Burrup Peninsula Air Pollution Study: Interim Report on Concentrations of Air Pollutants on the Burrup Peninsula July 2007

7 August 2007

Summary of Interim Report
Rock Art Monitoring Management Committee

SUMMARY AND CONCLUSIONS

The purpose of this study is to report on concentrations of some air pollutants on the Burrup Peninsula measured by CSIRO Marine and Atmosphere Research. Previous reports have documented levels of air pollutants measured during 2004-5. This interim report summarises gas and particulate matter concentrations on the Burrup Peninsula collected over about four months from February to the beginning of June 2007 and compares them with average levels measured at the same locations during 2004-5. Future reports will provide data on air quality over the next couple of years. A total of eight sites were used in the study, seven of these, Sites 1, 3, 4, 5, 6, 7, and 8, were on the Burrup Peninsula and one was located in Karratha. This reports summarises concentrations of gases including sulfur dioxide, nitrogen dioxide, nitric acid, ammonia and benzene, toluene, ethylbenzene, o-xylene, m-xylene and p-xylene (BTEX) gases. Samples of total suspended particulate, that is, all particles below about 50 µm in diameter suspended in the atmosphere (TSP) were collected at seven sites, and conditional sampling for particulate matter in the air with an aerodynamic diameter of 10 µm (micrometres) or less (PM_{10}) was carried out at Site 8 and near the ore loading facilities at Parker Point. Sampling was conducted over monthly periods and TSP concentration and chemical composition were measured on the samples.

The gas concentrations show that in all cases, concentrations were very low compared to urban areas. Local background concentrations, deduced from sites 1, 3 and 10, were ammonia 0.5 parts per billion (ppb), nitrogen dioxide 0.6 ppb, sulfur dioxide 108 parts per trillion (ppt) and nitric acid 155 ppt. Ammonia concentrations showed little spatial variation in concentration indicating that most ambient ammonia in air on the Burrup has natural sources. There were some small elevations of concentrations of nitrogen dioxide, sulfur dioxide and nitric acid concentrations at sites near industries in comparison with concentrations at sites assumed to represent the local background. Even so, the concentrations of ammonia, nitrogen dioxide, sulfur dioxide and nitric acid were very low compared with measurements made at other remote locations. BTEX concentrations were also very low at all sites and for all sampling periods. The benzene concentration at the background sites 1, 3 and 10 was about 19 ppt and the average at the other sites about 21 ppt. Benzene and other BTEX gas concentrations showed little elevation over the background concentrations suggesting that their concentrations have a large natural component.

For total particulate (TSP) concentrations in air, sites 1 and 3, which were taken to represent the local background level, had an annual average concentration of about 18 microgram per cubic metre (µg m^{-3}). In contrast to this the annual average concentrations on the lower Burrup were about 31 µg m^{-3}. TSP concentrations on the lower Burrup, where most of the industrial and anthropogenic activities occur, were moderately elevated over the local background concentrations. Samples colleted near Parker Point and at other sites were analysed for a range of elements including iron. TSP at Sites 4, 5, 7 and 8 had a higher fraction of iron and less sea-salt than the background TSP at Site 1. This suggests that the observed increase in TSP at these sites could be due to dust from the ore loading and transportation processes. This suggestion is reinforced by elevated PM_{10} concentrations during a number of periods at Site 8 when the air was passing over the ore loading facilities at Parker Point. TSP concentration during the 2007 sampling period are not significantly different than those observed in the 2004/2005 sampling period.

Site Section

Eight sites were selected on the Burrup Peninsula, one of which was used only for PM_{10} particulate measurements. Sites 1 and site 3 are considered to be local background sites since they are distant from industrial development and anthropogenic influences. In addition two other sites, away from the Burrup Peninsula, were selected. One was in Karratha, to provide a comparison of gas concentrations on the Burrup with those in an adjacent urban area. The other was located at Mardie Station south west of the Burrup, to provide a comparison of gas concentrations in an adjacent area where there is no industrial activity. Table 1 shows the locations of the ten sites. It should be noted that Site 2 was not used for atmospheric measurements. Figure 1 shows equipment installed at Site 8.

