

PROPOSED PUMP STATION, UPPER COOMERA

79 - 99 Courtney Drive

Air Quality Assessment

HB QLD Pty Ltd

Date
7 November 2023

Report
237401.0141.R01V01

DOCUMENT CONTROL

Prepared by: Trinity Consultants Australia
 ABN 62 630 202 201
 A: Level 3, 43 Peel Street
 South Brisbane, QLD 4101
 T: +61 7 3255 3355
 E: brisbane@trinityconsultants.com

Reference	Date	Description	Prepared	Checked
237401.0141.R01V01	07/11/2023	Final Report	Hasan Shahariar	Andrew Martin & Hilbert Libres

Document Approval	
Approver Signature	
Name	Andrew Martin
Title	Manager Consulting Services – Air & Noise

COPYRIGHT AND DISCLAIMERS

This report has been prepared by Trinity Consultants Australia (Trinity), with all reasonable skill, due care and diligence in accordance with Trinity Quality Assurance Systems, based on ISO 9001:2015. This report and the copyright thereof are the property of Trinity and must not be copied in whole or in part without the written permission of Trinity.

This report takes account of the timescale, resources and information provided by the Client, and is based on the interpretation of data collected, which has been accepted in good faith as being complete, accurate and valid.

Trinity disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

This report has been produced specifically for the Client and project nominated herein and must not be used or retained for any other purpose. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from Trinity.

CONTENTS

1.	Introduction	1
1.1	Overview	1
1.2	Scope	1
2.	Study Area Description	2
2.1	Overview	2
2.2	Identification of Existing Sensitive Receptors.....	2
2.3	Description of Air Emission Sources in the Vicinity	3
3.	Proposed Development	4
4.	Assessment Criteria	8
5.	Meteorological Modelling.....	9
5.1	TAPM Meteorological Modelling	9
5.1.1	TAPM Fundamentals.....	9
5.1.2	Observational Data Assimilation	9
5.1.3	TAPM Configuration	10
5.2	Topography and Land Use Data	10
5.3	CALMET Modelling Configuration	12
5.4	Meteorological Predictions.....	13
5.4.1	Wind Predictions	13
5.4.2	Stability Class	14
5.4.3	Mixing Heights	16
6.	Sewage Pump Station Odour Inventory	17
6.1	Calculation of H ₂ S.....	17
6.1.1	Background to H ₂ S Production Model	17
6.1.2	Calibration of H ₂ S Production Model	17
6.1.3	Use of the Model to Calculate H ₂ S Concentration in the Rising Main	19
6.1.4	Calculation of H ₂ S Concentration in the Gas Phase	19
6.1.5	Calculation of Odour Concentration	20
6.2	Source Parameters	21
7.	Dispersion Modelling Method.....	22
7.1	Overview	22
7.2	CALPUFF Configuration	22
7.3	Downwash Structures.....	23
7.4	CALPOST	23
8.	Dispersion Modelling Results.....	24
9.	Conclusion.....	27
	References	28

APPENDICES

Glossary

FIGURES

Figure 2.1 Location of Site and Sensitive Receptors	3
Figure 3.1 Sewer Schematic Plan	5
Figure 5.1 Modelled Terrain	11
Figure 5.2 Modelled Land Use	12
Figure 5.3 Measured 2020 Wind Rose & TAPM 2020 Predicted Wind Rose	13
Figure 5.4 CALMET Site Predicted Wind Rose	14
Figure 5.5 Diurnal Frequency of Stability Classes.....	15
Figure 5.6 CALMET Site Predicted Mixing Heights	16
Figure 6.1 Modelled Biochemical Reactions (from Sharma et al 2008).....	18
Figure 6.2 Model Predictions and Measured Sulfide, Sulfate and VFA Concentrations in the Rising Main at 50m, 375m, 547m and 828m Distance from the Inlet	19
Figure 7.1 Modelled Sources and Sensitive Receptors	23
Figure 8.1 Predicted Ground Level Concentrations Around Discharge Manhole	25
Figure 8.2 Predicted Ground Level Concentrations Around Pump Station	26

TABLES

Table 5.1 Percentage of Wind Conditions.....	9
Table 6.1 Model Parameters Used	18
Table 6.2 Initial Concentrations Used	19
Table 6.3 Source Parameters	21
Table 8.1 Highest predicted concentrations at nearest sensitive receptors, 99.5th percentile	24

1. INTRODUCTION

1.1 Overview

Trinity Consultants Australia was commissioned by HB QLD Pty Ltd to provide an odour assessment for a proposed pump station and rising main to be located at 79 - 99 Courtney Drive, Upper Coomera. This report is to satisfy ROL Condition 44i of the COM/2018/82 and support the OPW application for the sewer pump station located off Courtney Drive, Upper Coomera Stage 2 Civil works. The assessment has been undertaken to determine potential impacts of the pump station vent and discharge manhole onto existing nearby sensitive receptors. The results of the assessment have been compared to the requirements of the Gold Coast Planning Scheme and odour criteria specified in the Department of Environment and Science (DES) Odour Impact Assessment from Development Guideline (2013).

1.2 Scope

This report describes the assessment of the air quality impacts, which is based on the following tasks:

- Review the project and the associated potential air emissions.
- Develop an emission inventory of odour based on the biochemical reactions taking place on upstream rising mains based on the design specifications.
- Model meteorological conditions using TAPM and CALMET.
- Model the dispersion of expected air pollutants based on proposed activities using CALPUFF to predict concentrations at sensitive receptors and develop contours over the modelling domain.
- Analyse the results of meteorological and pollutant dispersion modelling and compare modelling results with the relevant air quality criteria.
- Where exceedances are predicted, discuss potential mitigation measures.

To aid in the understanding of the terms in this report a glossary is included in **Appendix A**.

2. STUDY AREA DESCRIPTION

2.1 Overview

The site for the proposed pump station is within vacant land covered by grass, trees and bushes and is designated as being within an emerging community zone. The immediate surrounding land uses encompass the following:

- Low density residential area from south to south-east along Gordon Drive located within 100 meters of the site.
- Rural residential areas from north to west with residences located within 50 meters to a few hundred metres of the site.
- The development will include new residences to the south of the pump station.

2.2 Identification of Existing Sensitive Receptors

The default definition of sensitive land uses required to be considered by assessments for operators of environmentally relevant activities or addressed by a local planning scheme is that defined in the Queensland Planning Regulation 2017: caretakers accommodation, child care centre, community care centre, community residence, detention facility, dual occupancy, dwelling house, dwelling unit, educational establishment, health care services, hospital, hotel (to the extent the hotel provides accommodation for tourists or travellers), multiple dwelling, non-resident workforce accommodation, relocatable home park, residential care facility, resort complex, retirement facility, rooming accommodation, rural workers accommodation, short-term accommodation, a supervised accommodation service or a tourist park.

Receptors representative of sensitive places are shown in **Figure 2.1**. Since the sources are close to ground level, the most impacted receptors are those closest to the vent and discharge manhole as presented in **Figure 2.1**.

Figure 2.1 Location of Site and Sensitive Receptors



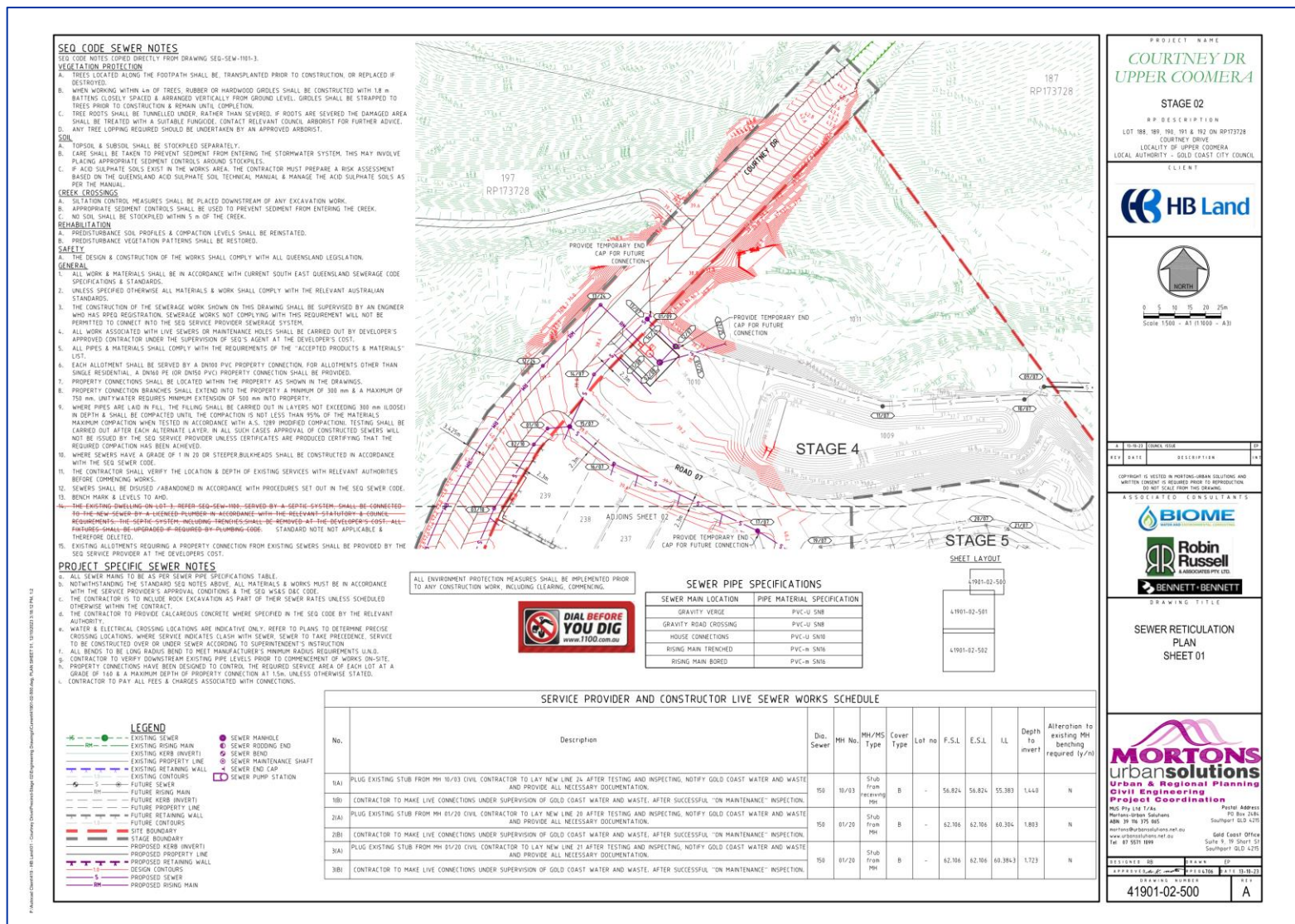
2.3 Description of Air Emission Sources in the Vicinity

