Aughinish Alumina Ltd.

Askeaton, Co. Limerick

IE Licence Reg. P0035-06

Annual Environmental Report

2016

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Aughinish Alumina Ltd.

Industrial Emissions Licence
Register No. P0035-06

Annual Environmental Report 2016

March 2017

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1. Introduction

This document comprises the Aughinish Alumina Limited (AAL) Annual Environmental Report (AER).

The report covers the period from the 1st January 2016 to the 31st December 2016 and has been prepared in accordance with the Environmental Protection Agency (EPA) 'Guidance Note on the Annual Environmental Report' and other relevant guidance as provided by the EPA on their website (www.epa.ie).

1.1 Description of the Activity

AAL was granted a revised Industrial Emissions Licence (IE Licence) in July 2014. The Licence grants AAL permission to carry out the following activities in accordance with the requirements and conditions set out in the Licence:

- The production of inorganic chemicals;
- The combustion of fuels installations with a total rated thermal input of 50MW or more; and
- The recovery or disposal of waste in a facility

The AAL plant extracts alumina from bauxite using the Bayer Process, a chemical method that has been developed and refined over the past century and is used by over 40 alumina extraction plants worldwide.

Approximately 70% of the bauxite processed by AAL comes for Guinea in West Africa with the remainder coming from Brazil. The finished product, alumina, is exported for further processing through smelting to aluminium metal.

The production output of the plant in 2016 was 1,898,054 tonnes of alumina (1,975,076 tonnes of alumina hydrate).

1.2 Management Structures

Since March 2008, AAL has been wholly owned by United Company RUSAL, which is the largest integrated aluminium company worldwide.

AAL has a structured management approach to the operation of the business in terms of product quality, process control, environment, safety, training and analytical capability. Training of personnel is a key function in the successful operation of the plant.

The IE Licence requires the company to establish and maintain an Environmental Management System (EMS) and the conditions of the licence outline the form that the EMS should take at AAL. In order to demonstrate its commitment to environmental protection, AAL gained certification of its EMS to the international standard ISO 14001:2004. In 2016, a gap analysis was completed towards achieving certification to ISO14001:2015 in 2017.

Additionally, in 2016 the company achieved certification to ISO5001 for energy management.

Safety, environmental, energy and quality management systems are audited on an on-going basis by a combination of internal audit teams and external certification surveillance audits by our certification body Det Norske Veritas (DNV UK).

ISRS (International Safety Rating System) recertification, Level 8, was achieved in November 2016.

1.3 Organisational Structure

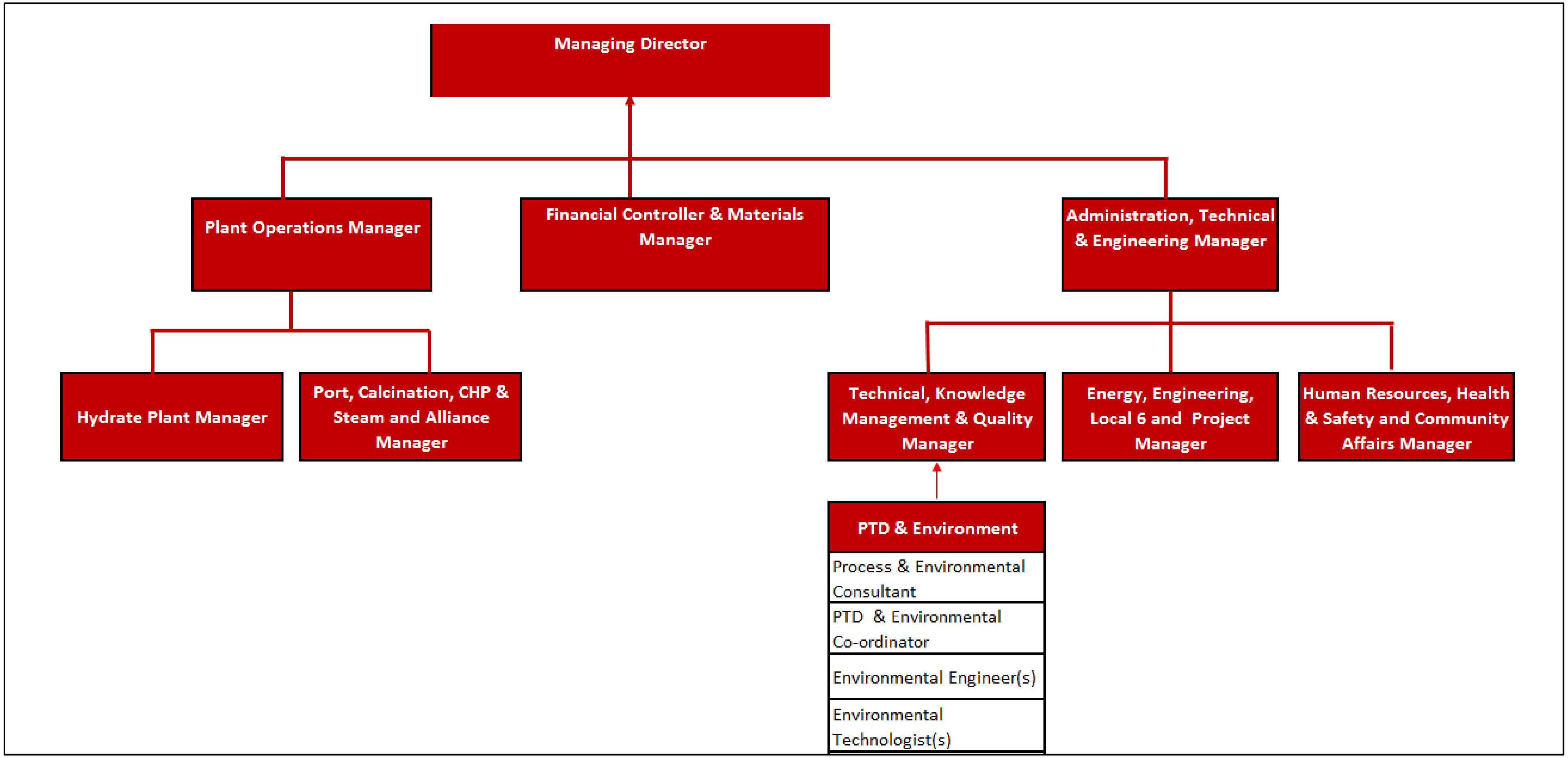
AAL operates a relatively flat management structure with a strong emphasis on team working. The company structure in 2016 is set out in the organogram overleaf and outlines the responsibility for day-to-day management of environmental issues at the plant.

The PTD and Environmental Co-ordinator has overall responsibility for environmental management and reports directly to the Management Team.

The Environmental Co-ordinator is supported in the day-to-day activities by the Senior Environmental Engineer(s), who have responsibility for the maintenance of the Environmental Management System, undertaking specific projects of an environmental nature and evaluating compliance with the IE Licence.

The Environmental Technologists are responsible for environmental monitoring activities including sampling and analysis of all emissions and discharges from the site.

The Contractor Alliance comprises three main contractor companies providing various engineering, operational and maintenance services all of whom are based on-site. As part of contractor induction training, an Environmental Manual is issued to each contractor. This contains information on site environmental requirements and instructions for environmental management and control to ensure compliance with the IE Licence. Contractors are regularly updated through regular training and safety briefings.


Managing Director
Plant Operations Manager
Financial Controller & Materials Manager
Administration, Technical & Engineering Manager
Hydrate Plant Manager
Port, Calcination, CHP & Steam and Alliance Manager
Technical, Knowledge Management & Quality Manager
Energy, Engineering, Local 6 and Project Manager
Human Resources, Health & Safety and Community Affairs Manager
PTD & Environment
Process & Environmental Consultant
PTD & Environmental Co-ordinator
Environmental Engineer(s)
Environmental Technologist(s)

1.4 Environmental Policy

RUSAL
AUGHINISH

Statement of Environmental Policy

Protection of the environment is a high priority for every employee, contractor and director of RUSAL Aughinish. This objective requires our full co-operation in a continuing effort to improve our products and production processes.

The process we employ at RUSAL Aughinish, the 'Bayer Process', is the accepted industrial method for the manufacture of alumina world-wide. Our principal product, smelter grade alumina, is used to manufacture aluminium, a metal with many recognised environmental benefits.

Successful integration of our environmental objectives with our health, safety, quality and cost objectives is required to ensure our competitive position.

We will continue to:

- Comply with all legal requirements and where appropriate, use more stringent internal standards based on our expertise.
- Use world class practices to ensure that we prevent pollution and meet social, economic and environmental demands.
- Develop opportunities with suppliers and customers to improve our products and to minimise waste and environmental impacts.
- Make effective use of environmental management systems that continually improve our performance consistent with defined goals.
- Review our environmental objectives and targets regularly to ensure that these remain both relevant and appropriate to our operations.
- Communicate with employees, consumers, communities, businesses and government to achieve greater environmental understanding.
- Ensure that RUSAL Aughinish's environmental policy is communicated to all employees and contractors and is made available to the public.

By fulfilling these objectives, we will have due regard to the environmental expectations of our many stakeholders.

signed:

Seán Garland

Seán Garland MD
January 2016

MANAGEMENT SYSTEM CERTIFICATION
DNV·GL
ISO 9001 • ISO 14001

2. Emissions

AAL implements a comprehensive environmental monitoring programme to assess the significance of emissions from site activities. The programme includes emissions to air, effluent discharges, surface water and waste monitoring. An overview of the results of monitoring conducted during 2016 is presented in this section.

This section also includes an evaluation of compliance with the conditions and schedules of the IE Licence, together with a summary of environmental incidents reported to the Agency during 2016.

Summary information on all emissions, discharges and waste arising from operations at AAL has been submitted to the Agency via the AER/PRTR Annual Environmental Reporting website. Monitoring data, summarised in the following sections, shows continued compliance with IE Licence Conditions and Emission Limit Values (ELV's).

2.1 Emissions to Air

There are 15 IE licensed air emission points at AAL. The primary sources of emissions to air in 2016 were the Gas Boilers (Emission Point Ref. A4-A, A4-B), Combined Heat and Power Plant (CHP) (Emission Point Refs. A3-A and A3-B), Calciners (Emission Point Ref. A2) and HFO Boilers (Emission Point Ref. A1). The gas boilers were installed and commissioned in 2014 and replaced the HFO boilers as primary sources of steam.

The remaining emission sources comprise bag house and cyclone exhausts for control of particulate emissions from materials handling operations and three diesel fired boilers for heating buildings.

2.1.1 HFO Boiler Emissions

HFO Boiler emissions were reduced in 2016 compared with previous years. The HFO boilers are no longer utilised as a primary generators of steam and were only utilised infrequently as back-up to the new gas boilers in 2016. Depending on the parameter, monitoring varies from continuous online monitoring to quarterly analyses as specified in Schedule C.1.1 (Control of Emissions to Air) of the IE Licence. A summary of the actual mass emissions for the licensed parameters during the reporting period is tabulated in Table 1 below.

Actual mass emissions of oxides of sulphur (as SO_2), as tabulated below, are generated by calculation, based on the sulphur content of the fuel and the quantity of fuel oil consumed in 2016. Nitrogen oxides mass emissions (as NO_2) are derived from measured NO_2 values, and estimated exhaust gas flow rates. Dust mass emissions from the boilers are calculated from the measured particulate emissions and estimated exhaust gas flow rates. The gas flow rate estimation is based on the quantity of fuel used, as there is a stoichiometric relationship between air flow and fuel consumption.

Licensed mass emissions are based on emissions concentration and flow rate at ELV, taking a 365 day operational period.

Table 1 Mass Emissions to Air – HFO Boilers

Emission Point Ref. A1 Boilers	Mass Emission (kg) 2015	Mass Emission (kg) 2016	Licensed Mass Emissions (kg)
Oxides of Sulphur (as SO_2)	49,618	10,792	5,474,299
Nitrogen Oxide (as NO_2)	20,869	3,980	2,415,132
Dust	2,493	396	161,009

Emissions of sulphur dioxide, nitrogen oxides and dust from the main site boilers were significantly below licensed mass emission rates permitted for these parameters.

The actual mass emission of SO_2 from the boilers decreased by 78% in 2016 compared to the 2015 figure. Emissions of nitrogen oxides (as NO_2) decreased by 81% and particulates decreased by 84% during the same period.

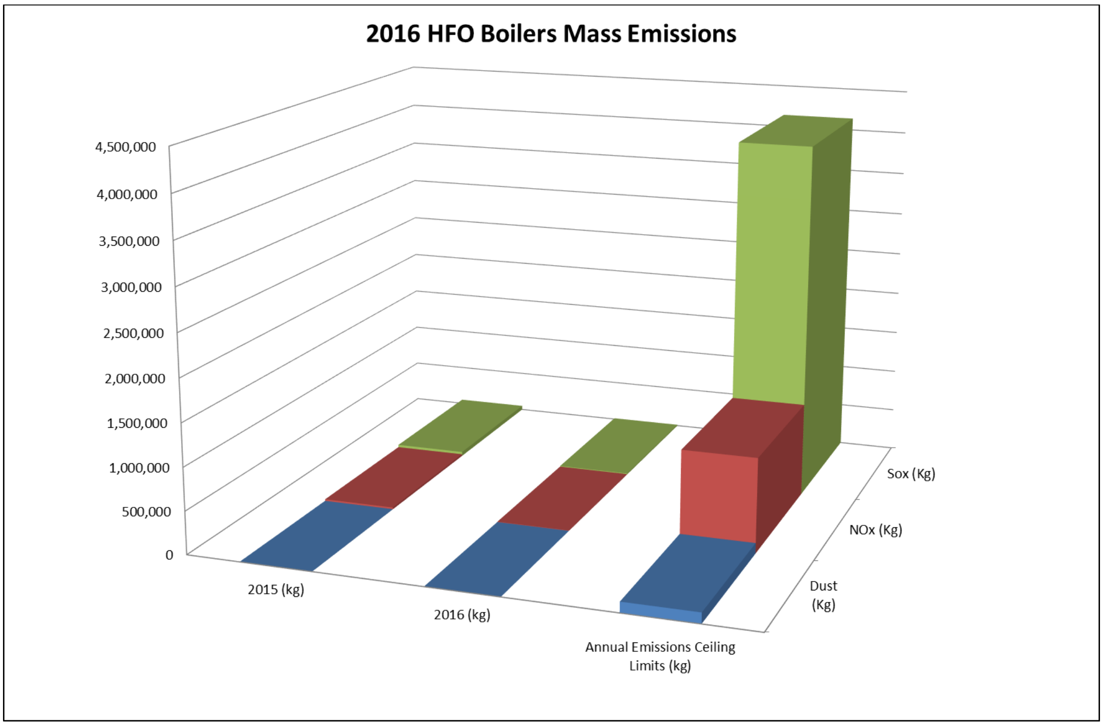


Figure 1 HFO Boiler Mass Emissions 2016

2.1.2 Gas Boiler Emissions

Emissions from the gas boilers are summarised in Table 2 below as actual annual mass emissions (in kgs) for the licensed parameters during the 2016 reporting period. There was an increase in gas boiler emissions in 2016 when compared with 2015 as GT2 in the CHP plant was offline for approximately 1 month and therefore the boilers were operated at higher rates in order to compensate for the loss in steam production.

Table 2 Mass Emissions to Air - Gas Boilers

Emission Point Ref. A4-A & A4-B – Gas Boilers	Mass Emission (Kgs) 2015	Mass Emission (Kgs) 2016	Licensed Mass Emissions (Kgs)
Nitrogen Oxides (as NO_2)	84,024	89,910	227,760
Carbon Monoxide	13,019	17,302	227,760

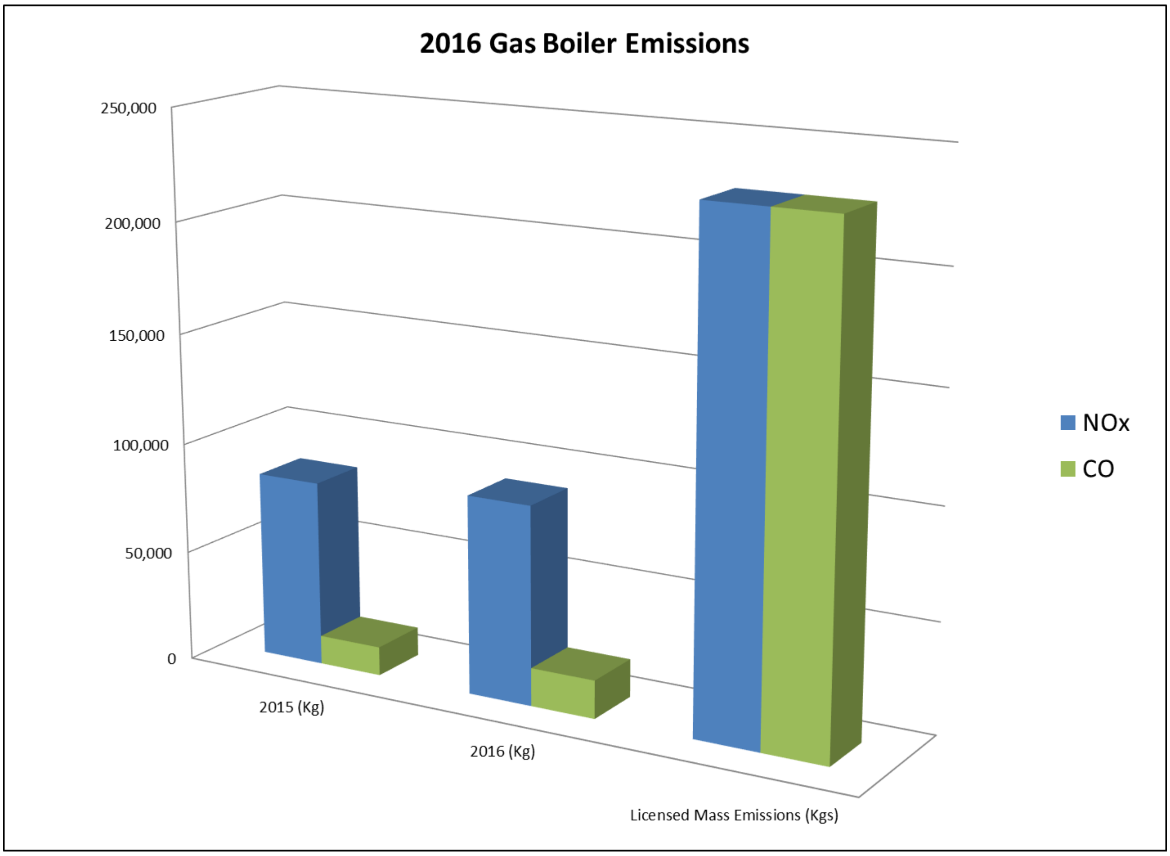


Figure 2 Gas Boiler Mass Emissions 2016

2.1.3 Calciner Emissions

Emissions from the calciners are summarised in Table 3 below as actual annual mass emissions (in kgs) for the licensed parameters during the 2016 reporting period.

The calciners operated on natural gas only in 2016 so there were no emissions of oxides of sulphur. Particulate mass emissions are based on the measured particulates, monitored as part of the IE Licence requirements, and estimated exhaust gas flow rates.

Table 3 Mass Emissions to Air - Calciners

Emission Point Ref. A2 – Calciner	Mass Emission (Kgs) 2015	Mass Emission (Kgs) 2016	Licensed Mass Emissions (Kgs)
Oxides of Sulphur (as SO_2)	0	0	7,029,024
Particulates	108,556	118,571	235,060
Nitrogen Oxides (as NO_2)	537,316	528,245	878,628

Emissions of sulphur dioxide, particulates and nitrogen oxides from the calciners were significantly below licensed emission rates permitted for these parameters.

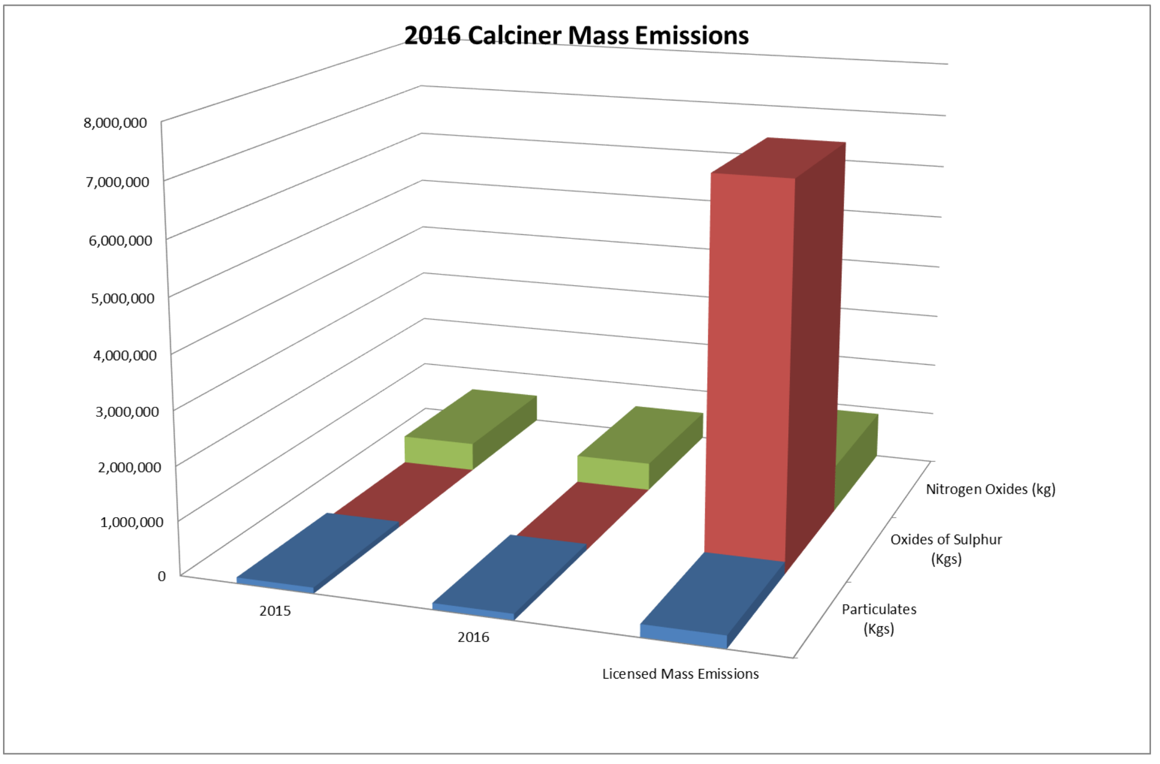


Figure 3 Calciner Mass Emissions 2016

2.1.4 CHP Emissions

Schedule C.1.2 of the IE Licence requires continuous monitoring of oxides of nitrogen (as NO_2). Monitoring of carbon monoxide (CO) became a new requirement in IE Licence P0035-06 issued in July 2014.

The licence requirements for the CHP heat recovery steam generator stack are as outlined below:

- No 24-hour value shall exceed the emission limit value of 75 mg/Nm^3 for Nitrogen Oxides and 100mg/Nm^3 for Carbon Monoxide.
- No hourly value shall exceed twice the ELV.

The NO_2 and CO monitoring results for 2016 are shown in Table 4 below and are significantly below the licensed emission limit values.

Table 4 Mass Emissions to Air - CHP

Emission Point Ref. A3A & A3B – CHP	Mass Emission (Kg) 2015	Mass Emission (Kg) 2016	Licensed Mass Emissions (Kg)
Nitrogen Oxides (as NO_2)	291,084	391,570	946,080
Carbon Monoxide	19,474	61,837	1,261,440

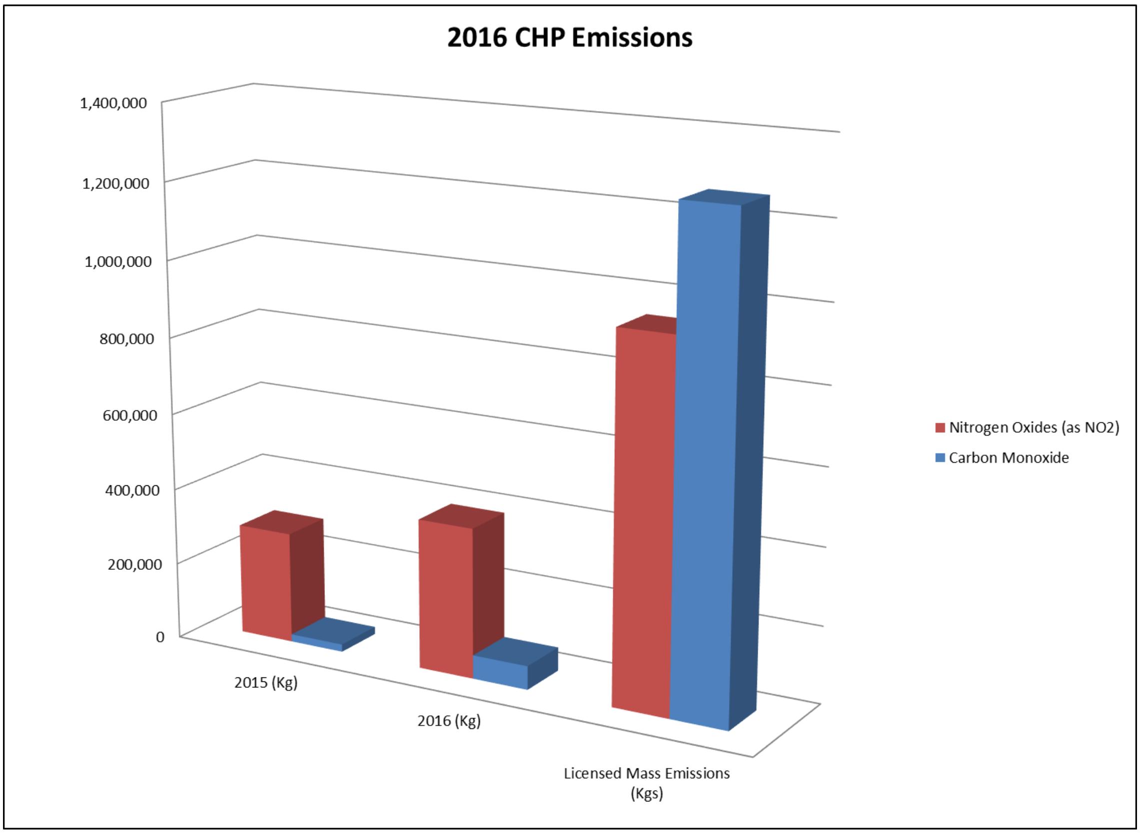


Figure 4 CHP Mass Emissions 2016

Annual mass emissions are well within licence limits. It is noted that the CEMS units were replaced on both gas turbines in October 2015. These new CEMS units are more sensitive instruments.

2.1.5 Other Emission Points (Dust Collection Units)

There are 9 other licensed process air emission points of which 6 were operational during 2016. These emissions are from dust collection units (DCUs) associated with bauxite and alumina handling and conveying operations at the plant.

Actual mass emissions of particulates from each of the licensed emission points are tabulated below and are based on average quarterly monitoring results and total hours of operation during 2016.

The combined actual annual mass emission of particulates from the licensed emission points was 8,694kg during 2016 which is significantly lower than the permitted annual mass emission for the combined sources of 174,567 kg.

In addition, each individual sample collected during the monitoring periods was significantly below the relevant emission limit value for that source.

Table 5 Summary of Particulate Emissions from Dust Collection Units

Emission Point Ref./Description		Mass Emission 2015 (kg)	Mass Emission 2016 (kg)	Licensed Emission (kg)
5	Transfer Tower 4 & 5 Exhaust Fan	N/A	N/A	51,757
6	Bauxite Crusher Scrubber Exhaust Fan	3,683	3,021	49,034
8	Transfer Tower 3 Scrubber Exhaust Fan	N/A	N/A	21,535
11	Alumina Loader Dust Fan FA49AL03 Outer	N/A	N/A	20,659
12	Alumina Loader Dust Fan FA49A Inner	1,610	831	9,682
16	Alumina Silo 1 Exhaust Fan FA12A017	2,934	1,255	6,570
17	Alumina Silo 2 Exhaust Fan FA12A018	1,795	2,770	6,570
18	Alumina Silo 3 Exhaust Fan FA12A019	1,412	511	4,380
19	Alumina Silo 1/2 Exhaust Fan FA12A020	642	306	4,380
Total		**12,075**	**8,694**	**174,567**

2.1.6 Emissions to Air Compliance Summary

Compliance with the relevant emission limit values (ELV's) for emissions to atmosphere is evaluated as follows for all active boilers, calciners and CHP emissions.

HFO Boiler Emissions

The overall annual level of compliance with emission limit values for continuous monitoring of HFO boiler emissions to atmosphere is tabulated below for the 48-hour and the monthly average compliance requirements as specified in Condition 4.1.2 of the IE Licence. The parameters evaluated are sulphur dioxide and nitrogen oxides. It should be noted that Boiler B is no longer in use.

It is noted that the total run-time for the HFO boilers in 2016 was <3% of the total hours in the year.

- No monthly mean shall exceed the ELV (750 mg/Nm^3 for NOx and 1700 mg/Nm^3 for SO_2)
- 95% of 48-hour mean values shall not exceed 825 mg/Nm^3 for NOx
- 97% of 48-hour mean values shall not exceed 1,825 mg/Nm^3 for SOx

The evaluation indicates that HFO boiler emissions were fully compliant with both the 48-hour (Table 6) and monthly average (Table 7) emission limits as specified in Condition 4.1.2 of the IE Licence.

Table 6 Evaluation of Compliance with 48-hour Average ELV's – HFO Boilers

Parameter	**Oxides of Sulphur (as SO_2)**		**Nitrogen Oxides (as NO_2)**	
No. Measurement Intervals	**183**		**183**	
Boiler Ref.	**A**	**C**	**A**	**C**
No. of Periods above 1.1 x ELV	0	0	0	0
% of 48-hour periods below 1.1 x ELV	100%	100%	100%	100%
Target % below 1.1 x ELV for compliance	97%	97%	95%	95%
Compliant	**Yes**	**Yes**	**Yes**	**Yes**

Table 7 Evaluation of Compliance with Monthly Average ELV's – HFO Boilers

Parameter	**Oxides of Sulphur (as SO_2)**		**Nitrogen Oxides (as NO_2)**	
# Measurement Intervals	**12**		**12**	
Boiler Ref.	**A**	**C**	**A**	**C**
No. of Periods above ELV	0	0	0	0
% of monthly periods below ELV	100%	100%	100%	100%
Target % monthly periods below ELV for compliance	100%	100%	100%	100%
Compliant	**Yes**	**Yes**	**Yes**	**Yes**

Gas Boiler Emissions

For gas boiler overall compliance is assessed in accordance with Condition 4.1.1:

- 100% of validated monthly average values shall not exceed 100mg/Nm^3 for NOx & CO.
- 100% of validated daily average values shall not exceed 110mg/Nm^3 for NOx & CO.
- 95% of validated hourly average values shall not exceed 200mg/Nm^3 for NOx & CO.

The evaluation confirms that gas boiler emissions were fully compliant with all the parameters specified in Condition 4.1.1 of the IE Licence as summarised in Table 8 below.

Table 8 Evaluation of Compliance – Gas Boilers

Parameter	**ELV (mg/m^3)**	**Actual 2016 (mg/m^3)**	**Comment**
A4-A (D Boiler) Monthly average NO_X	100% <100	100% <100	Compliant
A4-A (D-Boiler) Daily average NO_X	100% <110	100% <110	Compliant
A4-A (D Boiler) Hourly average NO_X	95% <200	100% <200	Compliant
A4-B (E Boiler) Monthly average NO_X	100% <100	100% <100	Compliant

Parameter	ELV (mg/m^3)	Actual 2016 (mg/m^3)	Comment
A4-B (E-Boiler) Daily average NO_X	100% <110	100% <110	Compliant
A4-B (E-Boiler) Hourly average NO_X	95% <200	100% < 200	Compliant
A4-A (D Boiler) Monthly average CO	100% <100	100% <100	Compliant
A4-A (D-Boiler) Daily average CO	100% <110	100% <110	Compliant
A4-A (D Boiler) Hourly average CO	95% <200	100% <200	Compliant
A4-B (E Boiler) Monthly average CO	100% <100	100% <100	Compliant
A4-B (E-Boiler) Daily average CO	100% <110	100% <110	Compliant
A4-B (E-Boiler) Hourly average CO	95% <200	100% <200	Compliant

Calciner Emissions

The requirements for Calciner particulate emissions as outlined in Condition 4.1.3 of the IE licence are as follows:

- No daily mean value shall exceed the ELV (50 mg/Nm^3)
- No hourly mean shall exceed twice the ELV (100 mg/Nm^3)
- 97% of hourly mean values shall not exceed 1.2 times the ELV (60mg/Nm^3)

An evaluation of the continuous monitoring data for 2016 is summarised in Table 9.

Table 9 Evaluation of Compliance – Calciners

Parameter	ELV (mg/Nm^3)	Actual 2016 (mg/m^3)	Comment
Daily Average Particulates	100% <50	100%<50	Compliant
Hourly Average Particulates	100% <100	100% <100	Compliant
Hourly Average Particulates	97% <60	99.93% <60	Compliant

In addition, for quarterly non-continuous monitoring of particulates and nitrogen oxides (as NO_2), individual results were fully compliant with the relevant ELV's for calciner emissions.

CHP Emissions

In accordance with Schedule C.1.2, continuous monitoring of Oxides of Nitrogen and Carbon Monoxide was assessed. A summary of evaluation of compliance of CHP emissions is presented in Table 10 below. In all cases, the emissions were compliant with the relevant ELVs.

Table 10 Evaluation of Compliance - CHP

Parameter	ELV (mg/m^3)	Actual 2016 (mg/m^3)	Comment
A3-A (GT1) Monthly average NO_X	100%< 75	100% < 75	Compliant
A3-A (GT1) Daily average NO_X	100%< 82.5	100% < 82.5	Compliant
A3-A (GT1) Hourly average NO_X	95%< 150	100% <150	Compliant
A3-B (GT2) Monthly average NO_X	100%< 75	100% < 75	Compliant
A3-B (GT2) Daily average NO_X	100%< 82.5	100% < 82.5	Compliant
A3-B (GT2) Hourly average NO_X	95%< 150	100% < 150	Compliant
A3-A (GT1) Monthly average CO	100%< 100	100%< 100	Compliant
A3-A (GT1) Daily average CO	100%< 110	100%< 110	Compliant
A3-A (GT1) Hourly average CO	95%< 200	99.97%< 200	Compliant
A3-B (GT2) Monthly average CO	100%< 100	100%< 100	Compliant
A3-B (GT2) Daily average CO	100%< 110	100%< 110	Compliant
A3-B (GT2) Hourly average CO	95%< 200	99.99%< 200	Compliant

Dust Collection Units

Other particulate emissions are required to be sampled on a bi-annual basis.

All monitoring results for each of the emission points were fully compliant with the specified emission limit values set out in the IE licence.

2.1.7 EN14181 Compliance Summary

As per the European Directive 2001/80/EC on the emissions into air from large combustion plant (LCPD) and the EPA Guidance document AG3 (Air Guidance Note on the Implementation of I.S. EN 14181), AAL carries out annual monitoring of emissions from the boiler and gas turbine (CHP) continuous emissions measuring systems (CEMS) against Standard Reference Methods (SRMs) so as to validate their accuracy.

In 2015, QAL 2 Testing and Annual Surveillance Testing (AST) was undertaken by RPS Consultants on the CEMS for the primary steam generating sources for the site, as required - D gas boiler, E gas boiler, GT1 and GT2. It should be noted that the CEMs units on GT1 and GT2 were upgraded in 2015 and new QAL2 reports were generated accordingly. The current calibration functions for the relevant CEMS is shown in Table 11 below. It is noted that required Annual Surveillance Testing (AST) of D gas boiler, E gas boiler, GT1 and GT2 was carried out in 2016 by RPS Consultants. As a result of the testing the calibration functions outlined in Table 11 remain unchanged.

D and E gas boilers replaced A, B and C HFO boilers as primary sources of steam generation since 2014. A and C HFO boilers will be used only as a back-up units for D and E gas boilers, as required.

Table 11: EN14181 CEMS Calibration Functions

Unit	Parameter	Established Calibration Function		Year Established	Next QAL2 Required
		A	B		
A Boiler	NOx	0	0.85	2013	2018
	SOx	2.583	1.202	2013	2018
D Boiler	NOx	0.284	1.026	2015	2020
	CO	-1.335	0.958	2015	2020
E Boiler	NOx	-0.694	0.999	2014	2019
	CO	0.309	0.82	2014	2019
GT1	NOx	1.272	0.9189	2015	2020
	CO	3.042	0.965	2015	2020
GT2	NOx	1.324	1.0085	2015	2020
	CO	3.26	0.9436	2015	2020

2.2 Emissions to Water

AAL has two licensed discharges of treated effluent to the Shannon Estuary as follows:

Table 12 Licensed Discharges to Water

Licence Reference	Receiving Water	Characteristics
W1-1	Shannon Estuary	Treated Industrial (Process) Effluent
Sanitary Effluent	Shannon Estuary	Treated Sanitary Effluent

Discharges of treated industrial (process) and sanitary effluents to the Shannon Estuary are made at an outfall point close to the AAL Marine Terminal. Both discharges are sampled continuously for both flow and pH, and for other parameters at weekly, quarterly and bi-annual frequencies, as specified in Schedules C.2.1 (Control of Emissions to Water) and C.2.2 (Monitoring of Emissions to Water) of the IE Licence.

2.2.1 Process Effluent (W1-1)

Treated process effluent is discharged to the Shannon Estuary at emission point W1-1. Summary monitoring results for 2016 are tabulated in Table 13 below.

Screening for heavy metals, VOC's (Volatile Organic Compounds) and toxicity is also carried out and results are detailed in Sections 2.2.2, 2.2.3 and 2.2.4 respectively.

The data reported in Table 13 is for the 12 months of 2016. Figures for 2015 are included by way of comparison.

It is noted that annual mass emissions for all parameters during the reporting period were within licensed emission limit values (ELV's).

Table 13 Process Effluent (W1-1) Mass Emissions

Parameters	Mass Emissions (kg) 2015	Mass Emissions (kg) 2016	Licensed Emissions (kg)
Volume (m^3)	5,479,337	4,844,726	10,950,000
BOD	160,326	372,863	861,400
Suspended Solids	70,318	80,083	547,500
Oils Fats & Greases	5,479	5,005	164,250

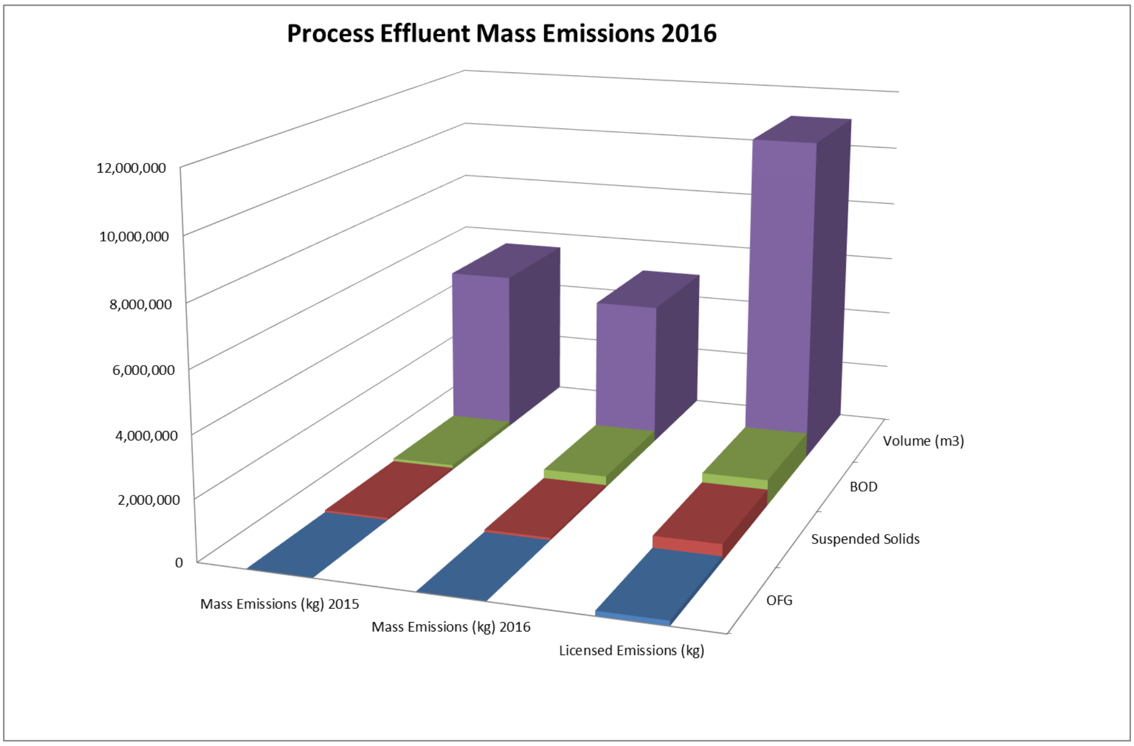


Figure 5 Process Effluent Mass Emissions 2016

2.2.2 Heavy Metal, Aluminium and Soda Analysis

AAL is required to analyse treated process effluent for heavy metals, aluminium and soda under IE Licence Schedule C.2.2 Monitoring of Emissions to Water.

Heavy Metals

Heavy metal analysis of the effluent discharged at emission point W1-1 was undertaken by Fitz Scientific Ltd. on a bi-annual basis during 2016. Analytical results are shown in Table 14 below.

Table 14 Process Effluent (W1-1) - Heavy Metal Results

Parameter	Conc. (mg/l)	Conc. (mg/l)
	H1	**H2**
As	0.064	0.069
Cd	0.0034	0.0001
Cr	0.014	0.007
Cu	0.014	0.006
Hg	0.019	0.011
Ni	0.012	0.004
Pb	0.0002	0.0010
Zn	0.005	0.007
Ti	0.008	0.006
Fe	0.151	0.124
Mg	8.710	6.322

Aluminium & Soda

The results of the analyses for aluminium and soda are detailed in Table 15. The figure provided for each parameter is the average result for the 2016 monthly and quarterly monitoring intervals. 2015 data is provided for comparison.

Table 15 Process Effluent (W1-1) Soda & Aluminium Analysis

Parameter	Units	Annual Average 2015	Annual Average 2016	ELV
Aluminium	mg/l Al	3.36	1.87	Not specified
Soda	g/l Na_2O	2.72	2.85	Not specified

2.2.3 Effluent VOC Screen

Screening of industrial effluent (at W1-1) for VOC's is undertaken biannually as specified in Schedule C.2.2 of the IE Licence. Biannual sampling and analysis was undertaken in February and July 2016. Laboratory analysis was undertaken by Fitz Scientific Ltd. using a modified version of the US EPA Method 524.2, as approved by the Agency (Ref. M35/AP/12).

The VOC concentration in the sample taken in February and July 2016 was <5 µg/l.

Table 16 Process Effluent (W1-1) - VOC Analysis

Date	Units	Test	Method	Result	ELV
22/02/2016	µg/l	VOC	USEPA 542.2	<5	Not specified
19/07/2016	µg/l	VOC	USEPA 542.2	<5	Not specified

The VOC results are included as ***Attachment 1***.

2.2.4 Toxicity

Schedule B.2 (Emissions to Water) and Schedule C.2.2 (Monitoring of Emissions to Water) of the IE Licence requires biannual toxicity testing of the treated effluent. The ELV for toxicity is 5 Toxic Units (TU).

Samples of treated effluent (24 hour flow proportional composite samples) was collected and submitted to the Aquatic Services Unit, Environmental Research Institute, Lee Road, Cork for toxicity testing in April and September 2016.

The acute toxicity of each sample was analysed on suitable sensitive aquatic indicator species i.e. *Tisbe battagliai* and *Vibrio fischeri*.

The results (see Table 17) show that the both effluent samples were compliant with the ELV for toxicity.

The toxicity testing reports are included as ***Attachment 1***.

Table 17 Process Effluent - Toxicity Testing Results

Test Parameter	April 2016 Results (TU)	September 2016 Results (TU)	ELV (TU)
48h LC_{50} to *Tisbe battagliai*	2.7	2.7	5
30 min EC_{50} to *Vibrio fischeri*	1.4	<1	5

Note: Values denoted less than (<) are below the relevant threshold or limit of detection for that test

2.2.5 Sanitary Effluent

Treatment of sanitary effluent is provided for by a proprietary biological effluent treatment plant, which comprises an activated sludge (aeration) stage and a settlement/clarification stage, prior to discharge. The system discharges to the industrial effluent discharge pipeline at a point upstream of the final discharge at W1-1.

Annual mass emissions are tabulated in Table 18 below. 2015 data is provided for comparison.

Table 18 Sanitary Effluent Mass Emissions

Parameter	Mass Emissions (kg) 2015	Mass Emissions (kg) 2016	Licensed Emissions (kg)
Volume (m^3)	22,038	19,840	87,600
BOD	187	113	2,190
Suspended Solids	88	101	3,066

The annual volumetric discharge mass emissions for all parameters were significantly below licence limits for the monitoring period.

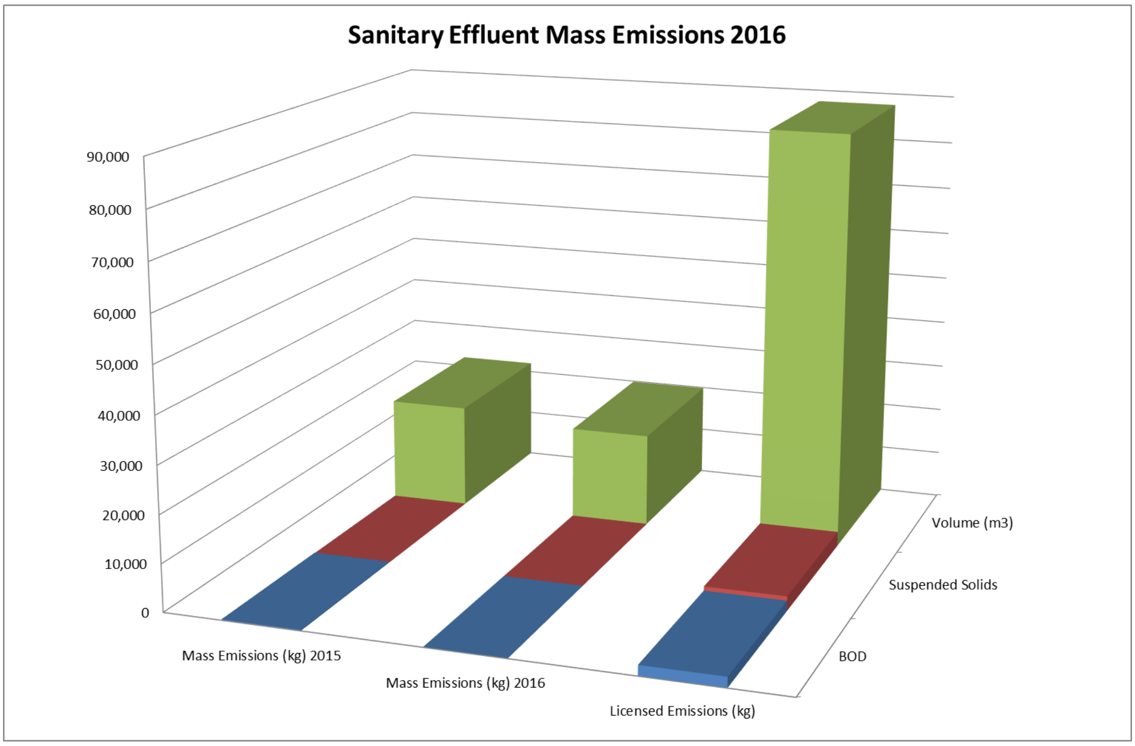


Figure 6 Sanitary Effluent Mass Emissions 2016

2.2.6 Surface Water Monitoring

Monitoring of surface water run-off from the site is undertaken at five discharge locations referred to as Surface Streams (SS).

Monitoring results for each emission point are summarised in Table 19 as the average value for the monitoring period.

Table 19 Surface Water Discharge Monitoring Results

Emission Point Reference	pH	Conductivity (µS/cm)	Na_2O (g/l)
Frequency	**Monthly**	**Monthly**	**Monthly**
SS 1	8.7	146	0.02
SS 2	8.2	244	0.02
SS 3	8.1	257	0.02
SS 4	8.1	121	0.01
SS 5	8.3	306	0.04

(Note: Results are numerical average of 2016 data)

2.2.7 Surface Water Monitoring at the BRDA

Monitoring of surface water run-off in the area of the existing BRDA is undertaken at three licensed locations – Mangan's Lough, the OPW Channel and Phase 2 West Robertstown Gate.

Results for each emission point are detailed in Table 20 and show the average value over the monitoring period. As the surface water in the area is subject to saline intrusion, the soda and conductivity values are subject to sodium interference owing to the presence of sodium salts in the brackish water.

Table 20 BRDA Surface Water Monitoring Results

Description	pH	Conductivity µS/cm	Soda (Na_2O) g/l
Mangan's Lough	7.6	1,977	0.43
OPW Channel	7.7	3,063	0.64
West Robertstown Gate	7.7	4,283	0.98

(Note: Results are numerical average of 2016 data)

2.2.8 Discharges to Water Compliance Summary

All discharges of treated process wastewater and sanitary effluent during the reporting period complied fully with the relevant emission limit values set out in the IE Licence.

3. Waste Management

The national waste database table, providing a summary of waste arising at the AAL facility has been compiled for the calendar year 2016. The information is tabulated on Tables 21 and 22.

3.1 Waste Quantities 2016

Table 21 Summary Information on Waste Quantities Generated

	2012	2013	2014	2015	2016
Total Quantity of waste produced in calendar year (tonnes)	**1,305,251**	**1,345,370**	**1,465,781**	**1,509,598**	**1,516,557**
Quantity of waste disposed of on-site	1,303,765	1,343,879	1,464,306	1,507,468	1,514,519
Quantity of waste disposed of off-site	215	243.4	389	751	748
Quantity of waste recovered on-site	0	19.8	0	0	0
Quantity of waste recovered off-site	1,270	1,228	1,086	1,379	1,289
	2012	**2013**	**2014**	**2015**	**2016**
Quantity of Non-Hazardous waste produced in calendar year (tonnes)	**1,289,351**	**1,329,485**	**1,447,040**	**1,490,269**	**1,498,168**
Quantity of non-hazardous waste disposed of on-site	1,287,957	1,328,123	1,445,765	1,488,267	1,496,215
Quantity of non-hazardous waste disposed of off-site	195	221	373	739	737
Quantity of non-hazardous waste recovered on-site	0	0	0	0	0
Quantity of non-hazardous waste recovered off-site	1,199	1,141	902	1,263	1,216
	2012	**2013**	**2014**	**2015**	**2016**
Quantity of Hazardous waste produced in calendar year (tonnes)	**15,900**	**15,885**	**18,741**	**19,329**	**18,389**
Quantity of hazardous waste disposed of on-site	15,808	15,756	18,541	19,201	18,304
Quantity of hazardous waste disposed of off-site	20.5	22.3	16.4	12.5	11.1
Quantity of hazardous waste recovered on-site	0	19.8	0	0	0
Quantity of hazardous waste recovered off-site	71	87	184	116	74

The quantities of waste disposed of to the plant Bauxite Residue Disposal Area (BRDA) are estimated using a number of methods:

- Volumes of red mud disposed of to the BRDA are calculated from the annual production figures and the determined mud factor generated by analysis of the bauxite ores used during the reporting period.
- Volumes of salt cake, process scale and other process wastes are based on the number of containers multiplied by typical container net weight.

There was an overall increase of 6,959 tonnes of waste generated on site in 2016 compared to 2015. This increase was attributed primarily to fluctuations in bauxite quality.

Results of quarterly waste analysis carried out by AAL during 2016 are included as ***Attachment 2***.

Table 22 Information on Individual Waste Streams

LoW Code	Haz (Y/N)	Description of Waste	Name of Waste Collection Contractor	Waste Collection Permit No.	Name of Waste Disposal/ Recovery Contractor	Method of Disposal/Recovery	Location of Disposal/ Recovery	Waste Licence/ Permit No.	Quantity (Tonnes/ annum)
15 01 11	Y	Aerosol Cans	John Malone Transport	WCP-LK-543-08b	Rilta Environmental Ltd., Greenogue Business Park, Rathcoole, Co. Dublin	D10 Incineration on land	(b) Off-site Abroad	W0192-03	3.0
17 06 01	Y	Asbestos	John Malone Transport	WCP-LK-543-08b	Rilta Environmental Ltd., Greenogue Business Park, Rathcoole, Co. Dublin	D5 Engineered Landfill	(c) Off-site Abroad	W0192-03	4.5
16 06 01	Y	Batteries	John Malone Transport	WCP-LK-543-08b	Rilta Environmental Ltd. Greenogue Business Park, Rathcoole, Co. Dublin	R4 Recycling/reclamation of metals & metal compounds	(b) Off-site Ireland	W0192-03	8.10
20 01 01	N	Cardboard	Greenstar	WCP-DC-08-1120-01	Greenstar, Dock Road, Limerick	R3 Recycling/reclamation of organic substances which are not used as solvents	(b) Off-site Ireland	W0082-02	15.5
16 05 06	Y	Chemical Waste	Lehane Environmental	WCP-CK-08-0574-02	Rilta Environmental Ltd. Greenogue Business Park, Rathcoole, Co. Dublin	R1 Use as a fuel (other than in direct incineration) or other means to generate energy	(b) Off-site Abroad	W0192-03	3.10
18 01 03	Y	Clinical Waste	SRCL	WCP-DC-09-1178-01	SRCL Ltd., 420-430 Beech Road, Western Industrial Estate, Naas Road, Dublin 12	D9 Physico chemical treatment	(b) Off-site Ireland	W0055-02	0.001
17 05 03	Y	Contaminated Soil	John Malone Transport	WCP-LK-543-08b	Rilta Environmental Ltd. Greenogue Business Park, Rathcoole, Co. Dublin	R13 Accumulation of material intended for any operation numbered R1-R12	(b) Off-site Abroad	W0192-03	2.4

LoW Code	Haz (Y/N)	Description of Waste	Name of Waste Collection Contractor	Waste Collection Permit No.	Name of Waste Disposal/ Recovery Contractor	Method of Disposal/Recovery	Location of Disposal/ Recovery	Waste Licence/ Permit No.	Quantity (Tonnes/ annum)
17 04 01	N	Copper	United Metals	WCP-LK-10-657-01	United Metals, Eastway Business Park, Limerick	R4 Recycling/reclamation of metals & metal compounds	(c) Off-site Abroad	WFP-LK-2013-147A-R1	0.1
16 11 04	N	Flue Stack Residue (Refractory Waste)	N/A	N/A	Aughinish Alumina Ltd.	D1 Deposit on, in or under land	Site landfill	P0035-06	140
20 01 21	Y	Fluorescent Bulbs	Irish Lamp Recycling	WCP-DC-08-1115-01	Irish Lamp Recycling, Athy, Co Kildare	R4 Recycling/reclamation of metals & metal compounds	(b) Off-site Ireland	WFP-KE-08-0348-01	8
20 03 01	N	General Waste	Greenstar	WCP-DC-08-1120-01	Greenstar, Dock Road, Limerick	D1 Deposit on, in or under land	(b) Off-site Ireland	W0082-02	173.8
01 03 99	N	Lime Grits/Stone	N/A	N/A	Aughinish Alumina Ltd.	D1 Deposit on, in or under land	Site landfill	P0035-06	5,620
06 04 04	Y	Mercury Liquid	Irish Lamp Recycling	WCP-DC-08-1115-01	Irish Lamp Recycling, Athy, Co Kildare	R4 Recycling/reclamation of metals & metal compounds	(b) Off-site Ireland	WFP-KE-08-0348-01	0.001
15 01 04	N	Metal Containers (empty IBC's & drums)	John Malone Transport	WCP-LK-543-08b	Rilta Environmental Ltd., Greenogue Business Park, Rathcoole, Co. Dublin	R4 Recycling/reclamation of metals & metal compounds	(b) Off-site Ireland	W0192-03	11.0
16 01 07	Y	Oil Filters	Enva	WCP-DC-08-1116-01	Enva Shannon, Smithstown Industrial Estate, Shannon, Co. Clare	R11 Uses of residual materials obtained from any of the operations numbered R1-R10	(b) Off-site Abroad	W0041-01	0.10

LoW Code	Haz (Y/N)	Description of Waste	Name of Waste Collection Contractor	Waste Collection Permit No.	Name of Waste Disposal/ Recovery Contractor	Method of Disposal/Recovery	Location of Disposal/ Recovery	Waste Licence/ Permit No.	Quantity (Tonnes/ annum)
15 02 02	Y	Oily Rags / Oil Dry	John Malone Transport	WCP-LK-543-08b	Rilta Environmental Ltd. Greenogue Business Park, Rathcoole, Co. Dublin	D10 Incineration on land	(b) Off-site Ireland	W0192-03	3.6
20 01 01	N	Paper/Documents	DGD Papers	WCP/LK/021/02b WCP/LK/021/05c WCP/LK/062/02b	DGD Papers Ltd., Bay M1, Raheen Business Park, Limerick	R3 Recycling/reclamation of organic substances which are not used as solvents	(b) Off-site Ireland	WFP-LK-2008-09C	1.8
20 01 39	N	Plastic containers (clean empty IBC's & drums)	John Malone Transport	WCP-LK-543-08b	Rilta Environmental Ltd., Greenogue Business Park, Rathcoole, Co. Dublin	R9 Used oil re-refining or other reuses of previously used oil	(b) Off-site Ireland	W0192-03	41.3
20 01 36	N	Printer Toner Cartridges	Condells	N/A	Condells The Office Centre, 9 Roches St., Limerick	R4 Recycling/reclamation of metals & metal compounds	(b) Off-site Ireland	N/A	0.10
01 03 99	N	Process Waste (tank cleanout scale, sludge etc)	N/A	N/A	Aughinish Alumina Ltd.	D1 Deposit on, in or under land	Site landfill	P0035-06	15,996
01 03 09	N	Red Mud	N/A	N/A	Aughinish Alumina Ltd.	D1 Deposit on, in or under land	Site landfill	P0035-06	1,371,301
01 03 07	Y	Salt Cake	N/A	N/A	Aughinish Alumina Ltd.	D1 Deposit on, in or under land	Site landfill	P0035-06	18,304
01 03 06	N	Sand	N/A	N/A	Aughinish Alumina Ltd.	D1 Deposit on, in or under land	Site landfill	P0035-06	103,158

LoW Code	Haz (Y/N)	Description of Waste	Name of Waste Collection Contractor	Waste Collection Permit No.	Name of Waste Disposal/ Recovery Contractor	Method of Disposal/Recovery	Location of Disposal/ Recovery	Waste Licence/ Permit No.	Quantity (Tonnes/ annum)
19 08 05	N	Sanitary Effluent Sludge	Ecojet	WCP-LK-12-685-01	Ecojet Ltd., Bay M1, Raheen Business Park, Raheen, Limerick	D8 Biological Treatment	(b) Off-site Ireland	D0013-01	541.0
17 04 07	N	Steel & Aluminium Scrap Metal	United Metals	WCP-LK-10-657-01	United Metals, Eastway Business Park, Limerick	R4 Recycling/reclamation of metals & metal compounds	(c) Off-site Abroad	WFP-LK-2013-147A-R1	966.0
20 01 38	N	Timber Reels (used)	Hegarty Metals Recycling	WCP-LK-027-02b	Hegarty Metals Recycling, Ballysimon Rd., Limerick	R11 Uses of residual materials obtained from any of the operations numbered R1-R10	(b) Off-site Ireland	WFP-LKC-11-001-01	10.0
19 12 04	N	Used Hosing & Belting (Rubber)	Greenstar	WCP-DC-08-1120-01	Greenstar, Dock Road, Limerick	R11 Uses of residual materials obtained from any of the operations numbered R1-R10	(b) Off-site Ireland	W0082-02	66.9
20 01 25	N	Vegetable Oils & Greases	Frylite	WCP-DC-10-1297-01	Frylite Dublin Ltd., Unit J1, Ballymount Industrial Estate, Dublin 12	R3 Recycling/reclamation of organic substances which are not used as solvents	(b) Off-site Ireland	WCP-DC-10-1297-01	1.7
16 02 14	N	Waste Electrical & Electronic Equipment (WEEE)	Greenstar	WCP-DC-08-1120-01	Greenstar, Dock Road, Limerick	R4 Recycling/reclamation of metals & metal compounds	(b) Off-site Ireland	W0082-02	0.001

LoW Code	Haz (Y/N)	Description of Waste	Name of Waste Collection Contractor	Waste Collection Permit No.	Name of Waste Disposal/ Recovery Contractor	Method of Disposal/Recovery	Location of Disposal/ Recovery	Waste Licence/ Permit No.	Quantity (Tonnes/ annum)
20 01 08	N	Waste Food	Greenstar	WCP-DC-08-1120-01	Greenstar, Dock Road, Limerick	R3 Recycling/reclamation of organic substances which are not used as solvents	(b) Off-site Ireland	W0082-02	21.4
20 01 38	N	Wood - recycling	Hegarty Metals Recycling	WCP-DC-08-1120-01	Greenstar, Dock Road, Limerick	R3 Recycling/reclamation of organic substances which are not used as solvents	(b) Off-site Ireland	W0082-02	80.2
20 01 38	N	Wood - landfill	Hegarty Metals Recycling	WCP-DC-08-1120-01	Greenstar, Dock Road, Limerick	D1 Deposit on, in or under land	(b) Off-site Ireland	W0082-02	22.4
13 07 01	Y	Waste Oil	John Malone Transport	WCP-LK-543-08b	Rilta Environmental Ltd., Greenogue Business Park, Rathcoole, Co. Dublin	R9 Used oil re-refining or other reuses of previously used oil	(b) Off-site Ireland	W0192-03	51.8
								TOTAL	1,516,557

Hazardous Waste

Non Hazardous Waste

4. Monitoring and Enforcement

4.1 Monitoring

The EPA, and their representatives, made 4 separate monitoring visits or inspections during 2016.

- In February 2016, EPA inspector visited the site following a complaint from a neighbouring property. Areas inspected by the EPA included the complainant's property and the BRDA.
- In March 2016, EPA personnel collected samples of treated process effluent, sanitary effluent, and surface water for analysis.
- In July 2016, EPA representatives conducted monitoring of air emissions from calciner emission point reference A2.
- In December 2016, EPA personnel collected samples of treated process effluent and sanitary effluent for analysis.

No non-compliances were recorded by the EPA in 2016.

4.2 Third Party Inspections

AAL obtained certification to the international environmental management system (EMS) standard ISO14001 in 2000.

DNV-QA (Det Norske Veritas Quality Assurance) carried out a surveillance audit of the system in October 2016. There were no non-conformances recorded.

AAL operates a rigorous internal audit schedule in order to ensure conformance with plant operating systems (production, quality, safety, environmental) and to facilitate the process of continual improvement in those systems.

ISRS recertification, Level 8, was achieved in November 2016.

5. Resource Consumption

5.1 Energy Consumption

Owing to the nature of the Bayer process used at AAL for alumina manufacturing and post extraction processing, energy represents the most economically significant impact to the process.

For this reason, AAL was designed with energy efficiency in mind. Heat recovery and power efficiency are two of the key process efficiency targets that receive close scrutiny.

Table 23 Energy Consumption 2014 – 2016

Source	2014 (MW)	2015 (MW)	2016 (MW)
Heavy Fuel Oil	50.2	2.7	0.5
Power (Electrical)	44.1	44.2	44.3
Diesel	0.5	0.6	0.4
Natural Gas	631.6	677.9	704.3
Total	726.4	725.4	749.4

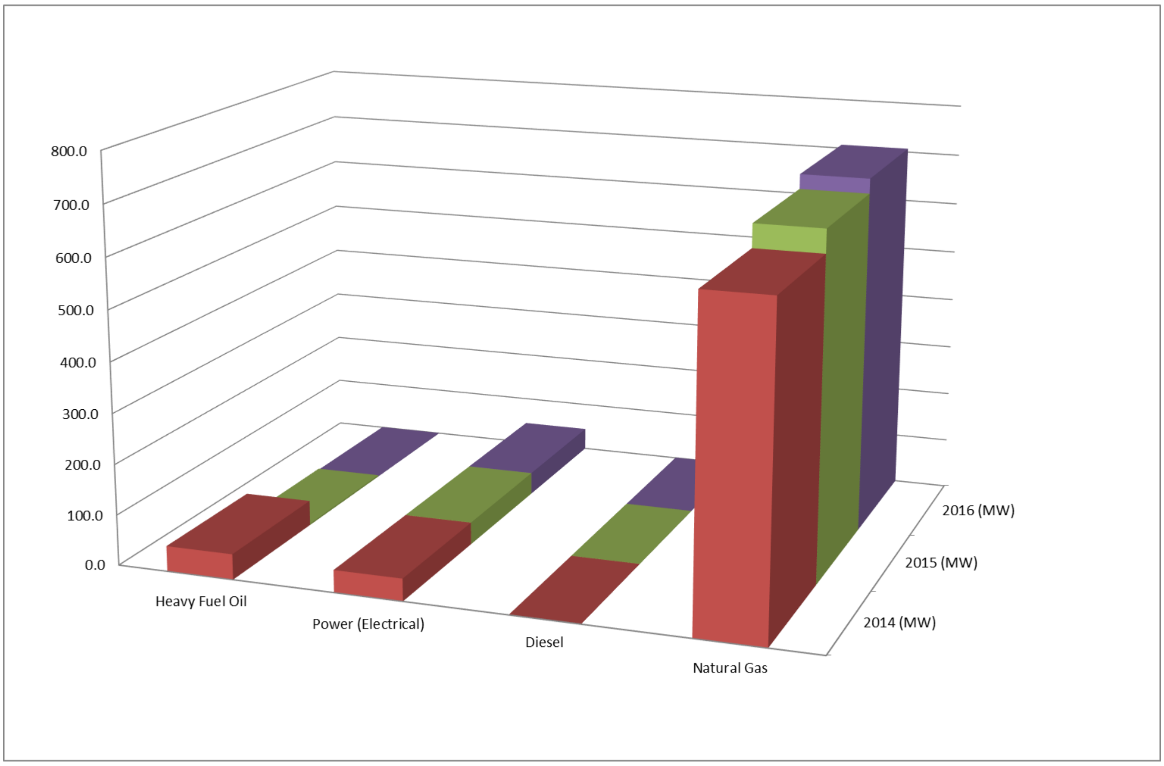


Figure 7 Energy Consumption 2014 – 2016

5.1.1 Energy Efficiency Report 2016

The 2016 energy efficiency report is provided as ***Attachment 3***.

- ISO 50001 accreditation was achieved in January 2016, with a successful surveillance audit completed in September.
- In 2016 AAL achieved a record total steam efficiency performance of 5.62 GJ/t (previous best was 2015 at 5.71 GJ/t).
- There was a step change down since June due to heater descaling and retubing work carried out.
- The power efficiency performance result for 2016 was 0.707 GJ/t, which shows no significant change from the 0.706 result achieved in 2015. The best ever result of 0.704 was achieved in 2008.

5.2 Water Consumption

AAL receives potable water from Limerick City & County Council for process and domestic uses.

The bulk of the potable water is demineralised in the AAL water treatment plant for use in boiler steam generation. The balance of the potable water is used for process make-up, where process condensate (re-condensed water from the process) supply is not available, and also as domestic water.

AAL does not abstract any groundwater for process or domestic purposes.

Table 24 Water Consumption 2013 - 2016

Year	Total (m^3)	Relative Consumption (m^3/tonne product)
2016	5,121,103	2.59
2015	5,177,594	2.62
2014	5,191,722	2.66
2013	5,161,997	2.65

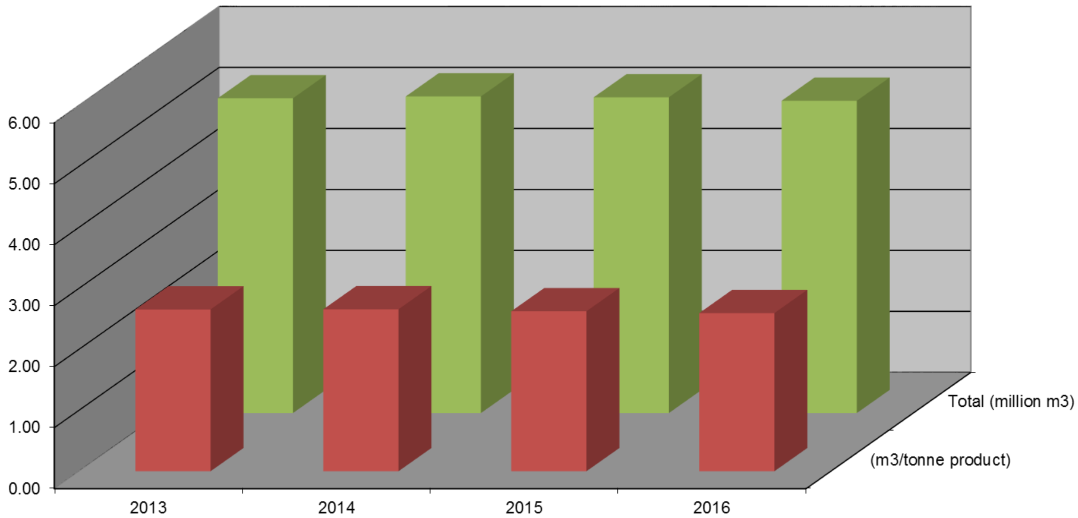


Figure 8 Water Consumption 2013 – 2016

5.3 Raw Materials Efficiency and Waste Reduction

AAL continually strives to improve the efficiency of its processes in order to reduce the raw materials consumed and the waste produced.

Table 25 shows the volumes of raw materials consumed and waste produced for 2015 and 2016. The relative consumption for each parameter is calculated as the volume consumed per tonne of alumina hydrate produced.

Table 25 Raw Material Efficiency & Waste Reduction

Material	2015 Consumption	Relative Consumption (Volume/tonne alumina)	2016 Consumption	Relative Consumption (Volume/tonne alumina)
Alumina Produced (tonnes)	1,974,017	N/A	1,975,077	N/A
Bauxite Ore Consumed (tonnes)	4,627,457	2.3	4,677,921	2.4
Sodium Hydroxide (tonnes)	134,444	0.07	132,857	0.07
Sulphuric Acid (tonnes)	18,972	0.01	18,243	0.01
Heavy Fuel Oil (tonnes)	3,710	0.002	852	0.0004
Water (m^3)	5,177,594	2.6	5,121,103	2.6
Waste (tonnes)	1,509,598	0.8	1,516,557	0.8
Energy (GJ)	725.4	11.6	749	12.0

5.4 Progress on Minimising Water Demand and Volume of Trade Effluent Discharges

AAL continually strives to improve the efficiency of its processes in order to reduce both the quantity of raw water consumed and waste effluent produced.

6. Environmental Incidents and Complaints

AAL has a procedure in place for classification and reporting of environmental incidents. As part of the requirements of the IE Licence, AAL operates, through the plant Environmental Management System, a procedure for logging and responding to any complaints received from the public.

6.1 Category 1 Incidents

There were no Category 1 (minor) incidents notified to the EPA during 2016.

6.2 Category 2 – 5 Incidents

There were no Category 2, 3, 4 or 5 (Limited, Serious, Very Serious or Catastrophic) environmental incidents during 2016.

6.3 Complaints

One complaint was received during 2016. Details are as follows:

- On the 8th February, a complaint was received by AAL from a nearby resident regarding dust outfall on their property. This complaint was subsequently made to the EPA formally. The resident was met at his property by AAL personnel on the 8th February and further details were obtained. The complaint was investigated and following analysis of weather conditions, BRDA activities at the time and extensive air monitoring data in and around the residential property and site boundary, it was concluded that there was no material emission from the BRDA on the day in question. Responses were submitted to the EPA including details of the investigation and the complainant was also contacted. This complaint has been closed by the EPA.

7. Environmental Management Programme

This section contains summary information on the AAL Environmental Management Programme (EMP).

A revised Schedule of Objectives and Targets for 2016 is presented in Section 7.2 for Agency approval.

Both the EMP and Schedule of Objectives and Targets fall under the site ISO 14001 Environmental Management System. Accordingly, they are included within a structured system of management review and periodic auditing by both internal auditors and independent third party auditors (DNV).

The Pollution Release and Transfer Register (PRTR), which is a requirement of Condition 6.17 of the IE Licence, has been updated to reflect emissions during the 2016 monitoring period.

7.1 Environmental Management Programme (EMP) Report 2016

The AAL Environmental Management Programme (EMP) is a continuously updated plan showing the status of key environmental improvement programmes being undertaken within the plant and is reviewed as part of the ISO 14001 Environmental Management System (EMS).

Progress in achieving planned objectives and targets during 2016 is summarised in Table 26. It sets out the objectives, associated targets and a comment on progress in meeting those targets.

Table 26 EMP 2016 Report

No.	Objective	Target	Progress
1	**Implement conditions of Industrial Emissions licence**	Agree 150 mg/Nm^3 ELV for calciner NO_x with Agency	Advised by EPA that licence review required.
		Identify soil monitoring locations for site	Potential soil monitoring locations to be agreed with the Agency in 2017.
		Complete fire water retention risk assessment	Completed in Q1 2016.
		Update the Environmental Liabilities Risk Assessment to reflect red mud transfer to BRDA via pipeline	Completed in Q1 2016.
		Update the Plant Closure and Aftercare Plan in light of AMEC feedback and have the costs quantified by a qualified independent consultant	To be completed in 2017.
		Review of IE licence conditions	Completed in Q1 2016.
		ISO50001 certification	Achieved in Q1 2016.
2	**Design & operate the BRDA to best practice**	Continue vegetation program on side slopes of Phase 1 BRDA	Complete as per 2016 programme.
		Implement 2016 screening programme for Phase 1 and II	Fully implemented in 2016.
		Continue development of mud discharge and grading strategy to facilitate thin layer deposition	Mud deposition completed as per 2016 plan.
		Implement 2016 rehabilitation programme	Agreement required in 2017 from EPA for amendment methodology.
		Update 2007 Residue Sustainability report	On development of demonstration area for farmed residue.
		Consultation with LCCC on the BRDA External Emergency plan	Correspondence issued to LCCC in 2016.
		Continue Wetlands study for treatment of BRDA leachate	Wetlands continued to successfully operate in 2016.
		Issue annual BRDA update in AER to include: Wetlands study, rehabilitation program and BRDA stability report	Completed in Q1 2016

No.	Objective	Target	Progress
		Review BRDA Operational & Safety manual	Completed in Q1 2016
		Develop application of GPS (geofencing)	Completed in Q2 2016
		Upgrade of effluent composite samplers	Completed in Q3 2016.
3	**Quality assurance for monitoring of industrial air emissions**	Conduct 'Annual Surveillance Testing' as required under EN14181 on GTs, A/C HFO boilers and D/E gas boilers	Completed in Q4 2016.
		ISO 17025 independent cross check of internal air monitoring	Annual surveillance testing completed by ISO 17025 certified contractor.
		Complete calibration of calciner 3 CEMS	Completed in 2016.
4	**Continual improvement of ambient air emissions**	Implement alumina dust improvement 2016 project.	2016 programme fully implemented.
5	**Continual improvement program for groundwater and surface water**	Achieve 100% compliance on Integrity Testing Programme & implement planned repairs for 2016	Integrity of structures tested in 2016 confirmed and repairs completed where required.
		Conduct monthly inspection and recording of leaks from all external valves and flanges	Completed in 2016.
		Recovery system upgrade for groundwater East of Precipitation	Four new groundwater recovery systems installed in 2016.
		Close the process caustic balance for 2016	Complete.
6	**Continual improvement of Environment Management System**	Update Register of Regulations quarterly	Complete for 2016.
		Review Register of Aspects	Commenced in 2016. Due for completion in Q1 2017.

No.	Objective	Target	Progress
		Maintain ISO14001 Certification via internal and external auditing programme	Certification maintained in 2016 following compliant external audit.
7	**Seveso Registration**	Review status wrt HFO consumption and inventory	Review complete and site remains as a non-Seveso site.

7.2 Environmental Objectives and Targets 2017

AAL reviews the plant Environmental Management System on an on-going basis with the aim of updating and refining the Environmental Management Programme (EMP) to take account of progress in meeting objectives and targets.

In addition, new targets are added on the basis of achievement of existing targets and where issues have been identified as requiring a formal and structured EMP approach to drive their implementation.

New targets, which have been added for 2017 are summarised in Table 27. This list highlights only those targets added to the EMP and excludes the significant work involved in on-going programmes and projects to achieve existing targets, the detail of which is set out in the EMP for 2016.

