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Sydney Water

**North West Treatment
Hub Plant Upgrades –
Growth Package**

Riverstone WRRF
Air Quality Impact
Assessment

wsp

March 2026

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North West Treatment Hub Plant Upgrades – Growth Package Riverstone WRRF Air Quality Impact Assessment

Sydney Water

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WSP acknowledges that every project we work on takes place on First Peoples lands. We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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1 Introduction

Sydney Water's North West Treatment Hub (NWTB) comprises of the Castle Hill Water Resource Recovery Facilities (WRRF), Rouse Hill WRRF and Riverstone WRRF. The NWTB provides wastewater servicing to Sydney's north west including the North West Growth Area (NWGA) and North West Urban Renewal Corridor along the new Metro North West Line.

In 2022, Sydney Water proposed the NWTB upgrades to address rapid growth, meet future regulatory requirements and provide a solution that minimises impacts to the community and the environment. The proposed works included:

- upgrading at Rouse Hill WRRF and Riverstone WRRF.
- constructing a new sludge transfer system between the three WRRFs to centralise solid treatment at Riverstone.

The potential environmental impacts and mitigation measures for these works were assessed under the NWTB Upgrades and Sludge Transfer System – Growth Package, July 2022 (approved Review of Environmental Factors (REF)).

Following this, Sydney Water identified an opportunity to diversify methods for solids processing. A review of technology available for advanced processing of biosolids to reduce contaminants of concern found that carbonisation with upstream digestion, dewatering, and drying was the preferred technology for the NWTB upgrade project.

The proposed changes to the approved REF include the following:

- Riverstone WRRF
 - a new carbonisation plant and associated infrastructure including drying, heating, and carbonisation systems; this will result in production of biochar rather than biosolids
 - no change to existing anaerobic digestion and no upgrade to waste gas burners
 - additional bioreactors and membrane bioreactors
 - deletion of cogeneration unit.
- Rouse Hill WRRF
 - new dewatering and outloading building to cater for sludge treatment
 - expansion of the construction footprint to include a compound site in 7 Money Close, Rouse Hill (5/-/DP1158760) and new access roads into the facility
 - ongoing use of part of existing biological nutrient removal (BNR) treatment and existing aerobic digester
- Sludge transfer systems
 - deletion of both sludge transfer pipelines (Rouse Hill WRRF to Riverstone WRRF, and Castle Hill WRRF to Rouse Hill WRRF).

WSP Australia Pty Ltd (WSP) was appointed by Sydney Water to prepare this Air Quality Impact Assessment (AQIA) for Riverstone WRRF, to inform the REF Addendum, which will be assessed against under Part 5.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

Construction impacts will be consistent those previously assessed by Jacobs Group (Australia) Pty Ltd (Jacobs) for the REF (documented in: *IS373500_NWH_Riverstone_Air_Quality_Final_rev0*), and no additional assessment is required. This assessment will supersede the operational impacts assessed in 2022 (Jacobs, 2022).

1.1 Scope of assessment

This AQIA was prepared in accordance with the NSW Environment protection Authority (EPA) “*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*” (Approved Methods). Following the level 2 assessment approach, this report details the following steps taken in the assessment:

- **Section 2** – Identification of applicable legislation for the proposed upgrades
- **Section 3** – Background air quality data was sourced, and cumulative impacts were calculated and modelled to assess the potential for the project to impact air quality in the local area.
- **Section 4** – Developing an emissions inventory for the proposed changes to the existing facility and original REF, using available information such as manufacturers specifications, emission estimation techniques or data available from other facilities that have published monitoring data for equivalent processes.
- **Section 5** – Assessment criteria for the Riverstone WRRF AQIA were established considering the legislation identified in Section 2.
- **Section 6** – Air dispersion modelling, using (CALPUFF) to predict ground level concentrations for pollutants of interests at identified sensitive receptors.
- **Section 7** – Air quality impacts were assessed by comparing modelling results against assessment criteria for each pollutant identified.

2 Legislation and policy context

The legislative considerations and advisory documents relevant to assessing air pollutants associated with the operation of the proposed Riverstone WRRF are discussed below.

2.1 Commonwealth legislation and policy

2.1.1 *National Environment Protection Council Act 1994*

The National Environment Protection Council (NEPC) was established under the National Environment Protection Council Act 1994 (NEPC Act). The primary functions of the NEPC are to:

- prepare National Environment Protection Measures (NEPMs)
- assess and report on the implementation and effectiveness of the NEPMs in each state and territory.

NEPMs are a special set of national objectives designed to assist in protecting or managing aspects of the environment, e.g., air quality.

The NEPM relevant to air quality for the project are:

- National Environmental Protection (Ambient Air Quality) Measure 2021 (Air NEPM)
- National Environmental Protection (Air Toxics) Measure 2011 (Air Toxics NEPM).

2.1.1.1 National Environment Protection (Air Quality) Measure 2021

The Air NEPM outlines standards and goals for key pollutants that are required to be achieved nationwide, with due regard to population exposure. The national environment protection standards, relevant to this project are presented in Section 5.

2.1.2 *National Environment Protection (Air Toxics) Measure 2011*

The objective of the Air Toxics NEPM is to improve knowledge regarding ambient air toxic pollutants within areas containing sensitive receptors that are likely to be impacted by elevated concentrations to facilitate development of standards that will allow for the protection of human health and well-being. Assessment criteria specific to this project are further discussed in Section 5.

2.2 NSW legislation and policy

2.2.1 *Protection of the Environment Operations Act 1997*

The Protection of the Environment Operations Act 1997 (POEO Act) provides the legislative framework for the protection and enhancement of air quality in NSW. Its primary objectives are to reduce risks to harmless levels through pollution prevention, cleaner production, application of waste management hierarchy, continual environmental improvement, and environmental monitoring. The following sections of the POEO Act refer to air pollution related activities of relevance to this project:

- Section 124: Operation of Plant (Other Than Domestic Plant): deals with the operation of industrial plant (excluding domestic plant) and aims to prevent air pollution. Occupiers of non-residential premises must ensure that they operate their plant in a proper and efficient manner to avoid causing air pollution.

- Section 125: Maintenance Work on Plant (Other Than Domestic Plant): Similar to Section 124, this section focuses on maintenance work related to industrial plant (excluding domestic plant). It emphasises proper maintenance practices to prevent air pollution.
- Section 126: Dealing with Materials: Section 126 addresses the handling of materials in a way that avoids air pollution. Occupiers of non-residential premises must ensure that they handle materials properly and efficiently to prevent pollution.
- Section 128: Standards of Air Impurities Not to Be Exceeded: This section sets standards for air impurities. It prohibits exceeding these standards to maintain air quality and prevent pollution. These are further discussed Section 5 of this assessment.

2.2.2 Protection of the Environment Operations (Clean Air) Regulation 2022

The NSW Protection of the Environment Operations (Clean Air) Regulation 2022 ‘the Clean Air Regulation’ (which came into force on 16 December 2022), provides statutory emission limits and operating requirements for industrial plant and activities. The Clean Air Regulation provides emission limits applicable to Group 6 Afterburners and other thermal treatment plants (excluding flares) which is the closest description of carbonisation technology available in the POEO. These emission limits apply to gases within the exhaust stack for operational periods in which the plant is operational, excluding plant start-up and shutdown.

Table 2.1 provides a summary of emission limits most relevant to Carboniser plant options being considered.

Table 2.1 Summary of Group 6 Clean Air Regulation emission limits for afterburners and thermal treatment plants

Pollutant		Emission limit
units		mg/Nm ³ @7% O ₂
Nitrogen dioxide (NO ₂)		350
Sulphur dioxide (SO ₂)		1000
Total Suspended Particulates (TSP)		50
Carbon monoxide (CO)		125
Type 1 substances and Type 2 substances (in aggregate)	Lead	1
	Arsenic and compounds	
	Chromium VI compounds	
	Nickel	
	Selenium	
Cadmium		0.2
Mercury		0.2
Dioxins and furans ¹		0.0001
Hydrogen chloride		100

(1) Units are µg/m³

Sydney Water proposes to procure a plant that complies with the requirements of the POEO Act and Clean Air Regulation and has sought manufacturer assurances on the capabilities of prospective plant options to address the requirements outlined in Table 2.1.

Within this assessment, emission estimates have been developed within these requirements. Further discussion of this process is provided in Section 4.

Section 69, Part 5, Division 5 of the POEO act states that the emissions of an afterburner without a catalytic control system must comply with:

- (a) *the time between an air impurity entering and exiting the afterburner is—*
 - i. *if the air impurity originates from material containing a principal toxic air pollutant—more than 2 seconds, or*
 - ii. *otherwise—more than 0.3 seconds, and*
- (b) *the temperature for the combustion of an air impurity by the afterburner is—*
 - i. *if the air impurity originates from material containing a principal toxic air pollutant—more than 980°C, or*
 - ii. *otherwise—more than 760°C, and*
- (c) *the destruction efficiency of the plant, in relation to an air impurity entering the plant, is—*
 - i. *if the air impurity originates from material containing a principal toxic air pollutant—more than 99.9999%, or*
 - ii. *otherwise—more than 99.99%.*

The carboniser used for the project has an oxidation chamber for management of syngas that could be considered an afterburner, although the establishment of the design requirements in legislation did not consider a carbonisation processes. The principal air toxic pollutants identified in Section 69 of the Clear Air Regulation associated with emissions from the carbonisers are As, Cd, Cr, Ni, dioxins, furans, and PAH. Section 4.1.5.2 provides discussion on the reasonableness and feasibility of implementing design requirements on the residence time, temperature and destruction efficiency of the carbonisation process.

Notwithstanding the design requirements of the Clean Air Regulation, this AQIA prioritises the predicted environmental outcomes and are based off the estimated air emissions rather than the reasonableness and feasibility of implementing design requirements of Section 69 of the Clear Air Regulation.

2.2.3 *Environmental Planning and Assessment Act 1979 (EP&A Act)*

The Environmental Planning and Assessment Act 1979 (EP&A Act) is the primary land use planning statute in New South Wales (NSW), Australia. It plays a crucial role in governing various aspects related to land use planning and development, including:

- **Planning Administration:** The EP&A Act establishes the framework for planning administration in NSW. It outlines the roles and responsibilities of planning authorities, councils, and other relevant bodies involved in land use planning.
- **Development Assessments:** The EP&A Act sets out the process for assessing development applications. It defines the criteria for determining whether a proposed development complies with planning regulations. The Act also covers integrated development assessments, which involve multiple approvals (e.g., planning and environmental approvals).
- **Building Certification:** Building regulation and certification provisions within the EP&A Act ensure the design, construction, and safety of buildings in NSW. These provisions work alongside the Building Professionals Act 2005 and the Home Building Act 1981.
- **Infrastructure Finance:** The Act addresses infrastructure financing related to development. It provides mechanisms for funding infrastructure projects required to support new developments.

- Appeals and Enforcement: The EP&A Act outlines the process for appealing decisions made by planning authorities. It also includes provisions for enforcement actions against non-compliance with planning regulations.

Overall, the EP&A Act aims to create a balanced and efficient planning system that considers community needs, environmental protection, and sustainable development.

Division 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act) pertains to specific activities that may be undertaken without requiring formal development consent. These activities are often carried out by councils, government departments, state agencies, or public authorities (such as Sydney Water).

Certain projects, such as the Riverstone WRRF, fall under the category of “development permitted without consent.” These activities do not require formal approval. Many of these activities are permitted under the State Environmental Planning Policy (Transport and Infrastructure) 2021. Examples include essential infrastructure projects and other activities that contribute to public benefit.

Before work can commence, public authorities must assess the environmental impacts of a project. This assessment process is called a Review of Environmental Factors (REF). The Guidelines for Division 5.1 Assessment provide guidance on conducting REFs.

2.2.4 Approved Methods for the Modelling and Assessment of Air Quality in NSW (2022)

Pursuant to the POEO Act, the Approved Methods for Modelling and Assessment of Air Quality in NSW 2022 (Approved Methods) prescribes the statutory methods for modelling and assessing air emission sources in NSW.

The Approved Methods lists impact assessment criteria (IAC) and individual air toxics criteria for a range of pollutants against which emissions from an activity is to be assessed. The IAC and individual air toxics relevant to this assessment are presented in Section 5.

3 Existing environment

3.1 Location

The Riverstone WRRF is located at 108 Bandon Road in Vineyard, New South Wales, which is approximately 40 km north-west (NW) of Sydney city centre (Figure 3.1). The site is approximately 230 m west (W) of Riverstone Parade, approximately 240 m south-west (SW) of Vineyard Station, and approximately 2.8 km NW and 5 km south-east (SE) of the Riverstone and Windsor town centres, respectively.

The centre of the project site is located at approximately Universal Transverse Mercator (UTM) Zone 56 South 300430 m East, 6274100 m (or latitude 33.65426 °South, longitude 150.84781 °East).

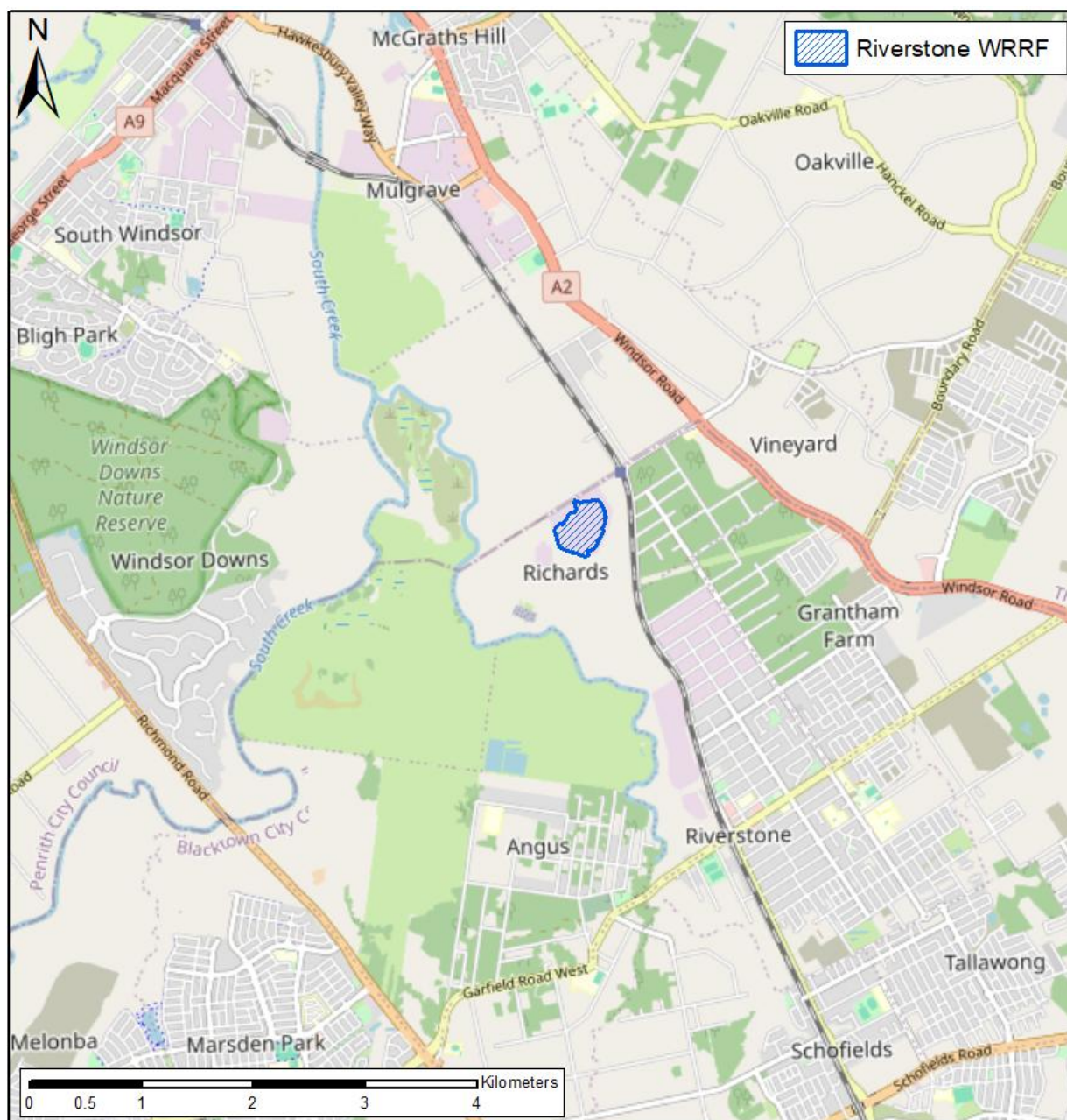


Figure 3.1 Location of the Riverstone WRRF

3.2 Sensitive receptors

The Approved Methods (NSW EPA, 2022) describes a sensitive receptor as ‘A location where people are likely to work or reside; this may include a dwelling, school, hospital, office, or public recreational area. An air quality impact assessment should also consider the location of any known or likely future sensitive receptor.’

The sensitive receptors identified for this AQIA are summarised in Table 3.1. The location of these receptors in relation to the Riverstone WRRF is presented in Figure 3.2. The closest sensitive receptors to the project site were identified and include residential properties, a childcare facility and the Vineyard railway station.

Table 3.1 Sensitive receptors

Receptor number	Name	X (m)	Y (m)	Receptor type
1	Victoria St Industry	300993	6273148	Industrial/commercial
2	Eastern Creek 3	300263	6272936	Water course
3	Ashford Rd	300922	6274116	Residential
4	Otago St	301080	6273903	Residential
5	Camberwell Rd	300878	6274449	Residential
6	Vineyard Early Learning	300822	6274685	Education (early learning)
7	Brisbane Rd	301063	6273722	Residential
8	House North	300410	6274660	Residential
9	Eastern Creek 1	299419	6274281	Water course
10	Eastern Creek 2	299223	6273457	Water course
11	Hawkesbury Model Air Sports	299901	6273347	Recreation
12	Vineyard Train Station	300732	6274534	Service
13	Western Storage 1	300615	6274439	Industrial/commercial
14	Western Storage 2	300656	6274268	Industrial/commercial
15	Western Storage 3	300684	6274028	Industrial/commercial
16	Western Storage 4	300580	6273859	Industrial/commercial

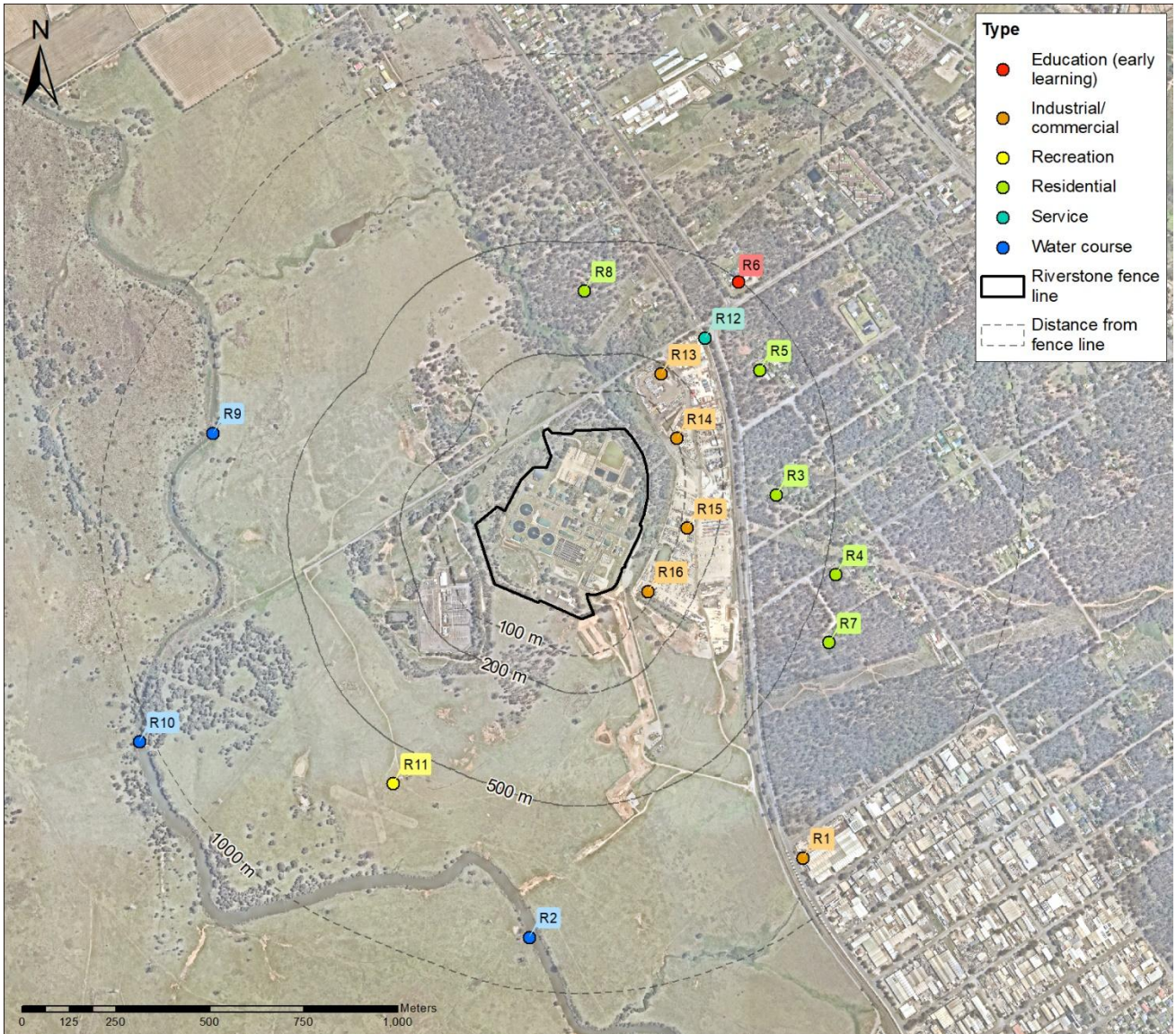
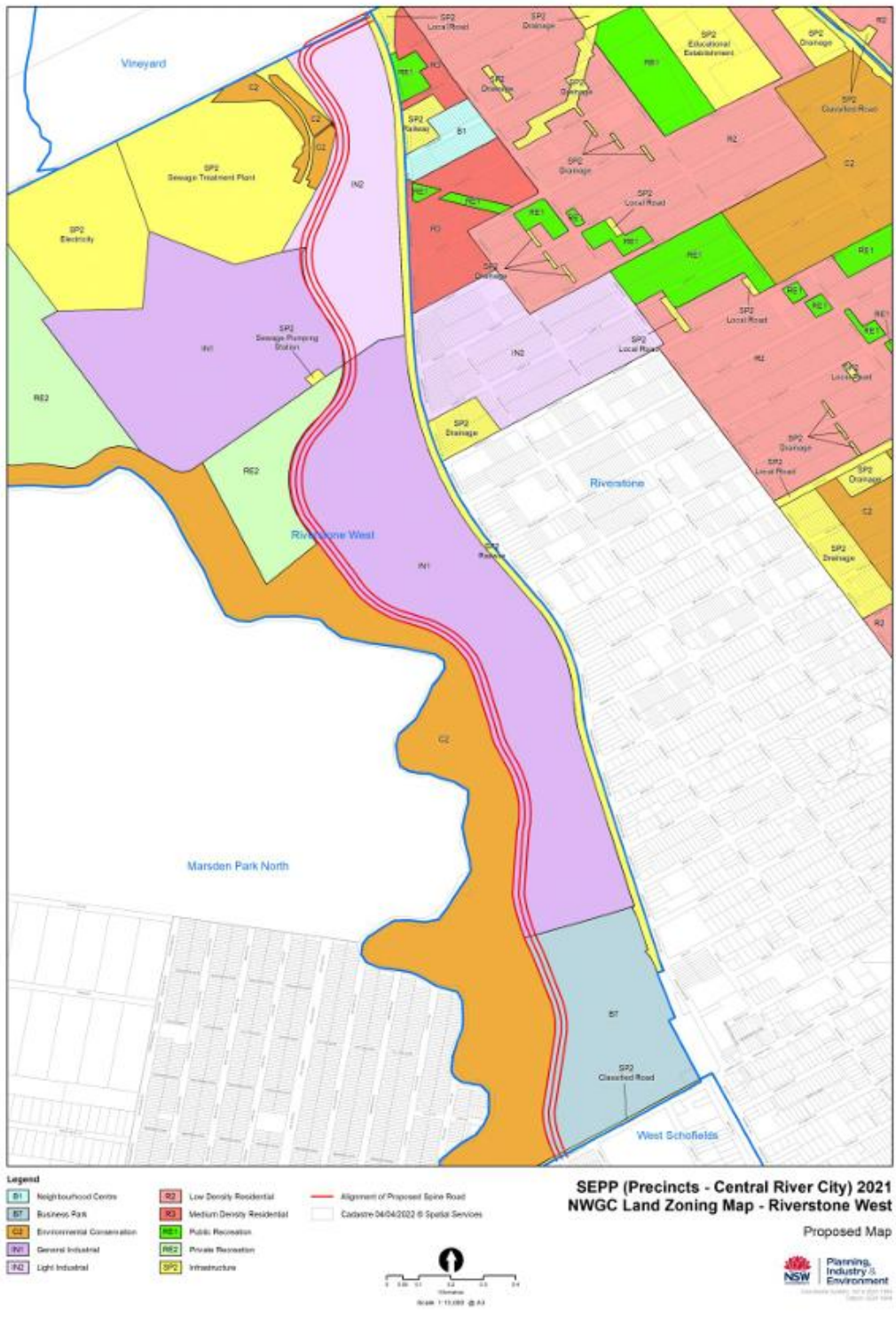


Figure 3.2 Discrete receptors identified in the vicinity of Riverstone WRRF

3.3 Land use zoning

The area surrounding Riverstone WRRF is currently neighbored by land use zoning IN1 (General Industrial) and IN2 (Light Industrial) according to the State Environmental Planning Policy (SEPP) (Precincts – Central River City, 2021) (Figure 3.3).



NSW Department of Planning and Environment

Figure 3.3 Current landuse zoning surrounding Riverstone according to the SEPP (Precincts – Central River City) 2021)

3.4 Climate and meteorology

Meteorological conditions are important for determining the direction and rate at which emissions from a source disperses. The key meteorological parameters for air dispersion are wind speed, wind direction, temperature, rainfall, and relative humidity. Historical meteorological data in the vicinity of the Project study area was reviewed in this section to demonstrate the existing local meteorological conditions.

Meteorological monitoring is not carried out at the plant, but the DPIE commenced operation of a meteorological station at Rouse Hill, 6 km to the southeast of the plant, in mid-2019. Based on the topography and proximity of this station to the plant, this station would be classified as “site-representative” under the *Approved Methods* terminology.

