HARRISON MANUFACTURING CO

Odour Emissions Review and Mitigation Assessment Study

Brookvale, New South Wales

Final Report 1.0

March 2024

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EXECUTIVE SUMMARY

In July 2023, The Odour Unit (**TOU**) was commissioned by Harrison Manufacturing Co Pty Ltd (**HMC**) to carry out an odour emissions review and mitigation study (the **Study**) of the grease manufacturing operations at 75 Old Pittwater Road, Brookvale NSW (the **Brookvale Facility**). The Study consists of six (6) phases, namely:

- **Phase 1** – Operational air emissions analysis;
- **Phase 2** – Optioneering study on future odour control options;
- **Phase 3** – Dispersion modelling to advise on a suitable performance target for the preferred odour control option and future odour impact risk profile;
- **Phase 4** – The undertaking of a detailed design of the preferred odour management option;
- **Phase 5** – Engineering, procurement, and construction management; and
- **Phase 6** – Commissioning and validation testing.

The Study includes the completion of the following milestones:

- Phase 1 was completed between September 2023 and December 2023 and is documented in a TOU report titled *Harrison Manufacturing Co - Operational Air Emissions Analysis – Brookvale, New South Wales – Final Report Revision 2* dated 10 January 2024 (the **Phase 1 Report**);
- Phase 2 was completed between December 2023 and January 2024 and is documented in a TOU report titled *Harrison Manufacturing Co - Optioneering Study on Future Odour Control System – Brookvale, New South Wales – Final Report* dated 21 January 2024 (the **Phase 2 Report**); and
- Phase 3 was completed between January 2024 and March 2024 and reflects the undertaking of an air dispersion modelling assessment to advise on a suitable performance target for the preferred odour control option and future odour impact risk profile identified in the Phase 2 Report (the **Phase 3 Study**).

The following report documents the outcomes from the Phase 3 Study in the context of the Phase 1 Report and Phase 2 Report. This approach ensures that the report for the Phase 3 Study can be adopted as a stand-alone document.

Scope of Work

The scope of work for the Phase 3 Study consists of the following components:

- The development of a site-specific dispersion model to evaluate a suitable performance target for the preferred odour control option;

- Identify whether the emissions are treated and discharged via a short or tall stack, as well as the tolerance in treatment performance (i.e., what kind of performance is acceptable to avoid nuisance beyond the boundary); and

- The completion of a site-specific air quality impact risk assessment to evaluate the efficacy and resultant improvement that can be realised from the preferred odour control option identified in the Phase 2 Report.

In summary, the dispersion modelling serves three (3) key functions in 'testing' the concept design scenario process, namely:

1. Determine if the preferred concept design is suitable from an odour impact and regulatory perspective;

2. Establish a baseline of the emissions profile for the current fume extraction and emissions management system upon which future improvement can be benchmarked. This sought to establish a future performance target criterion for the odour control option; and

3. Support the development approval submission process to the local Council and/or New South Wales Environment Protection Authority (**NSW EPA**).

Legislative Framework

The regulatory authority guidelines for odorous impacts of gaseous process emissions are not designed to satisfy a 'zero odour impact criteria', but rather to minimise the nuisance effect to acceptable levels of these emissions to a large range of odour-sensitive receptors within the local community. The documents referenced for the Phase 3 Study are as follows:

- NSW EPA document titled *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* dated January 2022 (**NSW EPA Approved Methods**);

- NSW EPA guideline document titled *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* dated August 2022 (**NSW EPA Modelling Guideline**);

- NSW EPA document titled *Technical Framework (and notes): Assessment and management of odour from stationary sources*. Sydney: Department of Environment and Conservation dated 2006 (**NSW EPA Technical F & N**);

- Barclay & Scire, 2011 titled *Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the* '*Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia*' (the **Modelling Settings**); and

- Protection of the Environment Operations (Clean Air) Regulation 2021 under the Protection of the Environment Operations Act 1997 (the **Clean Air Regulation**).

The above documents specify that the dispersion modelling for Level 3 odour impact assessments, upon which the Phase 3 Study has been conducted, be based on the use of:

- 99.0th percentile dispersion model predictions;
- 1-hour averaging times with built-in peak-to-mean ratios to adjust the averaging time to a 1-second nose-response-time;
- The peak-to-mean ratios for point and volume sources is 2.3; and
- The appropriate impact assessment criterion (**IAC**) for the target air pollutant.

Modelled Scenario

The Phase 3 Study assumed the following design basis and future treatment configuration, as documented in the Phase 2 Report:

- Treatment Stage 0;
- Treatment Stage 1; and
- Treatment Stage 2

The design scenario calculations adopted in the Phase 2 Report are summarised in **Table 1**.

Table 1 – Airflow and heat balance calculation results for the determination of the future design airflow as documented in the Phase 2 Report

Source ID	Process Airstream	Airflow (m^3/hr)	Temperature (°C)	Relative Humidity (%)	Enthalpy (kJ/kg dry air)
P1	Process Exhaust Airstream (GP1+GP2+GP3+GP8)	2,000	80	100	1,578
P2-A	Building Ventilation Air	18,000	35	50	82
P2-B			35	75	106
P2-C			35	100	130
P3-A	P1+P2-A	20,000	39.1	96	156
P3-B	P1+P2-B		41.3	100	180
P3-C	P1+P2-C		43.9	100	205

Using the design scenario analysis adopted in the Phase 2 Report, the modelled emission parameters are as follows:

- Total design airflow of 20,000 m^3/hr, based on 2,000 m^3/hr of process exhaust air and 18,000 m^3/hr of building ventilation air;
- A stack diameter of 700 mm to achieve a stack design exit velocity of 15 m/s;

- A stack discharge temperature of 40°C; and
- A total stack height of 9.69 m from ground level.

Notably, the derived values adopted from the Phase 1 Report are conservative and assume that the emission rates are continuous and constantly (24/7) at peak levels. In reality, the three (3) phases of the grease manufacturing process (including acid melt, dehydration, and shearing) occur on a batch basis at different times and durations with varying product formulations and intensity. As such, the Phase 1 Report reflects a peak emission scenario that does not reflect normal operations at the Brookvale Facility. This worst-case operating scenario was deliberately replicated to generate a conservative emissions dataset upon which to base the future treatment configuration at the Brookvale Facility.

Phase 3 Study Findings

The Phase 3 Study was conducted in order to assess the potential impacts of the operation of the Brookvale Facility with the future treatment configuration as documented in the Phase 2 Report. The Phase 3 Study incorporated site-specific meteorological data, emissions sources, and geographic representation of receptors in the surrounding receiving environment.

A site-specific meteorological data was generated using The Air Pollution Model (**TAPM**) and CALMET meteorological modelling system. A single scenario was modelled with emissions for odour, H_2S, CS_2, and a number of VOCs identified as part of the Phase 1 Report and Phase 2 Report.

The air dispersion modelling was conducted using the most recent stable version of the CALPUFF model (v7.2.1). CALPUFF was configured based on the NSW EPA guidance documents. The ground-level pollutant concentrations were predicted at identified discrete receptors and the surrounding receiving environment.

The results of the air dispersion modelling analysis indicate that:

- Predicted offsite 99th percentile one-hour odour concentrations comply with the impact assessment criteria of 2 ou;
- Predicted offsite 99th percentile one-hour H_2S concentrations comply with the impact assessment criteria of 1.38 µg/m^3;
- Predicted offsite maximum one-hour CS_2 concentrations comply with the impact assessment criteria of 70 µg/m^3; and
- Predicted offsite maximum one-hour VOC concentrations for all detected VOCs comply with their respective impact assessment criteria.

Concluding Remarks

Overall, the performance outlet targets identified as part of the Phase 3 Study indicate that the proposed odour control system developed as part of the Phase 1 Report and Phase 2 Report will mitigate future air quality and odour impact risks from the operations at the Brookvale Facility to a level where the surrounding sensitive environment will not be adversely affected.

CONTENTS

FIGURES

TABLES

ABBREVIATIONS & DEFINITIONS

Brookvale Facility	the HMC grease manufacturing plant located at 75 Old Pittwater Road, Brookvale NSW 2100
Clean Air Regulation	Protection of the Environment Operations (Clean Air) Regulation 2021 under the Protection of the Environment Operations Act 1997
HMC	Harrison Manufacturing Co Pty Ltd
IAC	impact assessment criteria
NSW EPA	New South Wales Environment Protection Authority
NSW EPA Approved Methods	NSW EPA document titled *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* dated January 2022
NSW EPA Modelling Guideline	NSW EPA guideline document titled *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* dated August 2022
NSW EPA Technical F & N	NSW EPA document titled *Technical Framework (and notes): Assessment and management of odour from stationary sources. Sydney: Department of Environment and Conservation* dated 2006
OCS	odour control system
OER	odour emission rate
P/M60	one second peak-to-mean
PG	Pasquill-Gifford
Phase 1 Report	TOU report titled *Harrison Manufacturing CO - Operational Air Emissions Analysis – Brookvale New South Wales – Final Report Revision 2* dated 10 January 2024
Phase 2 Report	the second phase of the Study, reflecting the optioneering study on future odour control options
Phase 3 Study	the third phase of the Study, dispersion modelling to advise on a suitable performance target for the preferred odour control option and future odour impact risk profile
TAPM	The Air Pollution Model

the Modelling Settings	Barclay & Scire, 2011. Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the '*Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia*'
the Study	odour emissions review and mitigation design study conducted at the Brookvale Facility by TOU
TOU	The Odour Unit

UNITS OF MEASUREMENT

°C	degree Celsius
atm	atmosphere (unit of air pressure)
d	day
h	hour
K	Kelvin (unit of temperature)
km	kilometre
kPa	kilopascals
L	litres
LAI	leaf area index
lpm	litres per minute
m	metre
m/s	metres per second
m^2	square metres
m^3	cubic metre
m^3/s	cubic metres per second
min	minute
mm	millimetre
Nm^3/s	normalised cubic metres per second (0^oC, 1 atm)
ou	odour units, as defined by AS/NZS 4323.3

ppb	parts per billion, by volume
ppm	parts per million, by volume
Sm^3/s	standard cubic metres per second (25^oC, 1 atm)
t	tonne
yr	year

CHEMICAL NOMENCLATURE

H_2S	hydrogen sulphide
CS_2	carbon disulphide
VOCs	volatile organic compounds

1 INTRODUCTION

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The following report documents the outcomes from the Phase 3 Study in the context of the Phase 1 Report and Phase 2 Report. This approach ensures that the report for the Phase 3 Study can be adopted as a stand-alone document.

1.1 PHASE 3 STUDY SCOPE OF WORKS

The scope of work for the Phase 3 Study consists of the following:

- The development of a site-specific dispersion model to evaluate a suitable performance target for the preferred odour control option;

- Identify whether the emissions are treated and discharged via a short or tall stack, as well as the tolerance in treatment performance (i.e., what kind of performance is acceptable to avoid nuisance beyond the boundary); and

- The completion of a site-specific air quality impact risk assessment to evaluate the efficacy and resultant improvement that can be realised from the preferred odour control option identified in the Phase 2 Report.

