BEFORE A COMMISSIONER APPOINTED BY THE OTAGO REGIONAL COUNCIL AND THE CENTRAL OTAGO DISTRICT COUNCIL

IN THE MATTER OF the Resource Management Act 1991

AND

IN THE MATTER OF applications by Cromwell Certified Concrete Limited for resource consents to expand Amisfield Quarry

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STATEMENT OF EVIDENCE OF ROGER CUDMORE ON BEHALF OF CROMWELL CERTIFIED CONCRETE LIMITED

(AIR QUALITY)

Dated: 30 November 2021

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1 INTRODUCTION

1.1 My full name is Roger Steven Cudmore. I am a Principal of Golder Associates (NZ) Limited (Golder) and the National Technical Leader for Golder's Environmental Services. My area of expertise is air quality management and related impact assessments.

1.2 Following the retirement of Prue Harwood (Beca), I was engaged by Cromwell Certified Concrete Limited (the Applicant) to provide advice in relation to its proposal to deepen and expand the existing Amisfield Quarry (the quarry) located at 1248 Luggate-Cromwell Road (State Highway 6), north of Cromwell.

Qualifications and Experience

1.3 I graduated from the University of Canterbury with a degree in Chemical Engineering awarded with honours in 1986. I am a certified air quality practitioner (CAQP) with the Clean Air Society of Australia and New Zealand (CASANZ).

1.4 I have worked as a consultant in air quality and wastewater management for 26 years. Over this time, I have provided expert air quality management advice to Industry, Regional Councils, and the Ministry for the Environment (MfE). I have had significant involvement in the development of national guideline documents for air quality management including the MfE ambient air quality guidelines (AAQGs) for New Zealand (MfE 2002a). I produced several reports during the 1990s for MfE and industry on the topic of odour measurement and assessment that were included in MfE's air quality technical report 24 - Review of Odour Management in New Zealand (MfE, 2002b). That report was the primary reference for the first MfE Odour Guideline (MfE, 2003) and is still largely referred to in the update to the Odour Guideline (MfE, 2016). I was a member of the Golder team that was engaged by an industry group to review and make substantive recommendations on the draft MfE Good Practice Guides for assessing and managing Odour, Dust and Industrial Discharges before these were updated and published in late 2016.

1.5 I have significant experience in the assessment of air quality effects from a wide range of industrial air discharge sources including aggregate quarrying and mining developments in New Zealand, Eastern Europe and the Pacific, peat mining, fertiliser and food manufacture, wastewater and energy plants, incineration facilities, and the oil and gas industry. This has include providing expert evidence on air discharges effects.

1.6 In 2019/2020, I provided expert air quality advice and evidence in relation to Fulton Hogan's proposed Roydon quarry, a substantial (about 100 ha in area) new quarry which is to be located at Templeton in Canterbury. That work encompassed assessment of the potential for dust nuisance and health related effects and associated mitigation measures for the proposal. As part of that work, I also reviewed the air quality investigations of dust effects from the multiple Yaldhurst quarry sites. In 2020, I provided advice and air quality evidence in relation to Fulton Hogan's proposed 41 ha Carter's block extension at its Miners Road quarry, which had 3 residential dwellings within 250 m of the proposed quarry. Consents for both of those proposals were granted subject to a suite of conditions. The Roydon quarry proposal had 12 residential houses within 200m of the proposed quarrying areas and down of prevalent dry windy conditions.

1.7 A more detailed list of my experience in air quality management is included in **Attachment A** to my evidence.

Involvement in this Proposal

1.8 As I have described, I was engaged by the Applicant to provide air quality advice in relation to its quarry deepening and expansion proposal. As part of that work, I undertook a review of the assessment of air quality effects undertaken by Beca (Beca 2020)[1] and considered a range of other information including the submissions on the resource consent applications for the proposal. The primary author of the Beca 2020 report on dust discharge

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[1] Beca (2020) Amisfield Quarry – Technical Assessment of Potential Effects of Dust Discharges by Beca Limited, 22 October 2020.

effects, Prue Harwood, retired before submissions on the applications for resource consents were lodged.

1.9 Having reviewed the Beca 2020 report and the submissions, I visited the site on 20 July 2021 to familiarise myself with it and the surrounding area. I then undertook further detailed analysis of site wind patterns, using diagnostic modelling and data from a met station at Fulton Hogan's Parkburn quarry (the same data set used by the Beca 2020 report), and rainfall data from a Harvest.com weather station on Mr Douglas Cook's property. Mr Cook has an orchard on his property (which is located to the south of the application site) and kindly agreed to provide me with access to data from his orchard weather station. This modelling and data enabled the estimation of approximate particulate exposures and deposition rates (using the CALPUFF air dispersion model) as a result of vehicle induced suspended particulate emissions from an uncontrolled main haul road (with 5 % silt), located near the centre of the new expansion area. My reason for focusing on this road is that of all potential dust sources on the site, it has the highest potential to cause dust impacts beyond the boundary of the site if it is not controlled.

1.10 Having undertaken this work, I provided a report to the Applicant[2] which I understand has been provided to the consent authorities, the air quality experts advising those authorities, and submitters. In summary, I considered that the Beca 2020 report appropriately relies on guidance from the MfE dust management guide, and therefore adequately addresses the significance of potential impacts from fine respirable dust size fractions, as well as the potential for adverse effects during dry wind days. I considered it provided a reasonable assessment of the dust sources on the site and key mitigation measures required to control dust effects. However, I considered a more detailed assessment was required given the presence of commercial orchards.

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[2] Golder (2021) Review of dust effects assessment – Amisfield Quarry, Golder Letter No. 21480092-003-L-RevA, dated 11 November, 2021.

1.11 I have therefore subsequentially undertaken my own further detailed assessment of the sensitivity of the receiving environment, potential dust impacts and recommended dust mitigation measures. The main outcomes of my review and independent assessment has been the preparation of draft air discharge conditions (which are attached to my evidence as **Attachment H**) and a revised draft dust management plan (DMP)[3] which is attached to my evidence as **Attachment I**. My draft DMP supersedes the earlier draft DMP which was prepared by Beca in 2021 in response to a s92 request[4].

2 SCOPE OF EVIDENCE

2.1 My evidence addresses the following:

(a) The proposed quarrying deepening and expansion (the Proposal);

(b) Dust generating activities with the Proposal site;

(c) The character of quarry dust associated with the Proposal;

(d) The receiving environment insofar as it relates to air quality, including:

(i) Site description and surrounding land uses;

(ii) Key off-site receptor locations;

(iii) Topography and meteorology;

(iv) Background air quality; and

(v) Sensitivity of receptors to quarry dust impacts.

(e) Potential air quality effects of the Proposal;

(f) Proposed dust mitigation including key aspects of the draft proposed site-wide DMP;

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3 Dust Management Plan - Amisfield Quarry, Golder Report No. 21480092-001-R-Rev0, November 2021.

4 BECA (2021): Amisfield Quarry - Draft Air Quality Management Plan, prepared for Cromwell Certified Concrete Limited, March 2021.

(g) Assessment of the effects with proposed mitigation;

(h) Submissions on the applications which raise specific issues in relation to dust effects;

(i) The Section 42A report; and

(j) Consent conditions.

2.2 In preparing this evidence, I have read and considered the following documents:

(a) The applications, the AEE and the supporting BECA 2020 report in relation to air discharges[5];

(b) Section 92 request for further information from Central Otago District Council (CODC) (email from Oli McIntosh to Matthew Curran dated 3 December 2020);

(c) Preliminary technical air quality review by NZ AIR dated 12 January 2020;

(d) Section 92 request for further information from Otago Regional Council (ORC) (letter dated 21 January 2021);

(e) The applicant's response to the request for further information[6];

(f) NZ Air's technical air quality review of the Section 92 Response (dated 12 March 2021);

(g) Pattle Delamore Partner's (PDP) review of the proposed Amisfield Quarry Expansion effects on air quality (dated 17 March 2021);

(h) Submissions on the proposal relevant to air quality effects;

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5 Amisfield Quarry – Technical Assessment of Potential Effects of Dust Discharges by Beca Limited, 22 October 2020.

6 Letter from BECA to Landpro, *Amisfield Quarry Air Discharges- RC 200343 - Response to Request for Further Information from Central Otago District Council*, dated 1 March 2021. The BECA response also includes a draft Air Quality Management Plan for CCC.

(i) The Section 42A report prepared by Mr Whyte, including the evidence of Ms Ryan and Mr Van Kekem in relation to air quality matters;

(j) The evidence of Travis Allison (the quarry manager), the ecological evidence of Mr Cees Bevers (in relation to the potential effects of the Proposal on the Mahaka Katia Scientific Reserve which is administered by the Department of Conservation (DoC) and the evidence of Ruth Underwood in relation to the potential effects of dust on orchards.

2.3 I acknowledge that I have read and agree to comply with the Environment Court's Code of Conduct for Expert Witnesses, contained in the Environment Court Practice Note 2014. My qualifications as an expert are set out above. Other than where I state that I am relying on the advice of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

3 SUMMARY

3.1 To date, Amisfield Quarry has not required an air discharge permit because its processing rate does not exceed the threshold for a permitted activity in the Otago Air Plan. An expansion of the quarry and an increase in production is proposed, such that an air discharge permit is now required.

3.2 Both Beca and I have assessed the effects of the expansion proposal. As part of that work, we have each reviewed the dust control methods employed both historically and currently on the site and recommended further controls to ensure that any dust generated as a result of the expansion does not have offensive or objectionable effects beyond the boundary of the site.

3.3 My analysis indicates that for the most sensitive receptors (the existing and consented residential dwellings on the Clark land and the Amisfield Orchard land, and the vineyards and orchards immediately adjacent to the quarry boundaries), there is the potential for elevated dust impacts to occur in both dry windy and light/moderate wind conditions unless mitigated. This applies equally to both the existing and proposed expansion areas.

3.4 On this basis of this finding, and to minimise any potential for dust generated on the site being offensive or objectionable beyond the boundary, I have recommended additional mitigation and monitoring methods, which represent current best internal practice in my view. This is set out in the conditions of the air discharge permit proposed by the applicant, and provided to the consent authorities by the Applicant on 11 November 2021 (attached as **Attachment H**).

3.5 These additional proposed mitigation and monitoring methods include permanent continuous on-site monitoring of wind speed and wind direction and continuous monitoring of ambient respirable particulate matter (PM_{10}) concentrations at strategically selected locations. This will provide effective warning of wind conditions which have the potential to impact on the nearest sensitive receptors. Windspeed and PM_{10} concentration alert limits are proposed which will trigger deployment of additional dust control measures on the site. If windspeed remains high and PM_{10} limits have been reached, activities on the site which have the potential to create dust would be required to cease until conditions improve and drop back within limits.

3.6 With implementation of those measures and routine compliance with the proposed PM_{10} trigger levels, the risk of dust discharges beyond the boundary of the site being offensive or objectionable is considered to be low. The relevant air quality standards and guidelines will not be exceed and any adverse effects, including health effects on people or adverse effects on crop production, are likely to be less than minor.

3.7 Finally, it is my view that the proposed conditions and associated Dust Management Plan can be practically employed so as to ensure compliance with the proposed PM_{10} trigger levels and limits without heavy reliance on using a water cart for dust control. With those levels and limits, I consider that potential nuisance dust effects are likely to be minor, or less.

4 THE PROPOSAL

4.1 Amisfield Quarry has been operating in its current location for at least 25 years. To date, the quarry has operated as a permitted discharge to air activity (under the rules in the Otago Air Plan), such that an air discharge permit has not been required.

4.2 Consents are now sought to increase annual production on the site to 200,000 m^3/yr of aggregate extraction, which equates to a weight of approximately 360,000 T/yr. This will be achieved via excavation of aggregates from deeper within the existing quarry site (below the groundwater table), and excavating an adjoining parcel of land to the same deeper level. With this increase in production, I understand that the quarrying would not be a permitted activity and an discharge permit is required.

4.3 The total area of the site following the proposed expansion will be approximately 27 ha. A 3 ha active working area[7] is proposed which includes the quarry face and working area, haul roads and processing plant. I note that the size of the quarry is described in the s42A report as significant. I disagree. The size of the quarry is not large compared to many quarries I have advised on and is some degree smaller than the two quarries at Parkburn, 2km to the south of the Amisfield site.

