The Carcinogenic Silica Dust Health Risks at Freeth Farm

By Dr Peter Alberry

Summary

Ultra-fine silica dust particles at a size of 10 µm or less (known as PM10 particles) are absorbed by the lining of the lungs and, as a consequence, silica dust has been classified as a grade 1 carcinogen. The World Health Organisation 24 hour limit for exposure to PM10 particles of silica dust is 50 $\mu g/m^3$ and HSE's limit is 100 $\mu g/m^3$, which is equivalent to an exposure of around 120,000 to 240,000 PM10 particles/m^3.

All quarries that either extract sand or rock are required to have an appropriate buffer zone to protect local residents from the carcinogenic dust. Buffer zone protection works by giving sufficient distance for coarse sand particles to settle out within the buffer zone and for fine sand particles to be sufficiently diluted by the air volume within the buffer zone so as not to cause a serious health hazard.

The buffer zone for sand quarries is typically set at around 100m but it is increased to 250 to 500m for hard rock quarries as the blasting creates very fine dust which travels much further than coarser sand particles.

The carcinogenic health risks from the 35m buffer zone and extraction activities have not been properly assessed and have been dismissed as insignificant by Wiltshire Council's Environmental Health Officer who considers that the potential for dust release is very low because the Freeth Farm sand is coarse and damp.

HQPL's consultants (ACS Testing Limited) report dated 29 November 2018 have confirmed that the Freeth Farm sand is not coarse but is classified as the finest of fine sand classifications with around 70 million fine particles (less than 63 microns in diameter) in every kilogram of sand.

However, the Freeth Farm sand contains very large amounts of PM10 sand particles, as has previously been confirmed by light microscopy. Consequently, a detailed measurement of the actual particle sizes using a laser based Particle Size Analyser was commissioned from Lawson Scientific Limited. Their analysis of 2 separate samples of Freeth Farm sand taken close to the Phase 5 excavation area showed that there are on average around 100 million PM10 particles per kilogram of sand.

The ultra-fine Freeth Farm sand PM10 particles are finer than talcum powder particles and all surface layers will dry out in less than 15 minutes in dry conditions so that PM10 particles will lift from the surface in light winds. The PM10 particles are invisible to the naked eye and can only be reliably detected by continuous dust monitoring equipment.

HQPL's dust mitigation strategy during the extraction of 307,200 te of ultra-fine sand relies on a 35m buffer zone; 4m high x 19m wide noise attenuation bunds and the sand remaining damp at all times. HQPL also have an option to deploy a water bowser for dust suppression under dry ambient conditions at the discretion of the site manager.

This report shows that the dust mitigation strategy is wholly inadequate. A buffer zone of 35m is unprecedented and not in line with the normal UK planning authority practice (100m); does not meet the DoE planning guidance (100m); does not meet the Institute of Air Quality Management (IAQM) guidance (100m); and will not keep levels of carcinogenic PM10 particles to within acceptable 24 hour health limits set by the World Health Organisation (WHO) and the Health and Safety Executive (HSE).

In addition, there is no protection from the PM10 particles that will arise during the construction and removal of the noise attenuation bunds that involve the overall movement of 50,000 te of sandy top soil and no protection to prevent the surface layers of the sand on the 2.5 km long open conveyor from drying out and releasing PM10 particles.

This report provides a quantitative assessment of these risks as required under the Control of Substances Hazardous to Health Regulations 2002 (COSHH).

On the basis of the Lyneham weather station data, dry conditions would be expected for 65% of days per year.

For the sand extraction activities, light breeze conditions (>3m/s) from the north and east would be expected to occur on around 30% of days per year, so there is a 20% probability that PM10 particles could affect the nearest residents on any given day of the 260 days of operation per year over a 5 year period. This risk can be significantly offset by the use of a water bowser but the sand has to be excavated, tipped into a lorry, transported across the site to the screener and then dropped in a stream onto the open conveyor. This means that there is a significant risk that parts of the ultra-fine sand will dry out and release large quantities of PM10 particles before a water bowser can be deployed and even if the water bowser has been deployed. This risk can only be properly mitigated by the use of an appropriate buffer zone to provide a sufficient dilution volume so that the WHO and HSE 24 hour exposure limits are not breached.

For the 35m bund construction and removal activities surrounding Freeth Farm Cottages, light breeze conditions (>3m/s) from all wind directions except the north and west would be expected to occur on around 70% of days per year. This means that there is a 50% chance of exceeding the WHO and HSE 24 hour exposure limits for carcinogenic PM10 silica particles on each of the 89 days while the noise attenuation bunds are being constructed and removed. This risk would be eliminated by the use of a 100m (or greater) buffer zone as the need for the 35m noise attenuation bunds to keep noise levels within statutory limits would be eliminated.

For the open conveyor operation, light breeze conditions (>3m/s) from the south and east would be expected to occur on around 20% of days per year. This means that there is a 13% chance of exceeding the WHO and HSE 24 hour exposure limits for carcinogenic PM10 silica particles on each of the 1260 days of open conveyor operation. This risk can only be mitigated by using closed conveyors and water sprays consistent with industry best practice.

In conclusion, it is strongly recommended that a sensible buffer zone of at least 100m in line with UK norms together with continuous dust monitoring (which can be achieved using inexpensive equipment) be included as part of the planning conditions for HQPL's sand extraction proposal in order to provide appropriate environmental health protection for local residents.

Background

HQPL's proposal to extract 307,200 te of ultra-fine sand at Freeth Farm over a 4-5 year period involves the use of Volvo excavators and loading shovels as shown below.

HQPL's proposal involves the removal of sandy top-soil which is used to form a total length of over 2.5 km of bunds of various sizes over a 4-5 year period, involving the overall movement of around 200,000te. Some of these bunds are then removed from a given excavation phase and reconstructed in a separate location before the next excavation phase. The largest bunds are 4m high x 19m wide bunds and start at 16m from Freeth Farm Cottages boundary and involve the overall movement of around 50,000 te of sandy top soil, see full details in Annex 1.

HQPL's dust mitigation strategy involves a buffer zone of 35m; 4m high and 19m wide noise attenuation bunds; visual observation of dust conditions together with the sand remaining permanently wet at all times, using a water bowser if required.

However, HQPL's dust mitigation strategy is flawed as the water bowser cannot be deployed quickly enough to stop the surface layers from drying out (15 minutes in dry light breeze conditions) and the water bowser will not prevent sand dry out during the periods of bund construction and removal using a long reach Volvo excavating shovel, as shown below, and will not stop the sand on the conveyors from drying out.

So each of the bund formation and conveyor transport activities have the potential to generate significant amounts of dust with little or no dust mitigation possible, particularly as the proposal involves open conveyors in direct contravention of best practice.



The health risk from PM10 silica dust has not been assessed or quantified by the applicant as required by the COSSH Regulations 1992 but will be addressed in detail later in this report.

HPQL's submissions admit the potential for dust formation during top soil removal and bund formation and states that:

> *"there are receptors to the west which would be within 200m of these potentially dusty operations, particularly bund formation. Freeth Farm Cottages in particular have the potential to be affected when the wind is blowing from the north, east and south (depending on the stage of bund construction)."*

HQPL appear to believe that dusty conditions causing nuisance dust will only be caused by strong winds. HQPL's Environmental Statement states that ***"****Fortunately strong winds from the east and south east in particular are not as common as those from the south west and would be for 31 days in the year (21.5% of dry days in the year on average)."*

HQPL also state that the Freeth farm sand is likely to be damp when it is extracted so that *"the potential for dust release during the extraction phase is considered to be very low"*.

Rather than carry out a formal risk assessment as required under the COSSH regulations, HQPL have simply claimed that there is always a dust risk to local residents during farming activities such as ploughing.

However, ploughing only penetrates the top-soil and does not disturb the sand deposits beneath. All the surrounding land to the site is in maize production for animal feed and is not normally ploughed apart from once a year in the spring when the soil is still moist.

The minimal ploughing that has taken place in recent years takes place generally at distances much greater than 16m from the Freeth Farm Cottage boundaries.

In addition, although the topsoil is sandy the water table is close to ground level and the ground is invariably very wet in late Autumn and Winter, so the dust risk from ploughing is minimal and not at all similar to heaping and removing 27,000 te of sandy top-soil at 16m from the Freeth Farm Cottages property boundaries over a 24 week period during Phases 5, 6 and 7.

HQPL's argument that a reduced level of environmental protection should be allowed on the basis that an increased buffer zone beyond 35m would render the proposed development commercially non-viable has been exposed as a gross misrepresentation of the true commercial position.

In any event, this does not excuse them from carrying out a health risk assessment and then to provide appropriate public health protection as required by best practice.

The irrefutable fact is that the Freeth Farm sand contains millions of very fine PM10 silica particles that are quickly dried and entrained to a significant extent by light winds (as is demonstrated later) with no possible dust risk mitigation during giant bund construction and open conveyor operation. Proper environmental protection can only be provided by an adequate buffer zone and continuous dust monitoring.

The Wiltshire Council case officer's report states (Page 389, para 134) that:

> ***"The concerns raised by local people regarding the 'Freeth Farm sand' being a "Grade 1 carcinogen" that can be entrained in light winds and carried towards the nearby properties are noted, but these fears are not supported by the expert assessment carried out and no objections or concerns have been raised by the Environmental Health Officer on this issue. The assessment finds as the mineral itself is formed of coarse particles and does not require blasting (as would be the case for hard rock minerals) the potential for dust release during the extraction phase is considered to be very low, particularly as the material is damp. The potential emissions from the wet, coarse extracted mineral are very low, even adjacent to the workings. Potential impacts are assessed as not significant."***

This statement is at best incorrect and misleading as the Freeth Farm sand is not coarse but has been shown to be exceptionally fine, as detailed in reports sent to the case officer with key details reproduced in this report. It will also not remain wet.

Normally a buffer zone for quarries is set at around 100m but it is increased to 250 to 500m for hard rock quarries as the blasting creates very fine dust.

Buffer zone protection works by giving sufficient distance for coarse sand particles to settle out within the buffer zone and for fine sand particles to be sufficiently diluted by the air volume within the buffer zone so as not to cause a health hazard.

This is why the World health Organisation and the Health and Safety Executive have set 24 hour exposure limits at around 125,000 to 250,000 PM10 silica particles per cubic metre.

This is also why rock quarries which produce very fine dust from blasting usually have a 250 to 500m buffer zone so that the fine dust is diluted to below the statutory exposure limits.

The Freeth Farm sand is clearly not a coarse sand classification contrary to Wiltshire Council's Environmental Health Officer comments. It an exceptionally fine sand as shown in this report so a 35m buffer zone is completely inappropriate to the extent that it will put local residents at significant risk as shown in this report.

Wiltshire Council's Environmental Health Officer has a fundamental misunderstanding which appears to be based on HQPL's "air quality expert" report dated 16 May 2016

The applicant's "air quality expert" (Mr. M. Stoaling of Isopleth Limited) admits that *"crystalline silica is a health risk where sufficiently high exposure occurs"* and further admits that *"smaller particles travel further as a function of deposition velocity"*.

