J

Air quality assessment details

Appendix J Air quality assessment details

1. Air quality assessment methodology

In general, the use of sophisticated modelling tools allows the user to study a wide range of conditions that may otherwise not be practical or possible. The ability to make modifications and refinements with relative ease has resulted in a dramatic increase in the number and type of problems that can be studied in detail. The ability of the modeller to simulate current, past and future conditions makes computer modelling an invaluable tool for furthering our understanding of our environment.

If sufficient reliable data exists, then numerical experiments of past and current conditions can be validated using the available observational information. However, model validation requires extensive, quality data that is both temporally and spatially dense. The validation process is in general, time consuming and expensive. Thus, model users must often rely on: default parameter values as recommended within the model user guides or input files; advice from model developers (if available); or results published in the literature, for guidance.

Once a model has been tested and accepted for use for a particular class of problems (such as the dispersion models Cal3QHCR and AUSPLUME), the modeller can use the model with confidence. However, it is important that the user ensures that the model is applied within the scope intended and that the results are interpreted within the documented limitations of the model.

In addition to model validation, long-term records of observational data collected at monitoring sites may provide very useful information as to any regional and or local trends in air pollutant levels. If such trends exist, they may provide some insight into future conditions if it is reasonable to assume that the trend is sustained into the future.

Both short and long-term records of observational data may provide insight into site-specific levels of pollutants. Careful consideration of the interpretation of observational data is required as instruments used to make the measurements are not able to differentiate between natural and anthropogenic sources.

Often, observational data is used to define a background level of a pollutant. However, by definition, the background level of a particular species is the level that would be recorded in the absence of any anthropogenic sources. In general, the concentration of air pollutants in a rural area is dependant on many factors, such as the proximity to sources of air pollutants, meteorological conditions, the specific activities that occur at any one point in time and the level of air pollutants on a regional basis.

With these limitations noted, for the current study we have used data from EPA monitoring sites to estimate background levels of oxides of nitrogen as well as particulate matter at the Jilalan Rail Yard.

2. Project information

The aspects of the proposed upgrade of the Jilalan Rail Yard that are relevant to the air quality assessment include:

- New wagon maintenance tracks to the east of existing tracks
- New by-pass and provisioning rail lines to the east of the new wagon maintenance lines
- The relocating of wagon maintenance activities to the new wagon maintenance shed
- The relocating of provisioning activities to the new provisioning shed
- The expansion of the locomotive workshop to include the existing wagon maintenance facility
- The increase in train capacity through the yard, as well as
- Yard activities and changes in the frequency and duration of yard activities

2.1 Nearest residences

The location of the nearest residences was provided by Connell Hatch (refer Figure 4.3 in Volume 1 EIS). Their coordinates are summarised in Table J1.

Based on the proximity of the sensitive receptors in relation to the proposed new rail lines, residential dwellings 2 and 4 to 7 were removed from the assessment because part of all of these properties will be acquired by QR.

Table J1 Sensitive receptor locations in AGM (55) coordinates

Sensitive receptor (residential dwelling)	Easting (m)	Northing (m)
1	731855	7629816
2	732812	7629664
3	732869	7629342
4 to 7	732443	7628374
8	732858	7627969
9	733072	7627948
10	732471	7627486
11	732920	7627550
12	732459	7626669
13	732189	7626305
14	732288	7626304
15	732210	7626066
16	732131	7625860
17	730463	7624282
18	730478	7624711
19	730601	7625356
20	730564	7626471
21	730360	7626484
22	731036	7626880
23	730449	7626933
24	730777	7627244
25	731023	7627575
26	730725	7627723
27	732151	7628166
28	732112	7627542

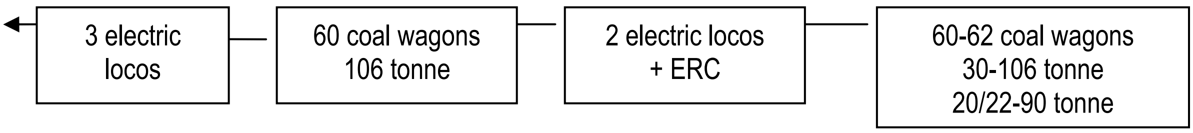
2.2 Train set characteristics

For this assessment the number and size of the trains were provided by QR. This information is summarised in Table J2.

