

Estimation of Volatile Organic Compound Emissions from 45K Cooling Towers at Wagerup Refinery

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1. Executive Summary

Alcoa has undertaken considerable work over an extensive period of time to achieve the most reliable estimate of Volatile Organic Compound (VOC) emissions from Building 45K Cooling Towers at the Wagerup Refinery (**45K cooling towers**).

The current basis for estimating emissions is set out in the report *Wagerup Air Quality Action Plan Sign Off Report prepared for the CSIRO Resolution Committee - Recommendation 2: Cooling Tower Emissions* submitted to the then Department of Environment Regulation in February 2014 (Alcoa 2014). The report reviewed results from emission sampling of the cooling towers using conventional stack testing methodologies and set out the concentration data set to be used for estimating average and peak concentrations for potential key VOCs emitted from the cooling towers.

While the report concluded that this provided the best basis for estimating VOC emissions at the time, it also recognised that further work should be undertaken to endeavour to improve the emissions estimation from the towers.

The 2014 report identified acetone and formaldehyde as the largest potential VOC emissions from the cooling towers. It also highlighted significant uncertainty in concentration data used to derive mass emission estimates. In particular, two key factors affected the estimated quantity of these VOCs. These were:

i. Conservatism Applied to Acetone Concentration Data

The data set adopted for acetone included four high acetone sample results obtained in the 2002 and 2003 period. There are three high readings on one day in January 2002 ranging from 2.2 – 2.3 mg/m³. There is also one high reading in December 2003 (3.5 mg/m³), although two other readings on the same day are below 0.1 mg/m³. All other samples of acetone (13) recorded either non-detect or close to detection limit (about 0.1 mg/m³).

The four high results contribute roughly 95% of the 0.63 mg/m³ average concentration calculated for the acetone data set.

The 2014 report noted that concentration data collected pre-2004 is higher when compared to concentration data collected in 2004-2006, indicating that acetone emissions reduced from 2004. The report stated “there was significant improvement and optimisation in cooling tower operation around this time (2004) which may have contributed to the decreased acetone” (Alcoa 2014).

ii. Uncertainty in Formaldehyde Concentration Data

The data set for formaldehyde includes 34 sampling results, 27 of which were non-detects. The other seven sampling results are close to the level of detection (about 0.4 mg/m³). Where a non-detect has been recorded in sampling, the data set adopts half the detection level as the estimated formaldehyde emission concentration. Adopting half detection level contributes 64% of the 0.25 mg/m³ average concentration calculated for the formaldehyde data set. The 2014 report noted that “advances in measurement / monitoring technology are required to reliably measure formaldehyde emissions from cooling towers” (Alcoa 2014).

Although concentrations of acetone and formaldehyde are low, the uncertainty in concentration data proves problematic when estimating mass emissions as the Cooling Towers have a high flow rate. This means that small concentration changes have a big impact on mass emissions and potentially skew the refinery emission profile.

From 2017 Alcoa has undertaken a number of tasks to improve the reliability of the cooling tower VOC emission estimates, in particular to address uncertainty in measured concentrations. These have included:

- i. A literature search of other potential direct emission measurement methods for cooling towers, aimed at reliable measurement of formaldehyde and continuous measurement over a period of time to ascertain emission variability;

- ii. Implementation of a trial of the Open Path Fourier Transform Infrared Spectroscopy (OP-FTIR) measurement technique, identified from the literature search;
- iii. Further characterisation using conventional emission sampling methods during the OP-FTIR trial;
- iv. Review of historical cooling tower water quality data and additional water quality testing of key cooling tower water streams to enable calculation of mass loads of acetone and formaldehyde to the cooling towers.

This further work has shown that the cooling towers are only a minor source of acetone and formaldehyde emissions. The work and findings are outlined in this report.

Based on feedback from the Department of Water and Environment Regulation (DWER) Alcoa proposes to undertake further review of the OP-FTIR measurement technique. During this period Alcoa will not utilise results from the OP-FTIR work.

Alcoa considers it appropriate however, to amend the basis for calculating the average acetone emission concentration by removing the high 2002 and 2003 data points based on a review of the acetone concentration data derived from conventional emission testing methodologies and mass balance calculations. As a conservative measure, Alcoa will retain the highest reading from the 2002 to 2003 period in the acetone data set for determination of estimated peak emission concentration.

Also as a conservative measure, Alcoa will retain the current data set for estimating average and peak formaldehyde concentration, which adopts half detection level where non-detection is recorded, even though the mass balance indicates the likelihood of measurable formaldehyde emissions is much lower.

Based on the further work, Alcoa now also proposes to initiate periodic monitoring of VOCs in the cooling tower water streams as a means of verifying on-going low emissions from this source.

Subject to this monitoring indicating continued low levels of VOCs in the water, Alcoa will further review the approach (and data sets) for estimation of emissions from the cooling towers.

2. Cooling Tower Operation

Some parts of the Wagerup alumina refinery's Bayer process require cooling of hot caustic liquor, slurries or calcined alumina. The cooling is undertaken by passing cooled water through non-contact (indirect) heat exchangers called Secondary Interstage Coolers (SISC's). The water that is used for process cooling gains heat and is returned (recirculated) to cooling towers, where it is cooled again and re-used for process cooling. A schematic showing the inputs and outputs of the cooling towers and the SISCs is shown in Figure 1.

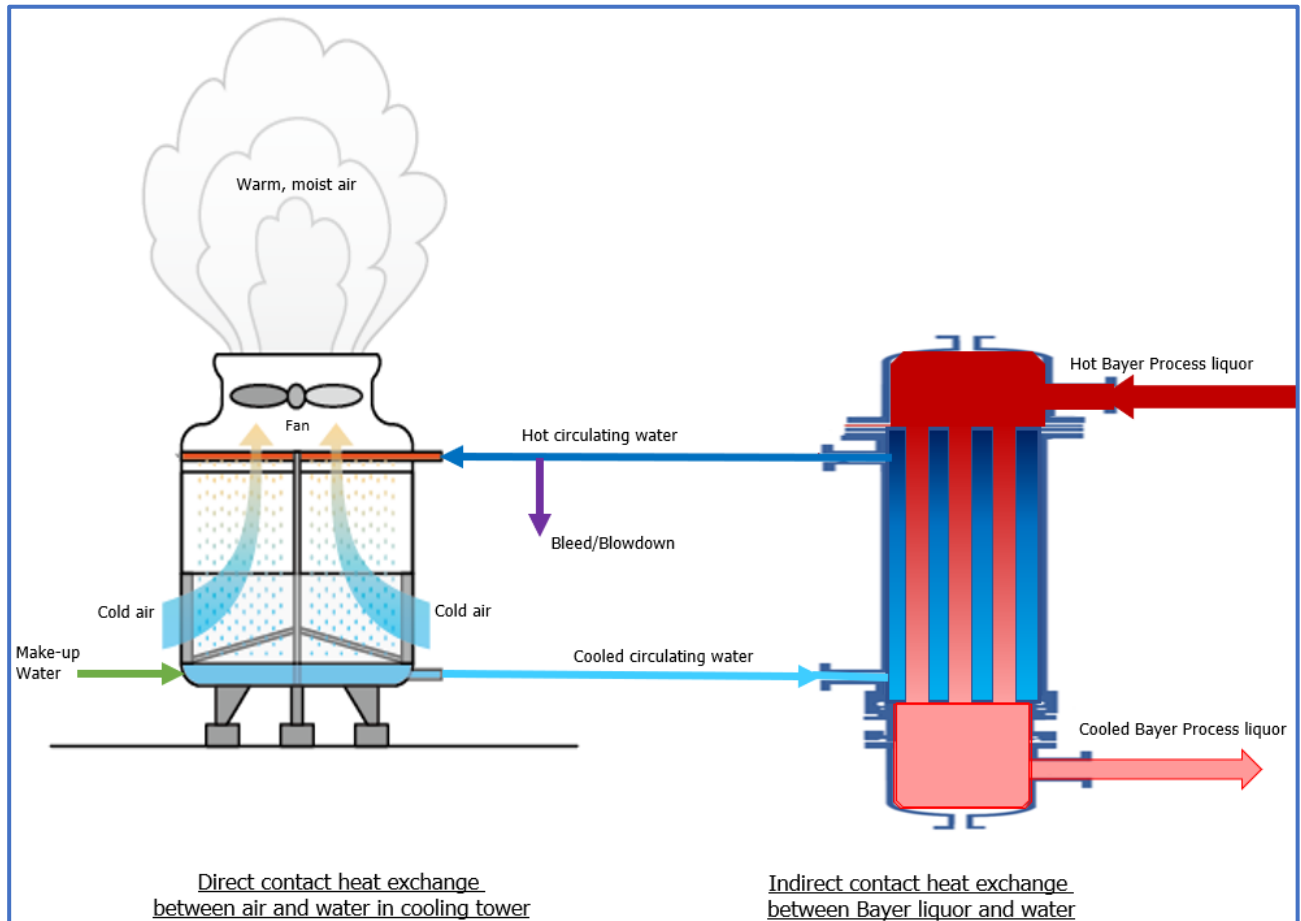


Figure 1: Schematic Showing Inputs and Outputs of Indirect Coolers (SISCs) & Cooling Towers

The cooling towers are evaporative coolers which cool water to near ambient temperature. Some of the water fed to the cooling tower evaporates into the air, cooling the water and heating the air in the process. The remaining water circulates through the tower and is used again for indirect cooling. Water generally circulates through the cooling towers about six times before being discharged.

The cooling towers require feedwater (known as make-up water) to replace the evaporating water and a bleed (blowdown) stream to limit the concentration of substances in the recirculating water.

The moist, warm environment of cooling towers can promote corrosion, algae growth and bacteria growth (e.g. legionella) which would pose a health risk to the workforce if not controlled. Disinfectant and anti-scaling chemicals are added to the cooling towers as a control measure by a third-party contractor.

At Wagerup Refinery, cooling towers are operated in the milling, powerhouse, precipitation and calcination areas.

2.1. Milling and Powerhouse Cooling Towers

The cooling towers for milling and the powerhouse areas (Buildings 25, 30, 110, 48, 47 and 984Y) are small and supplied with make-up water from the Upper Dam¹. No significant emissions are expected from these towers, so they are not included in the 2018 Emission Inventory.

2.2. Calcination Cooling Towers

The calcination cooling towers (50C cooling towers) mostly use Upper Dam water as makeup water, but occasionally use Lower Dam water². The 50C cooling towers are included in the 2018 Emission Inventory with a factor applied to account for emissions if Lower Dam water is used.

2.3. Precipitation Cooling Towers

The precipitation cooling towers are large with both significant water and air flows. There are three cooling towers (45K1, 45K2 and 45K3). The water basin in the cooling towers has a storage capacity of about 585 kilolitres (kL). These towers are supplied make-up water from the Lower Dam. Since the condensate from the digestion area contains some VOCs, emissions from the 45K cooling towers could contain VOC's if VOCs are stripped into the cooling tower air stream and discharged to the atmosphere.

The ratio of make-up water flowrate to blowdown water flowrate in the 45K cooling towers is typically about 6:1 (i.e. water will generally circulate through the cooling towers about six times before being discharged), meaning that substances present in water which are not stripped through emissions can concentrate up to about 6 times in the recirculating water before being discharged. Water circulates about once every 18 minutes.

Typical flow information for the 45K cooling towers is shown in Table 1. This will vary daily depending on cooling tower loads and ambient temperature.

Table 1: Typical Water Flow Rates through 45K Cooling Towers³

Cooling Tower Water Stream	Flow Rate (kL/h)
Make-up (Lower Dam)	130
Recirculating water	2400
Blow-down	20

¹ The Upper Dam water source is 'fresh surface water' sourced from rainfall runoff and Yalup Brook. This is used predominantly as the Refinery potable water supply.

² The Lower Dam water is sourced from rainfall runoff and digestion condensate.

³ Typical water flows based on review of 2017 operational data.

3. Current Basis for Estimating VOC Emissions from the 45K Cooling Towers

Alcoa has undertaken considerable work over an extensive period of time to achieve the most reliable estimate of VOC emissions from 45K cooling towers.

The current basis for estimating emissions is set out in the report *Wagerup Air Quality Action Plan Sign Off Report prepared for the CSIRO Resolution Committee - Recommendation 2: Cooling Tower Emissions* submitted to the then Department of Environment Regulation in February 2014 (Alcoa, 2014).

The report reviewed results from conventional emission sampling of the cooling tower stacks. The report identified that there are five VOCs which potentially may occur in the cooling tower emissions. These are acetone, formaldehyde, 2-butanone (Methyl Ethyl Ketone), toluene and styrene.

Table 2 lists the sampling method considered most reliable for each compound together with the detection limit achievable. USEPA Method 30 (VOST) was considered the best-established method for four of the VOCs but is not considered reliable for formaldehyde. No method was identified as being reliable for measurement of formaldehyde. In the absence of method capable of reliable measurement of formaldehyde, data obtained using ECS Method 6 (ECS M6), which is a modification of USEPA TO-5⁴ has been used by Alcoa.

Table 2: Summary of Sampling Methods used to Characterise Cooling Tower Emissions

VOC	Sampling Method	Detection limit ⁽¹⁾ (mg/m ³)
Acetone	USEPA Method 30 (VOST)	0.05-0.35
Formaldehyde	ECS Method 6 (based on USEPA TO-5)	0.4
2-butanone	USEPA Method 30 (VOST)	0.02- 0.35
Toluene	USEPA Method 0030 (VOST)	0.002-0.17
Styrene	USEPA Method 0030 (VOST)	0.002-0.12

1. Wet, based on 13% saturation at approximately 26°C.

Based on a detailed review of available data, the 2014 report sets out the dataset of emission concentration results to be used for estimating average and peak VOC emission rates for each compound from the 45K cooling tower source. As a conservative measure, where a sampling run did not detect a compound, half the method detection limit (½ MDL) was adopted for the emission concentration.