Table 1. Locations of the ten sampling sites.

Site No.	Site Name	Latitude	Longitude
1	Dolphin Island	20.45233	116.85233
3	North Burrup	20.52611	116.83067
4	Woodside east	20.60167	116.78276
5	Burrup Road	20.62093	116.76928
6	Water Tank	20.61800	116.78516
7	Deep Gorge	20.63692	116.78848
8	King Bay south	20.64416	116.75067
8HI	Hamersley Iron	20.64218	116.74037
9	Karratha	20.73575	116.83662
10	Mardie Station	21.16790	116.12000

Figure 1. Equipment installed at Site 8.

Figure 2 shows a map of the sites located on the Burrup Peninsula and the site in Karratha. Site 10, Mardie Station, is not shown on this scale. It is located about 81 km from Dampier at a bearing of about 215^{o}.

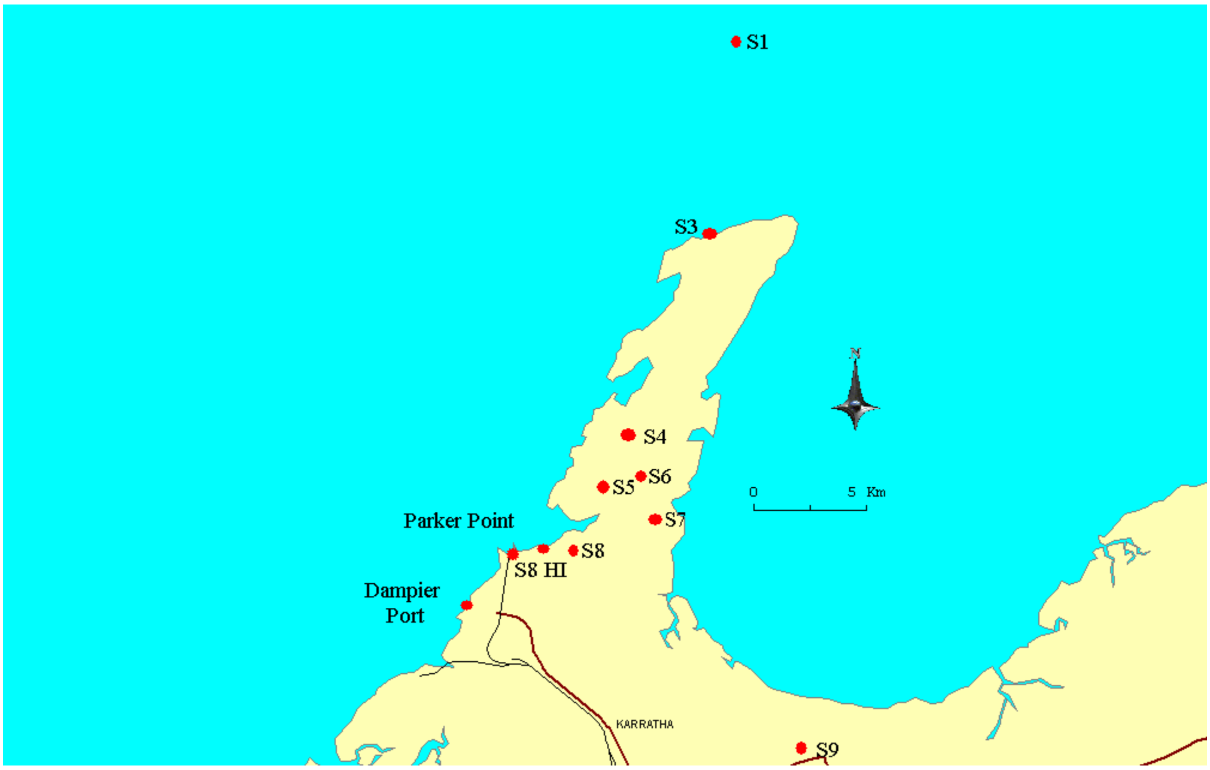

Figure 2. Burrup Peninsula Sampling Sites. Although Site 1 shown on this map Dolphin Island is not. Site 10 is located 81 km southwest.

