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Environmental Improvement Program – Particulate Matter Control Best Practice Study

Prepared for:

Port Kembla Coal Terminal

June 2017

Final

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Document Control

Deliverable #:	D16067-5
Title:	Environmental Improvement Program – Particulate Matter Control Best Practice Study
Version:	1.0 (Final)
Client:	Port Kembla Coal Terminal
Document reference:	D16067-5 EIP Best Practice Particulate Matter Controls v1.0.docx
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Reviewed by:	Simon Welchman
Approved by:	Simon Welchman 27/06/2017

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Glossary

Term	Definition
µm	micrometre
mm	millimetre
m	metre
m/s	metres per second
ha	hectare
kg	kilogram
t	tonnes
tpa	tonnes per annum
Mtpa	megatonnes per annum
Nomenclature	**Definition**
TSP	Total suspended particulates
PM_{10}	particulate matter with a diameter less than 10 micrometres
$PM_{2.5}$	particulate matter with a diameter less than 2.5 micrometres
Abbreviations	**Definition**
EF	Emission factor
EIP	Environment Improvement Program
EPA	Environment Protection Authority
EPL	Environment Protection Licence
NPI	National Pollutant Inventory database
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
PKCT	Port Kembla Coal Terminal
PRP	Pollution Reduction Program
POEO Act	*Protection of the Environment Operations Act 1997*

EXECUTIVE SUMMARY

In October 2016, the NSW EPA issued PKCT with a notice to vary EPL 1625 (Notice Number 1544414) to include the Environmental Improvement Program (EIP) U2 *Environmental Improvement Program (EIP) – Particulate Matter Control Best Practice Study*. A methodology was applied based on the Determination Guideline and NSW Coal Benchmarking Study to complete a study of best practice particulate matter controls.

The existing measures that are being used to minimise particle emissions at PKCT were identified and quantified as part of an emissions inventory. The inventory indicated that the following are the major sources of particulate matter emissions at PKCT:

- Coal stockpiles
- Bulk product stockpiles
- Conveyors
- Exposed spillage areas
- Stacking and reclaiming.

The best practice measures that could be used to minimise particle emissions at PKCT were identified and quantified. PKCT has implemented the following best practice measures for controlling dust emissions:

- Full enclosure of inloading conveyors
- New stackers and a reclaimer will be commissioned prior to July 2018 with best practice dust controls
- Belt washing system installed on the wharf conveyor NC14
- Automated stockyard spray system currently installed and optimisation study underway
- Misting sprays underneath yard conveyors.

A number of areas were identified where further measures could be introduced to ensure PKCT is operating at best-practice. The practicability of implementing these measures was evaluated using a cost-benefit analysis. The analysis looked at the following controls:

- Applying chemical suppressants to the coal stockpiles
- Throughloading of coal
- Applying water to maintain DEM
- Applying chemical suppressants to the bulk product and waste coal stockpiles
- Constructing bunds/berms around the bulk product and waste coal stockpiles
- Enclosing conveyors
- Installing belt cleaning systems on yard conveyors
- Operation of a suction truck to clean spillage areas.

The analysis identified that the most cost-effective controls for controlling dust are likely to be, in order, the following:

- Applying chemical suppressants to the coal stockpiles
- Applying chemical suppressants to the bulk product stockpiles
- Applying water to maintain DEM.

1. INTRODUCTION

Port Kembla Coal Terminal (PKCT) is a coal exporting facility on Australia's east coast, located in the Inner Harbour at Port Kembla, approximately 70 km south of Sydney. PKCT services the Southern and Western coalfields of New South Wales (NSW), exporting high quality coking and steaming coal to customers around the world.

Under the NSW *Protection of the Environment Operation Act 1997* (POEO Act), PKCT's activities are managed through an Environmental Protection Licence (EPL 1625) that authorises the carrying out of scheduled activities including: *coal works and shipping in bulk*. In October 2016, the NSW Environment Protection Authority (NSW EPA) issued PKCT with a notice to vary EPL 1625 (Notice Number 1544414) to include the Environmental Improvement Program (EIP) U2 *Environmental Improvement Program (EIP) – Particulate Matter Control Best Practice Study*.

1.1 Background to EPL variation

The mining sector of NSW has been required under a Notice by the NSW EPA to conduct best practice benchmarking studies aimed to achieve reduced emissions of particulate matter from coal mining activities over the last five years. To guide the studies, the NSW EPA published the *Coal Mine Particulate Matter Control Best Practice: Site-Specific Determination Guideline* (OEH, 2011) (Determination Guideline) and the *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Katestone, 2011) (NSW Coal Benchmarking Study).

The NSW EPA has issued similar notices to each coal export terminal in NSW that require completion of a study of best practice particulate matter controls.

Although there are many sources of particulate emissions including natural, domestic and industrial, air quality in the Illawarra has improved over time. However, the community remains sensitive to particulate matter and its potential effect on health and amenity and continuous improvement in environmental management is an expectation of the POEO Act.

1.2 Scope of work

The scope of work required to be completed under the NSW EPA notice includes:

- Conduct a Best Management Practice Study to identify the most practicable means to reduce particle emissions at PKCT.
- The study report includes the following:
    - Identification, quantification and justification of existing measures that are being used to minimise particle emissions at PKCT
    - Identification, quantification and justification of best practice measures that could be used to minimise particle emissions at PKCT
    - Evaluation of the practicability of implementing these best practice measures at PKCT.

2. PKCT OVERVIEW

2.1 PKCT operations

Coal is received at PKCT by rail and road. Approximately seven trains are unloaded per day each delivering around 3,300 tonnes of coal, with coal delivered in 75-tonne payload bottom dump wagons that allow for continuous discharge at PKCT's rail receival bins. Coal is recovered from the receival bins through under-bin belt feeders at a rate of up to 4,200 tonnes per hour. At the road receival facility trucks dump the coal through steel grids into two bins with a total capacity of 3,000 tonnes, where under-bin rotary arm plough feeders recover the coal from the bins at a rate of 4,400 tonnes per hour.

Coal is transported by conveyor from the rail and road receival bins to the stockyard. Three rail-mounted stackers distribute the coal into stockpiles. If necessary, different coal types can be blended during the stacking process. The terminal's stockyard has an east and a west pad, each 50 metres wide and 1 kilometre long. The stockyard has a total capacity of 850,000 tonnes with an optimal working capacity of 600,000 tonnes.

PKCT currently has two track-mounted bucket-wheel reclaimers that reclaim the coal from the stockpiles. Coal is transported from the reclaimers via conveyors to the ship loader. The reclaimers have ten buckets on a large wheel that are capable of reclaiming 6,600 tonnes of coal per hour. On the way to the vessel, the coal passes through a sampling plant where samples are taken to measure coal quality, moisture and ash content. The three stackers and two reclaimers will be replaced with three new stackers and a single reclaimer, all of which are expected to be operational by July 2018.

PKCT has two ship loading berths. Berth 102 is the main coal berth, while Berth 101 is primarily used for loading coke, slag and other bulk products. The coal berth has two rail-mounted ship loaders capable of loading at 6,600 tonnes per hour. Berth 101 has a separate stockpile area where bulk cargo, usually coke or steelworks slag, are stored prior to loading. Bulk products are loaded using mobile equipment.

2.2 Air quality at PKCT

PKCT has an air quality monitoring program that consists of:

- Two continuous particulate matter monitors. One is located at the southern end of the site and the other between PKCT and the nearest residences to the north.
- Dust deposition gauges. Three gauges are located in residential areas offsite and 11 located onsite.

The monitoring program measures ambient levels in the community and estimates PKCT's contribution. The monitoring data shows that air quality is typically good, and that PKCT's contribution to any elevated levels is generally minor. Summaries of the data collected by the program is reported publicly as part of PKCT's Annual Environmental Management Reports.

