

TSP Community Assessment Methodology

Prepared for:

Adelaide Brighton Cement Ltd

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Final

Prepared by:

Katestone Environmental Pty Ltd

ABN 92 097 270 276

Ground Floor, 16 Marie Street | PO Box 2217
Milton, Brisbane, Queensland, 4064, Australia

ENVIRONMENT PROTECTION AUTHORITY

THIS IS THE APPROVED TSP Community Assessment Plan

REFERRED TO IN CONDITION U-1562

OF EPA AUTHORISATION NUMBER 1126

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www.katestone.global

admin@katestone.com.au

Ph +61 7 3369 3699

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Prepared by: Ricky Gellatly

Reviewed by: Simon Welchman

Approved by:



Simon Welchman

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Glossary

Term	Definition
$\mu\text{g}/\text{m}^3$	micrograms per cubic metre
°	degrees
g	grams
km	kilometres
m	metres
m^2	square metres
m^3	cubic metres
Nomenclature	Definition
PM ₁₀	particulate matter with a diameter less than 10 micrometres
PM _{2.5}	particulate matter with a diameter less than 2.5 micrometres
TSP	Total suspended particulates
Abbreviations	Definition
ABC	Adelaide Brighton Cement Ltd
AS	Australian Standard
EPA	Environment Protection Authority
HVAS	high-volume air sampler
ICPMS	inductively coupled plasma mass spectrometry
Lu	Lutetium
NATA	National Association of Testing Authorities
Pt	Platinum
SA	South Australia
Sm	Samarium
Tb	Terbium
XRD	X-ray diffraction
XRF	X-ray fluorescence
Y	Yttrium

1. INTRODUCTION

Katestone Environmental Pty Ltd (Katestone) was commissioned by Adelaide Brighton Cement Ltd (ABC) to develop a methodology to address condition U-1562 as applied to the amended licence (1126) for the ABC Birkenhead Cement Plant (the Facility) issued by the South Australian (SA) Environment Protection Authority (EPA) on 1 November 2022. The condition states:

TOTAL SUSPENDED PARTICULATE (TSP) COMMUNITY ASSESSMENT (U -1562)

The Licensee must:

4.7.1 develop and submit a plan, to the satisfaction of the EPA, by the compliance date listed below, which includes but need not be limited to:

- a) a methodology and framework for a TSP community assessment to be undertaken by the Licensee that ensures that the nature and composition of TSP material at locations within the residential community adjacent to the Premises is assessed by the Licensee;*
- b) a methodology and framework that ensures that the TSP community assessment includes a comparison and correlation of materials used at, and emissions from, the Premises with the nature and composition of TSP material assessed at locations within the residential community adjacent to the Premises; and*
- c) proposed timeframes and duration of the TSP community assessment.*

Compliance Date: 30-Jun-2023

A meeting was held with the EPA prior to issuing of the amended licence, in which the EPA's expectations for the assessment were made clear. The EPA expects TSP samples to be collected using a high-volume air sampler (HVAS) and for the collected samples, and samples of materials used at the Facility, to be analysed chemically in an attempt to 'fingerprint' the Facility's contribution to measured TSP concentrations.

Section 2 of this report sets out a summary of the background to this study, providing details of historic studies into dust deposition as a result of emissions from the Facility and how the requirements of this study must be informed by these previous studies.

Section 3 of this report discusses the key materials that are handled on site that might form particulate emissions, and those that have been chemically analysed to inform this assessment methodology (and the TSP community assessment itself). The results of the chemical analysis are discussed in Section 4 and the full report from Sharp & Howells laboratory is provided in Appendix A.

Section 5 discusses the limitations of the methodology, which are largely unavoidable and important to acknowledge.

Section 6 of this report provides analysis of seasonal trends in particulate concentrations and meteorological conditions, used to inform the recommend time period over which the TSP community assessment is carried out.

Section 7 sets out the proposed methodology for the TSP community assessment in full.

2. PREVIOUS STUDIES

2.1 Birkenhead residential air-fall dusts: microscopic and x-ray diffraction characterisation (2005)

Graham Ohmsen of the Environmental Health Service within the South Australian Department of Health published a study in May 2005 that utilised optical microscopy and x-ray diffraction (XRD) techniques to characterise materials that had settled on 1m² stainless steel trays positioned on the roofs of three structures located within 200-500m of the Facility between 29 September 2004 and 6 October 2004, and again between 15 and 25 October 2004. The monitoring locations were at 51 Mary Street, 4 Little Craigie Street and on land between Semaphore Road and Jenkins Street. The study was instigated in response to concerns and complaints from residents about the impact of the deposited material on their property.

Dust from the trays was brushed into petri dishes for analysis by optical microscopy. The report notes that a limitation of this approach was the inability to clearly resolve particles smaller than approximately 5 µm in size and to discriminate between minerals of this size with similar physical and optical properties. The author describes the approach as semi-quantitative, with estimates of individual components in the dust being ±10%. The author states that the method provides information on the physical characteristics of the particles in the dust, such as shape and colour, which can form the basis for more detailed studies.

The report lacks detail in terms of how much of each sample was able to be analysed by optical microscopy; it states that visual estimation of each component in the dusts was based on areal distribution of the component in the sample and involved examination of many fields at several magnifications. This suggests that the entirety of each sample was not analysed, rather that a number of 'areal fields' within each sample were analysed, but there is uncertainty around this.

The report summarises the samples from all three locations as being composed of the following, acknowledging some variation between different samples:

- 20-50% Quartz – clear to milky white grains, 10-400 µm diameter, some coated with pale orange iron oxide
- 10-25% Calcite – small, clear angular fragments with 10-50 µm diameter and larger blocky grains with 100-300 µm diameter
- 5-15% pyrolytic carbon/coke breeze - present in two distinct morphologies; dull black elongate particles 30-250 µm long (pyrolytic carbon) and grey porous spheres 5-80 µm in diameter (coke)
- 5-10% transparent blocky grains - 5-20 µm in size with high refractive index (>quartz)
- 2-4% glassy dark grey grains - blocky aggregates 50- 400 µm in size
- 3-10% Organic (also misleadingly labelled as “background”) - mainly vegetable/plant matter and insect carcasses 0.5-3mm in size
- 2-3% Mica - present as clear to pale yellow flaky grains 20-200 µm in size
- 1-5% Halite (Nadi) - present as clear cubic crystals 2-300 µm in size
- 2-9% “Other” - included white blocky grains 20-50 µm in size and porous white aggregates 30-200 µm in size.

Samples of lime sand, gypsum, iron stone, iron blast furnace slag, raw meal, ground cement dust and cement kiln dust were also collected from the Facility, for analysis by optical microscopy only. The report states that:

“Wetting of the air-fall dusts and subsequent evaporation led to the recrystallisation of the soluble salts in the dusts. The recrystallised material occurred as pale milky white rounded grains, approximately 50 µm

in diameter, and constituted ~5% of the dust. Application of the same treatment to CKD and cement dust led to the crystallisation of a compound with the same morphology, colour and size as that observed in the air-fall dusts”.

The report states that XRD analysis was undertaken on the samples by Amdel Pty Ltd for identification of the crystalline phases and to confirm the mineralogy identified by optical assessment. It states that the XRD method was limited to identification of individual components present in the dust at amounts greater than 2% by volume and that the limitation on this analytical method is the inability to identify amorphous components of the dusts, particularly the pyrolytic carbon, coke and organic material. Regarding the XRD analysis, the report states:

“The XRD analysis (Appendix 2) identified 13 crystalline phases in the dusts, with quartz and calcite identified as the main constituents at all sampling sites. Quartz occurred as dominant constituent in samples from “hot spot” van and 51 Mary Street, whilst calcite was the dominant mineral at Little Craigie Street. Minerals identified as background ‘crustal’ constituents in the dusts were mica, K-feldspar, plagioclase feldspar and kaolinite (Al-clay). These occurred at all locations from trace to accessory amounts (~5-20%)”.

The report states *“three definite phases derived from the manufacture of cement were identified in the air-fall dusts from all sampling sites. These were alite (3CaO.SiO₂), ferrite (4CaO.Al₂O₃.Fe₂O₃) and bi-calcium aluminate (3CaO.Al₂O₃)”.* Confusingly, it does not provide the proportions of the samples that were made up of these materials, except in Appendix 2 where it is indicated that ferrite and bi-calcium aluminate appeared in trace amounts (<5%) in most samples and alite appeared in accessory amounts (5-20%) in 2 of the six samples, but not in the other four.

The study gives no consideration to the rate of dust deposition; thus it is impossible to judge what the proportions of materials in the samples collected mean in terms of the actual mass that will be being deposited in the community.

The study also gives no consideration to meteorology during the periods of sample collection, which means that no consideration has been given to the proportion of time that the sampling locations were downwind of the Facility. No reference samples at background locations were collected, thus no consideration is given to the potential for other sources to have contributed to quantities of measured materials that are assumed to originate from the Facility.

The discussion section of the report is somewhat incoherent and some of the conclusions do not seem particularly evidence based. It is stated that:

“The identification of cement compounds in the air-fall dusts suggests that post-depositional hydration of these particles may be responsible for the problems encountered by residents. The hydration of these particles by dew or under humid conditions will lead to the production of Ca-Si-H₂O gel and caustic Ca(OH)₂ which adhere to and corrode surfaces such as cars, roofs and window sills”.

It is later stated that *“the presence of 10-20% cement phases in the dusts does indicate that an amenities problem exists at ABC”*, but this statement is not backed up by the figures in the report, which do not suggest 10-20% cement phases in the dust.

The report goes on to conclude that:

“The limited number of source dusts examined in this work made unequivocal identification of the source(s) responsible for the air-fall dusts impossible. In terms of the overall components of the air-fall dust attributable to ABC, if all the calcite in the dusts is considered to be from this source, then the total contribution is estimated to be approximately 30-60% of the air-fall dusts depositing at the sampling locations. The relatively coarse grain size and crustal origin of the majority of the dusts depositing on residential area surrounding ABC's facility are unlikely to pose any health problems for the residents”.

It is unclear how Ohmsen arrives at this figure of 30-60% originating from the Facility but there is a clear lack of discussion around the uncertainties associated with it, or the potential range if alternative assumptions regarding sources of different minerals are made. The “Main Findings” section of the report then states a different figure of 35-60% as being attributable to the Facility.

Objective consideration of Ohmsen’s report has to conclude that there is a bias towards identifying the Facility as the source of dust collected and suggesting that dust from the Facility is causing amenity issues, as the limited scope of the study (e.g., not considering actual dust deposition rates and not considering background samples) means that such conclusions cannot be drawn with any confidence. By way of an example of this perceived bias, the study describes the presence of some particles present that are not thought to originate from the Facility in all samples as “problematic”, without proceeding to give any significant consideration to the potential for other sources to be contributing to the presence of any or all of the mineral phases detected in the samples collected. The contribution of many, varied sources to dust deposition should be expected, whereas the study appears to have been carried out with a starting assumption that the Facility is the source of the bulk of the dust deposited in the local area.

2.2 Deposited matter sampling at Birkenhead in the vicinity of Adelaide Brighton Cement Limited (2017)

SA Environment Pollution Monitoring Services carried out a study between March 2016 and March 2017 whereby dust deposition sampling was carried out at nine sites within 500 m of the Facility (with sites selected based on community complaints about dust perceived to emanate from the Facility) and at two ‘background’ locations, with the collected samples subsequently analysed by scanning electron microscope (SEM) (Adelaide University Microscopy Department) and XRD (CSIRO) to determine their composition.

Sampling had previously been carried out at 14 locations, including background locations, for a period of one month using trays sprayed with lithium grease to collect deposited particulate matter. Concerns were raised regarding the use of this spray as it caused problems with the analytical processes, and the long exposure period was also considered a concern given the potential for rainfall and moisture to trigger chemical reactions in cementitious materials. However, of note from this initial analysis was the detection of alite and tri-calcium aluminate (cement phases) in 10 of the 14 samples, including two background sites located a considerable distance from the Facility.

Five short-term sampling events (28 to 98 hours) were subsequently carried out using two different types of untreated trays to collect deposited particulate matter. The timing of the events was mainly determined by the predicted occurrence of winds from a 90-degree sector North East (45°) to South East (135°), lack of rainfall and dew point being reached. Trays were weighed before and after exposure to determine the dust deposition rate.

While the study was able to identify dust deposition rates, it concluded that the SEM and XRD analyses did not adequately quantify the mineral phases present in the samples collected. The Adelaide University Microscopy Department was only able to analyse by SEM a tiny fraction (no more than 3.4%) of the samples collected, thus this analysis was not (and cannot be) considered representative of the entire sample. Organic matter had to be excluded from both the SEM and XRD analyses. The results of the XRD analyses appear to have been discounted due to CSIRO’s lack of confidence in the results and the grouping of the results into broad percentage ranges for each mineral phase, rather than the provision of an explicit percentage value for each phase.

Given the uncertainties around the results of the SEM and XRD analyses, no attempt is made in the report to quantify the contribution of the Facility to measured deposited dust, and the report explicitly recommends that no attempts should be made to do so.

However, cement phases were identified by XRD in a number of samples, in particular those collected closest to the Facility, but this is to be expected and is not especially meaningful without robust quantification of the mass of such contributions. It must also be noted that cement phases were not detected in a large number of samples.

The report notes that the major mineral phases found, i.e., quartz, calcite, dolomite etc. were found at most sampling sites, including the background sites, and thus the material could be described as ubiquitous. This contrasts to the findings of Graham Ohmsen, who chose to assume that calcite originated from the Facility.

Some consideration was given to meteorological conditions during the sampling events, but only in the sense that the proportion of time when the Facility was upwind of sampling locations is stated. These data are not used in any interpretation of the results.

The conclusions of the study are clear from the following excerpts from the report:

“While both CSIRO and Adelaide University Microscopy Department were able to detect cement phases at the sampling sites located within 500 metres of the Adelaide Brighton Cement Ltd plant they could not accurately quantify the amounts found. Their assessments could therefore be described as semi-qualitative at best.

One of the difficulties in ascribing a particular source to many of the raw mineral species used by Adelaide Brighton Cement Ltd to make cement is that many of them are present as dust in the ambient environment”.

“Data obtained from both CSIRO’s XRD and Adelaide University’s SEM are not precise enough to allow robust calculations of relative concentration of specific minerals and other particulate components from the deposited matter collected”.

2.3 Victoria Road Air Quality Study (2021)

The Victoria Road Air Quality Monitoring Study was carried out by the City of Port Adelaide Enfield (CPAE) and SA EPA, with a focus on air quality in the vicinity of Victoria Road, in particular particulate concentrations. Monitoring was undertaken from March 2020 to May 2021, with a focus on PM_{2.5} and carbon monoxide. The study concluded that:

- Overall concentrations of measured pollutants were similar to those observed in other parts of metropolitan Adelaide.
- PM_{2.5} was highest in winter and mostly from local sources, with domestic wood-burning heaters likely to be an important contributor in the winter months.
- In summer, PM_{2.5} originated from a greater distance away to the northwest. Sources may include dust from dryer parts of the state, sea spray and pollution from ships.

Katestone notes that non-Australian Standard monitors were used for this study, thus its results must be treated as indicative only. However, the influence of wood-burning on particulate concentrations in the colder months is an important consideration for the TSP community assessment; this is discussed further in Section 6.2.1 and will require consideration during the analysis of the results of the study.

It is important to also note that concerns around the effects of deposition of cement phases are likely to focus on deposited dust much larger in size than PM_{2.5}.

2.4 Summary and Discussion

Katestone’s opinion of the Ohmsen report is that some of the conclusions drawn are not backed up by the evidence collected, and that the methodology adopted was not detailed enough for conclusions about the contribution of the Facility to dust deposition to be drawn. The lack of specifics about the methodology adopted also raise concerns about what proportions of the samples collected were actually analysed. However, the study does clearly identify the presence of cement phases in dust deposited in the community, albeit in relatively small amounts compared to other mineral phases. It also identifies the presence of a variety of mineral phases that may or not be associated

with emissions from the Facility. It provides a reasonable basis from which to identify the need for further analysis but does not provide conclusive results.

The SA Environment Pollution Monitoring Services further identifies the potential for the Facility to be contributing to dust in the community, while also identifying the extreme difficulties in quantifying this contribution, in particular that of cement phases. It identifies issues with the use of dust deposition monitoring as the basis for this type of study, along with issues relating to SEM and XRD analysis. It does not add significantly Ohmsen's work but does cast doubt on some of the conclusions that Ohmsen has drawn. It highlights that any further work will require very careful planning and is still likely to come with a high risk of failure in terms of its ability to draw meaningful results.

The Victoria Road Air Quality Study highlights the need to consider the potential contribution of both road traffic emissions (including wheel-generated dust) and wood-burning stoves to particulate concentrations.