Table J2 Train characteristics and volumes

Property	Current	Future
Number of train sets	22	30
Number of locomotives per train	5	3
Type of locomotive	electric	electric
Number of coal wagons per train	120-122	120-122
Total payload (tonnes)	9600	9600
Number of train cycles per day (7 days/week)	28	40-42
Average number of trains per hour (7 days/week)	1.17	1.7-1.75
Average velocity (km/hour)	25	40

The train sets are currently configured as illustrated below. If the prototype locomotive currently under development is introduced in the future, the five electric locomotives may be replaced with three of the prototypes. The configuration of the coal wagons is not expected to differ from that depicted. Train sets are approximately 2 km long.



2.3 Coal wagon characteristics

Summarised in Table J3 are the characteristics of the coal wagons.

Table J3 Coal wagon characteristics.

Type	Gross weight (t)	Length (m)	Width (m)	Height (m)	Source of info (diagram number)
VSNL	90	14.766	2.9	3.180	P-498A
VCAS	106	14.960	3.2	3.465	P-542L
VSAL	106	14.936	3.2	3.444	P-526A
VSHL	104	14.936	3.2	3.302	P-495D

2.4 Shunt locomotive characteristics

Information supplied by QR that relates to the characteristics and operation of the diesel shunt locomotives is summarised in Table J4 and Table J5.

Table J4 Diesel shunt train exhaust characteristics based on information provided by QR for the 2400/2470 class locomotive

Parameter	Units	Value
Number of outlets per locomotive	-	2
Distance between outlets	m	1.5
Height of exhaust stack above ground	m	3.9
Stack diameter	m	0.22

Parameter	Units	Value
Exit velocity (Switch cycle)	m/s	17.0
Exit velocity (Line haul cycle)	m/s	48.7
Exhaust gas temperature	C	422

Table J5 Diesel shunt train operating characteristics

Parameter	Units	Current	Future
Number of shunt locos used in yards	-	2	3
Number of hours operating	/day	12-16	12-16
Number of shunt locos used in sheds	-	1	1
Number of hours operating	/day	4-6	4-6
Total number of shunt locos	-	3	4
Maximum total number of hours of operation of locos	/day	38	54
Total fuel consumed (approximate)	Litres/week	20,000	28,500
	Litres/day	2,857	4,060

3. Emissions associated with the operation of the Jilalan Rail Yard

The main source of emissions associated with the operation of the Jilalan Rail Yard include:

- Coal dust emissions from coal wagons associated with northbound trains
- Emissions associated with the combustion of diesel fuel by the shunt locomotives used in the yards and sheds

How each of these emission sources were modelled is discussed in detail in the sections below.

3.1 Emissions of particulate matter from coal wagons in transit

There is very little advice available on the best way to model emissions of dust from fully loaded coal wagons in transit.

In order to estimate the emission rate of dust from moving coal wagons, consideration was given to the speed dependent formula suggested in Parrett (1992, Table J5) for storage piles, namely:

$E = 0.181(U_{wind})$

where:

- U_{wind} is the wind speed (in m/s)
- E is the emission rate in g/m^2/hour

where:

- U_{train} is the speed of the train in m/s
- $Umax_{wind}$ is the maximum wind speed (in m/s) that was predicted to occur at the site during the year

- $U_{threshold}$ is the threshold velocity which for coal dust particles in the range of 20-30 µm range, is approximately 3.1 m/s
- E is the emission rate in g/m^2/hour

Based on the information provided in Tables J2 and J3, (using the maximum value where applicable) a conservative estimate of the emission rate of TSP has been determined. This information is summarised in Table J6.

Table J6 Emission rate of TSP from coal wagons in transit.

Property	Units	Current	Future
Average number of wagons	Per hour	142.3	213.5
Surface area of emissions	m^2/wagon	47.9	47.9
Release height of emissions	m	3.0	3.0
Average velocity	m/s	6.9	11.1
Time each wagon takes to travel 1 km	Hr	0.04	0.025
Emission rate (modified Parrett's formula)	g/hr/wagon	100.3	136.5
	g/km/wagon	4.0	3.4
Total emission rate	g/km/hour	570.9	728.4

3.2 Emissions of particulate matter and nitrogen dioxide from diesel shunt locomotives

Emissions of particulate matter and nitrogen dioxide from the diesel shunt trains were estimated based on recommendations of the US EPA (1997), Table J2.

