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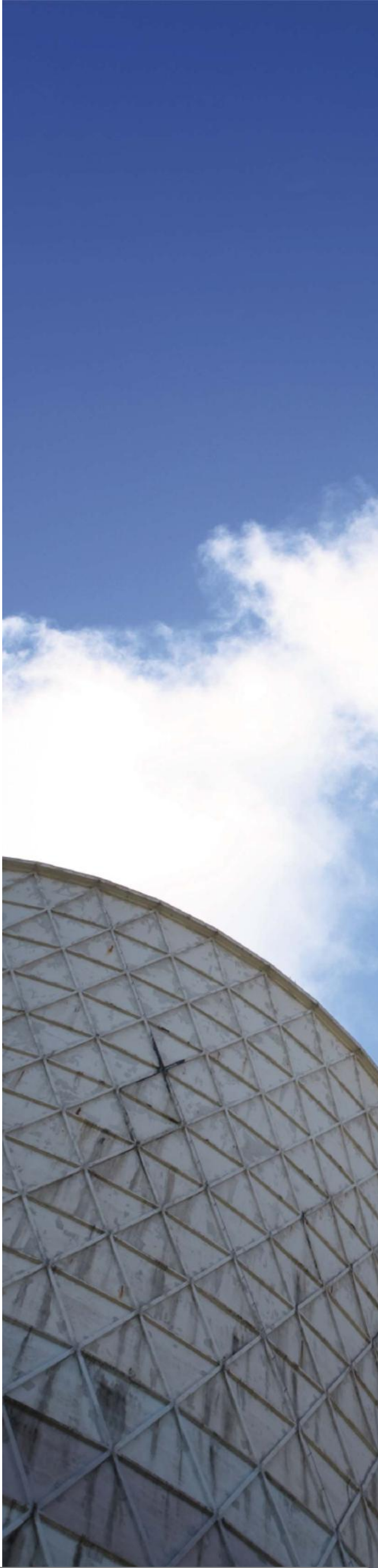

REPORT

DURALIE COAL MINE PRP U2 MONITORING PLAN – WHEEL GENERATED DUST

Duralie Coal Pty Ltd

Job No: 7933

26 July 2013

PROJECT TITLE:	Duralie Coal Mine PRP U2 Monitoring Plan – Wheel Generated Dust
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CONTENTS

1 INTRODUCTION

In June 2011 the NSW Environmental Protection Agency (EPA) published the draft best practice document 'NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining' (**OEH, 2011a**).

Following on from the Benchmarking Study the EPA developed a series of 'Pollution Reduction Programs' (PRPs) for coal mines. The PRPs required Duralie Coal Pty Ltd to prepare a report on the practicability of implementing best practice measures to reduce particle emissions from mining operations at their Duralie Coal Mine (DCM).

On 21 March 2013, the Environmental Protection Licence (EPL) for DCM (no. 11701) was modified to include three new PRPs related to Particulate Matter Control, as follows:

- U2: Particulate Matter Control Best Practice Implementation - Wheel Generated Dust
- U3: Particulate Matter Control Best Practice Implementation - Disturbing and Handling Overburden under Adverse Weather Conditions
- U4: Particulate Matter Control Best Practice Implementation - Trial of Best Practice Measures for Disturbing and Handling Overburden

Condition U2 (*Particulate Matter Control Best Practice - Wheel Generated Dust)* states that DCM must achieve and maintain a dust control efficiency of 80% or more on its haul roads and requires the licensee to prepare a Monitoring Program to assess compliance with this condition.

This document presents the proposed Monitoring Program for Condition U2 (reproduced in full in **Appendix A**).

1.1 Definitions

Definitions of some of the terms used in this report are provided below:

Active haul road	A road used for hauling material during the shift when sampling is taking place.
CE	Control efficiency - as per the equation in EPL Condition U2.1.
GPS	Global Positioning System.
REX	Road Emission eXpert, the mobile haul road monitoring device
Haul road	A site road that is used for hauling material.
KPI	An indicator or surrogate for PM control efficiency.
Monitoring implementation period	The period following approval of this Monitoring Program by the EPA and prior to the submission of a written report to the EPA (due by 15 August 2014).
Node	Fixed point on the road network, typically an intersection.
PM	Particulate Matter.
Section length	The distance of a given stretch of road between nodes.
Uncontrolled section	A section of road, at least 150 m in length, left untreated with either water of dust suppressant for a minimum of 12 hours prior to sampling.
VKT	Vehicle kilometres travelled.
Site-specific control efficiency	Site average CE, weighted by VKT.
Wet weather	More than 0.1 inches (~ 0.3 mm) of rain in the 12-hour period before sampling (**USEPA, 1974**)

2 MONITORING PROGRAM

2.1 Overview

The following steps will be taken to complete the Monitoring Program required by Condition U2.

1. Planning and information gathering.
2. Haul road monitoring.
3. Data analysis and presentation.
4. Ongoing operational management.

Each of the steps outlined in the following sections addresses the requirements for monitoring (Condition U2.2) and analysis (Condition U2.3).

PM emissions from haul roads will be measured using the mobile sampling system REX (Road Emissions eXpert). REX measures the concentration of PM from vehicles travelling on unpaved roads. By comparing data collected from haul roads with and without controls, control efficiencies can be calculated. In this way, REX can measure the average control efficiency (%) for each haul road section.

The system is described in more detail in **Appendix B** which also provides results from the first round of monitoring completed as part of the Monitoring Program, conducted during May 2013.

2.2 Planning / Information gathering

Prior to monitoring, a detailed analysis of meteorological data shall determine a suitable frequency for monitoring. The analysis will:

- Obtain five to ten years of meteorological data collected at the site.
- Determine how key meteorological parameters vary on a monthly and seasonal basis. These variables will include, but will not be limited to:
  - Temperature
  - Rainfall
  - Solar radiation
  - Evaporation
- Identify suitable periods for monitoring to capture the effects of meteorological variation on PM control efficiency. For example, these periods should include:
  - Warm, sunny day with high evaporation potential
  - Cool, cloudy day with low evaporation potential

The following planning is then completed for each nominated monitoring campaign:

- Identification, with mine personnel, of representative haul road types that will be active during the planned sampling day for REX monitoring[a].
- Identification, with mine personnel, of representative section(s) of haul road to be left uncontrolled for a minimum of 12 hours prior to sampling.
- Identification, with mine personnel, of other data required (detailed in **Section 2.3.2**).
- Identify node points on the haul road network, and separate the network into sections of road between nodes.
- Schedule a member of site personnel to drive the REX vehicle on the monitoring day.

[a] As the location of the haul roads will change between each monitoring campaign, it is not possible to state exactly where sampling will take place until immediately prior to each monitoring campaign.

2.3 Haul road monitoring

The deployment of REX on the monitoring day will be conducted as follows:

- Confirm that no more than 0.3 mm of precipitation has been recorded at the closest meteorological station in the preceding 12 hours.
- Confirm that control sections of haul roads have been left unwatered/untreated for at least 12 hours prior to monitoring with REX.
- Complete all monitoring procedures, as outlined in the Quality Management Plan for mobile haul road monitoring (**Pacific Environment, 2013**).
- Complete monitoring at a constant speed of 40 km/h (a function of the system flow requirement).
- Repeat circuits of mine 4 – 5 times during the sampling day to capture varying diurnal conditions.

2.3.1 Sampling Frequency

The REX sampling frequency will be based on the variability of key meteorological parameters. As discussed above, a detailed analysis of 5 years of meteorological data would be used to determine the required frequency.

As a minimum, sampling would be conducted on at least two occasions, one of which will be during, dry and warm summer time conditions (which are anticipated to be worst case for achieving high control efficiency).

2.3.2 Data collection

The following information will be collected for each representative haul road type or road section and used for developing an overall PM-control efficiency for the site.

- Vehicle movement routes, included loaded weight direction
- Number of vehicle movements
- Vehicle weights
- Vehicle speed
- Frequency, duration, rate and quantity of water applied to haul roads (can also be derived from water cart volumes)
- Frequency, duration, rate and quantity of suppressant applied to haul roads in comparison to manufacturer's specifications
- Procedural information on the method of watering, including the width of application
- Rainfall, wind speed, wind direction, temperature and humidity data from the site for the sampling day and for the week prior to sampling

2.4 Data analysis and presentation

The following analysis is completed to determine control efficiency.

