Department of Science, Information Technology and Innovation

# Western–Metropolitan Rail System Coal Dust Monitoring Program

January to December 2016

Queensland Government

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# Executive summary

In 2013, the Queensland Resources Council engaged the then Department of Science, Information Technology, Innovation and the Arts (now the Department of Science, Information Technology and Innovation) to conduct a dust monitoring program, with a focus on coal dust, along the Western–Metropolitan Rail System on behalf of the users and operators of the network. This monitoring program has been undertaken in two phases: Phase 1 (from March to June 2013) to assess background particle levels along the rail corridor and the effectiveness of additional dust mitigation measures implemented at one coal mine; and Phase 2 (from February 2014 and ongoing) to assess the effectiveness of the fully implemented South West System Coal Dust Management Plan.

Continuous information on ambient $PM_{10}$ (particles less than 10 micrometres (µm) in diameter), $PM_{2.5}$ (particles less than 2.5 µm in diameter) and TSP (total suspended particles) are collected at the rail corridor boundary at Cannon Hill, along with deposited dust levels at the rail corridor boundary at Cannon Hill, Fairfield and Toowoomba.

Results from Phase 1 and Phase 2 monitoring through to December 2015 showed that rail transport emissions were compliant with ambient air quality criteria. Coal haulage and passenger rail transport emissions represented a minor contribution to ambient particle levels, primarily through re-suspension of dust from the rail corridor by air turbulence generated by the passage of all train types. The monitoring results through to December 2015 showed that implementation of the South West System Coal Dust Management Plan had been highly effective in reducing the loss of coal dust from loaded rail wagons during transport.

As part of the users and operators' commitment to demonstrate ongoing compliance on the Western-Metropolitan Rail System, Phase 2 monitoring remains in effect.

For the period January to December 2016, $PM_{10}$, $PM_{2.5}$ and TSP concentrations at Cannon Hill complied with ambient air quality criteria, with the exception of one day when $PM_{2.5}$ concentrations exceeded the 24-hour criterion. Winds on this day indicated that long-range transport of smoke from inland areas, and not rail transport, was the primary cause of the elevated $PM_{2.5}$ concentrations.

In 2016 measured dust deposition rates (resulting from all sources including coal trains) at all monitoring sites complied with the Department of Environment and Heritage Protection guideline for avoidance of dust nuisance of 120 mg/m$^2$/day. Maximum dust deposition rates at individual monitoring sites during 2016 ranged from 32 mg/m$^2$/day to 80 mg/m$^2$/day.

The mass of coal deposited during 2016 was very low, with the annual average coal dust deposition rate at each of the three monitoring locations being less than 1 mg/m$^2$/day. Across the three monitoring locations, 67 per cent of all valid deposited dust samples collected in 2016 contained no measurable deposition of coal dust. Of the remaining samples, the amount of coal deposited did not exceed 3 mg/m$^2$/day.

In 2016 the average coal dust deposition rate across the rail corridor as a whole was 0.4 mg/m$^2$/day, down from 0.6 mg/m$^2$/day in 2014-2015 and 7.9 mg/m$^2$/day prior to the commencement of the additional coal dust mitigation measures. The 2016 coal deposition results show a continuing reduction in overall emissions of coal to the atmosphere along the rail corridor.

The Phase 2 monitoring results for 2016 confirm that the South West System Coal Dust Management Plan coal dust mitigation measures continue to be highly effective in reducing the loss of coal dust from loaded rail wagons during transport.

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# Introduction

Approximately seven million tonnes of coal is exported each year from the Port of Brisbane[1]. The coal is mined in the Clarence–Moreton and Surat Basins in southern Queensland and transported to the Port of Brisbane via the Western–Metropolitan Rail System, which begins near Miles in southern Queensland and passes through Dalby, Toowoomba, Ipswich and the western and southern suburbs of Brisbane. Queensland Rail owns and manages this network and the coal haulage (train) services are undertaken by Aurizon.

Prior to 2013, concerns were raised by some community members that the uncovered rail wagons (loaded and unloaded) operating on the Western–Metropolitan Rail System released significant coal dust, contributing to high ambient airborne particle levels, and impacts on human health and amenity. In response to these concerns, the Queensland Resources Council (QRC) engaged the then Department of Science, Information Technology, Innovation and the Arts (now the Department of Science, Information Technology and Innovation (DSITI)) to conduct a dust monitoring program, with a focus on coal dust, along the Western–Metropolitan Rail System on behalf of the users and operators of the rail network.

The monitoring program was undertaken in two phases:

1. Phase 1, conducted from March to June 2013, assessed:
   a) background particle levels at representative sites, followed by
   b) the effectiveness of additional dust mitigation measures, including load profiling and veneering, voluntarily implemented at one mine.
2. Phase 2, conducted since February 2014, assesses the effectiveness of the fully implemented South West System Coal Dust Management Plan (the Coal Dust Management Plan)[2], which outlines a suite of coal dust mitigation and management commitments for the supply chain members on the Western-Metropolitan Rail System.

Results of Phase 1 monitoring[3] indicated that emissions from coal haulage rail transport were compliant with ambient air quality criteria prior to the implementation of the additional dust mitigation measures. Regional particle emission sources, such as motor vehicles, industry and bushfires, were shown to have greater impacts on particle levels than coal haulage and passenger rail transport combined. Given the limited time available to test the effectiveness of the additional dust mitigation measures, the monitoring program was extended (Phase 2) to determine if there were statistically significant changes in monitored airborne particle levels.

Results of Phase 2 monitoring for the period between February 2014 and December 2015[4] indicated that emissions from coal haulage rail transport remained compliant with ambient air quality criteria. Coal haulage and passenger rail transport emissions represented a minor contribution to ambient particle levels primarily through re-suspension of dust from the rail corridor by air turbulence generated by the passage of all train types. Regional particle emission sources were once again shown to have greater impacts on particle levels than coal haulage and passenger rail transport combined.

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[1] based on trade statistics for 2014, 2015 and 2016 obtained from www.portbris.com.au/trade-logistics/trade-statistics.

[2] report available from www.qrc.org.au/wp-content/uploads/2016/07/09-South-West-System-Coal-Dust-Management-Plan-2013.pdf

[3] report available from www.ehp.qld.gov.au/management/coal-dust/monitoring.

[4] report available from www.ehp.qld.gov.au/management/coal-dust/monitoring.

Furthermore, Phase 2 monitoring showed a significant reduction in coal depositing from the air compared with the background levels measured in Phase 1 (which were already in compliance), demonstrating that the Coal Dust Management Plan coal dust mitigation and management measures had been effective in reducing the loss of coal dust from wagons during transport.

As part of the users and operators' commitment to demonstrate ongoing compliance on the Western-Metropolitan Rail System, Phase 2 monitoring remains in effect. This report presents the Phase 2 monitoring results obtained by DSITI for the period January to December 2016.

# Monitoring program design

Airborne particles can have a range of effects on human health and amenity (dust nuisance), depending on particle size, concentration and exposure time. Adverse health effects are generally associated with particles less than 10 µm in diameter ($PM_{10}$) with particles less than 2.5 µm in diameter ($PM_{2.5}$) now appearing to be most correlated with negative health outcomes[5]. Amenity degradation effects are mainly associated with larger suspended particles (TSP) and dust settling out under gravity (deposited dust).

Airborne particles can be generated by a variety of sources. In general, combustion processes (e.g. motor vehicle engines, bushfires and solid fuel heaters) produce smaller particles than mechanical processes (e.g. earthworks, construction activities and wind erosion). In relation to coal haulage rail transport, particle emissions can result from fuel combustion by diesel locomotives and mechanical processes, such as wind erosion of the coal surface of wagons and re-entrainment of dust in the rail corridor. As the coal is washed prior to loading, any coal dust lost from the wagons would most likely be present as larger particles (TSP) although some may exist as $PM_{10}$.

