Before Independent Hearings Commissioners Appointed by Canterbury Regional Council and Selwyn District Council

In the matter of	The Resource Management Act 1991
And	
In the matter of	Applications by **Fulton Hogan Limited** for all resource consents necessary to establish, operate, maintain and close an aggregate quarry (**Roydon Quarry**) between Curraghs, Dawsons, Maddisons and Jones Road, Templeton

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COLLATION OF THE KEY EVIDENCE ALREADY PROVIDED BY ROGER STEVEN CUDMORE IN RESPECT OF PM_{10} EMISSIONS FROM THE ROYDON QUARRY

DATED: 29 NOVEMBER 2019

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EVIDENCE IN CHIEF - 23 SEPTEMBER 2019

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Existing Ambient Particulate

18 The respirable particulate less than 10 microns (PM_{10}) concentrations have been monitored at the Proposal site using an NES certified monitor (BAM) since 22 December 2017[1].

19 Wind and temperature data (15 minute averages) have also been monitored at the Proposal site from 30 May 2018. Prior to this time, these data needed to be obtained from the nearby Yaldhurst quarry area to the north.

20 Additionally, Golder has recently established a continuous PM_{10} and $PM_{2.5}$[2] monitor and meteorological station (using a US EPA certified TAPI T640x monitor). This has provided additional PM and wind data during August-September 2019 at the Proposal site, although QA/QC checks have not been completed at the time of writing this statement and I will be able to provide an update on this at the hearing.

21 Using all available background monitoring data that has been collected at the Proposal site from December 2017 to September 2019 for both PM_{10} to $PM_{2.5}$ the following Table 1 provides a summary of background 24 hour values versus prevalent wind conditions for each mid-night to mid-night period.

Table 1 : Summary of Background 24 hour PM_{10} and $PM_{2.5}$

Wind Direction	**24 hour PM_{10} background concentration (µg/m³)**			**24 hour $PM_{2.5}$ background concentration (µg/m³)**		
	Maximum	**2nd highest**	**Average**	**Maximum**	**2nd highest**	**Average**
N	23	20	13	7	6	4
NW	26	25	15	8	7	4
NE	45	40	15	13	12	4
S	28	26	14	11	8	4
SW	26	20	11	7	7	4
W	21	21	13	10	7	4

[1] Mote, 2018
[2] $PM_{2.5}$ is the size fraction of ambient particles below 2.5 microns in aerodynamic diameter and is a subset of PM_{10}.

Wind Direction	24 hour PM_{10} background concentration (µg/m³)			24 hour $PM_{2.5}$ background concentration (µg/m³)		
	Maximum	**2nd highest**	**Average**	**Maximum**	**2nd highest**	**Average**
All directions	45	40	14	13	12	4

Note: The 24 hr PM_{10} background concentration was monitored from 22 December 2017 to 30 June 2019 by BAM and from 10 August to 10 September 2019 by T640x.

The 24 hr $PM_{2.5}$ data was derived by using the monitored BAM PM_{10} data and an average Nephelometer $PM_{2.5}/PM_{10}$ ratio of 0.29 (Nephelometer PM_{10} and $PM_{2.5}$ were monitored from 22 December 2017 to April 2018) and the monitored T640x $PM_{2.5}$ concentrations (for period from 10 August to 10 September 2019).

22 Table 1 results show that the highest 24-hour PM_{10} concentrations occur at the Proposal site during north east winds. On 16 January 2018 the maximum 24-hour concentration of 45 µg/m³ was recorded.[3] On 15 January 2018 the second highest 24-hour concentration of 40 µg/m³ was recorded for north easterlies.

23 When wind predominantly blows from the northwest (more than 10 hours/day), the 24-hour PM_{10} background concentrations are lower (i.e. a maximum of 26 µg/m³, 2nd highest of 25 µg/m³ and an average of 15 µg/m³).

24 During days of predominant southwest to westerly winds (more than 10 hours/day), the maximum of 24-hour PM_{10} background concentration is 26 µg/m³, with the 2nd highest concentration of 21 µg/m³ and an average concentration of 13 µg/m³.

25 I consider that these background concentrations of 24 hour and long term PM_{10} and $PM_{2.5}$ concentrations are typical of rural areas of the Canterbury Plains with low population density. Although the winds from the north east do have significantly higher peak 24 hour concentrations for which the likely source is the working of farmland – which appears to be north of the large Yaldhurst quarry area.

26 Figure 1 shows a plot of 1-hour PM_{10} concentrations (measured at the Proposal site) as a concentration wind rose.[4] The analysis of hourly PM_{10} versus hourly wind direction shows that winds blowing from the north east produces the higher background levels. A second concentration wind rose is

[3] It is noted that a paddock adjacent to the site was being ploughed at the time. Pers Comms C Nieuwenhuijsen (Golder) and P. Banham of Mote (17 September 2019).

[4] A concentration wind rose presents graphicly wind direction and contaminant concentrations. Each petal shows % of time wind blows from that direction and shows the % of time the contaminant concentration is within each band.

shown in Figure 2 for 1-hour PM_{10} measured just to the north of the nearby Yaldhurst multiple quarry area.

27 Similar plots to those shown in Figures 2 and 3 are provided in Appendix B which are based on the additional BAM PM_{10} versus wind data (June 2018 and up to September 2019), as well as the additional T640x PM_{10} and $PM_{2.5}$ data (August – September 2019) at the Proposal site. These plots produce the same patterns that are highlighted in Figures 2 and 3.

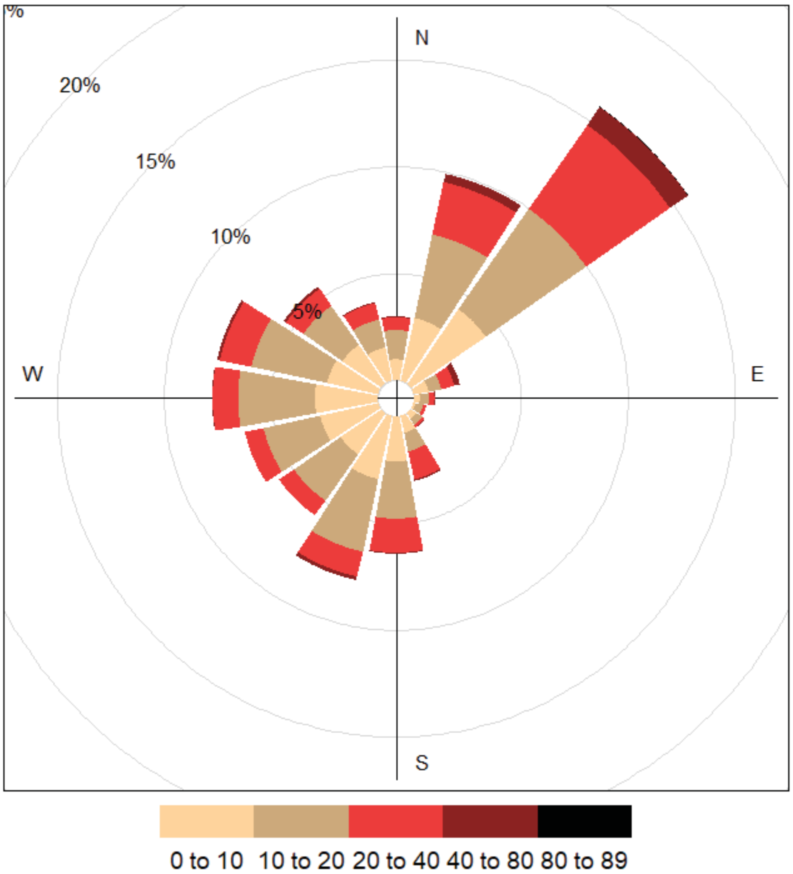

Figure 1: Proposal Site 1-hour average PM_{10} concentration (µg/m³) concentration rose. *Using BAM PM_{10} (Roydon from 22 December 2017 – 22 June 2018). Note wind data was used from the nearby Yaldhurst site up to 22 April 2018, then site wind data was available for May 2018 – 20 June 2018.*

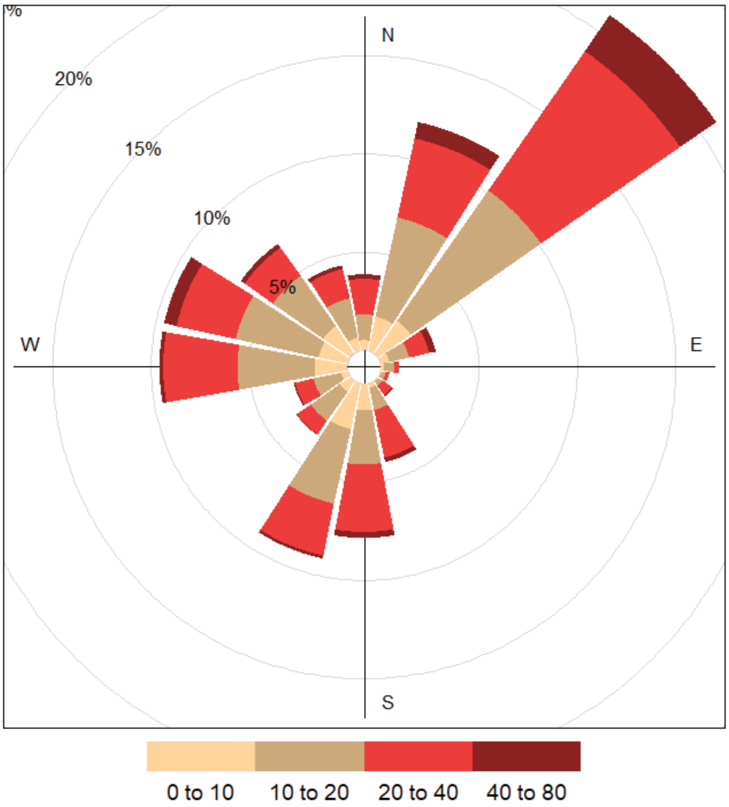

Figure 2: North of the Yaldhurst multiple quarry area (Site 2) 1-hour average PM_{10} concentration (µg/m³) wind rose. *Using BAM data from 22 December 2017 – 22 April 2018 (2,595 hrs) and site wind data.*

Potentially Sensitive Receptors

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37. The southwest extent of the Gazetted airshed boundary for Christchurch City runs along the eastern side of Dawson's Road as shown in Figure 1, paragraph 17 above. This boundary would be approximately 30 m from the active quarry for those periods of time when quarry activities extends to the most eastern of the proposed quarrying area.

38. The Ministry for Environment (MfE, 2012) state that "Councils have identified and made public (through the New Zealand Government Gazette) populated areas that are known, or have the potential, to have air quality which exceeds the national air quality standards." However, in my view the area of land to the immediate east of the site (and extending about 0.5 kms towards Templeton) and located within the Gazetted airshed boundary Christchurch City is not likely to have degraded air quality to an extent that exceeds the national air quality standards.

39. For this application, Section 17 of the NES requires the applicant to show that the discharge of PM_{10} will not be likely, at any time, to increase the concentration of PM_{10} (calculated as a 24-hour mean under Schedule 1) by more than 2.5 µg/m^3 in any part of a polluted airshed other than the site on which the consent would be exercised unless an offsite is provided. As discussed later in my evidence, I consider the Proposal is likely to achieve this outcome.

40. Having regard to the current perceptions around quarries and emissions to air, I consider it important to note that not meeting the requirements of Section 17(1) in this instance does not at all indicate a potential for adverse health effects due to cumulative ambient PM_{10} levels, or exacerbation of existing non-compliance with the NES. In this instance the hurdle created by Section 17(1) is simply a consequence of where the Gazetted boundary has been drawn, as opposed to where a pollution problem exists. In this case, and in my view, the "line" for the airshed extends well beyond the polluted areas of the urban airshed.

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Water Requirements for dust suppression

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66. The open area of 6 ha that may require dust suppression is estimated in Table 2. This is based on 2 ha of the central processing area, 1 ha for the excavation area, 2 ha for the clean filling and rehabilitation process and 1 ha for the field conveyor and service lanes. It is assumed all the site roads will be sealed or have reject material/rounds on them.

67. Water requirements for dust suppression are based on daily requirements of net evaporation (the difference between evaporation and rainfall (mm)). This is assumed to be applied to the area that are expected to require the use of water for dust suppression (6 ha). I have provided Mr Van Nieuwkerk with information on water demand requirements for dust suppression. Mr van Nieuwkerk's evidence outlines water supply and storage requirements to ensure that there is sufficient water available for dust suppression and other site water requirements.

Table 2 : Estimated open area requiring dust suppression.

