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April 2007

DATA REPORT

Louisa Creek Dust Monitoring
September - December

for

BMA Hay Point Services

BMA
BHP Billiton Mitsubishi Alliance

Dalrymple Bay Coal Terminal

DBCT

Babcock and Brown Infrastructure Group

BABCOCK & BROWN INFRASTRUCTURE

Ports Corporation of Queensland

PCQ

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Background

This study was commissioned through a partnership of stakeholders associated with the monitoring of ambient dust from coal loading terminals at the Port of Hay Point. "The Partners" collectively operate a network of ambient dust monitors to measure and manage the impact of fugitive dust from the two coal terminals within the Port and comprise:

- BMA Hay Point Services
- Dalrymple Bay Coal Terminal Pty Ltd
- Babcock and Brown Infrastructure Group
- Ports Corporation of Queensland

Coal from mines in the Bowen Basin is supplied to the two terminals by through integrated rail services provide by Queensland Rail. A locality plan is shown at Figure 1

The ambient dust monitoring system currently incorporates four (4) Tapered Element Oscillating Microbalance (TEOM) units configured to measure Total Suspended Particulates (TSP); this equipment is nearing the end of its economic life. With the intent of improving network capabilities, The Partners identified alternate ambient dust monitors for evaluation and negotiated required amendments to Environmental Authority conditions to allow for testing and use of alternate monitoring equipment by agreement with the Queensland Environmental Protection Agency (EPA).

The OSIRIS monitor manufactured by Turnkey Industries was selected by The Partners as a potential alternative to take through an equivalence testing program. In lieu of an applicable Australian Standard method, this test program, evaluation and report preparation was undertaken in accordance with European Standard EN 12341 : 1998 *Determination of the PM10 fraction of suspended particulate matter – Reference method and field test procedure to demonstrate reference equivalence of measurement methods*.

On successful completion of the study, the results of the data collected and analysed in this report were to form the basis of a submission to the Queensland EPA for approval to use OSIRIS instruments as an equivalent method for determination of the 24-hour average TSP concentration in ambient air at the Port of Hay Point for the purpose of monitoring dust levels against management objectives.

Figure 1: Locality Plan

Executive Summary

The coal terminals within the Port of Hay Point operate under Environmental Authorities administered by the Queensland EPA. Monitoring and measuring programs and the assessment of environmental controls designed to minimise potential dust impacts are undertaken to confirm compliance with the Environmental Authorities.

Fugitive dust may be liberated during the processes of unloading, handling and storage of coal at the terminals. To minimise dust levels within the terminals and the surrounding communities, The Partners operate various dust control processes depending on meteorological and operational conditions, installed plant and individual coal types handled. Continuous or ambient dust monitoring is undertaken to identify when additional control processes may be required.

Monitoring results are used to assess the effectiveness of dust management programs and terminal compliance with environmental management objectives. With the current system of four TEOMs nearing the end of its economic life, The Partners initiated a program to validate the performance of the OSIRIS dust monitors for monitoring ambient dust against recognised reference methods. The reference methods used where High Volume (HiVol) samplers configured to measure Total Suspended Particulates (TSP) and Particulate Matter with an aerodynamic diameter less than 10 microns (PM10). The capability of the OSIRIS instrument to function as an equivalent monitoring method to the HiVols was undertaken using the methodology described in the European European Standard EN 12341 : 1998 *Determination of the PM10 fraction of suspended particulate matter – Reference method and field test procedure to demonstrate reference equivalence of measurement methods*. While this standard refers to the PM10 size fraction, the method for testing equivalence was applied to the TSP fraction as well in recognition that management objectives for the terminals are defined in these units.

The locations of current air quality monitoring locations surrounding the Port facilities are shown at Figure 2. Monitoring has been conducted using EPA nominated equipment, namely TEOM units and dust deposition gauges (DDGs) measuring TSP and average daily deposition rates for insoluble solids. TEOM's require a relatively large site and expensive support infrastructure including a requirement for an air-conditioned enclosure. This makes TEOM's prohibitively expensive technology in terms of costs and resource requirements when considering potential to expand the monitoring network. Additionally, the TEOM's are difficult to be utilised as a mobile unit due to calibration and vibration isolation constraints. In the case of the DDG's the method, is based on a monthly time step and while useful information is obtained it is a lag indicator of performance and not useful for management response purposes.

