ABN 92 160 694 011

Odour Assessment –

Te Mata Mushrooms Waipukurau Site

Report prepared for:
The Te Mata Mushroom Company Limited

9 November 2020

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9 November 2020

1 Introduction

The Te Mata Mushroom Company (TMM) proposes to develop a compost making facility on Mt Herbert Road, 4km from Waipukurau (the “site”). The compost will be used as a substrate for growing mushrooms. The proposed compost throughput rate will be up to 900 tonnes per week (“Tpw”).

The proposed composting plant is a new facility designed by GTL Europe (based in The Netherlands), using best practice processing equipment and odour control to minimise odour discharges. GTL Europe provides advisory and engineering services on installation technology, civil engineering, machine construction and automation for composting and mushroom cultivation[1].

The compost consists of straw, chicken litter and gypsum. Other additives such as maize are also used when available. The composting activity comprises three phases of compost production: (1) active aerated composting in closed bunkers; (2) maturation and pasteurisation in closed tunnels; and (3) mixing with mushroom spawn and incubation. All three phases of composting will be carried out at the new site.

The purpose of this report is to assess the potential odour impact arising from the proposed TMM operation at the site.

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[1] http://www.gtl-europe.nl/en/about-us/engineering

2 Site Location

2.1 Neighbouring Land Uses

The site is located at 302-464 Mt Herbert Road, Waipukurau. The location is shown in Figure 1. Nearby houses and separation distances to the closest residences are also shown on Figure 1. The nearest residences are over 1400m from the proposed location of the composting operation.

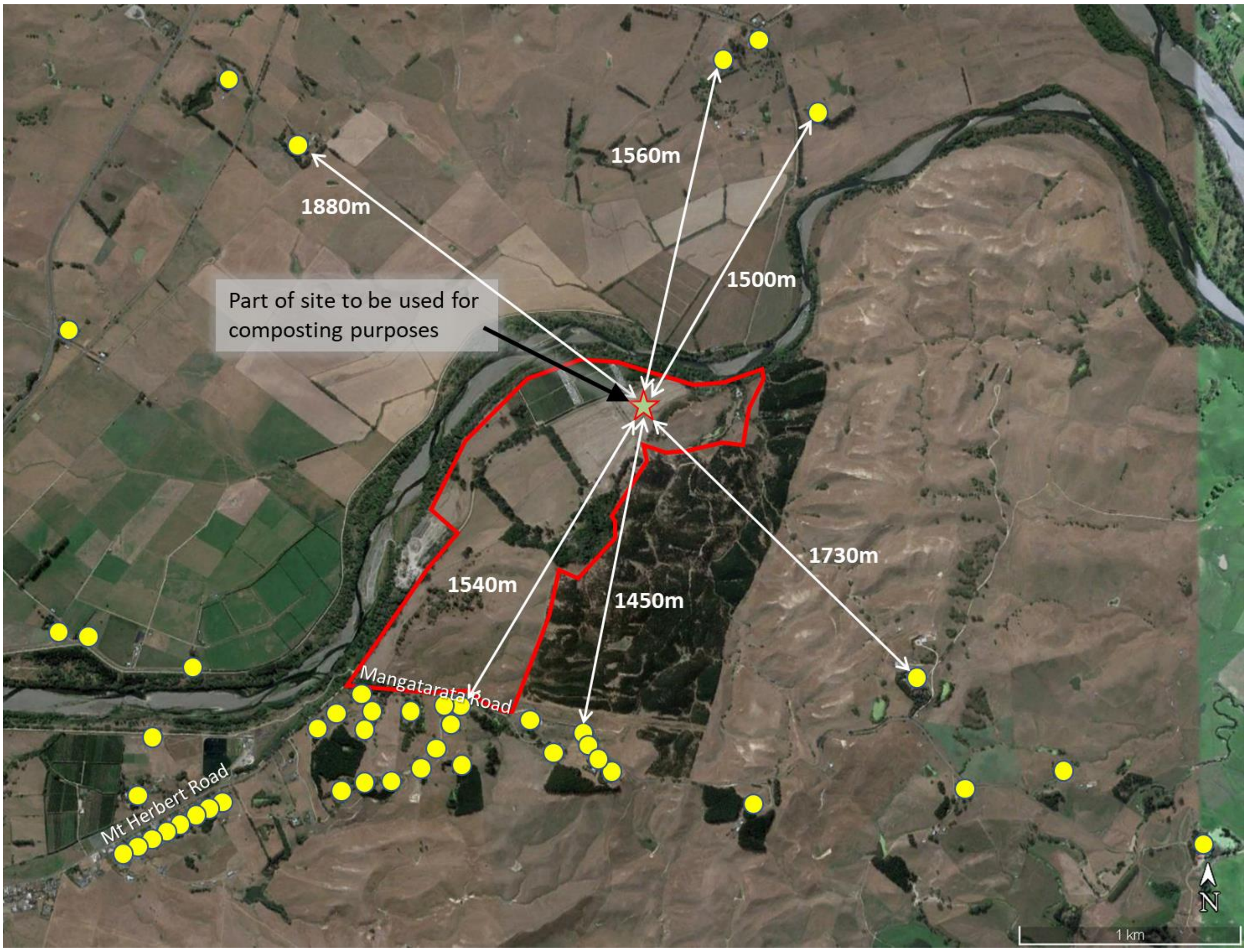

Figure 1: Site location (red outline). Image source: Google Earth Pro, image flown 4 September 2017. Nearby houses shown by yellow circles.

The site is bounded by farmland and forestry land uses, including some nearby walking and cycling tracks which are part of the Tukituki Trail (see Figure 2 and Figure 3). A local Wahi Tapu site of significance is located northeast of the TMM site, approximately 500 m from the proposed composting plant location (approximate location shown on Figure 5).

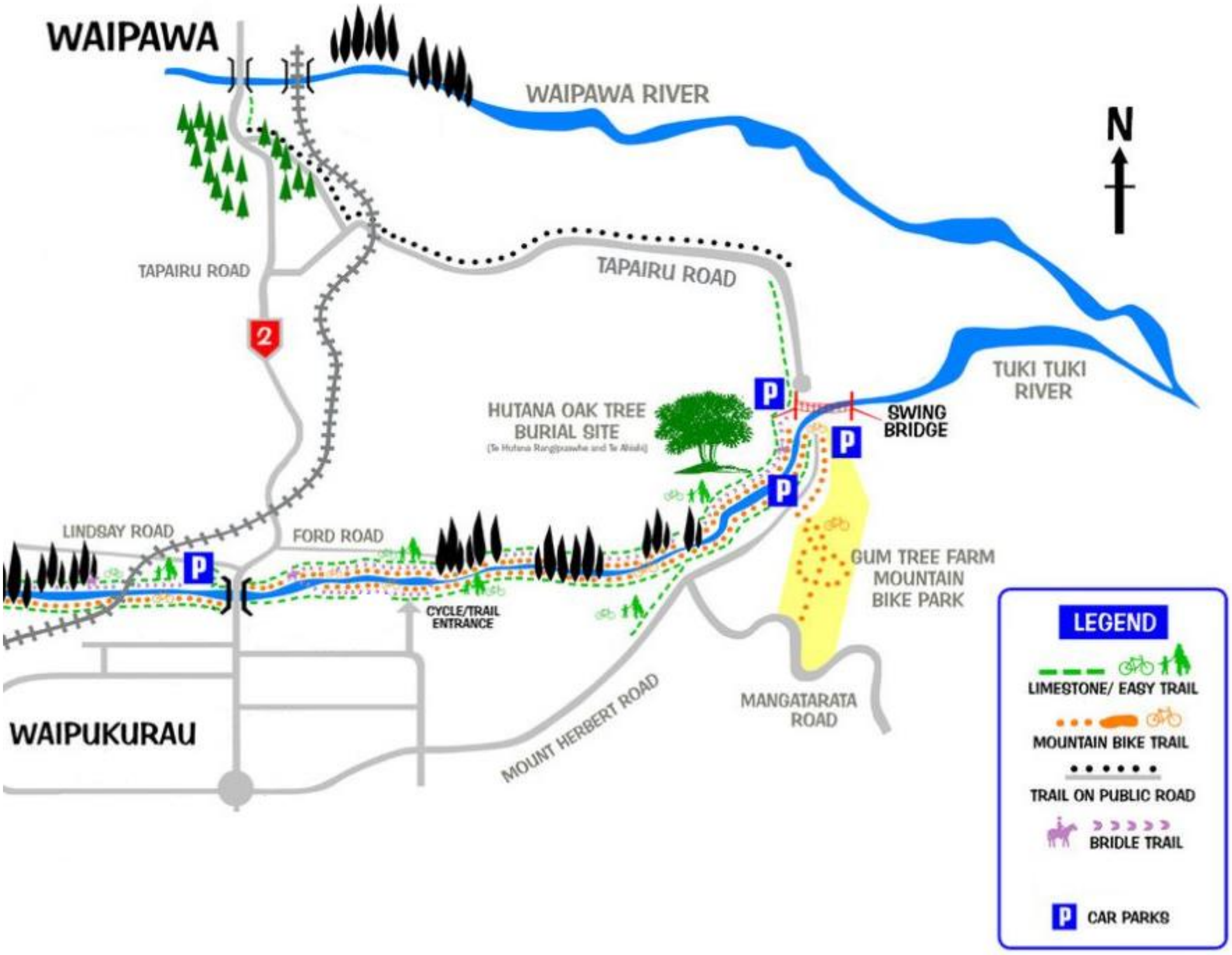

Figure 2: Schematic map of Tukituki Trail, edited from https://www.tukitukitrail.com/maps accessed 25/10/20.

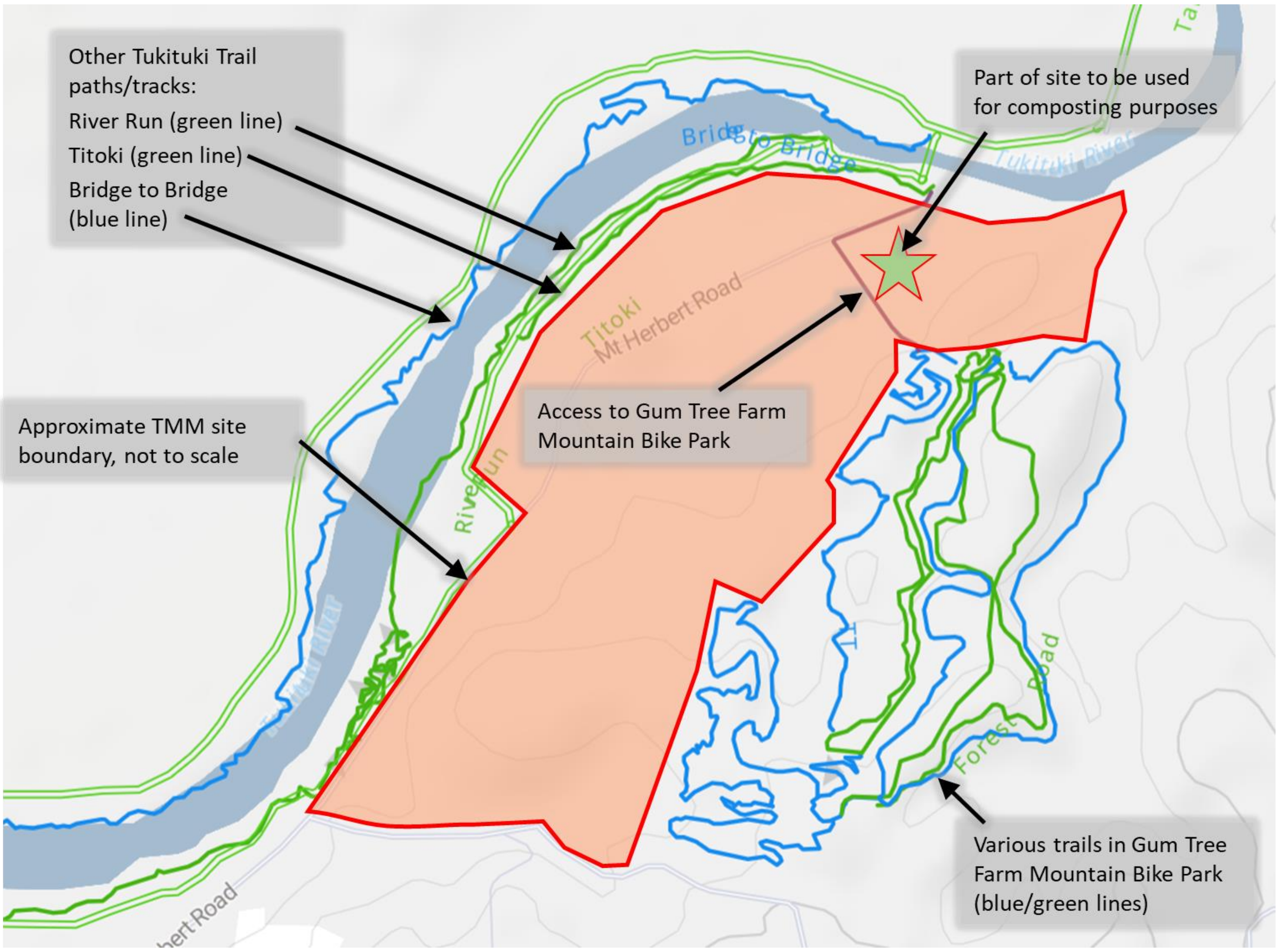

Figure 3: Location of Tukituki Trail paths and tracks near the site, from https://www.trailforks.com/region/the-tukituki-trail-18812/ accessed 25/10/20.

2.2 Topography

The Waipukurau area is characterised by a mix of rolling hills, flat pastoral land, and a shallow valley system defined by the Tukituki River and the Waipawa River. The regional topography is shown in Figure 4, with a closer view of the topography around the site shown in Figure 5. The black dashed line on Figure 5 following the south bank of the Tukituki River from Waipukurau to the north end of Mt Herbert Road indicates the location of the River Run and Titoki trails shown previously on Figure 3. The trails also passes adjacent to the Waipukurau Wastewater Treatment Plant which is located between the site and Waipukurau.

The part of the site proposed for the composting operation is on flat land at an elevation of about 120m above sea level, with the river to the immediate east and north, and rolling hills peaking at 250m above sea level to the immediate west and south. The houses to the south of the site on Mangatarata Road shown on Figure 1 are located along on the higher slopes of these rolling hills.

These terrain features will affect the direction of wind flows in the area around the site and assist with deflection of odour discharges away from the houses at elevated locations. This is discussed further in Section 4.

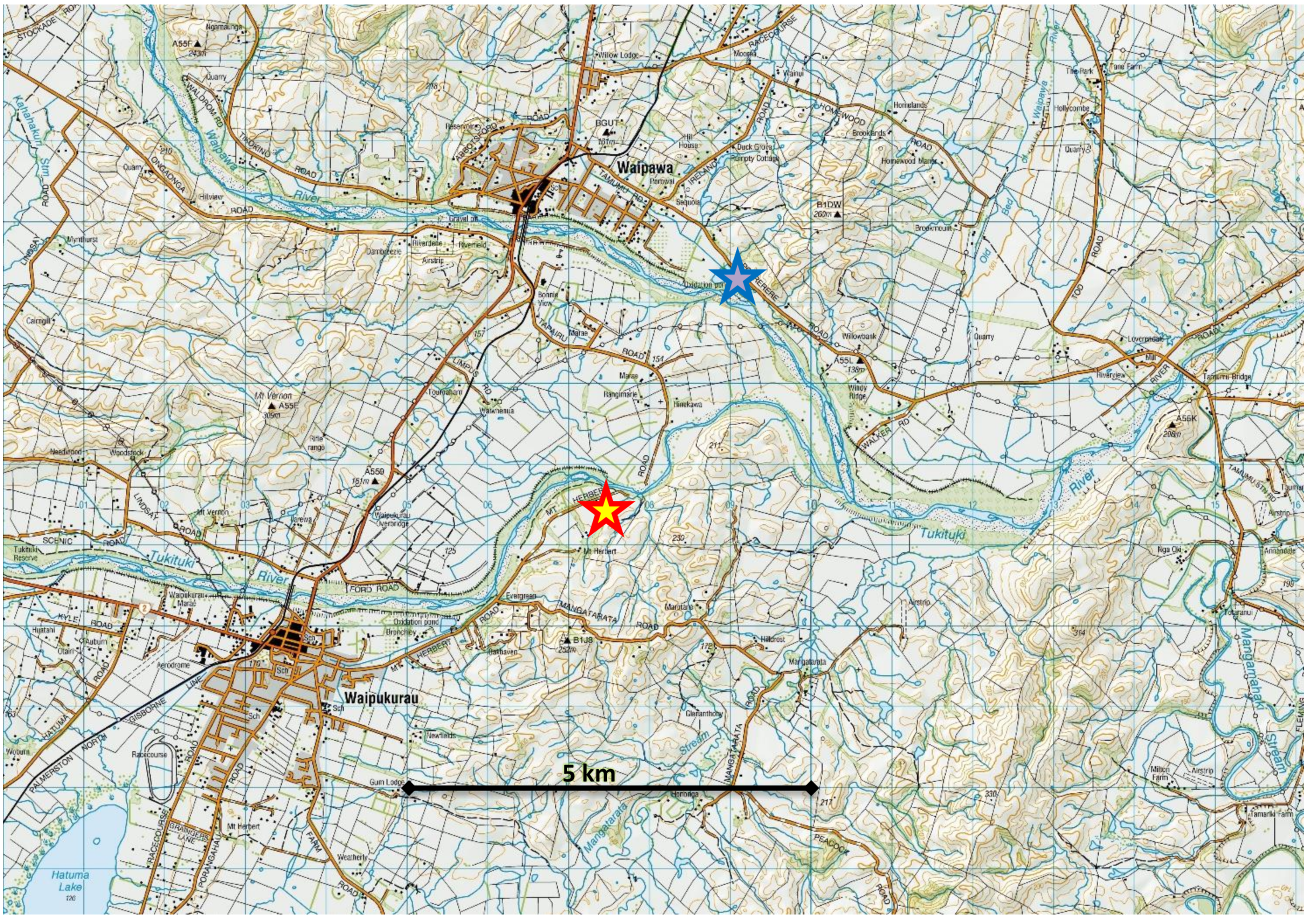

Figure 4: Regional topography. Image source: NZ Topo50 Map BL38. Downloaded from https://data.linz.govt.nz, April 2018. Red-outlined star marks location of proposed composting operation. Blue-outlined star marks location of Waipawa meteorological station (refer Section 4).

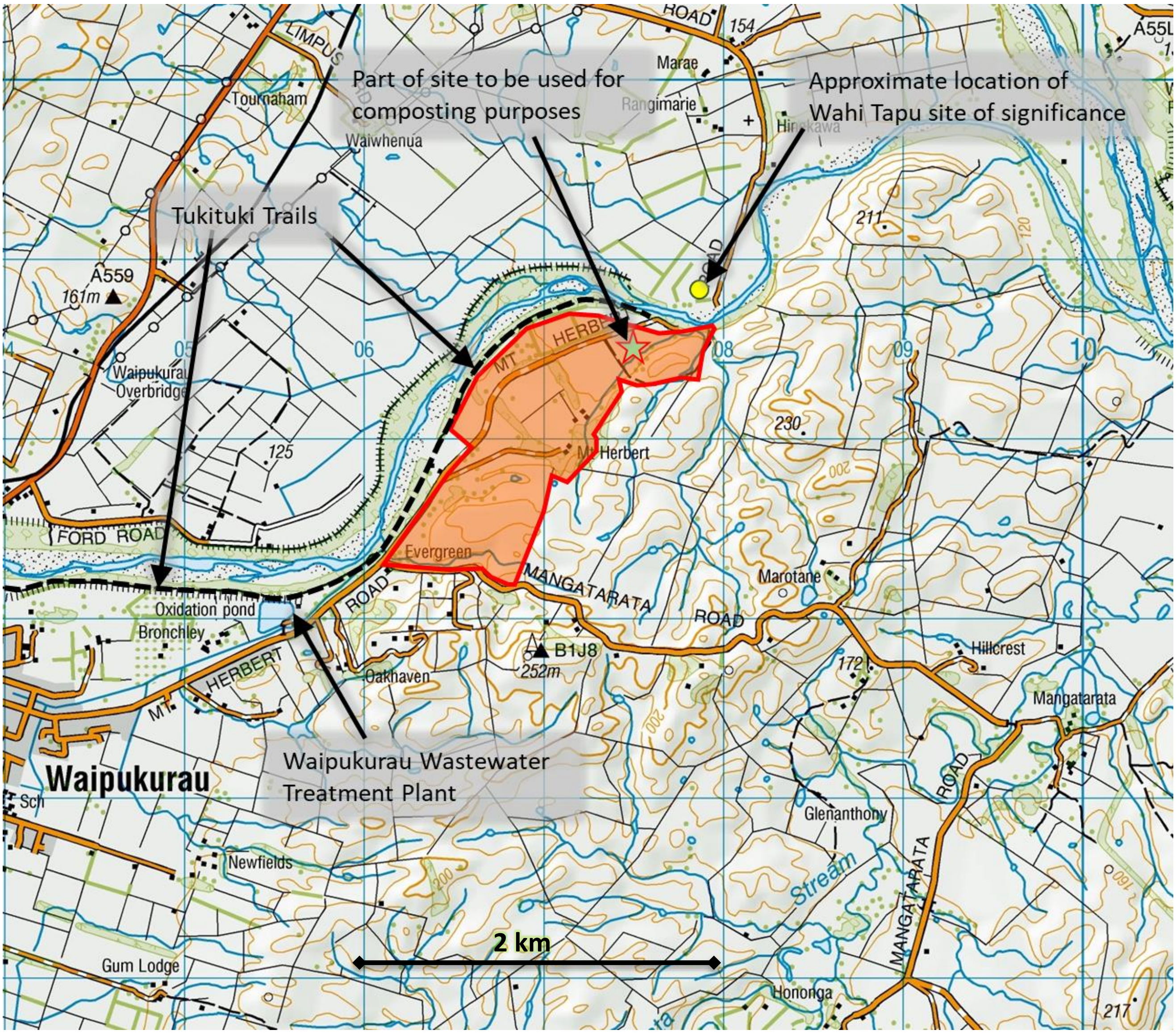

Figure 5: Topography and land use features near site, with site shown in red outline. Image source: NZ Topo50 Map BL38. Downloaded from https://data.linz.govt.nz, April 2018.

3 Description of Proposed Activities

3.1 Overview of Composting Process

Compost is an essential part of the mushroom growing process and is used as part of the substrate that the mushrooms are grown on. Compost consists of straw, chicken litter and gypsum. The key components of the composting process are described in this section.

Composting occurs in three phases, transforming the raw materials into a medium suitable for growing mushrooms. Phase 1 composting starts with the mixing of pre-wetted straw and pre-mixed chicken litter and gypsum. The mix is then loaded into one of multiple Phase 1 bunkers. During the composting in Phase 1 air is blown through the newly mixed and composting material to maintain aerobic conditions. The bunkers are progressively emptied and filled to facilitate turning of compost via transferring the compost from one bunker to another (known as “bunker-to-bunker transfer”). These bunkers have a concrete floor, two concrete walls and insulated panel roof, and the end openings are closed with solid sliding doors when not in use. The Phase 1 bunker concrete floors have recessed lines which act in parallel as both aeration lines and a leachate collection system.

The bunkers are operated under a slight vacuum or negative pressure compared to outside air to avoid leaking of odorous air from the bunkers. Foul air within the bunker is drawn from the top of each bunker and treated to remove odour before discharge to atmosphere.

At the completion of the Phase 1 process, the compost is transferred removed from the Phase 1 bunkers and into Phase 2 tunnels. During the Phase 2 cycle, air in the bunker is recirculated at one end of the bunker, and a portion of the air is drawn from the bunker and treated to remove odour. After Phase 2, the compost is transferred to Phase 3, and then is used in the mushroom growing operation.

Phase 1 takes about 12 days to complete, and the whole process from pre-wetting of bales until the compost is ready to grow mushrooms is nearly four weeks. Multiple batches of compost are in various stages of production at any time so that fresh compost is always available for starting the mushroom spawning process.

3.2 Proposed Composting Methods

An overview showing the layout of the site and a drawing of the processing buildings is provided in Appendix A. The 900 Tpw processing capacity will require a total of five bunkers for Phase 1, and nine tunnels for Phases 2 and 3 (four for Phase 2, and five for Phase 3). A description of each part of the process is provided below.