Considering the outcomes of these previous studies, the methodology adopted for the TSP community assessment must:

- Quantify the mass of each ambient sample collected.
- Allow for chemical/elemental/mineralogical analysis of a representative proportion of each sample collected – SEM analysis, for example, cannot feasibly consider more than a tiny fraction of the sample collected.
- Ensure that the results of these analyses are returned with a high level of precision.
- Enable identification of cement phases in the samples collected, where present.
- Incorporate analysis of background samples so that wider regional contributions to particulate concentrations can be identified, including the presence of various mineral phases potentially attributable to emissions from the Facility in these background samples.
- Incorporate analysis of the materials handled at the Facility, for comparison against those within the TSP samples collected.
- Incorporate consideration of meteorological effects, in particular identifying when sampling locations are downwind of the Facility and how variations in particulate concentrations over time (using real-time data) can be used to determine the likely relative contribution of the Facility to measured particulate concentrations.
- Enable the outcomes of the elemental and mineralogical analyses to be used alongside the particulate concentration data and estimated Facility contribution to particulate concentrations to determine the likely contribution of the Facility to total concentrations of each marker element/mineral identified.

It is important to note that a requirement of the study is that it focusses on TSP, not deposited dust, and TSP concentrations do not necessarily correlate directly with dust deposition. Nuisance dust deposition and the potential for deposited dust to react with property is understood to be the concern driving the requirement for this study, so there is a disconnect of sorts here. However, a focus on TSP eliminates one of the key issues with previous studies, this being reactions between deposited dust and water, as rainfall will not affect the collected TSP samples. This offers a greater potential to identify cement phases in the collected samples.

3. KEY MATERIALS IN TERMS OF POTENTIAL DUST GENERATION

Katestone reviewed previous emissions inventories and dispersion modelling for the Facility, and liaised with ABC, to identify the key sources of emissions to air, and the composition of the materials forming those emissions. The key materials stockpiled externally at the Facility, and thus the key sources of wind-blown dust and emissions from material handling, are as follows:

- Limestone
- Bauxite
- Gypsum
- Mocolta clay/shale
- Black sand
- Mill scale
- Slag.

Emissions from other sources at the Facility, such as from dust collectors or fugitive emissions from buildings, will also be primarily composed of the above materials, except where materials have undergone chemical transformation, such as in the cement kiln. The output from the cement kiln is clinker, and this could also be emitted from sources such as dust collectors or fugitive emissions from buildings.

Having established these key materials that will make up the bulk of the emissions to air of particulates from the Facility, some of which have multiple origins, Katestone collected samples of 10 different stockpiled materials at the Facility in March 2023, all of which were analysed chemically by Sharp & Howells laboratory using the following methods:

- X-ray fluorescence (XRF) analysis targeting the complete elemental composition of each material
- Complementary inductively coupled plasma mass spectrometry (ICPMS) analysis for elements
- XRD analysis targeting the presence and amount of each mineral species present.

The materials analysed were:

- Limestone from Shell Block
- Bauxite sourced from Queensland
- Bauxite sourced from Tasmania
- Gypsum
- Mocolta clay/shale
- Black sand
- Mill scale
- Japanese slag
- Whyalla slag
- Clinker.

The results of the chemical analyses are discussed in Section 4, including discussion of the chemical 'fingerprints' that are likely to be targeted during the HVAS sampling. However, the exact elements and minerals that will be used cannot be identified with certainty until the HVAS samples have been collected and analysed, as it is the presence of specific elements and minerals in these samples collected in the community that will dictate how the presence of materials from the Facility will be determined. The full analysis report from Sharp & Howells is provided in Appendix A.

4. RESULTS OF CHEMICAL ANALYSIS

The full analysis report from Sharp & Howells for the ten material samples collected at the Facility is provided in Appendix A. As described in Section 2, the exact elements and minerals that will be used as chemical 'fingerprints' or markers cannot be identified with certainty until the HVAS samples have been collected and analysed, as it is the presence of specific elements and minerals in these samples collected in the community that will dictate how the presence of materials from the Facility will be determined. However, some initial potential markers can be identified as follows:

- The minerals calcite, dolomite, rutile, kaolinite and muscovite have all been identified in the limestone sample from the Facility; if these minerals are all present in similar proportions in the TSP samples collected in the community, then it is highly likely that the Facility is the source.
- The limestone sample also contains platinum (Pt), while no other samples do. If there is no platinum in TSP samples collected at a background monitoring location, yet there is platinum in samples collected in the community near to the Facility, then this is highly likely to indicate that a proportion of the sample is particles from the Facility, and this proportion may be estimated based on the platinum content.
- The mill scale sample contains the mineral quatranaite and the elements Samarium (Sm) and Terbium (Tb), and the black sand sample also contains Samarium and Terbium, all of which are uncommon and thus likely to be reliable markers of the contribution of the Facility to measured TSP concentrations.
- The ratio of wuestite to hematite in the black sand sample could identify the presence and proportion of this material in the TSP samples collected in the community.
- The presence of Yttrium (Y) and Lutetium (Lu) in the Whyalla slag sample, and their specific ratios, could be used to identify the presence and proportion of this material in the TSP samples collected in the community.
- The minerals identified in the clinker sample are relatively uncommon, and their specific ratios are likely to allow identification of the presence of clinker in TSP samples collected in the community, and the specific proportion of the sample made up of clinker dust.

This is only a selection of initial potential chemical markers; there are many other combinations of the presence of specific elements and minerals, and their specific ratios, that could be of potential significance in identifying materials from the Facility in TSP samples collected in the community, which will be investigated further once TSP samples have been collected.

5. LIMITATIONS TO THE ASSESSMENT APPROACH

The approach required by SA EPA introduces certain limitations to the assessment methodology, and it is important that these are acknowledged, and their effects discussed.

A fundamental limitation to this TSP community assessment is the requirement to use HVAS and the size of sample collected by these instruments. Sharp & Howells has advised that the absolute minimum sample size that can be analysed is 0.1g for ICPMS, 0.2g for XRD and 0.2g for XRF. Therefore, in order for both elemental and mineral analysis to be carried out, an absolute minimum sample size of 0.3g is required (assuming only ICPMS and XRD are carried out), although it should be noted that XRF analysis provides a more complete elemental analysis, and thus would be preferable to conducting ICPMS. If XRF were to be carried out instead of ICPMS then a sample of at least 0.4g would be required, while if all three analyses are to be carried out, a sample size of at least 0.5g would be required. These are absolute minima, and robust results are much more likely with a larger sample.

SA EPA's Le Fevre 1 monitor measures monthly average PM₁₀ concentrations in the range 18-23 µg/m³ (see Figure 4 in Section 6.2.1) and an overall average concentration of 21.2 µg/m³ (see Figure 8). Assuming a PM₁₀/TSP ratio of roughly 0.7, it would be reasonable to expect average TSP concentrations of around 30 µg/m³. In order to adhere to Australian Standard AS 3580.9.3, a minimum flow rate of 1 m³ per minute is required for the HVAS. If 1 m³ per minute of air with an average TSP concentration of 30 µg/m³ is drawn into the sampler, it would take 7 full days to collect a 0.3g sample, this being the absolute bare minimum that would enable elemental and mineral analysis. In reality, sampling for just 7 days would risk insufficient sample being collected, thus it will be necessary to sample for longer in order give a greater chance of achieving the aims of the assessment. The proposed approach towards HVAS sampling periods is detailed in Section 7.3.

The chemical analyses described in Sections 2 and 4 were carried out using plentiful samples of around 500g for each material. While the analyses will have been carried out on sub-samples, these sub-samples will have been greater than the minimum sample sizes described above. When using smaller sample sizes collected by the HVAS, minerals and elements detected in very low concentrations in the original chemical analyses of stockpile samples will likely fall below the limits of detection of the instruments, thus some potentially important markers may not be detectable. This is unavoidable given the requirement to use HVAS but is a limitation of the methodology that must be acknowledged.

It is also important to acknowledge that there is uncertainty around the potential to successfully quantify the proportion of materials in the TSP samples collected in the community that have originated from the Facility. While it is very much anticipated that the approach will enable identification of certain materials that have originated from the Facility, some elements and minerals will have multiple sources in the local area, which will complicate the determination of the specific contribution of the Facility. It is for this reason that the use of a background monitoring location where the contribution of the Facility will be minimal is of great importance, so that an estimation of the presence of certain elements and minerals in background particulate concentrations can be achieved (see Section 7.2 for further details on proposed monitoring locations). However, no background monitoring location will enable isolation of the Facility's contribution from that of other surrounding industrial sources of particulate emissions; as such, there will remain uncertainty as to whether some portion of the material attributed to the Facility might actually have come from other nearby sites.

It is important that we acknowledge that these limitations mean that, at best, the assessment will provide an estimate of the proportion of TSP measured in the community that has originated from the Facility, likely as a range. However, there is no guarantee of success, and it is possible that the range given is so large as to be ambiguous.

It must also be acknowledged that the samples collected at the Facility in March 2023 represent a snapshot in time in terms of the materials on site. Stockpiles are continuously being depleted and replenished, and there may be variances in their composition over time. It has also been assumed that the relatively small samples (~500g) collected are representative of the composition of the wider stockpiles; while every effort was made to collect representative samples, there may be variances in the composition of the materials within the stockpiles. These

factors introduce additional uncertainties when it comes to analysing and making assumptions about the composition of TSP samples collected in the future.

6. SEASONAL TRENDS

The aim of this project is to quantify the proportion of TSP samples collected within the residential community adjacent to the Facility that can be attributed to emissions from the Facility. A key consideration in trying to achieve this aim is the frequency with which emissions from the Facility are transported towards the residential community. This Section considers seasonal trends in meteorology and particulate concentrations, to inform a targeted assessment methodology.

6.1 Meteorology

SA EPA's Le Fevre 1 monitoring station measures wind speed and direction data using instrumentation that is understood to adhere to Australian Standard AS 3580.14. Data from this site should be representative of wind conditions across Port Adelaide and surrounding areas. Data are available from the SA EPA website for the year 2018 onwards.

The residential community adjacent to the Facility is to the west, thus it is only winds with an easterly component that will transport emissions from the Facility towards the community. In reality, bearing in mind the locations of the key dust sources on-site relative to the community, it is winds from between 10 - 155° that are most likely to transport emissions to the community.

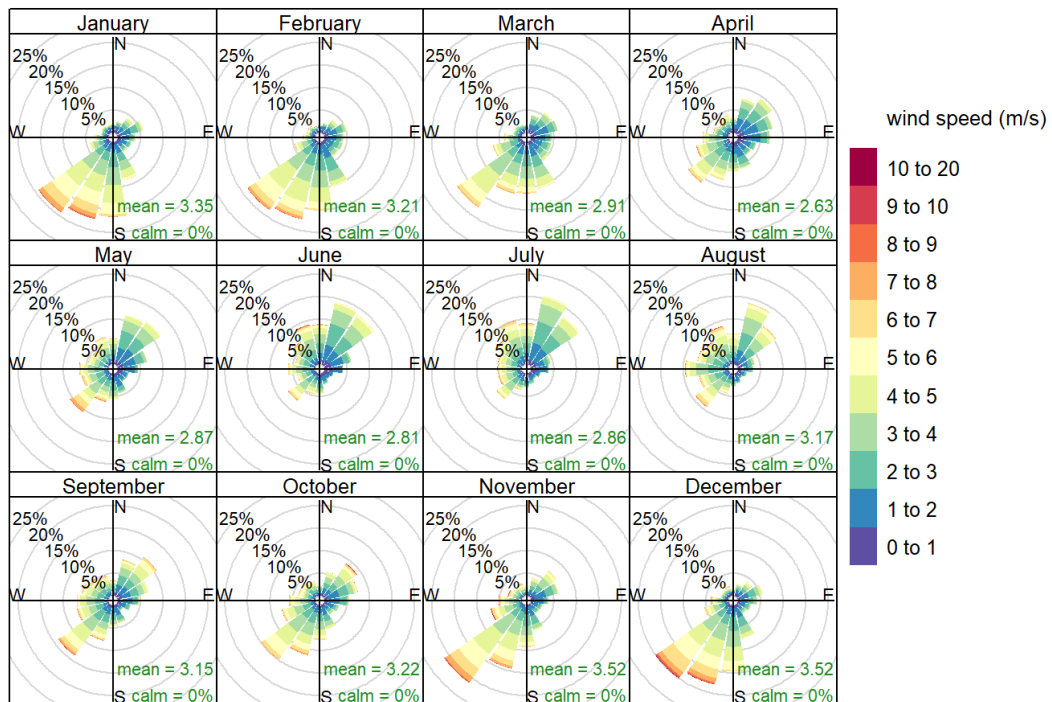
Figure 1 shows the locations of the Le Fevre 1 monitor, ABC's monitoring sites and the residential community to the west of the facility.



Figure 1 The Facility, the adjacent residential community and air quality monitoring sites

Figure 2 presents monthly average wind roses produced using data covering the period 1 January 2018 to 31 January 2023. Table 1 presents the percentage of valid 10-minute average wind direction measurements in each

month that were in the range 10 - 155°. Winds from 10 - 155° are most frequent between April and July, and infrequent between November and February.



Frequency of counts by wind direction (%)

Figure 2 Monthly wind roses for Le Fevre 1

Table 1 Proportion of winds from 10 - 155° at Le Fevre 1 by month of the year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
%	25	27	33	43	41	43	43	37	37	36	28	24

Figure 3 presents the 10-minute average wind direction measurements in each month that were in the range 10 - 155° coloured by wind speed. This plot was produced using data covering the period 1 January 2018 to 31 December 2022. January 2023 has been removed to ensure a consistent number of records for each month. The plot shows that, while winds from 10 - 155° are most common in April to July, this is a result of a higher number of records for lighter winds (<3 m/s). August, September and October see the greatest frequency of stronger winds (>4 m/s) from 10 - 155°, in particular winds >6 m/s, which can be expected to generate much more in the way of dust emissions from stockpiles at the Facility.

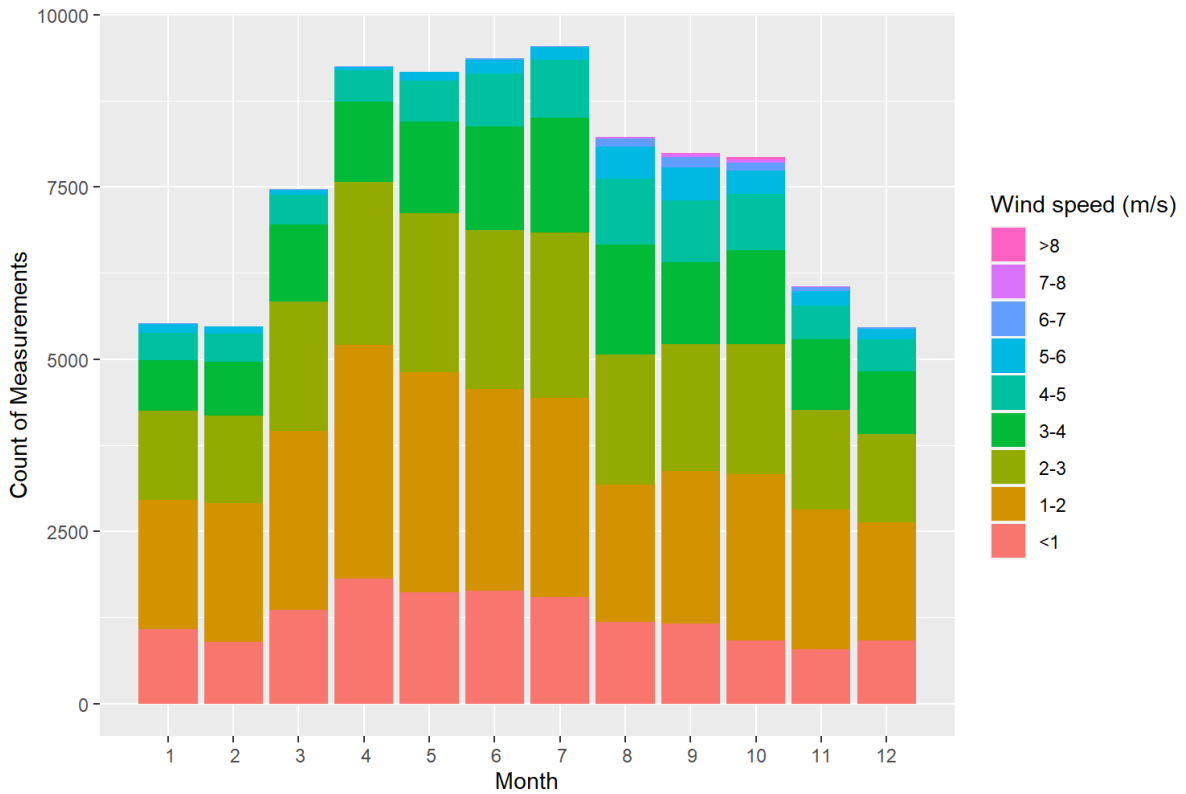


Figure 3 Bar chart of 10-minute average wind speeds during winds from 10 - 155° by month at Le Fevre 1

6.2 Particulate concentrations

This section focusses on PM₁₀ concentrations as a proxy for TSP concentrations, as TSP concentration data are not available.

