Figure 5-7. Several receptors have been chosen across the ANSTO site including workplaces, parking areas, and future (potential) residential areas.

Note for completeness, non-sensitive receptors associated with passive and active recreation, both present and future (projected), have been incorporated.

Table 5-2: Identified Receptors (UTM m)

Number	Easting	Northing	Comments
R01	315,291	6,230,519	Residential (suburban)
R02	315,263	6,231,684	Residential (suburban)
R03	315,765	6,232,035	Educational institute
R04	314,432	6,231,747	Existing: Passive recreation area, Future: potential residential development
R05	314,770	6,232,321	Active recreation
R06	313,402	6,233,054	Existing: Passive recreation area Future: potential residential development
R07	314,700	6,230,769	Motel
R08	312,789	6,230,839	Passive recreation
R09	312,877	6,230,442	Active recreation (Minibike Club track)
R10	313,333	6,230,382	Commercial
SR1	314,857	6,232,229	Active recreation
SR2	315,265	6,231,671	Residential (suburban)
SR3	315,053	6,231,702	Active recreation
SR4	314,864	6,231,489	Commercial
SR5	315,891	6,231,503	Residential (suburban)
SR6	315,975	6,231,304	Residential (suburban)
SR7	315,998	6,231,207	Residential (suburban)
SR8	316,060	6,230,648	Residential (suburban)
SR9	315,372	6,230,529	Residential (suburban)
SR10	315,355	6,230,524	Residential (suburban)
SR11	315,340	6,230,525	Residential (suburban)
SR12	315,322	6,230,525	Residential (suburban)
SR13	315,300	6,230,513	Residential (suburban)
SR14	315,302	6,230,491	Residential (suburban)
SR15	315,301	6,230,474	Residential (suburban)
SR16	315,312	6,230,461	Residential (suburban)
SR17	315,311	6,230,445	Residential (suburban)
SR18	314,201	6,230,797	Commercial
SR19	314,093	6,230,739	Commercial
SR20	314,003	6,230,661	Commercial
SR21	313,643	6,230,566	Commercial
SR22	313,416	6,230,390	Commercial
SR23	313,324	6,230,356	Commercial

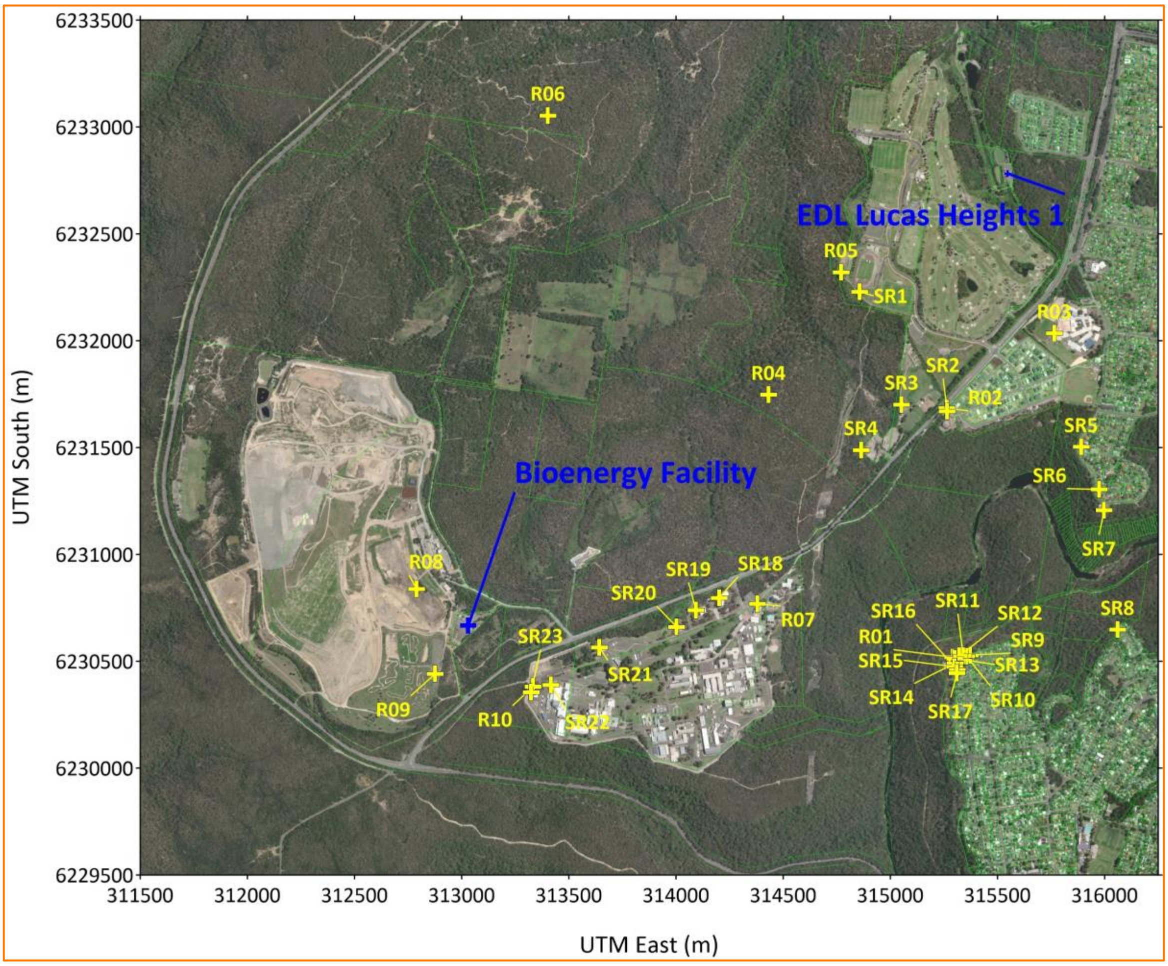

Figure 5-7: Sensitive Receptors

6 RESULTS

The modelling was completed for 33 identified receptors (sensitive and non-sensitive), including 10 receptors from the Lucas Heights Bioenergy Facility Noise Impact Assessment (GHD, 2025), and SR18 to SR23 which incorporate sensitive locations at the ANSTO facility.

The results show all twenty gas generators operating continually and where applicable the background concentrations summarised in Section 5.3 and the Lucas Heights 1 site have been added to the results to present a cumulative assessment as required by the Approved Methods.

6.1 Weather Station Validation

To compare the data for the period from September 2022 to August 2023, TAPM was modelled with, only synoptic data. The run was centred as close as practicable to the weather station location and data was extracted at that point.

The paired hourly data from the weather station and TAPM for the same period from a 300 m grid were analysed using the statistical benchmarks detailed in Emery *et al.* (2001) and Johnson (2019). Johnson recommended daily gross error checks for direction as an alternative opposed to hourly only. The purpose of these benchmarks is not necessarily to give a passing or failing grade to any one meteorological model application, but rather to put its results into the proper context (Emery, et al., 2001).

The benchmarks used were as follows (noting that not all apply to both wind speed and direction):

- Bias – comparison of average values;
- Gross error – the measure of the difference between paired hourly values;
- Root mean square error (RMSE) – the square root of the mean squared difference in prediction-observation pairings;
- SKILLE – indicative of how much of the standard deviation in the observations is unsystematic;
- SKILLR – evaluates systematic and unsystematic concerning the observed standard deviation;
- SKILLV – how closely the modelled standard deviation matches the observed standard deviation; and a
- Index of Agreement (IO) – a measure of the match between the departure of each prediction from the observed mean and the departure of each observation from the observed mean. A IOA of 1 is a perfect agreement.

Further information on the statistical methods can be found in publications including USEPA (2020) and Hurley *et al.* (2008c).

We also considered the benchmarks for model performance under complex conditions including areas with variable terrain heights and land uses as detailed in USEPA (2020). This document sets a gross error benchmark of ≤55° for wind direction and a bias benchmark of ≤20° for areas with complex features.

The American Meteorological Society (2012) defines complex terrain as “A region having irregular topography, such as mountains or coastlines. Complex terrain can also include variations in land use, such as urban, rural, irrigated, and unirrigated”. Therefore, the Project area can be considered as complex terrain.

An analysis of the weather station and TAPM dataset is presented below in Table 6-1 for wind speed and Table 6-2 for wind direction.

The results show the TAPM derived data compares well with the on-site observed data and confidence can be given to the use of TAPM data filling data gaps for the CALMET input file (surf.dat) for a limited number of hours. For example, where the weather station data has missing hourly data, we filled it with TAPM data.

Table 6-1: Wind Speed Statistics – TAPM v Observed (m/s)

Variable	Calculated Value	Criteria	Meets Criteria?
Bias	-0.8	±0.5 ±1.5 (complex)	Yes for complex
RMSE	1.6	<2	Yes
IOA	0.72	>0.6	Yes
SkillE	0.9	<1	Yes
SkillR	0.6	<1	Yes
SkillV	0.7	<1	Yes

Table 6-2: Wind Direction Statistics – TAPM v Observed (degrees)

Variable	Calculated Value	Criteria	Meets Criteria?
Bias (hourly)	-8.6°	±10° ±20° (complex)	Yes
Gross Error (hourly)	33.5°	≤30° ≤55° (complex)	Yes for complex
Bias (daily)	-8.0°	±10 ±20° (complex)	Yes
Gross Error (daily)	22.0°	≤30° ≤55° (complex)	Yes

6.2 NO_2 and CO

The predicted ground level concentrations (GLC) of NO_2 and CO in isolation and cumulatively with background concentrations from Liverpool and emissions from EDL Lucas Heights 1 are presented below as follows:

- Table 6-3: Predicted GLC for NO_2 and CO – Isolation and Cumulative;
- Figure A-1: Predicted annual average NO_2 in isolation;
- Figure A -2: Predicted 15 minute maximum CO in isolation;
- Figure A -3: Predicted 1 hour maximum CO in isolation;
- Figure A -4: Predicted 8 hour maximum CO in isolation;
- Figure B-14: Predicted 15 minute maximum CO cumulative with background;
- Figure B-15: Predicted 1 hour maximum CO cumulative with background; and
- Figure B-16: Predicted 8 hour maximum CO cumulative with background.

The results show:

- Compliance was predicted for the 1 hour and annual average NO_2 concentrations using the ozone limiting method (OLM – see Section 4.5.2) at all sensitive receptors; and
- The predicted ground level concentrations (GLCs) for CO for the 15-minute, 1 hour and 8-hour maximum concentrations are also low with compliance predicted at all sensitive receptors.

Table 6-3: Predicted GLC for NO_2 and CO – Isolation and Cumulative with background

Receptor	NO_2 – Hourly - Ozone Limiting Method (µg/m^3)		NO_2 – Annual Average – Ozone Limiting Method (µg/m^3)		CO – 15 minute maximum (µg/m3)		CO – 1 hour maximum (µg/m3)		CO - 8 hour maximum (µg/m^3)	
	Isolation – OLM	Cumulative – OLM	Isolation – 100%	Cumulative – OLM	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative
R01	75.9	75.9	0.7	18.4	537	3,176	407	2,407	110	1,801
R02	75.9	82.7	0.9	18.9	595	3,291	451	2,494	142	1,833
R03	75.9	98.8	0.5	18.9	384	3,023	291	2,291	94	1,785
R04	78.6	78.6	1.3	19.1	663	3,302	503	2,503	256	1,947
R05	79.1	79.1	0.8	19.4	358	2,997	271	2,271	134	1,825
R06	75.9	75.9	0.5	18.3	264	2,903	200	2,200	70	1,761
R07	75.9	75.9	0.9	18.6	438	3,077	332	2,332	211	1,902
R08	114.3	114.4	10.6	23.4	2,039	4,678	1,546	3,546	631	2,322
R09	160.4	160.4	9.1	22.1	2,205	4,844	1,671	3,671	1,257	2,948
R10	109.8	109.8	5.1	21.3	1,755	4,394	1,330	3,330	321	2,013
SR1	75.9	76.6	1.5	19.2	400	3,039	303	2,303	102	1,793
SR2	78.8	79.5	0.9	19.4	482	3,121	365	2,365	183	1,874
SR3	75.9	80.8	0.9	18.9	604	3,302	458	2,502	146	1,837
SR4	75.9	82.0	0.9	18.8	556	3,260	421	2,471	88	1,779
SR5	75.9	78.4	1.0	18.9	588	3,315	445	2,512	117	1,808
SR6	75.9	76.4	0.6	18.5	268	2,907	203	2,203	62	1,753
SR7	75.9	81.2	0.7	18.4	685	3,324	520	2,520	86	1,777
SR8	75.9	76.1	0.6	18.4	842	3,481	638	2,638	96	1,787
SR9	75.9	76.9	0.6	18.3	689	3,331	522	2,525	114	1,805
SR10	75.9	75.9	0.7	18.4	546	3,185	414	2,414	114	1,805
SR11	75.9	75.9	0.7	18.4	548	3,187	415	2,415	114	1,805
SR12	75.9	75.9	0.7	18.4	547	3,186	414	2,414	114	1,805
SR13	75.9	75.9	0.7	18.4	540	3,179	409	2,409	112	1,803
SR14	75.9	75.9	0.7	18.4	547	3,186	415	2,415	113	1,804

Receptor	NO$_2$ – Hourly - Ozone Limiting Method (µg/m^3)		NO$_2$ – Annual Average – Ozone Limiting Method (µg/m^3)		CO – 15 minute maximum (µg/m3)		CO – 1 hour maximum (µg/m3)		CO - 8 hour maximum (µg/m^3)	
	Isolation – OLM	Cumulative – OLM	Isolation – 100%	Cumulative – OLM	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative
SR15	75.9	75.9	0.7	18.4	580	3,219	440	2,440	119	1,810
SR16	75.9	75.9	0.7	18.4	602	3,241	456	2,456	123	1,814
SR17	75.9	75.9	0.7	18.4	626	3,265	474	2,474	129	1,820
SR18	75.9	75.9	0.7	18.4	637	3,276	483	2,483	131	1,822
SR19	75.9	75.9	1.7	19.4	365	3,004	277	2,277	117	1,808
SR20	75.9	75.9	1.9	19.5	360	2,999	272	2,272	108	1,799
SR21	75.9	75.9	2.0	19.6	466	3,105	353	2,353	132	1,823
SR22	86.6	86.6	3.7	20.8	966	3,605	732	2,732	182	1,873
SR23	99.9	99.9	4.3	20.9	1,716	4,355	1,301	3,301	296	1,987
Background	**75.9**	**75.9**	**NA**	**18.3**	**NA**	**2,639**	**NA**	**2,000**	**NA**	**1,691**
Criteria	**NA**	**164**	**NA**	**31**	**NA**	**100,000**	**NA**	**30,000**	**NA**	**10,000**

6.3 TVOCs and Benzene

The predicted ground level concentrations for TVOCs (as Benzene) have been presented as:

- Table 6-4: Predicted maximum GLC for TVOCs and Benzene – Isolation;
- Figure A -5: Predicted 1 hour maximum Benzene in isolation; and
- Figure B-17: Predicted 1 hour maximum Benzene cumulative with background.

The results show the predicted ground level concentration of Benzene based on the breakdown of total VOCs in biogas gas from USEPA AP42, Fifth Edition (USEPA, 2008) for the 1 hour maximum is predicted to comply with the criteria.

The ground level concentration of TVOCs as n-propane has been presented for information purposes only and provides a conservative assessment of impacts if the assumption was made that all VOCs were present as Benzene.

