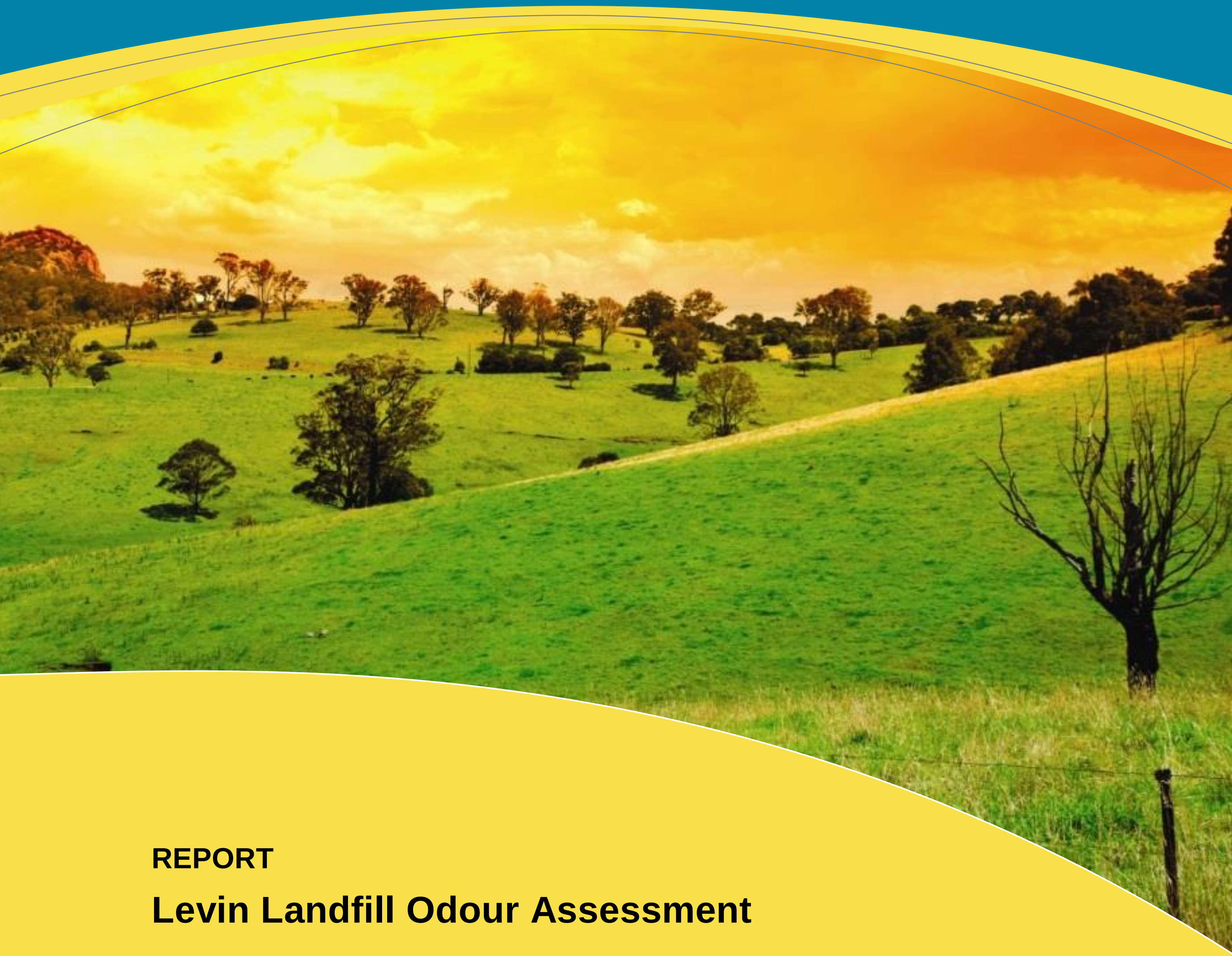

REPORT

Levin Landfill Odour Assessment

Prepared for Horowhenua District Council

February 2015

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Executive Summary

Horowhenua District Council (HDC) is currently considering implementing a number of odour mitigation measures to control odour at the Levin Landfill site, located at 665 Hōkio Beach Road, Levin. As part of this process, MWH New Zealand Limited (MWH) was commissioned by the HDC to undertake an odour assessment to determine the potential for odour nuisance effects beyond the Levin Landfill site boundary.

This report seeks to quantify the potential odour impact at the nearest identified sensitive receptors resulting from the operation of the existing landfill, and to make recommendations regarding the control of odour at the site, where required.

In order to determine the potential for odour nuisance effects in the surrounding community due to odorous emissions at the Levin Landfill, MWH undertook the following assessments:

- A field odour investigation, odour emissions monitoring and surface emissions monitoring for methane (as a surrogate for odorous landfill gas emissions) at the landfill in November 2014 to identify the principal odour emission sources on the site and their potential to cause nuisance effects beyond the site boundary;
- A detailed assessment involving dispersion modelling techniques in order to predict the level of impact that may be experienced in the surrounding community, using site specific-odour emissions monitoring data for the principal odour emissions sources input into the model. The aim of the dispersion modelling assessment was not to confirm or deny the odour complaints history, but to assess the potential benefits associated with undertaking a number of mitigation options (assessed as four separate modelling scenarios); and,
- A review of HDC's recent odour complaints record for the landfill.

Employing the mitigation measures recommended in this report has the potential to significantly reduce the likelihood of causing odour nuisance effects in the surrounding community. These mitigation measures should be implemented in two phases: phase one includes applying effective capping across Stage 2 to reduce landfill gas and odour emissions to the minimum practicable level, and also implementing improvements at the leachate pond, working face and leachate collection manhole; whilst phase two involves operating a suitably sized flare to control odour (if required). These recommendations have been incorporated into the proposed site Odour Management Plan contained in this report.

Providing that the mitigation measures recommended in this report are adhered to by the landfill operator at all times, MWH considers that the potential for further odour nuisance effects will be significantly reduced. The phase one mitigation measures should be implemented onsite by HDC at the earliest possible opportunity.

Horowhenua District Council

Levin Landfill Odour Assessment

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Abbreviations

Abbreviation	Description
ADMLC	UK Atmospheric Dispersion Modelling Liaison Committee
AWS	Automatic Weather Station (operated by MetService)
BOD	biochemical oxygen demand
CALMET	California Meteorological Model
CALPUFF	California Puff Model
CH_4	methane
CliFlo	National Climate Database (maintained by NIWA)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CV	calorific value or coefficient of variation
DDO	dynamic dilution olfactometry
DO	dissolved oxygen
E	East
EA	UK Environment Agency
ENE	East North East
ESE	East South East
EWS	Electronic Weather Station (operated by NIWA/AgResearch)
FIDOL	(F)requency, (I)ntensity (D)uration, (O)ffensiveness and (L)ocation (of odour impact)
GCL	geosynthetic clay liner
GIS	Geographical Information System
GPG	Good Practice Guide
GPS	Global Positioning System
ha	Area (as ‘hectares’)
HH:MM:SS	Time (as ‘hour: minutes: seconds’)
hPa	Atmospheric Pressure (as 'hectopascals')
HDC	Horowhenua District Council
HDPE	high density polyethylene
HRC	Horizons Regional Council (or Manawatu-Wanganui Regional Council)
HSE	Health and Safety in Employment Act 1992
km	Distance (as 'kilometres’)
L/min	Volumetric flow rate (as 'litres per minute')
LDMP	Landfill Development and Management Plan
LEL	lower explosive limit
LFG	landfill gas
m	Distance (as 'metres’)
m^2	Area (as ‘metres squared’)
m^3/s	Volumetric flow rate (as 'metres cubed per second')
mg/m^3	Concentration (as ‘milligrams per cubic metre of air’)
mm	Distance or Rainfall Amount (as 'millimetres’)
m/s	Velocity (as 'metres per second')
MfE	Ministry for the Environment
MVM	mulched woody material
N	North

Abbreviation	Description
NASA	National Aeronautics and Space Administration (United States)
NATA	National Association of Testing Authorities (Australia)
NE	North East
NLG	neighbourhood liaison group
NNE	North North East
NNW	North North West
NW	North West
NZTM	New Zealand Transverse Mercator
OER	Odour Emission Rate (e.g. odour units per second or ‘OU/s’)
OMP	Odour Management Plan
OU	Odour Units
OU/m^3	Odour concentration (as ‘odour units per cubic metre of air’)
$OU/s/m^2$	Odour emission rate (as ‘odour units per second per square metre’)
ppm	Concentration (as ‘parts per million’)
R	sensitive receptor (e.g. residential property)
RAP	Horizons Regional Air Plan
RMA	Resource Management Act 1991
RPS	Horizons Regional Policy Statement
S	South
SE	South East
SRC	odour emission source (e.g. leachate pond)
SRTM	Shuttle Radar Topography Mission
SSE	South South East
SSW	South South West
SW	South West
TAPM	The Air Pollution Model
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VOC	volatile organic compounds
W	West
WNW	West North West
WSW	West South West
99.9%ile	99.9^{th} percentile
%	Percent
%ile	Percentile
^{o}	Degrees (e.g. ‘°S’ = ‘degrees South’)
ºC	Temperature (as ‘degrees Celsius’)

1 Introduction

1.1 Project Overview

MWH New Zealand Limited (MWH) was commissioned by Horowhenua District Council (HDC) to undertake an odour impact assessment at Levin Landfill located off Hōkio Beach Road, Levin (the 'Project Site'). The aim of the odour impact assessment was to determine the potential for odour nuisance effects beyond the Levin Landfill site boundary. Five resource consents (numbers 6009, 6010, 6011, 7289, 102259) were granted to HDC by Horizons Regional Council (HRC) in 2002, and the consent conditions were reviewed and amended in May 2010 under section 128 of the Resource Management Act 1991 (RMA). The existing resource consents will expire in 2037. Resource consent (discharge permit) number 6011 authorises the discharge to air of contaminants (including landfill gas, odour and dust) associated with the landfill activities undertaken at the project site. Reference should be made to **Appendix A** for further details regarding resource consent number 6011. The landfill is currently operated by EnviroWaste Services Limited (EnviroWaste) under contract to HDC.

As HDC is the consent holder for the Levin Landfill, it holds primary responsibility for ensuring compliance with the conditions of the resource consents for the site. As the regional council, however, HRC is responsible under the RMA for monitoring compliance with the conditions of the landfill site resource consents by HDC. It also has the power to take enforcement action in the event of a breach in the consent conditions.

Irrespective of the site, odour issues from landfills in New Zealand (and internationally) may arise from: release of odorants from waste which is being tipped at a site (i.e. at the 'working face' on the open or active cells); fugitive emissions of landfill gas (LFG) on the closed area (e.g. cells that have been capped or covered with intermediate cover); passive (uncontrolled) emissions of LFG and odour from vents or wells; open storage of leachate; and engines and flares (unburned LFG). Landfill gas is generated by the anaerobic breakdown of biodegradable (putrescible) waste, and the rate of production of landfill gas is affected by the waste composition, landfill geometry and design, and meteorological conditions. Landfill gas is predominantly comprised of methane and carbon dioxide, which are both odourless. Landfill gas odours, on the other hand, predominantly comprise of hydrogen sulphide, methyl mercaptan, carbon disulphide, ethyl mercaptan, acetaldehyde, butyric acid and dimethyl disulphide, amongst others.

The odour sources at the project site were identified by MWH during a site visit on 18 and 19 November 2014. The flare at the site was not in operation for the period between 11 November 2014 (a week prior to the site visit) and 22 December 2014 (i.e. it was not operating during the site visit).

This report examines the potential odour effects that may arise during the operation of the landfill. A number of mitigation measures and a proposed odour management plan for the project site are presented in **Section 6** and **Appendix E**, respectively.

1.2 Study Overview

This report seeks to quantify the potential odour impact at the nearest identified sensitive receptors resulting from the operation of the existing landfill, and to make recommendations regarding the control of odour at the site, where required.

In order to determine the potential for odour nuisance effects in the surrounding community due to odorous emissions at the project site, MWH undertook a field odour investigation in November 2014 to identify the existing emission sources on the site and their potential to cause nuisance effects beyond the site boundary. In addition, this assessment also involved undertaking a review of the project site's odour complaints record, undertaking odour emissions and surface emissions monitoring for methane at the landfill and undertaking a detailed assessment involving dispersion modelling techniques in order to predict the level of impact that may be experienced in the surrounding community (refer to **Section 5** for further details). The assessment undertaken in this report was carried out in accordance with the following Ministry for the Environment (MfE) guidance documents:

- "*Good Practice Guide for Assessing and Managing Odour in New Zealand*", Ministry for the Environment, June 2003 (MfE, 2003); and,
- "*Good Practice Guide for Atmospheric Dispersion Modelling*", Ministry for the Environment, June 2004 (MfE, 2004).

1.3 Study Location

The project site is located at 665 Hōkio Beach Road, Levin and is legally described as Lot 3 DP 40743. The site covers an area of approximately 72 hectares (ha). The landfill site is in undulating sand dune country surrounded by pastoral farming, with the Hōkio Stream (the single outlet of Lake Horowhenua) close to the northern boundary. This stream flows westwards to the sea, which is 2.5 km away.

The centre of the project site is located at approximately New Zealand Transverse Mercator (NZTM) 1787100 metres East and 5502390 metres North (or Universal Transverse Mercator (UTM) Zone 60 South 348700 metres East and 5503200 metres North, or latitude 40.6082 ºSouth, longitude 175.2116 ºEast).

The project site is located approximately 6 km to the west-north-west of Levin town centre, 38 km north-east of Paraparaumu Airport and 43 km to the south-west of Palmerston North. The location of the project site is shown in **Figure 1–1**. The figure was produced using OpenStreetMap under the Open Database License. OpenStreetMap has been used throughout this report and MWH has acknowledged OpenStreetMap and its contributors, where relevant. The Open Database License can be read in full on the OpenStreetMap website (http://opendatacommons.org/licenses/odbl/1.0/).

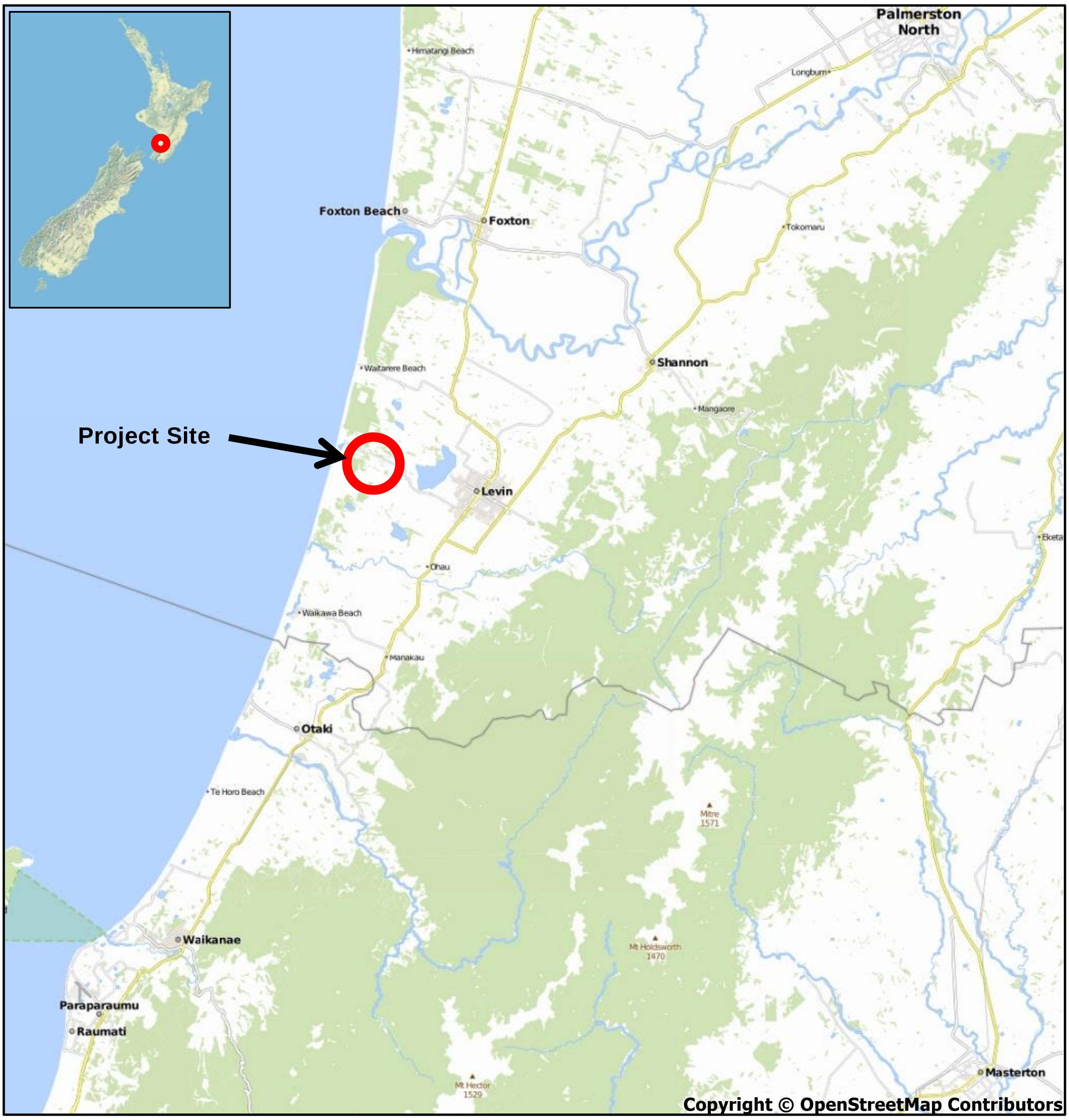

Figure 1-1: Site Location Plan Showing the Wider Environment

The Project Site falls under the jurisdiction of HDC and HRC. The site is owned by HDC and landfill operations are currently contracted out to EnviroWaste. The site is zoned ‘rural’ in the proposed HDC District Plan 2013 (as amended by decisions) and is designated for the purpose of a ‘rubbish dump’ under designation number ‘D122’.

The boundary of the project site is indicated on the aerial photo shown in **Figure 1–2** by a solid red line. Note that this boundary is indicative only and follows the lease boundary for the whole site.

Figure 1-2: Site Location Plan Showing the Boundary of the Project Site

1.4 Surrounding Environment and Topography

1.4.1 Land Use

The project site is surrounded by a range of rural land uses, including rural lifestyles and pastoral farming. Within a radius of 1 km from the site boundary, there are approximately twelve residential properties and a marae located to the north-east of the site, and approximately four residential properties located to the north-west of the site. These properties are shown in **Figure 1–2**. Further discussion of the land use and sensitive receptor locations in the vicinity of the project site is provided in **Section 3**.

1.4.2 Terrain

The terrain in the immediate vicinity of the project site is relatively flat. The terrain slopes gently downhill from the leachate pond located onsite (at an approximate elevation of 40 m above mean sea level) to the nearest residential property located at 645 Hōkio Beach Road (at an elevation of 16 m above mean sea level), which is over a ground distance of approximately 340 m. The terrain is relatively complex (e.g. more than 1 in 10) further afield, towards the south-east of the site. The terrain within the Tararua Forest Park, which is approximately 25 km to the south-east of the site, rises to 1,400 m above mean sea level. **Figure 1–3** shows a site location plan for the wider area surrounding the project site, including the terrain.

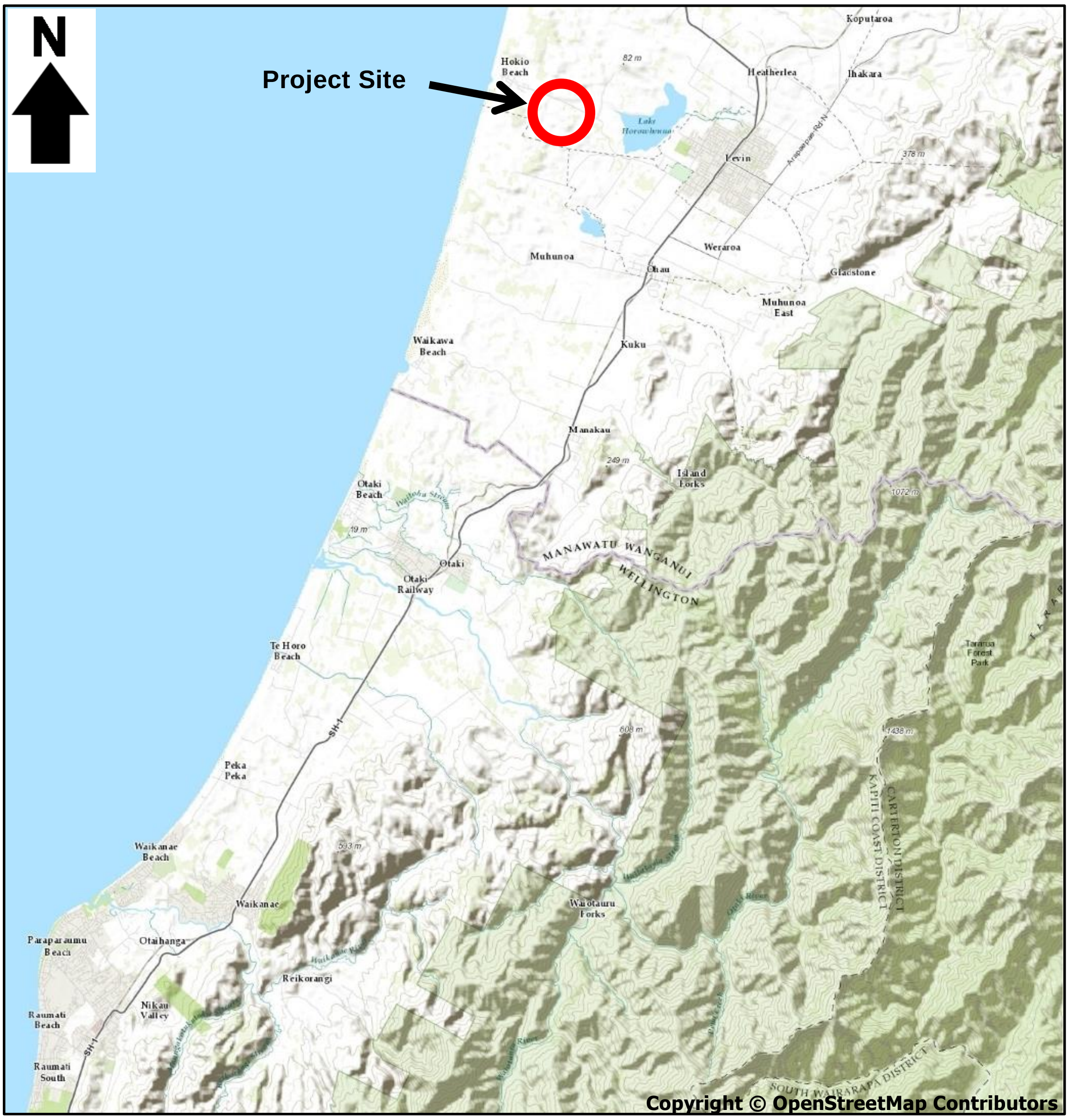

Figure 1-3: Site Location Plan Showing the Terrain in the Vicinity of the Project Site

In light of the above, the project site has the potential to be influenced by katabatic winds (cold air drainage/winds), which generally occur during the winter months and which may limit odour dispersion at the site from time to time. Given the project site's close proximity to the coast (the Tasman Sea is approximately 2.5 km to the west), the site also has the potential to be influenced by coastal sea-breezes in the warmer (summer) months.

1.5 Site History and Existing Activities

The Levin Landfill has operated since the mid-1970s. The site is located within a sequence of coastal sand dune deposits with both shallow (unconfined) and deeper (partially confined) groundwater systems.

The old un-lined landfill was closed in 2004 and a final cap was put in place in 2005. It is understood that the final cap thickness is in the order of 1 m, in accordance with the requirements of the resource consent conditions.

The new lined landfill was opened in 2004. The first stage, 'Stage 1a', is located to the south of the site office. The LFG flare is located to the east of Stage 1a.

Stage 2 was constructed in 2007. Given the lack of locally available clay, the landfill liner is a geocomposite liner consisting of an underlying geosynthetic clay liner (GCL) overlain by a high density polyethylene (HDPE) geomembrane, as required by the resource consent conditions. Stage 2 was closed in 2013 and intermediate cover material consisting of sand and mulch was placed over the surface.

Stage 3 is the current active area (working face) and tipping on this stage has occurred since 2013. Stage 3 will eventually consist of three separate "lifts" ('Stages 3a, 3b and 3c') and to date 'Stages 3a and 3b' have been constructed.

The consent process resulted in three specific conditions being attached to discharge permit 6009 (conditions 32, 33 and 34). HDC, as consent holder, was required to establish a Neighbourhood Liaison Group (NLG) including representatives of the Lake Horowhenua Trustees, the owners and occupiers of specified properties adjoining the landfill, a representative from each of the HDC and HRC, and other parties invited by the consent holder. Under the conditions of the resource consent, the NLG was required to meet once a year. The NLG was formed to address concerns regarding potential environmental effects due to activities undertaken at the project site (e.g. effects to groundwater). The potential effects to groundwater have not been discussed in this report, and are beyond the scope of the present study.

The odour sources at the project site were identified by MWH staff during a site visit on 18 and 19 November 2014. The flare at the site was not in operation for the period between 11 November 2014 (a week prior to the site visit) and 22 December 2014. As the flare was not operating during the site visit, MWH staff were not able to assess the flare as a potential source of odour. The flare itself is a potential source of unburned volatile organic compounds (VOCs), including odour, particularly if it is incorrectly sized and the combustion efficiency is low. MWH recommends that the odour emissions from the flare should be assessed by an experienced field odour investigator (odour scout) at the earliest possible opportunity (see **Section 6**).

In MWH's opinion, based on the assessment contained in this report, the principal odour emission sources are as follows:

- The leachate collection manhole; and,
- Stage 2 – inactive landfill cell with intermediate (temporary) cover (emission "hotspots").

The following locations are also considered to be potentially significant sources of odour at the project site:

- Delivery and handling of waste: high odour emissions at landfills are typically associated with the delivery and handling of refuse at the working (tipping) face, particularly waste with high intensity odours; and,
- The leachate pond (open storage).

The staging of the filling, including the odour emission sources, are shown in **Figure 1–4**.

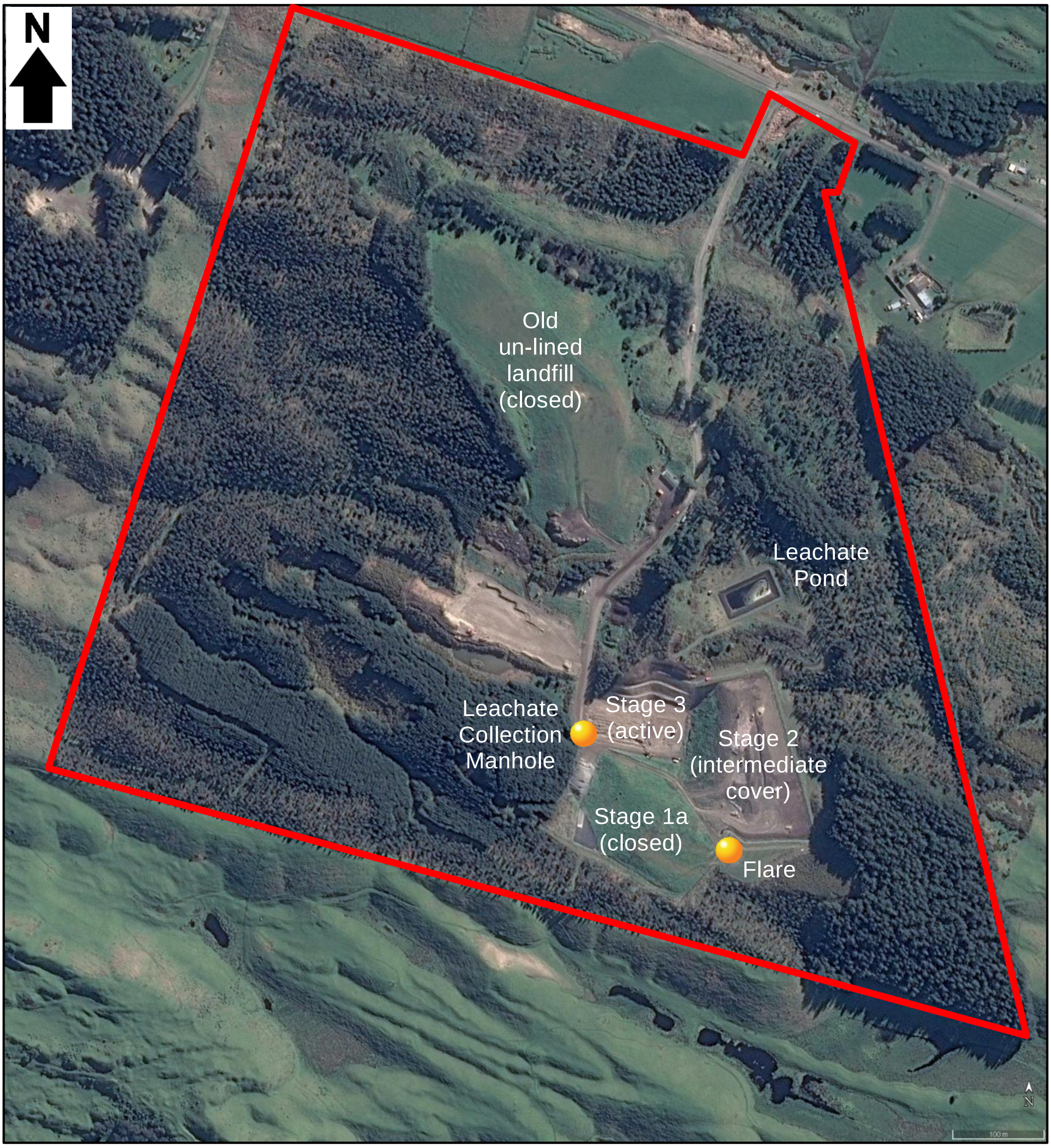

Figure 1-4: Site Layout Plan Showing the Landfill Stages and Odour Sources on the Project Site

1.6 History of Odour Complaints

There is a history of odour complaints at the project site. It is, however, not known whether these complaints have been verified by HRC.

MWH has reviewed the complaints record kept by HDC for the period between 13 February 2014 and 3 September 2014 (202 days in duration), during which there were 69 complaints from Mr and Mrs Grange who live at 645 Hōkio Beach Road, which is the nearest residential property to the project site (approximately 90 m to the north-east of the site boundary). As the complaints record does not make a complete year (i.e. 365 days), analysis of the data is more difficult (particularly as the data is not complete over the warmer months in spring and summer), however, the record does indicate that, on average, a complaint was received by HDC once every 3 days.

The complaints received by HDC regarding odour from the Levin Landfill between 13 February 2014 and 3 September 2014 is shown graphically in **Figure 1–5**. The figure indicates that on 9 separate occasions 2 complaints were made on the same day, whilst 3 complaints were made on the same day on 2 occasions.

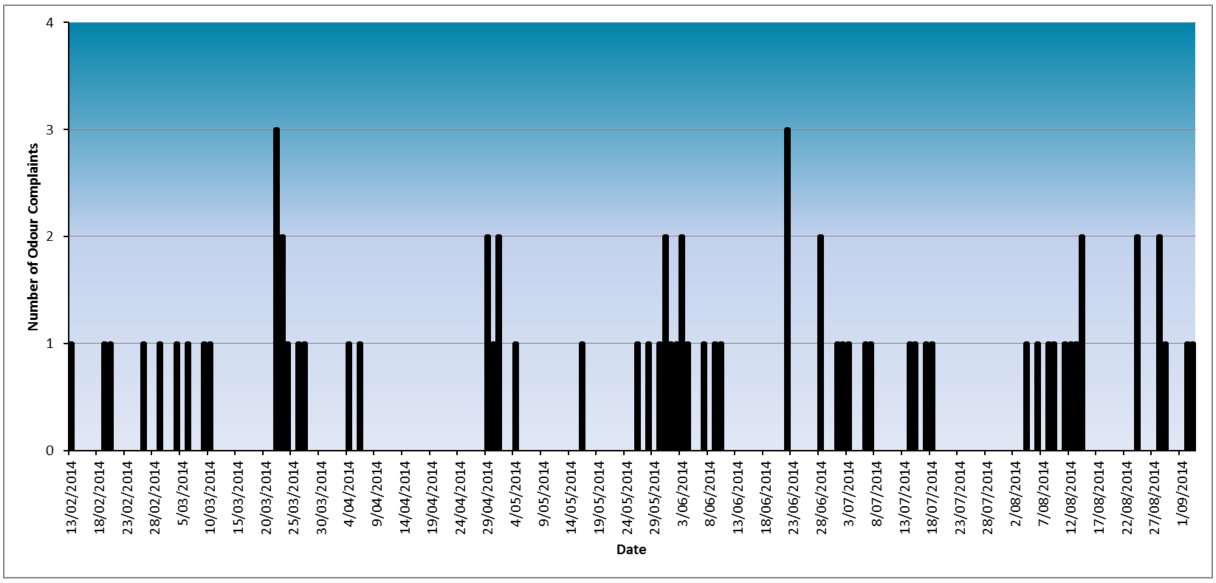

Figure 1-5: Odour Complaints Record Held by HDC for the Project Site

The frequency of odour complaints is therefore considered to be fairly high, particularly given the scale of the landfill and the activities undertaken onsite and, rather interestingly, given the relatively low frequency of winds from the south-west which would carry odour released onsite towards the complainant's property (see **Section 4**). Furthermore, the majority of the complaints indicated that odour was detected between 6:00 am and 8:00 am (46%) and between 4:00 pm and 7:00 pm (37%), however, on some occasions the odour event duration was several hours (e.g. all day or all night).

The complaints record also indicates that it is unlikely that seasonal changes in odour emissions at the site (e.g. warmer atmospheric conditions causing higher bacterial activity in the leachate pond or high intensity odorous waste such as food waste being tipped at the working face) will have a significant difference in terms of the potential to cause odour nuisance beyond the site boundary. Rather, it would appear as though there is a long-term emission source (or sources) which is releasing odour at the site. This report seeks to identify the location of these emission sources and to make recommendations regarding the control of odour at the site.

It is noted that the existing flare at the site was not in operation for the period between 11 November 2014 (a week prior to MWH's site visit) and 22 December 2014. During the site visit, the principal odour emission sources were identified as being the leachate collection manhole and the Stage 2 emission hotspot locations, as discussed above. However, the fact that the flare was not operating seems to have caused an adverse impact on odour in the surrounding community as there were a number of complaints made by Mr and Mrs Grange late in the evening or early in the morning (e.g. 11:30 pm and 5:30 am) during the shut-down period. The landfill operator, Shane Tahuri, EnviroWaste, and Arron Cox, HDC, confirmed that the odour intensity near the flare and Stage 2 had increased during the period that the flare was shut-down. Consequently, the flare was turned back on on 22 December 2014.

1.7 Limitations

MWH has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of HDC. No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to HRC and other persons for an application for permission or approval to fulfil a legal requirement.

This report is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the email from Phil Landmark to Arron Cox (HDC) dated 8 October 2014. The scope of work was accepted by HDC in an email from Thomas Natsa (HDC) to Phil Landmark dated 23 October 2014.

The methodology adopted and sources of information used by MWH are outlined in this report.

This report was prepared between November 2014 and February 2015 and is based on the conditions encountered and information reviewed at the time of preparation. MWH disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.

2 Assessment Criteria for Odour

The assessment contained in this report has considered the matters outlined in the following statutory documents:

- Resource Management Act 1991 (RMA), as amended December 2014;
- Operative One Plan (Chapter 15), dated 19 December 2014;
- Regional Air Plan, dated December 1998;
- Regional Policy Statement, dated July 1998.

2.1 National Assessment Criteria

Section 5(1) sets out the purpose of the RMA, which is "*to promote the sustainable management of natural and physical resources*".

Section 5(2)(c) provides for this to occur while "*avoiding, remedying, or mitigating any adverse effects of activities on the environment*".

Section 2 of the RMA defines *'environment'* and *'amenity values'* as follows:

> *"**Environment***
>
> *includes –*
>
> *(a) ecosystems and their constituent parts, including people and communities; and*
>
> *(b) all natural and physical resources; and*
>
> *(c) amenity values; and*
>
> *(d) the social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) of this definition or which are affected by those matters.*
>
> ***Amenity values***
>
> *those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes."*

Since offensive odours can be considered to cause effects on amenity values, people and communities, they should be managed under the RMA. Since the compounds that cause odour effects are air contaminants, their discharge is therefore controlled under section 15 of the RMA. Under section 15(1) of the RMA, discharges from industrial or trade premises are only allowed if they are authorised by a rule in a regional plan, a resource consent, or regulations. If the activity is prohibited under the plan, then no resource consent can be obtained.

2.2 Regional Assessment Criteria

2.2.1 Operative One Plan

The Horizons One Plan (Chapter 15) was prepared by the HRC and became operative on 19 December 2014. From that date, the earlier Regional Policy Statement and regional plans, and all proposed versions of the One Plan ceased to have legal effect. The One Plan contains a number of regional standards for ambient air quality.

Clause 15.3 states:

> *"**Offensive and objectionable***
>
> *Case law has established that an odour is deemed offensive or objectionable only if a reasonable ordinary person, who is neither sensitive nor insensitive, would be offended or find it objectionable. It is not enough for a neighbour or some other person within the relevant environment to consider the activity or matter to be offensive or objectionable.*
>
> *In determining whether an odour is offensive or objectionable, a council enforcement officer may consider the following:*
>
> - *frequency - how often an individual is exposed to odour,*

- *intensity - the strength of the odour,*
- *duration - the length of a particular odour event,*
- *offensiveness/character - the character relates to the hedonic tone of the odour, which may be pleasant, neutral or unpleasant,*
- *location - the type of land use and nature of human activities in the vicinity of an odour source,*
- *the sensitivity of the receiving environment, including reverse sensitivity,*
- *the Good Practice Guide for Assessing and Managing Odour in New Zealand (Ministry for the Environment, 2003)."*

Activities undertaken on the landfill associated with solid waste disposal are deemed 'discretionary activities' under Rule 15-17(a), thereby requiring resource consent. Discharges to air must not result in offensive or objectionable odour or dust beyond the site boundary or at the boundary of any sensitive area as defined in Policy 15-2(d).

2.2.2 Regional Air Plan

The Regional Air Plan for Manawatu-Wanganui (dated December 1998), or 'Horizons Regional Air Plan' (or 'RAP'), was prepared by the Manawatu-Wanganui Regional Council (HRC) under Section 65 and the First Schedule to the RMA.

Policy 6 of the Horizons Regional Air Plan concerns the management of odour, dust and smoke and states that (with emphasis where odour has been mentioned):

"To avoid, remedy or mitigate adverse effects on amenity values, human health and well-being or property arising from:

*a) the frequency, intensity, duration or offensiveness and location of **odour**; and*

b) the discharge of dust, smoke, or other particulate matter; and

*c) the creation of **odour**, dust and smoke nuisance from land use."*

Several regional rules in the Horizons Regional Air Plan require that effects such as odour are not "objectionable" beyond the property boundary. In particular, Rule 17.1.d is a General Discretionary Activity Rule and states that:

"The storage, transfer, treatment or disposal of waste, including combustion for the recovery of energy, that is not specifically provided for in RAP Rule 12."

Rule 12 states is a Permitted Activity rule concerning discharges to air associated with storage, transfer, treatment and disposal of waste. Whilst Rule 12 does not apply the discharge to air of landfill gas (this is covered by Rule 17 shown above), the rule states:

"There is no objectionable odour or objectionable deposition of dust at or beyond the property boundary or on public land.'

2.2.3 Regional Policy Statement

The Regional Policy Statement for Manawatu-Wanganui (dated July 1998), or 'Horizons Regional Policy Statement' (or 'RPS'), was prepared by the Manawatu-Wanganui Regional Council (HRC) under Section 60 and the First Schedule to the RMA.

Objective 26 of the Horizons Regional Policy Statement makes specific mention of landfills and states (with added emphasis) that:

*"To avoid, remedy or mitigate the adverse effects associated with **landfills**, industrial waste disposal and contaminated sites."*

2.3 Resource Consent Conditions

Resource consent (discharge permit) number 6011 (see **Appendix A**) was granted by HRC in 2002 and amended in 2010, and authorises the discharge to air of contaminants (including landfill gas, odour and dust) associated with the landfill activities undertaken at the Levin Landfill. There are a total of seven conditions specified in the resource consent.

Condition number 2 of the resource consent states:

"The Permit Holder will ensure dust is controlled on access roads and on the landfill, if necessary, by watering or other methods."

Condition number 3 of the resource consent states:

"There shall be no discharge of odour or dust from the landfill that in the opinion of a Regional Council Enforcement Officer is noxious, dangerous, offensive, or objectionable beyond the property boundary. The Permit Holder will also ensure that:

a) On-site and off-site Health and Safety Effects of landfill gas being emitted by the old landfill should be quantified by sampling groundwater monitoring wells for evidence of landfill gas when groundwater samples are taken from the wells. As a minimum, the gases tested for are to include methane, carbon dioxide and oxygen; and

b) Any building constructed on the landfill site is adequately ventilated."

Condition number 5 of the resource consent states:

"The Permit Holder shall take all practicable steps to avoid, remedy or mitigate significant adverse effects of the discharge of landfill gases to air."

Condition number 4 prohibits the open burning of waste or other material on the landfill, and condition number 6 requires HDC (the 'Permit Holder') to keep a record of any complaints received.

3 Assessment Methodology

3.1 Sensitive Receptors

In the context of this odour assessment, the term 'sensitive receptor' includes any persons, locations or systems that may be susceptible to changes in abiotic factors as a consequence of the discharges to air (namely odour) from the project site. Typical locations for sensitive receptors include:

- Residential properties;
- Retirement villages;
- Hospitals or medical centres;
- Schools;
- Marae;
- Libraries; and,
- Public outdoor locations (e.g. parks, reserves, sports fields, beaches).

A desk-study was undertaken to identify discrete receptors deemed sensitive to changes in the baseline odour conditions as a result of discharges to air from the project site. The search was undertaken for a radius of 1,000 m from the project site boundary.

The nearest potentially affected sensitive receptors are all residential properties and are situated to the north-east, east and north-west of the site and are summarised in **Table 3–1**.

Table 3-1: Sensitive Receptor Locations

Ref.	Type	Address	UTM Zone 60 South		Direction from Boundary	Elevation (m)
			Easting (m)	Northing (m)		
R1	Residential	645 Hōkio Beach Road	349048	5503585	North-East	15.6
R2	Residential	621 Hōkio Beach Road	349221	5503533	North-East	12.1
R3	Residential	619 Hōkio Beach Road	349295	5503564	North-East	12.6
R4	Residential	583 Hōkio Beach Road	349585	5503407	North-East	13.4
R5	Residential	575 Hōkio Beach Road	349573	5503257	East	12.7
R6	Residential	582 Hōkio Beach Road	349657	5503486	North-East	14.0
R7	Residential	578 Hōkio Beach Road	349661	5504034	North-East	15.1
R8	Residential	588 Hōkio Beach Road	349603	5503538	North-East	13.9
R9	Residential	602 Hōkio Beach Road	349482	5503572	North-East	13.1
R10	Residential	628 Hōkio Beach Road	349320	5503697	North-East	13.2
R11	Residential	630 Hōkio Beach Road	349219	5503681	North-East	11.7
R12	Residential	616 Hōkio Beach Road	349338	5503626	North-East	12.5
R13	Residential	737 Hōkio Beach Road	348190	5503973	North-West	18.7
R14	Residential	747 Hōkio Beach Road	348138	5504055	North-West	16.8
R15	Residential	765 Hōkio Beach Road	347995	5504099	North-West	13.4
R16	Residential	767 Hōkio Beach Road	347940	5504123	North-West	15.8

The nearest receptor to the project site is a residential property (receptor 'R1'), which is approximately 90 m to the north-east of the site boundary and is owned by Mr and Mrs Grange (see **Section 1.6**).

Figure 3–1 shows the location of the potentially affected sensitive receptors identified in this assessment.

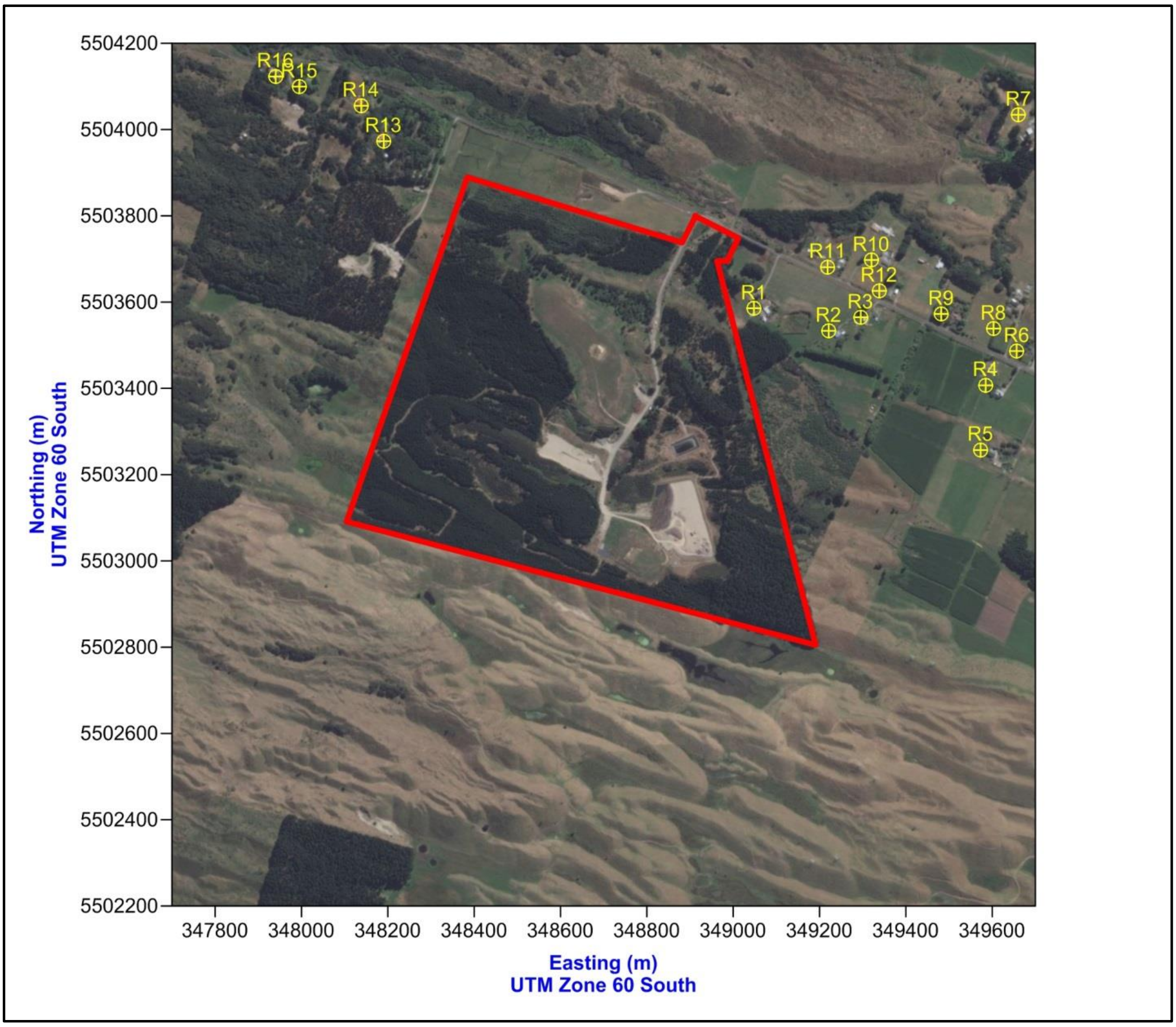

Figure 3-1: Sensitive Receptor Locations

3.2 Odour and its Potential to Cause Nuisance

3.2.1 Odour Nuisance Effects

Odour is defined in MfE (2003) as:

> *"Odour is perceived by our brains in response to chemicals present in the air we breathe. Odour is the effect that those chemicals have upon us. Humans have sensitive senses of smell and they can detect odour even when chemicals are present in very low concentrations.*
>
> *Most odours are a mixture of many chemicals that interact to produce what we detect as an odour. Fresh air is usually perceived as being air that contains no chemicals or contaminants that could cause harm, or air that smells "clean". Fresh air may contain some odour, but these odours will usually be pleasant in character or below the human detection limit.*
>
> *Different life experiences and natural variation in the population can result in different sensations and emotional responses by individuals to the same odorous compounds. Because the response to odour is synthesised in our brains, other senses such as sight and taste, and even our upbringing, can influence our perception of odour and whether we find it acceptable, objectionable or offensive."*

The difficulty when assessing odours is the fact that the same odour has the potential to cause an effect that may be considered "acceptable", "objectionable" or "offensive" depending on the context, the sensitivity of the receiving environment and the person carrying out the assessment. An "objectionable" or "offensive" effect may occur where an odorous compound is present in a sample of air in very low concentrations, usually far less than the concentration that could cause adverse effects on the physical health of humans or impacts on any other part of the environment.

Typical odour effects reported by people include the following: nausea; headaches; retching; difficulty breathing; frustration; annoyance; depression, stress; tearfulness; reduced appetite; sleep deprivation; and embarrassment in front of visitors. Odour effects, such as those described above, contribute to a reduced quality of life for the individuals who are exposed to the odour.

Olfactometry is the technique used to measure the concentration of an odour, by taking samples of odorous air and evaluating the number of dilutions at which the sample has a probability of 0.5 of being detected under the conditions of the test. Odour concentration is measured in terms of odour units (OU) per cubic metre of air (OU/m^3). 1 OU/m^3 is the concentration of odour-containing air that can just be detected by 50% of members of an odour panel (persons chosen as representative of the average population sensitivity to odour). This process is defined within Australian/New Zealand Standard AS/NZS 4323.3 (2001) Stationary Source Emissions – Part 3: Determination of Odour Concentration by Dynamic Olfactometry.

An odour emission rate (OER) is the product of the odour concentration (OU/m^3) and the volumetric flow rate (m^3/s or m^3/min), and is often annotated as $OU.m^3/s$, or $OU.m^3/min$. Alternatively, an odour emission rate can be thought of as the volume of clean air that would be required to dilute the concentration of odorous gas emitted per unit time down to 1 OU/m^3.

Therefore, the difference between the terms 'odour concentration' and 'odour intensity' can be thought of as, in the case of the former, a measure of the detectability of an odour as assessed by an independent panel of people, whilst the latter refers to the perceived magnitude of a stimulus and increases as a function of concentration.

3.2.2 Potential Odour Nuisance Effects

Under the RMA, the main concern with odour is its ability to cause an effect that could be considered "objectionable" or "offensive" beyond the boundary of the project site. Whether an odour has an objectionable or offensive effect will depend on the factors described below and the decision as to whether an odour nuisance has occurred will depend on the judgement of the local authority who will investigate the potential for nuisance in response to complaints from the public.

The odour assessment contained in this report has been carried out regarding the potential for the activities and processes at the project site to cause odour effects at sensitive receptors (e.g. residential properties) located in close proximity to the site boundary.

The sensory perception of odour has four major dimensions: detectability, intensity, character, and hedonic tone. These are explained in greater detail below:

- ***Odour detectability***: this is otherwise known as the odour threshold. It is the concentration of a compound necessary for detection by 50% of the population.
- ***Odour intensity***: this refers to the perceived strength of the odour sensation. Generally, intensity increases exponentially with the concentration of the compound. As the relationship between odour intensity and concentration is logarithmic, an increase or decrease in concentration will not always produce a corresponding proportional change in odour strength as perceived by the human nose. For example, increasing the concentration of an odorous compound or mixture by a factor of 10 may only increase its perceived intensity by a factor of 2. Conversely, an odour control plant or facility may only need to reduce odour concentrations at sensitive receptors by 90% in order to halve the intensity of odours they perceive.
- ***Odour character***: this is what the substance smells like. A standard list of descriptors is commonly used, which includes "fishy, hay, nutty, creosote, turpentine, rancid, sewer, and ammonia".
- ***Hedonic tone***: this is the judgement of the relative pleasantness or unpleasantness of the odour. It is this aspect that primarily dictates whether an odour nuisance occurs. A person's perception of odour may vary significantly from individual to individual. For example, some individuals may consider some odours as pleasant, such as petrol, paint and creosote.

A summary of hedonic scores (or Dravnieks) is contained in the UK Environment Agency's Technical Guidance Note IPPC: H4 (EA, 2002), which are based on laboratory experiments. A selection of these hedonic scores is shown in **Table 3–2**, where 'cork' is about neutral. It should be noted that the higher the positive score, the "more pleasant" the odour descriptor, whereas the higher the negative score, the "more unpleasant" the odour descriptor.

Based on MWH's experience, the hedonic scores that are closest to the potential odour sources on the project site are shown in **Table 3–2** as bold text. The table indicates that the release of odour on the site has the potential to be relatively unpleasant (negative hedonic scores).

Table 3-2: Hedonic Scores and Odour Descriptions

Description	Hedonic Score*	Description	Hedonic Score*
Cadaverous (dead animal)	-3.75	Bakery	+3.53
Putrid, foul, decayed	**-3.74**	Rose	+3.08
Sewer odour	-3.68	Strawberry	+2.93
Sickening (vomit)	-3.34	Orange	+2.86
Fermented (rotten) fruit	**-2.76**	Chocolate	+2.78
Ammonia	-2.47	Meaty (cooked, good)	+2.34
Fishy	**-1.98**	Banana	+2.00
Musty, earthy, mouldy	**-1.94**	Clove	+1.67
Sour, vinegar	-1.26	Anise (liquorice)	+1.21
Paint	-0.75	Soapy	+0.96
Cork	+0.19		

Complaints are likely to occur when odours become detectable and recognisable. However, there are many situations when the release of a potentially odorous compound does not result in an odour nuisance effect. It is the subjective judgement of an odour's hedonic tone that enables the decision to be made as to whether it is a nuisance or not.

The factors that contribute to an odour nuisance effect include the frequency (F) of odour impact, the intensity (I), the duration of exposure (D), the offensiveness (O) and the location (L), which is consistent with the Horizons Regional Air Plan and MfE (2003).

The FIDOL factors are explained in greater detail below:

- ***Frequency***: relates to how often an individual is exposed to odour. Factors determining this include the frequency that the source releases odour (including its source type, characteristics and the rate of emission of the compound or compounds); prevailing meteorological conditions; and topography.
- ***Intensity***: is the perceived strength of the odour or the odour detection capacity of individuals to the various compound(s) on a scale of 1 to 6 (1 = 'very weak'; 6 = 'extremely strong'). An increase in intensity of odour will increase the potential for odour complaints. Odour concentrations, where applicable, are measured in odour units (OU or OU/m^3).
- ***Duration***: is the amount of time that an individual is exposed to odour. Combined with frequency, this indicates the exposure to odour. The duration of an odour, like its frequency, is related to the source type and discharge characteristics, meteorology and location. The longer the odour detection persists in an individual location, the greater the level of complaints that may be expected, particularly if the odours are unpleasant or obnoxious.
- ***Offensiveness***: is a subjective rating of an odour's pleasantness and relates closely to hedonic tone. Offensiveness is related to the sensitivity of the 'receptors' to the odour emission (i.e. whether the odorous compound is more likely to cause nuisance, such as the sick or elderly, who may be more sensitive).
- ***Location***: is the type of land use and the nature of human activities in the vicinity of an odour source. The same process in a different location may produce more or less odour depending on local topography and meteorological conditions. It is also important to note that in some locations certain odours may be more acceptable than in others (e.g. the expectation that rural smells will occur as part of the rural environment and industrial smells will occur in industrial areas).

Most regulators in New Zealand require that odour assessments should consider whether the odour discharge is of low-intensity odour occurring frequently over a long period, or high-intensity odour occurring infrequently, or both (MfE, 2003). In fact, the FIDOL principle demonstrates that there are several factors that may be 'influenced' in order to mitigate odour impacts at a particular site. Employing one or more methods to influence these factors, where appropriate, may significantly decrease the likelihood of causing a serious odour event.

3.2.3 Sensitivity of the Receiving Environment and Land Use

As the sensitivity of the receiving environment must be taken into account under the RMA, it must be considered in an odour assessment. The degree of sensitivity in a particular location is based on characteristics of the land use, including the time of day and the reason why people are at the particular location (e.g. for work or recreation). Different locations have different sensitivities to odour and can be classified as having 'high', 'medium' or 'low' sensitivity.

The sensitivity that can be assigned to a range of different land uses is described in **Table 3–3** for 'residential', 'rural residential', 'rural' land uses, which has been summarised from MfE (2003).

The 'rural residential' and 'rural' land uses shown in **Table 3–3** is appropriate for the residential properties located within 1,000 m to the north-east and north-west of the project site and referred to in this assessment as sensitive receptors 'R1' to 'R16' (see **Section 3.1**). In other words, these sensitive receptors represent locations where people of *high* sensitivity to odours have the potential to be exposed to any odours released on the landfill site.

Table 3-3: Odour Sensitivity in Areas of Low Population Density

Land Use Type	Sensitivity Classification			Comments and Reasons for Classification
	High	Medium	Low	
Residential / living (high-density residential)	✓			People of high sensitivity to odours can be exposed.
Rural residential (low-density residential, minimum property size around 1 ha)	✓		✓	People can be present at all times of day and night, both indoors and outdoors.
Rural	✓		✓	Visitors to the area who are unfamiliar with an odour are likely to raise awareness of a problem.
Public roads			✓	In cases of mixed land uses, where the residences are present with industry, the use may be judged to have the same sensitivity as residential depending on the circumstances.

3.2.4 Classification of Potential Odour Nuisance Effects

Objectionable and offensive effects from odour can occur from low-intensity, moderately unpleasant odours occurring frequently over a long period, or from high-intensity, highly unpleasant odours occurring infrequently. These effects relate to different combinations of the FIDOL factors and can be termed 'chronic' and 'acute' effects, respectively. Chronic effects are low-intensity odours occurring frequently over a long period, while acute effects are high-intensity odours occurring infrequently. It is useful to know what type of effect predominates, although odour effects will often result from a combination of acute and chronic odours. Chronic and acute effects are encompassed in the definition of 'effect' under the RMA, which refers to temporary, permanent and cumulative effects.

The potential for odour nuisance effects will also depend on the management practices and odour control methods employed at the landfill site (see **Section 6** and the Odour Management Plan in **Appendix E**).

3.3 Landfill Surface Emissions Monitoring

A surface emissions monitoring walkover survey was undertaken at the project site in November 2014 by an experienced air quality consultant using a portable methane monitor. Whilst methane itself is odourless, methane was used in this study as an indicator determinant (or surrogate) of odorous LFG, or to determine potential peak emission (hotspot) locations, such as areas where the final capping layer has been compromised (e.g. cracking has occurred), or where the intermediate cover is ineffective.

3.4 Field Odour Investigation

A subjective field odour investigation (or sniff test) was carried out at the project site in November 2014 by an experienced odour assessor using the above FIDOL factors to determine an odour impact rating for several different locations across the site and beyond the site boundary. The investigations were carried out in accordance with the guidance contained in MfE (2003) to determine the significance of off-site odour from the landfill site.

The MWH odour assessor was recently ‘calibrated’ by Watercare Laboratory Services and was of ‘normal’ sensitivity to odour (i.e. representative of the normal range of the population).

3.5 Odour Emissions Monitoring

AirQuality Limited was engaged by MWH to collect 19 odour samples (including 1 blank) at the Levin Landfill on the 18 and 19 November 2014. AirQuality's odour monitoring report dated 30 November 2014 is contained in **Appendix B**.

All sampling was undertaken using a flux chamber in accordance with *AS/NZS 4323.3:2001 Stationary Source Emissions: Part 3 Determination of Odour Concentration by Dynamic Olfactometry*.

Odour samples were collected at the following locations:

- **Monitoring Location A** Leachate Pond;
- **Monitoring Location B** Leachate Collection Manhole Cover;
- **Monitoring Location C** Stage 2 Landfill Surface (open pipe, such as an uncapped gas collection wellhead, near eastern boundary of Stage 2);
- **Monitoring Location D** Working Face (4 separate 'roaming' locations);
- **Monitoring Location E** Stage 2 Landfill Surface (2 m west of **Monitoring Location C** near eastern boundary of Stage 2);
- **Monitoring Location F** Stage 2 Landfill Surface (hose pipe protruding from landfill surface near southern boundary of Stage 2).

Triplicate samples were collected at each location except for Monitoring Location C (where 2 samples were taken) and Monitoring Location D (where 4 samples were taken from 4 separate sites at the working face). Photos of the odour monitoring locations are contained in **Appendix C**.

The 19 odour samples were sent to EML Air Pty Limited (part of Ektimo Pty Limited) in Melbourne, Australia. Ektimo (EML Air) is accredited by the National Association of Testing Authorities (NATA) for the analysis of air pollutants (including odour) from industrial sources (accreditation number 2732).