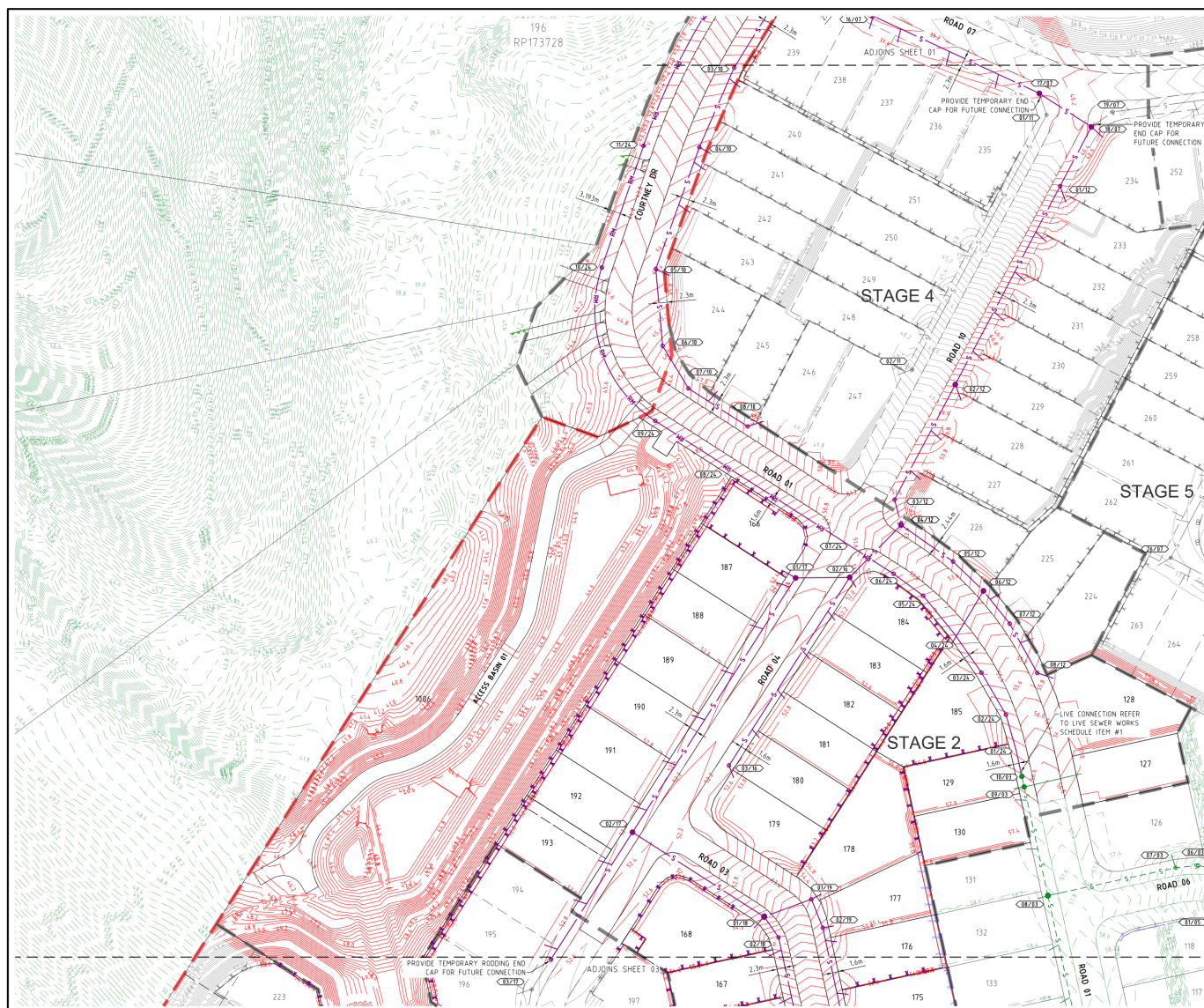
A survey of the surrounding area was conducted and found no other significant sources of air emissions or odour in the vicinity of the current development.

3. PROPOSED DEVELOPMENT

The proposed pump station and rising main are to be constructed at 79 - 99 Courtney Drive, Upper Coomera. The Courtney Drive Development has a total of 196 residential lots, 4 open space (environmental) lots, 5 open space (drainage lots, 2 open space (recreation) lots and 1 utility lot. The pump station is to be designed and constructed in accordance with SEQ water guidelines for sewer pump stations. The sewer plan for the development is shown in **Figure 3.1**.

Figure 3.1 Sewer Schematic Plan





PROJECT NAME
**COURTNEY DR
UPPER COOMERA**

STAGE 02

RP DESCRIPTION
LOT 188, 189, 190, 191 & 192 ON RP173728
COURTNEY DRIVE
LOCALITY OF UPPER COOMERA
LOCAL AUTHORITY - GOLD COAST CITY COUNCIL

CLIENT
HB Land

NORTH

0 5 10 15 20 25m
Scale 1:500 - A1 1:1000 - A3

REV	DATE	DESCRIPTION	BY
1	15-10-21	ISSUE	IT
2	15-10-21	ISSUE	IT

COPYRIGHT IS VESTED IN MORTONS URBAN SOLUTIONS AND WRITTEN CONSENT IS REQUIRED PRIOR TO REPRODUCTION. DO NOT SCALE FROM THIS DRAWING.

ASSOCIATED CONSULTANTS

BIOME
water and environmental consultants

Robin Russell
landscape architects

BENNETT • BENNETT

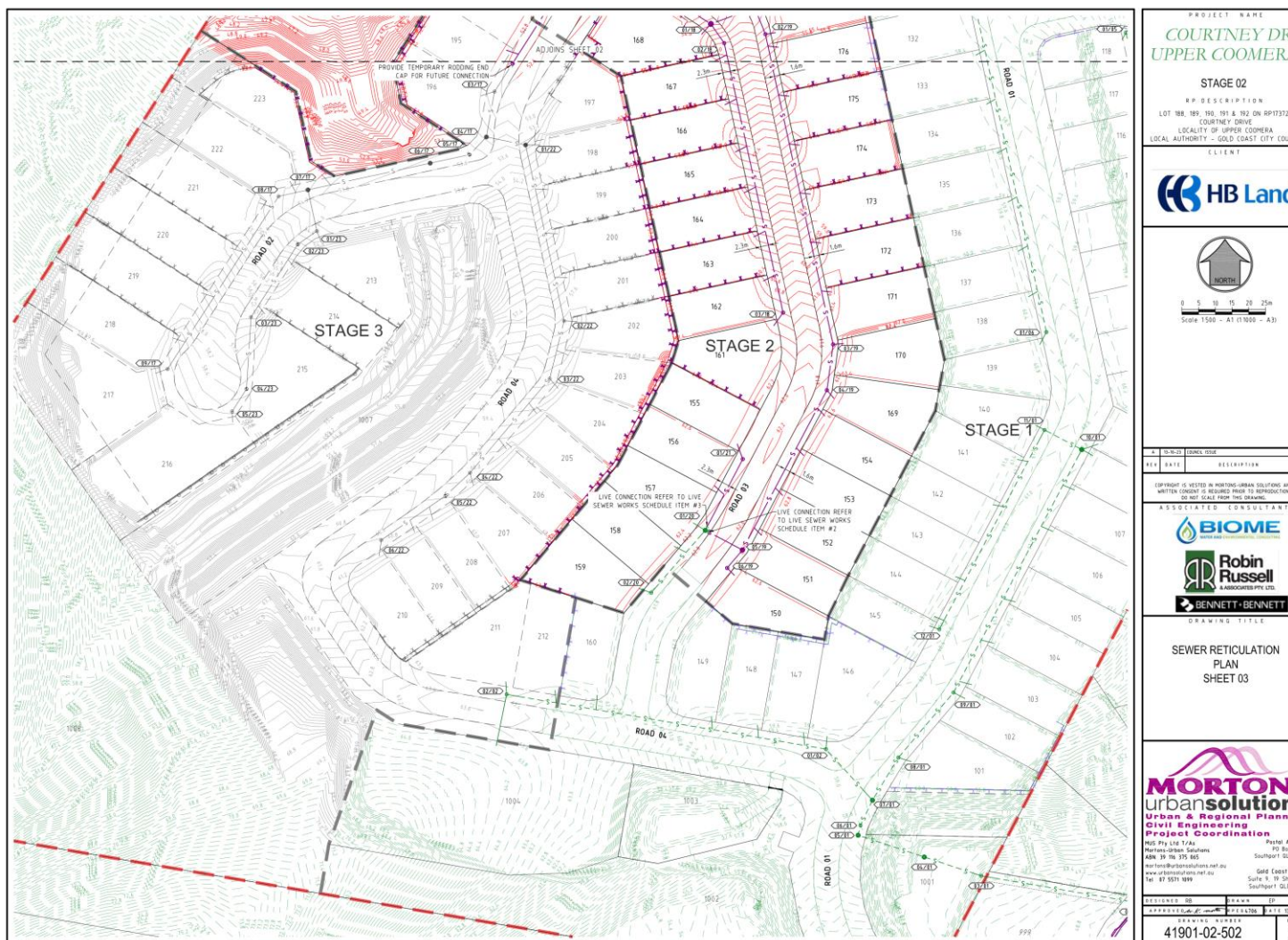
DRAWING TITLE
**SEWER RETICULATION
PLAN
SHEET 02**

**MORTONS
urbansolutions**
Urban & Regional Planning
Civil Engineering
Project Coordination

MUS Pty Ltd T/A:
Mortons Urban Solutions
ABN 39 16 375 065
mortons@urbansolutions.net.au
www.urbansolutions.net.au
Tel: 67 5531 1099

Postal Address
PO Box 1246
Southport QLD 4215
Gold Coast Office
Suite 9, 19 Short St
Southport QLD 4215

DESIGNED BY	DRAWN BY	APPROVED BY	DATE	REV
			15-10-21	
41901-02-501		A		



4. ASSESSMENT CRITERIA

The assessment has been undertaken in accordance with relevant criteria from:

- Gold Coast City Council (GCCC) – City Plan applicable policies, codes and overlays.
- Environmental Protection (Air) Policy 2019.
- Department of Environment and Heritage Protection (2013), Guideline: Odour Impact Assessment from Developments, Queensland Government.

