14. APPENDIX A - REVIEW OF DUST FROM COAL TRAINS IN QUEENSLAND REPORT: PREPARED BY KATESTONE ENVIRONMENTAL LTD

Review of Dust from Coal Trains in Queensland, report to the Senate Standing Committee on Community Affairs Inquiry: "The impacts on health of air quality in Australia"

Prepared for

Queensland Resources Council

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Final

Prepared by

Katestone Environmental Pty Ltd
ABN 92 097 270 276
Ground Floor, 16 Marie Street
PO Box 2217
Milton, Queensland, Australia 4064

www.katestone.com.au
environmental@katestone.com.au
Ph +61 7 3369 3699
Fax +61 7 3369 1966

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Prepared by: Andrew Vernon and Michael Burchill

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Contents

Tables

Figures

Glossary

Term	Definition
Units of measurement	
g/m^2	gram per square metre
g/km/wagon	gram per kilometre per wagon
km	kilometre
km/hr	kilometre per hour
m	metre
mm	millimetre
$mg/m^2/day$	milligram per square metre per day
Mt	million tonnes
Mtpa	million tonnes per annum
t	tonne
µm	micron
$\mu g/m^3$	microgram per cubic metre

Air pollutants and chemical nomenclature

TSP	Total Suspended Particulates
PM_{10}	particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than 2.5 microns

Other abbreviations

Air EPP	Environmental Protection (Air) Policy
Air NEPM	National Environmental Protection Measure (Ambient Air Quality)
ARTC	Australian Rail Track Corporation
AS	Australian Standard
BREE	Bureau of Resources and Energy Economics
CFD	Computational Fluid Dynamics
DEHP	Department of Environment and Heritage Protection
DEM	Dust Extinction Moisture
DSITIA	Department of Science, Information Technology, Innovation and Arts
EP Act	Environmental Protection Act 1994
NPI	National Pollutant Inventory
NSW OEH	New South Wales Office of Environment and Heritage
PRP	Pollution Reduction Program
TEOM	Tapered Element Oscillating Microbalance

Review Summary

In the 2011 - 2012 financial year approximately 300 million tonnes (Mt) of coal produced in Australia was exported to overseas markets (BREE, 2012). The Queensland coal industry is the largest in Australia with an estimated 34 billion tonnes of raw coal resources currently identified from drilling operations. A large proportion of coal production in Queensland is destined for overseas market. Recently there has been concern in some communities regarding potential health and amenity impacts that they associate with coal trains that pass through their communities during coal transit from mine to export terminal.

This review of the available literature seeks to answer the following questions in relation to coal trains:

- *Is there evidence that coal dust is emitted from coal trains in transit?*
- *If so, what are the sources of coal dust emissions from coal trains?*
- *Further, what factors influence coal dust emissions from coal trains?*
- *What are the potential effects of coal dust in the community?*
- *Has air quality monitoring been conducted in the vicinity of rail corridors carrying coal trains and what does this monitoring show?*
- *If significant coal dust emissions are occurring can they be managed so they do not adversely impact the communities?*

This review is to be submitted by the Queensland Resources Council (QRC) to the Senate Standing Committee on Community Affairs Inquiry on "The impacts on health of air quality in Australia".

Background on coal production and transport in Queensland

In Queensland the largest and most active areas of existing and proposed coal production are the Clarence-Moreton Basin coal measure in southeast Queensland, the Surat Basin coal measure in south central Queensland, the Bowen Basin coal measure in central Queensland, and the Galilee Basin coal measure in central west Queensland.

Coal extracted from these areas is transported to one of six active coal export terminals via rail systems. There are five rail systems that connect the mines to the export terminals:

- *Western System - connects to the Port of Brisbane*
- *Moura System - connects to the Port of Gladstone (two active terminals with a third under construction)*
- *Blackwater System – also connects to the Port of Gladstone*
- *Goonyella System - connects to the Port of Hay Point south of Mackay (two active terminals). The Goonyella Abbot Point (GAP) Expansion connects the Goonyella System to the Newlands System and thereby connecting to the Port of Abbot Point.*
- *Newlands System - connects to the Port of Abbott Point (near Bowen)*

The Goonyella System is the most active in Queensland and carries approximately 50% of the coal exported per annum to the Port of Hay Point south of Mackay. In 2010-2011, QR National estimated that 20 trains per day travelled on the Goonyella System with an average train payload of 10,000 tonnes. The Western System to the Port of Brisbane carries the smallest amount of coal per annum, but passes through the most urbanised area. In 2010-2011, QR National estimated that 9 trains per day travelled on the Western System with an average train payload of 1,925 tonnes.

Is there evidence that coal dust is emitted from coal trains in transit?

There is both theoretical information and reported observations that provide evidence that coal dust may be emitted from coal trains in transit. Coal is a naturally occurring geological material that can become dusty if it is crushed and dried. Dust complaints were received by QR Limited over a number of years in relation to coal trains in central Queensland (Connell Hatch, 2008). Occasionally complaints cited visible dust emissions from coal trains.

What are the sources of coal dust emissions from coal trains?

Coal dust can be emitted from the following activities and sources on a typical coal rail system:

- *Erosion of the coal surface of loaded wagons (primarily during transit)*
- *Coal leakage from doors of loaded wagons*
- *Wind erosion of spilled coal in the rail corridor*
- *Residual coal in unloaded wagons and leakage of residual coal from doors*
- *Parasitic load on sills, shear plates and bogies of wagons*

What factors influence coal dust emissions from coal trains?

The amount and rate of coal dust emitted from coal trains is variable and is dependent upon the following factors:

- *Surface area of coal exposed to air currents*
- *Coal properties - dustiness*
- *Train speed*
- *Train vibration*
- *Transport distance and route characteristics*
- *Load characteristics, such as the shape or profile of load*
- *Amount of precipitation*
- *The extent and effectiveness of dust controls*

Experience in central Queensland suggests that wagons with an uneven or undulating load profile and wagons that are overloaded can be an important cause of dust emissions and coal deposition within and potentially beyond the rail corridor. Deposition of coal into the ballast that supports the tracks can damage the track foundation. Fortunately, a range of actions can be readily implemented to reduce coal loss in transit by improving the load profile to a flat "garden bed" shape. These approaches are being progressively implemented at mines in central Queensland.

What are the potential effects of coal dust on the community?

Generically, dust or particulate matter can have a variety of health and amenity effects depending on the concentration, the size of particles and the exposure time. Studies have linked increases in hospital admissions to elevated particulate matter exposure. Health effects associated with exposure to elevated levels of particulate matter include: coughing, sneezing, wheezing and increased breathlessness. Potential amenity effects of elevated dust levels include short term reduction in visibility, build up of particulate matter on homes and soiling of washing.

The Queensland Government, through the Environmental Protection Act 1994, has provided for the protection of the air environment through the creation of the Environmental Protection (Air) Policy (Air EPP), 2008. The Air EPP defines air quality objectives for over 90 air pollutants, including particulate matter. The Air EPP objectives are used to ensure protection of human health, wellbeing and biological integrity of the air environment. This is *done by comparing measured or predicted concentrations of air pollutants with the Air EPP objectives.*

Has air quality monitoring been conducted in the vicinity of rail corridors carrying coal trains and what does this monitoring show?

A review of studies that have conducted air quality monitoring in the corridor and around rail systems has shown that whilst coal dust and the influence of coal trains on dust levels has been detected, the levels of coal dust were found to be well below the air quality objectives for the protection of human health and amenity impacts. The studies showed that outside of the rail corridor, defined as approximately 10 metres from the tracks, coal dust concentrations were much lower than within the corridor and were below air quality objectives for the protection of human health and amenity.

Future ambient air monitoring studies are proposed along the Western Rail System (Brisbane).

Can dust emissions be managed so they do not adversely impact the communities?

A comprehensive set of measures to control dust lift-off from coal trains was developed by Aurizon (and its predecessors Queensland Rail and QR National) and represents leading practice in Australia.

Working with the environmental regulator and mining companies, Aurizon, the rail operator in central Queensland, has successfully implemented a program to ensure that coal dust emissions from coal trains are adequately managed. Following an extensive study of the issue and a cost benefit analysis of potential solutions, actions detailed in Section 7.2 are being implemented across the central Queensland coal supply chain.

One of the main actions to date is the implementation of veneering stations at loadout facilities of central Queensland coal mines. Application of a veneer to the coal surface of a loaded wagon ensures coal dust lift-off is reduced. The degree of reduction will depend on a range of conditions, but wind tunnel studies suggest that a reduction in coal dust lift-off of better than 85% is achievable. At the end of 2012, 57% of coal mines in central Queensland had veneering stations installed and by the end of 2013 all mines in central Queensland will have veneering stations installed at their loadout facilities. Coal dust monitoring results to date along the central Queensland rail systems indicate a reduction in dust from trains.

A similar strategy, with a focus on initial monitoring is being implemented for the Western Rail System (Brisbane), and a coal mine that uses the System has recently committed to the installation of a veneering station at the rail loadout facility.

Timeframe	*Actions for Central Queensland Coal Supply Chain*
Current (2010-2013)	*Implementation of effective dust suppression (veneering) strategy across the central Queensland coal supply chain*
	Train speed indicators
	Sill brushes to remove parasitic load
	Profile design of chute loaders to improve load profiling
	Effective loading procedure to avoid overloading
	Community liaison
	Procedural review and operational training to avoid overloading and improve load profiling
	Coal dust removal (ballast cleaning)
	Coal dust monitoring systems
	Modify existing unloading facilities to avoid coal remaining in wagons and potential spillage associated with carry-back
	Wheel washing
Short - Medium Term (3-5 years)	*Ballast spoil management*
	Wagon loading practices and wagon design to avoid overloading and improve load profiling
	Load-out facility infrastructure to avoid overloading and improve load profiling
	Coal moisture regulating system
	Internal communications
	Wagon vibrators to avoid coal remaining in wagons and potential spillage associated with carry-back
	Coal type testing for dustiness

1. Introduction

In the 2011 - 2012 financial year approximately 300 million tonnes (Mt) of coal produced in Australia was exported to overseas markets, with an estimated value of AUS$47 billion (BREE, 2012). With a rich endowment of approximately 34 billion tonnes (raw coal in-situ) (Department of Natural Resources and Mines, 2012a), Queensland's coal industry is the largest in Australia and a major contributor to Queensland's economy.

In recent years dust emissions associated coal trains and, to a lesser extent coal trucks, have had media attention, particularly in the lower Hunter region of NSW and in southeast Queensland. The articles cite community concerns about the expansion of the coal industry and the potential impacts on health and amenity.