3.6 Dispersion Modelling Assessment for Odour

3.6.1 Meteorological Modelling

3.6.1.1 TAPM

TAPM (The Air Pollution Model) is a prognostic model which may be used to predict three-dimensional meteorological data, with no local data inputs required. TAPM Version 4.0.5 was used in the present study and was developed in Australia by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The TAPM modelling domain was centred on the project site at latitude 40°36.5' S, longitude 175°13.0' E (or UTM 349131 m E, 5503192 m N zone 60 south). Wind speed and wind direction observations at the nearest automated weather stations to the project site, which are located in Levin, Palmerston North and at Paraparaumu Airport (see **Section 4.1**), for the year 2012 were used in TAPM to nudge the predicted solution towards the observations. This process is called 'data assimilation' and requires the development of an observation (*.obs) file for input into TAPM. The parameters used in the TAPM meteorological modelling are summarised in **Table 3–4**.

Modelling of complex physical systems is based on the use of numerical techniques to solve a set of governing equations. In general, the more complicated the system that is modelled, the more parameterisations (or approximations) that are required in order to solve these equations; particularly in relation to the representation of sub-grid scale processes. Thus, there are inherently a number of 'tuneable' parameters that are required as input into the models. Model developers often suggest default values for these parameters which may be based on observational data, laboratory experiments or professional experience. Depending on the scale of the project, assessing the sensitivity of model results to input data and/or the value of tuneable parameters can be prohibitive, either in terms of computational requirements, timeframes for completion of the assessment, and/or budget constraints.

A challenge facing the meteorology modeller is the uncertainty in relation to the preciseness and representativeness of input data combined with limited observational data which are key factors contributing to the lack of comprehensive model validation studies for the majority of assessments.

The limitations of the TAPM model are as follows:

- TAPM is suitable for horizontal domain sizes below approximately 1,500 km by 1,500 km. It should not generally be used for larger domains because of the neglect in the model of the curvature of the earth; and,
- TAPM cannot be used to accurately represent deep atmospheric circulations or extreme weather events, due to the above reasons, the assumption of incompressibility in the model, and the fact that non-hydrostatic effects are not represented above 5,000 m. The winds, temperature and humidity are increasingly smoothed from this level up to the model top at 8,000 m, in order to minimise reflections of waves from the model top back into the lower part of the model.

Table 3-4: Meteorological Parameters used in TAPM for this Study

TAPM Version 4.0.5	
Number of grids (spacing: outermost to innermost)	5 (30 km, 10 km, 3 km, 1 km, 0.3 km)
Number of grid points (x, y, z)	25 x 25 x 20
Year(s) of analysis	2012 (1 January to 31 December)
Centre of grid	Project Site – 40º36.5' S, 175º13.0' E (x = 13, y = 13) or – UTM 349131 m E, 5503192 m N
Meteorological data assimilation	Data assimilation using data from: – Levin AWS (Agent No. 03275) – Paraparaumu Aero AWS (Agent No. 08567) – Palmerston North EWS (Agent No. 21963)
Grid receptor location(s) used to generate CALMET surface meteorological data file (SURF.DAT)	Data were extracted from: – Project Site UTM 349131 m E, 5503192 m N (Grid #5: x = 13, y = 13) – Levin AWS UTM 352431 m E, 5501692 m N (Grid #5: x = 24, y = 8) – Paraparaumu Aero AWS UTM 331131 m E, 5470192 m N (Grid #3: x = 7, y = 2)
Grid receptor location(s) used to generate CALMET upper air meteorological data file (UP.DAT)	Data were extracted from: – Project Site UTM 349131 m E, 5503192 m N (Grid #5: x = 13, y = 13)

3.6.1.2 CALMET

CALMET (Version 6.4.0, Level 121203) was used in this study. CALMET is a meteorological model which includes a diagnostic wind field generator containing objective analysis and parameterised treatments of slope flows, kinematic terrain effects, terrain blocking effects, and a divergence minimisation procedure, and a micro-meteorological model for overland and overwater boundary layers. CALMET forms part of the CALPUFF dispersion modelling suite (see the following section).

Hourly surface meteorological data were extracted from TAPM for the closest grid receptors to the Paraparaumu Airport and Levin automatic weather stations (surface stations 'S1' and 'S2', respectively) for comparison against the observation data, and also for the project site (surface station 'S3'). The

TAPM-generated meteorological data for the project site was assigned the code '54321' for identification purposes. SMERGE Version 5.7.0 Level 121203 was used to produce the CALMET-formatted surface meteorological data input file. A CALMET-formatted upper air meteorological data input file for the project site (S3) was developed and used as input into CALMET (see below for further details).

The CALMET modelling domain was centred at UTM 347500 m E, 5486000 m N (zone 60 south). A 40 km by 40 km Cartesian grid was used at a resolution of 200 m, and included the three surface meteorological stations and one upper air station.

The location of the meteorological stations S1 to S3 are shown by the symbol '⊛' in **Figure 3–2**, which was produced using OpenStreetMap and Golden Software's Surfer® 12 (Version 12.5.905). The figure also shows the extent of the CALMET modelling grid and the terrain contour data (in metres) input into the model.

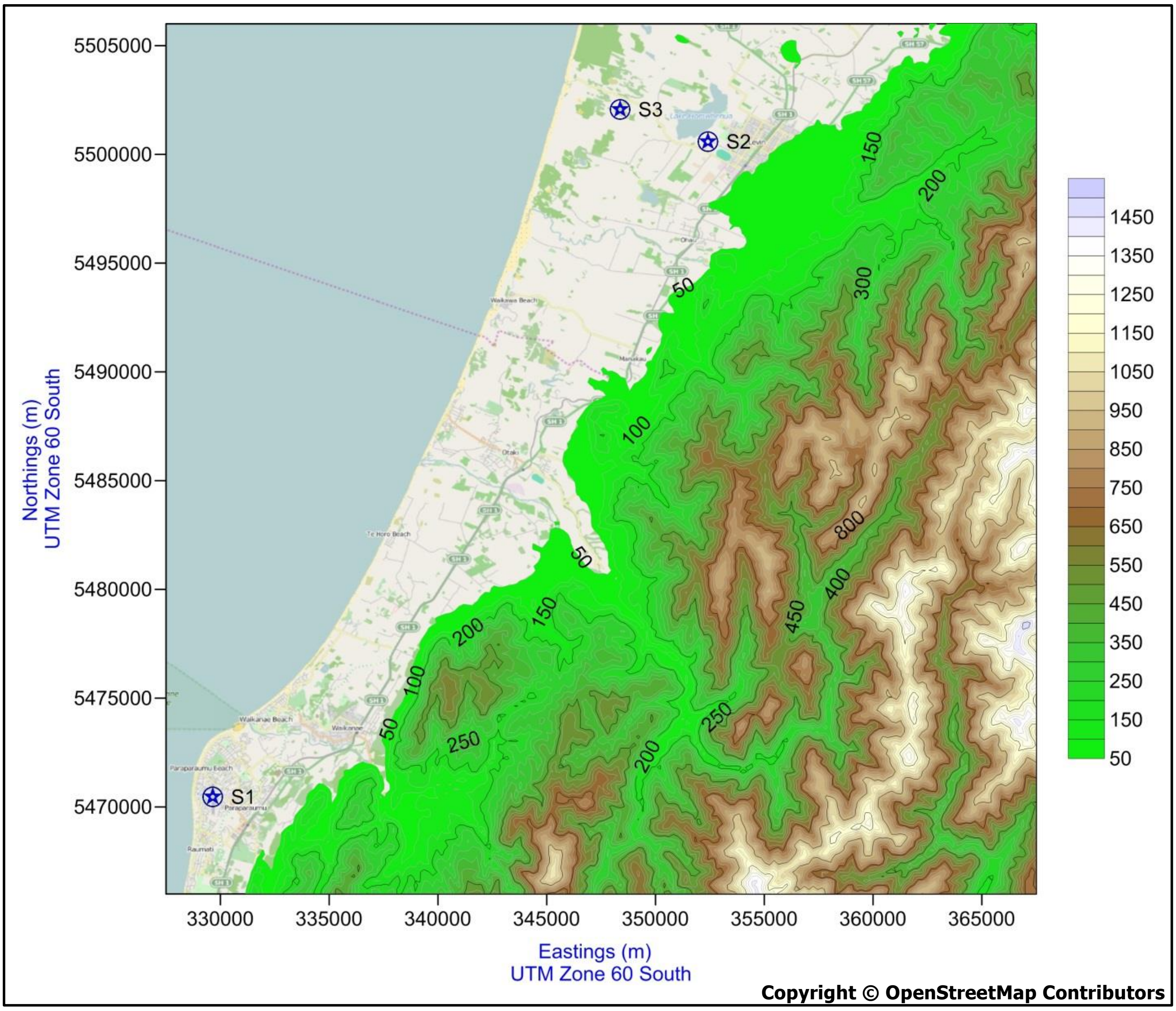

Figure 3-2: Map Showing the Location of the Surface Meteorological Stations and Terrain

Figure 3–2 clearly shows the complex terrain to the south-east of the project site, which has the potential to influence the wind field across the modelling domain.

Geophysical (terrain and land use) data were input into the CALMET model at a resolution of 200 m. The land use data input into the model were based on the United Stated Geological Survey (USGS) land use and land cover classification scheme, as follows:

- Category 10 Urban or Built-up Land (e.g. residential areas, State Highways and mixed urban);
- Category 30 Rangeland (e.g. herbaceous rangeland);
- Category 40 Forest Land (e.g. evergreen forests);
- Category 52 Lakes (e.g. Lake Horowhenua);
- Category 54 Bays and Estuaries;
- Category 55 Ocean (e.g. Tasman Sea); and,
- Category 70 Barren Land (e.g. beaches).

Figure 3–3 shows the land use data input into CALMET.

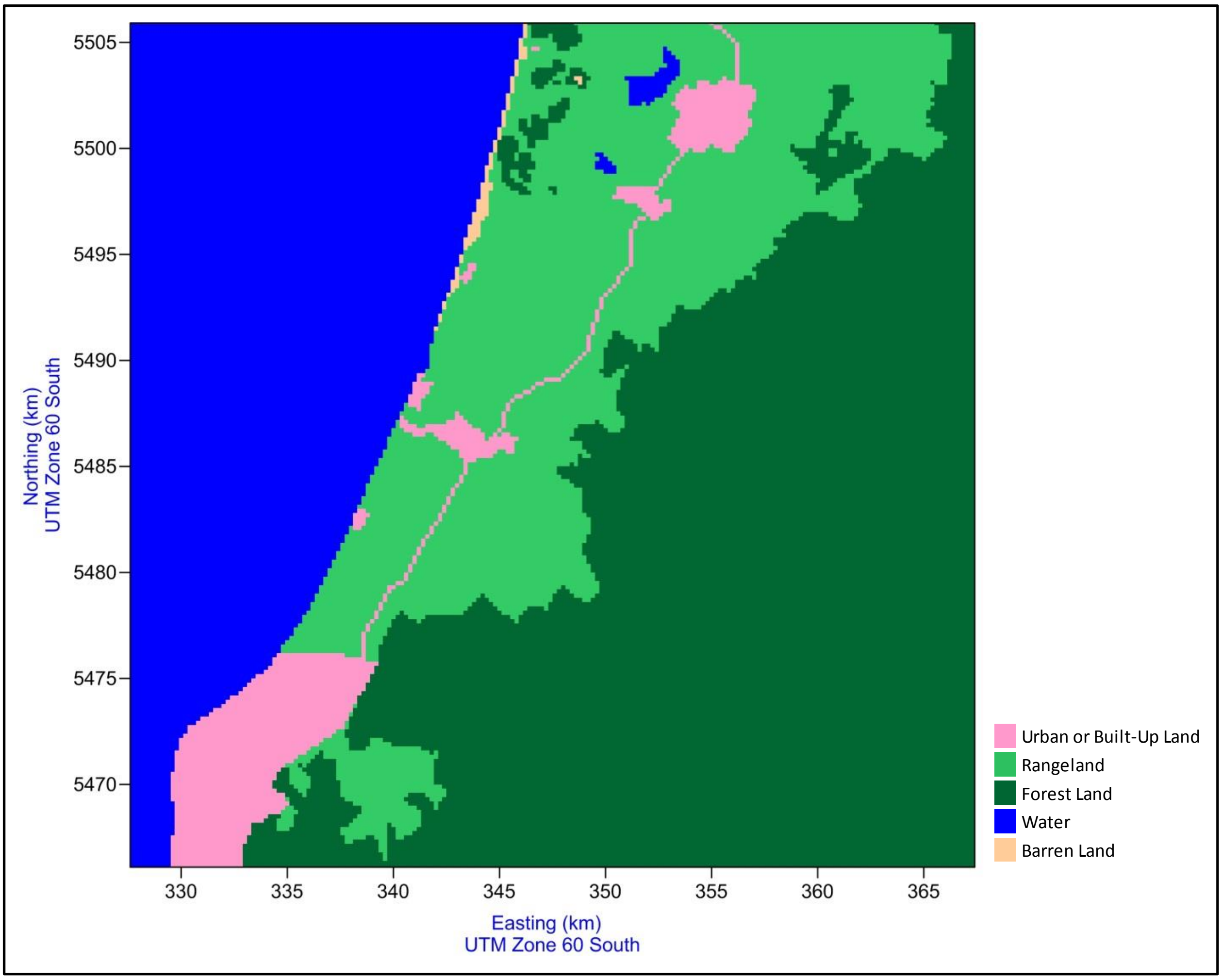

Figure 3-3: Land Use Data Input into CALMET

The surface elevation (terrain) data were taken from Lakes Environmental Software's website (www.webGIS.com), which was based on the Shuttle Radar Topography Mission (SRTM-3) digital elevation model (90 m resolution) data (Version 2) originally produced by NASA. **Figure 3–4** shows the terrain data (in metres) input into CALMET.

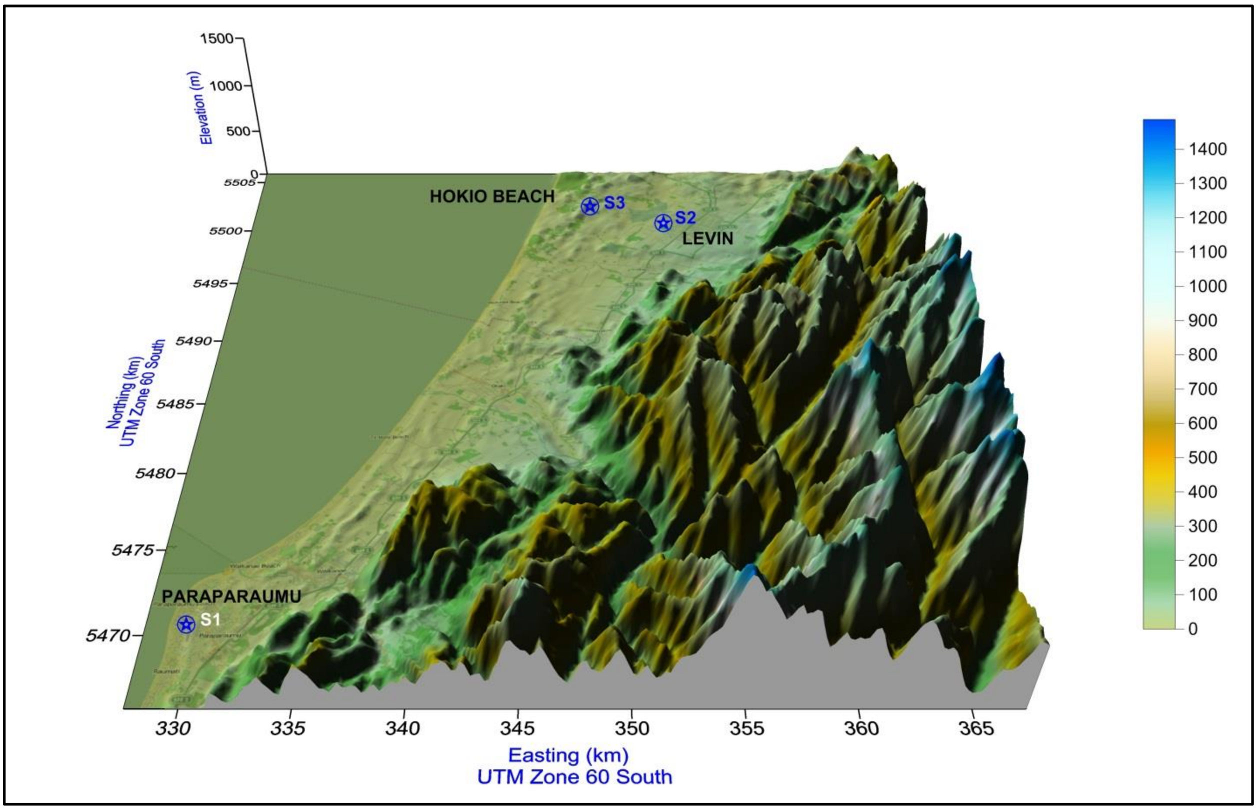

Figure 3-4: Terrain Data Input into CALMET

The project site is situated on relatively flat terrain, with significant terrain features situated to the south-east (Tararua Forest Park). The average elevation change within the CALMET domain to the south-east of the Levin Landfill site boundary is approximately 14% over a ground distance of 25.3 km. Further analysis indicates, however, that the terrain south-east of the site up to a distance of 12 km is fairly flat (less than 10%), but at a distance of 12 km south-east of the site boundary and across a ground distance of 13.3 km, the average elevation change is 27%. Therefore, the terrain to the south-east of the project site has the potential to impact the dispersion of odour plumes from emission sources located on the project site under certain meteorological conditions.

The parameters used in the CALMET meteorological modelling are summarised in **Table 3–5**.

The total runtime (duration) of the CALMET model run was 91.5 hours (almost 4 days) between 5 December 2014 and 9 December 2014. A total of 8,784 hours were included in the CALMET model run.

Table 3-5: Meteorological Parameters used in CALMET for this Study

CALMET Version 6.4.0 (Level 121203)	
Meteorological grid size	40 km x 40 km
Meteorological grid coordinates	Lower left corner: UTM 327500 m E, 5466000 m N (zone 60 south) Top right corner: UTM 367500 m E, 5506000 m N (zone 60 south)
Meteorological grid resolution	200 m
Number of grid points (x, y, z)	200 x 200 x 9
Year(s) of analysis	2012 (1 January to 31 December)
Centre of grid	Approximately 3 km east of Otaki UTM 347500 m E, 5486000 m N (zone 60 south)
TAPM-generated meteorological data	Surface Data: – S1 – Paraparaumu Aero AWS (No. 08567) – S2 – Levin AWS (No. 03275) – S3 – Project Site (No. 54321) Upper Air Data: – Project Site (No. 54321)
Terrain Data	Lakes Environmental Software's SRTM-3 digital elevation model (90 m resolution)
Land Use Data	Data were developed based on USGS land use and land cover classification scheme

3.6.2 Dispersion Modelling

The atmospheric dispersion modelling assessment was conducted through the use of CALPUFF, which is a US EPA approved atmospheric dispersion model. CALPUFF has been used extensively in New Zealand and Australia and is a recommended model in MfE (2004), particularly for sites surrounded by complex terrain and where sea-breeze conditions are likely to occur.

CALPUFF is a non-steady state Lagrangian Gaussian puff model containing modules for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation. In other words, the model can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and removal.

CALPUFF (Version 6.42, Level 110325) was used in the present study. The model was set up in accordance with the guidance contained in MfE (2004). Ground-level odour concentrations were predicted over a regular Cartesian receptor grid covering a 2 km by 2 km computational domain (in the X and Y directions). The CALPUFF grid was centred on the project site at UTM 348700 m E, 5503200 m N (zone 60 south), which was approximately 17 km to the north of the centre of the CALMET grid, and the grid resolution was 50 m.

3.6.2.1 Modelling Scenarios

The aim of the dispersion modelling assessment in this study was not to confirm or deny the odour complaints history (refer **Section 1**). Rather, its purpose was to assess the potential benefits associated with undertaking a number of mitigation options (assessed as four modelling scenarios).

The following dispersion modelling scenarios were assessed:

- Scenario 1 Baseline emissions (as measured in November 2014);
- Scenario 2 Baseline emissions except with a proposed biofilter to control odour from the leachate collection manhole;
- Scenario 3 Baseline emissions except with the implementation of effective capping across Stage 2 (e.g. clay layer) to eliminate/reduce the fugitive odour emissions on Stage 2;
- Scenario 4 A combination of Scenarios 2 and 3 (i.e. baseline emissions, but with a proposed biofilter at the leachate collection manhole and effective capping on Stage 2).

The CALPUFF model runtimes for each scenario were as follows:

- Scenario 1 27.6 hours (21/01/2015 to 22/01/2015);
- Scenario 2 30.1 hours (21/01/2015 to 22/01/2015);
- Scenario 3 27.6 hours (21/01/2015 to 22/01/2015); and,
- Scenario 4 30.1 hours (21/01/2015 to 22/01/2015).

3.6.2.2 Odour Emission Sources

The odour emission rates input into the model for Scenarios 1 to 4 are shown in **Table 3–6** to **Table 3–9**, respectively. All sources were input as four-sided polygonal areas (quadrilaterals) and the emission rates were assumed to be constant (i.e. 24 hours a day, 7 days a week).

The odour emission rates for Scenario 1 (existing conditions) shown in **Table 3–6** for the leachate pond, leachate collection manhole, the Stage 3 working face and the Stage 2 emission hotspots are based on the highest odour emission rates measured at each location by AirQuality using a flux chamber and via dynamic dilution olfactometry (DDO) in November 2014 (see **Section 5.3**). The emission rates for the covered areas on Stages 2 and 3 were assumed to be half of the lowest emission rate measured at the Stage 3 working face. The Stage 2 emission hotspots were determined from the landfill surface emission monitoring. Refer to **Section 5** for further details regarding the odour emissions monitoring.

Table 3-6: Emission Parameters for Sources Input into the Model for Scenario 1

Source Ref.	Source Name	Odour Emission Rate ($OU/s/m^2$)	Release Height (m)	Initial Sigma *z* (m)	Source Area (m^2)
SRC_1	Leachate Pond	0.110	0.5	1.0	880
SRC_2	Leachate Collection Manhole	23.75	0.5	1.0	4
SRC_3	Stage 3 – Working Face	1.500	0.5	1.0	81
SRC_4	Stage 3 – Covered Area	0.075	0.2	1.0	3,600
SRC_5	Stage 2 – Hotspot #1	5.830	0.5	1.0	4
SRC_6	Stage 2 – Hotspot #2	1.130	0.5	1.0	4
SRC_7	Stage 2 – Hotspot #3	1.790	0.5	1.0	4
SRC_8	Stage 2 – Covered Area	0.075	0.2	1.0	13,600

The table indicates that the highest odour emission rates were measured at the leachate collection manhole, however, due to its relatively small surface area, this source's contribution is relatively low compared with the other sources, particularly the Stage 2 and Stage 3 covered areas (SRC_8 and SRC_4, respectively).

The emission rates for Scenario 2 shown in **Table 3–7** for the proposed leachate collection manhole biofilter assumed that the odour emissions from the leachate collection manhole (source SRC_2) will reduce by 90% following the implementation of the biofilter, whilst the biofilter itself (source SRC_9) was assumed to achieve an odour capture rate of 90%.

Table 3-7: Emission Parameters for Sources Input into the Model for Scenario 2

Source Ref.	Source Name	Odour Emission Rate (OU/s/m^2)	Release Height (m)	Initial Sigma *z* (m)	Source Area (m^2)
SRC_1	Leachate Pond	0.110	0.5	1.0	880
SRC_2	Leachate Collection Manhole	2.375	0.5	1.0	4
SRC_3	Stage 3 – Working Face	1.500	0.5	1.0	81
SRC_4	Stage 3 – Covered Area	0.075	0.2	1.0	3,600
SRC_5	Stage 2 – Hotspot #1	5.830	0.5	1.0	4
SRC_6	Stage 2 – Hotspot #2	1.130	0.5	1.0	4
SRC_7	Stage 2 – Hotspot #3	1.790	0.5	1.0	4
SRC_8	Stage 2 – Covered Area	0.075	0.2	1.0	13,600
SRC_9	Leachate Collection Manhole Biofilter (proposed)	2.375	0.5	1.0	25

The emission rates for Scenario 3 shown in **Table 3–8** for the Stage 2 hotspots and covered area (sources SRC_5 to SRC_8) were assumed to reduce by 99% following the implementation of effective capping across Stage 2.

Table 3-8: Emission Parameters for Sources Input into the Model for Scenario 3

Source Ref.	Source Name	Odour Emission Rate (OU/s/m^2)	Release Height (m)	Initial Sigma *z* (m)	Source Area (m^2)
SRC_1	Leachate Pond	0.110	0.5	1.0	880
SRC_2	Leachate Collection Manhole	23.75	0.5	1.0	4
SRC_3	Stage 3 – Working Face	1.500	0.5	1.0	81
SRC_4	Stage 3 – Covered Area	0.075	0.2	1.0	3,600
SRC_5	Stage 2 – Hotspot #1	0.058	0.5	1.0	4
SRC_6	Stage 2 – Hotspot #2	0.011	0.5	1.0	4
SRC_7	Stage 2 – Hotspot #3	0.018	0.5	1.0	4
SRC_8	Stage 2 – Covered Area	0.001	0.2	1.0	13,600

The emission rates for Scenario 4 shown in **Table 3–9** are based on the anticipated reduction in odour emissions following the implementation of both a biofilter at the leachate collection manhole and effective capping on Stage 2. On a surface area pro rata basis, the total odour emission rates for Scenario 4 are approximately 70% lower than the total existing odour emission rates (Scenario 1).

Table 3-9: Emission Parameters for Sources Input into the Model for Scenario 4

Source Ref.	Source Name	Odour Emission Rate (OU/s/m²)	Release Height (m)	Initial Sigma *z* (m)	Source Area (m²)
SRC_1	Leachate Pond	0.110	0.5	1.0	880
SRC_2	Leachate Collection Manhole	2.375	0.5	1.0	4
SRC_3	Stage 3 – Working Face	1.500	0.5	1.0	81
SRC_4	Stage 3 – Covered Area	0.075	0.2	1.0	3,600
SRC_5	Stage 2 – Hotspot #1	0.058	0.5	1.0	4
SRC_6	Stage 2 – Hotspot #2	0.011	0.5	1.0	4
SRC_7	Stage 2 – Hotspot #3	0.018	0.5	1.0	4
SRC_8	Stage 2 – Covered Area	0.001	0.2	1.0	13,600
SRC_9	Leachate Collection Manhole Biofilter (proposed)	2.375	0.5	1.0	25

The emission source locations are shown in **Figure 3–5**.

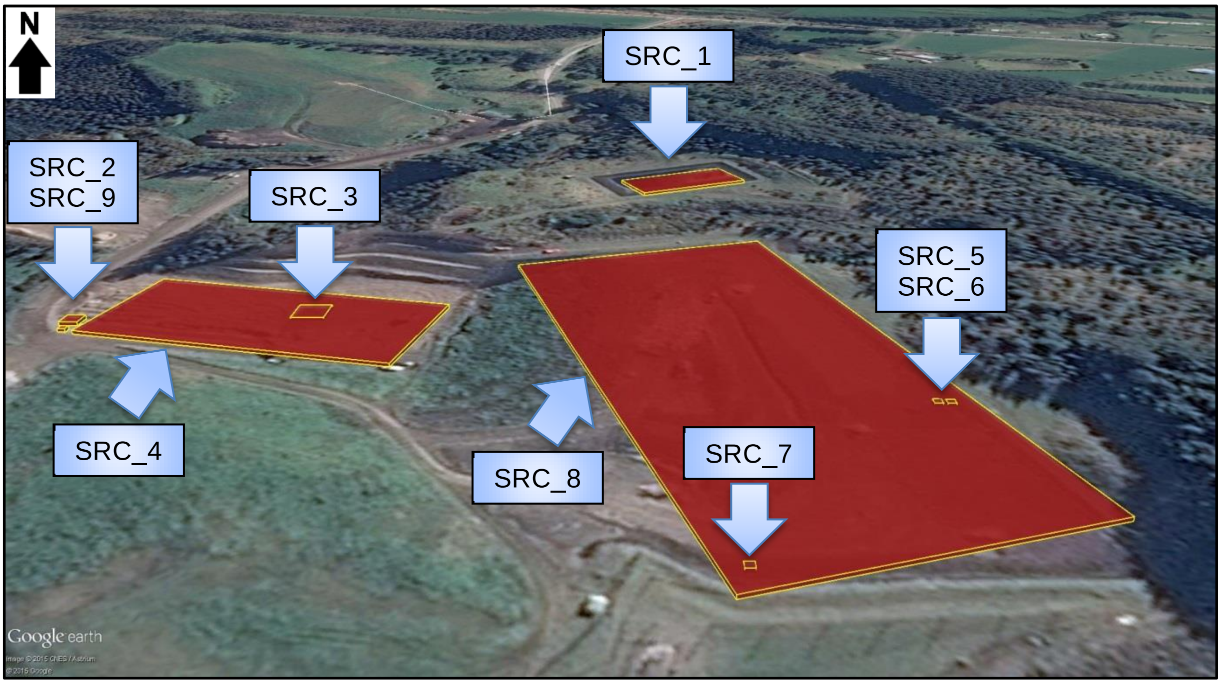

Figure 3-5: Emission Sources Input into CALMET

3.6.2.3 Discrete Receptors

Discrete receptor locations deemed sensitive to potential odour emissions at the landfill site were identified from a desktop GIS study. The discrete receptors (referred to herein as 'R1' to 'R16') are all residential properties located within 1,000 m of the landfill site boundary. The discrete receptors were input into the CALPUFF model (see **Section 3.1**).

The nearest receptor to the project site is a residential property (receptor 'R1'), which is approximately 90 m to the north-east of the site boundary.

In addition, ground-level odour concentrations were predicted at the 50 m by 50 m CALPUFF grid receptors.

3.6.2.4 Assumptions and Model Parameters

The key parameters used in the CALMET meteorological modelling are summarised in **Table 3–10**.

Table 3-10: Meteorological Parameters used in CALPUFF for this Study

CALMET Version 6.4.0 (Level 121203)	
CALPUFF grid size	2 km x 2 km
CALPUFF grid coordinates	Lower left corner: UTM 347700 m E, 5502200 m N (zone 60 south) Top right corner: UTM 349700 m E, 5504200 m N (zone 60 south)
CALPUFF grid resolution	50 m (nesting factor of 4 or MESHDN = 4)
Number of grid receptor points (x, y)	40 x 40 (1600) (cells 102,182 to 111,191)
Number of discrete receptor points	16
Year(s) of analysis	2012 (1 January to 31 December)
Centre of grid	Project Site UTM 348700 m E, 5503200 m N (zone 60 south)
CALMET meteorological data	40 km x 40 km (200 cells x 200 cells) Lower left corner: UTM 327500 m E, 5466000 m N (zone 60 south) Top right corner: UTM 367500 m E, 5506000 m N (zone 60 south)
Wind Speed Profile	ISC Rural
Plume Element Modelling Method	Puff (discrete packet of pollutant material)
Dispersion Option(s)	Dispersion coefficients were calculated internally from the micrometeorological variables (MDISP = 2)
PDF Method for Sigma-z in the convective boundary layer	Not Selected (MPDF = 0)
Complex Terrain Effects	Partial plume path adjustment

3.6.3 Assessment Criteria Adopted in the Dispersion Modelling Study

Table 3–11 summarises the assessment criterion selected for the dispersion modelling assessment, which is consistent with the criteria used in MWH's previous modelling assessments. The use of the 2 OU/m^3 assessment criterion (at the 99.9th percentile or '99.9%ile') has been recommended by the MfE (refer MfE, 2003)[1] for high sensitivity receptor locations under neutral or stable atmospheric conditions. It is noted that stable atmospheric conditions have the potential to limit the dispersion of an odour plume from an emission source and are consequently associated with 'worst-case' conditions (i.e. higher odour concentrations or potential odour nuisance effects).

Whilst the use of the 99.5th percentile is sometimes also used in odour modelling studies in New Zealand, and is the 'baseline' assessment criterion in MfE (2003), MWH has not adopted it in this assessment. Rather, MWH has presented the maximum and 99.9%ile odour modelling results against the 2 OU/m^3 assessment criterion in order or provide a robust assessment.

[1] Good Practice Guide for Assessing and Managing Odour in New Zealand prepared for the Ministry for the Environment (MfE), June, 2003.

Table 3-11: Assessment Criteria Used in the Modelling Study

Authority	Averaging Period	Assessment Criteria Concentration (OU/m^3)	Assessment Criteria Reference
MfE	1-hour (99.9%ile)	2.0	MfE (2003)

4 Local Meteorological Conditions

4.1 Wind Speed and Direction

The nearest automated weather stations (AWS) to the project site are located in Levin and Palmerston North and at Paraparaumu Airport. The details of these surface meteorological stations, which are all included in the national climate database (CliFlo) maintained by NIWA, are summarised in **Table 4–1**.

Table 4-1: Nearest Weather Stations to the Project Site

Name	Agent Number	Operator	UTM Zone 60 South		Distance (km) and Direction from Site Boundary	
			Easting (m)	Northing (m)		
Levin AWS	03275	MetService	352573	5501743	3.6	SE
Paraparaumu Aero AWS	08567	MetService	330208	5469610	38	SW
Palmerston North EWS	21963	NIWA/AgResearch	381940	5528920	42	NE

Analysis of hourly wind data for these three meteorological stations between 1 January 2008 and 31 December 2012 indicates that winds from all directions are experienced at each monitoring site. However, the predominant winds measured at the Levin AWS were from the west-north-west (WNW), east (E), west (W) and east-north-east (ENE). The data capture for the five-year monitoring period was excellent at 99.5%: only 207 hours were missing from a total of 43,848 available hours. The majority of the missing hours (183 hours or 88% of the total missing hours) occurred in 2008 and there was only 1 missing hour in 2012. The frequency of winds originating from the south-south-west (SSW) over this period was low (less than 5%), which is potentially significant as SSW winds have the potential to transport odour released on the Levin Landfill towards the nearest sensitive receptor locations (e.g. receptor ‘R1’). This is discussed further in **Section 5**.

The predominant winds measured at the Paraparaumu Aero AWS between 2008 and 2012 were from the north-east (NE), north-north-east (NNE), north (N), south (S) and south-south-west (SSW). The data capture for the five-year monitoring period was excellent at 99.8%: only 107 hours were missing from a total of 43,848 available hours. The majority of the missing hours (79 hours or 74% of the total missing hours) occurred in 2008 and there was only 4 missing hours in 2012.

The predominant winds measured at the Palmerston North Electronic Weather Station (EWS) between 2008 and 2012 were from the WNW and east-south-east (ESE). The data capture for the five-year monitoring period was excellent at 99.9%: only 47 hours were missing from a total of 43,848 available hours. The majority of the missing hours (23 hours or 49% of the total missing hours) occurred in 2008 and no missing hours were recorded in 2012.

The annual and seasonal wind roses for the three meteorological stations for 2008 to 2012 are presented in **Figures D–1** to **D–36** in **Appendix D**. The annual wind roses indicate that there was very little inter-annual variation in wind direction at the meteorological stations between 2008 and 2012. The seasonal wind roses for Levin AWS (**Figures D–7** to **D–12** in **Appendix D**) indicate that:

- In summer, the prevailing wind directions were from the WNW, W and north-west (NW), i.e. there is a tendency for sea-breeze conditions at this time of the year;
- In autumn, the prevailing wind directions were from the E, ENE and WNW;
- In winter, the prevailing wind directions were from the E, ENE, and NE; and,
- In spring, the prevailing wind directions were from the WNW, NW and W.

In other words, the seasonal wind roses for Levin AWS indicate that there was little variation in wind direction during the spring and summer, compared with the annual wind roses. However, there is a more significant difference in the winter-time, when the winds are more frequent from the E, ENE and NE, compared with the annual wind roses.

The wind roses for Levin AWS split by hour of the day for 2008 to 2012 are presented in **Figure D–37** in **Appendix D**. The hour-of-the-day wind roses for Levin AWS indicate that:

- In the early morning (Hour 1 to Hour 6), the prevailing wind directions were from the E, ENE, ESE, SE and NE;
- In the morning (Hour 7 to Hour 12), the prevailing wind directions were from the E, ENE and NE;
- In the afternoon (Hour 13 to Hour 18), the prevailing wind directions were from the WNW, W and NW; and,
- In the evening (Hour 19 to Hour 24), the prevailing wind directions were from the WNW, W and E.

The strongest winds measured at the Levin AWS originated from the WNW, NW and W. The average wind speed recorded between 2008 and 2012 at the Levin AWS was 2.8 m/s. The wind speed statistics for the Levin AWS between 2008 and 2012 are shown in **Table 4–2**. Note that the use of the term ‘calms’ in this report (including wind roses) refers to wind speeds of less than or equal to 0.45 m/s.

Table 4–2 indicates that the average frequency of calms over the 5-year monitoring period was 4.2%, and that 2008 and 2010 were below-average years for calms (3.2% and 3.4%, respectively) while 2009, 2011 and 2012 were above average (4.3%, 5.1% and 5.1%, respectively). The annual average wind speed for 2008 was equal to the 5-year average wind speed (2.8 m/s), and 2009 and 2010 were slightly above average (2.9 m/s) while 2011 and 2012 were slightly below average (2.7 m/s). Based on MWH’s experience, it is these light wind conditions which have the greatest potential to cause odour nuisance effects due to the reduction in the dispersion and dilution of the odour plume. Therefore, based on these meteorological data alone, the ‘worst-case’ years for odour dispersion at the project site are likely to have been 2011 and 2012. Calm conditions are discussed in more detail in the following section.

Table 4-2: Annual Average Wind Speed at Levin AWS for 2008 to 2012

Year	Meteorological Parameter			
	Annual Average Wind Speed (m/s)	Percentage Calms (%)	Minimum Wind Speed (m/s)	Maximum Wind Speed (m/s)
2008	2.8	3.2	0.0	17.0
2009	2.9	4.3	0.0	14.9
2010	2.9	3.4	0.0	14.5
2011	2.7	5.1	0.0	14.3
2012	2.7	5.1	0.0	13.3
All Data	2.8	4.2	0.0	17.0

The annual average wind speed frequency distributions for Levin AWS between 2008 and 2012 are shown in **Table 4–3**.

Table 4-3: Annual Wind Speed Frequency Distribution at Levin AWS for 2008 to 2012

Wind Speed Class (m/s)	2008 (%)	2009 (%)	2010 (%)	2011 (%)	2012 (%)	All Data (%)
Calms	3.2	4.3	3.4	5.1	5.1	4.2
0.5 – 1.5	40.6	37.3	32.9	33.6	34.0	35.7
1.5 – 3.0	17.8	19.8	28.5	28.7	27.8	24.5
3.0 – 5.5	24.5	24.0	22.6	21.2	21.2	22.7
5.5 – 8.0	9.8	10.4	8.7	7.4	8.7	9.0
8.0 – 10.5	3.6	3.5	3.0	3.0	2.5	3.1
>10.5	0.6	0.7	1.0	1.0	0.6	0.8

The wind speed frequency data shown in **Table 4–3** indicate that there was generally relatively little inter-annual variation during the meteorological monitoring period. The majority of the winds (64%) over the 5-year period were below 3 m/s (Beaufort 2, or 'light breeze' conditions).

The wind speed frequency distributions for the Levin AWS between 1 January 2008 and 31 December 2012 are shown in **Figure 4–1**.

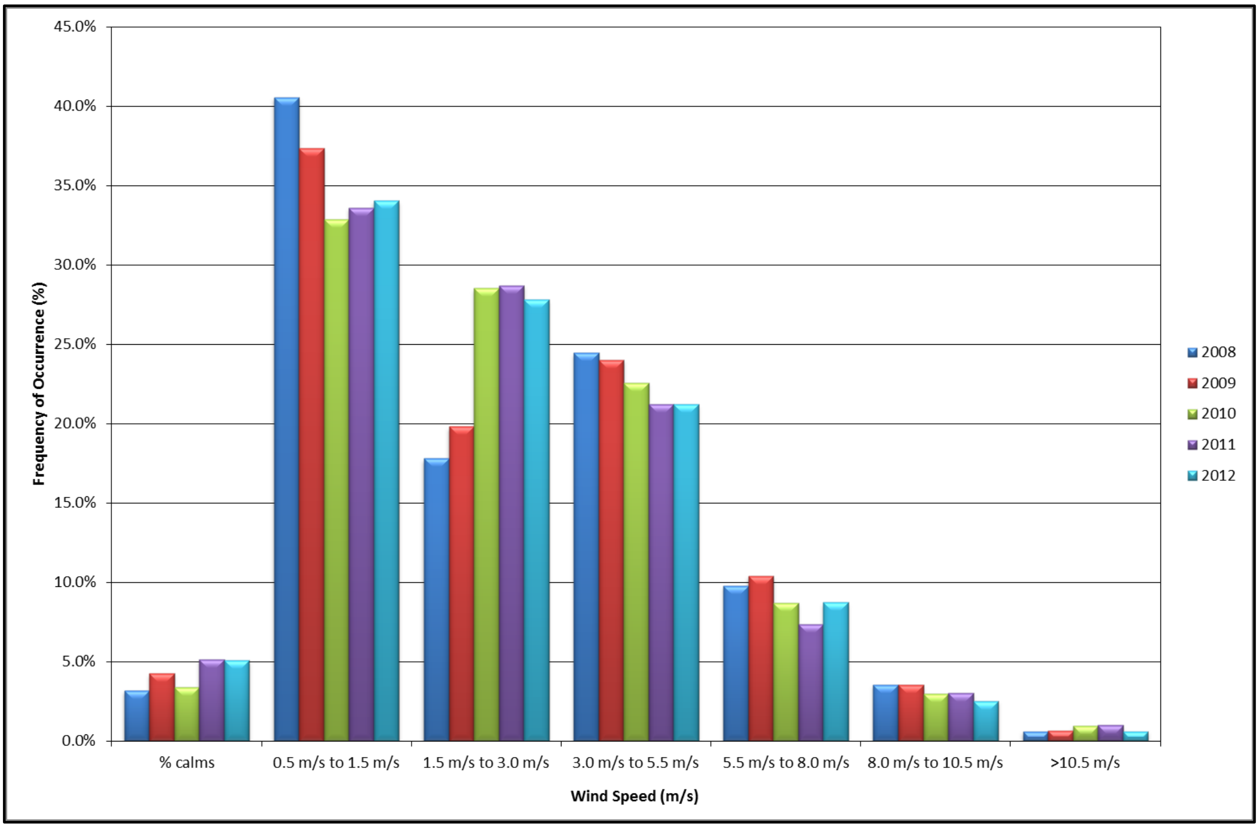

Figure 4-1: Wind Speed Frequency Distribution at Levin AWS for 2008 to 2012

The seasonal average wind speed frequency distributions for Levin AWS between 2008 and 2012 are shown in **Table 4–4** and indicate that there was generally relatively little variation throughout the meteorological monitoring period. However, the data do indicate that, on average, the highest wind speeds were recorded in spring, while the lowest wind speeds occurred in autumn.

Table 4-4: Seasonal Average Wind Speed at Levin AWS for 2008 to 2012

Season	Average Wind Speed (m/s)					
	2008	2009	2010	2011	2012	All Data
Summer	2.8	2.9	2.9	2.4	2.8	2.8
Autumn	2.1	2.6	2.6	2.5	2.2	2.4
Winter	3.2	2.6	2.4	2.6	2.3	2.6
Spring	3.3	3.5	3.6	3.3	3.5	3.4

The strongest winds measured at the Paraparaumu Aero AWS originated from the NW and NNW and WNW. The average wind speed recorded between 2008 and 2012 at the Paraparaumu Aero AWS was 4.3 m/s (compared with 2.8 m/s at the Levin AWS). The wind speed statistics for the Paraparaumu Aero AWS between 2008 and 2012 are shown in **Table 4–5**.

Table 4–5 indicates that the average frequency of calms over the 5-year monitoring period was 0.3%, and that 2009 to 2012 were below-average years for calms while 2008 was above average (0.8%). The annual average wind speeds for 2008, 2011 and 2012 were below the 5-year average wind speed (4.3 m/s), while 2009 and 2010 were slightly above average (4.6 m/s and 4.4 m/s, respectively).

Table 4-5: Annual Average Wind Speed at Paraparaumu Aero AWS for 2008 to 2012

Year	Meteorological Parameter			
	Annual Average Wind Speed (m/s)	Percentage Calms (%)	Minimum Wind Speed (m/s)	Maximum Wind Speed (m/s)
2008	4.1	0.8	0.0	14.9
2009	4.6	0.1	0.0	16.0
2010	4.4	0.2	0.0	15.7
2011	4.2	0.2	0.0	14.9
2012	4.2	0.1	0.0	13.9
All Data	4.3	0.3	0.0	16.0

The annual average wind speed frequency distributions for Paraparaumu Aero AWS between 2008 and 2012 are shown in **Table 4–6** and indicate that there was generally relatively little variation throughout the meteorological monitoring period. The majority of the winds (69%) over the 5-year period were below 5.5 m/s (Beaufort 3, or 'gentle breeze' conditions).

Table 4-6: Annual Wind Speed Frequency Distribution at Paraparaumu Aero AWS (2008 to 2012)

Wind Speed Class (m/s)	2008 (%)	2009 (%)	2010 (%)	2011 (%)	2012 (%)	All Data (%)
Calms	0.8	0.1	0.2	0.2	0.1	0.3
0.5 – 1.5	18.3	16.3	13.2	15.3	16.6	16.0
1.5 – 3.0	14.5	12.8	19.3	19.7	19.4	17.1
3.0 – 5.5	38.0	34.8	35.7	37.3	33.9	35.9
5.5 – 8.0	21.1	26.5	24.0	21.3	23.3	23.2
8.0 – 10.5	6.1	7.8	6.2	4.8	5.5	6.1
>10.5	1.2	1.7	1.4	1.4	1.1	1.4

The annual wind speed frequency distributions for the Paraparaumu Aero AWS between 1 January 2008 and 31 December 2012 are shown in **Figure 4–2**.

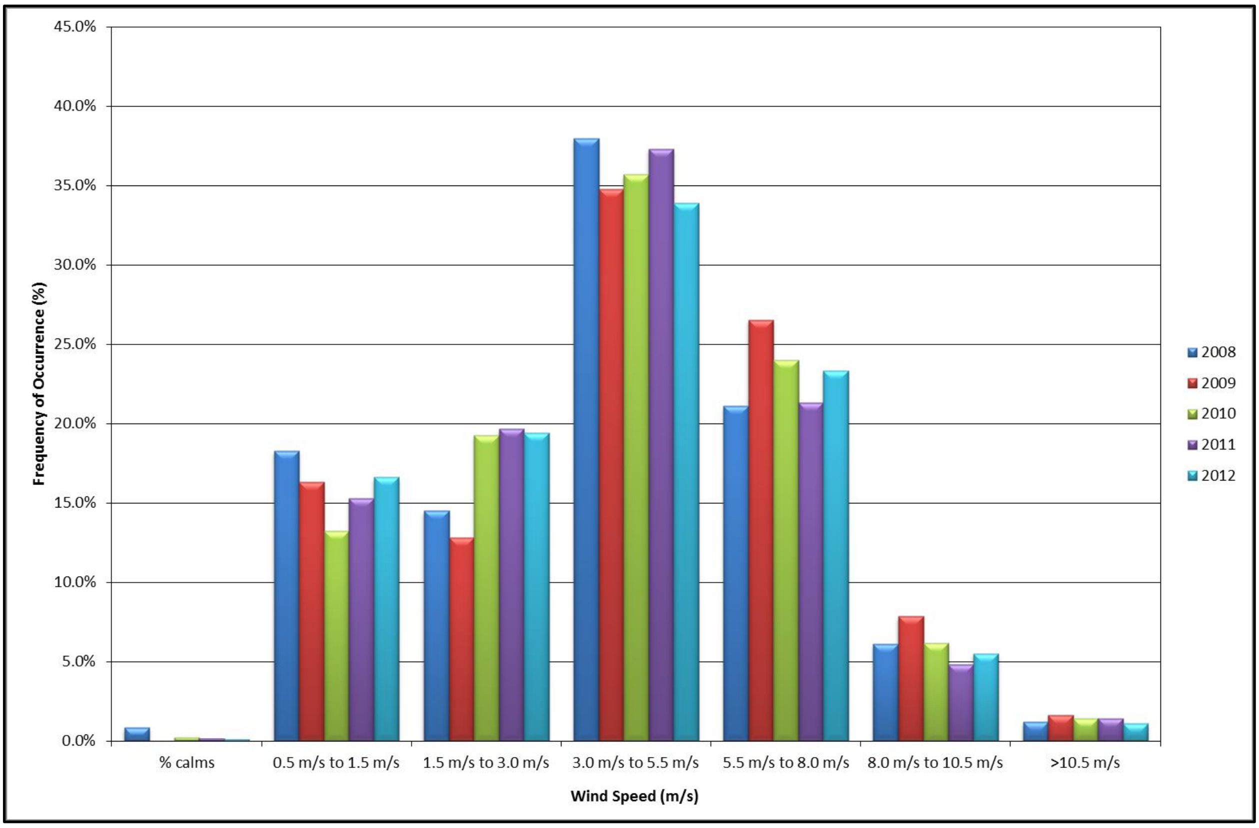

Figure 4-2: Wind Speed Frequency Distribution at Paraparaumu Aero AWS for 2008 to 2012

The seasonal average wind speed frequency distributions for Paraparaumu Aero AWS between 2008 and 2012 are shown in **Table 4–7** and indicate that there was generally relatively little variation throughout the meteorological monitoring period. However, the data do indicate that, on average, the highest wind speeds were recorded in spring, while the lowest wind speeds occurred in winter.

Table 4-7: Seasonal Average Wind Speed at Paraparaumu Aero AWS for 2008 to 2012

Season	Average Wind Speed (m/s)					
	2008	2009	2010	2011	2012	All Data
Summer	4.1	4.8	4.6	4.1	4.3	4.3
Autumn	3.3	4.3	4.4	4.2	4.0	4.1
Winter	4.5	4.0	3.8	4.2	3.5	4.0
Spring	4.7	5.3	5.0	4.5	5.1	4.9

The strongest winds measured at the Palmerston North EWS originated from the WNW. The average wind speed recorded between 2008 and 2012 at the Palmerston North EWS was 3.3 m/s (compared with 2.8 m/s at the Levin AWS). The wind speed statistics for the Palmerston North EWS between 2008 and 2012 are shown in **Table 4–8**.

Table 4–8 indicates that the average frequency of calms over the 5-year monitoring period was 2.1%, and that 2009, 2011 and 2012 were below-average years for calms (1.4%, 1.8% and 1.6%, respectively) while 2008 and 2010 were above-average (3.2% and 2.7%, respectively). The annual average wind speed for 2008, 2010 and 2011 were equal to the 5-year average wind speed (3.3 m/s), while 2009 and 2012 were slightly above average (3.4 m/s).

Table 4-8: Annual Average Wind Speed at Palmerston North EWS for 2008 to 2012

Year	Meteorological Parameter			
	Annual Average Wind Speed (m/s)	Percentage Calms (%)	Minimum Wind Speed (m/s)	Maximum Wind Speed (m/s)
2008	3.3	3.2	0.0	13.7
2009	3.4	1.4	0.0	15.4
2010	3.3	2.7	0.0	14.8
2011	3.3	1.8	0.0	13.7
2012	3.4	1.6	0.0	15.3
All Data	3.3	2.1	0.0	15.4

The annual average wind speed frequency distributions for Palmerston North EWS between 2008 and 2012 are shown in **Table 4–9** and indicate that there was generally relatively little variation throughout the meteorological monitoring period. The majority of the winds (53%) over the 5-year period were below 3 m/s (Beaufort 2, or 'light breeze' conditions).

Table 4-9: Annual Wind Speed Frequency Distribution at Palmerston North EWS for 2008 to 2012

Wind Speed Class (m/s)	2008 (%)	2009 (%)	2010 (%)	2011 (%)	2012 (%)	All Data (%)
Calms	3.2	1.4	2.7	1.8	1.6	2.1
0.5 – 1.5	24.8	25.4	24.8	26.0	24.8	25.1
1.5 – 3.0	25.3	25.8	25.8	26.4	25.3	25.7
3.0 – 5.5	30.2	30.5	30.9	29.1	31.4	30.4
5.5 – 8.0	12.9	12.4	11.7	12.5	12.8	12.5
8.0 – 10.5	3.2	3.7	3.3	3.2	3.6	3.4
>10.5	0.4	0.9	0.8	0.9	0.5	0.7

The annual wind speed frequency distributions for the Palmerston North EWS between 1 January 2008 and 31 December 2012 are shown in **Figure 4–3**.

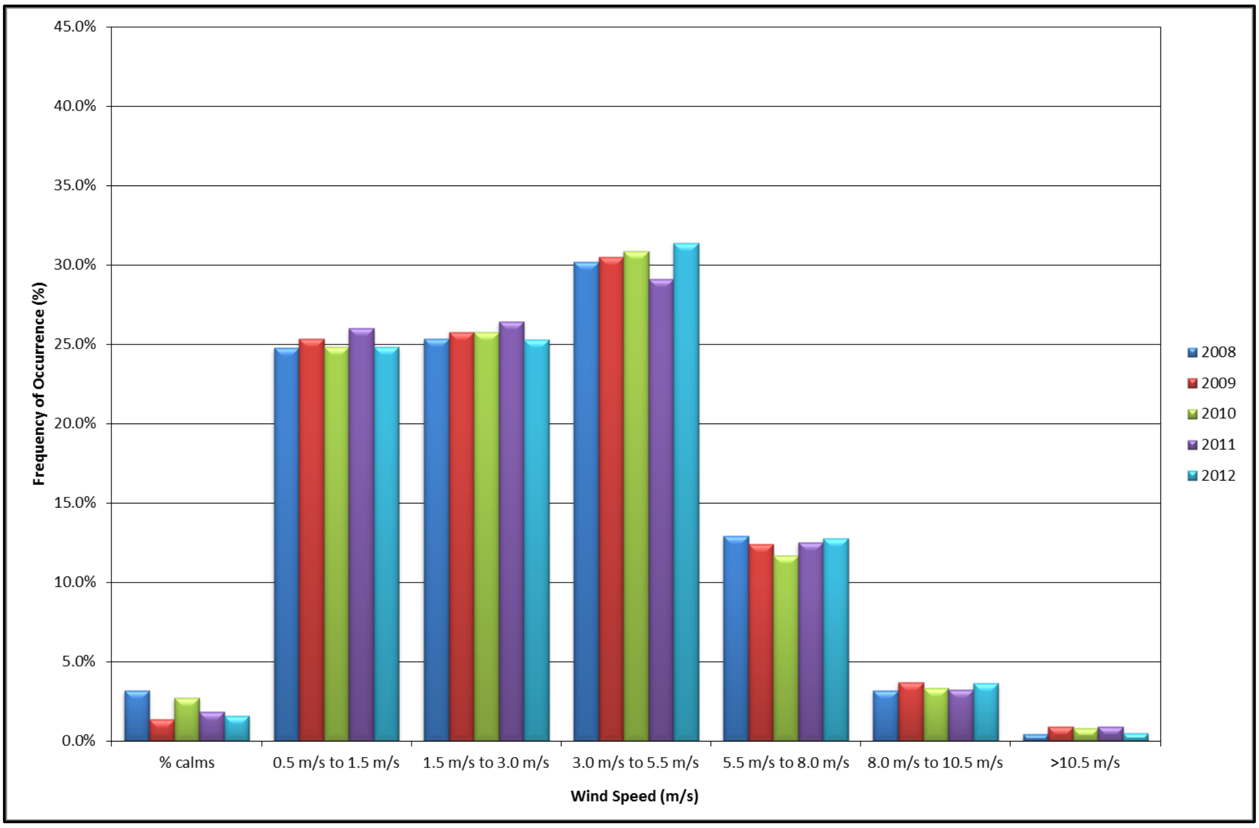

Figure 4-3: Wind Speed Frequency Distribution at Palmerston North EWS for 2008 to 2012

The seasonal average wind speed frequency distributions for Palmerston North EWS between 2008 and 2012 are shown in **Table 4–10** and indicate that there was generally relatively little variation throughout the meteorological monitoring period. However, the data do indicate that, on average, the highest wind speeds were recorded in spring and summer, while the lowest wind speeds occurred in winter.

Table 4-10: Seasonal Average Wind Speed at Palmerston North EWS for 2008 to 2012

Season	Average Wind Speed (m/s)					
	2008	2009	2010	2011	2012	All Data
Summer	3.9	3.8	3.7	3.7	3.9	3.8
Autumn	2.9	3.0	3.1	3.0	3.0	3.0
Winter	2.8	3.0	2.5	2.9	2.7	2.8
Spring	3.6	3.7	4.0	3.7	3.9	3.8

4.2 Low Wind Speed Conditions

As mentioned earlier, the majority of the winds (64%) measured at the Levin AWS over the period between 2008 and 2012 were below 3 m/s (i.e. less than Beaufort 2 or 'light breeze' conditions). These low wind speed conditions are generally considered to have the greatest potential to cause odour nuisance effects in the surrounding community due to the reduction in the potential for dispersion and dilution of an odour plume. For this reason, the Levin AWS wind speed and direction data for 2008 to 2012 were re-analysed, with particular focus being given to potential low wind speed conditions at the project site.

Analysis of the hourly low wind speed data indicates that low winds were experienced at the Levin AWS from all directions. However, the predominant winds were from the E, ENE and NE. There were a total of 28,250 hours over the 5-year period corresponding to low wind speed conditions. The frequency of low winds originating from the SSW over this period was less than 5%. The wind rose for Levin AWS showing low wind speeds (<3 m/s) is presented in **Figure D–38** in **Appendix D**.

4.3 Temperature, Atmospheric Pressure and Relative Humidity

Hourly air temperature, atmospheric pressure and relative humidity data for Levin AWS and Paraparaumu Aero AWS for 1 January 2012 to 31 December 2012 were also analysed.

The annual average and the 1-hour maximum and minimum temperature, atmospheric pressure and relative humidity recorded at the two weather stations in 2012 are shown in **Table 4–11**.

Table 4-11: Temperature, Atmospheric Pressure and Relative Humidity in 2012

Site	Air Temperature (°C)			Atmospheric Pressure (hPa)			Relative Humidity (%)		
	Annual Mean	1-hr Min.	1-hr Max.	Annual Mean	1-hr Min.	1-hr Max.	Annual Mean	1-hr Min.	1-hr Max.
Levin AWS	12.7	-3.3	29.2	1014	978	1036	75	33	100
Paraparaumu Aero AWS	12.8	-4.0	29.2	1014	980	1037	75	24	100

The annual average temperature measured at the Levin and Paraparaumu Aero AWS sites were similar at 12.7 °C and 12.8 °C, respectively. Furthermore, the minimum temperatures were similar at the Levin and Paraparaumu Aero AWS sites (-3.3 °C and -4.0 °C, respectively) whilst the maximum temperatures were the same (29.2 °C). As expected, the coldest months were June, July and August (winter), and the warmest months were December, January and February (summer).

The hourly air temperatures measured at the Levin and Paraparaumu Aero AWS sites in 2012 are shown in **Figures 4–4** and **4–5**, respectively.

