

**Pinjarra Alumina Refinery Efficiency Upgrade**

**Alcoa World Alumina Australia**

**Emission Reduction Program**



**December 2007**

## **FOREWARD**

This document has been prepared in accordance with Ministerial 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:

The Environmental Manager  
Alcoa World Alumina Australia  
Pinjarra Refinery  
PO Box 172  
Pinjarra WA 6208

or by email to: [ian.lockley@alcoa.com.au](mailto:ian.lockley@alcoa.com.au)

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

*This Emission Reduction Program (ERP) documents the emission control technology that will be installed to minimise point source emissions as part of the Pinjarra Efficiency Upgrade Project (the Efficiency Upgrade).*

*Where installation of emission control technology is not considered practicable as part of the Efficiency Upgrade, this ERP outlines a program of investigations to be implemented after project completion. These investigations are aimed at improving knowledge about refinery emissions and their impacts, to determine if future application of control technology is practicable.*

*In particular, the Program meets the requirements of Condition 7 of Statement No. 000646 of the Minister for the Environment of the Government of Western Australia, dated 3 March 2004, to develop an Emission Reduction Program that addresses:*

- *Emissions likely to increase as a result of the upgrade (Condition 7-1.1).*

*VOC's: 2-butanone and acetone*

*Other Gases: Ammonia (NH<sub>3</sub>), carbon monoxide (CO), sulphur dioxide (SO<sub>2</sub>) and dioxins & furans*

*Metals: Manganese and selenium*

- *Emissions of mercury, arsenic and NO<sub>x</sub> (Condition 7-1.2);*
- *Practicable methods of reducing formaldehyde emissions from the refinery (Condition 7-1.3)*

*A key document associated with this Emissions Reduction Program is the Alcoa Pinjarra Health Risk Assessment which used dispersion modelling and ground level sampling to identify the potential for acute, chronic and carcinogenic risks associated with emissions from the refinery. This risk based approach compared the predicted estimates for each compound to the relevant health standards and concluded that there is "little likelihood of health effects being caused by either acute or chronic exposure of the general public to refinery emissions from the Alcoa Pinjarra Refinery"(Toxikos 2003).*

*This program is focused on point source emissions. Area source emissions are addressed in the Air Quality Management Plan, Dust Management Plan and the Long Term Residue Management Strategy which were also prepared as a requirement of Ministerial Statement 000646.*

## **1 INTRODUCTION**

### **1.1 BACKGROUND**

The Alcoa Pinjarra Refinery is located within the Shire of Murray in the Peel region south of Perth, Western Australia and is approximately 6 km east of the Pinjarra town site. The refinery is located on industrial-zoned land owned by Alcoa. The area incorporates the refinery, the residue drying areas (RDAs) and surrounding freehold land, occupying a total area of 6,086 ha. The land surrounding Alcoa's property is predominantly rural, with most of the region between the South Western Highway and the Darling Scarp cleared of natural vegetation. The major agricultural activities in the region are beef and dairy cattle and sheep grazing.

Pinjarra Alumina Refinery uses the Bayer process to produce approximately 3.5 million tonnes per annum (Mtpa) of alumina. The efficiency of the refinery is being upgraded to increase alumina production capacity to approximately 4.2 Mtpa. The majority of the increase will come from yield increases in the precipitation process primarily as a result of the Alcoa Pinjarra Efficiency Upgrade Project (Efficiency Upgrade) and approximately 100,000 t from other efficiency gains.

In addition to production efficiency improvement, a key focus of the Efficiency Upgrade is to identify and where practicable reduce refinery emissions to air.

Approval to proceed with the project was granted by Ministerial Statement No. 000646. Condition 7 of Statement 000646 requires the development of Emission Reduction Program (ERP) (see Appendix A for a complete list of the condition specified by the Minister for the Efficiency Upgrade).

## 1.2 PURPOSE

This Emission Reduction Program (ERP) has been developed to address:

- Emissions likely to increase as a result of the upgrade<sup>1</sup> (Condition 7-1.1).
  - VOCs: 2-butanone and acetone
  - Other Gases: Ammonia (NH<sub>3</sub>), carbon monoxide (CO), sulphur dioxide (SO<sub>2</sub>) and dioxins & furans
  - Metals: Manganese and selenium
- Emissions of mercury, arsenic and Nitrogen Oxides (NO<sub>x</sub>) (Condition 7-1.2);
- Practicable methods of reducing formaldehyde emissions from the refinery (Condition 7-1.3)

This document also outlines;

- the community and stakeholder consultation and expert peer review processes used by Alcoa during the development of the program (Condition 7-1(a) & (b)); and
- the process that will be used to allow for adaptive management, regular reviews and update (Condition 7-1(c)).

## 1.3 SCOPE

This ERP documents the emission control technology that will be installed to minimise point source emissions as part of the Efficiency Upgrade.

Where installation of emission control technology is not considered practicable as part of the Efficiency Upgrade, this ERP outlines a program of investigations to be implemented after project completion. These investigations are aimed at improving knowledge about refinery emissions and their impacts, to determine if future application of control technology is practicable.

This plan forms a separate project-related management plan beneath the Air Quality Management Plan (AQMP) required by Condition 6 of Ministerial Statement 000646, under which all emissions to air are managed. This Program does not document ongoing management and monitoring processes for the emission controls installed as part of the Efficiency Upgrade. Details of the emissions monitoring and management processes for emission control equipment are provided in the AQMP. The implementation of the AQMP will provide information to assess performance against this Emission Reduction Plan.

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<sup>1</sup> Compounds were identified for inclusion in the Emission Reduction Program by comparing the estimated refinery peak and average emissions for the baseline (pre-upgrade) and upgrade scenarios (SKM, 2003). Any compound predicted to have an increase in either peak or average emissions were included if they were not specifically referenced in Condition 7 of Ministerial Statement 000646.

The Emission Reduction Program is linked to Pinjarra Refinery's Environmental Management System (EMS) which is certified to ISO14001.

#### **1.4 LEGISLATIVE, POLICY AND OTHER REQUIREMENTS**

The Pinjarra Refinery Environmental Licence and the Efficiency Upgrade Project Works Approval (WA No's. 3927 and 4391 as re-issued on 25 October 2007) set emission targets and limits for some of the emissions addressed in this Emission Reduction Program.

The National Environment Protection Council (NEPC) has produced the following national ambient air quality guidelines for the protection of human health:

- The National Environmental Protection (Ambient Air Quality) Measure (NEPC, 1998 & NEPC, 2002) which sets national air quality standards for the criteria pollutants (carbon monoxide, nitrogen dioxide, photochemical oxidants (as ozone), sulphur dioxide, lead and particulates (as PM<sub>10</sub> and PM<sub>2.5</sub>).
- Draft National Environment Protection (Air Toxics) Measure (NEPC, 2003) which proposes Investigation Levels for the air pollutants benzene, benzo(a)pyrene (as a marker for Polycyclic Aromatic Hydrocarbons [PAH's]), formaldehyde, toluene and xylenes.

There are no ambient air quality guidelines for some of the emissions addressed in this Program. A quantitative health risk assessment has been conducted to assess impacts against health guidelines (refer section 2.3).

## **2 REFINERY EMISSIONS**

The main point sources of emissions to air from the Pinjarra refinery are combustion processes, in particular the powerhouse boilers, calciners and oxalate kiln. These all produce CO, CO<sub>2</sub>, NO<sub>x</sub>, and some Volatile Organic Compounds (VOCs), as well as water vapour. Some of these sources, in particular the calciners and kilns, 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 volatile 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 including flocculants and dewatering aids.

Metals such as mercury, arsenic and selenium are introduced to the Bayer process primarily through trace amounts present in the bauxite ore. The current knowledge indicates the majority of metals are re-circulated as metal ions or complexes in the caustic liquor stream or deposited with the residue as oxides, hydroxides or salts, or unchanged in their original mineral form. The exception to this is mercury which can exist as a vapour. Trace amounts of metals can be present in emissions from various point sources at the refinery.

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.

### **2.1 PREDICTED EMISSION CHANGES RESULTING FROM THE EFFICIENCY UPGRADE**

The Efficiency Upgrade will involve both process changes and the installation of emission control equipment to reduce emissions from key areas of the refinery. The Efficiency Upgrade is predicted to achieve reductions in some atmospheric emissions (due to the installation of emission control technology) and increases in other emissions (in proportion to the increase in production capacity).

During the feasibility and planning phase of the Efficiency upgrade, an inventory of refinery emissions was developed and published in the Environmental Protection Statement (Environ, 2003). Two emission scenarios were considered:

Baseline scenario: representing emissions from Pinjarra Refinery prior to the Efficiency Upgrade for the 2002-2003 year.

Upgrade scenario: representing predicted emissions from the Pinjarra refinery after the Efficiency Upgrade.

Figure 1 illustrates the percent change in total refinery emissions for the Upgrade scenario compared to the Baseline scenario.