- Collate and match the measured PM concentration with the GPS data from REX
- Map the data to a site aerial or plan
- Determine the node to node locations for each section of haul road
- Determine PM-control efficiency (CE) for each haul road section, using the following equation:

$$CE = \frac{E\,(uncontrolled) - E\,(controlled)}{E\,(uncontrolled)} \times 100$$

Where:
E (uncontrolled) is the average PM concentration of the uncontrolled section
E (controlled) is the average PM concentration of each node-to-node length

To determine the overall site control efficiency, individual road section control efficiencies may be weighted to account for haul truck movements and lengths of road (i.e. VKT). The overall site % control efficiency will then be compared to the compliance target.

Sampling will be repeated until control efficiency of 80% or over has been demonstrated for the meteorological variability identified in **Section 2.2**.

If less than 80% control efficiency is achieved across the site, a review will be completed to determine the most appropriate controls to increase the control efficiency prior to the next monitoring campaign and may include, but are not limited to:

- Increased watering and/or suppressant use
- Identifying sections of the site that require remediation in terms of increased watering if appropriate
- Remediation of intersections where higher silt loading occurs

Following changes to control measures, subsequent sampling will determine whether these changes have reduced haul road dust with the aim of achieving ≥ 80% PM-control efficiency.

If the monitoring has resulted in ≥ 80% PM-control efficiency across the site, surrogate KPIs will be developed to measure continued compliance (refer **Section 2.5**).

A summary of the monitoring method is shown in **Figure 1**.

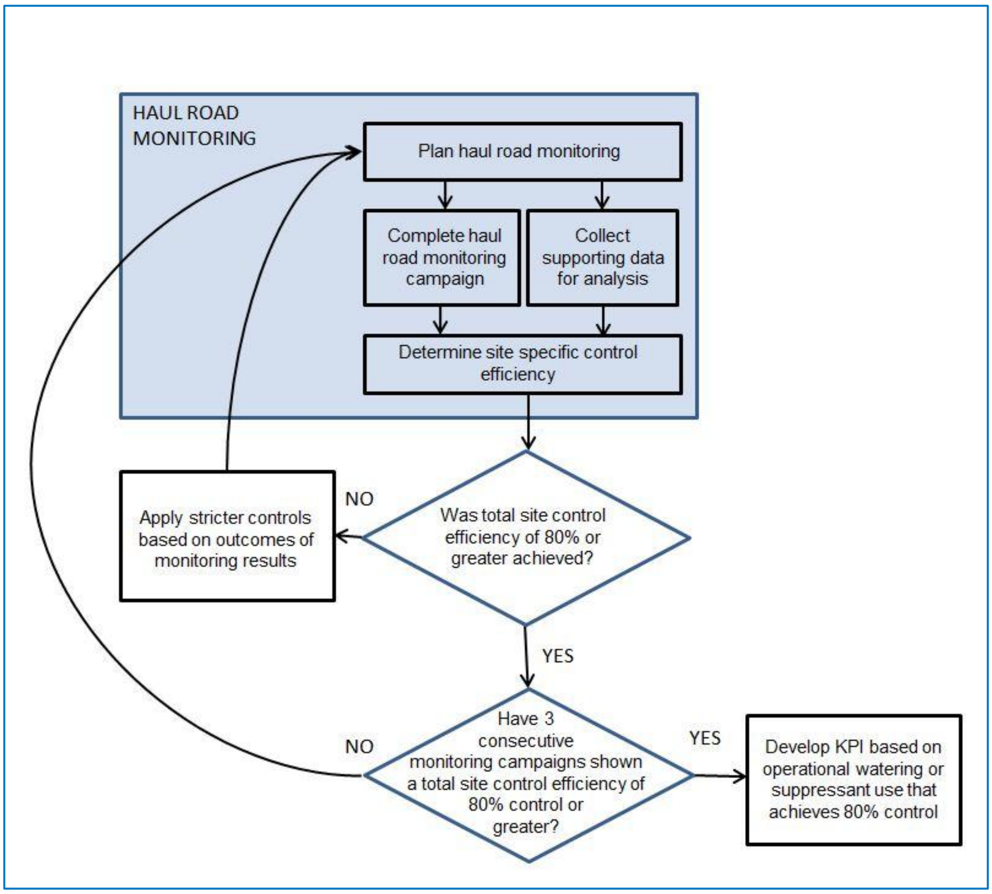

Figure 1: Haul road monitoring program

2.5 Operational management and KPIs

The two proposed Key Performance Indicators (KPI) are presented in **Table 2.1**. The primary KPI (to achieve PM-control efficiency of 80%) is determined directly based on REX monitoring (see **Appendix B**). The secondary KPI is based on a correlation between PM-control efficiency and the watering application rate at the time of REX sampling. The secondary KPI is used to report ongoing performance in-between sampling events.

Table 2.1: Summary of KPIs for U2

KPI	Description	Specific	Measurable	Attainable	Relevant	Time-bound
Primary KPI – to achieve PM control efficiency of 80%	• Specific to PM-control efficiency target • Measured directly from REX monitoring • Attainable and required by EPL • Directly relevant to Condition U2 • Timing to be determined based on frequency of monitoring.	✓	✓	✓	✓	✓
Secondary KPI - Watering application rate to maintain efficiency of 80% on non-rain days	• Related to PM-control efficiency target • Measured based on water truck hours of operation or VKT, number of water trucks circuits/day, number of fill events • Attainable and required by EPL • Directly relevant to Condition U2 • Determined daily (for non-rain days).	✓	✓	✓	✓	✓

The target watering application rate may vary under different meteorological conditions, i.e. higher in summer, lower in winter. Any significant changes to operation (i.e. changes to material moved, changes to truck weights) would need to be accounted for in determination of whether the control is being met and whether repeated sampling is required. Re-sampling can be undertaken annually to confirm that the KPI value is still enabling the site to meet the 80% PM-control threshold. An overview of the ongoing operational management is shown in **Figure 2**.

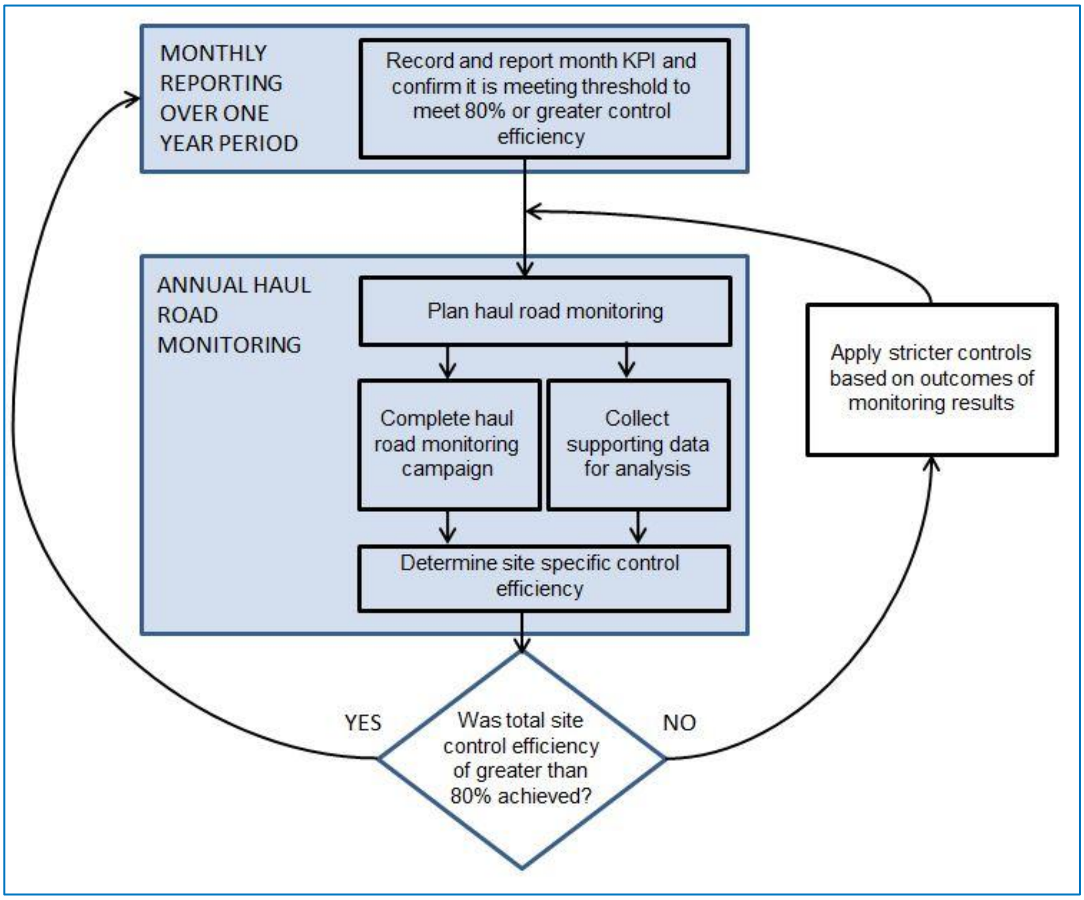

Figure 2: Ongoing management of haul roads

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Pacific Environment (2013). Quality Management Plan – Mobile Haul Road Monitoring. 03 January 2013.

