IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of an application for resource consent by Fulton Hogan to establish Roydon Quarry

SUPPLEMENTARY STATEMENT OF LOUISE FLEUR WICKHAM (AIR QUALITY)

CALLED BY CANTERBURY DISTRICT HEALTH BOARD

21 February 2020

1.0 Introduction

1. My full name is Louise Fleur Wickham. I am a Director and Senior Air Quality Specialist at Emission Impossible Ltd. I have previously provided a submission dated 17 October 2019 and a supplementary statement dated 21 November 2019. I also contributed to two (air quality) joint witness statements dated 14 November 2019 and 9 December 2019.

2. This submission is in response to a request for comment on PM_{10} offset calculations by Commissioners in Minute 14 dated 10 February 2020.

3. In preparing this statement I reviewed the following additional documents:
   - Supplementary Statement of Mr Roger Cudmore on behalf of Fulton Hogan Ltd (PM_{10} Offsetting) dated 5 February 2020
   - Addendum to Synopsis of Closing Legal Submissions for Fulton Hogan Ltd (PM_{10} Emissions) dated 5 February 2020

4. My submission will address:
   - Difference of opinion between air quality experts over emissions estimates
   - Clarification on bund formation emissions
   - Requirement for offsets
   - General comments on offsets
   - Offset calculations

2.0 Emissions Estimates

2.1 Difference of opinion

5. As Mr Cudmore has noted, the key differences in the air quality expert's emissions estimates arise from differences in base assumptions, particularly those regarding the size of exposed areas, distances travelled by trucks and

mitigation efficiency. These seemingly minor points of disagreement become very significant when calculating emissions from such a large-scale operation. This is why my first indicative PM_{10} emissions estimates (7 – 8 tonnes/year) are so much larger than my current emissions estimates (2 – 3 tonnes/year). My first estimate assumed 26 hectares of wind-exposed, open ground and 50,000 vehicle kilometres travelled. Based on changes to the proposal subsequently advised by Mr Cudmore, my current estimate now assumes only 5 hectares of open ground and less than 15,000 vehicle kilometres travelled.

6. It is also worth noting that whilst the four expert's figures are different, Mr Cudmore's estimates are significantly less than Ms Ryan, Mr Kirkby and my own estimates. This speaks to Mr Cudmore's opinion that the maximum impact of the proposal is likely to be around 2.4 $\mu g/m^3$ PM_{10} as a 24-hour average (i.e. just under the significance threshold of 2.5 $\mu g/m^3$ in Regulation 17 requiring offsets). This leaves no room for error if his calculations are underestimates, as appears to be the case when comparing with other experts.

7. Ms Ryan, Mr Kirkby and I do not agree with Mr Cudmore's assumption of an additional 80% emissions reduction to the US EPA emissions factor (which itself assumes reduction due to water controls) for a comparable aggregate product. The lesser number of screens is immaterial to an emission factor based on actual throughput (which was already assumed to be reduced by 50%).

8. Another key point of disagreement between myself and Mr Cudmore is the 84% mitigation efficiency he has assumed for emissions of PM_{10} from trucks travelling on pea gravel roads.[1] I wish to draw to Commissioners attention that

[1] NB: However, I have agreed with the use of an 84% reduction factor for pea gravel applied to exposed areas based on an Australian National Pollutant Inventory publication. Refer page 26 of JWS dated 9 Dec 2019.

Mr Cudmore's assumption of 84% mitigation is not based on any published data. Rather it has just been assumed.

9. I further wish to note that all my emissions estimates assume at least 70% reduction due to water control, which may or may not be reflected in proposed conditions of consent. This is a significant assumption and therefore, my emissions estimates are not overly conservative.

2.2 Bund formation estimate

10. Mr Cudmore has asserted that my estimate of PM_{10} emissions from bund formation was unrealistically high because of two factors.

11. The first factor was my assumption of a moisture content of 1% for PM_{10} emissions from topsoil handling. This assumption was taken from Mr Cudmore's November statement of evidence and was subsequently revised to 8% (with subsequent downwards revision of PM_{10} emissions) during our second round of joint witness conferencing in December. I therefore agree with Mr Cudmore that PM_{10} emissions from handling of over 200,000 tonnes of topsoil, provided they are well controlled (watering), should be very low (~10 kg/year). In any case conditions of consent (i.e. watering of topsoil piles and minimum 8% moisture content) would provide further certainty.