It is noted that the GCCC City Plan does not specify odour criteria for assessments. Therefore, reference has been made to the Department of Environment and Science Odour Impact Assessment from Developments guideline (EHP (2013)), which specifies the methods to be used to assess odour impacts.

The DES guideline specifies the following criteria for sensitive receptors:

- 0.5 OU, 1-hour average, 99.5th percentile for wake free stacks; and
- 2.5 OU, 1-hour average, 99.5th percentile for ground-level sources and down-washed plumes from short stacks; and
- for facilities which do not operate continuously, the 99.5th percentile must be applied to the actual hours of operation.

In this case, there are no wake-free stacks, so the appropriate criterion is 2.5 OU.

5. METEOROLOGICAL MODELLING

5.1 TAPM Meteorological Modelling

5.1.1 TAPM Fundamentals

The meteorological component of The Air Pollution Model (TAPM) was used to provide wind fields over the region. Wind speed and direction data from the nearest continuous monitoring station were assimilated into the model.

The databases required to run TAPM are provided by CSIRO and include global and Australian terrain height data, vegetation and soil type datasets, sea surface temperature datasets and synoptic scale meteorological datasets.

The Australian terrain data is in the form of 9-second grid spacing (approximately 0.3 kilometres) and is based on data available from Geosciences Australia. Australian vegetation and soil type data is on a longitude/latitude grid at 3-minute grid spacing (approximately 5 kilometres) and is public domain data provided by CSIRO Wildlife and Ecology.

The synoptic scale meteorology dataset used is a six-hourly synoptic scale analysis on a longitude/latitude grid at 0.75 or 1.0-degree grid spacing (approximately 75 kilometres or 100 kilometres). The database is derived from the US NCEP reanalysis synoptic product.

TAPM dynamically fits the gridded data for the selected region to finer grids taking into account terrain, surface type and surface moisture conditions. It produces detailed fields of hourly estimated temperature, winds, pressure, turbulence, cloud cover and humidity at various levels in the atmosphere as well as surface solar radiation and rainfall.

5.1.2 Observational Data Assimilation

Meteorological data from the BoM Gold Coast Seaway station (ID 040764) located approximately 17 kilometres south-east of the site were available for assimilation into the model run. Wind conditions in the five recent years at the BoM Gold Coast Seaway station is presented in **Table 5.1**.

Table 5.1 Percentage of Wind Conditions

Year	Calm (%)	Average Wind Speed (m/s)	Wind Speeds <0.5-2m/s (%)
2017	0.2	5.4	2.7
2018	0.2	5.6	2.4
2019	0.6	5.4	2.9
2020	1.4	4.8	3.9
2021	2.4	4.4	5.4
Average	1	5.1	3.5

Calm and low wind speed conditions are important for air dispersion modelling assessments of wake-affected sources, as these conditions correspond to poor pollutant dispersion conditions. Data for the year 2020 was used as it is representative of longer-term averages.

5.1.3 TAPM Configuration

TAPM was set up using four nested 25 x 25 grids centred on latitude 27°52' south, and longitude 153°17' east.

The four nested grids were as follows:

- 750 km x 750 km with 30 km resolution
- 250 km x 250 km with 10 km resolution
- 75 km x 75 km with 3 km resolution
- 22.5 km x 22.5 km with 0.9 km resolution

Thirty (30) vertical levels were used with lower-level steps at 10, 25, 50, 75 and 100 metres up to 8 kilometres in altitude. This is greater than the normal number of vertical layers in order to provide a better resolution of vertical layers. Boundary conditions on the outer grid were derived from the synoptic analysis. Non-hydrostatic pressures were ignored due to the gentle terrain and moderate resolution.

5.2 Topography and Land Use Data

Terrain data for the area surrounding the development was obtained from the Digital Elevation Model (DEM) 5 Metre Grid of Australia derived from LiDAR model, which represents a national 5 metre (bare earth) DEM that has been derived from some 236 individual LiDAR surveys between 2001 and 2015. Data for a 10 km x 10 km area (0.1 km spacing) has been extracted for use in the modelling.

The TERRAD value in CALMET is used to determine the radius of influence for terrain features within the model domain. The TERRAD value has been calculated based on the rule 'ridge-to-ridge divided by 2, rounded up' recommended by the NSW Office of Environment and Heritage (TRC, 2011). Based on an average ridge to ridge distance, a TERRAD value of 1 kilometre has been adopted.

Land use data was also created based on the Queensland Government Land Use Dataset and satellite imagery and incorporated into the CALMET model. Where land use categories do not correspond with the CALMET land use input file categories, satellite imagery has been reviewed to determine the most appropriate land use category. **Figure 5.1** and **Figure 5.2** present the modelled terrain and land use in CALMET.

Figure 5.1 Modelled Terrain

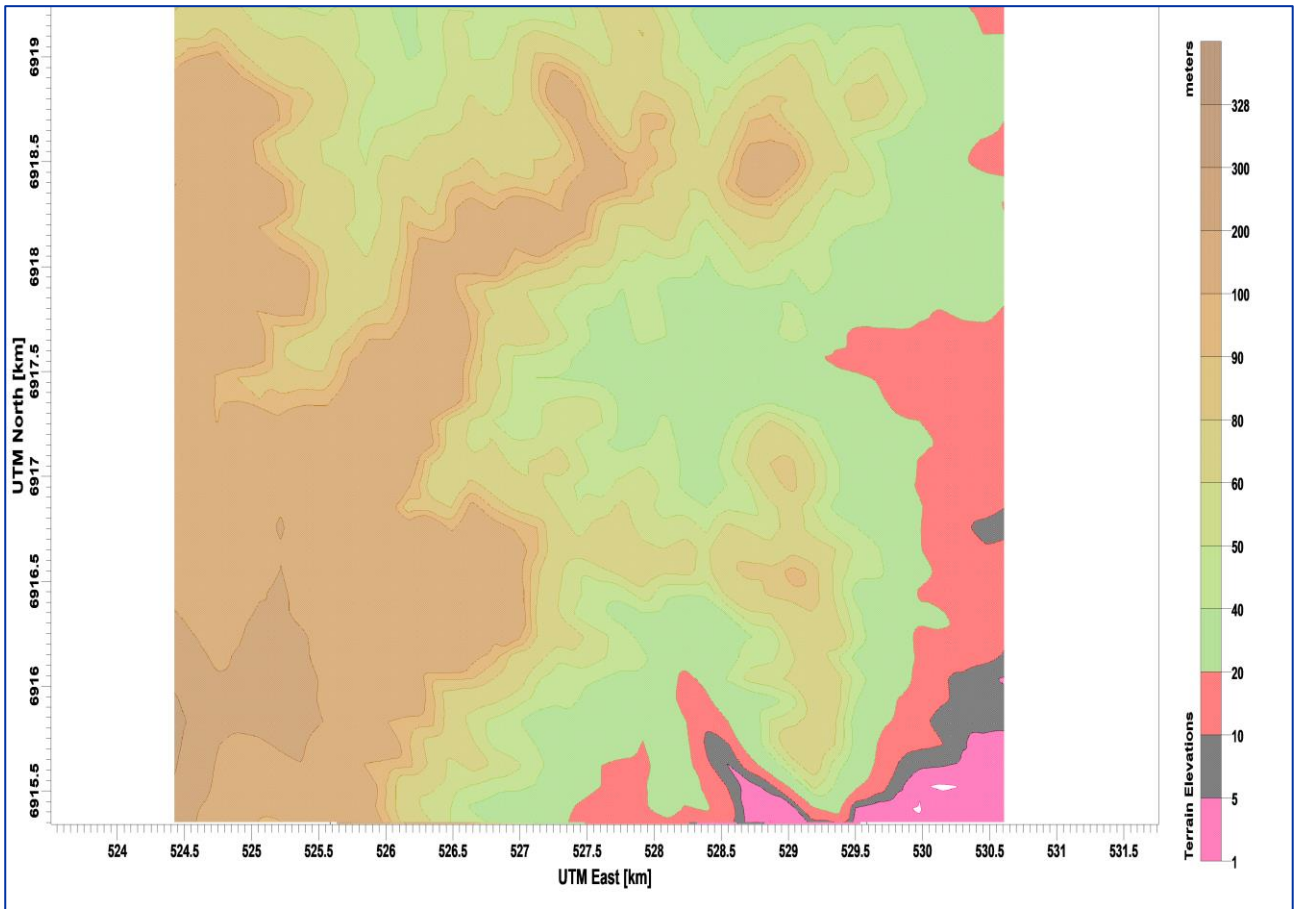
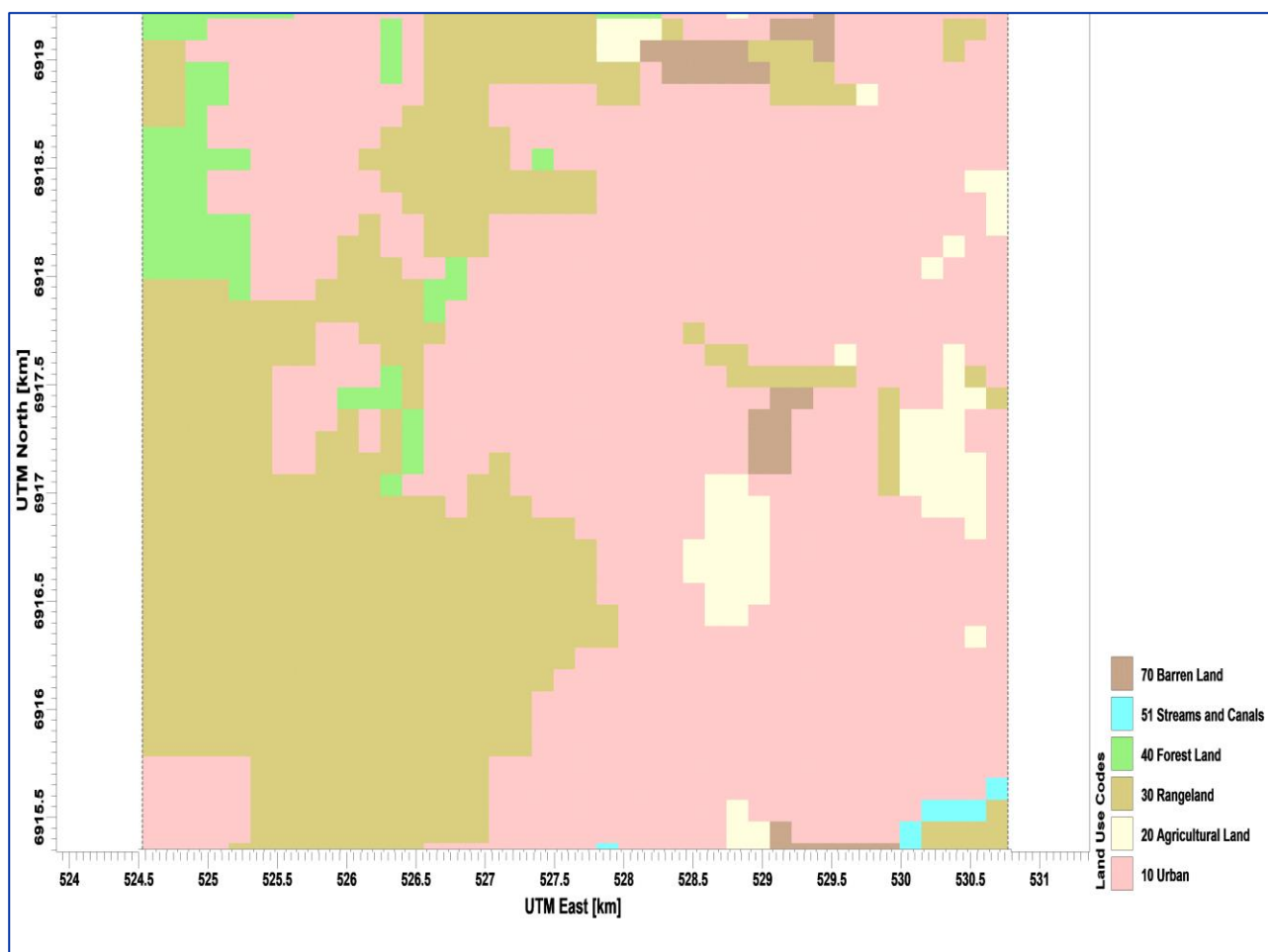