Table 3.2 summarises the climatology between 2019 and 2023 at Rouse Hill meteorological station.

Table 3.2 Summary statistics of the climate at Rouse Hill AQMS for 2019–2023 by season

Parameter	Units	Summer (DJF)	Autumn (MAM)	Winter (JJA)	Spring (SON)
Max. Temp	°C	29.6	24.7	19.0	25.8
Min. Temp	°C	18.0	12.3	4.7	11.9
RH (9am)	%	64.2	73.0	74.4	61.9
RH (3pm)	%	85.7	90.2	92.7	85.1
Monthly Rainfall	mm	68.8	35.0	16.6	38.2
Days of rain	#	4	4	3	4
Wind Speed	m/s	5.3	5.0	4.6	5.6

3.4.1 Temperature

Figure 3.4 presents the mean temperature at Rouse Hill over a year. The area is characterised by cool to mild winters and warm summers, typical for the Sydney region. The mean maximum temperature is around 29.6°C and 19°C for summer and winter, respectively.

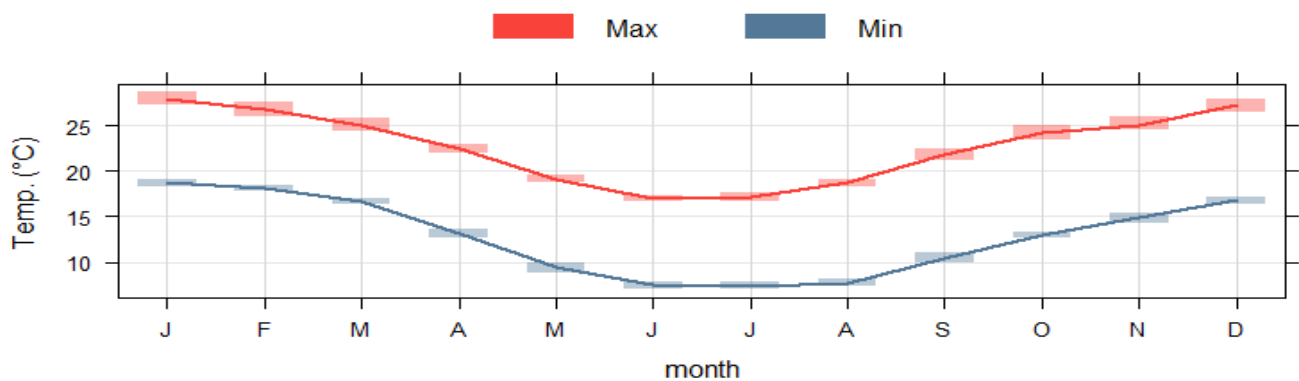


Figure 3.4 Mean monthly maximum and minimum temperature for 2019–2023 at Rouse Hill AQMS. The shaded bars indicate 95% confidence intervals.

3.4.2 Relative humidity

Figure 3.5 presents the mean monthly relative humidity (RH) at Rouse Hill and demonstrates the humid climate throughout the year, with the highest humidity observed in the Autumn months.

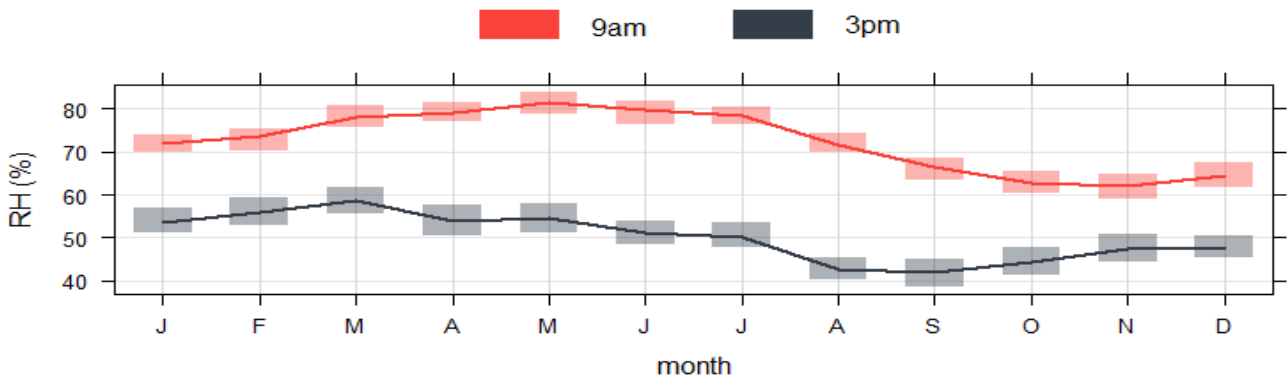


Figure 3.5 Mean monthly relative humidity for 2019–2023 at Rouse Hill AQMS. The shaded bars indicate 95% confidence intervals.

3.4.3 Precipitation

The mean monthly precipitation at Rouse Hill is presented in Figure 3.6. Typical of the region, the highest rainfall is during the summer to early spring. However, significant rain events are also observed during the winter period (Figure 3.7).

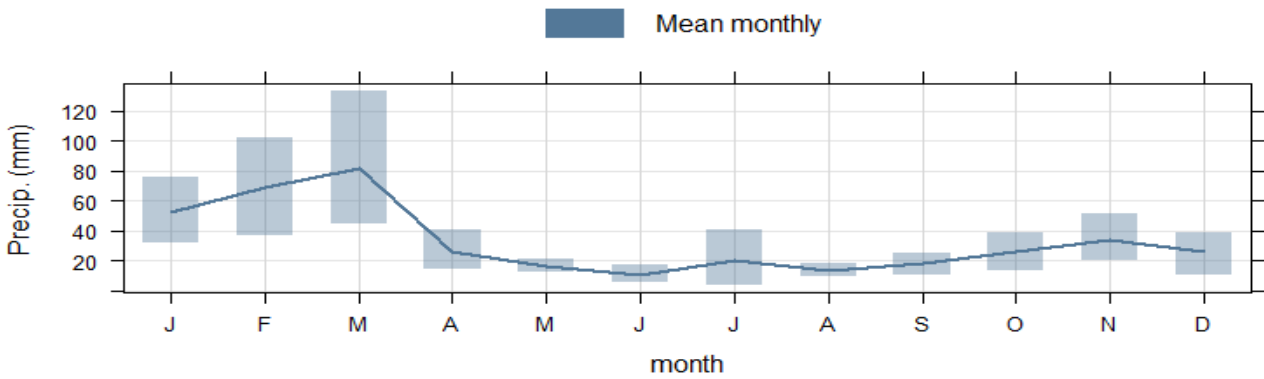


Figure 3.6 Mean monthly precipitation (mm) for 2019–2023 at Rouse Hill AQMS. The shaded bars indicate 95% confidence intervals.

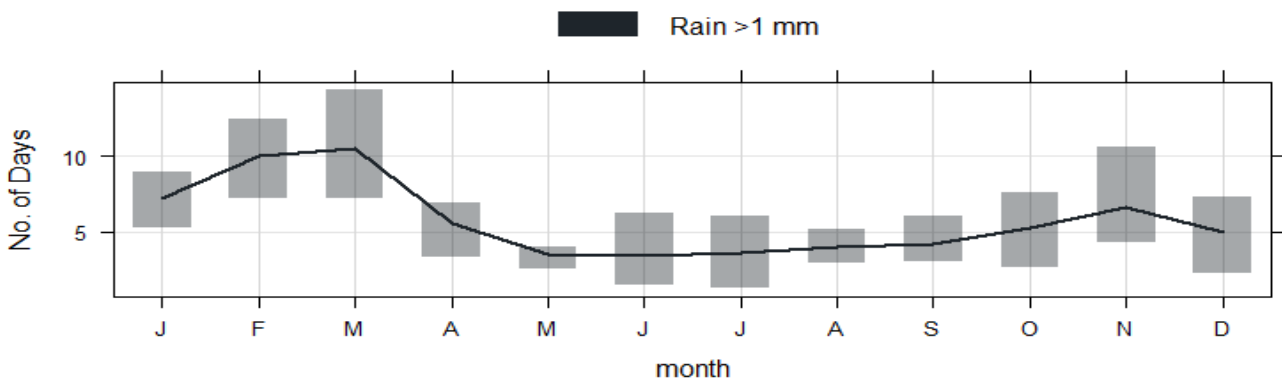


Figure 3.7 Mean number of days per month when rainfall was greater than 1 mm for 2019–2023 at Rouse Hill AQMS. The shaded bars indicate 95% confidence intervals.

3.4.4 Winds

Wind rose plots for each season between 2019 and 2023 are shown in for Rouse Hill. Figure 3.8 indicates that the predominant wind direction is from the north for all seasons. Figure 3.9 indicates lower wind speeds are typically observed in the winter and autumn. The highest wind speeds are observed from the southwest during spring and summer.

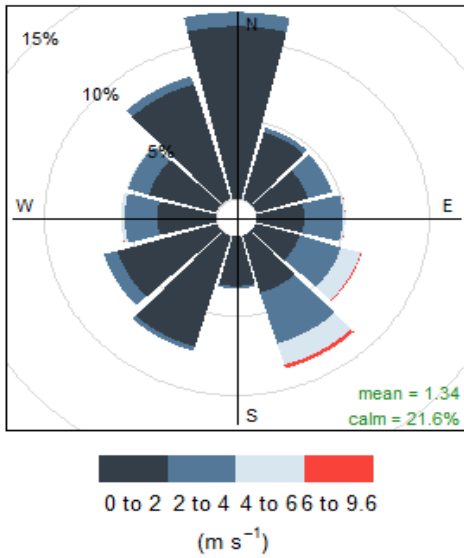


Figure 3.8 Annual average wind rose plot for 2019–2023 for Rouse Hill

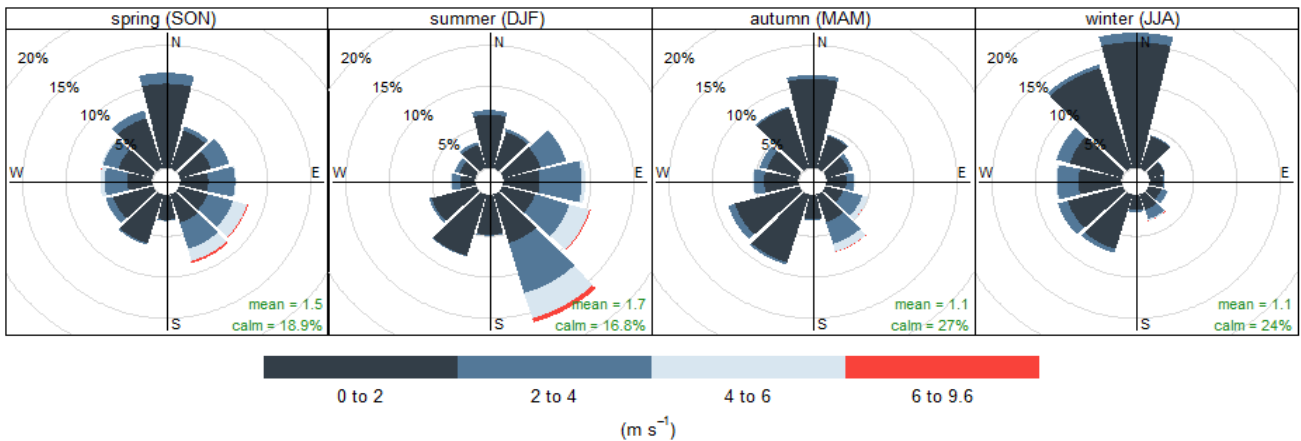


Figure 3.9 Seasonal average wind rose plot for 2019–2023 for Rouse Hill

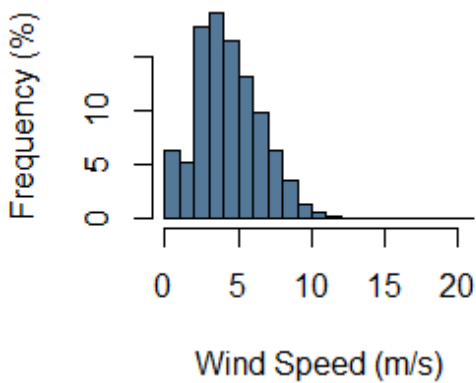


Figure 3.10 Histogram of wind speed frequencies at Rouse Hill during 2019–2023

3.5 Existing ambient air quality

3.5.1 Existing “baseline” REF scenario

The approved REF project conditions were previously assessed by Jacobs Group (Australia) Pty Ltd (Jacobs) (document reference: *IS373500_NWH_Riverstone_Air_Qaulity_Final_rev0*). This was considered the existing scenario and included the following sources of potential impacts to air quality (Table 3.3).

Table 3.3 Baseline scenario emission sources

Source	Ref.	Type	Area	Height	Stack tip diameter	Base elevation	Temperature	Velocity	Air flow	Odour concentration	Specific odour emissions rate	Total odour emissions rate
			m ²	m	m	m	K	m/s	m ³ /s	OU	OU.m ³ /m ² /s	OU.m ³ /s
Thickening Building Fan	TB_FAN	Point	-	8	0.5	28	293	5	0.98	300	-	295
Dewatering Building Fan	DB_FAN	Point	-	8	0.5	33	293	5	0.98	300	-	295
Flare 1 (existing)	-	Point	-	3	1.69	31	1073	0	0	4263	-	0
Digester heater	D_HTR	Point	-	6	0.5	30	1073	4.06	0.8	4263	-	929
OCU	OCU	Point	-	18	0.9	30	293	20.09	12.78	500	-	6389
Grit tank (covered)	G_TANK	Area	4	2.5	-	32	-	-	-	8893	3.43	15
Foul Water Lagoon	FW_LGN	Area	990	0	-	27	-	-	-	670	0.26	258
Foul Water Lagoon Overflow	FW_LGNO	Area	400	0	-	26	-	-	-	670	0.26	103
Biological reactor	BIO_R	Area	3750	3	-	32	-	-	-	754	0.5	1875
Secondary clarifier 1	SC_1	Area	1024	1	-	31	-	-	-	151	0.1	102
Secondary clarifier 2	SC_2	Area	1024	1	-	31	-	-	-	151	0.1	102
Secondary clarifier 3	SC_3	Area	1024	1	-	31	-	-	-	151	0.1	102

The Jacobs, 2022 report reviewed the existing environment and concluded.

“Operation of the existing plant has not caused adverse odour impacts in the local community based on historical records that have not revealed any complaints in the past 9 years.”

In the period of time between the Jacobs, 2022 report and this assessment no additional odour complaints have been received.

The results of the modelling exercise showed that the 2 OU contours did not encroach on any private sensitive receptors or residential areas in the baseline scenario (Figure 3.11).

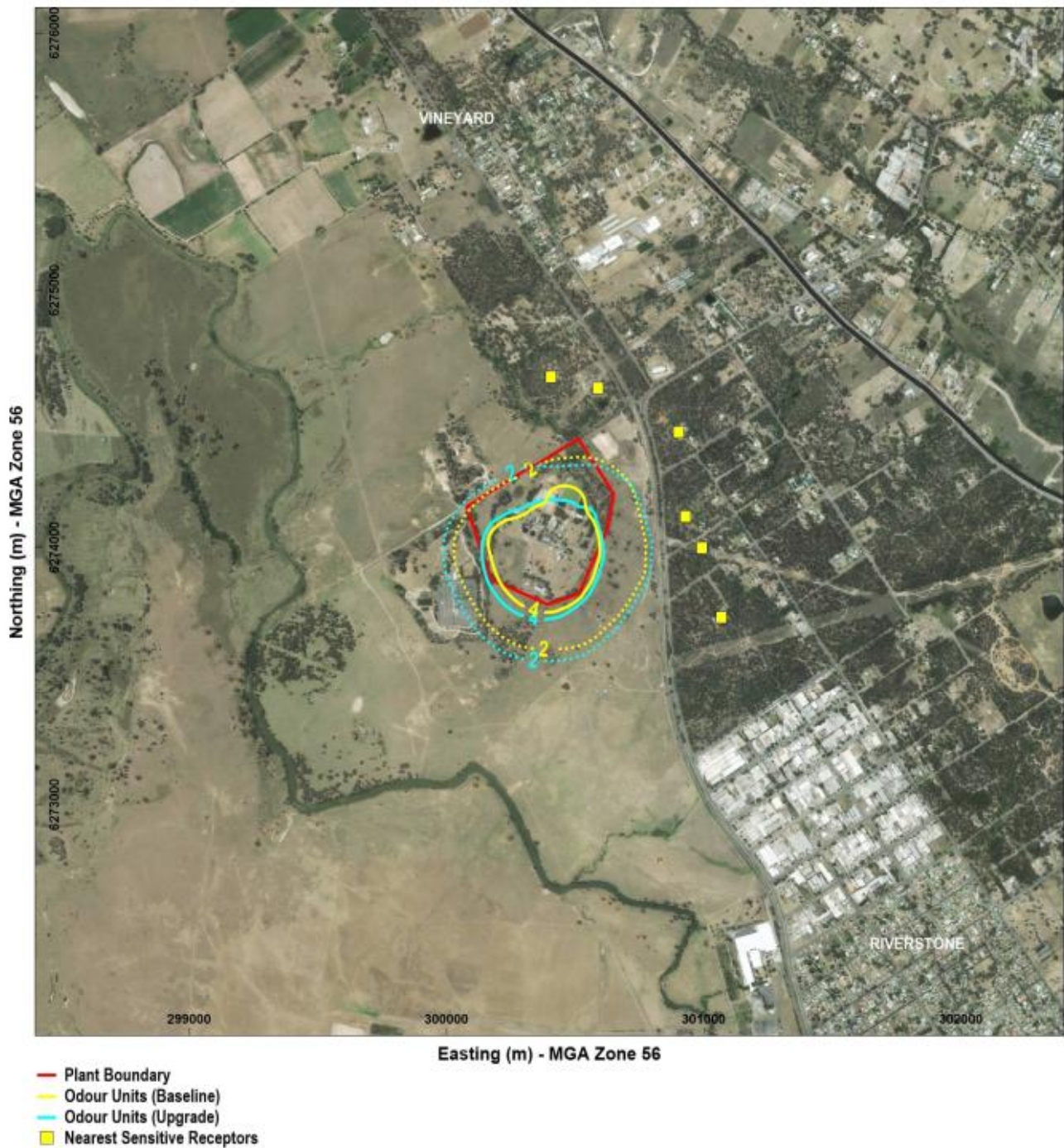


Figure 3.11 Baseline “existing” odour modelling results, from (Jacobs , 2022)

3.5.2 Background monitoring

The closest NSW air monitoring station with relevant air quality parameters is Rouse Hill, an urban station located approximately 6 km of the Project site. The Rouse Hill AQMS was commissioned in June 2019 and measures SO₂, NO₂, O₃, PM_{2.5}, and PM₁₀. Data for these parameters were obtained for 2019–2023 and analysed to assess the background air quality at the Project site. The results of this analysis are summarised in Table 3.4.

During 2019- 2023, no exceedances were observed in 1-hr average and annual NO₂, 1-hr and 24-hr average SO₂ and 1-hr and 8-hr average CO (See Figure 3.14, Figure 3.15, and Figure 3.17 for time series plots of 1-hr average NO₂, 1-hr average SO₂, and 8-hr average CO, respectively). There were exceedances observed for 8-hr average ozone, 24-hr average PM₁₀ and PM_{2.5} and annual PM₁₀ and PM_{2.5} at Rouse Hill AQMS, as listed in Table 3.5. Figure 3.12, Figure 3.13, and Figure 3.16 indicate that these exceedances were primarily observed during the summer of 2019-2020. NSW experienced an unusually extreme bushfire season, with several large bushfires in southern NSW, and these were the cause of the high air pollution during this period. A number of exceedances were also observed in 24-hr average PM_{2.5} during September 2023. According to the *NSW annual air quality statement 2023*, this was due to an exceptional event, namely hazard reduction burns, which resulted in poor air quality across Sydney. Therefore, regional sources (namely bushfires and hazard reduction burns) were significant cause of exceedances at Rouse Hill.

Table 3.4 Summary of measured maximum concentrations (µg/m³) at Rouse Hill by year from 2019 to 2023

Pollutant	SO ₂		NO ₂		O ₃	PM _{2.5}		PM ₁₀		CO ¹	
	1-hr	24-hr	1-hr	Annual	8-hr	24-hr	Annual	24-hr	Annual	1-hr	8-hr
Criteria	286	57	164	31	139	25	8	50	25	30	10
2019 ²	94	14	102	12	188	183	12.6	216	27.3	7.8	4.5
2020	54	13	70	10	155	62	7.0	220	18.3	15	2.4
2021	52	9.5	70	9.8	143	40	5.9	51	15.1	1.9	1.9
2022	60	11	68	10	114	15	4.6	24	11.8	1.1	0.8
2023	74	18	74	10	118	33	6.7	49	15.4	1.4	0.9

(1) Units are mg/m³

(2) The measurements began at Rouse Hill in June 2019

Table 3.5 Number of exceedances for PM₁₀, PM_{2.5}, and O₃ at Rouse Hill AQMS during 2019–2023

Pollutant	O ₃	PM _{2.5}	PM ₁₀
<i>Averaging period</i>	<i>8-hr</i>	<i>24-hr</i>	<i>24-hr</i>
Criteria	139	25	50
2019 ¹	43	24	24
2020	15	10	10
2021	5	4	1
2022	0	0	0
2023	0	5	0

(1) The measurements began at Rouse Hill in June 2019

3.5.2.1 Time series plots

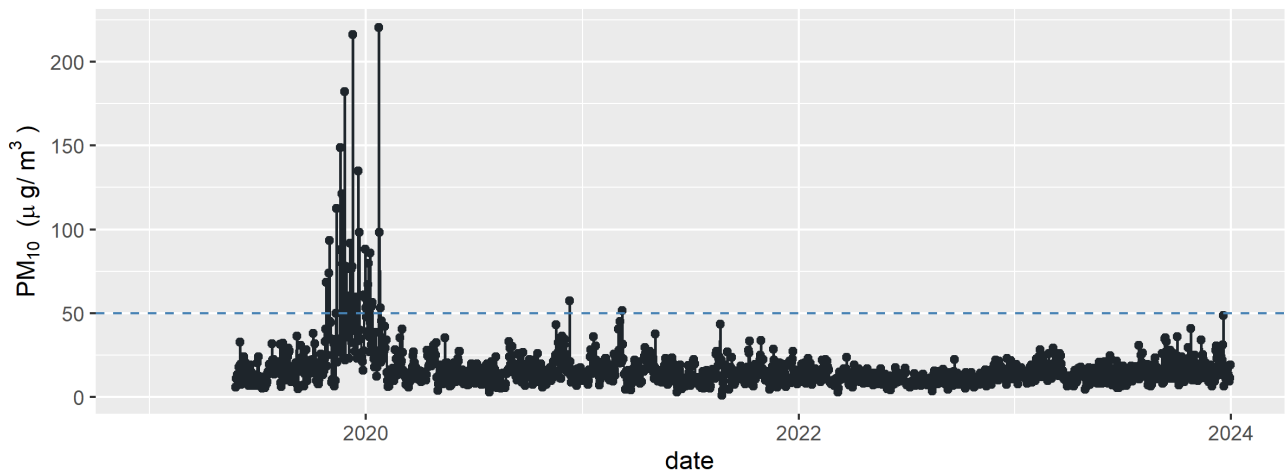


Figure 3.12 Time series of 24-hr average PM₁₀ mass concentrations at Rouse Hill AQMS from 2019–2023. The dashed line indicates the 24-hr average standard (50 µg/m³).

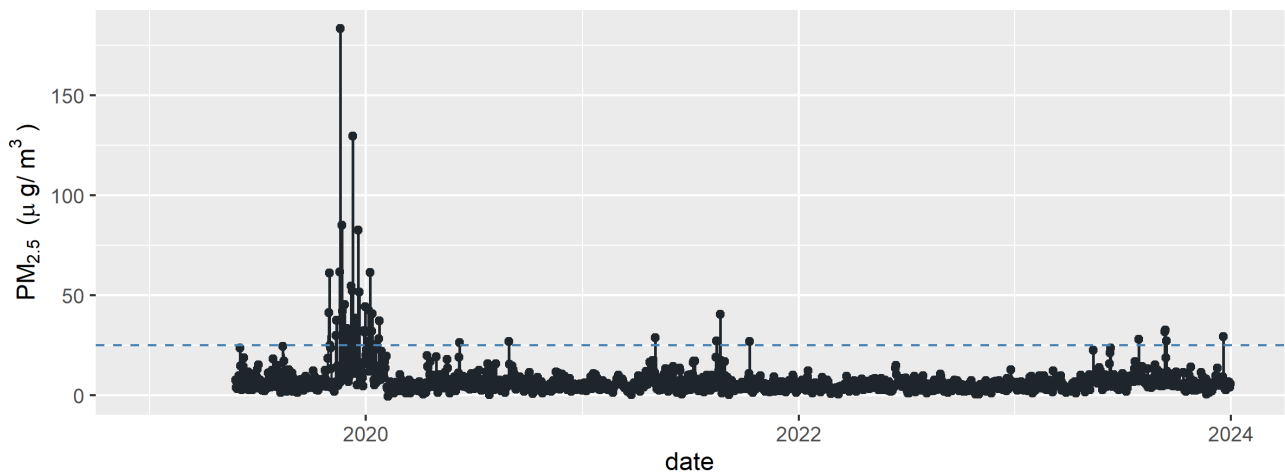


Figure 3.13 Time series of 24-hr average PM_{2.5} mass concentrations at Rouse Hill AQMS from 2019–2023. The dashed line indicates the 24-hr average standard (25 µg/m³).

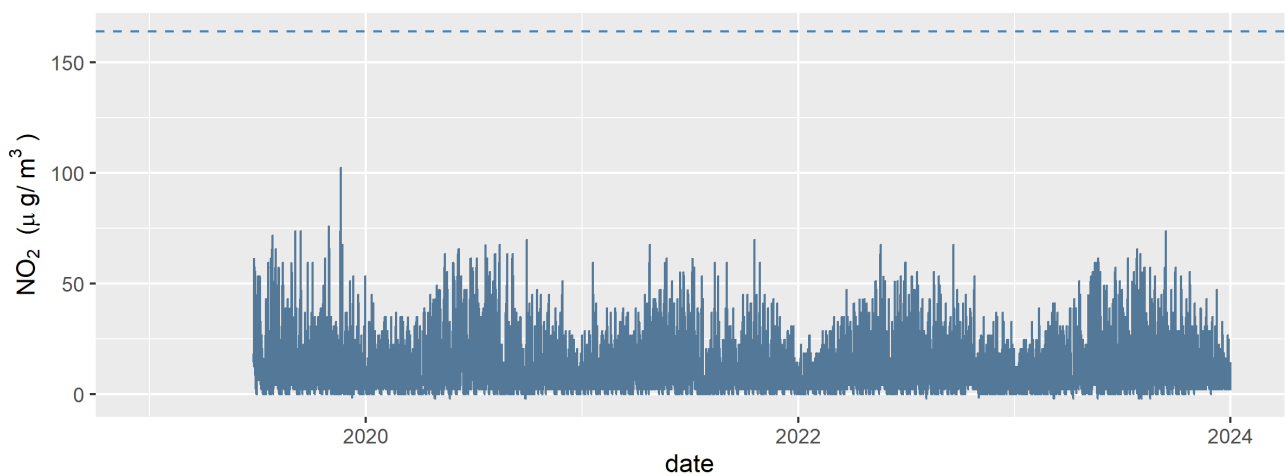


Figure 3.14 Time series of 1-hour average NO₂ concentration at Rouse Hill AQMS. The dashed line indicates the 1-hr average standard (164 µg/m³).

