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***RESPIRABLE AIRBORNE DUST MONITORING AT VARIOUS  
LONDON UNDERGROUND STATIONS AND TRAIN LINES***

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# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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INITIAL	8 <sup>TH</sup> JULY 2016	ISSUED FOR COMMENT
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# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## Executive Summary

At the request of Louise Dearman, Occupational Hygiene Adviser - London Underground Limited, personal dust monitoring for respirable dust exposure was undertaken on Station Staff and Train Operators at various stations and within train line cabins. In addition, personal monitoring was conducted in the saloon cars for simulated passenger journeys. Selected samples from the Train Operator monitoring were also analysed for crystalline silica and metals for particles of  $<2.5\mu\text{m}$ . The samples were collected using respirable dust cyclone heads and cyclone inhalable samplers worn by, Train Operators and/or Station Staff during their shifts and by 4-RAIL Analysts undertaking passenger journeys.

Static air sampling was also undertaken to assist in the assessment of airborne dust levels in cases where little or no platform duties were carried out by Station Staff, or where Station Staff were not comfortable wearing personal sampler. The Grimm portable aerosol spectrometer was also used within the train cabs, to assess the dust size distribution and dust concentration in real time.

The Stations where monitoring was carried out were Aldgate East, Baker Street, Elephant and Castle, Euston Square, Hampstead, King's Cross, Oxford Circus, Piccadilly Circus, Tottenham Court Road, Vauxhall, Waterloo and Paddington. The Train Operator and passenger dust exposure monitoring was carried out on the District, Jubilee, Piccadilly, Victoria, Bakerloo, Central, Northern, Circle and Hammersmith & City lines.

For Train Operators, the highest respirable dust concentration measured was  $0.86\text{ mg/m}^3$  for the Bakerloo Line, with most levels being below  $0.50\text{ mg/m}^3$  on the rest of the lines. Whilst these results are not directly comparable to previous dust monitoring exercises because Train Operator duties vary, as a good general indication, the respirable dust concentration exposure levels for Train Operators were in general similar to those measured previously. The lowest dust levels were recorded for Train Operators working on the District, Circle and Hammersmith & City Lines. For the simulated passengers journeys, the results were all below or equivalent to  $0.63\text{ mg/m}^3$ . The levels recorded for all lines were significantly less than the Workplace Concentration Exposure Limit of  $4\text{ mg/m}^3$  (long term 8 hour Time Weighted Average). No defined short term exposure limits exist for airborne dust, but typically the short-term exposure limits are estimated to be 3 times the long term exposure limit i.e.  $12\text{ mg/m}^3$  over a 15 minute period. Therefore, the levels measured for the Train Operators and passengers of the different lines were significantly below the inferred short-term workplace exposure limit.

For Station Staff on duty at Euston Square and Aldgate Stations, the dust levels measured were  $0.20$  and  $0.31\text{ mg/m}^3$ , and therefore well below the Workplace Exposure Limit of  $4\text{ mg/m}^3$  (long term 8 hour Time Weighted Average). Where personal monitoring could not be carried out on the Station Staff, static monitoring was employed. The combined results of personal samples on Station Staff and the static monitoring from station Gate Lines samples indicate that the respirable dust concentrations at the stations assessed were below the Workplace Exposure Limit of  $4\text{ mg/m}^3$  (long term 8 hour Time Weighted Average); highest concentration recorded was at Piccadilly Circus station Gate Line ( $0.58\text{ mg/m}^3$ ). The static samples were similar to those measured previously, with static samples situated on platforms giving the highest readings. Lower dust concentrations were recorded for personal samples taken on staff on gate line duties than for those on platform duties.

Selected samples taken from collectors worn by Train Operators were analysed for crystalline silica content by the Institute of Occupational Medicine (IOM). In all cases, the levels found were same as or below the detection limit of  $<0.01\text{ mg/filter}$ , and therefore well below the Workplace Exposure Limit of  $0.1\text{ mg/m}^3$  (long term 8 hour Time Weighted Average).

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Also, samples taken from PM2.5 collectors worn by Train Operators were analysed for metals. Apart from iron, the levels of metals found were below the respective detection limits and in all cases, the results were well below the HSE workplace long term exposure limits. Iron levels are likely elevated due to wear at the wheel rail interface.

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### 1. Introduction

- 1.1 At the request of Mrs Louise Dearman, London Underground Limited, personal monitoring for respirable airborne dust exposure was to be undertaken on LUL Train Operators whilst driving, on 4-RAIL Analysts undertaking passenger journeys and on Station Staff conducting gate line duties, platform duties (Station Assistant Trains, SATs) and other station duties. It should be noted that where personal monitoring could not be carried out on the London Underground Station Staff, static monitoring was conducted.
- 1.2 Static monitoring for respirable airborne dust was also carried out at various platforms. A minimum of one sample for each Line, collected whilst monitoring Train Operator exposure, was to be analysed for respirable crystalline silica and for metals on the samples collected with the 2.5µm size selective head (for comparison with the IOM Report Ref TM/03/02). In addition to this, a Grimm laser scatter dust monitor was to be used for one shift per line to gather data on the particle size distribution.
- 1.3 The specific stations and locations where personal and static monitoring was undertaken were:

Stations	Sampling Locations	Sample Type
Aldgate	Gate line duties.	Personal
	District line platforms.	Static
Baker Street	Jubilee, Bakerloo, Hammersmith & City, and Circle lines platforms, Ticket Halls and Gate lines.	Static
Elephant and Castle	Bakerloo line platforms, Ticket Halls and Gate lines.	Static
Euston Square	Gate line duties.	Personal
	Circle and Hammersmith & City line platforms, Ticket Hall & Gate lines.	Static
Hampstead	Northern line platforms & Ticket Hall, Gate lines.	Static
King's Cross	Piccadilly, Victoria, Northern, Hammersmith & City, Circle and Metropolitan lines platforms & Ticket Halls, Gate lines.	Static
Oxford Circus	Bakerloo, Central and Victoria lines platforms & Gate lines.	Static
Piccadilly Circus	Piccadilly line platforms & Main gate line.	Static
Tottenham Court Road	Central and Northern lines platforms & Northern Gate line.	Static
Vauxhall	Victoria line platforms	Static

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Stations	Sampling Locations	Sample Type
Waterloo	Waterloo & City and Bakerloo line platforms	Static
Paddington	District & Circle, Bakerloo lines platforms	Static

- 1.4 Train operator and simulated passenger journey monitoring was to be carried out on the District, Jubilee, Piccadilly, Victoria, Bakerloo, Central, Northern and Circle and Hammersmith & City lines.
- 1.5 Open sections of the District, Metropolitan and Hammersmith and City lines were included in the respirable dust monitoring shifts, as they are representative to the Train Operator's duty/ journey, hence his/her exposure.

## 2. Technical Background

- 2.1 The health effects concerning inhalation exposure to dust are dependent upon the size, shape and composition of the particles. In occupational health, general dust is classified in terms of particle size, termed as inhalable, thoracic or respirable. The inhalable fraction of dust is defined as particles that can be inhaled and deposited throughout the respiratory tract, i.e. from the nasal to the alveolar region in the lungs. Thoracic dust is the fraction of inhaled airborne material penetrating beyond the larynx. Respirable dust is the term given to dust particles that are small enough to penetrate the deep lung and therefore largely deposit in the alveolar region where gas exchange takes place.
- 2.2 Respirable and inhalable dusts are currently assessed against the respective Workplace Exposure Limits (WEL's) of 4 mg/m<sup>3</sup> and 10 mg/m<sup>3</sup> averaged over an 8-hour reference period (Health and Safety Executive Document EH40/05, 2<sup>nd</sup> Edition 2011). Short-term exposure limits do not currently exist for airborne dust, but usually the short-term exposure limits are taken to be 3 times the long-term exposure limits.
- 2.3 The long-term 8 hour exposure limits are averages for an 8 hour shift. Consequently, if during a shift the operator is only exposed to a level of dust for 6 hours, to allow comparison with the HSE limits the 8 hour time weighted average exposure needs to be calculated. For the example of 6 hours exposure in an 8 hour period the time weighted average is 3/4 of the level measured for the six hour period. The values quoted in the results tables are dust concentrations, therefore they are equivalent to 8 hours exposure in an 8 hour period. Actual exposure will be less than this.
- 2.4 Prolonged exposure to respirable quartz may result in silicosis, a progressive and irreversible condition in which healthy lung tissue becomes replaced with areas of fibrosis. The HSE Workplace Exposure Limit (WEL) for respirable crystalline silica has been set at a level of 0.1 mg/m<sup>3</sup> averaged over an 8-hour reference period (HSE Document EH40/05, 2<sup>nd</sup> Edition 2011).
- 2.5 Prolonged exposure to fine metal particles may also cause respiratory illnesses. The HSE Workplace Exposure Limits (WEL) for Iron, Zinc, Chromium, Copper, Nickel and Manganese are detailed within the following table:

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Substance		Long - term exposure limit of (8-hour time weighted average)	Units
Iron salts (as Fe)		1	mg/m <sup>3</sup>
Copper dusts and mists (as Cu)		1	mg/m <sup>3</sup>
Total Chromium		0.5	mg/m <sup>3</sup>
Chromium (VI) compounds (as Cr)		0.05	mg/m <sup>3</sup>
Nickel and its organic compounds	Water-soluble	0.1	mg/m <sup>3</sup>
	Water insoluble	0.5	mg/m <sup>3</sup>
Manganese and its inorganic compounds		0.5	mg/m <sup>3</sup>
Zinc chloride fume		1	mg/m <sup>3</sup>

### 3. Method

- 3.1 Respirable dust levels were measured following the guidance set out in the Health & Safety Executive Document MDHS 14/4: General methods for sampling and gravimetric analysis of respirable, thoracic and inhalable aerosols, and in house test procedure 4R-E206 Issue 7.
- 3.2 Sampling pumps equipped with respirable dust cyclone heads or cyclone inhalable samplers as appropriate were worn by the Train Operators, Station Staff and Analysts on passenger journeys. The locations and location codes are given in the tables of results. Examples of a cyclone (respirable) dust head and a cyclone inhalable sampler to monitor particular matter of 2.5µm are shown in Figures 9 and 10.
- 3.3 Respirable airborne dust monitoring was carried out at each of the stations for one shift; timed to include the peak hours. Simulated passenger monitoring for respirable dust took place for one set of journeys on each of the eight lines, with minimum duration of 4 hrs per line, where possible.
- 3.4 The Train Operators monitoring was undertaken over three shifts on each line, again timed to include peak hours. The cyclone inhalable sampler was used in one of the shifts to monitor dust of 2.5 µm. Apart from personal dust exposure measurements, a Grimm laser scatter static dust monitor was also used during one of the shifts to take a continuous air sample. This instrument measures in real time different size particles by the physical principle of orthogonal light scattering. For this sampling programme the particle sizes chosen for measurement were 10 µm, 2.5 µm and 1 µm.
- 3.5 The personal samples were collected on 25 mm glass fibre type A/E filters for gravimetric analysis or 37 mm glass fibre type A/E filters for gravimetric analysis and subsequent analysis for metals by Mass Spectrometry; or 25 mm GLA 5000 PVC filters to allow both gravimetric analysis and then subsequent analysis for respirable quartz by infrared spectroscopy.

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- 3.6 One of the primary aims was to obtain personal monitoring data for a shift on each occasion. This was either achieved by one person wearing the monitoring pump for the duration of the shift or a sequence of individuals wearing the same sampling head, or each wearing a separate sampling head. Where separate sampling heads were used, each was run for sufficient time to allow the filter to make a measurable weight gain in order to ensure accurate results.
- 3.7 On stations where there would be little or no duties on the platforms, static sampling pumps connected to cyclone heads loaded with 25 mm glass fibre type A/E filters were set up in strategic locations where possible. This procedure was also adopted if station staff were not comfortable wearing personal sampler. However, it should be noted that static results are not the same as personal sampling results, although they can be indicative in some circumstances.
- 3.8 Sampling periods are chosen to obtain sufficient dust on the filters for reliable gravimetric analysis.

### **4. Analysis**

- 4.1 The samples taken on site were returned to the laboratory and gravimetric analysis was undertaken in accordance with MDHS 14/4.
- 4.2 Following gravimetric analysis of the personal respirable dust samples, selected personal respirable dust samples, together with blanks were submitted to the Institute of Occupational Medicine (IOM) for quartz analysis.
- 4.3 Following gravimetric analysis of the personal 2.5 µm dust samples, samples were submitted together with the blanks for analysis of metals.
- 4.4 The Grimm laser scatter meter is factory calibrated to a synthetic dust comprising monodisperse 1µm latex and micro Dolomit DR80 polydisperse powder (0.2 – 80 µm).

## 5. Results

### 5.1 **4-RAIL Analyst simulating passenger journeys**

5.1.1 The respirable dust exposure levels assessed as representative for passengers travelling on the different lines are given in Table 1. Monitoring was undertaken on one set of journeys on each of the eight lines, between 22<sup>nd</sup> April 2016 and 3<sup>rd</sup> May 2016.

The respirable dust results obtained were from <0.02 to 0.63 mg/m<sup>3</sup>. The lines with highest results were the Victoria and Bakerloo lines with levels of 0.56 mg/m<sup>3</sup> and 0.63 mg/m<sup>3</sup> respectively. The Circle and District lines presented the lowest exposure results with respirable dust levels of <0.02 and 0.08 mg/m<sup>3</sup>.

### 5.2 **Train Operators**

5.2.1 The monitored levels of respirable dust and of particulate matter of 2.5µm that Train Operators were exposed to during the train driving in each of the lines are given in Tables 2 to 9.

- District Line

The respirable dust and PM2.5 exposure levels for the District Line measured on the 22<sup>nd</sup> March, 30<sup>th</sup> August and 08<sup>th</sup> September 2016, are given in Table 2. The respirable dust results were between 0.07 and 0.08 mg/ m<sup>3</sup>. The measured level of PM2.5 was 0.14 mg/m<sup>3</sup>.