1. Bale pre-wetting

Bale pre-wetting will occur by dunking the bales into a sump filled with goodie water (see Section 3.3). The bales are then stacked on an aerated pad outside the Phase 1 bunkers for about 9 days. If necessary, the bales may be occasionally irrigated with goodie water during this 9-day period.

2. Chicken litter/gypsum storage and handling

Chicken litter will be imported to the site approximately once per week, mixed immediately with gypsum and then stored in a covered bunker in the same room as where bale break occurs (see below).

3. Bale break, mixing, and material placement in bunkers

The mixing process will occur in a purpose-designed automated bale-break machine within a semi-enclosed building called the “Mixing Hall”. The machine will break up the bales, mix in the correct amount of chicken litter/gypsum and water, and then deposit the mixed substrate directly onto a conveyor for transport to one of five Phase 1 bunkers. Compost is placed evenly into the bunker via a telescopic, automated filling line with a capacity of 200 tonnes per hour (“Tph”).

The process will occur over a period of up to 8 hours between the hours of 8am and 6pm to avoid potential odour emissions during stable atmospheric conditions in the early morning and evening. The process will occur typically 1-2 days per week and will usually occur on weekdays, but may occur at weekends if necessary.

4. First and second turning of compost in Phase 1 bunkers

During Phase 1, the compost will be turned twice by removing the compost from the bunker using a front-end loader, mixing the material and adding moisture in the bale break machine, and then immediately returning the compost to a spare bunker via the conveyor system and bunker filling line; this is known as “bunker-to-bunker” transfer. One bunker is always kept spare for this process; i.e. with five bunker operation (for 900 Tpw production) only four bunkers are used for composting and the fifth is kept available for turning operations. The process is illustrated in Figure 7.

The process takes about 8 hours, and will be conducted only during the hours of 8am to 6pm at the Mt Herbert site.

5. Removal of compost from Phase 1 bunkers, mixing and placement into Phase 2 tunnels

At the end of the Phase 1 composting period 12 days after initial mixing, the compost will be removed from the Phase 1 bunkers by front end loader and returned to the Mixing Hall. There, it will be turned again using the bale break machine. The compost will then be transported using the same conveyor system into a fully-enclosed building housing the Phase 2 and 3 composting operations.

6. Phase 2 and 3 composting

Phase 2 and 3 composting operations will be conducted in tunnels inside a fully-enclosed building. Compost will not be exposed outdoors again until after the compost has been turned into mushroom cultivation substrate.

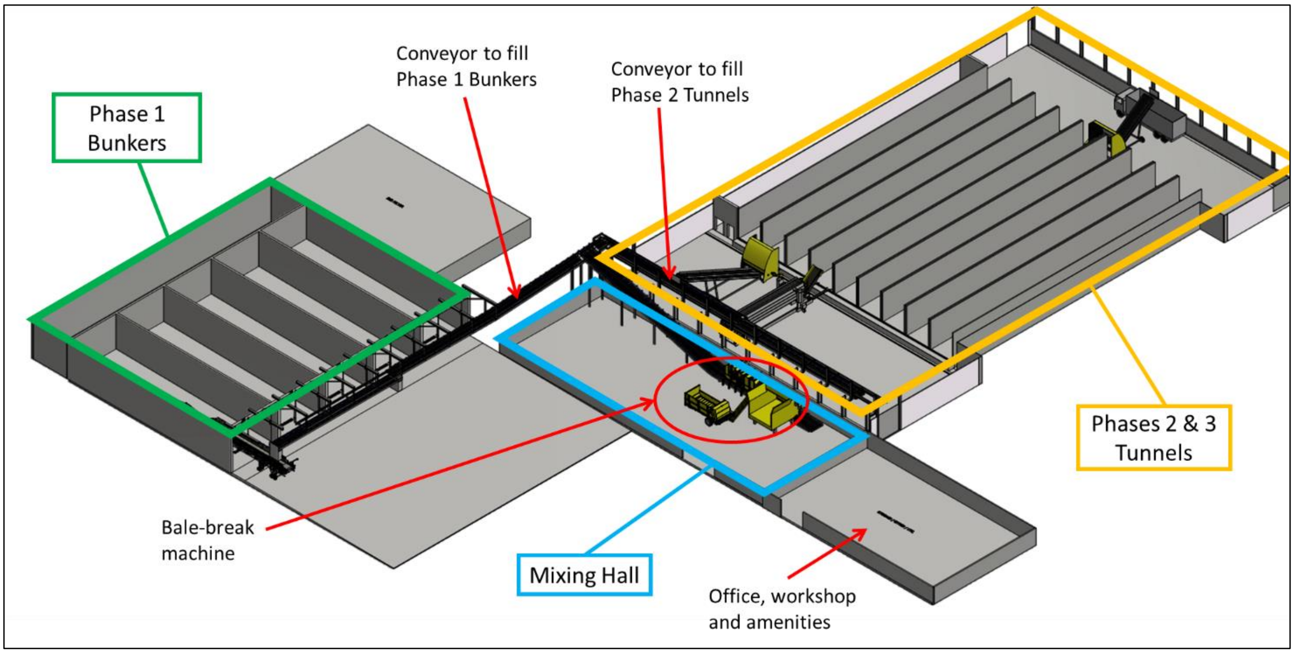

Figure 6: Schematic view of Phase 1 Bunkers, Mixing Hall, and Phase 2 Tunnels.

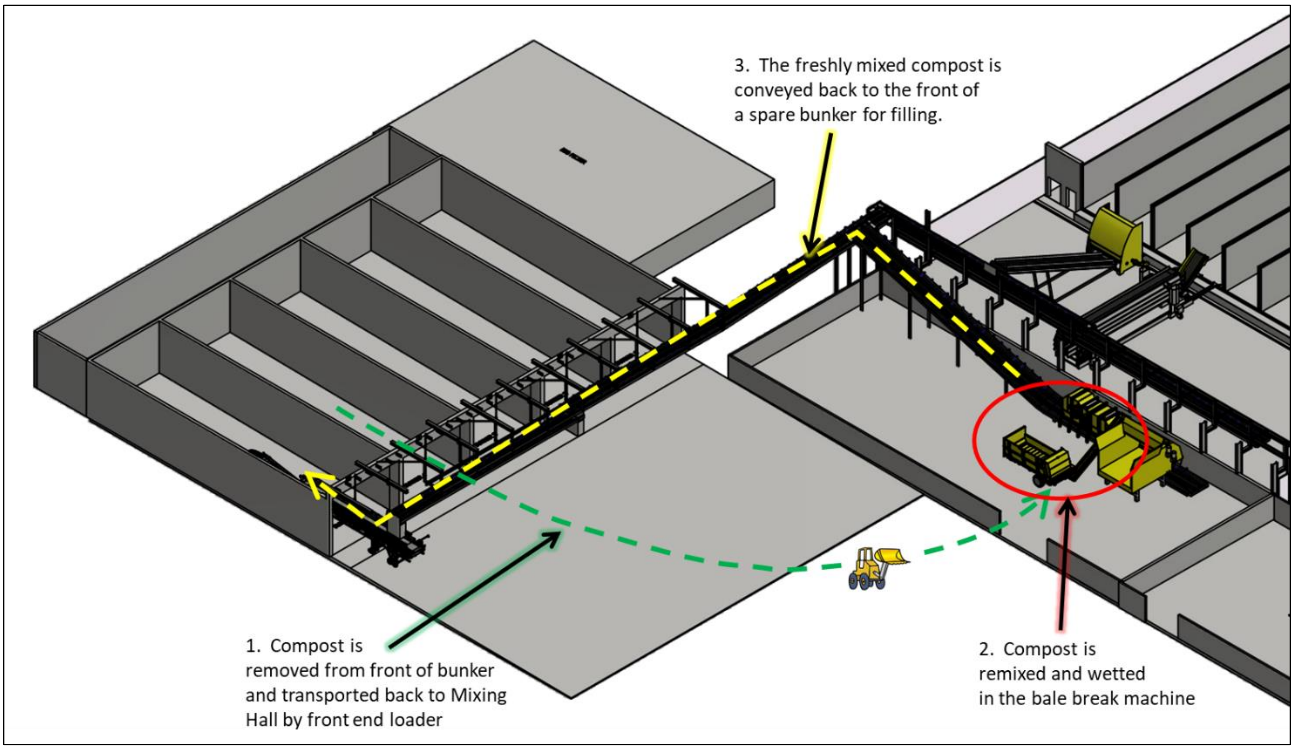

Figure 7: Illustration of bunker-to-bunker transfer process.

3.3 Recycled Water Collection and Storage

The site will include two ponds:

1. Freshwater runoff pond,
2. Phase 1 compost leachate pond ("goodie water").

The goodie water is loaded with organic compounds leached during the composting process, and the goodie water pond will be aerated and mixed to maintain aerobic conditions. The pond will be about 500 m^2 surface area and 4 m deep at full capacity, but will usually operate at about 240 m2 surface area except in extreme rainfall events. The aeration design will be similar to the system currently used successfully at TMM's Brookvale Road site, which uses an SAR™ Aerator from Hydro Processing and Mining Ltd (Canada)[2], proven in the field for mushroom composting farms. The aerator design recirculated recycled water through a land-mounted aerator, with the aerated water returned to the pond.

The goodie water is used to pre-wet the bales, and will be topped up with fresh water when needed.

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[2] http://www.hpmltd.ca/Aeration.html

4 Meteorology

4.1 Influence of Meteorology in Odour Dispersion

The most important meteorological conditions affecting dispersion of odour after emission are wind speed and direction, and atmospheric stability.

Wind speed: For emissions occurring close to ground or entrained in building downwash eddies, low wind speeds (roughly less than about 2 - 3 metres per second, or 4 - 6 knots) tend to result in noticeable odour at greater downwind distances than at higher wind speeds.

Atmospheric stability: The atmospheric stability is a measure of the vertical mixing, or turbulence, of the atmosphere close to ground. During low wind speeds around sunset and sunrise, and overnight, the atmosphere can be very stable with “inversion” caps keeping pollutants emitted close to the ground from rising high into the atmosphere. If such conditions coincide with odour emissions from sources located close to the ground, such as the potential odour sources from the composting operations at the TMM site, the dispersion of odour downwind from the source can be slow with odour nuisance more likely to be noticed by downwind sensitive receptors.

4.2 Local Wind Records

The nearest long-term meteorological monitoring station with publicly available data is 2.5 km east of Waipawa at the Waipawa wastewater treatment plant, about 3.2 km north-northeast of the proposed composting location (location marked on Figure 4).

Wind patterns at the TMM site may differ somewhat to those at Waipawa because the TMM site will be sheltered from southerly and easterly winds by the hill features to the east and south of the site, whereas at the Waipawa meteorological station the terrain is flat to the south but rolling hills are quite close to the northeast and east.

Hourly wind speed and direction data between January 2010 and December 2019 for Waipawa was downloaded from the online National Climate Database (also known as the NIWA Cliflo Database)[3]. Station information provided with the Cliflo data indicates that wind records from this station are expressed as a one-hour average. A windrose for Waipawa for that period of ten years is shown in Figure 8. Low wind speeds are dominantly from the northwest quadrant, following the course of the river along the path of least terrain elevation.

Windroses for the individual calendar years within that 10-year period are provided in Appendix 1. Each year shows a similar overall trend of prevailing wind directions, but with varying frequency of low wind speeds, particularly from directions where low wind speeds are uncommon. A breakdown of wind speed frequencies by year is shown in Table 1. A similar analysis of wind speeds was also prepared for only winds from the less frequent northeast to south sector (specifically 40 degrees to 180 degrees) and is provided in Table 2 – these

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[3] https://cliflo.niwa.co.nz/.

wind directions may also represent winds with the potential to carry odours from the composting operation towards sensitive receptors to the southwest on Mt Herbert Road, or towards the Tukituki River Esplanade.

Two calendar years were selected for the meteorological simulations described in Section 4.3; an “average” year, and a “worst case” year. The “average” year selected was 2014, based on the windrose for 2014 compared to the 10-year windrose, the speed distributions shown in Table 1 and Table 2, and the climate summary for 2014 from the NIWA website[4].

For the “worst case” year, the 2017 was selected as that year showed the largest proportions of low wind speeds, as well as the greatest proportion of those light winds coming from the northeast to south sector (as per Table 1 and Table 2). The climate summary for 2017 from the NIWA website[5] describes 2017 as a year with La Niña conditions (typically bringing more northeasterly winds and higher than normal temperatures[6]).

Table 1: Breakdown of wind speed frequency by year, Waipawa 2010-2019; all directions.

Wind speed, m/s	Percent of hourly-average records less than wind speed in year										
	2010-2019	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	1.8	0.1	0.4	1.9	2.0	2.4	0.2	1.7	3.7	3.2	1.8
<0.5	14.6	3.0	11.0	18.1	14.4	14.1	10.0	16.3	21.1	21.6	16.9
<1	33.5	15.6	31.3	37.7	37.3	35.0	34.3	35.2	37.9	37.3	34.0
<2	60.2	60.8	59.5	62.9	63.5	60.5	60.2	60.1	60.8	58.2	55.7
<3	78.6	82.5	78.9	80.6	81.6	78.4	80.6	78.9	76.5	74.4	73.7
<5	95.1	95.8	95.9	95.5	96.6	95.1	97.3	95.3	94.3	93.1	92.1
<8	99.4	99.3	99.5	99.4	99.5	99.1	99.9	99.0	99.4	99.6	99.7
>=8	0.6	0.7	0.5	0.6	0.5	0.9	0.1	1.0	0.6	0.4	0.3

Table 2: Breakdown of wind speed frequency by year, Waipawa 2010-2019; only winds coming from 40-180 degrees.

Wind speed, m/s	Percent of hourly-average records less than wind speed in year										
	2010-2019	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<0.5	12.7	2.3	8.9	12.3	11.3	12.2	11.2	17.3	21.6	17.1	15.6
<1	32.5	14.6	29.6	32.2	31.9	33.8	37.0	37.7	42.4	33.3	35.3
<2	64.3	63.4	61.9	63.2	61.2	66.0	67.4	68.7	72.2	56.8	64.5
<3	85.7	89.6	82.2	87.1	84.2	86.8	88.8	89.9	89.7	76.3	85.1
<5	98.1	99.3	97.2	98.3	98.4	98.1	99.4	99.2	99.4	94.0	98.0
<8	99.9	100.0	99.8	100.0	100.0	99.7	100.0	100.0	99.9	99.7	99.9
>=8	0.1	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.1	0.3	0.1

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[4] https://niwa.co.nz/climate/summaries/annual/annual-climate-summary-2014
[5] https://niwa.co.nz/climate/summaries/annual-climate-summary-2017
[6] https://niwa.co.nz/climate/information-and-resources/elnino/elnino-impacts-on-newzealand

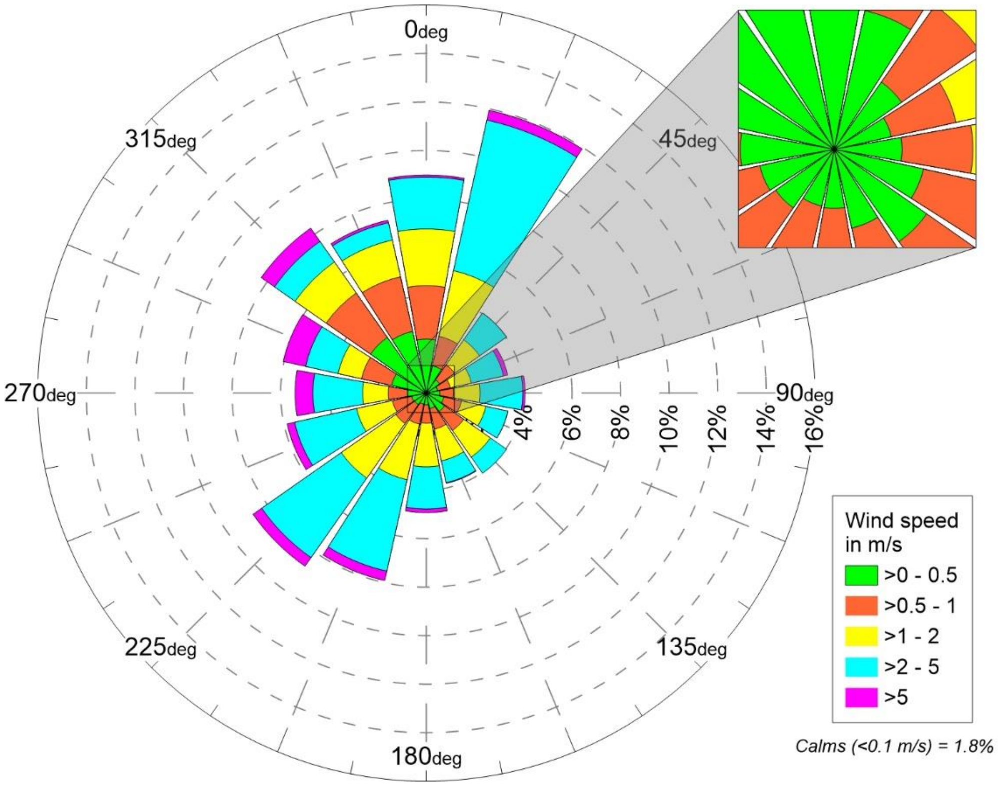


Figure 8: Windrose showing hourly-average wind observations from Waipawa meteorological data station, January 2010 to December 2019. Refer Appendix 1 for windroses for individual years.

4.3 Regional Windfield Simulation

To provide additional information about wind fields in the vicinity of the TMM site, particularly during low wind speeds, the CALMET meteorological model was used to simulate wind fields in the region. As described in the previous section, the years 2014 and 2017 were selected for processing. Outputs from the CALMET meteorological model for these two years were also used as an input to the CALPUFF atmospheric dispersion model to study dispersion patterns for potential odour emissions from the TMM site (refer Section 6).

Guidance on running CALMET and CALPUFF for modelling applications in New South Wales was prepared for the NSW EPA by TRC Environmental Corporation (OEH, 2011). Since its publication, the guidance in OEH (2011) has become widely adopted by consultants in Australia and New Zealand as a best practice guideline for CALMET and CALPUFF modelling. The guidance in that document was followed in the preparation of CALMET and CALPUFF models for this report.

The CALMET model was run in “NO-OBS” mode, following the guidelines in OEH (2011). In this mode, gridded numerical model output from the prognostic meteorological model TAPM is used as the input meteorological data in CALMET. This option was necessary due to the lack of local cloud cover observations, which is a required input for running CALMET with observations as a direct input. Waipawa observation records of wind speed and direction were therefore used as inputs to the TAPM model.

The parameters used for the TAPM model setup were as follows.

- Centre co-ordinate 39° 58.0’S, 176° 36.5’E
- Four nested grids, grid spacings 24000m, 8000m, 2400m, 700m.
- Number of grid nodes: 31 in both N-S and E-W directions, and 30 vertical levels.
- Waipawa observations included, with a radius of influence of 20km.
- Default advanced settings.

The CALMET model setup was as follows:

- Model executable version CALMET 6.5.0 (released June 22, 2015)
- Graphical user interface for model setup – Lakes Environmental CALPUFF View
- January - December 2014 and 2017 time periods; one-hour time step
- UTM Map Projection, zone 60S
- Grid spacing 0.125km with 112 grid cells in x-direction and 112 grid cells in y-direction, centred on the TMM Site (14km x 14km grid extent).
- 10 vertical levels used, with cell face heights from 20m to 4000m
- Geophysical data –
    - 3-second (approximately 90m interval) data loaded from global SRTM database module in CALPUFF View.
    - Land use data generated using “Land Use Creator” tool in CALPUFF View, referenced to aerial photograph of modelling domain from Google Earth.
- TAPM output used as initial guess field for CALMET grid, converted using “CALTAPM” processor.
- Radius of influence of terrain features (TERRAD) – 2.0km.

An input file for CALMET summarising key input and model settings is provided in Appendix 2.

Windroses were extracted for both years from the CALMET model at the location of the TMM site. These windroses are shown in Appendix 3 and show the wind patterns that would be experienced at the location shown in the figure in Appendix 3.

Due to the hills immediately to the east and southeast of the site, the extracted windrose varies quite significantly with the location from which the data is extracted from the model. For example, at the base of the hill at the alternative location shown on the figure in Appendix 3, the second pair of windroses provided in Appendix 3 shows that winds are highly dominated by northeast and southwest flows at that location, following the contour of the hill. This is to be expected, and shows the influence of terrain on wind vectors simulated by CALMET.

4.4 TMM Site Wind Monitoring

Establishment of a wind monitoring station at the site was recommended by AirQP to commence gathering of an onsite local wind dataset, and this was implemented by TMM in September 2020.

The wind sensor at the monitoring station is located on a mast 10m above ground, and the mast is located consistent with the recommendations of "AS NZS 3580.14-2014 Methods for sampling and analysis of ambient air - Meteorological monitoring" so that wind measurements at the site are not influenced by nearby obstacles such as tall trees or buildings. The mast location is shown in Figure 9.

The collection of wind data will serve three main purposes:

1. Future verification of potential causes of complaints, if any complaints arise.
2. Assessment and verification of odour risk through measurement of frequency and direction of wind patterns with the greatest potential to cause complaints due to offensive odour.
3. Measurement of data required for development of site-specific meteorological data files suitable for atmospheric dispersion modelling, if required in the future.

Figure 9: Location of on-site meteorological monitoring site installed and operated by TMM.

5 Description of Odour Sources

The odour control strategy for the composting operation is as follows:

- Extraction of odour from Phase 1 bunkers and Phase 2 tunnels and treatment of extracted air in biofilter to remove odour before discharge to air.
- Best practice design of bunker air extraction to minimise fugitive emissions during emptying of bunkers. Restriction of hours of operation to avoid fugitive odour emissions during worst case meteorological conditions.
- Point source extraction of odour from above the bale break machine for odour treatment in the biofilter.
- Some residual odour emissions and minor odour sources discharging to air without odour treatment.

The potential sources of odour are:

1. Bale pre-wetting.
2. Chicken litter mixing and storage.
3. Bale breaking.
4. First and second turning of compost in Phase 1 bunkers by bunker-to-bunker transfer.
5. Removal of compost from Phase 1 bunkers and transfer to Phase 2 tunnels.
6. Residual odour from biofilter after odour treatment.
7. Goodie water storage pond.

A summary of the composting process and the odour controls applied is provided in Figure 10 at the end of this section. The ways in which odour is generated and discharged from each of these sources of odour are explained below.

1. Bale pre-wetting

Odour from bale pre-wetting is generated from presence of goodie water during dunking, bale draining, and supplementary irrigation if required. The magnitude of odour emissions is highly dependent on the quality of the goodie water. The proposed aeration of the goodie water pond will minimise the potential for odour emissions during the bale pre-wetting process, although some relatively minor odour emissions are likely.

2. Chicken litter mixing and storage

Chicken litter will be delivered to the concrete pad outside the Mixing Hall, mixed immediately with gypsum, and then stored in an enclosed bunker within the Mixing Hall. The best way to minimise odour emissions from chicken litter is to keep the litter dry in storage, which is enabled through this design approach.

3. Bale breaking

The breaking and mixing of pre-wetted bales releases some odour. Bale break will occur in the Mixing Hall which is mostly enclosed except for doorways for movement of front end loaders and openings for the conveyors to transport the mixed raw materials to the Phase 1 bunkers.

The Mixing Hall will be fitted with point source extraction from above the bale break machine and associated hopper, which will capture most of the odour emissions from the bale break process. However, as the doors to the Mixing Hall will be open during the bale break process, odour which is not captured by the point source extraction may escape outside the Mixing Hall as "fugitive" emissions.

Minimising the generation of odour and the degree of unpleasantness of that odour during the bale break process involves the following:

1. Keeping the chicken litter/gypsum mix dry during storage and only accepting chicken litter onto site which has been appropriately stored off-site (i.e. not anaerobic upon delivery).
2. Keeping the recycled water aerobic so that odorous by-products of anaerobic decomposition do not accumulate inside the bales.
3. Aerating the bales.

These measures are all proposed to be implemented at the site. In addition, operating hours for the bale breaking process will be limited to between 8am and 5pm to avoid potential fugitive odour emissions during stable atmospheric conditions when odour dispersion is typically poor.