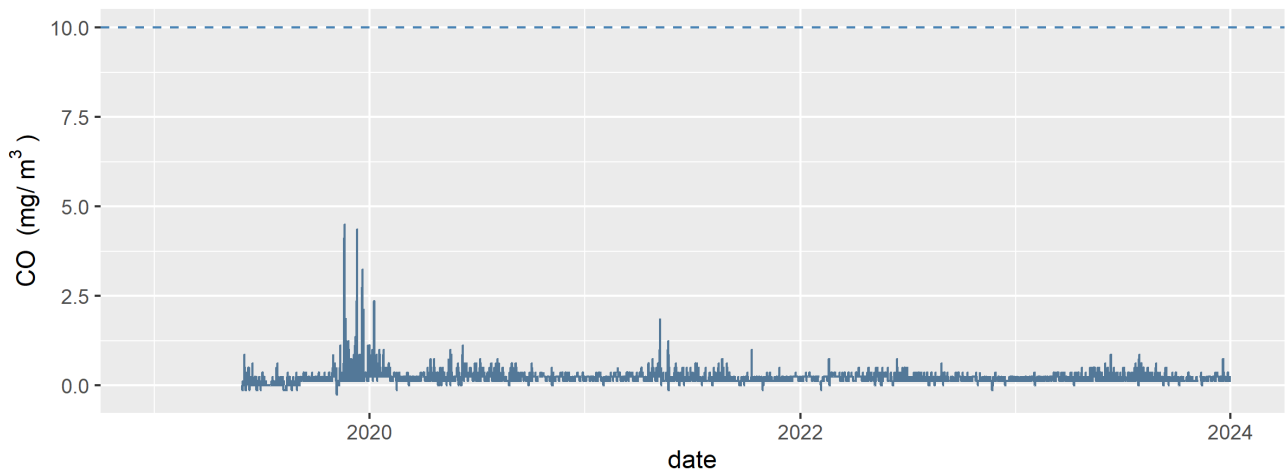


Figure 3.15 Time series of 8-hr CO concentration at Rouse Hill AQMS. The dashed line indicates the 8-hr average standard ($10 \mu\text{g}/\text{m}^3$).

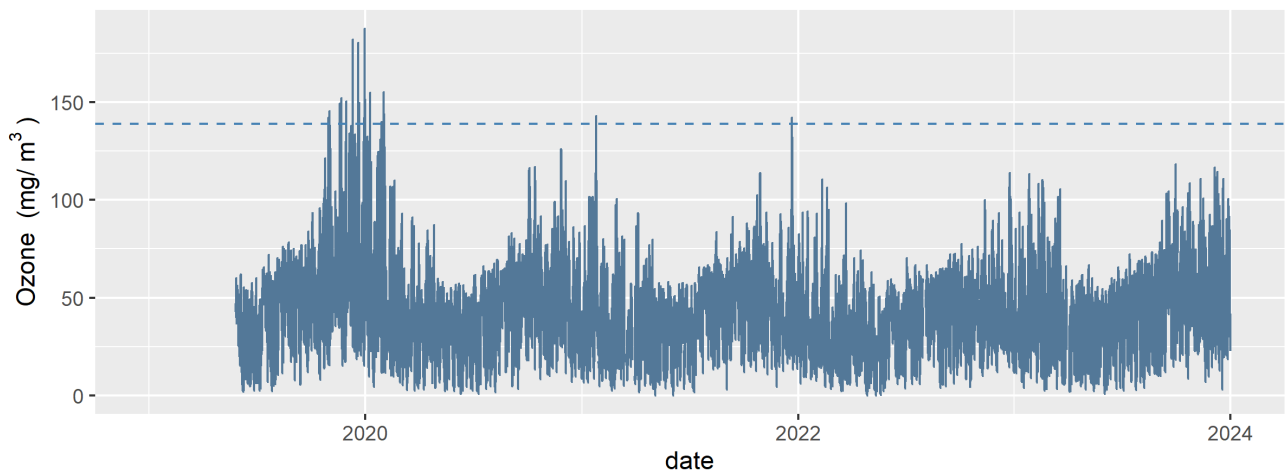


Figure 3.16 Time series of 8-hr rolling average O_3 concentration at Rouse Hill AQMS. The dashed line indicates the 8-hr average standard ($139 \mu\text{g}/\text{m}^3$).

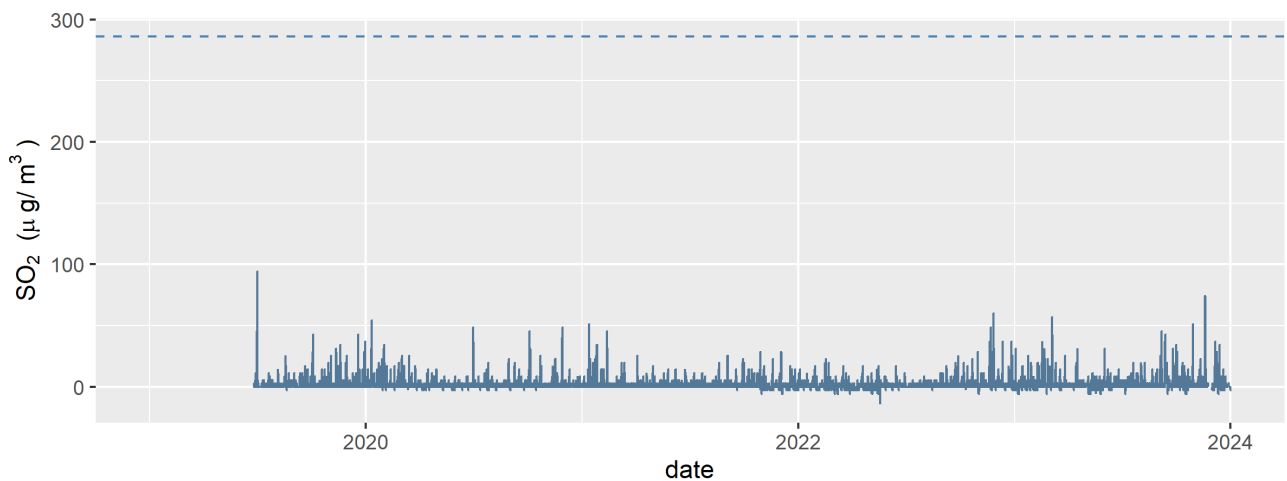


Figure 3.17 Time series of 1-hr rolling average SO_2 concentration at Rouse Hill AQMS. The dashed line indicates the 1-hr average standard ($286 \mu\text{g}/\text{m}^3$).

3.5.3 Background values used in assessment

The maximum measurements for key criteria pollutants from between 2019–2023 at Rouse Hill AQMS (Table 3.4) were assessed to determine suitable background values for the assessment. As NSW experienced an unusually severe bushfire season in the summer of 2019/2020 that resulted in a number of exceedances of NO₂, PM₁₀, and PM_{2.5}, this period was excluded as it was deemed to not be representative of typical background. For completeness, however, this period is included in the Level 2 contemporaneous assessment presented in Section 7.3.

The applied background levels used in the AQIA are summarised in Table 3.6.

Table 3.6 Applied background levels in the AQIA for key criteria pollutants

Pollutant	Averaging Period	Criteria (µg/m ³)	Max conc. (µg/m ³)
SO ₂	1-hour	286	74
	24-hour	57	18
NO ₂	1 hour	164	74
	Annual	31	10
Ozone	8-hour	139	143
PM ₁₀	24-hour	50	51
	Annual	25	15.4
PM _{2.5}	24-hour	25	40.5
	Annual	8	6.7
CO	1-hour	30,000	1875
	8-hour	10,000	1875

4 Emissions inventory

The emissions inventory describes the process, sources of air emissions associated with different parts of the process, available emissions control technologies, supplier emissions data and emissions data from comparable example facilities. As the project involves developing an emerging technology yet to be well established in Australia, Appendix A describes in further detail the carbonisation process and the selection process for estimating air emissions for the AQIA. The selection process included using what is expected to be conservative estimations of emissions for each pollutant of concern from the following information sources:

- 1 Data available from the site operations for known equipment; and
- 2 For new equipment (dryer and carboniser):
 - a Data from suppliers of the equipment being proposed
 - b Data from the REF
 - c Data from similar projects (Loganholme demonstration plant, QLD)
 - d POEO limits
 - e Licence emissions limits from similar projects (Loganholme demonstration plant, QLD).

The following emissions inventory section summarises the process overview, emissions control technology and the estimated emissions utilised in the AQIA.

The Riverstone WRRF sources modelled under the peak operational loading scenario are shown in Figure 4.1. These include:

- The new sources associated with the carbonisation process:
 - carbonisation exhaust stacks: GAS1 and GAS2 (GAS2 is a standby unit that isn't operated at the same time as GAS1)
 - gas heaters: GH1, GH2, and GH3 (GH3 is a standby unit that isn't operated at the same time as GH1 and GH2)
- The existing odour emissions sources, as per (Jacobs , 2022):
 - thickening building fan: TBFAN
 - dewatering building fan: DBFAN
 - odour control unit: OCU
 - biological reactor: BIOR
 - three secondary clarifiers: SC1, SC2, and SC3.
- Additional odour sources associated with the Stage 2 extension:
 - Bioreactors (BNR) and membrane bioreactors (MBR): BIOR2

Air pollutant emissions associated with the new carbonisation process are described in Section 4.1 and odour emissions for existing sources and new carbonisation process are described in Section 4.2.

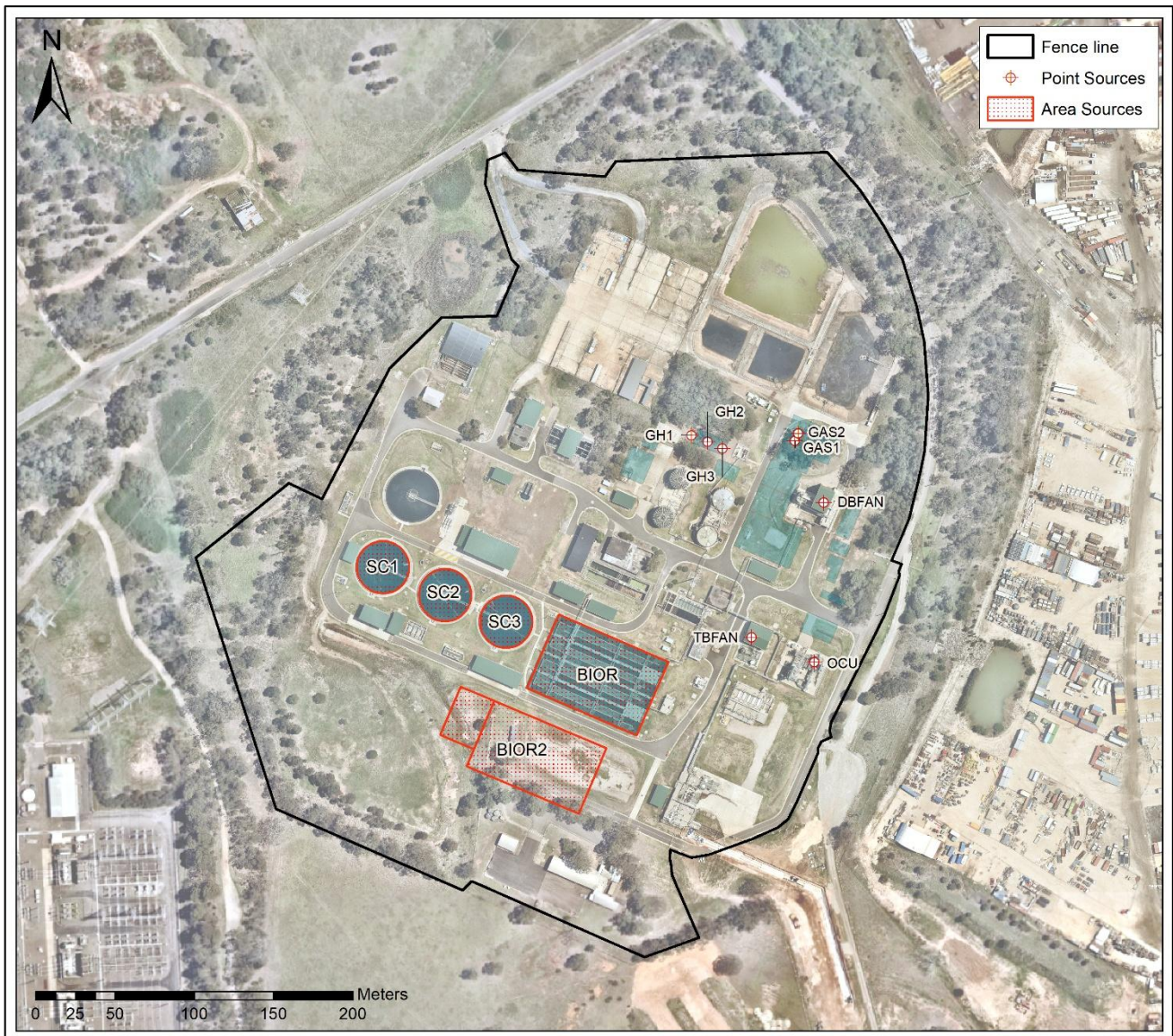


Figure 4.1 Riverstone WRRF emissions sources assessed

4.1 Carbonisation process air pollutant emissions

As discussed in Section 0, the revisions to the Riverstone WRRF include a new carbonisation plant and associated infrastructure including drying, heating and carbonisation systems.

4.1.1 Process overview

Currently, biosolids at Riverstone are anaerobically digested and dewatered to around 23 w/w% solids for beneficial reuse offsite.

Carbonisation of biosolids in an integrated process that produces biochar. Biosolids for processing in carbonisation are a blend of waste activated sludge (WAS) and digested primary sludge. Biochar is a more stable product that is desirable due to the significantly reduced volume and lower level of contaminants of concern. For efficient carbonisation, it is a requirement to dry biosolids in a thermal dryer to approximately 90 w/w%. In drying, biosolids are extruded onto a conveyer belt and hot air is blown over them to evaporate water.

The dried biosolids are fed to a carboniser reactor where biosolids are heated to 650°C in a low oxygen environment. In these conditions, the volatile organic fraction in the biosolids (approximately 50%) becomes gaseous and is refined by partial oxidation and reforming reactions to produce a syngas. The solids that remain after carbonisation are called biochar at around 70-80%DS containing significantly lower organic contaminants than the dried biosolids feed product.

Syngas from carbonisation is treated at high temperatures in a thermal oxidiser, where heat is recovered from the exhaust gas of the oxidiser. This heat is exchanged to a hot water loop, which heats the air used in the dryer. Supplementary heat for the dryer is provided by a gas water heater if required. Figure 4.2 provides an overview of the process flow for the carbonisation process.

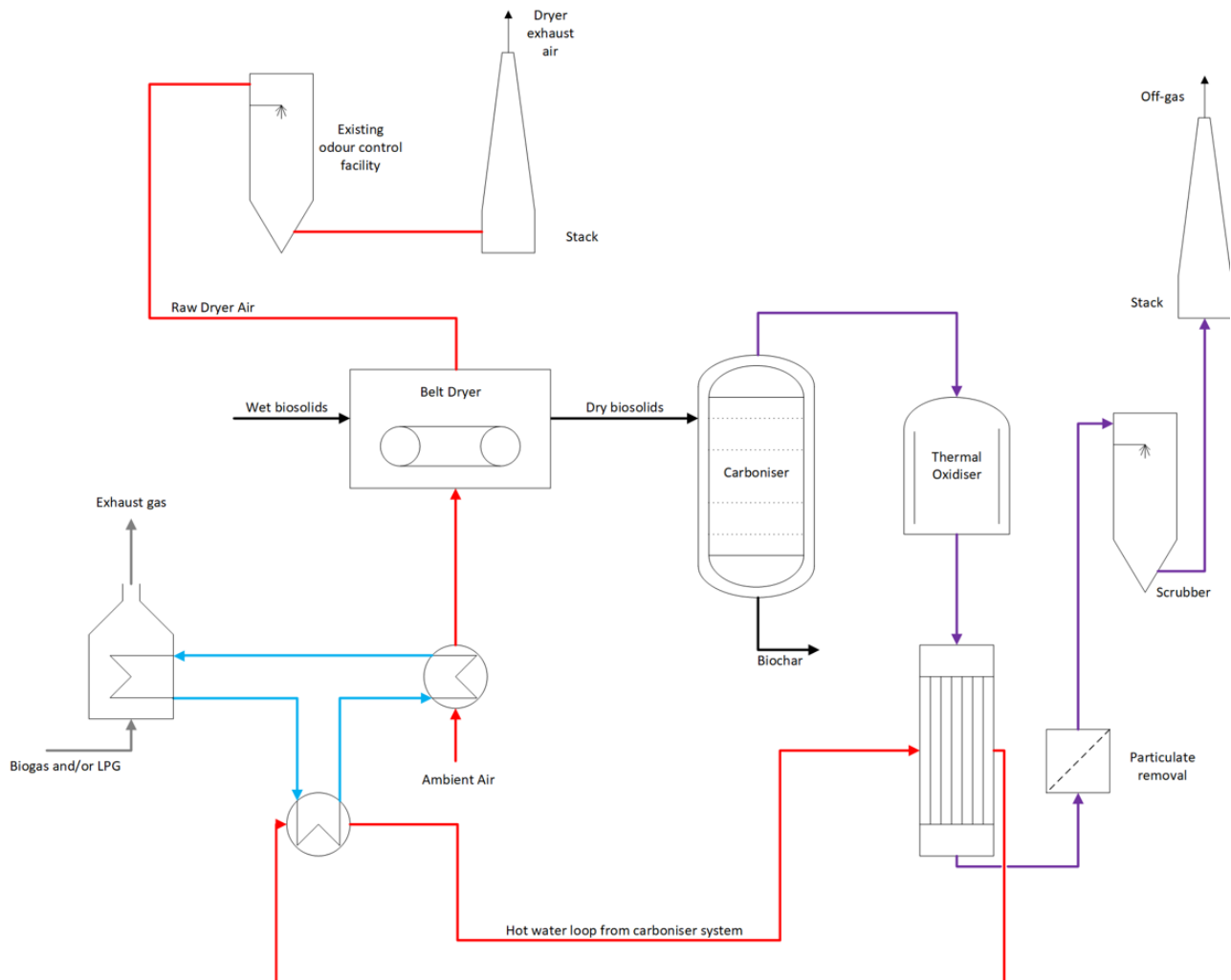


Figure 4.2 Process flow diagram of the dryer integrated with the carbonisation process, including generalised air treatment steps.

Air pollution emission sources associated with the new Riverstone WRRF carbonisation plant are summarised as follows:

- Carboniser emissions through two stacks consisting of:
 - Carboniser 1
 - Carboniser 2 (standby unit)
- Dryer emissions, which will be routed to the odour treatment unit (OCU) (see section 4.1.5.1)
- Gas heater emissions from:
 - Gas heater 1

- Gas heater 2
- Gas heater 3 (standby unit).

An emissions inventory representative of a peak operational loading scenario has been developed for each of the above identified sources. Table 4.1 provides a summary of the identified air pollutants that are associated with each of the identified sources. Stack release parameters for each source are provided in Table 4.2.

The carbonisers 1 and 2 will be operated in a duty and standby arrangement, with only one carboniser operating at any time. Therefore, to assess the realistic potential operational impacts, emissions from a single carboniser have been included in the emissions inventory. Similarly, gas heaters 1, 2 and 3 will be operated in a two duty and one standby arrangement with a maximum of two gas heaters operating at any time. Therefore, to assess the realistic potential operational impacts, emissions from two gas heaters have been included in the emissions inventory.

Table 4.1 Pollutants emitted from each source

Pollutant	Carboniser 1	Gas heater 1	Gas heater 2
Nitrogen dioxide (NO ₂)	Yes	Yes	Yes
Sulphur dioxide (SO ₂)	Yes	Yes	Yes
Total Suspended Particulates (TSP)	Yes	Yes	Yes
PM ₁₀	Yes	Yes	Yes
PM _{2.5}	Yes	Yes	Yes
Carbon monoxide (CO)	Yes	Yes	Yes
Lead	Yes	Yes	Yes
Arsenic	Yes	Yes	Yes
Chromium VI	Yes	Yes	Yes
Nickel	Yes	Yes	Yes
Selenium	Yes	Yes	Yes
Zinc	Yes	Yes	Yes
Copper	Yes	Yes	Yes
Cadmium	Yes	Yes	Yes
Mercury	Yes	Yes	Yes
Dioxins and furan	Yes	Yes	Yes
Hydrogen fluoride	Yes	No	No
Polycyclic aromatic hydrocarbon (as benzo[a]pyrene)	Yes	Yes	Yes
Hydrogen chloride	Yes	No	No
PFAS	Yes	No	No
Hydrogen sulphide	Yes	No	No

Table 4.2 Stack source release parameters

Source	Units	Carboniser 1	Gas heater 1	Gas heater 2
Release Type		Point	Point	Point
Stack Height	m	19.8	7	7
Exit Temp	°C	70	170	170
Exit Diameter	m	0.35	0.4	0.4
Exit Velocity	m/s	7.9	5.2	5.2
Oxygen Content	%	4	3	3
Moisture Content	%	31	27	27
Flow Rate Actual	Am ³ /s	0.759	0.654	0.654
Flow Rate Normalised. dry	Nm ³ /s	0.417	0.294	0.294

4.1.2 Carboniser emissions

To conservatively estimate potential emissions from the two Riverstone WRRF carboniser stacks, the following applicable emissions information sources has been considered:

- POEO group 6 concentration standards for Afterburners and other thermal treatment plant, excluding flares
- An example carbonisation facility in Loganholme Queensland. Emissions information associated with the Loganholme facility include:
 - the DESI License emissions limits for the Loganholme facility
 - emissions data from the demonstration plant
 - Representative emissions data from the full-scale version of the plant
- Potential equipment supplier data from Supplier A
- Potential equipment supplier data from Supplier B
- Metals composition of existing Riverstone WRRF sludge based on sampling conducted in November 2023.

Metals composition from the Riverstone WRRF sludge sampling is provided in Table 4.3.

Table 4.3 Estimated metals composition

Metal	November 2023 sludge sample average (µg/kg solid)	Percent composition	Grouped heavy metals emission concentration (mg/Nm ³)	Individual metals emission concentration (mg/Nm ³)
Lead	14.4	16%	0.3	0.049
Arsenic	2.6	3%		0.009
Chromium	31.7	36%		0.109
Nickel	28.7	33%		0.099
Selenium	10	11%		0.034
TOTAL	87.4	100%	-	0.300

^A average of 10 assumed to be half the LOR of <20 µg/kg).

Modelled emissions rates for each of the two carboniser stacks are presented in Table 4.4. The emissions estimates are based on stack parameters in Table 4.2, emissions estimates and the metals composition in Table 4.3.

Table 4.4 Stack emission – Carboniser 1

Pollutant	Emission Rate	Emission Concentration at stack ^A O ₂	Emission Concentration at reference 7% O ₂	Regulation Emission limit at 7% O ₂
units	g/s	mg/Nm ³	mg/Nm ³	mg/Nm ³
Nitrogen dioxide (NO ₂)	0.18	426	350	350
Sulphur dioxide (SO ₂)	0.15	365	300	1000
Total Suspended Particulates (TSP)	0.025	61	50	50
PM ₁₀	0.015	36	30	-
PM _{2.5}	0.010	24	20	-
Carbon monoxide (CO)	0.063	152	125	125
Lead	0.000025	0.06	0.049	1
Arsenic	0.000005	0.01	0.009	
Chromium VI	0.000055	0.13	0.109	
Nickel	0.000050	0.12	0.099	
Selenium	0.000017	0.04	0.034	
Zinc	0.000051	0.12	0.10	-
Copper	0.000025	0.06	0.05	-
Cadmium	0.000051	0.12	0.100	0.2
Mercury	0.000051	0.12	0.100	0.2
Dioxins and furans	5.07E-11	1.22E-07	1.00E-07	0.0001
Hydrogen fluoride	0.000507	1.22	1.0	-
Polycyclic aromatic hydrocarbon (as benzo[a]pyrene)	3.04E-06	0.01	6.00E-03	-
Hydrogen chloride	0.005066	12.16	10.0	100
PFAS	1.01E-07	2.43E-04	2.00E-04	-
Hydrogen sulphide	0.000608	1.46	1.2	-

A – Refer to Table 4.2 for stack conditions

The emission concentrations in Table 4.3 and Table 4.4 were based off a variety of information including supplier data and a theoretical mass balance. The emission concentrations for each model input were carefully considered in the modelling process. A summary of the selection process for justifying each model input is provided in Table 4.5.

Table 4.5 Summary of model input values for the carboniser emissions and the justification behind their selection

Pollutant	Clean Air Regulation Group 6 limit (7% O ₂)	Model input value	Justification
	mg/Nm ³	mg/Nm ³	
Products of combustion			
NO _x	350	350	Data available from operating plants indicates that emissions will be below the Group 6 limit. A lower level was not adopted as operation at lower temperature to achieve lower NO _x may impede heat recovery or removal of other compounds.
SO _x	1000	300	All data was well below the Group 6 limit due to effective caustic scrubbing. Data elsewhere is considered representative of the data with some margin for higher sulphur in Riverstone biosolids.
CO	125	125	The data from suppliers shows that equipment could be engineered to lower CO emissions below the limit. The Group 6 limit was adopted to reflect some uncertainty on equipment performance for CO.
Particulates			
TSP	50	50	This input was based on data from suppliers with consideration to the type of air filtration technology used. Some data from existing plants indicates levels up to 50 mg/Nm ³ , although with additional measures this is expected to be lower. This value is adopted for a conservative assumption in air emissions modelling to assess maximum potential impact.
PM ₁₀		30	
PM _{2.5}		20	
Metals			
Lead	1	0.3	Theoretical calculations were used for determining this value based on the metal content of biosolids and volatility to the gas phase. This was verified with data.
Arsenic			
Chromium			
Nickel			
Selenium			
Zinc	-	0.1	Theoretical calculations were used for determining this value based on the metal content of biosolids and volatility to the gas phase. This was verified with limited data.
Copper	-	0.05	Theoretical calculations were used for determining this value based on the metal content of biosolids and volatility to the gas phase. This was verified with limited data.
Cadmium	0.2	0.1	Theoretical calculations were used for determining this value based on the metal content of biosolids and volatility to the gas phase. This was verified with limited data.