12. The second factor was my assumption of a 1 km each way distance travelled by haul trucks bringing topsoil to the central processing area first (500 metres), and then out to the edges of the site to form the bund (another 500 metres). I have seen no evidence to contradict this practical, central staged approach to bund construction and I have agreed with Mr Cudmore (JWS dated 9 Dec 2019 at para 18) that it would result in a significant travel distance (total around 20,000 vehicle kilometres travelled). This simply reflects the large scale of the proposed activity; bringing over 200,000 tonnes of topsoil in 20 tonne trucks

will require over 10,000 truck movements to create a bund over 4 kilometres in length.

13. As an alternative, should the applicant make each truck travel to each perimeter of the site directly from the site entrance, then this would still be around 14,500 vehicle kilometres travelled (refer Appendix A for details). Even allowing a 70% reduction in emissions due to watering, published emission factors (that all experts agree on) indicate this high amount of travel on unpaved areas (the site is not formed yet) will result in around 1.9 tonnes of PM_{10}. Appendix B provides an updated calculation for the first year (this updates my Table D-2 in the JWS dated 9 Dec 2019) assuming a reduced throughput (150,000 tonnes of gravel processing only). The total estimate of PM_{10} is around 2.3 tonnes/year.

14. It should be noted that this updated estimate does not address emissions of PM_{10} from the following sources:
    a. 5-hectare site preparation - travelling by scraper & haul trucks
    b. Topsoil stockpiles
    c. Loader forming bund

15. My calculations of emissions for the first year are not therefore particularly conservative. Despite this they are significant, being the same order of magnitude as PM_{10} emissions from normal processing.

3.0 Offsets

3.1 Requirement for Offsets

16. Mr Cudmore has reiterated his view that the proposal will not trigger the significance criterion in Regulation 17 of the *Resource Management (National Environmental Standards for Air Quality) Regulations 2004* (the Regulations). More specifically, Mr Cudmore considers that the proposal is not likely to result in downwind PM_{10} concentrations greater than 2.5 $\mu g/m^3$ as a 24-hour

average. As such, Mr Cudmore considers that offsets are not required for the proposal. Please permit me to also reiterate my view that "based on the size and scope of the proposal, and my experience monitoring quarries in the Canterbury region, I consider that discharges of PM_{10} are very likely to result in an increase in daily PM_{10} of more than 2.5 $\mu g/m^3$ in the Christchurch airshed".[2]

17. In the first year, there is simply no way that you can move 50,000 tonnes of topsoil to the edge of a polluted airshed to construct a one-kilometre bund without causing this level of (small) increase in daily PM_{10} offsite. Similarly, during normal quarry operations, even with absolute adherence to best practice mitigation, the sheer size and scale of proposed works are such that this increase is likely – screening alone annually emits half a tonne of PM_{10}, a pollutant known to travel kilometres.

18. BOPRC have provided guidance for applicants to demonstrate that they should be exempt from the requirement for offsets. My assessment of the proposal against these requirements (refer Appendix C) concludes that the applicant has not satisfactorily demonstrated the proposed activity is not likely to increase the daily, off-site maximum concentration of PM_{10} by more than 2.5 $\mu g/m^3$ in the Christchurch Airshed.

3.2 General comments

19. Mr Caldwell has submitted his interpretation of the purpose and intent of Regulation 17 in the Regulations.[3] I am not a lawyer but while working for the Ministry for the Environment I provided technical assistance to Parliamentary Counsel who drafted the Regulations. Please also permit me to offer some comments as to intent.

[2] Statement of Louise Wickham dated 17 October 2019. At [49]

[3] Addendum Closing Legal Submissions for Fulton Hogan Ltd dated 5 February 2020. At [38]

20. The Regulations were promulgated in 2004 with the intent of compliance with the PM_{10} standard by 2013 (MfE, 2010).[4] At that time, Regulation 19 set a bottom line requirement, that after 2013 no resource consent may be issued for any discharge of PM_{10} in an over-allocated airshed. This had the effect of placing the burden of compliance primarily on industry, who required consent. This was subsequently deemed inequitable given the primary source of non-compliance in most New Zealand urban airsheds was (non-consented) domestic fires. By 2010 it was further apparent that compliance was not going to be achieved in 2013 in at least 15 airsheds (MfE, 2010).[5]

21. To address these inequities, in 2011 the Regulations were amended to revoke the 2013 deadline and introduce explicit provisions for offsets (Regulation 17).[6] It is notable that the amendments also extended the deadline for compliance for the Christchurch Airshed to 1 September 2020 (Regulation 16B). Despite significant improvements since 2004 (when there were around 33 exceedances per year),[7] the Christchurch Airshed will still not comply with the PM_{10} standard (currently averaging 8 exceedances per year but only one is permitted) by this new deadline.[8] This places even more importance on measures, such as offsets, to assist Environment Canterbury to meet the PM_{10} standard.