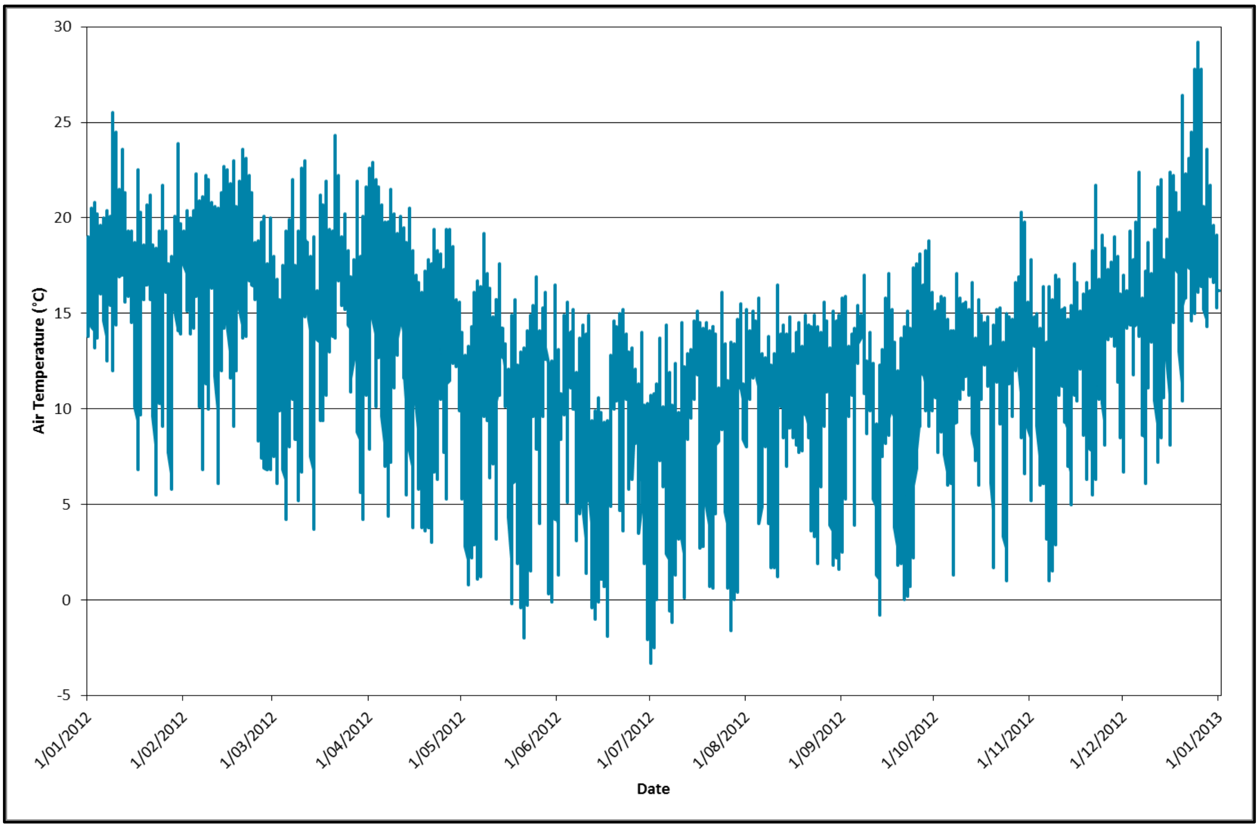

Figure 4-4: Hourly Air Temperature at Levin AWS in 2012

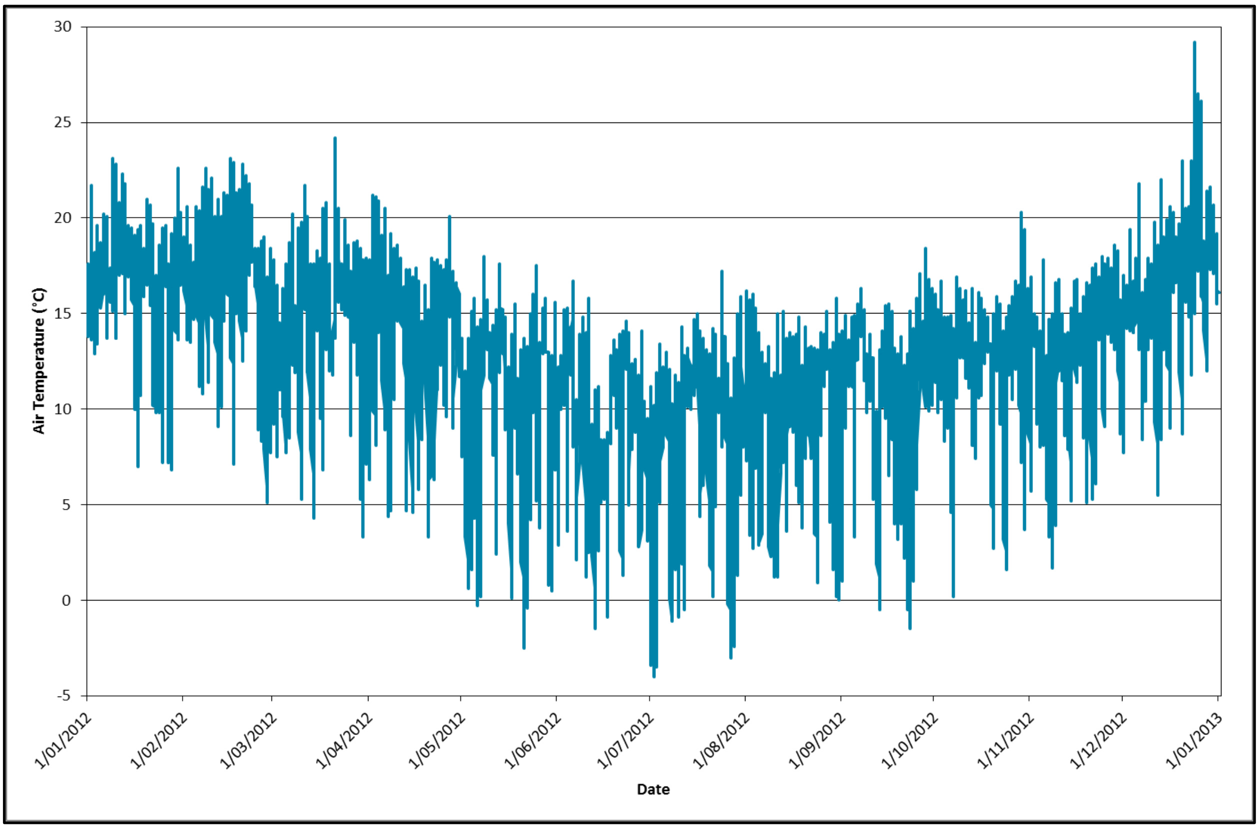

Figure 4-5: Hourly Air Temperature at Paraparaumu Aero AWS in 2012

5 Odour Assessment

5.1 Landfill Surface Emissions Monitoring

On 18 November 2014, a landfill surface emission monitoring walkover survey was undertaken across the project site using a pre-calibrated Bascom-Turner Gas-Rover^{TM} portable methane monitor (Model VGI-201). The instrument was mostly operated in “survey” mode (response time was approximately 0.6 seconds). However, at the leachate collection manhole and at the Stage 2 emission hotspots, the instrument automatically switched to “monitor” mode (response time was approximately 1 second), due to the high concentrations of methane (CH_4) measured at these locations.

A GPS unit was used during the walkover survey to determine accurate geo-spatial data (e.g. tracks and waypoints) at a time-resolution of 1 second. The clock on the GPS unit was synchronised with the Gas-Rover and the 1-second mean concentration and spatial data were post-processed in Microsoft Excel.

The 1-second mean methane concentrations were recorded by the Gas-Rover^{TM} in units of parts per million by volume (‘ppmv’ or simply ‘ppm’), percent methane by volume (i.e. concentration in ppm divided by 10,000) and as percent of the lower explosive limit (LEL) for methane by volume (i.e. 100% LEL = 50,000 ppm or 5% by volume). A methane concentration of 1 ppm equates to 0.7 milligrams per cubic metre (mg/m^3) at an air temperature of 20 °C.

The results of the walkover survey are summarised in **Table 5–1**.

Table 5-1: Summary of the Landfill Surface Emission Monitoring Walkover Survey Results

Location / Description & Date / Time	1-Second Mean CH_4 Conc. Range	1-Second Mean CH_4 Conc. (90th %ile)	Notes
East (Downwind) of Litter Fence on Eastern Boundary of Stage 2 11:30 to 11:53 (18/11/14)	0 ppm to 32 ppm 0% to <0.1% methane 0% LEL	29 ppm <0.1% gas 0% LEL	Generally low concentrations present
Leachate Collection Manhole Cover 12:13 to 13:08 (18/11/14)	0 ppm to 380,500 ppm 0% to 38.05% methane 0% LEL to 100% LEL	6,200 ppm 0.62% gas 12% LEL	Very high concentrations with a total of 140 seconds above LEL (out of 3316 seconds, or 4% of total) – potentially explosive atmosphere
Stage 2 Walkover Survey 14:16 to 14:57 (18/11/14)	0 ppm to 39,007 ppm 0% to 3.9% methane 0% LEL to 78% LEL	201 ppm <0.1% gas 0% LEL	Generally low concentrations present but high to very high concentrations present at 3 “hotspot” locations

Surface emissions monitoring commenced across the closed areas of the landfill (i.e. the old un-lined landfill and Stage 1a) at approximately 15:00 on 18 November (i.e. following the completion of the Stage 2 walkover survey), until it was completed at the site office car park at 15:51.

The monitoring was initially undertaken across Stage 1a (the closed area of the landfill to the south-west of Stage 2 or south of the Stage 3 working face). The methane concentrations measured between 15:00 and 15:10 were generally very low (e.g. 0 ppm or below the level of detection) with occasional values of <20 ppm. There was no evidence of surface cracking and the surface was covered in grass. There was also no evidence of ponding of rainwater or large surface depressions.

The walkover then continued northwards along the site access road via the leachate collection manhole towards the closed area (the old un-lined landfill) to the north-west of the site office. The methane concentrations measured downwind of the leachate collection manhole between 15:07 and 15:08 were generally very low (e.g. 0 ppm or below the level of detection) with occasional values of <190 ppm.

The methane concentrations measured on the old un-lined landfill between 15:12 and 15:23 were generally very low (e.g. 0 ppm or below the level of detection) with occasional values of <20 ppm. There was no evidence of surface cracking and the surface was covered in grass. There was also no evidence of ponding of rainwater or large surface depressions.

The results of the walkover survey summarised in **Table 5–1** and described above indicate that the principal sources of methane at the project site were the leachate collection manhole (40° 36.536' S, 175° 12.706' E) and the Stage 2 emission hotspots, which were namely:

- Hotspot #1 Eastern Boundary of Stage 2 (open pipe or uncapped gas collection wellhead passively venting to atmosphere; 40° 36.559' S, 175° 12.863' E);
- Hotspot #2 Eastern Boundary of Stage 2 (landfill surface, approximately 2 m west of Hotspot #1; 40° 36.559' S, 175° 12.862' E); and,
- Hotspot #3 Southern Boundary of Stage 2 (landfill surface with hose pipe protruding from surface; 40° 36.590' S, 175° 12.825' E).

The maximum 1-second mean methane concentrations measured at each hotspot location on 18 November were as follows:

- Hotspot #1 5,827 ppm (0.6% methane or 0% LEL) at 14:29:50 (HH:MM:SS);
- Hotspot #2 18,006 ppm (1.8% methane or 0% LEL) at 14:28:53; and,
- Hotspot #3 39,007 ppm (3.9% methane or 78% LEL) at 14:18:53.

The location of the Stage 2 emission hotspots and the leachate collection manhole are shown in **Figure 5–1**.

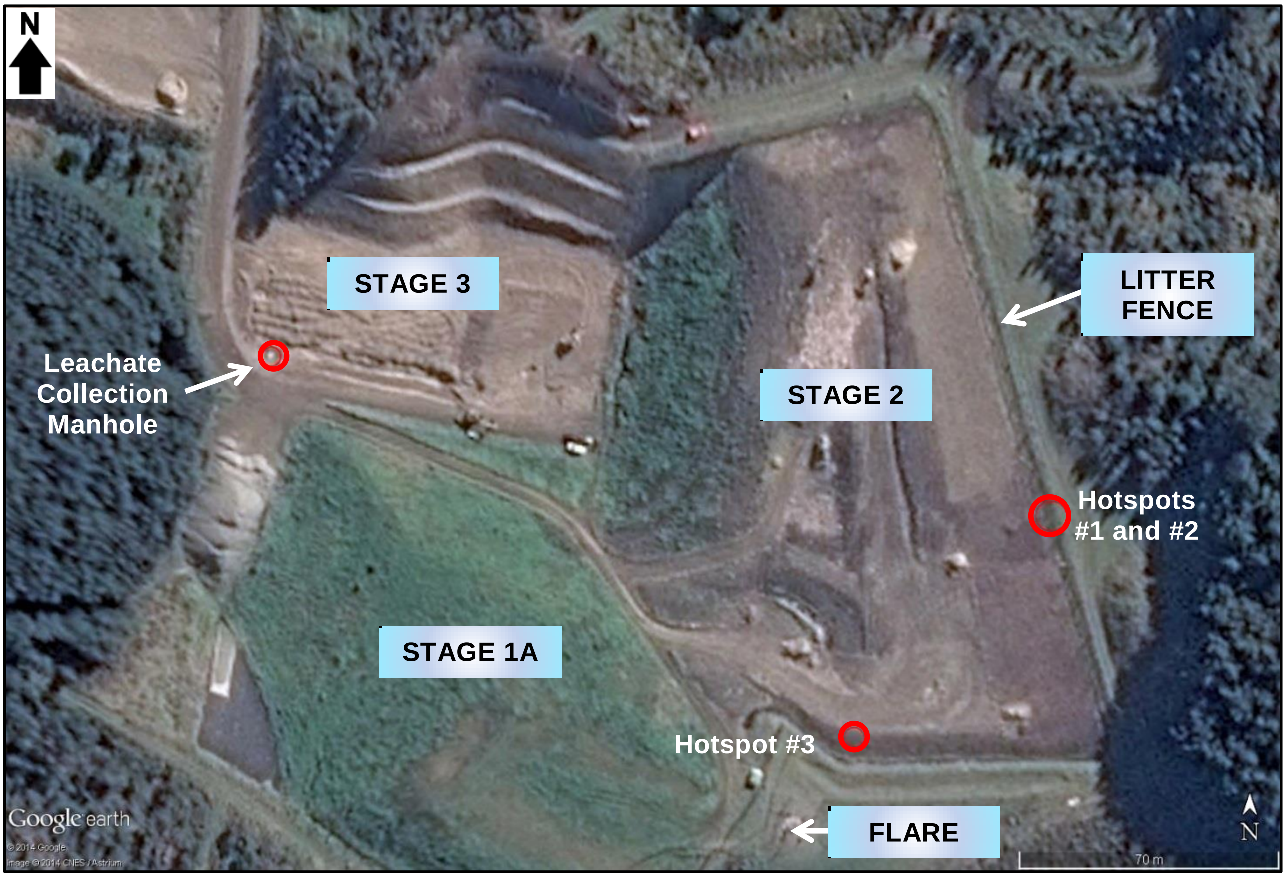

Figure 5-1: Principal Emission Sources of Methane Identified during Walkover Survey

The methane concentrations measured during the walkover survey across Stage 2 (between 14:16 and 14:57 on 18 November) are shown in **Figure 5–2**.

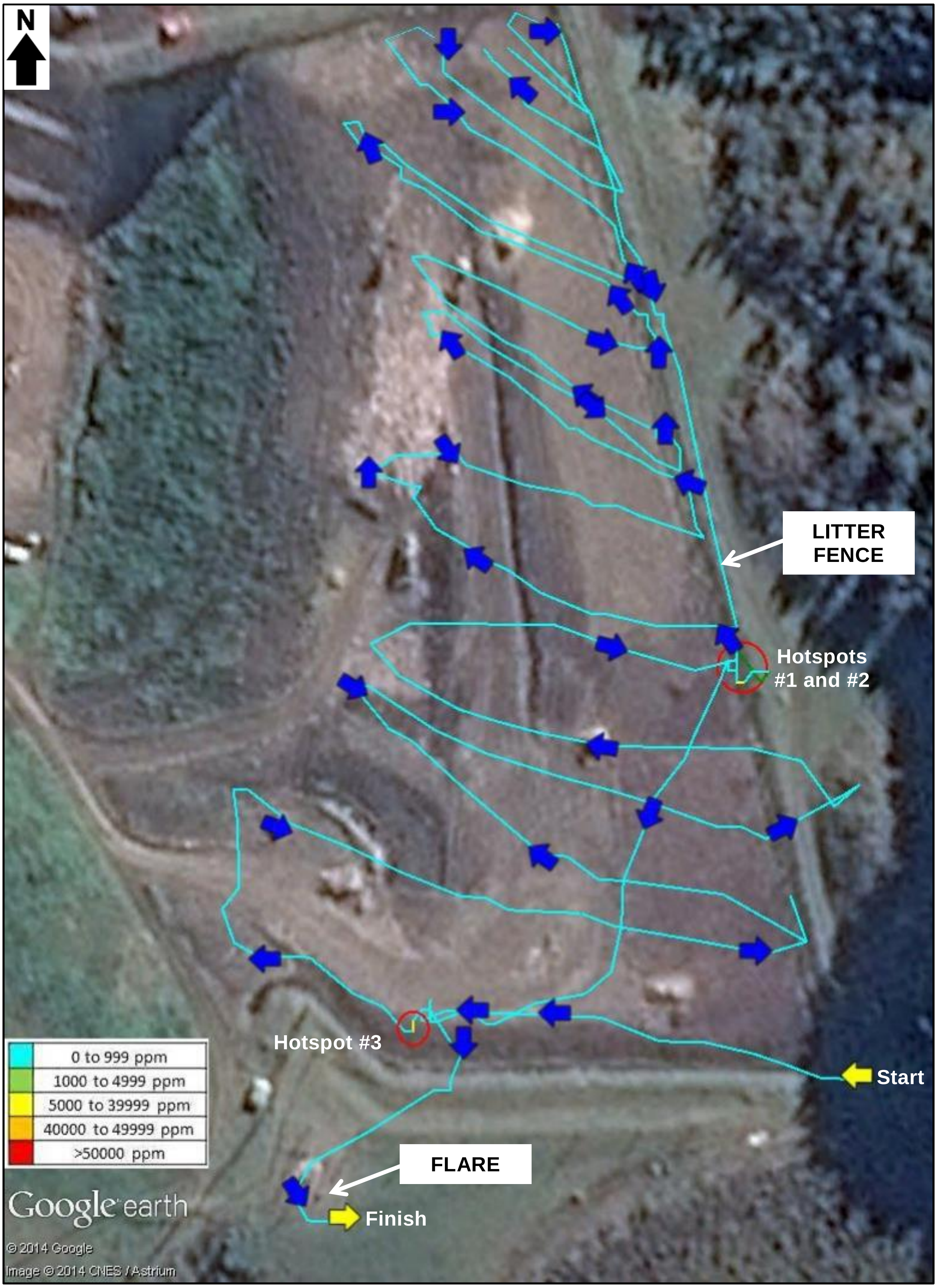

Figure 5-2: Methane Concentrations Measured on 18 November during Stage 2 Walkover Survey

Surface emissions monitoring for methane using the Gas-Rover™ re-commenced at Stage 2 Hotspot #3 at approximately 9:23 am on 19 November under falling atmospheric pressure conditions (as discussed in the section below). The walkover survey across Stage 2 was of shorter duration (approximately 40 minutes) compared with the survey undertaken on the previous day and was terminated at the SE corner of Stage 2 at approximately 10:00 am. The 1-second mean surface methane concentrations were found to be generally <100 ppm at all monitoring locations, however, concentrations increased at the previously identified emission hotspots and at another emission hotspot location (40° 36.521' S, 175° 12.846' E, hereafter 'Hotspot #4') identified approximately 70 m NNW of Hotspots #1 and #2 on the eastern boundary of Stage 2. The maximum methane concentrations measured at the identified hotspot locations on 19 November were as follows:

- Hotspot #1 5,000 ppm (0.5% methane or 0% LEL) at 9:55:18 (HH:MM:SS);
- Hotspot #2 24,500 ppm (2.5% methane or 49% LEL or) at 9:54:48;
- Hotspot #3 4,962 ppm (0.5% methane or 0% LEL) at 9:31:47; and,
- Hotspot #4 1,387 ppm (0.1% methane or 0% LEL) at 9:45:20.

In summary, the surface emissions monitoring results for the 18 and 19 November indicate that the methane concentrations measured on 18 November at Hotspot #3 were extremely high (maximum of 39,007 ppm or 3.9% methane or 78% LEL). However, on the 19 November (i.e. when the odour emissions monitoring was being undertaken at this location) the surface methane concentrations measured were significantly lower (4,962 ppm or 0.5 % methane). Furthermore, the surface methane concentrations measured on 18 November at Hotspot #2 at the time that the odour emissions monitoring was undertaken (18,006 ppm or 1.8% methane or 36% LEL) were lower than the surface methane concentrations measured on 19 November (24,500 ppm or 2.5% methane or 49% LEL). These findings suggest that there is the potential for high temporal variations in the emission rates at the hotspot locations and that the odour emissions determined for these particular locations have the potential to be higher from time-to-time compared with the odour emissions presented in this report (which were also used as input into the dispersion modelling assessment presented herein).

Despite this, the surface methane concentrations measured at Hotspots #1, #2 and #3 are considered to be high, and HDC should investigate the cause of the elevated emissions and to implement corrective measures in order to reduce the landfill gas and odour emissions at these locations. It is noted that there were no visible signs of surface cracking at Hotspots #2, #3 and #4. Whilst it is possible that there is a leak (or multiple leaks) from one (or several) of the landfill gas collection pipes fitted to the wellheads located along the eastern boundary of Stage 2, what is known from the surface monitoring undertaken in this report is that the intermediate cover (sand and mulch layer) is not currently adequate to control landfill gas emissions and odour at the hotspot locations identified from the surface emissions monitoring. MWH recommends that the vacuum control valves fitted on each wellhead on Stage 2 and Stage 1a are checked to ensure that the gas collection system is functioning correctly and in accordance with best practice. It may be necessary to adjust the vacuum applied at each individual wellhead and, if monitoring ports have been fitted, to measure the flow (e.g. differential pressure), temperature, pressure, and composition of the LFG. The leachate collection efficiency should also be determined either from visual inspections or from monitoring the liquid inside each wellhead, as a build-up of leachate inside a well will reduce the potential for gas to move into the well (thus reducing the collection efficiency).

5.2 Field Odour Investigation

A subjective field odour investigation was undertaken on 18 and 19 November by MWH staff at various locations across the landfill site and at the eastern site boundary (downwind), in accordance with the guidance for field odour investigations contained in MfE (2003). The MWH odour assessor was 'calibrated' by Watercare Laboratory Services using forced choice dynamic dilution olfactometry (DDO), in accordance with the Australian/New Zealand Standard (AS/NZS 4323.3:2001, Section 9.7.2) screening procedure for an olfactometry panellist. The results of the testing determined that the assessor met the AS/NZS Standard and was of 'normal' sensitivity to odour (i.e. representative of the normal range of the population).

MWH staff arrived onsite at 10:45 am on 18 November and departed the site at approximately 4:00 pm. On 19 November, MWH staff arrived onsite at 9:00 am and departed the site at approximately 11:00 am.

On both days, the weather conditions were sunny with scattered clouds and fresh to strong winds (with occasional strong gusts) originating from the NW and WNW. The wind speed and atmospheric pressure at the site was determined using a hand-held instrument. The wind speeds were generally between

5 m/s and 14 m/s (Beaufort Scales 4 and 6 or 'moderate breeze' and 'strong breeze', respectively). The atmospheric pressure was between 1,004 hPa and 1,009 hPa.

Meteorological data from a private AWS site located in Levin (WeatherUnderground ref. 'IHOROWHE2' located at latitude 40.623 °S, longitude 175.296 °E) for 18 and 19 November 2014 were analysed. This AWS site is approximately 7 km ESE of the Levin Landfill. The hourly data are shown in **Table 5–2** for 11:00 am to 16:00 on 18 November and 9:00 am to 11:00 am on 19 November 2014 (corresponding to the time MWH staff were onsite) and are in agreement with the weather observation data recorded during the site visit.

Table 5-2: Meteorological Data for Levin on 18 and 19 November 2014

Date/Time	1-hr Mean Wind Speed (m/s)	1-hr Mean Wind Direction (degrees)	1-hr Mean Wind Direction (compass)	1-hr Mean Air Temp. (°C)	1-hr Mean Atmos. Pressure (hPa)	1-hr Mean Relative Humidity (%)
18/11/2014 11:00	8.6	306	NW	16.1	1004	68
18/11/2014 12:00	10.0	289	WNW	16.6	1006	64
18/11/2014 13:00	7.9	291	WNW	17.0	1006	63
18/11/2014 14:00	7.9	305	NW	17.6	1007	60
18/11/2014 15:00	6.7	306	NW	17.1	1008	58
18/11/2014 16:00	8.3	311	NW	17.2	1008	59
19/11/2014 9:00	5.6	313	NW	14.2	1009	77
19/11/2014 10:00	6.0	316	NW	14.5	1008	76
19/11/2014 11:00	6.8	311	NW	14.3	1007	78

The air temperatures were higher on 18 November compared with 19 November and the relative humidity was lower on 18 November compared with 19 November. Whilst the atmospheric pressure data shown in the table appear to be relatively stable during both days, the pressure on the 19 November was actually falling from a peak of 1,011 hPa at midnight on 18 November. Falling atmospheric conditions is potentially significant as these conditions often give rise to higher odour and landfill gas emissions, compared with stable atmospheric conditions.

5.2.1 Field Odour Investigation Locations

On 18 November 2014, the field odour investigation was carried out at various upwind and downwind locations on the project site, including, but not limited to the following locations:

- Location L1_1: Leachate Pond (six 'sniff test' locations around the pond);
- Location L1_2: Leachate Collection Manhole;
- Location L1_3: Eastern Boundary of Stage 2 (alongside litter fence); and,
- Location L1_4: Eastern Boundary of Stage 2 (approximately 20 m east of litter fence).

On 19 November 2014, the field odour investigation was carried out at various upwind and downwind locations on the project site, including, but not limited to the following locations:

- Location L2_1: Stage 2 (downwind of the working face);
- Location L2_2: Stage 2 (hotspots #1 & #2 – odour emission monitoring locations);
- Location L2_3: Stage 2 (hotspot #3 – odour emission monitoring location);
- Location L2_4: Flare (30 m to E of flare – not operating at time of site visit);
- Location L2_5: Eastern Boundary of Stage 2 (alongside litter fence); and,
- Location L2_6: Leachate Pond (six 'sniff test' locations around the pond).

The field odour investigation locations are shown in **Figure 5–3**.

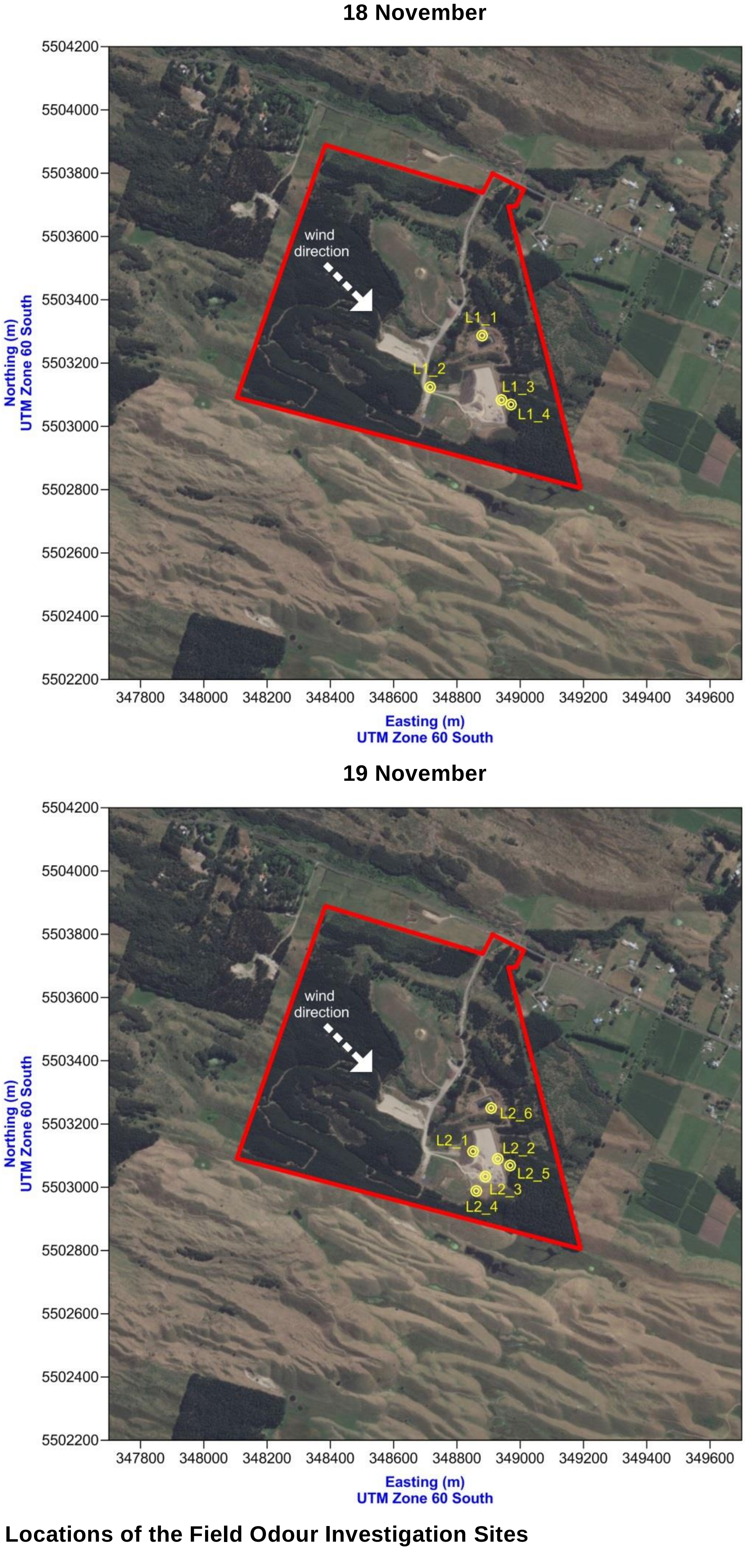

Figure 5-3: Locations of the Field Odour Investigation Sites

5.2.2 Field Odour Investigation Findings

Based on the field odour investigation, the principal odour emission sources at the project site are as follows:

- Leachate Collection Manhole; and,
- Stage 2 (emission hotspots).

The emission hotspots on Stage 2 were also determined from the landfill surface emissions monitoring for methane (refer previous section).

Whilst odour was detected from the working (tipping) face and leachate pond during the field odour investigation, these particular emission sources were not deemed to be significant at least during MWH's site visit, compared with the leachate collection manhole and Stage 2 hotspots. It is possible, however, that odour emissions at the working face and leachate pond may be higher under certain conditions (e.g. in summer due to elevated bacterial activity at this time of the year).

The intensity of odour detected across the project site was classified by the MWH assessor as "*weak*" to "*distinct*" (e.g. at the working face and leachate pond), and occasionally "*strong*" and "*extremely strong*" (e.g. at the leachate collection manhole and at the Stage 2 hotspots) in nature. Odour intensity was found to decrease with distance downwind of the odour source and the odours soon became more transient in nature.

As the wind conditions at the time of the visit were generally strong and from the NW and WNW, the frequency that odour was detected was fairly high in close proximity and downwind of the principal odour emission sources. At greater distances from the principal emission sources (downwind), odours were generally transient in nature and only increased during gusts. The odour characteristics were generally described as "*weak*" or "*faint*" "*rubbish-type odour*" or "*organic odour*" (e.g. at the leachate pond and working face) or to "*strong*" to "*very strong*" "*landfill gas odour*" (e.g. at the leachate collection manhole and at the Stage 2 hotspots).

Potentially *objectionable* or *offensive* odours were detected at the leachate collection manhole and at the Stage 2 hotspots.

No *objectionable* or *offensive* odours were detected at or beyond the boundary of the project site.

5.3 Odour Emissions Monitoring

Odour concentrations (in OU/m^3 or simply 'OU') and emission rates were determined for the following monitoring locations at the project site:

- **Monitoring Location A** Leachate Pond;
- **Monitoring Location B** Leachate Collection Manhole Cover;
- **Monitoring Location C** Stage 2 Landfill Surface (open pipe or gas collection wellhead near eastern boundary of Stage 2);
- **Monitoring Location D** Working Face (4 separate 'roaming' locations);
- **Monitoring Location E** Stage 2 Landfill Surface (2 m west of **Monitoring Location C** near eastern boundary of Stage 2);
- **Monitoring Location F** Stage 2 Landfill Surface (hose pipe protruding from landfill surface near southern boundary of Stage 2).

The odour concentrations and odour emission rates per unit area (odour units per second per square metre or OU/s/m^2) are shown in **Table 5–3**. The table indicates that the highest concentration and emission rate were measured at the leachate collection manhole cover (57,000 OU/m^3 and 23.8 OU/s/m^2, respectively). The results in the table indicate that, at the time that the monitoring was undertaken, the odour emissions from the leachate pond and working face were relatively low. Based on MWH's experience, there is the potential for odour emissions from the leachate pond and working face to be significantly higher than those measured in November 2014, particularly under warmer meteorological conditions (e.g. higher bacterial activity, temperature inversions, or maintenance on the leachate pond).

Reference should also be made to AirQuality's odour monitoring report dated 30 November 2014, which is presented in **Appendix B**. Photos of MWH's site visit, including odour monitoring locations, are contained in **Appendix C**.

The highest emission rates shown in **Table 5–3** were used as input into the dispersion model.

Table 5-3: Odour Emissions Monitoring Data for Levin Landfill on 18 and 19 November 2014

Sample ID	Source	Flow Rate (L/min)	Flow Rate (m^3/s)	Odour Concentration (OU/m^3)	Flux Hood Area (m^2)	Odour Emission Rate ($OU.m^3/s/m^2$)	Minimum Odour Concentration (OU/m^3)	Maximum Odour Concentration (OU/m^3)	Range in Odour Concentration (OU/m^3)	Mean Odour Concentration (OU/m^3)	Coefficient of Variation (CV) (as %)
001	**Monitoring Location A** Leachate Pond	3	0.00005	220	0.12	0.09	170	270	100	220	23%
002		3	0.00005	270	0.12	0.11	-	-	-	-	-
003		3	0.00005	170	0.12	0.07	-	-	-	-	-
004	**Monitoring Location B** Leachate Collection Manhole Cover	3	0.00005	57000	0.12	23.75	53000	57000	4000	55667	4%
005		3	0.00005	57000	0.12	23.75	-	-	-	-	-
006		3	0.00005	53000	0.12	22.08	-	-	-	-	-
007	**Blank**	3	0.00005	<16	0.12	-	-	-	-	-	-
008	**Monitoring Location C** Stage 2 Landfill Surface - Open Pipe Near Eastern Boundary of Stage 2	3	0.00005	11000	0.12	4.58	11000	14000	3000	12500	17%
009		3	0.00005	14000	0.12	5.83	-	-	-	-	-
010	**Monitoring Location D** Working Face (Roaming: 4 Separate Monitoring Locations)	3	0.00005	360	0.12	0.15	360	3600	3240	2240	73%
011		3	0.00005	1400	0.12	0.58	-	-	-	-	-
012		3	0.00005	3600	0.12	1.50	-	-	-	-	-
013		3	0.00005	3600	0.12	1.50	-	-	-	-	-
014	**Monitoring Location E** Stage 2 Landfill Surface - Near Eastern Boundary of Stage 2	3	0.00005	2700	0.12	1.13	2400	2700	300	2567	6%
015		3	0.00005	2600	0.12	1.08	-	-	-	-	-
016		3	0.00005	2400	0.12	1.00	-	-	-	-	-
017	**Monitoring Location F** Stage 2 Landfill Surface - Near Southern Boundary of Stage 2	3	0.00005	1200	0.12	0.50	1200	4300	3100	2733	57%
018		3	0.00005	4300	0.12	1.79	-	-	-	-	-
019		3	0.00005	2700	0.12	1.13	-	-	-	-	-

5.4 Dispersion Modelling Assessment for Odour

5.4.1 Meteorological Modelling

5.4.1.1 Wind Speed and Direction

The annual wind roses for the hourly wind speed and direction data output from TAPM for 2012 for the project site, Levin AWS and Paraparaumu Aero AWS are shown in **Figures D–39** to **D–41** in **Appendix D**, respectively.

The annual wind roses for the hourly wind speed and direction data output from CALMET for 2012 for the project site, Levin AWS and Paraparaumu Aero AWS are shown in **Figure D–42**, **Figure D–45** and **Figure D–46** in **Appendix D**, respectively. The seasonal and hour of the day wind roses for 2012 using hourly data extracted from CALMET for the Project Site are shown in **Figures D–43** and **D–44** in **Appendix D**, respectively.

Analysis of the CALMET data indicates that the annual mean wind speed for 2012 for the project site was 3.0 m/s, compared with the annual mean wind speed of 2.7 m/s measured at the Levin AWS in 2012. The frequency of calm wind conditions over the 1-year period was 4.4% (compared with 5.1% measured at the Levin AWS).

The following wind speed frequencies were predicted at the project site over the 1-year period:

- Wind speeds between 0.5 m/s and 1.5 m/s 'Light Air' or Beaufort 1 26.9%;
- Wind speeds between 1.5 m/s and 3 m/s 'Light Breeze' or Beaufort 2 29.9%;
- Wind speeds between 3 m/s and 5.5 m/s 'Gentle Breeze' or Beaufort 3 24.4%;
- Wind speeds between 5.5 m/s and 8 m/s 'Moderate Breeze' or Beaufort 4 10.2%;
- Wind speeds between 8 m/s and 10.5 m/s 'Fresh Breeze' or Beaufort 5 3.4%; and,
- Wind speeds greater than or equal to 10.5 m/s 'Strong Breeze' or Beaufort 6 0.8%.

The wind speed frequencies predicted at the project site over the 1-year period are also shown in **Figure 5–4**.

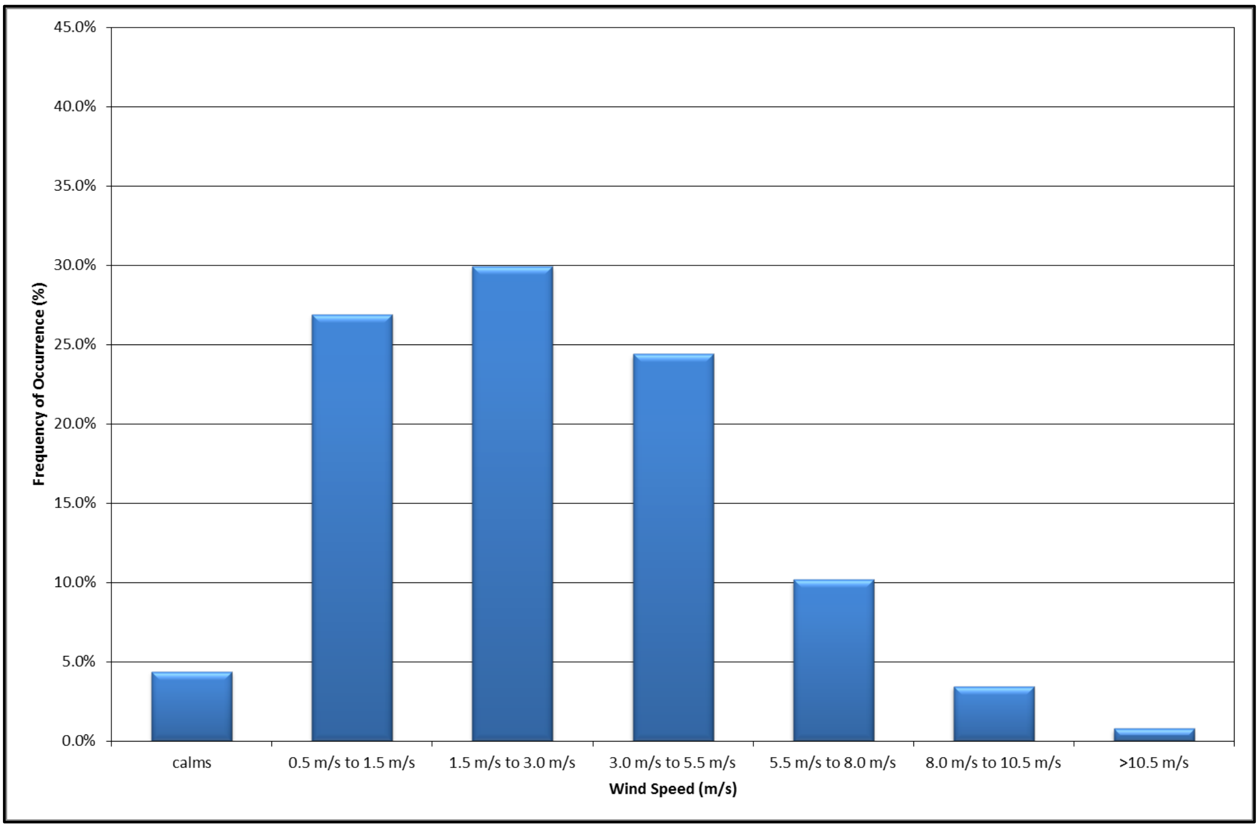

Figure 5-4: Wind Speed Frequency Distribution at the Project Site for 2012

The annual and seasonal wind roses predicted by CALMET for the project site are in good agreement with the wind roses for the TAPM-generated data for the project site (CALMET input data) and the actual monitoring data collected at the Levin AWS in 2012. The annual wind rose generated using the CALMET output data for the project site shows that the predominant wind directions were from the WNW, W and NW, and the highest wind speeds (>10.5 m/s) occurred during winds from the WNW and NW.

5.4.1.2 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford assignment scheme identifies six stability classes: “A” to “F”, which categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions.

Stability class “A” represents highly unstable conditions that are typically found during summer, categorised by strong winds and convective conditions. Conversely, Stability class “F” relates to highly stable conditions which typically occur at night-time and are associated with clear skies, light winds and the presence of a temperature inversion. Classes “B” through to “E” represent conditions intermediate to these extremes.

The frequency of occurrence of each stability class predicted by CALMET at the project site for the 1-year period is presented in **Figure 5–5**.

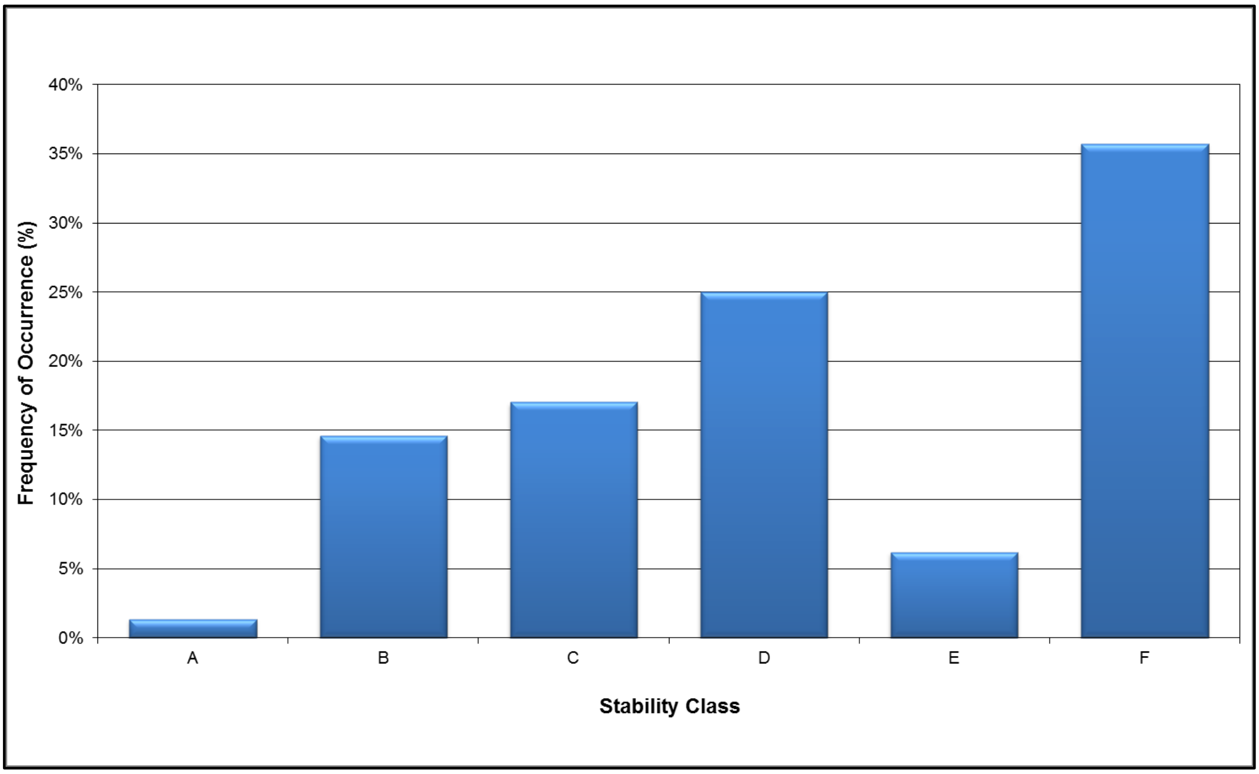

Figure 5-5: Stability Class Frequency Distribution at the Project Site for 2012

The results indicate a high frequency of conditions typical of stability class “F”, indicative of highly stable conditions which have the potential to impede atmospheric odour dispersion at the project site. These conditions were predicted to occur during the early morning and evening.

5.4.1.3 Mixing Height

Diurnal variations in maximum and average mixing heights predicted by CALMET at the project site for the 1-year period are shown in **Figure 5–6**.

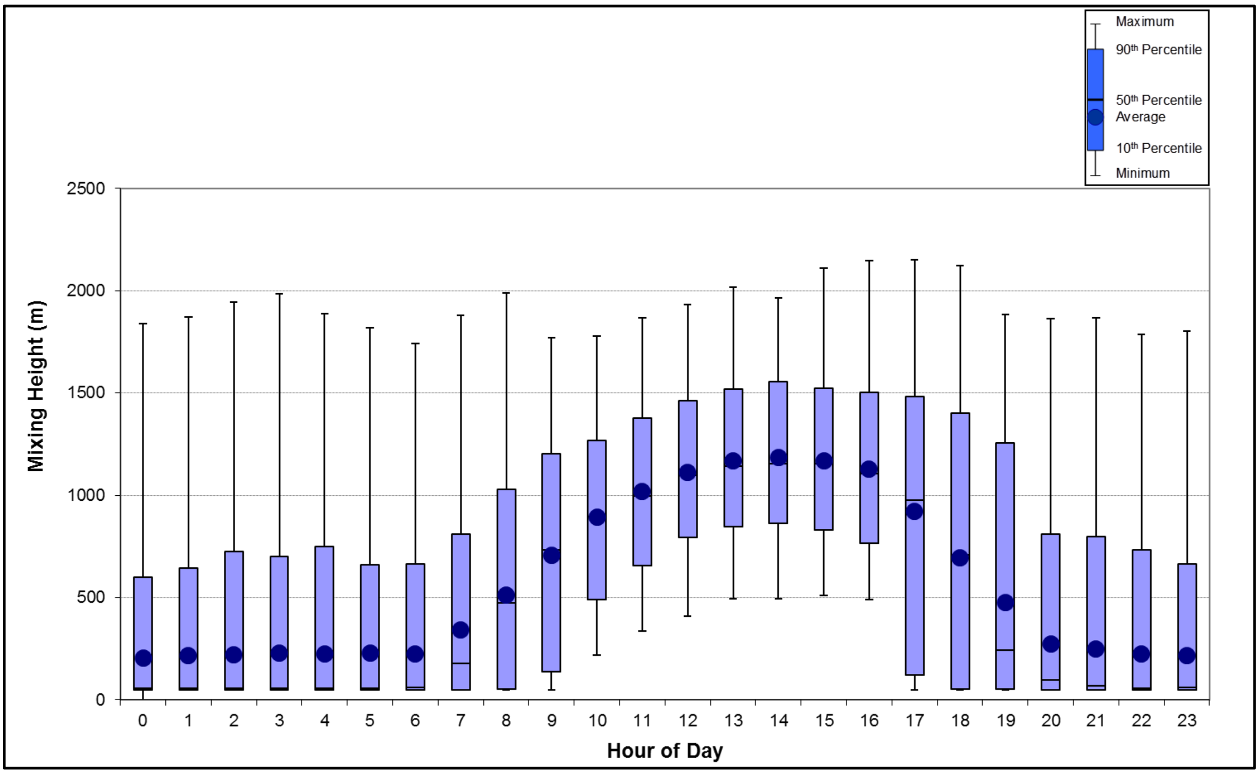

Figure 5-6: Diurnal Variations in Mixing Height at the Project Site for 2012

It can be seen that an increase in the mixing height occurs during the morning, due to the onset of vertical mixing following sunrise. The figure indicates that the maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and the growth of the convective mixing layer.

5.4.1.4 Ambient Temperature

A time-series plot of the hourly air temperature data extracted from CALMET for the 1-year period at the project site is shown in **Figure 5–7**. As expected, the highest temperatures were predicted to occur in the summer months (December to February) and the lowest temperatures occurred in the winter months (June to August).

Diurnal variations in maximum and average ambient temperature predicted by CALMET at the project site for the 1-year period are shown in **Figure 5–8**. It can be seen that an increase in temperature occurred during the morning following sunrise, and that the maximum temperature occurred in the mid afternoon.

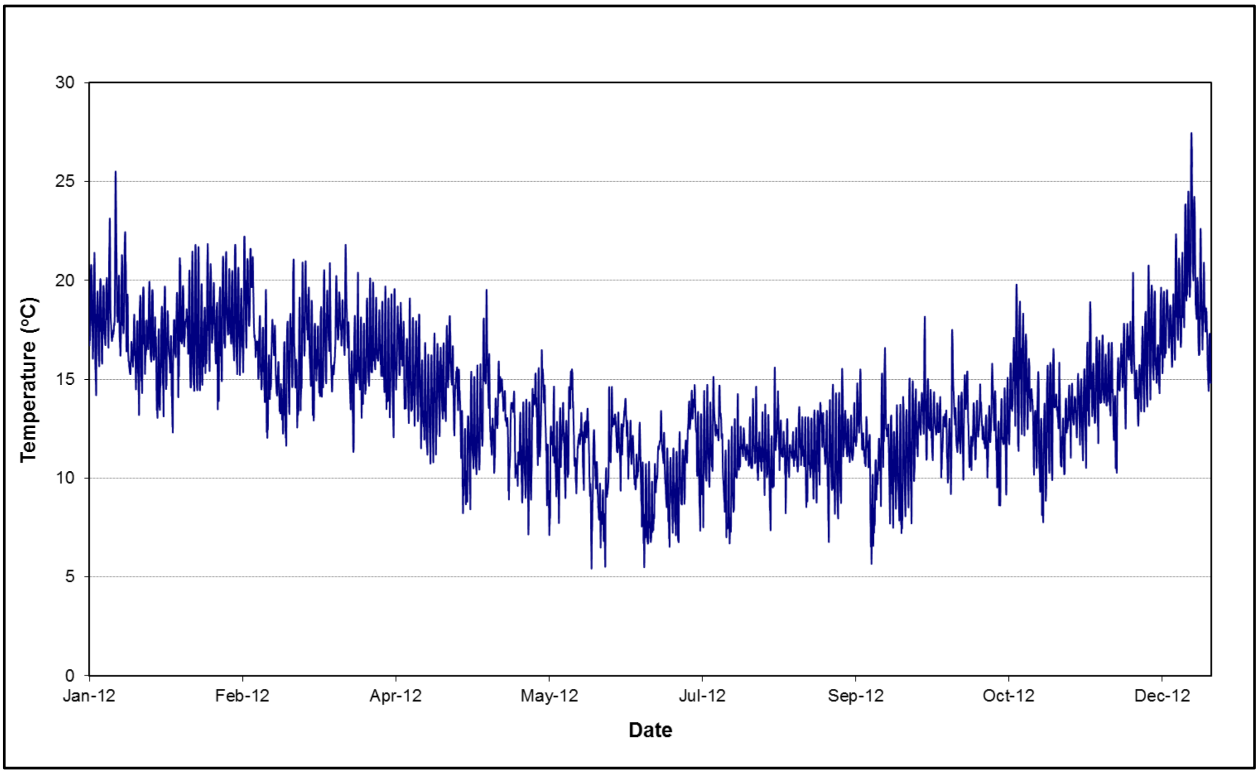

Figure 5-7: Time-series Plot Showing Ambient Temperature at the Project Site for 2012

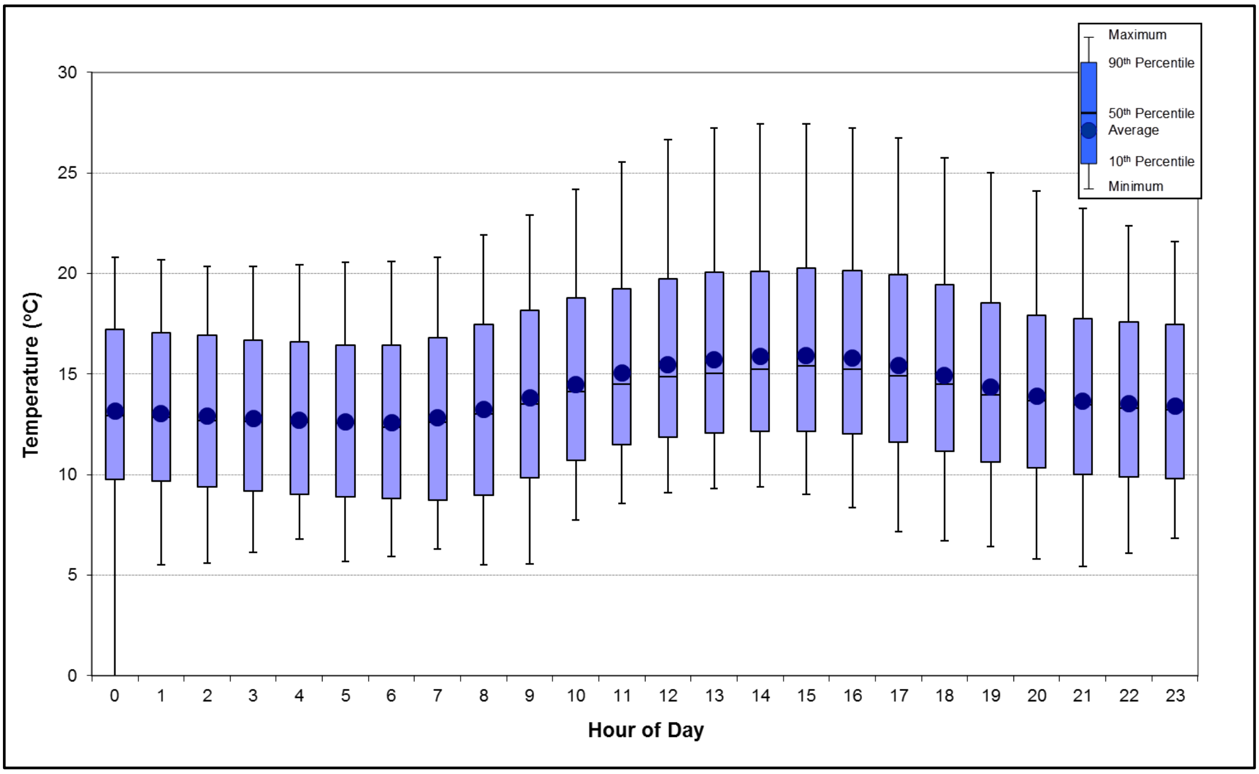

Figure 5-8: Diurnal Variations in Ambient Temperature at the Project Site for 2012

5.4.2 Dispersion Modelling

The aim of the dispersion modelling assessment in this study was not to confirm or deny the odour complaints history (refer **Section 1**) but to assess the potential benefits associated with undertaking a number of mitigation options (assessed as four separate modelling scenarios). Furthermore, there is an accepted degree of uncertainty regarding results generated by atmospheric dispersion modelling, particularly for odour. Some of the limitations of the present dispersion modelling study include:

- Potential under-estimation of odour emissions at the leachate pond and working face. As noted earlier, there is the potential for odour emissions at these sources to be higher from time-to-time, particularly in the warmer, summer months due to an increase in bacterial activity, leading to an increase in odour emissions. It is also possible that the landfill gas and odour emissions from the Stage 2 hotspot locations are variable, and that the emission rates at these locations were also under-estimated, based on the results of the landfill surface emissions monitoring;
- The influence of local site-specific meteorology (as opposed to TAPM-generated meteorology) on the dispersion of odour and uncertainties in meteorological data used, including model input parameters and assumptions (involving both TAPM and CALMET), including differences between the 2012 CALMET data file and the actual meteorology corresponding to the period of complaints;
- Local buildings/structures, trees and/or complex terrain on odour dispersion. Simplifications in building and site topography and reduced ventilation effects around trees have the potential to lead to under-predictions by the model; and,
- General limitations and assumptions contained within the dispersion model algorithms.

The 99.9th percentile (99.9%ile) 1-hour mean ground-level odour concentrations predicted at each discrete sensitive receptor location by CALPUFF for Scenarios 1 to 4 are shown in **Table 5–4**.

Table 5-4: 99.9%ile 1-hour Mean Ground Level Odour Concentrations

Sensitive Receptor Ref.	99.9th Percentile 1-hour Mean Odour Concentration (OU/m^3)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
R1	0.24	0.23	0.10	0.10
R2	0.18	0.17	0.08	0.07
R3	0.16	0.16	0.07	0.07
R4	0.14	0.14	0.05	0.05
R5	0.15	0.15	0.06	0.06
R6	0.13	0.13	0.05	0.05
R7	0.10	0.09	0.04	0.04
R8	0.13	0.13	0.05	0.05
R9	0.14	0.14	0.06	0.05
R10	0.15	0.14	0.06	0.06
R11	0.15	0.15	0.06	0.06
R12	0.14	0.14	0.06	0.06
R13	0.13	0.13	0.05	0.05
R14	0.11	0.11	0.05	0.04
R15	0.09	0.09	0.04	0.04
R16	0.09	0.09	0.04	0.04

The 99.9th percentile 1-hour mean ground-level odour concentrations predicted by the model for Scenarios 1 to 4 (refer **Section 3.6** for further details) are shown in the isopleth (contour) plots in **Figure 5–9** to **Figure 5–12**, respectively.

The modelling results indicate that no exceedances of the assessment criterion of 2 OU/m^3 were predicted at or beyond the site boundary (including the sensitive receptor locations) for all four modelling scenarios.