The Phase 2 monitoring program collects information on:

- $PM_{10}$ and $PM_{2.5}$ – for assessment against criteria for protection of human health
- TSP – for assessment against longer-term (annual) criteria for protection of human health and short-term (24-hour) amenity-based (dust nuisance) criteria
- deposited dust – for assessment against amenity-based (dust nuisance) criteria
- particle composition of deposited dust – for assessment of the contribution of coal and other particle types to overall deposited dust levels
- meteorology (e.g. wind speed and direction) – to assist with identifying possible particle sources.

It is important to note that airborne particle levels monitored as part of Phase 2 are the sum of all local and regional particle emission sources, such as motor vehicles and industry, not just rail transport.

Dust contributions have been assessed by comparing monitored particle concentrations and deposited dust levels with the air quality criteria listed in Table 1, drawn from the Queensland Environment Protection (Air) Policy 2008 (EPP Air), the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM), and the Department of Environment and Heritage Protection

[5] World Health Organization Regional Office for Europe, *Review of evidence on health aspects of air pollution – REVIHAAP project: final technical report*, 2013; available from www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report.

(DEHP) guideline document *Application requirements for activities with impacts to air*[6] (Air Impacts Guideline). There are currently no health-based air quality criteria for airborne particles derived for exposure periods less than 24 hours. It is for this reason that assessment is based on a minimum averaging period of 24 hours.

**Table 1. Air quality criteria used for assessment purposes.**

| Pollutant | Air quality criterion | Allowable exceedences | Source | Assessment type |
|---|---|---|---|---|
| $PM_{10}$ | 50 µg/m$^3$ (24-hour) | 5 | EPP Air | Health |
| | 25 µg/m$^3$ (annual) | 0 | AAQ NEPM | Health |
| $PM_{2.5}$ | 25 µg/m$^3$ (24-hour) | 0 | EPP Air | Health |
| | 8 µg/m$^3$ (annual) | 0 | EPP Air | Health |
| TSP | 90 µg/m$^3$ (annual) | 0 | EPP Air | Health |
| | 60 µg/m$^3$ (24-hour) | 0 | Air Impacts Guideline* | Amenity |
| Deposited dust | 120 mg/m$^2$/day (averaged over a 30-day period) | 0 | Air Impacts Guideline | Amenity |

* The Air Impacts Guideline specifies that 24-hour average TSP concentrations should comply with the dust nuisance trigger levels specified in the New Zealand Ministry for the Environment (NZ MfE) document *Good practice guide for assessing and managing dust*[7].

## Monitoring sites

Monitoring equipment is located at three sites along the Western-Metropolitan Rail System — Cannon Hill, Fairfield and Toowoomba (see Figure 1, Figure 2 and Figure 3 respectively). Continuous $PM_{10}$, $PM_{2.5}$, TSP and meteorological data are collected at Cannon Hill. Two deposited dust samplers are deployed at Cannon Hill and Toowoomba, one on each side of the rail corridor, to ensure any dust fallout resulting from rail transport is captured in at least one of the samplers. During 2016 only one deposited dust sampler was in operation at Fairfield, located on western side of the rail corridor. The sampler on the eastern side of the rail corridor at Fairfield was decommissioned in late 2015 following repeated vandalising of the equipment.

Table 2 details the monitoring sites, equipment position relative to the rail corridor, wind direction range for impacts from rail corridor emissions and parameters measured.

[6] available from www.ehp.qld.gov.au/assets/documents/regulation/era-gl-air-impacts.pdf.

[7] available from www.mfe.govt.nz/sites/default/files/media/Air/good-practice-guide-dust.pdf.


**Figure 1. Monitoring equipment sites at Cannon Hill.**


**Figure 2. Monitoring equipment site at Fairfield.**


**Figure 3. Monitoring equipment sites at Toowoomba.**

**Table 2. Monitoring site details.**

| Monitoring site | Number of rail lines | Max. train speed (km/h) [a] | | Position relative to rail tracks | Distance from nearest rail track (m) | Distance from furthest rail track (m) | Rail corridor impacts wind range (degrees) | Measurement parameters |
|---|---|---|---|---|---|---|---|---|
| | | Freight [b] | Passenger [c] | | | | | |
| Cannon Hill | 3 | 60 (both directions) | 80 (both directions) | North | 6 | 21 | 70 to 260 | Continuous $PM_{10}$<br>Continuous $PM_{2.5}$<br>Continuous TSP<br>Deposited dust<br>Meteorology |
| | | | | South | 4 | 18 | 0 to 90 and 250 to 360 | Deposited dust |
| Fairfield | 3 | 60 (both directions) | 80 (from City)[a] | West | 6 | 22 | 20 to 220 | Deposited dust |
| Toowoomba | 2 | 60 (both directions) | 60 (both directions) | East | 18 | 22 | 160 to 330 | Deposited dust |
| | | | | West | 8 | 12 | 0 to 140 and 310 to 360 | Deposited dust |

[a] Express trains are permitted to travel at 100 km/h.
[b] Most freight services are likely to be travelling at speeds less than the maximum speeds listed due to restricted signals, track bends and priority for passenger services.
[c] Non-express passenger trains at Cannon Hill and Fairfield would be travelling slower than maximum speeds listed as they would be preparing to stop at, or accelerating away from, the station.

## Monitoring equipment

Continuous $PM_{10}$ and $PM_{2.5}$ concentrations are monitored at Cannon Hill using a Model 1405DF dichotomous tapered element oscillating microbalance (TEOM™) instrument operated in accordance with the Australian/New Zealand Standard AS/NZS 3580.9.13:2013 *Method 9.13: Determination of suspended particulate matter—$PM_{2.5}$ continuous direct mass method using a tapered element oscillating microbalance monitor*.

The dichotomous TEOM™ instrument operates by first drawing air through a size-selective inlet that excludes particles larger than $PM_{10}$. The instrument then splits the air stream into two separate particle streams, one containing $PM_{2.5}$ and the other containing $PM_{2.5-10}$. The two particle streams pass through separate filters mounted on hollow glass tubes (tapered elements) vibrating at their natural frequencies (similar to how a tuning fork operates). The oscillating frequency of each tube changes following particle deposition on the filters, with these frequency changes being a function of the particle mass deposited. Particle concentrations are then calculated using the deposited mass and flow rates for each particle stream, with $PM_{10}$ concentrations calculated as the sum of the simultaneous measurements from the $PM_{2.5}$ and $PM_{2.5-10}$ particle streams.

Continuous TSP concentrations are monitored at Cannon Hill using a Model 1405 TEOM™ instrument operated in accordance with the requirements of Australian Standard AS 3580.9.8—2008 *Method 9.8: Determination of suspended particulate matter—$PM_{10}$ continuous direct mass method using a tapered element oscillating microbalance analyser*, with a TSP inlet fitted in place of a size-selective $PM_{10}$ inlet. This TEOM™ instrument operates in the same manner as the dichotomous TEOM™ used to measure $PM_{10}$ and $PM_{2.5}$, although only one particle stream (TSP) passes through the instrument.

Deposited dust levels are measured at Cannon Hill, Fairfield and Toowoomba using dust deposition gauges (comprising a funnel and collection bottle), which catch dust settling on the internal surface area of a funnel over monthly periods. Following the collection of each sample, the dust is washed from the bottle and then filtered and weighed. Results from dust deposition sampling are expressed as the weight of dust collected per unit of surface area per day, averaged over a standardised 30-day sampling period (i.e. mg/m$^2$/day averaged over a 30-day period).

Deposited dust samples are further characterised as insoluble solids (the fraction of total particles deposited which are not water-soluble), ash (the part of the insoluble dust fraction which remains after heating the sample to a temperature of 850 degrees Celsius for 30 minutes) and combustible matter (the part of the insoluble dust fraction which is lost on heating the sample to a temperature of 850 degrees Celsius for 30 minutes). Insoluble solids are the particles typically responsible for nuisance impacts. Deposited dust is collected and analysed in accordance with the Australian/New Zealand Standard AS/NZS 3580.10.1:2016 *Method 10.1: Determination of particulate matter—Deposited Matter—Gravimetric method*.