[4] Ministry for the Environment, (2010). *Regulatory Impact Statement – Amending the PM_{10} Air Quality Standards: Final Recommendations.* [Online: https://www.mfe.govt.nz/sites/default/files/ris-air-quality-standards.pdf] Accessed 19 Feb 2020.

[5] *Ibid*. At page 5.

[6] Resource Management (National Environmental Standards for Air Quality) Amendment Regulations 2011 (SR 2011/103)

[7] Average for the 5-year period 2002 – 2006

[8] Average for the 5-year period 2014 – 2018

22. Regarding intent, Mr Caldwell is correct that the purpose of Regulation 17 is to prevent new PM_{10} discharges into a polluted airshed so as not to make existing air pollution worse.[9] As Bay of Plenty Regional Council states (BORPC, 2014):[10]

> *The intent is that the offset balances the impact so that there is zero overall effect.*

23. Importantly, in doing so Regulation 17(3)(b) requires offsets to take effect within 12 months of the granting of the consent and to **be effective for the remaining term of the consent** (my emphasis added). This raises obvious issues for the proposed Roberts Road offset, as the Roberts Road quarry emissions will cease in 2022 with expiry of consent. The Roberts Road quarry cannot, therefore, be a viable offset for the Roydon quarry under Regulation 17 because the Roberts Road quarry was never going to operate for the duration of the Roydon Road quarry.

24. Anticipating this, Mr Cudmore has offered two other proposals for offsets:
    a. Pound Road Quarry – gravel processing
    b. Pound Road Quarry – asphalt and sand bagging plant

25. Mr Cudmore has not provided any details of his calculations for these sites. This means I cannot provide any independent verification of the proposed offsets. I anticipate that Environment Canterbury, having consented these processes, is in a more informed position regarding verification.

26. I draw Commissioners attention to Ministry for the Environment guidance on offsets, which states (MfE, 2014 paraphrased):[11]

[9] Addendum Closing Legal Submissions for Fulton Hogan Ltd dated 5 February 2020. At [38]

[10] Bay of Plenty Regional Council, (2014). *Offsets Guidance for the Rotorua Airshed*. October.

[11] MfE, (2014). *Users Guide to the revised National Environmental Standards for Air Quality 2011: Updated 2014*. Wellington. January. At page 77.

a. **The offsets need to be 'real'** (and not emissions that might be potentially discharged). The nominated asphalt plant may be consented for an emission of 20 tonnes per year of PM_{10}, but it may not actually be emitting this in practice. Offsetting an emission that is not actually occurring does not reduce real emissions and would result in a net increase in emissions to the Christchurch Airshed.

b. **The offsets need to be greater than any decreases that would otherwise occur during the term of the consent** (i.e. emission reductions that would be achieved through 'business as usual' anyway). Mr Cudmore has been careful to note that his proposed emissions reductions for both Roberts Road and the Pound Road Quarries are not those that would occur during rehabilitation. Commissioners will need to satisfy themselves over this detail.

c. **Offsets are only required for the "amount likely to be discharged into the relevant airshed"** (Regulation 17(3)(a)). In principle I agree with Mr Cudmore that only discharges from the proposal into the Christchurch Airshed (under certain wind conditions) require offsetting. This is discussed further below at para [30 - 36]

d. **The offsets must be a consented discharge to air** (i.e. not a land use consent alone) to meet the requirements of Regulation 17(1). I note this because Commissioners appear to be interested in other Fulton Hogan properties (Appendix 1 of Minute dated 10 February 2020).

27. I further consider that **replacing like with like**, i.e. reducing PM_{10} emissions from other quarrying activities inside the Christchurch Airshed to offset the proposed new quarry, is the ideal way to meet the intent of the Regulations. More specifically, removing identical or very similar emission sources (e.g. removing one 250 tonne per hour screen and consenting one new 250 tonne

per hour screen) addresses valid concerns over the robustness of emissions estimates. As Commissioners no doubt appreciate, this requires careful attention to detail to provide assurance that the magnitude of emissions being offset is real. For example, matching proposed with actual truck movements and vehicle kilometres travelled over unsealed areas.

28. Notwithstanding the above, it is not a regulatory requirement to replace like with like. As an alternative, Fulton Hogan could work with Environment Canterbury to remove coal-fired boilers, or domestic fires to provide PM_{10} reductions.