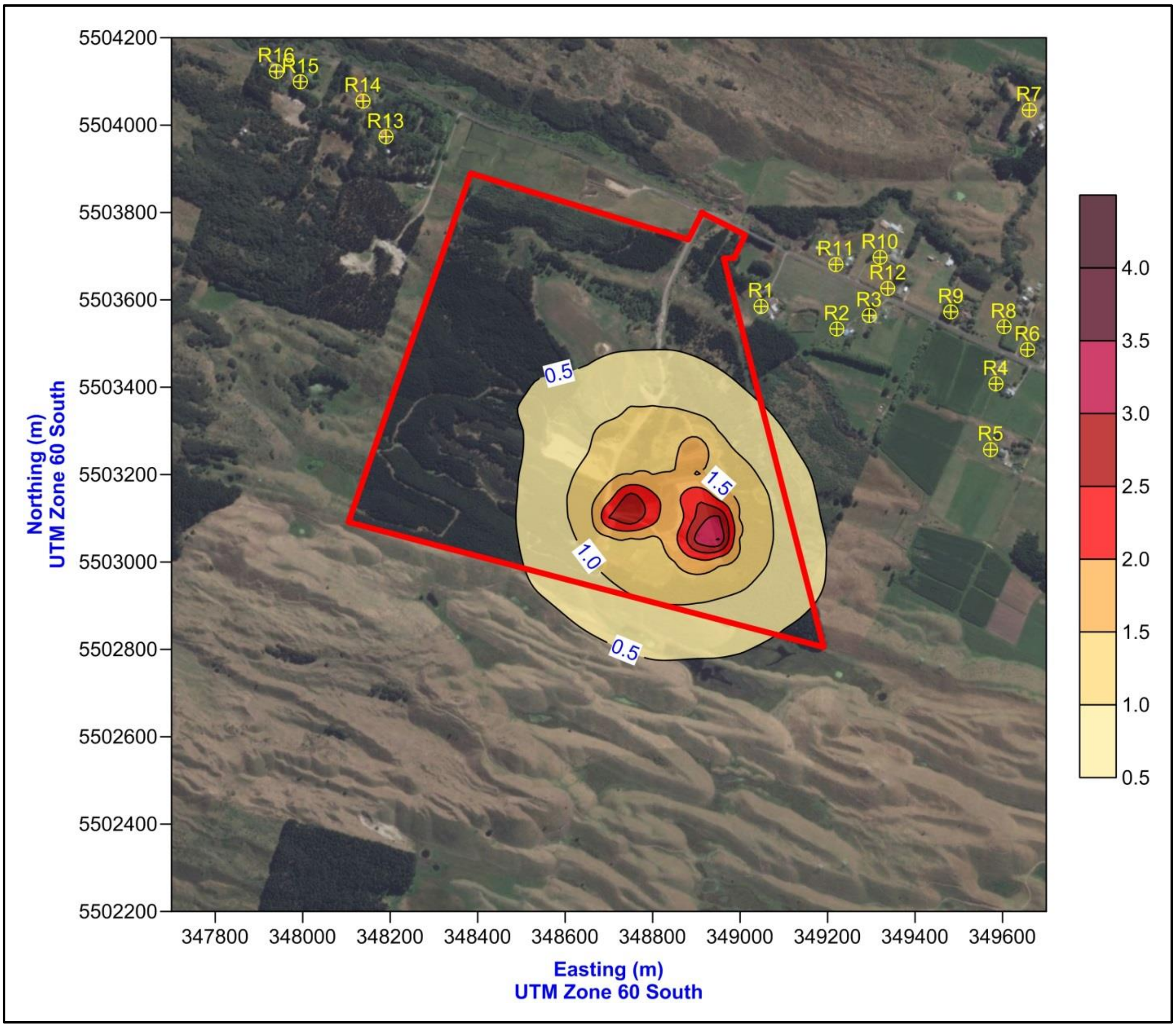

Figure 5-9: 99.9%ile 1-hour Mean Ground Level Odour Concentration (OU/m^3) for Scenario 1

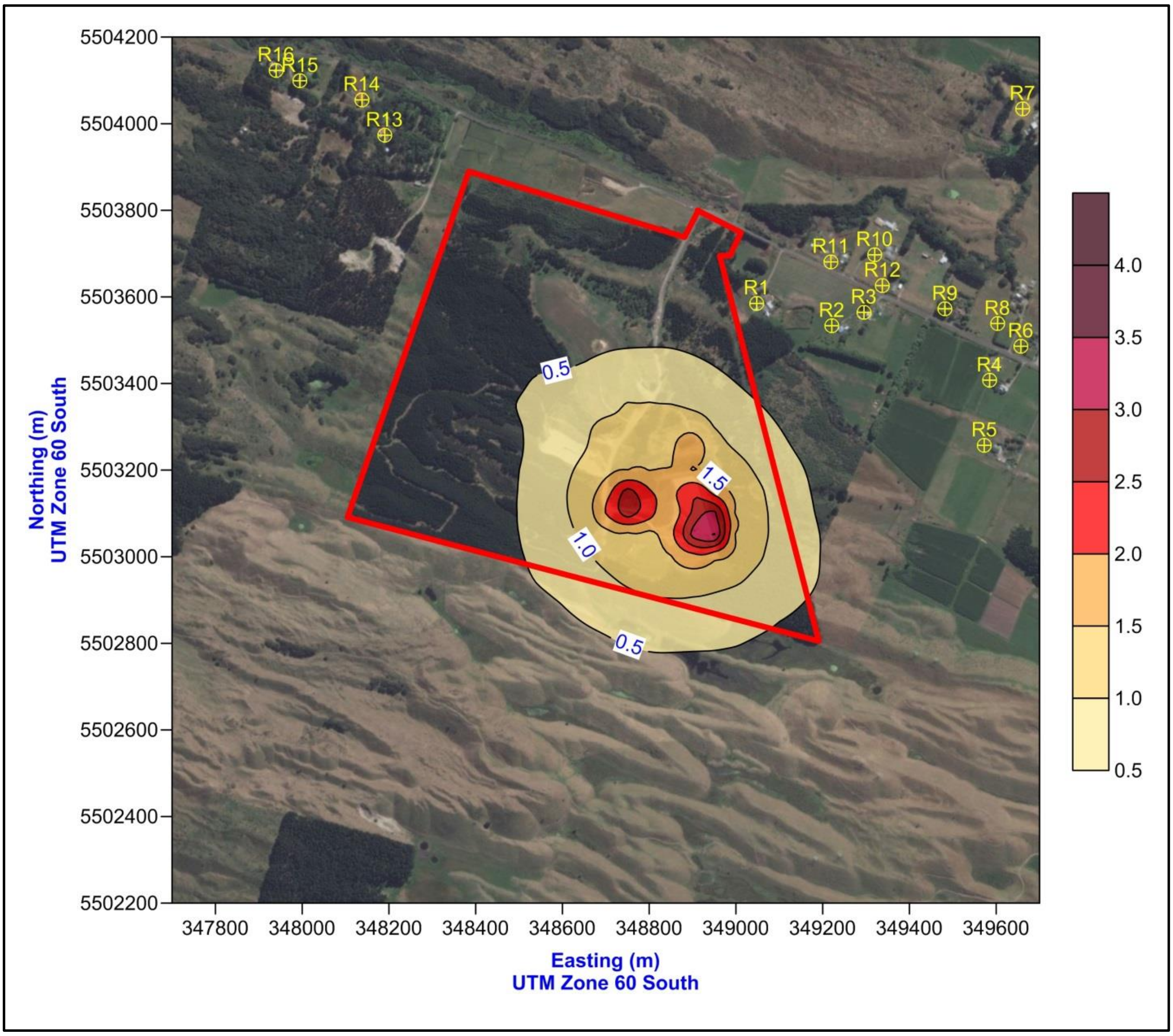

Figure 5-10: 99.9%ile 1-hour Mean Ground Level Odour Concentration (OU/m^3) for Scenario 2

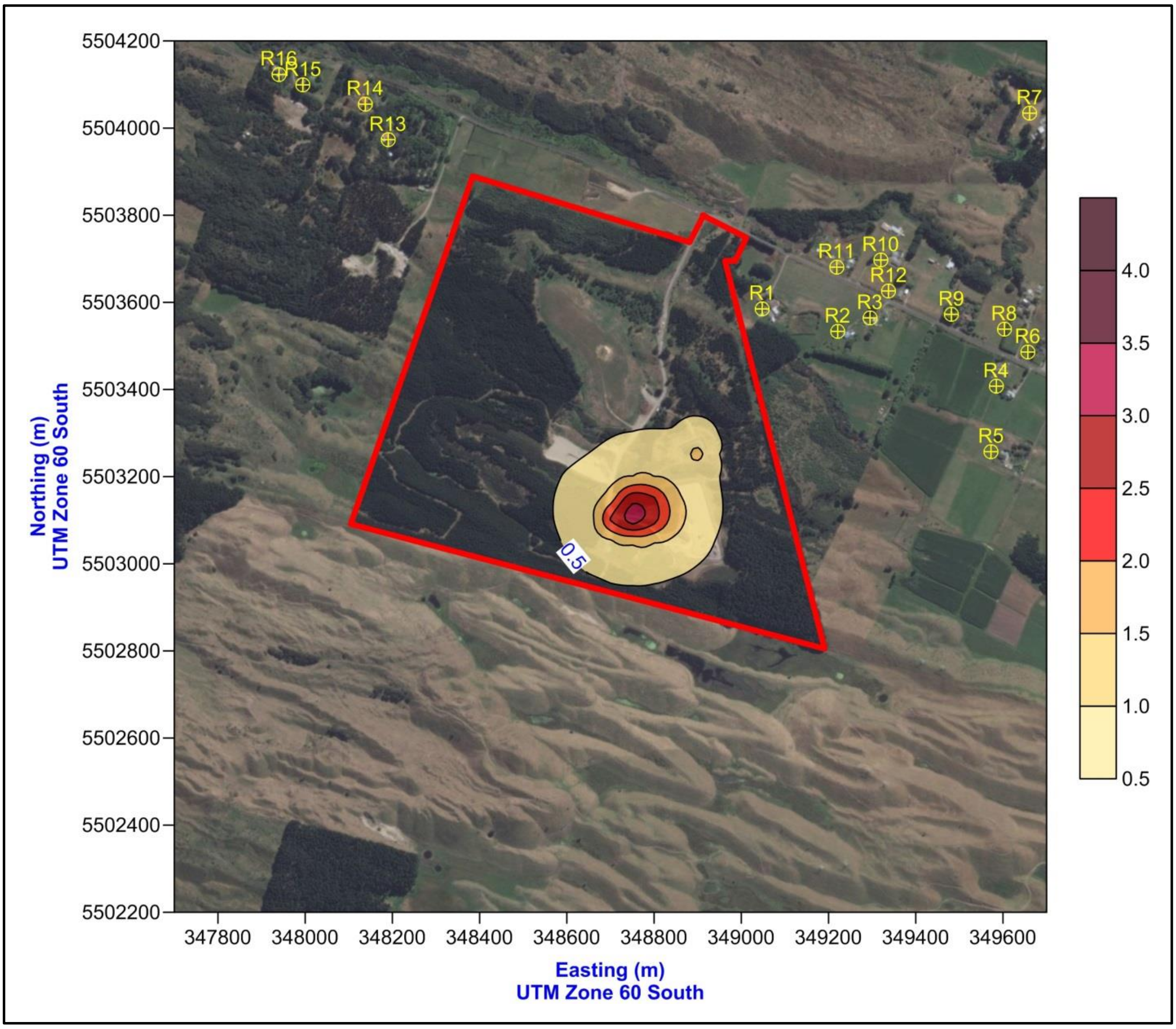

Figure 5-11: 99.9%ile 1-hour Mean Ground Level Odour Concentration (OU/m^3) for Scenario 3

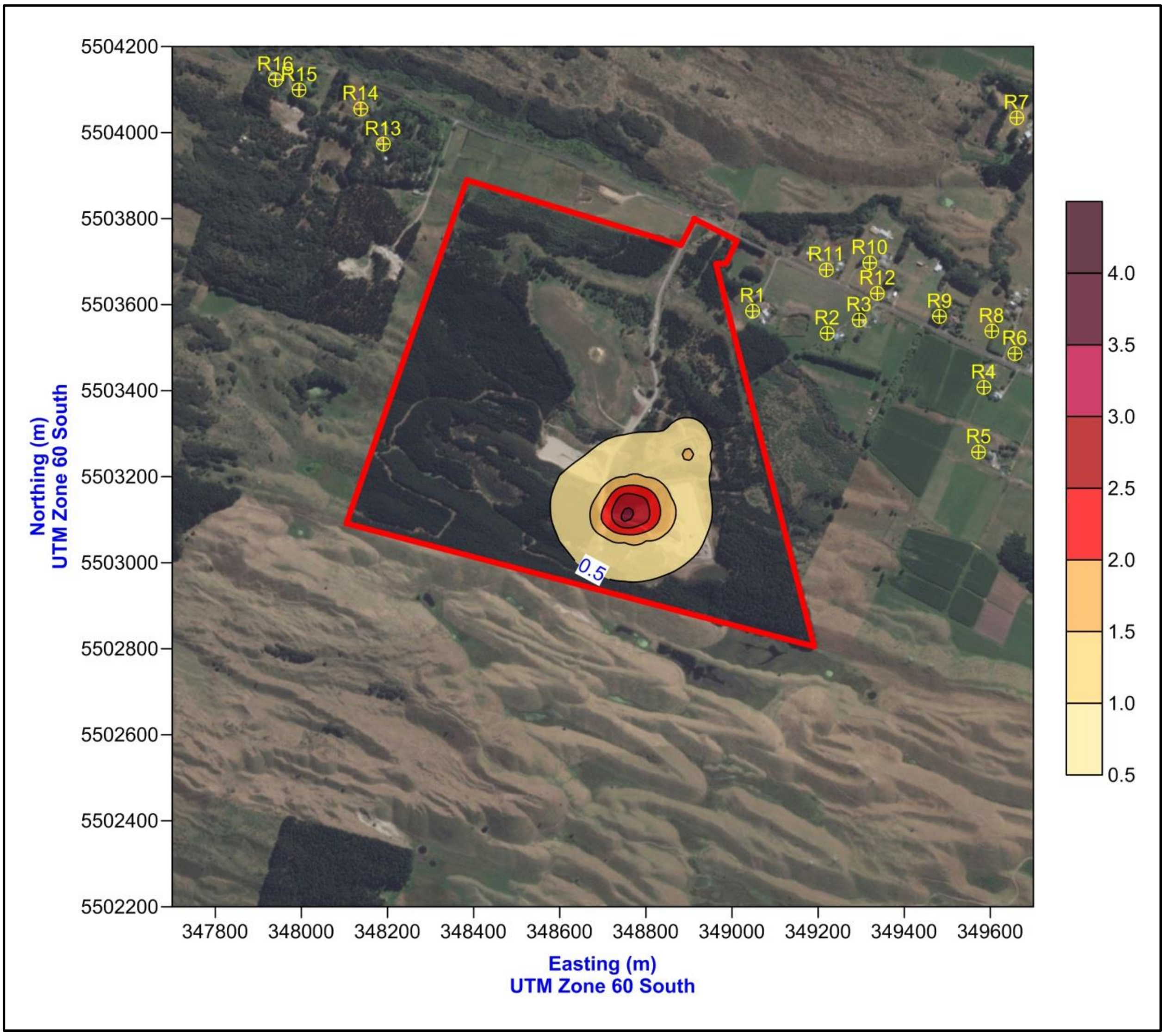

Figure 5-12: 99.9%ile 1-hour Mean Ground Level Odour Concentration (OU/m^3) for Scenario 4

Table 5–4 and **Figure 5–9** indicate that the highest 99.9th percentile 1-hour mean odour concentration predicted at any location beyond the site boundary for Scenario 1 (existing or baseline conditions) was 0.5 OU/m^3, whilst the highest concentration predicted at any sensitive receptor location was 0.2 OU/m^3 (receptor 'R1'). This residential property is owned by Mr and Mrs Grange and is located at 645 Hōkio Beach Road. The odour complaints made by Mr and Mrs Grange regarding odour emissions at the landfill were discussed in **Section 1.6**.

The results for Scenario 1 (**Figure 5–9**) also indicate that the maximum onsite concentration was predicted to be 4 OU/m^3 on Stage 2 and slightly downwind of the litter fence, which would suggest that there is the potential for offensive or objectionable odours at these locations. This is in agreement with the results of the field odour investigation presented in **Section 5.2.2**.

Assuming that the modelling uncertainty in the present study is a factor of 10 (i.e. the predicted modelling results presented above are multiplied by 10), the highest 99.9th percentile 1-hour mean odour concentration predicted at any location beyond the site boundary for Scenario 1 would be 5 OU/m^3, whilst the highest concentration predicted at any sensitive receptor location would be 2 OU/m^3. In other words, the adjusted modelling results (after applying a conservative arbitrary correction factor) would indicate that there is the potential for odour nuisance effects at receptor 'R1', which would corroborate the odour complaints made by Mr and Mrs Grange.

However, the adjusted modelling results (after correction) also indicate that there are unlikely to be odour nuisance effects at receptor 'R1' following the implementation of the mitigation measures recommended in this report. For example, the results for Scenario 3 suggest that with the implementation of effective cover across Stage 2 the maximum 99.9th percentile 1-hour mean concentration at receptor 'R1' would be 1 OU/m^3, which means that odour has the potential to be detected from time-to-time but is unlikely to be objectionable or offensive (i.e. result in a nuisance complaint).

The results (after correction) for Scenario 2 indicate that with the implementation of a biofilter at the leachate collection manhole to control odour from the manhole there is unlikely to be a significant reduction in odour concentrations beyond the site boundary: the maximum 99.9th percentile 1-hour mean concentration at receptor 'R1' would be similar to the existing or baseline conditions (Scenario 1) at 2 OU/m^3. In other words, based on the site's complaints record, there is still the potential for odour nuisance effects at receptor 'R1' unless the Stage 2 fugitive emissions are effectively controlled. The recommended improvements to the leachate collection manhole (refer **Section 6**) have a greater potential to alleviate health and safety concerns regarding work undertaken at and within the manhole rather than to result in a significant reduction in odour nuisance effects, based on the modelling results.

The modelling assessment has incorporated an arbitrary uncertainty factor of 10, which is considered to be conservative, based on MWH's experience. However, the use of uncertainty factors in New Zealand and Australia (and internationally) in dispersion modelling assessments is still not common, however, modellers commonly quote a 'factor of two' as being a tolerable limit of accuracy for model predictions (MfE, 2004); and it must be borne in mind that model predictions are only an *indication* of expected concentrations. Another method of assessing modelling uncertainty is to undertake a sensitivity study involving multiple (or iterative) modelling runs whereby a number of input parameters are used (such as different emission rates and varying emission profiles, source characteristics, site-specific meteorological data, higher resolution terrain and land use data, and different dispersion options). After re-running the model several times for different key input parameters, the mean plus or minus twice the standard deviation could then be reported to give an estimate of uncertainty (ADMLC, 2004). Ultimately, however, the actual uncertainty factor in the present study is rather academic, and given the high level of complaints lodged by Mr and Mrs Grange, the modelling results have been adjusted using an arbitrary uncertainty factor of 10 to assess the potential benefits associated with undertaking a number of different mitigation options. The uncertainty factor of 10 used in this report was based on a review of the potential sources of modelling error (discussed above), particularly the potential under-estimation of some of the odour emission sources input into the model, and following a simple model 'headroom' analysis. The latter involved subtracting the odour guideline (2 OU/m^3) from the model prediction for Scenario 1 at receptor 'R1' (0.24 OU/m^3) to determine the 'gap' between the two values. Dividing the gap by the odour guideline then gives the model 'headroom'. In this case, the headroom is 0.88, which is considered to be '*high*' or '*large*' (>0.8 for 1-hour predictions), according to EA (2007), and, therefore, an uncertainty factor of 10 in the present study is considered appropriate, if not conservative.

In summary, providing that the mitigation measures recommended in this report are adhered to by the landfill operator at all times (refer **Section 6**), including but not limited to effectively controlling the fugitive landfill gas and odour emissions across Stage 2, the results of the dispersion modelling assessment indicate that the potential for odour nuisance effects will be significantly reduced.

5.5 Discussion

Mr and Mrs Grange currently own a property located at 645 Hōkio Beach Road (or receptor 'R1') and they have recently made a number of complaints regarding odour emissions at the Levin Landfill. The odour complaint's record was reviewed earlier in this report (see **Section 1**). Despite that fact that it is not known whether HRC has verified these complaints, the complaint's record was given precedence over the results of the dispersion modelling assessment, in accordance with MfE (2003).

Based on a review of the complaint's record and the odour assessment undertaken in this report, MWH considers that the odour nuisance events at 645 Hōkio Beach Road are mostly likely to be low-intensity odours being detected frequently over a long period, with high-intensity odours being detected less frequently.

Whilst the local meteorological data indicates that the frequency that winds blow towards the complainant's property is low (less than 5%), the findings presented in this report indicate that odour emissions, particularly from emission hotspots located on Stage 2, have the greatest potential to cause odour nuisance effects in the surrounding community, particularly under stable atmospheric conditions with calm or low wind speeds (e.g. temperature inversions).

Employing the mitigation measures recommended in **Section 6** has the potential to significantly reduce the likelihood of causing further odour nuisance effects. These mitigation measures include applying effective capping across Stage 2 to reduce landfill gas and odour emissions to the minimum practicable level, and also implementing improvements at the leachate pond, working face, leachate collection manhole and flare/landfill gas collection system (if required). These recommendations have been incorporated into the proposed Odour Management Plan contained in **Appendix E**.

Providing that these mitigation measures are adhered to by the landfill operator at all times, MWH considers that the potential for further odour nuisance effects will be significantly reduced. These measures should be implemented onsite by HDC at the earliest possible opportunity.

6 Mitigation Measures

This section contains a number of mitigation measures which should be implemented at the Levin Landfill in order to reduce the potential for odour nuisance effects. These mitigation measures should be implemented in two phases. The Phase One mitigation measures should be implemented immediately, while the Phase Two (higher level odour control) mitigation measures should only be implemented if it is determined from ambient air quality monitoring and additional surface emissions monitoring and field odour investigations (as recommended in Phase One), that odour is still not being effectively controlled such that there are no objectionable or offensive odours beyond the site boundary. Reference should also be made to the Odour Management Plan (OMP) in **Appendix E**.

An example of an odour complaint recording sheet is contained in **Appendix F**.

All work at the Levin Landfill should be undertaken in accordance with the requirements of the RMA, the Health and Safety in Employment Act 1992 (HSE) and the Health and Safety in Employment Regulations 1995 (as amended December 2013).

6.1 Phase One Mitigation

6.1.1 Field Odour Investigation for the Flare

As the flare was not operating during MWH's site visit, it was not possible to assess it. The flare is a potential source of unburned volatile organic compounds (VOCs), including odour, particularly if it is incorrectly sized and the combustion efficiency is low. MWH recommends that, in addition to undertaking continuous, real-time ambient air quality monitoring, as recommended in **Section 6.1.8**, that a field odour investigation (sniff testing) is undertaken in accordance with MfE (2003) by an experienced odour scout at the earliest possible opportunity, possibly coinciding with the ambient air quality monitoring. The purpose of the field odour investigation should be to determine whether odour emissions from the existing flare have the potential to cause odour nuisance effects beyond the site boundary. It would also be useful to undertake a field odour investigation for the principal odour emission sources identified in this report.

6.1.2 Leachate Pond

The following mitigation measures should be implemented at the leachate pond to reduce the potential for the release of nuisance odour from this source:

- Ensure that the residence time of the leachate held in the leachate pond is reduced as far as practicable before it is pumped for treatment at the Levin Wastewater Treatment Plant, as this will ensure that the intensity of any odour released from the pond is kept to a minimum. According to HDC, the residence time is currently 12 days and it is considered that this may need to be reduced from time-to-time to control the release of odour from this source;
- Ensure that the build-up of algae and/or scum on the surface of the pond is avoided as far as is possible and practicable and that the sides of the pond are regularly cleaned to remove any deposited material that may have accumulated;
- There is the potential for the release of offensive odours from the anaerobic decay of wet organic matter following a significant drop in the water level of the leachate pond. Avoid significant changes to the leachate level in the leachate pond, where possible and practicable;
- Ensure that the leachate in the pond is sufficiently aerated (e.g. monitor for dissolved oxygen (DO) on a monthly basis). In the event that an aerator is required to be used, care should be taken not to disturb the sludge at the bottom of the pond as this has the potential to release odour; and
- Ensure that the leachate collection system and pipework are regularly inspected and maintained to ensure that they are in full working order. The leachate collection system and pipework should be regularly cleaned and flushed to ensure that there are no blockages and that they are free from algae and/or scum. Ensure that any maintenance work, including de-sludging of the pond, is undertaken with sufficient prior warning having been given to the local residents and avoid certain meteorological conditions (e.g. winds from the SW or SE), as far as possible and practicable. It may also be necessary to cover the pond if maintenance work is to be repeated over more than one working day, and this work should be scheduled so as to avoid the potential for working extending into the weekend, as far as practicable.

Options to treat the leachate onsite before it is pumped to the Levin Wastewater Treatment Plant are currently being considered by HDC. Whilst aerobic treatment systems have often been used on landfill sites in the past, they are costly to construct and operate, and often space is limited. An alternative option involving a low-cost, low-maintenance treatment system for closed landfills or for small to medium sized landfills, such as the Levin Landfill, has been considered, which uses peat as the treatment medium to remove both the biochemical oxygen demand (BOD) and ammonia in the leachate. Whilst no detailed description or designs were available at the time of writing this report, the design of such a treatment system must take into account the potential for odour emissions (ammonia) to be generated. The potential benefit of reducing the release of odour from the leachate pond (and BOD and ammonia in the leachate) must be weighed against the potential increase in ammonia-type odours.

In the absence of a leachate treatment system and in the event that high intensity odours which have the potential to cause adverse effects beyond the site boundary are released from the leachate pond over a sustained period of time, HDC should consider replacing the open leachate storage with tanks. Alternatively, the leachate pond could be covered and the air extracted for treatment in a biofilter or combusted in a flare. At this stage, however, MWH does not consider that this mitigation measure is required to be undertaken, based on the findings of this report.

6.1.3 Working Face and Waste Disposal

HDC should ensure that the landfill contractor has an adequate supply of suitable daily cover to ensure that the depth and type of cover used is effective in the mitigation of odour releases at the working face. Daily cover should be progressively applied and should comprise of non-putrescible, non-odorous, non-combustible material and may include soil and sand. In other words, daily cover material should not be itself a source of odour. Typical depths of daily cover at the working face and flanks should be approximately 150 mm (for soils and sand) by the end of each working day. However, the type and thickness of daily cover required will depend on the nature and age of the waste, the meteorological conditions (including the surface and air temperature) and the wind speed (usually low winds speeds are associated with odour complaints) and wind direction in relation to sensitive receptors, and the rate of site filling. A degree of caution is required if shredded green waste is to be used as daily cover as some waste may have composted and, therefore, may have become a source of odour.

Whilst sand is readily available at the project site, MWH considers that, on occasion, soils or mulched woody material (MWM), such as wood chips or bark, could be used. MWM or soil-based cover materials containing micro-organisms may promote oxidation of trace organic chemicals diffusing through it, thereby reducing the odour potential of the emission source. It may be necessary to apply thicker layers of daily cover, from time to time, or to designate certain cells for intermediate cover (e.g. areas where filling will not be daily). However, a degree of caution is needed if non-draining soil types are to be used. The main problems arising from the use of non-draining soil types (e.g. soils with a high clay and silt content) include the formation of low permeability layers within the waste when subsequent layers of waste are compacted, which could result in difficulties in leachate and landfill gas control. Careful consideration should also be given to the use of contaminated soils, if applicable, as this may be a source of odour. Furthermore, emissions to air of dust and particulate matter from the storage, transfer and application of soil or sand as a daily cover material should be effectively mitigated such that there are no dust nuisance effects at or beyond the site boundary.

Cover integrity should be continually assessed by site staff during operations. Regular inspections by the landfill site manager should be carried out during the day and at the end of each working day to check that the cover is adequate and to audit the effectiveness of ongoing inspections. These audits and inspections are particularly important prior to periods of unmanned site closure, such as weekends and holidays.

Malodorous waste must be buried immediately once received and covered with non-odorous waste (daily cover). It may be necessary to consider implementing waste acceptance criteria, thereby not receiving specific types of odorous loads, or to change the operation in regard to when odorous loads are accepted and how they are handled. If it is not possible or practicable to refuse the tipping of highly odorous material (e.g. putrefied food waste or animal carcasses) unless it is treated prior to arrival onsite, HDC should consider only tipping this material under certain meteorological conditions which are not likely to lead to complaints (e.g. stable atmospheric conditions with low wind speeds from the SW, which may inhibit dilution and dispersion and cause odour nuisance at nearby sensitive receptors). It is noted, however, that the disadvantage of tipping highly odorous waste under these meteorological conditions must be weighed against the advantage gained through rapid tipping of waste to prevent a sustained period of impact. The tipping of malodorous waste should also be restricted after 4:00 pm and before 7:00 am the following day in order to reduce the potential for high intensity odours being released after site closure.

Rather than implementing waste acceptance criteria, it may be necessary for the landfill operator to liaise with the local transfer stations and its customers to minimise the time that the material is stored in transfer stations prior to arrival to site (e.g. through a ‘first in, first out’ stock rotation programme). This will reduce the age of waste at the time of delivery to the landfill to the minimum practicable level and, if possible, will ensure that the waste is delivered prior to putrefaction.

The landfill site staff should assess the risk of all waste to determine whether it has a low, medium or high odour risk (based on its hedonic tone), and it may be necessary, from time to time, to inspect the incoming waste. Gypsum and other high sulphate-bearing waste, for example, must not be disposed of in the same cell as other biodegradable waste in order to reduce the potential production of hydrogen sulphide (including odour). Additional control measures may be required for high odour risk waste, such as weather-related/seasonal tipping restrictions, immediate deep burial or damping down during tipping.

HDC should ensure that the total surface area of the working (tipping) face is limited in size, as far as practicable, so that the area of uncovered material is restricted. It is noted, however, that the tipping area must be sufficiently large to allow waste to be disposed of and compacted in a safe and timely manner. The landfill operator currently operates over a tipping area of approximately 80 m^2.

Whilst the use of odour masking agents (e.g. perfumes) may reduce the effect of odours, based on MWH’s experience, they can be, in some cases, just as unpleasant as the waste odour they are masking. Therefore, a degree of caution is required in the selection and operation of odour masking agents, if they are to be used onsite.

6.1.4 Stage 2 Effective Capping

The intermediate cover (sand and mulch) currently on Stage 2, based on MWH’s experience, does not meet current best practice or best available technique for odour control, partly because the monitoring results have indicated that it is not being effective at reducing odour emissions to the minimum practicable level, but also due to the fact that it is likely to remain as intermediate cover for a period of more than 6 months.

HDC should consider applying effective capping (e.g. clay layer) across Stage 2 to reduce fugitive odour and landfill gas emissions across the current intermediate (sand and mulch) cover area, particularly at the hotspot locations determined during the surface emissions monitoring walkover survey (refer **Section 5**). The configuration and staging of the landfill will determine whether this effective capping layer should be temporary or final. However, the clay cap should be of sufficient thickness (e.g. at least 1 m) to reduce the potential for fugitive emissions from settlement-induced surface cracks.

Whilst the effectiveness of the Stage 2 landfill gas collection system (e.g. pipe materials and well spacing) and flare was not assessed as part of the present study, MWH considers that the continued operation of the gas collection system and flare (see below), and the implementation of effective capping across Stage 2 (including fixing the open pipe/gas collection wellhead on the eastern boundary) has the potential to significantly reduce the fugitive odour and landfill gas emissions across Stage 2. The immediate removal of any material (such as hose pipes) protruding from the landfill surface on Stage 2 and the installation of an effective cap across Stage 2 with high integrity and low conductivity will allow for effective landfill gas (and odour) capture and will minimise fugitive emissions from the landfill surface.

MWH recommends that a landfill surface emissions monitoring walkover survey is undertaken following the implementation of the Stage 2 effective capping and aforementioned maintenance measures to ensure that odour and landfill gas emissions have been reduced to the minimum practicable level and that there are no defects (weakness or failures) in the capping layer. A similar walkover survey (along with visual and odour or “sniff” investigations) should be undertaken at least once a month by the landfill operator to ensure that the capping layer has not been compromised over time. This should not be restricted to Stage 2, but should also be undertaken across the final capping area on the old closed landfill and Stage 1a, albeit on a less frequent (e.g. 6 monthly) basis, or as otherwise required. Any defects identified during the inspections and monitoring surveys should be reported to the landfill site manager and repaired as soon as practicable.

The Stage 2 capping and gas collection and flaring operation should remain unaffected by the Stage 3 (or future) operations. Upon completion of Stage 3, and at the time of final capping across Stages 2 and

3, the landfill operator should avoid the need for excavation into old waste wherever possible, as this has the potential to release high intensity odours.

It was also mentioned earlier that there were no visible signs of surface cracking at the Stage 2 emission hotspot locations, and that the exact cause of these high LFG and odour emissions is not known. It is possible that there is a leak (or multiple leaks) from one (or several) of the landfill gas collection pipes fitted to the wellheads located along the eastern boundary of Stage 2. MWH recommends that the vacuum control valves fitted on each wellhead on Stage 2 and on Stage 1a are checked to ensure that the gas collection system is functioning correctly and in accordance with best practice. It may be necessary to adjust the vacuum applied at each individual wellhead and, if monitoring ports have been fitted, to measure the flow (e.g. differential pressure), temperature, pressure, and composition of the LFG. The leachate collection efficiency should also be determined either from visual inspections or from monitoring the liquid inside each wellhead, as a build-up of leachate inside a well will reduce the potential for gas to move into the well (thus reducing the gas collection efficiency).

6.1.5 Leachate Collection Manhole

The leachate collection manhole was determined from the landfill surface emissions monitoring walkover survey to contain a potentially explosive atmosphere (above LEL for methane), whilst also being a significant, albeit local, emission source of odour and LFG. MWH recommends that consideration is given to extracting the air from the leachate collection manhole for treatment by combustion in a flare, or if that is not possible or practicable, by biofiltration. It is noted that there is sufficient room for a biofilter immediately to the north of the leachate collection manhole. Providing that the air can be extracted and treated safely and effectively for treatment in a flare or biofilter, the LFG and odour emissions at this source have the potential to be significantly reduced.

MWH has also recommended to HDC that a cordon (e.g. security fence and access gate) should be immediately put in place around the manhole to restrict access to the manhole until an odour control facility (e.g. biofilter) has been installed and has been found to be operating effectively at reducing LFG and odour emissions, and monitoring for methane and hydrogen sulphide has determined that it is safe for staff to work at the manhole. Regular monitoring for methane and/or hydrogen sulphide should be undertaken thereafter on a monthly basis, or as otherwise required.

6.1.6 Engagement and Communication

A number of the recommendations discussed above involve a proactive and transparent communication style between, predominantly, the landfill operator (including HDC) and the local community (including the Neighbourhood Liaison Group), and consequently the role of the regulator as a conduit for information transfer is reduced. It is possible that by adopting an operator-public dominated communication style, foreseen odour events (e.g. planned maintenance or tipping of highly odorous waste) can be avoided, and in the case of unforeseen events, can be resolved promptly and transparently.

Further benefits may include:

- Reduced delays in receipt of odour complaints by the site, implementing corrective action and responding to complaints. Direct communication may even lead to a reduction in complaints recorded by the regulator;
- The regulator is able to follow-up with the landfill operator upon receipt of an odour complaint to ensure that corrective action and a response to the complainant have been undertaken (without direct pressure from the public);
- The local community will be able to receive direct, accurate and relevant feedback from the landfill operator in relation to any specific unforeseen event; and
- The landfill operator will be able to effectively notify the public before carrying out any scheduled works which have the potential to cause a significant increase in odour emissions, such as a short-term odour event (e.g. de-sludging the leachate pond) which has a long-term benefit.

MWH recommends that any odour complaints received by the landfill operator or HDC should be reported to HRC within 7 working days of receiving the complaint, and should detail any corrective measures implemented onsite, and the follow-up action taken with regards responding to the complainant. An example of an odour complaint recording sheet is contained in **Appendix F**.

6.1.7 Weather Station

As part of the OMP (see **Appendix E**), it is recommended that a meteorological station is established in a suitable location on the site to measure, as a minimum, the onsite wind speed and direction. Other parameters which could also be measured at little additional cost include: ambient temperature; relative humidity; atmospheric pressure; and rainfall.

The meteorological station should be positioned as far away from buildings and trees as possible, as these structures may affect the wind flow. The onsite meteorological data may be used for the following reasons:

- To manage the occasions when high intensity odours may be released at the site. For example, it may be necessary to avoid undertaking maintenance work on the leachate pond (e.g. de-sludging) under SW winds as these winds may carry odour towards the nearest sensitive receptor (645 Hōkio Beach Road or sensitive receptor 'R1'). It may also be necessary to not accept highly odorous material under SW wind conditions if tipping such material is likely to cause odour complaints; and
- To corroborate (or contradict) any odour nuisance complaints that may arise during the continued operation of the landfill.

The meteorological station should be sited and operated in accordance with the MfE's *'Good Practice Guide for Air Quality Monitoring and Data Management'* (MfE, 2009).

6.1.8 Continuous Ambient Air Quality Monitoring

In addition to the operation of a weather station on the site (see above), consideration should be given to installing and operating a continuous, real-time air quality monitor to measure ambient concentrations of methane as an indicator (surrogate) of odour. Alternatively, monitoring for ambient concentrations of hydrogen sulphide and/or VOCs could be undertaken. The ambient air quality monitoring would be particularly useful when planning to undertake maintenance on the leachate collection manhole and/or landfill gas collection system (or any event which may cause a significant discharge to air of LFG or odour).

As per the meteorological station, the ambient air quality monitor should be positioned as far away from buildings and trees as possible, and preferably at the same location as the weather station. However, the co-location of the air quality monitor with the weather station is not crucial and it may be more appropriate to locate the monitor between the emission source and the nearest sensitive receptor (residence at 645 Hōkio Beach Road, or receptor 'R1'). The operator may wish to position the monitor either close to the emission source or to the nearest sensitive receptor, depending on the nature and type of the release (e.g. providing it is safe), and providing that a power supply can be installed.

As mentioned earlier, continuous ambient air quality monitoring (in addition to ongoing landfill surface emissions monitoring and field odour investigations/sniff testing), also has the potential to determine the effectiveness of the flare (and gas collection system) in controlling LFG and odour emissions at the site.

The ambient air quality monitoring station should be sited and operated in accordance with the MfE's *'Good Practice Guide for Air Quality Monitoring and Data Management'* (MfE, 2009).

6.1.9 Dust Control and Litter Management

In addition to the above mitigation measures for odour, MWH recommends that the onsite stockpiles of sand, soil and mulch are regularly damped down to reduce the onsite propagation of particulate matter by wind, and thus the potential for dust nuisance effects at or beyond the site boundary. It may also be necessary to screen some of the stockpiles where fine material is stored (e.g. sand), and to damp down the sand deposited at the working face (and across Stage 3) during dry and windy meteorological conditions.

During MWH's site visit in November 2014, it was noted that there was a small amount of windblown litter which had been caught in the litter fence located at the SE corner of Stage 2, and also some litter which had blown over the top of the litter fence and had been caught in the adjoining trees and vegetation. Whilst the amount of litter beyond the litter fence was relatively low, compared with other landfill sites, and despite the fact that a strong wind was blowing from the WNW during the visit, MWH recommends that improvements are made to the litter fence (including litter management practices) in order to reduce the potential for windblown litter evading the litter fence in the future.

6.2 Phase Two Mitigation

Continuous ambient air quality monitoring, as recommended in **Section 6.1.8**, in addition to ongoing landfill surface emissions monitoring and field odour investigations (sniff testing), has the potential to determine the effectiveness of the existing flare in controlling LFG and odour emissions at the site.

Upon completion of the implementation of the Phase One mitigation measures, and in the event that the ambient air quality monitoring and ongoing surface emissions monitoring and field odour investigations indicate that the release of odour at the landfill, including the flare, is being effectively controlled such that there are no objectionable or offensive odours beyond the site boundary, in the opinion of an HRC enforcement officer or experienced odour scout, HDC may wish to review the costs/benefits of continuing to operate the existing flare. This may also involve undertaking an independent odour assessment, and/or stack emissions testing or ambient monitoring for VOCs to determine the destruction efficiency of the flare. HDC will need to clearly demonstrate to HRC that the implementation of the Phase One mitigation measures has reduced the potential for further odour nuisance events in the surrounding community.

However, in the event that additional monitoring (as described above) indicates that odour emissions from the existing flare have the potential to cause offensive and objectionable odour effects beyond the site boundary, even after the implementation of the Phase One mitigation measures, MWH recommends that HDC replaces the existing flare with a more suitably sized one. The replacement flare, if required, should be used to control LFG and odour emissions at the site at all times, providing that there continues to be sufficient pressure and calorific value (CV) to allow for effective/efficient gas collection and treatment. The flare's odour (or more accurately VOC) destruction efficiency has the potential to be at least 98%, providing that it is operated at a minimum temperature of 750 °C and with a residence time of 0.5 seconds (i.e. in accordance with industry best practice). The flare should be designed to ensure that the minimum temperature and residence time can be achieved.

The gas collection system should be regularly inspected to ensure that there is adequate condensate removal and gas extraction vacuum to the flare. Where maintenance work to the flare or gas collection system is required which has the potential to release high intensity odours, consideration should be given to avoiding certain meteorological conditions (e.g. SW winds) and to giving local residents sufficient prior warning before embarking on such activities.

7 Conclusions

Based on the odour assessment undertaken in this report for Levin Landfill, MWH considers that the recent odour nuisance events at 645 Hōkio Beach Road (or receptor ‘R1’) are mostly likely to be low-intensity odours being detected frequently over a long period, with high-intensity odours being detected less frequently.

Whilst the local meteorological data indicates that the frequency that south-westerly winds may blow towards the complainant’s property is low (less than 5%), the findings presented in this report indicate that onsite odour emissions, particularly from emission hotspots located on Stage 2, have the potential to cause odour nuisance effects in the surrounding community, particularly under stable atmospheric conditions with calm or low wind speeds (e.g. temperature inversions), in the absence of appropriate mitigation.

Employing the mitigation measures recommended in **Section 6** has the potential to significantly reduce the likelihood of causing further odour nuisance effects in the surrounding community. These mitigation measures should be implemented in two phase: phase one includes applying effective capping across Stage 2 to reduce landfill gas and odour emissions to the minimum practicable level, and also implementing improvements at the leachate pond, working face and leachate collection manhole; whilst phase two involves operating a suitably sized flare to control odour (if required). These recommendations have been incorporated into the proposed site Odour Management Plan contained in **Appendix E**.

Providing that the mitigation measures recommended in this report are adhered to by the landfill operator at all times, MWH considers that the potential for further odour nuisance effects in the surrounding community will be significantly reduced. The phase one mitigation measures should be implemented onsite by HDC at the earliest possible opportunity.

8 References

ADMLC 2004. Guidelines for the Preparation of Dispersion Modelling Assessments for Compliance With Regulatory Requirements – An Update to the 1995 Royal Meteorological Society Guidance. ADMLC/2004/1 V1 for public comment.

EA, 2002. Integrated Pollution Prevention and Control Horizontal Guidance for Odour: Part 1 – Regulation and Permitting (Technical Guidance Note IPPC: H4), UK Environment Agency (EA), 2002.

EA, 2004. Using Science to Create a Better Place: Review of Dispersion Modelling for Odour Predictions, Science Report: SC030170/SR3, UK Environment Agency (EA), 2004.

MfE, 2003. Good Practice Guide for Assessing and Managing Odour in New Zealand, Ministry for the Environment, June 2003

MfE, 2004. Good Practice Guide for Atmospheric Dispersion Modelling, Ministry for the Environment, June 2004.

MfE, 2009. Good Practice Guide for Air Quality Monitoring and Data Management, Ministry for the Environment, April 2009.

Appendix A Existing Resource Consent

Determination – Discharge Permit 6011

Consent is granted to the Horowhenua District Council to **discharge landfill gas, odour and dust to air** at the Levin landfill, Hokio Road, Levin, legally described as Lot 3 DP 40743 Blk II Waitohu Survey District, for a term expiring 35 years from the commencement of the consent subject to the following conditions:

1. Charges, set in accordance with section 36(1)c of the Resource Management Act 1991, and section 690 A of the Local Government Act 1974, shall be paid to the Regional Council for the carrying out of its functions in relation to the administration, monitoring and supervision of this resource consent and for the carrying out of its functions under section 35 (duty to gather information, monitor, and keep records) of the Act.

   [**Note**: Section 36(1)c of the Act provides that Council may from time to time fix charges payable by holders of resource consents. The procedures for setting administrative charges are governed by section 36(2) of the Act and is currently carried out as part of the formulation of the Council's Annual Plan.]

   Environmental Effects

2. The Permit Holder will ensure dust is controlled on access roads and on the landfill, if necessary, by watering or other methods.

3. There shall be no discharge of odour or dust from the landfill that in the opinion of a Regional Council Enforcement Officer is noxious, dangerous, offensive, or objectionable beyond the property boundary. The Permit Holder will also ensure that:

   a. On-site and off-site Health and Safety Effects of landfill gas being emitted by the old landfill should be quantified by sampling groundwater monitoring wells for evidence of landfill gas when groundwater samples are taken from the wells. As a minimum, the gases tested for are to include methane, carbon dioxide and oxygen; and

   b. Any building constructed on the landfill site is adequately ventilated.

4. There shall be no deliberate burning of waste or other material at the landfill. If fires occur at the landfill they shall be extinguished as quickly as possible.

5. The Permit Holder shall take all practicable steps to avoid, remedy or mitigate significant adverse effects of the discharge of landfill gases to air.

   Monitoring and Reporting

6. The Permit Holder shall keep a record of any complaints received. The complaints record shall include the following, where possible:

   a. Names and addresses of complainant;

   b. Nature of complaint;

c. Date and time of the complaint and alleged event;

d. Weather conditions at the time of the event; and

e. Any action taken in response to the complaint.

The record shall be made available to the Regional Council on request.

The Permit Holder shall also keep a record of landfill gas monitoring results including:

a. Date and time of sampling;

b. The concentrations of gasses detected.

c. Weather conditions at the time of sampling.

The monitoring results shall be made available to the Regional Council on a quarterly basis.

7. The Regional Council shall initiate a publicly notified review of Conditions 3 and 6 of this permit in April 2015, 2020, 2025, 2030 and 2035, unless the Neighbourhood Liaison Group (NLG) agrees that a review is unnecessary. The reviews shall be for the purpose of:

a. Assessing the effectiveness of Conditions 3 and 6 of this consent;

in avoiding, remedying or mitigating adverse effects on the environment surrounding the Levin Landfill, the review of conditions shall allow for the:

b. Changes to Conditions 3 and 6 of this consent; and

c. Addition of new conditions as necessary;

to avoid, remedy or mitigate adverse effects on the environment surrounding the Levin Landfill.

Appendix B Odour Monitoring Report

AirQuality

Odour Monitoring

Levin Landfill

Final Report for:
MWH

30 November 2014

Report Number 1412.02

21 Barrys Point Road, Takapuna, Auckland. +64 (09) 282 5275
www.airqualityltd.com

Odour Monitoring Report

Levin Landfill

Monitoring Period:	17 November 2014 - 19 November 2014
Report Date	30 November 2014
Report Status:	Final
Report contents:	This report has been prepared for MWH. The report may be reproduced, either in part or in full, by any third party as long as the authors are cited as the source.
Authors:	Paul Baynham, AirQuality Ltd, ph 09 282 5275 Brett Wells, AirQuality Ltd, ph 09 282 5275
Distribution List:	Doug Boddy (MWH)

Executive Summary

AirQuality Ltd undertook odour sampling at the Levin Landfill over a two day period. A total of nineteen samples including one blank were collected during the monitoring period.

Source	Sample 1 Ou	Sample 2 Ou	Sample 3 Ou	Sample 4 Ou	Average Ou
Monitoring location A Leachate Pond	220	270	170	-	**220**
Monitoring location B Leachate collection manhole cover	57,000	57,000	53,000	-	**55,667**
Monitoring location C Stage 2 Landfill Surface - Open Pipe Near Eastern Boundary of Stage 2.	11,000	14,000	-	-	**12,500**
Monitoring location D Working Face (Roaming – 4 Separate Locations)	360	1400	3600	3600	**2240**
Monitoring location E Stage 2 Landfill Surface - Near Eastern Boundary of Stage 2.	2700	2600	2400	-	**2567**
Monitoring location F Stage 2 Landfill Surface - Near Southern Boundary of Stage 2.	1200	4300	2700	-	**2733**
Blank	<16				**<16**

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1.0 Introduction

AirQuality Limited were engaged by MWH to collect nineteen odour samples from the Levin Landfill over a three day period commencing on 17 November and concluding on 19 November 2014.

The work scope was in accordance with the draft proposal submitted by Mark Bart and accepted by MWH.

This report details the results of the odour monitoring carried out at the Levin Landfill on the 18th and 19th of November 2014.

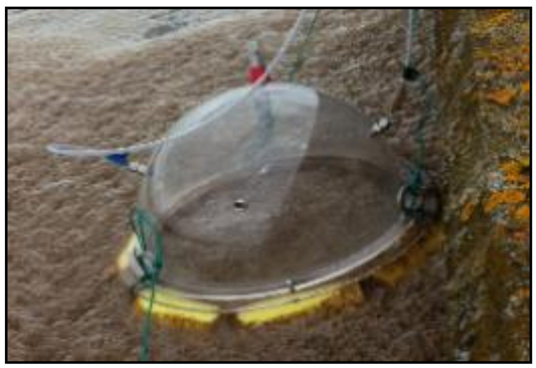
2.0 Methodology

2.1 Sampling methods

A total of eighteen samples and one blank were collected over a two day period.

All sampling was undertaken in accordance with AS/NZS 4323.3:2001 *Stationary Source Emissions: Part 3 Determination of odour concentration by dynamic olfactometry*. Sample lines consisted of heavy wall ¼" polytetrafluoroethylene (PTFE) tubing with stainless steel swagelok fittings.

Purpose made acrylic domes were manufactured to comply with the requirements of AS/NZS 4323.3:2001. The flux chambers were scrubbed and washed with clean water following each sample.



Tedlar odour sample bags were used. These bags were prepared by the odour testing laboratory in accordance with AS/NZS 4323.3:2001 prior to sampling. Each sample bag was preconditioned twice with the sample gas prior to sample collection.

Odourless ultra-pure nitrogen was used as a carrier gas. This was used in preference to zero air for two reasons:

1. Nitrogen is inert and assists with minimising chemical reactions between odorous chemical species during transport to the laboratory; and

2. Nitrogen reduces any risk of combustion from methane within the odour sample during transport (by plane) to the laboratory.

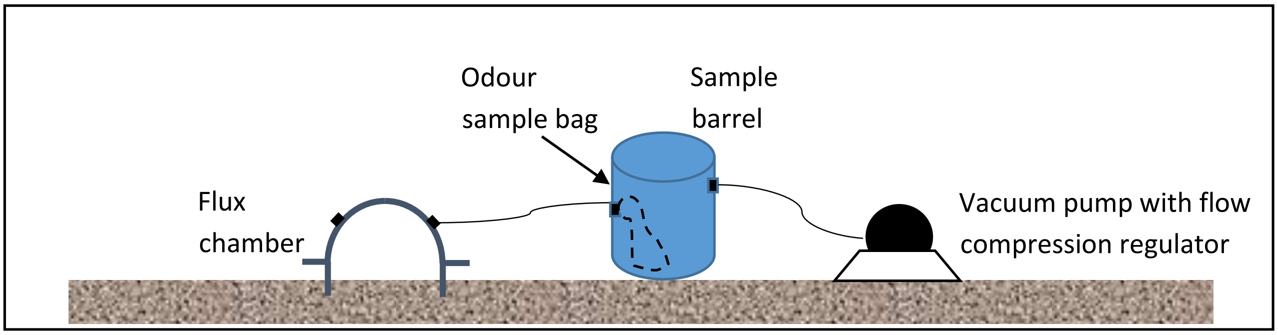
All lines were flushed with nitrogen for a minimum of 2 minutes following sampling to remove any residual odour.

Samples collected using the flux chamber used variable flow rates to ensure steady state conditions (and these conditions were maintained within the flux chamber during sampling). Following deployment, the sample chamber was left to condition for a minimum of 10 minutes prior to commencing odour sampling.

The calibration equipment is listed in **Appendix B**.

In order to accurately quantify each source, two different techniques were used. These are described in sections 2.1.1 – 2.1.2.

2.1.1 Static flux chamber

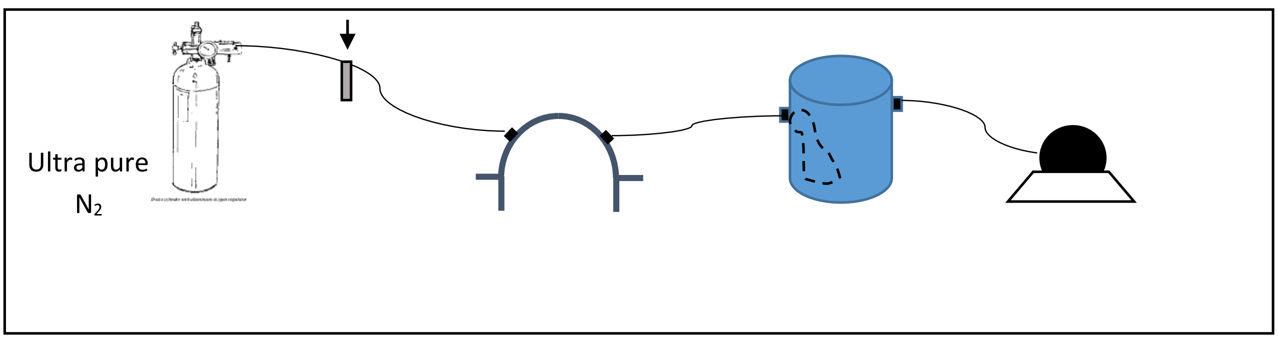


The static flux chamber was used on landfill beds with a low to moderate air flow of between 4 and 5 litres per minute.

After the flux chamber was installed, it was left for several minutes to ensure ambient air was purged from the chamber and steady state emissions could be maintained within the chamber. The airflow from the chamber was then measured using a calibrated gas flow meter and the flow rate calculated (based on the area of the flux chamber).

If the flow rate from the chamber was low, the vacuum pump was used to assist with sample collection, however flow rates with this system needed to be very low to ensure steady state conditions were maintained throughout the sampling.

2.1.2 Dynamic flux chamber



The dynamic flux chamber method was used to sample odour from the leachate pond.

The technique involves introducing a 'sweep' gas usually either ultra-pure nitrogen or 'zero' grade air to collect odours from the surface. The gases are then extracted from the flux chamber into a sampling bag by using a vacuum pump coupled with a compression flow regulator to create a vacuum within the sampling barrel.

2.2 Sample locations

Figure 1.0 below is a satellite photograph of the Levin Landfill. The locations of the various sampling points are highlighted on the image below.

Figure 1.0 Satellite photograph of Levin Landfill (source Google Earth)

2.2.1 Monitoring Location A: Leachate Pond

The leachate pond was the first source sampled for odour at the Levin Landfill. The sampling point was located on the northern boundary of the pond adjacent to the gateway. The pond level had risen approximately 0.5 metres in depth due to heavy rainfall during the preceding day. There was a moderate westerly wind blowing at the time of sampling, although the site itself was relatively sheltered. There were faint dimethyl sulphide odours immediately adjacent to the surface of the pond, although these odours were not evident downwind of the pond during an odour screening survey.

Three odour samples were collected from the Leachate pond.

Figure 2.1 : Preparing the flux chamber for sampling at the edge of the leachate pond

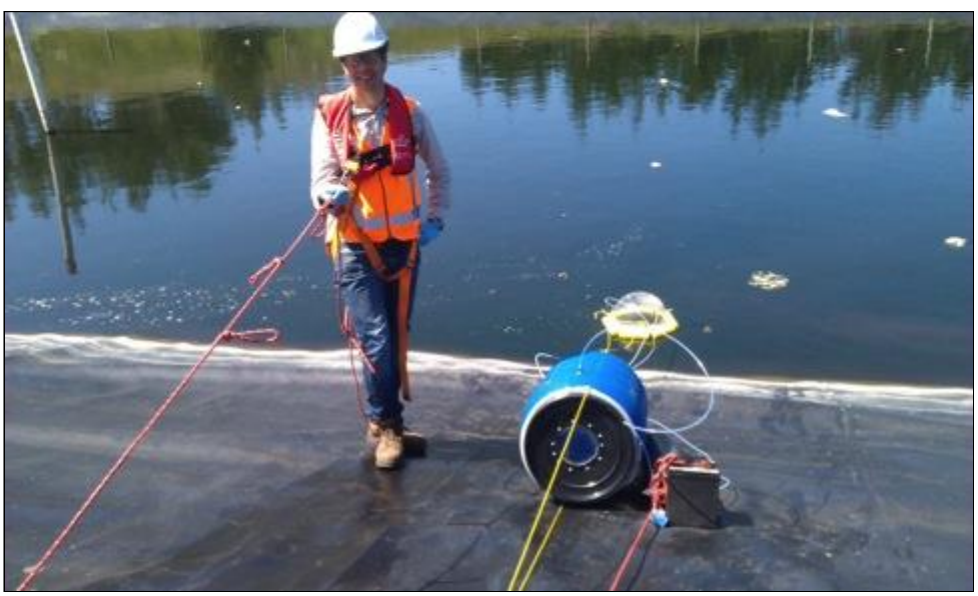


Figure 2.2 Sampling the Leachate pond. Minimal pond scum was evident during the sampling.

2.2.2 Monitoring Location B: Leachate collection manhole cover

The second sampling site was at the leachate collection manhole cover below the landfill tip face. There was a distinctive hydrogen sulphide odour present in the vicinity of the cover and the use of the Gas Rover instrument indicated relatively high methane levels. For this reason, care was taken to ensure the pump and power supply were situated well upwind of the manhole area.

The site consisted of a concrete manhole covered with a hinged iron grill. The rear section of the manhole contained a stainless steel pipe that extended approximately 4 metres into the air. While we initially intended to sample the gases from the manhole pipe, the height and location of the pipe made this impractical. As an alternative, it was noted that some gases were discharged from edge of the manhole cover and a decision was made to sample these fugitive emissions. The sample hood was placed over the corner of the grill from which most of the gases were discharging. Unfortunately, it was not possible to determine the flow rate from the manhole ventilation pipe at the time of sampling, based upon the leakage rate at the base of the vent, the author estimates a relatively low discharge rate of between 0.5 to 2 litres per minute.

2.2.3 Monitoring Location C: Stage 2 Landfill Surface - Open Pipe Near Eastern Boundary of Stage 2.

A third site was selected along the eastern landfill boundary where an uncovered drainage pipe exited from the landfill. Previous monitoring using the handheld Gas Rover instrument had identified this area as a source of methane.

Figure 3.1 and 3.2. Sampling odours discharging from the black pipe at the edge of the landfill. The black drainage pipe can just be seen inside the flux chamber.

This site was situated on the eastern boundary of the landfill and the prevailing westerly wind meant that this site was downwind of the landfill. Moderate landfill odours were evident throughout the sample period at this locality.

2.2.4 Monitoring Location D: Working Face (Roaming – 4 Separate Locations)

The fourth set of samples were collected early the following morning to avoid disrupting normal landfill operations at the tip face. Four samples were collected from a variety of locations across the active tip face. All four sites consisted of refuse that had been deposited the previous day and which had varying amounts of sand placed on or around the refuse. The weather conditions were similar to the previous day with light to moderate westerly winds in the morning rising to strong winds later in the day.

The active tip face consisted of an approximately 70 metre escarpment aligned roughly in a north to south orientation. The refuse consisted of general household and domestic debris including kitchen waste, paper, plastic and general household waste. The sample sites were selected on the basis of being generally representative of the active tip face.

SITE 1.

Site 1 consisted of general household waste partially buried with sand. It appeared to be a day or two older than the rest of the tip face as much of the organic waste was drier than that evident on the rest of the active tip face.

Figures 4.1 and 4.2 depicting the location of sample site one on the active tip face.

SITE 2.

Site 2 was situated approximately 10 metres south of Site 1 and also consisted of partially buried domestic waste. The waste at site 2 appeared to have been deposited more recently than the waste at Site 1.

Figures 4.3 depicting the location of sample site two on the active tip face while **Figure 4.4** reveals the refuse upon which the flux hood was sampling.

SITE 3.

Site 3 was approximately 20 metres south of site 2 and consisted of recently disposed domestic refuse. The sample was collected further up the tip face than the previous two samples.

Figure 4.5 depicting the location of sample site three on the active tip face while **Figure 4.6** reveals the refuse upon which the flux hood was sampling.

SITE 4.

The final site was located on the southern boundary of the tip face and appeared to be the most recent refuse present at the tip face.

Figures 4.7 depicting the location of sample site four on the active tip face while **Figure 4.8** reveals the refuse upon which the flux hood was sampling.

2.2.5 Monitoring Location E: Stage 2 Landfill Surface - Near Eastern Boundary of Stage 2.

The fifth set of samples were collected from a gas dsicharge identified during a walkover screening survey. Aside from a slight depression in the surface of the landfill, there was nothing significant about the site. The odour monitoring flux hood was placed over the site and left to equilibrate over a 20 minute period prior to sampling commencing.

Three samples were collected from this site over a 60 minute period.

Figure 5.1 Sampling of the gas discharge identified during the walkover survey the preceding day.

Figure 5.2 Sampling of the gas discharge identified during the walkover survey the preceding day.

2.2.6 Monitoring Location F: Stage 2 Landfill Surface - Near Southern Boundary of Stage 2.

The final site was identified as a piece of alkathene hose which protruded from the surface of the landfill. The site was situated approximately 40 metres north of the flare stack. The site had been identified as a source of methane gas using the Gas Rover instrument during a walk over the preceeding day.

The flux hood was used to cover both the landfill surface and the entire length of hose. The flux hood was left to equilibrate for a 20 minute period prior to sampling commencing.

The black hose can be seen within the flux chamber in Figure 6.0 below.

Figure 6.0 Sample collection at the final site. The black hose can be seen within the flux hood.

2.3 Laboratory analysis

The samples were analysed by EML Air Pty limited, a Melbourne based laboratory that specialises in odour measurement. EML Air is accredited by the (Australian) National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources (Accreditation number 2732). EML Air is also accredited to Australian Standard 17025 – General Requirements for the Competence of Testing and Calibration Laboratories.

The convention (i.e. best practice) in AS/NZS 4323.3:2001 is to ensure that odour samples are analysed within 30 hours of collection. In order to meet this requirement and to allow sufficient time to transport the samples to the odour measurement laboratory in Melbourne, sample collection commenced at 06:00 New Zealand Standard Time (NZST) and was completed by 12:30 NZST.

2.4 Emission calculations

Flow rates were corrected to normal temperature and pressure (0°C, 101.3 kPa).

The odour concentration, expressed in odour units (OU), is the amount of dilution required for a trained panel of persons to detect a difference between the diluted air, and non-odorous air. Panellists must be within the normal population range against a reference (n-butanol). In other words, panellists must not have a too sensitive, or not sensitive enough, sense of smell.

Copies of the laboratory results field sheets and chain of custody documentation are appended to this report as **Appendix C.** The EML odour analysis report is appended to this report as **Appendix D.**

3.0 Results

The laboratory report is attached as **Appendix E** and summary results are presented below for the Levin Landfill.

3.1 Results

Table 1. Odour emissions from various sources at the Levin Landfill

Sample Number	Source ID	Flow rate		AirP	AirT	Flow rate	Odour concentration	Area of Flux hood	Specific Odour Emission Rate	CoV
		Actual	Standard[1]							
		l/s	l/s	hPa	DegC	m^3/s	Ou/m^3	m^2	$OU.m^3/m^2/s$	%
001	**Monitoring location A** Leachate Pond	3.0	3.1	1001	15.0	5.2E-05	220	0.12	0.10	23
002		3.0	3.1	1001	15.0	5.2E-05	270	0.12	0.12	
003		3.0	3.1	1001	16.0	5.2E-05	170	0.12	0.07	
004	**Monitoring location B** Leachate collection manhole cover	3.0	3.2	1005	16.0	5.3E-05	57000	0.12	24.94	4
005		3.0	3.2	1005	16.0	5.3E-05	57000	0.12	24.94	
006		3.0	3.2	1005	17.0	5.3E-05	53000	0.12	23.27	
007	Blank	-	-	-	-	-	-	-	-	-

[1] Set to 0 Degrees Celsius and 101.3 kPa.

Sample Number	Source ID	Flow rate		AirP	AirT	Flow rate	Odour concentration	Area of Flux hood	Specific Odour Emission Rate	CoV
		Actual l/s	Standard[2] l/s	hPa	DegC	m^3/s	Ou/m^3	m^2	$OU.m^3/m^2/s$	%
008	**Monitoring Location C** Stage 2 Landfill Surface - Open Pipe Near Eastern Boundary of Stage 2	3.0	3.2	1005	18.0	5.3E-05	11000	0.12	4.85	17
009		3.0	3.2	1005	17.0	5.3E-05	14000	0.12	6.15	
010	**Monitoring Location D** Working Face (Roaming – 4 Separate Locations)	3.0	3.1	1006	11.0	5.2E-05	360	0.12	0.15	93
011		3.0	3.1	1006	12.0	5.2E-05	1400	0.12	0.60	
012		3.0	3.1	1006	12.0	5.2E-05	3600	0.12	1.56	
013		3.0	3.1	1006	12.0	5.2E-05	3600	0.12	1.56	
014	**Monitoring Location E** Stage 2 Landfill Surface - Near Eastern Boundary of Stage 2.	3.0	3.1	1003	13.0	5.2E-05	2700	0.12	1.17	6
015		3.0	3.1	1003	13.0	5.2E-05	2600	0.12	1.12	
016		3.0	3.1	1003	13.0	5.2E-05	2400	0.12	1.04	
017	**Monitoring Location F** Stage 2 Landfill Surface - Near Southern Boundary of Stage 2.	3.0	3.1	1002	13.0	5.2E-05	1200	0.12	0.52	57
018		3.0	3.1	1002	14.0	5.2E-05	4300	0.12	1.86	
019		3.0	3.1	1002	13.0	5.2E-05	2700	0.12	1.17	

[2] Set to 0 Degrees Celsius and 101.3 kPa.