Purpose	**Nominal Area (ha)**	**Estimated Open area requiring dust suppression water (ha)**	**Comments**
Central processing area, including fixed plant, stockpiles, portable plant etc.	7	2	Based on central processing layout diagram provided, it has been calculated that up to 2 ha of this area is not sealed road, fixed plant or stockpiles and therefore may need dust suppression. This includes areas where loaders travel to loadout. Note, the processing plant water requirements (including stockpile dust suppression) are estimated separately.
Excavation in process (active quarry area)	5	1	While maximum of 5 ha is applied for the vast majority of this will be assumed to be controlled via the rounds or reject material) and, the residual area that may require dust suppression is the area where the loader is travelling from the excavation face to the conveyor hopper. A maximum travel is estimated to be 100 m therefore a maximum area of 100m by 100m (1 ha) has been assumed.
Fill and rehabilitation in process	5	2	Based on discussions with Fulton Hogan (30/8/2019 RC, SE MM, KJ), a maximum of 2 ha area is estimated to require dust suppression water. This is based on the active clean filling area (1ha) and a 1ha area that is not completely remediated. The water required for rehabilitation irrigation is estimated separately.
Site roads – unsealed	5	0	All assumed to be sealed or stable via use of rounds or reject material

Purpose	Nominal Area (ha)	Estimated Open area requiring dust suppression water (ha)	Comments
Field conveyor, service lanes	4	1	Main service lanes assumed to be sealed or stable via use of rounds or reject material. Based on advice from Fulton Hogan, temporary service lanes are estimated to be one quarter of this.
Total open area (max)	**26**	**6**	

SUMMARY OF ASSESSMENT OF AIR QUALITY EFFECTS

Potential for Dust Nuisance Effects

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98. I have set out the mitigation measures for this quarry starting at Paragraph 64. I consider that the design and mitigation measures proposed, including the ability to carry out proactive management based on real time PM_{10} monitoring represents the Best Practicable Option (BPO) for mitigation of dust discharges. The design (including sealed roads, minimal open areas, and the use of reject material to minimise water requirements) all set the quarry up to have a significantly lower risk of dust emissions and consequent offsite ambient air quality effects compared to what is experienced around other alluvial gravel quarries near Christchurch.

99. The comprehensive use of proactive dust management that is underpinned by rigorous real time ambient PM_{10} monitoring combined with direct investigation of off-site dust impacts effects, enables the quarry operator to be fully aware of dust impacts occurring at sensitive offsite locations. This helps ensure that increased dust controls are employed promptly when this is important and avoids watering and other controls and actions being taken when there is no material environmental benefit.

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Potential for Health Effects

104. The PM_{10}, $PM_{4.0}$ (for RCS) and $PM_{2.5}$ are increasingly smaller size fractions of quarry dust emissions that have the potential to cause adverse health effects on exposed people. Because there is not reliable particulate emissions data for the wide range of quarry activities, we cannot reliably model the increase in ambient levels of these contaminants due to the Proposal (and beyond its site boundary), but we can utilise relevant monitoring data to undertake an assessment of the potential environment significance in this instance.

105. In particular, the ambient monitoring levels for PM_{10}, $PM_{4.0}$ (for RCS) and $PM_{2.5}$ were measured at sites around the Yaldhurst quarry area (reported by Mote, 2018). This provides a substantive base of ambient contaminant levels (downwind of a large quarry area as well as background levels) and associated health guideline criteria was used to assess the potential for health effects from the Proposal.

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Yaldhurst ambient particulate impacts vs the Proposal

110. In my view the of the proposed quarry (26 ha of active open area at any one time) and the design of the proposed quarry, combined with the proposed control/mitigation measures for control of dust discharges, would readily achieve a 10-fold reduction in the increase in ambient respirable particulate levels compared to that measured for the 230 ha Yaldhurst gravel quarry area. In other words, I expect that the increase in respirable particulate due to the Proposal will be less than 10% of that measured across the Yaldhurst Quarry Zone.

111. The Yaldhurst gravel quarry area has multiple operators, with multiple processing plants, includes the processing/handling of finer grade materials, involves large areas of open unpaved quarry and has a predominant use of trucks for onsite transfer of excavated gravels.

112. Given the above, I consider that applying at least a ten-fold reduction to the incremental PM_{10} and $PM_{2.5}$ concentrations measured due to the existing Yaldhurst quarry area provides the only robust approach for assessing the potential effects of RCS, PM_{10} and $PM_{2.5}$ immediately beyond the Proposal boundary. I will discuss these below.

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Respirable PM_{10} effects

118. The estimated increases in 24 hour PM_{10} at the Yaldhurst quarry site are established in Table 3 (based on the RCS study data set) for a range of wind conditions. The background 24 hour PM_{10} values were provided earlier in this evidence (Table 1). From Table 3 it can be seen that a maximum increase of 2.4 µg/m³ is predicted due to the Proposal. When considering existing background concentrations, no exceedances of the NES are expected. Cumulative concentrations to the south west of the quarry are expected to be below 45 µg/m³ and these are dominated by existing background levels.

119. From the assessment of potential cumulative 24 hour PM_{10} downwind of the Proposal I conclude that the NES for ambient 24 hour PM_{10} is likely to be complied with and that increases due to the Proposal are relatively small compared to the existing background.

Table 3: Estimated cumulative 24 hour PM_{10} at the Proposal site boundary

Wind	**Background 24 hr PM_{10} (µg/m³)***	**Peak 24 hr PM_{10} increment due to Roydon Quarry (µg/m³)+ (range in brackets).**	**Cumulative 24 hr PM_{10} concentration (µg/m³) #**
N	20	2.4	22
NW	25	2.7 *(0.6 – 4.7)*	26 – 30
NE	40	1.5 *(1.1 – 2.0)*	41 – 42
S	26	1.0	27
SW	20	0.7 *(0.1 – 1.7)*	20 – 22

** Assumed background value is the second highest recorded (see Table 1).*

+ Values are based on maximum measured increase in 24 hour PM_{10} values across the large Yaldhurst quarry area between 22 December 2017 and 22 April 2018 at five nearby boundary sites and one background site as described by Mote (2018). A factor of 0.1 (i.e. a 10-fold reduction) was applied to these measured increased PM_{10} levels to estimate the magnitude of the 24 hour PM_{10} increment due to the much smaller proposed Roydon Quarry site.

Under some wind directions (NW, NE, SW), the peak increment ranges are based on two to three calculated peak increments using different combination of monitoring sites.

 # NES criteria are 50 µg/m³ exceeded once per year for 24 hour average and 20 µg/m³ for annual average.

Respirable $PM_{2.5}$ effects

120. The estimated increases in 24 hour $PM_{2.5}$ at the Yaldhurst quarry site are established in Table 4 (based on the RCS study data set) for a range of wind

conditions. The background 24 hour $PM_{2.5}$ values were provided earlier in this evidence (Table 1). From Table 4 it can be seen that the increase due the quarry is less than 1 µg/m³ and the resultant cumulative 24 hour $PM_{2.5}$ concentrations are mostly below 10 µg/m³.

121. From the assessment of potential cumulative 24 hour $PM_{2.5}$ downwind of the Proposal I conclude that the WHO ambient guideline for 24 hour and annual average $PM_{2.5}$ are likely to be readily complied with. Furthermore, the increase in ambient levels due to the Proposal are relatively small compared to the existing background.

Table 4: Estimated cumulative 24 hour $PM_{2.5}$ at the Proposal site boundary

Wind	Peak background 24 hr $PM_{2.5}$ (µg/m³)*	24 hr $PM_{2.5}$ increment due to Roydon Quarry (µg/m³)+ (range in brackets).	Cumulative 24 hr $PM_{2.5}$ concentration (µg/m³) #
N	6	0.4	6.4
NW	7	0.4 (0.1 – 0.8)	7 – 8
NE	12	0.2 (0.2 – 0.3)	12
S	8	0.2	8.2
SW	7	0.1 (0.02 – 0.3)	7 – 7.3

** Assumed background value is the second highest recorded (see Table 1).*

+ Values are based on increase in 24-hour PM_{10} values measured across the large Yaldhurst quarry area between 22 December 2017 and 22 April 2018 at five nearby boundary sites and one background site as described by Mote (2018) and using the average $PM_{2.5}$ to PM_{10} ratio of 0.17 measured at boundary site.

 # WHO criteria are 25 µg/m³ for 24 hour average and 10 µg/m³ for annual average.

Regulation 17(1) of the NES

122. In my opinion it is westerly and south-westerly winds that will typically result in any PM_{10} emissions from the Proposal dispersing towards the Gazetted airshed. North west and southerly winds would do the same but only on rare occasions. Table **3** provides my estimated worst cast increments in 24 hour PM_{10} concentrations due to the proposal. In my view, this indicates that the NES regulation 17(1) for PM_{10} impacts from new applications is likely to be met.

Canterbury Air Regional Plan (CARP) Policy 6.25

123. Policy 6.25 of the CARP states that:

Applications for resource consent for discharges into air from industrial or trade activities or large-scale fuel burning devices classified as discretionary shall address:

- *a. where the discharge includes PM_{10}, the mass emission rate of the proposed discharge relative to the total emission rate of all discharges within the Clean Air Zone; and the degree to which the proposed discharge exacerbates cumulative effects within the Clean Air Zone; and*
- *b. localised effects of the proposed discharge and the location of sensitive receptors; and*
- *c. available mitigation and emission control options; and*
- *d. the duration of consent being sought and the practicability for the effects of the discharge to be reduced over time.*

124. With respect to Policy 6.25 of the CARP, it is my view that PM_{10} emission factors for quarry surfaces and activities are grossly conservative and unreliable – they will provide an unrealistic indication of significance against current airshed emissions. Putting that aside, the use of these factors indicates a grossly conservative emission from the active clean fill and extraction areas to be well below 1% of the total winter time PM_{10} emissions from transport, home heating and industry of approximately 2600 kg/day (as reported by Environment Canterbury Report R14/116 for 2014). The emission of PM_{10} from the proposed quarry, that is over 500 m to the east of Templeton, will not exacerbate cumulative PM_{10} concentrations within the polluted areas of the Christchurch airshed to any measurable extent. They will only cause a localised minor rise in PM_{10} near the quarry boundary where the airshed is not considered to be "polluted" – that is the area enjoys relatively low ambient PM_{10} levels which in my view, were not intended to be included within MfE Gazetted airshed boundaries.

125. The PM_{10} impacts from the Proposal at the nearest residential dwellings will have a minor impact on the existing ambient PM_{10} levels that are also relatively low compared to those elevated levels experienced in the polluted areas of Christchurch's clean air zone.

126. Regarding dust controls, my view is that the state of the art is being proposed by Fulton Hogan in terms of a design that restricts any emissions as well as enabling standard mitigation controls to be far more effective at eliminating dust emissions compared to conventional alluvial gravel operations near Christchurch.

Section 42A Report

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131. There are three areas where Ms Ryan does not agree with the AQA assessment. These are:

131.1 *One Hour PM_{10} trigger limit value:* As discussed earlier in my evidence, I consider the MfE recommended one hour PM_{10} concentration trigger limits are appropriate. The lower trigger limit values proposed in the original AQA as initial DMP trigger levels and by Ms Ryan are likely to require the operation to cease when there are no visible dust plumes extending beyond the site boundary. That is the lower triggers are likely to be too conservative and impractical.

131.2 *Compliance with the NES Regulation 17(1):* Table 3 provides my assessment of estimated incremental 24 hour PM_{10} impacts near the site boundary during a range of prevalent daily winds conditions. This is based on the Proposal achieving a 10-fold reduction on the peak increments as measured for the Yaldhurst quarry area (readily achievable in my view). The estimated increments in 24 hour PM_{10} met the maximum limit of 2.5 $\mu g/m^3$ for the most prevalent wind conditions including the south westerlies and westerlies. These latter wind conditions will generally place active parts of the quarry upwind of the Gazetted airshed boundary. Southerly and north west winds would do this far more infrequently given the orientation of the Proposal site with respect to the airshed boundary (see Map in paragraph 17).

131.3 *Requirements for PM_{10} offsets:* While it is likely that the requirements of the NES regulation 17(1) for 24 hour PM_{10} can be met, Ms Ryan considers that this is not absolutely certain and note she has recommended the consideration of off-sets by the applicant. I understand that with this quarry being developed, there are likely to be opportunities to complete and rehabilitate existing quarry sites within the airshed.

131.4 *Compliance with the NES for 24 hour PM_{10}:* As discussed above I consider that given the quarry design, relatively small size and dust controls proposed, is very likely that the NES target for 24 hour PM_{10}

of 50 µg/m^3 is routinely met. Table 3 provides my assessment of cumulative PM_{10} impacts near the site boundary for which the cumulative 24 hour concentrations are well within the NES criterion.

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Submissions

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Health Effects

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140. Regarding the sub fraction of dust that is related to health effects, i.e. PM_{10} and $PM_{2.5}$, I fully expect this Proposal to have a very small effect on existing background concentrations. Therefore, relevant ambient health guidelines are likely to be readily complied with and the existing rural type of air quality is likely to be maintained.

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Monitoring

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153. I provide the following responses to these matters:

    153.1 PM_{10} monitoring is proposed at the site's eastern boundary at a location downwind of the proposed active quarry area and when quarry operations are within 500m of off-site sensitive locations.