Table 6-4: Predicted maximum GLC for TVOCs and Benzene – Isolation

Receptor	TVOCs as n-propane – 1hr maximum (µg/m^3)		Benzene – 1 hr maximum (µg/m^3)	
	Isolation	Cumulative	Isolation	Cumulative
R01	8.9	14.8	0.01	0.02
R02	9.8	46.9	0.02	0.08
R03	6.3	41.3	0.01	0.07
R04	11.0	27.3	0.02	0.04
R05	5.9	20.9	0.01	0.03
R06	4.4	7.1	0.01	0.01
R07	7.2	7.2	0.01	0.01
R08	33.7	33.7	0.05	0.05
R09	36.4	36.4	0.06	0.06
R10	29.0	29.0	0.05	0.05
SR1	6.6	29.2	0.01	0.05
SR2	8.0	20.5	0.01	0.03
SR3	10.0	45.0	0.02	0.07
SR4	9.2	29.0	0.01	0.05
SR5	9.7	21.2	0.02	0.03
SR6	4.4	14.8	0.01	0.02
SR7	11.3	17.6	0.02	0.03
SR8	13.9	13.9	0.02	0.02
SR9	11.4	20.2	0.02	0.03
SR10	9.0	13.3	0.01	0.02
SR11	9.1	13.6	0.01	0.02
SR12	9.0	13.9	0.01	0.02
SR13	8.9	14.3	0.01	0.02
SR14	9.0	14.5	0.01	0.02
SR15	9.6	14.0	0.02	0.02
SR16	9.9	13.7	0.02	0.02
SR17	10.3	13.7	0.02	0.02
SR18	10.5	13.8	0.02	0.02

Receptor	TVOCs as n-propane – 1hr maximum (µg/m³)		Benzene – 1 hr maximum (µg/m³)	
	Isolation	Cumulative	Isolation	Cumulative
SR19	6.0	14.3	0.01	0.02
SR20	5.9	10.9	0.01	0.02
SR21	7.7	13.2	0.01	0.02
SR22	15.9	25.0	0.03	0.04
SR23	28.3	28.3	0.05	0.05
Background	**NA**	**NA**	**NA**	**NA**
Criteria	**NA**	**NA**	**NA**	**29**

6.4 PM_{10} and $PM_{2.5}$

The predicted ground level concentrations of PM_{10} and $PM_{2.5}$ in isolation and cumulatively with background concentrations from Liverpool and emissions from EDL Lucas Heights 1 are presented below as follows:

- Table 6-5: Predicted maximum GLC for PM_{10} and $PM_{2.5}$ - Isolation and Cumulative with Background;
- Figure A -6: Predicted maximum 24 hour average PM_{10} in isolation;
- Figure A -7: Predicted annual average PM_{10} in isolation;
- Figure A-8: Predicted maximum 24 hour average $PM_{2.5}$ in isolation;
- Figure A-9: Predicted annual average $PM_{2.5}$ in isolation;
- Figure B-18: Predicted maximum 24 hour average PM_{10} cumulative with background;
- Figure B-19: Predicted annual average PM_{10} cumulative with background;
- Figure B-20: Predicted maximum 24 hour average $PM_{2.5}$ cumulative with background; and
- Figure B-21: Predicted annual average $PM_{2.5}$ cumulative with background,

Whilst not typically assessed for biogas gas generators the Project has been modelled in isolation and cumulatively with the Lucas Heights 1 site and then added to the maximum background concentration at Liverpool for a conservative assessment.

The results show:

- The predicted ground level concentrations of both PM_{10} and $PM_{2.5}$ are low due to low emissions from the combustion of biogas as detailed in Section 3; and
- Compliance is predicted for both the maximum 24 hour and annual average for PM_{10} and $PM_{2.5}$ at all sensitive receptors.

Table 6-5: Predicted maximum GLC for PM_{10} and $PM_{2.5}$ - Isolation and Cumulative with Background

Receptor	PM_{10} - 24 hour (µg/m^3)		PM_{10} – Annual Average(µg/m^3)		$PM_{2.5}$ - 24 hour (µg/m^3)		$PM_{2.5}$ – Annual Average(µg/m^3)	
	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative
R01	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
R02	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
R03	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
R04	0.1	43.5	0.01	17.21	0.1	22.2	0.01	6.71
R05	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
R06	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
R07	0.1	43.5	0.00	17.20	0.1	22.2	0.00	6.70
R08	0.4	43.8	0.04	17.24	0.4	22.5	0.04	6.74
R09	0.6	44.0	0.03	17.23	0.6	22.7	0.03	6.73
R10	0.1	43.5	0.02	17.22	0.1	22.2	0.02	6.72
SR1	0.0	43.4	0.01	17.21	0.0	22.1	0.01	6.71
SR2	0.1	43.5	0.00	17.20	0.1	22.2	0.00	6.70
SR3	0.1	43.5	0.00	17.20	0.1	22.2	0.00	6.70
SR4	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR5	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR6	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR7	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR8	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR9	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR10	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR11	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR12	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR13	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR14	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR15	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR16	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70

Receptor	PM$_{10}$ - 24 hour (µg/m^3)		PM$_{10}$ – Annual Average(µg/m^3)		PM$_{2.5}$ - 24 hour (µg/m^3)		PM$_{2.5}$ – Annual Average(µg/m^3)	
	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative
SR17	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR18	0.0	43.4	0.00	17.20	0.0	22.1	0.00	6.70
SR19	0.0	43.4	0.01	17.21	0.0	22.1	0.01	6.71
SR20	0.0	43.4	0.01	17.21	0.0	22.1	0.01	6.71
SR21	0.1	43.5	0.01	17.21	0.1	22.2	0.01	6.71
SR22	0.1	43.5	0.01	17.21	0.1	22.2	0.01	6.71
SR23	0.1	43.5	0.02	17.22	0.1	22.2	0.02	6.72
Background	**NA**	**43.4**	**NA**	**17.2**	**NA**	**22.1**	**NA**	**6.7**
Criteria	**NA**	**50**	**NA**	**25**	**NA**	**25**	**NA**	**8**

6.5 SO_2, H_2SO_4 and H_2S

The predicted ground level concentrations of SO_2 and H_2SO_4 in isolation and cumulatively with background concentrations from Liverpool and emissions from EDL Lucas Heights 1 are presented below as follows:

- Table 6-6: Predicted SO_2 and H_2SO_4 GLC – in isolation and cumulative with background concentrations;
- Figure A-11: Predicted 1 hour maximum SO_2 in isolation;
- Figure A-12: Predicted 24 hour maximum SO_2 in isolation;
- Figure A-13: Predicted 1 hour maximum H_2SO_4 in isolation;
- Figure B-22: Predicted 1 second 99th percentile H_2S cumulative with background;
- Figure B-23: Predicted maximum 1 hour average SO_2 cumulative with background;
- Figure B-24: Predicted maximum 24 hour average SO_2 cumulative with background; and
- Figure B-25: Predicted maximum 1 hour average H_2SO_4 cumulative with background

The results show:

- The predicted ground level concentrations of both the 1 hour and 24 hour maximum SO_2 cumulatively with background concentrations are predicted to comply at all sensitive receptors;
- Compliance is predicted at all sensitive receptors for the maximum 1 hour H_2SO_4 assuming a 10% conversion of SO_2 to SO_3 and using a stoichiometric conversion to estimate H_2SO_4 concentrations; and
- Compliance is predicted at all sensitive receptors for the 99th percentile 1 second H_2S concentrations.

Table 6-6: Predicted SO_2 and H_2SO_4 GLC – in isolation and cumulative with background concentrations

Receptor	SO_2 – 1 hour maximum (µg/m^3)		SO_2 – 24 hour maximum (µg/m^3)		H_2SO_4 – 1 hour maximum (µg/m^3)		H_2S – 1hr 99th percentile (µg/m^3)	
	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative
R01	11.3	79.9	1.0	13.1	1.4	1.6	0.01	0.03
R02	12.5	81.5	1.5	13.6	1.5	3.5	0.01	0.06
R03	8.1	76.7	0.9	13.0	1.0	3.1	0.01	0.06
R04	13.9	82.5	2.5	14.6	1.7	2.0	0.02	0.06
R05	7.5	76.1	1.2	13.3	0.9	1.6	0.01	0.06
R06	5.5	74.1	1.0	13.1	0.7	0.8	0.01	0.02
R07	9.2	77.8	2.0	14.1	1.1	1.1	0.02	0.02
R08	42.8	111.4	11.0	23.1	5.2	5.2	0.12	0.12
R09	46.3	114.9	19.1	31.2	5.7	5.7	0.18	0.18
R10	36.8	105.4	4.2	16.3	4.5	4.5	0.07	0.07
SR1	8.4	77.0	1.2	13.3	1.0	2.2	0.02	0.04
SR2	10.1	78.7	1.7	13.8	1.2	1.5	0.01	0.07
SR3	12.7	81.7	1.5	13.6	1.6	3.4	0.01	0.06
SR4	11.7	80.8	1.0	13.1	1.4	2.2	0.01	0.05
SR5	12.3	81.6	1.3	13.4	1.5	2.4	0.01	0.04
SR6	5.6	74.2	0.7	12.8	0.7	1.1	0.01	0.03
SR7	14.4	83.0	0.8	12.9	1.8	1.8	0.01	0.03
SR8	17.7	86.3	0.9	13.0	2.2	2.2	0.01	0.02
SR9	14.5	83.1	1.1	13.2	1.8	1.8	0.01	0.03
SR10	11.5	80.1	1.1	13.2	1.4	1.4	0.01	0.02
SR11	11.5	80.1	1.1	13.2	1.4	1.4	0.01	0.03
SR12	11.5	80.1	1.1	13.2	1.4	1.5	0.01	0.03
SR13	11.3	79.9	1.0	13.2	1.4	1.5	0.01	0.03
SR14	11.5	80.1	1.1	13.2	1.4	1.6	0.01	0.03
SR15	12.2	80.8	1.1	13.2	1.5	1.5	0.01	0.03
SR16	12.6	81.2	1.2	13.3	1.5	1.5	0.01	0.03

Receptor	SO_2 – 1 hour maximum (µg/m^3)		SO_2 – 24 hour maximum (µg/m^3)		H_2SO_4 – 1 hour maximum (µg/m^3)		H_2S – 1hr 99th percentile (µg/m^3)	
SR17	13.1	81.7	1.2	13.3	1.6	1.6	0.01	0.03
SR18	13.4	82.0	1.2	13.3	1.6	1.6	0.01	0.03
SR19	7.7	76.3	1.4	13.5	0.9	1.1	0.02	0.04
SR20	7.5	76.1	1.4	13.5	0.9	0.9	0.02	0.03
SR21	9.8	78.4	1.9	14.0	1.2	1.2	0.02	0.04
SR22	20.3	88.9	3.3	15.4	2.5	2.5	0.04	0.05
SR23	36.0	104.6	3.7	15.8	4.4	4.4	0.06	0.06
Background	**NA**	**68.6**	**NA**	**12.1**	**NA**	**NA**	**NA**	**NA**
Criteria	**NA**	**215**	**NA**	**57**	**NA**	**18**	**NA**	**2.07**

6.6 Worst Case Assessment

For a worst case assessment, modelling was undertaken that assumed Project emissions were exceeding the Clean Air Regulation and manufacturer's specifications by 15% as a sensitivity analysis. This was achieved by modelling six of the twenty engines with emissions 50% higher than allowable under the Clean Air Regulation.

The results are shown in Table 6-7 and Table 6-8. The tables show that the assessment predicts compliance at all sensitive receptors. Note this hypothetical scenario is considered highly unlikely to occur, as all engines are operated to comply with the Clean Air Regulation.

Based on this modelling the results indicate that the project will not exceed air quality criteria at any identified sensitive receptor even under worst case conditions.

Table 6-7: Predicted GLC – Cumulative with Background Worst Case

Receptor	NO_2 – Ozone Limiting Method (µg/m^3)	NO_2 – Annual Average -Ozone Limiting Method (µg/m^3)	CO – 15 minute maximum (µg/m3)	CO – 1 hour maximum (µg/m3)	CO - 8 hour maximum (µg/m^3)	TVOCs as n-propane – 1hr maximum (µg/m^3)	Benzene – 1 hr maximum (µg/m^3)
R01	75.9	18.4	3,228	2,446	1,812	15.4	0.02
R02	82.7	18.9	3,349	2,538	1,846	46.9	0.08
R03	98.8	18.9	3,062	2,320	1,795	41.3	0.07
R04	78.7	19.2	3,370	2,554	1,973	27.3	0.04
R05	79.3	19.4	3,032	2,298	1,837	20.9	0.03
R06	75.9	18.4	2,929	2,220	1,768	7.1	0.01
R07	75.9	18.7	3,123	2,367	1,924	8.0	0.01
R08	115.9	23.6	4,840	3,668	2,382	36.3	0.06
R09	162.0	22.3	5,058	3,834	3,076	40.0	0.06
R10	119.5	21.5	4,565	3,460	2,046	31.8	0.05
SR1	76.6	19.3	3,078	2,333	1,804	29.2	0.05
SR2	79.5	19.4	3,166	2,399	1,891	20.5	0.03
SR3	80.8	18.9	3,360	2,547	1,851	45.0	0.07
SR4	82.0	18.9	3,314	2,512	1,787	29.0	0.05
SR5	78.4	18.9	3,373	2,557	1,819	22.1	0.04
SR6	76.4	18.5	2,934	2,224	1,760	14.8	0.02
SR7	81.2	18.5	3,395	2,573	1,786	17.6	0.03
SR8	76.1	18.4	3,569	2,705	1,798	15.4	0.02
SR9	76.9	18.3	3,400	2,577	1,816	20.2	0.03
SR10	75.9	18.4	3,237	2,454	1,816	13.8	0.02
SR11	75.9	18.4	3,240	2,456	1,816	14.1	0.02
SR12	75.9	18.4	3,239	2,455	1,816	14.5	0.02
SR13	75.9	18.4	3,231	2,449	1,814	14.9	0.02
SR14	75.9	18.4	3,240	2,455	1,815	15.1	0.02
SR15	75.9	18.4	3,276	2,483	1,822	14.6	0.02
SR16	75.9	18.4	3,300	2,501	1,826	14.2	0.02

Receptor	NO_2 – Ozone Limiting Method (µg/m^3)	NO_2 – Annual Average -Ozone Limiting Method (µg/m^3)	CO – 15 minute maximum (µg/m3)	CO – 1 hour maximum (µg/m3)	CO - 8 hour maximum (µg/m^3)	TVOCs as n-propane – 1hr maximum (µg/m^3)	Benzene – 1 hr maximum (µg/m^3)
SR17	75.9	18.4	3,327	2,522	1,832	13.7	0.02
SR18	75.9	18.4	3,339	2,531	1,835	13.8	0.02
SR19	80.1	19.5	3,040	2,304	1,820	14.3	0.02
SR20	75.9	19.6	3,035	2,300	1,809	10.9	0.02
SR21	75.9	19.8	3,146	2,384	1,836	13.2	0.02
SR22	91.9	21.0	3,704	2,807	1,891	25.0	0.04
SR23	109.0	21.1	4,522	3,427	2,014	31.1	0.05
Background	**75.9**	**18**	**2,639**	**2,000**	**1,691**	**0**	**0**
Criteria	**164**	**31**	**100,000**	**30,000**	**10,000**	**NA**	**29**

Table 6-8: Predicted GLC – Cumulative with Background Worst Case (Sulfur Compounds)

Receptor	SO_2 – 1 hour maximum (µg/m^3)	SO_2 – 24 hour maximum (µg/m^3)	H_2SO_4 – 1 hour maximum (µg/m^3)	H_2S – 1hr 99th percentile (µg/m^3)
R01	81.0	13.2	1.7	0.03
R02	82.8	13.7	3.5	0.06
R03	77.5	13.1	3.1	0.06
R04	83.9	14.8	2.0	0.06
R05	76.8	13.5	1.6	0.06
R06	74.7	13.2	0.8	0.02
R07	78.8	14.3	1.2	0.02
R08	114.8	24.1	5.7	0.13
R09	119.4	33.2	6.2	0.20
R10	109.0	16.7	5.0	0.08
SR1	77.8	13.4	2.2	0.04
SR2	79.7	14.0	1.5	0.07
SR3	83.0	13.8	3.4	0.06
SR4	81.9	13.2	2.2	0.05
SR5	82.9	13.5	2.5	0.04
SR6	74.8	12.9	1.1	0.03
SR7	84.5	13.0	1.9	0.03
SR8	88.1	13.1	2.4	0.02
SR9	84.5	13.3	2.0	0.03
SR10	81.2	13.3	1.5	0.03
SR11	81.2	13.3	1.5	0.03
SR12	81.2	13.3	1.6	0.03
SR13	81.0	13.3	1.6	0.03
SR14	81.2	13.3	1.7	0.03
SR15	82.0	13.3	1.6	0.03
SR16	82.5	13.4	1.7	0.03
SR17	83.0	13.4	1.8	0.03
SR18	83.3	13.4	1.8	0.03
SR19	77.0	13.7	1.1	0.04
SR20	76.9	13.6	1.0	0.04
SR21	79.2	14.1	1.3	0.04
SR22	91.0	15.8	2.7	0.05
SR23	108.1	16.2	4.8	0.07
Background	**68.6**	**12.1**	**NA**	**NA**
Criteria	**215**	**57**	**18**	**2.07**

6.7 Level 1 Ozone Assessment

An ozone assessment using the *Level 1 Screening Procedure Tool for Estimating Ground-Level Ozone Impacts from Stationary Sources in the NSW Greater Metropolitan Region* (GMR) has been used for the Project.

The methodology to calculate the incremental change in ozone and requires:

- Selection of a source region (e.g. Newcastle, Sydney Central/East/West or Wollongong);
- VOC input options (default reactivities or user specified);
- Daily emissions of NOx, CO and VOCs; and
- Whether the source is in an ozone attainment or non-attainment area.

The inputs used are summarised in Table 6-9 below.

Table 6-9: Input Values for Ozone Assessment

Parameter	Value	Units/Comments
Source Region	Sydney Central	Calculated
VOC Input Option	Default VOC Reactivities	Default
CO	3.81	Tonnes/day
NOx	0.93	Tonnes/day
VOC	0.08	Tonnes/day

A review of ozone data from the Liverpool station for 2019 to 2023 confirmed that the Project is within a non-attainment area, based on maximum 1-hour and 4-hour concentrations.

Using the screening impact level of 1 ppb from Environ (2011), a level 2 assessment is not required as the increment was calculated to be 0.33 ppb and 0.21 ppb for the 1-hour and 4-hour averaging periods.