6.2.1 Monthly average concentrations

Figure 4 presents monthly average PM₁₀ concentrations at Le Fevre 1 (solid blue line), as well as the 95th percentile confidence intervals for each month, using data for the years 2015-2022. The Le Fevre 1 monitor is an Australian Standard monitor (AS 3580.9.6). The plot highlights that average PM₁₀ concentrations are highest between December and May, and lowest in August and September.

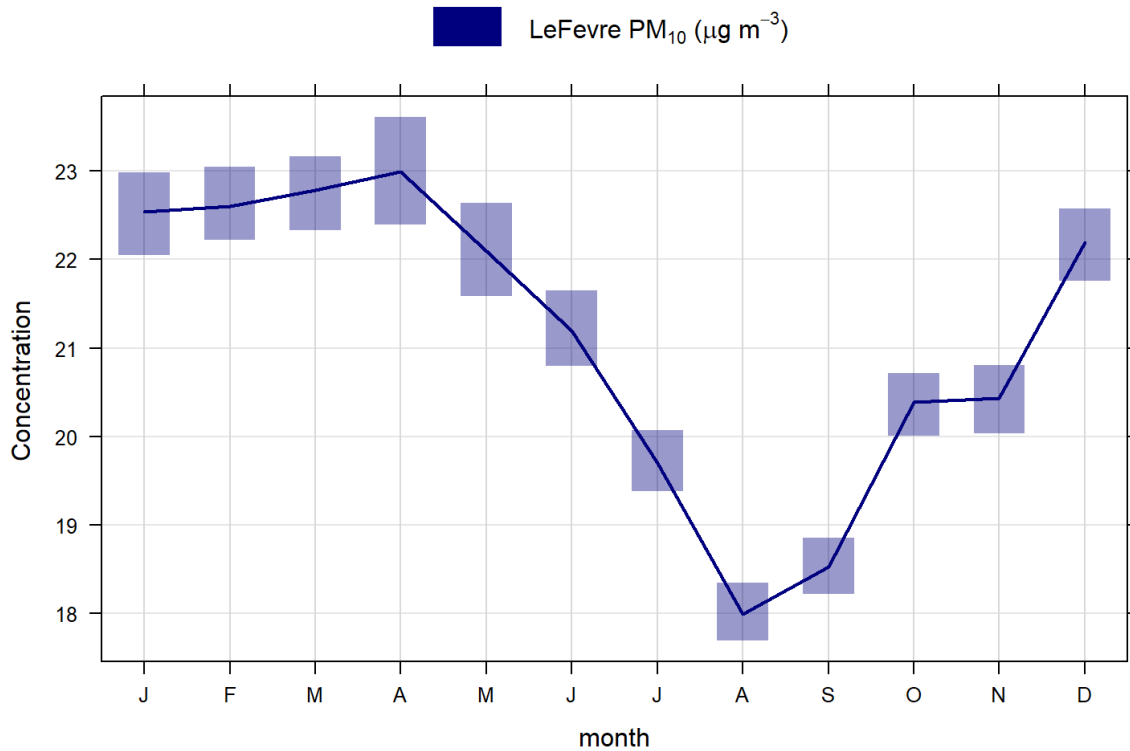


Figure 4 Monthly variation in PM₁₀ concentrations at LeFevre 1 (µg/m³)

Figure 5 presents monthly average PM₁₀ concentrations at the ABC monitoring sites (see Figure 1 for monitoring locations), using data for the years 2019-2022. The ABC monitors are DustTrak DRX aerosol monitors, which are not Australian Standard monitors and must, therefore, be considered indicative.

The plots for DT2 Eastern, DT3 Block 9 and DT5 Northern are all very similar, with the highest concentrations occurring December to March, and generally low concentrations from April to November. The plots for Community Park, Gunn Street and DT1 Southern are different, also seeing high concentrations in January and December, but with relatively high concentrations also occurring between April and July. With these three monitors all being located to the south and west of the Facility, this may be an indication that the greater prevalence of winds from between 10 - 155° in April to July is leading to higher concentrations in these months. However, it must be noted that the LeFevre 1 monitor, also located to the southwest of the Facility, does not show the same trend. ABC has advised that smoke from wood burning stoves in the community tends to contribute to high particulate concentrations on cold, still nights in winter, and other studies (see Section 2.3) have also drawn the same conclusion, thus it is possible that this signal in April to July is a result of very local wood burning and not emissions from the Facility.

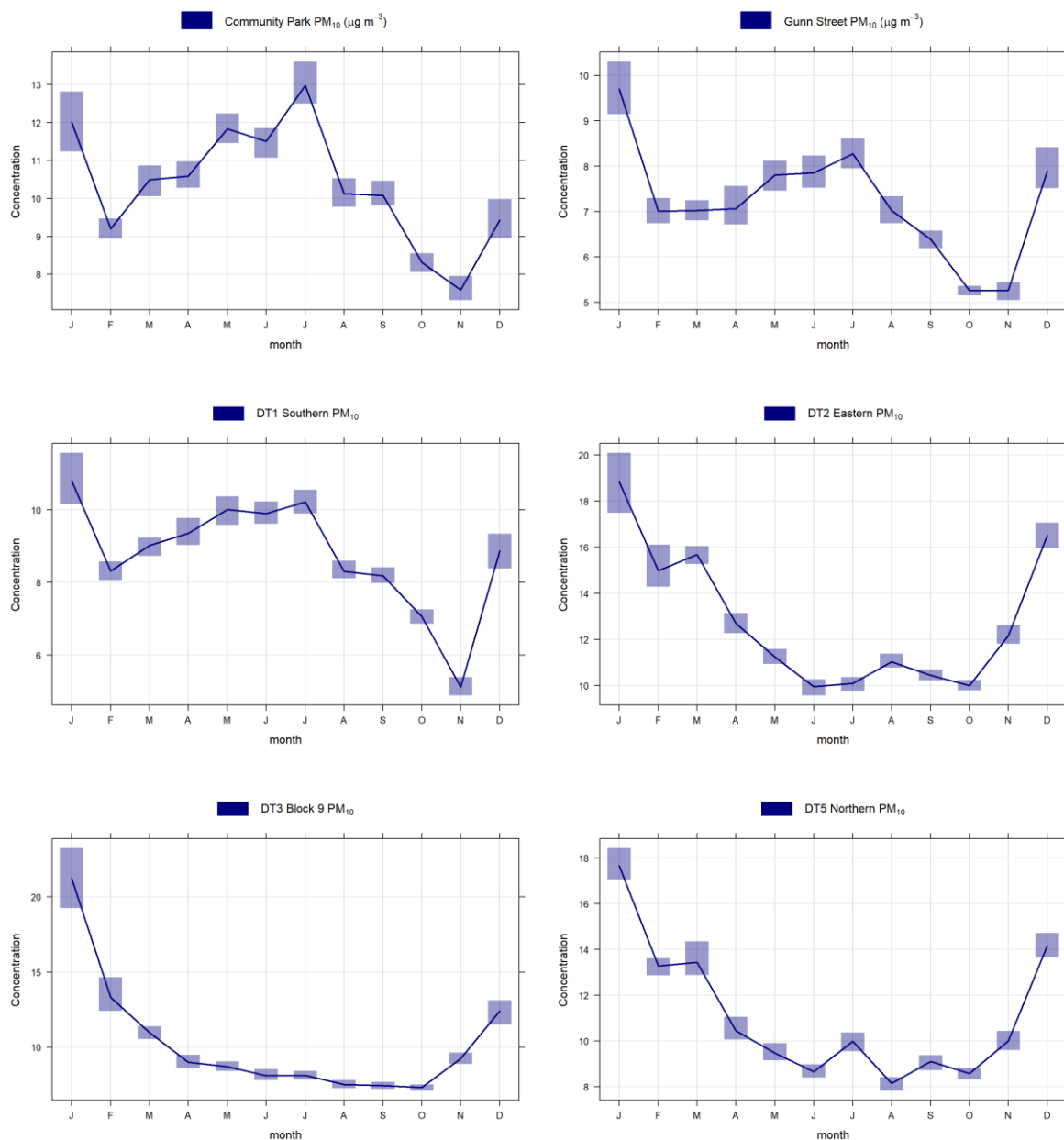


Figure 5 Monthly variation in PM₁₀ concentrations at ABC monitoring sites (µg/m³)

6.2.2 Directional plots

Figure 6 presents a polar plot of 1-hour average PM₁₀ concentrations at Le Fevre 1, again using data for the years 2015-2022. Polar plots present average pollutant concentrations by binned wind direction and wind speed, with colour reflecting the average concentration and the radial axis reflecting the wind speed. Polar plots can identify whether specific wind speed and wind direction combinations lead to higher average concentrations; for example, a 'blob' of colour denoting higher concentrations that is offset from the centre of the plot likely represents a source of emissions located in that general direction. The further from the centre of the plot a 'blob' is located, the more distant the source. High average concentrations at the centre of the plot (i.e., under light winds) indicate a very local source of emissions.

Figure 6 demonstrates that the highest average concentrations occur under strong winds from the north-northwest to the east. This could represent the contribution of the Facility under high wind speeds, but at the same time could also be reflective of regional dust transport from inland under such conditions. High average concentrations appear

to occur at wind speeds above about 4 m/s, but are highest when wind speeds are above 6 m/s. However, it is obvious from Figure 3 that wind speeds above 6 m/s are very rare, thus the plot may be skewed by a small number of measurements under such wind conditions, remembering that each bin in the plot is not made up of the same number of measurements (some may have thousands, while others may have only a handful).

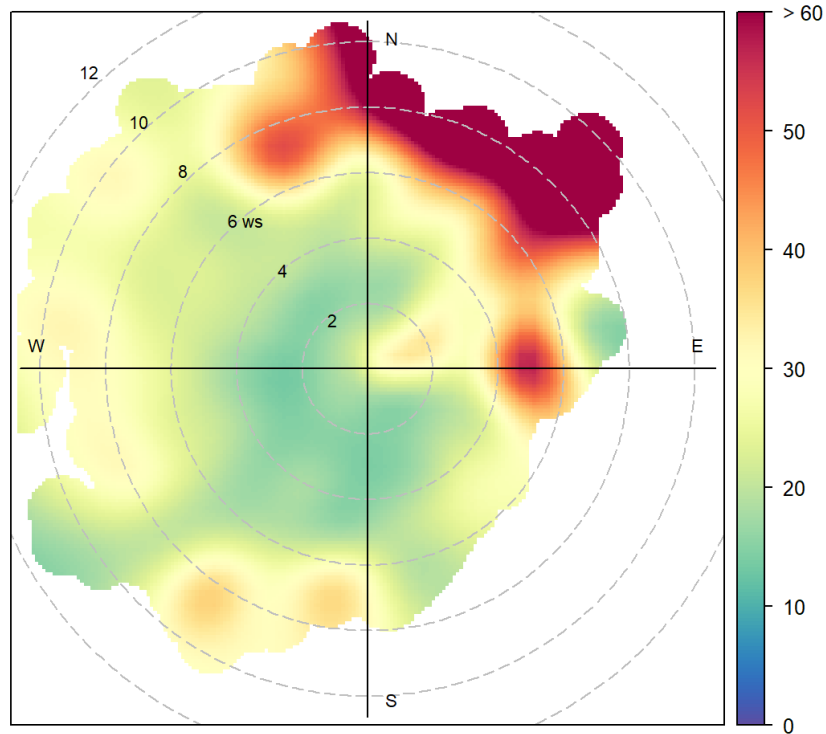


Figure 6 Polar plot of PM₁₀ concentrations at Le Fevre 1 (µg/m³)

Figure 7 presents polar plots of 1-hour average PM₁₀ concentrations at the ABC monitoring sites, using data for the years 2019-2022. Most of these plots also show high average concentrations under strong winds from the north or east, perhaps suggesting that it is regional transport of dust from inland under such conditions that is causing the elevated concentrations. However, this pattern is not obvious in every plot, thus it cannot be said with confidence that the Facility is not the source of at least some of this PM₁₀ at some monitors. The plots for DT2 Eastern, DT3 Block 9 and DT5 Northern do indicate that stronger winds from the direction of the Facility (southwest for DT2 Eastern and DT3 Block 9, southeast quadrant for DT5 Northern), in particular material stockpiles at the Facility, lead to high average concentrations.

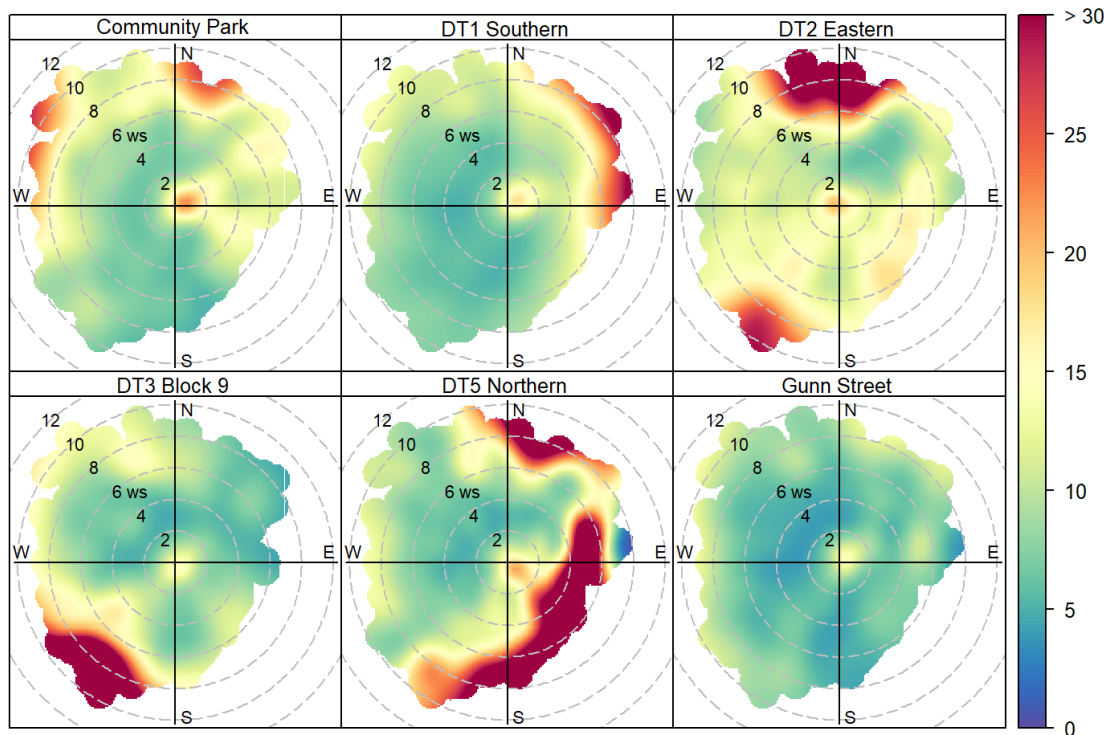
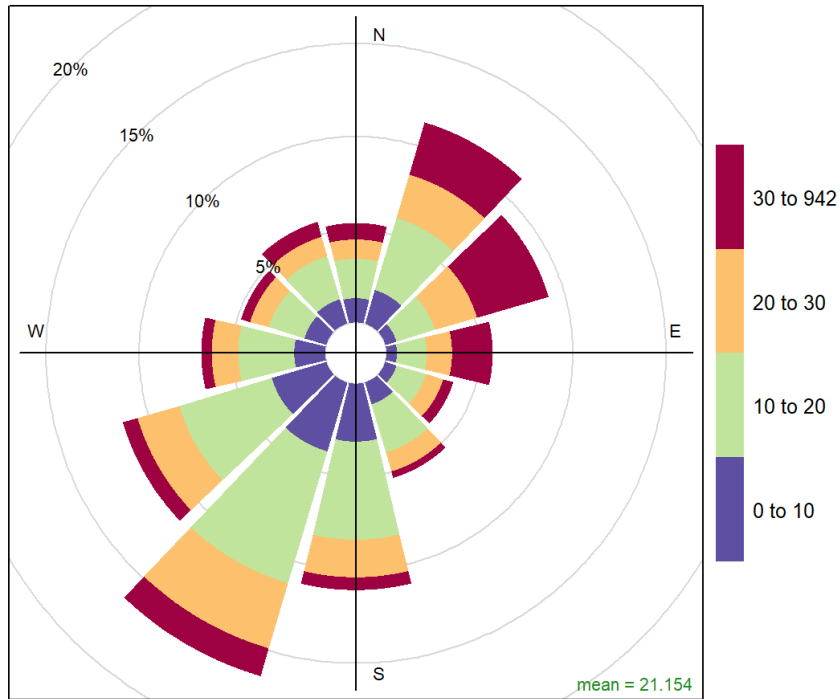


Figure 7 Polar plot of PM₁₀ concentrations at ABC monitoring sites (µg/m³)