Katestone Environmental Pty Ltd (Katestone) has been commissioned by the Queensland Resources Council (QRC) to undertake a review of studies addressing the effect of coal trains on air quality. The intention is that this review will be included in QRC's submission to the current inquiry by the Senate Standing Committee on Community Affairs titled - "*The impacts on health of air quality in Australia*"

This review has considered studies that have investigated the effect of coal trains on air quality, specifically looking at impacts of coal dust emissions from trains during transit between mine and export terminal. The study has focused on Queensland as the majority of literature and studies have been undertaken on coal transportation in Queensland. The review has also considered other studies that have been undertaken across Australia and intentionally.

This review has been structured to include the following sections:

- Summary of present Queensland coal industry
- Description of coal dust, the potential health effects and current legislation
- Explanation of how coal dust is released into the air during transit
- Factors that contribute to coal dust emissions
- Review of studies that measured air quality in the rail corridor
- Management and mitigation techniques to reduce coal dust emissions

2. Coal production and transport in Queensland

Australia has a rich coal resource. The Australian Government's Bureau of Resources and Energy Economics (BREE) reported that in 2011 -2012, annual coal production in Australia was 347.2 million tonnes (Mt) (BREE, 2012). In 2011 - 2012 approximately 300 Mt, or 86%, of coal produced in Australia was exported, with an estimated market value of AUS$47 billion (BREE, 2012).

The Queensland coal industry is the largest in Australia with an estimated resource of 34 billion tonnes (raw coal in-situ) (Department of Natural Resources and Mines, 2012a). In 2011 total saleable coal production in Queensland was 174 Mt, with 160 Mt being exported (Department of Natural Resources and Mines, 2012b). In 2011, approximately 56% of Australia's total coal export occurred from Queensland.

Queensland's coal deposits are spread right across the state as shown in Figure 1. At the end of the 2011-2012 financial year there were 55 active mines in Queensland, composed of 44 open cut mines and 11 underground mines (Department of Natural Resources and Mines, 2012b).

The largest and most active areas of Queensland for existing and proposed coal extraction are the Clarence-Moreton Basin coal measure in southeast Queensland, the Surat Basin coal measure in south central Queensland, the Bowen Basin coal measure in central Queensland, and the Galilee Basin coal measure in central west Queensland. Figure 2, Figure 3 and Figure 4 respectively, provide details of these main coal mining areas in Queensland and include information on the location of existing and proposed mines.

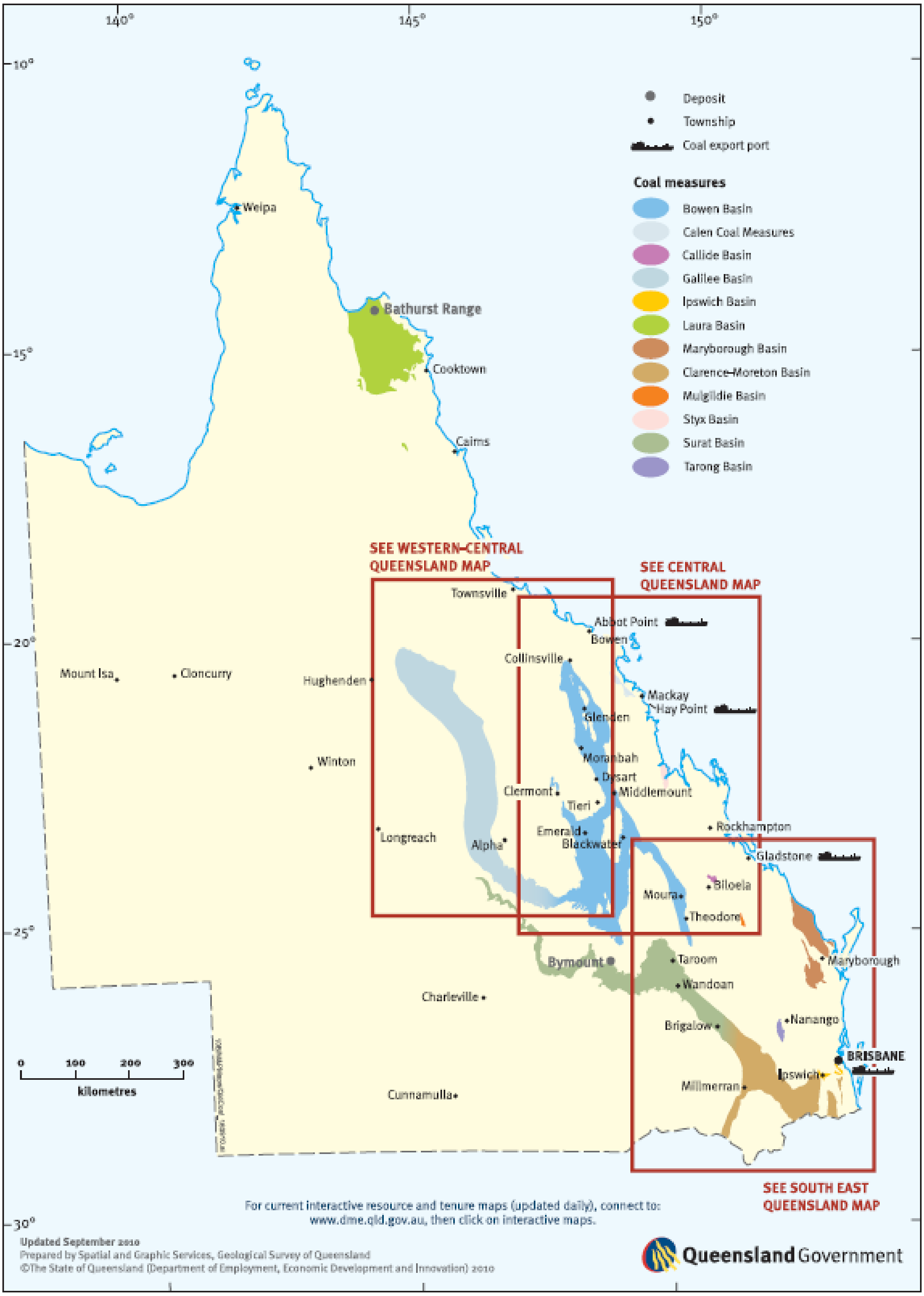


Figure 1 **Queensland Coal Measures Map (Queensland Department of Natural Resources and Mines, 2013)**

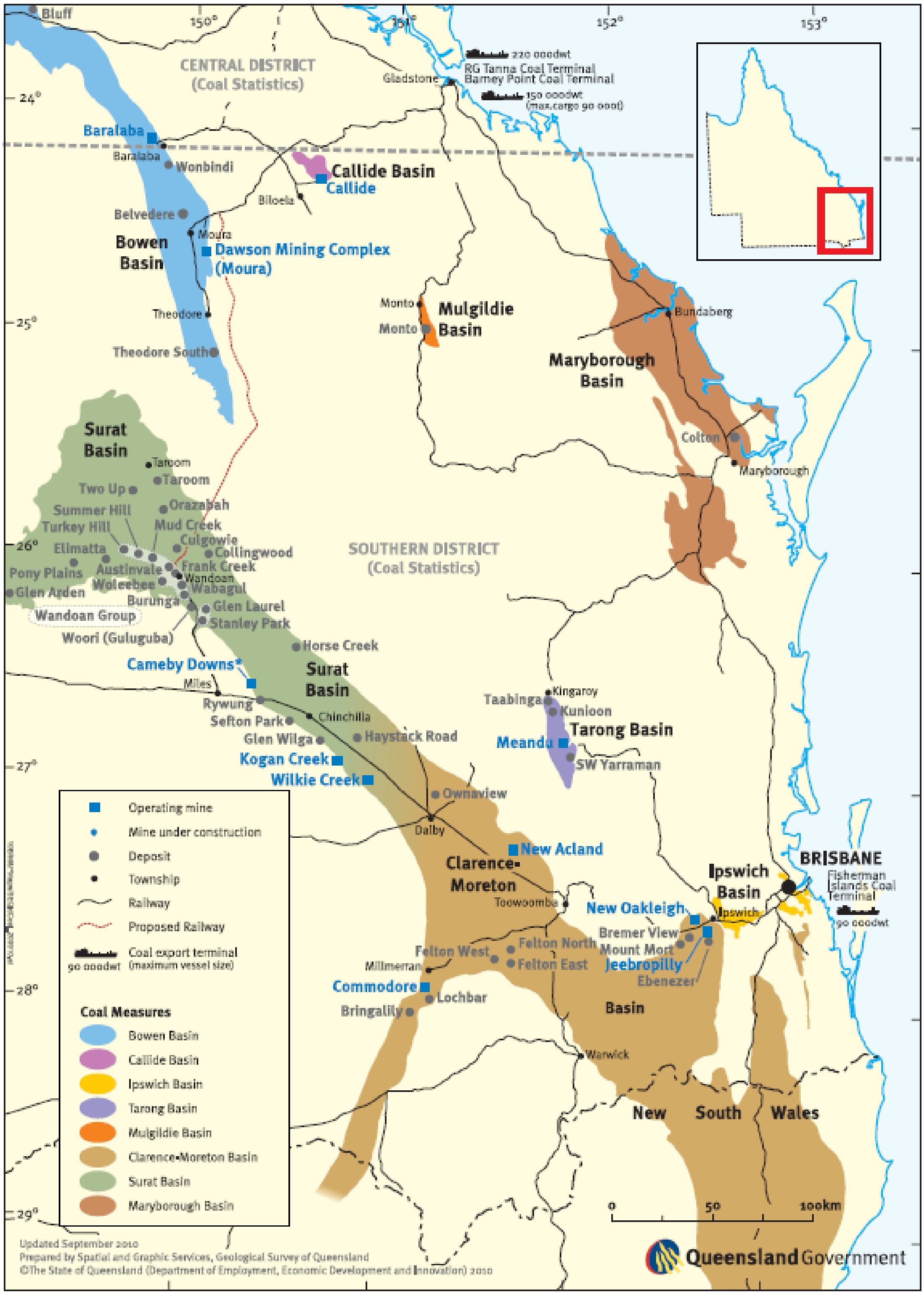


Figure 2 **Southeast Queensland Coal Measures Map (Queensland Department of Natural Resources and Mines, 2013)**