- Jubilee Line

The respirable dust and PM2.5 exposure levels for the Jubilee Line Train Operators measured on the 24<sup>th</sup>, 25<sup>th</sup> and 28<sup>th</sup> March 2016, are given in Table 3. The respirable dust results were between 0.05 and 0.27 mg/m<sup>3</sup>. The measured level of PM2.5 was 0.05 mg/m<sup>3</sup>.

- Piccadilly Line

The respirable dust and PM2.5 exposure levels for the Piccadilly Line Train Operators measured on the 29<sup>th</sup>, 30<sup>th</sup> and 31<sup>st</sup> March 2016, are given in Table 4. The respirable dust results were between 0.24 and 0.60 mg/m<sup>3</sup>. The measured level of PM2.5 was 0.60 mg/m<sup>3</sup>.

- Victoria Line

The respirable dust and PM2.5 exposure levels for the Victoria Line Train Operators measured on the 1<sup>st</sup>, 4<sup>th</sup> and 5<sup>th</sup> April 2016, are given in Table 5. The respirable dust results were between 0.23 and 0.57 mg/m<sup>3</sup>. The measured level of PM2.5 was 0.57 mg/m<sup>3</sup>.

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- Bakerloo Line

The respirable dust and PM2.5 exposure levels for the Bakerloo Line Train Operators measured on the 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> April 2016, are given in Table 6. The respirable dust results were 0.44 and 0.86 mg/m<sup>3</sup> and the PM2.5 result was 0.71 mg/m<sup>3</sup>.

- Central Line

The respirable dust and PM2.5 exposure levels for the Central Line Train Operators measured on the 11<sup>th</sup>, 12<sup>th</sup> and 13<sup>th</sup> April 2016, are given in Table 7. The respirable dust obtained results were 0.25 and 0.32 mg/m<sup>3</sup> with a concentration of 0.32 mg/m<sup>3</sup> for the PM2.5 result.

- Northern Line

The respirable dust and PM2.5 exposure levels for the Northern Line Train Operators measured on the 14<sup>th</sup>, 15<sup>th</sup> and 18<sup>th</sup> April 2016, are given in Table 8. The respirable dust results were 0.21 and 0.63 mg/m<sup>3</sup>. The measured level of PM2.5 was 0.63 mg/m<sup>3</sup>.

- Circle and Hammersmith & City Lines

The respirable dust and PM2.5 exposure levels for the Circle and H&C Line Train Operators measured on the 19<sup>th</sup>, 20<sup>th</sup> and 21<sup>th</sup> April 2016, are given in Table 9. The respirable dust results were 0.05 and 0.08 mg/m<sup>3</sup>. The level of PM2.5 was 0.08 mg/m<sup>3</sup>. However, the result recorded is indicative only, due to incomplete monitoring session.

- 5.2.2 Selected respirable dust samples taken during the train operator monitoring across all of the different Lines, together with blanks, were submitted to the Institute of Occupational Medicine (IOM) for quartz analysis.

The results for each of the Lines are given in Table 23 and the certificates for the analysis of quartz are included in Appendix 1. For each filter, the level of crystalline silica found was below or same as the detection limit of the analytical method, 0.01mg/filter. The calculated levels of airborne respirable crystalline silica were therefore all <0.02 mg/m<sup>3</sup> when the volume of air sampled was accounted for.

- 5.2.3 The PM2.5 samples taken during the train operator monitoring across all of the different Lines and blanks were submitted for the analysis of metals. The results are given in Tables 24 to 26 and the certificates for the analysis of metals are included in Appendix 2.

For each filter, the levels of analysed metals were significantly lower than the HSE applicable Workplace Exposure Limits. For Copper and Manganese, the concentrations were below or same as the detection limit of the analytical method i.e <1.0 µg/filter and < 0.30 µg/filter. Chromium and Nickel concentrations were found to be all below 0.001 mg/m<sup>3</sup>. The calculated levels of 2.5 µm metals (apart from Iron and Zinc) were all <0.008 mg/m<sup>3</sup> when the volume of air sampled was accounted for.

When the volume of air sampled was accounted for, the Iron levels detected were between 0.04 and 0.33 mg/m<sup>3</sup> and the Zinc levels detected were between 0.001 and 0.095 mg/m<sup>3</sup>.

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### 5.2.4 The Grimm results are shown in graphs Figures 1 to 8.

Several peaks can be observed on all of the graphs which match with times when opening of cab doors or windows took place and also when changing ends of train at the end of routes. The Grimm monitor was also disconnected during breaks and this can be also noted in some of the graphs where there was no data for a certain time period which correspond to the break time. On one occasion, during monitoring on Central Line, the Grimm was not switched off during lunch break; Figure 6 shows the lower levels recorded during the Train Operator's duty while not driving the train. Some peaks can be observed during this period; however this may coincide with the time when the 4-RAIL personnel and Train Operator were distancing/ approaching the train environment, i.e. walking on the platform.

It can be deduced from the graphs that the Piccadilly and Northern lines presented higher dust concentration than the rest of the lines. The District and Hammersmith & City and Circle lines had the lowest dust concentration due to their more frequent and longer open sections.

### 5.3 **Station Staff**

#### 5.3.1 The dust levels in stations are known to be highest on the station platforms and on some gate line areas where the air currents carry dust from the platforms and tunnels past the gate line. The aim of the monitoring is to ensure that exposure is ALARP (As Low As Reasonably Practicable) hence the monitoring was conducted primarily within gate line and platform areas. Two personal samples were collected on this occasion, from personnel carrying out gate line duties at Aldgate East and Euston Square stations.

Where no platform duties were carried out or station staff were not comfortable wearing personal samplers, static samples were taken but these cannot directly replace personal samples. However, they do allow for an assessment of indicative personal exposure.

### 5.4 **Stations**

#### **Aldgate East Station**

The results for the monitoring at Aldgate East Station are given in Table 10. The monitoring was carried out on the 4<sup>th</sup> May 2016. The result for the personal sample was 0.31 mg/m<sup>3</sup>. The results for the static samples at the ticket hall, westbound and eastbound platforms were 0.38, 0.41 and 0.55 mg/m<sup>3</sup> respectively.

#### **Baker Street Station**

The results for the monitoring at Baker Street Station are given in Table 11. The monitoring was carried out on the 5<sup>th</sup> May 2016.

Only static monitoring was carried out. The results for the static samples were between <0.02 and 1.18 mg/m<sup>3</sup>. The highest dust concentrations recorded were on the Bakerloo and Jubilee Lines.

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### **Elephant and Castle Station**

The results for the monitoring at Elephant and Castle Street Station are given in Table 12. The monitoring was carried out on the 6<sup>th</sup> May 2016. Only static monitoring was carried out. The results for the static samples at the platforms and gate lines were between 0.03 and 0.69 mg/m<sup>3</sup>, with the highest recorded on the Northern northbound platform.

### **Euston Square Station**

The results for the monitoring at Euston Square Station are given in Table 13. The monitoring was carried out on the 9<sup>th</sup> May 2016. The results for the personal sample was 0.20 mg/m<sup>3</sup>. The results for the static samples at the ticket hall and westbound and eastbound platforms were 0.37 and 0.46 mg/m<sup>3</sup> respectively.

### **Hampstead Station**

The results for the monitoring at Hampstead Station are given in Table 14. The monitoring was carried out on the 10<sup>th</sup> May 2016. Only static monitoring was carried out. The results for the static samples at the Northern Line platforms and ticket office were between 0.10 and 0.84 mg/m<sup>3</sup>.

### **King's Cross Station**

The results for the monitoring at King's Cross Station are given in Table 15. The monitoring was carried out on the 11<sup>th</sup> May 2016. The results for the static samples throughout the station, on various train line platforms and ticket offices, were between 0.03 and 0.62 mg/m<sup>3</sup>.

### **Oxford Circus Station**

The results for the monitoring at Oxford Circus Station are given in Table 16. The monitoring was carried out on the 12<sup>th</sup> May 2016. The results for the static samples were between 0.09 and 0.69 mg/m<sup>3</sup>, with highest results recorded at Bakerloo Line platforms.

### **Archway**

The results for the monitoring at Archway Station are given in Table 17. The monitoring was carried out on the 13<sup>th</sup> May 2016. The results for the static samples at the Northern Line platforms and at station gate line were between 0.22 to 0.56 mg/m<sup>3</sup>.

### **Piccadilly Circus Station**

The results for the monitoring at Piccadilly Circus Station are given in Table 18. The monitoring was carried out on the 16<sup>th</sup> May 2016. The results for the static samples were between 0.54 to 1.01 mg/m<sup>3</sup>, with highest results recorded at Bakerloo Line platforms.

### **Tottenham Court Road Station**

The results for the monitoring at Tottenham Court Road Station are given in Table 19. The monitoring was carried out on the 17<sup>th</sup> May 2016. The results for the static samples at the Northern and Central Line platforms were between 0.10 to 1.30 mg/m<sup>3</sup> with highest result recorded at Central Line Eastbound platform.

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### **Vauxhall Station**

The results for the monitoring at Vauxhall Station are given in Table 20. The monitoring was carried out on the 18<sup>th</sup> May 2016. The results for the static samples at the Victoria Line platforms and by the ticket office were between 0.08 to 0.77 mg/m<sup>3</sup>.

### **Waterloo Station**

The results for the monitoring at Waterloo Station are given in Table 21. The monitoring was carried out on the 19<sup>th</sup> May 2016. The results for the static samples throughout the station, on various train line platforms and ticket office were between 0.06 to 1.19 mg/m<sup>3</sup>, with highest results recorded at Bakerloo Line platforms.

### **Paddington Station**

The results for the monitoring at Paddington Station are given in Table 22. The monitoring was carried out on the 20<sup>th</sup> May 2016. The results for the static samples at the platforms and gate lines were between 0.01 and 0.12 mg/m<sup>3</sup>.

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### 6. Discussions and Conclusions

- 6.1 The levels of airborne respirable dust for the personal samples taken on Train Operators and on 4-RAIL analysts undertaking passenger journeys travelling on the following lines: District, Jubilee, Piccadilly, Victoria Bakerloo, Central, Northern, Circle and Hammersmith & City, were all below the Workplace exposure limit of 4 mg/m<sup>3</sup> for respirable dust (long-term 8 hour time weighted average).
- 6.2 The highest gravimetric result obtained was for the sample of a train operator on the Bakerloo Line and the lowest results were for the samples of the train operators on the District, H&C and Circle Lines. As a passenger, the higher levels were found on the Bakerloo and Victoria Lines. The Grimm laser scatter data showed that the Piccadilly, Northern and Central Lines presented higher dust concentration than for the other lines. The District, Circle and Hammersmith & City line had the lowest concentration.
- 6.3 The levels of airborne respirable dust measured for personal samples taken on staff carrying out platform/gate line/station check duties as part of their shifts at the following stations: Aldgate East and Euston Square were below the Workplace exposure limit of 4 mg/m<sup>3</sup> for respirable dust (long-term 8 hour time weighted average). Also, all the static samples at specific stations (platforms and gate lines) resulted in concentrations below the Workplace exposure limit. However, it was noted that the samples from Tottenham Court Road station's platforms – Central & Northern Lines, were significantly higher (between 0.79 and 1.15 mg/m<sup>3</sup>) than the previous round of monitoring carried out in 2014 (<0.02 and 0.52 mg/m<sup>3</sup>).
- 6.4 It should also be noted that the respirable dust levels reported for the station personnel, 4-RAIL passengers and train operators are for the monitoring period in each case. Where a shift lasts for less than 8 hours, the 8 hours time weighted average exposure will be lower than the measured level so the results would all be further below the 4 mg/m<sup>3</sup> limit. No limit exists for short-term exposure, but typically, short-term exposure limits are taken as three times the limit for long-term exposure i.e. 12 mg/m<sup>3</sup> over a 15 minute period. Therefore, the levels recorded for the train operators, 4-RAIL passengers and station personnel were significantly below the short-term exposure limit.
- 6.5 The results of the static samples on the platforms would suggest that personal exposure to respirable dust on the platforms would be below the Workplace exposure limit for respirable dust of 4 mg/m<sup>3</sup> (long term 8 hour time weighted average). Generally the higher results (>1 mg/m<sup>3</sup>) were for the Bakerloo and Central Lines platforms at Waterloo & Baker Street, and at Tottenham Court Road station.
- 6.6 Quartz silica and metals results for the train drivers were all below the HSE applicable Workplace Exposure Limits.
- 6.7 Compared to the latest monitoring exercise (4RS-RL-140792-R440676, issued 1<sup>st</sup> May 2015) the majority of the metal analysis results for the Train Operators were similar and consistently lower than the HSE Workplace Exposure Limits (WEL) listed in paragraph 2.5 of this report. However, iron levels were noted to be higher (between 0.04 – indicative only – and 0.334 mg/m<sup>3</sup>) than the past results (between <0.004 and 0.08 mg/m<sup>3</sup>). The highest iron concentrations recorded were on Piccadilly and Bakerloo Lines, 0.327 and 0.334 mg/m<sup>3</sup>, respectively.
- 6.8 Although not all of the duties and locations were monitored exactly the same as performed in 2007, 2008, 2009, 2011, 2013 and 2014 those that were repeated, in similar locations, generally gave similar results with no significant variations.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 1. 4-RAIL Analyst simulating LUL Passenger Journeys**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/49	RD	4RS49 - 4-RAIL Analyst, District Line	22.04.16	08:40	13:34	2.2	646.80	0.08	Edgware Road → Wimbledon → Upminster → Richmond → Upminster → Richmond → Turnham Green → Ealing Broadway → Westminster
153196/50	RD	4RS50 - 4-RAIL Analyst, Piccadilly Line	25.04.16	09:01	11:45	2.2	587.40	0.33	Green Park → Heathrow Terminal 1,2,3 & 5 → Arnos Grove → Heathrow Terminal 5 → Russell Square → Rayners Lane → Green Park
				12:00	13:43				
153196/51	RD	4RS51- 4-RAIL Analyst, Jubilee Line	26.04.16	08:51	13:19	2.2	589.60	0.31	Dollis Hill → Stratford → Stanmore → Stratford → Stanmore → North Greenwich → Neasden
153196/52	RD	4RS52 - 4-RAIL Analyst, Victoria Line	27.04.16	10:36	14:53	2.2	539.00	0.63	Green Park → Walthamstow → Brixton → Walthamstow → Brixton → Walthamstow → King's Cross
				13:48	14:00				
153196/53	RD	4RS53- 4-RAIL Analyst, Bakerloo Line	28.04.16	08:40	12:40	2.2	528.00	0.56	Baker Street → Elephant & Castle → Harrow & Wealdstone → Elephant & Castle → Harrow & Wealdstone → Elephant & Castle → Harrow & Wealdstone → Elephant & Castle
153196/54	RD	4RS54 - 4-RAIL Analyst, Central Line	29.04.16	13:32	17:43	2.2	552.20	0.44	Bond Street → Hainault via Newbury Park → Ealing Broadway → Newbury Park → Ealing Broadway
153196/55	RD	4RS55 - 4-RAIL Analyst, Circle Line	02.05.16	10:32	14:38	2.2	541.20	<0.02	Wood Lane → Aldgate via Baker Street → Edgware Road via Victoria → Aldgate via Baker Street → King's Cross via Baker Street (Hammersmith Line) → Wood Lane via Baker Street
153196/56	RD	4RS56 - 4-RAIL Analyst, Northern Line	03.05.16	12:55	16:55	2.2	528.00	0.46	King's Cross → Edgware via Charring Cross → Morden via Bank → High Barnet via Charring Cross → Clapham North → Waterloo via Charring Cross