Particle composition analysis of the deposited dust samples is conducted by the University of Queensland’s Materials Performance Laboratory (UQMP) to assist with identifying likely sources of the dust. Sub-samples of the insoluble fraction of deposited dust samples are examined through a microscope and the proportions of different types of particles in each sub-sample are measured based on their surface area coverage. This analysis method can identify a range of black-coloured particles (coal, soot and rubber dust), mineral dust particles (e.g. soil, rock, cement and glass), biological particles (e.g. insects and plants) and other general organic particles (e.g. wood, fibres and plastics). The accuracy of this method is ±5 per cent.

Importantly, this microscopic examination is based on surface area coverage and not particle mass, therefore the proportions of different particle types (based on area) cannot be directly applied to particle deposition based on mass. To estimate the mass of coal dust and other particles deposited, typical densities for the different particle types[8] were applied to the surface area proportions.

Wind speed and direction, relative humidity, temperature and rainfall are also monitored at Cannon Hill to assist with determining sources contributing to $PM_{10}$, $PM_{2.5}$, TSP and deposited dust levels. Onsite meteorology monitoring is not conducted at the other two monitoring sites. For the Fairfield monitoring site, wind data from DSITI's Rocklea ambient air quality monitoring site and rainfall data from the Bureau of Meteorology's measurement site at Archerfield Airport have been used. For the Toowoomba monitoring sites, wind data from DSITI's ambient air monitoring site at Jondaryan[9] and rainfall data from the Bureau of Meteorology's measurement site at Toowoomba Airport have been used.

[8] The following densities were applied to the different particle types:

| Particle type | Density ($g/cm^3$) | Reference |
|---|---|---|
| Coal | 1.5 | A.J. Mutton, *Queensland Coals: Physical and Chemical Properties, Colliery and Company Information*, 14th Edition, Department of Natural Resources and Mines Bureau of Mining and Petroleum, 2003, downloaded from www.dnrm.qld.gov.au/ ?a=267497. |
| Fly ash | 2.4 | Cement Australia, Safety Data Sheets for Fly Ash, www.cementaustralia.com.au/ wps/wcm/connect/website/bulk/Bulk-Home/technical-product-information/#msds. |
| Insect material | 0.7 | Locust, dry value, *Density of Bulk Materials*, www.simetric.co.uk/si_materials.htm. |
| Paint | 1.2 | B. Müller and U. Poth, *Coatings Formulation*, Vincentz Network, 2011, downloaded from www.european-coatings.com/var/StorageVincentz/VN-Link/285_Leseprobe.pdf. |
| Plant material | 0.3 | Bark, wood refuse value, *Density of Some Common Materials*, The Engineering Toolbox www.engineeringtoolbox.com/density-materials-d_1652.html. |
| Plastic | 1.2 | Average of listed densities for common plastics on www.dotmar.com.au/density.html. |
| Soil / rock | 2.1 | J. Priddle, D. Lacey, B. Look and C. Gallage, *Residual Soil Properties of South East Queensland*, Australian Geomechanics Journal, 48(1), pp. 67-76, 2013, downloaded from eprints.qut.edu.au/59538/. |
| Soot | 1.8 | R.C. Flagan and J.H. Seinfeld, *Fundamentals of Air Pollution Engineering*, Prentice-Hall, 1988, p381, downloaded from authors.library.caltech.edu/25069/1/ AirPollution88.pdf. |
| Tyre rubber | 1.2 | Geosyntec Consultants, *Guidance Manual For Engineering Uses of Scrap Tires*, Maryland Department of the Environment, 2008, accessed from www.mde.state.md.us/assets/document/Guidance_Manual_For_Scrap_Tires.pdf. |

[9] Following the closure of the Jondaryan air quality monitoring station in August 2016, wind data from the Bureau of Meteorology weather station at the Toowoomba Airport was used.

# Results and discussion

## Meteorology

Meteorology can influence rail corridor dust emissions. Heavy and persistent rainfall can suppress dust emissions by reducing coal loss from rail wagons and the amount of dust re-entrained during the passage of trains. Figure 4 compares monthly rainfall totals measured in 2016 (black columns) with median rainfall totals from 1996 to 2016 (white columns) at Bureau of Meteorology rainfall stations close to the three rail corridor monitoring sites[10].

Figure 4 shows that monthly rainfall in 2016 was often at or below the long-term median value. Particle measurements during periods of higher than average rainfall could under-represent levels expected for those months (e.g. June). However, during months with low rainfall totals particle emissions will not have been supressed to any significant extent and measurements obtained during these months can be assumed to have included values in the upper portion of the particle exposure range.

Particle levels measured are also dependent on wind direction during the sampling period and the location of particle emissions sources relative to the monitoring site. In the event of an exceedance of air quality criteria, wind direction data has been used to assess the likely cause. The proportion of winds coming from the direction of the rail corridor are presented alongside the deposited dust measurements in this report.

[10] 2016 rainfall data and median rainfall totals sourced from http://www.bom.gov.au/climate/data/.

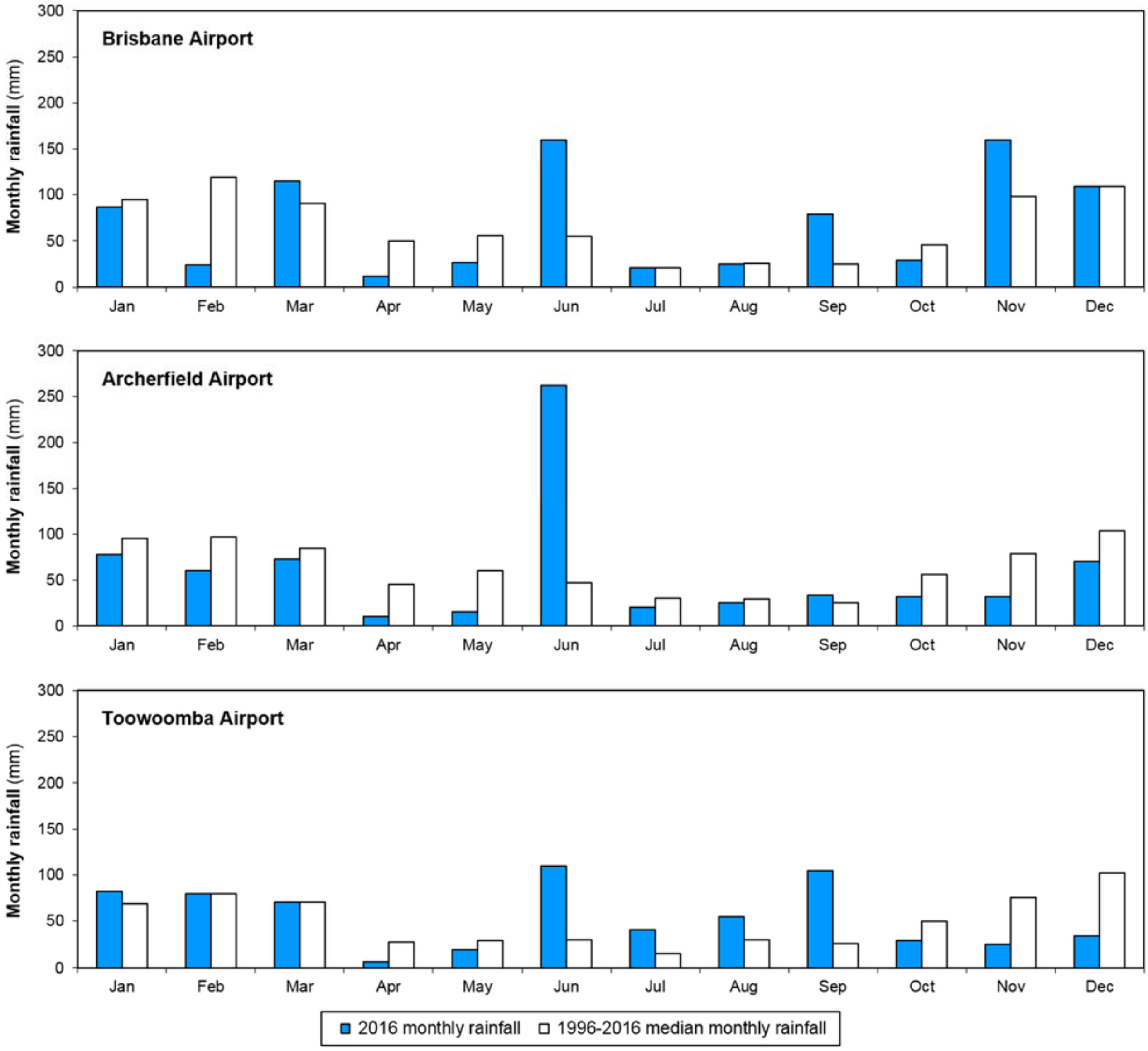


**Figure 4. 2016 monthly rainfall totals for Bureau of Meteorology stations in Brisbane and Toowoomba in close proximity to the rail corridor monitoring sites.**