The emission factors that apply to diesel locomotives that were manufactured between 1973 and 2001 and are summarised in Table J7. This document contains emission rates for 'line-haul-cycle' and 'switch-cycle'. Based on the American Bureau of Transportation Statistics, line-haul cycle emission rates are weighted towards higher power notches and is typical of line-haul applications. The switch duty-cycle is associated with idling and low power locomotive activities.

In relation to the combustion of diesel fuel, the emission rate of particulate matter is primarily associated with particles that are less than 10 microns in diameter. Thus, for the current assessment, the emission rate of TSP by the shunt locomotives is assumed to be equivalent to the emission rate of PM_{10}.

Table J7 Emission rates of PM_{10}, TSP and oxides of nitrogen for diesel locomotives manufactured in 1973-2001

Pollutant	Units	Switch-cycle	Line-haul cycle
PM_{10}	g/l/loco[1]	2.4	1.8
	g/s/loco	0.05	0.04
Total suspended particulates	g/l/loco[1]	2.4	1.8
	g/s/loco	0.05	0.04
Oxides of nitrogen	g/l/loco[1]	69.1	47.0
	g/s/loco	1.44	0.98

Table Note:
1 grams of pollutant emitted per litre of diesel fuel consumed per locomotive

4. Dispersion modelling

4.1 Meteorological data for dispersion modelling

The meteorological files used by the dispersion models cover the period 1 January 2001 to 31 December 2001. Katestone Environmental frequently uses the numerical modelling tool TAPM (The Air Pollution Model, developed by the CSIRO), to provide reliable simulated meteorological data for areas that are not adequately represented by existing monitoring sites. Data assimilation ensures that as much observational data as possible is used to produce this numerically generated data in order to guide the model towards accurate predictions of the meteorological conditions in areas where observational data is available. This data assimilation process attempts to minimise potential errors and to give confidence in numerical output used to represent meteorological conditions.

The meteorological data that is used as input into the Cal3QHCR model includes, wind speed, wind direction, stability class, ambient temperature and mixing height. A wind rose showing the frequency of occurrence of wind speeds and direction, constructed from the meteorological files used by Cal3QHCR is presented in Figure J1.