4.4 The active working area on the expansion land will be set back at least 25 m from the boundary of that land (apart from along a right of way between the existing quarry and the expansion land) and 50 m in the vicinity of the Clark residence. Bunds will also be constructed along these boundaries which will be 3 m high by 6 m wide. However I understand that along the boundary with the Amisfield Orchard land, the bund height will be up to 6 m high to

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[7] The 3 ha active working area is the area of the quarry that includes the working face and adjacent working area, the haul roads and the area surrounding the processing plants. Land surrounding the active areas, which has not been worked for some time are is not a significant source of dust unless it is disturbed has formed crusts and therefore has not been included in the 3 ha working area.

account for land dipping and to maintain uniform elevation. I understand that the bunds will be irrigated and be covered with low native vegetation, and selected in consultation with DoC and Mana Whenua.

4.5 Excavation of aggregates will typically occur for up to 12 hours per day, 6 days a week (no activities on Sundays or public holidays other than dust suppression) and for at least 50 weeks per year. On this basis, for my assessment, I have assumed that in any one calendar year, there would quarrying activity occurring for 3600 hours per year spread over 300 operational days.

4.6 The mine plan for the Proposal is to complete the existing quarry (see Map 1 in the Mine Plan which is attached to Mr Allison's evidence and also as **Attachment B** to this evidence). Following this, it is planned to excavate the existing quarry more deeply and rehabilitate the existing excavation in two stages, as shown on maps 2 and 3 of the Mine Plan.

4.7 These new deeper quarrying stages will involve excavation of aggregates below the ground water table and no material changes to the location of processing plant, stockpiles, sediment pond, site access roads and other infrastructure.

4.8 The current quarry's excavation area is approximately 2 – 3 ha. The proposed new excavation area within the expansion land is approximately 7 ha. Maps 3 and Map 4 of the Mine Plan (**Attachment B**), respectively show the proposed first and second stages of excavations, with the second stage involving extraction of aggregates below the ground water table.

4.9 The quarry produces a range of different grades of aggregate including sand, as explained in Mr Allison's evidence.

5 DUST GENERATING ACTIVITIES

5.1 Most activities undertaken within a quarry have potential to generate dust. That potential which ranges from minor to significant if not appropriately controlled. All such activities (except for those which cause negligible dust discharge) are listed in approximate order of the quarry process flow (not in order of their potential to generate dust) as follows:

(a) Stripping of overburden, stockpiling and building bunds;

(b) Extraction of gravel;

(c) Haulage of excavated gravel;

(d) Screening and washing of aggregates (has a low potential);

(e) Primary and secondary crushing;

(f) Vehicle movements within processing area;

(g) Stockpiling of aggregates;

(h) Transportation of aggregate products; and

(i) Rehabilitation of quarried areas.

Stripping of Overburden, Stockpiling and Building Bunds

5.2 In terms of this Proposal, stripping of the topsoil (approximately 200 mm deep) of the entire expansion land (see Figure 2-1, **Attachment C**) will occur in winter months. It will then be covered with an aggregate product to a suitable depth (at least 50 mm of pea gravel) as a temporary cover until it is quarried. The stripped topsoil will be used to form the bunds around the boundary of that land. Because both the stripping and bund formation will be undertaken in winter months and completed by early spring, followed by a temporary cover, any potential for generation of dust this source is significantly reduced with no further controls required.

Excavation of Gravel

5.3 Gravel will be excavated by traditional truck and shovel techniques (see Figure 3-1, **Attachment C**). There is no blasting required and currently the excavation occurs to a maximum depth of 15 m below ground level, which is close to the groundwater level. The Proposal would allow for the maximum depth of the excavation to extend approximately 30 m below ground level, and/or 10 m below the groundwater level.

5.4 The excavation and loading of trucks with aggregate will be at an average rate of 100 T/hr (giving 360,000 Tonnes/yr). The aggregate excavated deeper within the existing quarry will be very damp, as it will mostly be quarried below the groundwater level (effectively, it will be dredged). For the first stage of mining the expansion land (i.e., above the groundwater table), the aggregate is also expected to be moist on most occasions and therefore not prone to generating dust during excavation or loading of haul trucks. However during summer and autumn months, the top surface layer of excavated material may become dry and prone to dusty emissions when loaded into haul trucks if not controlled. While not usually required, the use of surface pre-wetting or water sprays can be employed in such conditions.

5.5 The excavation (with pit run material at a typical rate of 1200 T/day) will generate approximately 38 haulage trucks movements per day, with each truck carrying an average of 32 Tonnes of aggregate per load back to the existing processing area.

Haulage of Excavated and Processed Aggregate

5.6 Trucks transporting excavated pit run material from the active quarry face to central processing plants (i.e., screening/washing and crushing plants) is typically the largest source of dust discharge from aggregate quarries. This is because it involves relatively heavy loaded/unloaded haul trucks running back and forwards over unpaved haul roads, which constantly generates new fine dust inventory (due to truck tyres) and discharge of dust to air from the turbulence generate by the truck movement itself.

5.7 The locations of the haul road for the existing quarry area, and new expansion area are shown in Map 3 of the Mine Plan (**Attachment B**). For the Proposal I estimate that approximately 3 haulage trucks/hr would be travelling back to the central processing plant (each carrying a typical play load of 32 Tonnes of pit run gravel). Therefore, an empty or loaded haul truck (respectively weighing 23 T or 55 T) would travel along the site haul road at least every ten minutes (6.3 movements per hour on average).

5.8 Given the above, I consider that the haul road for the proposed new expansion area (approximately 900 metres in total length for the new expansion area) will have the highest potential to cause adverse dust effects beyond the site boundary if not controlled appropriately. To avoid such effects occurring, this new haul road and the existing site's haul road will require either watering with a water cart, covering with reject gravel, or a combination of both.

Screening and Washing of Aggregates

5.9 The location of the screening and washing plant is shown in Figure 2-1 and a photograph of the plant is shown in Figure 3-3, **Attachment C**. It can be seen that the plant and surrounding stockpiles sit at the upper level of the quarry, but below the ground level of surrounding land.

5.10 All 200,000 m^3/yr of excavated pit run gravel will be run through the screening plant and segregated into different aggregate size categories. Unlike most quarries, the vast majority of the screened aggregate is washed before it is processed (crushed) except for large gabion rocks (representing around 4% of the total excavated material). Silt and clay materials washed from the pit run gravel are discharged to a settling pond. I understand that the process of washing aggregate during screening was employed at this plant because originally it was set up for concrete aggregate supply. The washing helps with the retention of sand which is a required product.

5.11 Generally the screening and washing plant would produce minimal dust, because it employs water application during screening operations.

Primary and Secondary Crushing

5.12 The crushing plant sits within the base of the existing quarry floor (see Figure 3-2, **Attachment C**), which helps minimise its exposure to wind. Given this, I expect only the finer fraction of dust generated by the crushing plant (i.e., <30 microns in size) to be able to escape beyond the site boundary if not appropriately controlled. Therefore settleable dust generated by the crushing plant (in the order of 30 microns and larger) is likely to remain fully contained within the quarry site boundary, except during the more extreme dry winds above 10 m/s (one hour average).

5.13 I understand that of the proposed 200,000 m^3/yr of excavated pit run material, the majority (in the order of 75 %) will only be washed and screened to produce the products described in Mr Allison's evidence and 'reject' material with no market value (pea gravel, silt and clay).

5.14 Therefore, only the balance (in the order of 25 % of the excavated aggregate) is screened, washed and processed through the crushing plant.

5.15 Of all screened and washed material which is processed through the crushing plant, the majority is only primary crushed. Only approximately 10 % (20,000 m^3/yr) of total quarried material is processed through both the primary and secondary crusher to produce crusher sand (i.e., AP5) and other fine chip products. This low percentage value and the use of water, is why I consider the crushing activity at this site to be a less significant source of dust compared to other alluvial gravel quarry sites in the South Island.

Truck & Loader Movements Around the Processing Area

5.16 Loaders are primarily used to transfer washed and screened materials to their respective stockpiles. Likewise, crushed aggregate products are mainly transferred to their stockpiles using loaders.

5.17 Much of the natural 20/40 mm screened and washed aggregate, which is destined for the crushing plant is transferred to the plant by pushing this material over the bank (the eastern side of the screening plant). This falls down to the crusher plant, located at the base of the quarry. The balance of the washed and screened aggregate will be transferred to the crusher plant by loaders or trucks.

5.18 Movements of loaders and trucks around the processing plant area will constantly generate an inventory of fine dust due to abrasion of unpaved surfaces. Therefore these areas which are subject to high frequency of loader and truck movements will require dust suppression methods.

Stockpiling of Aggregates

5.19 Stockpiles of raw and processed materials are located within three areas of the site, as shown in Figure 2-1, **Attachment C**. There are three stockpile areas located to the north, east and southwest of the screening and crushing plants. The tops of the stockpiles are kept below the natural level of the surrounding land. The stockpiles of most types of aggregate products create a low potential source of dust in my view, as the material is not mobile and is relatively clean. The exception to this is the stockpiles of crusher dust (AP5) and stockpiles of natural sand. These are likely to require dampening and possibly use of dust suppression chemicals during strong dry wind conditions.

Transport of Aggregate Products

5.20 At present up to 47 trucks service the quarry per day (94 trips/day), and that this is anticipated to increase up to 75 trucks per day (150 trips/day) following the proposed expansion. Currently during the peak hour, up to 20 trucks arrive at the site.

5.21 The quarry is accessed from SH6 (Luggate Cromwell Road) by a sealed access road, which extends for 120 m before transitioning to an unsealed surface. Given the high frequency of trucks arriving and leaving the site, the sealed section of the access road will need periodic cleaning/vacuuming. Likewise the unsealed section will require maintenance and dust suppression measures. Otherwise the truck movements associated with the export of products could be a large source of dust discharge from the site.

5.22 I consider that the loading up of trucks with aggregate product has the potential to generate low levels of dust discharge, but again any dust from the movement of the loader itself over unpaved surfaces can be controlled (e.g., through use of the mobile water truck/cart).

Rehabilitation of quarried areas

5.23 The rehabilitation of worked areas (or diligent control of those areas which are ready for rehabilitation) is also a key measure for reducing the areas within the quarry site which can be prone to dust erosion during strong dry wind conditions.

5.24 I understand that it is proposed to progressively rehabilitate the existing quarry pit in general accordance with the extraction plan. This would involve filling the excavated areas above groundwater level and contouring the sides of the quarry to a finished battered slope of 3.5:1.0 using available reject gravel, silts and topsoil. The battered walls and finished floor would by hydro-seeded at a minimum and/or involve native plantings in consultation with DoC and Mana Whenua.

5.25 For the new expansion area, the sides would be battered in the same manner as for the existing quarry, however the floor will remain below the ground water table and therefore creating a lake.

5.26 As described in Mr Allison's evidence, to date, only minor rehabilitation works at the site have been able to be carried out as the majority of the site is being actively used for quarrying and storage of materials. Areas of the quarry which have been worked are backfilled with overburden when it is available. In the meantime, dust in areas which are awaiting rehabilitation can be controlled by covering these dormant areas with reject clean gravels . I have recommended that further rehabilitation work is mainly undertaken during winter months so that this activity itself would only generate low levels of dust.

Inactive Open Areas

5.27 There are currently some in-active areas of the excavated quarry floor (including excavated quarry faces). The in-active quarry floor can contain fine dust/silt material which is prone to wind erosion if not controlled, whereas the in-active quarried faces are relatively clear of fine silt material. The proposed DMP would require the covering of these areas with clean reject gravel.

Character of Dust Discharges

5.28 The dust generated from the above activities will primarily consist of sediment dust, which is derived from natural silts, clay and fine sediment. The parent gravel and stones are likely to consist of greywacke sandstone, greywacke gravels and maybe some basalt and andesite. These materials have naturally high silica content in the order of 80 wt.% and testing to date indicates respirable crystalline silica (RCS) to be approximately 66 wt.%[8].