3.2 Discussion

The results from most of the sites were reasonably consistent and the variation between results was within the normal variation expected for odour sources of this type. There were two notable exceptions to this, Monitoring Location D - the working face and Monitoring Location F - the landfill surface monitoring near the southern boundary of Stage 2.

In relation to the working face, the results clearly demonstrate significant variation of up to one order of magnitude between sites. This is likely to be due to the highly variable nature of the refuse being deposited. It was evident during that monitoring that odorous decomposing meat and organic waste was deposited alongside less odorous waste paper. In terms of site selection an attempt was made to capture odours from a range of sites including both fresh and older waste material in addition to both exposed and partially covered waste. Given the variation in both the nature and type of waste material being deposited, a significant amount of variation between results is to be expected.

The second site which demonstrated significant variation between samples was the landfill surface monitoring near the southern boundary of Stage 2. This site contained a piece of black plastic hose which appeared to act as a conduit to exhaust gases from within the landfill. It is unclear what could have caused the variation within these results. Generally the sampling personnel attempt to remain stationary during the sampling to minimise the potential for increasing or decreasing the release of gases from beneath the ground into the flux chamber. It is possible that the sampling personnel could have inadvertently impacted upon the release of odours by moving across the surface of the landfill while the sample bags were changed. Alternatively, it was noted that the wind was strong and gusty – a gale warning was in effect at the time of sampling. It is possible that this could have caused some variability in the emission rate during sampling.

Aside from the variability described above, the remaining sites were reasonably consistent and within the normal degree of variation expected for such emission sources. The low blank result provides confidence that the sample results were not compromised by poor sampling practice, contaminated odour bags or contamination during transit.

4.0 Conclusions & Recommendations

AirQuality Ltd undertook odour sampling at six sites within the Levin landfill to determine the odour emission rate from each of these sources. A total of eighteen odour samples and one blank were collected over a three day period commencing Monday 17 November.

4.1 Recommendations for future monitoring

Please note that this recommendation refers to any future potential odour sampling programmes which may be undertaken at the site.

1. In relation to the monitoring at Monitoring Location B – the Leachate Collection Manhole cover. The original intention was to sample gases from the leachate collection manhole ventilation pipe and also ascertain the flow rate from this source. However prior to sampling, a walkover survey with the gas rover identified very high methane concentrations in the vicinity of the manhole ventilation pipe. These high concentrations exceeded the lower explosive limit for methane and this coupled with the height of the manhole ventilation pipe meant that for health and safety reasons, it was not possible to safely sample gases directly from the manhole ventilation pipe as was originally intended. As discussed earlier, a safer alternative method was employed which involved sampling the gases discharging from the top of the manhole cover. This alternative method has a greater degree of uncertainty than we would prefer, primarily because it was not possible to determine the flow rate from this source and it is therefore possible that the discharge rate of the gases from the manhole cover could be less than the sample rate, leading to potential dilution of the sample with ambient air.

   If the collection manhole ventilation pipe is subsequently identified as a significant odour source, it *could* be possible to better quantify emissions from this source by temporarily removing the manhole ventilation pipe from the manhole collection block. Such an activity is likely to trigger the need for a specific health and safety plan which is likely to entail further methane, oxygen and hydrogen sulphide monitoring, the requirement for intrinsically safe equipment, suitable training and PPE and prior written approval from the agencies concerned.

5.0 References

Good Practice Guide for Assessing and Managing Odour in New Zealand, June 2003. Ministry for the Environment. Ref ME473

Australian Standard 4323.3:2001 Stationary source emissions - Determination of odour concentration by dynamic olfactometry (Note that the Australian Standard has been based on the CEN standard).

Committé Européen de Normalisation, "Odour Concentration measurement by dynamic olfactometry, CEN EN 13725:2003

The German Standard VDI 3882 Part 1, "Olfactometry Determination of Odour Intensity" October 1992 should then be used for the subsequent odour intensity calculations.

United Kingdom Environment Agency's horizontal guidance note H4, Horizontal Guidance for Odour.

The Dutch Standard NVN 2820 "Air Quality, Sensory odour measurement using an olfactometer", March 1995;

APPENDIX A Sample Collection Times

Sample	Sample start time (NZST)	Analysis completion time (NZST)	Total elapsed time Hours:minutes
001	18/11/2014 10:05	19/11/2014 14:50	28:45
002	18/11/2014 10:25	19/11/2014 15:10	28:45
003	18/11/2014 10:50	19/11/2014 15:30	28:40
004	18/11/2014 12:05	19/11/2014 16:00	27:55
005	18/11/2014 12:25	19/11/2014 16:10	27:45
006	18/11/2014 12:45	19/11/2014 16:21	27:36
007	18/11/2014 12:50	19/11/2014 16:32	27:42
008	18/11/2014 13:20	19/11/2014 17:05	27:45
009	18/11/2014 13:40	19/11/2014 17:21	27:41
010	19/11/2014 6:00	20/11/2014 11:33	29:33
011	19/11/2014 6:30	20/11/2014 11:50	29:20
012	19/11/2014 6:50	20/11/2014 12:12	29:22
013	19/11/2014 7:10	20/11/2014 12:30	29:20
014	19/11/2014 7:50	20/11/2014 12:50	29:00
015	19/11/2014 8:10	20/11/2014 13:00	28:50
016	19/11/2014 8:30	20/11/2014 13:10	28:40
017	19/11/2014 9:10	20/11/2014 13:22	28:12
018	19/11/2014 9:30	20/11/2014 13:35	28:05
019	19/11/2014 9:50	20/11/2014 13:50	28:00

APPENDIX B Calibration Equipment

INSTRUMENT	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	QUALITY NUMBER	CALIBRATION EXPIRY DATE
Flowmeter	BIOS Drical defender	DC-2	100801	QN-00073	01/03/2015
Relative Humidity	Omega	THPen-8709	1002547	QN-00152	30/11/2015
Air Temperature	Omega	THPen-8709	1002547	QN-00152	30/11/2015
Gas Regulator	BOC scientific	505 CGG	112602	QN-00094	01/07/2015

AirQuality

APPENDIX C Fieldsheets

AirQuality

AirQuality

Odour Sample Collection Field Sheet

Section 1: Sample data

Location Levin Landfill leachate Pond		Sample ID: 001	
Today's date: 18.11.14		Start time NZST (24 hr): 10:05	End time NZST (24 Hr) 10:20
Sample personnel: PAB MB.		Form completed by: PAB	
Temperature (°C): 15	Weather (at time of sampling): F(R)		Last 24 hours: (R)
Latitude: —	Longitude: —	GPS Unit: —	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- Other: Landfill - leachate

Notes (e.g.., description of odour if present): Slight DMS.

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☐ Static sample		☐ Yes ☐ No		
☑ Dynamic sample	☐ None ☑ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☑ No	3.0	—
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	10 l	Liter
	Percentage full		%
	Time to fill		min
☐ Bag preconditioned?	☐ No ☑ Yes	x 2	

AirQuality

AirQuality **ODOUR SAMPLE COLLECTION FIELD SHEET**

Section 1: Sample data

Location Levin Landfill: leachate Pond.		Sample ID: 002	
Today's date: 18.11.14		Start time NZST (24 hr): 10:25	End time NZST (24 Hr) 10:45
Sample personnel: PAB, MB.		Form completed by: PAB	
Temperature (°C): 15	Weather (at time of sampling): F (R)		Last 24 hours: (R)
Latitude: –	Longitude: –	GPS Unit: –	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- Other: Landfill – leachate

Notes (e.g.., description of odour if present): slight DMS – + ethanoic acid.

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☐ Static sample		☐ Yes ☐ No		
☑ Dynamic sample	☐ None ☑ Nitrogen ☐ Purified air ☐ Other: _____	☐ Yes ☑ No	3.0	–
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: _____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	10 l.	Liter
	Percentage full	40%	%
	Time to fill	4	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	x 2.	

AirQuality

AirQuality

ODOUR SAMPLE COLLECTION FIELD SHEET

Section 1: Sample data

Location Levin Landfill	leachate Pond	Sample ID:	003
Today's date:	18.11.14	Start time NZST (24 hr): 10:50	End time NZST (24 Hr) 11:20
Sample personnel:	PAB	Form completed by:	PAB
Temperature (°C): 16	Weather (at time of sampling): F (R)	Last 24 hours:	R
Latitude: —	Longitude: —	GPS Unit:	—
Photographs Y/N:	Y	Camera:	PAB

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ✓ Other: leachate pond.

Notes (e.g.., description of odour if present): Slight DMS

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☐ Static sample		☐ Yes ☐ No		
☑ Dynamic sample	☐ None ☑ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☑ No	3.0	—
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15 ℓ	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No ☑ Yes	x 2	

AirQuality

AirQuality

ODOUR SAMPLE COLLECTION FIELD SHEET

Section 1: Sample data

Location Levin Landfill: Manhole Vent		Sample ID: 004	
Today's date: 18.11.14		Start time NZST (24 hr): 12:05	End time NZST (24 Hr) 12:20
Sample personnel: PAB, MB		Form completed by: PAB	
Temperature (°C): 15	Weather (at time of sampling): F	Last 24 hours: R	
Latitude: –	Longitude: –	GPS Unit: –	
Photographs Y/N: N		Camera: –	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ✓ Other: Manhole Vent

Notes (e.g.., description of odour if present): Strong H_2S

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: _____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: _____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15 l	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No ☑ Yes	x 2	

AirQuality

AirQuality

ODOUR SAMPLE COLLECTION FIELD SHEET

Section 1: Sample data

Location Levin Landfill Manhole Vent		Sample ID: 005	
Today's date: 18.11.14		Start time NZST (24 hr): 12:25	End time NZST (24 Hr) 12:40
Sample personnel: PAR, MR		Form completed by: PAR	
Temperature (°C): 17	Weather (at time of sampling): F	Last 24 hours: R	
Latitude: –	Longitude: –	GPS Unit: –	
Photographs Y/N: N		Camera: –	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- Other: Manhole vent

Notes (e.g.., description of odour if present): Strong H_2S.

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	–
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: _____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: _____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50%	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	x 2	

AirQuality

AirQuality

ODOUR SAMPLE COLLECTION FIELD SHEET

Section 1: Sample data

Location Levin Landfill	Manhole Vent	Sample ID:	006
Today's date:	18.11.14	Start time NZST (24 hr): 12:45	End time NZST (24 Hr) 13:05
Sample personnel:	PAB MB	Form completed by:	PAB
Temperature (°C): 17	Weather (at time of sampling): F	Last 24 hours:	R
Latitude: –	Longitude: –	GPS Unit:	–
Photographs Y/N:	N	Camera:	–

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ☑ Other: Manhole vent

Notes (e.g.., description of odour if present): Strong H_2S

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	–
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: _____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: _____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	x 2.	

AirQuality

AirQuality

Odour Sample Collection Field Sheet

Section 1: Sample data

Location Levin Landfill BLANK	Sample ID: 007
Today's date: 18.11.14	Start time NZST (24 hr): 12:50 End time NZST (24 Hr) 12:50
Sample personnel: PAB MB	Form completed by: PAP
Temperature (°C): 17 Weather (at time of sampling): F	Last 24 hours: R
Latitude: — Longitude: —	GPS Unit: —
Photographs Y/N: N	Camera: —

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☑ Blank
- Other:

Notes (e.g.., description of odour if present):

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	BLANK	
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

PARAMETER		FIELD DATA FOR FLOWING OUTFALLS RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	N/A	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	x2	

AirQuality

AirQuality

Odour Sample Collection Field Sheet

Section 1: Sample data

Location Levin Landfill	GAS Vent Pipe	Sample ID:	008
Today's date:	18.11.14	Start time NZST (24 hr): 1320	End time NZST (24 Hr) 13:35
Sample personnel:	PAB MB	Form completed by:	PAB
Temperature (°C): 18	Weather (at time of sampling): F	Last 24 hours:	R
Latitude: —	Longitude: —	GPS Unit:	—
Photographs Y/N:	Y	Camera:	PAB

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ✓ Other: Landfill

Notes (e.g.., description of odour if present): Landfill odour - methyl sulphide.

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	—
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: _____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: _____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	x 2.	

AirQuality

AirQuality

Odour Sample Collection Field Sheet

Section 1: Sample data

Location Levin Landfill Gas vent pipe		Sample ID: 009	
Today's date: 18.11.14		Start time NZST (24 hr):	End time NZST (24 Hr)
Sample personnel: PAB MB		Form completed by: PAB	
Temperature (°C): 17	Weather (at time of sampling): F		Last 24 hours: R
Latitude: —	Longitude: —	GPS Unit: —	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ✓ Other: Landfill

Notes (e.g.., description of odour if present): MS.

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	—
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	× 2.	

AirQuality

AirQuality

ODOUR SAMPLE COLLECTION FIELD SHEET

Section 1: Sample data

Location Levin Landfill: Tip Face		Sample ID: 010	
Today's date: 19.11.14		Start time NZST (24 hr): 0600	End time NZST (24 Hr) 0620
Sample personnel: PAB		Form completed by: PAB	
Temperature (°C): 11	Weather (at time of sampling): F		Last 24 hours: F
Latitude: –	Longitude: –	GPS Unit: –	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- Other: Tip face. North.

Notes (e.g.., description of odour if present): MS. Landfill odour, mercaptans.

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☑ Yes ☐ No	3.0	—
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	x 2	

AirQuality

AirQuality **ODOUR SAMPLE COLLECTION FIELD SHEET**

Section 1: Sample data

Location Levin Landfill Tip face.		Sample ID: 011	
Today's date: 19.11.14		Start time NZST (24 hr): 0630	End time NZST (24 Hr) 0645
Sample personnel: PAB		Form completed by: PAB	
Temperature (°C): 12	Weather (at time of sampling): F		Last 24 hours: F
Latitude: —	Longitude: —	GPS Unit: —	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- Other: Tip face. 10m S of sample 010

Notes (e.g.., description of odour if present): Landfill odour.

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	—
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	x 2	

AirQuality

AirQuality

Odour Sample Collection Field Sheet

Section 1: Sample data

Location Levin Landfill: Tip Face		Sample ID: 012	
Today's date: 19.11.14		Start time NZST (24 hr): 0850	End time NZST (24 Hr) 0805
Sample personnel: PAB		Form completed by: PAB	
Temperature (°C): 12	Weather (at time of sampling): F	Last 24 hours: F	
Latitude: —	Longitude: —	GPS Unit: —	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ✓ Other: Tip face. 20m S of Site 011

Notes (e.g.., description of odour if present): Landfill odour.

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	—
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☐ Yes	x 2	

AirQuality

AirQuality **ODOUR SAMPLE COLLECTION FIELD SHEET**

Section 1: Sample data

Location Levin Landfill: Tip Face		Sample ID: 013	
Today's date: 19.11.14		Start time NZST (24 hr): 0810	End time NZST (24 Hr) 08:25
Sample personnel: PAB		Form completed by: PAB	
Temperature (°C): 12	Weather (at time of sampling): F		Last 24 hours: F
Latitude: –	Longitude: –	GPS Unit: –	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- Other: Tip Face.

Notes (e.g.., description of odour if present):

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	–
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	x 2.	

AirQuality

AirQuality

ODOUR SAMPLE COLLECTION FIELD SHEET

Section 1: Sample data

Location Levin Landfill GAS Vent	Sample ID: 014
	Start time NZST (24 hr): 07:50 — End time NZST (24 Hr) 08:05
Today's date: 19.11.14	Form completed by: PAB
Sample personnel: PAB	Last 24 hours: F
Temperature (°C): 13 — Weather (at time of sampling): F	GPS Unit: –
Latitude: – — Longitude: –	Camera: PAB
Photographs Y/N: Y	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ✓ Other: Landfill.

Notes (e.g.., description of odour if present): –

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☑ Yes ☐ No	3.0	–
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

PARAMETER		FIELD DATA FOR FLOWING OUTFALLS RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No ☑ Yes	x 1	

AirQuality

AirQuality

Odour Sample Collection Field Sheet

Section 1: Sample data

Location Levin Landfill: Gas vent.		Sample ID: 015	
Today's date: 19.11.14		Start time NZST (24 hr): 08.10	End time NZST (24 Hr) 08:25
Sample personnel: PAB		Form completed by: PAB	
Temperature (°C): 13	Weather (at time of sampling): F	Last 24 hours: F	
Latitude: —	Longitude: —	GPS Unit: —	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- Other: Landfill

Notes (e.g.., description of odour if present): DMS

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	—
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: _____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: _____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan	Volume	15	Liter
	Percentage full	50	%
☐ PTFE ☐ Stainless steel	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☑ Yes	x 1	

AirQuality

AirQuality **ODOUR SAMPLE COLLECTION FIELD SHEET**

Section 1: Sample data

Location Levin Landfill Gas Vent		Sample ID: 016	
Today's date: 19.11.14		Start time NZST (24 hr): 08:30	End time NZST (24 Hr) 08:45
Sample personnel: PAB		Form completed by: PAB	
Temperature (°C): 13	Weather (at time of sampling): F		Last 24 hours: F
Latitude: –	Longitude: –	GPS Unit: –	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ☑ Other: Landfill

Notes (e.g.., description of odour if present): DMS/ MS

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	—
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☐ Yes	x 1	

AirQuality

AirQuality

ODOUR SAMPLE COLLECTION FIELD SHEET

Section 1: Sample data

Location Levin Landfill: Hose by Flare		Sample ID: 017	
Today's date: 19.11.14		Start time NZST (24 hr): 09:10	End time NZST (24 Hr): 09:25
Sample personnel: PAB		Form completed by: PAB	
Temperature (°C): 13	Weather (at time of sampling): F		Last 24 hours: F
Latitude: –	Longitude: –	GPS Unit: –	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ☑ Other: Landfill

Notes (e.g.., description of odour if present): PMS/MS

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☒ Yes ☑ No	3.0	–
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: _____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: _____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☐ Yes	x 1	

AirQuality

AirQuality

Odour Sample Collection Field Sheet

Section 1: Sample data

Location Levin Landfill Hose by Slave		Sample ID: 018	
Today's date: 19.11.14		Start time NZST (24 hr): 09:30	End time NZST (24 Hr) 09:45
Sample personnel: PAB		Form completed by: PAB	
Temperature (°C): 14	Weather (at time of sampling): F	Last 24 hours: F	
Latitude: –	Longitude: –	GPS Unit: –	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

☐ Wastewater treatment plant (pre treatment)
☐ Wastewater treatment plant (post treatment
☐ Biofilter
☐ Pumping station
☐ Poultry farm (egg laying)
☐ Poultry farm (broiler)
☐ Blank
✓ Other: Landfill

Notes (e.g.., description of odour if present):

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3.0	–
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☐ Yes	x 1	

AirQuality

AirQuality

Odour Sample Collection Field Sheet

Section 1: Sample data

Location Levin Landfill Hose by Slave		Sample ID: 019	
Today's date: 19.11.14		Start time NZST (24 hr): 09:50	End time NZST (24 Hr): 10.05
Sample personnel: PAB		Form completed by: PAB	
Temperature (°C): 13	Weather (at time of sampling): F, 7/10 c		Last 24 hours: F
Latitude: –	Longitude: –	GPS Unit: –	
Photographs Y/N: Y		Camera: PAB	

Type of odour sample

- ☐ Wastewater treatment plant (pre treatment)
- ☐ Wastewater treatment plant (post treatment
- ☐ Biofilter
- ☐ Pumping station
- ☐ Poultry farm (egg laying)
- ☐ Poultry farm (broiler)
- ☐ Blank
- ✓ Other: Landfill

Notes (e.g.., description of odour if present): MS. DMS

Section 2: Sample method data

SAMPLE TYPE	CARRIER GAS	TEMP/RH MONITORED?	SAMPLE FLOW RATE (L/MIN)	COMMENTS
☑ Static sample		☐ Yes ☑ No	3·0	—
☐ Dynamic sample	☐ None ☐ Nitrogen ☐ Purified air ☐ Other: ____	☐ Yes ☐ No		
☐ Wind tunnel		☐ Yes ☐ No		
☐ Cover and capture		☐ Yes ☐ No		
☐ Direct process sample	☐ Pipe ☐ Duct ☐ Other: ____	☐ Yes ☐ No		

Section 3: Sample collected

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER		RESULT	UNIT
☑ Tedlar bag ☐ Nalophan ☐ PTFE ☐ Stainless steel	Volume	15	Liter
	Percentage full	50	%
	Time to fill	5	min
☐ Bag preconditioned?	☐ No		
	☐ Yes	x 1	

APPENDIX D Odour Laboratory Monitoring Report

AirQuality

Ektimo

Trading as Ektimo (EML Air)

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Report Number R000248

Odour Analysis Report
Aiquality Ltd, Levin Landfill

Melissa Reddan
BAppSc
Compliance Manager

AirQuality

Document Information

Client Name:	Airquality Ltd
Report Number:	R000248
Report Title:	Odour Analysis Report
Date of Issue:	28/11/2014
Attention:	Paul Baynham
Address:	21 Barrys Point Road Takapuna Aukland 622 New Zealand

Sampling Information

Sampling Date: November 2014

Report Status

Format	Document Number	Report Date	Prepared By	Reviewed By (1)	Reviewed By (2)
Preliminary Report	-	-	-	-	-
Draft Report	-	-	-	-	-
Final Report	R000248	28/11/14	AD	MR	
Amend Report	-	-	-	-	-

Internal Reference: jk doc:

Amendment Record

Document Number	Initiator	Report Date	Section	Reason
Nil	-	-	-	-

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Appendices

Nil

AirQuality

EXECUTIVE SUMMARY

19 samples were received at our laboratory on 19th & 20 November 2014 and analysed at the request of Airquality Ltd.

Please refer to the following pages for results, test methods, quality assurance / quality control information and definitions.

AirQuality

RESULTS

Leachate Pond – Odour Analysis Results

Date	19/11/2014	**Client**	Airquality Ltd
Report	R000248	**Site ID**	Leachate Pond
Licence No.	-	**Location**	Levin Landfill
Reason for testing:	Determine odour concentrations		

Odour		Sample 1 Leachate Pond		Sample 2 Leachate Pond		Sample 3 Leachate Pond	
			(AEST)		(AEST)		(AEST)
Analysis date & Time		19/11/14	12:50	19/11/14	13:10	19/11/14	13:30
Dilution factor & Threshold		1	220 ou	1	270 ou	1	170 ou
Laboratory temp	20						
Last calibrated	10/01/14						
No. ITE's used		10		10		10	
Concentration		220		270		170	
Lower Uncertainty Limit		100		130		78	
Upper Uncertainty Limit		480		600		370	
n-Butanol threshold		32 ppb		32 ppb		32 ppb	

Manhole – Odour Analysis Results

Date	20/11/2014	**Client**	Airquality Ltd
Report	R000248	**Site ID**	Manhole
Licence No.	-	**Location**	Levin Lanfill
Reason for testing:	Determine odour concentrations		

Odour		Sample 4 Manhole		Sample 5 Manhole		Sample 6 Manhole	
			(AEST)		(AEST)		(AEST)
Analysis date & Time		19/11/14	14:00	19/11/14	14:10	19/11/14	14:21
Dilution factor & Threshold		1	57000 ou	1	57000 ou	1	57000 ou
Laboratory temp	20						
Last calibrated	10/01/14						
No. ITE's used		10		10		10	
Concentration		57000		57000		53000	
Lower Uncertainty Limit		26000		26000		24000	
Upper Uncertainty Limit		120000		120000		120000	
n-Butanol threshold		32 ppb		32 ppb		32 ppb	

AirQuality

Blank - Odour Analysis Results

Date	19/11/2014	**Client**	Airquality Ltd
Report	R000248	**Site ID**	Blank
Licence No.	-	**Location**	Levin Landfill
Reason for testing:	Determine odour concentrations		

Odour	Sample 7 Blank	
		(AEST)
Analysis date & Time	19/11/14	14:32
Dilution factor & Threshold	1	<16 ou
Laboratory temp	20	
Last calibrated	10/01/14	
No. ITE's used	10	
Concentration	<16	
Lower Uncertainty Limit	<7.4	
Upper Uncertainty Limit	<35	
n-Butanol threshold	32 ppb	

Landfill Top Pipe - Odour Analysis Results

Date	19/11/2014	**Client**	Airquality Ltd
Report	R000248	**Site ID**	Landfill Top Pipe
Licence No.	-	**Location**	Levin Landfill
Reason for testing:	Determine odour concentrations		

Odour	Sample 8 Landfill Top Pipe		Sample 9 Landfill Top Pipe	
		(AEST)		(AEST)
Analysis date & Time	19/11/14	15:05	19/11/14	15:21
Dilution factor & Threshold	1	11000 ou	1	14000 ou
Laboratory temp 20				
Last calibrated 10/01/14				
No. ITE's used	10		10	
Concentration	11000		14000	
Lower Uncertainty Limit	5000		6600	
Upper Uncertainty Limit	24000		31000	
n-Butanol threshold	32 ppb		32 ppb	

Tipface – Odour Analysis Results

Date	20/11/2014	**Client**	Airquality Ltd
Report	R000248	**Site ID**	Tipface
Licence No.	-	**Location**	Levin Landfill
Reason for testing:	Determine odour concentrations		

Odour		Sample 10 Tipface		Sample 11 Tipface	
			(AEST)		(AEST)
Analysis date & Time		20/11/14	09:33	20/11/14	09:50
Dilution factor & Threshold		1	360 ou	1	1400 ou
Laboratory temp	20				
Last calibrated	10/01/14				
No. ITE's used		12		12	
Concentration		360		1400	
Lower Uncertainty Limit		170		630	
Upper Uncertainty Limit		790		3000	
n-Butanol threshold		31 ppb		31 ppb	

Date	20/11/2014	**Client**	Airquality Ltd
Report	R000248	**Site ID**	Tipface
Licence No.	-	**Location**	Levin Landfill
Reason for testing:	Determine odour concentrations		

Odour		Sample 12 Tipface		Sample 13 Tipface	
			(AEST)		(AEST)
Analysis date & Time		20/11/14	10:12	20/11/14	10:30
Dilution factor & Threshold		1	3600 ou	1	3600 ou
Laboratory temp	20				
Last calibrated	10/01/14				
No. ITE's used		12		12	
Concentration		3600		3600	
Lower Uncertainty Limit		1700		1700	
Upper Uncertainty Limit		7900		7900	
n-Butanol threshold		31 ppb		31 ppb	

AirQuality

Gas Vent – Odour Analysis Results

Date 20/11/2014	**Client**	Airquality Ltd	
Report R000248	**Site ID**	Gas Vent	
Licence No. -	**Location**	Levin Landfill	
Reason for testing:	Determine odour concentrations		

Odour	Sample 14 Gas Vent	Sample 15 Gas Vent	Sample 16 Gas Vent
Analysis date & Time	(AEST)	(AEST)	(AEST)
Dilution factor & Threshold	20/11/14 10:50	20/11/14 11:00	20/11/14 11:10
Laboratory temp 20	1 2700 ou	1 2600 ou	1 2400 ou
Last calibrated 10/01/14			
No. ITE's used			
Concentration	12	12	10
Lower Uncertainty Limit	2700	2600	2400
Upper Uncertainty Limit n-Butanol threshold	1300	1200	1100
	5900	5600	5300
	31 ppb	31 ppb	32 ppb

1B Hose by Flare – Odour Analysis Results

Date 20/11/2014	**Client**	Airquality Ltd	
Report R000248	**Site ID**	Hose by Flare	
Licence No. -	**Location**	Levin Landfill	
Reason for testing:	Determine odour concentrations		

Odour	Sample 17 Hose by Flare	Sample 18 Hose by Flare	Sample 19 Hose by Flare
	(AEST)	(AEST)	(AEST)
Analysis date & Time	20/11/14 11:22	20/11/14 11:35	20/11/14 11:50
Dilution factor & Threshold	1 1200 ou	1 4300 ou	1 2700 ou
Laboratory temp 20			
Last calibrated 10/01/14			
No. ITE's used	12	12	12
Concentration	1200	4300	2700
Lower Uncertainty Limit	560	2000	1300
Upper Uncertainty Limit n-Butanol threshold	2600	9400	5900
	31 ppb	31 ppb	32 ppb

PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Airquality Ltd's records for complete process conditions.

TEST METHODS

All analysis was performed by Ektimo (EML Air) unless otherwise specified. Specific details of the methods are available upon request

Test Method Table

Parameter		Test Method Accredited Limit	Method Detection	Uncertainty*	NATA
				Sampling	**Analysis**
Odour	AS 4323.3	16ou	not specified	NA	✓

* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

QUALITY ASSURANCE/ QUALITY CONTROL INFORMATION

Ektimo (EML Air) is accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources (Accreditation number 2732). Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for Ektimo (EML Air) at NATA's website www.nata.asn.au.

Ektimo (EML Air) is accredited by NATA (National Association of Testing Authorities) to Australian Standard 17025 – General Requirements for the Competence of Testing and Calibration Laboratories. Australian Standard 17025 requires that a laboratory have a quality system similar to ISO 9002. More importantly it also requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Quality Assurance Manager.

NATA is a member of APLAC (Asia Pacific Laboratory Accreditation Co-operation) and of ILAC (International Laboratory Accreditation Co-operation). Through the mutual recognition arrangements with both of these organisations, NATA accreditation is recognised world –wide.

A formal Quality Control program is in place at Ektimo (EML Air) to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

DEFINITIONS

The following symbols and abbreviations may be used in this test report:

NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
TOC	The sum of all compounds of carbon which contain at least one carbon to carbon bond, plus methane and its derivatives.
OU	The number of odour units per unit of volume. The numerical value of the odour concentration is equal to the number of dilutions to arrive at the odour threshold (50% panel response).
$PM_{2.5}$	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 2.5 microns (µm).
PM_{10}	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 10 microns (µm).
BSP	British standard pipe
NT	Not tested or results not required
NA	Not applicable
D_{50}	'Cut size' of a cyclone defined as the particle diameter at which the cyclone achieves a 50% collection efficiency ie. half of the particles are retained by the cyclone and half are not and pass through it to the next stage. The D_{50} method simplifies the capture efficiency distribution by assuming that a given cyclone stage captures all of the particles with a diameter equal to or greater than the D_{50} of that cyclone and less than the D_{50} of the preceding cyclone.
D	Duct diameter or equivalent duct diameter for rectangular ducts
<	Less than
>	Greater than
≥	Greater than or equal to
~	Approximately
CEM	Continuous Emission Monitoring
CEMS	Continuous Emission Monitoring System
DER	WA Department of Environment & Regulation
DECC	Department of Environment & Climate Change (NSW)
EPA	Environment Protection Authority
FTIR	Fourier Transform Infra Red
NATA	National Association of Testing Authorities
RATA	Relative Accuracy Test Audit
AS	Australian Standard
USEPA	United States Environmental Protection Agency
Vic EPA	Victorian Environment Protection Authority
ISC	Intersociety committee, Methods of Air Sampling and Analysis
ISO	International Organisation for Standardisation
APHA	American public health association, Standard Methods for the Examination of Water and Waste Water
CARB	Californian Air Resources Board
TM	Test Method
OM	Other approved method

CTM	Conditional test method
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
NIOSH	National Institute of Occupational Safety and Health
XRD	X-ray Diffractometry

Appendix C Site Visit Photos

Figure C–1: Photo Looking West Showing the Stage 3 Active Landfill Area

Figure C–2: Photo Looking South-East Showing the Stage 3 Active Landfill Area

Figure C–3: Photo Looking South-West Showing Odour Monitoring at the Leachate Pond

Figure C–4: Photo Looking East Showing Odour Monitoring at the Leachate Collection Manhole

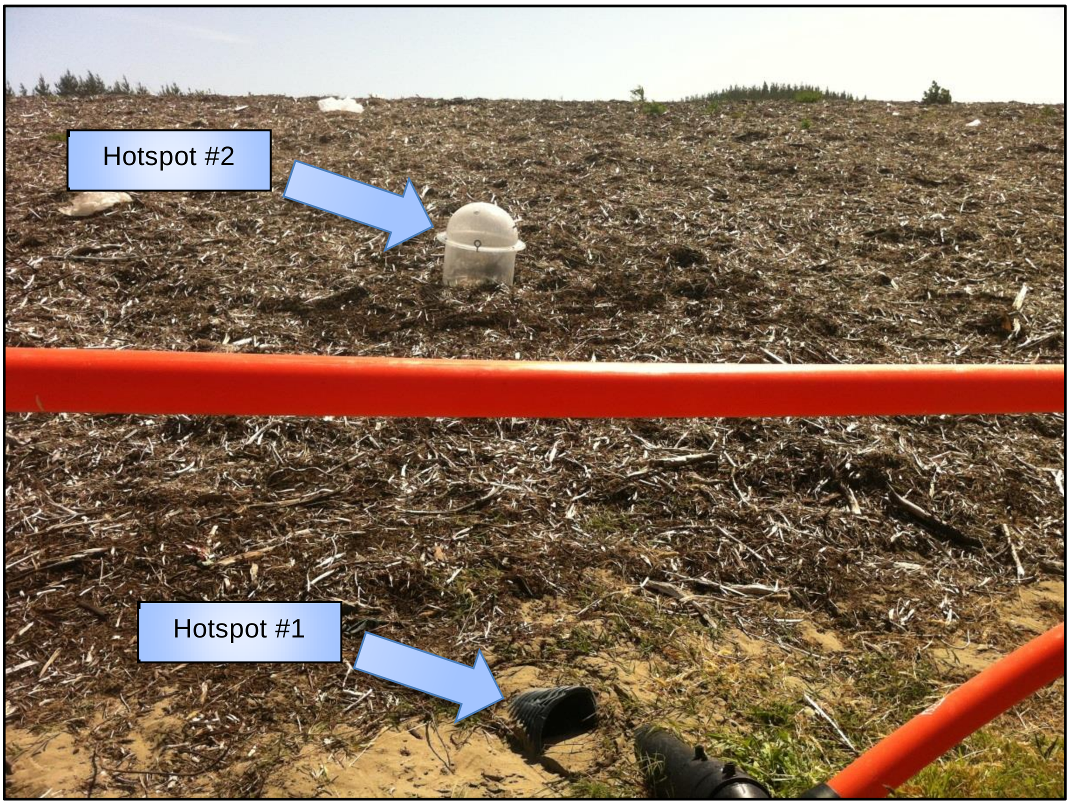

Figure C–5: Photo Looking West Showing the Stage 2 Emission Hotspots #1 and #2

Figure C–6: Photo Looking East Showing Odour Monitoring at the Stage 2 Emission Hotspot #3

Appendix D Wind Roses

The following figures are contained in this appendix:

Levin AWS – Annual and Seasonal Wind Roses

- Figure D–1: Wind Rose for Levin AWS for 2008 to 2012
- Figure D–2: Annual Wind Rose for Levin AWS for 2008
- Figure D–3: Annual Wind Rose for Levin AWS for 2009
- Figure D–4: Annual Wind Rose for Levin AWS for 2010
- Figure D–5: Annual Wind Rose for Levin AWS for 2011
- Figure D–6: Annual Wind Rose for Levin AWS for 2012
- Figure D–7: Seasonal Wind Roses for Levin AWS for 2008 to 2012
- Figure D–8: Seasonal Wind Roses for Levin AWS for 2008
- Figure D–9: Seasonal Wind Roses for Levin AWS for 2009
- Figure D–10: Seasonal Wind Roses for Levin AWS for 2010
- Figure D–11: Seasonal Wind Roses for Levin AWS for 2011
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Paraparaumu Aero AWS – Annual and Seasonal Wind Roses

- Figure D–13: Wind Rose for Paraparaumu Aero AWS for 2008 to 2012
- Figure D–14: Annual Wind Rose for Paraparaumu Aero AWS for 2008
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- Figure D–16: Annual Wind Rose for Paraparaumu Aero AWS for 2010
- Figure D–17: Annual Wind Rose for Paraparaumu Aero AWS for 2011
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- Figure D–20: Seasonal Wind Roses for Paraparaumu Aero AWS for 2008
- Figure D–21: Seasonal Wind Roses for Paraparaumu Aero AWS for 2009
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Palmerston North EWS – Annual and Seasonal Wind Roses

- Figure D–25: Wind Rose for Palmerston North EWS for 2008 to 2012
- Figure D–26: Annual Wind Rose for Palmerston North EWS for 2008
- Figure D–27: Annual Wind Rose for Palmerston North EWS for 2009
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- Figure D–29: Annual Wind Rose for Palmerston North EWS for 2011
- Figure D–30: Annual Wind Rose for Palmerston North EWS for 2012
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- Figure D–33: Seasonal Wind Roses for Palmerston North EWS for 2009
- Figure D–34: Seasonal Wind Roses for Palmerston North EWS for 2010
- Figure D–35: Seasonal Wind Roses for Palmerston North EWS for 2011
- Figure D–36: Seasonal Wind Roses for Palmerston North EWS for 2012

Levin AWS – Hour of the Day and Low Wind Speed Wind Roses

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TAPM Output: Annual Wind Roses

- Figure D–39: Annual Wind Rose Predicted by TAPM for the Project Site for 2012
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CALMET Output: Annual, Seasonal and Hour of the Day Wind Roses

- Figure D–42: Annual Wind Rose Predicted by CALMET for the Project Site for 2012
- Figure D–43: Seasonal Wind Rose Predicted by CALMET for the Project Site for 2012
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- Figure D–45: Annual Wind Rose Predicted by CALMET for Levin AWS for 2012
- Figure D–46: Annual Wind Rose Predicted by CALMET for Paraparaumu AWS for 2012