The NSW Office of Environment and Heritage (OEH) conducts ambient air quality monitoring at a number of monitoring sites in NSW, three of which are located in the Illawarra region: Wollongong, Kembla Grange and Albion Park South. The NSW OEH's monitoring data indicates that the air quality in the region was either very good or good for 87% of days between 2012 and 2016.

2.3 Obligations under Act and EPL

In NSW, environmental protection from the effects of emissions is primarily administered under the POEO Act. The POEO Act provides a framework for the:

- Development of Protection of the Environment Policies

- Licensing by NSW EPA of activities that are defined under Schedule 1 of the POEO Act
- Development of regulations and guidelines that promulgate impact assessment criteria and emission standards for industry
- Definition of offences and penalties in relation to air pollution under Sections 124-129
- Provision of a mechanism for public participation in the environmental assessment of activities that may be licensed by OEH, in conjunction with the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Sections 124-127 are of particular relevance to a facility that has the potential to generate emissions of dust:

124 Operation of plant (other than domestic plant)

The occupier of any premises who operates any plant in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupier's failure:

(a) to maintain the plant in an efficient condition, or

(b) to operate the plant in a proper and efficient manner

126 Dealing with materials

(1) The occupier of any premises who deals with materials in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupier's failure to deal with those materials in a proper and efficient manner.

(2) In this section:

"deal" with materials means process, handle, move, store or dispose of the materials.

"materials" includes raw materials, materials in the process of manufacture, manufactured materials, by-products or waste materials.

127 Proof of causing pollution

To prove that air pollution was caused from premises, within the meaning of sections 124-126, it is sufficient to prove that air pollution was caused on the premises, unless the defendant satisfies the court that the air pollution did not cause air pollution outside the premises.

PKCT operates under Environment Protection Licence (EPL) 1625, which specifies a range of conditions that must be met whilst carrying out the scheduled activity (coal works and shipping in bulk). The EPL includes the following conditions that pertain to dust:

- O3.1: The premises must be maintained in a condition which minimises or prevents the emission of dust from the premises.
- O3.2: Activities occurring in or on the premises must be carried out in a manner that will minimise the generation or emissions, of wind blown or traffic generated dust.

3. EXISTING ACTIVITIES AND CONTROL MEASURES

In the following sections, PKCT's activities that have the potential to generate emissions of TSP, PM_{10} and $PM_{2.5}$ have been identified and their emission rates estimated for the 2015/16 financial year accounting for existing emission control measures. These emission rate estimates have been used to quantify the potential benefits that may be achieved by adopting alternative particulate matter controls. The activities at PKCT that produce the highest emissions of TSP, PM_{10} and $PM_{2.5}$ have been identified as priorities for evaluation of additional emission controls.

3.1 Sources of emissions of Particulate Matter

Emissions of TSP, PM_{10} and $PM_{2.5}$ at PKCT can occur at any point where coal and bulk product are handled, conveyed or open to erosion by the wind. Activities at PKCT that have the potential to generate emissions of TSP, PM_{10} and $PM_{2.5}$ include the following:

- Road and rail receival of coal and bulk product
- Conveyors
- Transfer points
- Stacking and reclaiming
- Stockpiling of coal and bulk product
- Ship loading
- Bulk product handling
- Vehicle movements on unpaved or high silt roads
- Exposed areas and material spillage.

The quantity of emissions from these activities will depend on a number of parameters including coal and bulk product throughput, equipment numbers and utilisation, stockpile area, coal and bulk product characteristics and weather conditions such as wind speed and rainfall. These factors are summarised in Table 1 for the 2015/16 financial year.

From time to time, changes in weather patterns bring strong winds from the south of the coal terminal. These strong winds can result in higher levels of generation of particulate matter and have been associated with complaints to PKCT in the past.

Table 1 Summary of key activity parameters and information for the estimation of particulate matter emissions at PKCT for the 2015/16 financial year

Parameter	Unit	Magnitude
Road receival - coal	tpa	6,627,692
Road receival – bulk material	tpa	153,922
Rail receival - coal	tpa	3,906,756
Transfer points	#	8
Conveyors	#	15
Stackers	#	3
Reclaimers (bucket wheel)	#	2
Coal stockpile height	m	23.0
Coal stockpile area	ha	14.4
Bulk product stockpile height	m	5.0
Bulk product stockpile area	ha	7.4
Exposed spillage areas	ha	2.6
Exposed cleared/trafficed areas	ha	0.8
Average silt content of coal and bulk product	%	7
Average moisture content of coal and bulk product	%	8
Shiploading	tpa	10,691,787
Average on-site wind speed (2015/16 financial year) at 6.1 m	m/s	3.5
Average on-site wind speed (2015/16 financial year) at 10 m	m/s	4.0
Average on-site wind speed (2015/16 financial year) at 23 m	m/s	4.9
Rain days (2015/16 financial year)	#	133

3.2 Existing Particle Matter Control Measures

A variety of particulate matter suppression and mitigation strategies are implemented at PKCT. They are as follows:

- Yard sprays are installed along the coal stockpiles and operate on an automatic cycle that repeats with a period of between 30 minutes and 6 hours depending on wind conditions. More intensive application of water is triggered when:
    - Wind speed exceeds 10 m/s
    - Coal moisture is reduced through drying
    - Early warning is received of increased wind speeds (automatic weather station (AWS) located approximately 60 km south at Crookhaven Heads).
- A road sweeper and water cart are deployed routinely for minimisation of particulate matter emissions from site roads.
- Water sprays are installed at road receival that operate automatically with manual control if required.
- Rail receival occurs within a building.
- Inloading conveyors are fully enclosed, with some sections underground.
- Outloading conveyors have wind guards installed.
- All transfer points are fully enclosed except TS6, which has an enclosed chute.

- Road receival facility has truck washing facilities.
- Car washing facilities are available for site vehicles.
- Variable height stackers are used to load coal into stockpiles.
- A belt washing station is installed on the NC14 (outloading) conveyor.
- Most roads and open areas on site have been paved.

PKCT has an Air Quality Improvement Strategy (AQIS) that consists of benchmarking and performing cost/benefit analyses of dust management technologies and process improvements. The AQIS is routinely reviewed and updated.

PKCT has also developed a dust management strategy that consists of the following:

a) Networking with other similar terminals to ensure PKCT is up to date with best practice dust management methodologies.

b) Monitoring of ambient levels using two continuous particulate matter monitors and a network of dust deposition gauges. This real time data enables PKCT to better understand particulate matter emissions and their relationship to weather conditions.

c) Investigating the benefits of using agglomerating chemicals to reduce the dustiness of the materials that are handled on-site and to reduce wind erosion of unsealed areas.

d) Investigating the dust extinction moisture levels (DEM) of the materials that are handled on-site to ensure that products are received and maintained at their optimum moisture content and are, therefore, less prone to particulate matter emission.

e) Continuous improvement of site practices and housekeeping to reduce the likelihood of fugitive particulate matter emissions.

f) Providing effective environmental management practices through ISO 14001 certification.

g) Increasing environmental accountability, competency and awareness via a sustainability program.

3.3 Planned Particle Control Measures

PKCT has a program for the introduction of enhanced particulate matter mitigation strategies in addition to those listed above. The following measures are either in the process of being implemented or have been committed to and will be implemented in the future:

- The existing three stackers and two reclaimers will be replaced with three new stackers and one new reclaimer by July 2018. The design specifications for the new stackers and reclaimer include the following best practice features for particulate matter control:
    - Dust suppression sprays at coal transfer points and adjacent to the boom discharge.
    - Surfaces of the various structural elements designed to shed water and coal particles and to minimise encrustation.
    - Chutes and conveyor skirtings designed to minimise spillage and dust generation.
    - Floors will be fully sealed.
    - Conveyor underpans will be provided with wash sprays.
    - Conveyors will have one side-wall wind break.
    - All material transfers will be "soft loading" type.