5.29 The size fractions of the sediment dust which have the potential to impact beyond the site boundary if not controlled consist of some settleable material (in the order of 20 microns and larger) but mostly smaller size fractions below 20 to 30 microns, including respirable size dust fractions (mainly PM_{10} and low levels of $PM_{2.5}$). These smaller size fractions (< 30 microns) do not readily settle out and deposit and are likely to be the main size fraction that could escape from the quarry pit if not adequately controlled.

5.30 In my experience, these suspended fine fractions are likely to be the primary driver of potential adverse nuisance and health effects once beyond 50 m from a dust source.

5.31 This has become apparent from my experiences over the yeas investigating dust impacts on houses, property and crops. This indicated that lodgment of dust into materials, crops, and entrainment into buildings and other confined spaces was consistent with dust being stripped from the wind as it passes through, over and around these obstacles. Certainly, for short distances, the rapid settling of large particles is often the more the dominant mechanism of nuisance via surface deposition (e.g., gravel road dust discharges within 50 m of an unpaved road).

5.32 Along with the above experience, I have found dust deposition monitoring to be an effective tool for monitoring dust nuisance effects. I note that this method of monitoring has been abandoned

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8 Precise (October, 2019): Report prepared for Amisfield Quarry Cromwell, Silica in Alluvial Gravel. Precise Consulting, October 2019, Version 1.0.

for various air consents over the last 20 years and this is because the resultant data is not useful.

5.33 This is strong evidence in my view, that the discharge of heavy particles and subsequent gravity settling onto surfaces is often not the primary mechanism of dust nuisance effects. If it was, then dust deposition monitoring would most likely have been a more useful monitoring tool for nuisance monitoring.

5.34 Finally, it useful to note that fine TSP particles which are < 30 microns are what produces observable dust plumes, such has those generated from riverbeds gravel roads etc., and the examples shown in videos of dust coming from the Amisfield quarry during strong dry windy condition. As with rain clouds, these visual plumes are a result of light scattering which is due to the high concentrations of small particles (within the PM_{30} size range).

5.35 Given the above, light continuous light scattering based methods for measuring ambient particulate levels are more reliable at measuring fine size fractions. Consequentially they are more reliable at measuring PM_{10} than larger TSP fractions, and more reliable at measuring $PM_{2.5}$ than PM_{10} levels in the air. This needs to be considered when specifying ambient trigger levels for dust management monitoring.

6 ENVIRONMENTAL SETTING

6.1 All the area surrounding the quarry is zoned Rural in the Central Otago District Plan. The immediate area surrounding the existing quarry is dominated by vineyards and orchards in most directions, except to the north of the site where land owned by Nicola and Bryson Clark is used for animal grazing and to store vehicles, and the DoC Mahaka Katia Reserve is located.

6.2 The following map image is reproduced from Figure 1 to the Beca Report in **Attachment F**, and has sensitive receptor location identifiers, which I refer to in this evidence. Figure 1 shows the following information:

(a) The location of 19 discreet receptors labelled R1 to R19 for which I have analysed potential dust impacts from the haul road for the new expansion area and active exposed areas.

(b) My estimate of active exposed quarry areas when the northern extent of the proposed expansion area is being quarried. The existing quarry has a larger assumed area of around 5.5 ha (compared to the active section of the excavation area of about 1.5 ha, which will be subjected to frequent loader and truck movements). This includes unloading/loading operations, aggregate screening & crushing, stockpiling etc.

(c) A representative location of the main internal site haul road between the excavation area and the central processing/stockpiling area.

Figure 1: Layout of the quarry site and surrounding land

Neighbouring Activities - Expansion Area

6.3 To the west of the quarry expansion area is the Clark's rural property (including grazed rural land, a residential dwelling (R12) and what I understand is a commercial storage shed (R1)).

6.4 When allowing for internal buffer distance of 50 m, as shown in Figure 2-1, **Attachment C**, the notional boundary of the Clark's residential dwelling is approximately 60 m from boundary of the proposed expansion area.

6.5 The Clark's commercial storage shed (R1) is approximately 45 m west of the boundary of the proposed expansion area.

6.6 At 25 m to the north of quarry expansion area is the DoC Reserve land (R2 and R3), which is described in the evidence Mr Cees Bevers.

6.7 Approximately 60 m to the east of the proposed expansion area (and located on a lower river terrace) is an established cherry orchard owned by the Amisfield Orchard Limited (see Figure 2-1, **Attachment C**) (Receptors R4 to R9 and R13).

6.8 I understand that applications for two building platforms (to be used for worker accommodation) (R6 and R9) were lodged and granted after the applications for the quarry expansion were lodged. R6 is located between the established cherry orchard on the Amisfield Orchard land and the eastern boundary of the proposed expansion area. I estimate R6 is approximately 40 m to the east of the proposed expansion area and 50m from the active quarry area on the expansion land. R9 is located a similar distance to the south of the new expansion area . The existing dwelling/worker accommodation building on the Amisfield Orchard land (R13) is 140 m to the east southeast of the proposed expansion area.

6.9 Immediately to the south of the expansion area is a 115 m wide section of the existing quarry.

Neighbouring activities - Existing quarry area

6.10 To the north of the existing quarry's active mining and stockpiling areas is the Clark's rural property. The notional boundary of Clark's house (R12) is approximately 200 m from the existing quarry, while their commercial storage shed (R1) is approximately 35 m north of the existing quarry and the future underground access to the new expansion area.

6.11 There are also established vineyards (R11) owned by Manuka Fifty at approximately 20 m to the north of the existing quarry entrance and stockpiling areas.

6.12 At approximately 70 m to the east of the existing quarry is the southern extent of Amisfield Orchard's existing cherry orchard (R8). The consented building platform (R9) is approximately 40 m to the east, whereas the existing dwelling/worker accommodation (R13) is approximately 180 m east of the existing quarry.

6.13 To the south of the existing quarry is land owned by the Hayden Little Family Trust which is being developed into a new cherry orchard (R18 and R19). That land is approximately 70 m from the existing quarry. The consented building platform on that land (R9) is located about 30 m from the existing quarry.

6.14 There is a residential dwelling (90 Smiths Way)[9] whose notional boundary is approximately 340 m to the south of the existing quarry (R14).

6.15 There is an established cherry orchard (owned by Mr Douglas Cook) located approximately 50 m south-west of the existing quarry (R17). In my view, this orchard would be the most frequently exposed to dust discharges to air from the existing quarry (i.e., during prevalent north easterly winds).

6.16 To the west of the quarry and across Luggate Cromwell Road there are established vineyards (100 m away) and residential properties. This includes houses with notional boundaries of 470 m (southwest), and approximately 100 m to the northwest of the existing quarry (respectively R16, and R15).

6.17 Amisfield Road, which is located to the south of Hayden Little Family Trust's southern orchard is a small gravelled road which provides public access to Lake Dunstan and both the Hayden little Family Trust and Amisfield Orchard. Approximately 2 km to the south of the existing quarry are the two large quarries at Parkburn, operated by Downer and Fulton Hogan. As described in the s42A report, the

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9 Owned by Towyn Trust and Lake Terrace Cherries Limited.

residential settlement of Pisa Moorings is located immediately adjacent to Fulton Hogan's quarry and the nearest house is 45m (and its notional boundary only 25 m from the quarry). Also there appears to be a cherry orchard with a pack house and office located directly across the site boundary. As with the Cook cherry orchard, this would be most exposed to any quarry dust emissions during prevalent north east winds.

7 TOPOGRAPHY/SITE WIND PATTERN

7.1 The site is located down within a valley system (which is approximately 4 km across including Lake Dunstan) and is bounded on both sides by substantive mountain ranges (reaching over 1000 m) which are within a north-east to south-west alignment. At the north-eastern end of this system, it widens into the Tarras basin (i.e., near the point where Lake Dunstan is fed by the Clutha River).

7.2 These terrain features influence the dominant winds which blow from the southwest and north east directions. I expect that regional katabatic drainage flows would flow from the north-eastern head of the valley and down the lake, towards Cromwell. This regional cold air drainage flow would no doubt interact with local drainage flows emanating from the northwest and southeast, due to cold air moving down the slopes of the local mountain ranges which bound Lake Dunstan. Conversely light adiabatic winds on warm days will flow in the reverse directions described for katabatic winds.

7.3 Although these light katabatic and adiabatic wind conditions are not widely discussed by accepted dust management guidelines[10,11], they are relevant considerations for dust impact assessments as they can be associated with off-site dust impacts from haul roads, or other areas of the quarry where dust is generated by truck movements.

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10 MfE 2016. Good Practice Guide for Assessing and Managing Dust. Wellington: Ministry for the Environment. Publication number: ME 1277.

11 IAQM 2016. Guidance on the Assessment of Minerals Dust Impacts for Planning, Version 1.1 (Institute of Air Quality Management, 2016). www.iaqm.co.uk.

Site Wind Patterns

7.4 The wind patterns at the site are described by Beca (2020)[1] using surface wind measurements from the nearby Fulton Hogan site from September 2019 to April 2020. I agree with the use of this data, but have collected further data from September 2019 to December 2020. Furthermore, I have had weather modelling undertake for the site using (TAPM) and diagnostic wind field model (CALMET) for the 2018, 2019 and 2020 years. This has produced predicted wind information for 6 km by 9 km area (encompassing both the Parkburn quarries and the Amisfield quarry site). The modelling is documented in **Attachment D** to my evidence.

7.5 The site's surface wind patterns predicted via that modelling are similar to those measured at the Parkburn sites, but predict less northerly winds and a greater frequency of south-westerly and north-easterly winds.

7.6 I was able to access Harvest.com wind and rainfall data[12], which is collected at Mr Cook's cherry orchard (south west of the existing quarry). Wind roses for this data are also provided in **Attachment D** and are compared to the three years of CALMET wind data. Unfortunately Harvest installed that weather station in the shadow of a container which explains its unusually high frequency of light winds and low frequency of strong wind conditions when compared to the CALMET data sets. Therefore for my own assessments, I have relied on the use of these modelled wind data sets for site.

7.7 The CALMET wind rose plots for 2018 and 2019 in Figure 3, **Attachment D** can be compared to that modelled for 2020, which is influenced by winds measured at the Parkburn sites. In my opinion, the modelled wind rose patterns (with and without the use of Parkburn surface data inputs) provide a useful range of estimates for the true long term wind pattern at the site (i.e., the wind roses in Figure 3 for 2018, 2019 and 2020).

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[12] Harvest electronics sets up and operates weather monitoring services for clients throughout New Zealand.

Site Rainfall Patterns

7.8 I have utilised 10 years of hourly rainfall data collected at the Cromwell weather station (2010 through the end of 2020). This station is 12 km southwest of the site, and its data used to confirm dates of wet and dry days for the 3 years of wind modelling (2018, 2019 and 2020). The analysis of 26,280 hours of rainfall data is documented in **Attachment E** to my evidence.

7.9 As with the modelled wind data for the site, I have compared the Cromwell rainfall data against the rainfall data records from the Harvest operated weather station at Mr Cook's orchard (see last pages of **Attachment E**). There is a sufficiently close match in rainfall between the two sites, so I consider that it is appropriate to use of Cromwell rain data for the analysis of wet days at the site.

7.10 The analysis of rainfall data from the Cromwell weather station indicates the months of May, June, and July tend to be wet most days. This decreases in August but this month is still relatively wet. By comparison, the months of April and September can be relatively dry (with only 2 days of rain each), but can also approach 1 in 3 days being wet for some years.

7.11 The months of October to March are relatively dry with an approximate average of 3 days a month being wet.

7.12 Given the above, I expect that ground conditions (when above the water table) at the quarry site will be relatively wet during the months of May, June and July and probably do not start to dry out (if much at all) until September. Ground conditions are likely to become relatively dry sometime during October each year and remain dry until frequent rainfall events commence again in May the following year.

7.13 The months of November through to April would have the most dry ground conditions and therefore are the most prone to dust erosion during dry windy conditions.

Dry Windy Days

7.14 To be able to assess potential effects on any one receptor, it is important to understand the frequency in which they would be downwind of active exposed quarry areas during dry windy days (when there is potential for surface dust erosion), how long these episodes last for, and also the typical lag between dust events.

7.15 The frequency of being downwind during dry windy days will vary significantly for different offsite locations. Table 1 below (reproduced from Table 2, **Attachment G** to my evidence) shows the calculated frequency of dry windy conditions, for all receptor locations shown in Figure 1 of this evidence.