Table 27 EMP Objectives and Targets 2017

No.	Objective	Target
1	**Conformance to Industrial Emissions Licence**	Complete soil monitoring as per Schedule C.6
		Update the Plant Closure and Aftercare Plan in light of AMEC feedback and have the costs quantified by a qualified independent consultant
2	**Design & operate the BRDA to best practice**	Implement 2017 BRDA vegetation programme
		Implement 2017 BRDA screening programme
		Update 2007 Residue Sustainability report
		Continue Wetlands study for treatment of BRDA leachate
		Review BRDA Operational & Safety manual
		Upgrade of effluent continuous monitors
3	**Quality assurance for monitoring of industrial air emissions**	Conduct 'Annual Surveillance Testing' as required under EN14181 on GTs, and D/E gas boilers
		Upgrade of gas boilers continuous oxygen analysers
4	**Continual improvement of ambient air emissions**	Installation of new continuous particulate monitor
5	**Continual improvement program for groundwater and surface water**	Implement structural integrity programme for 2017
		Installation of new stainless steel lined process drain
		Installation of flow meters on ES7 and ES12 groundwater recovery
		Upgrade of POW1 recovery system

No.	Objective	Target
		Close the process caustic balance for 2017
6	**Continual improvement of Environment Management System**	Review Register of aspects
		Achieve certification ISO14001:2015
7	**Resource Efficiencies**	Commence installation of deep cone thickener

7.3 Pollutant Release and Transfer Register (PRTR)

The Pollutant Release and Transfer Register (PRTR) has been updated to provide further data for the calendar year 2016. Based on the emissions arising from the boilers and calciners, and also emissions which currently appear on the European Pollutant Emission Register (EPER), the following substances are included in the PRTR for 2016;

- Sulphur dioxide (SO_2)
- Oxides of nitrogen (as NO_2)
- Particulate matter
- Carbon dioxide
- Carbon monoxide
- Arsenic
- Cadmium
- Chromium
- Copper
- Nickel
- Zinc
- Mercury
- Lead
- Aluminium
- Iron
- Magnesium
- Biological oxygen demand
- Fats, oils and greases
- Suspended solids

Sulphur dioxide mass emissions are based on measured 'S' concentration in HFO multiplied by HFO consumption rate.

Nitrogen dioxide, carbon monoxide and particulate mass emissions have been calculated based on results of direct stack gas measurement multiplied by calculated stack gas flow rates.

Carbon dioxide and heavy metal emissions have been calculated based on fuel consumption multiplied by the appropriate emission factor.

In line with EPA correspondence, the PRTR is now submitted to the Agency via the AER/PRTR Reporting Website. The PRTR data submitted to the EPA is also shown in **Attachment 4.**

AAL proposes to monitor and report the same parameters for the 2017 PRTR.

7.3.1 Caustic Mass Balance

The mass balance undertaken during 2016, and tabulated below in Table 28, has closed off the input-output cycle and resolved caustic consumption at the plant to -0.86kg caustic (sodium hydroxide) per tonne of alumina hydrate produced. This is likely to be due to slight margins of error in sampling and measurement of caustic concentrations of minor streams which are based on periodic grab samples.

Table 28 Caustic Mass Balance 2016

Element	Units (kg/tH)
Input	
Total Caustic Consumption	67.30
Outputs	
Caustic in Mud	57.91
Caustic in Alumina	4.60
Caustic in Alumina Hydrate Ships	0.14
Caustic in Sand to BRDA	0.46
Caustic in Saltcake to BRDA	3.07
Caustic in process scale from Tank Turnarounds shipped to BRDA	0.89
Caustic in West pond disposal to the BRDA (Storm Water Pond)	1.21
Caustic in treated (neutralized & clarified) industrial effluents to the river	0.00
Caustic recovery to process from the BRDA	-0.12
Total Output	**68.16**
Unaccounted	-0.86

8. Other Reports

This section contains additional information required under the various conditions of the IE Licence.

Generally, where documentation has already been submitted to the Agency, summarised information is provided. Full text reports are included as attachments where relevant.

Monitoring data from annual surveys (noise) together with results from ambient air quality, dust deposition and groundwater monitoring are summarised.

Updates regarding the facility Closure, Restoration and Aftercare Management Plan (CRAMP), the Environmental Liabilities Risk Assessment (ELRA) and the costings and financial provisions associated with both are provided.

The BRDA Status Report in Section 8.10 contains details of the quantities of waste deposited and development works undertaken in the BRDA during the 2016 calendar year.

8.1 Noise Monitoring Programme

AAL is required to carry out an annual noise survey in accordance with IE Licence Conditions 4.5 and 6.16. Schedule B.4 sets out the relevant noise limits at off-site noise sensitive locations (NSL) as:

- Day-time: 55 dB (A) L_{eq}
- Evening-time: 50 dB (A) L_{eq}
- Night-time: 45 dB (A) L_{eq}

A survey of noise levels at boundary and off-site noise sensitive locations was carried out in August and October 2016. At each monitoring location, day-time, evening-time and night-time measurements were made for the following measurement parameters: LA_{eq}, LA_{max}, LA_{min}, LA_{90} and LA_{10}. Monitoring was undertaken in accordance with the EPA *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)*.

The monitoring results are summarised on Table 29 and 30.

Table 29 Noise Survey Results – Noise Sensitive Locations

Location	Day-time			Evening			Night-time		
	LA_{eq}	LA_{90}	LA_{10}	LA_{eq}	LA_{90}	LA_{10}	LA_{eq}	LA_{90}	LA_{10}
NSL 1	45	41	47	48	46	49	43	40	45
NSL 2	46	35	45	47	42	48	37	31	39
NSL 3	49	42	50	49	39	50	42	29	45
NSL 4	58	35	60	36	30	38	34	29	36
NSL 5	57	36	50	57	35	55	54	30	40

Table 30 Noise Survey Results – Boundary Locations

Location	Day-time			Night-time		
	LA_{eq}	LA_{90}	LA_{10}	LA_{eq}	LA_{90}	LA_{10}
B 1	58	45	61	54	47	56
B 2	56	55	57	55	54	56
B 3	62	58	65	59	58	59
B 4	46	38	47	38	33	38
B 5	34	31	35	41	38	43
B 6	48	47	50	51	50	53
B 7	36	31	37	36	32	38
B 8	35	30	36	39	36	42
B 9	49	35	54	37	28	39

2016 Noise Survey Report Conclusions

Noise monitoring was conducted in August and October 2016 at NSLs and boundary locations associated with the Aughinish Alumina Ltd. facility as per IE Licence.

Compliance at NSLs was assessed using the LA_{90} (30 minute) parameter, to remove extraneous (non-site related) influences at these monitoring locations. This parameter best represented the potential noise emissions from AAL at NSLs.

Day-time monitoring results at NSLs were compliant with the IE Licence specified limits of LA_r (30 minute) 55dB. Evening-time monitoring results at NSLs were compliant with the IE Licence specified limits of LA_r (30 minute) 50dB. Night-time monitoring results at NSLs were compliant with the IE Licence specified limits of LA_{eq} (30 minute) 45dB.

No tones or impulsive noise was recorded during the survey periods at NSLs associated with activities at the facility.

Boundary monitoring locations were in line with both historic day and night-time monitoring results. Some variability is recorded at NSL locations however it is noted that results continue to remain in line with both historic day and night-time monitoring results.

Based upon the monitoring conducted in 2016, the Aughinish Alumina Ltd. facility is compliant with the requirements of the IE Licence for noise at NSLs.

The full noise survey report is included as ***Attachment 5***.

8.2 Groundwater Monitoring

AAL undertakes an extensive groundwater monitoring programme. Overall, 87 groundwater monitoring locations have been established with the agreement of the Agency and are routinely monitored in accordance with Schedule C.8 of the IE Licence. The current IE Licence does not specify limit values for groundwater quality.

Monitoring locations can be categorised into the following:

(i) **Estuarine Springs (ES)** are foreshore springs which discharge from the limestone bedrock at the foreshore (ES1 - 16)

(ii) **Plant Observation Wells (POW)** around the process plant (POW1 - 33); the area around the south pond (SPW1 - 6) and the north pond (NPW1 - 3) and the boreholes (BH1 - 4) in the fuel storage tank area.

(iii) **Observation Wells (OW)** around the perimeter of the Phase 1 and Phase 2 BRDA (OW1-45) installed within estuarine alluvium, glacial till and limestone bedrock.

To meet the requirement of Condition 6.15.2 of the IE Licence, an independent groundwater risk screening and technical assessment was undertaken and a report was submitted to the Agency in 2015.

8.2.1 Estuarine Springs

Estuarine springs (referred to as ES's) are locations where the water table level intersects ground level to allow groundwater to directly discharge to the surface. The ES's are therefore accepted as the main indicators of groundwater quality beneath the plant area. Sixteen individual estuarine springs (ES1 - 16) have been identified and are routinely monitored when there is flow. It is noted that ESs 4, 5, 6, 8, 14, and 15 had no flow in 2016.

Table 31 contains a summary of monitoring results for the 2016 reporting period. Reporting is as per Schedule C.6 of the IE Licence.

Table 31 Estuarine Spring Monitoring Results 2016

Emission Point Reference	pH*	Conductivity* (µS/cm)	Soda* (g/l)
ES 1**	10.5	1,548	0.5
ES 2	7.7	39800.0	4.9
ES 3	8.0	13610.0	2.6
ES 7	7.8	983.5	0.1
ES 9	7.9	15070.0	3.6
ES 10	7.8	1575.8	0.3
ES 11	8.3	3277.5	0.3
ES 12**	11.5	3360.5	1.0
ES 13	8.5	476.3	0.1
ES 16**	8.7	791.5	0.2

*Numerical average of the data for the reporting period
**Spring recovered for treatment - no direct discharge to estuary

The results show that there has been a gradual and sustained improvement in the quality of the spring discharges and that only two currently have pH >9; ES1 and ES12. There has been an improvement in pH at ES 16 down from 10.5 in 2015 to 8.7 in 2016. It should be noted that there is no direct discharge to surface water from ES1, ES12 and ES16 as these streams are intercepted and recovered to the effluent plant for treatment.

8.2.2 Plant Observation Wells (POW)

Table 32 contains a summary of plant observation well (POW) groundwater monitoring results for 2016. The table also includes data for those wells located around the north containment pond (NPW) and the south containment pond (SPW).

Monitoring results are reported to the Agency in the quarterly monitoring reports. The values reported here are the average of analytical results returned during the 2016 monitoring period.

Table 32 POW Monitoring Results 2016

POW	pH	Conductivity	Total Alk.	Cl	Fl	Soda	Al	As	Cd	Cr	Cu	Fe	Pb	Mg	Hg	Ni	SO_4	Ti	Zn
Ref.		**µS/cm**	**mg/l $CaCO_3$**	**mg/l**	**mg/l**	**g/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**mg/l**	**µg/l**	**µg/l**	**mg/l SO_4**	**µg/l**	**µg/l**
POW 1	11.7	7,265	1,022	526	0.7	2.35	23,271	41.7	0.25	0.7	3.9	650	0.17	0.38	1.3	7.7	1755	5.0	13.5
POW 2	9.8	2,002	107	160	0.2	0.53	2,388	2.7	0.09	0.7	1.5	524	0.18	4.77	0.2	1.1	588	5.0	23.7
POW 3	10.4	1,991	175	140	0.6	0.61	366	9.7	0.1	0.7	2.3	194	0.26	2.43	0.2	1.1	534	5.0	14.3
POW 5	12.4	9,775	2,843	92	4.5	4.0	37,984	157.4	0.7	0.7	6.1	14	0.17	0.1	6.3	16.3	143	5.0	19.9
POW 6	9.1	205	82	12	0.1	0.03	778	0.7	0.3	1.7	4.0	444	2.92	4.7	0.2	1.2	10	23.2	52.5
POW 7	10.2	5,344	2,872	76	3.8	2.83	1,256	38.1	0.5	6.2	64.1	647	0.36	2.4	2.981	11.6	52	5.0	11.0
POW 8	8.1	655	126	40	0.09	0.1	42	0.35	0	0.68	1.2	648	0.49	12.4	0.3355	0.4	112	5.0	7.9
POW 9	7.7	474	197	21	0.1	0.03	39	0.4	0.09	1	2.1	176	0.27	4.0	0.2	0.5	8	5.0	15.8
POW 10	7.9	406	164	24	0.1	0.04	1,372	0.6	0.5	2.13	37.5	4063	16.59	4.2	0.2	5.3	6	5.0	201.8
POW 11	12.0	5,051	2,194	43	2.3	1.38	109,195	71	0.2	0.68	3.9	25	1.17	0.2	2.0	2.6	30	5.0	45.2
POW 12	11.1	2,060	737	29	0.9	0.73	45,610	43.1	0.25	1	11.5	47	0.37	1.0	1.1	2.4	21	5.0	11.6
POW 13	10.4	1,584	682	25	0.8	0.36	38,120	38.5	0.2	0.68	5.9	64	0.62	2.0	1.0	2.9	17	5.0	9.1
POW 14	7.2	841	336	28	0.3	0.09	64	0.4	0.15	1	3.4	5755	0.77	6.3	0.2	1.3	3	5.0	14.6
POW 15	7.3	1,063	458	41	0.1	0.17	31	1.6	0.1	0.68	4.2	3090	0.88	12.3	0.2	1.2	2	5.0	15.8
POW 16	9.1	1,461	660	27	0.6	0.38	19,766	30	1.17	1	71.3	441	18.16	2.4	0.6	5.8	26	5.6	29.8
POW 17	12.2	10,475	2,813	59	5	2.36	9,502	149	1.3	1.5	9.1	7	0.17	0.3	7.6	3.5	40	5.0	66.1
POW 18	12.0	4,207	1,377	36	1.3	1.08	118,730	69	0.3	0.7	7.6	34	1.31	0.54	1.8	3.0	26	5.0	11.5
POW 19	11.9	4,169	1,302	38	1.4	0.93	102,855	80	0.3	0.7	8.8	41	1.77	0.10	2.3	5.7	34	5.0	6.3
POW 20	11.3	2,419	928	32	0.8	0.69	73,610	59.1	0.4	0.7	8.1	50	1.60	0.1305	1.8	3.1	26	5.0	10.1
POW 21	8.1	522	191	26	0.1	0.05	65	0.4	0.09	1	1.1	96	0.24	11.3	0.2	0.4	21	5.0	6.0

Alk. = Alkalinity
Cl = Chloride
Fl = Fluoride

POW	pH	Conductivity	Total Alk.	Cl	Fl	Soda	Al	As	Cd	Cr	Cu	Fe	Pb	Mg	Hg	Ni	SO_4	Ti	Zn
Ref.		**µS/cm**	**mg/l $CaCO_3$**	**mg/l**	**mg/l**	**g/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**mg/l**	**µg/l**	**µg/l**	**mg/l SO_4**	**µg/l**	**µg/l**
POW 22	8.5	250	79	18	0.1	0.03	121	0.4	0.09	0.68	1.2	273	0.29	5.0	0.2	0.4	11	5.0	15.4
POW 23	8.9	443	142	24	0.2	0.10	2,386	7.9	0.56	4.2	8.5	1039	2.03	3.1	0.20	6.2	33	5.0	54.3
POW 24	8.5	573	220	38	0.2	0.14	158	2.5	0.09	0.7	2.0	26.9	0.21	5.7	0.3	0.4	20	5.0	9.0
POW 25	8.1	594	165	31	0.1	0.09	136	0.6	0.09	1	2.4	71	0.42	3.6	0.21	0.9	17	5.0	20.4
POW 28	9.4	849	386	29	0.4	0.25	2,128	7	0.2	0.7	6.0	84	0.48	4.72	0.5	1.5	17	5.0	80.4
POW 29	10.2	1,995	905	50	1.9	0.66	40,520	33	0.4	1	1.3	237	1.34	1.3	0.9	9.9	51	5.0	147.3
POW 30	9.3	887	368	32	0.55	0.22	10,312	27	0.26	1.4	10.7	204	2.61	5.8	1.0	10.4	45	9.4	114.7
POW 31	7.8	601	227	31	0.08	0.08	186	1.2	0.11	0.9	2.8	3154	0.47	7.2	0.20	0.9	35	5.0	65.2
POW 32	8.0	594	239	31	0.06	0.1	218	1.5	0.09	0.68	3.5	1820	0.38	7.4	0.2	0.8	35	5.0	62.2
POW 33	8.0	837	280	51	0.2	0.15	44	0.6	0.1	0.7	3.5	652	0.19	12.8	0.20	0.5	108	21.8	65.9
SPW 1	8.3	894	235	25	0.7	0.3	318	56.9	0.1	0.68	3.0	206	0.76	5.8	0.3	1	308	6.3	17.6
SPW 2	9.5	421	129	17	0.3	0.10	766	4	0.1	1.2	1.8	38	0.25	1.8	0.2	0.6	33	5.0	56.1
SPW 3	7.8	486	205	18	0.1	0.04	467	0.9	0.09	0.70	1.2	12	0.23	5.7	0.200	0	14	5.0	63.3
SPW 4	8.4	323	126	16	0.1	0.54	195	0.6	0.1	0.6915	0.8	17	0.24	3.8	0.2	0.4	15	5.0	60.3
SPW 5	8.4	2,009	267	34.8	0.4	1.6	93	2.2	0.1	0.8	862.9	26.1	0.32	12.1	0.4	0.4	677	5.0	64.5
SPW 6	9.2	308	128	18	0.3	3.11	3,523	4.0	0.09	3.3	1.8	136	0.97	1.5	0.2	0.5	22	98.8	87.9
NPW 1	10.0	755	295	20	0.3	0.24	680	3.4	0.1	0.68	2.9	342	0.24	0.4	0.3	0.5	51	5.0	57.8
NPW 2	9.5	1,112	323	47	0.89	0.32	300	3.2	0.09	0.68	6.5	162	0.37	5.5	0.4	1.5	150	5.0	60.7
NPW 3	8.0	378	132	22	0.1	0.05	40	0.4	0.1	0.68	6.2	143	0.37	5.8	0.2	0.8	13	5.0	82.3

Alk. = Alkalinity
Cl = Chloride
Fl = Fluoride

*POW 4, 26 and 27 have been decommissioned

8.2.3 BRDA Observation Wells (OW)

Table 33 contains a summary of summary of BRDA Observation Well (OW) groundwater monitoring results for 2016 as per Schedule C.8 of the IE Licence. The current licence does not set out limit values for groundwater quality.

Monitoring results are reported to the Agency in the quarterly monitoring reports. The values reported here are the average of analytical results returned during the 2016 monitoring period.

In April 1997, OW's 3, 4, 5 and 6 were capped as part of an extension of the original BRDA. OW's 7, 8, 16, 17, 18, 19 and 23 were decommissioned during 2010 as part of the Phase 2 BRDA extension.

Due to the tidal nature of the surrounding environment a number of the wells are subject to saline intrusion and accordingly, the measured electrical conductivity, chloride and soda (Na_2O) values are subject to interference.

A review of the monitoring results for pH in 2016 indicate that pH is below 9 in all BRDA observation wells.

Table 33 BRDA OW Monitoring Results 2016

OW Ref.	pH	Conduct-ivity	Total Alkalinity	Chloride	Fluoride	Soda	Al	As	Cd	Cr	Cu	Fe	Pb	Mg	Hg	Ni	Sulphate	Ti	Zn
		µS/cm	mg/l $CaCO_3$	mg/l	mg/l	g/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	mg/l SO_4	µg/l	µg/l
OW 1	7.8	2227	393	119	0.4	0.6	81	2.7	0.1	0.7	3	75	2.1	19	0.2	0.6	545	5.0	366
OW 2	8.4	2621	403	199	1.0	0.9	2321	8.8	0.5	1.3	16	985	14.7	28	0.4	5.6	623	5.9	987
OW 9	7.0	18523	719	4104	0.3	4.7	448	10.9	0.1	1.2	6	4897	14.9	449	0.2	11.9	758	7.2	103
OW 10	7.1	30005	244	10414	0.3	6.3	57	1.5	0.9	0.7	2	2394	2.7	867	0.2	14.9	842	5.0	16460
OW 11	7.1	29645	1448	9956	0.1	7.3	80	4.0	0.1	3.2	1	353	1.3	822	0.2	0.7	569	25.2	104
OW 12	7.1	29650	1309	10004	0.1	8.0	68	10.4	0.1	2.5	2	1292	1.0	853	0.2	5.5	501	18.1	174
OW 13	7.6	516	231	39	0.0	0.0	61	0.4	0.1	0.7	3	299	0.5	9	0.2	1.1	9	5.0	13
OW 14	7.4	647	275	24	0.1	0.0	242	0.8	1.5	1.7	14	19220	1.9	9	0.2	9.8	8	8.4	153
OW 15	7.3	616	250	17	0.1	0.0	24	0.4	0.1	0.7	4	116	0.4	9	0.2	2.0	7	5.0	12
OW 20	7.7	3100	533	533	1.8	0.9	75	4.4	0.2	0.8	6	964	0.8	58	0.2	10.5	227	5.6	22
OW 21	7.1	24758	1567	6444	0.3	6.6	36	1.1	0.1	1.6	4	1913	0.5	626	0.2	3.1	48	18.7	12
OW 22	7.1	5218	459	1291	0.5	1.1	173	3.9	0.2	1.1	6	3572	2.9	76	0.2	7.1	189	8.2	46
OW 24	7.0	14913	694	4556	0.2	3.7	80	21.8	0.4	1.7	9	8894	1.2	358	0.2	10.5	836	7.7	31
OW 25	6.9	12800	697	3365	0.3	3.2	49	3.7	0.6	1.9	5	3290	0.7	342	0.2	9.1	800	407.0	27
OW 26	7.4	7723	678	1966	1.0	2.2	51	4.1	0.2	0.8	7	331	0.3	173	0.2	2.8	445	6.7	27
OW 27	7.1	11540	683	3387	0.2	2.8	599	65.8	0.3	2.5	7	23310	8.2	341	0.2	11.6	642	297.2	165
OW 28	7.1	17378	670	5835	0.3	4.0	112	5.6	0.2	1.6	5	3305	0.8	474	0.2	9.7	783	6.6	13
OW 29	7.2	17990	712	6345	0.1	4.1	64	10.4	0.1	1.4	7	5383	0.7	461	0.2	11.1	853	7.9	13
OW 30	7.1	3125	562	394	0.3	0.5	46	2.3	0.5	0.7	4	151	0.3	95	0.2	2.3	461	6.7	9
OW 31	7.1	15488	734	5146	0.1	4.6	227	6.4	0.6	1.3	5	4661	2.2	448	0.2	5.4	657	13.1	15

OW Ref.	pH	Conduct-ivity	Total Alkalinity	Chloride	Fluoride	Soda	Al	As	Cd	Cr	Cu	Fe	Pb	Mg	Hg	Ni	Sulphate	Ti	Zn
		µS/cm	mg/l $CaCO_3$	mg/l	mg/l	g/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	mg/l SO_4	µg/l	µg/l
OW 32	6.7	38150	585	11923	0.1	10.6	202	8.8	0.3	3.5	8	22241	2.8	1244	0.2	14.5	2363	15.6	68
OW 33	7.0	21563	645	6742	0.2	5.5	330	3.7	0.7	5.0	12	2157	1.4	770	0.2	9.1	2627	13.3	57
OW 34	7.6	889	277	82	0.1	0.1	102	0.5	0.1	0.7	4	1061	2.6	27	0.2	1.2	65	5.0	15
OW 35	7.2	10555	480	3270	0.3	2.4	277	75.4	0.5	2.3	8	41940	11.4	191	0.2	11.5	313	20.7	4485
OW 36	7.3	14128	489	4655	0.2	3.6	52	4.4	0.2	0.8	6	2464	0.6	306	0.2	5.7	473	6.9	317
OW 37	7.4	767	209	74	0.1	0.0	20	0.4	0.1	0.7	5	74	0.3	15	0.2	0.8	60	5.0	16
OW 38	7.6	662	226	31	0.1	0.0	7	0.4	0.1	0.7	4	16	0.2	8	0.2	0.7	19	3.3	6
OW 39	7.5	754	209	19	0.1	0.0	36	0.4	0.1	0.7	3	73	0.8	19	0.2	0.6	112	5.0	6
OW 40	7.5	675	224	35	0.2	0.0	83	0.4	0.1	0.7	2	130	1.8	19	0.2	1.0	40	5.0	10
OW 41	7.5	639	225	35	0.1	0.0	48	0.4	0.1	0.7	3	116	0.7	11	0.2	0.6	13	5.0	11
OW 42	7.1	809	269	24	0.0	0.0	31	0.4	0.1	0.7	3	58	0.4	8	0.2	0.6	19	5.0	11
OW 43	7.8	2460	188	618	0.1	0.4	19	0.4	0.1	0.7	3	45	0.4	42	0.2	0.6	89	5.0	19
OW 44	7.2	853	270	47	0.1	0.0	23	0.4	0.1	0.7	3	76	1.2	19	0.2	0.4	28	5.0	20
OW 45	7.4	766	263	39	0.1	0.0	524	1.5	0.2	1.5	7	780	11.6	15	0.2	2.0	35	12.5	136

8.3 Leak Detection Monitoring System

In accordance with the IE Licence conditions, AAL is required to undertake annual groundwater monitoring for hydrocarbons in four monitoring boreholes (BH1- BH4) located in the underground fuel storage area.

The fuel storage area comprise three steel underground storage tanks (UST's), two of which were used for diesel and one for petrol. The two diesel UST's were decommissioned after Agency approval in 2005.

Low levels of diesel range organic hydrocarbons (DRO) and polycyclic aromatic hydrocarbons (PAH) were detected in groundwater samples taken during 2010. This was believed to be related to historic leaks prior to the decommissioning of the UST's. AAL commenced an in situ remediation programme in late 2010 involving the application of an oxygen release compound (calcium oxyhydroxide) which biodegrades the hydrocarbons and the programme is ongoing.

The results of groundwater monitoring carried 2016 are tabulated in Table 34 below.

Table 47 Borehole Groundwater Monitoring Results 2016

Borehole Ref.	Date	DRO* (μg/l)	PAH* (μg/l)
BH 1	07/03/16	159	<0.01
BH 2	07/03/16	3,419	<0.01
BH 3	07/03/16	142	<0.01
BH 4	07/03/16	<1	<0.01

**DRO – Diesel Range Organic hydrocarbons; PAH - Polycyclic Aromatic Hydrocarbons.*

The residual DRO contamination evident in BH 2 is being remediated in situ in recent years.

8.4 Fugitive Emissions in the AAL Plant Area

AAL undertakes monitoring for fugitive dust emissions at thirty locations within the site perimeter, with two locations having been added in 2016 following a review of locations at the site, i.e. DG 34 and DG 35.

The dust deposition gauges (labelled DG 1–28, 34 and 35) measure deposited particulate material, collected over a 30-day period in accordance with TA Luft/VDI Guidelines 2119 Part 2. In total, there are 21 deposition gauges located around the BRDA to monitor dusting from the landfill area including the Phase 2 BRDA (DG 4–13, 20–28, 34 and 35). Two additional dust gauges were installed adjacent to the BRDA in 2016, i.e. dust gauge 34 and 35. The remainder are in the plant area.

Dust deposition measures the daily quantity of dust settling over a specified area (m^2) and is expressed as milligrams per square metre per day ($mg/m^2/day$).

Average results for 2016 are summarised in Table 35. Results are presented as mean annual rates for each location, together with the range of monthly data recorded throughout the year.

Table 35 Dust Deposition Rates ($mg/m^2/day$) in 2016

Deposition Gauge No.	Average Deposition Rate (mg/m2/day)	Range (Min - Max) ($mg/m^2/day$)	TA Luft Guideline Limit $mg/m^2/day$
D.G. 1	68	25 - 162	350
D.G. 2	76	33 - 119	350
D.G. 3	38	22 - 56	350
D.G. 4	43	17 - 103	350
D.G. 5	29	12 - 112	350
D.G. 6	36	7 - 113	350
D.G. 7	44	7 - 157	350
D.G. 8	17	3 - 96	350
D.G. 9	15	4 - 38	350
D.G. 10	26	2 - 170	350
D.G. 11	21	8 - 33	350
D.G. 12	23	9 - 69	350
D.G. 13	79	3 - 230	350
D.G. 14	23	3 - 64	350
D.G. 15	19	3 - 34	350
D.G. 16	20	7 - 36	350
D.G. 17	44	8 - 142	350
D.G. 18	58	10 - 110	350
D.G. 19	110	27 - 215	350
D.G. 20	17	5 - 41	350
D.G. 21	28	3 - 115	350
D.G. 22	24	5 - 65	350
D.G. 23	10	3 - 26	350
D.G. 24	12	1 - 24	350
D.G. 25	15	2 - 31	350
D.G. 26	13	6 - 23	350
D.G. 27	24	4 - 94	350
D.G. 28	10	3 - 30	350
D.G. 34	13	10 - 21	350
D.G. 35	26	7 - 67	350

8.5 Ambient Air Quality Monitoring

A programme of ambient air quality monitoring (both on-site and off-site) is carried out by AAL in accordance with Conditions 5.8 and 6.18 of the IE Licence.

The parameters monitored as part of the ambient air quality monitoring programme are:

- Sulphur Dioxide
- Deposited Dust
- Particulate Matter below 10 µm (PM_{10})
- Particulate Matter below 2.5 µm ($PM_{2.5}$)

Results from the off-site ambient air quality monitoring programme are reviewed against the Ambient Air Quality and Cleaner Air for Europe (CAFE) Directive 2008/50/EC as transposed into Irish legislation by the Air Quality Standard Regulations 2011 (SI 180/2011). On-site ambient air quality monitoring is also reviewed.

8.5.1 Ambient Air Sulphur Dioxide Monitoring

For the 2016 year, from January to August, ambient sulphur dioxide (SO_2) concentrations were monitored continuously via two SO_2 monitors located at Foynes and Ballysteen, along with passive diffusion tubes placed at 9 locations (including co-location with the continuous monitors). A submission was made to the EPA in May 2016 to reduce the scope of the monitoring, which included the removal of the continuous SO_2 monitors. The submission concluded that ambient air monitoring had demonstrated that SO_2 levels are at negligible levels and the extent of SO_2 monitoring was no longer warranted. As such, approval was sought from the EPA to reduce the monitoring requirements as follows:

- Discontinue diffuse SO_2 monitoring at 9 of the 11 monitoring locations immediately, with a continuation of diffuse monitoring at Ballysteen and Foynes.
- Discontinue continuous SO_2 monitoring at Foynes and Ballysteen.

This was approved by the EPA in July 2016.

A summary of the continuous sulphur dioxide results are shown in Table 36. The values shown are inclusive of all monitoring values recorded from 1st January 2016 to 17th August 2016. The maximum hourly and daily average values recorded at Ballysteen are not attributable to activities at AAL, primarily due to the fact that HFO is no longer the main fuel source, with the plant operating fully on natural gas. Furthermore the maximum hourly and daily average values recorded occurred on the 6th and 5th May, respectively, with no HFO boiler running at the AAL site and hence no SO_2 emissions. The Ballysteen monitoring site is approximately 7km off-site, and therefore is most likely to be impacted by sources closer to the monitoring station.

Table 36 Ambient Air SO_2 Continuous Monitoring Results (μg/m³)

Continuous SO_2 Monitors	SO_2 Monitoring Location		AQS Limits (μg/m³)	Basis of Application of Limit Value
	Foynes	Ballysteen		
Max Hourly Value (μg/m³)	63.1	468.6	**350**	Not to be exceeded more than 24 times in a calendar year
Max Daily Average (μg/m³)	8.5	240.0	**125**	Not to be exceeded more than 3 times in a calendar year
Winter Mean (μg/m³)	5.5	0.3	**20**	1st October to 31st March
# Daily Averages >50μg/m³	0.0	5.0	**50**	NAQS Lower Assessment Threshold: 40% of 24-hour limit, not to be exceeded more than 3 times in a calendar year

As agreed with the EPA in July 2016 all but two of the diffusion tube monitoring locations (locations 1 and 9) were removed from the scope of the ambient SO_2 monitoring requirements. A summary of the ambient sulphur dioxide diffusion tubes results are tabulated in Table 37, along with a description of their locations. All passive sulphur dioxide (SO_2) monitoring data was within AQS limits for 2016.

Table 37 Ambient Air SO_2 Diffusion Tubes Monthly Results (μg/m³)

Monitoring Location	Annual Mean (μg/m³)	Min Result (μg/m³)	Max Result (μg/m³)	National Air Quality Standard Lower Assessment Threshold
House (1)	1.67	0.95	4.07	<50μg/m³ (Not to be exceeded more than 3 times per year)
House (1A)	0.30	0.59	0.59	
Raw Water Intake (2)	0.00	0.00	0.00	
House (3)	0.00	0.00	0.00	
Water Works (4)	0.00	0.00	0.00	
Foynes (5)	1.23	1.57	2.13	
House (6)	0.95	1.41	1.45	
House (7)	0.67	1.01	1.01	
Aughinish (8)	0.78	0.79	1.54	
Foynes Reservoir (9)	0.65	1.29	1.29	
Foynes Reservoir (9A)	0.00	0.00	0.00	

* Locations shown on ***Attachment 6*** Ambient Air Monitoring Locations Map
**CAFE threshold shown is lower assessment threshold for SO_2 (40% of 24-hour limit value)

8.5.2 Ambient Air Particulate Deposition

Particulate deposition is normally monitored at two off-site locations as part of the ambient air quality monitoring programme. Since 2014 three additional locations have been monitored. Table 38 below shows a summary of the results for these monitoring locations during 2016. All values were within the TA Luft guideline limit of 350mg/m²/day.

Table 38 Ambient Air Mean Monthly Particulate Deposition Rates

Site No.	Dust Gauge Ref.	Deposition Rate ($mg/m^2/day$)	Range ($mg/m^2/day$)
3*	29	11	5 - 31
7	30	15	1 - 33
11	31	14	6 - 49
12**	32	15	2 - 46
13	33	19	1 - 73

8.5.3 Ambient Air $PM_{2.5}$ & PM_{10} Monitoring Ambient Air Particulate Deposition

Monitoring of particulate matter below 2.5µm ($PM_{2.5}$) and below 10µm (PM_{10}) is carried out at 5 locations (2 on-site and 3 off-site) by AAL. The monitoring is carried out using Osiris Continuous Air Sampling Monitors. Table 39 (external) and Table 40 (internal) below show a summary of the results obtained for the 2016 monitoring.

Table 39 External Ambient Air Daily $PM_{2.5}$ & PM_{10} Monitoring Results

Monitoring Location	Foynes	Ballysteen	LCC WTP	CAFE Directive Limits
$PM_{2.5}$ Annual Mean $\mu g/m^3$	4	3	2	25 $\mu g/m^3$
PM_{10} Annual Mean $\mu g/m^3$	9	7	4	40 $\mu g/m^3$

Table 40 Internal Ambient Air Daily $PM_{2.5}$ & PM_{10} Monitoring Results 2016

Monitoring Location	SW of Plant	NE of Plant
$PM_{2.5}$ Annual Mean $\mu g/m^3$	7	6
PM_{10} Annual Mean $\mu g/m^3$	36	18

With reference to Schedule 3 of Air Quality Standard Regulations 2011 regarding location of sampling points, the AQS regulations do not apply to on-site ambient air monitoring.

In summary, the results of the off-site monitoring indicate the ambient air quality at off-site monitoring points is good (as defined by EPA ambient air monitoring programme) with all parameters monitored falling within the relevant targets/limits for those parameters.

8.6 Bund, Tank and Pipeline Integrity Testing

Condition 6 of the IE Licence (Control and Monitoring) states the requirements for the protection of groundwater from spills, leaks and improper storage. Specifically, Conditions 6.10 and 6.11 deal with the inspection and testing of bunding structures, tanks, underground pipelines and open drains carrying caustic effluent.

8.6.1 Bunds and Tanks

The site has a number of integrity testing and repair programmes.

The integrity testing of all bunding structures and tanks is carried out on an on-going three-year cycle. In total, there are 372 separate items requiring integrity testing at AAL and in 2016 the integrity of 165 bunds, sumps, tanks, underground pipelines and drains was confirmed.

Over the past number of years substantial sections of the drainage network have been upgraded with a steel or stainless steel liner to minimise the risk of groundwater contamination.

8.6.2 Underground Pipelines

Structural integrity of all underground sanitary pipelines was inspected in 2016. Three sections of pipeline were identified for repair and repairs have been completed.

8.6.3 Process Drains

AAL carried out a detailed risk assessment of open process drains during 2014. The assessment identified a total of 34 sections of open drain that require integrity testing. A proposal was submitted to the Agency in October 2014 and approved by the Agency. Tests have been scheduled and will be completed over a 3-year period. In 2016, 11 process drains were tested and passed.

8.7 Decommissioning and Residuals Management Plan (DRMP)

Condition 10 of the IE Licence requires that AAL shall maintain a detailed and fully costed Decommissioning and Residuals Management Plan (DRMP), also referred to as a Closure Restoration and Aftercare Plan (CRAMP) which is adequate to assure the Agency that AAL is at all times capable of financing the environmental decommissioning and restoration of the AAL site after closure. The plan must be reviewed annually.

8.7.1 Update of DRMP/CRAMP

A total estimated cost of €27,984,656 was formally approved by the Agency in 2014. AAL have engaged independent consultants to conduct a further review of the costings. This will be completed in 2017.

8.7.2 Financial Provision

In 2016, AAL agreed a Financial Provision with the Agency.

8.8 Environmental Liabilities Risk Assessment (ELRA) Review

8.8.1 Update of ELRA

A revised ELRA was conducted by independent consultants PM Group and submitted to the EPA in February 2015. The cost, calculated in accordance with the EPA Guidance, for unknown liabilities associated with the operational and closure phases of the AAL facility was calculated at €1,191,873. This is associated with the potential for a spill or leak from a mobile tanker delivering diesel to the plant.

In January 2016, the Agency requested a revision to the ELRA to include the Special Area of Conservation adjacent to the BRDA as well as the transfer pipeline for bauxite residue to the BRDA. This was completed and submitted to the Agency in February 2017. There was no change to the cost for unknown liabilities.

8.8.2 Statement of Measures in Relation to Prevention of Environmental Damage

The measures currently undertaken by AAL in relation to the prevention of environmental damage and possible remedial actions were detailed in the revised CRAMP and ELRA submitted to the EPA.

8.9 Public Information Programme

In accordance with IE Licence Condition 2.2.2.7, AAL maintains a public awareness and information programme. Copies of quarterly monitoring reports and annual environmental reports are retained at the main Reception/Security building at AAL. This documentation can be reviewed by any member of the public at all reasonable times.

AAL held a public meeting with its neighbours on the 15th December 2016. The agenda included:

- Overview of Aughinish and the business
- Key project around the site
- Environmental performance and regulatory visits
- BRDA operation and associated landscaping updates
- A pictorial seasonal review of community events and flora and fauna in Aughinish in 2016

8.10 Annual BRDA (Landfill) Status Report

The Bauxite Residue Disposal Area (BRDA) has been classified as a Category A facility under the Extractive Waste Directive. The basis for this classification is the environmental sensitivity of the Special Area of Conservation lands and estuarine habitats adjacent to the BRDA. Operational information required under Schedule D of the IE Licence in respect of the BRDA is tabulated in Table 41 below. There are no closed areas within the BRDA and all areas are currently operational.

Table 41 BRDA Operational Status

Parameter	**Details**
Landfill name & Licence number	Aughinish Alumina Ltd. (BRDA) IE Licence Reg. P0035-06
Landfill location	Aughinish Island (National Grid Ref. 127300E, 152200N)
Reporting period	Jan 01 – Dec 31 2016
Owner and/or operator	Aughinish Alumina Ltd.
Area occupied by waste	168.5 hectares (94.5 ha Phase 1 BRDA, 74 ha Phase 2 BRDA)
Tonnage and composition of waste deposited in the preceding year	1,514,519 tonnes (See Table 42)
Methods of depositing	Pumping/Trucking
Time and duration of depositing	24 hours per day, 365 days per year
Total accumulated quantities of waste deposited	29,890,166 tonnes (Table 43)
Calculated remaining capacity	24,269,311 tonnes (Table 44)
Calculated final capacity of site	54,159,637 tonnes
Year in which final capacity of site is expected to be reached	2032
Stability checks undertaken	See Section 8.10.3 & ***Attachment 8***
Results of monitoring programme	See Section 8.10.3 & ***Attachment 8***
Summary of any monitoring non-compliances and corrective actions taken	No non-compliances in 2016
Summary of any development/remedial works carried out in the preceding year	See Section 8.10.8
Revisions to Landfill Operational Plan	See ***Attachment 7***
Progress on restoration of completed cells	In 2016 the program of amending and vegetating the wide stage 5 - 6 plateau of the North & West sides of BRDA Phase 1 continued

8.10.1 BRDA Waste Composition and Tonnage Data

Information on current and projected waste disposal rates, together with a breakdown of waste types is tabulated below.

Table 42 BRDA Waste Composition & Tonnage 2016

Waste Stream	LoW Code	Jan – Dec 2016 Total (t)	As % of total waste landfilled
Red Mud (dry)	01 03 09	1,371,301	90.54%
Sand	01 03 99	103,158	6.81%
Salt Cake (wet)	01 03 07	18,304	1.21%
Process Waste (wet)	01 03 99	15,996	1.06%
Lime Grits (wet)	01 03 99	5,620	0.37%
Fluestack Residues (dry) 2015 data	16 11 04	140	0.01%
Total Waste		**1,514,519**	**100.00%**

Table 43 Accumulated Quantities of Waste to BRDA

Waste Stream	LoW Code	1983 – Dec 2016	As % of total waste landfilled
Red Mud (dry)	01 03 09	26,585,537	88.94%
Salt Cake (wet)	01 03 07	433,571**	1.45%
Process Waste (wet) (includes sand)	01 03 99	2,715,931	9.09%
Lime Grits (wet)	01 03 99	145,808	0.49%
Fluestack Residues (dry)	16 11 04	4,939	0.02%
Effluent Sludge A34 Clarifier (dry)*	06 05 03	4,380	0.01%
Total Waste		**29,890,166**	**100%**

(Note1: The data for all residues for 1983 - 1997 other than red mud are estimated based on pro-rata tonnages for the period 1997 to 2000)

* Material no longer generated.
** It is noted that there was a summation error in the salt cake value reported in the 2015 AER. The value for 2016 is now correct.

Engineering estimates of the total occupied and remaining capacity of the BRDA have been updated to reflect recorded quantities of waste deposited at the facility during 2015 and take into account the residue deposited in both the Phase 1 BRDA and the Phase 2 BRDA commissioned since 2011 and are tabulated below.

Table 44 Estimated Capacity of BRDA

Period	MOM Note 1	Waste during period (t)	Accumulated waste (t)	Remaining capacity of BRDA (t)
1983-2000	R	9,952,703	9,952,703	9,762,404
2001	R	1,110,916	11,063,619	8,651,488
2002	R	1,111,886	12,175,505	7,539,602
2003	R	1,053,818	13,229,323	6,485,784
2004	R	1,077,940	14,307,263	5,407,844
2005	R	1,224,053	15,531,316	4,183,791
2006	R	1,270,270	16,801,586	2,913,520
2007	R	1,221,369	18,022,955	1,692,151
2008	R	1,240,695	19,263,651	451,455
2009	R	994,993	20,165,917	3,213,230 Note 2
2010	R	1,251,060	21,416,978	1,962,170
2011	R	1,341,079	22,758,056	26,909,500 Note 3
2012	R	1,302,383	24,060,439	25,607,117
2013	R	1,343,516	25,403,955	24,263,601
2014	R	1,464,224	26,868,179	27,475,746 Note 4
2015	R	1,507,468	28,375,647	25,968,278
2016	R	1,514,519	29,890,166	24,269,311 Note 5
2017	E	1,514,519	31,404,685	22,754,792

[1] MOM – Method of Measurement; R = Recorded (Measured); E = Engineering Estimate
[2] Increase in capacity of Phase 1 BRDA with increase in height to 32 meters (i.e. going from Stage 7 perimeter lift to Stage 10 perimeter lift) following issue of IPPCL P0035-04 in 2008.
[3] Phase 2 BRDA was commissioned in Aug 2011 increasing the overall capacity from 31st Dec 2011 onwards.
[4] The results of the 2014 laboratory testing as part of the 2014 BRDA Site Investigation indicated increase in consolidated dry density of the insitu accumulated residue, therefore the remaining capacity of the BRDA was increased in 2014.
[5] The remaining capacity based on topographical survey by drone in December 2016

8.10.2 BRDA Containment Capacity

Containment capacity within the BRDA is developed by rockfill embankments constructed upstream on the hardened residue inside the BRDA perimeter. These embankments are constructed in stages, each stage increasing the elevation of the BRDA by 2 metres. For the Phase 1 BRDA approximately 33% of the Phase 1 BRDA perimeter is currently at Stage 10, 47% of the BRDA perimeter is currently at Stage 9, 20% is at Stage 8. For the Phase 2 BRDA, 44% perimeter at Stage 1, 14% at Stage 2 and 7% of perimeter at Stage 3 and 35% of perimeter is retained by drainage wall on the east side currently at levels between Stage 2 and Stage 3. The current IE Licence and planning permission permits the entire existing Phase 1 and Phase 2 BRDA perimeters to be raised to Stage 10. This extends the lifetime of the BRDA to 2032 at current business plan production rates.

8.10.3 BRDA Monitoring Programme

The 2016 Report on the BRDA monitoring programme is reported in the Golder 2016 Annual (Stability) Review the executive summary of which is included as ***Attachment 8*** in compliance with Schedule C.7. Monitoring of the BRDA geotechnical instrumentation continued in 2016.

Nine movement monitoring pins were installed on the south east side of the Phase 1 BRDA in March 2016. There has been no movement of significance recorded on these pins.

Monitoring of environmental conditions at the BRDA is undertaken on a routine basis through the collection of samples of groundwater from observation wells (OW's) and surface waters for analysis. Monitoring results for the 2016 reporting period are detailed in Section 2.2.7 (Surface Waters) and 8.2.3 (Groundwater) of this AER.

There are 30 dust deposition gauges at various locations around the site with a number or gauges at the perimeter of the BRDA to determine the rates of dusting from the BRDA. Monitoring results for the 2016 reporting period have been detailed in Section 8.4 (Fugitive Emissions in the AAL Plant Area).

8.10.4 Implementation of Golder Breakout Study Recommendations

The Breakout Study and Risk Assessment for the BRDA was revised in Quarter 1 2013 and submitted to the EPA in accordance with Condition 8.4.30. This was an update of the 2006 study (referred to in Condition 8.4.16 of the IE Licence). The revised report takes account of the improved stability of the BRDA brought about by the implementation of and further advances in 'mud farming'.

The result of mud farming has been to increase the undrained shear strength of the red mud and this has been incorporated in the updated stability analyses for the red mud placed above stages 7 in Phase 1 BRDA and all the stages of Phase 2 BRDA. Mud farming has increased the stability of the side slopes significantly on the upper levels of Phase 1, thus further reducing any of failure and reducing the ability of the material to mobilise. In addition, as the facility is raised, the effective stress (self-weight) on the red mud increases which consolidates stiffens and, in turn, increases the red mud strength.

The study recommended that following procedures/actions be undertaken to alleviate the identified risks or mitigate the consequences:

- Ensure there is no excessive build-up of pore pressures in the foundation or glacial fill materials due to leakage in accordance with the design criteria as outlined in References 3.3 and 3.4;
  - Quarterly monitoring is undertaken by Golder Associates for AAL. Monitoring of the inclinometers, extensometers and piezometers combined with the 2014 Cone Penetration Tests confirm that the BRDA walls are stable at the current elevations and that the BRDA structural integrity is in accordance with the design.

- 8 No. Piezometers were installed in the estuarine soil around the downstream perimeter of the Phase 1 BRDA in Q1 2015 to measure any pore pressures in the downstream estuarine strata.

- Ensure that the undrained shear strength of the red mud forming the foundations for the upstream raise of the BRDA are monitored in accordance with the design criteria as outlined in the Phase 1 optimisation design and Phase 2 design reports (2005);
  - This is monitored and reported by Golders during CPT testing which was undertaken in 2014.
- Avoid water collecting in the Perimeter Interceptor Channel along Sector E (east side of Phase 2 BRDA) and Sector F (east side of Phase 1 BRDA) by ensuring sufficient gradient in the channel to allow water to migrate to lower sectors of the Perimeter Interceptor Channel;
  - Operational sequence for displacement and drainage of ponded water on east side of Phase 2 BRDA (Sector E) was developed during 2014.
  - A perimeter wall consisting of drainage stone was constructed along Stage 2 wall elevation of the east side of Phase 2 BRDA to facilitate drainage of water along the east perimeter of Phase 2 and was raised during 2016.
  - Pumping of surface water from the east side Phase 2 BRDA is undertaken from a sump within the Stage 2 drainage wall to prevent any water ponding along the east side of Phase 2 BRDA.
  - Drainage of east side of Phase 1 BRDA (Sector F) is totally satisfactory.
- Install and monitor the piezometers, inclinometers and settlement systems in accordance with the recommendations given in References 3.3 and 3.4;
  - Existing instruments are monitored quarterly and additional instruments were installed in Quarter 2 of 2014.
  - In addition 8 piezometers were installed in Quarter 1 of 2015 to monitor pore pressures on the estuarine layer downstream of the Phase 1 BRDA perimeter west and north sides and along the north side of the Storm Water Pond.
  - 4 inclinometers were also installed in Q1 of 2015 to monitor movement under the upper stages of Phase 1 perimeter.
  - Movement pins were monitored on the north east and south west stage lifts of the Phase 1 BRDA.
- Provide erosion protection (gabion mattresses) to the outer face of the Outer Perimeter Wall, Storm Water Pond and Liquid Waste Pond in support of the Phase 1 optimisation and Phase 2 designs;
  - Gabion mattresses were installed in 2013 up to elevation 3.5m around the majority of the north and west perimeters of the Phase 1 and Phase 2 BRDA, and this installation was completed in Quarter 1 of 2014.
- Provide a secure mechanism (valve) for isolating and locking closed the intake to the sluice gate valve;
  - A penstock valve was installed in Quarter 3 2014.
- Regularly inspect the integrity of the flood tidal defence berm.(OPW seawall);
  - The wall is inspected periodically for defects.
  - An engineering study to repair localised erosion on the OPW seawall approximately 100 metres away from the north side of the Phase 1 BRDA was commenced during Q4 of 2016 and the appropriate regulatory approval applications for these works will be submitted in 2017.

Other management measures which are already in place include:

- Visual inspection of the facilities indicates no signs of distress in the walls.
- The outer and inner perimeter walls, the storm water and liquid waste ponds are performing in accordance with the structural design.

8.10.5 Report on Annual BRDA Review

Golder Associates were commissioned by AAL to prepare an annual BRDA review report as required under Schedule C.7 of the IE Licence. The Executive Summary is included as ***Attachment 8***.

The stability assessment summarises the monitoring results from the Casagrande piezometers, the inclinometers / extensometers and visual inspection of the facilities and assesses the stability of the BRDA, the inner and outer perimeter walls forming the perimeter interceptor channel, the storm water and liquid waste ponds.

AAL have successfully raised the stack wall for Phase 1 to above Stage 8 , Stage 9 and Stage 10 in various sector around the perimeter. For Phase 2, stack walls have been raised to Stage 1, Stage 2 and Stage 3 in various sectors around the perimeter.

From the results of the monitoring of the inclinometers, extensometers and piezometers in 2016 in the Phase 1 BRDA together with the previous 2014 CPT testing, it is apparent that the stack wall of the BRDA is stable at the current elevations with a factor of safety above 2 and the facility is performing in accordance with the design.

No additional site investigation work has been undertaken on Phase 1 since there has been little rise in the structure since the 2014 CPT campaign as the majority of red mud is discharged into Phase 2. It is anticipated that additional site work will be undertaken when the majority of the structure is at Stage 10.

Continuous Penetration Testing (CPT) and instrumentation of the Phase 2 BRDA will be undertaken when the walls have been upstream raised to Stage 3 at an approximate elevation of 12m AMSL.

The outer and inner perimeter walls of the Phase 1 and Phase 2 BRDA, the storm water and liquid waste ponds are performing in accordance with the design.

Visual inspection of the facilities indicates no signs of distress in the walls.

8.10.6 Biennial Audit at the BRDA

In January 2013, AAL submitted a proposal to the Agency outlining the scope of the biennial audit and the frequency of the equivalent Safety Evaluation of Existing Dams (SEED) audit to be undertaken at the BRDA. Golder Associates undertake both the Annual Review and the Biennial Independent Audit in accordance with the scope submitted to the Agency.

8.10.7 Revisions to BRDA Operational Plan

The BRDA Operational Plan was reviewed in November 2016 to ensure that all relevant information is up to date and connected via hyperlinks to the source information in the Business Performance Improvement system and to update the plan layout of the mud farming cells and is included as ***Attachment 7***.

8.10.8 BRDA Development/Remedial Works 2016

The notable developments/works in the BRDA during 2016 were:

- The completion of the 2.25 raise of downstream walls of the salt cake cell from existing elevation 24.0 to elevation 26.25 to facilitate increased capacity of the cell.
- The raising of the drainage stone wall to between Stage 2 and Stage 3 elevation along the east side of the Phase 2 BRDA to facilitate drainage and to prevent ponding.
- The construction of Stage 1 Perimeter Raise on west side of Phase 2 BRDA and the construction of Stage 9 Perimeter Raise along the south and east sides of the Phase 1 BRDA.

There were no remedial works required in the BRDA during 2016.

8.10.9 Progress on Closure Planning and Re-vegetation of BRDA

IE Licence Condition 8.4.17 requires that AAL continues to strive to implement the recommendations in the relevant sub-sections of the Residues Solutions Report submitted to the Agency in July 2007. The subsections to be addressed are:

- Closure Planning
- Closure Re-vegetation
- Post-Closure Management
- Alternative Uses of Residue

Successful employment of the mud farming practice on the BRDA promotes carbonation of the red mud within the BRDA resulting in partial neutralisation to a stable pH of < 11.5.

The established closure demonstration trial cell is self-sustaining. ***Attachment 9*** contains details of nutrient and elemental analysis on the closure demonstration cell over a 4 year period from 2013 to 2016.

Attachment 10 contains details of the work conducted by Enrich in 2016 of the restoration works occurring at Stage 5 of the BRDA.

In 2014 AAL joined the BRAVO (Bauxite Residue and Aluminium Valorisation Operations) consortium coordinated by the University of Limerick which focuses on potential re-use of bauxite residue as a valuable raw material for other Industries. The BRAVO consortium has over 30 party members including Industry representatives, SME's and leading Universities and Institutes within Ireland and the EU. A major focus area within this research consortium is being driven by climate change and the requirement for a global reduction of carbon emissions. The cement industry produces approx. 5% of CO_2 emissions globally. Therefore, the use of geopolymers within the production of cement is now an important research area towards reducing CO_2 emissions. In this regard, the BRAVO consortium is researching the application of bauxite residue in the production process of geopolymers. On 21st and 22nd of September, AAL hosted a conference on residue re-use. It was attended by experts from all over Europe as well representatives from the IDA and EPA.

8.10.10 BRDA Constructed Wetland Project

Bauxite residue from the Bayer process contains residual caustic soda with alkaline leachate of pH > 10.5. The DRMP/CRAMP for the BRDA must address the timeframes required for leachate to reduce to ≤ pH 9.0 so it can be discharged to the receiving environment. A novel approach to ensure that BRDA leachate can be passively treated and made suitable for discharge within a short period (months) of BRDA closure is to incorporate constructed wetland(s) into the CRAMP. Constructed wetlands are gaining global acceptance by regulators in mine closure. However, little research has been conducted into the using wetlands to treat bauxite residue leachate.

In 2012, Aughinish Alumina received funding from its owner Rusal and the International Aluminium Association for a four year study programme investigating the use of a constructed wetland to treat residue leachate. Part one of this study was a two-year (2012-2014) laboratory based investigation of the potential mechanisms that buffer residue pH in wetlands. Parameters included volume and quality of diluting waters, effects of carbonation and soil quality in decreasing pH. Part two of the study is a three year field operation of a constructed wetland within the Aughinish BRDA. An automatic leachate dilution and dosing system feeds the wetland inlet at the target pH and flow-rate. Water inflow and outflow are monitored on a continual basis with soil and herbage analysed seasonally.

In 2013 AAL constructed and commenced operation of a 40 m^2 trial constructed wetlands effluent treatment area in collaboration with the University of Limerick and the International Aluminium Institute. The 40 m^2 plastic lined reed bed is located within the Aughinish BRDA and contains three types of reeds typically found in wetlands ((*Phragmites australis, Typha latifolia* and *Sparganium erectum*). An automatic leachate dilution and dosing system feeds the wetland inlet at the target pH and flow-rate. Within the wetland microbial activity generates CO_2 which carbonates the water and thereby reduces the pH. A discharge pH of < 8.0 has been achieved with efficiency highest in the warmer spring and summer months. This research demonstrates that a constructed wetland would be capable to render BRDA leachate suitable for discharge to the environment even if the pH was higher than projected in the AAL CRAMP. The project continued to be a key research topic in 2016. ***Attachment 11*** contains an overview outlining progress made to date throughout 2016.

8.10.11 BRDA Events 2016

There were zero events related to the BRDA which required notification to the Agency during 2016.

8.10.12 Implementation of Extractive Waste Management Plan

AAL is required under Condition 8.3.1 of the IE Licence to maintain an Extractive Waste Management Plan for the minimisation, treatment, recovery and disposal of extractive waste in accordance with Regulation 5 of the Waste Management (Management of Waste from Extractive Industries) Regulations, 2009. The Extractive Waste Management Plan was prepared and issued to the Agency in April 2013.

Extractive waste is treated and disposed to the on-site Bauxite Residue Disposal Area (BRDA) according to the Extractive Waste Management Plan. Waste materials suitable for internal road building within the BRDA are recovered for that purpose.

Any other wastes for disposal within the BRDA (such as process contaminated pipes) are disposed following Agency approval on a case by case basis. These arrangements are detailed in the Extractive Waste Management Plan.

8.10.13 Emergency Planning for the BRDA

In 2015, AAL consulted with representatives of Limerick City and County Council (LCCC) (Fire Service and Environment Department) regarding the External Emergency Plan for the BRDA published in September 2013 as required by Condition 9.4.5 of the IE Licence. The consultation process consisted of written and verbal communication. A successful desk top exercise of the adequacy of the plan took place on-site on the 6th March 2015 and was attended by the Principal Response Agencies (LCCC, the HSE, An Garda Siochana) and the EPA as well as all the relevant personnel from AAL. AAL are awaiting response from LCCC on the updated plan.

8.11 Progress on Bauxite Residue Neutralisation

During 2016 the process of industrial mud farming continued to be implemented in BRDA Phase 1 employing ‘thin layer’ deposition. In this manner, fresh mud is deposited in layer depths of approximately 40 cms to facilitate fast de-watering and compaction. When a mud cell has been filled during 2 -3 days of operation the fresh mud discharge is moved to a new cell. After a period of 21 - 28 days the cell which has been filled with red mud is ready to be ‘amphirolled’ to express residual water from the mud and to aid its compaction. Following 10 passes of an amphiroll over a 2 month period the mud reaches a steady state compaction level with the solids concentration increased from 58% to >70%. This is the most important and time-consuming step in mud farming. It is important to speed up this compaction to provide the maximum window for preparing the cell for sealing by grading or subsequent harrowing and the associated carbonation.

Following amphirolling, the mud cells in Phase 1 were levelled and graded using a tracked bulldozer. In all of the cells, residue carbonation to pH <11.5 was achieved by amphirolling alone. It was not necessary to deploy the tractor towed spader equipment which effectively rotovates the bauxite residue and exposes the residue particles to the atmosphere

During 2016 the Phase 2 BRDA area surface continued to be shaped with thicker layers of residue to develop the necessary gradient for thin layer deposition. This slowed down the amphirolling rate and thus industrial scale carbonation was not possible. This area will be developed during 2017 and thin layer mud deposition and carbonation will be introduced.

8.11.1 Testing Methodology to confirm Bauxite Residue Neutralisation

As per the requirements of IE Licence Condition 8.4.20, AAL has documented the test method to be utilised to confirm neutralisation of the bauxite residue by mud farming.

The mud is sampled per cell and analysed for pH until target pH of <11.5 is achieved. Three samples per cell are taken and labelled with cell number, date and location. Samples may be taken following amphirolling and if required after harrowing. Once pH < 11.5 is achieved then no further sampling is required.

The quarterly composite analysis on “farmed red mud” as per condition 8.4.20 is listed in the 4 quarterly waste reports located in ***Attachment 2*** Waste Analysis 2016.

Attachment 1
Process Effluent VOC & Toxicity Reports

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Customer	**Sean O' Sullivan**	*Lab Report Ref. No.*	**3120/544/03**
	Aughinish Alumina Ltd	*Date of Receipt*	**23/02/2016**
	Auginish Island	*Sampled On*	**22/02/2016**
	Askeaton	*Date Testing Commenced*	**23/02/2016**
	Co Limerick	*Received or Collected*	**Courier: TNT**
	Ireland	*Condition on Receipt*	**Acceptable**
Customer PO		*Date of Report*	**03/03/2016**
Customer Ref	**Effluent W1-1 21/02/16**	*Sample Type*	**Trade Effluent**
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
1,1,1,2-Tetrachloroethane (Industrial	154	GCMS	<0.66	ug/L	UKAS
1,1,1-Trichloroethane (Industrial Eff.)	154	GCMS	<0.39	ug/L	UKAS
1,1,2,2-Tetrachloroethane (Industrial	154	GCMS	<5.00	ug/L	
1,1,2-Trichloroethane (Industrial Eff.)	154	GCMS	<1.26	ug/L	UKAS
1,1-Dichloroethane (Industrial Eff.)	154	GCMS	<0.51	ug/L	UKAS
1,1-Dichloroethene (Industrial Eff.)	154	GCMS	<0.50	ug/L	UKAS
1,1-Dichloropropene (Industrial Eff.)	154	GCMS	<0.39	ug/L	UKAS
1,2,3-Trichlorobenzene (Industrial Eff	154	GCMS	<0.61	ug/L	UKAS
1,2,3-Trichloropropane (Industrial Eff.	154	GCMS	<1.31	ug/L	UKAS
1,2,4-Trichlorobenzene (Industrial Eff	154	GCMS	<0.48	ug/L	UKAS
1,2,4-Trimethylbenzene (Industrial Ef	154	GCMS	<0.64	ug/L	UKAS
1,2-Dibromo-3-chloropropane (Indust	154	GCMS	<5.00	ug/L	
1,2-Dibromoethane (Industrial Eff.)	154	GCMS	<1.04	ug/L	UKAS
1,2-Dichlorobenzene (Industrial Eff.)	154	GCMS	<0.66	ug/L	UKAS
1,2-Dichloroethane (Industrial Eff.)	154	GCMS	<0.65	ug/L	UKAS
1,2-Dichloropropane (Industrial Eff.)	154	GCMS	<0.72	ug/L	UKAS
1,3,5-Trimethylbenzene (Industrial Ef	154	GCMS	<0.59	ug/L	UKAS
1,3-Dichlorobenzene (Industrial Eff.)	154	GCMS	<0.53	ug/L	UKAS
1,3-Dichloropropane (Industrial Eff.)	154	GCMS	<0.77	ug/L	UKAS
1,4-Dichlorobenzene (Industrial Eff.)	154	GCMS	<1.16	ug/L	UKAS
2,2-Dichloropropane (Industrial Eff)	154	GCMS	<5.00	ug/L	
2-Chlorotoluene (Industrial Eff.)	154	GCMS	<0.50	ug/L	UKAS
4-Chlorotoluene (Industrial Eff.)	154	GCMS	<0.51	ug/L	UKAS
Benzene (Industrial Eff.)	154	GCMS	<0.47	ug/L	UKAS

Signed : A Harmon

Date : 03/03/2016

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2802

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Customer PO		*Date of Report*	03/03/2016
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Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Bromobenzene (Industrial Eff.)	154	GCMS	<0.60	ug/L	UKAS
Bromochloromethane (Industrial Eff.)	154	GCMS	<0.71	ug/L	UKAS
Bromodichloromethane (Industrial Eff	154	GCMS	<0.62	ug/L	UKAS
Bromoform (Industrial Eff.)	154	GCMS	<5.00	ug/L	UKAS
Bromomethane (Industrial Eff.)	154	GCMS	<5.00	ug/L	
Carbon tetrachloride (Industrial Eff.)	154	GCMS	<5.00	ug/L	UKAS
Chlorobenzene (Industrial Eff.)	154	GCMS	<0.27	ug/L	UKAS
Chloroethane (Industrial Eff.)	154	GCMS	<5.00	ug/L	
Chloroform (Industrial Eff.)	154	GCMS	2.367	ug/L	UKAS
Chloromethane (Industrial Eff.)	154	GCMS	<5.00	ug/L	
cis-1,2-Dichloroethene (Industrial Eff.	154	GCMS	<0.58	ug/L	UKAS
cis-1,3-Dichloropropene (Industrial Ef	154	GCMS	<0.85	ug/L	UKAS
Dibromochloromethane (Industrial Eff	154	GCMS	<0.43	ug/L	UKAS
Dibromomethane (Industrial Eff.)	154	GCMS	<0.88	ug/L	UKAS
Dichlorodifluoromethane (Industrial E	154	GCMS	<5.00	ug/L	
Dichloromethane (Industrial Eff.)	154	GCMS	<5.00	ug/L	
Ethylbenzene (Industrial Eff.)	154	GCMS	<0.45	ug/L	UKAS
Hexachlorobutadiene (Industrial Eff.)	154	GCMS	<0.70	ug/L	UKAS
Isopropylbenzene (Industrial Eff.)	154	GCMS	<0.36	ug/L	UKAS
m- & p-Xylene (Industrial Eff.)	154	GCMS	<0.70	ug/L	UKAS
Naphthalene (Industrial Eff.)	154	GCMS	<0.70	ug/L	UKAS
n-Butylbenzene (Industrial Eff.)	154	GCMS	<0.41	ug/L	UKAS
n-Propylbenzene (Industrial Eff.)	154	GCMS	<0.31	ug/L	UKAS
o-Xylene (Industrial Eff.)	154	GCMS	<0.48	ug/L	UKAS

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Date : 03/03/2016

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Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
p-Isopropyltoluene (Industrial Eff.)	154	GCMS	<0.67	ug/L	UKAS
sec-Butylbenzene (Industrial Eff.)	154	GCMS	<0.34	ug/L	UKAS
Styrene (Industrial Eff)	154	GCMS	<0.53	ug/L	UKAS
tert-Butylbenzene (Industrial Eff)	154	GCMS	<0.49	ug/L	UKAS
Tetrachloroethene (Industrial Eff)	154	GCMS	<0.39	ug/L	UKAS
Toluene (Industrial Eff)	154	GCMS	<0.54	ug/L	UKAS
Total Xylene (Industrial Eff)	154	GCMS	<0.70	ug/L	UKAS
trans-1,2-Dichloroethene (Industrial E	154	GCMS	<0.61	ug/L	UKAS
trans-1,3-Dichloropropene (Industrial	154	GCMS	<4.00	ug/L	UKAS
Trichloroethene (Industrial Eff)	154	GCMS	<5.00	ug/L	
Trichlorofluoromethane (Industrial Eff	154	GCMS	<5.00	ug/L	
Vinyl chloride (Industrial Eff.)	154	GCMS	<5.00	ug/L	
Volatile Organic Compounds	154	GCMS	<5	ug/L	

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	Auginish Island	***Sampled On***	**19/07/2016**
	Askeaton	***Date Testing Commenced***	**20/07/2016**
	Co Limerick	***Received or Collected***	**Courier: TNT**
	Ireland	***Condition on Receipt***	**Acceptable**
Customer PO		***Date of Report***	**08/08/2016**
Customer Ref	**Effluent Composite W1-1 18/07/16**	***Sample Type***	**Trade Effluent**
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
1,1,1,2-Tetrachloroethane (Industrial	154	GCMS	<0.66	ug/L	UKAS
1,1,1-Trichloroethane (Industrial Eff.)	154	GCMS	<0.39	ug/L	UKAS
1,1,2,2-Tetrachloroethane (Industrial	154	GCMS	<5.00	ug/L	
1,1,2-Trichloroethane (Industrial Eff.)	154	GCMS	<1.26	ug/L	UKAS
1,1-Dichloroethane (Industrial Eff.)	154	GCMS	<0.51	ug/L	UKAS
1,1-Dichloroethene (Industrial Eff.)	154	GCMS	<0.50	ug/L	UKAS
1,1-Dichloropropene (Industrial Eff.)	154	GCMS	<0.39	ug/L	UKAS
1,2,3-Trichlorobenzene (Industrial Eff	154	GCMS	<0.61	ug/L	UKAS
1,2,3-Trichloropropane (Industrial Eff.	154	GCMS	<1.31	ug/L	UKAS
1,2,4-Trichlorobenzene (Industrial Eff	154	GCMS	<0.48	ug/L	UKAS
1,2,4-Trimethylbenzene (Industrial Ef	154	GCMS	<0.64	ug/L	UKAS
1,2-Dibromo-3-chloropropane (Indust	154	GCMS	<5.00	ug/L	
1,2-Dibromoethane (Industrial Eff.)	154	GCMS	<1.04	ug/L	UKAS
1,2-Dichlorobenzene (Industrial Eff.)	154	GCMS	<0.66	ug/L	UKAS
1,2-Dichloroethane (Industrial Eff.)	154	GCMS	<0.65	ug/L	UKAS
1,2-Dichloropropane (Industrial Eff.)	154	GCMS	<0.72	ug/L	UKAS
1,3,5-Trimethylbenzene (Industrial Ef	154	GCMS	<0.59	ug/L	UKAS
1,3-Dichlorobenzene (Industrial Eff.)	154	GCMS	<0.53	ug/L	UKAS
1,3-Dichloropropane (Industrial Eff.)	154	GCMS	<0.77	ug/L	UKAS
1,4-Dichlorobenzene (Industrial Eff.)	154	GCMS	<1.16	ug/L	UKAS
2,2-Dichloropropane (Industrial Eff)	154	GCMS	<5.00	ug/L	
2-Chlorotoluene (Industrial Eff.)	154	GCMS	<0.50	ug/L	UKAS
4-Chlorotoluene (Industrial Eff.)	154	GCMS	<0.51	ug/L	UKAS
Acetone	328	GC-FID	<0.22	mg/L	

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Customer PO		*Date of Report*	**08/08/2016**
Customer Ref	**Effluent Composite W1-1 18/07/16**	*Sample Type*	**Trade Effluent**
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Acetonitrile	328	GC-FID	<0.33	mg/L	
Benzene (Industrial Eff.)	154	GCMS	<0.47	ug/L	UKAS
Bromobenzene (Industrial Eff.)	154	GCMS	<0.60	ug/L	UKAS
Bromochloromethane (Industrial Eff.)	154	GCMS	<0.71	ug/L	UKAS
Bromodichloromethane (Industrial Eff	154	GCMS	<0.62	ug/L	UKAS
Bromoform (Industrial Eff.)	154	GCMS	<5.00	ug/L	UKAS
Bromomethane (Industrial Eff.)	154	GCMS	<5.00	ug/L	
Carbon tetrachloride (Industrial Eff.)	154	GCMS	<5.00	ug/L	UKAS
Chlorobenzene (Industrial Eff.)	154	GCMS	<0.27	ug/L	UKAS
Chloroethane (Industrial Eff.)	154	GCMS	<5.00	ug/L	
Chloroform (Industrial Eff.)	154	GCMS	<0.62	ug/L	UKAS
Chloromethane (Industrial Eff.)	154	GCMS	<5.00	ug/L	
cis-1,2-Dichloroethene (Industrial Eff.	154	GCMS	<0.58	ug/L	UKAS
cis-1,3-Dichloropropene (Industrial Ef	154	GCMS	<0.85	ug/L	UKAS
Dibromochloromethane (Industrial Eff	154	GCMS	<0.43	ug/L	UKAS
Dibromomethane (Industrial Eff.)	154	GCMS	<0.88	ug/L	UKAS
Dichlorodifluoromethane (Industrial E	154	GCMS	<5.00	ug/L	
Dichloromethane (Industrial Eff.)	154	GCMS	<5.00	ug/L	
Ethanol	328	GC-FID	<0.35	mg/L	
Ethylbenzene (Industrial Eff.)	154	GCMS	<0.45	ug/L	UKAS
Hexachlorobutadiene (Industrial Eff.)	154	GCMS	<0.70	ug/L	UKAS
Isopropyl Alcohol	328	GC-FID	<0.34	mg/L	
Isopropylbenzene (Industrial Eff.)	154	GCMS	<0.36	ug/L	UKAS
m- & p-Xylene (Industrial Eff.)	154	GCMS	<0.70	ug/L	UKAS

Signed : A Harmon

Date : 08/08/2016

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Ref 3			

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Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
MEK	328	GC-FID	<0.22	mg/L	
Methanol	328	GC-FID	<0.45	mg/L	
Naphthalene (Industrial Eff.)	154	GCMS	<0.70	ug/L	UKAS
n-Butylbenzene (Industrial Eff.)	154	GCMS	<0.41	ug/L	UKAS
n-Propylbenzene (Industrial Eff.)	154	GCMS	<0.31	ug/L	UKAS
o-Xylene (Industrial Eff.)	154	GCMS	<0.48	ug/L	UKAS
p-Isopropyltoluene (Industrial Eff.)	154	GCMS	<0.67	ug/L	UKAS
sec-Butylbenzene (Industrial Eff.)	154	GCMS	<0.34	ug/L	UKAS
Styrene (Industrial Eff)	154	GCMS	<0.53	ug/L	UKAS
tert-Butylbenzene (Industrial Eff)	154	GCMS	<0.49	ug/L	UKAS
Tetrachloroethene (Industrial Eff)	154	GCMS	<0.39	ug/L	UKAS
Toluene (Industrial Eff)	154	GCMS	<0.54	ug/L	UKAS
Total Xylene (Industrial Eff)	154	GCMS	<0.70	ug/L	UKAS
trans-1,2-Dichloroethene (Industrial E	154	GCMS	<0.61	ug/L	UKAS
trans-1,3-Dichloropropene (Industrial	154	GCMS	<4.00	ug/L	UKAS
Trichloroethene (Industrial Eff)	154	GCMS	<5.00	ug/L	
Trichlorofluoromethane (Industrial Eff	154	GCMS	<5.00	ug/L	
Vinyl chloride (Industrial Eff.)	154	GCMS	<5.00	ug/L	
Volatile Organic Compounds	154	GCMS	<5	ug/L	

Signed : A Harmon

Aoife Harmon - Technical Supervisor

Date : 08/08/2016

UKAS TESTING 2802

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU (Drinking water) Regulations (SI 122 2014)
For bacterial analysis a result of 0 means none detected in volume examined
All organic results are analysed as received and all results are corrected for dry weight at 104 C
Results shall not be reproduced, except in full, without the approval of Fitz Scientific
Results contained in this report relate only to the samples tested (P) : Presumptive Results

** : The test result for this parameter may be invalid as it has exceeded the recommended holding time (BS EN ISO 5667-3:2012)

Report on the Industrial Emissions Licencing (IEL)Testing of the Aughinish W1-1B final effluent
on behalf of
Aughinish Alumina
April 2016

Report prepared by

Aquatic Services Unit,
Environmental Research Institute.
Lee Road.
Cork

Introduction

Toxicity testing was requested by for the final effluent sample at the Aughinish Alumina facility as part of their Industrial Emissions licensing requirements. The sample code for the Aughinish effluent is W1-1 and the IE License number for the effluent is P0035-06. Two aquatic species from different trophic levels were selected for the testing namely the marine copepod (*Tisbe battagliai*) and the bacteria (*Vibrio fischeri*). Testing commenced on April 20th, 2016 and finished on April 22nd, 2016.

Methodology

The W1-1B effluent sample was collected on April 19th, 2016 by Aughinish Alumina personnel and transported by courier service to the Aquatic Services Unit (ASU) laboratory. The effluent sample arrived to the ASU laboratory on April 20th, 2016 and had temperature of 9.1ºC on arrival; the sample was then immediately placed in a refrigerator at 4 ºC until required for testing.

Tisbe battagliai Bioassay

The *Tisbe* bioassay was carried out following standard methods as described in Environment Agency's Methods for the Examination of Waters and Associated Materials (Environment Agency, 2007). The effluent was tested for toxicity at the following concentrations 4.25, 8.5, 17, 34, and 68% effluent. The salinity of the effluent was adjusted to 30 parts per thousand (ppt) using hypersaline brine to make the sample suitable for testing. Twenty *Tisbe* isolates (animals 6 days old) were tested for each concentration. These animals were added into 4 replicates of five animals per test chamber for each concentration. Testing was carried out in a constant temperature room at a temperature of 20 ºC ± 2 throughout the test. A light regime of 16 hours light/8 hours dark was used throughout the testing period. The test duration was 48 hours. Filtered seawater adjusted to 30 ppt by the addition of distilled water was used as control and dilution water. An additional salt water control comprising of distilled water and hypersaline brine was also tested. A concurrent reference toxicant using zinc sulphate was conducted to assess the sensitivity of the test organisms. The *T. battagliai* were obtained from in house cultures at the ASU.

Vibrio fischeri bacteria bioassay using Microtox system.

The luminescent bacteria *Vibrio fischeri* are used exclusively in the Microtox system. Testing was carried out following the ISO 11348-3 guidelines (ISO, 2007). The concentrations of effluent tested ranged from 6.25% to 80%. Two replicates were used for each concentration tested. A concurrent reference toxicant bioassay was also carried out to determine the health and suitability of the bacteria.