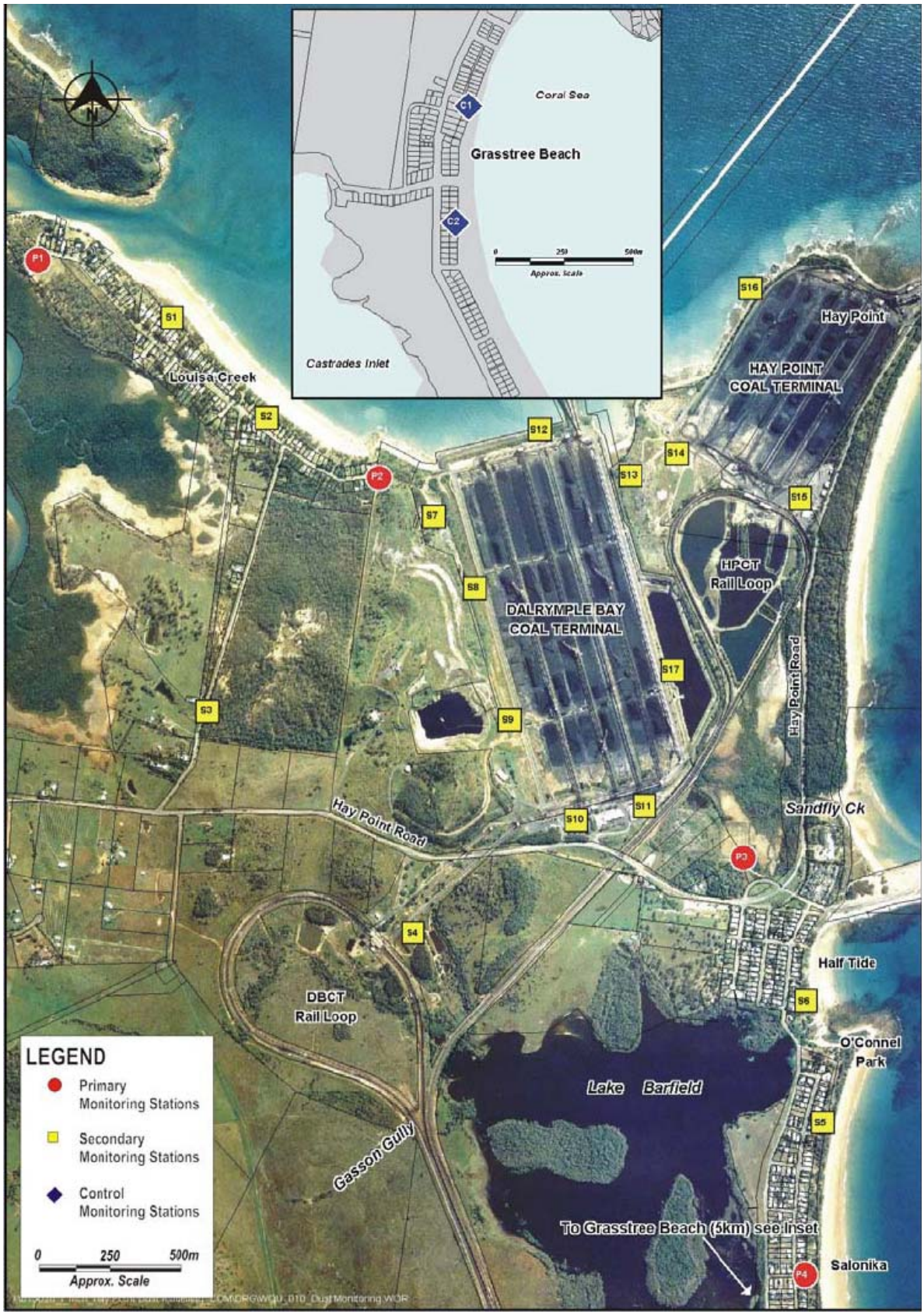

Coral Sea
C1
Grasstree Beach
C2
Castrades Inlet
Approx. Scale
P1
S1
Louisa Creek
S2
P2
S7
S8
S3
S12
S13
S14
S15
S16
Hay Point
HAY POINT
COAL TERMINAL
HPCT
Rail Loop
DALRYMPLE BAY
COAL TERMINAL
S17
S9
S11
S10
Hay Point Road
Sandfly Ck
P3
S4
DBCT
Rail Loop
Half Tide
S6
O'Connel
Park
Lake Barfield
S5
Gasson Gully
To Grasstree Beach (5km) see Inset
P4
Salonika
LEGEND
Primary
Monitoring Stations
Secondary
Monitoring Stations
Control
Monitoring Stations
0
250
500m
Approx. Scale

Figure 2: Port of Hay Point air monitoring network locality plan

The P1 monitoring site at Louisa Creek was selected as the test site for this study; this site currently operates a TEOM unit with supporting meteorological equipment. The study required forty (40) twenty-four hour paired samples between the candidate sampler (OSIRIS) and reference sampler (HiVol). The 24-hour TSP and PM10 gravimetric results from the HiVol grab samples were then compared to the 24-hour average monitored in real time by the OSIRIS samplers for both TSP and PM10 size fractions.

The P1 site was set up by installing two (2) OSIRIS samplers to the existing tower at a height of around 1800 millimetres (mm). The instruments contained internal data loggers and were programmed to measure and collect both TSP and PM10 values at ten (10) minute intervals. One of the OSIRIS units was fitted with anemographic equipment at a level of around 3000 millimetres. All units were installed in accordance with the appropriate siting standards (AS 2922-1987 Ambient Air - Guide for the siting of sampling units) and were calibrated in accordance to the manufactures specifications. The general arrangement and set up of the study site is shown overleaf at Figure 5.

The P1 TEOM ran concurrently through the program and it was initially intended that results from the TEOM be compared against the reference results as confirmation of this instruments current equivalence ranking. Unfortunately reliability issues with the TEOM precluded collection of the requisite number of concurrent 24 hour samples to allow comparative analysis as part of this study.

