MWH

BUILDING A BETTER WORLD

10 July 2015

Horowhenua District Council
Private Bag 4002
LEVIN 5540

Attention: Gerry O'Neill

Dear Gerry

Continuous Ambient Air Quality Monitoring for Hydrogen Sulphide—Levin Landfill

MWH New Zealand Limited (MWH) was engaged by the Horowhenua District Council (HDC) to measure ambient concentrations of hydrogen sulphide (H_2S) at a residential property located at 645 Hōkio Beach Road (herafter 'the monitoring location').

The monitoring was undertaken over a period of three months between 2:25 pm on 17 March and 4:05 am on 18 June 2015. The monitoring location was referred to as 'sensitive receptor R1' in MWH's report entitled 'Levin Landfill Odour Assessment' dated February 2015, and was situated approximately 90 m north-east of the Levin Landfill site boundary at 349021 metres east, 5503599 metres north (UTM Zone 60 South; or latitude 40.60467 degrees south, longitude 175.21545 degrees east).

H_2S was used in the present monitoring study as an indicator determinant of odorous compounds which have the potential to be discharged to air during activities currently undertaken at the landfill (refer to MWH's odour assessment report). The purpose of the monitoring study was to further investigate the potential for odour nuisance effects (objectionable or offensive odours) at 645 Hōkio Beach Road, in light of the odour complaints record kept by HDC for the period between 13 February 2014 and 3 September 2014, during which there were 69 complaints from the owners of the residential property. Analysis of the monitoring results also enables other potential emission sources of H_2S in the vicinity of the monitoring site to be identified.

The results of the monitoring study are presented in this letter report. MWH acknowledges the assistance provided by HDC, AirQuality Limited and the owners of the property on Hōkio Beach Road (receptor 'R1'), and also the use of the 'openair' R package for air quality data analysis (Carslaw and Ropkins, 2012). R version 3.2.1 and openair version 1.5 were used in this study.

1 Methodology

An API 100E ultraviolet (UV) fluorescence sulphur dioxide (SO_2) analyser coupled to an API M501 catalytic H_2S oxidiser with an Environics 6103 gas calibrator and an Ecotech zero air scrubber was used in this study. The instruments were housed in an air-conditioned enclosure held to 20 °C. The sampling port was positioned at a height of 2 m above ground level. An ultrasonic anemometer was co-located with the sampling port and was used to measure wind speed and direction at a height of 2 m above ground level. In addition, ambient temperature, relative humidity and atmospheric pressure were also measured.

The performance of the analyser was audited using an auto-calibration gas dilution system every 72 hours and during routine servicing by AirQuality Limited. Calibration gas was introduced into the sampling manifold to check the response and performance of the analyser. The analyser was also periodically checked for zero-drift by introducing purified air into the sampling manifold and checking the values. Data were streamed to a website in real-time for continuous performance monitoring. During post-processing of

the data, AirQuality Limited compared the values against the manufacturer's specifications, with adjustments being made to the data as required.

2 Assessment Criteria

The New Zealand Ambient Air Quality Guideline (AAQG) for H_2S is 7 micrograms per cubic metre (µg/m^3) as a 1-hour mean (MfE, 2002), which equates to approximately 5 parts per billion by volume (ppb) at 20 °C.

Unlike the other health-based AAQGs (e.g. carbon monoxide, nitrogen dioxide, lead), the value for H_2S is based on preventing odour annoyance (or odour nuisance) and the resulting impacts on "well-being" (or amenity) rather than specific health effects. It is noted in MfE (2002) that the guideline value may not be suitable for geothermal areas, which is not applicable in the present study.

H_2S is a colourless gas with a distinctive odour at low concentrations. Humans detect the compound at concentrations of between 0.2 µg/m^3 and 2.0 µg/m^3, depending on its purity, and this is known as the odour detection threshold (ODT), which is defined as the concentration at which 50% of a group of people can detect an odour (MfE, 2002). According to MfE (2002), H_2S smells like rotten eggs at "about three to four times this concentration range", which equates[1] to a range of between 0.6 µg/m^3–0.8 µg/m^3 and 6 µg/m^3–8 µg/m^3. MfE (2002) also states that H_2S causes nuisance effects because of its unpleasant odour at concentrations well below those that cause health effects, and that continuous exposure to H_2S reduces sensitivity to this odour.

3 Results

The results of the continuous H_2S monitoring undertaken between 2:25 pm on 17 March and 4:05 am on 18 June 2015 (inclusive) are summarised below.

Due to two independent power outage events, the instrument did not operate between 2:00 pm on 1 April and 2:43 pm on 2 April 2015 and 5:06 am on 25 April and 2:43 pm on 1 May 2015. For the 1-minute mean H_2S data analysed in this study, the percent valid data achieved was 91%, while the percent data capture and percent data loss achieved were 92% and 8%, respectively. The 25th percentile, 50th percentile (median), 75th percentile and 95th percentile 1-minute mean H_2S concentrations were -0.1 ppb, 0.2 ppb, 0.5 ppb and 1.6 ppb, respectively, which indicates that generally only low concentrations were measured.