Statistical Analyses

Statistical analyses to generate LC_{50} (Lethal Concentration to cause 50 percent mortality) or EC_{50} (Effective Concentration to cause 50 percent effect) data were performed using the ToxCalc v5.0.32 Environmental Toxicity Data Analysis System, (Tidepool Scientific, 2007). Microtox statistical analyses were carried out using the manufacturers software programme MicrotoxOmni.(Azur Environmental Ltd., 1995)

Results and Discussion

Tisbe battagliai Bioassay

This test was deemed to be valid given that there was greater than 90% survival in the controls indicating that the animals and testing conditions were satisfactory (Environment Agency, 2007). A LC_{50} value of 36.7 % effluent was calculated for this bioassay. This would correspond to a Toxicity Unit (TU) value of 2.7 for the effluent. Results of this bioassay are displayed in Figure 1. A concurrent reference toxicant bioassay using zinc sulphate was carried out alongside the effluent bioassay. This bioassay produced an EC_{50} of 0.391 mg/L of Zinc sulphate, this EC_{50} value is in agreement with previously published data for *Tisbe sp.* (US EPA, 2007) and with ongoing toxicity testing at the ASU. This indicates that the animals were of suitable sensitivity to be used for toxicity testing. Water quality measurements in the test chambers remained within normal limits for the duration of the bioassay. These data are presented in Appendix 2.

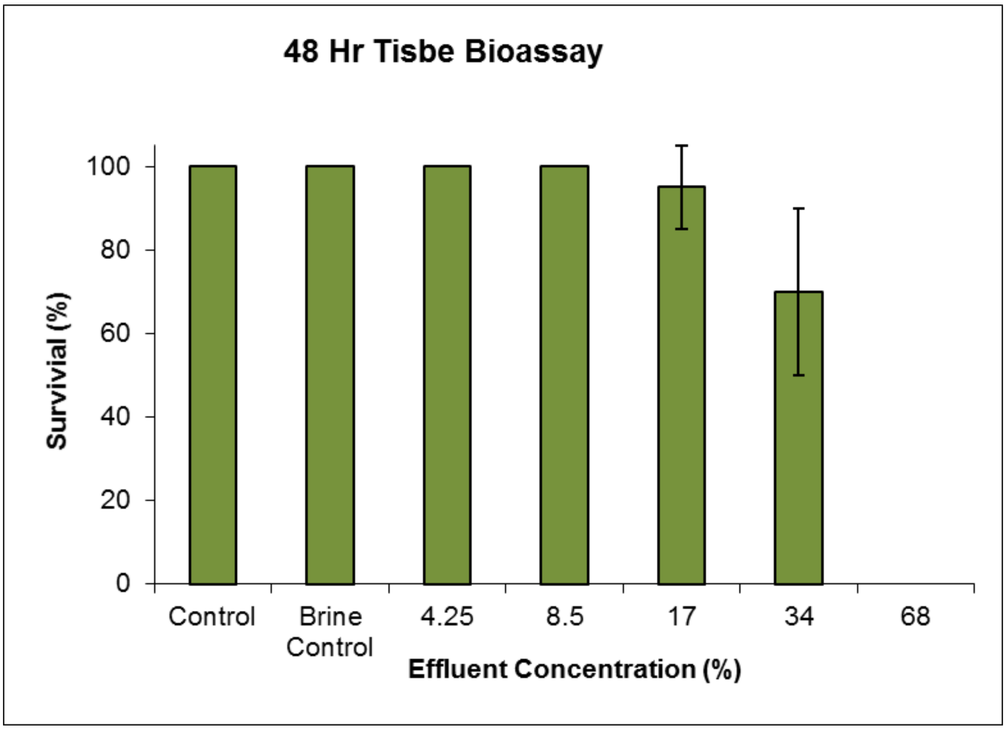

Figure 1 Average survival of *Tisbe battagliai* after 48 hours in a concentration series of the Aughinish Alumina effluent.

Microtox results.

The Microtox bioassay carried out on April 21st, 2016 was deemed to be valid. A reference toxicant test was carried out before actual testing of samples took place to ensure that the bacterium and reagents were suitable for testing. The reference toxicant using $Zinc^{++}$ ion determined an EC_{50} of 1.17 mg/L after 15 minutes exposure. This is within the guideline range of 0.6-2.2 mg $Zinc^{++}$/L as specified by the Microtox manufacturer (Azur Environmental, 1995). These data are presented in Appendix 2.

A G_L value of 12 was generated for this test. The G_L value is the dilution level at which a waste water effluent causes less than 20% inhibition to the species. Effluent samples with G_L values ranging from 1-10 are considered to have low toxicity, G_L values of 10-100 are considered to be moderate toxicity and G_L values greater than 100 are considered to have high toxicity. This G_L ranking system is based on research carried out on selected effluents (Wang et al., 2002). Exposure to the effluent only produced significant toxicity at the 50 and 80% concentrations. The Microtox test generated an EC^{50} of 70.9% effluent, this would equate to a TU value of 1.4. The data for the Microtox effluent test are presented in Figure 2.

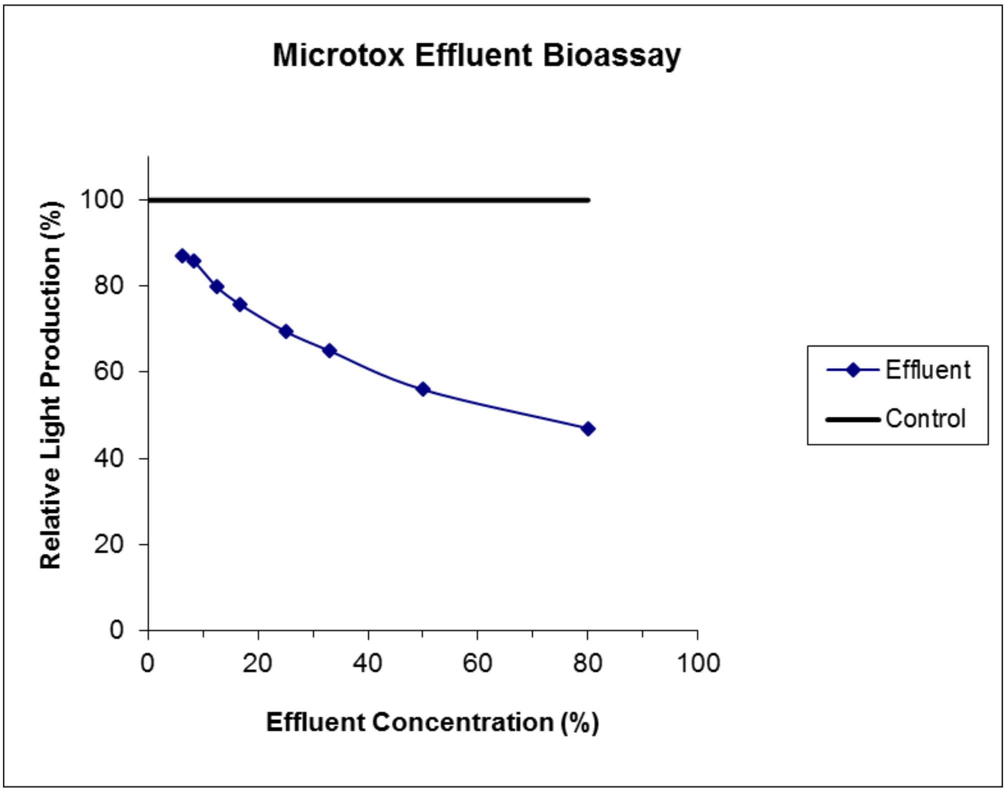

Figure 2 Plot of the Microtox results for the W1-1 effluent sample. Values represent light production relative to the controls. The highest concentration of effluent tested was 80%.

Summary and Conclusions

The marine copepod, *Tisbe battagliai*, was more sensitive to the effluent during this round of testing. The *Tisbe* bioassay produced a TU value of 2.7. In the Microtox bioassay, a dose dependent decrease in light production was observed across the concentration series. The Microtox bioassay was less sensitive to the effluent and a TU value of 1.4 was determined during this round of testing. The toxicity of effluents has been classified based on their TU values using the following scale TU<1 (relatively not acutely toxic), TU between 1 and 10 (minor acutely toxic), TU between 10 and 100 (moderately acutely toxic) and TU>100 (very acutely toxic) (Tonkes et al., 1999). Based on this scale, the results from the bioassays performed on the Aughinish Alumina W1-1 final effluent sampled on April 19th, 2016 indicate that the sample is minor acutely toxic. All of the bioassays performed in the current round of testing were deemed to be valid as they meet all of the criteria as specified in the guidelines.

References

Azur Environmental, 1995. Microtox Acute Basic Test Procedures. Azur Environmental ,. Carlsbad, California, USA.

Environment Agency, 2007. The direct toxicity assessment of aqueous environmental samples using the marine copepod *Tisbe battagliai* lethality test. Methods for the Examination of Waters and Associated Materials. http://www.environment-agency.gov.uk/nls

ISO 11348-3:2007. Water quality-Determination of the inhibitory effect of water samples on the light emission of Vibrio fischeri (Luminescent bacteria test)—Part 3: method using freeze dried bacteria. International Standards Organisation.

Tonkes, M. Graaf, P.J.F., and Jannes, G.,1999. Assessment of Complex Industrial Effluents in the Netherlands using a Whole Effluent Toxicity (or WET) Approach. Water Science and Technology, Vol. 39, No. 10-11, pp 55-61.

U.S EPA, 2007. ECOTOX User Guide: ECOTOXicology Database System. Version 4. http:/www.epa.gov/ecotox.

Wang, C., Yediler, A., Lienert, D., Wang, Z., and Kettrup, A., 2002. Toxicity evaluation of reactive dyestuffs , auxiliaries and selected effluents in the textile finishing industry to luminescent bacteria *Vibrio fischeri*. Chemosphere, 46, pp 339-344

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Appendix 1- Water Quality Measurements for *Tisbe battagliai* Bioassay

48 Hour Tisbe Bioassay
Aughinish Effluent 20/04/16

Concentration	Survival			D.O (mg/L)			pH			Salinity (ppt)			Temp (°C)		
(%)	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs
Control A	5	5	5	7.5		7.4	7.97		7.99	29		29	19.0	21.5	21.2
Control B	5	5	5												
Control C	5	5	5												
Control D	5	5	5												
Control 2A	5	5	5	7.5		7.4	7.97		7.99	29		29	19.0	21.5	21.2
Control 2B	5	5	5												
Control 2C	5	5	5												
Control 2D	5	5	5												
Brine Control A	5	5	5	7.7		7.6	7.91		7.86	29		29	19.0	21.5	21.2
Brine Control B	5	5	5												
Brine Control C	5	5	5												
Brine Control D	5	5	5												
Brine Control 2A	5	5	5	7.7		7.6	7.91		7.86	29		29	19.0	21.5	21.2
Brine Control 2B	5	5	5												
Brine Control 2C	5	5	5												
Brine Control 2D	5	5	5												
4.25 A	5	5	5	7.6		7.5	7.94		8.07	28		29	19.1	21.5	21.2
4.25 B	5	5	5												
4.25 C	5	5	5												
4.25 D	5	5	5												
8.5 A	5	5	5	7.5		7.5	7.93		8.20	29		29	19.0	21.5	21.2
8.5 B	5	5	5												
8.5 C	5	5	5												
8.5 D	5	5	5												
17 A	5	5	5	7.4		7.6	7.90		8.30	29		29	19.0	21.5	21.2
17 B	5	5	5												
17 C	5	5	5												
17 D	5	5	4												
34 A	5	5	3	7.5		7.6	7.84		7.41	29		29	19.0	21.5	21.2
34 B	5	5	3												
34 C	5	5	5												
34 D	5	5	3												
68 A	5	2	0	7.3		7.4	7.73		8.43	28		29	19.0	21.5	21.2
68 B	5	2	0												
68 C	5	1	0												
68 D	5	0	0												

Notes

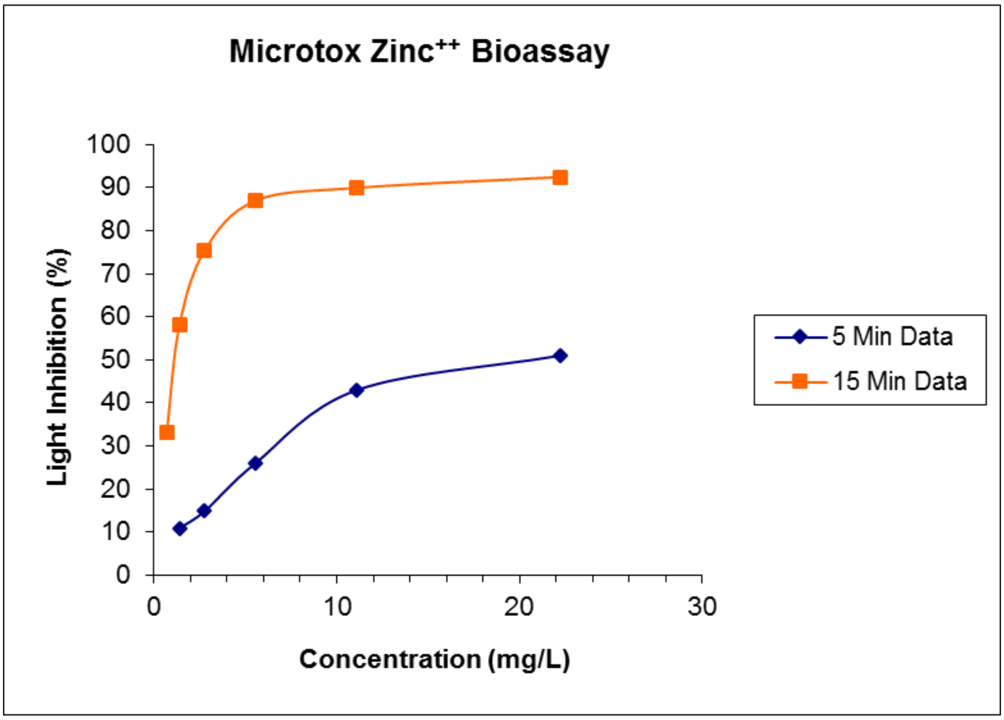
Day 0 Initiated at 14.30 , Animals 6 days old at initiation

24hrs 10.05

48hrs Terminated at 12.30

Testing performed by Aquatic Services Unit, ERI Building, Lee Rd., Cork

Appendix 2- Microtox Reference Toxicant Bioassay



Plot of light inhibition relative to the controls versus Zinc^{++} concentration after 5 and 15 minutes exposure.

The toxicity testing carried out for this report complies with internationally accepted guidelines. The results of these toxicity tests contained in this report are deemed valid under these guidelines.

Signed: ______________________________

David Gillespie MSc (Toxicology)

Report on the Industrial Emissions Licencing (IEL)Testing of the Aughinish W1-1B final effluent
on behalf of
Aughinish Alumina
September 2016

Report prepared by

Aquatic Services Unit,
Environmental Research Institute.
Lee Road.
Cork

Introduction

Toxicity testing was requested by for the final effluent sample at the Aughinish Alumina facility as part of their Industrial Emissions licensing requirements. The sample code for the Aughinish effluent is W1-1 and the IE License number for the effluent is P0035-06. Two aquatic species from different trophic levels were selected for the testing namely the marine copepod (*Tisbe battagliai*) and the bacteria (*Vibrio fischeri*). Testing commenced on September 15th, 2016 and finished on September 17th, 2016.

Methodology

The W1-1B effluent sample was collected on September 13th, 2016 by Aughinish Alumina personnel and transported by courier service to the Aquatic Services Unit (ASU) laboratory. The effluent sample arrived to the ASU laboratory on September 13th, 2016 and had temperature of 12.6 ºC on arrival; the sample was then immediately placed in a refrigerator at 4 ºC until required for testing.

Tisbe battagliai Bioassay

The *Tisbe* bioassay was carried out following standard methods as described in Environment Agency's Methods for the Examination of Waters and Associated Materials (Environment Agency, 2007). The effluent was tested for toxicity at the following concentrations 4.25, 8.5, 17, 34, and 68% effluent. The salinity of the effluent was adjusted to 30 parts per thousand (ppt) using hypersaline brine to make the sample suitable for testing. Twenty *Tisbe* isolates (animals 6 days old) were tested for each concentration. These animals were added into 4 replicates of five animals per test chamber for each concentration. Testing was carried out in a constant temperature room at a temperature of 20 ºC ± 2 throughout the test. A light regime of 16 hours light/8 hours dark was used throughout the testing period. The test duration was 48 hours. Filtered seawater adjusted to 30 ppt by the addition of distilled water was used as control and dilution water. An additional salt water control comprising of distilled water and hypersaline brine was also tested. A concurrent reference toxicant using zinc sulphate was conducted to assess the sensitivity of the test organisms. The *T. battagliai* were obtained from in house cultures at the ASU.

Vibrio fischeri bacteria bioassay using Microtox system.

The luminescent bacteria *Vibrio fischeri* are used exclusively in the Microtox system. Testing was carried out following the ISO 11348-3 guidelines (ISO, 2007). The concentrations of effluent tested ranged from 6.25% to 80%. Two replicates were used for each concentration tested. A concurrent reference toxicant bioassay was also carried out to determine the health and suitability of the bacteria.

Statistical Analyses

Statistical analyses to generate LC_{50} (Lethal Concentration to cause 50 percent mortality) or EC_{50} (Effective Concentration to cause 50 percent effect) data were performed using the ToxCalc v5.0.32 Environmental Toxicity Data Analysis System, (Tidepool Scientific, 2007). Microtox statistical analyses were carried out using the manufacturers software programme MicrotoxOmni.(Azur Environmental Ltd., 1995)

Results and Discussion

Tisbe battagliai Bioassay

This test was deemed to be valid given that there was greater than 90% survival in the controls indicating that the animals and testing conditions were satisfactory (Environment Agency, 2007). A LC_{50} value of 36.7 % effluent was calculated for this bioassay. This would correspond to a Toxicity Unit (TU) value of 2.7 for the effluent. Results of this bioassay are displayed in Figure 1. A concurrent reference toxicant bioassay using zinc sulphate was carried out alongside the effluent bioassay. This bioassay produced an EC_{50} of 0.45 mg/L of Zinc sulphate, this EC_{50} value is in agreement with previously published data for *Tisbe sp.* (US EPA, 2007) and with ongoing toxicity testing at the ASU. This indicates that the animals were of suitable sensitivity to be used for toxicity testing. Water quality measurements in the test chambers remained within normal limits for the duration of the bioassay. These data are presented in Appendix 2.

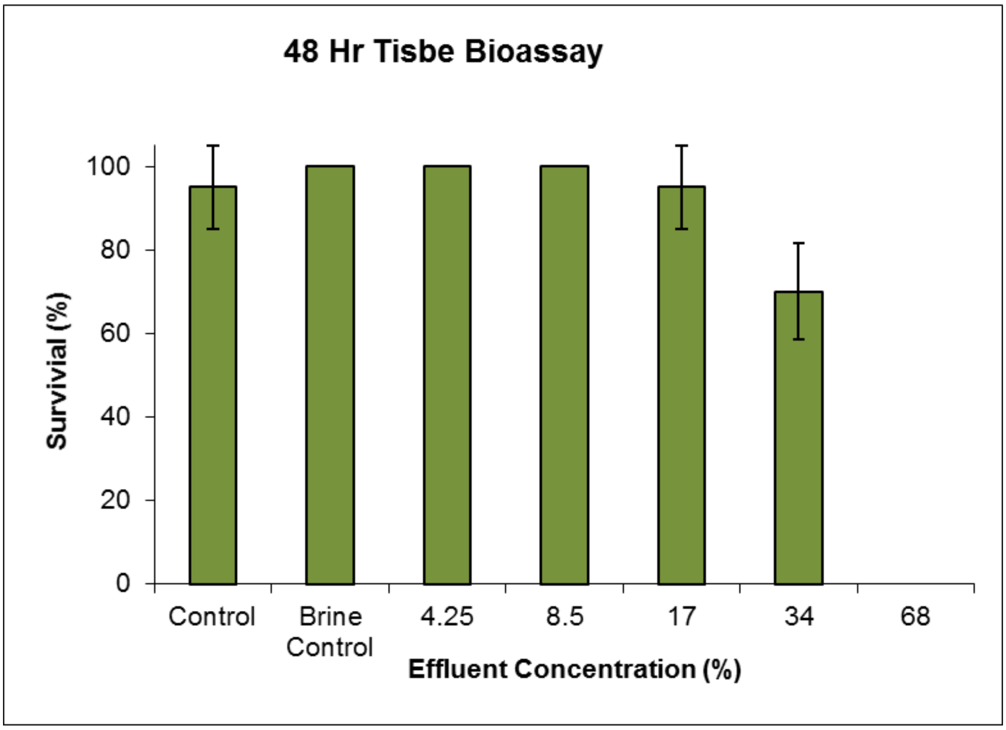


Figure 1 Average survival of *Tisbe battagliai* after 48 hours in a concentration series of the Aughinish Alumina effluent.

Microtox results.

The Microtox bioassay carried out on September 15th, 2016 was deemed to be valid. A reference toxicant test was carried out before actual testing of samples took place to ensure that the bacterium and reagents were suitable for testing. The reference toxicant using $Zinc^{++}$ ion determined an EC_{50} of 1.6 mg/L after 15 minutes exposure. This is within the guideline range of 0.6-2.2 mg $Zinc^{++}$/L as specified by the Microtox manufacturer (Azur Environmental, 1995). These data are presented in Appendix 2.

A G_L value of 3 was generated for this test. The G_L value is the dilution level at which a waste water effluent causes less than 20% inhibition to the species. Effluent samples with G_L values ranging from 1-10 are considered to have low toxicity, G_L values of 10-100 are considered to be moderate toxicity and G_L values greater than 100 are considered to have high toxicity. This G_L ranking system is based on research carried out on selected effluents (Wang et al., 2002). Exposure to the effluent only produced significant toxicity at the 50 and 80% concentrations. The Microtox test generated an EC^{50} of greater than 100% effluent, this would equate to a TU value of less than 1. The data for the Microtox effluent test are presented in Figure 2.

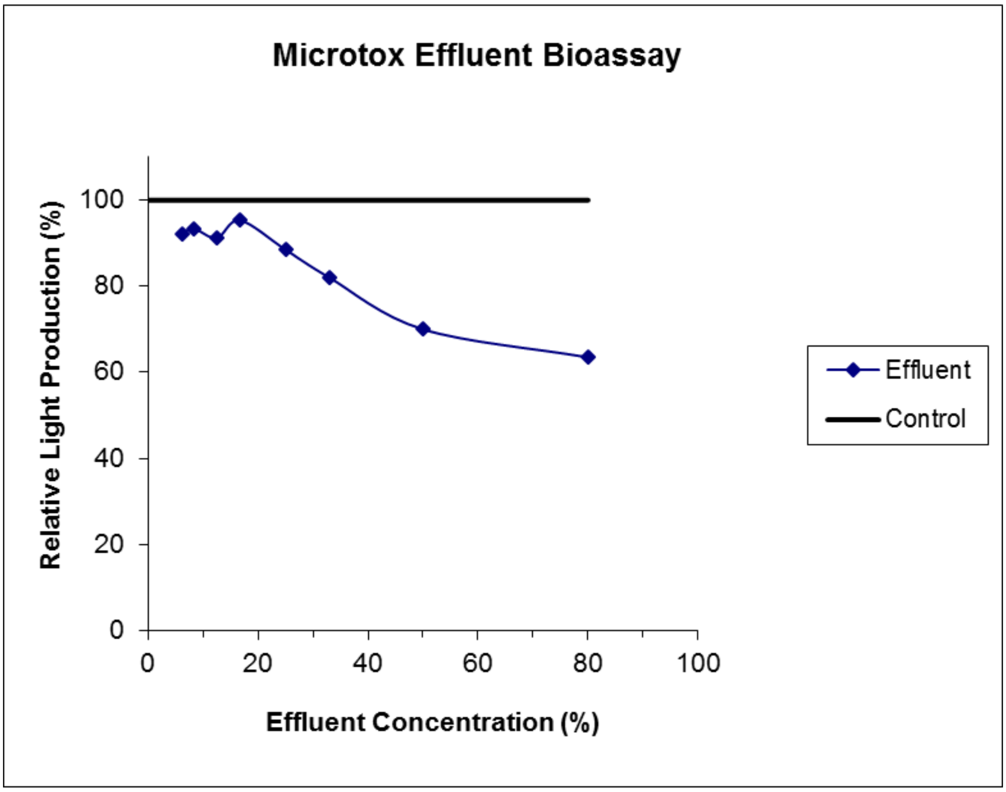


Figure 2 Plot of the Microtox results for the W1-1 effluent sample. Values represent light production relative to the controls. The highest concentration of effluent tested was 80%.

Summary and Conclusions

The marine copepod, *Tisbe battagliai*, was more sensitive to the effluent during this round of testing. The *Tisbe* bioassay produced a TU value of 2.7. The Microtox bioassay was less sensitive to the effluent and a TU value of less than 1 was determined during this round of testing. The toxicity of effluents has been classified based on their TU values using the following scale TU<1 (relatively not acutely toxic), TU between 1 and 10 (minor acutely toxic), TU between 10 and 100 (moderately acutely toxic) and TU>100 (very acutely toxic) (Tonkes et al., 1999). Based on this scale, the results from the bioassays performed on the Aughinish Alumina W1-1 final effluent sampled on September 13th, 2016 indicate that the sample is minor acutely toxic. All of the bioassays performed in the current round of testing were deemed to be valid as they meet all of the criteria as specified in the guidelines.

References

Azur Environmental, 1995. Microtox Acute Basic Test Procedures. Azur Environmental ,. Carlsbad, California, USA.

Environment Agency, 2007. The direct toxicity assessment of aqueous environmental samples using the marine copepod *Tisbe battagliai* lethality test. Methods for the Examination of Waters and Associated Materials. http://www.environment-agency.gov.uk/nls

ISO 11348-3:2007. Water quality-Determination of the inhibitory effect of water samples on the light emission of Vibrio fischeri (Luminescent bacteria test)—Part 3: method using freeze dried bacteria. International Standards Organisation.

Tonkes, M. Graaf, P.J.F., and Jannes, G.,1999. Assessment of Complex Industrial Effluents in the Netherlands using a Whole Effluent Toxicity (or WET) Approach. Water Science and Technology, Vol. 39, No. 10-11, pp 55-61.

U.S EPA, 2007. ECOTOX User Guide: ECOTOXicology Database System. Version 4. http:/www.epa.gov/ecotox.

Wang, C., Yediler, A., Lienert, D., Wang, Z., and Kettrup, A., 2002. Toxicity evaluation of reactive dyestuffs , auxiliaries and selected effluents in the textile finishing industry to luminescent bacteria *Vibrio fischeri*. Chemosphere, 46, pp 339-344

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Appendix 1- Water Quality Measurements for *Tisbe battagliai* Bioassay

48 Hour Tisbe Bioassay
Augh W1-1 Effluent 15/09/16

Concentration (%)	Survival			D.O (mg/L)			pH			Salinity (ppt)			Temp (°C)		
	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs
Control A	5	5	5	7.5		7.9	7.91		7.76	30		30	19.7	21.2	21.2
Control B	5	5	5												
Control C	5	5	5												
Control D	5	5	5												
Control 2A	5	5	5	7.5		7.9	7.91		7.76	30		30	19.9	21.2	21.2
Control 2B	5	5	5												
Control 2C	5	5	5												
Control 2D	5	4	4												
Brine Control A	5	5	5	7.3		7.4	8.22		8.12	29		30	20.1	21.2	21.2
Brine Control B	5	5	5												
Brine Control C	5	5	5												
Brine Control D	5	5	5												
Brine Control 2A	5	5	5	7.3		7.4	8.22		8.12	29		30	20.1	21.2	21.2
Brine Control 2B	5	5	5												
Brine Control 2C	5	5	5												
Brine Control 2D	5	5	5												
4.25 A	5	5	5	7.5		7.3	8.14		8.12	30		30	20.2	21.2	21.2
4.25 B	5	5	5												
4.25 C	5	5	5												
4.25 D	5	5	5												
8.5 A	5	5	5	7.5		7.6	8.09		8.22	30		30	20.2	21.2	21.2
8.5 B	5	5	5												
8.5 C	5	5	5												
8.5 D	5	5	5												
17 A	5	5	5	7.6		7.7	8.05		8.32	30		30	20.1	21.2	21.2
17 B	5	5	5												
17 C	5	5	5												
17 D	5	5	4												
34 A	5	5	3	7.4		7.7	8.00		8.42	30		30	20.2	21.2	21.2
34 B	5	5	3												
34 C	5	5	4												
34 D	5	5	4												
68 A	5	2	0	7.2		7.6	7.92		8.47	29		30	20.3	21.2	21.2
68 B	5	1	0												
68 C	5	2	0												
68 D	5	0	0												

Notes

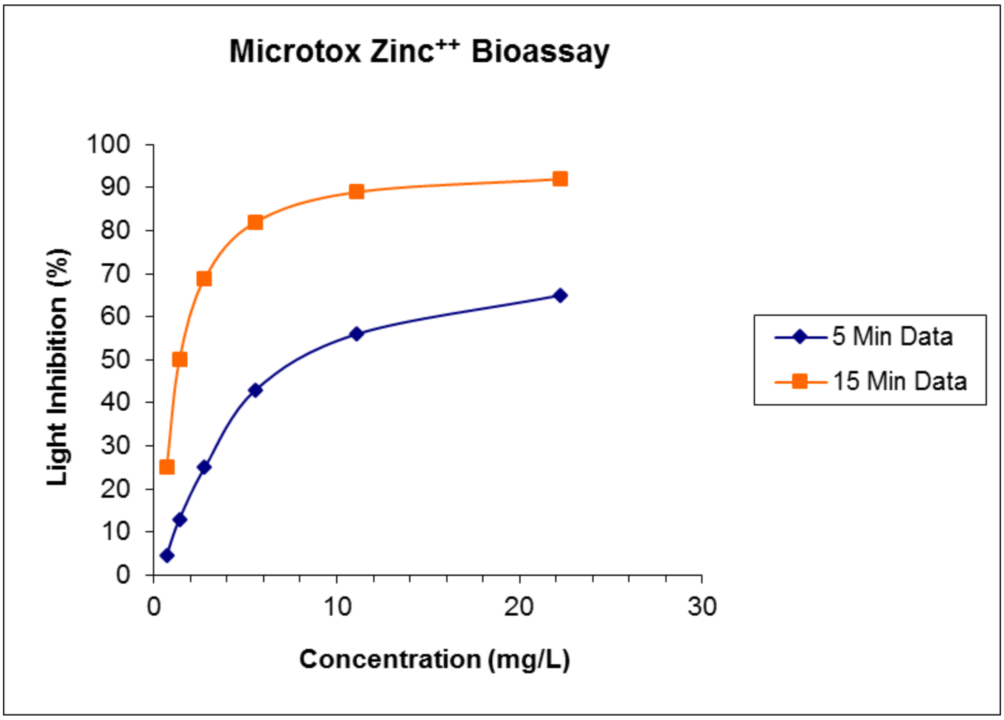
Day 0 Initiated at 16.00 , Animals 6 days old at initiation

24hrs 12.30

48hrs Terminated at 16.30

Testing performed by Aquatic Services Unit, ERI Building, Lee Rd., Cork

Appendix 2- Microtox Reference Toxicant Bioassay



Plot of light inhibition relative to the controls versus $Zinc^{++}$ concentration after 5 and 15 minutes exposure.

The toxicity testing carried out for this report complies with internationally accepted guidelines. The results of these toxicity tests contained in this report are deemed valid under these guidelines.

Signed: ______________________________

David Gillespie MSc (Toxicology)

Attachment 2
Waste Analysis

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Waste Monitoring Results
Quarterly Report

Quarter 1 2016

Emission Point Reference	Description	Date	IEL	pH	Dry matter	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
			Limits		%	mg/Kg	mg/Kg	mg/Kg	mg/Kg $CaCO_3$	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
C.4 Waste Monitoring	**Red Mud****	Jan	N/A	10.3	74	7	21	857	1612	41539	0.525	<0.01	322	3.75075	14895	8.00954	48.78	0.0374	1.52353	1262	2.45943
	Sand	Jan	N/A	12.2	82	76	34	4957	10245	15581	1.96653	<0.01	234.5	3.214	4999	13.195	68.71	0.0329	3.149	282	11.737
	Salt Cake	Jan	N/A	13.1	56	4639	1777	217969	447670	51976	86.40	0.02361	0.28166	1.19	26.26	<0.01	8.37	2.105	1.443	1.437	2.458
				pH	**--**	**Chloride**	**Fluoride**	**Soda**	**Total Alkalinity**	**Al***	**As***	**Cd***	**Cr***	**Cu***	**Fe***	**Pb***	**Mg***	**Hg***	**Ni***	**Ti***	**Zn***
						mg/l	mg/l	mg/l	mg/l $CaCO_3$	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Red Mud stack Leachate	Mar	N/A	12.1	--	112	28	2670	1244	3.4	142.7	3.98	25.23	48.45	7.293	<0.173	<0.104	18.4	5.46	10.41	<0.86
				pH	**Dry matter**	**Organic matter**	**N**	**P**	**--**	**Al***	**As***	**Cd***	**Cr***	**Cu***	**Fe***	**Pb***	**Mg***	**Hg***	**Ni***	**Ti***	**Zn***
					%	%	mg/l	mg/l		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Sanitary Sludge	March	N/A	7.1	0.45	99.9	284.2	15.4	--	37720	8.278	4.733	76.75	5060	33340	43.99	20.29	4.853	87.41	128.4	3205

***Metal analysis & Sanitary Sludge analysis : Fitz Scientific**
**** Farmed red mud**

Waste Monitoring Results
Quarterly Report

Quarter 2 2016

Emission Point Reference	Description	Date	IEL	pH	Dry matter	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
			Limits		%	mg/Kg	mg/Kg	mg/Kg	mg/Kg $CaCO_3$	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
C.4 Waste Monitoring	Red Mud**	May	N/A	10.7	75	91	38.00	4199	5276	37917	0.822	<0.01	2652	3.79528	15460	7.8665	55.28	0.0002	1.14516	6655	2.83572
	Sand	May	N/A	12.2	81	74	3	4920	10013	23182	4.96685	<0.01	343.4	7.309	131767	17.330	47.22	0.0009	2.328	2414	19.248
	Salt Cake	May	N/A	13.0	59	4335	526.00	207950	458895	65000	23.31	<0.01	<0.01	1.17	28.38	<0.01	10.47	1.111	0.709	4.47797	2.495
				pH	--	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
						mg/l	mg/l	mg/l	mg/l $CaCO_3$	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Red Mud stack Leachate	May	N/A	11.7		219	33.46	6140	8833	256.9	653.4	4.304	29.82	54.91	1738	<0.173	0.5228	32.34	9.2230	206.1	4.432
				pH	Dry matter	Organic matter	N	P	--	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
					%	%	mg/l	mg/l		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Sanitary Sludge	May	N/A	7.4	<0.1	100.0	337.1	49.2		26010	9.412	4.214	75.75	3827	31290	47.41	27.29	5.982	73.53	243.5	2378

***Metal analysis & Sanitary Sludge analysis : Fitz Scientific**
**** Farmed red mud**

Waste Monitoring Results
Quarterly Report

Quarter 3 2016

Emission Point Reference	Description	Date	IEL	pH	Dry matter	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
			Limits		%	mg/Kg	mg/Kg	mg/Kg	mg/Kg $CaCO_3$	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
C.4 Waste Monitoring	**Red Mud****	May	N/A	11.25	76	92	94.90	4144	6459	35845	0.657	<0.01	239	3.7189	12066	7.22815	61.65	<0.0025	1.40228	1637	3.50985
	Sand	May	N/A	12.0	83	22	31	2974	5623	21651	5.24929	<0.01	410.6	6.921	114617	19.863	67.85	<0.0025	2.737	921	23.573
	Salt Cake	May	N/A	13.1	89	4893	429.20	219157	423261	46741	27.42	<0.01	<0.01	0.91	19.61	<0.01	11.32	<0.0025	0.747	0.797326	2.363
				pH	**--**	**Chloride**	**Fluoride**	**Soda**	**Total Alkalinity**	**Al***	**As***	**Cd***	**Cr***	**Cu***	**Fe***	**Pb***	**Mg***	**Hg***	**Ni***	**Ti***	**Zn***
						mg/l	**mg/l**	**mg/l**	**mg/l $CaCO_3$**	**mg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**mg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**
	Red Mud stack Leachate	May	N/A	11.4		136	25.80	6360	6461	55.2	0.156117	<0.01	<0.01	0.04537	0.175486	<0.01	0.00038	0.0025	<0.01	0.02038	0.0128
				pH	**Dry matter**	**Organic matter**	**N**	**P**	**--**	**Al***	**As***	**Cd***	**Cr***	**Cu***	**Fe***	**Pb***	**Mg***	**Hg***	**Ni***	**Ti***	**Zn***
					%	**%**	**mg/l**	**mg/l**		**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**mg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**
	Sanitary Sludge	May	N/A	7.1	0.51	99.9	28.6	46.5		11378.4	<10	<10	22.83	1808.47	13909	32.04	9.07	1.73	36.65	117.187	1424.18

***Metal analysis & Sanitary Sludge analysis : Fitz Scientific**
**** Farmed red mud**

Quarter 4 2016

Emission Point Reference	Description	Date	IEL	pH	Dry matter	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
			Limits		%	mg/Kg	mg/Kg	mg/Kg	mg/Kg $CaCO_3$	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
C.4 Waste Monitoring	Red Mud**	Nov	N/A	10.93	75	71	81.30	3754	5403	24583	0.935	<0.01	223	3.521	8853	7.648	0.05938	0.0737	1.1815	1219	4.24
	Sand	Nov	N/A	12.1	83	42	43	3820	8709	9537	1.193.3	<0.01	113.6	1.924	27998	9.555	0.08275	0.0738	0.942	811	7.813
	Salt Cake	Nov	N/A	13.1	56	4794	2659.00	208382	28520	39204	345.66	<0.01	0.199936	1.00	13.98	<0.01	0.00959	0.341	0.57536	0.55634	3.807
				pH	--	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
						mg/l	mg/l	mg/l	mg/l $CaCO_3$	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Red Mud stack Leachate	Nov	N/A	11.7		154	38.30	6870	1173	6.1	51.08	2.250	4.774	44.35	1.014	<0.173	<0.104	8.193	6.455	93.42	3.362
				pH	Dry matter	Organic matter	N	P	--	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
					%	%	mg/l	mg/l		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Sanitary Sludge	Nov	N/A	7.1	0.51	99.9	192.0	4.2		65733.7	<10	<10	590.92	4144.84	14000	<10	25.6	1.11	<10	117.984	4909.43

***Metal analysis & Sanitary Sludge analysis : Fitz Scientific**
**** Farmed red mud**

Attachment 3
Energy Efficiency Report

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ENERGY EFFICIENCY REPORT 2016

RUSAL AUGHINISH

1. Table of Contents

1. Background

This report summarises the 2016 energy performance for inclusion in the Annual Environmental Report for RUSAL Aughinish. Reports for earlier years were included in previous Environmental Reports.

2. Energy Management System

We successfully achieved ISO 50001 certification and a subsequent surveillance audit in September was successfully completed.

In addition, the plant again qualified as a high quality CHP site under the UK CHPQA self-assessment scheme. The plant is also certified as high efficiency CHP through the commission for Energy Regulation's scheme.

3. Steam Efficiency

Steam efficiency is reported as the energy in the total steam produced by the plant divided by the hydrate production; GJ/t. The chart below shows steam efficiency data for each year since 2013. A significant improvement has been seen with 2016 the best ever performance at 5.62GJ/t (previous best was 5.71GJ/t in 2015).

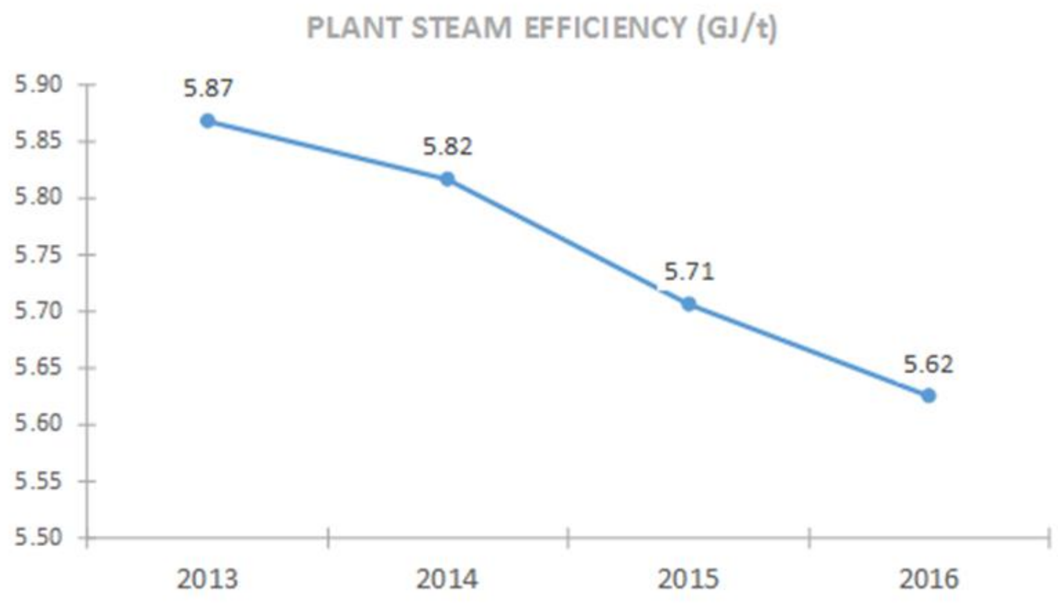

Figure 1 Steam efficiency since 2013 to 2016; best ever performance 2016 @ 5.62GJ/t

The monthly performance for 2016 is shown in the chart below. The monthly target varied in line with expected equipment outages.

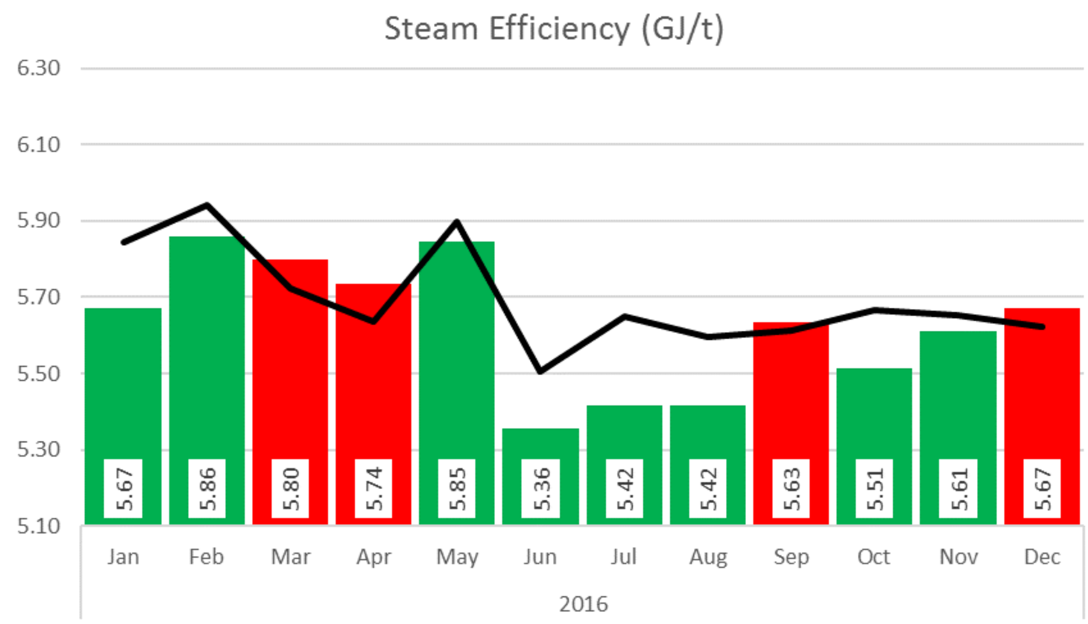

Figure 2 Steam Efficiency month performance 2016

The performance up until June was impacted by higher ambient heat losses as well as planned flash tank outages.

The digestion temperature was reduced to 248degC, a reduction of about 4degC from 2015, the steam saving associated with this reduction is about 10t/h (0.14GJ/t).

Digestion area heaters 7B, 8B, 8C and 9D were successfully manually descaled and heaters 8A, 8D and 9C were retubed.

In vacuum flash, the B chain heaters were successfully manually descaled.

4. Power Efficiency

The chart below shows the power efficiency performance for each year since 2013. The 2016 result was 0.707 showed no significant change from the 2015 result of 0.706.

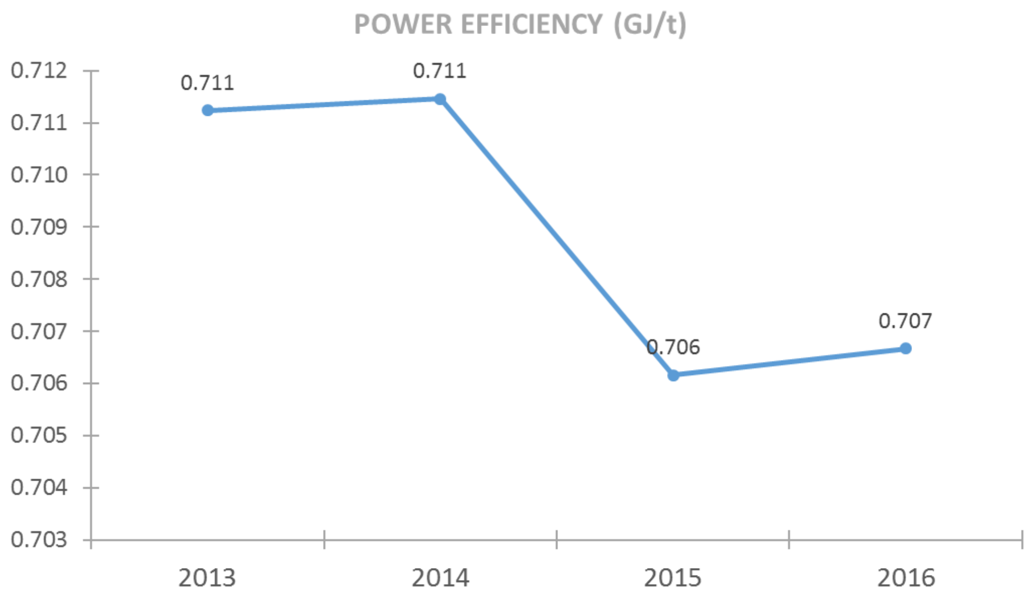

Figure 3 Power Efficiency since 2013

5. Calcination

In January of 2016, Corrib gas came online, which has a lower energy content than pre-Corrib gas. This change would have reduced the efficiency of the calculation process due to an increase in the percentage excess air. To offset this, the air to fuel ratio was reduced from approximately 12.5 to 11.8 for all 3 calciners. The overall efficiency performance for 2016 was in line with 2015.

6. Energy Programme for 2017

The main projects affecting heat recovery are:

- Manually descale poorly performing digestion heaters
- Re-tube 9B, 7B, 7D
- Manually descale the B chain in the vacuum flash area
- Replace a number of power meters in mud separation area

Attachment 4
PRTR Workbook

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Guidance to completing the PRTR workbook

PRTR Returns Workbook

Version 1.1.19

REFERENCE YEAR	2016

1. FACILITY IDENTIFICATION

Parent Company Name	Aughinish Alumina Limited
Facility Name	Aughinish Alumina Limited
PRTR Identification Number	P0035
Licence Number	P0035-06

Classes of Activity

No.	**class_name**
-	Refer to PRTR class activities below

Address 1	Aughinish East, Aughinish West,
Address 2	Island Mac Teige, Glenbane West , and Fawnamore
Address 3	Askeaton
Address 4	
	Limerick
Country	Ireland
Coordinates of Location	-9.05928 52.6243
River Basin District	IEGBNISH
NACE Code	2442
Main Economic Activity	Aluminium production
AER Returns Contact Name	Louise Clune
AER Returns Contact Email Address	Louise.Clune@augh.com
AER Returns Contact Position	Environmental Co-ordinator
AER Returns Contact Telephone Number	061 604243
AER Returns Contact Mobile Phone Number	
AER Returns Contact Fax Number	
Production Volume	1975076.0
Production Volume Units	tonnes
Number of Installations	1
Number of Operating Hours in Year	8760
Number of Employees	450
User Feedback/Comments	Releases to air: Emissions from point 1 reduced by more than 50% from previous year due to significant reduction in use of HFO fuel as facility relies on natural gas as primary fuel source. Points 5-9 variances due to limited monitoring data (biannual only). Note:other releases to air were not +/-50% variance on previous years data but comment showed up when entering data for most other values. CO data included as now a monitored licence parameter. Emissions to water: Metals variances (higher and lower than 50%) due to limited monitoring data (bi-annual). BOD >50% variance on 2015 due to limited biannual sampling data.
Web Address	

2. PRTR CLASS ACTIVITIES

Activity Number	**Activity Name**
4(b)	Gases, such as ammonia, chlorine or hydrogen chloride,fluorine or hydrogen fluoride, carbon oxides, sulphur compounds,nitrogen oxides, hydrogen, sulphur dioxide, carbonyl chloride,Acids, such as chromic acid, hydrofluoric acid, phosphoric acid, nitric acid, hydrochloric acid, sulphuric acid, oleum, sulphurous acids,Bases, such as ammonium hydroxide, potassium hydroxide, sodium hydroxide,Salts, such as ammonium chloride, potassium chlorate, potassium carbonate, sodium carbonate, perborate...
5(a)	Installations for the recovery or disposal of hazardous waste
5(d)	Landfills
50.1	General

3. SOLVENTS REGULATIONS (S.I. No. 543 of 2002)

Is it applicable?	No
Have you been granted an exemption ?	
If applicable which activity class applies (as per Schedule 2 of the regulations) ?	
Is the reduction scheme compliance route being used ?	

4. WASTE IMPORTED/ACCEPTED ONTO SITE

Guidance on waste imported/accepted onto site

Do you import/accept waste onto your site for on-site treatment (either recovery or disposal activities) ?	No

This question is only applicable if you are an IPPC or Quarry site

SECTION A : SECTOR SPECIFIC PRTR POLLUTANTS

RELEASES TO AIR					Please enter all quantities in this section in KGs											
POLLUTANT		METHOD												QUANTITY		
			Method Used		HFO Boiler House (Emm point ref A1)	Calciner Stack (Emm point ref A2)	Gas Turbines (Emm point ref A3-A, A3-B)	Gas Boilers (Emm ref point A4-A, A4-B)	Bauxite Crusher Scrubber Exhaust fan (6)	Alumina Loader Dust fan FA49A (12)	Alumina Silo 1 Exhaust Fan FA12A017 (16)	Alumina Silo 2 Exhaust Fan FA12A018 (17)	Alumina Silo 3 Exhaust Fan & Silo 1/2 Exhaust fan (18&19)			
No. Annex II	Name	M/C/E	Method Code	Designation or Description	Emission Point 1	Emission Point 2	Emission Point 3	Emission Point 4	Emission Point 5	Emission Point 6	Emission Point 7	Emission Point 8	Emission Point 9	T (Total) KG/Year	A (Accidental) KG/Year	F (Fugitive) KG/Year
08	**Nitrogen oxides (NOx/NO2)**	C	OTH	Calculation based on flow rates and direct measurement of stack emission concentrations	3980.0	528245.0	391570.0	89910.0	0.0	0.0	0.0	0.0	0.0	1013705.0	0.0	0.0
11	Sulphur oxides (SOx/SO2)	C	OTH	Calculation based on fuel	10792.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10792.0	0.0	0.0
17	Arsenic and compounds (as As)	C	OTH	Calculation based on fuel consumption and emission factor previously submitted to EPA	0.000102	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000102	0.0	0.0
18	Cadmium and compounds (as Cd)	C	OTH	Calculation based on fuel consumption and emission factor previously submitted to EPA	0.000111	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000111	0.0	0.0
19	Chromium and compounds (as Cr)	C	OTH	Calculation based on fuel consumption and emission factor previously submitted to EPA	0.000136	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000136	0.0	0.0
20	Copper and compounds (as Cu)	C	OTH	Calculation based on fuel consumption and emission factor previously submitted to EPA	0.000136	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000136	0.0	0.0
21	Mercury and compounds (as Hg)	C	OTH	Calculation based on fuel consumption and emission factor previously submitted to EPA	0.000017	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000017	0.0	0.0
22	Nickel and compounds (as Ni)	C	OTH	Calculation based on fuel consumption and emission factor previously submitted to EPA	0.004834	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.004834	0.0	0.0
23	Lead and compounds (as Pb)	C	OTH	Calculation based on fuel consumption and emission factor previously submitted to EPA	0.000272	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000272	0.0	0.0
24	Zinc and compounds (as Zn)	C	OTH	Calculation based on fuel consumption and emission factor previously submitted to EPA	0.000391	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000391	0.0	0.0
86	Particulate matter (PM10)	C	OTH	Calculation based on flow rates and direct measurement of stack emission concentrations	396.0	118571.0	0.0	0.0	3021.0	831.0	1255.0	2770.0	817.0	127661.0	0.0	0.0
03	Carbon dioxide (CO2)	C	ETS		3350788.0	322779965.0	714024743.0	194948914.0	0.0	0.0	0.0	0.0	0.0	#########	0.0	0.0
02	Carbon monoxide (CO)	C	OTH	Calculation based on flow rates and direct measurement of stack emission concentrations	0.0	0.0	61837.0	17302.0	0.0	0.0	0.0	0.0	0.0	79139.0	0.0	0.0

* Select a row by double-clicking on the Pollutant Name (Column B) then click the delete button

SECTION B : REMAINING PRTR POLLUTANTS

RELEASES TO AIR					Please enter all quantities in this section in KGs			
POLLUTANT		METHOD			QUANTITY			
			Method Used					
No. Annex II	Name	M/C/E	Method Code	Designation or Description	Emission Point 1	T (Total) KG/Year	A (Accidental) KG/Year	F (Fugitive) KG/Year
					0.0	0.0	0.0	0.0

* Select a row by double-clicking on the Pollutant Name (Column B) then click the delete button

SECTION C : REMAINING POLLUTANT EMISSIONS (As required in your Licence)

RELEASES TO AIR					Please enter all quantities in this section in KGs			
POLLUTANT		METHOD			QUANTITY			
			Method Used					
Pollutant No.	Name	M/C/E	Method Code	Designation or Description	Emission Point 1	T (Total) KG/Year	A (Accidental) KG/Year	F (Fugitive) KG/Year
					0.0	0.0	0.0	0.0

* Select a row by double-clicking on the Pollutant Name (Column B) then click the delete button

Additional Data Requested from Landfill operators

For the purposes of the National Inventory on Greenhouse Gases, landfill operators are requested to provide summary data on landfill gas (Methane) flared or utilised on their facilities to accompany the figures for total methane generated. Operators should only report their Net methane (CH4) emission to the environment under T(total) KG/yr for Section A: Sector specific PRTR pollutants above. Please complete the table below:

Landfill: Aughinish Alumina Limited

Please enter summary data on the quantities of methane flared and / or utilised			Method Used			
	T (Total) kg/Year	**M/C/E**	**Method Code**	**Designation or Description**	**Facility Total Capacity m3 per hour**	
Total estimated methane generation (as per site model)	0.0				N/A	
Methane flared	0.0				0.0	(Total Flaring Capacity)
Methane utilised in engine/s	0.0				0.0	(Total Utilising Capacity)
Net methane emission (as reported in Section A above)	0.0				N/A	

4.2 RELEASES TO WATERS Link to previous years emissions data

SECTION A : SECTOR SPECIFIC PRTR POLLUTANTS

Data on ambient monitoring of storm/surface water or groundwater, conducted as part of your licence requirements, should NOT be submitted under AER / PRTR Reporting as this only concerns Releases from your facility

RELEASES TO WATERS					Please enter all quantities in this section in KGs			
POLLUTANT					QUANTITY			
			Method Used		Industrial Effluent (Emm Point ref W1-1)			
No. Annex II	Name	M/C/E	Method Code	Designation or Description	Emission Point 1	T (Total) KG/Year	A (Accidental) KG/Year	F (Fugitive) KG/Year
17	Arsenic and compounds (as As)	M	OTH	APHA SMEW &WW 3125	322.2	322.2	0.0	0.0
18	Cadmium and compounds (as Cd)	M	OTH	APHA SMEW &WW 3126	8.5	8.5	0.0	0.0
19	Chromium and compounds (as Cr)	M	OTH	APHA SMEW &WW 3127	50.9	50.9	0.0	0.0
20	Copper and compounds (as Cu)	M	OTH	APHA SMEW &WW 3128	48.4	48.4	0.0	0.0
21	Mercury and compounds (as Hg)	M	OTH	APHA SMEW &WW 3129	72.7	72.7	0.0	0.0
22	Nickel and compounds (as Ni)	M	OTH	APHA SMEW &WW 3130	38.8	38.8	0.0	0.0
23	Lead and compounds (as Pb)	M	OTH	APHA SMEW &WW 3131	2.9	2.9	0.0	0.0
24	Zinc and compounds (as Zn)	M	OTH	APHA SMEW &WW 3132	29.1	29.1	0.0	0.0

* Select a row by double-clicking on the Pollutant Name (Column B) then click the delete button

SECTION B : REMAINING PRTR POLLUTANTS

RELEASES TO WATERS					Please enter all quantities in this section in KGs			
POLLUTANT					QUANTITY			
			Method Used					
No. Annex II	Name	M/C/E	Method Code	Designation or Description	Emission Point 1	T (Total) KG/Year	A (Accidental) KG/Year	F (Fugitive) KG/Year
					0.0	0.0	0.0	0.0

* Select a row by double-clicking on the Pollutant Name (Column B) then click the delete button

SECTION C : REMAINING POLLUTANT EMISSIONS (as required in your Licence)

RELEASES TO WATERS					Please enter all quantities in this section in KGs			
POLLUTANT					QUANTITY			
			Method Used		Industrial Effluent (Emm Point ref W1-1)			
Pollutant No.	Name	M/C/E	Method Code	Designation or Description	Emission Point 1	T (Total) KG/Year	A (Accidental) KG/Year	F (Fugitive) KG/Year
240	Suspended Solids	M	OTH	APHA SMEW & WW 2540D	80083.0	80083.0	0.0	0.0
303	BOD	M	OTH	APHA SMEW & WW 2540D	372863.0	372863.0	0.0	0.0
314	Fats, Oils and Greases	M	OTH	APHA SMEW & WW 2540D	5005.0	5005.0	0.0	0.0
320	Magnesium	M	OTH	APHA SMEW & WW 3127	36412.0	36412.0	0.0	0.0
355	Aluminium	M	OTH	APHA SMEW & WW 3125	9059.6	9059.6	0.0	0.0
357	**Iron**	M	OTH	APHA SMEW & WW 3126	666.2	666.2	0.0	0.0

* Select a row by double-clicking on the Pollutant Name (Column B) then click the delete button

Please enter all quantities on this sheet in Tonnes

Transfer Destination	European Waste Code	Hazardous	Quantity (Tonnes per Year)	Description of Waste	Waste Treatment Operation	Method Used		Location of Treatment	Haz Waste : Name and Licence/Permit No of Next Destination Facility Non Haz Waste: Name and Licence/Permit No of Recover/Disposer	Haz Waste : Address of Next Destination Facility Non Haz Waste: Address of Recover/Disposer	Name and License / Permit No. and Address of Final Recoverer / Disposer (HAZARDOUS WASTE ONLY)	Actual Address of Final Destination i.e. Final Recovery / Disposal Site (HAZARDOUS WASTE ONLY)
						M/C/E	Method Used					
Within the Country	01 03 07	Yes	18304.0	Salt Cake	D1	C	Volume Calculation	Onsite of generati	Aughinish Alumina Ltd.,IPPC Licence P0035-05	Aughinish Island,Askeaton,Askeaton,Co Limerick,Ireland	Aughinish Alumina ,IPPC Licence P0035-05,Aughinish Island,.,Askeaton,Co. Limerick,Ireland	Aughinish Island,.,Askeaton,Co. Limerick,Ireland
Within the Country	01 03 06	No	103158.0	Sand (from alumina production)	D1	C	Volume Calculation	Onsite of generati	Aughinish Alumina Ltd.,IPPC Licence P0035-05	Aughinish Island,Askeaton,Askeaton,Co Limerick,Ireland		
Within the Country	01 03 09	No	1371301.0	Red mud from alumina production other than the wastes mentioned in 01 03 07	D1	C	Volume Calculation	Onsite of generati	Aughinish Alumina Ltd.,IPPC Licence P0035-05	Aughinish Island,Askeaton,Askeaton,Co Limerick,Ireland		
Within the Country	01 03 99	No	5620.0	Lime grits	D1	C	Volume Calculation	Onsite of generati	Aughinish Alumina Ltd.,IPPC Licence P0035-05	Aughinish Island,Askeaton,Askeaton,Co Limerick,Ireland		
Within the Country	01 03 99	No	15996.0	Process wastes (sand, scales, tank cleanout sludges)	D1	C	Volume Calculation	Onsite of generati	Aughinish Alumina Ltd.,IPPC Licence P0035-05	Aughinish Island,Askeaton,Askeaton,Co Limerick,Ireland		
Within the Country	06 04 04	Yes	0.001	wastes containing mercury	R4	M	Weighed	Offsite in Ireland	Irish Lamp Recycling,WFP-KE-08-0348-01	Athy,Athy,Co Kildare,Co Kildare,Ireland	Irish Lamp Recycling,WFP-KE-08-0348-01,Athy,Co Kildare,.,.,Ireland	Athy,Co Kildare,.,.,Ireland
Within the Country	13 07 01	Yes	51.8	Waste oil and diesel	R9	M	Volume Calculation	Offsite in Ireland	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland
Within the Country	15 02 02	Yes	3.6	Oily rags/waste oil dry absorbent	D10	C	Weighed	Offsite in Ireland	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland	Rilta Environmetnal Ltd,W0192-03,Greenogue Business Park,Rathcoole,Co. Dublin,.,Ireland	Greenogue Business Park,Rathcoole,Co. Dublin,.,Ireland
Within the Country	15 01 04	No	11.0	Metallic packaging/drums/containers	R4	M	Weighed	Offsite in Ireland	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland		
Within the Country	15 01 10	Yes	41.3	Plastic containers (contaminated empty IBC'c & drums)	R9	M	Weighed	Offsite in Ireland	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland	Rilta Environmetnal Ltd,W0192-03,Greenogue Business Park,Rathcoole,Co. Dublin,.,Ireland	Greenogue Business Park,Rathcoole,Co. Dublin,.,Ireland
To Other Countries	15 01 11	Yes	3.0	Aerosol cans empty	D10	M	Weighed	Abroad	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland	De-Pack Limited ,EAWML/43679,Wymeswold Industrial Estate ,Burton on the Wolds ,Leicestershire ,.,United Kingdom	Wymeswold Industrial Estate ,Burton on the Wolds ,Leicestershire ,.,United Kingdom
To Other Countries	17 05 03	Yes	2.4	Contaminated soil	R13	M	Weighed	Abroad	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland	Avalstoffen Terminal Moerdijk (ATM),ATM,Vlasweg 12 ,4782 PW ,Moerdijk,The Netherlands,Netherlands	Vlasweg 12 ,4782 PW ,Moerdijk,The Netherlands,Netherlands
To Other Countries	16 01 07	Yes	0.1	Oil filters	R11	M	Weighed	Abroad	Enva Shannon,WCP-DC-08-1116-01	Smithstown Industrial Estate,Shannon,Co. Clare,0,Ireland	Recyfuel,Not known,Zoning Industriel d?Ehein,Zoning Industriel d?Ehein,Engis,B-4480 ,Belgium	Zoning Industriel d?Ehein,Zoning Industriel d?Ehein,Engis,B-4480 ,Belgium
Within the Country	16 02 14	No	0.001	Waste electronic and electrical equipment (WEEE)	R4	M	Weighed	Offsite in Ireland	Greenstar,W0082-02	Dock Road,Dock Road,Limerick,Limerick,Ireland		
To Other Countries	16 05 06	Yes	3.1	laboratory chemicals, consisting of or containing dangerous substances, including mixtures of laboratory chemicals	R1	M	Weighed	Abroad	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland	Recyfuel,Not known,Zoning Industriel d?Ehein,Zoning Industriel d?Ehein,Engis,B-4480 ,Belgium	Zoning Industriel d?Ehein,Zoning Industriel d?Ehein,Engis,B-4480 ,Belgium
Within the Country	**16 06 01**	**Yes**	8.1	Lead batteries	R4	M	Weighed	Offsite in Ireland	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland	Rilta Environmetnal Ltd,W0192-03,Greenogue Business Park,Rathcoole,Co. Dublin,.,Ireland	Greenogue Business Park,Rathcoole,Co. Dublin,.,Ireland
Within the Country	16 11 04	No	140.0	Flue stack residue - refractory waste	D1	C	Volume Calculation	Onsite of generati	Aughinish Alumina Ltd.,IPPC Licence P0035-05	Aughinish Island,Askeaton,Askeaton,Co Limerick,Ireland		
Within the Country	17 04 01	No	0.1	Copper	R4	M	Weighed	Offsite in Ireland	United Metals,WCP LK 10 657 01	Eastway Business Park,Ballysimon,Limerick,0,Ireland		
Within the Country	17 04 07	No	966.0	Mixed metals	R4	M	Weighed	Offsite in Ireland	United Metals,WCP LK 10 657 01	Eastway Business Park,Ballysimon,Limerick,0,Ireland		
To Other Countries	17 06 01	Yes	4.5	Insulation materials containing asbestos	D5	M	Weighed	Abroad	Rilta Environmental Ltd,W0192-03	Greenogue Business Park,Rathcoole,Co. Dublin,Co. Dublin,Ireland	GroBenasper Entsorgungsgesellschaft mbh & Co. KG,eg0108,Bimohler Str. 57a,24623 GroBenaspe ,Hamburg ,.,Germany	Bimohler Str. 57a,24623 GroBenaspe ,Hamburg ,.,Germany
Within the Country	18 01 03	Yes	0.001	wastes whose collection and disposal is subject to special requirements in order to prevent infection	D9	M	Weighed	Offsite in Ireland	SRCL,W0055-02	420-430 Beech Road,Western Industrial Estate,Naas Road,Dublin 12,Ireland	SRCL,W0055-02,420-430 Beech Road,Western Industrial Estate,Naas Road,Dublin 12,Ireland	420-430 Beech Road,Western Industrial Estate,Naas Road,Dublin 12,Ireland
Within the Country	19 08 05	No	541.0	sludges from treatment of urban waste water	D8	M	Volume Calculation	Offsite in Ireland	Ecojet Ltd.,WCP LK 12 685 01	Raheen Business Park,Bay M1,Raheen Limerick,0,Ireland		
Within the Country	19 12 04	No	66.9	Rubber hosing	R11	M	Weighed	Offsite in Ireland	Greenstar,W0082-02	Dock Road,Dock Road,Limerick,Limerick,Ireland		
Within the Country	20 01 01	No	15.5	Cardboard	R3	M	Weighed	Offsite in Ireland	Greenstar,W0082-02	Dock Road,Dock Raod,Limerick,Limerick,Ireland		
Within the Country	20 01 01	No	1.8	Paper	R3	M	Weighed	Offsite in Ireland	DGD Papers,WFP-LK-2008-09C	Bay M1,Raheen Business Park,Limerick,Limerick,Ireland		
Within the Country	20 01 21	Yes	8.0	Fluorescent tubes and other mercury-containing waste	R4	M	Weighed	Offsite in Ireland	Irish Lamp Recycling,WFP-KE-08-0348-01	Athy,Athy,Co Kildare,Co Kildare,Ireland	Irish Lamp Recycling,WFP-KE-08-0348-01	Athy,Athy,Co Kildare,Co Kildare,Ireland
Within the Country	20 01 25	No	1.7	Edible oil and fat	R3	E	Volume Calculation	Offsite in Ireland	Frylite Dublin Ltd.,WCP-DC-10-1297-01	Ballymount Industrial Estate,Unit J1,Dublin 12,12,Ireland		
Within the Country	20 01 36	No	0.1	Used printer toner catridges	R4	C	Weighed	Offsite in Ireland	Condells The Office Centre,None	Roches Street,9,Limerick,Limerick,Ireland		
Within the Country	20 01 38	No	10.0	Used timber reels	R11	M	Weighed	Offsite in Ireland	Hegarty Metals Recycling,WFP-LKC-11-001-01	Ballysimon Road,Ballysimon Road,Limerick,Limerick,Ireland		
Within the Country	20 01 38	No	80.2	Wood for recycling	R3	M	Weighed	Offsite in Ireland	Greenstar,W0082-02	Dock Road,Dock Road,Limerick,Limerick,Ireland		
Within the Country	20 01 38	No	22.4	Wood for landfill	D1	M	Weighed	Offsite in Ireland	Greenstar,W0082-02	Dock Road,Dock Raod,Limerick,Limerick,Ireland		
Within the Country	20 03 01	No	173.8	Mixed municipal waste	D5	M	Weighed	Offsite in Ireland	Greenstar,W0082-02	Dock Road,Dock Road,Limerick,Limerick,Ireland		
Within the Country	20 01 08	No	21.4	biodegradable kitchen and canteen waste	R3	M	Weighed	Offsite in Ireland	Greenstar,W0082-02	Dock Road,Dock Raod,Limerick,Limerick,Ireland		

* Select a row by double-clicking the Description of Waste then click the delete button

Link to previous years waste data
Link to previous years waste summary data & percentage change
Link to Waste Guidance

Attachment 5
Noise Survey Report

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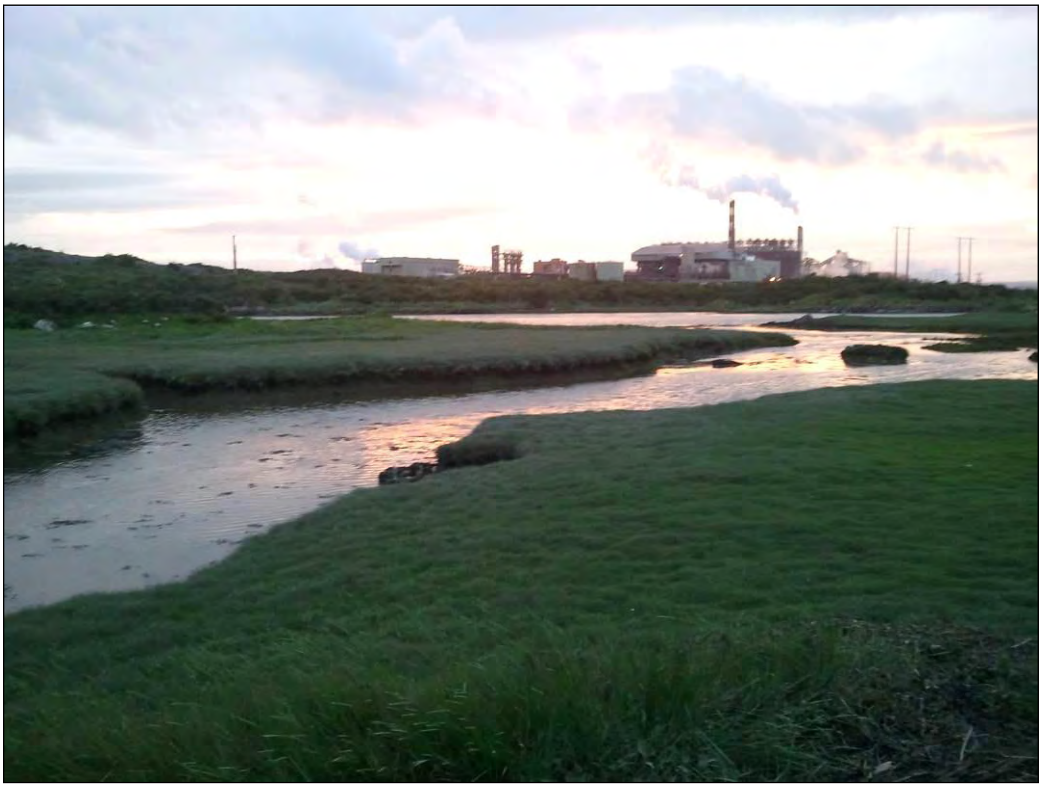
Aughinish Alumina Ltd.

Aughinish Island, Askeaton, Co. Limerick.
Industrial Emissions Licence Reg No. P0035-06



Report on

Annual Environmental Noise Survey 2016

November 2016

ENVIRONMENT ISO 14001:2004 NSAI Certified
HEALTH & SAFETY OHSAS 18001:2007 NSAI Certified
QUALITY ISO 9001:2008 NSAI Certified

Control Sheet

Document Title:	Report on Annual Environmental Noise Survey 2016	**Document No.**	R1_1017_39		
Rev	**Description**	**Originator**	**Reviewer**	**Change**	**Date**
00	Draft	SM	LW	Draft	04/09/2016
01	Final	SM	LW/POL	Final	08/11/2016

This report is produced solely for the benefit of Aughinish Alumina Ltd. and no liability is accepted for any reliance placed on it by any other party unless specifically agreed in writing otherwise. This report refers, within the limitations stated, to the condition of the normal operating conditions of the site at the time of the noise compliance site survey. No warranty is given as to the possibility of future changes in the condition of the normal operating conditions of the site.

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Aughinish Alumina Ltd.
Aughinish Island, Askeaton, Co. Limerick

Annual Environmental Noise Survey 2016

Contents

Attachments

1 Introduction

OES Consulting (OES) was commissioned by Aughinish Alumina Ltd. (AAL) to undertake its annual environmental noise survey at its facility on Aughinish Island, Askeaton, Co. Limerick.

The noise assessment was undertaken in accordance with Conditions and Schedules set out in the Industrial Emissions Licence (IEL) registration number P0035-06. The relevant Conditions and Schedules of the Licence are as follows:

- In accordance with Condition 4.5 of the licence *''noise from the installation shall not give rise to sound pressure levels ($L_{Aeq,T}$) measured at the specified noise sensitive locations (including those specified in Schedule C.5 Noise Monitoring Locations, of this licence) which exceed the limit value(s).''*

- In accordance with Condition 6.16 of the licence *''the licensee shall carry out a noise survey of the site operations annually. The survey programme shall be undertaken in accordance with the methodology specified in the 'Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)', as published by the Agency.''*

- In accordance with Schedule B.4 of the licence daytime limits of $L_{Ar\ (30\ minutes)}$ of 55 dB(A), Evening time limits of $L_{Ar(30\ minutes)}$ of 50 dB(A) and Night-time $L_{Aeq\ (15\text{-}30\ minutes)}$ of 45 dB(A) apply. In addition, Schedule B.4 states that "*there shall be no clearly audible tonal component or impulsive component in the noise emission from the activity at any noise sensitive location.''*

- Schedule C.5 Noise Monitoring sets out the monitoring locations, parameters to be measured, measurement frequency, measurement periods, and minimum survey duration as tabulated below:

Location	**Measurement**	**Frequency**
NSL1-NSL5 (incl.) B1-B9 Any other NSL which the Agency deems appropriate.	LAeq(15minute) / LAeq(30 minute) LAr,T (30 minute)	Annually
Period	**Minimum Survey Duration**	
Daytime	4 hour survey* with a minimum of 3 sampling periods at each monitoring location. **Note2**	
Evening Time	2 hours survey* with a minimum of 1 sampling period at each noise monitoring location.	
Night-Time**Note1**	3 hour survey* with a minimum of 2 sampling periods at each noise monitoring location.	
Note1: Night-time measurements should be made between 2300hrs and 0400hrs, Sunday to Thursday, with 2300hrs being the preferred start time.		

Note2: Sampling period is to be the time period T stated within the relevant licence. Typically this will be either 15 minutes or 30 minutes in duration. This applies to day, evening and night time periods.

*The latest NG4 Guidance no longer specifies minimum survey durations as specified in Schedule C.5. of the licence.

2 Methodology

The noise survey was undertaken in accordance with the 'Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)' as revised and published by the Environmental Protection Agency in January 2016 and in accordance with the Conditions and Schedules of IEL P0035-06.

The survey was carried out between Tuesday 23rd August to Thursday 25th August 2016 and also on the night of Wednesday 12th October to Thursday 13th October 2016 (dates inclusive). The noise survey was undertaken by Ms. Siobhan Maher who is a Member of the Institute of Acoustics (MIOA). Ms. Maher was assisted by Ms. Aisling Walsh, an Environmental Consultant working under the supervision and guidance of Ms. Siobhan Maher.

2.1 Measurement Locations

The noise survey was conducted at 9 Boundary Locations (B1 to B9) and 5 Noise Sensitive Locations (NSL1 to NSL5) as shown in Figure 1, Attachment 1 and described in Table 1 below.

Table 1: Noise Monitoring Locations

Monitoring location	GPS Cordinates	Location type	Location relative to Aughinish Alumina Ltd. installation
B1	528276 655432	Boundary	Located on the North-West corner of the jetty where ships are unloaded and loaded.
B2	528807 653808	Boundary	Located at the North East of the facility, close to the cooling towers.
B3	528676 652702	Boundary	Located towards the North side of the main access road.
B4	528153 651916	Boundary	Located to the South of the facility, close to the Nature Trail car-park.
B5	526797 652555	Boundary	Located to the Western corner of the site in the vicinity of the Bauxite Residue Disposal Area (BRDA).
B6	528002 653635	Boundary	Located on the Shore Road providg access to the Southwest of the main plant.
B7	526713 652467	Boundary	Located in the BRDA to the Southwest of the site.
B8	527668 650952	Boundary	Located to the South of the BRDA Phase II.
B9	528780 651096	Boundary	Located to the Southeast of the BRDA Phase II.