Analysis of data collected during the study found that the OSIRIS instruments fulfilled the requirements of the standard for both TSP and PM10 size fractions. The OSIRIS instrument could therefore be considered an appropriate equivalence method for monitoring the 24 hour average ambient TSP concentration of particulates in air against management objectives for terminal operations at the Port of Hay Point.

Testing Laboratory

All HiVol sample filters were subject to gravimetric analysis at the NATA accredited Ecowise Environmental laboratory in Pinjara Western Australia. Samples were sent to the Pinjara office from 04/11/2006 to 09/12/2006. Due to the nature of the OSIRIS instrument there was no requirement for laboratory analysis of results. OSIRIS results were downloaded, analysed and the 24-hour average concentrations calculated by Ecowise Environmental Mackay.

HiVol Reference Samplers

Four (4) High Volume Air Samplers (2 x PM10 and 2 x TSP) were employed to provide reference data for the study. Figure 3 shows standard TSP and PM10 models.

Figure 3: Typical HiVol samplers TSP (left) and PM_{10} (right)

Details of TSP HiVol units deployed

- Serial number – A007, High Volume Air Sampler, Total Suspended Particles, Date of Manufacture (DoM) 2002, Lear Seigler Australia.
- Serial number – R4, High Volume Air Sampler, Total Suspended Particles, DoM 1998, Lear Seigler Australia.

Details of the PM10 HiVol units deployed

- Serial number – A015, High Volume Air Sampler, PM^{10}, DoM 1995, Lear Seigler Australia.
- Serial number – B174, High Volume Air Sampler, PM^{10}, DoM 2006, Lear Seigler Australia.

Hi Vol Sampler Siting and Operation

- Units were sited as per EN 12341 : 1998 and AS 2922-1987 *Ambient Air - Guide for the siting of sampling units*
- Units were setup and operated as per Australian Standards 3580.9.3 & 3580.9.6

OSIRIS Candidate Sampler

As per the standard two (2) OSIRIS candidate units were employed for the study, Figure 4 shows an example of the instrument used. The instrument measures non-fibrous dusts based on optical scattering methods. The optical technology was developed by HSE's Safety Engineering Laboratory primarily for use in the EU coal-mining industry as an alternative to gravimetric sampling. Dust particles are sized and counted through a light scattering technique using a photometer which gives simultaneous indications of PM^{1} $PM^{2.5}$, PM^{10} and TSP with particle size measurement made through the diffracted angle of incidence of the laser in the counting chamber (diffraction angle α particle size). The accumulated count and calculated particle volume is then converted to a mass concentration per unit flow rate by applying an average particle density.

Figure 4: OSIRIS real-time dust monitor.

Details of OSIRIS units deployed

- Serial number – 2851, Turnkey OSIRIS Airborne Particle Monitor, DoM Jan 2006, Turnkey Industries
- Serial number – 2580, Turnkey OSIRIS Airborne Particle Monitor, DoM Jan 2006, Turnkey Industries
- Hardware and software manual : *Turnkey OSIRIS Airborne Particle Monitor*

OSIRIS Siting and Operation

- Units were sited as per the standard and AS 2922-1987 *Ambient Air - Guide for the siting of sampling units.*
- As per section 5.1.3 of the standard, reference and candidate samplers were operated in accordance with the instructions supplied by the manufacturer.
- The average value of the preceding 10 min interval was logged for analysis.

Site Description

An established air quality monitoring station Louisa Creek (designated P1 at Figure 2) was selected as the most appropriate location for the study. The site is located to the WNW of its operations approximately 3.38kM line of at co-ordinates S 21°16'20.17" E 149°15'45.57". The general arrangement of the site is shown at Figure 5.

The addition of the OSIRIS and High Volume units occurred on 04/11/2006. The units were set up according to the requirements stipulated under the relevant standards previously referenced.

The selected test site and arrangement of equipment within the site satisfied the particulars of section 5.1.1. of the standard namely:

I. the flow around the sampler's inlet was unrestricted without any obstructions (such as balconies, trees, vertical surfaces or walls, etc) affecting the air flow in the vicinity of the samplers;
II. the inlets were well extended from each other in order to avoid mutual interference on the sampling process
III. inlets were be set at the same height between 1.5 and 8m above the ground;
IV. inlets were positioned away from local sources in order to avoid drifting plumes.