Gas concentrations

Ammonia concentrations during the 2007-2008 sampling period showed little change from those reported in the 2004-5 study. Concentrations ranged from 0.1 ppb to 1.2 ppb at the Burrup sites.

The monthly mean nitrogen dioxide concentrations for the 2004/2005 period, and the initial results for the 2007/2008 period are also presented in Table 2. Monthly mean concentrations ranged from 0.2 ppb at site 10 during September 2004 to 3.8 ppb at site 9, during May 2004. The nitrogen dioxide concentrations averaged over the 12 sampling periods show that the lowest annual average concentration of 0.5 ppb were measured at Mardie Station, although concentrations measured at sites 1 and 3, at 0.6 ppb and 0.7 ppb, on the Northern end of the Burrup, were also very low. Assuming these sites define a regional background the local background concentration for nitrogen dioxide is about 0.6 ppb. The limit of detection for nitrogen dioxide measurements using passive samplers for 30 days is about 0.06 ppb.

Sites 4 to 8 are all located on the lower Burrup, closer to industry and anthropogenic influences and they could be reasonably be expected to show elevated nitrogen dioxide concentrations. The annual average concentrations at these sites range from 1.4 ppb to 2.4 ppb. Taken together, these sites have nitrogen dioxide concentrations of about 1.9 ppb, and this is a moderate elevation over the local background sites on the northern Burrup and Mardie Station.

The initial results for the 2007/2008 period range from 0.8 ppb at Site 3 to 2.8 ppb at Site 8, indicating that there are no significant changes to the concentrations between the two sampling periods. In the previous report on air pollution monitoring at the Burrup sites a gradation in nitrogen dioxide was observed from low concentrations at the northern sites to higher concentrations at the southern sites (Gillett et al. 2006). Although only a limited data set is available at this stage a similar gradient is becoming apparent.

Table 2. Concentrations of ammonia and nitrogen dioxide at the nine sampling sites in 2004 - 2005 and during the first half of 2007. Concentrations are in ppb. Relative percent differences are calculated. Where both samples of the pair are below the limit of detection the average concentration is set at half the limit of detection. If only one sample is above the limit of detection that value is entered as the average concentration. C signifies contaminated sample.

Date on	Date off	NH_3 (ppb)	NH_3 ppb mean	RPD %	NO_2 (ppb)	NO_2 (ppbv) mean	RPD %
Site 1 04/05							
Mean			***0.3***			***0.6***	
Site 1 07/08							
4/05/07	14/06/07	<0.5	0.2				
4/05/07	14/06/07	<0.5					
Site 3 04/05							
Mean			***0.5***			***0.7***	
Site 3 07/08							
29/01/07	22/02/07	1.0	1.2	44.0	0.8	0.8	9.2
29/01/07	22/02/07	1.5			0.8		
22/02/07	20/03/07				1.0	1.00	11.0
22/02/07	20/03/07				1.0		

Site 4 04/05							
Mean			***0.4***			***1.8***	
Site 4 07/08							
3/05/07	7/06/07	<0.5	0.2	24.6			
3/05/07	7/06/07	<0.5					

Site 5 04/05							
Mean			***0.4***			***2.4***	
Site 5 07/08							
3/05/07	7/06/07	0.4	0.5	33.2			
3/05/07	7/06/07	0.6					

Site 6 04/05							
Mean			***0.5***			***1.8***	
Site 6 07/08							
3/05/07	7/06/07	0.8	0.7	5.0			
3/05/07	7/06/07	0.7					

Site 7 04/05							
Mean			***0.4***			***1.4***	
Site 7 07/08							
3/05/07	7/06/07	<0.5	0.1	134.70			
3/05/07	7/06/07	0.2					