Table 1: Frequency of receptors downwind of CPA and excavation areas during dry windy conditions

Receptor	Autumn (%)	Spring (%)	Summer (%)	Winter (%)
R1	**4.9**	**7.6**	**7**	1
R2	**4.6**	**6.6**	**9.4**	1.5
R3	1.8	2.2	2.5	0.4
R4	0.1	0	0	0
R5	0.1	0	0	0
R6	0.1	0.3	0.3	0.1
R7	0	0.1	0.1	0.1
R8	0	0.4	0.5	0.1
R9	0.1	1	1.1	0.1
R10	0.8	0.6	1.1	0.1
R11	**3.4**	**3.6**	**6.5**	0.8
R12	1.4	1.8	2.1	0.2
R13	0	0.2	0.2	0.1
R14	0.4	2.9	2.7	0.3
R15	0.4	0.8	1.9	0.1
R16	0.7	0.5	0.7	0.1
R17	**4.9**	**9.6**	**8.5**	1.2
R18	**4.3**	**10.7**	**9.5**	1.3
R19	**2.8**	**8**	**6.3**	1

7.16 Table 1 indicates that most receptors will only be downwind of active quarry areas (defined as purple shaded areas in Figure 1, **Attachment F**) a low percentage of time during dry windy conditions. The exceptions are for locations to the north and to the south to southwest of the active areas (R1, R2, R11, R17, R18 & R19), which have higher frequencies. This includes the DoC Reserve north of the expansion area. It also includes the existing Cook cherry orchard and the establishing Hayden Little Family Trust cherry orchard, which are southwest and south of the existing central processing area.

7.17 For potential dust erosion impacts, it is also important to understand the typical duration of exposure to specific dry windy episodes and the lag time between these events.

7.18 **Attachment G** to my evidence provides an analysis of duration for each receptor being downwind of open areas of quarry during dry windy conditions as well as the lag time between such conditions occurring. On average, offsite receptors can be downwind of active open areas of the quarry during dry windy conditions for several hours in summer, autumn and spring. However the plots in **Attachment G** also indicate that some offsite receptors (i.e., R1, R2, R11, R17, R18, & R19) can sometimes be downwind of open quarry areas for periods of 1 to almost 2 days, when a dry windy southerly or north easterly is blowing.

Background Air Quality

7.19 The Beca 2020 report estimated background ambient total suspended particulate and dust deposition levels (respectively being 10-20 µg/m^3 as a 24 hour average and 1 g/m^2/30-days), which I consider to be realistic for Amisfield. From experience, I estimate this environment to have ballpark peak 1 hour and 24 hour PM_{10} values of at least 50 µg/m^3 and 30 µg/m^3, respectively.

7.20 I expect 24 hour $PM_{2.5}$ to be very approximately 1/3rd of background PM_{10} concentrations (≈7 µg/m^3). Furthermore, I expect that background annual average PM_{10} and $PM_{2.5}$ concentrations would be in the order of 12 µg/m^3 and 4 µg/m^3, respectively. These are estimate from my experience of other rural airsheds with good air quality, the actual values maybe up to 20% higher).

7.21 I consider that background respirable crystalline silica (RCS) concentrations would be close to zero for both hourly and annual average time frames. This material is produced by blasting and crushing activities, but is not a significant component of natural windblown dust.

7.22 In summary, I estimate the following background concentrations for various respirable particulate size ranges, as follows:

- 1-hr PM_{10}: ≥ 50 µg/m^3 (Peak)
- 24-hr PM_{10}: 15 - 20 µg/m^3 (typical)
- 24-hr PM_{10}: 30 µg/m^3 (Peak)
- Annual PM_{10}: 12 µg/m^3
- 1-hr $PM_{2.5}$: 7 µg/m^3
- 24-hr $PM_{2.5}$: 7 µg/m^3
- Annual $PM_{2.5}$: 4 µg/m^3

7.23 Overall, I expect that background air quality is good most of the time and typical for a rural working environment. During strong dry north easterly winds, the background levels of sediment-based particulate may increase from exposed dry areas of the Clutha Riverbed, rural unpaved roads and land.

Sensitivity of Receptors to Quarry Dust Impacts

7.24 The Clark dwelling (R12), and the consented worker accommodation on the Amisfield Orchard property (R6)are the nearest residential land uses, and by the nature of those uses, would have a high sensitivity to dust emissions when downwind of active quarry areas or haul roads. If a dwelling were consented at R9, the same would apply.

7.25 The very close proximity of the Clark's commercial storage facility to new haul roads, the existing quarry's central processing area and proposed expansion area means that this activity may also have a high sensitivity to dust emissions from the haul road as well as any uncontrolled dust emissions from the existing quarry.

7.26 With respect to the orchards and DoC Reserve land, I consider these to generally have moderate to high sensitivity to dust emissions. However there may be times when orchards are more sensitive to dust impacts, for during example during flowering in spring.

8 POTENTIAL AMBIENT DUST EFFECTS OF THE PROPOSAL

Health Effects on People

8.1 The potential adverse effects on people from the discharge of dust from the quarry if not controlled appropriately includes health effects, general dust nuisance and amenity effects.

8.2 Health effects are generally associated with exposure to the fine size fractions of dust, which are the most prone to travelling beyond quarry boundaries. These include the respirable dust fraction that is ten microns or less (PM_{10}). The fine respirable particulate fraction that is 2.5 microns or less (referred to as $PM_{2.5}$) creates the most potential for health effects on people, but this size range is relatively small for quarry dust which is generated from abrasion of larger particles. The effects of respirable particulate are generally related to respiratory and pulmonary and cardiovascular diseases in humans and other mammals.

8.3 Respirable crystalline silica (RCS) is another fraction of PM_{10}, which is measured within particles of 4.0 microns or less. RCS exposure to humans is associated with silicosis which is another form of pulmonary disease resulting from crystalline forms of silica being breathed. As discussed, RCS is a significant natural component of the greywacke rock at the site. However it generally requires crushing and/or blasting to be released from the quarried aggregate and tends only to occur at unsafe ambient levels within some onsite mining/quarrying environments, such as where the aggregate process plant is enclosed.

8.4 The relevant ambient criteria for the protection of human health from the above fractions of dust are listed in the following table.

Table 2: Summary of respirable particulate concentration criteria

Contaminant	Criteria (µg/m³)	Averaging period	Allowable exceedances per year	Source
PM_{10}	50	24-hour	1	NESAQ*
	20	Annual	0	AAQG#
$PM_{2.5}$	25	24-hour	3	WHO+
	10	Annual	0	WHO+
$PM_{2.5}$	15	24-hour	3	Proposed by WHO
	5	Annual	0	Proposed by WHO
RCS	3##	Annual	N/A	OEHHA**
RCS	47	1-hour	N/A	TCEQ%

Based on the $PM_{4.0}$ size fraction.

* MfE National Environmental Standards for Air Quality (NESAQ)

MfE Ambient Air Quality Guidelines for Air Quality (AAQGs)

+ World Health Organisation (WHO)

** California Office of Environmental Health Hazard Assessment (OEHHA)

% Texas Commission on Environmental Quality

8.5 The NESAQ standards are designed to protect public health (including vulnerable groups such as asthmatics, elderly and children) and the environment of New Zealand by, among other things, setting concentration limits for criteria air pollutants. The contaminant relevant to this application is PM_{10}.

8.6 Regulation 17 of the NESAQ restricts the granting of a new resource consent for discharges of PM_{10} if the discharge would be likely to increase 24-hour average PM_{10} concentrations in a polluted airshed by more than 2.5 µg/m^3 (unless this can be offset).

8.7 However the nearest polluted air shed is the Cromwell Air Zone, which is approximately 10.5 km to the south of the quarry. Therefore Regulation 17 does not apply to this application.

8.8 Ministry for the Environment has proposed amendments to the NESAQ which includes adoption of the current WHO criteria listed in the above table. I should note that WHO are currently considering a reduction to existing $PM_{2.5}$ criteria, which are detailed in the above table.

8.9 There are no MfE criteria for respirable crystalline silica (RCS). In such cases, it is good practice to use other credible sources such WHO, OEHHA and TCEQ. The TCEQ criteria for 1-hour RCS exposure was established and agreed recently via Joint Witness

Statement between myself and other air quality experts and an expert toxicologist[13].

Nuisance Effects on People

8.10 The MfE dust guide[12] recommends a "trigger" level for deposited dust of no more than 4 g/m^2/30-days above background levels, which applies to residential areas. This only applies to inert sediment type dust such at that produced at this site. This is a very general guideline value and so for sensitive receptors such as residential dwellings, actual residual deposition rates from an activity would preferably be well with this value. I assume this is applicable to commercial crops such as cherries, this long term deposition trigger rate of insert sediment dust is specified for sensitive residential activities, and equates to daily average value of only 0.13 g/m^2/day.

8.11 Table 4 of the MfE dust guide recommends "trigger" levels for total suspended particulate (TSP) concentrations for a range of receiving environment sensitivities and averaging times. It appears that these triggers are relevant to the receiving environment, as opposed to the site boundary of a quarry. A summary of MfE dust nuisance criteria for ambient TSP and high sensitivity receptors (e.g. a house hold) are as follows:

- 250 µg/m^3 (5 min)
- 200 µg/m^3 (1 hour)
- 60 µg/m^3 (24 hour)

8.12 MfE indicates that these criteria have been used for successfully controlling dust generated by NZTA roading construction projects in New Zealand, however there is no published reporting of this experience referenced in the MfE dust guide. The 5-minute and

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13 Joint Witness Statement of D Ryan, R Cudmore, A Wagner, Charlie Kirkby, and L Wickham, 14 November 2019, 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 Roads, Templeton.

24-hour TSP triggers do appear to be very low in comparison with the 1-hour TSP trigger value of 200 μg/m^3.

8.13 Notwithstanding this, I recommend the use of the PM_{10} trigger value of 150 μg/m^3 (1-hour average). TSP is more difficult to measure accurately with continuous light scattering devices, and ambient TSP levels change dramatically with distance due to the gravity deposition of heavy particles. Therefore in my opinion, the PM_{10} trigger value is a more reliable basis for establishing a trigger for protection against both nuisance and health effects of suspended particulate. It is also less sensitive to location from the source, as is TSP, due to gravity settling of heavy particles.

8.14 The MfE dust guide's recommended trigger levels are for areas with a high sensitivity such as residences. This would not apply to the boundary of a quarry. Further, once dust has travelled over several hundred meters, then the remaining suspect particulate would be effectively managed by the 1-hour PM_{10} trigger value, when this is also conservatively applied to the site boundary.

Adverse Crop Effects

8.15 To inform my assessment of the potential effects of quarry dust on surrounding commercial crops, I asked a horticulturist at WSP[14] to undertake a literature review for any guidelines for dust impacts on crops or other applicable research. I also sought the advice of a plant physiologist, Ruth Underwood, a horticultural consultancy.

8.16 From the above, it is my understanding that the potential effects of dust on commercial crops includes:

(a) Potential for reduction in photosynthetic activity (and potential consequential loss of production) if dust were to be deposited on leaves or rain covers at levels which block the amount of light needed for photosynthesis to occur;

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14 Lisa Arnold (August 2021): Memorandum to Roger Cudmore, Amisfield Quarry – potential effects of dust on orchards.

(b) Deposits of dust on vegetation or fruit combining with moisture from rain or sprays, leading to potential fungal/mould damage to fruit;

(c) Inhibiting insects which control pests and enabling pests to flourish;

(d) Inhibiting spray effectiveness for control of pests;

(e) Interference with stomata on leaves; and

(f) Down grading of fruit value due to contamination around the time of harvest and especially at fruit washing and packing stages.

8.17 Given the above, there are clearly key times of the year when the crops are more sensitive to dust impacts (flowering and harvesting), and it also appears that short-term dust impacts from specific dust events are of most relevance to potential adverse effects on crops.

8.18 I understand that flowering in the spring occurs mainly from September through to mid-October and harvesting can occur through the summer to early Autumn.

8.19 As with general nuisance, I consider that potential for dust impacts on any sensitive receptor under lighter wind conditions is an important consideration (and often over looked). With respect to potential effects of dust on crops, I consider that strong dry wind events may not be the significant driver of potential adverse effects.