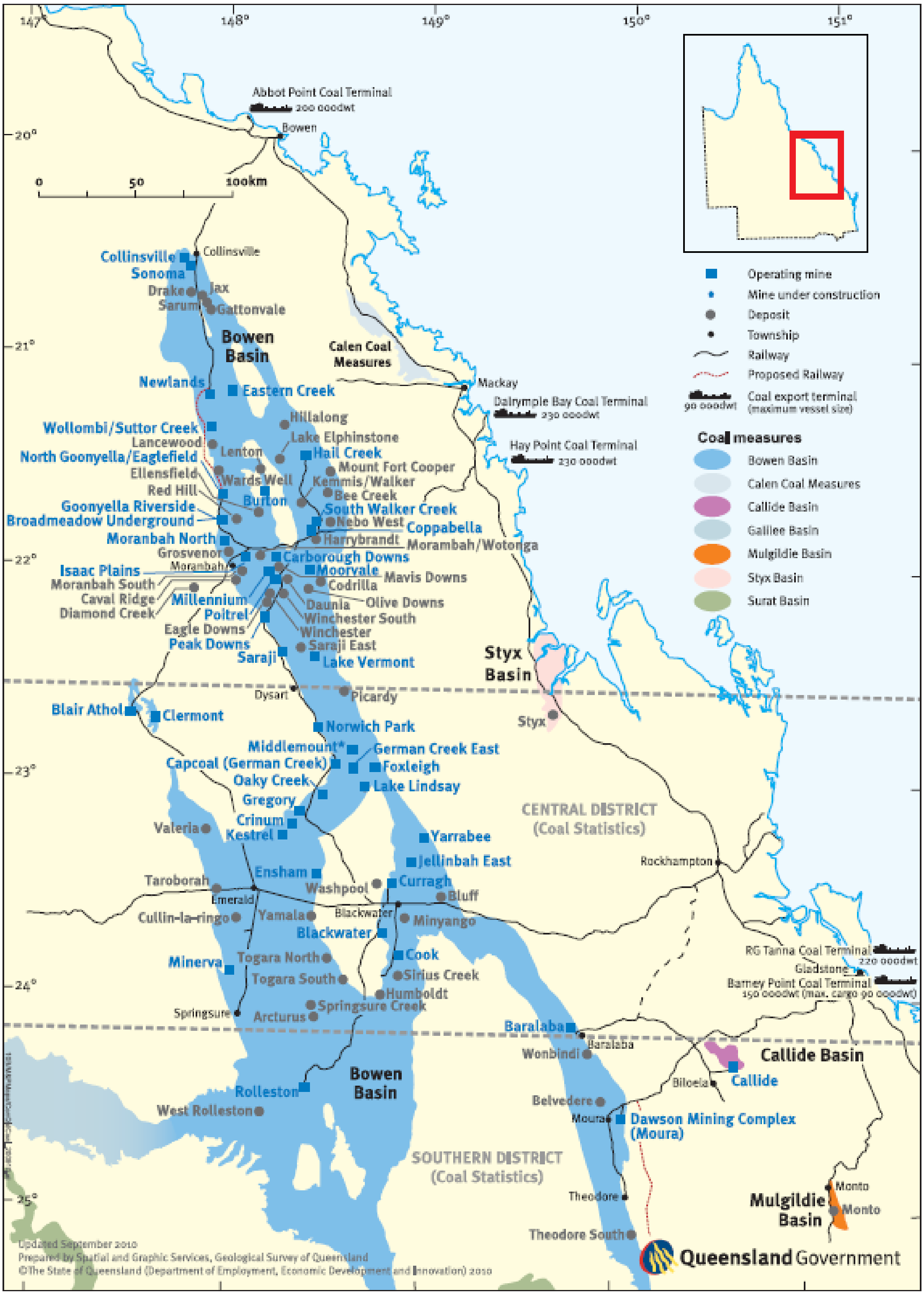


Figure 3 Central Queensland Coal Measures Map (Queensland Department of Natural Resources and Mines, 2013)

Figure 4 Western Central Queensland Coal Measures Map (Queensland Department of Natural Resources and Mines, 2013)

To facilitate the export of coal, a network of rail systems have been constructed to connect the mines with the coal export terminals. Rail is a cost effective and efficient method of transporting large quantities of coal over land, especially when the distance from mine to export terminal can be in excess of 200km.

There are currently six active coal export terminals, located on the Queensland coast, namely:

- Port of Brisbane
    - Fishermans Island Coal Terminal
- Port of Gladstone
    - RG Tanna Coal Terminal
    - Barney Point Coal Terminal
    - Wiggins Island Coal Terminal (under construction)
- Port of Hay Point
    - Hay Point Coal Terminal
    - Dalrymple Bay Coal Terminal
- Port of Abbot Point
    - Abbot Point Coal Terminal

2.1 Annual coal movements

Table 1 and Figure 5 show the annual coal export (million tonnes) from each coal export terminal in Queensland over the last 5 years. Table 2 shows the amount of coal exported from each Queensland export terminal over the past five years as a percentage of the total.

The data shows that every year for the past 5 years, over 150 Mtpa of coal has been exported from Queensland export terminals. The most active export terminals are the Dalrymple Bay coal terminal south of Mackay, Gladstone (which includes two export terminals - the majority of coal is shipped through the RG Tanna coal terminal) and Hay Point coal terminal south of Mackay. The Port of Brisbane exports the smallest amount of coal of all the Queensland export terminals, although exports have doubled over the last 5 years to almost 9 Mtpa.

Table 1 Annual coal export from Queensland coal export terminals (million tonnes) (Department of Natural Resources, 2012b)

Coal Terminal	2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012
Abbot Point	11.15	12.54	14.44	16.93	15.06	13.60
Brisbane	4.14	5.50	6.24	6.30	6.61	8.84
Dalrymple Bay	50.35	42.97	48.00	63.50	54.69	50.97
Gladstone*	51.43	53.94	56.13	60.10	53.04	59.40
Hay Point	36.22	37.13	35.16	36.29	33.07	31.98
Total	**153.29**	**152.08**	**159.97**	**183.12**	**162.47**	**164.79**

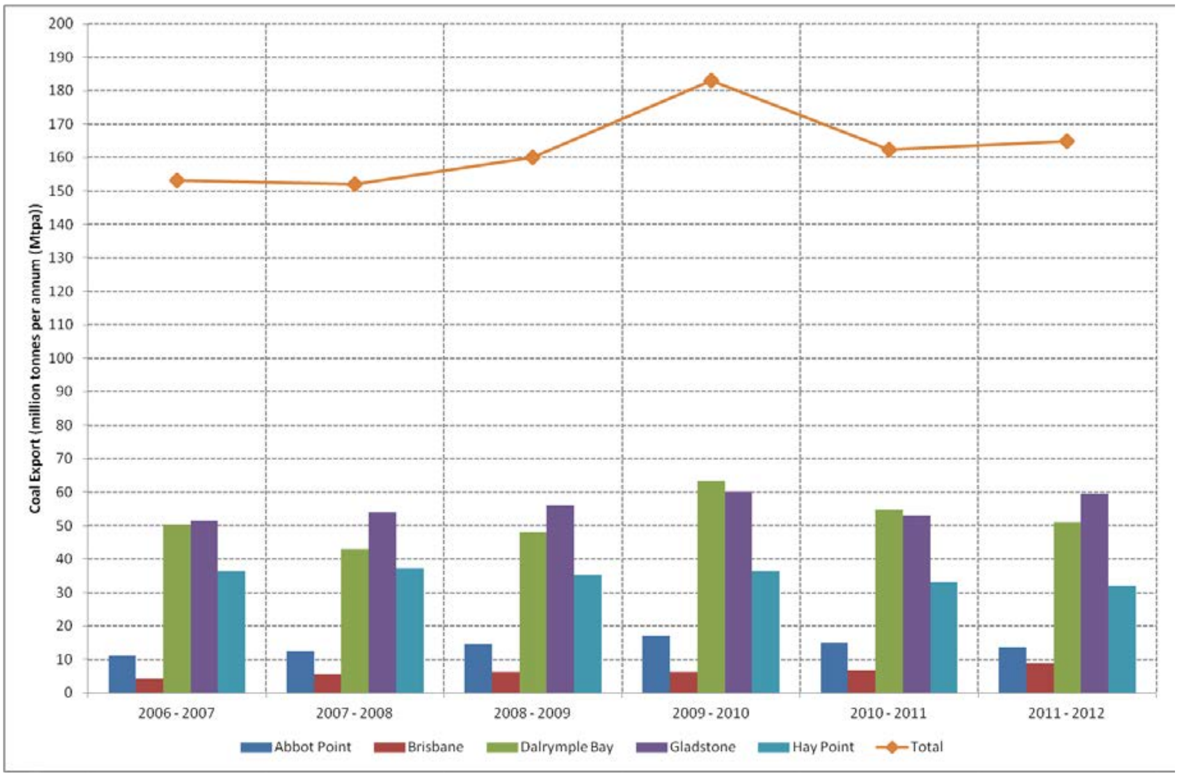
Table note:
* Includes RG Tanna and Barney Points coal export terminals

Table 2 Annual coal export from Queensland coal export terminals (percent of total) (Department of Natural Resources, 2012b)

Coal Terminal	2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012
Abbot Point	7%	8%	9%	9%	9%	8%
Brisbane	3%	4%	4%	3%	4%	5%
Dalrymple Bay	33%	28%	30%	35%	34%	31%
Gladstone*	34%	35%	35%	33%	33%	36%
Hay Point	24%	24%	22%	20%	20%	19%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table note:
* Includes RG Tanna and Barney Points coal export terminals

Figure 5 Annual coal export from Queensland coal export terminals (million tonnes) (Department of Natural Resources, 2012b)



2.2 Queensland coal rail system

There are five coal railway systems that connect the coal mines to the export coal terminals in Queensland. The five rail systems are shown in Figure 6 and are listed from south to north below:

- Western System
- Moura System
- Blackwater System
- Goonyella System
- Newlands System

2.2.1 Western System

The Western System transports coal from mines in the Clarence-Moreton and Surat Basins to the Fishermans Island Coal Terminal at the Port of Brisbane. Coal trains on this system use the Brisbane City network owned by Queensland Rail.

In 2010-2011, QR National estimated that 6.65 Mt of coal was hauled on this system, which amounted to 3,453 train services with an average payload of 1,925 tonnes (QR National, 2011a). It is noted that tonnages for this year were affected by widespread flooding and that a proportion of the train services were to the Swanbank Power Station, which closed in 2012.

Table 2 shows that the Fishermans Island Coal Terminal at the Port of Brisbane accounted for between 3-5% of the total coal exported from Queensland over the last 5 years, the smallest amount from the Queensland export terminals

2.2.2 Moura and Blackwater System

The Moura System transports coal from mines in the Callide and south-eastern Bowen Basins to the coal export terminals in Gladstone (RG Tanna and Barney Point). The Moura System also provides coal to the Gladstone Power Station and the Gladstone operations of Queensland Alumina Limited and Rio Tinto Aluminium.