USEPA (1974). Development of Emission Factors for Fugitive Dust Sources. U.S Environmental Protection Agency, Office of Air and Waste Management. Research Triangle Park, North Carolina 27711.

Appendix A PRP CONDITION

U2 Particulate Matter Control Best Practice Implementation - Wheel Generated Dust

U2.1 The Licensee must achieve and maintain a dust control efficiency of 80% or more on all haul roads by 22 March 2013[b].

The control efficiency is calculated as:

$$CE = \frac{E\,(\text{uncontrolled}) - E\,(\text{controlled})}{E\,(\text{uncontrolled})} \times 100$$

Where E = the emission rate of the activity.

U2.2 The Licensee must prepare a Monitoring Program to assess its compliance with Condition U2.1 under varying meteorological conditions. The Monitoring Program must detail the following:

- parameters to be monitored.
- methods to be used to monitor each parameter.
- locations where each parameter will be monitored.
- frequency at which each parameter will be monitored.
- Key Performance Indicators that will be used to determine compliance with Condition U2.1.
- A detailed justification for each Key Performance Indicator selected.

As a guide, the EPA anticipates that the following parameters will be monitored:

- Moisture and silt contents of haul roads.
- Frequency, duration, rate and quantity of water applied to haul roads.
- Frequency, duration, rate and quantity of suppressant applied to haul roads in comparison to manufacturer's specifications.
- Vehicle kilometres travelled.
- Haul truck weight.
- Haul truck speed.
- Dust levels on haul roads.

The Monitoring Program must be submitted by the Licensee to the Environment Protection Authority Regional Manager Hunter, at PO Box 488G, NEWCASTLE by 31 May 2013.

The EPA intends to require the licensee to implement the Monitoring Program once it is approved by the EPA.

U2.3 The Licensee must submit a written report to the EPA providing the results of the Monitoring Program. The report must include an assessment of the dust control effectiveness, dust levels and the Licensee's compliance with Condition U2.1. The report must be submitted by the Licensee to the Environment Protection Authority Regional Manager Hunter, at PO Box 488G, NEWCASTLE by 15 August 2014.

[b] Date as it was written in the licence

Appendix B REX Sampling at Duralie Mine

1 INTRODUCTION

This report presents the analysis of a baseline monitoring campaign completed to determine the current haul road dust particulate matter control efficiency on unsealed roads being achieved at Duralie Coal Mine (DCM). Sampling was done on 8 May 2013 and included active haul roads.

1.1 Background

Haul road dust particle matter (PM) emissions are a large source of emissions from open-cut coal mining operations. These emissions are also one of the most manageable sources to control; typically this is done by the application of water and/or suppressants onto the road surface. Theoretical control efficiencies are applied to determine the effectiveness of these management techniques on overall site emissions for site emission inventory development, but these theoretical controls fail to incorporate the inherent variability of emissions from sites as a result of changes in conditions and operations.

Haul road emissions vary depending on a number of variables, including:

- Meteorological conditions
  - Wind speed and direction
  - Ambient temperature and humidity
- Vehicle Specifications
  - Vehicle number
  - Vehicle weight
  - Number of wheels
  - Airflow generated at the road surface
- Road Construction
  - Particle size distribution
  - Compaction and bonding of surface material
- Road maintenance
  - Type of watering control used (i.e. chemical suppressants)
  - Frequency of application

There are a number of significant benefits from increasing the control of PM_{10} emissions on haul roads. These advantages, as outlined below, range from site cost reductions to improved health and safety conditions and reduced impact on the surrounding environment, as outlined below:

- Maintenance Costs
  - Reduced vehicle wear and tear (engine, tyres, filters)
  - Reduced deterioration of the roadway
  - Reduced loss of surface aggregate
- Health and Safety
  - Increased driver sight distance
  - Improved ride quality
  - Reduced health impacts on operators and the community
- Environmental
  - Reduced exceedances in air quality criteria
  - Reduced impacts on surrounding land and water

1.2 Objectives of the study

Pacific Environment was commissioned by Duralie Coal Pty Ltd (DCPL) to measure the effectiveness of current measures in place at DCM to control dust emissions from unsealed haul roads. Monitoring was completed using the Road Emissions eXpert (REX) tool, a concept originally developed by MRIGlobal (MO, USA). The system has been redeveloped by Pacific Environment as part of a research grant from the Australian Coal Association Research Program (ACARP Grant C20023). The research program is currently in the second stage and is seeking to define the temporal and spatial variability of dust on haul roads relative to changing conditions and materials at coal mines in NSW.

This study seeks to determine changes in the temporal and spatial distribution of dust emissions under normal operating conditions at each site. The control efficiency from the current watering management control program has been determined using data collected from sections of the road that were left uncontrolled for more than 12 hours prior to the sampling.

1.3 Scope of Work

This work is considered a baseline study to determine the usefulness of the data that can be collected from the sampling system at DCM. The results from this study are indicative of the conditions on the sampling day. The inherent variability of wheel generated dust based on changes in meteorological conditions, road construction and operational management will be explored in greater detail in ACARP project 20023 (as described in **Section 1.2**). These results will be available to the site to determine best practice management of wheel generated dust emissions.

2 STUDY APPROACH AND METHODOLOGY

The sampling program sought to define particles of less than 10 µm (PM_{10}) concentrations to determine the watering control efficiency under normal operating conditions.

2.1 Haul road monitoring using the Road Emission eXpert (REX)

The system measures road dust particulate matter emission potential (dust plume concentration) from vehicles travelling on unpaved roads and can be used to quantify relative control efficiencies across a site. The method measures the change in particulate matter (PM) concentrations of road dust emitted from the interaction with the vehicle tyres and the road surface. The mobile instrument can be used to characterise a large number of roads in a relatively short time period. The system measures the relative control efficiency of haul road emissions and has been proven to produce robust and reliable results over many hours of sampling.

The elevated PM concentration has been shown to be directly related to the amount of road dust PM emitted per unit distance travelled by the test vehicle and that in conjunction with the Plume Profiling method the mass of the test vehicle can be used as a scaling parameter to quantify the PM emissions from the other vehicles travelling on the same road (**Gillies *et al.*, 2005; Kuhn *et al.*, 2010**) to determine an emission rate for haul roads. The impact that vehicle parameters such as truck weight, size and number traveling along the road will be analysed in greater detail in ACARP project 20023.

The REX system is shown mounted on a light vehicle in **Figure 2.1**. The schematic illustrates the main components of the system; a high volume cyclone preseperator and a continuous laser photometer (TSI DustTrak 8530), configured to measure PM_{10}.

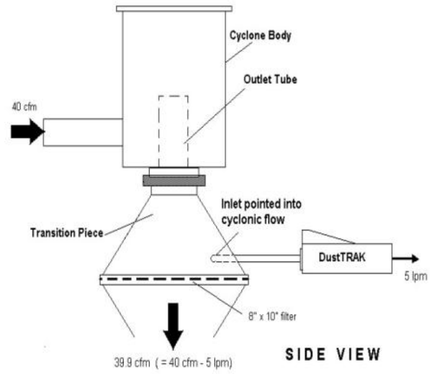

Figure 2.1: Photo and Schematic of the Road Emission eXpert (REX)

The battery operated laser photometer was selected due to it being easily deployed, moved, robust, lightweight and not requiring 240V power. While the DustTrak it is not a reference method for determining particle concentrations, it can provide useful and reliable data if operated and calibrated correctly for a relative measure of particle concentration.