Figure 5.2 Modelled Land Use



5.3 CALMET Modelling Configuration

The CALMET configuration used is consistent with NSW OEH guidance (TRC, 2011).

To include the effects of both regional and local complex terrain and varying surface features, CALMET was run over two nested domains. The model was run over the full year of 2020 based on a 3-dimensional grid produced using the Caltapm utility program to convert TAPM data to MM5 format suitable for CALMET to read. The first CALMET domain was set to grid spacing of 300 metres and 75 by 75 grid points. The output of the first CALMET domain, along with TAPM extracted surface and upper air input files, was used as input into the second CALMET domain. The second CALMET run was undertaken to refine the initial CALMET domain with higher resolution.

Twelve vertical layers were modelled with cell face heights of 0, 20, 40, 80, 160, 300, 450, 650, 900, 1200, 1700, 2300, and 3200 metres. This is greater than normal number of vertical layers in order to provide better resolution of vertical layers.

Mixing height calculation parameters were set to default values except the Coriolis parameter which was set to 6.8×10^{-5} as calculated from the Coriolis parameter equation, $f = 2\Omega \sin(\phi)$ where f is the Coriolis parameter, Ω is the Earth's rotation rate ($2\pi/86400$ or 7.29×10^{-5} rad's $^{-1}$) and ϕ is the latitude which in this case is -27.87° .

Temperature prediction parameters were set to default.

Divergence minimisation was used. Slope flow effects were included. The radius of influence of terrain features was set to 2 kilometres for the outer CALMET run and 1 kilometre for the inner CALMET run. As surface and upper air input files are required as input to run a second CALMET nest, surface and upper air files were

extracted at a point close to the site location. The maximum radius of influence for wind field interpolation (RMAX1, RMAX2 and RMAX3) was set to 0.5 kilometre and the relative weighting of step 1 field vs. observations was set to 0.2 kilometres (R1 and R2).

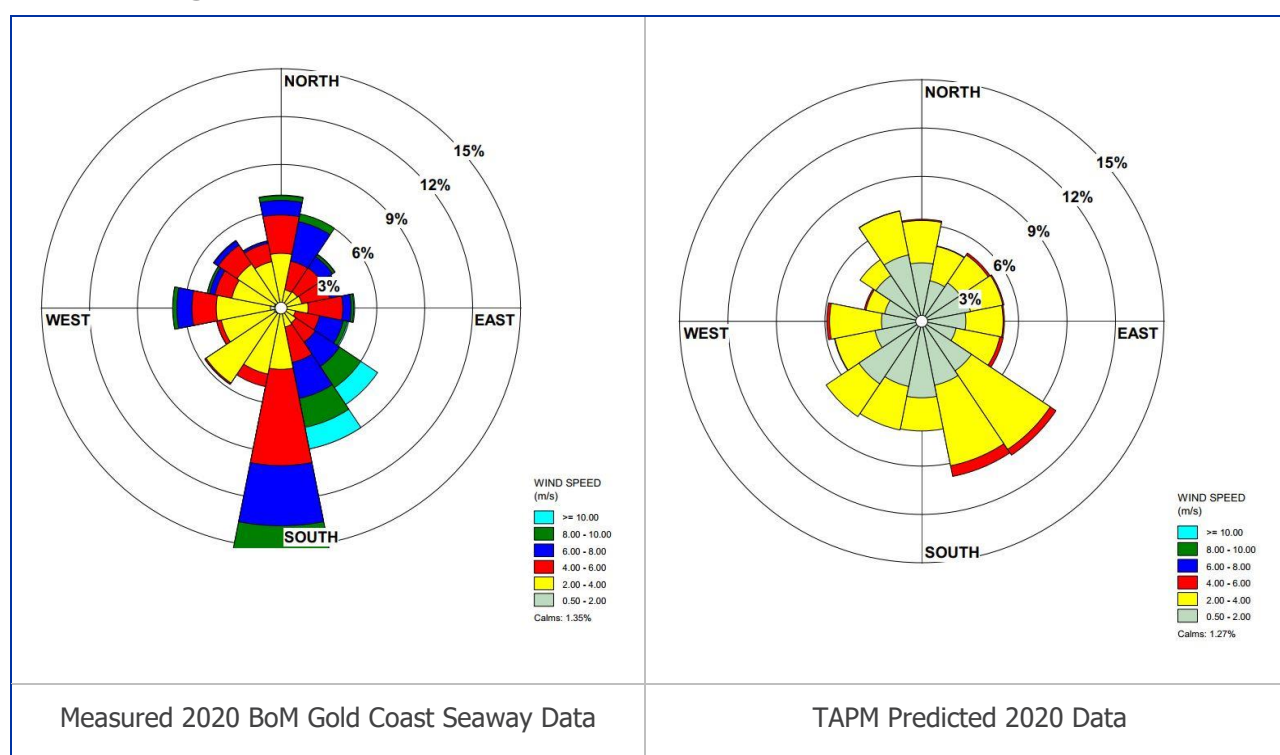
The output from the inner CALMET run was a three-dimensional grid of wind-field data for incorporation into CALPUFF.

5.4 Meteorological Predictions

5.4.1 Wind Predictions

Predicted 2020 wind conditions have been compared to observed wind data (2020) at the meteorological station at BoM Gold Coast Seaway, as shown in **Figure 5.3**.

Figure 5.3 Measured 2020 Wind Rose & TAPM 2020 Predicted Wind Rose

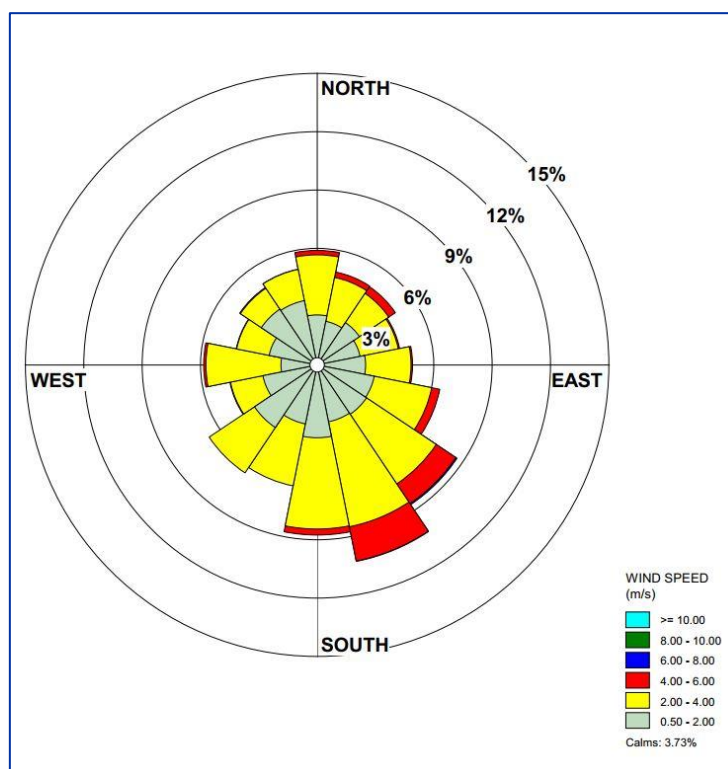


There are some differences between the predicted and measured wind roses at the Gold Coast Seaway station in terms of wind speed and wind direction. Key differences include TAPM predicting a larger percentage of low wind speeds from all directions when compared to measured data. In terms of calm conditions, TAPM prediction is similar occurrence with observed data. Low wind speeds, which are associated with poorer dispersion of pollutants, are comparatively higher with TAPM predictions.

Meteorological data from the BoM Gold Coast Seaway station has been incorporated into the first CALMET run for the outer domain. The Coast Seaway dataset is noted to be 99.9% complete for all modelled parameters, and just small gaps (no more than 2 continuous hours). Where gaps occurred in the dataset, they have been filled using linear interpolation.

Figure 5.4 presents the predicted site wind rose from CALMET. Compared to the TAPM predicted data, the predicted wind rose is more comparable to measured wind conditions at the BoM Gold Coast Seaway station (with a greater proportion of south and south-easterlies).