## $PM_{10}$, $PM_{2.5}$ and TSP

$PM_{10}$, $PM_{2.5}$ and TSP concentrations monitored at Cannon Hill (North) are the sum of contributions from all emission sources, such as motor vehicles and industry, as well as rail transport; with coal haulage rail transport representing a very small portion of total particles. Table 3 shows summary statistics for $PM_{10}$, $PM_{2.5}$ and TSP concentrations recorded at the Cannon Hill (North) monitoring site in 2016. Hourly percentile values (values below which a given percentage of all measurements fall) are included to show the distribution of 1-hour average particle concentrations.

**Table 3. $PM_{10}$, $PM_{2.5}$ and TSP concentrations at the Cannon Hill (North) monitoring site, January to December 2016.**

| Pollutant | No. of samples | | Concentration ($\mu g/m^3$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hourly | Daily[d] | Average | Maximum 24-hour[d] | No. days > criteria | 1-hour average percentiles | | | | | |
| | | | | | | 99th | 98th | 95th | 90th | 75th | 50th |
| $PM_{10}$[a] | 8287 | 345 | 14.8 | 32.8 | 0 | 39.3 | 34.4 | 28.5 | 24.3 | 18.7 | 13.7 |
| $PM_{2.5}$[b] | 8576 | 358 | 7.7 | 26.9 | 1 | 25.0 | 21.7 | 17.0 | 13.9 | 9.9 | 6.9 |
| TSP[c] | 8388 | 350 | 24.5 | 58.5 | 0 | 67.5 | 59.0 | 47.6 | 40.4 | 30.8 | 22.6 |

[a] The $PM_{10}$ EPP Air 24-hour objective is 50 $\mu g/m^3$ and the AAQ NEPM annual standard is 25 $\mu g/m^3$.
[b] The $PM_{2.5}$ EPP Air objectives are 25 $\mu g/m^3$ (24-hour) and 8 $\mu g/m^3$ (annual).
[c] The TSP EPP Air annual objective is 90 $\mu g/m^3$ and the NZ MfE 24-hour dust trigger level for residential areas is 60 $\mu g/m^3$.
[d] calendar day where data availability during the 24-hour period is at least 75 per cent.

Figure 5 displays the 24-hour average $PM_{10}$, $PM_{2.5}$ and TSP concentrations measured at the Cannon Hill (North) monitoring site on each day in 2016.

The air quality criteria for protection of human health used to assess $PM_{10}$ concentrations at Cannon Hill are the AAQ NEPM annual standard of 25 $\mu g/m^3$ and the EPP Air 24-hour objective of 50 $\mu g/m^3$. $PM_{10}$ concentrations recorded at the Cannon Hill (North) monitoring site in 2016 complied with these criteria by a considerable margin.

The EPP Air objectives for $PM_{2.5}$ for protection of human health are an annual average concentration of 8 $\mu g/m^3$ and a 24-hour average concentration of 25 $\mu g/m^3$. The average $PM_{2.5}$ concentration recorded at the Cannon Hill (North) monitoring site during 2016 complied with the EPP Air annual objective. The EPP Air 24-hour objective was exceeded once at Cannon Hill (North) during the reporting period, on 31 July 2016. On this day, winds blew predominantly from the west to northwest, indicating that any contribution from rail transport emissions would have been minimal. $PM_{2.5}$ concentrations measured at other South East Queensland air quality monitoring sites were also elevated on this day, indicating that a region-wide source of $PM_{2.5}$, identified as long-range transport of smoke from inland areas, was the main contributor to this exceedence.

The EPP Air health-based objective for TSP is 90 $\mu g/m^3$, averaged over a one-year period. To minimise dust nuisance impacts, the DEHP Air Impacts Guideline specifies that 24-hour average TSP concentrations should comply with the dust nuisance trigger levels set by the New Zealand Ministry for the Environment (NZ MfE). The NZ MfE recommends that in sensitive areas (e.g. residential areas) 24-hour TSP concentrations do not exceed 60 $\mu g/m^3$. TSP concentrations recorded at the Cannon Hill (North) monitoring site on the rail corridor boundary complied with both these criteria during 2016.

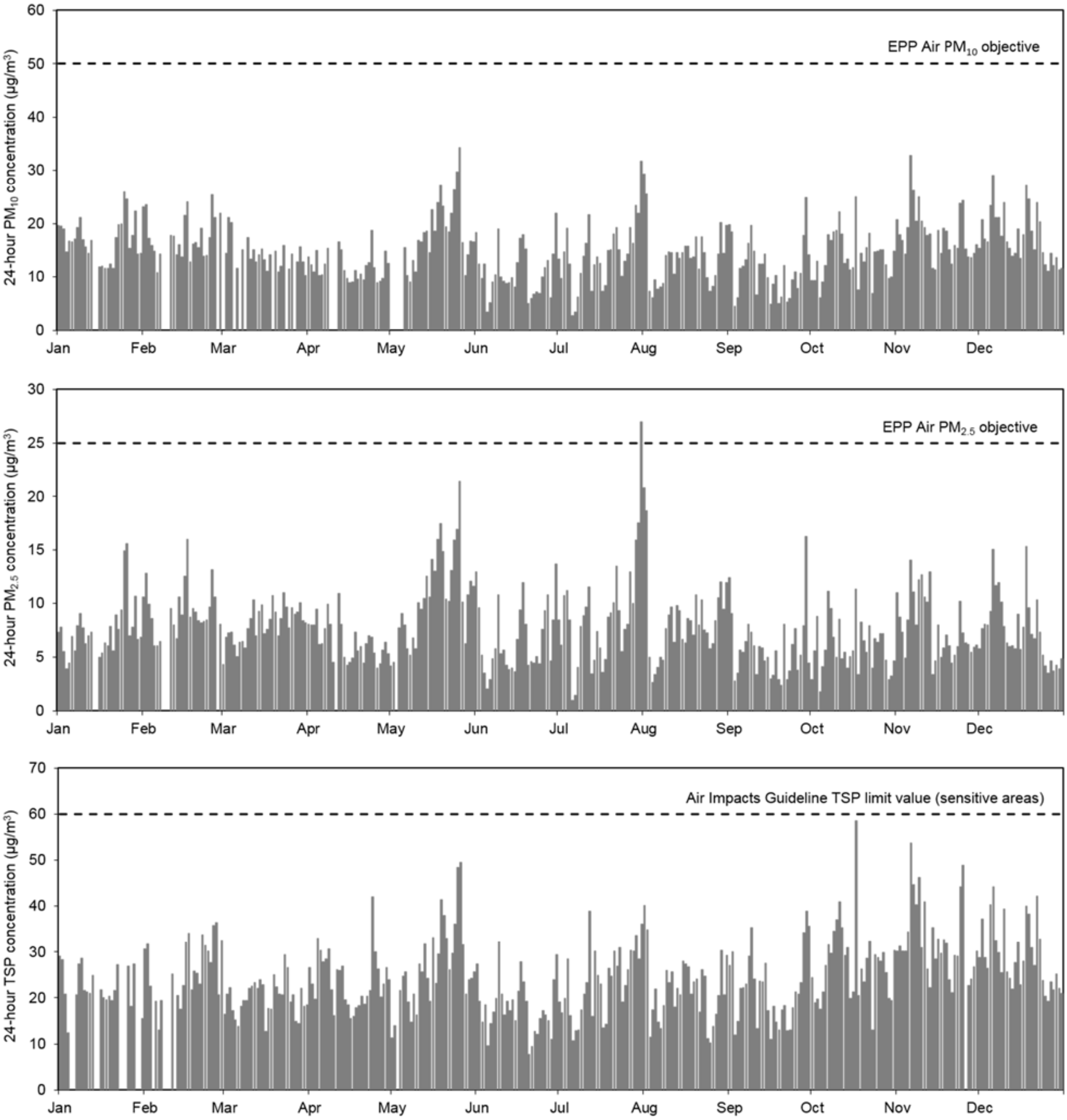


**Figure 5. Daily average $PM_{10}$, $PM_{2.5}$ and TSP concentrations at the Cannon Hill (North) monitoring site, January to December 2016.**

