Pinjarra Alumina Refinery Efficiency Upgrade

Alcoa World Alumina Australia

Air Quality Management Plan

December 2007

FOREWARD

This document has been prepared in accordance with Ministerial and Works Approval conditions granted for the Pinjarra Efficiency Upgrade Project, and is intended to reflect Alcoa's public commitment to transparency in its environmental management program. Public comments and submissions on its contents may be forwarded by mail to:

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This document is based on drafts prepared for Alcoa by consultants Environ with revisions to take into account feedback from stakeholders and independent expert review.

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EXECUTIVE SUMMARY

The purpose of this Air Quality Management Plan is to provide the framework for an effective programme of control and monitoring of emissions to air so as to ensure that air quality criteria are met to the satisfaction of all stakeholders, with particular reference to the additional pollution control equipment installed as part of the Pinjarra Efficiency Upgrade project.

The Plan meets the requirements of Condition 6 of Ministerial Statement No. 000646 of the Minister for the Environment of the Government of Western Australia, stated 3 March 2004, to provide a detailed plan for the monitoring of emissions from point sources and areas sources, and for assessing impacts on ambient air quality in the surrounding region.

The Plan also addresses the requirements of Condition A13 of Works Approval Number 3927 (and 4391 revised October 2007), by outlining how Alcoa will demonstrate compliance against the air-emissions discharge performance requirements outlined in the Works Approval and in Schedule 2 of Ministerial Statement No. 000646.

The Plan has been developed by Alcoa with the assistance of expert consultants and in consultation with a comprehensive range of stakeholders through the Stakeholder Reference Group which was formed to undertake consultation on a range of issues related to the Efficiency Upgrade project, and addressing matters raised in the project peer review process.

1 INTRODUCTION

1.1 BACKGROUND

The Pinjarra Refinery is located within the Shire of Murray in the Peel region south of Perth, Western Australia and approximately 6 km east of the Pinjarra town site within industrial-zoned land owned by Alcoa. The refinery is sited at the foot of the Darling Scarp and incorporates the refinery footprint, the residue drying areas (RDAs) and surrounding cattle grazing areas encompassing an area of 6,086 ha of freehold property. Bauxite is supplied to the refinery from the Huntly Mine, situated in state forest east of the refinery.

Prior to the Efficiency Upgrade, the refinery had a production capacity of approximately 3.5 million tonnes per annum of alumina. As with the majority of other alumina refineries throughout the world, the Bayer process is used. Commencing in late 2004, the efficiency of the refinery was upgraded to increase alumina production capacity to 4.2 million tonnes per annum. This is known as the Pinjarra Efficiency Upgrade (the Efficiency Upgrade, or PEU) project. The production increase was achieved primarily by improving the efficiency of the refinery by increasing the alumina yield from the Bayer liquor circuit through improvements in the precipitation process.

1.2 EMISSIONS TO AIR

The main sources of gaseous emissions to air are combustion processes, in particular the power station, calciners and the oxalate kiln. These all produce CO, CO_2, NO_x, and some Volatile Organic Compounds (VOCs), as well as water vapour. The calciners and kiln also have the potential to emit dust.

VOCs are also produced in the Bayer process itself, in which bauxite is reacted with caustic soda to liberate the alumina. In this process, a proportion of the organic compounds in the bauxite react to form compounds which may be emitted to air from various points in the refinery as VOCs. VOCs may also be produced from reagents added to the process as flocculants and dewatering aids.

Emissions from the refinery may occur from localised points (“point sources”) and from open areas of liquids or solids (“area sources”). Area sources include the Residue Disposal Area (RDA) and associated process liquor and water storages, which are potential sources of VOCs and dust, the bauxite stockpiles and transport systems which are potential sources of bauxite dust, and the alumina transport system which is a potential source of alumina dust.

Emissions of gases and dusts have the potential to affect the air quality in the surrounding region. Effective control and monitoring are essential to ensure that perceptible odour and dust events are minimised, and that no substances are present at levels that could be of concern to human or environmental health.

1.3 PURPOSE AND SCOPE OF PLAN (Works Approval Condition A13 (iii))

The purpose of this Air Quality Management Plan is to provide the framework for an effective programme of control and monitoring of emissions to air so as to ensure that air quality criteria are met to the satisfaction of all stakeholders.

In particular, the Plan addresses the requirements of the PEU Works Approval[1] Condition A13, which requires Alcoa to provide a report that outlines how it will demonstrate compliance against the air-emissions discharge performance requirements outlined in conditions A2, A3(a), A4, A6, A7 and A8(b) of the Works Approval, and Schedule 2 of Ministerial Statement 000646[2]. Works Approval Condition A13 also states that:

"The report shall include but not be limited to:

- *(i) identification of baseline mass emissions (all sources to be listed individually) for VOCs, particulate matter, CO, NO_x, and heavy metals,*
- *(ii) a plan for comparison of the performance of the refinery after the Upgrade is completed with the base case referred to in the Environmental Protection Statement, December 2003,*
- *(iii) the Air Quality Management Plan required under Ministerial Statement 646, under Part IV of the Environmental Protection Act 1986,*
- *(iv) source monitoring program proposed to measure performance of new pollution control equipment comprising Digestion RTO, Oxalate Kiln RTO and Calciner #7 Stack, and*
- *(v) identification and locations of sampling ports used to compile the baseline data and for ongoing monitoring."*

Section A13 (iii) of Works Approval A13 (above) refers to Section 6 of Ministerial Statement No. 000646[2], which requires Alcoa to provide a Plan to address the following:

"Point source emissions

- *1 details of air pollution control equipment;*
- *2 a description of air pollution control equipment emission monitoring to be undertaken during the construction, commissioning, and operation of the plant, including, where practicable and appropriate, continuous monitoring;*
- *3 a list of chemical species to be monitored with particular focus on NO_x, arsenic and mercury;*
- *4 monitoring locations, sampling frequency, sampling methods, analytical test methods, and quality assurance/quality control procedures;*

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[1] Works Approval Number 4391/2007/1, Department of Environment and Conservation, Western Australia, re-issued 25 October 2007; Original Works Approval Number 3927 issued 14 April 2004
[2] Ministerial Statement 000646, Government of Western Australia Minister for the Environment, 3 March 2004

5 a contingency plan for unplanned and planned shut-down of the pollution control equipment;

Area source emissions

6 details of methods, quality assurance/quality control procedures and sampling frequency for monitoring particulate emissions (including ultrafine particles), metals emissions from the Residue Disposal Area and stockpile area as recommended in the expert peer review of the Air Quality and Air Dispersion Modelling reports. This work shall also include and assessment of cumulative particulate emissions taking into account background levels from other refinery sources.

Ambient air quality

7 details of sampling locations, methods (including continuous monitoring or campaign monitoring using continuous techniques) and quality assurance/quality control procedures; and

8 receptor locations with a particular focus on locations to the north of the refinery identified within the Health Risk Assessment (HRA) as having the highest potential risk."

See Appendix A for a complete list of the Works Approval and Ministerial Conditions of relevance to this Plan.

1.4 DEVELOPMENT OF THE PLAN

The Plan has been developed by Alcoa and its expert consultants, with input from stakeholder consultation and specific comments from DEC, DoH, and the independent expert review by J Chiodo[3] (Appendix C). Feedback from these groups and reviews has been incorporated into this Plan where appropriate. For details see Section 7 of this Plan.

[3] Project Review, Pinjarra Alumina Refinery Efficiency Upgrade, CH Environmental, 28 December 2006 (Appendix C of this Plan)

2 POINT SOURCE EMISSIONS

2.1 BASELINE EMISSIONS (Works Approval Condition A13 (i) and (v))

During the feasibility and planning phase of the Efficiency Upgrade, an inventory of refinery emissions was developed and published in the Air Quality Data Environmental Protection Statement[2]. A Baseline scenario was developed for the refinery, representing emissions from the Pinjarra refinery prior to the Efficiency Upgrade for the 2002-2003 year. The baseline point source mass emissions for VOCs, particulate matter, CO, NO_x and heavy metals have been identified and are described in detail in the PEU Environmental Protection Statement[4] (EPS). The EPS also describes the nature and significance of each of the sources or groups of sources, and provides an assessment of the emission rates on an annual average basis and a maximum (peak) emissions basis. The average case Baseline is provided for reference in this Plan as Appendix D. Appendix D also includes information on the identification and location of sampling ports used to compile the Baseline data as required by Works Approval Condition A13(v).

The point sources identified for the installation of additional pollution control equipment in the Efficiency Upgrade were chosen on the basis of their contributions to the overall masses of key substances emitted prior to the Efficiency Upgrade, in order that the control equipment would have the maximum benefit to emissions reduction overall. These are therefore also the sources that are the focus of the point source emissions monitoring programme.

The key emission sources chosen on this basis are summarised in Table 1 below. The Table shows the main point source emission sources for the priority pollutants identified in the EPS. The overall point source emission rate (in grams per second) is given, along with the percentage accounted for by each of the priority point sources. All of the data in Table 1 are derived from the original Base Case emissions as presented in the Air Quality Data EPS[5] (also see Appendix D of this Plan), and refer to point sources only.

[4] Environmental Protection Statement, Alcoa Pinjarra Efficiency Upgrade, ENVIRON, December 2003

Table 1: Base Case Data - Refinery Point Source Emissions Summary as Estimated Prior to Efficiency Upgrade

	% Contribution						
Emission Source	Dust	VOC	CO	NO_x	SO_2	Mercury	Arsenic
Oxalate Kiln	4	3	5	<1	1	44	97
Calciners	79	29	88	28	78	22	<1
ALD	17	4	<1	4	2	<1	<1
Boilers	<1	3	6	68	19	<1	3
Cooling Towers	<1	29	<1	<1	<1	2	<1
Other Sources	<1	32	1	<1	<1	32	1
TOTAL (%)	100	100	100	100	100	100	100
Total emission (g/s)	6.1	5.6	26	35	2.7	0.0036	0.0033

Note: These figures include only point sources from the refinery; they exclude emissions from the proposed gas turbines at the Pinjarra Alinta Cogeneration plant, and area sources, including the Cooling Lake.

Of the sources listed, all but ALD (the Alumina Leach-Dry process), have been identified for the installation of additional pollution control equipment with the Efficiency Upgrade. It was anticipated that the product quality improvements expected following the installation of the new seed filtration building may be sufficient to allow ALD to be shut down.

The sources grouped as "Other Sources" are:

1. The discharge vapours from the Vacuum Pumps in Digestion and Buildings 30E, 35J, 40 and 42, and the vapours from all eight Slurry Storage (Building 25A) tanks, and
2. The Condensate Droppers in the Building 25A&C Vapour lines, Excess Blowoff Vapour, Sand Rake Classifier Stacks (Building 34), Vents in Buildings 35A, F&D, Washer Area Vents (Building35C), Miscellaneous Vents in the Clarification area (Operating Centre 2), Seed Filtration (Building 44), Calciner Vacuum Pumps, ALD Vacuum Pump, ALD Cooling Tower

These two groups each account for approximately half of the Other Sources emissions. The first group was chosen for routing to the Digestion RTO on the basis of engineering feasibility and positive workplace impact. Accordingly, the Digestion RTO is expected to reduce the emissions from the Other Sources by approximately half, accounting for about 15% of the overall Base Case VOC emissions.

It should be noted that the figures given in Table 1 are based on the Baseline emissions as defined during the planning stages of the Efficiency Upgrade. Subsequent and ongoing investigations are providing additional information which is leading to improved understanding of the refinery emissions profile, and the Baseline will be updated once the investigations have been completed and reviewed. Preliminary indications are that the Baseline rate of VOC emissions from the Cooling

Towers is significantly less than previously thought, which has lowered the overall VOC emissions from the refinery as well as the percentage contribution of the Cooling Towers. The Baseline values will be updated accordingly in due course, and any implications for the emissions will be incorporated into future plans for emissions reduction and monitoring.

A summary of the point source monitoring program during the different phases of the commissioning and initial operation of the new and upgraded equipment is given in Appendix B. Further information on the monitoring regime for each point source is found in Section 2.

2.2 PERFORMANCE COMPARISON PLAN (Works Approval Condition A13 (ii))

The comparison of the performance of the refinery after completion of the Efficiency Upgrade will be based on the results of the Point Source Monitoring Program (Appendix B). The monitoring program specifically outlines what substances are being sampled, the frequency of sampling and the methodology used. To enable accurate assessment of the influence of the Efficiency Upgrade on the emissions, additional monitoring is carried out during the commissioning and initial periods of operation of all new equipment. Reference is made in this document to 'Commissioning', 'Performance Verification', 'Interim' and 'Ongoing' checks and monitoring, as follows:

- ***Commissioning checks*** – functional testing and calibration of emissions control and continuous monitoring equipment prior to commissioning of the related process equipment.
- ***Performance Verification monitoring* -** intensive investigation of emissions following Efficiency Upgrade commissioning, to determine the nature and extent of emissions generated during normal operation, and in particular to assess the performance of new emissions control equipment.
- ***Interim monitoring*** – additional monitoring during the first 12 months following commissioning of facilities to provide information on the long term variability of the emissions as a function of operating parameters, and to confirm the performance of new emissions control equipment.
- ***Ongoing monitoring*** – routine monitoring during normal operating conditions to confirm the ongoing performance of all equipment, and ensure that emissions remain within specified levels.

In designing the monitoring program, consideration was also given to the contribution that each source makes to the total emission for each type of substance. The choice of priority point sources for monitoring was based on extensive analysis of the main emission points for the variety of emitted substances as described in the Air Quality Data Environmental Protection Statement (Air Quality Data EPS)[5].