8.20 There are also combination light wind conditions, when any uncontrolled dust generated by truck/loader movements could drift off-site (if not controlled) with restricted dispersion. This could in practice be the main driver of potential effects. Such conditions result in less effective dilution of dust emissions, and if this was not controlled and was to disperse onto damp crops such as after spraying events) could lead to high retention of dust onto leaves, flowers or fruit. Note this dust is most likely to impact via dispersion, rather than settling out of atmosphere and depositing onto crops.

8.21 Strong dry winds associated with potential dust discharges from the quarry could subject crops to the highest ambient dust exposures. However there is likely to be lower potential for retention of dust on vegetation/fruit due to wind strength and dryness of the crop itself. I also understand that bees tend to stay in the hive during windy conditions when there is the potential for surface dust erosion. They also tend to avoid rain, but will leave the hive once rain has cleared.

8.22 I have investigated relevant ambient dust criteria for the protection of crops. There is very little industry or national guidance with respect to this. This aside, I consider that the long term nuisance criteria for settleable dust (4 g/m^2/30 days, discussed in paragraph 8.10) is likely to provide a useful guide as to the level within which long term dust deposition should be well within (i.e. >50 % of this criteria) to avoid adverse crop and associated infrastructure effects (such as on covering/shading systems).

8.23 With regards to short-term criteria, I rely on the information provided by WSP[16], this quotes research which points to adverse effects on photosynthesis, transpiration and respiration of plants occurring above 1.0 g/m^2/day of dust deposition. Research into the impact of road generated dust on crops in New Zealand was also discussed by WSP and is relevant to the dust generated in this instance. This research also supports the criteria of 1.0 g/m^2/day to protect crops from adverse effects due to quarry dust deposition (via gravitational settling and impaction processes). I should note that dust from some industrial sources, which is more chemically active than inert dust from alluvial quarries, is likely to require lower criteria to avoid adverse effects.

8.24 In summary, there are a range of potential ways for dust emissions to adversely affect crop production and quality. I consider that the daily and monthly criteria discussed above provides a upper limit to dust impacts (via direction impaction and gravity settling) which are likely result in effects that are minor or less. Ms Underwood can comment further on the use of these criteria in absence of the crop industry having any of their own criteria.

9 PROPOSED DUST MITIGATION INCLUDING KEY ASPECTS OF THE DUST MANAGEMENT PLAN

9.1 The draft DMP prepared by Beca recommended a number of dust mitigation measures within Section 7.1 and 7.2. Those incorporated most best practice dust management methods for alluvial quarries. However, there are some aspects I have modified in an updated draft DMP[6]. I have also incorporated some additional measures and provided more certainty around procedures.

9.2 My view is that the application of water to unpaved site roads should be used when needed and as a contingency, and not relied on as the primary dust mitigation measure. The primary mitigation method should be the maintenance of access roads and haul roads such that they maintain low levels of silt in the surface layer (approximately 20 mm to 50 mm thickness), so there is minimal visible dust generated from truck movements or wind erosion. In this state, vehicle speed restrictions need only relate to health and safety outcomes. As such the DMP now has a limit of 30 km/hr, instead of the usual impractical limits of 15 – 20 km/hr which are often specified in DMPs.

9.3 I am also of the view that speed restrictions on haul roads are generally ineffective when the road surfaces themselves are not adequately maintained.

9.4 Therefore I recommend that unpaved site roads, which are used by haul trucks and for transporting aggregates off site, are constructed using clean aggregate (or any clean reject gravels, crushed or uncrushed) which is practical to use for road surfaces.

9.5 I also recommend that this clean aggregate is replenished as necessary to ensure low levels of silts, which will allow for truck movements at 30 km/hr while not producing visible dust emissions.

9.6 Another key aspect of the updated draft DMP is the use of clean aggregate (typically washed reject gravel) to cover large areas of the quarry pit, or open areas which are awaiting rehabilitation, or stripped prior to quarrying and are non-active.

9.7 With respect to the stripping of topsoil and overburden material prior to quarrying, I recommend this occurs in winter months when ground conditions are damp, and that bunds are formed and able to support vegetation growth at the start of the spring season. Furthermore, that the stripped and exposed non active areas of the new quarry are also covered with clean gravel.

9.8 Although recommended by the MfE dust guide, I do not consider that tree shelter belts are a useful dust mitigation measure. Tree shelter belts can exacerbate the intensity of offsite dust impacts (acute dust impact events) during strong wind events – these typically result in trees discharging a large dust plume over several hours or much less, which has been accumulated over the previous weeks or much longer.

9.9 Table 7-1 of the Beca 2021 report[5] provides recommended TSP based trigger levels for ceasing quarry activities, and/or implementing additional dust mitigation measures. My view is that this pro-active monitoring of dust at the boundary and the quarry management responding to real-time ambient PM_{10} levels represents best practice for the industry. This is supported by the regional governance body of the London region[15], which is also referred to by the MfE Dust guide.

9.10 As such, I recommend the use of real time continuous PM_{10} monitoring at the quarry boundary and adopting a 1-hour average trigger value of 150 μg/m^3. This is consider to be international best practice[15] and referenced by the MfE dust guide. Note that during monitoring the this value would be updated once every 10 minutes.

9.11 Another key recommendation in the draft DMP is the requirement that when trigger values are reached or exceeded, dust mitigation actions to be actioned irrespective of what is downwind of the monitor and how far away it is. This is a simplification to the initial draft of the DMP (where actions are on the proviso of sensitive receptors within a specified distance downwind).

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15 Greater London Authority. 2014. The Control of Dust and Emissions During Construction and Demolition – Supplementary Planning Guidance. London: Greater London Authority. Also referenced in the MfE dust guide[10]

9.12 As such, I have worded the updated DMP, and consent conditions so these are more clear about the location of real-time dust monitors (including one at a permanent site and at least two mobile units), which will be positioned at strategic locations (in agreement with the ORC). Further, the requirement for quarry activities to cease operation applies to relevant activities which could potentially cause a dust event. This requires real-time wind information and GPS location of each monitor to be known in real time. This has been required as a condition of air consent for quarries in Canterbury.

9.13 The Beca report recommends a wind speed threshold trigger of 5 m/s as a 1-hour average. This is the value used in the IAQM risk assessment method[12], but is well below the typical threshold speed where dust erosion becomes significant. This occurs around 7 m/s. This threshold velocity (as a 1-hour average) has been typically assumed to be the velocity when mobilising dust from a quarry surface can become significant. As such this threshold speed is commonly referenced in quarry DMP's.

9.14 I recommend a monitoring mast height of 6 m above ground level to ensure routine servicing and calibration of instruments is much easier than when otherwise using a 10 m mast height. This reduced height effectively increases the threshold wind speed at 10 m height, so therefore reducing the averaging period can be used to offset this factor. Furthermore, a sub hourly average time is desirable for dust effects management.

9.15 Given the above, I recommend that the averaging time for the 7 m/s wind speed, be reduced from 1-hour to a ten minute rolling average, which is updated once per minute. This value has been included into the draft DMP which provided in **Attachment H**. It is proposed to be provided to ORC for certification before the new consents (if granted) are exercised. The key approach for controlling dust emissions after hours is to ensure haul roads are not prone to dust erosion, and that only some fine chip material stockpiles and limited areas around the excavation site could require watering.

10 ASSESSMENT OF QUARRY DUST EFFECTS WITH PROPOSED MITIGATION

General Approach

10.1 The general approach for assessing potential dust effects from quarries is to consider the extent and type of mitigation measures that are likely to be necessary to avoid nuisance and health effects beyond the site boundary. This largely the approach I have taken for this assessment.

10.2 However my assessment has also been assisted by the following:

(a) Use of the models CALPUFF, TAPM and CALMET to generate 3 years of hourly site specific meteorological data and simulation of dust impacts which could result from an uncontrolled haul road servicing the expansion land's excavation area and the central processing plant.

(b) Meteorological modelling of site specific wind patterns to (results and details in **Attachment D** to my evidence) augment existing available monitoring data from Fulton Hogan's Parkburn quarry.

(c) Analysis of hourly rainfall data from Cromwell (results and details in **Attachment E** to my evidence) and rainfall data from the nearby Cook orchard to combine with modelled hourly wind data over a 3 year period of 2018, 2019 and 2020.

(d) Dispersion modelling of ambient dust concentrations and deposition rates (results and details in **Attachment F** to my evidence) for various timeframes would could arise from uncontrolled dust emissions from the new expansion area haul road. I consider this to be the most significant potential source of dust discharge.

(e) Analysis of dry and wet day frequency for each month of the year, including the frequency of dry windy conditions, their typical duration and lag time between these events which create the potential for surface dust erosion if not controlled (results and details in **Attachment G** to my evidence).

10.3 To be clear, all the above modelling of wind and particulate impacts has not been used as per a conventional modelling, whereby modelling of all sources and subsequent cumulative impacts is used to confirm the potential dust effects of a proposal. The modelling has focused specifically on truck wheel induced emissions from the haul road for the new expansion area only. The approximate uncontrolled dust emissions (and associated size fractions) from this key source can be predicted. Furthermore, if uncontrolled, it would be the most significant source of dust impact on the Clark property and Amisfield Orchard property. The modelled dust impacts from truck movements on haul roads, help to clarify which receptors have relative low or high risk to dust effects and the degree of dust mitigation required – especially during key periods of spring and summer. As such I will refer to this information which has been generated for a wide range of sensitive receptor locations.

10.4 I also note that modelling based assessments of potential health and nuisance impacts is not usually undertaken for quarry proposals in New Zealand. However I considered that instructive information can be obtained by modelling dust emissions from a unpaved internal haul road between the gravel excavation and the central processing area (CPA), when using accepted emission factors. This is because of its proximity to the nearest residential dwellings, and in my view, it would be the most significant source of nuisance dust and respirable particulate discharge, if not controlled.

10.5 Notwithstanding the above, the difficulty in reliably modelling surface erosion type processes, makes this less practical to undertake a reliably modelling-based assessment of cumulative impacts due to all potential dust sources within the quarry. As such, full blown modelling based assessments are not commonly undertaken for the assessment of quarry dust impacts in New Zealand.

Potential Health Effects – respirable dust

10.6 When assessing potential health effects, I focused on the three closest residential locations, including the Clark dwelling (R12), the consented worker accommodation units at the existing Little

Orchard (R6 and R9), and the nearest house to the existing quarry at 7 Mt Pisa Road (R15).

10.7 The Clark dwelling (R12) is relatively close (110 m) to the proposed new quarry expansion area. However its location is such that it is only downwind of active and dry quarry areas (excavation of new area and existing central processing) during more infrequent wind conditions.

10.8 While the dwelling is downwind of a large area of the existing quarry during frequent southerly winds, the further excavations proposed within the existing quarry will largely involve wet conditions as the excavation will extend into the local groundwater table and effectively result in gravel being dredged. While there are aggregate stockpiles within the existing quarry within 200 -300 m of the nearest residential dwellings, these are not significant sources of dust given product is washed and any dust arising can be readily eliminated via wetting and use of polymer (as proposed in the draft DMP).

10.9 I consider that Clark dwelling (R12) would have the most potential (of all sensitive receptors) for any adverse dust impacts as a result of the future haul road within the new expansion area. The potential for these impacts to cause effects is addressed by maintaining the haul road surfaces with clean aggregate, as specified in the draft DMP[6].

10.10 Table 8 in **Attachment F** to my evidence show that wheel generated dust from an uncontrolled internal haul road (within the expansion land) could cause maximum daily and annual PM_{10} concentrations which are respectively 20 % and 5 % of the relevant health-based NESAQ and WHO criteria for PM_{10}.

10.11 These increases would be unlikely to cause a breach of either the NESAQ or AAQG health criteria (when allowing for background 24-hour concentration 30 $\mu g/m^3$). However the haul road mitigation measures proposed in the DMP would readily achieve a 90% reduction in the particulate emission rates derived from standard emission factor equations for unpaved roads (detailed in **Attachment F**). In my view, this would ensure that the new haul road (with proposed mitigation) would cause existing background 24 hour and annual average background PM_{10} concentrations to increase respectively, by a maximum of approximately 5 % and < 1%.