## Deposited dust

Dust that settles from the air is made up almost entirely of particles 30 micrometres and greater in diameter[11]. Dust annoyance is primarily associated with levels of the insoluble deposited matter fraction (in coastal areas much of the soluble deposited matter is marine salt), which is further characterised as ash (minerals) or combustible (organic) matter. Any coal particles present in the insoluble deposited dust will be part of the organic matter fraction, along with other organic material such as soot, plant and insect material, wood dust and rubber dust.

[11] J.H. Fairweather, A.F. Sidlow and W.L. Faith, *Particle size distribution of settled dust*, Journal of the Air Pollution Control Association, 15:8, 345-347, 1965, available at http://dx.doi.org/10.1080/00022470.1965.10468389.

Deposited dust levels measured at the Cannon Hill, Fairfield and Toowoomba rail corridor monitoring sites for 2016, together with proportion of winds from the rail corridor and rainfall totals, are presented in Table 4. The measured deposited dust levels are the sum of contributions from all emission sources, such as motor vehicles and industry, as well as rail transport.

Insoluble dust deposition levels monitored at the rail corridor monitoring sites complied with the DEHP dust nuisance assessment value of 120 mg/m$^2$/day, with the exception of the sample collected at the Toowoomba (East) site in January 2016. However, for the reasons explained in the following paragraph, the Toowoomba (East) January 2016 result is considered invalid, meaning that compliance with the DEHP dust nuisance criterion was achieved at all monitoring sites during 2016.

The measured dust deposition rate of 434 mg/m$^2$/day at the Toowoomba (East) site in January 2016 was of the order of 10 to 15 times greater than the results for the preceding and following months, and four times greater than the next highest monthly deposition rate recorded during the three years that Phase 2 monitoring has been undertaken at this site. This result contrasts with the January 2016 dust deposition levels at all other rail corridor monitoring sites, and at another DSITI air monitoring site 200 metres from the rail corridor at Jondaryan, 40 kilometres northwest of Toowoomba, which were not significantly elevated during this period.

Meteorological data collected by DSITI at Jondaryan shows rainfall during the January 2016 sampling period was higher than that measured during most other sampling periods and wind speeds were comparable to those experienced at other times of the year. Under such conditions increased levels of windblown dust would be unlikely. The composition of the January 2016 Toowoomba (East) deposited dust sample also differed considerably from that of other samples, having a much lower soil content and a much higher biological material content.

Based on the above observations, the most likely explanation for the elevated dust deposition result at Toowoomba (East) in January 2016 is that the sampling equipment was tampered with during the sampling period. The fact that the sampling equipment at the co-located Toowoomba (West) monitoring site was vandalised during the same period adds weight to this conclusion. As a result, the January 2016 Toowoomba (East) sample has been excluded from analysis of the 2016 deposited dust results.

Table 5 and Figure 6 show the particle composition analysis results[12] for each valid deposited dust sample. Analysis of the deposited dust samples collected in 2016 showed soil and rock dust consistently being the main particle type present at all rail corridor monitoring sites. Across the three deposited dust monitoring locations, sixty per cent of all samples collected in 2016 contained no measurable coal content. Of the remaining samples, the proportion of coal present did not exceed seven per cent.

[12] Particle types which were artefacts of the sampling method and not present in the air environment (e.g. copper sludge formed from the copper sulfate algicide added to the sampler and photosynthetic slime and fungi from biological growth) were removed from the reported composition results and the surface area of the remaining particle types proportionally scaled up to give a total surface area coverage of 100 per cent for atmospheric particles.

**Table 4. Average daily dust deposition rates at rail corridor monitoring sites, January to December 2016.**

| Station and month | Dust deposition rate (mg/m²/day) | | | | | | Winds from direction of rail corridor (%) | | Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|---|
| | Insoluble solids[a] | | Ash | | Combustible matter | | | | |
| ***Cannon Hill*** | ***North*** | ***South*** | ***North*** | ***South*** | ***North*** | ***South*** | ***North*** | ***South*** | |
| January | 30 | 52 | 23 | 33 | 7 | 20 | 59 | 58 | 42 |
| February | 41 | 47 | 23 | 28 | 18 | 19 | 91 | 19 | 21 |
| March | 29 | 38 | 26 | 23 | 3 | 15 | 81 | 39 | 75 |
| April | 37 | 58 | 24 | 27 | 13 | 31 | 78 | 24 | 8 |
| May | 22 | 29 | 11 | 18 | 11 | 11 | 59 | 59 | 1 |
| June | 13 | 44 | 7 | 27 | 6 | 17 | 50 | 63 | 130 |
| July | 17 | 31 | 8 | 14 | 9 | 16 | 55 | 60 | 9 |
| August | 31 | 36 | 18 | 21 | 14 | 15 | 60 | 54 | 18 |
| September | 23 | 42 | 15 | 17 | 8 | 25 | 49 | 72 | 42 |
| October | 42 | 66 | 22 | 38 | 20 | 28 | 44 | 71 | 24 |
| November | 33 | 36 | 22 | 22 | 11 | 14 | 54 | 65 | 42 |
| December | 44 | 65 | 25 | 28 | 20 | 37 | 48 | 63 | 147 |
| ***Fairfield*** | ***West*** | | ***West*** | | ***West*** | | ***West*** | | |
| January | 31 | | 21 | | 10 | | 68 | | 43 |
| February | 32 | | 19 | | 12 | | 71 | | 40 |
| March | 15 | | 14 | | 1 | | 63 | | 62 |
| April | 27 | | 21 | | 6 | | 57 | | 25 |
| May | 24 | | 14 | | 10 | | 50 | | 2 |
| June | 21 | | 12 | | 8 | | 43 | | 261 |
| July | 19 | | 8 | | 11 | | 40 | | 11 |
| August | 25 | | 14 | | 11 | | 58 | | 16 |
| September | 29 | | 20 | | 10 | | 47 | | 28 |
| October | 16 | | 14 | | 2 | | 55 | | 11 |
| November | no data[b] | | no data[b] | | no data[b] | | 71 | | 20 |
| December | no data[b] | | no data[b] | | no data[b] | | 76 | | 120 |
| ***Toowoomba*** | ***East*** | ***West*** | ***East*** | ***West*** | ***East*** | ***West*** | ***East*** | ***West*** | |
| January | invalid[c] | no data[b] | invalid[c] | no data[b] | invalid[c] | no data[b] | *20* | 86 | 80 |
| February | 27 | 38 | 14 | 26 | 13 | 12 | 5 | 95 | 59 |
| March | 46 | 31 | 27 | 25 | 19 | 6 | 11 | 89 | 53 |
| April | 3 | 22 | 3 | 17 | 0 | 4 | 12 | 87 | 12 |
| May | no data[b] | 38 | no data[b] | 26 | no data[b] | 11 | 50 | 53 | 51 |
| June | 7 | 28 | 6 | 16 | 1 | 11 | 53 | 50 | 102 |
| July | 76 | 37 | 39 | 27 | 37 | 10 | 63 | 42 | 26 |
| August | 37 | 31 | 23 | 20 | 15 | 10 | 36 | 68 | 50 |
| September | 47 | 25 | 22 | 15 | 25 | 10 | 62 | 43 | 109 |
| October | 32 | 40 | 23 | 30 | 9 | 10 | 41 | 65 | 15 |
| November | 51 | 74 | 35 | 43 | 16 | 31 | 25 | 80 | 29 |
| December | 36 | 80 | 20 | 46 | 16 | 34 | 11 | 90 | 103 |

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 mg/m²/day (averaged over a one month period) to minimise dust nuisance impacts.
[b] no sample due to sampling equipment being vandalised.
[c] measured values (insoluble solids: 434 mg/m²/day; ash: 70 mg/m²/day; combustible matter: 356 mg/m²/day) assessed as being the result of sample tampering, and not indicative of ambient deposition rates.