Once the compost leaves the Mixing Hall on the conveyors, it is transported to the Phase 1 bunker and deposited into a hopper for automated filling at the bunker. The conveyors and hopper will not be covered and therefore there will be some evolution of odour from this source. During the filling process, the bunker air extraction system will operate at maximum capacity and will remove nearly all of the odour caused by the actual filling activity.

4. First and second turning of compost in Phase 1 bunkers by bunker-to-bunker transfer

During the bunker-to-bunker extraction process, the bunker air extraction system will operate at maximum capacity. However, some odour will still emitted during the process due to the movement of front-end loaders in and out of the bunker, and from the compost in the bucket on the front-end loader whilst the loader is moving from the bunker back to the Mixing Hall.

As during the bale break operation, the Mixing Hall will be mechanically ventilated via point source extraction hoods over the bale mixing line during the bunker-to-bunker transfer process. This extraction will remove most of the odour caused by the mixing process. However, is it likely that some of the odour from within the Mixing Hall will escape as fugitive emissions through the open doorways.

Potential hours of operation of this process are 8am to 6pm.

5. Removal of compost from Phase 1 bunkers and transfer to Phase 2 tunnels

There are likely to be some emissions of odour during the process of removing the finished Phase 1 compost from the bunkers by front-end loader and transferring it back to the Mixing Hall, with the same potential odour sources as described above for bunker-to-bunker transfers. However, at this stage the odour will be less offensive than earlier in the Phase 1 composting period, as the compost has completed the most active stage of biodegradation. Potential hours of operation of this process are 8am to 6pm.

6. Residual odour from Phase 1 bunkers after odour treatment

Air extracted from the bunkers holding Phase 1 compost will be passed through a biofilter custom-designed for the site by GTL Europe. GTL Europe has recommended the design air flow volumes for the biofilter for the 900 Tpw operation shown in Table 4. When all bunkers and tunnels are closed and there are no yard operations requiring any bunkers or tunnels to be open for unloading/filling, the design air flow rate is at the baseline rate of 96,000 m^3/hr.

However, when any bunkers or tunnels are open higher air flow rates are required to contain odour emissions. The increased air flow rates during these times will increase the overall air flow delivered to the biofilter. The highest design ventilation demand occurs when two Phase 1 bunkers are open for bunker-to-bunker transfer (one bunker unloading, and one bunker filling). This rate of air flow is 216,000 m^3/hr, and would only occur for the duration of this scenario (up to a few hours per week during working hours); once the bunkers/tunnels are closed and operations in the Mixing Hall are finished the ventilation would return to the baseline ventilation rates.

Table 3: Baseline ventilation demand for biofilter sizing (no bunkers/tunnels open) – 900 Tpw operation.

Operation being ventilated	Basis of air flow calculation	Number of bunkers/tunnels	Air flow required
Phase 1 bunker process air (bunkers filled and undisturbed)	4,000 m^3/h per bunker	4	16,000 m^3/h
Phase 2 process air extraction	20,000 m^3/h per tunnel	4	80,000 m^3/h
TOTAL			**96,000 m^3/h**

Table 4: Summary of highest design ventilation demand for biofilter sizing – 900 Tpw operation.

Operation being ventilated	Basis of air flow calculation	Number of processes	Air flow required
Phase 1 bunker process air (bunkers filled and undisturbed)	4,000 m^3/h per bunker	2	8,000 m^3/h
Phase 1 exhaust bunker during emptying/filling	40,000 m^3/h per bunker	2	80,000 m^3/h
Mixing Hall point source extraction	48,000 m^3/hr	1	48,000 m^3/h
Phase 2 process air extraction	20,000 m^3/h per tunnel	4	80,000 m^3/h
TOTAL			**216,000 m^3/h**

The biofilter design will be based on a loading rate of 50 m^3/hr air per m^3 biofilter for the highest design ventilation demand. The proposed biofilter media depth is 1.8 m, and the media itself will be bark as has been used successfully at TMM's existing Brookvale Road site.

For an air flow of 216,000 m^3/hr, the required volume of biofilter media is 4,320 m^2 (= 216,000 ÷ 50). The corresponding surface area for a depth of 1.8 m is 2,400 m^2.

6. Goodie water storage pond

The design and operation of the goodie water storage pond was described earlier in Section 3.3. Odour emissions from this source are expected to minor, and no additional mitigation measures are proposed. Dissolved oxygen concentration in the goodie water storage pond will be continuously monitored and logged.

7. Residual odour from Phase 2

All filling and emptying operations for the Phase 2 tunnels will be carried out in an enclosed building with air extracted to the biofilter for treatment. Similarly, all process air extracted from the Phase 2 tunnels will also be extracted and treated in the biofilter. Therefore, no fugitive odour releases to the atmosphere without treatment are expected from this process.

There is no ventilation of odour from the Phase 3 tunnels as odour concentrations in the compost are very low.

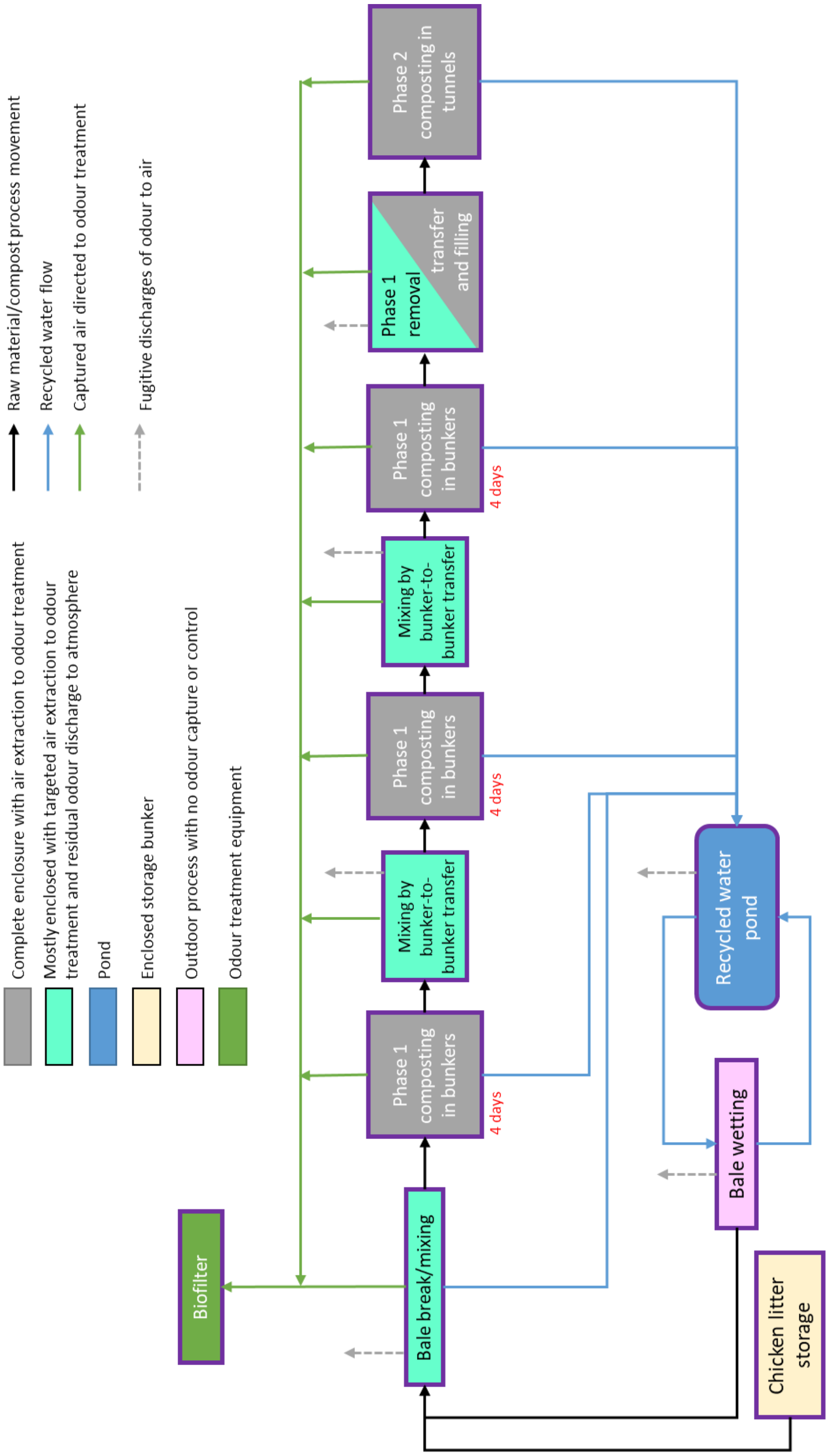


Figure 10: Summary of composting processes and odour control.

6 Odour Dispersion from TMM site

6.1 Approach and Set-Up

The behaviour of odour emissions at the TMM site once they are discharged from potential odour sources and dispersed with the wind was simulated with an atmospheric dispersion model, CALPUFF.

CALPUFF is an advanced "puff" dispersion model that can simulate dispersion in complex situations with very low wind speeds and non-uniform topography. In a "puff" model, pollutant releases are represented by a series of puffs of material which are transported by the winds across the modelling domain. CALPUFF is widely used in Australia and New Zealand in complex modelling situations where topography has a significant influence on dispersion patterns.

The meteorological simulation from CALMET, described in Section 4.3, was used as an input to the CALPUFF model.

Most of the potential odour sources at the proposed composting site at Mt Herbert Rd are "fugitive" sources, being odour emissions from spaces or processes that are very difficult to capture and quantify. Therefore, the dispersion modelling has not attempted to quantify these emission rates. Instead, the modelling has examined the dispersion patterns from these sources given the emission types and times of day when the emissions occur, and therefore considered the risk and potential frequency of offensive odour carrying beyond the site to both existing residences and to the Tukituki River Esplanade.

The CALPUFF model was run with the following settings:

- Model executable version CALPUFF 7.2.1
- Graphical user interface for model setup – Lakes Environmental CALPUFF View
- Time period January – December (both 2014 and 2017); one-hour time step
- Calm condition wind speed threshold = 0.2 m/s
- Minimum sigma-v: 0.2 m/s for all land stability classes
- Grid spacing: 125m
- Terrain adjustments included

A sample CALPUFF input file is provided in Appendix 3.

6.2 Emission Scenarios Tested in the Model

Several different emission scenarios were tested in the dispersion model:

1. Normal odour emissions, no site processing activities (i.e. no bale break, bunker-to-bunker transfers, or Phase 1 to Phase 2 transfers). Sources included were:
    a. Emission of odour from biofilter 24 hours per day, process air only (i.e. air flow 96,000 m^3/h).
    b. Emission of odour from goodie water pond, 500 m^2, at a nominal emission rate typical of an aerated bioreactor used for municipal wastewater treatment – 0.5 $OU.m^3/m^2/s$.
2. As per Scenario (1) but with biofilter operating at maximum output (216,000 m^3/h) during the hours of 8am to 6pm, 365 days per year.
3. Fugitive emissions from processing activities (such as bale breaking, or use of the Mixing Hall for bunker-to-bunker transfers). (No biofilter or pond emissions included in this scenario).
4. Cumulative worst case emissions – combining Scenarios 2 and 3 and assuming these activities occur 365 days per year.

For Scenarios 1 and 2, the odour concentration in the air discharged from the biofilter under baseline ventilation rates was assumed to be 500 OU which is a common performance criteria for biofilters.

For Scenario 3, the fugitive odour emissions were assumed to be equal to 10,000 $OU.m^3/s$. This estimate is a nominal “best guess” by AirQP and is considered to be an order-of-magnitude approximation – with the proposed odour extraction from the open bunkers and Mixing Hall it is considered that the likely fugitive emission rate will be more than 1000 $OU.m^3/s$, but certainly well less than 100,000 $OU.m^3/s$. It is not possible to accurately verify or calculate an OER for this type of fugitive odour source. The purpose of running this Scenario is to assess the potential frequency and intensity of odours occurring beyond the site boundary, and the uncertainty in the actual odour emission rate will be accounted for in the interpretation of model results.

The odour sources in the Scenarios are summarised in Table 5.

Table 5: Odour sources in Scenarios 1 - 5, 900 Tpw operation.

Source	Source dimensions	Odour emission rate basis	Odour emission rate
Scenario 1			
Biofilter, 24-hours per day	2,400 m^2	500 OU x 96,000 m^3/h (26.7 m^3/s)	13,333 OU.m^3/s
Goodie water pond	500 m^2	0.5 OU.m^3/m^2/s	250 OU.m^3/s
Scenario 2			
Biofilter, hours 8am to 6pm	2,400 m^2	500 OU x 216,000 m^3/h (60.0 m^3/s)	30,000 OU.m^3/s
Biofilter, hours 6pm to 8am	2,400 m^2	500 OU x 96,000 m^3/h (26.7 m^3/s)	13,333 OU.m^3/s
Goodie water pond	500 m^2	0.5 OU.m^3/m^2/s	250 OU.m^3/s
Scenario 3			
Fugitive emissions from processing activities, hours of 8am to 6pm only	Volume source, 40m x 40m centred over processing yard	Hours of 8am to 6pm only	10,000 OU.m^3/s
Scenario 4			
Biofilter, hours 8am to 6pm	2,400 m^2	500 OU x 216,000 m^3/h (60.0 m^3/s)	30,000 OU.m^3/s
Biofilter, hours 6pm to 8pm	2,400 m^2	500 OU x 96,000 m^3/h (26.7 m^3/s)	13,333 OU.m^3/s
Goodie water pond	500 m^2	0.5 OU.m^3/m^2/s	250 OU.m^3/s
Fugitive emissions from processing activities, hours of 8am to 6pm only	Volume source, 40m x 40m centred over processing yard		10,000 OU.m^3/s

In the dispersion model, the biofilter emission was simulated using point sources rather than area sources. This allowed the initial dilution of the emissions to be accounted for, as well as the buoyancy of the emission during cold ambient conditions. The temperature of the discharge air was assumed to be a constant 20°C due to the heat from the composting process – in summer the discharge temperature may be warmer than this but the dispersion model is insensitive to the assumption of constant discharge temperature in such conditions. The source characterisation settings used in the model for the biofilter were:

- Four point sources, each of diameter equivalent to 25% of the biofilter surface area.
  - Each source cross-sectional area: 600 m2.
  - Each source diameter: 27.6 m.
- Vertical exit velocity calculated from air flow rate delivered to biofilter
  - Scenario 1: 0.011 m/s.
  - Scenario 2: 0.025 m/s.
- Height of release: 2 m
- Building downwash included:

- Biofilter structure 2 m high
- Bunker building 7.5 m high
- Tiered structure for the tunnels/Mixing Hall building of 9.0m along the ridgeline and 5.3m at either end.

6.3 Odour Modelling Guidelines

Odour modelling guidelines are tools against which dispersion model results are compared to determine whether significant adverse are predicted to occur. They usually contain two components; a concentration, and a percentage compliance (for example, 'odour concentration shall exceed X OU/m^3 for less than Z% of the modelled hours"). X is the odour concentration predicted by the dispersion model. Z reflects the reliability of model results, and the probability of the model results giving an accurate representation, as well as a risk assessment approach for the very few highest odour concentrations that may occur infrequently.

The values of X and Z are set to represent the qualitative standard of 'no offensive or objectionable odour' and vary depending on the situation.

The Ministry for the Environment's Good Practice Guide for Assessing and Managing Odour in New Zealand (MfE, 2016) (herein referred to as the "MfE Odour Guide") gives general guidance for odour modelling guidelines, as summarised in Table 6.

Table 6: Recommended Odour Modelling Guideline Values (MfE, 2016).

Sensitivity of receiving location	Concentration	Percentile
High (worst case impacts during unstable to semi-unstable conditions)	1 OU	0.1% and 0.5%
High (worst case impacts during neutral to stable conditions)	2 OU	0.1% and 0.5%
Moderate (all conditions)	5 OU	0.1% and 0.5%
Low (all conditions)	5-10 OU	0.5%

Other background guidance to the MfE Odour Guide provides additional explanation of the selection of percentiles, stating that the 'baseline' percentile is 0.5%, although 0.1th percentile can also be used to assist in the evaluation of model results depending on the type of source and consistency of emission data.

In this case, the 0.5th percentile is appropriate, due to the lack of sensitive receptors (in particular dwellings) very close to the TMM site and the rural nature of surrounding land use. The sensitivity of the receiving environment is regarded as "moderate" because the nearby residences are located in rural areas, and also because most of the odours discharged from the site (particularly from the biofilter and the pond) will be similar to background rural odours once diluted and dispersed.

Therefore, the appropriate odour modelling guideline for sensitive receptors (in this case, residential dwellings) is 5 OU, 0.5th percentile.

For other potentially-sensitive land uses near the composting plant, such as the Wahi Tapu site, Tukituki Trail users, and Mountain Bike Park users, these locations are also considered to have "moderate" sensitivity with the 5 OU, 0.5th percentile guideline perhaps being applicable. However, for these land uses the interpretation of model results needs to take into account the low frequency and short duration of exposure to any odour that users at these locations would experience because of the nature of activities being carried out. The risk of odour being offensive or objectionable at these locations is much less than the risk of that same odour being offensive or objectionable at a residential dwelling.

The CALPUFF model calculates ground level odour concentrations (GLCs) at every receptor on the modelling domain for every hour of the meteorological data. For each year of meteorological data, the model stores 8760 concentration data points for each receptor. The model finally calculates the 99.5th percentile of the hourly concentration data at each receptor (i.e. the 43rd highest GLC at each point), and this is the output concentration for that receptor. This is the same as the concentration that is exceeded for less than 0.5% of the time – i.e. as required by the odour modelling guideline. A similar logic can be applied to determine the 0.1th percentile result.

The graphed model results in this report show the 99.5th percentile highest GLCs predicted at each receptor from both the full 2014 and 2017 years of hourly meteorological data.

6.4 Model Results and Discussion

6.4.1 Scenario 1

The 99.5th percentile dispersion model results for Scenario 1 are shown in Figure 11. This shows the dispersion of normal site odour emissions when no compost processing activities are occurring – i.e. emissions from biofilter with all bunkers and tunnels full and closed, emissions from pond, and no activities in Mixing Hall. The figure shows both 2014 and 2017 model results. The GLCs are very similar between the two years, and this is found in all the model results presented in this report.

The highest GLC at a residence is 0.74 OU, occurring in the 2017 year.

Figure 6 shows the dispersion of odour from the pond alone, illustrating the relatively small contribution of this source to predicted off-site odour GLCs.

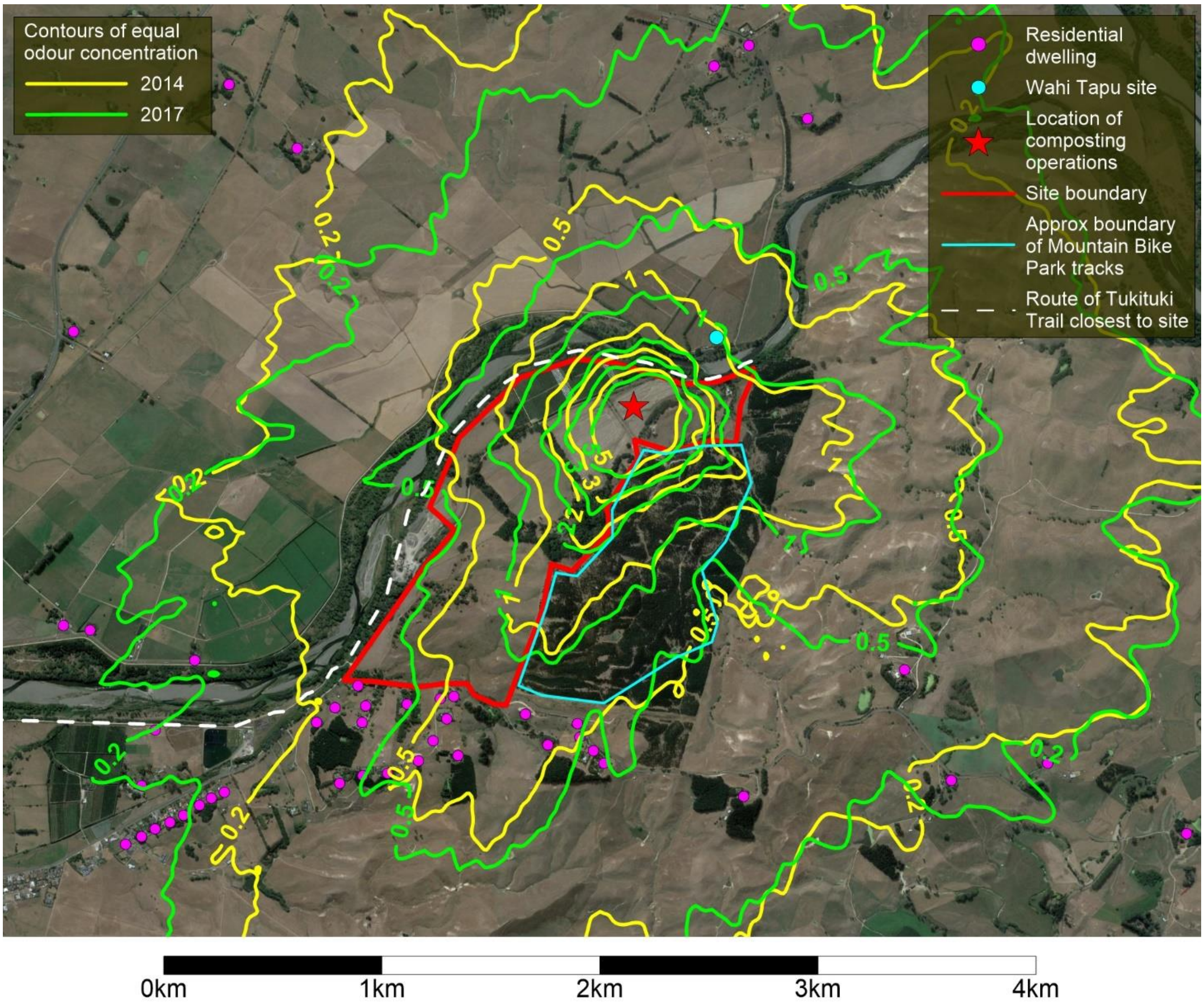


Figure 11: Model results for Scenario 1. Contours show 99.5th percentile, 1-hour average odour concentrations.

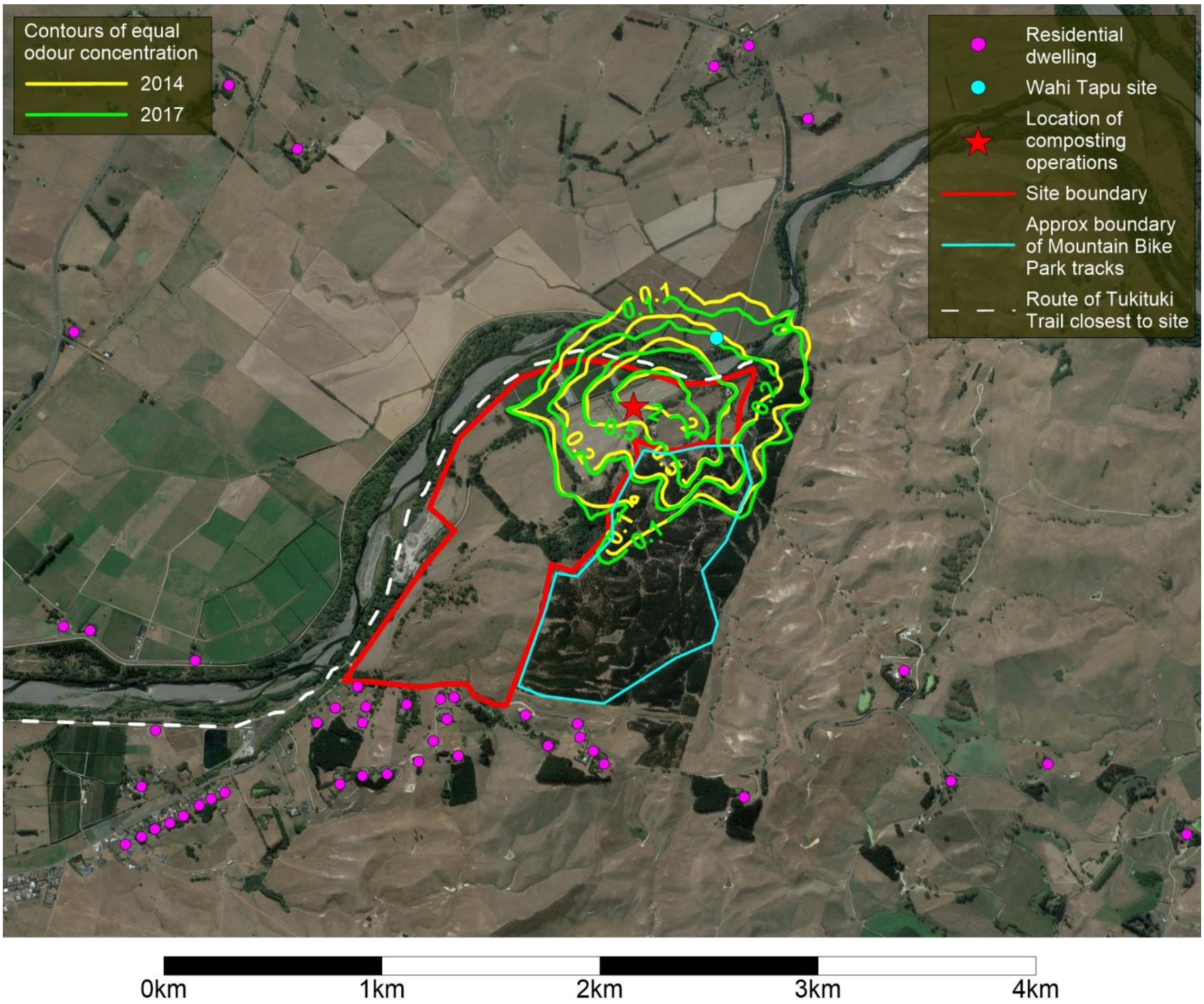


Figure 12: Model results for odour emissions from pond only. Contours show 99.5th percentile, 1-hour average odour concentrations.