- PKCT has embarked on a Stockpile Spray Control Improvement project that aims to improve the control logic for the stockpile spray system. As part of the initial phase of this project, PKCT has commissioned a study by Red Planet Innovations Pty Ltd. As the study is currently ongoing it is not possible to quantify the outcomes that may be achieved in additional control, but the project aims to produce benefits in particulate matter mitigation in the following areas:
    - Greater automation of water sprays. This will allow proactive maintenance of a consistent moisture level and level of control and remove reliance on operator judgement and reactive measures. The system would also ensure consistency across all stockpile areas during the day and night.
    - Improved spray logic. This will ensure the system can apply water to the stockpiles more effectively and efficiently. More effective water application will reduce dust emissions by targeting stockpiles with the highest potential to liberate dust and varying spray intervals and durations based on weather conditions.
    - Optimisation of water usage, minimising of slumping. Overwatering of stockpiles may cause the stockpile to slump, which can lead to an increase in the area exposed to wind erosion and coal on roads that may be subsequently pulverised and resuspended by traffic. Slumping may also cause coal to be spilled outside of water spray reach.

3.4 Estimated emissions of TSP, PM_{10} and $PM_{2.5}$

Emissions of TSP, PM_{10} and $PM_{2.5}$ have been estimated for each activity at PKCT using emission factors published in National Pollutant Inventory (NPI) Emission Estimation Handbooks and the US EPA AP-42 documents. Table 2 presents the emission rates of TSP, PM_{10} and $PM_{2.5}$ estimated for PKCT based on coal throughput and meteorological data for the 2015/16 financial year but excluding the benefit of existing emission controls. These theoretical “uncontrolled” emission rates have been presented as a baseline to provide context for the existing controls and analysis of the potential benefits of additional controls.

A detailed breakdown of the method, inputs and calculations for estimating the emissions for each activity are described in Appendix A.

Table 2 Uncontrolled emissions from PKCT activities during the 2015/16 financial year

Activity		TSP Emissions (t/year)	PM_{10} Emissions (t/year)	$PM_{2.5}$ Emissions (t/year)
Wind erosion	Coal stockpiles	102.1	51.1	7.7
	Bulk product stockpiles	25.3	12.7	0.9
	Exposed spillage areas	8.9	4.4	0.7
	Exposed cleared areas	2.7	1.4	0.2
Conveyors	Conveyors	25.7	9.4	1.8
Handling	Stacking	5.1	2.4	0.4
	Reclaiming	5.1	2.4	0.4
	Shiploading	4.0	1.9	0.3
	Transfer points	26.3	12.4	1.9
	Road receival	2.5	1.2	0.2
	Rail receival	1.4	0.7	0.1
	Bulk material handling	0.2	0.1	0.0
Vehicle movements	Unpaved areas	0.6	0.2	0.0
Total		**209.8**	**100.1**	**14.5**

The particulate matter emission reduction efficiencies for the control measures in use at PKCT and described in Section 3.2 are estimated in Table 3, based on the relevant literature.

Controlled emissions of TSP, PM_{10} and $PM_{2.5}$ have been estimated by applying an emissions reduction efficiency to the uncontrolled emissions detailed in Table 2 based on the control measures detailed in Table 3. Controlled emission rates of TSP, PM_{10} and $PM_{2.5}$ are presented in Table 4. Figure 1 presents a comparison PM_{10} emissions with and without controls.

Table 3 PKCT particulate matter control measures – emissions reduction efficiencies

Activity		Particulate matter control	Particulate matter reduction efficiency	Source
Wind erosion	Coal stockpiles	Water application	50%	NPI Mining v3.1
	Bulk product stockpiles	Water application	50%	NPI Mining v3.1
	Exposed spillage areas	Cleanliness Misting sprays Beltwash	n/a 50% 95%	n/a NPI Mining v3.1 Estimated
	Exposed cleared areas	Water cart	50%	
Conveyors	Conveyors	Fully enclosed Enclosed on two sides	70% 40%	NPI Mining v3.1 Estimated
Handling	Stacking	Variable height with water sprays	63%	NPI Mining v3.1
	Reclaiming			
	Shiploading	Telescopic chute into ship	70%	NPI Mining v3.1 (Transfer - Enclosure)
	Transfer points	Enclosed by building Enclosed with skirt	95% 70%	Estimated NPI Mining v3.1
	Road receival	Water sprays	70%	NPI Mining v3.1
	Rail receival	Enclosed by building	70%	NPI Mining v3.1
	Bulk material handling	none	n/a	n/a
Vehicle movements	Unpaved areas	Water cart	50%	NPI Mining v3.1

Table 4 Controlled emissions from PKCT activities during the 2015/16 NPI reporting period

Activity		TSP Emissions (t/year)	PM_{10} Emissions (t/year)	$PM_{2.5}$ Emissions (t/year)
Wind erosion	Coal stockpiles	51.1	25.5	3.8
	Bulk product stockpiles	12.7	6.3	0.5
	Exposed spillage areas	5.4	2.7	0.4
	Exposed cleared areas	1.4	0.7	0.1
Conveyors	Conveyors	14.3	5.2	1.0
Handling	Stacking	1.9	0.9	0.1
	Reclaiming	1.9	0.9	0.1
	Shiploading	1.2	0.6	0.1
	Transfer points	3.3	1.5	0.2
	Road receival	0.7	0.3	0.1
	Rail receival	0.4	0.2	0.0
	Bulk material handling	0.2	0.1	0.0
Vehicle movements	Unpaved areas	0.3	0.1	0.0
Total		**94.7**	**45.1**	**6.5**

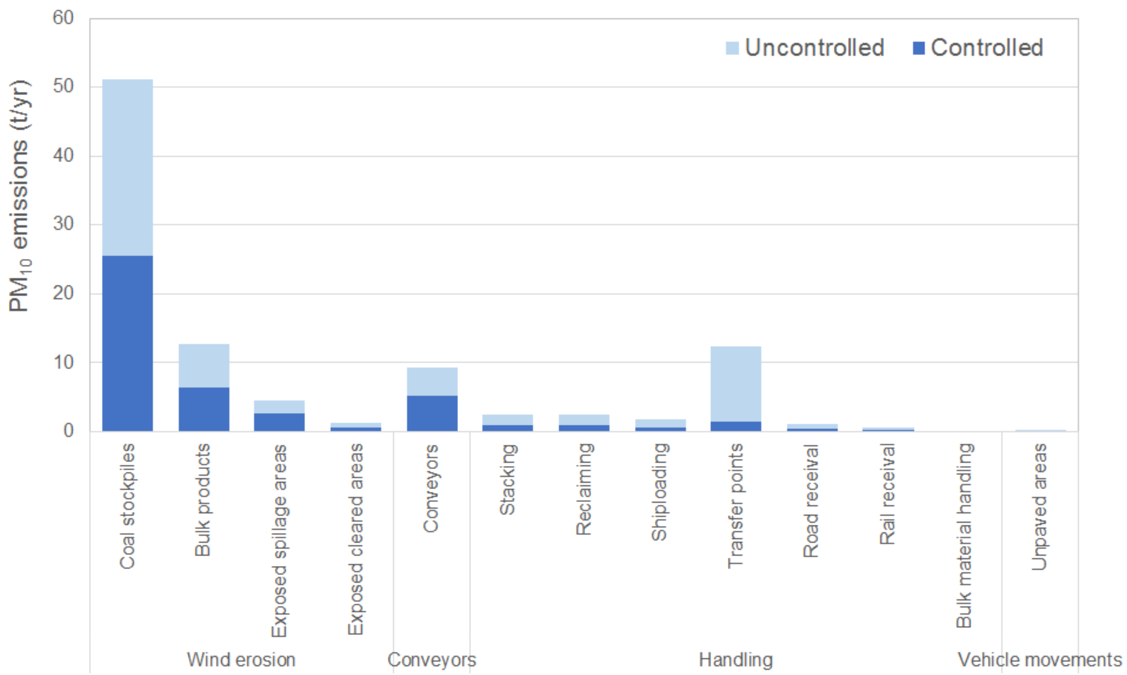

Figure 1 **Uncontrolled and controlled emissions of PM_{10} from PKCT activities during the 2015/16 financial year**

3.5 Activity Ranking

Table 5 presents the activities at PKCT with the highest emission rates based on throughput and meteorological data for the 2015/16 financial year. These activities contribute more than 90% of emissions of TSP, PM_{10} and $PM_{2.5}$ from PKCT.