The results of the continuous ambient air quality monitoring are summarised in **Table 1** for the period between 17 March and 18 June 2015. The maximum 1-minute mean, 1-hour mean and 24-hour mean H_2S concentrations measured were 43.1 ppb, 16.7 ppb and 2.1 ppb, respectively.

Table 1: Ambient H_2S Concentrations for 17 March to 18 June 2015

Averaging Period	H_2S Concentration (ppb)
1-minute mean	0.4
1-minute minimum	-3.3
1-minute maximum	43.1
1-hour mean	0.4
1-hour minimum	-2.9
1-hour maximum	16.7
24-hour mean	0.4
24-hour minimum	-0.7
24-hour maximum	2.1

[1] This equates to an approximate H_2S concentration range of between 0.4 ppb–0.6 ppb and 4.3 ppb–5.7 ppb at 20 °C.

The 1-hour mean wind speed and wind direction frequency for the 3-month monitoring period is shown as a wind rose in **Figure 1**. The figure indicates that the predominant wind directions measured at the site were from the W, WSW and east (E). Unfortunately, there was a relatively low frequency of winds that blew from the landfill towards the monitoring site (i.e. SW and SSW).

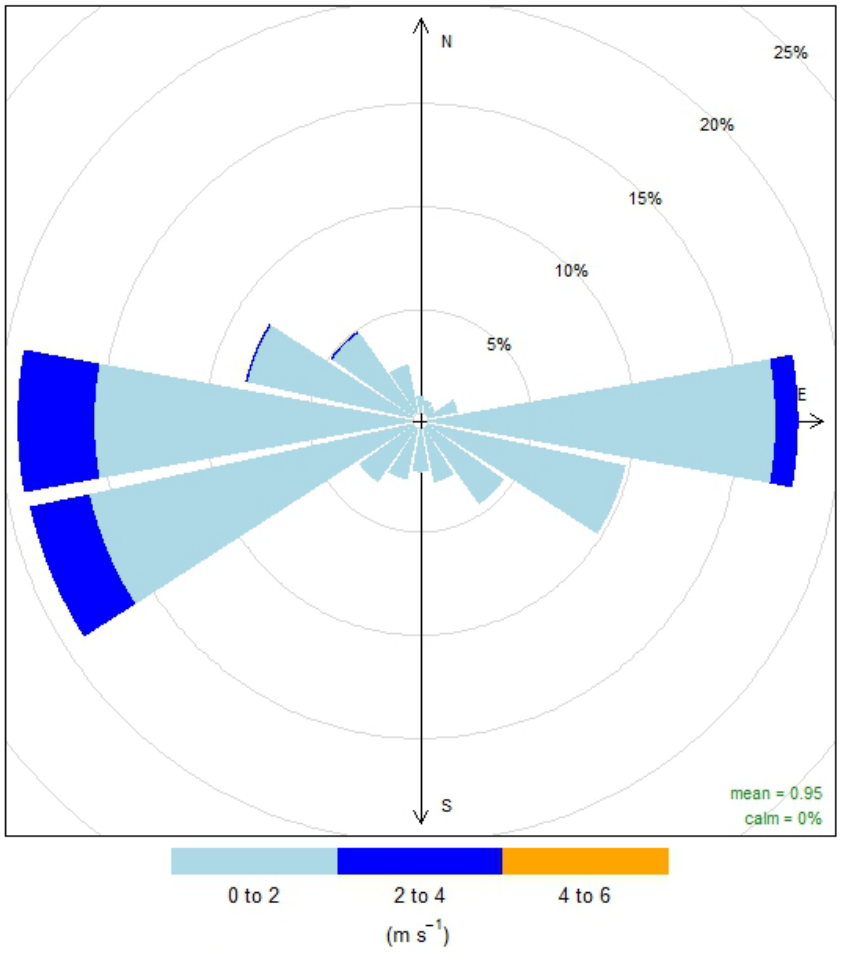

Figure 1: Wind Rose Showing 1-hour Mean Wind Speed and Direction

Exceedances of the 1-hour mean AAQG were measured on 23 separate occasions, which represents 1% of the total 1-hour periods (2,221 hours). The majority of the exceedances occurred during west (W) winds (43%), west-north-west (WNW) winds (22%) and west-south-west (WSW) winds (13%). Winds from the direction of the landfill, namely south-west (SW) and south-south-west (SSW), occurred only 9% and 4% of the time, respectively. Furthermore, the monitoring data indicate that the exceedances occurred during the evening or early morning and under calm to low wind conditions: the 1-hour mean wind speeds ranged between 0.2 m/s and 0.7 m/s.

The exceedances of the 1-hour mean AAQG are shown in **Table 2**. The data highlighted in grey in the table indicate that there were only three 1-hour exceedance events associated with winds blowing from the SW and SSW (i.e. from the landfill), which occurred during hours '22', '23' and '00' (i.e. late at night).