29. As an aside, I note the Canterbury Regional Air Plan states (Environment Canterbury, 2017 – my emphasis added):[12]

> *The Air Plan gives effect to the Policy Statement by:*
>
> - *setting out objectives, policies and methods that provide a framework to reduce PM_{10} concentrations, including by controlling discharges of contaminants into air from home heating, industry and other sources and encouraging the uptake of cleaner technology, in polluted airsheds so that the targets set by the NESAQ can be achieved; and*
> - ***providing a framework that enables consideration of industry offsets in accordance with Regulation 17** of the Resource Management (National Environmental Standards for Air Quality) Regulations 2004, and which provides opportunity for industry to access offsetting opportunities in the domestic market; and*
> - ***setting a framework for the management of PM_{10} and other contaminants discharged into air that ensures air quality is maintained or improved across the Region**, and sensitive and discharging activities are protected from each other.*

[12] Environment Canterbury, (2017). *Canterbury Regional Air Plan*. [Online: https://eplan.ecan.govt.nz/eplan/#Rules/0/234/1/16856] Accessed: 19 Feb 2020.

Despite this, I could find no further reference to offsets in the plan. This has necessitated my reliance on Ministry for the Environment and BOPRC guidance regarding offsets.

3.3 Offsets calculation

30. Regarding Mr Cudmore's reduction in overall emissions based on wind direction. **Figure 2** of my submission dated 17 October 2019 shows the wind directions under which the proposed quarry will impact the Christchurch Airshed. This figure is reproduced here for clarity.

Figure 2 Wind directions potentially impacting on Christchurch Airshed (wind rose generated from Golders met set with filtered values <180 (S) and > 315° (NW)).

31. Figure 2 shows that winds from the south through to the north west will potentially transport discharges to air from the proposed quarry to the Christchurch Airshed.

32. I used WindRose Pro (version 3.1.279) under license with Enviroware Ltd to estimate the time fraction for different wind directions. My calculations are provided in Appendix D. These calculations show that winds will direct emissions from the quarry to the Christchurch Airshed for 42.5% of the time. However, this analysis is based on only one year of meteorological data and is not sufficiently robust as to justify any decimal places. It is more reasonable to say that around 40% of the time the quarry will discharge to the Christchurch airshed.

33. Mr Cudmore states that he has "undertaken a more refined analysis" of wind directions to account for *inter alia* the changing location of active areas.[13] However, he has not provided any data or workings so I cannot independently verify his estimate.

34. Mr Cudmore goes on to make some statements about the distance from the boundary for various activities, implying that only activities within 500 metres of the boundary need be considered. I disagree with this approach. PM_{10} is not dust you can see, or dust that will drop out or fall to the ground within a few hundred metres. PM_{10} is particulate matter less than 10 micrometres in size. It is so small it behaves like a gas and can travel for significant distances. As noted in the *Good Practice Guide for Assessing and Managing Dust* (MfE, 2016):[14]

> *When dust particles are released into the air they tend to fall back to ground at a rate proportional to their size. This is called the settling velocity. For a particle 10 micrometres in diameter, the settling velocity is about 0.5 cm/sec, while for a particle 100 micrometres in diameter it is about*

[13] Supplementary statement of Mr Cudmore dated 5 February 2020. At [20]

[14] Ministry for the Environment, (2016). *Good Practice Guide for Assessing and Managing Dust*. Wellington. November. At page 17. NB: There is an error in this publication, whereby the 10 and 100 micron designations have been reversed. The text quoted here is corrected.

45 cm/sec in still air. In a 10-knot wind (5 m/sec), the 100-micrometre particles would only be blown about 10 metres away from the source while the 10-micrometre particles have the potential to travel about a kilometre. Fine particles can therefore be widely dispersed, while the larger particles simply settle out in the immediate vicinity of the source (under calm conditions).

35. Applying this to the proposal, this means that the visible dust from screening and crushing will typically settle out within 50 metres. However, non-visible PM_{10} is highly likely to travel well into the Christchurch Airshed.

36. In summary therefore, I consider it reasonable to assume only 40% of emissions will be discharged into the Christchurch Airshed. Incorporating an updated estimate for bund formation, I estimate the following offsets are required:

    a. First year (site preparation, processing 150,000 tonnes/year)
    0.4 x 2.3 tonnes/year = 0.9 tonnes/year

    b. Subsequent years (processing 625,000 tonnes/year)
    0.4 x 2.9 tonnes/year = 1.2 tonnes/year

4.0 Closing Comments

37. From an air quality perspective, the key issue with quarries is that emissions cannot be controlled all the time (like emissions can be controlled from a point source with air pollution control equipment). Quarry emissions require active management of the site. All the assumptions in the emissions estimates assume perfect on-site management control which requires staff (people) input. Perfect management, with even the most well-trained staff, doesn't happen in practice. For example, the weather can be unfavourable, people

might not notice a sprinkler is not working or high wind conditions might occur outside of operational hours.

