BEFORE THE HEARINGS PANEL
FOR THE QUEENSTOWN LAKES
PROPOSED DISTRICT PLAN

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of Hearing Stream 17 – Chapter 18A – General Industrial Zone

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STATEMENT OF EVIDENCE OF CLINT RISSMAN ON BEHALF OF SCOPE RESOURCES LIMITED (FS3470)

Dated this 5th day of June 2020

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1 Introduction

1.1 My name is Clinton Rissmann. I have an undergraduate degree in environmental toxicology, biogeochemistry and earth sciences, a masters in earth sciences and aqueous geochemistry and PhD in earth sciences and fluid (gases and liquids) chemistry.

1.2 I am have held roles as a regional council scientist, principal scientist and as a senior scientist at an NZ Crown Research Institute. I am currently an Adjunct Senior Fellow to the Waterways Centre for Freshwater Management that spans the engineering, earth and environment schools at the University of Canterbury. I am the founder and director of Land and Water Science Ltd.

1.3 My company provides monitoring, measurement and technical services to Scope Resources Limited ("SRL") with a focus on Land Fill Gas ("LFG") dynamics at the Victoria Flats Landfill ("VFL"). This work follows on from my PhD, post-doctoral and consulting work that investigated the temporal and spatial controls over variation in greenhouse gas emissions from landfill, soil and geothermal systems. I have undertaken similar landfill related work for regional and district landfills from Taupo through to Southland.

1.4 My company has monitored landfill gas emissions and odour dynamics at VFL since 2014.

1.5 I have read the Code of Conduct for Expert Witnesses in the Environment Court consolidated Practice Note (2014). I agree to comply with this Code of Conduct. This evidence is within my area of expertise, except where I state I am relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

2 Scope of Evidence

2.1 I have prepared evidence in relation to the further submission 3470. My evidence assesses and explains:

a) Landfill Odours;

b) Odours at the VFL.

3 Landfill Odours

3.1 While CO_2 and CH_4 are the dominant gas species at landfills, neither have any odour. Odour arises from trace gas species that typically compromise <1% of the bulk gas. Of the odour causing trace gases, gaseous inorganic and organic sulphur compounds produced during anaerobic digestion of sulphate-rich waste dominate at landfill sites around the world [1](UKEA, 2002; Ko et al., 2008).

3.2 The following table lists the twelve components with the greatest potential to cause odour at landfill sites based on 45,000 records from 79 sites across the UK, Europe, North America and Japan[2]:

	Chemical Name	CASRN	Chemical Group	Physical Ranking	Odour Ranking	Odour Importance
1	hydrogen sulphide	7783-06-4	Organo Sulphur Compounds	2	5	10
2	methanthiol	74-93-1	Organo Sulphur Compounds	2	5	10
3	carbon disulphide	75-15-0	Organo Sulphur Compounds	2	3	6
4	1-propanethiol	107-03-9	Organo Sulphur Compounds	1	5	5
5	butyric acid	107-92-6	Carboxylic Acids	1	5	5
6	dimethyl disulphide	624-92-0	Organo Sulphur Compounds	1	5	5
7	ethanal	75-07-0	Aldehyde	1	5	5
8	ethanethiol	75-08-1	Organo Sulphur Compounds	1	5	5
9	1-butanethiol	109-79-5	Organo Sulphur Compounds	1	4	4
10	1-pentene	109-67-1	Alkenes	2	2	4
11	dimethyl sulphide	75-18-3	Organo Sulphur Compounds	1	4	4
12	ethyl butyrate	105-54-4	Ester	1	4	4

3.3 As can be seen from the chemical group categorisation above, hydrogen sulphide is considered the strongest and most persistent odour causing agent at landfill sites. The high ranking reflects both the low odour threshold, as low as 0.5 parts per billion (ppb), and high mobility of hydrogen sulphide (UKEA, 2002; Ko et al., 2008).

3.4 Human detection limits in relation to odorous trace gases associated with landfills are set out in tabular[3] format and in an accompanying literature review[4] contained in Appendix 1 to my evidence. The human nose is sensitive to as little as 0.5 parts per billion or 0.5-parts hydrogen sulphide in 1 billion parts of air (0.5: 1,000,000,000). As such, the human nose is highly sensitive to even the smallest quantity of hydrogen sulphide.

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[1] Jae Hac Ko, Qiyong Xu & Yong-Chul Jang (2015) Emissions and Control of Hydrogen Sulfide at Landfills: A Review, Critical Reviews in Environmental Science and Technology, 45:19, 2043-2083, DOI: 10.1080/10643389.2015.1010427

[2] UKEA, 2002. Investigation of the Composition and Emissions of Trace Components in Landfill Gas R&D Technical Report P1-438/TR. T. Parker, J. Dottridge, and S. Kelly. United Kingdom Environmental Agency.

[3] Ruth, J. H. (1986) Odour thresholds and irritation levels of several chemical substances: a review. Am. Ind. Hyg. Assoc. J., 47, 142-151.

[4] UKEA, 2002; Ko et al., 2008

3.5 Although hydrogen sulphide typically dominates the odour profile at most landfill sites, landfill odours are usually a cocktail of differing trace gas species[5]. Consequently, odour may vary both spatially and temporally across a landfill site according to waste composition, age and oxygen content. Significantly, odour production is enhanced by high moisture contents within the waste pile.

4 Victoria Flats Landfill

4.1 According to VFL register of odour complaints the majority occur during the winter months. Importantly, a significant number of these complaints are from areas several kilometres beyond the existing buffer zone.