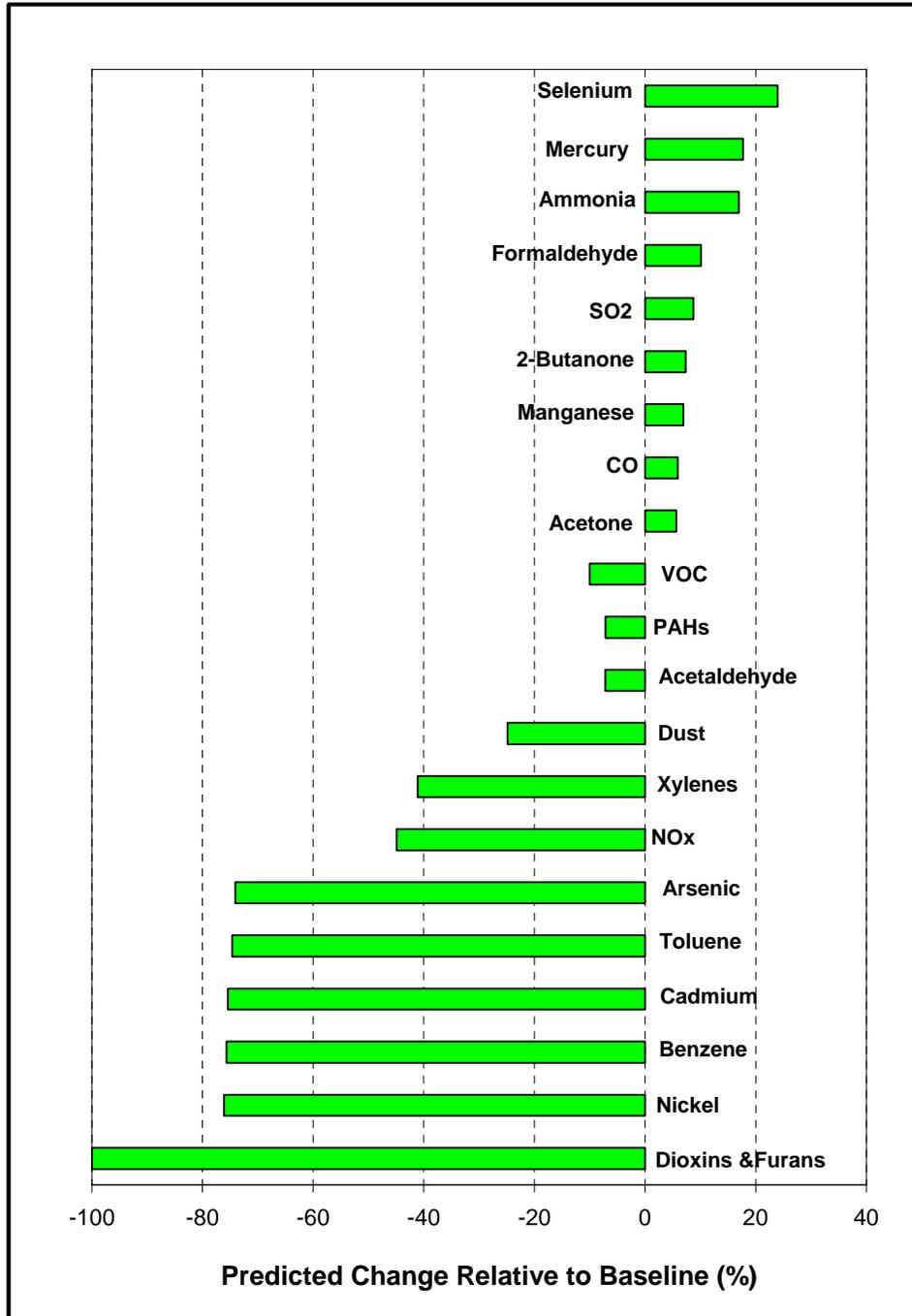


Figure 1: Predicted % Changes in Pinjarra Refinery Annual Emissions after the Efficiency Upgrade

It should be noted that the information presented in the tables and figures within this document are based on the Baseline and Upgrade scenario's as defined during the planning stages of the Efficiency Upgrade in 2003. Subsequent and ongoing investigations will provide additional information which will lead to improved understanding of the refinery emissions profile. The Baseline and Upgrade scenario's will be updated accordingly and in due course, and any implications for the emissions will be incorporated into future programs through the ERP review process outlined in section 4.

## 2.2 EFFICIENCY UPGRADE AIR QUALITY IMPACT ASSESSMENT

As part of the impact assessment process for the Efficiency Upgrade, air quality impacts were assessed using atmospheric dispersion modelling techniques to predict the maximum ground level concentration of pollutants at nearby residences. These ground level concentrations were compared to the relevant ambient air quality guidelines (for those pollutants covered in the NEPMs - refer section 1.4).

Table 1 presents the maximum and annual ground level concentrations of the criteria pollutants addressed in this ERP, generated from the atmospheric dispersion modelling for the Efficiency Upgrade scenario and compares these to NEPM guideline values where these exist. This assessment suggests that the predicted ground level concentrations of these emissions after the Efficiency Upgrade would remain well within the relevant ambient air quality guidelines (Environ 2003).

**Table 1: Maximum and Annual Average Ground Level Concentrations Predicted at the Receptor Location Associated with the Highest Potential Impact**

<b>Emission</b>	<b>Averaging Period</b>	<b>Predicted Concentration (mg/m<sup>3</sup>)</b>	<b>Percent of NEPM Guideline</b>
Nitrogen dioxide	1-hour	144.1	58.6
	Annual	1.70	2.7
Carbon monoxide	8-hour	95.0	0.8
Sulphur dioxide	1-hour	33.4	5.8
	24-hour	3.98	1.7
	Annual	0.19	0.3
Formaldehyde	24-hour	0.84	5.0

## 2.3 HEALTH RISK ASSESSMENT

After consultation with the Department of Health a quantitative health risk assessment was conducted by independent specialists Toxikos Pty Ltd to examine the potential health impact of emissions from the Efficiency Upgrade to the population working at and residing near the refinery (Toxicos, 2003).

The Health Risk and Toxicological Assessment compared the Baseline scenario with the Upgrade scenario. Modelled ground level concentrations were assessed at fourteen residential receptor locations. In order to assess the air quality impacts associated with potential acute (short-term) and chronic (long-term) exposure, emissions associated with daily peak and annual average plant activity were modelled for both the 'Baseline' and 'Upgrade' scenarios (Toxikos, 2003). Four locations were selected to reflect worst case exposure situations for each locality. The potential health impacts were assessed by comparing predicted ground level concentrations with health based air guideline values<sup>2</sup> for the individual emission components.

In each case the predicted ground level concentrations of modelled substances were found to meet accepted health risk criteria.

For emission components that are listed as carcinogens, the carcinogenic risk from an assumed life time exposure was calculated and compared with a target risk of below one in a million of developing cancer<sup>3</sup> (Toxikos, 2003). The carcinogenic substances in Pinjarra Refinery emissions incorporated into the assessment included acetaldehyde, benzene, cadmium, nickel, polyaromatic hydrocarbons (PAHs), arsenic and vinyl chloride.

The non-carcinogenic emissions considered within the assessment include NO<sub>x</sub>, NO<sub>2</sub>, CO, SO<sub>2</sub>, acetone, 2-butanone, formaldehyde, mercury, selenium, ammonia and manganese. A complete list of compounds considered in the health risk assessment is contained within Toxikos (2003), Health Risk and Toxicological Assessment of Emissions from Upgrade Alcoa Pinjarra Alumina Refinery.

The Health Risk Assessment found that there was little likelihood of health impacts from the refinery emissions because:

- All hazard quotients and indices for all receptor locations are less than unity.
- The highest concentrations are modelled from the worst case emission scenarios and will rarely be achieved.
- The 95th percentile acute hazard indices are substantially below unity and approximately an order of magnitude less than the 1 hour maximum hazard indices.

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<sup>2</sup> Guidelines were sourced from reputable regulatory agencies and incorporate large safety factors to ensure they are protective of public health (Environ, 2003).

<sup>3</sup> Lifetime cancer risk is calculated by multiplying the average lifetime exposure to a chemical by an estimate of the carcinogenic potency of the chemical. For air borne carcinogens, the "unit" is generally 1 µg/m<sup>3</sup>". This is often interpreted as meaning, if 200 people were exposed to 1 µg/m<sup>3</sup> for their lifetime then one individual may develop cancer (i.e. one chance in 200). The conservative acceptable risk target adopted for this assessment is 1 x 10<sup>-6</sup>, i.e. with a lifetime exposure there is one chance in a million of developing a tumour. (Toxikos 2003)

- Results from the assessment demonstrated that the chronic hazard indices for the existing plant and the upgrade were all markedly less than unity (Toxikos, 2003).

The Alcoa Pinjarra Health Risk Assessment concluded that there is little likelihood of health effects being caused by either acute or chronic exposure of the general public to atmospheric emissions from the Pinjarra Refinery (Toxikos 2003).

### **3 MANAGEMENT PROGRAM**

This section outlines the emission reduction program for the emissions referenced in Condition 7 of Ministerial Statement 000646.

The program is based on the Air Quality Impact Assessment and Health Risk Assessment for each emission (Refer to section 2.2 and 2.3).

#### **3.1 MERCURY, ARSENIC & NO<sub>x</sub> (CONDITION 7-1.2)**

Of the emissions from the refinery, mercury, NO<sub>x</sub> and arsenic were assessed as the greatest contributors to the acute hazard index for the Baseline scenario. For the Upgrade scenario, mercury is the largest contributor, contributing up to 40% of the overall acute hazard index.

The health risk from mercury, arsenic & NO<sub>x</sub> emissions is considered negligible as the hazard quotient for the individual emissions is well below unity (Toxikos, 2003). The health risk assessment concluded that there is little likelihood of health effects being caused by either acute or chronic exposure of the general public to emissions from the Alcoa Pinjarra refinery (Toxikos, 2003).

##### **3.1.1 Mercury**

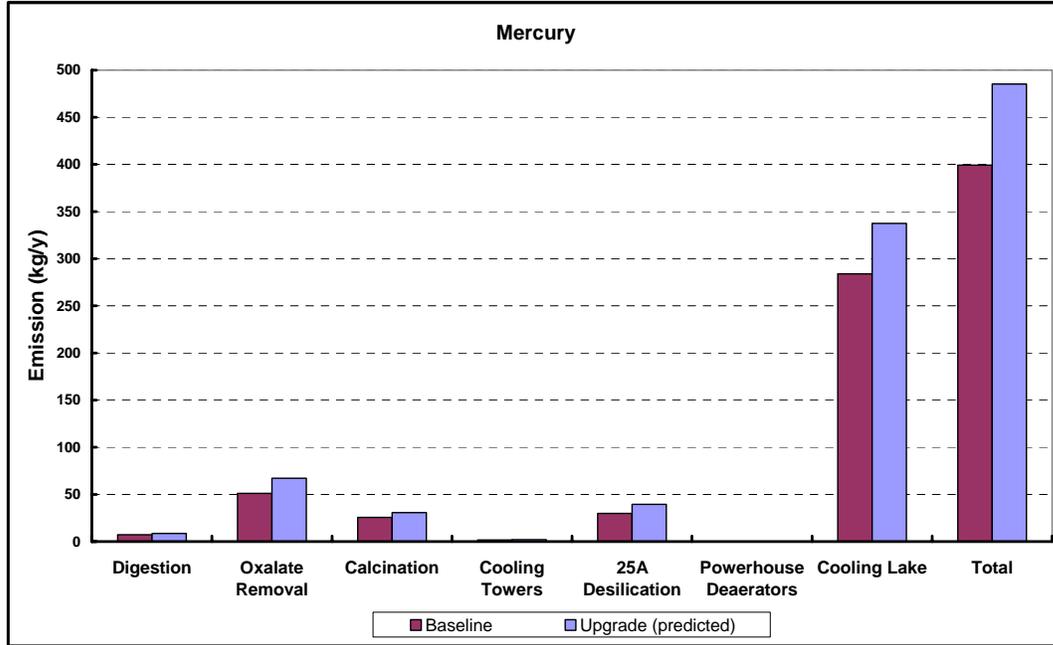
Elemental mercury is present at trace levels in bauxite ore. A proportion of the mercury in the bauxite can be reduced to the metallic form, and a proportion of that can be vaporised in the high temperature sections of the refinery process. Mercury is the only metal that behaves in this way, due to its ease of reduction of the metal and its uniquely high vapour pressure. Current knowledge indicates that some mercury in the bauxite reports unchanged to the residue. The portion that reacts and enters the liquor is mostly re-circulated within the process liquor stream, however trace quantities have been found in emissions from various sources at the Pinjarra Refinery, in particular the oxalate kiln, calciners and vapour sources. It is also assumed that a portion of the mercury that enters the cooling lake is emitted from the cooling lake.