However, Mr Stoaling concentrates on nuisance dust blow which involves larger 30 μm sand particles and fails to provide any meaningful assessment of the potential health risk from *"sufficiently high exposure"* to very fine carcinogenic 10 μm (or PM10) sand particles.

Mr Stoaling simply states (Appendix 1B, page 8) that *"Jason Day is content that the dust measures may be conditioned to prevent such exposure at residences"*.

At the time Mr Stoaling submitted his report in 2016 so he would not have been aware of the report from HQPL's consultants ACS Testing Limited on 29 November 2019 which states that *"We have estimated the likely average grading in accordance with the ISO 656 sieve apertures"* as a *"0/2mm FP Cat f_3 fine concreting sand"*.

The 0/2mm FP Cat f_3 classification is the finest of fine sand classifications that means that up to 3% of the content by weight will pass through a 63μm sieve, as shown below.

If it assumed that the largest particles are all 63μm, this would mean that each spherical particle would weigh around 0.433×10^{-6} g, so that a 1kg sample of Freeth Farm sand would contain up to 30g of fines which would equate to 70 million particles in every kilogram of Freeth Farm sand.

This raises the question as to whether the Environmental Health Officer has been confused by the expert assessment of the nuisance dust risk from coarse sand particles without properly taking account of the carciongenic dust risk from the very large numbers of ultra-fine PM10 particles that were confirmed by ACS Testing Limited in November 2019 and which have also recently been independently measured by Lawson Scientifc Limited.

This was detailed in the reports that were submitted to the case officer in 2021.

This also raises the issue as to whether the Environmental Health Officer has actually seen the 2019 and 2021 reports or read them properly so as to be able to dismiss public health concerns.

This is potentially a very serious issue as grossly misleading advice in public health cases can lead to subsequent criminal charges.

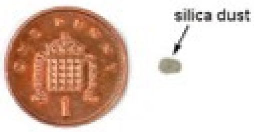
As a consequence of the failure of Wiltshire Council's failure to make any proper assessment based on the corrrect information, the potential health risks from normal sand excavation activities; noise attenuation bund construction and removal and open conveyor operation are examined in the next sections.

Carcinogenic Health Risks of PM10 Silica Particles

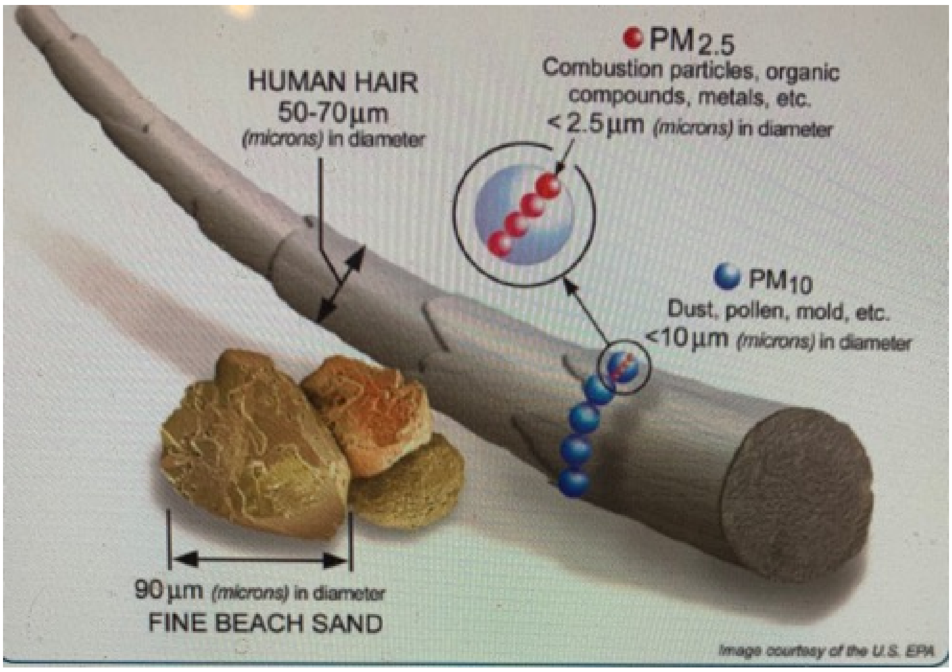
By itself, silica dust is not toxic. The health risk arises when silica particles are small enough to get into the deepest parts of the lungs, especially the alveoli where inhaled air passes into the bloodstream. Chronic or long-term exposure to fine silica particles can lead to lung inflammation and produce a severe lung disease known as silicosis. This has prompted government and international health agencies to declare silica to be a human carcinogen (IARC, 2012; NTP, 2011; Steenland, 2014).

The recommended World Health Organisation exposure limit for PM10 silica particles is around 50 $\mu g/m^3$ over a 24 hour period.

The Health and Safety Executive (HSE) 24 hour exposure limit to avoid adverse health effects is around 0.1 mg/m^3 or 100 $\mu g/m^3$. HSE have provided a graphic visual illustration of this tiny amount, as shown below and in Annex 2.



To put the 10 μm (PM10) and 2.5 μm (PM2.5) particles into perspective, the diameter of a human hair is around 50-70 μm and fine beach sand has a typical diameter of around 90 μm. Talcum powder has a mean particle diameter of around 15 μm and pollen grains have a diameter of around 10 μm (see blue balls below) and PM2.5 particles have a diameter of 2.5 μm as shown by the very tiny red dots superimposed onto the blue pollen balls below. These PM2.5 and PM10 particles are so fine that they make fine beach sand look like boulders. The PM10 particles are invisible to the naked eye and are highly dangerous as they dry out quickly and are blown about even in light winds and absorbed by the lining of the lungs if breathed in.



PM10 Particles in Freeth Farm Sand

The Freeth Farm sand has been classified by HQPL's consultants ACS Testing Limited. Their evaluation dated 29 November 2018 states that *"We have estimated the likely average grading in accordance with the ISO 656 sieve apertures"* as a *"0/2mm FP Cat f_3 fine concreting sand"*.

The 0/2mm FP Cat f_3 classification is the finest of fine sand classifications that means that up to 3% of the content by weight will pass through a 63µm sieve, as shown below.

Line	Particle size fractions *d/D*	Fines content	Category
	mm	% m/m	
1	0/2 to 0/5	≤ 3	f_3
2	0/2 to 0/5	≤ 16	f_{16}
3	0/2 to 0/5	> 16	$F_{declared}$
4	2/4 to 32/63	≤ 0.5	$f_{0.5}$
5	2/4 to 32/63	≤ 1	f_1
6	2/4 to 32/63	≤ 2	f_2
7	2/4 to 32/63	≤ 3	f_3
8	2/4 to 32/63	≤ 4	f_4
9	2/4 to 32/63	> 4	$F_{declared}$
Note: For special areas of application, the particle size fraction/grade of delivered particles 1/3 mm in category $f_{0.5}$, f_1 or f_3 may be used.			

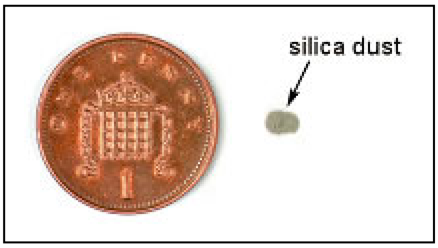
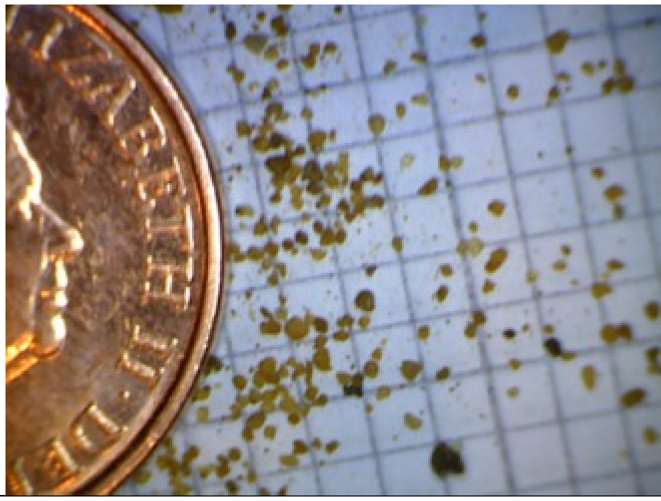
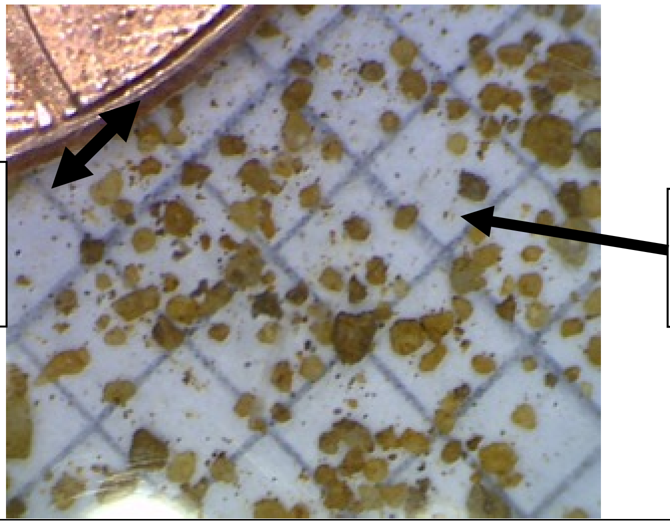
The Freeth Farm sand is clearly not a coarse sand classification contrary to Wiltshire Council's Environmental Health Officer comments based on HQPL's "expert assessment".

If it assumed that the largest particles are all 63µm, this would mean that each spherical particle would weigh around 0.433 x 10^{-6} g, so that a 1kg sample of Freeth Farm sand would contain up to 30g of fines which would equate to 70 million particles in every kilogram of Freeth Farm sand.

The World Health Organisation and HSE 24 hour exposure limits for PM10 silica particles are 50 µg/m^3 and 100 µg/m^3 respectively, which equates to 120,000 and 240,000 PM10 silica particles/m^3.

In order to carry out a proper risk assessment, as required by Control of Substances Hazardous to Health Regulations 2002 (COSHH), further details on the number and distribution of PM10 silica particles is required.

A visual impression of the PM10 particle size distribution can be obtained from the representative sample of the Freeth Farm examined under a microscope to determine the distribution of sand particle sizes, as shown below.