    153.2 The eastern boundary monitor will provide real time ambient particulate levels at the site boundary which would be higher than levels at Templeton when the wind is blowing towards this area (from the site). The monitoring site will not always be directly in-between the active quarry area and Templeton but instead will be downwind in the more frequent south westerly winds – this will provide sufficient indication of the potential air quality impacts on Templeton which will be much lower given its distance from the Proposal site (700 m).

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Conclusion

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163. Regarding potential health effects, PM_{10} concentration increases are fully expected to comply with the requirements of the NES. The increases in ambient concentrations of this contaminant are also likely to be managed so that they meet the additional restrictions imposed under the NES with respect to Gazetted airsheds.

164. Finally, with respect to RCS and $PM_{2.5}$ fractions of PM_{10}, these ambient levels are likely to be increased to a very low extent beyond the site boundary. As such the cumulative ambient levels of these contaminants are expected to be negligible for RCS, and in the case of $PM_{2.5}$, well within WHO guideline values for acute and long term exposure.

REBUTTAL EVIDENCE – 21 OCTOBER 2019
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10. At paragraph 20, Mr Kirkby states that scaling factor of 0.1 is somewhat arbitrary and may be insufficiently conservative. This is in relation to the increase in PM_{10} measured during the Yaldhurst Air Quality Monitoring study reported by Mote (2018).[5] I disagree with this assessment of the scaling factor.

11. The assumption that a ten-fold reduction in the impact of the proposed Roydon quarry (the Proposal) on ambient PM_{10} compared to the multiple sites at Yaldhurst is based on a qualitative comparison of the physical features of the Proposal to the multiple contiguous sites at Yaldhurst, and specifically in relation to northwest wind conditions. These conditions were found to create the most significant increased ambient PM_{10} at the Yaldhurst quarry site (which is not a surprise given the hot, very dry and gusty character of these winds). During such conditions, the area active quarry available for generating dust is in the order 10x greater at Yaldhurst than it would be the Roydon site (230 ha versus 26 ha). However, this is not the key difference that supports the 0.1 scaling factor – it is the radically different design features of Roydon versus the Miners Block of quarries at Yaldhurst that is most significant.

12. The design features for Roydon will, without any doubt, result in dust generation per unit area that is at least an order of magnitude or more less than the dust generation per unit area at the Miners Block quarries at Yaldhurst. To reiterate my primary evidence, the key design features (from my perspective) include the use of a fully sealed, periodically vacuumed access ring road, conveying of extracted materials in-stead of multiple haul truck movements, reject material covering internal access lanes and open areas. Finally, the compact and simplified layout of the central processing plant with its high level of dust control effectively eliminates its influence on ambient PM_{10} levels.

13. As noted by Mr Kirkby (his paragraph 20), the ambient monitoring downwind of the Yaldhurst site was 100 m from the site boundary. However, this is a minor factor (i.e. causing a further reduction in PM_{10} within the order of only

[5] Mote (2018): *Yaldhurst Air Quality Monitoring – Summary Report 22 December – 21 April 2018*, June 2018, Paul Baynham.

10% down from levels occurring at that boundary). This is of very minor significance compared to the overriding impact of the relatively lower area and very low dust generation potential per unit area for the Roydon site.

14. Given the above, I consider that the scaling factor of 0.1 and much lower, is very likely to be conservative and this points to compliance with Regulation 17 (1) of the NESAQ, being practical to achieve given the compact layout, design features and proposed mitigation measures for the proposed Roydon quarry.

15. At paragraph 21, Mr Kirkby states that he does not agree with my estimates of increased ambient PM_{10} due to the proposal (Table 4 of my primary evidence), based on the scaled results from Yaldhurst that vary with wind directions. I understand Mr Kirkby's point of contention is that the variations in ambient PM_{10} effects at Yaldhurst will not necessarily apply to the Roydon site. His reasons for this are reasonable for sites of similar design features.

16. However, given the design features for the Roydon quarry (summarised in paragraph 12 above), I consider that the different characteristics of different types of winds will be most influential at Roydon as they were at Yaldhurst. Southerlies have the characteristic of being cold and associated with rainfall, and northwesters and to a lesser extent, norther easterlies are associated with fine, dry conditions, which have a far greater potential to cause dust emissions compared to southerlies. Table 4 of my primary evidence reflects this.

17. The NESAQ for PM_{10} requires a maximum cumulative impact of 50 $\mu g/m^3$ (24 hour average) at the nearest house. Whichever incremental ambient PM_{10} values are used in Table 4 (for any wind direction), I conclude that this outcome is likely to be met.

18. Having considered the inherent conservatism within the 0.1 scale factor (discussed in paragraphs 11 to 14 above), and the range of results of estimated incremental ambient PM_{10} in Table 4 of my primary evidence, I also conclude that compliance with Regulation 17 for incremental ambient PM_{10} effects within the neighbouring gazetted airshed is likely to be met.

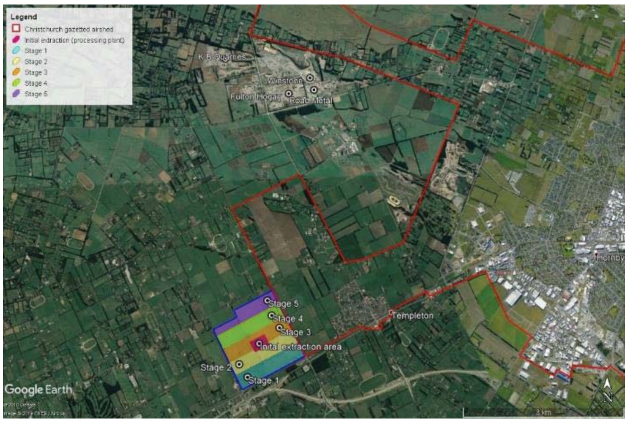
19. At paragraph 22, Mr Kirkby states his view that the applicant has not demonstrated that the Proposal will comply with the requirements of Regulation 17. I assume Mr Kirkby means that the Applicant has not

demonstrated that it is *likely* that the Proposal will comply with Regulation 17, but in my view, Mr Kirkby has provided no basis for statement. Mr Kirkby has questioned the 0.1 scale factor's validity, but has not provided an alternative analysis of how the proposed Roydon quarry design will perform in terms of dust effects. Therefore, with due respect, I do not consider Mr Kirkby's evidence provides any material support for reaching the view that compliance with Regulation 17 is not achieved in this instance.

20. Irrespective of the above, it is my professional view that Regulation 17 is irrelevant to this proposal in terms of effects on air quality. There is a lack of case law regarding this matter, but this aside, there are rational reasons for not applying Regulation 17 to this application in my view. The main one being that doing so represents an unintended use of the regulation as it applies to a scenario where the air quality impacts are not within a polluted area of the Christchurch airshed. As such the PM_{10} emissions from the proposed quarry would not exacerbate existing ambient PM_{10} levels across the boundary that are non-compliant with the NESAQ.

21. Regulation 17 was designed to avoid applications for new air discharges being able for further exacerbate levels of ambient PM_{10} where these were at or near to the NESAQ limits and therefore causing adverse effects. Gazetted airshed boundaries should by definition apply to such areas. However, in this instance the Christchurch gazetted boundary extends well beyond significantly affected areas as it extends into rural land. This area is well to the east of Christchurch City's dense urban population and associated winter-time pollution issues.

22. In this instance the western extent of the gazetted airshed boundary has nothing to do with problematic ambient PM_{10} levels. This is highlighted by the following figure, which shows the boundary as a redline. From this it is clear that application of Regulation 17 in this instance, applies to rural land where people are not exposed for the relevant time frame and for which degraded urban air quality does not apply. This is not the purpose for which Regulation 17 was promulgated in my view. This means investigation of compliance by Fulton Hogan is necessary to address a technical issue but regardless, Fulton Hogan's discharges of PM_{10} are not very likely to cause, or exacerbate adverse effects that are related to elevated ambient PM_{10} during cold still days within polluted areas of Christchurch City's urban air shed.


Legend
Christchurch gazetted airshed
Initial extraction (processing plant)
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
K B Quarries
Winstone
Fulton Hogan
Road Metal
Hornby
Templeton
Stage 5
Stage 4
Stage 3
Initial extraction area
Stage 2
Stage 1
Google Earth
3 km

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SUPPLEMENTARY REBUTTAL – 5 NOVEMBER 2019

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Regulation 17(1) Compliance

26. The main difference in my view regarding compliance with Regulation 17 versus the counter view (summarised in Paragraph 4 of Ms Wickham's evidence) arises from our different assessments of the extent to which the Proposal is likely to achieve a lower level of ambient PM_{10} impact than measured at the Yaldhurst Quarries (i.e. the reduction factor or scale factor assessment).

27. We have also assessed the incremental PM_{10} impacts due to existing quarries (i.e. the monitoring data collected from the Yaldhurst Study) using different approaches, but as I explain below, I consider that we reach similar positions on this matter.

Incremental PM_{10} assessment – Yaldhurst Quarries

28. Ms Wickham is incorrect (at paragraph 39) to surmise that I have limited my assessment of PM_{10} impacts on the airshed, to south west and westerly wind conditions. I have analysed incremental PM_{10} impacts for all wind conditions. However, with reference to Figure 12 in the air quality assessment by Golder (2018), it is clear that north west winds only result in active areas of the quarry being directly upwind of the gazetted airshed boundary for limited periods of the quarry life-time. Most of the proposed quarry area including the processing plant, the mobile processing plant, the main site access/exit roads are not upwind of the airshed boundary during northwest winds at any stage of the quarry life cycle.

29. To a lesser extent, southerly winds also place a portion of future active quarry areas upwind of the airshed boundary. These winds place active quarry areas upwind of the airshed boundary at times when there would be a significant distance to that boundary. The converse is true for south westerly wind conditions, which will always place the active part of the quarry upwind of the gazetted airshed boundary. Furthermore, these winds are far more prevalent than north west or southerly winds

30. Ms Wickham also criticises the incremental PM_{10} assessment on the basis wind speeds less than 7m/s (and greater than 5m/s) should have been

assessed (her paragraph 41). I consider Ms Wickham's recommended wind speed trigger of 5 m/s - for instigating increased dust management or ceasing operations - is too low. The proposed threshold of 7 m/s for dust erosion effects has been widely used and confirmed, from my own experience. Figure 14 of Golder's assessment of effects document (Golder, 2018) presents research that supports the hourly average wind speed limit of 7 m/s. I am not aware of any similar research that points to a lower threshold wind speed.

31. I note that Section 2.1.1 of the MfE Dust Management Guideline (MfE, 2017) presents a theoretical analysis of particle size versus settling velocity, which finds that PM_{10} can travel up to a kilometre before settling. Section 5.2.5 of the MfE guideline suggests that fine material stored in stockpiles can be subject to erosion at winds above 5 m/s. However, for materials that are not fine - such as stockpiles of soil, overburden and aggregate products - wind speeds of greater than 7 m/s have been well established (see Figure 14, Golder (2018)) as the point where dust erosion has the potential to cause off site effects that are more than minor.

Relevance of the Yaldhurst Study

32. In paragraph 49 of her evidence, Ms Wickham concludes that PM_{10} discharges are very likely to result in an increase in PM_{10} within the airshed that exceeds the threshold level of 2.5 $\mu g/m^3$ (24 average). However, the proposed Roydon Quarry design is vastly different to existing nearby gravel quarries in that key dust sources have been eliminated. I discuss these differences in my primary evidence dated 23 September 2019 at paragraphs 47 to 63. As such, past experience (in particular the monitoring available from the Yaldhurst study) is not directly applicable to the Proposal.

33. To make the Yaldhurst Study experience relevant to the Proposal, it is necessary to consider the reduction in potential effects the Proposal design is likely to achieve. Ms Wickham disagrees with the reduction factor I use (her paragraphs 92-96 for example). I disagree with her view on this and explain this further in paragraphs 52 to 56 of this evidence. I note that Ms Wickham does not appear to have undertaken her own independent analysis of this key factor. Her analysis of the Yaldhurst Study and her use of this to assess the potential PM_{10} and RCS air quality effects of the Proposal indicates that

Ms Wickham considers there is no reduction and therefore the reduction factor is effectively 1.

34. In paragraph 70 of Ms Wickham's evidence, it is stated that the Yaldhurst Study period was a particularly wet summer and ambient PM_{10} levels may have been lower than during other years. I disagree with this assessment and also the subsequent statement that any conclusions drawn from the Yaldhurst Study are not likely to be conservative. Ms Wickham's view is based on the analysis provided in Attachment B2 of her evidence, where she also concludes that RCS measured during the study monitoring period may be lower than during other years. Ms Wickham's view of this appears to be a result of the soil moisture being 22.3 % compared to the 10 year average of 17.9%, which is not a valid reason.

35. In my view the dust emissions associated with the Yaldhurst RCS study were very unlikely to be low compared to other years. While there was a concentrated rainfall event (during the study period) this is likely to have elevated soil moisture levels for a short time. I do not consider this will have had a corresponding impact on the average level of surface moisture within the Yaldhurst Quarries itself. This is because the quarry surface moisture levels decrease rapidly with the absence of rain (typically drying out within ½ a day), whereas soil systems have a much slower decay in moisture with changing ambient conditions.