6.8 Greenhouse Gas Assessment

With the pending decommissioning of the existing power station, and the continuation of active landfill activities at LHRRP out until the late 2040's, the Project will capture and combust otherwise fugitive landfill gas to generate up to 190,000 MWh of baseload, renewable energy for supply to the local grid each year, while reducing (fugitive) greenhouse gas (GHG) emissions and air quality issues associated with potential odour generation. The method used to calculate GHG emissions associated with the Project are discussed below, and note that post LHRRP closure, the Project will continue to operate until full bioenergy facility decommissioning is completed.

6.8.1 Methodology

The National Greenhouse Accounts (NGA) Factors (DISER, 2020) defines three scopes (Scope 1, 2 and 3) for different emission categories. The categories are presented in Table 6-10 below.

Table 6-10: Emission Categories

Scope	Definition	Included?
1	Direct (or point-source) emission factors give the kilograms of carbon dioxide equivalent (CO2-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.).	Yes
2	Indirect emissions from the generation of the electricity purchased and consumed by an organisation as kilograms of CO2-e per unit of electricity consumed. Scope 2 emissions are physically produced by the burning of fuels (coal, natural gas, etc.) at the power station.	Yes
3	Indirect emissions which are not included in scope 2, occurring within an organisation's value chain.	No

Emissions generated in all three scopes defined above provide a suitable approximation of the total GHG emissions associated with the Project. Scope 3 emissions can be a significant component of the total emissions inventory; however, these emissions are typically not controlled by the operation.

Various sources associated with the Project such as Scope 1 emissions generated by employees travelling to and from the site are minor but have been included in this assessment.

Greenhouse gases reported under the National Greenhouse and Energy Reporting (NGER) Scheme include:

- carbon dioxide (CO_2);
- methane (CH_4);
- nitrous oxide (N_2O);
- sulphur hexafluoride (SF_6); and
- specified kinds of hydrofluorocarbons and perfluorocarbons.

For the Project, the dominant gas species are CO_2 and CH_4. Relevant inputs and assumptions provided by LMS used in the calculations are detailed in Table 6-11 below.

Table 6-11: Inputs (Source LMS)

Parameter	Assumption	Reference/Comment
Volume of Gas at 15°C	11,880,000 m^3/year	Client supplied
Diesel Use	102.9 kL/year	
Unleaded Petrol use	0.24 kL/year	
Electricity Use	15,263 kWh/year	
% CH4	50%	Client supplied. Consistent with CER (2024).
% CO2	50%	Client supplied. Consistent with literature values.
Landfill Gas Energy content factor	37.7 x 10^{-3} GJ/m^3	DCCEEW (2023)
CO_2 emission factor	0 kg CO_2-e/GJ	
CH_4 emission factor	6.4 kg CO_2-e/GJ	
Global warming potential (GWP) of CH_4	28	DCCEEW (2023)
Density of Methane	0.679 kg/m^3	1 atm and 15°C

6.8.2 Scope 1 Emissions

Using the inputs in Table 6-11 above, the volume of methane per year is calculated using Equation 2. The CO_2-e associated with releasing the methane to the atmosphere, was calculated using Equation 3 (Methane only).

$$Q_{Total} = 11{,}880{,}000\ \frac{m3}{year} * 50\%\ CH_4 = 56{,}940{,}000\ \frac{CH_4 m^3}{year}$$

Equation 2

$$CO_2 - e\ (t/yr) = 56{,}940{,}000\ \frac{CH_4 m^3}{year} \times 0.679 \frac{kg\ CH_4}{m3} \times \frac{1\ ton}{1{,}000\ kg} \times 28 = \ 1{,}082{,}543$$

Equation 3

The CO_2-e emissions, associated with engines burning methane are shown below using Equation 4. This scenario assumes the full volume of methane is combusted.

$$\begin{aligned} &CO_2 - e\ \ (tons\ per\ year) \\ &= 56{,}940{,}000\ \frac{m^3}{year} \times 0.0377 \frac{GJ}{m^3} \times 6.4 \frac{kg\ CO_2 - e}{GJ} \times \frac{1\ ton}{1000\ kg} \\ &= 13{,}738\ t\ CO_2 e \end{aligned}$$

Equation 4

We are informed by LMS that their emissions from burning N_2O and Diesel use on site is a total of 201 t CO_2-e per year. This is based on 102.9 kL per year of diesel, and 0.24 kL per year of unleaded petrol being combusted per year. Therefore, the total t CO_2-e per year is 13,939.

The combusted and un-combusted CO_2-e in tons per year for the Scope 1 emissions are summarised in Figure 6-1 where the total reduction is 1,068,604 t CO_2-e per year.

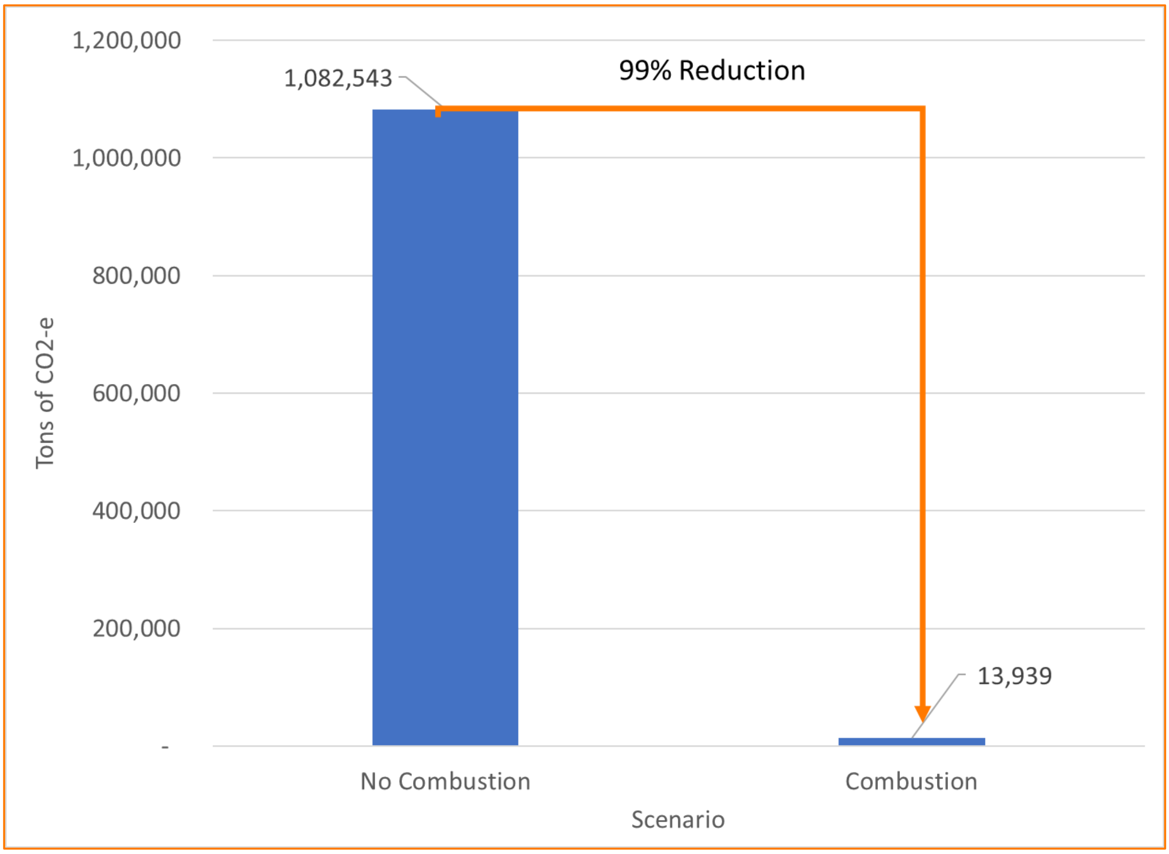

Figure 6-1: Methane, N_2O and Diesel GHG Impact with and Without Combustion

6.8.3 Scope 2 Emissions

The Scope 2 GHG Emissions have been provided by LMS and are based on an estimated import of 15,263 kWh per year. Based on a grid intensity of 0.52 t CO_2e per MWh, the Scope 2 emissions for 2025 are predicted to be 7.9 t CO_2-e. With a decreasing grid intensity, this is predicted to drop to 0.5 t CO_2-e by 2034. Compared to the Scope 1 emissions, the Scope 2 emissions are considered negligible.

7 DISCUSSION

7.1 Impacts to future site users

The Project would be located within an operational area within the current power station footprint and will be fenced and therefore inaccessible to the public. Landfill gas requires ongoing management throughout the post closure period of the LHRRP and therefore it is necessary for the Project and associated flare facility to operate for both environmental and health reasons. No exceedances of the criteria were identified, even under the worst case scenario (see Section 6.6).

The modern generator units proposed here will meet the current emission requirements in the regulations detailed in Section 2.1 above. For clarity as the existing units to the west are taken offline they will be replaced with units associated with the Project. The Project is therefore slightly further from the proposed parkland than the existing generation facility.

The Project is not expected to create significant conflicts with the post-closure rehabilitation of the LHRRP or its integration into the broader community parkland.

7.2 Mitigation measures

Considering the potential impacts of the proposed modification, no additional measures are considered necessary to avoid, mitigate, or manage impacts associated with the Project. This is because equipment that meets relevant emission limits will be installed, operated and maintained.

The design and positioning of the gas generators, as shown by the modelling, prevent conflicts with the LHRRP post-closure rehabilitation strategy and ensures compatibility with future site uses.

7.3 Recommended Emissions Sampling Program

Beyond the testing normally performed by LMS, it is recommended that post commissioning emissions testing be conducted on the Project to validate the assumptions modelled here and to show compliance with regulator emission thresholds.

As required by contemporary Environmental Protection Licence requirements, we recommend that emissions testing should occur for relevant variables and pollutants at each engine in line with the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* (NSW EPA, 2022b) as follows:

- Within four weeks of commissioning;
- Between 9 and 15 months from commissioning; and
- Every five years thereafter.

8 CONCLUSION

This assessment considered potential air quality impacts associated with the construction and operation of the Lucas Heights Bioenergy Facility.

Modelling was performed in line with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022). A site-specific meteorological dataset that included observation data from the Cleanaway Automatic Weather Station was generated using TAPM and CALMET. The dispersion of the emissions from the proposed Caterpillar G3516 engines and other identified sources were predicted using CALPUFF.

The assessment incorporated background data from the Liverpool air quality monitoring station. Compliance was predicted at all receptors for all pollutants including NO_2 (using the Ozone Limiting Method) for the normal and worst case scenarios.

Regarding the Project construction phase, particulate emissions are expected to be minor and readily managed by controls detailed in the construction environmental management plan (CEMP).

Based on our assessment we recommend that the Project be approved, and stack emission monitoring be conducted post-commissioning to confirm the assumptions presented here.

9 REFERENCES

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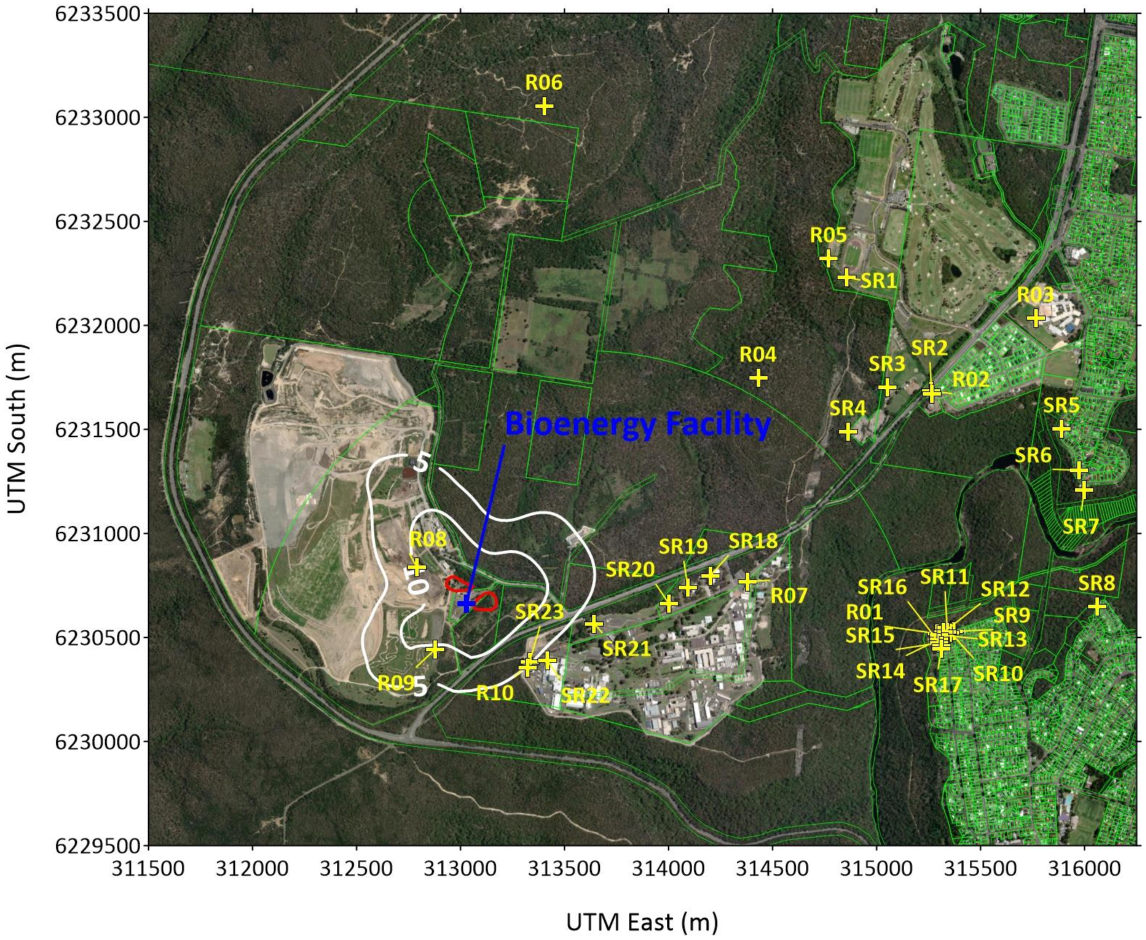
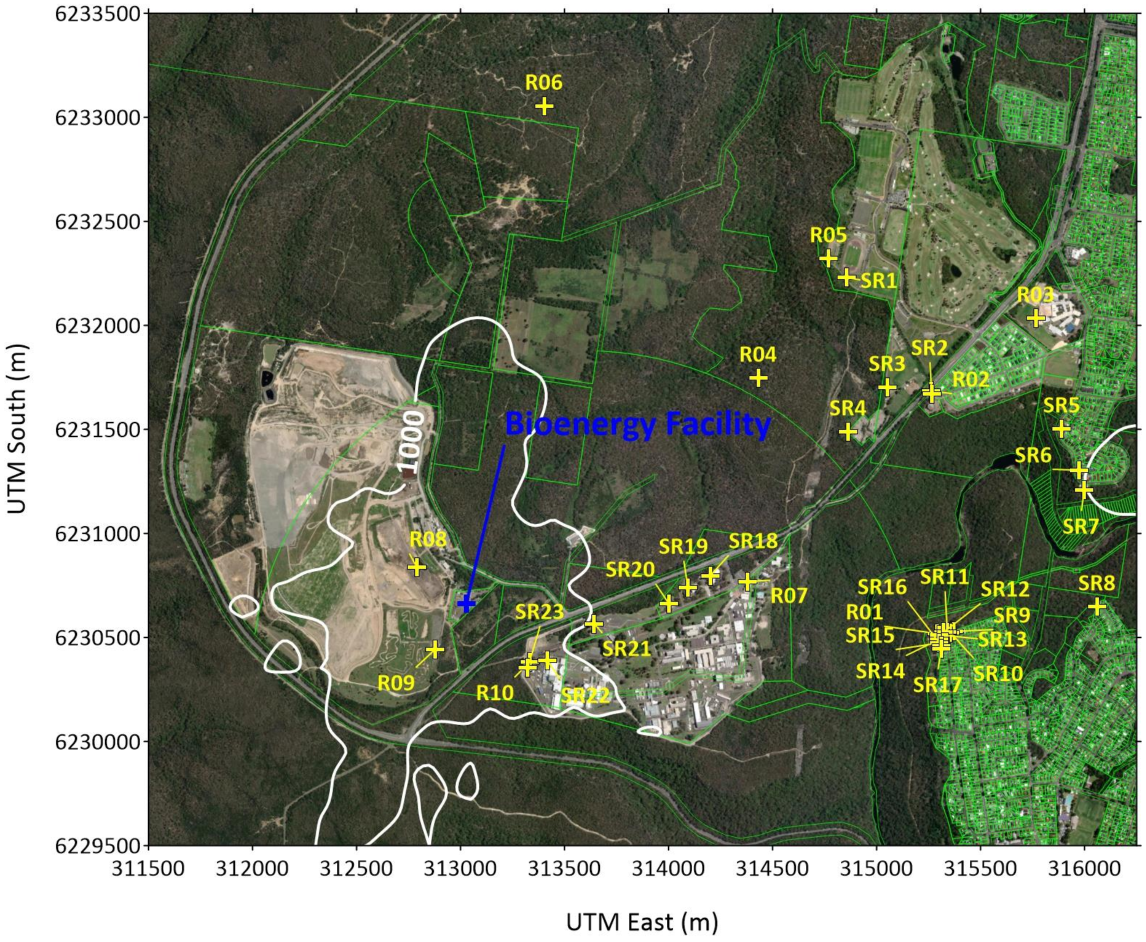
APPENDIX A. CONTOUR PLOTS – ISOLATION