<table>
<tr>
<td>HSE Silica Dust Particle

</td>
<td>Freeth Farm sand particle sizes
</td>
</tr>
<tr>
<td colspan="2">Scale 2mm or 2000µm

Ultra-fine particles 2-10µm</td>
</tr>
</table>

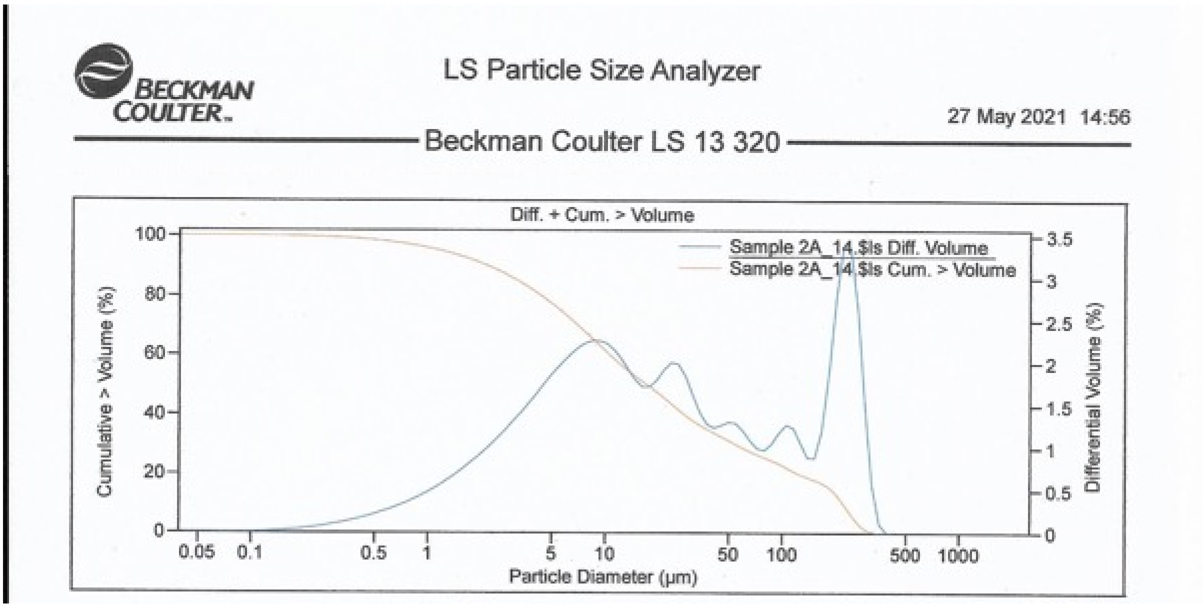
The microscopic examination shows that the Freeth Farm sand is a very fine sand, with a particle size distribution consisting of large particles (around 500-1000 µm in diameter) and ultra-fine particles (around 2-10 µm diameter).

The smallest sized particles appear as fine dots and are around 2-10µm in diameter, which is a size range that is respirable.

In terms of the number of particles in the sand, the Freeth Farm sand has been estimated to contain around 35% of fine <10µm particles (by number) and 65% of larger particles (by number).

However, an accurate measurement of the number of PM10 particles per kilogram has been recently carried out by Lawson Scientific Limited. The report was subsequently provided to the case officer.

The actual particle size distributions for 2 Freeth Farm sand samples taken from close to Phase 5 have been analysed using a Beckman Coulter laser based Particle Size Analyser on 27 May 2021, as shown in the example below with full details given in Annex 2.



The results show that Sample 1 has over 54 million PM10 particles per kilogram and Sample 2 has over 162 million PM10 particles per kilogram, as shown below, representing a simple average of around 100 million PM10 particles per kilogram.

	Percentage of Particles less than 2.5 µm (PM2.5)	**Percentage of Particles less than 10 µm (PM10)**	**PM10 particles per kilogram**	**Maximum Particle Size**
Sample 1	**4.3%**	**13%**	**54,680,288**	**948 µm**
Sample 2	**11%**	**38%**	**162,552,158**	**340 µm**

An average of 100 million PM10 particles per kilogram is very close to the number of fine particles that are likely to be present in Freeth Farm sand of 70 million fine particles per kilogram based on data supplied by HQPL’s own consultant ACS Testing Limited.

Buffer Zones

All quarries that either extract sand or rock are required to have an appropriate buffer zone to protect local residents from the carcinogenic dust. Buffer zone protection works by giving sufficient distance for coarse sand particles to settle out within the buffer zone and for fine sand particles to be sufficiently diluted by the air volume within the buffer zone so as not to cause a serious health hazard.

The buffer zone for sand quarries is typically set at around 100m but it is increased to 250 to 500m for hard rock quarries as the blasting creates very fine dust which travels much further than coarser sand particles.

The results from a study of airborne respirable silica near a sand and gravel facility in central California (Environ Sci Technol., December 2002 by Shiraki & Holmen) confirm the absolute need for appropriate buffer zones. The California study showed that PM10 levels were above World Health Organisation 24 hour exposure limits of 50 $\mu g/m^3$ at distances of 22m (60.6 $\mu g/m^3$) and 62.4 $\mu g/m^3$ at 62m.

In the UK, although some planning authorities prefer to treat planning applications on a case by case basis rather than being too prescriptive, the best practice exclusion zones adopted by various planning authorities to keep noise and dust levels to within statutory limits are shown below:

Planning Authority	Exclusion Zone or Stand-off Distance
Buckinghamshire	**200m (or 100m with a 5m bund)**
Durham	**250m**
Hampshire	**250m**
Lancashire	**100m**
Somerset	**200m**
West Dorset	**100-250m**
Wales	**100m**

This best practice is underpinned by the Department of the Environment and the Institute of Air Quality Management.

The Department of the Environment Planning Guide, Section 5.3 states that:

> *"Residents living in proximity to quarries can potentially be affected by dust up to 0.5km from the source, although continual or severe concerns about dust are most likely to be experienced within about 100m of the dust source. The main potential impacts of dust are visual impacts, coating/soiling of property (including housing, washing and cars), coating of vegetation, contamination of soils, water pollution, change in plant species composition, loss of sensitive plant species, increased inputs of mineral nutrients and altered pH balances. Respirable particles, i.e. those less than 10 micrometres (10µm) in diameter, have the potential to cause effects on human health, depending on exposure levels".*

In relation to quarry dust, the Department of Environment issued a detailed technical report on buffer zones in 1995 which states:

> *"The DoE study concluded that severe or persistent concerns about dust are most likely to be experienced near to significant dust sources (generally within 100m). In*

practice, standoff distances are often incorporated into local planning policy, with distances of 250-500 metres typically adopted"

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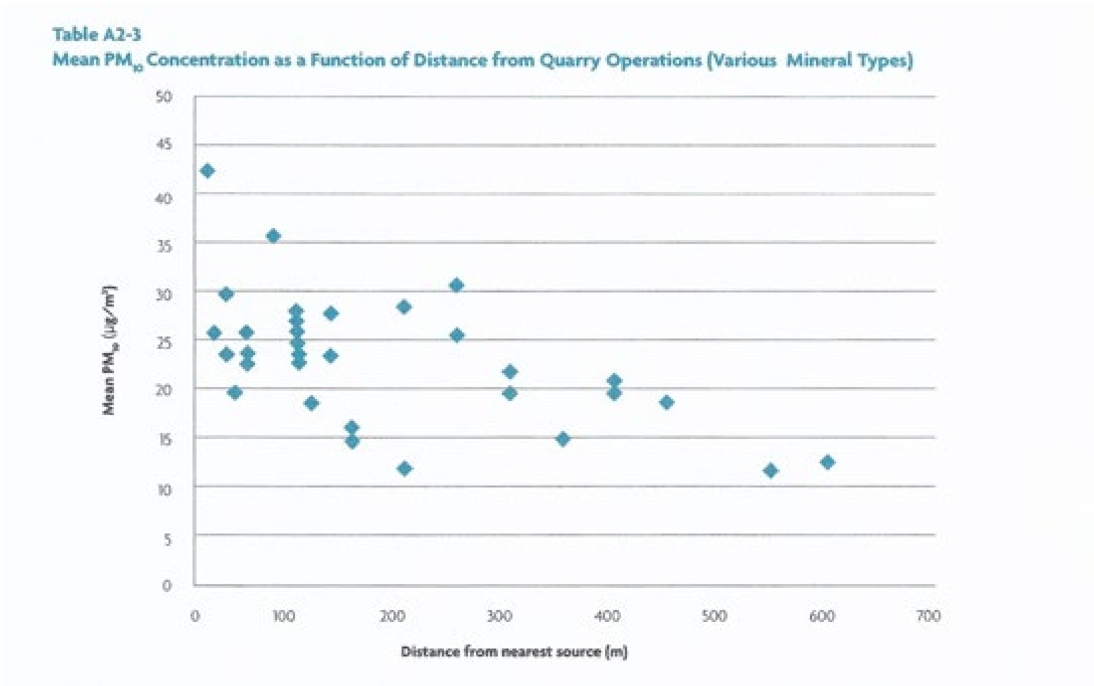
The IAQM guidance for Mineral Dust also considers the effects of 10µm particles (PM_{10}) as a function of distance from quarry operations as shown below:



The graph shows that PM10 levels only reduce to consistent low levels at distances greater than 300-400m.

The IAQM guidance for Mineral Dust (*Box 2. Typical Impacts with Distance From the Experience of the Working Group*):

"Adverse dust impacts from sand and gravel sites are uncommon beyond 250m and beyond 400m from hard rock quarries measured from the nearest dust generating activities (see Appendix 2). In the absence of other information it is commonly accepted that the greatest impacts will be within 100m of a source and this can include both large (>30 µm) and small dust particles. The greatest potential for high rates of dust deposition and elevated PM_{10} concentrations occurs within this distance. Intermediate-sized particles (10 to 30 µm) may travel up to 400 m, with occasional elevated levels of dust deposition and PM_{10} possible. Particles less than 10µm have the potential to persist beyond 400m but with minimal significance due to dispersion"

Assessment of the Carcinogenic Health Risks of PM10 Silica Particles from Sand Extraction Activities

HQPL's sand extraction activities involve the removal of around 200,000 te of sandy topsoil followed by the excavation of around 307,200 te of sand.

The sand the sand has to be excavated, tipped into a lorry, transported across the site to the screener and then dropped in a stream onto the open conveyor before being transported off site.

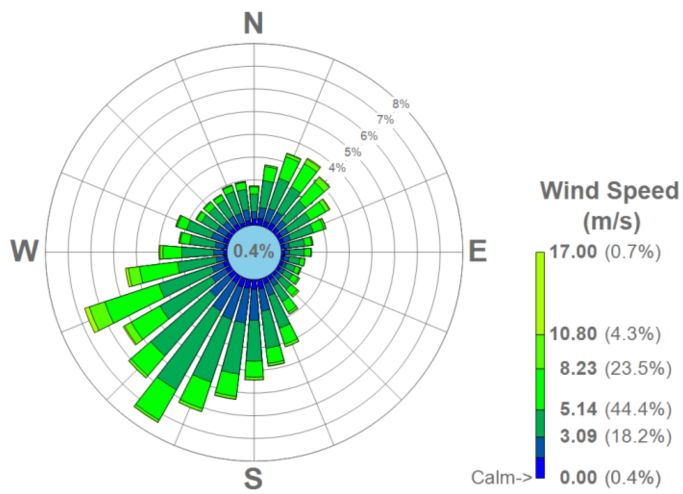
This means that there is a significant risk that parts of the ultra-fine sand will dry out and release large quantities of PM10 particles before a water bowser can be deployed and even if the water bowser has been deployed.

This means that there is a relatively high probability of PM10 particle release under dry conditions when the wind is in the right direction to transport PM10 particles towards the local properties.

On the basis of the Lyneham weather station data, dry conditions would be expected for 65% of days per year and light breeze conditions (>3m/s) from all wind directions except from the north and west which would be expected to occur on 72% of days per year.