36. As such the concentrated distribution of the total rainfall during the study period was not likely to reduce the fraction of days when the quarry floor would be dry and prone to dust erosion compared to years. Ms Wickham's assessment of the frequency of days where rainfall is > 1 mm for the study period in her Attachment B2 is consistent with this in my view.

37. Therefore, I am satisfied as to the usefulness of the Yaldhurst Study for the purposes I have used it and that its data is representative/typical of what will occur in other years.

38. Paragraph 81 of Ms Wickham's evidence discusses Golder's analysis of hourly PM_{10} increments across the Yaldhurst quarry area that were measured during south westerly winds and during operational hours. I agree with Ms Wickham's view that other wind conditions needed to be considered (which I accounted for in my own analysis) and also that the most significant

increment in PM_{10} results from north west wind conditions (paragraph 82 of her evidence).

39. In preparing my primary evidence I analysed both hourly and 24 hourly increments in PM_{10} that were directly measured changes across the quarries. The results of which are built into the second column of data provided in Table 4 of my primary evidence. Therefore, my primary evidence did consider a range of wind directions and analysed both hourly and 24 hourly changes in PM_{10} based on the Yaldhurst Study data.

40. The hourly data analysis was useful as I could compare these results to 24 hour PM_{10} increments which are mostly consistent with results established by Ms Wickham and reported in Attachment B of her evidence. In other words, the assessment of incremental PM_{10} effects from the Yaldhurst Study that I presented in my primary evidence, superseded information provided earlier by Golder. This appears to have been over-looked by Ms Wickham when drafting paragraph 82 of her evidence.

41. In paragraph 83, Ms Wickham describes her approach to look at the difference between daily PM_{10} at various locations near to the Yaldhurst Quarries and the background site (i.e. the Proposal site). It is stated that this was the purpose of the background site. However, this only allows for a comparison of monitoring result statistics at the Yaldhurst site versus the background site. The background site does not strictly allow for the direct measurement of incremental changes in ambient PM_{10} due to the Yaldhurst Quarries alone, for any one day.

42. This is a subtle but important difference, as it means that the approach employed by Ms Wickham to estimate incremental ambient PM_{10} changes due to the Yaldhurst Quarries (discussed in Attachment B.5 to her evidence), has a flaw which can produce a number of false maxima values. Therefore, the maximum and the 99th percentile values for increased PM_{10} in Tables B-4 and B-6 of Attachment B.5 of Ms Wickham's evidence, are not reliable in my view. By comparison, the 99.5th percentile values are likely to be reliable and provide more realistic estimates of the true extent of incremental ambient PM_{10} that is caused by the Yaldhurst Quarries.

43. The issue with Ms Wickham's approach is that the incremental PM_{10} calculations are based on differences between various locations near the

Yaldhurst Quarries compared to the site at Roydon, that is some 5 kms away. However, the proposed Roydon quarry background will not always reflect the ambient PM_{10} levels at locations that were generally upwind of the quarries on a particular day.

44. This problem is avoided by the approach I employed, which is to consider hourly and daily average changes in PM_{10} measured upwind and downwind of the quarries. The daily PM_{10} changes relates to days which were dominated (i.e. more than 10 hours per day) by a specific type of wind condition (southerly, south westerly, north-westerly etc). This compares the difference in 24 hour PM_{10} recorded at the associated upwind and downwind sites for those days. This approach is also not without limitations (especially the low number of data points), but I consider it is of similar robustness to the approach employed by Ms Wickham's, given her maximum and 95th percentile values are used. On this basis – and ignoring her highest values – I consider both assessment outcomes to be similar and could be given similar weight.

45. As such, I consider the criticisms expressed in paragraph 82 of Ms Wickham's evidence are not relevant to the assessment I have undertaken.

46. My own analysis of upwind and downwind PM_{10} monitoring data (hourly and 24 hour averages) concludes that increases in ambient PM_{10} are typically in the range of 10 to 20 $\mu g/m^3$ as 24 hour average. These are very similar to the range of 95th and 99th 24 hour percentile values presented Table B-4 of Attachment B.5 to Ms Wickham's evidence. This relates to all winds except for northwest winds which indicate increments in the range of 30 to 45 $\mu g/m^3$. For these winds, my maximal results and Ms Wickham's 99th percentile estimates are consistent.

47. The statement within the first sentence of Attachment B6 to Ms Wickham's evidence is inaccurate. Neither the original air quality assessments by Golder (2018) and Golder (2019) or the assessment presented in my primary evidence have assessed PM_{10} concentrations against a 24 hour average wind direction. Instead, what I have assessed is daily PM_{10} values for days where different types of wind conditions (synonymous with Canterbury) were dominant.

48. Attachment B6 to Ms Wickham's evidence goes on to suggest that hourly BAM data for PM_{10} (NES certified method) is not reliable whereas hourly data from a Nephelometer is reliable. I disagree with this and consider the reverse is more likely to be true. Ms Wickham's evidence is effectively suggesting that a referenced method, which produces a 24-hour PM_{10} concentration based on hourly measurements, nevertheless produces hourly values of PM_{10} that are not reliable. Furthermore, her evidence is suggesting that a non-referenced method which is known to produce unreliable 24-hour PM_{10} concentrations, nevertheless produces reliable hourly values of PM_{10} – at least more reliable than produced by a referenced method.

49. This is not a valid assumption in my view and the provision of one graph of hourly PM_{10} (for the 16 of January 2018) does not provide any substantive evidence to support Ms Wickham's above claim. In this particular example, it is more likely that the BAM hourly concentrations are responding to increased wind speeds as would be expected during the windier and warmer day time. Whereas the Nephelometer is likely to be demonstrating its tendency to measure mist/fog during late evening/small hour periods when fog tends to occur. In my view the very low wind speeds measured during these early hours supports this scenario as the likely cause of Nephelometer trends shown in Ms Wickham's figures B.17, B.18 and B.19.

50. I remain satisfied that it was appropriate to use data obtained from the BAM and the Nephelometer (I used all available data sets), despite the fifth paragraph of Attachment B6 to Ms Wickham's evidence.

51. In summary, it is my opinion the analysis provided in Attachment B6 to Ms Wickham's evidence is unreliable. Furthermore, its description of my own assessment mispresents the actual approach that I have employed. As I discuss in paragraph 44 of this evidence, the results of my analysis of PM_{10} data from the Yaldhurst Study are consistent with Ms Wickham's own assessment of these data if her maximum and 99.9 percentile values are ignored.

Reduction factor for incremental dust impacts

52. Ms Wickham criticises the 10-fold reduction factor I have used. In my view the reduction factor is appropriate based on accepted science regarding the physical drivers for potential dust emission that support this reduction factor.

These include the physical/operational features of the large block of quarries at Yaldhurst versus the Proposal. From this analysis and the use of established facts and science, a conservative reduction factor can be reliably estimated. I explain this in more detail in paragraphs 54 to 56 of this evidence.

53. In paragraphs 11 and 12 of my first rebuttal brief (dated 21 October 2019), I explained the basis for my estimate of the reduction in off-site ambient particulate impacts measured by the Yaldhurst Study compared to the Proposal.

54. **Attachment B** to this evidence provides an analysis of relative PM_{10} emissions per year for different sources at the proposed Roydon quarry, existing Yaldhurst Quarries and other Fulton Hogan owned and operated quarries at Pound and Roberts Road.

55. The results in Attachment B for the proposed Roydon quarry and the Yaldhurst Quarries highlight a ratio in annual PM_{10} emissions of how the much larger unpaved exposed area of the Yaldhurst Quarries (20x), higher total production (3x), processing of top-coarse at Roydon only compared to more finely crushed product at Yaldhurst (4x reduction in specific PM_{10} emissions), and greater use of haul trucks for aggregate transfer/unloading, indicates Yaldhurst Quarries would produce in the order of 30x PM_{10} emissions than the proposed Roydon quarry.

56. My original conservative estimate of the reduction factor of 10x (as discussed in paragraph 110 of my primary evidence) was based on a consideration of area and design changes between the two sites. Use of emission factor equations and applying these to the respective quarries to estimate relative annual emissions confirms that a 10-fold reduction factor is likely to be conservative – it is probably much higher. This is especially given that the PM_{10} emissions associated with the asphalt plant and concrete batching plant at the Yaldhurst Quarries site have been ignored in my analysis.

57. In paragraph 53 of Ms Wickham's evidence, it is stated that in the absence of requiring offsets, Regulation 17(1) requires the application to be declined. I consider this is not justified given the quantified level of incremental PM_{10} that has been comprehensively established by the Yaldhurst Study and the relative levels of incremental ambient PM_{10} that are likely to result from the

Proposal (i.e. > 10-fold reduction from Yaldhurst levels). I maintain that the activities at the proposed Roydon Quarry are not likely to result in an exceedance.

Existing PM_{10} emissions

58. Attachment B to this evidence also provides a summary of annual PM_{10} emissions from other Fulton Hogan sites that are located within or adjacent to the gazetted airshed for Christchurch City.

59. The Roberts and Pound Road sites effectively work together as a combined extraction, aggregate haulage, clean fill and processing site. I understand Roberts Road would cease operation prior to the proposed Roydon quarry commencing, while additional areas of Pound Road will be rehabilitated as the Roydon quarry becomes operational. Both these sites sit within the Christchurch airshed.

60. The existing Pound Road site's air consent also allows for a significant discharge of PM_{10} from the operation of an Asphalt Plant (20,000 kg/year). I note the Barters Road clean fill site, directly adjacent to the Christchurch airshed, will also be progressively rehabilitated.

61. The emission rates from these sites is set out in Table 1 below. As can be seen from the table, Fulton Hogan has a range of options to offset any PM_{10} generated by the proposed Roydon quarry through reductions that can be achieved on any of these existing sites. For the Proposal, I understand the central processing plant and any mobile plant will now both be located 500 m or more away from the gazetted airshed boundary; and so, I consider these are sufficiently far away to have a negligible impact on ambient PM_{10} levels within the gazetted airshed.

62. The PM_{10} emissions from the proposed active quarry areas (i.e. excluding the central processing and mobile plant areas which are 500 m or more away from the gazetted airshed boundary) are calculated to be the order of 3 times lower than those generated from fugitive emissions occurring at the Pound/Roberts Rd operations. The total estimated PM_{10} emissions from the Proposal (including process emissions) are also in the order of 20x lower than those that the existing air consent allows for from an Asphalt Plant at the Pound Road site.

63. I therefore consider that Fulton Hogan would, if required, be able to offset an equivalent or greater amount of PM_{10} emissions from the Proposal, through either one or a combination of the sources identified in Table 1. These could take effect within 12 months of the Roydon Quarry being granted consent and remain effective for the remaining duration of the consent, as required by Regulation 17(3)(b).

Table 1: Summary of Annual PM_{10} emission estimates (kg/yr)

Site	Site prep.	Erosion	Bulk handling (loading/unloading)	Trucks/unpaved	Processing	Total
Yaldhurst Quarries[(a)]	-	8,400	1,500	21,700	3,900	35,400
Pound & Roberts Road – current[(b)]	-	1,500	400	200	900	2,900
Barters Road block - current	-	200	NC*	NC	0	200
Pound Road Asphalt Plant	-	-	-	-	20,000	20,000
Proposed Roydon Quarry[(c)]	100	100	460	300	200	1,200

*NC = Not calculated,
[a] 2,000,000 T/yr, [b] 440,000 T/yr, [c] 600,000 T/yr

…

73. Attachment D to Ms Wickham's evidence provides a summary of estimated PM_{10} emissions from the proposed Roydon Quarry. I consider many of the inputs assumed for these calculations are highly inaccurate and likewise the emission factor equations themselves have a high level of inaccuracy. I have had a fellow colleague review the emission factor equations employed by Ms Wickham and he reaches the same view as myself that the approach of Ms Wickham has produced a gross overestimate of likely PM_{10} emissions from the Proposal.

74. Attachment B to this evidence provides a summary of Ms Wickham's calculations for the Proposal and these are compared to my own calculations. My assessment of PM_{10} emissions from the Proposal (1 tonne/yr) are an order of magnitude lower than Ms Wickham's estimates (8 tonnes/yr). This is despite my assumption of a 600,000 T/yr processing rate versus Ms Wickham's assumption of 400,000 T/yr. Some of the reasons why

Ms Wickham appears to grossly overstated emissions can be summarised as follows:

- Emission factors have been calculated with the combination of erroneous inputs being applied to conservative equations.
- The absence of Barmac type crusher plant producing dry 5 mm dust and chip at Roydon (fines crushing).
- Only using cone crushers at Roydon to make Basecourse material which are typically around 4-5% moisture and 20 mm minimum size (tertiary crushing).
- Gross overstatement of truck movements over exposed surfaces.
- Underlying assumptions of low moisture levels that are unrealistic for the Proposal.