Pollutant	Clean Air Regulation Group 6 limit (7% O ₂)	Model input value	Justification
	mg/Nm ³	mg/Nm ³	
Mercury	0.2	0.1	Mercury is expected to be sufficiently removed in the scrubber and activated carbon. Available data shows this emission concentration is achievable.
Other Principal Toxic Compounds			
PCDD (dioxins)	0.0000001	1x10 ⁻⁷	Suppliers advised PCDD/F emissions aren't likely due to lack of chlorine and unburnt carbon. Data also shows emissions are at limit of detection (LOD) and below the Clean Air Regulation Group 6 limit.
PCDF (furans)	0.0000001	1x10 ⁻⁷	
PAH (b[a]p)	-	0.006	The limited data available on PAH showed the technology achieved low levels of emissions, so this was used as a basis for the model.
Other Contaminants of Concern			
PFAS	-	0.0002	Current research shows PFAS destruction is high in thermal oxidiser, theoretically this value simulates 98.5% PFAS destruction which is achievable.
total fluoride (as HF)	50	1	All data showed HF levels were well below the limit. HF isn't a significant pollutant in this process but it will still be removed in the scrubbing stage. Data from a demonstration plant was used as a benchmark.
Hydrogen chloride	100	10	This input value is representative of the emission data for HCl which is consistently low across all plants as a result of high efficiency removal in the caustic scrubber.
H ₂ S	5	1.2	Reporting on H ₂ S was limited, although data from a demonstration plant indicates low production/high degree of removal in scrubber.
Odour	-	1000	Expected to vary substantially and limited data available. Evidence of odour emission rates in the order of 1000OU with an outlier of 3000OU from a demonstration plant, but this is likely due to limited use of gas treatment technologies.

4.1.3 *Dryer emissions*

The plant will have a single dryer and will be routed to the existing Odour Control Unit (OCU) for dryer exhaust scrubbing. This process is further discussed in Section 4.1.5.1.

4.1.4 *Heater emissions*

Modelled emissions rates for each of the three gas heater stacks are presented in Table 4.6. The emissions estimates are based on stack parameters in Table 4.2, and comparable emissions factors in NPI EETM Combustion in Boilers Manual. The emissions factors are from Table 21 in the manual and are for the combustion of natural gas. The Riverstone WRRF gas heaters are expected to have a fuel consumption rate of approximately 69 kg of LPG per hour, which equates to approximately 3 Gigajoules (Gj) per hour.

Table 4.6 Stack emission concentrations – Gas Heaters 1, 2, and 3

Pollutant	NPI emission factor	Emission state	Emission concentration (Stack O ₂)
units	(kg/Gj)	g/s	mg/Nm ³
Nitrogen dioxide (NO ₂)	4.86E-02	0.0415	12.2
Sulphur dioxide (SO ₂)	5.37E-04	0.0005	0.1
Total Suspended Particulates (TSP)	3.60E-03	0.0031	0.9
PM ₁₀	3.60E-03	0.0031	0.9
PM _{2.5}	3.60E-03	0.0031	0.9
Carbon monoxide (CO)	4.10E-02	0.035	10.3
Lead	2.43E-07	2.07E-07	6.09E-05
Arsenic	9.74E-08	8.31E-08	2.44E-05
Chromium VI	6.82E-07	5.82E-07	1.71E-04
Nickel	1.02E-06	8.70E-07	2.56E-04
Selenium	1.15E-08	9.81E-09	2.88E-06
Zinc	1.40E-05	1.19E-05	3.50E-03
Copper	4.14E-07	3.53E-07	1.04E-04
Cadmium	5.36E-07	4.57E-07	1.34E-04
Mercury	1.26E-07	1.08E-07	3.18E-05
Dioxins and furans	2.41E-12	2.06E-12	6.06E-10
Polycyclic aromatic hydrocarbon (as benzo[a]pyrene)	3.11E-07	2.65E-07	7.79E-05

4.1.5 Emissions control technology

All estimated source emissions data presented in Table 4.4 and Table 4.5 are based on utilising reasonable and feasible control technology discussed the following sections.

4.1.5.1 Dryer Unit

Dryer exhaust emissions will be routed to the existing odour control unit (OCU) after passing through a condenser module that will remove dust generated by the drying process. The condenser module operates with hydrogen peroxide and sodium hydroxide dosing which will provide chemical treatment of the air prior to the biological and physical removal stages of the OCU. The existing OCU consists of bio-trickling filters followed by activated carbon filters and was constructed with additional capacity for future expansions. The additional airflow and concentrations associated with the dryer exhaust have been assessed to fall within the design loading of the OCU. The original supplier has advised the OCU is suitable for treating this combination of wastewater and dryer exhaust. The design outlet concentrations of the OCU are below the Group 6 standards of concentration for gas emissions in the POEO (POEO Clean air Regulation, 2022).

4.1.5.2 Carboniser Unit

The plant is designed for two carboniser units to operate in a duty and standby arrangement in the process train. The carboniser is planned to have one stack on each carboniser unit, but depending on the supplier it might have a single stack for both units. The carboniser can be heated in the range of 500-800°C, with typical operation at around 650°C. By controlling the oxygen levels inside the reactor at this temperature, the volatile organic fraction of the biosolids is converted to syngas. The gas produced is sent to a thermal oxidiser that reaches 980°C with specially designed NO_x control technology. After oxidation, the gas is treated as follows:

- Wet scrubber
- Particulate removal with a combination of (depending on supplier):
 - Filters
 - Wet Electrostatic precipitator (WSP); and/or
 - Activated carbon filter.

The process gas is fed into the thermal oxidiser where it is combusted at 950–980°C for the required time in a controlled stoichiometric level of air to ensure complete combustion. In this step, all volatile organic compounds are combusted in conditions that favour minimal CO and NO_x formation. The two main ways to minimise NO_x formation is with (1) flue gas recirculation to manage the temperature within the right band (flameless combustion) or (2) selective non-catalytic reduction (SNCR) by dosing the gas stream with urea to convert it to N₂. The limited PCDD/F that forms in the carboniser will be destroyed at the higher temperature of the oxidiser. Additionally, the highly fluorinated PFAS are mainly broken down to produce hydrofluoric acid (HF).

The exhaust gas is then sent to a heat exchanger to recover excess heat. The heat exchanger extracts usable heat for the dryer, which cools the gas to around 200°C.

Inorganic pollutants are removed from the flue gas in a packed-bed wet scrubber. The gas stream is sprayed with an alkaline solution to remove acidic species from the gas, namely HCl, HF, H₂S, and SO_x. These acidic compounds are neutralised by the alkaline solution and either precipitate or are solubilised and removed in the liquid stream. Metal impurities also precipitate as metal hydroxides or salts and be captured in the liquid stream. Particulates captured in the liquid stream are returned to the process in the liquid returns, which are in small volumes and are not expected to cause adverse effect on the treatment plant operation.

Suppliers offer different options for particulate removal from the process gas as a final treatment step to ensure emission requirements for particulates and metals are achieved. These include physical separation processes such as using a ceramic hot gas filter or bag filter in the process train. Alternatively, a wet Electrostatic precipitator can be used to capture fine particulates on the backend of the gas stream (supplier dependent). This works by electrically charging particulate matter and capturing them on an oppositely charged surface.

As discussed in Section 2.2.2 of this assessment, Section 69 of the Clean Air Regulation specifies emissions control design requirements for residence time, temperature and destruction efficiency. Discussion on where technical design considerations for residence time, temperature and destruction efficiency are considered reasonable and feasible for the proposed carbonisation process is provided below. Specifically, a residence time of less than 2 seconds is shown through supplier backed research to not be reasonably required, as a residence time of 0.7 seconds when coupled with the designed turbulence and temperature in the combustion chamber can achieve the same level of contaminant destruction as the intent of the blanket 2-second requirement rule. Additionally, due to low inlet pollutant concentrations, a destruction efficiency of 99.99999% is not considered feasible for the process.

Residence Time Requirement

A residence time of over 2 seconds is the default requirement of the Clean Air Regulation for afterburners. This is to allow sufficient reaction time for full oxidation and complete combustion of the gas.

Suppliers have concerns around meeting this residence time in their proposed carbonisation system and moreover are confident that outcomes in terms of emissions can be achieved at a lower residence time. Appendix B outlines the ability to minimise emissions without meeting the afterburner residence time. This claim is backed by the supplier and has been proved across the many plants the operate in worldwide.

Temperature Requirement

The Clean Air Regulation states that a combustion temperature $>980^{\circ}\text{C}$ is required for afterburners as a default requirement. Suppliers can achieve this temperature for the thermal oxidiser of the carbonisation unit. However, as outlined by one supplier in Appendix B, this is generally not considered a requirement to meet outcomes with appropriate turbulence in the oxidation chamber. Operating below the temperature required by the Clean Air Regulation may be preferred for NO_x emissions and the overall energy balance. If required for emissions, the need to reach $>980^{\circ}\text{C}$ in the thermal oxidiser is not expected to be an issue however it is not considered necessary or beneficial to have this as a fixed design requirement.

Destruction Efficiency Requirement

Where toxic air pollutants are present, 99.9999% removal is required as a default under the Clean Air Regulation for afterburners with toxic compounds. Due to low concentrations of compounds in both biosolids and biogas, regardless of the point of initial reference, it is not possible to meet this section of the Clean Air Regulation for toxic pollutants. However, given the very low inlet concentrations, outlet concentrations are similarly low and not expected to have an adverse impact on the local environment from a health or environmental perspective. Confirmation of predicted environmental impacts from toxic air pollutants compared with assessment criteria is provided in Section 5.2.

4.2 Odour emissions

Odours in domestic wastewater treatment plants primarily result from the decomposition of organic matter. During the anaerobic decomposition process, various chemical compounds are released, contributing to the unpleasant smells. Some key compounds include:

- Hydrogen Sulphide (H_2S): This compound is a natural byproduct produced during the breakdown of biosolids. It is often associated with the characteristic “rotten egg” smell.
- Ammonia (NH_3): Ammonia is another volatile compound emitted during wastewater treatment. It has a pungent odour.
- Mercaptans and Amines: These organic compounds containing nitrogen and sulphur emit strong odours detectable even at low concentrations.
- Other Volatile Organic Compounds (VOCs): These contribute to the overall odour mixture.

In order to maintain consistency with the REF, this assessment adopts the approved REF odour emissions previously compiled by Jacobs Group (Australia) Pty Ltd (Jacobs) (document reference: *IS373500_NWH_Riverstone_Air_Quality_Final_rev0*) (Jacobs, 2022) for the existing sources.

The odour emissions inventory (Table 4.7) compiled by Jacobs (2022) referenced the extensive Sydney Water odour emissions database which provides odour emissions data for all key wastewater treatment processes at almost all plants in their network. Emission data were derived from historical site reviews and sampling programs and were measured using dynamic olfactometry according to the “Australian/New Zealand Standard: Stationary source emissions – Part 3: Determination of odour concentration by dynamic olfactometry (AS/NZS4323.3:2001).

Note: The intention of the (Jacobs, 2022) inventory was to capture the most significant emission sources that may influence off-site odour. Not every source was captured. It is possible that there were other sources of odour, such as leaks from covers and maintenance activities including cleaning that were not captured. These potential sources were not expected to be significant enough to change odour impact outcomes.

Table 4.7 Existing odour emissions sources extracted from the (Jacobs , 2022) AQIA

Source	Ref.	Type	Area	Height	Stack tip diameter	Base elevation	Temperature	Velocity	Air flow	Odour concentration	Specific odour emissions rate	Total odour emissions rate
			m ²	m	m	m	K	m/s	m ³ /s	OU	OU.m ³ /m ² /s	OU.m ³ /s
Thickening Building Fan	TBFAN	Point	-	8	0.5	28	293	5	0.98	300	-	295
Dewatering Building Fan	DBFAN	Point	-	8	0.5	33	293	5	0.98	300	-	295
OCU	OCU	Point	-	18	0.9	30	293	20.09	12.78	500	-	6389
Biological reactor	BIOR	Area	3750	3	-	32	-	-	-	754	0.5	1875
Secondary clarifier 1	SC1	Area	1024	1	-	31	-	-	-	151	0.1	102
Secondary clarifier 2	SC2	Area	1024	1	-	31	-	-	-	151	0.1	102
Secondary clarifier 3	SC3	Area	1024	1	-	31	-	-	-	151	0.1	102

Odour emissions rates for the new sources associated with the carbonisation process and Stage 2 expansion are listed in Table 4.8. The carboniser odour concentration is based on maximum samples of the comparable full-scale Loganholme plant. The Loganholme plant had odour concentrations of 801 ou for the pilot plant and then up to a maximum of 3000 ou for the full-scale plant.

Table 4.8 Odour emissions rates for new sources

Source	Ref.	Type	Area	Height	Stack tip diameter	Temperature	Velocity	Air flow	Odour concentration	Specific odour emissions rate	Total odour emissions rate
			m ²	m	m	K	m/s	m ³ /s	OU	OU.m ³ /m ² /s	OU.m ³ /s
Carboniser 1	GAS1	Point	-	19.8	0.35	343	7.9	0.76	3000	-	840
Stage 2 Bioreactor & Membrane Bioreactor	BIOR2	Area	3350	3	-	-	-	-	754	0.5	1675

5 Assessment criteria

Given the number and variety of potential pollutants from the carbonisation plant and associated infrastructure, several sources were used to assign assessment criteria for those pollutants. The following hierarchy was used:

- 1 NSW EPA Approved Methods (NSW EPA, 2022)
- 2 Guidance from other Australian States (i.e., Victoria)
- 3 International guidance (i.e., the Texas Commission on Environmental Quality).

Assessment criteria adopted for this assessment are summarised in the sections below.

5.1 Impact assessment pollutants

Assessment criteria for impact assessment pollutants, as listed in the NSW EPA Approved Methods, are presented in Table 5.1.

Table 5.1 Assessment criteria for impact assessment pollutants (NSW EPA, 2022)

Potential pollutant	Assessment criteria	Averaging period	Source of assessment criteria
Sulphur dioxide (SO ₂)	286 µg/m ³	1 hour ¹	NEPC (2021)
	215 µg/m ³	1 hour ²	NEPC (2021)
	57 µg/m ³	24 hour	NEPC (2021)
Nitrogen dioxide (NO ₂)	164 µg/m ³	1 hour	NEPC (2021)
	31 µg/m ³	Annual	NEPC (2021)
Photochemical oxidants (as ozone)	139 µg/m ³	8 hour	NEPC (2021)
Lead	0.5 µg/m ³	Annual	NEPC (1998)
PM _{2.5}	25 µg/m ³	24 hours	NEPC (2021)
	8 µg/m ³	Annual	NEPC (2021)
PM ₁₀	50 µg/m ³	24 hours	NEPC (2021)
	25 µg/m ³	Annual	NEPC (2021)
Total suspended particulates (TSP)	90 µg/m ³	Annual	NHMRC (1996)
Deposited dust ⁵	4 g/m ² /month ³ (incremental)	Annual	NERDDC (1988)
	4 g/m ² /month ³ (cumulative)		
Carbon monoxide (CO)	100 mg/m ³	15 minutes	WHO (2000)
	30 mg/m ³	1 hour	WHO (2000)
	10 mg/m ³	8 hours	NEPC (2021)

Potential pollutant	Assessment criteria	Averaging period	Source of assessment criteria
Hydrogen fluoride (HF)	0.25 µg/m ³	90 days	ANZECC (1990)
	0.4 µg/m ³	30 days	ANZECC (1990)
	0.8 µg/m ³	7 days	ANZECC (1990)
	1.5 µg/m ³	24 hours	ANZECC (1990)

- (1) This impact assessment criterion applies to assessments prepared before 1 January 2025
- (2) This impact assessment criterion applies to assessments prepared after 1 January 2025
- (3) Maximum increase in deposited dust level
- (4) Maximum total deposited dust level
- (5) Dust is assessed as insoluble solids as defined by AS 3580.10.1–1991 (AM-19)
- (6) General land use, which includes all areas other than specialised land use
- (7) Specialised land use, which includes all areas with vegetation sensitive to fluoride, such as grapevines and stone fruits

5.2 Individual toxic air pollutants

Assessment criteria for toxic air pollutants, as listed in the *NSW EPA Approved Methods*, are presented in Table 5.2.

Assessment criteria for pollutants and/or averaging periods not included in the *Approved Methods* were sourced from the Victorian EPA Publication 1961 (Table 5.3), Texas Commission on Environmental Quality website (Table 5.4) and the Michigan PFAS Action Response Team screening levels for PFAS in air (

Table 5.5).

The Victorian EPA Publication 1961 is a technical guide for air pollution practitioners that presents air pollutant assessment criteria (APACs) for the assessment and management of air emissions. These APACs are not intended to be concentration limits, below which no action is required. Rather, the APACs provide concentration benchmarks against which potential risks to human health and the environment may be understood. In the modelling context, exceedance of one or more of the APACs indicates that an activity has the potential to pose an unacceptable risk to human health or the environment.

Table 5.2 Impact assessment criteria (mg/m³) for principal toxic air pollutants (NSW EPA, 2022)

Potential pollutant	Assessment criteria	Averaging period	Code
Acrolein	0.00042	1 hour	1
Acrylonitrile	0.008	1 hour	2
Alpha chlorinated Toluenes and benzoyl chloride	0.009	1 hour	3
Arsenic and compounds	0.00009	1 hour	4
Asbestos	0.18	1 hour	4
Beryllium and beryllium compounds	0.000004	1 hour	4
1,3-butadiene	0.04	1 hour	3
Cadmium and cadmium compounds	0.000018	1 hour	4
Chromium VI compounds	0.00009	1 hour	4
1,2-dichloroethane (ethylene dichloride)	0.07	1 hour	5
Dioxins and furans ²	2.0x10 ⁻⁰⁹	1 hour	4

Potential pollutant	Assessment criteria	Averaging period	Code
Epichlorohydrin	0.014	1 hour	3
Ethylene oxide	0.0033	1 hour	4
Formaldehyde	0.02	1 hour	6
Hydrogen cyanide	0.20	1 hour	1
MDI (diphenylmethane diisocyanate)	0.00004	1 hour	1
Nickel and nickel compounds	0.00018	1 hour	4
Polycyclic aromatic hydrocarbon (as benzo[a]pyrene)	0.0004	1 hour	3
Pentachlorophenol	0.0009	1 hour	1
Phosgene	0.007	1 hour	1
Propylene oxide	0.09	1 hour	2
TDI (toluene-2,4-diisocyanate; toluene-2,6-diisocyanate)	0.00004	1 hour	1
Trichloroethylene	0.5	1 hour	3
Vinyl chloride	0.024	1 hour	4

Gas volumes are expressed at 25°C and at an absolute pressure

Toxic equivalent as defined in clause 41 of the Regulation.

Codes

- (1) USEPA extremely toxic
- (2) USEPA Group B1 carcinogen (probable human carcinogen)
- (3) IARC Group 2A carcinogen (probable human carcinogen)
- (4) IARC Group 1 carcinogen (known human carcinogen)
- (5) Mutagen (USEPA)
- (6) IARC Group 2B carcinogen (possible human carcinogen)

Table 5.3 Assessment criteria sourced from the health based Victorian APACs

CAS number	Substance	Cumulative/ incremental	Averaging period	ppm	µg/m ³	Basis
7440-38-2	Arsenic and arsenic compounds	Incremental	1 year	-	0.007	WHO
7440-43-9	Cadmium and cadmium	Cumulative	1 year	-	0.005	WHO
18540-29-9	Chromium (hexavalent)	Cumulative	1 year	2.3x10 ⁻⁶	0.005	ATSDR
1746-01-6	Dioxins and furans (as TCDD equivalents)	Cumulative	1 year	3x10 ⁻⁹	0.00004	OEHHA
7440-50-8	Copper and copper compounds	Cumulative	1 hour	-	100	OEHHA
7647-01-0	Hydrogen chloride	Cumulative	1 hour	1.4	2,100	OEHHA
			1 year	0.01	20	US EPA
7783-06-4	Hydrogen sulphide	Cumulative	24 hours	0.1	150	WHO
			1 year	0.001	2	US EPA
7439-97-6	Mercury and mercury compounds	Cumulative	1 year	-	1	WHO
7440-66-6	Zinc and zinc compounds	Cumulative	1 hour	-	20	TCEQ
			1 year	-	2	TCEQ

Table 5.4 Assessment criteria sourced from (TCEQ, 2024)

Pollutant	Averaging period	Impact	Criterion
Selenium	99 th percentile, 1-hour average	Incremental	2 µg/m ³

Table 5.5 Assessment criteria sourced from Michigan PFAS Action Response Team

Pollutant	Averaging period	Impact	Criterion
PFAS in Air	24-hour average	Incremental	0.07 µg/m ³
	Annual average	Incremental	1 µg/m ³

5.3 Odour

The criteria for evaluating the effects of complex odour combinations have been established to recognize the community’s spectrum of odour sensitivities and to offer extra safeguards for those who are particularly reactive to odours. This is implemented through a statistical strategy that varies with the population count. An increase in population density tends to raise the fraction of odour-sensitive individuals, signifying the need for stricter assessment criteria in such conditions (NSW EPA, 2022).

Table 5.6 provides a summary of appropriate impact assessment criteria for various population densities according to the *Approved Methods*.

Table 5.6 Odour assessment criteria (NSW EPA, 2022)

Population of affected community	Impact assessment criteria for complex mixtures of odorous air pollutants (OU)
Urban (≥2000) &/or schools and hospitals	2
~ 500	3
~ 125	4
~ 30	5
~ 10	6
Single rural residence (≤ ~ 2)	7

With consideration of the existing sensitive receivers, discussed in Section 3.2, and neighbouring land use zoning, discussed in Section 3.3, the applicable odour criteria for application on this assessment are 4 OU for locations on industrial land uses and 2 OU for locations not on industrial land uses (e.g. residential, etc.).

6 Dispersion modelling

The CALPUFF dispersion model (Version 7.2.1) was used to predict the ground level concentrations (GLCs) of all identified pollutants based on a year-long period (2020) of hourly meteorological data.

CALPUFF is an advanced, integrated Gaussian puff modelling system for the prediction of atmospheric pollution dispersion. The model has been accepted by the United States Environmental Protection Agency (USEPA) in its Guideline on Air Quality Models as a preferred model for i) assessing long range transport of pollutants and ii) on a case -by case basis for certain near-field applications involving complex meteorological conditions.

The modelling system consists of three main components: CALMET (a diagnostic 3-dimensional meteorological model), CALPUFF (the air quality dispersion model), and CALPOST (a post-processing package).

The following sections describe the model development process and the inputs used in the construction of the model.

6.1 Meteorology

In order to maintain consistency with the REF, meteorological data was sourced from the same meteorological station (Rouse Hill) for the same year (2020) as the 2022 Riverstone AQIA (Jacobs , 2022). The data was processed using the same methodology described in the 2022 Riverstone AQIA as far as practicable. The following sections describe this process.

6.1.1 The Air Pollution Model (TAPM)

In the absence of a full suite of site-specific meteorological data, The Air Pollution Model (TAPM) was used to generate meteorological files. The meteorological component of TAPM is an incompressible, optionally non-hydrostatic, primitive equation model with a terrain-following vertical co-ordinate for three-dimensional simulations. The model is connected to databases containing terrain, vegetation and soil type, leaf area index, sea-surface temperature, and synoptic scale meteorological analysis for various regions around the world.

TAPM (Version 4.0.5) was run in accordance with the requirements from the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, 2016 (Barklay & Scire, 2016), using the following parameters (Table 6.1):

Table 6.1 TAPM configuration

Parameter	TAPM configuration
Model version	4.0.5
Reference point (Centre)	UTM Zone 56H 305336 m E 6270975 m S
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grid points	35 x 35 x 25
Vertical levels	25 (10 m, 25 m, 50 m, 100 m, 150 m, 200 m, 250 m, 300 m, 400m, 500 m, 600 m, 750 m, 1000 m, 1250 m, 1500 m, 1750 m, 2000 m, 2500 m, 3000 m, 3500 m, 4000 m, 5000 m, 6000 m, 7000 m, and 8000 m)
Year(s) of analysis)	2020
Terrain data source	STRM 30 m
Land use data source	Default

Parameter	TAPM configuration
Observation file for wind speed and wind direction assimilation	Rouse Hill met station (2020)
Radius of influence	15 km (4 vertical levels for assimilation)

The prognostic TAPM data covered a domain of 50 km x 50 km centred on the Project Site, at a resolution of 1 km x 1 km grid. CALTAPM was used to convert the TAPM prognostic hourly meteorological data outputs into CALMET inputs.

6.1.2 CALMET

CALMET is a meteorological model which includes a diagnostic wind field generator. It accounts for the treatment of slope flows and terrain effects, such as blocking and the micrometeorological effects on overland and overwater boundary layers. CALMET can be run using gridded data fields generated by models (such as the TAPM or WRF model), hourly observational data from weather stations, or a combination of the two. CALMET links to a database (<http://www.webgis.com>), which accesses both terrain (SRTM1) and land use files specific to the study area being modelled.

The prognostic hourly meteorological outputs from TAPM for 2020 were input to CALMET as an initial guess wind field, which enabled higher resolution three-dimensional hourly wind and temperature fields to be generated over the modelled domain. Associated two-dimensional fields such as mixing height, surface characteristics, and dispersion properties were also included in the CALMET output file.

The diagnostic CALMET wind field was modelled at a resolution of 100 m over a 10 km x 10 km grid. A total of 10 vertical cells (layers) were modelled within the grid, ranging from ground level to 3 km. Most these cells were within the bottom 1 km of the atmosphere to provide better coverage of boundary layer circulations, within which dispersion of pollutants from low-level sources would occur. The output of the diagnostic data was in a format suitable for input to the CALPUFF atmospheric dispersion model.