The sample inlet is located directly downstream of the emission source, in this instance the interface between the front tyre and road surface. The inlet is pointed to the front of the vehicle and positioned high enough above the road surface to collect truly airborne material and close enough to the surface to collect an adequate sample mass. Flow is drawn through the system at approximately 40 cfm (1.13 m^3/min). PM_{10} particles are drawn into the outlet tube of the cyclone body by the flow pump, and the laser photometer samples from the cyclone effluent. The laser photometer had a PM_{10} impactor plate fitted to ensure only PM_{10} particles were sampled. The sampler was zero calibrated at the start of sampling, where the filter was oiled and the other filters checked to be clear of particles. Flow rates of the system were checked to ensure consistency throughout the sampling day using a handheld anemometer.

The system incorporates a GPS unit which logs a location output with the laser photometer output to a website in real-time. The system is powered directly from the vehicle battery in order to meet the strict safety requirements of the mine. Where possible the vehicle maintained a constant speed of 40 km/h during sampling.

2.2 Sampling Methodology

Control efficiency for each circuit was calculated by first determining a baseline using an average the total concentration measured when travelling across the uncontrolled sections during each circuit. This was calculated using Equation 1, from U2.1 of the EPL:

Equation 1

$$CE = ((E\ uncontrolled - E\ controlled) / E\ uncontrolled) \times 100$$

Sampling was completed 8 May 2013 at Duralie mine. The weather on the sampling day was fog in the morning and fine and sunny in the afternoon. Sampling was conducted once the morning fog had cleared. The rain gauge reported 0.2mm of rain between 7:45 – 8:00am on the sampling day. Conditions are deemed dry if there is less than 0.3 mm of rain in the 12 hours prior to sampling (**USEPA, 1974**).

In order to determine watering control efficiency at Duralie, a section of road was left uncontrolled for at least 12 hours prior to sampling. The section was located on the road toward the dump at the level of the 110 MRL dump (shown in grey on **Figure 2.2**.

Six sampling circuits of the site were completed consecutively as the day progressed. The time of the start of each run was as follows:

- Circuit 1 – 9:40 am
- Circuit 2 – 10:15 am
- Circuit 3 – 10:48 am
- Circuit 4 – 11:16 am
- Circuit 5 – 12:45 pm
- Circuit 6 – 1:31 pm

The site location and haul roads sampled are shown in **Figure 2.2**.

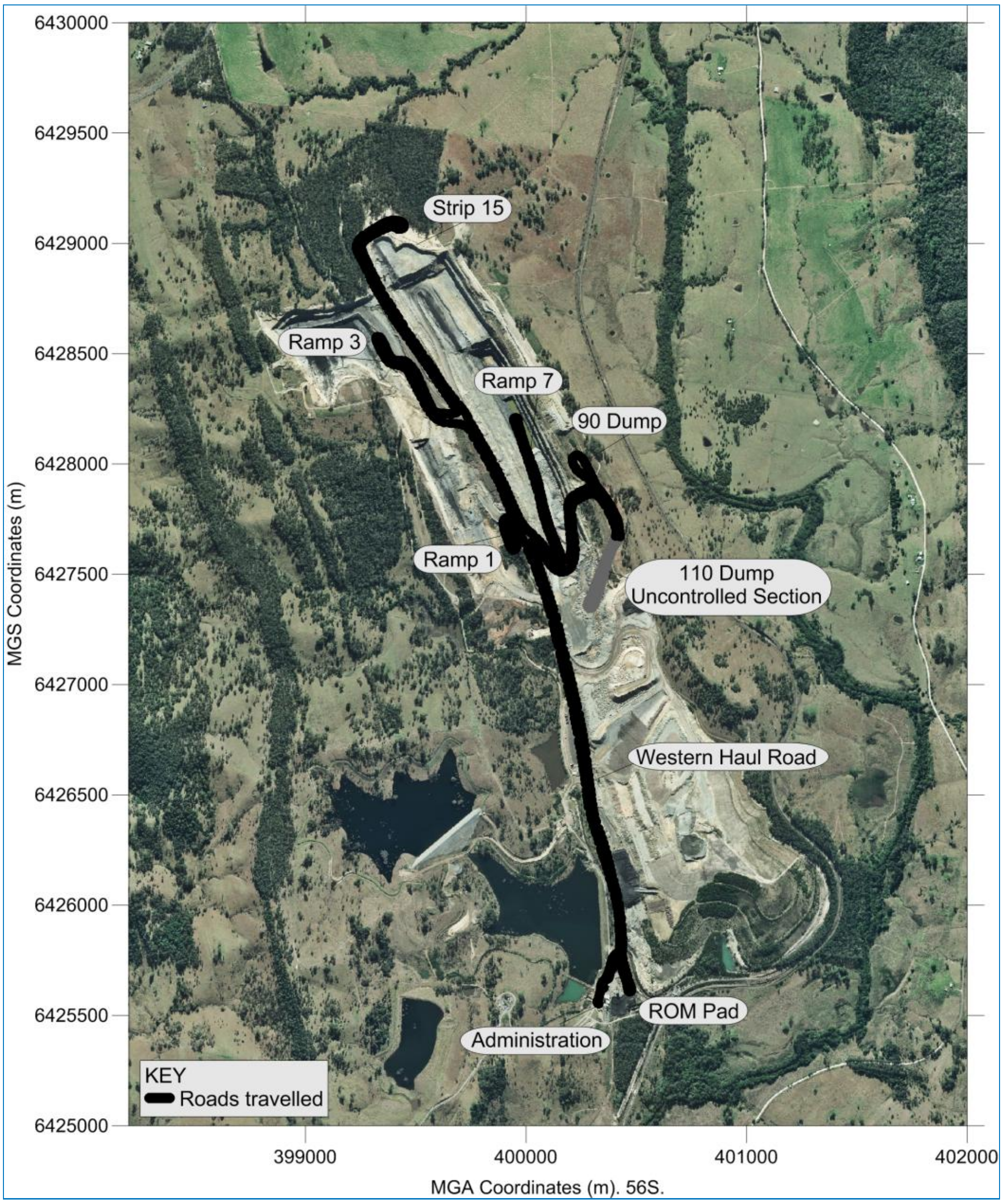

Figure 2.2: Map of haul roads sampled at Duralie Mine

Haul trucks used at the site are CAT 785. Haul roads are currently treated using water and there is excess water at the site. Two water carts are used on site (CAT 789). Generally one is always running but during dusty conditions two are used. The roads are graded and the majority of the roads are gravelled.

3 RESULTS

The average concentration measured during each circuit on controlled and uncontrolled sections is shown in **Figure 3.1**.

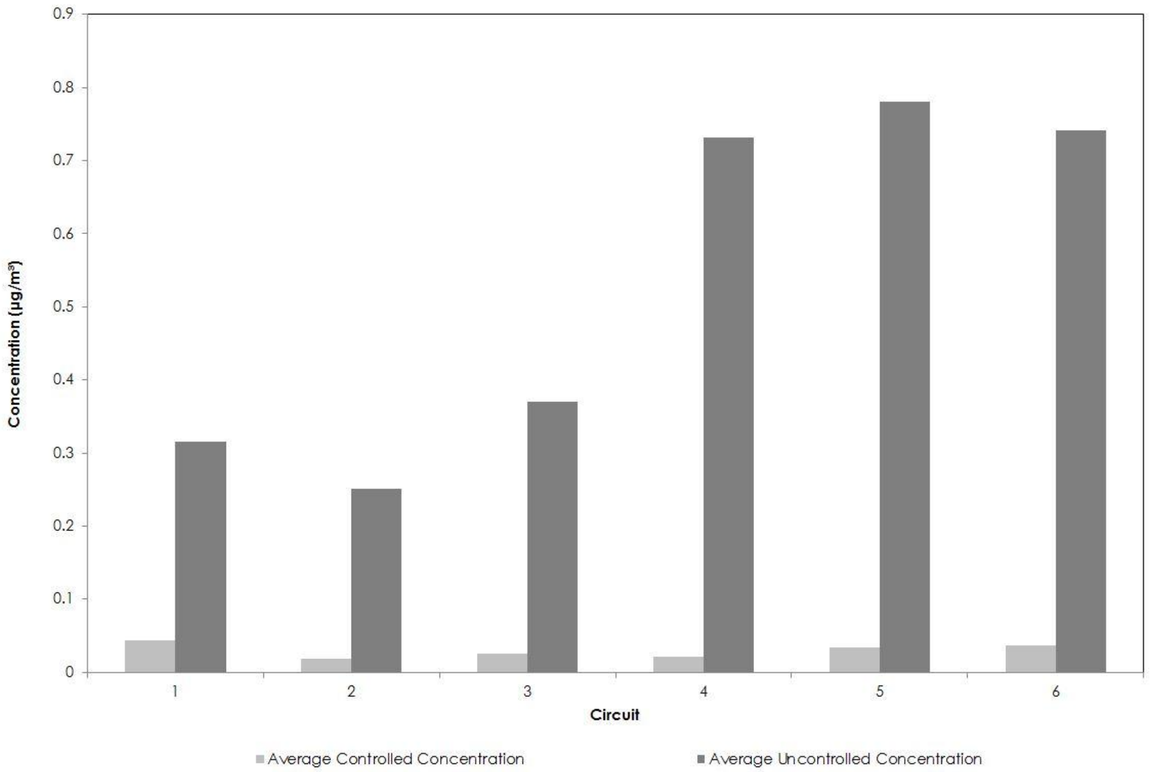

Figure 3.1: Average concentration measured during each run on controlled and uncontrolled sections