In 2010-2011, QR National estimated that 10 Mt of coal was hauled on this system which amounted to 1,992 train services with an average payload of 5,022 tonnes (QR National, 2011b). It is noted that tonnages for this year were affected by widespread flooding and rainfall.

The Blackwater System transports coal from mines in the southern Bowen Basin to the export terminals at the Port of Gladstone (RG Tanna and Barney Point) and the Stanwell Power Station. The Blackwater system includes the North Coast rail line, which also carries passenger and freight trains travelling between Cairns and Brisbane.

In 2010-2011, QR National estimated that 45.8 Mt of coal was hauled on this system which amounted to 5,978 train services with an average payload of 7,667 tonnes (QR National, 2011c). It is noted that tonnages for this year were affected by widespread flooding and rainfall.

Table 2 shows that the amount of coal transported on the Moura and Blackwater Systems to the export terminals in Gladstone (RG Tanna and Barney Point) ranges from 33-36% of the total coal exported from Queensland over the last 5 years. A third coal export terminal (Wiggins Island) and associated rail infrastructure in Gladstone is currently under construction and is expected to result in an increased amount of coal transported on these rail systems upon completion in 2014.

2.2.3 Goonyella System

The Goonyella System transports coal from mines in the northern Bowen basin to the Hay Point and Dalrymple Bay export terminals south of Mackay. In 2010-2011, QR National estimated that 74.1 Mt of coal was hauled on this system which amounted to 7,409 services with an average payload of 10,000 tonnes (QR National, 2011d). It is noted that tonnages for this year were affected by widespread flooding and rainfall.

The Goonyella System is already the largest metallurgical coal rail system in the world and is currently undergoing expansion to increase the rail capacity by a further 11 Mt per year (QR National, 2011d).

Table 2 shows that the amount of coal transported on the Goonyella System to the Hay Point and Dalrymple Bay export terminals range from 50-56% of the total coal exported from Queensland over the last 5 years.

2.2.4 Newlands System

The Newlands System transports coal from mines in the northern Bowen Basin to the Abbot Point Coal Terminal near Bowen. In 2010-2011 QR National estimated that 15.4 Mt of coal was hauled on this system which amounted to 3,047 services with an average payload of 5,054 tonnes (QR National, 2011e). It is noted that tonnages for this year were affected by widespread flooding and rainfall.

Table 2 shows that the amount of coal transported on the Newlands System to Abbot Point export terminal ranges from 7-9% of the total coal exported from Queensland over the last 5 years. The Newlands System will increase in capacity to approximately 50 Mtpa as works to link the Newlands and Goonyella Systems via the GAP Expansion, which was opened in December 2011.

2.2.5 Summary

Table 3 provides a summary of Queensland's coal rail systems for the 2010-2011 financial year.

Table 3 Summary of Queensland's coal rail systems for 2010-2011

Facts	Coal Rail System*				
	Western	**Moura**	**Blackwater**	**Goonyella**	**Newlands**
Coal export terminal	Fishermans Island (Brisbane)	RG Tanna and Barney Point (Gladstone)	RG Tanna and Barney Point (Gladstone)	Hay Point and Dalrymple Bay (Port of Hay Point)	Abbot Point (Port of Abbot Point)
Coal haulage	6.65 Mt	10 Mt	45.8 Mt	74.1 Mt	15.4 Mt
Coal train services (year)	3,435	1,992	5,978	7,409	3,047
Coal train services (day)	9	5	16	20	8
Average payload	1,925 t	5,022 t	7,667 t	10,000 t	5,054 t

Table note:
* Data extracted from QR National Coal Rail Systems Factsheets

Figure 6 Queensland Coal Rail Systems Map (extracted from Queensland Department of Infrastructure and Planning, 2010)

3. Health effects associated with particulate matter

3.1 Definitions of particulate matter

Particulate matter is a term used to define solid or liquid particles that may be suspended in the atmosphere. Particulate matter is a generic term that is commonly used interchangeably with other terms such as smoke, soot, haze and dust (including coal dust). The potential effect of particulate matter on the environment, human health and amenity depends on the size of the particles, the concentration of particulate matter in the atmosphere and the rate of deposition.

Concentration is the mass of particulate matter that is suspended per unit volume of air. Suspended particulate matter in ambient air is usually measured in micrograms per cubic metre ($\mu g/m^3$). Deposition is the mass of particulate matter that settles per unit surface area. Deposited particulate matter is usually measured as the mass in grams that accumulates per square metre (g/m^2) over a 1 month period.

Particulate matter with an aerodynamic diameter greater than 10 micrometres (µm) tend to be associated with amenity impacts, while particulate matter less than 10 µm are associated with health impacts. For this reason, particulate matter is sub-divided into a number of metrics based on particle size. These metrics are total suspended particulates (TSP), PM_{10}, $PM_{2.5}$ and dust deposition rate:

- TSP refers to the total of all particles suspended in the air. When TSP is measured using a high volume air sampler, the maximum particle size has been found to be approximately 30 µm (US EPA, 2010). TSP was first used as a human health metric, but research has found a poor correlation between the concentration of TSP and health effects. TSP is now used as a metric of the potential for particulate matter to affect amenity.
- PM_{10} is a subset of TSP (US EPA, 2010) and refers to particles suspended in the air with an aerodynamic diameter less than 10 µm.
- Coarse particulate matter (US EPA, 2010) is a subset of TSP and PM_{10} and refers to particles suspended in the air with an aerodynamic diameter between 2.5 and 10 µm.
- $PM_{2.5}$ is a subset of TSP and PM_{10} and refers to particles suspended in the air with an aerodynamic diameter less than 2.5 µm. $PM_{2.5}$ is also called fine particulate matter (US EPA, 2010).
- Dust deposition rate is the mass of particulate matter that collects on an area over a one month period. Dust deposition rate is used as a metric of the potential for particulate matter to affect amenity.

The atmospheric lifetime of particulate matter, that is how long the particle is airborne, depends on the size of the particle with coarse particulate matter tending to deposit quickly and in relatively close proximity to its point of emission, whilst fine particulate matter may remain suspended in the atmosphere for many days and travel many hundreds of kilometres. The atmospheric lifetimes of particles and potential travel distances based on the particle size are summarised in Table 4 (USEPA, 1996). It should be noted that, whilst smaller particles have longer atmospheric lifetimes, they also disperse as they travels. Dispersion will quickly reduce the overall concentration of particles.

Table 4 Atmospheric lifetime and potential travel distance for particles of various size categories

Particle size	Description	Atmospheric lifetime	Travel distance
TSP	Total of all particles suspended in the atmosphere	Minutes to hours	Typically deposits within the proximate area downwind of the point of emissions
PM_{10}	A subset of TSP, including all particles smaller than 10 µm in diameter.	Days	Up to 100 kilometres or more
$PM_{2.5}$	A subset of the PM_{10} and TSP categories, including all particles smaller than 2.5 µm in diameter.	Days to weeks	Hundreds to thousands of kilometres

Figure 7 shows the sizes of particulate matter as $PM_{2.5}$ and PM_{10} relative to the average width of a human hair, which is 70 µm (US EPA, 2010).

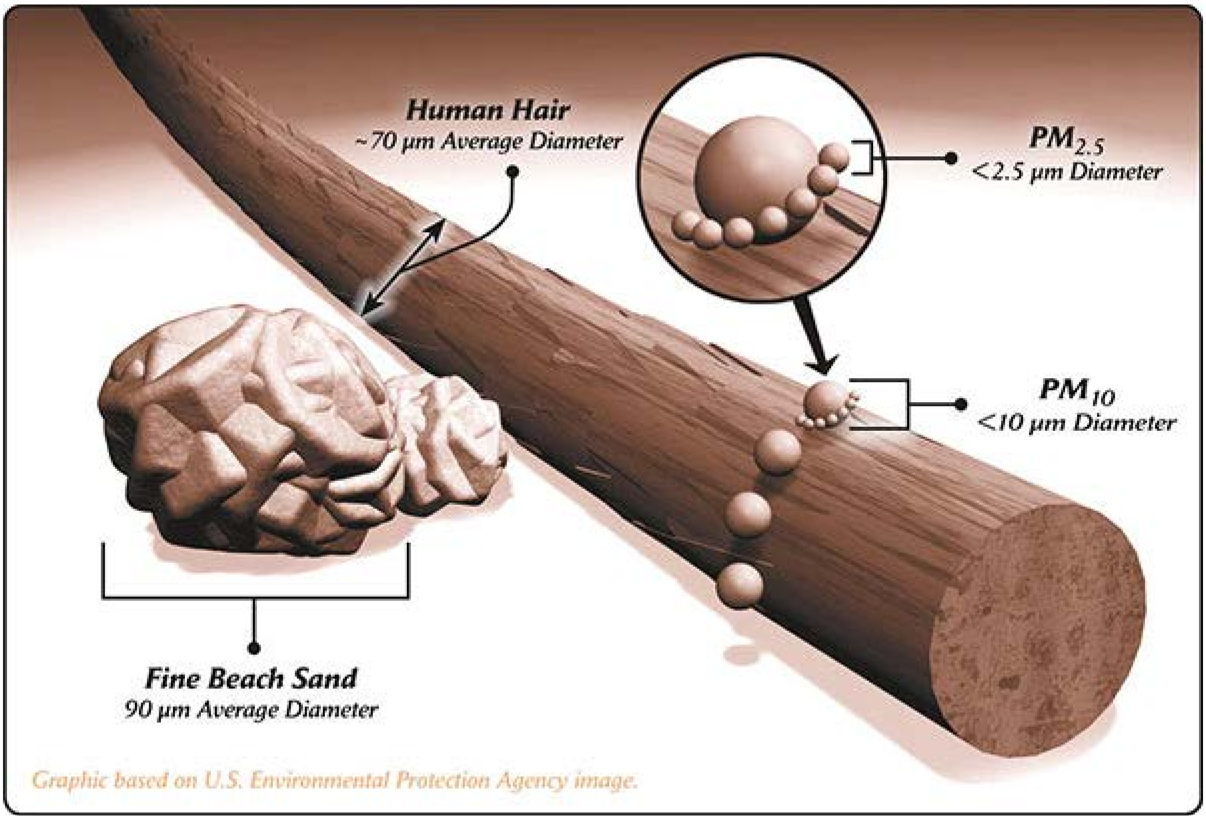


Figure 7 Sizes of particulate matter smaller than $PM_{2.5}$ and PM_{10} relative to the average width of a human hair

3.2 Amenity impacts of particulate matter

Amenity impacts can occur when levels of particulate matter become elevated (NSW Health, 2007). The following impacts on amenity are commonly noted:

- Short-term reduction in visibility. For example, at a local scale particulate matter may pass across a road and temporarily affect a driver's ability to see oncoming traffic. At a regional scale, a visible plume of particulate matter may adversely affect the aesthetics of the environment such as scenic views.
- Build up of particulate matter on surfaces within homes resulting in the occupant needing to clean more frequently.
- Soiling of washing.
- Build up of particulate matter on the roofs of houses and, during rainfall, the flushing of the particulate matter into rainwater tanks potentially affecting quality of drinking water or tank capacity.