**Table 5. Deposited dust particle composition analysis results at rail corridor monitoring sites, January to December 2016.**

| Station and month | Surface coverage (%) of deposited dust sample[a,b] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Coal dust | | Other black particles | | Inorganic and mineral | | Other particle types | |
| ***Cannon Hill*** | ***North*** | ***South*** | ***North*** | ***South*** | ***North*** | ***South*** | ***North*** | ***South*** |
| January | 5 | trace | 5 | 2 | 85 | 89 | 5 | 8 |
| February | 5 | 5 | 5 | 5 | 80 | 85 | 10 | 5 |
| March | 0 | 0 | trace | 5 | 85 | 80 | 15 | 15 |
| April | 2 | 5 | 0 | 5 | 78 | 80 | 20 | 10 |
| May | 5 | 5 | 0 | 21 | 55 | 37 | 40 | 37 |
| June | 5 | 5 | 10 | 0 | 45 | 45 | 40 | 50 |
| July | 0 | trace | 5 | 5 | 60 | 84 | 35 | 11 |
| August | trace | 0 | 0 | 5 | 55 | 65 | 45 | 30 |
| September | 0 | 0 | 12 | 24 | 65 | 53 | 24 | 22 |
| October | 2 | 2 | 8 | 5 | 82 | 93 | 8 | trace |
| November | 2 | trace | 5 | 2 | 93 | 87 | trace | 11 |
| December | 0 | trace | 2 | trace | 98 | 95 | trace | 5 |
| ***Fairfield*** | ***West*** | | ***West*** | | ***West*** | | ***West*** | |
| January | trace | | 10 | | 90 | | trace | |
| February | 5 | | 20 | | 65 | | 10 | |
| March | 0 | | 22 | | 71 | | 7 | |
| April | 5 | | 20 | | 60 | | 15 | |
| May | 2 | | 30 | | 58 | | 10 | |
| June | 0 | | 30 | | 40 | | 30 | |
| July | trace | | 10 | | 85 | | 5 | |
| August | trace | | 5 | | 65 | | 30 | |
| September | 0 | | 30 | | 50 | | 20 | |
| October | trace | | 11 | | 84 | | 5 | |
| November | no data[c] | | no data[c] | | no data[c] | | no data | |
| December | no data[c] | | no data[c] | | no data[c] | | no data | |
| ***Toowoomba*** | ***East*** | ***West*** | ***East*** | ***West*** | ***East*** | ***West*** | ***East*** | ***West*** |
| January | invalid[d] | no data[c] | invalid[d] | no data[c] | invalid[d] | no data[c] | invalid[d] | no data[c] |
| February | trace | 5 | 5 | 5 | 65 | 55 | 30 | 35 |
| March | trace | 0 | trace | 2 | 63 | 83 | 38 | 15 |
| April | 7 | 0 | 3 | 20 | 91 | 70 | trace | 10 |
| May | no data[c] | trace | no data[c] | 30 | no data[c] | 60 | no data[c] | 10 |
| June | 5 | trace | 20 | 20 | 55 | 65 | 20 | 15 |
| July | 2 | trace | 6 | 15 | 92 | 65 | trace | 20 |
| August | trace | 0 | 10 | 20 | 70 | 70 | 20 | 10 |
| September | trace | 0 | 5 | 5 | 53 | 55 | 42 | 40 |
| October | 2 | 0 | 6 | 10 | 70 | 86 | 22 | 4 |
| November | 0 | 0 | 2 | trace | 93 | 95 | 5 | 5 |
| December | trace | no data[e] | trace | no data[e] | 79 | no data[e] | 21 | no data[e] |

[a] the uncertainty in the measurement of surface coverage is typically ±5%.
[b] particle types which were artefacts of the sampling method and not present in the air environment (such as copper sludge from the added algicide and photosynthetic slime and fungi from biological growth) have been excluded and the surface area coverage of the remaining particle types proportionally scaled up to give a total surface area coverage for atmospheric particles of 100 %.
[c] no sample due to sampling equipment being vandalising.
[d] measured values (coal: 13%; other black particles: 0%; inorganic and mineral: 25%; other particle types: 63%) assessed as being the result of sample tampering, and not indicative of the composition of dust depositing from the air.
[e] laboratory error.

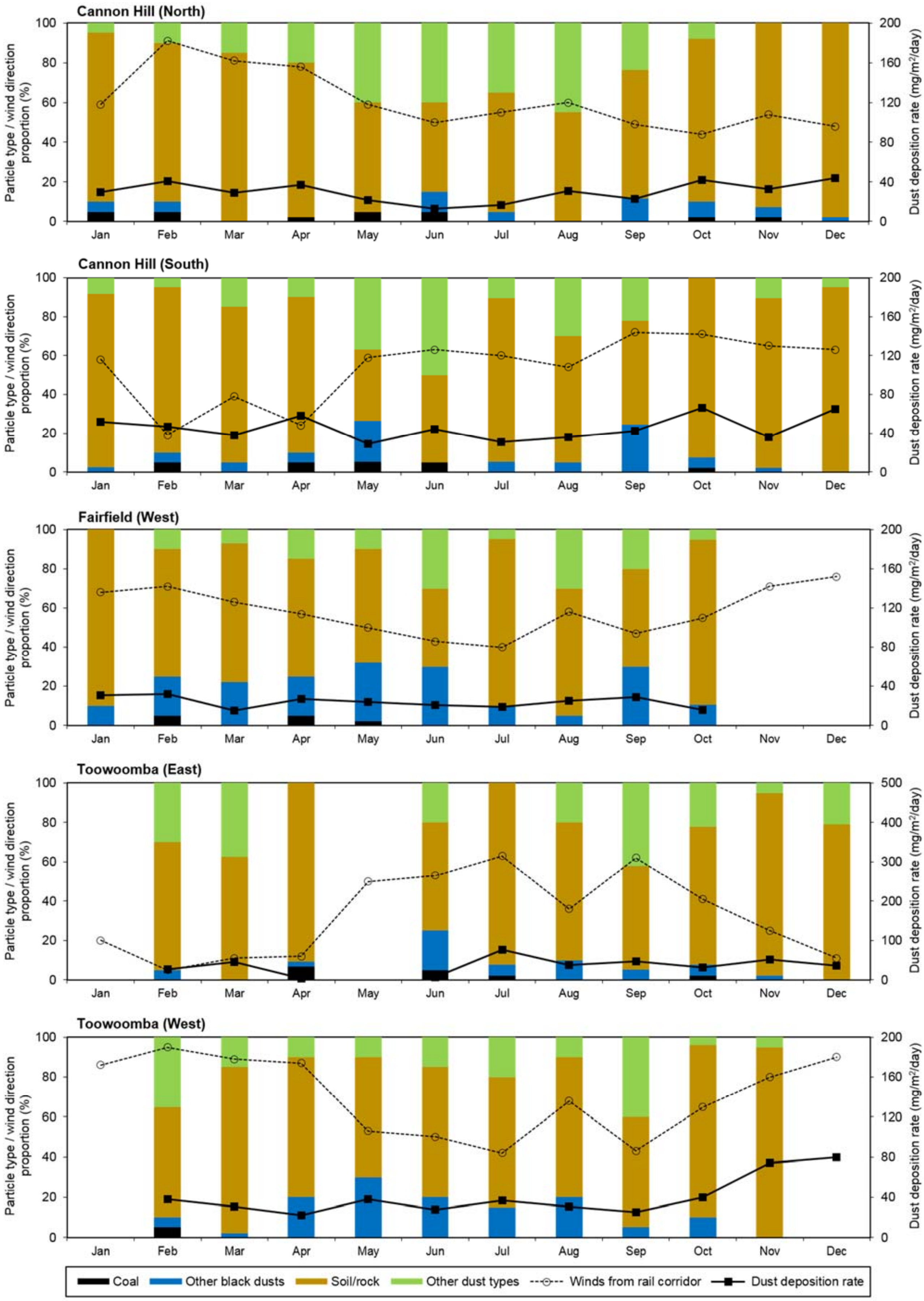


**Figure 6. Deposited dust composition at rail corridor monitoring sites, January to December 2016.**

## Coal deposition

Table 6 and Figure 7 show dust deposition (insoluble solids) sampling results and the approximate mass deposition rate fractions for coal dust, soil and rock dust, and other particle types (calculated from the deposition rate, particle composition analysis and particle density) at the three rail corridor monitoring sites during 2016.