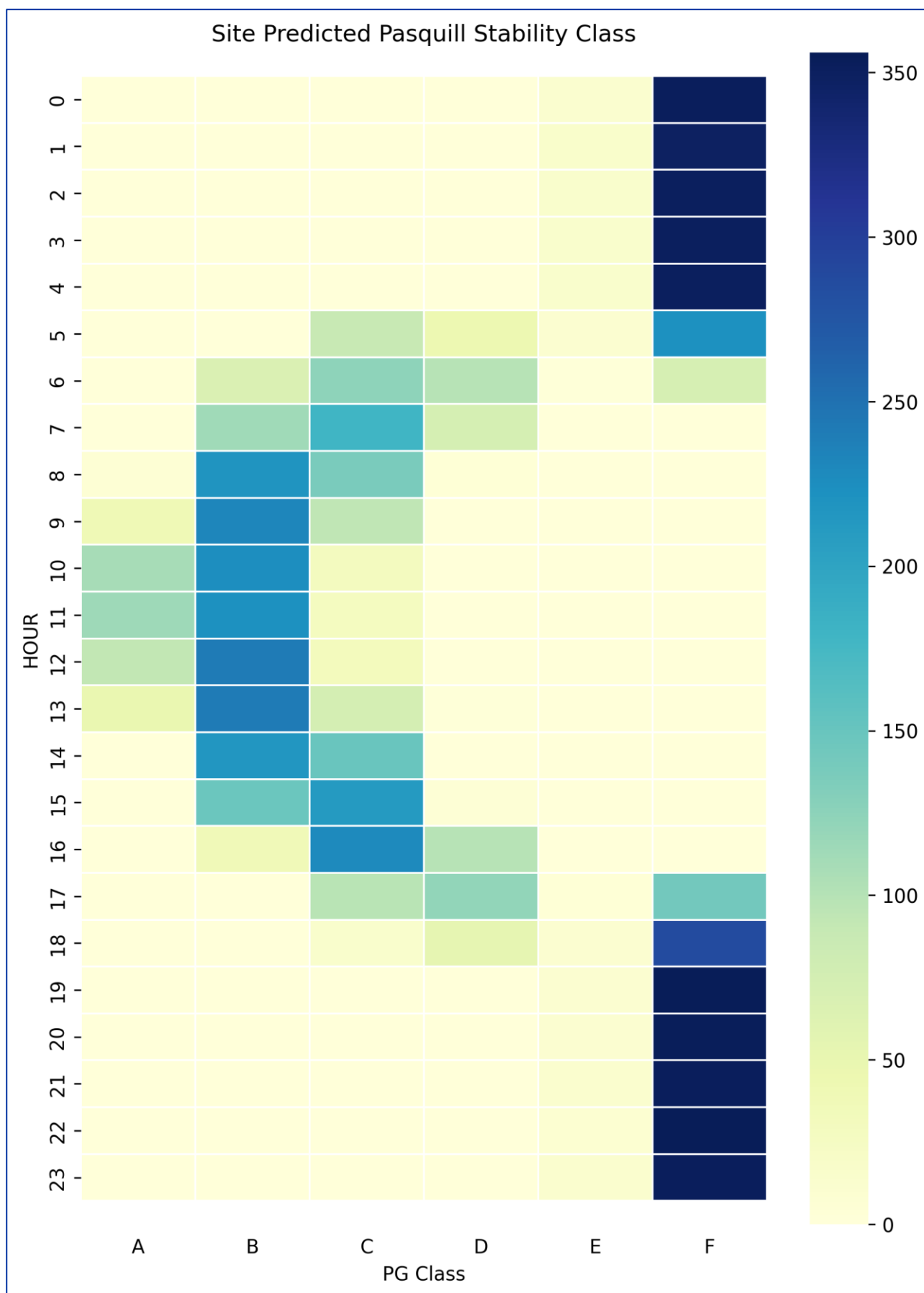
Figure 5.4 CALMET Site Predicted Wind Rose



5.4.2 Stability Class

Figure 5.5 shows the frequency of stability classes throughout the day. Daytime conditions are either neutral or unstable, whilst night-time conditions are stable.

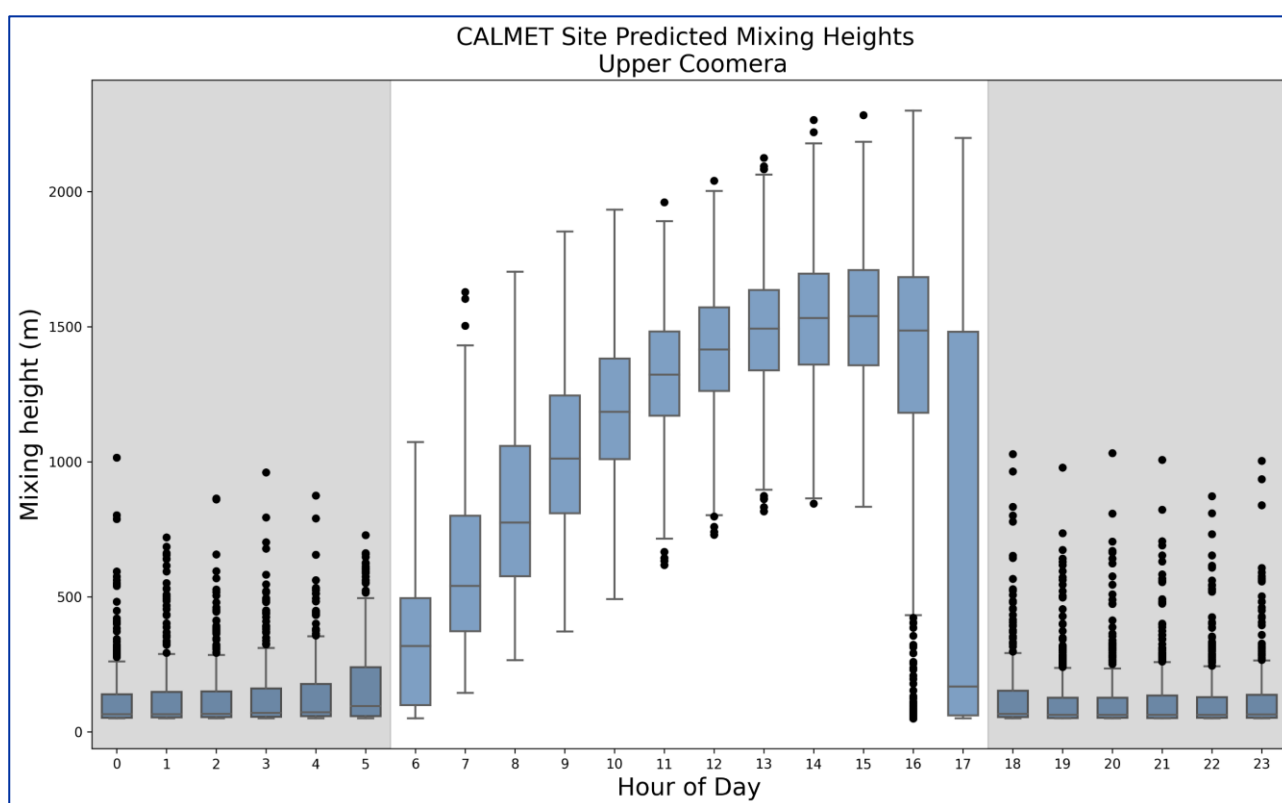
Figure 5.5 Diurnal Frequency of Stability Classes



5.4.3 Mixing Heights

Figure 5.6 presents a plot showing predicted mixing heights for each hour of the day. As expected, higher mixing heights occur during the day, while lower mixing heights occur during the night period when stable conditions are dominant and temperature inversions occur. In the morning, the mixing rises gradually, reaching an average of approximately 1.5 kilometres by the afternoon, then reforming near ground level again at nightfall.

Figure 5.6 CALMET Site Predicted Mixing Heights



6. SEWAGE PUMP STATION ODOUR INVENTORY

Odorous compounds emitted from sewerage systems with residential catchments include hydrogen sulfide, dimethyl sulfide, skatole, and ammonia. Odour from sewage pump stations varies depending on sewage flow rates, upstream feed and propensity for sulfur compounds to form in the pipes.

The following sections discuss the calculation methodology for estimating hydrogen sulfide and odour emissions from the primary air emission sources (air release vents and rising main discharge). While odour from sewage comprises a complex mixture of chemicals, estimated hydrogen sulfide concentrations can be used to estimate total odour based on known relationships and/or conservative factors.

6.1 Calculation of H₂S

6.1.1 Background to H₂S Production Model

In the absence of a readily available model capable of accurately predicting the H₂S production along the rising main, Trinity has developed its own model according to the Sewex methodology presented by Sharma et al (2008). Sharma et al (2008) modelled the H₂S production in the rising mains with relatively good agreement with their measurements. The model represents the rising main as a series of tanks, with each tank representing a 25 metre segment of the rising main. The modelled biochemical reactions are in Table 3 of Sharma et al (2008) and presented in **Figure 6.1**.

6.1.2 Calibration of H₂S Production Model

The Trinity-developed model was calibrated by inputting the system parameters from a case study presented by Sharma et al (2008) and comparing the results to the H₂S measured by Sharma et al (2008) in that case study. This was the same case study used for the Sewex model development. **Table 6.1** presents the parameters used in the Trinity model while **Table 6.2** presents the initial concentrations used. Some of the values in **Table 6.1** were taken from other literature while the ones which were not readily available were assumed and tested to match the Trinity model predictions to the measured values of Sharma et al (2008) as close as practicable. Similarly, the initial concentrations used were also assumed and tested to match the Trinity model predictions to the measured values of Sharma et al (2008) as close as practicable. A factor to account for reduced reaction rates during periods of no flow was also determined. This factor was multiplied by the hydraulic retention time and is as follows:

$$\frac{e^{-t/3}}{4}$$

where t is the hydraulic retention time. Based on this factor, the reaction rate would reduce exponentially with time during periods of no flow or mixing. In the absence of information, the production of ammonia was not considered in the model. **Figure 6.2** presents the Trinity model calibrated against the Sharma et al (2008) measured sulfide, sulfate and volatile fatty acids (VFA) concentrations at various locations in the rising main.