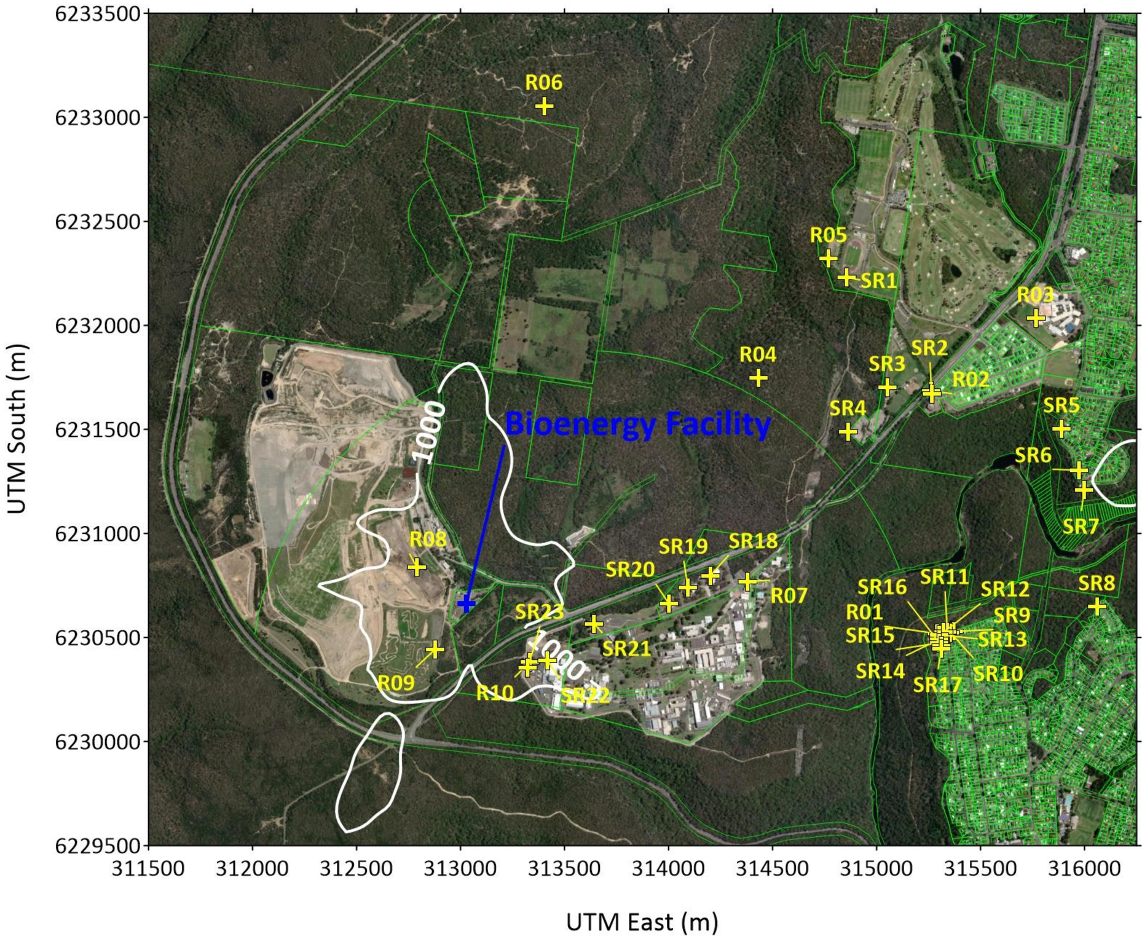
Species: NO$_2$	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** Annual	**Percentile:** Average
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A-1: Predicted annual average NO$_2$ in isolation



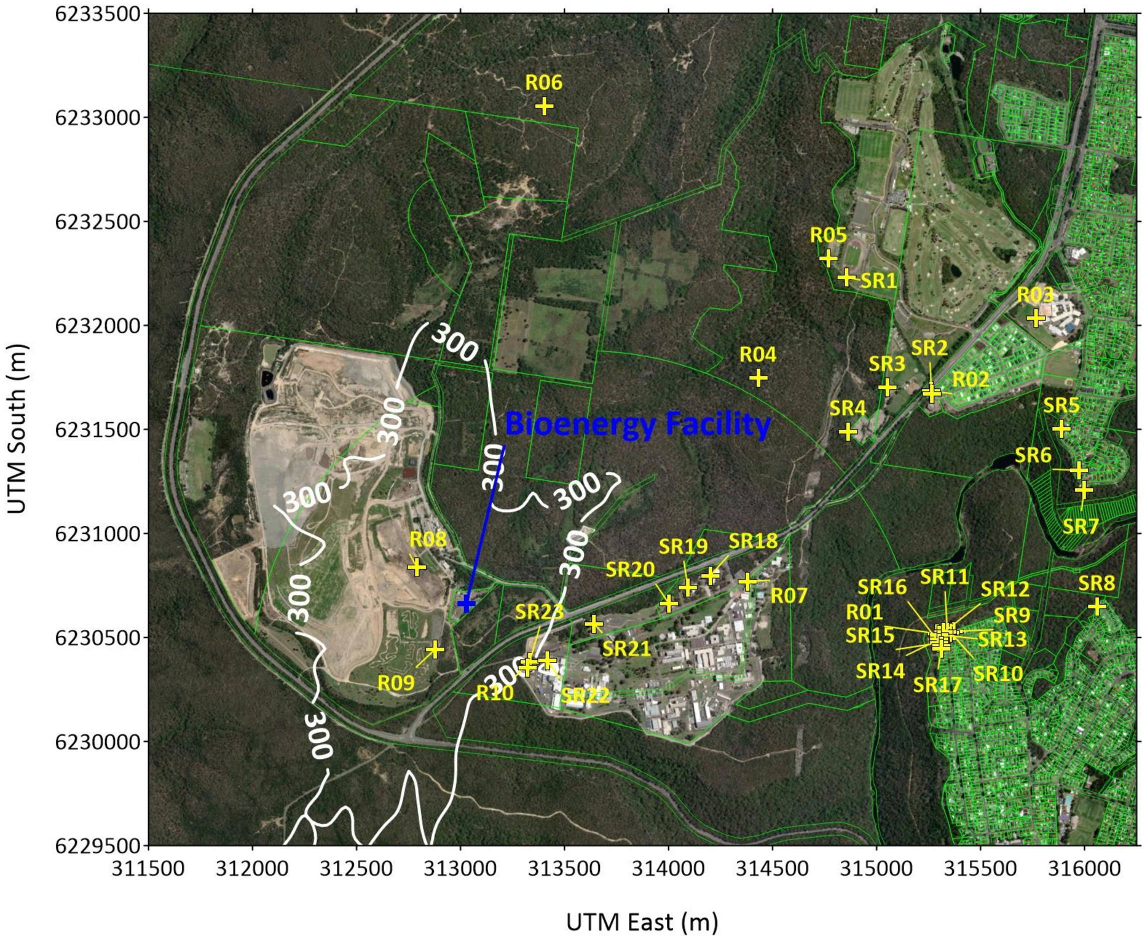
Species: CO	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** 15 minutes	**Percentile:** Maximum
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A -2: Predicted 15 minute maximum CO in isolation



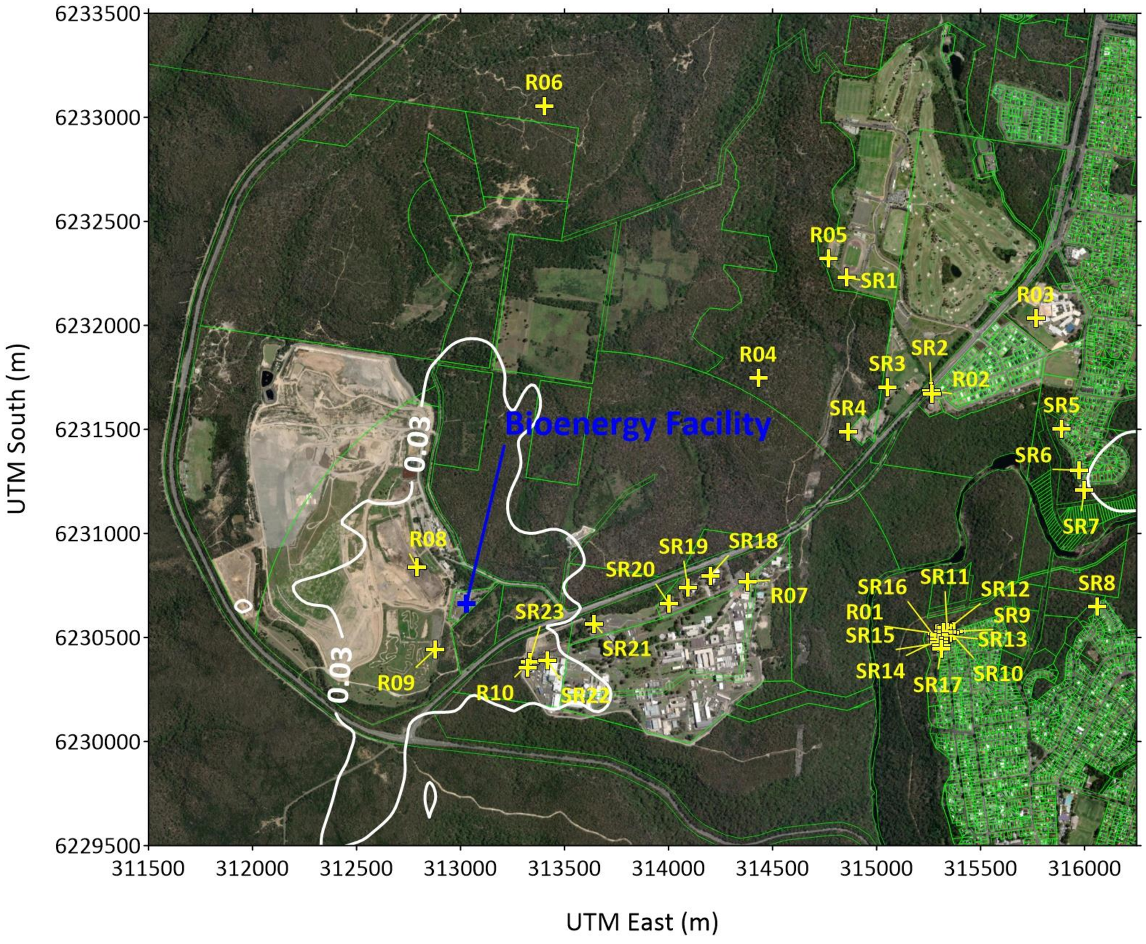
Species: CO	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** 1 hour	**Percentile:** Maximum
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A -3: Predicted 1 hour maximum CO in isolation



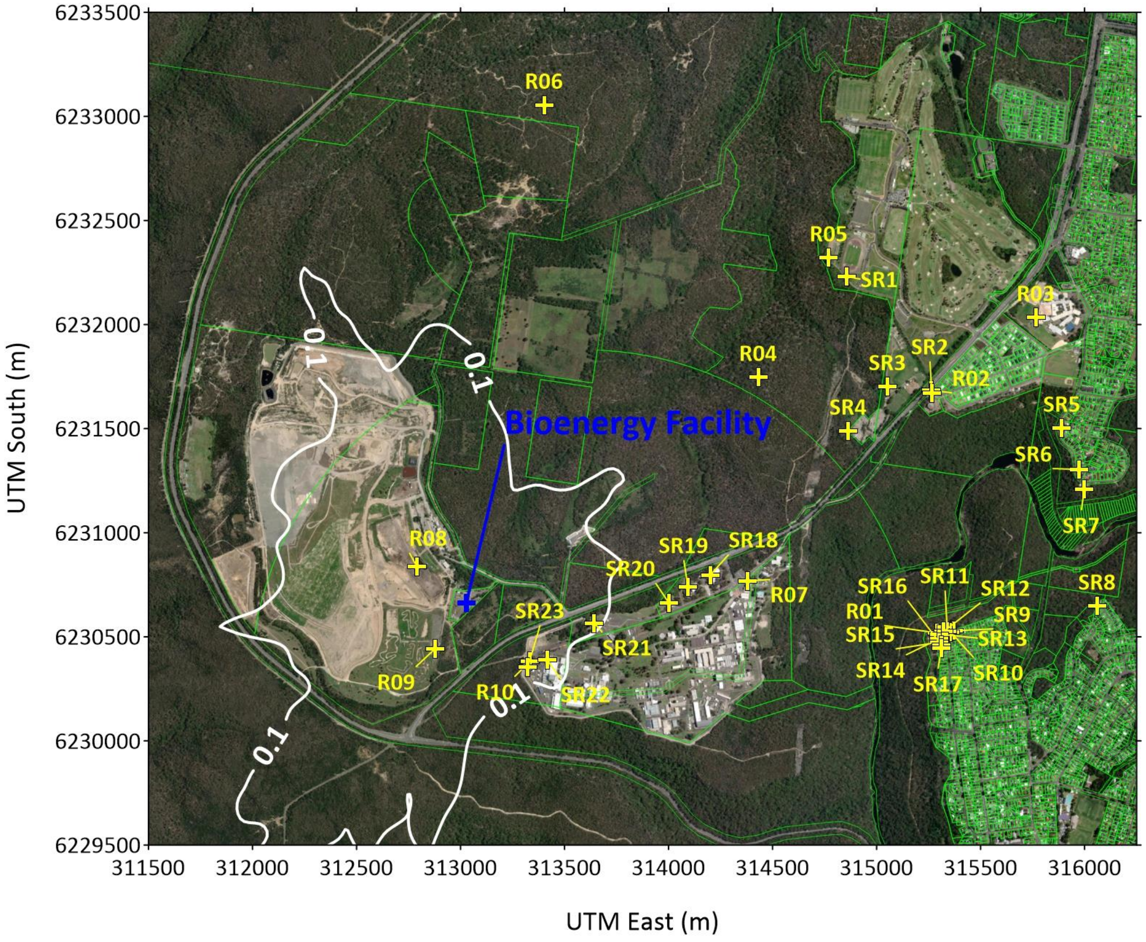
Species: CO	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** 8 hour	**Percentile:** Maximum
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A -4: Predicted 8 hour maximum CO in isolation



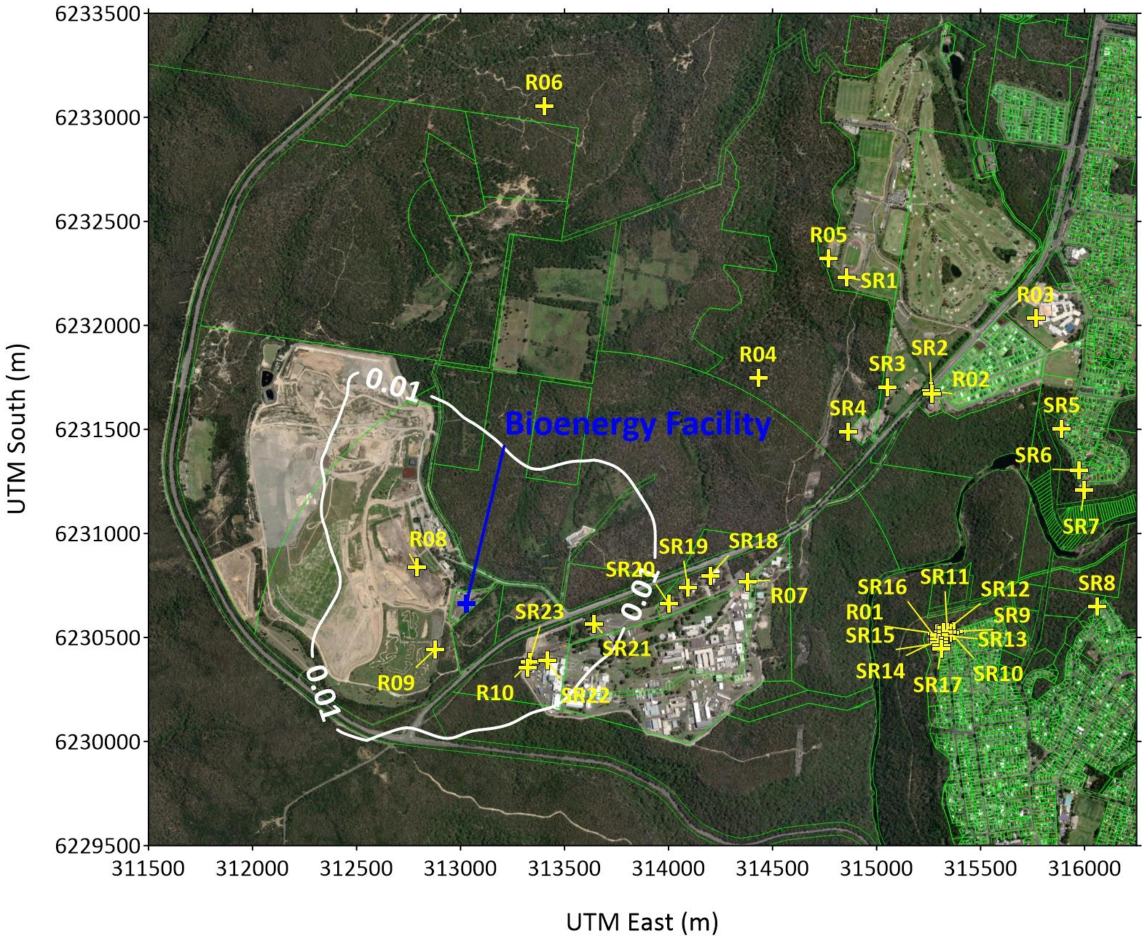
Species:	**Background:**	**Scenario:**	**Averaging Period:**	**Percentile:**
Benzene	N/A	Isolation	1 hour	Maximum
Criterion:	**Units:**	**Meteorology:**	**Model:**	**Author:**
N/A	µg/m^3	01/07/22 to 30/06/23	CALPUFF v 6.42	W. Shillito