The circuits were completed consecutively as the day progressed and consequently the temperatures increased, creating conditions that are typically likely to have a greater dust generation potential. This is illustrated by the increase in concentration from the uncontrolled section. The uncontrolled section emissions were lower in the morning (0.31 mg/m³ circuit 1; 0.25 mg/m³ circuit 2; 0.37 mg/m³ circuit 3) and higher in the afternoon (0.73 mg/m³ circuit 4, 0.78 mg/m³ circuit 5, 0.74 mg/m³ circuit 6).

The uncontrolled concentration measured for each run is shown to increase with increased average temperature (**Figure 3.2**). This suggests that lower concentrations may be measured from the haul roads during the evening and night periods. In depth analysis into night time emissions is planned for the ACARP research project. The increase in uncontrolled concentration during the day may also be explained by the increased traffic as the day progressives, which would act to pulverise the surface of the road and generate more particles which would then be available for entrainment as wheel generated dust.

Increased emissions are also likely to be associated with increased traffic on the roadway throughout the day. The impact of this variable was not able to be correlated as in-depth traffic data was not available. This variable will be explored in greater detail in the ACARP project.

The overall site control efficiency during the sampling day was calculated as 94.9%. All circuits showed a total control efficiency of greater than 80% (**Figure 3.3**).

Dust particulates emitted from roadways have significant inherent variability due to changes in watering operations, operational conditions, meteorological conditions and silt loading on road surfaces. Mapping of the control efficiency achieved spatially across the site is shown in **Figure 3.4** to **Figure 3.9**.

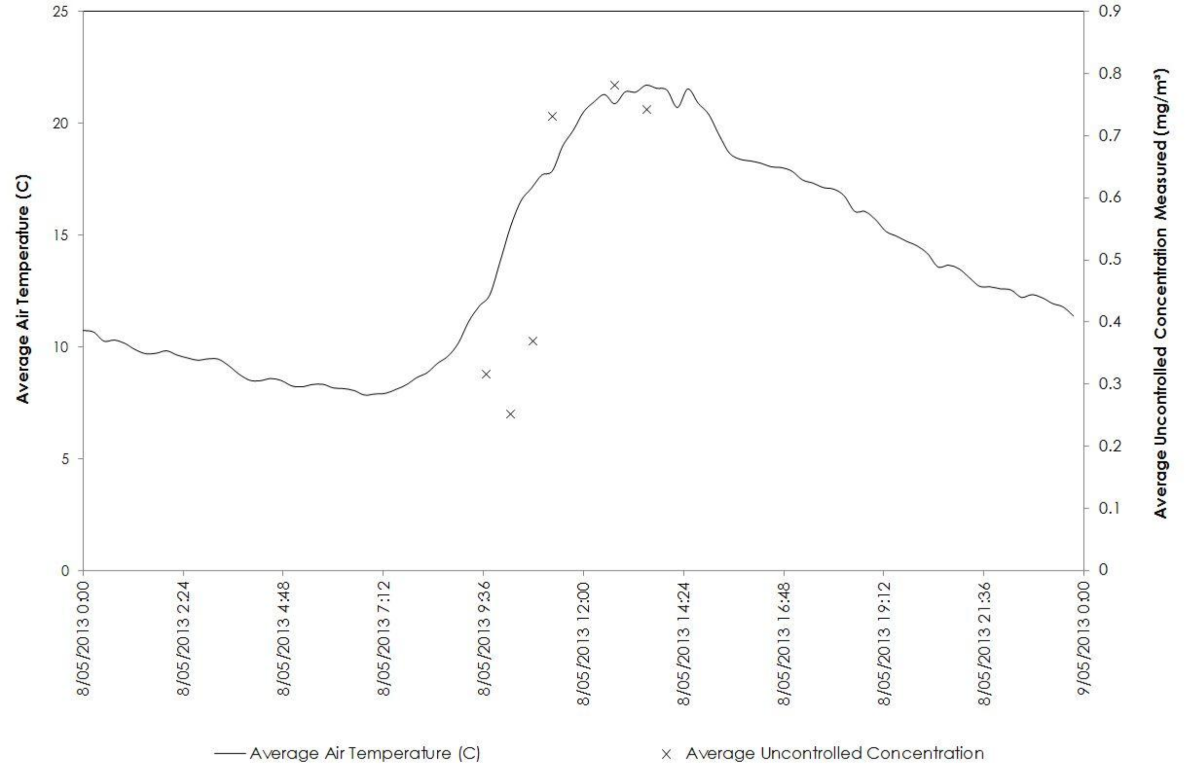

Figure 3.2: Average air temperature (°C) and average uncontrolled concentration measured (mg/m^3)