Table 3 sets out the estimated average and peak concentrations for the five VOCs based on these datasets, and average and peak emission rates (based on 2018 refinery flows).

Table 3: Estimated VOC emissions from 45K cooling towers based on 2014 approach

VOC	Concentration (mg/m ³)		Mass emission 2018 (g/s)		% of average cooling tower emissions
	average	peak	average	peak	
Acetone	0.63	3.5	0.72	4.0	66%
Formaldehyde	0.25	0.53	0.28	0.6	26%
2-butanone	0.068	0.7	0.08	0.8	7%
Toluene	0.0027	0.009	0.003	0.01	0.5%
Styrene	0.0024	0.008	0.003	0.01	0.5%

⁴ ECS Method 6 is based on USEPA TO-5 for sampling aldehydes and ketones in ambient air. It was modified to allow sampling from a vent.

It can be seen that acetone and formaldehyde represent the key potential VOC emissions from the cooling towers, around 93%, based on the estimation approach documented in 2014.

While the report concluded that this approach provided the best basis for estimating VOC emissions at the time, it also recognised that further work should be undertaken due to concerns about the reliability of data due to methodology limitations for the source. Two key factors were identified as affecting the VOC emission estimates from the cooling towers:

i. Conservatism Applied to Concentration Data

Acetone

Review of the acetone data set shows that acetone emission rates are highly influenced by a small number of results (Figures 2a & 2b).

Acetone concentrations measured in 2002-2003 are distinctly different to concentrations measured from 2004 (Figure 2a and 2b). There are three high readings on one day in January 2002 ranging from 2.2 – 2.3 mg/m³. There is also one high reading in December 2003 (3.5 mg/m³), although two other readings on the same day are below 0.1 mg/m³. All samples for the period 2004 to 2006 (13 results) recorded either non-detect or close to detection limit (about 0.1 mg/m³).

The 2014 report noted that *“the 2002-2003 VOST data is also higher compared to 2004-2006 VOST data indicating acetone emissions have reduced from 2004. There was significant improvement and optimisation in cooling tower building operation around this time and this may have contributed to the decreased acetone emissions”* (Alcoa, 2014).

The four high readings contribute around 95% of the 0.63 mg/m³ average concentration calculated for the acetone dataset.

2-butanone, Toluene & Styrene

The 2-butanone, toluene and styrene datasets exhibit similarity to the acetone data set. The dataset for 2-butanone is shown in Figure 2d.

Although there are no VOST sampling results for 2002, the three datasets all show high readings in December 2003 similar to the acetone dataset, although again, two other samples on that day recorded low concentrations for each compound.

All results for these VOCs were non-detect or very low for the period 2004 to 2006.

ii. Uncertainty in Formaldehyde Concentration Data

Review of the formaldehyde dataset shows that formaldehyde emission rates are highly influenced by the adoption of the ‘½ MDL protocol where emissions were unable to be quantified (Figure 2c).

The dataset includes 34 sampling results, 27 of which were non-detects. The other seven sampling results are close to the level of detection (about 0.4 mg/m³). Where a non-detect has been recorded, the dataset adopts half the detection level as the estimated formaldehyde emission concentration. Adopting half detection level contributes 64% of the average concentration calculated for the formaldehyde data set (0.25 mg/m³).

The 2014 report noted that the detection limit achievable for formaldehyde using ECS M6 is relatively high and concluded that *“advances in measurement / monitoring technology are required to reliably measure formaldehyde emissions from cooling towers”* (Alcoa, 2014).

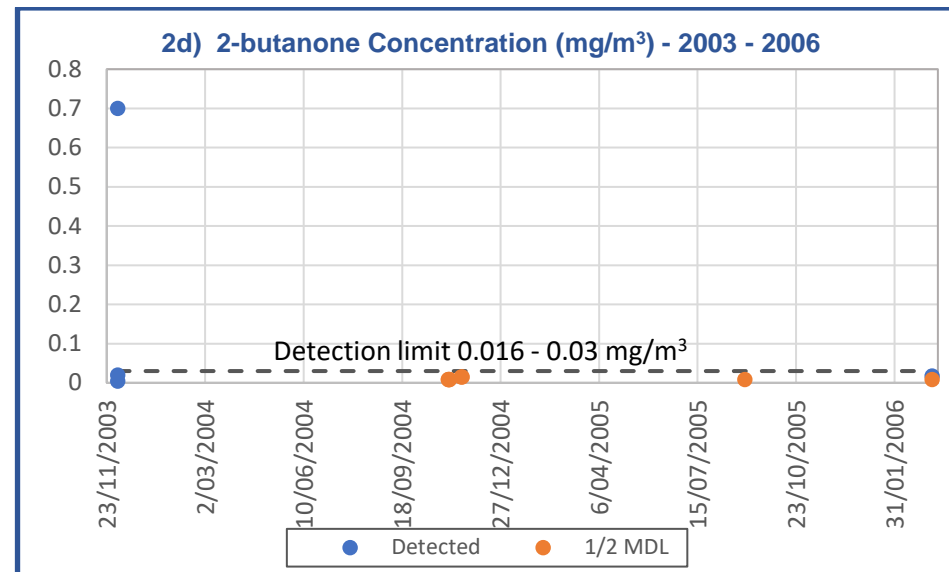
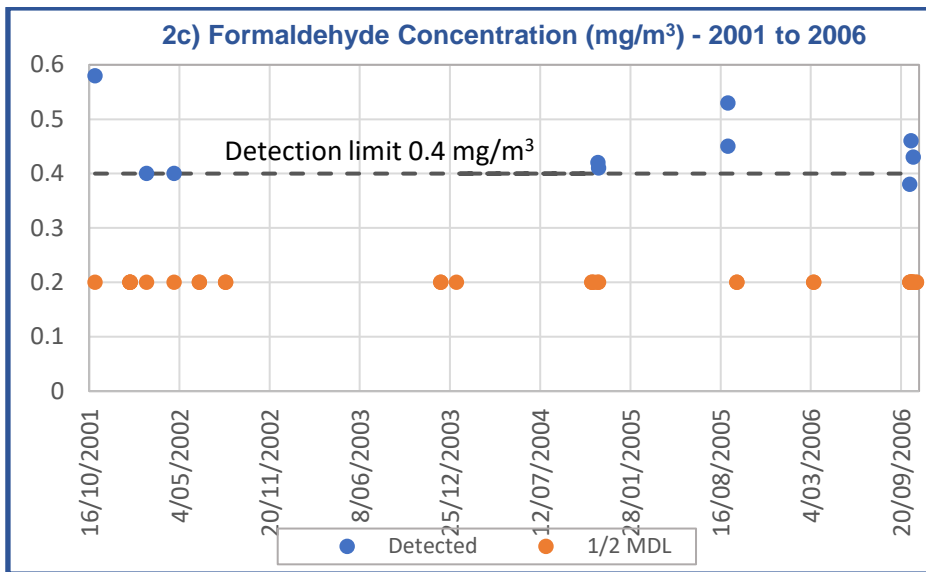
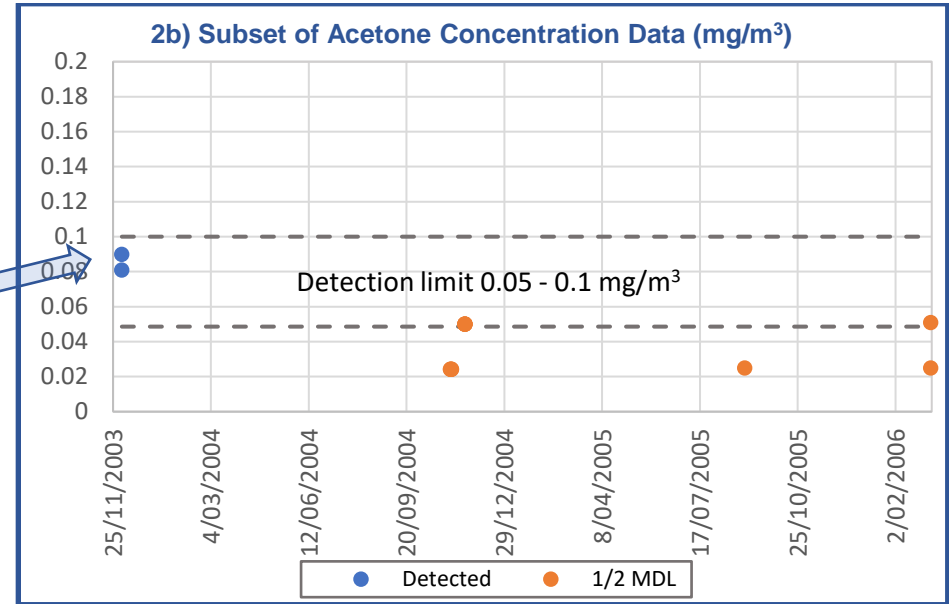
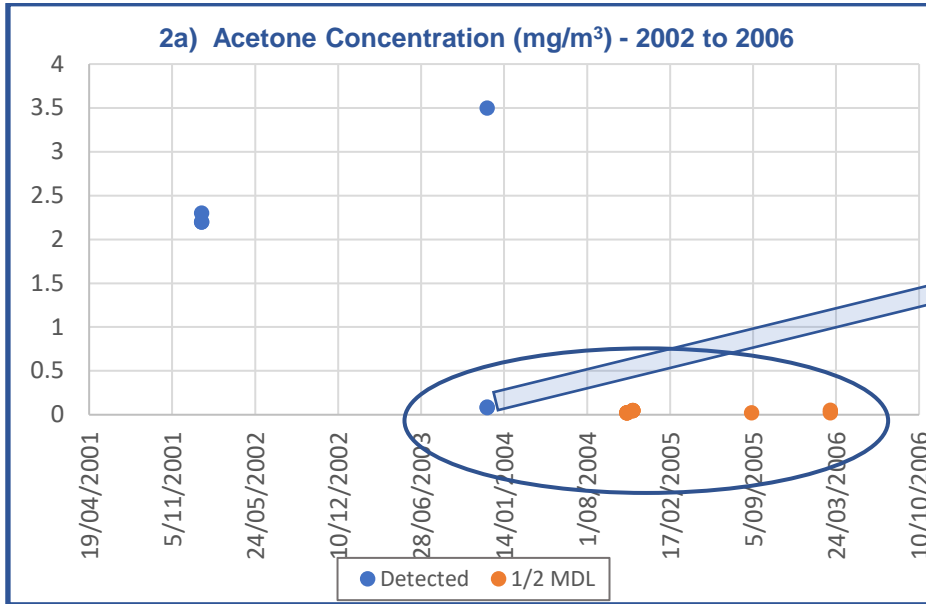


Figure 2a to 2d: 45K Cooling Tower Acetone, Formaldehyde and 2-butanone (MEK) Concentration Data

4. Further Work on 45K Cooling Tower Emission Estimation

Alcoa has undertaken a number of activities aimed at improving the reliability of the cooling tower VOC emission estimates following the preparation of the 2014 report (Alcoa, 2014). The work is summarised in sections 4.1 to 4.4 below.

4.1. Review of Cooling Tower Characterisation Approach at Alcoa's Global Alumina Facilities

Alcoa operates alumina refineries in Spain, Brazil and the United States of America (U.S.A). A review of cooling tower emission characterisation approach was conducted and identified the following:

- | | |
|----------------|---|
| Brazil: | No requirement to quantify emissions from cooling towers at alumina refineries. |
| Spain: | No requirement to quantify emissions from cooling towers at alumina refineries. |
| U.S.A: | No requirement to quantify emissions from cooling towers at alumina refineries. |

Colleagues from the U.S.A advised that emission estimation methods for cooling towers based on calculation or use of emission factors are used in U.S.A and Canada to estimate VOC emissions from cooling towers for select industries (petroleum refineries and chemical manufacturing facilities) where heat exchangers service hydrocarbon process streams (Govt of Canada, 2018; SCAQMD⁵⁵, 2017 and US EPA, 1995). Cooling tower VOC Emission factors are not provided for other industries and no estimate of VOC emissions is required.

The use of emission factors derived for petroleum or chemical manufacturing industries is not considered appropriate for estimation of VOC's from the 45K cooling towers since Bayer liquor is not a hydrocarbon process stream.

4.2. Review of Alternative Methods to Estimate VOC Emissions

The 45K cooling towers present the following challenges for stack monitoring:

- The source has a non-ideal sampling plane. The vent is approximately 8m diameter and sample ports are located <1m downstream of the cooling tower fans. This compromises flow rate measurements.
- The source is saturated (13% moisture at 26°C) and contains some water droplets. This affects (increases) method detection limits and also interferes with the detection of some compounds.
- Low concentration emissions. This affects the certainty of results where low method detection limits can't be achieved.

These challenges have been identified previously and a review of conventional sampling methodologies was conducted (Alcoa, 2014) and the most reliable methods identified (refer section 3).

A review of other potential direct sampling methods for cooling towers was conducted in 2017. The review aimed at identifying a method that can:

- reliably quantify formaldehyde,
- achieve low detection limits for VOC's of interest (acetone, formaldehyde, 2-butanone, toluene and styrene.
- provide information on emission variability.

⁵⁵ SCAQMD is the air pollution agency responsible for regulating stationary sources of air pollution in the South Coast Air Basin, in Southern California

The review identified:

- the same conventional stack sampling methods that were available in 2014;
- an alternative ambient monitoring technique, Open Path Fourier Transform Infrared Spectroscopy (OP-FTIR) that may be applicable for measurement of cooling tower emissions with some modification;
- estimation techniques based on mass balance calculations.