6.4.2 Scenario 2

The 99.5th percentile dispersion model results for Scenario 2 are shown in Figure 13. This shows the dispersion of odour emissions from the biofilter and pond including the assumption that compost processing activities are occurring every day of the year between 8am and 6pm – i.e. emissions from biofilter at maximum design flow rate between 8am and 6pm. No fugitive emissions from the Mixing Hall or processing yard are included in this scenario.

The predicted GLCs are slightly higher than under Scenario 1, and the highest odour GLC at a residence is 0.77 OU, occurring in the 2017 year.

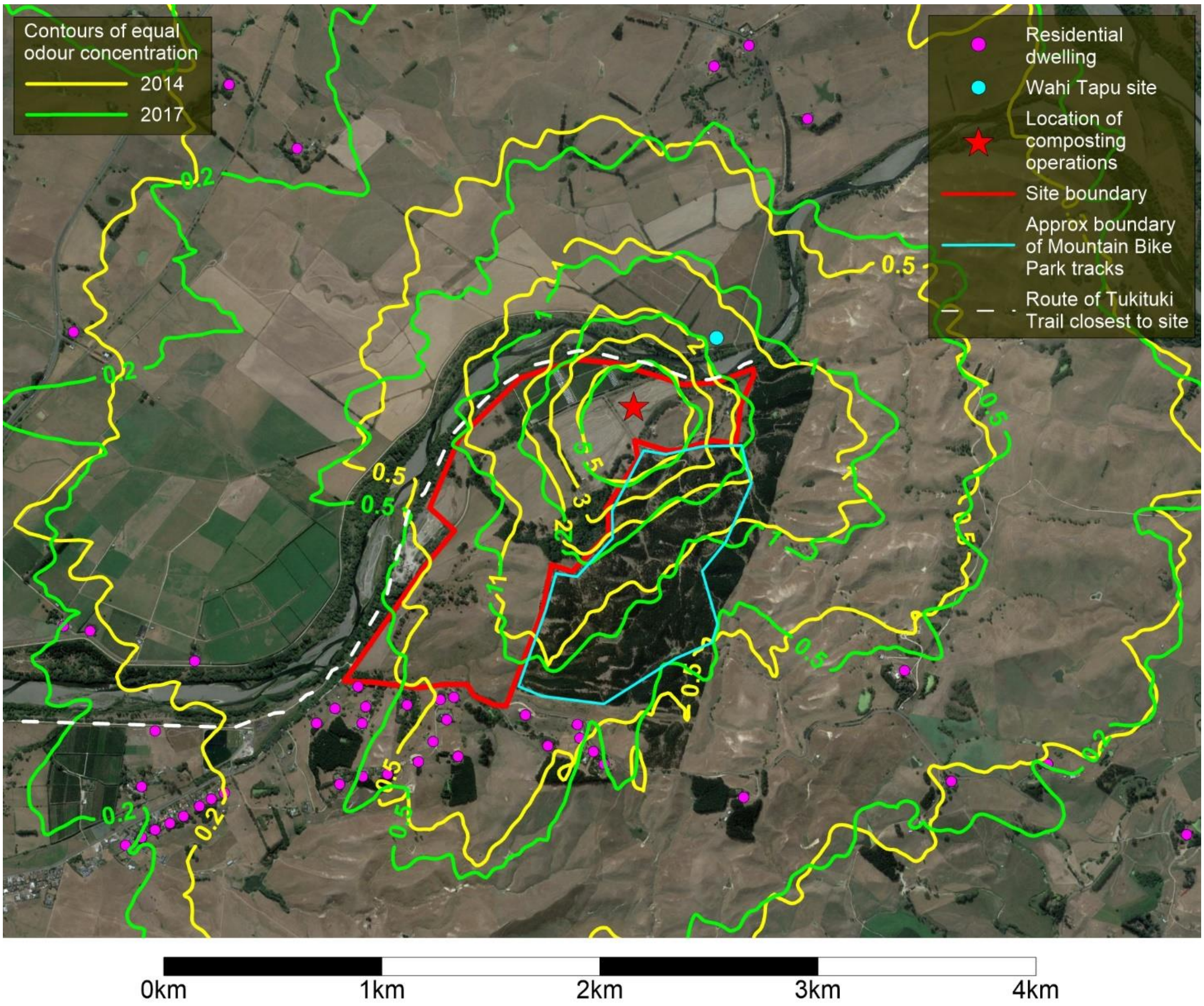


Figure 13: Model results for Scenario 2. Contours show 99.5th percentile, 1-hour average odour concentrations.

6.4.3 Scenario 3

The 99.5th percentile dispersion model results for Scenario 3 are shown in Figure 14. This shows the dispersion of odour emissions from a fugitive odour source representing residual odour emissions not captured by the bunker ventilation or Mixing Hall extraction systems during processing activities such as bale break, bunker-to-bunker transfers, or Phase 1 to Phase 2 transfers. It is assumed that these compost processing activities are occurring every day of the year between 8am and 6pm. The model does not include odour emissions from the biofilter or the pond.

The predicted GLCs in the vicinity of houses are low, with the highest odour GLC at a residence being 0.15 OU, occurring in the 2017 year. It is reiterated that the odour emission rate used with this source is at order-of-magnitude accuracy only. However, the low model results indicate that even if the odour emission rate was several times higher than the value of 10,000 OU.m^3/s used in the model, the potential for this odour source to cause offensive or objectionable effects for at dwellings is very low.

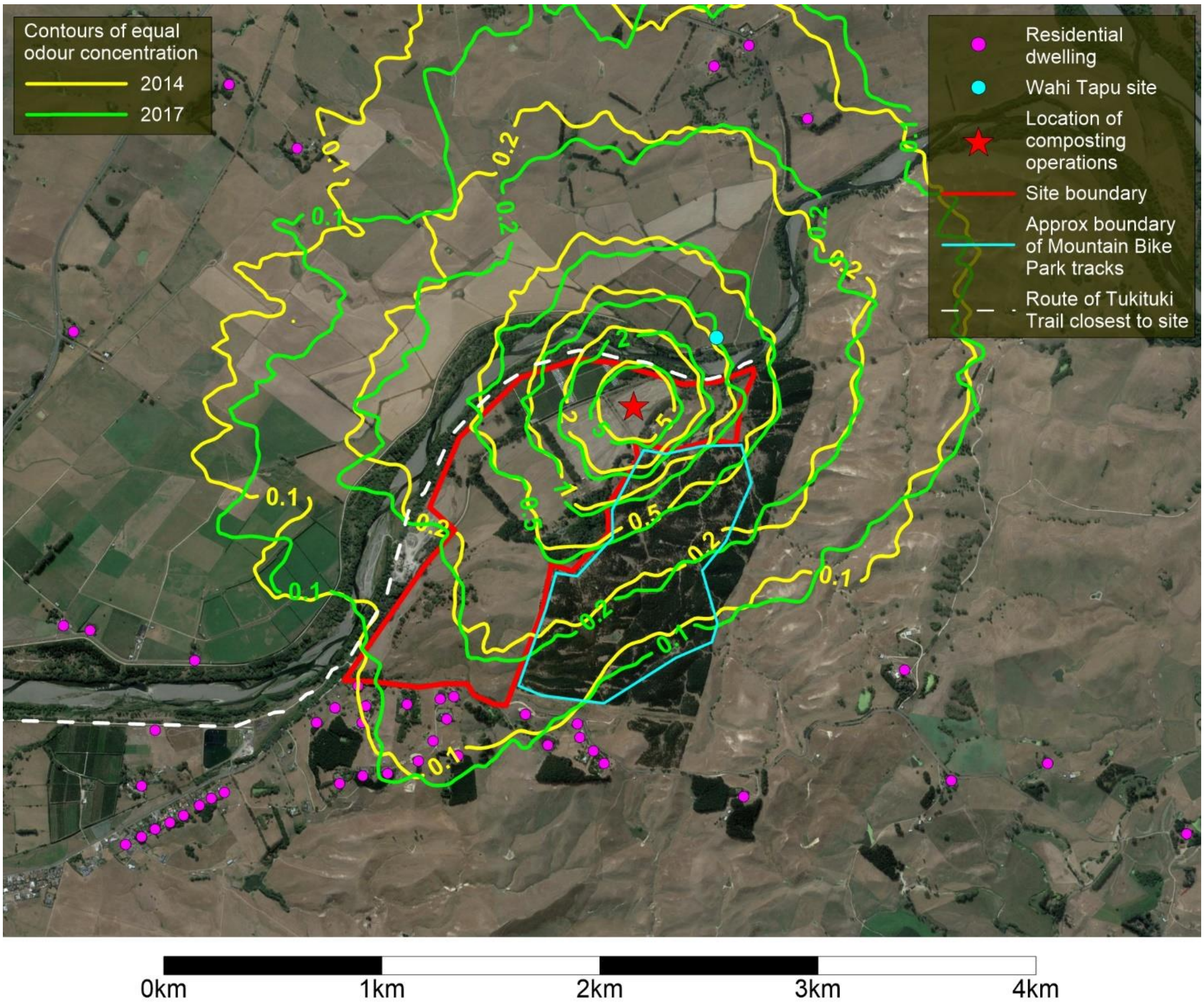


Figure 14: Model results for Scenario 3. Contours show 99.5th percentile, 1-hour average odour concentrations.

6.4.4 Scenario 4

The 99.5th percentile dispersion model results for Scenario 4 are shown in Figure 15. This is the worst case scenario for total odour emissions, with the combined emissions from the biofilter running at the "Scenario 2" odour emission rate, plus the fugitive odour source for processing emissions (operating from 8am to 6pm), plus the pond.

Even under this worst case scenario, the predicted GLCs in the vicinity of houses are low, with the highest odour GLC at a residence being 0.78 OU, occurring in the 2017 year. Most of this odour GLC is contributed by the biofilter. The GLCs in the vicinity of houses are much lower than the odour modelling guideline of 5 OU.

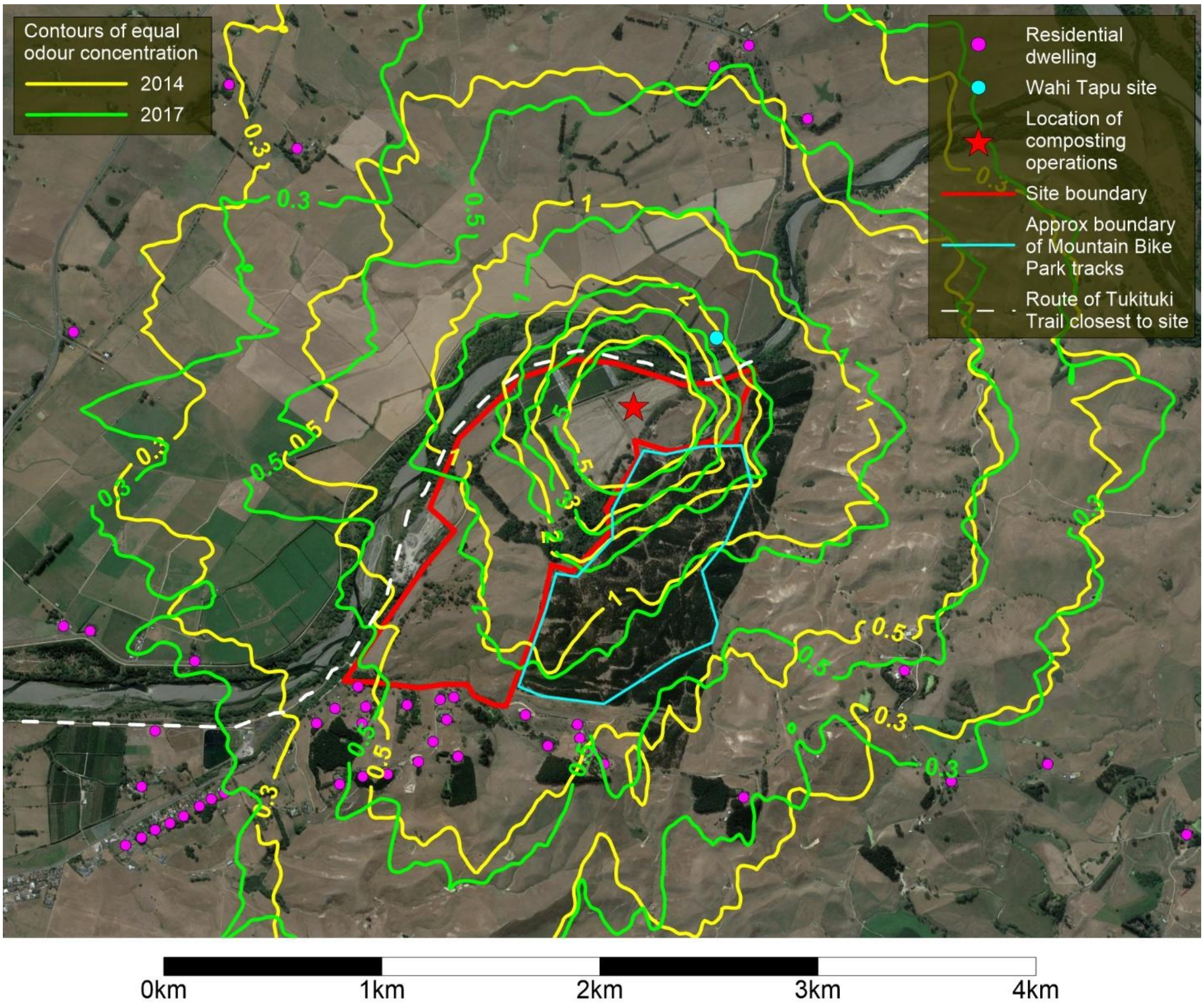


Figure 15: Model results for Scenario 4. Contours show 99.5th percentile, 1-hour average odour concentrations.

6.4.5 Results Analysis at Residential Locations

Assessment of the frequency of highest GLCs occurring at the closest residences and other nearby potentially-sensitive locations has been carried out. Figure 16 shows the location of 15 discrete receptors for which model results were extracted for further analysis. Receptors 1 to 6 are at dwellings, Receptor 7 is at the Wahi Tapu site, Receptors 8 to 11 are at locations along the Tukituki Trail on the south side of the river where people using the track for recreational purposes may encounter odour for brief periods, and Receptors 12 to 15 are in the Mountain Bike Park at the northwest end closest to the proposed composting site.

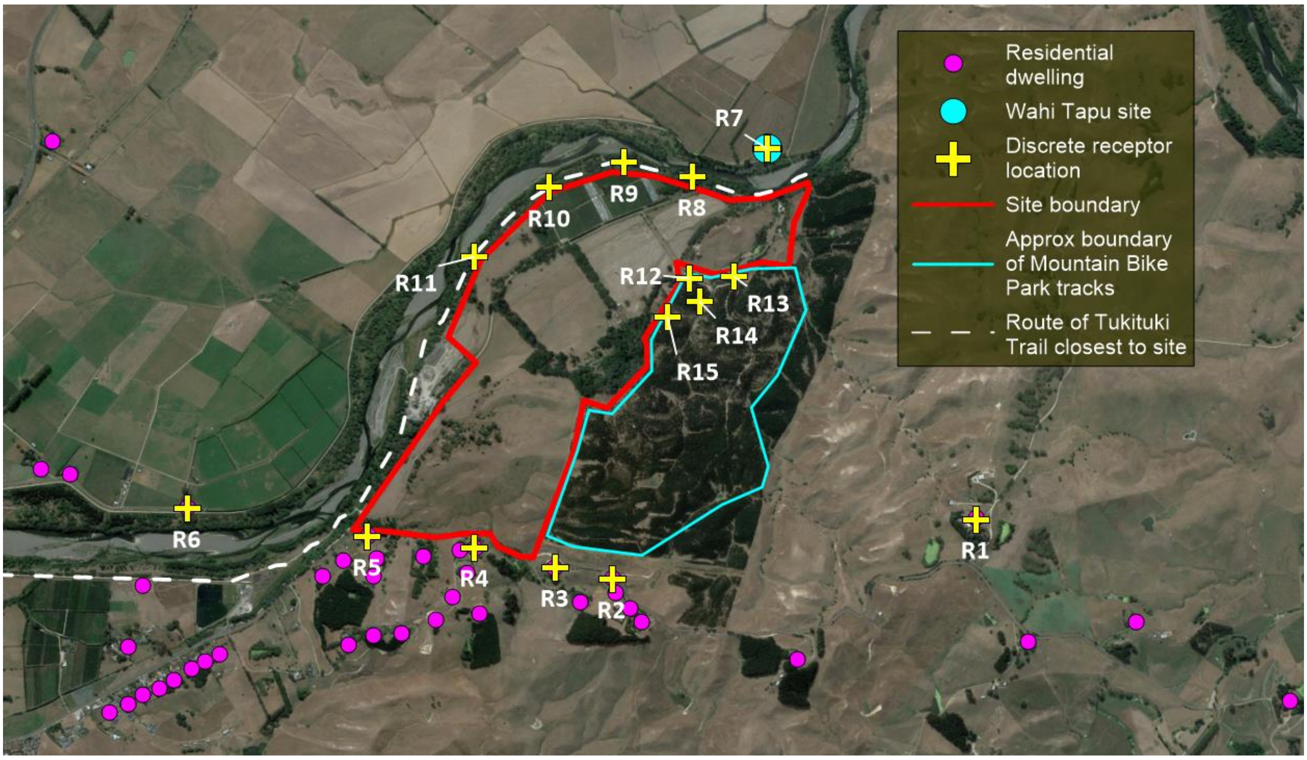


Figure 16: Location of discrete receptors used for detailed analysis of model results.

The cumulative percentiles of odour GLCs predicted at the residential receptors R1 to R6 for Scenario 4 are shown in Figure 17 for 2014 and Figure 18 for 2017. Note that the graphs use a logarithmic scale for the y-axis. The graphs show that the highest GLCs occur very infrequently. There is less than a factor of 2.5 between the 99.5th and 99.9th percentiles (in most cases, less than a factor of 2).

It is noted also that Scenario 4 assumes the worst case odour emission situation of compost-processing activities occurring in the Mixing Hall (with two open bunkers) 10 hours per day 365 days per year. Therefore, the GLCs shown in these cumulative percentile graphs significantly overstate the potential frequency of GLCs because of the following cumulative factors of conservatism:

- Compost processing activities occur constantly from 8am to 6pm – in reality the processing will not require 10 hours in a day.
- Compost processing activities occur every day – in reality these activities will occur 1-2 days per week, depending on site needs.

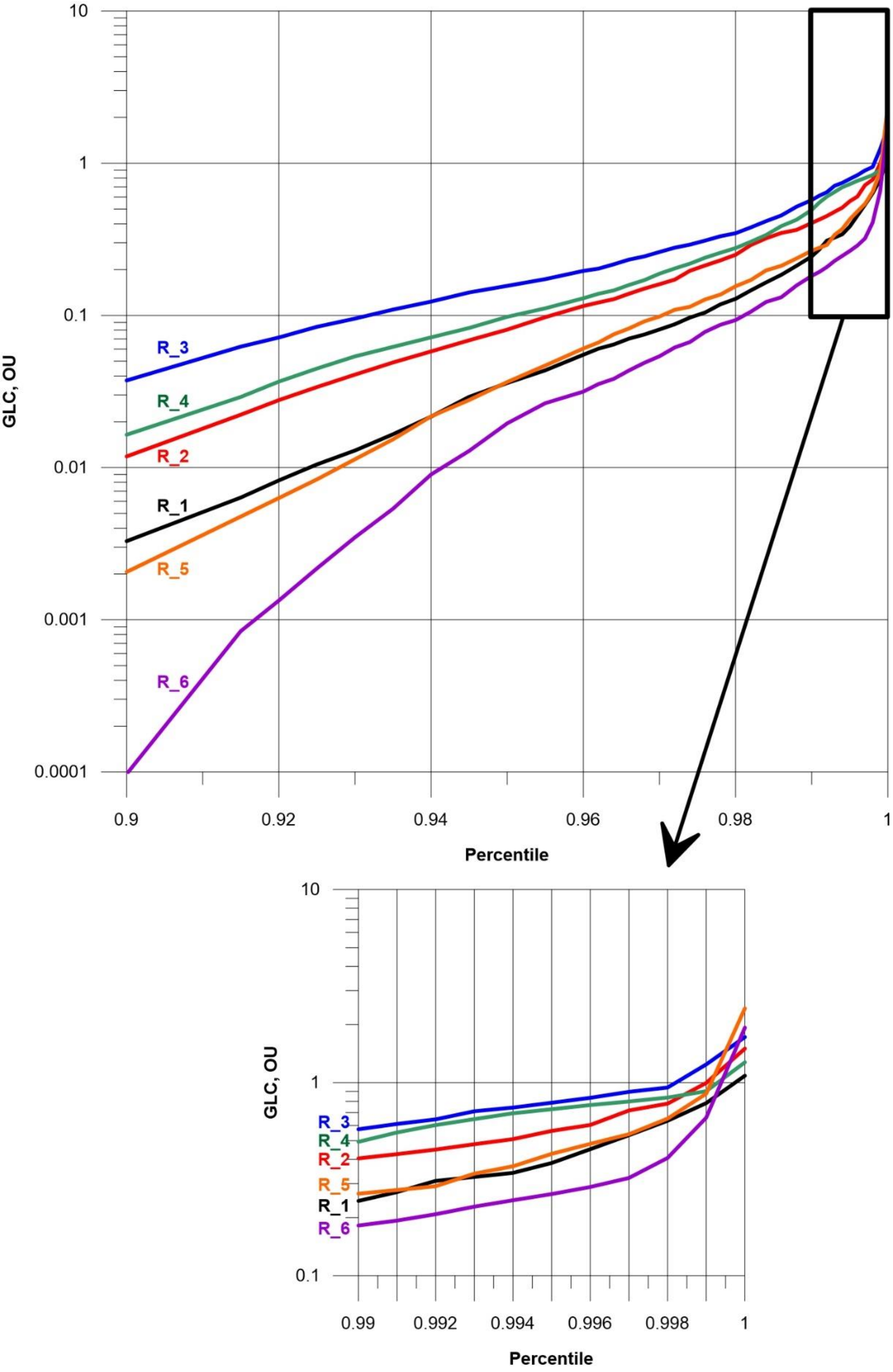


Figure 17: Cumulative percentiles of odour GLCs predicted for Scenario 4 at the residential receptors R1 to R6. 2014 meteorological dataset. Refer Figure 16 for receptor locations.