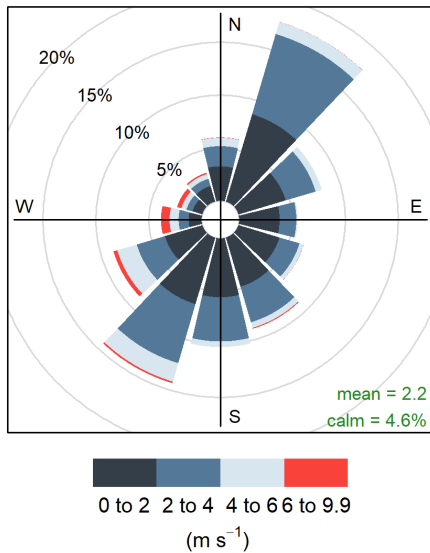
Table 6.2 CALMET configuration parameters

CALMET	Configuration
Model version	7.2.1
Met data option	Hybrid
Simulation length	8,784 hours
Grid domain	20 km x 20 km
Grid resolution	200 m
Year(s) of analysis)	2020
Surface meteorological station	Rouse Hill met. Station
Upper air data	Derived from TAPM (biased towards surface observations: -1, -0.8, -0.6, -0.4, -0.2, 0, 0, 0
Terrain data source	STRM 30 m
Land use data source	Default
R1, R2	0.5, 1
RMAX1, RMAX2	5, 20
TERRAD	5

6.1.3 Site-specific environment

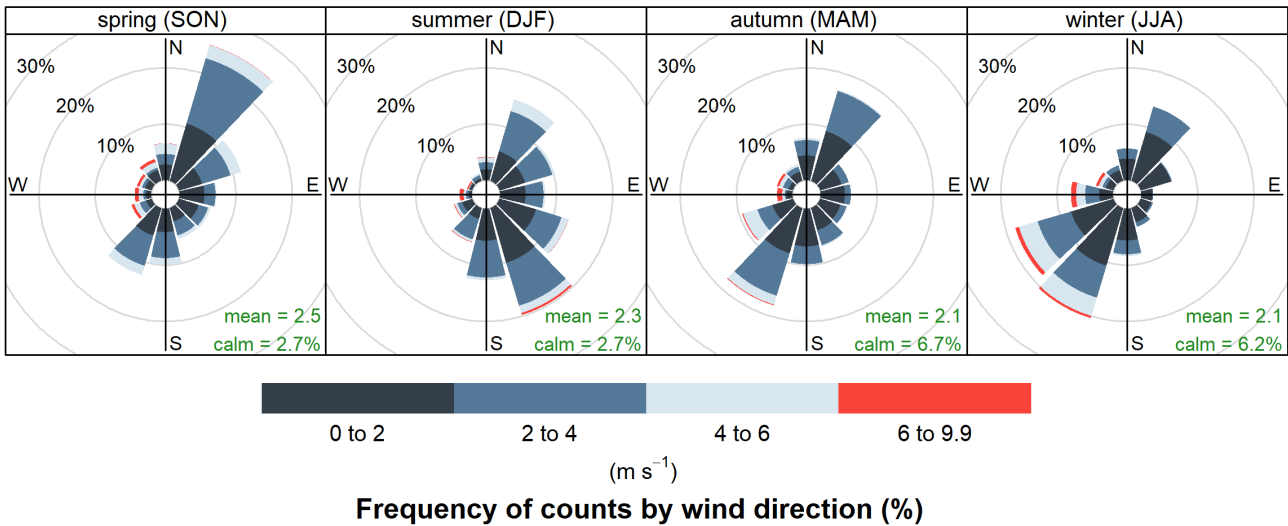
6.1.3.1 Wind conditions

Site-specific wind direction and wind speed data were extracted from CALMET for 2020. Annual and seasonal wind roses are presented in Figure 6.1 and Figure 6.2, respectively. Figure 6.1 indicates that the predominant wind direction is from the northeast and southeast for all seasons. Figure 6.2 indicates that there was seasonal variability in both wind direction and speed. During spring, wind speeds were typically higher and from the northeast, while during the autumn/winter the wind speeds were typically lower and from the southeast.



Frequency of counts by wind direction (%)

Figure 6.1 Annual average wind rose plot



Frequency of counts by wind direction (%)

Figure 6.2 Seasonal average wind rose plots

6.1.3.2 Stability class

Stability categories are used as indicators of atmospheric turbulence and the dispersive properties of the atmosphere by Gaussian plume dispersion models. Higher stability of the atmosphere typically results in poor dispersion conditions and higher ground level concentrations, whilst unstable atmospheres typically have the opposite impact.

Stability classes described by Pasquill-Gifford are presented in Table 6.3. Usually, Class F and G are combined into one class, F.

Table 6.3 Atmospheric stability classes

Stability class	Category	Description
A	Very stable	Low winds, clear skies, hot daytime conditions
B	Unstable	Moderate winds, clear skies, daytime conditions
C	Slightly unstable	Moderate winds, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Slightly stable	Moderate winds, slightly overcast night-time conditions
F	Stable	Low winds, clear skies, cold night-time conditions
G	Very stable	

Figure 6.3 and Figure 6.4 show the predicted frequency of stability classes at the Riverstone WRRF site.

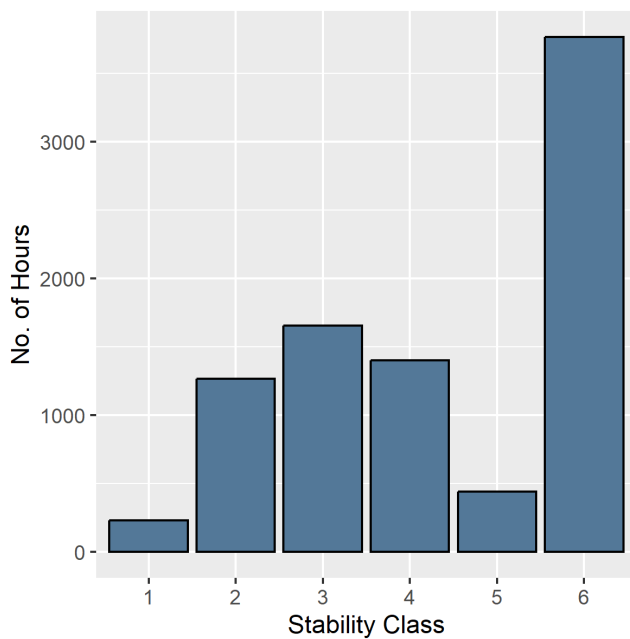


Figure 6.3 Annual frequency of stability classes

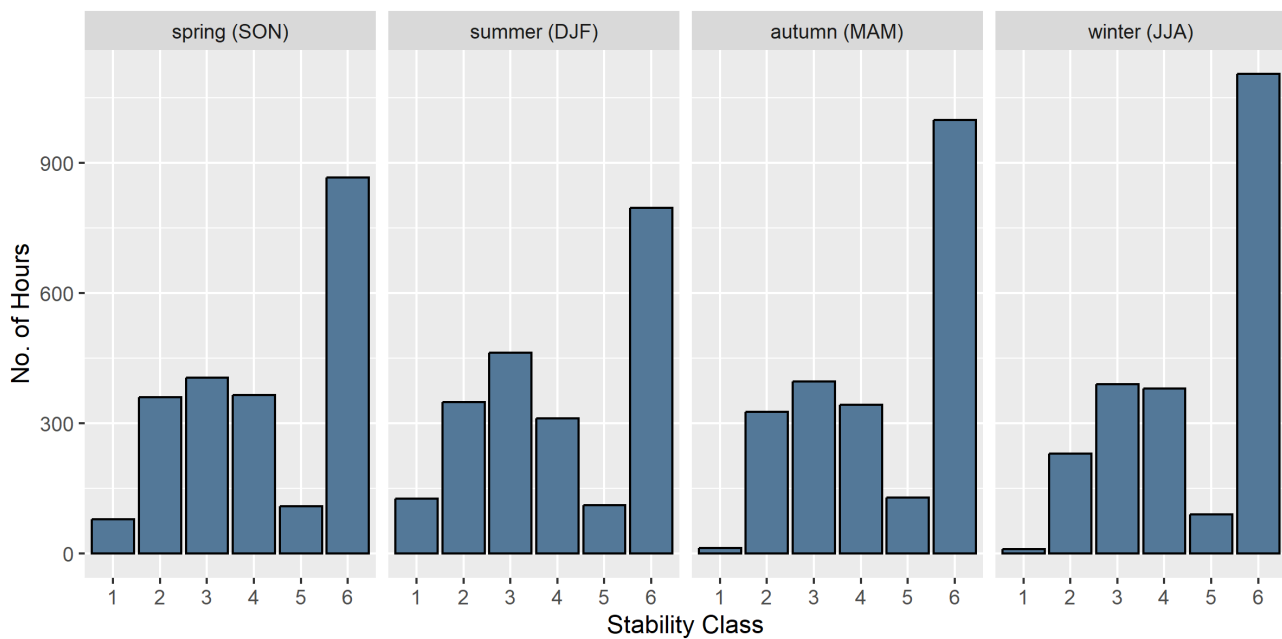


Figure 6.4 Seasonal frequency of stability classes

6.2 CALPUFF dispersion modelling

A summary of the CALPUFF configuration parameters for the Project is presented in Table 6.4.

CALPUFF is a transport and dispersion model that advects “puffs” of a given material/gaseous species emitted from modelled sources, in turn simulating dispersion and transformation processes within the atmosphere as dictated by the CALMET-generated meteorological fields. The model produces hourly concentration outputs at discrete and/or gridded receptors, generated by the model user, which are subsequently processed (using CALPOST) and converted into tabulated concentration results equivalent to the required averaging time.

Table 6.4 CALPUFF configuration parameters

Parameter	Value
Depletion options	Concentration and deposition
Exponential decay	None
Dispersion coefficient	Turbulence computed from micrometeorology
Terrain included	Yes (30 m grid spacing)
Map projection	UTM Zone 56S
Meteorological Grid	5 km x 5 km
Computational Grid	20 km x 20 km
Modelled year	2020
Discrete receptors	See Sensitive Receptors (Section 3.2)

Parameter	Value
Gridded receptors	500 m from centre: 20 m spacing 1000 m from centre: 30 m spacing 1500 m from centre: 100 m spacing 3000 m from centre: 250 m spacing
Output type	Concentration ($\mu\text{g}/\text{m}^3$), deposition ($\mu\text{g}/\text{m}^3/\text{s}$) and odour units (OU)

6.2.1 Modelling scenarios

One peak operational loading scenario for the Riverstone WRRF was modelled which included the proposed carbonisation plant, dryers and heaters as described in the Emissions Inventory (Section 4).

6.2.2 Treatment of terrain and land use data

To represent the influence of terrain elevations in the dispersion of pollutants, a digital elevation file was used in CALPUFF, based on Shuttle Radar Topography Mission (SRTM1) data with a resolution of 30 m (Figure 6.5). For both the modelled discrete receptors and grid points, the recommended Lakes Inverse Distance interpolation was used. This function interpolates the neighbouring points using inverse distance to obtain the elevation at the desired point. The terrain variations included in the dispersion modelling are depicted in Figure 6.5.

Global Land Cover Characterisation (GLCC) data were obtained from CALPUFF's database (<http://www.webgis.com>) for the modelled area at a resolution of 1 km.

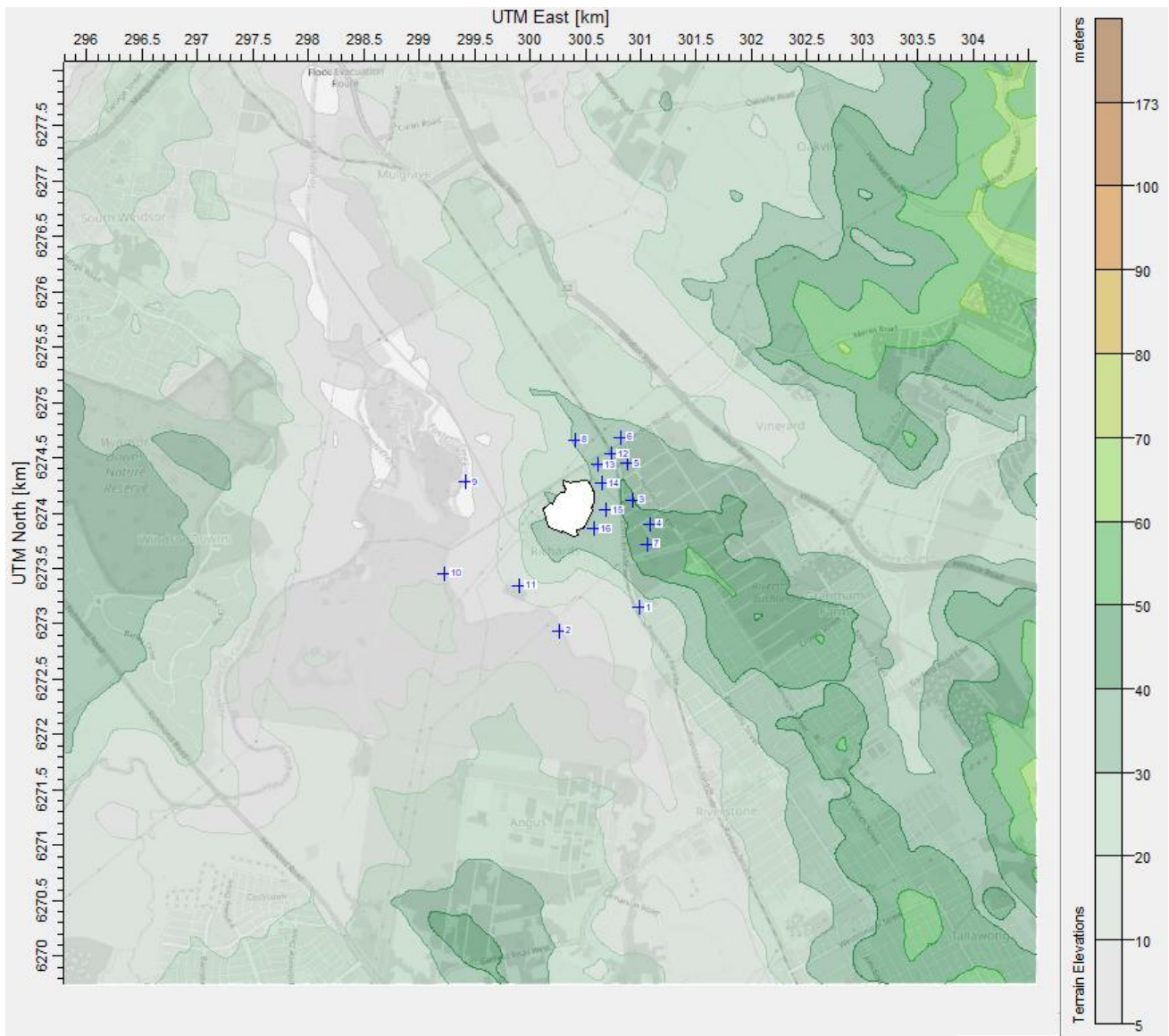


Figure 6.5 Shuttle Radar Topography Mission (SRTM1) data used in the Riverstone WRRF model

6.2.3 Building downwash

The Building Profile Input Program-Plume Rise Model Enhancements (BPIP-PRIME) downwash module within CALPUFF accounts of the influence of buildings and structures that may influence the dispersion of air emissions, through entering the heights and corner locations of buildings and infrastructure in the vicinity.

The following existing and proposed building data was included in the BPIP-PRIME (Table 6.5):

Table 6.5 Buildings and structures included in the model

ID	Base elevation	Height	Diameter	X Length	Y Length	Rotation	X	Y
	[m]	[m]	[m]	[m]	[m]	(deg)	[m]	[m]
BLD_1	29.4	4	-	25	21	337	300274	6274167
BLD_2	30.3	4	-	12	9	336	300261	6274137
BLD_3	30.8	4	-	11	29	337	300317	6274111
BLD_4	30.6	4	-	10	17	338	300347	6274104

ID	Base elevation	Height	Diameter	X Length	Y Length	Rotation	X	Y
	[m]	[m]	[m]	[m]	[m]	(deg)	[m]	[m]
BLD_5	31.2	6	-	13	8	336	300305	6274088
BLD_6	31.8	8	-	32	15	337	300287	6274042
BLD_7	31.9	4	-	20	8	336	300344	6274015
BLD_8	32.3	4	-	18	8	337	300365	6274005
BLD_9	31.6	6	-	10	29	337	300352	6274032
BLD_10	30.9	4	-	14	8	338	300382	6274073
BLD_11	31.2	6	-	13	11	337	300377	6274041
BLD_12	30.6	8	14	-	-	-	300414	6274063
BLD_13	30.5	8	13	-	-	-	300424	6274087
BLD_14	30.5	7	14	-	-	-	300451	6274074
BLD_15	30.6	7	14	-	-	-	300441	6274051
BLD_16	33.1	4	-	31	10	337	300293	6273967
BLD_17	31.9	4	-	8	14	337	300239	6273991
BLD_18	31.5	6	-	17	10	336	300221	6273999
BLD_19	31.4	4	-	8	12	337	300211	6274037
BLD_20	34.3	4	-	8	13	335	300405	6273883
BLD_21	32.4	4	-	15	13	336	300464	6273985
BLD_22	31.4	16	-	10	14	337	300507	6274069
BLD_23	31.2	10	7	-	-	-	300501	6274075
BLD_24	31.6	4	-	5	24	337	300514	6274058
BLD_25	30.4	4	-	16	8	335	300407	6274116
BLD_26	31.1	12	-	-	-	-	300526	6274116
BLD_27	30.6	4	-	26	8	339	300428	6274112
BLD_28	30.6	4	-	7	7	246	300448	6274099
BLD_29	30.5	4	-	19	16	339	300389	6274094
BLD_30	32.7	4	-	8	13	337	300430	6273975
BLD_31	33.6	4	-	6	11	337	300412	6273941
BLD_32	31.3	4	-	18	8	336	300467	6274029
BLD_33	31.6	4	-	14	11	336	300441	6274009

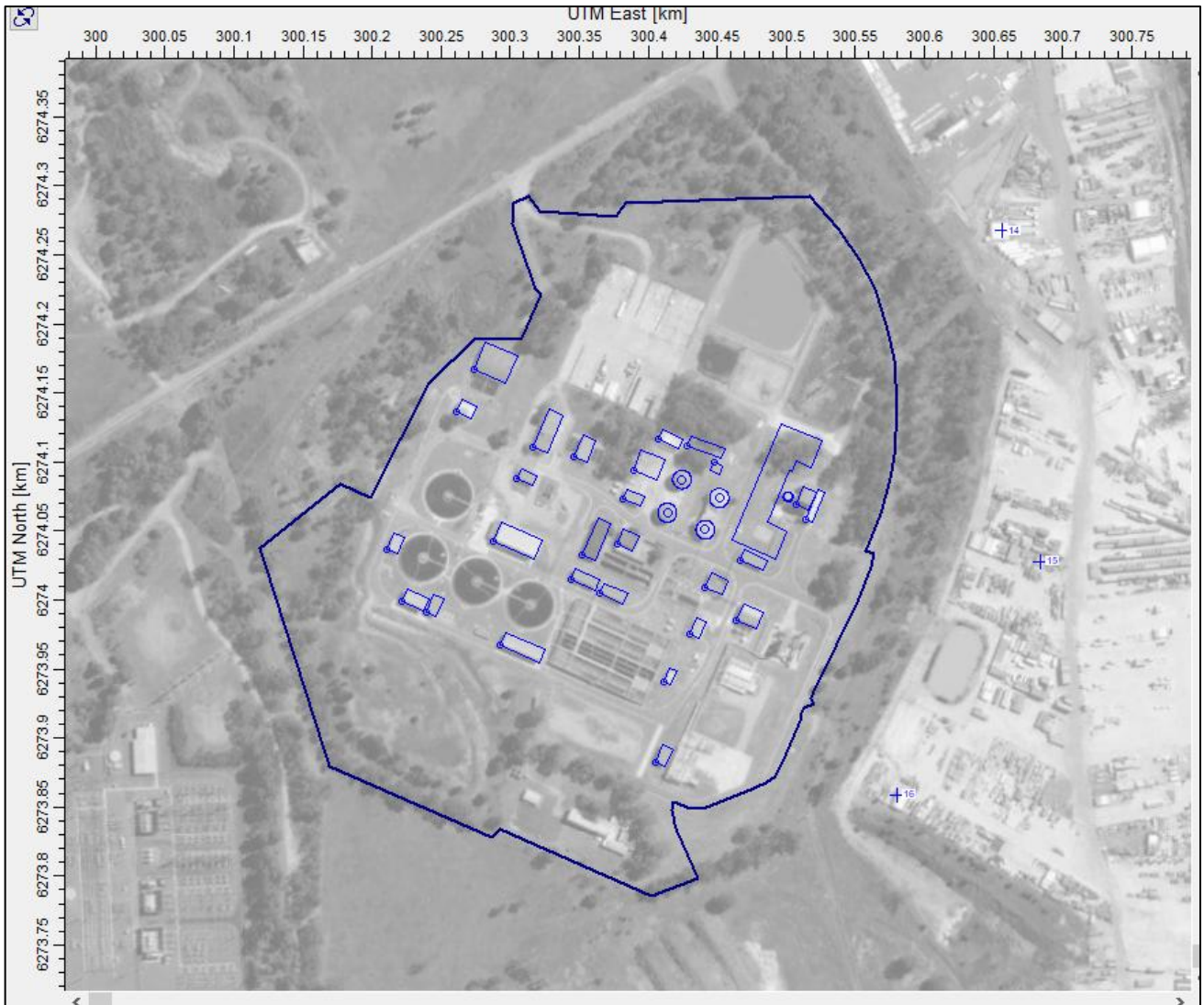


Figure 6.6 Modelled existing and proposed buildings (blue) at the Riverstone WRRF (plan view)

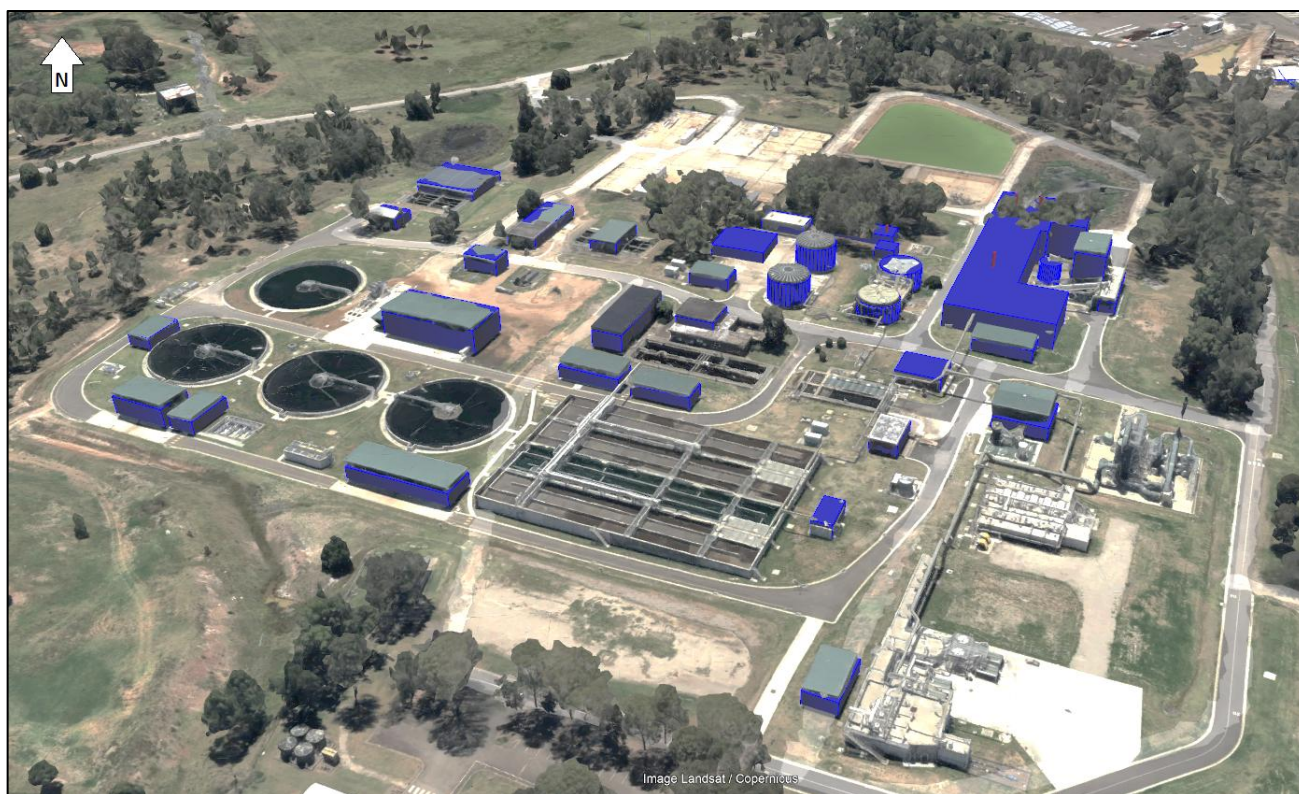


Figure 6.7 Modelled existing and proposed buildings Riverstone WRRF (oblique view)

6.2.4 NO_x to NO₂ conversion

One of the important primary pollutants from combustion activities is NO_x. NO_x refers to the sum of the two most common oxides of nitrogen, namely nitric oxide (NO) and nitrogen dioxide (NO₂). The contaminant of concern for potential human health effects is NO₂. However, the relative proportions of NO and NO₂ in a discharge plume change with distance downstream, as NO converts to NO₂ in the presence of solar radiation and ozone (O₃).

For this assessment, a conservative 1:1 conversion is adopted, assuming 100% of the NO is converted to NO₂.

6.2.5 Odour modelling

The *NSW EPA Approved Methods* requires odour impacts to be evaluated on a nose-response-time average which is approximately one second. The odour emissions data have been multiplied by “peak-to-mean” factors to convert the model’s one hour averaging time to a nose-response averaging time, as developed by Katestone Scientific (1995, 1998) and adopted by the NSW EPA.

The ratios presented in Table 6.6 were applied to the emission rates entered into the dispersion model.