*\*Note: Hammersmith and City line had delays throughout the line on the 2<sup>nd</sup> May 2016. Circle line was monitored instead.*

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 2. District Line Train Operators**

FILTER NUMBER*	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/137	RD	LU137 TO – Driver – Duties 585 & 381	30/08/16	08:52	12:47	2.2	517	0.07	Train 047 - Upminster → Ealing Broadway → Upminster (West Ham Stop)

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/04	RD	LU04 TO – Driver – Duties 533 & 535	22/03/16	09:13	12:34	2.2	726	0.08	Train 001 - Upminster → Richmond. Richmond → Barking → Upminster Train 004 - Upminster → Richmond → Victoria.
				13:14	15:23				

FILTER NUMBER*	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/139	PM 2.5	LU139 TO – Driver – Duty 206	08/09/16	09:10	11:20	3.5	863.5	0.14	Train 077 – Earls Court → Wimbledon → Edgware Road → Wimbledon Change trains - Train 056- at Earls Court → Wimbledon → Tower Hill (Westminster stop)
				12:09	13:58				

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 3. Jubilee Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/07	RD	LU07 TO – Driver – Duty 641	24/03/16	09:04	12:15	2.2	767.8	0.27	Train 346 - Wembley Park → Stratford. Train 320 - Stratford → Stanmore → Stratford. Train 324 - Stratford → Stanmore → North Greenwich → Stanmore
				13:19	15:57				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/11	RD	LU11 TO – Driver – Duty 017	25/03/16	09:01	11:39	2.2	624.8	0.23	Train 331 - Stratford → Wembley Park → Stratford → Wembley Park. Train 307 → Wembley Park → Stanmore → Stratford. Train 321 - Stratford → Stanmore
				12:42	14:48				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/12	PM 2.5	LU12 TO – Driver – Duty 822	28/03/16	11:49	15:49	3.5	738.5	0.05	Train 331 - Wembley Park → Stratford → Wembley Park → North Greenwich → Stanmore → Stratford (Waterloo Stop)

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 4. Piccadilly Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/13	RD	LU13 TO – Driver – Duty 527	29/03/16	08:04	10:22	2.2	699.6	0.49	Train 306 - Northfields → Cockfosters → Heathrow (Acton Town Stop). Train 236 - Acton Town → Heathrow T1,2,3 & 5 → Cockfosters → Heathrow (Duty finishes at Acton town)
				11:30	14:30				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/17	RD	LU17 TO – Driver – Duties 504 & 537	30/03/16	09:42	13:15	2.2	631.4	0.24	Train 227 - Acton Town → Uxbridge - Cockfosters → Heathrow T 1,2,3 & 5 (Northfields Stop). Duty change 537 - Train 316 Northfields → Heathrow T1,2,3 & 4 → Cockfosters (Earl's Court Stop)
				14:21	15:35				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/18	PM 2.5	LU18 TO – Driver – Duties 508 & 528	31/03/16	09:04	12:03	3.5	1309	0.60	Train 241 - Acton Town → Rayners Lane → Wood Green → Acton Town. Train 227 (Duty 528) - Acton Town → Heathrow T5 → Cockfosters → Acton Town.
				13:16	16:31				

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 5. Victoria Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/19	RD	LUL19 TO – Driver Duty 817	01/04/16	08:59	11:19	2.2	598.4	0.23	Train 214 - Brixton → Seven Sisters Sidings → Brixton. Train 222 Brixton - Walthamstow Central. Train 242 - Walthamstow Central → Brixton. Train 233 Brixton → Seven Sisters → Brixton. Train 214 Brixton → Walthamstow → Brixton (Vauxhall Stop)
				12:18	14:30				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (L/MIN)	VOLUME OF AIR (LITRES)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/23	RD	LUL23 TO – Driver Duty 817	04/04/16	08:53	11:17	2.2	609.4	0.27	Train 214 - Brixton → Seven Sisters Sidings → Brixton. Train 222 Brixton → Walthamstow Central. Train 242 - Walthamstow Central → Brixton. Train 233 Brixton → Seven Sisters → Brixton. Train 214 Brixton → Walthamstow → Brixton (Green Park Stop)
				12:17	14:30				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/24	PM 2.5	LUL24 TO – Driver Duty 819	05/04/16	09:06	11:00	3.5	661.5	0.57	Train 224 - Brixton → Northumberland Park Depot. Train 227 to Brixton - Change train 210 to Walthamstow. Train 236 Seven Sisters → Walthamstow → Brixton → Walthamstow → Brixton → Green Park
				12:45	15:00				

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 6. Bakerloo Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF A R (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/26	RD	LUL26 TO – Driver Duties 121, 020, 129	06/04/16	08:42	12:10	2.2	748	0.86	Train 207 - Queen's Park → Elephant & Castle → Harrow & Wealdstone → Elephant & Castle. Train 236 - Elephant & Castle → Stonebridge Park → Queen's Park. Train 237- Queen's Park → Harrow & Wealdstone → Elephant & Castle. Train 204 - Elephant & Castle → Stonebridge Park.
				13:29	15:41				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF A R (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/29	RD	LUL29 TO – Driver Duties 116, 018, 121	07/04/16	08:53	12:44	2.2	675.4	0.44	Train 224 Queens Park → Elephant & Castle. Train 237 Harrow & Wealdstone → Elephant & Castle. Duty 18; Train 235 - Elephant & Castle- Harrow & Wealdstone - Queens Park. Duty 121; Train 214 - Queens Park - Elephant & Castle. Train 221 to Stonebridge Park.
				13:45	15:01				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF A R (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/30	PM 2.5	LUL30 TO – Driver Duties 008, 118, 117, 233, 126	08/04/16	08:24	12:19	3.5	1109.5	0.71	Train 205 - Queen's Park → Elephant & Castle. Train 247 - Harrow & Wealdstone → Elephant & Castle → Queen's Park. Train 233 - Elephant & Castle → Queen's Park → (Train 236) Elephant & Castle → (Train 206) Stonebridge Park.
				14:06	15:28				

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 7. Central Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF A R (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/32	RD	LUL32 TO – Driver Duties 807, 802, 213, 326, 634	11/04/16	09:07	14:54	2.2	763.4	0.25	Train 60 - Hainault → Leytonstone → (Train 032) West Ruislip → Epping → Loughton (Train 032) → West Ruislip (Train 032) → Bond Street (Train 047) → Ealing Broadway

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF A R (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/33	RD	LUL33 TO – Driver Duty 633	12/04/16	08:47	12:27	2.2	798.6	0.30	Train 067 - Hainault → Ealing Broadway via Woodford → Hainault → White City Train 062 → Hainault → Newbury Park → Hainault → White City
				13:20	15:43				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF A R (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/36	PM 2.5	LUL36 TO – Driver Duty 633	13/04/16	08:50	12:26	3.5	684.2	0.32	Train 067 - Hainault → Ealing Broadway → Hainault via Newbury Park → White City
				13:22	14:57				

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 8. Northern Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF A R (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/38	RD	LUL38 TO – Driver Duties 316 & 322	14/04/16	09:09	10:35	2.2	6616	0.26	Train 132 - High Barnet → Kennington via Charring Cross → High Barnet Train 150 - High Barnet → Morden via Bank → Kennington.
				11:55	15:09				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF A R (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/41	RD	LUL41 TO – Driver Duty 315	15/04/16	08:30	11:23	2.2	633.6	0.21	Train 107 - High Barnet → Kennington via Charring Cross → High Barnet → Morden via Bank. Train 117 - Morden → High Barnet via Bank → Waterloo.
				12:14	14:09				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF A R (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/42	PM 2.5	LUL42 TO – Driver Duty 314	18/04/16	08:24	11:08	3.5	945	0.63	Train 105 - High Barnet → Kennington via Charring Cross → High Barnet → Morden via Bank. Train 115 - Morden → High Barnet via Bank → Kennington via Charring Cross
				12:03	13:49				

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 9. Hammersmith & City and Circle Lines Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START T ME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/44	RD	LU44 TO – Driver Duty 617	19/04/16	12:38	16:30	2.2	591.8	0.05	Train 276 - Barking → Hammersmith → Barking → Hammersmith → Edgware Road → Hammersmith → Barking
				17:46	18:23				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START T ME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/47	RD	LU47 TO – Driver Duty 615	20/04/16	11:36	15:10	2.2	573	0.05	Train 211 to Edgware Road via King's Cross → Hammersmith via Victoria → Edgware Road via King's cross. Train 277 Edgware Road - Hammersmith → Edgware Road
				16:10	16:56				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START T ME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
153196/48	PM 2.5	LU48 TO – Driver Duty 615	21/04/16	11:36*	14:26*	3.5	374*	0.08*	Train 211 to Edgware Road (Circle Line) via Victoria. Edgware Road → Hammersmith via Victoria → Edgware Road → Liverpool Street

\*The result is indicative only due to incomplete monitoring session. The assigned driver was requested to go at Barking Station.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 10. Aldgate East Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)*	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	OTHER COMMENTS
153196/57	RD	Static - Westbound - Platform 1	04.05.16	09:55	13:55	2.2	528.00	0.41	Dust levels within the station, during monitoring session, were noted by 4RS staff to be satisfactory. Increased dust levels were noted around 13:10pm.
153196/58	RD	Static - Eastbound -Platform 2	04.05.16	10:00	14:00	2.2	528.00	0.55	
153196/59	RD	Static - Ticket Hall (East side - High Street)	04.05.16	10:10	14:10	2.2	528.00	0.38	
153196/60	RD	Personal – LU60 Gate line Personnel	04.05.16	10:18	12:04	2.2	228.80	0.31	
153196/61	RD	Static - Ticket Hall (Whitechapel side)	04.05.16	10:26	14:26	2.2	528.00	0.41	

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 11. Baker Street Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F INISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
153196/62	RD	Static - Bakerloo Line	05.05.16	09:22	13:09	2.20	499.40	1.18	Southbound Platform 8. Some visible dust noted.
153196/63	RD	Static - Bakerloo Line	05.05.16	09:18	13:06	2.20	501.60	0.93	Northbound Platform 9. Some visible dust noted.
153196/64	RD	Static - Hammersmith & Circle Line	05.05.16	09:37	13:34	2.20	521.40	0.27	Eastbound Platform 5
153196/65	RD	Static - Jubilee Line	05.05.16	09:21	13:10	2.20	503.80	0.90	Southbound Platform 7. Some visible dust noted.
153196/66	RD	Static - Jubilee Line	05.05.16	09:14	13:05	2.20	508.20	0.98	Northbound Platform 10. Some visible dust noted.
153196/67	RD	Static - Ticket Hall	05.05.16	09:27	13:48	2.20	574.20	<0.02	Madame Tussaud's Exit
153196/68	RD	Static - Ticket Hall	05.05.16	09:32	13:38	2.20	Negative weight		Outside Station Supervisor Office
153196/69	RD	Static - Hammersmith & Circle Line	05.05.16	09:44	13:38	2.20	514.80	0.11	Westbound Platform 6
153196/70	RD	Static - Ticket Hall/ Gate Lines	05.05.16	13:26	16:34	2.20	413.60	0.20	No visible dust noted
153196/71	RD	Static -Metropolitan Line	05.05.16	13:24	16:33	2.20	415.80	0.12	Eastbound Platform 3 & 4
153196/72	RD	Static -Metropolitan Line	05.05.16	13:31	16:37	2.20	409.20	0.04	Westbound Platform 1 & 2

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 12. Elephant and Castle Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F INISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
153196/73	RD	Static - Northern Line	06.05.16	09:57	13:56	2.20	525.80	0.45	Southbound - Platform 2. Slight levels of dust visible on platforms around 13:00pm.
153196/74	RD	Static - Bakerloo Line	06.05.16	09:51	13:51	2.20	528.00	0.20	Northbound - Platform 4
153196/75	RD	Static -Bakerloo Ticket Hall	06.05.16	10:10	14:07	2.20	Filter damaged		Gate line
153196/76	RD	Static - Bakerloo Line	06.05.16	09:47	13:47	2.20	Filter damaged		Northbound - Platform 3
153196/77	RD	Static -Northern Line	06.05.16	10:14	14:12	2.20	523.60	0.03	Ticket Hall – Gate line
153196/78	RD	Static - Northern Line	06.05.16	10:01	13:59	2.20	523.60	0.69	Northbound - Platform 1. Slight levels of dust visible on platforms around 13:00pm.