3.3 Health effects of particulate matter

Particulate matter is the major air pollutant that is emitted from the transport of coal from mine to export terminal.

There is a demonstrated statistical association between health effects and the concentration of fine particulate matter. Generically, exposure to particulate matter can cause a variety of health effects (NSW Health, 2007). For example, numerous studies link levels of fine particulate matter to increased hospital admissions and emergency room visits. Both long (over years) and short term (hours or days) particle exposure has been linked to health problems.

The human body's respiratory system has a number of defence mechanisms to protect against the harmful effects of particulate matter (NSW, 2007). Coarse particulate matter may be trapped in the mucus on the walls of the airways and can be removed by cilia, small hair-like structures that line the surface of the airways. The particulate matter is expelled from the body by coughing or is swallowed.

However, recent studies Ono (Ono, 2007), Cowherd and Donaldson (Coward & Donaldson, 2005) and USEPA (USEPA, 2006) indicate that in susceptible sub-populations, fine particulate matter from combustion related sources are markedly more detrimental to health than coarse particulate fractions ($PM_{10-2.5}$). There is data associating PM_{10} from a combustion origin with health effects but this fraction also contains $PM_{2.5}$ (Drew, 2009) and, hence, the specific cause cannot be delineated.

There is clearly a fundamental distinction between particulate matter originating from the combustion of fuel and secondary chemical reactions, and mechanically generated crustal particulate matter. Where the former is generated for example by motor vehicles and power stations and consists predominantly of fine particulate matter ($PM_{2.5}$), the latter originates from earthworks and mining (including coal dust emissions from rail transit) and consists predominantly of coarse particulate matter (PM_{10}).

Ono (Ono, 2007), Cowherd and Donaldson (Coward & Donaldson, 2005) and USEPA (USEPA, 2006) noted there are clear distinctions between:

- The character of the ambient mix of particles generally found in urban areas as compared to that found in rural areas.
- The nature of the evidence concerning health effects associated with thoracic coarse particles generally found in urban versus rural areas.

Further, the mix of particles typically found in areas with combustion sources such as industrial sites and urban areas contain a number of contaminants that are not commonly present, or not present to the same degree, in the mix of natural crustal particles. Particles of crustal origin, which are predominately in the coarse fraction, appear to be relatively non-toxic under most circumstances, compared to combustion-related particles.

4. Air quality legislation

The *Environmental Protection Act 1994* (EP Act) provides for the management of the air environment in Queensland. The legislation applies to government, industry and individuals and provides a mechanism for the delegation of responsibility to other government departments and local government and provides all government departments with a mechanism to incorporate environmental factors into decision-making.

The EP Act gives the Department of Environment and Heritage Protection (EHP) the power to create Environmental Protection Policies that identify, and aim to protect, environmental values of the atmosphere that are conducive to the health and well-being of humans and biological integrity. *The Environmental Protection (Air) Policy* (Air EPP) was made under the EP Act and gazetted in 1997; the Air EPP was revised and reissued in 2008.

The objective of the Air EPP is:

...to identify the environmental values of the air environment to be enhanced or protected and to achieve the objective of the Environmental Protection Act 1994, i.e. ecologically sustainable development.

The environmental values to be enhanced or protected under the Air EPP are the qualities of the environment that are conducive to:

- protecting health and biodiversity of ecosystems
- human health and wellbeing
- protecting the aesthetics of the environment, including the appearance of building structures and other property
- protecting agricultural use of the environment

Schedule 1 of the Air EPP specifies air quality indicators and objectives for Queensland for approximately 93 contaminants that may be present in the air environment.

The Air EPP air quality objectives relevant to the air pollutants that may be generated from coal trains i.e. particulate matter, are presented in Table 5. Other contaminants that may be contained in the coal, such as metals, are at low levels and are unlikely to cause adverse impacts on air quality.

Dust nuisance can occur due to the deposition of larger dust particles. Elevated dust deposition rates can cause reduced public amenity, as an example through soiling of clothes, building surfaces and other surfaces. Table 5 also shows the dust deposition guideline commonly used in Queensland as a benchmark for avoiding amenity impacts due to dust. The dust deposition guideline is not defined in the Air EPP and is therefore not enforceable by legislation, but is commonly recommended by the EHP as a design objective and is commonly applied in approval conditions, including through the recently developed model conditions for Environmental Authorities, thus ensuring EHP's ability to enforce its application.

The impact assessment criteria from the NSW Office of Environment and Heritage (OEH), *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW DEC, 2005), defines the annual deposition rate of dust for general land-use, including all areas other than specialised land-use.

Table 5 Ambient air quality indicators, objectives and guidelines for particulate matter

Indicator	Averaging period	Objective	Source
Particulate matter (as $PM_{2.5}$)[a]	24-hour	25 $\mu g/m^3$	Air EPP
	Annual	8 $\mu g/m^3$	Air EPP
Particulate matter (as PM_{10})[b, c]	24-hour	50 $\mu g/m^3$	Air EPP
Particulate matter (as TSP)	Annual	90 $\mu g/m^3$	Air EPP
Dust deposition rate (total insoluble solids)	Annual	130 $mg/m^2/day$	OEH[d]
	Monthly	120 $mg/m^2/day$	EHP recommended guideline

Note:
[a] $PM_{2.5}$ are particles that have aerodynamic diameters that are less than 2.5 µm
[b] PM_{10} are particles that have aerodynamic diameters that are less than 10 µm
[c] Five exceedences allowed per year
[d] Office of Environmental and Heritage (OEH) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW DEC, 2005)

5. Considerations for the generation of particulate matter from coal trains

This section describes the potential sources of particulate matter from coal train movements between the mine and export terminal and provides specific details of the factors and circumstances that can contribute to particulate matter emissions from the largest source; the surface of loaded coal wagons.

5.1 Sources of particulate matter from coal trains

Particulate matter can be emitted from the following sources on a typical rail system:

- Erosion of the coal surface of loaded wagons (primarily during transit)
- Coal leakage from doors of loaded wagons
- Wind erosion of spilled coal in the rail corridor
- Residual coal in unloaded wagons and leakage of residual coal from doors
- Parasitic load on sills, shear plates and bogies of wagons

Particulate matter will also be generated from the combustion of diesel in the engines of a train. Both diesel and electric locomotives are used on the Blackwater, Goonyella and Newlands Systems. The diesel locomotive emissions are relatively small compared to the emissions from loaded coal wagons and trains generally pass through an area quickly so the risk of impact is minimal. Hence, these emissions are not the focus of this review and have not been considered further.

5.1.1 Erosion of coal surface of loaded wagons

The exposed coal surface of a loaded coal wagon constitutes the largest area of coal exposed to air currents as the train travels from mine to export terminal. The magnitude of coal dust emissions from this source will depend on a number of factors, but most important are the coal surface area exposed to the open air moving at high speeds and the inherent dustiness of the coal. The total coal surface area will depend on the size of the wagon and the profile of the coal that has been loaded into the wagon.

Previous studies undertaken for Queensland Rail indicated that the final few wagons on a coal train emit more dust than others due to the slipstream of the forward wagons and the first few wagons behind the locomotive tend to emit less (Connell Hatch, 2008).

5.1.2 Coal leakage from doors of loaded wagons

Coal is unloaded at the export terminal via Kwik-Drop doors built into the bottom of a coal wagon. Coal dust can leak form the Kwik-Drop doors during transit from the mine to the export terminal. The amount of coal dust falling from the Kwik-Drop doors will depend on the nature of the coal being transported (e.g. moisture level, particle sizes) and the vibrational forces acting on the wagons. Dust particles falling from the Kwik-Drop doors may become entrained in the aerodynamic wake induced by the movement of the train.

There is no quantitative data that allows the relative contribution of door leakage to coal dust emissions to be quantified. It is likely that its contribution to environmental impacts outside of the corridor is relatively small compared to lift-off from erosion of the coal surface of loaded wagons because:

- The relatively small surface area of release compared to the open surface of the coal wagons
- The release height is relatively close to the ground
- Air movement will be predominantly in the direction of the tracks with very little opportunity for cross winds to entrain the particles due to the shielding effect of the bogies and wagon structure

Some coals are quite wet when loaded into a wagon at the mine. During transit water can drain out of the Kwik-Drop doors and carry with it some particles of coal. In this instance the coal is likely to fall directly into the ballast. Once in the ballast, the coal dust is unlikely to be re-entrained into the ambient air because of the shielding effect of the large ballast particles. Little, if any, is likely to be carried far from the rail line.

5.1.3 Wind erosion of spilled coal in corridor

Coal can be spilt from the tops of wagons, both at the mine and during transit. Coal spills could occur due to a combination of poor, uneven loading or overloading of a wagon at the coal mine loading station and the rocking and tipping of wagons in transit and on bends.

5.1.4 Residual coal in unloaded wagons

Empty coal wagons returning to the mine after unloading at the port may be a potential source of coal dust emissions if there is residual coal in the wagons. This residual coal can dry and can become entrained in the air currents that develop in the empty wagons as the trains travel back to the mine.

Some of this coal will fall into the wagon above the Kwik-Drop doors and if emitted will fall through the gap in the doors. As discussed above, the coal that falls through the doors is likely to remain in the ballast.

The QR Environmental Evaluation (Connell Hatch, 2008) estimated that unloaded trains contribute about 4% to total dust emissions associated with coal trains.

5.1.5 Parasitic load

Coal dust can be emitted from the surface of the parasitic load that may be carried by the wagons. The parasitic load is coal that is spilt on the sills, shear plates and bogies of the wagons during loading at the mine. Parasitic load can also occur due to coal ploughing that can occur during unloading the wagons. Coal ploughing occurs when the rate of wagon unloading is too fast for the discharge pits at the unloading facility. This results in the build-up of coal above the discharge grates and the wagons travelling through the built up coal. Coal ploughing results in coal being carried on the wagon bogies.