Figure 6.1 Modelled Biochemical Reactions (from Sharma et al 2008)

Table 3 – Summary of model processes and kinetic expressions

Sl. no.	Process	Reaction	Reference component	Reaction rate
1	Aerobic growth of biomass in bulk liquid	$\frac{1}{Y_{Hw}}(FCOD + VFA) + \frac{(1 - Y_{Hw})}{Y_{Hw}} O_2$ $\rightarrow Bw + \frac{(1 - Y_{Hw})}{Y_{Hw}} \frac{100}{32} CO_2$	X_{Bw}	$\mu_H \frac{(S_{FCOD} + S_{VFA})}{K_{Sw} + (S_{FCOD} + S_{VFA})} \frac{S_{O_2}}{K_{O_2} + S_{O_2}} X_{Bw}$
2	Aerobic growth of biomass in biofilm	$\frac{1}{Y_{Hf}}(FCOD + VFA) + \frac{(1 - Y_{Hf})}{Y_{Hf}} O_2$ $\rightarrow Bw + \frac{(1 - Y_{Hf})}{Y_{Hf}} \frac{100}{32} CO_2$	X_{Bw}	$k_{1/2} \sqrt{S_{O_2}} \frac{Y_{Hf} A}{(1 - Y_{Hf}) V} \frac{(S_{FCOD} + S_{VFA})}{K_{Sf} + (S_{FCOD} + S_{VFA})}$
3	Aerobic maintenance requirement	$Bw + O_2 \rightarrow \frac{100}{32} CO_2$	X_{Bw}	$-q_m \frac{S_{O_2}}{K_{O_2} + S_{O_2}} X_{Bw}$
4	Aerobic hydrolysis of slowly biodegradable substrate	$SBCOD \rightarrow$ $FCOD + iSXS \cdot H_2S + iSXiN \cdot NH_3$	X_{SBCOD}	$-k_h \frac{X_{SBCOD} + X_{Bw}}{K_X + X_{SBCOD} + X_{Bw}} \frac{S_{O_2}}{K_{O_2} + S_{O_2}} (X_{Bw} + \epsilon X_{Bf} \frac{A}{V})$
5	Anaerobic hydrolysis of slowly biodegradable substrate	$SBCOD \rightarrow$ $FCOD + iSXS \cdot H_2S + iSXiN \cdot NH_3$	X_{SBCOD}	$-\eta_{fe} k_h \frac{X_{SBCOD} + X_{Bw}}{K_X + X_{SBCOD} + X_{Bw}} \frac{S_{O_2}}{K_{O_2} + S_{O_2}} (X_{Bw} + \epsilon X_{Bf} \frac{A}{V})$
6	Fermentation	$FCOD \rightarrow VFA$	S_{FCOD}	$-q_{fe} \frac{S_{FCOD}}{K_{fe} + S_{FCOD}} \frac{K_{O_2}}{K_{O_2} + S_{O_2}} (X_{Bw} + \epsilon X_{Bf} \frac{A}{V})$
7	Sulfide generation using fermentable substrate	$2FCOD + SO_4 \rightarrow H_2S$	S_{H_2S}	$k_{H_2S} \frac{(S_{FCOD} + S_{VFA})}{K_{Sf} + (S_{FCOD} + S_{VFA})} \frac{S_{SO_4}}{K_{SO_4} + S_{SO_4}} \frac{K_{O_2}}{K_{O_2} + S_{O_2}} \frac{A}{V} \frac{S_{FCOD}}{S_{FCOD} + S_{VFA}}$
8	Sulfide generation using VFA	$2VFA + SO_4 \rightarrow H_2S$	S_{H_2S}	$k_{H_2S} \frac{(S_{FCOD} + S_{VFA})}{K_{Sf} + (S_{FCOD} + S_{VFA})} \frac{S_{SO_4}}{K_{SO_4} + S_{SO_4}} \frac{K_{O_2}}{K_{O_2} + S_{O_2}} \frac{A}{V} \frac{S_{VFA}}{S_{FCOD} + S_{VFA}}$
9	Chemical sulfide oxidation	$2O_2 + H_2S \rightarrow SO_4$	S_{SO_4}	$k_{chem-oxi} S_{O_2} S_{H_2S}$
10	Biological sulfide oxidation	$2O_2 + H_2S \rightarrow SO_4$	S_{SO_4}	$k_{bio-oxi} \sqrt{S_{O_2}} \sqrt{S_{H_2S}} \frac{A}{V}$

Units: S_{FCOD} , S_{VFA} , S_{O_2} , X_{Bw} and X_{SBCOD} —mg COD/L; X_{Bf} —mg COD/m²; S_{CO_2} —mol/L as CaCO₃; S_{H_2S} and S_{SO_4} —mg S/L; S_{NH_3} —mg N/L.

Table 6.1 Model Parameters Used

Symbol	Unit	Description	Value used
μ_H^a	d ⁻¹	maximum specific growth rate for heterotrophic biomass	7
Y_{Hw}^a	gCOD/gCOD	suspended biomass yield constant for heterotrophics	0.55
K_S^a	gCOD/m ³	saturation constant for readily biodegradable substrate	1
K_O^a	gO ₂ /m ³	saturation constant for DO	0.5
q_m^a	d ⁻¹	maintenance energy requirement rate constant	1
$k_{1/2}^a$	gO ₂ ^{0.5} m ^{-0.5} d ⁻¹	1/2 order rate constant	2.5
Y_{Hf}^a	gCOD/gCOD	biofilm yield constant for heterotrophic biomass	0.55
K_{Sf}^a	gCOD/m ³	saturation constant for readily biodegradable substrate	1
ϵX_{Bf}^b	gCOD/m ²	ϵ = efficiency constant for the biofilm biomass X_{Bf} = concentration of active heterotrophic biomass in biofilm	40
k_{h2}^a	d ⁻¹	hydrolysis rate constant (slow)	1
K_{X2}^a	gCOD/gCOD	saturation constant for hydrolysis	0.2
η_{fe}^a	-	anaerobic hydrolysis reduction factor	0.14
q_{fe}^a	d ⁻¹	maximum rate for fermentation	3
K_{fe}^a	gCOD/m ³	saturation constant for fermentation	20
k_{H2S}^c	gS/m ² d	maximum sulfide production rate	10
$k_{chem-oxi}^c$	/(mgO ₂ /L)h	chemical sulfide oxidation rate	0.05

Symbol	Unit	Description	Value used
$K_{SO_4}^d$	mgS/L	saturation constant for sulfate	0.32
$k_{bio-oxi}^b$		biological sulfide oxidation rate	0.05
i_{SXS}^b	gS/gCOD	sulfur content of biomass	0.005

^a Source: Vollertsen et al (1999)

^b Assumed value

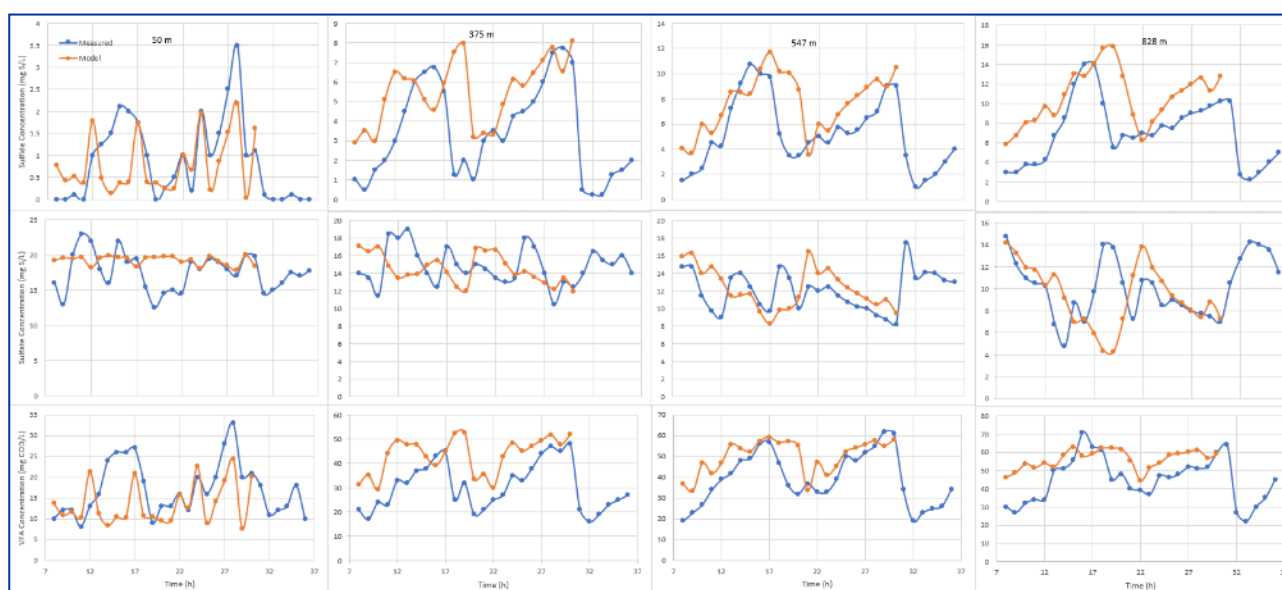
^c Source: Sharma et al (2008)

^d Source: Nethe-Jaenchen & Thauer (1983)

Table 6.2 Initial Concentrations Used

Symbol	Unit	Description	Value used
S_{H_2S}	mgS/L	Hydrogen sulfide	0
S_{FCOD}	mgCOD/L	Fermentable substrate	50
S_{VFA}	mgCOD/L	Volatile fatty acid	8
S_{SO_4}	mgS/L	Sulfate	20
S_{O_2}	mgO ₂ /L	Dissolved oxygen	2
X_{SBCOD}	mgCOD/L	Slow biodegradable substrate	450
X_{BW}	mgCOD/L	Active heterotrophic biomass in the water phase	100

Figure 6.2 Model Predictions and Measured Sulfide, Sulfate and VFA Concentrations in the Rising Main at 50m, 375m, 547m and 828m Distance from the Inlet



6.1.3 Use of the Model to Calculate H₂S Concentration in the Rising Main

The model parameters and initial concentrations determined as discussed in **Section 6.1.2** were used to model the rising main. Since the model was only developed for rising mains (as a series of tanks), the wet well was modelled as the initial tank but with different dimensions to the other “tanks” in series. The detention time for the pump station and manhole was calculated as 0.3 and 0.1 hours, respectively. The reactions occurring in gravity mains and the potential reduction of sulfide concentrations due to emissions of H₂S have not been considered, erring on the conservative side. Furthermore, assuming emissions are constant per hour should provide sufficient conservatism for the purposes of this assessment.

6.1.4 Calculation of H₂S Concentration in the Gas Phase

The H₂S in the liquid phase will be in the dissociated and undissociated form. The proportions that are dissociated and undissociated are a function of pH. At low pH, majority of the H₂S exists in the undissociated

form which escapes in the gas phase according to Henry's law. At neutral pH, the dissociated and undissociated forms exist in equal numbers. At high pH, majority of the H₂S is in the dissociated form which does not escape in the gas phase.