Site 8 04/05							
Mean			***0.4***			***2.1***	
Site 8 07/08							
24/01/07	22/02/07	0.2	0.2	52.3	2.8	2.8	
24/01/07	22/02/07	0.3					
22/02/07	20/03/07	0.9	0.8	20.6	2.3	2.2	7.0
22/02/07	20/03/07	0.8			2.2		
20/03/07	03/05/07	<0.5	0.4	189.2			
20/03/07	03/05/07	0.8					
03/05/07	7/06/07	0.6	0.7	24.4			
03/05/07	7/06/07	0.8					

Site 9 04/05							
Mean			***2.6***			***2.2***	
Site 9 07/08							
4/05/07	7/06/07 13:00	1.3	1.3	7.3			
4/05/07	7/06/07 13:00	1.4					

Site 10 04/05							
Mean			***0.8***			***0.5***	

Table 3 displays the concentrations of sulphur dioxide and nitric acid measured at the Burrup sites and at Mardie Station over the annual period from August 2004 to mid September 2005, and a limited amount of data from January 2007 until June 2007. Average monthly concentrations of sulphur dioxide ranged from 19 ppt during August 2005 at Site 10 to 367 ppt at Site 4 during April 2005. The average annual sulphur dioxide concentrations range dfrom 83 ppt at Site 10 to 215 ppt at Site 5. The concentrations, measured at sites 1, 3 and 10, are assumed to be regional background levels and appear to be in the range of about 83 ppt to 139 ppt, with an annual average of about 108 ppt. The annual average concentration at sites 4 – 8 is only about 175 ppt, with a maximum of 215 ppt, so the enhancement in sulphur dioxide concentrations at these sites is very small.

During the current sampling period from January 2007 until June 2007 sulfur dioxide concentrations ranged from 75 ppt at Site 3 to 270 ppt at Site 8. These are consistent with sulfur dioxide concentrations observed during the previous study (Gillett et al., 2006), and no real changes have been observed.

Nitric acid concentrations from the 2004/2005 study and limited results from January 2007 to June 2008 are also presented in Table 3; these were measured as nitrate ion which is collected with the sulphur dioxide passive sampler. The monthly average concentrations ranged from 21 ppt at site 10 during August 2004 to 632 ppt at site 9 during May 2005. The assumed background sites of 1, 3 and 10 have nitric acid concentrations of 144 ppt, 162 ppt and 160 ppt respectively, indicating an average annual background concentration of about 155 ppt. At Sites 4 – 8, on the southern Burrup Peninsula, annual average concentrations ranged from 198 ppt at site 4 to 250 ppt at site 8 giving a southern area average of 229 ppt. Although the concentration increase from the background to the southern Burrup sites is noticeable, the enhancement is small, and the concentrations are very low.

The limited results from the latest study period indicate that nitric acid concentrations range from 100 ppt at Site 3 and 335 ppt at Site 8. These results, although limited, indicate that no significant difference in nitric acid concentrations exists between the two sampling periods.

Table 3. Concentrations of sulphur dioxide and nitric acid at the nine sampling sites from 2004 -2005 and during the first half of 2007. Concentrations are in ppt. Where both samples of the pair are below the limit of detection the average concentration is set at half the limit of detection. If only one sample is above the limit of detection that value is entered as the average concentration.

Date on	Date off	SO_2 (ppt)	SO_2 (ppt) mean	RPD %	HNO_3 (ppt)	HNO_3 (ppt) mean	RPD %
Site 1 04/05							
mean			***101***			***144***	
Site 3 04/05							
Mean			***139***			***162***	
Site 3 07/08							
29/01/07	22/02/07	97	75	60	125	100	48.5
29/01/07	22/02/07	52			76		
22/02/07	20/03/07	171	160	14	263	230	29.3
22/02/07	20/03/07	149			196		
Site 4 04/05							
Mean			***178***			***198***	
Site 5 04/05							
Mean			***215***			***240***	
Site 6 04/05							
Mean			***176***			***241***	
Site 7 04/05							
Mean			**141**			**210**	
Site 8 04/05							
Mean			***164***			***250***	
Site 8 07/08							
24/01/07	22/02/07	260	270	7.9	205	216	10.1
24/01/07	22/02/07	281			227		
22/02/07	20/03/07	171	202	31.2	375	335	24.0
22/02/07	20/03/07	234			295		
Site 9 04/05							
Mean			***89***			***276***	
Site 10 04/05							
Mean			***83***			***160***	