Table 5 **Top particulate matter generating activities at PKCT for the 2015/16 financial year, ranked by PM_{10} emissions**

Rank	Source	TSP emissions (t/year)	PM_{10} emissions (t/year)	$PM_{2.5}$ emissions (t/year)
1	Coal stockpiles	51.1	25.5	3.8
2	Bulk product stockpiles	12.7	6.3	0.5
3	Conveyors	14.3	5.2	1.0
4	Exposed spillage areas	5.4	2.7	0.4
5	Stacking and reclaiming	3.8	1.8	0.3

4. BEST PRACTICE MEASURES TO MINIMISE PARTICLE EMISSIONS

The following section identifies best practice measures to minimise particle emissions from the top four ranking particulate matter generating activities at PKCT. Best practice measures have been identified from relevant literature and industry experience and used to estimate best practice emission rates of TSP, PM_{10} and $PM_{2.5}$ from PKCT.

4.1 Best practice control measures

4.1.1 Coal stockpiles and bulk product stockpiles

Coal and bulk product stockpiled at PKCT have been identified as the two largest sources of particulate matter emissions, accounting for approximately 65% of total PM_{10} emissions from PKCT (Table 4). Therefore, controlling particulate matter emissions from these sources has the potential to provide the greatest benefit.

Material stockpiles have a large erodible surface area that is susceptible to generation of emissions of particulate matter by the wind (wind erosion). In addition to stockpile surface area, height, shape and configuration, emissions generated by wind erosion are also dependent on the frequency of disturbance of the erodible surface and the characteristics of coal in the stockpile.

The NSW Coal Benchmarking Study (Katestone, 2011) identified the following control measures in the literature to minimise stockpile emissions and stated their effectiveness (Table 6):

- Bypassing stockpiles to load directly into ships (throughloading)
- Watering to minimise lift-off with automatic control through continuous cycling and increased application based on meteorological conditions
- Chemical suppressants to bind loose fine surface material in response to adverse weather conditions
- Enclose, tarp, fence, bund or build shelterbelts to reduce ambient wind speeds over stockpiles
- Minimise residence time of coal in stockpiles.

Note that these control measures have been listed without regard to whether their application may be feasible at a particular site.

The NSW Coal Benchmarking Study (Katestone, 2011) identified that the current best practice measures to control emissions of particulate matter from coal stockpiles include:

- Shaping and orientation to minimise emissions of particulate matter
- Stockpile watering on continuous cycle with modification of cycle depending on prevailing weather conditions to allow greater or lesser watering intensity.

Table 6 **Effectiveness of best practice control measures to reduce particulate matter emissions from coal stockpiles (Katestone, 2011)**

Control Measure		Effectiveness
Avoidance	Bypassing stockpiles	100% reduction in wind erosion for coal bypassing stockpiles
Surface stabilisation	Water spray	50%
	Chemical wetting agents	80-99% 85% 90%
	Surface crusting agent	95%
	Carry over wetting from load in	80%
Enclosure	Silo with bag house	100% 95-99% 99%
	Cover storage pile with a tarp during high winds	99% [A]
Wind speed reduction	Vegetative wind breaks	30%
	Reduced pile height	30%
	Wind screens/wind fences	>80% 75-80%
	Pile shaping/orientation	<60%
	Erect 3-sided enclosure around storage piles	75%

Note
[A] Estimated based on the effectiveness of chemical surface treatments

There are 11 active coal terminals in Australia. All coal terminals use water sprays to manage emissions of particulate matter from coal stockpiles. Several coal terminals also apply chemical suppressants to stockpiles in response to weather conditions.

The study *Coal Dust Control Techniques – Review of Current Practice* (John Planner, 2010) identified that understanding coal dustiness characteristics and the DEM level is key to achieving particulate matter management from stockpiles and across all bulk handling activities. Maintaining the moisture content above DEM has been shown to be highly effective in reducing particulate matter emissions and is achieved through application of water at the mine or at the coal terminal: at receiving points, conveyor transfers, stackers and on stockpiles. This method also requires the regular testing of coal to ensure moisture is above the relevant DEM.

A number of coal terminals in Australia have developed proactive systems to help with the management of particulate matter emissions. The aim of proactive systems is to pre-empt conditions conducive to generating particulate matter emissions so that effective responses may be implemented. The proactive systems use weather forecasts to predict particulate matter risk from site activities. Real time monitoring data and information on current operational activities are also used to trigger actions (such as, more intensive regime of water sprays on stockpiles) when certain conditions occur. Whilst shown to be very effective, the control efficiency of proactive systems has not been quantified in the literature.

The orientation of the stockpiles is fixed by the layout of the terminal, which is itself constrained by its location. In the case of PKCT, the stockpiles are arranged in a generally north-south direction, which minimises the area of coal that may be subject to wind erosion with strong southerly winds. Therefore, no further improvements in this area is necessary or practical.

Whilst enclosure of stockpiles is feasible in some limited circumstances, the large scale of coal terminal stockpiles makes enclosure impractical and unviable. No coal terminals in Australia have enclosed stockpiles.

A summary of management and control measures for stockpiles at PKCT is presented in Table 7.

Table 7 PKCT benchmarking against best practice for stockpiles

Activity / management approach	Best practice example	Current PKCT implementation
Avoidance	Minimise residence time Maximise throughloading	Minimise residence time
Surface stabilisation	Chemical dust suppressant Stockpile watering on continuous cycle with modification of cycle depending on prevailing weather conditions to allow greater or lesser watering intensity	Trialled Watering including reactive management In progress – proactive management of stockpile watering, automated process
Wind speed reduction	Shape/orientation Bunds/walls Reduced pile height	North-south orientation 23 m maximum height

4.1.2 Conveyors

The NSW Coal Benchmarking Study (Katestone, 2011) identified that the design of the conveyors within the material transport system has a large bearing upon their potential to emit particulate matter. Water application and wind shielding were the most important items in reducing the quantity of particulate matter emitted. Table 8 summarises the best practice control measures identified for conveyors.

Table 8 Effectiveness of best practice control measures to reduce particulate matter emissions from conveyors

Control Measure	Effectiveness
Application of water at transfer between conveyors	50%
Wind shielding – roof or side wall	40%
Wind shielding – roof and side wall	70%
Belt cleaning and spillage minimisation	94% control (on site measurements)

Water application up to the DEM is an important basic premise to the reduction of particulate matter emissions. Surface addition of water at each point of coal disturbance (such as a transfer from one conveyor to another) reduces the emission of particulate matter. To minimise lift-off of particulate matter from the conveyors, wind shielding and enclosure of the conveyors are beneficial.

Other solutions to reduce the particulate matter generated by the conveyor system are centred upon avoiding spillage and diligent clean-up of spillage when it occurs. Other items include: clean-up launders under conveyors, integrated control systems to prevent overloading of conveyors to prevent spillage, belt washing stations on heads of belts and wind shielding.

A summary of management and control measures for conveyors is presented in Table 9.