The equilibrium concentration in the liquid phase according to pH is determined using the following equation:

$$[H_2S]_{(undissociated)} = [S]_{(total)} \frac{[10^{-pH}]^2}{[10^{-pH}]^2 + 10^{-6.98} * 10^{-pH} + 10^{-6.98} * 10^{-13.45}} \quad (\text{Evanson, 2018})$$

To calculate the H₂S concentration in the gas phase, a Henry's law constant of 0.19 M/atm at 25°C (Sander, 1999) was applied to the H₂S (undissociated) concentration in the liquid phase. This is assuming the concentration of undissociated H₂S in the liquid phase would remain the same when it reaches equilibrium. In reality, the concentration of H₂S in the liquid phase would decrease as the H₂S is released in the gas phase, especially at low pH.

Unless the system is very turbulent, the concentration in the bulk of the gas phase will rarely reach equilibrium with the concentration in the bulk of the liquid phase. The species will have to migrate by diffusion to the liquid-gas interface where only at the thin film in the interface will gas-liquid equilibrium occur. The gas species from the thin film will also have to diffuse to the bulk of the gas phase. The concentration of H₂S in the headspace of pump stations is 10 to 20% based on perfect equilibrium (Evanson, 2018). Hence, the H₂S emission rates from each of the discharge points have been calculated based on Henry's law equilibrium multiplied by a factor of 20%.

6.1.5 Calculation of Odour Concentration

Previous sampling of hydrogen sulphide by Air Noise Environment at existing pump stations has indicated an odour-to-hydrogen sulphide relationship of 4000 OU:2.5 ppm of hydrogen sulphide. However, it is noted that the OU:H₂S ratio is only applicable at 2.5 ppm. A review of the literature indicates a non-linear H₂S to odour relationship (Gostelow & Parsons, 2000, Dincer & Muezzinoglu, 2007). The non-linear relationship is expressed in the following equation:

$$C_{OU} = mC_{H_2S}^n$$

Where:

C_{OU} = Concentration (Odour Units)

C_{H₂S} = Concentration of H₂S (ppm)

m and n = constants specific to sewage source

It is not possible to identify constants without site specific data. However, available research indicates an alternative approach to calculate the odour concentrations, as shown with the below equation:

$$C_{OU} = \frac{C_{H_2S} * \text{Adjustment Factor}}{\text{Threshold}}$$

Where:

Adjustment factor for other compounds = 3

H₂S odour threshold= 0.005

For the purpose of the assessment, the more conservative of the two methods has been adopted (i.e. the first approach).

Once the odour concentration has been established, an emission rate (OUV/s) has been derived using the following equation:

$$\text{OER (OUV/hr)} = \text{Odour Concentration (OU)} \times \text{Air Flow Rate (m}^3/\text{s)}$$

The airflow rate is defined by the amount of water pumped through the rising main, which is a function of the water flow rate into the pump station and the pump capacity.

6.2 Source Parameters

Based on the calculation methodology described above, the source parameters used in modelling are provided in **Table 6.3**. The velocity will vary depending on sewer flows and ambient conditions but was assumed to be a low 0.1 m/s which will conservatively model low vertical momentum.

Table 6.3 Source Parameters

Source	Easting (m) WGS84, Zone 56	Northing (m) WGS84, Zone 56	Height (m)	Diameter (m)	Velocity (m/s)	Peak Emission Rate (OU/s)
Discharge Manhole	527443	6917205	1	1.05	0.1	16
Pump Station Vent	527416	6917454	8	0.1	0.1	19

7. DISPERSION MODELLING METHOD

7.1 Overview

In order to predict the fate of pollutants after they are emitted to air, a mathematical model is used to simulate their dispersion and deposition. It is accepted by regulatory agencies that this type of modelling has associated uncertainties. These are normally addressed by using statistics over long simulation times, and deriving emission rates based on published emission factors or data representing high emission conditions.

CALPUFF (Version 7.2.1) was chosen as the appropriate model in this assessment. The predictions undertaken for this assessment are based on the following method:

- H₂S emission estimates were based on the Sewex methodology of predicting H₂S production along the rising main and theoretical calculation of equilibrium concentration.
- Prediction of input meteorology was completed using TAPM developed by the CSIRO Division of Atmospheric Research. TAPM has a prognostic 3 dimensional meteorological component which can be used to generate hourly meteorological data for input into dispersion models. TAPM was run over a full representative year (2020) to include all seasons. It uses gridded terrain data at approximately 300 metre grid spacing to shape the wind fields.
- TAPM input meteorology was enhanced using CALMET, the meteorological pre-processor for CALPUFF. This fits the wind fields to the terrain based on gridded terrain data at approximately 30 metre grids spacing.
- Ambient odour and H₂S concentrations were predicted using CALPUFF.

7.2 CALPUFF Configuration

The three dimensional wind fields from CALMET were entered into CALPUFF for the full year 2020. CALPUFF was run over a computational grid the same as the meteorological grid (4 kilometres x 4 kilometres) with spacing of 50 metres, and with receptors gridded over a smaller domain (1.5 kilometres x 1.5 kilometres) with a resolution of 25 metres.

Wind speed profile was set to the Industrial Source Complex (ISC) Urban-1 exponents. Transitional plume rise and partial penetration of boundary layers were included. Briggs rise algorithm was used since the sources are not very hot.

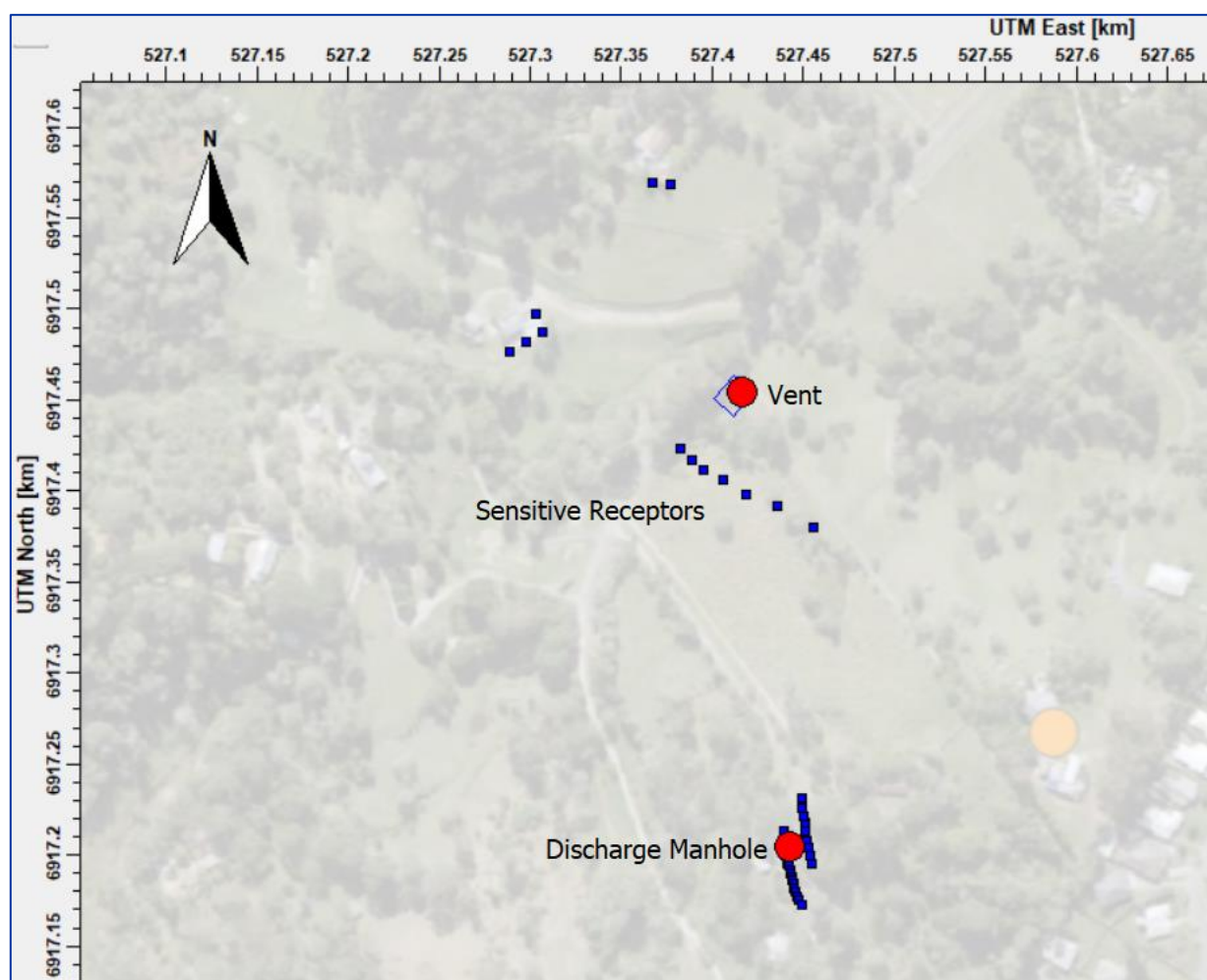
The emissions were modelled as puffs (not slugs) since there are no receptors in the near vicinity of area sources. Puff-splitting was turned off.

Dispersion coefficients were derived by the model using turbulence generated by micrometeorology. The Heffter curve was used to compute time-dependent dispersion beyond 550 metres. The partial plume height adjustment method was used to allow winds to approach hills as terrain increases.

The minimum turbulence velocity, sigma v, was set to 0.2 m/s.

Figure 7.1 shows modelled sources and sensitive receptors.

Figure 7.1 Modelled Sources and Sensitive Receptors



7.3 Downwash Structures

Based on a review of the modelled stack heights and surrounding area, the pump station building itself has been considered as a downwash structure for the pump station vent and modelled as 3 metres high.

7.4 CALPOST

Post processing of modelled emissions is undertaken using the CALPOST package. This allows the rigorous analysis of pollutant predictions generated by the CALPUFF system. In particular, CALPOST is able to provide an analysis of predicted pollutant concentrations for a range of averaging periods from 1 hour to 1 year.

8. DISPERSION MODELLING RESULTS

Table 8.1 presents the maximum predicted odour concentrations for receptors around the sewage pump station vent and the rising main discharge manhole. **Figure 8.1** and **Figure 8.2** represent predicted ground-level concentrations at sensitive receptors for the discharge manhole and sewage pump station vent, respectively. Concentrations provided in tabular form are a prediction at a point in space and are hence more accurate than the contours, which are graphical interpolations.

The results of the modelling show predicted compliance with the odour limit at all sensitive receptors, provided that the pump station vent height is at or above the modelled height of 8 metres above ground.

Based on the presented results, odour mitigation such as dosing or carbon filters is considered not necessary at the proposed pump station or manhole.

Upset conditions, such as excessive residence time of sewage in the rising main could result in higher odour emissions than considered in the modelling, hence maintaining normal pump operating conditions is a key element in minimising the risk of adverse community odours.