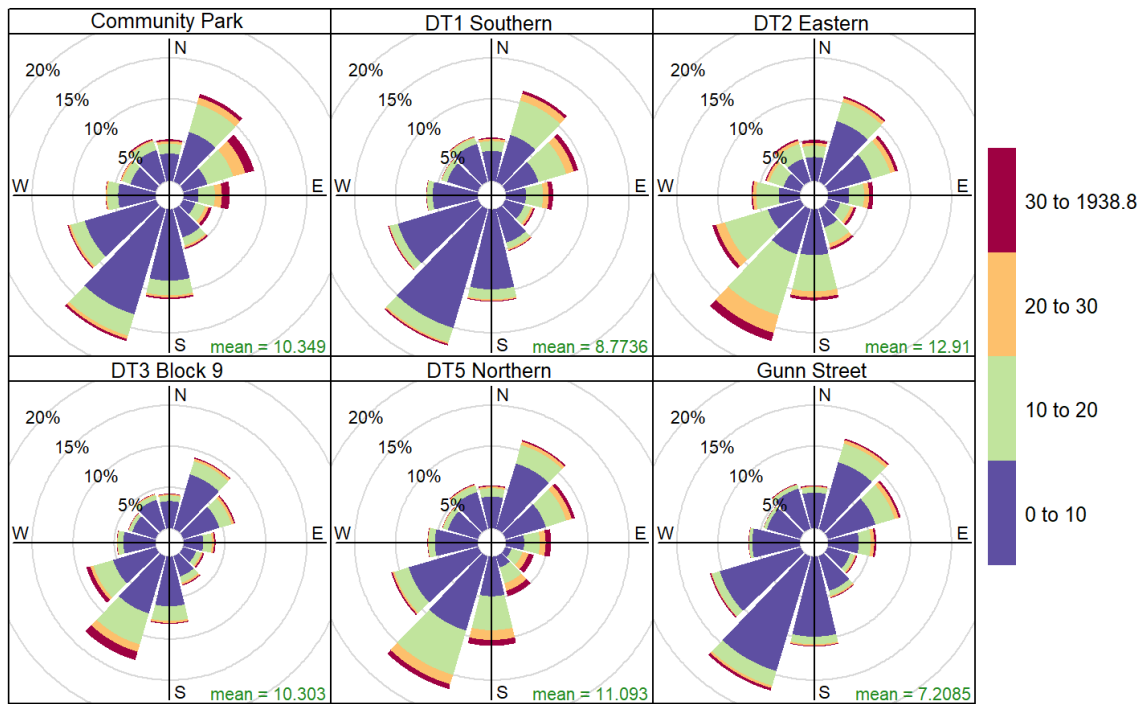
Figure 8 presents a pollution rose plot of 1-hour average PM₁₀ concentrations at Le Fevre 1, again using data for the years 2015-2022. Pollution roses are similar to wind roses, but instead of the colouring of the rose arms representing wind speed, they represent the pollutant concentration. They are useful for highlighting which wind directions are associated with the highest concentrations. The plot highlights that the highest concentrations are most common under winds from the north-northeast to east.

Figure 9 presents pollution rose plots of 1-hour average PM₁₀ concentrations at the ABC monitoring sites, using data for the years 2019-2022. Given that they use the same wind direction data as Figure 8, they also show the same general shape, but it is obvious that concentrations measured by the ABC monitors are typically much lower, and they do not measure higher concentrations with the same frequency.



Frequency of counts by wind direction (%)

Figure 8 Pollution rose plot of PM₁₀ concentrations at Le Fevre 1 (µg/m³)



Frequency of counts by wind direction (%)

Figure 9 Pollution rose plots of PM₁₀ concentrations at ABC monitoring sites (µg/m³)

Figure 10 presents a proportion contribution rose plot of 1-hour average PM₁₀ concentrations at Le Fevre 1, again using data for the years 2015-2022. Proportion contribution roses are very similar to pollution roses, but instead of the radial extent of each rose arm reflecting the percentage of wind records from that direction, it represents the percentage of the period mean PM₁₀ concentration that winds from that 30° sector have contributed, while the colouring of the arm reflects the magnitude of the concentrations measured under those wind conditions (and their respective relative contribution to the period mean concentration). Proportion contribution roses highlight which wind directions carry the highest concentrations of air pollutants to a monitor over a given period of time, as well as whether especially high concentrations from specific wind directions are contributing a significant portion of the period mean concentration, as might be expected to occur when a monitor is downwind of a nearby pollution source.

Figure 10 highlights that periods of high concentrations (>30 µg/m³) under winds from the north-northeast to east, despite not being very common (see Figure 8), are significant contributors to the 2015-2022 mean concentration measured at Le Fevre 1. Of the proportion contribution rose plots for the ABC monitoring sites presented in Figure 11, the plot for Community Park is very similar to that for Le Fevre 1, albeit with consistently lower concentrations.

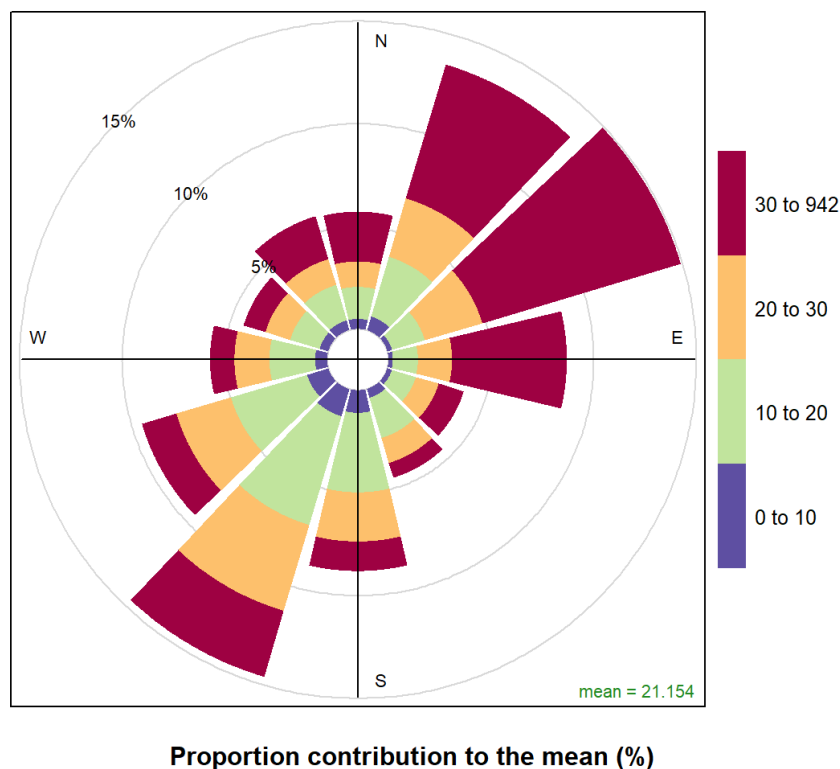
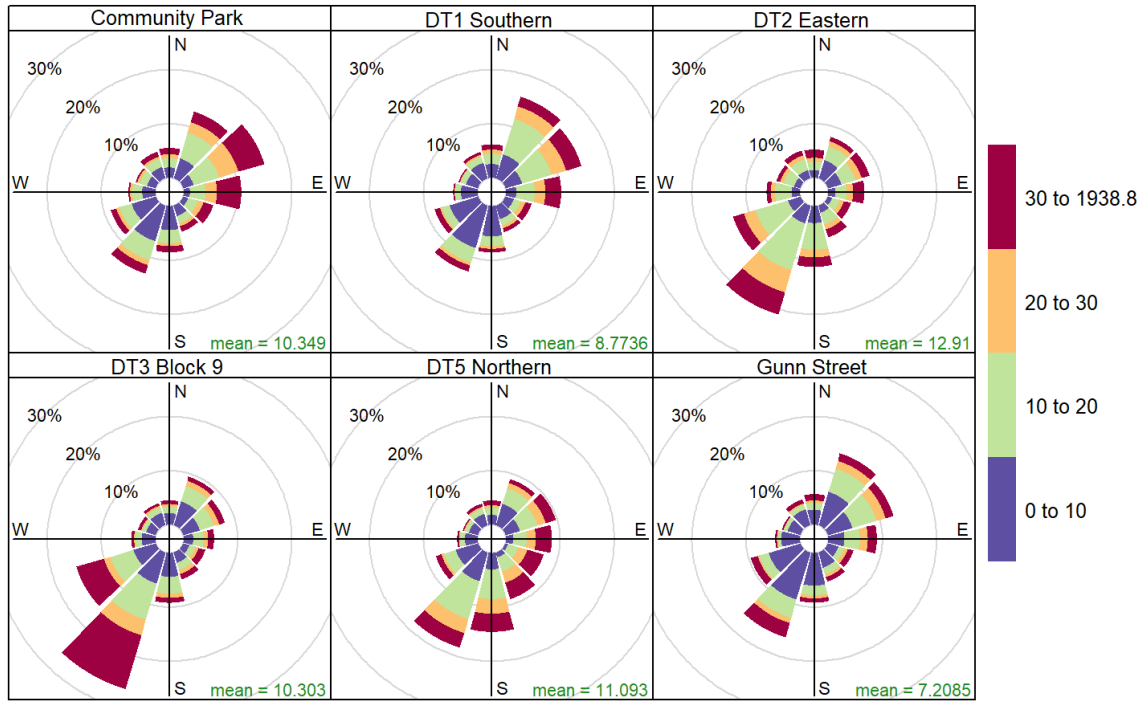


Figure 10 Proportion contribution rose plot of PM₁₀ concentrations at Le Fevre 1 (µg/m³)

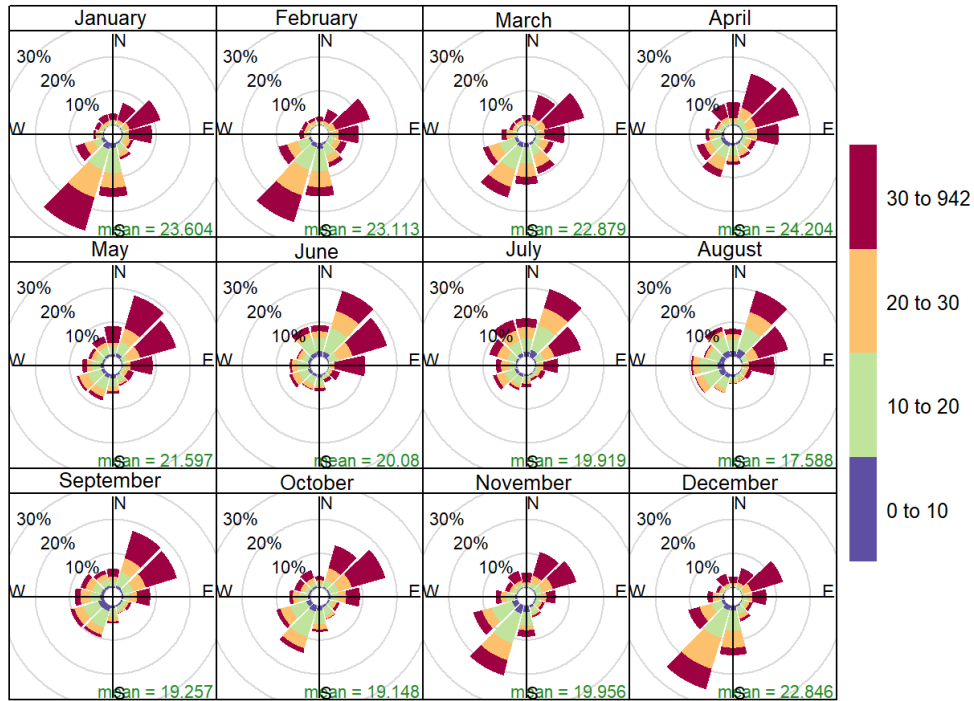


Proportion contribution to the mean (%)

Figure 11 Proportion contribution rose plots of PM₁₀ concentrations at ABC monitoring sites (µg/m³)

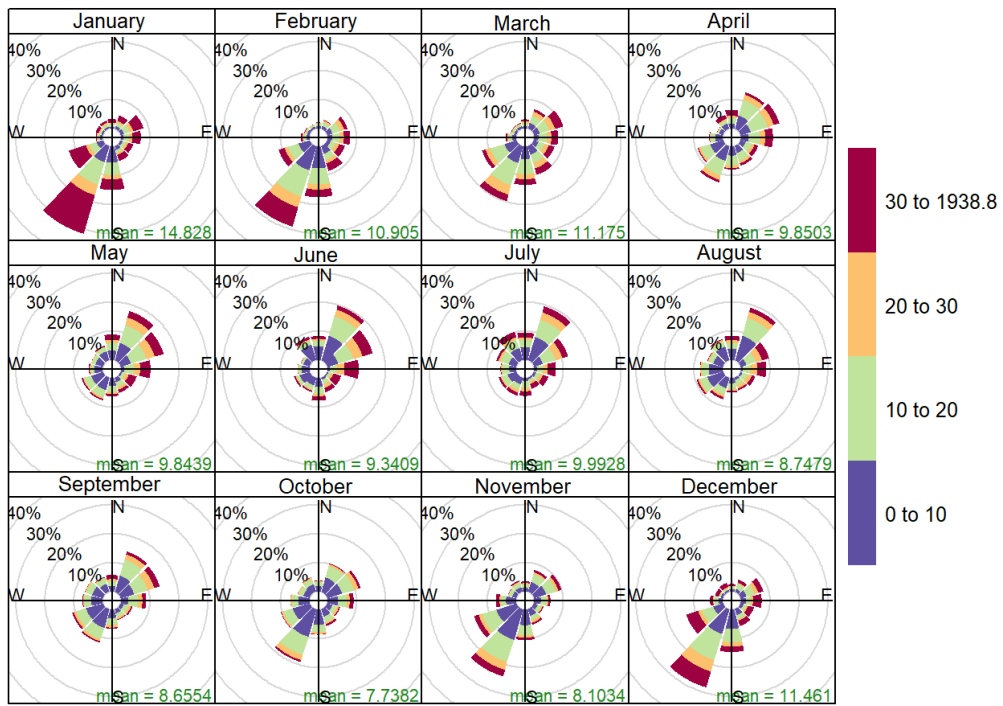
6.2.3 Month-by-month Directional plots

It is obvious from the analysis presented above that, in terms of concentrations in the community, based on measurements from Le Fevre 1 and Community Park, the contribution from the Facility will be greatest under winds from the north-northeast to east. The monitoring program for the TSP community assessment must, therefore, focus on those periods when strong winds from these directions are most common, and when those strong winds are associated with high concentrations. Figure 12 and Figure 13 have been produced to aid in determining this, presenting monthly proportion contribution rose plots for Le Fevre 1 and Community Park, respectively. These plots highlight that the proportion contribution to monthly mean concentrations of high concentrations under winds from the north-northeast to east is consistently greatest between April and September. However, when combined with the monthly polar plots presented in Figure 14 and Figure 15, it is obvious that high concentrations are less frequent in the months of May, June and August (note the much lower mean concentrations that occur in these months, and lack of high average concentrations under strong winds in the polar plots (except for August at Le Fevre 1)).