4.3. Additional Direct Measurement of 45K Cooling Tower

Based on the outcome of the literature search, further source monitoring was conducted in 2017. The OP-FTIR technique was trialled to determine its applicability for cooling tower emission measurement. Alcoa has agreed not to use data from the OP-FTIR trial in the 2018 Emission Inventory.

At the same time, the cooling tower emission was sampled using conventional stack sampling methodologies. Alcoa has not used data from this program in the 2018 Emission Inventory as sampling was not conducted isokinetically (Alcoa, 2019). Data is provided in Appendix 1 for reference.

Further direct measurement of 45K cooling tower is planned as part of the Emissions Inventory Improvement Program.

4.4. 45K Cooling Tower Water Monitoring

Cooling Tower water streams (make-up, recirculating & Blow-down) were sampled during the 2017 cooling tower monitoring program and their chemical composition analysed. This water quality data was collected to enable calculation of cooling tower VOC emissions via mass balance. Water quality data is presented in Table 4.

Table 4: 2017 VOC Concentration in Cooling Tower Water Streams

Compound	Unit	Make-Up Water				Recirculating Water			
		26-Apr	26-Apr	1-May	Average	26-Apr	26-Apr	1-May	Average
Acetone	mg/L	0.33	0.41	0.30	0.35	0.06	0.07	0.07	0.067
Formaldehyde	mg/L	nd	nd	nd		0.21	0.21	0.28	0.233
2,4-Dimethylphenol	µg/L	6.8	6.4	5.6	6.27	2.4	2.3	2.4	2.37
2-Methylphenol	µg/L	5.7	4.7	4.0	4.8	0.8	0.4	1.0	0.73
2-Picoline	µg/L	0.7	0.5	0.3	0.5	nd	nd	nd	
3 & 4-methylphenol	µg/L	3.7	2.9	1.9	2.83	1.2	0.6	1.3	1.03

1. nd = not detected.

The water quality data shows that the main analytes present in cooling tower make-up and recirculating water streams are acetone and formaldehyde. These are at low concentration. All other analytes detected were at insignificant concentrations (Refer to Appendix 2).

5. VOC Emission Estimation by Mass Balance Calculation

The NPI Emission estimation technique manual for Alumina refining Version 2.0 November 2007 lists mass balance as one of five types of emission estimation techniques (EETs) that may be used to calculate emissions from alumina refineries (Department of the Environment, Water, Heritage and the Arts, 2007). The Government of Canada also specifically recognises mass balance as an accepted approach for estimating emissions of VOCs from wet cooling towers as part of their National Pollutant Release Inventory (Government of Canada, 2018).

The emissions of acetone and formaldehyde from the 45K cooling towers can be estimated by calculation based on knowledge of the mass load of these compounds in cooling tower make-up water, recirculating water and Blow-down streams as shown in Figure 3.

Boundary for mass balance

IN = OUT

$$C = G + F$$

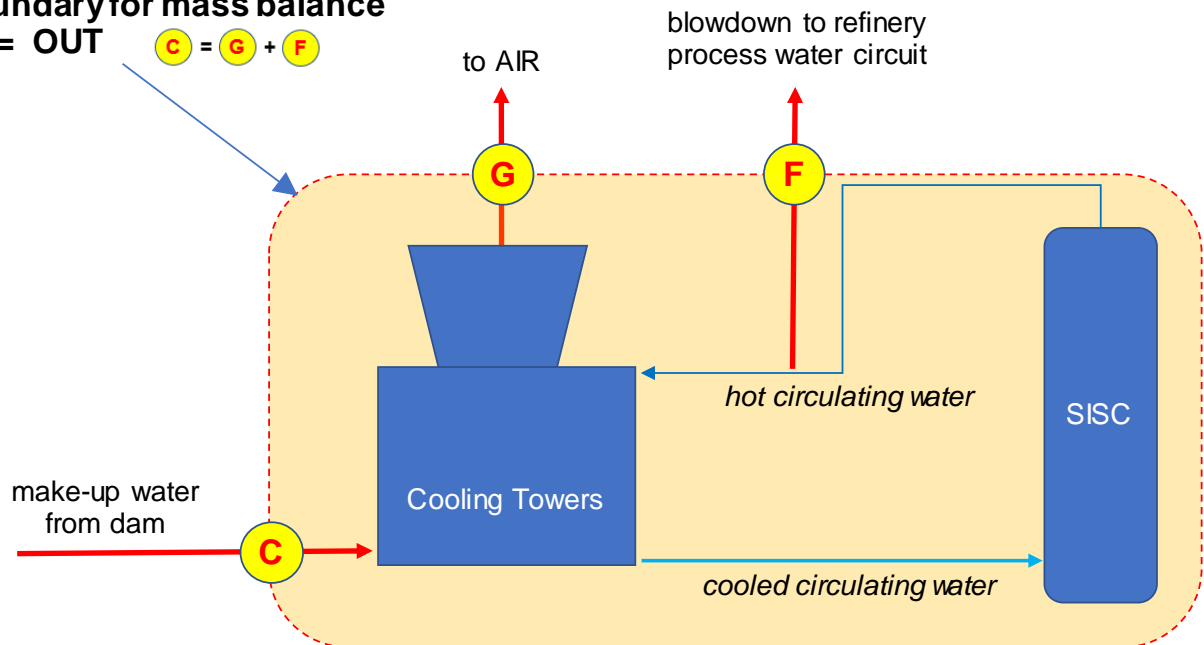


Figure 3: Schematic Showing Boundaries of the Cooling Tower Mass Balance

The **emission rate** of a VOC to air from a cooling tower can be estimated using the formula:

$$\text{VOC mass emission rate [g/s]} = \text{VOC input mass rate} - \text{VOC output mass rate}$$

Where:

$$\text{VOC input mass rate [g/s]} = \frac{C_{\text{VOC,In}} \times \text{Make-up water Flow Rate}}{3600}$$

$$\text{VOC output mass rate [g/s]} = \frac{(C_{\text{VOC,Out}}) \times \text{Blow-down Water Flow Rate}}{1000 \text{ [mg/g]} \times 3600}$$

And:

$C_{\text{VOC,In}}$ = Concentration of VOCs in the make-up water to the cooling tower

$C_{\text{VOC,Out}}$ = Concentration of VOCs in the blow-down water leaving the cooling tower

The **VOC concentration** in the cooling tower emissions can be estimated using the formula:

$$\text{VOC concentration [mg/m}^3\text{]} = \frac{\text{VOC mass emission rate} \times 3600}{\text{Air Flow Rate} \times 1000}$$

This calculation approach will provide a sound estimate of mass emission rate and concentration of a VOC to air from a cooling tower where the following assumptions hold:

- i. There is not significant drift losses of water particles from the cooling towers;
- ii. There is not cross contamination from the product being cooled to the cooling water in the heat exchange process; and
- iii. The VOC is not formed or destroyed as a result of the chemical or microbial processes occurring within the cooling tower.

Alcoa believes the first two assumptions are satisfied. The 45K cooling towers are fitted with drift eliminators to minimise any drift losses of water particles from the system so drift losses will be minimal.

Alcoa has replaced the majority of mild steel cooler tubes in the indirect heat exchangers (SISCs) with stainless steel to minimise the risk of holes developing in the tubes and causing cross contamination of the cooling tower recirculating water stream. This is supported by water quality data for the cooling tower as the recirculating water stream has lower analyte concentrations than the make-up water, with the exception of formaldehyde, discussed below.

It is likely that chemical and microbial processes do occur in the 45K cooling towers. Formaldehyde has not been detected in the cooling tower make-up water stream but it was detected in the cooling tower recirculating water stream. To account for the presence of formaldehyde in the recirculating water stream and as a conservative measure, the estimation of formaldehyde emissions by mass balance has used the formaldehyde concentration of the recirculating water stream as the input VOC value ($CVOC_{in}$) rather than the formaldehyde concentration of the make-up water stream (section 5.3).

5.1. Acetone Emission Estimation for 2017 by Mass Balance Calculation

While Lower Dam water quality has been monitored since 1989 analysis has generally not included VOCs. VOC monitoring of cooling tower make-up water, recirculating water and blow-down water has been undertaken for the 45K cooling towers in 2017.

Tables 5 and 6 below summarise the cooling tower water analysis data and presents estimated acetone emission rates and emission concentration derived using the calculations presented in section 5.

The ratio of acetone concentration in the make-up water to the blow down water is around 1:0.2, indicating acetone is being stripped from the recirculating water stream and not forming within the cooling tower.

The estimated concentrations of acetone in cooling tower emissions calculated based on the mass of acetone in make-up water and blow-down water for the cooling towers, is generally below the detection limit of the USEPA Method 30 (VOST) for acetone (Table 6).

The emission calculations indicate there is little acetone emission from the 45K cooling towers. This is consistent with data collected using conventional stack testing methodologies and the OP-FTIR trial (section 3).

Table 5: Estimated Acetone Emission Rates Based on 2017 Cooling Tower Water Analysis Data

Sample date	Make-up Water Acetone Concentration mg/L, g/kL	Make-up Water Flow kL/h	MASS IN Make-up water g/s	Blow-down Acetone Concentration mg/L, g/kL	Blowdown Water Flow kL/h	MASS OUT Blowdown g/s	MASS OUT Acetone Emission Rate to Air g/s	Recirculation Flow Rate kL/h	Mass Circulation Rate in Cooling Water g/s	Estimated Acetone Stripping Ratio to Air (%)
26-Apr-17	0.33	132.2	0.0121	0.06	20.0	0.0003	0.0118	2101	0.0350	34
26-Apr-17	0.41	132.2	0.0151	0.07	20.0	0.0004	0.0147	2101	0.0408	36
1-May-17	0.30	138.3	0.0115	0.07	20.0	0.0004	0.0111	2625	0.0510	22
Column Calculation	A	B	C (A x B) / 3600	D	E	F (D x E) / 3600	G C - F	H	I (D x H) / 3600	J (G / I) * 100

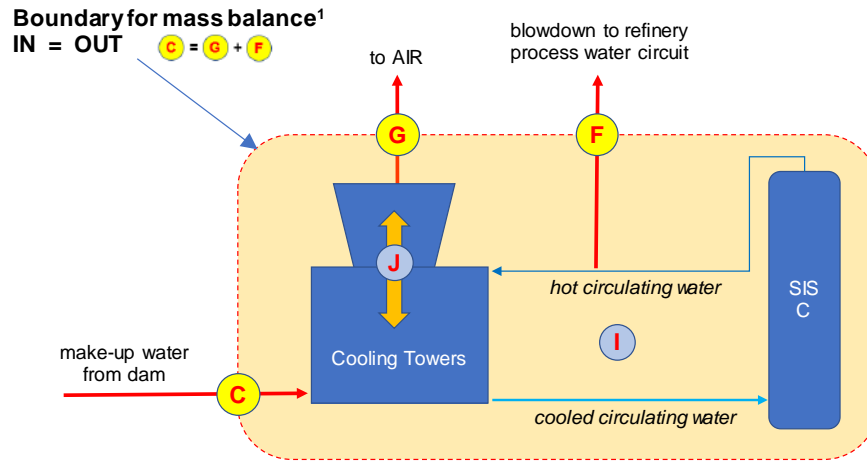


Table 6: Estimated Acetone Emission Rate and Emission Concentration Based on 2017 Cooling Tower Water Analysis Data

Sampling Date	MASS OUT Acetone Emission Rate to Air g/s	Cooling Towers online #	Estimated Cooling Tower Air Flow Mm ³ /h	Estimated Acetone Air Emission Concentration mg/m ³	USEPA M30 Detection Limit mg/m ³	Comment
26-Apr-17	0.0118	3	4.9	0.009	0.050 - 0.350	<i>below M30 detection limit</i>
26-Apr-17	0.0147	3	4.9	0.011		<i>below M30 detection limit</i>
1-May-17	0.0111	3	4.9	0.008		<i>below M30 detection limit</i>
Column :	A	B	C	D		
Calculation :				A x 3.6 / C		

5.2. Acetone Emission Estimation for 2004 – 2005 by Mass Balance Calculation

There is also a period where VOCs in the Lower Dam and make-up water to 45K cooling towers were monitored in 2004 – 2005 (Table 7). While VOCs were not monitored in the cooling tower blow-down stream during this period, a conservative estimate of emissions from the cooling towers can be made by assuming zero mass rate of VOCs in the blow-down water (i.e. 100% of input VOC mass rate is lost to air emissions).

Table 7 summarises the estimated emission rates and concentration of acetone for 45K cooling towers for 2004 – 2005 based on acetone loads in the make-up water.

Table 7: Estimated Acetone Emission Rates Based on 2004 Water Analysis Data

Date	Acetone			
	Make-up water concentration (mg/L)	Make-up water flow rate	Emission rate ⁽¹⁾ (g/s)	Emission concentration ⁽²⁾ (mg/m ³)
	USEPA M30 Detection Limit (mg/m ³)			0.05-0.35
27-05-2004	0.37	100	0.015	0.012
13-07-2004	0.25	100	0.010	0.008
27-09-2004	<0.01	100	<0.0003	<0.0003
20-01-2005	0.05	100	0.002	0.002

1. Estimated make-up water rate for 2004 at 2.4 Mtpa production 100 kL/hr
2. Estimated air flow rate for 2004 at 2.4 Mtpa 4.0 Mm³/hr (dry)
3. Conservatively assumes 100% of acetone mass in make-up water is emitted to air.

The estimated concentrations of acetone in cooling tower emissions calculated based on the mass of acetone in make-up water for the cooling towers for the 2004 – 2005 period is also below the detection limit of the USEPA Method 30 (VOST) for acetone. This is consistent with the emission sampling results in the acetone dataset for this sampling method for the 2004 – 2006 period, as described in section 3.