In summary, the dispersion modelling serves three key functions in ‘testing’ the concept design scenario process, namely:

4. Determine if the preferred concept design is suitable from an odour impact and regulatory perspective;

5. Establish a baseline of the emissions profile for the current fume extraction and emissions management system upon which future improvement can be benchmarked. This sought to establish a future performance target criterion for the odour control option; and

6. Support the development approval submission process to the local Council and/or New South Wales Environment Protection Authority (**NSW EPA**).

The following report documents the findings of the Phase 3 Study.

2 RELEVANT BACKGROUND AND CONTEXT

2.1 OVERVIEW OF THE PHASE 1 ANALYSIS

The following section provides an overview and commentary on the outcomes of the Phase 1 Report as they relate to the Phase 2 Study for the Brookvale Facility and is structured in the following manner:

- **Section 2.1.1** summarises the key process air contaminants from the grease manufacturing operations are summarised in; and
- **Section 2.1.2** summarises the operational odour potential; and
- **Section 2.1.3** summarises other design factors that could not be reasonably quantified.

2.1.1 Key Air Contaminants

The key process air contaminants generated from GP1, GP3, and GP8 identified in the Phase 1 Report were as follows:

- Hydrogen sulphide (**H_2S**), discussed further in **Section 2.1.1.1**;
- Carbon disulphide (**CS_2**), discussed further in **Section 2.1.1.2**, and
- Aromatic volatile organic compounds (**VOC**) are discussed further in **Section 2.1.1.3**.

Furthermore, the Phase 1 Report highlighted that GP2 has the potential to emit high concentrations of VOCs. However, this had minimal impact on the concentrations of these compounds when this process airstream converged to the common extraction duct. This effect is likely due to the small volume of gas conveyed to the common extraction duct from GP2 during a venting cycle due to condensation. As such, H_2S and carbon disulphide are the primary focus of the optioneering analysis for the Phase 2 Study, given that these gaseous compounds are well known to have low odour detection threshold concentrations.

Whilst aromatic VOCs vary in their contribution to odour potential, these compounds are known to have low solubility in water and are regulated air pollutants by the NSW EPA. As a result, the optioneering analysis for the Phase 2 Study has considered how to achieve a significant degree of removal of aromatic VOCs to minimise the risk of environmental harm and human health impacts and satisfy any applicable regulatory obligation. Alcohols, alkanes, and the other analysed sulphur compounds are readily soluble in water. As such, they impose a lower weighting in the context of the technology selection process for the optioneering analysis conducted as part of the Phase 2 Study.

2.1.1.1 Hydrogen Sulphide

H_2S is a gas with colourless, corrosive, toxic, and odorous properties. It has a distinct rotten egg-like odour that is commonly described as unpleasant at the detection and recognition concentration threshold (the lowest reported by TOU is 3 parts per billion (**ppb**) by volume). H_2S is commonly presented in a range of industrial processes, particularly where sulphur-containing materials are utilised and exposed to heat, chemical and/or biological transformation, and aqueous conditions that favour the liberation of H_2S gas. It is readily soluble in water and acts as a weak acid.

Based on the outcomes of the Phase 1 Report, H_2S was detected and quantified at concentrations that meet the requirement for air emissions treatment. The details are characterised as follows:

- H_2S was reported at a collective concentration of 52 parts per million (**ppm**). Additionally, an Acrulog instrument was utilised to monitor H_2S concentration at the common extraction duct for the duration of processing on 18 September 2023. This monitoring generated a trend that demonstrated H_2S concentration in the common extraction duct was sensitive and impacted by the different grease manufacturing stages and process conditions;

- The data collected from GP1, GP3, and GP8 indicated the process stage with the highest odour potential is the dehydration phase, accounting for approximately two-thirds of total odour generation over the duration of a grease manufacturing production cycle, with H_2S presenting as a primary air contaminant; and

- H_2S was presented at a problematical concentration, 270 ppm, during the shearing stage of GP8; and

- H_2S did not present itself as a key air contaminant from the GP2 operations.

Given these outcomes, H_2S is identified as an air contaminant of concern for the treatment of process air emissions from GP1, GP3, and GP8. As such, H_2S is considered as part of the optioneering analysis in the Phase 2 Study.

2.1.1.2 Carbon Disulphide

CS_2 is a common by-product of thermally intensive processes where organic and sulphur-containing process materials are present. CS2 has a higher odour detection and recognition threshold relative to H_2S, but it is still an odorous compound, given the measured concentrations reported in the Phase 1 Report. It is commonly characterised by a sweet/rotten-radish odour. CS_2 in gaseous form is relatively insoluble in water and has a low boiling point of approximately 46°C at atmospheric and high vapour pressure.

Based on the outcomes of the Phase 1 Report, CS_2 was detected and quantified at concentrations that meet the requirement for air emissions treatment. The details are characterised as follows:

- CS_2 was reported at a collective concentration of 47 ppm;

- GP1 – GP1 was processing Castrol SBX2 grease. CS_2 was presented at a concentration of 19 ppm during the dehydration process stage;

- GP3 – GP3 was processing Castrol Ultratak grease. CS_2 was presented at a concentration of 110 ppm during the acid melt process stage and 230 ppm during the dehydration stage;

- GP8 – On 18 September 2023, GP3 was processing Castrol premium heavy-duty grease. As per collected gas speciation data, CS_2 was presented at the following concentrations, namely:

  - 37 ppm during the acid melt stage; and

  - 19 ppm during the dehydration stage.

- CS_2 was not identified as a key air contaminant from the GP2 operations.

Similar to H_2S, CS_2 is identified as an air contaminant of concern for the treatment of process air emissions from GP1, GP3, and GP8. As such, CS_2 is considered as part of the optioneering analysis in the Phase 2 Study.

2.1.1.3 Aromatic Volatile Organic Compounds

The aromatic VOCs are gaseous compounds that are often produced as by-products from oils and/or other long-chain hydrocarbons (in this case of the Brookvale Facility, they will be associated with the additives included as part of the grease manufacturing process) in a high-temperature environment. In contrast to H_2S and CS_2, aromatic VOCs have a relatively high odour threshold but are regulated air pollutants, represent an occupational health and safety issue, and can cause harm to the environment if not adequately managed. They also generally have a relatively low solubility in water.

Based on the outcomes of the Phase 1 Report, aromatic VOCs were detected and quantified at concentrations that meet the requirement for air emissions treatment. The details are characterised as follows:

- Toluene, xylene, hexane, heptane, and trimethylbenzene derivatives were detected at notable concentrations for GP1, GP3, GP8 across the various process stages. This finding was similar for GP2;

- **GP1** – GP1 was processing Castrol SBX2 grease. Aromatic VOCs were presented at the following concentrations, reported as an aggregate of quantifiable VOCs:

  - 3-4 ppm during the acid melt stage;

  - 84-88 ppm during the dehydration stage; and

  - 27-28 ppm during the shearing stage;

- **GP3** – GP3 was processing Castrol Ultratak grease. Aromatic VOCs were presented at the following concentrations, reported as an aggregate of quantifiable VOCs:

- 125-129 ppm during the acid melt stage;
- 275-279 ppm during the dehydration stage; and
- 22 ppm during the shearing stage;

- **GP8** – GP8 was processing Castrol premium heavy-duty grease. Aromatic VOCs were presented at the following concentrations, reported as an aggregate of quantifiable VOCs:
  - 50-55 ppm during the acid melt stage;
  - 124-128 ppm during the dehydration stage; and
  - 38-43 ppm during the shearing stage.
- **GP2 knock-out drum –** GP2 was processing LM EP 680. Aromatic VOCs were presented at the concentrations of 1,500-1,503 ppm, reported as an aggregate of quantifiable VOCs during the main depressurisation of GP2; and
- **Common extraction duct** – As described in **Section 2.1.1.1,** the common extraction duct was effectively a composite sample across two (2) operational scenarios, as follows:
  - GP1, GP3 and GP8 across all process stages (acid melt, dehydration, and shearing). Aromatic VOCs in the common extraction duct were presented at concentrations of 65-70 ppm.
  - GP2 and GP3 processing LM EP 680 and Castrol Ultratak grease, respectively. Aromatic VOCs in the common extraction duct were presented at concentrations of 30-31 ppm.

It should be noted that the reported aromatic VOCs reflect a scenario where there is minimal dilution of the process airstream. In the future, as outlined in the Phase 1 Report, the process airstream flowing to the nominated odour control system (**OCS**) will reflect an airstream that is a combination of process exhaust and building ventilation air. This will deliver an improvement to the general amenity from an air quality perspective and reduce the aromatic VOC loading on a concentration basis, simplifying the design and performance demands of the future OCS. This is further discussed in **Section 2.2.1**.

2.1.2 Operational Odour Potential

The odour emissions data from GP1, GP3, and GP8 derived as part of the Phase 1 Report indicated odour concentration values that exceeded 1,000,000 odour units (**ou**) during the shearing phase for all products being processed at the time. The common extraction duct composite sample, which is considered to reflect the average concentration from all process stages over the grease production cycle, was 410,000 ou. This emissions data suggests a highly odorous process, particularly during the shearing phase. The acid melt and dehydration phases are also odorous but to a significantly lesser extent relative to the shearing phase.

Overall, the odour concentration levels reported in the Phase 1 Report are consistent with the H_2S, CS_2 and gas speciation emissions data, suggesting that the state of knowledge surrounding the key odorous compounds have been reasonably identified and correlated with specific air containments. Furthermore, the odour emission rates derived as part of the Phase 1 Report highlight the potential odour emission risk if the process exhaust air emissions are not adequately extracted and treated prior to atmospheric release.

GP2 knock-out drum was shown in the Phase 1 Report to have minimal odour generation potential, with this observation likely attributed to condensation of the condensable component of the process exhaust airstream during depressurisation and the very low volumetric displacement of the non-condensable component of the process exhaust airstream. Notwithstanding this, the influence of GP2 is considered as part of the future OCS in the Phase 2 Study.

2.1.3 Other Design Factors

As part of the Phase 1 Report, it was identified that there are other considerations for the optioneering analysis in the Phase 2 Study, including:

- The rate of deposition and fouling within the extraction air duct servicing the kettles and contactor vessel;
- The management of GP2 during active and non-active operations;
- The requirement of fresh air provision for the kettles (GP1, GP3, and GP8) in the future, given that they operate at atmospheric conditions; and
- The cleaning-in-place protocol and requirements in the future to minimise fouling effects and maintenance and improve process reliability and safety.

As such, these factors were considered as part of the concept for the optioneering analysis in the Phase 2 Report, of which an overview is provided in **Section 2.2**.

2.2 OVERVIEW OF PHASE 2 TECHNOLOGY OPTIONS REVIEW

The following section provides an overview and commentary on the outcomes of the Phase 2 Report as they relate to the Phase 3 Study for the Brookvale Facility, and is structured in the following manner:

- **Section 2.2.1** summaries the reviewed technology options for the future OCS that could be applicable to the grease manufacturing industry; and
- **Section 2.2.2** summarises the future design airflow basis for the future OCS; and
- **Section 2.2.3** summarises the recommended and preferred OCS based on the outcomes of the optioneering analysis.