Table 9 PKCT benchmarking against best practice for conveyors

Activity / management approach	Best practice example	Current PKCT implementation
Inloading conveyors	Wind shielding Application of water at transfers	Full enclosure implemented
Yard conveyors	Wind shielding Application of water at transfers	Wind shielding
Outloading conveyors	Wind shielding Application of water at transfers	Roof and/or side wall Application of water at transfers

4.1.3 Spillage areas

Wind erosion of exposed areas of spillage is minimised through good housekeeping practices that minimise spillage of material in the first instance or reduce the time before spilled material is cleaned. Good housekeeping practices identified in the literature include:

- Cleaning up spillages when they occur
- Wetting down hard standing areas
- Utilising mobile water carts
- Investigating causes of spillage
- Implementing a site management plan that includes protocols for identification and clean-up of spillage.

The literature does not quantify the effectiveness of implementing good housekeeping practices because the effectiveness will depend on the specific improvements that are implemented. In some instances, the effectiveness of certain interventions can be inferred from experience with other activities. For example, a 50% effectiveness could be applied to the action of wetting down hard standing areas based on the literature for stockpile control measures. The emission rate of particulate matter has been estimated from the area of available hardstand that may be soiled by spilled material. Application of measures to reduce the area that may be subject to spillage would provide a further basis for quantifying the benefits of addressing these areas.

Spillage from the stockpile area can occur when the stockpiles slump. This occurs when the coal becomes too wet, primarily cause by significant rainfall, but occasionally by overwatering by stockyard sprays.

A summary of management and control measures for exposed areas is presented in Table 10.

Table 10 PKCT benchmarking against best practice for exposed areas

Activity / management approach	Best practice example	Current PKCT implementation
Management	Spill minimisation Wetting down working area Site management plan	Spill minimisation Beltwashing on some conveyors Misting sprays under yard conveyors Water sprays at road receival Site management plan

4.1.4 Stacking and reclaiming

Stacking at a coal export terminal refers to the process of creating stockpiles in designated areas for short to medium term storage. Coal received from trains or trucks is transferred by conveyor system to a stacker within the stockyard area where it is placed in designated stockpiles. A typical stacker consists of a tripper conveyor (transfers coal from the inloading conveyor to the stacker) and a boom (conveyor). The boom type stacker can be one or a mix of the following:

- Rigid
- Extendable
- Luffing (up and down)
- Slewing (side-to side)

Dust is generated from the stacking process when material is dropped from the stacker into the stockpile. The highest potential for dust emissions during coal stacking would be when stacking dusty coal types during windy conditions and large drop heights. The NSW Coal Benchmarking Study (Katestone, 2011) identified that the following measures are applied to minimise emissions of dust from stacking:

- Bypass coal stockpile (through loading)
- Variable height stacking (luffing)
- Use of chutes and wind shields
- Water application (boom tip sprays)

Reclaiming at a coal export terminal is the process of transferring coal from a stockpile onto the outloading conveyor and into ships ready for export. The majority of reclaiming at export terminals uses either a gravity feed system where coal is transferred on conveyors underneath a stockpile or by using bucket wheel reclaimers. Bulldozers and front-end loaders are sometimes used for reclaiming small stockpiles. The NSW Coal Benchmarking Study (Katestone, 2011) identified that the following measures are applied to minimise emissions of dust from reclaiming:

- Bypass coal stockpile (through loading)
- Use of bucket wheel reclaimer
- Water application
- Minimise residence in stockpiles
- Coal moisture management.

Table 11 summarises the best practice control measures identified for stacking and reclaiming.

Table 11 Effectiveness of best practice control measures to reduce particulate matter emissions from conveyors

Control Measure		Effectiveness
Avoidance	Throughloading	100% reduction in emissions
Stacking	Variable height	25%
	Boom tip water sprays	50%
	Telescopic chute with water sprays	75%
Reclaiming	Bucket wheel with water application	50%

A summary of management and control measures for stacking and reclaiming is presented in Table 12.

Table 12 PKCT benchmarking against best practice for stacking and reclaiming

Activity / management approach	Best practice example	Current PKCT implementation
Avoidance	Throughloading	
Stacking	Variable height Boom tip water sprays Telescopic chute	Variable height Boom tip water sprays
Reclaiming	Bucket wheel with water application	Bucket wheel with water application

4.2 Best practice control summary

A summary of the best practice control measures and their effectiveness is shown in Table 13 for the highest PKCT particulate matter (PM_{10}) generating activities.

Table 13 Summary of best practice control measures

Source	Current control	Effectiveness	Best practice control	Effectiveness
Coal stockpiles	Watering	50%	Chemical suppressant	up to 80% [a]
Bulk product stockpiles				up to 80% [a]
Conveyors	Roof and/or side wall	40% - 70%	Minimum: roof and side wall	70%
Exposed spillage areas	Spill minimisation Beltwash	Not quantified 94%	Spill minimisation, wetting down working areas, beltwash site management plan	50% - 94%
Stacking and reclaiming	Water sprays Variable height	50% 25%	Water sprays Variable height Throughloading	50% 25% Variable

[a] The nominal control efficiency of chemical suppressants is 80%. In practice, suppressants may not be applied at all times, for example it may not be practical where coal has a short residence time in stockpiles.

4.3 Best practice control emissions inventory

Table 14 presents emissions of TSP, PM_{10} and $PM_{2.5}$ from the highest emitting activities assuming application of additional best practice controls with no consideration of feasibility. Emissions are calculated from the 2015/16 financial year inventory.

Table 14 Best practice controlled emissions from the highest PKCT activities

Activity		TSP Emissions (t/year)	PM_{10} Emissions (t/year)	$PM_{2.5}$ Emissions (t/year)
	Existing Controls Total	**87.3**	**41.5**	**6.0**
Wind erosion	Coal stockpiles	20.4	10.2	1.5
	Bulk product stockpiles	5.4	2.5	0.2
	Exposed spillage areas	3.2	1.6	0.2
Conveyors	Conveyors	7.7	2.8	0.6
Transfers	Stacking and reclaiming	3.8	1.8	0.3
	Best Practice Controls Total	**40.5**	**18.9**	**2.8**
Possible reduction: no consideration of feasibility		**54%**	**54%**	**53%**

5. PRACTICABILITY OF IMPLEMENTATION OF CONTROLS

5.1 Coal Stockpiles

5.1.1 Chemical suppressants

Whilst application of water to the surface of coal stockpiles is an effective technique for dust control, its effectiveness is limited. As water evaporates from the surface, most coals become more susceptible to dust generation by wind erosion and so water needs to be continually applied to maintain dust suppression. The purpose of chemical suppressants is to mitigate dust emissions from wind erosion of stockpiles by agglomerating the coal fines on the stockpile surface. Chemical suppressants or surface veneers have been demonstrated in laboratory wind tunnel tests and in the field to be effective agents for controlling dust emissions from erodible surfaces.

The control efficiency of chemical suppressants depends on:

- Dilution rate of the mixture
- Application rate
- Disturbance of the surface
- Time between applications
- Meteorological conditions.

Chemical suppressants reduce the effects of wind erosion by binding the surface into a crust. Spraying of suppressants onto stockpiles is normally carried out by truck to target application to problem areas. There are number of local and international companies that sell suppressants into the Australian market. The key benefit of a suppressant is in reducing the need for frequent water application. Subsequent watering of the surface can reactivate the chemical suppressant.

PKCT has investigated the use of chemical suppressants on its stockpiles. It was found that the existing stockyard spray system was not a viable means of applying suppressant, but suppressant could be applied by water cart. To achieve this, an additional water cart would be required and a water cart veneering station.

There are no regulatory requirements that relate to the use of chemical suppressants. The potential to cause environmental impacts will depend on the product. Most advertise minimal risk to the environment with the application of routine precautions. Safety implications will depend on product, most advertise minimal risks with routine precautions.

The costs associated with implementing a system to use chemical suppressants to control dust are documented in Appendix B. The analysis indicates that chemical suppressants may reduce emissions of PM_{10} by 11.5 tonnes/year at a cost of $25,374 per tonne reduced. This is the most cost-effective control measure that was identified in the analysis.