The estimated acetone concentrations based mass load in cooling tower make-up water for 2004 – 2005 are significantly below the high sampling results of 2.2 – 2.3 mg/m³ recorded in January 2002 and 3.5 mg/m³ recorded in April 2003. The higher concentrations could be a result of either:

- higher acetone levels in the Lower Dam make-up water at those times;
- cross contamination from slurries through the heat exchangers (SISCs); or
- sampling error.

Water quality data is available for the Lower Dam for January 2002 and April 2003, but it does not include VOCs. Other analytes sampled in the Lower Dam in these months are not materially different from the 2004 – 2005 period. To generate a cooling tower emission concentration of 2.2 – 2.3 mg/m³, the acetone concentration in make-up water would need to be in the order of 70 mg/L and to generate an emission concentration of 3.5 mg/m³ in the order of 108 mg/L. Such acetone concentrations do not appear realistic based on available water quality monitoring data for the Lower Dam.

It is also unlikely that cross contamination occurred within the indirect heat exchangers, as two low acetone emission concentration results (0.081 mg/m³ and 0.09 mg/m³) were recorded in samples collected on the same day in December 2003 as the high reading of 3.5 mg/m³. The most likely reason for the high reading is therefore sampling error

5.3. Formaldehyde Emission Estimation for 2017 by Mass Balance Calculation

Table 8 summarises the formaldehyde make-up water and blow-down water analysis data available for the 45K cooling towers in 2017.

Table 8: Formaldehyde Concentration in Make-up Water and Blow-down Water 2017

Sampling Date	Make-up water Concentration (50% MDL=0.005) mg/L, g/kL	Make-up water flow kL/h	MASS IN Make-up water g/s	Blow-down Concentration mg/L, g/kL	Blowdown water flow kL/h	MASS OUT Blowdown g/s	Comment
26-Apr-17	0.005	132.2	0.0002	0.21	20.0	0.0012	Mass out larger than input
26-Apr-17	0.005	132.2	0.0002	0.21	20.0	0.0012	Mass out larger than input
1-May-17	0.005	138.3	0.0002	0.28	20.0	0.0016	Mass out larger than input
Column Calculation	A	B	C (A x B) / 3600	D	E	F (D x E) / 3600	

The data indicates that the ratio of formaldehyde concentration in the blow-down water to make-up water is well above the typical maximum concentration ratio 6:1 based on make-up water and blow-down water flow rates. This indicates formaldehyde is being formed within the cooling towers. It is expected this is as a result of microbial or chemical processes occurring within the tower and is not linked to tower input.

A very conservative emission estimate can be made by assuming 100% of formaldehyde in the recirculating water is lost to air emissions in each circulation. The stripping of all formaldehyde to air is considered very conservative as the rate of stripping of acetone to air is in the order of 30% per circulation based on the emission calculations presented in section 5.1 (Table 5).

Table 9 below summarises the formaldehyde concentration in the recirculating water and estimated maximum emission rate and concentration of formaldehyde based on this data.

The estimated maximum formaldehyde concentrations based on the mass of formaldehyde in the cooling tower blow-down (recirculating) water in 2017 is below the detection limit of ECS M6 (modified USEPA Method TO-5) for formaldehyde.

The emission calculations indicate there is little formaldehyde emission from the 45K cooling towers. This is consistent with data collected using conventional stack testing methodologies between 2004 and 2017 and the OP-FTIR trial.

Table 9: Maximum Estimated Formaldehyde Emission Rate and Concentration Based on 2017 Cooling Tower Water Analysis Data

Sampling date	Recirculation concentration mg/L, g/kL	Recirculation flow rate kL/h	Mass Circulation Rate in Cooling Water g/s	MASS OUT EMISSION RATE TO AIR (Assuming 100% stripping per cycle) g/s	Cooling Towers online #	Estimated Cooling Tower Air Flow Mm ³ /h	Estimated Formaldehyde Air Emission Concentration (Assuming 100% stripping per cycle) mg/m ³	ECS M6 (modified USEPA TO-5) Detection limit mg/m ³	Comment
26-Apr-17	0.21	2101	0.123	0.123	3	4.9	0.09	0.4	<i>Below method detection limit</i>
26-Apr-17	0.21	2101	0.123	0.123	3	4.9	0.09		
1-May-17	0.28	2625	0.204	0.204	3	4.9	0.15		
Column Calculation	A	B	C (A x B) / 3600	D equals C	E	F	G D x 3.6 / F	H	

5.4. Mass Balance of Formaldehyde 2004 – 2005 by Mass Balance Calculation

Table 10 summarises estimated emission rates and concentration of formaldehyde for 45K cooling towers for 2004 – 2005 based on formaldehyde loads in the make-up water.

While VOCs were not monitored in the cooling tower blow-down stream during this period, a conservative estimate of emissions from the cooling towers can be made by assuming zero mass rate of VOCs in the blow-down water (i.e. 100% of input VOC mass rate is lost to air emissions), if no formaldehyde was formed or added within the system.

Table 10: Estimated Emission Rates and Concentration of Formaldehyde 2004 – 2005

Date	Formaldehyde		
	Make-up water Concentration (mg/L)	Emission rate ⁽¹⁾ (g/s)	Emission Concentration ⁽²⁾ (mg/m ³)
27-05-2004	<0.05	<0.002	<0.002
13-07-2004	<0.05	<0.002	<0.002
27-09-2004	<0.05	<0.002	<0.002
20-01-2005	<0.05	<0.002	<0.002

1. Estimated make-up water rate for 2.4 Mtpa production 145 kL/hr
2. Estimated air flow rate for 2.4 Mtpa 4.420 (check wet or dry???) Mm³/hr

The estimated maximum formaldehyde concentrations based on the mass of formaldehyde in the cooling tower make-up water for the period 2004 - 2005 is below the detection limit of ECS M6 (modified USEPA Method TO-5) for formaldehyde.

While six non-detects were recorded from samples using ECS M6 during the 2004-2005 period, there were also four detects ranging from 0.41 mg/m³ to 0.53 mg/m³. Alcoa is not confident in the formaldehyde emission measurement data.

5.5. Other VOCs in the Lower Dam Feedwater and Recirculating water

Appendix 1 provides results of a comprehensive water quality analysis for make-up water and recirculating water for the 45K cooling towers from 2017. Table 4 summarises the concentration of VOCs (other than acetone) detected in the water.

All concentrations are at micrograms per litre which could result in only very small emissions. As such, these compounds will not be added to the 2018 Emissions Inventory. Alcoa will review any health risk levels associated with these concentrations and include them in the periodic water monitoring program.

6. Proposed Approach for Estimating 45K Cooling Tower Emissions for 2018 Emissions Inventory

On the basis of the data review conducted in section 3 and comparison with mass balance calculations conducted in section 5, Alcoa considers it appropriate to amend the basis for calculating the VOC emission concentrations presented in the 2018 Emission Inventory.

6.1. Calculation of Acetone Emission Concentration

Average acetone emission concentration will be derived from data collected from 2004 to 2017 using conventional stack testing methodologies i.e. will involve removal of the 4 elevated acetone concentrations recorded over 2 days in 2002 and 2003.

As a conservative measure, the peak acetone emission concentration will be estimated using the highest concentration result from 2002 and 2003.

6.2. Calculation of Formaldehyde Emission Concentration

As a conservative measure, Alcoa will retain the current data set for estimating average and peak formaldehyde concentration, which adopts half detection level where non-detection is recorded, even though calculations presented in section 6 indicates the likelihood that formaldehyde emissions are much lower.

Alcoa will continue to investigate alternative monitoring methods capable of accurate quantification of low concentrations of formaldehyde.

6.3. Other VOCs

Average and peak emission estimates of 2-butanone, toluene and styrene will be derived from data collected from 2004 to 2017 using conventional stack testing methodologies i.e. will involve removal of elevated concentrations recorded over 2 days in 2002 and 2003.

As a conservative measure, the peak 2-butanone, toluene and styrene concentration will be estimated using the highest concentration result from 2002 and 2003.

6.4. Calculation of Mass Emission Rates

Average and peak emission rates will be calculated using the applicable concentration value multiplied by the applicable flow rate.

Average Emission Rate = average concentration x average flow rate

Peak Emission Rate = peak concentration x peak flow rate

7. Future Work

7.1. Water Quality Testing of Cooling Tower Water Streams

Alcoa will implement periodic monitoring of VOCs in the cooling tower make-up and recirculating water streams as a means of verifying on-going low emissions from this source. Subject to the monitoring indicating continued low levels of VOCs in the water Alcoa will further review the approach (and data) used for estimation of emissions from the cooling towers.

7.2. Direct Measurement of Emissions

Alcoa is seeking further advice from Ektimo, a leading national emissions monitoring company, on the best practicable sampling approach and detection limits for measuring emissions from the cooling towers. Alcoa would like to work collaboratively with DWER on a proposed further program of stack sampling to compliment the OP-FTIR trial works and improve the characterisation of the cooling tower source.

8. References

Alcoa, 2014, Wagerup Wagerup Air Quality Action Plan Sign Off Report prepared for the CSIRO Resolution Committee - Recommendation 2: Cooling Tower Emissions.

Alcoa, 2019, Advanced Optical Remote Sensing Technology Study – Measurement of Wagerup Precipitation Cooling tower Emissions by OP-FTIR, Alcoa of Australia.

Department of the Environment, Water, Heritage and the Arts, 2007, Emission Estimation Technique Manual for Alumina Refining, Version 2.0.

Government of Canada, 2018, Wet Cooling Towers: Guide to Reporting.

South Coast Air Quality Management Division (SCAQMD), 2017, Guidelines for Calculating Emissions from Cooling Towers.

US EPA, 1995, Compilation of Air Pollutant Emissions Factors, AP 42, Volume 1, Fifth Edition, Chapter 13.4 Wet Cooling Towers.

9. Appendices

9.1. Appendix 1 – 2017 Conventional Stack Sampling Results for 45K Cooling Towers

As reported in Table 3 of Alcoa Advanced Optical Remote Sensing Technology Study (Alcoa, 2019)

All values in red and italics require further investigation and therefore cannot be used.

Class (NATA accreditation varies for stack sampling and lab analysis)	Compound	PQL (mg/m ³)	Test 1	Test 2
Ammonia [Ektimo (ETC) 330]	Ammonia	0.1	nd	nd
Halides [USEPA 26A]	<i>Hydrogen chloride</i>		<i>0.21</i>	<i>0.088</i>
	<i>Chlorine</i>	<i>0.01</i>	<i>0.17</i>	<i>nd</i>
	Hydrogen bromide	0.02	nd	nd
	Bromine	0.01	nd	nd
A&Ks [Ektimo (ETC) 390]	All compounds	0.09	nd	nd
VOCs [USEPA 18]	All compounds	0.008	nd	nd
VOCs [USEPA TO17]	<i>Dichlorodifluoromethane</i>	<i>0.0008</i>	<i>0.015</i>	<i>0.015</i>
	<i>Toluene</i>	<i>0.0008</i>	<i>0.0015</i>	<i>nd</i>
	<i>Trichlorofluoromethane (Freon 11)</i>	<i>0.008</i>	<i>0.0022</i>	<i>0.002</i>
	<i>1,2,4-Trimethylbenzene</i>	<i>0.0008</i>	<i>0.0008</i>	<i>nd</i>
	<i>Chloroform (Trichloromethane)</i>	<i>Not Analysed</i>		
Alcohols [USEPA 308] (5th May)	Methanol	0.45	nd	nd
	Ethanol	0.45	nd	nd
Chloroamines [OSHA Mod Method] (5th May)	Trichloroamine		0.057	0.058

9.2. Appendix 2 - Analytical Report 2017 CT Water Quality Monitoring.

9.2.1. Water Sample Register

Sample Number	Job Number	Sample Location	Sample type	Analysis	Date
S170002-1	RCC17002	Lower Dam Water	Water	VOC's	26/04/2017
S170002-2	RCC17002	Lower Dam Water	Water	Turbidity, pH, EC,BOD	26/04/2017
S170002-3	RCC17002	Lower Dam Water	Water	Chloramines, SVOC's	26/04/2017
S170002-4	RCC17002	Lower Dam Water	Water	Ammonia	26/04/2017
S170002-5	RCC17002	Lower Dam Water	Water	Metals	26/04/2017
S170002-6	RCC17002	Lower Dam Water	Water	VOC's	26/04/2017
S170002-7	RCC17002	Lower Dam Water	Water	Turbidity, pH, EC,BOD	26/04/2017
S170002-8	RCC17002	Lower Dam Water	Water	Chloramines, SVOC's	26/04/2017
S170002-9	RCC17002	Lower Dam Water	Water	Ammonia	26/04/2017
S170002-10	RCC17002	Lower Dam Water	Water	Metals	26/04/2017
S170002-11	RCC17002	CT Recirc Water	Water	VOC's	26/04/2017
S170002-12	RCC17002	CT Recirc Water	Water	Turbidity, pH, EC,BOD	26/04/2017
S170002-13	RCC17002	CT Recirc Water	Water	Chloramines, SVOC's	26/04/2017
S170002-14	RCC17002	CT Recirc Water	Water	Ammonia	26/04/2017
S170002-15	RCC17002	CT Recirc Water	Water	Metals	26/04/2017
S170002-16	RCC17002	CT Recirc Water	Water	VOC's	26/04/2017
S170002-17	RCC17002	CT Recirc Water	Water	Turbidity, pH, EC,BOD	26/04/2017
S170002-18	RCC17002	CT Recirc Water	Water	Chloramines, SVOC's	26/04/2017
S170002-19	RCC17002	CT Recirc Water	Water	Ammonia	26/04/2017
S170002-20	RCC17002	CT Recirc Water	Water	Metals	26/04/2017
S170002-21	RCC17002	Lower Dam Water	Water	VOC's	1/05/2017
S170002-22	RCC17002	Lower Dam Water	Water	Turbidity, pH, EC,BOD	1/05/2017
S170002-23	RCC17002	Lower Dam Water	Water	Chloramines, SVOC's	1/05/2017
S170002-24	RCC17002	Lower Dam Water	Water	Ammonia	1/05/2017
S170002-25	RCC17002	Lower Dam Water	Water	Metals	1/05/2017
S170002-26	RCC17002	CT Recirc Water	Water	VOC's	1/05/2017
S170002-27	RCC17002	CT Recirc Water	Water	Turbidity, pH, EC,BOD	1/05/2017
S170002-28	RCC17002	CT Recirc Water	Water	Chloramines, SVOC's	1/05/2017
S170002-29	RCC17002	CT Recirc Water	Water	Ammonia	1/05/2017
S170002-30	RCC17002	CT Recirc Water	Water	Metals	1/05/2017

9.2.2. Leeder Analytical Report

Chiappalone Consulting

PO Box 7,

Bulimba,

QLD, 4171

Attn: Carmelo Chiappalone

REPORT NUMBER: L170092

Your Reference: RCC17002

Order No: RCC17002

Date: 26th May 2017

CERTIFICATE OF ANALYSIS

SAMPLES: Thirty water samples were received for analysis

DATE RECEIVED: 8th May 2017

DATE COMMENCED: 8th May 2017

METHOD: As Listed within report

RESULTS:

Please refer to attached pages for the results.