2.2.1 Technology Options Review

As part of the Phase 2 Study, TOU investigated all readily available odour emission control technology that can be utilised at the Brookvale Facility. In undertaking the Phase 2 Study, TOU has drawn on the following information bases, namely:

- TOU's extensive knowledge and skills in the field of odour control design and engineering;
- A literature review of readily available technologies specific to the grease manufacturing industry; and
- Existing facilities where fats, industrial oils, and grease-laden process air streams are successfully extracted and treated.

In reviewing the possible technology options for the Brookvale Facility, it is important to consider the following key factors:

- The optimum mode of treatment including physical, chemical and/or biological;
- The solubility and dissociation of the target odorous compounds into the liquid phase or biological film boundary layer;
- The thermodynamic influences on the choice of odour control technology such as temperature and moisture control;
- The discharge configuration of the treated air;
- The required level of odour removal and air quality performance;
- The on-going operational and maintenance requirements with employed odour control technologies;
- Available real estate and constraints;
- Capital expenditure and operating expenditure versus benefit and actual performance;
- How readily established is the efficacy of the employed odour control technology in the grease manufacturing industry; and
- How reasonably practicable it is to implement at the Brookvale Facility.

The above factors are considered for the purpose of undertaking an optioneering analysis of the various technologies.

2.2.2 Future Design Airflow Specification

The design airflow for the future OCS is based on achieving the following objectives at the Brookvale Facility:

- Cooling of the process airstream;
- Provide a level of mechanical ventilation air extraction to improve the internal building airspace of the grease manufacturing process area; and
- Reduce the inlet concentration loading prior to air emissions treatment.

The highest process exhaust air temperature during the Phase 1 Report was approximately 80ºC, recorded immediately upstream of the main extraction fan on the common extraction duct. With this in mind, and as part of a conservative approach, TOU has assumed the following in its determination of a design airflow for the future OCS, namely:

- The process exhaust air temperature will remain at 80 degrees Celsius (**ºC**) throughout the acid melt, dehydration, and shearing phases of a typical grease manufacturing production cycle;
- GP1, GP3 and GP8 are always in active operation;
- GP2 is always venting;
- The combined process exhaust air extraction will be 2,000 cubic metres per hour (m^3/hr) at 80ºC and saturated conditions; and
- The building ventilation air is 35ºC at 50%, 75% and 100% relative humidity. Based on the nearest metrological recording, this assumption is inherently conservative. As such, the potential for adiabatic cooling through dilution is expected to be greater in magnitude than that reported in the Phase 2 Study Report.

Based on these assumptions, the expected total design airflow of the future odour control will likely be up to 20,000 m^3/hr, based on 2,000 m^3/hr of process exhaust air and 18,000 m^3/hr of building ventilation air. This will be ratified as part of the engineering design process to ensure that the ratio of process exhaust air to building ventilation air will deliver the required outcomes, including minimisation of fugitive emissions from the kettles/contactor vessel and improvement of the air quality within the building airspace of the grease manufacturing process area. However, the total design airflow is not anticipated to change, given the conservative assumptions adopted in its determination.

2.2.3 Recommended OCS

Based on the technology review outcomes, the following technology options should be considered for adoption as part of the future OCS for the management of the process air emissions from the grease manufacturing operations at the Brookvale Facility:

1. **Treatment Stage 0:** Pre-treatment with a purpose-designed gas separator in the form of a knock-out drum downstream of each process unit and prior to entry into the future central header duct. The function of the knock-out drum will be to remove condensate and aerosol entrainment prior to flowing to the future central

header duct. The knock-out drum will require regular blowdown, draining, and/or cleaning of settled deposits and liquid. The potential design configurations for the pre-treatment stage could include:

   a. A central knock-out drum to service all connected process vessels. For a combined process design airflow of 2,000 m^3/hr, the knock-out drum could require a diameter of 800-1,000 millimetres (**mm**) and a height of up to 1-2 metres (**m**); or

   b. An individual knock-out drum to service each process vessel. For a design airflow of 500 m^3/hr per process extraction point, the knock-out drum will likely require a diameter of 400-500 mm and a height of up to 1-2 m.

2. **Treatment Stage 1:** Primary treatment via a single-stage chemical scrubbing system that involves water dosed with caustic and/or an oxidant as the scrubbing liquor. This is currently in use in various industries requiring odour and particulate matter removal. This option is considered the preferred treatment technology for the Brookvale Facility, based on the identified air containments and concentration loadings, space constraints, variability in process operations, existing infrastructure, operability, and ability to retrofit a secondary treatment stage if required (such as a biofilter). For a design airflow of approximately 20,000 m^3/hr, the scrubber system will likely consist of the following preliminary design specifications and features:

   a. A counter-current vertical flow scrubber with a packed column;

   b. A vessel diameter specification of approximately 1.8 – 2.0 m, with an overall height of 7-8 m;

   c. A fully automated system that regulates the scrubbing liquor quality and bleed;

   d. A hydrocyclone separator to treat the spent scrubbing liquor prior to further treatment or trade waste discharge. This will likely require a buffer tank for temporary storage of the drained scrubbing liquor. The buffer tank can be connected to the OCS to manage odour emissions from this point; and

   e. An outlet for atmospheric release via a suitably designed discharge stack (refer to Treatment Stage 2); and

   f. A provision for a stack by-pass to enable flow to a secondary treatment stage, if required (refer to Treatment Stage 3).

3. **Treatment Stage 2:** Secondary treatment via initial plume dispersion. Following primary treatment via the wet scrubber, the treated airstream will discharge via a suitably designed discharge stack. The discharge stack will likely consist of a diameter of approximately 650-700 mm to achieve a discharge velocity of 15

metres per second (**m/s**). The height of the stack will ideally be 1-2 m higher than the grease manufacturing process building. The final stack velocity and height is ratified as part of the Phase 3 Study;

4. **Treatment Stage 3:** If deemed necessary, secondary treatment via a biofilter. A biofilter is considered to be the preferred secondary treatment technology for the Brookvale Facility prior to atmospheric discharge. This technology is well-proven and readily used for the effective management of VOCs and odour. For a design airflow of approximately 20,000 m^3/hr, the scrubber system will likely consist of the following preliminary design specifications and features:

    a. A total footprint of 150-180 square metres (**m^2**). TOU understands this might represent a challenge given the available real estate at the Brookvale Facility; and

    b. Open-bed design with direct discharge to atmosphere.

5. **Treatment Stage 4:** An advanced oxidation system could be adopted in the central ducting to provide an initial level of air emissions treatment prior to flowing to the wet scrubber system. The design configuration can include the retrofit of an ozone generator at the furthest end of the future central header duct to enable good mixing and contact time. This may also provide a level of cleaning-in-place in the upstream ducting.

All wetted parts for the future OCS will be 304 stainless steel or higher grade.

3 LEGISLATIVE FRAMEWORK

3.1 REGULATORY FRAMEWORK

The regulatory authority guidelines for odorous impacts of gaseous process emissions are not designed to satisfy a 'zero odour impact criteria', but rather to minimise the nuisance effect to acceptable levels of these emissions to a large range of odour sensitive receptors within the local community. The documents referenced for the Phase 3 Study are as follows:

- NSW EPA document titled *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* dated January 2022 (**NSW EPA Approved Methods**);
- NSW EPA guideline document titled *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* dated August 2022 (**NSW EPA Modelling Guideline**);
- NSW EPA document titled *Technical Framework (and notes): Assessment and management of odour from stationary sources*. Sydney: Department of Environment and Conservation dated 2006 (**NSW EPA Technical F & N**);
- Barclay & Scire, 2011 titled *Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the* '*Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia*' (the **Modelling Settings**); and
- Protection of the Environment Operations (Clean Air) Regulation 2021 under the Protection of the Environment Operations Act 1997 (the **Clean Air Regulation**).

The above documents specify that the dispersion modelling for Level 3 odour impact assessments, upon which Phase 3 Study has been conducted, be based on the use of:

- 99.0th percentile dispersion model predictions;
- 1-hour averaging times with built-in peak-to-mean ratios to adjust the averaging time to a 1-second nose-response-time;
- The peak-to-mean ratios for point and volume sources is 2.3; and
- The appropriate impact assessment criterion (**IAC**) for the target air pollutant.

3.2 CLEAN AIR REGULATION

The potential environmental impacts of proposed developments in New South Wales are primarily regulated under the Clean Air Regulation. The emissions limit relevant to the Brookvale Facility is listed in *Schedule 2 Standards of concentrations for scheduled premises (afterburners and other thermal units)* of the Clean Air Regulation. Any afterburner or other thermal treatment plant treating air impurities that originate from material not containing any principal toxic air pollutant have a defined standard of concentration of 40 milligrams per cubic metre (**mg/m³**) of VOC as n-propane equivalent.

3.3 Determination of Impact Assessment Criteria

3.3.1 Odour

The IAC for complex mixtures of odours is designed to include receptors with a range of sensitivities. Therefore, a statistical approach is used to determine the acceptable ground level concentration of odour at the nearest sensitive receptor. This criterion is determined by the following equation outlined on page 35 of the NSW EPA Modelling Guideline:

$$IAC = \frac{log_{10}(p) - 4.5}{-0.6}$$

Equation 3.1 – The IAC equation as prescribed by NSW EPA

where**:**

- **IAC** = impact assessment criterion (ou)
- ***p*** = population

Table 3.1 - Impact assessment criteria for complex mixtures of odorous air pollutants (99%, P/M60)

Population of affected community	Impact assessment criteria for complex mixtures of odorous air pollutants (ou)
Urban Area (≥ ~2000) and/or schools or hospitals	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single rural residence (~2)	7.0

Source: *Table 18* of the NSW EPA Modelling Guideline

Based on **Equation 3.1**, **Table 3.1** outlines the odour performance criteria for six different affected population density categories and is reproduced from the NSW EPA Modelling Guideline. It states that higher odour concentrations are permitted in lower population density applications. The Odour IAC for the Phase 3 Study is 2.0 ou (99%, P/M60) as required for an urban area.

3.3.2 Hydrogen Sulphide

The **IAC** for H_2S is designed to include receptors with a range of sensitivities. This criterion is determined by the following equation outlined on page 33 of NSW EPA Modelling Guideline:

$$IAC = \frac{log_{10}(p) - 4.5}{-0.87}$$

Equation 3.2 – The IAC equation as prescribed by NSW EPA

where:

- **IAC** = Impact Assessment Criterion (µg/m^3)
- ***p*** = population

Table 3.2 - Impact assessment criteria for H_2S (99%, P/M60)	
Population of affected community	**Impact assessment criteria (µg/m^3)**
Urban Area (≥ ~2000) and/or schools or hospitals	1.38
~500	2.07
~125	2.76
~30	3.54
~10	4.14
Single rural residence (~2)	4.83

Source: *Table 17* of the NSW EPA Modelling Guideline

Based on

Equation 3.2, Table **3.2** outlines the H_2S performance criteria for six (6) different affected population density categories and is reproduced from the NSW EPA Modelling Guideline. It states that higher H_2S concentrations are permitted in lower population density applications. The H_2S IAC for the Phase 3 Study is 1.38 µg/m^3 (99%, P/M60) as required for an urban area.