10.12 Given $PM_{2.5}$ emissions from haul roads due to truck movements are in the order of 10% of the PM_{10} emission (see Table 2, **Attachment F**), then the residual increase $PM_{2.5}$ from the new haul road is likely to be negligible. With the proposed mitigation, the existing background 24 hour and annual $PM_{2.5}$ concentrations would only increase in the order of 1.5 % and 0.2 %, respectively.

10.13 The predicted maximum annual and 1-hour average $PM_{2.5}$ concentrations at the Clark house (or any location) due to the haul road provides a reliable basis for estimating maximum annual and 1-hour average RSC concentrations. I have previously analysed the RCS versus $PM_{2.5}$ data reported by Mote (2018)[16], which was established by the study of RCS concentrations downwind of the large Yaldhurst alluvial quarrying sites near Christchurch. My analysis of the Mote results has found that RCS concentrations were approximately 6% of $PM_{2.5}$ concentrations[17]. Therefore, when allowing for the higher RCS content of the Greywacke gravels at Amisfield compared to Yaldhurst, a reasonable estimate of RCS concentration would be 10% of the $PM_{2.5}$ value for any one location.

10.14 Therefore at the Clark household, the worst-case RCS concentrations due to haul road dust (without any dust controls), would be approximately 0.3% and 1.3%, respectively of the WHO criteria for annual average RCS and the TCEQ criteria for 1-hour RCS.

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16 Mote (2018). Yaldhurst Air Quality Monitoring: Summary Report: 22 December-21 April 2018. Prepared for Environment Canterbury, June 2018, Paul Baynham, Mote Ltd.

17 The raw data from the Mote (2018) study was analysed and results presented in statement evidence of R Cudmore, 23 September 2019, presented at hearings for applications by Fulton Hogan Limited for all resource consents necessary to establish, operate, maintain and close an aggregate quarry (Roydon Quarry), Templeton.

10.15 The same analysis described above has also been undertaken for the nearest off-site residential dwelling locations with results summarised in Table 3 as follows:

Table 3: Summary of maximum respirable particulate impacts from truck induced haul road emissions (assuming proposed mitigation)

Contaminant	Criteria (µg/m³)	% Increase against criteria				% Increase to Background			
		R6	R9	R12	R15	R6	R9	R12	R15
PM_{10}	50 (24-hour) *	3.5	3.3	2.0	0.6	9	8	5	2
	20 (annual) #	0.5	0.6	0.5	0.05	0.8	0.9	0.8	0.1
$PM_{2.5}$	25 (24-hour) +	0.7	0.7	0.4	0.1	2.5	2.4	1.5	0.4
	10 (annual) +	0.1	0.1	0.1	0.01	0.2	0.3	0.2	0.03
RSC	3 (annual) **	0.3	0.4	0.3	0.03	-	-	-	-
RSC	47(1-hour) %	2.5	2.0	1.3	0.6	-	-	-	-

Based on the $PM_{4.0}$ size fraction.

* MfE National Environmental Standards for Air Quality (NESAQ)

MfE Ambient Air Quality Guidelines for Air Quality (AAQGs)

\+ World Health Organisation (WHO)

** California Office of Environmental Health Hazard Assessment (OEHHA)

% Texas Commission on Environmental Quality

10.16 Results in **Attachment F** for receptors R6 and R9 show that wheel generated dust from an uncontrolled internal haul road within the new expansion area could cause maximum daily and annual PM_{10} concentrations which are respectively 35 % and 5 % of the relevant health-based NESAQ and WHO criteria for PM_{10}.

10.17 Table 3 above highlights the expected particulate impacts from truck movements on the main haul road, given the proposed mitigation. This indicates that the existing 24 hour and annual average background PM_{10} concentrations would increase respectively, by an approximate maximum of 9% and < 1% (for locations R6 and R9).

10.18 Likewise the increase in $PM_{2.5}$ from the new haul road at R6 and R9 is likely to be negligible (i.e., the existing background 24 hour and annual $PM_{2.5}$ concentrations (approximately 7 µg/m^3 and 4 µg/m^3, respectively), would only increase in the order of 2.5 % and 0.3 %, respectively.

10.19 The predicted annual and 1-hour average RCS concentrations at R6 and R9, with proposed mitigation (based on a conservative assumption that $PM_{2.5}$ concentrations equate to RCS), are conservatively estimated to reach a maximum of 0.4 % and 2.5 % of their respective heath guideline criteria.

10.20 The respirable particulate results in Table 3 above, for the residential dwelling at 7 Mt Pisa Road (R15) are very low. However, this location is much closer to the existing site access road to the quarry than it would be to the internal haul road for the new expansion area. In practice, I expect that any potential effects at this location would be similar level to those at R12 (the Clark dwelling).

10.21 In summary, the potential for health effects due to respirable particulate which could be generated from uncontrolled haul road dust emissions (due to truck movements) would most likely be minor at the nearest four residential dwellings. With the implementation of proposed measures to minimise haul road dust, I consider that the potential for health effects at these dwellings is likely to be well within guidelines and less than minor. For houses further afield, the potential for health effects would be lower again.

10.22 The modelling-based assessment of potential respirable dust impacts from the haul road within the proposed expansion area highlights the need to control the same emissions from the site access road and all other frequently trafficked areas within the site.

10.23 The other key outcome of this modelling is that this indicates that employing dust mitigation measures across the site such that boundary TSP concentration are routinely well below the proposed PM_{10} dust management trigger limit (1 hour average concentration of 150 $\mu g/m^3$) is very likely to ensure cumulative respirable dust emissions from the quarry only cause a less than minor potential for adverse health effects for all off site locations where people live or work.

Potential Nuisance Effects – Residential Dwellings

10.24 For the assessment of potential nuisance effects, I have focused on the same residential dwellings, which are closest to either the existing and/or proposed quarry expansion area (i.e., R12, R6, R9 and R15). Additionally, I have included the Clark's commercial storage business (R1), given this the closest activity to the existing quarry and proposed expansion area.

10.25 For the Clark dwelling, Table 5 (**Attachment F**) shows that wheel generated dust from an uncontrolled internal haul road (within the quarry expansion area) could cause daily TSP deposition rates to increase by a maximum of 0.07 g/m^2/day. This can be compared to approximate background deposition rates which are within the order of 0.03 g/m^2/day (based on typical values of 1.0 g/m^2/month). Without any controls, these modelled levels indicate some low to moderate nuisance from the haul road alone. With the proposed haul road controls, then the increased deposition would be reduced to well below levels that have a potential to cause conventional dust soiling type nuisance effects.

10.26 Haul road generated TSP concentrations for varying time frames are provided in Tables 5, 6 and 7 (**Attachment F**). For the Clark dwelling, the maximum TSP values are 29 µg/m^3 and 226 µg/m^3 respectively for 24 hour and 1 hour averages. Having regard to MfE nuisance criteria detailed in paragraph 8.11, these results indicate a potential for moderate nuisance from dust generated from an uncontrolled haul road within the expansion area. The proposed dust controls are therefore important, and will reduce actual impacts by a factor of ten, to well below nuisance threshold levels.

10.27 Unlike the truck generated dust emissions from haul roads, the quantification of reasonable surface dust erosion emissions rates associated with dry windy conditions (and subsequent modelling of impacts) is not practical in my view due to unreliable emission rate information. However a frequency and duration analysis of dry windy conditions has been undertaken to understand the dust erosion risk for specific offsite receptor locations. An analysis of these conditions for all identified receptors is provided in **Attachment G** for a future quarry development scenario, as shown in Figure 1, **Attachment G**.

10.28 I have chosen the above scenario, as the active extraction area would be at its closest proximity to the Clark dwelling. There are other scenarios I could have assessed but I consider that results from this scenario shown in Figure 1 of **Attachment G** are sufficient to inform the assessment of potential dust risk from wind erosion events.

10.29 The analysis undertaken for each off-site receptor, establishes:

(a) the fraction (%) downwind of active quarry areas (Table 2, **Attachment G**) during dry windy conditions;

(b) the typical duration (hours) of these events (Figure 2, **Attachment G**);

(c) the median lag times between these events (Figures 3 and 4, **Attachment G**); and

(d) the frequency of dry windy events outside of winter months.

10.30 The above frequency information is also presented as timeseries plots of dry windy conditions for each receptor location, when they would be downwind of the dust erosion source.

10.31 Table 4 below provides a summary of the above analysis, and subsequent dust impacts for all four nearest residential dwellings (R6, R9, R12 and R15and the Clark commercial storage building.

10.32 To reiterate, the TSP deposition rates and ambient concentrations in Table 4 below are related to uncontrolled dust emissions from a future unpaved haul road within the proposed quarry expansion area, whereas the % dry windy conditions and associated frequency duration results are associated with the future quarry development stage as presented in Figure 1 of **Attachment G**.

Table 4: Haul road dust impacts for nearby residential dwellings and R1

Parameter	Criteria	R1	R6	R9	R12	R15
Daily deposition (g/m^2/day)	**0.03#**	0.2	0.08	0.08	0.07	0.02
1-hour TSP (µg/m³)	**200**	804	446	355	226	114
24-hour TSP (µg/m³)	**60**	102	45	44	29	6
% dry windy conditions	**0.5***	7	0.3	1	2	2
No. dry-windy events (Jan-May)# #	n/a	42	5	11	23	17
No. dry-windy events (Sept-Dec) ##	n/a	58	7	19	15	24
Medium duration (hrs)+	n/a	2	1	2	2	2
Medium lag time (hrs)+	n/a	19	274	30	63	39

selected from year of highest annual frequencies (2018, 2019 and 2020)

based on daily average of typical background level of 1 g/m^2/day (not an official guideline)

* based on odour nuisance modelling criteria – assumed to indicate a maximum frequency associated with less than minor potential for nuisance due to dust erosion during dry windy conditions (not an official guideline)

+ For summer time conditions

10.33 This analysis indicates that the Clark dwelling (R12) would be downwind of the excavation area or the central processing area during dry windy conditions for about 2% of the time during summer. The median duration of dry windy conditions at this location is 2 hours with the median lag time lag between these wind events 63 hours during summer. During the year (but excluding the wet months of June, July and August), dry windy events at this location occur approximately once per week on average.

10.34 The lag-time between dry windy conditions of about 2.5 days provides some opportunity for an inventory of erodible dust[18] to establish on unpaved haul roads (due to surface abrasion from truck tyres), but it does not provide much opportunity for the site's stockpiles, or open inactive areas to replenish an inventory of erodible dust[19].

10.35 The analysis also shows a significant potential for haul road generated dust impacts at the Clark storage facility (R1), including both deposition and high ambient TSP levels. This building would be downwind of the expansion area's excavation area and/or the central processing areas during dry windy conditions, for about 7% of the time during summer. The median durations of these events is also 2 hours, however the median lag time lag between these wind events is only 19 hours during summer. The frequency of these events (outside of winter months), is high (i.e. approximately 2-3 times a week on average).

10.36 There is also significant potential for haul road generated dust impacts at worker accommodations(R6 and R9),consented for the Little cherry orchard (to the east of the new expansion area).

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18 Erodible dust is area material that is formed by aggregation or otherwise settles from the atmosphere and then readily entrained during subsequent dry windy conditions.

19 Note that individual erosion events tend to strip away the existing inventory of dust from a surface. Before another dust erosion event can occur, an inventory of new material need to establish over time.

However, these exposures are not associated with dry windy conditions and the potential exposure of these locations and the existing cherry orchard to dry dusty conditions is relatively low.

10.37 Location R6 is downwind during dry windy conditions for only 0.3% of the summer and averages just over one short duration event per month. The dwelling at location R9 has moderately higher exposure times which are associated with the existing quarry CPA, which in practice will have a low potential for surface dust erosion due to mining below the local groundwater table and subsequent rehabilitation.

10.38 In contrast to residential locations R6 and R9, the results in Table 4 indicates that the house at 7 Mt Pisa Road (R15) would have a relatively low exposure to dust emissions from an uncontrolled haul road within the quarry expansion area. However, compared to R6 and R9, this house would has a far more significant potential for exposure to surface dust erosion, which is generated within the CPA and site access road.

10.39 While not modelled, it is clear that truck movement induced dust emissions from unpaved sections of the site access road could also cause significant nuisance dust impacts at this location, if not mitigated by design and active controls.