Results are based on the samples received and analysed by Leeder Analytical

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REPORT BY:



Dr John F Leeder (BAppSci, MBA, PhD, FRACI, CCHEM)

Principal



LA-38 METALS

Analytical Results

ANALYTE	CAS No	Leeder ID	L170092-5	L170092-10	L170092-15	L170092-20	L170092-25	L170092-30	L170092-5	Method
		Client ID	S170002-5	S170002-10	S170002-15	S170002-20	S170002-25	S170002-30	S170002-5	Blank
		PQL							Duplicate	
Arsenic (As)	7440-38-2	0.001	0.002	0.002	0.01	0.01	0.003	0.01	0.003	nd
Barium (Ba)	7440-39-3	0.001	0.004	0.004	0.02	0.022	0.004	0.02	0.004	nd
Beryllium (Be)	7440-41-7	0.0005	nd	nd	nd	nd	nd	nd	nd	nd
Boron(B)	7440-42-8	0.02	nd	nd	0.07	0.08	nd	0.07	nd	nd
Cadmium (Cd)	7440-43-9	0.0001	nd	nd	nd	nd	nd	nd	nd	nd
Calcium (Ca)	7440-70-2	0.5	6.4	6.4	34	33	6.2	29	6.4	nd
Chromium (Cr)	7440-47-3	0.001	nd	nd	nd	0.001	nd	nd	nd	nd
Cobalt (Co)	7440-48-4	0.001	nd	nd	nd	nd	nd	nd	nd	nd
Copper (Cu)	7440-50-8	0.001	nd	nd	0.01	0.01	nd	0.007	nd	nd
Iron (Fe)	7439-89-6	0.01	0.02	nd	1.0	1.1	0.02	1.1	0.02	nd
Lead (Pb)	7439-92-1	0.001	nd	nd	nd	nd	nd	nd	nd	nd
Magnesium (Mg)	7439-95-4	0.5	3.3	3.4	18	18	3.2	15	3.3	nd
Manganese (Mn)	7439-96-5	0.005	nd	nd	0.04	0.05	nd	0.04	nd	nd
Molybdenum(Mo)	7439-98-7	0.001	0.02	0.02	0.11	0.11	0.02	0.11	0.02	nd
Nickel (Ni)	7440-02-0	0.001	nd	nd	nd	0.001	nd	nd	nd	nd
Potassium (K)	7440-09-7	0.5	1.2	1.2	6.5	6.5	1.2	5.8	1.2	nd
Selenium (Se)	7782-49-2	0.001	0.005	0.005	0.03	0.03	0.005	0.02	0.005	nd
Sodium (Na)	7440-23-5	0.5	41	42	330	300	43	290	41	nd
Tin (Sn)	7440-31-5	0.001	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium (V)	7440-62-2	0.001	0.02	0.02	0.08	0.08	0.02	0.08	0.02	nd
Zinc (Zn)	7440-66-6	0.001	nd	nd	2.5	2.5	0.002	2.3	nd	nd

Results expressed in mg/L, unless specified otherwise

PQL- Practical Quantitational Limit



Inorganic Analysis

Analytical Results

ANALYTE	Units	Leeder ID	L170092-2	L170092-7	L170092-12	L170092-17	L170092-22	L170092-27	L170092-2	Method Blank
		Client ID	S170002-2	S170002-7	S170002-12	S170002-17	S170002-22	S170002-27	S170002-2	
		PQL							Duplicate	
LA-72 Turbidity Turbidity	NTU	0.1	4.1	0.8	32	23	6.5	30	-	nd
LA-68 pH pH	units	0.1	8.6	8.6	7.2	7.1	8.6	7.4	8.6	-
LA-65 Electrical Conductivity Electrical Conductivity	mS/cm	0.001	358000	361000	1775	1749	368000	1764	360000	-
LA-53B BOD Biological Oxygen Demand	mg/L	5	nd	nd	10	13	11	8	-	nd

ANALYTE	Units	Leeder ID	L170092-4	L170092-9	L170092-14	L170092-19	L170092-24	L170092-29	L170092-4	Method Blank
		Client ID	S170002-4	S170002-9	S170002-14	S170002-19	S170002-24	S170002-29	S170002-4	
		PQL							Duplicate	
LA-21 Ammonia Ammonia (CAS - 7664-41-7)	mg/L	0.05	13	12	5.9	2.4	12	9	15	nd



LA-26 Volatile Organic Compounds

Analytical Results

Matrix: Water

ANALYTE	CAS No	PQL	Leeder ID	L170092-1	L170092-6	L170092-11	L170092-16	L170092-21	Method Blank
			Client ID	S170002-1	S170002-6	S170002-11	S170002-16	S170002-21	
Benzene	71-43-2	0.001		nd	nd	nd	nd	nd	nd
Toluene	108-88-3	0.001		nd	nd	nd	nd	nd	nd
Ethyl benzene	100-41-4	0.001		nd	nd	nd	nd	nd	nd
m/p-xylene	106-42-3, 108-38-3	0.002		nd	nd	nd	nd	nd	nd
o-xylene	95-47-6	0.001		nd	nd	nd	nd	nd	nd
Styrene (vinyl benzene)	100-42-5	0.001		nd	nd	nd	nd	nd	nd
Isopropylbenzene (cumene)	98-82-8	0.001		nd	nd	nd	nd	nd	nd
n-propyl benzene	103-65-1	0.001		nd	nd	nd	nd	nd	nd
1,3,5-trimethyl benzene	108-67-8	0.001		nd	nd	nd	nd	nd	nd
tert-butyl benzene	98-06-6	0.001		nd	nd	nd	nd	nd	nd
1,2,4-trimethyl benzene	95-63-6	0.001		nd	nd	nd	nd	nd	nd
sec-butyl benzene	135-98-8	0.001		nd	nd	nd	nd	nd	nd
4-isopropyl toluene	99-87-6	0.001		nd	nd	nd	nd	nd	nd
n-butyl benzene	104-51-8	0.001		nd	nd	nd	nd	nd	nd
Chloroform (trichloromethane)	67-66-3	0.001		nd	nd	nd	nd	nd	nd
Bromodichloromethane	75-27-4	0.001		nd	nd	nd	nd	nd	nd
Dibromochloromethane	124-48-1	0.001		nd	nd	nd	nd	nd	nd
Bromoform (tribromomethane)	75-25-2	0.001		nd	nd	nd	nd	nd	nd
1,1,1,2-tetrachloroethane	630-20-6	0.001		nd	nd	nd	nd	nd	nd
1,1,1-trichloroethane	71-55-6	0.001		nd	nd	nd	nd	nd	nd
1,1,2,2-tetrachloroethane	79-34-5	0.001		nd	nd	nd	nd	nd	nd
1,1,2-trichloroethane	79-00-5	0.001		nd	nd	nd	nd	nd	nd
1,1-dichloroethene	75-35-4	0.001		nd	nd	nd	nd	nd	nd
1,2-dichloroethane	107-06-2	0.001		nd	nd	nd	nd	nd	nd
cis-1,2-dichloroethene	156-59-2	0.001		nd	nd	nd	nd	nd	nd
trans-1,2-dichloroethene	156-60-5	0.001		nd	nd	nd	nd	nd	nd
Carbon tetrachloride	56-23-5	0.001		nd	nd	nd	nd	nd	nd
Hexachlorobutadiene (HCBD)	87-68-3	0.001		nd	nd	nd	nd	nd	nd
Tetrachloroethene	127-18-4	0.001		nd	nd	nd	nd	nd	nd
Trichloroethene	79-01-6	0.001		nd	nd	nd	nd	nd	nd
Vinyl chloride	75-01-4	0.01		nd	nd	nd	nd	nd	nd
Dichlorodifluoromethane	75-71-8	0.01		nd	nd	nd	nd	nd	nd
Chloromethane	74-87-3	0.01		nd	nd	nd	nd	nd	nd
Bromomethane (methyl bromide)	74-83-9	0.01		nd	nd	nd	nd	nd	nd
Dibromomethane	74-95-3	0.001		nd	nd	nd	nd	nd	nd
Chloroethane	75-00-3	0.01		nd	nd	nd	nd	nd	nd
Trichlorofluoromethane	75-69-4	0.01		nd	nd	nd	nd	nd	nd
1,1-dichloroethane	75-34-3	0.001		nd	nd	nd	nd	nd	nd
Bromochloromethane	74-97-5	0.001		nd	nd	nd	nd	nd	nd
1,2-dibromo-3-chloropropane	96-12-8	0.001		nd	nd	nd	nd	nd	nd
1,3-dichloropropane	142-28-9	0.001		nd	nd	nd	nd	nd	nd
1,2,3-trichloropropane	96-18-4	0.001		nd	nd	nd	nd	nd	nd
1,1-dichloropropene	563-58-6	0.001		nd	nd	nd	nd	nd	nd
2,2-dichloropropane	594-20-7	0.001		nd	nd	nd	nd	nd	nd
1,2-dichloropropane	78-87-5	0.001		nd	nd	nd	nd	nd	nd
trans-1,3-dichloropropene	10061-02-6	0.001		nd	nd	nd	nd	nd	nd
cis-1,3-dichloropropene	10061-01-5	0.001		nd	nd	nd	nd	nd	nd
1,2-dibromoethane	106-93-4	0.001		nd	nd	nd	nd	nd	nd
Chlorobenzene	108-90-7	0.001		nd	nd	nd	nd	nd	nd
Bromobenzene	108-86-1	0.001		nd	nd	nd	nd	nd	nd
2-chlorotoluene	95-49-8	0.001		nd	nd	nd	nd	nd	nd
4-chlorotoluene	106-43-4	0.001		nd	nd	nd	nd	nd	nd
1,2-dichlorobenzene	95-50-1	0.001		nd	nd	nd	nd	nd	nd
1,3-dichlorobenzene	541-73-1	0.001		nd	nd	nd	nd	nd	nd
1,4-dichlorobenzene	106-46-7	0.001		nd	nd	nd	nd	nd	nd
1,2,3-trichlorobenzene	87-61-6	0.001		nd	nd	nd	nd	nd	nd
1,2,4-trichlorobenzene	120-82-1	0.001		nd	nd	nd	nd	nd	nd
Cyclohexane	544-10-5	0.001		nd	nd	nd	nd	nd	nd
Surrogate % Recovery									
Dibromofluoromethane				97%	97%	96%	96%	95%	100%
Toluene-d8				100%	102%	101%	98%	98%	102%
4-BFB				112%	111%	110%	109%	111%	103%

Results expressed in mg/L, unless stated otherwise
 PQL - Practical Quantitation Limit, nd-not detected, less than PQL.