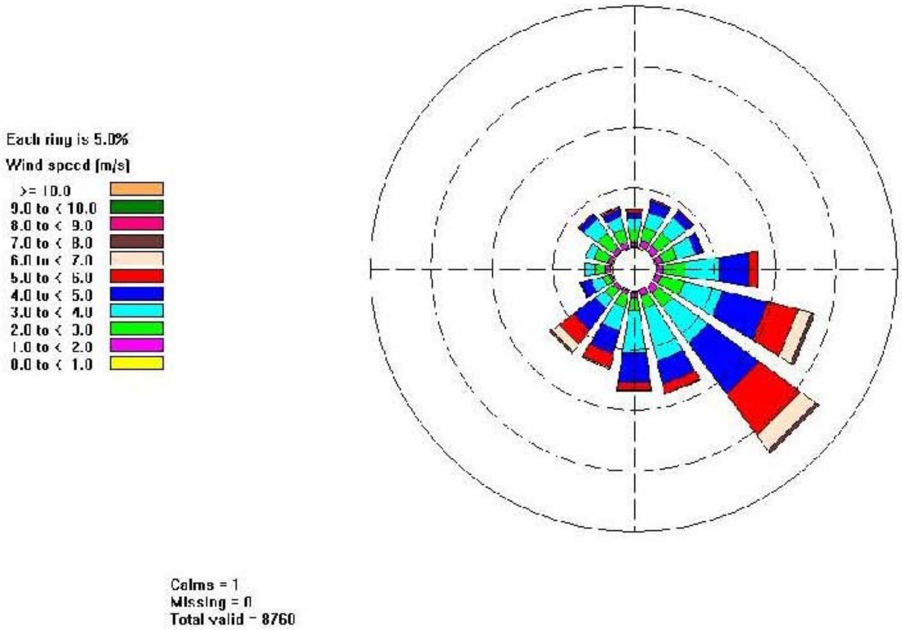


Figure J1 TAPM Wind rose for 2001

Stability classification is a measure of the atmospheric turbulence where Class A represents very unstable atmospheric conditions that may typically occur on a sunny day. Class F represents very stable atmospheric conditions that typically occur during light wind conditions at night. During unstable conditions (stability class A-C), atmospheric turbulence caused by solar heating of the ground is greater and is responsible for the degree of dispersion. Dispersion processes for the most frequently occurring Class D conditions are dominated by mechanical turbulence generated as the wind passes over irregularities in the local surface. The higher wind speeds associated with Class D conditions generally result in lower ground-level concentrations than classes A-C. During the night time the atmospheric conditions are predominantly stable (Class E and F).

Table J8 shows the percentage of stability classes determined from the TAPM meteorological file.

Table J8 Frequency of occurrence (%) of surface atmospheric stability conditions

Pasquill-Gifford Stability Class	Frequency %	Classification
A	0.2	Extremely unstable
B	5.8	Unstable
C	20.5	Slightly unstable
D	63.7	Neutral
E	4.1	Slightly stable
F	5.7	Stable

The extent of the mixing height and the strength of the temperature inversion are very important features that can limit the degree of dispersion of pollutants. The height of the mixed layer changes with time of day and season. Shallow mixing heights occur at night under stable atmospheric conditions. Generally, lower mixing heights occur during winter when stronger temperature inversions and reduced solar radiation restrict the growth of the mixing depth until later in the morning. The degree of dispersion or mixing within the mixed layer is determined by the atmospheric stability.

After daybreak the mixing height increases due to two processes. The first is solar radiation heating the ground and consequent heating of the air close to the ground giving rise to convection. This causes erosion of any stable stratification of the atmosphere thus allowing air aloft to reach ground level where mechanical turbulence is generated through interaction with terrain features. Both these mechanisms – thermal convection and mechanical turbulence – contribute to increasing the depth of the mixing height.

Figure J2 shows the calculated mixing heights versus hour of day generated by TAPM at the location of the Jilalan Rail Yard. The mixing heights show a typical diurnal profile increasing from 8 am and reducing from 1 pm.