\*Note: LU personnel refused to wear monitoring equipment. Only static monitoring could be carried out.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 13. Euston Square Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
153196/79	RD	Personal -LU79 Gate line personnel	09.05.16	10:40	13:40	2.20	396.00	0.20	Dust levels satisfactory within gate line area.
153196/80	RD	Static – Metropolitan, Hammersmith & City, Circle Lines	09.05.16	10:46	14:46	2.20	528.00	0.37	Westbound Platform 1 Dust levels visible – 12:45 – north tunnel particularly, but satisfactory by 14:30
153196/81	RD	Static – Metropolitan, Hammersmith & City, Circle Lines	09.05.16	10:50	14:50	2.20	528.00	0.46	
153196/82	RD	Static -Ticket Hall/ Gate Lines	09.05.16	11:00	15:00	2.20	Filter damaged		Warren Street Exit

**Table 14. Hampstead Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
153196/83	RD	Static - Northern Line	10.05.16	10:05	14:05	2.20	528.00	0.27	Southbound Platform
153196/84	RD	Static - Northern Line -	10.05.16	10:14	14:14	2.20	528.00	0.84	Northbound Platform
153196/85	RD	Static - Ticket Hall/ Gate line	10.05.16	10:35	14:33	2.20	523.60	0.10	-

\*Note: LU personnel refused to wear monitoring equipment. Only static monitoring could be carried out.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 15. King's Cross Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F INISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
153196/87	RD	Static - Piccadilly Line	11.05.16	10:20	14:27	2.20	543.40	0.03	Westbound Platform 5
153196/88	RD	Static - Victoria Line	11.05.16	10:05	13:20	2.20	429.00	0.62	Northbound Platform 3
153196/89	RD	Static - Victoria Line	11.05.16	10:10	13:18	2.20	413.60	0.36	Southbound Platform 4
153196/90	RD	Static - Piccadilly Line	11.05.16	10:16	14:30	2.20	558.80	0.34	Eastbound Platform 6
153196/91	RD	Static - Northern Line	11.05.16	10:06	13:21	2.20	429.00	0.29	Northbound Platform 7
153196/92	RD	Static - Northern Line	11.05.16	10:14	14:22	2.20	545.60	0.57	Southbound Platform 8
153196/B94	RD	Static - Hammersmith & City, Circle, Metropolitan Lines	11.05.16	10:27	14:40	2.20	556.60	0.20	Eastbound Platform 2
153196/93	RD	Static - Hammersmith & City, Circle, Metropolitan Lines	11.05.16	10:36	14:37	2.20	Negative weight		Westbound Platform 1
153196/94	RD	Static - Main Gate Line	11.05.16	13:32	16:30	2.20	391.60	0.04	-
153196/95	RD	Static - Northern Line Gate/ Ticket Hall	11.05.16	13:40	16:37	2.20	389.40	0.07	-
153196/96	RD	Static - Western Gate Line	11.05.16	13:38	16:32	2.20	382.80	0.11	-

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 16. Oxford Circus Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS	
153196/97	RD	Static - Victoria Line	12.05.16	10:58	15:00	2.2	532.40	0.58	Southbound Platform 5	Slight levels of dust noted between 13:20 – 13:50 hours.
153196/98	RD	Static - Gate Line	12.05.16	11:22	15:22	2.2	Negative weight		By Station Supervisor Office Exits 1 - 4	
153196/99	RD	Static - Gate Line	12.05.16	11:17	15:17	2.2	528.00	0.13	Exits 5 - 8	
153196/100	RD	Static - Bakerloo Line	12.05.16	10:49	14:54	2.2	539.00	0.64	Northbound Platform 4	Slight levels of dust noted on all platforms between 13:20 – 13:50 hours.
153196/101	RD	Static - Central Line	12.05.16	11:05	15:07	2.2	532.40	0.09	Westbound Platform 1	
153196/102	RD	Static - Bakerloo Line	12.05.16	10:54	14:58	2.2	536.80	0.69	Southbound Platform 3	
153196/103	RD	Static - Victoria Line	12.05.16	10:45	14:53	2.2	545.60	0.57	Northbound Platform 6	
153196/104	RD	Static - Central Line	12.05.16	11:10	15:10	2.2	528.00	0.65	Eastbound Platform 2	

\*Note: LU personnel refused to wear monitoring equipment. Only static monitoring could be carried out.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 17. Archway Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS	
153196/105	RD	Static - Station Gate Line	13.05.16	10:34	14:34	2.20	528.00	0.22	LU Gate line personnel inform 4RS staff of elevated dust levels in the early hours, prior to monitoring commencing.	
153196/107	RD	Static - Northern Line	13.05.16	10:23	14:23	2.20	528.00	0.31	Northbound Platform	Slight levels of dust visible on the platforms around 10:30am.
153196/108	RD	Static - Northern Line	13.05.16	10:27	14:27	2.20	528.00	0.56	Southbound Platform	

**Table 18. Piccadilly Circus Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS	
153196/109	RD	Static - Piccadilly Line	16.05.16	10:49	14:51	2.20	532.40	0.54	Eastbound Platform 3	No visible dust levels noted at the beginning of the sampling period. Slight levels of dust noted around 13:30 hours.
153196/110	RD	Static - Piccadilly Line	16.05.16	10:53	14:54	2.20	530.20	0.71	Westbound Platform 4	
153196/111	RD	Static - Bakerloo Line	16.05.16	10:43	14:48	2.20	539.00	0.86	Southbound Platform 2	
153196/112	RD	Static - Bakerloo Line	16.05.16	10:37	14:46	2.20	547.80	1.01	Northbound Platform 1	
153196/113	RD	Static - Main Gate Line	16.05.16	10:57	14:58	2.20	530.20	0.58	-	

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 19. Tottenham Court Road Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS	
153196/114	RD	Static - Central Line	17.05.16	10:12	14:13	2.20	530.20	1.15	Eastbound Platform 2	Slight levels of dust visible around 13:10 hours.
153196/115	RD	Static - Central Line	17.05.16	10:19	14:19	2.20	528.00	1.30	Westbound Platform 1	
153196/116	RD	Static - Northern Line	17.05.16	10:28	14:28	2.20	528.00	0.79	Northbound Platform 3	
153196/117	RD	Static - Northern Line	17.05.16	10:35	14:35	2.20	528.00	1.12	Southbound Platform 4	
153196/118	RD	Static - Northern & Central Gate Lines	17.05.16	10:43	14:43	2.20	528.00	0.10	-	

\*Note: LU personnel refused to wear monitoring equipment. Only static monitoring could be carried out.

**Table 20. Vauxhall Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS	
153196/119	RD	Static – Victoria Line	18.05.16	10:23	14:34	2.2	552.2	0.57	Northbound Platform 1	No visible dust noted throughout the sampling period.
153196/120	RD	Static – Victoria Line	18.05.16	10:31	14:31	2.2	528	0.77	Southbound Platform 2	
153196/121	RD	Static – Ticket Hall/ Gate Line	18.05.16	10:41	14:41	2.2	528	0.08	No visible dust noted throughout the sampling period.	

\*Note: LU personnel refused to wear monitoring equipment. Only static monitoring could be carried out.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 21. Waterloo Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
153196/122	RD	Static - Gate Line – Northern & Bakerloo Lines	19.05.16	09:57	13:15	2.2	435.6	0.42	-
153196/123	RD	Static – Jubilee Line	19.05.16	10:10	14:10	2.2	528	1.02	Eastbound Platform 6
153196/124	RD	Static – Jubilee Line	19.05.16	10:15	14:15	2.2	528	0.86	Westbound Platform 5
153196/125	RD	Static – Bakerloo Line	19.05.16	10:06	13:25	2.2	437.8	0.98	Northbound Platform 3
153196/126	RD	Static – Bakerloo Line	19.05.16	10:13	14:22	2.2	547.8	1.19	Southbound Platform 4
153196/127	RD	Static – Northern Line	19.05.16	10:19	14:26	2.2	543.4	1.08	Southbound Platform 2
153196/128	RD	Static – Northern Line	19.05.16	10:24	14:29	2.2	539	1.02	Northbound Platform 1
153196/129	RD	Gate Line – Jubilee Line	19.05.16	10:40	14:40	2.2	528	0.06	-
153196/130	RD	Static - Waterloo & City Line	19.05.16	13:20	16:20	2.2	396	0.06	Platform Head Wall
153196/B109	RD	Static - Waterloo & City Line	19.05.16	13:35	16:30	2.2	385	0.36	Platform End Wall

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 22. Paddington Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	F NISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS	
153196/131	RD	Static – District & Circle Lines	20/05/16	12:05	16:05	2.2	528	0.08	Westbound Platform 1	No visible dust noted on the platforms as they are located in an open air section.
153196/132	RD	Static – District & Circle Lines	20/05/16	12:11	16:11	2.2	528	0.01	Eastbound Platform 2	
153196/133	RD	Static – District & Circle Gate Line	20/05/16	12:15	16:15	2.2	528	0.10	No visible dust noted.	
153196/134	RD	Static – Bakerloo & National RAIL Gate Line	20/05/16	12:22	16:22	2.2	528	0.12	Bakerloo Line trains not running at the time of sampling	

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 23. Train Operator Respirable Crystalline Silica Monitoring**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION – PROCESS MONITORED	DATE	VOLUME OF AIR (litres)	CRYSTALLINE SILICA (mg/filter)	CRYSTALLINE SILICA (mg/m <sup>3</sup> )	LOCATIONS & COMMENTS
153196/04	RD	District Line Train Operators Driving Trains	22/03/16	726	< 0.01	<0.02	Train 001 - Upminster → Richmond. Richmond → Barking → Upminster Train 004 - Upminster → Richmond → Victoria
153196/11	RD	Jubilee Line Train Operator Driving Trains	25/03/16	624.8	< 0.01	<0.02	Train 331 - Stratford → Wembley Park → Stratford → Wembley Park. Train 307 → Wembley Park → Stanmore → Stratford. Train 321 - Stratford → Stanmore
153196/17	RD	Piccadilly Line Train Operator Driving Trains	30/03/16	631.4	0.01	0.016	Train 227 - Acton Town → Uxbridge - Cockfosters → Heathrow T 1,2,3 & 5 (Northfields Stop). Duty change 537 - Train 316 Northfields → Heathrow T1,2,3 & 4 → Cockfosters (Earl's Court Stop)
153196/23	RD	Victoria Line Train Operators Driving Trains	04/04/16	609.4	< 0.01	<0.02	Train 214 - Brixton → Seven Sisters Sidings → Brixton. Train 222 Brixton → Walthamstow Central. Train 242 - Walthamstow Central → Brixton. Train 233 Brixton → Seven Sisters → Brixton. Train 214 Brixton → Walthamstow → Brixton (Green Park Stop)
153196/29	RD	Bakerloo Line Train Operators Driving Trains	07/04/16	675.4	< 0.01	<0.02	Train 224 Queens Park → Elephant & Castle. Train 237 Harrow & Wealdstone → Elephant & Castle. Duty 18; Train 235 - Elephant & Castle - Harrow & Wealdstone - Queens Park. Duty 121; Train 214 - Queens Park - Elephant & Castle. Train 221 to Stonebridge Park.
153196/33	RD	Central Line Train Operator Driving Trains	12/04/16	798.6	0.01	0.013	Train 067 - Hainault → Ealing Broadway via Woodford → Hainault → White City Train 062 → Hainault → Newbury Park → Hainault → White City
153196/41	RD	Northern Line Train Operator Driving Trains	15/04/16	633.6	0.01	0.016	Train 107 - High Barnet → Kennington via Charring Cross → High Barnet → Morden via Bank. Train 117 - Morden → High Barnet via Bank → Waterloo.
153196	RD	Hammersmith & City Line Train Operator Driving Trains	20/04/16	573	< 0.01	<0.02	Train 211 to Edgware Road via King's Cross → Hammersmith via Victoria → Edgware Road via King's cross. Train 277 Edgware Road - Hammersmith → Edgware Road

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 24. Train Operator PM 2.5 Iron and Zinc Monitoring**

FILTER NUMBER	SAMPLE TYPE (RESP RABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION – PROCESS MONITORED	DATE	VOLUME OF AIR (litres)	IRON (mg/filter)	ZINC (mg/filter)	IRON CONC. (mg/m <sup>3</sup> )	ZINC CONC. (mg/m <sup>3</sup> )	LOCATIONS & COMMENTS
153196/139	PM 2.5	District Line Train Operators Driving Trains	08/09/16	863.5	0.02	Rejected sample*	0.02	-	Train 077 – Earls Court → Wimbledon → Edgware Road → Wimbledon Change trains - Train 056- at Earl's Court → Wimbledon → Tower Hill (Westminster stop)
153196/12	PM 2.5	Jubilee Line Train Operator Driving Trains	28/03/16	738.5	0.026	Rejected sample*	0.035	-	Train 331 - Wembley Park → Stratford → Wembley Park → North Greenwich → Stanmore → Stratford (Waterloo Stop)
153196/18	PM 2.5	Piccadilly Line Train Operator Driving Trains	31/03/16	1309	0.437	0.125	0.334	0.095	Train 241 - Acton Town → Rayners Lane → Wood Green → Acton Town. Train 227 (Duty 528) - Acton Town → Heathrow T5 → Cockfosters → Acton Town.
153196/24	PM 2.5	Victoria Line Train Operators Driving Trains	05/04/16	661.5	0.124	Rejected sample*	0.19	-	Train 224 - Brixton → Northumberland Park Depot. Train 227 to Brixton - Change train 210 to Walthamstow. Train 236 Seven Sisters → Walthamstow → Brixton → Walthamstow → Brixton → Green Park
153196/30	PM 2.5	Bakerloo Line Train Operators Driving Trains	08/04/16	1109.5	0.363	0.088	0.327	0.08	Train 205 - Queen's Park → Elephant & Castle. Train 247 - Harrow & Wealdstone → Elephant & Castle → Queen's Park. Train 233 - Elephant & Castle → Queen's Park → (Train 236) Elephant & Castle → (Train 206) Stonebridge Park.
153196/34	PM 2.5	Central Line Train Operator Driving Trains	13/04/16	684.2	0.2	Rejected sample*	0.29	-	Train 067 - Hainault → Ealing Broadway → Hainault via Newbury Park → White City
153196/42	PM 2.5	Northern Line Train Operator Driving Trains	18/04/16	945	0.210	0.027	0.22	0.03	Train 105 - High Barnet → Kennington via Charring Cross → High Barnet → Morden via Bank. Train 115 - Morden → High Barnet via Bank → Kennington via Charring Cross
153196/48	PM 2.5	Hammersmith & City Line Train Operator Driving Trains	21/04/16	374	0.017**	Rejected sample*	0.04**	-	Train 211 to Edgware Road (Circle Line) via Victoria. Edgware Road → Hammersmith via Victoria → Edgware Road → Liverpool Street