3 MAJOR POINT SOURCES AND SOURCE MONITORING (Works Approval Condition A13(iv))

There are five major point source groups within the upgraded Pinjarra Refinery, as follows:

[5] Pinjarra Refinery Efficiency Upgrade: Air Quality Data Environmental Protection Statement, ENVIRON Australia Pty Ltd, 28 October 2003

- Oxalate Kiln Stack;
- Digestion RTO Stack;
- Calciner Stacks (1 – 7);
- Boilers Stacks (2 – 7); and
- 45 T Cooling Tower.

The details of the control and monitoring of each of these are given in the following sections.

3.1 OXALATE KILN STACK (Works Approval Conditions A3, A4)

3.1.1 Description

Sodium oxalate is a by-product of the bauxite refining process that is removed from the production stream and converted to sodium carbonate in a rotary kiln. The combustion process results in the production of CO and a range of VOCs as products of incomplete combustion, and fine particulates that report to the exhaust gases. In the original design, the exhaust gases from the kiln passed through a wet scrubber to remove particulates prior to discharge to the atmosphere via a stack.

The Efficiency Upgrade includes an increase in the capacity of the oxalate kiln, and the installation of improved emissions reduction equipment, specifically a more efficient wet scrubber and a Regenerative Thermal Oxidiser (RTO). In the upgraded scrubber, the original venturi scrubber is replaced by two combination high pressure venturi scrubbers to clean and cool the gas stream before it goes to the RTO. This increases the scrubbing efficiency substantially, reducing the dust concentration in the stack emissions from approximately 80 mg/m^3 to less than 10 mg/m^3.

The RTO heats the scrubbed exhaust gases to 850^{o}C, at which temperature over 90% of the VOC and CO are converted to CO_2 and water. The temperature is as specified by the manufacturer, HPS-Enerflex, who designed the RTO specifically for this purpose on the basis of the specified gas compositions and flows and the required destruction efficiency. The RTO consists of beds filled with inert ceramic material to provide the heat transfer required. The beds are swapped between hot and cold duty on a 2 to 5 minute cycle to maximise destruction efficiency and heat recovery. The existing kiln stack Number 2 has been retained, but the exhaust gas is hotter and has lower moisture content than before the upgrade, and the kiln stack discharge nozzle was also modified to improve dispersion. This has eliminated the visible plume and improved the dispersion characteristics of the exhaust.

Since the efficiency of the RTO is intrinsically linked to the temperature at which it operates, continuous temperature monitors are installed. Continuous CO monitors are also installed at the inlet and outlet of the RTO to enable direct measurement of overall destruction efficiency. CO has a higher ignition temperature than the VOCs, so the VOCs react at lower temperatures than CO in the RTO. This means that the CO destruction efficiency provides an indication of the minimum VOC destruction that is occurring (ie the actual VOC destruction efficiency can be expected to be always greater than the measured CO destruction efficiency).

The design of the RTO specifies continuous operation capability. To ensure efficient and reliable operation, the design allows for up to fifteen days per year for inspection, planned maintenance and overhaul. RTO maintenance will be planned to coincide with kiln shutdowns, to maximise the overall effectiveness of the system in relation to both oxalate destruction and emissions minimisation. Other minor or breakdown maintenance will be scheduled as part of the Equipment Management Strategy as required to maintain efficient operation.

3.1.2 Nature of Emissions

Table 1 shows that the pre-Efficiency Upgrade oxalate kiln stack was a relatively minor source of Dust, VOCs and CO, and a negligible source of NO_x and SO_2. Nevertheless, it had a significant intermittent localised impact in the workplace in relation to odour (caused by VOCs), CO and dust. The high efficiency scrubber and RTO are designed to reduce all of these emissions substantially, and in particular achieve the Works Approval[1] and Ministerial Statement 646[2] commitments of at least 90% reduction in CO and VOC emissions, and a particulate emissions concentration of not greater than 20 mg/m^3. The dust emitted from the oxalate kiln also contains metal oxides as a result of oxidation of trace metals in the liquor and oxalate burnt in the kiln, so that the pre-Efficiency Upgrade oxalate stack was the main source of emission of As to air (See Table 1) from the refinery. The high efficiency scrubber is expected to reduce these emissions substantially as a result of reducing dust emissions overall. Mercury is emitted from the kiln as the gaseous metal, so it is uncertain to what extent the improved scrubbing may reduce mercury stack emissions.

3.1.3 Monitoring Program

The key parameters to be monitored for effective operation of the RTO are operating temperature and CO destruction efficiency. The temperature of the RTO is the main parameter that determines the effectiveness of operation and CO destruction is an indicator of the actual destruction achieved for VOCs as well as CO itself. Both temperature and CO are monitored continuously (except during instrument down time). The VOC and CO destruction efficiencies will be measured by analysing the inlet and outlet of the RTO for VOCs and CO.

Commissioning checks

During commissioning of the oxalate kiln and RTO, the temperature control and CO monitoring systems will be tested to confirm correct functioning, and calibrated to ensure accurate measurements.

Performance Verification Monitoring

The targets for emission reduction capabilities of the wet scrubbers and RTO have been set by the Schedule 2 commitments included in the Ministerial Statement 000646, and the Efficiency Upgrade Works Approval, as follows:

- 90% VOC removal by the oxalate kiln RTO (Works Approval Condition A4);
- 90% CO removal by the oxalate kiln RTO (Ministerial Condition, Schedule 2);
- Particulate matter concentration from the oxalate kiln RTO stack not to exceed 20 mg/m^3 (Works Approval Condition A3(a)); and
- Particulate matter mass emissions equivalent to 0.55 g/s and concentration not to exceed 20mg/m^3 from the oxalate kiln RTO stack (Works Approval Condition A3);
- A reduction of approximately 10% in VOC emissions *(refinery overall)* (Ministerial Condition 000646, Schedule 2)

Performance Verification Monitoring during operation of the upgraded oxalate kiln will be carried out during the first four months of operation to assess performance of the emissions control equipment in relation to the removal of CO, VOCs and particulates according to the schedule given in Appendix B.

The design capability for each of the two wet scrubbers to be operated in isolation of the other when the kiln is in operation will be confirmed (Works Approval Condition A3(a)).

Interim Monitoring

Additional monitoring may be carried out during the first twelve months of operation if required to provide additional information to confirm the performance of the equipment, the variability of the results, or for trouble-shooting purposes.

Ongoing Monitoring

Ongoing monitoring will be carried out as follows (Appendix B):

- Continuous monitoring of RTO temperature and CO input and output concentrations;
- Six monthly monitoring of particulates as required under the existing premises licence.

3.1.4 Failure Response and Contingency Plan

Key Control Parameters:

- The key control parameter to ensure the effective operation to the RTO is RTO temperature. The RTO is operated at the design temperature of 850°C (with a minimum of 800°C) specified by the manufacturer to meet the design of >90% VOC destruction. The CO stack monitor provides a direct indication of destruction performance on a continuous basis. In the event of the RTO temperature dropping below 800°C, priority is given to restoration of the correct operating temperature. If the temperature remains below 800°C, feed will be taken off the kiln within a period of time to allow for trouble shooting until the RTO temperature is restored.
- The key control parameters for the wet scrubber are water flow and pressure drop. If these are outside normal operating ranges for a sustained period an investigation is initiated and corrective actions are taken.

Maintenance and Equipment Failure:

- The RTO design allows for up to 15 days per year for inspection, planned maintenance and overhauls to ensure its continuing reliability and effectiveness. Inspection, planned maintenance and overhauls will be managed within the Alcoa Equipment Management System to ensure the continuing reliability and effectiveness of the equipment.
- Planned shutdowns of the RTO will be scheduled to coincide with Kiln shutdowns so that there is no effect on emissions. Unplanned shutdowns, eg as a result of equipment failure, will be managed to minimise emissions (see Table 2 for details). In the event of an unplanned shutdown of the RTO, or if the RTO bed temperature is less than 800°C, oxalate feed will be taken off the kiln within a period of time to allow for trouble shooting until normal RTO operation is restored.

3.1.5 Management Plan Summary

The key actions required for management of the emissions from the Oxalate Kiln Stack are summarised in Table 2.

Table 2: Action Plan for the Oxalate Kiln Stack

Aspect	Action	Timing
Operation	RTO temperature continuously recorded, with allowance for instrument down time; the kiln is operated at a target temperature of 850°C with a minimum of 800 °C	From commissioning onwards
Operation	The CO concentration continuously monitored at points before and after the RTO; procedures are in place to manage emissions and ensure timely repair in the event of failure of the continuous monitor	From commissioning onwards
Maintenance	The RTO will be shut down for up to 15 days per year for planned inspection, maintenance and overhaul to ensure effective operation	To coincide with oxalate kiln shutdown
Maintenance	Equipment Management Plan in the Alcoa Equipment Management System to manage equipment reliability and planned shutdowns, and to minimise unplanned shutdowns	Within 12 months of Efficiency Upgrade commissioning
Monitoring	Oxalate Kiln stack exit gases monitored according to the Point Source Monitoring Schedule (Appendix B)	Refer to Appendix 3
Reporting	Performance Verification Report including evaluation of the performance of the pollution control equipment	Within 12 months of Efficiency Upgrade commissioning
Reporting	Particulate emission monitoring results reported to the Department of Environment according to licence requirements	Annual
Reporting	Reporting of other key performance data, for example CO destruction efficiency and Reliability, to be determined in consultation with the Department of Environment	Within 12 months of Efficiency Upgrade commissioning
Contingency	Operating procedures in the Alcoa Performance Support System to ensure that the equipment is operated so as to meet the emission control intent and to minimise emissions in the event of planned or unplanned shutdown of the equipment	Within 12 months of Efficiency Upgrade commissioning
Contingency	In the event of an unplanned shutdown of the RTO, or if the bed temperature is less than 800°C, feed will be taken off the kiln within a period of time to allow for trouble shooting until normal RTO operation is restored	Within 12 months of Efficiency Upgrade commissioning
Contingency	Each wet scrubber can be operated in isolation of the other. The kiln will not be operated without at least one wet scrubber in operation.	From commissioning onwards

3.2 DIGESTION RTO STACK (Works Approval Condition A2)

3.2.1 Description

In Digestion, bauxite is treated with caustic liquor under pressure to extract the alumina. In that process, a proportion of the organic material contained in the bauxite also reacts with the caustic liquor. One of the consequences of this is the formation of a range of VOC species. A proportion of these VOCs are susceptible to release with steam emissions at various points within the plant liquor circuit, along with VOCs produced from chemicals added to the liquor for such purposes as improving mud settling and filtration. The original Pinjarra Refinery was designed with multiple exit points for these steam emissions and their associated VOCs. Each of these individual emission points was a relatively minor source of emissions to air, however collectively they accounted for approximately one third of the total point source VOC emissions for the refinery (Table 1).

As part of the Efficiency Upgrade, a number of key emission points in the refinery will be collected together and fed to an RTO located in the Digestion area ("Digestion RTO") for VOC destruction. The sources combined together are:

- 25A – Slurry storage tank vents;
- 25V – Digestion vacuum pump exhaust;
- 30E – Liquor to mills evaporator vacuum pump exhaust;
- 35J – Causticiser heating vacuum pump exhaust;
- 40 – Heat interchange vacuum pump exhaust; and
- 42 – Evaporation vacuum pump exhaust.

Together these sources account for approximately 15% of the VOC emissions from point sources in the refinery. The RTO is of a similar design to the RTO installed on the Oxalate Kiln, except that it has been designed to operate at a higher temperature (1000°C) because of the higher proportion of the more stable VOCs expected to be present. It was supplied by the same manufacturer (HPS-Enerflex).

As with the Oxalate RTO, the key operating parameter for ensuring VOC destruction is the RTO temperature, which is monitored continuously. The sources directed to the Digestion RTO do not contain significant CO, so CO monitors are not installed as they would not give a useful indication of overall destruction efficiency.

The design of the RTO specifies continuous operation capability. To ensure efficient and reliable operation, up to fifteen days per year are required for inspection, planned maintenance and overhaul. Other minor or breakdown maintenance will be scheduled as required as part of the Equipment Management Strategy to maintain efficient operation. Unlike the oxalate kiln, it is not possible to shut down the processes feeding the Digestion RTO during periods of RTO maintenance or breakdown. Therefore every effort is made to ensure that down-times are minimised and on-line performance is maximised.

3.2.2 Nature of Emissions

The emissions from the steam sources are primarily water vapour (steam) along with varying quantities of VOCs. The RTO has been designed to be capable of reducing VOC emissions to air by at least 90% when operating under design conditions, in conformance with Works Approval conditions.

3.2.3 Monitoring Program

The key parameter to be monitored for effective operation of the RTO is the operating temperature of the RTO beds, which determines the effectiveness of VOC destruction. Temperature will be monitored continuously. The VOC destruction efficiency will be measured by analysing the inlet and outlet of the RTO for VOCs.

Commissioning Checks

During commissioning the RTO temperature control systems will be tested to confirm correct functioning, and calibrated to ensure accurate measurements.

Performance Verification Monitoring

Regulatory targets for emission reductions have been set by Ministerial Statement 000646 Schedule 2 commitments, and the Efficiency Upgrade Works Approval, as follows:

- Design and construct an RTO capable of removing a minimum of 90% of the total combined mass emissions of VOCs from those sources under normal operating conditions (Works Approval Condition A2):
  - Slurry storage tanks (25A)
  - Evaporation non-condensable gases (42)
  - Digestion vacuum pumps – non-condensable gases (25V)
  - Causticization heater non-condensable gases (35J), and
  - Heat Interchange vacuum pump non-condensable gases (40)
- A reduction of approximately 10% in VOC emissions *(refinery overall)* (Ministerial Condition Schedule 2)

Performance Verification Monitoring of the Digestion RTO will be carried out during the initial period of operation to assess performance of the emissions control equipment in relation to the removal of VOCs according to the schedule given in Appendix B. The destruction efficiency will be evaluated by measuring and comparing the VOC and Carbonyls content of the RTO inlet and outlet gases.