The outcomes of the analysis are dependent on the input assumptions, including that 75% of coal can be veneered within a very short timeframe after stacking, removing the requirement for watering. Additional analysis is recommended into a comprehensive system that includes optimising the use of both water and veneer to ensure efficient use of both while minimising emissions and costs.

5.2 Stacking, reclaiming, transfers and shiploading

5.2.1 Throughloading

Throughloading involves bypassing the stockpiles and loading a ship directly with coal unloaded from road or rail. This reduces emissions by eliminating stacking and reclaiming. It may also reduce wind erosion potential if less coal is stored in the stockpile.

At PKCT, throughloading would involve changing the destination of unloaded coal from the yard conveyors to a bypass conveyor to take the coal directly to the shiploader.

Throughloading would not introduce any additional regulatory requirements, environmental impacts or safety implications.

Throughloading is not performed currently at PKCT due to it being logistically unfeasible. The barriers to implementing throughloading are:

- Infrastructure. Throughloading is technically feasible under the current system but to be implemented would require recommissioning of the bypass system.
- Logistical. Throughloading requires that the coal being unloaded be of the same type as the being shiploaded. As PKCT has a number of clients and no control over the delivery timetable of coal, throughloading cannot be scheduled with any reliability.
- The rate of throughloading is limited by the amount of coal that can be delivered by rail while a ship is in berth.

The costs associated with ensuring that throughloading is possible have been documented in Appendix B.

The benefit associated with throughloading is highly dependent on how much product can be feasibly throughloaded given the logistical constraints. Under current operating parameters, it would seem feasible that a maximum of 20% of a shipload could be throughloaded; however, in practice this is likely to be limited to the size of a single trainload (e.g. approx. 5%) and this is unlikely to be possible for every ship.

The cost benefit analysis is documented in Appendix B shows that while throughloading may reduce PM_{10} emissions by 0.4 tonnes/year, the cost of $138,956 per tonne reduced indicates that it is not a cost-efficient method for reducing particulate matter emissions.

5.3 In-bound coal moisture management

Coal moisture affects the amount of coal dust generated when it is dropped. When the coal moisture level is equal to the Dust Extinction Moisture (DEM) Level for the individual coal, minimal dust is produced during handling. In effect, the finer fractions remain within the coal mass rather than being liberated.

Each coal has a relatively unique DEM Level. Consequently, laboratory testing is required to determine the DEM for each individual coal type. However, several issues must be taken into consideration before the DEM concept can be applied at a particular coal terminal. These issues include: the volume of water required to reach DEM, the contract moisture content of the coal, the ability of coals to retain the water and the risk of slumping in the stockpile.

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 DEM Level.

PKCT has begun work on the In-bound Coal Moisture Measurement project to install a coal moisture analyser on the in-bound Rail conveyor stream. The coal moisture analyser has the capability to provide PKCT with accurate coal moisture content data in real-time. Since commissioning the coal moisture analyser, the data has not been used or verified. The coal moisture analyser will likely need to be recommissioned and the data validated.

The In-bound Coal Moisture Control project includes the following plant and equipment:

- New Water Spray bars and Nozzles –To apply water to the coal surface on conveyors NC2 and NC5.
- Stockpile Spray Pump Upgrades – Two new 75kW multistage VVVF controlled pumps to supply water to the sprays.
- New Water Supply Piping – To supply water from the existing water mains to the new sprays.
- Existing NC2 Belt Weigher (Road only) – Measures the linear mass (i.e. tph) of in-bound coal on conveyor NC2.
- New NC5 Belt Weigher (Rail only) – Measures the linear mass (i.e. tph) of in-bound coal on conveyor NC5.

The In-bound Coal Moisture Control project will provide PKCT with a system capable of increasing the coal moisture content by ~4%. To increase the coal moisture content greater than 4%, or to treat free-draining coals, additional agglomeration chemicals are required.

There are no additional regulatory requirements, environmental impacts or safety implications to PKCT operations associated with the implementation of In-Bound Coal Moisture Control.

The costs associated with implementing a system to manage in-bound coal moisture are documented in Appendix B. The analysis indicates that this system may reduce emissions of PM_{10} by 3.9 tonnes/year at a cost of $95,197 per tonne reduced. The main driver of this cost is water use. Optimising the system to target the dustiest coals will lead to less water usage while maximising the control efficiency of the system and will reduce the cost per tonne of PM_{10} reduced.

5.4 Chemical Suppressant on bulk products and waste coal areas

Similar to the coal stockpiles, chemical suppressants could be applied to the bulk products and the waste coal areas. The chemical suppressant would be applied using a water cart. To achieve this, an additional water cart would be required and a water cart veneering station.

There are no regulatory requirements that relate to the use of chemical suppressants. Environmental impacts will depend on product, most advertise minimal risk to the environment with routine precautions. Safety implications will depend on product, most advertise minimal risks with routine precautions.

The costs associated with implementing a system to apply chemical suppressants to the bulk products and waste coal areas are documented in Appendix B. The analysis found that application of suppressants to bulk products and waste coal may reduce emissions of PM_{10} by 3.8 tonnes/year at a cost of $59,491 per tonne reduced, indicating that chemical suppressants on bulk product and waste coal areas is one of the more cost-effective means of controlling dust.

5.5 Chemical suppressant on other exposed areas

Similar to the coal stockpiles, chemical suppressants could be applied to exposed areas. The chemical suppressant would be applied using a water cart. To achieve this, an additional water cart would be required and a water cart veneering station.

There are no regulatory requirements that relate to the use of chemical suppressants. Environmental impacts will depend on product, most advertise minimal risk to the environment with routine precautions. Safety implications will depend on product, most advertise minimal risks with routine precautions.

The costs associated with implementing a system to use chemical suppressant to control dust from exposed areas will depend on the size of area being controlled, activities that may occur in the area and the surface type. Due to the small size of other exposed areas compared to the coal and bulk product stockpiles, this has not been considered further. However, if the use of chemical suppressants is implemented on coal or bulk product stockpiles, their use on other exposed areas should be considered.

5.6 Bunds/Berms on Bulk Products Area

The bulk product stockpile area is located to the south of the coal stockyard. The area is used for storing non-coal bulk materials and also processing of waste material collected from the coal stockyard area such as runoff and waste water.

The bulk product area does not have clearly defined stockpile areas or vehicle paths, which leads to the area being dustier than if the area had well defined and managed boundaries. Construction of bunds / berms or walls around areas used for stockpiling bulk product and waste coal would provide a clearly defined area to contain spillage. Additionally, the construction of bunds / berms or walls would help break the wind flow across the bulk product area thereby reducing the potential for dust lift-off from the stockpiles.

There are no additional regulatory requirements, environmental impacts or safety implications to PKCT operations for constructing bunds / berms or walls in the bulk product stockpile area.

The cost associated with construction of berms around the bulk product area is presented in Appendix B. The analysis indicates that construction of berms around the bulk product area may reduce emissions of PM_{10} by 0.36 tonnes/year at a cost of $429,201 per tonne reduced. Based on the analysis, this is one of the least cost-effective means of controlling particulate matter emissions. However, the analysis is based on emissions of dust only and has not accounted for other potential benefits, such as improved water quality and waste reduction. This analysis has not considered that the mitigation measure may also reduce the risk of potential material environmental non-compliance events.

5.7 Conveyors

Section 4.1.2 identified measures for controlling dust emissions from conveyors including:

- Application of water at transfer points
- Wind shielding - roof or side wall
- Wind shielding – roof and side wall (enclosure)
- Belt cleaning and spillage minimisation.

Best practice control of dust emissions from conveyors was identified as wind shielding – roof and side wall (enclosure). The practicability of enclosing the unenclosed conveyors at PKCT and adding belt cleaning systems is discussed in the following sections. Whilst not identified as a best practice measure, the addition of belt cleaning systems to conveyors can greatly reduce the amount of coal spilled from a conveyor.