Soil and rock particles continue to be the largest contributor to measured insoluble dust mass deposition rates at the rail corridor monitoring sites in 2016, regularly comprising more than 80 per cent of the total deposited mass in individual samples.

The mass of coal deposited was very low. The annual average coal dust deposition rate at each of the three monitoring locations during 2016 was less than 1 mg/m$^2$/day. Sixty-seven per cent of all valid deposited dust samples collected in 2016 contained no measurable deposition of coal dust. Of the remaining samples, the amount of coal deposited did not exceed 3 mg/m$^2$/day.

The 2016 coal deposition results show a continuing reduction in overall emissions of coal to the atmosphere along the rail corridor (as illustrated in Table 7 and Figure 8). In 2016 the average coal dust deposition rate across the rail corridor as a whole was 0.4 mg/m$^2$/day, down from 0.6 mg/m$^2$/day in 2014-2015 and 7.9 mg/m$^2$/day prior to the commencement of the additional coal dust mitigation measures outlined in the Coal Dust Management Plan.

These coal deposition results demonstrate that the Coal Dust Management Plan coal dust mitigation measures continue to be highly effective in reducing coal dust loss from loaded rail wagons during transport.

**Table 6. Approximate mass deposition results for different particle types, January to December 2016.**

| Station and month | Insoluble dust deposition rate (mg/m²/day)[a] | | Approximate dust particle type deposition rate (mg/m²/day)[b] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Coal dust | | Soil and rock dust | | Other particle types | |
| ***Cannon Hill*** | ***North*** | ***South*** | ***North*** | ***South*** | ***North*** | ***South*** | ***North*** | ***South*** |
| January | 30 | 52 | 1 | 0 | 28 | 50 | 1 | 2 |
| February | 41 | 47 | 2 | 2 | 37 | 43 | 3 | 2 |
| March | 29 | 38 | 0 | 0 | 28 | 35 | 1 | 3 |
| April | 37 | 58 | 1 | 2 | 33 | 52 | 3 | 4 |
| May | 22 | 29 | 1 | 2 | 18 | 17 | 2 | 10 |
| June | 13 | 44 | 1 | 3 | 9 | 36 | 3 | 6 |
| July | 17 | 31 | 0 | 0 | 15 | 29 | 2 | 2 |
| August | 31 | 36 | 0 | 0 | 26 | 32 | 5 | 4 |
| September | 23 | 42 | 0 | 0 | 19 | 31 | 4 | 11 |
| October | 42 | 66 | 1 | 1 | 38 | 63 | 4 | 2 |
| November | 33 | 36 | 1 | 0 | 31 | 35 | 1 | 1 |
| December | 44 | 65 | 0 | 0 | 43 | 65 | 1 | 0 |
| ***Fairfield*** | ***West*** | | ***West*** | | ***West*** | | ***West*** | |
| January | 31 | | 0 | | 29 | | 2 | |
| February | 32 | | 1 | | 25 | | 5 | |
| March | 15 | | 0 | | 12 | | 3 | |
| April | 27 | | 1 | | 21 | | 5 | |
| May | 24 | | 0 | | 18 | | 6 | |
| June | 21 | | 0 | | 13 | | 8 | |
| July | 19 | | 0 | | 18 | | 1 | |
| August | 25 | | 0 | | 23 | | 2 | |
| September | 29 | | 0 | | 20 | | 9 | |
| October | 16 | | 0 | | 15 | | 1 | |
| November | no data[c] | | no data[c] | | no data[c] | | no data[c] | |
| December | no data[c] | | no data[c] | | no data[c] | | no data[c] | |
| ***Toowoomba*** | ***East*** | ***West*** | ***East*** | ***West*** | ***East*** | ***West*** | ***East*** | ***West*** |
| January | invalid[d] | no data[c] | invalid[d] | no data[c] | invalid[d] | no data[c] | invalid[d] | no data[c] |
| February | 27 | 38 | 0 | 2 | 23 | 30 | 4 | 6 |
| March | 46 | 31 | 0 | 0 | 40 | 29 | 6 | 2 |
| April | 3 | 22 | 0 | 0 | 3 | 18 | 0 | 4 |
| May | no data[c] | 38 | no data[c] | 0 | no data[c] | 29 | no data[c] | 9 |
| June | 7 | 28 | 0 | 0 | 5 | 23 | 1 | 5 |
| July | 76 | 37 | 1 | 0 | 72 | 31 | 2 | 6 |
| August | 37 | 31 | 0 | 0 | 33 | 26 | 4 | 5 |
| September | 47 | 25 | 0 | 0 | 37 | 20 | 10 | 5 |
| October | 32 | 40 | 1 | 0 | 28 | 37 | 3 | 3 |
| November | 51 | 74 | 0 | 0 | 50 | 73 | 1 | 1 |
| December | 36 | 80 | 0 | no data[e] | 36 | no data[e] | 0 | no data[e] |

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 mg/m²/day (averaged over a one month period) to minimise dust nuisance impacts.
[b] the approximate coal dust deposition rate was derived by applying typical particle type densities to the surface area proportion results from the particle composition analysis.
[c] sampling equipment vandalised.
[d] sample assessed as being invalid due to tampering, and not indicative of dust depositing from the air.
[e] laboratory error.