LA-26 Volatile Organic Compounds

Analytical Results

Matrix: Water			Leeder ID	L170092-26				
			Client ID	S170002-26				
ANALYTE	CAS No	PQL						
Benzene	71-43-2	0.001	nd					
Toluene	108-88-3	0.001	nd					
Ethyl benzene	100-41-4	0.001	nd					
m/p-xylene	106-42-3, 108-38-3	0.002	nd					
o-xylene	95-47-6	0.001	nd					
Styrene (vinyl benzene)	100-42-5	0.001	nd					
Isopropylbenzene (cumene)	98-82-8	0.001	nd					
n-propyl benzene	103-65-1	0.001	nd					
1,3,5-trimethyl benzene	108-67-8	0.001	nd					
tert-butyl benzene	98-06-6	0.001	nd					
1,2,4-trimethyl benzene	95-63-6	0.001	nd					
sec-butyl benzene	135-98-8	0.001	nd					
4-isopropyl toluene	99-87-6	0.001	nd					
n-butyl benzene	104-51-8	0.001	nd					
Chloroform (trichloromethane)	67-66-3	0.001	nd					
Bromodichloromethane	75-27-4	0.001	nd					
Dibromochloromethane	124-48-1	0.001	nd					
Bromoform (tribromomethane)	75-25-2	0.001	nd					
1,1,1,2-tetrachloroethane	630-20-6	0.001	nd					
1,1,1-trichloroethane	71-55-6	0.001	nd					
1,1,2,2-tetrachloroethane	79-34-5	0.001	nd					
1,1,2-trichloroethane	79-00-5	0.001	nd					
1,1-dichloroethene	75-35-4	0.001	nd					
1,2-dichloroethane	107-06-2	0.001	nd					
cis-1,2-dichloroethene	156-59-2	0.001	nd					
trans-1,2-dichloroethene	156-60-5	0.001	nd					
Carbon tetrachloride	56-23-5	0.001	nd					
Hexachlorobutadiene (HCBD)	87-68-3	0.001	nd					
Tetrachloroethene	127-18-4	0.001	nd					
Trichloroethene	79-01-6	0.001	nd					
Vinyl chloride	75-01-4	0.01	nd					
Dichlorodifluoromethane	75-71-8	0.01	nd					
Chloromethane	74-87-3	0.01	nd					
Bromomethane (methyl bromide)	74-83-9	0.01	nd					
Dibromomethane	74-95-3	0.001	nd					
Chloroethane	75-00-3	0.01	nd					
Trichlorofluoromethane	75-69-4	0.01	nd					
1,1-dichloroethane	75-34-3	0.001	nd					
Bromochloromethane	74-97-5	0.001	nd					
1,2-dibromo-3-chloropropane	96-12-8	0.001	nd					
1,3-dichloropropane	142-28-9	0.001	nd					
1,2,3-trichloropropane	96-18-4	0.001	nd					
1,1-dichloropropene	563-58-6	0.001	nd					
2,2-dichloropropane	594-20-7	0.001	nd					
1,2-dichloropropane	78-87-5	0.001	nd					
trans-1,3-dichloropropene	10061-02-6	0.001	nd					
cis-1,3-dichloropropene	10061-01-5	0.001	nd					
1,2-dibromoethane	106-93-4	0.001	nd					
Chlorobenzene	108-90-7	0.001	nd					
Bromobenzene	108-86-1	0.001	nd					
2-chlorotoluene	95-49-8	0.001	nd					
4-chlorotoluene	106-43-4	0.001	nd					
1,2-dichlorobenzene	95-50-1	0.001	nd					
1,3-dichlorobenzene	541-73-1	0.001	nd					
1,4-dichlorobenzene	106-46-7	0.001	nd					
1,2,3-trichlorobenzene	87-61-6	0.001	nd					
1,2,4-trichlorobenzene	120-82-1	0.001	nd					
Cyclohexane	544-10-5	0.001	nd					
Surrogate % Recovery								
Dibromofluoromethane			97%					
Toluene-d8			99%					
4-BFB			111%					

Results expressed in mg/L, unless stated otherwise
 PQL - Practical Quantitation Limit, nd-not detected, less than PQL.



LA-80 ALDEHYDE AND KETONES

Analytical Results

ANALYTE	CAS No	Leeder ID	L170092-3	L170092-8	L170092-13	L170092-18	L170092-23	L170092-28	L170092-3	Method Blank
		Client ID	S170002-3	S170002-8	S170002-13	S170002-18	S170002-23	S170002-28	S170002-3	
		PQL							duplicate	
Formaldehyde	50-00-0	0.01	nd	nd	0.21	0.21	nd	0.28	nd	nd
Acetaldehyde	75-07-0	0.01	nd	nd	nd	nd	nd	nd	nd	nd
Acrolein	107-02-8	0.01	nd	nd	nd	nd	nd	nd	nd	nd
Acetone	67-64-1	0.01	0.33	0.41	0.06	0.07	0.30	0.07	0.39	nd
Propanal	123-38-6	0.01	nd	nd	nd	nd	nd	nd	nd	nd
Butenal	4170-30-3	0.01	nd	nd	nd	nd	nd	nd	nd	nd
Butanal	123-72-8	0.01	nd	nd	nd	nd	nd	nd	nd	nd
Benzaldehyde	100-52-7	0.01	nd	nd	nd	nd	nd	nd	nd	nd
Tolualdehyde (m-)	620-23-5	0.01	nd	nd	nd	nd	nd	nd	nd	nd
Pentanal	110-62-3	0.01	nd	nd	nd	nd	nd	nd	nd	nd
Hexanal	66-25-1	0.01	nd	nd	nd	nd	nd	nd	nd	nd
LA-125 Chloramines										
Chloramine	10599-90-3	0.6	nd	nd	nd	nd	nd	nd	nd	nd

Results expressed in mg/L, unless otherwise specified
 PQL- Practical Quantitational Limit



Semivolatiles Analysis

Analytical Results

ANALYTE	CAS No	Leeder ID	L170092 3	L170092 8	L170092 13	L170092 18	L170092 23	L170092 28	Method Blank
		Client ID	S170002-3	S170002-8	S170002-13	S170002-18	S170002-23	S170002-28	
		PQL							
1,2,3,4-Tetrachlorobenzene	634-66-2	0.1	nd	nd	nd	nd	nd	nd	nd
1,2,3,5-Tetrachlorobenzene	634-90-2	0.1	nd	nd	nd	nd	nd	nd	nd
1,2,3-Trichlorobenzene	87-61-6	0.1	nd	nd	nd	nd	nd	nd	nd
1,2,4,5-Tetrachlorobenzene	95-94-3	0.1	nd	nd	nd	nd	nd	nd	nd
1,2,4-Trichlorobenzene	120-82-1	0.1	nd	nd	nd	nd	nd	nd	nd
1,2-Dichlorobenzene	95-50-1	0.1	nd	nd	nd	nd	nd	nd	nd
1,2-Dinitrobenzene	528-29-0	0.1	nd	nd	nd	nd	nd	nd	nd
1,3,5-Tribromobenzene	626-39-1	0.1	nd	nd	nd	nd	nd	nd	nd
1,3,5-Trichlorobenzene	108-70-3	0.1	nd	nd	nd	nd	nd	nd	nd
1,3-Dichlorobenzene	541-73-1	0.1	nd	nd	nd	nd	nd	nd	nd
1,3-Dinitrobenzene	99-65-0	0.1	nd	nd	nd	nd	nd	nd	nd
1,4-Dichlorobenzene	106-46-7	0.1	nd	nd	nd	nd	nd	nd	nd
1,4-Dinitrobenzene	100-25-4	0.1	nd	nd	nd	nd	nd	nd	nd
1-Chloronaphthalene	90-13-1	0.1	nd	nd	nd	nd	nd	nd	nd
1-Methylnaphthalene	90-12-0	0.1	nd	nd	nd	nd	nd	nd	nd
2,2'-OXYBIS(1-CHLOROPROPANE)	52438-91-2	0.1	nd	nd	nd	nd	nd	nd	nd
2,3,4,6-Tetrachlorophenol	58-90-2	0.1	nd	nd	nd	nd	nd	nd	nd
2,3,5,6-Tetrachlorophenol	935-95-5	0.1	nd	nd	nd	nd	nd	nd	nd
2,4,5-Trichlorophenol	95-95-4	0.1	nd	nd	nd	nd	nd	nd	nd
2,4,6-Trichlorophenol	88-06-2	0.1	nd	nd	nd	nd	nd	nd	nd
2,4-Dichlorophenol	120-83-2	0.1	nd	nd	nd	nd	nd	nd	nd
2,4-Dimethylphenol	105-67-9	0.1	6.8	6.4	2.4	2.3	5.6	2.4	nd
2,4-Dinitrophenol	51-28-5	0.1	nd	nd	nd	nd	nd	nd	nd
2,4-Dinitrotoluene	121-14-2	0.1	nd	nd	nd	nd	nd	nd	nd
2,6-Dichlorophenol	87-65-0	0.1	nd	nd	nd	nd	nd	nd	nd
2,6-Dinitrotoluene	606-20-2	0.1	nd	nd	nd	nd	nd	nd	nd
2-Chloronaphthalene	91-58-7	0.1	nd	nd	nd	nd	nd	nd	nd
2-Chlorophenol	95-57-8	0.1	nd	nd	nd	nd	nd	nd	nd
2-Cyclohexyl-4,6-Dinitrophenol (DINEX)	131-89-5	0.1	nd	nd	nd	nd	nd	nd	nd
2-methyl-4,6-dinitrophenol (DNOC)	534-52-1	0.1	nd	nd	nd	nd	nd	nd	nd
2-Methylnaphthalene	91-57-6	0.1	nd	nd	nd	nd	nd	nd	nd
2-Methylphenol (o-cresol)	95-48-7	0.1	5.7	4.7	0.8	0.4	4.0	1.0	nd
2-Nitroaniline	88-74-4	0.1	nd	nd	nd	nd	nd	nd	nd
2-Nitrophenol	88-75-5	0.1	nd	nd	nd	nd	nd	nd	nd
2-Picoline	109-06-8	0.1	0.7	0.5	nd	nd	0.3	nd	nd

Results expressed in ug/L, unless otherwise specified
 PQL- Practical Quantitational Limit



Semivolatiles Analysis

Analytical Results

ANALYTE	CAS No	Leeder ID	L170092 3	L170092 8	L170092 13	L170092 18	L170092 23	L170092 28	Method Blank
		Client ID	S170002-3	S170002-8	S170002-13	S170002-18	S170002-23	S170002-28	
		PQL							
3 & 4-methylphenol	108-39-4/106-44-5	0.1	3.7	2.9	1.2	0.6	1.9	1.3	nd
3-Chloroaniline	108-42-9	0.1	nd	nd	nd	nd	nd	nd	nd
3-Methylcholanthrene	56-49-5	0.1	nd	nd	nd	nd	nd	nd	nd
3-Nitroaniline	99-09-2	0.1	nd	nd	nd	nd	nd	nd	nd
4-Aminobiphenyl	92-67-1	0.1	nd	nd	nd	nd	nd	nd	nd
4-Bromophenyl phenyl ether	101-55-3	0.1	nd	nd	nd	nd	nd	nd	nd
4-Chloro-3-methylphenol	59-50-7	0.1	nd	nd	nd	nd	nd	nd	nd
4-Chloroaniline	106-47-8	0.1	nd	nd	nd	nd	nd	nd	nd
4-Chlorophenyl phenyl ether	7005-72-3	0.1	nd	nd	nd	nd	nd	nd	nd
4-Nitroaniline	100-01-6	0.1	nd	nd	nd	nd	nd	nd	nd
4-Nitrophenol	100-02-7	0.1	nd	nd	nd	nd	nd	nd	nd
7,12-Dimethylbenz(a)anthracene	57-97-6	0.1	nd	nd	nd	nd	nd	nd	nd
Acenaphthalene	208-96-8	0.1	0.8	nd	nd	nd	nd	nd	nd
Acenaphthene	83-32-9	0.1	nd	nd	nd	nd	nd	nd	nd
Acetophenone	98-86-2	0.1	nd	nd	nd	nd	nd	nd	nd
Alachlor	15972-60-8	0.1	nd	nd	nd	nd	nd	nd	nd
Aldrin	309-00-2	0.1	nd	nd	nd	nd	nd	nd	nd
Ametryne	834-12-8	0.1	nd	nd	nd	nd	nd	nd	nd
a-Naphthylamine	134-32-7	0.1	nd	nd	nd	nd	nd	nd	nd
Aniline	62-53-3	0.1	nd	nd	nd	nd	nd	nd	nd
Anthracene	120-12-7	0.1	nd	nd	nd	nd	nd	nd	nd
Atraton	1610-17-9	0.1	nd	nd	nd	nd	nd	nd	nd
Atrazine	1912-24-9	0.1	nd	nd	nd	nd	nd	nd	nd
Azinphos-methyl	86-50-0	0.1	nd	nd	nd	nd	nd	nd	nd
Azobenzene	103-33-3	0.1	nd	nd	nd	nd	nd	nd	nd
Benzidine	92-87-5	0.1	nd	nd	nd	nd	nd	nd	nd
Benzo(a)anthracene	56-55-3	0.1	nd	nd	nd	nd	nd	nd	nd
Benzo(a)pyrene	50-32-8	0.1	nd	nd	nd	nd	nd	nd	nd
Benzo(b)fluoranthene	205-99-2	0.1	nd	nd	nd	nd	nd	nd	nd
Benzo(e)pyrene	192-97-2	0.1	nd	nd	nd	nd	nd	nd	nd
Benzo(g,h,i)perylene	191-24-2	0.1	nd	nd	nd	nd	nd	nd	nd
Benzo(k)fluoranthene	207-08-9	0.1	nd	nd	nd	nd	nd	nd	nd
Benzyl alcohol	100-51-6	0.1	nd	nd	nd	nd	nd	nd	nd
Benzyl butyl phthalate (BBP)	85-68-7	0.1	nd	nd	nd	nd	nd	nd	nd
BHC, Alpha	319-84-6	0.1	nd	nd	nd	nd	nd	nd	nd

Results expressed in ug/L, unless otherwise specified
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Semivolatiles Analysis