This probability of the wind being in the right direction (wind from the north and north east) to transport PM10 particles towards the local properties can be estimated using the wind rose data from the nearby weather station at Lyneham as shown below.

Figure 2.1: Windrose - Lyneham



The combination of dry conditions and light breeze conditions will occur on a given day with a probability of 0.468. This means that there is a 50% chance of exceeding the WHO and HSE 24 hour exposure limits for carcinogenic PM10 silica particles on each of the 89 days while the noise attanuation bunds are being constructed and removed.

For the sand extraction activities, light breeze conditions (>3m/s) from the north and east would be expected to occur on around 30% of days per year, so there is a 20% probability that PM10 particles could affect the nearest residents on any given day of the 1300 days of operation over a 5 year period.

Although this risk can be significantly offset by the use of a water bowser it cannot be eliminated as the sand has to be excavated, tipped into a lorry, transported across the site to the screener and then dropped in a stream onto the open conveyor.

This means that parts of the ultra-fine sand will have time to dry out (15 minutes in light breeze conditions) which will release large quantities of PM10 particles before a water bowser can be deployed and the sand will still dry even if the water bowser has been deployed.

A buffer zone of 35m does not provide sufficient dilution volume so that the WHO and HSE 24 hour exposure limits are not breached.

This risk can only be properly mitigated by the use of an appropriate buffer zone of between 100 metres and 250 metres as is best practice in the UK.

Assessment of the Health Risk from PM10 Silica Dust during Noise Attenuation Bund Formation

The 4m high x 19m wide noise attenuation bunds surrounding Freeth Farm Cottages will be formed using around 27,000 te of top soil during Phases 5, 6 and 7 and the bunds will be partly removed in Phase 7 with the final part of the bund being removed in Phase 8.

Phase	Noise Attenuation Bund Lengths (m)	Location	Volume of Material (m^3)	Estimated Tonnes of Material	Estimated Time (weeks)
Phase 5	4m x 19m x 200m	N-NE-E	8400	12600	4.73
Phase 6	4m x 19m x 140m	All	5880	8820	3.56
Phase 7	Remove 4m x 19m x 140m	N-NE-E	5880	8820	3.61
Phase 7	4m x 19m x 150m	E	6300	9450	3.87
Phase 8	Remove 4m x 19m x 150m	S-SE-E	4200	6300	2.07
Total			30,660	46,990	17.84

Top soil will be dug out from the respective Phase or transferred from an existing bund in a previous Phase using an excavator and dropped into large dump trucks, transported to close to the bund formation area and tipped.

The tipped pile of top soil will then be formed into one of the 4m high noise attenuation bunds surrounding Freeth Farm Cottages on 3 sides by scooping up from the tipped pile and dropping it onto a new pile using a second excavator described as having a long reach, as shown below.

The top soil is very sandy as it is on top of a sand deposit and, in dry weather the top soil will be relatively dry. In addition, the initial excavation will probably extract a small amount of sand with the top soil as the surface of the sand deposit is neared, particularly as HQPL estimate that 15% of the sand depsoit will be lost during excavating and processing.

This extracted sand and the sand in the top soil itself will quickly dry as it is dropped onto the top of the bund during the bund formation activities at varying heights between ground level at the start and increasing to a height of around 6m at the maximum height.

In dry conditions there will be a considerable amount of PM10 carcinogenic dust blow, most of which will be invisible to the operators as it is too fine to be visible and which will carry at least 100m according to the Institute of Air Quality Management data.

The total tonnage moved over the 17.8 weeks (89 days) of bund formation and removal is estimated to be around 47,000 te (using HQPL's sand density of 1.5 te/m^3), which amounts to around 47 million kg.

The working week lasts from Monday to Friday at 6 hours per day, so the total hours of exposure is around 534 hours.

Each kilogram of Freeth Farm sand contains on average 100 million PM10 particles, so the PM10 particle production during the noise attenuation bund formation is 4,700 million million PM10 particles over the 534 hour period.

This amounts to the production of around 8.8 million million PM10 particles per operating hour which, for a 6 hour operating day, equates to around 52 million million PM10 particles per day.

However, these PM10 particles produced will be diluted by the volume of air wihin the 35m buffer zone surrounding Freeth Farm Cottages. If this is assumed to be a 35m cube of air, then the total dilution volume would be 43,000 m^3, so the actual potential particle exposure would be around 12,000 million particles over each 24 hour period.

The World Health Organisation and HSE 24 hour exposure limits for PM10 silica particles are 50 $\mu g/m^3$ and 100 $\mu g/m^3$ respectively, which equates to an exposure of around 120,000 and 240,000 PM10 particles/m^3 over a 24 hour period.

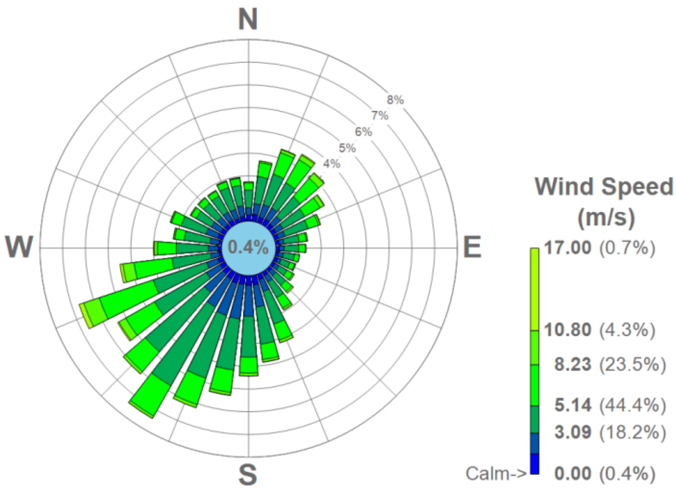
So on this simplistic basis, the average level of exposure for a 35m buffer zone would be around 50,000 to 100,000 times the 24 hour WHO and HSE 24 hour exposure limits which is a significant health concern.

However, this is mitigated to some extent by the wind direction as, on some days during bund formation, some of the dust will be blown away by the prevailing winds. However, the 4m x 19m noise attenuation bunds will be built and removed from 3 sides of Freeth Farm Cottages, as shown below.

This means that there is a relatively high probability that the wind direction will be unfavourable.

This probability can be estimated using the wind rose data from the nearby weather station at Lyneham as shown below.

Figure 2.1: Windrose - Lyneham



On the basis of the Lyneham weather station data, dry conditions would be expected for 65% of days per year and light breeze conditions (>3m/s) from all wind directions except from the north and west which would be expected to occur on 72% of days per year.

The combination of dry conditions and light breeze conditions will occur on a given day with a probability of 0.468. This means that there is a 50% chance of exceeding the WHO and HSE 24 hour exposure limits for carcinogenic PM10 silica particles on each of the 89 days while the noise attanuation bunds are being constructed and removed.

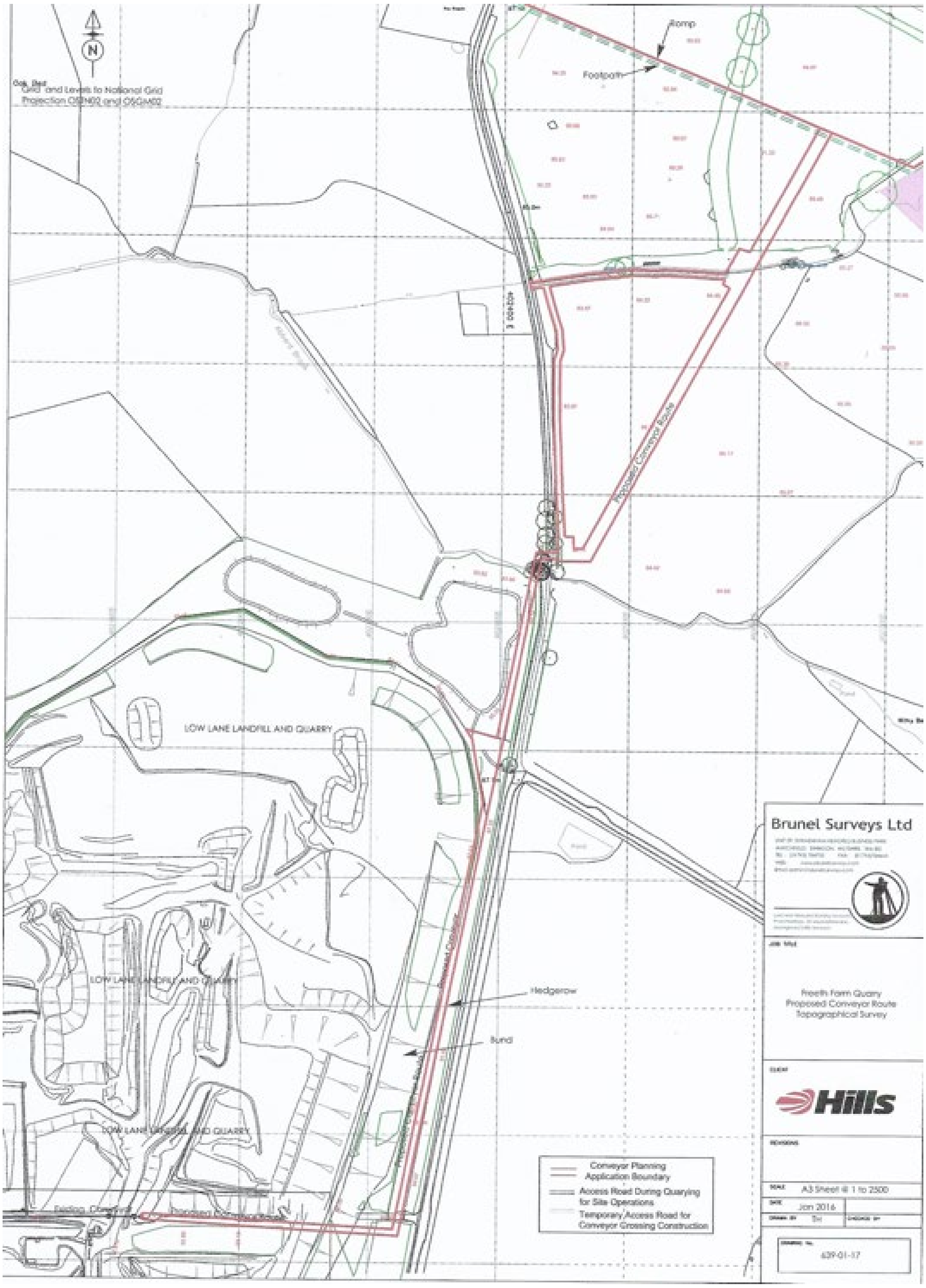
Overall there is a high carcinogenic health risk from the ultra-fine PM10 silica particles with a 35m buffer zone which needs 4m x 19m noise attenuation bunds.

This carcinogenic risk could be significantly reduced with a 100-250m buffer zone where there would be no need for the 4m x 19m noise attenuation bunds and as an added bonus, the noise levels would also remain within staturory noise limits.

Assessment of the Health Risk from PM10 Silica Dust during Conveyor Operation

The applicant has not properly considered the health risk he has simply assumed that the ultra-fine sand will remain wet during conveyor transport and has completely ignored the potential for the drying and entrainment of PM10 carcinogenic silica particles from the 1.2km open conveyor that transports the sand from the excavation site to Sands Farm.