Levin AWS – Annual and Seasonal Wind Roses

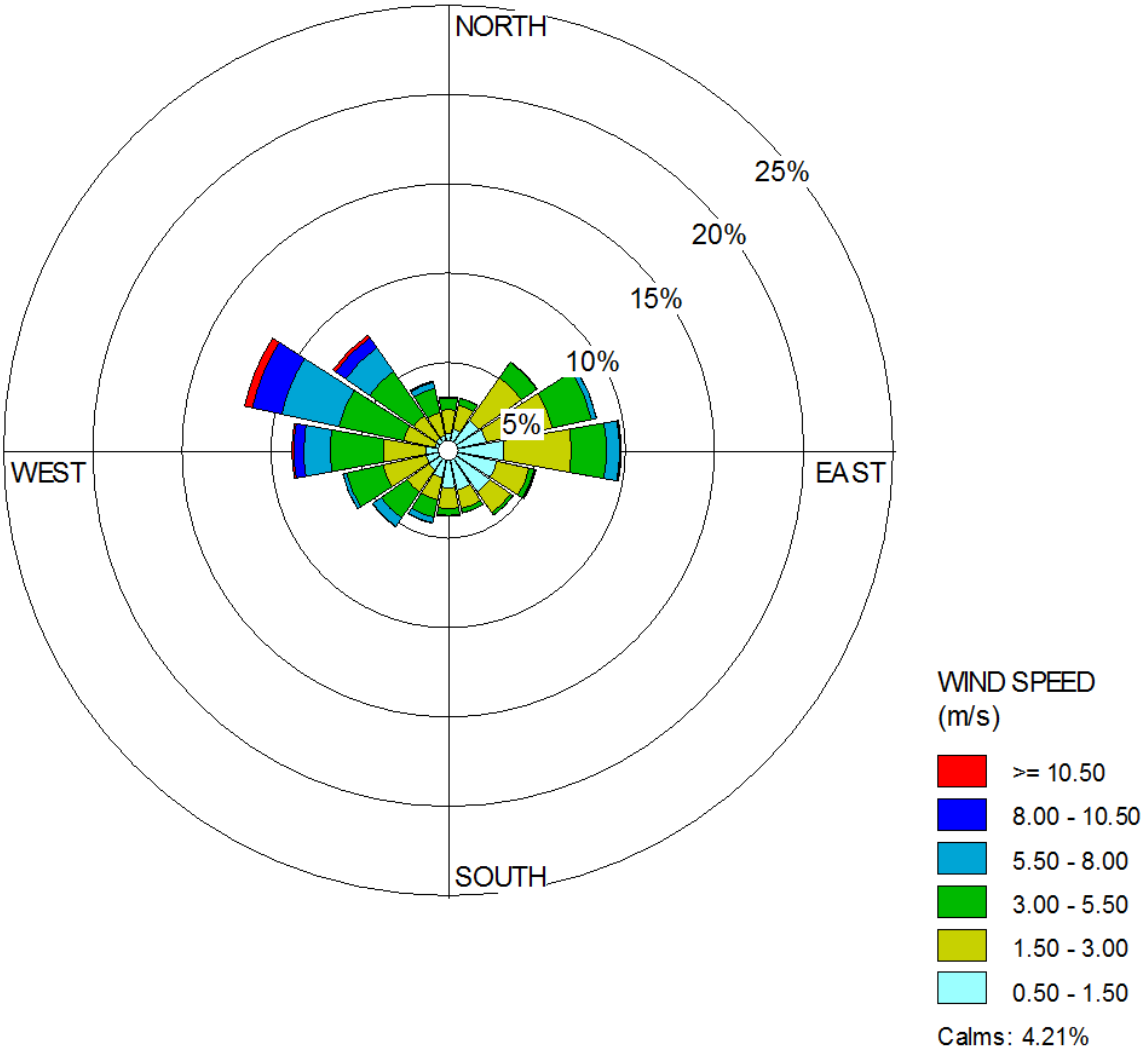

Figure D–1: Wind Rose for Levin AWS for 2008 to 2012

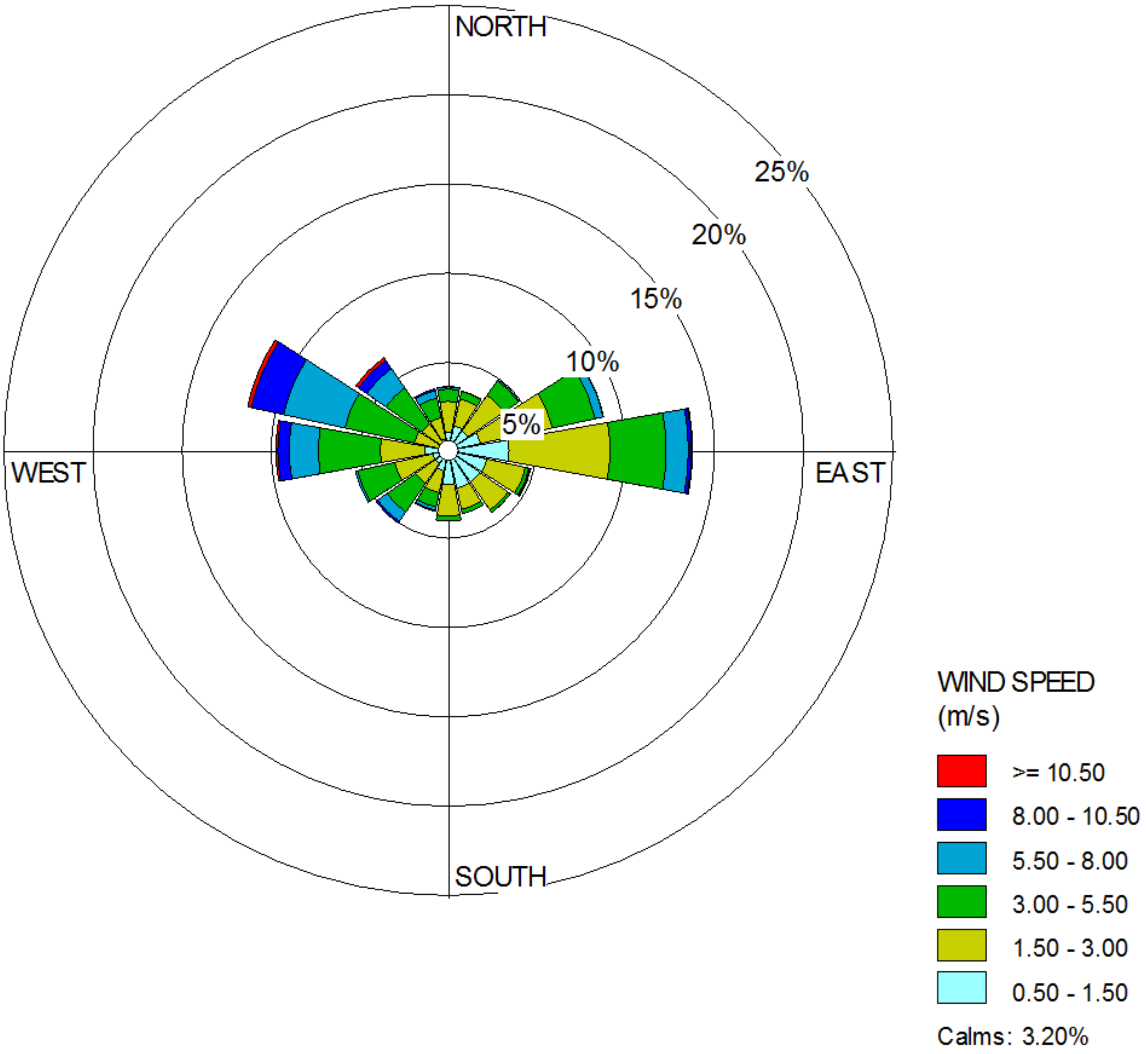

Figure D–2: Annual Wind Rose for Levin AWS for 2008

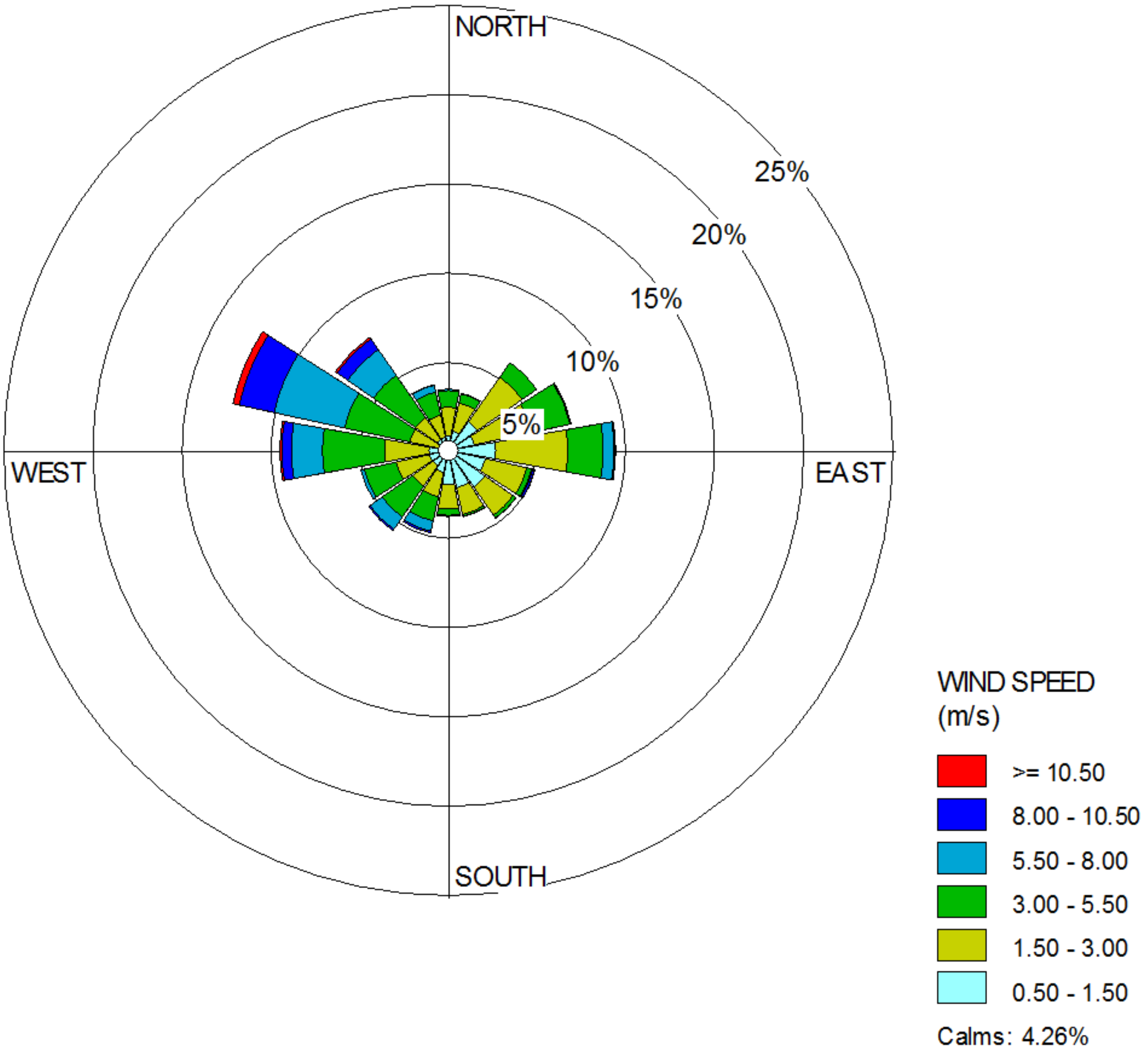

Figure D–3: Annual Wind Rose for Levin AWS for 2009

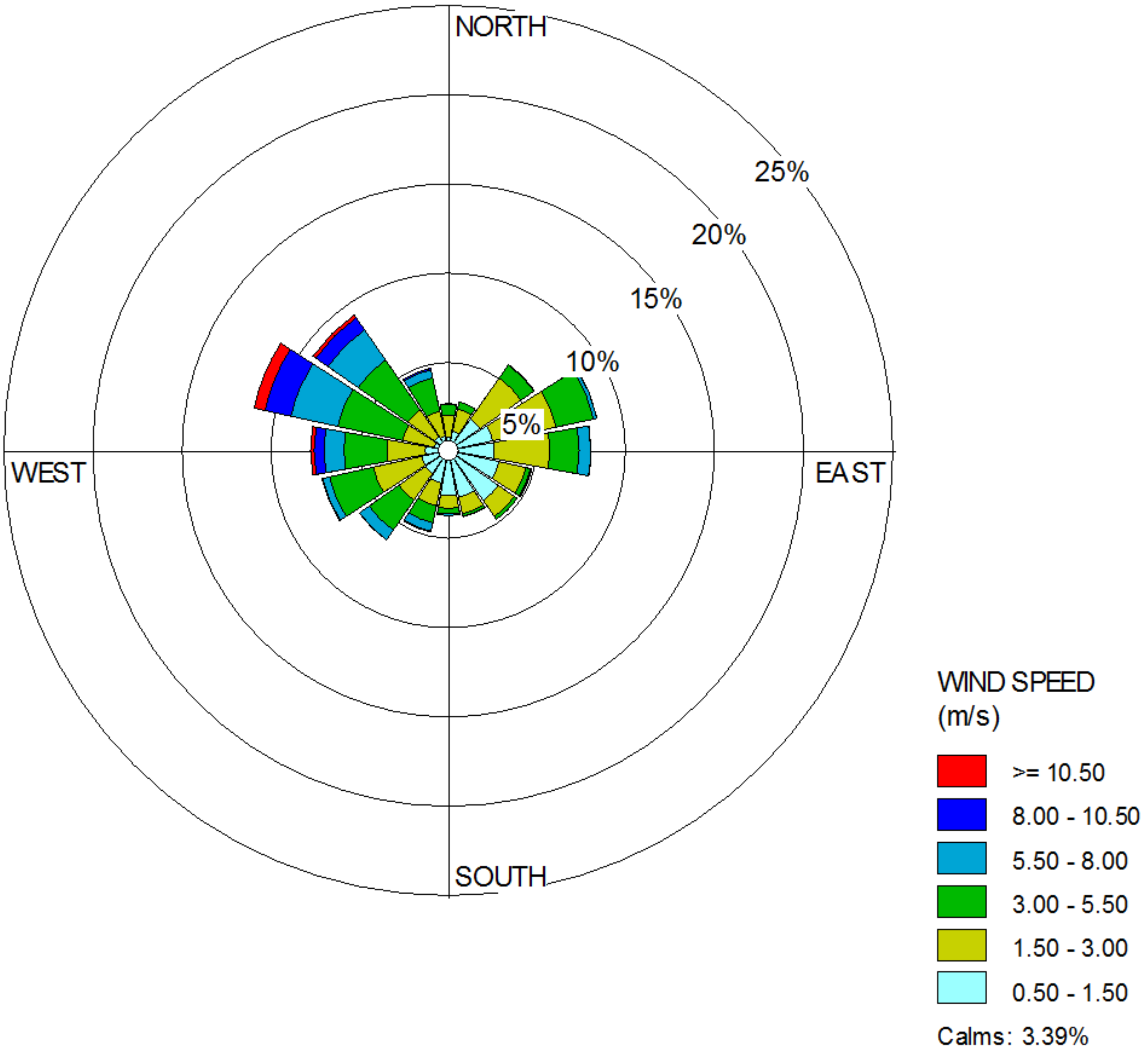

Figure D–4: Annual Wind Rose for Levin AWS for 2010

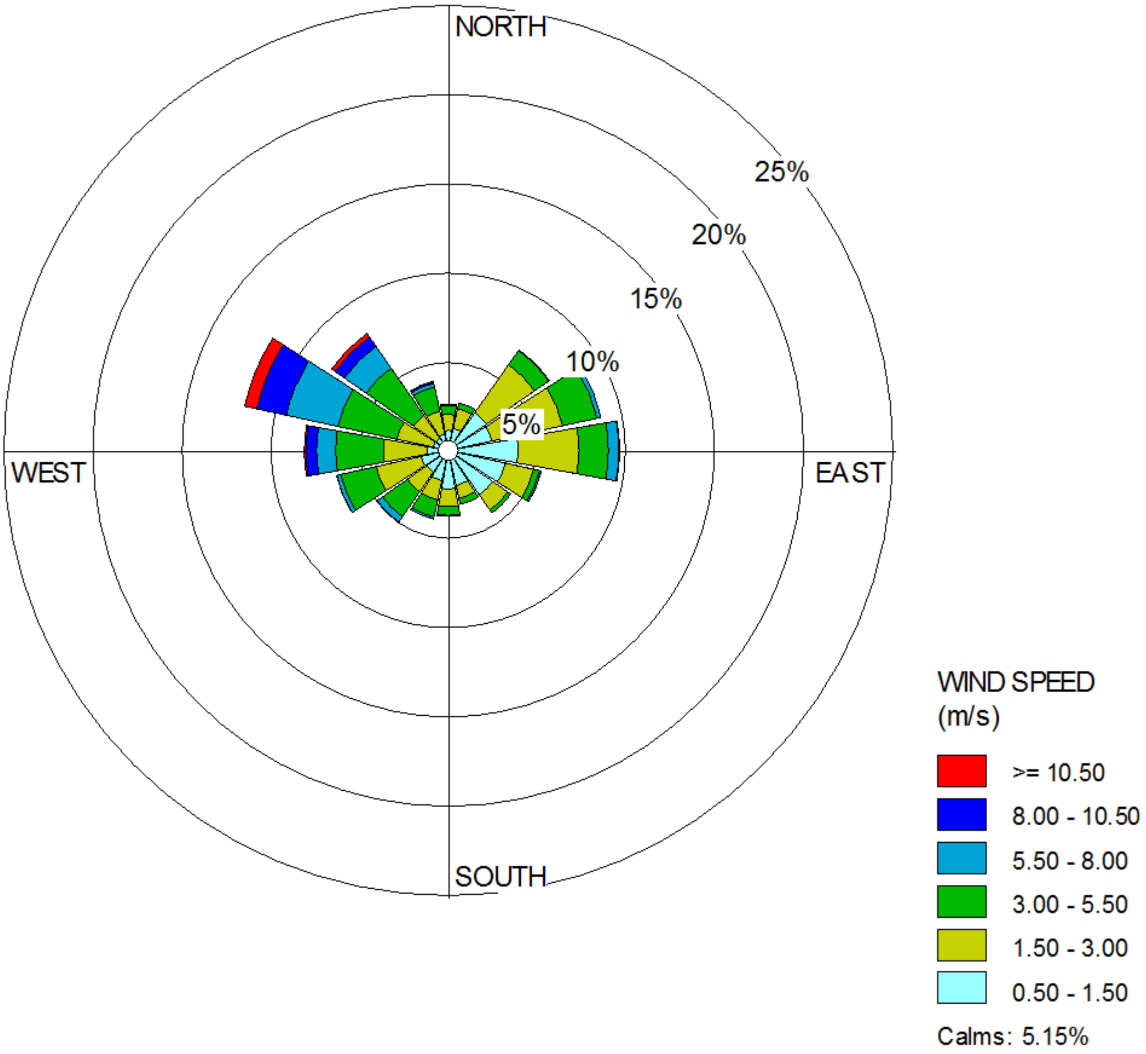

Figure D–5: Annual Wind Rose for Levin AWS for 2011

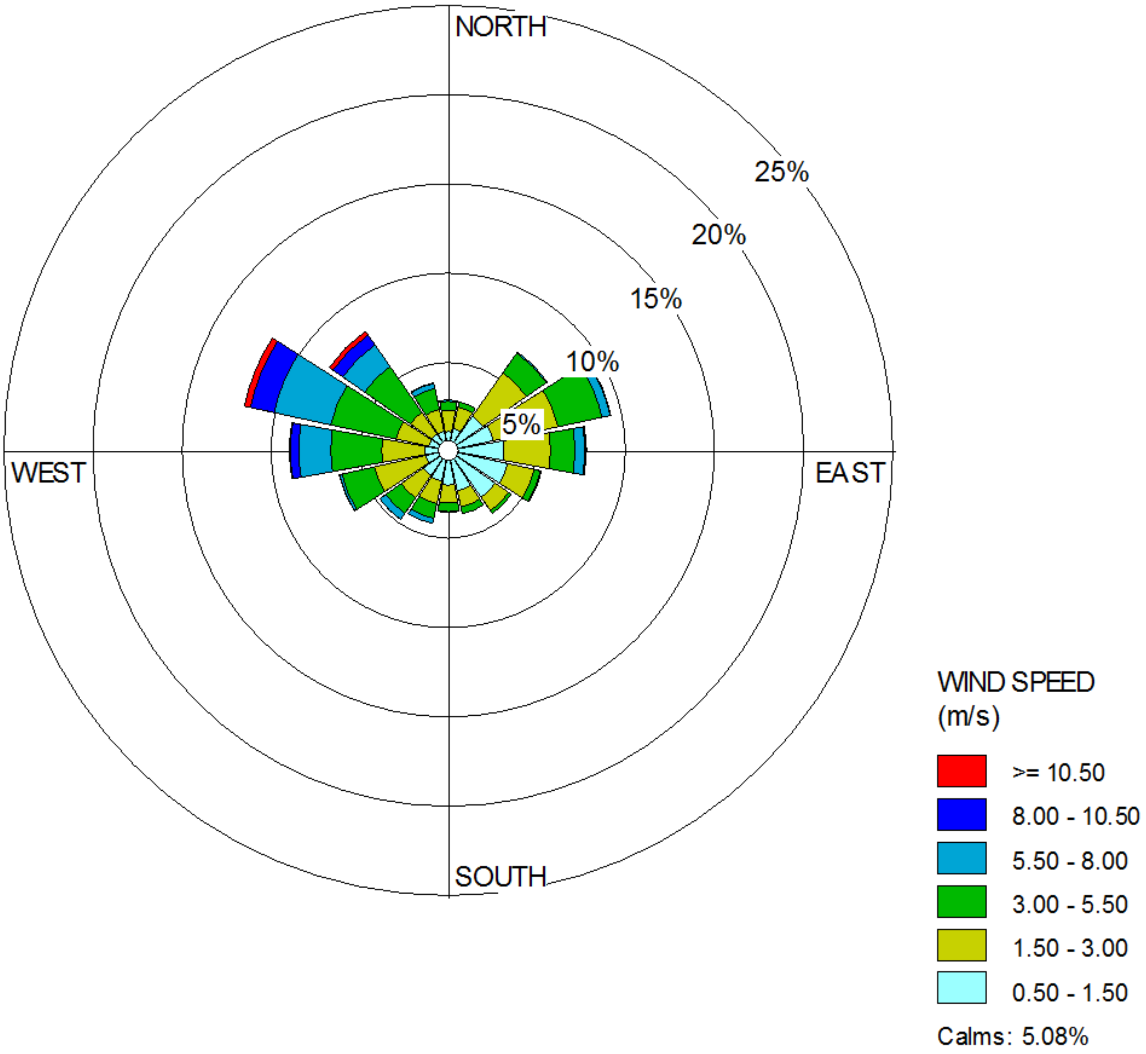

Figure D–6: Annual Wind Rose for Levin AWS for 2012

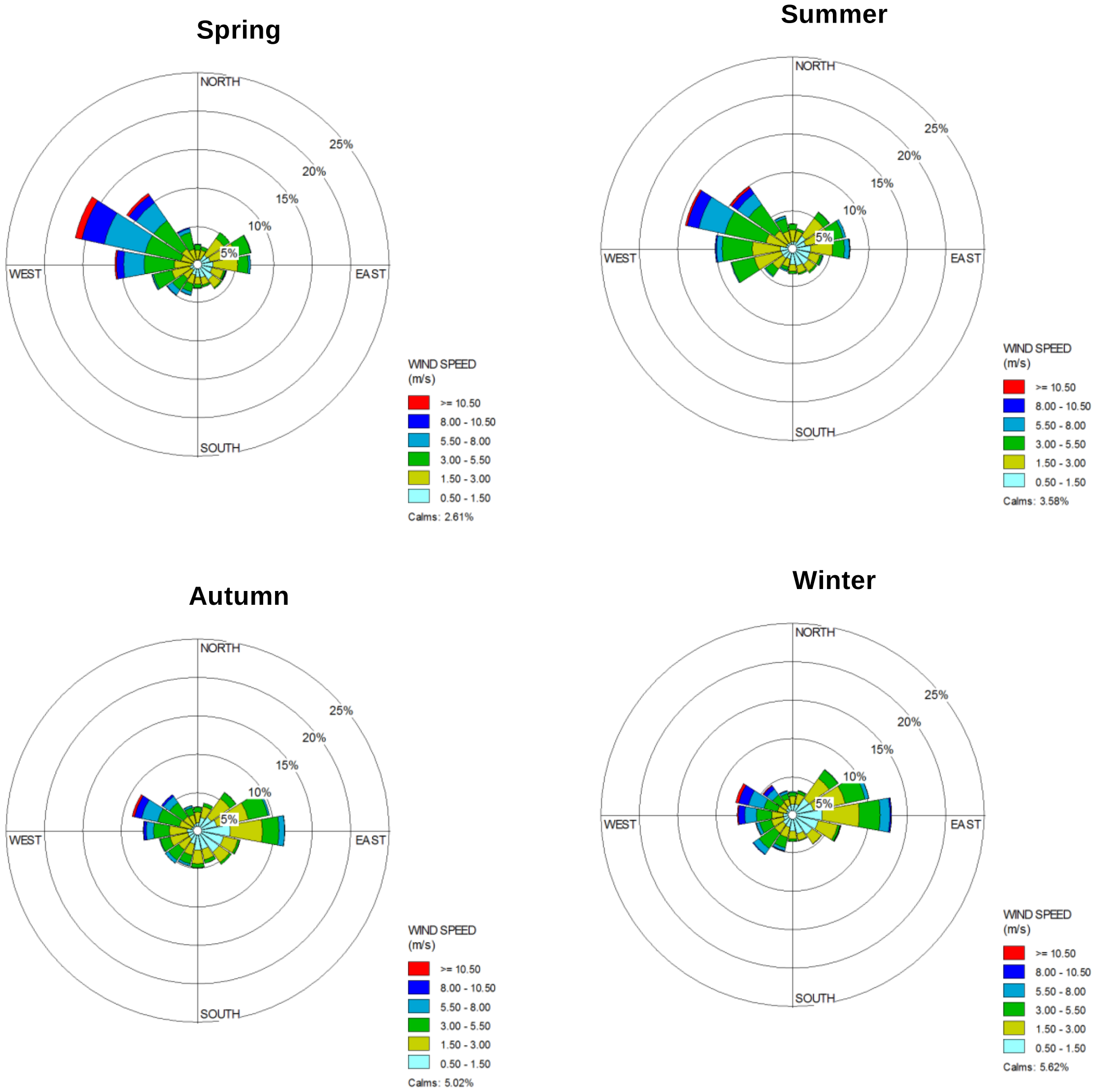

Figure D–7: Seasonal Wind Roses for Levin AWS for 2008 to 2012

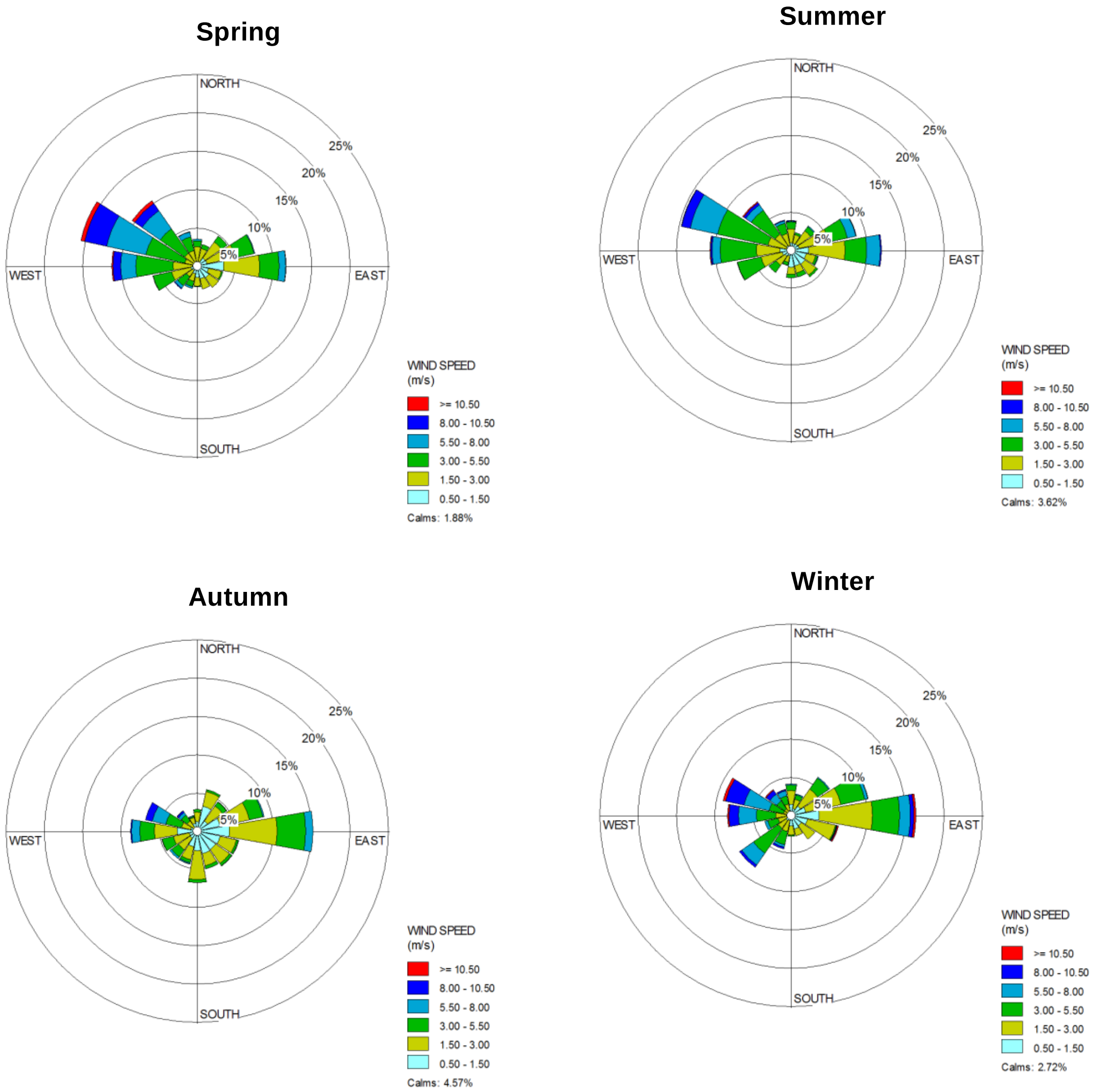

Figure D–8: Seasonal Wind Roses for Levin AWS for 2008

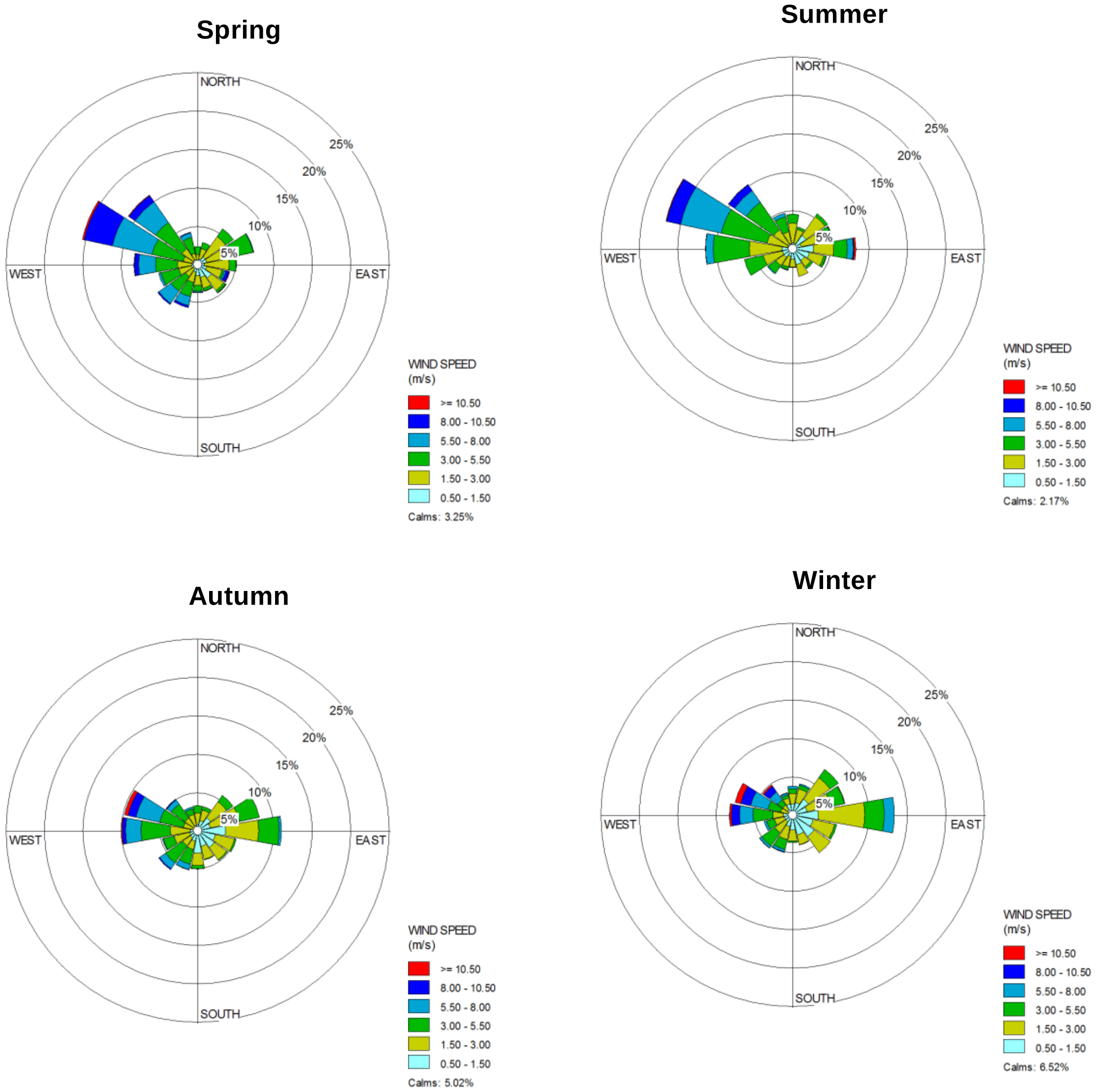

Figure D–9: Seasonal Wind Roses for Levin AWS for 2009

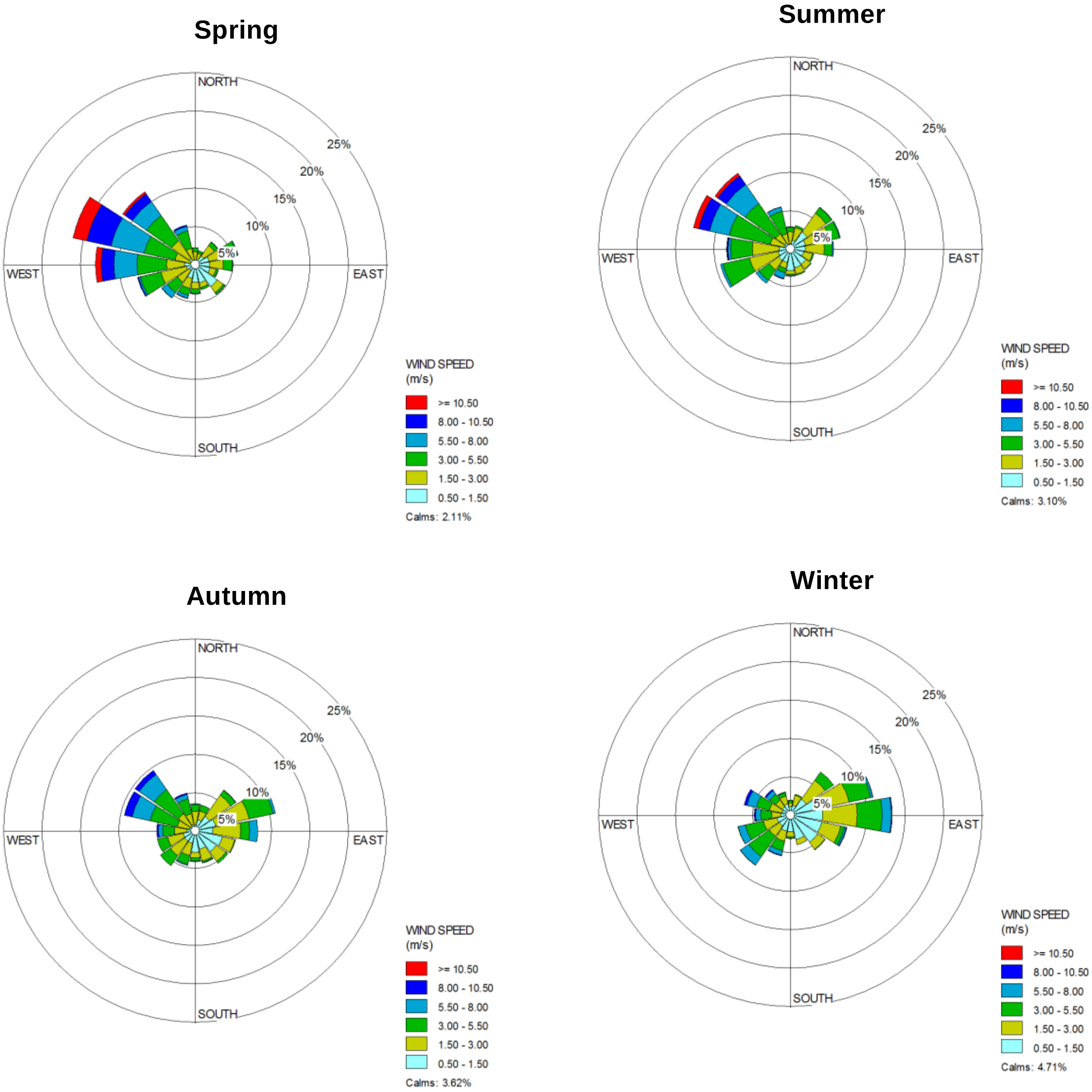

Figure D–10: Seasonal Wind Roses for Levin AWS for 2010

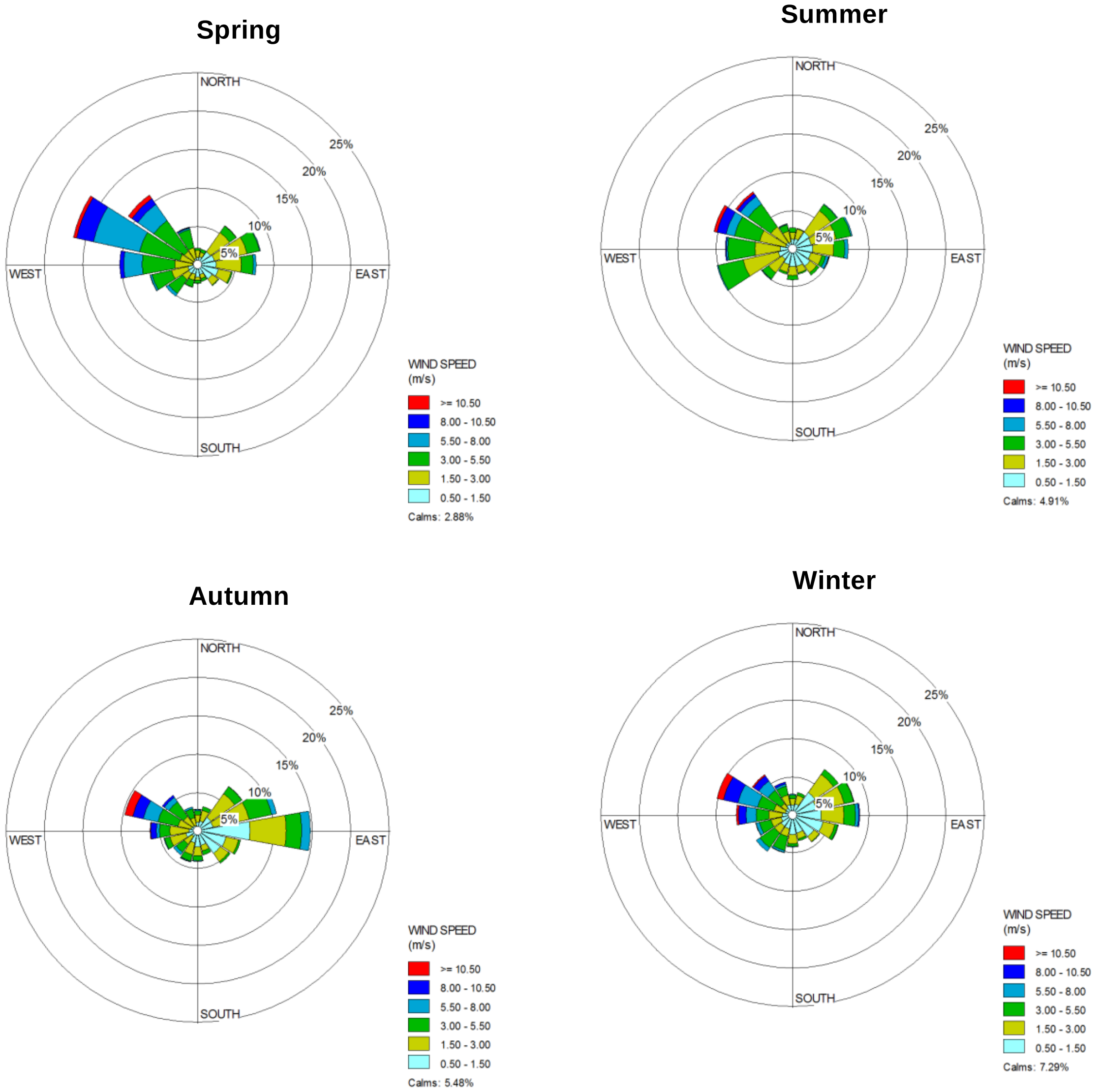

Figure D–11: Seasonal Wind Roses for Levin AWS for 2011

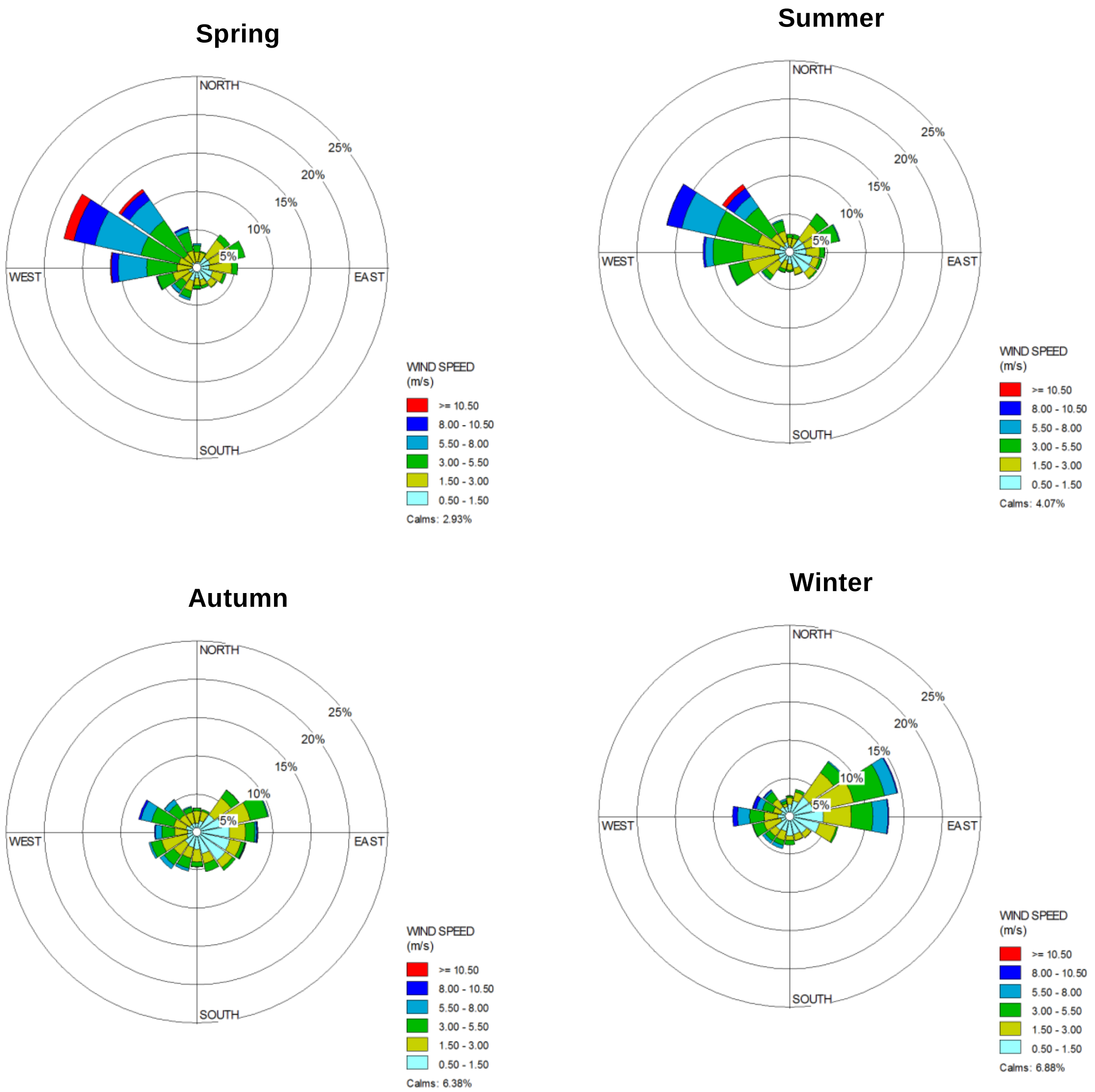

Figure D–12: Seasonal Wind Roses for Levin AWS for 2012

Paraparaumu Aero AWS – Annual and Seasonal Wind Roses

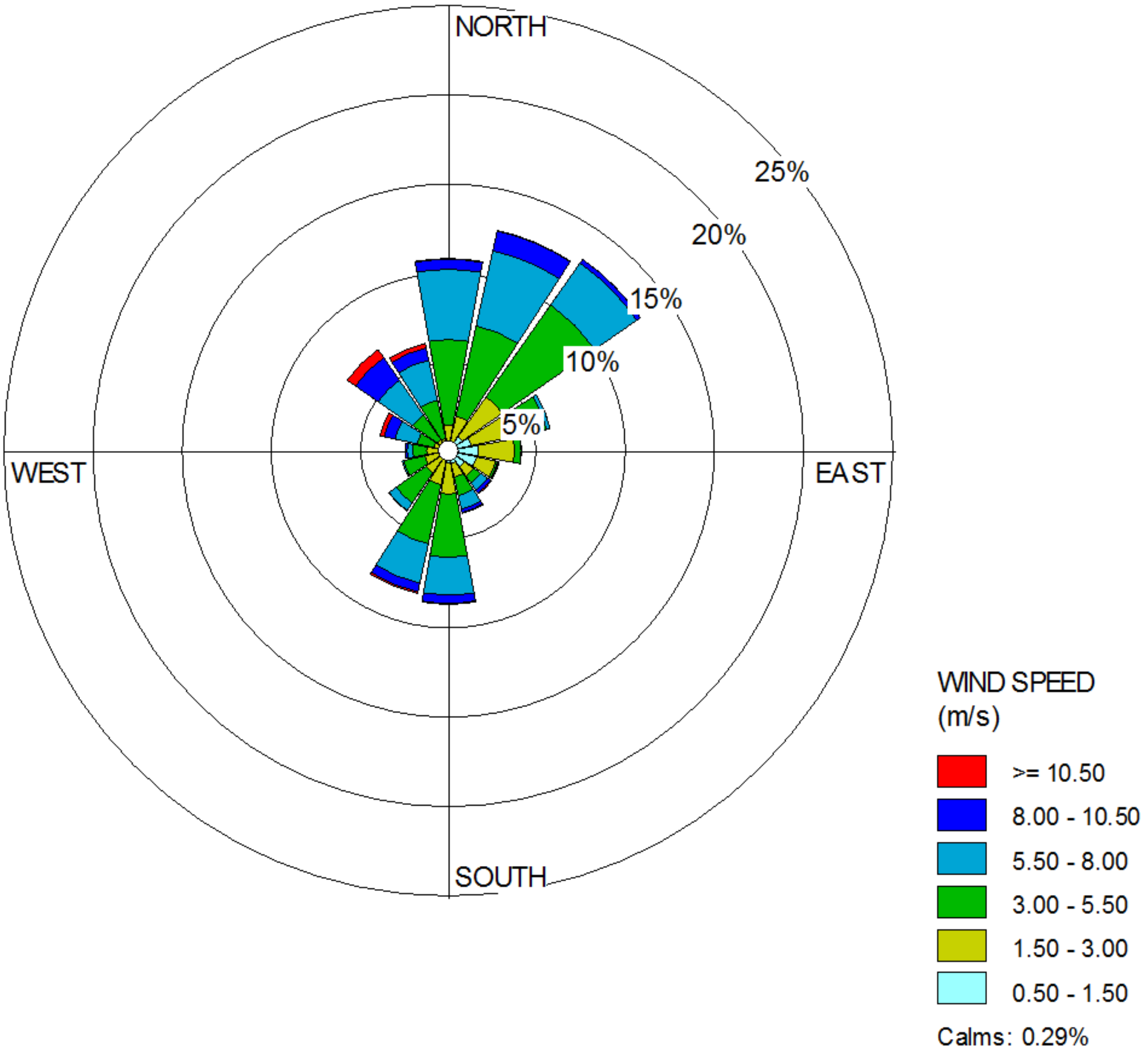

Figure D–13: Wind Rose for Paraparaumu Aero AWS for 2008 to 2012

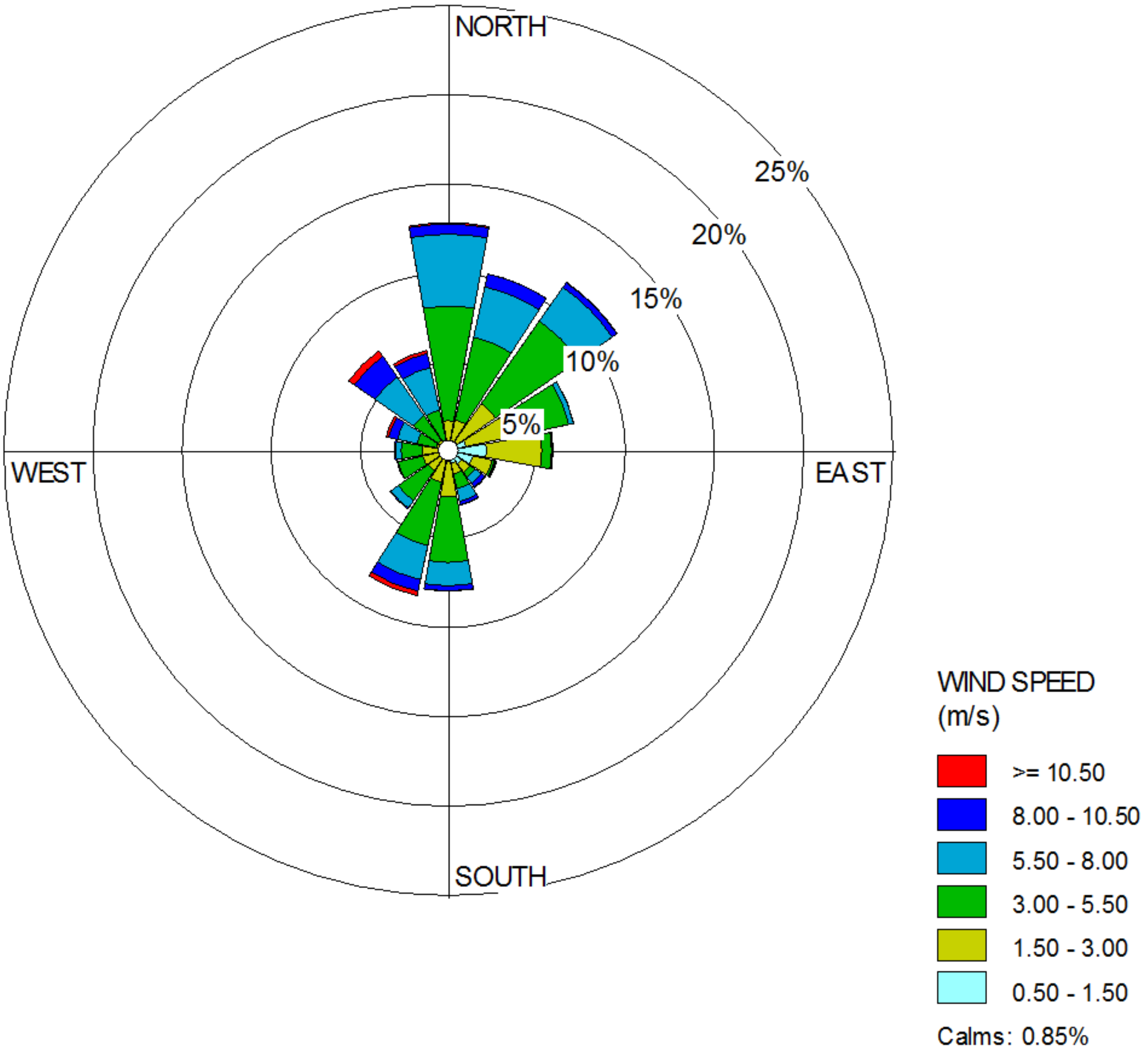

Figure D–14: Annual Wind Rose for Paraparaumu Aero AWS for 2008

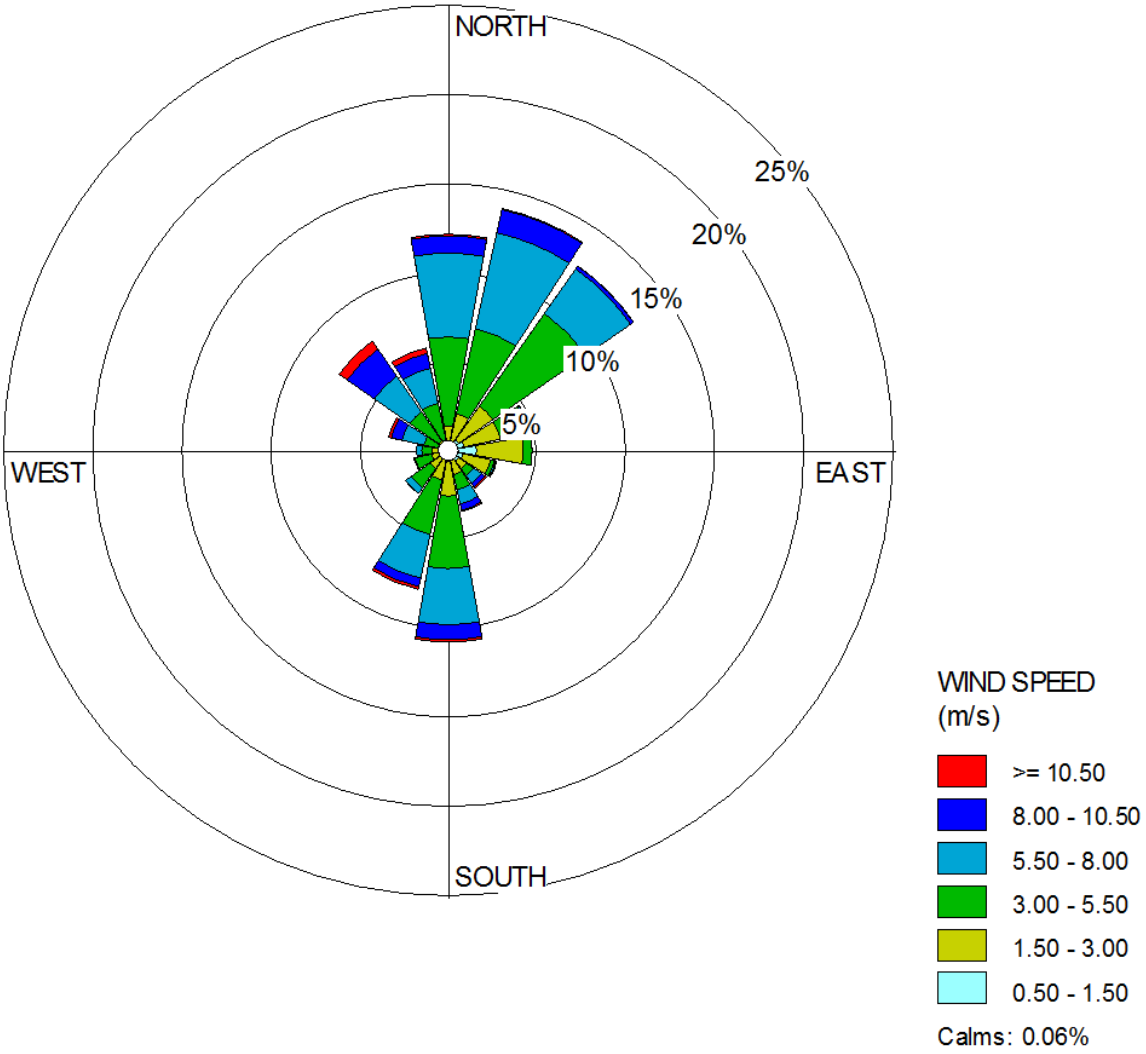

Figure D–15: Annual Wind Rose for Paraparaumu Aero AWS for 2009

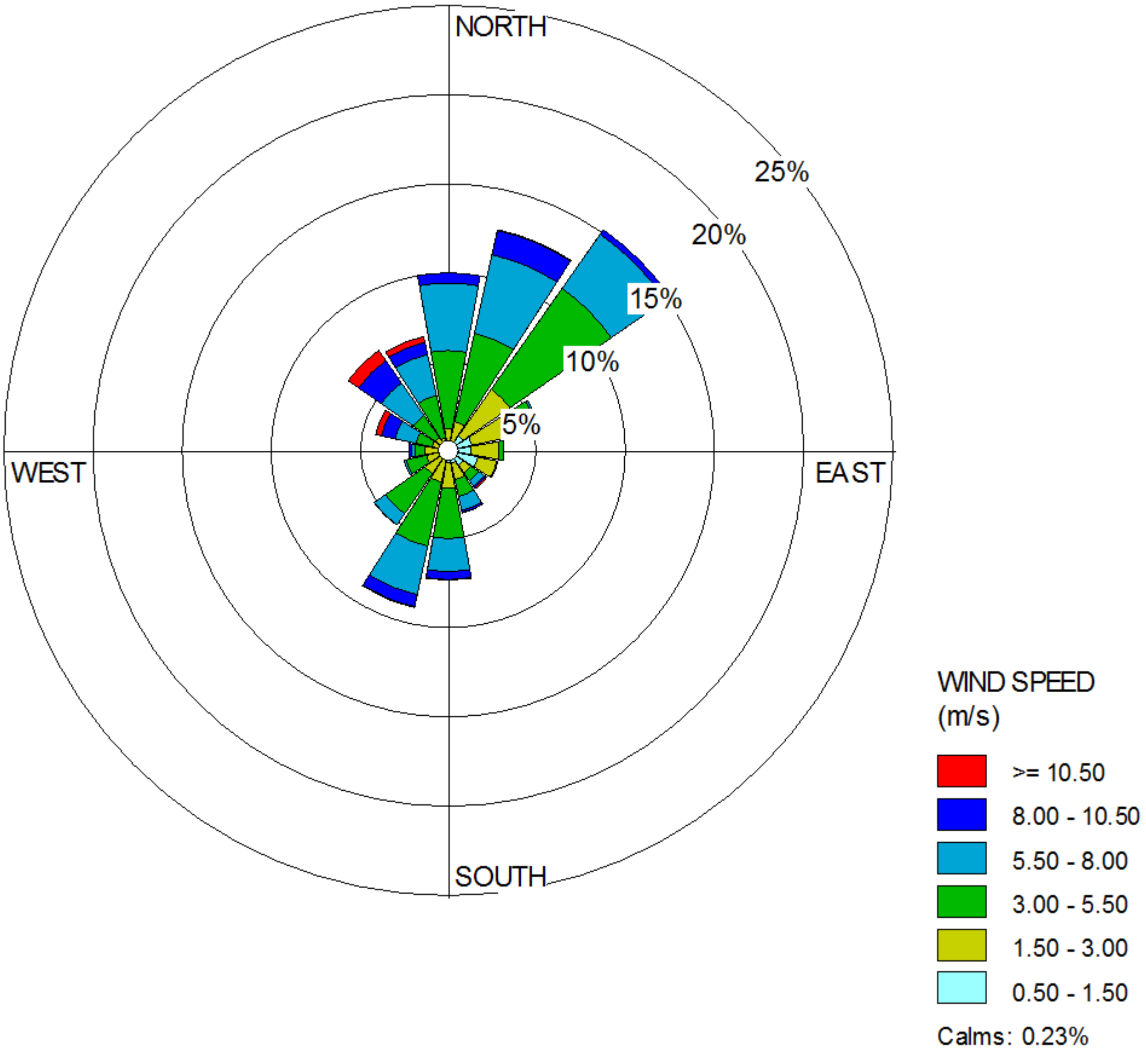

Figure D–16: Annual Wind Rose for Paraparaumu Aero AWS for 2010

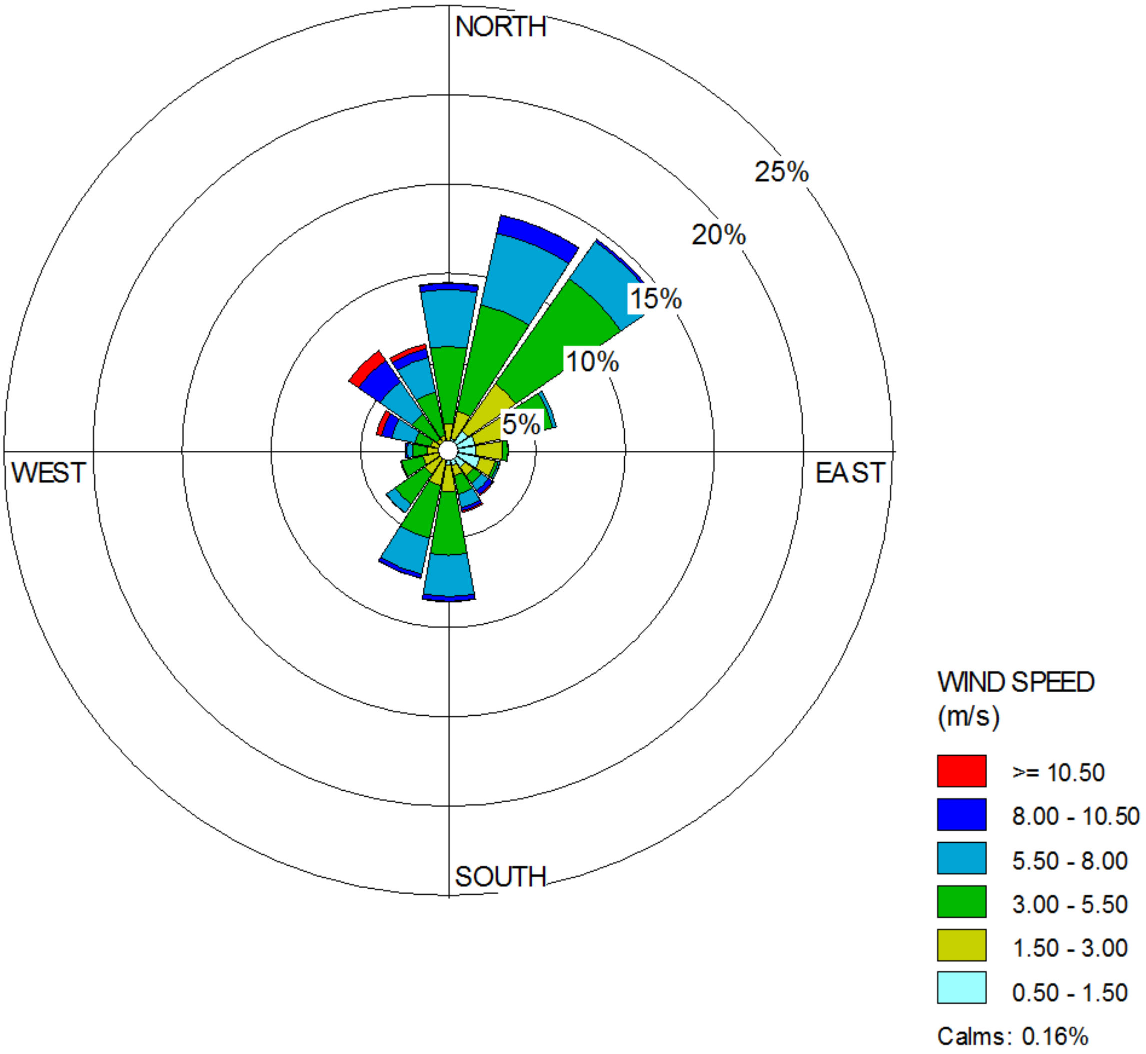

Figure D–17: Annual Wind Rose for Paraparaumu Aero AWS for 2011

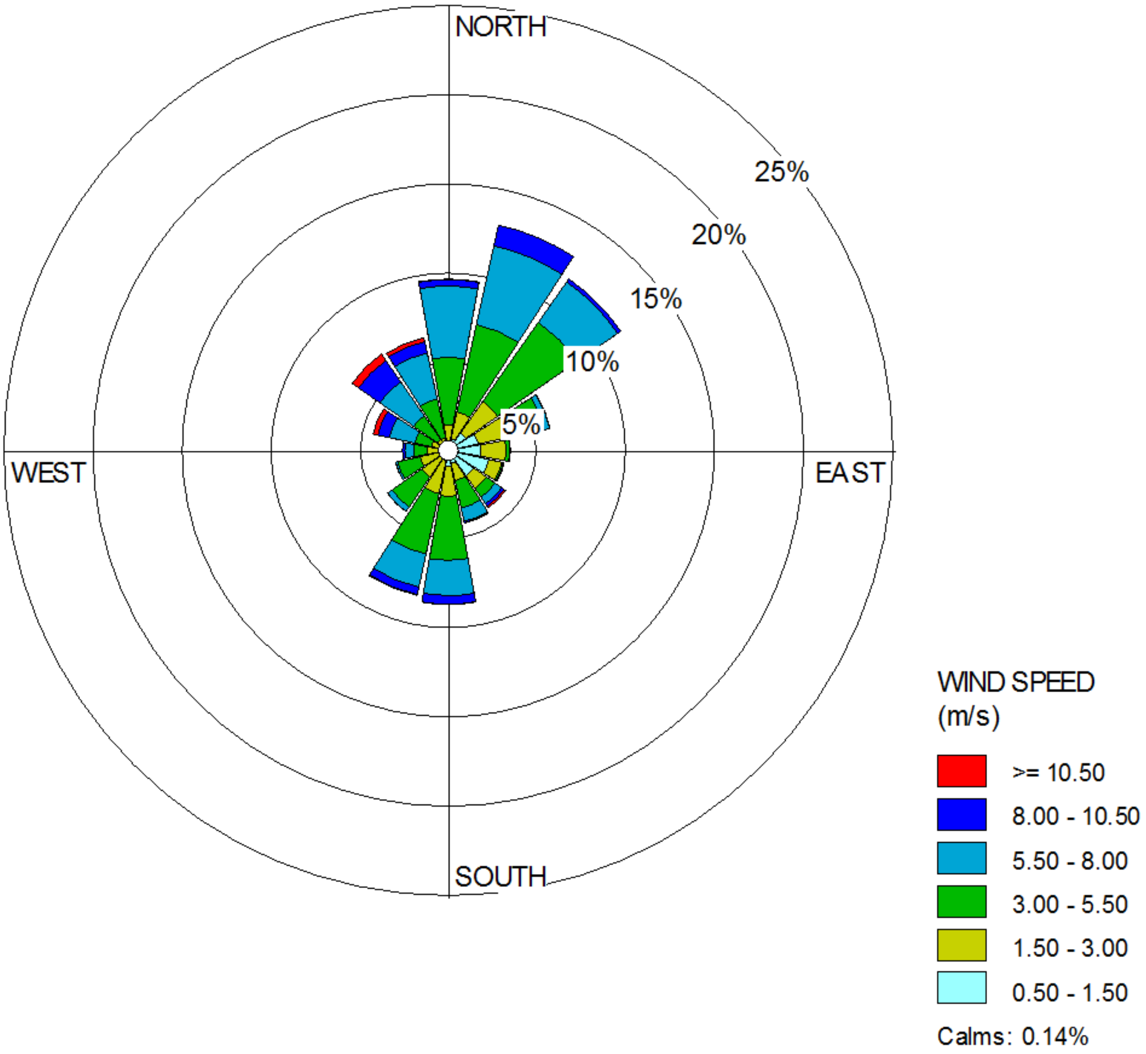

Figure D–18: Annual Wind Rose for Paraparaumu Aero AWS for 2012

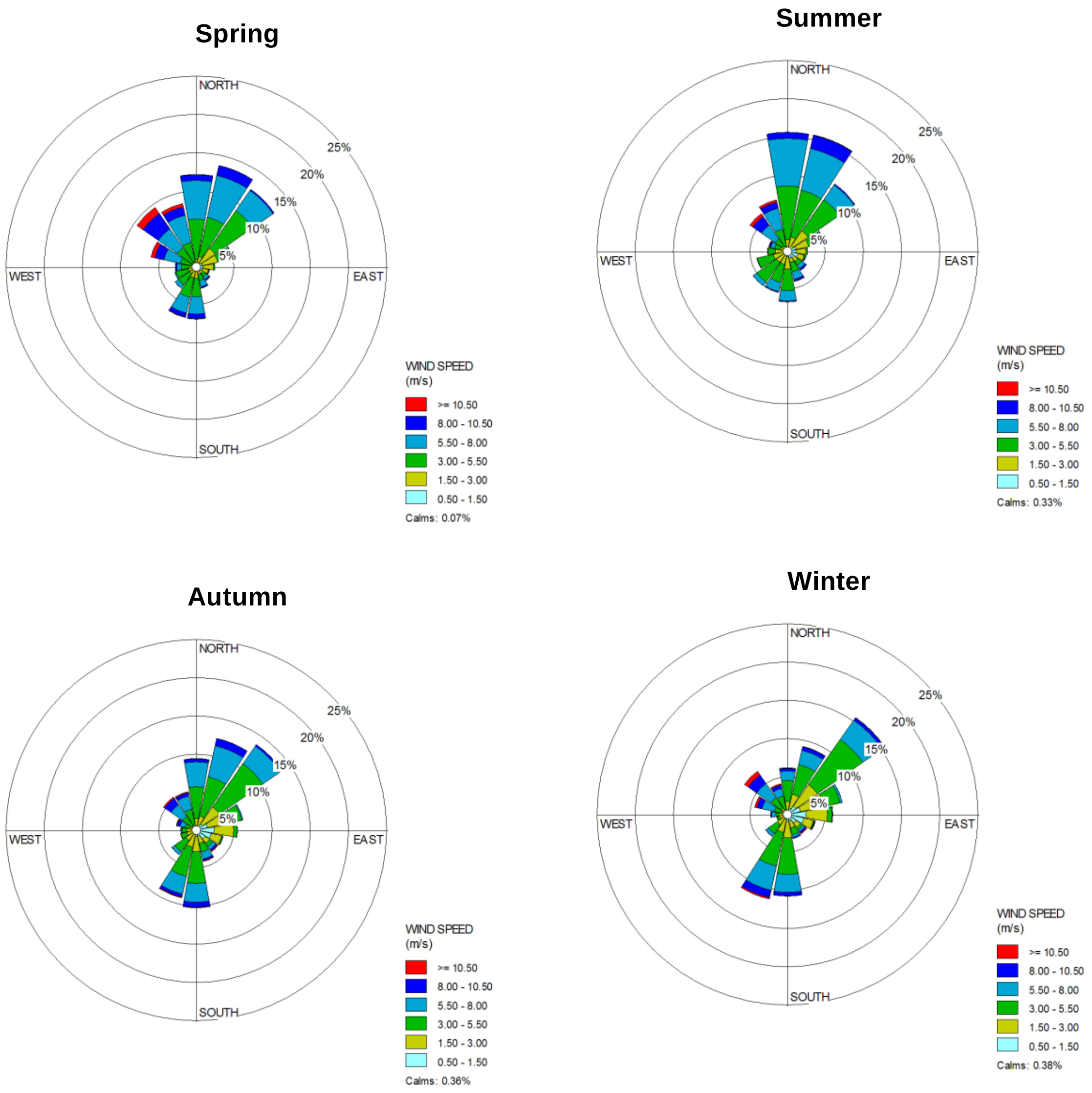

Figure D–19: Seasonal Wind Roses for Paraparaumu Aero AWS for 2008 to 2012

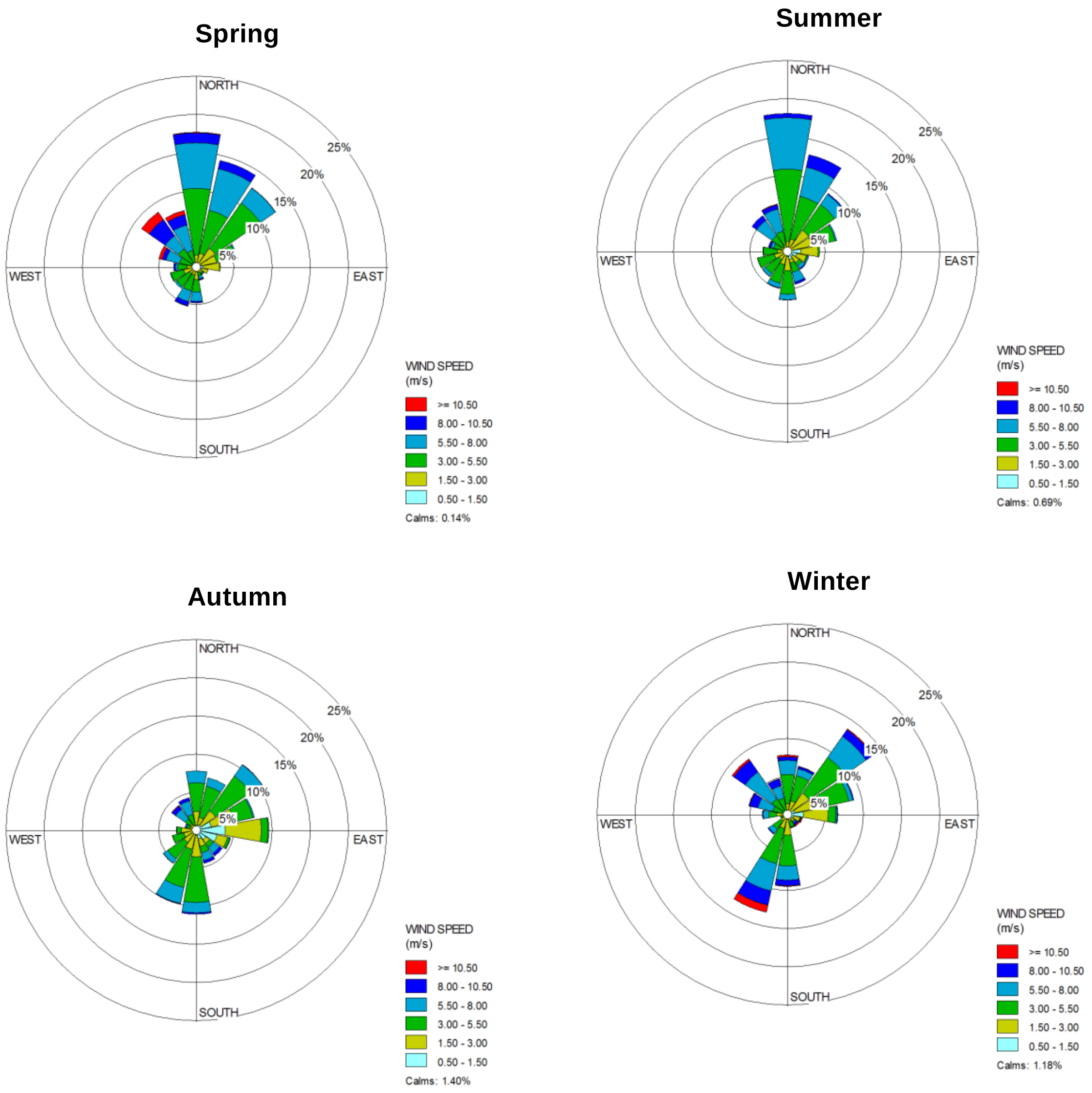

Figure D–20: Seasonal Wind Roses for Paraparaumu Aero AWS for 2008