Monitoring location	GPS Cordinates	Location type	Location relative to Aughinish Alumina Ltd. installation
NSL1	529168 652761	Noise sensitive location	Located approximately 600m South East of the facility adjacent Poulaweela Creek.
NSL2	529000 651731	Noise sensitive location	Located approximately 1,200m to the South East of the facility in the vicinity of a residential dwelling.
NSL3	527720 649969	Noise sensitive location	Located approximately 3km to the South of the facility in the townland of Oola.
NSL4	526069 652096	Noise sensitive location	Located approximately 2.6km to the South West. Located at the eastern end of Foynes Port.
NSL5	528805 651209	Noise sensitive location	Located 1.9km directly South of the facility in the vicinity of a residential building at a crossroads.

2.2 Survey Periods

In accordance with IEL P0035-06 and NG4 Guidelines, three sampling periods are required at each noise monitoring location during the daytime, one sampling period is required during the evening period and two sampling periods are required during the night-time surveys. This results in six sampling events at each noise monitoring location over the course of the survey.

Sample periods were 15 minutes for Boundary Locations and 30 minutes for NSLs during the daytime, evening and night-time surveys.

The survey was undertaken during a typical operational production period as required for compliance evaluation.

A couple of night time measurements were made between 04.00 – 04.30 hrs at B7 and B2. The dawn did not break until later in the morning therefore the dawn chorus did not interfere with the measurements and it is considered that these readings were representative of the night time period notwithstanding that 23.00 - 04.00 hrs is the preferred monitoring period.

2.3 Weather

Weather conditions were favourable for monitoring of environmental noise. General weather information was sourced from the Met Eireann Shannon Airport Observatory automatic synoptic station. This is shown in Attachment 2. The weather during the daytime periods was pleasantly warm (day highs of 18-20°C) and with generally calm conditions and some light to gentle breezes (0 – 4m/s) on occasion. During the night-time survey the wind regime reduced to very calm with very occasional light breezes (1-2 m/sec). Night time periods were cooler and temperatures dropped to approximately 10-12°C in August and 6°C in October. Conditions were dry for the duration of the monitoring period.

2.4 Instrumentation

All measurements were undertaken using Type 1 Precision Integrating Sound Level Meters and associated hardware (calibrators, tripods) and software. Calibration certificates for the noise meters and calibrators are presented in Attachment 3.

Details of the monitoring equipment used are provided in Table 2.

Table 2: Monitoring Equipment

Instrument Type	Manufacturer	Model Number	Serial Number
Sound Level Meter	Cirrus Research plc	CR:171B	G056143
Acoustic Calibrator	Cirrus Research plc	CR:515	55191
Sound Level Meter	NTi Audio	XL2	A2A-08898-E0
Acoustic Calibrator	Larson Davis	CAL200	11728

The Sound Level Meters and associated software and accessories conform to the following standards:

- IEC 61672-1, Class 1, Group X
- IEC 60651, Type 1, Group X
- IEC 60804, Type 1, Group X
- IEC 61260, IEC 60942, Class 1
- ANSI S1.4 & ANSI S1.4A, Type 1
- ANSI S1.43, Type 1

The Acoustic Calibrators were calibrated to published data as described and recommended by IEC standard Electroacoustic – Sound Calibrators IEC 60942:2003, IEC 90942:1997, BS EN 60942:1998 and BS EN 60942:2003.

2.5 Procedure

The monitoring kits were positioned at each monitoring location. Refer to Attachment 4 for Photolog showing meter locations. Care was taken to ensure that the meters were a minimum distance of 3.5m from any reflective surface other than the ground, and placed upon a tripod with a microphone height of 1.2-1.5m off the ground as per the requirements of NG4. The sound level meter (SLM) was set to record results for either 15 or 30 minutes as appropriate.

The results were saved to the instrument memory for later analysis. Survey personnel noted all primary noise sources contributing to noise readings. The noise meters were attended at all times during the survey. The survey results were noted into Field Notebooks immediately following each measurement.

The meter was calibrated before and at the end of each survey period at a minimum with calibration regularly conducted during the survey.

2.6 Measurement Parameters

The survey results are presented in terms of the following parameters:

L_{Aeq} is the A-weighted equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level (or steady sound) over the sample period.

L_{Amax} is the A-weighted instantaneous maximum sound level measured during the sample period.

L_{A10} is the A-weighted sound level that is exceeded for 10% of the sample period time. It is typically used as a descriptor for intermittent high noise level features during a monitoring event such as road traffic.

L_{A90} is the A-weighted sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise.

In addition to the above, the following definitions may also apply to the report discussion:

$L_{Ar,T}$ The Rated Noise Level is equal to the L_{Aeq} during a specified time interval (T), plus specified adjustments for tonal character and/or impulsiveness of the sound.

The "A" suffix denotes sound levels that have been "A-weighted" in order to account for the non-linear nature of human hearing to sounds of different frequencies.

Tonal sounds are defined as sounds which cover a range of only a few Hz which contains a clearly audible tone, i.e. distinguishable, discrete or continuous noise (whine, hiss, screech, or hum etc.) are referred to as being 'tonal'.

A simplified objective method for determining if tones are present is set out in Annex D of ISO 1996-2:2007(E) Acoustics – Description, measurement and assessment of environmental noise, Part 2: Determination of environmental noise levels.

According to the simplified method, an audible tone is normally defined as being greater than or equal to the following values in both adjacent one third octave bands:

- 15dB in low frequency one third octave bands (25Hz to 125Hz);
- 8dB in middle frequency bands (160Hz to 400Hz), and;
- 5dB in high frequency bands (500Hz to 10,000Hz).

1/3 Octave Analysis is defined as frequency analysis of sound such that the frequency spectrum is subdivided into narrower bands of one–third of an octave each in order to objectively determine if a sound is tonal or not.

All sound levels in this report are expressed in terms of decibels (dB) relative to $2x10^{-5}$ Pa.

3 Noise Monitoring Results

Detailed noise monitoring summary sheets for all noise monitoring locations are appended as Attachment 5 of this report. These sheets contain the logged values for the main parameters measured over time and the overall spectrum recorded at each location for each individual measurement. Attachment 6 contains the tabulated 1/3 octave band spectral data as required under the revised NG4 Guidelines, 2016.

A summary of the overall main parameters $L_{Aeq,t}$, L_{ama}, $L_{A90,t}$, $L_{A10,t}$ measured at each location and findings of tonal analysis in accordance with Annex D of ISO 1996-2:2007(E) for day, evening and night time measurements are outlined in Tables 3 to 5 overleaf respectively.

A summary assessment of compliance with the limit values and conditions at NSLs is also presented in Tables 3 – 5. Where an $L_{Aeq't}$ value is below the required limit value for NSLs with no tones or impulsive sound present, then no further detailed analysis of the logged data has been conducted and the L_{Aeq} is listed as the $L_{Ar,T}$ even though the plant related noise may actually be lower as the L_{Aeq} may have been influenced by extraneous sources. Where the $L_{Aeq,t}$ exceeds the limit value then further detailed analysis is conducted and commentary provided to determine an appropriate $L_{Ar,t}$.

Boundary locations are not NSLs and therefore the limit values have not been applied to these measurements as indicated in the tables overleaf.

Table 3: Daytime Noise Monitoring Results Summary

Noise location	Date Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	L_{AR}	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is L_{Ar} compliant with noise limit?
Noise Sensitive Locations - Monitoring Results										
NSL1	2016-08-24 11.34	46.1	58.6	48.6	41.8	No	46.1	**Facility**. Steady broadband sound predominant from the plant. Intermittent, muffled construction type noise. **Other.** Song birds and gulls cackling at times.	55	Yes
	2016-08-24 12.07	43.6	60.4	45.2	39.5	No	43.6		55	Yes
	2016-08-24 12.40	44.4	56.0	46.3	41.5	No	44.4		55	Yes
NSL2	2016-08-24 11.45	47.8	71.7	47.3	36.5	No	47.8	**Facility**. Faint steady sound from west/BRDA direction but likely to be from local authority water treatment plant. Muffled reverse beeping from BRDA audible. **Other.** Birds tweeting. Gentle rustling of leaves on occasion. Distant traffic on N69 audible. Occasional passing car on local road.	55	Yes
	2016-08-24 12.16	45.7	69.4	44.8	34.7	No	45.7		55	Yes
	2016-08-24 12.50	45.0	72.7	43.4	33.7	No	45.0		55	Yes
NSL3	2016-08-23 15.27	50.3	75.6	49.4	40.7	No	50.3	**Facility.** Facility not audible. **Other**. Frequent traffic on the N69 predominant constant noise source. Occasional passing cars, noise from construction works at local NSL constant and unsteady. Birds tweeting constantly. Some wind induced leaf rustling affected reading (slight to negligible).	55	Yes
	2016-08-23 15.58	48.5	76.1	50.1	41.5	No	48.5		55	Yes
	2016-08-23 16.28	48.3	66.0	50.7	42.3	No	48.3		55	Yes
NSL4	2016-08-23 13.35	56.6	77.3	57.6	35.5	No	35.5	**Facility**: Facility generally inaudible. **Other.** Loading of loose bulk material at	55	Yes

Noise location	Date Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	L_{AR}	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is L_{Ar} compliant with noise limit?
	2016-08-23 14.07	58.0	77.1	60.2	32.6	No	32.6	port by tracked excavator occurring approx. 100m from meter position. HGVs passing the meter on occasion to and from loading area. Low steady hum (80 Hz) from port predominant when bulk loading stopped on occasion. As port noise was predominant and the facility was more or less inaudible, the L_{A90} value is stated as the $L_{AR,t}$.	55	Yes
	2016-08-23 14.38	58.9	81.3	60.9	35.9	No	35.9		55	Yes
NSL5	2016-08-24 13.25	56.3	79.6	48.6	33.9	No	<45	**Facility.** Muffled construction plant type sound from BRDA audible. L_{AF} approx. 43 - 47 dB in traffic noise lulls. **Other.** Distant traffic on N69 as background sound. Fast moving intermittent passing cars on local road increased L_{Aeq} values above L_{A10}.	55	Yes
	2016-08-24 13.55	56.8	78.5	49.9	37.2	No	<45		55	Yes
	2016-08-24 14.29	57.1	81.1	52.3	37.9	No	<45		55	Yes
Boundary Location - Noise Monitoring Results										
B1	2016-08-24 15.41	57.7	78.6	60.0	46.8	N/A	N/A	New project on-going. Construction noise and low hum from conveyor in background. Dredger in operation close to meter at times. Tone at 2.5k Hz due to dredger.	N/A	N/A
	2016-08-24 15.56	56.6	79.5	59.3	44.4	N/A	N/A		N/A	N/A
	2016-08-24 16.12	60.5	84.8	62.7	44.0	N/A	N/A		N/A	N/A
B2	2016-08-24 15.30	55.7	59.7	56.7	54.7	N/A	N/A	Plant sources predominant.	N/A	N/A
	2016-08-24 15.45	55.7	64.0	56.6	54.5	N/A	N/A		N/A	N/A
	2016-08-24 16.00	55.9	61.4	56.8	54.7	N/A	N/A		N/A	N/A

Noise location	Date Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	L_{AR}	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is L_{Ar} compliant with noise limit?
B3	2016-08-24 13.30	61.3	81.1	63.6	57.9	N/A	N/A	Plant sources predominant both fixed and mobile.	N/A	N/A
	2016-08-24 13.45	59.7	69.7	60.9	58.3	N/A	N/A		N/A	N/A
	2016-08-24 14.00	65.2	73.2	71.5	58.8	N/A	N/A		N/A	N/A
B4	2016-08-24 14.22	45.7	67.9	47.1	38.5	N/A	N/A	BRDA mobile plant audible. Cars pulling into car-park.	N/A	N/A
	2016-08-24 14.38	44.1	64.1	43.6	37.0	N/A	N/A		N/A	N/A
	2016-08-24 14.54	49.0	66.9	48.8	37.4	N/A	N/A		N/A	N/A
B5	2016-08-24 17.15	33.2	52.8	34.2	30.5	N/A	N/A	Main facility not particularly audible. Gentle sound of water flowing in BRDA and animal sounds.	N/A	N/A
	2016-08-24 17.30	34.3	54.0	34.6	30.8	N/A	N/A		N/A	N/A
	2016-08-24 17.45	35.9	52.3	37.3	31.0	N/A	N/A		N/A	N/A
B6	2016-08-24 17.13	47.9	54.1	49.6	46.1	N/A	N/A	Sound from main plant predominant.	N/A	N/A
	2016-08-24 17.31	48.2	57.9	49.7	46.5	N/A	N/A		N/A	N/A
	2016-08-24 17.46	48.6	55.3	50.0	46.9	N/A	N/A		N/A	N/A
B7	2016-08-24 18.15	37.4	49.5	39.4	33.1	N/A	N/A	Location beside electrical plant in BRDA. Slight hum. Port noise predominant.	N/A	N/A
	2016-08-24 18.30	36.4	61.2	34.8	30.5	N/A	N/A		N/A	N/A
	2016-08-24 18.45	34.8	51.2	37.5	29.9	N/A	N/A		N/A	N/A
B8	2016-08-24 18.14	37.0	54.0	39.3	31.3	N/A	N/A	Very quiet with faint hum. Distant traffic on N69. Planes overhead.	N/A	N/A

Noise location	Date Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	L_{AR}	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is L_{Ar} compliant with noise limit?
	2016-08-24 18.30	32.1	54.1	33.6	29.7	N/A	N/A		N/A	N/A
	2016-08-24 18.45	34.6	53.3	36.1	29.1	N/A	N/A		N/A	N/A
B9	2016-08-23 17.08	48.8	61.4	54.0	36.4	N/A	N/A	N69 and local traffic predominant. Vehicles in BRDA audible during lulls in traffic. L_{AF} < 40dB. BRDA ceased at approx. 17.30 hrs.	N/A	N/A
	2016-08-23 17.27	48.8	65.9	53.0	34.0	N/A	N/A		N/A	N/A
	2016-08-23 17.43	48.9	66.0	53.5	35.5	N/A	N/A		N/A	N/A

**Only tones or impulsive sounds associated with the AAL operations are considered.*

Table 4: Evening Noise Monitoring Results Summary

Noise location	Date / Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	$L_{Ar,}$	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is L_{Ar} compliant with noise limit?
Noise Sensitive Locations - Monitoring Results										
NSL1	2016-08-23 19.57	47.5	61.6	48.7	46.1	No	47.5	**Facility**. Eastern sources at facility are clearly audible and steady in nature. Broadband type sound. **Other**. 3 cars are parked at this location. The area was being used for picnics with car occupants returning to car. Meter paused. Cars arriving and leaving. Birdsong and overhead planes also audible.	50	Yes
NSL2	2016-08-23 19.19	47.1	66.3	47.5	41.6	No	47.1	**Facility**: Faint facility noise audible when local noises sources were low. **Other.** Occasional cars passing, tractor operating approx. 100m from meter location, birdsong, locals talking. Distant traffic on N69 also audible as well as occasional overhead airplanes.	50	Yes
NSL3	2016 -08-23 19.57	48.8	72.6	50.0	39.4	No	48.8	**Facility**: Could not hear facility amongst local background noises. **Other.** Traffic on the N69 a steady dominant noise. Birds tweeting constantly. Residents talking nearby.	50	Yes
NSL4	2016 -08-23 19.14	36.4	58.0	37.6	30.3	No	36.4	**Facility.** Facility not audible. **Other.** Port jetty sound predominant at 80Hz. N69 traffic noise also audible. Seagulls cackling.	50	Yes

Noise location	Date / Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	$L_{Ar,}$	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is L_{Ar} compliant with noise limit?
NSL5	2016-08-23 20.39	56.7	79.5	54.8	34.7	No	<45	**Facility.** Faint facility noise only barely audible during times of very low local noise. Individual sources not distinctive. **Other**. Car traffic on the N69 and traffic on local roads primary sources of noise. Football match on-going at adjoining pitch.	50	Yes
Boundary Monitoring Location Results.										
B1	2016-08-23 22.00	51.4	68.9	54.1	48.0	N/A	N/A	Maintenance work at jetty. Low hum from conveyor. Sound of waves, tide coming in. Flag in breeze up to 5 m/sec.	N/A	N/A
B2	2016-08-23 22.41	54.1	57.2	55.1	53.3	N/A	N/A	Plant sound predominant.	N/A	N/A
B3	2016-08-23 22.41	58.2	61.1	58.6	57.6	N/A	N/A	Plant sound predominant.	N/A	N/A
B4	2016-08-23 21.19	43.9	64.7	43.3	33.9	N/A	N/A	Beside Nature Trail carpark. The evening is a busy period for activities. Plant audible at <35 dB in lulls in extraneous sources.	N/A	N/A
B5	2016-08-23 20.45	43.1	67.4	40.1	33.6	N/A	N/A	Port noise audible 80Hz. Facility not audible.	N/A	N/A
B6	2016-08-23 22.18	52.8	57.5	54.7	50.7	N/A	N/A	Plant sound predominant.	N/A	N/A
B7	2016-08-23 21.05	35.1	49.9	36.7	30.5	N/A	N/A	Port sound predominant. Birds tweeting.	N/A	N/A
B8	2016-08-23 21.25	34.7	59.6	37.0	30.1	N/A	N/A	N69 traffic noise predominant. Plant faint. Birds still tweeting.	N/A	N/A

Noise location	Date / Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	$L_{Ar,}$	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is L_{Ar} compliant with noise limit?
B9	2016-08-23 21.47	36.8	52.8	38.0	32.4	N/A	N/A	Plant audible constantly but faint. Distant traffic on N69 and seagulls.	N/A	N/A

**Only tones or impulsive sounds associated with the AAL operations are considered.*

Table 5: Night-Time Noise Monitoring Results Summary

Noise location	Date/ Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is the L_{Aeq} compliant with noise limit?
Noise Sensitive Locations - Monitoring Results									
NSL1	2016-10-12 23.33	44.2	62.6	44.9	40.7	No	**Facility**. Sources at the eastern quarter of the facility audible as steady constant noise. **Other.** Occasional birds chirping. Two cars parked at location, occupants quiet however cars engines started up at end of Reading #2. Voices also audible.	45	Yes
	2016-10-13 00.07	42.4	57.1	44.3	39.1	No		45	Yes
NSL2	2016-08-24 00.20	38.2	61.2	40.6	31.5	No	**Facility**: Plant audible as a constant steady source. Individual sources were not distinct. **Other:** Distant traffic on N69 audible. In frequent birdsong and dogs barking nearby.	45	Yes
	2016-08-24 00.50	35.4	58.2	38.2	30.5	No		45	Yes
NSL3	2016-08-24 01.38	43.0	60.1	46.4	27.5	No	**Facility**. Plant inaudible to very faint. **Other.** Occasional traffic on N69. Port audible.	45	Yes
	2016-08-24 02.10	41.3	57.5	44.3	31.3	No		45	Yes
NSL4	2016-08-24 00.26	34.4	60.2	36.7	29.6	No	**Facility.** Plant inaudible. **Other.** Port jetty sound audible at 80Hz low hum. Tonal source from port.	45	Yes
	2016-08-24 00.56	33.4	49.2	36.1	28.3	No		45	Yes
NSL5	2016-08-24 01.28	58.0	85.8	40.3	29.4	No	**Facility.** Plant machinery from direction of BRDA area slightly audible. Infrequent distant banging sound from plant. LAF <35 dB related to plant sounds. **Other**. Occasional traffic passing on local road (7 No.#1) and N69 in distance. Dogs barking on occasion. Local traffic increased L_{Aeq} values above background.	45	Yes
	2016-08-24 01.59	49.3	79.6	40.6	29.6	No		45	Yes

Noise location	Date/ Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is the L_{Aeq} compliant with noise limit?
Boundary Location - Noise Monitoring Results									
B1	2016-08-25 01.38	53.9	69.1	57.0	46.4	N/A	Dredger in operation. Plant sound predominant.	N/A	N/A
	2016-08-25 01.53	53.4	77.3	55.6	46.6	N/A		N/A	N/A
B2	2016-08-24 03.57	55.3	59.1	56.1	54.6	N/A	Plant sound predominant.	N/A	N/A
	2016-08-24 04.12	55.2	59.3	56.2	54.2	N/A		N/A	N/A
B3	2016-08-25 02.20	58.7	72.0	59.1	57.8	N/A	Plant sound predominant.	N/A	N/A
	2016-08-25 02.35	58.3	60.6	58.9	57.8	N/A		N/A	N/A
B4	2016-08-24 03.17	41.4	64.3	40.1	34.4	N/A	Plant audible. Higher L_{Aeq} for reading #1 due to security arriving plus a car passed on the local road.	N/A	N/A
	2016-08-24 03.33	34.6	51.2	36.0	32.3	N/A		N/A	N/A
B5	2016-08-24 03.15	35.4	49.3	37.6	32.0	N/A	Main plant and port sound (80Hz) predominant.	N/A	N/A
	2016-08-25 00.28	47.0	63.3	48.6	44.7	N/A		N/A	N/A
B6	2016-08-25 00.55	52.0	57.6	53.4	50.6	N/A	Plant sound predominant.	N/A	N/A
	2016-08-25 01.12	50.5	54.3	51.8	49.1	N/A		N/A	N/A
B7	2016-08-24 03.55	36.0	49.0	39.0	31.9	N/A	Port noise predominant (80Hz). Occasional planes overhead.	N/A	N/A
	2016-08-24 04.10	35.5	65.2	36.5	31.5	N/A		N/A	N/A
B8	2016-08-24 23.48	38.8	53.4	41.2	35.0	N/A	N69 distant traffic noise predominant. Also steady sound from plant audible. Tractor type noise from	N/A	N/A

Noise location	Date/ Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}	Tonal or Impulsive noise* (Y/N)	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	IEL Limit	Is the L_{Aeq} compliant with noise limit?
	2016-08-25 00.03	39.6	62.1	42.6	36.3	N/A	direction of main plant at times.	N/A	N/A
B9	2016-08-24 02.37	41.9	63.9	43.0	30.0	N/A	Distant hum from plant. Cars passed by during #1 resulting in a higher L_{Aeq}.	N/A	N/A
	2016-08-24 02.55	31.2	56.0	34.0	26.1	N/A		N/A	N/A

**Only tones or impulsive sounds associated with the AAL operations are considered.*

4 Discussion of Results

In addition to the summary tables presented in Section 3, a further brief discussion of the monitoring results recorded at the NSLs and boundary locations is presented below. Results for 2016 are compared to historical values since 2010 onwards for both NSLs and boundary locations. The effects of location, terrain and meteorological conditions are considered below where necessary. Section 4.3 presents a Statement of Uncertainty as required under the NG4 revised Guidelines, 2016.

4.1 Noise Sensitive Locations (NSLs)

4.1.1 NSL Daytime Results

The daytime $L_{Ar(30\ minute)}$ 55 dB was not exceeded at any of the NSLs due to facility related sound. Facility related sound was mostly faint to inaudible at all NSLs with the exception of NSL1 where it was clearly audible. The L_{Aeq} values recorded were below the daytime limit value at NSL1, 2 and 3 but above it at NSL 4 and 5. Both of these locations were dominated by extraneous sources. The facility noise was either inaudible at NSL4 (Foynes Port) or low to faint at NSL5. NSL5 is dominated by traffic noise as it is beside a crossroads. The L_{AF} values observed during lulls in traffic noise were noted to be < 45 dB on average. Accordingly, the daytime limit was complied with at NSL5.

The daytime values recorded at the NSLs are within the range typically recorded historically. The elevated L_{Aeq} value recorded at NSL4 was due to the loading of trucks using an excavator occurring at Foynes port in close proximity to this monitoring location.

4.1.2 NSL Evening Time Results

The evening time $L_{Ar(30\ minute)}$ 50dB was not exceeded at any of the NSLs due to facility related sound. As during the day, facility related sound was mostly faint to inaudible with the exception of NSL1 where it was clearly audible. The L_{Aeq} values recorded were below the evening time limit value at all NSLs with the exception of NSL5 for the same reasons as outlined in relation to the daytime results. Accordingly, the evening time limit was complied with at NSL5.

Evening time monitoring originally commenced in 2013 in accordance with the latest license. The evening time values recorded at the NSLs in 2016 are generally within the range typically recorded since 2013. A relatively low L_{Aeq} value was recorded at NSL4 during the 2016 evening survey. The port was unusually quiet during the evening time and this factor may have contributed to the low levels recorded. During the day and evening time some variation is to be expected between years due to the variation in extraneous noise levels and seasonal factors. For example, locals were picnicking in the evening at NSL1 during the 2016 survey.

4.1.3 NSL Night-Time Results

The night time $L_{Aeq(30\ minute)}$ 45dB was not exceeded at any of the NSLs due to facility related sound. Facility related sound was inaudible at NSL3 and 4 although it was audible to varying degrees at NSL1, 2 and 5. A tone at 80Hz was noted at NSL4 however this was directly related to the Foynes port jetty and was not connected to AAL activities. The L_{Aeq} values recorded were below the night-time limit value at NSL1, 2, 3 and 4 but above it at NSL5. The 1st night time reading at NSL5 was heavily influenced by up to 7 direct passing vehicles on the access road to the facility compared to the 2nd reading when less vehicles passed by. Intermittent N69 traffic also contributed to the L_{Aeq} values recorded at NSL5. The L_{AF} on the meter was noted at approx. 35 dB during lulls in traffic and when the plant sources were audible. Accordingly, plant related sound at NSL5 is compliant with the night time limit value. Subjectively, sound from the facility was faint and/or muffled. Refer to attachment 5 for the logged data illustrating the peaks associated with passing traffic that significantly influences the L_{Aeq} values.

4.2 Boundary Locations

There are nine boundary locations varying in proximity to the main plant sources. B1 is located on the jetty at sea and was influenced by construction activities associated with a new project and dredging works which occurred during the day, evening and night. This location was also more influenced by breezy conditions during the day and evening due to its location at sea. There was no unloading of raw material during the 2016 survey.

B2, B3 and B6 are dominated by un-varying (day, evening and night) plant noise as they are located in close proximity to the main plant. By contrast, B4 and B9 are located further away from the main plant and are also screened from the BRDA by mounding created along the boundary. Sounds emanating from the BRDA were audible at both B4 and B9, although both locations were significantly influenced by extraneous sources. B5, B7 and B8 are within the BRDA and are not particularly influenced by the main plant noise sources. These locations were found to be generally quiet although the predominant sound was from the port (80Hz) at B5 and B7. The predominant sound at B8 was the N69 traffic flow although the main plant was audible as a faint hum with muffled sound from equipment operating west of the reception building audible at night time.

Generally, it is noted that the night time results for boundary locations are within the range recorded historically and are at the lower end of the range. There was more variability in the evening time with some of the highest and lowest evening values ever recorded. This may however be due to the smaller range of values for evening time where monitoring only commenced in 2014 at boundary points. During the daytime, values recorded for most boundary points were lower than normal or within range with the exception of B3 where the highest value for this location was recorded during the 2016 survey. This was due to a tractor idling close by the monitoring location as spraying of weeds was being conducted.

4.3 Statement of Uncertainty

As required under the 2016 NG4 Guidelines, the level of uncertainty in the measurement data is considered below.

Weather conditions can affect noise monitoring. Aughinish Island covers a wide area and, although the general forecast for the area was for low wind speeds during the survey period, it was noted that locations B1 and B6 which are at sea or on the western shore road were affected at times by gusts above favourable levels for noise monitoring. These locations are however dominated by plant noise and activities and the level of noise from activities was higher than the wind related sound. Accordingly, there was little effect on the measured values.

Drifts on the meters was generally very low however it was noted that the offset following calibration on the Cirrus meter after two night time measurements in October 2016 was +0.65 dB. The measurements were still under the limit value even when the drift was taken into account.

Post - processing, rounding of values was only completed on final averages.

Type 1 meters were used. The degree of tolerance for a Type 1 meter is +/- 0.7 dB.

Detailed notes were taken during the measurements and the LAF values observed during lulls in extraneous noise to assist in assessing compliance levels.

Repeat measurements correlated well, both during the 2016 survey, and when compared with historic results.

5 Conclusions and Recommendations

Noise monitoring was conducted in August & October 2016 at NSLs and boundary locations associated with the Aughinish Alumina Ltd. facility.

Boundary monitoring locations were generally in line with both historic day and night-time monitoring results.

No tones or impulsive noise associated with the activities at the facility were recorded during the survey periods at all NSLs during all monitoring periods.

Day-time, evening and night-time monitoring results for facility related sound were compliant with the daytime, evening and night-time specified limits of $L_{Ar(30\ minute)}$ 55 dB, $L_{Ar(30\ minute)}$ 50 dB and $L_{Aeq(30\ minute)}$ 45dB respectively at all NSLs.

1. Safety Concerns

Access to NSL1 at Poulaweela Creek, is via a 1km narrow dirt track/laneway out to the point of a headland surrounded by the sea. Two vehicles are not easily accommodated going in opposite directions and the route can be easily blocked. The area is subject to anti-social behavior at night time. This presents a very high safety risk to monitoring personnel. Attempts to monitor were interrupted on a number of occasions in 2016 and previously in other years due to concerns regarding personal safety of noise monitoring personnel. Meters can be left on site unattended, however it is considered that there is a high risk of damage to the equipment.

2. Definition of an NSL

NSL 1is not locate close to any buildings or residential dwellings. The nearest dwelling is over 1km south and close to NSL2. The Creek is utilised by locals as a berth for small row boats and as a parking area to access the local bird hide and short walking trails during the day. It is used as an amenity area during the day and also the evening as evidenced by the latest survey. These activities generally depend on daylight and do not occur during the night-time (2300-0700) period. It is, therefore, considered that NSL1 does not qualify as a NSL at night time when compared to the definition of an NSL as described in NG4 where '*any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment required the absence of noise at nuisance levels*'. The same definition is also provided in the IEL which forms the legal basis for assessing compliance.

It is additionally noted that limit values set in licenses are related to international guidance considering the effects of noise on humans.

Due to the above factors, it is recommended that the relevance and suitability of monitoring at NSL1 during the night time period addressed by AAL with the Agency.

6 References

‘Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)’ as revised and published by the Environmental Protection Agency in January 2016.

IS0 1996-2:2007(E) Acoustics - Description and Measurement of Environmental Noise.

Attachment 1 - Site Location Map

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Legend

- Boundary Monitoring Locations (B)
- Noise Sensitive Locations (NSL)

RUSAL

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Client	Aughinish Alumina Ltd (Rusal)
Project	Environmental Noise Survey
Title	Noise Monitoring Locations
Scale	1:30,303
Ref.	11/08/2014
OES Ref.	F1_1017_30
Revision	01
Document Control	By: KG
	Chkd By: TQ
	App. By: TQ

Attachment 2 - Meteorological Data

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The Irish Meteorological Service Online

Tuesday, 30 August 2016 | Limerick 20 S Moderate | Search:

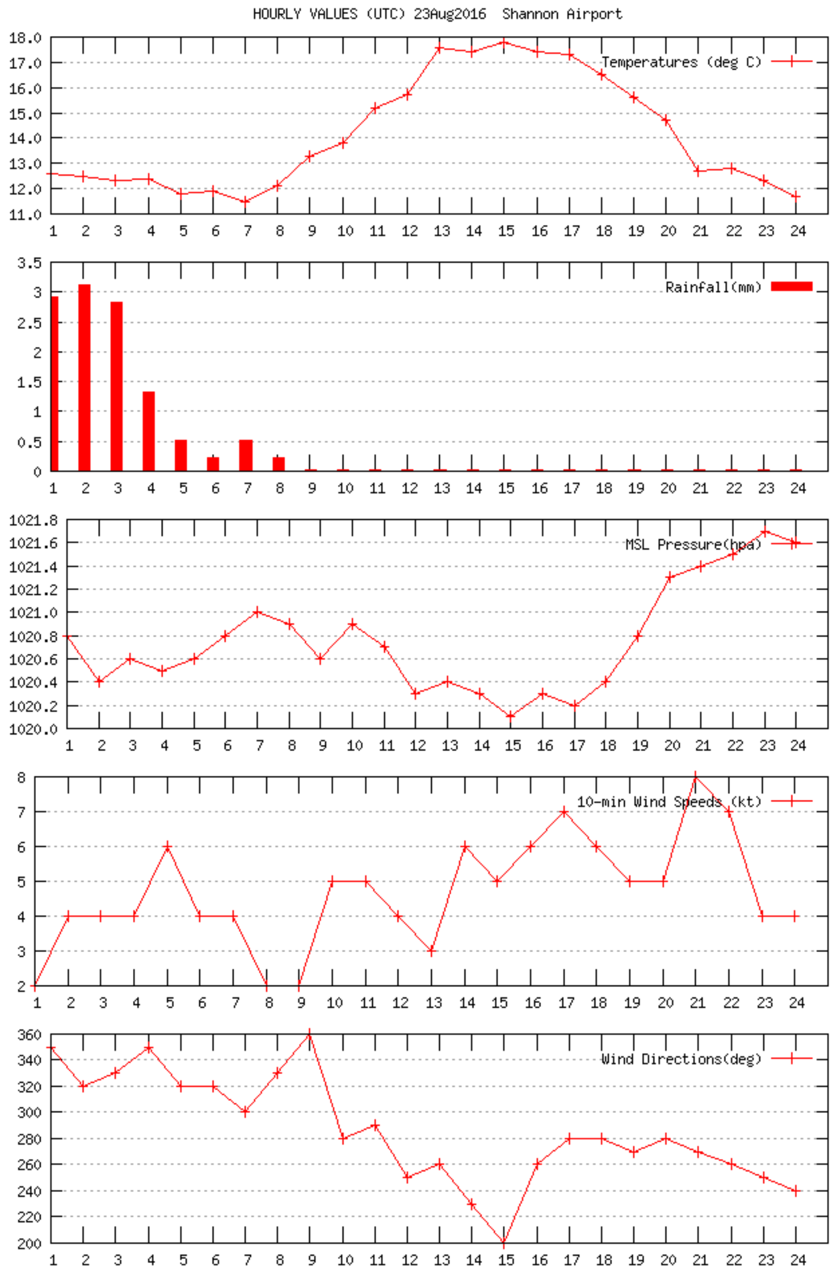
Daily Data

Weather Station Data - From 30/08/2014 to 29/08/2016

Please Select a Station and Date from the menu on the right.

REPORTS FROM SHANNON AIRPORT

Date	Rainfall (mm)	Max Temp (°C)	Min Temp (°C)	Grass Min Temp (°C)	Mean Wind Speed (knots)	Maximum Gust (if >= 34 knots)	Sunshine (hours)
23/8/2016	11.5	18.2	11.5	8.5	4.7		3



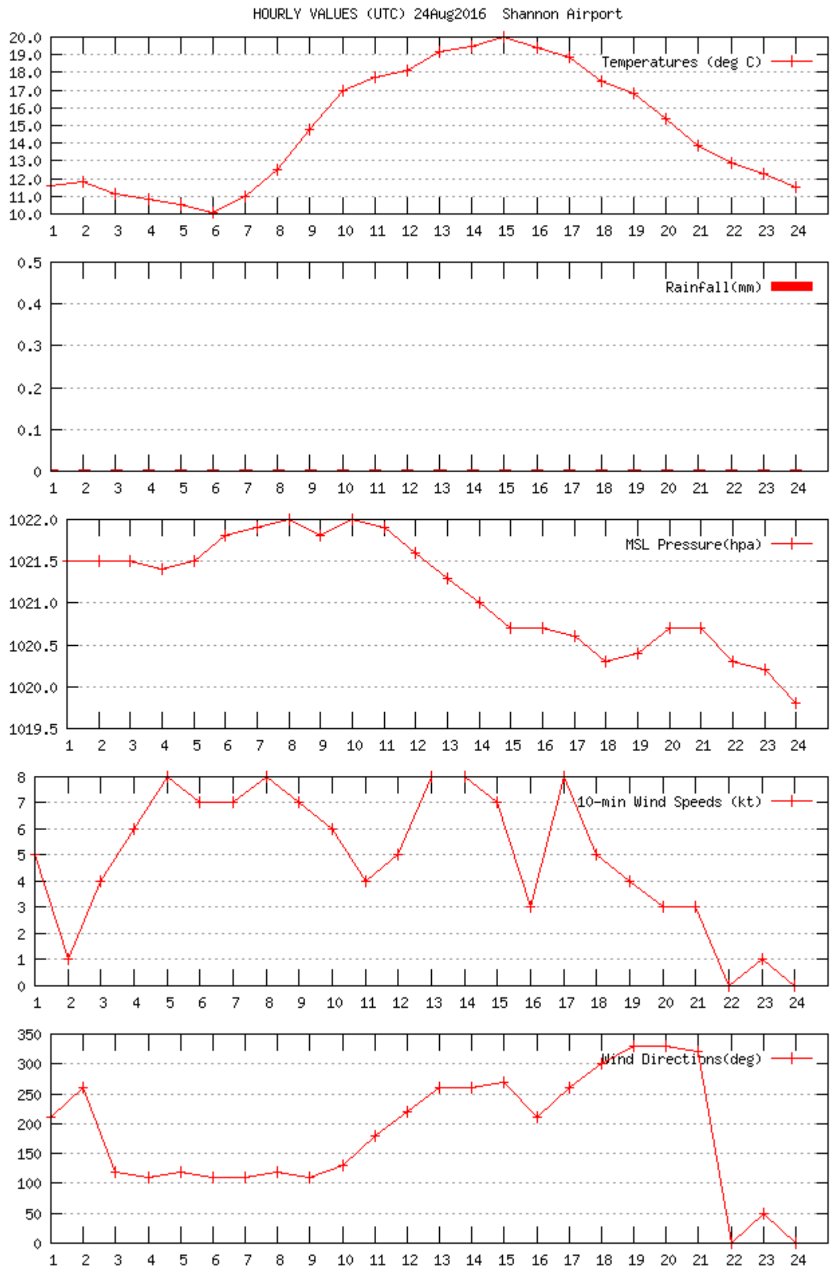
Daily Data

Weather Station Data - From 30/08/2014 to 29/08/2016

Please Select a Station and Date from the menu on the right.

REPORTS FROM SHANNON AIRPORT

Date	Rainfall (mm)	Max Temp (°C)	Min Temp (°C)	Grass Min Temp (°C)	Mean Wind Speed (knots)	Maximum Gust (if >= 34 knots)	Sunshine (hours)
24/8/2016	0	20.3	10.1	7	4.9		9.9



The Irish Meteorological Service Online

Tuesday, 30 August 2016 | Limerick 20 S Moderate | Search:

Home - Climate - Daily Data

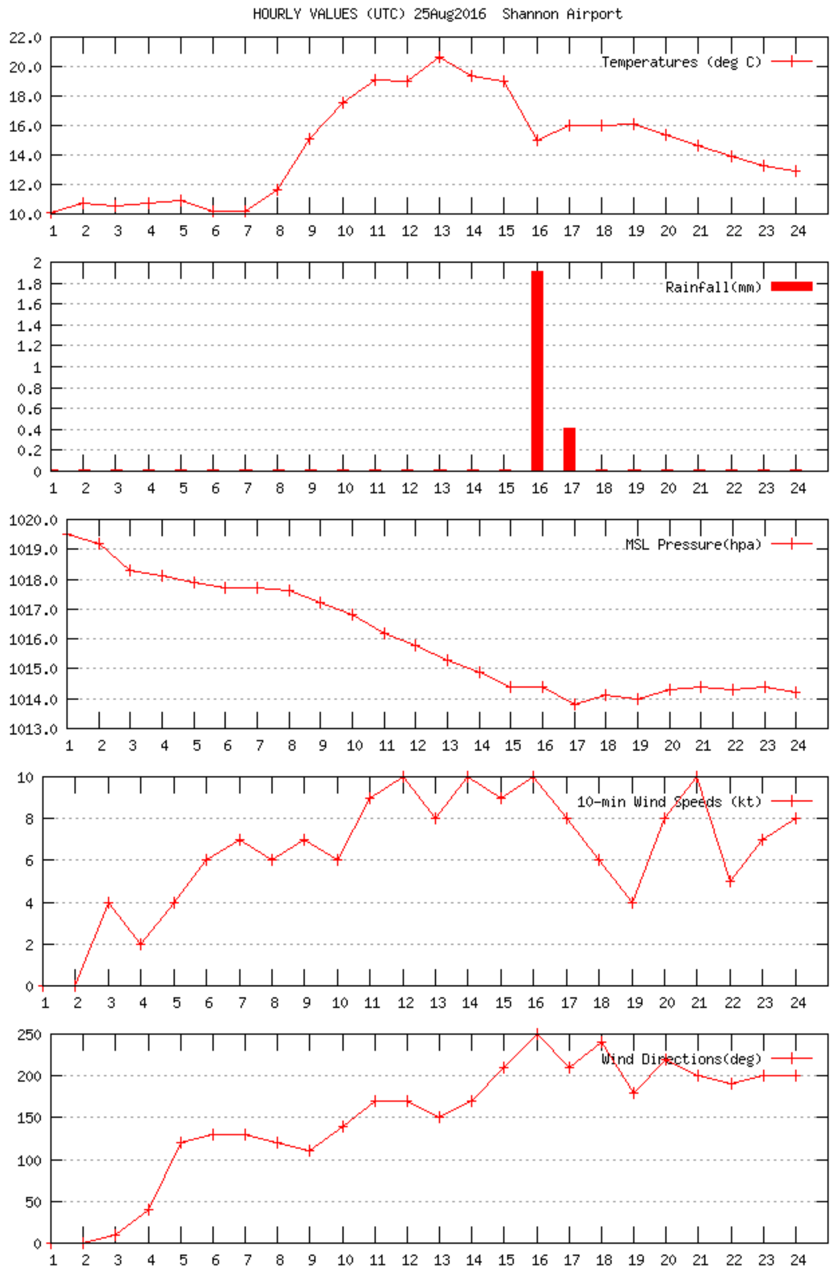
Daily Data

Weather Station Data - From 30/08/2014 to 29/08/2016

Please Select a Station and Date from the menu on the right.

REPORTS FROM SHANNON AIRPORT

Date	Rainfall (mm)	Max Temp (°C)	Min Temp (°C)	Grass Min Temp (°C)	Mean Wind Speed (knots)	Maximum Gust (if >= 34 knots)	Sunshine (hours)
25/8/2016	2.4	20.8	9.6	7.4	6.4		6.6



Attachment 3 - Certificates of Calibration

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Manufacturer Calibration Certificate

The following instrument has been tested and calibrated to the manufacturer specifications.
The calibration is traceable in accordance with ISO/IEC 17025 covering all instrument functions.

• Device Type:	M2230	consisting of		
		MA220	Serial Number:	5062
		Capsule	Serial Number:	8694

• Date of Calibration: 15 September 2015

• Results: PASSED
(for detailed report see next page)

Tested by: M.Frick

Signature:

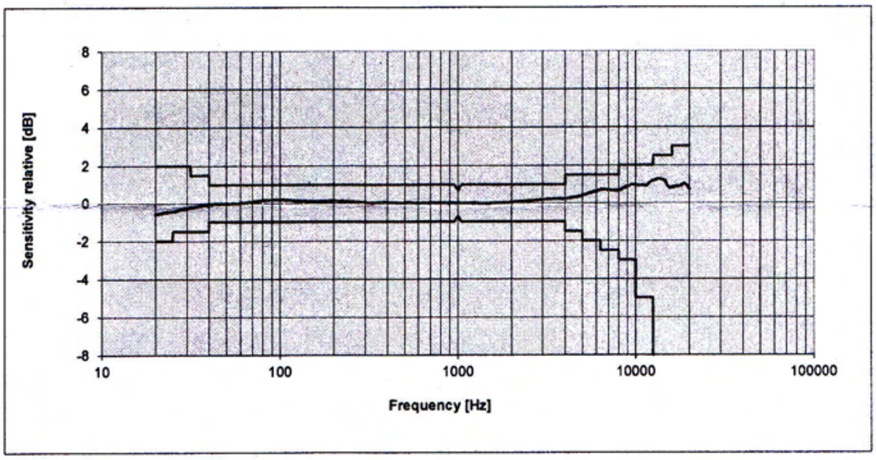
Stamp:

NTi Audio AG
Im alten Riet 102
LI - 9494 Schaan
www.nti-audio.com

Date:	15 September 2015		
Calibration of:	M2230 consisting of		
	MA220	Serial Number:	5062
	Capsule	Serial Number:	8694

- Detailed Calibration Test Results:

		actual	calibration uncertainty[1]
System calibration			
Sensitivity @ 1 kHz, 114 dBSPL		45.4 mV/Pa	±2.85%
Frequency response	Class 1	acc. IEC 61672	



- Test Conditions:

	Temperature:	25.7°C	±0.5 °C
	Relative Humidity:	43.4%	±2%
	Air Pressure:	95.98 kPa	±0.25 kPa

- Calibration Equipment Used:

- Norsonic Sound Calibrator, Type 1251, S/No. 30930
  Last Calibration: 3. Dec. 2014, Next Calibration: 2. Dec. 2016
  Calibrated by Metas, Switzerland

- NTi Audio FX100, S/No. 11094
  Last Calibration: 17. Aug. 2015, Next Calibration: 16. Aug. 2016
  Calibrated by NTi Audio meeting product specifications

- MTG MV203, S/No. 0630 / Mic Capsule, MK221 S./No. 13164
  Last Calibration: 26. Jun. 2014, Next Calibration: 25. Jun. 2016
  Calibrated by MTG, Germany

[1] The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with the regulations of the GUM.

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www.nti-audio.com • HR-Nr: 2.012.557 • MwStNr: 54306 • Bank: VP Bank, Vaduz, Acc No: 322.235.015

Sonitus Systems

Certificate of Calibration

Issued to:	Certificate Number
Redkite Environmental Ltd Huntersmoon Ballykeane Road Redcross Co. Wicklow	AC15002

Test Date: 12/11/2015
Procedure: TP-ACOCAL-1

Equipment Information

Item Calibrated:	Acoustic Calibrator	**Model:**	CAL200
Make:	Larson Davis (NTi)	**Serial Number:**	11728

Calibration Procedure

The above calibrator was verified in line with the requirements of BS EN 60942:2003. The calibrator was allowed to stablize for a suitable period, as described in the manufacturer's instruction manual, in laboratory conditions. The sound pressure level in the cavity (half-inch) was measured. The operating frequency and signal distortion were also measured.

Calibration Standards

Description	Serial Number	Calibration Date
National Instruments PXI-4461	19C91D2	29-12-2014
GRAS 42AA Pistonphone	227947	31-08-2015
GRAS 46A0 Pressure Field Microphone	228216	15-06-2015

The standards used in this calibration are traceable to NIST and/or other National Measurement Institutes (NMI's) that are signatories of the International Committee of Weights and Measures (CIPM) mutual recognition agreement (MRA).

Signed on behalf of Sonitus Systems:

Paul McDonald

Sonitus Systems

Calibration Report

Equipment Information

Model: CAL200
Serial Number: 11728

Ambient Conditions

Measurement conditions were within the tolerances defined in BS EN 60942.

Barometric Pressure: 102 hPa
Temperature: 21.7 °C
Relative Humidity: 45 %

Results

Calibrator Setting	Measured Parameter	Measured Value	Tolerance +/-	Uncertainty +/-
94 dB, 1KHz	Sound pressure level (dB)	93.97	0.4 dB	0.14 dB
	Frequency (Hz)	1000.44	10 Hz	0.25 Hz
	Distortion (%)	0.19	3.0 %	0.3 %
114 dB, 1KHz	Sound pressure level (dB)	113.97	0.4 dB	0.14 dB
	Frequency (Hz)	1000.42	10 Hz	0.25 Hz
	Distortion (%)	0.27	3.0 %	0.3 %

RESULT: PASS

As public evidence was available, from a testing organization responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in Annex A of IEC 60942:2003, the sound calibrator tested is considered to conform to all the Class 1 requirements of IEC 60942:2003

The manufacturers guidelines concerning free-field correction should be ovserved when using the calibrator.

Notes

1. All measurements were made with the half-inch configuration of the calibrator in place.
2. The measurement uncertainty is reported as a standard uncertainty multiplied by a coverage factor k=2 which, for a normal probabbility distribution, corresponds to a coverage probability of approximately 95%.
3. The given uncertainty corresponds to measured values only and does not relate to the long term stability of the device under test.
4. The user manual for the device under test was obtained from the manufacturer's website.

Attachment 4 - Photo Log

Committed to your success

Plate 01: NSL1

Plate 02: NSL2

Plate 03: NSL3

Plate 04: NSL4

Plate 05: NSL5

Plate 06: B1

Plate 07: B2

Plate 08: B3

Plate 09: B4

Plate 10: B5

Plate 11: B6

Plate 12: B7

Plate 13: B8

Plate 14: B9

Attachment 5 - Noise Monitoring Report Sheets

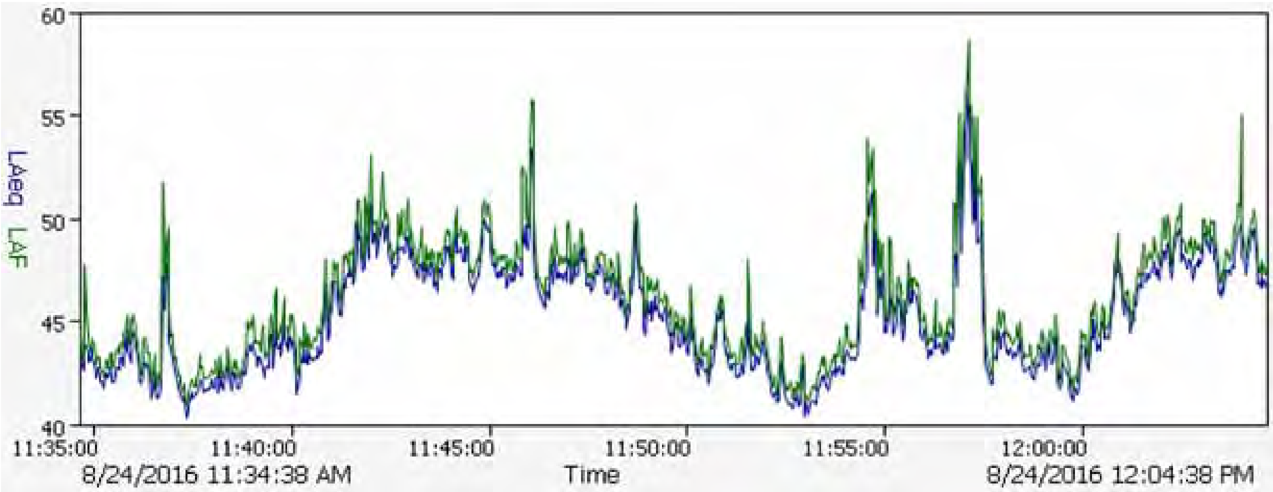
Cirrus Research plc

Measurement Summary Report

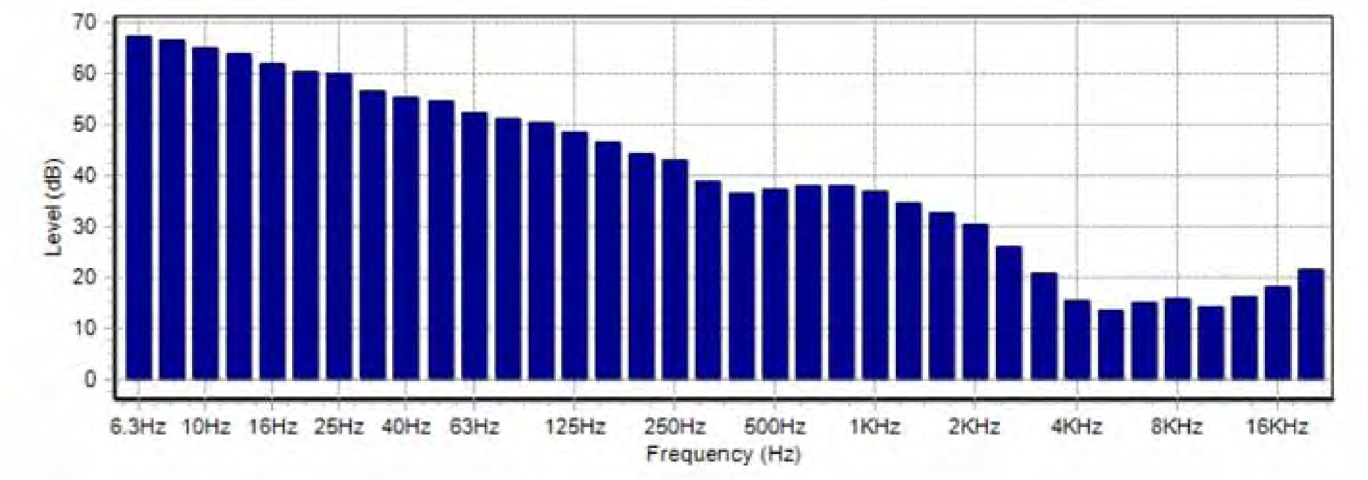
Name	NSL1 Daytime #1	**Summary**		LAF1	52.3 dB
Time	8/24/2016 11:34:38 AM	LAeq	46.1 dB	LAF5	49.3 dB
Duration	00:30:00	LAE	78.7 dB	LAF10	48.6 dB
Instrument	GO56143, CR:171B	LAFMax	58.6 dB	LAF50	44.8 dB
				LAF90	41.8 dB
				LAF95	41.4 dB
				LAF99	40.7 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 11:13:44 AM	-0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:11:36 PM	0.12 dB			

Time History



Frequency Bands



Report ID

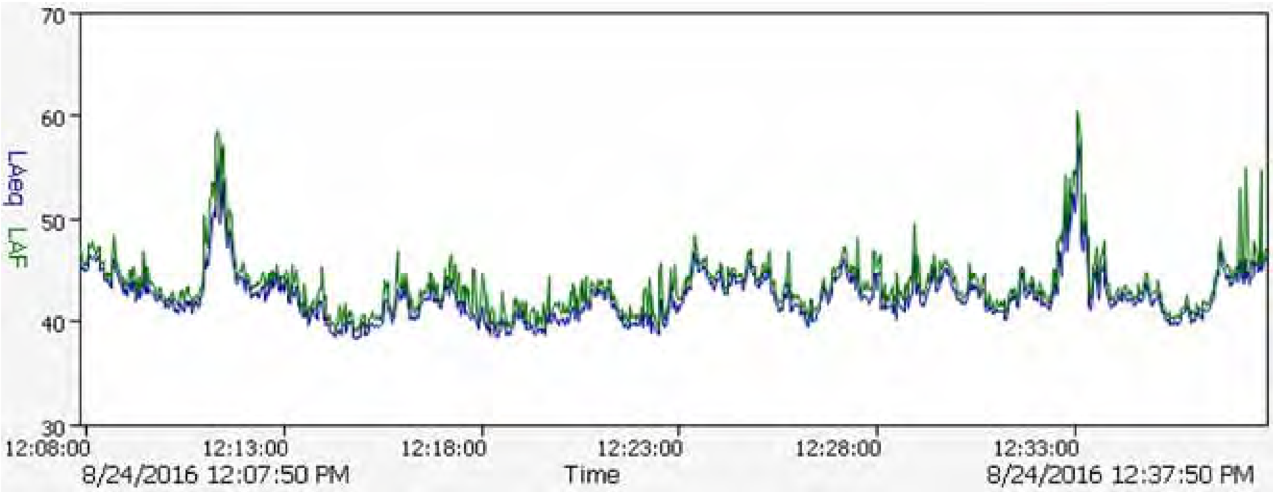
Cirrus Research plc

Measurement Summary Report

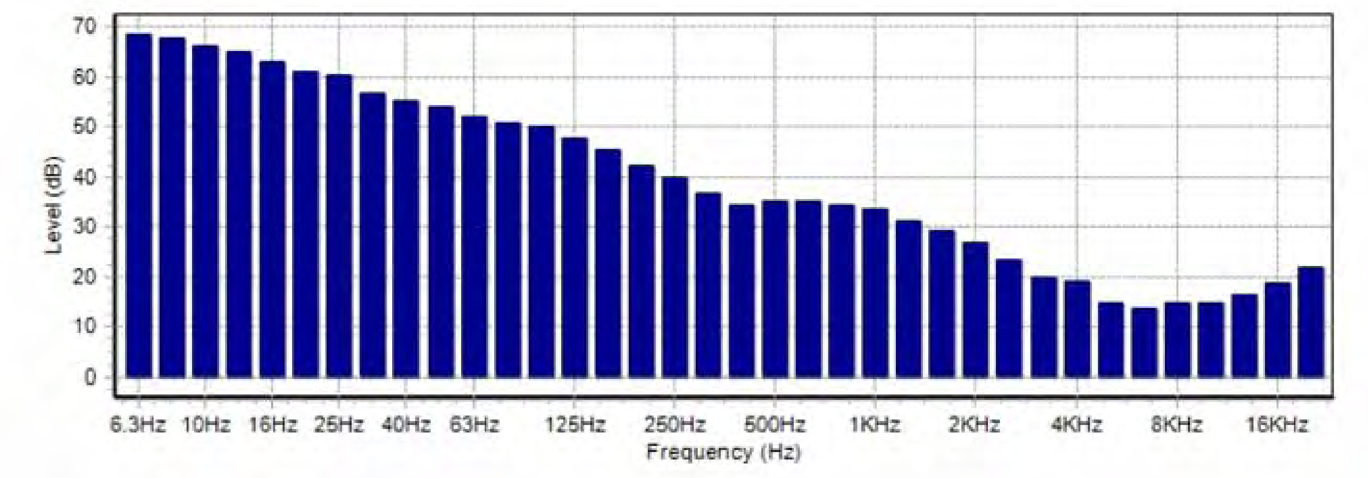
Name	NSL1 Daytime #2	**Summary**		LAF1	52.0 dB
Time	8/24/2016 12:07:50 PM	LAeq	43.6 dB	LAF5	46.4 dB
Duration	00:30:00	LAE	76.2 dB	LAF10	45.2 dB
Instrument	GO56143, CR:171B	LAFMax	60.4 dB	LAF50	42.1 dB
				LAF90	39.5 dB
				LAF95	39.0 dB
				LAF99	38.3 dB

Calibration Information		Person	Place	Project
8/24/2016 11:13:44 AM	-0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:11:36 PM	0.12 dB			

Time History



Frequency Bands



Report ID

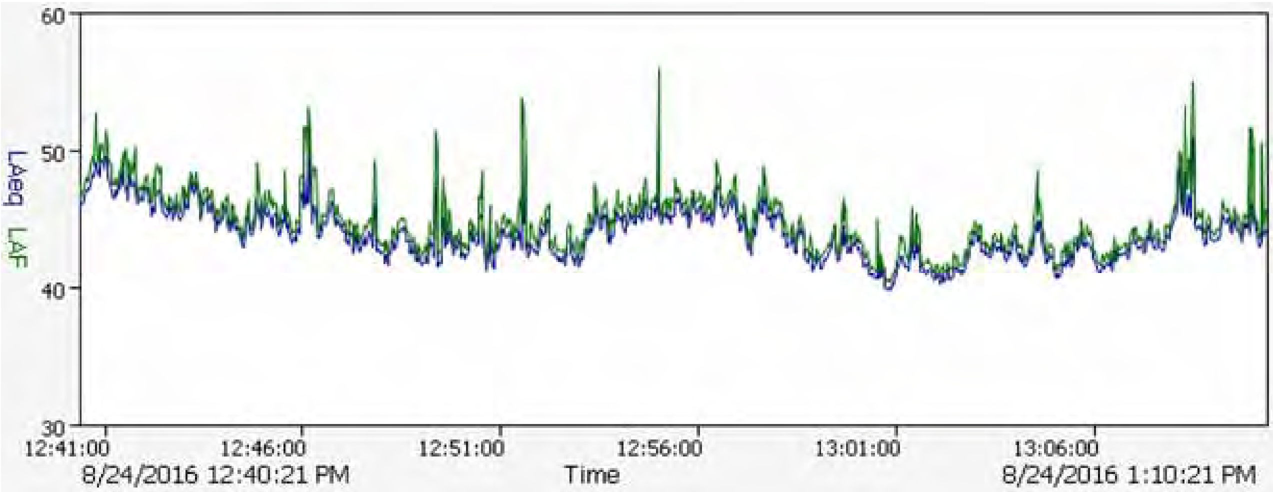
Cirrus Research plc

Measurement Summary Report

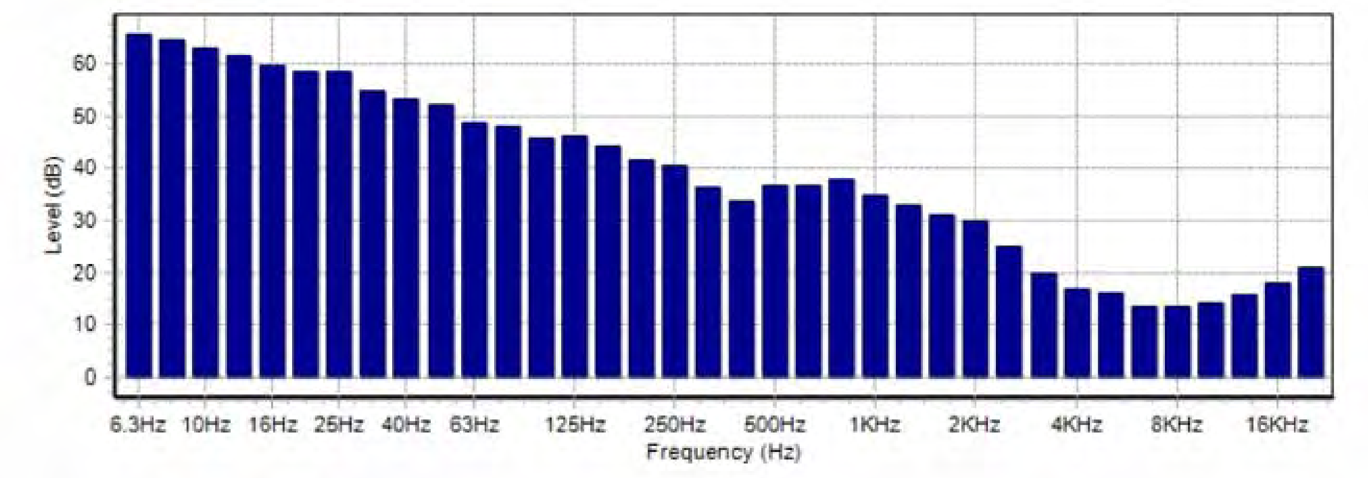
Name	NSL1 Daytime #3	**Summary**		LAF1	48.9 dB
Time	8/24/2016 12:40:21 PM	LAeq	44.4 dB	LAF5	47.2 dB
Duration	00:30:00	LAE	76.9 dB	LAF10	46.3 dB
Instrument	GO56143, CR:171B	LAFMax	56.0 dB	LAF50	43.7 dB
				LAF90	41.5 dB
				LAF95	41.0 dB
				LAF99	40.2 dB

Calibration Information		Person	Place	Project
8/24/2016 11:13:44 AM	-0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:11:36 PM	0.12 dB			

Time History



Frequency Bands

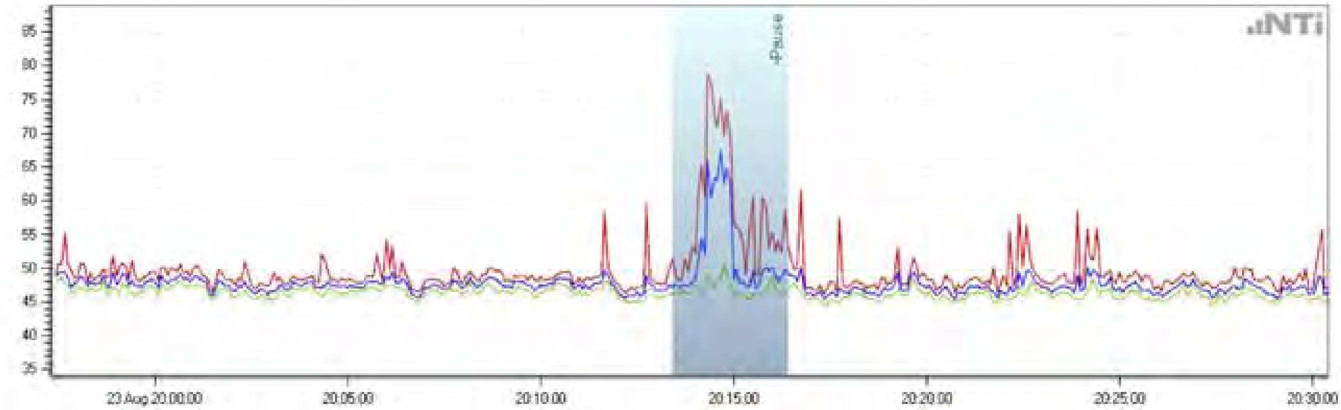


Report ID

NSL1 Evening #1

Start: 2016-08-23 19:57:24

End: 2016-08-23 20:30:22.2



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

Range: 20 - 120 dB

LN based on: LAeq_dt

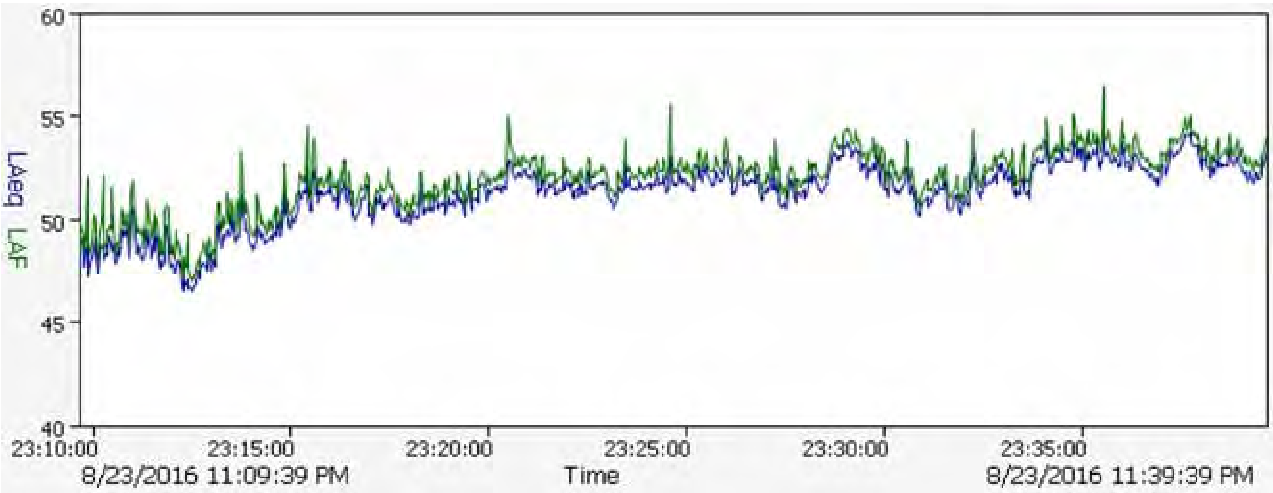
Cirrus Research plc

Measurement Summary Report

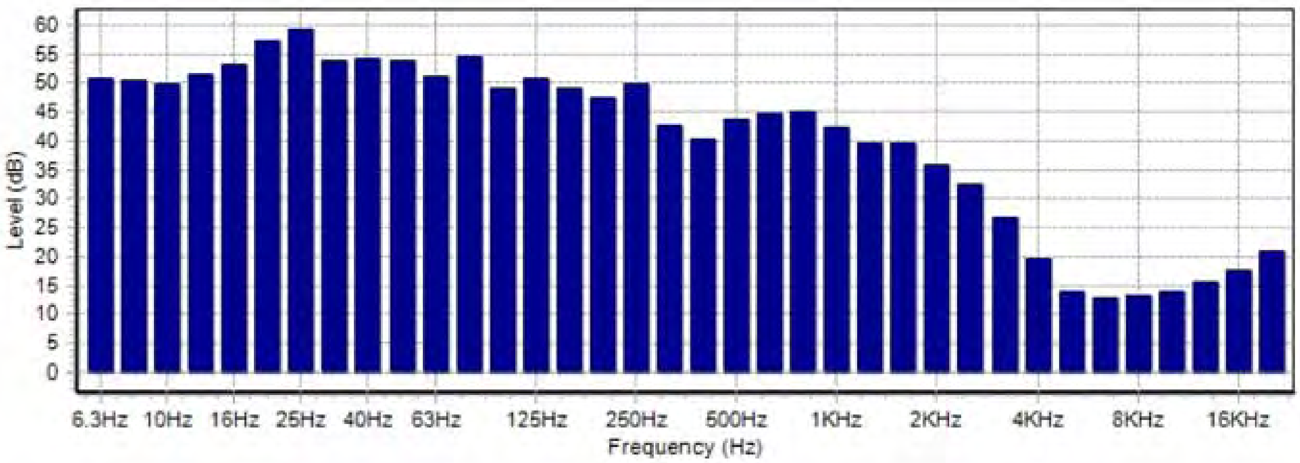
Name	NSL1 Night time #1	**Summary**		LAF1	53.9 dB
Time	8/23/2016 11:09:39 PM	LAeq	51.5 dB	LAF5	53.3 dB
Duration	00:30:00	LAE	84.0 dB	LAF10	52.9 dB
Instrument	GO56143, CR:171B	LAFMax	56.5 dB	LAF50	51.5 dB
				LAF90	48.8 dB
				LAF95	48.0 dB
				LAF99	46.9 dB

Calibration Information		**Person**	**Place**	**Project**
8/23/2016 10:44:33 PM	0.21 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 12:25:09 AM	-0.15 dB			

Time History



Frequency Bands



Report ID

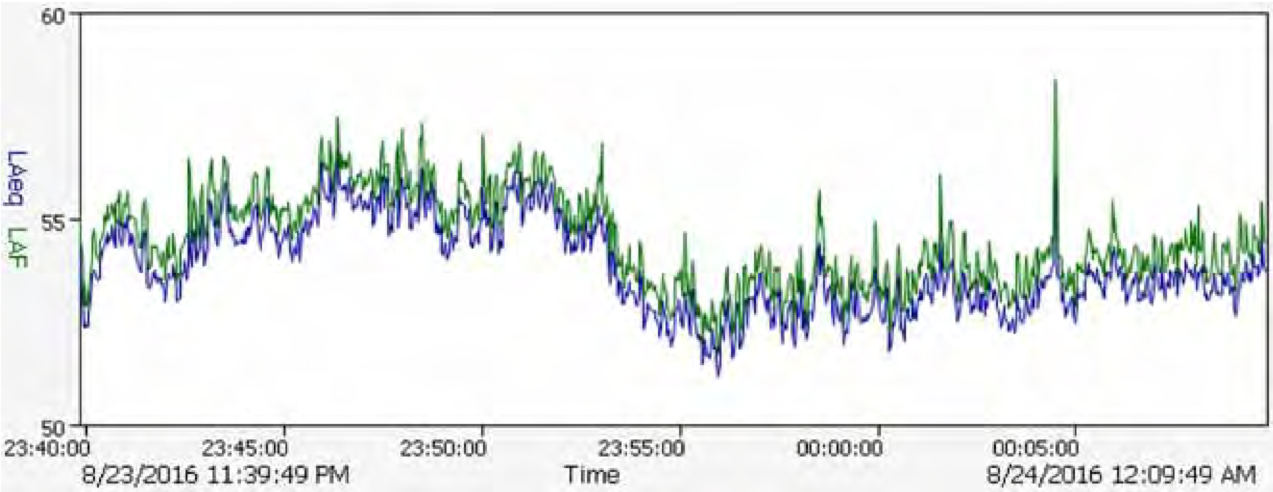
Cirrus Research plc

Measurement Summary Report

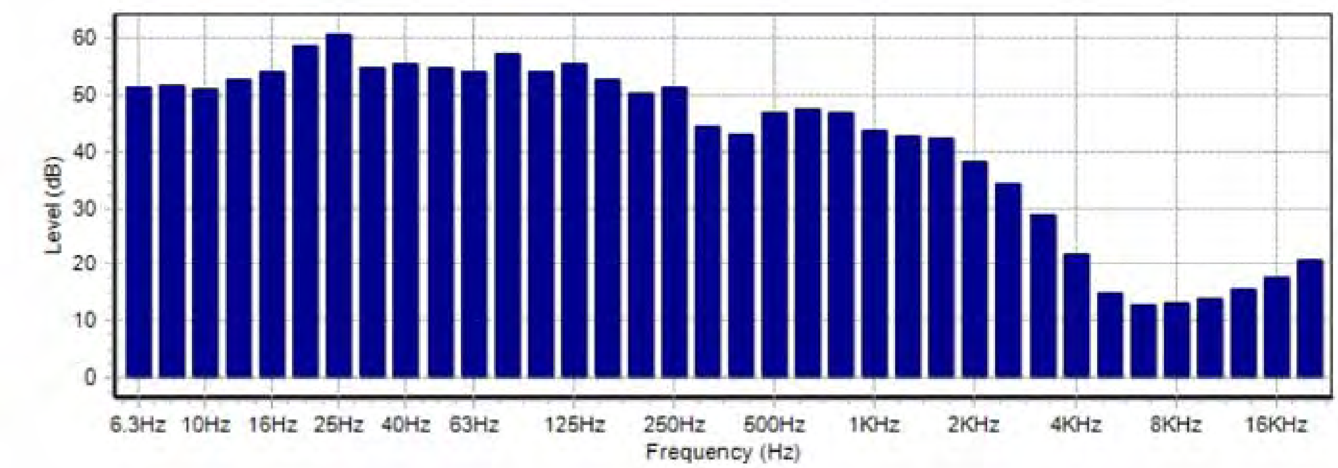
Name	NSL1 Night time #2	**Summary**		LAF1	56.1 dB
Time	8/23/2016 11:39:49 PM	LAeq	54.0 dB	LAF5	55.6 dB
Duration	00:30:00	LAE	86.5 dB	LAF10	55.3 dB
Instrument	GO56143, CR:171B	LAFMax	58.3 dB	LAF50	53.6 dB
				LAF90	52.4 dB
				LAF95	52.1 dB
				LAF99	51.6 dB

Calibration Information		Person	Place	Project
8/23/2016 10:44:33 PM	0.21 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 12:25:09 AM	-0.15 dB			

Time History



Frequency Bands



Report ID

Date Printed 9/2/2016

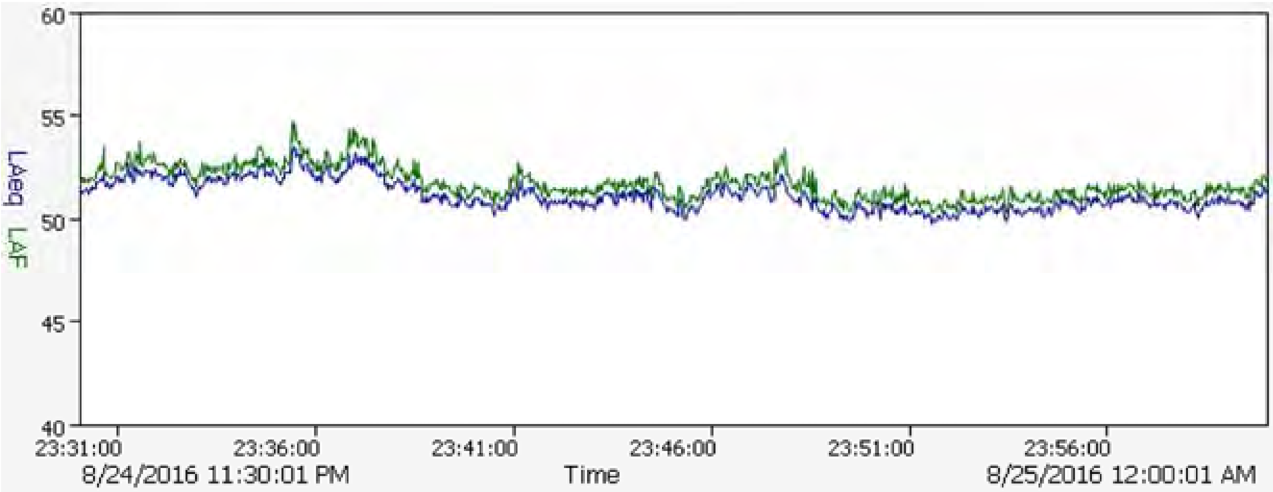
Cirrus Research plc

Measurement Summary Report

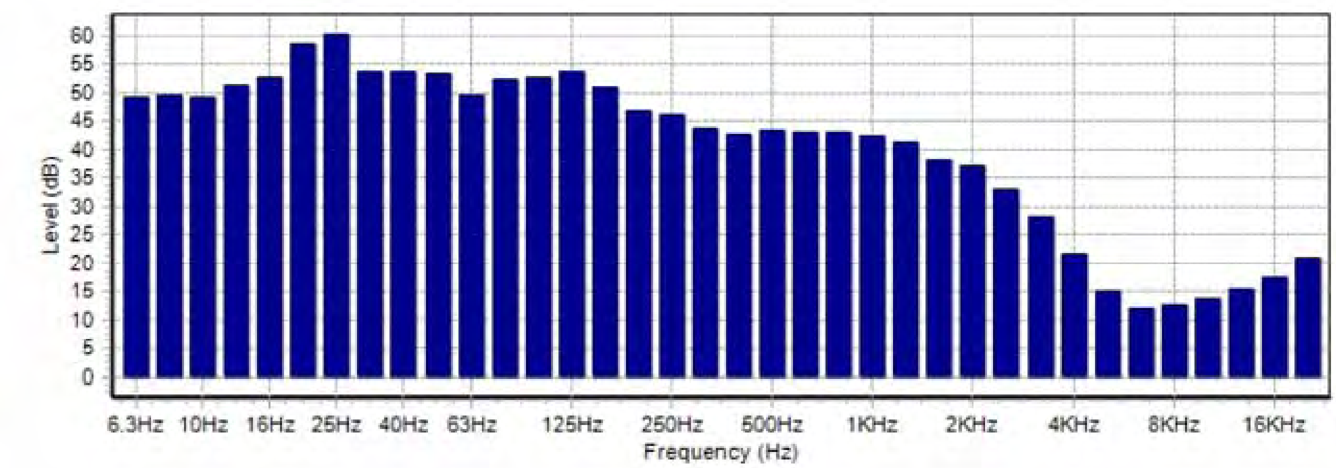
Name	NSL1 Night #3	**Summary**		LAF1	53.0 dB
Time	8/24/2016 11:30:01 PM	LAeq	51.2 dB	LAF5	52.4 dB
Duration	00:30:00	LAE	83.7 dB	LAF10	52.1 dB
Instrument	GO56143, CR:171B	LAFMax	54.7 dB	LAF50	50.9 dB
				LAF90	50.2 dB
				LAF95	50.0 dB
				LAF99	49.7 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 11:07:28 PM	0.36 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/25/2016 3:23:38 AM	0.10 dB			