Time-series plots of the 1-minute mean and 1-hour mean H_2S concentrations are shown in **Figure 2(a)** and **Figure 2(b)**, respectively.

Table 2: Exceedances of the 1-hour Mean AAQG for H_2S for 17 March to 18 June 2015

Date and Time	Wind Speed (m/s)	Wind Direction (degrees)	Wind Direction (compass points)	1-hour Mean H_2S Concentration (ppb)
16/06/2015 20:00	0.3	260	W	16.7
16/06/2015 19:00	0.2	166	SSE	12.4
19/05/2015 20:00	0.4	272	W	10.1
4/06/2015 21:00	0.2	280	W	9.7
27/05/2015 2:00	0.3	100	E	9.2
6/06/2015 0:00	0.3	199	SSW	8.5
25/05/2015 19:00	0.2	264	W	8.4
16/06/2015 21:00	0.2	258	WSW	7.2
27/05/2015 22:00	0.7	230	SW	6.8
5/06/2015 2:00	0.4	245	WSW	6.6
15/06/2015 22:00	0.4	270	W	6.6
27/05/2015 0:00	0.5	274	W	6.4
5/06/2015 1:00	0.4	259	W	6.3
19/05/2015 6:00	0.5	283	WNW	6.2
15/06/2015 23:00	0.4	234	SW	5.9
27/05/2015 1:00	0.3	276	W	5.8
5/06/2015 19:00	0.4	257	WSW	5.6
24/04/2015 1:00	0.4	298	WNW	5.5
23/05/2015 20:00	0.6	265	W	5.1
20/03/2015 23:00	0.2	290	WNW	5.1
18/04/2015 23:00	0.2	286	WNW	5.0
24/04/2015 0:00	0.3	274	W	5.0
19/04/2015 4:00	0.3	284	WNW	5.0