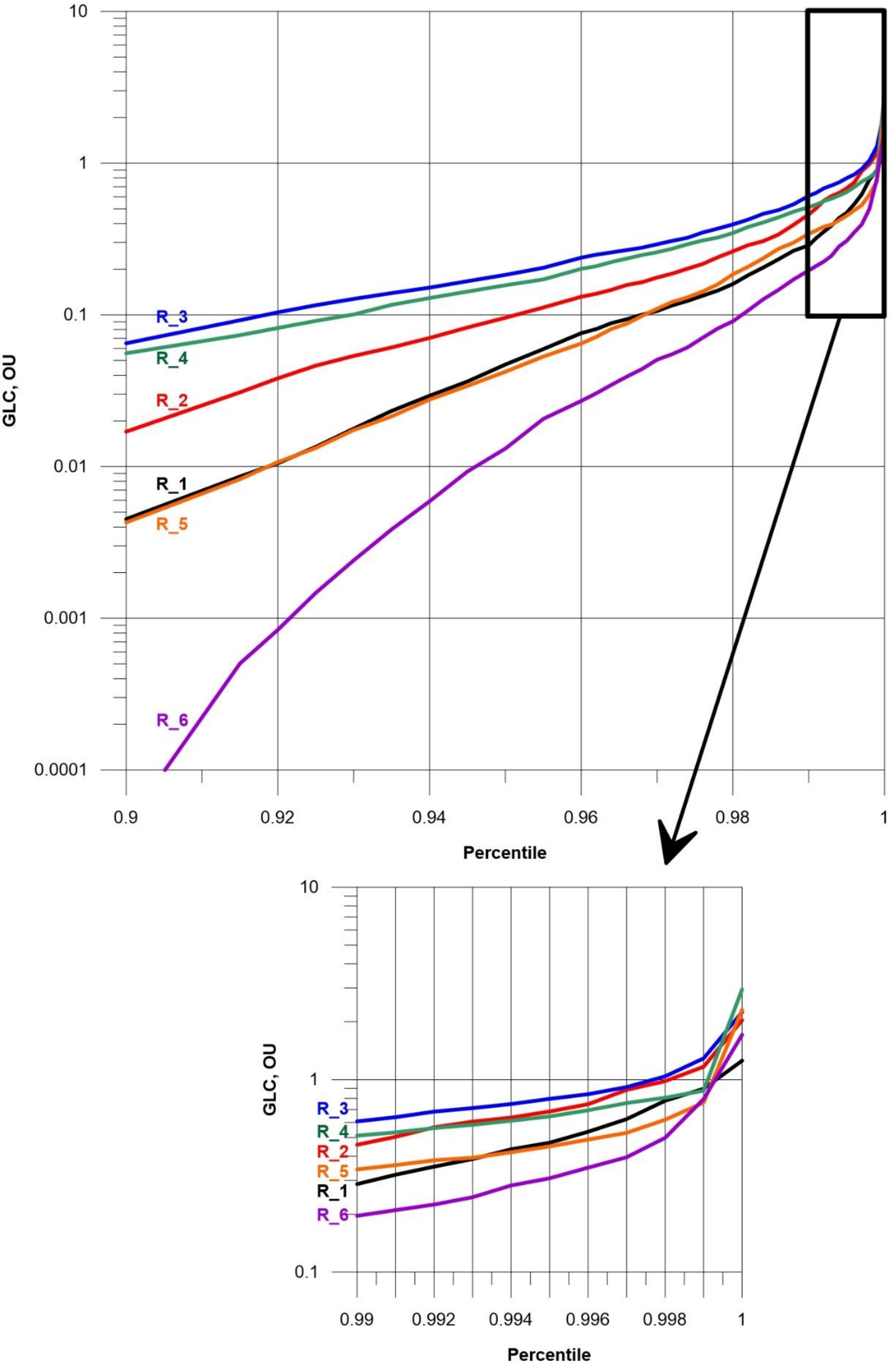


Figure 18: Cumulative percentiles of odour GLCs predicted for Scenario 4 at the residential receptors R1 to R6. 2017 meteorological dataset. Refer Figure 16 for receptor locations.

When these factors of conservatism are combined with the percentile frequency plots and the 99.5th percentile model plots in Figure 15, and compared to the odour modelling guideline of 5 OU, it is concluded that the potential for offensive or objectionable odour effects to occur at nearby dwellings due to composting operations at the site is less than minor.

6.4.6 Results Analysis at Wahi Tapu Site

The cumulative percentiles of odour GLCs for Scenarios 1 and 4 predicted at the receptor R7, representing the Wahi Tapu site, are shown in Figure 22 for both 2014 and 2017. The highest 99.5th percentile GLC occurring at the receptor is 1.3 OU for Scenario 1 (baseline scenario with no compost mixing/turning activities), and 2.3 OU for Scenario 4 (highest odour emission rates during compost mixing/turning). These concentrations are well below the suggested odour guideline of 5 OU. In addition, the graphs show that the highest GLCs occur very infrequently.

The model results show that for people visiting the Wahi Tapu site, the potential for offensive or objectionable effects to occur due to that odour is less than minor.

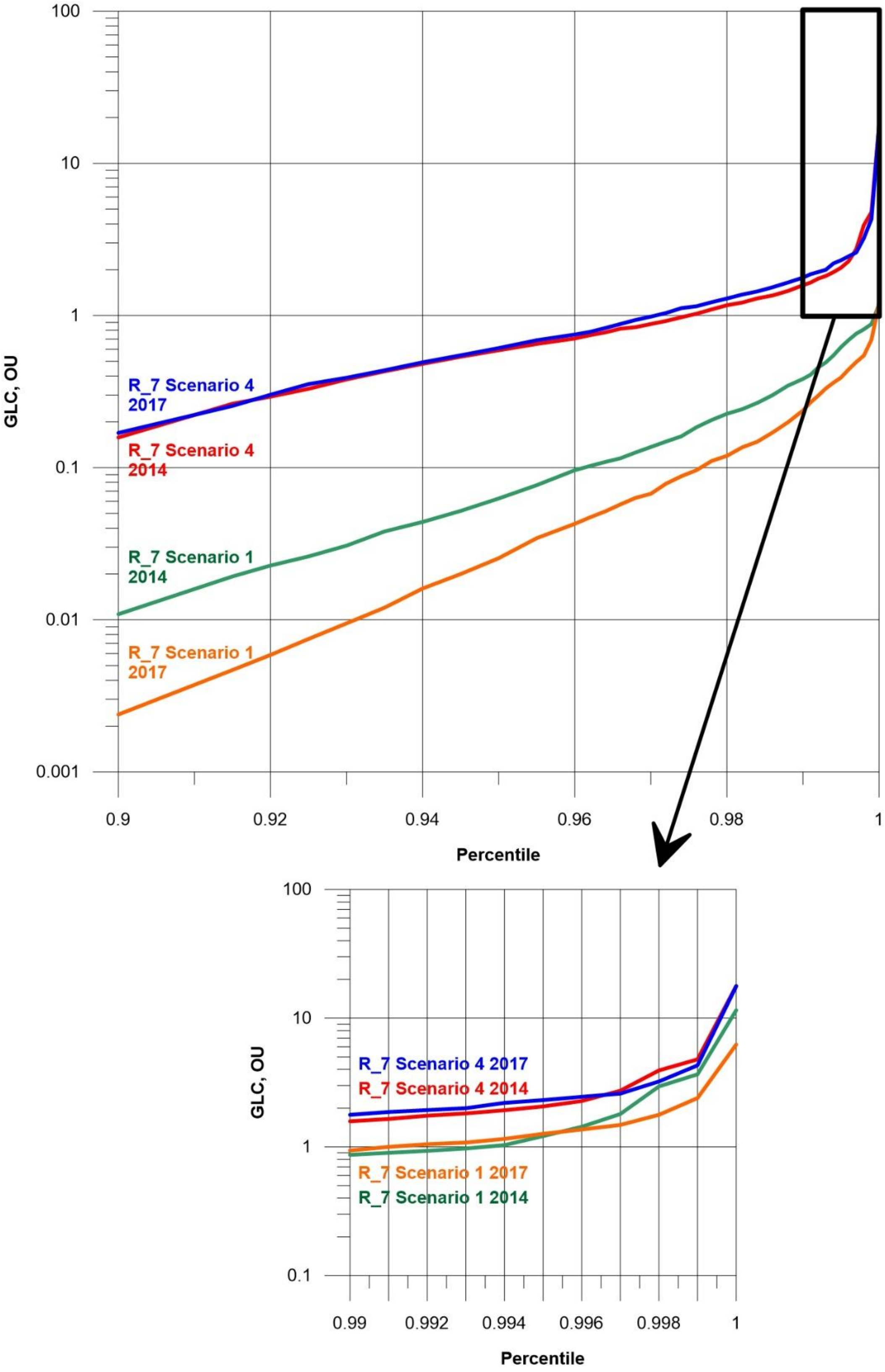


Figure 19: Cumulative percentiles of odour GLCs predicted for Scenario 4 at receptor R7. Both 2014 and 2017 meteorological datasets. Refer Figure 16 for receptor location.

6.4.7 Results Analysis at Tukituki Trail Receptors

The cumulative percentiles of odour GLCs predicted at the receptors R8 to R11 along the Tukituki Trail close to the compost processing area are shown in Figure 20 and Figure 21 for Scenario 1, and Figure 22 and Figure 23 for Scenario 4. Each pair of figures shows the 2014 and 2017 model results respectively.

The highest 99.5th percentile GLC occurs at R8; 5.4 OU for Scenario 1 and 10 OU for Scenario 4. At receptors R9-R11, the 99.5th percentile GLC are less than 2.1 OU for Scenario 1, and 4.5 OU for Scenario 4.

The graphs also show that the highest GLCs occur very infrequently.

These receptors along the Tukituki Trail are not sensitive receptors, as activities considered to be sensitive to odour are not carried out at these locations. However, the model results show that people using the track for walking, running, cycling etc may notice odour as they pass along the track downwind of the composting facility on a small number of hours per year – particularly where the odour concentration exceeds about 10 OU as shown in the cumulative percentile figures; i.e. in the vicinity of R8. However, this odour is not expected to be strong.

The figures for Scenario 4 significantly overstate the potential frequency of GLCs because of the same cumulative factors of conservatism listed in the Section 6.4.5. With the receptors along the Tukituki Trail, there are addition factors of conservatism due to the low probability that a person will be present downwind of the composting site at the same time as the worst case GLCs occur, and the duration of exposure will be very limited.

Overall, it is concluded that although users of the Tukituki Trail close to the composting site may at times be able to smell odour when close to the composting facility, this is likely to be infrequent and for short duration. Any odour is likely to be localised to the northeast end of the trail (in the vicinity of R8). Overall, considering the frequency, intensity, duration, offensiveness and location of the odours that may occur, the potential for offensive or objectionable effects to occur due to that odour is considered to be less than minor.

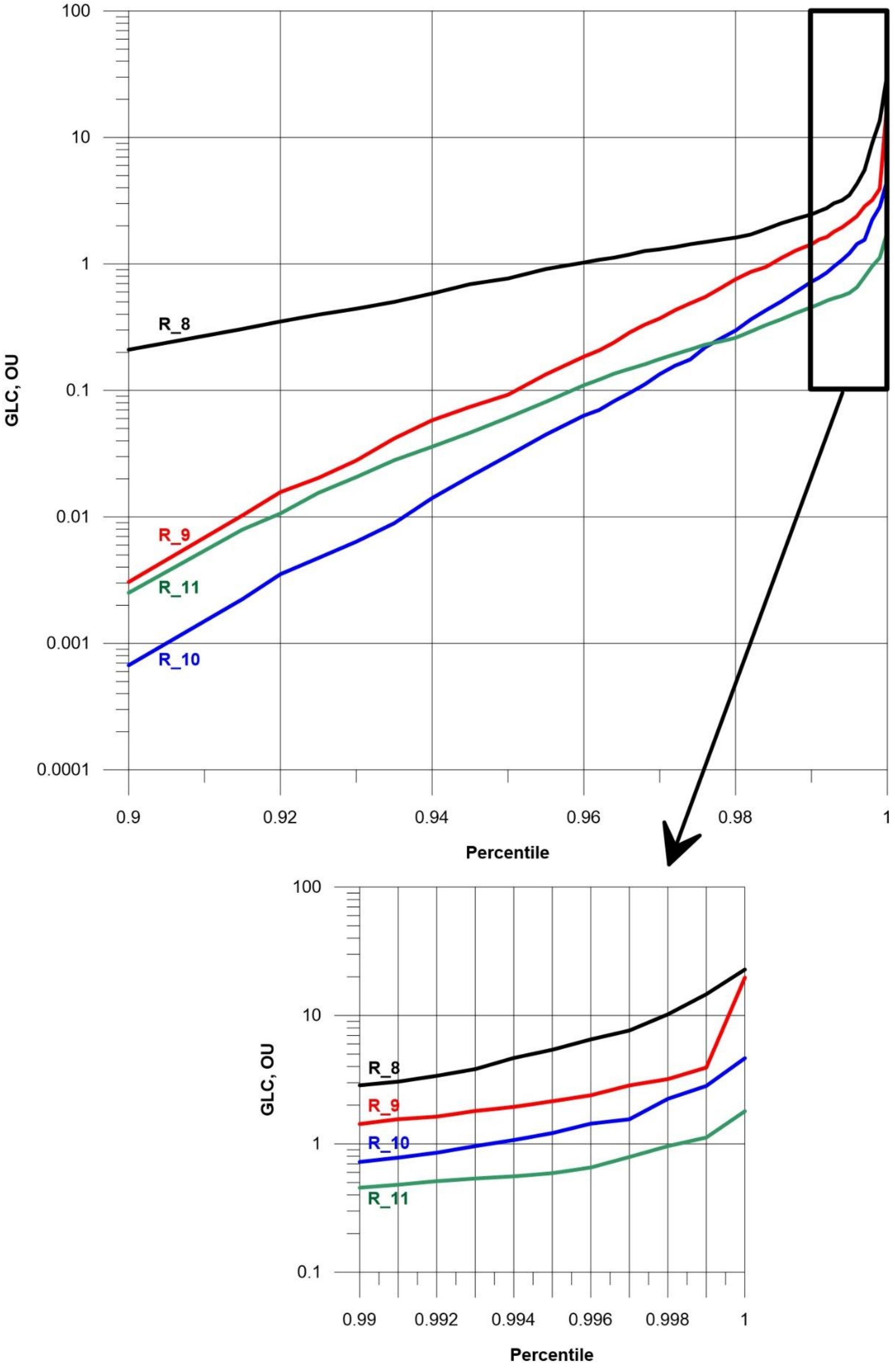


Figure 20: Cumulative percentiles of odour GLCs predicted for Scenario 1 at receptors R8 to R11. 2014 meteorological dataset. Refer Figure 16 for receptor locations.

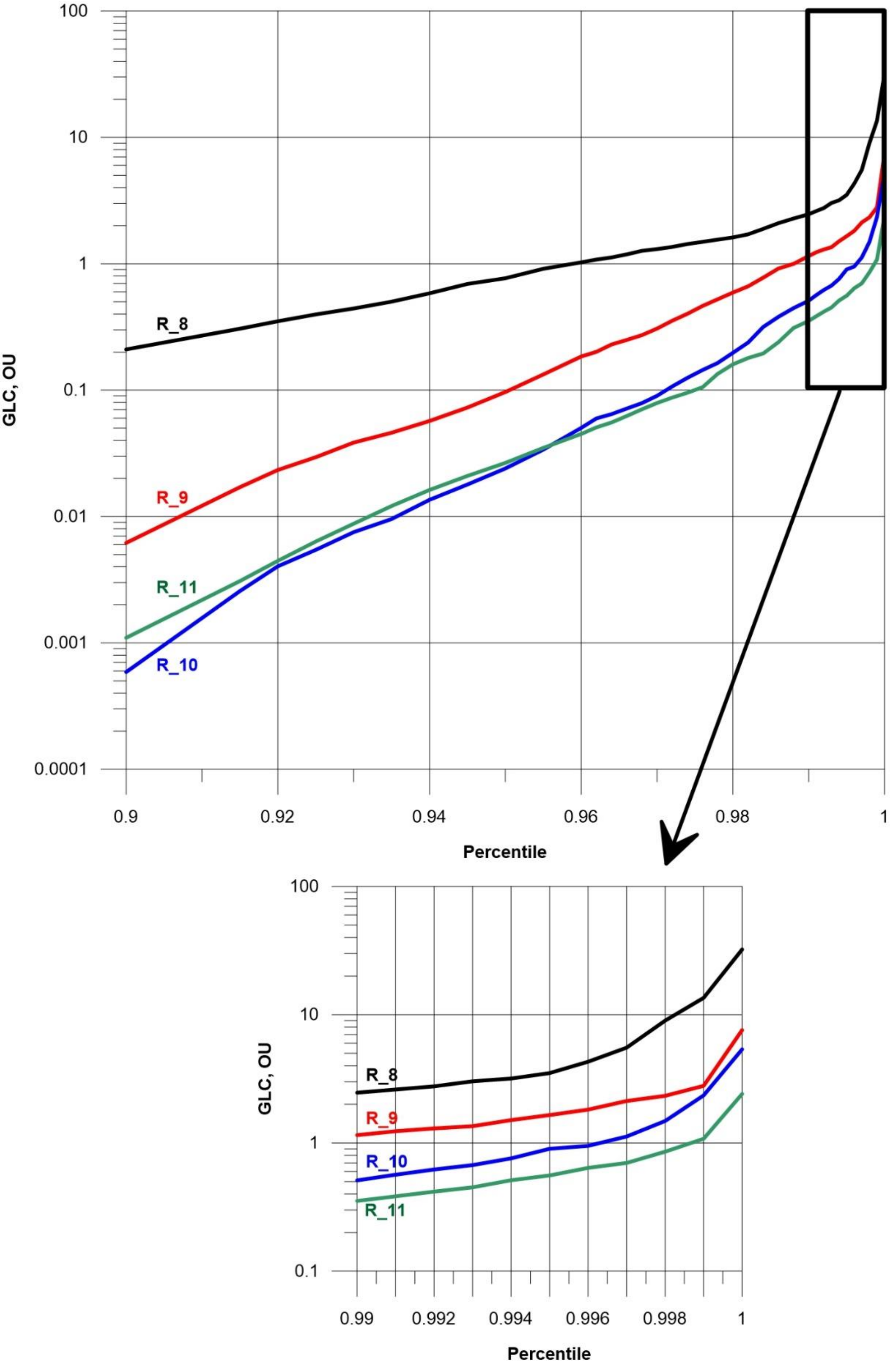


Figure 21: Cumulative percentiles of odour GLCs predicted for Scenario 1 at receptors R8 to R11. 2017 meteorological dataset. Refer Figure 16 for receptor locations.

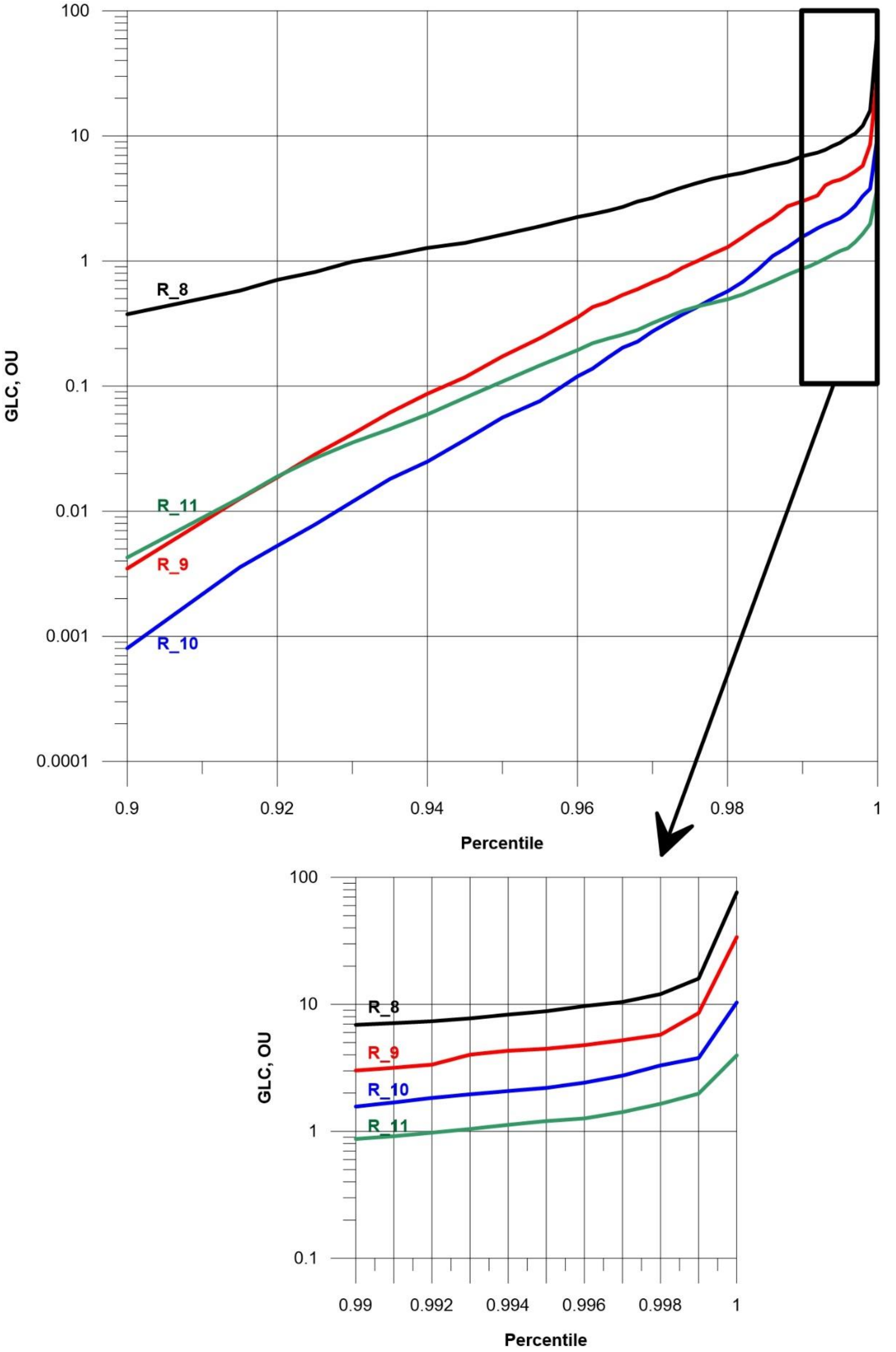


Figure 22: Cumulative percentiles of odour GLCs predicted for Scenario 4 at receptors R8 to R11. 2014 meteorological dataset. Refer Figure 16 for receptor locations.