Interim Monitoring

Additional monitoring may be carried out during the first twelve months of operation if required to provide additional information to confirm the performance of the equipment, the variability of the results, or for trouble-shooting purposes.

Ongoing Monitoring

The VOC emission reduction rates will be reconfirmed by stack testing on an as required basis, according to the methods specified in Appendix B. The emissions reductions achieved will be included in a review of the overall emissions reductions achieved by the PEU to confirm performance against the 10% VOC reduction target overall.

3.2.4 Failure Response and Contingency Plan

Key Control Parameters

The key control parameter that ensures effective operation of the RTO is the RTO temperature. The RTO is operated at the design temperature of 1000°C (with a minimum of 950°C) specified by the manufacturer to meet the design of >90% reduction in VOCs emitted to air. In the event of the RTO temperature dropping below 950°C priority is given to restoration of the correct operating temperature.

Maintenance and Equipment Failure

It is not possible to shut down any of the production processes that feed the RTO, so all steps will be taken to ensure that down time is minimised. The RTO design allows for up to 15 days per year for inspection, planned maintenance and overhauls to ensure its continuing reliability and effectiveness. An Equipment Management Plan will be developed and managed within the Alcoa Equipment Management System to ensure the ongoing reliability and effectiveness of the equipment.

3.2.5 Management Plan Summary

The key actions required for management of the emissions from the Digestion RTO are summarised in Table 3.

Table 3: Action Plan for the Digestion RTO Stack

Aspect	Action	Timing
Operation	The temperature of the RTO continuously recorded, with allowance for instrument down time; the RTO is operated at the target temperature of 1000°C with a minimum of 950°C	From commissioning onwards
Maintenance	The RTO will be shut down for up to 15 days for planned inspection, maintenance and overhaul each year to ensure effective operation	At end first year of operation; according to Equipment Management Strategy thereafter
Maintenance	Equipment Management Plan in Alcoa's Equipment Management System to manage equipment reliability and planned shutdowns, and to minimise unplanned shutdowns	Within 12 months of Efficiency Upgrade commissioning
Monitoring	Digestion RTO stack exit gases monitored according to the Point Source Monitoring Schedule	Refer to Appendix 3
Reporting	Performance Verification Report including evaluation of the performance of the pollution control equipment	Within 12 months of Efficiency Upgrade commissioning
Reporting	Reporting of other key performance data to be determined in consultation with the Department of Environment	Within 12 months of Efficiency Upgrade commissioning
Contingency	Operating procedures in the Alcoa Performance Support System to ensure that the equipment is operated so as to meet the emission control intent and to minimise emissions in the event of planned or unplanned shutdown of the equipment	Within 12 months of Efficiency Upgrade commissioning
Contingency	In the event of an unplanned RTO shutdown, or if the bed temperature is less than 950°C, corrective actions will be initiated to minimise the time required before normal RTO operation is restored	Within 12 months of Efficiency Upgrade commissioning

3.3 CALCINERS (Works Approval Conditions A5, A6, A7)

3.3.1 Description

The final stage of the alumina refining process is Calcination, in which aluminium hydroxide ("hydrate") is converted to alumina by heating to around 950^{o}C with the evolution of three molecules of water per molecule of alumina. At Pinjarra, this is achieved in a set of stationary fluid bed kilns, or calciners. Prior to the Efficiency Upgrade there were six calciners at Pinjarra. Calciner 7 was added as part of the Efficiency Upgrade. The calciners use natural gas as the fuel.

3.3.2 Nature of Emissions

The predominant emissions from the calciners are steam produced from the calcination process itself, at a rate of approximately half a tonne of steam per tonne of alumina produced, and products of combustion, predominantly CO_2 and water from the combustion of natural gas. The other main combustion products are CO and NO_x. The emissions also contain trace quantities of SO_2 and VOCs including formaldehyde from combustion of fuel and chemicals present in the calciner feed material, and trace quantities of elemental mercury.

In addition to the gaseous emissions, the calcination of hydrate creates fine particulates which can be emitted as dust. The dust emissions are mitigated and controlled to low levels by the use of Electrostatic Precipitators (ESPs) on the calciner stacks. Each calciner stack is fitted with Continuous Emission Monitoring (CEM) in the form of continuous Dust Concentration Monitors (DCMs), which assist in managing dust emissions from the calciners. Dust emissions are regulated according to the Environmental Licence[6], on the basis of isokinetic sampling according to USEPA methods to a schedule specified in the licence. The Efficiency Upgrade includes the installation of a three zone ESP system to the new calciner (Calciner 7), and upgrades to the ESPs on calciners 4, 5 and 6.

3.3.3 Monitoring Program

The key indicator for the performance of the calciner emissions control equipment (the ESPs) is the dust concentration in the stack gases. This is monitored continuously by the DCMs for control purposes, and periodically by isokinetic sampling for verification and regulation purposes. Additional isokinetic measurements have been incorporated for the new and upgraded equipment installed in the Efficiency Upgrade, and the DCMs will be used for continuous assessment of ESP performance during and after commissioning, with allowance for instrument down time.

Commissioning checks

During the commissioning of Calciner 7, the new DCM will be tested to confirm correct functioning. The DCM will be correlated against isokinetic sampling using USEPA Method 5 or 17, as per Works Approval Condition A6 so it provides an indication of stack dust concentration.

[6] Western Australia Department of Environment and Conservation Licence Number 5271/10

Performance Verification Monitoring

Regulatory targets for emission reductions have been set by Ministerial Schedule 2 commitments**Error! Bookmark not defined.**, and the Efficiency Upgrade Works Approval**Error! Bookmark not defined.**, as follows:

- A reduction of approximately 25% particulate emissions from the calciners (Ministerial Condition, Schedule 2**Error! Bookmark not defined.**);
- 80 mg/m^3 or less particulate emissions from each of Calciners 4, 5 and 6 under normal operating conditions (Works Approval Condition A7); and
- 30 mg/m^3 or less particulate emissions from the newly installed Calciner 7 under normal operating conditions (Works Approval Condition A6).

After the commissioning of the ESP upgrades on each of Calciners 4, 5 and 6, isokinetic stack samples will be collected daily for one week in each case, using USEPA Method 5 or 17. The data from these samples will be combined with the continuous DCM data from the same period to verify that the emission concentrations are within the 80 mg/m^3 (second dot point above). Similarly, the performance of Calciner 7 to the 30 mg/m^3 criterion (third dot point above) will be verified once Calciner 7 and its associated ESP are commissioned.

Interim Monitoring

Following the confirmation of dust emissions reductions described in the previous section, a program of additional monitoring for a broader range of species will be undertaken in the first year of operation of the upgraded and new equipment, in order to provide data required for model validation as specified in Section 8.2 of Ministerial Statement 000646. For this, the all of the calciner stacks will be sampled quarterly for four successive quarters for analysis of: Particulates, CO, NO_x, VOCs, trace metals and SO_2.

Ongoing Monitoring

Ongoing monitoring is carried out for each calciner stack as follows (Appendix B):

- Continuous monitoring of particulates by DCM
- Quarterly isokinetic sampling for:
  - Particulates
  - CO
  - NO_x
- Isokinetic sampling for other species, in particular VOCs, on an as required basis

3.3.4 Failure Response and Contingency Plan

Key Control Parameters:

The key control parameters relating to stack particulate emissions are ESP temperature, ESP voltages, and particulate concentration as measured by the DCMs. Alcoa has operating procedures which set the required operating ranges and specify responses in the event of any deviations from those operating ranges.

Maintenance and Equipment Failure

Inspection, planned maintenance and overhauls of the ESPs and DCMs will be managed within Alcoa's Equipment Management System to ensure the continuing reliability and effectiveness of the equipment. The DCMs are correlated on an annual basis against stack sampling by USEPA Method 5 or 17 according to established procedures. In the event of DCM failure, procedures are in place to ensure that emissions remain in control and that the DCM is repaired and brought back into operation as soon as practicable.

3.3.5 Management Plan Summary

The key actions required for management of the emissions from the Calciner stacks are summarised in Table 4.

Table 4: Action Plan for the Calciners

Aspect	Action	Timing
Operation	The operation of continuous DCMs will be maintained in each calciner, with allowance for instrument down time; procedures are in place to manage emissions and ensure timely repair in the event of failure of the continuous monitor	Continuous while calciner in operation
Operation	Alcoa will operate the calciners within the regulatory limit of 250 mg/m^3 particulate emissions from each calciner	Continuous based on DCM data
Maintenance	The ESPs will be shut down according to the Equipment Management Strategy for inspection, planned maintenance and where applicable overhaul to ensure effective operation	During shutdown of corresponding calciner
Maintenance	Equipment Management Strategy in Alcoa's Equipment Management System to manage equipment reliability and planned shutdowns, and to minimise unplanned shutdowns	Within 12 months of Efficiency Upgrade commissioning
Monitoring	Calciner stack exit gases will be monitored according to the Point Source Monitoring Schedule	Refer to Appendix B
Reporting	Particulate emission monitoring results included in monitoring report to the Department of Environment	Annual
Reporting	Performance Verification Report including evaluation of the performance of the pollution control equipment	Within 12 months of Efficiency Upgrade commissioning
Contingency	Dust emission events (defined as sustained emissions above the target levels) will be identified and acted upon as quickly as possible, in accordance with established procedures	Ongoing

3.4 BOILERS

3.4.1 Description

The Pinjarra powerhouse generates steam using six gas fired boilers (numbered 2 to 7), which will be supplemented by two Heat Recovery Steam Generators (HRSGs) from the adjacent Alinta cogeneration plant after the Pinjarra Efficiency Upgrade (Efficiency Upgrade) project. Boilers 2, 6 and 7 were manufactured by International Combustion Australia Limited (ICAL), and boilers 3, 4 and 5 were manufactured by John Thompson Australia (JTA).

The heat input into the boiler is via front wall mounted burners. The burners are integral to the boiler operation, and are the only source of heat input into the unit for steam generation. Each of boilers 2, 6 and 7 has six identical burners per boiler. Individual burners can be shut down, with a corresponding reduction in steam output. The burners can also operate at varying firing rates up to a maximum rating.

The boilers operate using natural gas as the primary fuel, and distillate (diesel) as the emergency back up fuel during curtailment of gas supply.

As part of the Efficiency Upgrade project, the burners on boiler 2 and boiler 6 will be replaced with Low-NO_x burners that generate less oxides of nitrogen (NO_x). The burners on boiler 7 were retrofitted with the same low NO_x type in 2000. Boilers 3, 4 & 5 will not be retrofitted with this low NO_x burner, but are expected to be removed from service once the adjacent cogeneration plant reaches an accepted level of demonstrated reliability.

3.4.2 Nature of Emissions

The main emissions from the gas-fired boilers are water and carbon dioxide, the intended products of combustion of the fuel gas. Small quantities of CO and traces of VOCs are formed as products of incomplete combustion. In addition, oxides of nitrogen (NO_x) are formed by reaction of oxygen and nitrogen in the air within the hottest part of the burner flame. NO_x is the main contaminant in the flue gases. It can be reduced by the use of improved burner designs ("low-NO_x burners") which reduce the oxidation of atmospheric nitrogen by reducing the flame temperatures reached in the combustion process. This is achieved by improving the air-fuel mixing process, resulting in lower flame temperatures and improved combustion efficiency.

The installation of low-NO_x burners is expected to reduce the NO_x emissions by at least 55% for each installation. This is according to the design of the burners, and has been incorporated as Condition A8 in the Works Approval.

3.4.3 Monitoring Program

The performance of the burners is determined by analysis of the flue gas for NO_x and CO. Multi-gas analysers are permanently installed on each of boilers 2 & 6. These measure methane (CH_4), CO_2, CO, and O_2. These parameters are inputs into the Burner Management System, and are used during commissioning to monitor combustion safety. The NO_x concentration is monitored by stack sampling and analysis according to USEPA Method 7E Modified, as specified in the Works Approval.

Commissioning checks

The new burners will be commissioned according to procedures specified by the manufacturer and required by the regulations governing gas fired boilers, leading to approval by an accredited independent Type B Appliance Inspector for the issuing of Certificates of Compliance.

Performance Verification Monitoring

The performance of the burners will be established over a full range of load conditions to verify the NO_x reductions achieved, and to establish the relationship between NO_x and CO emissions and boiler load.

Interim Monitoring

Monthly NO_x samples will be taken from each of the boiler 2 and 6 stacks for the first 12 months of operation of the new burners.

Ongoing Monitoring

After 12 months' satisfactory operation, the monitoring regime will revert to quarterly monitoring.

3.4.4 Failure Response and Contingency Plan

The low NO_x burners are an integral part of the boiler. The boiler cannot be operated without the installed NO_x control equipment. Individual burners can be removed from service in the event of a malfunction. This can reduce boiler output, but does not affect NO_x emission levels from the individual boilers.

3.4.5 Management Plan Summary

The key actions required for management of the emissions from the boiler stacks are summarised in Table 5.