Table 6.6 Peak-to-mean factors for each stability class

Source	Pasquill-Gifford stability class					
	A	B	C	D	E	F
Carboniser 1	2.3	2.3	2.3	2.3	2.3	2.3
Carboniser 2	2.3	2.3	2.3	2.3	2.3	2.3
Thickening Building Fan	2.3	2.3	2.3	2.3	2.3	2.3
Dewatering Building Fan	2.3	2.3	2.3	2.3	2.3	2.3
Odour Control Unit	4	4	4	7	7	7

Source	Pasquill-Gifford stability class					
	A	B	C	D	E	F
Biological Reactor	2.3	2.3	2.3	2.3	1.9	1.9
Secondary Clarifier 1	2.3	2.3	2.3	2.3	1.9	1.9
Secondary Clarifier 2	2.3	2.3	2.3	2.3	1.9	1.9
Secondary Clarifier 3	2.3	2.3	2.3	2.3	1.9	1.9
Dryer 1 & 2 scrubber discharge	2.3	2.3	2.3	2.3	2.3	2.3

6.2.6 Assumptions and limitations

6.2.6.1 Modelled emissions data

The following key assumptions were made in the development of the Riverstone WRRF emissions inventory and subsequent modelling exercise:

- the carbonisation plant will operate continuously, 24 hours a day, 7 days a week
- building heights were estimated based on Google Earth 3D building observations
- emission sources are as described in Section 4.

6.2.7 Atmospheric dispersion modelling limitations

Atmospheric dispersion models are mathematical tools that link an emission source to a receptor, simulate the substance (gas or aerosol) behaviour, and predict its fate. They use differential equations that account for transport, turbulent diffusion, chemical transformation, and soil deposition (dry and wet) of the emitted substances. By solving these equations numerically (or analytically in simple cases) in time and space, they estimate the concentrations around and away from the source(s).

Solving this process accurately and completely is challenging due to the uncertainties and approximations in the input data (three-dimensional meteorological fields, source terms, terrain features) and the stochastic variability of the turbulent dispersion processes in the atmosphere.

In general, models have difficulty in accurately predicting dispersion under light wind speeds (less than 1 m/s) due to the dominance of physical processes other than advection and or turbulent diffusion under such conditions. The inability to accurately predict the minimum mixing height is another limiting factor of dispersion modelling and is particularly important when dealing with low level, non-buoyant (or low buoyancy) emission sources.

Different metrics can be used to evaluate model performance such as maximum concentrations, frequency of exceedances, or temporal and spatial correlations. However, these metrics often disagree with each other, and a model may perform well in some aspects but poorly in others. It is therefore recommended that model performance be considered holistically, taking into account the quality and representativeness of the input data, the suitability and accuracy of the model for the application, and the errors and biases in the measured data.

7 Dispersion modelling results

7.1 Predicted project contributions

The results of the dispersion modelling at the boundary and discrete sensitive receptors are presented in the sections that follow. These results are expressed as a percentage of the assessment criteria, coloured coded on a graduated scale, ranging from blue (< 1% of the criterion) to red (>99% of the criterion).

Annual and 24-hour averages represent the 100th percentile (1st highest) predicted concentrations. The 99.9th percentiles were used for the 1-hour averages, and 99th percentile for the odour concentrations, as specified in the *Approved Methods (EPA 2022)*.

For a full list of the predicted concentrations (in $\mu\text{g}/\text{m}^3$), see Appendix C, Table C.1.

Selected contour plots are presented in Appendix D.

7.1.1 Impact assessment pollutants

Predicted impact assessment pollutant concentrations at the receptors are summarised in Table 7.1.

Predicted NO_2 concentrations reach a maximum of 16% of the hourly-average criterion ($164 \mu\text{g}/\text{m}^3$) at R15, on the south side of the Western Storage facility, with GLCs ranging from 2% to 14% at the remaining receptors. Annual average GLCs peak at 7% of the criterion ($31 \mu\text{g}/\text{m}^3$) at R15, also within the Western Storage facility, with GLCs ranging from <1% to 4% at the remaining receptors.

Predicted 24-hour average SO_2 concentrations peak at 16% of the assessment criterion ($57 \mu\text{g}/\text{m}^3$) at the closest receptor, i.e., the neighbouring Western Storage facility (R14). Predicted 1-hour GLCs are predicted to remain below 8% of the assessment criteria ($57 \mu\text{g}/\text{m}^3$) at all receptors.

Predicted $\text{PM}_{2.5}$ 24-hour average GLCs peak at 5% of assessment criteria ($25 \mu\text{g}/\text{m}^3$) at the Western Storage facility (R14), with all other receptors remaining below 2%. Predicted annual average GLCs at the receptors range from <1% to 2% of the criterion ($8 \mu\text{g}/\text{m}^3$).

Similarly, maximum predicted PM_{10} concentrations reach 3% of the 24-hour average and 1% of the annual average assessment criteria ($50 \mu\text{g}/\text{m}^3$ and $25 \mu\text{g}/\text{m}^3$, respectively) at the Western Storage Facility.

Predicted hydrogen fluoride GLCs remain below 2% of the assessment criteria at all receptors for all averaging periods.

The remaining pollutant GLCs are predicted to be 1% or lower than the relevant assessment criteria.

7.1.2 Individual toxic air pollutants

Predicted toxic air pollutant concentrations at the receptors are summarised in Table 7.2.

1-Hour average cadmium compound GLCs reach a maximum of 87% of the assessment criterion ($0.018 \mu\text{g}/\text{m}^3$) at the boundary. At the neighbouring Western Storage facility, GLCs are reduced to 15% and 12% at R15 and R16 respectively. The GLCs remain below 12% of the 1-hour assessment criterion at all residential receptors and 5% at the Vineyard Early Learning centre (R06). Annual average GLCs remain below 1% of the assessment criterion ($0.005 \mu\text{g}/\text{m}^3$) at the boundary and at all receptors.

1-Hour average chromium compounds reach a maximum of 19% of the assessment criteria ($0.09 \mu\text{g}/\text{m}^3$) at the Riverstone boundary. 1-hour and annual average concentrations are predicted to remain below 9% of the relevant criteria at all receptor locations.

Nickel and nickel compound GLCs are predicted to reach a maximum of 8% of the 1-hour assessment and >1% of the annual criteria (0.18 $\mu\text{g}/\text{m}^3$ and 0.009 $\mu\text{g}/\text{m}^3$ respectively) at the boundary. Short and long term GLCs remain below 1% of the criteria at all receptors.

The remaining pollutant GLCs are predicted to be less than 1% of the relevant assessment criteria.

Table 7.1 Predicted impact assessment pollutant concentrations at the receptors, expressed as a percentage of the assessment criteria

Pollutant	Averaging period	Units	Assessment Criteria	Industrial/commercial	Water course	Residential	Residential	Residential	Education (early learning)	Residential	Residential	Water course	Water course	Recreation	Service	Industrial/commercial	Industrial/commercial	Industrial/commercial	Industrial/commercial
				R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16
Carbon monoxide (CO)	15-Minutes	µg/m ³	100000	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
	1-Hour	µg/m ³	30000	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
	8-Hour	µg/m ³	10000	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Hydrogen Fluoride (HF)	07-Days	µg/m ³	0.8	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
	24-Hour	µg/m ³	1.5	<1%	<1%	1%	<1%	1%	1%	<1%	<1%	<1%	<1%	<1%	1%	1%	2%	1%	1%
	30-Days	µg/m ³	0.4	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
	90-Days	µg/m ³	0.25	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Nitrogen dioxide (NO ₂)	1-Hour	µg/m ³	164	3%	2%	9%	8%	9%	7%	8%	7%	2%	2%	3%	9%	11%	14%	16%	13%
	Annual	µg/m ³	31	<1%	<1%	1%	1%	3%	2%	1%	1%	<1%	<1%	1%	3%	4%	7%	2%	2%
Lead (PB)	Annual	µg/m ³	0.5	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
PM ₁₀	24-Hour	µg/m ³	50	<1%	<1%	1%	<1%	1%	1%	<1%	1%	<1%	<1%	<1%	1%	1%	3%	1%	1%
	Annual	µg/m ³	25	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	1%	<1%	<1%
PM _{2.5}	24-Hour	µg/m ³	25	<1%	<1%	2%	1%	2%	2%	1%	1%	<1%	<1%	1%	2%	2%	5%	2%	2%
	Annual	µg/m ³	8	<1%	<1%	<1%	<1%	1%	1%	<1%	<1%	<1%	<1%	<1%	1%	1%	2%	<1%	1%
Sulphur dioxide (SO ₂)	1-Hour	µg/m ³	215	2%	1%	3%	3%	3%	3%	3%	2%	1%	1%	2%	3%	4%	5%	8%	6%
	24-Hour	µg/m ³	57	2%	1%	7%	3%	7%	5%	3%	4%	1%	1%	3%	7%	8%	16%	9%	7%
TSP	Annual	µg/m ³	90	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Dust	Annual	g/m ² /month	4	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%

Table 7.2 Predicted toxic air pollutant concentrations at the receptors and Riverstone boundary, expressed as a percentage of the assessment criteria

Pollutant	Averaging period	Units	Assessment Criteria	Industrial/commercial	Water course	Residential	Residential	Residential	Education (early learning)	Residential	Residential	Water course	Water course	Recreation	Service	Industrial/commercial	Industrial/commercial	Industrial/commercial	Industrial/commercial	Maximum predicted at the boundary
				R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	
Arsenic and compounds	1-Hour	µg/m ³	0.09	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	1%
	Annual	µg/m ³	0.007	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Cadmium and cadmium compounds	1-Hour	µg/m ³	0.018	3%	2%	6%	5%	6%	5%	5%	6%	2%	2%	3%	7%	8%	12%	15%	12%	87%
	Annual	µg/m ³	0.005	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Chromium VI compounds	1-Hour	µg/m ³	0.09	1%	<1%	1%	1%	1%	1%	1%	1%	1%	<1%	1%	1%	2%	3%	3%	3%	19%
	Annual	µg/m ³	0.005	<1%	<1%	1%	<1%	2%	1%	<1%	1%	<1%	<1%	1%	2%	3%	5%	1%	2%	9%
Copper dusts and mists	1-Hour	µg/m ³	18	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Hydrogen sulphide	Annual	µg/m ³	2	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Hydrogen chloride	1-Hour	µg/m ³	140	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	1%
	Annual	µg/m ³	20	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Mercury inorganic	1-Hour	µg/m ³	1.8	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	1%
	Annual	µg/m ³	1	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Nickel and nickel compounds	1-Hour	µg/m ³	0.18	<1%	<1%	1%	<1%	1%	1%	<1%	1%	<1%	<1%	<1%	1%	1%	1%	1%	1%	<1%
	Annual	µg/m ³	0.009	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Polycyclic aromatic hydrocarbon (as benzo[a]pyrene)	1-Hour	µg/m ³	0.4	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	8%
PFAS	Annual	µg/m ³	1	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Selenium	1-Hour	µg/m ³	2	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Dioxins and furans	1-Hour	µg/m ³	0.0002	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
	Annual	µg/m ³	0.0004	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Zinc	1-Hour	µg/m ³	20	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
	Annual	µg/m ³	2	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%

7.1.3 Odour

The 99th percentile predicted odour concentrations (OU) at the receptors are provided in Table 7.3. The assessment criteria are based on the population affected as stated in the *NSW EPA Approved Methods* (see Table 5.6). Predicted GLCs are highest at the Western Storage receptors (R13–R16), located within 100 m of the Riverstone WRRF, where concentrations reach a maximum of 3.1 OU. A GLC of 1.2 OU is predicted at the Vineyard Early Learning Centre.

Predicted odour concentrations at the residential receptors range from 0.4 OU to 1.5 OU and are all below the assessment criteria.

Figure 7.1 presents the predicted future OU concentration contours in relation to the baseline contours reported by Jacobs (2022). The minor expansion (to the south-west and north-east) and contraction (to the north-west and south-east) of the future odour contours relative to the baseline is negligible and is likely the result of resolution and interpolation variations between the modelling iterations. The impact of the carbonisation process and the Stage 2 bio- and membrane-reactors on baseline odour is therefore expected to be insignificant.

Table 7.3 Predicted odour concentrations (OU) at the receptor locations

Receptor ID	Receptor name	Receptor type	Assessment criteria	Population affected	Predicted odour conc. (OU)	Percentage of criteria
R01	Victoria St Industry	Industrial/commercial	4	~125	0.4	9%
R02	Eastern Creek 3	Water course	2	Urban	0.2	10%
R03	Ashford Rd	Residential	2	Urban	1.5	75%
R04	Otago St	Residential	2	Urban	0.8	42%
R05	Camberwell Rd	Residential	2	Urban	1.5	77%
R06	Vineyard Early Learning	Education (early learning)	2	School	1.2	62%
R07	Brisbane Rd	Residential	2	Urban	0.8	40%
R08	House North	Residential	2	Urban	1.2	62%
R09	Eastern Creek 1	Water course	2	Urban	0.2	11%
R10	Eastern Creek 2	Water course	2	Urban	0.2	11%
R11	Hawkesbury Model Air Sports	Recreation	2	Urban	0.4	20%
R12	Vineyard Train Station	Service	2	Urban	1.6	79%
R13	Western Storage 1	Industrial/commercial	4	~125	1.8	46%
R14	Western Storage 2	Industrial/commercial	4	~125	2.4	59%
R15	Western Storage 3	Industrial/commercial	4	~125	2.5	63%
R16	Western Storage 4	Industrial/commercial	4	~125	3.1	76%

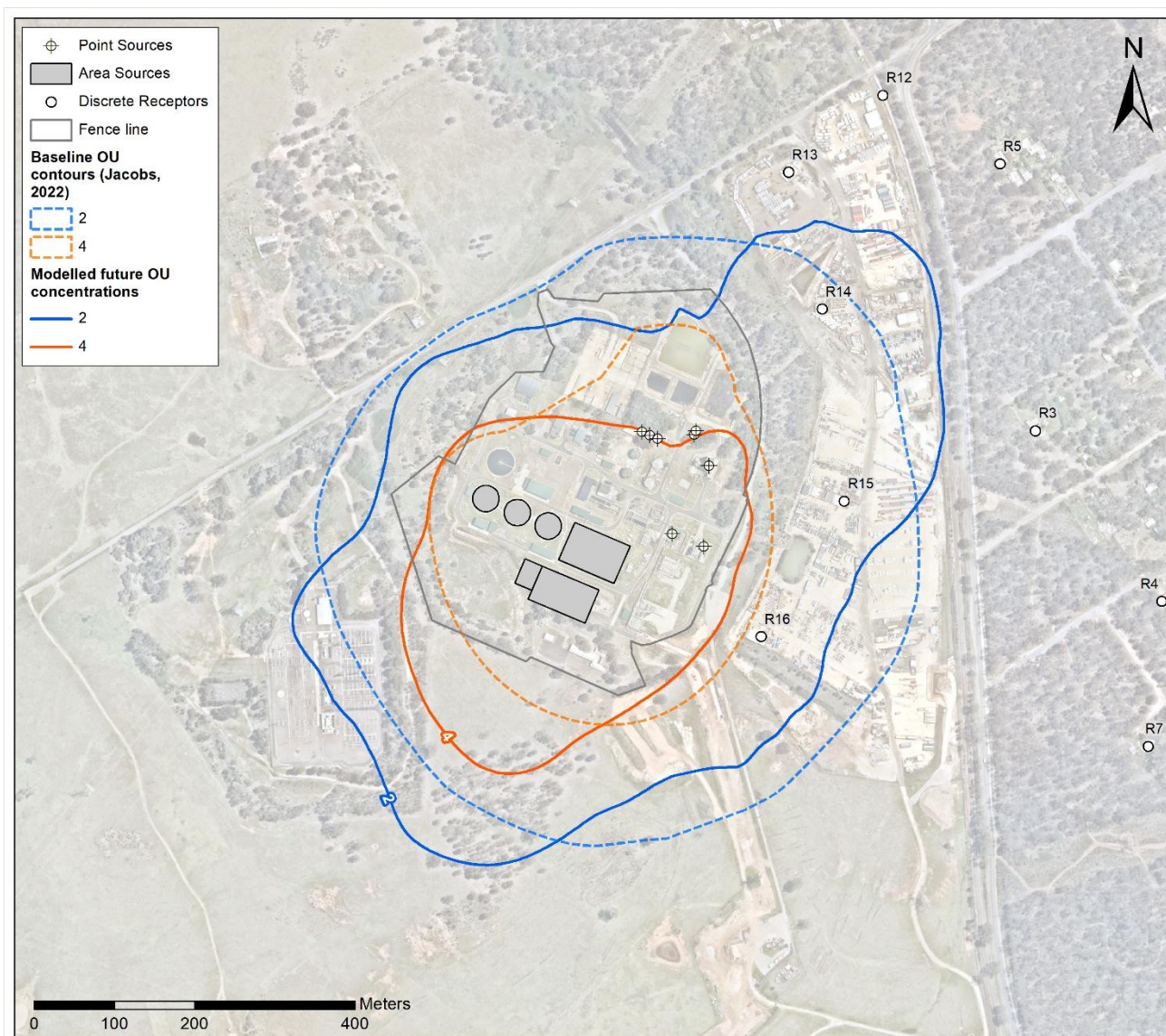


Figure 7.1 Predicted future OU concentration contours in relation to the baseline contours reported by Jacobs (2022).

7.2 Cumulative impacts

The cumulative impact of the Riverstone WRRF peak operational loading scenario was calculated using the background concentrations discussed in Section 3.5.3 and predicted GLCs presented in Section 7.1.

The predicted cumulative concentrations at the receptors are summarised in Table 7.4, expressed as a percentage of the assessment criteria. The results are colour coded on a graduated scale, ranging from blue (<1% of the criterion) to red (>99% of the criterion).

The results show:

- Despite the nominal contribution of the project to ambient particulate concentrations (Table 7.1), cumulative 24-hour PM_{10} and $PM_{2.5}$ concentrations are predicted to exceed the assessment criteria ($50 \mu\text{g}/\text{m}^3$ and $25 \mu\text{g}/\text{m}^3$, respectively) at all discrete receptor locations. These results are examined in further detail in the *Level 2 Contemporaneous Assessment* (Section 7.3).
- 1-Hour average NO_2 cumulative concentrations are predicted to range from 47% to 61% of the criterion ($164 \mu\text{g}/\text{m}^3$).

- Predicted cumulative annual average NO₂ concentrations range from <1% to 7% of the criterion (31 µg/m³).
- 24-Hour SO₂ concentrations are higher at the Western Storage receptors (R13 – R16), ranging from 40% to 42% of the criteria, compared to the 35–37% predicted at the residential receptors (R03 – R08).
- 8-Hour average cumulative carbon monoxide concentrations are 19% of the 10,000 µg/m³ assessment criterion. 15-Minute and 1-Hour average concentrations remain below 6%.
- Lead, deposited dust, and hydrogen fluoride cumulative concentrations remained below 1% of the relative assessment criteria at all receptor locations.

Table 7.4 Predicted cumulative concentrations at the receptors, expressed as a percentage of the assessment criteria

Pollutant	Averaging period	Units	Assessment Criteria	Industrial/commercial	Water course	Residential	Residential	Residential	Education (early learning)	Residential	Residential	Water course	Water course	Recreation	Service	Industrial/commercial	Industrial/commercial	Industrial/commercial	Industrial/commercial
				R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16
Carbon monoxide (CO)	15-Minutes	µg/m ³	100000	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
	1-Hour	µg/m ³	30000	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
	8-Hour	µg/m ³	10000	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
Hydrogen Fluoride (HF)	07-Days	µg/m ³	0.8	<1%	<1%	1%	<1%	1%	0%	<1%	<1%	<1%	<1%	<1%	1%	1%	1%	0%	1%
	24-Hour	µg/m ³	1.5	<1%	<1%	1%	<1%	1%	1%	<1%	<1%	<1%	<1%	<1%	1%	1%	2%	1%	1%
	30-Days	µg/m ³	0.4	<1%	<1%	1%	<1%	1%	1%	0%	1%	<1%	<1%	<1%	1%	1%	3%	1%	1%
	90-Days	µg/m ³	0.25	<1%	<1%	<1%	<1%	1%	1%	0%	1%	<1%	<1%	<1%	1%	1%	3%	1%	1%
Nitrogen dioxide (NO ₂)	1-Hour	µg/m ³	164	49%	47%	54%	53%	54%	53%	53%	52%	48%	47%	48%	54%	56%	59%	61%	58%
	Annual	µg/m ³	31	<1%	<1%	1%	1%	3%	2%	1%	1%	0%	0%	1%	3%	4%	7%	2%	2%
Lead (PB)	Annual	µg/m ³	0.5	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
PM ₁₀	24-Hour	µg/m ³	50	102%	102%	103%	102%	103%	103%	102%	103%	102%	102%	102%	103%	103%	105%	103%	103%
	Annual	µg/m ³	25	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
PM _{2.5}	24-Hour	µg/m ³	25	162%	162%	164%	163%	164%	164%	163%	163%	162%	162%	163%	164%	164%	167%	164%	164%
	Annual	µg/m ³	8	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	85%	85%	85%	84%	84%
Sulphur dioxide (SO ₂)	1-Hour	µg/m ³	215	36%	35%	38%	37%	37%	37%	37%	37%	36%	35%	36%	38%	39%	40%	42%	40%
	24-Hour	µg/m ³	57	33%	33%	38%	34%	39%	37%	34%	36%	33%	32%	34%	38%	39%	48%	41%	39%
TSP	Annual	µg/m ³	90	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Dust	Annual	g/m ² /month	4	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%

7.3 Level 2 contemporaneous assessment

Cumulative 24-hour PM_{2.5} and PM₁₀ concentrations are predicted to exceed the assessment criteria (25 µg/m³ and 50 µg/m³, respectively) at all discrete receptor locations. A *Level 2 Contemporaneous Assessment* is therefore required in terms of the *NSW EPA Approved Methods for Modelling (2022)*. In this assessment, for each pollutant, the coincident model predictions and corresponding background value were combined to derive a cumulative concentration, with the goal of proving no additional exceedances occur as a result of the project. Based on the maximum predicted 24-hour concentrations (Table 7.5), three sensitive receptors were selected for detailed assessment:

- Residential receptor R03. This receptor displayed the highest predicted PM_{2.5} and PM₁₀ project related GLCs at a residence.
- The Vineyard Early Learning Centre, (R06).
- The neighbouring Western Storage facility (R14), located within 100 m of the Riverstone WRRF, and which registered the highest predicted PM_{2.5} and PM₁₀ project related concentrations overall.

Table 7.5 Maximum predicted 24-hour particulate concentrations (µg/m³) at receptors in 2020

	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	Avg.
PM _{2.5}	0.1	0.1	0.5	0.2	0.5	0.4	0.2	0.3	0.1	0.0	0.1	0.5	0.5	1.1	0.5	0.4	0.3
PM ₁₀	0.1	0.1	0.6	0.2	0.7	0.5	0.2	0.4	0.1	0.1	0.2	0.6	0.7	1.4	0.7	0.6	0.5

The modelled project contributions presented in the following sections represent the 100th Percentile (maximum) predicted concentrations for the 24-hour average PM_{2.5} and PM₁₀.

Background (measured) concentrations were sourced from the Rouse Hill air quality station as described in Section 3.5.

Exceedances of the relevant assessment criteria are shaded in grey.

7.3.1 PM_{2.5}

Table 7.6 shows the total predicted concentration on days with the highest background, while

Table 7.7 shows the total predicted concentration on days with the highest predicted project contribution. The results show there are no additional exceedances of the 24-hour PM_{2.5} assessment criterion (25 µg/m³) as a result of the project (

Table 7.8).

Table 7.6 Top 10 PM_{2.5} concentrations measured in 2020, coincident predicted project contribution and cumulative concentration at each receptor

Top 10 measured background PM _{2.5} in 2020		Corresponding maximum project contribution at receptor (µg/m ³)			Cumulative concentration at receptor (µg/m ³)		
Concentration (µg/m ³)	Date	R03	R06	R14	R03	R06	R14
61.33	8/01/2020	8.62E-12	1.23E-03	1.27E-03	61.3	61.3	61.3
42.60	5/01/2020	4.99E-04	2.86E-03	7.16E-04	42.6	42.6	42.6
40.75	12/01/2020	0.00E+00	3.36E-02	5.75E-03	40.8	40.8	40.8
37.08	24/01/2020	2.52E-03	1.36E-01	3.05E-01	37.1	37.2	37.4
31.92	11/01/2020	5.52E-04	7.83E-02	6.10E-02	31.9	32.0	32.0
28.35	23/01/2020	5.72E-05	1.75E-06	5.46E-06	28.3	28.3	28.3
26.95	29/08/2020	1.59E-02	2.36E-03	1.11E-02	27.0	26.9	27.0

Top 10 measured background PM _{2.5} in 2020		Corresponding maximum project contribution at receptor (µg/m ³)			Cumulative concentration at receptor (µg/m ³)		
26.78	4/01/2020	3.06E-07	2.46E-09	1.76E-07	26.8	26.8	26.8
26.34	7/06/2020	3.23E-05	1.31E-01	9.82E-02	26.3	26.5	26.4
25.19	17/01/2020	7.81E-05	2.34E-03	1.00E-03	25.2	25.2	25.2

Table 7.7 Top 10 predicted PM_{2.5} concentrations, coincident measured background concentrations, and cumulative concentration at each receptor

Receptor	Top 10 predicted PM _{2.5} 24-hour project contribution at receptor (µg/m ³)	Date	Corresponding Measured PM _{2.5} (µg/m ³)	Cumulative concentration at receptor (µg/m ³)
R03	0.5	16/08/2020	2.7	3.2
	0.3	20/08/2020	2.3	2.7
	0.3	15/08/2020	3.3	3.6
	0.3	17/08/2020	2.2	2.4
	0.2	22/08/2020	1.7	2.0
	0.2	1/06/2020	2.1	2.3
	0.2	26/09/2020	2.3	2.5
	0.2	23/08/2020	1.4	1.6
	0.2	5/08/2020	2.6	2.8
	0.2	5/04/2020	3.0	3.2
R06	0.4	14/05/2020	6.9	7.3
	0.4	8/06/2020	4.6	5.0
	0.3	26/05/2020	6.1	6.5
	0.3	30/07/2020	6.1	6.4
	0.3	28/06/2020	9.3	9.6
	0.3	15/05/2020	3.9	4.2
	0.2	13/07/2020	6.7	6.9
	0.2	26/06/2020	7.3	7.6
	0.2	29/05/2020	8.9	9.2
	0.2	10/08/2020	4.7	4.9

Receptor	Top 10 predicted PM _{2.5} 24-hour project contribution at receptor (µg/m ³)	Date	Corresponding Measured PM _{2.5} (µg/m ³)	Cumulative concentration at receptor (µg/m ³)
R14	1.1	27/07/2020	0.1	1.2
	1.1	28/07/2020	2.4	3.5
	1.0	9/08/2020	2.9	3.9
	0.9	10/05/2020	3.4	4.3
	0.9	5/07/2020	6.1	7.0
	0.9	24/05/2020	2.2	3.0
	0.8	13/07/2020	6.7	7.5
	0.8	16/07/2020	3.0	3.8
	0.8	25/06/2020	4.7	5.5
	0.8	25/05/2020	3.5	4.3

Table 7.8 Number of exceedances of the PM_{2.5} assessment criterion in 2020

PM _{2.5} concentration		Number of exceedances of the 25 µg/m ³ assessment criterion
Measured background 24-hour PM _{2.5} in 2020		10
Predicted project contribution to 24-hour PM _{2.5} in 2020	R03	0
	R06	0
	R14	0
Cumulative 24-hour PM _{2.5} in 2020	R03	10
	R06	10
	R14	10

7.3.2 PM₁₀

Table 7.9 shows the total predicted concentration on days with the highest background, while

Table 7.10 shows the total predicted concentration on days with the highest predicted project contribution. The results show there are no additional exceedances of the 24-hour PM₁₀ assessment criterion (50 µg/m³) as a result of the project (

Table 7.11).