75. As I have stated earlier in this evidence, the emission factor equations can be useful to demonstrate relative contributions of PM_{10} from different sources given they have realistic inputs (i.e. truck movements, distances on unpaved surfaces, mitigation control efficiencies, etc). However, it would be imprudent to place absolute accuracy on these values, which is why modelling these emissions to predict downwind concentrations of PM_{10} is likely to be misleading. This situation is somewhat reflective of assessing odour emissions from some processes such as mushroom composting and by-products rendering, where a mitigation/control-based assessment is the only practical option for considering the potential air quality effects.

76. Ms Wickham's statement in paragraphs 97 infers that the calculated PM_{10} emissions should have been modelled to reliably predict ambient PM_{10} levels beyond the proposal boundary. My view is that this was not a practical option that would produce reliable information. The consideration of measured PM_{10} impacts near the existing Yaldhurst Quarries and considering how these would reduce given the scale, design and increased level of emission controls, was the only practical approach for assessing this Proposal.

77. In summary, it is my view that the statements in Ms Wickham's evidence (at paragraphs 98 and 99) are based on unreliable analysis of PM_{10} emissions

from the Proposal and unrealistic extrapolation of PM_{10} impacts measured via the Yaldhurst Quarries study. Furthermore, I consider Ms Wickham (paragraph 56 of her evidence) would overstate the ability for the local environment at Roydon to assimilate its residual particulate emissions from the Proposal. I refer the commissioners to my comments in paragraph 65 of my evidence on this matter. Ms Wickham has correctly pointed out that there is an existing level of degradation of air quality at the proposed site, but has overstated its significance and implications for the Proposal in my view.

…

Conclusions

91. I conclude that Ms Wickham's evidence has relied too heavily upon the ambient effects of the Yaldhurst Study as a direct indication of the potential PM_{10} and RCS related effects of the Proposal. In practice the latter Proposal is for a vastly different type of quarry design that is very likely to have a fraction of the potential for air quality effects compared to the cumulative impact of the Yaldhurst Quarries.

92. As such, I disagree with Ms Wickham's conclusion regarding potential PM_{10} effects and compliance with the NESAQ as stated in paragraph 111 of her evidence.

93. My overall assessment of Ms Wickham's evidence is that it has overstated how much PM_{10} is likely to be discharged from the Proposal and the potential for health effects from particulate discharges associated with the Proposal. Further, Ms Wickham has heavily criticised the original assessment of air quality effects prepared by Golder (2018) and my later assessments and evidence. I have considered her arguments that the air quality effects of Proposal have not been assessed thoroughly. After re-consideration, I am satisfied the air quality effects – as evaluated by myself – have been robustly considered.

94. I conclude that the air quality effects of the Proposal are able to be mitigated to an acceptable level, and compliance is expected with Regulation 17 of the NESAQ and the NESAQ target for ambient PM_{10}. Once operational, these outcomes will be able to be confirmed by robust monitoring which is proposed for the quarry. Notwithstanding this, Fulton Hogan has a range of options for PM_{10} offsets available to it, from both within and adjacent to the

Christchurch airshed, should the commissioners be of a mind that an offset is required.

Appendix B

Attachment B – Rebuttal evidence of R Cudmore - PM10 Emission Calculations

Summary of Ms. Wickham's and Golder's estimates for Roydon is presented in Table G1. Detailed calculations are provided in Table G2 to G7.

Table G1: Summary of Ms. Wickham's and Golder's estimates for Roydon

	L. Wickham	Golder		Comments
1.0 Site Preparation				
1.1 Topsoil removal	377	116	kg	Difference is due to assumption on area opened per year. An area of 5 ha/year is considered more reasonable for the first year, as well as 2.2 ha for the other years. All other assumptions remain the same. Although it is considered unlikely that all material will need to be loaded and loaded from trucks as some will be pushed up to form bunds.
1.2 Loading of topsoil into trucks\loader	69	22	kg	
1.3 Dumping of topsoil	69	22	kg	
PM10 for site preparation first year	515	161	kg	
PM10 for site preparation subsequent year	Not calculated	71	kg	Golder assumed 2.2 ha of topsoil is removed for the subsequent years
2.0 Wind erosion				
2.1 Dust pickup	2,210	98	kg/yr	L.W assumptions exclude any control and incorrectly assume 26 ha of open area vulnerable due dust erosion. Golder calcs apply 5 ha of active area that is controlled via covering exposed ground with reject material and water suppression (control efficiency of 84% for covering and 70% for additional water control). In effect reject cover ground has close to zero emissions.
3.0 Gravel loading/unloading				
3..1 LW Loading of gravel into trucks \ loader to conveyor	71.3	59	kg/yr	Difference is due to the use of a higher excavation rate of 600,000 tonne/year. Golder calcs are for loader tipping material into conveyor hopper and then conveyor unloading into process plant hopper both with water emission control
3.2 L.W Unloading of gravel from trucks/Golder: conveyor to processing plant hopper	71.3	59	kg/yr	
3.3 Excavation	Not calculated	59	kg/yr	Golder has accounted for emissions from loader excavating at the face.
4.0 Gravel processing (includes fixed and mobile plant)				Note, these rates/equipment estimates are expected to be sufficient to allow for mobile plant operation
4.1 Crushing (controlled)	108	65	kg/yr	Golder calcs allow for 2 crushers and an excavation rate of 600,000 tonne/year, plus an additional 80% reduction as the site only has wet top coarse production. No secondary crushing to fine grade products onsite.

	L. Wickham	Golder		Comments
4.2 Screening (controlled)	148	133	kg/yr	Golder allowed for 3 screens and an excavation rate of 600,000 tonne/year, plus an additional 80% reduction.
4.3 Conveyor transfers (uncontrolled\controlled)	2,200	28	kg/yr	Golder used emission factor for controlled emission (0.000023 kg/tonne) and assumed 10 transfer points at process plant L.W assumed uncontrolled conveyor transfers and 10 transfer points. Golder allowed for 80% reduction due to top course plant operation and controls.
4.4 Truck loading - conveyor crushed	20	30	kg/yr	Golder allowed for higher excavation rate of 600,000 tonne/year and a controlled efficiency of 70% for the use of water
5.0 Trucks				
5.1 Trucks -topsoil transferring first year	1,400	251	kg/yr	Golder calcs allow for 5 ha rather than 26 ha and capacity of trucks is 20T
Total PM10 (first year)	**6.7**	**0.9**	**T/yr**	
5.2 Trucks -topsoil transferring subsequent year	Not calculated	28	kg/yr	Golder assumed 2.2 ha topsoil is removed for other years
5.3 Trucks - mobile plant subsequent years	3,499	124	kg/yr	Truck capacity is expected to be typically 20 tonnes on average and minority of annual extraction is processed in mobile site (peak of 158,400 tonnes compared to L.W 250,000 m³ - 500,500 tonnes). Note when mobile plant is being used for first central extraction area, the mobile plant will be maintained within 100m of the extraction face and therefore the emissions are covered by the loader to face and loader to conveyor hopper emissions in 3.0 above).
6.0 Clean fill operation				
6.1 Loader pushing up cleanfill	Not calculated	149	kg/yr	Golder calculated the emissions from the cleanfilling operation. The same equations used for Sections 4.0 and 5.0 have been used. The moisture content of 1% was assumed for cleanfill material and a maximum of 160,000 tonne/yr cleanfill was estimated based on 1/3 of the pit filled. This gives to 8000 cleanfill trucks/day travelling on unformed roads. (approximately 100 m in return)., the remainder of access will be either sealed or regularly washed reject material with an almost zero emission.
6.2 Trucks Dumping cleanfill	Not calculated	149	kg/yr	
6.3 Road	Not calculated	125	kg/yr	
Total PM10 (subsequent years)	**8.3**	**1.2**	**T/yr**	

Table G2: Ms. Wickham's and Golder's estimates for Roydon – Site preparation

1.0 Site preparation						
	L. Wickham			**Golder revised**		**Comments**
1.1 Topsoil removal by scraper						
TSP	0.029	kg/Mg		0.029	kg/Mg	AP-42 Table 11.9-4
PM30	0.029	kg/Mg		0.029	kg/Mg	
Assume	0.5	m deep		0.5	m deep	0.5 to 1.0 m depth (Golders, 2018). At section 3.5. Page 9.
First stage only	26	ha		5	ha	Assume 5 ha for the first year and 2.2 ha for the subsequent years
	260,000	m2		50,000	m2	
Topsoil to remove	130,000	m3		25,000	m3	
Assume	1	Mg/m3		1.6	Mg/m3	Assume topsoil density
	130,000	Mg		40,000	Mg	
PM30	3,770	kg		1,160	kg	
Assume PM10	10%			10%		Assume 10% of PM30
PM10	**377**	**kg**		**116**	**kg**	
1.2 Loading of excavated material into trucks\loader movements						
Topsoil to load	130,000	Mg		40,000	Mg	
PM10	k x 0.0016 x (U/2.2)1.2 / (M/2)1.4			k x 0.0016 x (U/2.2)^1.3 / (M/2)^1.4		AP42 Section 13.2 Aggregate Handling The correct equation k x (0.0016) x (U / 2.2)1.3/[(M / 2)1.4] used by Golder – this makes very little difference to factor.
k	0.35			0.35		AP42
U	3.9	m/s		3.9	m/s	mean wind speed, Annual average Golders met set
M	3.4	%		3.4	%	AP-42 Table 13.2.4-1 (exposed ground)
PM10	0.000529578	kg/Mg		0.000561	kg/Mg	
PM10	**69**	**kg**		**22**	**kg**	
1.3 Truck dumping of topsoil						
PM10	k x 0.0016 x (U/2.2)1.2 / (M/2)1.4			k x 0.0016 x (U/2.2)^1.3 / (M/2)^1.4		AP42 Section 13.2 Aggregate Handling
PM10	**69**	**kg**		**22**	**kg**	
Total PM10 for site preparation year 1	**515**	**kg/year**		**161**	**kg/year**	
Total PM10 for site preparation other years	Not calculated			**71**	**kg/year**	Scaled based on 2.2 ha comparing to 5 ha for year 1

Table G3: Ms. Wickham's and Golder's estimates for Roydon – Wind erosion

2.0 Wind erosion of exposed areas									
	L. Wickham			**Golder revised**				**Comments**	
2.1 Dust pickup									
TSP	0.85	Mg/ha/yr			PM10 emission	0.085	Mg/ha/yr	AP-42 Table 11.9-4, assumed 10% of TSP emission	
	26	ha		Area	Cleanfill area (starting rehab)	1	ha		
	22.1	Mg/yr			Cleanfill dumping area	0.75	ha		
Assume PM10	10%	PM30			Cleanfill area where truck is dumping	0.25	ha		
PM10	**2,210**	**kg/yr**			Daily Active Excavation area	0.3	ha		
					Residual active excavation area	0.7	ha		
					Central processing area	1	ha	Assumed residual open	
					Mobile plant	1	ha	Assumed conservative	
				Uncontrolled emission	Cleanfill area (starting rehab)	0.09	Mg/year		
					Cleanfill dumping area	0.06	Mg/year		
					Cleanfill area where truck is dumping	0.02	Mg/year		
					Daily Active Excavation area	0.03	Mg/year		
					Residual active excavation area	0.06	Mg/year		
					Central processing area	0.09	Mg/year		
					Mobile plant	0.09	Mg/year		
				Controlled emission	Cleanfill area (starting rehab)	0.014	Mg/year	84%	Reduction, controlled due to reject material *
					Cleanfill dumping area	0.010	Mg/year	84%	Reduction, controlled due to reject material *
					Cleanfill area where truck is dumping	0.006	Mg/year	70%	Reduction, controlled (due to being wetted)
					Daily Active Excavation area	0.008	Mg/year	70%	Reduction, controlled (due to being wet)
					Residual active excavation area	0.010	Mg/year	84%	Reduction, controlled due to reject material*
					Central processing area	0.026	Mg/year	70%	Reduction, controlled (due to being wetted)
					Mobile plant	0.026	Mg/year	70%	Reduction, controlled (due to being wetted)
					Total PM10 emission	**98**	**kg/year**	**Controlled emission**	

*NPI Emission estimation technique manual for fugitive emissions version 2.0 January 2012

Table G4: Ms. Wickham's and Golder's estimates for Roydon – Gravel loading/unloading

3.0 Gravel loading \ unloading						
	L. Wickham			Golder revised		Comments
3.1 Loading of gravel into trucks / loader to conveyor						
k	0.35			0.35		AP42 13.2.4.1
U	3.9	m/s		3.9	m/s	mean wind speed
M	7.4	%		5	%	lower estimate, provided by Fulton Hogan
	0.000178269	kg/Mg		0.00033	kg/Mg	k x 0.0016 x (U/2.2)^1.3 / (M/2)^1.4
	400,000	Mg/year		600,000	Mg/year	Extraction rate (Fulton Hogan)
PM10	**71.3**	kg/year		196	kg/year	Uncontrolled emission
				70	%	Wet extracted material, therefore assume water control (efficiency of 70%)
				59	kg/year	Controlled emission
3.2 Unloading of gravel into trucks / unloading of gravel from conveyor						
PM10	**71.3**	kg/year		**59**	kg/year	Controlled emission
3.3 Excavation						
	Not calculated			**59**	kg/year	Controlled emission