\*Sample was rejected, due to negative weight obtained when correcting for field blank, meaning minimal metal deposition

\*\* Results are indicative due to incomplete monitoring session; assigned driver requested at Barking station.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 25. Train Operator PM 2.5 Chromium and Copper Monitoring**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION – PROCESS MONITORED	DATE	VOLUME OF AIR (litres)	CHROMIUM (mg/filter)	COPPER (mg/filter)	CHROMIUM CONC. (mg/m <sup>3</sup> )	COPPER CONC. (mg/m <sup>3</sup> )	LOCATIONS & COMMENTS
153196/139	PM 2.5	District Line Train Operators Driving Trains	08/09/16	863.5	<0.001	<0.001	<0.001	<0.001	Train 077 – Earls Court → Wimbledon → Edgware Road → Wimbledon Change trains - Train 056- at Earls Court → Wimbledon → Tower Hill (Westminster stop)
153196/12	PM 2.5	Jubilee Line Train Operator Driving Trains	28/03/16	738.5	<0.001	<0.001	<0.001	<0.001	Train 331 - Wembley Park → Stratford → Wembley Park → North Greenwich → Stanmore → Stratford (Waterloo Stop)
153196/18	PM 2.5	Piccadilly Line Train Operator Driving Trains	31/03/16	1309	<0.001	<0.001	<0.001	<0.001	Train 241 - Acton Town → Rayners Lane → Wood Green → Acton Town. Train 227 (Duty 528) - Acton Town → Heathrow T5 → Cockfosters → Acton Town.
153196/24	PM 2.5	Victoria Line Train Operators Driving Trains	05/04/16	661.5	<0.001	<0.001	<0.001	<0.001	Train 224 - Brixton → Northumberland Park Depot. Train 227 to Brixton - Change train 210 to Walthamstow. Train 236 Seven Sisters → Walthamstow → Brixton → Walthamstow → Brixton → Green Park
153196/30	PM 2.5	Bakerloo Line Train Operators Driving Trains	08/04/16	1109.5	<0.001	<0.001	<0.001	<0.001	Train 205 - Queen's Park → Elephant & Castle. Train 247 - Harrow & Wealdstone → Elephant & Castle → Queen's Park. Train 233 - Elephant & Castle → Queen's Park → (Train 236) Elephant & Castle → (Train 206) Stonebridge Park.
153196/34	PM 2.5	Central Line Train Operator Driving Trains	13/04/16	684.2	<0.001	<0.001	<0.001	<0.001	Train 067 - Hainault → Ealing Broadway → Hainault via Newbury Park → White City
153196/42	PM 2.5	Northern Line Train Operator Driving Trains	18/04/16	945	<0.001	<0.001	<0.001	<0.001	Train 105 - High Barnet → Kennington via Charring Cross → High Barnet → Morden via Bank. Train 115 - Morden → High Barnet via Bank → Kennington via Charring Cross
153196/48	PM 2.5	Hammersmith & City Line Train Operator Driving Trains	21/04/16	374	<0.001	<0.001	0.001	<0.001	Train 211 to Edgware Road (Circle Line) via Victoria. Edgware Road → Hammersmith via Victoria → Edgware Road → Liverpool Street

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 26. Train Operator PM 2.5 Nickel and Manganese Monitoring**

FILTER NUMBER	SAMPLE TYPE (RESP RABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION – PROCESS MONITORED	DATE	VOLUME OF AIR (litres)	NICKEL (mg/filter)	MANGANESE (mg/filter)	NICKEL CONC. (mg/m <sup>3</sup> )	MANGANES E CONC. (mg/m <sup>3</sup> )	LOCATIONS & COMMENTS
153196/139	PM 2.5	District Line Train Operators Driving Trains	08/09/16	863.5	Rejected sample*	<0.001	-	<0.001	Train 077 – Earls Court → Wimbledon → Edgware Road → Wimbledon Change trains - Train 056- at Earl's Court → Wimbledon → Tower Hill (Westminster stop)
153196/12	PM 2.5	Jubilee Line Train Operator Driving Trains	28/03/16	738.5	<0.001	<0.001	<0.001	<0.001	Train 331 - Wembley Park → Stratford → Wembley Park → North Greenwich → Stanmore → Stratford (Waterloo Stop)
153196/18	PM 2.5	Piccadilly Line Train Operator Driving Trains	31/03/16	1309	<0.001	0.005	<0.001	0.004	Train 241 - Acton Town → Rayners Lane → Wood Green → Acton Town. Train 227 (Duty 528) - Acton Town → Heathrow T5 → Cockfosters → Acton Town.
153196/24	PM 2.5	Victoria Line Train Operators Driving Trains	05/04/16	661.5	<0.001	0.005	<0.001	0.007	Train 224 - Brixton → Northumberland Park Depot. Train 227 to Brixton - Change train 210 to Walthamstow. Train 236 Seven Sisters → Walthamstow → Brixton → Walthamstow → Brixton → Green Park
153196/30	PM 2.5	Bakerloo Line Train Operators Driving Trains	08/04/16	1109.5	<0.001	0.004	<0.001	0.004	Train 205 - Queen's Park → Elephant & Castle. Train 247 - Harrow & Wealdstone → Elephant & Castle → Queen's Park. Train 233 - Elephant & Castle → Queen's Park → (Train 236) Elephant & Castle → (Train 206) Stonebridge Park.
153196/34	PM 2.5	Central Line Train Operator Driving Trains	13/04/16	684.2	<0.001	0.002	<0.001	0.002	Train 067 - Hainault → Ealing Broadway → Hainault via Newbury Park → White City
153196/42	PM 2.5	Northern Line Train Operator Driving Trains	18/04/16	945	<0.001	0.002	<0.001	0.002	Train 105 - High Barnet → Kennington via Charring Cross → High Barnet → Morden via Bank. Train 115 - Morden → High Barnet via Bank → Kennington via Charring Cross
153196/48	PM 2.5	Hammersmith & City Line Train Operator Driving Trains	21/04/16	374	<0.001**	<0.001**	<0.001**	<0.001**	Train 211 to Edgware Road (Circle Line) via Victoria. Edgware Road → Hammersmith via Victoria → Edgware Road → Liverpool Street

\*Sample was rejected, due to negative weight obtained when correcting for field blank, meaning minimal metal deposition

\*\* Results are indicative due to incomplete monitoring session; assigned driver requested at Barking station.

Figure 1. GRIMM monitor dust concentration data at the District line on the 22<sup>nd</sup> April 2016.

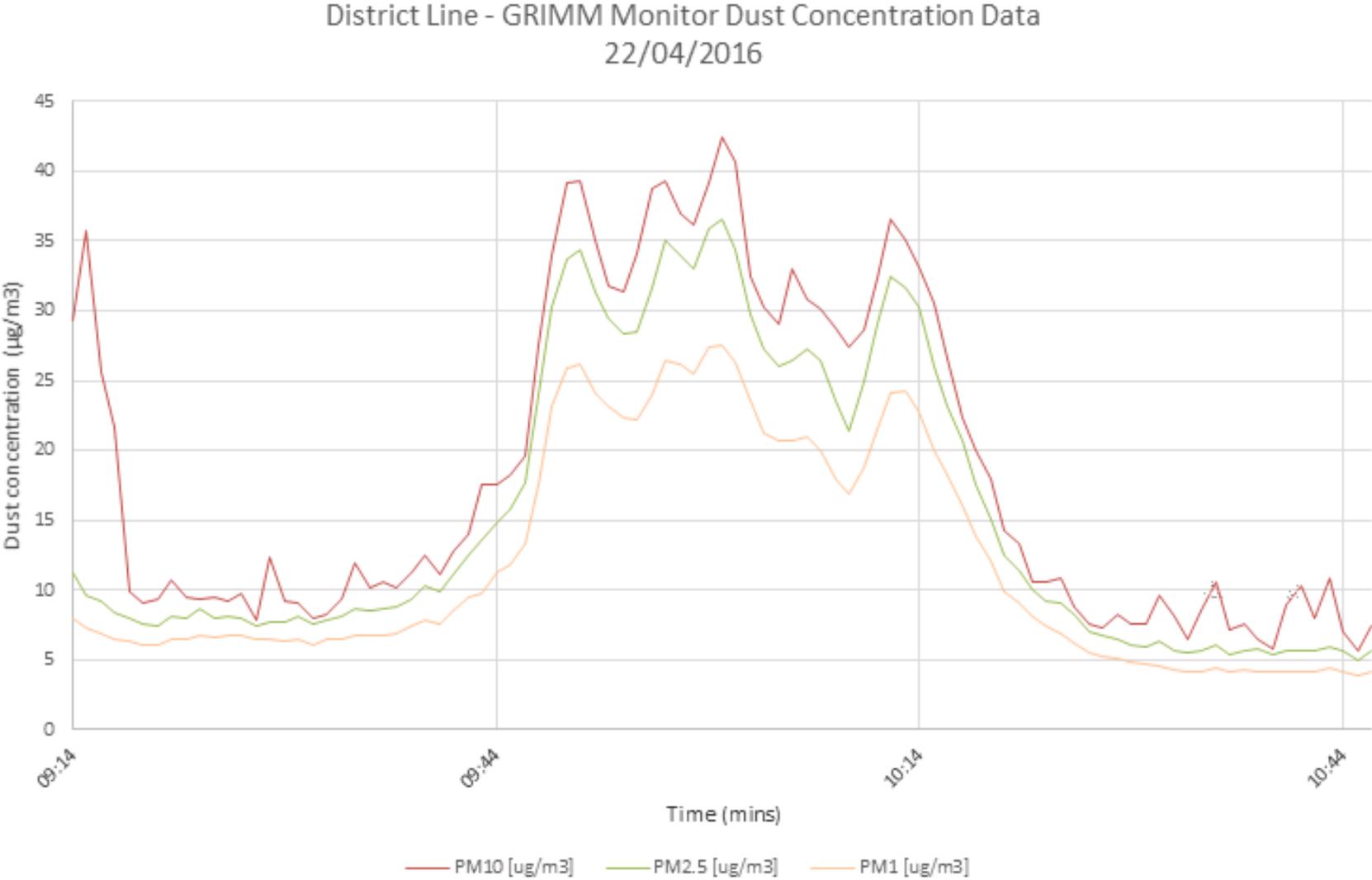


Figure 2. GRIMM monitor dust concentration data at the Jubilee line on the 28<sup>th</sup> March 2016.

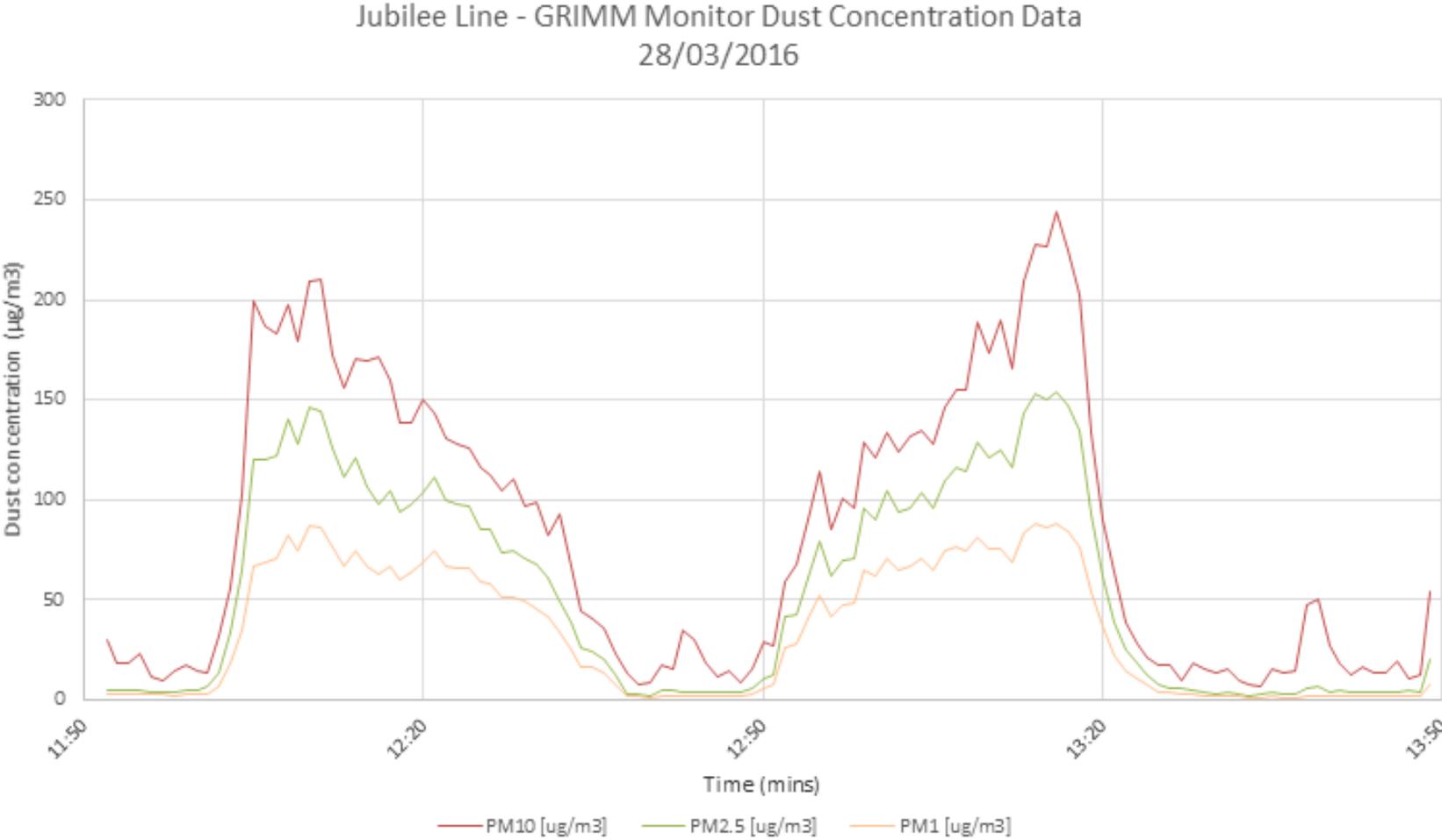


Figure 3. GRIMM monitor dust concentration data at the Piccadilly line on the 31<sup>st</sup> March 2016.