Figure A -5: Predicted 1 hour maximum Benzene in isolation



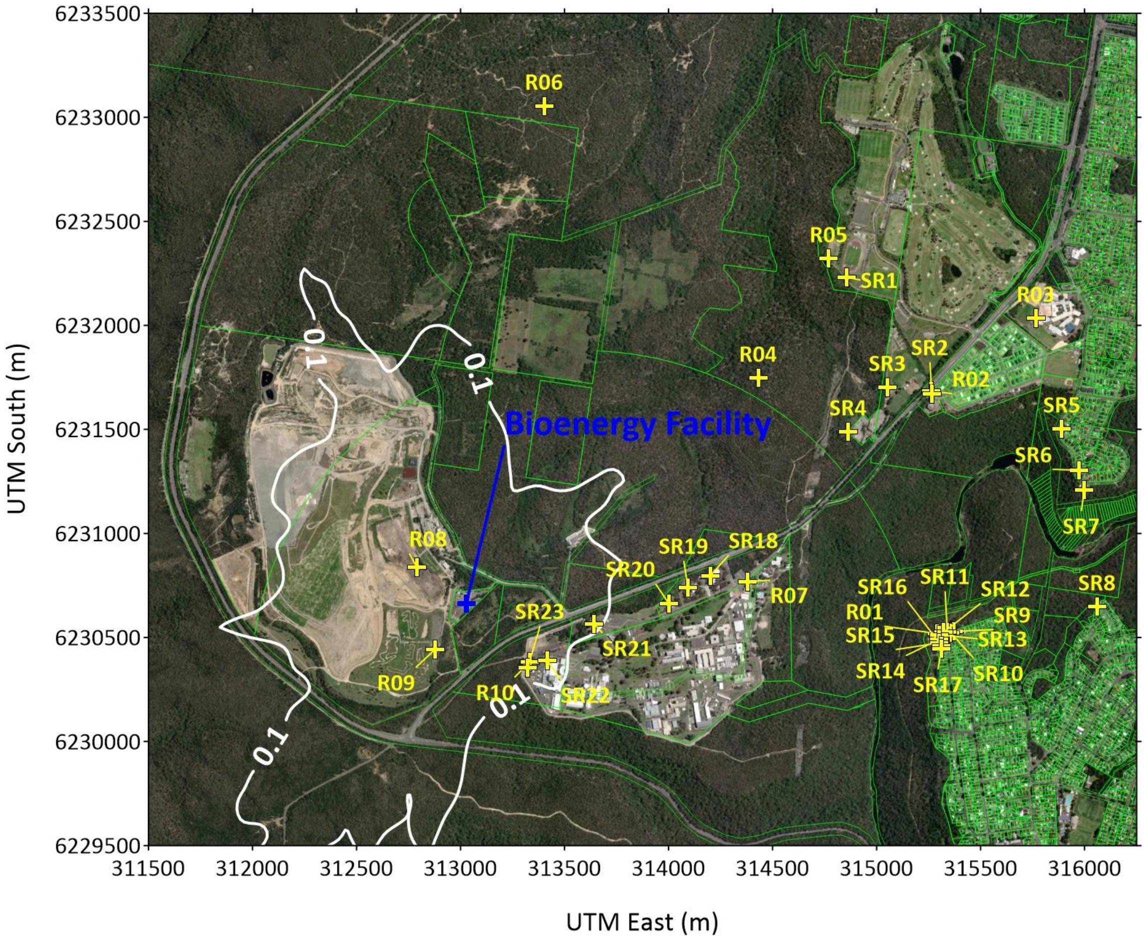
Species: PM10	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** 24 hour	**Percentile:** Maximum
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A -6: Predicted maximum 24 hour average PM_{10} in isolation



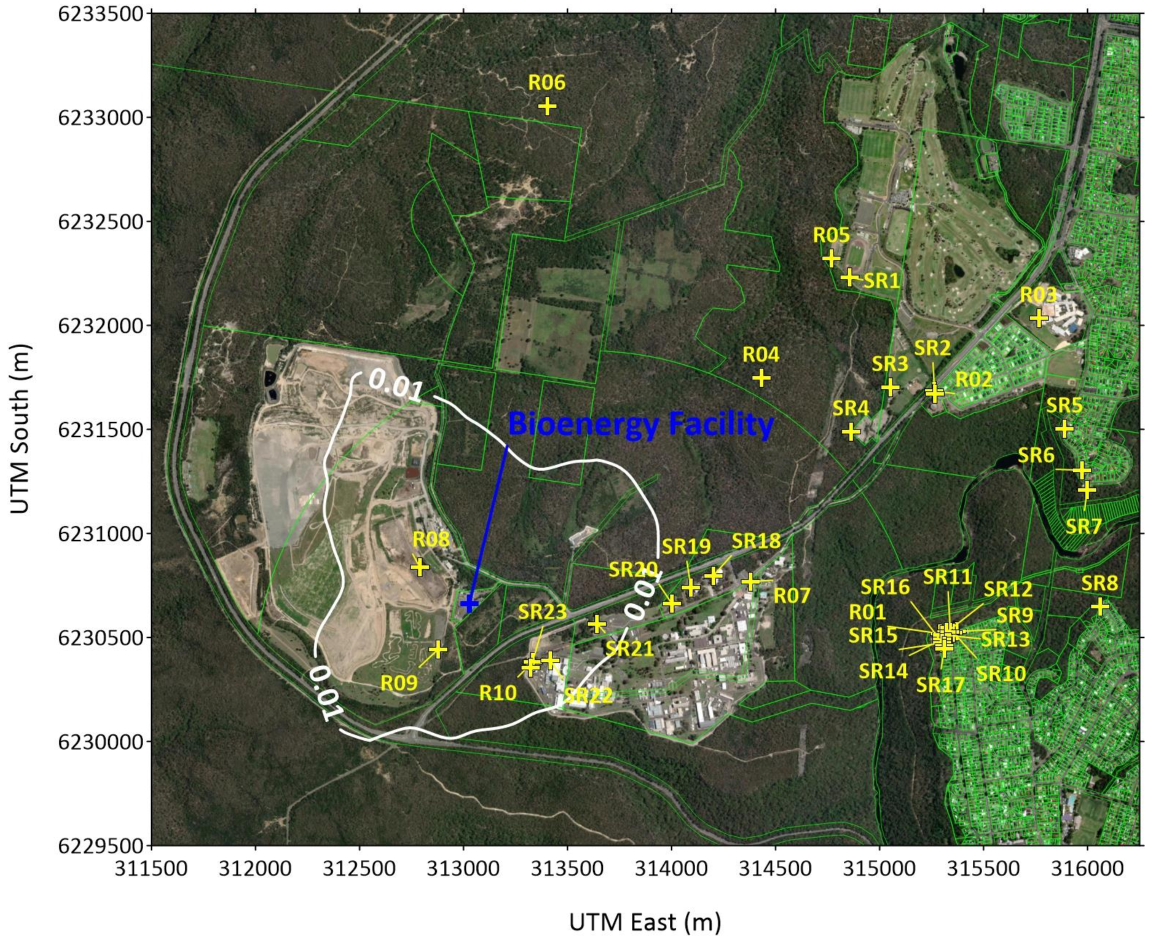
Species: PM_{10}	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** Annual	**Percentile:** Average
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A -7: Predicted annual average PM_{10} in isolation



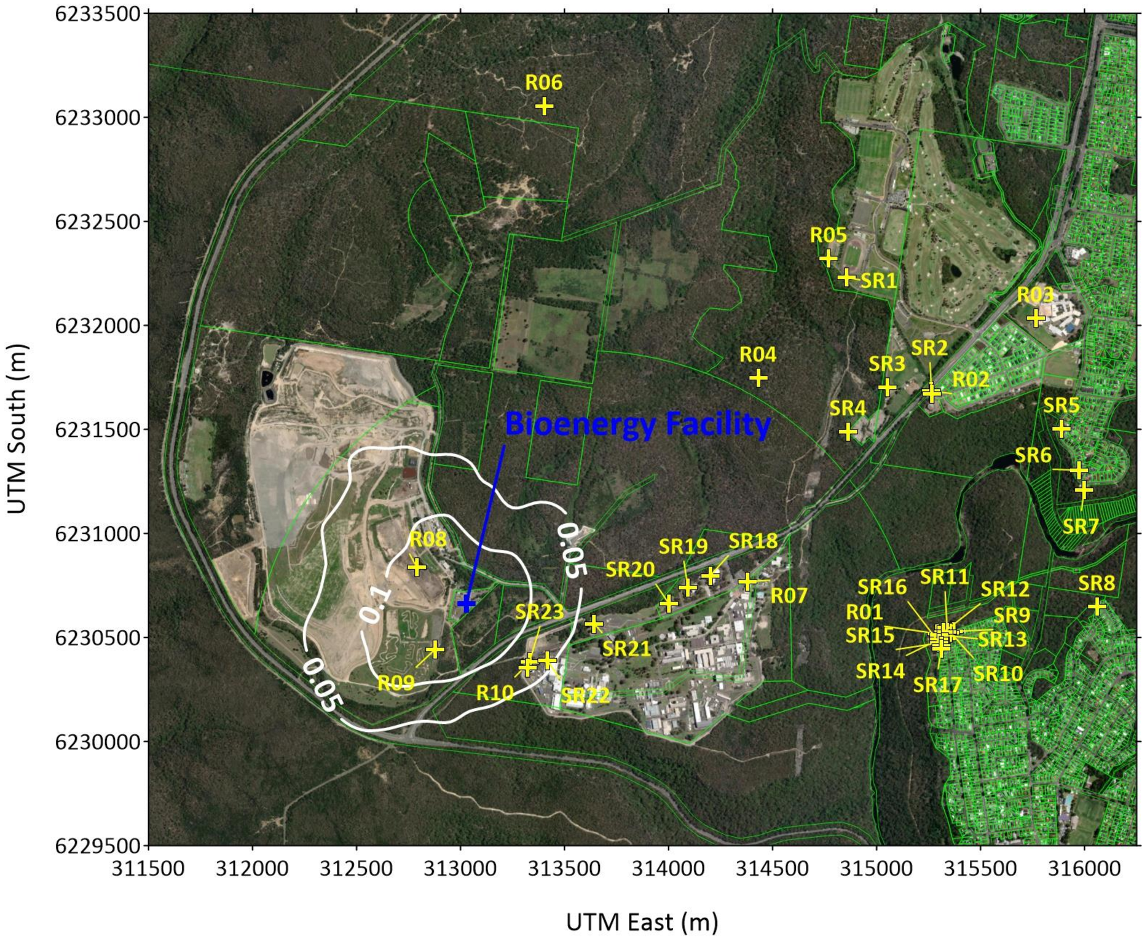
Species: $PM_{2.5}$	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** 24 hour	**Percentile:** Maximum
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A-8: Predicted maximum 24 hour average $PM_{2.5}$ in isolation



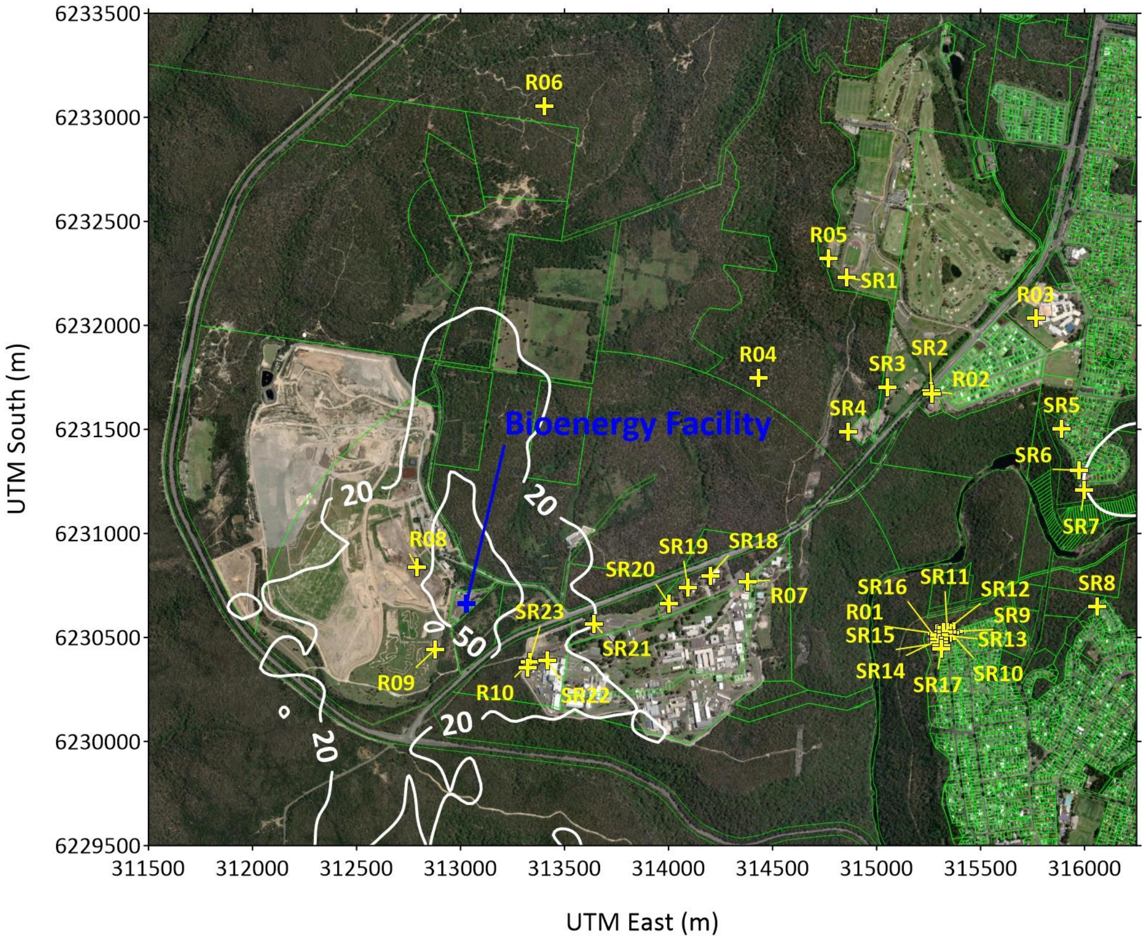
Species: PM$_{2.5}$	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** Annual	**Percentile:** Average
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A-9: Predicted annual average PM$_{2.5}$ in isolation