Proportion contribution to the mean (%)

Figure 12 Monthly proportion contribution rose plots of PM₁₀ concentrations at Le Fevre 1 (µg/m³)



Proportion contribution to the mean (%)

Figure 13 Monthly proportion contribution rose plots of PM₁₀ concentrations at Community Park (µg/m³)

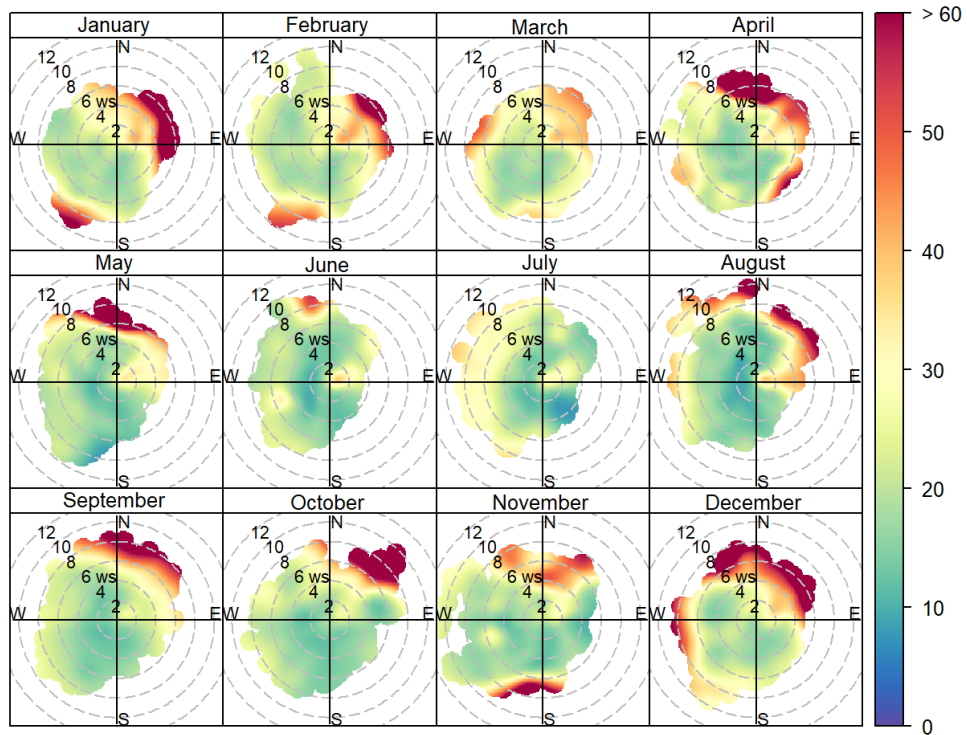


Figure 14 Monthly polar plots of PM₁₀ concentrations at Le Fevre 1 (µg/m³)

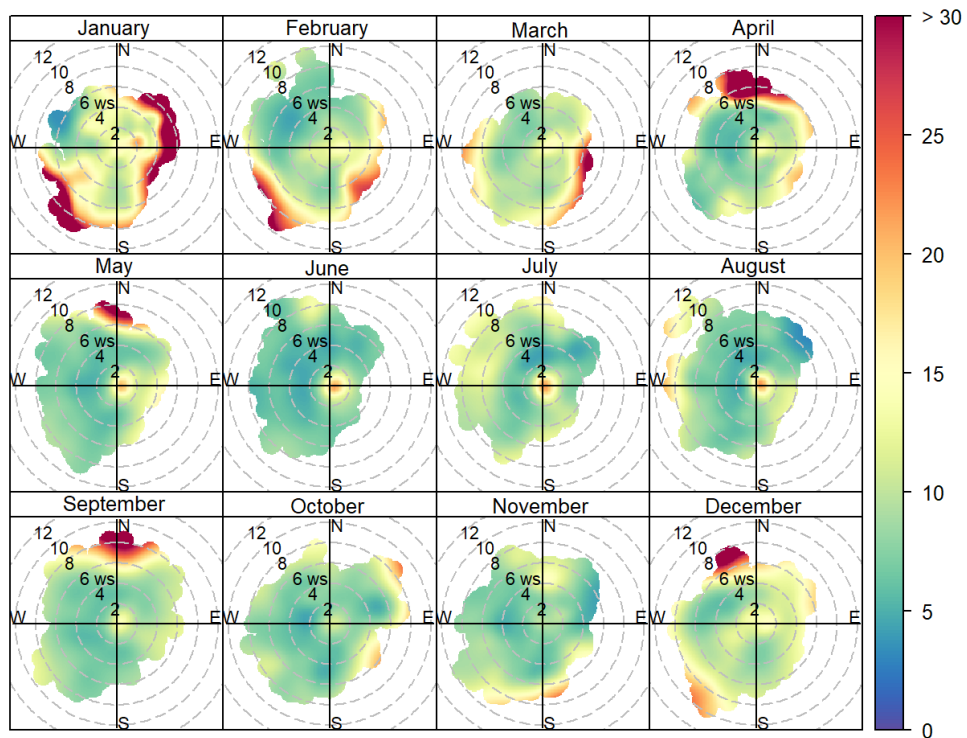


Figure 15 Monthly polar plots of PM₁₀ concentrations at Community Park (µg/m³)

6.2.4 Summary

On the basis of the analysis of meteorological and PM₁₀ concentration data presented above, it can be concluded that the contribution of the Facility to particulate concentrations in the community is likely to be greatest in the months of March, April and May. As such, it would be logical to focus the TSP monitoring program on these months of the year, acknowledging that the results will be worst-case, as the proportion contribution of the Facility to measured TSP concentrations in the rest of the year can be expected to be lower. A focus on these three months will ensure the greatest possibility of successfully identifying chemical signatures of materials handled at the Facility in TSP samples collected in the community. Extending monitoring into months when the contribution of the Facility to measured TSP concentrations will be smaller would lead to the results of the chemical analyses being more likely to be ambiguous, and thus is considered counter-productive.

7. PROPOSED TSP COMMUNITY ASSESSMENT METHODOLOGY

7.1 Monitoring period

It has been identified in Section 6 that the contribution of the Facility to particulate concentrations in the community can be expected to be greatest in the months of March, April and May. Therefore, it is recommended that the study is carried out in March to May of 2024. The results of monitoring over this period will be worst-case, as the proportion contribution of the Facility to measured TSP concentrations in the rest of the year can be expected to be lower.

The proposed monitoring period provides the best possible opportunity to identify contributions from the Facility in the collected samples and will offer a worst-case result. Given that there is uncertainty regarding the likelihood of success of the proposed methodology (see Section 5), it is prudent to focus initially on testing the methodology while seeking to obtain this worst-case result. A longer monitoring period, extending into months when TSP concentrations and contributions from the Facility are likely to be smaller, is unlikely to improve the potential for success. As such, it is recommended that the approach is tested over three months before consideration is given to a longer monitoring period, or a permanent installation being implemented in future. Katestone considers the proposed period of monitoring to be adequate in terms of achieving the specific requirements of licence condition U-1562.

Monitoring will be carried out for a minimum of three months, with HVAS deployed by 1 March and the final samples extending into June i.e., sampling will not cease in the month of May.

Prior to the commencement of monitoring, Katestone will work with ABC to review the stockpiles on site at that time and whether any might have significant differences in terms of their chemical or elemental composition as compared to the samples collected in March 2023. If any potentially significant differences are identified, additional stockpile samples will be collected and sent to Sharp and Howells for analysis.

7.2 Monitoring locations

It is recommended that monitoring be carried out at two locations in the community to the southwest of the Facility, and at one background location. Key considerations when selecting a monitoring location include:

- Accessibility – the monitors will need to be checked daily and filters changed regularly, thus they must be readily accessible
- Security – the monitors must be in a secure location where they cannot easily be interfered with, stolen or vandalised
- Permission – permission will be required from landowners and the relevant authorities for the monitors and their supporting structures, if these do not already exist.

The first HVAS is proposed to be co-located with ABC's Community Park dust monitor, located at the corner of Hargrave Street and Alfred Street (see Figure 1). This location is secure, accessible and can be used without requiring further permissions, while also being reasonably reflective of worst-case exposure in the local community to emissions from the Facility. The data from ABC's co-located dust monitor could also be used to consider how fluctuations in measured particulate concentrations over the monitoring period might have affected TSP concentrations measured by the HVAS. It is, therefore, an ideal monitoring location.

There are two viable options for the second community monitoring location:

- The monitor could be co-located with SA EPA's Le Fevre 1 monitoring station (see Figure 1 for location). This location would be secure and usable with permission from SA EPA only. SA EPA would also need to grant access to the monitoring subcontractors for installation, servicing and decommissioning of the monitor, as well as ABC staff for routine daily checks of the monitor. This location is representative of

typical exposure in Birkenhead and the co-located high quality particulate monitoring carried out by SA EPA could also be used in the analysis of HVAS results. As such, it is also an ideal monitoring location, if SA EPA is willing to cooperate on access.

- Alternatively, ABC is in the process of seeking a replacement location for its Gunn Street monitor, which had to be removed from its previous location due to the land being sold and redeveloped. The replacement location is likely to be suitable for a second monitor, as it can be expected to be reasonably representative of exposure in the community while also being secure, accessible and usable without requiring further permissions, while also being co-located with a real-time particulate monitor. However, this relies on the assumption that this monitoring station will be in place by the time that the TSP community assessment is carried out, which is not certain at this point in time, nor is the specific location of this monitor. ABC has had discussions with Port Adelaide Enfield Council over siting this monitor within the Birkenhead Naval Reserve, to the southwest of the Facility, and it is understood that SA EPA is supportive of this location. As such, ABC will seek to expedite the process towards installation of a monitoring station in this reserve that can also be used for the TSP community assessment. However, Katestone considers it important to highlight that ABC's monitors are not Australian Standard monitors, thus they will not provide the same high-quality particulate monitoring data that SA EPA's Le Fevre 1 monitoring station would for consideration in the analysis of HVAS results. However, with the Birkenhead Naval Reserve being in the same general direction from the Facility as the Le Fevre 1 monitoring station, data from Le Fevre 1 could potentially still be used and considered indicative of concentrations at Birkenhead Naval Reserve.

The third monitor should be installed in a 'background' location, where measured TSP will be representative of regional contributions from across Adelaide and further afield, while being minimally influenced by emissions from the Facility. Preferred locations for this monitor would be co-locations with either of SA EPA's Northfield or Elizabeth monitors. These locations are sufficiently distant from the Facility (11 km for Northfield and 22.5 km for Elizabeth) that its contribution to TSP samples should be minimal, while still being representative of typical TSP exposure in Northern Adelaide. They are also infrequently downwind of the Facility in the months of March to May (see Figure 2), especially Northfield. Both monitors are in residential areas, several kilometres from any significant industry.

The main drawback of using either of these sites is that the contribution from the other industries near to the Facility to measured TSP concentrations will also be minimal, thus these 'background' measurements will not allow for easy separation of the contribution of the Facility in TSP samples collected in the community from that of other surrounding industries, of which there are many, and a number of which are known sources of dust emissions. However, there are no viable locations that would readily enable this separation. The only alternative 'background' location would be SA EPA's Le Fevre 2 monitoring station, located 4 km north of the Facility, but at this relative proximity some contribution from the Facility would be expected, and this needs to be avoided.

The preferred location for the 'background' monitor based on the frequency of winds from the direction of the Facility would be Northfield, as it is less frequently downwind of the Facility in the months of March to May. However, the EPA's monitoring station at Northfield does not measure particulate concentrations. As such, in order to be able to use co-located high quality particulate monitoring in the analysis of HVAS results, a co-location with the Elizabeth monitor is preferable. Again, monitoring here would require SA EPA to grant access to the monitoring subcontractors for installation, servicing and decommissioning of the monitor, as well as ABC staff for routine daily checks of the monitor.

The SA EPA monitoring locations nearest to the Facility are shown in Figure 16.



Figure 16 Nearby SA EPA Air Quality Monitors

7.3 HVAS sampling specifics

HVAS sampling will be carried out by an appropriately experienced subcontractor who specialises in ambient air pollutant monitoring, with sample analysis carried out in a National Association of Testing Authorities (NATA) accredited laboratory.

Katestone understands that HVAS are commonly configured with a filter block warning, whereby if the filter becomes sufficiently blocked that the controller cannot adjust the flow sufficiently within the instrument's defined range as to achieve the average set flow, the unit will cease sampling. This ensures that the average flow rate remains above the Australian Standard AS 3580.9.3 minimum flow rate of 1 m³ per minute. In order to collect as much sample as possible, to give the greatest potential for meaningful chemical analysis results, it is proposed that the HVAS sample until the filter block warning is activated and the units shut down.

A minimum sample size of 0.6g is targeted, although a sample of at least 1g would be preferred. Preliminary calculations, based on broad assumptions informed by discussions with monitoring companies with extensive experience of operating HVAS, suggest that HVAS are likely to be able to continue to operate without triggering the filter block warning for a period of around 2-4 weeks, collecting a sample size of roughly 0.6-1.2g. In reality, the HVAS will be operated for as long as possible, to collect as much sample as possible, but the period of operation is anticipated to be around 2-4 weeks per sample.

Site staff from the Facility will initially need to carry out daily checks of the HVAS monitors, so that the cessation of sampling is identified as soon as possible. Following cessation of sampling, a changeover of filters will be carried out as soon as practicable, with the collected sample returned to the monitoring subcontractors' laboratory for analysis to determine the quantity of TSP collected, and thus the period average concentration. Following this weighing of the sample, it will be shipped to the Sharp & Howells laboratory for chemical analysis.

Filter changeovers can either be carried out by the monitoring subcontractors, or site staff from the Facility could be trained to carry out the changeovers, which would reduce both the cost of the sampling program and the downtime after the filter block warning is triggered.

7.4 Chemical analysis

All samples will undergo XRD and XRF analysis. If identified by Sharp & Howells as likely significantly increasing the chances of successful identification of particulates from the Facility in the collected TSP samples, and if there is sufficient sample available, ICPMS analysis will also be carried out, on a case-by-case basis. Approval from the client will be sought before any such ICPMS is carried out.

The experts at Sharp & Howells will review the results of the chemical analysis, considering the presence of various elements and minerals and their specific ratios, to identify whether there are materials from the Facility in each sample and to estimate, as a range, the proportion of the collected TSP sample that is made up of the specific materials sampled at the Facility. Katestone will critically review Sharp & Howells' findings to ensure that the results are as robust and informative as possible. Katestone will also consider the likely influence of meteorology upon the results in terms of total TSP concentrations and the estimated contribution from the Facility, using meteorological data from SA EPA's Le Fevre 1 monitoring station.

7.5 Record keeping

ABC should maintain records of abnormal/infrequent events taking place at the facility during the study period, for example any intensive delivery campaigns of imported bulk materials (e.g., slag or bauxite), or any periods of operational downtime that affect a significant proportion of the Facility, so that any correlation between these events and measured TSP concentrations in the community can be investigated.

Any activities observed to be taking place near to the HVA's that generate significant dust emissions should also be logged, such as roadworks or construction works.

7.6 Reporting

Katestone will report back to the client and SA EPA the results and conclusions drawn from the analysis as soon as the first set of TSP samples have been collected and analysed. There is likely to be a significant lead time following completion of the first monitoring period (samples must be transported to the sampling subcontractors' laboratory, weighed, then shipped to Sharp & Howells where they will undergo chemical analysis, following which Sharp & Howells will review the results and prepare a report), such that one or more further TSP samples will have been collected by the time that results for the first sample have been received. As such, there is likely to be little opportunity to amend or abandon the adopted approach, should the results be inconclusive, before the study is at least half complete.

Following completion of the 3+ month monitoring study and receipt of all results back from the laboratories, Katestone will prepare a summary report setting out the methodologies applied, the TSP concentrations measured, the elemental and mineralogical compositions of those samples, and the overall proportion of the period-average sample that is estimated to have originated from the Facility, as a range. This will be used alongside the seasonal analysis presented in Section 5 to provide a rough estimate of the annual average contribution of the Facility to TSP concentrations in the community.

APPENDIX A SHARPS & HOWELLS CHEMICAL ANALYSIS REPORT



TEST REPORT NO.: 23 -0159A

Report Date: 19th May 2023`
Client: KATESTONE Environmental Pty Ltd
Address: PO Box 2217,
MILTON, QLD. 4064
Attention: Ricky Gellatly
By Email: Ricky,gellatly@katestone.com.au.
Sample(s): 10 of Solid
Sampled By: Client
Lab Number(s): 23/A/1323- 23/A/1332
Date Commenced: 20th April 2023
Analysis: Various

Notes:

This laboratory was not involved with, consulted, or requested to undertake sampling of the specimens provided, and testing of those test specimens has been conducted as received in the laboratory.

Accordingly, no responsibility is taken for the integrity, authenticity, appropriateness, or representativeness, of any of the test specimens provided and this must be taken into account when reviewing, comparing or checking the test results published in this report.

Unless otherwise notified, all samples will be disposed of in three months from reporting date.

Yours faithfully,

Sharp and Howells Pty. Ltd.

Michael Wright
D.App.Sc. (App. Chem.), MRACI, C.Chem
Technical Consultant/Senior Scientist

INTRODUCTION and BACKGROUND:

We were provided with ten samples for analysis. The samples represent stockpiles of material stored on a clients facility. The client has had a condition applied to their new licence requiring them to monitor TSP (total suspended particulates) in the community surrounding their facility and *"ensure that the TSP community assessment includes a comparison and correlation of materials used at, and emissions from, the Premises with the nature and composition of TSP material assessed at locations within the residential community adjacent to the Premises"*.

The aim of this analysis is to identify some kind of chemical signature from the stockpiled materials that can then be linked to the samples collected from the high volume samplers.

The samples were assigned Laboratory Numbers for internal identification within the laboratory as follows:-

Client Identification	Laboratory Number	Analysis
Mill Scale	23/A/1323	XRF, XRD, ICP screen
Moculta Clay	23/A/1324	XRF, XRD, ICP screen
Limestone	23/A/1325	XRF, XRD, ICP screen
Blacksand	23/A/1326	XRF, XRD, ICP screen
Queensland Bauxite	23/A/1327	XRF, XRD, ICP screen
Gypsum	23/A/1328	XRF, XRD, ICP screen
Whyalla Slag	23/A/1329	XRF, XRD, ICP screen
Clinker	23/A/1330	XRF, XRD, ICP screen
Japanese Slag	23/A/1331	XRF, XRD, ICP screen
Tasmanian Bauxite	23/A/1332	XRF, XRD, ICP screen

Sample Images (As Received):





METHODOLOGY:

- ICP-OES Elemental analysis was conducted by Inductively Coupled Plasma Optical Emission Spectroscopy using a Perkin Elmer Avio 200 instrument.
- XRF Elemental analysis was conducted by X-Ray Fluorescence (XRF) Spectroscopy using a Thermo Scientific ARL OPTIM'X WDXRF Spectrometer.
- XRD Mineral Phase Analysis was conducted by X-Ray Diffraction (Powder Diffraction) using a Bruker-AXS Phaser with copper radiation at 30kv and 10mA, over a range of 5 to 80 degrees 2 θ . A Ni filter was used in the diffracted beam for elimination of Kbeta radiation. Identification of phases present was carried out using Bruker Search/Match software and the ICDD PDF-2 database. The quantitative phase analysis was performed using SIROQUANT version 4 software.