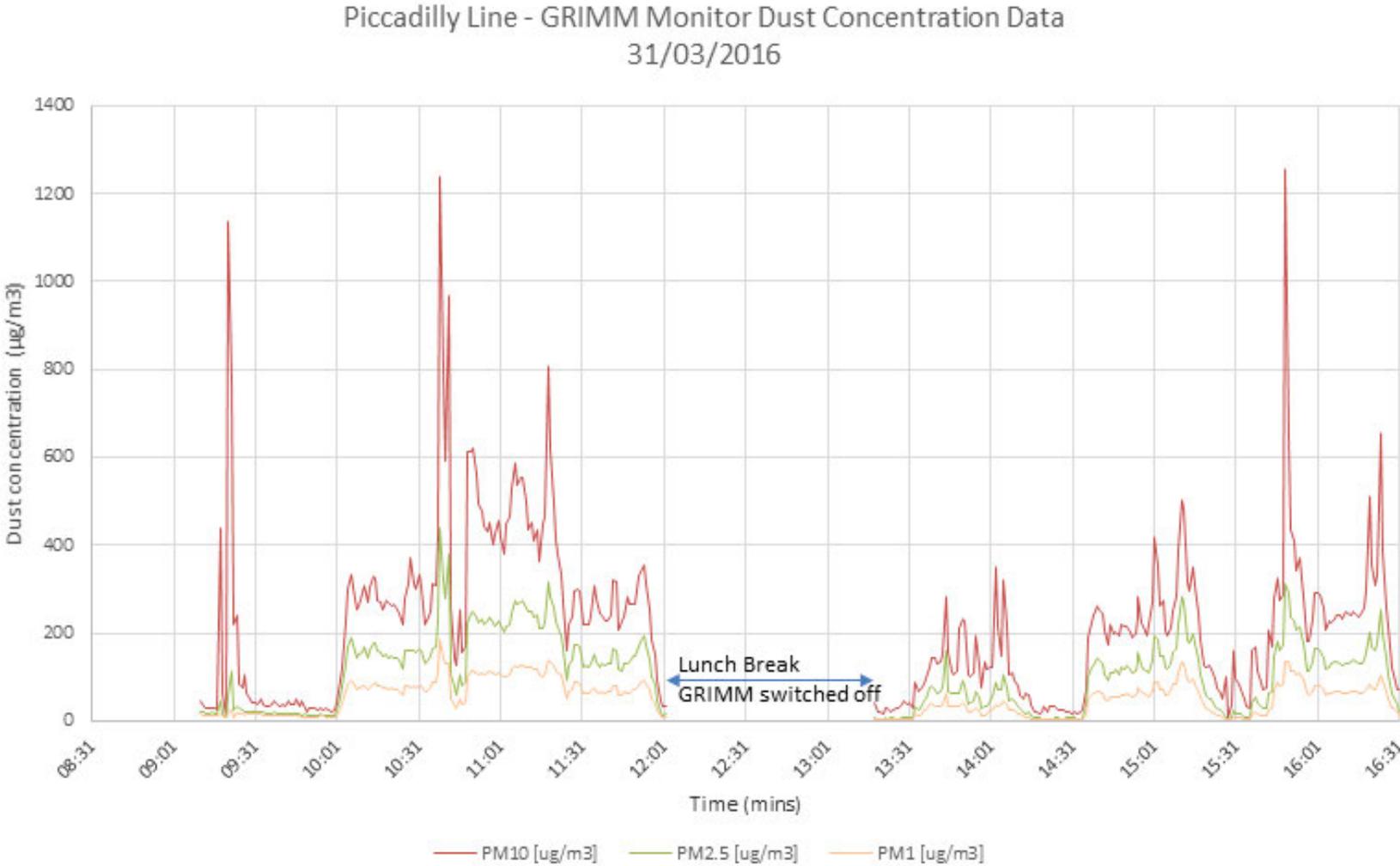


Figure 4. GRIMM monitor dust concentration data at the Victoria line on the 5<sup>th</sup> April 2016.

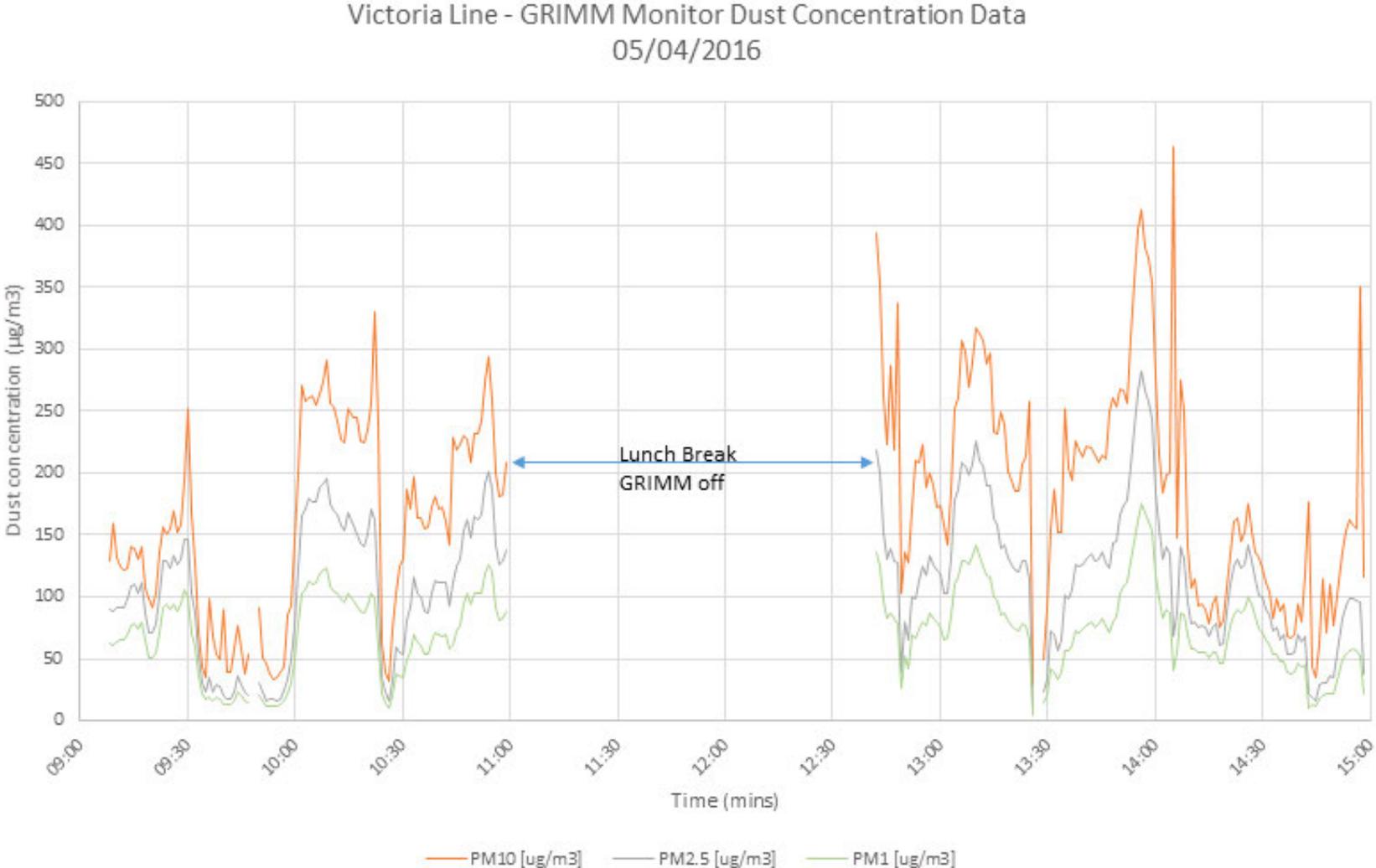


Figure 5. GRIMM monitor dust concentration data at the Bakerloo line on the 8<sup>th</sup> April 2016.

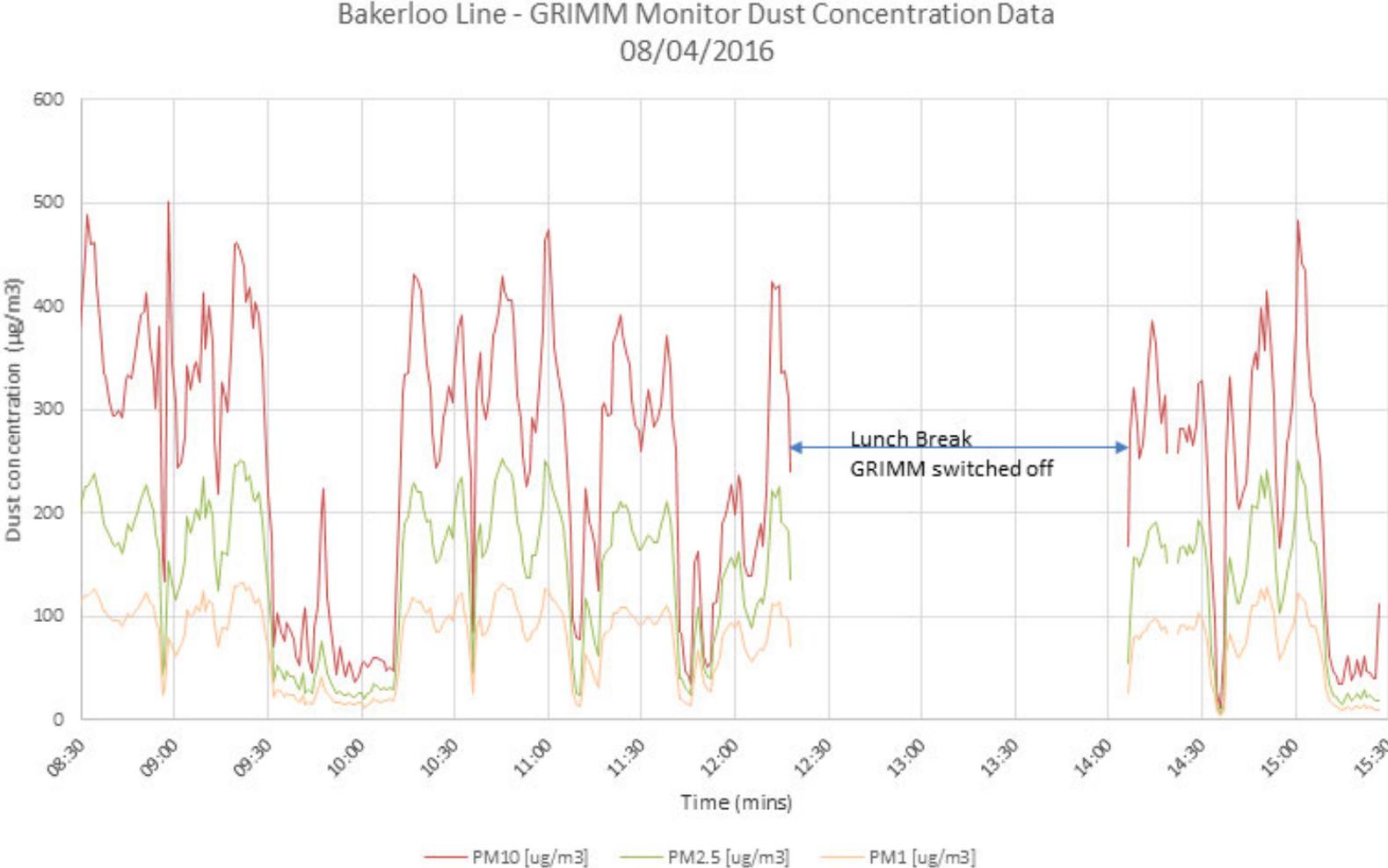


Figure 6. GRIMM monitor dust concentration data at the Central line on the 13<sup>th</sup> April 2016.