38. In closing, I would like to note my agreement with Mr Caldwell that quarry air emissions are, by their nature, somewhat of an ill-fit with the requirements of the Regulations. [15] However, it is also fair to say that from a health perspective, quarry air emissions are an ill-fit with a polluted airshed.

Louise Wickham
21 February 2020

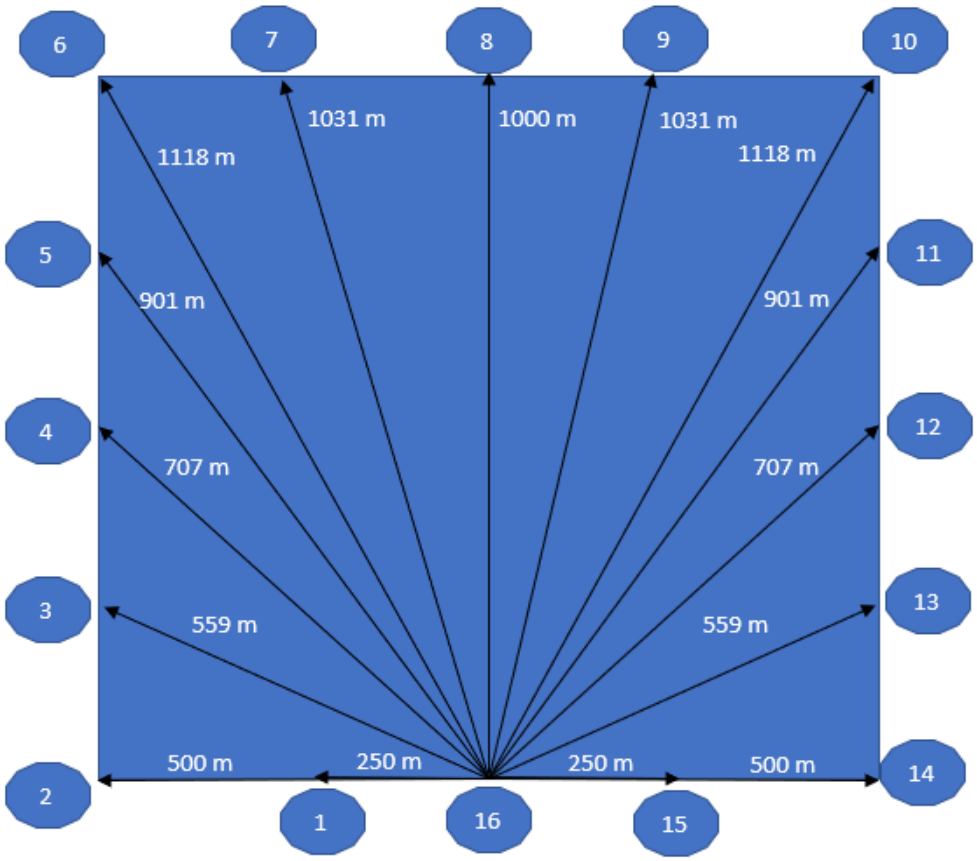
[15] Addendum to synopsis of closing legal submissions for Fulton Hogan Ltd dated 5 February 2020. At [43]

Appendix A Bund Formation Calculations

Original Estimate (Table D-2, Air Quality JWS dated 9 Dec 2019)

Topsoil required to form bund:	203,520 tonnes
Truck capacity:	20 tonnes
No. trucks:	10,176
Distance each truck travels to central processing area:	500 m
Distance each truck travels to bund:	500 m
Distance each truck travels from central processing area:	500 m
Distance each truck travels from bund:	500 m
Total distance travelled:	2 km
Total vehicle kilometres travelled (VKT)	10,176 x 2
	20,352 VKT

Alternative Estimate (no staging)



200,000	tonnes
20	tonnes/truck
10,000	trucks
16	staging sites
625	trucks/ staging site

		Staging Site No.	VKT to	VKT from	Total VKT	
Southern Perimeter	0	16	-	-		
	250	1	156	156	313	
	500	2	313	313	625	
	250	15	156	156	313	
	500	14	313	313	625	
Western Perimeter						
	559	3	349	349	699	
	707	4	442	442	884	
	901	5	563	563	1,126	
	1118	6	699	699	1,398	
Northern Perimeter						
	1031	7	644	644	1,289	
	1000	8	625	625	1,250	
	1031	9	644	644	1,289	
	1118	10	699	699	1,398	
Eastern Perimeter						
	901	11	563	563	1,126	
	707	12	442	442	884	
	559	13	349	349	699	
	500	14	313	313	625	
		Totals	**7,270**	**7,270**	**14,540**	**VKT**

Appendix B Updated US EPA AP-42 PM_{10} Annual Emissions Estimates (Site setup, Throughput 150,000 T/yr)

NB: This table only updates previous evidence (i.e. it does not repeat calculations which have not changed). For further information please refer Table D-2 in Appendix D of JWS dated 9 Dec 2019.