Time History



Frequency Bands



Report ID

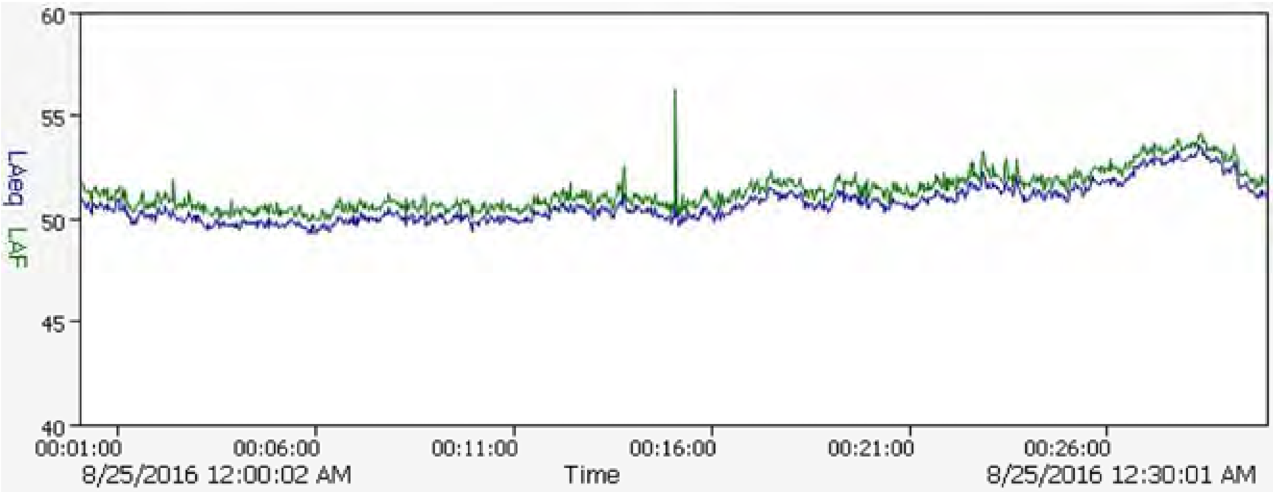
Cirrus Research plc

Measurement Summary Report

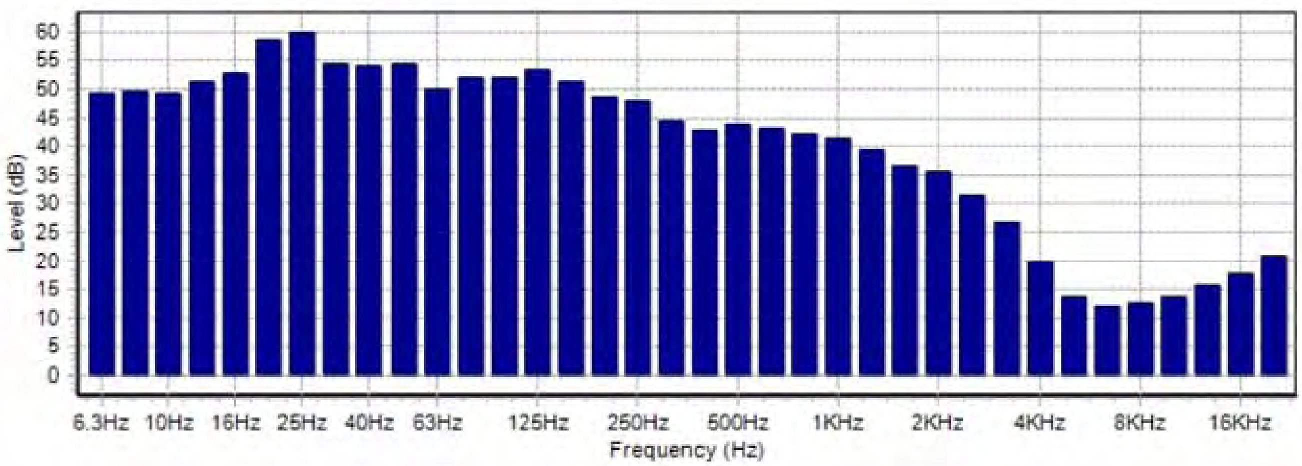
Name	NSL1 Night #4	**Summary**		LAF1	53.2 dB
Time	8/25/2016 12:00:02 AM	LAeq	50.8 dB	LAF5	52.7 dB
Duration	00:30:00	LAE	83.4 dB	LAF10	52.0 dB
Instrument	GO56143, CR:171B	LAFMax	56.2 dB	LAF50	50.5 dB
				LAF90	49.7 dB
				LAF95	49.5 dB
				LAF99	49.2 dB

Calibration Information		Person	Place	Project
8/24/2016 11:07:28 PM	0.36 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/25/2016 3:23:38 AM	0.10 dB			

Time History



Frequency Bands



Report ID

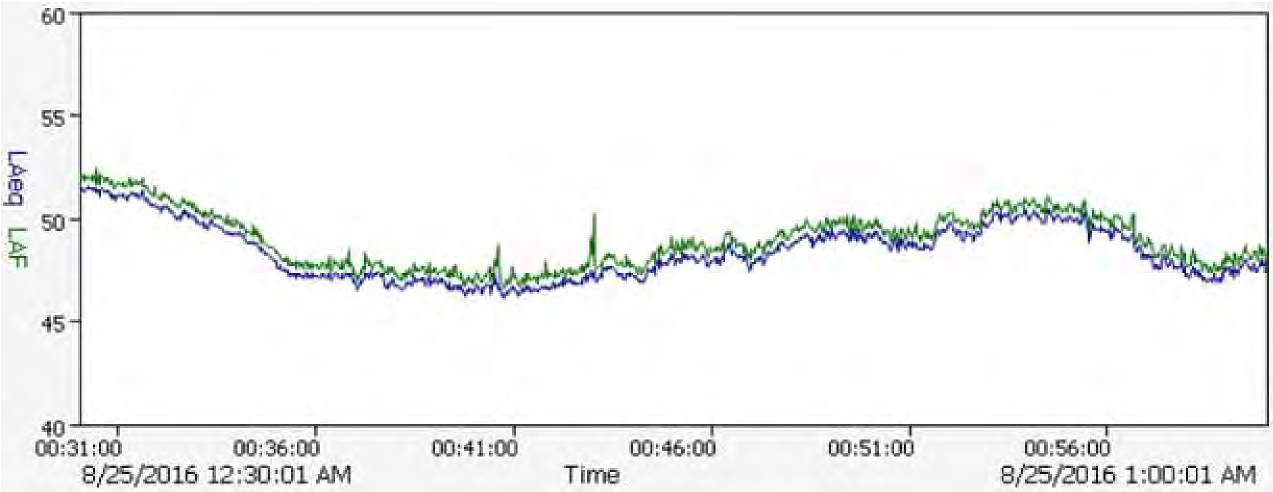
Cirrus Research plc

Measurement Summary Report

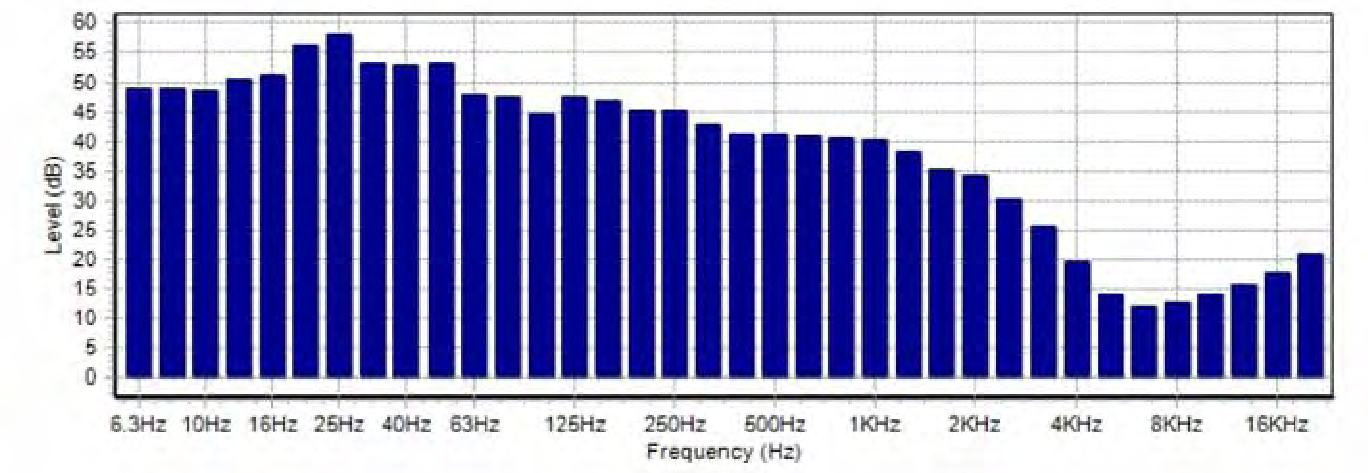
Name	NSL1 Night #5	**Summary**		LAF1	51.4 dB
Time	8/25/2016 12:30:01 AM	LAeq	48.6 dB	LAF5	50.9 dB
Duration	00:30:00	LAE	81.2 dB	LAF10	50.2 dB
Instrument	GO56143, CR:171B	LAFMax	52.4 dB	LAF50	48.2 dB
				LAF90	46.7 dB
				LAF95	46.5 dB
				LAF99	46.2 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 11:07:28 PM	0.36 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/25/2016 3:23:38 AM	0.10 dB			

Time History



Frequency Bands



Report ID

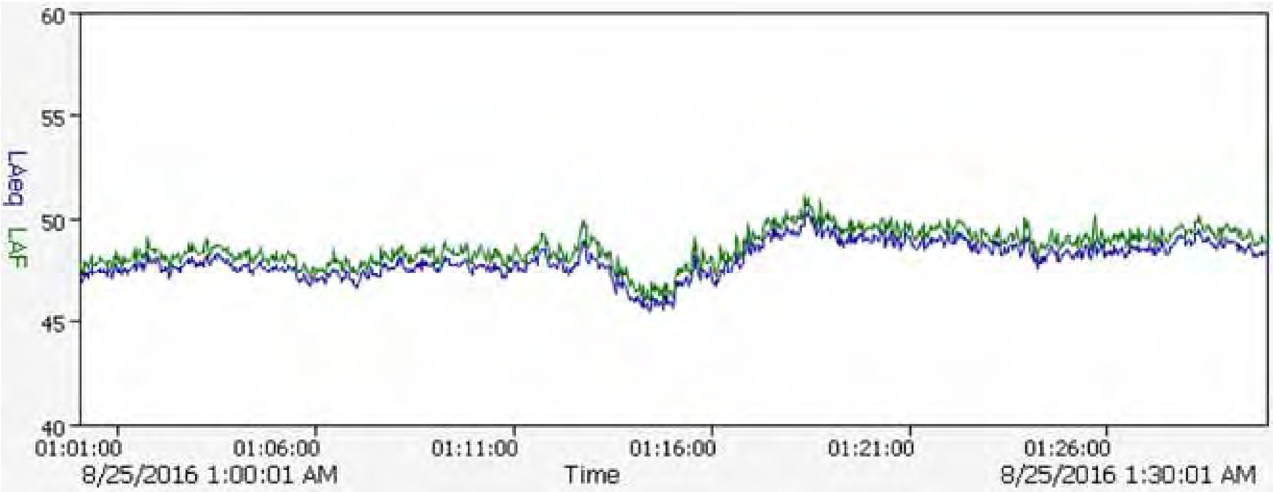
Cirrus Research plc

Measurement Summary Report

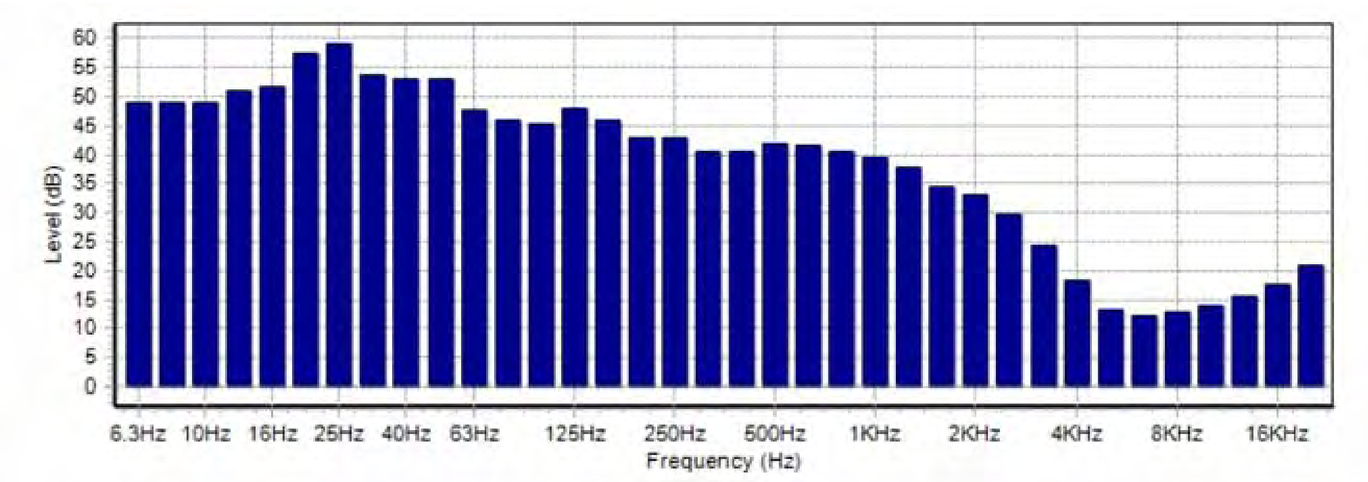
Name	NSL1 Night #6	**Summary**		LAF1	49.8 dB
Time	8/25/2016 1:00:01 AM	LAeq	48.1 dB	LAF5	49.3 dB
Duration	00:30:00	LAE	80.7 dB	LAF10	49.1 dB
Instrument	GO56143, CR:171B	LAFMax	51.1 dB	LAF50	48.0 dB
				LAF90	47.0 dB
				LAF95	46.5 dB
				LAF99	45.7 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 11:07:28 PM	0.36 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/25/2016 3:23:38 AM	0.10 dB			

Time History



Frequency Bands



Report ID

Cirrus Research plc

Measurement Summary Report

Name	NSL1 Night #7
Time	8/25/2016 1:30:01 AM
Duration	00:30:00
Instrument	GO56143, CR:171B

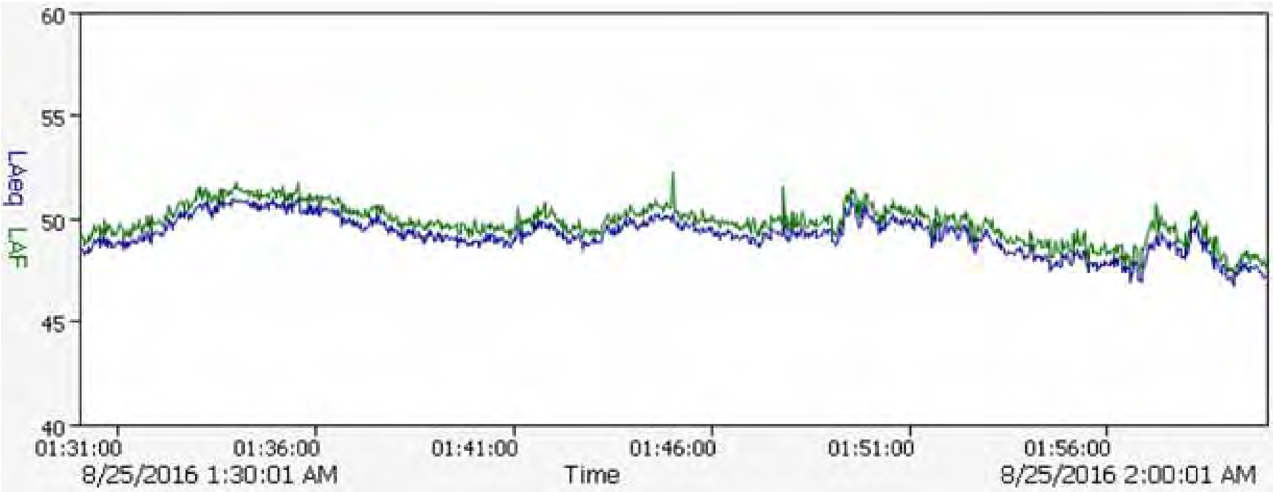
Summary

LAeq	49.3 dB
LAE	81.9 dB
LAFMax	52.3 dB

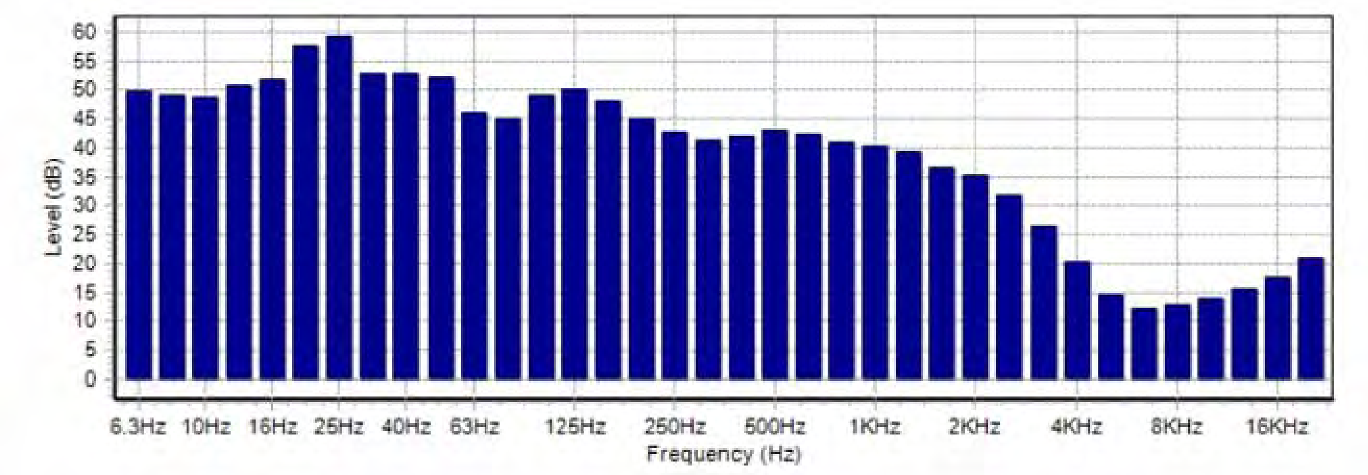
LAF1	51.0 dB
LAF5	50.6 dB
LAF10	50.4 dB
LAF50	49.2 dB
LAF90	47.9 dB
LAF95	47.5 dB
LAF99	47.0 dB

Calibration Information		Person	Place	Project
8/24/2016 11:07:28 PM	0.36 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/25/2016 3:23:38 AM	0.10 dB			

Time History



Frequency Bands



Report ID

Cirrus Research plc

Measurement Summary Report

Name	NSL1 Night #8
Time	8/25/2016 2:00:01 AM
Duration	00:30:00
Instrument	GO56143, CR:171B

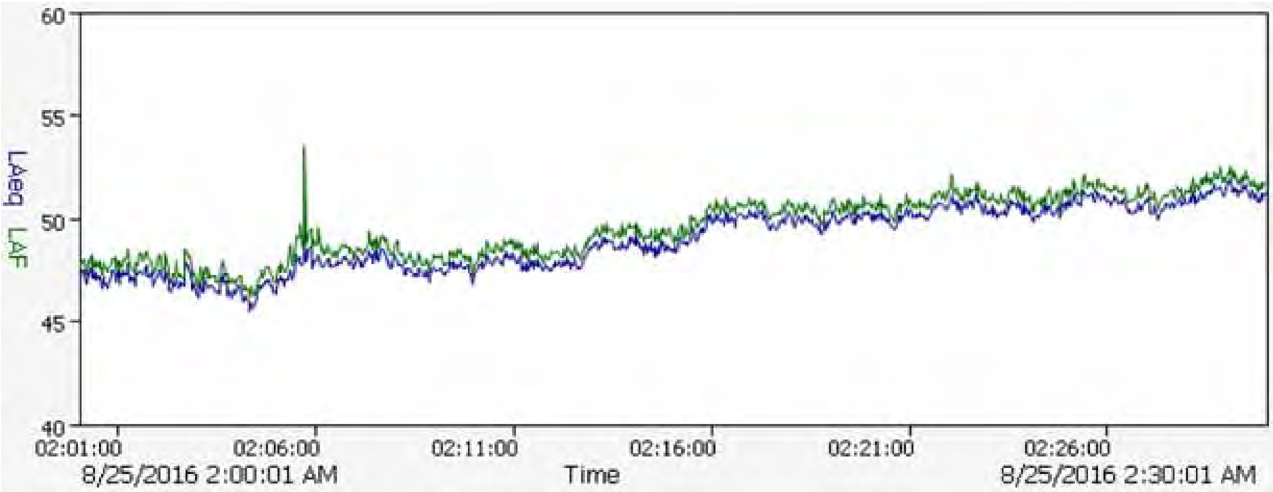
Summary

LAeq	49.2 dB
LAE	81.8 dB
LAFMax	53.5 dB

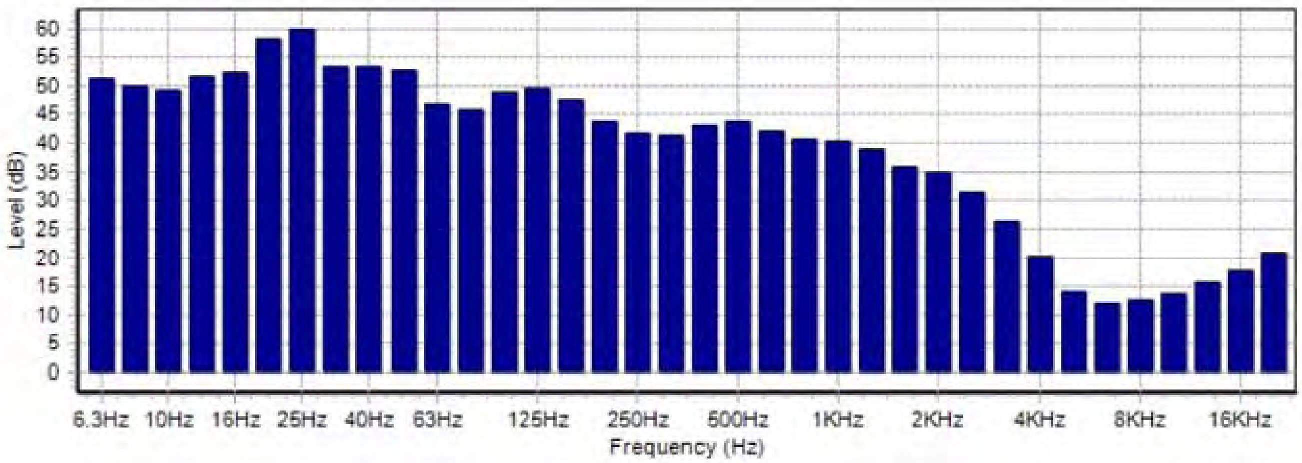
LAF1	51.6 dB
LAF5	51.2 dB
LAF10	50.9 dB
LAF50	48.9 dB
LAF90	46.9 dB
LAF95	46.5 dB
LAF99	46.0 dB

Calibration Information		Person	Place	Project
8/24/2016 11:07:28 PM	0.36 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/25/2016 3:23:38 AM	0.10 dB			

Time History



Frequency Bands



Report ID

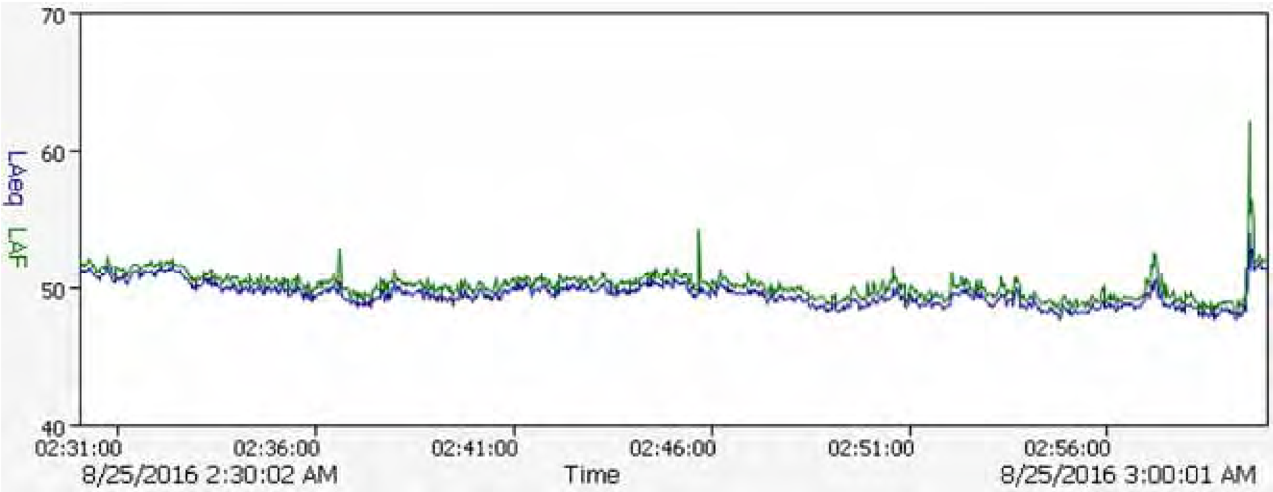
Cirrus Research plc

Measurement Summary Report

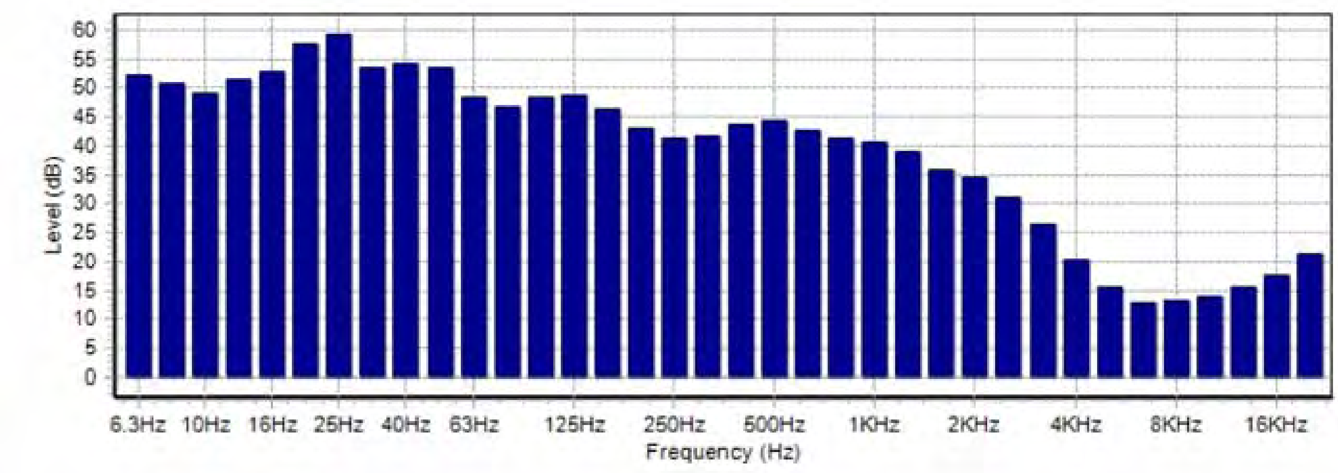
Name	NSL1 Night #9	**Summary**		LAF1	51.5 dB
Time	8/25/2016 2:30:02 AM	LAeq	49.6 dB	LAF5	51.1 dB
Duration	00:30:00	LAE	82.1 dB	LAF10	50.6 dB
Instrument	GO56143, CR:171B	LAFMax	62.1 dB	LAF50	49.4 dB
				LAF90	48.3 dB
				LAF95	48.1 dB
				LAF99	47.7 dB

Calibration Information		Person	Place	Project
8/24/2016 11:07:28 PM	0.36 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/25/2016 3:23:38 AM	0.10 dB			

Time History



Frequency Bands

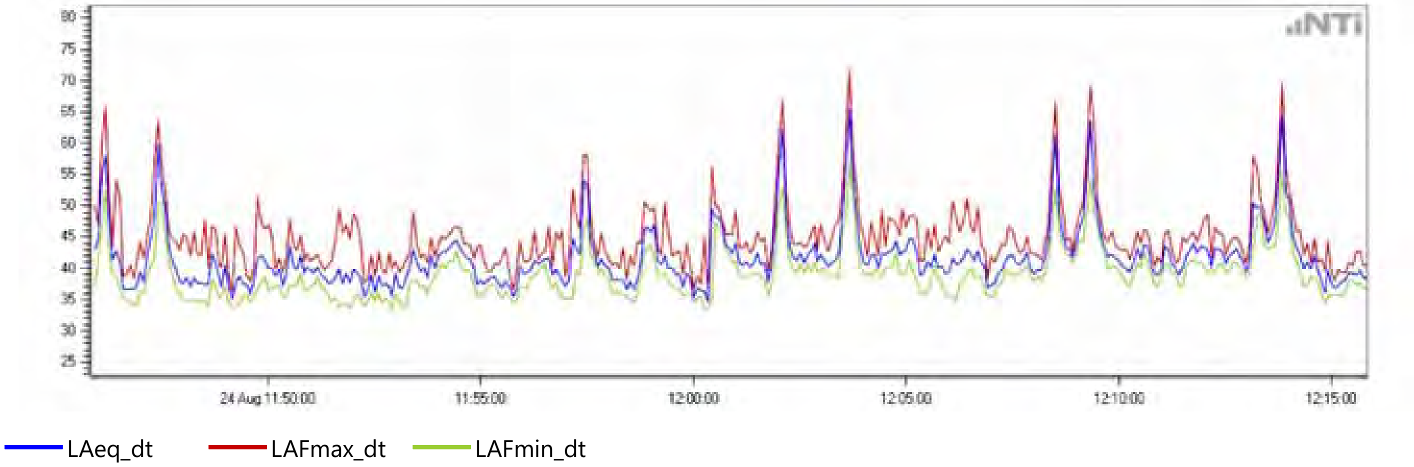


Report ID

NSL2 Daytime #1

Start: 2016-08-24 11:45:50

End: 2016-08-24 12:15:50



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-24 11:43

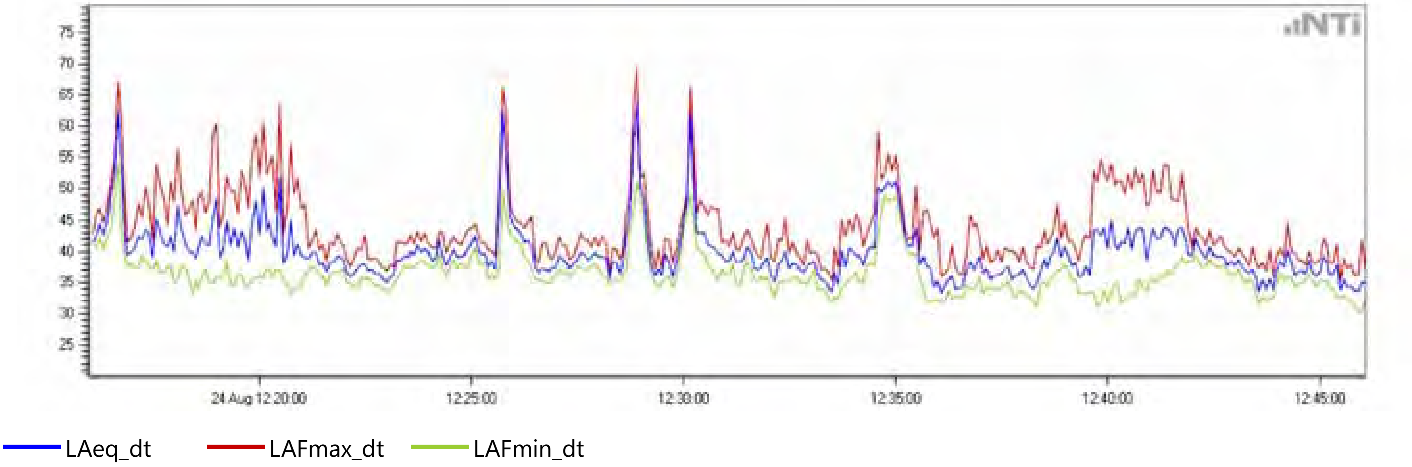
Mic Sensitivity: 43.8 mV/Pa

Range: 20 - 120 dB

NSL2 Daytime #2

Start: 2016-08-24 12:16:04

End: 2016-08-24 12:46:04



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-24 11:43

Mic Sensitivity: 43.8 mV/Pa

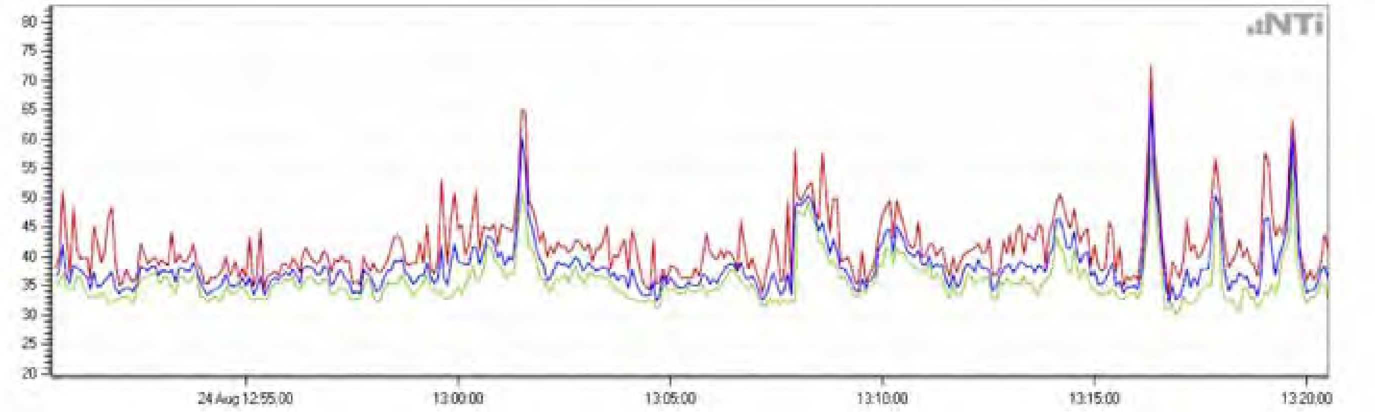
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL2 Daytime #3

Start: 2016-08-24 12:50:28

End: 2016-08-24 13:20:28



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-24 11:43

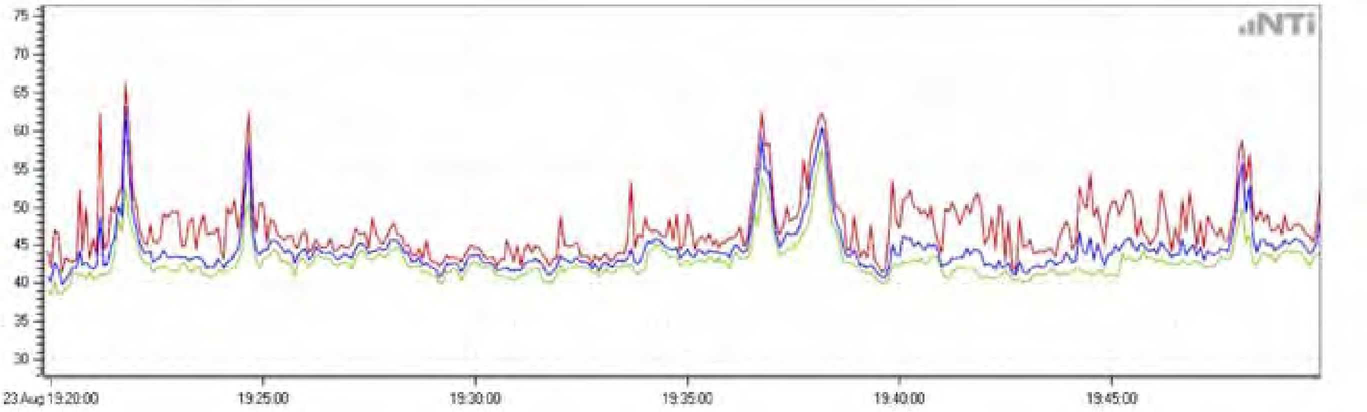
Mic Sensitivity: 43.8 mV/Pa

Range: 20 - 120 dB

NSL2 Evening #1

Start: 2016-08-23 19:19:52

End: 2016-08-23 19:49:52



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

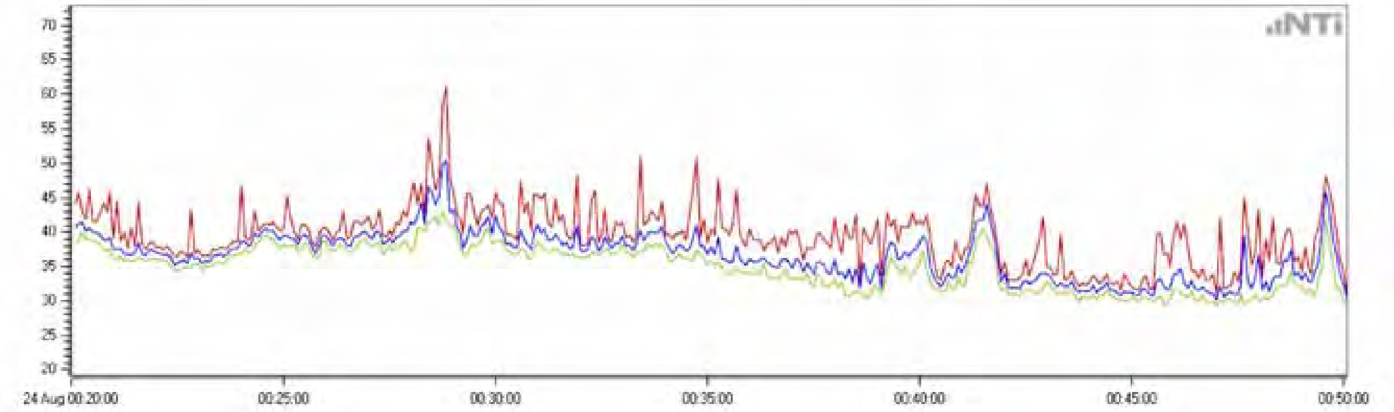
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL2 Night time #1

Start: 2016-08-24 00:20:02

End: 2016-08-24 00:50:02



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

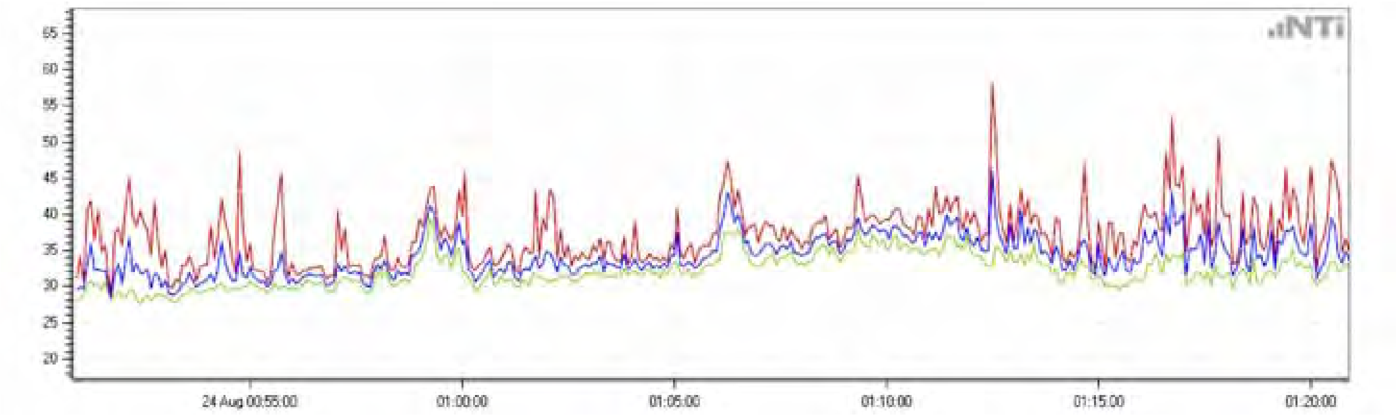
Mic Sensitivity: 43.7 mV/Pa

Range: 20 - 120 dB

NSL2 Night time #2

Start: 2016-08-24 00:50:52

End: 2016-08-24 01:20:52



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

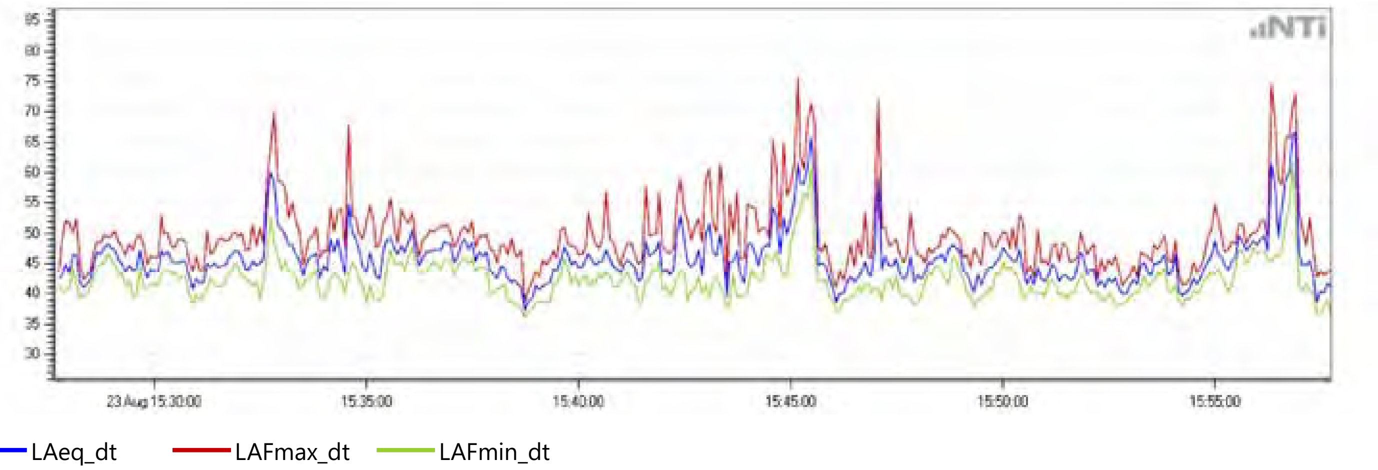
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL3 Daytime #1

Start: 2016-08-23 15:27:44

End: 2016-08-23 15:57:44



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 13:32

Mic Sensitivity: 43.7 mV/Pa

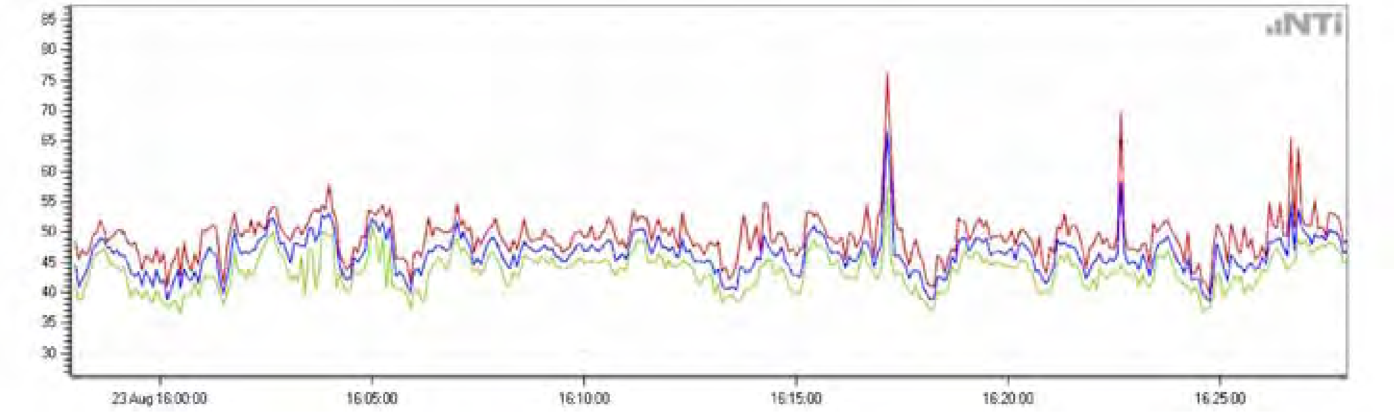
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL3 Daytime #2

Start: 2016-08-23 15:57:58

End: 2016-08-23 16:27:58



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 13:32

Mic Sensitivity: 43.7 mV/Pa

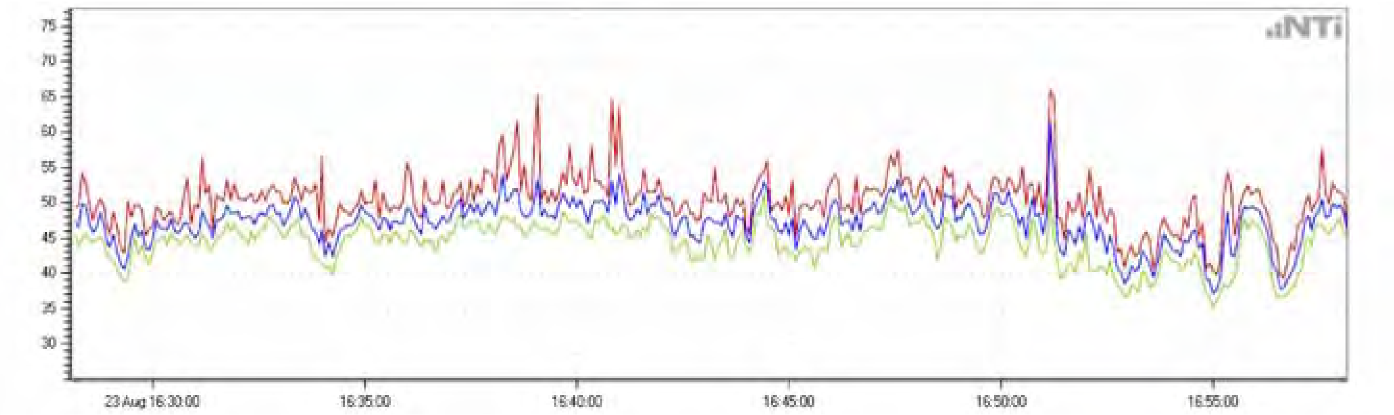
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL3 Daytime #3

Start: 2016-08-23 16:28:06

End: 2016-08-23 16:58:06



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 13:32

Mic Sensitivity: 43.7 mV/Pa

Range: 20 - 120 dB

LN based on: LAeq_dt

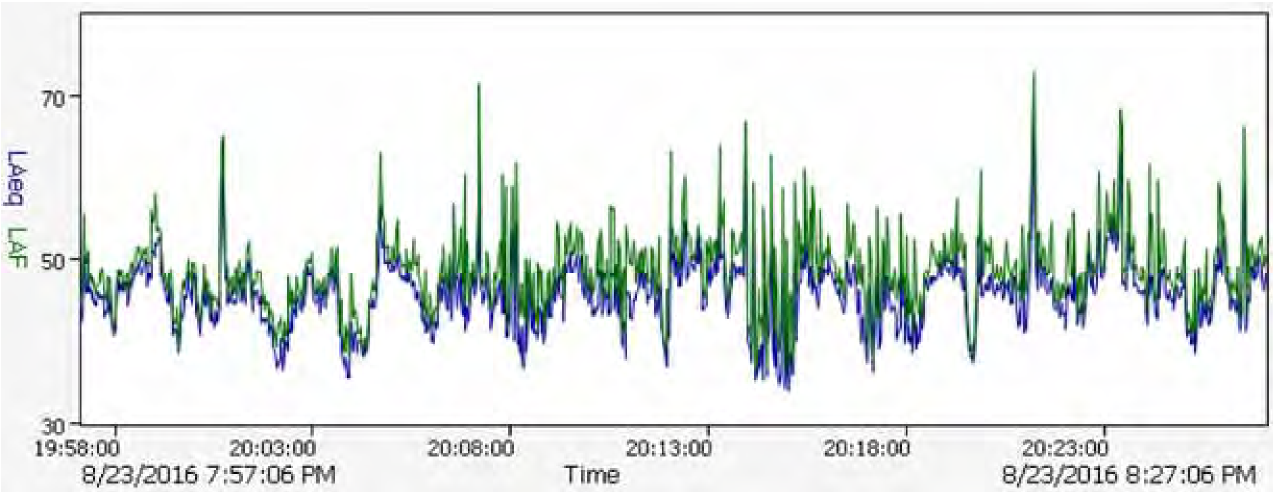
Cirrus Research plc

Measurement Summary Report

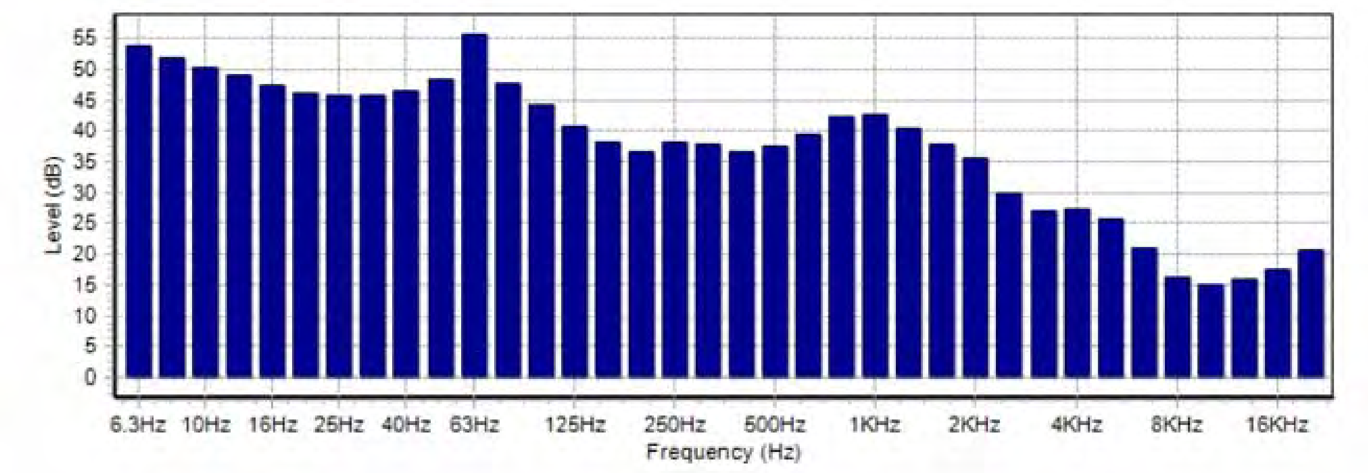
Name	NSL3 Evening #1	**Summary**		LAF1	57.2 dB
Time	8/23/2016 7:57:06 PM	LAeq	48.8 dB	LAF5	51.6 dB
Duration	00:30:00	LAE	81.3 dB	LAF10	50.0 dB
Instrument	GO56143, CR:171B	LAFMax	72.7 dB	LAF50	45.4 dB
				LAF90	39.4 dB
				LAF95	37.6 dB
				LAF99	34.5 dB

Calibration Information		**Person**	**Place**	**Project**
8/23/2016 7:13:08 PM	0.08 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/23/2016 10:44:33 PM	0.21 dB			

Time History



Frequency Bands



Report ID

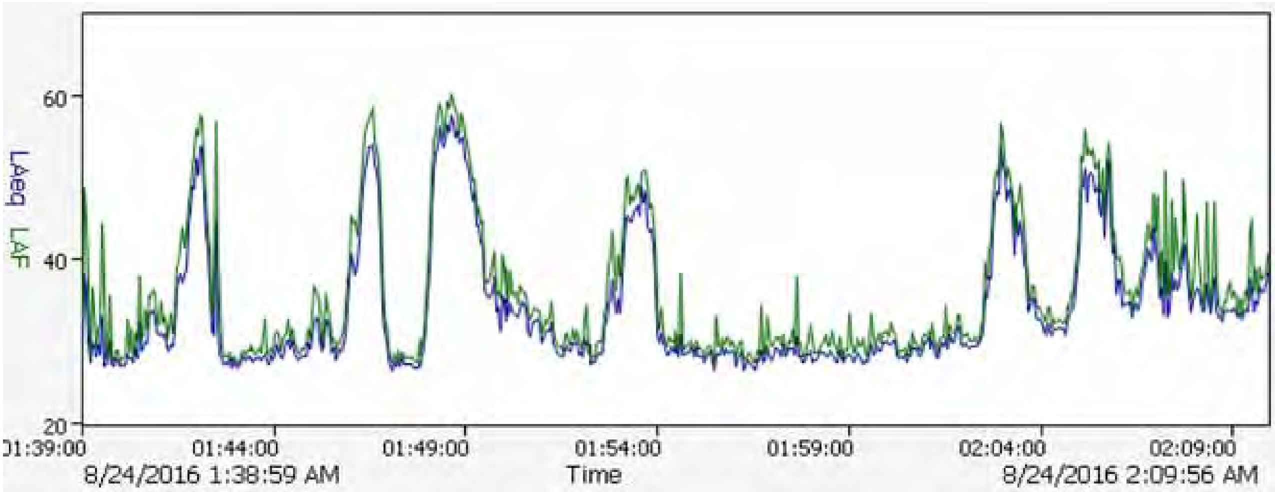
Cirrus Research plc

Measurement Summary Report

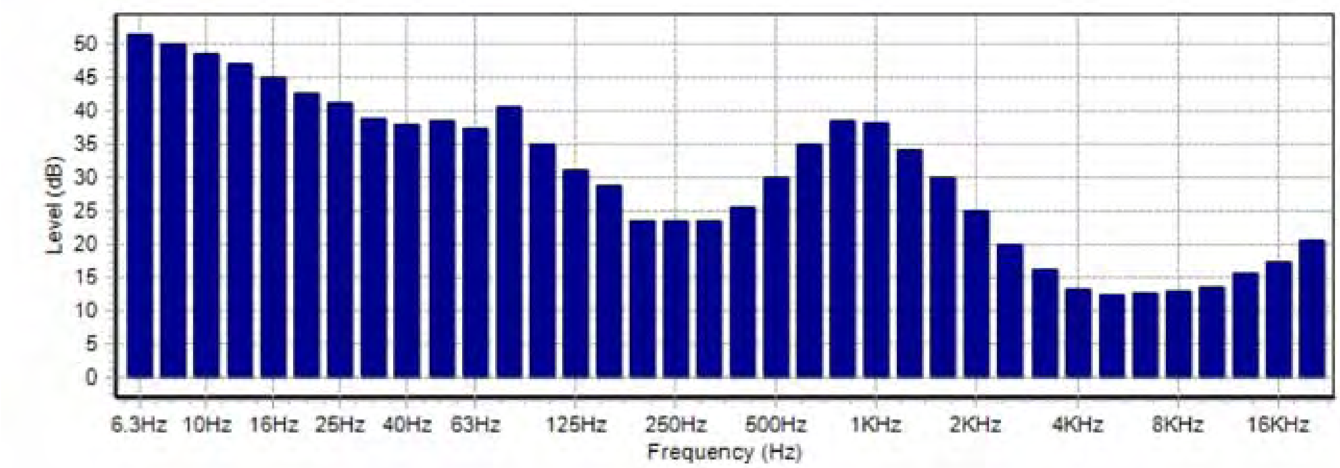
Name	NSL3 Night time #1	**Summary**		LAF1	55.5 dB
Time	8/24/2016 1:38:59 AM	LAeq	43.0 dB	LAF5	50.6 dB
Duration	00:30:57	LAE	75.7 dB	LAF10	46.4 dB
Instrument	GO56143, CR:171B	LAFMax	60.1 dB	LAF50	30.5 dB
				LAF90	27.5 dB
				LAF95	27.1 dB
				LAF99	26.6 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 12:25:09 AM	-0.15 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:03:31 AM	-0.18 dB			

Time History



Frequency Bands



Report ID

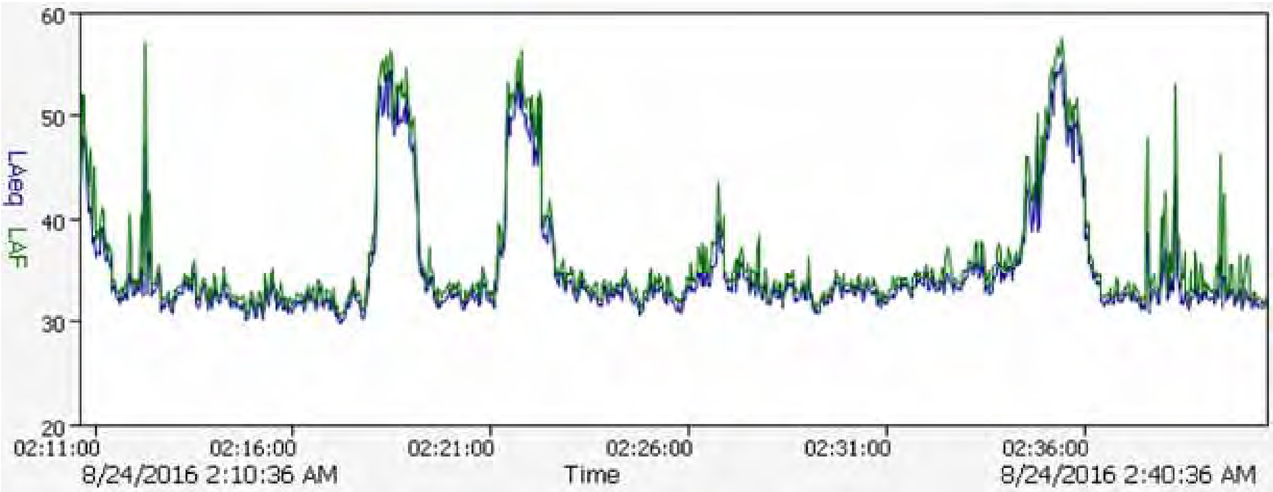
Cirrus Research plc

Measurement Summary Report

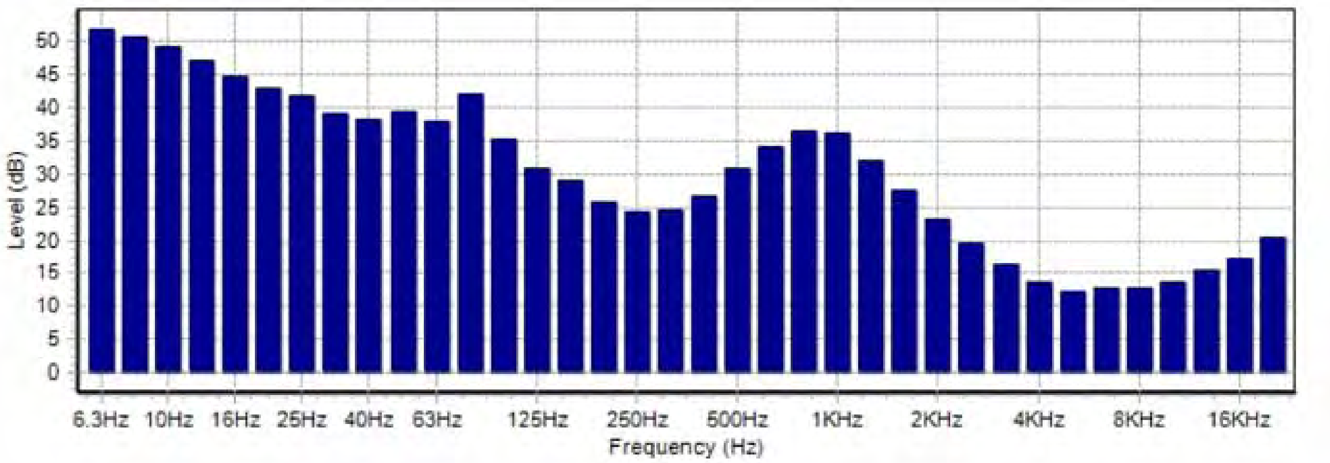
Name	NSL3 Night time #2	**Summary**		LAF1	53.4 dB
Time	8/24/2016 2:10:36 AM	LAeq	41.3 dB	LAF5	49.4 dB
Duration	00:30:00	LAE	73.8 dB	LAF10	44.3 dB
Instrument	GO56143, CR:171B	LAFMax	57.5 dB	LAF50	32.9 dB
				LAF90	31.3 dB
				LAF95	31.0 dB
				LAF99	30.2 dB

Calibration Information		Person	Place	Project
8/24/2016 12:25:09 AM	-0.15 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:03:31 AM	-0.18 dB			

Time History



Frequency Bands

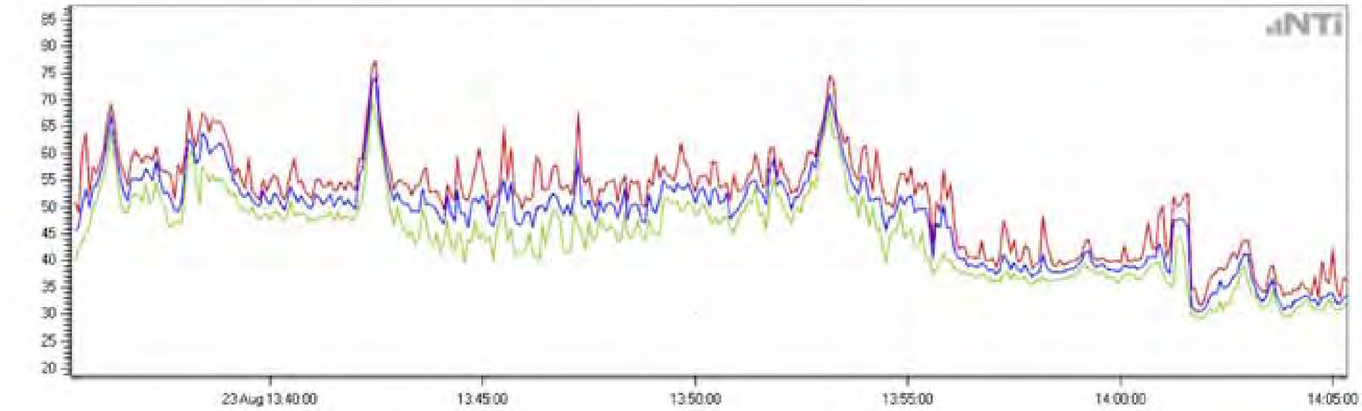


Report ID

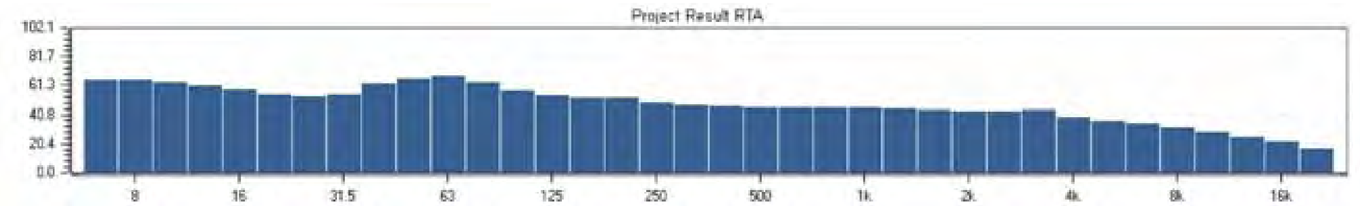
NSL4 Daytime #1

Start: 2016-08-23 13:35:20

End: 2016-08-23 14:05:20



LAeq_dt LAFmax_dt LAFmin_dt



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 13:32

Mic Sensitivity: 43.7 mV/Pa

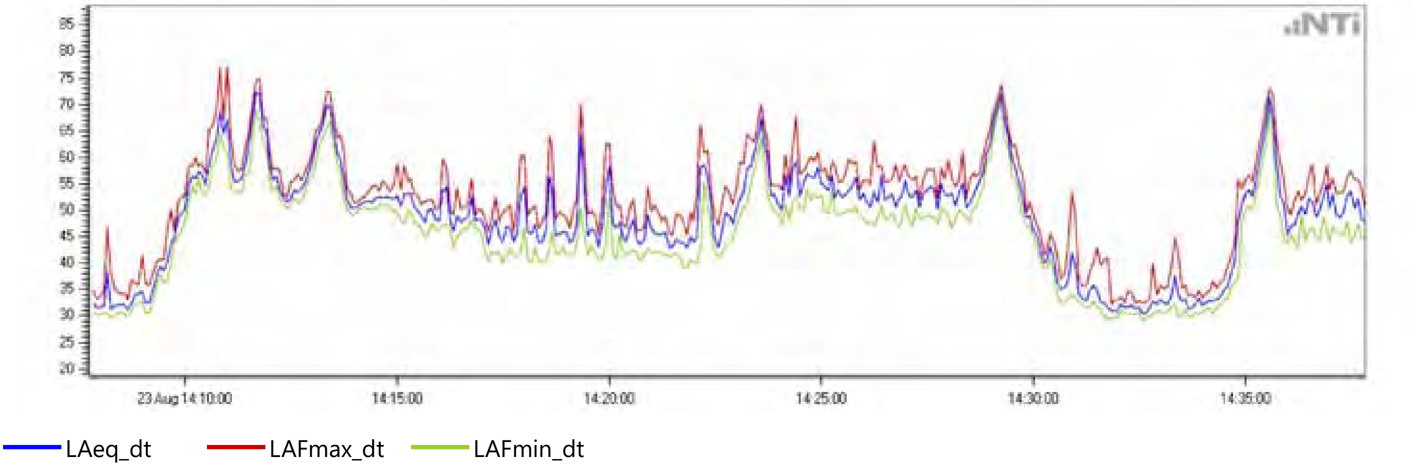
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL4 Daytime #2

Start: 2016-08-23 14:07:48

End: 2016-08-23 14:37:48



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 13:32

Mic Sensitivity: 43.7 mV/Pa

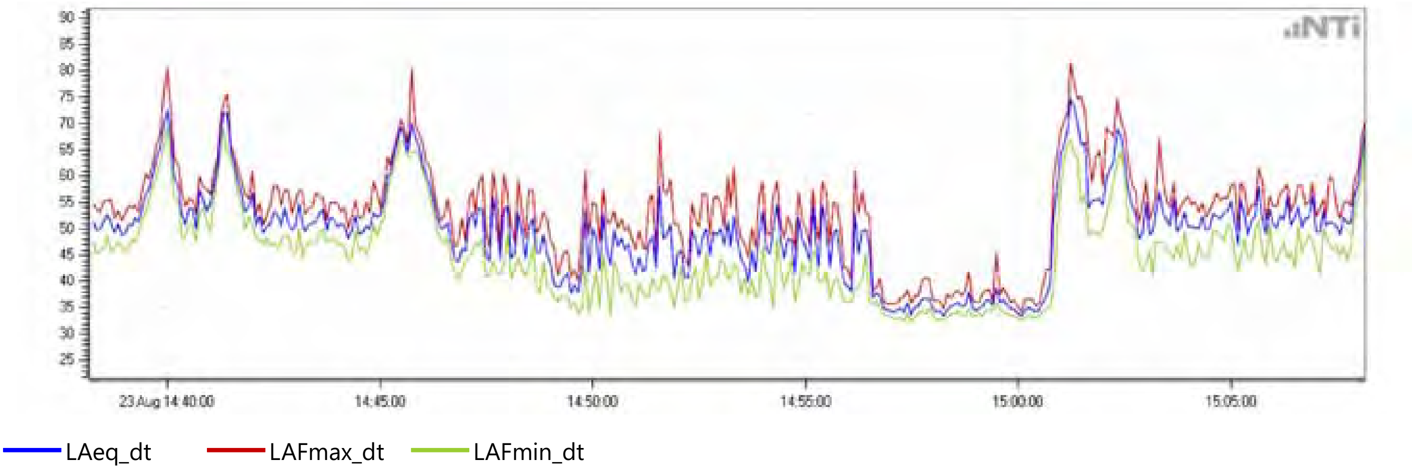
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL4 Daytime #3

Start: 2016-08-23 14:38:10

End: 2016-08-23 15:08:10



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 13:32

Mic Sensitivity: 43.7 mV/Pa

Range: 20 - 120 dB

LN based on: LAeq_dt

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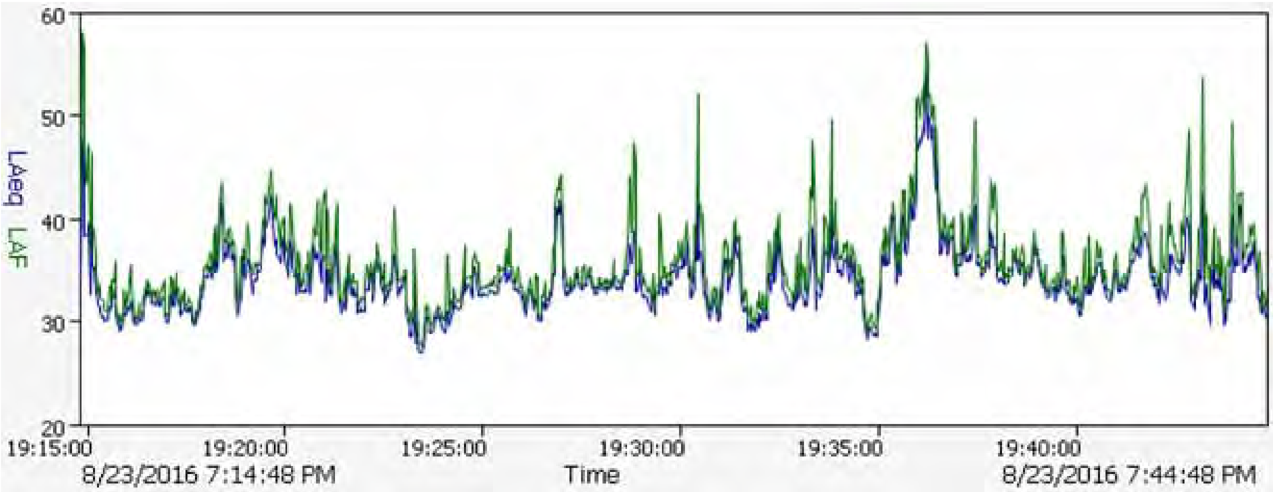
Measurement Summary Report

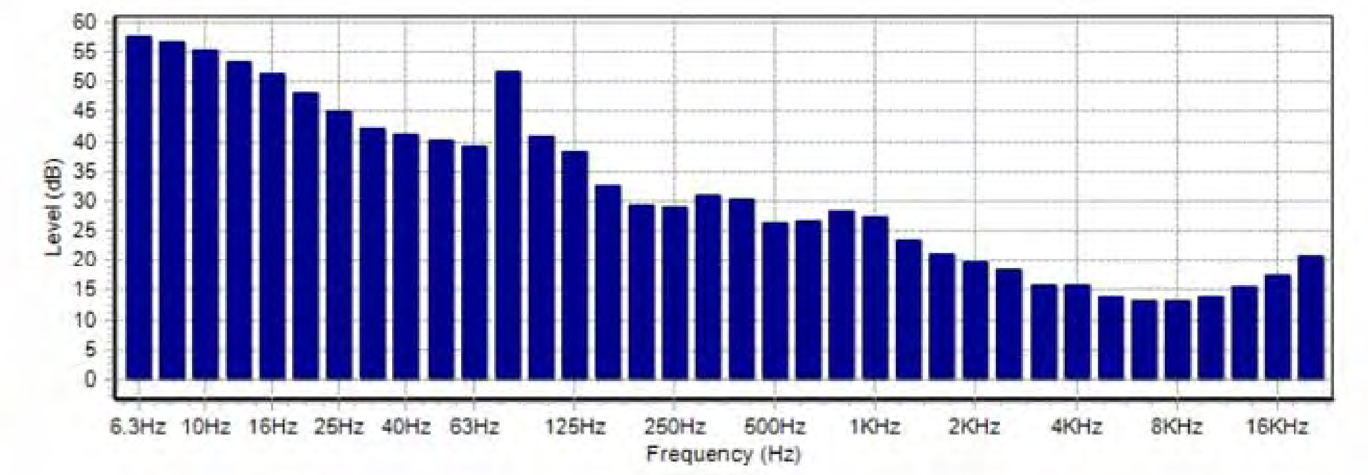
Name	NSL4 Evening #1	**Summary**		LAF1	47.4 dB
Time	8/23/2016 7:14:48 PM	LAeq	36.4 dB	LAF5	39.7 dB
Duration	00:30:00	LAE	69.0 dB	LAF10	37.6 dB
Instrument	GO56143, CR:171B	LAFMax	58.0 dB	LAF50	33.4 dB
				LAF90	30.3 dB
				LAF95	29.6 dB
				LAF99	28.2 dB

Calibration Information		**Person**	**Place**	**Project**
8/23/2016 7:13:08 PM	0.08 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/23/2016 10:44:33 PM	0.21 dB			

Time History



Frequency Bands



Report ID

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Measurement Summary Report

Name	NSL4 Night time #1
Time	8/24/2016 12:26:35 AM
Duration	00:30:00
Instrument	GO56143, CR:171B

Summary

LAeq	34.5 dB
LAE	67.0 dB
LAFMax	60.2 dB

LAF1	38.8 dB
LAF5	37.4 dB
LAF10	36.7 dB
LAF50	33.7 dB
LAF90	29.6 dB
LAF95	28.3 dB
LAF99	25.8 dB