Table 5: Action Plan for Boilers

Aspect	Action	Timing
Operation	The low NO_x burners are an integral part of the boiler, which therefore cannot be operated without the installed NO_x control equipment.	From commissioning onwards
Monitoring	Boiler exit gases will be monitored according to the schedule in the Point Source Monitoring Schedule (Appendix B)	From commissioning onwards
Maintenance	The burners will be maintained according to the schedule and procedures specified in the Equipment Management Strategy to ensure long term effective operation	From commissioning onwards
Reporting	Performance Verification Report including evaluation of the performance of low NO_x burners.	Within 12 months of Efficiency Upgrade commissioning
Contingency	The low NO_x burners are an integral part of the boiler, which therefore cannot be operated without the installed NO_x control equipment. Individual burners can be removed from service in the event of a malfunction. This can reduce boiler output, but does not affect NO_x emission levels from the individual boilers.	Routine operation

3.5 45T COOLING TOWER

3.5.1 Description

The 45T Cooling Tower takes cooling water from the heat exchangers in the Precipitation area of the plant and cools it by evaporation. The cooled water is recycled to the heat exchangers continuously to extract heat from the main plant liquor circuit. Water lost by evaporation in the cooling tower is replaced by makeup water, which is primarily from the Fresh Water Lake or other potable water source. The water in the cooling tower is treated with biocides to prevent the growth of bacteria, in particular *Legionella*. These biocides contain chlorine and bromine compounds, and are therefore a possible source of halogenated hydrocarbons as a result of reaction with organic compounds in the cooling tower water. Organic compounds may be present in the water from other additives, contamination in the makeup water, or leakage of Bayer process liquor into the cooling water from the process heat exchangers. The pH is monitored and any process liquor content is neutralised by CO_2 addition.

3.5.2 Nature of Emissions

The 45T Cooling Tower is a low temperature, low velocity, high volume emission source. The vent mouth has a diameter of 17 metres, and the volumetric flow of 162,000 m^3/min makes it the highest volume vent on the premises. The main component of the emission is steam resulting in a high visibility discharge. The possible sources of VOCs in the emissions are organic compounds and amines contained in condensate, organics in the makeup water, and organics and halogens in the water treatment chemicals.

Due to the configuration of the Cooling Tower discharge vent and the low concentrations of VOCs in the high volume flow, quantifying the emission rates of VOCs by sampling and analysis is very difficult. Early attempts to do this resulted in intermittent detection of some VOCs, in particular acetone, 2-pentanone and formaldehyde. In addition, preliminary mass balances using highly conservative assumptions were done in an attempt to estimate possible emission rates as an alternative to sampling the vent. As a result of these investigations it was estimated that the Cooling Tower emissions, though at low concentration, could be responsible for around 25% of the total VOC emissions of the refinery due to the high volumetric flow. This was the information used in the original Base Case emissions profile in the Efficiency Upgrade modelling. It was acknowledged that this was a highly conservative figure, and that there were significant uncertainties in relation to both the chemical analysis method used in the stack emission measurements and the mass balance approach.

Given that the emissions from 45T were estimated to increase by 20% as a result of the Efficiency Upgrade, it is a priority that this uncertainty be addressed in order that the overall refinery VOC emissions profile can be correctly estimated, and that the Efficiency Upgrade emissions reductions can be properly allocated.

3.5.3 Monitoring and Research Program

Given that there is no specific upgrade to 45T in the Efficiency Upgrade, the monitoring program is not divided into phases as for the installation of pollution control equipment. Rather, there is an ongoing investigation in progress involving Pinjarra and Alcoa Technology Delivery Group (TDG) personnel in relation to the technical issues relating to the estimation of emissions from cooling towers (summarised in Table 6).

The key technical issues to be resolved are:

- Determine the capability of the methods used to sample the stack. This is required because it has not been possible to sample in compliance with the USEPA guidelines for stack sampling due to the configuration of the exhaust system. This is a recognised issue throughout the industry, and is being researched by the Alumina Industry Air Emissions Forum (AIAEF) on behalf of the industry as a whole. The Alcoa TDG is playing a leading role in this research effort.
- Assess the available analytical methods and specify the most appropriate methods for this application. In particular, the pre-Efficiency Upgrade estimates were based on analysis by ECS Method 6, which has a detection limit of 0.4 mg/m^3 for carbonyl compounds (eg acetone). Method 6 is routinely used for the analysis of other stack emissions, such as

calciner stacks, and is capable for those sources. However because of the lower concentrations anticipated in the cooling tower emissions, its capability in this application has been questioned, both in relation to the adequacy of the detection limit and the potential for contamination in the analysis process by common laboratory chemicals, in particular acetone. The proposal is to test it against USEPA Method 30, which, though more difficult to apply, has the benefit of a 10-fold improvement in detection limit and a much smaller chance of contamination in the analysis process.

- Further refine the mass balance method to provide a check on the stack sampling results and to better understand the possible sources of contamination and means of control.

Table 6: Action Plan for 45T Cooling Tower

Aspect	Action	Timing
Investigation	▪ Determine capability of method for sampling CT vent ▪ Assess ECS Method 6 (Modified USEPA Method TO5) and USEPA Method 30 in relation to detection limit and contamination potential and recommend most appropriate method ▪ Refine mass balance method	Within 12 months of Pinjarra Efficiency Upgrade commissioning
Operation	Identify and implement appropriate controls to ensure CT emissions minimised	As above
Monitoring	Confirm emissions estimates using methods of sampling and analysis recommended from Investigation phase	As above
Reporting	Summary report to DEC on the outcomes of the Investigation and Monitoring	As above

4 AREA SOURCE EMISSIONS

4.1 MONITORING METHODS, QA/QC AND FREQUENCY

The monitoring of particulate emissions from area sources exceeds the DEC's licence requirements. Ambient particulate concentration samplers are distributed around the refinery boundary, closer to possible dust sources and at North Pinjarra. The monitoring specifically targets dust emissions from the Residue Disposal Area (RDA) and the bauxite stockpiles. High Volume Air Samplers (HVAS) are used to measure dust levels at various locations, and Tapered Element Oscillating Membrane (TEOM) samplers are used for continuous monitoring of dust levels at the RDA boundary and in the vicinity of the stockpiles, in accordance with the Environmental Licence.[6] This data is used for dust management purposes and to provide data for the assessment and modelling of dust distribution and dispersion.

The HVAS samplers are used to determine Total Suspended Solids (TSP) and PM_{10} concentrations according to the applicable Australian standards over a 24 hour period. Two Low Volume Air Samplers (LVAS) have also been deployed to provide additional PM_{10} and $PM_{2.5}$ information. The dust monitoring network is supported by a local weather station. A summary of the locations and nature of the dust monitoring network at Pinjarra is given in Table 7 below.

This network is used as the basis of investigations into the sources, distribution and compositions of dusts, as well as for validation of dust dispersion modelling. Chemical analysis of dusts is carried out when required to determine major and trace metal compositions, to support studies of specific dust events or more general studies including dust source attribution, and dust generation and dispersion modelling when required. All chemical analysis is carried out by standard techniques in independent, NATA accredited laboratories for all routine analyses and for all investigations as far as is practicable, although this may be varied if necessary for specific reasons if a procedure not covered by such standards is required for a particular investigation. The dust monitoring network is summarised in Table 7.

Table 7: Alcoa Pinjarra Dust Monitoring Network as at August 2005

Monitoring Site Name	Monitoring Site Code	Licence Requirement	Monitoring Type	Size Fraction Measured	Averaging Period	Sampling Methods
Pinjarra Race Track	RT001	Yes	HVAS	TSP	24-hour	AS/NZS 3580.9.3
		No	HVAS	PM_{10}	24-hour	AS/NZS 3580.9.6
		No	LVAS	PM_{10} & $PM_{2.5}$	6-day	USEPA, see below*
		No	TEOM	TSP	6-minute	AS/NZS 3580.9.3
Fairbridge Airstrip	FB001	Yes	HVAS	TSP	24-hour	AS/NZS 3580.9.3
		No	LVAS	PM_{10} & $PM_{2.5}$	6-day	USEPA, see below*
RDA 500 m (north)	NO001	No	HVAS	TSP	24-hour	AS/NZS 3580.9.3
RDA 500 m (central)	CE001	No	HVAS	TSP	24-hour	AS/NZS 3580.9.3
RDA 500 m (south)	SO001	No	HVAS	TSP	24-hour	AS/NZS 3580.9.3
Oakley South	QA001	Yes	HVAS	TSP	24-hour	AS/NZS 3580.9.3
Eastern Boundary	EB001	No	HVAS	TSP	24-hour	AS/NZS 3580.9.3
Oakley Dam	OA002	No	HVAS	TSP	24-hour	AS/NZS 3580.9.3
Bauxite Stockpile	BW001	No	HVAS	TSP	24-hour	AS/NZS 3580.9.3
	PD001	No	TEOM	TSP	6-minute	USEPA, see below*

*USEPA Manual Reference Methods RFPS-1928-126 and RFPS-0499-129

4.2 CUMULATIVE PARTICULATE EMISSIONS

In response to the recommendations of the expert peer review[7], an assessment of cumulative particulate emissions taking into account background levels from other refinery sources has been carried out. The study and results are detailed in the referenced report[8]. The report concludes that the area sources, in particular the RDA, account for the majority of the dust generated by the refining operation, and the refinery point sources generally are a small component of the overall contribution to particulate levels. Successful implementation of the proposed RDA dust suppression sprinkler upgrade can therefore be expected to have a significant benefit in reducing overall particulate emissions, and management and improvement of dust suppression is the appropriate a key focus area for improvement in relation to dust levels overall.

5 AMBIENT AIR QUALITY

5.1 SAMPLING LOCATIONS, METHODS AND QA/QC PROCEDURES

5.1.1 Gaseous Pollutants

The goal of ambient monitoring for gaseous compounds will be primarily to assist in the calibration and validation of the dispersion modelling used to predict the refinery contributions to the ground level concentrations of pollutants. This approach is preferred over the alternative of extensive monitoring of a range of pollutants because the contribution of the refinery to the levels of VOCs for example is generally small in relation to existing background levels and as such is generally not

[7] "Desktop Review – Pinjarra Alumina Refinery Efficiency Upgrade", CH Environmental, 13 November 2003
[8] "Pinjarra Refinery Cumulative Particulate Monitoring", Air Assessments, March 2007

distinguishable from background and the contributions of other sources by direct observation. It is therefore more informative to concentrate on developing the modelling approach, which can then be used to assess the likely impact of different future scenarios of refinery configuration, expansion, and pollution control options. The species that are most useful for model validation are NO_x and CO[7]. This is because:

i. NO_x is the most prevalent gaseous species apart from water vapour and CO_2 in the refinery point source emissions, and along with CO is present in all combustion source emissions
ii. NO_x and CO are amenable to continuous monitoring by well established technology, and
iii. It has been demonstrated that NO_x and CO measurements can be used to provide a refinery signal that can be distinguished from background and from other point sources by analysis of data from suitably deployed monitors.

Nevertheless, care must be taken to ensure that the effects of other sources, in particular trains, motor vehicles and other mobile equipments, and other industrial sources, are taken into account when analysing the monitoring results. Despite these complications, considerable success has been achieved in using NO_x and CO data for model validation. Based on the investigations to date, it has been recommended that a monitoring campaign based on two monitors located at opposite sides of the refinery so as to capture upwind-downwind paired data over a period of two years (two complete cycles of seasons) would provide sufficient information to enable a useful degree of additional confidence in the model predictions[9].

Alcoa proposes to progress this additional monitoring programme commencing in 2008, according to a study design to be developed on the basis of current knowledge and in consultation with the DEC and external experts.

Sampling Locations:

The exact sampling locations will be determined in the study design process, with the intent of providing the best possible upwind-downwind data for model validation.

Methods and QA/QC:

Measurements of NOx and CO will be according to the applicable Australian Standard methods.[10,11]

5.1.2 Dust Monitoring

The monitoring locations, methods and procedures currently in place for dust monitoring at Pinjarra are as described in Section 3.1 above. In addition to routine monitoring, this monitoring network has been used as a basis for a detailed study of the distribution of dust and the associated metal oxides carried out for Alcoa's Western Australian Operations (WAO) during 2005-6. The specific project

[9] "Air Quality Model Validation – Pinjarra Refinery – Final October 2006", Air Assessments, 2006
[10] AS/NZS 3580.5.1 (1993): Methods for sampling and analysis of ambient air - Determination of oxides of nitrogen - Chemiluminescence method
[11] AS/NZS 3580.7.1 (1992): Methods for sampling and analysis of ambient air - Determination of Carbon Monoxide - Direct reading instrumental method

objectives as originally defined by Alcoa in 2004, (see Appendix A in Air Assessments, 2004) and redefined in June 2006 are to:

a) Quantify the Alcoa residue area contribution to the regional dust loading for TSP, PM_{10} and $PM_{2.5}$;
b) Quantify the ratio of TSP, PM_{10} and $PM_{2.5}$ emissions/concentrations at or near the residue area and how the concentrations vary with distance. This will provide ratios of the emissions, e.g. $PM_{2.5}/PM_{10}$ ratios at the residue area;
c) Quantify the change in chemical composition of the residue dust for the three dust fractions with distance from the residue area;
d) Determine the chemical components within dust emission and recommend appropriate chemical concentration factors that shall be used in mass emission loading calculations for other work to be undertaken by Alcoa; and
e) Evaluate the level of health risk associated with residue dust emissions for the Pinjarra, Kwinana and Wagerup refineries.

5.2 EFFECTS AT RECEPTOR LOCATIONS

The results of the studies of gaseous pollutants and dusts described in the previous sections will be used to refine the estimates of health risk factors at receptors in the region of the refinery. For the gaseous species particular attention will be given to the receptors to the north of the refinery identified within the original Health Risk Assessment (HRA) as having the highest potential risk. In the case of particulate emissions the highest impacts are to the west of the refinery due to the effect of the prevailing easterly winds in summer. A preliminary evaluation of the effects of particulate emissions on health risk factors as recently been made[12], based results obtained in the WAO Dust Study. Further assessments will be made as appropriate on the basis of these ongoing studies.