1.0 Site Preparation			
1.1 Topsoil removal	162	kg	
1.2 Loading of topsoil	9	kg	
1.3 Dumping of topsoil	9	kg	
2.0 Bund Formation			
2.1 Topsoil handling	10	kg	(Updated)
2.2 Loader forming bund	*Not estimated*		
2.3 Travelling by trucks to bund	1,994	kg	(Updated)
3.0 Gravel Processing (First Year Assumes 150,000 t/yr only)			
3.1 Screening (controlled)	111	kg	
3.2 Crushing (controlled)	41	kg	
3.3 Truck loading	8	kg	
Total PM_{10} (Site set up + 150,000 t/yr)	2.3	T/yr	(Updated)

2.0 Bund Formation

2.1 Topsoil handling

$PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$			AP42 section 13.2 Aggregate Handling
k	0.35		AP42 section 13.2 Aggregate Handling
U	3.9	m/s	Mean wind speed, annual average Golders met set
M	8	%	Updated to reflect JWS 9 Dec 2019
PM_{10}	0.0002	kg/Mg	
	203,520	Mg/year	Tonnes of bund to be formed
PM_{10}	**34**	**kg/year**	
Watering control reduction	70%		NB: Big assumption
PM_{10}	**10**	**kg/year**	

2.2 Travelling by haul trucks carrying bund fill

	203,520	Tonnes to be brought in and formed into bund	
	20	T/truck	
	10,176	Trucks	
	14,540	VKT	No staging (refer Appendix A)
PM_{10}	457	g/VKT	AP42 13.2.2
	6,647	kg	
Watering control reduction	70%		NB: Big assumption
PM_{10}	**1,994**	**kg/year**	

Appendix C Assessment of Proposal Against BOPRC Requirements to Demonstrate Offsets Not Needed

Table C-1 is my assessment of the proposal against the BOPRC requirements for an exemption from offsets (BOPRC, 2014). I conclude that the applicant has not satisfactorily demonstrated the proposed activity is not likely to increase the daily, off-site maximum concentration of PM_{10} by more than 2.5 µg/m^3 in the Christchurch Airshed.

Table C-1 Assessment of Exemption from Regulation 17 (BOPRC, 2014)

Applicants wishing to demonstrate that offsets are not needed are must satisfy the following criteria:		*Evaluation*
i.	*Preparation of an assessment of PM_{10} discharges from the proposed activity into the Christchurch airshed*	✓
ii.	*Representative emissions data based on referenced, clear and repeatable emissions calculations or test data. If using data from another existing plant for a new build, the applicant will need to show that the data is representative of the proposed plant*	✓*
iii.	*Independently peer reviewed atmospheric dispersion modelling in accordance with the Good Practice Guide for Atmospheric Dispersion Modelling. The Regional Council can arrange for peer review on request, alternatively the applicant may arrange it themselves.*	*X*
iv.	*Modelling of discharges at maximum operation (i.e. maximum consented discharge rate, not actual operation)*	*X*
v.	*Modelling to use a minimum of one full year of meteorological data for the Rotorua airshed*	*X*
vi.	*The proposed activity employs best available technology and emissions control*	✓
vii.	*An assessment of the likely impact of fugitive emissions, even if only qualitatively*	✓
viii.	*Uncertainties, and likely variation in emissions estimates, must be quantified and documented*	*X**
ix.	***Monitoring only (i.e. without modelling) to demonstrate compliance with the 'substantial' criterion is not acceptable***	***X***
x.	*Dilution (i.e. increasing the stack height, exit velocity or buoyancy), to reduce downwind emissions below the 'substantial' criterion, is not permitted*	*NA*

*The air quality experts have provided quantified estimates of key emissions with documentation on areas of disagreement. However, this does not address variation or uncertainty.