Table 7.9 Top 10 PM₁₀ concentrations measured in 2020, coincident predicted project contribution, and cumulative concentration at each receptor

Top 10 measured background PM ₁₀ in 2020		Corresponding maximum project contribution at receptor (µg/m ³)			Cumulative concentration at receptor (µg/m ³)		
Concentration (µg/m ³)	Date	R03	R06	R14	R03	R06	R14
220.3	23/01/2020	5.93E-05	1.77E-06	5.52E-06	220.3	220.3	220.3
98.3	24/01/2020	3.38E-03	1.64E-01	4.20E-01	98.3	98.5	98.7
86.0	1/08/2020	8.60E-12	1.69E-03	1.79E-03	86.0	86.0	86.0
79.9	1/05/2020	6.43E-04	4.17E-03	9.58E-04	79.9	79.9	79.9
67.2	1/04/2020	3.51E-07	2.44E-09	2.11E-07	67.2	67.2	67.2
57.6	12/10/2020	1.31E-02	7.45E-03	3.16E-02	57.6	57.6	57.6
56.4	1/12/2020	0.00E+00	4.41E-02	8.63E-03	56.4	56.5	56.5
54.3	1/11/2020	6.24E-04	9.87E-02	8.52E-02	54.3	54.4	54.4
53.3	1/01/2020	7.27E-05	3.09E-02	2.09E-02	53.3	53.4	53.4
53.2	25/01/2020	2.70E-08	9.11E-02	4.55E-02	53.2	53.3	53.2

Table 7.10 Top 10 predicted PM₁₀ concentrations, coincident measured background concentrations, and cumulative concentrations at each receptor

Receptor	Top 10 predicted PM ₁₀ 24-hour project contribution at receptor (µg/m ³)	Date	Corresponding Measured PM ₁₀ (µg/m ³)	Cumulative PM ₁₀ concentration at receptor (µg/m ³)
R03	0.6	16/08/2020	5.3	5.9
	0.4	20/08/2020	7.2	7.6
	0.4	15/08/2020	7.0	7.4
	0.4	17/08/2020	6.1	6.4
	0.3	22/08/2020	5.9	6.2
	0.3	26/09/2020	6.8	7.1
	0.3	23/08/2020	5.5	5.8
	0.3	5/08/2020	8.2	8.5
	0.3	1/06/2020	9.2	9.5
	0.2	5/04/2020	12.3	12.5

Receptor	Top 10 predicted PM ₁₀ 24-hour project contribution at receptor (µg/m ³)	Date	Corresponding Measured PM ₁₀ (µg/m ³)	Cumulative PM ₁₀ concentration at receptor (µg/m ³)
R06	0.5	14/05/2020	20.1	20.6
	0.5	8/06/2020	9.6	10.1
	0.4	26/05/2020	12.5	13.0
	0.4	28/06/2020	15.1	15.5
	0.4	15/05/2020	11.5	11.9
	0.4	30/07/2020	13.7	14.1
	0.3	29/05/2020	20.6	20.9
	0.3	5/09/2020	15.7	16.0
	0.3	13/07/2020	9.0	9.3
	0.3	26/06/2020	17.1	17.4
R14	1.4	27/07/2020	3.1	4.5
	1.3	28/07/2020	7.3	8.7
	1.3	9/08/2020	5.8	7.1
	1.1	13/07/2020	9.0	10.2
	1.1	10/05/2020	7.8	8.9
	1.1	5/07/2020	9.7	10.8
	1.1	24/05/2020	7.6	8.8
	1.1	25/05/2020	8.9	10.0
	1.1	25/06/2020	13.4	14.5
	1.0	15/07/2020	7.5	8.5

Table 7.11 Number of exceedances of the PM₁₀ assessment criterion in 2020

PM ₁₀ concentration		Number of exceedances of the 50 µg/m ³ assessment criterion
Measured background 24-hour PM ₁₀ in 2020		10
Predicted project contribution to 24-hour PM ₁₀ in 2020	R03	0
	R06	0
	R14	0
Cumulative 24-hour PM ₁₀ in 2020	R03	10
	R06	10
	R14	10

8 Conclusions

An air quality impact assessment has been conducted for proposed changes to the Riverstone WRRF approved REF. The proposed changes include the following:

- a new carbonisation plant and associated infrastructure including drying, heating and carbonisation systems; this will result in production of biochar rather than biosolids
 - no change to existing anaerobic digestion and no upgrade to waste gas burners
 - additional bioreactors and membrane bioreactors
- deletion of cogeneration unit.

Construction impacts are expected to be consistent with those previously assessed by Jacobs Group (Australia) Pty Ltd (Jacobs) for the REF (documented in: *IS373500_NWH_Riverstone_Air_Quality_Final_rev0*), and no additional assessment of construction impacts was required.

Operational impacts of the proposed changes considered NSW legislative and policy requirements of the new carbonisation plan. Considerations of the Clean Air Regulation and the Approved Methods for Modelling and Assessment of Air Quality in NSW 2022 are discussed in Section 2.2.

To aid in the understanding of the potential emissions from the proposed changes Sydney Water has prepared a technical memorandum detailing the air emissions characteristics of the carbonisation process, Appendix A. The memorandum describes the process, sources of air emissions associated with different parts of the process, available emissions control technologies, supplier emissions data and emissions data from comparable example facilities. Section 4.1.5 of this AQIA provides details on emissions control technologies and discussion of the reasonability and feasibility of Section 69 of the Clean Air Regulation specifies emissions control design requirements for residence time, temperature and destruction efficiency. Specifically, despite not being able to meet the specific design requirements of Section 69 of the Clean Air Regulation the carbonisation process is expected to achieve the intended outcomes of Section 69 of the Clean Air Regulation through sufficient destruction of toxic air pollutants to achieve compliance with Group 6 assessment criteria.

In order to maintain consistency with the REF, estimated emissions from the proposed changes have been assessed by CALPUFF dispersion model configured in the same manner as the REF Air Quality Assessment.

Dispersion modelling results indicated that the air quality environmental outcomes for all incremental and cumulative impact assessment and toxic air pollutant concentrations are predicted to remain below the relevant assessment criteria at all receptor locations, with the exception of particulate matter.

Despite the nominal contribution of the project to ambient particulate concentrations, elevated background PM₁₀ and PM_{2.5} concentrations attributed to the “Black Summer” bushfires in 2019/2020, result in cumulative 24-hour PM₁₀ and PM_{2.5} concentrations exceeding the assessment criteria (50 µg/m³ and 25 µg/m³, respectively) at all discrete receptor locations. To further understand potential particulate matter impacts due to the project a Level 2 Contemporaneous Assessment was undertaken. The environmental outcomes of the Level 2 Contemporaneous Assessment confirmed that no additional PM_{2.5} or PM₁₀ exceedances were predicted with the addition of the Project.

The predicted odour concentrations are highest at the Western Storage receptors (R13 – R16) reaching a maximum of 3.1 OU. A GLC of 1.2 OU is predicted at the Vineyard Early Learning Centre. Predicted odour concentrations at the residential receptors range from 0.4 OU to 1.5 OU and are all below the assessment criteria.

A comparison between the predicted future OU concentration contours and baseline contours reported by Jacobs (2022), showed marginal differences, attributed to variations in resolution and interpolation techniques between the modelling iterations. The impact of the carbonisation process and the Stage 2 bio- and membrane-reactors on baseline odour was therefore expected to be nominal.

In summary, the Riverstone WRRF air quality impact assessment for the REF addendum concludes the following:

- Construction dust impacts are expected to be consistent with the approved REF.
- Emissions from the proposed Carboniser plant has been shown to be able to meet the criteria set out in group 6 concentration standards for Afterburners and other thermal treatment plant, outlined in the Clean Air Regulation.
- Reasonable and feasible emissions control technologies are proposed for the new Carboniser plant and odour control units are being utilised for existing odour sources.
- Operational air quality impacts are predicted to be below all incremental and cumulative impact assessment and toxic air pollutant assessment criteria at all sensitive receptor locations, with the exception of particulate matter.
- Existing particulate matter background environment already exceeds particulate matter assessment criteria. Project contribution of particulate matter is predicted to be minor and a Level 2 Contemporaneous Assessment confirmed that no additional PM_{2.5} or PM₁₀ exceedances were predicted with the addition of the Project
- Predicted odour concentrations are below the nominated assessment criteria at all sensitive receptor locations.

Overall, the air quality environmental outcomes for the addendum REF for Riverstone WRRF is considered acceptable and will meet the intent of EPA's Approved Methods and the Protection of the Environment Operations (Clean Air) Regulation 2022.

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Appendix A

Sydney Water carbonisation air emissions
technical memorandum



“Redacted due to sensitive commercial information”

Appendix B

Supplier statement on combustion chamber design



Appendix 3



NET ZERO TECHNOLOGY

PYREG statement on combustion chamber design and suitability of our FLOX combustion to safely avoid release of persistent organic hazardous substances such as PCDD/F and PFAS via the exhaust stream.

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1. General introduction

The principle of the “2-second requirement rule” is derived by EPA from research studies made by Yamada et al. & Taylor et al. [1, 2]. When employing direct combustion methods, gases tend to traverse slowly through the feedstock grate of the combustor, characterized by minimal turbulence, sluggish gas speeds, and uneven oxygen dispersion within the feedstock [4]. Conversely, in the PYREG system, gas combustion occurs separately from the feedstock, facilitated by a high-speed burner (FLOX), inducing intense turbulence during gas mixing. The efficacy of combustion within the FLOX chamber adheres to the "3t-rule": time, temperature, and turbulence. Higher turbulence, coupled with temperatures reaching approximately 1,000°C, within a residence time of 0.7 seconds, is sufficient for the destruction of organic contaminants and PFAS.

The PYREG® system is designed and optimized for the production of Biochar. The system transforms a solid biomass into a solid product Biochar, and a process gas stream. The process-gas gets oxidized immediately in the combustion chamber after leaving the reactor and passing the process gas filter. As the filter is insulated, the process gas cannot condensate and produce environmentally dangerous tars and oil. Finally, the combustion air ratio is $0.1 < \lambda < 0.4$ in the reactors and $1.05 < \lambda < 1.2$ in the burning chamber. The exhaust from the combustion of the process gas is used to maintain the required process conditions, e.g. process temperatures. The components “combustion chamber (~ 1.000 °C)” and “PYREG® reactor” (~ 650 °C) are functionally coupled and work only in close combination and with no separation from each other. Operators can make use of PYREGs state of the art software programming to adjust settings for most of the process conditions within the ranges given below. Not only because of the commercial aspect of the plant, the production of high quality Biochars is main character of the PYREG®-technology. The complete, residue free and environmentally friendly upcycling of waste and biomasses is the goal.

Table 1: Important operating parameters of PYREG machine

Parameter	unit	values
Pressure inside reactor	Pa	50...150
Pressure exhaust fans	Pa	> 3.000
Lambda reactor		0,1...0,4
Lambda combustion		1,05...1,2
Temperature reactor	°C	500...800
Temperature combustion	°C	850...1100
Temperature exhaust (chimney)	°C	60...300

2. Residence time of 0.7 seconds

The example Figure 1.a below represents how temperature influences CO and other hydrocarbons (CxHy molecules – Kohlenwasserstoffe) degradation and underscores the importance of maintaining sufficiently high temperatures for complete combustion. In practical applications like internal combustion engines, oil, and gas firing systems, it's typically not the temperature of combustion (often exceeding 1,000°C) that limits the process, but rather the quality of the fuel and oxidizer mixture (e.g. turbulence) [3]. Residence time, turbulence (mixing), and stoichiometry (the relative mixture of waste to fuel, oxygen, and other gas-phase constituents) within the combustion zone all impact the completeness of the combustion process [5].

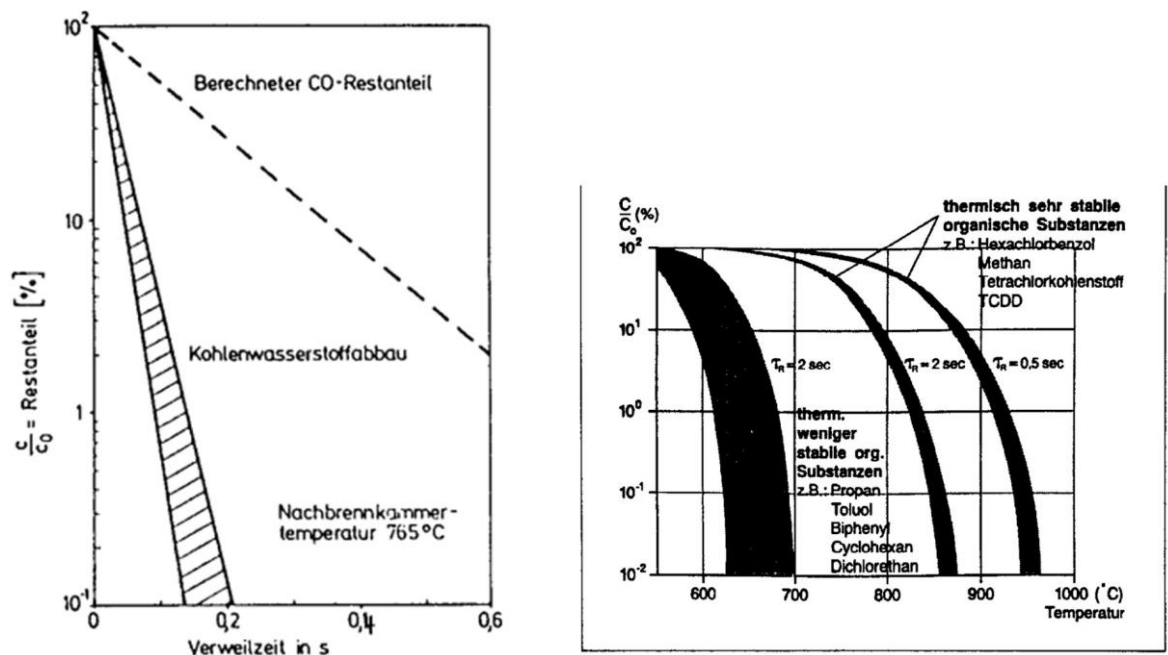


Figure 1: a) Decomposition rates of residual hydrocarbons and carbon monoxide as a function of residence time according to Leuckel and Römer [1979] [left side]. b) Thermal destructibility of various organic substances in air according to Hasberg [1989] [right side].

Figure 1.a shows that hydrocarbons as well as CO are safely destroyed within temperatures of only 765°C and a residence time of 0.7 s. The degradation of more complex hydrocarbons or other difficult carbon molecules at significantly higher temperatures can be assumed reviewing the Figure 1.b, where the degradation of TCDD (Tetrachlordibenzodioxin, also known as Seveso Poison) is reported to occur well below 0.7 seconds when combusted at ~ 1,000 °C [3].

3. Destruction of PFAS

Thermal incineration has been reported as a critical method for destroying PFAS in the Sewage sludge. Fourier transform infrared spectroscopy (FTIR) and evacuated canister grab sampling were lately used for PFAS detection in the exhaust gas [5]. Thoma et al. who detected PFAS in flue gas scrubber water of pyrolysis units run at 600°C with syngas combustion at 1020 °C [5,6].

The temperature used for thermal incineration of PFAS in carbon regeneration is usually higher than 1,000°C; however, in laboratory studies, more than 99% of PFOS is degraded at 600°C [4]. In a research study by Bioforcetech [8] on PYREG P500 reactor, they also demonstrated that it is possible to achieve PFAS and PFOA removal to non-detect levels.

Sormo et al showed significant destruction of PFAS during pyrolysis at 700–900°C. Concentrations of PFAS_{tot} in the biochar samples ranged between <LOD and 3.4 ng g⁻¹ and were thus 1-3 orders of magnitude less than the concentrations in the original feedstocks. Total PFAS-concentrations in the exhaust gas, both particle and gaseous fractions included, ranged from <LOD to 100 ng m⁻³ with a mean concentration of 50 ± 70 ng m⁻³ [6]. However, the combustion conditions are not mentioned, but a statement related to temperature and turbulence is cited below,

“The fraction of PFAS in the original organic wastes that ends up being released with the flue gas is relatively low (<3%). However, despite the fact that the emissions make up small fraction of the total mass of PFAS being treated, the total emissions from large scale operations could be significant. Considering that the complete presence and nature of degradation products in the flue gas is unknown, flue gas cleaning such as exhaust scrubbing (and AC filtration) might be necessary to avoid PFAS compounds being cycled back into the environment; alternatively, pyrolysis conditions and the pyrolysis reactor design could be optimized to either lower the formation of short chain PFAS” [6].

4. Control of organic hazardous compounds in exhaust streams

Bilitewski et al. (1985) were able to show, that higher-value hydrocarbons such as PAHs (polyaromatic hydrocarbons) and soot are formed as synthesis products in the radical-rich flame. The formation of these substances cannot be completely avoided. In some combustion processes, the formation of soot as an intermediate product is desired (e.g. in furnaces and diesel engines to release heat through radiation or in the candle for radiation in the visible range). The prerequisite to avoid these substances is the realization of a narrow residence time spectrum through a suitable design, which is attained with our FLOX combustion chamber [3].

Sormo et al have reported a similar study to several organic hazardous compounds (not including PFAS) and finding full degradation of PCDD/F, PAH and PCB:

“PCDD/F emissions from the presently studied unit were very low (≤ 2.7 pg TEQ Nm³) despite some feedstocks with relatively high Cl-contents were pyrolyzed. PAH emissions were mostly particle bound (70–100%) and total emission concentrations of \sum PAH16 (0.22–421 μ g/Nm³) were below the suggested industrial limit of 0.05 mg/Nm³) This suggests that for pyrolysis systems with condensation of pyrolysis gas and efficient post-combustion, it might not be necessary to clean the flue gas to manage PCDD/Fs, PAHs and possibly other persistent pollutants. The potential environmental impact of emissions from scaling up waste pyrolysis should however be considered in future work” [7].

Emissions Factors (EFs) measured for sludge at 600 °C in a Pyreg-500 pyrolysis unit was 20 ± 0.2 mg tonne⁻¹. In the study by Thoma et al [4], it is reported that gas-phase-PAHs accounted for 43 ± 22 % of the emitted PAHs and that the small PAHs (2–3 rings) were mainly found in this phase. In the work by Sormo et al [5], the gas phase PAH-fraction was higher (70–100 % of the total emissions), but the distribution of small (2–3 rings) and large (4 – 6 rings) PAHs (number of PAH rings between the gas and particle phase respectively) was the same. The dominance by small PAHs and gas phase emissions could be a result of conditions in the combustion chamber favoring more complete combustion (high O₂ concentration and temperature), and that larger PAHs (4 – 6 rings) are more efficiently scavenged by the pyrolysis condensate. The observed distribution is a positive effect, as the carcinogenic PAHs were mainly found in the less significant particle fraction (31 % of the total emissions) [7].

Wet scrubbers are especially efficient for scenarios when the target contaminants are associated with particles who demonstrated a reduction of 90% in emissions of dioxins from waste incinerators with high particle loads [7].

In general, the following measures are proposed to reduce organic hazardous compounds (such as PCDD / PCDF, PFAS, PAH, PCB, VOC) via the exhaust gas stream [3]:

- Complete oxidation to destroy the precursor substances or short fragments of organic hazardous compounds, as well as for the breakdown of CO and any other hydrocarbons (particulate carbon fragments, soot).
- Combustion operation with the lowest possible oxygen content (excess air).
- Dust separation as extensive as possible (□ PYREGs process gas filtration keeping dust emissions safely below 10 mg/m³).
- Dust separation post combustion (□ PYREGs pocket filter)
- Exhaust scrubbing using alkaline solvents (□ PYREGs exhaust scrubber with NaOH)
- Adsorption activated carbon (□ PYREGs AC filtration)

So, our PYREG machines with two stage carbonization process with necessary process gas filter, wet scrubber, activated carbon, and additional pocket filter enables to destroy PFAS within 0.7 seconds and meeting world-wide emission standards.

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Appendix C

Dispersion modelling results



Table C.1 Predicted pollutant concentrations at the receptor locations

Incremental results								Receptor															
Category	Substance	Period	Percentile	Type	Units	Criteria	Background	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16
IAP	CO	1HR	99.9th	CONC	µg/m3	30000	1875	2.96E+00	1.84E+00	9.05E+00	7.68E+00	9.28E+00	7.34E+00	8.50E+00	6.75E+00	1.94E+00	1.71E+00	2.89E+00	9.09E+00	1.07E+01	1.46E+01	1.41E+01	1.08E+01
		8HR	100th	CONC	µg/m3	10000	1875	2.14E+00	1.27E+00	6.00E+00	4.58E+00	8.39E+00	6.76E+00	4.79E+00	6.65E+00	1.30E+00	7.63E-01	2.01E+00	8.33E+00	9.54E+00	1.44E+01	1.17E+01	8.66E+00
	HF	24HR	100th	CONC	µg/m3	1.5	-	3.14E-03	2.66E-03	1.27E-02	4.97E-03	1.31E-02	9.58E-03	4.80E-03	7.49E-03	2.17E-03	1.52E-03	4.82E-03	1.24E-02	1.43E-02	3.03E-02	1.77E-02	1.39E-02
	NOX	1HR	99.9th	CONC	µg/m3	164	74	5.71E+00	3.59E+00	1.53E+01	1.31E+01	1.47E+01	1.21E+01	1.33E+01	1.14E+01	4.10E+00	3.42E+00	5.22E+00	1.49E+01	1.75E+01	2.30E+01	2.56E+01	2.07E+01
		Annual	100th	CONC	µg/m3	31	-	8.97E-02	1.53E-01	3.19E-01	1.61E-01	9.24E-01	7.56E-01	1.67E-01	4.39E-01	1.09E-01	9.31E-02	3.50E-01	1.05E+00	1.27E+00	2.06E+00	6.12E-01	6.94E-01
	PB	Annual	100th	CONC	µg/m3	0.5	-	8.76E-06	1.71E-05	2.97E-05	1.45E-05	8.07E-05	6.31E-05	1.36E-05	3.75E-05	1.09E-05	9.55E-06	3.53E-05	8.89E-05	1.11E-04	2.06E-04	6.44E-05	7.34E-05
	PM10	24HR	100th	CONC	µg/m3	50.0	51.0	1.38E-01	9.33E-02	6.12E-01	2.34E-01	6.52E-01	5.00E-01	2.34E-01	3.95E-01	8.56E-02	6.00E-02	1.88E-01	6.43E-01	6.91E-01	1.40E+00	7.01E-01	5.77E-01
		Annual	100th	CONC	µg/m3	25	15.4	7.50E-03	1.30E-02	2.63E-02	1.33E-02	7.57E-02	6.17E-02	1.37E-02	3.58E-02	9.12E-03	7.85E-03	2.93E-02	8.53E-02	1.04E-01	1.70E-01	5.10E-02	5.79E-02
	PM2.5	24HR	100th	CONC	µg/m3	25.0	40.5	1.06E-01	6.77E-02	4.84E-01	1.88E-01	5.39E-01	4.06E-01	1.97E-01	3.19E-01	6.37E-02	4.61E-02	1.39E-01	5.23E-01	5.47E-01	1.14E+00	5.23E-01	4.37E-01
		Annual	100th	CONC	µg/m3	8	6.7	5.65E-03	9.35E-03	2.02E-02	1.03E-02	5.93E-02	4.89E-02	1.09E-02	2.82E-02	6.81E-03	5.78E-03	2.18E-02	6.73E-02	8.12E-02	1.29E-01	3.78E-02	4.28E-02
	SO2	1HR	99.9th	CONC	µg/m3	215	74	3.25E+00	2.24E+00	7.43E+00	6.34E+00	6.32E+00	5.73E+00	5.46E+00	5.37E+00	2.60E+00	2.24E+00	3.45E+00	7.07E+00	9.10E+00	1.17E+01	1.69E+01	1.29E+01
		24HR	100th	CONC	µg/m3	57	18	9.50E-01	7.99E-01	3.84E+00	1.51E+00	3.96E+00	2.91E+00	1.45E+00	2.27E+00	6.56E-01	4.57E-01	1.45E+00	3.76E+00	4.33E+00	9.13E+00	5.35E+00	4.21E+00
	DUST	24HR	100th	DFLX	g/m2/month	4	-	2.27E-05	2.51E-05	2.14E-04	7.87E-05	2.49E-04	1.26E-04	7.30E-05	9.67E-05	2.05E-05	1.75E-05	5.28E-05	1.92E-04	2.31E-04	5.25E-04	3.56E-04	1.53E-04
		Annual	100th	CONC	µg/m3	90	-	1.12E-02	2.04E-02	3.86E-02	1.93E-02	1.09E-01	8.74E-02	1.93E-02	5.11E-02	1.37E-02	1.20E-02	4.43E-02	1.21E-01	1.49E-01	2.54E-01	7.73E-02	8.80E-02
OU	ODOR	1HR	99.0th	CONC	µg/m3	2	-	3.73E-01	2.03E-01	1.50E+00	8.44E-01	1.55E+00	1.25E+00	8.01E-01	1.23E+00	2.21E-01	2.23E-01	4.09E-01	1.58E+00	1.82E+00	2.35E+00	2.50E+00	3.06E+00
TP	AS	1HR	99.9th	CONC	µg/m3	0.09	-	3.95E-05	2.65E-05	8.98E-05	7.15E-05	8.27E-05	7.36E-05	6.79E-05	8.41E-05	3.12E-05	2.57E-05	3.94E-05	9.03E-05	1.13E-04	1.57E-04	1.95E-04	1.61E-04
		Annual	100th	CONC	µg/m3	0.007	-	6.51E-07	1.26E-06	2.09E-06	9.97E-07	6.07E-06	5.08E-06	9.59E-07	3.82E-06	8.18E-07	6.99E-07	2.69E-06	7.12E-06	9.03E-06	1.62E-05	4.44E-06	5.41E-06
	CD	1HR	99.9th	CONC	µg/m3	0.018	-	5.29E-04	3.71E-04	1.17E-03	9.38E-04	1.08E-03	9.75E-04	8.57E-04	1.14E-03	4.30E-04	3.59E-04	5.52E-04	1.21E-03	1.53E-03	2.14E-03	2.73E-03	2.22E-03
		Annual	100th	CONC	µg/m3	0.05	-	8.81E-06	1.74E-05	2.78E-05	1.32E-05	8.02E-05	6.68E-05	1.24E-05	5.12E-05	1.11E-05	9.55E-06	3.67E-05	9.39E-05	1.20E-04	2.20E-04	6.05E-05	7.39E-05
	CR	1HR	99.9th	CONC	µg/m3	0.09	-	5.72E-04	3.98E-04	1.27E-03	1.01E-03	1.17E-03	1.06E-03	9.34E-04	1.24E-03	4.63E-04	3.86E-04	5.93E-04	1.30E-03	1.65E-03	2.31E-03	2.94E-03	2.39E-03
		Annual	100th	CONC	µg/m3	0.005	-	9.51E-06	1.88E-05	3.01E-05	1.43E-05	8.69E-05	7.23E-05	1.35E-05	5.53E-05	1.20E-05	1.03E-05	3.96E-05	1.02E-04	1.30E-04	2.38E-04	6.52E-05	7.96E-05
	CU	1HR	99.9th	CONC	µg/m3	18	-	2.70E-04	1.86E-04	6.03E-04	4.74E-04	5.54E-04	4.99E-04	4.48E-04	5.88E-04	2.17E-04	1.81E-04	2.77E-04	6.14E-04	7.77E-04	1.09E-03	1.37E-03	1.12E-03
		Annual	100th	CONC	µg/m3	2	-	1.08E-04	2.18E-04	3.32E-04	1.58E-04	9.46E-04	7.85E-04	1.46E-04	6.06E-04	1.37E-04	1.19E-04	4.51E-04	1.10E-03	1.41E-03	2.62E-03	7.24E-04	8.86E-04
	HCL	1HR	99.9th	CONC	µg/m3	140	-	5.23E-02	3.82E-02	1.12E-01	9.29E-02	1.03E-01	9.50E-02	8.17E-02	1.12E-01	4.30E-02	3.67E-02	5.60E-02	1.19E-01	1.50E-01	2.12E-01	2.71E-01	2.22E-01
		Annual	100th	CONC	µg/m3	20	-	8.99E-04	1.82E-03	2.77E-03	1.32E-03	7.89E-03	6.54E-03	1.22E-03	5.05E-03	1.14E-03	9.95E-04	3.76E-03	9.18E-03	1.17E-02	2.18E-02	6.03E-03	7.38E-03
	HG	1HR	99.9th	CONC	µg/m3	1.8	-	5.14E-04	3.71E-04	1.12E-03	9.22E-04	1.04E-03	9.45E-04	8.19E-04	1.11E-03	4.23E-04	3.57E-04	5.49E-04	1.18E-03	1.50E-03	2.10E-03	2.71E-03	2.20E-03
		Annual	100th	CONC	µg/m3	1	-	8.61E-06	1.72E-05	2.69E-05	1.27E-05	7.74E-05	6.42E-05	1.18E-05	4.97E-05	1.09E-05	9.37E-06	3.60E-05	9.04E-05	1.16E-04	2.15E-04	5.92E-05	7.25E-05
	NI	1HR	99.9th	CONC	µg/m3	0.18	-	4.96E-04	3.36E-04	1.12E-03	8.87E-04	1.03E-03	9.19E-04	8.38E-04	1.07E-03	3.96E-04	3.27E-04	5.01E-04	1.13E-03	1.42E-03	1.99E-03	2.49E-03	2.04E-03
		Annual	100th	CONC	µg/m3	0.09	-	8.20E-06	1.60E-05	2.62E-05	1.25E-05	7.60E-05	6.35E-05	1.19E-05	4.80E-05	1.03E-05	8.83E-06	3.40E-05	8.91E-05	1.13E-04	2.05E-04	5.60E-05	6.83E-05
	PAH	1HR	99.9th	CONC	µg/m3	0.4	-	3.14E-05	2.29E-05	6.74E-05	5.57E-05	6.20E-05	5.70E-05	4.90E-05	6.71E-05	2.58E-05	2.20E-05	3.36E-05	7.11E-05	9.02E-05	1.27E-04	1.63E-04	1.33E-04
		Annual	100th	CONC	µg/m3	1	-	1.80E-08	3.63E-08	5.54E-08	2.63E-08	1.58E-07	1.31E-07	2.44E-08	1.01E-07	2.28E-08	1.99E-08	7.51E-08	1.84E-07	2.34E-07	4.36E-07	1.21E-07	1.48E-07