10.40 In summary, the above results for these residential locations (R6, R9, R12 and R15) and the storage facility (R1) highlight significant differences in the risk of nuisance dust impacts (from the new expansion area haul road, or dust erosion) between these locations.

10.41 These results reinforce the importance of the internal haul road and site access road maintenance/mitigation, proposed in the DMP. This would avoid significant surface dust erosion events as well as wheel generated dust emissions. Although stockpiles would cause a much lower potential for dust emissions, routine watering (with polymers) of sand, soil/overburden stockpiles, and crusher dust stockpiles, ahead of dry windy conditions, is also recommended where these have not formed a natural vegetative layer. In my view, the proposed DMP should ensure that this occurs.

Potential Dust Impacts on Surrounding Orchards

10.42 The analysis of uncontrolled dust emission impacts associated with an unpaved/uncontrolled haul road within the proposed quarry expansion area, and analysis of dry windy conditions (for the quarry development stage presented in Figure 1 of **Attachment G**) has also been applied to surrounding orchard receptor locations and the DoC land immediately adjacent to the northern extent of the quarry expansion area (R2).

10.43 This analysis includes the vineyard to the north (R11), the established Cook cherry orchard to the southwest (R17) and the Little's new cherry orchard to the south of the CPA (R18 and R19) as the most impacted horticultural receptors. Table 5 provides frequency, duration information for dry windy conditions when specific receptor locations would be downwind. Again this analysis relates to the future quarry development scenario, as shown in Figure 1, **Attachment G**.

Table 5: Haul road dust impacts for nearby orchards & DoC land

Parameter	Criteria	R2	R11	R17	R18	R19
Daily deposition ($g/m^2/day$)	**1.0**[#]	0.1	0.04	0.05	0.05	0.07
1-hour TSP ($\mu g/m^3$)	**200**	380	232	200	200	265
24-hour TSP ($\mu g/m^3$)	**60**	30	18	16	24	40
% dry windy conditions	**0.5***	9	6.5	8.5	9.5	6.3
No. dry-windy events (Jan-April)	n/a	43	54	40	37	33
No. dry-windy events (Sept-Dec)	n/a	43	55	50	49	41
Medium duration (hrs)[+]	n/a	3.5	2	3	4	3
Medium lag time (hrs)[+]	n/a	19	17	15	17	18

[#] based on research into unpaved road dust impacts on crops by McCrae (1990)

[*] based on odour nuisance modelling criteria – assumed to indicate a maximum frequency associated with less than minor potential for nuisance due to dust erosion during dry windy conditions (not an official guideline)

[+] For summer time conditions

10.44 As can be seen above, the analysis confirms that any land/orchard to the north to north east or south to southwest of either the existing CPA or excavation areas in the expansion area, will be downwind of these areas during dry windy conditions for an average of several events per week (outside of winter months) lasting for 2 to 4 hours.

10.45 The dust deposition and ambient levels impacts due to the internal haul road at the orchards to the south and southwest of the site (R17, R18 and R19), are similar to those predicted for DoC land to the north (R2). They are also similar (albeit lower) to impacts at the consented accommodation facilities at the eastern edge of the Little's established cherry orchard (R6 and R9). These impacts differ little from those within this orchard at receptor locations R5 and R8.

10.46 The predicted deposition levels are very low against the 1 $g/m^2/day$ criterion, whilst the elevated ambient TSP concentrations are well above the PM_{10} 1-hour dust management trigger level. As a reminder, these modelled impacts relate solely to wheel generated dust from the main internal haul road alone (show in Figure 1 of **Attachment F**) and not cumulative dust impacts from all sources.

10.47 On my analysis the proposed dust mitigation measures for this road and other site haul roads, would reduce the dust impact concentrations presented in Table 5 to very low levels, and that dust deposition would then be negligible.

10.48 This aside, I anticipate that cumulative ambient dust concentrations due to the combined discharges from all uncontrolled unpaved haul and internal site roads, and to a lesser extent, stockpiles, could cause excessive contamination/soiling of orchard vegetation and fruit. This would not be driven by dry windy conditions and subsequent dust erosion, the mainly wheel generated dust emissions occurring during light, or even calm wind conditions. As such, I have recommended that the proposed dust mitigation is applied irrespective of wind speed, and to an extent that achieves routine compliance with the dust management trigger (at the site boundary), to ensure less than minor adverse effects on the surrounding commercial vineyards and orchards.

10.49 My view is that it is practical to employ the measures proposed in the DMP and to an extent that achieves the proposed dust management trigger level for hourly PM_{10} concentration at the site boundary. With this mitigation in place, then the relatively frequent occurrence of dry windy conditions are not likely to cause breaches of the PM_{10} trigger value and therefore adverse effects (due to short term elevated exposures or long term low level exposures) on commercial orchards during their more sensitive stages of production (i.e., flowering and harvesting) will only minor.

11 **PROPOSED CONDITIONS**

11.1 I have reviewed the conditions of recently granted consents for air discharges associated with alluvial gravel quarries in Canterbury (including consents for Fulton Hogan's Roydon quarry, Templeton at Dawsons Road, Carter's block extension at Miners Road, Yaldhurst) and conditions proposed by Taggart Earthmoving for a proposed new quarry at Rangiora[20]. Subsequently, I have utilised what I consider to be the most appropriate and relevant elements of those consents to prepare a draft set of conditions for this Proposal.

11.2 These conditions are attached to my evidence. I have also attached conditions, which have the amendments to those conditions which are recommended in the s42A report. My proposed conditions are heavily focused on the requirements of the DMP and specify the key dust mitigation measures and the PM_{10} dust trigger level at the site boundary. These are as per my recommendations in this evidence, as well as the new dust and wind monitoring requirements and associated trigger levels. Therefore I am satisfied that these conditions would effectively requirement the implementation of the key dust mitigation measures discussed in this section 9 of this evidence.

11.3 In summary these key mitigation measures (which are set out in proposed Condition 13) include:

(a) Maintenance of haul and other site access roads such that they have a minimum of 50 mm deep surface consisting of visually clean aggregate. This will enable trucks and other

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[20] That proposal was declined for reasons not related to air quality effects.

vehicles to travel at speeds of up to 30 km/hr without generating dusty plumes.

(b) Regular cleaning of the sealed section of the site's main access road.

(c) Use of dust suppression water with polymers on haul and access roads as a back-up contingency to the maintenance of the haul road condition as per (a) above.

(d) Use of dust suppression water with polymers to dampen active open areas of quarry and stockpiles of sand, crusher dust and other fine chip material, both prior to and during dry windy conditions.

(e) Covering of inactive areas of quarry floor with clean reject gravels.

(f) Covering of trucks which transport fine dusty materials from the site.

11.4 The real time wind and dust monitoring requirements are included in Conditions 14, 15 and 16 (wind) and 17 to 22 for ambient particulate. These ensure the following outcomes:

(a) Placement of permanent and mobile real-time PM_{10} monitors (with GPS information) such that real-time ambient PM_{10} levels are measured at the boundary of the site and generally nearest off-site sensitive receptors, which are most often downwind of active quarry areas.

(b) Use of real time 10 minute averaged wind direction and speed monitoring data along with ambient PM_{10} monitoring data to warn if trigger levels have been met in terms of wind speed and/or high particulate levels at the site boundary, and therefore the need to either cease dust generating activities, and/or implement mitigation actions to effectively reduce dust emissions.

12 SECTION 42A REPORT

ORC's s42a report

13 I have read the ORCs section 42a report by Mr Whyte and provide the following comments.

13.1 The report concludes that there will be more than minor adverse dust effects on neighbouring sensitive receptors, including the Clark and Amisfield Orchard Limited properties. This appears to be based largely upon Mr van Kekem's conclusion that 100 m buffer distance from sensitive receptors is needed. I assume that this effectively means 100 m between sensitive receptors and active dust generating activities. The officer also quotes the evidence of PDP (i.e., evidence of Ms Ryan) in support of his conclusions. From my own assessment of haul dust emission impacts and the likely effectiveness of proposed dust mitigation measures, I consider that the proposed expansion area of the quarry can be developed and excavated, while causing less than minor dust related effects on crops and property, and less than minor potential for adverse health effects. The ability to achieve this outcome is substantially aided by the prevalent southwest to northwest wind direction pattern at the site. With respect to Ms Ryan's evidence, I have the impression that she wanted to review my evidence and further assessments before providing a firm view on the ability of the proposed mitigation measures to adequately control dust effects, or not. Whereas the applicant's condition 9 is standalone in my opinion.

13.2 The officer's report has attached recommended conditions for an air discharge consent (RM20.360.03). Most of these conditions are the same as those proposed by the applicant. The officer's conditions have an additional general condition 1, for which I have no comment.

13.3 The officer's condition 11 includes the same 1-hour average PM_{10} concentration for a dust management trigger, as proposed by the applicant. However, the applicant's condition proposes that quarry activities recommence when particulate levels fall below the trigger value. Whereas the officer's condition 11 requires the site to comply with the wind speed trigger (the ORC's condition 10). I am not sure if this is a reference error, or not, but I consider the applicant's condition 10 is more appropriate, as it allows for quarry activities to be recommenced (following their shut down due to the ambient particulate trigger being reached), when ambient particulate levels fall below the trigger level.

13.4 The officer's condition 12 restates the PM10 for dust management trigger value as defined in their condition 11 and goes onto add a list of TSP concentration triggers. I do not disagree with the numeric values listed in this case for 1-hour TSP, but I do have concerns regarding the reliability of real-time TSP measurement which relies on light scattering. I also consider it is better to rely on the PM_{10} trigger value to protect against dust nuisance and potential health effects offsite. I am less confident that the MfE's 5-minute and 24-hour TSP trigger criteria are reliable – both appear to be unreasonably low when compared to the 1-hour average value.

13.5 Given the above, I consider the PM_{10} trigger value is the most reliable form of dust nuisance trigger and that the officer's condition 12 can be deleted.

13.6 The officer's condition 16 mirrors the applicant's condition 13 which lists mitigation measures. The only difference is the deletion of the final clause (m) from the applicants' version which requires watering to be a contingency measure for controlling dust from access roads. It does not concern me that this clause is deleted, as long as the DMP gives clear direction that the primary method for mitigating road generated dust is via the use of clean aggregate.

13.7 The officer's condition 17 requires the weather station to have a 10 m high mast. I have discussed mast height in paragraph 9.14 of this evidence and consider that a minimum height of 6 m is acceptable where this can be located away from trees or any structure which would otherwise influence wind speed and direction results. This allows for telescopic type mast designs which enables safe lowering of the mast for instrument serving and calibration.

CODC Report

14 I have read the statement of evidence from Ms Deborah Ryan with respect to my review of the Beca 2020 report and it appears we have no areas of disagreement, but I note Ms Ryan needs to read my evidence to be clearer about the potential for adverse dust impacts and the effectiveness of the proposed mitigation.

ORC Report

14.1 I have read the statement of evidence from Mr van Kekem. This comments on my review of the Beca 2020 report and confirms that we have disagreement on some matter. Mr van Kekem does indicate that having read my evidence, he may better understand my justification and reasoning for advise on specific matters. However, I provide my responses below to some key points of difference.

14.2 In paragraph 19 of his evidence, Mr Kekem disagrees with my evidence regarding the primary role of fine particles (rather than coarse particles) in causing potential dust nuisance effects. He states that my evidence is unsubstantiated and contradictory to the information presented in the current good practice guidance. I do not accept the first point as I consider my evidence has a substantial evidential basis. However, I agree that my evidence does not fully align with several aspects of the MfE dust management guide.

14.3 To reiterate, my view is that, the discharge of fine dust size fractions, which don't readily settle, is a more significant cause potential adverse nuisance beyond the site boundary, compared to coarse particles discharges, which rapidly settle to ground.

14.4 Some key reasons for my disagreement with Mr Kekem's criticisms of my assessment are outlined in paragraphs 5.30 to 5.33 of this evidence. However, it also pertinent to consider the modelling results for dust deposition versus ambient TSP concentrations due to unpaved haul road (**Attachment F** of this evidence). This further highlights that off-site TSP concentrations are far more significant in terms of potential dust nuisance, than the modelled deposition via gravity settling.