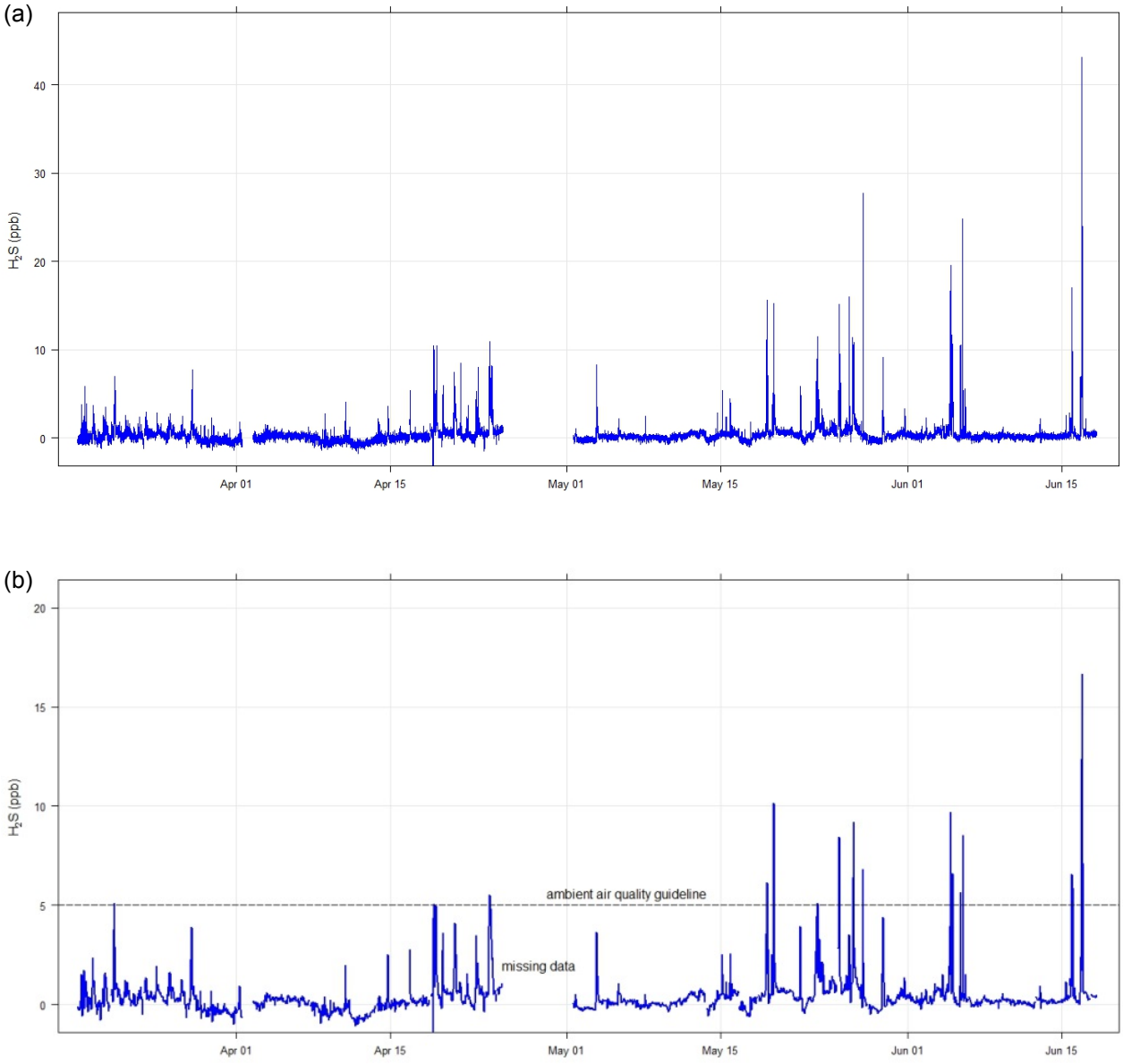

Figure 2: Time-series Plots for 17 March to 18 June 2015 for (a) 1-minute Mean H_2S (ppb) and (b) 1-hour Mean H_2S (ppb)

Figure 3 shows the 1-hour mean concentrations of H_2S measured at the site as a pollution rose, i.e. it presents the same data as per the wind rose shown in **Figure 1**, however, the wind speed data were substituted for the H_2S concentration data. The figure indicates that the highest H_2S concentrations were measured during winds blowing from the W, WSW and WNW. In other words, based on the data for the period, the figure indicates that there is likely to be an emission source of H_2S located to the W and WNW of the monitoring site.

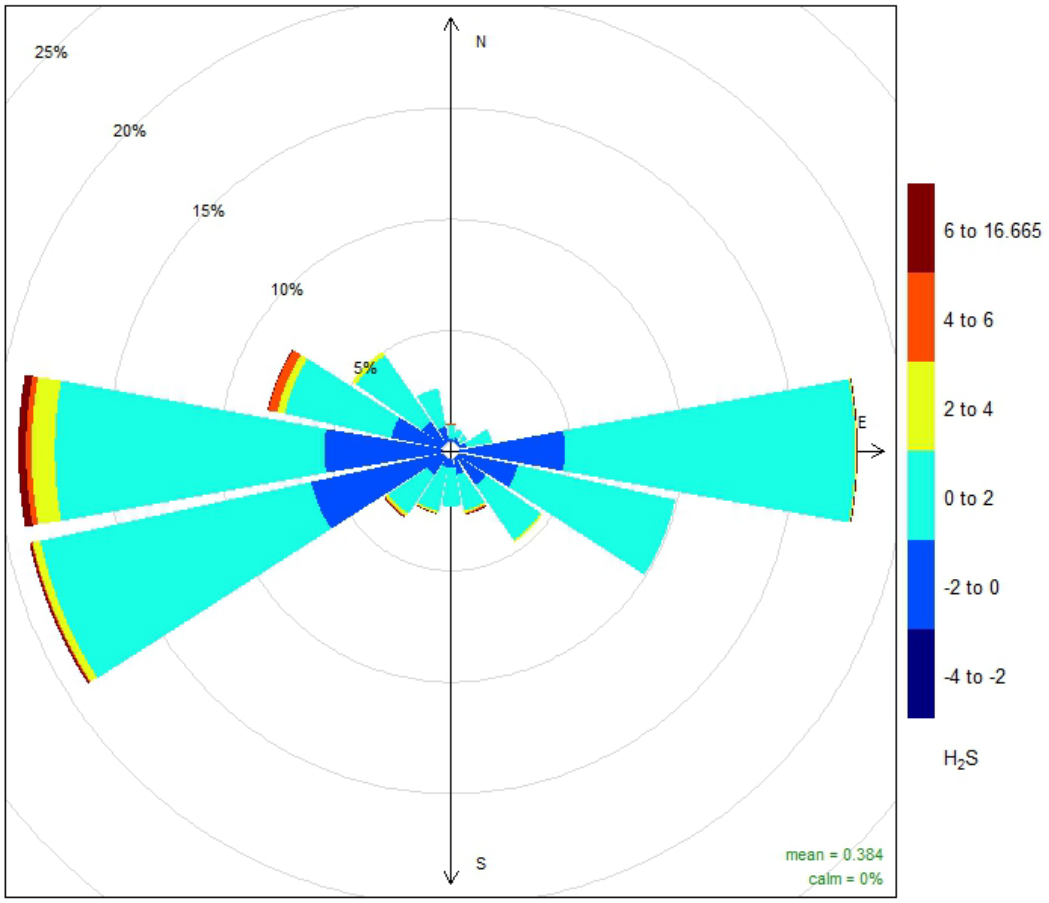

Figure 3: Pollution Rose for 1-hour Mean H_2S (ppb) and Wind Direction

Figure 4 shows the 1-hour mean concentrations of H_2S measured at the site as a polar plot, or a bivariate plot of concentrations varying by wind speed and wind direction. The figure shows the H_2S concentrations in polar coordinates by both 1-hour mean wind speed and wind direction. Mean concentrations were calculated for wind speed-direction 'bins' (e.g. wind speeds of 0–1, 1–2 m/s, and wind directions of 0–22.5, 22.5–45 degrees etc.). The figure further corroborates the suggestion that there is another emission source of H_2S located to the W and NW of the monitoring site; as the highest concentrations were measured during low wind speeds (<1 m/s) originating from the W and NW.