5.1.6 Summary

The QR Environmental Evaluation (Connell Hatch, 2008) estimated the relative contribution of each source of coal dust described in the previous sections. Figure 8 illustrates the estimated source contribution of coal dust during rail transit form mine to export terminal.

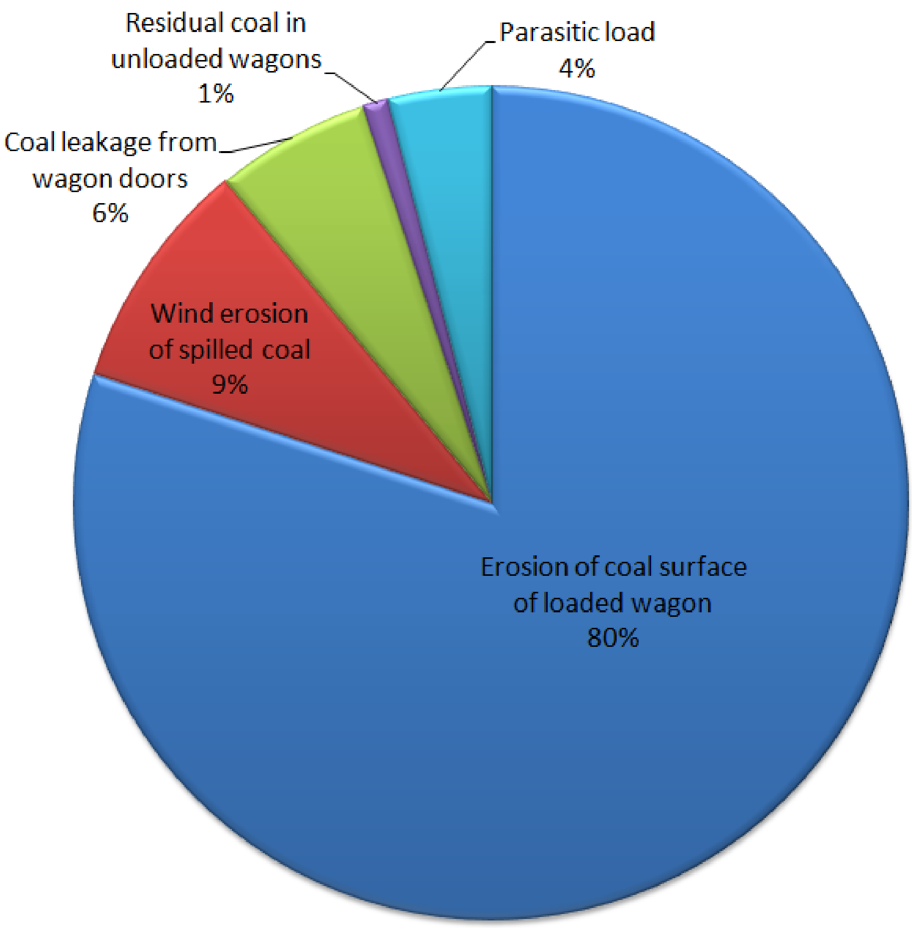


Figure 8 Source contribution to coal dust emissions from a coal train

5.2 Factors and circumstances contributing to particulate matter emission rate from the surface of loaded coal wagons

Visual observations, ambient monitoring data and anecdotal evidence suggest that dust emissions from coal trains are not uniform. The focus of the available literature that considers the emissions of coal from rail systems is on wind erosion of the loaded wagons and to a lesser extent on wind erosion of the unloaded wagons. Upper bound estimates of the emission rates from the other sources suggest that coal dust from the surface of loaded wagons is substantially greater.

There are a range of factors that contribute to the magnitude of dust emissions from the surface of loaded wagons. The most important factors are discussed below based on a review of the current literature, especially the Queensland Rail Environmental Evaluation Study (Connell Hatch, 2008).

5.2.1 General description of coal dust lift-off

The majority of coal wagons in Queensland consist of open top wagons to facilitate quick and efficient loading of coal from overhead bins. Open coal wagons provide a substantial surface area of coal that may be subject to erosion by the wind. Figure 9 shows a typical open top coal wagon.

Figure 9 Typical coal wagon

The airflow induced by the movement of the train (reaching speeds of 60-80 km/hr) is the dominant factor with the effect of the ambient wind adding up to 10-15 km/hr on average and peaking at about 36 km/hr (Connell Hatch, 2008). The effect of the ambient wind will be greatest when the train is travelling directly into the wind. The influence of the ambient wind on dust emissions will be relatively minor when the wind is perpendicular or behind the train (Connell Hatch, 2008).

The airflow across the wagon can move coal particles by three transport modes:

- Suspension
- Saltation
- Surface creep.

Saltation occurs when particles (from 75 to 500 μm in size) move and bounce in the layer close to the interface between the coal surface and the flow of air. Particles that are less than 75 μm in size are small enough to become suspended in the airflow and readily follow the air currents. Larger particles (from 500 to 1000 μm) move by surface creep propelled by wind and the impact of particles moving by saltation.

The surface wind speed (or friction velocity) at which dust begins to be raised from the surface is called the threshold friction velocity. Dust emissions will be negligible below the threshold friction velocity. The threshold friction velocity is intrinsic to the material. Wind tunnel testing of coals from the Callide and Bowen Basins has shown a wide variability in wind tunnel speeds that result in saltation and lift-off of coal dust (Connell Hatch, 2008).

5.2.2 Coal properties

Coal properties can vary significantly between mines. The following characteristics (Connell Hatch, 2008) explain the variability in the dustiness of coal:

- Hydrophobic/hydrophilic nature
- Density
- Chemical composition
- Fines content and particles size distribution

The individual influence of each of these characteristics on coal dustiness has not been studied in detail. However, there is a direct relationship between dustiness and moisture content of coal. A laboratory test procedure has been developed, as detailed in Australian Standard AS 4156.6-2000, Coal Preparation Part 6: Determination of dust/moisture relationship for coal, to determine the relationship between moisture content and dustiness for each coal type. From this procedure it is possible to determine the Dust Extinction Moisture (DEM) content for each coal type. Keeping coal at or above the DEM level will keep dust emissions to a minimum over relatively short train journeys. Over longer journeys, the coal surface will dry and, hence, additional controls may be necessary.

5.2.3 Train speed and ambient wind speed

The primary mechanism for coal dust lift-off from coal trains is the erosion of the transported coal by the movement of air. However, there is limited information available that can directly relate the rate of emissions of coal dust from a train to the speed of air flowing over the coal surface. The air speed travelling across the coal surface will be the combination of the speed of travel of the train and the component of the wind in the local area travelling against the direction of travel of the train.

5.2.4 Train passing a loaded train

Some parts of Queensland's rail transport system have duplicated (or more) tracks, especially in urban areas, allowing trains to pass travelling in opposite directions. Depending on the location and conditions, empty coal trains and passenger trains can travel at up to 100 km/hr and can, therefore, induce significant air flows and turbulence within the region of the neighbouring tracks.

The induced turbulence and airflow from the passing trains can enhance the emission rate of dust from both trains. At the point where the trains pass, the emission rate may increase by a factor of 5-10 (Connell Hatch, 2008) depending on the degree to which the unloaded train contributes to dust emissions and the magnitude of turbulence induced by the trains.

On single lines, unloaded trains are normally stopped in the crossing loop whilst a loaded train passes. Only on double track can trains pass potentially contributing to a higher relative wind speed.

5.2.5 Train frequency or system throughput

The emission rate of coal dust from coal trains may increase in proportion with any increase in the frequency of train movements or the coal throughput of the coal transport system; in the case of the latter, provided the characteristics of the coal transport system (e,g. train speed), mix of coal types and so on, remain unchanged.

5.2.6 Train vibration

Evidence from coal fouling of ballast indicates that coal loss is more intense in areas where the vibration forces are greater. This is consistent with Parrett (1992) that indicates that disturbance of the surface of static stockpiles of material increases the emission rate of dust particles. Vibration could also cause coal particles to break, producing finer material that will be lifted more readily from the coal surface.

More significantly, train vibration is likely to enhance the spillage of coal from the surface of heavily loaded wagons and from Kwik-Drop doors.

5.2.7 Profile of coal load

The profile of the coal load refers to the shape of the exposed surface area above the sill of a coal wagon. Works undertaken in Queensland (e.g. McGilvray, 2006) indicate that coal loads in wagons that are shaped in an irregular way, such as with multiple peaks, can produce more dust than a flat 'garden bed' shape (Figure 10). Poorly loaded wagons can also spill coal onto the ballast and within the corridor (Figure 11).

The irregularly shaped load has a greater erodible surface area and is subject to greater air speeds than the 'garden bed' shape. Wind tunnel modelling has shown that the three mound case (representing the irregularly shaped load) exhibits slightly higher velocities and turbulence intensities than the 'garden bed' configuration (Connell Wagner, 2008).

The effect of the greater turbulence intensities and air speeds across the coal surface will increase the dust emission rate from each irregularly shaped coal load in a wagon.

Figure 10 Photograph showing a 'garden bed' shape load profile (Photograph taken by Jim Harrison at Boggabri Coal on 13 July 2007) (extracted from Connell Hatch, 2008)

Figure 11 Photograph showing a poorly loaded wagon (extracted from Connell Hatch, 2008)

5.2.8 Transport distance

The longer the distance from mine to export terminal the higher the potential dust emissions. This is logical given the preceding discussion of other factors that influence the magnitude of coal dust emissions from wagons. In particular, the speed and vibration of the trains can ensure that there is a continual supply of coal particles that may be emitted from the coal surface and so trains travelling larger distances will potentially produce more coal dust. This is particularly the case where loading practice leads to irregularly shaped loads rather than the preferred "garden bed" profile.

Other factors may also exacerbate coal dust emissions at the end of a long journey such as the evaporation of moisture from the surface of the coal.

5.2.9 Precipitation

Rainfall is likely to reduce or eliminate coal dust emissions where moderate to heavy rain falls on the wagons. After the rain event, the surface of the coal will gradually dry out and dust emissions may return to the levels prior to rainfall, when the travel distance is sufficiently long.

6. Air quality in the rail corridor

The following sections provide a review of ambient air monitoring studies that have been conducted in rail corridors used to transport coal in Queensland and New South Wales. The available studies have focused on coal dust emissions in an attempt to quantify and determine air quality impacts.