Calibration Information

8/24/2016 12:25:09 AM -0.15 dB

8/24/2016 3:03:31 AM -0.18 dB

Person

Siobhan Maher

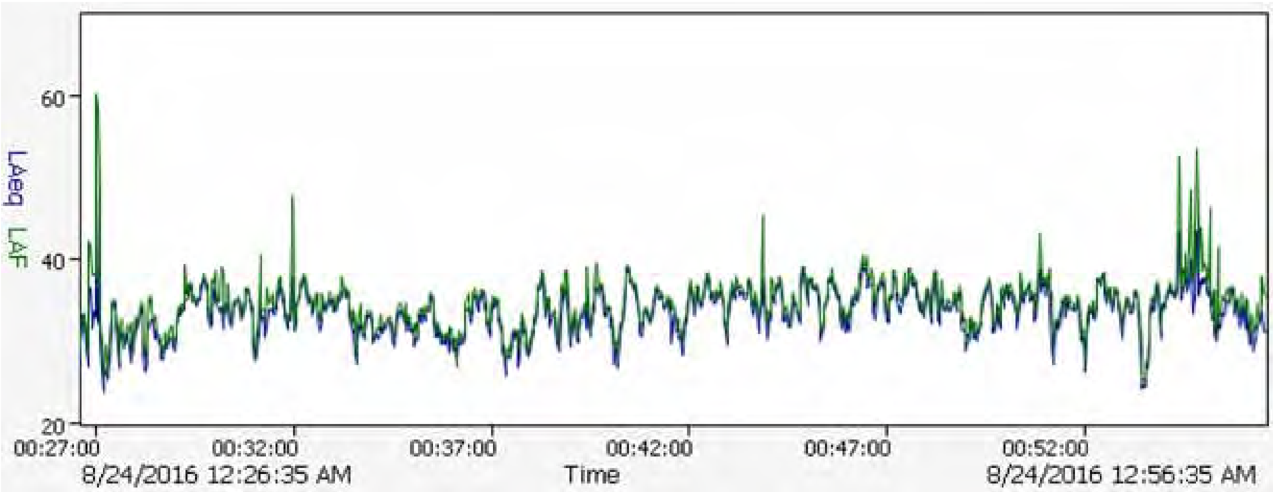
Place

Aughinish, Co. Limerick

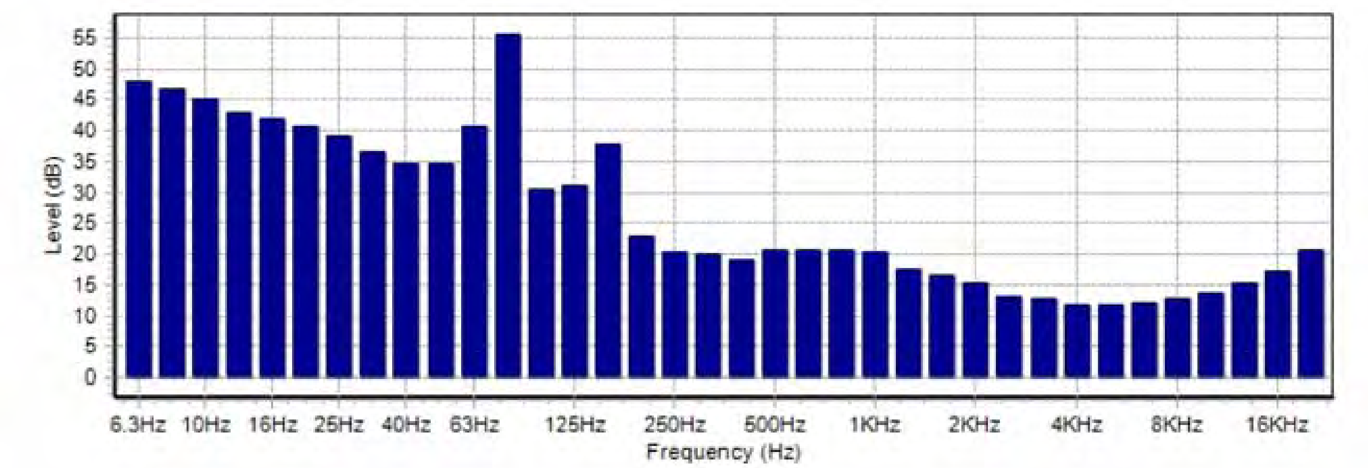
Project

AAL 2016

Time History



Frequency Bands



Report ID

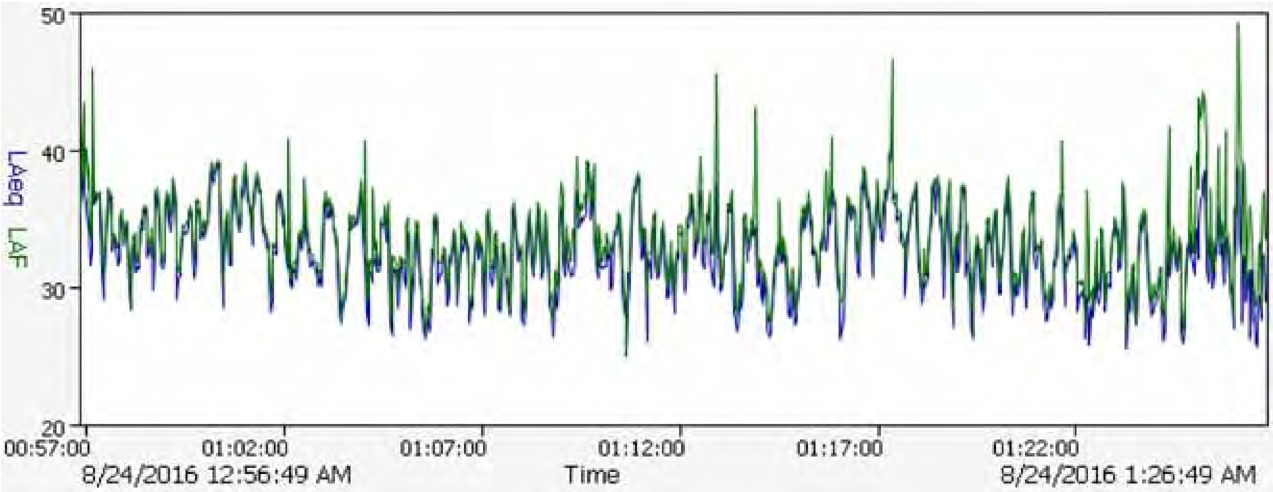
Cirrus Research plc

Measurement Summary Report

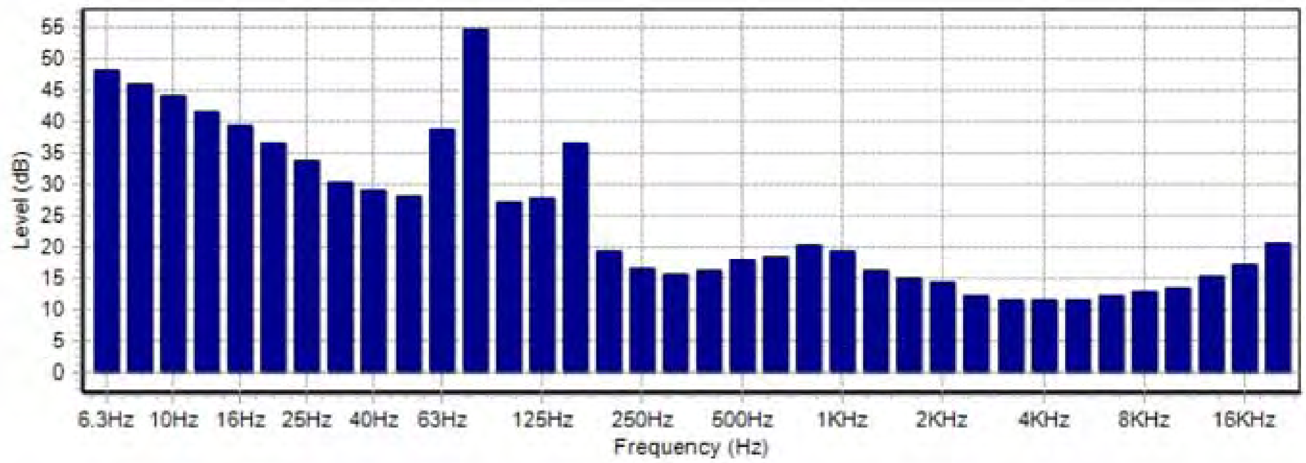
Name	NSL4 Night time #2	**Summary**		LAF1	38.7 dB
Time	8/24/2016 12:56:49 AM	LAeq	33.4 dB	LAF5	36.9 dB
Duration	00:30:00	LAE	65.9 dB	LAF10	36.1 dB
Instrument	GO56143, CR:171B	LAFMax	49.2 dB	LAF50	32.4 dB
				LAF90	28.3 dB
				LAF95	27.3 dB
				LAF99	25.8 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 12:25:09 AM	-0.15 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:03:31 AM	-0.18 dB			

Time History



Frequency Bands

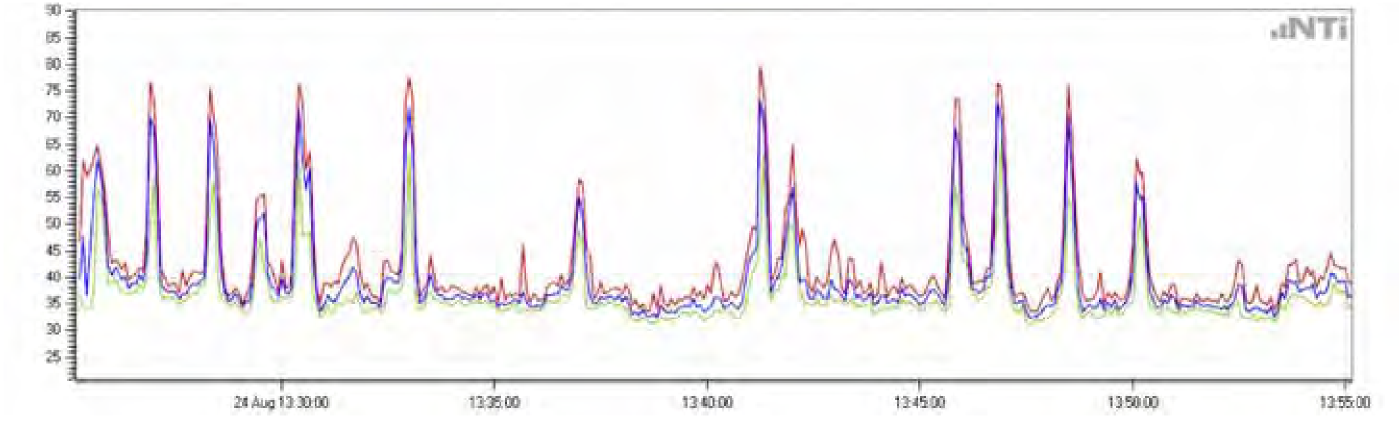


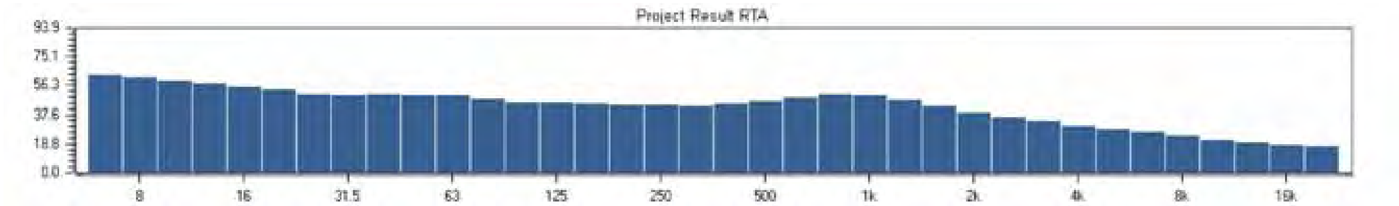
Report ID

NSL5 Daytime #1

Start: 2016-08-24 13:25:10

End: 2016-08-24 13:55:10





Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.8 mV/Pa (from NTi Audio M2230, SNo. 5062, User calibrated 2016-08-24 11:43)

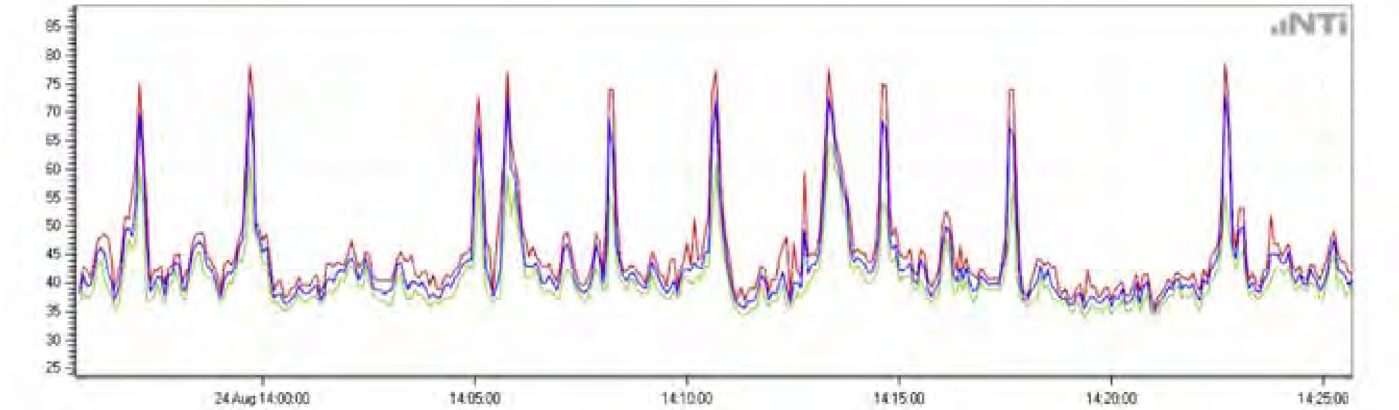
Range: 20 - 120 dB

LN based on: LAeq_dt

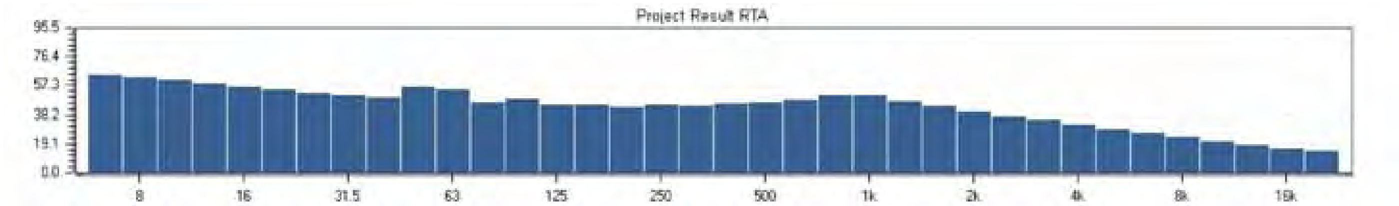
NSL5 Daytime #2

Start: 2016-08-24 13:55:38

End: 2016-08-24 14:25:38



LAeq_dt LAFmax_dt LAFmin_dt



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.8 mV/Pa (from NTi Audio M2230, SNo. 5062, User calibrated 2016-08-24 11:43)

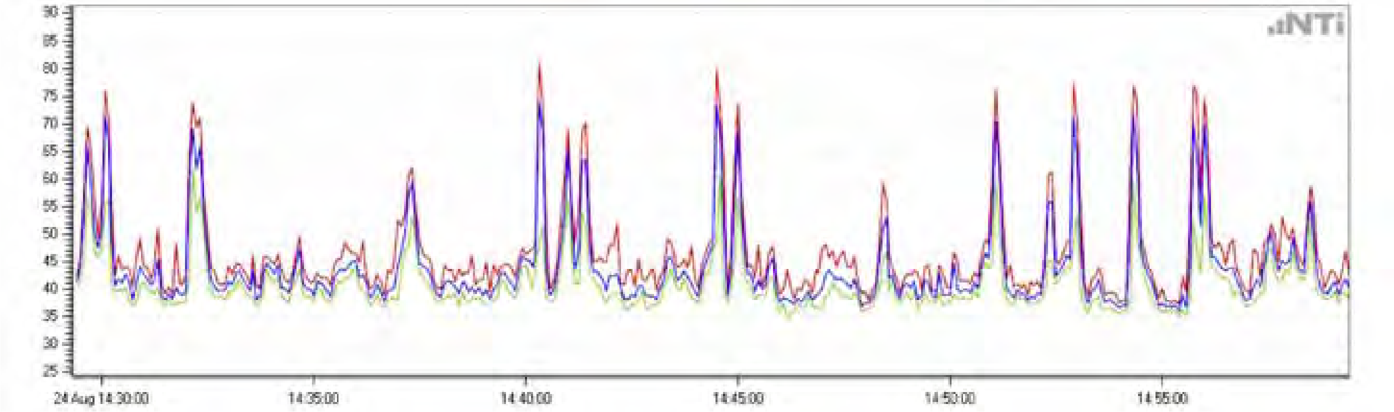
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL5 Daytime #3

Start: 2016-08-24 14:29:24

End: 2016-08-24 14:59:24



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.8 mV/Pa (from NTi Audio M2230, SNo. 5062, User calibrated 2016-08-24 11:43)

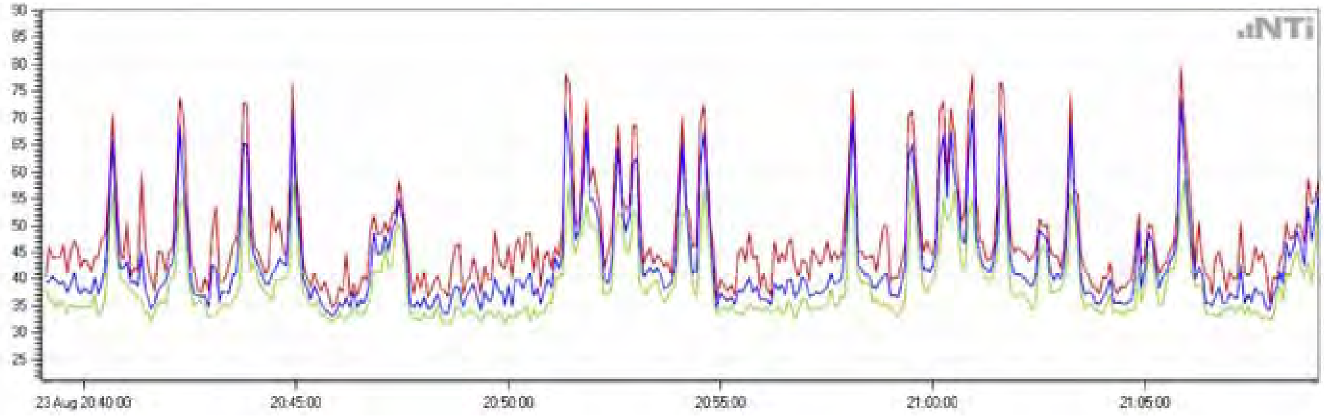
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL5 Evening #1

Start: 2016-08-23 20:39:02

End: 2016-08-23 21:09:02



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

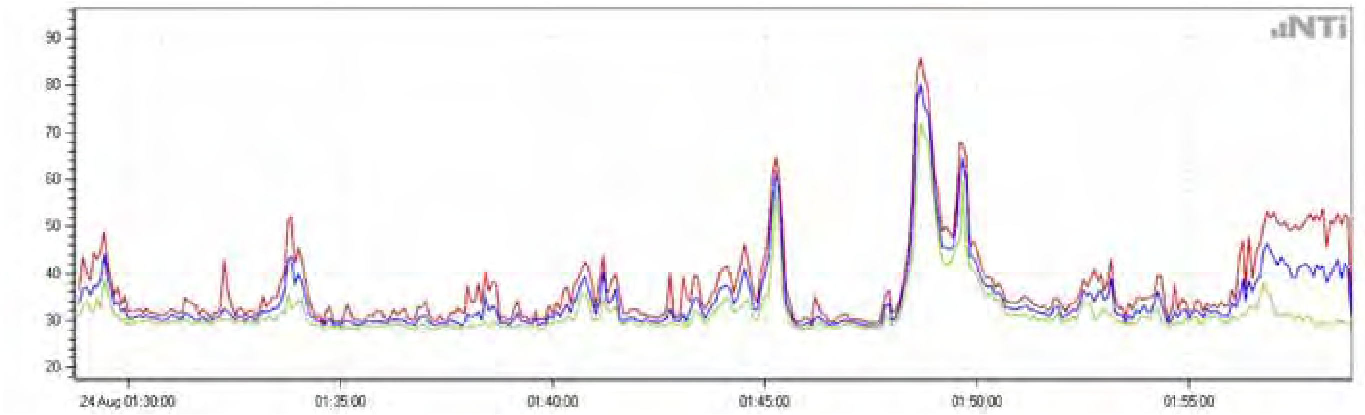
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL5 Night time #1

Start: 2016-08-24 01:28:46

End: 2016-08-24 01:58:46



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

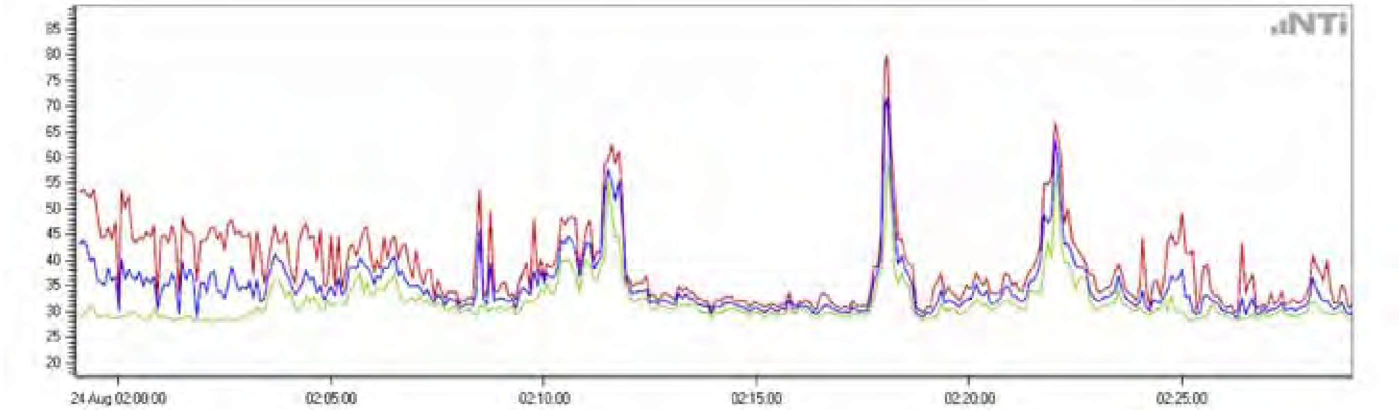
Range: 20 - 120 dB

LN based on: LAeq_dt

NSL5 Night time #2

Start: 2016-08-24 01:59:00

End: 2016-08-24 02:29:00



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

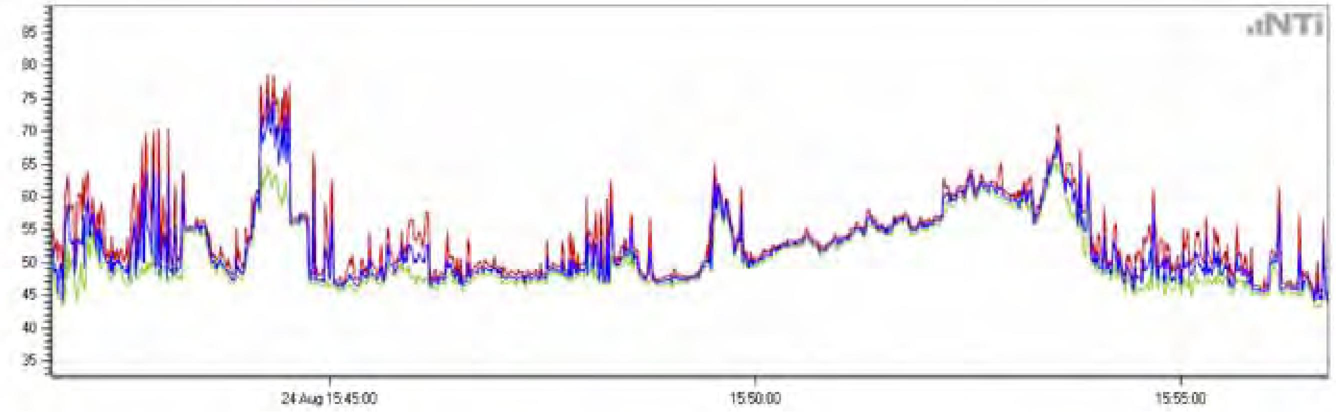
Range: 20 - 120 dB

LN based on: LAeq_dt

B1 Daytime #1

Start: 2016-08-24 15:41:44

End: 2016-08-24 15:56:44



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

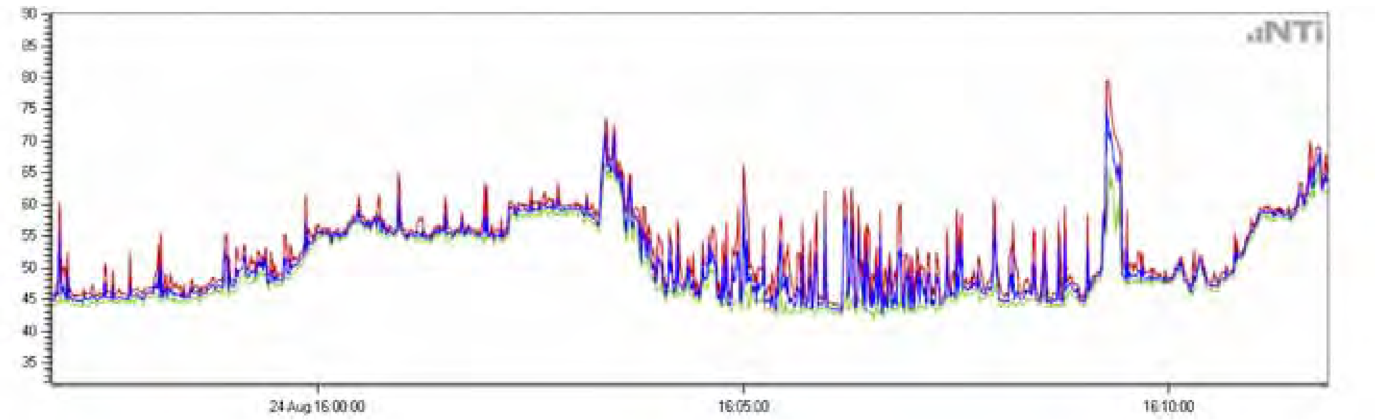
Mic Sensitivity: 43.5 mV/Pa (User calibrated 2016-08-24 15:00)

Range: 20 - 120 dB

B1 Daytime #2

Start: 2016-08-24 15:56:52

End: 2016-08-24 16:11:52



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.5 mV/Pa (User calibrated 2016-08-24 15:00)

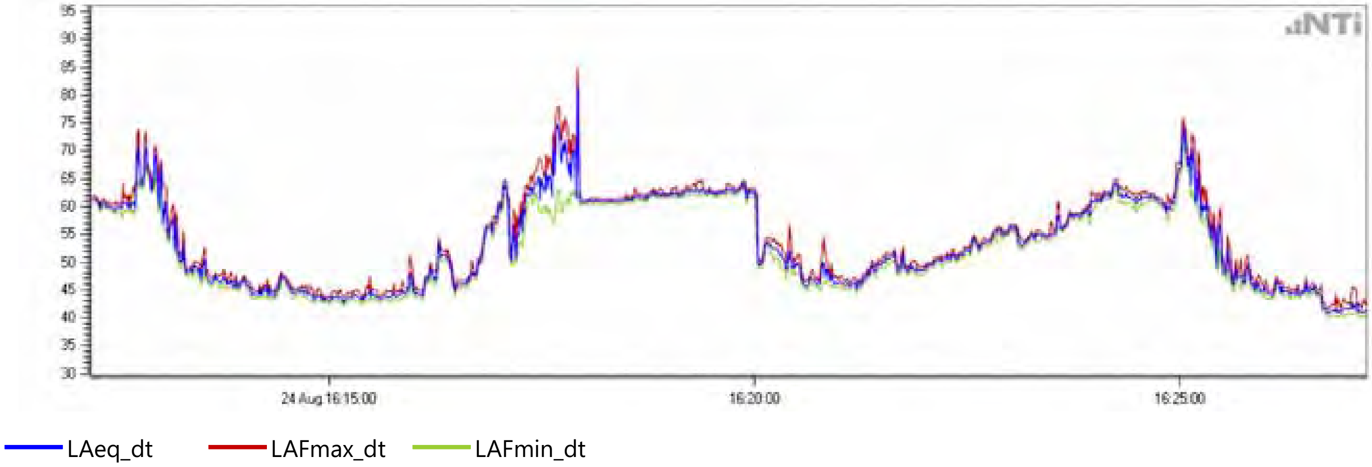
Range: 20 - 120 dB

LN based on: LAeq_dt

B1 Daytime #3

Start: 2016-08-24 16:12:12

End: 2016-08-24 16:27:12



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.5 mV/Pa (User calibrated 2016-08-24 15:00)

Range: 20 - 120 dB

LN based on: LAeq_dt

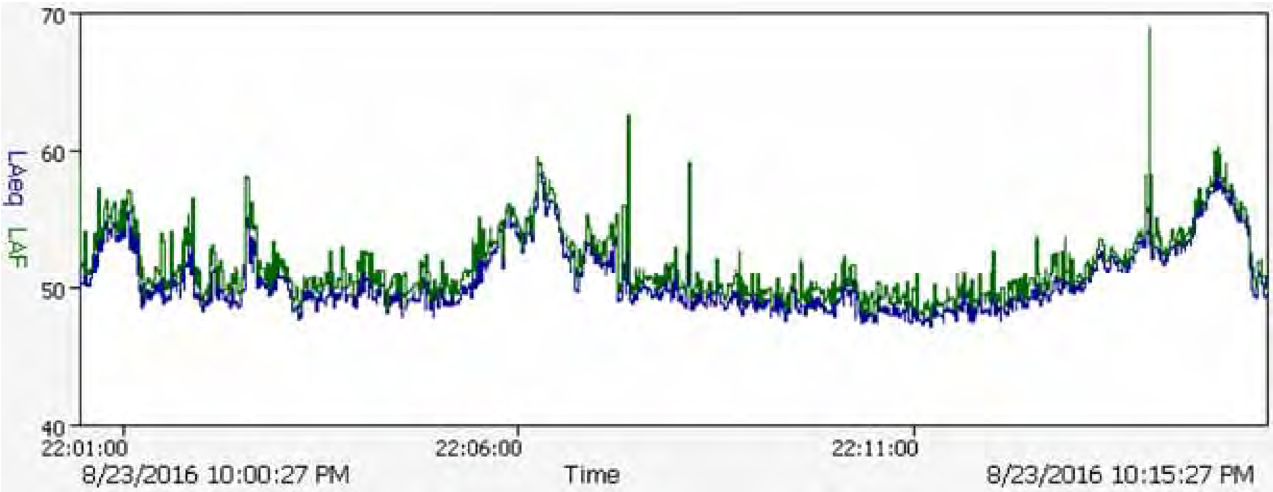
Cirrus Research plc

Measurement Summary Report

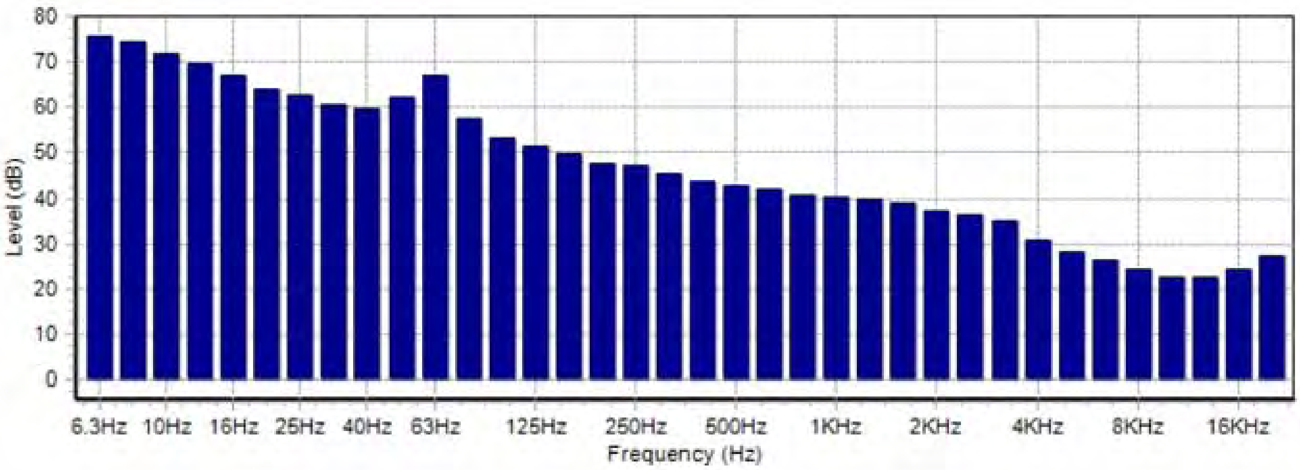
Name	B1 Evening #1	**Summary**		LAF1	57.5 dB
Time	8/23/2016 10:00:27 PM	LAeq	51.4 dB	LAF5	55.5 dB
Duration	00:15:00	LAE	80.9 dB	LAF10	54.1 dB
Instrument	GO56143, CR:171B	LAFMax	68.9 dB	LAF50	49.6 dB
				LAF90	48.0 dB
				LAF95	47.7 dB
				LAF99	47.1 dB

Calibration Information		Person	Place	Project
8/23/2016 7:13:08 PM	0.08 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/23/2016 10:44:33 PM	0.21 dB			

Time History



Frequency Bands

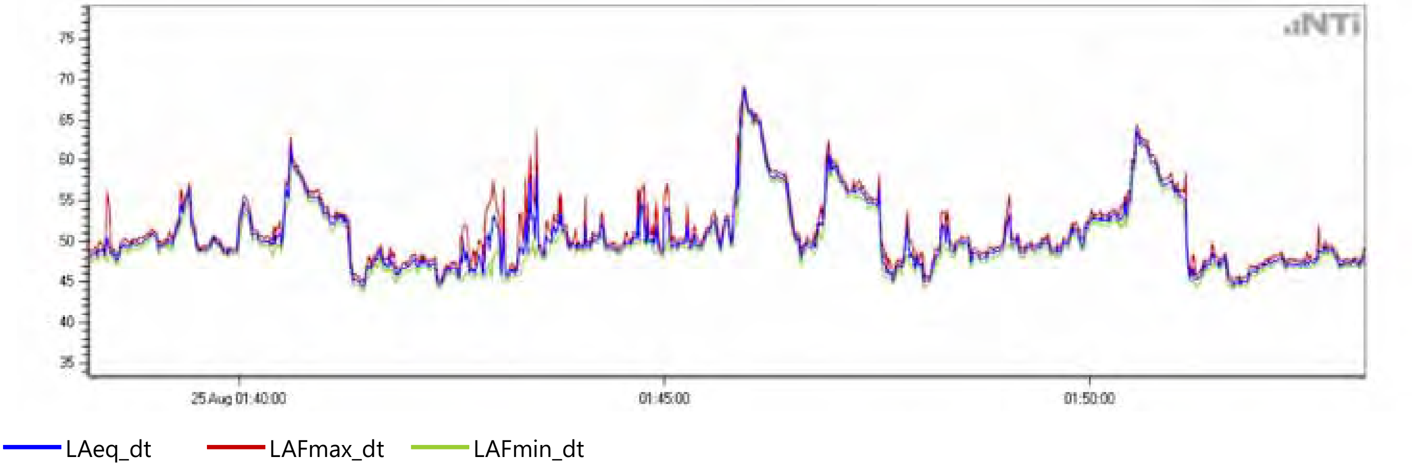


Report ID

B1 Night time #1

Start: 2016-08-25 01:38:14

End: 2016-08-25 01:53:14



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-25 00:54

Mic Sensitivity: 44.3 mV/Pa

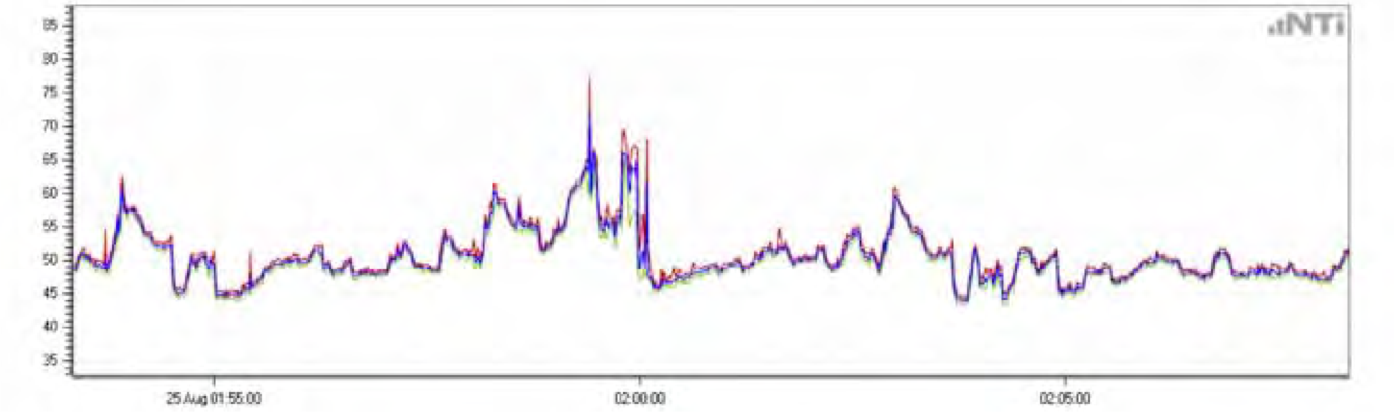
Range: 20 - 120 dB

LN based on: LAeq_dt

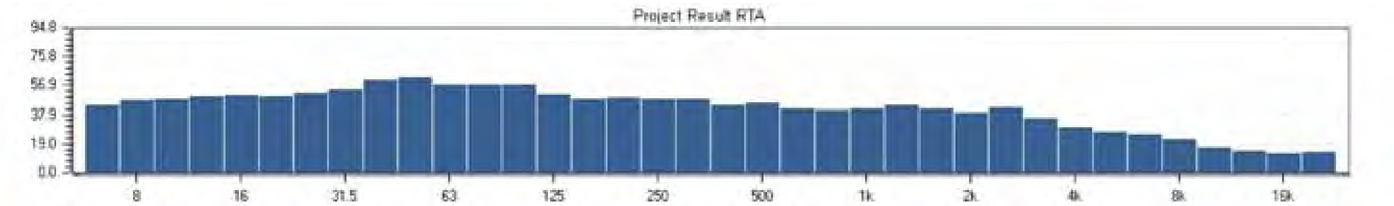
B1 Night time #2

Start: 2016-08-25 01:53:20

End: 2016-08-25 02:08:20



LAeq_dt LAFmax_dt LAFmin_dt



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-25 00:54

Mic Sensitivity: 44.3 mV/Pa

Range: 20 - 120 dB

LN based on: LAeq_dt

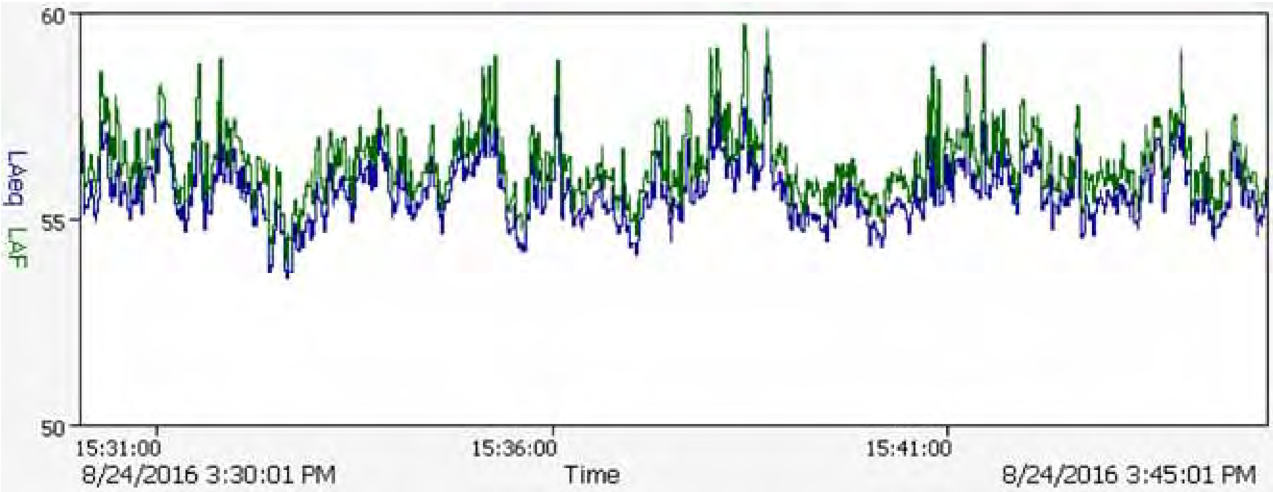
Cirrus Research plc

Measurement Summary Report

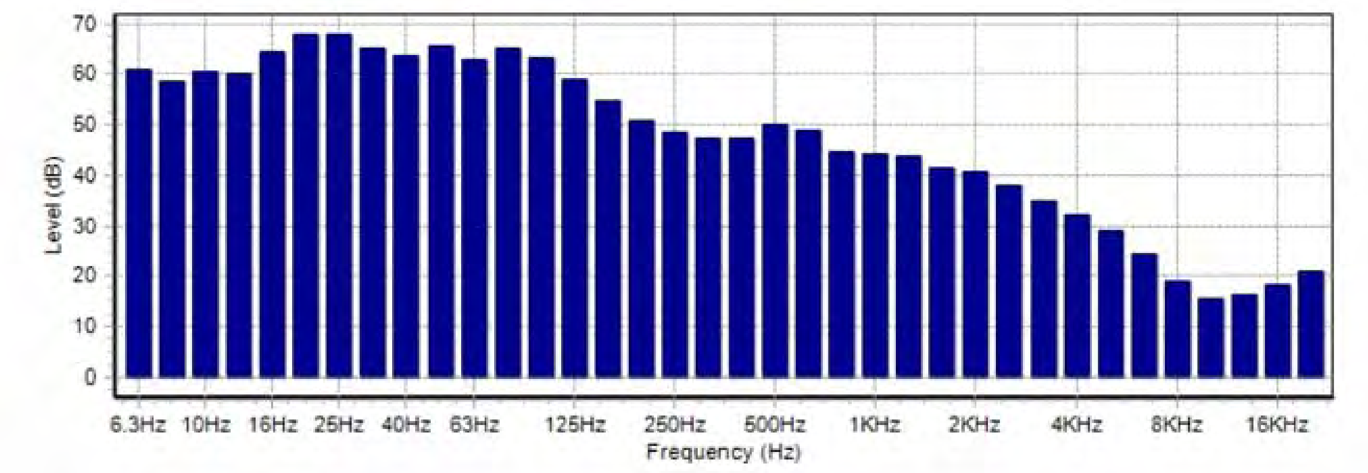
Name	B2 Daytime #1	**Summary**		LAF1	57.9 dB
Time	8/24/2016 3:30:01 PM	LAeq	55.7 dB	LAF5	57.0 dB
Duration	00:15:00	LAE	85.3 dB	LAF10	56.7 dB
Instrument	GO56143, CR:171B	LAFMax	59.7 dB	LAF50	55.5 dB
				LAF90	54.7 dB
				LAF95	54.4 dB
				LAF99	53.9 dB

Calibration Information		Person	Place	Project
8/24/2016 3:11:36 PM	0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:07:28 PM	0.36 dB			

Time History



Frequency Bands



Report ID

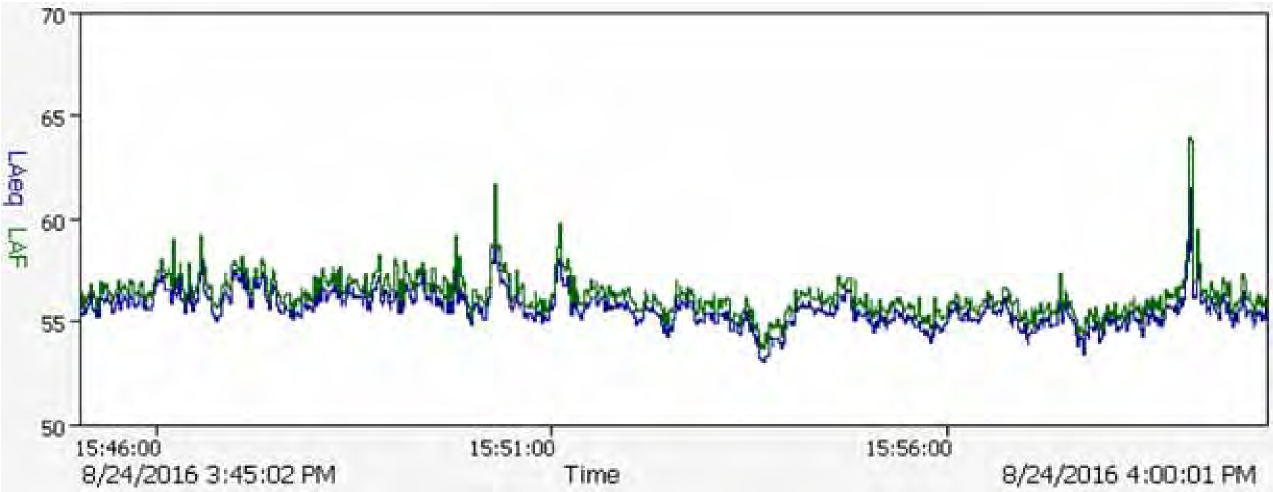
Cirrus Research plc

Measurement Summary Report

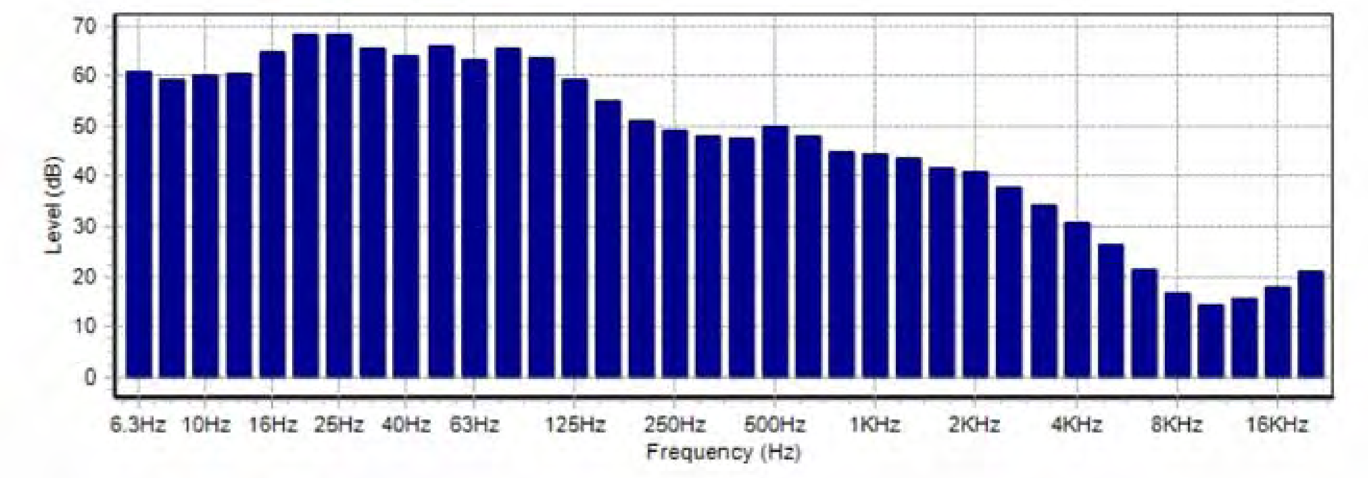
Name	B2 Daytime #2	**Summary**		LAF1	58.0 dB
Time	8/24/2016 3:45:02 PM	LAeq	55.7 dB	LAF5	57.0 dB
Duration	00:15:00	LAE	85.2 dB	LAF10	56.6 dB
Instrument	GO56143, CR:171B	LAFMax	64.0 dB	LAF50	55.5 dB
				LAF90	54.5 dB
				LAF95	54.2 dB
				LAF99	53.4 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 3:11:36 PM	0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:07:28 PM	0.36 dB			

Time History



Frequency Bands



Report ID

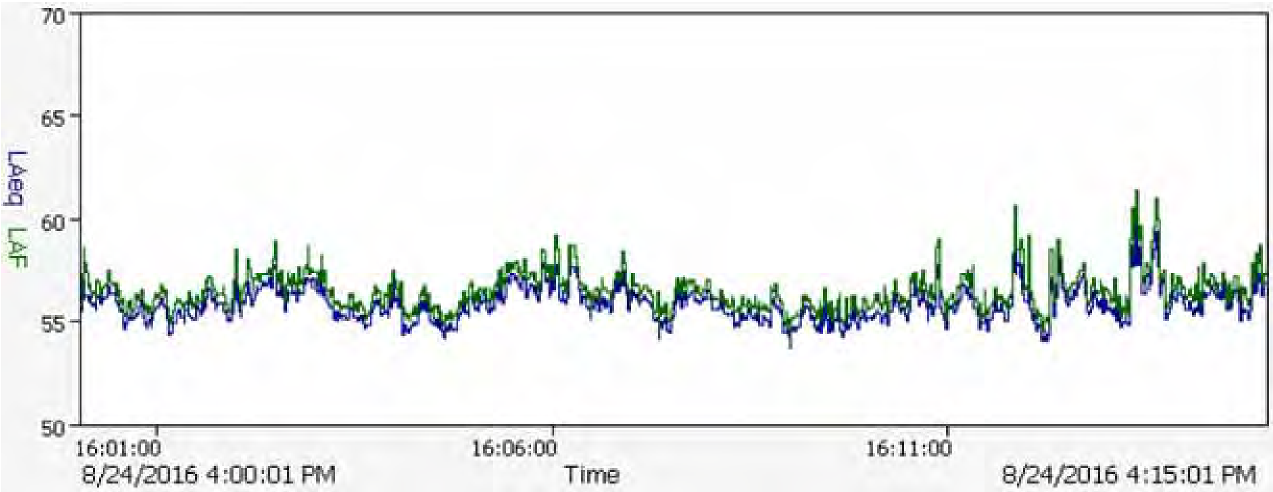
Cirrus Research plc

Measurement Summary Report

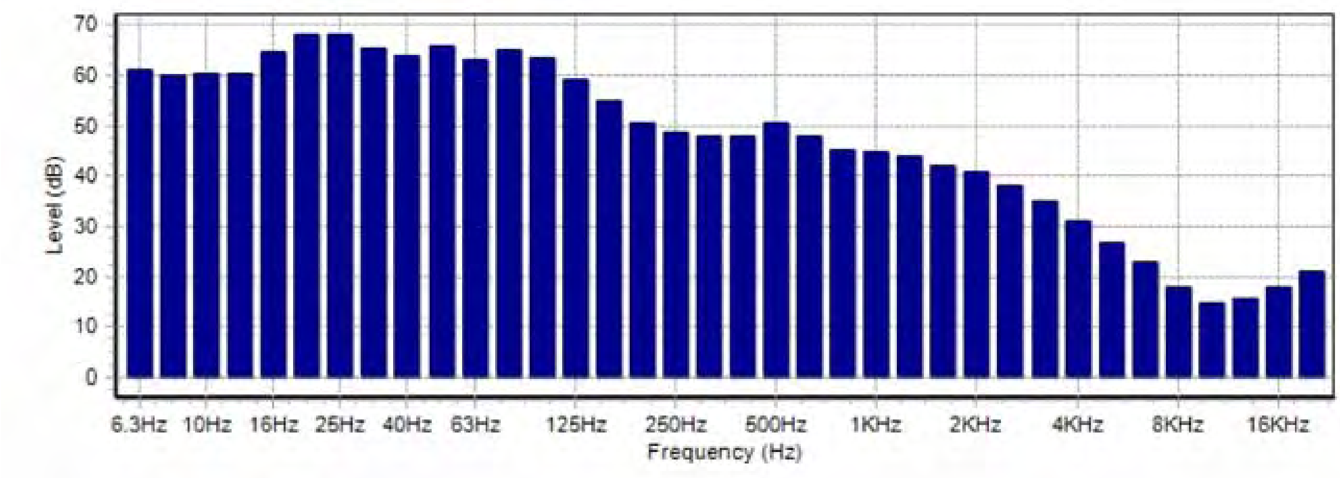
Name	B2 Daytime #3	**Summary**		LAF1	58.4 dB		
Time	8/24/2016 4:00:01 PM	LAeq	55.9 dB	LAF5	57.2 dB		
Duration	00:15:00	LAE	85.4 dB	LAF10	56.8 dB		
Instrument	GO56143, CR:171B	LAFMax	61.4 dB	LAF50	55.7 dB		
				LAF90	54.7 dB		
				LAF95	54.5 dB		
				LAF99	54.1 dB		

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 3:11:36 PM	0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:07:28 PM	0.36 dB			

Time History



Frequency Bands

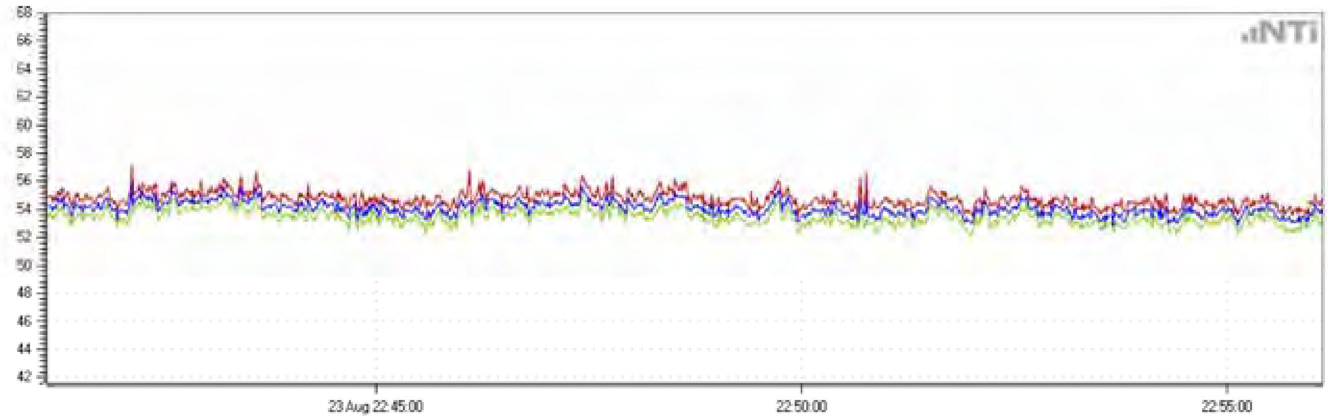


Report ID

B2 Evening #1

Start: 2016-08-23 22:41:08

End: 2016-08-23 22:56:08



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

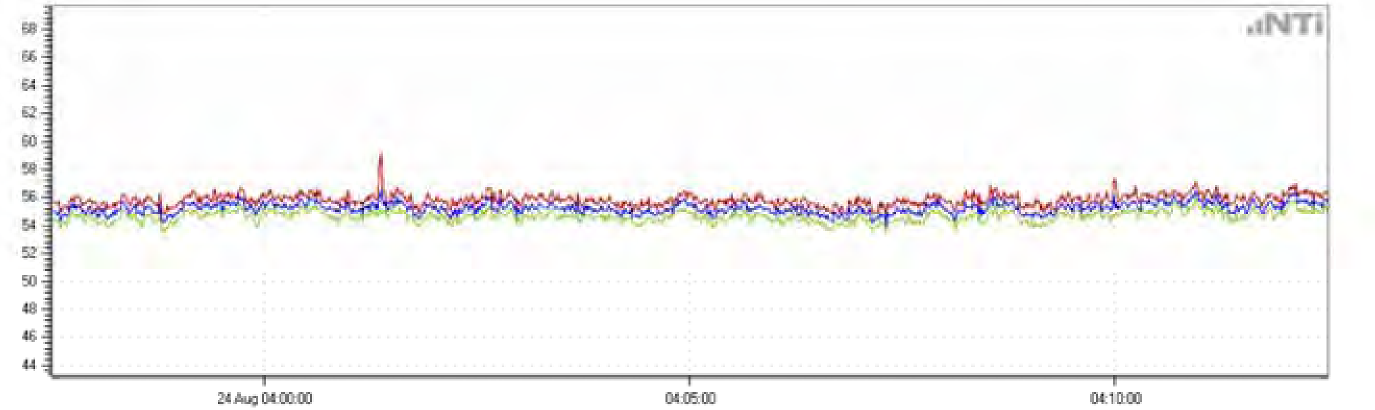
Range: 20 - 120 dB

LN based on: LAeq_dt

B2 Night time #1

Start: 2016-08-24 03:57:30

End: 2016-08-24 04:12:30



LAeq_dt LAFmax_dt LAFmin_dt

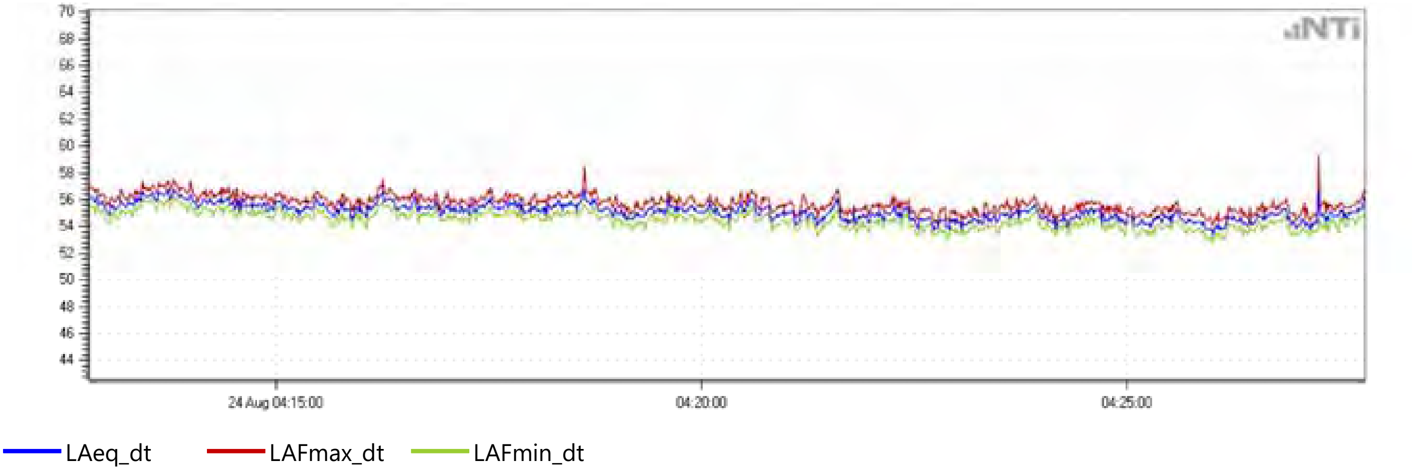
Configuration

Device Info:	XL2, SNo. A2A-08898-E0, FW3.12
Mic Type:	NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59
Mic Sensitivity:	43.7 mV/Pa
Range:	20 - 120 dB
LN based on:	LAeq_dt

B2 Night time #2

Start: 2016-08-24 04:12:48

End: 2016-08-24 04:27:48



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

Range: 20 - 120 dB

LN based on: LAeq_dt

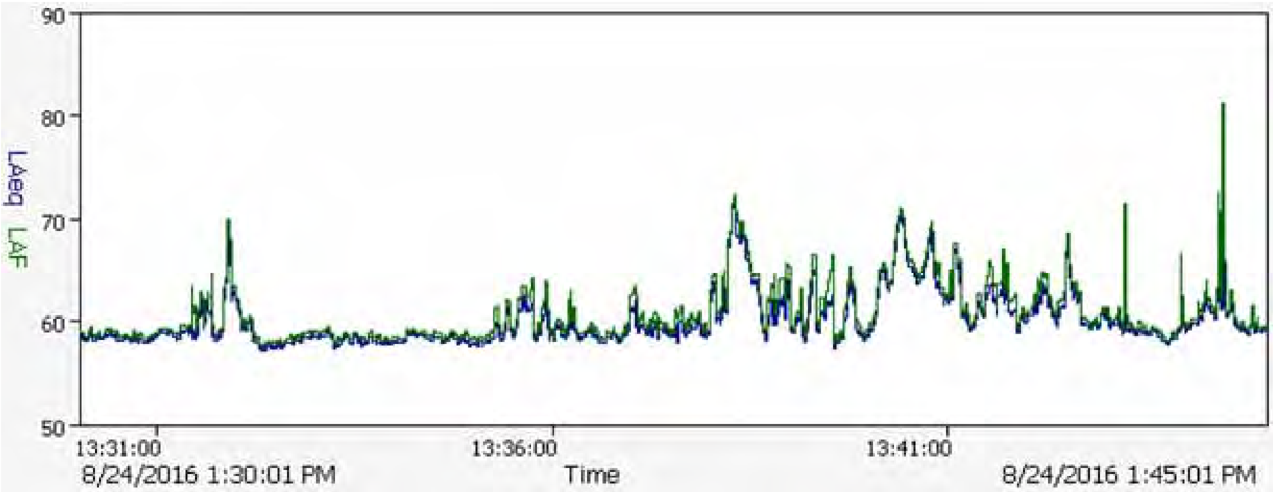
Cirrus Research plc

Measurement Summary Report

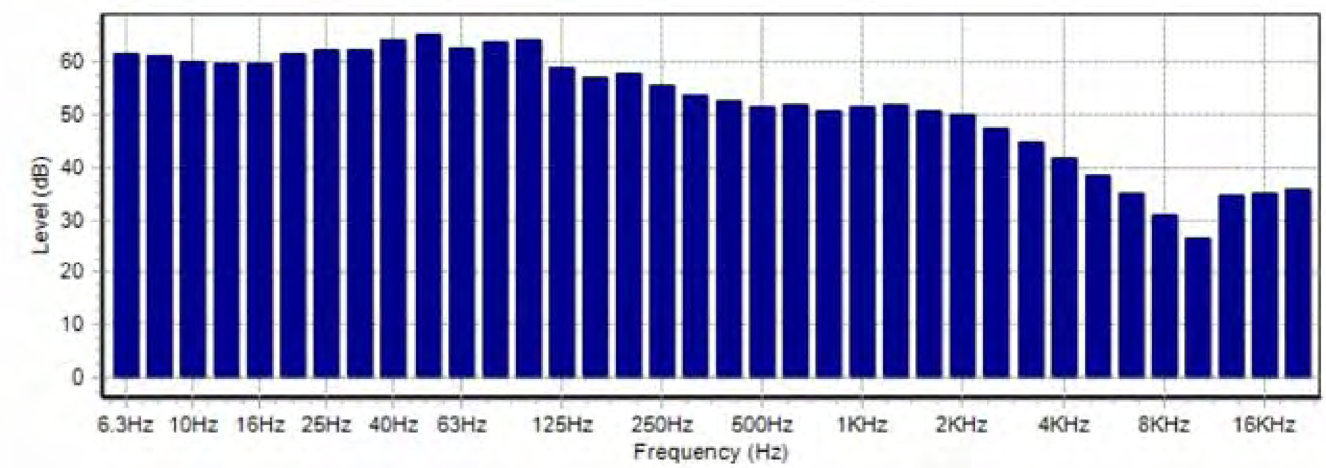
Name	B3 Daytime #1	**Summary**		LAF1	69.5 dB
Time	8/24/2016 1:30:01 PM	LAeq	61.3 dB	LAF5	65.5 dB
Duration	00:15:00	LAE	90.8 dB	LAF10	63.6 dB
Instrument	GO56143, CR:171B	LAFMax	81.1 dB	LAF50	59.0 dB
				LAF90	57.9 dB
				LAF95	57.7 dB
				LAF99	57.2 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 11:13:44 AM	-0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:11:36 PM	0.12 dB			

Time History



Frequency Bands



Report ID

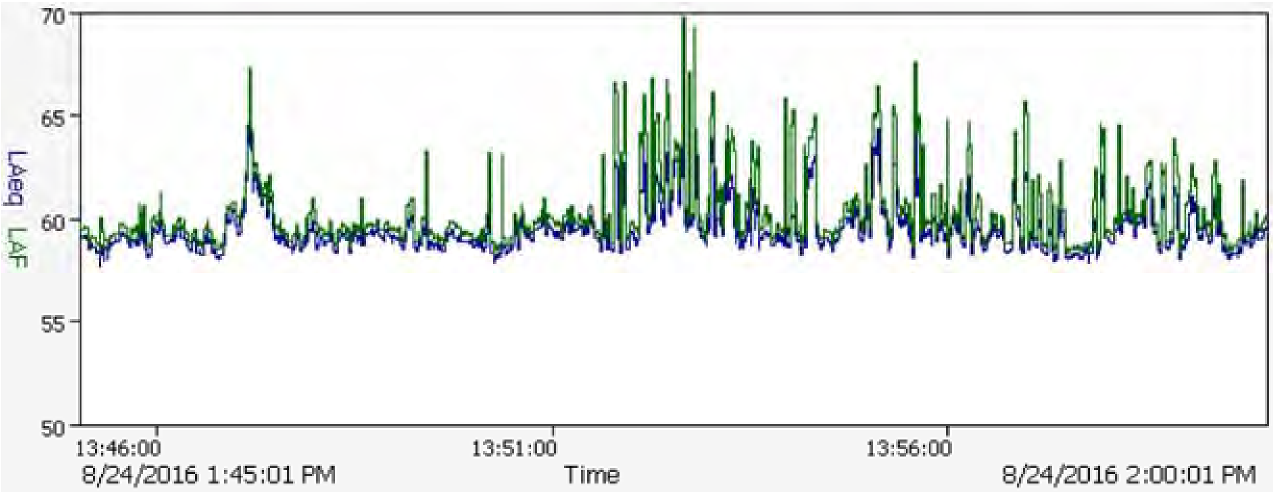
Cirrus Research plc

Measurement Summary Report

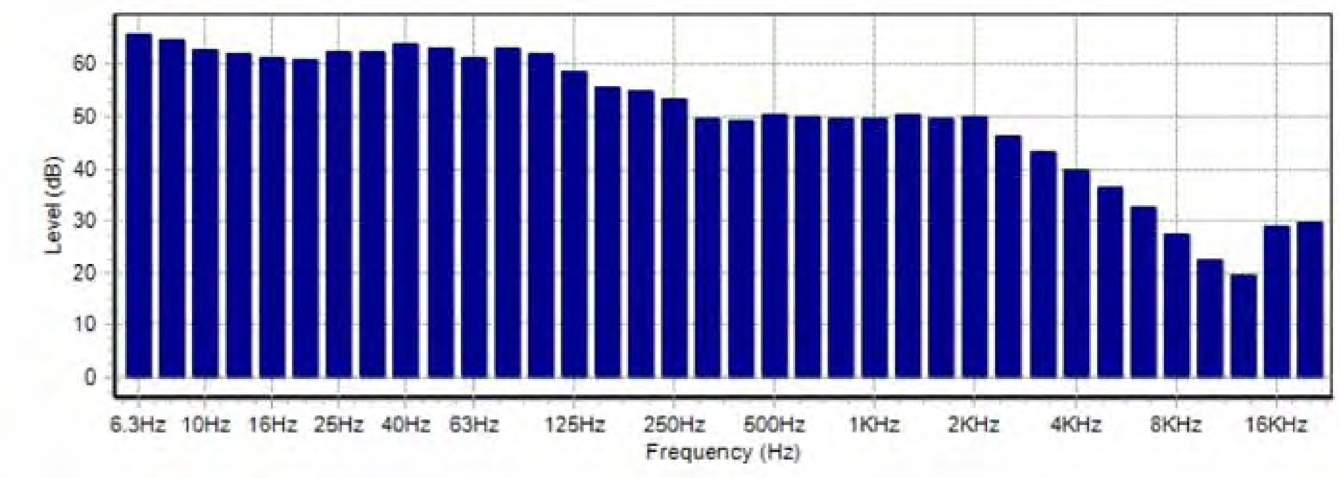
Name	B3 Daytime #2	**Summary**		LAF1	64.3 dB
Time	8/24/2016 1:45:01 PM	LAeq	59.7 dB	LAF5	62.0 dB
Duration	00:15:00	LAE	89.2 dB	LAF10	60.9 dB
Instrument	GO56143, CR:171B	LAFMax	69.7 dB	LAF50	59.1 dB
				LAF90	58.3 dB
				LAF95	58.1 dB
				LAF99	57.9 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 11:13:44 AM	-0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:11:36 PM	0.12 dB			

Time History



Frequency Bands



Report ID

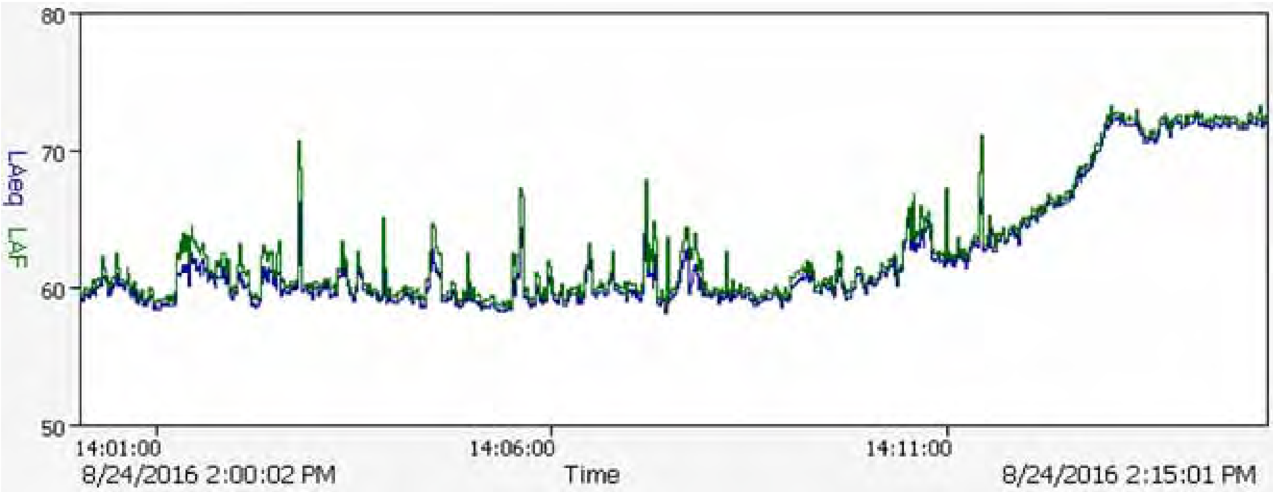
Cirrus Research plc

Measurement Summary Report

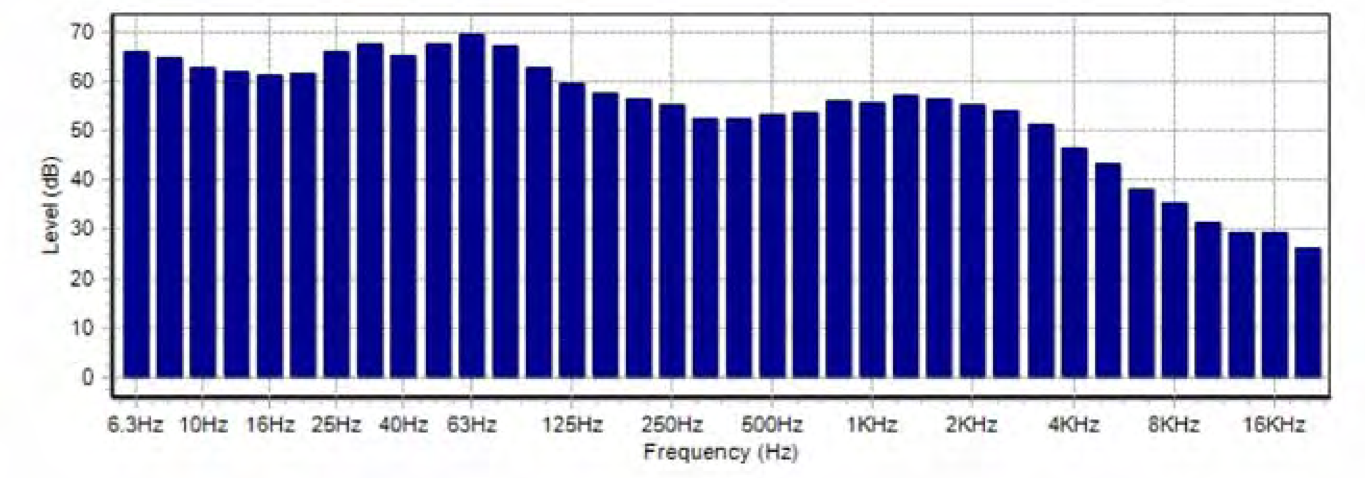
Name	B3 Daytime #3	**Summary**		LAF1	72.2 dB
Time	8/24/2016 2:00:02 PM	LAeq	65.2 dB	LAF5	71.9 dB
Duration	00:15:00	LAE	94.7 dB	LAF10	71.5 dB
Instrument	GO56143, CR:171B	LAFMax	73.2 dB	LAF50	60.1 dB
				LAF90	58.8 dB
				LAF95	58.5 dB
				LAF99	58.2 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 11:13:44 AM	-0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:11:36 PM	0.12 dB			

Time History



Frequency Bands



Report ID

Cirrus Research plc

Measurement Summary Report

Name	B3 Evening #1
Time	8/23/2016 10:26:17 PM
Duration	00:15:00
Instrument	GO56143, CR:171B

Summary

LAeq	58.2 dB
LAE	87.7 dB
LAFMax	61.1 dB

LAF1	59.2 dB
LAF5	58.8 dB
LAF10	58.6 dB
LAF50	58.1 dB
LAF90	57.6 dB
LAF95	57.5 dB
LAF99	57.2 dB

Calibration Information

8/23/2016 7:13:08 PM 0.08 dB

8/23/2016 10:44:33 PM 0.21 dB

Person

Siobhan Maher

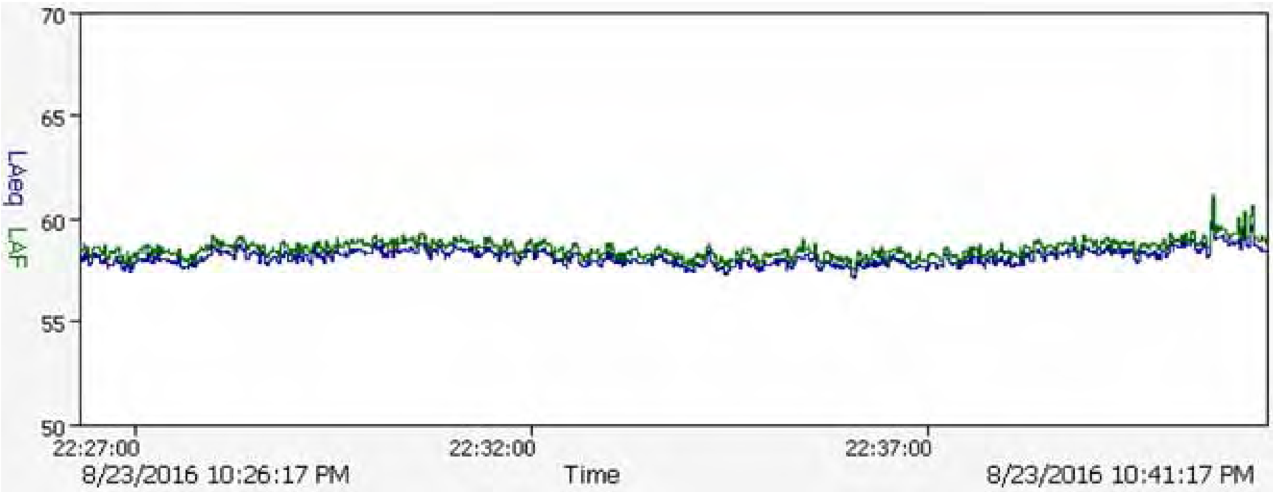
Place

Aughinish, Co. Limerick

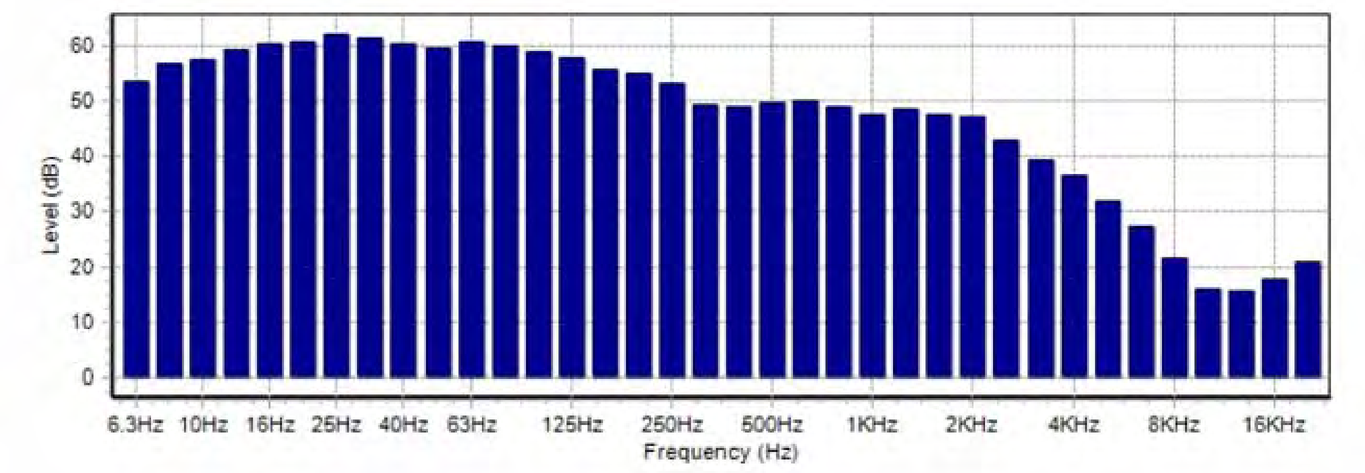
Project

AAL 2016

Time History



Frequency Bands



Report ID

B3 Night time #1

Start: 2016-08-25 02:20:00

End: 2016-08-25 02:35:00

LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-25 00:54

Mic Sensitivity: 44.3 mV/Pa

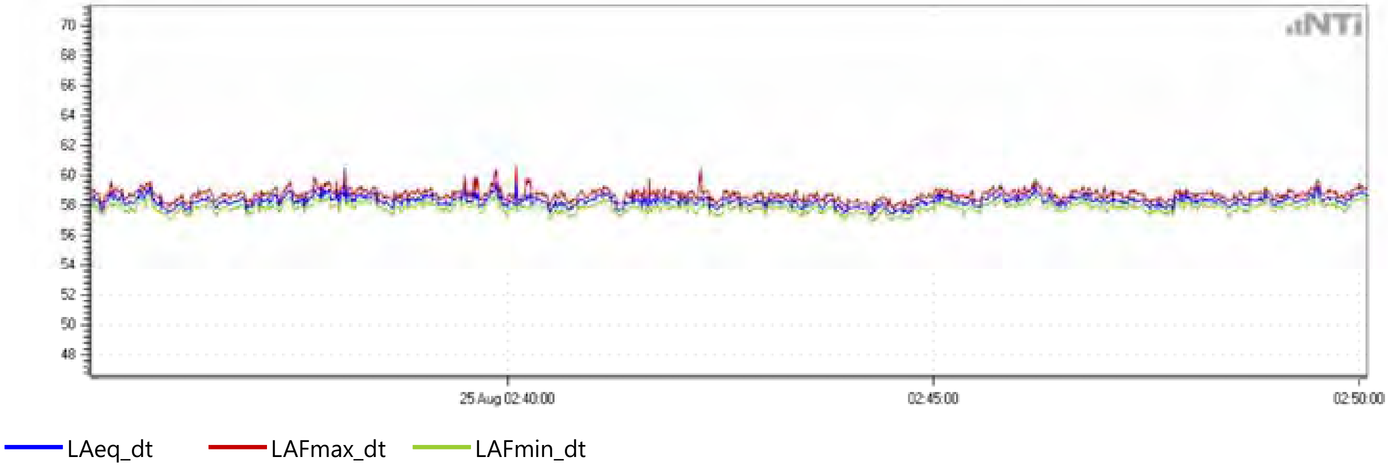
Range: 20 - 120 dB

LN based on: LAeq_dt

B3 Night time #2

Start: 2016-08-25 02:35:06

End: 2016-08-25 02:50:06



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-25 00:54

Mic Sensitivity: 44.3 mV/Pa

Range: 20 - 120 dB

LN based on: LAeq_dt

Cirrus Research plc

Measurement Summary Report

Name	B4 Daytime #1
Time	8/24/2016 2:22:25 PM
Duration	00:15:00
Instrument	GO56143, CR:171B