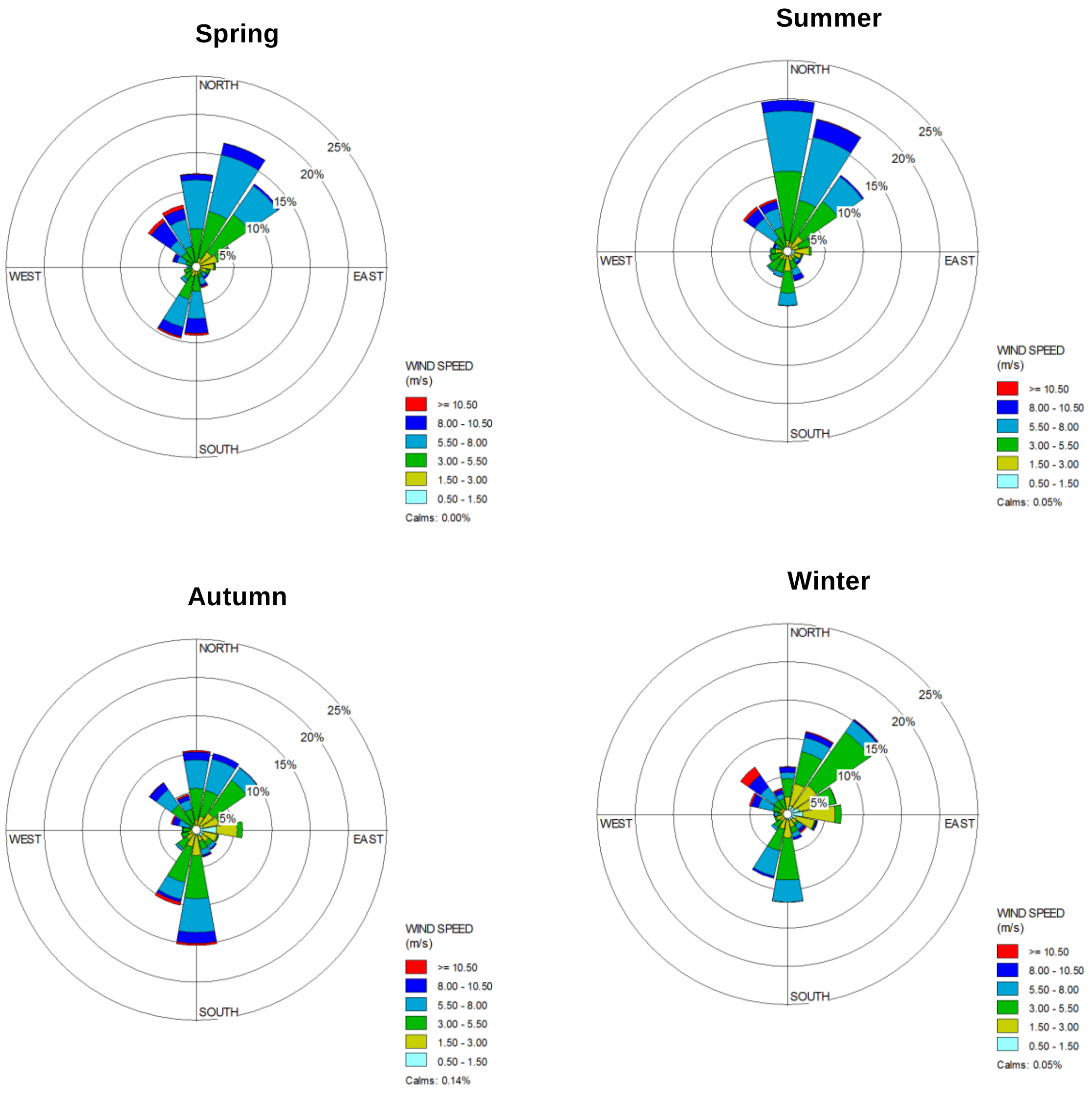

Figure D–21: Seasonal Wind Roses for Paraparaumu Aero AWS for 2009

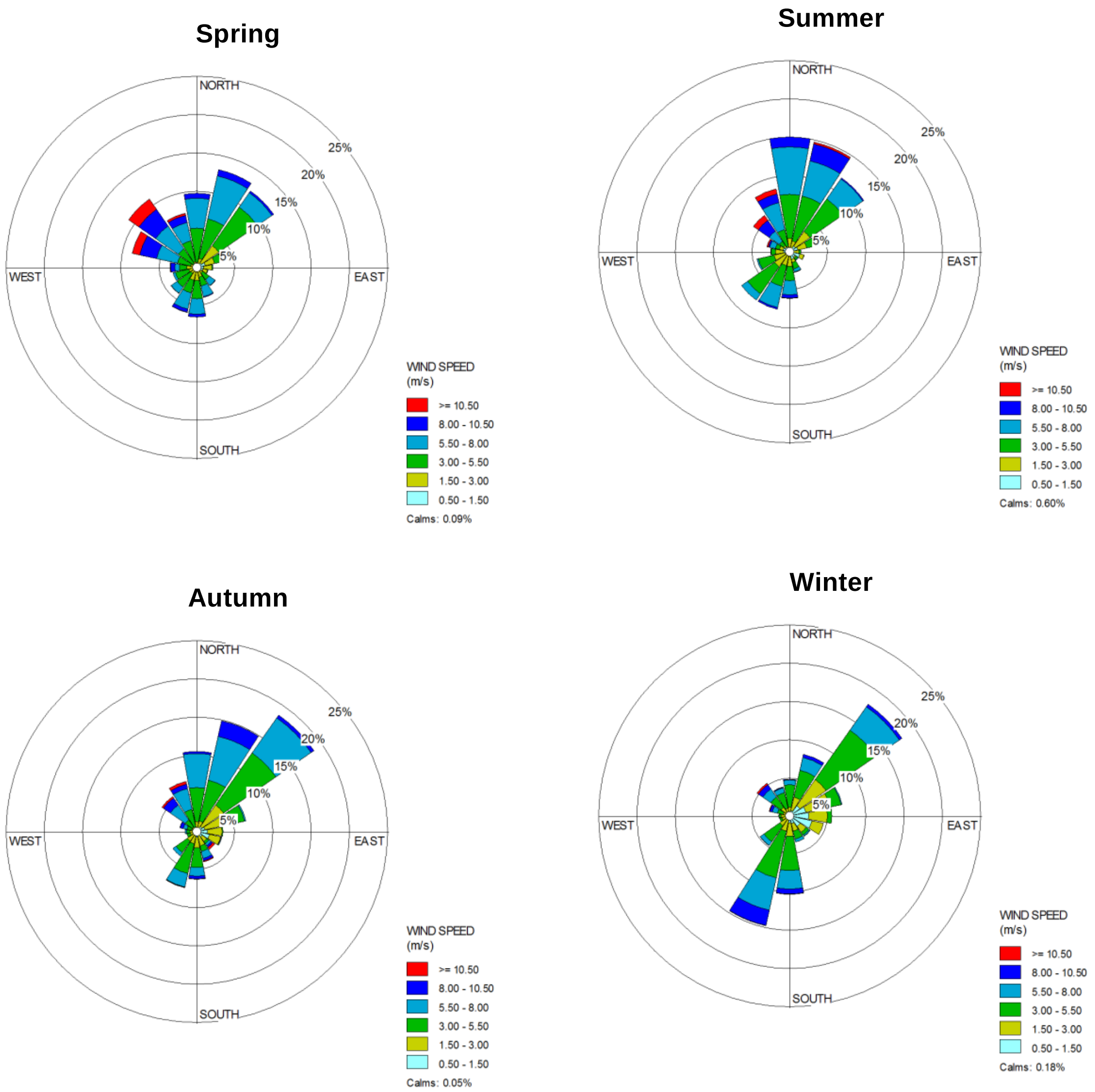

Figure D–22: Seasonal Wind Roses for Paraparaumu Aero AWS for 2010

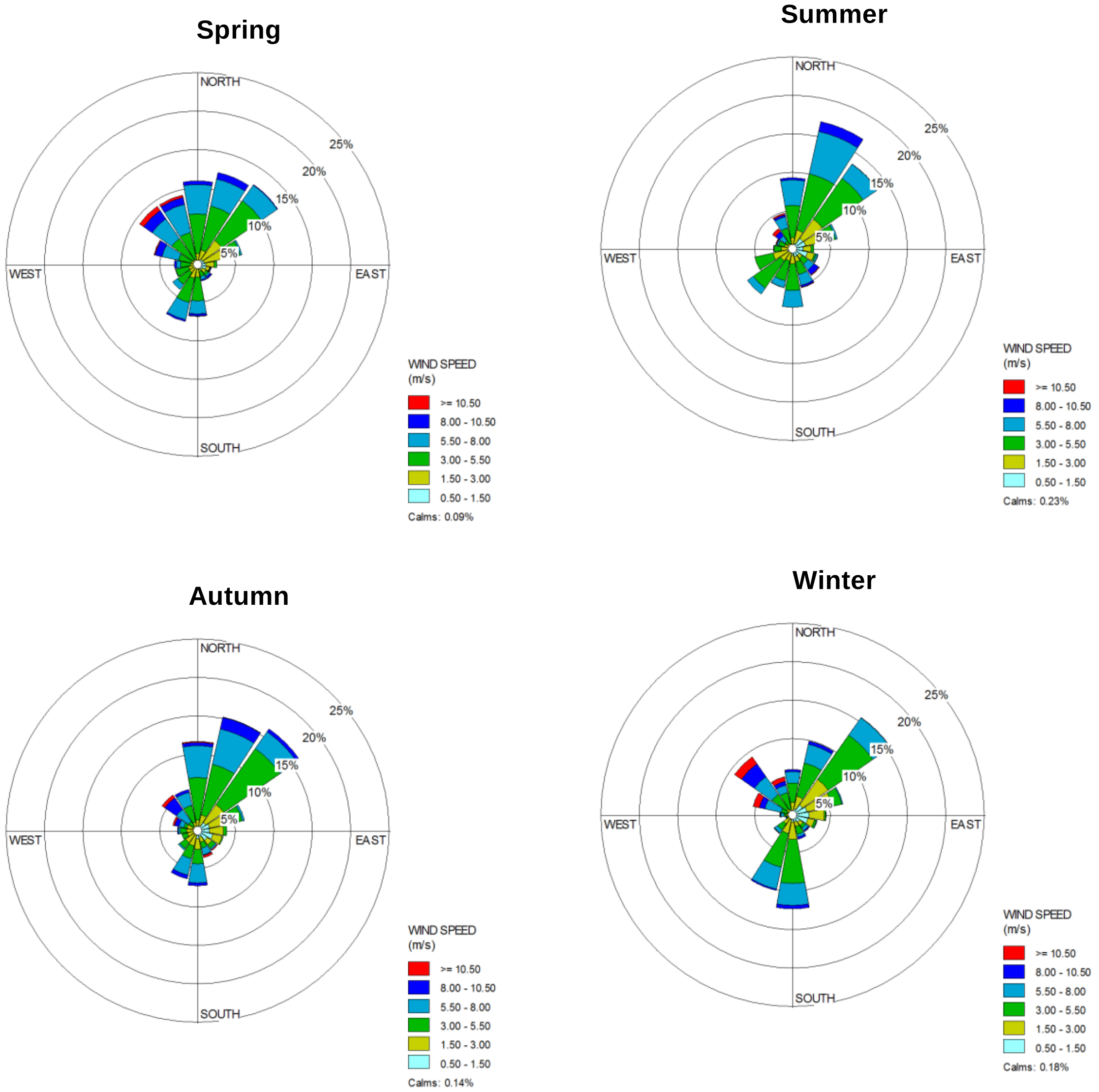

Figure D–23: Seasonal Wind Roses for Paraparaumu Aero AWS for 2011

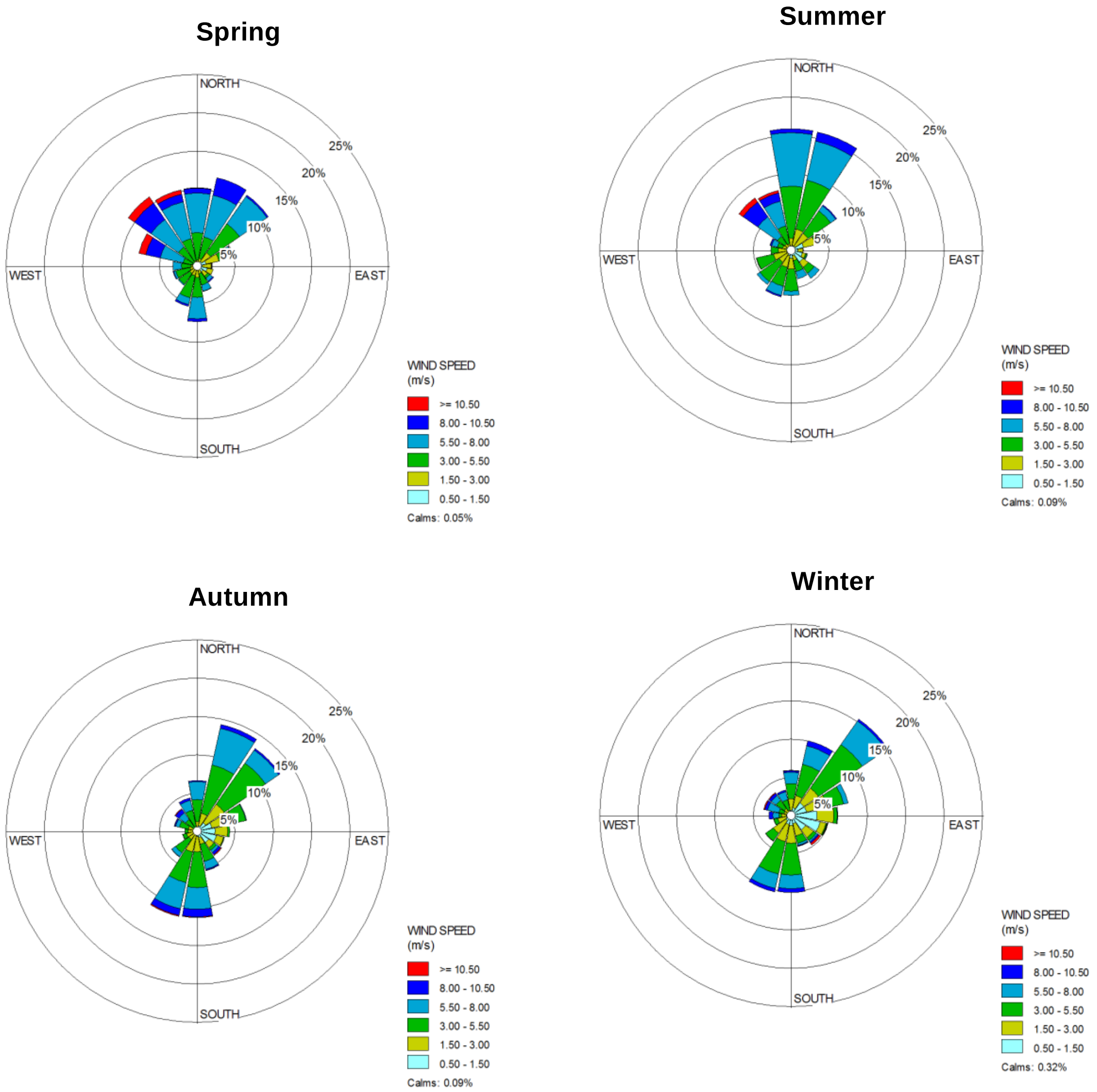

Figure D–24: Seasonal Wind Roses for Paraparaumu Aero AWS for 2012

Palmerston North EWS – Annual and Seasonal Wind Roses

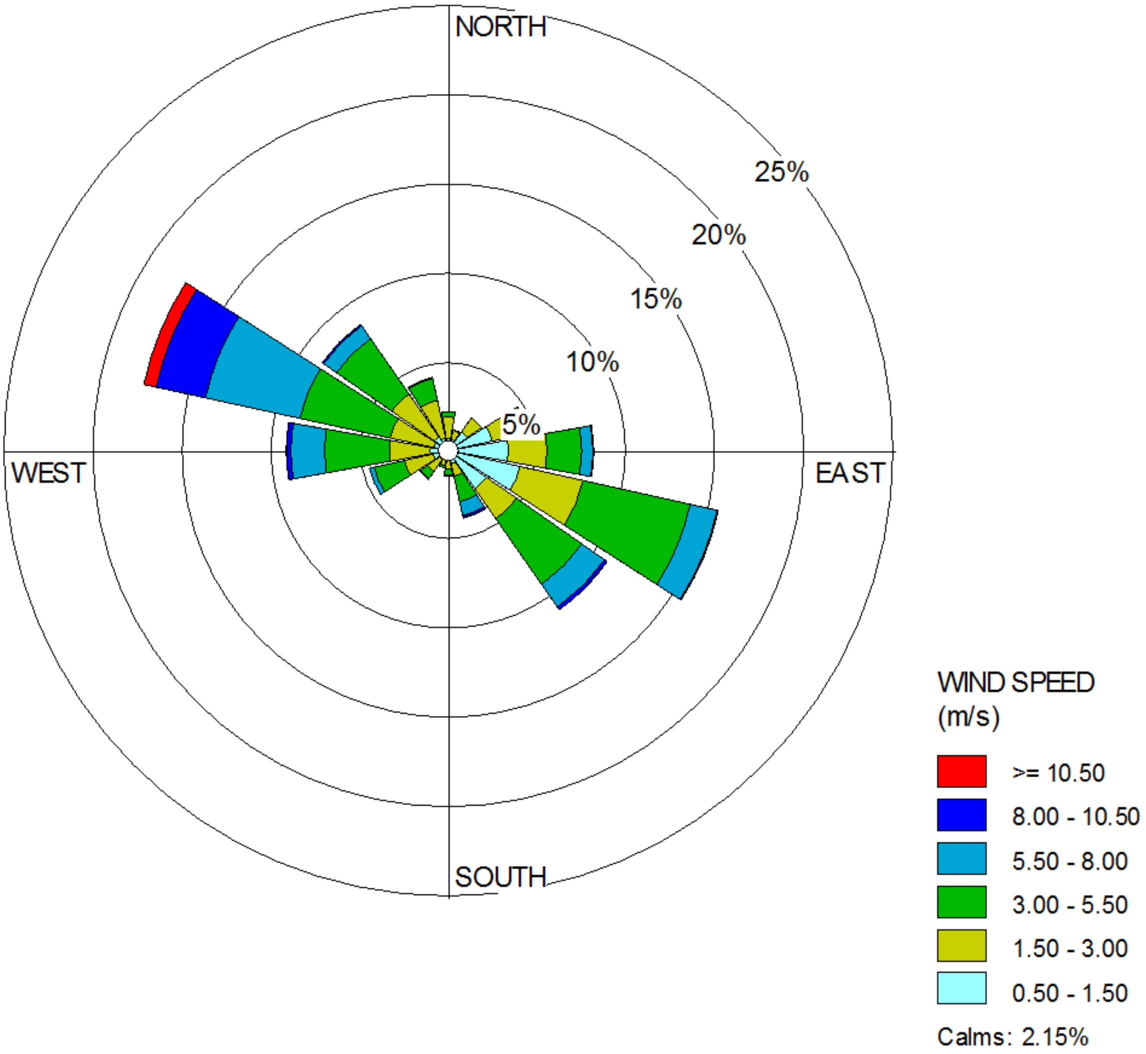

Figure D–25: Wind Rose for Palmerston North EWS for 2008 to 2012

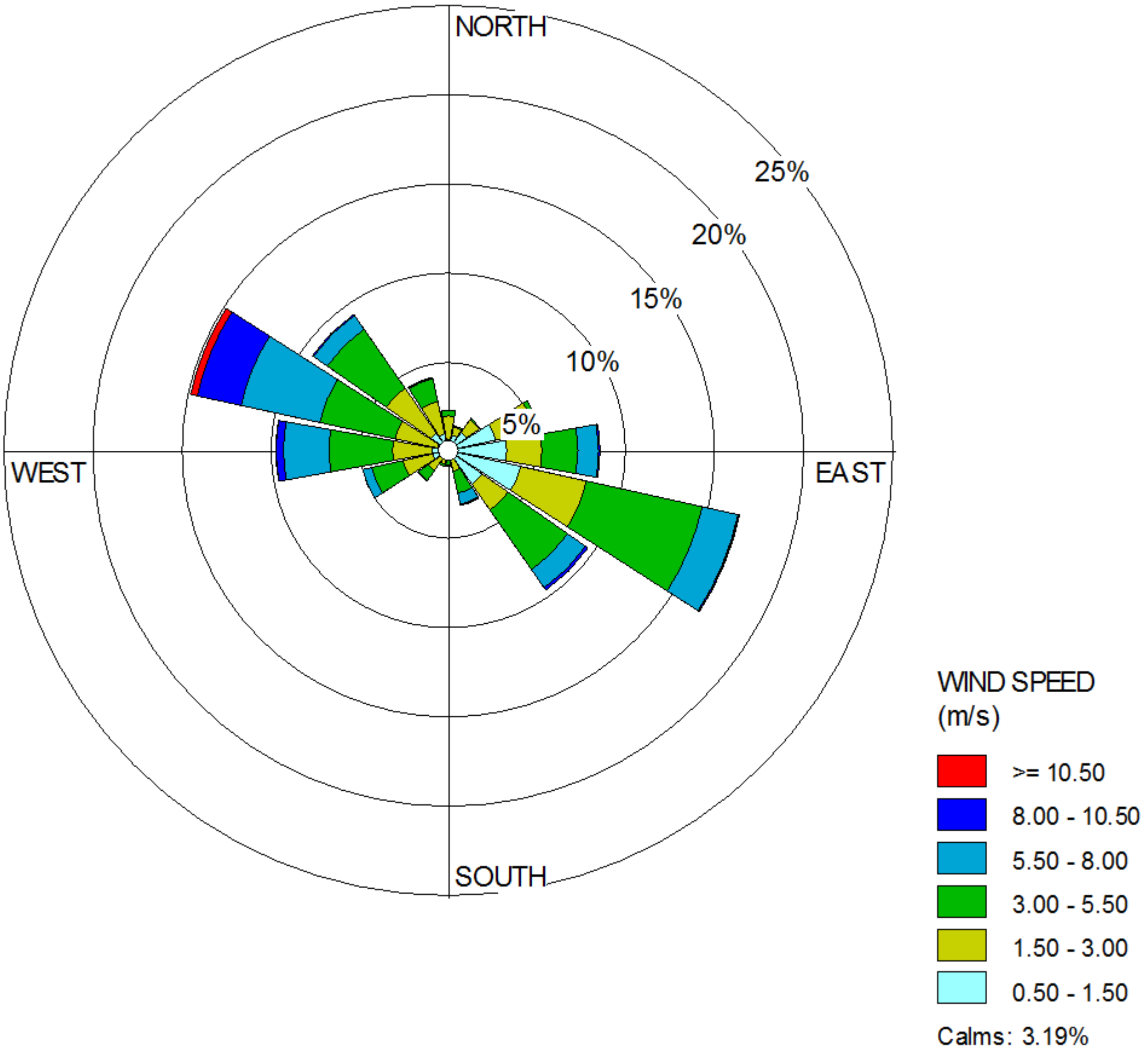

Figure D–26: Annual Wind Rose for Palmerston North EWS for 2008

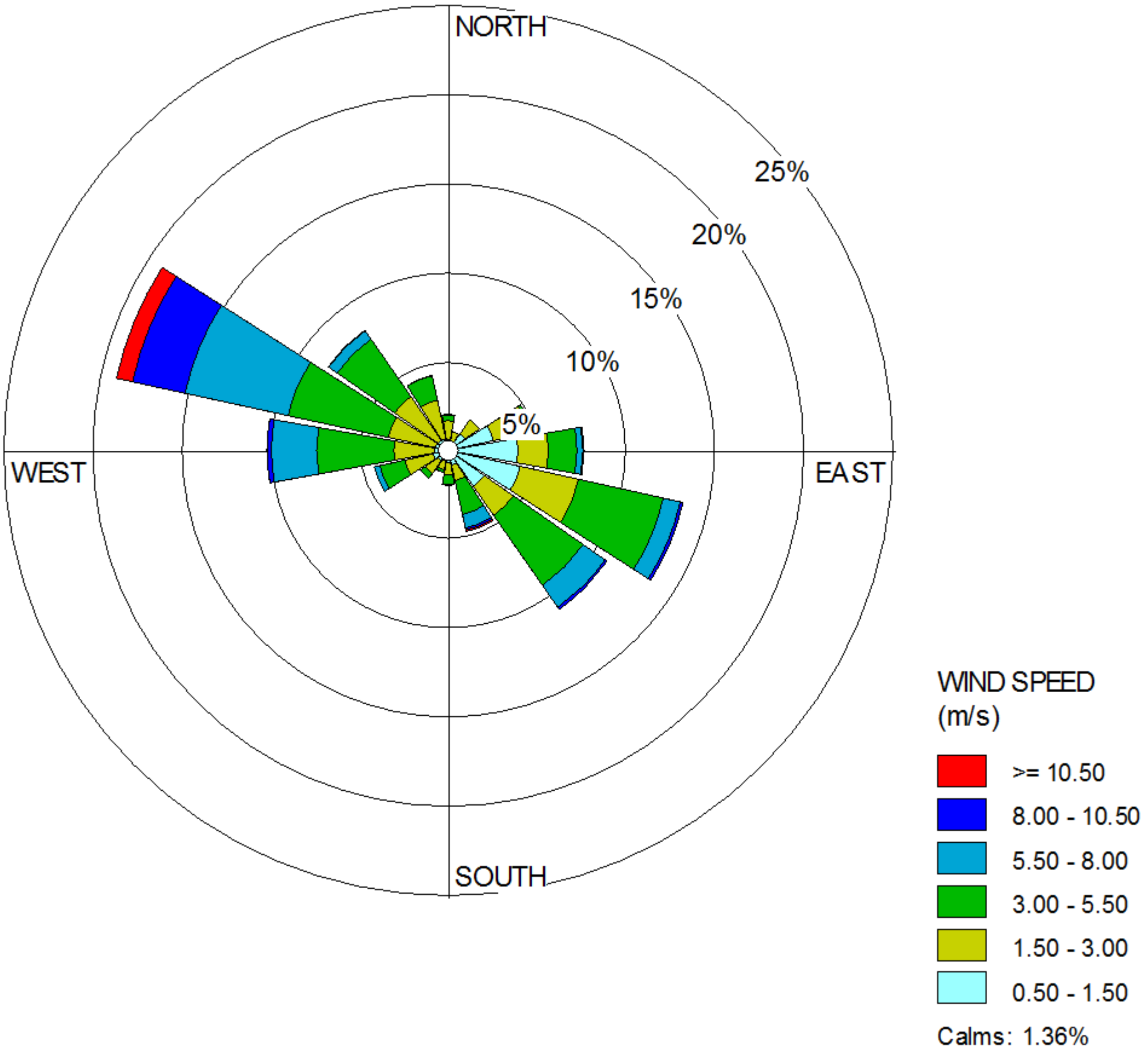

Figure D–27: Annual Wind Rose for Palmerston North EWS for 2009

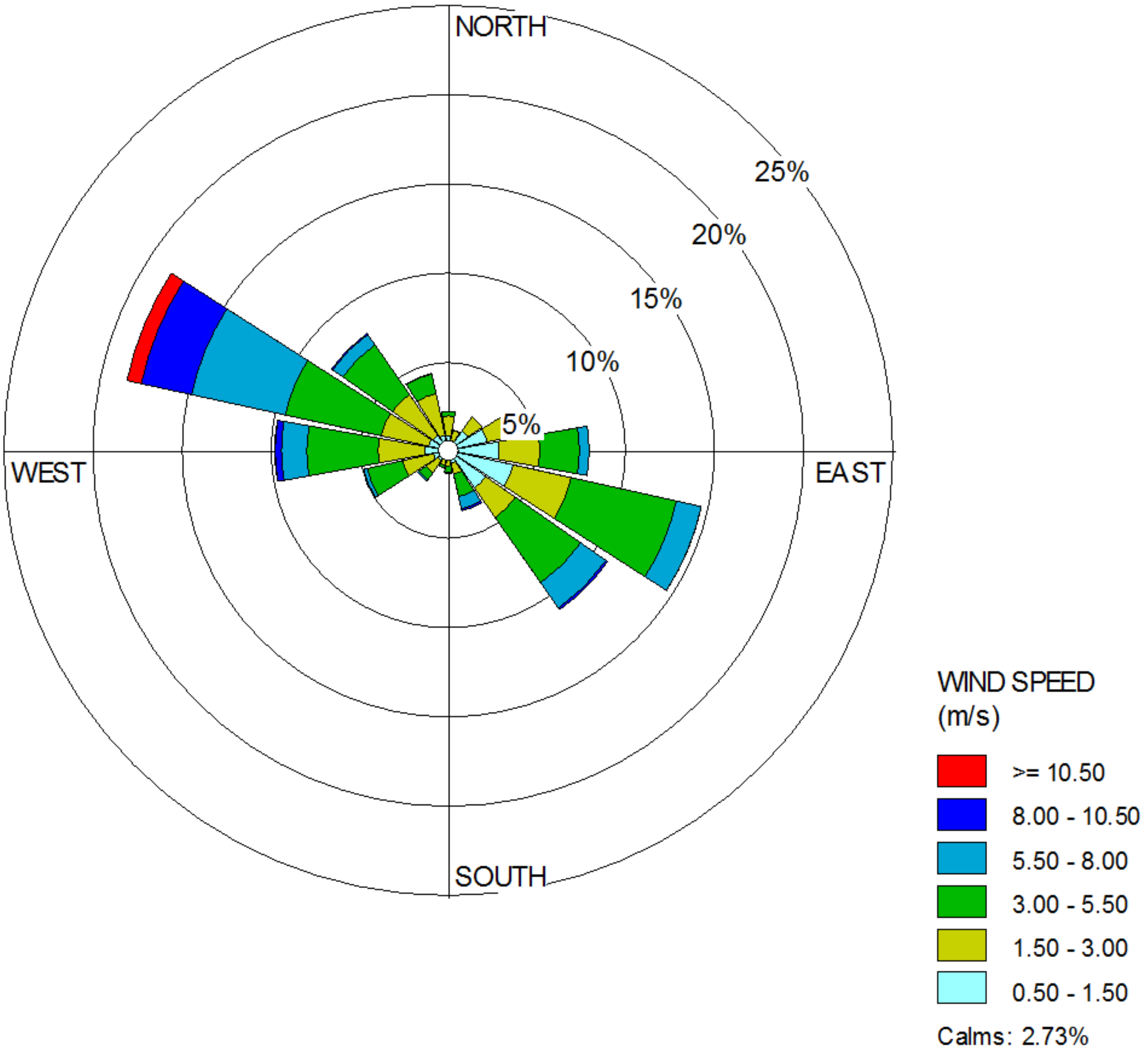

Figure D–28: Annual Wind Rose for Palmerston North EWS for 2010

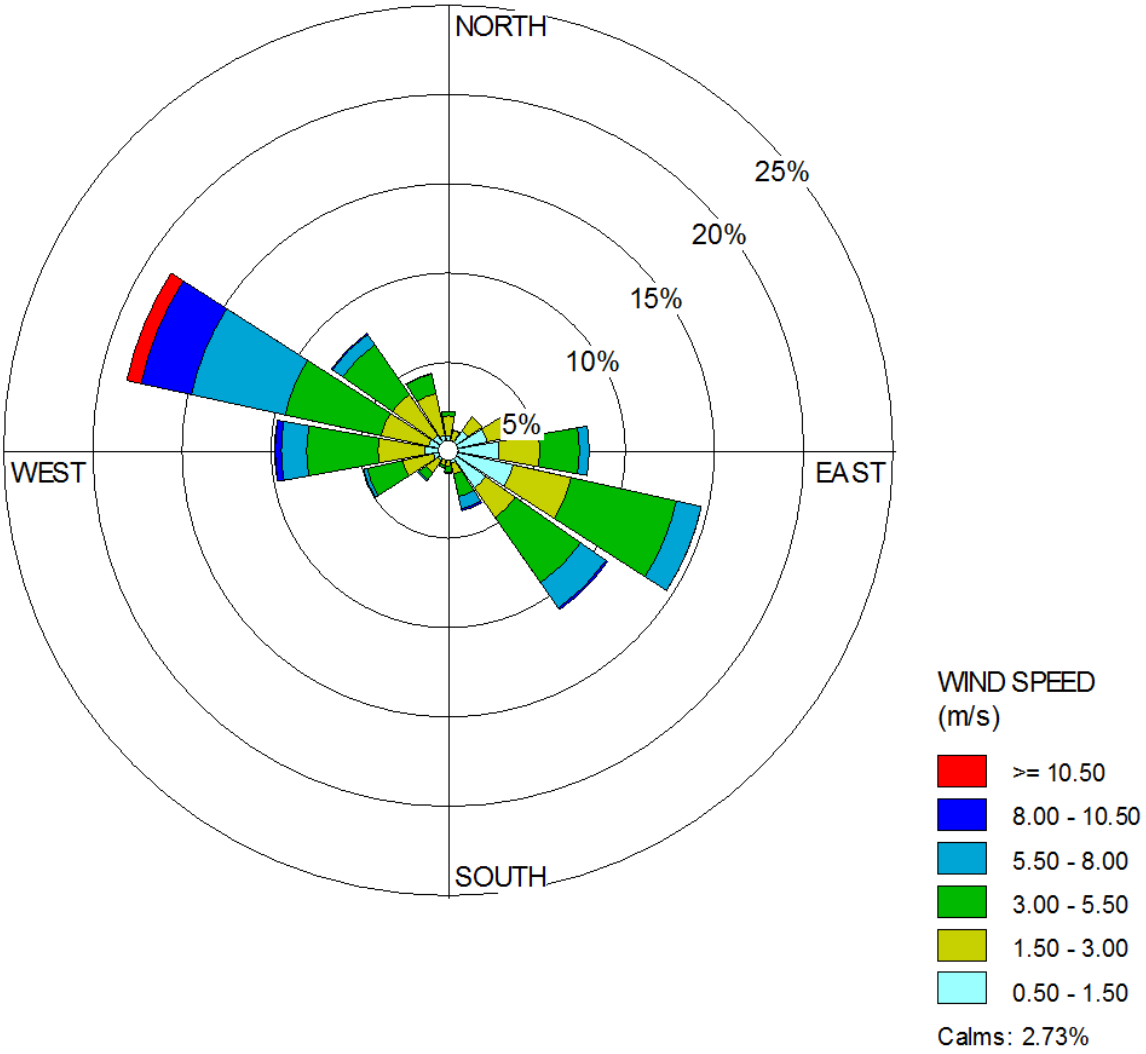

Figure D–29: Annual Wind Rose for Palmerston North EWS for 2011

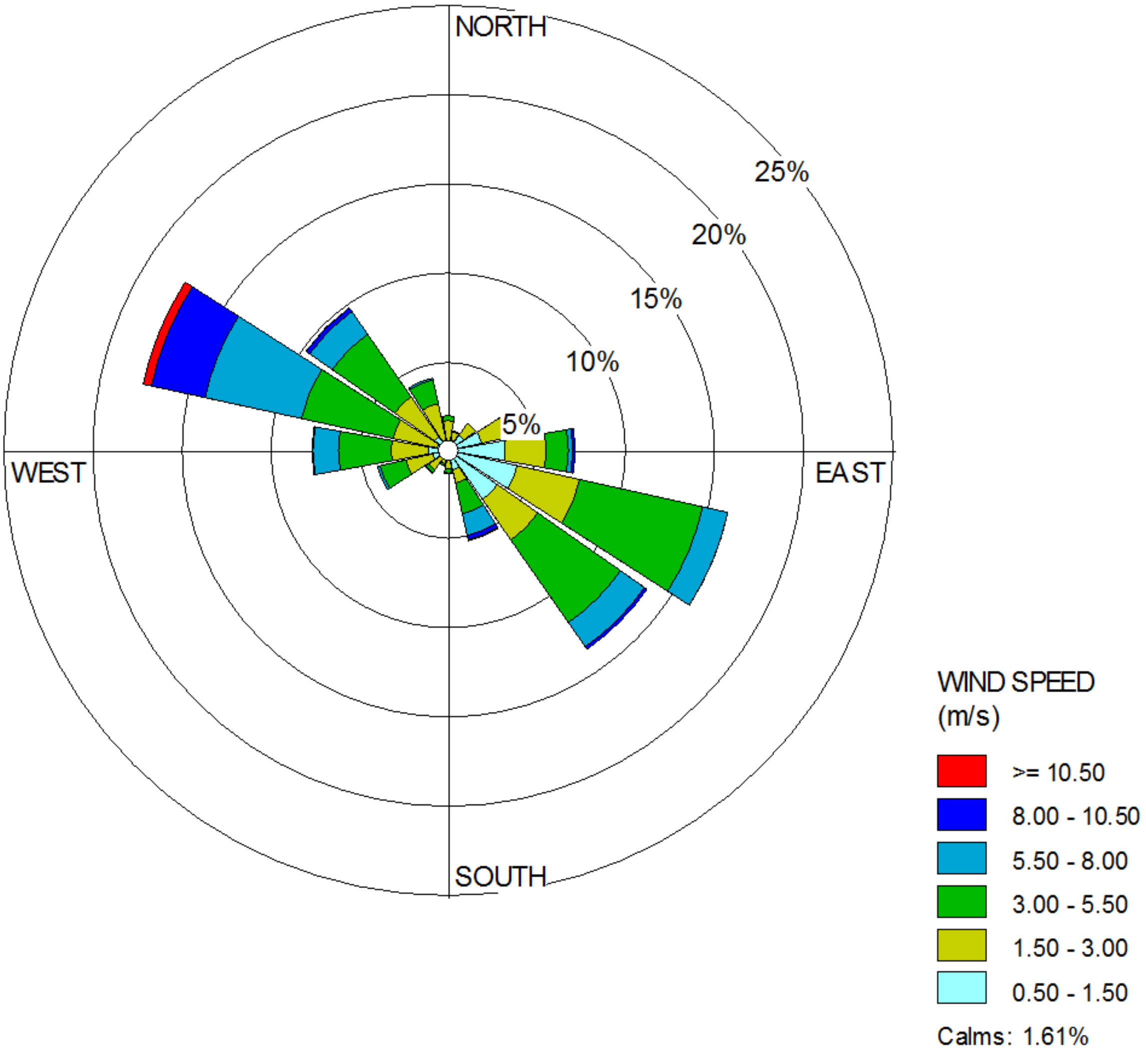

Figure D–30: Annual Wind Rose for Palmerston North EWS for 2012

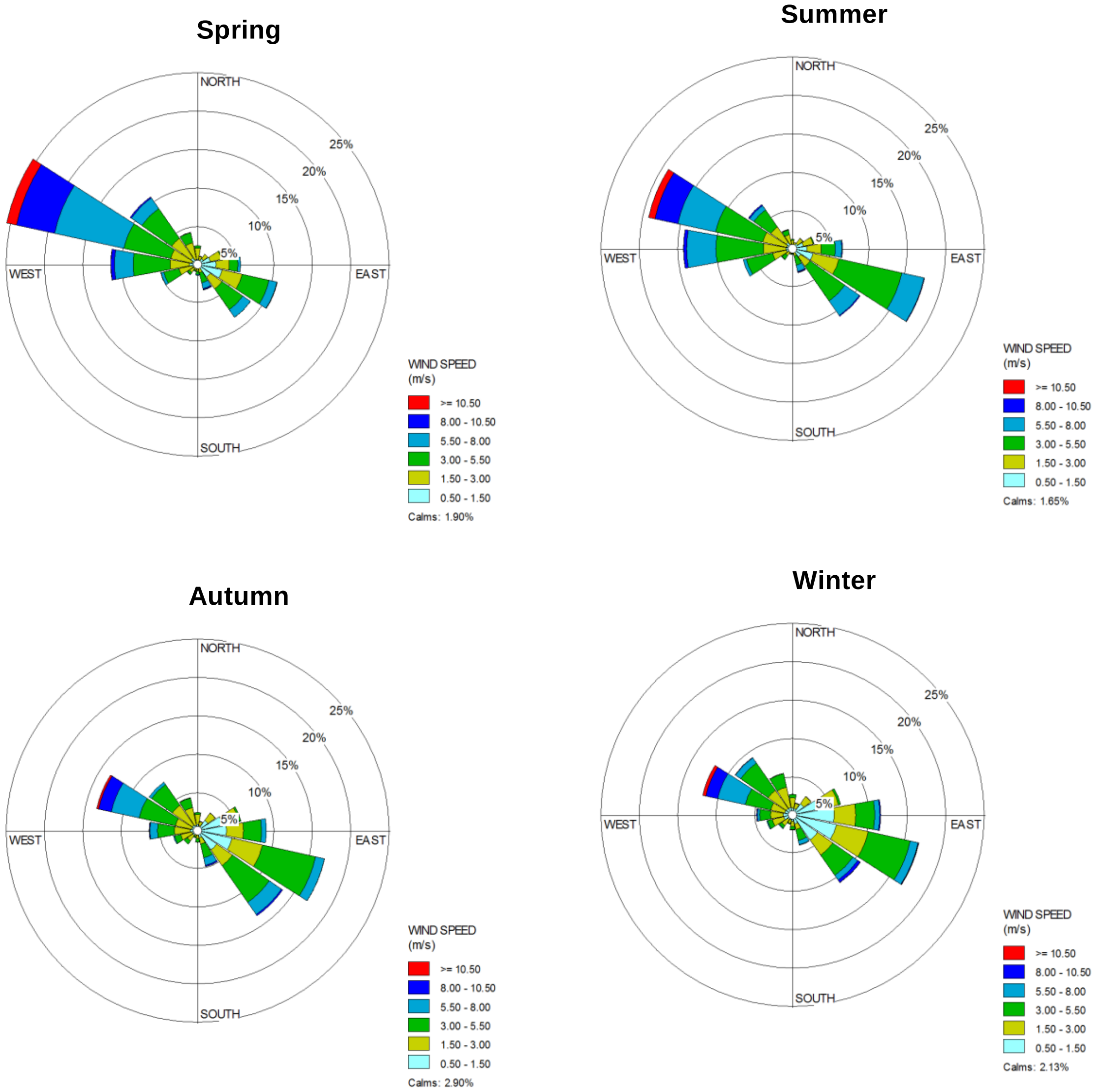

Figure D–31: Seasonal Wind Roses for Palmerston North EWS for 2008 to 2012

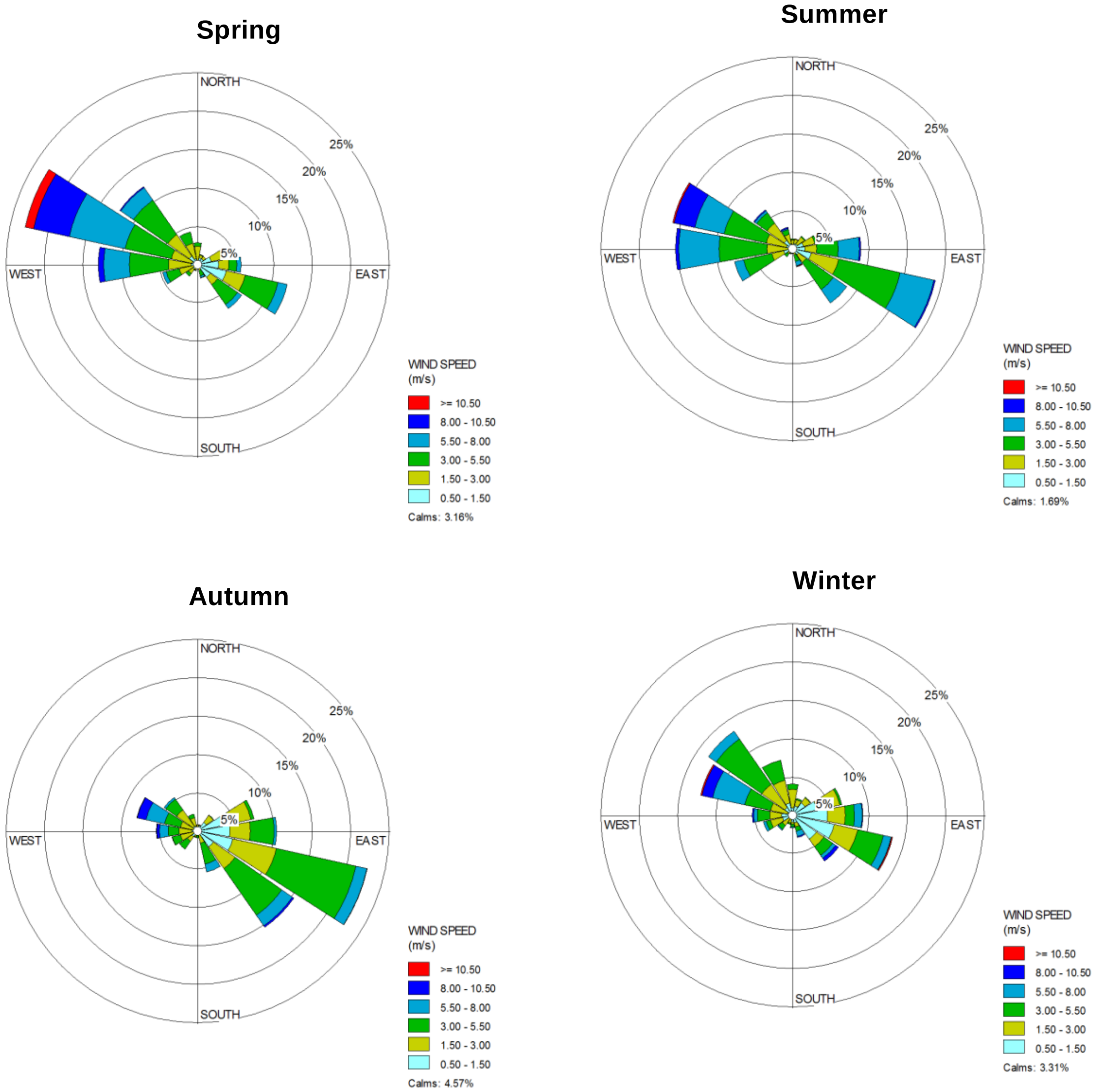

Figure D–32: Seasonal Wind Roses for Palmerston North EWS for 2008

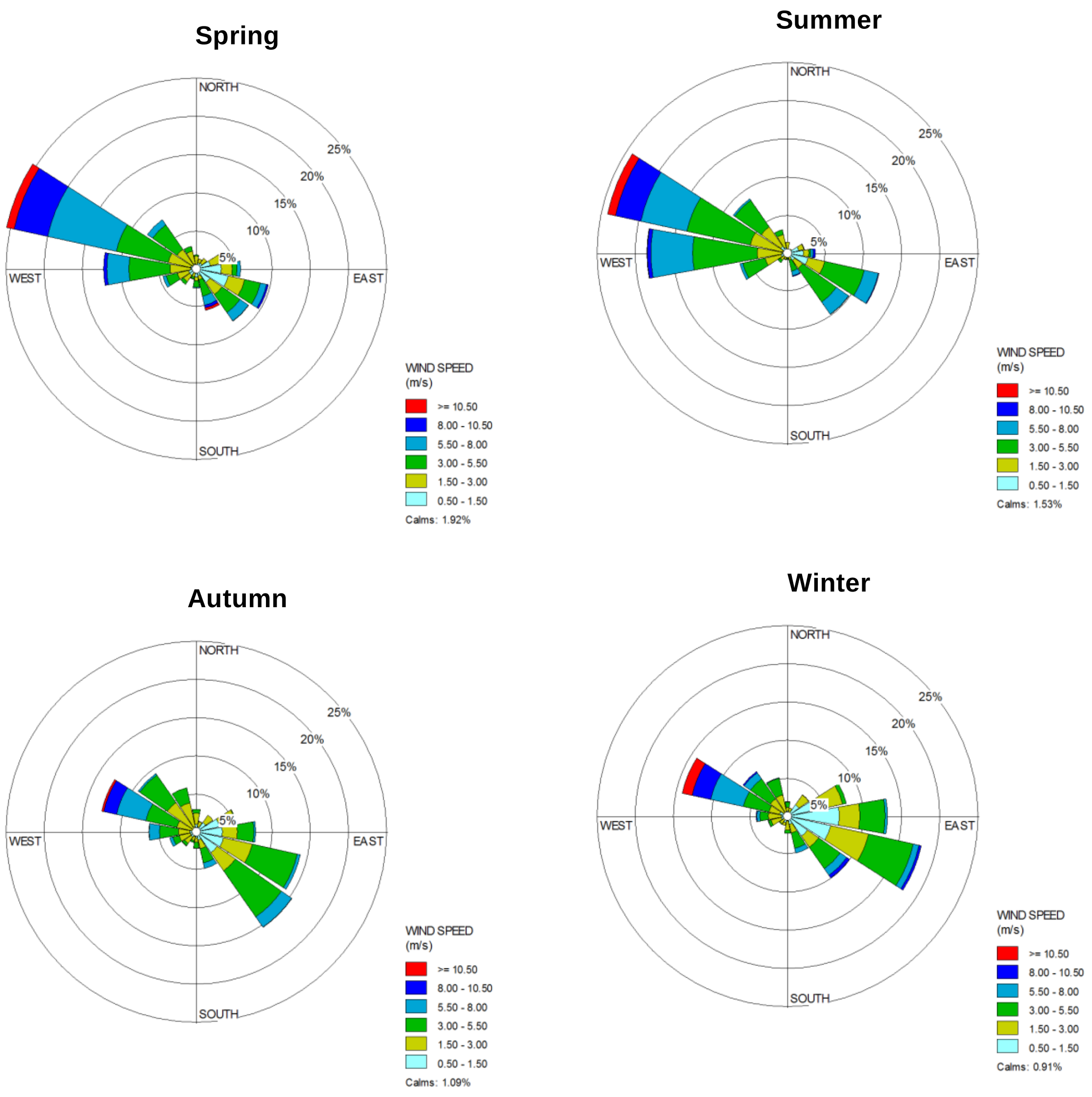

Figure D–33: Seasonal Wind Roses for Palmerston North EWS for 2009

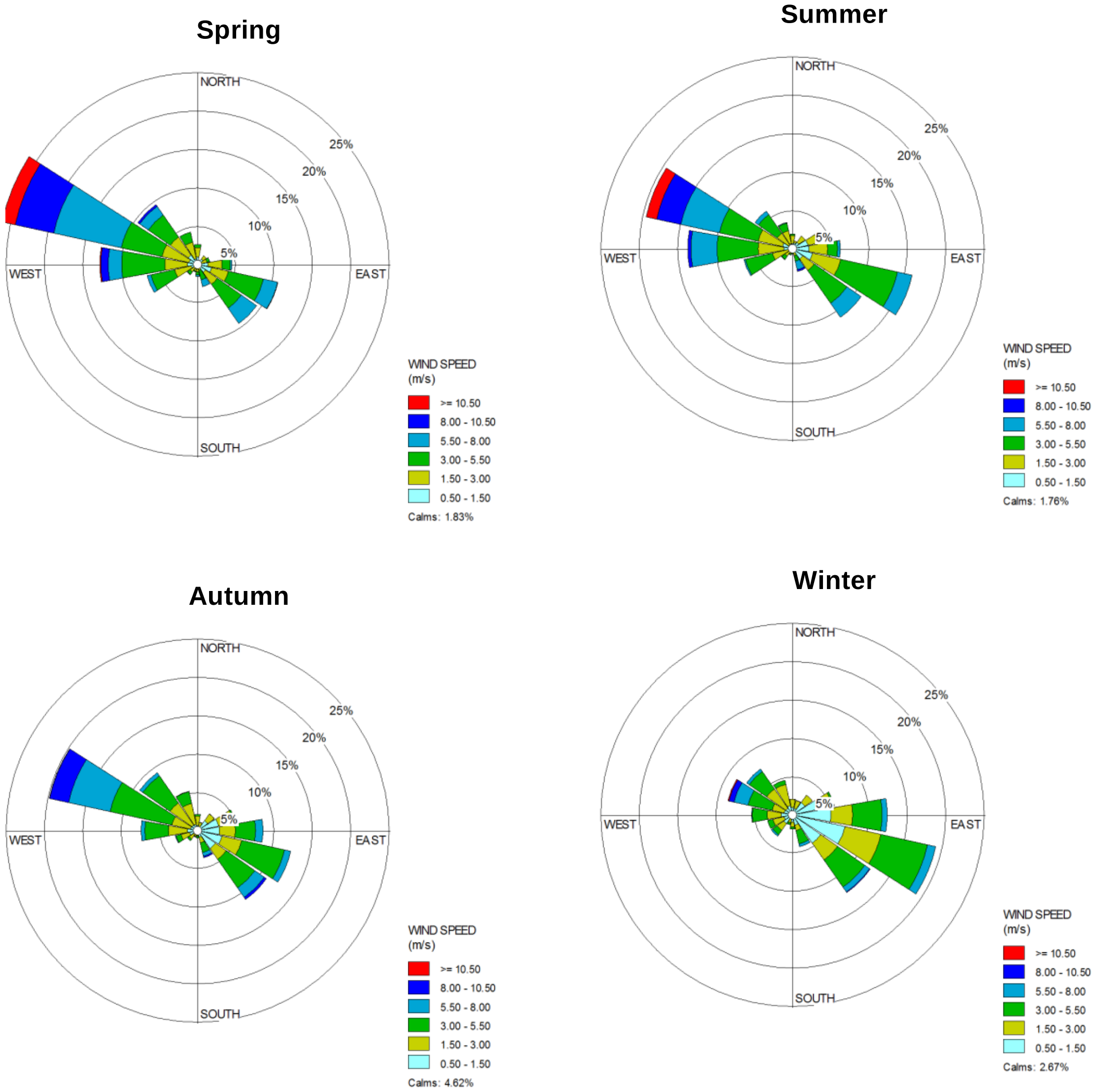

Figure D–34: Seasonal Wind Roses for Palmerston North EWS for 2010

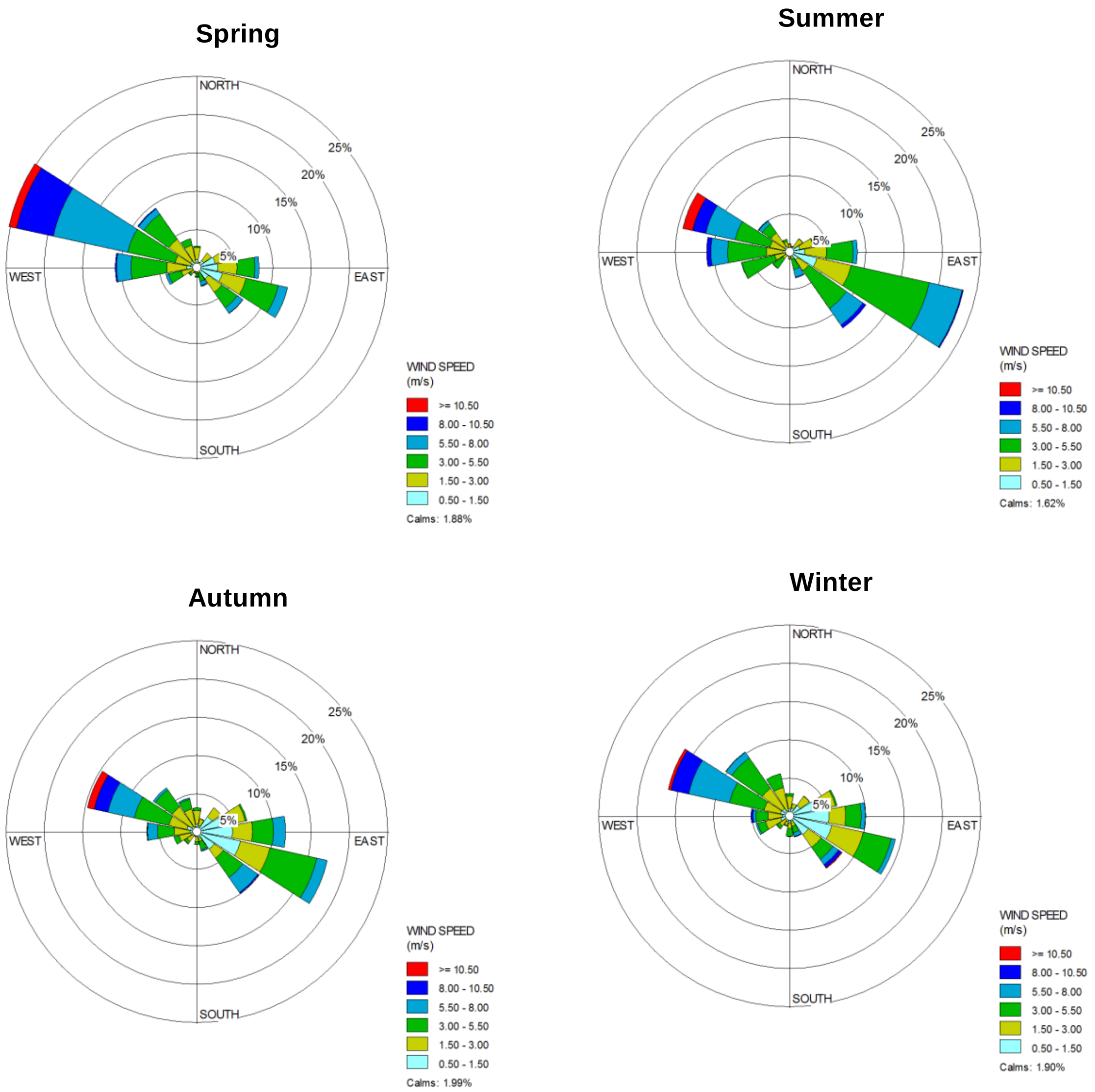

Figure D–35: Seasonal Wind Roses for Palmerston North EWS for 2011

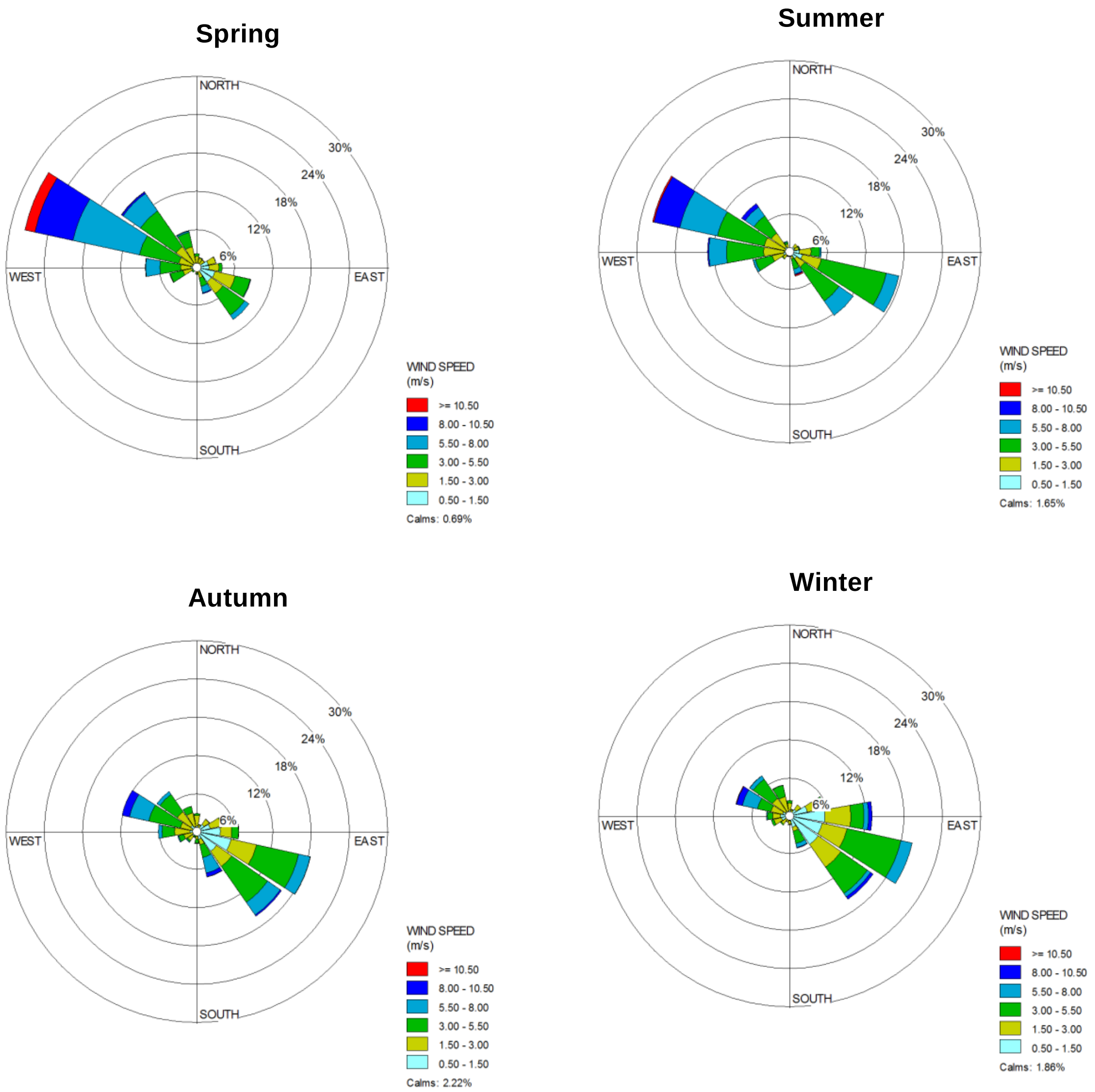

Figure D–36: Seasonal Wind Roses for Palmerston North EWS for 2012

Levin AWS – Hour of the Day Wind Roses

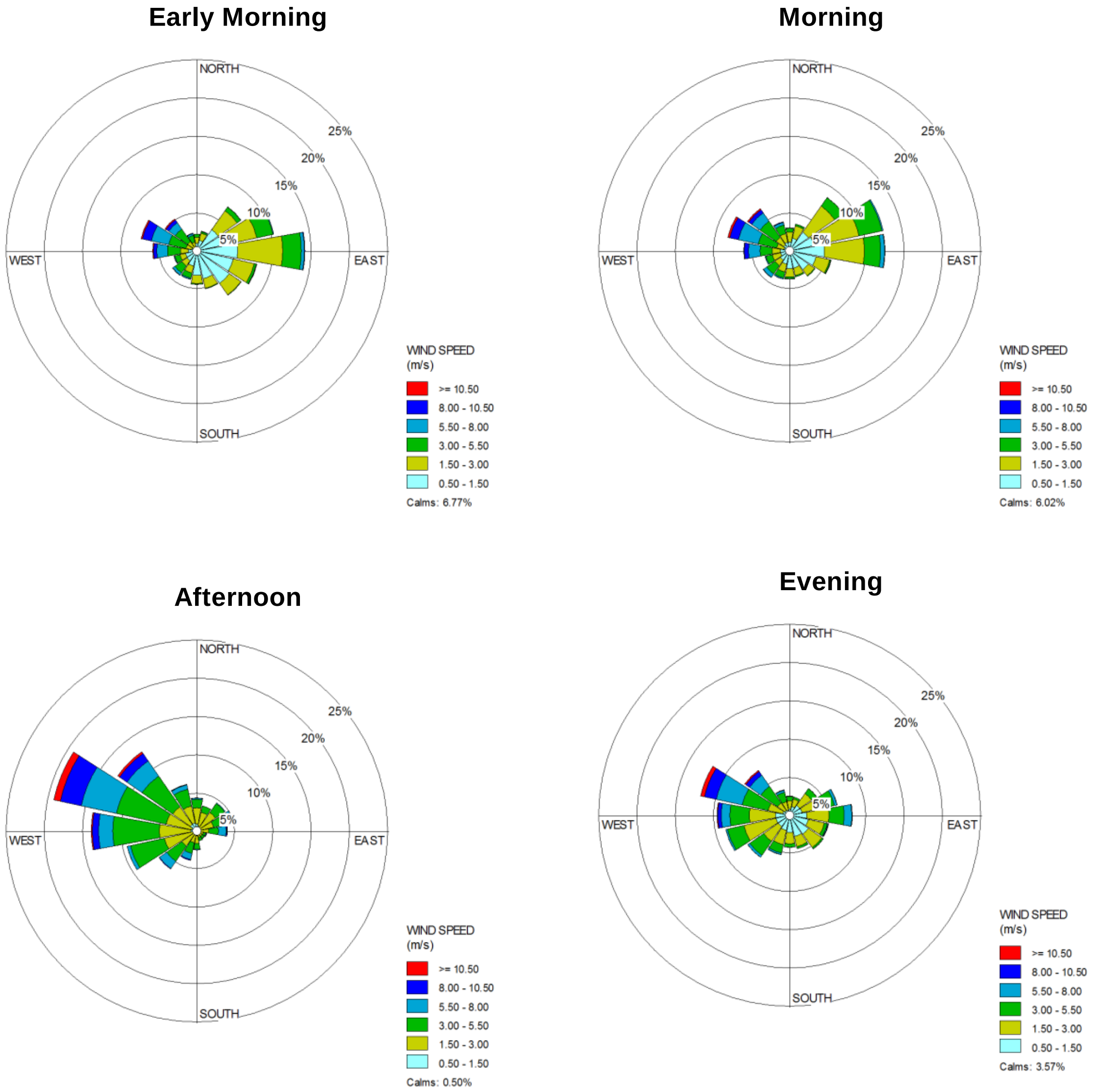

Figure D–37: Hour of the Day Wind Roses for Levin AWS for 2008 to 2012

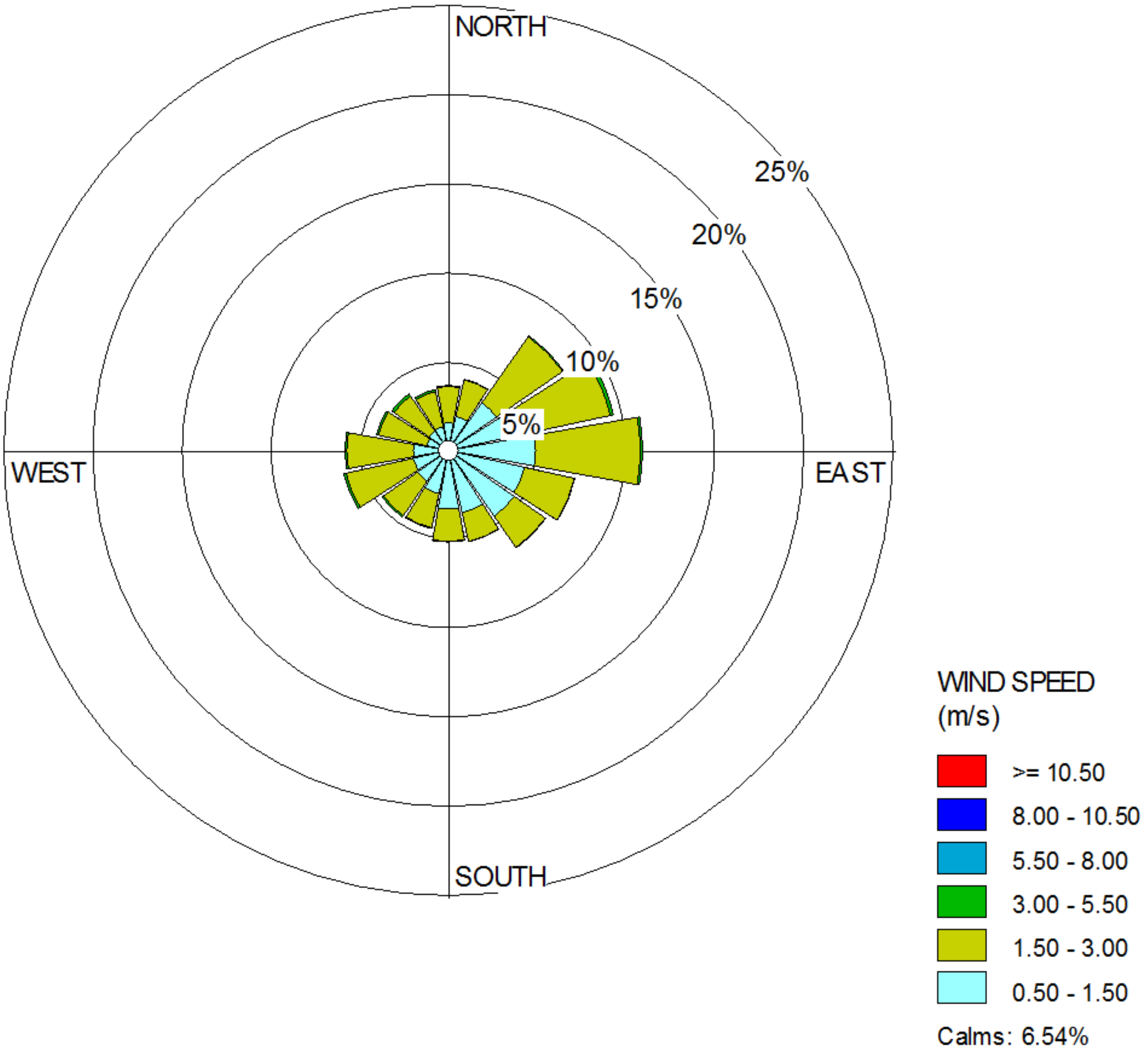

Figure D–38: Wind Rose for Levin AWS for 2008 to 2012 Showing Low Wind Speeds (<3 m/s)