5.7.1 Wind shielding – roof and side wall (enclosure)

Table 9 in Section 4.1.2 benchmarks the current PKCT conveyor system against best practice dust controls. The inloading conveyors at PKCT are already fully enclosed and do not require further dust controls. The yard conveyors and outloading conveyors at PKCT have wind shielding from the side but are not enclosed with a roof.

The yard conveyors at PKCT cannot be modified to incorporate a roof structure because the rail mounted stackers and reclaimers require access to the conveyor from above. A roof structure could be designed but is likely to be cost prohibitive and has not been considered. Further to this, coal on the yard conveyors is somewhat protected from wind erosion by the coal stockpiles (when present) and the stockpile berms.

The outloading conveyors at PKCT are fitted with wind shields on the side of the conveyors and so there may be capacity to fit a roof structure to further reduce dust emissions. It should be noted that the conveyor connected to the shiploader cannot be fitted with a roof structure because the shiploader needs access from above.

Therefore, only three of the outloading conveyors (C12, C13 and C15) at PKCT are able to be fitted with roof structures. This represents only 9% of the length of the conveyor system.

There are no additional regulatory requirements, environmental impacts or safety implications to PKCT operations for adding wind shielding to the three outloading conveyors.

The cost associated with installation of enclosures on conveyors is presented in Appendix B. The analysis indicates that this will reduce emissions by 0.18 tonnes/year at a cost of $247,815 per tonne reduced, which is not a cost-effective means of control relative to other methods in the analysis. However, the analysis is based on emissions of dust only and has not accounted for other potential benefits, such as improved water quality and waste reduction. This analysis has not considered that the mitigation measure may also reduce the risk of potential material environmental non-compliance events.

5.7.2 Belt cleaning

Conveyor belt cleaning systems reduce the spillage of any carry back (coal adhering to the conveyor belt) that can be a potential source of dust emissions that requires manual cleanup. PKCT has recently installed a belt cleaning system on its wharf conveyor (NC14) to reduce the potential of carry back spillage along Berth 102. The results of testing carry back on NC14 before and after installation of the belt cleaning system showed an 85% to 95% reduction in carry back that equates to avoidance of approximately 90 tonnes of spilled coal per year.

Belt cleaning systems could be installed on the yard conveyors at PKCT to reduce the amount of manual cleanup that is required. The risk of carry back spillage from the yard conveyors generating dust impact is less of a concern because misting sprays are installed on the yard conveyors but would greatly reduce manual cleanup.

There are no additional regulatory requirements, environmental impacts or safety implications to PKCT operations for adding belt cleaning systems to the three yard conveyors.

The cost associated with installation of belt cleaning systems is presented in Appendix B. The analysis indicates that installation of belt cleaning systems on the three yard conveyors will reduce emissions by 1.13 tonnes/year at a cost of $259,862 per tonne reduced, which is not a cost-effective means of control relative to other methods in the analysis.

The analysis is based on emissions of dust only and has not accounted for other potential benefits, such as improved water quality and waste reduction. In addition to its benefits in reduction in particulate matter emissions, the NC14 belt cleaning upgrade was implemented to address an outdated cleaning system, minimise the risk of potential material environmental non-compliance events related to the NC14 conveyor's proximity to the inner harbour and to mitigate safety risks involved in operations and maintenance activities. Potential benefits of this type have not been included in the analysis in Appendix B.

5.8 Shiploading area

Katestone's observation during the site inspection was that there was a significant amount of coal spillage on Berth 102. Spillage is associated with the shiploading conveyors and the shiploading spout, particularly, coal that falls from the shoot during retraction. Modern shiploaders are supplied with boom conveyors which have containment trays underneath, to enable recovery of spillage back to the shoreline rather than spilling onto the wharf or ships deck. When the boom pivots above horizontal, the trays are washed back into the shore based recovery systems.

Such systems add load to the shiploader boom, which needs to be allowed for in the design of the shiploader. It is unlikely that the existing shiploader design will have capability for the additional loading which would be imposed upon the structure in the case of a major spillage.

To further investigate these possibilities, considerable design input is required to determine the load carrying capacity and practicality of retrofitting systems to the existing installations.

PKCT has previously identified shiploader washdown systems as a possible control measure that would require further investigation prior to determining its feasibility. PKCT has previously determined that a wharf washdown system would not be feasible, but has identified and has committed to implemented a number of improvements to assist with dry clean-up on the wharf.

5.9 Suction trucks

The introduction of a suction truck at other facilities has been found to allow timely and effective dust cleanup as required to improve the site cleanliness without increasing site costs in a major manner. The advantage of this system is the speed, lack of rework and ultimately cleanliness across the site where required. The introduction of the suction truck will also require additional infrastructure within the site to enable the cleaning of difficult to access areas such as transfer towers. Other areas that could be cleaned using the suction truck are the wharf area, drains and spill recovery pits.

There are no additional regulatory requirements, environmental impacts or safety implications to PKCT operations for use of suction trucks at PKCT.

The cost associated with a suction truck is presented in Appendix B. The analysis indicates that a suction truck will reduce emissions by 2.04 tonnes/year at a cost of $307,426 per tonne reduced, which is not a cost-effective means of control relative to other methods in the analysis.

6. CONCLUSIONS

In October 2016, the NSW EPA issued PKCT with a notice to vary EPL 1625 (Notice Number 1544414) to include the Environmental Improvement Program (EIP) U2 *Environmental Improvement Program (EIP) – Particulate Matter Control Best Practice Study*. A methodology was applied based on the Determination Guideline and NSW Coal Benchmarking Study to complete a study of best practice particulate matter controls.

The existing measures that are being used to minimise particle emissions at PKCT were identified and quantified as part of an emissions inventory. The inventory indicated that the following are the major sources of particulate matter emissions at PKCT:

- Coal stockpiles
- Bulk product stockpiles
- Conveyors
- Exposed spillage areas
- Stacking and reclaiming.

The best practice measures that could be used to minimise particle emissions at PKCT were identified and quantified. PKCT has implemented the following best practice measures for controlling dust emissions:

- Full enclosure of inloading conveyors
- New stackers and a reclaimer will be commissioned prior to July 2018 with best practice dust controls
- Belt washing system installed on the wharf conveyor NC14
- Automated stockyard spray system currently installed and optimisation study underway
- Misting sprays underneath yard conveyors.

A number of areas were identified where further measures could be introduced to ensure PKCT is operating at best-practice. The practicability of implementing these further best practice measures was evaluated using a cost-benefit analysis. The analysis looked at the following controls:

- Applying chemical suppressants to the coal stockpiles
- Throughloading of coal
- Applying water to maintain DEM
- Applying chemical suppressants to the bulk product and waste coal stockpiles
- Constructing bunds/berms around the bulk product and waste coal stockpiles
- Enclosing conveyors
- Installing belt cleaning systems on yard conveyors
- Operation of a suction truck to clean spillage areas.

The analysis identified that the most cost-effective controls for controlling dust are likely to be, in order, the following:

- Applying chemical suppressants to the coal stockpiles
- Applying chemical suppressants to the bulk product stockpiles
- Applying water to maintain DEM.

7. REFERENCES

Katestone Environmental, 2011. NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining. Prepared for the Office of Environment and Heritage.

Office of Environment and Heritage (OEH), 2011, Coal Mine Particulate Matter Control Best Practice – Site specific determination guideline, State of NSW.

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APPENDIX A DETAILED EMISSIONS INVENTORY

A1 WIND EROSION – COAL STOCKPILES

The emission rate of TSP from wind erosion of coal stockpiles at PKCT has been calculated using the following emission factor equation (NPI, 2012, Equation 22) (Equation 1).