[12] "Screening Health Risk Assessment of Particulate Emissions from Alcoa's Pinjarra Refinery Residue Disposal Area", ENVIRON, 2007

6 QUALITY CONTROL

Quality control is an essential component of both source and ambient monitoring programs to ensure that the results produced are representative of actual concentrations.

The key actions Alcoa will undertake to ensure quality control in all of its air monitoring programs at the Pinjarra refinery are summarised in Table 8.

Table 8: General quality control commitments

Implementation Phase	Action
Sampling	All sampling for regulatory compliance will be conducted by parties holding NATA accreditation for that activity, where available.
	Sampling will be performed in accordance with the relevant Australian/NZ Standards or USEPA methods. Where NATA certifiable process are possible, monitoring and sampling will be undertaken by NATA certified facilities carrying out the appropriate NATA certified processes against the appropriate Australian Standard and analysis process. When variations to these methods are employed, the variation will be recorded and explained.
	Sampling will be conducted by a suitably qualified external consultants
	Each time a stack test is performed, standard methods will be used to determine the temperature, moisture and volumetric flow rate wherever this is possible.
	Sufficient volumes of gas will be collected to achieve suitable limits of detection for each key parameter.
	Where possible, stack samples will be collected under steady state operating conditions.
	Field blanks and duplicates will be included in sampling runs.
	Samples will be preserved in accordance with relevant standards and analysed as soon as possible after collection.
	Records of the chain of custody will be maintained for all samples.
Analysis	All analysis for regulatory compliance will be conducted by parties holding NATA accreditation for that activity, where available. Where a NATA accredited laboratory is not available, analysis will be performed at a laboratory with sound quality control procedures.
	Analysis will be performed in accordance with the relevant USEPA or AS methods where possible. When variations to these methods are employed, the variation will be recorded and justified.
Reporting	All reports will include the date and time of sample collection, and any unusual operating conditions at the time of collection.
	All results will be presented with limits of detection for each parameter recorded.
	Results will be presented with information on potential errors in sampling, preservation and analysis.

7 REVIEW AND REPORTING

This Plan may be altered from time to time for reasons such as changes to production requirements or stakeholder expectations. Care will be taken to ensure that any changes are consistent with the original intent of the Plan, and that there is stakeholder consultation whenever alterations are made, at a level appropriate to the nature and significance of the alteration.

Results of the monitoring and investigations undertaken under this Plan will be reported to DEC annually as part of the Compliance Reporting process for Ministerial Conditions.

Hard copies of the plan will be made available in government and local libraries as summarised in Table 9 below.

Table 9: Locations for viewing hardcopies of the plan.

Location	Address	Copies Available
DEC library	The Atrium, Level 4, 168 St Georges Terrace, Perth WA	2 hardcopies
Battye Library	Battye Library. Located inside the Alexander Library Building, Cultural Centre, Perth	2 hardcopies
Murray Shire Library	Located at the corner of Pinjarra Rd & Forrest St. Pinjarra WA	2 hardcopies

Information about the management plan, or the results of the monitoring programs described in it, can be obtained by contacting Alcoa.

8 DEVELOPMENT OF THE PLAN

In September 2003, Alcoa established a Stakeholder Reference Group (SRG) for consultation on a range of issues related to the Pinjarra Efficiency Upgrade. This group has twelve members representing the following interests:

- Local community and Pinjarra residents;
- Farming community and Pinjarra refinery neighbours;
- Pinjarra refinery workforce;
- Local Government;
- Pinjarra businesses;
- Local education and training departments;
- Indigenous community;
- Local Landcare groups;
- Pinjarra refinery Community Consultative Network;
- Department of Environment;
- Department of Industry and Resources; and

- Pinjarra Efficiency Upgrade project team.

The Draft AQMP was tabled for comment at the SRG meeting of 8th September 2004. The time line for the development of this Plan is summarised in Table 10 below:

Table 10: Time Line for Plan Development

Date	Item
8th September 2004	DRAFT Version 1 presented to the Stakeholder Reference Group
30th September 2004	Version 1 submitted to the Licensing Branch of DEC
30th September 2004	Copy of Version 1 provided to Air Quality Management Branch of DEC
21st October 2004	Copy of Version 1 presented to the Audit Branch of DEC who requested that they receive final version prior to commissioning of Oxalate Kiln RTO in January 2005.
29th October 2004	Licensing Branch of DEC requested additional information
30th November 2004	Version 2 submitted to Licensing and Audit Branches of DEC
	Submitted to DoH
13th January 2005	Comments back from DEC and DoH requesting revisions and additions prior to resubmission of final Plan
7th December 2007	Discussion of main contents of revised Plan with AQMB officers
13th December 2007	Discussion of main contents of revised Plan with DoH officers
19th December 2007	Target date for submission of final Plan to DEC Licensing and Audit Branches of DEC

8.1 INDEPENDENT EXPERT REVIEW

Comment on the Air Quality Management Plan was included in the independent expert review[3] (Appendix C). The comments from the Review have been addressed in this Plan as summarised in Table 11.

Table 11: Responses to Expert Review Comments

Review Reference	Review Comment	Alcoa Response
Page 8 section 6.1	The plan deals only with point source monitoring, and excludes targeted emission reductions, ambient dust management and monitoring, greenhouse gases, and the Alinta cogeneration facility. The report could therefore be more correctly titled a Point Source Monitoring Plan to avoid confusion with the more commonly understood meaning of an AQMP that would include monitoring, emission management measures and operational systems.	The Plan has been redrafted to include area sources and ambient monitoring, so that the Plan addresses the requirements tor specified in the Ministerial Condition for the Air quality Management Plan. The overall emissions reduction and greenhouse aspects are the subject of separate reports.
Page 9 section 6.1	There are four monitoring phases in the body of the report, but only three in the executive summary, and these should be consistent to avoid confusion. The commissioning phase is about testing the monitoring equipment. It is extremely important for this to be carried out, but probably warrants discussion separately from the actual monitoring.	This has been corrected in the revised Plan.
Page 9 section 6.1	An issue relates to emissions data on metals, and specifically Cadmium and Chromium 6. Alcoa is of the view that these metals will not be emitted. It would be desirable that their presence or otherwise be tested in Performance verification monitoring.	Chromium and cadmium are included in the metal suite analysed for 30RTO, Excess blow off and Calciners for the post upgrade monitoring program. Metals were also analysed for oxalate kiln (performance verification monitoring). Boiler and Cogeneration data will be estimated from Wagerup data and natural gas composition data as sampling ports are too difficult to erect for metals. Area source metals emissions are also considered in the Fine Particulates Study.
Page 10 section 6.1	The difficulties in measuring VOC emissions from the cooling tower are noted, as is the projected increase in VOC following the upgrade. Mass balances do not capture the variability in emissions associated with upstream process variables and upsets, but measurement methods relying on sampling and analysis are also problematic. It would be useful to explain the rationale for this. It would also be useful to know whether the mass balance is based on evaporative loads only, or includes liquid entrainment losses.	The section on Cooling towers has been revised to address this.
Page 10 section 6.1	There are a number of apparent anomalies in stated emission commitments and standards, as indicated below. **Oxalate Kiln Stacks** Particulate emissions from the RTO are given on page 14 as 20 mg/m^3 or less and 0.55 g/s or lessPage 15 refers to an operating limit of 250 mg/m^3 under normal operating conditions.The Emission Reduction Report gives upgrade normal emission rate from the oxalate kiln for dust as 0.047 g/sec **Calciners** Page 19 refers to 80 mg/m^3 for calciners 4, 5, and 6, and 30 mg/m^3 for calciner 7Page 20 refers to an existing license limit of 250 mg/m^3 under normal operating conditions.There is a need to explain these anomalies.Need to explain the difference between mean and peak and why such a difference (particularly from Oxalate kiln stacks) and the expected frequency of the peak emissions and their implications for modelling and HRA studies.	These details and anomalies have been addressed in the current revision of the Plan

9 REFERENCES

The references are given as footnotes in the text. They are provided here as a list in order of reference for convenience.

- Project Review, Pinjarra Alumina Refinery Efficiency Upgrade, CH Environmental, 28 December 2006 (also provided as Appendix C of this Plan)
- Pinjarra Refinery Efficiency Upgrade: Air Quality Data Environmental Protection Statement, ENVIRON Australia Pty Ltd, 28 October 2003
- Works Approval Number 3927, Department of Environment and Conservation, Western Australia, 14 April 2004 (Works Approval Number 4391/2007/1 re-issued 25 October 2007)
- Ministerial Statement 646, Government of Western Australia Minister for the Environment, 3 March 2004
- Western Australia Department of Environment and Conservation Licence Number 5271/10
- Desktop Review – Pinjarra Alumina Refinery Efficiency Upgrade, CH Environmental, 13 November 2003
- Pinjarra Refinery Cumulative Particulate Monitoring, Air Assessments, March 2007
- Air Quality Model Validation – Pinjarra Refinery – Final October 2006, Air Assessments, 2006
- AS/NZS 3580.5.1 (1993): Methods for sampling and analysis of ambient air - Determination of Oxides of Nitrogen - Chemiluminescence method
- AS/NZS 3580.7.1 (1992): Methods for sampling and analysis of ambient air - Determination of Carbon Monoxide - Direct reading instrumental method
- Screening Health Risk Assessment of Particulate Emissions from Alcoa’s Pinjarra Refinery Residue Disposal Area, ENVIRON, 2007
- Pinjarra Refinery Efficiency Upgrade – Air Dispersion Modelling, SKM, 3 December 2003

10 GLOSSARY

Abbreviations

ALD	Alumina leach dryer
APHA	American Public Health Association
AQMP	Air quality management plan
CEMS	Continuous emissions monitoring system
CO	Carbon monoxide
DCM	Dust concentration monitor
DEC	Department of Environment and Conservation
DoH	Department of Health
EMS	Environmental management system
ESP	Electrostatic precipitator
NATA	National Association of Testing Authorities
NO_x	Oxides of nitrogen
PEU	Pinjarra Efficiency Upgrade
RTO	Regenerative thermal oxidiser
SO_2	Sulphur dioxide
SRG	Stakeholder reference group
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compounds

Units

g/s	grams per second
mg/m^3	milligram per cubic metre (expressed dry at 0 degrees Celsius and 1 atmosphere)
ppm	parts per million
%	percent

Appendix A

Regulatory environmental approval conditions

Ministerial Statement 646

Condition 6.1

Prior to commissioning the processing plant, the proponent shall prepare an Air Quality Management Plan, for monitoring and management of point source emissions, area source emissions and ambient air quality to the requirements of the Minister for the Environment on advice of the EPA. This plan shall address the following:

Point source emissions:

1. Details of air pollution control equipment.
2. A description of air pollution control equipment emission monitoring to be undertaken during construction, commissioning and operation of the plant, including, where practicable and appropriate, continuous monitoring.
3. A list of chemical species to be monitored with a particular focus on NO_x, arsenic and mercury.
4. Monitoring locations, sampling frequency, sampling methods, analytical test methods and quality assurance/quality control procedures.
5. A contingency plan for unplanned and planned shut-down of the pollution control equipment.

Area source emissions:

1. Details of methods, quality/assurance/quality control procedures and sampling frequency for monitoring particulate emissions (including ultra fine particles), metals emissions from the Residue Disposal Area and stockpile area as recommended in the expert peer review of the Air Quality Data and Air Dispersion Modelling reports. This work shall also include an assessment of cumulative particulate emissions taking into account background levels and levels from other refinery sources.

Ambient air quality:

1. Details of sampling locations, methods (including continuous monitoring or campaign monitoring using continuous techniques) and quality assurance/quality control procedures; and
2. Receptor locations with a particular focus on locations to the north of the refinery identified in the Health Risk Assessment (HRA) as having the highest potential risk.

This plan shall:

- Be developed in consultation with the community and stakeholders;
- Include an expert peer review; and
- Allow for adaptive management with regular reviews and updating.

Note: This Air Quality Management Plan does not include management of emissions from area sources or ambient air quality sampling. These are covered by a separate Dust Management Plan.

Condition 6.2

The proponent shall implement the Air Quality Management Plan required by Condition 6.1 to the requirements of the Minister for the Environment on advice from the EPA.

Condition 6.3

The proponent shall make the Air Quality Management Plan required by Condition 6.1 publicly available to the requirements of the Minister for the Environment on advice from the EPA. Note: In preparation of advice to the Minister for the Environment, the EPA expects that the advice of the following agencies will be obtained: DEP (Air Quality Management Branch); and Department of Health.

Schedule 2 Commitments

Install air pollution control equipment designed to achieve:

- reduction of 10% in VOC emissions;
- reduction of 25% of particulates from calciners;
- reduction of 90% of CO from the oxalate kiln; and
- offset of NO_x by installing low NO_x burners.

Works Approval 3927 & 4391

Condition A2 – Digestion RTO

The works approval holder shall design and construct an RTO connected to the following emission sources, to remove a minimum of 90% of the total combined mass emissions of VOC's from those sources under normal operating conditions (refer to condition A13 for details on how monitoring for compliance is to be achieved):

(i) slurry storage tanks;
(ii) evaporation non-condensable gases;
(iii) digestion vacuum pumps – non condensable gases;
(iv) causticisation heater non-condensable gases; and
(v) heater interchange vacuum pump non-condensable gases.

Condition A3(a) – Oxalate Kiln Wet Scrubbers

The works approval holder shall design and construct (2) Wet Scrubbers (condensing venturi tray type) as specified in the works approval application to achieve the following, when measured in the exit gases from the Oxalate Kiln RTO under normal operating condition, measured in accordance with USEPA Method 5 or 17:

(i) particulate matter concentration not to exceed 20 mg/m^3;
(ii) particulate matter mass emission equivalent to 0.55 g/s; and
(iii) each Wet Scrubber shall be capable of being operated in isolation to the other when the oxalate kiln is operated.