The conveyor route to Sands Farm is not straight and has a number of dog legs as shown below and has to rise to a height of 6.1m in order to cross the Freeth Farm access road.



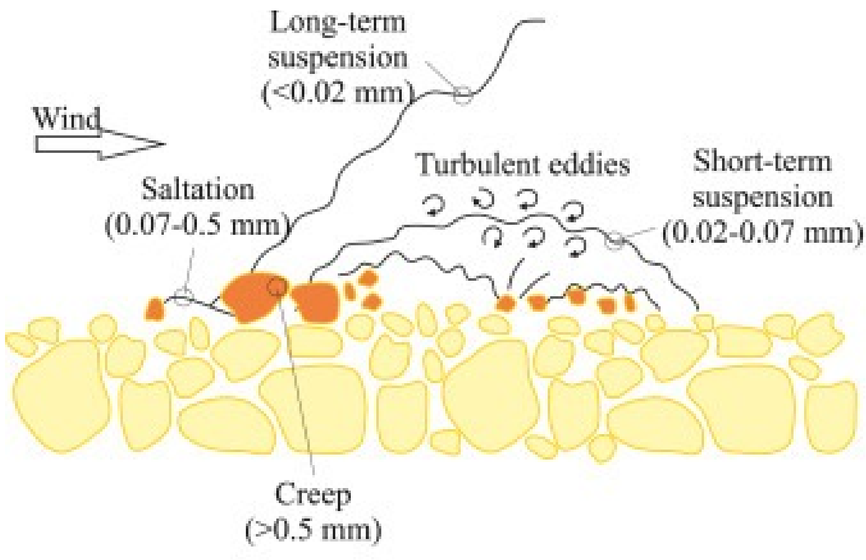
Each of the changes in conveyor direction relate to where the sand is dropped from the first conveyor down onto a receiving conveyor close, as shown below, which gives an ideal opportunity for the PM10 particles to dry and be released.

It is well known that the top 1-2mm of sand on open conveyors dries out in around 15 minutes in dry conditions with a light breeze, so there is a very significant potential the top surfaces of the sand on the 1.2km open conveyor to lose material as it is transported to Sands Farm.

This is why industry good practice as set out in Process Guidance Note 3/08(12) requires fine sand conveyors to be covered with additional water sprays at the ends to ensure that fine sand stays wet and the ultra-fine dust is properly suppressed.

Since the conveyor route is located to the south and west of Freeth Farm Cottages, The Freeth and The Lodge, the PM10 silica particles (0.010mm) will be entrained (long term suspension) by light breezes from the south and south west and carried towards all of these dwellings.

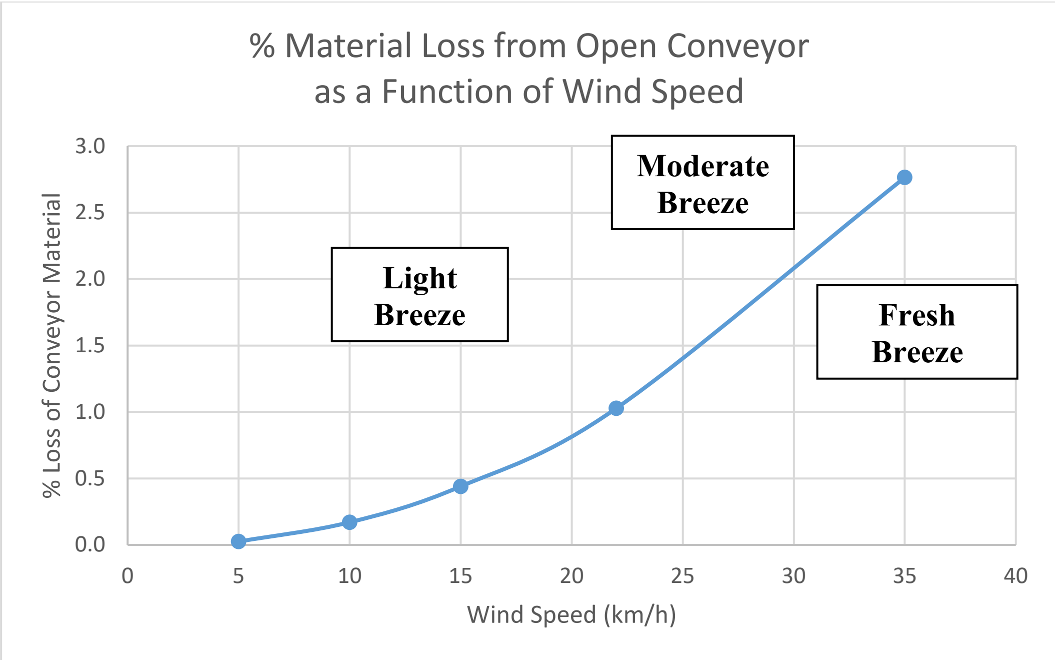
The physics of sand entrainment are well established as shown below:



The measurement and prediction of dust loss from open conveyors under various wind conditions has been determined by Witt, Carey and Nguyen, 2002, (Applied Mathematical Modelling, Volume 26, Issue 2, February 2002, pages 297-309).

The research carried out on open conveyors showed that *"particles from the belt surface can be entrained by air motion and be carried away from the conveyor"*, that after 15 minutes "*only the surface material, perhaps 1-2mm was dry while the bulk of the material retained its moisture"*, that the *" Loss of product from the belt can be of the order of 1.5%"*, and that *"Dust lift-off was not visible during the time of each test (as commonly depicted by dust clouds)."*

The % loss of fine material from the open conveyor is shown below:



The HQPL submissions show that the open conveyor will transport around 36 te per hour (36,000 kg), so that at a loss rate of 1.5% it would be expected that around 540 kg per hour of sand would be lost even under light breeze conditions.

The 540 kg of sand contains around 100 million PM10 silica particles per kilogram which amounts to around 54,000 million PM10 particles being lost per hour during each of the 6 working hours per day.

In the worst possible extreme case, if the drying and lifting of the 540kg occurred preferentially for fine particles leaving coarser particles behind so that the 540kg loss was totally made up from PM10 particles, then in the extreme case there would be 1,300,000,000,000,000 PM10 particles liberated every hour.

So the residents of Freeth Farm Cottages and The Freeth will potentially be exposed to a health risk from PM10 wind blown carcinogenic particles from open conveyors for 4-5 years This represents a total of 1260 days excluding weekends and bank holidays when the plant will not be allowed to opperate.

The Lyneham weather station data indicates that a carcinogenic health risk from the surface layers of the sand in transit on the conveyors will occur after 15 minutes in dry conditions (65% of the time) combined with light breeze conditions (<3m/s) and from wind directions from the south and east (20% of the time).

This means that there is a 13% chance of exceeding the WHO and HSE 24 hour exposure limits for carcinogenic PM10 silica particles on each of the 1260 days of open conveyor operation.

The PM10 loss of 54,000 million PM10 particles per hour equates to 3,240,000 million PM10 particles (3.24 x 10^{12} particles) over a 6 hour working day which represents the likely maximum 24 hour exposure but this will be diluted by the surrounding air volume before the PM10 particles reach any nearby poperties, with the level of dilution increasing rapidly at more remote distances.

However, it is not possible to calculate the PM10 exposure risks with any accuracy due to the 1.2km conveyor length parts of which will be exposed to different wind directions and strengths.

The only reliable method of ensuring that the dust risk is properly mitigated would be by the use of continuous dust monitoring equipment or the use of closed conveyors with dust suppression sprays which is good industry practice following the process Guidance Note 3/08(12) – Statutory Guidance for Quarry Processes.

Continuous Dust Monitoring

Hills dust mitigation strategy appears to relate to wind blown dust nuisance and not carcinogenic dust, so it does not involve any continuous dust monitoring.

It relies on 4 main factors: 1. Coarse wet sand at all times; 2. Screening bunds (although these are largely for noise protection); 3. Visual observation by the site staff and quarry manager; and 4. Deployment of a water bowser as required.

None of these dust mitigation measures is at all effective for the risk of wind blown PM10 silica particles which can arise very rapidly over a 15 minute period from surface layers under dry light breeze conditions and since the PM10 particles are not visible to the naked eye the operators will be unaware of the risk, particluarly on the remote conveyors.

The health risk is so serious that the Control of Substances Hazardous to Health Regulations 2002 (COSHH), as amended, requires a formal risk assessment to be carried out to control exposure to respirable crystalline silica.

As a consequence it should be mandatory that continuous dust monitoring should be required to detect any life threatening PM10 particle blows that may arise from time to time without the knowledge of the opertors.

Continuous dust monitoring equipment such as the one shown below are inexpensive and easy to use and are routinely used in Wiltshire for air quality particle monitoring in AQMAs and should be imposed as a planning condition to provide adequate environmental protection.

This health risk is non-trivial to the extent that Hills Quarry Products Limited should be asked to provide an indemnity against future health claims from the local community against Wiltshire Council in the event that this development is consented in its present form.

In addition, Hills Quarry Products Limited should put their insurers on notice of the likely increased risks arising from these activities or their insurance cover may be jeopardised.

ANNEX 1

Details of Normal and Temporary Activities

Phase 1

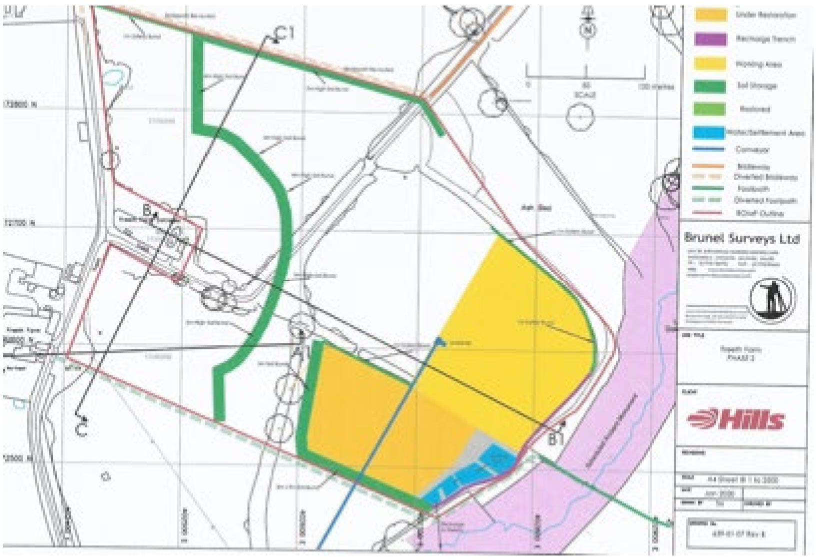
Phase 1 involves the following temporary activities: stripping 4600 m^3 of top soil from Phase 1; constructing a 1m x 2m x 200m safety bund along the top edge of Phase 1; constructing a 3m x 9m x 220m noise attenuation bund along the bottom edge of Phase 1; excavation of the re-charge trench and settlement ponds; and the installation of a 60m length (Phase 1 only) of open conveyor, as shown below. The temporary activities are followed by normal operations involving the extraction of 26,600 te of sand and it's removal by open conveyor. The total time for Phase 1 is 24 weeks.