Table G5: Ms. Wickham's and Golder's estimates for Roydon – Gravel processing

4.0 Gravel processing (includes fixed and mobile plant)						
	L. Wickham			Golder revised		Comments
4.1 Crushing (controlled)						
PM10	0.00027	kg/Mg		0.00027	kg/Mg	AP-42 11.19.2
	400,000	Mg/year		600,000	Mg/year	
	108	kg/year		324	kg/year	Assuming 2 crushers, controlled emission
Reduction factor				0.8		Assuming 80% reduction as Roydon only has wet top coarse production, i.e. 20 mm for smallest product. No Barmac/APS crusher onsite.
PM10	**108**	kg/year		**65**	kg/year	
4.2 Screening (controlled)						
PM10	0.00037	kg/Mg		0.00037	kg/Mg	AP-42 11.19.2
	400,000	Mg/year		600,000	Mg/year	
PM10	148	kg/year		666	kg/year	assuming 3 screens, controlled emission
Reduction factor				0.8		Assuming 80% reduction as Roydon only has wet top coarse production, i.e. 20 mm for smallest product. No Barmac/APS crusher onsite.
PM10	**148**	kg/year		**133**	kg/year	
4.3 Conveyor transfer points (uncontrolled)\(controlled) *						
PM10	0.00055	kg/Mg		0.000023	kg/Mg	AP-42 11.19.2 controlled emission factor
Assume	10			10		transfer points
	400,000	Mg/year		600,000	Mg/year	
PM10	2,200	kg/year		138	kg/year	controlled emission

4.0 Gravel processing (includes fixed and mobile plant)						
	L. Wickham			Golder revised		Comments
Reduction factor				0.8		Assuming 80% reduction as Roydon only has wet top coarse production, i.e. 20 mm for smallest product. No Barmac/APS crusher onsite.
PM10	**2200**	kg/year		**28**	kg/year	
4.4 Truck loading - conveyor crushed						
PM10	0.00005	kg/Mg		0.00005	kg/Mg	AP-42 11.19.2
	400,000	Mg/year		600,000	Mg/year	
PM10	20	kg/year		30	kg/year	
Reduction factor				0		
PM10	**20**	kg/year		**30**	kg/year	

* Note that Ms Wichkam assumed no control for the conveyor transfer points, however these are controlled therefore Golder assumed controlled emission factor

Table G6: Ms. Wickham's and Golder's estimates for Roydon – Trucks on unsealed areas

5.0 Trucks on unsealed areas of site							
	L. Wickham				Golder revised		
5.1 Trucks \or Loader - Topsoil first year							
Assume	26	ha	Open ground		5	ha	Open ground
Assume	0.5	m	excavated to 0.5m		0.5	m	excavated to 0.5m
Topsoil to remove	130,000	m3			25,000	m3	
					40,000	Tonne	Based on topsoil density of 1.6 Mg/m3
Truck capacity	5	m3			20	Tonne	Average truck capacity
No. trucks	26,000	trucks/yr			4,000	trucks/yr	
1 lb/VMT	281.9	g/VKT			281.9	g/VKT	
k	1.5		AP-42 Table 13.2.2-2		1.5		AP-42 Table 13.2.2-2
a	0.9		AP-42 Table 13.2.2-2		0.9		AP-42 Table 13.2.2-2
b	0.45		AP-42 Table 13.2.2-2		0.45		AP-42 Table 13.2.2-2
s	4.8	%	Silt content, AP-42 Table 13.2.2-1 Plant road, gravel processing		4.8	%	Silt content, AP-42 Table 13.2.2-1 Plant road, gravel processing
W	5	Mg	mean vehicle weight (tons)		20	Mg	Mean vehicle weight
Assume	5.5	Mg	assumed average between empty (3) and full (8)		30	Mg	Average weight assuming 20 T capacity and 20T tare
PM10	0.83	lb/VMT			1.85	lb/VMT	
	233.28	g/VKT			522.44	g/VKT	
	0.23	kg/VKT			0.52	kg/VKT	
Assume each truck	1000	m	distance travelled on unsealed ground on site (i.e. 500 m one way and 500 m back)		400	m	Assume travel distance of 400 m
	20,000	trucks/yr			4000	trucks/yr	

5.0 Trucks on unsealed areas of site						
	L. Wickham			**Golder revised**		
PM10	4666	kg/yr		836	kg/yr	
Assume	0.7		with watering @ 70% efficient emissions reduction	0.7		
PM10	**1,400**	**kg/yr**		**251**	**kg/yr**	Controlled emission
5.2 Trucks \or Loader - Topsoil subsequent year						
Assume travel distance				**100**	**m**	Assume travel distance of 100 m
PM10	Not calculated			**28**	**kg/yr**	Scaled based on 2.2 ha and 100 m for subsequent years comparing to 5 ha and 400m for first year
5.3 Trucks \ or loader to mobile plant						
Trucks to mobile crushing site				Trucks \ or loader to mobile crushing site		
Gravel to move	250,000	m3		158,400	Tonne/yr	Assume average production rate of 120 t/hr for the mobile plant and working 11hrs/day and 120 days/yr
Truck capacity	5	m3		20	Tonne	Average truck capacity
No. trucks	50,000	trucks/yr		7,920	trucks/yr	
1 lb/VMT	281.9	g/VKT		281.9	g/VKT	
k	1.5		AP-42 Table 13.2.2-2	1.5		
a	0.9		AP-42 Table 13.2.2-2	0.9		
b	0.45		AP-42 Table 13.2.2-2	0.45		
s	4.8	%	Silt content, AP-42 Table 13.2.2-1 Plant road, gravel processing	4.8	%	
W	5	Mg	mean vehicle weight (tons)	20	Mg	
Assume	5.5	tonnes	assumed average between empty (3) and full (8)	30	Mg	Average weight assuming 20 T capacity and 20T tare.
PM10	0.8	lb/VMT	k x (s/12)a(W/3)b	1.9	lb/VMT	k x (s/12)a(W/3)b
	233	g/VKT		522	g/VKT	
	0.233	kg/VKT		0.522	kg/VKT	
Assume each truck	1,000	m	travelled on unsealed ground on site (i.e. 500 m one way and 500 m back)	100	m	Assume travel distance of 100 m base on 50m between mobile plant and washed reject material road/area
	50,000	trucks/yr		7,920	trucks/yr	
PM10	11,664	kg/yr		414	kg/yr	
Assume water reduction	70%		Watering control reduction	70%		Watering control reduction
PM10	**3,499**	**kg/yr**		**124**	**kg/yr**	Controlled emission water control

Table G7: Golder's estimates for Roydon – Cleanfill operation

6.0 Clean fill operation*			
	Golder estimates		
6.1 Loader pushing up cleanfill			
PM10			
k	0.35		AP42 13.2.4.1
U	3.9	m/s	Mean wind speed
M	1	%	Based on advice from Fulton Hogan
	0.00311075	kg/Mg	k x 0.0016 x (U/2.2)1.2 / (M/2)1.4
Amount of cleanfill	100,000	m3/year	Assuming 1/3 of the extracted volume will be filled
	160,000	Mg/year	Assuming cleanfill density of 1.6 kg/m3
PM10	498	kg/year	uncontrolled emission
Assume water reduction	70%		
PM10	**149**	kg/year	Controlled emission
6.2 Trucks Dumping cleanfill			
PM10			
k	0.35		
U	3.9		
M	1	%	Based on advice from Fulton Hogan
	0.00311075	kg/Mg	
Amount of cleanfill	160,000	Mg/year	Assuming 1/3 of the extracted volume will be filled
PM10	498	kg/year	uncontrolled emission
Assume water reduction	70%		
PM10	**149**	kg/year	Controlled emission
6.3 Road			
Trucks between reject material road and dumping area			
No. cleanfill trucks	8,000	trucks/yr	
Truck capacity	20	Tonne	Average truck capacity
1 lb/VMT	281.9	g/VKT	
k	1.5		
a	0.9		
b	0.45		
s	4.8		
W	30	Tonne	Average weight assuming 20 T capacity and 20T tare.
PM10	1.9	lb/VMT	
	522	g/VKT	
	0.522	kg/VKT	
Assume each truck	100	m	Assume travel distance based on 50 m between reject material road and dumping area
	8,000	trucks/yr	
PM10	418	kg/yr	uncontrolled emission
Assume water reduction	70%		
PM10	**125**	**kg/yr**	controlled emission

*Note: Ms. Wickham hasn't calculated emission associated with cleanfill activities

Golder's estimates for Roydon, Yaldhurst, Pound Rd, Roberts Rd and Barters quarries are presented in Table G8. Breakdowns are provided in Table G9 to G13.

Table G8: Summary of Annual PM10 emission estimates (kg/yr)

Site	Site prep.	Erosion	Bulk handling (loading/unloading)	Trucks/ unpaved	Processing	Total
Yaldhurst Quarries[a]	-	8,400	1,500	21,700	3,900	35,400
Pound & Roberts Rd - current[b]	NC	1,500	400	200	900	2,900
Barters block - current	-	200	NC*	NC	0	200
Pound Asphalt	-	-	-	-	20,000	20,000
Roydon[c]	100	100	460	300	200	1,200

- *NC = Not calculated,
- [a] 2,000,000 T/yr, [b] 440,000 T/yr, [c] 600,000 T/yr

Table G9: Golder's estimates for Roydon, Yaldhurst, Pound Rd, Roberts Rd and Barters quarries- Wind erosion

Sites	Roydon		Yaldhurst		Pound Rd		Barters		Roberts Rd	
PM10 emission factor (Mg/ha/yr)	0.085		0.085		0.085		0.085		0.085	
Open area (ha)	5	Assumed total open area	115	assume 50% of 230 ha is open area	42.6	Current open area	6.44	Current open area	14.6	Current open area
Uncontrolled emission (Mg/year)	0.43		9.78		3.62	Current emission rate -uncontrolled	0.55	Current emission rate -uncontrolled	1.24	Current emission rate -uncontrolled
Controlled emission (kg/year)	**98**	control efficiency of 84% for the use of gravel and 70% for wet material	**8,407**	based on 20% of the open area has water suppression	**1,086**	Control efficiency of 70% for wet material	**164**	Control efficiency of 70% for wet material	**372**	Control efficiency of 70% for wet material

Table G10: Golder's estimates for Roydon, Yaldhurst, Pound Rd, Roberts Rd and Barters quarries- Gravel loading/unloading

	Roydon[a]		Yaldhurst[b]			Pound road [c]/Roberts Rd		
Excavation (Roydon and Yaldhurst Quarries)						**Excavation at Roberts Rd (Roberts Rd only)**		
k	0.35							
U	3.9	m/s						
M	5	%						
	0.00033	kg/Mg						
	600,000	Mg/year						
Uncontrolled	196	kg/year						
Reduction	70	%						
PM10	**59**	kg/year	**196**	kg/year	Scaled by the Yaldhurst extraction rate of 2 million tonnes/yr to the Roydon rate of 0.6 million tonnes/yr	**44**	kg/year	Scaled by Pound rd processing rate of 0.44 million T/hr to the Roydon rate of 0.6 million tonnes/yr
loader to conveyor \truck								
PM10	**59**	kg/year	**196**	kg/year	Same as the above	**44**	kg/year	Same as the above
Truck/conveyor unloading (Roydon and Yaldhurst Quarries)						**Pit run truck unloading at Pound Rd (Pound Road only)**		
	59	Kg/year	**98**	kg/year	Same as the above, but assumed 50% gravels transferred by trucks	**44**	Kg/year	Same as the above

Note: [a] 600,000 T/yr, [b] 2,000,000 T/yr, [c] 440,000 T/yr

Table G11: Golder's estimates for Roydon, Yaldhurst, and Pound Rd quarries- Gravel processing

	Roydon[a]		Yaldhurst Quarries[b]		Comments	Pound Rd[c]		Comments
Crushing (controlled)								
PM10	0.00027	kg/Mg						
	600,000	Mg/year						
PM10 Before applying reduction	324	kg/year	**1080**	kg/year	Scaled based on the estimated Yaldhurst extraction rate of 2 million tonnes/yr comparing to the Roydon rate of 0.6 million tonnes/yr	240	kg/year	Scaled based on Pound rd processing rate of 0.44 million T/hr to the Roydon rate of 0.6 million tonnes/yr
Reduction factor	0.8					0.8		Assuming 80% reduction as Pound only has wet top coarse production, i.e. 20 mm for smallest product. No Barmac/APS crusher onsite.
PM10	**65**	kg/year				**48**	kg/year	
Screening (controlled)								
PM10	0.00037	kg/Mg						
	600,000	Mg/year						
PM10 Before applying reduction	666	kg/year	**2,220**	kg/year	Same as the above	493	kg/year	Scaled based on Pound rd processing rate of 0.44 million T/hr to the Roydon rate of 0.6 million tonnes/yr
Reduction factor	0.8					0.8		
PM10	**133**	kg/year				**99**	kg/year	
Conveyor transfer points (controlled)								
PM10	0.000023	kg/Mg						
Assume	10							
	600,000	Mg/year						
PM10	138	kg/year	**460**	kg/year	Same as the above	102	kg/year	Same as the above
Reduction factor	0.8					0.8		
PM10	**28**	kg/year				**20**	kg/year	
Truck loading - conveyor crushed								
PM10	0.00005	kg/Mg						
	600,000	Mg/year						
PM10	**30**	kg/year	**100**	kg/year	Same as the above	**22**	kg/year	Same as the above