Condition A3(b) – Oxalate Kiln Wet Scrubbers

The works approval holder shall install the following equipment for the purposes of controlling the exit gases from the Oxalate Kiln:

(i) suitable ducting to ensure exit gases from the Oxalate Kiln are captured and directed through the (2) wet scrubbers;
(ii) suitable ducting to enable the Wet Scrubbers to be operated alternately; and
(iii) suitable ducting between the Wet Scrubbers and Oxalate Kiln RTO to capture and direct exit gases from either of the Wet Scrubbers through the Oxalate Kiln RTO.

Condition A4 – Oxalate Kiln RTO

The works approval holder shall design and construct an RTO connected to the Oxalate Kiln to remove a minimum of 90% of the total combined mass emissions of VOC’s from the Oxalate Kiln under normal operating conditions (refer to condition A13 for details on how monitoring for compliance is to be achieved).

Condition A5 – Additional Calcination Unit

The works approval holder shall design and construct an additional Calciner (#7) and shall direct the exit gases from Calciner (#7) through an ESP

The works approval holder shall design and construct an ESP to treat the exit gases from Calciner (#7) so that the concentration of particulate matter contained in the exit gases from the ESP shall not exceed 30 mg/m^3 under normal operating conditions, measured in accordance with USEPA Method 5 or 17.

Condition A7 – Calciner ESP Upgrades

The works approval holder shall upgrade the ESP’s servicing existing Calciners 4, 5 and 6 so that the concentration of particulate matter contained in the exit gases from each calciner ESP shall not exceed 80 mg/m^3 during normal operating conditions, measured in accordance with USEPA Method 5 or 17.

Condition A8(a) – Powerhouse Boiler Low NO_X Burners

The works approval holder shall install low-NO_x burners on Powerhouse Boilers 2 and 6, and prior to installation of the low-NO_x burners, shall provide a report to the Director that outlines the type, specification and likely performance of the low-NO_x burners that will be installed on Powerhouse Boilers 2 and 6.

Condition A8(b) – Powerhouse Low NO_X Burners

The low-NO_x burners specified in condition A8(a) shall, when installed on Powerhouse Boilers 2 and 6, reduce the mass emissions of NO_x from each boiler by a minimum of 55%. NO_x contained in the exit gases from Powerhouse Boilers 2 and 6 shall be measured under normal operating conditions using USEPA Method 7E (modified). (Refer to condition A13 for details on how monitoring for compliance is to be achieved).

Condition A9(a) – Collection of Process Performance Parameters

The woks approval holder shall install continuous monitoring systems in accordance with Table 1 for the purposes of comparative performance evaluation of pollution control equipment:

Table 1 Process Performance Parameters to be Continuously Monitored

Location	**Parameters**
Digestion RTO Stack	Temperature, gas consumption (gas units)
Oxalate Kiln RTO Stack	CO, temperature, gas consumption (gas units)
Calciner #7 Stack	Optical density (opacity)
Calciner #7 Baghouse Exhaust Duct	Dust concentration using triboelectric emissions monitors (broken bag detectors)

Condition A13 – Investigation Air Emissions Source Monitoring

The works approval holder shall provide a report to the Director by 30 September 2004, that outlines how it will demonstrate compliance against the air emissions discharge performance requirements outlined in conditions A2, A3(a), A4, A6, A7, A8(b) and Schedule 2 of Ministerial Statement 646. The report shall include but not be limited to:

(i) identification of baseline mass emissions (all sources to be listed individually) for VOC's particulate matter, CO, NO_x, and trace metals;

(ii) a plan for comparison of the performance of the refinery after the Efficiency Upgrade is completed with the base case referred to in the Environmental Protection Statement, December 2003;

(iii) the Air Quality Management Plan required under Ministerial Statement 646, under Part IV of the *Environmental Protection Act 1986*;

(iv) source monitoring program proposed to measure performance of new pollution control equipment comprising Digestion RTO, Oxalate Kiln RTO and Calciner #7 ESP; and

(v) identification and locations of sampling ports used to compile the baseline data and for ongoing source monitoring.

Appendix B

Point Source Monitoring Program

POINT SOURCE MONITORING PROGRAM

Location	Species Monitored	Method	Location	Current Sampling Schedule	
				Performance Verification and Investigative Monitoring[13]	**Ongoing Monitoring**
Oxalate kiln RTO stack	Particulates	USEPA method 5	RTO stack	8 duplicates over 4 months	Quarterly[14]
	Carbon Monoxide	ECS method 11 ECS method 11 CO monitor	RTO inlet RTO stack RTO stack	5 over 1 month 5 over 1 month (paired to inlet) On-line	As required As required Continuous
	Volatile Organic Compounds	USEPA method 18 USEPA method 18 USEPA method 30	RTO inlet RTO stack RTO stack	3 duplicates over 2 months 3 duplicates over 2 months (paired to inlet) 3 duplicates over 2 months (paired to inlet)	As required As required As required
	Carbonyls	ECS method 6 ECS method 6	RTO inlet RTO stack	8 duplicates over 4 months 8 duplicates over 4 months (paired to inlet)	As required As required
	Trace Metals	USEPA method 29	RTO stack	6 including 2 duplicates over 3 months	As required
Digestion RTO stack	Volatile Organic Compounds	USEPA method 18	RTO inlet RTO stack	5 duplicates over 1 month 5 duplicates over 1 month	As required As required
	Carbonyls	RTO inlet and stack – ECS method 6	RTO inlet RTO stack	5 duplicates over 1 month 5 duplicates over 1 month	As required As required
	Trace metals	USEPA method 29	RTO stack	6 including 2 duplicates over 3 months	As required

[13] Note that timings of samples given here are targets and subject to change depending on circumstances
[14] Licence requirement

Location	**Species Monitored**	**Method**	**Location**	**Current Sampling Schedule**	
				Performance Verification and Investigative Monitoring[13]	**Ongoing Monitoring**
Calciners	Particulates	USEPA method 17 or 5 DCM	Calciner 4 to 7 stacks Calciner 7 stack Calciner 4 to 7 stacks	5 duplicates over 5 months Initial DCM correlation	Six Monthly[14] Continuous (with annual DCM correlation)
	VOC	USEPA method 18	Calciner stacks	13 over 5 months	As required
	Carbonyls	ECS Method 6	Calciner stacks	9 over 5 months	As required
	CO	ECS Method 11	Calciner stacks	Quarterly from each calciner	Monthly
	NO_x	ECS Method 12	Calciner stacks	Quarterly from each calciner	Monthly
	SO_2	ECS Method 13	Calciner stacks	Quarterly from each calciner	Monthly
	Trace metals	USEPA method 29	Calciner stacks	2 duplicates from Calciner 7 over 1 week	As required
Boilers 2 & 6 (new low NO_x burners)	NO_x	USEPA Method 7E	Boiler stacks	12 over 2 months for each boiler	Monthly
	CO	USEPA Method 10	Boiler stacks	12 over 2 months for each boiler	Monthly
	SO_2	USEPA Method 6	Boiler stacks	12 over 2 months for each boiler	Monthly
	VOC	USEPA Method 18	Boiler stacks	4 duplicates over 10 months	As required
	Carbonyls	ECS Method 6	Boiler stacks	3 duplicates over 10 months	As required
Boiler 7 (existing low NO_x burner)	NO_x	USEPA method 7E	Boiler stack	Equipment not modified in PEU	Monthly
	CO	USEPA method 10	Boiler stack	Equipment not modified in PEU	Monthly
	SO_2	USEPA method 6	Boiler stack	Equipment not modified in PEU	Monthly
	VOC	USEPA method 18 or 30	Boiler stack	Equipment not modified in PEU	As required

Location	Species Monitored	Method	Location	Current Sampling Schedule	
				Performance Verification and Investigative Monitoring[13]	Ongoing Monitoring
Boilers 3, 4 and 5 (no modifications)	NO_x	USEPA method 7E	Boiler stacks	Equipment not modified in PEU	Monthly
	CO	USEPA method 10	Boiler stacks	Equipment not modified in PEU	Monthly
	SO_2	USEPA method 6	Boiler stacks	Equipment not modified in PEU	Monthly
	Trace metals	USEPA method 29	Boiler stacks	Equipment not modified in PEU	As required
45T Cooling tower	VOC	Methods 18 & 30	Tower 45T stack	Schedule to be determined by TDG investigators	As required

Appendix C

Independent Peer Review

PROJECT REVIEW

PINJARRA ALUMINA REFINERY EFFICIENCY UPGRADE

REVIEWER: JACK CHIODO - CH ENVIRONMENTAL

DATE: 28 DECEMBER 2006

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1 REVIEW SUMMARY

A review has been conducted of several reports documenting how Alcoa will meet its commitments for environmental improvements as part of the Pinjarra alumina refinery efficiency upgrade. This has involved reviewing three reports, viz the air quality management plan, the emission reduction plan, and the model validation reports, as well as related reports.

In general, the reduction plan and the management plan reports are adequate to meet the commitments reflected in the Ministerial Statement and the Works Approval. However, there are a number of issues relating to emissions variability, model validation, and area based sources that need to be addressed in order to improve the planned updating of the Health Risk Assessment. This will necessitate further analysis, which is beyond the scope of reviewed reports and the current review.

2 BACKGROUND

Alcoa is in the process of completing construction and commissioning of an efficiency upgrade to its Pinjarra alumina refinery that will see the plant capacity increase by 17% to 4.2 million t/y of refined alumina. The Company has in place a community consultation program as an integral part of the process for addressing community concerns and obtaining environmental approval. Reviews of project documentation by independent reviewers acceptable to the Stakeholder Reference Group form part of this process.

Accordingly, Alcoa has commissioned CH Environmental to undertake an independent review of various reports relating to the management of air emissions and air quality impacts from the upgraded refinery at Pinjarra. The primary reports forming part of this review are:

Emission Reduction Program, Alcoa, October 2006
Air Quality Management Plan Point Source (Stack) Emissions including appendices, Alcoa, October 2006,
Air Quality Model Validation Pinjarra Refinery, Air Assessments, October 2006

A number of other project reports are also of relevance for this review. These are:

Dust Management Plan for the Alcoa Pinjarra Bauxite Residue Disposal Area, Alcoa October 2006

Pinjarra Alumina Refinery Efficiency Upgrade Greenhouse Gas Management Plan, Alcoa 2006

Pinjarra Refinery Efficiency Upgrade – Air Dispersion Modelling, SKM, October 2003

Preliminary Draft Environmental Protection Statement, Sect 1-4, Environ, October 2003

3 FOCUS OF REVIEW

In seeking approval for the Pinjarra upgrade project, Alcoa made a number of environmental commitments which have been incorporated in Ministerial statement 646 and Works Approval 3927. These commitments include:

- An emission reduction program
- An air quality management plan documenting proposed source monitoring to demonstrate achievement of emission reductions
- A model validation study to test model predictions
- An upgraded health study to incorporate further monitoring data, and any changes in model predictions ensuing from the model validation study.

This review will therefore focus primarily on the extent to which the reports are consistent with, and explain the approach taken to meeting these commitments. A secondary aspect of the review is providing comment and suggestions for post commissioning environmental measurements and studies.

4 SUMMARY OF PREVIOUS REVIEW

CH Environmental previously reviewed the Air Quality Data Report, Environ, 2003, in December 2003, included as Appendix 2 of the Air Quality Management Plan report. A number of issues from that review are relevant to the current review and are summarised below, with further comment as appropriate.

4.1 HEAVY METALS

The metals content (and emission rates) of dust emitted from bauxite stockpiles, the Residue Drying Area, and cooling water ponds were not included in the analysis (modelling and Health Risk Assessment). In particular, ambient levels of Chromium, Cadmium, Mercury, and Magnesium from all sources (area and point sources) data need to be evaluated as input requirements for the planned upgraded Health Risk Assessment. Provision of source and ambient monitoring data on metals is a priority for the upgrade.

It is noted that the Dust Management Plan for the RDA refers to a WA dust study completed in April 2006 which includes as an objective the compilation of an intensive set of dust emissions data for the Pinjarra Upgrade Health Risk Assessment. It is presumed that this includes source and ambient data on metals. However, this is not clear, nor is it clear how this relates to the requirement in the ministerial statement[15]

The potential leaching of metals into ground and surface waters is beyond the scope of an air assessment, but needs to be borne in mind.

4.2 ODOURS

The documentation implies that odours from the plant impact the community, and state that planned VOC reductions will reduce impacts. Odour impact assessment is not considered in depth in the current documentation and hence in the current review.

Issues previously raised however remain relevant for ongoing odour management. These include: area source emissions of odour, odour quality and odour intensity considerations, and odour emission rates during plant upset conditions which are likely to greatly exceed the variability associated with production rate changes. By way of comment, it is difficult to imagine how a relatively small reduction in normal odour emission rates would have a substantial impact on any existing odour problem.

4.3 DATA FOR MODEL VALIDATION

Given the complexity in source emissions, and the interaction of complex terrain and coastal meteorology, a full model validation would require many more sites than proposed, or other methodology. Three monitoring sites as proposed in the SKM modeling report (SKM, October 2003) were established for model validation. Section 7 of this report discusses the subsequent model validation.