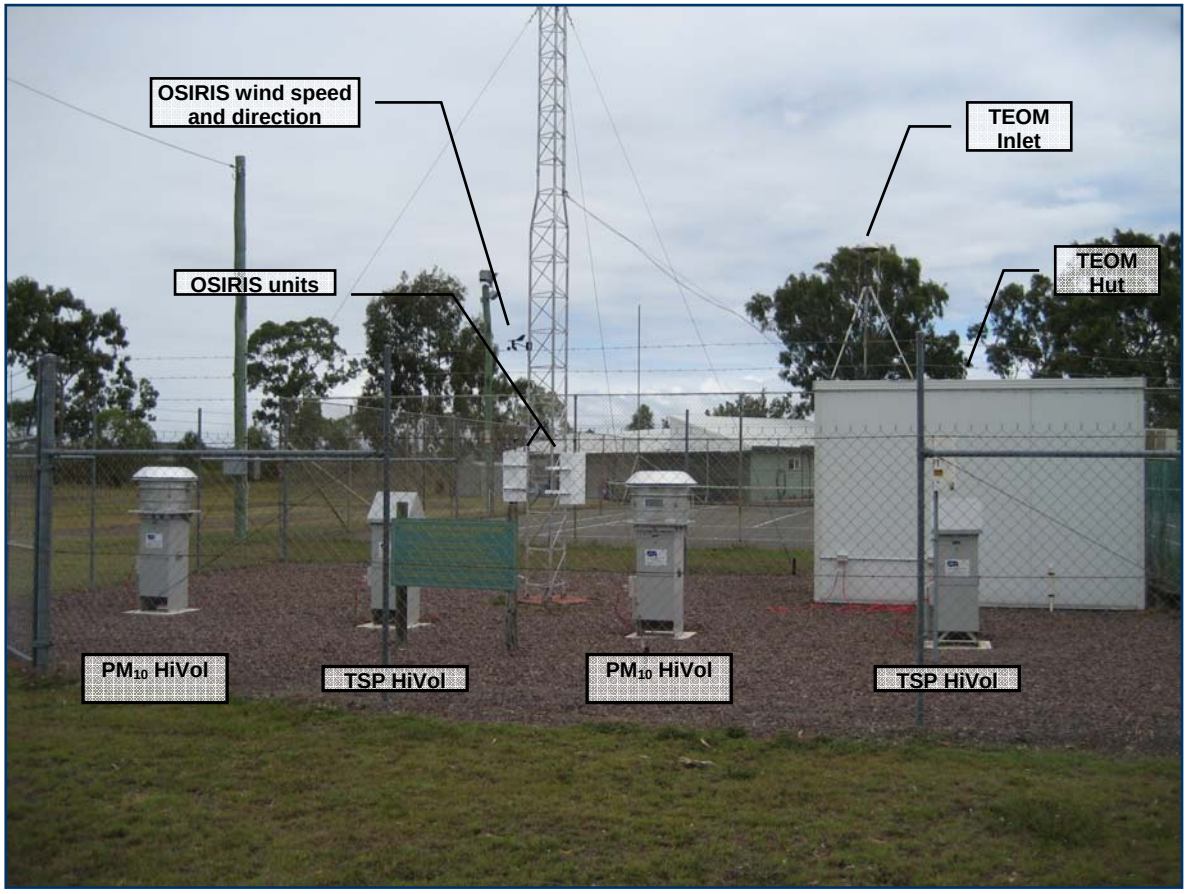


Figure 5: Study site set up showing general arrangement

Calibration and Operation

Each unit was independently calibrated. High Volume samplers were calibrated according to OEM specifications and AS/NZS 3580.9.6:2003 sections 7.4 and 6(b). All servicing staff were trained and competent in the calibration, operation and maintenance of the units prior to field deployment and during the initial commissioning stage.

Flow mass calculations were determined:

$Q_{mi} = (273 / T_1) \times (P_1 / 101.3) \times 1.13$

Where

Q_{mi} = *flow rate in cubic meters per minute, corrected to reference conditions 0°C and 101.3 kPa*

T_1 = *estimated mean temperature over sampling period. Data for this project was obtained from the Bureau of Meteorology.*

P_1 = *estimated mean ambient barometric pressure not corrected to MSL. Data for this project was obtained from the Bureau of Meteorology.*

Equation relating mass flow rate (Q_{mi}) to differential pressure (ΔP) across calibration orifice plate:

$\Delta P = (Q_{mi} / {}^{c}_{MASS})^2 \times (101.3 / 273) \times (T_{AC} / P_{AC})$

Where

Q_{mi} *= flow rate in cubic meters per minute*

T_{AC} *= temperature at time of calibration (AC refers to actual calibration). Data for this project was obtained from the Bureau of Meteorology.*

P_{AC} *= Barometric pressure at time of calibration. Data for this project was obtained from the Bureau of Meteorology.*

${}^{c}_{MASS}$ *= Orifice plate coefficient*

The OSIRIS units were calibrated and maintained as per the *Turnkey OSIRIS airborne particle monitor Revision 3.03 Issue 2*. and *Turnkey Instruments Ltd Topas and OSIRIS Environmental Monitor Training Manual Issue 1.*

HiVol Operation & Servicing Procedure

Operation and servicing of the HiVol samplers was undertaken in accordance with the requirements of:

- AS/NZS 3580.9.3:2003 *Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - Total suspended particulate matter TSP) - High volume sampler gravimetric method*

- AS/NZS 3580.9.6:2003 *Methods for sampling and analysis of ambient air - determination of suspended particulate matter - PM(sub)10(/sub) high volume sampler with size-selective inlet - Gravimetric method*

Prior to mobilisation to site, five (5) weighed filters from the laboratory were unpacked and loaded into filter canisters using gloved hands and tweezers in a controlled air conditioned room, and canister covers attached. The numbers on the filter papers were entered onto the CoC sheet. A field filter blank was taken with each sample set for QA/QC purposes. The canisters were packed inside another plastic bag and sealed in an industrial *Pelican Case*® along with the CoC.