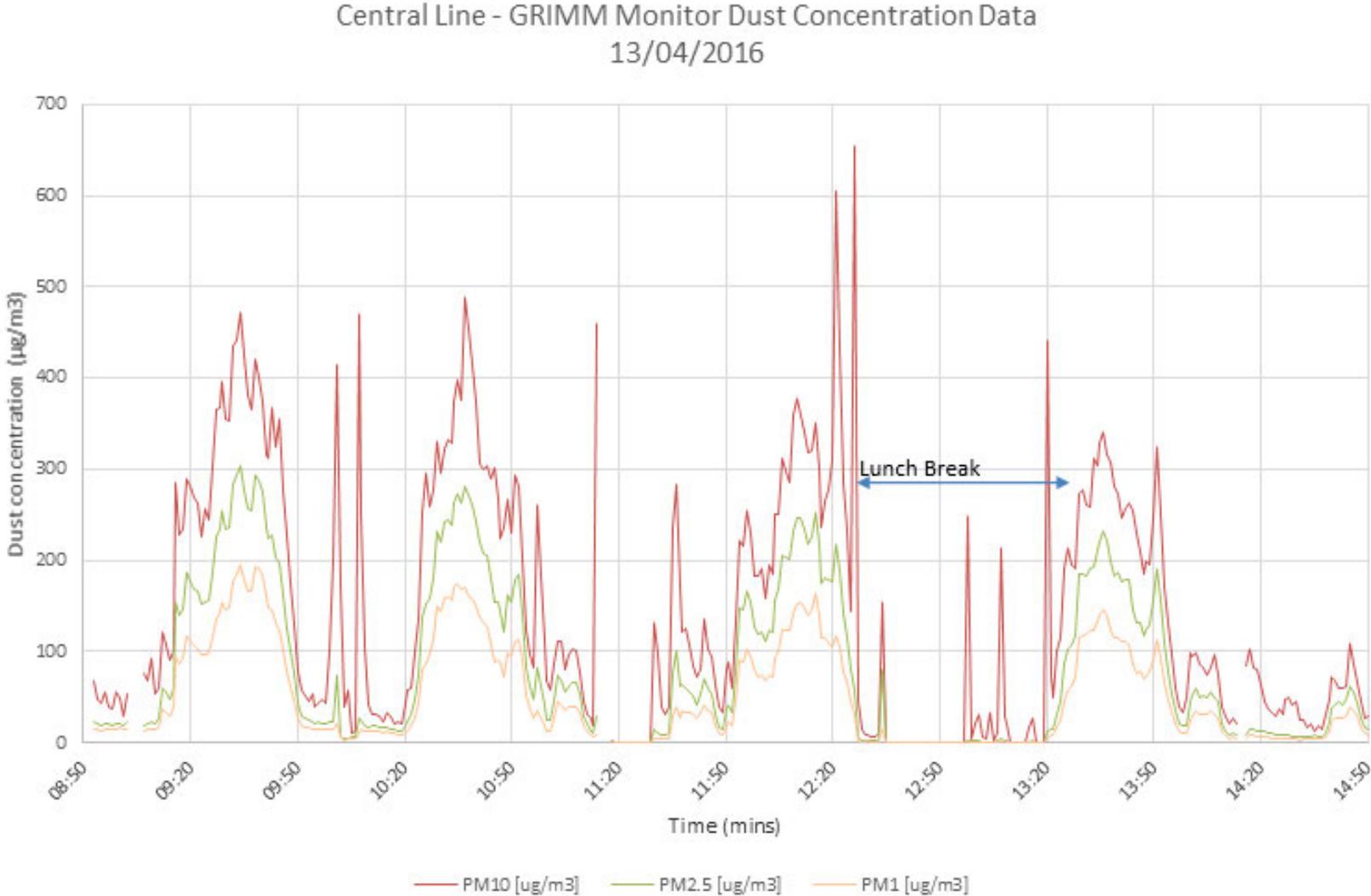


Figure 7. GRIMM monitor dust concentration data at the Northern line on the 18<sup>th</sup> April 2016.

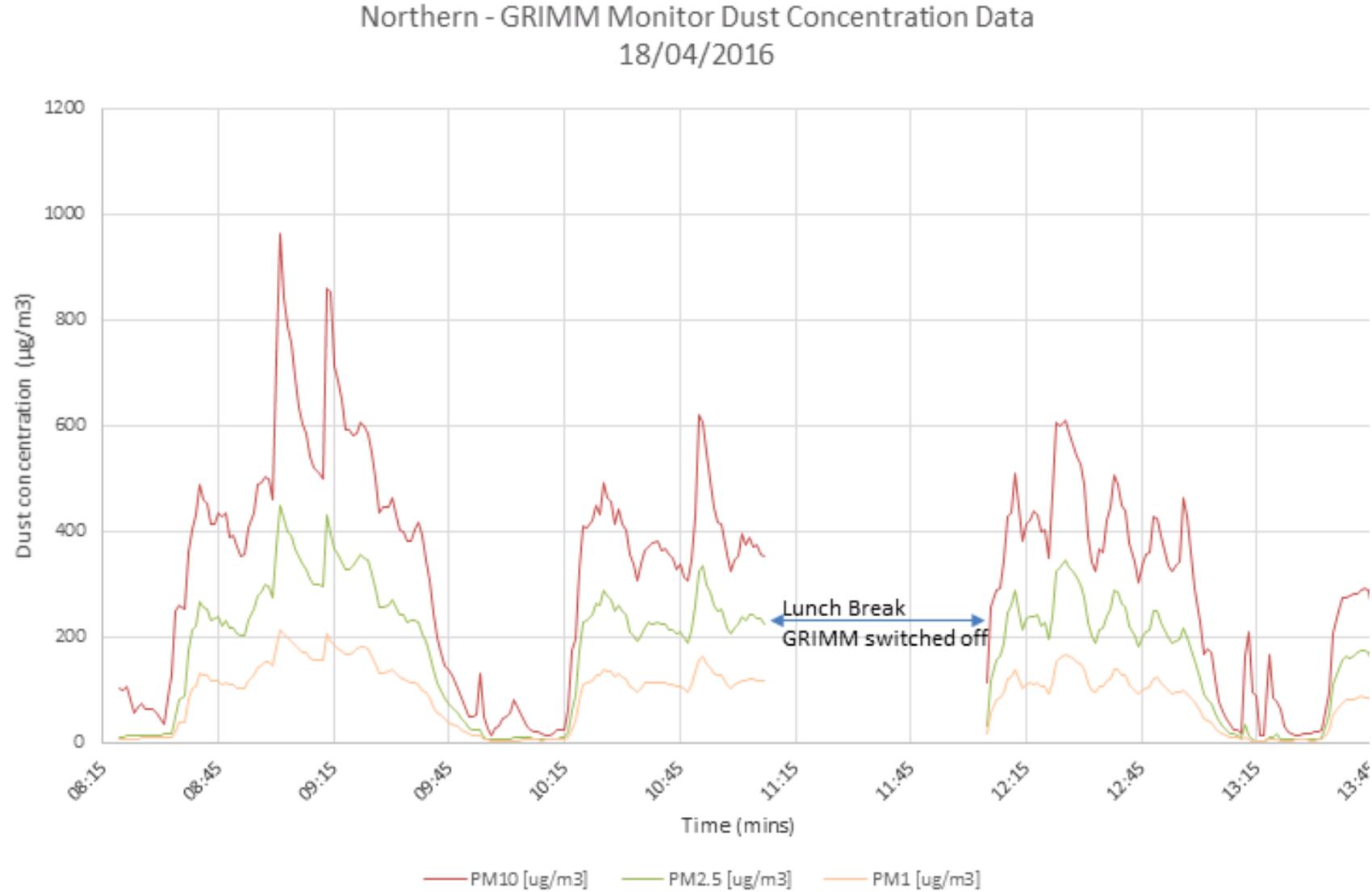
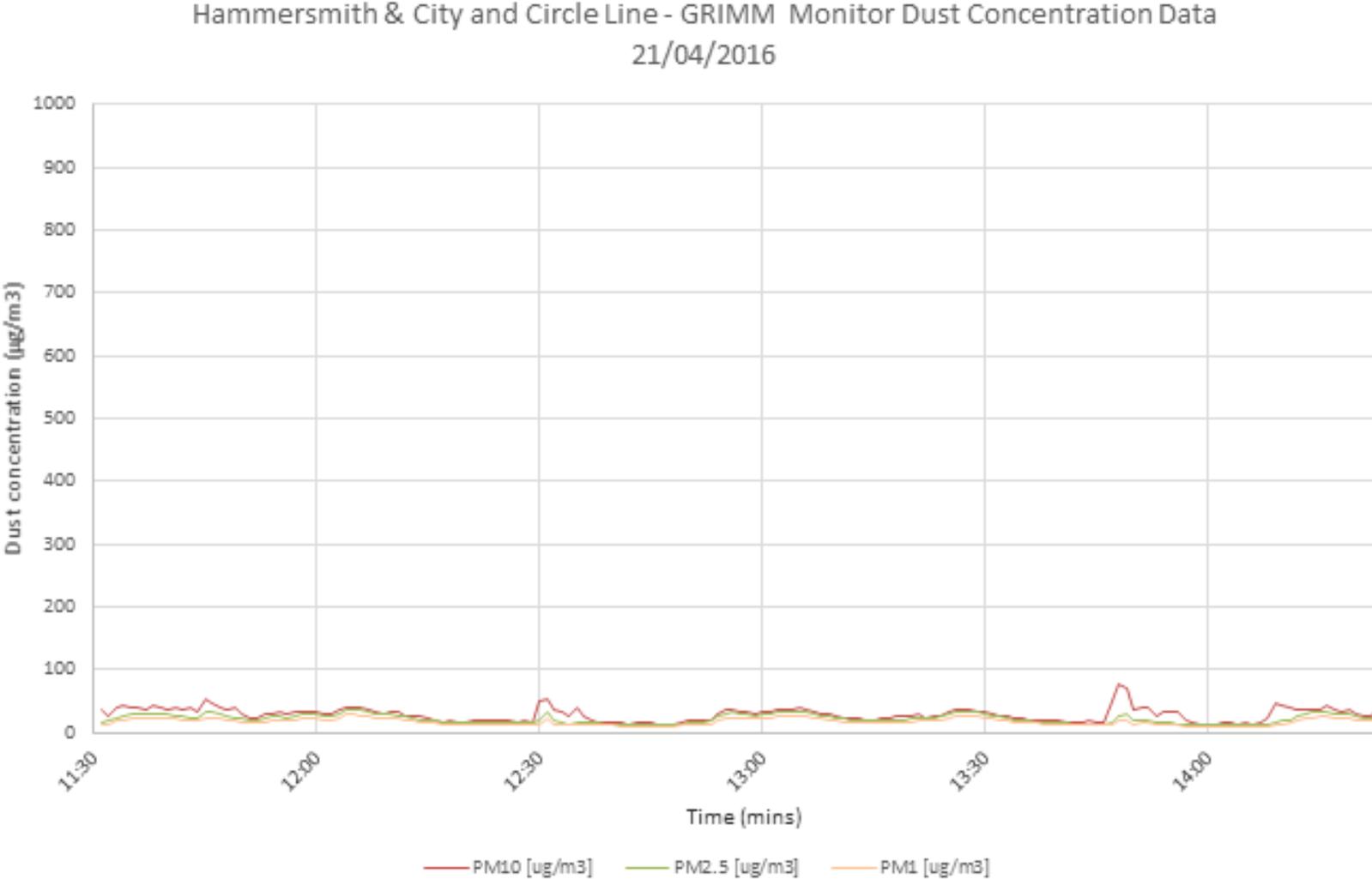
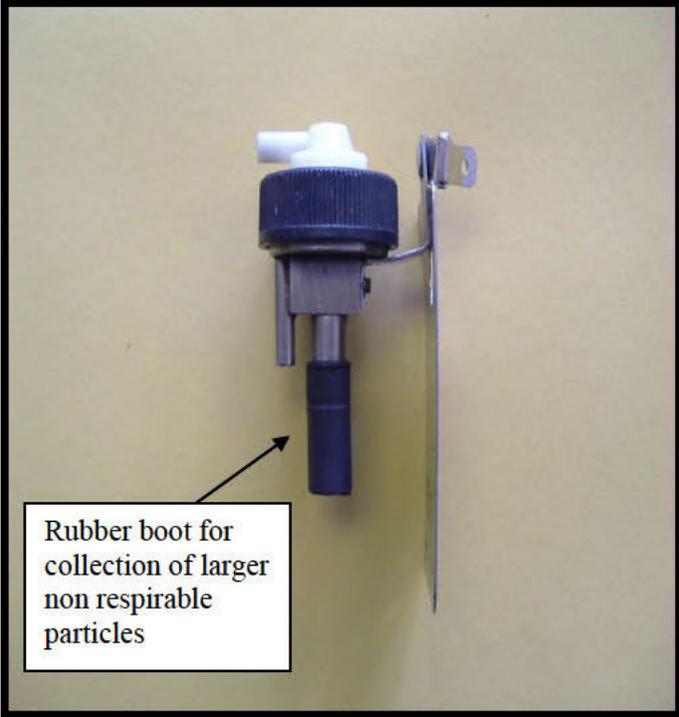


Figure 8. GRIMM monitor dust concentration data at the Hammersmith & City and Circle lines on the 21<sup>st</sup> April 2016.



**Figure 9. Cyclone Dust Head to monitor Respirable Dust.**



**Figure 10. Cyclone Inhalable Sampler to monitor PM 2.5.**



# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## Appendix 1. Laboratory certificates for crystalline Respirable Silica results.



### CERTIFICATE OF ANALYSIS

**ANALYSIS REQUESTED BY:** 4-Rail Services Ltd  
Unit 11  
Ironbridge Close  
Great Central Way  
London  
NW10 0UF

**CONTRACT NO:** 48249

**PROJECT NO:** 610

**DATE OF ISSUE:** 03.05.16

**DATE SAMPLES RECEIVED:** 29.04.16

**DATE SAMPLES ANALYSED:** 02.05.16

**SAMPLES:** 25mm "GLA-5000" PVC filters

**NO. OF SAMPLES:** Nine

**ANALYSIS REQUESTED:** Respirable Crystalline Silica (as Quartz)

**METHOD:** The samples were analysed using an in-house method described in IOM instruction manual number 2 (IM2) using a modification of the following method;

**MDHS 101/2:** Health and Safety Executive (2014). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy or X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101/2. HMSO, London.

Page 1 of 2

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**Tel:** 0131 449 8000 **Fax:** 0131 449 8084 **Email:** [iom@iom-world.org](mailto:iom@iom-world.org)

IOM CONSULTING LIMITED, registered in Scotland No. SC205670



# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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CONTRACT NO: 48249  
PROJECT NO: 610  
DATE OF ISSUE: 03.05.16

## RESULTS:

Sample Reference	Quartz Weight (mg)
153196/33	0.01
153196/41	0.01
153196/47	<0.01
153196/B52	<0.01
153196/B64	<0.01
153196/B73	<0.01
162010/10	0.08
162010/12	<0.01
162010/B7	<0.01

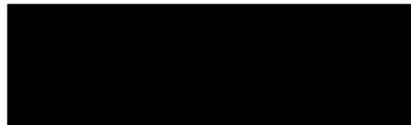
Our detection limit for quartz using this method is 0.01mg.

## COMMENTS:

IOM Consulting cannot accept responsibility for samples that have been incorrectly collected or despatched by external clients.