Phase 1	Tonnes of Material	Estimated Time (weeks)
Strip 4600 m^3 Top Soil Phase 1	6210	3.97
1m x 2m x 200m Safety Bund (Top edge Phase 1)	270	0.17
3m x 9m x 220m Bund (Bottom edge Phase 1)	4455	2.85
Excavate re-charge trench & settlement pond		
Install Conveyor + Screener (60m into Phase 1)		
Pump water into re-charge trench		
Excavate Phase 1 Sand	26600	17.01
Total tonnage moved (te)	37535	
Movement Rate (Tonnes per week)	1564	
Total Time (weeks)	24	24.00

The time for each of the temporary activities has been estimated by keeping the total time for Phase 1 at 24 weeks and using pro rata time estimates for the respective tonnages.

Phase 2

Phase 2 involves the following temporary activities: stripping 7200 m^3 of top soil from Phase 2; restoring Phase 1 (excluding the recharge trench and resettlement ponds; removing 1m x 2m x 100m of the Phase 1 safety bund; constructing a 1m x 2m x 150m safety bund along the top edge of Phase 2; constructing a 3m x 9m x 190m noise attenuation bund across the centre of the site (lower half); constructing a 4m x 9m x 190m noise attenuation bund across the centre of the site (upper half); constructing a 2m x 4m x 225m bund next to the diverted bridleway along the north edge of the site; constructing a 1m x 2m x 90m safety bund in the north corner of the site also next to the diverted bridleway; extending the open conveyor by 80m from Phase 1, as shown below. The temporary activities are followed by normal operations involving the extraction of 68,400 te of sand and it's removal by open conveyor. The total time for Phase 2 is 59 weeks.



Phase 2	Tonnes of Material	Estimated Time (weeks)
Strip 7200 m^3 Top Soil Phase 2	9720	6.08
Restore Phase 1 except Settlement Ponds	5589	3.49
Remove 1m x 2m x 100m Safety bund (Top edge Phase 1)	135	0.08
1m x 150m Safety Bund (Top Edge Phase 2)	203	0.13
3m x 9m x 190m Central Bund (Lower Half)	3848	2.41
4m x 9m x 190m Central Bund (Upper Half)	5130	3.21
2m x 4m x 225m Bund (North Edge)	1215	0.76
1m x 2m x 90m Safety Bund (North Edge)	121.5	0.08
Extend Conveyor + Screener (80m) from Phase 1		
Excavate Phase 2 Sand	68400	42.77
Total tonnage moved (te)	94361	
Movement Rate (Tonnes per week)	1599	
Total Time (weeks)	59	59.00

Phase 3

Phase 3 involves the following temporary activities: stripping 5300 m^3 of top soil from Phase 3; completing the restoration of Phase 1 and restoring Phase 2 (7200 m^3); constructing a 1m x 2m x 100m safety bund along the top edge of Phase 3; extending the open conveyor by 80m from Phase 2, as shown below. The temporary activities are followed by normal operations involving the extraction of 45,600 te of sand and it's removal by open conveyor. The total time for Phase 3 is 40 weeks.

Phase 3	Tonnes of Material	Estimated Time (weeks)
Strip 5300m^3 Top Soil Phase 3	7155	4.57
Complete Phase 1 & Restore 7200m^3 Phase 2	9720	6.21
1m x 2m x 100m Safety Bund (Top Phase 3)	135	0.09
Extend Conveyor + Screener (80m) from Phase 2		
Extend Settlement Lagoons		
Excavate Phase 3 Sand	45600	29.13
Total tonnage moved (te)	62610	
Movement Rate (Tonnes per week)	1565	
Total Time (weeks)	40	40.00

Phase 4

Phase 4 involves the following temporary activities: stripping 4400 m^3 of top soil from Phase 4; restoring Phase 3 (5300 m^3); removing 1m x 2m x 90m of the Phase 1 safety bund (top edge); removing 1m x 2m x 150m of the Phase 2 safety bund (top edge); removing 3m x 9m x 220m of the lower Phase 1 noise attenuation bund; extending the open conveyor by 225m from Phase 3, as shown below. The temporary activities are followed by normal operations involving the extraction of 39,300 te of sand and it's removal by open conveyor. The total time for Phase 4 is 33 weeks.

Phase 4	Tonnes of Material	Estimated Time (weeks)
Strip 4400 m^3 Top Soil Phase 4	5940	3.43
Restore 5300 m^3 Top Soil on Phase 3	7155	4.13
Remove 1m x 2m x 100m Safety Bund (Top edge Phase 1)	135	0.08
Remove 1m x 2m x 150m Safety Bund (Top edge Phase 2)	203	0.12
Remove lower 3m x 9m x 220m Bund from Phase 1	4455	2.57
Extend Conveyor + Screener (225m) from Phase 3		
Excavate Phase 4 Sand	39300	22.68
Total tonnage moved (te)	57188	
Movement Rate (Tonnes per week)	1733	
Total Time (weeks)	33	33.00

Phase 5

Phase 5 involves the following temporary activities: stripping 12,400 m^3 of top soil from Phase 5; restoring Phase 4 (4400 m^3); removing 1m x 2m x 100m of the Phase 1 safety bund (top of Phase 3); removing 3m x 9m x 190m of the central noise attenuation bund (lower half); removing 4m x 9m x 190m of the of the central noise attenuation bund (upper half); increasing the safety bund from 1m to 3m x 9m x 90m (north edge); constructing a 3m x 9m x 140m noise attenuation bund (Phase 5 top left corner); constructing a 4m x 19m x 200m noise attenuation bund next to Freeth Farm Cottages; extending the open conveyor by 90m from Phase 4, as shown below. The temporary activities are followed by normal operations involving the extraction of 45,800 te of sand and it's removal by open conveyor. The total time for Phase 2 is 39 weeks.

Phase 5	Tonnes of Material	Estimated Time (weeks)
Strip 12400 m^3 Top Soil Phase 5	16740	6.98
Restore 4400 m^3 on Phase 4	5940	2.48
Remove 1m x 2m x 100m Safety Bund (Top Phase 3)	135	0.06
Remove 3m x 9m x 190m Central Bund (Lower Half)	3848	1.61
Remove 4m x 9m x 190m Central Bund (Upper Half)	5130	2.14
Increase 1m Safety Bund to 3m x 9m x 90m (North Edge)	1701	0.71
3m x 9m x 140m Bund (Top Left Corner)	2835	1.18
4m x 19m x 200m Bund (Next to Cottages)	11340	4.73
Extend Conveyor + Screener (90m) from Phase 4		
Excavate Phase 5 Sand	45800	19.11
Total tonnage moved (te)	93469	
Movement Rate (Tonnes per week)	2397	
Total Time (weeks)	39	39.00

Phase 6

Phase 6 involves the following temporary activities: stripping 5000 m^3 of top soil from Phase 6; restoring Phase 5 (6200 m^3); removing 3m x 9m x 90m of the bund at the north edge of Phase 5 next to the diverted bridleway; removing 3m x 9m x 140m of part of the noise attenuation bund leading away from Freeth Farm Cottages; constructing 4m x 19m x 90m noise attenuation bund around Freeth Farm Cottages; constructing a 3m x 9m x 375m noise attenuation bund along the edge of Phase 6; extending the open conveyor by 40m from Phase 5, as shown below. The temporary activities are followed by normal operations involving the extraction of 43,000 te of sand and it's removal by open conveyor. The total time for Phase 6 is 38 weeks.

Phase 6	Tonnes of Material	Estimated Time (weeks)
Strip 6200 m^3 Top Soil Phase 6	8370	3.75
Restore 12400 m^3 Top Soil on Phase 5	16740	7.50
Remove 2m x 4m x 225m (Bridleway Bund)	1215	0.54
Remove 4m x 19m x 50m (Near Cottages)	2835	1.27
4m x 19m x 90m Bund (Next to Cottages)	5103	2.29
3m x 9m x 375m (Edge of Phase 6)	7594	3.40
Extend Conveyor + Screener (40m) from Phase 5		
Excavate Phase 6 Sand	43000	19.26
Total tonnage moved (te)	84857	
Movement Rate (Tonnes per week)	2233	
Total Time (weeks)	38	38.00

Phase 7

Phase 7 involves the following temporary activities: stripping 5000 m^3 of top soil from Phase 7; restoring Phase 6 (6200 m^3); removing 3m x 9m x 90m of the noise attenuation bund at the north edge of Phase 5 next to the diverted bridleway; removing 3m x 9m x 140m of the noise attenuation bund at the top corner of Phase 5 next to the access road; removing 4m x 19m x 140m from the noise attenuation bund surrounding the top of Freeth Farm Cottages; removing a 350m section of the open conveyor extending along Phases 5, 6 and 3/7, as shown below. The temporary activities are followed by normal operations involving the extraction of 38,500 te of sand and it's removal by open conveyor. The total time for Phase 7 is given as 34 weeks.

Phase 7	Tonnes of Material	Estimated Time (weeks)
Strip 5000 m^3 Top Soil Phase 7	6750	3.07
Restore 6200 m^3 Top Soil on Phase 6	8370	3.81
Remove 3m x 9m x 90m (North Edge)	1822.5	0.83
Remove 3m x 9m x 140m Bund (Top Corner)	2835	1.29
Remove 4m x 19m x 140m (Next to Cottages)	7938	3.61
4m x 19m x 150m (Between Cottages/Phase 8)	8505	3.87
Remove Conveyor (350m) + Move Screener (175m) from Phase 6		
Excavate Phase 7 Sand	38500	17.52
Total tonnage moved (te)	74721	
Movement Rate (Tonnes per week)	2198	
Total Time (weeks)	34	34.00

Phase 8

Phase 8 involves the following temporary activities: restoring Phase 7 (5000 m^3); removing the last 3m x 9m x 400m of the noise attenuation bund (at the edge of Phases 6 and 7); removing the last 4m x 19m x 150m of the noise attenuation bund surrounding Freeth Farm Cottages; removing the last 175m section of the open conveyor, as shown below. The total time for Phase 8 is given as 8 weeks.

Phase 8	Tonnes of Material	Estimated Time (weeks)
Restore 5000 m^3 Top Soil on Phase 7	6750	2.06
Remove last 3m x 9m x 400m Bund (Phases 6 & 7 edge)	8100	2.48
Remove 4m x 19m x 150m Bund (Next to Cottages)	6784	2.07
Remove 4m x 19m x 100m (Central Strip)	4523	1.38
Remove Conveyor and Screener (175m)		
Total tonnage moved (te)	26156	
Movement Rate (Tonnes per week)	3270	
Total Time (weeks)	8	8.00

Annex 2

Lawson Scientific Limited Particle Size Measurements

LAWSON
SCIENTIFIC

Lawson Scientific Ltd
Unit 3, Clipstone Brook Industrial Estate
Cherrycourt Way
Leighton Buzzard
Bedfordshire
LU7 4GP

Calculation of Number of Particles in 1kg

To calculate the total number of particles in 1kg that are 2.5 µm or smaller and 10 µm or smaller, I have used the individual particle diameters and percentage volumes for each particle size in each sample using the following methodology:

1. Calculate the volume of single particle for each of the particle sizes using the individual particle diameters.
2. Calculate the weight of a single particle for each particle size by multiplying the single particle volume by a density of 2.5 g/cc.
3. Calculate the weight of each particle size fraction by multiplying the weight of each single particle by its measured volume fraction (derived from the percentage volumes).
4. Calculate the combined total weight for all the particle sizes.
5. Hence the weight of each particle size fraction exists as part of the combined total weight for all the particle sizes.
6. Calculate the weight of each particle size fraction that would arise in a combined total weight of 1 kilogram.
7. Calculate the number particles per kilogram for each size fraction by dividing the weight of each particle size fraction by the weight of a single particle.
8. Calculate the number of particles that are 2.5 µm or smaller by summating the number of particles for each size fraction up to a size of 2.5 µm.
9. Calculate the number of particles that are 10 µm or smaller by summating the number of particles for each size fraction up to a size of 10 µm.