Mercury emissions have been estimated using a conservative mass balance approach and reported under the National Pollutant Inventory (NPI) to the State and Commonwealth governments. Alcoa has been improving its understanding of the mercury mass balance and emission sources for each of the Western Australian refineries with the goal of reducing emissions.

Alcoa has a global target to reduce mercury emissions and has been developing mercury reduction technology for several years. Mercury reduction technology trials are being conducted at several Alcoa locations worldwide, including the Wagerup refinery in Western Australia. When the reduction technologies are proven, they will be considered for application at refineries including the Pinjarra refinery.

### 3.1.1.1 Mercury Emission Reduction Program

The Efficiency Upgrade is expected to increase mercury emissions as a result of the increase in bauxite throughput, as shown in Figure 2.



**Figure 2: Comparison of Mercury Emissions for Baseline and Upgrade Scenarios**

NOTES:

- Figure 2 doesn't include mercury deposited with residue solids.

The key actions planned for mercury are summarised in Table 2.

**Table 2: Mercury Emission Reduction Program**

<b>Emission Control:</b>	Improvements in the mercury condensing systems with the aim of collection of mercury & disposal via a licensed waste collector for recycling. The timing of the improvements is dependent on the outcome of mercury reduction technology trials and is likely to occur after completion of the Efficiency Upgrade. A phased approach will be taken including: <ul style="list-style-type: none"> <li>a) Upgrade existing, or install additional condensers</li> <li>b) Trial of sulphide dosing within Alcoa's WA operations (most likely at Wagerup Refinery) to review possible emission controls for oxalate kiln and calciners.</li> </ul>
<b>Investigations:</b>	Continue development of mercury emission reduction technology and understanding of mercury behaviour in the Bayer process in line with Alcoa worldwide strategy.

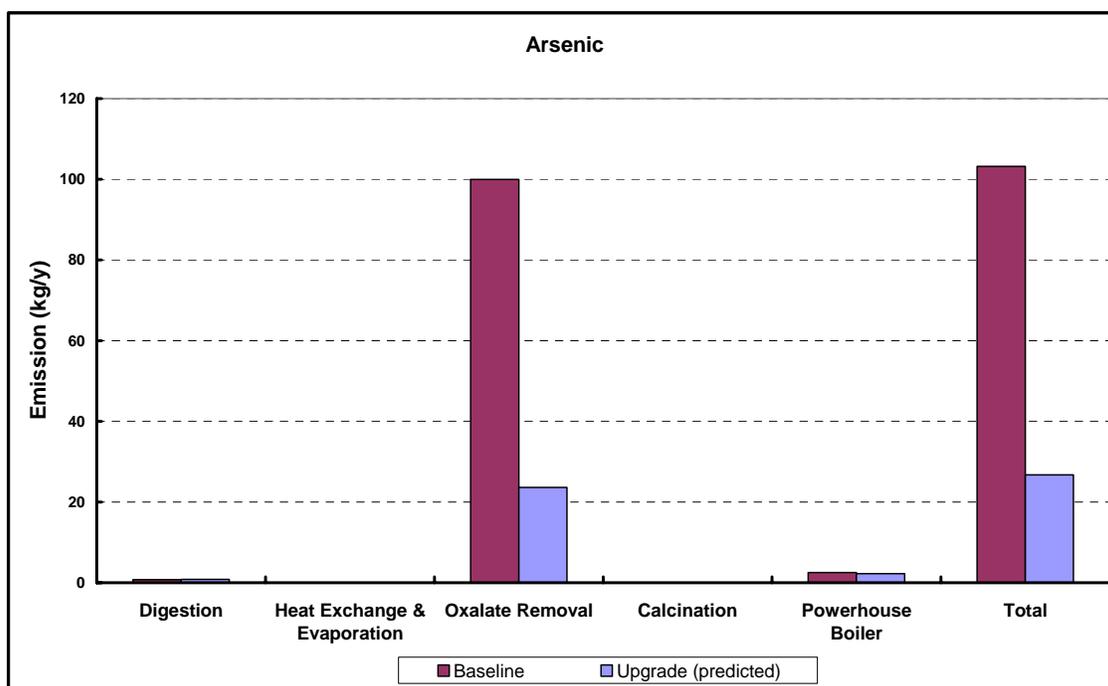
### 3.1.2 Arsenic

Arsenic is found in trace amounts in bauxite ore. Current knowledge indicates that, in common with other trace metals, the majority of the arsenic in the bauxite reports unchanged to the residue. That which dissolves mostly recirculates with the liquor, from which a proportion may report to emissions to air.

Trace amounts of arsenic have been found in emissions from several sources at the Pinjarra Refinery. The largest contributor identified in the baseline survey is the oxalate kiln. It is likely that arsenic is present in the emissions as a particulate metal oxide.

#### 3.1.2.1 Arsenic Emission Reduction Program

The Alcoa Pinjarra Efficiency Upgrade is expected to decrease arsenic emissions due to the installation of emission control equipment on the oxalate kiln. Figure 3 shows the predicted changes to arsenic emissions with the Efficiency Upgrade.



**Figure 3: Comparison of Arsenic Emissions for Baseline and Upgrade Scenarios**

The key actions planned for arsenic are summarised in Table 3.

**Table 3: Arsenic Emission Reduction Program**

<b>Emission Control:</b>	Installation of improved wet scrubbers on oxalate kiln with Efficiency Upgrade to control dust will reduce arsenic emissions.
<b>Investigations:</b>	Confirm and quantify arsenic emissions after Efficiency Upgrade completion.

### 3.1.3 Nitrogen Oxides (NO<sub>x</sub>)

NO<sub>x</sub> is a by-product of combustion and consists of three species, nitrous oxide (N<sub>2</sub>O), nitrogen oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). Monitoring of refinery sources indicated that the refinery emits mainly NO.

Combustion of natural gas in the powerhouse boilers and calciners is the main contributor to refinery NO<sub>x</sub> emissions. Other combustion sources including the oxalate kiln are minor NO<sub>x</sub> emitters.

#### 3.1.3.1 NO<sub>x</sub> Emission Reduction Program

The sources contributing to NO<sub>x</sub> emissions from the Pinjarra refinery are not expected to change significantly as a result of the Efficiency Upgrade, apart from the addition of a seventh calcination unit and minor contributions from two regenerative thermal oxidisers (RTOs).

NO<sub>x</sub> emissions from the refinery are expected to decrease after the upgrade due installation of low-NO<sub>x</sub> burners on boilers 2 and 6. Alcoa is targeting a 55% reduction in mass emissions for each of these boilers.

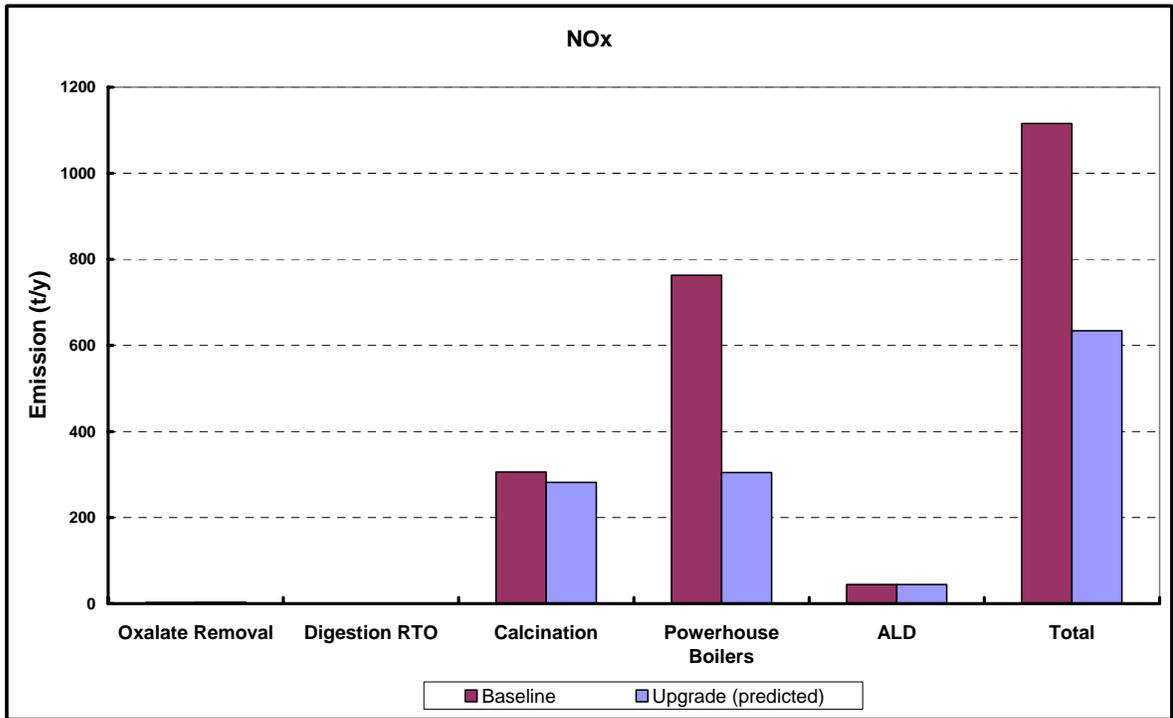
NO<sub>x</sub> emissions from Alcoa boilers 3, 4 & 5 are also expected to decrease as a result of the Alinta Cogeneration Project<sup>4</sup>. The cogeneration plant will supply some of the refinery's steam requirements, thereby allowing Alcoa to reduce steam production (and therefore NO<sub>x</sub> emissions) from its own less efficient boilers. Easing of powerhouse boilers will be possible once the Alinta Cogeneration Project is capable of reliably meeting the refinery steam requirements. The NO<sub>x</sub> emissions generated by the Alinta Cogeneration Project are not addressed by this plan since the cogeneration plant is the subject of a separate environmental approval and is not owned by Alcoa<sup>5</sup>.

Figure 4 shows the changes to NO<sub>x</sub> emissions predicted during the feasibility and planning phase of the Efficiency Upgrade in 2003/2003. It is now considered likely that NO<sub>x</sub> emissions from calcination will increase as a result of the Efficiency Upgrade.

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<sup>4</sup> The Alinta Cogeneration Project has been granted separate approval under Part IV of the *Environmental Protection Act, 1986* for two 140 MW-capacity gas turbine generators and two heat recovery steam generators capable of generating 210 tph of high pressure steam and generating electrical power that will be sold to customers connected to the South West Interconnected System (SWIS).

<sup>5</sup> Alinta Cogeneration Project NO<sub>x</sub> emissions were considered during atmospheric dispersion modelling and the Health Risk Assessment due to the potential for cumulative effects on ground level concentrations and health risk.