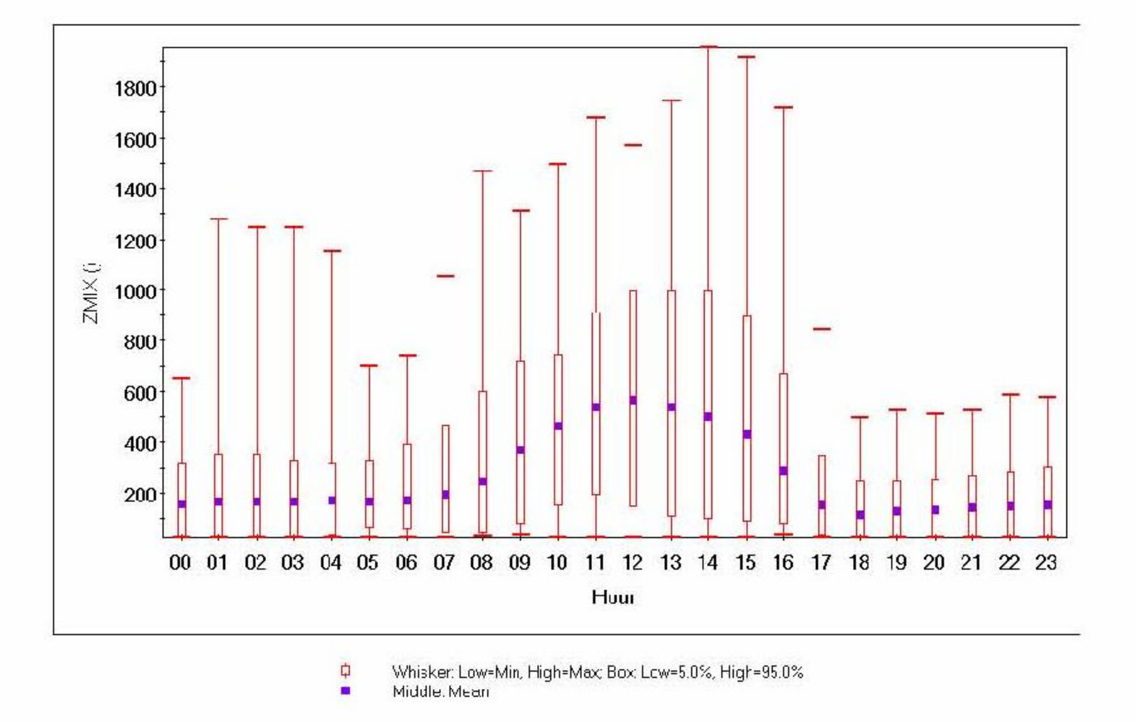


Figure J2 TAPM Mixing height

4.2 Modelling the impact of emissions from coal wagons in transit

In order to model the impacts on air quality of dust and oxides of nitrogen emissions from the Jilalan Rail Yard, the dispersion model Cal3QHCR requires an extensive array of input information including emission rates along sections of the railway lines.

The hourly emission rate of total suspended particulates per kilometre of by-pass rail line emitted from the coal wagons used in the modelling was as summarised in Table J9.

In order to model emissions from the coal wagons in transit the proposed eastern-most by-pass rail line was divided into approximately 30 metre lengths for a total of 248 links.

A receptor grid that follows the length of the study area was applied with a spacing of 30 metres in the north-south direction and variable spacing in the east-west direction depending on the distance of the receptor from the rail line. A total of 10,472 receptors were used to develop the regional contours.

The values of other parameters used in Cal3QHCR are summarised in Table J9.

Table J9 Miscellaneous Cal3QHCR modelling parameters

Parameter	Value
Surface roughness (cm)	100 (combination of crop (74)and park (127))
Urban/Rural Setting	Rural
Receptor height (m)	1
Source height (m)	3
Mixing zone width (m)	9.2

4.3 Modelling the impact of emissions from shunting activities

Specifying the precise location and frequency of activities associated with the shunting of both wagons and locomotives within the rail yard is difficult. Therefore, in order to estimate the worst-case impacts from emissions associated with shunting activities the following assumptions have been applied for the purposes of the dispersion modelling and are based on the post-upgrade information:

- All emissions for each locomotive are emitted from a single outlet
- The shunt locomotives are stationary
- Three shunt locomotives are closely located and are assumed to be in the vicinity of the existing locomotive shed
- Two of the shunt locomotives are operating with switch-cycle emission characteristics and one with line-cycle emission characteristics
- The shunt locomotives operate 24 hours/day, 7 days/week
- The emission characteristics of the locomotives are based on those presented in Tables J4 and J5 and are given in Table J10

Based on studies of the composition of particulate emissions associated with the combustion of diesel fuel, for the purposes of the current assessment, it has been assumed that all TSP that is produced is in the form of PM_{10}.

Two sets of emission rates are presented in Table J10. For the purposes of estimating the post-upgrade, worst-case impact of shunting activities on the 1-hour average ground-level concentration of nitrogen dioxide emission rates are based on a diesel consumption rate 75 litres/hour per locomotive. Emission rates that were used for estimating the impact of shunting activities on the 24-hour and annual average ground-level concentration of particulate matter, were based on a daily total consumption of 4,060 litres of diesel fuel (Table J5).

Table J10 Emission rates of TSP, PM10 and oxides of nitrogen used in the modelling of the impacts of shunt locomotives activities on air quality

Pollutant	Units	Switch-cycle		Line-cycle	
		1-hour	24-hour & annual	1-hour	24-hour & annual
Total suspended particulates	g/s/loco	0.05	0.03	0.04	0.02
Particulate matter as PM_{10}	g/s/loco	0.05	0.03	0.04	0.02
Oxides of nitrogen	g/s/loco	1.44	0.81	0.98	0.55

Impacts of the emission of nitrogen dioxide and particulate matter resulting from the combustion of diesel fuel by the shunt locomotives were predicted using AUSPLUME.

4.4 Modelling dust deposition

In order to model dust deposition, a particle size dependent dust deposition velocity has been calculated based on consideration of the method employed in ISC, as well as the formulation for the terminal velocity of dust particles suggested in Table 1 of Parrett (1992).