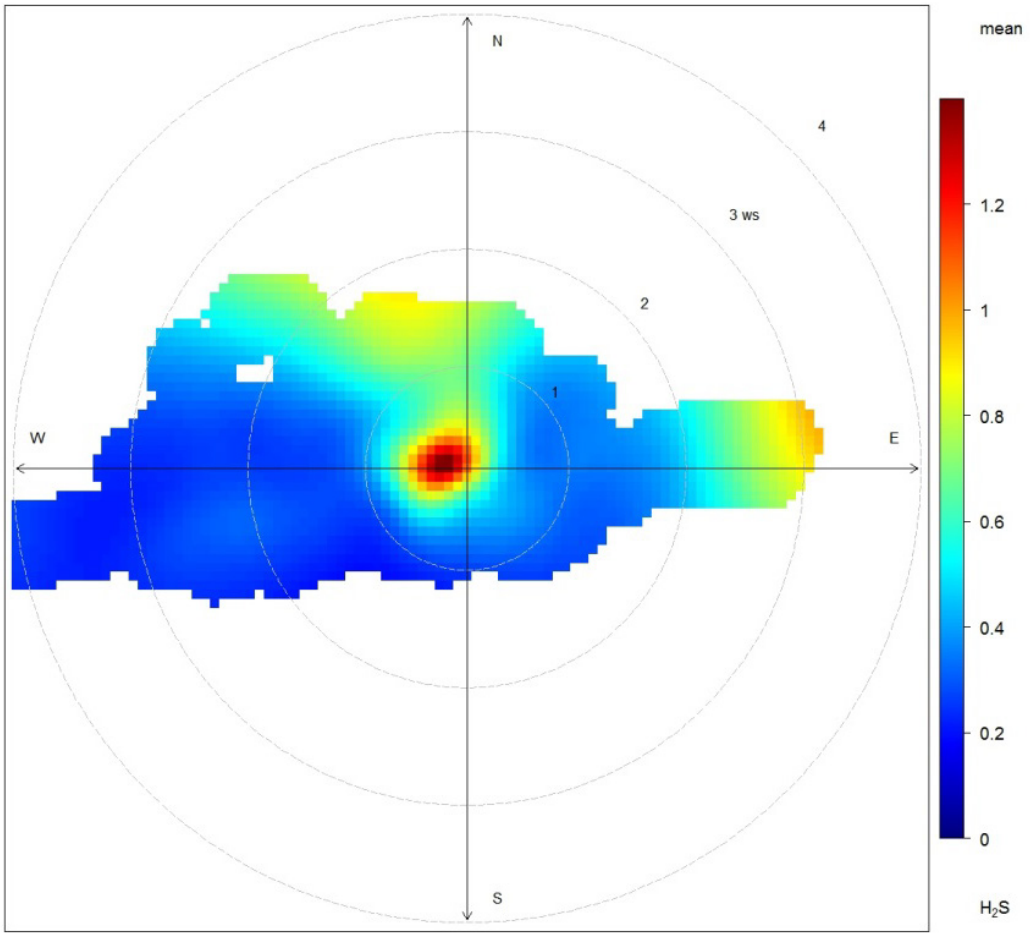

Figure 4: Polar Plot for 1-hour Mean H_2S (ppb), Wind Speed and Wind Direction

Figure 5 shows the 1-hour mean concentrations of H_2S measured at the site as a percentile rose, or percentile concentrations of H_2S varying by 10 degree wind direction segments. The figure shows the distribution of H_2S concentrations by wind direction, conditioned on time of day (i.e. day-time and night-time). The figure further corroborates the suggestion that there is another emission source of H_2S located to the W and NW of the monitoring site; as the highest concentrations were measured during the night-time and under winds originating from the W and NW.