**Figure 4: Comparison of NO<sub>x</sub> Emissions for Baseline and Upgrade Scenarios**

NOTES:

1. Alinta Cogeneration project emissions are not included in this chart.

The key actions planned for NO<sub>x</sub> are summarised in Table 4.

**Table 4: NO<sub>x</sub> Emission Reduction Program**

<b>Emission Control:</b>	Installation of low NO <sub>x</sub> burners on Alcoa Boilers 2 & 6 with the Efficiency Upgrade.
	Continue to operate Alcoa Boiler 7 with low NO <sub>x</sub> burners.
	Cogeneration agreement with Alinta to purchase steam from more efficient units.
	Reduce load of boilers 3, 4 & 5 once Alinta Cogeneration project can reliably meet refinery steam requirement.
<b>Investigations:</b>	<p>Following the improvements in powerhouse NO<sub>x</sub> emissions, the focus will be on improving the understanding of calcination NO<sub>x</sub> emissions.</p> <p>Continue calciner combustion efficiency study to determine opportunities for practicable emission reductions, including investigation of correlations between NO<sub>x</sub> &amp; load, other selected operating parameters, and differences between calciner units.</p>

### 3.2 PRACTICABLE METHODS OF REDUCING FORMALDEHYDE (CONDITION 7-1.3)

Of the emissions from the refinery, formaldehyde was assessed as a contributor to the acute hazard index for the Baseline and Upgrade scenarios.

Formaldehyde is a carcinogen and known irritant. If formaldehyde levels in air are kept well below gross irritating levels formaldehyde presents little risk to humans. Based on the predicted ground level concentrations of formaldehyde for the Baseline and Upgrade scenarios, the health risk from formaldehyde emissions is considered negligible as its hazard quotient is well below unity (Toxikos, 2003). The health risk assessment concluded that there is little likelihood of health effects including irritation, being caused by either acute or chronic exposure of the general public to emissions from the Alcoa Pinjarra refinery (Toxikos, 2003).

#### 3.2.1 Formaldehyde

Formaldehyde is an odorous gas from the aldehyde family of organic chemicals. Current knowledge indicates that formaldehyde emissions originate primarily from incomplete combustion of natural gas, and also from the decomposition of organics that occur in the bauxite ore when the bauxite is reacted with caustic soda. The majority of the formaldehyde emissions from the refinery are from calcination.

##### 3.2.1.1 Formaldehyde Emission Reduction Program

The Efficiency Upgrade is expected to increase formaldehyde emissions from the refinery due to the installation of an additional calciner (Calciner 7). Figure 5 shows the predicted changes to formaldehyde emissions with the Efficiency Upgrade.

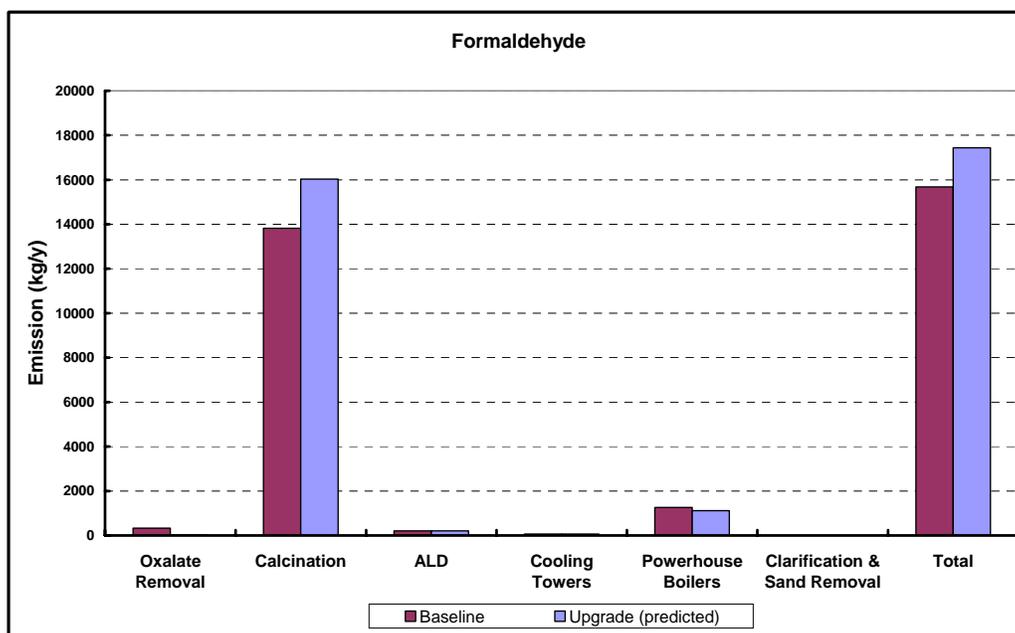


Figure 5: Comparison of Formaldehyde Emissions for Baseline and Upgrade Scenarios

The key actions planned for formaldehyde are summarised in Table 5.

**Table 5: Formaldehyde Emission Reduction Program**

<b>Emission Control:</b>	No practicable emissions control opportunities were identified for installation with the Efficiency Upgrade.
<b>Investigations:</b>	Continue calciner combustion efficiency study with the aim of identifying practicable formaldehyde emission reduction opportunities.

### **3.3 EMISSIONS LIKELY TO INCREASE AS A RESULT OF THE UPGRADE (CONDITION 7-1.1)**

The emission estimates generated for the Upgrade scenario indicated that several emissions were likely to increase as a result of the upgrade. The emissions predicted to increase included:

VOC's:	2-butanone and acetone
Other Gases:	Ammonia (NH <sub>3</sub> ), carbon monoxide (CO), sulphur dioxide (SO <sub>2</sub> ) and dioxins & furans
Metals:	Manganese and selenium

Despite the predicted increase in these emissions, all emissions were well below relevant ambient guidelines and the health risk for all of the emissions is considered negligible as the hazard quotient for the individual emissions are well below unity (Toxikos, 2003). Based on the health risk assessment, there is little likelihood of health effects being caused by either acute or chronic exposure of the general public to any of the emissions from the Efficiency Upgrade (Toxikos, 2003).

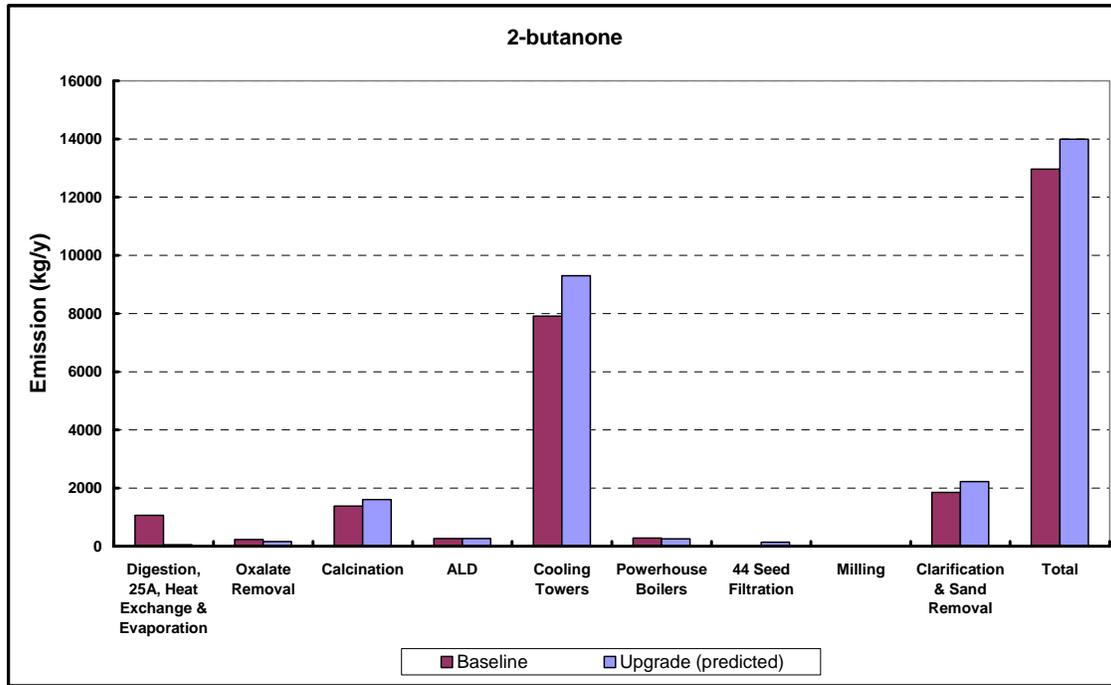
These emissions are included in this program because they were predicted to increase with the Efficiency Upgrade in proportion to the production increase.

#### **3.3.1 2- butanone**

2-butanone is an odorous gas from the ketone family of organic compounds. Current knowledge indicates that 2-butanone emissions originate from the decomposition of organics that occur in the bauxite ore when the bauxite is reacted with caustic soda. Point sources at the Pinjarra refinery where 2 – butanone is emitted include the oxalate kiln, calciners, boilers and digestion sources. 2-butanone has also been identified in cooling tower vapour.

##### **3.3.1.1 2-butanone Emission Reduction Program**

Figure 6 shows the predicted changes to 2-butanone emissions with the Efficiency Upgrade.



**Figure 6: Comparison of 2-butanone Emissions for Baseline and Upgrade Scenarios**

The key actions planned for 2-butanone are summarised in Table 6.

**Table 6: 2-butanone Emission Reduction Program**

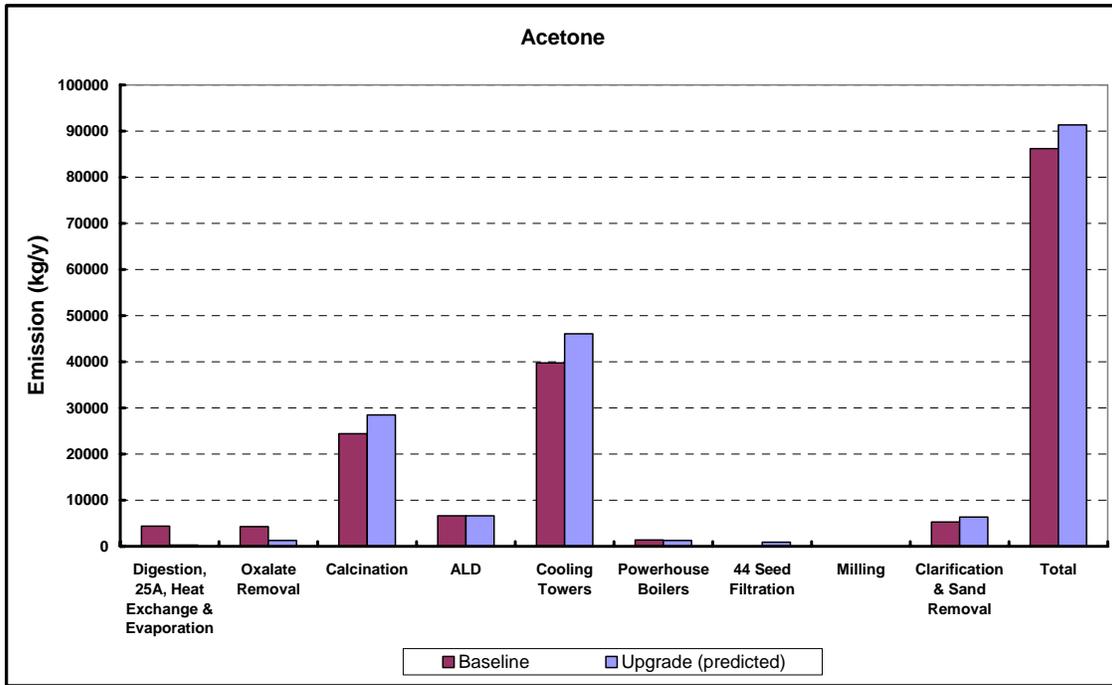
<b>Emission Control:</b>	Installation of RTO to treat digestion vacuum pump, desilication tank, heat exchange and evaporation emissions with Efficiency Upgrade.
	Installation of improved scrubbers and RTO to treat oxalate kiln emissions with Efficiency Upgrade.
<b>Investigations:</b>	Review methodology for cooling tower emissions estimation.