Note: [a] 600,000 T/yr, [b] 2,000,000 T/yr, [c] 440,000 T/yr

Table G12: Golder's estimates for Roydon and Yaldhurst quarries- Trucks on unsealed area

	Roydon				Yaldhurst Quarries		
Trucks \or Loader Movements - Topsoil first year (Roydon Only)							
Assume	5	ha	Open ground				
Assume	0.5	m	excavated to 0.5m				
Topsoil to remove	25,000	m3					
	40,000	Tonne	Based on topsoil density of 1.6 Mg/m3				
Truck capacity	20	Tonne	Average truck capacity				
No. trucks	4,000	trucks/yr					
1 lb/VMT	281.9	g/VKT					
k	1.5		AP-42 Table 13.2.2-2				
a	0.9		AP-42 Table 13.2.2-2				
b	0.45		AP-42 Table 13.2.2-2				
s	4.8	%	Silt content, AP-42 Table 13.2.2-1 Plant road, gravel processing				
W	20	Mg	Mean vehicle weight				
Assume	30	Mg	Average weight assuming 20 T capacity and 20T tare				
PM10	1.85	lb/VMT					
	522.44	g/VKT					
	0.52	kg/VKT					
Assume each truck	400	m	Assume travel distance of 400 m				
	4000	trucks/yr					
PM10	836	kg/yr					
Assume	0.7						
PM10	**251**	**kg/yr**	Controlled emission		Not calculated		
Trucks \or Loader Movements - Topsoil subsequent year (Roydon Only)							
Assume travel distance	**100**	**m**	Assume travel distance of 100 m				
PM10	**28**	**kg/yr**	Scaled based on 2.2 ha and 100 m for subsequent years comparing to 5 ha and 400m for first year		Not calculated		
Trucks \ or loader movements - mobile plant (Roydon Only)					**Truck entering/leaving the site - unsealed road (Yaldhurst Only)**		
Gravel to move	158,400	Tonne/yr	Assume average production rate of 120 t/hr for the mobile plant and working 11hrs/day and 120 days/yr		2,000,000	Tonne/yr	Extraction rate for Yaldhurst quarries

	Roydon				Yaldhurst Quarries		
Truck capacity	20	Tonne	Average truck capacity		20	Tonne	Average truck capacity
No. trucks	7,920	trucks/yr			100,000	trucks/yr	
1 lb/VMT	281.9	g/VKT			281.9	g/VKT	
k	1.5				1.5		
a	0.9				0.9		
b	0.45				0.45		
s	4.8	%			4.8	%	
W	20	Mg			20	Mg	
Assume	30	Mg	Average weight assuming 20 T capacity and 20T tare.		30	Mg	Average weight assuming 20 T capacity and 20T tare.
PM10	1.9	lb/VMT	k x (s/12)a(W/3)b		1.9	lb/VMT	k x (s/12)a(W/3)b
	522	g/VKT			522	g/VKT	
	0.522	kg/VKT			0.522	kg/VKT	
Assume each truck	100	m	Assume travel distance of 100 m base on 50m between mobile plant and washed reject material road/area		1,000	m	on unsealed road
	7,920	trucks/yr			100,000	trucks/yr	
PM10	414	kg/yr			52,244	kg/yr	
Assume water reduction	70%		Watering control reduction		70%		Watering control reduction
PM10	**124**	**kg/yr**	Controlled emission water control		**15,673**	**kg/yr**	Controlled emission water control
					Extraction to processing plant on unsealed road (Yaldhurst Only)		
					500	m	on unsealed road
					3,918	**kg/yr**	Half assumed via trucks due to conveyor at Miner's block

Table G13: Golder's estimates for Roydon, Yaldhurst and Pound Road quarries- Cleanfill operation

	Roydon[a]		**Yaldhurst quarries[b]**			**Pound Rd[c]**		
Loader pushing up cleanfill								
PM10								
k	0.35							
U	3.9	m/s						
M	1	%						
	0.00311075	kg/Mg						
Amount of cleanfill	100,000	m3/year						
	160,000	Mg/year						
PM10	498	kg/year						
Assume water reduction	70%							
PM10	**149**	kg/year	**498**	kg/year	Scaled based on the estimated Yaldhurst extraction rate of 2 million tonnes/yr comparing to the Roydon rate of 0.6 million tonnes/yr	**110**	kg/year	Scaled based on Pound rd processing rate of 0.44 million T/hr to the Roydon rate of 0.6 million tonnes/yr
Trucks Dumping cleanfill								
PM10								
k	0.35							
U	3.9							
M	1	%						
	0.00311075	kg/Mg						
Amount of cleanfill	160,000	Mg/year						
PM10	498	kg/year						
Assume water reduction	70%							
PM10	**149**	kg/year	**498**	kg/year	Same as the above	**110**	kg/year	Same as the above
Movement on unsealed road								
No. cleanfill trucks	8,000	trucks/yr						
Truck capacity	20	Tonne						
1 lb/VMT	281.9	g/VKT						
k	1.5							
a	0.9							
b	0.45							
s	4.8							
W	30	Tonne						
PM10	1.9	lb/VMT						
	522	g/VKT						
	0.522	kg/VKT						
Assume each truck	100	m	500	m	on unpaved road	200	m	on unpaved road
	8,000	trucks/yr						
PM10	418	kg/yr						
Water reduction	70%							
PM10	**125**	kg/year	**2090**	kg/year	Scaled based on Yaldhurst extraction rate of 2 million tonnes/yr and travel distance of 500m comparing to the Roydon rate of 0.6 million tonnes/yr and travelling 100 m	**186**	kg/year	Scaled based on Pound rd processing rate of 0.44 million T/hr and travel distance of 200 m to the Roydon rate of 0.6 million tonnes/yr and travelling 100 m

Note: [a] 600,000 T/yr, [b] 2,000,000 T/yr, [c] 440,000 T/yr

HEARING PRESENTATION – 19 NOVEMBER 2019 (TRANSCRIBED FROM AUDIO)

This is typed from the audio available on the CRC website. Speakers are not identified and there are inaudible parts. However, the substance of the oral evidence as to PM_{10} emissions, Regulation 17 of the NES and the 10-fold reduction factor. can be discerned.

Questions are in italics. Answers from Mr Cudmore are in normal text.

Commissioner McGarry questions:

…

Your assessments really based on the quite new information that we got from Yaldhurst which ????? didn't have anything there about we just had people's perceptions of dust um if we just put the scaling factor aside for one bit we looked at we look at what you do have you're satisfied that we had similar wind patterns similar meteorological conditions similar type of aggregate all of those things are similar in terms of making comparisons
Absolutely its 5k ??? its very similar
And I think later on you can give me an idea of the area exposed at Yaldhurst which was I don't know off the top of my head but a very large area
Yes that's right so its??? 2? Hectares overall those quarries combined but I've been onsite a few times and I excavated around and half that area is actually exposed and the other half there's some vegetation here and there and what have you reject terrain as well
So in your view other than the area exposure this is the best available information that we've got for giving basing our assessment on
Yeah it's unusual for quarry assessment you don't normally have that you've got to rely on what do they call it mitigation controls based assessment just as we do for Roydon but to have this level of monitoring and such a everything similar in turns of a type of material but the difference is I guess what it gives you a benchmark so for me it was a benchmark in terms of pegs from that site to then look at what ok we look at that what's going to occur in all probability what's going to occur at Roydon when you allow for the different design factors and what have you
And then you've gone with this ten-fold reduction approach and that the proposal

will be less than 10% of that measured in the Yaldhurst quarry and all of those things that went in to that but at the end of the day that 10% is kind of your gut feeling on the basis of the information that you had
It was a bit more than a gut feeling like you are right initially I thought it must be a large factor where you just have to eyeball those two sites and the design of the site and then look at what goes on Yaldhurst and you know it's going to be a lot less I mean I think to say it's going to be a bit less it would be disingenuous so we know the effects in a proposal given the way its laid out and the scale and its design it's going to be a lot less so that's a gut reaction
Have you also looked at different quarries I'm very conscious that Miners Road uses the conveyor system they're using the ?? they are using the ?? a lot of what's being proposed here for dust control is already being used in some extent on Miners Road so have you kind of looked at the dust emissions from a Miners Road type operation as opposed to I don't want to name another quarry operator but maybe one that's not using some of those techniques is that something that is weighed in to it in terms of reduction as well
Yes it is I mean when I mentioned before about what area is exposed in the whole Yaldhurst area I took in to account for what areas reject overbears so part of that estimation of the area that is actually eroding over Yaldhurst allowed for the fact that Miners is largely got reject material so turn ??? has a source but the thing about looking at the Miners Road site is that so much of the dust impacts at Miners the Fulton Hogan's Miners site is driven by other sites you've got so many sites joined to each other it's pretty hard to do ??? you've really got a multiple quarry site and yes you've got one that's much better controlled I'd still argue it's nowhere near I think a lot of thinking has gone into Roydon has been tested and developed at Miners and also at sites down in Central Otago but there's still a lot of significant differences why Roydon's another step better in my mind but that aside looking at a reduction factor certainly allow for the fact that Miners and a large part of the quarry will open and miners and also some of rogue metals is actually rejected already and when I look at it more quantitatively that reduction which is where I start to look at least start to compare ?? emissions ???????????????? which I say are good for comparisons then when you find those equations and you allow for the fact that a lot of those quarries use trucks for haulage and ?? they don't use most of them don't use conveyors they use trucks and they have clean fill operations where they dump on clean land and the

trucks run over the clean fill they don’t they run over the top of the clean fill and they drag out mud on to the road and all of that stuff. When you like for like compare the ??? equation to Roydon and apply it a model size you sought of come up with that sought of factor max 20 to 30 times more emission so that's a bit more quantitative about it and you can just look at simply things like the um you think of wind fetch on a plane you'll think of fetch so we talk about fetch across the water so distance across the water you can look at quarries in the same way and so no matter how you look at it you find you get these factors of 10 or more differences and all those factors drive the potential emission its just as simple as that and the exposed area the tonnage's of processing going on at those sites
All of those factors, so have you done any sensitivity analysis into all of those factors to see to test your experiment
Well not really I don’t see you know the I think what I've done is just picked as much as I can apples for apples comparisons of the operations and followed the equations exactly the same way so you're getting a fair comparison so if you're going to do a sensitivity analysis then it's like changing one and not the other I mean I think that it would make sense I think what that's what analysis makes sense when you are saying hey look what is the actual emission what could it be and as we get to the absolute emission question and I just haven't gone there but I think that it's just too the equation is not good enough to do that sort of analysis but certainly if you were going to go down the path of trying to quantify your emissions so you hang your head on a number and then put it into a model and model it
Yeah
Yeah absolutely you'd do a sensitivity analysis but doing a comparison of two sites the ??? is getting the numbers consistent even though the equations might be well they are unreliable and absolute terms it's just getting those comparisons
She we move on from ?????? OK *Just looking at Table 4 of your evidence on page 30 the point there is that it is showing that the NES standard for PM_{10} would be met at all wind directions*
That’s right
Yep we go over the page to Table 5 which is $PM_{10,\ 2.5}$ and am I right that this

shows that regulation 17 is likely to be breached at some time during the term of the consent during the 35 years
Ah we are looking up to 2.5 17 relates to PM_{10} right
Yeah I'm looking at table 5
Yes table 5 yeah which is PM_{10} so that's $PM_{2.5}$ and that's showing increments less than well the order
Oh so it's table 4
Table 4 yeah so the one condition where if you look at the extreme value for a nor-west you've got that upper range of 4.7 I think you might be referring to that um and I haven't given that too much weight and I'll tell you why if you look at the Yaldhurst study which had all of these sites dotted around a quarry and you had a site 3 which is basically downwind of a nor-wester condition it's one of the closer sites but it was essentially monitored site 3 essentially had 1km of quarry upwind of it during a nor-west condition and ?? that one extreme number of let's say close to 5 and if you look at wind at site 3 you've got several process plants within 200m at least 2 you've also got an asphalt plant you've got a concrete bashing plant just across that boundary so any site is going to stick out as being a bit as being atypical to the rest of the sites that was it so I looked at that and I thought well really it's not reasonable to give too much weight to that to those high numbers it makes sense that yes that the nor-wester gives you the highest numbers but you would be trying to assess Roydon and its increment of PM10 based on data that's influenced by an asphalt plant and a concrete bashing plant and several ?? plants directly upwind at much closer proximity than what you would have at Roydon and having processes that don't ??? and I noticed um Miss ?? her evidence I read a paragraph and she made that statement how her and Mr what's his name Bayne so she made a comment there in her evidence how her and Mr Bayne have noticed that the site 3 they tend to notice that the dust they observe is associated with vehicle movements and trucks moving around and I can see that makes a lot of sense but it just says to me that that site is upwind of a lot of of a very dusty area that's probably the one part of that quarry that's not so going back to your question earlier about is this a fair study to be ???? that's the one little black hole in that study is there and as I say you can look on a map and see all of these process plants. Asphalt plants, concrete bashing plants lots of truck movements within a few hundred meters or less a lot less of that monitor so that's why I

though well that number I can see why that's high but the other numbers on top have a lot more maybe a lot more weight and relied on
So in terms of regulation 17 paragraph 122 you said in the last sentence my view ?? that the NES regulation 17 or PM_{10} in fact from the new applications ?? met you didn't say at all times when you ended that. You acknowledged that at times it won't
No what I by saying that regulation 17 is likely to be met means that if it meets it it means that it must meet it all the time so I am saying that
At all times
They have a total ability at that site to and it's up to the ???? of the mitigation and controls but they had every ability I believe that site to control it so you never go above that now you may well argue that it's a perfect world and they may not always implement mitigation to achieve that outcome but what I'm saying the evidence is that if they with that design there's every reason why it's actually practical to achieve that in my view where I would have said in a ?? quarry you wouldn't I'd have a different conclusion you almost certainly wouldn’t