3.3.3 Carbon Disulphide

The impact assessment criteria for carbon disulfide in New South Wales is 70 µg/m³ (0.023 ppm) as specified in the Clean Air Regulation.

3.3.4 Volatile Organic Compounds

The IAC for VOCs that is relevant to the Brookvale Facility is detailed in **Table 3.3**.

Table 3.3 - Impact assessment criteria for VOC's

Substance	Impact assessment criteria (µg/m³)
Ethanol	2,100
Acetone	22,000
Methyl Ethyl Ketone	3,200
Hexane	3,200
Hexane	19,000
Benzene	290
Cyclohexane	19,000
Toluene	360
m-& p-Xylene	190
o-Xylene	190
4-ethyl toluene	360

Source: *Tables 7.2a, 7.2b, and 7.4a* - NSW EPA Modelling Guideline

4 AIR DISPERSION MODELLING

4.1 OVERVIEW

The potential impacts from the future OCS stack outlined in **Section 5** were assessed based on a dispersion modelling study that incorporates source characteristics, odour emission rates, local meteorology, and geographical features in the surrounding environment. The CALPUFF dispersion model was used to predict the target air pollutant concentrations at sensitive receptors and the surrounding receiving environment, as outlined in **Section 3.3**.

4.2 METEOROLOGICAL DATA

The site-specific meteorological dataset required to drive the CALPUFF dispersion model was developed using the TAPM prognostic model and the CALMET diagnostic model. The three-dimensional wind field produced by TAPM/CALMET was then used to create a meteorological file suitable for use with the CALPUFF dispersion model.

4.2.1 TAPM Prognostic Model

TAPM is a prognostic meteorological model widely used in Australia to predict 3D meteorological conditions at varying scales. TAPM solves the fundamental fluid dynamics equations to predict meteorology at a mesoscale (20 kilometres (**km**) to 200 km) to a local scale (resolution of hundreds of meters). TAPM includes parameterisations for cloud/rain micro-physical processes, urban/vegetation canopy and soil, and radiative fluxes.

TAPM uses synoptic meteorological information for the region, generated by a global using observations from multiple weather stations gridded to an approximate resolution of 75 km. This synoptic information is used in conjunction with surrounding terrain, land use, soil moisture content, and soil type to simulate the meteorology of a region as well as a specific location.

Where required, terrain and land-use data generated from the TAPM default database were improved. This included a visual analysis of available imagery and more complex methods using spatial analysis and techniques based on GIS (Geographic Information Systems).

TAPM (version 4.0.5) was configured as follows:

- modelling period for one year from 1 January to 31 December 2019
- 33 x 33 grid points with an outer grid of 30 km and nesting grids of 10 km, 3 km, and 1 km;
- 35 vertical levels from 10 m to 8 km;
- grid centred near the Brookvale Facility (latitude –33° 46’ 00”, longitude 151° 16’ 00”);

- terrain data for the two innermost nests customised using SRTM 90-m (version 4.0) dataset (CGIAR, 2004);
- land use data customised using the Australian Land Use and Management Classification Version 8 (ACLUMP, 2016);
- coastal delineation improved where required; and
- soil and leaf area index (**LAI**) improved based on coastal delineation.
- no data assimilation

All settings comply with the NSW EPA Modelling Guideline.

4.2.2 CALMET Meteorological Model

CALMET is an advanced non-steady-state diagnostic 3D meteorological model typically used as the meteorological pre-processor for the CALPUFF dispersion model. CALMET is capable of reading hourly meteorological data from single or multiple sites within the modelling domain. CALMET can also be initialised with gridded 3D data from prognostic models such as TAPM. This can improve dispersion model output, particularly over complex terrain, as the near-surface meteorological conditions are calculated for each grid point.

CALMET was used to simulate meteorological conditions in the region, using a combination of surface observations and TAPM-generated 3D meteorological data in hybrid mode. The modelling domain is shown in **Figure 4.1**, which was selected to include the BoM station at Terry Hills (station Id 066059) and the EPA monitoring station at Macquarie Park. These two sites were used as surface stations in the CALMET configuration. Hourly meteorological data collected at these sites were used in conjunction with the gridded TAPM 3D wind field data from the innermost nest. CALMET treats the prognostic model output as the initial guess field for the CALMET diagnostic model wind fields. The initial guess field is then adjusted for the kinematic effects of terrain, slope flows, blocking effects and 3D divergence minimisation.

CALMET was configured in accordance with modelling and assessment guidelines detailed in the NSW EPA Guideline 2017 and Further CALPUFF Guidance 2011. CALMET (version 6.5.0) was configured as follows:

- modelling period for one year from 1 January to 31 December 2019;
- domain area of 101 by 81 grid points at 200 m spacing;
- Twelve vertical levels set at 20 m, 40 m, 80m, 160 m, 320 m, 640 m, 1000 m, 1500 m, 2000 m, 2500 m, and 3000 m;
- Extrapolation of surface station information using similarity theory, ignoring layer 1 data;
- Elevation data customised using SRTM 90-m (version 4.0) dataset (CGIAR, 2004);

- Land use data customised using the Australian Land Use and Management Classification Version 8 (ACLUMP, 2016)
- Terrain radius of influence set at 10 km;
- Hybrid mode using surface observations and prognostic wind fields generated by TAPM input as MM5/3D.dat at upper air as initial guess field;
- Relative weighting of the first guess field and observations in the surface layer (R1) set to 3 km;
- Relative weighting of the first guess field and observations in the layers aloft (R2) set to 4 km;
- Maximum radius of influence over land in the surface layer (RMAX1) set to 5 km;
- Maximum radius of influence over land aloft (RMAX2) set to 7km; and
- All other options set to default.

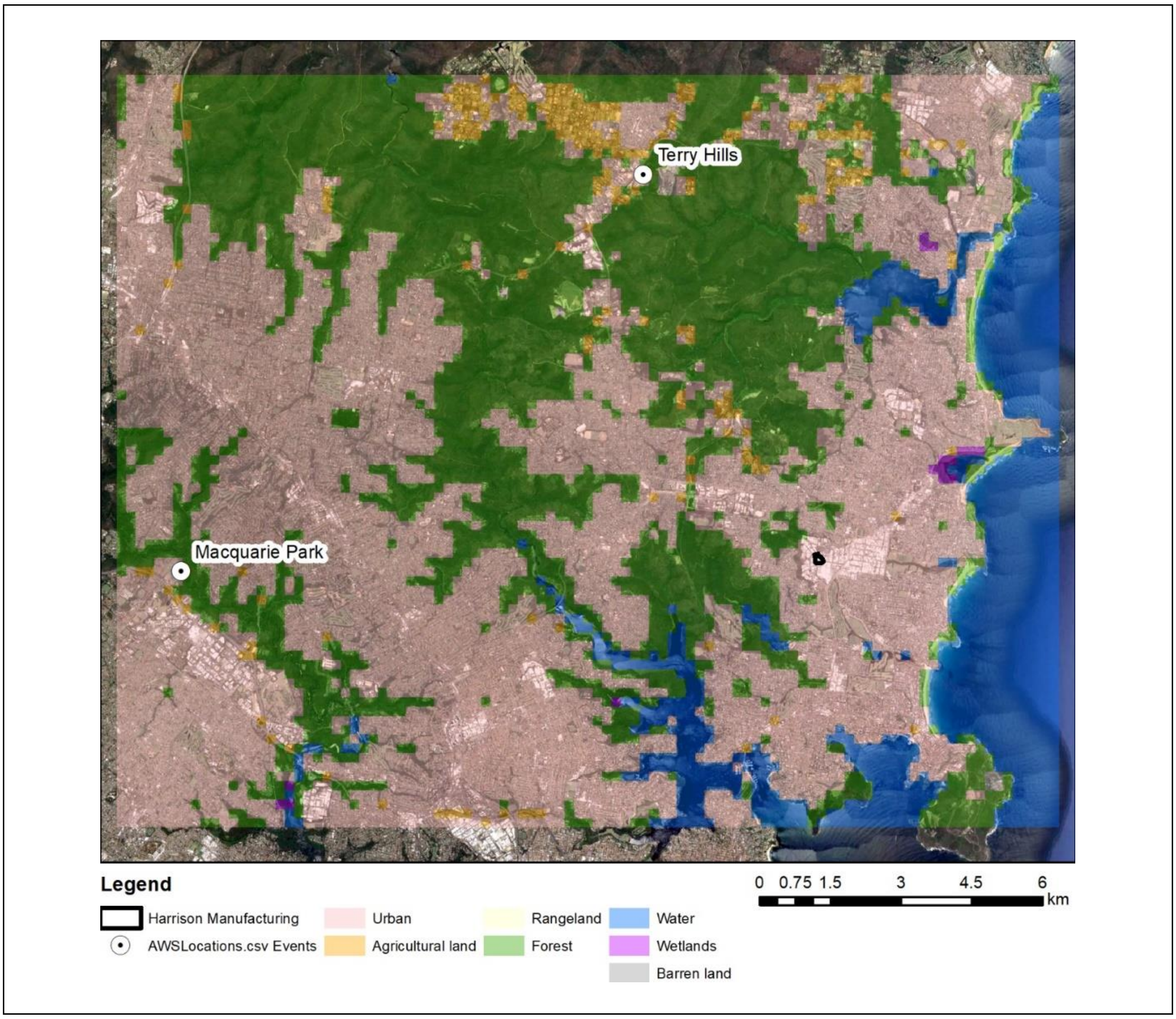

Figure 4.1 – Land use dataset as adopted in the Phase 3 Study

4.3 DISPERSION METEOROLOGY

This section presents an analysis of the site-specific meteorological data generated by the TAPM/CALMET meteorological modelling system. Analysis of meteorological parameters critical to the dispersion of pollutants at the locations of the proposed facilities is presented in the following sections.

4.3.1 Wind Speed and Direction

The wind speed and wind direction are important meteorological parameters that drive the dispersion of air pollutants. Distributions of winds predicted at the Brookvale Facility are presented in **Figure 4.2**. **Figure 4.2** shows that moderate winds (2 to 4 m/s) from the north to north-eastern sectors (N to NE) occur approximately 15% of the time, and winds from the west (SW to NW) occur approximately 21% of the time. Winds above 4 m/s generally come from the western sectors. The calm winds are infrequent, occurring less than 2% of the time. Strong wind speeds are also infrequent. The seasonal wind roses are shown in **Figure 4.3**, showing that light to moderate winds from the north-eastern sectors occur most frequently during summer but are also frequent during autumn and spring. The western winds occur most frequently in winter but may also occur during autumn and spring.