### 3.3.2 Acetone

Acetone is an odorous gas from the ketone family of organic compounds. Current knowledge indicates that acetone emissions originate from the decomposition of organics that occur in the bauxite ore when the bauxite is reacted with caustic soda. Point sources at the Pinjarra refinery where acetone is emitted include the oxalate kiln, calciners, boilers and digestion sources. Acetone has also been identified in cooling tower vapour.

#### 3.3.2.1 Acetone Emission Reduction Program

Figure 7 shows the predicted changes to acetone emissions with the Efficiency Upgrade.



**Figure 7: Comparison of Acetone Emissions for Baseline and Upgrade Scenarios**

The key actions planned for acetone are summarised in Table 7.

**Table 7: Acetone Emission Reduction Program**

<b>Emission Control:</b>	Installation of RTO to treat digestion vacuum pump, desilication tank, heat exchange and evaporation emissions with Efficiency Upgrade.
	Installation of improved scrubbers and RTO to treat oxalate kiln emissions with Efficiency Upgrade.
<b>Investigations:</b>	Review methodology for cooling tower emissions estimation.

### 3.3.3 Ammonia

Ammonia is believed to originate from naturally occurring organo-nitrogen compounds present in the bauxite ore. Ammonia emissions may result from breakdown of these compounds in caustic solution at elevated temperatures. Ammonia is a known component of condensate. Condensate treatment technology trials are being conducted at Wagerup refinery. Current knowledge indicates that the main point sources of ammonia are the desilication (25A slurry tanks) and digestion sources.

### 3.3.3.1 Ammonia Emission Reduction Program

Figure 8 shows the predicted changes to Ammonia emissions with the Efficiency Upgrade.

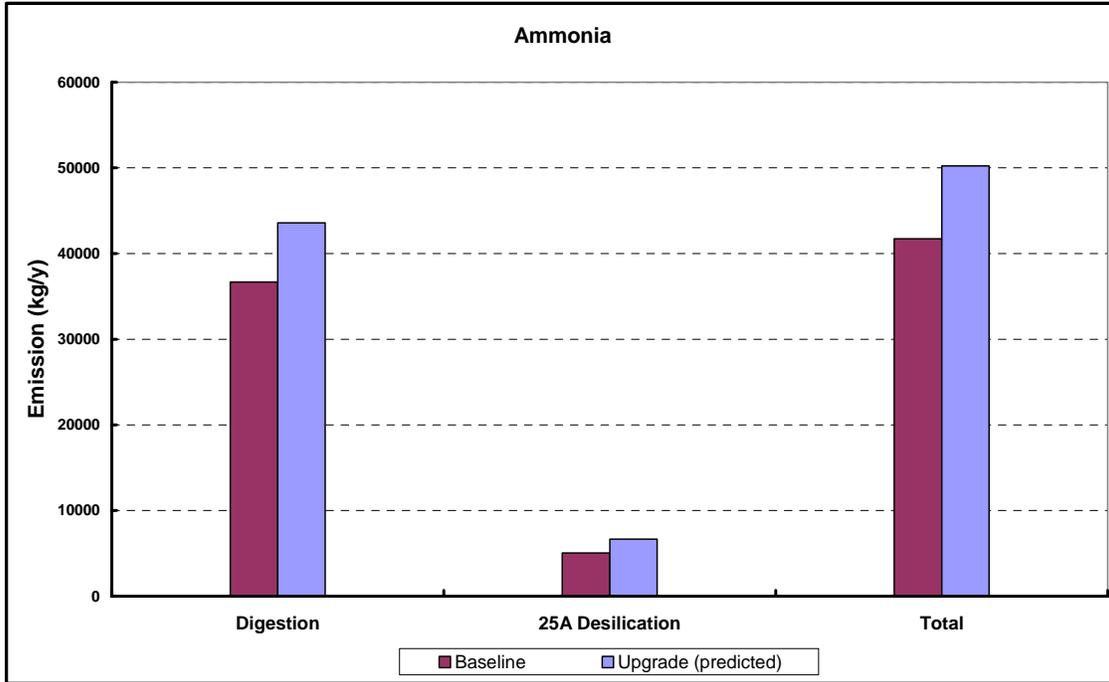


Figure 8: Comparison of Ammonia Emissions for Baseline and Upgrade Scenarios

The key actions planned for Ammonia are summarised in Table 8.

Table 8: Ammonia Emission Reduction Program

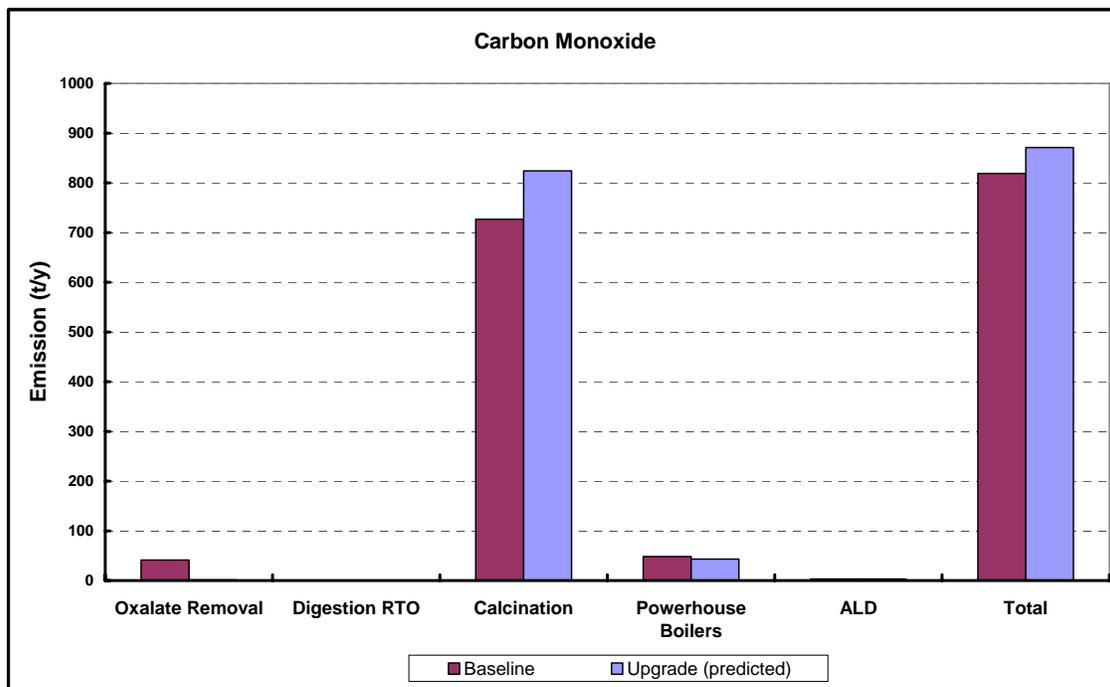
<b>Emission Control:</b>	Installation of RTO to treat digestion vacuum pump, desilication tank, heat exchange and evaporation emissions with Efficiency Upgrade.
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### 3.3.4 Carbon Monoxide

Carbon Monoxide (CO) is a product of incomplete combustion of fuel. Combustion of natural gas in the powerhouse boilers and calciners are the main contributors to refinery CO emissions. Other combustion sources including the oxalate kiln are minor CO emitters.

#### 3.3.4.1 Carbon Monoxide Emission Reduction Program

It is predicted that there will be an increase in CO emissions as a result of the Efficiency Upgrade in proportion to the increased calciner throughput. It is predicted that there will be a reduction in CO emissions from the oxalate kiln stack after the upgrade due to the installation of a regenerative thermal oxidiser (RTO). Alcoa is targeting a 90% reduction in CO emissions at the oxalate kiln. Figure 9 shows the predicted changes to Carbon Monoxide emissions with the Efficiency Upgrade.



**Figure 9: Comparison of Carbon Monoxide Emissions for Baseline and Upgrade Scenarios**

NOTES:

- Alinta Cogeneration project emissions are not included in this chart.

The key actions planned for Carbon Monoxide are summarised in Table 9.

**Table 9: Carbon Monoxide Emission Reduction Program**

<b>Emission Control:</b>	Installation of RTO to treat oxalate kiln emissions with Efficiency Upgrade.
<b>Investigations:</b>	Continue calciner combustion study and review if there are practicable carbon monoxide emissions reduction opportunities.