Table 8.1 Highest predicted concentrations at nearest sensitive receptors, 99.5th percentile

Source	Highest Predicted Concentration (OU, 1-hour, 99.5 th %)	Criteria
Pump Station Vent	0.03	2.5 OU
Discharge Manhole	1.2	2.5 OU

Figure 8.1 Predicted Ground Level Concentrations Around Discharge Manhole

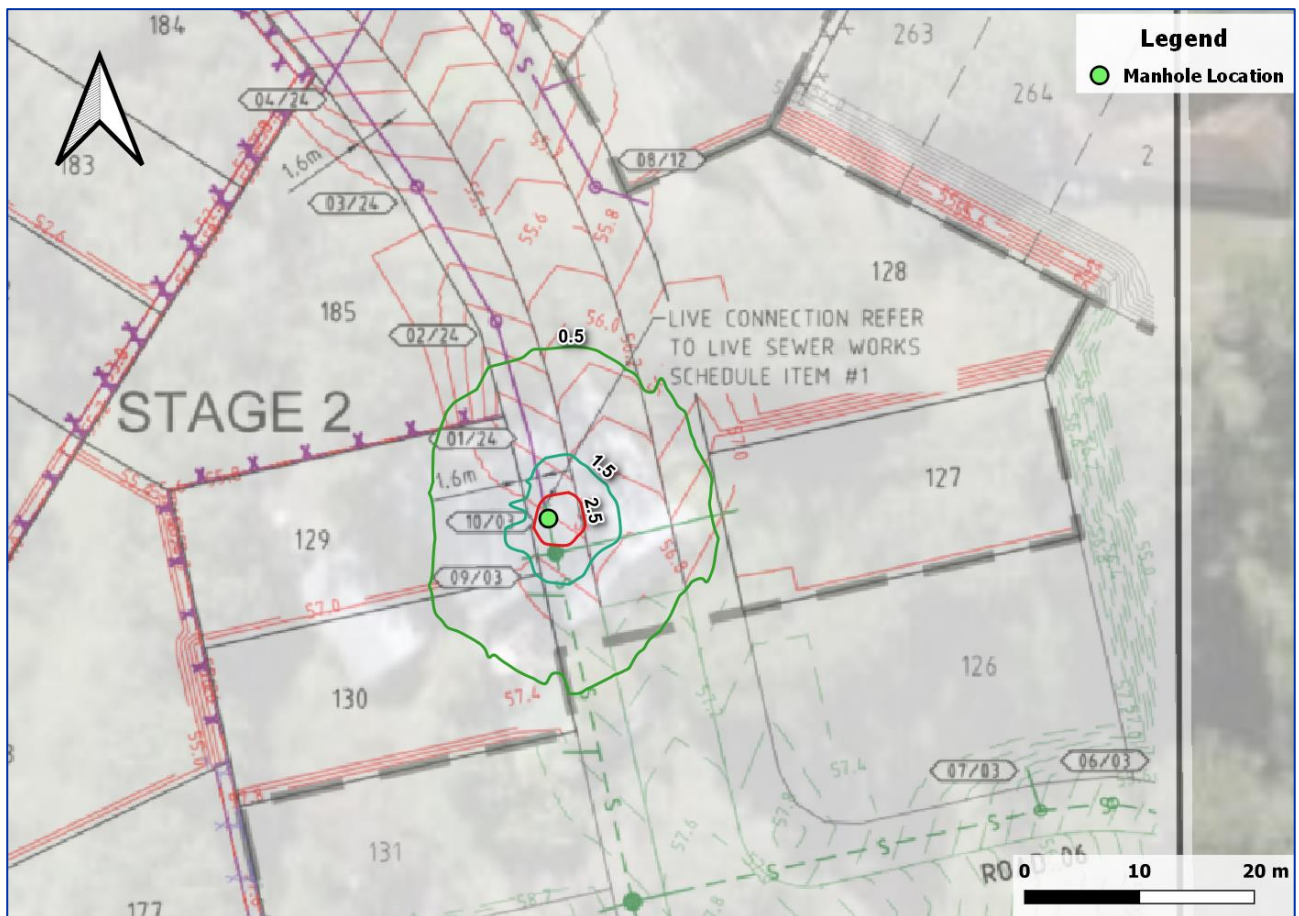
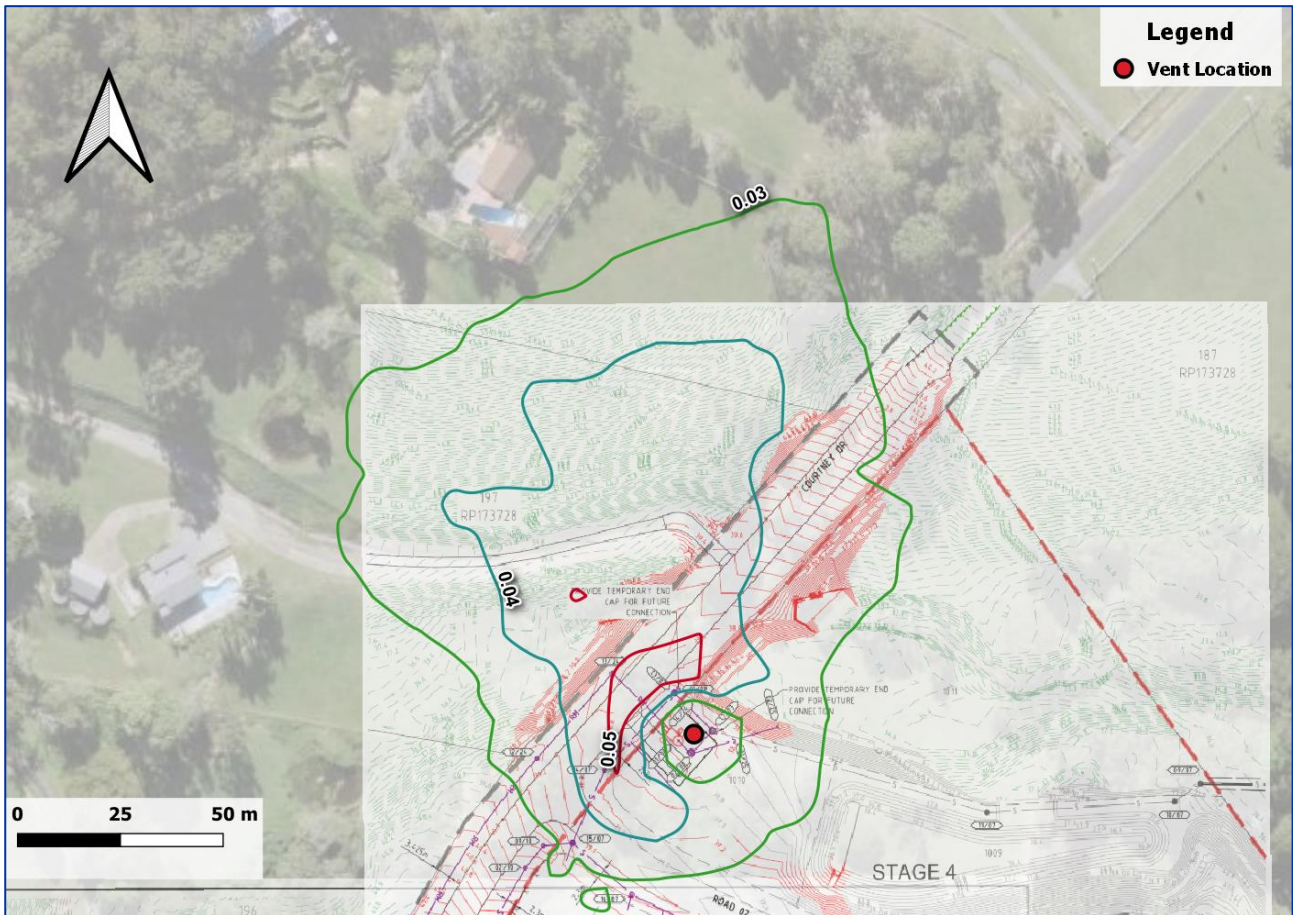


Figure 8.2 Predicted Ground Level Concentrations Around Pump Station



9. CONCLUSION

An assessment of potential odour impacts has been undertaken for a proposed pump station and rising main to be located at 79 - 99 Courtney Drive, Upper Coomera.

Based on the presented results, odour mitigation such as dosing or carbon filters is not considered necessary at the proposed manhole or pump station if the vent height is at least 8 metres from the ground level.

Upset conditions, such as excessive residence time of sewage in the rising main could result in higher odour emissions than considered in the modelling, hence maintaining normal pump operating conditions is a key element in minimising the risk of adverse community odours.

Overall, from an air quality perspective, the proposed placements of the pump station and rising main represent suitable locations at the site

REFERENCES

Evanson, I. (2018), Sewer Networks and Septicity, presented in the Odour Training Course by CASANZ in Brisbane, QLD, 22 March 2018.

Gostelow P and Parsons S (2000). Sewage treatment works odour measurement. Science and Technology, 41(6), pp 33-40.

Dincer F and Muezzinoglu A (2007). Odour Determination at Wastewater Collection Systems: Olfactometry versus H₂S Analyses. Clean – Soil, Air, Water, 35(6), pp 565-570.

Sharma K., Ganigue, R. and Yuan, Z. (2013), pH dynamics in sewers and its modeling, Water Research 47 (2013) 6086-6096.

TRC Environmental Corporation (March 2011) 'Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia' prepared on behalf of the NSW Office of Environment and Heritage.

GLOSSARY

Parameter or Term	Description
DEM	Digital Elevation Model
DES	Department of Environment and Science
ERA	Environmentally relevant activities
L/s	Litre per second
mg	Milligram
OU	Odour units
pH	Potential of hydrogen
ppm	Parts per million
TAPM	The Air Pollution Model developed by CSIRO and used by ASK for meteorological modelling
Trinity	Trinity Consultants Australia
UTM	Universal Transverse Mercator coordinate system
°C	Degree Celsius



BRISBANE

A: Level 3, 43 Peel Street
South Brisbane, QLD 4101
T: +61 7 3255 3355
E: brisbane@trinityconsultants.com

GLADSTONE (Vision Environment)

A: Unit 3, 165 Auckland Street
PO Box 1267
Gladstone, QLD, 4680
T: +61 7 4972 7530
E: office@visionenvironment.com.au

SYDNEY

A: Level 6, 69 Reservoir Street
Surry Hills, NSW 2010
T: +61 2 8217 0706
E: sydney@trinityconsultants.com