The original Lawson Scientific Limited data and the detailed calculations derived from the data are given in Annex 1 (Sample 1) and Annex 2 (Sample 2).

The results can be summarised as follows:

	Percentage of Particles less than 2.5 µm (PM2.5)	Number of PM2.5 particles per kilogram	Percentage of Particles less than 10 µm (PM10)	Number of PM10 particles per kilogram
Sample 1	**4.3%**	**186,67,656**	**13%**	**54,680,288**
Sample 2	**11%**	**554,97,976**	**38%**	**162,552,158**

Particles are defined by their diameter for air quality regulatory purposes and fine particulate matter is defined as particles that are 2.5 microns or less in diameter (PM2.5). Therefore, PM2.5 comprises a portion of PM10. As you will see from the results, sample one contains over 18.6 million particles less 2.5um and in total over 54 million particles less than 10um per kilogram.
Sample 2 contains over 55 million particles less than 2.5um and in total over 162 million particles less than 10um per kilogram.

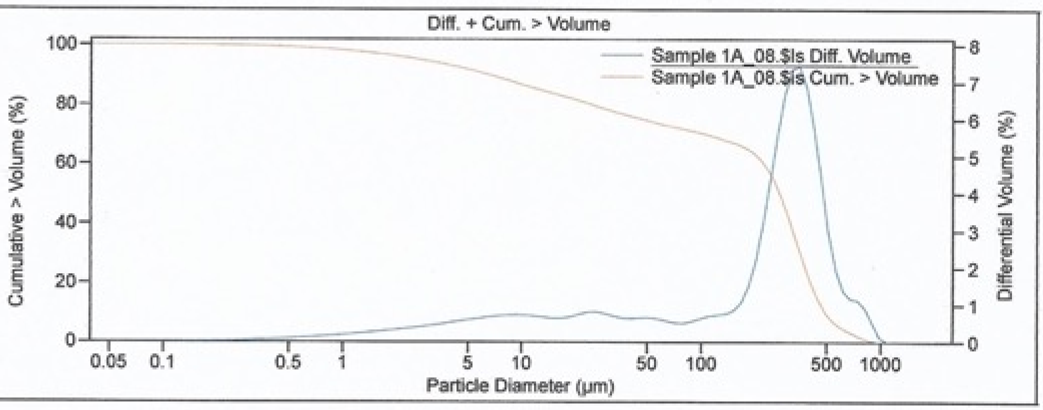
BECKMAN COULTER

LS Particle Size Analyzer

27 May 2021 14:56

Beckman Coulter LS 13 320

File name:	E:\Peter Alberry\Sample 1A_08.$ls Sample 1A_08.$ls		
File ID:	Sample 1A		
Sample ID:	Sample 1		
Operator:	MERITICS3		
Run number:	8		
Comment 2:	Dispersion, Direct		
Optical model:	Fraunhofer.rfd PIDS included		
Residual:	1.02%		
LS 13 320	Aqueous Liquid Module		
Start time:	10:49 27 May 2021	Run length:	64 seconds
Pump speed:	72		
Obscuration:	5%	PIDS Obscur:	46%
Fluid:	Water		
Software:	6.03	Firmware:	2.02



Volume Statistics (Arithmetic) Sample 1A_08.$ls

Calculations from 0.040 μm to 2000 μm

Volume:	100%		
Mean:	261.2 μm	S.D.:	200.0 μm
Median:	276.0 μm	Variance:	40013 μm^2
Mean/Median ratio:	0.946	C.V.:	76.6%
Mode:	356.1 μm	Skewness:	0.528 Right skewed
		Kurtosis:	0.135 Leptokurtic

d_{10}: 6.660 μm d_{50}: 276.0 μm d_{90}: 496.9 μm

<10%	<25%	<50%	<75%	<90%
6.660 μm	48.30 μm	276.0 μm	384.5 μm	496.9 μm

>10%	>25%	>50%	>75%	>90%
496.9 μm	384.5 μm	276.0 μm	48.30 μm	6.660 μm

BECKMAN COULTER

LS Particle Size Analyzer

27 May 2021 14:56

Beckman Coulter LS 13 320

Sample 1A_08.$ls

Channel Diameter (Lower) µm	Diff. Volume %	Cum. > Volume %
0.040	0.000020	100
0.044	0.000037	100
0.048	0.000078	100
0.053	0.00017	100
0.058	0.00032	100
0.064	0.00060	99.999
0.070	0.0011	99.999
0.077	0.0017	99.998
0.084	0.0025	99.996
0.093	0.0035	99.99
0.102	0.0048	99.99
0.112	0.0063	99.99
0.122	0.0079	99.98
0.134	0.0098	99.97
0.148	0.012	99.96
0.162	0.015	99.9
0.178	0.018	99.9
0.195	0.022	99.9
0.214	0.026	99.9
0.235	0.032	99.9
0.258	0.038	99.8
0.284	0.044	99.8
0.311	0.051	99.8
0.342	0.059	99.7
0.375	0.067	99.6
0.412	0.076	99.6
0.452	0.086	99.5
0.496	0.096	99.4
0.545	0.11	99.3
0.598	0.12	99.2
0.656	0.13	99.1
0.721	0.15	99.0
0.791	0.16	98.8
0.868	0.18	98.7
0.953	0.19	98.5
1.047	0.21	98.3
1.149	0.23	98.1
1.261	0.25	97.9
1.385	0.26	97.6
1.520	0.28	97.3
1.668	0.31	97.1
1.832	0.33	96.8
2.011	0.35	96.4
2.207	0.37	96.1
2.423	0.39	95.7
2.660	0.42	95.3
2.920	0.44	94.9
3.205	0.47	94.5
3.519	0.50	94.0
3.863	0.53	93.5
4.240	0.56	93.0
4.655	0.59	92.4
5.110	0.62	91.8
5.610	0.65	91.2
6.158	0.67	90.6
6.760	0.70	89.9
7.421	0.72	89.2
8.147	0.73	88.5
8.943	0.73	87.7
9.817	0.73	87.0
10.78	0.72	86.3
11.83	0.69	85.6
12.99	0.67	84.9
14.26	0.64	84.2
15.65	0.64	83.6
17.18	0.66	82.9
18.86	0.71	82.3
20.70	0.77	81.6
22.73	0.81	80.8
24.95	0.82	80.0
27.39	0.78	79.2
30.07	0.73	78.4
33.01	0.67	77.6
36.24	0.64	77.0
39.78	0.64	76.3
43.67	0.65	75.7
47.94	0.66	75.1
52.62	0.64	74.4
57.77	0.60	73.7
63.41	0.55	73.1
69.61	0.52	72.6
76.42	0.51	72.1
83.89	0.55	71.6
92.09	0.61	71.0
101.1	0.67	70.4
111.0	0.72	69.7
121.8	0.74	69.0
133.7	0.77	68.3
146.8	0.86	67.5
161.2	1.07	66.6
176.9	1.50	65.6
194.2	2.20	64.1
213.2	3.19	61.9
234.1	4.39	58.7
256.9	5.64	54.3
282.1	6.72	48.6
309.6	7.37	41.9
339.9	7.43	34.6
373.1	6.85	27.1
409.6	5.74	20.3
449.7	4.34	14.5
493.6	2.97	10.2
541.9	1.96	7.23
594.9	1.38	5.27
653.0	1.17	3.88
716.8	1.13	2.71
786.9	0.92	1.58
863.9	0.52	0.67
948.3	0.13	0.15
1041	0.015	0.015
1143	0	0
1255	0	0
1377	0	0
1512	0	0
1660	0	0
1822	0	0
2000		0

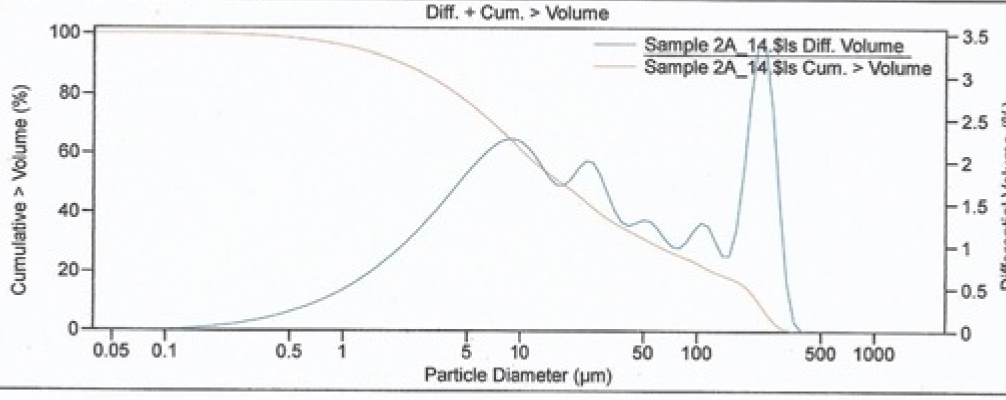
BECKMAN COULTER

LS Particle Size Analyzer

27 May 2021 14:56

Beckman Coulter LS 13 320

File name:	E:\Peter Alberry\Sample 2A_14.$ls Sample 2A_14.$ls		
File ID:	Sample 2A		
Sample ID:	Sample 2A		
Operator:	MERITICS3		
Run number:	14		
Comment 2:	Dispersion, Direct		
Optical model:	Fraunhofer.rfd PIDS included		
Residual:	1.08%		
LS 13 320	Aqueous Liquid Module		
Start time:	11:18 27 May 2021	Run length:	65 seconds
Pump speed:	72		
Obscuration:	6%	PIDS Obscur:	50%
Fluid:	Water		
Software:	6.03	Firmware:	2.02