Appendix D Calculation of Roydon Quarry Discharge into Christchurch Airshed

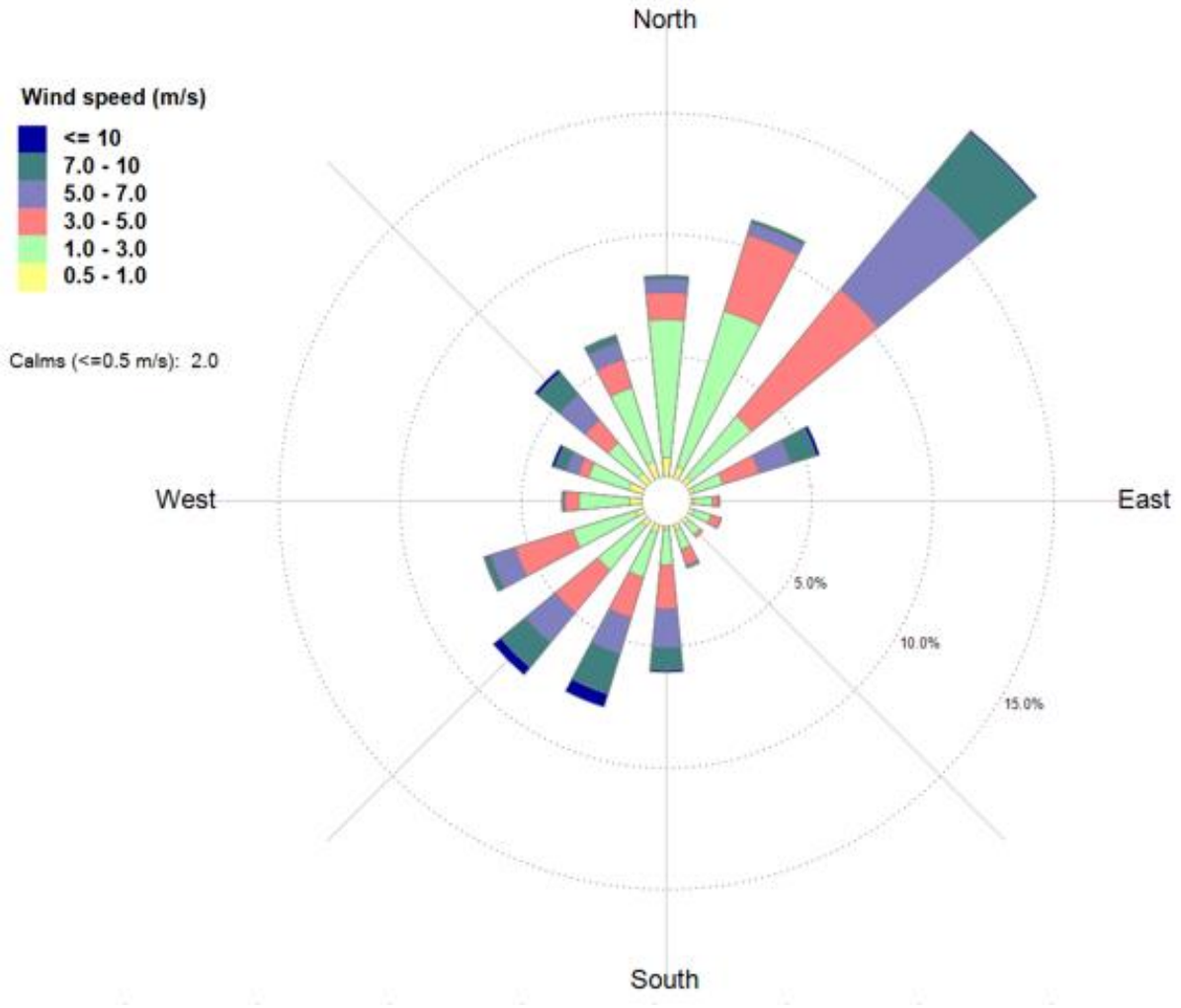


Figure D-1 Wind rose showing (1-hour average) wind speed and wind direction predicted for Roydon Quarry site in year 2006. Generated from Golders met set

WINDROSE PRO CALCULATIONS

Current date/time: Tuesday 01 October 13:18:33

File: C:\Golders met data extracted from CALMET Darfield.xlsx

Worksheet with data: formatted
Column with directions: WD (°)
Column with data: WS (m/s)
Column with 3rd variable: Not used
Column with dates: Date Time
Date/time format: mm/dd/yyyy hh:mm:ss

Total number of data in file: 8760

Number of valid data: 8760

Time zone: 0
Time zone is applied to data while reading them.