4.2. At the VFL, the potential for detectable odour is exacerbated by wintertime temperature inversion. Specifically, a ground frost that traps a layer of still air close to ground level. Under these conditions, odour is not dispersed by wind and instead odour pools close to ground level and may flow, slowly down gradient. Temperature inversion is a natural process that occurs in response to radiative cooling of the ground and frost formation.

4.3 The role of temperature inversion in relation to odour accumulation is not unusual for landfills located in the cooler regions of New Zealand, especially those that are inland. However, the role of temperature inversion in odour accumulation is especially relevant to Central Otago where the days of ground frost are much higher than in other regions of New Zealand.

4.4 Accordingly, for an equivalent amount of odour causing gases, the VFL site is considered especially sensitive to odour accumulation during the winter months due to its physical setting (inland valley) and a high number of ground frosts.

4.5 While the physical setting and ground frosts result in additional detectable odour, the surrounding physical setting includes predominately rural land uses with limited (if any) residential uses which limits the number of activities sensitive to odour.

5 Cardrona Cattle Company Submission (3349)

5.1 I have been provided with a copy of submission 3349 which seeks some 91.4ha of Industrial Zoning around the VFL and I understand that this submission seeks to re-zone

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[5] UKEA, 2002; Ko et al., 2008

land within the Landfill Buffer Zone as well as existing rural land within 1km of the landfill site.

5.2 In my experience, it is common practice for landfills to be surrounded by a buffer area to distance the source of odorous trace gases from members of the public[6]. While the point of odour measurement occurs at the boundary of the landfill site, the buffer area is an important mitigating factor in terms of odour detection as the VFL site is especially sensitive to odour accumulation[7].

5.3 Should the VFL buffer area be occupied by any members of the public through the re-zoning proposed by submission 3349 it is highly likely they will be exposed to odorous trace gases, particularly during the winter months. Due to the potential for detectable odour being exacerbated during wintertime temperature inversions, I cannot recommend any intensive people related activities (industrial) go into this locality while the landfill is still in operation.

5.4 On the basis of my experience and that reported in international peer-review literature it is also likely that this will result in a significant increase in the number of odour complaints, which could include enforcement action against the landfill, potential restriction on operational hours or lead to objections to renewals of the air discharge consent.

Clint Rissman

5th June 2020

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[6] See also the review paper of Ko et al.

[7] See also the review paper of Ko et al.

Appendix 1

Human detection limit and odour description of odorous trace gases associated with landfills (Ruth, 1986)

Compounds	Formula	Odour (Description)	Detection Limits (ug/m³)	(ppbᵥ)	Boiling Point (°C)	Molecular Weight (g)
Sulphur Compounds						
Hydrogen sulphide	H2S	rotten eggs	0.7	0.5	-60.7	34.1
Carbon disulfide	CS2	disagreeable, sweet	24.0	7.7	46.3	76.1
Dimethyl sulphide	CH3-S-CH3	rotten cabbage	2.5	1.0	37.3	62.1
Dimethyl disulfide	(CH3)2S2	rotten cabbage	0.1	0.026	109.7	94.2
Dimethyl disulfide	(CH3)2S3	rotten cabbage	6.2	1.2	165	126.2
Methyl mercaptan	(CH3)SH	rotten cabbage	0.04	0.02	6.2	48.1
Ethyl mercaptan	CH3CH2-SH	rotten cabbage	0.032	0.01	35	62.1
Allyl mercaptan	CH2=CH-CH2-SH	garlic coffee	0.2	0.1	NA	74.15
Propyl mercaptan	CH3-CH2-CH2-SH	Unpleasant	0.2	0.1	NA	76.16
Amyl mercaptan	CH3-(CH2)3-CH2-SH	Putrid	0.1	0.02	NA	104.22
Benzyl mercaptan	C6H5CH2-SH	Unpleasant	1.6	0.3	NA	124.21
Thiophenol	C6H5SH	putrid garlic	1.2	0.3	NA	110.18
Sulphur dioxide	SO2	Irritating	1175.0	449.3	NA	64.07
Carbon oxysulphide	COS	Pungent	NA	NA	-50.2	60.1
Nitrogen Compounds						
Ammonia	NH3	pungent, sharp	26.6	38.3	-33.4	17
Aminomethane	(CH3)NH2	fishy, pungent	25.2	19.5	-6.3	31.6
Dimethylamine	(CH3)NH2	fishy, amine	84.6	46.0	7.4	45.1
Trimethylamine	(CH3)3N	fishy, pungent	0.1	0.046	2.9	59.1
Skatole	C6H5C(CH3)CHNH	faeces, chocolate	0.00004	0.00001	265	131.1
Volatile Fatty Acids						
Formic	HCOOH	Biting	45.0	24.0	100.5	46
Acetic	CH3COOH	Vinegar	2500.0	1019.1	118	60.1
Propionic	CH3CH2COOH	rancid, pungent	84.0	27.8	141	74.1
Butyric	CH3(CH2)2COOH	Rancid	1.0	0.3	164	88.1
Valeric	CH3(CH2)3COOH	unpleasant	2.6	0.6	187	102.1
Ketones						
Acetone	CH3COCH3	sweet, minty	1100.0	463.9	56.2	58.1
Butanone	CH3COOCH2CH3	sweet, minty	737.0	250.4	79.6	72.1
2-Pentanone	CH3COCH2CH2CH3	Sweet	28000.0	7967.5	102	86.1
Acetaldehyde	CH3CHO	green sweet	0.2	0.1	20.8	44.1
Methanol	CH3OH	alcohol	13000	9953.1		32
Ethanol	CH3CH2OH	alcohol	342	342		60
Phenol	C6H5OH	medicinal	178	46	181.8	94.1