RESULTS OF ANALYSIS: - ICP

All results in mg/kg dry basis

	Mill Scale	Moculta Clay	Limestone	Blacksand	Qld Bauxite
	23/A/1323	23/A/1324	23/A/1325	23/A/1326	23/A/1327
Aluminium	5000	5000	5900	28000	150000
Antimony	14	< 10	< 10	150	< 10
Arsenic	22	3	8.7	100	4.6
Barium	210	220	39	710	< 10
Beryllium	< 2	< 2	< 2	< 2	< 2
Bismuth	< 10	< 10	< 10	< 10	< 10
Boron	35	< 10	< 20	73	< 20
Cadmium	20	< 0.4	< 0.4	1.4	< 0.4
Chromium	1700	50	14	610	120
Cobalt	36	5.1	< 5	120	< 5
Copper	980	41	< 5	2300	< 5
Iron	510000	46000	7800	280000	48000
Lead	430	5.3	< 5	330	21
Manganese	12000	100	230	13000	29
Mercury	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Molybdenum	67	< 5	< 5	83	< 5
Nickel	270	17	9.9	30	5.3
Selenium	< 2	< 2	< 2	< 2	< 2
Silver	3	< 2	< 2	7.7	< 2
Thallium	< 10	< 10	< 10	< 10	< 10
Tin	71	< 10	< 10	210	< 10
Titanium	400	370	73	1600	290
Uranium	< 10	< 10	< 10	< 10	< 10
Vanadium	150	96	33	88	190
Zinc	21000	19	6.1	12000	< 5
Calcium	69000	480	210000	110000	1500
Magnesium	12000	350	6000	7100	120
Potassium	180	270	1900	8400	26
Sodium	430	510	510	2900	37
Phosphorus	420	440	65	990	59
Sulphur	930	210	310	3600	360

RESULTS OF ANALYSIS: - ICP

All results in mg/kg dry basis

	Gypsum	Whyalla Slag	Clinker	Japan Slag	Tas. Bauxite
	23/A/1328	23/A/1329	23/A/1330	23/A/1331	23/A/1332
Aluminium	2500	39000	24000	< 20	43000
Antimony	< 10	< 10	< 10	< 10	< 10
Arsenic	< 2	< 2	18	< 2	< 2
Barium	24	220	150	< 10	48
Beryllium	< 2	6.6	< 2	< 2	< 2
Bismuth	< 10	< 10	< 10	< 10	< 10
Boron	< 20	50	56	< 20	< 20
Cadmium	< 0.4	< 0.4	0.6	< 0.4	< 0.4
Chromium	< 5	29	69	< 5	330
Cobalt	< 5	< 5	7.3	< 5	12
Copper	< 5	< 5	110	< 5	80
Iron	2200	13000	22000	< 20	160000
Lead	< 5	< 5	24	< 5	14
Manganese	9	1600	540	< 5	300
Mercury	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Molybdenum	< 5	< 5	< 5	< 5	< 5
Nickel	< 5	< 5	23	< 5	12
Selenium	< 2	2.5	< 2	< 2	< 2
Silver	< 2	< 2	< 2	< 2	< 2
Thallium	< 10	< 10	< 10	< 10	< 10
Tin	< 10	< 10	< 10	< 10	< 10
Titanium	26	1100	1200	< 10	2200
Uranium	< 10	< 10	< 10	< 10	< 10
Vanadium	< 10	33	66	< 10	220
Zinc	< 5	9.2	300	< 5	250
Calcium	82000	190000	310000	190000	9500
Magnesium	570	34000	7800	21000	1100
Potassium	650	2000	3800	2700	240
Sodium	210	1200	1500	860	320
Phosphorus	18	180	200	82	130
Sulphur	72000	9300	1200	9000	1600

SHARP & HOWELLS

RESULTS OF ANALYSIS: - XRF

All results in % w/w

	Mill Scale	Moculta Clay	Limestone	Blacksand	Qld Bauxite
	23/A/1323	23/A/1324	23/A/1325	23/A/1326	23/A/1327
Na	ND	ND	0.096	0.290	ND
Mg	1.990	0.298	1.070	1.740	0.215
Al	0.830	10.260	1.170	3.180	28.440
Si	1.390	28.770	5.350	10.960	4.340
P	0.046	0.067	0.007	0.086	0.029
S	0.130	0.024	0.030	0.296	0.078
Cl	0.052	0.058	0.010	0.017	0.013
K	0.011	0.426	0.288	0.810	0.009
Ca	7.550	0.189	32.070	13.100	0.186
Ti	0.065	0.688	0.057	0.187	1.750
V	0.014	0.011	ND	0.009	0.034
Cr	0.260	0.085	0.016	0.098	0.020
Mn	1.230	0.016	0.027	1.300	0.007
Fe	51.980	5.930	0.904	29.240	5.640
Co	ND	ND	ND	0.026	ND
Ni	0.034	ND	ND	ND	ND
Cu	0.096	ND	ND	0.302	ND
Zn	2.170	ND	ND	1.310	ND
Sr	0.015	0.009	0.025	0.245	ND
Y	ND	ND	ND	ND	ND
Zr	ND	0.049	0.009	0.017	0.141
Ru	ND	0.037	ND	ND	ND
Cd	ND	ND	ND	ND	ND
Sn	ND	ND	ND	ND	ND
Sb	ND	ND	ND	ND	ND
Te	ND	ND	ND	ND	ND
In	ND	ND	ND	ND	ND
Ba	0.034	0.031	ND	0.580	ND
Ce	ND	ND	ND	ND	0.020
Sm	0.092	ND	ND	0.058	ND
Tb	0.090	ND	ND	0.069	ND
Yb	ND	ND	ND	ND	ND
Lu	ND	ND	ND	ND	ND
Re	ND	ND	ND	ND	ND
Pt	ND	ND	0.011	ND	ND
Au	ND	0.021	ND	ND	ND
Pb	0.041	ND	ND	0.033	ND

[https://sharpandhowells2015.sharepoint.com/sites/Admin/Shared Documents/S&H Test Reports /2023/Investigative Katestone0159\(1323-1332\) Report.doc](https://sharpandhowells2015.sharepoint.com/sites/Admin/Shared Documents/S&H Test Reports /2023/Investigative Katestone0159(1323-1332) Report.doc)

SHARP & HOWELLS

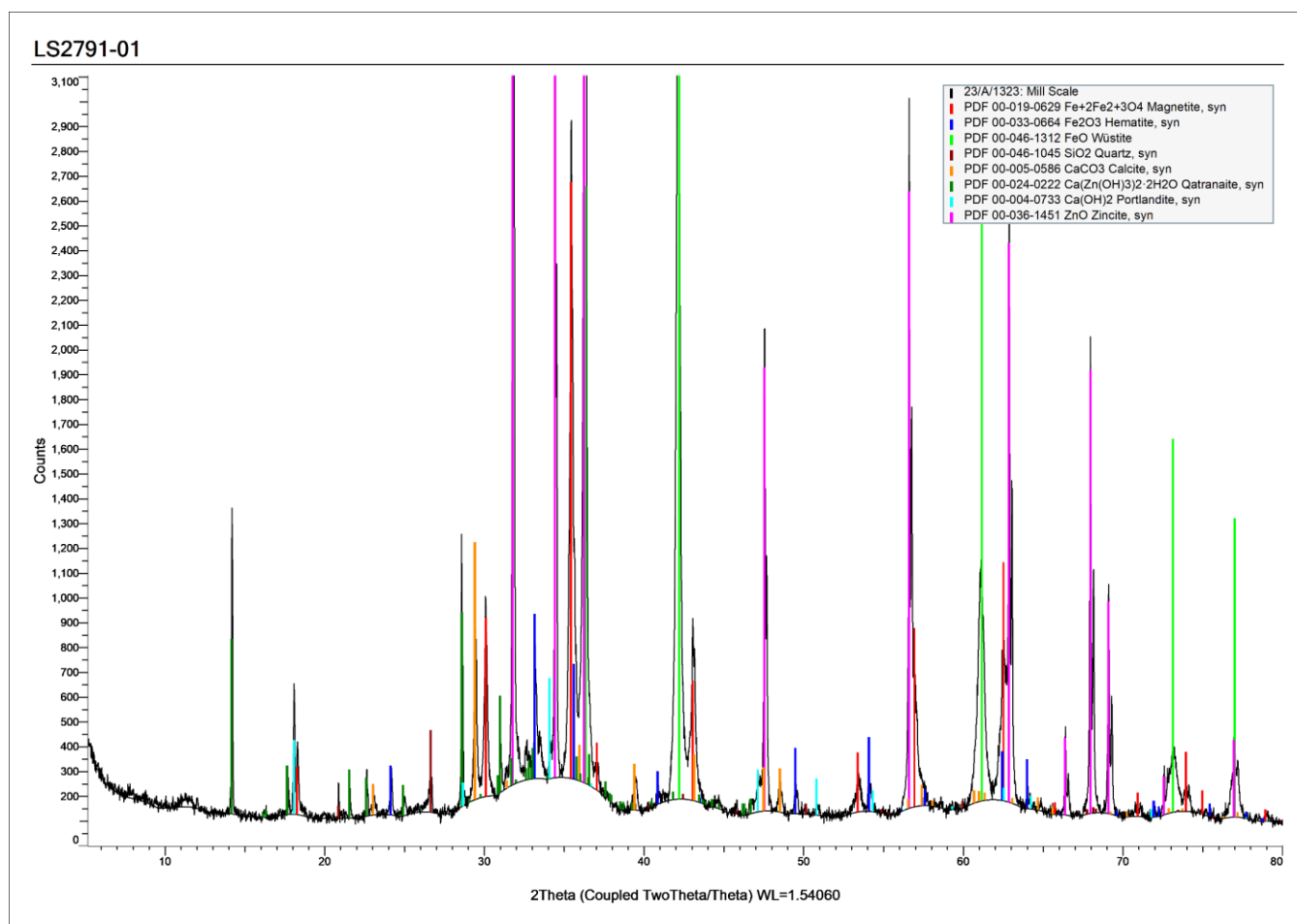
RESULTS OF ANALYSIS: - XRF

All results in % w/w

	Gypsum	Whyalla Slag	Clinker	Japan Slag	Tas. Bauxite
	23/A/1328	23/A/1329	23/A/1330	23/A/1331	23/A/1332
Na	ND	0.131	0.093	ND	ND
Mg	0.317	7.370	1.430	5.090	0.213
Al	0.804	5.440	2.710	7.750	17.250
Si	2.480	14.780	9.600	14.420	5.310
P	ND	0.010	0.012	ND	ND
S	14.230	0.771	0.051	0.669	0.076
Cl	ND	0.013	ND	ND	0.021
K	0.197	0.167	0.228	0.275	0.028
Ca	24.860	28.480	46.750	30.040	0.300
Ti	0.042	0.260	0.162	0.384	7.750
V	ND	ND	ND	ND	0.053
Cr	ND	0.007	0.016	0.015	0.057
Mn	ND	0.219	0.065	0.234	0.022
Fe	0.376	1.840	2.450	0.671	22.400
Co	ND	ND	ND	ND	0.011
Ni	ND	0.003	0.027	ND	ND
Cu	ND	0.012	0.040	ND	ND
Zn	ND	0.015	ND	ND	ND
Sr	0.599	0.056	0.039	0.084	ND
Y	ND	0.004	ND	ND	ND
Zr	ND	0.034	0.018	0.040	0.041
Ru	ND	ND	ND	ND	ND
Cd	ND	0.048	ND	ND	ND
Sn	ND	0.007	ND	ND	ND
Sb	ND	0.030	ND	ND	ND
Te	ND	0.024	ND	ND	ND
In	ND	0.121	ND	ND	ND
Ba	ND	ND	ND	ND	ND
Ce	ND	ND	ND	ND	ND
Sm	ND	ND	ND	ND	ND
Tb	ND	ND	ND	ND	0.056
Yb	ND	0.007	ND	ND	ND
Lu	ND	0.002	ND	ND	ND
Re	ND	0.005	ND	ND	ND
Pt	0.016	ND	ND	ND	ND
Au	ND	0.002	ND	ND	ND
Pb	ND	0.002	ND	ND	ND

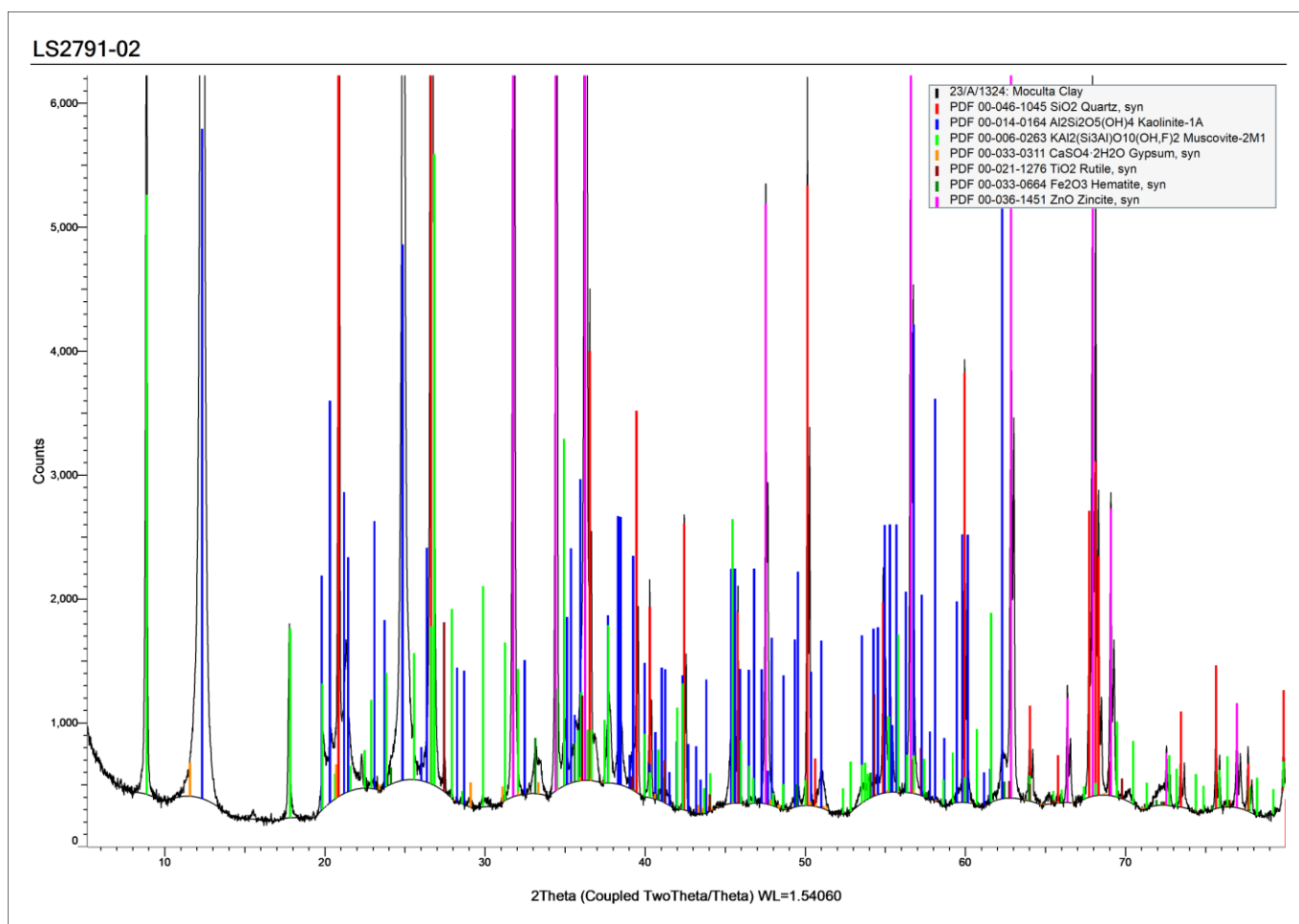
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RESULTS OF ANALYSIS: - XRD