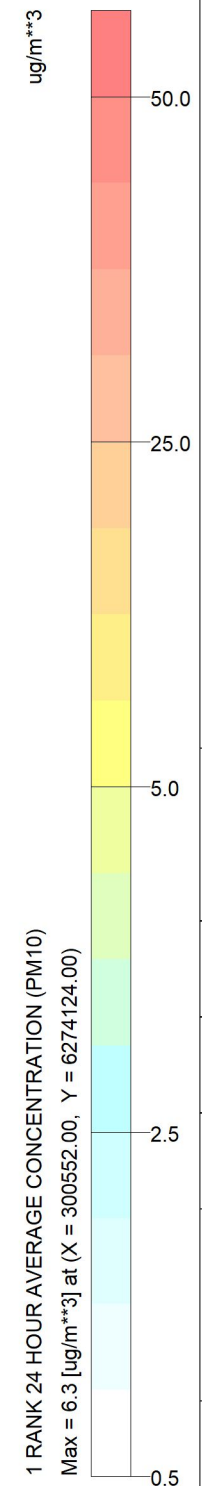
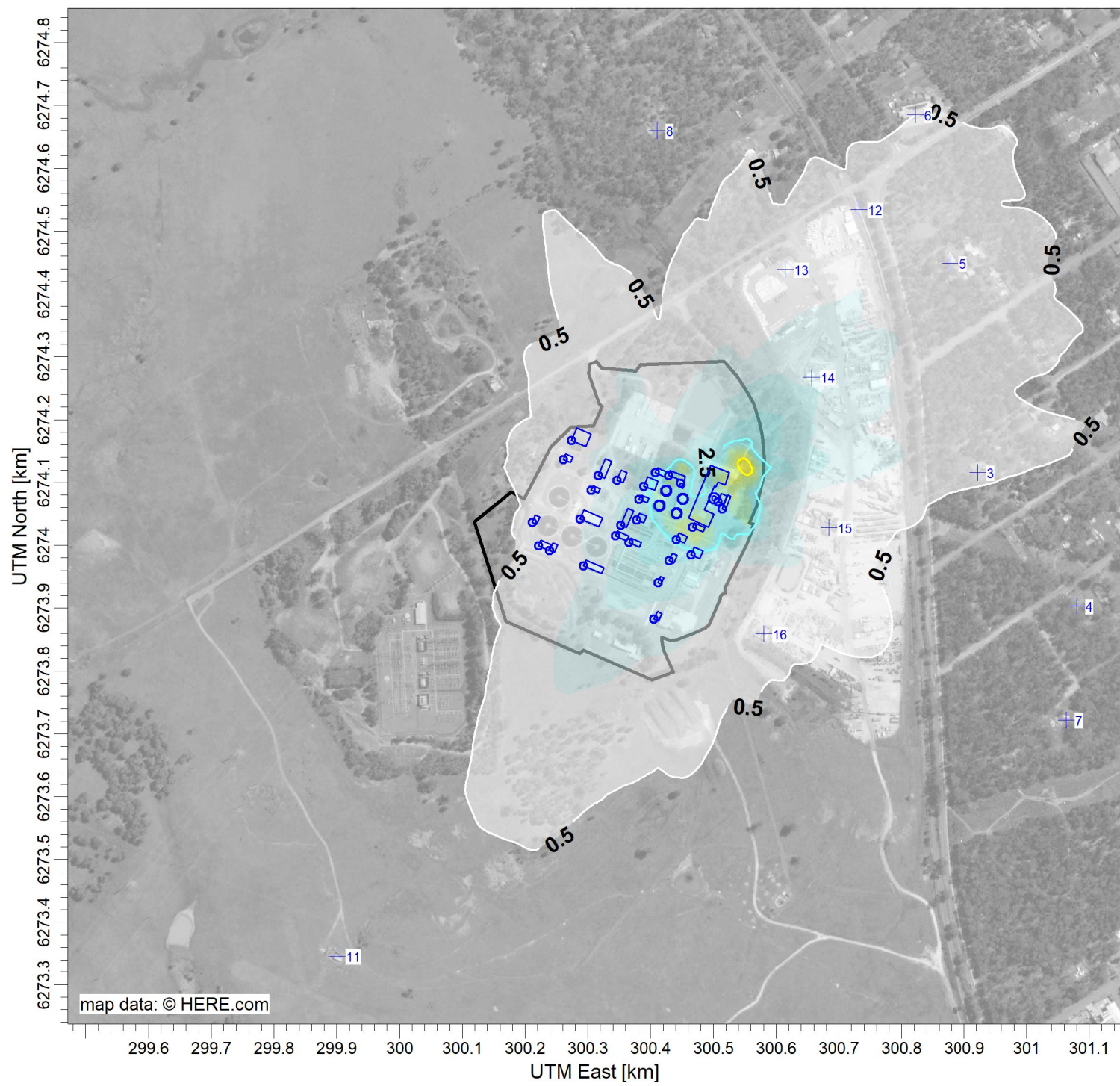
Incremental results								Receptor															
	SE	1HR	99.9th	CONC	µg/m3	2	-	1.60E-04	1.16E-04	3.50E-04	2.88E-04	3.21E-04	2.94E-04	2.53E-04	3.48E-04	1.32E-04	1.12E-04	1.72E-04	3.68E-04	4.69E-04	6.57E-04	8.45E-04	6.88E-04
	TEQ	1HR	99.9th	CONC	µg/m3	0.000002	-	5.97E-10	3.91E-10	1.40E-09	1.12E-09	1.31E-09	1.15E-09	1.11E-09	1.23E-09	4.60E-10	3.73E-10	5.85E-10	1.40E-09	1.72E-09	2.37E-09	2.79E-09	2.38E-09
		Annual	100th	CONC	µg/m3	0.00004	-	9.74E-12	1.84E-11	3.17E-11	1.53E-11	9.33E-11	7.84E-11	1.50E-11	5.78E-11	1.22E-11	1.03E-11	4.00E-11	1.10E-10	1.38E-10	2.43E-10	6.60E-11	8.02E-11
	ZN	1HR	99.9th	CONC	µg/m3	20	-	1.03E-03	6.15E-04	3.02E-03	2.69E-03	3.16E-03	2.53E-03	2.97E-03	2.39E-03	7.07E-04	5.62E-04	9.22E-04	3.12E-03	3.69E-03	4.93E-03	4.58E-03	3.92E-03
		Annual	100th	CONC	µg/m3	2	-	1.55E-05	2.41E-05	5.60E-05	2.83E-05	1.74E-04	1.50E-04	3.12E-05	9.87E-05	1.90E-05	1.53E-05	6.06E-05	2.07E-04	2.52E-04	3.80E-04	1.00E-04	1.19E-04

Appendix D

Selected contour plots



**Predicted PM10
24-Hour Average**



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM10)
 Max = 6.3 [ug/m**3] at (X = 300552.00, Y = 6274124.00)

WSP

19/03/2026

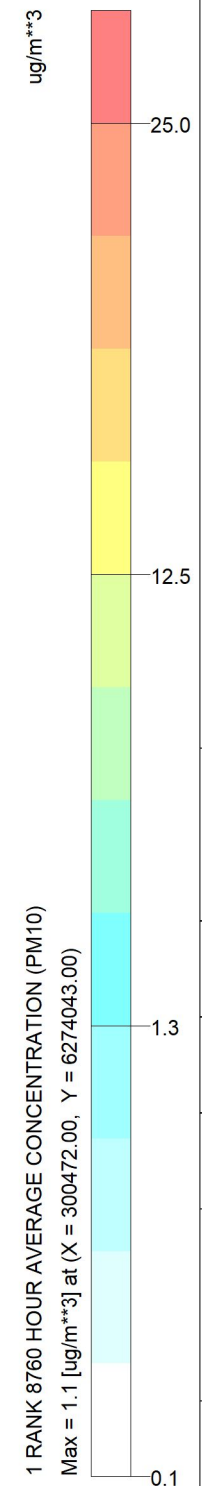
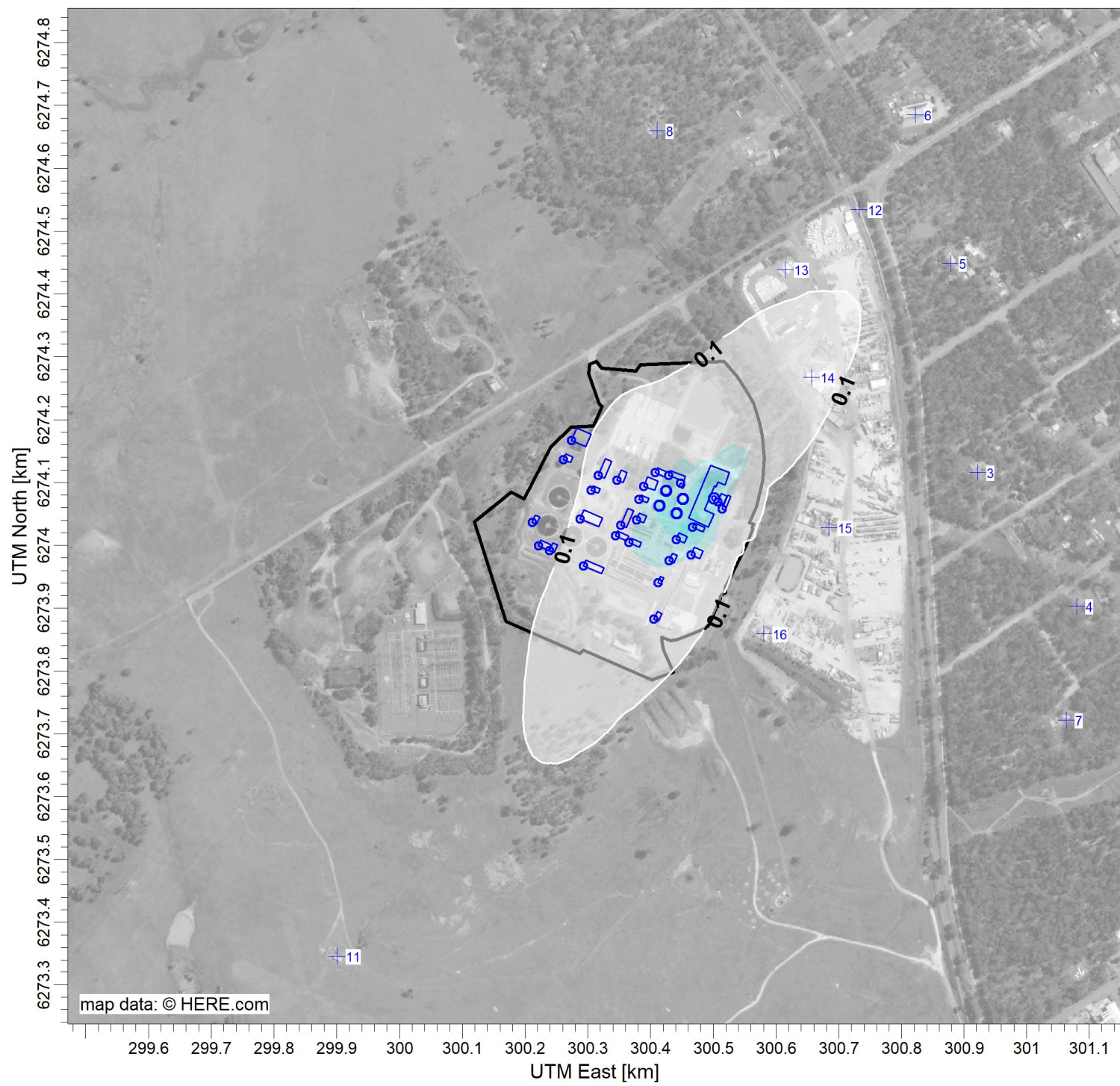
SCALE: 1:9,000
 0 0.2 km



PS209090

map data: © HERE.com

**Predicted PM10
Annual Average**



1 RANK 8760 HOUR AVERAGE CONCENTRATION (PM10)
Max = 1.1 [ug/m**3] at (X = 300472.00, Y = 6274043.00)

WSP

19/03/2026

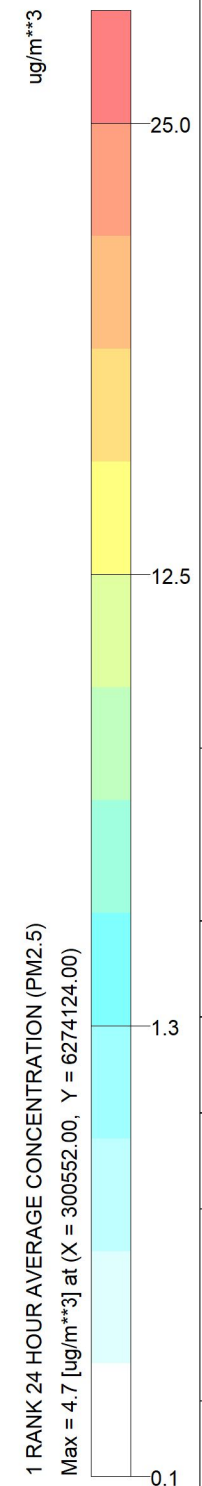
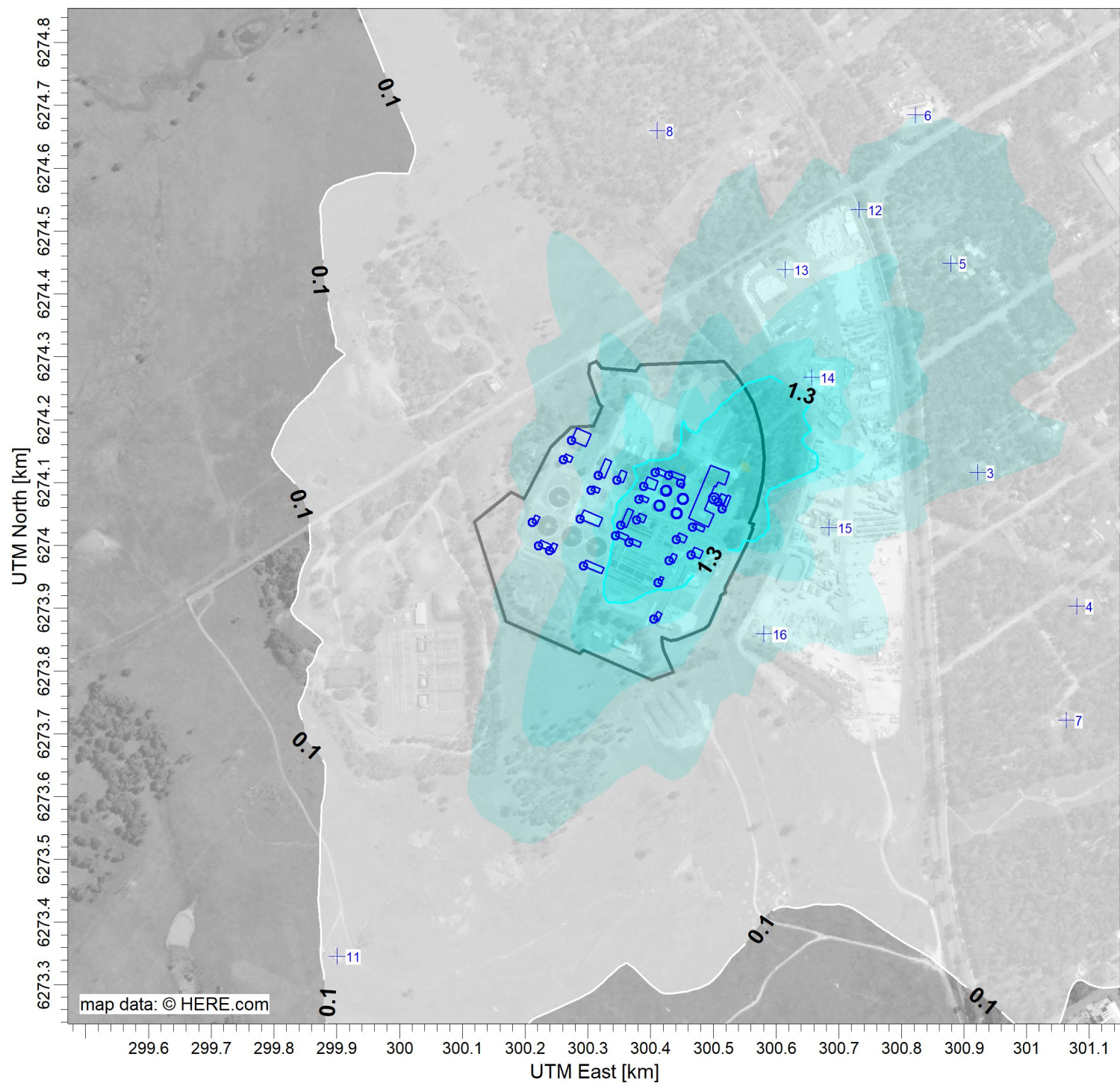
SCALE: 1:9,000



PS209090

map data: © HERE.com

**Predicted PM2.5
24-Hour Average**



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM2.5)
Max = 4.7 [ug/m**3] at (X = 300552.00, Y = 6274124.00)

WSP

19/03/2026

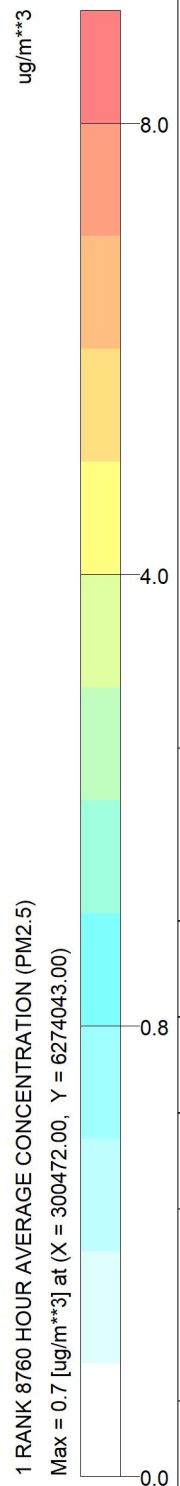
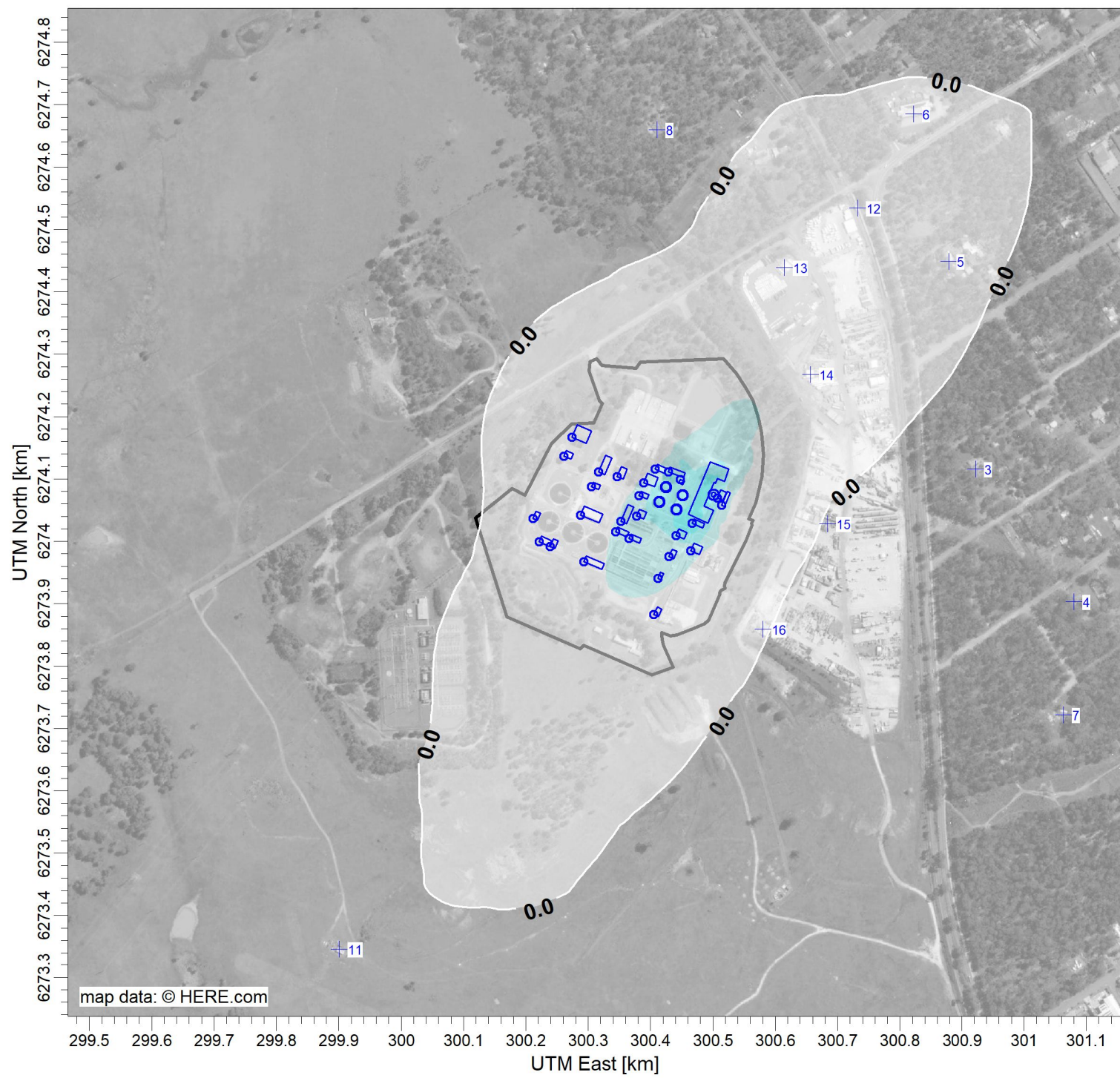
SCALE: 1:9,000
0 0.2 km



PS209090

map data: © HERE.com

**Predicted PM2.5
Annual Average**



1 RANK 8760 HOUR AVERAGE CONCENTRATION (PM2.5)
Max = 0.7 [ug/m**3] at (X = 300472.00, Y = 6274043.00)

WSP

19/03/2026

SCALE: 1:9,000

0 0.2 km

PS209090

About Us

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