Analytical Results

ANALYTE	CAS No	Leeder ID	L170092 3	L170092 8	L170092 13	L170092 18	L170092 23	L170092 28	Method Blank
		Client ID	S170002-3	S170002-8	S170002-13	S170002-18	S170002-23	S170002-28	
		PQL							
BHC, Beta	319-85-7	0.1	nd	nd	nd	nd	nd	nd	nd
BHC, delta	319-86-8	0.1	nd	nd	nd	nd	nd	nd	nd
BHC, gamma	58-89-9	0.1	nd	nd	nd	nd	nd	nd	nd
Bifenthrin	82657-04-3	0.1	nd	nd	nd	nd	nd	nd	nd
Bis(2-chloroethoxy) methane	111-91-1	0.1	nd	nd	nd	nd	nd	nd	nd
Bis(2-chloroethyl)ether	111-44-4	0.1	nd	nd	nd	nd	nd	nd	nd
Bis(2-ethoxyethyl)phthalate (DEEP)	605-54-9	0.1	nd	nd	nd	nd	nd	nd	nd
Bis(2-ethylhexyl)phthalate (DEHP)	117-81-7	0.1	nd	nd	nd	nd	nd	nd	nd
Bis(2-methoxyethyl)phthalate (DMEP)	117-82-8	0.1	nd	nd	nd	nd	nd	nd	nd
Bis(2-n-butoxyethyl)phthalate (DBEP)	117-83-9	0.1	nd	nd	nd	nd	nd	nd	nd
Bis(4-methyl-2-pentyl)phthalate	259139-51-0	0.1	nd	nd	nd	nd	nd	nd	nd
b-Naphthylamine	91-59-8	0.1	nd	nd	nd	nd	nd	nd	nd
Bromacil	314-40-9	0.1	nd	nd	nd	nd	nd	nd	nd
Butachlor	23184-66-9	0.1	nd	nd	nd	nd	nd	nd	nd
Butylate (Sutan)	2008-41-5	0.1	nd	nd	nd	nd	nd	nd	nd
Caffeine	58-08-2	0.1	nd	nd	nd	nd	nd	nd	nd
Carboxin	5234-68-4	0.1	nd	nd	nd	nd	nd	nd	nd
Chlordane alpha-cis	5103-71-9	0.1	nd	nd	nd	nd	nd	nd	nd
Chlordane gamma-trans	5103-74-2	0.1	nd	nd	nd	nd	nd	nd	nd
Chlorobenzilate	510-15-6	0.1	nd	nd	nd	nd	nd	nd	nd
Chloroneb	2675-77-6	0.1	nd	nd	nd	nd	nd	nd	nd
Chlorothalonil	1897-45-6	0.1	nd	nd	nd	nd	nd	nd	nd
Chlorpropham	101-21-3	0.1	nd	nd	nd	nd	nd	nd	nd
Chlorpyrifos-ethyl	2921-88-2	0.1	nd	nd	nd	nd	nd	nd	nd
Chlorthal-dimethyl (Dacthal)	1861-32-1	0.1	nd	nd	nd	nd	nd	nd	nd
Chrysene	218-01-9	0.1	nd	nd	nd	nd	nd	nd	nd
Coumaphos	56-72-4	0.1	nd	nd	nd	nd	nd	nd	nd
Cyanazine	21725-46-2	0.1	nd	nd	nd	nd	nd	nd	nd
Cycloate	1134-23-2	0.1	nd	nd	nd	nd	nd	nd	nd
DDD p,p	72-54-8	0.1	nd	nd	nd	nd	nd	nd	nd
DDE p, p	72-55-9	0.1	nd	nd	nd	nd	nd	nd	nd
DDT p,p	50-29-3	0.1	nd	nd	nd	nd	nd	nd	nd
Demeton-O	298-03-3	0.1	nd	nd	nd	nd	nd	nd	nd
Demeton-S (Disulfoton oxon)	126-75-0	0.1	nd	nd	nd	nd	nd	nd	nd
Diaryl phthalate	131-18-0	0.1	nd	nd	nd	nd	nd	nd	nd

Results expressed in ug/L, unless otherwise specified
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Semivolatiles Analysis

Analytical Results

ANALYTE	CAS No	Leeder ID	L170092 3	L170092 8	L170092 13	L170092 18	L170092 23	L170092 28	Method Blank
		Client ID	S170002-3	S170002-8	S170002-13	S170002-18	S170002-23	S170002-28	
		PQL							
Diazinon	333-41-5	0.1	nd	nd	nd	nd	nd	nd	nd
Dibenz(a,j)acridine	224-42-0	0.1	nd	nd	nd	nd	nd	nd	nd
Dibenzo(a,h)anthracene	53-70-3	0.1	nd	nd	nd	nd	nd	nd	nd
Dibenzofuran	132-64-9	0.1	nd	nd	nd	nd	nd	nd	nd
Dichlorvos	62-73-7	0.1	nd	nd	nd	nd	nd	nd	nd
Dicyclohexyl phthalate (DCHP)	84-61-7	0.1	nd	nd	nd	nd	nd	nd	nd
Dieldrin	60-57-1	0.1	nd	nd	nd	nd	nd	nd	nd
Diethylphthalate (DEP)	84-66-2	0.1	nd	nd	nd	nd	nd	nd	nd
Dimethoate	60-51-5	0.1	nd	nd	nd	nd	nd	nd	nd
Dimethylphthalate (DMP)	131-11-3	0.1	nd	nd	nd	nd	nd	nd	nd
Di-n-butylphthalate (DBP)	84-74-2	0.1	nd	nd	nd	nd	nd	nd	nd
Di-n-hexyl phthalate	84-75-3	0.1	nd	nd	nd	nd	nd	nd	nd
Di-n-octyl phthalate (DNOP)	117-84-0	0.1	nd	nd	nd	nd	nd	nd	nd
Dinonyl phthalate	84-76-4	0.1	nd	nd	nd	nd	nd	nd	nd
Dinoseb	88-85-7	0.1	nd	nd	nd	nd	nd	nd	nd
Diphenamid	957-51-7	0.1	nd	nd	nd	nd	nd	nd	nd
Diphenylamine	122-39-4	0.1	nd	nd	nd	nd	nd	nd	nd
Disulfoton	298-04-4	0.1	nd	nd	nd	nd	nd	nd	nd
Endosulfan peak 1	959-98-8	0.1	nd	nd	nd	nd	nd	nd	nd
Endosulfan peak 2	33213-65-9	0.1	nd	nd	nd	nd	nd	nd	nd
Endosulfan sulfate	1031-07-8	0.1	nd	nd	nd	nd	nd	nd	nd
Endrin	72-20-8	0.1	nd	nd	nd	nd	nd	nd	nd
Endrin Aldehyde	7421-93-4	0.1	nd	nd	nd	nd	nd	nd	nd
EPTC	759-94-4	0.1	nd	nd	nd	nd	nd	nd	nd
Ethoprop (Ethoprophos)	13194-48-4	0.1	nd	nd	nd	nd	nd	nd	nd
Etridiazole (Terrazole)	2593-15-9	0.1	nd	nd	nd	nd	nd	nd	nd
Fenamiphos	22224-92-6	0.1	nd	nd	nd	nd	nd	nd	nd
Fenarimol	60168-88-9	0.1	nd	nd	nd	nd	nd	nd	nd
Fenchlorfos	299-84-3	0.1	nd	nd	nd	nd	nd	nd	nd
Fensulfothion	115-90-2	0.1	nd	nd	nd	nd	nd	nd	nd
Fenthion	55-38-9	0.1	nd	nd	nd	nd	nd	nd	nd
Fluoranthene	206-44-0	0.1	nd	nd	nd	nd	nd	nd	nd
Fluorene	86-73-7	0.1	nd	nd	nd	nd	nd	nd	nd
Fluridone	59756-60-4	0.1	nd	nd	nd	nd	nd	nd	nd
Heptachlor	76-44-8	0.1	nd	nd	nd	nd	nd	nd	nd

Results expressed in ug/L, unless otherwise specified
 PQL- Practical Quantitational Limit



Semivolatiles Analysis

Analytical Results

ANALYTE	CAS No	Leeder ID	L170092 3	L170092 8	L170092 13	L170092 18	L170092 23	L170092 28	Method Blank
		Client ID	S170002-3	S170002-8	S170002-13	S170002-18	S170002-23	S170002-28	
		PQL							
Heptachlor epoxide	1024-57-3	0.1	nd	nd	nd	nd	nd	nd	nd
Hexachlorobenzene	118-74-1	0.1	nd	nd	nd	nd	nd	nd	nd
Hexachlorobutadiene	87-68-3	0.1	nd	nd	nd	nd	nd	nd	nd
Hexachlorocyclopentadiene	77-47-4	0.1	nd	nd	nd	nd	nd	nd	nd
Hexachloroethane	67-72-1	0.1	nd	nd	nd	nd	nd	nd	nd
Hexazinone	51235-04-2	0.1	nd	nd	nd	nd	nd	nd	nd
Hexyl 2-ethylhexyl phthalate	75673-16-4	0.1	nd	nd	nd	nd	nd	nd	nd
Indeno(1,2,3-cd)pyrene	193-39-5	0.1	nd	nd	nd	nd	nd	nd	nd
Isophorone	78-59-1	0.1	nd	nd	nd	nd	nd	nd	nd
Malathion	121-75-5	0.1	nd	nd	nd	nd	nd	nd	nd
Merphos	150-50-5	0.1	nd	nd	nd	nd	nd	nd	nd
Methoxychlor	72-43-5	0.1	nd	nd	nd	nd	nd	nd	nd
Metolachlor	51218-45-2	0.1	nd	nd	nd	nd	nd	nd	nd
Metribuzin	21087-64-9	0.1	nd	nd	nd	nd	nd	nd	nd
Mevinphos	7786-34-7	0.1	nd	nd	nd	nd	nd	nd	nd
MGK-264 A	113-48-4	0.1	nd	nd	nd	nd	nd	nd	nd
Mirex	2385-85-5	0.1	nd	nd	nd	nd	nd	nd	nd
Molinate (Ordram)	2212-67-1	0.1	nd	nd	nd	nd	nd	nd	nd
Naled	300-76-5	0.1	nd	nd	nd	nd	nd	nd	nd
Naphthalene	91-20-3	0.1	nd	nd	nd	nd	nd	nd	nd
Napropamide	15299-99-7	0.1	nd	nd	nd	nd	nd	nd	nd
Nitrobenzene	98-95-3	0.1	nd	nd	nd	nd	nd	nd	nd
Nitrofen	1836-75-5	0.1	nd	nd	nd	nd	nd	nd	nd
Nitrosopyrrolidine (NPYR)	930-55-2	0.1	nd	nd	nd	nd	nd	nd	nd
N-Nitrosodiethylamine (NDA)	55-18-5	0.1	nd	nd	nd	nd	nd	nd	nd
N-Nitrosodimethylamine (NDMA)	62-75-9	0.1	nd	nd	nd	nd	nd	nd	nd
N-Nitrosodi-n-butylamine (NDBA)	924-16-3	0.1	nd	nd	nd	nd	nd	nd	nd
N-Nitrosodi-n-propylamine (NDPA)	621-64-7	0.1	nd	nd	nd	nd	nd	nd	nd
N-Nitrosodiphenylamine	86-30-6	0.1	nd	nd	nd	nd	nd	nd	nd
N-Nitrosomethylethylamine (NMEA)	10595-95-6	0.1	nd	nd	nd	nd	nd	nd	nd
N-Nitrosomorpholine (NMOR)	59-89-2	0.1	nd	nd	nd	nd	nd	nd	nd
N-Nitrosopiperidine (NPIP)	100-75-4	0.1	nd	nd	nd	nd	nd	nd	nd
Nonachlor-trans	5103-73-1	0.1	nd	nd	nd	nd	nd	nd	nd
Norflurazon	27314-13-2	0.1	nd	nd	nd	nd	nd	nd	nd
Ortho-phenylphenol	90-43-7	0.1	nd	nd	nd	nd	nd	nd	nd

Results expressed in ug/L, unless otherwise specified
 PQL- Practical Quantitational Limit



Semivolatiles Analysis

Analytical Results

ANALYTE	CAS No	Leeder ID	L170092 3	L170092 8	L170092 13	L170092 18	L170092 23	L170092 28	Method Blank
		Client ID	S170002-3	S170002-8	S170002-13	S170002-18	S170002-23	S170002-28	
		PQL							
p-Acetophenetidide	62-44-2	0.1	nd	nd	nd	nd	nd	nd	nd
Paraoxon-methyl	950-35-6	0.1	nd	nd	nd	nd	nd	nd	nd
Parathion (ethyl)	56-38-2	0.1	nd	nd	nd	nd	nd	nd	nd
Parathion-methyl	298-00-0	0.1	nd	nd	nd	nd	nd	nd	nd
PCB 154 (2,2',4,4',5,6'-Hexachlorobiphenyl)	60145-22-4	0.1	nd	nd	nd	nd	nd	nd	nd
PCB 171 (2,2',3,3',4,4',6-Heptachlorobiphenyl)	52663-71-5	0.1	nd	nd	nd	nd	nd	nd	nd
PCB 201 (2,2',3,3',4,5',6,6'-Octachlorobiphenyl)	40186-71-8	0.1	nd	nd	nd	nd	nd	nd	nd
PCB 29 (2,4,5-Trichlorobiphenyl)	15862-07-4	0.1	nd	nd	nd	nd	nd	nd	nd
PCB 47 (2,2',4,4'-Tetrachlorobiphenyl)	2437-79-8	0.1	nd	nd	nd	nd	nd	nd	nd
PCB 5 (2,3-Dichlorobiphenyl)	16605-91-7	0.1	nd	nd	nd	nd	nd	nd	nd
PCB 98 (2,2',3',4,6-Pentachlorobiphenyl)	60233-25-2	0.1	nd	nd	nd	nd	nd	nd	nd
p-Dimethylaminoazobenzene	60-11-7	0.1	nd	nd	nd	nd	nd	nd	nd
Pebulate	1114-71-2	0.1	nd	nd	nd	nd	nd	nd	nd
Pentachlorobenzene	608-93-5	0.1	nd	nd	nd	nd	nd	nd	nd
Pentachlorophenol	87-86-5	0.1	nd	nd	nd	nd	nd	nd	nd
Permethrin peak 1	61949-76-6	0.1	nd	nd	nd	nd	nd	nd	nd
Permethrin peak 2	61949-77-7	0.1	nd	nd	nd	nd	nd	nd	nd
Phenanthrene	85-01-8	0.1	nd	nd	nd	nd	nd	nd	nd
Phenol	108-95-2	0.1	nd	nd	nd	nd	nd	nd	nd
Phorate	298-02-2	0.1	nd	nd	nd	nd	nd	nd	nd
Prometon	1610-18-0	0.1	nd	nd	nd	nd	nd	nd	nd
Prometryn	7287-19-6	0.1	nd	nd	nd	nd	nd	nd	nd
Propachlor	1918-16-7	0.1	nd	nd	nd	nd	nd	nd	nd
Propazine	139-40-2	0.1	nd	nd	nd	nd	nd	nd	nd
Propyzamide (Pronamide)	23950-58-5	0.1	nd	nd	nd	nd	nd	nd	nd
Prothiofos	34643-46-4	0.1	nd	nd	nd	nd	nd	nd	nd
Pyrene	129-00-0	0.1	nd	nd	nd	nd	nd	nd	nd
Quintozone (pentachloronitrobenzene)	82-68-8	0.1	nd	nd	nd	nd	nd	nd	nd
Resorcinol	108-46-3	0.1	nd	nd	nd	nd	nd	nd	nd
Simazine	122-34-9	0.1	nd	nd	nd	nd	nd	nd	nd
Simetryn	1014-70-6	0.1	nd	nd	nd	nd	nd	nd	nd
Sulprofos	35400-43-2	0.1	nd	nd	nd	nd	nd	nd	nd
Tebuthiuron	34014-18-1	0.1	nd	nd	nd	nd	nd	nd	nd
Terbacil	5902-51-2	0.1	nd	nd	nd	nd	nd	nd	nd
Terbufos	13071-79-9	0.1	nd	nd	nd	nd	nd	nd	nd