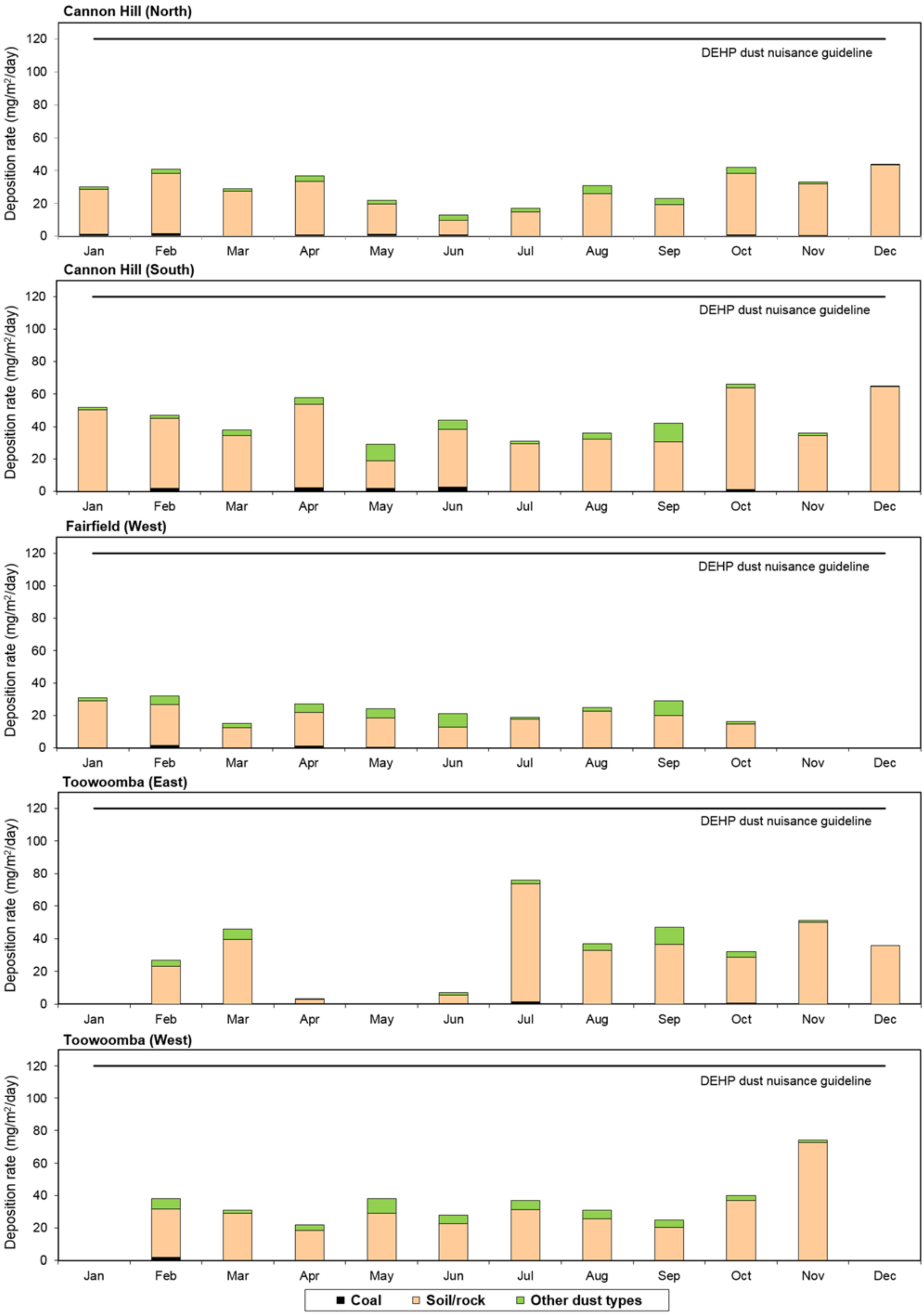


**Figure 7. Deposition rates for different particle types at rail corridor monitoring sites in 2016.**

**Table 7. Average coal deposition rates at rail corridor monitoring locations, before and following implementation of the South West System Coal Dust Management Plan coal dust mitigation actions.**

| Monitoring period | Average coal deposition rate (mg/m²/day) | | | |
|---|---|---|---|---|
| | Coorparoo / Cannon Hill | Fairfield | Willowburn / Toowoomba | Rail corridor average |
| March to April 2013 (no Coal Dust Management Plan actions) | 13.0 | 5.5 | 3.0 | **7.9** |
| May to June 2013 (limited Coal Dust Management Plan actions) | 2.5 | 1.3 | 0.5 | **1.5** |
| 2014 to 2015 (full Coal Dust Management Plan actions) | 0.7 | 0.4 | 0.6 | **0.6** |
| 2016 (full Coal Dust Management Plan actions) | 0.7 | 0.3 | 0.2 | **0.4** |

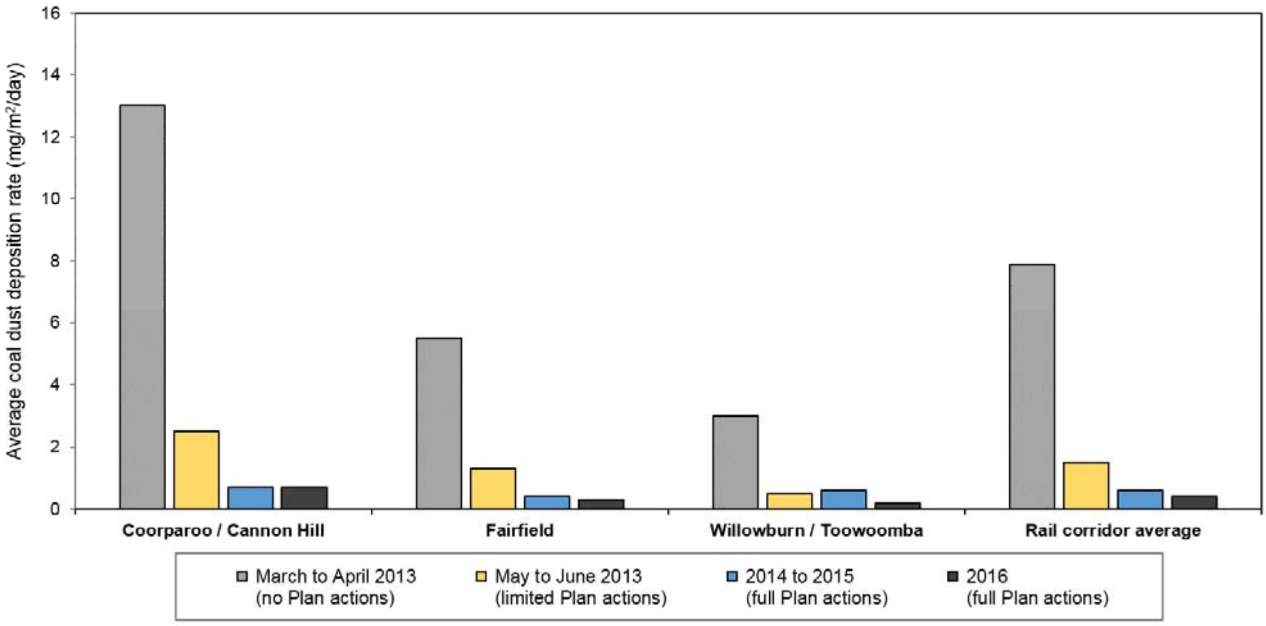


**Figure 8. Trend in coal deposition rates at the rail corridor monitoring locations.**

# Conclusions

This report presents the results from the Phase 2 monitoring program for the period January to December 2016.

$PM_{10}$ concentrations recorded at the Cannon Hill (North) monitoring site complied with the AAQ NEPM annual standard and the EPP Air 24-hour objective for protection of human health in 2016.

$PM_{2.5}$ concentrations recorded at the Cannon Hill (North) monitoring site complied with the EPP Air annual objective for protection of human health in 2016. The $PM_{2.5}$ EPP Air 24-hour objective for protection of human health was exceeded at Cannon Hill (North) on one day during the reporting period, however it was determined that this exceedance was not due to rail transport emissions, but to long-range transport of smoke from inland areas.

TSP concentrations recorded at the Cannon Hill (North) monitoring site in 2016 complied with both the EPP Air health-based annual objective and the DEHP Air Impacts Guideline 24-hour dust nuisance limit value for residential areas.

Measured dust deposition rates (resulting from all sources including coal trains) at all monitoring sites complied with the Department of Environment and Heritage Protection guideline for avoidance of dust nuisance of 120 mg/m$^2$/day during 2016. Maximum dust deposition rates at individual monitoring sites during 2016 ranged from 32 mg/m$^2$/day to 80 mg/m$^2$/day.

Soil and rock particles were again the largest contributor to measured insoluble dust mass deposition rates at the rail corridor monitoring sites in 2016, regularly comprising more than 80 per cent of the total deposited mass in individual samples.

The mass of coal deposited was very low, with the annual average coal dust deposition rate at each of the three monitoring locations during 2016 being less than 1 mg/m$^2$/day. Across the three monitoring locations, 67 per cent of all valid deposited dust samples collected in 2016 contained no measurable deposition of coal dust. Of the remaining samples, the amount of coal deposited did not exceed 3 mg/m$^2$/day.

The 2016 coal deposition results show a continuing reduction in overall emissions of coal to the atmosphere along the rail corridor. In 2016 the average coal dust deposition rate across the rail corridor as a whole was 0.4 mg/m$^2$/day, down from 0.6 mg/m$^2$/day in 2014-2015 and 7.9 mg/m$^2$/day prior to the commencement of the additional coal dust mitigation measures outlined in the South West System Coal Dust Management Plan.

The Phase 2 monitoring results for 2016 confirm that the South West System Coal Dust Management Plan coal dust mitigation measures continue to be highly effective in reducing the loss of coal dust from loaded rail wagons during transport.