On arriving on site, the four (4) High Volume units were unlocked. The time and flow rate of each unit ($70m^3$/hr TSP and $62m^3$/hr for PM_{10}) was noted and all four (4) units were shut down to 'bypass' mode. The site visit period was within +/- 2 hours of the preceding 24-hour interval. The following details were recorded on the CoC forms which (included as Appendix A):

- Site name
- Filter number in
- Filter number out
- Time on
- Time off
- Counter on
- Counter off
- Colour of spent filter
- Comments

The used filter from each unit was removed and covered before the new filter was fitted. Care was taken not to touch or damage the filter when fitting the retention clamps. Restart details were noted and recorded on the CoC and the units were given five (5) minutes to stabilise and flow rates confirmed before the site was vacated.

The recovered filters were unloaded into individual static proof plastic slips in a controlled air conditioned room. Filters were packed with the CoC records into the protective packaging supplied by the analysing laboratory and dispatched by express courier for analysis.

OSIRIS Operation & Servicing Procedure

The OSIRIS instruments were downloaded and checked for operational integrity weekly during the trial period. Memory usage, battery volts and flow rates were also observed and a review of recovered data was performed onsite. A standard QA function of the OSIRIS is a zero check interval. This QA test stops the sample pump at programmed intervals to check for zero point calibration during sample runs. The OSIRIS units where also fitted with a gravimetric filter. The purpose of this filter is to protect the pump mechanism and allow for calibration of the site factor and validation of real-time readings.

Each OSIRIS was checked for operation daily during the routine HiVol filter exchange visits. Pumping hours were checked on the Liquid Crystal Display (LCD) and after the nominated value reached, the units were paused and the pump filter was exchanged. These filters were controlled by CoC documents (Appendix B) and were sent to the nominated laboratory for weighing as a check to the filter weight calculated by the OSIRIS. An accumulation of more than 4.5mg required a full flow check and filter exchange. Full flow checks and adjustment were carried out during these exchanges as normal practice regardless of indicated filter weight.

OSIRIS data was downloaded directly onto a field laptop and transferred to the ECOWISE network in the Mackay office. Here the data was backed up and transferred to the HYDSTRA database, used to manage and analyse time-series data.

Data Set Construction

Results from the OSIRIS were immediately available as a time-series set. Results from the HiVol samplers required the used filter papers to be reweighed at the analysing lab for calculation of the average 24-hour concentrations for TSP and PM_{10} in $\mu g/m^3$.

In order to compare the results from both types of samplers, daily averaging had to be performed on the time-series data. The start and finish times of the HiVol samplers were extracted from the CoC form and OSIRIS data was averaged between these times +/- 5 minutes. This resulted in the assembly of the following data sets:

- OSIRIS 2580 TSP and PM_{10} averaged as detailed above
- OSIRIS 2581 TSP and PM_{10} averaged as detailed above

High Volume sampler data as supplied from the laboratory:

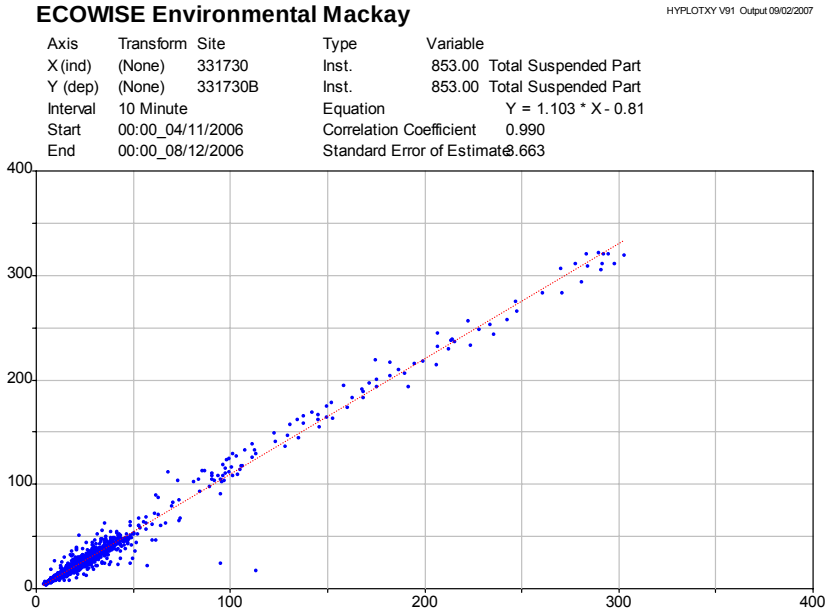
- A007 - TSP
- A015 - PM_{10}
- B174 - TSP
- R4 - PM_{10}

As per section 5.2.1 of the standard all data was reviewed and validated to ensure the data sets were error free from any interference due to technical problems. All data received from the laboratory was commented and declared fit for use. Erroneous data was made available in order to highlight any technical issues, such as damaged filter papers etc. Both candidate samplers were run separately, including power supplies to allow for detection of sporadic or instrument errors.