[15] *"Area source emissions: 1. Details of methods, quality/assurance/quality control procedures and sampling frequency for monitoring particulate emissions (including ultra fine particles), metals emissions from the Residue Disposal Area and stockpile area as recommended in the expert peer review of the Air Quality Data and Air Dispersion Modelling reports. This work shall also include an assessment of cumulative particulate emissions taking into account background levels and levels from other refinery sources."* Ministerial Statement 646

5 EMISSION REDUCTION PROGRAM REPORT

5.1 OVERALL COMMENT

The report provides a clear summary of expected changes to emissions from equipment and process changes resulting from the efficiency upgrade, and the expected environmental (largely health) impacts of the upgrade. It includes information on:

- Emissions that are expected to decrease and the methods whereby these reductions will be achieved
- Emissions that are expected to increase and the reasons for this
- A summary of the methodology and findings of the health risk assessment. There is a commitment to updating the health risk assessment (HRA) after plant commissioning.
- Planned research to explore further improvements on environmental performance

The report covers only point sources of emissions, and this is clearly stated. Area based sources eg, stockpiles and the RDA are discussed in other reports. Area source emissions have not been considered in the HRA and this is one of the reasons for it's updating.

5.2 SPECIFIC COMMENTS

5.1.1 Mercury.

Mercury is planned to increase in line with production, and there are no immediate plans for its reduction. In the US and Canada legislative trends are towards requiring emission reductions. It is noted that the health risk assessment of exposure to pollutants by inhalation indicates that mercury is the largest component of the acute hazard risk in the upgrade scenario, but that the individual component risk for mercury is low. The issue with mercury is bioaccumulation in the food chain, particularly fish. It is also noted that around two thirds of the listed mercury emissions come from the cooling lake emissions which have not been considered. This is one of the research areas that deserves priority attention.

5.1.2 Arsenic

Reductions of 70% - 80% in reductions via wet scrubbers on the oxalate kilns are worthy of note. The planned reductions should be readily achievable with properly designed and maintained scrubbers.

5.1.3 Nitrogen Oxides.

Refinery NO_x emission reductions of 40% – 50% overall are expected largely due to the installation of low NO_x burners at two boilers (60% reduction from these sources) and load relief resulting from the Alinta cogeneration stage 1 project. The combined reduction in NO_x (Alinta Stage 1 plus refinery upgrade) is expected to be 10% – 20%. Future plans involve stage 2 cogeneration at the Alinta plant and planned decommissioning of the refinery boilers.

5.1.4 NO_x Emission Data Anomalies

There are a number of inconsistencies in the NO_x and possibly other data in the various reports in which emission data are listed. The table below is a sample of data illustrating this point.

Average Emissions Given in Different Documents

Parameter	**Emission Reduction Program Document**		**AQMP Document Appendix 5**				
						AQMP – Gas turbine emissions	
	Baseline	Upgrade	Baseline	Upgrade	Gas Turbine Emissions	Baseline	Upgrade
NOx	49.89	27.48	64.28	49.02	28.9	35.38	20.12
CO	25.97	27.61	33.47	35.11	7.5	25.97	27.61
SO2	2.68	2.94	2.72	2.98	0.04	2.68	2.94
VOC	5.65	5.36	6.40	6.12	0.76	5.64	5.36
Acetaldehyde	0.75	0.70	0.77	0.71	0.02	0.75	0.69
Mercury	0.0127	0.0154	0.0127	0.0154	0.0	0.0127	0.0154
Arsenic	0.0033	0.00085	0.0034	0.00099	0.00014	0.0033	0.00085

The estimated emissions (except for NOx) in the AQMP document appear to reflect previous emission estimates (which included emissions from the two stage Alinta project) minus the Alinta emissions. For NOx, Alinta project emissions do not explain the differences. The reasons for this are not evident, but could be related to the staging of the gas turbine units.

Further, emissions from the 7th calciner planned for the upgrade do not appear to have been included anywhere in the current estimates, although it is noted that VOC emissions from the 7th calciner are proposed to be included in a revised HRA.

These apparent NOx anomalies need to be clarified or explained and any adjustments obviously also need to be included in the modelling work that may be undertaken for the HRA.

5.1.5 VOC and Acetaldehyde

Relatively small reductions in VOC and Acetaldehyde are projected due to the installation of RTO's on the oxalate kiln and the digestion system. Acetaldehyde, which has been previously identified as an indicator of odour emissions[16], is not separately discussed.

Research on reducing emissions of VOC and odour (including acetaldehyde and Ammonia) from condensates is included in the list of current research proposals. The calciners were a major source of VOC, Acetaldehyde, (and odour), and increases in emissions of these substances from these sources are projected in the refinery efficiency upgrade. The other major sources are the Cooling tower, and potential VOC emissions from the cooling pond(s) which has not been considered.

Odour impacts are a function of release height and emission rates, as well as other variables such as odour quality and intensity. Alcoa is proposing further research into odour reductions from the refinery, and should consider including further investigations of the calciners, the cooling tower, and cooling pond(s) in the research program. Emission reductions from the upgrade are unlikely to significantly affect odour impacts.

5.1.6 Dioxins and Furans

Alcoa is of the view that changes in additives to the oxalate kill will result in no emissions of these substances from the refinery, and intends to conduct a sampling an analysis program to verify this. This is an appropriate course of action.

5.1.7 Other substances and issues

The description and planned actions relating to other substances, including formaldehyde are appropriate. As a minor editorial issue, the Table of Contents needs to be updated as it not consistent with the pagination in the report.

6 AIR QUALITY MANAGEMENT PLAN REPORT

This report consists of the main report and the following appendices:

16 Coffey PS et al, Appendix C of the Air Quality Management Plan Report

1. Regulatory Approval Conditions:
   - Extracts from Ministerial Statement 646
   - Extracts from Works Approval 3927
2. *Air Quality Data Environmental Protection Statement*, Environ, October 2003
3. Summary of Point Source Monitoring Program
4. Baseline Emissions Data **-** Peak and Average
5. Predicted Efficiency Upgrade Emissions **-** Peak and Average
6. *Health Risk Assessment*, Toxikos, October 2003.

6.1 MAIN REPORT

6.1.1 General

The purpose of the Air Quality Management Plan (AQMP) report is clearly stated as documenting the existing emission monitoring plan and updating it to include additional monitoring ensuing the refinery efficiency upgrade. The plan deals only with point source monitoring, and excludes targeted emission reductions, ambient dust management and monitoring, greenhouse gases, and the Alinta cogeneration facility.

The report could therefore be more correctly titled a Point Source Monitoring Plan to avoid confusion with the more commonly understood meaning of an AQMP that would include monitoring, emission management measures and operational systems.

The report provides a clear context for the monitoring program including summaries of the emission reduction commitments, sources of emissions and contributions to total emissions, and the monitoring and health risk assessment. Table 1 showing the contribution of various sources to specific pollutants is a very useful indication of the emission reduction potential.

The methodology for assessing emission reduction commitments is clearly documented. The approach taken in dealing with major sources is sound, and that for grouping minor sources is also logical. Overall, the measurement program is appropriate for comparing post upgrade emissions with pre-upgrade emissions to assess compliance with reduction commitments, which is a main objective of the monitoring program.

As an editorial issue, Fig 1 is blurred and difficult to read. Figures 2 and 3 are too small and indecipherable. The final documentation should remedy these flaws, perhaps by fold out A 3 size diagrams.

Monitoring Phases

There are four monitoring phases in the body of the report, but only three in the executive summary, and these should be consistent to avoid confusion. The commissioning phase is about testing the monitoring equipment. It is extremely important for this to be carried out, but probably warrants discussion separately from the actual monitoring.

The logic of progressing from more intensive verification monitoring to less intensive routine monitoring is sound in principle. The rationale for the number of samples in any of the phases is however not given, which makes it difficult to assess its adequacy. A preliminary conclusion is that the amount of monitoring appears comparable to previous monitoring effort and will therefore be adequate for assessing emission reductions under steady state average and peak production rates to which the commitment relates.

A subsidiary initial conclusion is that the proposed monitoring program is probably not adequate for assessing minute to minute and hour to hour emission changes under process upset conditions. Information on short term variability goes beyond the scope of the current report, but would be extremely useful in dispersion model validation studies.

A further issue relates to emissions data on metals, and specifically Cadmium and Chromium 6. Alcoa is of the view that these metals will not be emitted. It would be desirable that their presence or otherwise be tested in Performance verification monitoring.

Oxalate Kiln Monitoring.

It is not clear whether the 24 samples from the RTO inlet and outlet refer to, eg does it mean 24 samples each from the inlet and outlet, and 24 samples each for the two methods.

Digestion RTO Stack

As for Oxalate Kiln on sample size.

45T Cooling Tower

The difficulties in measuring VOC emissions from the cooling tower are noted, as is the projected increase in VOC following the upgrade. Mass balances do not capture the variability in emissions associated with upstream process variables and upsets, but measurement methods relying on sampling and analysis are also problematic.

Modelling wet plumes for odours and trace components is difficult, and uncertainties in emissions make the task even more difficult. The undertaking by Alcoa to further investigate monitoring and emission reductions methods from the cooling tower is well worth while, given its contribution to VOC emissions. The biennial mass balance estimation of emissions seems infrequent at first glance. It would be useful to explain the rationale for this. It would also be useful to know whether the mass balance is based on evaporative loads only, or includes liquid entrainment losses.

Emission Standards Anomalies

There are a number of apparent anomalies in stated emission commitments and standards, as indicated below.

Oxalate Kiln Stacks

Particulate emissions from the RTO are given on page 14 as 20 mg/m^3 or less and 0.55 g/s or less

Page 15 refers to an operating limit of 250 mg/m^3 under normal operating conditions.

The Emission Reduction Report gives upgrade normal emission rate from the oxalate kiln for dust as 0.047 g/sec

Calciners

Page 19 refers to 80 mg/m^3 for calciners 4, 5, and 6, and 30 mg/m^3 for calciner 7

Page 20 refers to an existing license limit of 250 mg/m^3 under normal operating conditions.

There is a need to explain these apparent anomalies. There is clearly some consideration of variation in emissions from normal but this needs an explanation. In particular, the expected frequency of variation from normal, the frequencies of the variations, and the implications for modelling and HRA studies warrant comment. The more than 10 fold variations for the oxalate stack given the peak to mean assumption seems excessive.

6.2 ENVIRON REPORT - APPENDIX 2

This has been reviewed previously. Relevant comments have been discussed above in section 4. No further comment is provided here.

6.3 HEALTH RISK ASSESSMENT - APPENDIX 6

The HRA was previously reviewed by other reviewers in December 2003. Detailed comment on the methodology is therefore unnecessary. A number of issues relating to the adequacy of the input data supplied to the HRA have arisen during and subsequent to the HRA and other reviews. These potentially affect the conclusions of the HRA and comments are therefore provided.

Data used in HRA was in the form of peak and 95% dispersion model 1-hour and annual average predictions at four locations, one of which was representative of the location with the highest predicted levels. The predicted values for each pollutant were compared with health based guideline values from regulatory agencies according to enHealth specified priority, or derived according to published accepted protocols.

The emissions modelled were for the refinery in isolation and excluded emissions from other sources. However, a number of highly conservative assumptions were made in the assessment, and potential population exposure, i.e. how many people are exposed to various pollutant levels and for what period, was not undertaken.

The HRA is therefore a screening assessment, of potential incremental health risks from refinery emissions, and should be seen as such. If predicted values are below the criterion value for a pollutant, the probability of an adverse health effect is very low, and no further assessment is necessary, provided background levels are also low. If the predicted values are above the criteria, then further analysis may be needed, depending on various factors including the extent, frequency, and duration of the exceedences, the level of conservatism in the assumption, background levels, and the potentially exposed population.

Only point sources of emissions were modelled and area based sources were excluded. This is particularly relevant for metals, given that Alcoa are of the view that the incoming metals predominantly end up in the residue heaps and the cooling water ponds and systems.

Issues with the data are discussed in sections 4 and with the model predictions in section 7 of this report. The model validation studies indicate that the model used under predicts levels in some locations and over predicts levels in other locations, and despite considerable effort, the issue has not been fully resolved.

The model and data issues have obvious implications for the degree of confidence that can be place on the conclusions about potential health impacts. It is planned to update the HRA using the results of further measurements, modelling, and analysis. At this stage, it is not possible to be definitive as to whether the current HRA conclusions will be confirmed or otherwise in the updated HRA.

It would be highly desirable that the monitoring, HRA, and modelling personnel liase very closely on the type, quantity, and quality of data needed to meet their respective objectives. This may result in changes to the sequencing and timing for the various projects. It may be possible to base the HRA on measurement data, but obtaining such data would be very data intensive and probably prohibitively expensive, and not warranted unless modelling fails to deliver information of the requisite quality.

7 MODEL VALIDATION REPORT

GENERAL

A substantial amount of work has obviously been put into the model validation and this is reflected in the report. The validation has included a number of aspects. including:

- Review of the ambient monitoring data
- Comparison of model predictions and monitoring data
- Model adjustments
- Further Studies

7.1 MONITORING DATA REVIEW

Data from three monitoring stations were available for the review, one North east of the refinery representing highest hazard rating (from the HRA), the other 2, West and North west, representing potentially exposed populations. The data were adjusted by removing suspect values to produce a valid data set for the analysis. Further adjustments to the data were made to remove influences form other sources, so comparisons with refinery emissions could be made. Air quality parameters measured were CO and NOx, with the analysis focussing on NOx.

Meteorological data were similarly reviewed. The main meteorological data source was a meteorological station south of the refinery at Oakley South. The anemometer had limitations at low wind speeds making low wind speed data (less than 1 m/sec), inaccurate.

The data were compared to ambient NEPM health based standards and WHO vegetation standards and indicated full compliance by substantial margins in all cases.

7.2 MODEL COMPARISONS

Comparisons of observed data were made with predictions from Ausplume, CALPUFF, and TAPM. Comparisons were made of various statistics including predicted maxima, 99.9%, 99%, 95%, 90%, 99%, and the top 20 events. Events' analysis was also undertaken.