Volume Statistics (Arithmetic) Sample 2A_14.$ls

Calculations from 0.040 µm to 2000 µm

Volume:	100%		
Mean:	62.57 µm	S.D.:	86.48 µm
Median:	17.38 µm	Variance:	7479 μm^2
Mean/Median ratio:	3.601	C.V.:	138%
Mode:	223.4 µm	Skewness:	1.470 Right skewed
		Kurtosis:	0.794 Leptokurtic

d_{10}: 2.214 µm d_{50}: 17.38 µm d_{90}: 223.1 µm

<10%	<25%	<50%	<75%	<90%
2.214 µm	5.670 µm	17.38 µm	84.73 µm	223.1 µm

>10%	>25%	>50%	>75%	>90%
223.1 µm	84.73 µm	17.38 µm	5.670 µm	2.214 µm

BECKMAN COULTER

LS Particle Size Analyzer

Beckman Coulter LS 13 320

27 May 2021 14:56

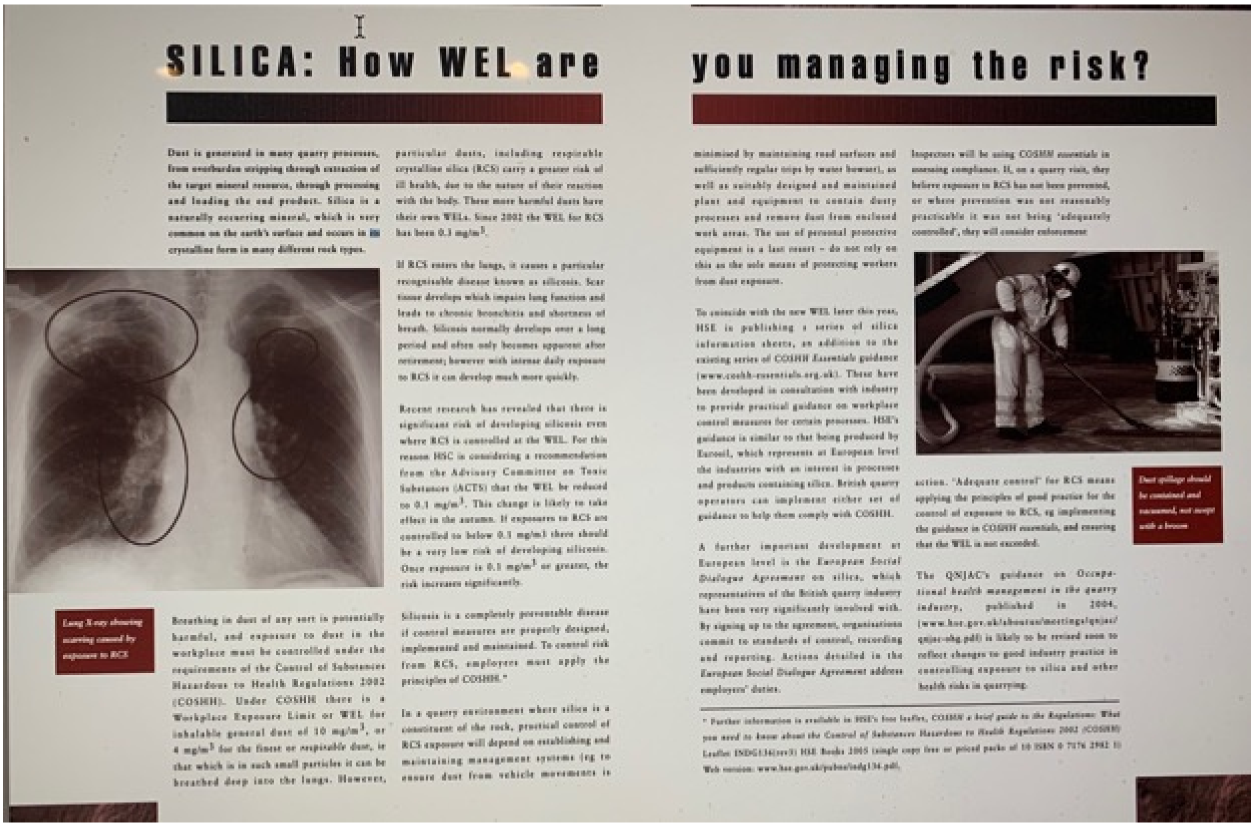
Sample 2A_14.$ls

Channel Diameter (Lower) µm	Diff. Volume %	Cum. > Volume %
0.040	0.000002	100
0.044	0.000019	100
0.048	0.000070	100
0.053	0.00017	100
0.058	0.00032	100
0.064	0.00057	99.999
0.070	0.0011	99.999
0.077	0.0021	99.998
0.084	0.0036	99.996
0.093	0.0055	99.99
0.102	0.0081	99.99
0.112	0.011	99.98
0.122	0.015	99.97
0.134	0.019	99.95
0.148	0.024	99.9
0.162	0.031	99.9
0.178	0.038	99.9
0.195	0.046	99.8
0.214	0.057	99.8
0.235	0.070	99.7
0.258	0.084	99.7
0.284	0.100	99.6
0.311	0.12	99.5
0.342	0.14	99.4
0.375	0.16	99.2
0.412	0.18	99.1
0.452	0.20	98.9
0.496	0.23	98.7
0.545	0.25	98.5
0.598	0.28	98.2
0.656	0.32	97.9
0.721	0.35	97.6
0.791	0.39	97.3
0.868	0.43	96.9
0.953	0.48	96.4
1.047	0.53	96.0
1.149	0.58	95.4
1.261	0.64	94.9
1.385	0.70	94.2
1.520	0.76	93.5
1.668	0.83	92.8
1.832	0.90	91.9
2.011	0.98	91.0
2.207	1.06	90.0
2.423	1.14	89.0
2.660	1.23	87.8
2.920	1.32	86.6
3.205	1.42	85.3
3.519	1.52	83.9
3.863	1.62	82.3
4.240	1.73	80.7
4.655	1.83	79.0
5.110	1.93	77.2
5.610	2.03	75.2
6.158	2.11	73.2
6.760	2.18	71.1
7.421	2.24	68.9
8.147	2.27	66.7
8.943	2.27	64.4
9.817	2.24	62.1
10.78	2.17	59.9
11.83	2.06	57.7
12.99	1.93	55.7
14.26	1.80	53.7
15.65	1.72	51.9
17.18	1.72	50.2
18.86	1.81	48.5
20.70	1.93	46.7
22.73	2.01	44.7
24.95	1.99	42.7
27.39	1.85	40.7
30.07	1.63	38.9
33.01	1.42	37.3
36.24	1.29	35.8
39.78	1.25	34.5
43.67	1.28	33.3
47.94	1.31	32.0
52.62	1.30	30.7
57.77	1.21	29.4
63.41	1.09	28.2
69.61	1.00	27.1
76.42	0.98	26.1
83.89	1.06	25.1
92.09	1.19	24.1
101.1	1.28	22.9
111.0	1.24	21.6
121.8	1.07	20.3
133.7	0.89	19.3
146.8	0.89	18.4
161.2	1.21	17.5
176.9	1.90	16.3
194.2	2.78	14.4
213.2	3.40	11.6
234.1	3.37	8.22
256.9	2.65	4.85
282.1	1.51	2.20
309.6	0.57	0.68
339.9	0.11	0.11
373.1	0.0077	0.0077
409.6	0	0
449.7	0	0
493.6	0	0
541.9	0	0
594.9	0	0
653.0	0	0
716.8	0	0
786.9	0	0
863.9	0	0
948.3	0	0
1041	0	0
1143	0	0
1255	0	0
1377	0	0
1512	0	0
1660	0	0
1822	0	0
2000		0

Annex 3

HSE Guidance on Carcinogenic Silica Dust Exposure

(0.1 mg/m^3 or 100 µg/m^3)



SILICA: How WEL are you managing the risk?

Dust is generated in many quarry processes, from overburden stripping through extraction of the target mineral resource, through processing and loading the end product. Silica is a naturally occurring mineral, which is very common on the earth's surface and occurs in its crystalline form in many different rock types.

Lung X-ray showing scarring caused by exposure to RCS

Breathing in dust of any sort is potentially harmful, and exposure to dust in the workplace must be controlled under the requirements of the Control of Substances Hazardous to Health Regulations 2002 (COSHH). Under COSHH there is a Workplace Exposure Limit or WEL for inhalable general dust of 10 mg/m^3, or 4 mg/m^3 for the finest or *respirable dust*, ie that which is in such small particles it can be breathed deep into the lungs. However, particular dusts, including respirable crystalline silica (RCS) carry a greater risk of ill health, due to the nature of their reaction with the body. These more harmful dusts have their own WELs. Since 2002 the WEL for RCS has been 0.3 mg/m^3.

If RCS enters the lungs, it causes a particular recognisable disease known as silicosis. Scar tissue develops which impairs lung function and leads to chronic bronchitis and shortness of breath. Silicosis normally develops over a long period and often only becomes apparent after retirement; however with intense daily exposure to RCS it can develop much more quickly.

Recent research has revealed that there is significant risk of developing silicosis even where RCS is controlled at the WEL. For this reason HSC is considering a recommendation from the Advisory Committee on Toxic Substances (ACTS) that the WEL be reduced to 0.1 mg/m^3. This change is likely to take effect in the autumn. If exposures to RCS are controlled to below 0.1 mg/m3 there should be a very low risk of developing silicosis. Once exposure is 0.1 mg/m^3 or greater, the risk increases significantly.

Silicosis is a completely preventable disease if control measures are properly designed, implemented and maintained. To control risk from RCS, employers must apply the principles of COSHH.*

In a quarry environment where silica is a constituent of the rock, practical control of RCS exposure will depend on establishing and maintaining management systems (eg to ensure dust from vehicle movements is minimised by maintaining road surfaces and sufficiently regular trips by water bowser), as well as suitably designed and maintained plant and equipment to contain dusty processes and remove dust from enclosed work areas. The use of personal protective equipment is a last resort – do not rely on this as the sole means of protecting workers from dust exposure.

To coincide with the new WEL later this year, HSE is publishing a series of silica information sheets, an addition to the existing series of COSHH *Essentials* guidance (www.coshh-essentials.org.uk). These have been developed in consultation with industry to provide practical guidance on workplace control measures for certain processes. HSE's guidance is similar to that being produced by Eurosil, which represents at European level the industries with an interest in processes and products containing silica. British quarry operators can implement either set of guidance to help them comply with COSHH.

A further important development at European level is the *European Social Dialogue Agreement* on silica, which representatives of the British quarry industry have been very significantly involved with. By signing up to the agreement, organisations commit to standards of control, recording and reporting. Actions detailed in the *European Social Dialogue Agreement* address employers' duties.

Inspectors will be using COSHH essentials in assessing compliance. If, on a quarry visit, they believe exposure to RCS has not been prevented, or where prevention was not reasonably practicable it was not being 'adequately controlled', they will consider enforcement action. 'Adequate control' for RCS means applying the principles of good practice for the control of exposure to RCS, eg implementing the guidance in COSHH essentials, and ensuring that the WEL is not exceeded.

Dust spillage should be contained and vacuumed, not swept with a broom

The QNJAC's guidance on *Occupational health management in the quarry industry*, published in 2004, (www.hse.gov.uk/aboutus/meetings/qnjac/qnjac-ohg.pdf) is likely to be revised soon to reflect changes to good industry practice in controlling exposure to silica and other health risks in quarrying.

* Further information is available in HSE's free leaflet, *COSHH a brief guide to the Regulations: What you need to know about the Control of Substances Hazardous to Health Regulations 2002 (COSHH)* Leaflet INDG136(rev3) HSE Books 2005 (single copy free or priced packs of 10 ISBN 0 7176 2982 1) Web version: www.hse.gov.uk/pubns/indg136.pdf.