Results and Discussion

The standard required testing of intra-instrument correlation for candidate samplers as well as correlation against the reference sampler results (inter-instrument correlation). Figure 6 (a) and (b) show the agreement between candidate samplers for TSP and PM_{10} size fractions respectively. The Figures show the OSIRIS instruments easily met the requirements of the standard for intra-instrument correlation with a correlation co-efficient of ≥0.99 for both size fractions against a standard requirement of ≥0.95.

(a)



(b)

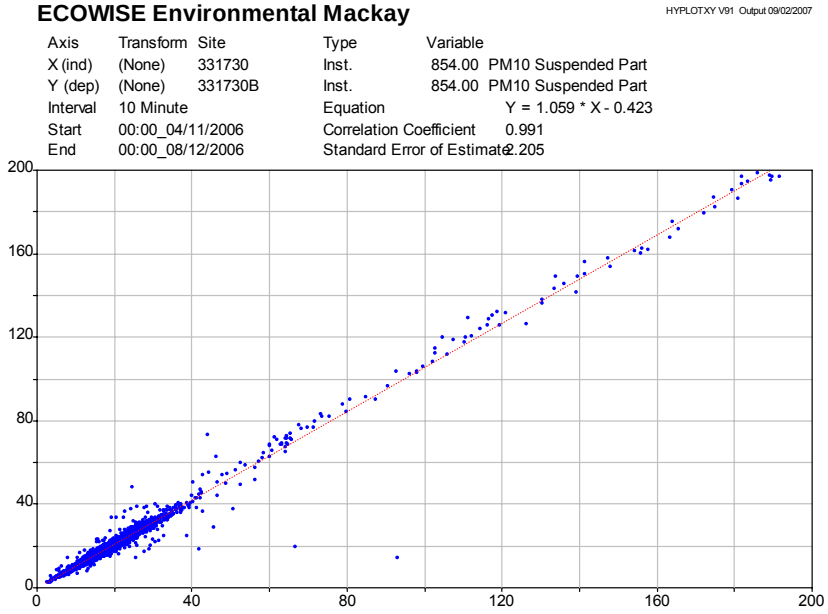


Figure 6: Correlation plots for OSIRIS 2581 Vs 2581 for (a) TSP and (b) PM_{10}

It is worth noting that the level of correlation between the OSIRIS samplers was determined using the 10-minute average data, not the 24-hour averages as allowed by the standard. Taking this into consideration, the calculated correlation coefficients and standard errors between the candidate samplers provide an indication of the level of precision offered by the OSIRIS monitors.

The standard requires that paired data from both candidate samplers be plotted against data from a single reference sampler to make a final determination of equivalence. Due to the high level of agreement between the OSIRIS samples, the standard allowed for the remainder of this analysis to be undertaken using only a single set of candidate data (Section 4.2[a]). The data sets *OSIRIS 2581 TSP* and *OSIRIS 2581PM10* where used for this purpose. Although not required by the standard, the candidate data sets were compared against both sets of reference data and regression analysis and equivalence assessment performed against both for completeness. The final tests for equivalence required assessment of results obtained against an acceptance envelope and achieving an $r^2 \geq 0.95$ by regression analysis.

These results are displayed as per section 5.2.4 sub section (c) of the standard:

TSP data was plotted on one graph (Figure 7) showing:

- the ideal reference equivalence function y = x ;
- calculated two (2) sided envelope (y = x + 10) µg/m^3 for concentration values < 100 µg/m^3 and 10% sided envelope for values > 100 µg/m^3
- the measured data pairs
- the calculated equivalence function (line of best fit and r^2)

PM_{10} data was plotted on one (Figure 8) graph showing:

- the ideal reference equivalence function $y = x$;
- calculated two (2) sided acceptance envelope ($y = x \pm 10$) µg/m^3 for concentration values $\leq$ 100 µg/m^3
- the measured data pairs
- the calculated equivalence function (line of best fit and r^2)

Generally the plots show the paired data points lie within the specified acceptance envelopes. The acceptance envelope of $\pm$ 10 µg/m^3 and 10% (>100 µg/m^3) was however exceeded at the upper end of the scale in a single instance. Investigation into this data point showed that on the 16/11/06 the CoC (number P1061116) had the colour 'Brown' noted next to the filter description for the recovered HiVol filter. This is significant as all other descriptions for the entire study recorded either a 'Grey' or 'Light Grey' colour associated with the used filters. Wind direction data for the day also indicated a swing to the south / south west (also been recorded on the CoC).

The brown colour and shift out of the acceptance envelope for this single point was attributed to agricultural activities due to the time of year and wind direction. All data resulting from the prevailing easterly winds fell within the range normally experienced at the site and was bounded by the acceptance envelope. It was concluded that the outlying result came about due to a shift in the make-up of the "average" dust particle resulting from the change in wind direction and therefore upwind sources of dust. In considering the context of this study, namely monitoring of fugitive dust potential arising from terminal activities, the data demonstrates that under potential terminal impact conditions (winds from the E-SE) data falls within the required acceptance envelopes for TSP and PM_{10}.