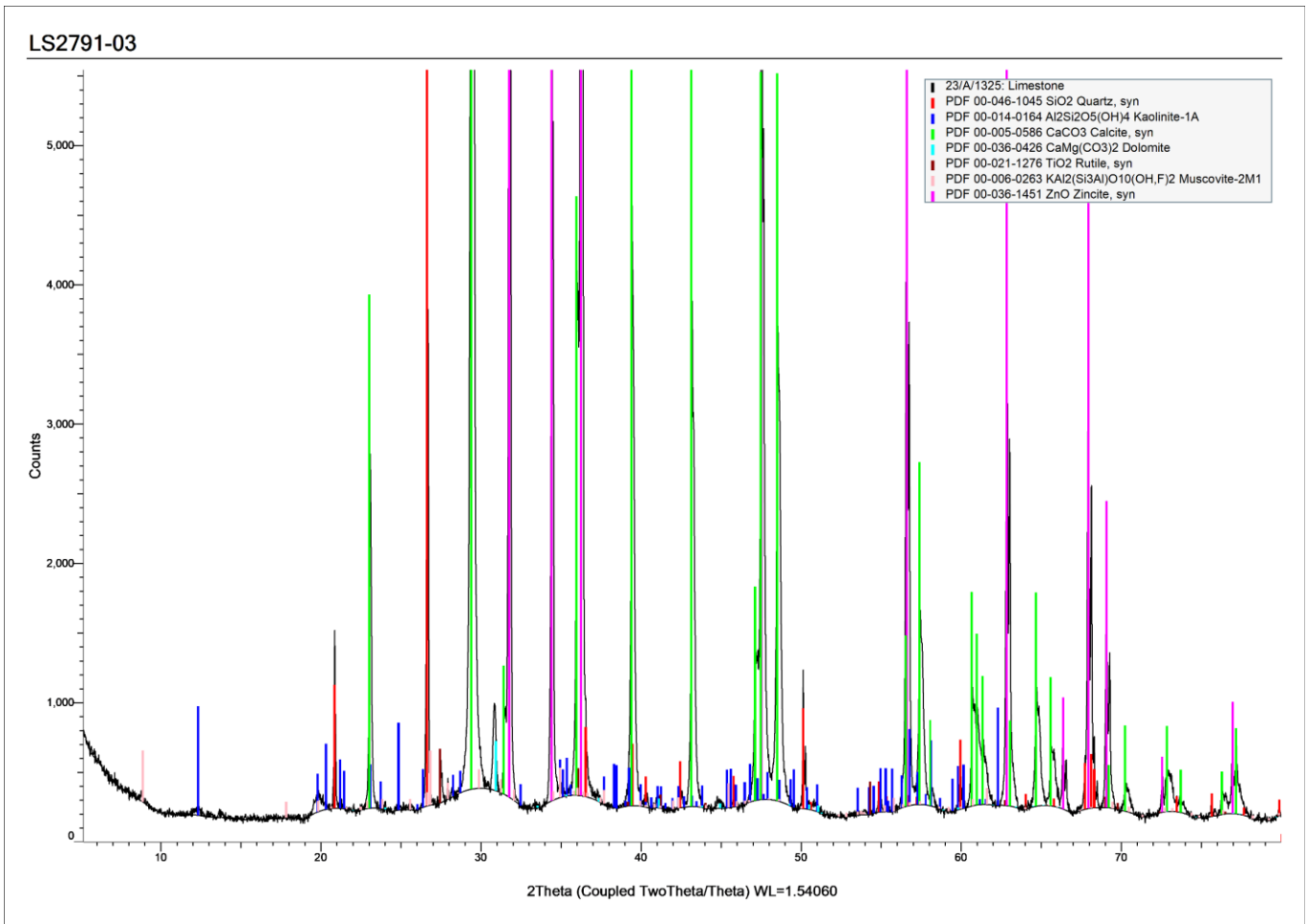
Sample ID:	23/A/1323	Mill Scale
Phase	Formula	Weight %
Magnetite	Fe ₃ O ₄	33
Hematite	Fe ₂ O ₃	6
Wustite	FeO	49
Quartz	SiO ₂	1
Calcite	CaCO ₃	5
Qatranite	Ca(Zn(OH) ₃) ₂ ·2H ₂ O	4
Portlandite	Ca(OH) ₂	2
Amorphous Material	N/A	ND

RESULTS OF ANALYSIS: - XRD



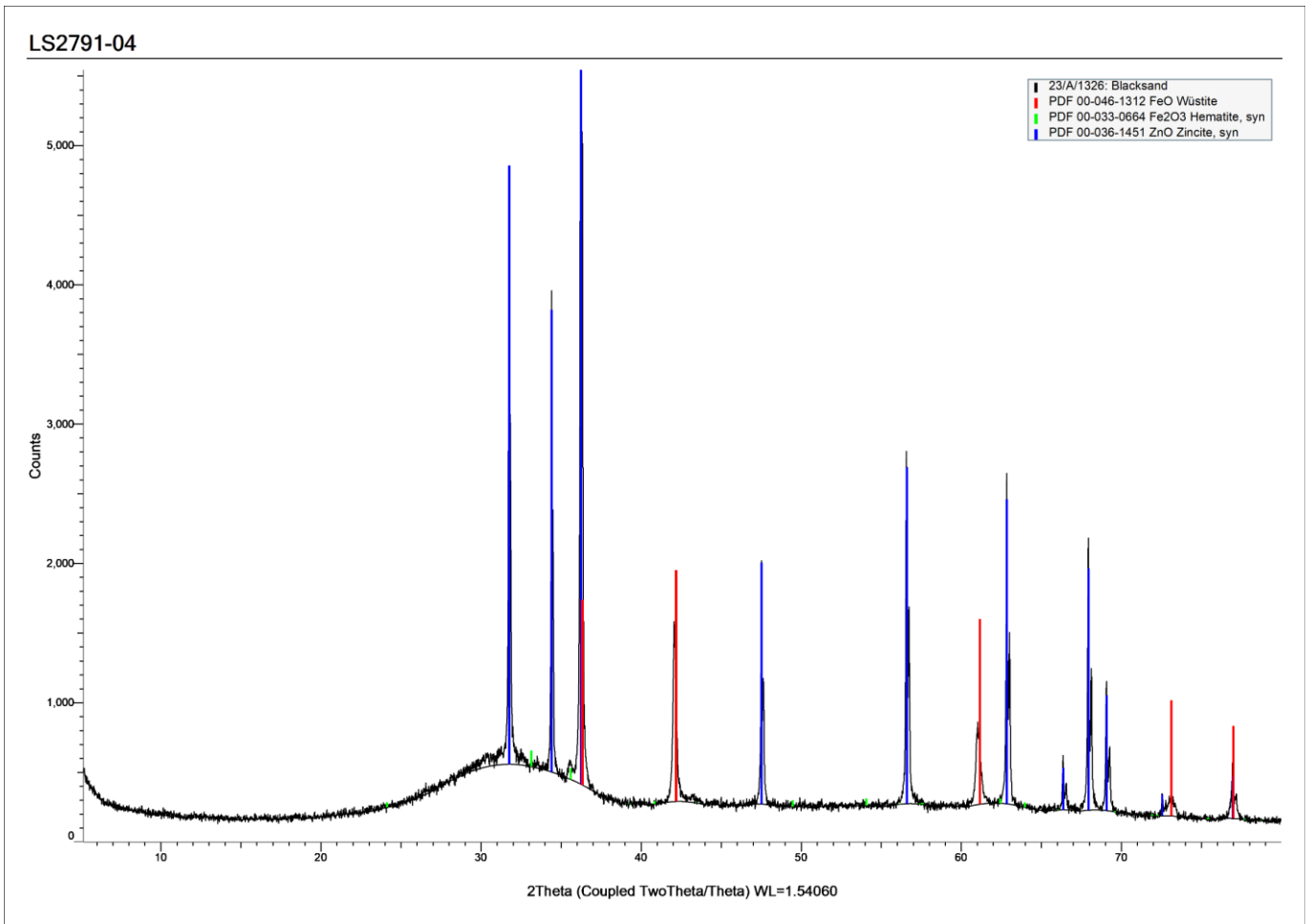
Sample ID:	23/A/1324	Moculta Clay
Phase	Formula	Weight %
Quartz	SiO ₂	43
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	42
Muscovite	KAl ₂ (Si ₃ Al)O ₁₀ (OH,F) ₂	4
Gypsum	CaSO ₄ .2H ₂ O	< 1
Rutile	TiO ₂	1
Hematite	Fe ₂ O ₃	2
Amorphous Material	N/A	8

RESULTS OF ANALYSIS: - XRD



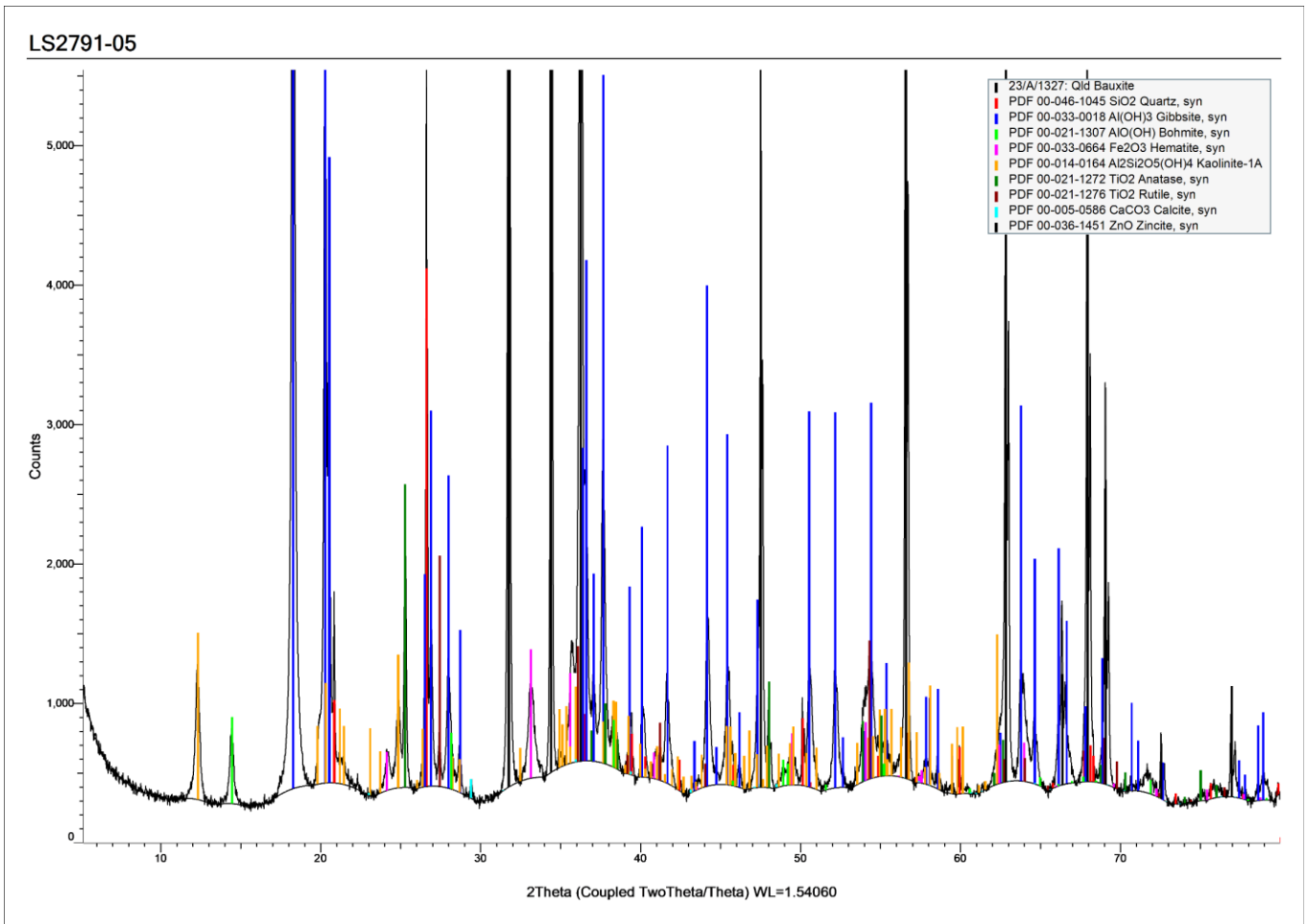
Sample ID:	23/A/1325	Limestone
Phase	Formula	Weight %
Quartz	SiO ₂	7
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	< 1
Muscovite	KAl ₂ (Si ₃ Al)O ₁₀ (OH,F) ₂	< 1
Calcite	CaCO ₃	90
Dolomite	CaMg(CO ₃) ₂	3
Rutile	TiO ₂	< 1
Amorphous Material	N/A	ND

RESULTS OF ANALYSIS: - XRD



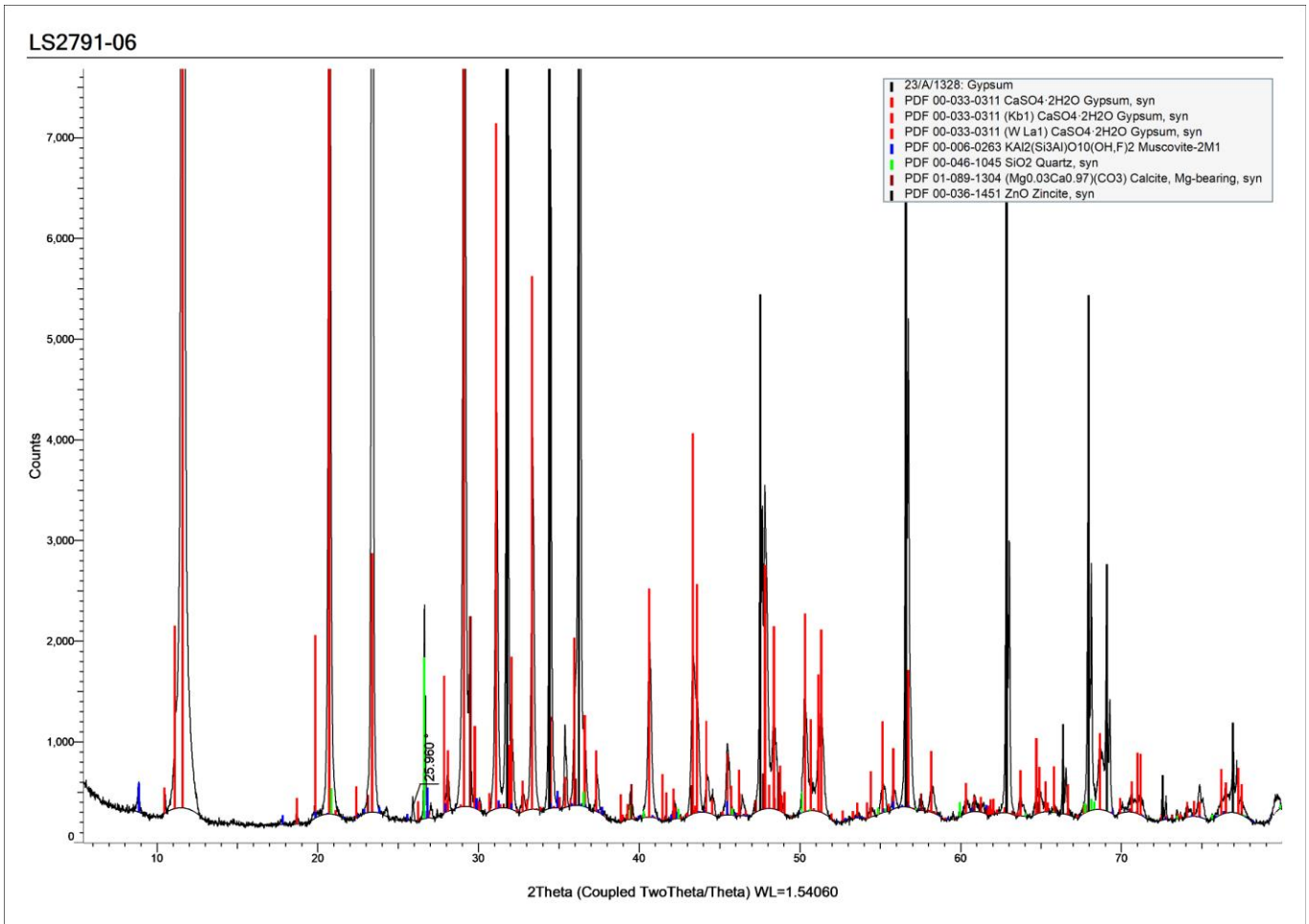
Sample ID:	23/A/1326	Blacksand
Phase	Formula	Weight %
Wuestite	FeO	15
Hematite	Fe ₂ O ₃	1
Amorphous Content	N/A	84