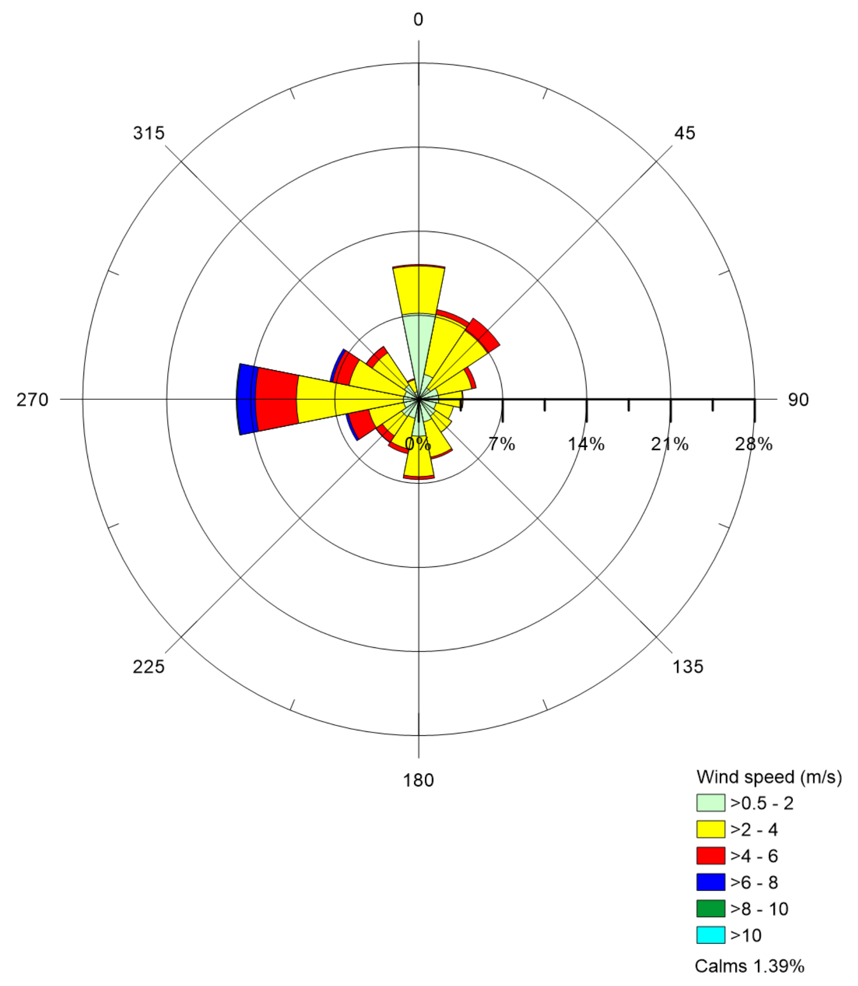

Figure 4.2 - Summary of wind distribution at the Brookvale Facility

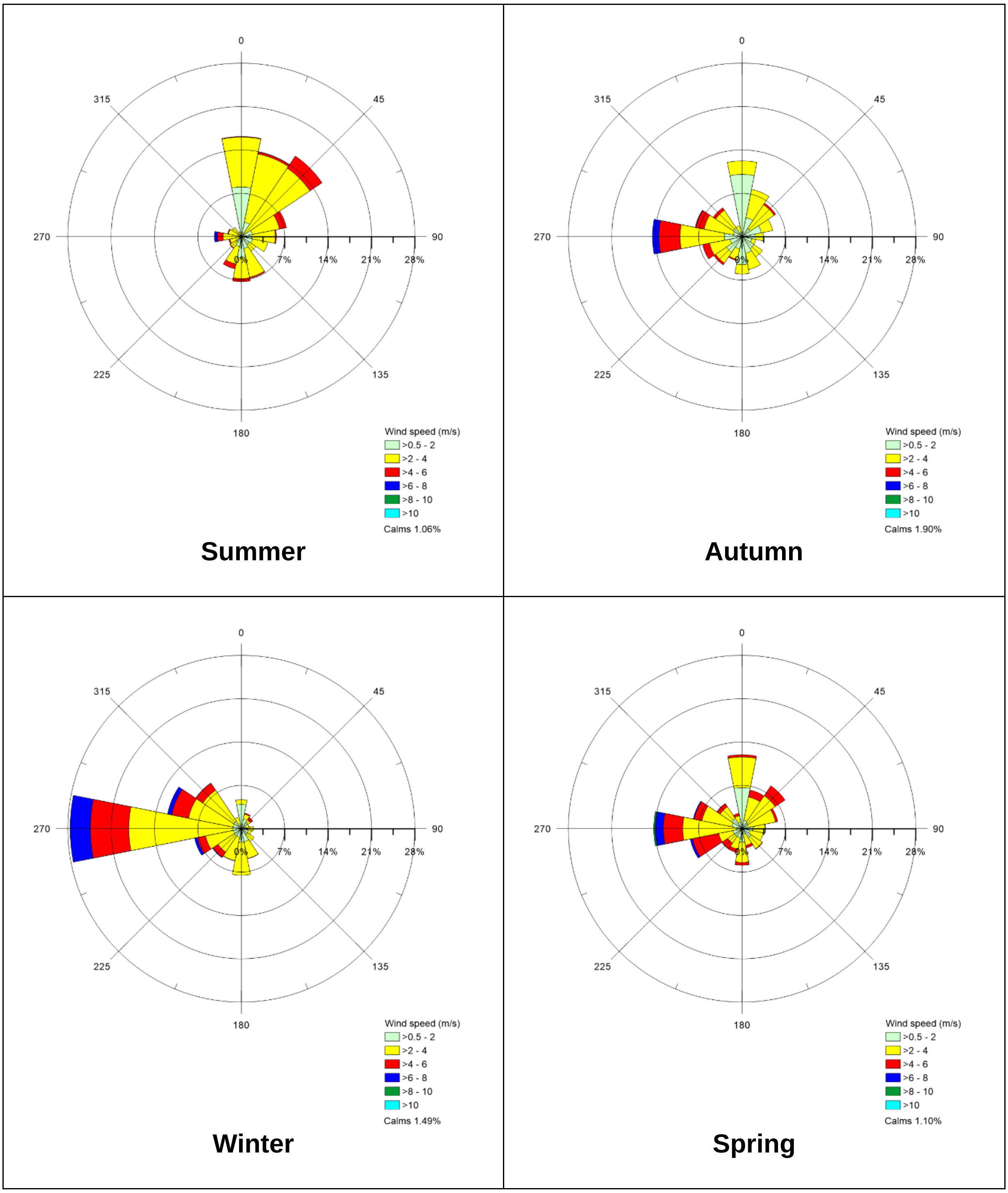

Figure 4.3 - Seasonal distribution of wind at the Brookvale Facility

4.3.2 Atmospheric Stability

The flow of air in the planetary boundary layer (the lowest one kilometre of the atmosphere) is an important factor in the dispersion of air pollutants. This flow is affected by turbulence, which describes the vertical and horizontal motion of air and how a plume may be spread out and diffused. The rate of plume diffusion is proportional to turbulence. Lower diffusion rates resulting from low turbulence results in higher concentrations in the plume.

Turbulence is driven by thermal and mechanical influences as the atmosphere interacts with the land surface. Thermally driven turbulence is generated by convection as the sun heats the ground and the air above it is warmed, causing it to rise. Mechanically driven turbulence is generated by frictional effects as wind passes over the surface or by wind shear, produced at the boundary of two coinciding layers of wind or two different air masses.

A key indicator of thermally driven turbulence or convection in the atmosphere is stability, which is measured by the environmental lapse rate or vertical temperature profile of the atmosphere. Stability is a term applied to the properties of the atmosphere that govern the acceleration of the vertical motion of an air parcel. The acceleration is positive in an unstable atmosphere (turbulence increases), zero when the atmosphere is neutral, and negative (deceleration) when the atmosphere is stable (turbulence is suppressed). The vertical temperature gradient in the atmosphere governs whether a parcel of air or plume, released into it will rise, fall, disperse, or remain relatively still. Plume warmer than the surrounding will tend to rise, while a plume cooler than the atmosphere will sink. Wind, or horizontal air movement, affects mechanical turbulence and therefore also affects atmospheric stability. As the wind speed increases, atmospheric stability will tend toward neutral conditions.

Atmospheric stability is commonly defined in terms of six main stability classifications. This is known as the Pasquill-Gifford (**PG**) stability classification and is widely used to describe the turbulent state of the atmosphere. The stability classes range from A Class, which represents very unstable atmospheric conditions that may typically occur on a sunny day, to F Class stability which represents very stable atmospheric conditions that typically occur during light wind conditions at night.

Unstable conditions (Classes A-C) are characterised by strong solar heating of the ground that induces turbulent mixing in the atmosphere close to the ground, and usually results in material from a plume reaching the ground closer to the source than for neutral or stable conditions. This turbulent mixing is the main driver of dispersion during unstable conditions. Dispersion processes for neutral conditions (Class D) are dominated by mechanical turbulence generated as the wind passes over irregularities in the local surface, such as terrain features and building structures. During the night, the atmospheric conditions are neutral or stable (Class D, E and F). During stable conditions, plumes from fugitive releases will be subject to minimal atmospheric turbulence. A plume released below an inversion layer during stable conditions that has insufficient vertical momentum or thermal buoyancy to penetrate the inversion will be trapped beneath it and result in elevated ground-level concentrations.

Atmospheric stability classes were derived from the meteorological dataset generated by the TAPM/CALMET meteorological modelling system. The frequency distribution of the PG classes by time of day at the site location is presented in **Figure 4.4**.

Figure 4.4 shows that neutral D classes are most common and occur at any time of the day. PG Class C are also common during the day. At night, E and F classes occur as frequently.