Equation 1 Emission Factor equation for calculation of stockpile TSP emission rate

$$EF_{TSP} = 1.9\left(\frac{s}{1.5}\right)\left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right)\ kg/ha/day$$

Where:

s = silt content (%).

p = number of days when rainfall is greater than 0.25 mm.

f = percentage of time that wind speed is greater than 5.4 m/s (wind speeds at 23 metres were used which represents 2/3 the height of the coal stockpiles)

The area of coal stockpiles was provided by PKCT as detailed in Table 1. Emissions of PM_{10} and $PM_{2.5}$ from wind erosion of coal stockpiles at PKCT were calculated by the ratio of PM_{10} to TSP (50%) and the ratio of $PM_{2.5}$ to TSP (7.5%).

A2 WIND EROSION – BULK PRODUCT STOCKPILES

The emissions of TSP, PM_{10} and $PM_{2.5}$ from wind erosion of bulk product stockpiles have been calculated using the same method described in Section A1 with the exception that the value for *f* was calculated using wind speeds at 6.1 meters which represents 2.3 the height of the bulk product stockpiles. The area of bulk product stockpiles was provided by PKCT as detailed in Table 1.

A3 WIND EROSION – EXPOSED AREAS (SPILLAGE)

Spillage of material onto exposed areas during everyday activities at PKCT can create the opportunity for minor emissions of TSP, PM_{10} and $PM_{2.5}$. The emission rate is dependent on a number of factors including the size of the exposed area, the proportion of area with spillage, the particle size distribution in the spilled material, rain and wind conditions.

The emission rate of TSP, PM_{10} and $PM_{2.5}$ from wind erosion of spillage was calculated using Equation 1, but with the wind speed percentage (*f*) conservatively represented at 6.1 metres above the ground.

A4 CONVEYORS

Estimation of TSP, PM_{10} and $PM_{2.5}$ emissions from conveyors at PKCT is based on data reported by GHD/Oceanics (1975) for conveyor emissions measured at a wind speed of 10 m/s. Account has also been taken of the distribution of particle sizes in the samples collected and the average wind speed at the site. The uncontrolled TSP emission factor for conveyors based on this data is 0.905 mg/m/s. Emissions of PM_{10} and $PM_{2.5}$ from conveyors were calculated by the ratio of PM_{10} to TSP (36%) and the ratio of $PM_{2.5}$ to TSP (7.5%).

The conveyor lengths, control factors and utilisation factors that have been used to calculate emissions from conveyors are summarised in Table 15.

Table 15 Length, controls and utilisation of each of the conveyors for PKCT

Conveyor	Length (m)	Capacity (tph)	Throughput (Mtpa)	Utilisation (%)	Control	
					%	Description
C1	192.6	3700	6.63	20.4	70	Fully enclosed
C2	57.1	3700	6.63	20.4	70	Fully enclosed
C3	67.4	3700	1.95	6.0	70	Fully enclosed
C4	87.1	3700	1.95	6.0	70	Fully enclosed
C5	265.7	3700	3.91	12.1	70	Fully enclosed
C6	82.7	3700	3.91	12.1	70	Fully enclosed
C7	145.2	3700	3.91	12.1	70	Fully enclosed
C8	1141.4	3700	5.27	16.3	40	Enclosed on two sides
C9	1089.6	3700	5.27	16.3	40	Enclosed on two sides
C10	Fully enclosed inside a building; emissions are assumed to be zero					
C11	1119.6	5000	10.53	24.1	40	Enclosed on two sides
C12	199.7	5000	10.53	24.1	40	Enclosed on two sides
C13	42.5	5000	10.53	24.1	40	Enclosed on two sides
C14	362.6	5000	10.53	24.1	40	Enclosed on two sides

A5 HANDLING - STACKING AND RECLAIMING

TSP, PM_{10} and $PM_{2.5}$ emissions from stacking and reclaiming activities at PKCT have been calculated using the following USEPA emission factor equation (USEPA, AP-42, Chapter 13.2.4) (Equation 2).

Equation 2 Emission Factor equation for calculation of stacking/reclaiming particulate matter emission rate

$$E = k \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{-1.4} kg/t$$

Where:

k	=	0.74 for particles less than 30 µm
k	=	0.35 for particles less than 10 µm
U	=	mean wind speed in m/s at 23 metres
M	=	material moisture content (%).

A6 HANDLING - ROAD AND RAIL RECEIVAL

The rate of PM_{10} emissions from road and rail receival has been calculated using the following USEPA emission factor equation (USEPA, AP-42, Chapter 13.2.4) (Equation 3).

Rail receival occurs within a partial enclosure while receival by road occurs in the open air with water sprays used to minimise particulate matter emissions. The coal is dumped into a hopper before being transferred onto conveyors. A constant coal throughput was adopted for both road and rail receival.

Equation 3 Emission Factor equation for calculation of road/rail receival particulate matter emission rate

$$E = k \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{-1.4} kg/t$$

Where:

k	=	0.74 for particles less than 30 µm
k	=	0.35 for particles less than 10 µm
U	=	mean wind speed in m/s
M	=	material moisture content (%).

A 70% control factor has been applied to the rail receival as the train unloading occurs within a building enclosed on all sides except the two ends where the train enters and exits. Similarly, a 70% control factor has been applied to road receival as water sprays are used to suppress particulate matter.

These control factors are recommended by the New South Wales Mineral Council (2000).

A7 HANDLING - TRANSFER POINTS

Transfer points are locations within the coal loading system where coal is transferred from one conveyor to another or from a conveyor to a hopper. The PM_{10} emission rates for each transfer point have been calculated using the following emission factor equation (USEPA, AP-42, Chapter 13.2.4) (Equation 4). Hourly wind speeds have been used to calculate the hourly emissions in kg/tonne.

Equation 4 **Emission Factor equation for calculation of transfer point particulate matter emission rate**

$$E = k \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{-1.4} \; kg/t$$

Where:

k	=	0.74 for particles less than 30 µm
k	=	0.35 for particles less than 10 µm
U	=	mean wind speed in m/s
M	=	material moisture content (%).

A 95 % control factor has been applied to all of the transfer points where emissions are enclosed within a building (NSW Minerals Council, 2000). Where the transfer point is not enclosed within a building but the transfer point is enclosed using features such as chutes and skirts, a control factor of 70% has been used.

A8 HANDLING - SHIP LOADING

The emission rate of PM_{10} during ship loading has been calculated using the following USEPA emission factor equation (USEPA, AP-42, Chapter 13.2.4) (Equation 5). Note that it is the same emission factor equation used to calculate emissions during road and rail receival, transfer, stacking and reclaiming activities. A 70% control factor was applied to the ship loading activities to account for the enclosed conditions with minimal particulate matter released.

Equation 5 **Emission Factor equation for calculation of particulate matter emission rate during ship loading**

$$E = k \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{-1.4} \; kg/t$$

Where:

k	=	0.74 for particles less than 30 µm
k	=	0.35 for particles less than 10 µm
U	=	mean wind speed in m/s
M	=	material moisture content (%).

A9 WIND SPEED SCALING

Wind speeds at heights of 10 m and 23 m were estimated from the measured 6.1 m wind speed using the logarithmic wind speed profile (Equation 6) and an estimate of atmospheric stability class (Table 16).

Equation 6 Wind speed scaling equation

$$u_h = u_{6.1} \times \left(\frac{h}{6.1}\right)^p$$

Where:

u_h = wind speed (m/s) at height h (m)

p = wind profile exponent, dependent on stability class

Table 16 Wind profile exponent for estimation of wind speed with height

Stability category:	Wind profile exponent (*p*):
1	0.15
2	0.15
3	0.2
4	0.25
5	0.4
6	0.6

Stability class is not measured directly at the PKCT Southern monitor, therefore it was required to be estimated using an iterative procedure. An initial estimate of stability class was made using the Solar Radiation Delta Temperature (SRDT) method (USEPA, 2000), assuming no cloud cover and that the wind speed was measured at 10 m. This estimate of stability class was used to scale up the 6.1 m wind speeds to a height of 10 m and the SRDT method was applied a second time. The outcome was found to be relatively insensitive to this estimation technique.