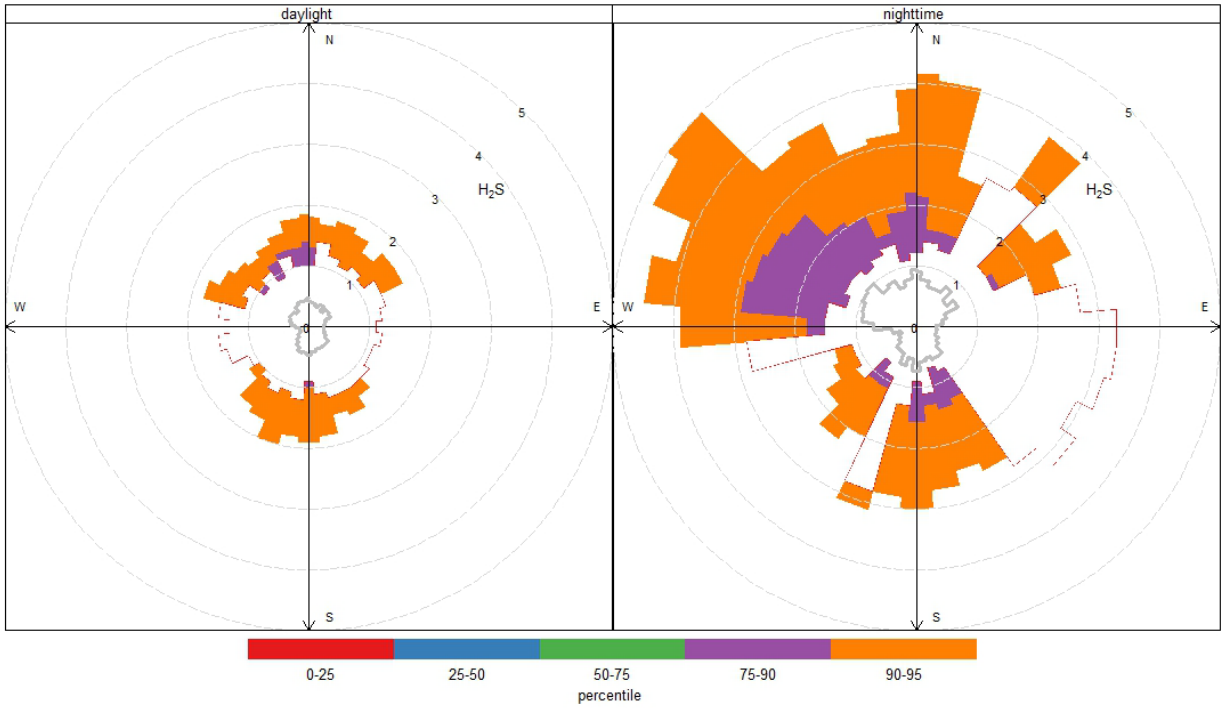

Figure 5: Percentile Plot for 1-hour Mean H_2S (ppb) and Wind Direction for Day- and Night-time

Figure 6 shows the 1-hour mean concentrations of H_2S measured at the site as a polar plot for each hour of the day. The figure further corroborates the suggestion that there is another emission source of H_2S located to the W and NW of the monitoring site; as the highest concentrations were measured during the night-time (e.g. hours '00', '01', '04', '06' and '20') and under winds originating from the W and NW.