A summary of the assumed particulate characteristics including deposition velocity are presented in Table J11.

Dust deposition has been calculated based on the annual average ground-level concentration of particulate matter at the location of the sensitive receptors.

Table J11 Dust particle characteristics

Size of particulate matter	Units	Fraction	Density (g/cm^3)	Deposition Velocity (m/s)
Greater than 10 microns diameter	µm	0.65	2.5	1.9E-1
Less than 10 microns diameter	µm	0.35	2.5	7.6E-3

5. Operational air quality impacts

5.1 Methodology

Dispersion modelling was conducted using Cal3QHCR and AUSPLUME using one year of simulated meteorological data. Coal wagon emissions of particulate matter as well as diesel shunt train emissions of particulate matter and nitrogen dioxide have been explicitly modelled.

5.1.1 Nitrogen dioxide

In presenting results from the dispersion modelling, for the maximum 1-hour average ground-level concentration of nitrogen dioxide it has been assumed that 30% of the oxides of nitrogen have been converted to nitrogen dioxide. For the annual average ground-level concentration of nitrogen dioxide it has been assumed that 30% of the oxides of nitrogen have been converted to nitrogen dioxide.

5.1.2 Total suspended particulates and particulate matter as PM10

For the modelling of dust emissions from the coal wagons in transit results from the dispersion modelling for the ground-level concentration of total suspended particulates, were used to calculate the maximum 24-hour average and annual average ground-level concentration of particulate matter as PM_{10} assuming that 35% of TSP consists of particles with an aerodynamic diameter of 10 microns or less.

For the modelling of emissions of particulate matter resulting from the combustion of diesel in the shunt locomotives, results for the ground-level concentration of PM_{10}, were used to calculate the annual particulate average ground-level concentration of TSP assuming that all particulate matter emitted from the diesel locomotive consists of particles with an aerodynamic diameter of 10 microns or less.

5.1.3 Interpretation of results

The objective of the current assessment is to aid in the project development process by identifying any possible air quality issues associated with the Jilalan Rail Yard Upgrade Project. As such, a conservative approach has been adopted that aims to quantify worst-case impacts associated with activities at the rail yard based on future operating practices. The methodologies and/or aspects of the modelling of the Jilalan Rail Yard Upgrade Project that have been applied in order to ensure a modestly conservative result include but are not limited to:

- The form of Perrett's equation used does not take into account the affect of rain to inhibit dust emissions.
- Although Cal3QHCR does incorporate hourly variations in wind speed and direction in order to predicted concentrations of pollutants, the emission rate of coal dust from trains was fixed at a constant value. This value was based on a worst case wind speed of 8.4 m/s that represents the maximum value for the wind that was predicted by TAPM in the vicinity of the Jilalan Rail Yard at any time during the one year period. This worst case emission rate has been assumed to be occurring at all hours of the day and all days of the year. The implications of this assumptions are particularly important when considering the predicted annual average concentrations of particulate matter.
- Emissions from diesel shunt trains have assumed that the shunt locomotives are stationary and closely located. Actual shunting activities will not be as localised as modelled.
- Shunt train activities are assumed to continue 24 hours/day, 365 days/year.

When considering results presented, it is important to note that the results from the dispersion modelling for the 1-hour average ground-level concentration of nitrogen dioxide and the 24-hour average ground level concentration of particulate matter are based on the maximum concentration of an air pollutant that is predicted at each of the receptors over the one-year period and thus represent a peak-impact scenario. The plots are constructed such that at each point in the domain, the maximum value is obtained and stored. As these maximum values may occur at different times for receptors at different locations, these figures do not represent a single snapshot of conditions at any given time.

It is also important to note that Cal3QHCR has been developed to estimate concentrations of pollutants at locations near major roadways with receptors required to be placed outside the 'mixing zone'. For the railway lines this restriction on the proximity of receptors to the railway equates to minimum distance of 4.6 m from the centre of the railway tracks which are assumed to be 3.2 m wide. Results presented within these boundaries are therefore not considered to be strictly valid. Visualisation packages such as the one used to present the results of the current study, interpolate results over a uniform domain, which includes the railway lines themselves. Therefore, only results presented that are outside the 'mixing zone' should be interpreted as being a valid estimate of concentration levels at that site.