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Commissioner Thomas questions:

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Okay thank you. So the other aspect of the NES of course that has been talked about and that it is the increase margin and that is how you can monitor and our responsibility is to make a call on that now not rely on some sort of future monitoring of that and Sharon asked you some questions about table 4 and table 4 is your assessment right? Table 4 does say that the NES from the north-west wind won't comply. You said
The problem is that table 4 isn't my assessment. Table 4 feeds into my assessment. So I have put that data up and shown it but I don't draw the conclusion that that, I am showing a number of 4.7 is being a high extreme ??? measured. But I don't conclude that that means for Roydon you can't meet regulation 17. ?? I might go back over to Ms Glengary but essentially I think that number is driven by the one part of the oldest quarry, it can't really be used to infer offence at Roydon. So at all the monitoring sites there is one site that is affected by ??? and close proximity to plants etc ??? so you can't really use that 4.7 I think the creeping levels can show it, and say this was measured rather than say oh it is not relevant so don't include it. I have included it but my assessment is that it doesn't apply.
What do you think the level will be?
I think we look at overall data and exclude that one number. It is going to be in the order of 2 or thereabouts or less. So most of the time it is going to be virtually non-measurable but I see that again with most controlled employed all the time, that they could live to a good ??? and a 4.7 doesn't say that but I am not giving weight to that number.
We have got this trigger that we are bound to by regulation of 2.5.

Yes and like my view is that, because that number 4.7 is in table 4, you shouldn't just grab that and say therefore its not going to meet it, I have explained why I discounted that and it is more a question of whether you agree whether that makes sense. I have explained to you why that should be discounted as the outlier and look at the other data in that table but I think it was more credible to include it and say this number did turn up but to then explain why I don't see that as a reason why okay it looks like you won't meet the 2.5. It would be inappropriate I think to just grab that number and say and look Mr Cudmore's table 4 says 4.7, and 2.5 is the number, that is a pass fail then you failed. My assessment is more broader than that.
Why, so does that explain why you have put in ranges for some wind directions and not others?
Which ones?
So you have got table 4 has got a range for north west a range for north east and a range for south west but not for south and north.
South is there, you've got North
No I say a range.
Oh I think south is just a value you had, there wasn't a range that was the value.
And why don't we have west and east and south east?
Well probably because those numbers are generated for the consideration of the issue boundary. We applied that, so those other winds wouldn't blow any emissions towards the boundary. So looking at what winds could possibly
West, west would surely?
Oh yes, that is a good point. Well I think west is sort of covered. I guess and I thought you were all clear about this,

but to my mind that is a good splatter of winds coming from that general direction and I think west is covered by that. I don't see. There was no data for west at the obvious quarry site to affirm that in the first place. But I think that gives you a good selection of range to say well okay in all probability west would fit into that group. There would be no reason why it wouldn't.
So rather than just leaving stuff out it was more controlled by the data you had available from the dust study.
The oldest study only covered, it covered quite a few direction but, well it did hear, but it didn't cover that straight westerly condition.
One of the difficulties we have is the at all time aspect. So we have got to be really careful that there aren't circumstances where this does trigger that is why we spent a bit of time on that. Just over the page on your evidence in chief from that table 4, I am paragraph 124 page 32 of your evidence in chief and that is where you consider the Canterbury Air Regional Plan policy 6.25 which you quoted in 123 and you say "with respect go policy 625 it is my view that the PM10 factors for quarry services and activities over ?? conservative and unreliable and provide unrealistic indications of significant against current air share emissions". Can you just explain that for me?
Yes certainly. To look at the erosion factor for instance, it is, it is a grand per unit area of exposed quarry or mine surface. It is derived from very little data from central parts of the United States which were large coal mines. We have looked at the studies, the conditions of those studies were far drier than what we have here in Canterbury. So you have got a study that has generated these emission factors for a large coal in a very dry climate and you just know that, you just know that that is going to be far more duster than what you would see given our climate here in New Zealand.

Sorry how does that relate to the policy? I was trying to relate it back to the policy and the wording of that policy.
So what I am saying, so what my statement here was is that those emissions factors in my mind are generally ?? conservative and that is the generally, what we generally find when they find that is that they don't stack up, they create very high numbers that don't make sense. That is the general experience of the emission factors for quarries or for exposed surfaces. So what I am saying is that, when it comes to regulation 17 you don't actually have a robust method I have tooked at to actually say what that, in absolute terms what that number really is. You have to look at, you have what I have done here is, is look at ambient modern data and apply it to the site. But to take this sort of approach and say, let's use for example the sulphate boiler or an asphalt plant, you have the stack and you can go and measure that emission and quantify it and get so many K's per hour of PM10 being discharged. You can do your sensitivity around that. Therefore we can look for an offset which manages that. But for this case you put emissions that are notoriously difficult to quantify especially when you know in winter, you have exclusion problems is the time in a quarry is essentially closer, well effectively zero in terms of emission source. You have got to somewhere calculate emissions which are absolutely correct that vary in time and space due to wind conditions, speed, temperature, when did it last rain, it just can't do. The equations are not that good. So if you are trying to look compliance of these, with these rules using those equations, you have got to be really, it is really poor science and its very hit and miss quite frankly.
Lets move on from that then. In a number of places and I am thinking of your rebuttal to Mr Kirk at, where I think you have made the point that, that kind of this Christchurch Air Shed issue is kind of an unfortunate set of circumstances arising in this particular case. Now, what I am keen to just understand is

that air shed was obviously established with considerable science behind it and it is a reasonably, well it not necessarily follows a logically shape in terms of ?? or anything like that. How was that established and is it reasonable for you to sort of make the comment that in 20 of this rebuttal well its really its not particularly relevant to what we are doing here?
I think is clear for me to say that. But I was, I got back to the days where I was part of research to work out how to develop community issues and be part of research. We talked about how to work out where elevated bush would be, and where the issued boundary needed to be. As we speak I am involved in projects with my colleagues Golder helping the Waikato Regional Council define where their air shed boundary should go based on model PM10 emissions over the whole air shed and work out at what point you do have ??? they want to change their boundary to match where they have an issue and at that case, the air shed sites, the best sites we have, and that was always the contentions. Now what I can tell is that looking at that air shed boundary for Christchurch City, that is not based on science. That is based on some planning boundaries or something that is not that shape. If you look at, if I could refer to a figure there where you take a few steps that way and suddenly you are in unclear air shed, well there is no way the body has change. So that boundary in parts is based on where the emission is excessive but certainly from west side but it is not based on a knowledge of the emissions of PM10 on a census unit basis or any model of those, and say okay that plus monitoring tells us we have the NES been approached or breached in these areas and here is a boundary where that starts to wain away where you have compliance. It is generally a modelling trend approach to keep that position. This boundary is not based on that, there is no way. Any size that come up with that boundary. 100% that is based on an arbitrary definition that could be, I suspect linked to future aspirations of plan and here I am speculating but it is a bureaucratic response to the NES it is not a science

response. At the end of the day that is where we have spent a lot of time and tax payers money trying to develop a scientific approach to develop these boundaries. This has not happened yet. So on totally rock solid ground I say this to you. I don't think you would find anybody that would disagree with me. In sense of this size versus that that is based on size I think.

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Commissioner Von Voorthuysen questions:

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Paragraph 118 which is at the bottom of page 29 third line from the bottom of that you say that in table 4 it can be seen that a maximum increase of 2.4 micrograms is predicted but when I read table 4 I see a maximum of 2.7 with a nor-west wind and not 2.4
Yeah you are dead right and I guess I've been a little bit of ?? here not to sought of explain in evidence what I've said, what I've explained to ?? about the about how much weight I put in that data
Sure but you'd simply change the 2.4 in paragraph 118 to 2.7
Yes you could yes absolutely. Not that it changes my assessment.
Now regarding table 4 so just so I'm understanding it in the third column the peak 24 hour ??? so those numbers are based on your 10fold reduction of the Yaldhurst data so if there was no tenfold reduction applied we just took base Yaldhurst data would that 2.4 in the first row become 24
Yes
Now we've established through earlier questions that you did a sensitivity analysis and your explained why that was the case, have you worked out what level of reduction from the Yaldhurst data would be required such that the NES regulation wasn't breached could you come at it from that direction? Because you implied tenfold reduction other experts have said well not sure if that correct but I'd be interested to know what level of

reduction is required such that you don't get a breach
Well Yaldhurst basically you would need a reduction ?? than you would a 20 to fit a nor-wester and if the winds blowing a nor-west and across the asphalt plant and those concentration sources that effect site 3 then that site 3 was to meet the NES for Yaldhurst you would need a 25 reduction
Sorry my question probably wasn't clear not to the point of breaching Yaldhurst but when you are using Yaldhurst figures what reduction factor would be required to be applied to the Yaldhurst numbers so that when you use them in Roydon you didn't get a breach of NES at Roydon. That might be hard to work out so I'm happy for you to work it out later
Can I just paraphrase that back to you so I understand what you are asking? So you are saying based on the Yaldhurst data and all of it including the nor-west value if that was to apply to Roydon what ? would you need to make that comply with regulation 17 and the answer to that is in two parts so if you ignore those circumstances that make the nor-wester a typical and recent site that answer would be 20 if you do what I have done which is to say I've had this count backdated because we know it's not an asphalt plant and a batching plant it's not two process plants within 300m of the eastern boundary of Roydon we know that then that's the basis normally you can discount that particular part of the data set if you include that particular part of the data set and look at all of the other data all other sites and then your answer is 10 whereabouts and I'm saying that Roydon can achieve through its mitigation 10 and some all of the analysis in a quantitative perspective say that
In your table 5 did you apply a tenfold reduction to the base data
I think so. Yes.
I just want to take you now to your rebuttal evidence I want to take you to your paragraph 20 the rebuttal evidence paragraph 20 So it's the one dated 21 October. Now what I take you to be saying there as well here you guys regulation 17 exists but you know we shouldn't really take it too seriously in this case but regulation 20 is a regulation it's equivalent to a rule so it's not like a policy that under section 1 ??? you need to have regard to you an discount what you consider inappropriate you can't do that to a rule or a

regulation you must apply as you find it so regardless of the issues that you raise we are bound to apply regulation as we find it
I think this is my opinion and I guess you have to put into context that this is really a legal planning argument primarily and I think in due respect it's probably better to get that answer from Legal Counsel submissions and Mr ?? I mean I am expressing my view as a practitioner and I say this based on?? that the whole thing I was a part of pretty much the bulk of the ?? days was the seats tried to be this is a misuse of its purpose there's and unintended use of its purpose and I don't know I 'm not an expert I can't I'm not an expert lawyer or planner so I can't really give an expert opinion on whether we can ignore it or not so you should see it in that light.
Ok that's fine I only asked because you referred to case law in that paragraph so
Fair enough and I just am not aware of any historic quarry in ?? of dust source that you can't quantify easily I'm just not aware of any case law that would cover that it would be interesting to see

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Well we look forward to receding that and any kind of explanation that you can give to back the proposal that would help us understand it and explain fully what you just disclosed to us. *Can I just ask a supplementary to that finally and that is your attachment B to your rebuttal set out on the table which came to compare your calculation of total pm10 per annum with Ms Wickhams, which obviously is a number that could become important in this offset, did the conferencing resolve any differences between you and Ms Wickham in that in the, I thought it might have been the subject that you worked on but it wasn't clear from the JWS*
To me I think Ms Wickahm's position was she wanted to go away and digest it and come back and I'm sure you will hear about her position