When subject to regression analysis, an r^2 correlation coefficient in excess of the of 0.95 was returned for both TSP and PM_{10} data sets. Both TSP paired data sets returned r^2 values of 0.97; the PM_{10} sets returned r^2 values of 0.95 and 0.96 .These results show that r^2 values $\geq$ 0.95 for all data was achieved by the OSIRIS instruments as required to be regarded as an equivalence method by the standard.

The final equivalence functions for transformation of 24-hour average OSIRIS data to the HiVol reference methods were determined to be:

- HiVol 24-hour average [TSP] = 0.6883(OSIRIS 24-hour average [TSP]) + 4.1491
- HiVol 24-hour average [PM_{10}] = 0.7688(OSIRIS 24-hour average [PM_{10}]) + 6.4340

Conclusion and Recommendations

Results showed that with the exception of a single data point associated with a significant shift in wind direction and source material the candidate OSIRIS samplers met the equivalence requirements of the standard for measuring the 24-hour average concentration of both TSP and PM_{10}particles in ambient air subject to application of calculated equivalence functions.

It is concluded that the calculated TSP equivalence function should allow the use of the OSIRIS instrument to replace the existing TEOMs within the ambient air monitoring network at Port of Hay Point. No comment was able to be made on the equivalence performance of the existing TEOM instrument due to repeated reliability issues resulting in a lack of sufficient 24-hour paired data to undertake analysis. This result in itself further highlights the identified need to replace the current instrumentation.

To provide for ongoing validation of the TSP equivalence equation with respect to seasonal effects and changes in regional and local sources it is recommended that the use of OSIRIS monitors be supported by the concurrent use of HiVol TSP samplers. These should be operated every sixth (6^{th}) day as per AS/NZS 3580.9.3:2003 *Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - Total suspended particulate matter (TSP) - High volume sampler gravimetric method*. Operation in this manner would provide an additional 60 paired data points per year to be collected to allow for ongoing refinement of equivalence equations. The deployment of HiVol samplers at the current primary monitoring locations (P1-P4 Figure 2) is regarded as sufficient to support a change to OSIRIS instruments in the existing network and to support any additional points installed as a result of moving forward to the more cost effective OSIRIS instrument.

Based on the results of this study, it is therefore concluded that the OSIRIS should be considered an acceptable equivalent monitoring method to replace the existing TEOMs within the monitoring network at Port of Hay Point for the purpose of measuring TSP concentrations in ambient air against management objectives contained in coal terminal Environmental Authority conditions.