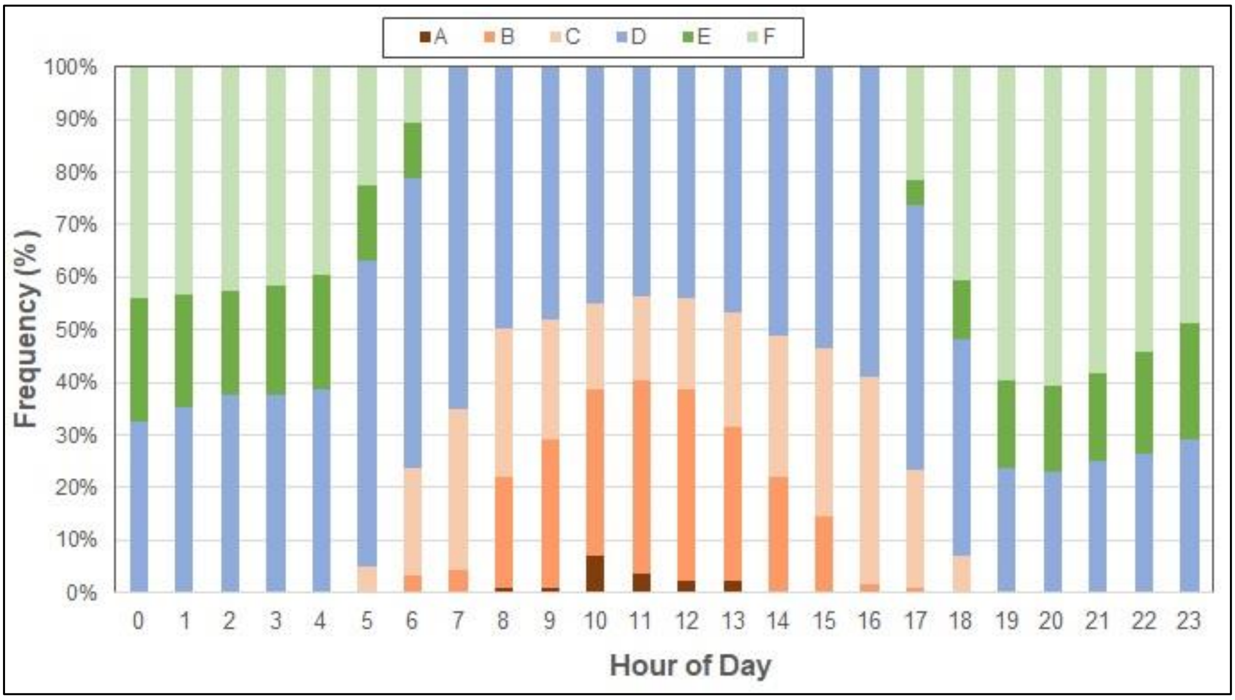

Figure 4.4 - Diurnal distribution of atmospheric stability classes

4.3.3 Mixing Height

The mixing height refers to the height above ground within which pollutants released at or near ground can mix with ambient air. During stable atmospheric conditions at night, the mixing height is often quite low, and pollutant dispersion is limited within this layer. During the day, incoming short-wave solar radiation from the sun heats the ground, which in turn re-radiates long wave radiation back into the atmosphere, heating the air above it. The heating of the air near the ground generates the growth of convection cells causing the air, and hence the mixing height, to rise. The air above the mixing height during the day is generally cooler. The growth of the mixing height is dependent on how well the air can mix with the cooler upper levels of air and therefore depends on turbulence, i.e. meteorological factors such as the intensity of solar radiation and wind speed. During strong wind speed conditions, the air will be well mixed, resulting in a high mixing height.

The hourly profile of the mixing height predicted by CALMET is shown in **Figure 4.5**. **Figure 4.5** shows that the mixing height develops around 0700 hrs, increases to a peak around midday before beginning descent at 1600 hrs.

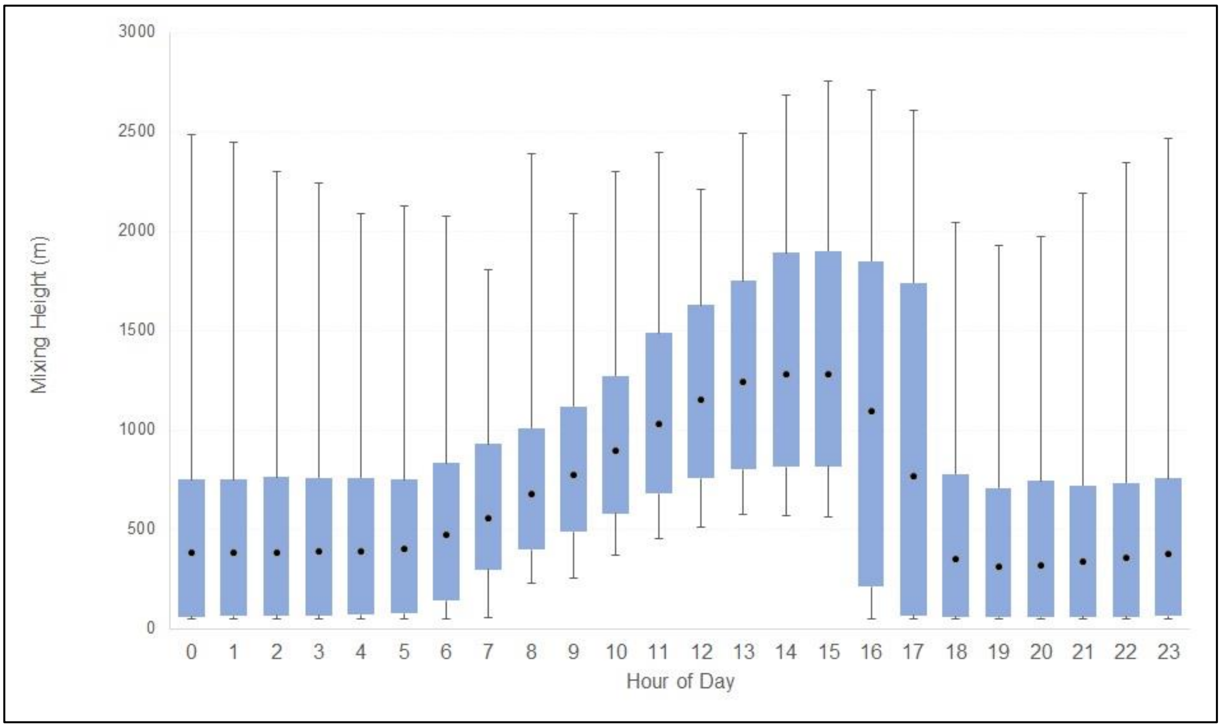

Figure 4.5 - Diurnal mixing height profile

4.4 DISPERSION MODELLING

4.4.1 CALPUFF Model

The Phase 3 Study was conducted by incorporating source characteristics and pollutant emission rates into a dispersion model using CALPUFF. CALPUFF is included in the list of dispersion models approved for use in NSW EPA Modelling Guideline.

CALPUFF is a standard regulatory model, preferred for complex meteorological conditions (i.e., non-steady state) and/or influences from geophysical factors such as coastal areas (i.e., land sea breeze), recirculation, reversal flows and other conditions such as stagnation. CALPUFF considers the geophysical features of the study area that affects dispersion of pollutants and ground-level concentrations of those pollutants in identified regions of interest. CALPUFF contains algorithms that can resolve near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub-grid scale terrain interactions, as well as the long-range effects of removal, transformation, vertical wind shear, overwater transport and coastal interactions. Emission sources can be characterised as arbitrarily varying point, area, volume and lines or any combination of those sources within the modelling domain.

The model was configured in accordance with the NSW EPA Modelling Guideline and the Modelling Settings. The key features of the CALPUFF model include:

- CALPUFF version 7.2.1 was used;
- modelling period consistent with TAPM and CALMET modelling;

- gridded 3D hourly-varying meteorological conditions generated by the TAPM and CALMET meteorological modelling system used to drive the dispersion of pollutants;
- appropriate number of grids trimmed from meteorological model domain for a final computational and sampling domain of 8 km × 8 km, centre on the source;
- nesting factor of 4 applied for a sampling grid resolution of 50 m;
- the OCU stack modelled as a single point source (Table 4.2);
- peak-to-mean factor of 2.3 for point sources applied based on NSW EPA Guideline 2017:
- partial plume path adjustment for terrain modelled;
- dispersion coefficients calculated internally from sigma v and sigma w using micrometeorological variables;
- building wake effects accounted for using the BPIP Prime algorithm; and
- all other options set to default.

4.4.2 Modelled Scenario

The Phase 3 Study has assumed the following design basis and future treatment configuration:

- Treatment Stage 0;
- Treatment Stage 1; and
- Treatment Stage 2

The design scenario calculations adopted in the Phase 2 Report are summarised in **Table 4.1**. Using the design scenario analysis in **Table 4.1**, the modelled emission parameters are as follows:

- Total design airflow of 20,000 m^3/hr, based on 2,000 m^3/hr of process exhaust air and 18,000 m^3/hr of building ventilation air;
- A stack diameter of 700 mm to achieve a stack design exit velocity of 15 m/s;
- A stack discharge temperature of 40^{o}C; and
- A total stack height of 9.69 m from ground level. The modelled scenario in the Phase 3 Study considered the proposed OCS stack to be located at 339,213.2 mE 6,262,529.5 mN (UTM Zone 56S). The location is shown in **Figure 4.6**.

Table 4.1 – Airflow and heat balance calculation results for the determination of the future design airflow as documented in the Phase 2 Report					
Source ID	**Process Airstream**	**Airflow (m^3/hr)**	**Temperature (°C)**	**Relative Humidity (%)**	**Enthalpy (kJ/kg dry air)**
P1	Process Exhaust Airstream (GP1+GP2+GP3+GP8)	2,000	80	100	1,578
P2-A	Building Ventilation Air	18,000	35	50	82
P2-B			35	75	106
P2-C			35	100	130
P3-A	P1+P2-A	20,000	39.1	96	156
P3-B	P1+P2-B		41.3	100	180
P3-C	P1+P2-C		43.9	100	205

Figure 4.6 – Location of proposed OCS stack and buildings

4.4.3 Source Configuration

The proposed OCS stack was modelled as a point source. Any wake effects from building downwash were accounted for using the BPIP Prime algorithm. The locations and heights of the buildings are shown in **Figure 4.6**. The modelled source parameters used are detailed in **Table 4.2**.

Table 4.2 – Modelled emission parameters

Parameter	Units	Value
Stack Height	m	9.69
Elevation	m	17.75
Stack Diameter	m	0.7
Exit Velocity	m/s	15
Exit Temperature	K	313.15

4.4.4 Modelled Receptors

The Phase 3 Study considered the potential odour impacts in the surrounding environment. A network of grid receptors covering an area 8 km by 8 km, at 50 m intervals was defined in the dispersion modelling.

4.5 Modelled Emissions Inventory

The modelled emission rates of odour and other relevant air pollutants are summarised in **Table 4.3**. Odour is the primary consideration in the Phase 3 Study and the key driver for environmental performance improvement at the Brookvale Facility. The derived odour emission rate for the Phase 3 Study is based on the details outlined in **Section 2.1.2** and **Table 4.3**.

The emission rates of H_2S, CS_2, and other VOCs are estimated based on the sampling undertaken in the Phase 1 Report. The concentrations of relevant pollutants were measured at a common extraction duct (1822-02-010) and considered representative of inlet airflow prior to any treatment or dilution. The fresh air drawn in from the building will dilute the extracted process exhaust air at a 9:1 ratio, equivalent to a dilution factor of 10. Following Treatment Stage 2, the concentration of odour and relevant air pollutants is further reduced by emissions treatment before atmospheric release via the proposed OCS stack into the surrounding receiving environment.

The emission rates of VOCs were assessed to comply with the emission limit of 40 mg/m^3 as n-propane equivalent for VOCs, which is equivalent to 0.231 g/s.

A conservative approach was applied in the Phase 3 Study of VOCs. As shown in **Table 4.3**, the emission rates listed are derived from the untreated and uncontrolled air from the inlet prior to the dilution of air. The air pollutant concentrations are expected to reduce upon dilution of the inlet air at a 9:1 dilution ratio (equivalent to a dilution factor of 10). Following Treatment Stage 2, the removal efficiencies outlined in **Table 4.3** will further reduce the air pollutants prior to atmospheric release via the proposed OCS stack. When conducting the dispersion modelling, the air emitted is assumed to comprise 100% of each of the VOCs being assessed.