6.1 Queensland Rail Environmental Evaluation

As part of the QR Environmental Evaluation (Connell Hatch, 2008), emissions of coal dust from coal trains were estimated and resultant environmental impacts determined, through a combination of a literature review, dispersion modelling and air quality monitoring. The study looked at existing estimates of coal dust emission rates as well as other dust sources to estimate emissions from the Goonyella, Blackwater and Moura lines under a number of different scenarios. Impacts of coal dust from coal trains on the environment were investigated through an ambient monitoring study of TSP as well as by looking at a number of prior monitoring studies conducted in Queensland.

6.1.1 Quantification of Coal Dust Emissions from Coal Trains

The Environmental Evaluation considered the following documents and studies:

- National Pollutant Inventory (NPI) emissions estimation handbooks
- United States EPA AP-42, Compilation of Air Pollutant Emission Factors
- Fugitive Coal Dust Emissions in Canada, a report from D. Cope Enterprises to the Canadian Council of Ministers of the Environment (D Cope Enterprises, 2001)
- Wind Tunnel Study of Coal Dust Release from Train Wagons (Ferreira et al, 2003)
- Prediction of Dust Loss from Conveyors using CFD Modelling (Witt et al, 1999)

Emission factors are generally reported in the literature in two forms: as a mass emission rate per distance travelled for each wagon (e.g. g/km/wagon) or as a percentage of coal lost over a journey. An estimated emission rate presented by Ferreira et al (2003), of 9.6 g/km/wagon, were determined to be consistent with monitoring results. This emission rate was adopted for emissions calculations, modified by a dependence on wind speed derived from the work of Witt et al (1999).

Estimates of the total annual coal dust emissions from the Goonyella, Blackwater and Moura lines were made. The calculated emissions were dependent on:

- Train speed
- Average wind speed
- Tonnage of coal transported
- Length of track

Approximately 80% of the emitted coal dust was attributed to wind erosion of the wagon surface.

6.1.2 Quantification of Environmental Impacts of Coal Dust

In quantifying the environmental impacts of coal dust from coal trains, the QR Environmental Evaluation (Connell Hatch, 2008) looked at the results of three previous monitoring programs:

- Gladstone, 1993-94 (Katestone Scientific, 1994)
- Praguelands, 2004 (Simtars, 2004)
- Callemondah, 2007 (Simtars, 2008)

Additionally, a monitoring program was conducted for the Environmental Evaluation between November 2007 and February 2008. The program comprised the following monitoring equipment:

- Partisol - measuring ambient TSP (24-hour average), located at 8 residential locations
- TEOM - performing continuous monitoring of TSP, located at 5 locations within the rail corridor
- Osiris - performing continuous monitoring of TSP, located at 3 locations within the rail corridor (2 co-located with TEOM)

The results of each of the studies were assessed against air quality goals for human health. The following observations can be made about the results of this assessment:

- Although the Air EPP PM_{10} goal was 150 µg/m³ at the time of the study, comparisons were also made against the Air NEPM standard of 50 µg/m³ (24-hour average), equivalent to the current Air EPP objective
- Exceedances of the Air NEPM standard at the monitoring locations were very rare and not likely to be caused by coal trains
- In cases where an exceedance was recorded, the contribution of coal dust was found to be minor
- The studies did not find the potential for health impacts inside or outside of the rail corridor as assessed against current air quality objectives due to coal dust emissions from trains. The studies did not find the potential for amenity impacts outside the rail corridor due to coal dust emissions from trains when assessed against current air quality guidelines for nuisance.

The results of each of the studies were also assessed against air quality guideline for amenity and the following conclusions were drawn:

- At 3 metres or 5 metres from the tracks, deposition rates were likely to be above the nuisance threshold of 120 mg/m²/day however at 10 metres from the tracks the deposition rate dropped well below the threshold

The coal content of deposited dust samples was determined by laboratory analysis as part of the 2007 Callemondah study by Simtars. At 10 metres from the track, coal was shown to make up between 35 and 75 percent of deposited dust.

Dispersion modelling was conducted based on emission rates calculated as described above. The results showed the predicted concentrations of dust fall sharply with distance from the rail line. No exceedances of air quality objectives were predicted to occur outside of the rail corridor (10 metres from the tracks), including at sensitive receptors, based on the rail activities at the time (2006/07).

The literature review and monitoring program conducted as part of the Environmental Evaluation identified the rail corridor as being approximately less than 10 metres from the rail line. Both the literature review and monitoring indicated that outside of the rail corridor the likelihood of coal dust from coal trains impacting on the environment was low.

Although atypical, observations and photographs taken during the QR Environmental Evaluation showed that visible dust was emitted by some coal trains operating in Queensland and that dust was observed to travel beyond the rail corridor. It was also found that many Queensland mines did not practice load profiling and did not apply water or chemical surface veneer treatments to the surface of coal wagons. Such occurrences suggested that, for some Queensland trains coal dust emissions were not effectively controlled.

6.2 EHP Tennyson Study

In 2012 the Department of Science, Information Technology, Innovation and the Arts (DSITIA) conducted a one-month study of dust in the Brisbane suburb of Tennyson in response to community concern over dust from coal trains. The Brisbane Metropolitan Rail System was used to transport approximately 9 million tonnes of coal to the port of Brisbane in 2012 from mines in the Clarence-Moreton and Surat coal measures (Western System). The coal trains pass through the suburb of Tennyson.

The Tennyson dust monitoring investigation involved three sites and a number of different pieces of dust monitoring equipment, summarised in Table 6.

Table 6 Sites and equipment used in the Tennyson dust monitoring investigation

Site	Location	Equipment	Description
Tennyson Station	6 metres from the northern track	Low-volume sampler (Partisol 2025)	24-hour average measurements of PM_{10}, for comparison to Air EPP
		Dust deposition gauge	1-month average dust deposition rate, proportion of coal in deposited dust
		Aerosol monitor (Dusttrak 8533)	5-minute average particle measurements, not for comparison to Air EPP
Myla Terrace	Residential street, 20 metres from the northern track	Dust deposition gauge	1-month average dust deposition rate, proportion of coal in deposited dust
Vivian Street	Residential street, 300 meters from the rail line	Dust deposition gauge	1-month average dust deposition rate, proportion of coal in deposited dust

The following limitations of the monitoring campaign should be noted, as identified within the study report:

- The monitoring program lasted a single month, therefore only a single data point was available for the assessment of dust deposition rates at each site
- While the exact distribution of trains on either track was not reported, full coal trains predominantly used the northern track while empty coal trains predominantly used the southern track. This is unlikely to have an effect on results at Myla Terrace or

Vivian Street monitoring sites; however, the Tennyson Station monitoring equipment was located approximately 6 metres from the nearest (northern) track, and approximately 9 metres from the farther (southern) track. This placement may have an influence on the results.

The study compared the measured values of 24-hour average PM_{10} concentrations to the Air EPP objective of 50 µg/m³ and dust deposition rates to the New Zealand Ministry for the Environment's recommended trigger level for dust nuisance of 130 mg/m²/day. No exceedance of either criterion was identified at any of the sites during the monitoring program.

Further analysis of samples indicated that the major component of the deposited dust at each site was mineral dust (e.g. soil, rock, fly ash, cement, glass), ranging between 40 and 50 percent. Coal was found to be between 10 and 20 percent of deposited dust in the samples. Another black coloured particle, rubber dust, was found as levels of 10% at all three monitoring sites. Rubber dust is generated from tyre action of vehicles.

A comparison of Dusttrak measurements made before and after the passing of trains was made. While loaded coal trains showed a higher average and median concentration, it was concluded that the re-entrainment of surface dust by air movements associated with the passing train appeared to be more important than the loss of coal dust from the surface of the wagons.

Empty coal trains were shown to produce the lowest average change in dust concentration after passing; lower than passenger or freight trains. This may be attributable to the monitor being further away from the empty than the full coal trains or the fact that only average and not peak contributions were presented.

The proportions of coal dust found in the insoluble dust samples in the Tennyson investigation (at between 10 and 20 percent) were higher than those determined from previous sampling carried out between July 1998 and August 1999 by Simtars (Coal Dust Monitoring: West Ipswich to Fishermans Island). The Simtars study found coal dust to be between 1 and 3 percent of the insoluble dust sample. The recent study notes that different methods were used to determine the fraction of coal dust in the sample and caution should be used when comparing the results like for like. However, the increase in coal dust fraction roughly relates to the threefold increase in coal haulage along the system since the Simtars study.

In summary, coal dust from trains was found to be a measurable source of dust in the Tennyson area; however, it was not the major source of dust and air quality objectives were not exceeded during the month long study.

6.3 ARTC (New South Wales)

Environ Australia Pty Ltd (Environ) conducted a pilot monitoring program of dust levels associated with coal trains as part of Pollution Reduction Program 4 (PRP4) required under Australian Rail Track Cooperation's (ARTC) Environmental Protection Licence (Environ, 2012). The aim of the study was to determine whether loaded coal trains are a source of particulate matter emissions on the Hunter Valley rail network and whether loaded coal trains were a larger source of particulate emissions than other trains on the network.

The pilot monitoring program used a light scattering laser photometer (Osiris) for continuous measurement of airborne concentrations of TSP, PM_{10} and $PM_{2.5}$. Monitoring was undertaken at two trackside locations (Metford and Mayfield) to capture particle emissions from passing trains. Monitoring was undertaken during the period 13 February 2012 to 20 March 2012. Train movement data recorded during the period of particulate matter monitoring were collated and the data paired in time to facilitate joint analysis.

TSP, PM_{10} and $PM_{2.5}$ concentrations measured to coincide with train passes were statistically analysed by train type, accounting for loaded coal trains, unloaded coal trains, passenger trains, freight trains and ‘no train’ passes. There was a greater degree of confidence in the results obtained for the Metford site as compared to the Mayfield site due to limitations with the Mayfield train movement data set.

Although the Osiris monitor is not compliant with the NSW EPA's standard monitoring requirements, it was accepted by the EPA as a reasonable indicator of $PM_{2.5}$ concentrations. The study found no exceedances of the NEPM standards for $PM_{2.5}$.

7. Coal Dust Management and Mitigation

The previous sections have introduced and reviewed the various methods and factors that may contribute to coal dust emissions occurring from coal trains during transit from mine to export terminal. This section discusses the management, mitigation and good practice measures that may assist in controlling coal dust emissions from coal trains. This comprehensive set of measures was developed by Aurizon (and its predecessors Queensland Rail and QR National) and represents leading practice in Australia for controlling coal dust lift-off from trains.

The first key step in the development of these measures was the Environmental Evaluation that was conducted by Queensland Rail in 2007 and 2008. The findings and recommendations of the Environmental Evaluation were implemented on the central Queensland rail networks by the Coal Dust Management Plan (QR Network, 2010). The Coal Dust Management Plan highlights current and future strategies to manage coal dust from coal trains travelling on the central Queensland rail systems.