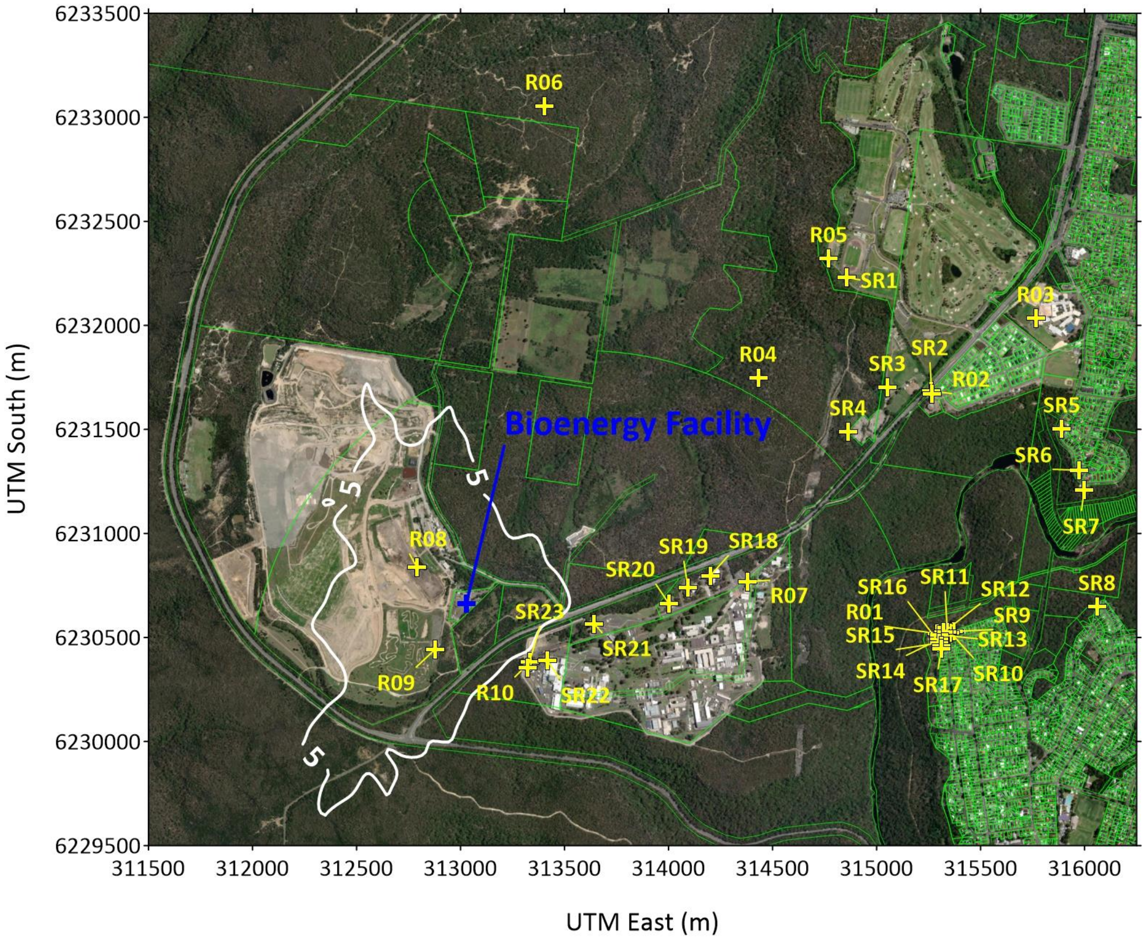
Species: H_2S	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** 1 second	**Percentile:** 99th
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A-10: Predicted 1 second 99th Percentile H_2S in isolation



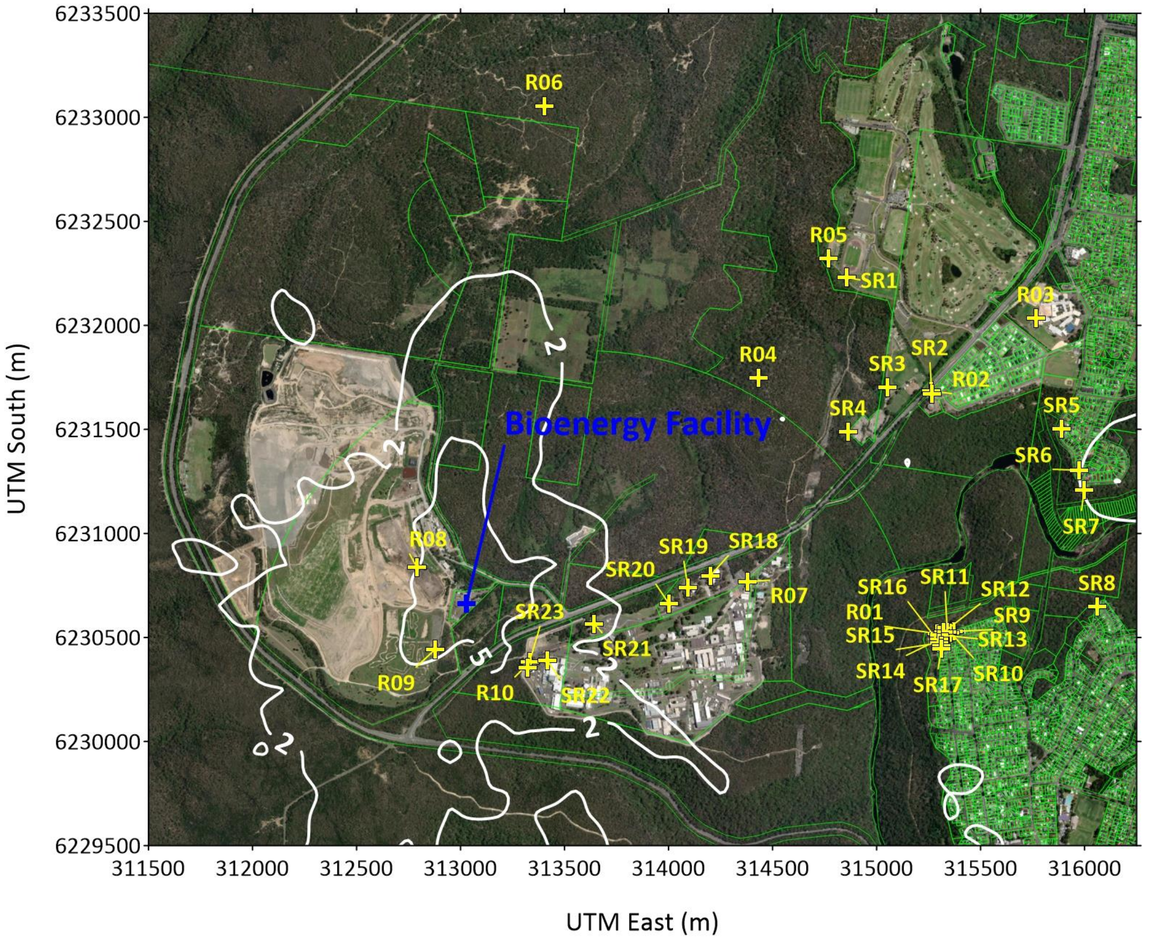
Species: SO_2	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** 1 hour	**Percentile:** Maximum
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure A-11: Predicted 1 hour maximum SO_2 in isolation



Species: SO_2	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** 24 hour	**Percentile:** Maximum
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

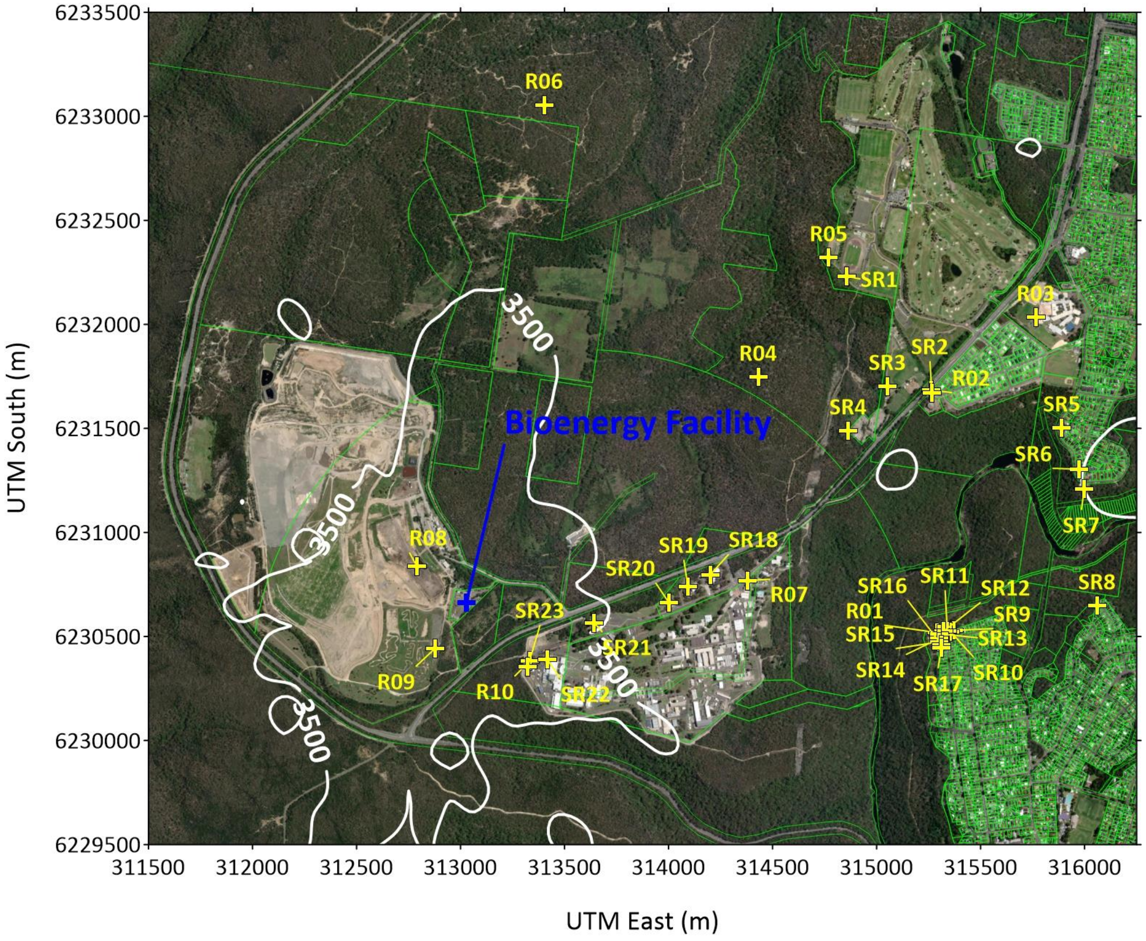
Figure A-12: Predicted 24 hour maximum SO_2 in isolation



Species: H_2SO_4	**Background:** N/A	**Scenario:** Isolation	**Averaging Period:** 1 hour	**Percentile:** Maximum
Criterion: N/A	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

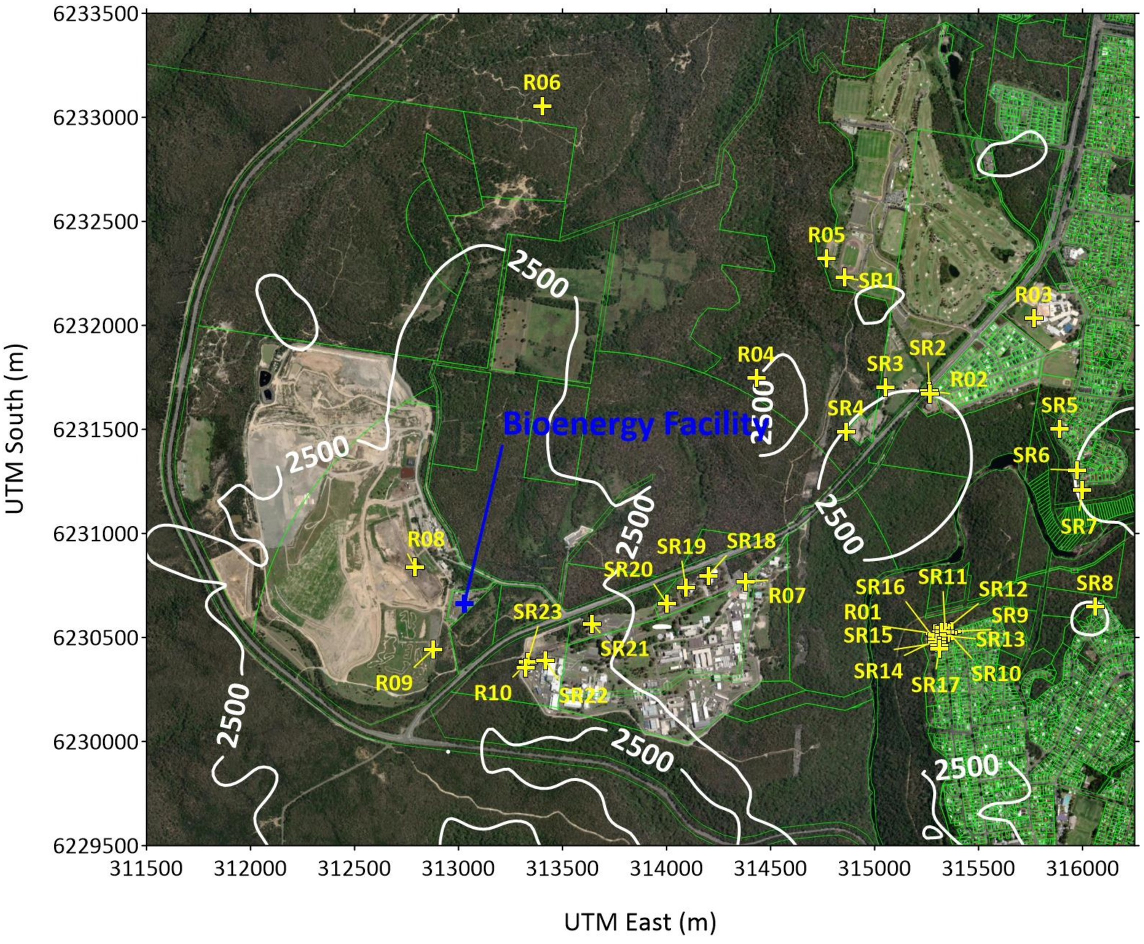
Figure A-13: Predicted 1 hour maximum H_2SO_4 in isolation

APPENDIX B. CONTOUR PLOTS – CUMULATIVE



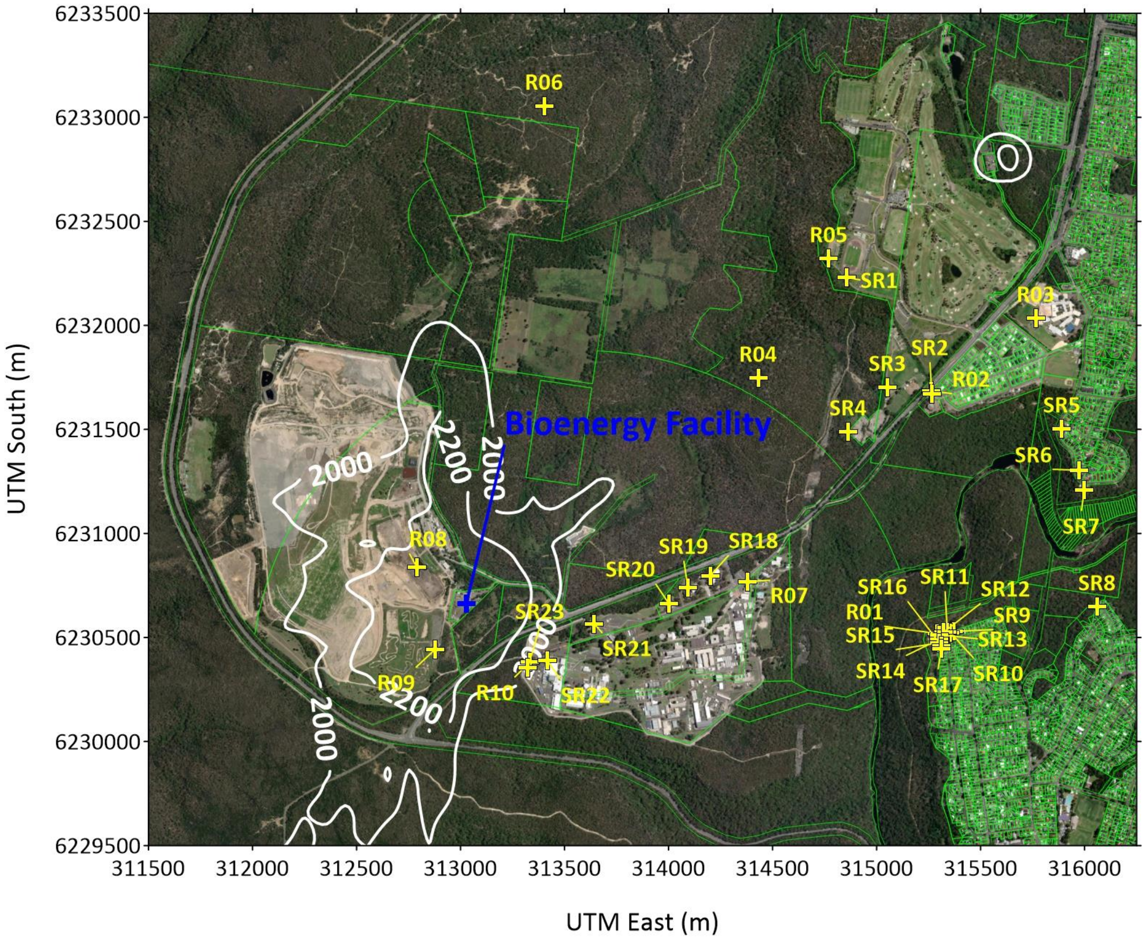
Species: CO	**Background:** 2,639	**Scenario:** Cumulative with Background	**Averaging Period:** 15 minutes	**Percentile:** Maximum
Criterion: 100,000	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-14: Predicted 15 minute maximum CO cumulative with background