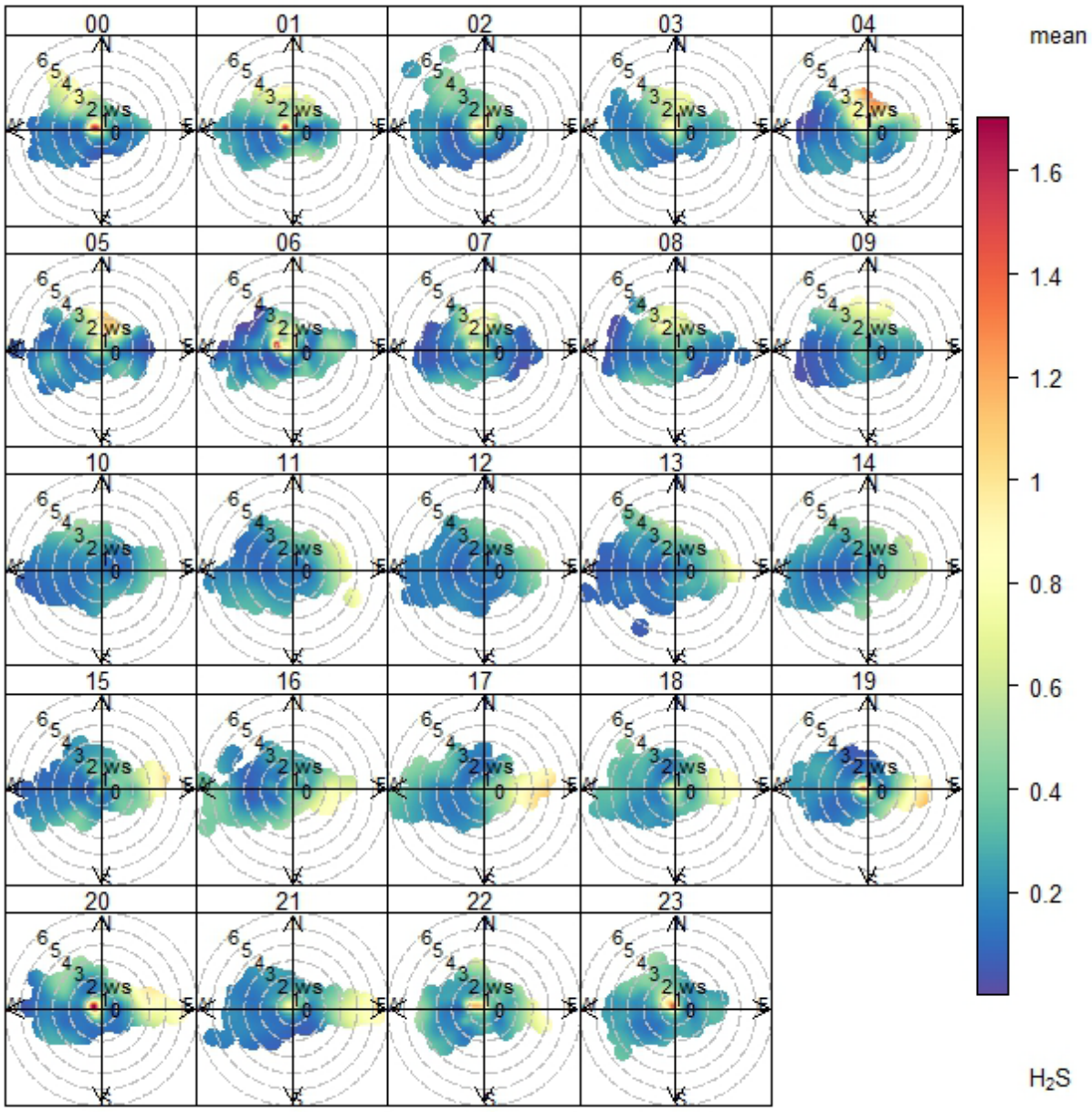

Figure 6: Polar Plot for 1-hour Mean H_2S (ppb), Wind Speed and Wind Direction for Each Hour

Figure 7 shows the 24-hour (daily) mean concentrations of H_2S measured at the site as a calendar plot i.e. in a conventional calendar format with the main purpose being to help visualise potentially complex data in a familiar way. **Figure 7(a)** shows the 24-hour mean concentrations of H_2S (in ppb) measured each day between 17 March and 18 June 2015 against a colour scale (magnitude), while **Figure 7(b)** shows the 24-hour mean wind vectors based on the daily mean wind speed and direction data. For example, the highest 24-hour mean H2S concentration of 2.1 ppb was measured on Wednesday 27 May 2015 during which light winds (0.8 m/s) blew from the NW.