Table 4 presents the concentrations of benzene, toluene and ethylbenzene at the sites on the Burrup Peninsula and at Karratha and Mardie Station for the first sampling period from August 2004 to mid September 2005, and a limited set of data from January 2007 until June 2007. At some sites the measurements were below the limit of detection, and in those cases the average was set to half the limit of detection. Limits of detection for benzene, calculated on a monthly basis from the standard deviation of blanks using an ISO (1994) technique, ranged from 1 ppt to 14 ppt over a 30 day sampling period. There were a number of instances where samplers were obviously contaminated. For most of these samplers contamination resulted because the ends of the samplers were not sealed sufficiently to prevent ambient air diffusing to the adsorbent during transport to Melbourne. Contaminated samplers are signified with ^{c}, and these have not been used to calculate averages. Some samplers at Site 9, Karratha may have been contaminated, but they were all included in the averages since it is more difficult to discern contamination in an urban area where petrol is often used. The maximum monthly mean of benzene concentration of 158 ppt was recorded at Site 9, Karratha and the minimum was 4 ppt at Site 10. The annual average benzene concentrations at sites 1, 3 and Mardie Station were about 19 ppt, and with an average of 21 ppt, sites 4 – 8 show no real enhancement above the background concentration.

During the 2007-8 sampling period benzene concentrations ranged from 4 ppt and 35 ppt on the Burrup Peninsula sites and 60 ppt at Site 9 in Karratha. Again, as observed with the other gas concentrations no significant changes are observed in benzene concentrations between the first and second sampling periods.

Table 4. Concentrations of benzene, toluene and ethylbenzene measured at the nine sites from 2004 -2005 and during the first half of 2007. Concentrations are in ppt. Where both samples of the pair are below the limit of detection the average concentration is set at half the limit of detection. Results marked with ^{c} are considered to be contaminated and were not used to produce averages.

Date On	Date Off	Benzene (ppt)	Benzene mean	Toluene (ppt)	Toluene mean	Ethylbenzene (ppt)	Ethylbenzene mean
Site 1 04/05							
Mean			***26***		***18***		***5***
Site 1 07/05							
04/05/07	14/06/07	21	18	<11	27	<7	4
04/05/07	14/06/07	15		49		<7	
Site 3 04/05							
Mean			***16***		***28***		***4***
Site 3 07/08							
22/02/07	20/03/07	10	9	12	16	<6	3
22/02/07	20/03/07	7		21		<6	
20/03/07	04/05/07	242^{c}	16	121	110	16	16
20/03/07	04/05/07	16		110		16	
04/05/07	14/06/07	25	35	14	31	<6	3
04/05/07	14/06/07	46		48		<6	
22/02/07	20/03/07	29	27	40	41	<6	3
22/02/07	20/03/07	25		43		<6	