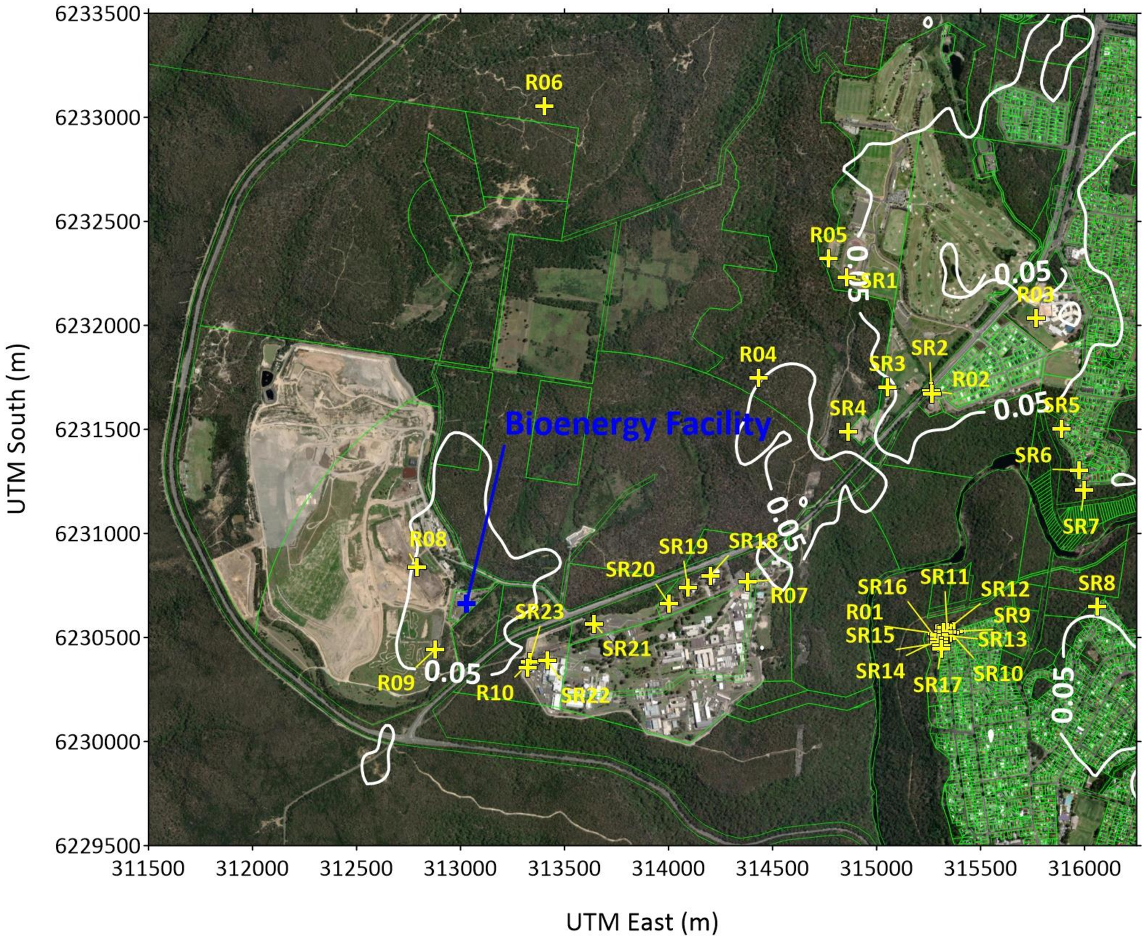
Species: CO	**Background:** 2,000	**Scenario:** Cumulative with Background	**Averaging Period:** 1 hour	**Percentile:** Maximum
Criterion: 30,000	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-15: Predicted 1 hour maximum CO cumulative with background



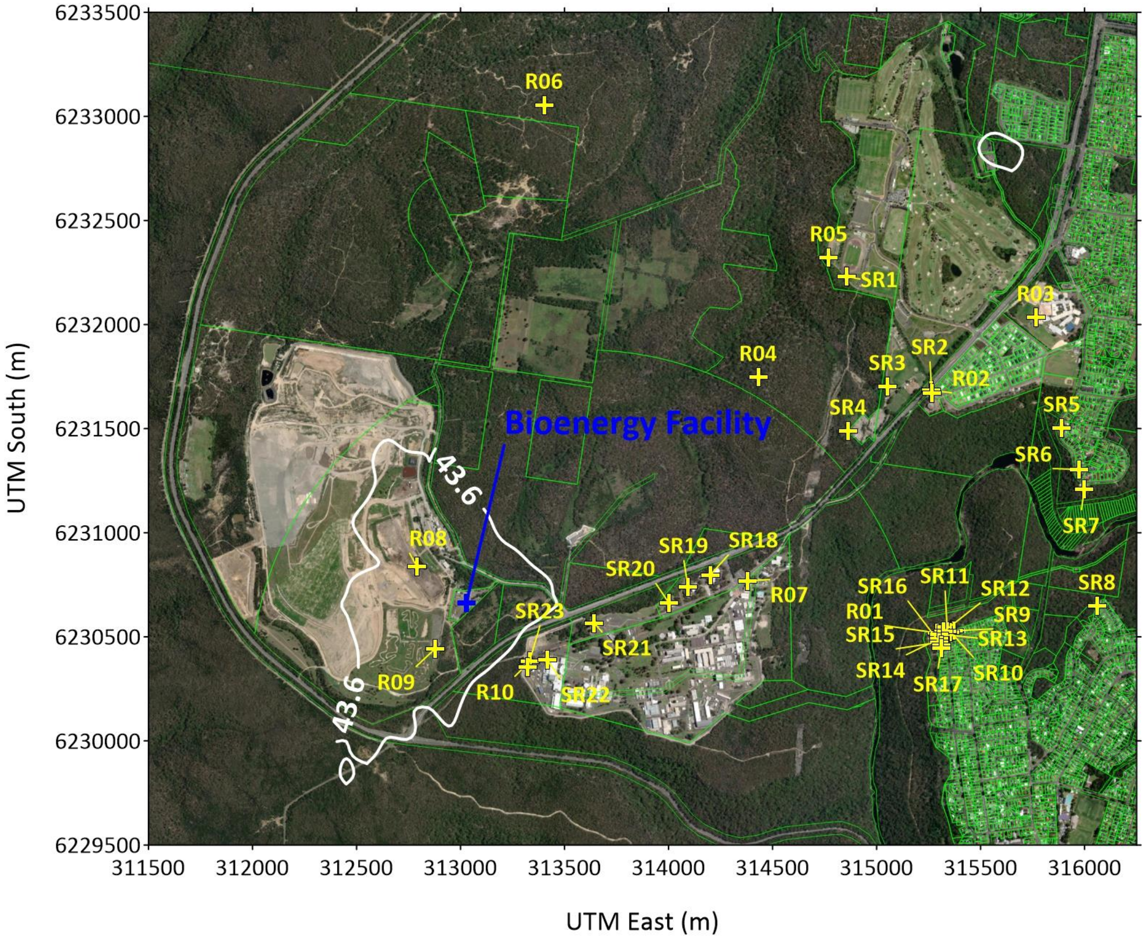
Species: CO	**Background:** 1,691	**Scenario:** Cumulative with Background	**Averaging Period:** 8 hour	**Percentile:** Maximum
Criterion: 10,000	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-16: Predicted 8 hour maximum CO cumulative with background



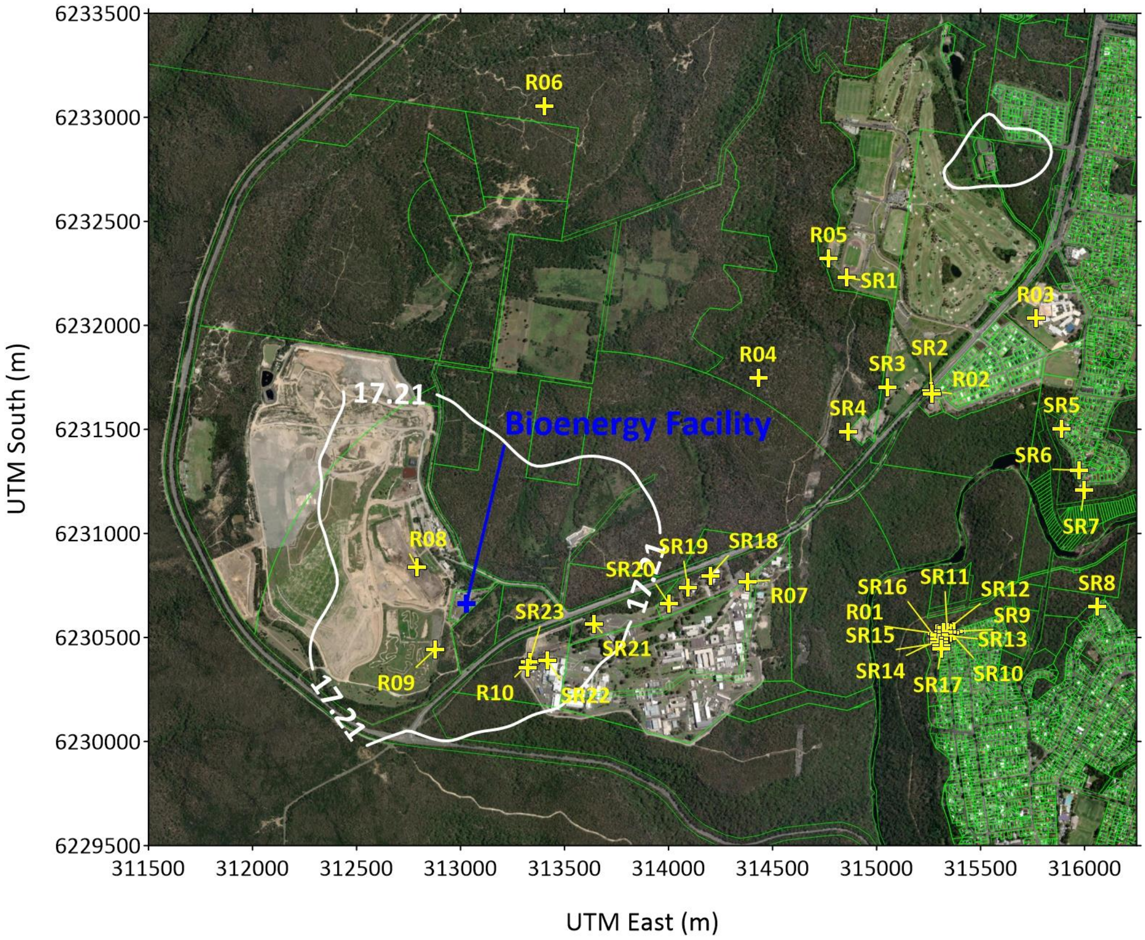
Species: Benzene	**Background:** N/A	**Scenario:** Cumulative with Background	**Averaging Period:** 1 hour	**Percentile:** Maximum
Criterion: 29	**Units:** µg/m³	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-17: Predicted 1 hour maximum Benzene cumulative with background



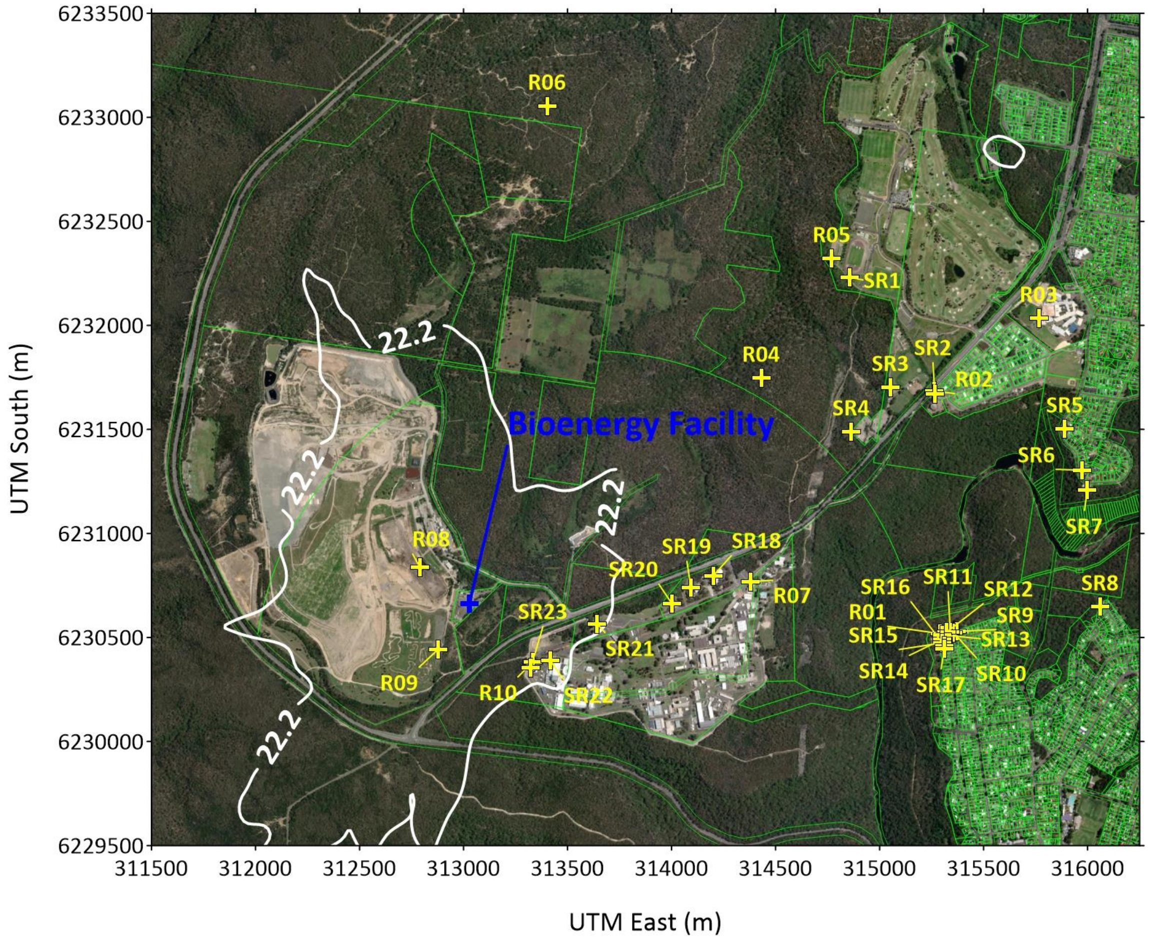
Species: PM10	**Background:** 43.4	**Scenario:** Cumulative with Background	**Averaging Period:** 24 hour	**Percentile:** Maximum
Criterion: 50	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-18: Predicted maximum 24 hour average PM$_{10}$ cumulative with background



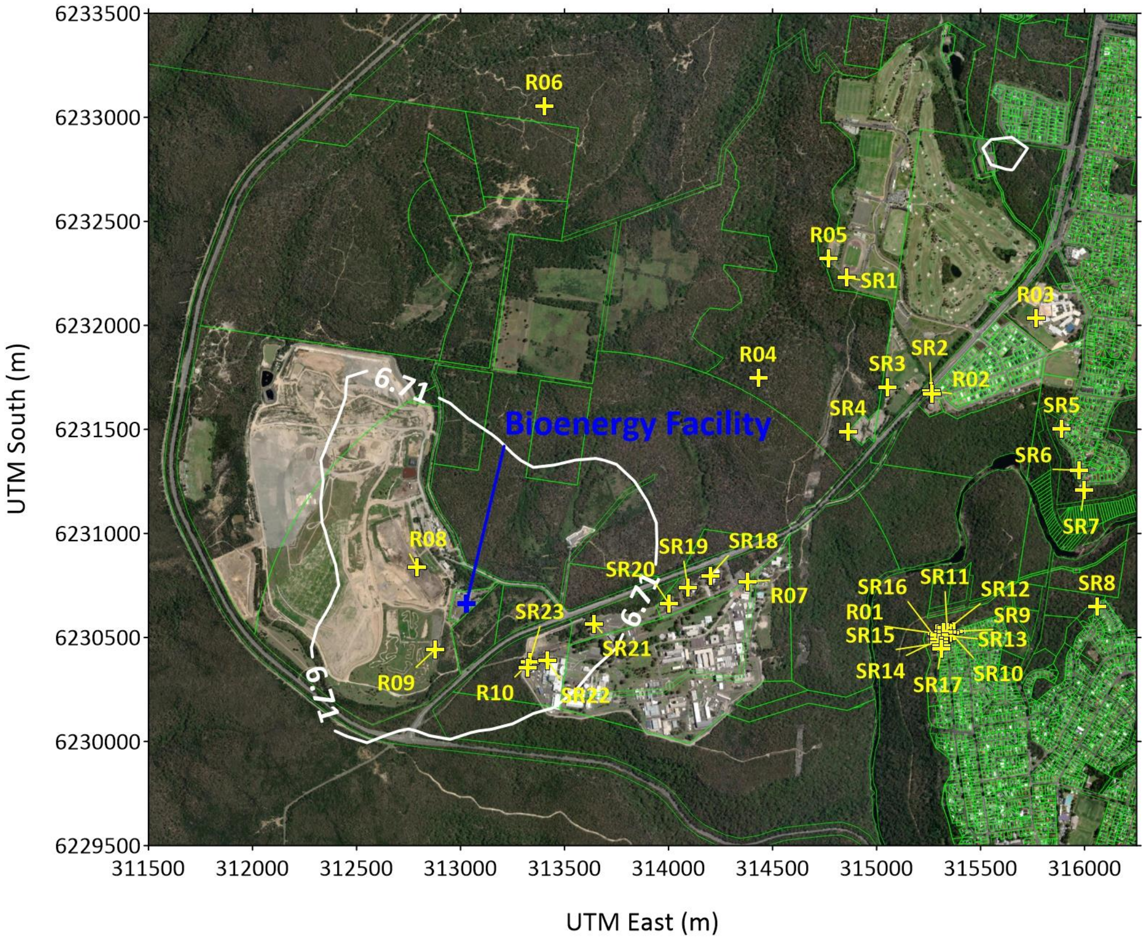
Species: PM$_{10}$	**Background:** 17.2	**Scenario:** Cumulative with Background	**Averaging Period:** Annual	**Percentile:** Average
Criterion: 25	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-19: Predicted annual average PM$_{10}$ cumulative with background