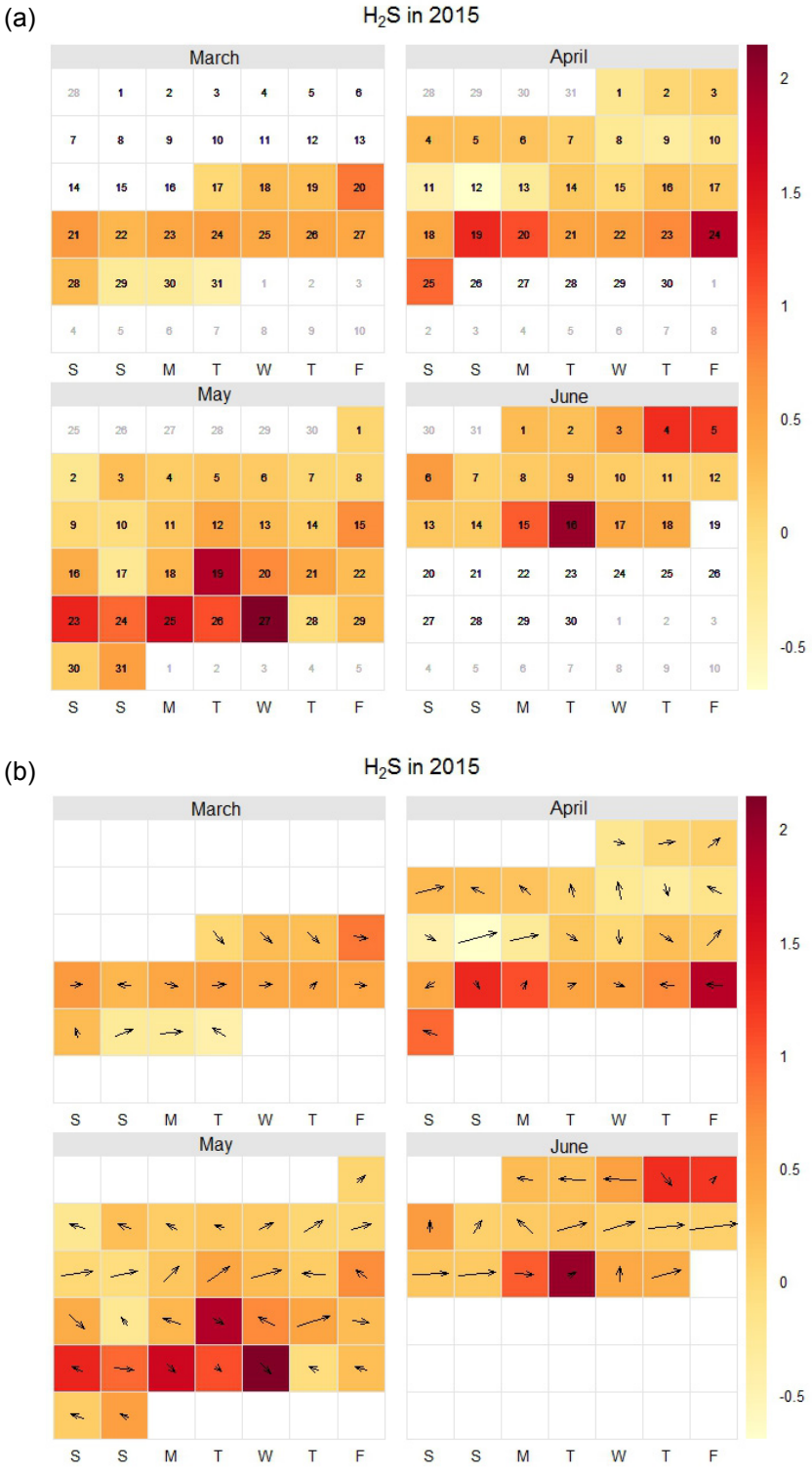

Figure 7: Calendar Plot for 24-hour Mean H_2S (ppb) for Each Day (a) and with Wind Vectors (b)

4 Discussion

The results for the 3-month monitoring period between March and June 2015 indicate that:

a) Generally, the concentrations of H_2S measured at the monitoring site were relatively low. However, there were 23 exceedances of the 1-hour mean AAQG during winds from the W, WNW, WSW, SW and SSW; and,
b) There is likely to be another emission source of H_2S located to the W and NW of the monitoring site, which may have contributed to the past odour nuisance events at 645 Hōkio Beach Road.

Whilst the frequency of winds during the 3-month monitoring period blowing from the Levin Landfill towards the monitoring site was low, which has the potential to skew the results slightly, another emission source of H_2S located to the W and NW of the monitoring site, in addition to the emission sources previously identified by MWH at the Levin Landfill (refer to MWH's odour assessment report dated February 2015), may have contributed to the ongoing odour issues reported by Mr and Mrs Grange, the current owners of the property located at 645 Hōkio Beach Road. Whilst the odour (and H_2S) emission sources previously identified by MWH at the Levin Landfill are situated to the SW of the monitoring site, it is still plausible that the potential source of H_2S located to the W and NW of 645 Hōkio Beach Road may be located within the landfill site boundary, but if that is the case, it is not likely to be related to the previously identified odour emission sources at the landfill (e.g. working face, leachate pond, Stage 2 emission hotspots and leachate collection manhole).

Despite the fact that 23 exceedances of the 1-hour mean AAQG were recorded during the 3-month period, the exceedance frequency is relatively low at only 1% of the total number of hours in the period covering 2,221 hours. It is possible that high intensity odours may have been detected at 645 Hōkio Beach Road, however, this is considered to be of low probability, given the time that they occurred (mostly at night-time). MWH understands that HDC and the landfill operator have implemented a number of the odour mitigation measures recommended in MWH's odour assessment report at the landfill, and that no odour complaints were received by HDC or the landfill operator during the 3-month monitoring period.

The results for the 3-month monitoring period, albeit for H_2S as a proxy for odorous compounds being discharged at the landfill, indicate that another, currently unidentified, source has perhaps a greater potential to contribute to the odour complaints recorded by Mr and Mrs Grange in the past than emission sources located at the landfill that are associated with existing landfill activities.

MWH considers that whilst the potential emission source of H_2S located to the W and NW of 645 Hōkio Beach Road currently remains unidentified, it is unlikely to be related to existing activities undertaken at the landfill, and covered by the landfill's existing resource consent number 6011, which was granted by Horizons Regional Council in 2002. HDC may wish to investigate the location of this potential source of H_2S, as it is possible that it is associated with fugitive emissions from the old unlined landfill located in the northern part of the site. It is not known at this stage whether the emission source is located within the landfill site boundary (e.g. the old unlined landfill or the low-lying vegetated area to the east of the exit to the landfill) or whether it is actually located beyond the landfill site boundary.

Providing that the mitigation measures recommended in MWH's odour assessment report dated February 2015 continue to be adhered to by the landfill operator at all times, MWH considers that the potential for further odour nuisance effects arising in the surrounding community as a result of odour emissions from the emission sources identified by MWH at the landfill will be significantly reduced.

5 References

Carslaw, D.C. and K. Ropkins, (2012). openair — an R package for air quality data analysis. *Environ. Model. Softw.*, Vol 27–28, 52–61.

MfE, (2002). Ambient Air Quality Guidelines, Ministry for the Environment (MfE) and Ministry of Health (MoH), Air Quality Report No 32, May 2002.

6 Closure

I trust that this meets your requirements. Should you require any additional information or clarification, please do not hesitate to contact me on (09) 580 4575 or 021 766 576.

Yours sincerely

Dr Doug Boddy
Senior Air Quality Consultant
MWH New Zealand Limited

Reviewed By:

Dr Paul Heveldt
National Environmental Science Specialist
MWH New Zealand Limited

Copy to: Phil Landmark
Roger Hulme