The overall outcome of the analysis was that for all three models, there was substantial apparent over prediction at the north east site (on the escarpment) and substantial apparent under prediction at the coastal plain sites. The analysis also showed that the highest values predicted occurred under light wind conditions, and usually in the late evening through the night and early morning.

Based on observed wind direction data, a number of high events were ascribed to other sources, with diesel trains identified as a possible source.

It is worth noting that:

- High levels are generally associated with light winds, where measurement of wind speeds and directions are least reliable.
- NO_2/NO ratios are generally high, indicative of aged pollutants, and possible recirculation.
- The meteorology of the region is complex, with land/water interfaces, coastal and elevated flow interactions, and observed wind rotors.
- In relation to emission sources, the hourly emission rates have been generated from daily average rates and the emissions therefore do not reflect process variations.
- As a related issue, NO_2/NO for the top 20 NOx levels at the three monitors ranged from 0.12, to 1.0, which suggests that the commonly assumed value of 0.1 as an input to non-reactive plume models is tenuous.

Under these conditions model validation is difficult, and conclusions about the reasons for the variation and potential sources must be seen as hypotheses to be tested by further measurements and analysis rather than firm conclusions.

Model adjustments

Various adjustments (model "tuning") were made in an attempt to match model predictions with observations. The adjustments were tested on the CALPUFF model. None of the changes made were able to resolve the differences, although differential improvements occurred at the different sites.

Train emissions were estimated and included in the models. Substantial improvements occurred in some cases. There are however some doubts as to whether the train emissions were correctly estimated and parameterised in the models, and it is not clear whether trains operate all through the night, which makes the noted improvements in model performance tenuous. (The train operating hours may have been checked).

"Tuning" the model can improve predictions to some extent. However, the improvements may only apply to the specific circumstances, and to the emissions configuration tested. The model tuning was based on elevated sources of NOx emissions only and for the three monitored locations. Dispersion from low-level sources may be different, and the meteorology and influences at other locations may also differ significantly from the test sites.

Further Studies

It is clear from the analysis, and from an understanding of modeling limitations, that model validation was going to be extremely difficult with the available dataset. The data set is insufficient to match model predictions in space, and even less adequate for matching predictions in time. The limitations arise from:

- Complex wind flows associated with complex terrain and sea/land interfaces
- Inaccurate wind measurements at low wind speed
- Uncertainties with stack emission variability
- Uncertainties about other emission sources.

Other comparisons that could have been made include CO comparisons, and predicting model distributions at multiple locations and assessing whether a location can be found at which the predicted distribution matches the monitored distribution at one of the monitored sites. It is however unlikely that validation would be successful.

The report makes a number of recommendations for improving the model validation. These are soundly based and generally endorsed. More accurate determination of the windfield is particularly important, and a network of surface (10 m) anemometers, complemented by several elevated anemometers and vertical wind structure measurements would be highly desirable. Alternative approaches using plume signatures (if these can be developed) or tracer gases may also be considered, but these are resource intensive and difficult to conduct.

Consideration could be given as to what error bars would be acceptable for the HRA as conducted, i.e. a screening assessment, or whether alternative HRA approaches that may compensate for data limitations are possible. This would require close liaison between HRA, modelers, and measurement personnel as previously stated.

Jack Chiodo

28/12/2006.

Appendix D

Base Case Emissions Summary (average emission rates)

and

Sample Port Identifications and Locations

Appendix D: Pinjarra Refinery Air Emissions - Baseline Case at Average Emissions (from SKM, 2003)

	Sample Port			Temp.	Stack Diameter	Velocity	NO_x	CO	SO_2	Dust	VOC	Acetone	Acetaldehyde	Formaldehyde	2-Butanone	Benzene	Toluene	Xylenes	PAHs	Mercury	Arsenic	Selenium	Dioxins & Furans(ITEQ)	Ammonia	Manganese & Compounds	Cadmium & Compounds	Nickel & Compounds
	Identification	Location																									
		Northing	Easting	(°C)	(m)	(m/s)	Emission Rate (g/s)																				
Combustion Equipment Point Sources:																											
Oxalate Kiln	Oxalate Kiln Stack	6387750.901	401144.558	65	1	7.6	0.08	1.31	0.022	0.263	1.53E-01	1.05E-01	1.87E-02	1.04E-02	3.20E-03	2.10E-03	3.19E-03	3.41E-04	7.46E-05	1.62E-03	3.17E-03	2.27E-03	2.35E-10			7.13E-05	7.13E-05
Calciner 1	Calciner 1 Stack	6387128.606	400678.601	158	1.537	32.1	1.03	1.56	0.228	0.363	3.02E-01	1.16E-01	7.19E-02	8.15E-02	6.09E-03	3.18E-03	1.21E-03	2.31E-04	1.23E-04	1.35E-04							
Calciner 2	Calciner 2 Stack	6387128.530	400670.604	159	1.537	33.1	0.99	10.35	0.563	0.917	3.11E-01	1.20E-01	7.40E-02	8.39E-02	6.27E-03	3.27E-03	1.24E-03	2.38E-04	1.27E-04	1.35E-04							
Calciner 3	Calciner 3 Stack	6387128.311	400647.611	155	1.537	30.9	2.25	1.92	0.419	0.487	2.93E-01	1.13E-01	6.98E-02	7.91E-02	5.92E-03	3.08E-03	1.17E-03	2.25E-04	1.20E-04	1.35E-04							
Calciner 4	Calciner 4 Stack	6387129.234	400639.604	166	1.829	15.8	0.67	2.57	0.248	0.534	2.11E-01	8.11E-02	5.02E-02	5.68E-02	4.25E-03	2.22E-03	8.41E-04	1.62E-04	8.59E-05	1.35E-04							
Calciner 5	Calciner 5 Stack	6387129.024	400617.612	175	1.829	16.4	1.91	2.6	0.237	0.658	2.15E-01	8.28E-02	5.12E-02	5.80E-02	4.34E-03	2.26E-03	8.59E-04	1.65E-04	8.77E-05	1.35E-04							
Calciner 6	Calciner 6 Stack	6387128.948	400609.614	172	1.829	22.1	2.84	4.04	0.4	1.876	2.91E-01	1.12E-01	6.94E-02	7.87E-02	5.88E-03	3.07E-03	1.16E-03	2.24E-04	1.19E-04	1.35E-04							
ALD	ALD Stack	6387077.460	400557.118	77	1.5	15	1.41	0.09	0.054	1.014	2.47E-01	1.64E-01	1.55E-02	6.64E-03	4.18E-03	2.40E-05	1.17E-03										
Boiler 2	Boiler 2 Stack	6387266.640	401105.184	120	3.05	7.7	8.22	0.69	0.259		6.11E-02	1.45E-02		1.29E-02	2.88E-03	2.09E-05	7.89E-06				2.58E-05				1.93E-03		
Boiler 5/6/7	Boiler 5, 6 & 7 Stack	6387248.588	400994.382	138	4.37	8.1	15.97	0.84	0.251		1.28E-01	3.02E-02		2.69E-02	6.01E-03	4.37E-05	1.65E-05				5.37E-05				4.03E-03		
Non Combustion equipment Point Sources																											
Oxalate Belt filter Vacuum Pump (OBF)	OBF Vacuum Pump vent	6387723.500	401144.558	60	0.9	8					3.94E-02	3.06E-02	4.03E-03		4.03E-03		1.39E-04	4.17E-04									
Calciner 4 - 6 Vacuum Pump	Calciner Vacuum Pump Stack 4-6 West	6387131.043	400619.592	50	0.6	2.5					1.26E-01	7.46E-02	2.82E-02		5.46E-03	1.87E-04	1.45E-03	1.18E-04	6.04E-06								
Calciner 1 -3 Vacuum Pump	Calciner Vacuum Pump Stack 1-3 East	6387131.434	400660.578	50	0.6	2.5					1.26E-01	7.46E-02	2.82E-02		5.46E-03	1.87E-04	1.45E-03	1.18E-04	6.04E-06								
ALD Vacuum Pumps	ALD vacuum pump Stack	6387078.507	400562.106	60	1	0.6					8.14E-02	4.68E-02	1.89E-02		4.13E-03	1.16E-05	1.10E-03	9.47E-05	2.41E-06								
45T Cooling Tower	45T Cell 4	6387362.242	400436.431	30	17	11.9					1.33E+00	1.05E+00			2.33E-01		9.22E-04			5.39E-05							
ALD Cooling Tower	ALD Cooling Tower Cell 2	6387105.194	400529.860	30	7.21	10					2.90E-01	2.11E-01	4.89E-02	2.22E-03	1.78E-02	3.33E-05	2.00E-04										
Grouped Sources:																											
25A Slurry Storage Tanks	24AS1 Tank vent	6387360.088	401364.231	90	0.255	15.5					2.45E-01	7.92E-02	7.41E-02		1.30E-02	1.47E-03	1.79E-02	1.21E-03	1.03E-04	9.48E-04		1.25E-04		1.60E-01	1.33E-03		2.08E-04
25A/C Droppers				100							4.39E-02	2.31E-02	1.26E-02		3.36E-03		6.94E-04	3.33E-05									
Excess BO - Pressure Relief Tanks & Containment Tanks	Digestion Pressure Relief Tank Vent U2 Digestion Containment Tank Vent U1, 3 & 5	6387491.701 6387428.266	401326.986 401384.577	100	0.755	3.2					3.95E-02	2.11E-02	8.97E-03		3.28E-03	5.56E-05	6.69E-04	6.25E-05		2.28E-04	2.22E-05	4.44E-05		3.44E-01	6.44E-03		4.78E-04
Digestion Vacuum Pumps	Digestion Vacuum Pumps U1-3 Vent Digestion Vacuum Pumps U4-5 Vent	6387439.100 6387439.472	401367.477 401406.465	50	0.154	6.5					5.27E-01	1.16E-02	3.69E-02		1.10E-02	7.34E-02	2.73E-01	3.20E-02	1.35E-04		3.34E-07	6.05E-05		8.19E-01	4.58E-07	4.58E-07	1.53E-06
B34 A-Rakes	Not sampled, estimated from digestion containment tank vent U1, 3 & 5			60	0.6	0.02					1.09E-02	5.81E-03	2.47E-03		9.01E-04	1.53E-05	1.84E-04	1.72E-05									
B40 Heat Interchange Vacuum Pumps	Heat Interchange vacuum pump U 4 & 5 vent	6387444.001	401042.508	50	0.154	4					3.70E-02	3.11E-03	4.12E-03		2.56E-03	2.13E-04	1.55E-02	1.78E-03	5.48E-04		4.35E-07	1.36E-05			4.90E-07	3.33E-07	1.16E-06
B42 Evaporator Vacuum Pumps	Evaporator vacuum pump U5, 6 & 7 vent	6387542.806	401024.570	55	0.078	13.1					2.92E-03	7.87E-04	5.73E-04		3.73E-04	7.87E-04	2.27E-04		1.73E-04		1.33E-07	2.27E-06					
35F Mud Thickener & 35D Filter Feed Tanks	35F21 tank vent 35D1 tank vent	6387649.126 6387667.796	401375.473 401341.303	98	0.255	6.4					1.09E-01	2.69E-02	1.14E-02		6.43E-03	1.14E-04	1.46E-02	8.81E-03	7.44E-04								
35A Filtrate Tanks	35A4 tank vent	6387720.168	401171.844	92	0.305	3					5.46E-02	1.34E-02	6.42E-03		3.58E-03	6.67E-05	7.54E-03	3.42E-03	3.33E-04								
Misc OC2 Liquor Tank Vents Oxalate seed heating tanks (35S) Washer overflow tanks (35H)	35S1 tank vent 35H1 tank vent	6387615.164 6387665.532	401168.846 401628.257	97	0.248	19.5					1.82E-01	4.47E-02	2.14E-02		1.19E-02	2.22E-04	2.51E-02	1.14E-02	1.11E-03								
35C Mud Washer Tanks - Banks 1-2	35C11 tank vent	6387645.425	401616.451	97	0.255	14					7.58E-02	3.08E-02	9.45E-03		1.43E-02	1.32E-04	5.15E-03	2.16E-03	2.11E-04								
35C Mud Washer Tanks - Banks 3-5	35C11 tank vent	6387645.425	401616.451	97	0.255	14					1.14E-01	4.62E-02	1.42E-02		2.15E-02	1.99E-04	7.73E-03	3.25E-03	3.17E-04								
Area Sources:																											
Fresh Water Storage Lake (area source)	Not applicable		Not applicable																	9.00E-03							
Point Source total							**35**	**26**	**2.7**	**6.1**	**5.6**	**2.7**	**7.52E-01**	**4.97E-01**	**4.11E-01**	**9.64E-02**	**3.84E-01**	**6.65E-02**	**4.43E-03**	**3.66E-03**	**3.27E-03**	**2.52E-03**	**2.35E-10**	**1.32E+00**	**1.37E-02**	**7.21E-05**	**7.60E-04**
Total							**35**	**26**	**2.7**	**6.1**	**5.6**	**2.7**	**7.52E-01**	**4.97E-01**	**4.11E-01**	**9.64E-02**	**3.84E-01**	**6.65E-02**	**4.43E-03**	**1.27E-02**	**3.27E-03**	**2.52E-03**	**2.35E-10**	**1.32E+00**	**1.37E-02**	**7.21E-05**	**7.60E-04**

Note 1: For a discussion on the substances included under PAHs refer to the PEU Environmental Protection Statement, Environ (2003)

Note 2: This plan summarises the emissions for the refinery only. Totals differ from those published in SKM (2003) because the Alinta Cogeneration emissions have not been included in this table

Note 3: Peak emissions have also been estimated for the Baseline scenario – refer to SKM (2003) for details