Data filtering options: None

Number of data after date/time filtering: 8760

Minimum value: 0.01
5th percentile: 0.78
25th percentile: 1.91
50th percentile: 3.33
75th percentile: 5.41
95th percentile: 8.58
Maximum value: 14.11

		97.9	Calms	2.0	100.0 %	
Direction: 0 Angle: 0.000 Data (%): 8.322	N	8.3				
Direction: 1 Angle: 22.500 Data (%): 11.130	NNE	11.1				
Direction: 2 Angle: 45.000 Data (%): 18.790	NE	18.8				
Direction: 3 Angle: 67.500 Data (%): 5.616	ENE	5.6				
Direction: 4 Angle: 90.000 Data (%): 1.210	E	1.2				
Direction: 5 Angle: 112.500 Data (%): 1.381	ESE	1.4				
Direction: 6 Angle: 135.000 Data (%): 0.947	SE	0.9				
Direction: 7 Angle: 157.500 Data (%): 1.884	SSE	1.9				
Direction: 8 Angle: 180.000 Data (%): 6.062	S	6.1			SW & W	11.6 %
Direction: 9 Angle: 202.500 Data (%): 7.877	SSW	7.9			NW & S	12.1 %
Direction: 10 Angle: 225.000 Data (%): 8.276	SW	8.3				
Direction: 11 Angle: 247.500 Data (%): 6.895	WSW	6.9				
Direction: 12 Angle: 270.000 Data (%): 3.333	W	3.3				
Direction: 13 Angle: 292.500 Data (%): 3.961	WNW	4.0				
Direction: 14 Angle: 315.000 Data (%): 6.050	NW	6.1	42.5 %			
Direction: 15 Angle: 337.500 Data (%): 6.199	NNW	6.2				
Interval: 0 From: 0.5 To: 1 #Data: 547 Data (%): 6.244	0.5-1	6.2				
Interval: 1 From: 1 To: 3 #Data: 3224 Data (%): 36.804	1-3	36.8				
Interval: 2 From: 3 To: 5 #Data: 2277 Data (%): 25.993	3-5	26.0				
Interval: 3 From: 5 To: 7 #Data: 1448 Data (%): 16.530	5-7	16.5				
Interval: 4 From: 7 To: 10 #Data: 931 Data (%): 10.628	7-10	10.6	12.4 %	7+ m/s		
Interval: 5 From: 10 To: 15 #Data: 152 Data (%): 1.735	10+	1.7	45 days			
		97.9	Calms	2.0	100.0 %	

EXCEEDING FREQUENCIES (Calculated using >)

Interval	Counts	Frequency	Value	Exceeding	Exceeding frequency(%)
0.5 - 1	547	6.244	0.5	8581	97.957
1-3	3224	36.804	1	8034	91.712
3-5	2277	25.993	3	4810	54.909
5-7	1448	16.53	5	2533	28.916
7-10	931	10.628	7	1085	12.386
10+	152	1.735	10	154	1.758

Input directions rotated of 0 degree

Calms defined as values <= 0.5
Number of calms: 179 (2.04% of valid data)

Direction: 0 Angle: 0.000 Min: 0.510 Avg: 2.408 Max: 9.350
Direction: 1 Angle: 22.500 Min: 0.520 Avg: 2.788 Max: 9.170
Direction: 2 Angle: 45.000 Min: 0.510 Avg: 4.854 Max: 10.890
Direction: 3 Angle: 67.500 Min: 0.520 Avg: 4.953 Max: 11.800
Direction: 4 Angle: 90.000 Min: 0.570 Avg: 2.430 Max: 7.260
Direction: 5 Angle: 112.500 Min: 0.520 Avg: 2.416 Max: 5.460
Direction: 6 Angle: 135.000 Min: 0.540 Avg: 2.043 Max: 4.610
Direction: 7 Angle: 157.500 Min: 0.520 Avg: 2.784 Max: 6.660
Direction: 8 Angle: 180.000 Min: 0.510 Avg: 4.722 Max: 11.810
Direction: 9 Angle: 202.500 Min: 0.550 Avg: 5.236 Max: 14.110
Direction: 10 Angle: 225.000 Min: 0.550 Avg: 4.739 Max: 12.900
Direction: 11 Angle: 247.500 Min: 0.580 Avg: 3.548 Max: 10.400
Direction: 12 Angle: 270.000 Min: 0.510 Avg: 2.190 Max: 9.370
Direction: 13 Angle: 292.500 Min: 0.520 Avg: 3.657 Max: 13.660
Direction: 14 Angle: 315.000 Min: 0.510 Avg: 4.565 Max: 12.550
Direction: 15 Angle: 337.500 Min: 0.520 Avg: 2.979 Max: 10.440