TAPM Output: Annual Wind Roses

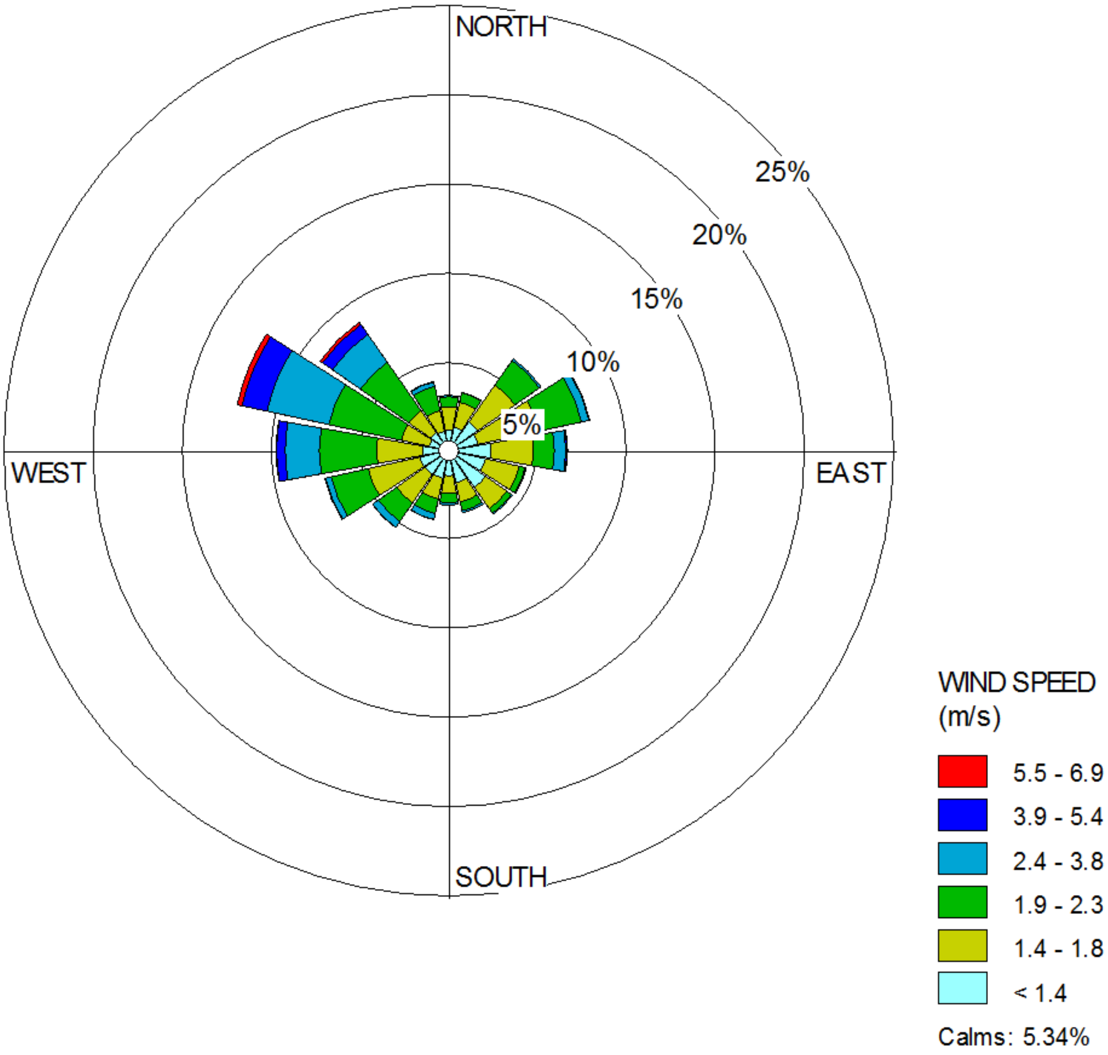

Figure D–39: Annual Wind Rose Predicted by TAPM for the Project Site for 2012

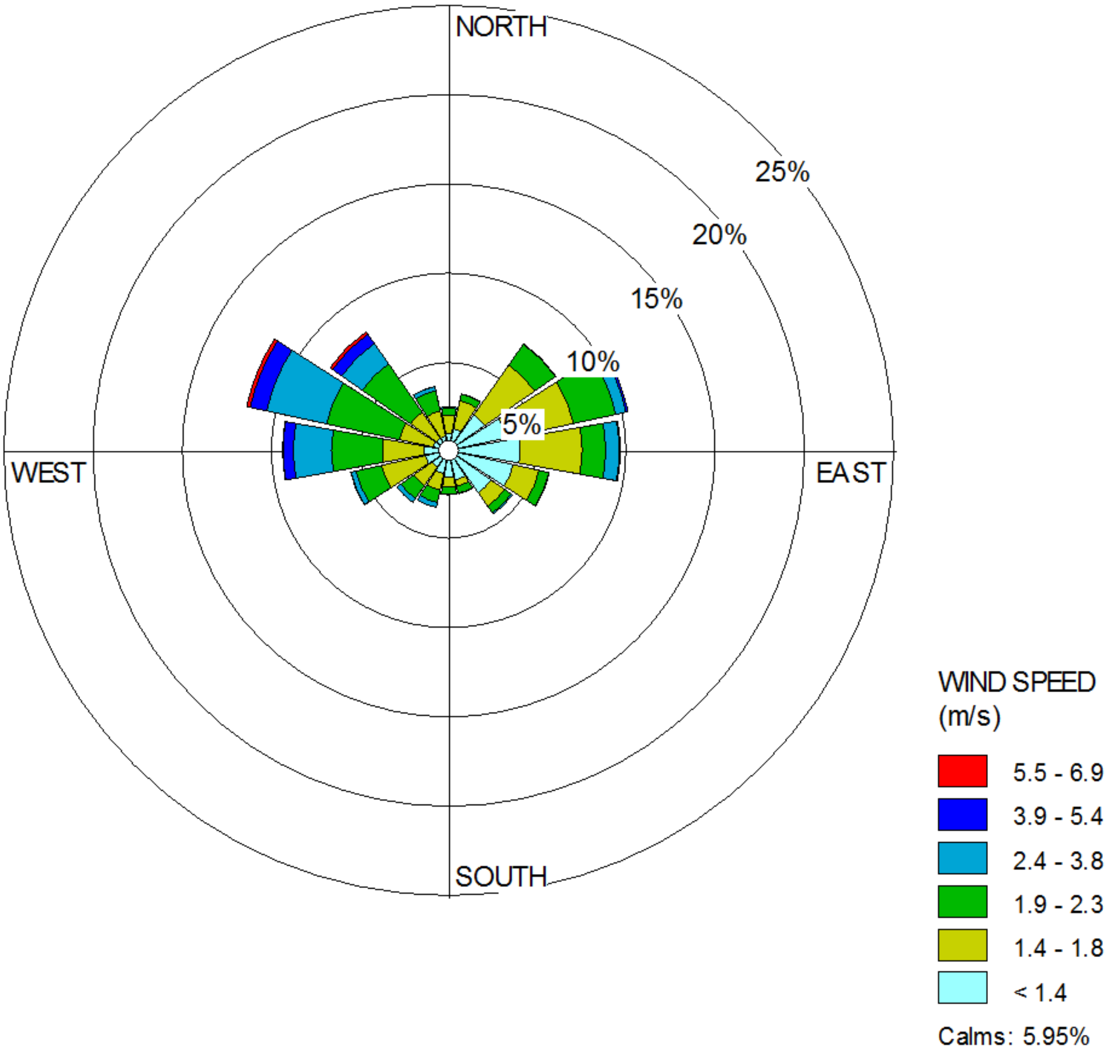

Figure D–40: Annual Wind Rose Predicted by TAPM for Levin AWS for 2012

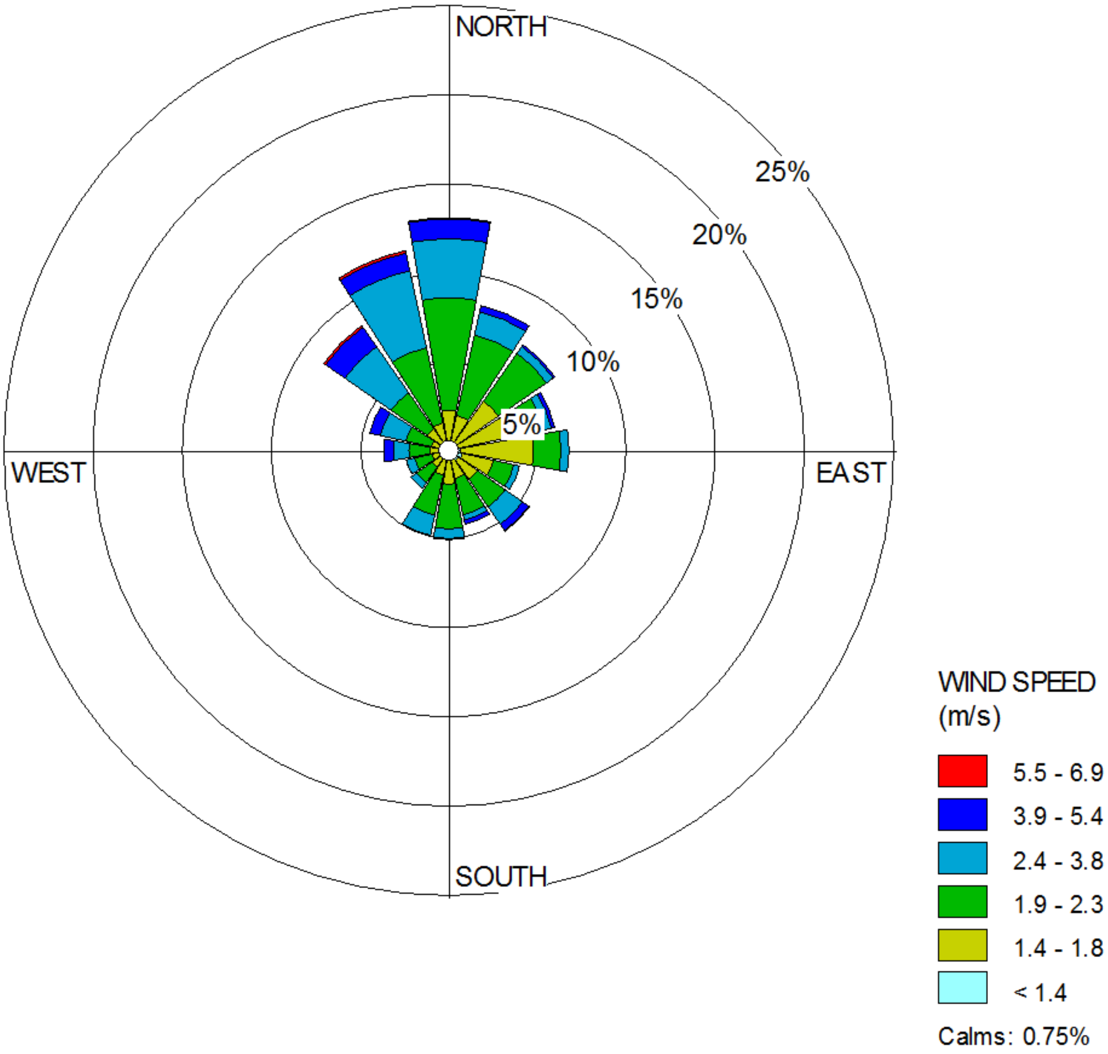

Figure D–41: Annual Wind Rose Predicted by TAPM for Paraparaumu Aero AWS for 2012

CALMET Output: Annual, Seasonal and Hour of the Day Wind Roses

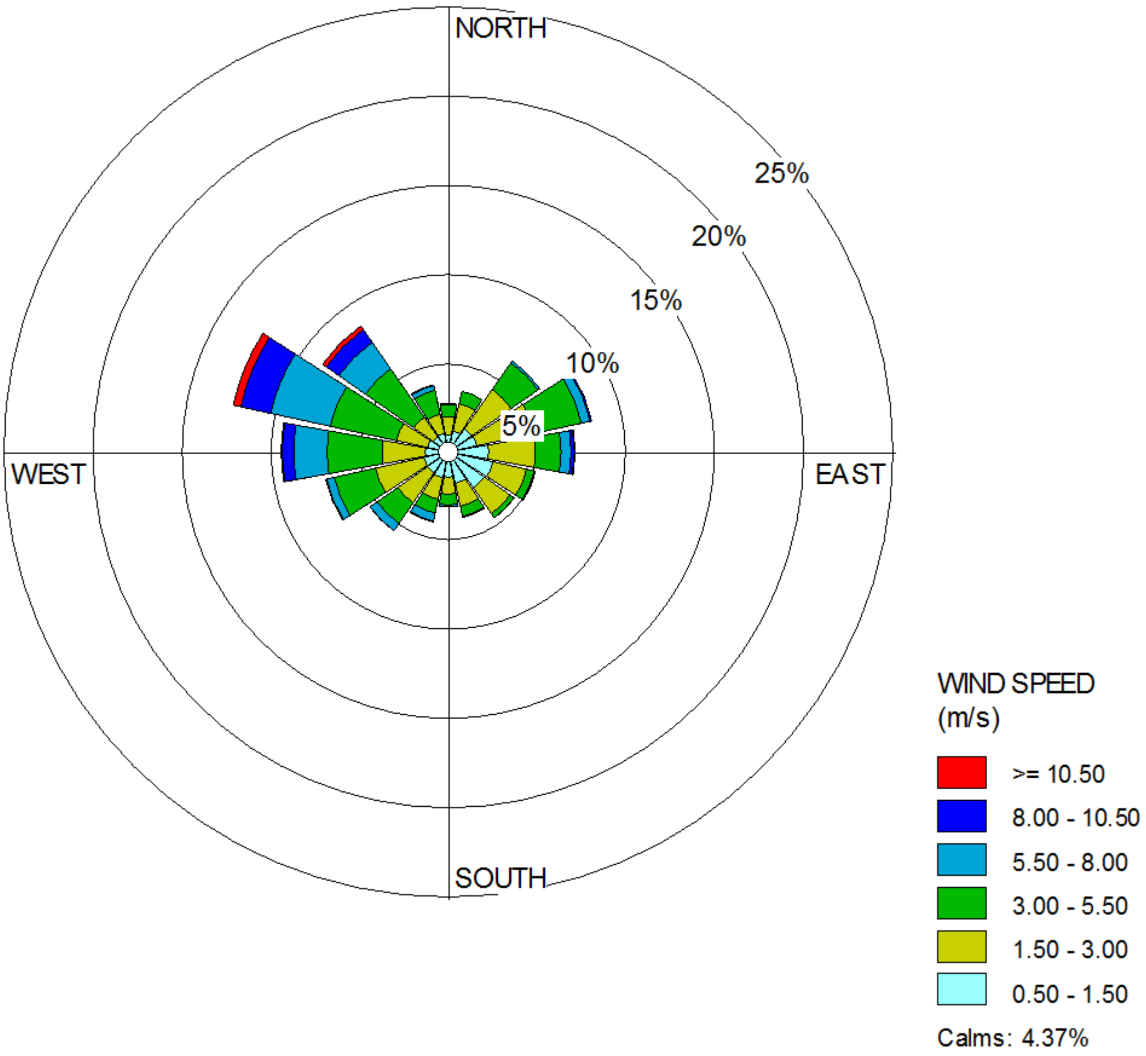

Figure D–42: Annual Wind Rose Predicted by CALMET for the Project Site for 2012

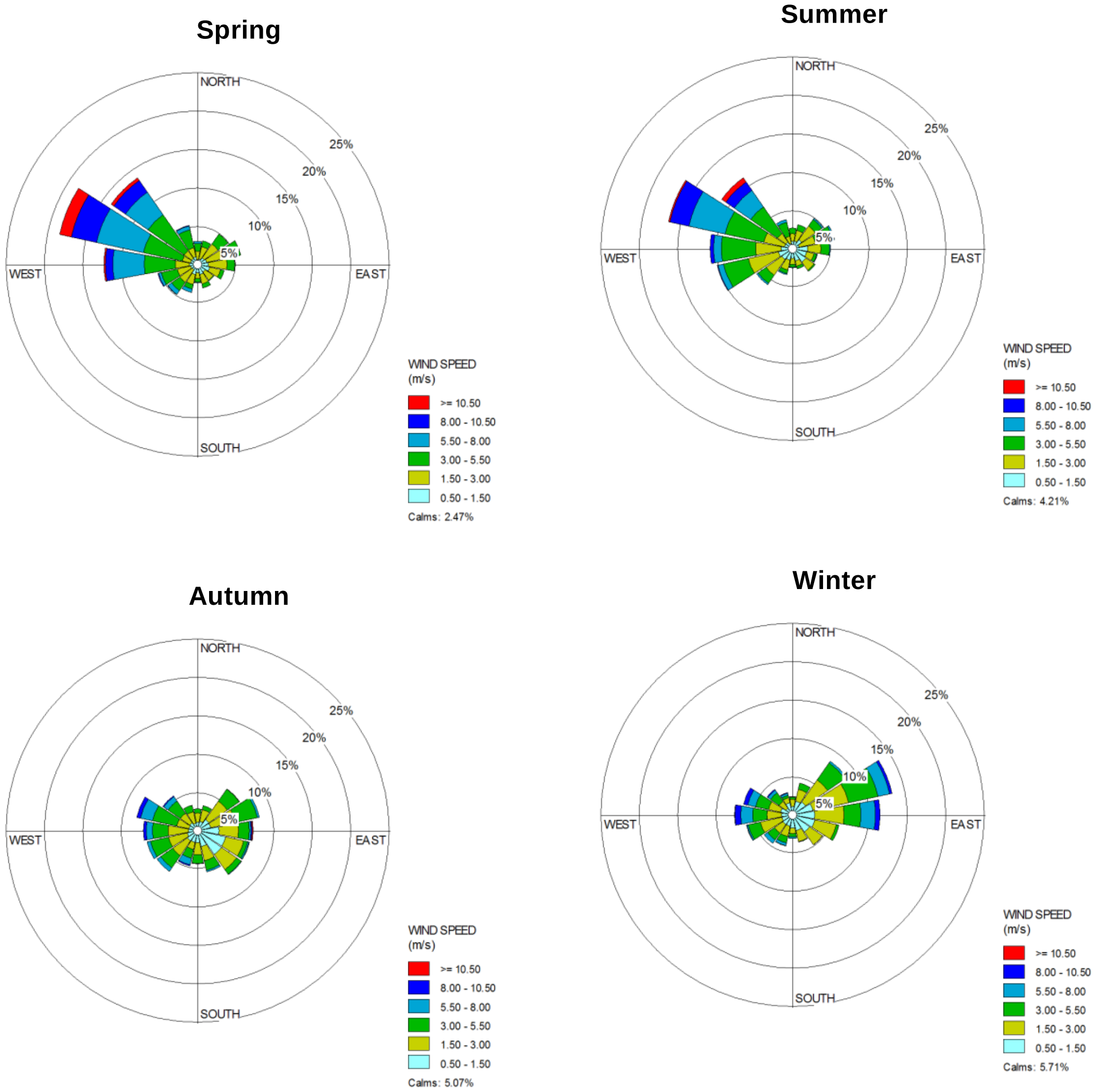

Figure D–43: Seasonal Wind Rose Predicted by CALMET for the Project Site for 2012

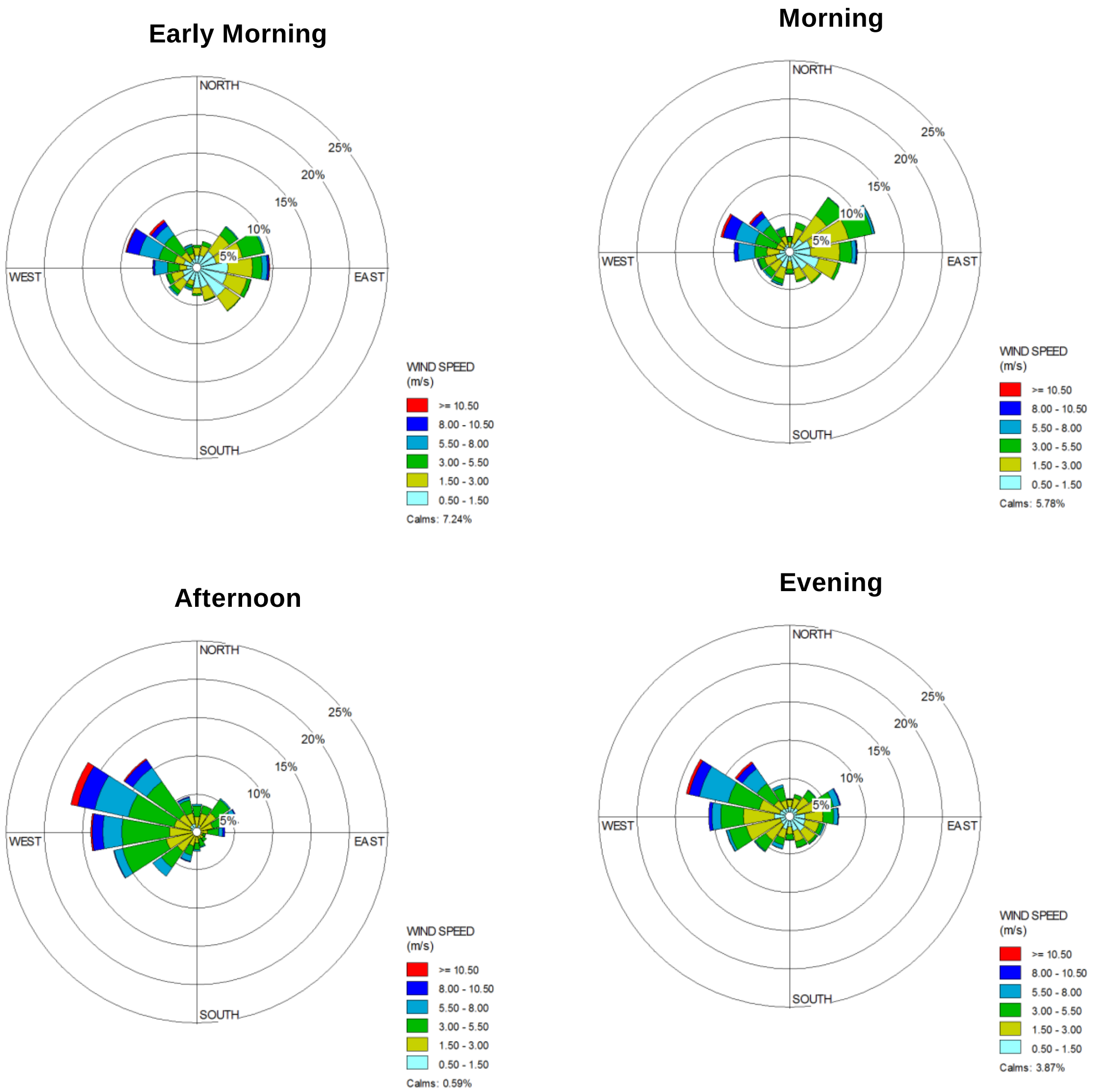

Figure D–44: Hour of the Day Wind Rose Predicted by CALMET for the Project Site for 2012

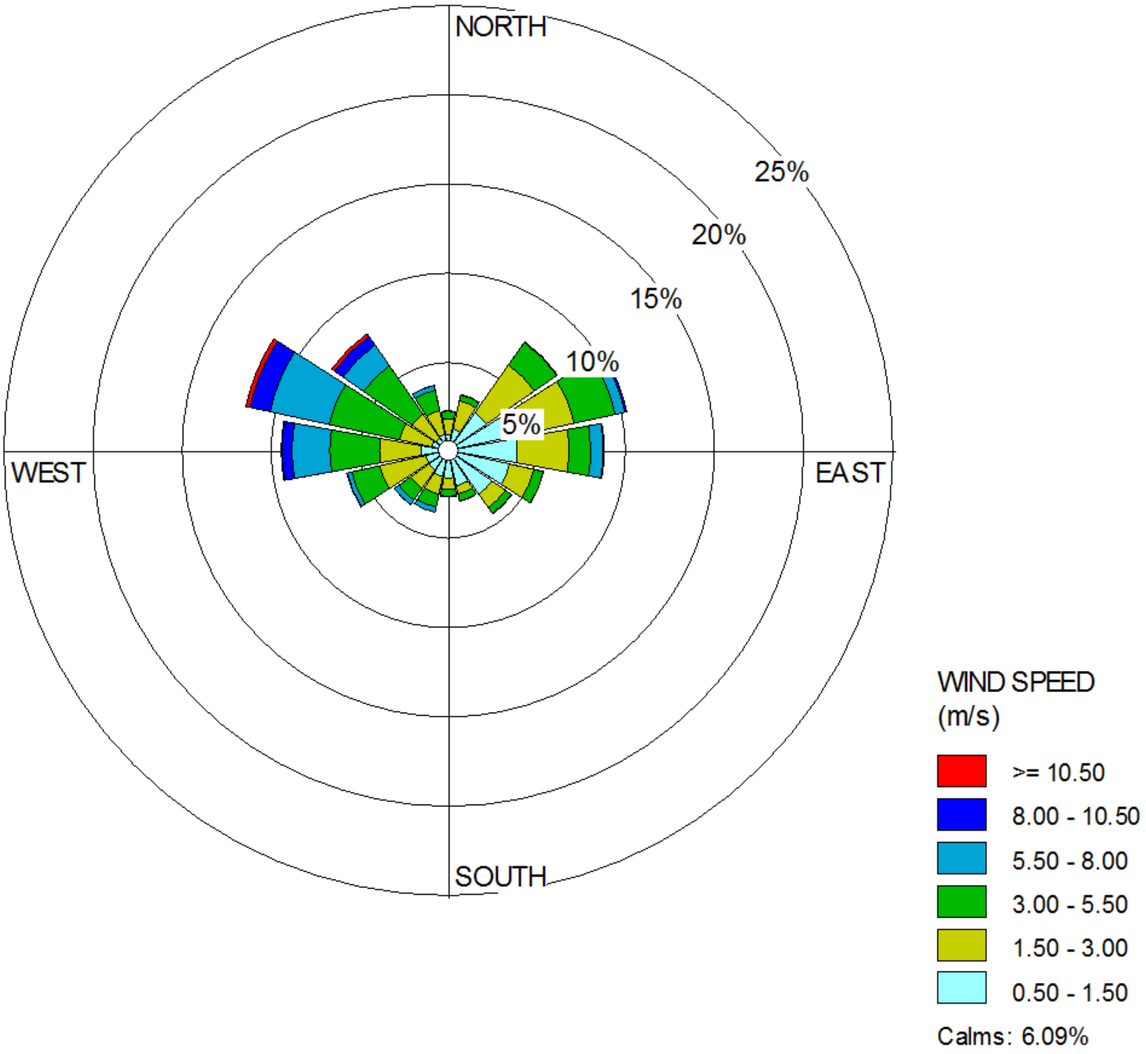

Figure D–45: Annual Wind Rose Predicted by CALMET for Levin AWS for 2012

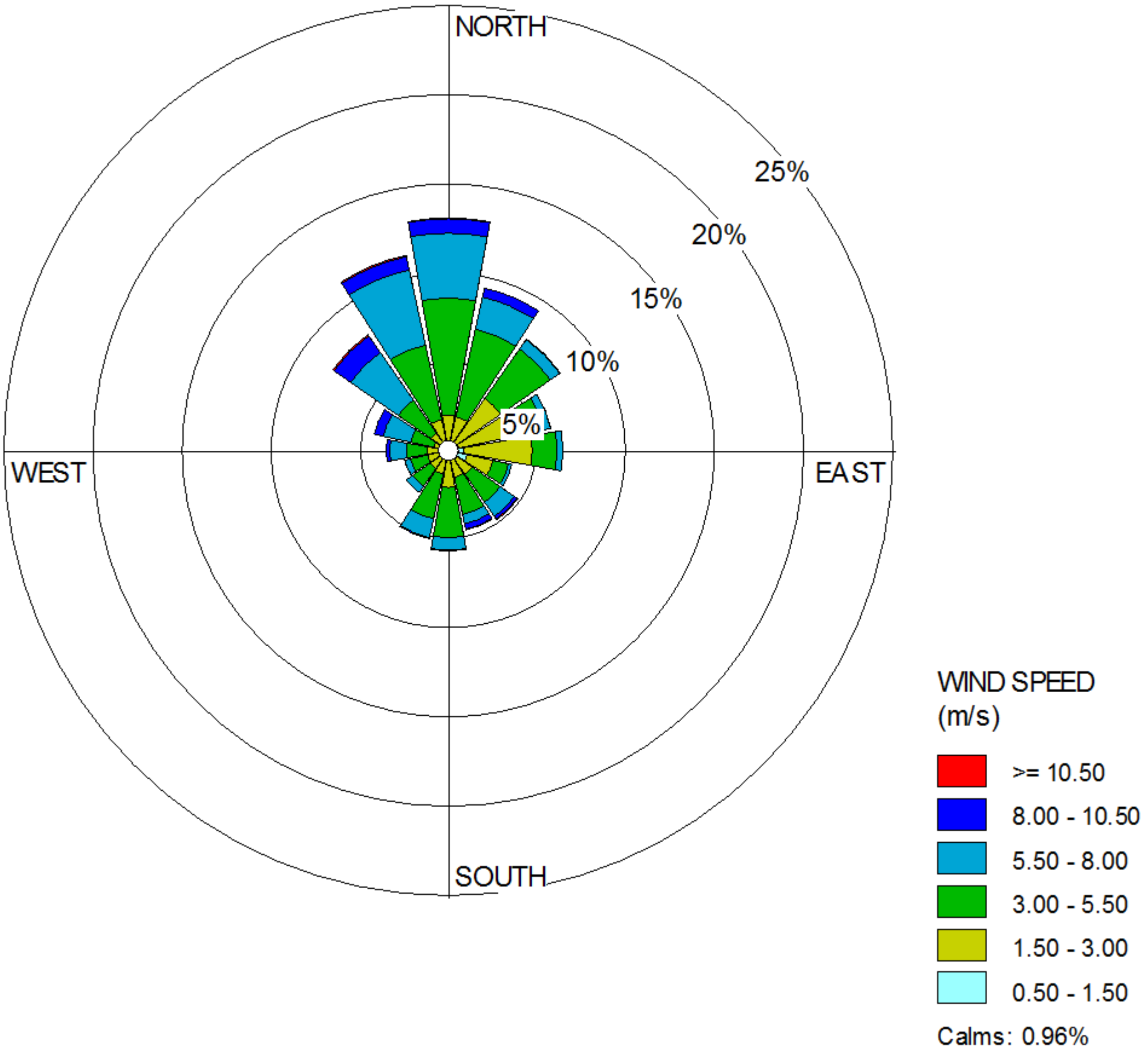

Figure D–46: Annual Wind Rose Predicted by CALMET for Paraparaumu AWS for 2012

Appendix E Odour Management Plan

Levin Landfill Odour Management Plan

1 Introduction and Purpose of the Plan

The Odour Management Plan (OMP) detailed below covers the activities undertaken at the Levin Landfill, which is located at 665 Hōkio Beach Road, Levin. The Levin Landfill is currently owned by the Horowhenua District Council and is operated under contract by EnviroWaste Services Limited (EnviroWaste). Horowhenua District Council is the consent holder for the Levin landfill. As such, it holds primary responsibility for ensuring compliance with the conditions of the resource consents for the site. Resource consent number 6011 authorises the discharge to air of landfill gas, odour and dust at the landfill site.

The OMP is an operational plan which details the measures to be employed by the landfill site operator, EnviroWaste, and to control the release of odour from the site. The OMP may form a stand-alone document or be incorporated into the existing Levin Landfill Development and Management Plan (LDMP).

The aim of the OMP is to detail how odours at the site are being managed and controlled so as to prevent or minimise the release of odours on the site. It also assigns managerial and operational responsibilities for maintaining the OMP, implementing the OMP and responding to odour related incidents and the response of the local community, including the Neighbourhood Liaison Group.

Reference should also be made to MWH New Zealand Limited's report entitled 'Levin Landfill Odour Assessment' (dated February 2015) for further details regarding the recommended odour mitigation measures to be employed onsite.

Document Approval

Name: Signature:	Tony Parsons, Horowhenua District Council
Position:	Acting Solid Waste Engineer
Status:	Draft
Date:	February 2015

2 Key Personnel and Contact Details

The site management responsibilities and procedures for this OMP and detailed below:

Key Personnel – Horowhenua District Council (Land Owner)

Name:	Tony Parsons, Horowhenua District Council (Consent Holder)
Responsibility:	Maintaining the OMP and ensuring all site staff are familiar with the requirements of the OMP and resource consent conditions, and comply with the OMP and the resource consent conditions at all times. Providing training to site staff (see Section 5). Recording odour complaints and responding to complainants (including informing Horizons Regional Council within 7 days of receiving a complaint). Attendance at Neighbourhood Liaison Group meetings and maintenance of odour complaints records, site monitoring data (e.g. odour emissions monitoring, landfill surface emissions monitoring, odour 'sniff' testing, meteorological monitoring, ambient air quality monitoring) and maintenance records.
Phone No:	(06) 366 0999
Mobile No:	TBC

Key Personnel – EnviroWaste Services Limited (Landfill Operator)

Name:	Shane Tahuri, EnviroWaste Services Limited
Responsibility:	Implementing the OMP and ensuring compliance with the OMP and resource consent conditions on a day-to-day basis.
Phone No:	TBC
Mobile No:	027 7038 173

3 Process Description and Site Activities

The Levin Landfill has operated since the mid-1970s. The old, unlined landfill was closed in 2004 and a final cap was put in place in 2005. It is understood that the final cap thickness is in the order of 1 m, in accordance with the requirements of the resource consent conditions.

Stage 1a was opened in 2004. Given the lack of locally available clay, a geocomposite liner consisting of an underlying geosynthetic clay liner (GCL) and a high density polyethylene (HDPE) geomembrane has been adopted, as required by the resource consent conditions. Stage 1a was followed by Stage 2 in 2007, which was closed off in 2013. To date, the top third of Stage 1a has been covered with a clay cap and the rest of it, together with the top and sides of Stage 2, have been remediated with an intermediate cover material consisting of sand and mulch.

Stage 3 is the current active area (working face) and tipping on this stage has occurred since 2013.

The odour sources at the site were identified by MWH during a site visit on 18 and 19 November 2014. The existing flare on the site was not in operation for the period between 11 November 2014 (a week prior to the site visit) and 22 December 2014 (i.e. it was not operating during the site visit). In MWH's opinion, based on their odour assessment report report, the principal odour emission sources on the site are as follows:

- The leachate collection manhole; and,
- Stage 2 – inactive landfill cell with intermediate (temporary) cover (emission "hotspots").

The following locations were also considered by MWH as being potentially significant sources of odour on the site:

- Delivery and handling of waste: the release of odour during the delivery and handling of refuse at the working (tipping) face of the landfill, particularly waste with high intensity odours; and,
- The leachate pond.

The staging of the filling at the site, including the odour emission sources, are shown in **Figure 1**.

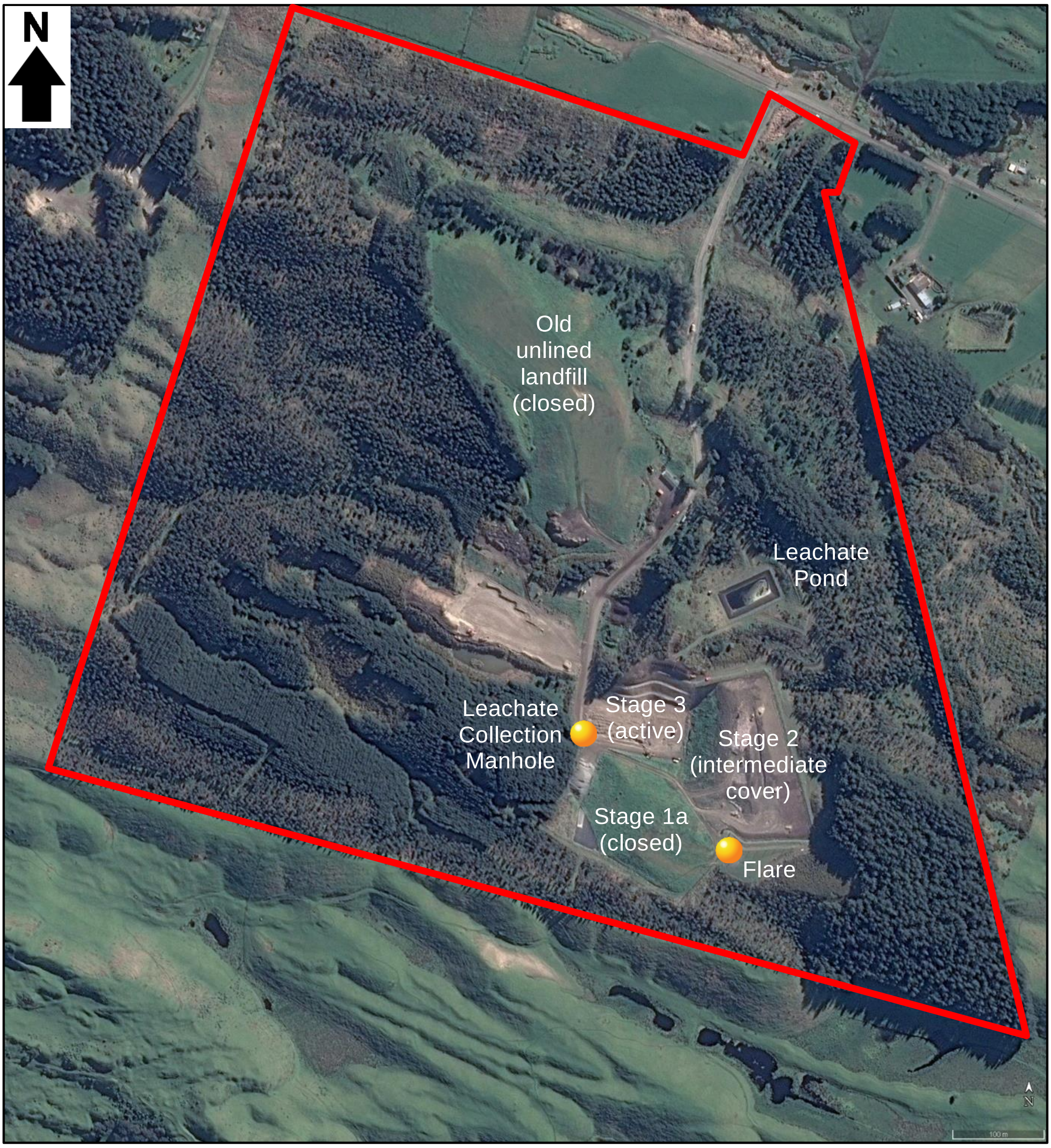

Figure 1: Site Layout Plan Showing the Landfill Stages and Odour Sources on the Project Site

The nearest potentially affected sensitive receptors to the Levin Landfill are all residential properties and are situated to the north-east, east and north-west of the site and are summarised in **Table 1**.

Table 1: Sensitive Receptor Locations

Ref.	Type	Address	UTM Zone 60 South		Direction from Boundary	Elevation (m)
			Easting (m)	Northing (m)		
R1	Residential	645 Hōkio Beach Road	349048	5503585	North-East	15.6
R2	Residential	621 Hōkio Beach Road	349221	5503533	North-East	12.1
R3	Residential	619 Hōkio Beach Road	349295	5503564	North-East	12.6
R4	Residential	583 Hōkio Beach Road	349585	5503407	North-East	13.4
R5	Residential	575 Hōkio Beach Road	349573	5503257	East	12.7
R6	Residential	582 Hōkio Beach Road	349657	5503486	North-East	14.0
R7	Residential	578 Hōkio Beach Road	349661	5504034	North-East	15.1
R8	Residential	588 Hōkio Beach Road	349603	5503538	North-East	13.9
R9	Residential	602 Hōkio Beach Road	349482	5503572	North-East	13.1
R10	Residential	628 Hōkio Beach Road	349320	5503697	North-East	13.2
R11	Residential	630 Hōkio Beach Road	349219	5503681	North-East	11.7
R12	Residential	616 Hōkio Beach Road	349338	5503626	North-East	12.5
R13	Residential	737 Hōkio Beach Road	348190	5503973	North-West	18.7
R14	Residential	747 Hōkio Beach Road	348138	5504055	North-West	16.8
R15	Residential	765 Hōkio Beach Road	347995	5504099	North-West	13.4
R16	Residential	767 Hōkio Beach Road	347940	5504123	North-West	15.8

Figure 2 shows the Levin Landfill site boundary (sold red line) and the location of the potentially affected sensitive receptors identified in this OMP.

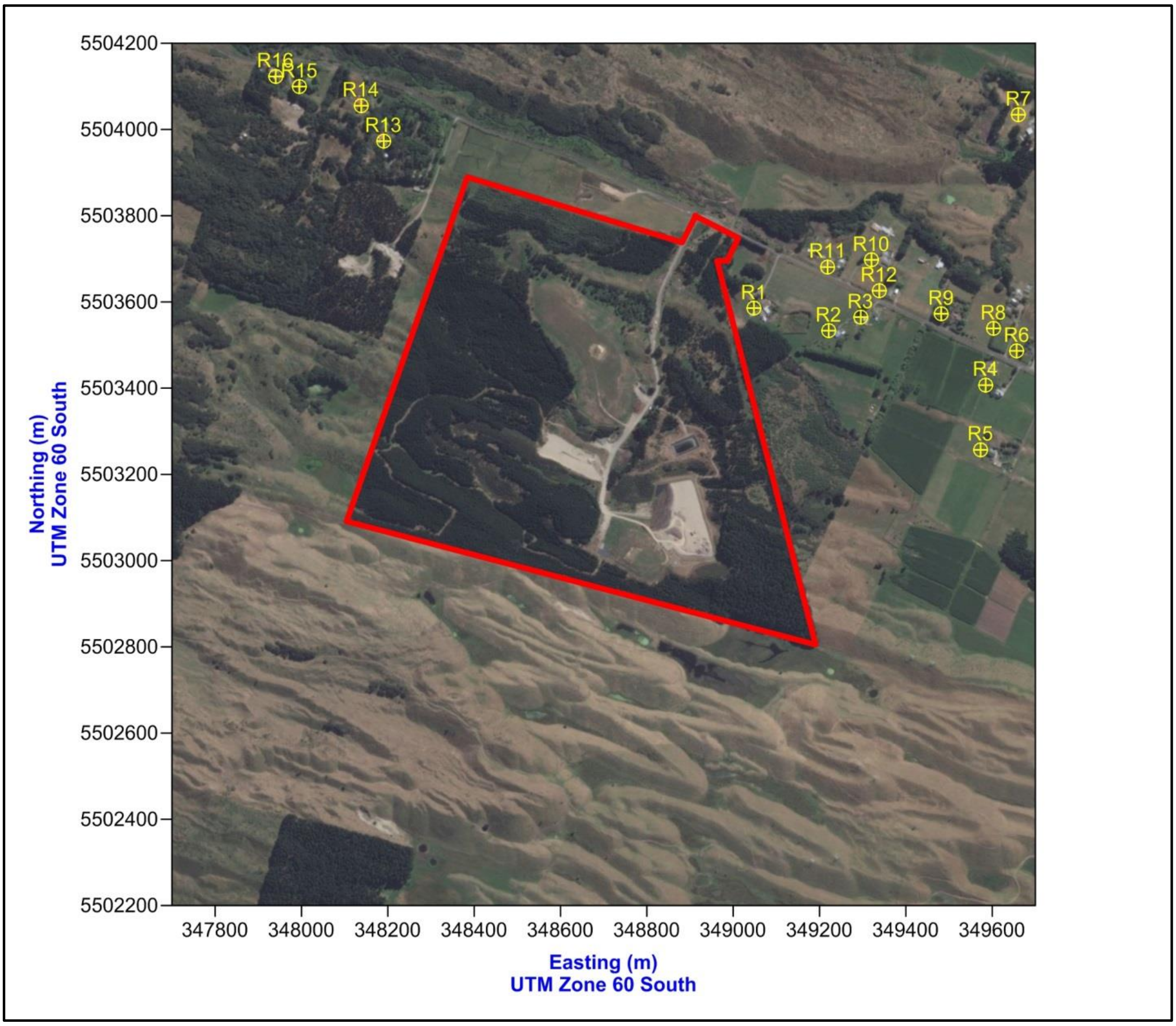

Figure 2: Sensitive Receptor Locations

4 Phase One Mitigation Measures

The following Phase One mitigation measures and operating procedures must be implemented onsite immediately:

Mitigation Measure 1: Leachate Pond **Timeframe: Implemented Immediately**

Description

The following mitigation measures should be implemented at the leachate pond to reduce the potential for the release of nuisance odour from this source.

Outcomes

- To reduce odour emissions from the leachate pond to the minimum practicable level such that there is no offensive or objectionable odour at or beyond the boundary of the site.
- To notify the local community before carrying out any scheduled works which have the potential to cause a significant increase in odour emissions, such as de-sludging the leachate pond.
- To record all odour complaints in a log book to be kept onsite and to give direct, accurate and relevant feedback to the local community in relation to any specific unforeseen event leading to an odour complaint. Inform Horizons Regional Council within 7 days of receiving a complaint.
- To reduce the delay from time of receiving an odour complaint and implementing corrective action to responding to a complaint.

Controls

- Ensure that the residence time of the leachate held in the leachate pond is reduced as far as practicable before it is pumped for treatment at the Levin Wastewater Treatment Plant, as this will ensure that the intensity of any odour released from the pond is kept to a minimum. It is understood that the residence time is currently 12 days and it is considered that this may need to be reduced from time-to-time to control the release of odour from this source.
- Ensure that the build-up of algae and/or scum on the surface of the pond is avoided as far as possible and practicable and that the sides of the pond are regularly cleaned to remove any deposited material that may have accumulated.
- There is the potential for the release of offensive odours from the anaerobic decay of wet organic matter following a significant drop in the leachate level of the leachate pond. Avoid significant changes to the water level in the leachate pond, where possible and practicable.
- Ensure that the leachate in the pond is sufficiently aerated (e.g. monitor for dissolved oxygen on a monthly basis). In the event that an aerator is required to be used, care should be taken not to disturb the sludge at the bottom of the pond as this has the potential to release odour.
- Ensure that the leachate collection system and pipework are regularly inspected and maintained to ensure that they are in full working order. The leachate collection system and pipework should be regularly cleaned and flushed (e.g. every 6 months) to ensure that there are no blockages and that they are free from algae and/or scum. Ensure that any maintenance work, including de-sludging of the pond, is undertaken with sufficient prior warning having been given to the local residents and avoid certain meteorological conditions (e.g. winds from the SW or SE), as far as possible and practicable. It may also be necessary to cover the pond if maintenance work is to be repeated over more than 1 working day, and should be scheduled so as to avoid the potential for working extending in to the weekend, as far as practicable.

Responsible Personnel: Shane Tahuri (EnviroWaste, Levin Landfill Site Manager)

Mitigation Measure 2: Working Face & Waste Disposal **Timeframe: Implemented Immediately**

Description

The following mitigation measures should be implemented at the working (tipping) face to reduce the potential for the release of nuisance odour from this source.

Outcomes

- To reduce odour emissions from the working face to the minimum practicable level such that there is no offensive or objectionable odour at or beyond the boundary of the site.
- To notify the local community before carrying out any scheduled works which have the potential to cause a significant increase in odour emissions, such as tipping high intensity odorous material (e.g. food waste or animal carcasses).
- To record all odour complaints in a log book to be kept onsite and to give direct, accurate and relevant feedback to the local community in relation to any specific unforeseen event leading to an odour complaint. Inform Horizons Regional Council within 7 days of receiving a complaint.
- To reduce the delay from time of receiving an odour complaint and implementing corrective action in responding to a complaint.

Controls

- Ensure that there is an adequate supply of suitable daily cover to ensure that the depth and type of cover used is effective in the mitigation of odour releases at the working face. Daily cover should be progressively applied and should comprise of non-putrescible, non-odorous, non-combustible material and may include soil and sand. Typical depths of daily cover at the working face and flanks should be approximately 150 mm (for soils and sand) by the end of each working day. However, the type and thickness of daily cover required will depend on the nature and age of the waste, the meteorological conditions (including the surface and air temperature) and the wind speed (usually low winds speeds are associated with odour complaints) and wind direction in relation to sensitive receptors) and the rate of site filling. A degree of caution is required if shredded green waste is to be used as daily cover as some waste may have composted and, therefore, may have become a source of odour.
- Cover integrity should be continually assessed by site staff during operations. Regular inspections by the landfill site manager should be carried out at the end of each working day to check that the cover is adequate and to audit the effectiveness of ongoing inspections. These audits and inspections are particularly important prior to periods of unmanned site closure, such as weekends and holidays.
- Malodorous waste must be buried immediately once received and covered with non-odorous waste (daily cover). It may be necessary to consider implementing waste acceptance criteria, thereby not receiving specific types of odorous loads, or to change the operation in regard to when odorous loads are accepted and how they are handled. If it is not possible or practicable to refuse the tipping of highly odorous material (e.g. food waste or animal carcasses), consider only tipping this material under certain meteorological conditions which are not likely to lead to complaints (e.g. stable atmospheric conditions with low wind speeds from the SW, which may inhibit dilution and dispersion and cause odour nuisance at nearby sensitive receptors). The tipping of malodorous waste should also be restricted after 4:00 pm and before 7:00 am the following day in order to reduce the potential for high intensity odours being released after site closure.
- Aim to ensure that the total surface area of the working face is limited in size, as far as practicable, so that the area of uncovered material is restricted (e.g. 80 m^2).

Responsible Personnel: Shane Tahuri (EnviroWaste, Levin Landfill Site Manager)

Mitigation Measure 3: Stage 2 Effective Capping	**Timeframe:** Implemented Immediately

Description

The following mitigation measures should be implemented on Stage 2 to reduce the potential for fugitive odour and landfill gas emissions.

Outcomes

- To reduce odour emissions from Stage 2 to the minimum practicable level such that there is no offensive or objectionable odour at or beyond the boundary of the site.
- To notify the local community before carrying out any scheduled works which have the potential to cause a significant increase in odour emissions, such as maintenance to the gas collection system and/or flare.
- To record all odour complaints in a log book to be kept onsite and to give direct, accurate and relevant feedback to the local community in relation to any specific unforeseen event leading to an odour complaint. Inform Horizons Regional Council within 7 days of receiving a complaint.
- To reduce the delay from time of receiving an odour complaint and implementing corrective action to responding to a complaint.

Controls

- Ensure that there is an effective cap with high integrity and low conductivity (e.g. temporary or permanent clay layer) across Stage 2 to reduce fugitive odour and landfill gas emissions.
- Operate the gas collection system and flare at all times in accordance with industry best practice such that the emissions to air of landfill gas and odour from Stage 2 is kept to the minimum practicable level.
- Regularly inspect and maintain the gas collection system and flare to ensure that they are fully operational and functioning correctly. Fix any wellheads and pipes which passively vent to atmosphere and cover/remove any material protruding from the landfill surface (e.g. hose pipes).
- Avoid the need for excavation into old waste wherever possible, as this has the potential to release high intensity odours and landfill gas.
- Undertake landfill surface emissions monitoring (e.g. for methane) by trained and experienced personnel upon completion of the Stage 2 cap to ensure that the cap is effective at reducing landfill gas and odour emissions. Landfill surface emissions monitoring should be undertaken on a regular basis thereafter (e.g. 6-monthly or as otherwise required) to ensure that the integrity of the cap has not been compromised over time by, for example, settlement.
- Undertake regular field odour investigations (sniff tests) by trained site staff (odour scouts), or external consultants, as required, to ensure compliance with the OMP and resource consent conditions.

Responsible Personnel: Shane Tahuri (EnviroWaste, Levin Landfill Site Manager)

Mitigation Measure 4: Leachate Collection Manhole	**Timeframe:** Implemented Immediately

Description

The leachate collection manhole was determined from the landfill surface emissions monitoring walkover survey undertaken by MWH in November 2014 to contain a potentially explosive atmosphere (above LEL for methane), whilst also being a significant, albeit local, emission source of odour and landfill gas. MWH recommended that the air from the leachate collection manhole should be extracted for treatment by combustion in a flare, or if that is not possible or practicable (e.g. due to low calorific value of the gas), by biofiltration. Providing that the air can be extracted and treated safely by a flare or a biofilter, and in accordance with best practice, the landfill gas and odour emissions from this source have the potential to be significantly reduced.

Outcomes

- To reduce landfill gas emissions from the leachate collection manhole to the minimum practicable level, thus reducing the potential for explosive atmospheres to develop.
- To reduce odour emissions from the leachate collection manhole to the minimum practicable level such that there is no offensive or objectionable odour at or beyond the boundary of the site.
- To notify the local community before carrying out any scheduled works which have the potential to cause a significant increase in landfill gas or odour emissions, such as installing a gas collection system for treatment in a flare or biofilter.
- To record all odour complaints in a log book to be kept onsite and to give direct, accurate and relevant feedback to the local community in relation to any specific unforeseen event leading to an odour complaint. Inform Horizons Regional Council within 7 days of receiving a complaint.
- To reduce the delay from time of receiving an odour complaint and implementing corrective action in responding to a complaint.

Controls

- The flare or biofilter should be designed and operated to ensure that the optimum temperature and residence times are achieved, in accordance with industry best practice.
- The gas collection system and flare/biofilter should be regularly inspected to ensure that there is adequate condensate/leachate removal and gas extraction vacuum to the flare/biofilter.
- If a biofilter is installed, it needs to be maintained at between 40-60% moisture content, and an irrigation system will need to be provided.
- Where maintenance work to the gas collection system and flare/biofilter is required, which has the potential to release high intensity odours, consideration should be given to avoiding certain meteorological conditions (e.g. SW winds) and to giving local residents sufficient prior warning before embarking on such activities.
- A cordon (e.g. security fence and gate) should be kept in place around the manhole to restrict access to the manhole until an odour control facility (e.g. biofilter) has been installed and has been found to be operating effectively at reducing landfill gas and odour emissions, and monitoring for methane and hydrogen sulphide has determined that it is safe for staff to work at the manhole. Regular monitoring for methane and/or hydrogen sulphide should be undertaken thereafter on a monthly basis, or as otherwise required.

Responsible Personnel: Shane Tahuri (EnviroWaste, Levin Landfill Site Manager)

The mitigation measures and operating procedures shown in **Box 1** are also recommended by MWH to be implemented onsite during Phase One:

Box 1 Additional Phase One Mitigation Measures

Field Odour Investigation for the Flare

As the flare was not operating during the site visit, MWH staff were not able to assess it as a potential source of unburned volatile organic compounds (VOCs), including odour, particularly if it is incorrectly sized and the combustion efficiency is low. MWH recommends that, in addition to undertaking continuous, real-time ambient air quality monitoring, as recommended below, that a field odour investigation (sniff testing) is undertaken by an experienced odour scout at the earliest possible opportunity, possibly coinciding with the ambient air quality monitoring. The purpose of the field odour investigation should be to determine whether odour emissions from the existing flare have the potential to cause odour nuisance effects beyond the site boundary. It would also be useful to undertake a field odour investigation for the principal odour emission sources identified in MWH's report.

Meteorological Station

A meteorological station should be established in a suitable location on the site to measure, as a minimum, the onsite wind speed and direction. The meteorological station should be positioned as far away from buildings and trees as possible, as these structures may affect the wind flow. The onsite wind speed and direction data may be used for the following reasons:

- To manage the occasions when high intensity odours may be released at the site during foreseen events (e.g. maintenance work); and,
- To corroborate (or contradict) any odour nuisance complaints that may arise during the continued operation of the landfill.

Other parameters which could also be measured at little additional cost include: ambient temperature; relative humidity; atmospheric pressure; and rainfall. These parameters are also useful to help control the release of landfill gas and odour at the site.

Ambient Air Quality Monitoring

In addition, consideration should be given to installing and operating a continuous, real-time air quality monitor to measure ambient concentrations of methane (or hydrogen sulphide or VOCs) as an indicator (surrogate) of odour. This would be particularly useful when planning to undertake maintenance on the leachate collection manhole and/or landfill gas collection system (or any event which may cause a significant discharge to air of landfill gas or odour).

As per the meteorological station, the ambient air quality monitor should be positioned as far away from buildings and trees as possible, and preferably at the same location as the weather station. However, the co-location of the air quality monitor with the weather station is not crucial and it may be more appropriate to locate the monitor between the emission source and the nearest sensitive receptor (residence at 645 Hōkio Beach Road). The operator may select to locate the monitor either close to the emission source or to the nearest sensitive receptor, depending on the nature and type of the release (e.g. providing it is safe), and providing that a power supply can be installed.

The continuous ambient air quality monitoring (in addition to ongoing landfill surface emissions monitoring and field odour investigations/sniff testing), also has the potential to determine the effectiveness of the flare (and gas collection system) in controlling LFG and odour emissions at the site.

Responsible Personnel: Shane Tahuri (EnviroWaste, Levin Landfill Site Manager)

5 Phase Two Mitigation

Continuous ambient air quality monitoring, as described in **Box 1**, in addition to ongoing landfill surface emissions monitoring and field odour investigations (sniff testing), has the potential to determine the effectiveness of the existing flare in controlling LFG and odour emissions at the site.

In the event that additional monitoring (as described above) indicates that odour emissions from the existing flare have the potential to cause offensive and objectionable odour effects beyond the site boundary, even after the implementation of the Phase One mitigation measures, MWH recommends that HDC replaces the existing flare with a more suitably sized one. The replacement flare, if required as Phase Two mitigation, should be used to control LFG and odour emissions at the site at all times, providing that there continues to be sufficient pressure and calorific value (CV) to allow for effective/efficient gas collection and treatment. The flare's odour (or more accurately VOC) destruction efficiency has the potential to be at least 98%, providing that it is operated at a minimum temperature of 750 °C and with a residence time of 0.5 seconds (i.e. in accordance with industry best practice). The flare should be designed to ensure that the minimum temperature and residence time can be achieved.

The gas collection system should be regularly inspected to ensure that there is adequate condensate removal and gas extraction vacuum to the flare. Where maintenance work to the flare or gas collection is required which has the potential to release high intensity odours, consideration should be given to avoiding certain meteorological conditions (e.g. SW winds) and to giving local residents sufficient prior warning before embarking on such activities.

6 Monitoring

As Horowhenua District Council is the consent holder for the Levin landfill, it holds primary responsibility for ensuring compliance with the conditions of the resource consents for the site. The responsibility for maintaining the odour complaints records (log book) and all site monitoring data (e.g. odour emissions monitoring, landfill surface emissions monitoring, odour 'sniff' testing, meteorological monitoring, ambient air quality monitoring) as detailed in the OMP, therefore, also lies with the Horowhenua District Council.

7 Staff Training

The Horowhenua District Council should ensure all site staff are familiar with the requirements of the OMP and resource consent conditions, such that there is no offensive or objectionable odour at or beyond the boundary of the site.

The contents of the OMP should be discussed at daily tool-box (Health and Safety) meetings with contractors and site staff, or as otherwise required. A copy of the OMP should be kept in the site office and be made available to all site staff and visitors upon arrival.

Site staff and/or Horowhenua District Council staff should also be trained to undertake the maintenance, landfill surface emissions monitoring (e.g. for methane and/or hydrogen sulphide) and field odour investigations ('sniff' testing) detailed in the OMP. All training records should be maintained by Horowhenua District Council.

Ambient air quality and meteorological monitoring equipment should be installed and maintained by an experienced and suitably qualified specialist.

8 Management and Reporting

Horowhenua District Council should inform Horizons Regional Council within 7 days of receiving an odour complaint and should discuss any response made to the complainant and any corrective/preventative actions undertaken. An example of an odour complaint recording sheet is contained in Appendix F of MWH's report.

The odour complaints records (log book), site monitoring data and maintenance records should be made available to Horizons Regional Council upon request.

Appendix F Complaint Recording Sheet

Complaint Notification

Today's Date: ________________________________ Time: ____________________________

Name of Person Filling in this Form ____

Date of Incident: ________________________ Time of Incident ________________________

Describe the Nature of the Incident Giving Rise to the Complaint (e.g. odour, any effects noted) ______

____

____

____

____

____

Location of Complainant during the Incident: ____

____

____

Frequency and Duration of the Problem: ____

____

____

Weather Conditions/Wind Direction: ____

____

____

Possible Cause: ____

____

____

____

Response Made & Any Corrective / Preventative Actions Taken: __________________________

____

____

Complainant's Name: ___________________________ Phone Number: ____________________

Address:

____

Follow-up required including providing details to the Horizons Regional Council
within 7 days of the complaint: ☐ **Tick if Yes**

Actioned by: __________________________ Date: _____________________________________