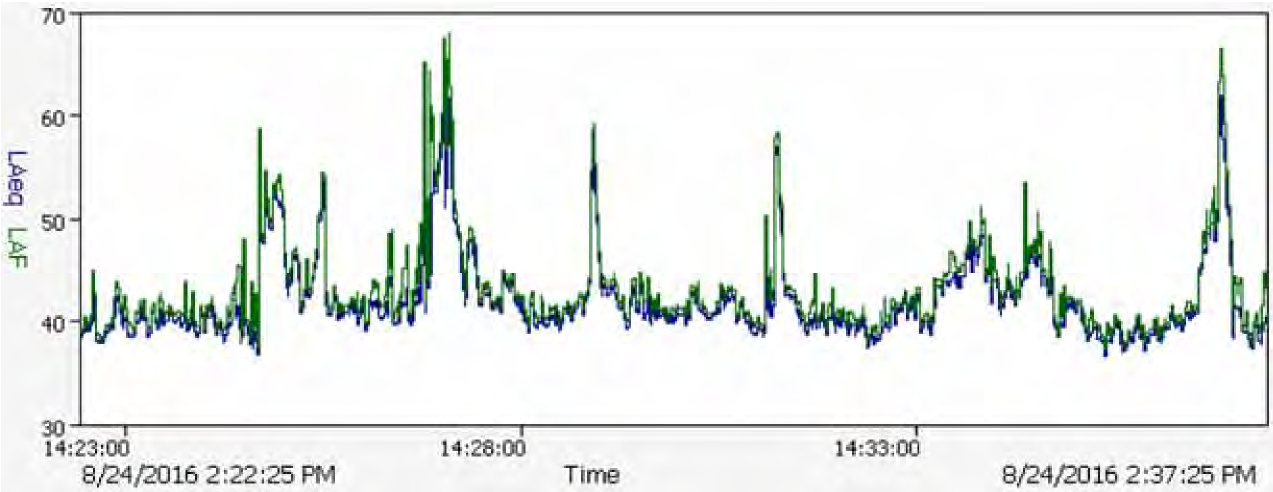
Summary

LAeq	45.7 dB
LAE	75.2 dB
LAFMax	67.9 dB

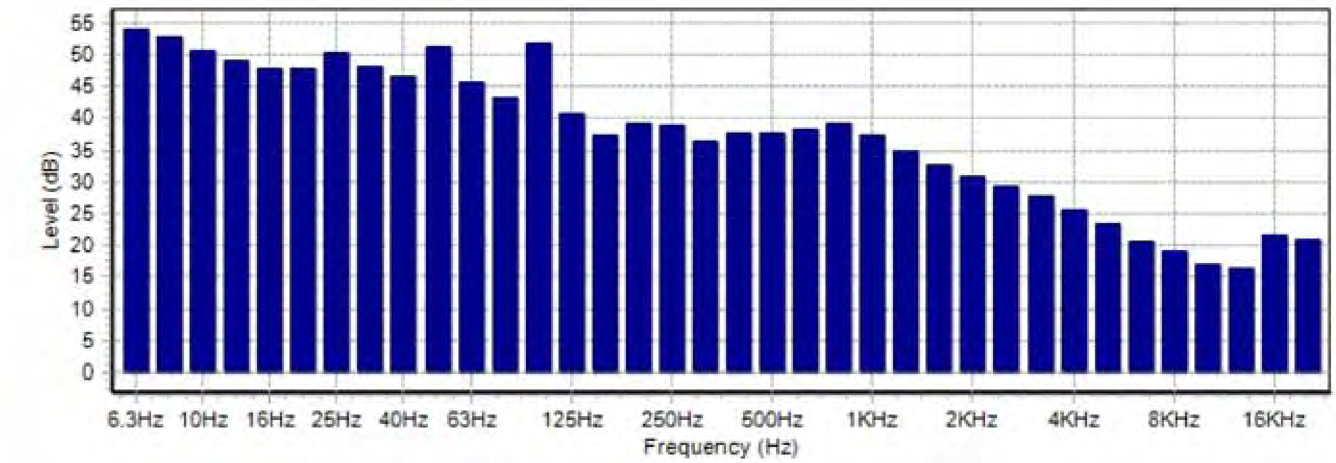
LAF1	57.2 dB
LAF5	50.4 dB
LAF10	47.1 dB
LAF50	40.8 dB
LAF90	38.5 dB
LAF95	38.0 dB
LAF99	37.1 dB

Calibration Information		Person	Place	Project
8/24/2016 11:13:44 AM	-0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:11:36 PM	0.12 dB			

Time History



Frequency Bands



Report ID

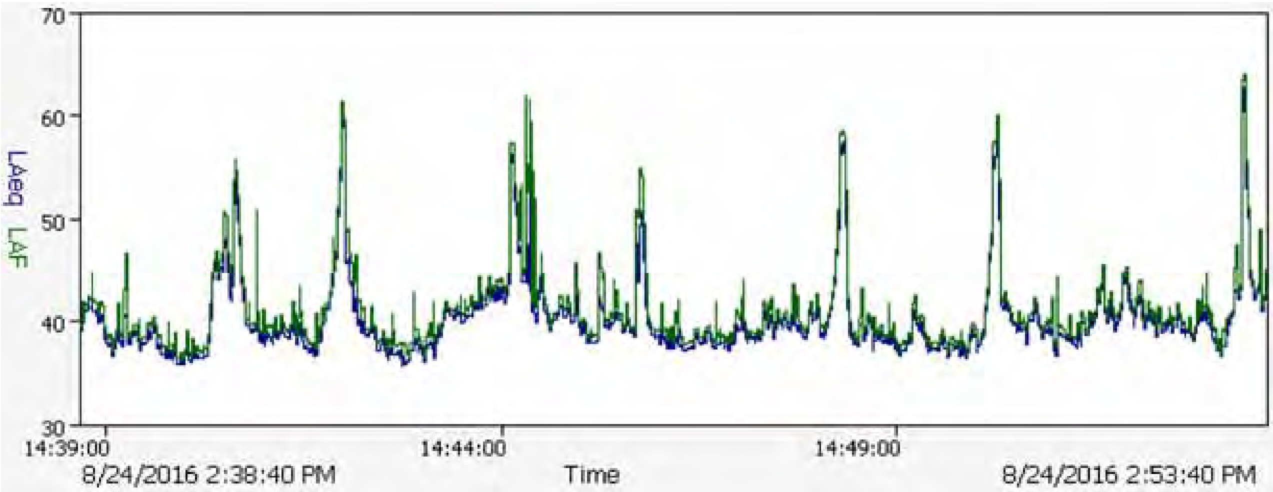
Cirrus Research plc

Measurement Summary Report

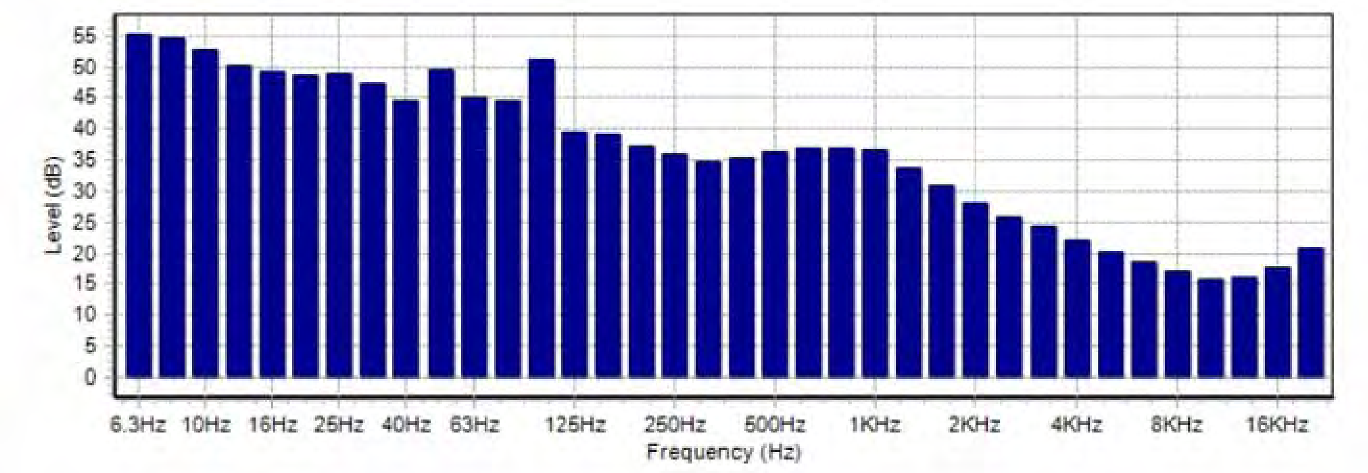
Name	B4 Daytime #2	**Summary**		LAF1	57.1 dB
Time	8/24/2016 2:38:40 PM	LAeq	44.1 dB	LAF5	47.1 dB
Duration	00:15:00	LAE	73.7 dB	LAF10	43.6 dB
Instrument	GO56143, CR:171B	LAFMax	64.1 dB	LAF50	39.1 dB
				LAF90	37.0 dB
				LAF95	36.6 dB
				LAF99	35.9 dB

Calibration Information		Person	Place	Project
8/24/2016 11:13:44 AM	-0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:11:36 PM	0.12 dB			

Time History



Frequency Bands



Report ID

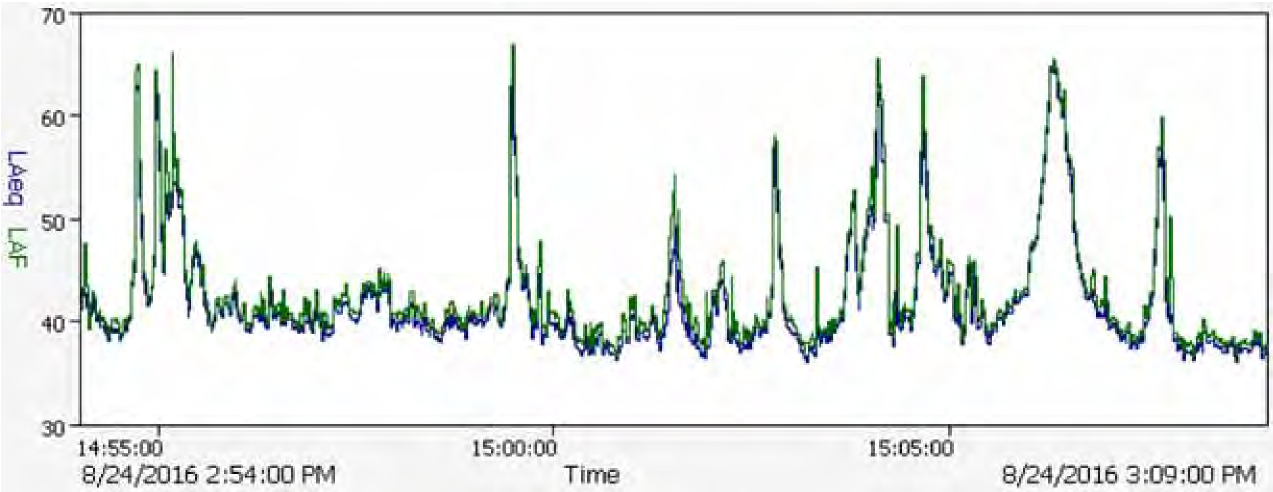
Cirrus Research plc

Measurement Summary Report

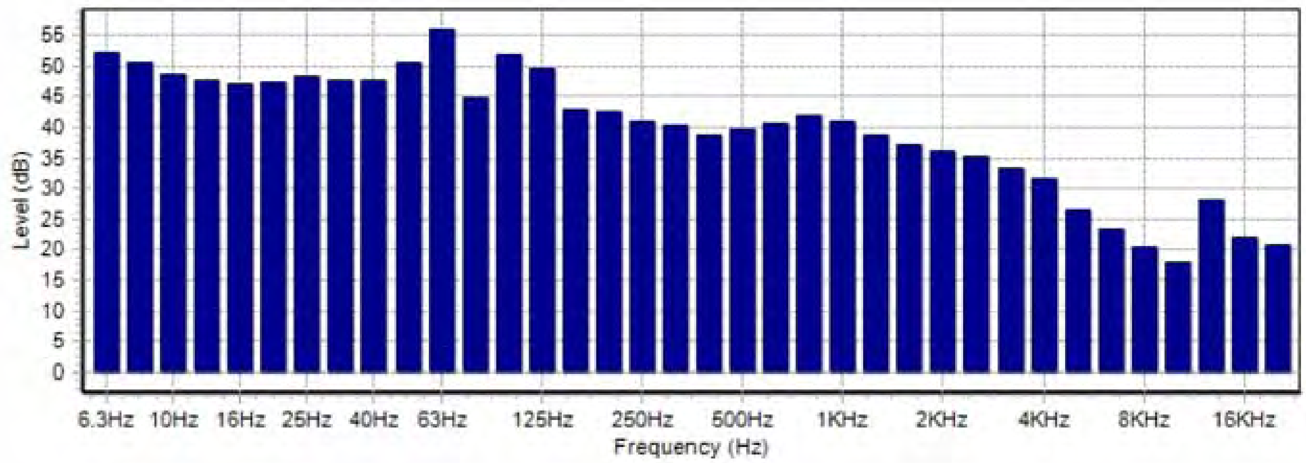
Name	B4 Daytime #3	**Summary**		LAF1	63.0 dB		
Time	8/24/2016 2:54:00 PM	LAeq	49.0 dB	LAF5	54.6 dB		
Duration	00:15:00	LAE	78.6 dB	LAF10	48.8 dB		
Instrument	GO56143, CR:171B	LAFMax	66.9 dB	LAF50	40.0 dB		
				LAF90	37.4 dB		
				LAF95	36.9 dB		
				LAF99	36.1 dB		

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 11:13:44 AM	-0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 3:11:36 PM	0.12 dB			

Time History



Frequency Bands



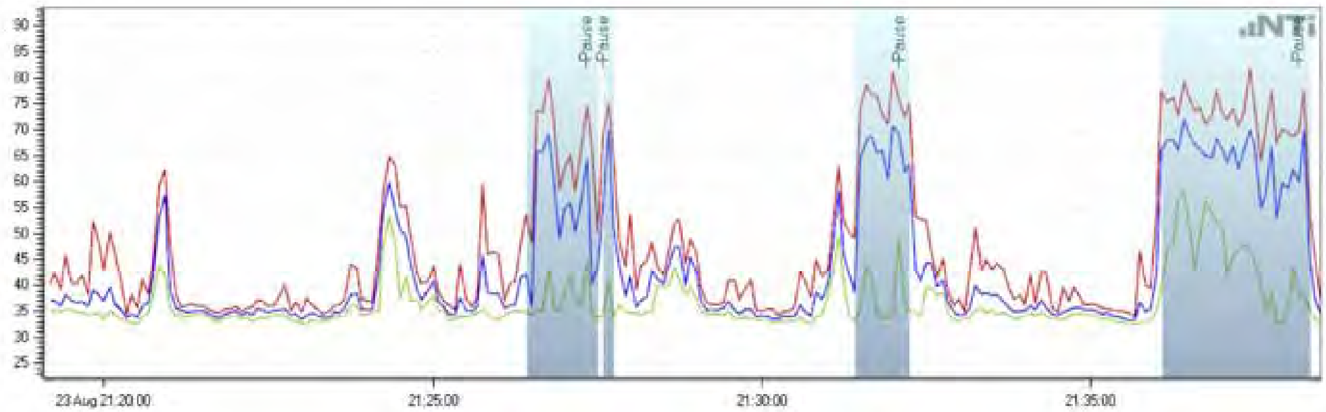
Report ID

B4 Evening #1

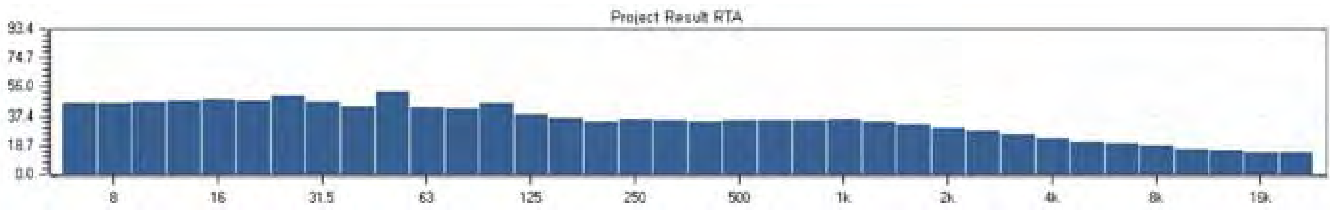
Start: 2016-08-23 21:19:08

End: 2016-08-23 21:38:28.5

Meter paused due to local asking questions.



LAeq_dt LAFmax_dt LAFmin_dt



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

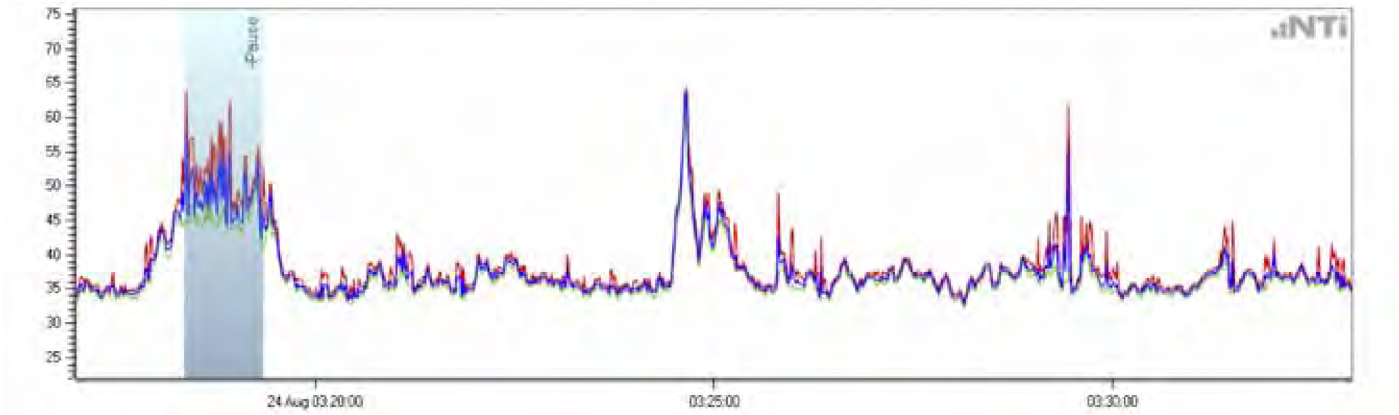
Range: 20 - 120 dB

LN based on: LAeq_dt

B4 Night time #1

Start: 2016-08-24 03:17:00

End: 2016-08-24 03:32:59.3



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

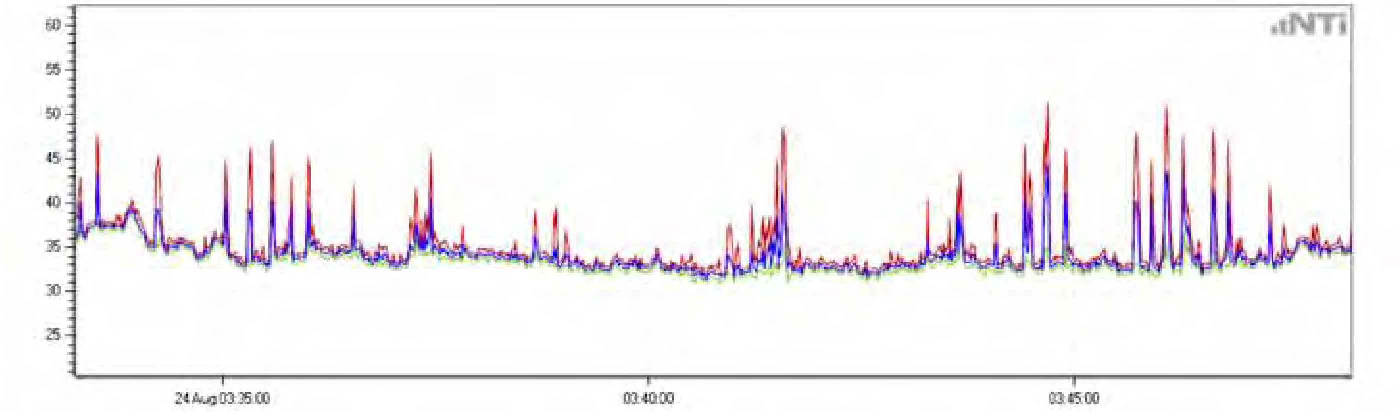
Range: 20 - 120 dB

LN based on: LAeq_dt

B4 Night time #2

Start: 2016-08-24 03:33:16

End: 2016-08-24 03:48:16



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

Range: 20 - 120 dB

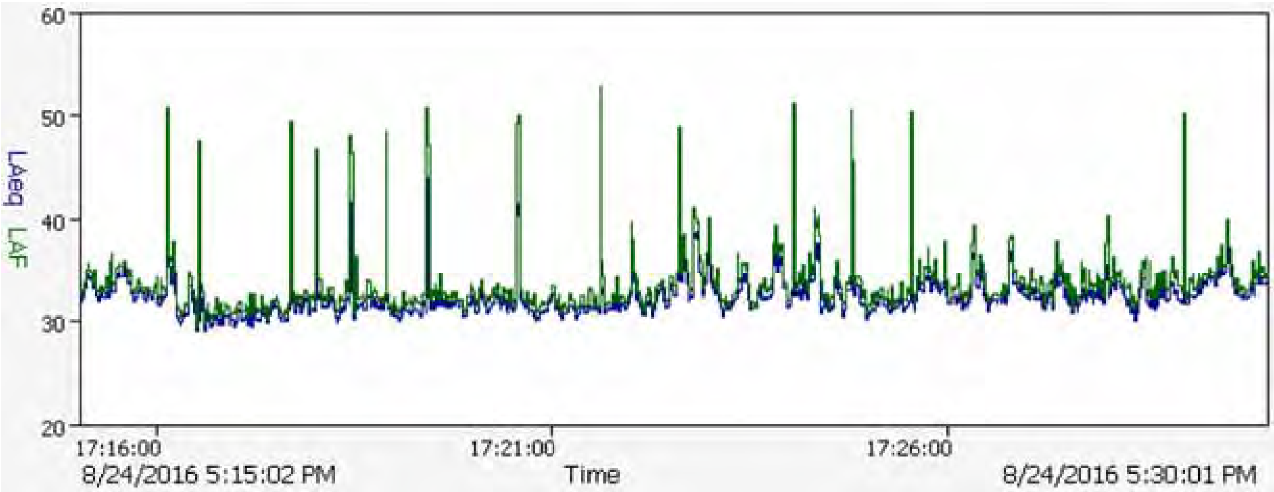
Cirrus Research plc

Measurement Summary Report

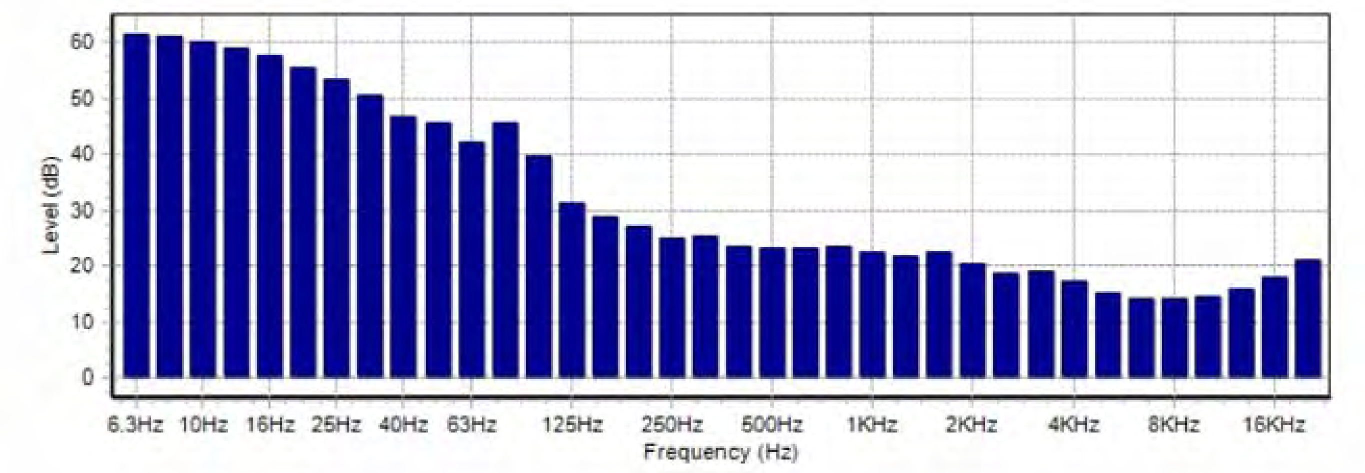
Name	B5 Daytime #1	**Summary**			LAF1	38.9 dB
Time	8/24/2016 5:15:02 PM	LAeq	33.2 dB		LAF5	35.2 dB
Duration	00:15:00	LAE	62.8 dB		LAF10	34.2 dB
Instrument	GO56143, CR:171B	LAFMax	52.8 dB		LAF50	31.9 dB
					LAF90	30.5 dB
					LAF95	30.1 dB
					LAF99	29.4 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 3:11:36 PM	0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:07:28 PM	0.36 dB			

Time History



Frequency Bands



Report ID

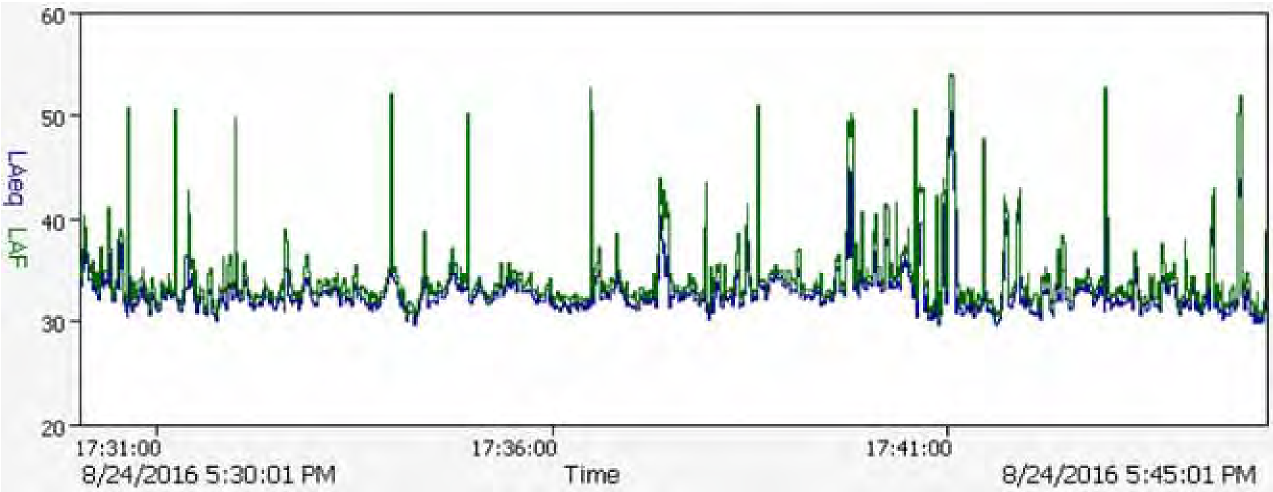
Cirrus Research plc

Measurement Summary Report

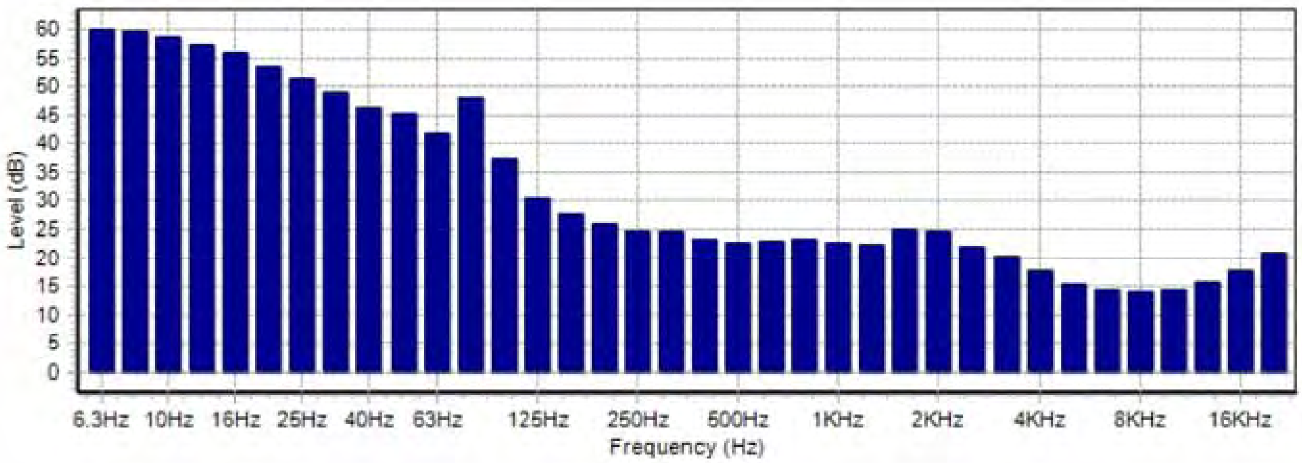
Name	B5 Daytime #2	**Summary**		LAF1	43.0 dB
Time	8/24/2016 5:30:01 PM	LAeq	34.3 dB	LAF5	36.5 dB
Duration	00:15:00	LAE	63.8 dB	LAF10	34.6 dB
Instrument	GO56143, CR:171B	LAFMax	54.0 dB	LAF50	32.2 dB
				LAF90	30.8 dB
				LAF95	30.5 dB
				LAF99	29.8 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 3:11:36 PM	0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:07:28 PM	0.36 dB			

Time History



Frequency Bands



Report ID

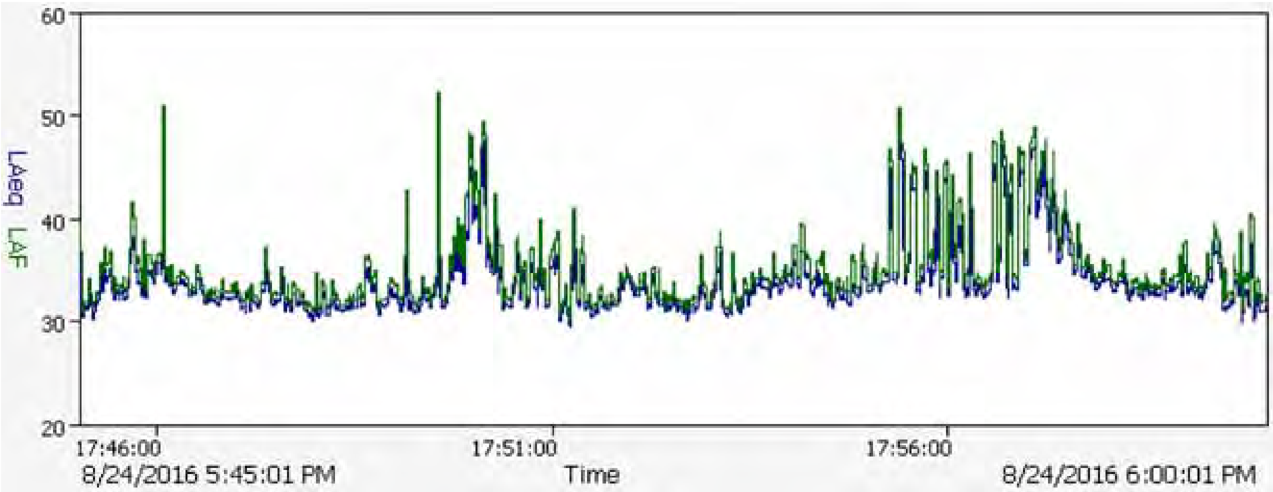
Cirrus Research plc

Measurement Summary Report

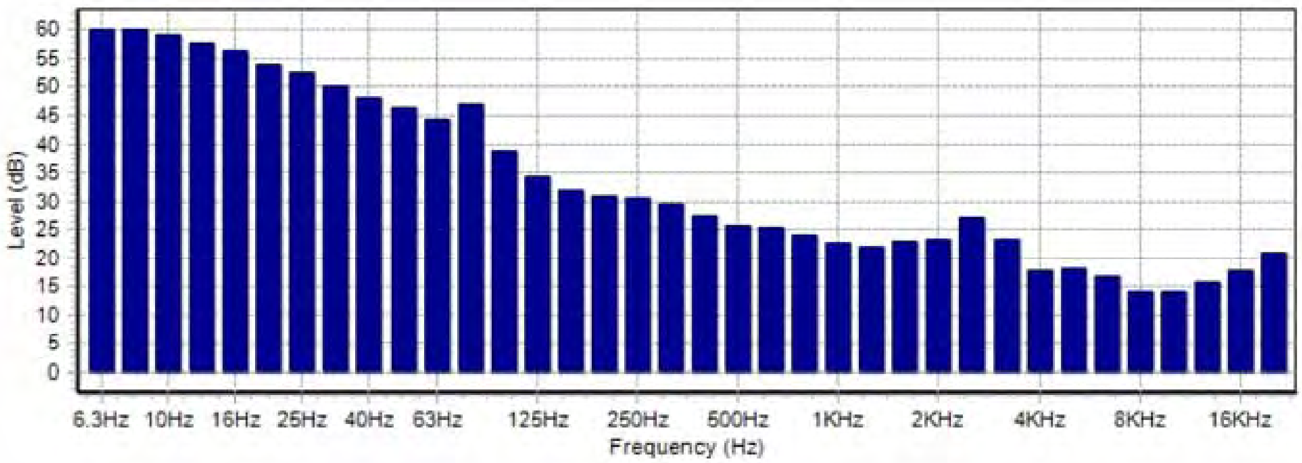
Name	B5 Daytime #3	**Summary**		LAF1	46.1 dB
Time	8/24/2016 5:45:01 PM	LAeq	35.9 dB	LAF5	41.6 dB
Duration	00:15:00	LAE	65.4 dB	LAF10	37.3 dB
Instrument	GO56143, CR:171B	LAFMax	52.3 dB	LAF50	32.9 dB
				LAF90	31.0 dB
				LAF95	30.7 dB
				LAF99	30.0 dB

Calibration Information		Person	Place	Project
8/24/2016 3:11:36 PM	0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:07:28 PM	0.36 dB			

Time History



Frequency Bands



Report ID

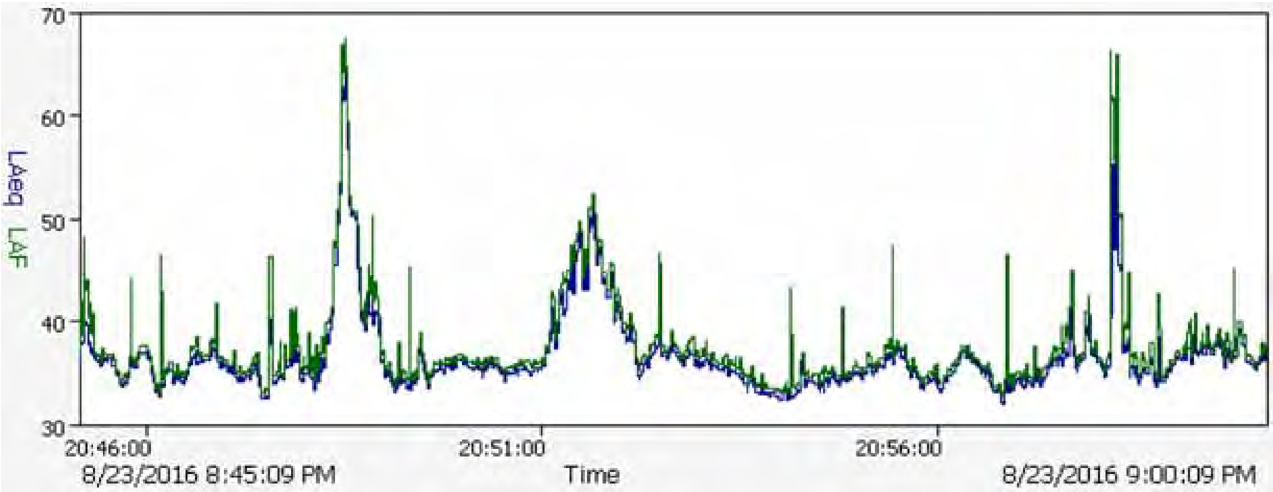
Cirrus Research plc

Measurement Summary Report

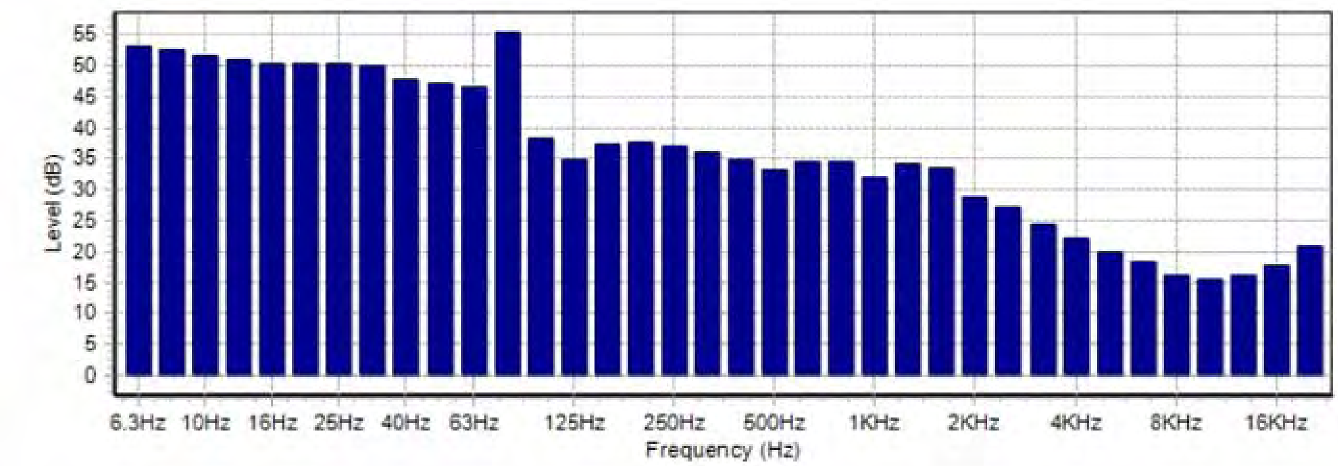
Name	B5 Evening #1	**Summary**		LAF1	52.8 dB
Time	8/23/2016 8:45:09 PM	LAeq	43.1 dB	LAF5	44.7 dB
Duration	00:15:00	LAE	72.7 dB	LAF10	40.1 dB
Instrument	GO56143, CR:171B	LAFMax	67.4 dB	LAF50	35.5 dB
				LAF90	33.6 dB
				LAF95	33.1 dB
				LAF99	32.4 dB

Calibration Information		**Person**	**Place**	**Project**
8/23/2016 7:13:08 PM	0.08 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/23/2016 10:44:33 PM	0.21 dB			

Time History



Frequency Bands



Report ID

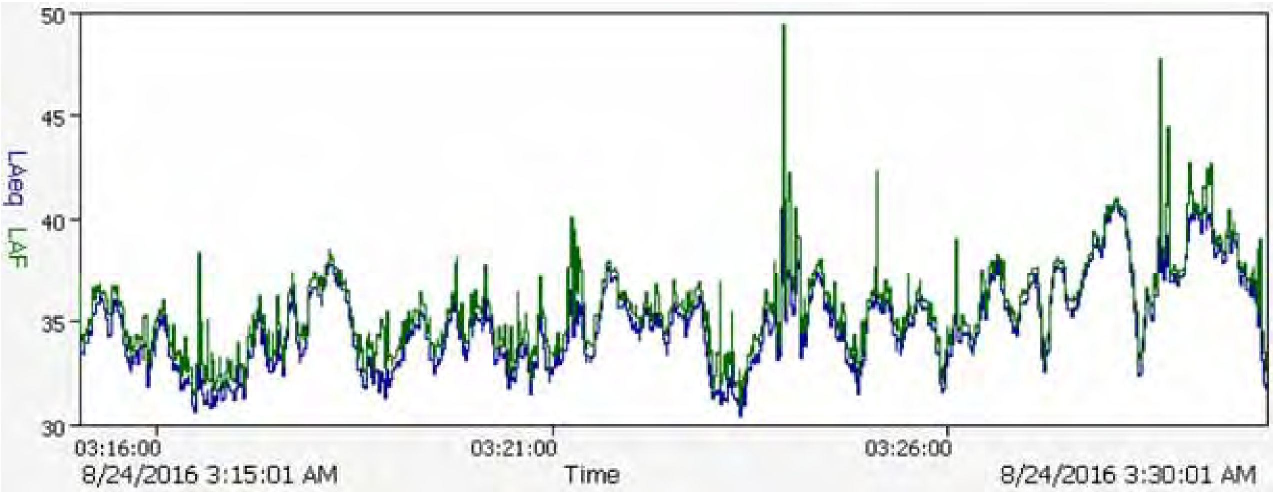
Cirrus Research plc

Measurement Summary Report

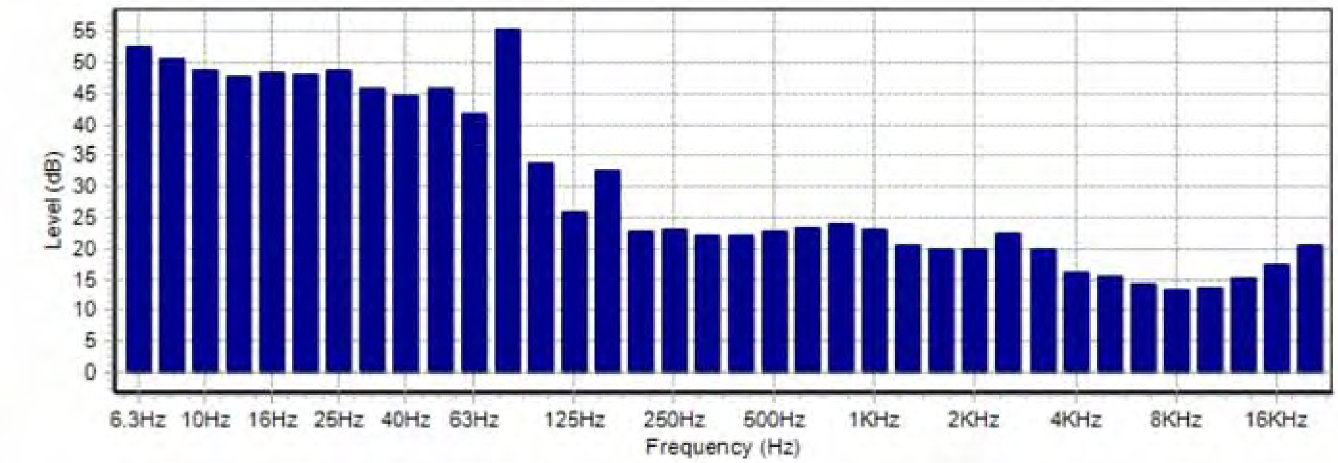
Name	B5 Night time #1	**Summary**		LAF1	40.4 dB
Time	8/24/2016 3:15:01 AM	LAeq	35.4 dB	LAF5	38.8 dB
Duration	00:15:00	LAE	65.0 dB	LAF10	37.6 dB
Instrument	GO56143, CR:171B	LAFMax	49.3 dB	LAF50	34.7 dB
				LAF90	32.0 dB
				LAF95	31.4 dB
				LAF99	30.7 dB

Calibration Information		Person	Place	Project
8/24/2016 3:03:31 AM	-0.18 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:13:44 AM	-0.12 dB			

Time History



Frequency Bands

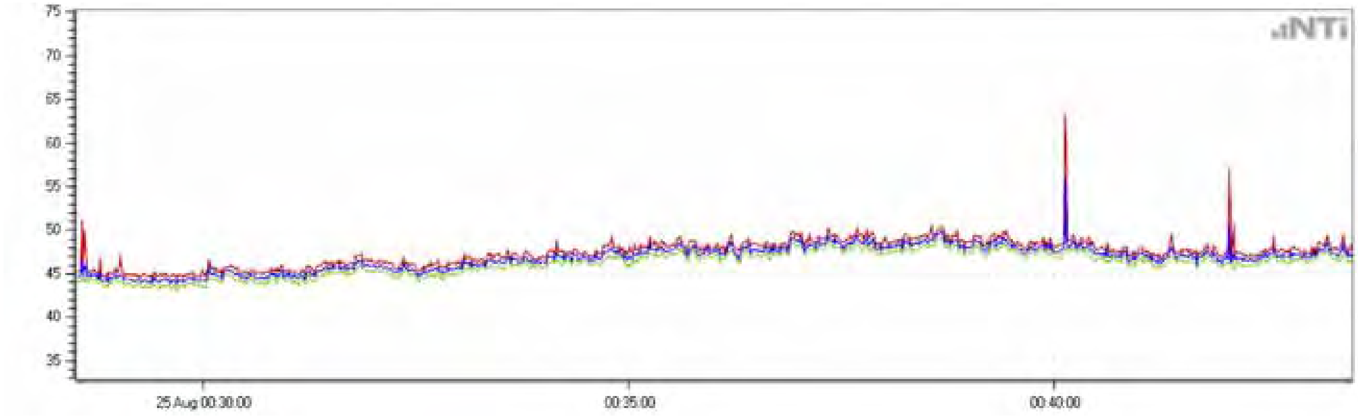


Report ID

B5 Night time #2

Start: 2016-08-25 00:28:30

End: 2016-08-25 00:43:30



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-24 11:43

Mic Sensitivity: 43.8 mV/Pa

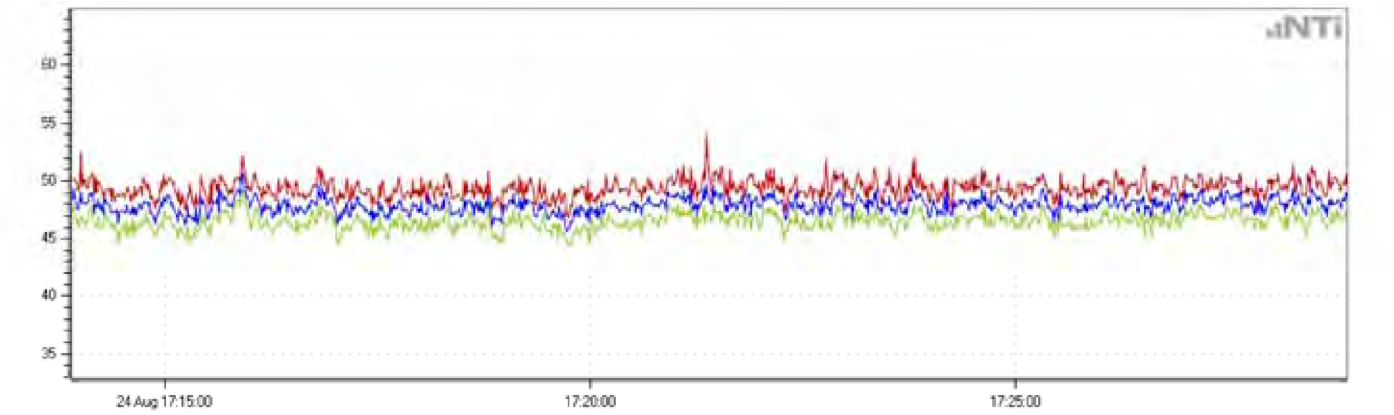
Range: 20 - 120 dB

LN based on: LAeq_dt

B6 Daytime #1

Start: 2016-08-24 17:13:54

End: 2016-08-24 17:28:54



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.5 mV/Pa (User calibrated 2016-08-24 15:00)

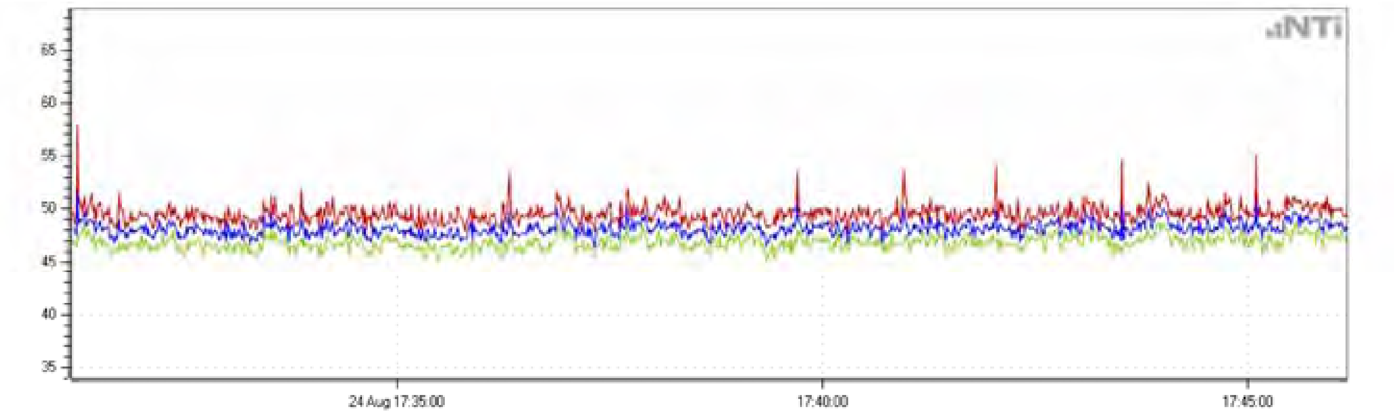
Range: 20 - 120 dB

LN based on: LAeq_dt

B6 Daytime #2

Start: 2016-08-24 17:31:10

End: 2016-08-24 17:46:10



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.8 mV/Pa (User calibrated 2016-08-24 17:29)

Range: 20 - 120 dB

LN based on: LAeq_dt

B6 Daytime #3

Start: 2016-08-24 17:46:18

End: 2016-08-24 18:01:18

LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.8 mV/Pa (User calibrated 2016-08-24 17:29)

Range: 20 - 120 dB

B6 Evening #1

Start: 2016-08-23 22:18:06

End: 2016-08-23 22:33:06

LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

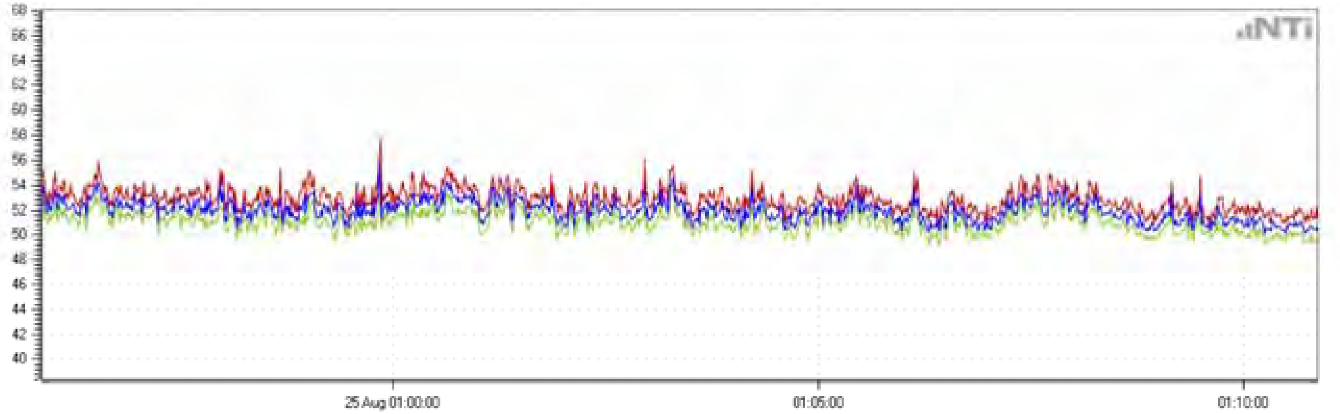
Range: 20 - 120 dB

LN based on: LAeq_dt

B6 Night time #1

Start: 2016-08-25 00:55:52

End: 2016-08-25 01:10:52



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-25 00:54

Mic Sensitivity: 44.3 mV/Pa

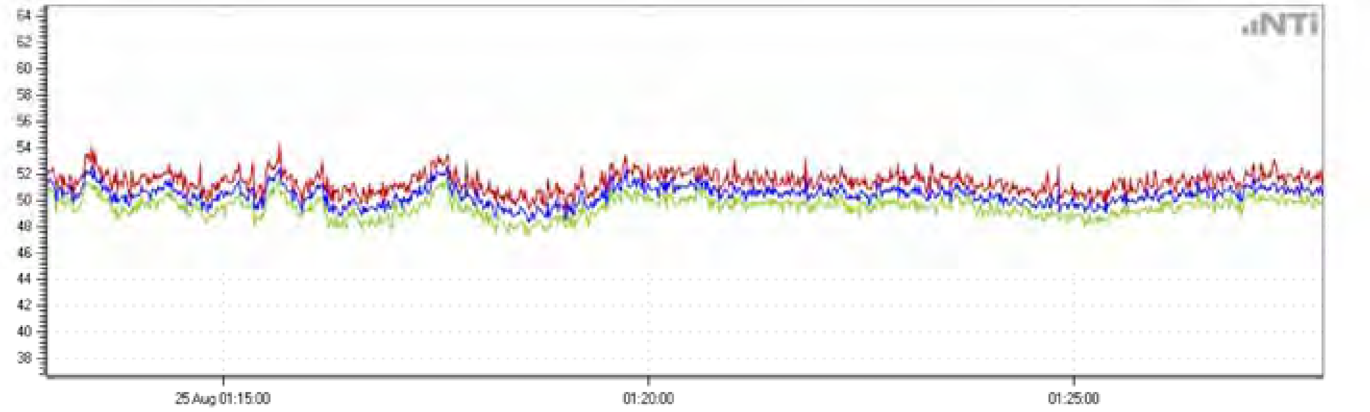
Range: 20 - 120 dB

LN based on: LAeq_dt

B6 Night time #2

Start: 2016-08-25 01:12:56

End: 2016-08-25 01:27:56



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-25 00:54

Mic Sensitivity: 44.3 mV/Pa

Range: 20 - 120 dB

LN based on: LAeq_dt

Date Printed 9/2/2016

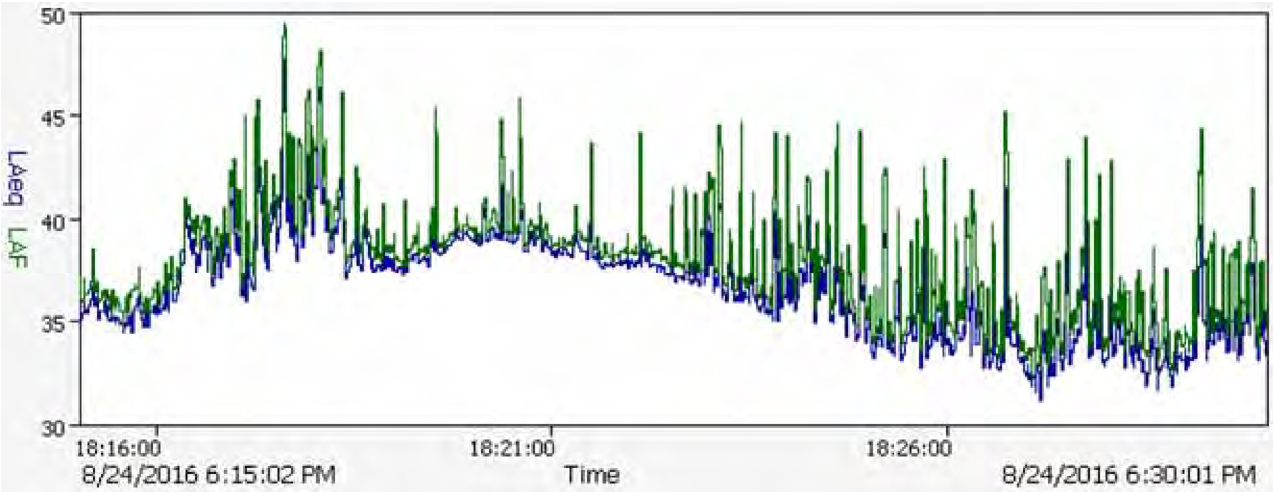
Cirrus Research plc

Measurement Summary Report

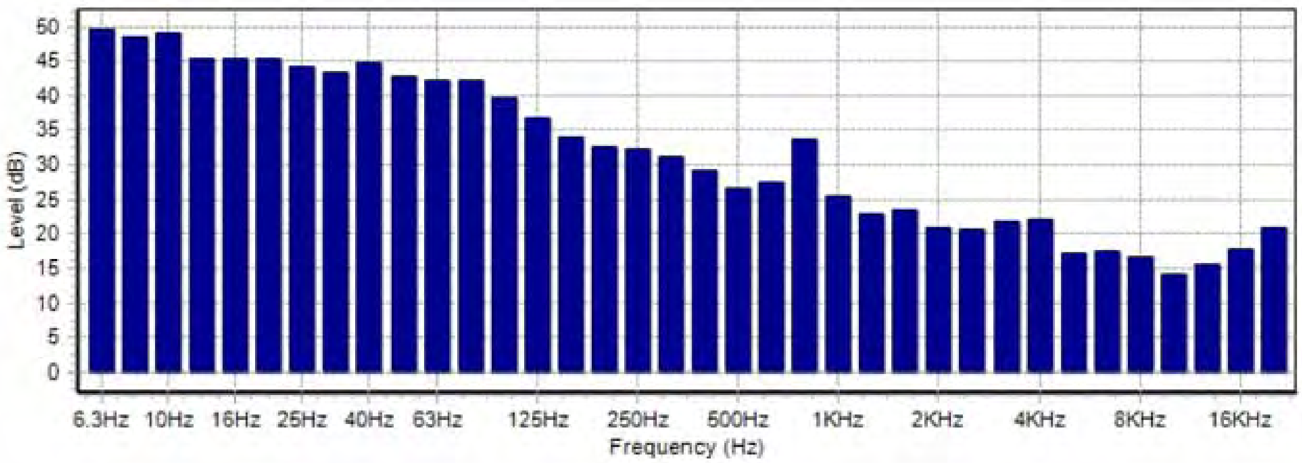
Name	B7 Daytime #1	**Summary**		LAF1	43.2 dB
Time	8/24/2016 6:15:02 PM	LAeq	37.5 dB	LAF5	40.5 dB
Duration	00:15:00	LAE	67.0 dB	LAF10	39.4 dB
Instrument	GO56143, CR:171B	LAFMax	49.5 dB	LAF50	36.8 dB
				LAF90	33.1 dB
				LAF95	32.6 dB
				LAF99	31.7 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 3:11:36 PM	0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:07:28 PM	0.36 dB			

Time History



Frequency Bands



Report ID

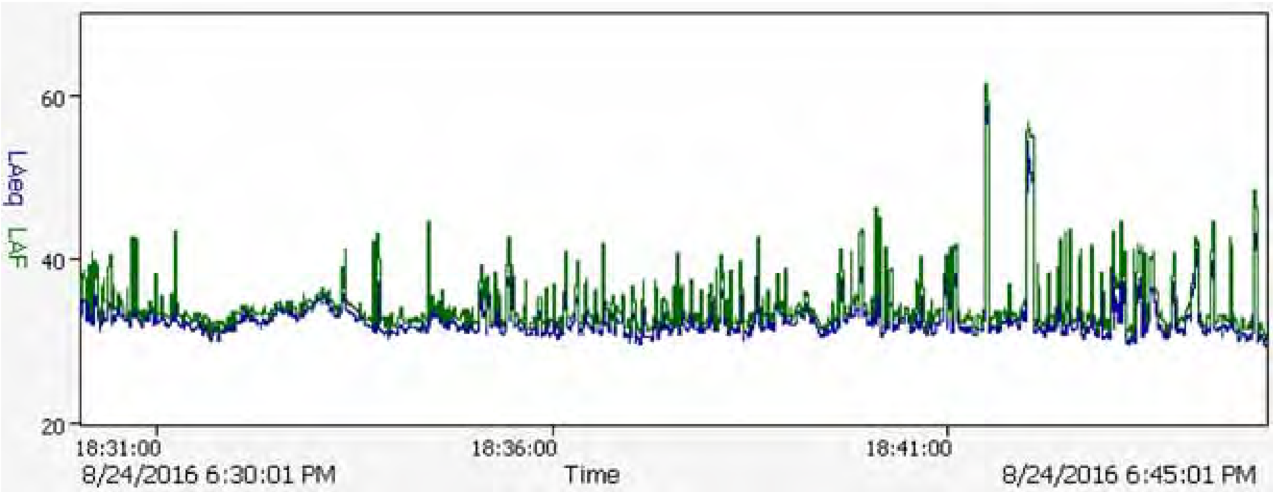
Cirrus Research plc

Measurement Summary Report

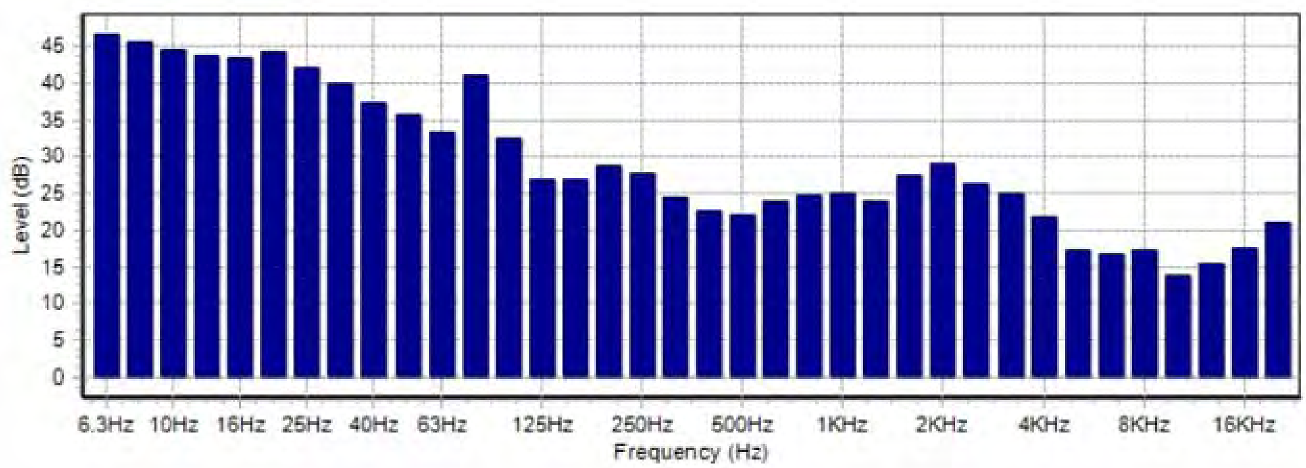
Name	B7 Daytime #2	**Summary**		LAF1	42.5 dB
Time	8/24/2016 6:30:01 PM	LAeq	36.4 dB	LAF5	36.9 dB
Duration	00:15:00	LAE	66.0 dB	LAF10	34.8 dB
Instrument	GO56143, CR:171B	LAFMax	61.2 dB	LAF50	32.0 dB
				LAF90	30.5 dB
				LAF95	30.2 dB
				LAF99	29.5 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 3:11:36 PM	0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:07:28 PM	0.36 dB			

Time History



Frequency Bands



Report ID

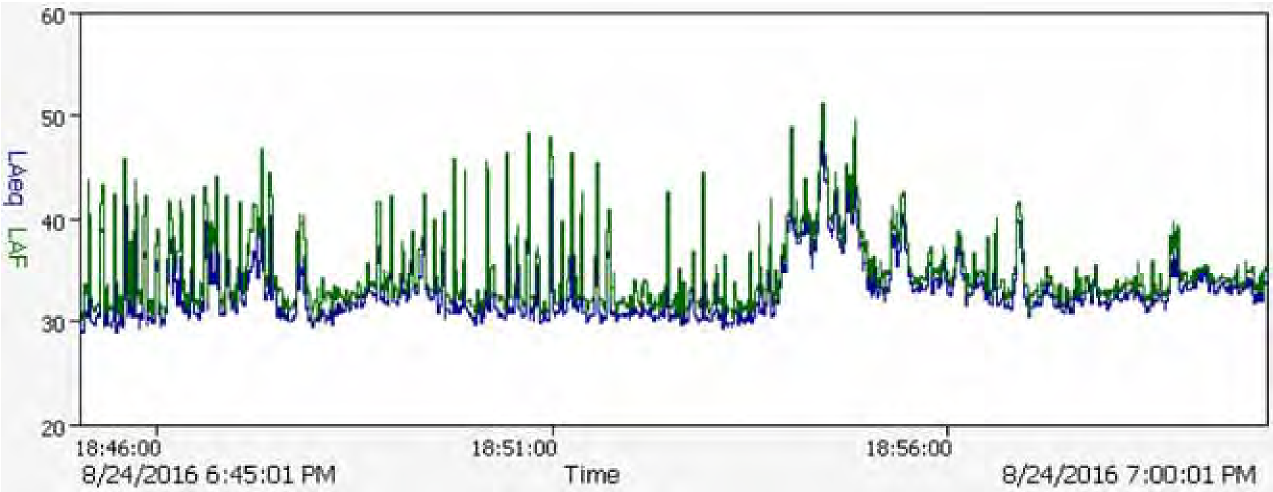
Cirrus Research plc

Measurement Summary Report

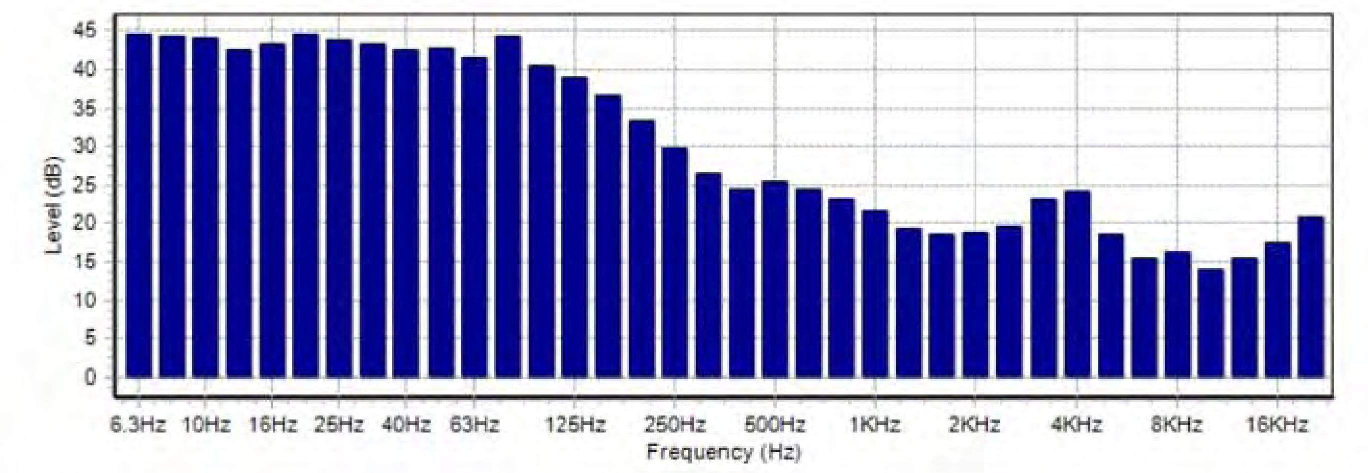
Name	B7 Daytime #3	**Summary**			LAF1	43.8 dB
Time	8/24/2016 6:45:01 PM	LAeq	34.8 dB		LAF5	39.6 dB
Duration	00:15:00	LAE	64.3 dB		LAF10	37.5 dB
Instrument	GO56143, CR:171B	LAFMax	51.2 dB		LAF50	32.1 dB
					LAF90	29.9 dB
					LAF95	29.5 dB
					LAF99	28.9 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 3:11:36 PM	0.12 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:07:28 PM	0.36 dB			

Time History



Frequency Bands



Report ID

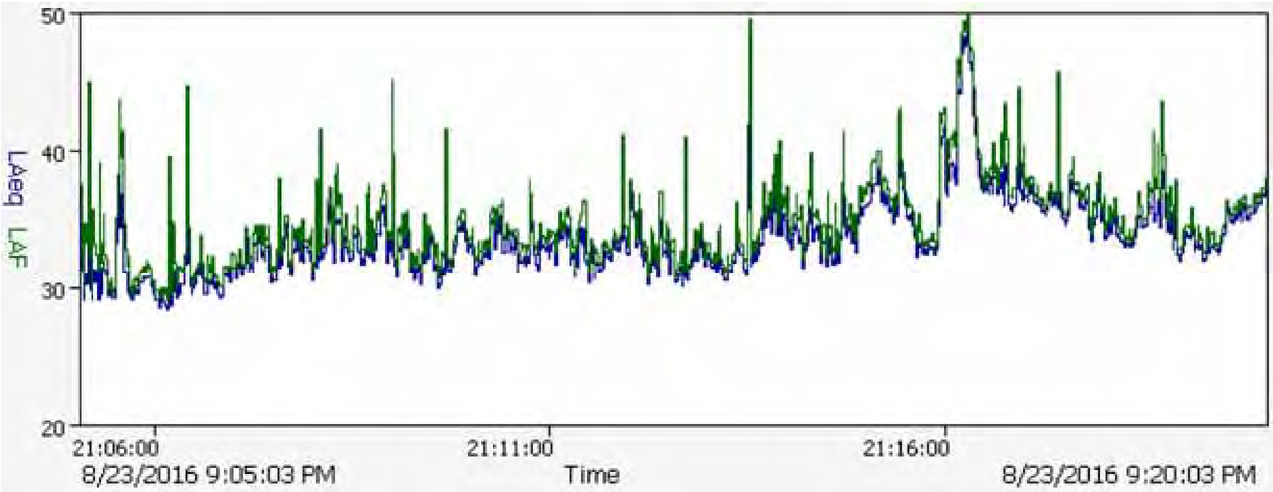
Cirrus Research plc

Measurement Summary Report

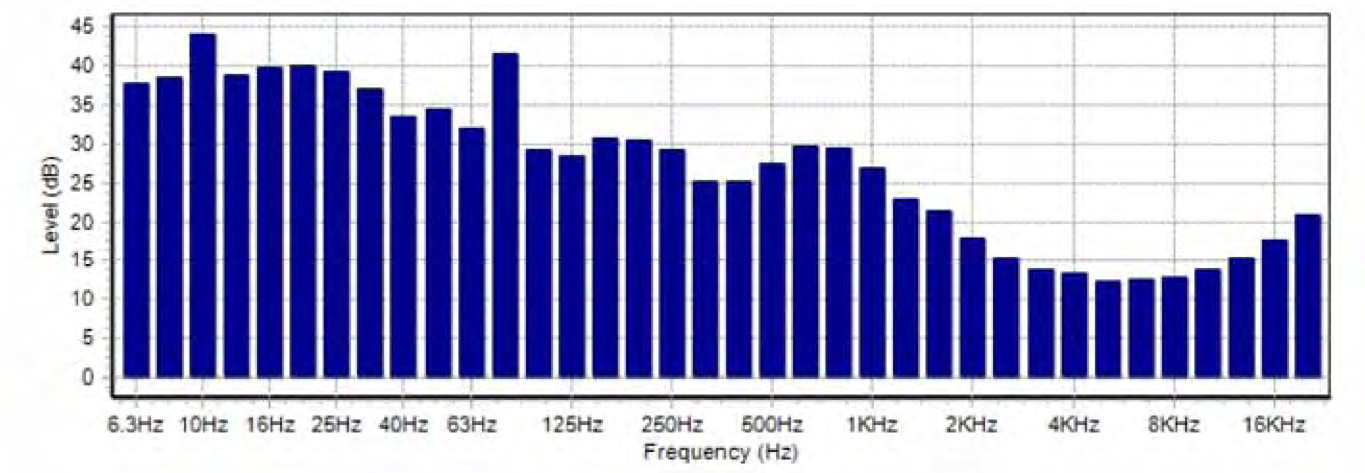
Name	B7 Evening #1	**Summary**			LAF1	45.0 dB
Time	8/23/2016 9:05:03 PM	LAeq	35.1 dB		LAF5	38.0 dB
Duration	00:15:00	LAE	64.6 dB		LAF10	36.7 dB
Instrument	GO56143, CR:171B	LAFMax	49.9 dB		LAF50	33.0 dB
					LAF90	30.5 dB
					LAF95	29.7 dB
					LAF99	28.8 dB

Calibration Information		**Person**	**Place**	**Project**
8/23/2016 7:13:08 PM	0.08 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/23/2016 10:44:33 PM	0.21 dB			

Time History



Frequency Bands



Report ID

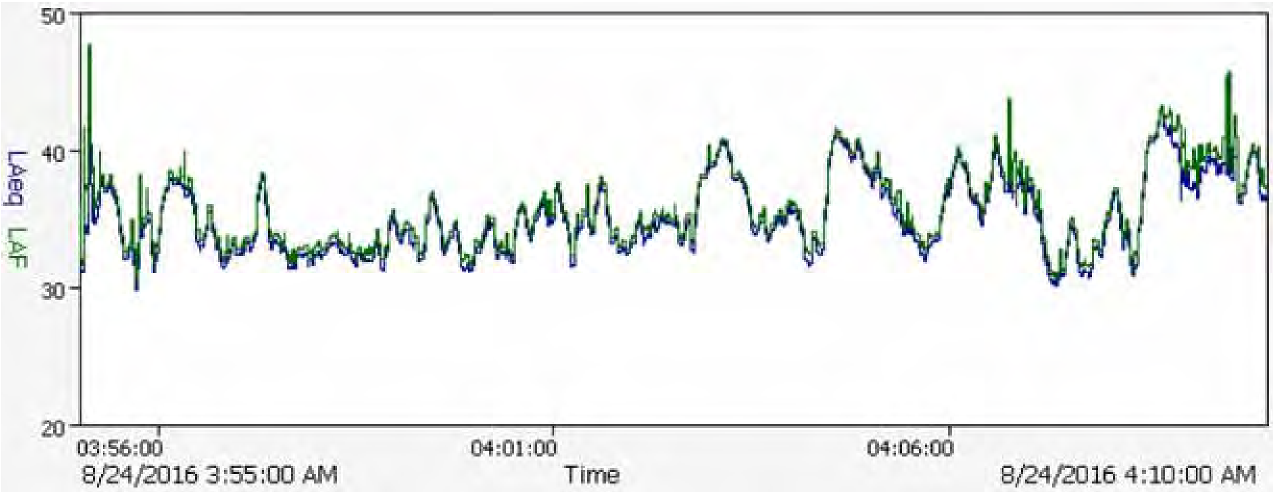
Cirrus Research plc

Measurement Summary Report

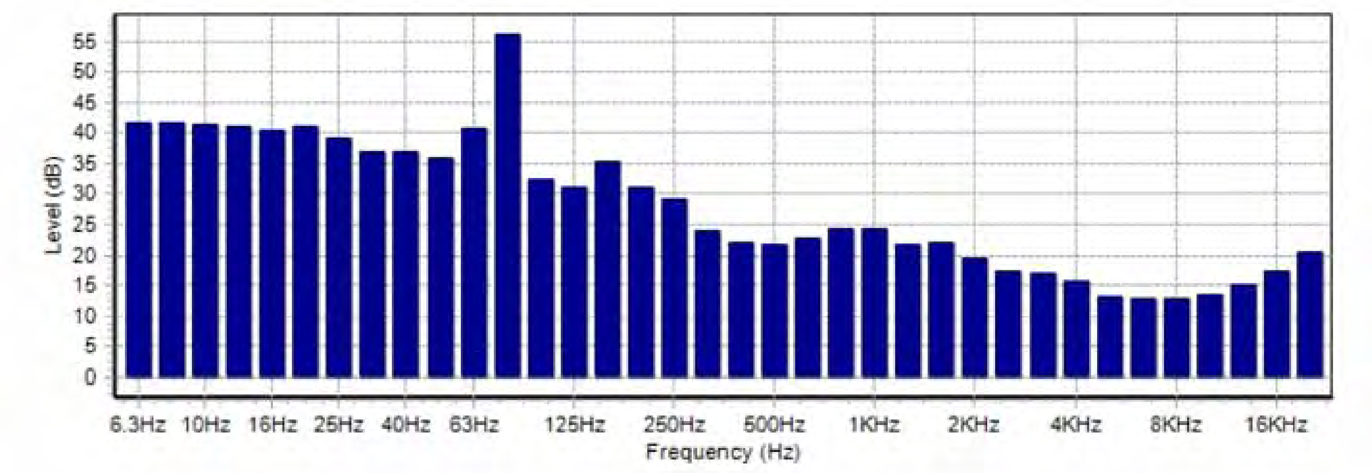
Name	B7 Night time #1	**Summary**		LAF1	41.5 dB
Time	8/24/2016 3:55:00 AM	LAeq	36.0 dB	LAF5	40.2 dB
Duration	00:15:00	LAE	65.5 dB	LAF10	39.0 dB
Instrument	GO56143, CR:171B	LAFMax	49.0 dB	LAF50	34.5 dB
				LAF90	31.9 dB
				LAF95	31.3 dB
				LAF99	30.4 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 3:03:31 AM	-0.18 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:13:44 AM	-0.12 dB			