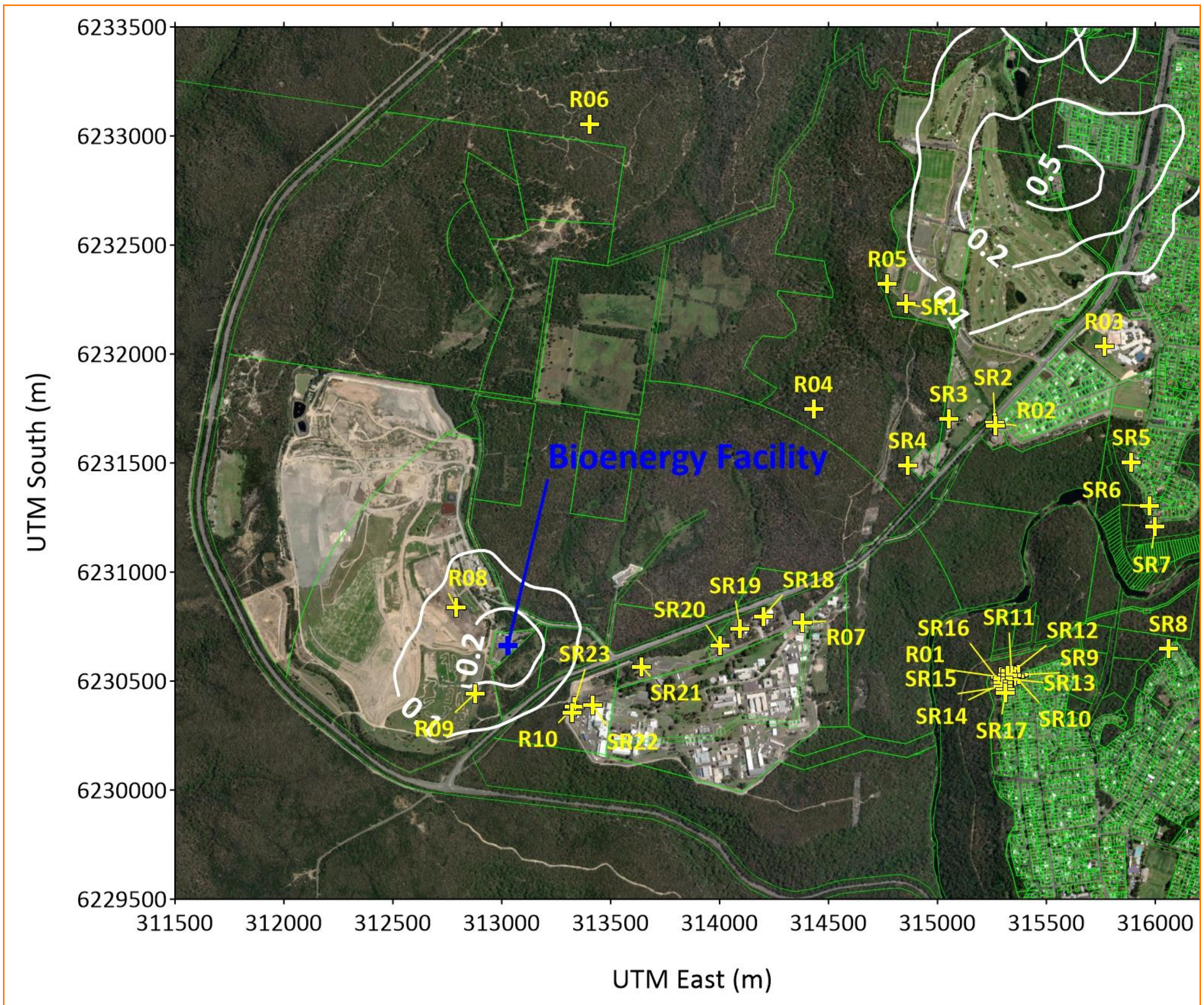
Species: $PM_{2.5}$	**Background:** 22.1	**Scenario:** Cumulative with Background	**Averaging Period:** 24 hour	**Percentile:** Maximum
Criterion: 25	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-20: Predicted maximum 24 hour average $PM_{2.5}$ cumulative with background



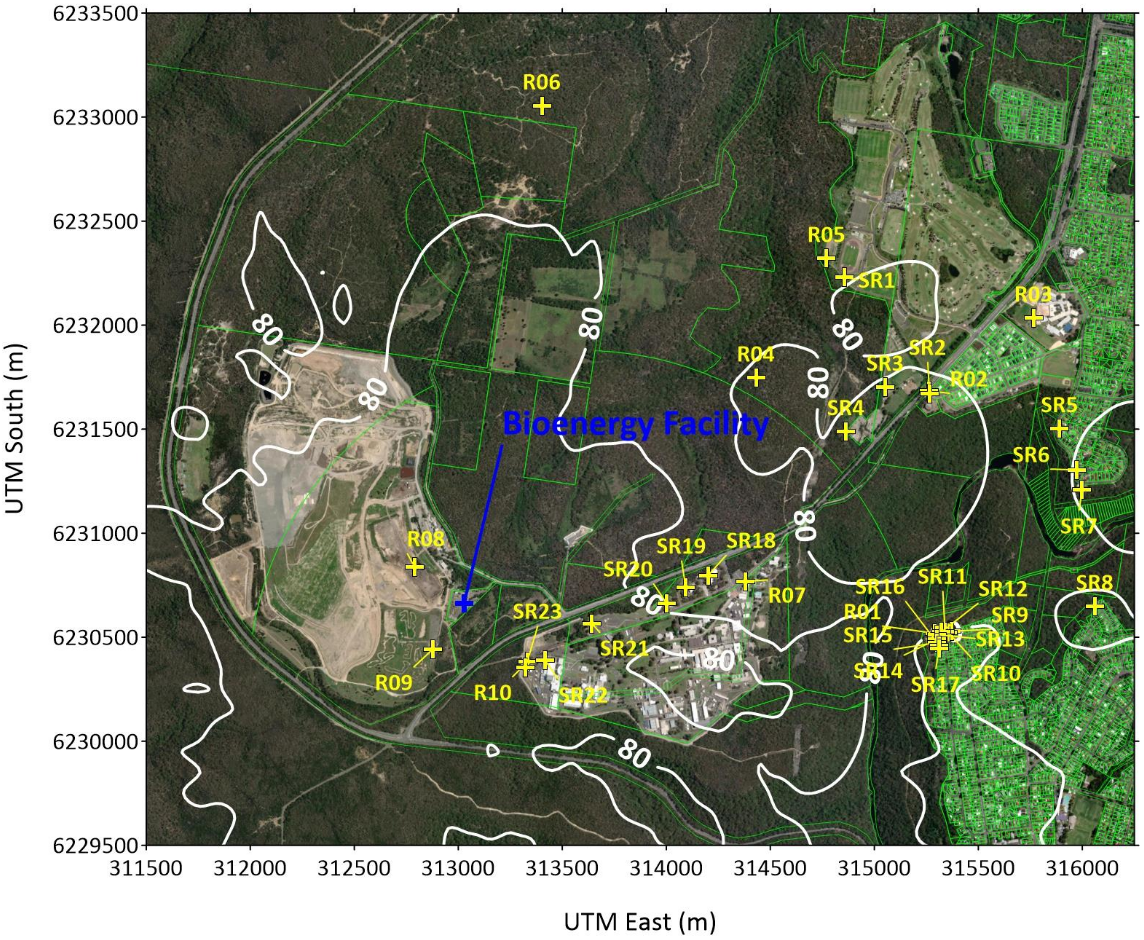
Species: $PM_{2.5}$	**Background:** 6.7	**Scenario:** Cumulative with Background	**Averaging Period:** Annual	**Percentile:** Average
Criterion: 8	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-21: Predicted annual average $PM_{2.5}$ cumulative with background



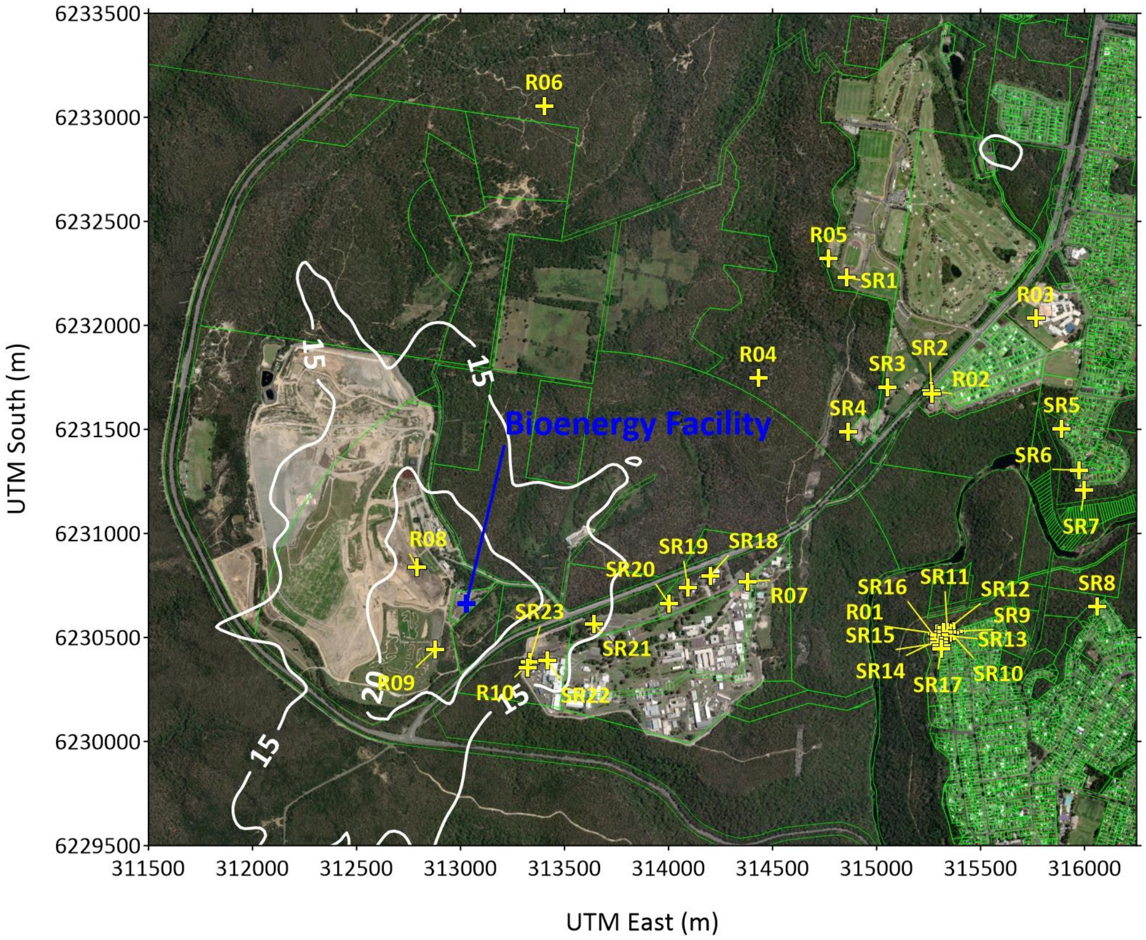
Species: H_2S	**Background:** 0	**Scenario:** Cumulative with Background	**Averaging Period:** 1 second	**Percentile:** 99th
Criterion: 2.07	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-22: Predicted 1 second 99th percentile H_2S cumulative with background



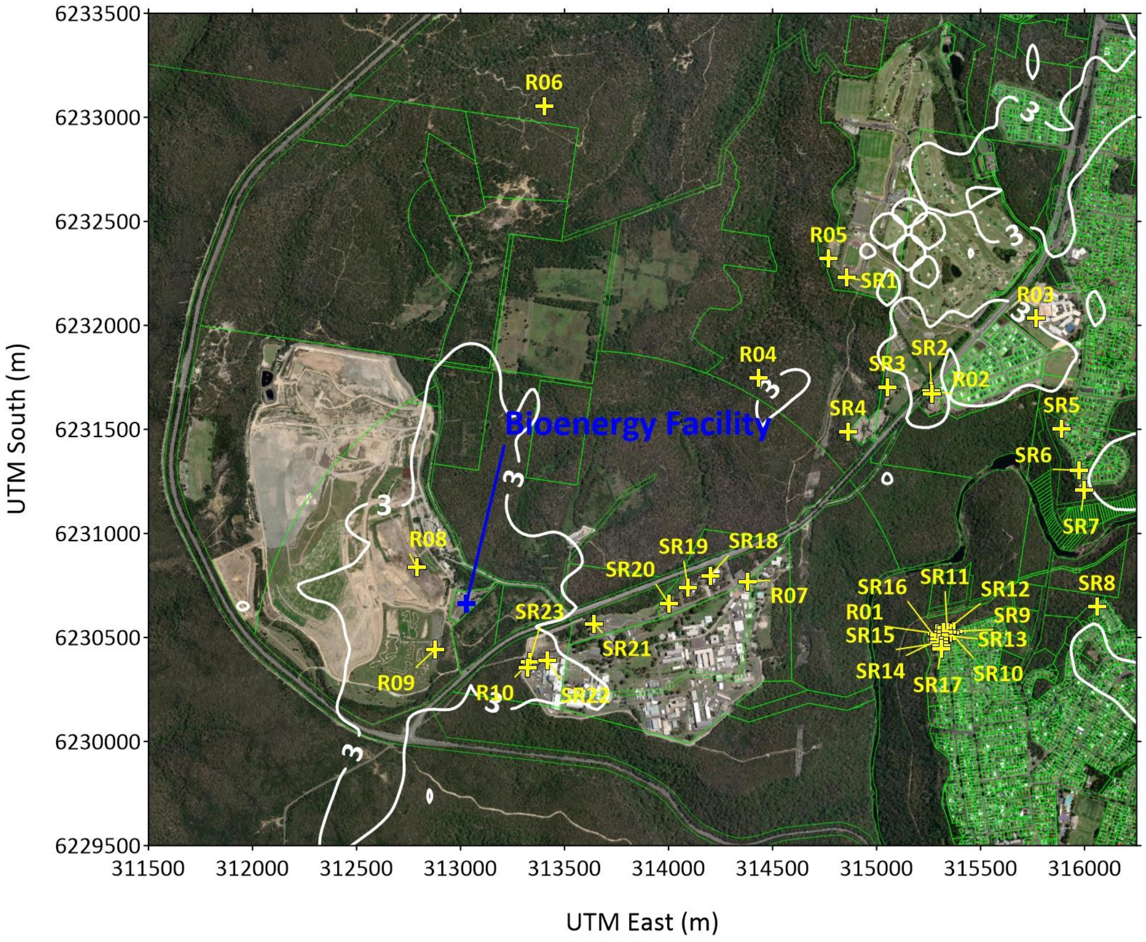
Species: SO_2	**Background:** 68.6	**Scenario:** Cumulative with Background	**Averaging Period:** 1 hour	**Percentile:** Maximum
Criterion: 215	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-23: Predicted maximum 1 hour average SO_2 cumulative with background



Species: SO_2	**Background:** 12.1	**Scenario:** Cumulative with Background	**Averaging Period:** 24 hour	**Percentile:** Maximum
Criterion: 57	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-24: Predicted maximum 24 hour average SO_2 cumulative with background



Species: H_2SO_4	**Background:** 0	**Scenario:** Cumulative with Background	**Averaging Period:** 1 hour	**Percentile:** Maximum
Criterion: 18	**Units:** µg/m^3	**Meteorology:** 01/07/22 to 30/06/23	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure B-25: Predicted maximum 1 hour average H_2SO_4 cumulative with background