Table 4.3 – Derived emission rates adopted in the Phase 3 Study					
Air Pollutant	**Uncontrolled concentration (untreated inlet air before dilution)**	**Concertation reduction from dilution (9:1 ratio)**	**After dilution and reduction from Treatment Stage 2 (at Proposed OCS Stack)**		
	mg/m³ [1]	**g/s**	**Removal Efficiency**	**g/s**	**ppm**
H_2S	68.7	3.96E-01	95%	1.19E-02	1.56
CS_2	139.7	8.06E-01	95%	2.42E-02	1.41
Ethanol	2.88	1.66E-02	70%	4.98E-04	0.05
Acetone	5.21	3.01E-02	70%	9.02E-04	0.07
Methyl Ethyl Ketone	4.50	2.60E-02	70%	7.79E-04	0.05
Hexane	5.38	3.11E-02	70%	9.32E-04	0.05
Benzene	0.22	1.28E-03	70%	3.84E-05	0.0022
Cyclohexane	0.69	3.98E-03	70%	1.19E-04	0.01
Toluene	7.19	4.15E-02	70%	1.24E-03	0.06
m-Xylene p-Xylene	2.82	1.63E-02	70%	4.88E-04	0.02
o-Xylene	16.57	9.56E-02	70%	2.87E-03	0.12
4-ethyl Toluene	2.16	1.25E-02	70%	3.74E-04	0.01
Odour	**ou**	**ou.m³/s**	**Scrubber efficiency**	**ou.m³/s**	**ou**
	410,000	227,800	98%	4,330	750

Note 1: referenced to sampling temperature of 39.1°C – refer to **Table 4.1**

Please note that the derived values in **Table 4.3** are conservative and assume that the emission rates are continuous and constantly (24/7) at peak levels. In reality, the three (3) phases of the grease manufacturing process (including acid melt, dehydration, and shearing) occur on a batch basis at different times and durations with varying product formulations and intensity. As such, the Phase 1 Report reflects a peak emission scenario that does not reflect normal operations at the Brookvale Facility. This worst-case operating scenario was deliberately replicated to generate a conservative emissions dataset upon which to base the future treatment configuration at the Brookvale Facility.

5 MODELLING RESULTS

A summary of the maximum odour and air pollutant concentrations predicted within the modelling domain is presented in **Table 5.1**.

Table 5.1 – Maximum predicted offsite ground level concentrations

Parameter	Statistics/averaging period	Units	Maximum offsite concentration	Air quality criteria	Status
Odour	99th percentile one-hour average	ou	1.94	2	complies
H_2S		µg/m³	0.71	1.38	complies
CS_2	Maximum one-hour average		14.47	70	complies
Ethanol			0.30	2,100	complies
Acetone			0.54	22,000	complies
Methyl Ethyl Ketone			0.47	3,200	complies
Hexane			0.56	3,200	complies
Benzene			0.02	290	complies
Cyclohexane			0.07	19,000	complies
Toluene			0.74	360	complies
m-Xylene p-Xylene			0.29	190	complies
o-Xylene			1.72	190	complies
4-ethyl Toluene			0.22	360	complies

5.1 ODOUR MODELLING RESULTS

The contour plot showing the spatial distribution of the 99th percentile one-hour ground-level concentration of odour, based on an assumed 98% reduction by the proposed OCS is presented in **Figure 5.1**. Outside of the Brookvale Facility boundary, the highest predicted 99th percentile odour concentration within the modelling domain is 0.22 ou, which is well within the impact assessment criteria of 2.0 ou for urban areas.

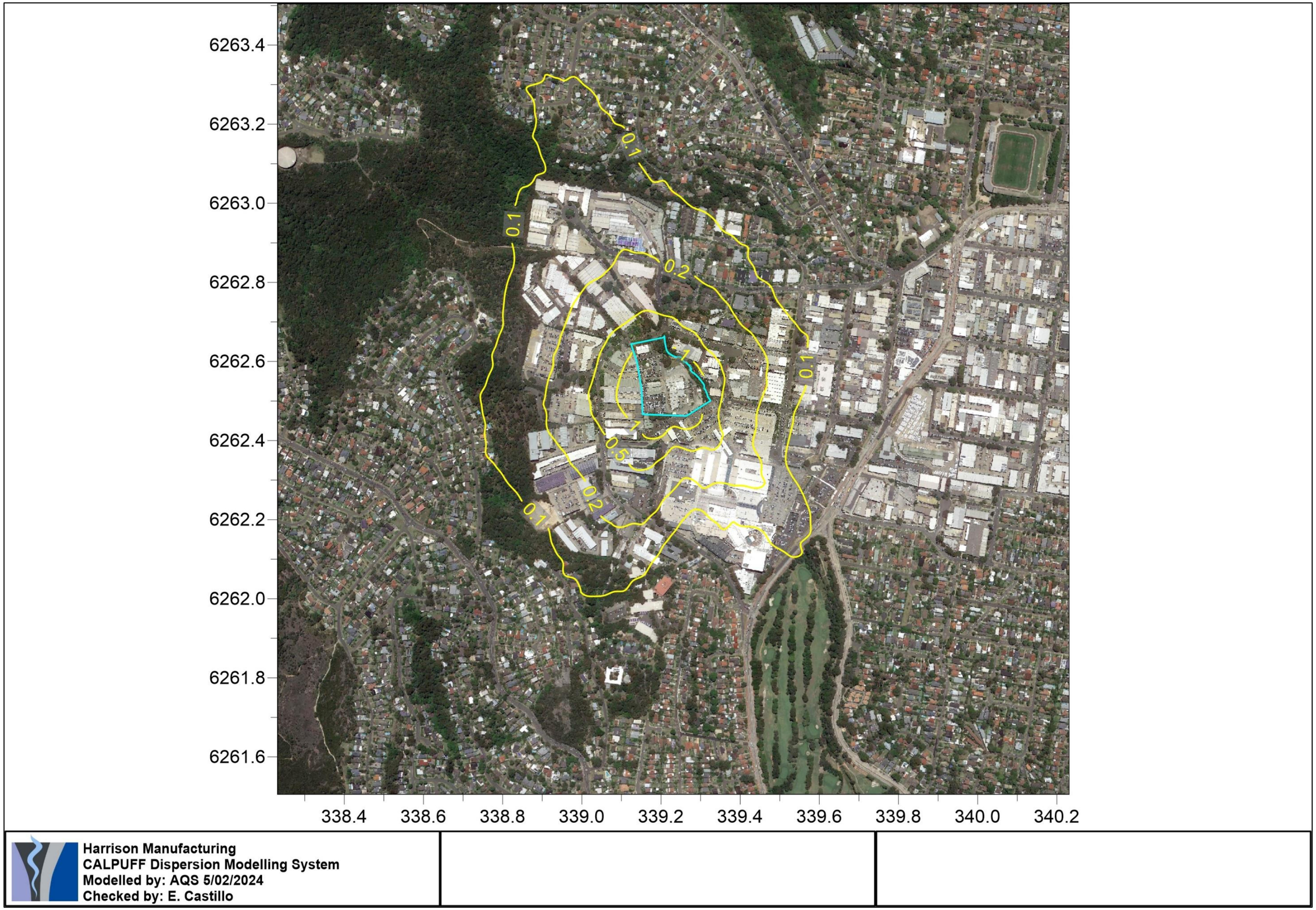

Figure 5.1 - Contour plot showing predicted ground-level odour concentration (ou) with an odour removal efficacy of 98%

5.2 HYDROGEN SULPHIDE

The contour plots showing the spatial distribution of the 99th percentile one-hour ground-level concentration of H_2S based on an assumed 95% reduction is presented in **Figure 5.2**. Outside of the Brookvale Facility boundary, the highest predicted 99th percentile odour concentration within the modelling domain is 0.71 µg/m³, well within the impact assessment criteria of 1.38 µg/m³ for urban areas.

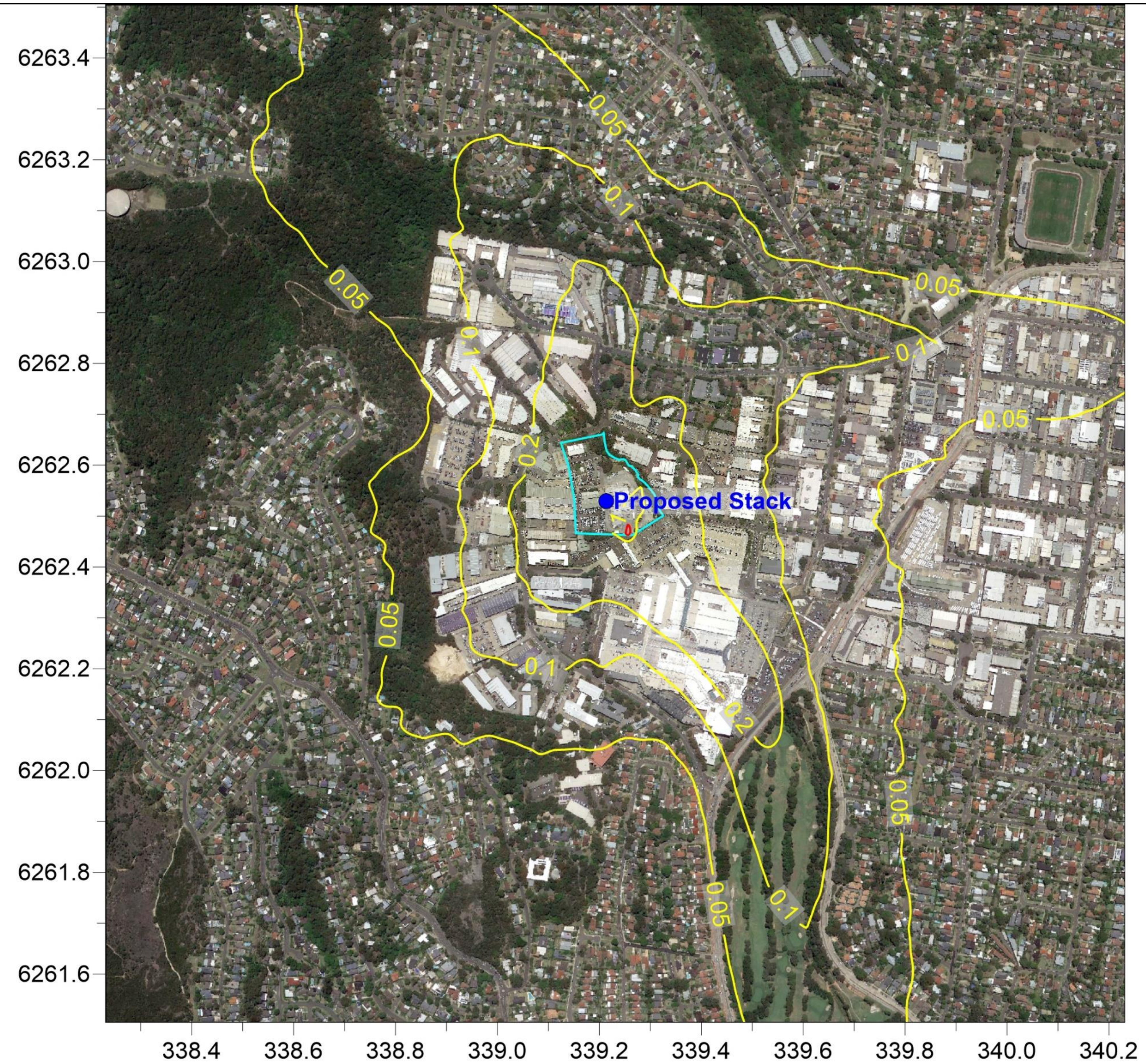

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Figure 5.2 - Contour plot showing predicted ground-level H_2S concentrations (µg/m³) with a dilution of 9:1 and removal efficiency of 95%

5.3 CARBON DISULFIDE

The contour plots showing the spatial distribution of the maximum one-hour ground-level concentration of CS_2 based on an assumed 95% reduction is presented in **Figure 5.3**.