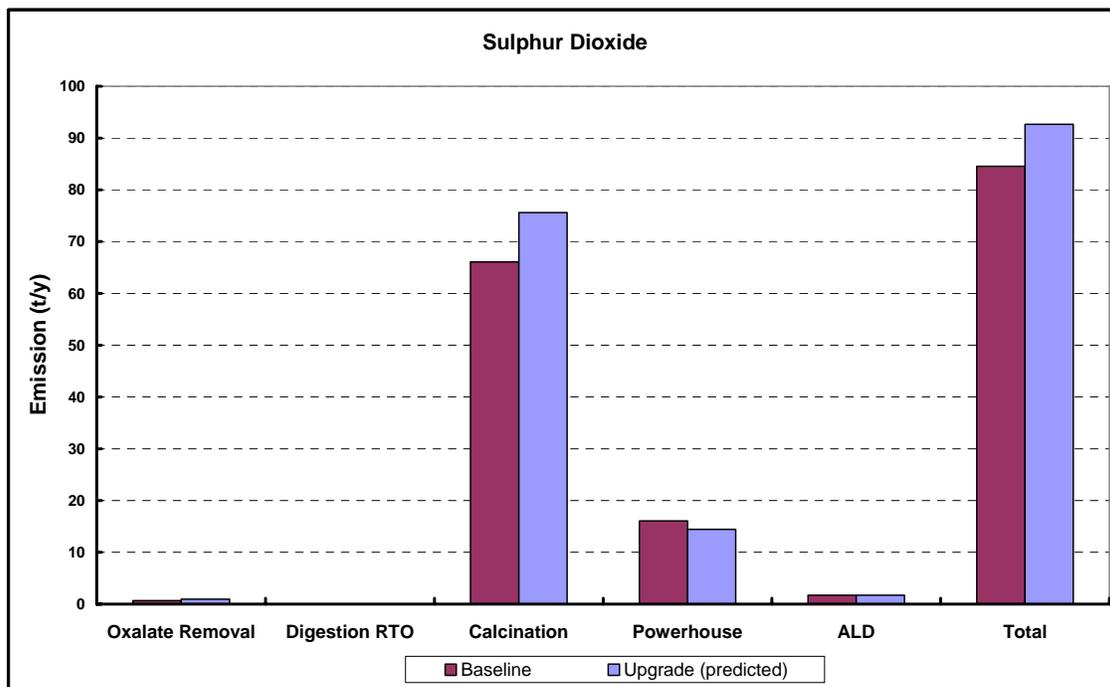
### 3.3.5 Sulphur Dioxide (SO<sub>2</sub>)

Sulphur dioxide (SO<sub>2</sub>) emissions result from oxidation of the mercaptan odorant (reduced sulphur compound) in the natural gas fuel used in the powerhouse, calciners and oxalate kiln. There could also be trace emissions from the oxidation of sulphides in the refinery liquor, which could originate from the bauxite or chemical additives, but this has not been demonstrated.

Pinjarra refinery has a low SO<sub>2</sub> emission rate because it uses natural gas as the primary fuel source. The back-up fuel for the powerhouse is ultra low sulphur diesel and is only used as an emergency fuel in the event of natural gas supply issues.

### 3.3.5.1 Sulphur Dioxide Emission Reduction Program

Figure 10 shows the predicted changes to Sulphur Dioxide emissions with the Efficiency Upgrade. It should be noted that the expected increase is from a small base, so that the absolute emission level remains low.



**Figure 10: Comparison of Sulphur Dioxide Emissions for Baseline and Upgrade Scenarios**

NOTES:

1. Alinta Cogeneration project emissions are not included in this chart.

The key actions planned for Sulphur Dioxide are summarised in Table 10.

**Table 10: Sulphur Dioxide Emission Reduction Program**

<b>Emission Control:</b>	Continue to use natural gas as a fuel source for combustion equipment.
	Use ultra low sulphur diesel as the back-up fuel for Powerhouse boilers (emergency use in event of natural gas supply issues).
<b>Investigations:</b>	There are no additional investigations planned for SO <sub>2</sub> reduction due to the very low absolute emission level, the small predicted change in emissions and the low health risk contribution.

### 3.3.6 Dioxins & Furans (ITEQ)

Trace concentrations of chlorinated dioxins and furans (ITEQ) emissions were initially identified from the oxalate kiln. An additive used in the oxalate kiln was found to be the precursor for the formation of these dioxins and furans.

Dioxins and furans were assessed in the Pinjarra Health Risk Assessment. Conservative estimates of background intakes were assumed. Even with the conservatism, overall intakes were much less than the intake level that Australian authorities have deemed to be tolerable and without adverse health effects (Toxikos 2003).

### 3.3.6.1 Dioxin & Furan Emission Reduction Program

In 2003, it was predicted that there would be an increase in dioxin and furan emissions as a result of the upgrade which was directly attributed to the increased use of the oxalate kiln. Since this time Alcoa has worked with the additive supplier and reformulated the additive so that it is no longer a precursor for formation of chlorinated dioxin or furan (ITEQ) emissions<sup>6</sup>.

The following emission reduction program for dioxins & furans has already been implemented at Pinjarra.

**Table 11: Dioxin and Furan Emission Reduction Program**

<b>Emission Control:</b>	Reformulation of oxalate kiln additive to remove precursor compounds.
	Installation of RTO to treat oxalate kiln emissions with Efficiency Upgrade.
<b>Investigations:</b>	Confirm and quantify dioxin & furan emissions after use of re-formulated additive.

### 3.3.7 Manganese

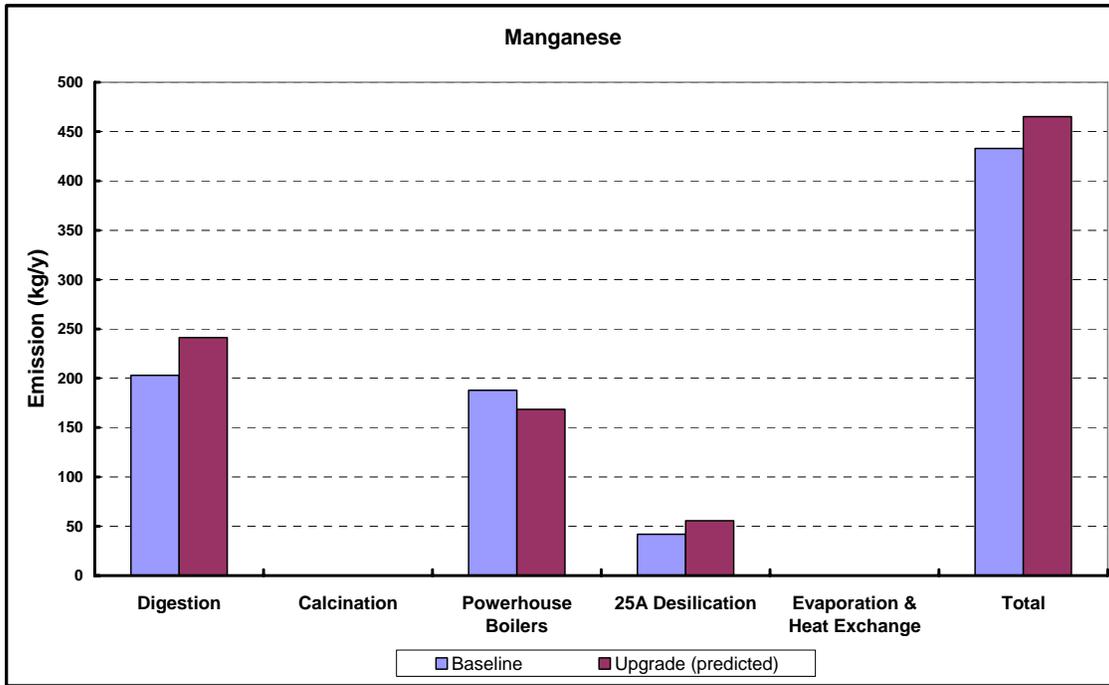
Manganese is present in trace amounts in bauxite ore. Current knowledge indicates that, in common with other trace metals, the majority of the manganese in the bauxite reports unchanged to the residue. That which dissolves mostly recirculates with the liquor, from which a proportion may report to emissions to air. It is likely that manganese is present in the emissions as a particulate metal oxide.

Trace amounts of manganese have been found in emissions from various sources at the Pinjarra Refinery. The largest contributor identified in the baseline survey are digestion and powerhouse sources.

#### 3.3.7.1 Manganese Emission Reduction Program

Figure 11 shows the changes to manganese emissions predicted to occur as a result of the Efficiency Upgrade, based on the results of the original survey and the increase in overall production.

<sup>6</sup> The oxalate kiln has been re-sampled and the only compound detected was the non-toxic congener non-2378-Tetrachlorodibenzofuran. As a result dioxins and furans will still be reported in the Pinjarra NPI.



**Figure 11: Comparison of Manganese Emissions for Baseline and Upgrade Scenarios**

The key actions planned for Manganese are summarised in Table 12.

**Table 12: Manganese Emission Reduction Program**

<b>Emission Control:</b>	No practicable emissions control opportunities were identified for installation with the Efficiency Upgrade.
<b>Investigations:</b>	Review manganese emissions after completion of Efficiency Upgrade. There are no additional investigations planned for manganese reduction due to the very low absolute emission level, the small predicted change in emissions and the low health risk contribution.

### 3.3.8 Selenium

Selenium is present in trace amounts in bauxite ore. Current knowledge indicates that a proportion of the selenium in the bauxite dissolves in the Bayer liquor where it is present as a recirculating trace component. The remainder reports to the bauxite residue.

Trace amounts of selenium have been found in emissions from several sources at the Pinjarra Refinery. The largest contributor identified in the baseline survey is the oxalate kiln. It is likely that selenium is present as a metal oxide so it will exist in particulate form.

### 3.3.8.1 Selenium Emission Reduction Program

At the time that the Health Risk Assessment was conducted a minor overall increase in selenium emissions was predicted as a result of the upgrade. This increase was attributed to the increased bauxite throughput. Figure 12 shows the changes to selenium emissions predicted during the feasibility and planning phase of the Efficiency Upgrade in 2003/2003. It is now considered likely that Selenium emissions will decrease as a result of the Efficiency Upgrade due to the installation of emission control equipment on the oxalate kiln.

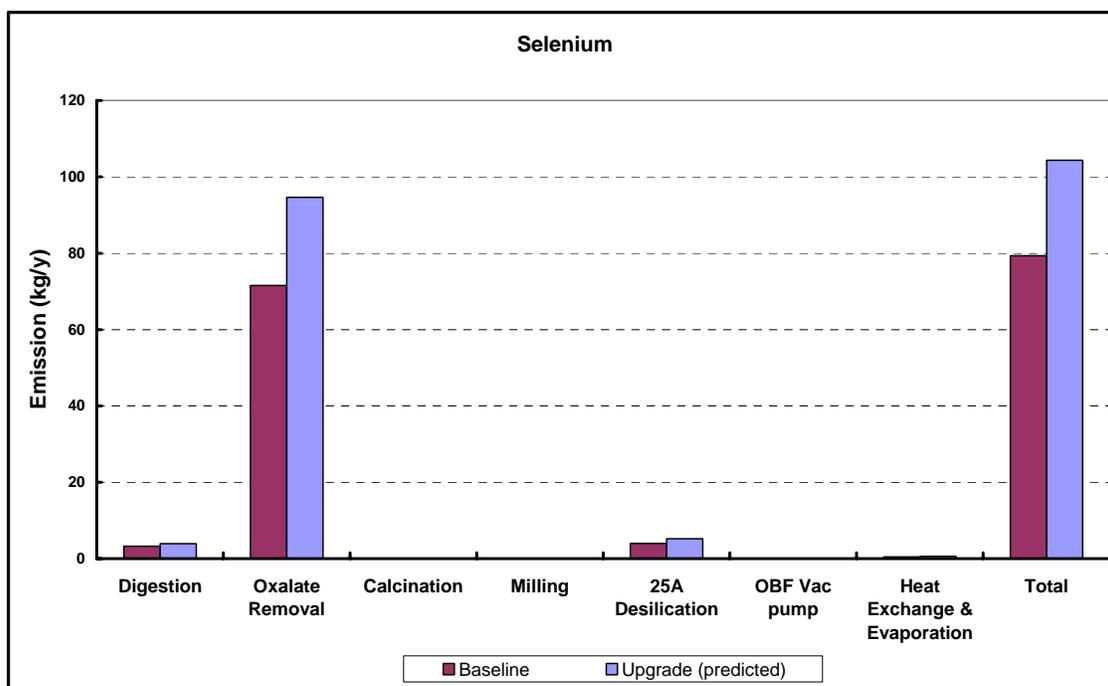


Figure 12: Comparison of Selenium Emissions for Baseline and Upgrade Scenarios

The key actions planned for Selenium are summarised in Table 13.