Any opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

AUTHORISED BY:



Carolyn McGonagle  
Senior Chemist

Page 2 of 2

**\*Note: Results from other projects were included in this certificate for purposes of non-alteration of the original analysis certificate. The results applicable to this air monitoring session are highlighted in the table above.**

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

---



## CERTIFICATE OF ANALYSIS

**ANALYSIS REQUESTED BY:** 4-Rail Services Ltd  
Unit 11  
Ironbridge Close  
Great Central Way  
London  
NW10 0UF

**CONTRACT NO:** 47910

**PROJECT NO:** 610

**DATE OF ISSUE:** 07.04.16

**DATE SAMPLES RECEIVED:** 05.04.16

**DATE SAMPLES ANALYSED:** 06-07.04.16

**SAMPLES:** 25mm "GLA-5000" PVC filters

**NO. OF SAMPLES:** Twenty four

**ANALYSIS REQUESTED:** Respirable Crystalline Silica (as Quartz)

**METHOD:** The samples were analysed using an in-house method described in IOM instruction manual number 2 (IM2) using a modification of the following method;

**MDHS 101/2:** Health and Safety Executive (2014). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy or X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101/2. HMSO, London.

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# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

---

CONTRACT NO: 47910  
PROJECT NO: 610  
DATE OF ISSUE: 07.04.16

## RESULTS:

Sample Reference	Quartz Weight (mg)
152147/99	<0.01
152147/100	<0.01
152147/103	<0.01
152147/104	<0.01
152147/B73	<0.01
152147/B76	<0.01
152223/26	<0.01
152223/28	<0.01
152223/B19	<0.01
152224/6	<0.01
152224/8	<0.01
152224/10	<0.01
152224/11	<0.01
152224/18	<0.01
152224/20	0.02
152224/B4	<0.01
152224/B7	<0.01
152224/B13	<0.01
153196/4	<0.01
153196/11	<0.01
153196/17	0.01
153196/B4	<0.01
153196/B16	<0.01
153196/B27	<0.01

Our detection limit for quartz using this method is 0.01mg.

## COMMENTS:

IOM Consulting cannot accept responsibility for samples that have been incorrectly collected or despatched by external clients.

Any opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

AUTHORISED BY: 

**S Clark**  
*Mineralogy Section Manager*

Page 2 of 2

**\*Note: Results from other projects were included in this certificate for purposes of non-alteration of the original certificate. The results applicable to this air monitoring session are highlighted in the table above.**

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

---



## CERTIFICATE OF ANALYSIS

**ANALYSIS REQUESTED BY:** 4-Rail Services Ltd  
Unit 11  
Ironbridge Close  
Great Central Way  
London  
NW10 0UF

**CONTRACT NO:** 48093

**PROJECT NO:** 610

**DATE OF ISSUE:** 22.04.16

**DATE SAMPLES RECEIVED:** 18.04.16

**DATE SAMPLES ANALYSED:** 21.04.16

**SAMPLES:** 25mm "GLA-5000" PVC filters

**NO. OF SAMPLES:** Sixteen

**ANALYSIS REQUESTED:** Respirable Crystalline Silica (as Quartz)

**METHOD:** The samples were analysed using an in-house method described in IOM instruction manual number 2 (IM2) using a modification of the following method;

**MDHS 101/2:** Health and Safety Executive (2014). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy or X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101/2. HMSO, London.

*Page 1 of 2*

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IOM CONSULTING LIMITED, registered in Scotland No. SC205670



# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

---

CONTRACT NO: 48093  
PROJECT NO: 610  
DATE OF ISSUE: 22.04.16

## RESULTS:

Sample Reference	Quartz Weight (mg)
153196-23	<0.01
153196-29	<0.01
153196-B36	<0.01
153196-B43	<0.01
162004-02	<0.01
162004-04	<0.01
162004-B1	<0.01
162008-10	<0.01
162008-12	<0.01
162008-B7	<0.01
162008-06	<0.01
162008-08	<0.01
162008-B5	<0.01
162010-06	<0.01
162010-08	<0.01
162010-B4	<0.01

Our detection limit for quartz using this method is 0.01mg.

## COMMENTS:

IOM Consulting cannot accept responsibility for samples that have been incorrectly collected or despatched by external clients.

Any opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

  
AUTHORISED BY: .....  
**S Clark**  
*Mineralogy Section Manager*

Page 2 of 2

**\*Note: Results from other projects were included in this certificate for purposes of non-alteration of the original certificate. The results applicable to this air monitoring session are highlighted in the table above.**

**Appendix 2. Laboratory certificates for 2.5 µm metal results.**

Richard Brox  
Laboratory ↑

London  
Laboratory

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## ANALYTICAL REPORT

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**4 Rail Services Ltd**  
**Unit 11 Iron Bridge Close**  
**Great Central Way**  
**London**  
**NW10 0UF**

**Certificate Number:** 330172-1 Final

**Order Number:** 25855

**Task Number:** 1342

**Date Received:** 06/04/2016

**Date Reported:** 11/04/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1986467	Description: 153196/12		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	0.43	µg/filter	*
	Received Date: 06-APR-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 06-APR-16	doc	Iron	34.49	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	0.38	µg/filter	*
		doc	Nickel	0.09	µg/filter	*
		doc	Zinc	432.72	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## ANALYTICAL REPORT

Page 1 of 1

**4 Rail Services Ltd**  
**Unit 11 Iron Bridge Close**  
**Great Central Way**  
**London**  
**NW10 0UF**

**Certificate Number:** 330183-1 Final

**Order Number:** 25855

**Task Number:** 1342

**Date Received:** 06/04/2016

**Date Reported:** 11/04/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1986470	Description: 153196/B19		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	0.32	µg/filter	*
	Received Date: 06-APR-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 06-APR-16	doc	Iron	8.95	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	<0.30	µg/filter	*
		doc	Nickel	0.09	µg/filter	*
		doc	Zinc	471.10	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
 Laboratory Manager

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## ANALYTICAL REPORT

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**4 Rail Services Ltd  
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NW10 0UF**

**Certificate Number:** 330173-1 Final

**Order Number:** 25855

**Task Number:** 1342

**Date Received:** 06/04/2016

**Date Reported:** 11/04/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1986468	Description: 153196/18		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	0.94	µg/filter	*
	Received Date: 06-APR-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 06-APR-16	doc	Iron	441.24	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	5.12	µg/filter	*
		doc	Nickel	0.42	µg/filter	*
		doc	Zinc	469.84	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
Laboratory Manager

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## ANALYTICAL REPORT

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**London**  
**NW10 0UF**

**Certificate Number:** 330184-1 Final

**Order Number:** 25855

**Task Number:** 1342

**Date Received:** 06/04/2016

**Date Reported:** 11/04/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1986471	Description: 153196/B28		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	0.19	µg/filter	*
	Received Date: 06-APR-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 06-APR-16	doc	Iron	4.60	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	<0.30	µg/filter	*
		doc	Nickel	0.07	µg/filter	*
		doc	Zinc	345.02	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
Laboratory Manager

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## ANALYTICAL REPORT

Page 1 of 1

**4 Rail Services Ltd  
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**Certificate Number:** 331639-1 Final

**Order Number:** PO25898

**Task Number:** 1342

**Date Received:** 19/04/2016

**Date Reported:** 22/04/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1950350	Description: 153196/24		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	0.76	µg/filter	*
	Received Date: 19-APR-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 19-APR-16	doc	Iron	136.94	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	1.34	µg/filter	*
		doc	Nickel	0.17	µg/filter	*
		doc	Zinc	736.70	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
 Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## ANALYTICAL REPORT

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**4 Rail Services Ltd  
Unit 11 Iron Bridge Close  
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NW10 0UF**

**Certificate Number:** 331641-1 Final

**Order Number:** PO25898

**Task Number:** 1342

**Date Received:** 19/04/2016

**Date Reported:** 22/04/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1990352	Description: 153196/B46		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	0.45	µg/filter	*
	Received Date: 19-APR-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 19-APR-16	doc	Iron	13.18	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	<0.30	µg/filter	*
		doc	Nickel	0.20	µg/filter	*
		doc	Zinc	786.20	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## ANALYTICAL REPORT

Page 1 of 1

**4 Rail Services Ltd**  
**Unit 11 Iron Bridge Close**  
**Great Central Way**  
**London**  
**NW10 0UF**

**Certificate Number:** 331640-1 Final

**Order Number:** PO25898

**Task Number:** 1342

**Date Received:** 19/04/2016

**Date Reported:** 22/04/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1990351	Description: 153196/30 Sample Type: FILTER Received Date: 19-APR-16 Sampling Date: 19-APR-16 Deviating: DATE-TIME		Sample Preparation	Yes		*
		doc	Chromium	1.34	µg/filter	*
		doc	Copper	<1.00	µg/filter	*
		doc	Iron	372.50	µg/filter	*
		doc	Manganese	3.76	µg/filter	*
		doc	Nickel	0.36	µg/filter	*
		doc	Zinc	807.40	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
 Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## ANALYTICAL REPORT

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**4 Rail Services Ltd**  
**Unit 11 Iron Bridge Close**  
**Great Central Way**  
**London**  
**NW10 0UF**

**Certificate Number:** 331642-1 Final

**Order Number:** PO25898

**Task Number:** 1342

**Date Received:** 19/04/2016

**Date Reported:** 22/04/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1990353	Description: 153196/B37		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	0.49	µg/filter	*
	Received Date: 19-APR-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 19-APR-16	doc	Iron	9.51	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	< 0.30	µg/filter	*
		doc	Nickel	0.12	µg/filter	*
		doc	Zinc	719.30	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
 Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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Southwood Business Park, Farnborough  
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## ANALYTICAL REPORT

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**4 Rail Services Ltd  
Unit 11 Iron Bridge Close  
Great Central Way  
London  
NW10 0UF**

**Certificate Number:** 334085-1 Final

**Order Number:** 25934

**Task Number:** 1342

**Date Received:** 03/05/2016

**Date Reported:** 09/05/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1996263	Description: 153196/34		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	1.72	µg/filter	*
	Received Date: 03-MAY-16	doc	Copper	1.28	µg/filter	*
	Sampling Date: 03-MAY-16	doc	Iron	204.88	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	1.90	µg/filter	*
		doc	Nickel	0.42	µg/filter	*
		doc	Zinc	718.14	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## ANALYTICAL REPORT

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**4 Rail Services Ltd  
 Unit 11 Iron Bridge Close  
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**Certificate Number:** 334088-1 Final

**Order Number:** 25934

**Task Number:** 1342

**Date Received:** 03/05/2016

**Date Reported:** 09/05/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1996266	Description: 153196/B55		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	1.55	µg/filter	*
	Received Date: 03-MAY-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 03-MAY-16	doc	Iron	9.34	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	0.36	µg/filter	*
		doc	Nickel	0.10	µg/filter	*
		doc	Zinc	727.44	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
 Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## ANALYTICAL REPORT

Page 1 of 1

**4 Rail Services Ltd  
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**Certificate Number:** 334086-1 Final

**Order Number:** 25934

**Task Number:** 1342

**Date Received:** 03/05/2016

**Date Reported:** 09/05/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1996254	Description: 153196/42		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	0.95	µg/filter	*
	Received Date: 03-MAY-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 03-MAY-16	doc	Iron	220.86	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	2.10	µg/filter	*
		doc	Nickel	0.15	µg/filter	*
		doc	Zinc	706.74	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## ANALYTICAL REPORT

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**Certificate Number:** 334100-1 Final

**Order Number:** 25934

**Task Number:** 1342

**Date Received:** 03/05/2016

**Date Reported:** 09/05/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1996267	Description: 153196/867 Sample Type: FILTER Received Date: 03-MAY-16 Sampling Date: 03-MAY-16 Deviating: DATE-TIME		Sample Preparation	Yes		*
		doc	Chromium	0.46	µg/filter	*
		doc	Copper	<1.00	µg/filter	*
		doc	Iron	10.59	µg/filter	*
		doc	Manganese	<0.30	µg/filter	*
		doc	Nickel	0.08	µg/filter	*
		doc	Zinc	680.12	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
 Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## ANALYTICAL REPORT

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**London**  
**NW10 0UF**

**Certificate Number:** 334087-1 Final

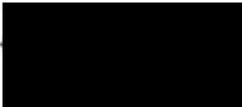
**Order Number:** 25934

**Task Number:** 1342

**Date Received:** 03/05/2016

**Date Reported:** 09/05/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1996265	Description: 153196/48		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	1.01	µg/filter	*
	Received Date: 03-MAY-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 03-MAY-16	doc	Iron	23.69	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	<0.30	µg/filter	*
		doc	Nickel	0.17	µg/filter	*
		doc	Zinc	655.88	µg/filter	*
The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.						

  
 Richard Brown  
 Laboratory Manager

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

South East Water Scientific Services  
3 Columbus Drive  
Southwood Business Park, Farnborough  
Hants, GU14 0NZ  
Telephone: 01634 276276  
Fax: 01634 276277  
E-Mail: sales@southeastwater.co.uk



## ANALYTICAL REPORT

Page 1 of 1

**4 Rail Services Ltd**  
**Unit 11 Iron Bridge Close**  
**Great Central Way**  
**London**  
**NW10 0UF**

**Certificate Number:** 334101-1 Final

**Order Number:** 25934

**Task Number:** 1342

**Date Received:** 03/05/2016

**Date Reported:** 09/05/2016

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
1996268	Description: 153196/B76		Sample Preparation	Yes		*
	Sample Type: FILTER	doc	Chromium	0.49	µg/filter	*
	Received Date: 03-MAY-16	doc	Copper	<1.00	µg/filter	*
	Sampling Date: 03-MAY-16	doc	Iron	7.10	µg/filter	*
	Deviating: DATE-TIME	doc	Manganese	<0.30	µg/filter	*
		doc	Nickel	0.18	µg/filter	*
		doc	Zinc	695.84	µg/filter	*

The date and time of sampling has not been recorded and as a result the test result(s) may be invalid.



Richard Brown  
Laboratory Manager