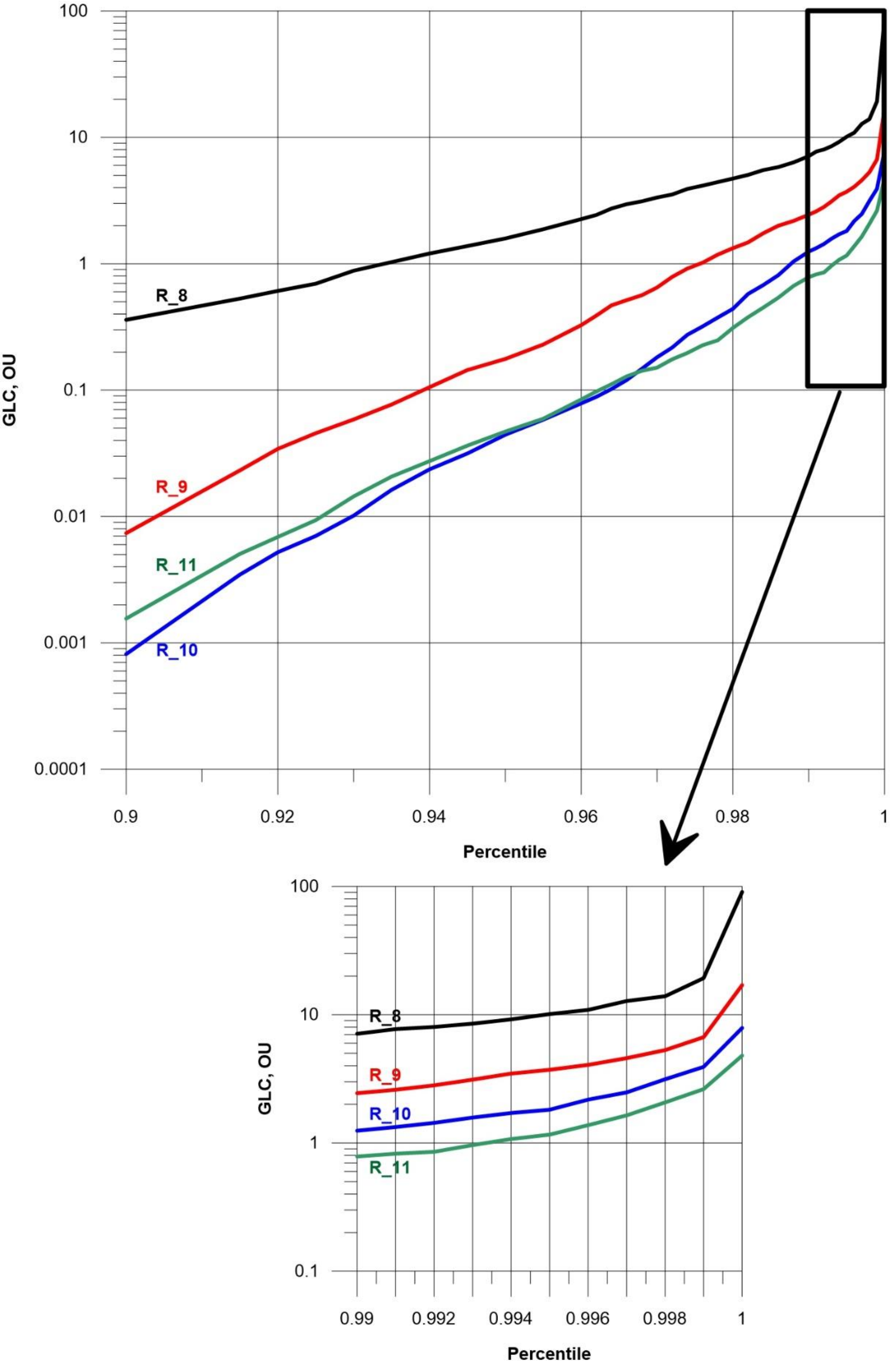


Figure 23: Cumulative percentiles of odour GLCs predicted for Scenario 4 at receptors R8 to R11. 2017 meteorological dataset. Refer Figure 16 for receptor locations. Results Analysis at Mountain Bike Park

6.4.8 Results Analysis at Mountain Bike Park

The cumulative percentiles of odour GLCs predicted at the receptors R12 to R15 at the northwest corner of the Mountain Bike Park are shown in Figure 24 and Figure 25 for Scenario 1, and Figure 26 and Figure 27 for Scenario 4. Each pair of figures shows the 2014 and 2017 model results respectively. These four receptor locations were chosen because the 5 OU contour in Scenario 4 (see Figure 15) extends to these locations in the northwest corner of the Park.

The highest 99.5th percentile GLC occurs at R12; 6.7 OU for Scenario 1 and 9.7 OU for Scenario 4. At receptors R13-R15, the 99.5th percentile GLC are less than 2.1 OU for Scenario 1, and 3.7 OU for Scenario 4.

The graphs also show that the highest GLCs occur very infrequently.

As in the previous section, the model results show that people using the Mountain Bike Park may notice odour as they pass along the tracks in the northwest corner of the Park on a small number of hours per year – particularly where the odour concentration exceeds about 10 OU. However, as with the analysis at the Tukituki Trail, this odour is not expected to be strong.

As discussed in the previous sections, the figures for Scenario 4 significantly overstate the potential frequency of GLCs because the activities included in the odour emissions under Scenario 4 do not occur all day every day. With the receptors in the Mountain Bike Park, there are addition factors of conservatism due to the low probability that a person will be present downwind of the composting site at the same time as the worst case GLCs occur, and the duration of exposure will be very limited.

Overall, it is concluded that although users of the Mountain Bike Park may at times be able to smell odour when close to the composting facility, this is likely to be infrequent and for short duration. Any odour will be localised to the northwest end of the Park. Overall, considering the frequency, intensity, duration, offensiveness and location of the odours that may occur, the potential for offensive or objectionable effects to occur due to that odour is considered to be less than minor.

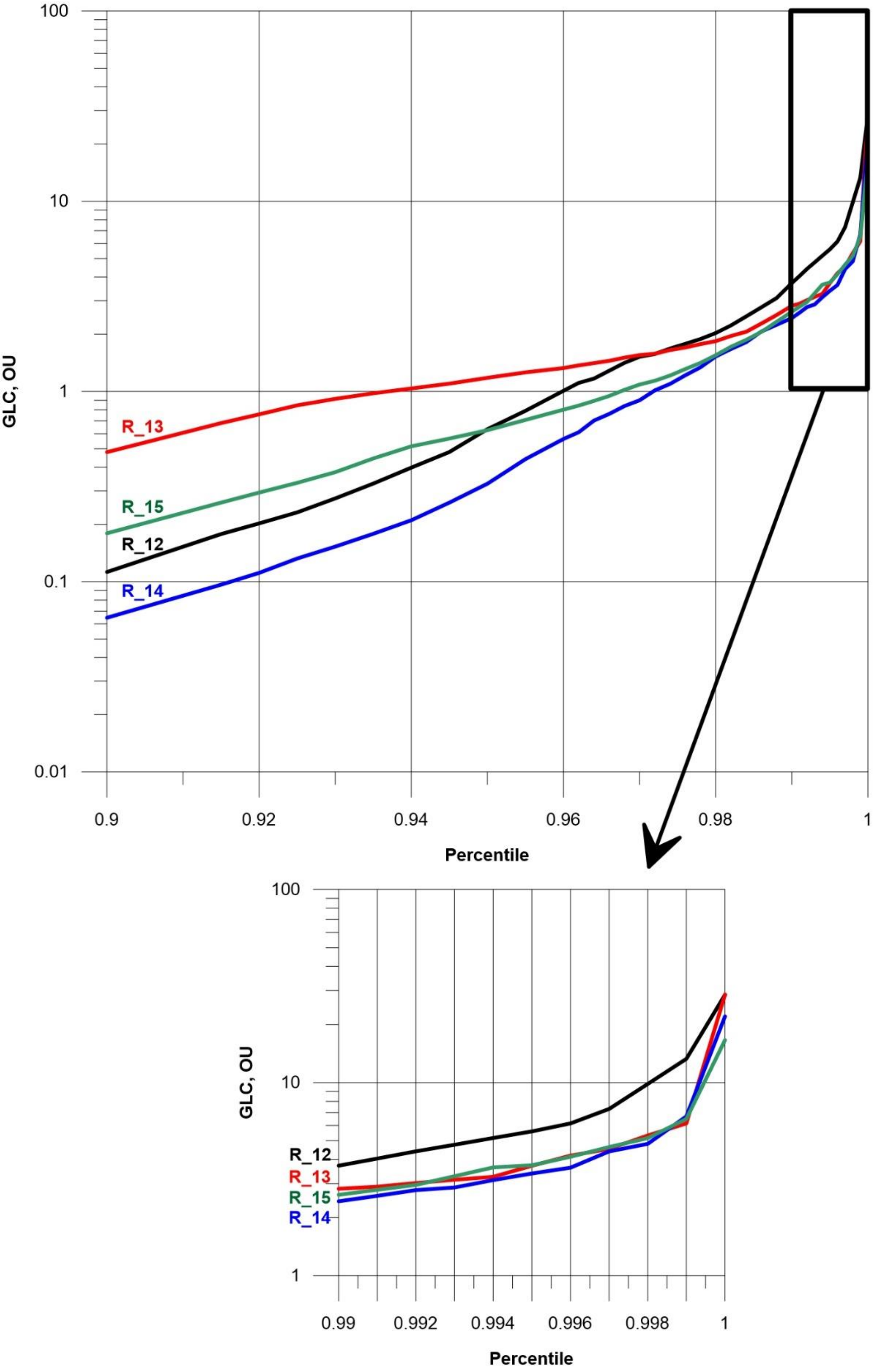


Figure 24: Cumulative percentiles of odour GLCs predicted for Scenario 1 at receptors R12 to R15. 2014 meteorological dataset. Refer Figure 16 for receptor locations.

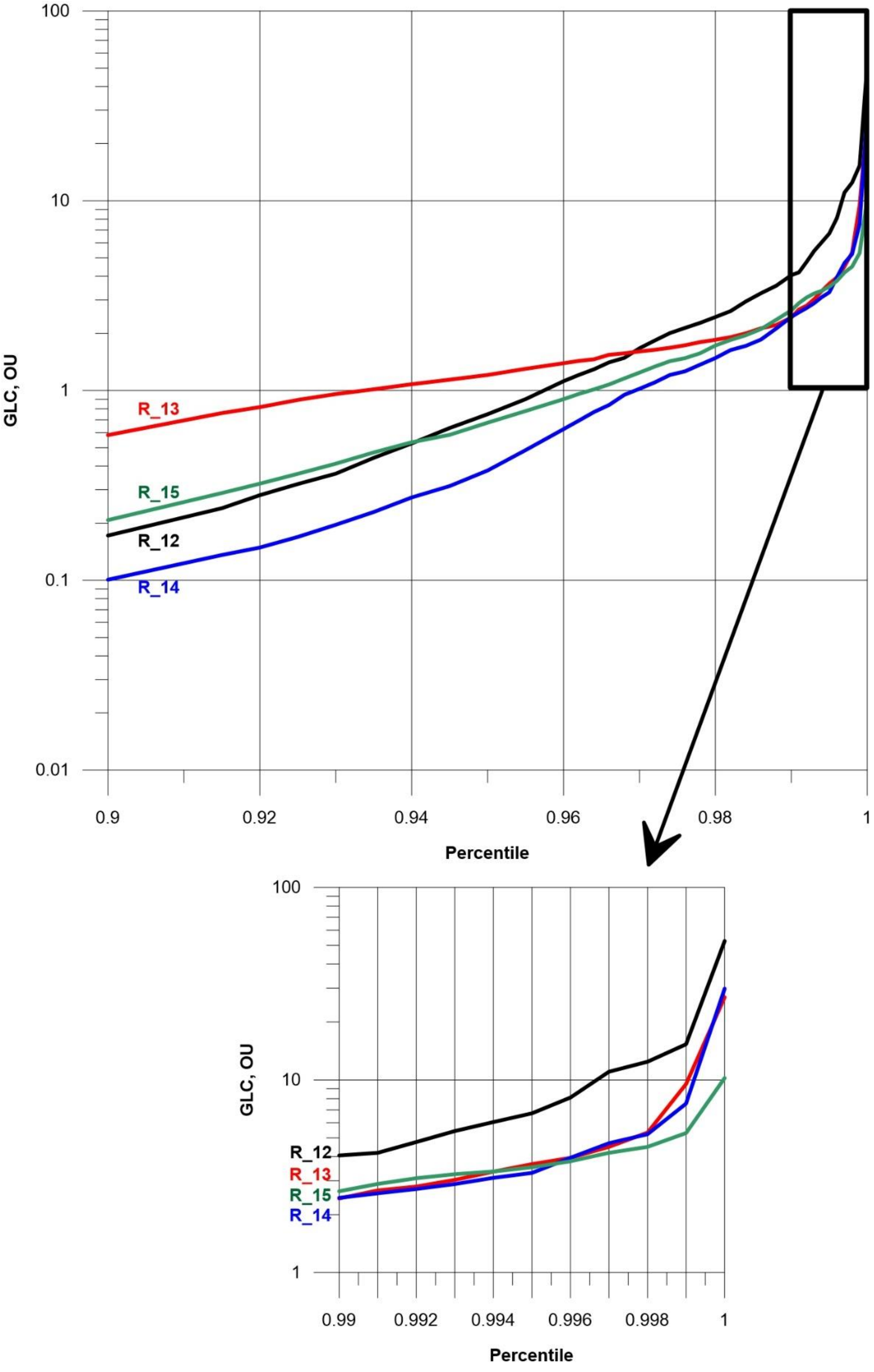


Figure 25: Cumulative percentiles of odour GLCs predicted for Scenario 1 at receptors R12 to R15. 2017 meteorological dataset. Refer Figure 16 for receptor locations.

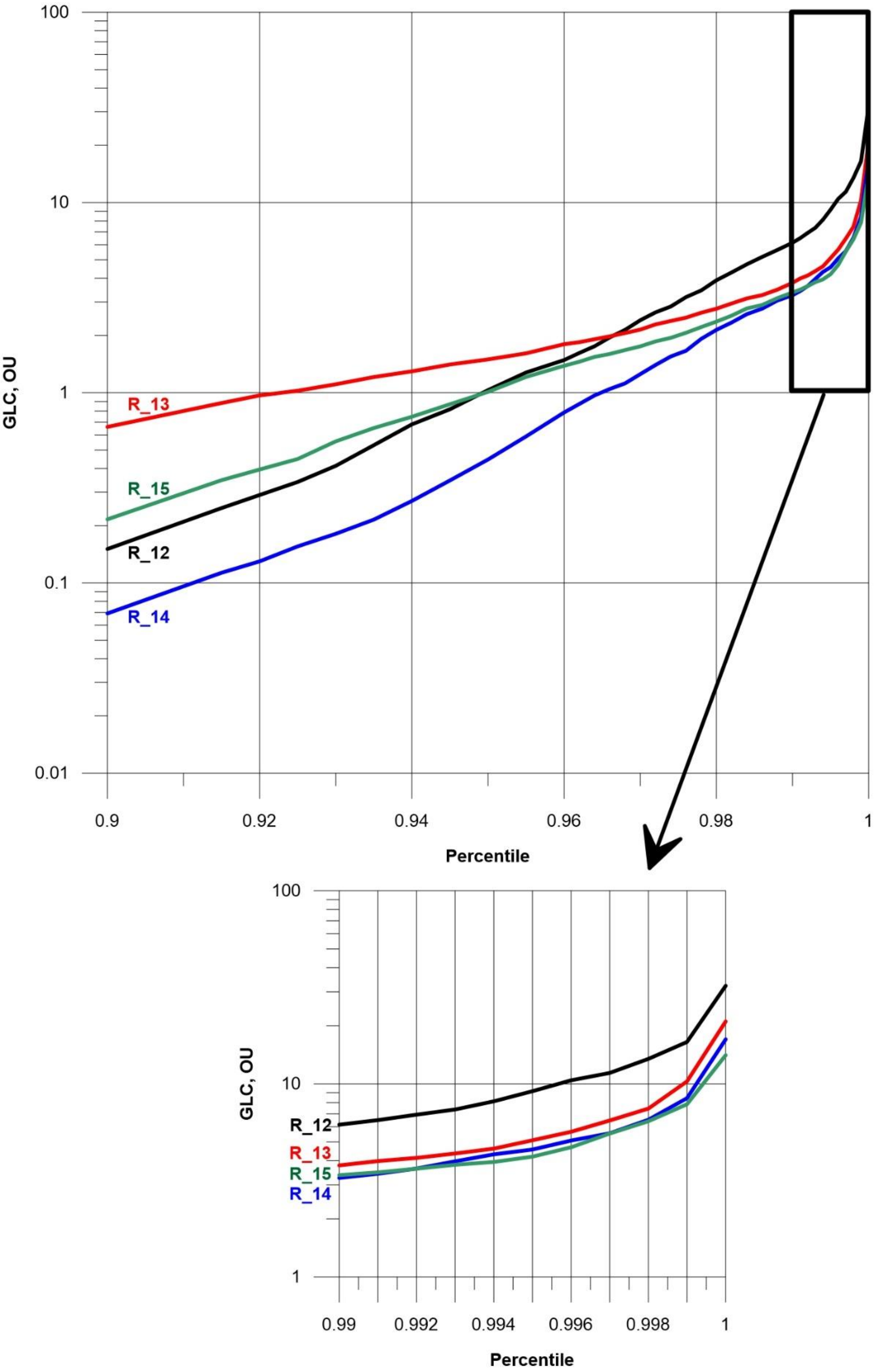


Figure 26: Cumulative percentiles of odour GLCs predicted for Scenario 4 at receptors R12 to R15. 2014 meteorological dataset. Refer Figure 16 for receptor locations.

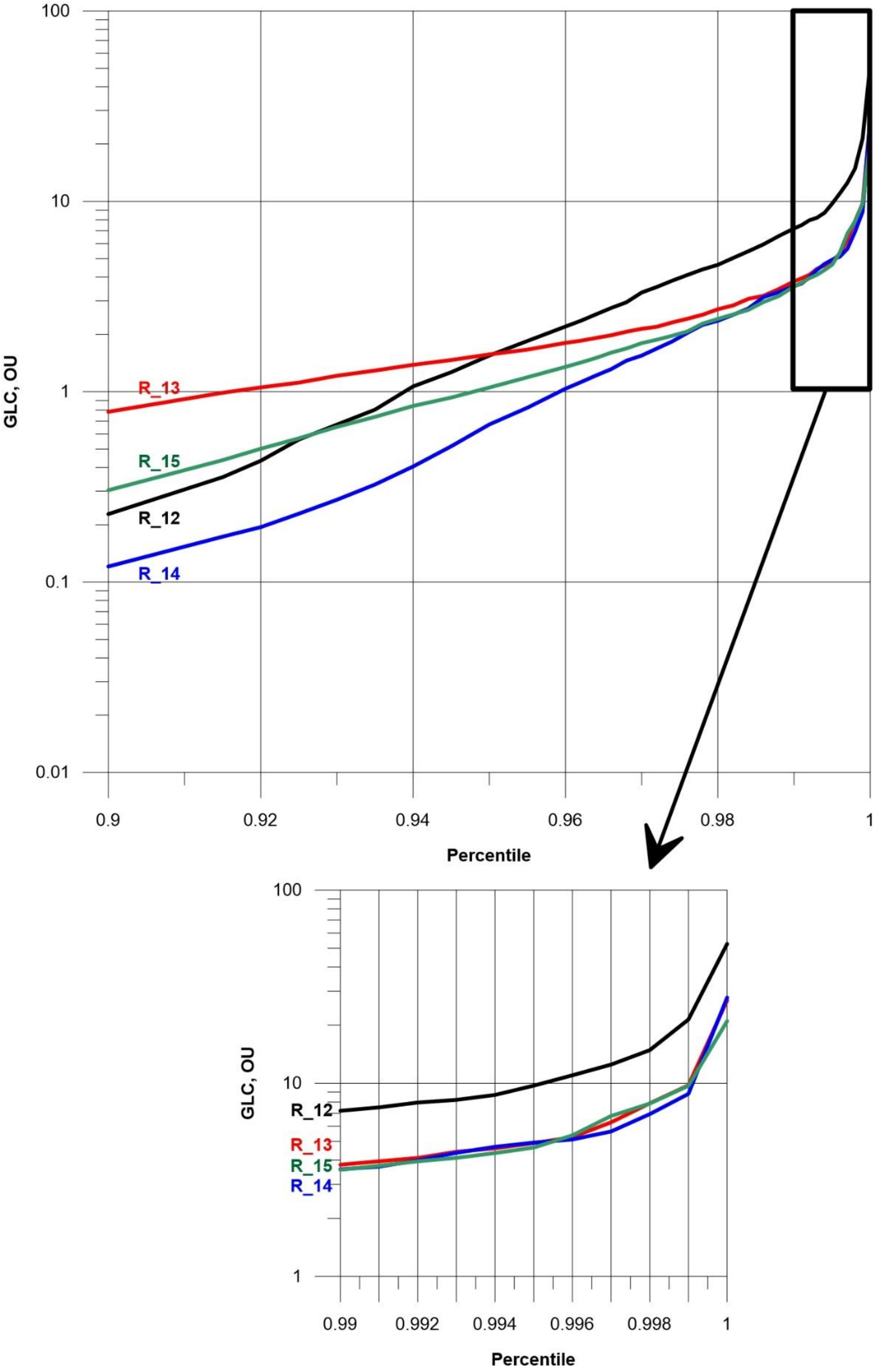


Figure 27: Cumulative percentiles of odour GLCs predicted for Scenario 4 at receptors R12 to R15. 2017 meteorological dataset. Refer Figure 16 for receptor locations.

7 Conclusion

TMM proposes development of a compost making facility on Mt Herbert Road, 4km from Waipukurau. The compost will be used as a substrate for growing mushrooms. The site is ideally located in an isolated rural location, with the nearest residences over 1400m from the proposed location of the composting operation.

The composting operation will be designed as a modern "best practice" facility with automated machinery and extensive air extraction and treatment to help minimise odour emissions from the composting processes. Despite this design, there will be some residual or fugitive odour emissions from the composting facility, including some emissions that are present 24 hours per day (predominantly from the biofilter) and other emission sources that are present only for a few hours per week (during bale breaking, bunker-to-bunker transfers for mixing Phase 1 compost, and removal of completed Phase 1 compost from the bunkers).

Meteorological modelling was conducted to simulate the movement of winds and atmospheric conditions around the site. This meteorological modelling was used to drive an atmospheric dispersion model for the odour emissions, to identify sensitive locations that could potentially be affected by offensive or objectionable odour effects. The modelling results were analysed using contour plots of the 99.5th percentile ground level concentrations, and also by examining cumulative percentile plots at individual receptor locations both at nearby dwellings and at other nearby land uses.

Overall, it was concluded that with the odour sources described in this report, considering the conservatism in the model inputs and the frequency, intensity, duration, offensiveness and location of the odours that may occur, the potential for offensive or objectionable effects to occur due to that odour is less than minor for all land uses around the site.

8 References

Ministry for the Environment (MfE), 2016. Good Practice Guide for Assessing and Managing Odour in New Zealand.

Office of Environment and Heritage (OEH) (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 for NSW Office of Environment and Heritage (now known as New South Wales Environment Protection Authority) by TRC Environmental Corporation. March 2011.

Appendix 1

Annual Windroses – Waipawa Meteorological Data Station, 2010 - 2019

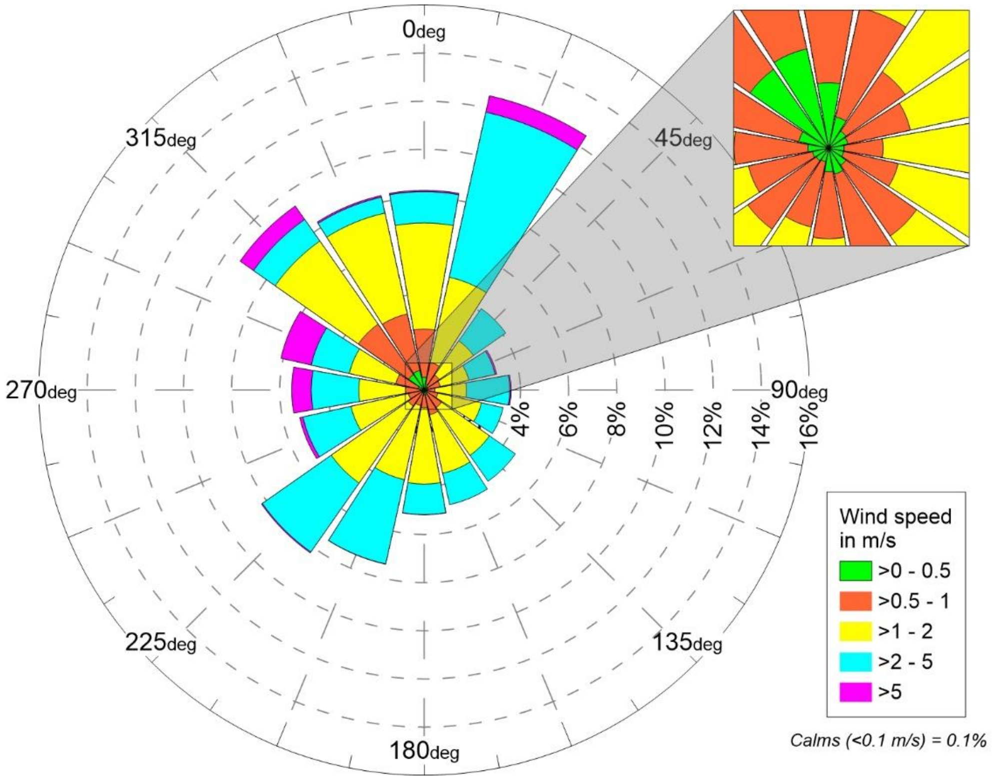


Figure A1.1: Hourly-average wind observations from Waipawa meteorological data station, January-December 2010.