Results expressed in ug/L, unless otherwise specified
 PQL- Practical Quantitational Limit



Semivolatiles Analysis

Analytical Results

ANALYTE	CAS No	Leeder ID	L170092 3	L170092 8	L170092 13	L170092 18	L170092 23	L170092 28	Method Blank
		Client ID	S170002-3	S170002-8	S170002-13	S170002-18	S170002-23	S170002-28	
		PQL							
Terbufos sulfone	56070-16-7	0.1	nd	nd	nd	nd	nd	nd	nd
Terbutryn	886-50-0	0.1	nd	nd	nd	nd	nd	nd	nd
Tetrachlorvinphos	22248-79-9	0.1	nd	nd	nd	nd	nd	nd	nd
Thiazopyr	117718-60-2	0.1	nd	nd	nd	nd	nd	nd	nd
Thiobencarb	28249-77-6	0.1	nd	nd	nd	nd	nd	nd	nd
Triadimefon	43121-43-3	0.1	nd	nd	nd	nd	nd	nd	nd
Tribuphos	78-48-8	0.1	nd	nd	nd	nd	nd	nd	nd
Trichloronate	327-98-0	0.1	nd	nd	nd	nd	nd	nd	nd
Triclosan	3380-34-5	0.1	nd	nd	nd	nd	nd	nd	nd
Tricyclazole	41814-78-2	0.1	nd	nd	nd	nd	nd	nd	nd
Trifluralin	1582-09-8	0.1	nd	nd	nd	nd	nd	nd	nd
Vernolate	1929-77-7	0.1	nd	nd	nd	nd	nd	nd	nd
Vinclozolin	50471-44-8	0.1	nd	nd	nd	nd	nd	nd	nd
Surrogate % Recovery									
2,4,6-Tribromophenol (surr) % Rec		-	120	98	133	130	110	137	89
2-Fluorobiphenyl (surr) % Rec		-	81	102	109	101	106	96	71
2-Fluorophenol (surr) % Rec		-	47	45	50	48	42	73	64
Nitrobenzene-d5 (surr) % Rec		-	102	95	99	87	96	88	62
Phenol-d6 (surr) % Rec		-	34	78	28	76	60	74	60
p-Terphenyl-d14 (surr) % Rec		-	117	125	128	128	114	125	106

Results expressed in ug/L, unless otherwise specified

PQL- Practical Quantitational Limit



LA-26 Volatile Organic Compounds

Analytical Results

Matrix: Water

		Leeder ID					
		Client ID	Laboratory Control				
ANALYTE	CAS No	PQL	Sample				
Chloroform (trichloromethane)	67-66-3	0.001	110				
Bromodichloromethane	75-27-4		107				
Dibromochloromethane	124-48-1		97				
1,1,1-trichloroethane	71-55-6		103				
1,1,2,2-tetrachloroethane	79-34-5		nd				
1,2-dichloroethane	107-06-2		110				
Tetrachloroethene	127-18-4		95				
Trichloroethene	79-01-6		93				
1,1-dichloroethane	75-34-3		102				
Surrogate % Recovery							
Dibromofluoromethane			96%				
Toluene-d8			98%				
4-BFB			104%				

LA-38 Metals

		Leeder ID	Laboratory Control	L170092-10			
		Client ID	Sample	S170002-10			
ANALYTE	CAS No	PQL	Sample	Spike			
Arsenic (As)	7440-38-2		104	89			
Barium (Ba)	7440-39-3		99	109			
Beryllium (Be)	7440-41-7		102	105			
Boron(B)	7440-42-8		110	90			
Cadmium (Cd)	7440-43-9		105	102			
Calcium (Ca)	7440-70-2		99	-			
Chromium (Cr)	7440-47-3		107	106			
Cobalt (Co)	7440-48-4		103	101			
Copper (Cu)	7440-50-8		107	96			
Iron (Fe)	7439-89-6		106	102			
Lead (Pb)	7439-92-1		103	103			
Magnesium (Mg)	7439-95-4		100	-			
Manganese (Mn)	7439-96-5		106	104			
Molybdenum(Mo)	7439-98-7		103	101			
Nickel (Ni)	7440-02-0		106	103			
Potassium (K)	7440-09-7		100	-			
Selenium (Se)	7782-49-2		104	88			
Sodium (Na)	7440-23-5		100	-			
Tin (Sn)	7440-31-5		124	99			
Vanadium (V)	7440-62-2		107	103			
Zinc (Zn)	7440-66-6		105	99			

		Leeder ID	Laboratory Control				
		Client ID	Sample				
ANALYTE	Units	PQL	Sample				
LA-72 Turbidity Turbidity	NTU		98				
LA-53B BOD Biological Oxygen Demand			82				

		Leeder ID	L170092-4	L170092-4			
		Client ID	S170002-4	S170002-4			
ANALYTE	CAS No	PQL	Spike	Spike Dup			
LA-80 Aldehyde and Ketones Formaldehyde	50-00-0	0.01	96	83			
Acetaldehyde	75-07-0	0.01	-	-			
Acrolein	107-02-8	0.01	-	-			
Acetone	67-64-1	0.01	80	83			
Propanal	123-38-6	0.01	-	-			
Butenal	4170-30-3	0.01	-	-			
Butanal	123-72-8	0.01	-	-			
Benzaldehyde	100-52-7	0.01	-	-			
Tolualdehyde (m-)	620-23-5	0.01	-	-			
Pentanal	110-62-3	0.01	-	-			
Hexanal	66-25-1	0.01	-	-			



Analytical Results

		Leeder ID	L170092-4	L170092-4				
		Client ID	S170002-4	S170002-4				
ANALYTE	CAS No	PQL	Spike	Spike Dup				
LA-21 Ammonia Ammonia	7664-41-7	0.05	98	105				

Results expressed in % recovery

PQL - Practical Quantitation Limit, nd-not detected, less than PQL.



APPENDIX 1

CHAIN OF CUSTODY



L170092

a 33 Steane St, Fairfield, VIC 3078
 t 03 9481 4167
 f 03 9489 0710 e enquiries@leeder-analytical.com

www.leeder-analytical.com
 Cerberus Global trading as Leeder Analytical
 enquiries@leeder-analytical.com

Contact Details		Job Details		Legend	
To: Carmelo CHIAPPALONE		Job No: RCL17002	Results Due By:	Sample Type: S - Solid, W - Water, A - Air, O - Other	
Company: CHIAPPALONE CONSULTING		Quote No:	Email Report To: Carmelo@consulting.net.au		
Address: PO BOX 7 BULimba QLD 4171		PO No:	Email Invoice To: Carmelo@consulting.net.au		
Phone: 0412194825		Special Instructions: COOLING TOWER REED SAMPLES.			
Email: Carmelo@consulting.net.au					
Sample ID	Date Sampled	Sample Type	Preservation Type	Required Analysis	Comments/Additional Information
S170002-1	26/4/17	W	HCL H2O3	VOCs TURBIDITY PH EC BOD Chloramines SUCC'S AMMONIA METALS APK	2 X JOA Vials
S170002-2	"	W			250ml NALGENE
S170002-3	"	W			500ml AMBERZ
S170002-4	"	W	X		100ml NALGENE
S170002-5	"	W	X		100ml NALGENE
S170002-6	"	W			2 X JOA VIALS
S170002-7	"	W			250ml NALGENE
S170002-8	"	W	X		500ml AMBERZ
S170002-9	"	W	X		100ml NALGENE
S170002-10	"	W	X		100ml NALGENE
Chain of Custody		Sample Condition			
Sampled By: ALCOA	Released By: Carmelo	Received By: N. Wheatey	Security Seals Intact:	Yes	No
Date/Time: 26/4/17	Date/Time: 3/5/17	Date/Time: 8/5/17 11:45am	Temperature:	Ambient	Chilled
Company: ALCOA	Company: CHIAPPALONE CONSULTING	Company: Leeder Analytical			Frozen
Signature:	Signature:	Signature: N. Wheatey			

Chain of Custody Record

Sheet 2 of 3



L170092

33 Steane St, Fairfield, VIC 3078
 03 9481 4167
 03 9489 0710

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 Ceberus Global trading as Leeder Analytical
 enquiries@leeder-analytical.com

Contact Details		Job Details												
To: CARMELO CHIARALONE	Job No: NCC17002	Results Due By:												
Company: CHIARALONE CONSULTING	Quote No:	Email Report To: Carmelo@consulting.net.au												
Address: PO BOX 7 BUNNABA QLD 4171	PO No:	Email Invoice To: Carmelo@consulting.net.au												
Phone: 0412194825	Special Instructions: COOLING TOWER RECIRC SAMPLES.													
Email: Carmelo@consulting.net.au														
Sample ID	Date Sampled	Sample Type	Preservation Type	Required Analysis					Legend	Comments/Additional Information				
S170002-11	26/4/17	W	HCl	VOCS	TURBIDITY	PH	FF	BOB	Chloramines	SOCS	Ammonia	Metals	AsK	2x VOA Vials
S170002-12	"	W			X	X	X	X	X					1x 500ml NALGENE
S170002-13	"	W												500ml AMBER
S170002-14	"	W	X											100ml NALGENE
S170002-15	"	W	X											100ml NALGENE
S170002-16	"	W												2x VOA VIALS
S170002-17	"	W			X	X	X	X	X					500ml NALGENE
S170002-18	"	W												500ml AMBER
S170002-19	"	W	X											100ml NALGENE
S170002-20	"	W	X											100ml NALGENE
Chain of Custody		Sample Condition												
Sampled By: AICOA	Released By: Carmelo	Security Seals Intact:	Yes	No	N/A									
Date/Time: 26/4/17	Date/Time: 8/5/17 11:45am	Temperature:	Ambient	Chilled	Frozen									
Company: AICOA	Company: Consulting													
Signature:	Signature: N. Wheately													

L170092

Contact Details		Job Details											
To: CARMELO CHIAPPALONE	Job No: ACC17002	Results Due By:											
Company: CHIAPPALONE CONSULTING	Quote No:	Email Report To: Carmelo@consulting.net.au											
Address: PO Box 7	PO No:	Email Invoice To: Carmelo@consulting.net.au											
Bulimba QLD 4171	Special Instructions: FEED & RECEIVED COOLING TOWER SAMPLES.												
Phone: 0412194825													
Email: Carmelo@consulting.net.au													
Sample ID	Date Sampled	Sample Type	Preservation Type	Required Analysis						Legend	Comments/Additional Information		
S170002-21	1/5/17	W	FC	VOC's	TURBIDITY	PH	BOD	Chloramines	SUCC'S	Ammonia	Metals	AsK	2 x VOA VIALS FEED
S170002-22	"	W		X	X	X	X	X	X	X	X		500ml NALGENE FEED
S170002-23	"	W		X	X	X	X	X	X	X	X		500ml AMBER FEED
S170002-24	"	W	X	X	X	X	X	X	X	X	X		100ml NALGENE FEED
S170002-25	"	W	X	X	X	X	X	X	X	X	X		100ml NALGENE FEED
S170002-26	"	W		X	X	X	X	X	X	X	X		2x VOA VIALS RECV
S170002-27	"	W		X	X	X	X	X	X	X	X		500ml NALGENE RECV
S170002-28	"	W	X	X	X	X	X	X	X	X	X		500ml NALGENE RECV
S170002-29	"	W	X	X	X	X	X	X	X	X	X		100ml NALGENE RECV
S170002-30	"	W	X	X	X	X	X	X	X	X	X		100ml NALGENE RECV
Chain of Custody		Sample Condition											
Sampled By: ALCOA	Released By: Carmelo	Security Seals Intact:	Yes No N/A										
Date/Time: 1/5/17	Date/Time: 3/5/17	Received By: N. Wheatley	Yes No N/A										
Company: ALCOA	Company: ALCOA	Date/Time: 8/5/17 11:45am											
Signature:	Signature: N. Wheatley	Company: Leeder Analytical											
		Signature: N. Wheatley											
		Temperature: Ambient	Frozen										

APPENDIX 2

PHOTOS