Table 4 continued

Date On	Date Off	Benzene (ppt)	Benzene mean	Toluene (ppt)	Toluene mean	Ethylbenzene (ppt)	Ethylbenzene mean
Site 4 04/05							
Mean			***27***		***47***		***8***
Site 4 07/08							
03/05/07	07/06/07	27	19	50	48	<6	3
03/05/07	07/06/07	11		45		<6	
Site 5 04/05							
Mean			***21***		***34***		***14***
Site 5 07/08							
03/05/07	07/06/07	19	21	97	106	6	12
03/05/07	07/06/07	23		115		19	
Site 5 04/05							
Site 6 04/05							
Mean			***19***		***24***		***9***
Site 6 07/08							
03/05/07	07/06/07	32	24	72	55	4	6
03/05/07	07/06/07	16		38		8	
Site 7 04/05							
Mean			***18***		***23***		***7***
Site 7 07/08							
03/05/07	07/06/07	3	4	8	10	1	1
03/05/07	07/06/07	5		12		2	
Site 8 04/05							
Mean			***18***		***26***		***9***
Site 8 07/08							
24/01/07	22/02/07	16	17	92	93	8	7
24/01/07	22/02/07	17		94		7	
22/02/07	20/03/07	14	10	105	107	17	13
22/02/07	20/03/07	6		108		10	
20/03/07	03/05/07	28	27	49	33	6	5
20/03/07	03/05/07	25		17		5	
03/05/07	07/06/07	13	13	60	41	<6	3
03/05/07	07/06/07	13		22		<6	
Site 9 04/05							
Mean			***72***		***743***		***93***
Site 9 07/08							
04/05/07	07/06/07	43	60	527	513	40	56
04/05/07	07/06/07	78		498		72	
Site 10 04/05							
05/08/05	15/09/05	<7		883[c]		7	
Mean			***12***		***13***	***7***	***5***

Particulate Measurements

TSP Measurements

Concentrations of TSP measured at sites 1 – 8, and PM_{10} measured at sites 8 and 8 HI with conditional sampling are presented in Table 5 for the period from August 2004 until September 2005. The average for sites 1 and 3, considered to represent background levels, is about 22 µg m^{-3} over the period from August 2004 until mid September 2005. The maximum monthly averaged TSP concentrations are 136 µg m^{-3} at Site 7, during January/February 2005 and 135 µg m^{-3} at Site 8, during January/February 2005, and the average for sites 4 – 8 is about 34 µg m^{-3}. This shows that TSP concentrations, probably due to anthropogenic activities, are enhanced on the lower Burrup Peninsula, at sites 4 – 8. This is particularly true at Site 8, which had an annual average TSP concentration of 51 µg m^{-3}.

A limited set of TSP measurements has been collected during the second sampling period from January 2007 until June 2007. These data are shown in Table 5. The TSP mass concentrations range from 12.6 µg m^{-3} at Site 3 to 88.1 µg m^{-3}, and indicate that no significant difference exits between the two sampling periods. It is clear that a seasonal cycle exists in TSP mass concentrations at all of the sites. This is mainly due to wind direction changes during the year. The same pattern is beginning to emerge in the TSP mass concentration data collected in the second sampling period.

Conditional sampling to measure PM_{10} was carried out at Site 8HI, about 0.5 km to 1 km east of the Hamersley Iron loading facilities at Parker Point, and at Site 8 which is located about 3 km east of Parker Point; see Figure 1 for site locations. Site 8HI was located in order to sample PM_{10} originating from Parker Point, and the sampler operated when the wind direction was between 225º and 315º. At Site 8 the conditional sampler operated when the wind direction was between 180º and 360º, also to collect PM_{10} from Parker Point. Figure 3 shows that at 116.6 µg m^{-3} and 19.8 µg m^{-3} at 8HI and Site 8 respectively, there is a large difference in PM_{10} mass concentration between the two sites. Filters from these sites have been analysed for a range of elements and soluble ionic species to seek a fingerprint for particulate originating from the Parker Point iron ore loading facilities.

Table 5. Concentrations of TSP at sites 1 – 8 and PM_{10} conditionally sampled at sites 8 and 8HI from 2004 -2005 and during the first half of 2007. Concentrations are in µg m^{-3}.