Figure 7: Reference Sampler Vs Candidate Sampler results plot TSP

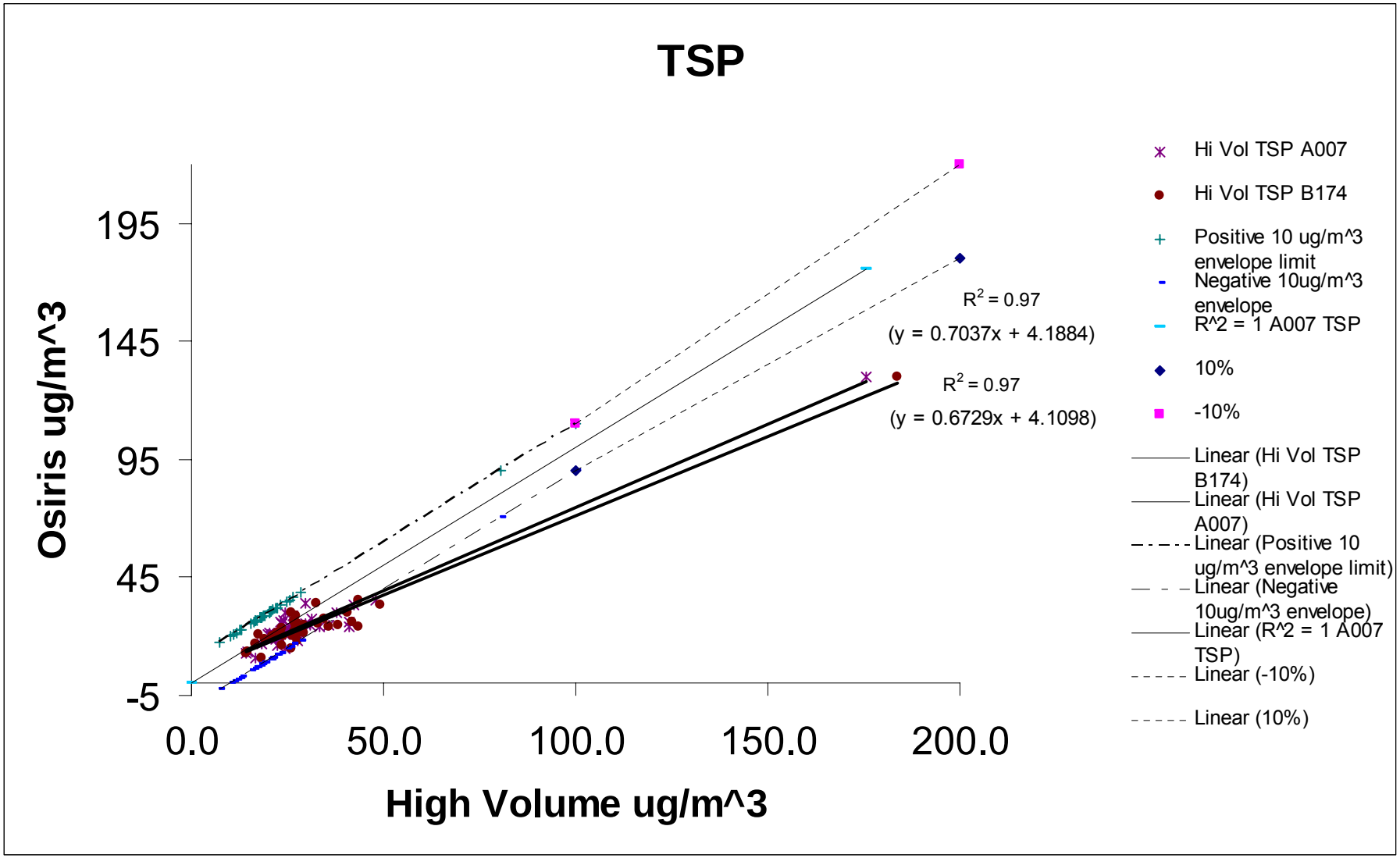
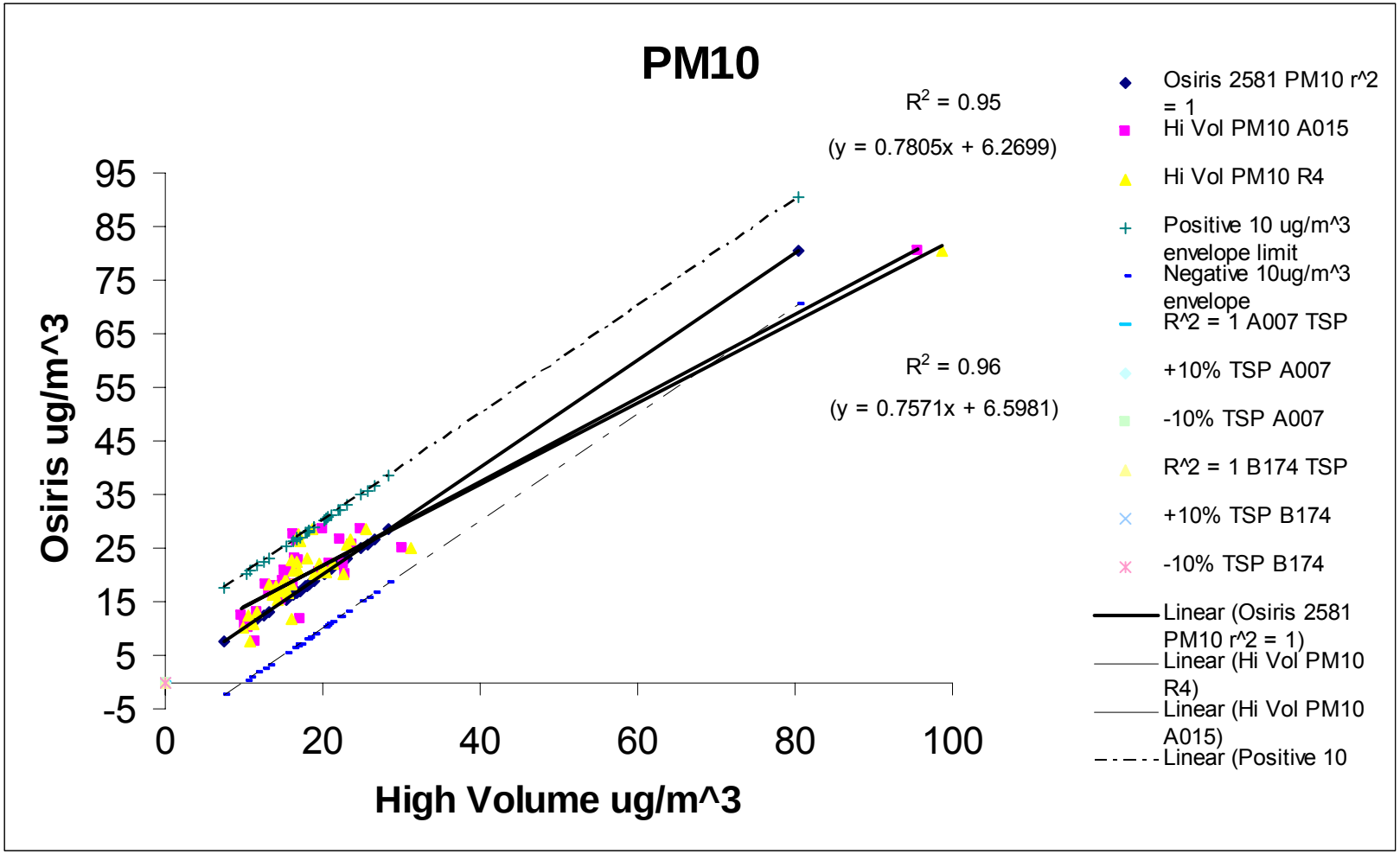


Figure 8: Reference Sampler Vs Candidate Sampler results plot PM_{10}



Appendix A

Sent in hard copy at client's request.