14.5 Therefore, I consider that I have provided a substantive evidential basis to support my views regarding the significance of fine particulate fractions – both in terms of fundamental modelling, and field experience with dust deposition monitoring over many years. This also supports my view regarding the potential significance of non-windy conditions with respect to potential nuisance dust effects.

14.6 In paragraph 20 of his evidence, Mr van Kekem confirms that he has reviewed research papers and states that in his experience with monitoring dust emissions around quarries/mines, the primary size fraction of dust discharged from quarrying activities is that referred to in the MfE dust guide. Furthermore, that the relative proportion of fine particulates (PM_{10} and $PM_{2.5}$) in the dust discharged is low.

14.7 I agree that my opinion regarding the primary role of fine non-settleable dust size fractions in causing nuisance is not entirely consistent with the MfE dust management guide. Neither is my contention that non windy conditions can cause significant dust nuisance, which is not dealt with sufficiently by the guide.

14.8 Therefore, it is my view that MfE dust guide does not provide a full description of dust nuisance mechanisms, and their cause and generally overlooks the role of fine particulate with respect to nuisance effects.

14.9 I agree with Mr Kekem, that the relative portion of PM_{10} and $PM_{2.5}$ in the discharge to air is low compared to larger size fractions (his paragraph, even when compared to PM_{30}. Established dust emission factors for different size fractions show this clearly (**Attachment F**), but that does not translate to the significance of these large size fractions, in terms of potential nuisance effects occurring off-site. I am not aware of any research papers that provide counter evidence to my assumptions. However I would be happy to review and consider the research Mr Van Kekem is referring to.

14.10 In paragraph 22 of his evidence, Mr van Kekem states that the faster deposition rates of TSP results in the most common adverse off-site effects associated with quarry effects which is the deposition of layers of dust on outdoor exposed surfaces, washing, inside houses when windows are left open, and in this case on surrounding crops.

14.11 I agree with this view, but when restricted to receptors within in the order of 50 m from a dust generating sources. However for receptors beyond 50 m, then suspended dust (which does not readily settle) becomes increasingly more influential (with distance) in driving potential nuisance effects.

14.12 The large particle fraction quickly dissipates with distance from sources (due to removal from the plume via gravity settling). The MfE dust guide does provide a useful explanation of why this occurs, which is quoted by Beca, 2020[1].

14.13 In paragraph 26 of his evidence, Mr van Kekem discusses RCS data. The test result I have for this composition was undertaken in 2019[8].

14.14 In paragraph 27 of his evidence, Mr van Kekem questions the representativeness of the diagnostic modelling of wind flow patterns. However, I have provided information on this modelling in **Attachment D** and consider the CALMET modelling will provide representative wind pattern information.

14.15 The diagnostic data sets do not suffer the flaws inherent in local Harvest.com monitoring sites (i.e., the Cook and Little's orchards) which have significant interference from nearby trees, structures and/or terrain. They also appear to use entry level instrumentation with high threshold winds speeds for stalling.

14.16 No source of wind information is perfect, however the sets derived by CALMET are considered to be sufficiently representative of site conditions to enable the dust risk to be assessed for individual sensitive receptors. When combined with concurrent rainfall data, they also allow a reliable analysis of dry windy condition frequency, and modelling of TSP ambient impacts for a full range of wind conditions, including calms.

14.17 I disagree with Mr Kekem's (paragraph 28 of this evidence) regarding the potential for adverse crop effects from suspended particulate generated at the quarry. Within hours of rainfall ceasing, heavily trafficked haul roads can generate dust and while a crop is still damp. Furthermore, the crops will also often be damp following spray applications during the summer season.

14.18 In paragraph 29, Mr van Kekem disagrees with my evidence, that the use of water for dust suppression on exposed surfaces and haul roads should be used as a contingency. However, I consider there is no sound rationale to argue otherwise. Avoiding significant dust emissions from unpaved haul roads is effectively achieved by removing the source – that is by maintaining a clean aggregate surface, which is low in silt.

14.19 This is an effective and enduring solution to any section of road that starts to generate significant dust. By comparison, watering will further assist, but its impact is temporary. Further, it does not ensure absence of dust being generate outside of operational hours.

14.20 In my view, the primary use of watering of site haul roads, has led to situations where mud formation and tracking has been a significant source of dust from some quarries. It is not easy for operations to discern what is the right amount of water in practice, and in my view, conventional consent conditions have encouraged over use of water and mud tracking issues at quarry sites.

14.21 In paragraph 32, Mr van Kekem disagrees with my view that speed limits on haul trucks are generally ineffective. I fully agree that the faster a vehicle travels on an unsealed road, then the higher the potential for dust emissions. However, when significant dust is being generated by a truck moving at, say 30 km/hr on an unpaved road, then in my view, it likely to remain a significant dust source at lower speeds.

14.22 So while reducing vehicle speeds minimises dust emissions, I contend that this reduction is rarely sufficient and thus not an effective mitigation measure. Replenishing the haul road surface with clean aggregate is the most robust and enduring mitigation response.

14.23 In paragraph 34, Mr Kekem agrees that bund formation and stripping of topsoil should occur during winter months. However we disagree about the benefits of staging of this process over time. I consider that progressive stripping in stages is not necessary, as is recommended by Mr Kekem.

14.24 My countering view, is that it would be beneficial for all stripping of overburden from the new expansion area to be completed in a single winter and installed into the new the bunds prior to spring. Then have the formed bunds ready for vegetation growth by the following spring period and before dry ground conditions set in.

14.25 However, I agree that the remaining open stripped area of quarry expansion area would be a dust source. However this can be mitigated by covering inactive areas with clean reject gravel (as per the draft DMP).

14.26 In paragraph 35, Mr Kekem argues that TSP monitoring at the site boundary would be a more effective tool than PM_{10} monitoring as proposed in the draft DMP and consent conditions from the applicant.

14.27 For reasons outlined in paragraphs 5.25, 5.35 and 8.11 to 8.14, I disagree, and consider that that monitoring of PM_{10} in real time would effectively control suspended TSP and respirable particulate impacts beyond the site boundary. I note that many recent decisions on quarry air discharge consents have accepted PM_{10} monitoring and associated trigger levels to warn of nuisance levels of ambient dust.

14.28 In paragraph 38, Mr Kekem expresses concern regarding the proposed use of a rolling 1-hour average for the PM_{10} trigger level and that a shorter-term average time of 10-minutes would be more appropriate. However, the rolling 1-hour average PM_{10} trigger concentration would be updated every 10-minutes ensures that the trigger is updated regularly.

14.29 In paragraph 40, Mr van Kekem argues that the minimum of height of the weather station mast should 10 m above ground level. However, a lower station height 6 m is effective when the mast can be located away from trees or any structure above several meters in height.

14.30 I accept that the standard height for general purpose surface weather monitoring stations is 10 m above ground level, but this height makes the structures very expensive to install and makes route maintenance/calibration an onerous and sometimes dangerous task. As long as the mast installation can be located away from trees etc, then in my view, the height of 6 m is optimal for monitoring wind speeds at a quarry site.

14.31 I also note that my recommendation for the 7 m/s wind speed trigger to be a 10-minute average at 6 m height, is effectively equivalent to a 7 m/s (1-hour average) wind speed trigger at 10 m height above ground level.

14.32 In paragraphs 43, Mr Van Kekem argues that there needs to be a 100-buffer distance (larger than the 50 m proposed) between extraction/dust producing activities and from adjacent sensitive receptors. My understanding is that the applicant proposes an internal 25 m buffer distance between the active quarry and the site boundary for the new expansion area, but increasing this to a 50 m internal buffer distance when close the Clark residential dwelling.

14.33 In my view, the significant alignment of strong winds blowing from southwest to the northeast, makes it viable to effectively mitigate haul roads and other dust sources within the proposed expansion area with the applicants proposed internal buffer distances – i.e., while not causing adverse dust impacts. This is greatly assisted by keeping the central processing and stock pile areas where they are currently located within the existing quarry area.

14.34 Furthermore, the proposed real time PM_{10} monitoring conditions and triggers for ceasing dust generating activities, further ensures that dust generating activities are ceased, and/or adequate dust mitigation would be employed to avoid adverse dust impacts on sensitive locations beyond the quarry site boundary.

15 SUBMISSIONS

15.1 I have reviewed all of the submissions on the proposal which raise air quality effects. I have addressed the matters raised in those submissions in my evidence. I have also viewed the HLFT videos/photo. I understand that dust control practices continue to be improved on the site and further controls are provided for in the proposed consent conditions and DMP.

15.2 In my view, the Trust's and other submitters experiences to date with dust effects from the quarry will not be representative of effects going forward, given what is proposed. In particular, the extensive dust plumes which the quarry has produced during strong dry wind conditions would be far less significant than those shown in video evidence. To me, these were indicative of a quarry that had significant exposed areas laden with silt like material – compliance with the proposed DMP measures would effectively remove these significant dust erosion sources.

15.3 The Amisfield Orchard submission refers to the recently granted Roydon quarry consent conditions. The requirements imposed by these conditions (including a 500 m internal buffer distance for the central processing plant), was primarily due to the presence of the Christchurch airshed boundary with respect to the quarry. This runs along the eastern border of the quarry.

15.4 Meeting stringent NESAQ criteria for incremental PM_{10} concentrations within the airshed was a key air quality issue for this proposal. It was the primary driver for such stringent mitigation by design being offered by the applicant and this also increased the stringency of conditions of consent.

15.5 The Amisfield quarry is a long way from the Cromwell airshed boundary and there is no issues with respect to meeting NESAQ criteria for discharges of PM_{10} within this airshed.

15.6 The Roydon quarry proposal placed residential dwellings within 200 m of the prevalent dry north east wind and southerly winds. However this proposal does not have any residential dwellings within 200 m of the quarry, which would be downwind during the most prevalent dry strong wind conditions.

15.7 When considering these factors for this proposal it is clear that minor dust nuisance and less than minor health effects can be achieved with the available buffer distances associated with this proposal.

15.8 I agree with the submitters that the local climate has relatively extreme wind conditions. I consider these to be comparable to the northwest winds which occur in Canterbury.

15.9 I generally agree with the concerns expressed by Amisfield Orchard and Hayden Little Family Trust's submission regarding the Beca 2020 report's use of only 8 months of meteorological data from the Fulton Hogan site (i.e., 2km away from the quarry). However, I consider that the diagnostic modelling of hour winds over a 3 year period has provided a sufficiently reliable set of wind data for assessing the dust risk associated with the proposal.

15.10 The locally measured wind data potentially available from Harvest.com operated sites appears to use entry level instrumentation, and locations of weather masts which are too close to trees or other structures. Therefore, I consider that these data sources cannot be relied on. I can rely on the diagnostic modelling of wind at the site, which was undertaken with fine resolution to account for local terrain effects on the local wind field.

15.11 Submitters appear to suggest that it does not rain as much in winter at the site. However, the Cromwell weather station's rain gauge and Harvest.com rain gauge data at the Cook orchard (which correlate closely), confirms that winter months have a high frequency of wet days (see **Attachment E**).

16 CONCLUSIONS

16.1 I conclude that the proposal by the applicant, to operate an expanded alluvial gravel quarry operation at Amisfield, can be undertaken while only causing minor dust nuisance, and less than minor potential health effects on people and commercial crops and associated activities within the surrounding area.

16.2 The above conclusion assumes the implementation and compliance with proposed consent conditions and dust mitigation measures. This includes the real-time PM_{10} and wind monitoring measures being implemented at the quarry and adherence to PM_{10} and wind speed trigger conditions.

16.3 I conclude that there are significant site and process features, which would help ensure the above environmental outcomes are practical to achieve, when employing the proposed dust mitigation/monitoring measures. These mitigating factors (aside from dust mitigation measures) include:

(a) The most prevalent strong dry windy conditions (south westerly and north easterly winds) would not result in the nearest residential dwellings (all within 200 m of the proposed quarry) being downwind;

(b) The application of water during aggregate screening processes;

(c) The crushing plant being located in the bottom of the existing quarry and only processing around 25% of washed aggregate, and only processing a small portion this (10%) into fine chip/sand type products;

(d) The availability of a large quantity of washed reject material that has no commercial value, which can be used for covering expansive areas of non-active quarry; and

(e) The absence of any clean filling activities.

Roger Cudmore

30 November 2021