Date on	Date Off	TSP µg m^{-3}	Date On	Date Off	TSP µg m^{-3}	PM_{10} µg m^{-3}
Site 1 04/05			**Site 3 04/05**			
Mean		***22.6***	***Mean***		***21.8***	
Site 1 07/08			**Site 3 07/08**			
04/05/07	14/06/07	14.1	29/01/07	22/02/07	45.4	
			22/02/07	20/03/07	27.8	
			20/03/07	04/05/07	14.8	
			04/05/07	14/06/07	12.6	
Site 4 04/05			**Site 5 04/05**			
Mean		***34.3***	***Mean***		***24.1***	
Site 4 07/08			**Site 5 07/08**			
03/05/07	07/06/07	20.0	03/05/07	07/06/07	17.5	
Site 6 04/05			**Site 7 04/05**			
Mean		***24.7***	***Mean***		***36.6***	
Site 6 07/08			**Site 7 07/08**			
03/05/07	07/06/07	18.7	03/05/07	07/06/07	16.7	
Site 8 04/05			**Site 8 04/05 Conditional**			
Mean		***51.1***	***Mean***			***19.8***
Site 8 07/08			**Site 8 07/08 Conditional**			
24/01/07	22/02/07	88.1	24/01/07	22/02/07	109.7	
22/02/07	20/03/07	43.2	22/02/07	20/03/07	57.4	
20/03/07	03/05/07	22.0	20/03/07	03/05/07	30.8	
03/05/07	07/06/07	17.0	03/05/07	07/06/07	33.1	
			Site 8 HI 04/05 Conditional			
			Mean			***116.6***
			Site 8 HI 07/08 Conditional			
			21/05/07	25/06/07	90.4	