Table 13: Selenium Emission Reduction Program

<b>Emission Control:</b>	Installation of improved wet scrubbers on oxalate kiln with Efficiency Upgrade to control dust is likely to reduce selenium emissions.
<b>Investigations:</b>	Confirm and quantify selenium emissions after completion of Efficiency Upgrade.  There are no additional research programs planned for selenium due to the predicted reduction associated with the oxalate kiln wet scrubber and the low health risk.

### 3.4 KEY MANAGEMENT ACTIONS TABLE

The management actions outlined in sections 3.1 to 3.3 are summarised in Table 14. This table has been prepared to form the basis of compliance reporting against this management plan.

**Table 14: Emission Reduction Program Summary Table**

<b>Emission</b>	<b>Emission Reduction Program</b>
<b>Mercury</b>	Improvements in the mercury condensing systems with the aim of collection of mercury & disposal via a licensed waste collector for recycling. The timing of the improvements is dependent on the outcome of mercury reduction technology trials and is likely to occur after completion of the Efficiency Upgrade. A phased approach will be taken including: <ul style="list-style-type: none"> <li>a) Upgrade existing, or install additional condensers</li> <li>b) Trial of sulphide dosing within Alcoa's WA operations (most likely at Wagerup Refinery) to review possible emission controls for oxalate kiln and calciners.</li> </ul>
	Continue development of mercury emission reduction technology and understanding of mercury behaviour in the Bayer process in line with Alcoa worldwide strategy.
<b>Arsenic</b>	Installation of improved wet scrubbers on oxalate kiln with Efficiency Upgrade to control dust will reduce arsenic emissions.
	Confirm and quantify arsenic emissions after completion of Efficiency Upgrade.
<b>NOx</b>	Installation of low NOx burners on Alcoa Boilers 2 & 6 with the Efficiency Upgrade.
	Continue to operate Alcoa Boiler 7 with low NOx burners
	Cogeneration agreement with Alinta to purchase steam from more efficient units
	Reduce load of boilers 3, 4 & 5 once Alinta Cogeneration project can reliably meet refinery steam requirement.
	Continue calciner combustion efficiency study to determine opportunities for practicable emission reductions, including investigation of correlations between NOx & load, other selected operating parameters, and differences between calciner units.
<b>Formaldehyde</b>	Continue calciner combustion efficiency study with the aim of identifying practicable formaldehyde emission reduction opportunities.
<b>Acetone &amp; 2-butanone</b>	Installation of RTO to treat digestion vacuum pump, desilication tank, heat exchange and evaporation emissions with Efficiency Upgrade.
	Installation of improved scrubbers RTO to treat oxalate kiln emissions with Efficiency Upgrade.
	Review methodology for cooling tower emissions estimation.
<b>Carbon Monoxide</b>	Installation of RTO to treat oxalate kiln emissions with Efficiency Upgrade.
	Continue calciner combustion study and review if there are practicable carbon monoxide emissions reduction opportunities.
<b>Sulphur Dioxide</b>	Continue to use natural gas as a fuel source for combustion equipment.
	Use ultra low sulphur diesel as the back-up fuel for Powerhouse boilers (emergency use in event of natural gas supply issues).

<b>Emission</b>	<b>Emission Reduction Program</b>
<b>Ammonia</b>	Installation of RTO to treat digestion vacuum pump, desilication tank, heat exchange and evaporation emissions with Efficiency Upgrade.
<b>Dioxins &amp; Furans</b>	Reformulation of oxalate kiln additive to remove precursor compounds. Installation of RTO to treat oxalate kiln emissions with Efficiency Upgrade Confirm and quantify dioxin & furan emissions after use of re-formulated additive.
<b>Manganese</b>	Review manganese emissions after completion of Efficiency Upgrade.
<b>Selenium</b>	Installation of improved wet scrubbers on oxalate kiln with Efficiency Upgrade to control dust is likely to reduce selenium emissions. Confirm and quantify selenium emissions after completion of Efficiency Upgrade.

## 4 REVIEW & REPORTING

This program will be reviewed and updated periodically as business, technological and operational conditions change. It is envisaged that the initial review will occur after completion of the post commissioning Health Risk Assessment required by Condition 8-2 of Ministerial Statement 000646.

Alcoa will undertake an appropriate level of stakeholder consultation whenever significant alterations are made to the management program. The level of consultation will be dependent upon the nature and significance of the alteration.

Results of the Emission Reduction Program will be reported to DEC annually as part of the Compliance Reporting process for Ministerial Conditions.

### 4.1 DEVELOPMENT OF THIS PROGRAM

The development of the Emission Reduction Program involved consultation with community and stakeholders including the DEC. The following summary describes the consultation that influenced the development of this management program:

**Table 15: Summary of Emission Reduction Program Consultation**

June 2005	Discussed ERP with Air Quality Management Branch of DEC. Summary of ERP presented to DEC.
July 2005	Summary of Emission Reduction Program presented to Pinjarra Community Consultative Network (CCN). The CCN expressed a desire to select the consultants for the Peer Review group.
August 2005	Discussed with and received input from the Pinjarra Environmental Improvement Plan (EIP) group. The EIP group provided advice on the scope of the document, clarification of role, relationship to the Health Risk Assessment and suggested focus areas of specific interest to the community. This advice has been incorporated into this document.
November 2006	Independent Peer Review conducted by J Chiodo (provided as Appendix D).
March 2007	ERP submitted to DEC.
August 2007	DEC provide comments on ERP.
December 2007	Re-submission of management program to address DEC comments.

The program will be made available to the wider community and general public at the locations shown in Table 16.

**Table 16: Locations for viewing hardcopies of the ERP**

<b>Location</b>	<b>Address</b>	<b>Copies Available</b>
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 WA	2 hardcopies
Murray Shire Library	Located at the corner of Pinjarra Rd & Forrest St, Pinjarra WA.	2 hardcopies

## 5 GLOSSARY OF TERMS

Acute Risk	Potential hazard from short-term exposure
ALD	alumina leach dryer used to improve the quality of alumina
Area source	Air emissions from an area e.g. a Bauxite Residue Drying Area (RDA)
Bayer Process	Process of extracting alumina from bauxite
Calcliner	Process equipment used to drive off water molecules within hydrate to form alumina.
Cleaner Production	(UNEP 1994): The continuous use of industrial processes and products to increase efficiency, to prevent pollution of air, water and land, to reduce waste at source and to minimise risks to human population and the environment.
Chronic Risk	Potential hazard from long-term exposure
CCN	Community Consultation Network
CO	Carbon Monoxide
CO <sub>2</sub>	Carbon Dioxide
DEC	Department of Environment and Conservation
EPA	Environmental Protection Authority
ERP	Emission Reduction Program
General Public	Employees and the surrounding population
HRA	Health Risk Assessment
ITEQ	International Toxicity Equivalent
NO	Nitrogen oxide
N <sub>2</sub> O	Nitrous oxide
NO <sub>2</sub>	Nitrogen Dioxide
NO <sub>x</sub>	Nitrogen Oxides. Includes nitrous oxide, nitrogen oxide and nitrogen dioxide.
NPI	National Pollutant Inventory
Oxalate kiln	Process equipment to remove oxalate an organic impurity found in Bauxite
PAH	Polycyclic aromatic hydrocarbons
Point Source	Air emissions from a specific point e.g. a stack
SO <sub>2</sub>	Sulphur Dioxide
TOC	Total Organic Compounds
SRG	Stakeholder Reference Group
Unity	Numerical value of one. Hazard index of a chemical or mixture of chemicals
VOC	Volatile Organic Compound.

## **6 REFERENCES**

ENVIRON 2003. Environmental Protection Statement, Alcoa Pinjarra Efficiency Upgrade, December 2003.

SKM, 2003. Alcoa Pinjarra Refinery Efficiency Upgrade- Air Dispersion Modelling, October 2003.

Toxikos, 2003. Health Risk & Toxicological Assessment of Emissions from the Upgrade at Alcoa Pinjarra Alumina Refinery, October 2003.



## **Appendix A**

*Ministerial Statement 000646 Pinjarra Refinery Efficiency Upgrade*

*Condition 7*

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## **7 Emissions Reduction Program**

7.1 Prior to commissioning, the proponent shall develop an Emissions Reduction Program to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

This program shall address:

1. emissions likely to increase as a result as a result of the upgrade;
2. mercury, arsenic and NO<sub>x</sub>; and
3. practicable methods of reducing formaldehyde emissions from the refinery.

This program shall:

- (a) be developed in consultation with the community and stakeholders;
- (b) include an expert peer review; and
- (c) allow for adaptive management with regular reviews and updating.

7-2 The proponent shall implement the Emissions Reduction Program required by condition 7-1 to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

7-3 The proponent shall make the Emissions Reduction Program required by condition 7-1 publicly available to the requirement of the Minister for the Environment on advice of the Environmental Protection Authority.



## **Appendix B**

### ***Baseline Emission Data - Average***

***From SKM, 2003, Alcoa Pinjarra Refinery Efficiency Upgrade- Air Dispersion Modelling***

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

	Temp.	Stack Diameter	Velocity	NO <sub>x</sub>	CO	SO <sub>2</sub>	Dust	VOC	Acetone	Acetaldehyde	Formaldehyde	2-Butanone	Benzene	Toluene	Xylenes	PAHs	Mercury	Arsenic	Selenium	Dioxins & Furans (TEQ)	Ammonia	Manganese & Compounds	Cadmium & Compounds	Nickel & Compounds		
	(°C)	(m)	(m/s)	Emission Rate (g/s)																						
<b>Combustion Equipment Point Sources:</b>																										
Oxalate Kiln Stack	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	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	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	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	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	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	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	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	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	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			
Total Boilers																										
<b>Non Combustion equipment Point Sources</b>																										
OBV Vac Pump Stack	60	0.9	8					3.94E-02	3.06E-02	4.03E-03		4.03E-03		1.39E-04	4.17E-04											
Calciner Vac Pump West	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 Vac Pump East	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 Vac Pump Stack	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	30	17	11.9					1.33E+00	1.05E+00			2.33E-01		9.22E-04			5.39E-05									
ALD Cooling Tower	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												
44 Seed Filtration	50	1.8	0										3.33E-05													
<b>Grouped Sources:</b>																										
25A Tank Vents	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 - PRT & CT	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	
Dign. Vac Pump Stacks	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-Rake Stacks	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 Vac Pumps	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 Vac Pumps	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 & D Vents	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 Vents	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	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 Washer Area Vents - Banks 1-2	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 Washer Area Vents - Banks 3-5	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										
Fresh Water Storage Lake (area source)																	9.00E-03									
<b>Point Source total</b>				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		
<b>Total</b>				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 Environ (2003).