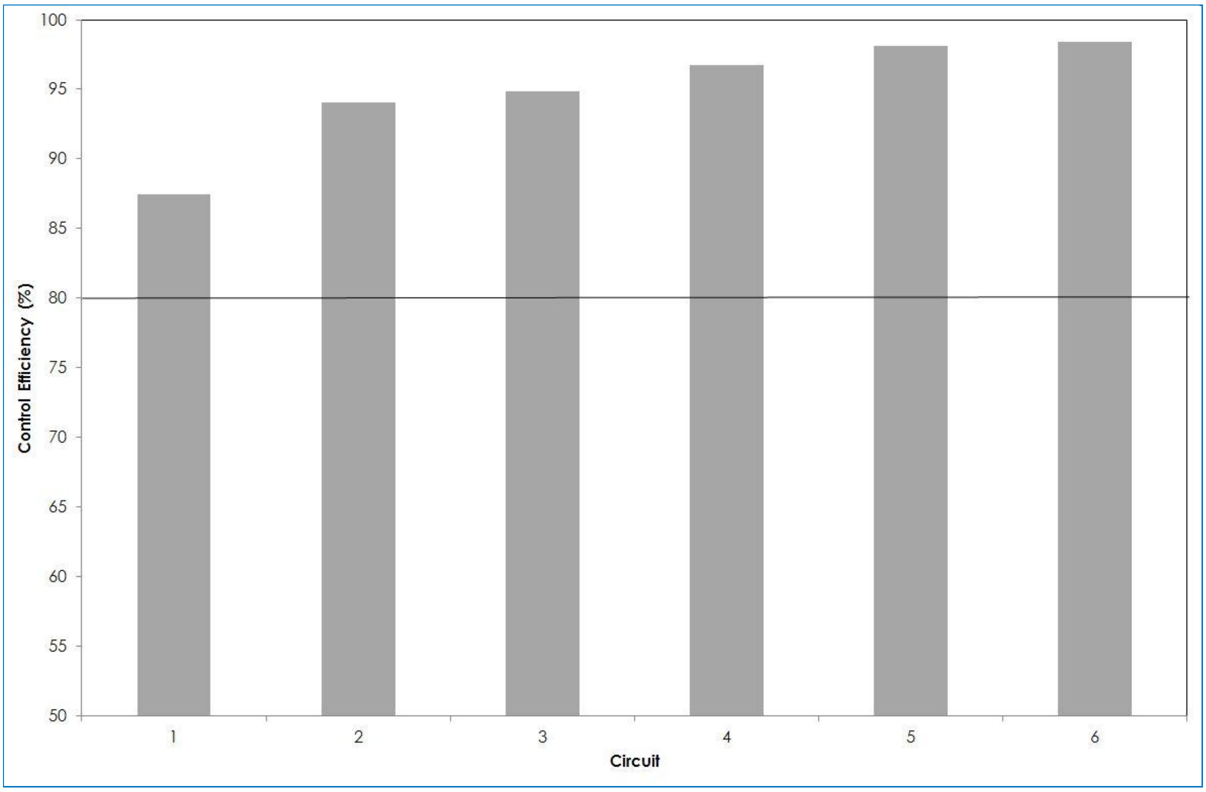

Figure 3.3: Average control efficiency of each circuit

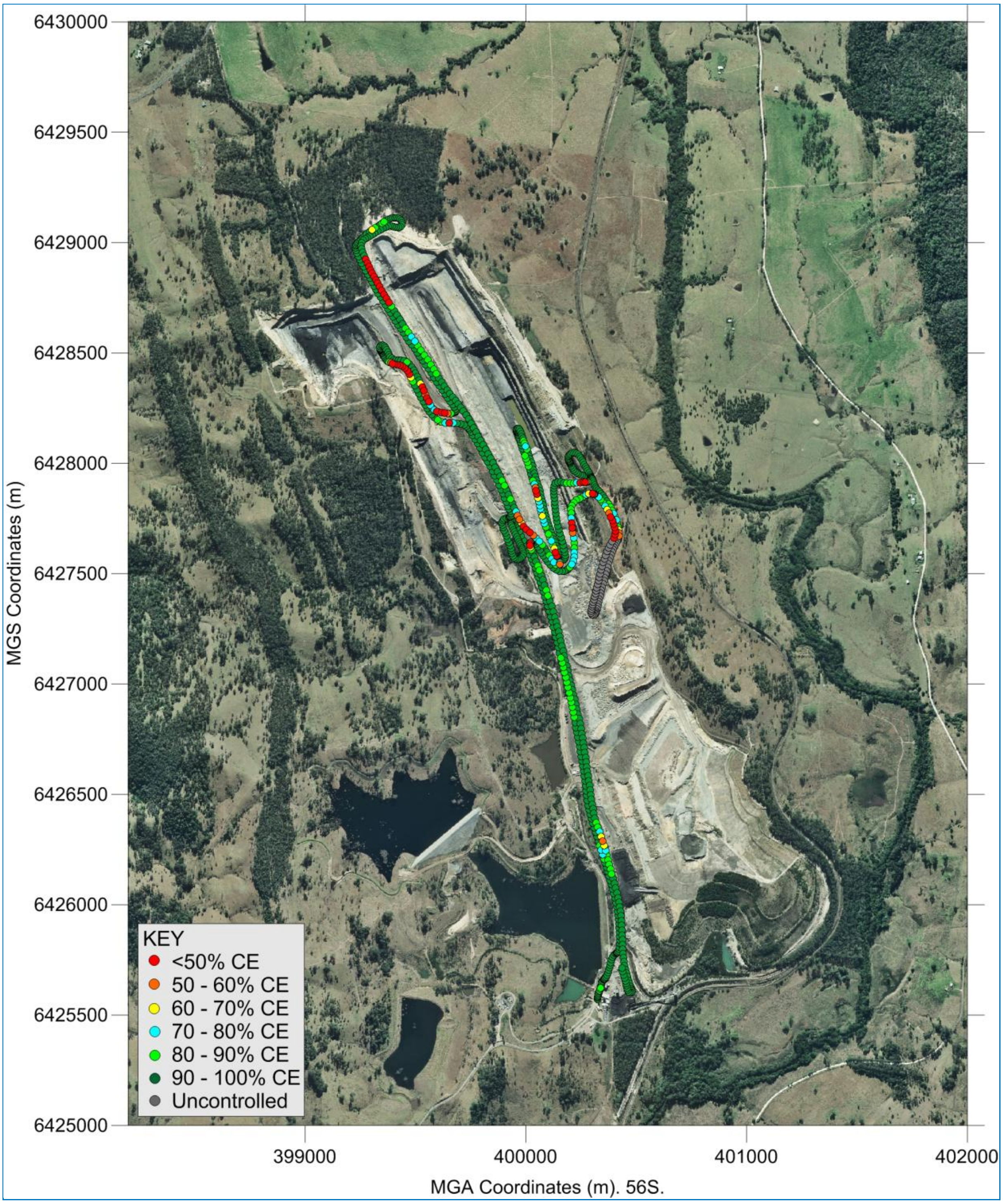

Figure 3.4: Control efficiency achieved during circuit 1

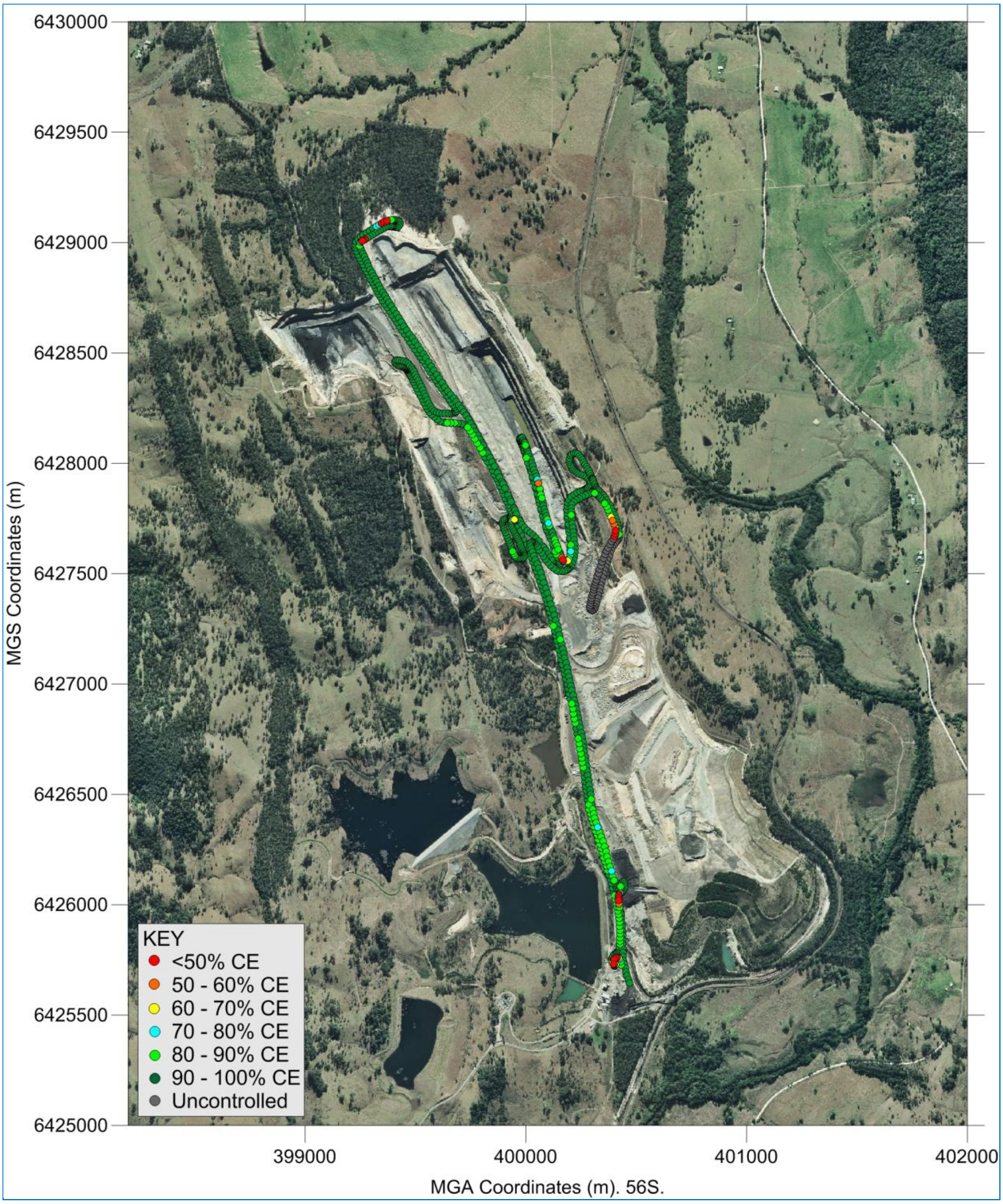

Figure 3.5: Control efficiency achieved during circuit 2

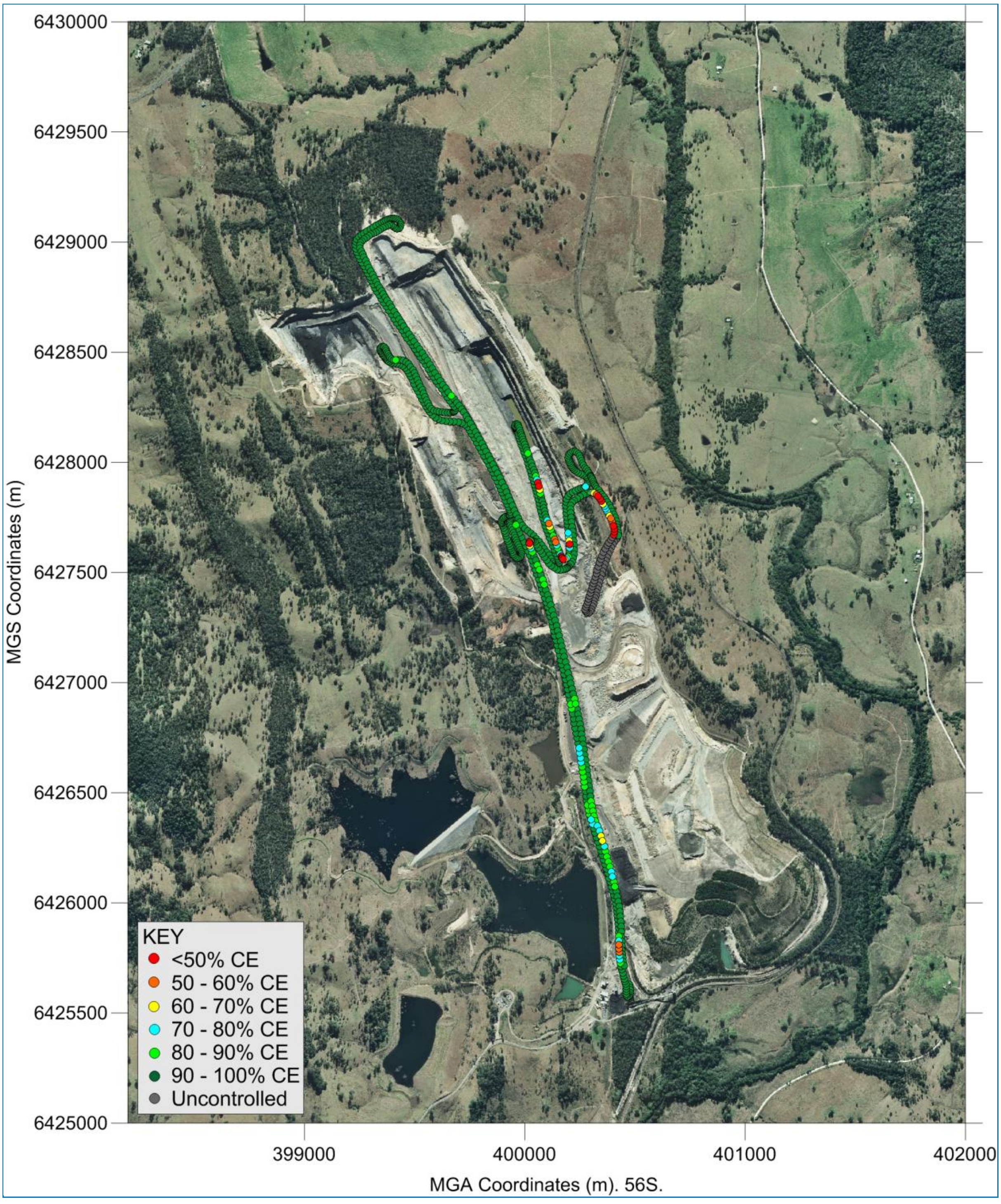

Figure 3.6: Control efficiency achieved during circuit 3

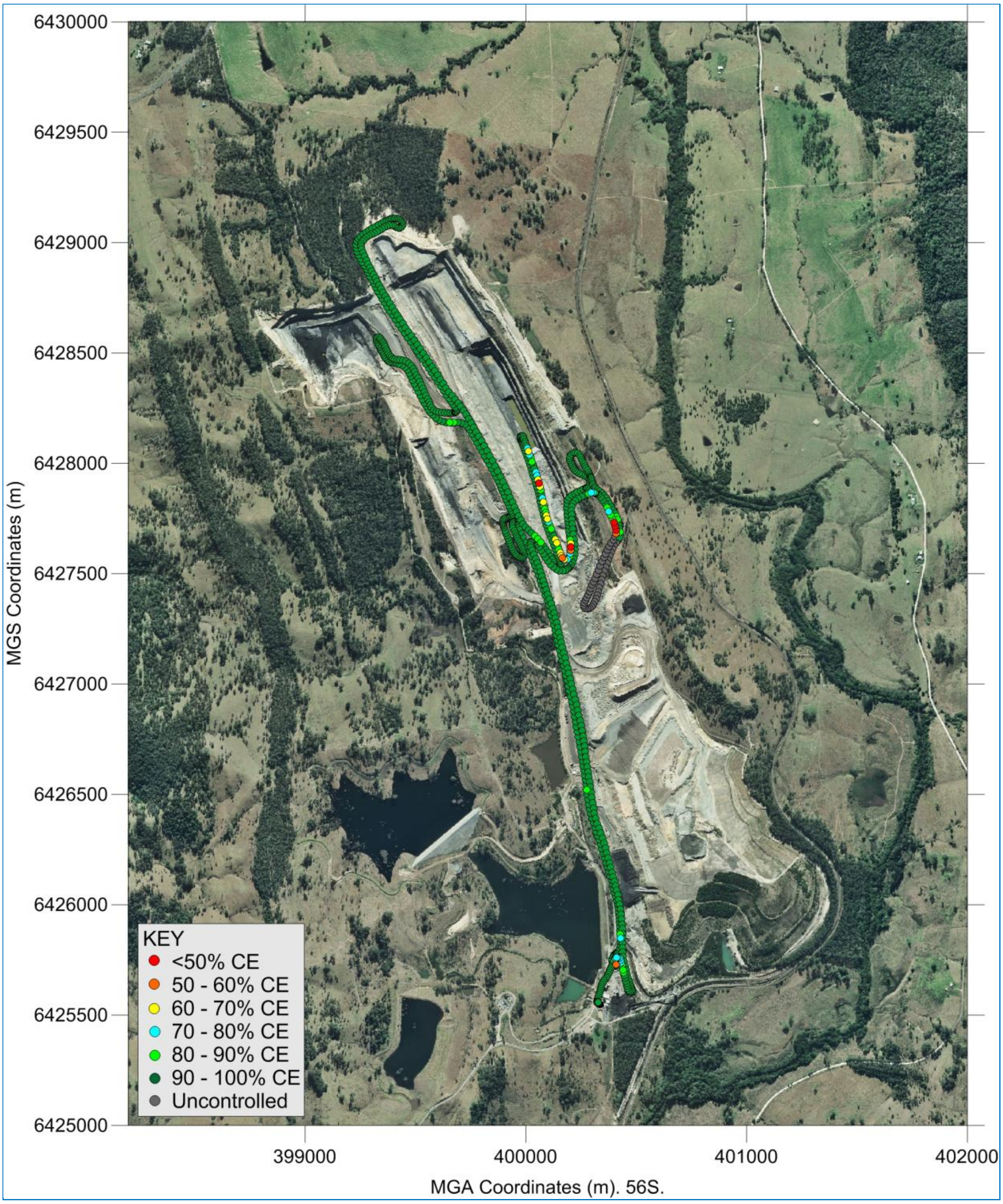

Figure 3.7: Control efficiency achieved during circuit 4

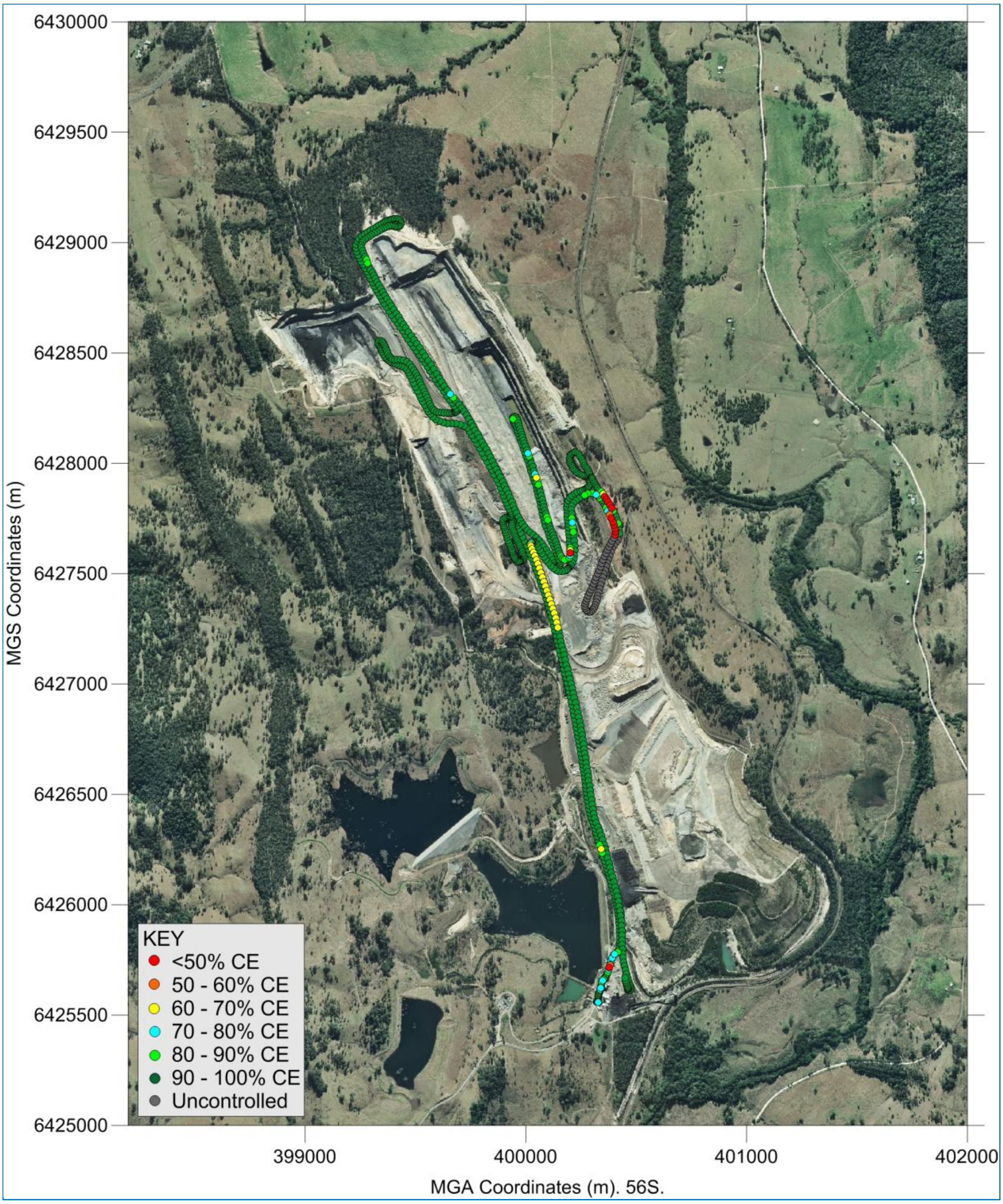

Figure 3.8: Control efficiency achieved during circuit 5

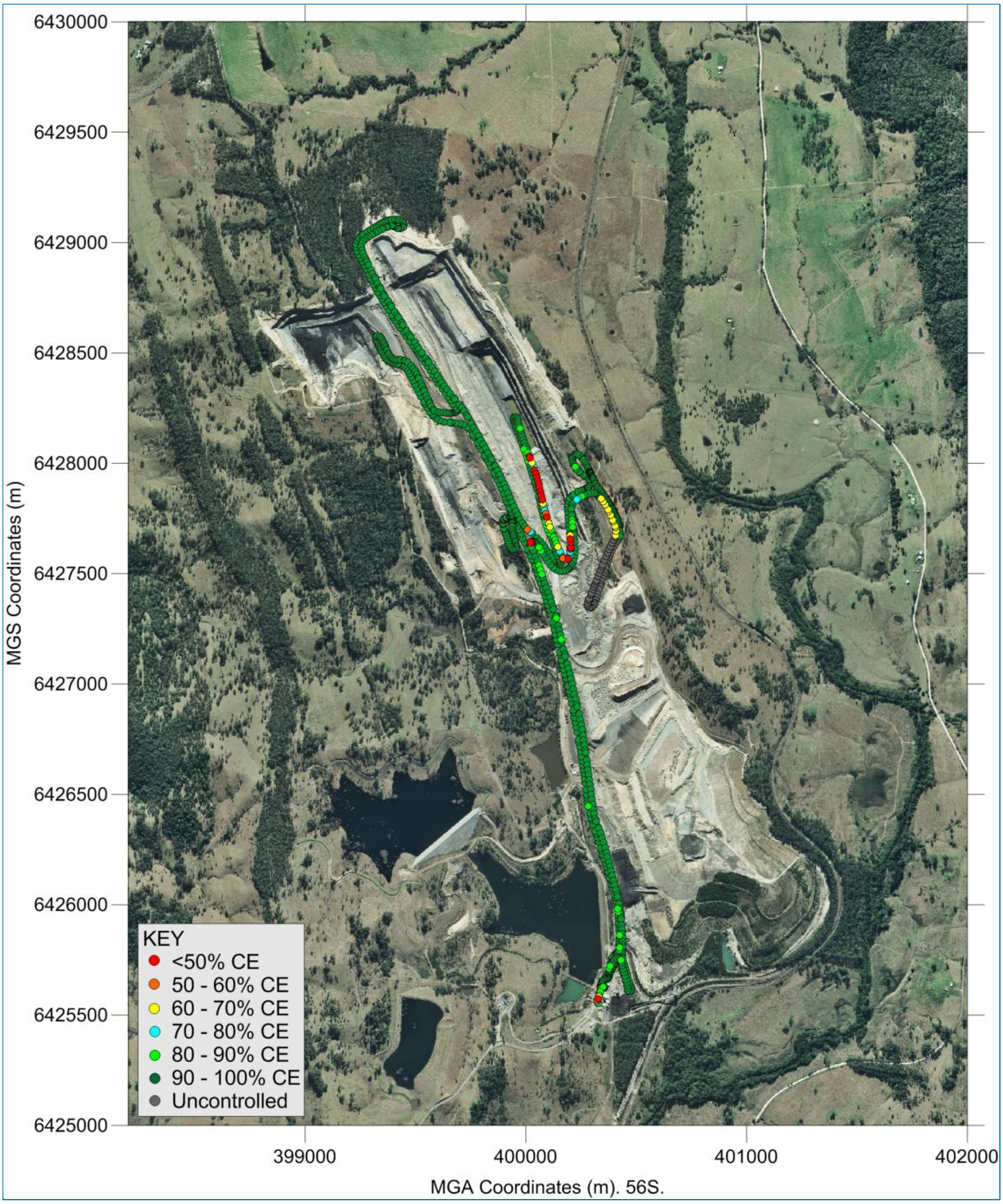

Figure 3.9: Control efficiency achieved during circuit 6

4 CONCLUSION

Haul road emissions are highly variable based on changes in ambient conditions and operating procedures. A mobile method for characterising these changes over changing conditions has been used at DCM during May 2013. The system can be used for rapid characterisation of a large number of roads and is a reasonably simple way to determine relative emissions. The methodology only samples active haul roads so assumes that there is little benefit in controlling sections of road from vehicle generated dust in areas that are not trafficked.

During normal management control of haul road dust during normal operating conditions at Duralie Mine was calculated to be 94.9%. The control efficiency varied across the day, where higher control efficiency was achieved during the afternoon (96.7%, 98.0% and 98.4% circuit 4 – 6 consecutively).

The uncontrolled concentrations measured at Duralie were shown to increase as the day progressed, which may be as a result of higher air temperatures (and therefore evaporation rate) but also due to the increased traffic which would act to pulverise the surface of the road and generate more particles which are then available for entrainment as wheel generated dust.

Overall the site was shown to be operating at a control efficiency of greater than 80% under normal operating conditions during this period. Further monitoring is required to determine the change in conditions due to seasonal and operational changes.

5 REFERENCES

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