These measures have also informed the strategy being adopted on the Western Rail System in southeast Queensland.

7.1 Queensland Rail Environmental Evaluation

The Queensland Rail Environmental Evaluation (Connell Hatch, 2008) identified and assessed a wide range of mitigation options for the prevention of coal dust emissions, including:

- Coal transported by covered conveyor through final leg of the journey into the export terminal
- Re-align coal corridors around communities
- Limit the capacity of the corridor (e.g. reduce speed)
- Veneering
    - Use of suppressants applied to the surface of the coal profile in the wagons at the mine site
    - Use of suppressants applied at a common point at the head of each corridor
    - Use of water/suppressants applied at entry to major cities
- Loading at the mine site –
    - Use of profilers to manage excess height
    - Maintaining the 100mm freeboard around the edge of the wagon
    - Change the types of loaders by additions to ensure a consistent profile
- Mechanism to remove parasitic coal from surface of wagons before leaving the mine site
- Wagon design adjustments
    - Apply lids to wagons
    - Apply deflector/container boards to edges of wagons
    - Adjust the doors to underside of the wagons to contain leakage
- Unloading Issues
    - Washing the wagons after unloading
    - Change in unloading techniques to minimise coal ploughing (clean up)

The key findings of the Queensland Rail Environmental Evaluation (Connell Hatch, 2008) assessment of coal dust mitigation options were:

- The literature review and test program indicate that veneering could achieve a reduction in coal lift-off from the surface of loaded wagons of at least 85%.

- Laboratory tests conducted at the TUNRA laboratory at the University of Newcastle on seven typical coal types and five veneer treatments indicate that all surface veneer products when applied at the supplier's recommended application rate and solution strength, achieved a significant reduction in dust lift-off compared with nil treatment.

- All surface veneer products were applied at a common application rate of one litre per square metre. The solution strength varied according to the supplier's recommendation. All test samples were exposed to a wind speed of 20 metres per second (72 km/hr) under test conditions for a period of 8 hours. Due to very rapid dust lift-off, the untreated samples (Nil treatment) were removed from the wind tunnel after exposure to the test conditions for only 1 minute. This observation applied to all tested coal types and indicates a high potential for lift-off for untreated wagons under normal train speeds.

- A range of measures were identified that show potential to reduce coal dust emissions. The following techniques were identified as practical and cost-effective:
    - Coal surface veneering using chemical dust suppressants at the mine
    - Improved coal loading techniques at the mine to reduce parasitic load on horizontal wagon surfaces and reduce over-filling and hence spillage during transport
    - Load profiling to create a consistent surface of coal in each wagon. To be implemented at the mine, and
    - Improved unloading techniques to minimise coal ploughing and parasitic load on wagons

- Connell Hatch reported that wagon lids are used in the transport of some materials in northern Queensland and in the transport of coal in North America where very cold conditions, snow and ice can adversely affect the coal.

- In its work on the Queensland Rail Environmental Evaluation, Connell Hatch (2008) conducted an analysis of the feasibility, practicality and cost-effectiveness of either retrofitting wagon lids to the existing fleet or redesigning wagons to incorporate lids across the central Queensland coal network

- Connell Hatch found that introducing wagon lids would provide the following advantages:
    - 99% reduction in coal dust emissions from the top of loaded and unloaded wagons
    - potential to completely seal the wagon doors
    - reduction in aerodynamic drag
    - Environmentally friendly solution

- The major disadvantages of introducing wagon lids include:
    - Large operating cost (retrofitting only)
    - Modifications to all loading and unloading facilities
    - Ramifications of lid failure

- The Connell Hatch investigation acknowledged that there are many potential adverse operational impacts and costs associated with implementing wagon lids that cannot be estimated without a thorough detailed investigation. The preliminary work presented in the environmental evaluation suggests that wagon lids are unlikely to be a feasible solution in the short term.

7.2 Coal Dust Management Plan

As a result of the findings of the Environmental Evaluation, Aurizon has prepared a Coal Dust Management Plan (CDMP) for the Central Queensland coal supply chain participants to manage coal dust from trains transporting coal on the central Queensland systems. The CDMP reflects a range of actions available across the coal supply chain to address dust and is a staged action approach based on factors such as business conditions, effectiveness of proposed action and timeframes for implementation.

The following sections detail the CDMP proposed actions for each coal supply chain participant. The proposed actions in CDMP were developed in 2010.

7.2.1 Actions for coal producers (mines)

Timeframe	Action
Current (2010 - 2013)	Implementation of effective dust suppression (veneering) strategy across the central Queensland coal supply chain
	Sill brushes to remove parasitic load
	Profile design of chute loaders to improve load profiling
	Effective loading procedure to avoid overloading
	Community liaison
	Procedural review and operational training to avoid coal remaining in wagons and potential spillage associated with carry back
Short - Medium Term (< 3 years)	Development of Standards informed by monitoring processes and coal type testing
	Increase number of veneer spray stations at load-out facilities
	Wagon loading practices and wagon design to avoid overloading and improve load profiling
	Load-out facility infrastructure to avoid overloading and improve load profiling
	Coal moisture regulating system
	Internal communications
	Coal type testing for dustiness
Long Term (>3 years)	Load-out facility infrastructure to avoid overloading and improve load profiling
	Batch weighing load-out system to avoid overloading
	Load-out chute retrofitting to improve load profiling

7.2.2 Actions for coal train operators

Timeframe	Action
Current (2010 - 2013)	Train speed indicators
	Operational procedures to avoid overloading and improve load profiling
	Operator procedural training to avoid overloading and improve load profiling
	Internal environmental awareness
	Community liaison and awareness
Short - Medium Term (< 5 years)	Wagon design to avoid overloading and improve load profiling
Long Term (>5 years)	Wagon replacement
	ECP brakes

7.2.3 Actions for rail network managers

Timeframe	Action
Current (2010 - 2013)	Coal dust removal (ballast cleaning)
	Complains management
	Community liaison
	Internal education and awareness
	Weighbridge to monitor loading
	Coal dust monitoring systems
	Commercial agreements
Short - Medium Term (< 3 years)	Ballast spoil management
	Corridor coal and spoil removal
	Corridor barriers and vegetation
	Commercial agreements
Long Term (>3 years)	Corridor barriers and vegetation
	Review monitoring system

7.2.4 Actions for coal export terminals

Timeframe	Action
Current (2010 - 2013)	Modify existing unloading facilities to avoid coal remaining in wagons and potential spillage associated with carry-back
	Operator procedural training to avoid spillage and hopper overloading
	Monitor empty wagons to avoid coal remaining in wagons and potential spillage associated with carry-back
	Community liaison and communication
	Increase internal environmental awareness
	Hopper level / train speed indicators
	Wheel washing (Dalrymple Bay Coal Terminal only)
Short - Medium Term (< 3 years)	Wagon vibrators to avoid coal remaining in wagons and potential spillage associated with carry-back
	Residual coal monitoring
	Wagon unloading practices
Long Term (>3 years)	Wagon unloading practices

7.2.5 Veneering strategy

In the Aurizon CDMP the most favourable actions to manage coal dust are the development and implementation of a veneering strategy and undertaking "garden bed" profiling of loaded coal.

Veneering is the application of a biodegradable polymer to the coal surface of a loaded wagon. The veneer forms a temporary seal on the coal surface and can significantly reduce coal dust emissions. Aurizon's veneering strategy has been implemented at train loading facilities located on Aurizon's network. Veneering obligations are included in each mine's loadout Transfer Facilities Licence (TFL). The TFL authorises the loading of coal trains onto the Aurizon network.

The current state of Aurizon's veneering strategy is that 12 out of the 14 priority mines, as identified by EHP, have had veneering stations installed at their rail loadout facilities. Out of the 36 loadout facilities on the Goonyella, Newlands, Blackwater and Moura systems, 21, or 57 percent, have veneering stations installed. All central Queensland coal mine loadout facilities will have veneering stations in place by December 2013.

7.2.6 Performance monitoring and reporting

Aurizon has developed an innovative monitoring system to identify dust levels on its rail systems (QR National, 2010). Currently, three monitoring stations have been installed, one each on the Blackwater, Goonyella and Moura rail systems. A second monitoring station is proposed on each of the above rail systems and two monitoring stations are proposed on the Newlands System, making a total of 8 stations across the Aurizon network.

The monitoring stations measure the opacity of the air across the top of moving coal trains. The three sites also concurrently record, wind speed and direction, relative humidity and rainfall to determine influences of weather on dust incidents. The monitoring system identifies when trains pass by the system and train movement information is used to determine the type of trains (coal (loaded or unloaded), freight or passenger).

The output from the three monitoring stations is recorded and can be used to identify dusty trains and to gauge the ongoing implementation and effectiveness of the CDMP. Data is reported to EHP on a monthly and annual basis. Specific data is not currently publicly available for this performance monitoring.

7.3 Future studies on the Western Rail System

Following on from the 2012 Tennyson Study, DSITIA has been contracted to carry out a further Coal Dust Monitoring Program to measure ambient air quality monitoring alongside the Western Rail System. The new study proposes to carry out campaign monitoring at seven sites along the Western Rail System for two separate sampling periods. The study will also conduct continuous monitoring for a 12-month period at a single site alongside the Western Rail System.

The Coal Dust Monitoring Program will measure dust emissions of primary concern comprising:

- **Deposited dust** (particles less than 1 mm in size) – visible dust deposition that can cause soiling, loss of amenity and minor health impacts. The composition analysis of the deposited dust will include the percentage of coal dust, other black dust including soot and black rubber, mineral dust, plant and insect debris. All seven monitoring sites will test for deposited dust.
- **Fine particles** – these are invisible to the naked eye and can impact human health. Due to their small size, these particles can remain suspended in air for considerable periods. Monitoring will obtain measurements of levels of PM10 (particles of less than 10 microns in diameter) and PM2.5 (particles of less than 2.5 microns in diameter). Five of the seven sites will test for fine particles.

Evaluation reports are proposed to be published on the DSITIA and DEHP websites.

An additional feature of the program will be a 12-month continuous dust monitoring component to measure seasonal coal dust emissions trends and to track the progress of measures to reduce coal dust emissions (eg New Hope's New Acland Mine veneering program) on ambient dust levels in a key population area on the metropolitan rail line.

The continuous monitoring equipment proposed to be used will enable information on ambient particle levels to be disseminated to the public via the DEHP website in near real-time.

The monitoring began in March 2013.

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