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

## **Appendix C**

### ***Predicted Efficiency Upgrade Emissions –Average***

***From SKM, 2003, Alcoa Pinjarra Refinery Efficiency Upgrade- Air Dispersion Modelling***

**Appendix C: Pinjarra Refinery Air Emissions - Upgrade Case at Average Emissions (from SKM, 2003)**

	Temp.	Stack Diameter	Velocity	NO <sub>x</sub>	CO	SO <sub>2</sub>	Dust	VOC	Acetone	Acetaldehyde	Formaldehyde	2-Butanone	Benzene	Toluene	Xylenes	PAHs	Mercury	Arsenic	Selenium	Dioxins & Furans (TEQ)	Ammonia	Manganese & Compounds	Cadmium & Compounds	Nickel & Compounds	
	(°C)	(m)	(m/s)	Emission Rate (g/s)																					
<b>Combustion Equipment Point Sources:</b>																									
Oxalate Kiln Stack	90	1	10.8	0.1	0.03	0.03	0.047	4.04E-03	2.76E-03	4.93E-04	2.75E-04	8.44E-05	5.53E-05	8.39E-05	8.97E-06	1.97E-06	2.13E-03	7.49E-04	3.00E-03	0.00E+00			1.68E-05	9.40E-05	
Calciner 1	158	1.537	31.7	1.02	1.55	0.226	0.359	2.99E-01	1.15E-01	7.12E-02	8.07E-02	6.03E-03	3.14E-03	1.19E-03	2.29E-04	1.22E-04	1.34E-04								
Calciner 2	159	1.537	31.8	0.95	9.95	0.541	0.882	2.99E-01	1.15E-01	7.12E-02	8.07E-02	6.03E-03	3.14E-03	1.19E-03	2.29E-04	1.22E-04	1.30E-04								
Calciner 3	155	1.537	31.5	2.29	1.96	0.428	0.496	2.99E-01	1.15E-01	7.12E-02	8.07E-02	6.03E-03	3.14E-03	1.19E-03	2.29E-04	1.22E-04	1.38E-04								
Calciner 4	157	1.829	24.6	1.56	4.01	0.388	0.598	3.29E-01	1.27E-01	7.83E-02	8.87E-02	6.63E-03	3.46E-03	1.31E-03	2.52E-04	1.34E-04	2.11E-04								
Calciner 5	157	1.829	24.6	1.56	4.1	0.363	0.598	3.29E-01	1.27E-01	7.83E-02	8.87E-02	6.63E-03	3.46E-03	1.31E-03	2.52E-04	1.34E-04	2.07E-04								
Calciner 6	157	1.829	24.6	1.56	4.55	0.451	0.598	3.29E-01	1.27E-01	7.83E-02	8.87E-02	6.63E-03	3.46E-03	1.31E-03	2.52E-04	1.34E-04	1.53E-04								
ALD	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	120	3.05	6.9	3.13	0.62	0.232		5.47E-02	1.30E-02		1.15E-02	2.58E-03	1.87E-05	7.06E-06				2.31E-05					1.73E-03		
Boiler 5/6/7	133	4.37	7.2	6.53	0.75	0.225		1.14E-01	2.71E-02		2.41E-02	5.38E-03	3.91E-05	1.47E-05				4.81E-05					3.61E-03		
<b>Non Combustion equipment Point Sources</b>																									
OBV Vac Pump Stack	60	0.9	10					4.94E-02	3.83E-02	5.04E-03		5.04E-03		1.74E-04	5.22E-04										
Calciner Vac Pump West	50	0.6	2.5					1.50E-01	8.86E-02	3.35E-02		6.49E-03	2.22E-04	1.72E-03	1.41E-04	7.17E-06									
Calciner Vac Pump East	50	0.6	2.5					1.50E-01	8.86E-02	3.35E-02		6.49E-03	2.22E-04	1.72E-03	1.41E-04	7.17E-06									
ALD Vac Pump Stack	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	30	19.01	11.3					1.58E+00	1.25E+00			2.77E-01	0.00E+00	1.09E-03			6.40E-05								
ALD Cooling Tower	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											
44 Seed Filtration	50	1.8	14.4					6.12E-02	2.89E-02	7.12E-03		4.44E-03	2.78E-04	1.45E-03	6.23E-04										
<b>Grouped Sources:</b>																									
25A Tank Vents	90	0.255	18.4					1.46E-02	4.70E-03	4.40E-03		7.69E-04	8.73E-05	1.06E-03	7.21E-05	6.13E-06	1.25E-03		1.65E-04		2.11E-01	1.76E-03		2.75E-05	
25A/C Droppers	100							2.19E-03	1.16E-03	6.32E-04		1.68E-04	0.00E+00	3.47E-05	1.67E-06										
Excess BO - PRT & CT	100	0.755	3.8					4.69E-03	2.51E-03	1.07E-03		3.89E-04	6.60E-06	7.95E-05	7.42E-06		2.71E-04	2.64E-05	5.28E-05		4.09E-01	7.65E-03		5.67E-05	
Dign. Vac Pump Stacks	50	0.154	7.7					1.25E-02	2.76E-04	8.77E-04		2.62E-04	1.74E-03	6.48E-03	7.61E-04	3.20E-06		3.96E-07	7.19E-05		9.73E-01	5.44E-07	5.44E-07	1.81E-06	
B34 A-Rake Stacks	60	0.6	0.02					1.29E-02	6.89E-03	2.93E-03		1.07E-03	1.81E-05	2.19E-04	2.04E-05										
B40 Vac Pumps	50	0.154	4					8.78E-04	7.38E-05	9.78E-05		6.09E-05	5.05E-06	3.68E-04	4.22E-05	1.30E-05		5.16E-07	1.62E-05			5.82E-07	3.96E-07	1.38E-06	
B42 Vac Pumps	55	0.078	13.1					6.94E-05	1.87E-05	1.36E-05		8.87E-06	1.87E-05	5.38E-06		4.12E-06		1.58E-07	2.69E-06						
35F & D Vents	98	0.255	7.6					1.29E-01	3.19E-02	1.36E-02		7.63E-03	1.35E-04	1.73E-02	1.05E-02	8.84E-04									
35A Vents	92	0.305	3.6					6.48E-02	1.59E-02	7.62E-03		4.26E-03	7.92E-05	8.96E-03	4.06E-03	3.96E-04									
Misc OC2 Liquor Tank Vents	97	0.248	24.4					2.28E-01	5.60E-02	2.68E-02		1.50E-02	2.78E-04	3.15E-02	1.43E-02	1.39E-03									
35C Washer Area Vents - Banks 1-2	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 Washer Area Vents - Banks 3-5	97	0.255	18.4					1.49E-01	6.07E-02	1.86E-02		2.82E-02	2.61E-04	1.01E-02	4.26E-03	4.16E-04									
Fresh Water Storage Lake																	1.07E-02								
<b>Point Source Total</b>				<b>20.1</b>	<b>27.6</b>	<b>2.9</b>	<b>4.6</b>	<b>5.4</b>	<b>2.9</b>	<b>6.98E-01</b>	<b>5.53E-01</b>	<b>4.44E-01</b>	<b>2.35E-02</b>	<b>9.75E-02</b>	<b>3.92E-02</b>	<b>4.11E-03</b>	<b>4.69E-03</b>	<b>8.48E-04</b>	<b>3.31E-03</b>	<b>0.00E+00</b>	<b>1.59E+00</b>	<b>1.48E-02</b>	<b>1.77E-05</b>	<b>1.81E-04</b>	
<b>Total</b>				<b>20.1</b>	<b>27.6</b>	<b>2.9</b>	<b>4.6</b>	<b>5.4</b>	<b>2.9</b>	<b>6.98E-01</b>	<b>5.53E-01</b>	<b>4.44E-01</b>	<b>2.35E-02</b>	<b>9.75E-02</b>	<b>3.92E-02</b>	<b>4.11E-03</b>	<b>1.54E-02</b>	<b>8.48E-04</b>	<b>3.31E-03</b>	<b>0.00E+00</b>	<b>1.59E+00</b>	<b>1.48E-02</b>	<b>1.77E-05</b>	<b>1.81E-04</b>	

Note 1: For a discussion on the substances included under PAHs refer to Environ (2003).

Note 2: This plan summarises the emission from the refinery only. Totals differ from those published in SKM, 2003 because the Alinta Cogeneration emissions have not been included within this table. Upgrade emission rates will be reviewed following completion of the Efficiency Upgrade in preparation for dispersion modelling and HRA required by condition 8-2 of Ministerial Statement 000646.

Note 3: Although not clearly specified within the table, Calciner emissions for the Upgrade scenario incorporate Calciner 7 emissions. Calciner 7 has been incorporated by increasing the flow rate through calciners 1 – 6. The post commissioning air dispersion modelling and HRA will include calciner 7 as a separate source.

## **Appendix D**

### ***Independent Peer Review***

***Section 5 addresses Emission Reduction Program***



# **PROJECT REVIEW**

## **PINJARRA ALUMINA REFINERY EFFICIENCY UPGRADE**

**REVIEWER: JACK CHIDO - 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<sup>7</sup>

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.

---

<sup>7</sup> “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

### **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.

## **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 NOx emission reductions of 40% – 50% overall are expected largely due to the installation of low NOx burners at two boilers (60% reduction from these sources) and load relief resulting from the Alinta cogeneration stage 1 project. The combined reduction in NOx (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 NOx Emission Data Anomalies**

There are a number of inconsistencies in the NOx 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				
	Baseline	Upgrade	Baseline	Upgrade	Gas Turbine Emissions	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 7<sup>th</sup> 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 7<sup>th</sup> 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<sup>8</sup>, 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 and 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:

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*8 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<sup>3</sup> or less and 0.55 g/s or less

Page 15 refers to an operating limit of 250 mg/m<sup>3</sup> 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<sup>3</sup> for calciners 4, 5, and 6, and 30 mg/m<sup>3</sup> for calciner 7

Page 20 refers to an existing license limit of 250 mg/m<sup>3</sup> 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 placed 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 liaise 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 from other sources, so comparisons with refinery emissions could be made. Air quality parameters measured were CO and NO<sub>x</sub>, with the analysis focussing on NO<sub>x</sub>.

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<sub>2</sub>/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<sub>2</sub>/NO for the top 20 NO<sub>x</sub> 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 NO<sub>x</sub> 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.