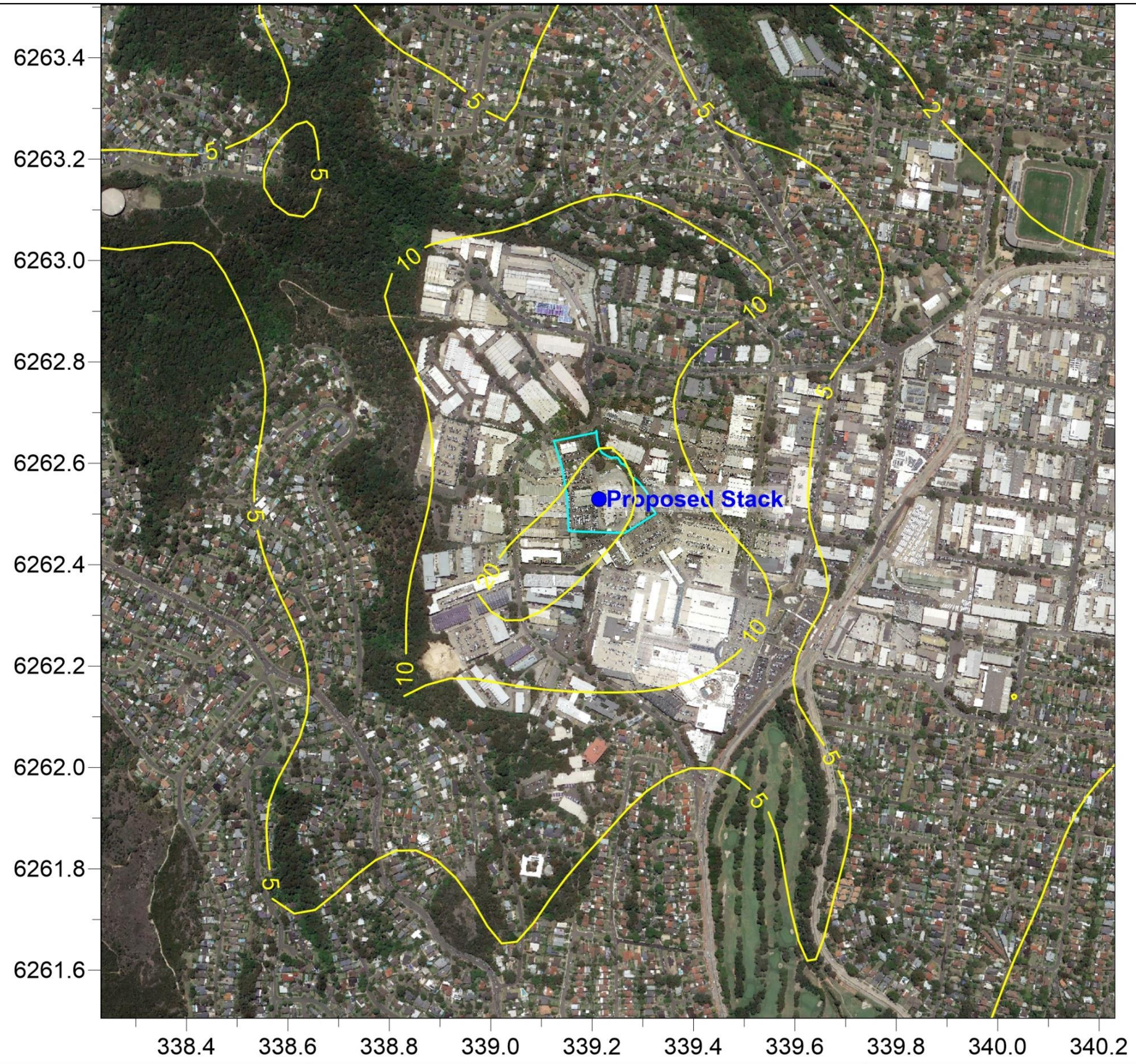

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Figure 5.3 - Contour plot showing predicted ground-level CS_2 concentrations (µg/m³) with dilution of 9:1 and removal efficiency of 95%

5.4 VOLATILE ORGANIC COMPOUNDS

The contour plot showing the spatial distribution of the maximum one-hour ground-level concentration of VOCs, based on the VOC with the highest emission rate. In this case, o-xylene with an emission rate of 0.003 g/s (16.6 mg/m³) is presented in **Figure 5.4**.

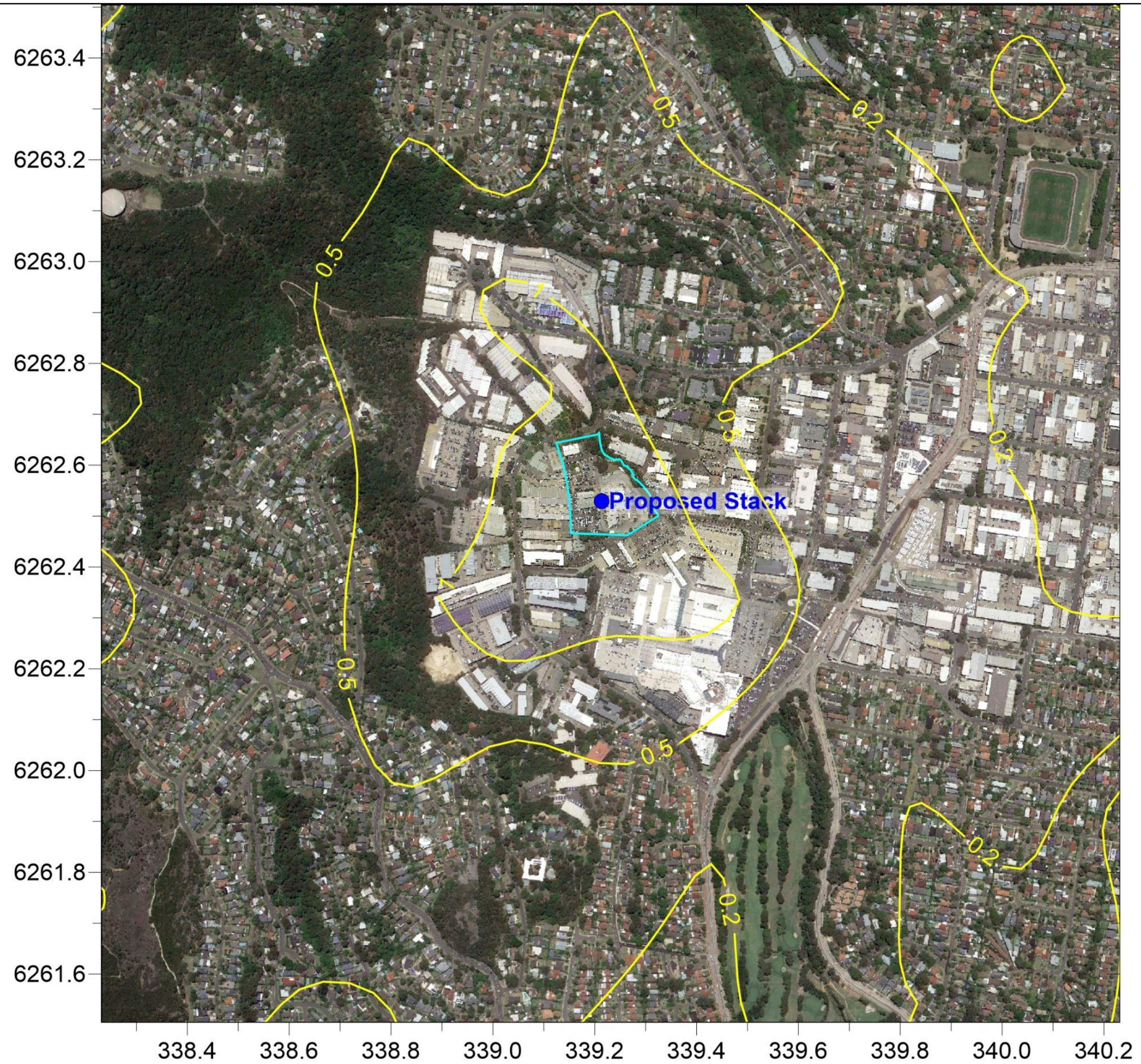

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Figure 5.4 - Contour plot showing predicted ground-level VOC concentrations (µg/m³) at an emission rate of 0.003 g/s, equivalent to an emissions concentration of 16.6 mg/m³

6 PHASE 3 STUDY FINDINGS

The Phase 3 Study was conducted in order to assess the potential impacts of the operation of the Brookvale Facility with the future treatment configuration as documented in the Phase 2 Report. The Phase 3 Study incorporated site-specific meteorological data, emissions sources, and geographic representation of receptors in the surrounding receiving environment.

A site-specific meteorological data was generated using the TAPM and CALMET meteorological modelling system. A single scenario was modelled with emissions for odour, H_2S, CS_2, and a number of VOCs identified as part of Phase 1 Report and Phase 2 Report.

The air dispersion modelling was conducted using the most recent stable version of the CALPUFF model (v7.2.1). CALPUFF was configured in consideration of the NSW EPA guidance documents. The ground-level pollutant concentrations were predicted at identified discrete receptors and the surrounding receiving environment.

The results of the air dispersion modelling analysis indicate that:

- Predicted offsite 99th percentile one-hour odour concentrations comply with the impact assessment criteria of 2 ou;
- Predicted offsite 99th percentile one-hour H_2S concentrations comply with the impact assessment criteria of 1.38 µg/m^3;
- Predicted offsite maximum one-hour CS_2 concentrations comply with the impact assessment criteria of 70 µg/m^3; and
- Predicted offsite maximum one-hour VOC concentrations for all detected VOCs comply with their respective impact assessment criteria.

Overall, the performance outlet targets identified as part of the Phase 3 Study indicate that the proposed odour control system developed as part of the Phase 1 Report and Phase 2 Report will mitigate future air quality and odour impact risks from the operations at the Brookvale Facility to a level where the surrounding sensitive environment will not be adversely affected.

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