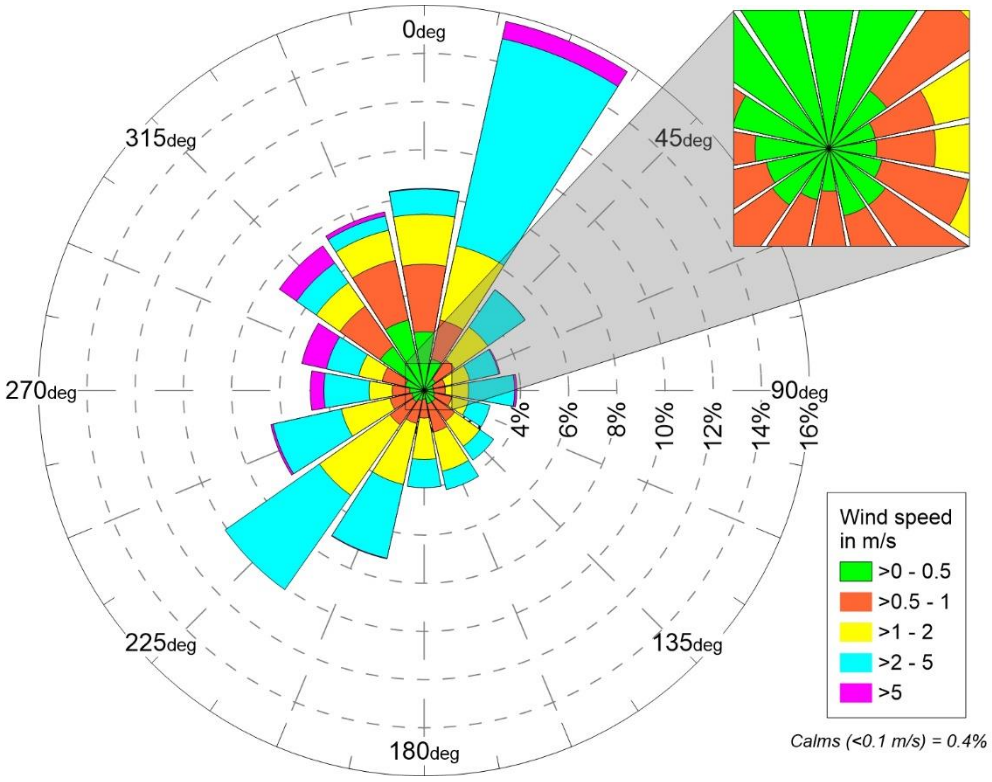


Figure A1.2: Hourly-average wind observations from Waipawa meteorological data station, January-December 2011.

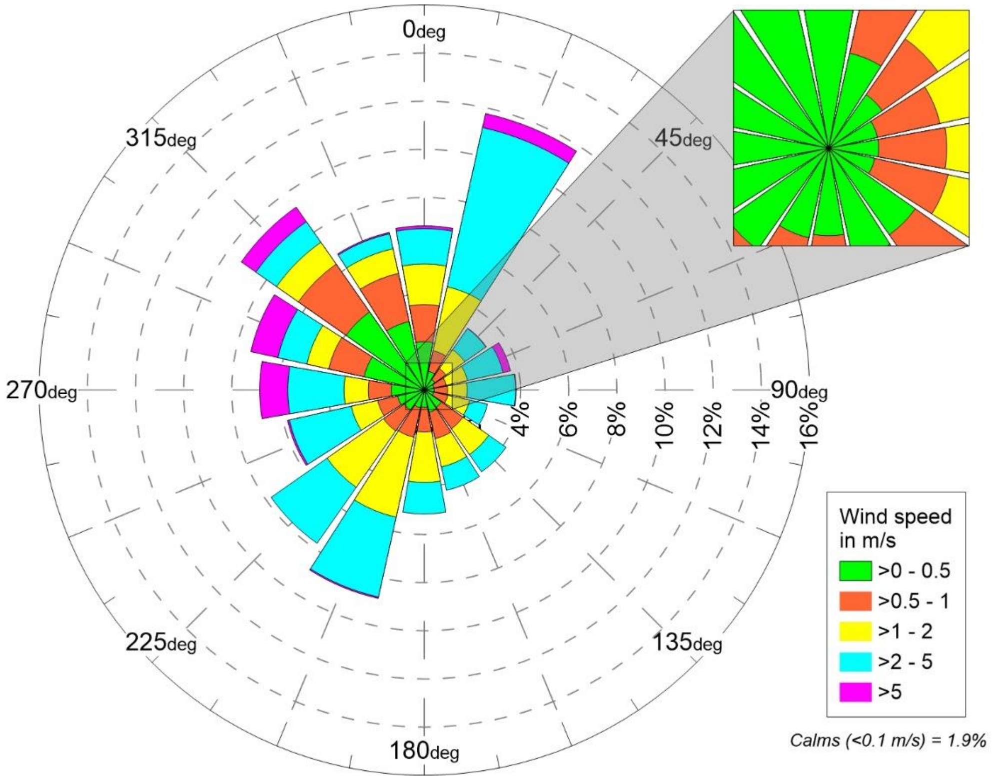


Figure A1.3: Hourly-average wind observations from Waipawa meteorological data station, January-December 2012.

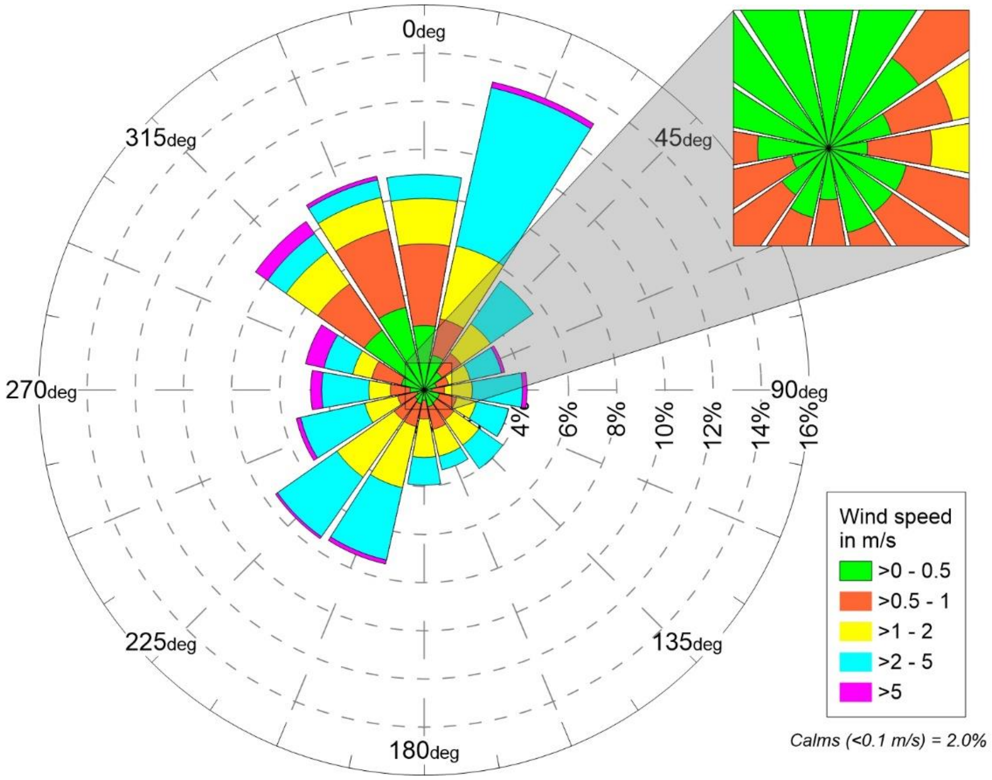


Figure A1.4: Hourly-average wind observations from Waipawa meteorological data station, January-December 2013.

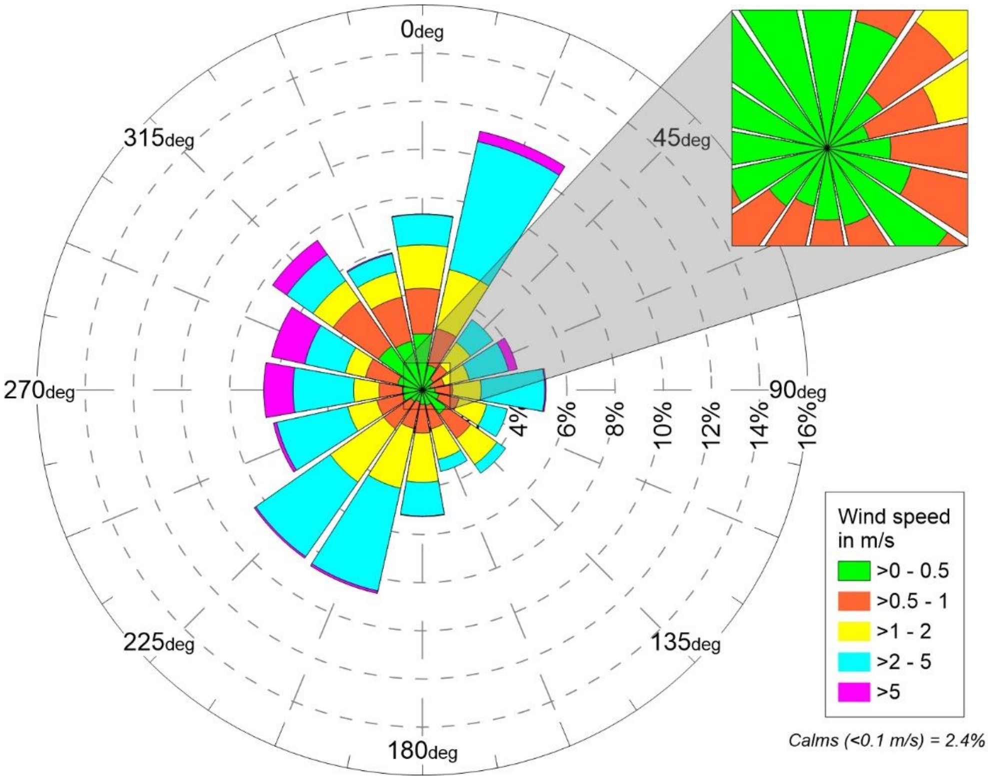


Figure A1.5: Hourly-average wind observations from Waipawa meteorological data station, January-December 2014.

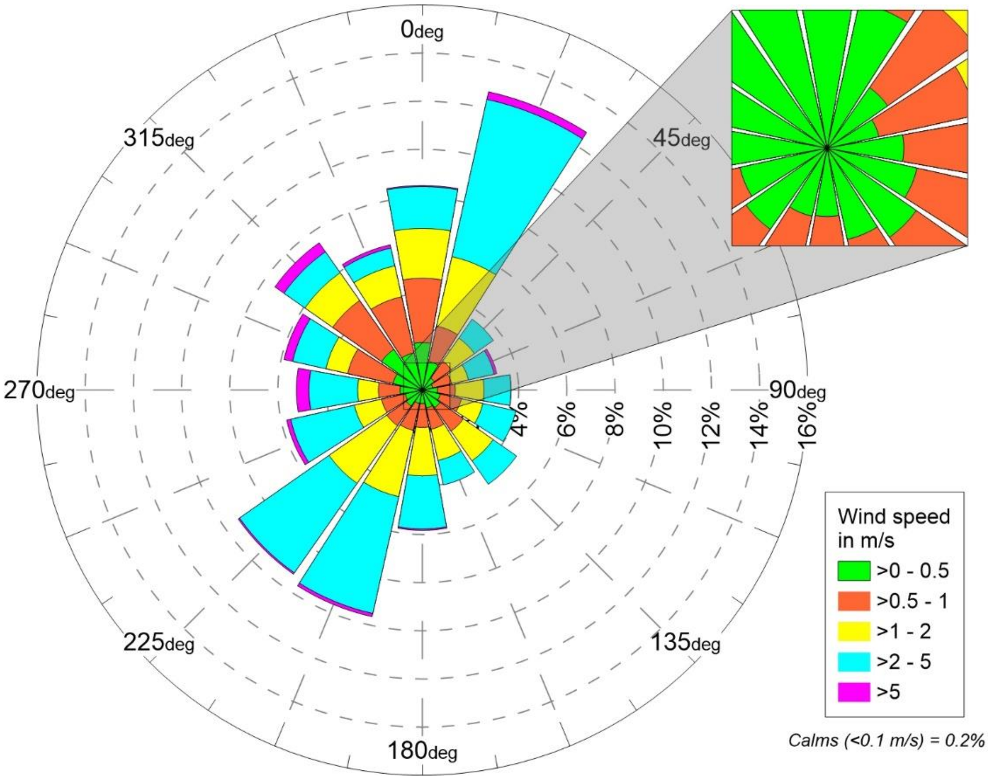


Figure A1.6: Hourly-average wind observations from Waipawa meteorological data station, January-December 2015.

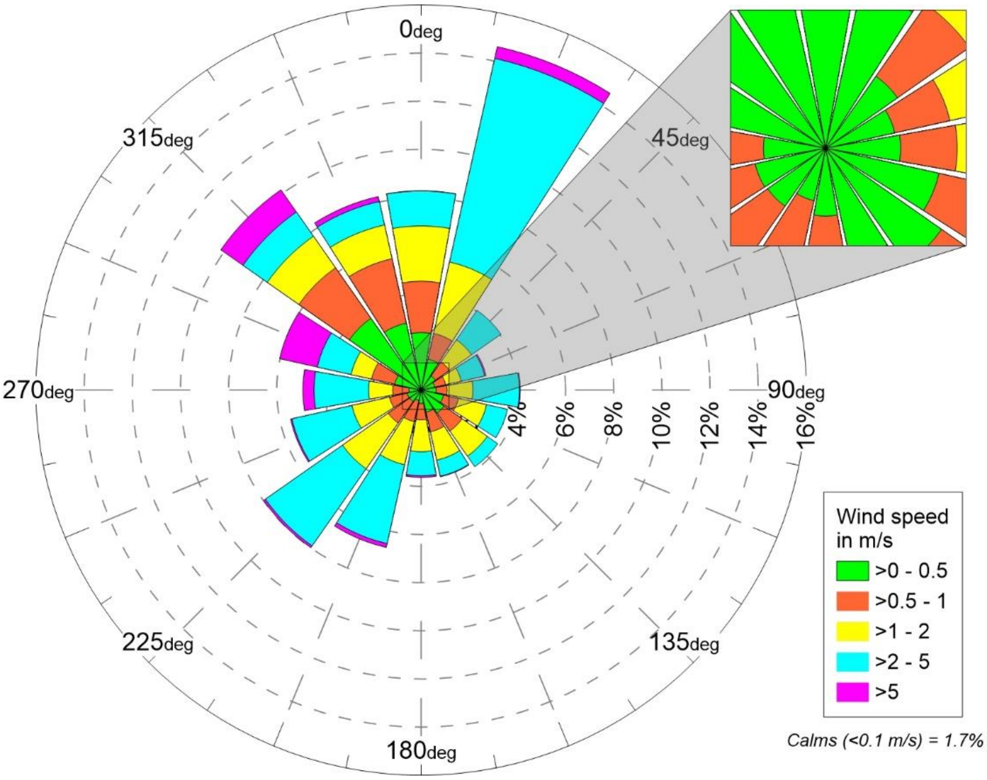


Figure A1.7: Hourly-average wind observations from Waipawa meteorological data station, January-December 2016.

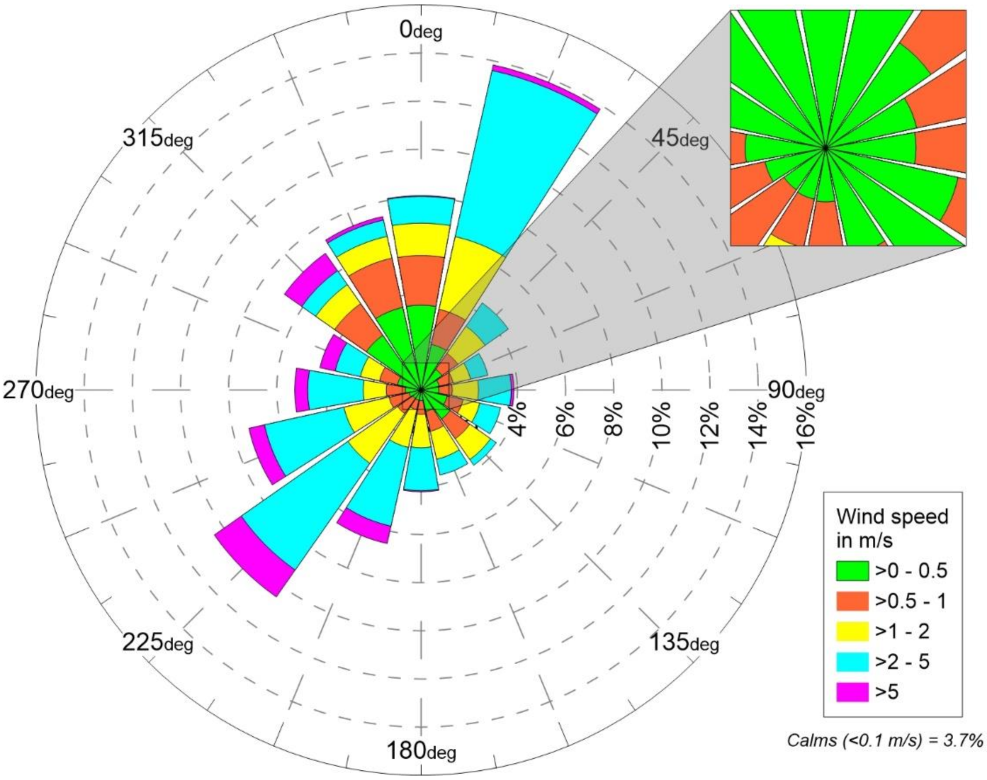


Figure A1.8: Hourly-average wind observations from Waipawa meteorological data station, January-December 2017.

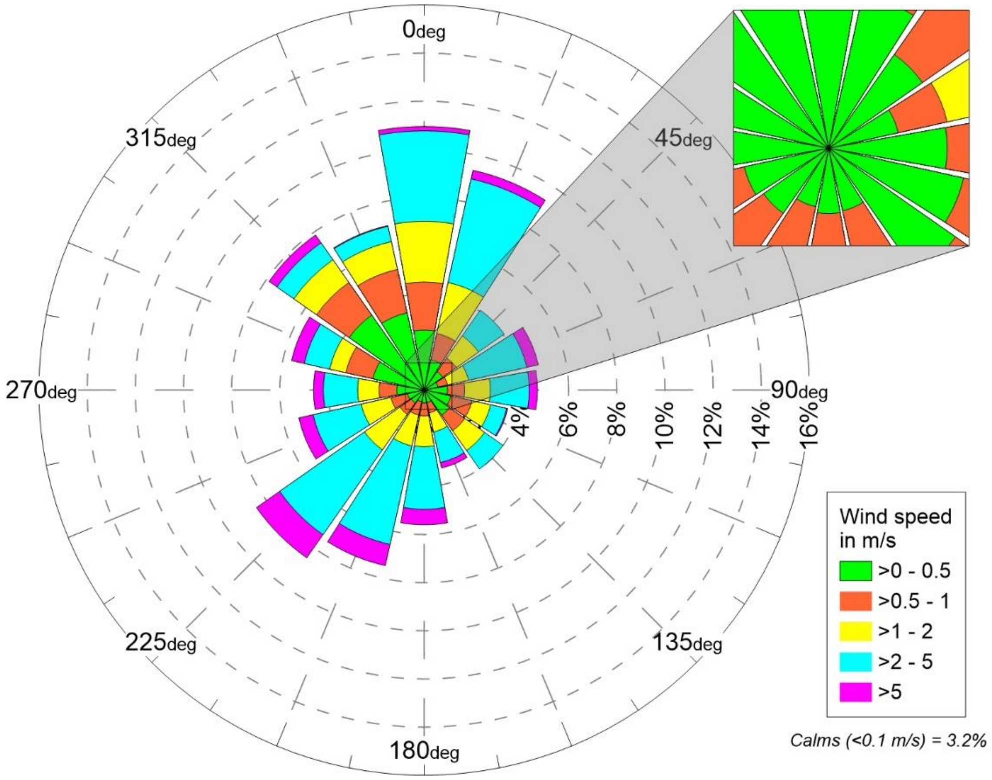


Figure A1.9: Hourly-average wind observations from Waipawa meteorological data station, January-December 2018.

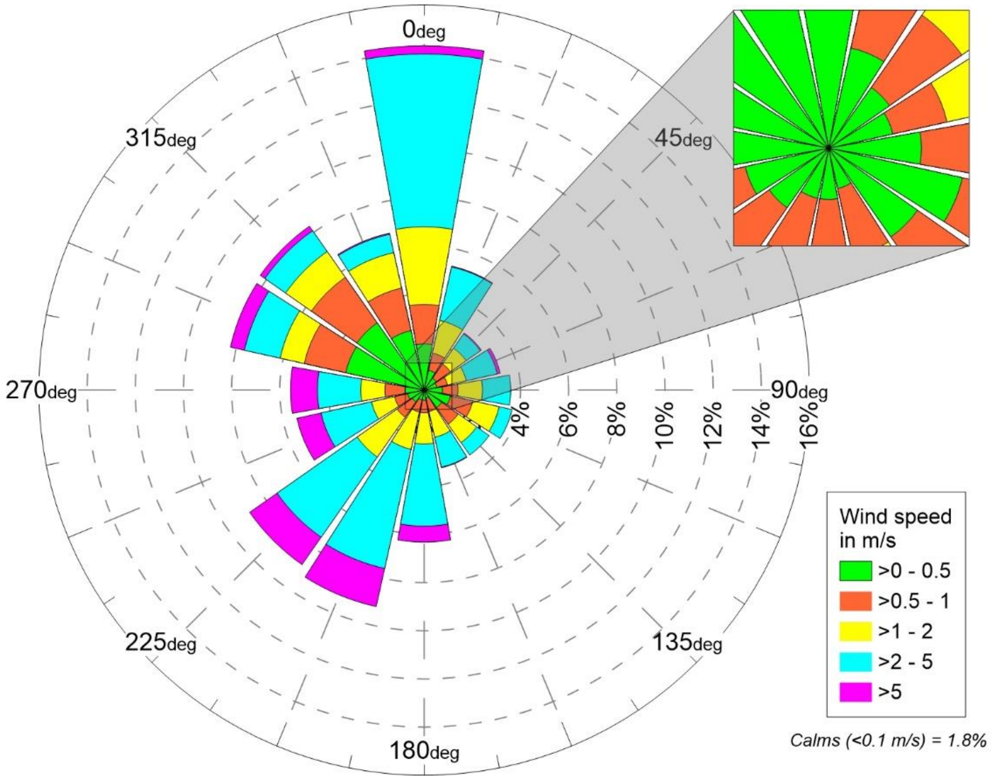


Figure A1.10: Hourly-average wind observations from Waipawa meteorological data station, Jan-Dec 2019.