RESULTS OF ANALYSIS: - XRD



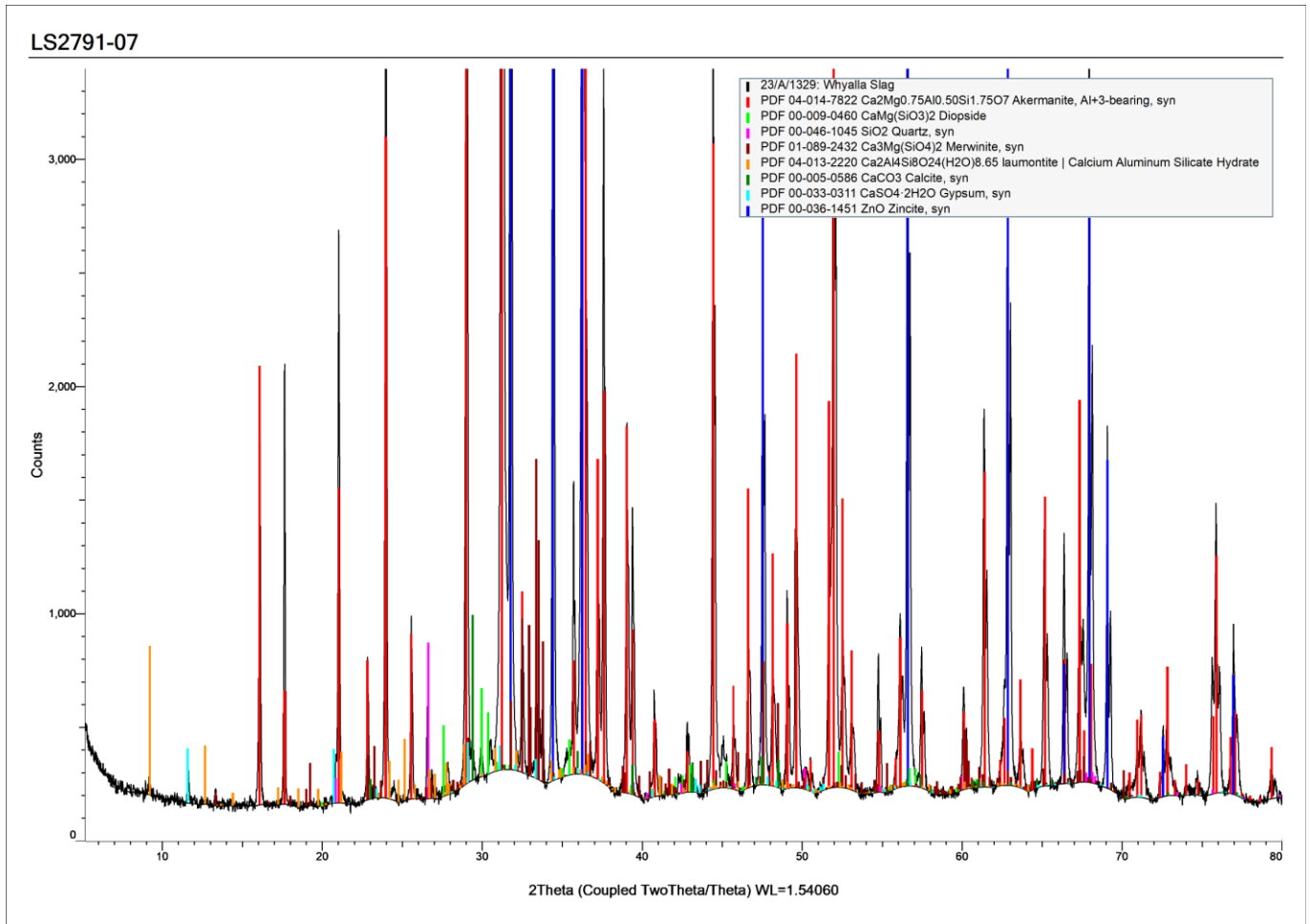
Sample ID:	23/A/1327	Qld Bauxite
Phase	Formula	Weight %
Quartz	SiO ₂	3
Gibbsite	Al(OH) ₃	49
Boehmite	AlO.OH	1
Hematite	Fe ₂ O ₃	9
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	12
Anatase	TiO ₂	2
Rutile	TiO ₂	1
Calcite	CaCO ₃	< 1
Amorphous Material	N/A	23

RESULTS OF ANALYSIS: - XRD



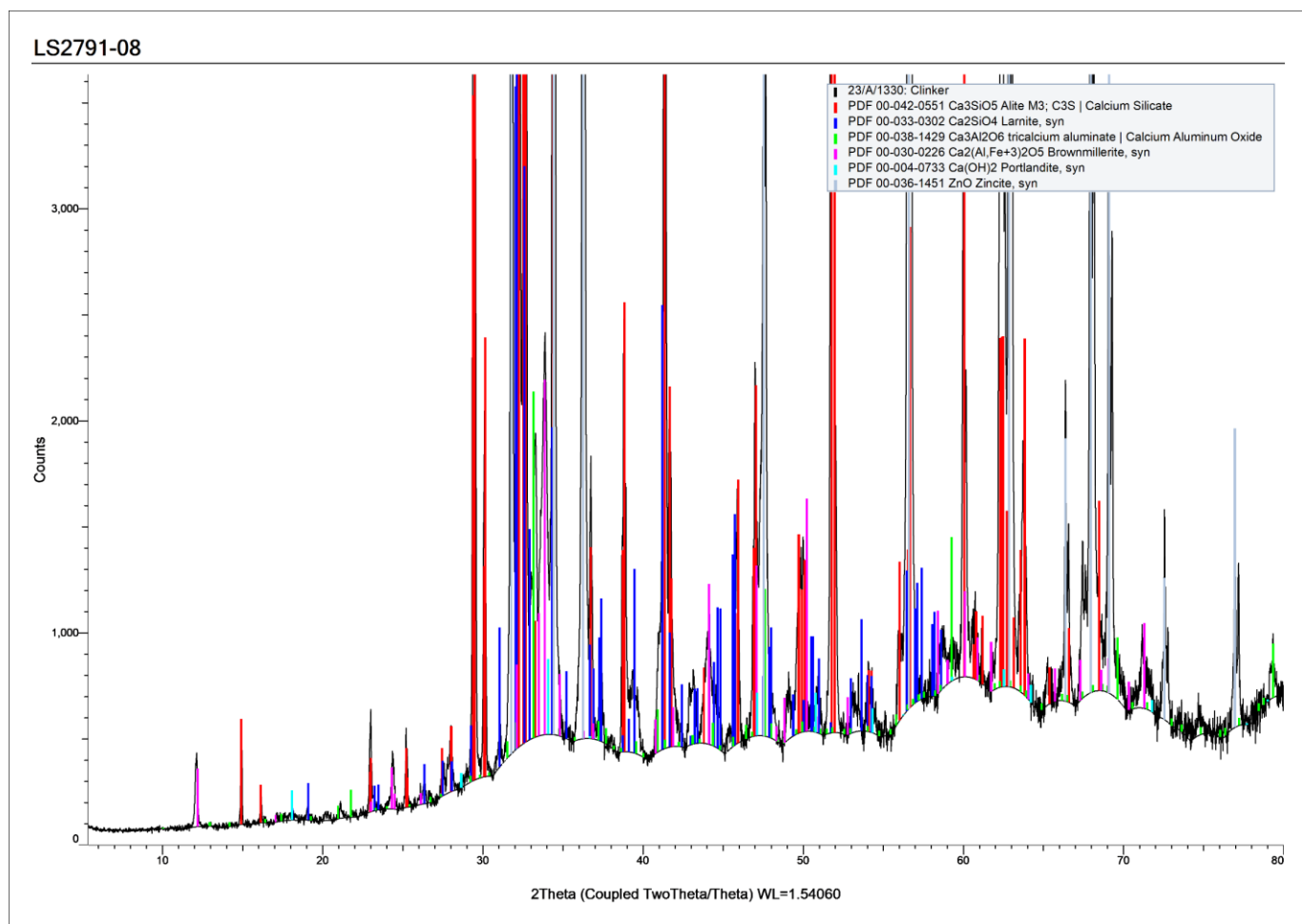
Sample ID:	23/A/1328	Gypsum
Phase	Formula	Weight %
Gypsum	CaSO4.2H2O	82
Muscovite	KAl2(Si3Al)O10(OH,F)2	1
Quartz	SiO2	2
Calcite	CaCO3	3
Amorphous Material	N/A	12

RESULTS OF ANALYSIS: - XRD



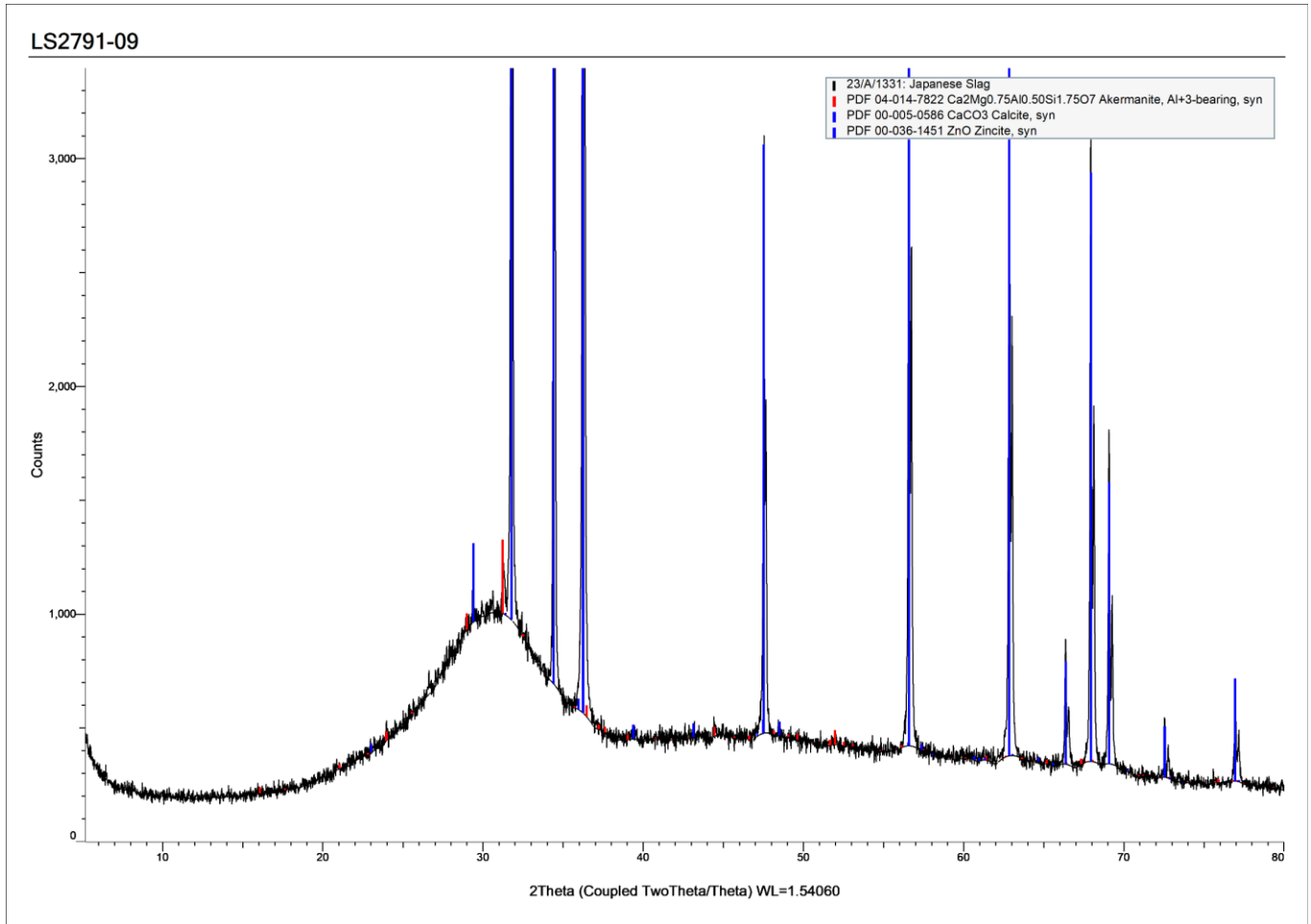
Sample ID:	23/A/1329	Whyalla Slag
Phase	Formula	Weight %
Akermanite	Ca ₂ Mg _{0.75} Al _{0.50} Si _{1.75} O ₇	94
Diopside	CaMg(SiO ₃) ₂	2
Quartz	SiO ₂	1
Merwinite	Ca ₃ Mg(SiO ₄) ₂	1
Laumontite	Ca ₂ Al ₄ Si ₈ O ₂₄ (H ₂ O) _{8.65}	< 1
Calcite	CaCO ₃	1
Gypsum	CaSO ₄ .2H ₂ O	1
Amorphous Content	N/A	< 1

RESULTS OF ANALYSIS: - XRD



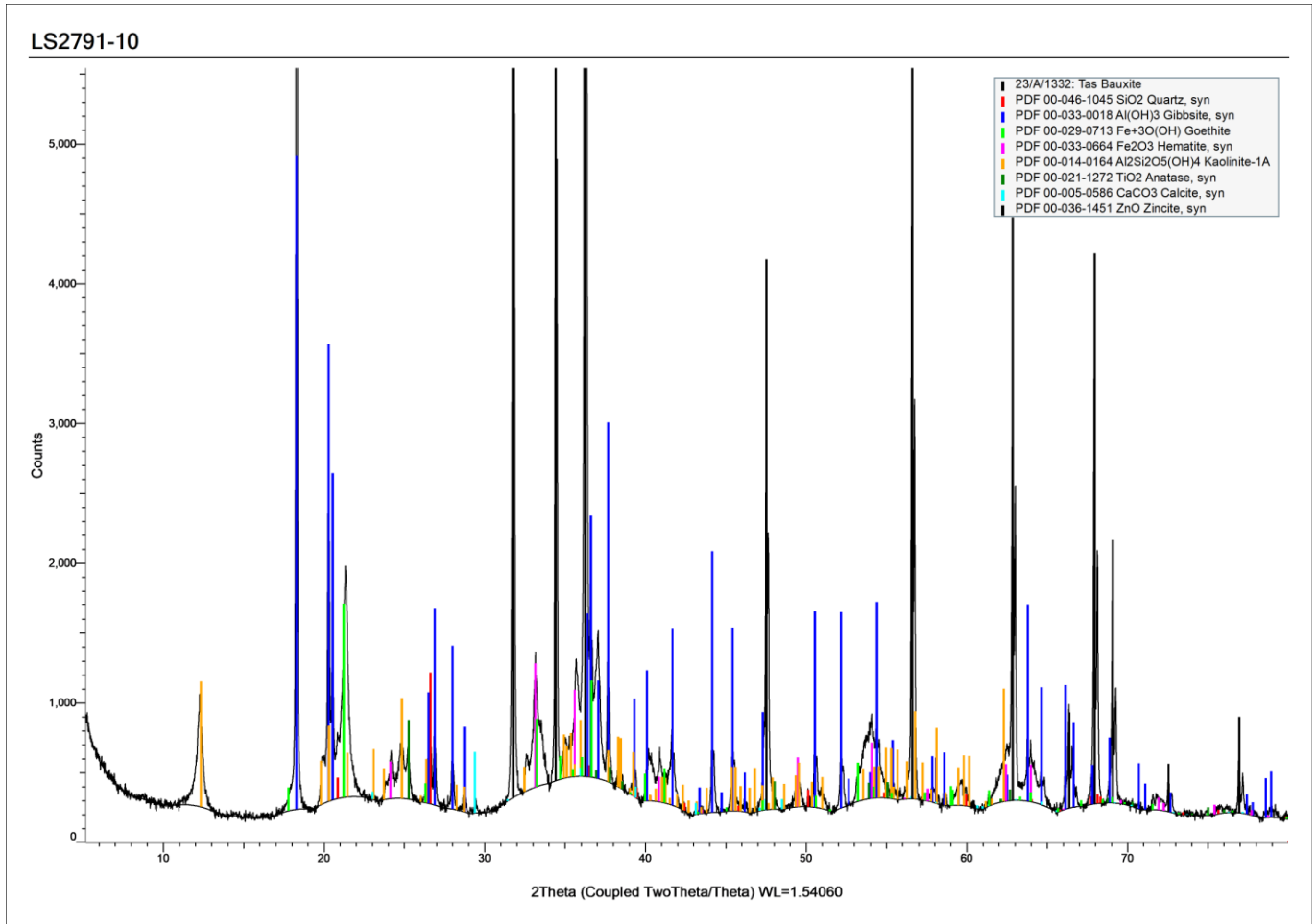
Phase	Formula	Weight %
Tricalcium Silicate (Alite, C3S);	Ca ₃ SiO ₅	67
Dicalcium Silicate (Belite, C2S);	Ca ₂ SiO ₄	14
Tricalcium Aluminate (C3A);	Ca ₃ Al ₂ O ₆	2
Brownmillerite (C4AF);	Ca ₂ (Al, Fe) ₂ O ₅	16
Portlandite	Ca(OH) ₂	1
Amorphous Material	N/A	ND

RESULTS OF ANALYSIS: - XRD



Sample ID:	23/A/1331	Japanese Slag
Phase	Formula	Weight %
Akermanite	Ca ₂ MgSi ₂ O ₇	2
Calcite	CaCO ₃	2
Amorphous Content	N/A	96

RESULTS OF ANALYSIS: - XRD



Sample ID:	23/A/1332	Tas. Bauxite
Phase	Formula	Weight %
Quartz	SiO ₂	< 1
Gibbsite	Al(OH) ₃	24
Goethite	FeO.OH	26
Hematite	Fe ₂ O ₃	10
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	20
Anatase	TiO ₂	< 1
Rutile	TiO ₂	ND
Calcite	CaCO ₃	< 1
Amorphous Material	N/A	20

IMPORTANT NOTE:

The data contained in this report is intended be used to compare with data obtained from dust samples obtained from High Volume Samplers.

The aim is to establish a unique chemical or mineralogical signature from each of the stockpiled materials and search for that 'signature' in samples collected from the high volume samplers.

It is thus critical that the tests performed above are also performed on the samples collected from High Volume Samplers.

It has been established that an absolute minimum of 0.5 grams is required from the High Volume Samplers to achieve this, but a larger sample size will provide more robust and informative results.