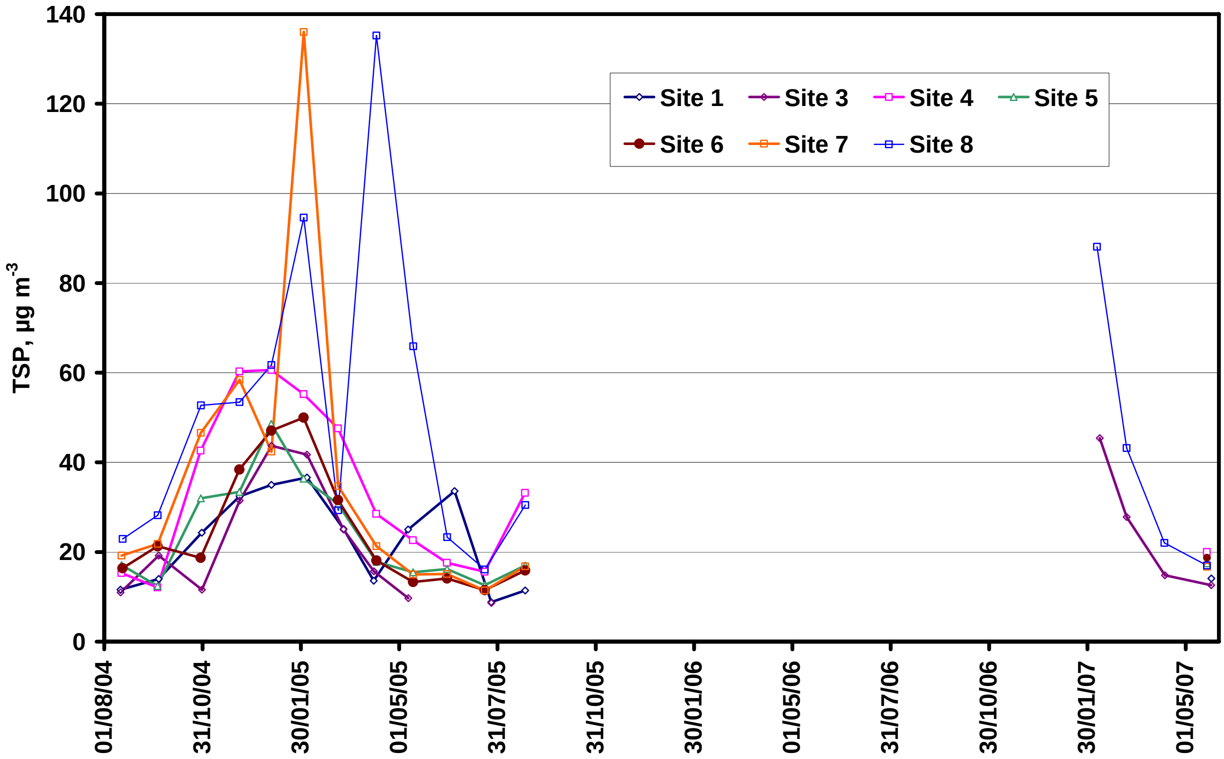

Figure 3. TSP mass concentrations plotted against the mid sampling date for the periods of August 2005 until August 2005 and from January 2007 until June 2007.

DustTrak Measurements

The data collected from January 2007 until June 2007 are little different from that presented in the previous Burrup Peninsula study for the 2004-5 period (Gillett et al., 2006). The data show that background PM_{10} concentrations at site 8 appear to be about 10 µg m^{-3}, based on the concentration envelope observed in wind directions about 150º and about 15º, as observed in the previous study. Site 8 is only about 2 – 3 km east of the iron ore loading facilities at Parker Point and it is evident that the activities at Parker Point have a large influence on PM_{10} concentrations at Site 8. There was a large increase in PM_{10} over background concentrations in wind directions ranging from about 220º to 280º, and this is directly downwind of Parker Point. The other influence on PM_{10} concentrations at site 8 is vehicle traffic travelling along Burrup Road. This increased PM_{10} concentrations, particularly in wind directions from about 43º to 105º.

REFERENCE

Gillett R.W., Paul Selleck, Geoff Kregor, Sarah Lawson, Kate Boast, Jenny Powell and Greg Ayers, Burrup Peninsula Air Pollution Study: Final Report, Final report to WA DOIR Rock Art Committee 2006.

ACKNOWLEDGEMENTS

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GLOSSARY

Simple definitions of various technical terms are given here to assist the reader. If required, the reader should look to other sources for more formal and technical definitions.

Aerosol	A suspension of fine solid, liquid or mixed-phase particles in air.
BTEX	Gaseous mixture of benzene, toluene, ethylbenzene, o-xylene, m-xylene and p-xylene.
CMAR	CSIRO Marine and Atmospheric Research http://www.cmar.csiro.au).
CSIRO	Commonwealth Scientific and Industrial Research Organisation (http://www.csiro.au).
Deposition flux	deposition of mass in the form of gas, particle or rainwater to an area of ground over a particular period of time. General units are in mass per area per time.
HNO_3	Nitric acid gas.
Limit of detection	The smallest concentration detectable by a measurement system as the concentration of the substance being measured approaches zero.
mg	Milligram (1 mg = 10^{-3} gram = 0.001 gram). One thousandth of a gram.
NH_3	ammonia gas.
NO_2	Nitrogen dioxide.
PM_{10}	Particulate matter in the air, with an aerodynamic diameter of 10 µm (micrometres) or less.
ppt	Parts per trillion (by volume): a unit of concentration of a gas in air. 1 ppt = 1 cubic metre in 1million million cubic metres of air.

ppb	Parts per billion (by volume): a unit for the concentration of a gas in the atmosphere based on the mixing ratio approach. A concentration of 1 ppb is equivalent to a volume of 1 cubic metre of pure undiluted gas in 1 thousand million cubic metres of air. The expression ppb is without dimensions. .
SO_2	Sulfur dioxide gas.
TSP	Total Suspended Particulates– all particles below about 50 µm in diameter suspended in the atmosphere.
µg	Microgram (1 µg = 10^{-6} gram = 0.000001 gram). One millionth of a gram
µm	Micrometre (1 µm = 10^{-6} metre = 0.000001 metre). One millionth of a metre.
µg m^{-3}	microgram per cubic metre. 1 µg m^{-3} = one millionth of a gram per cubic metre of air.
µmol l^{-1}	one millionth of a mole per litre.