Appendix 2

CALMET Input File

CALMET Parameters

TMM Mt Herbert site

Prognostic data only from TAPM, obs from Waipawa in TAPM input

125m Calmet grid resolution, 2014 year

INPUT GROUP: 0 -- Input and Output File Names		
Parameter	**Description**	**Value**
GEODAT	Input file of geophysical data (GEO.DAT)	GEO.DAT
METLST	Output file name of CALMET list file (CALMET.LST)	CALMET.LST
METDAT	Output file name of generated gridded met files (CALMET.DAT)	CALMET.DAT
LCFILES	Lower case file names (T = lower case, F = upper case)	F
NUSTA	Number of upper air stations	0
NOWSTA	Number of overwater stations	0
NM3D	Number of prognostic meteorological data files (3D.DAT)	3
NIGF	Number of IGF-CALMET.DAT files used as initial guess	0

INPUT GROUP: 1 -- General Run Control Parameters		
Parameter	**Description**	**Value**
IBYR	Starting year	2014
IBMO	Starting month	1
IBDY	Starting day	1
IBHR	Starting hour	0
IBSEC	Starting second	0
IEYR	Ending year	2015
IEMO	Ending month	1
IEDY	Ending day	1
IEHR	Ending hour	0
IESEC	Ending second	0
ABTZ	Base time zone	UTC+1200
NSECDT	Length of modeling time-step (seconds)	3600
IRTYPE	Output run type (0 = wind fields only, 1 = CALPUFF/CALGRID)	1
LCALGRD	Compute CALGRID data fields (T = true, F = false)	T
ITEST	Flag to stop run after setup phase (1 = stop, 2 = run)	2
MREG	Regulatory checks (0 = no checks, 1 = US EPA LRT checks)	0

INPUT GROUP: 2 -- Map Projection and Grid Control Parameters		
Parameter	**Description**	**Value**
PMAP	Map projection system	UTM
FEAST	False easting at projection origin (km)	0.0
FNORTH	False northing at projection origin (km)	0.0

INPUT GROUP: 2 -- Map Projection and Grid Control Parameters		
Parameter	**Description**	**Value**
IUTMZN	UTM zone (1 to 60)	60
UTMHEM	Hemisphere of UTM projection (N = northern, S = southern)	S
XLAT1	1st standard parallel latitude (decimal degrees)	30S
XLAT2	2nd standard parallel latitude (decimal degrees)	60S
DATUM	Datum-Region for the coordinates	WGS-84
NX	Meteorological grid - number of X grid cells	112
NY	Meteorological grid - number of Y grid cells	112
DGRIDKM	Meteorological grid spacing (km)	0.125
XORIGKM	Meteorological grid - X coordinate for SW corner (km)	458.8630
YORIGKM	Meteorological grid - Y coordinate for SW corner (km)	5568.6470
NZ	Meteorological grid - number of vertical layers	10
ZFACE	Meteorological grid - vertical cell face heights (m)	0.00,20.00,40.00,80.00,160.00,320.00,640.00,1200.00,2000.00,3000.00,4000.00

INPUT GROUP: 3 -- Output Options		
Parameter	**Description**	**Value**
LSAVE	Save met fields in unformatted output file (T = true, F = false)	T
IFORMO	Type of output file (1 = CALPUFF/CALGRID, 2 = MESOPUFF II)	1
LPRINT	Print met fields (F = false, T = true)	F
IPRINF	Print interval for output wind fields (hours)	1
STABILITY	Print gridded PGT stability classes? (0 = no, 1 = yes)	0
USTAR	Print gridded friction velocities? (0 = no, 1 = yes)	0
MONIN	Print gridded Monin-Obukhov lengths? (0 = no, 1 = yes)	0
MIXHT	Print gridded mixing heights? (0 = no, 1 = yes)	0
WSTAR	Print gridded convective velocity scales? (0 = no, 1 = yes)	0
PRECIP	Print gridded hourly precipitation rates? (0 = no, 1 = yes)	0
SENSHEAT	Print gridded sensible heat fluxes? (0 = no, 1 = yes)	0
CONVZI	Print gridded convective mixing heights? (0 = no, 1 = yes)	0
LDB	Test/debug option: print input met data and internal variables (F = false, T = true)	F
NN1	Test/debug option: first time step to print	1
NN2	Test/debug option: last time step to print	1
LDBCST	Test/debug option: print distance to land internal variables (F = false, T = true)	F
IOUTD	Test/debug option: print control variables for writing winds? (0 = no, 1 = yes)	0
NZPRN2	Test/debug option: number of levels to print starting at the surface	1
IPR0	Test/debug option: print interpolated winds? (0 = no, 1 = yes)	0
IPR1	Test/debug option: print terrain adjusted surface wind? (0 = no, 1 = yes)	0

INPUT GROUP: 3 -- Output Options		
Parameter	**Description**	**Value**
IPR2	Test/debug option: print smoothed wind and initial divergence fields? (0 = no, 1 = yes)	0
IPR3	Test/debug option: print final wind speed and direction? (0 = no, 1 = yes)	0
IPR4	Test/debug option: print final divergence fields? (0 = no, 1 = yes)	0
IPR5	Test/debug option: print winds after kinematic effects? (0 = no, 1 = yes)	0
IPR6	Test/debug option: print winds after Froude number adjustment? (0 = no, 1 = yes)	0
IPR7	Test/debug option: print winds after slope flow? (0 = no, 1 = yes)	0
IPR8	Test/debug option: print final winds? (0 = no, 1 = yes)	0

INPUT GROUP: 4 -- Meteorological Data Options		
Parameter	**Description**	**Value**
NOOBS	Observation mode (0 = stations only, 1 = surface/overwater stations with prognostic upper air, 2 = prognostic data only)	2
NSSTA	Number of surface stations	0
NPSTA	Number of precipitation stations	-1
ICLDOUT	Output the CLOUD.DAT file? (0 = no, 1 = yes)	0
MCLOUD	Method to compute cloud fields (1 = from surface obs, 2 = from CLOUD.DAT, 3 = from prognostic (Teixera), 4 = from prognostic (MM5toGrads)	4
IFORMS	Surface met data file format (1 = unformatted, 2 = formatted)	2
IFORMP	Precipitation data file format (1 = unformatted, 2 = formatted)	2
IFORMC	Cloud data file format (1 = unformatted, 2 = formatted)	1

INPUT GROUP: 5 -- Wind Field Options and Parameters		
Parameter	**Description**	**Value**
IWFCOD	Wind field model option (1 = objective analysis, 2 = diagnostic)	1
IFRADJ	Adjust winds using Froude number effects? (0 = no, 1 = yes)	1
IKINE	Adjust winds using kinematic effects? (0 = no, 1 = yes)	0
IOBR	Adjust winds using O'Brien velocity procedure? (0 = no, 1 = yes)	0
ISLOPE	Compute slope flow effects? (0 = no, 1 = yes)	1
IEXTRP	Extrapolation of surface winds to upper layers method (1 = none, 2 = power law, 3 = user input, 4 = similarity theory, - = same except layer 1 data at upper air stations are ignored)	-1
ICALM	Extrapolate surface winds even if calm? (0 = no, 1 = yes)	0
BIAS	Weighting factors for surface and upper air stations (NZ values)	0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
RMIN2	Minimum upper air station radius of influence for surface extrapolation exclusion (km)	4
IPROG	Use prognostic winds as input to diagnostic wind model (0 = no, 13 = use winds from 3D.DAT as Step 1 field, 14 = use winds from 3D.DAT as initial guess field, 15 = use winds from 3D.DAT file as observations)	14
ISTEPPGS	Prognostic data time step (seconds)	3600

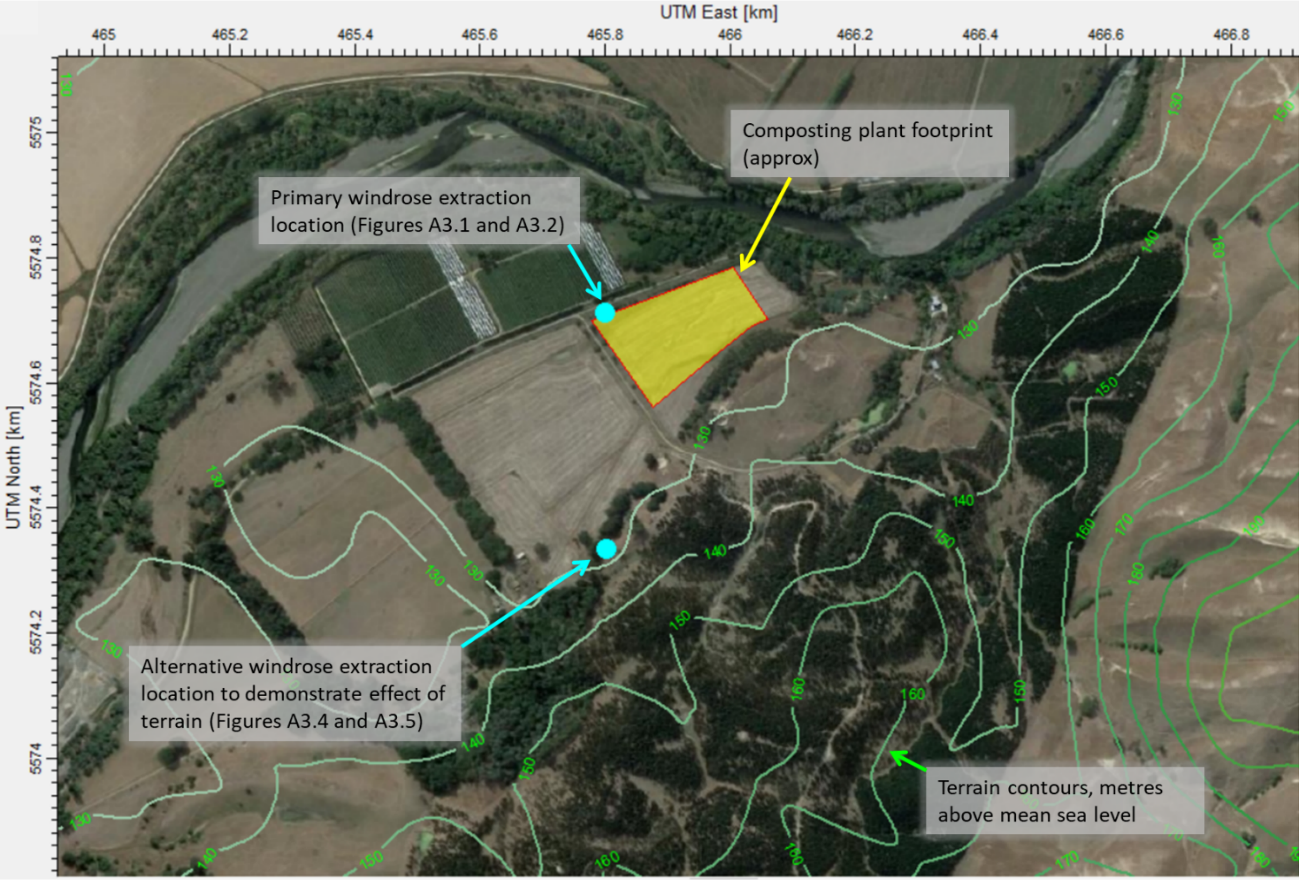
INPUT GROUP: 5 -- Wind Field Options and Parameters		
Parameter	**Description**	**Value**
IGFMET	Use coarse CALMET fields as initial guess? (0 = no, 1 = yes)	0
LVARY	Use varying radius of influence (F = false, T = true)	F
RMAX1	Maximum radius of influence in the surface layer (km)	0
RMAX2	Maximum radius of influence over land aloft (km)	0
RMAX3	Maximum radius of influence over water (km)	0
RMIN	Minimum radius of influence used in wind field interpolation (km)	0.1
TERRAD	Radius of influence of terrain features (km)	2
R1	Relative weight at surface of step 1 fields and observations (km)	0
R2	Relative weight aloft of step 1 field and observations (km)	0
RPROG	Weighting factors of prognostic wind field data (km)	0
DIVLIM	Maximum acceptable divergence	5E-006
NITER	Maximum number of iterations in the divergence minimization procedure	50
NSMTH	Number of passes in the smoothing procedure (NZ values)	2,9*4
NINTR2	Maximum number of stations used in each layer for interpolation (NZ values)	10*99
CRITFN	Critical Froude number	1
ALPHA	Empirical factor triggering kinematic effects	0.1
NBAR	Number of barriers to interpolation of the wind fields	0
KBAR	Barrier - level up to which barriers apply (1 to NZ)	10
IDIOPT1	Surface temperature (0 = compute from obs/prognostic, 1 = read from DIAG.DAT)	0
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	-1
IDIOPT2	Temperature lapse rate used in the computation of terrain-induced circulations (0 = compute from obs/prognostic, 1 = read from DIAG.DAT)	0
IUPT	Upper air station to use for the domain-scale lapse rate (between 1 and NUSTA)	-1
ZUPT	Depth through which the domain-scale lapse rate is computed (m)	200
IDIOPT3	Initial guess field winds (0 = compute from obs/prognostic, 1 = read from DIAG.DAT)	0
IUPWND	Upper air station to use for domain-scale winds	-1
ZUPWND	Bottom and top of layer through which the domain-scale winds are computed (m)	1.0, 1.00
IDIOPT4	Read observed surface wind components (0 = from SURF.DAT, 1 = from DIAG.DAT)	0
IDIOPT5	Read observed upper wind components (0 = from UPn.DAT, 1 = from DIAG.DAT)	0
LLBREZE	Use Lake Breeze module (T = true, F = false)	F
NBOX	Lake Breeze - number of regions	0

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters		
Parameter	**Description**	**Value**
CONSTB	Mixing height constant: neutral, mechanical equation	1.41

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters		
Parameter	**Description**	**Value**
CONSTE	Mixing height constant: convective equation	0.15
CONSTN	Mixing height constant: stable equation	2400
CONSTW	Mixing height constant: overwater equation	0.16
FCORIOL	Absolute value of Coriolis parameter (1/s)	0.0001
IAVEZI	Spatial mixing height averaging? (0 = no, 1 = yes)	1
MNMDAV	Maximum search radius in averaging process (grid cells)	1
HAFANG	Half-angle of upwind looking cone for averaging (degrees)	30
ILEVZI	Layer of winds used in upwind averaging (between 1 and NZ)	1
IMIXH	Convective mixing height method (1 = Maul-Carson, 2 = Batchvarova-Gryning, - for land cells only, + for land and water cells)	1
THRESHL	Overland threshold boundary flux (W/m**3)	0
THRESHW	Overwater threshold boundary flux (W/m**3)	0.05
ITWPROG	Overwater lapse rate and deltaT options (0 = from SEA.DAT, 1 = use prognostic lapse rates and SEA.DAT deltaT, 2 = from prognostic)	0
ILUOC3D	Land use category in 3D.DAT	16
DPTMIN	Minimum potential temperature lapse rate (K/m)	0.001
DZZI	Depth of computing capping lapse rate (m)	200
ZIMIN	Minimum overland mixing height (m)	50
ZIMAX	Maximum overland mixing height (m)	3000
ZIMINW	Minimum overwater mixing height (m)	50
ZIMAXW	Maximum overwater mixing height (m)	3000
ICOARE	Overwater surface fluxes method	10
DSHELF	Coastal/shallow water length scale (km)	0
IWARM	COARE warm layer computation (0 = off, 1 = on)	0
ICOOL	COARE cool skin layer computation (0 = off, 1 = on)	0
IRHPROG	Relative humidity read option (0 = from SURF.DAT, 1 = from 3D.DAT)	1
ITPROG	3D temperature read option (0 = stations, 1 = surface from station and upper air from prognostic, 2 = prognostic)	2
IRAD	Temperature interpolation type (1 = 1/R, 2 = 1/R**2)	1
TRADKM	Temperature interpolation radius of influence (km)	500
NUMTS	Maximum number of stations to include in temperature interpolation	5
IAVET	Conduct spatial averaging of temperatures? (0 = no, 1 = yes)	1
TGDEFB	Default overwater mixed layer lapse rate (K/m)	-0.0098
TGDEFA	Default overwater capping lapse rate (K/m)	-0.0045
JWAT1	Beginning land use category for temperature interpolation over water	999
JWAT2	Ending land use category for temperature interpolation over water	999
NFLAGP	Precipitation interpolation method (1 = 1/R, 2 = 1/R**2, 3 = EXP/R**2)	2
SIGMAP	Precipitation interpolation radius of influence (km)	100.
CUTP	Minimum precipitation rate cutoff (mm/hr)	0.01

Appendix 3

Windroses extracted from CALMET model



Composting plant footprint (approx)

Primary windrose extraction location (Figures A3.1 and A3.2)

Alternative windrose extraction location to demonstrate effect of terrain (Figures A3.4 and A3.5)

Terrain contours, metres above mean sea level

Figure A3.1: Locations for windrose extractions shown in Figures A3.2 to A3.5.

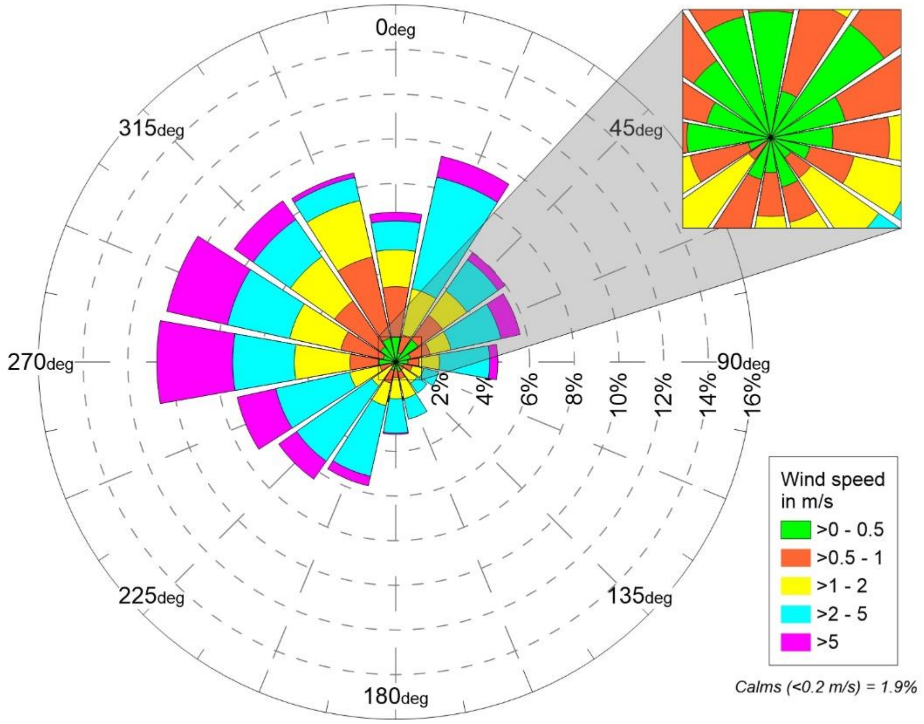


Figure A3.2: Windrose extracted from CALMET for TMM Site location, 2014 calendar year. Records show hourly average wind speed and direction 1 January to 31 December.

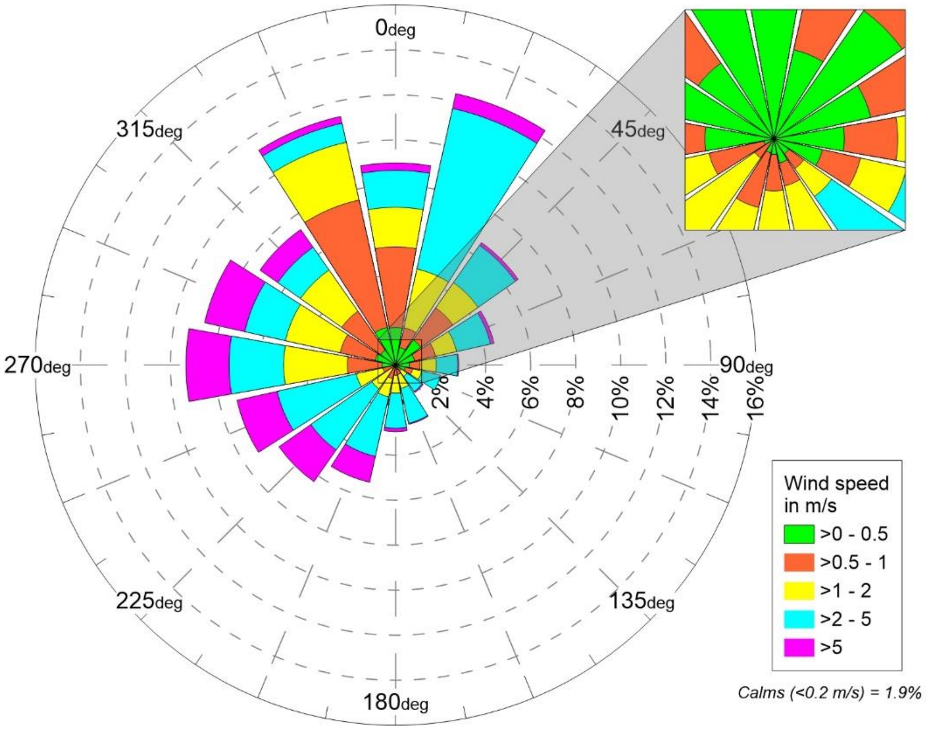


Figure A3.3: Windrose extracted from CALMET for TMM Site location, 2017 calendar year. Records show hourly average wind speed and direction 1 January to 31 December.

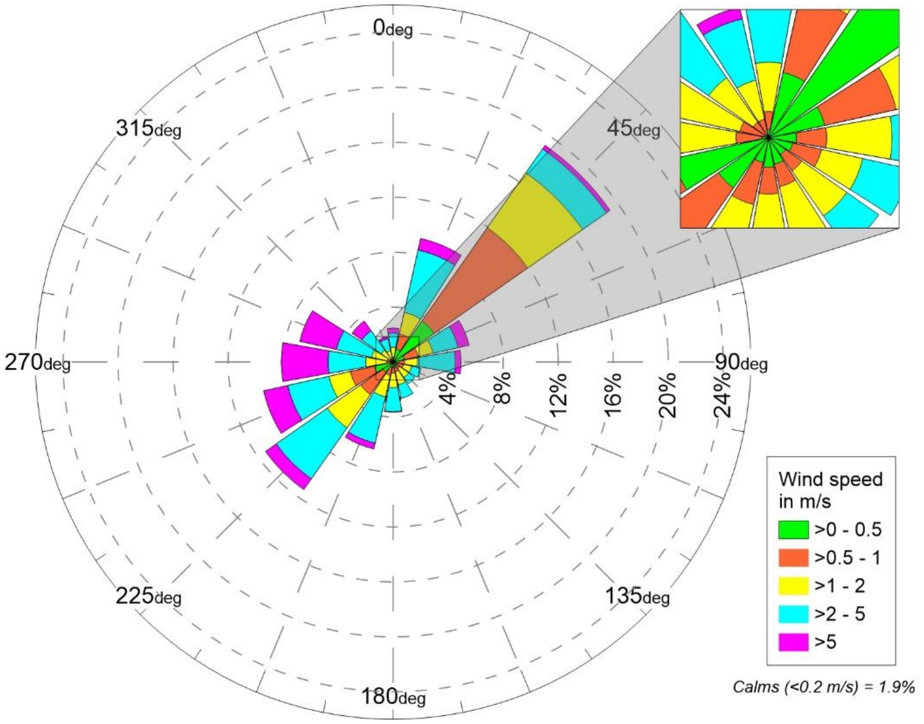


Figure A3.4: Windrose extracted from CALMET for alternate data extraction location shown on Figure A3.1, 2014 calendar year. Records show hourly average wind speed and direction 1 January to 31 December.

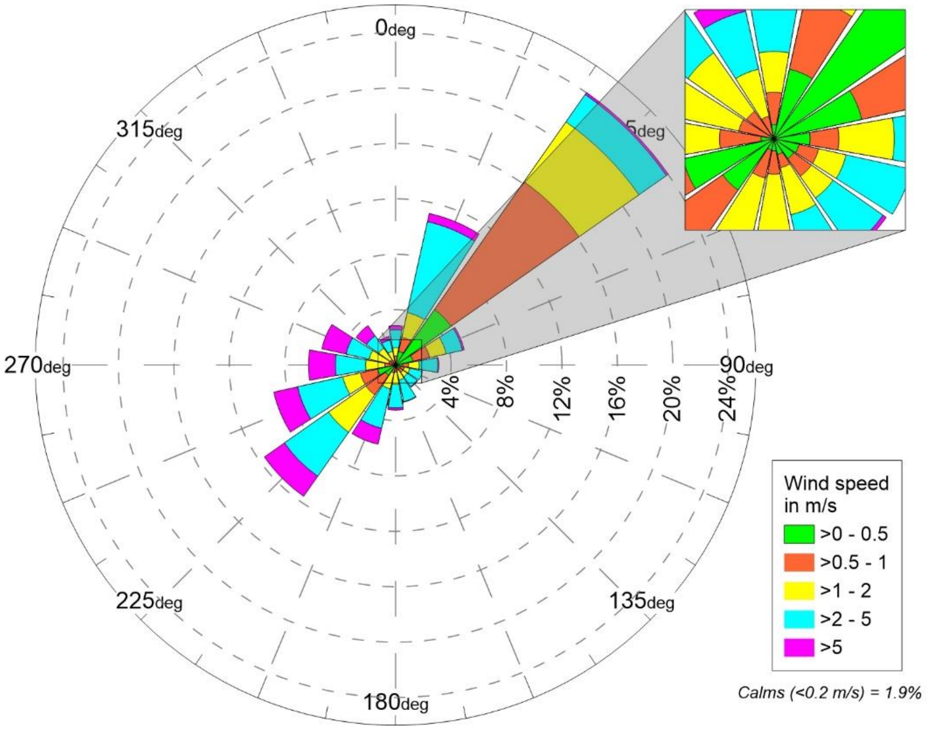


Figure A3.5: Windrose extracted from CALMET for alternate data extraction location shown on Figure A3.1, 2017 calendar year. Records show hourly average wind speed and direction 1 January to 31 December.