Time History



Frequency Bands



Report ID

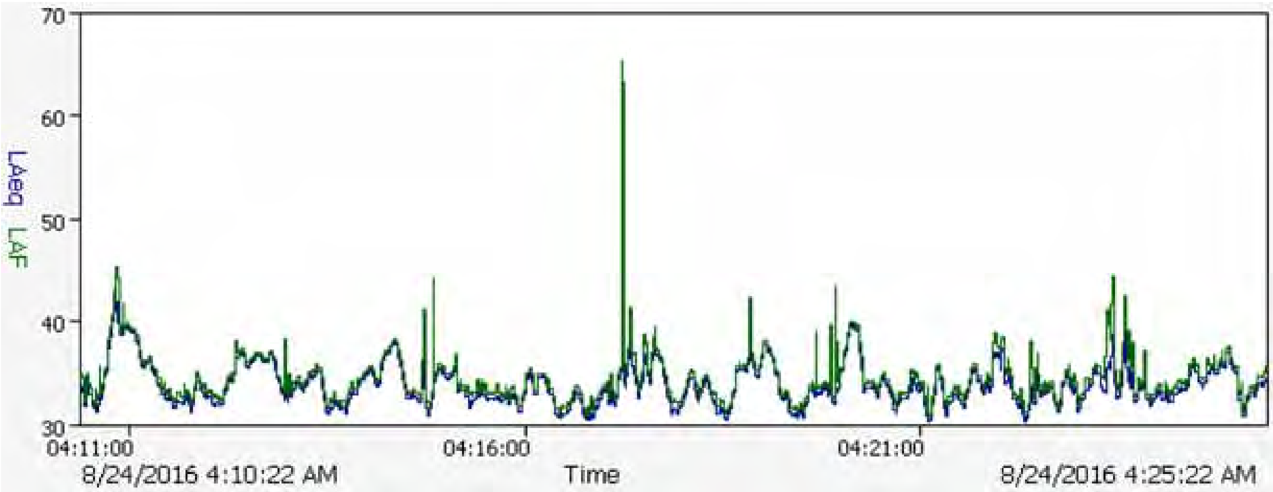
Cirrus Research plc

Measurement Summary Report

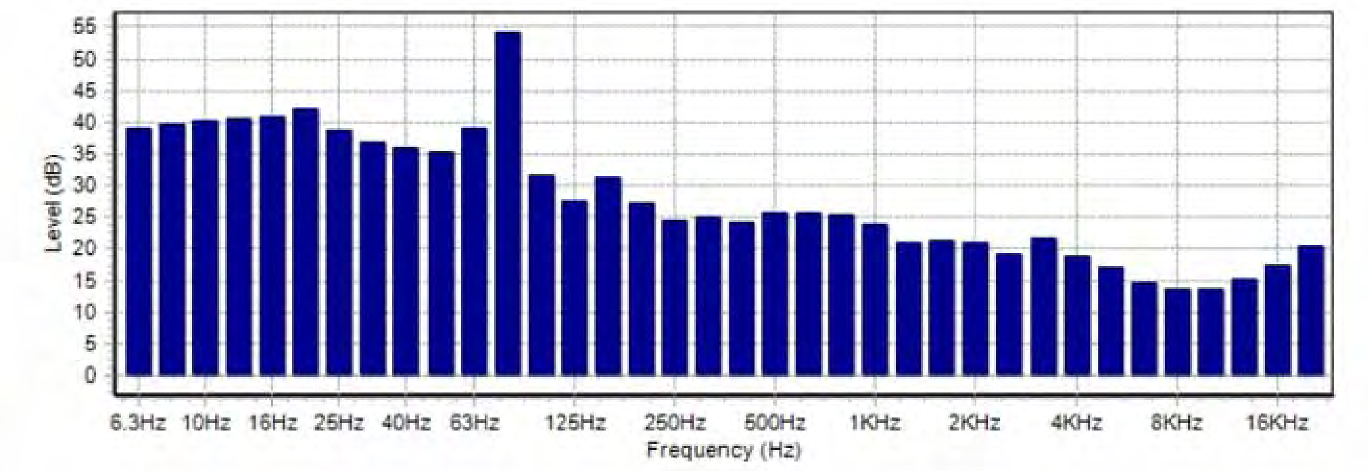
Name	B7 Night time #2	**Summary**		LAF1	39.7 dB
Time	8/24/2016 4:10:22 AM	LAeq	35.5 dB	LAF5	37.7 dB
Duration	00:15:00	LAE	65.0 dB	LAF10	36.5 dB
Instrument	GO56143, CR:171B	LAFMax	65.2 dB	LAF50	33.3 dB
				LAF90	31.5 dB
				LAF95	31.0 dB
				LAF99	30.4 dB

Calibration Information		**Person**	**Place**	**Project**
8/24/2016 3:03:31 AM	-0.18 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/24/2016 11:13:44 AM	-0.12 dB			

Time History



Frequency Bands

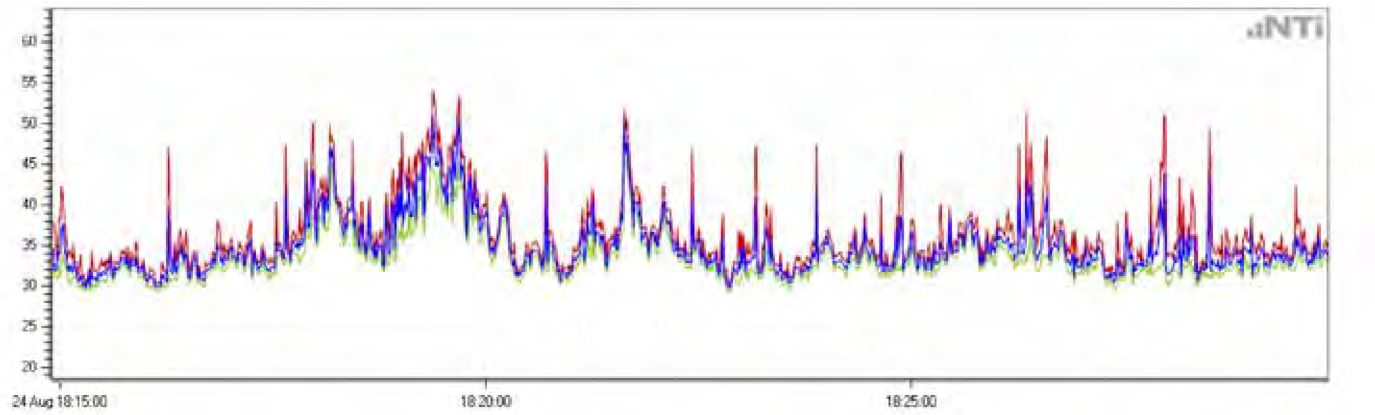


Report ID

B8 Daytime #1

Start: 2016-08-24 18:14:54

End: 2016-08-24 18:29:54



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.8 mV/Pa (User calibrated 2016-08-24 17:29)

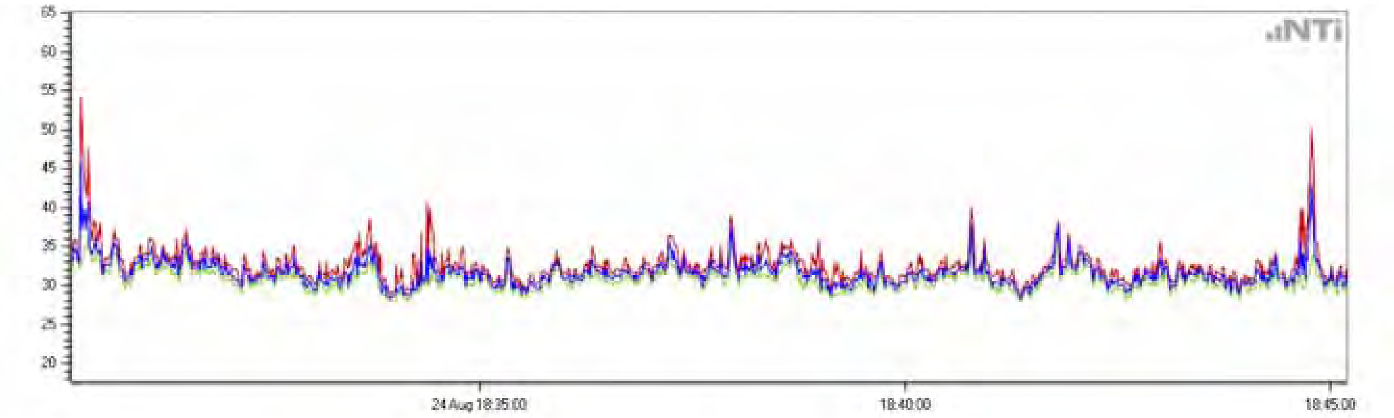
Range: 20 - 120 dB

LN based on: LAeq_dt

B8 Daytime #2

Start: 2016-08-24 18:30:12

End: 2016-08-24 18:45:12



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.8 mV/Pa (User calibrated 2016-08-24 17:29)

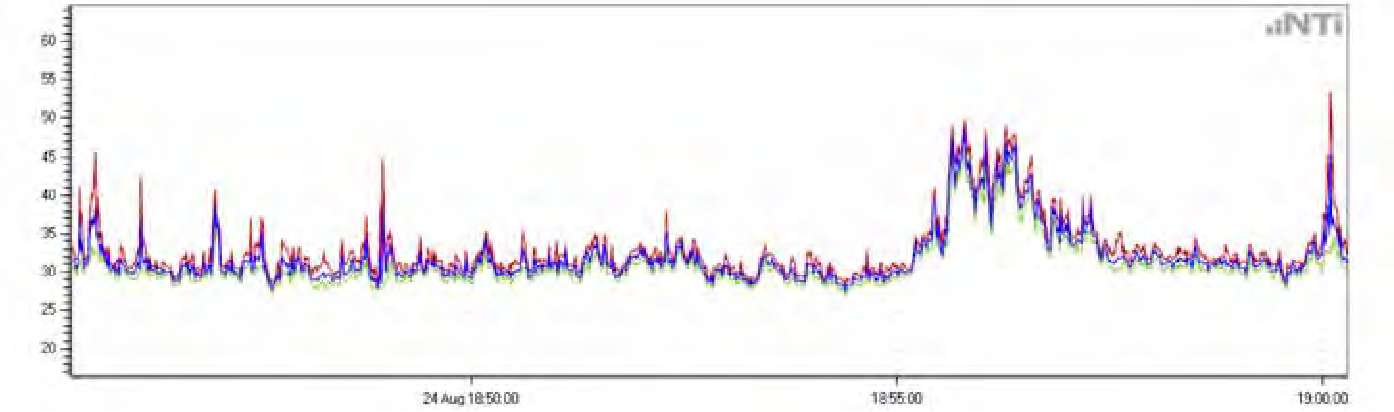
Range: 20 - 120 dB

LN based on: LAeq_dt

B8 Daytime #3

Start: 2016-08-24 18:45:18

End: 2016-08-24 19:00:18



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Sensitivity: 43.8 mV/Pa (User calibrated 2016-08-24 17:29)

Range: 20 - 120 dB

LN based on: LAeq_dt

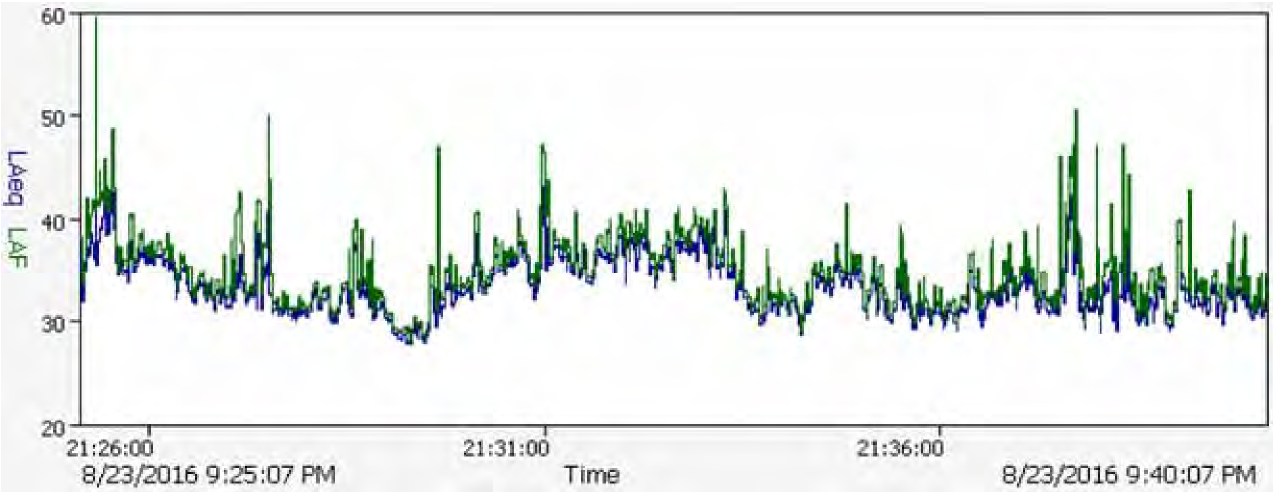
Cirrus Research plc

Measurement Summary Report

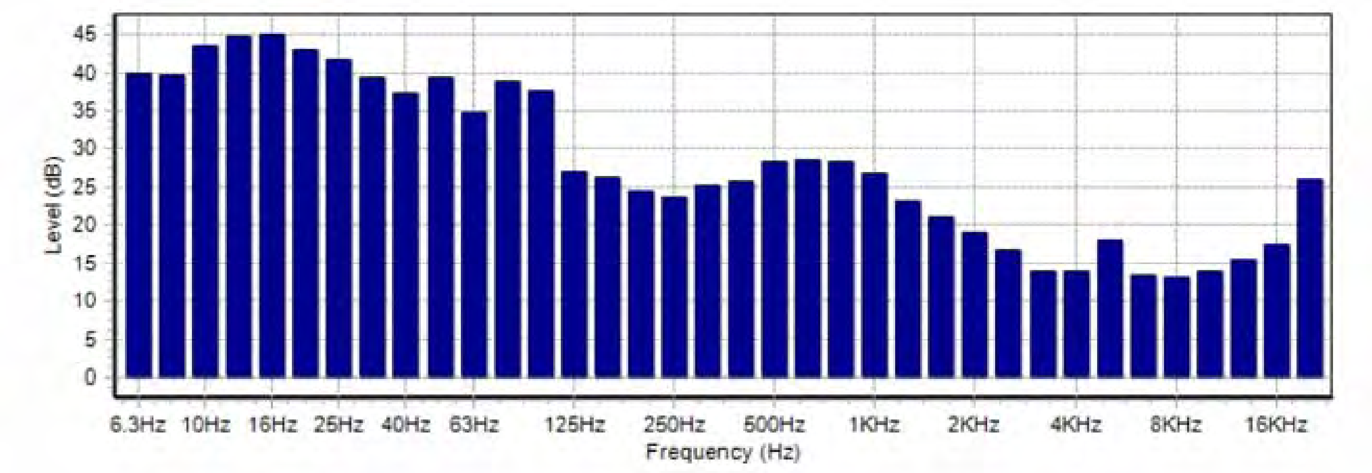
Name	B8 Evening #1	**Summary**		LAF1	41.4 dB
Time	8/23/2016 9:25:07 PM	LAeq	34.7 dB	LAF5	38.2 dB
Duration	00:15:00	LAE	64.2 dB	LAF10	37.0 dB
Instrument	GO56143, CR:171B	LAFMax	59.6 dB	LAF50	32.8 dB
				LAF90	30.1 dB
				LAF95	29.3 dB
				LAF99	28.1 dB

Calibration Information		Person	Place	Project
8/23/2016 7:13:08 PM	0.08 dB	Siobhan Maher	Aughinish, Co. Limerick	AAL 2016
8/23/2016 10:44:33 PM	0.21 dB			

Time History



Frequency Bands

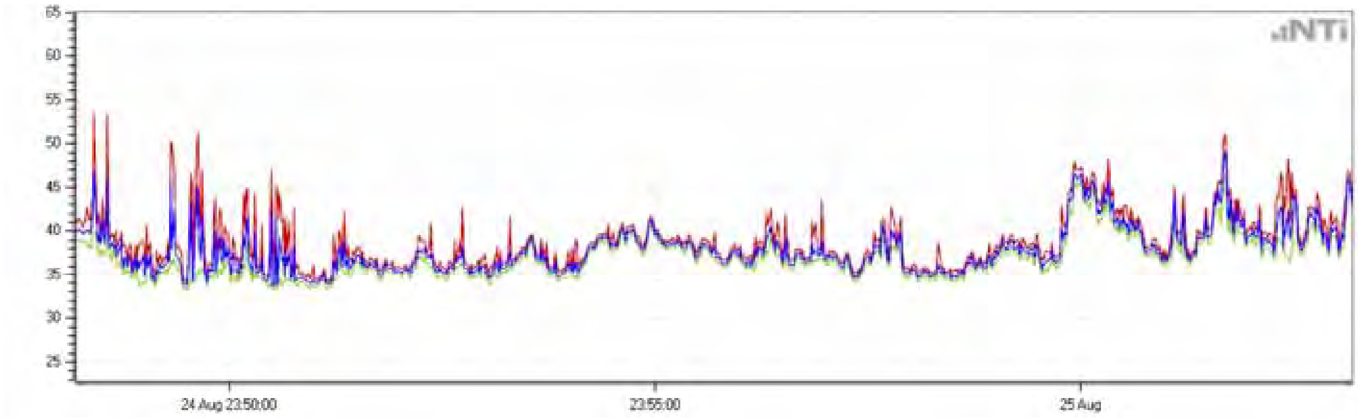


Report ID

B8 Night #1

Start: 2016-08-24 23:48:12

End: 2016-08-25 00:03:12



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-24 11:43

Mic Sensitivity: 43.8 mV/Pa

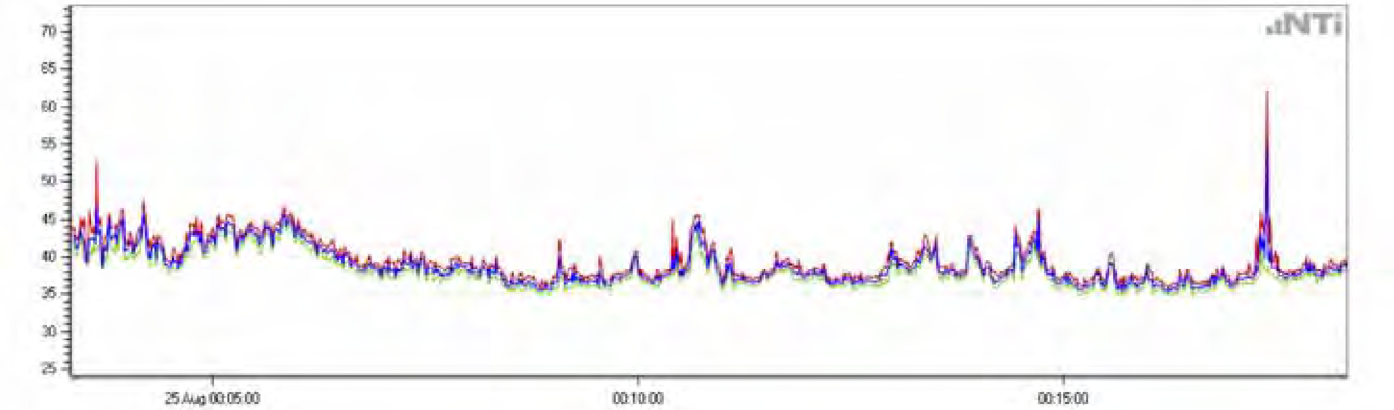
Range: 20 - 120 dB

LN based on: LAeq_dt

B8 Night time #2

Start: 2016-08-25 00:03:20

End: 2016-08-25 00:18:20



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-24 11:43

Mic Sensitivity: 43.8 mV/Pa

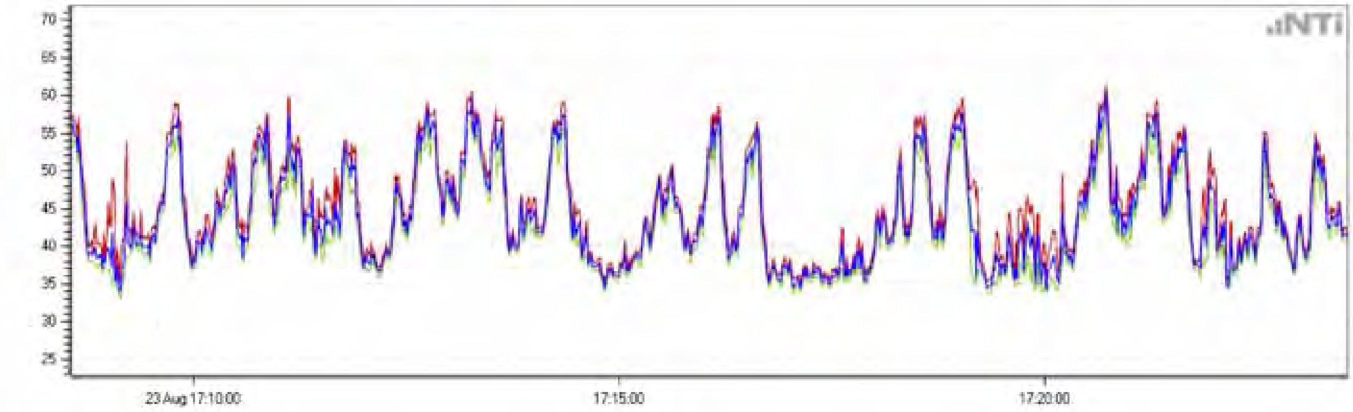
Range: 20 - 120 dB

LN based on: LAeq_dt

B9 Daytime #1

Start: 2016-08-23 17:08:34

End: 2016-08-23 17:23:34



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 17:04

Mic Sensitivity: 43.5 mV/Pa

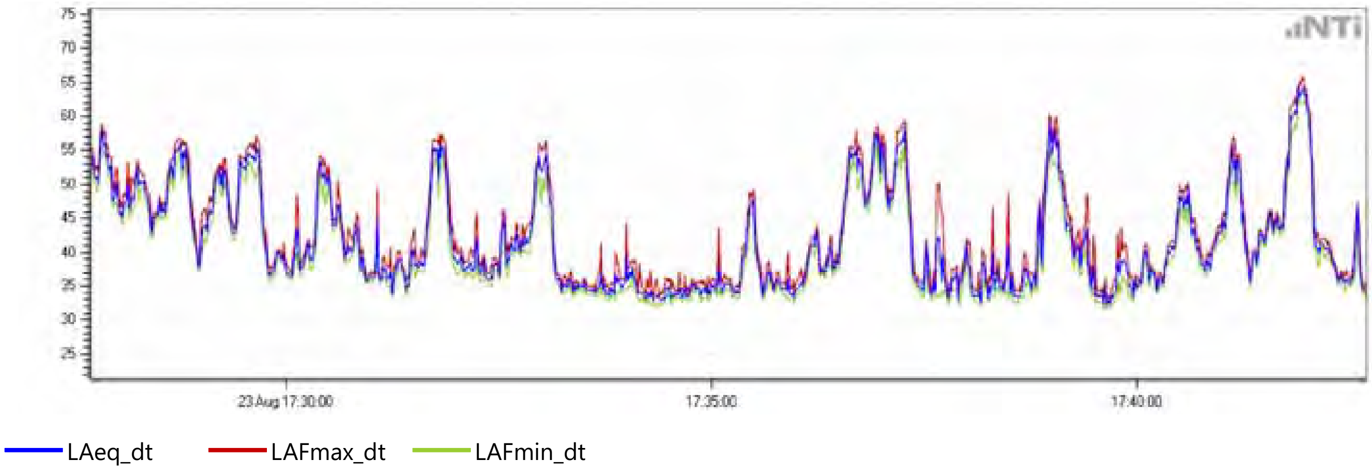
Range: 20 - 120 dB

LN based on: LAeq_dt

B9 Daytime #2

Start: 2016-08-23 17:27:42

End: 2016-08-23 17:42:42



Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 17:04

Mic Sensitivity: 43.5 mV/Pa

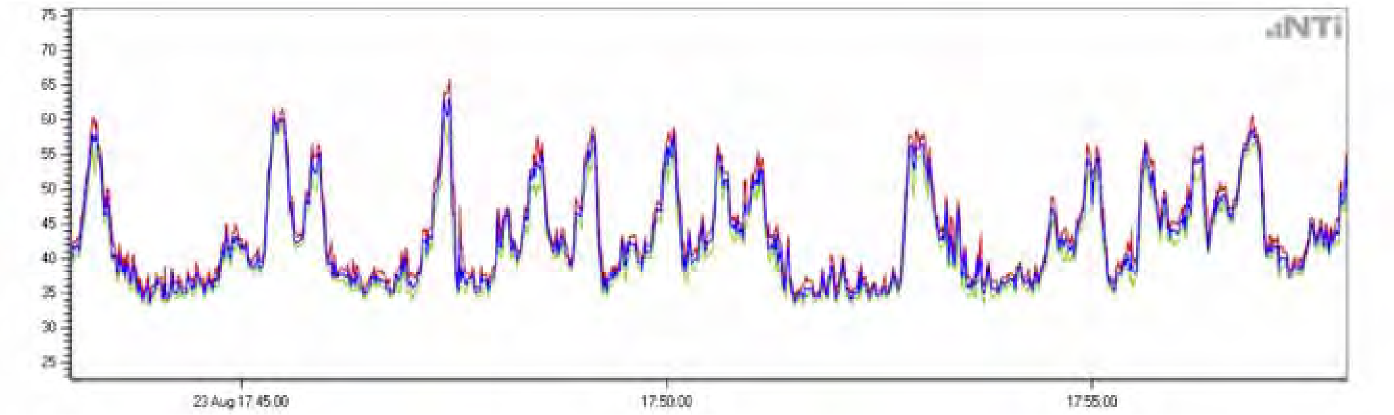
Range: 20 - 120 dB

LN based on: LAeq_dt

B9 Daytime #3

Start: 2016-08-23 17:43:00

End: 2016-08-23 17:58:00



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 17:04

Mic Sensitivity: 43.5 mV/Pa

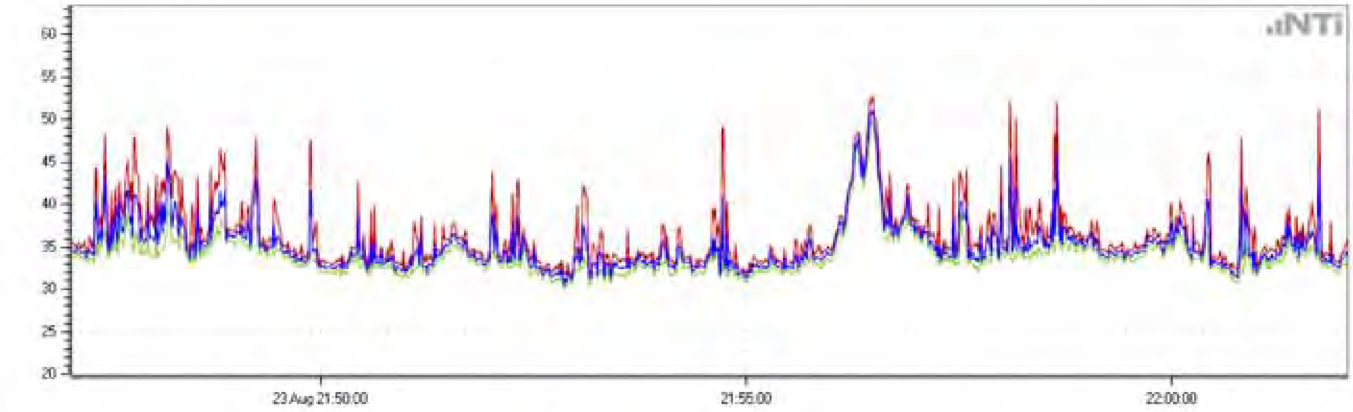
Range: 20 - 120 dB

LN based on: LAeq_dt

B9 Evening #1

Start: 2016-08-23 21:47:04

End: 2016-08-23 22:02:04



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

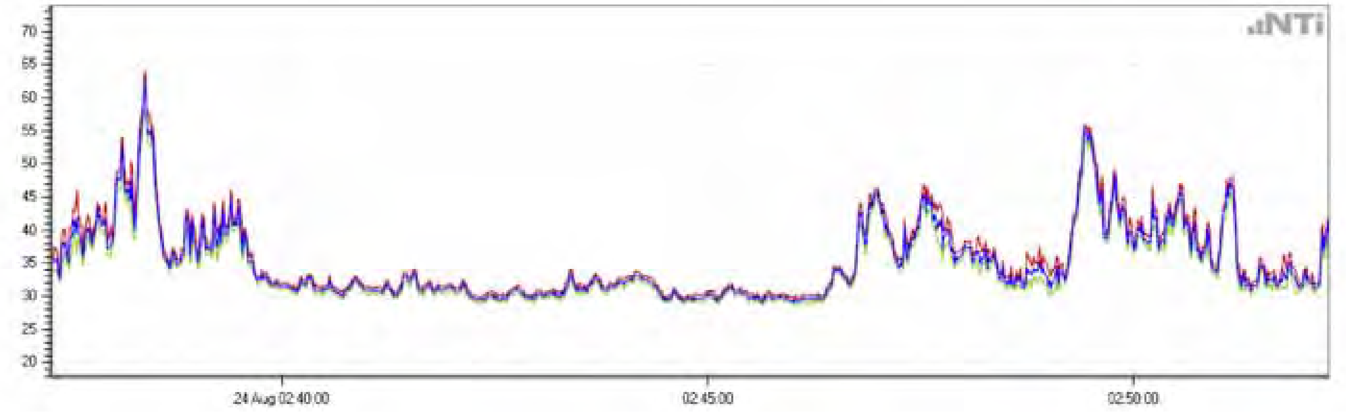
Range: 20 - 120 dB

LN based on: LAeq_dt

B9 Night time #1

Start: 2016-08-24 02:37:18

End: 2016-08-24 02:52:18



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

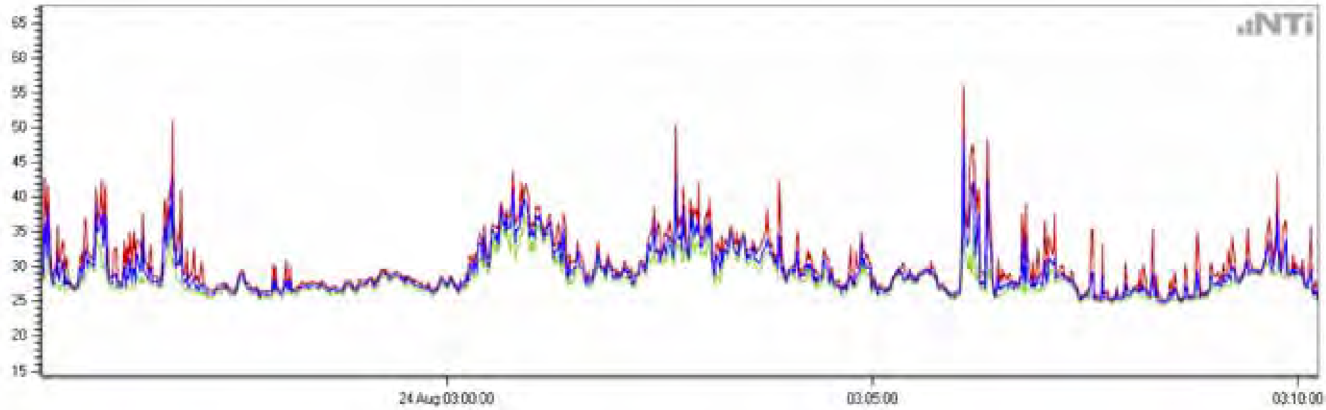
Range: 20 - 120 dB

LN based on: LAeq_dt

B9 Night time #2

Start: 2016-08-24 02:55:14

End: 2016-08-24 03:10:14



LAeq_dt LAFmax_dt LAFmin_dt

Configuration

Device Info: XL2, SNo. A2A-08898-E0, FW3.12

Mic Type: NTi Audio M2230, SNo. 5062, User calibrated 2016-08-23 18:59

Mic Sensitivity: 43.7 mV/Pa

Range: 20 - 120 dB

LN based on: LAeq_dt

Attachment 6 – Tabulated 1/3 Octave Band Data

Committed to **your** success

Nti Meter Data

Band (Hz)

Location	Period	No.	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800
NSL2	Daytime	#1	62.4	60.7	58.7	56.5	54.3	52.3	51.4	54.8	52.4	50.6	51	47.5	44.9	41	39.5	39.3	40.8	40.3	39	39.6	39.9	40
NSL2	Daytime	#2	57.6	55.2	53.3	50.8	48.8	48.3	47.8	52.8	54.2	47.6	46.7	46	42.8	40.1	39	37.5	38.9	37.9	36.1	36.8	37.6	37.7
NSL2	Daytime	#3	61.3	59.4	57.3	54.6	52.3	50.1	49.1	49.4	49	52.6	46.7	45.5	42.1	38.6	37.2	37.2	37.1	37.3	35	36.1	36.4	37.6
NSL3	Daytime	#1	69.1	67.1	64.5	61.5	58.9	56.7	54.1	54.7	55	53.6	53.5	50	48.4	46.6	44.5	43.7	41.7	41.6	40.5	41.4	42.1	42.9
NSL3	Daytime	#2	70.3	67.9	65.5	62.7	59.5	56.7	53.4	51.3	50.8	52.9	52.6	49.3	44.8	45.4	40.1	38.8	38.5	37.4	39.3	38.7	40.2	42.5
NSL3	Daytime	#3	68.3	66	63.6	60.6	57.6	55.1	51.6	49.7	49.6	51.1	51.6	49.8	48.3	47.4	40.7	37.3	36.5	36.4	35.7	37.1	39.6	42.8
NSL4	Daytime	#1	66.2	66	64.4	61.8	58.9	56	54	56.1	62.9	66.7	68.6	64.2	58	54.9	53	52.7	50.1	48.1	47	46.8	46.5	46.8
NSL4	Daytime	#2	66.5	65.1	63.6	61.4	59.2	56.3	57.4	63.5	65	65.5	68.4	66	57.9	55.2	54.1	53.6	50.7	48.6	47.8	47.4	47.6	48.2
NSL4	Daytime	#3	67.8	66.6	65.2	63.6	61.3	60.3	60.4	64.2	67	66.7	70.2	66.8	61.3	58.3	56.9	55.3	53	51.2	49.5	49.4	49.3	49.2
NSL5	Daytime	#1	63.7	62	59.7	57.9	55.9	54	51.4	50.5	51.1	50.8	50.1	47.9	45.8	45.7	44.8	44.2	44.2	43.4	45.1	46.6	48.9	51
NSL5	Daytime	#2	64.9	63.2	61.5	59.3	57	55.1	52.6	51.3	50	56.7	55.1	46.2	48.7	45.3	45	43.6	44.7	44.3	45.5	46.6	48.5	51.2
NSL5	Daytime	#3	65.5	63.6	61.8	59.8	57.1	54.8	52.5	50	50.6	50.8	49.5	48.5	47.3	43.9	43.7	43.6	44.5	43.9	44.9	46.4	48.3	51.3
NSL1	Evening	#1	59.3	57.6	55.4	54.8	54.5	58.1	59.3	54.1	54.4	53	48.9	48.4	46.3	48.2	47.1	43.9	45.3	38.9	37.9	40.4	40.1	39.3
NSL2	Evening	#1	48.2	47.5	47.8	47.3	49.5	50.7	51.5	50.2	52.1	54.5	46.2	46.4	49.7	48.1	43	40.5	41.6	39.8	39.2	40.6	38.6	38.5
NSL5	Evening	#1	49.8	48.1	48	48.1	48.2	49.6	48.2	46.8	50.8	53.6	50.4	47.8	47.6	45.7	45.2	44.3	44.6	44	44	46.1	47.9	51.3
NSL2	Night time	#1	47.6	47	47.4	47.4	49	49	48	44.5	42.2	39.7	37.1	36.6	34.5	31.8	24.9	25.7	28.7	29.1	30.5	33	32.9	31.9
NSL2	Night time	#2	48.6	48.1	48.1	48.3	50.1	48	47.4	44.5	41.1	39	34.7	37.2	33.9	30.6	22.1	23.8	25.5	28.3	27	29	28.9	27.3
NSL5	Night time	#1	45.4	45.1	45.8	47	46.3	44.1	44.1	42.2	46.7	44.3	46.2	46.7	44.8	43.3	42.8	40.8	41.7	43.2	43.2	45.2	48	51.4
NSL5	Night time	#2	46.3	46.5	47.1	48.9	48.7	47.2	46.9	43.5	47.8	44.1	40.5	42.9	39.9	37.9	36	34.7	35.7	36.6	36.2	38.5	40.5	43.5
B1	Daytime	#1	76.4	74.3	72	69.1	65.7	62.5	61.8	63.7	63.4	70.6	66.1	66.2	64.3	53.8	53.8	52.9	49.2	52.2	47	46.9	45.3	43.2
B1	Daytime	#2	72.1	70.3	67.4	64.1	60.8	57.2	57.8	60.6	63.3	71.5	65.3	67.2	66.1	55.9	54	53.3	49	51.4	48.1	45.8	45	43.1
B1	Daytime	#3	71.7	69.3	66.1	63	60	59.1	58	65.2	74.3	72.7	71.2	68.8	71	57.1	55	55.9	52.6	54.3	52.6	49.7	48.5	48
B6	Daytime	#1	74.4	72.9	71.2	69.5	67.8	67.5	63.6	61.4	62.8	64.3	58.4	57.1	63.5	54.9	48.2	48.4	44	35.9	33.9	32.4	34.8	32.1
B6	Daytime	#2	73.9	72.4	70.8	69.3	67.8	67.6	63.8	61.6	63.6	64.4	58.5	57.4	63.3	55	48.2	49	44.9	36.4	34.7	33.6	35.7	33.3
B6	Daytime	#3	73.5	72.4	70.7	69	67.6	67.3	63.9	61.7	64.1	63.8	58.9	57.4	63.3	55.2	48.4	49.1	45.2	37.5	36	35.2	37.2	35.3
B8	Daytime	#1	69.8	68.1	66.2	63.8	61.3	58.2	54.6	50.8	48.6	46.9	45.6	44.6	42.4	39.9	36.8	34.5	34.9	35.1	31.9	28.9	28.2	27.3
B8	Daytime	#2	64.1	62.3	60.5	57.9	55	52.3	48.9	44.8	42.4	42.1	38.6	40.1	36.8	29.4	25.8	23.8	22.2	21.2	21.7	23.3	24.7	26.2
B8	Daytime	#3	63.8	62.2	60.2	57.9	54.9	52	48.6	45.7	44.2	44.3	42.7	42.8	41.9	38.6	35.6	32.8	29.1	28.6	28.9	27.8	26.8	25.8
B9	Daytime	#1	57.1	55.7	53.8	50.9	49.1	48.9	48.5	45.6	46.9	49	47.1	49.9	43.7	38.9	36.5	35.3	35.3	34.2	35.1	37.4	40.4	43.7
B9	Daytime	#2	55.9	54.3	52.3	50.4	48.9	48.9	49	46.5	48.5	48.7	51.9	54.5	44.6	40.9	38.1	36.8	37.2	34.4	36.4	39	41	42.7
B9	Daytime	#3	59.9	58	56.1	54.3	52.4	51.5	52	49.6	49	52.4	49.3	46.2	45	41.2	38.8	36.7	35.9	35.1	35.3	38.1	40.6	43.4
B2	Evening	#1	59.6	57.8	59.9	60.7	63.6	67.8	67.7	65.3	63.5	64.9	63.3	65.9	62.1	58.9	56	50	44.7	42.5	45.3	48.2	46.8	44.4
B4	Evening	#1	46.5	46.5	47.3	47.7	48.9	47.8	50.9	47.3	44.2	53.1	43	42.7	46.4	39.5	37.2	35	36.3	35.6	34.5	35.2	35.2	35.7
B6	Evening	#1	64.2	63.3	63	64.6	66.1	70.8	65.9	63.3	65	66.7	61.8	62.6	69.6	57.6	52.3	51.6	47.2	43.3	40.3	39.1	37.6	36.1
B9	Evening	#1	44.6	44.1	44.9	47.5	48.7	49.7	48.1	41.8	41.8	38.4	36.3	36.3	32.5	26.5	24.2	25.7	29.7	30.2	30.8	29.9	28.8	29.5
B1	Night time	#1	45.2	47.9	47.7	49.7	49.4	49.6	52	54	60.3	61.2	57.7	58.5	58.7	52.3	49.8	50.1	49.8	48	44.5	47.7	42.8	42.3
B1	Night time	#2	44.7	47.6	48.6	50.4	50.9	50.4	52.5	54.9	61.1	62.4	58.3	57.8	58	51.3	49	49.3	48.9	48.2	44.4	46.1	42	41.5
B2	Night time	#1	57.4	57.9	60.3	61	63.4	68.3	67.9	65.1	64.5	65.6	63.7	65.6	62.8	59.7	56.1	50.9	46.8	43.1	46.4	48.7	48.5	46
B2	Night time	#2	59.2	57.7	60.8	61.4	64.5	68.9	69.1	66.6	64.6	65.5	63.7	65.8	62.6	59.4	55.7	50.1	45.7	42.9	46.3	50.5	48.8	45.6
B3	Night time	#1	56.2	57.1	56.7	58.7	59.5	60	61.2	59.6	59.1	60.1	59.7	58.9	67.9	56.5	55.7	55.4	52.8	49	49.1	50.2	49.9	48.6
B3	Night time	#2	56.8	57.6	56.7	58.6	59.3	59.8	61	58.9	58.6	60	59.2	59.1	69.1	56.2	55	55.3	52.8	48.8	48.9	49.9	49.5	48.4
B4	Night time	#1	44.2	46.2	47.1	45.4	46	46.6	46	45.5	45.1	52.4	46.8	43.5	44	40.4	33.7	31.9	32	30.2	28.8	30.7	33.3	33.8
B4	Night time	#2	44.4	45.7	46.4	45.9	46.4	47	46.4	40.5	40.6	51.4	36.7	40.9	43	35.7	28.4	24.1	24.2	23.7	23.1	25.4	26.8	24.6
B5	Night time	#2	59.2	57.7	56.3	56	57	57.3	54.5	50.7	50.2	52.5	48.7	57.2	45.9	39.9	39.1	42.8	44	43.8	42.7	41.3	39.7	39.2
B6	Night time	#1	59.1	59.5	60.3	61.8	63.1	68.5	62.9	60.9	63.9	64.7	59.4	57.9	64	54.6	48.2	48.4	42.2	39.9	40.8	41.2	41.6	44
B6	Night time	#2	56.3	57.8	59	61.3	62.6	68.4	62.2	60.6	63.7	65.8	59.3	57.9	63.7	54.7	48.3	48.4	41.3	39.4	39.4	41.1	40.3	41.2
B8	Night time	#1	44.9	45.6	46.7	47.2	44	43.5	40.3	37.5	39.3	45.2	40.1	42.8	41.8	36	30.5	30.1	30.5	30.2	29.4	30	30.9	32.4
B8	Night time	#2	43.2	45	46.5	46.9	43.4	42.5	43.1	42.3	42.3	43.8	42.5	43	42.9	38	33	33.7	33.1	32	31	32	32.4	33.4
B9	Night time	#1	44.7	44.7	44.7	46.8	46.3	48.1	47.2	42.1	42.8	43.7	43.8	43.1	37.2	33.4	27.9	25.7	27.2	28.7	31	32.9	34.6	36.7
B9	Night time	#2	42.2	42.8	42.8	43.8	43.6	45.2	44.8	39.3	40.8	38.2	32.8	44.5	28.3	18	16.7	16.1	18.9	20	21.5	22.2	21	22.9

Nti Meter Data

Location	Period	No.	Band (Hz) 1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
NSL2	Daytime	#1	40.5	38.4	36.2	33.3	31.6	30	29.9	27.3	25.6	23.4	20.3	18	15.9	14.7
NSL2	Daytime	#2	37.7	36.2	33.8	30.7	28.3	31	32.6	25.8	23.5	23.7	16.9	15.5	14.7	14.4
NSL2	Daytime	#3	37.8	35.3	33.6	31.6	28.5	27.5	26.8	24.4	22.6	21.5	18.5	16.7	15.2	14.6
NSL3	Daytime	#1	42.6	40.2	38.3	37.1	35.1	33.6	32.5	31	28.4	24.8	22.3	18	15.1	14.2
NSL3	Daytime	#2	42.4	38.5	34.5	33.5	29.6	31.2	29.4	28.4	25.1	21.6	19.2	15.7	14.1	14.1
NSL3	Daytime	#3	43.3	39	34.2	29.9	25.9	24.3	24.2	24	21.6	17.6	15.6	14	13.6	14.1
NSL4	Daytime	#1	46.5	45.4	44.7	44.2	43.5	44.8	39.4	37	35.3	32.7	29.7	26.5	22.4	17.7
NSL4	Daytime	#2	49.1	47.4	47.2	46.9	44.4	44.1	41.8	38.3	35.9	33	29.7	26	21.6	17.1
NSL4	Daytime	#3	49.3	48	47.6	47.1	44.9	43.4	41.1	37.3	35.2	32.7	29.6	26.1	21.3	16.9
NSL5	Daytime	#1	50.8	47.1	43.4	39.7	36.3	34	31.2	28.8	27.2	24.8	22.1	19.9	18.8	17.7
NSL5	Daytime	#2	51.6	47.7	44	40.7	37.6	35.2	32.3	29.3	27.2	24.7	21.6	19	16.8	15.2
NSL5	Daytime	#3	52.3	49	44.3	40.1	36.7	34.5	30.9	27.9	26	23.3	20.3	17.9	19.2	21.2
NSL1	Evening	#1	38.2	37.1	35.3	32.7	30.3	26	21.9	18	16.2	14.4	12.8	12.7	13.1	13.9
NSL2	Evening	#1	38.1	36.3	35.7	31.7	30.3	29.7	29.8	28.3	27.2	26.3	16.9	14.4	13.8	17.8
NSL5	Evening	#1	51.7	47.6	43.7	40.4	36.5	33.3	29.7	26.2	24.4	22.1	19.1	17.1	18.8	14.4
NSL2	Night time	#1	29.5	26.8	23.8	20.3	20.3	18.3	17.7	16.8	16.8	15	14.2	15.3	22.9	23.5
NSL2	Night time	#2	26.9	25.9	22.8	20.1	18	15.3	14.4	14	13.9	13.6	13.1	15.5	21.4	22.4
NSL5	Night time	#1	53.2	50.4	47	43.7	38.9	35.1	30.9	26.7	23.9	20.4	17.2	14.9	13.9	16
NSL5	Night time	#2	44.7	40.4	36.7	32.8	29.3	26.3	22.1	19	16.8	14.9	13.7	13.3	13.2	13.9
B1	Daytime	#1	43	42.6	42.2	44.2	52.6	36.6	33.8	32.8	32.4	28.4	24	19.6	16.4	14.8
B1	Daytime	#2	43.2	43.2	41.8	42.4	48.9	36.4	33.6	31	31.4	30.9	23.1	20.6	16.1	14.7
B1	Daytime	#3	48.3	46.4	44.2	44	52.3	41.9	42.1	42.7	44.7	45.7	42.4	39.1	35.1	28.4
B6	Daytime	#1	30	27.7	27.6	27.5	26.6	24.9	22.3	19.8	23.7	18.8	14	13.6	13.8	14.2
B6	Daytime	#2	31.3	28.8	28.6	28.1	27.2	25.7	22.7	19.9	24	19.2	13.6	13.4	13.6	14.1
B6	Daytime	#3	32.7	30.5	29.9	28.9	27.8	26.1	22.8	20.5	25	19.9	13.3	13.1	13.4	14
B8	Daytime	#1	25.5	21.7	19.7	19.6	16.2	14.6	13.9	13.1	12.9	13.1	13.3	13.3	13.5	14
B8	Daytime	#2	25	20	17.2	15.3	13.5	11.9	12.4	12.2	11.8	12	12.3	12.6	13.1	13.9
B8	Daytime	#3	23.9	19.2	17.3	15.8	14.9	13.7	12.8	12.2	11.8	12.1	12.3	12.6	13.1	13.9
B9	Daytime	#1	44	39.7	35.8	30.6	26.1	23.2	19.1	16.9	23.5	22.8	12.3	12.7	13.2	14
B9	Daytime	#2	43.2	40.1	36.5	33.9	29	25.4	22.5	20.2	17.5	14.4	13.1	13	13.3	14
B9	Daytime	#3	44	40.2	35.9	30.5	26.1	23.8	19.5	17.1	15.7	13	12.3	12.6	13.2	14
B2	Evening	#1	42.6	41	38.8	38.8	36.3	33.5	30.9	27	23.6	18.9	14.5	13.2	13.3	14.3
B4	Evening	#1	35.9	35	33.1	30.9	28.2	26.3	24.2	21.8	20.6	19.4	17.3	16.1	14.8	14.3
B6	Evening	#1	35.6	33.3	33.2	33.3	32.3	29.6	25.9	21.3	21.7	18.5	14.7	14	13.6	14
B9	Evening	#1	28.5	26	24.5	22	21.2	18.8	18	17.1	17.4	17	15.4	14.4	13.8	14
B1	Night time	#1	44	45.1	43.5	41.3	38.3	34.1	32.1	29.5	26.9	22.9	17.7	14.4	13.5	13.8
B1	Night time	#2	42.5	44.3	42.3	40.3	42.7	36	30.9	27.6	26	22.6	17.5	14.6	13.5	14.2
B2	Night time	#1	44.4	42.5	41	40.7	37.3	35.9	33	30.5	26.8	21.6	16.2	14	13.6	13.9
B2	Night time	#2	43.3	41.5	40.5	39.2	36.9	34.8	31.7	28.6	24.7	19.4	14.4	13	13.2	13.9
B3	Night time	#1	47.2	48.5	47.4	47.1	48.2	40	36.7	33.8	29.6	26.9	19.9	14.1	13.5	13.8
B3	Night time	#2	47	48.4	47.1	47.3	42.4	39.7	36.3	33.4	29	22.7	15.6	12.7	12.9	13.7
B4	Night time	#1	35.4	32.5	30.1	26.7	23.2	20.4	17.2	15.6	16.4	14.7	13.8	13.6	13.5	13.8
B4	Night time	#2	23.9	23.9	24.7	20.7	18	15.9	14	13	13.2	13.1	12.9	13	13.2	29.5
B5	Night time	#2	36.1	33.8	31.9	29.5	25.3	23.3	18.7	19.3	22.1	21.7	14	14.2	14	19.1
B6	Night time	#1	40.9	37.4	37.3	38.8	36.5	36	34.6	31.5	38.1	36.6	13.7	12.5	12.9	13.7
B6	Night time	#2	39.2	35.6	34.5	34.9	33.1	32	29.3	26.2	32.8	31.9	12.4	12.3	12.9	13.7
B8	Night time	#1	31.8	28.5	27.7	23.5	18.9	16.5	14.3	13.3	13.1	13.2	12.8	12.9	13.2	13.9
B8	Night time	#2	32.7	29	25.4	20.9	16.8	14.3	13.4	13	13.7	13.9	13.7	13.6	13.5	14.7
B9	Night time	#1	36.9	31.5	27.1	23.3	19.4	16.6	13.3	12.1	12	12	12	12.6	12.9	13.8
B9	Night time	#2	22.8	20.8	19.4	17.1	17.7	15.3	14.2	13.2	12.9	12.8	12.6	12.9	13.1	13.8

Daytime Spectra **Cirrus Meter**

Band	NSL1 #1	NSL1 #2	NSL1 #3	B2 #1	B2 #2	B2 #3	B3 #1	B3 #2	B3 #3	B4 #1	B4 #2	B4 #3	B5 #1	B5 #2	B5 #3	B7 #1	B7 #2	B7 #3
6.3Hz	67.34 dB	68.48 dB	65.55 dB	60.88 dB	60.78 dB	61.34 dB	61.8 dB	65.81 dB	65.71 dB	54.04 dB	55.23 dB	52.08 dB	61.43 dB	59.97 dB	60.08 dB	49.59 dB	46.61 dB	44.56 dB
8Hz	66.43 dB	67.77 dB	64.5 dB	58.8 dB	59.31 dB	60.15 dB	61.41 dB	64.51 dB	64.76 dB	52.74 dB	54.47 dB	50.63 dB	61.08 dB	59.65 dB	60.11 dB	48.43 dB	45.48 dB	44.2 dB
10Hz	65.18 dB	66.3 dB	62.93 dB	60.42 dB	59.95 dB	60.51 dB	60.1 dB	62.66 dB	62.73 dB	50.76 dB	52.61 dB	48.46 dB	60.14 dB	58.51 dB	59.06 dB	48.9 dB	44.48 dB	43.99 dB
12.5Hz	63.74 dB	64.81 dB	61.6 dB	60.31 dB	60.33 dB	60.4 dB	59.94 dB	61.93 dB	61.97 dB	49.24 dB	50.19 dB	47.73 dB	58.95 dB	57.32 dB	57.71 dB	45.32 dB	43.63 dB	42.57 dB
16Hz	61.85 dB	63.05 dB	59.7 dB	64.42 dB	64.87 dB	64.83 dB	59.87 dB	61.33 dB	61.29 dB	47.97 dB	49.22 dB	47.15 dB	57.69 dB	56.02 dB	56.47 dB	45.31 dB	43.46 dB	43.25 dB
20Hz	60.53 dB	61.24 dB	58.51 dB	67.9 dB	68.26 dB	68.23 dB	61.65 dB	61.08 dB	61.39 dB	47.8 dB	48.6 dB	47.43 dB	55.32 dB	53.48 dB	54.08 dB	45.26 dB	44.29 dB	44.57 dB
25Hz	60.18 dB	60.23 dB	58.61 dB	67.95 dB	68.09 dB	68.15 dB	62.36 dB	62.33 dB	65.94 dB	50.25 dB	48.94 dB	48.41 dB	53.45 dB	51.47 dB	52.66 dB	44.34 dB	42.09 dB	43.78 dB
31.5Hz	56.57 dB	56.81 dB	54.64 dB	65.19 dB	65.67 dB	65.46 dB	62.47 dB	62.4 dB	67.57 dB	48.3 dB	47.25 dB	47.71 dB	50.48 dB	48.95 dB	50.09 dB	43.32 dB	40.01 dB	43.42 dB
40Hz	55.45 dB	54.98 dB	53.26 dB	63.69 dB	64.03 dB	63.8 dB	64.35 dB	63.82 dB	65.21 dB	46.67 dB	44.37 dB	47.69 dB	46.61 dB	46.26 dB	48.18 dB	44.79 dB	37.42 dB	42.51 dB
50Hz	54.54 dB	54.06 dB	52.24 dB	65.6 dB	65.93 dB	65.84 dB	65.38 dB	63.05 dB	67.42 dB	51.14 dB	49.44 dB	50.42 dB	45.5 dB	45.07 dB	46.35 dB	42.92 dB	35.75 dB	42.73 dB
63Hz	52.3 dB	51.87 dB	48.83 dB	62.98 dB	63.24 dB	63.16 dB	62.82 dB	61.34 dB	69.47 dB	45.57 dB	45.04 dB	55.97 dB	42.01 dB	41.89 dB	44.21 dB	42.27 dB	33.32 dB	41.61 dB
80Hz	51.07 dB	50.85 dB	48.04 dB	65.36 dB	65.5 dB	65.27 dB	64.07 dB	63.35 dB	67.03 dB	43.37 dB	44.48 dB	44.93 dB	45.68 dB	48.09 dB	46.99 dB	42.16 dB	41.03 dB	44.39 dB
100Hz	50.26 dB	50.25 dB	45.68 dB	63.28 dB	63.54 dB	63.36 dB	64.29 dB	62.17 dB	62.63 dB	51.81 dB	51.28 dB	51.85 dB	39.82 dB	37.19 dB	38.78 dB	39.68 dB	32.6 dB	40.5 dB
125Hz	48.64 dB	47.88 dB	46.04 dB	59.17 dB	59.29 dB	59.19 dB	59.19 dB	58.74 dB	59.73 dB	40.65 dB	39.49 dB	49.53 dB	31.35 dB	30.39 dB	34.46 dB	36.7 dB	26.89 dB	38.93 dB
160Hz	46.7 dB	45.31 dB	44.18 dB	54.92 dB	55.12 dB	54.9 dB	57.01 dB	55.78 dB	57.37 dB	37.45 dB	39.25 dB	42.92 dB	28.68 dB	27.92 dB	31.9 dB	33.87 dB	26.8 dB	36.78 dB
200Hz	44.2 dB	42.17 dB	41.6 dB	50.83 dB	51.01 dB	50.76 dB	57.8 dB	54.86 dB	56.18 dB	39.2 dB	37.16 dB	42.48 dB	26.86 dB	25.93 dB	30.78 dB	32.55 dB	28.65 dB	33.48 dB
250Hz	43.17 dB	39.82 dB	40.32 dB	48.62 dB	49.07 dB	48.72 dB	55.52 dB	53.27 dB	55.01 dB	38.81 dB	36.09 dB	40.78 dB	24.8 dB	24.54 dB	30.4 dB	32.18 dB	27.62 dB	29.69 dB
315Hz	38.94 dB	36.88 dB	36.28 dB	47.25 dB	47.83 dB	47.93 dB	53.97 dB	49.68 dB	52.59 dB	36.42 dB	34.71 dB	40.19 dB	25.11 dB	24.57 dB	29.52 dB	31.13 dB	24.61 dB	26.61 dB
400Hz	36.53 dB	34.4 dB	33.79 dB	47.37 dB	47.75 dB	48.04 dB	52.75 dB	49.39 dB	52.56 dB	37.75 dB	35.5 dB	38.75 dB	23.47 dB	23.45 dB	27.42 dB	29.22 dB	22.6 dB	24.43 dB
500Hz	37.49 dB	35.12 dB	36.68 dB	50.11 dB	50.04 dB	50.73 dB	51.5 dB	50.29 dB	53.2 dB	37.62 dB	36.18 dB	39.62 dB	23.17 dB	22.69 dB	25.82 dB	26.68 dB	22.15 dB	25.43 dB
630Hz	38.26 dB	35.06 dB	36.73 dB	49.08 dB	47.97 dB	48.0 dB	51.9 dB	50.19 dB	53.76 dB	38.22 dB	36.82 dB	40.49 dB	23.21 dB	22.89 dB	25.34 dB	27.37 dB	23.91 dB	24.36 dB
800Hz	38.12 dB	34.49 dB	37.72 dB	44.84 dB	44.75 dB	45.29 dB	50.85 dB	49.76 dB	55.83 dB	39.17 dB	37.02 dB	41.82 dB	23.45 dB	23.27 dB	24.2 dB	33.78 dB	24.77 dB	23.29 dB
1kHz	36.98 dB	33.58 dB	35.02 dB	44.37 dB	44.45 dB	44.9 dB	51.38 dB	49.52 dB	55.67 dB	37.49 dB	36.76 dB	40.78 dB	22.55 dB	22.57 dB	22.79 dB	25.59 dB	24.97 dB	21.62 dB
1.25kHz	34.79 dB	31.39 dB	32.98 dB	43.78 dB	43.62 dB	44.04 dB	52.04 dB	50.46 dB	57.04 dB	34.77 dB	33.72 dB	38.66 dB	21.93 dB	22.38 dB	22.04 dB	23.03 dB	24.1 dB	19.47 dB
1.6kHz	32.67 dB	29.26 dB	31.26 dB	41.55 dB	41.83 dB	42.15 dB	50.99 dB	49.49 dB	56.19 dB	32.8 dB	30.81 dB	37.18 dB	22.44 dB	24.87 dB	22.9 dB	23.47 dB	27.33 dB	18.67 dB
2kHz	30.35 dB	27.17 dB	29.97 dB	40.61 dB	40.77 dB	41.05 dB	50.01 dB	49.86 dB	55.11 dB	30.97 dB	28.18 dB	36.09 dB	20.2 dB	24.84 dB	23.43 dB	20.94 dB	28.99 dB	18.94 dB
2.5kHz	26.15 dB	23.43 dB	25.18 dB	38.02 dB	37.99 dB	38.29 dB	47.57 dB	46.3 dB	53.85 dB	29.36 dB	25.85 dB	35.11 dB	18.44 dB	21.85 dB	27.1 dB	20.56 dB	26.25 dB	19.63 dB
3.15kHz	20.81 dB	20.1 dB	20.0 dB	34.85 dB	34.5 dB	34.93 dB	44.78 dB	43.08 dB	51.19 dB	27.88 dB	24.17 dB	33.12 dB	19.05 dB	20.34 dB	23.21 dB	21.85 dB	24.94 dB	23.29 dB
4kHz	15.34 dB	19.22 dB	16.85 dB	32.39 dB	30.78 dB	31.25 dB	41.91 dB	39.85 dB	46.62 dB	25.5 dB	22.06 dB	31.79 dB	17.31 dB	17.99 dB	17.86 dB	21.99 dB	21.91 dB	24.15 dB
5kHz	13.57 dB	14.83 dB	16.12 dB	28.96 dB	26.48 dB	26.99 dB	38.54 dB	36.63 dB	43.32 dB	23.43 dB	20.14 dB	26.58 dB	14.96 dB	15.42 dB	18.08 dB	17.25 dB	17.24 dB	18.68 dB
6.3kHz	14.86 dB	13.64 dB	13.42 dB	24.31 dB	21.6 dB	23.06 dB	35.12 dB	32.8 dB	37.97 dB	20.76 dB	18.63 dB	23.23 dB	14.17 dB	14.5 dB	16.75 dB	17.58 dB	16.84 dB	15.5 dB
8kHz	15.75 dB	14.86 dB	13.35 dB	19.22 dB	16.82 dB	17.8 dB	31.08 dB	27.55 dB	35.15 dB	19.22 dB	16.97 dB	20.5 dB	13.95 dB	13.92 dB	14.11 dB	16.8 dB	17.18 dB	16.26 dB
10kHz	14.39 dB	14.95 dB	14.15 dB	15.35 dB	14.44 dB	14.7 dB	26.54 dB	22.59 dB	31.31 dB	16.85 dB	15.69 dB	18.05 dB	14.41 dB	14.26 dB	14.23 dB	14.06 dB	13.98 dB	13.91 dB
12.5kHz	15.98 dB	16.52 dB	15.75 dB	16.16 dB	15.68 dB	15.69 dB	34.8 dB	19.59 dB	29.53 dB	16.3 dB	16.1 dB	28.05 dB	15.87 dB	15.74 dB	15.7 dB	15.59 dB	15.56 dB	15.55 dB
16kHz	18.12 dB	18.66 dB	17.88 dB	18.06 dB	17.79 dB	17.83 dB	35.02 dB	28.88 dB	29.55 dB	21.61 dB	17.74 dB	21.92 dB	17.86 dB	17.78 dB	17.75 dB	17.73 dB	17.7 dB	17.7 dB
20kHz	21.37 dB	21.92 dB	21.13 dB	21.12 dB	21.03 dB	21.03 dB	35.95 dB	29.78 dB	26.02 dB	20.92 dB	20.85 dB	20.82 dB	21.0 dB	20.95 dB	20.93 dB	20.94 dB	20.93 dB	20.93 dB

Evening Spectra **Cirrus Meter**

Band	NSL3 #1	NSL4 #1	B1 #1	B3 #1	B5 #1	B7 #1	B8 #1
6.3Hz	53.84 dB	57.64 dB	75.71 dB	53.65 dB	53.24 dB	37.76 dB	40.01 dB
8Hz	51.9 dB	56.66 dB	74.25 dB	56.61 dB	52.61 dB	38.48 dB	39.5 dB
10Hz	50.33 dB	55.29 dB	72.01 dB	57.44 dB	51.61 dB	44.05 dB	43.48 dB
12.5Hz	48.85 dB	53.47 dB	69.73 dB	59.26 dB	50.79 dB	38.79 dB	44.68 dB
16Hz	47.32 dB	51.22 dB	66.99 dB	60.29 dB	50.38 dB	39.86 dB	45.03 dB
20Hz	46.12 dB	48.14 dB	64.22 dB	60.61 dB	50.32 dB	40.13 dB	43.01 dB
25Hz	45.91 dB	45.04 dB	62.82 dB	62.1 dB	50.33 dB	39.29 dB	41.76 dB
31.5Hz	45.87 dB	42.01 dB	60.42 dB	61.48 dB	49.9 dB	37.1 dB	39.42 dB
40Hz	46.58 dB	41.23 dB	59.84 dB	60.17 dB	47.9 dB	33.55 dB	37.42 dB
50Hz	48.25 dB	40.06 dB	62.25 dB	59.62 dB	47.0 dB	34.4 dB	39.47 dB
63Hz	55.69 dB	39.27 dB	66.87 dB	60.79 dB	46.43 dB	32.03 dB	34.81 dB
80Hz	47.72 dB	51.78 dB	57.69 dB	59.88 dB	55.34 dB	41.61 dB	38.97 dB
100Hz	44.3 dB	40.87 dB	53.25 dB	59.03 dB	38.22 dB	29.32 dB	37.5 dB
125Hz	40.74 dB	38.08 dB	51.69 dB	57.67 dB	34.75 dB	28.52 dB	27.07 dB
160Hz	38.31 dB	32.66 dB	49.66 dB	55.58 dB	37.44 dB	30.72 dB	26.22 dB
200Hz	36.48 dB	29.2 dB	47.55 dB	55.08 dB	37.69 dB	30.44 dB	24.37 dB
250Hz	38.32 dB	29.06 dB	47.05 dB	53.4 dB	37.06 dB	29.14 dB	23.57 dB
315Hz	37.89 dB	31.12 dB	45.61 dB	49.34 dB	36.15 dB	25.27 dB	25.2 dB
400Hz	36.54 dB	30.32 dB	43.83 dB	49.12 dB	34.78 dB	25.22 dB	25.72 dB
500Hz	37.55 dB	26.39 dB	42.85 dB	49.68 dB	33.23 dB	27.45 dB	28.32 dB
630Hz	39.4 dB	26.81 dB	42.18 dB	49.87 dB	34.62 dB	29.65 dB	28.45 dB
800Hz	42.24 dB	28.35 dB	40.88 dB	48.94 dB	34.55 dB	29.33 dB	28.36 dB
1kHz	42.64 dB	27.48 dB	40.16 dB	47.61 dB	32.03 dB	26.87 dB	26.72 dB
1.25kHz	40.4 dB	23.27 dB	39.9 dB	48.67 dB	34.06 dB	22.84 dB	23.16 dB
1.6kHz	38.02 dB	21.03 dB	38.76 dB	47.66 dB	33.67 dB	21.52 dB	21.06 dB
2kHz	35.63 dB	19.83 dB	37.28 dB	47.19 dB	28.86 dB	17.77 dB	19.01 dB
2.5kHz	29.88 dB	18.39 dB	36.28 dB	43.03 dB	27.15 dB	15.25 dB	16.67 dB
3.15kHz	27.07 dB	15.95 dB	35.05 dB	39.5 dB	24.41 dB	13.76 dB	13.87 dB
4kHz	27.52 dB	15.8 dB	30.57 dB	36.41 dB	22.26 dB	13.39 dB	13.79 dB
5kHz	25.86 dB	13.82 dB	28.06 dB	31.84 dB	19.86 dB	12.42 dB	18.07 dB
6.3kHz	21.0 dB	13.28 dB	26.25 dB	27.3 dB	18.21 dB	12.49 dB	13.26 dB
8kHz	16.14 dB	13.18 dB	24.25 dB	21.52 dB	16.2 dB	12.93 dB	13.17 dB
10kHz	15.05 dB	13.97 dB	22.49 dB	16.11 dB	15.36 dB	13.81 dB	14.0 dB
12.5kHz	15.79 dB	15.51 dB	22.53 dB	15.79 dB	15.99 dB	15.44 dB	15.53 dB
16kHz	17.64 dB	17.59 dB	24.03 dB	17.64 dB	17.68 dB	17.54 dB	17.57 dB
20kHz	20.83 dB	20.85 dB	27.33 dB	20.81 dB	20.82 dB	20.81 dB	26.01 dB

Night time Spectra **Cirrus Meter**

Band	NSL1 #1	NSL1 #2	NSL3 #1	NSL3 #2	NSL4 #1	NSL4 #2	B5 #1	B7 #1	B7 #2
6.3Hz	50.75 dB	51.21 dB	51.52 dB	51.9 dB	47.9 dB	48.24 dB	52.46 dB	41.82 dB	38.91 dB
8Hz	50.62 dB	51.7 dB	49.95 dB	50.84 dB	46.76 dB	45.99 dB	50.77 dB	41.74 dB	39.78 dB
10Hz	49.9 dB	50.9 dB	48.54 dB	49.24 dB	45.04 dB	44.07 dB	48.85 dB	41.38 dB	40.25 dB
12.5Hz	51.68 dB	52.66 dB	46.98 dB	47.24 dB	42.89 dB	41.55 dB	47.88 dB	41.03 dB	40.68 dB
16Hz	53.14 dB	54.24 dB	44.92 dB	44.76 dB	41.78 dB	39.55 dB	48.34 dB	40.56 dB	40.94 dB
20Hz	57.15 dB	58.65 dB	42.68 dB	42.88 dB	40.56 dB	36.51 dB	48.12 dB	41.22 dB	42.03 dB
25Hz	59.32 dB	60.73 dB	41.09 dB	41.68 dB	39.15 dB	33.9 dB	48.75 dB	39.08 dB	38.75 dB
31.5Hz	53.86 dB	54.82 dB	38.9 dB	39.2 dB	36.53 dB	30.27 dB	45.77 dB	36.78 dB	36.72 dB
40Hz	54.13 dB	55.61 dB	38.08 dB	38.37 dB	34.74 dB	29.15 dB	44.61 dB	37.01 dB	35.97 dB
50Hz	54.01 dB	54.73 dB	38.58 dB	39.37 dB	34.72 dB	28.04 dB	45.86 dB	35.84 dB	35.23 dB
63Hz	51.22 dB	54.08 dB	37.5 dB	37.95 dB	40.63 dB	38.89 dB	41.87 dB	40.72 dB	39.03 dB
80Hz	54.51 dB	57.28 dB	40.58 dB	42.14 dB	55.6 dB	54.76 dB	55.39 dB	56.14 dB	54.2 dB
100Hz	49.03 dB	53.99 dB	35.06 dB	35.23 dB	30.58 dB	27.31 dB	33.75 dB	32.47 dB	31.55 dB
125Hz	50.94 dB	55.5 dB	31.11 dB	30.73 dB	31.05 dB	27.99 dB	25.99 dB	30.96 dB	27.6 dB
160Hz	49.12 dB	52.77 dB	28.89 dB	29.21 dB	37.84 dB	36.58 dB	32.54 dB	35.15 dB	31.15 dB
200Hz	47.53 dB	50.32 dB	23.68 dB	25.8 dB	22.99 dB	19.37 dB	22.92 dB	30.97 dB	27.27 dB
250Hz	49.83 dB	51.51 dB	23.65 dB	24.39 dB	20.32 dB	16.66 dB	23.25 dB	29.13 dB	24.33 dB
315Hz	42.83 dB	44.42 dB	23.41 dB	24.55 dB	19.98 dB	15.64 dB	22.29 dB	23.91 dB	25.17 dB
400Hz	40.41 dB	42.96 dB	25.68 dB	26.55 dB	18.98 dB	16.31 dB	22.11 dB	22.0 dB	24.11 dB
500Hz	43.72 dB	46.72 dB	29.93 dB	30.89 dB	20.76 dB	17.95 dB	22.74 dB	21.69 dB	25.77 dB
630Hz	44.6 dB	47.61 dB	34.89 dB	34.05 dB	20.8 dB	18.6 dB	23.27 dB	22.74 dB	25.81 dB
800Hz	45.02 dB	47.01 dB	38.53 dB	36.37 dB	20.81 dB	20.25 dB	23.95 dB	24.52 dB	25.41 dB
1kHz	42.35 dB	43.65 dB	38.13 dB	36.05 dB	20.25 dB	19.27 dB	23.03 dB	24.5 dB	23.8 dB
1.25kHz	39.55 dB	42.6 dB	34.1 dB	31.97 dB	17.48 dB	16.12 dB	20.42 dB	21.73 dB	21.21 dB
1.6kHz	39.74 dB	42.34 dB	30.08 dB	27.6 dB	16.48 dB	14.94 dB	19.97 dB	22.08 dB	21.24 dB
2kHz	35.94 dB	38.23 dB	24.91 dB	23.27 dB	15.36 dB	14.27 dB	19.87 dB	19.51 dB	20.96 dB
2.5kHz	32.39 dB	34.45 dB	20.07 dB	19.49 dB	12.98 dB	12.06 dB	22.61 dB	17.46 dB	19.31 dB
3.15kHz	26.82 dB	28.94 dB	16.23 dB	16.23 dB	12.57 dB	11.59 dB	19.91 dB	17.14 dB	21.63 dB
4kHz	19.6 dB	21.83 dB	13.22 dB	13.63 dB	11.82 dB	11.45 dB	16.18 dB	15.73 dB	18.76 dB
5kHz	13.83 dB	14.88 dB	12.36 dB	12.12 dB	11.72 dB	11.57 dB	15.43 dB	13.23 dB	16.92 dB
6.3kHz	12.82 dB	13.01 dB	12.52 dB	12.63 dB	12.2 dB	12.11 dB	14.32 dB	12.79 dB	14.54 dB
8kHz	13.26 dB	13.27 dB	12.88 dB	12.9 dB	12.75 dB	12.72 dB	13.33 dB	12.95 dB	13.65 dB
10kHz	14.04 dB	14.04 dB	13.68 dB	13.57 dB	13.59 dB	13.57 dB	13.69 dB	13.62 dB	13.76 dB
12.5kHz	15.61 dB	15.55 dB	15.58 dB	15.38 dB	15.22 dB	15.21 dB	15.21 dB	15.18 dB	15.19 dB
16kHz	17.66 dB	17.64 dB	17.4 dB	17.34 dB	17.3 dB	17.3 dB	17.26 dB	17.25 dB	17.25 dB
20kHz	20.9 dB	20.88 dB	20.72 dB	20.52 dB	20.55 dB	20.55 dB	20.51 dB	20.5 dB	20.49 dB

Attachment 7 – Historic Noise Monitoring Data

Committed to **your** success

Daytime Results

Year		2010			2011			2012			2013			2014			2015			2016	
Monitoring location	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10
B1	51	47	52	54	49	56	55	52	55	65	63	66	60	53	61	62	61	63	58	45	61
B2	49	48	51	56	55	57	56	55	57	54	53	56	47	46	48	56	55	56	56	55	57
B3	58	38	55	59	47	60	53	47	56	59	58	60	56	40	52	60	57	62	62	58	65
B4	54	42	52	53	41	48	52	43	52	62	42	64	45	36	47	49	35	51	46	38	47
B5	40	34	42	39	35	42	42	36	45	50	42	53	47	40	46	49	36	44	34	31	35
B6	54	51	56	52	50	54	52	48	54	51	48	53	54	52	56	50	49	52	48	47	50
B7	51	44	53	40	35	42	45	40	47	70	40	60	40	34	40	38	33	38	36	30	36
B8				40	37	41	42	36	45	55	35	51	37	33	39	41	37	43	35	31	36
B9	53	43	53	46	34	50	53	45	55	51	38	56	50	39	52	48	41	51	49	35	54
NSL1	35	31	36	45	42	46	49	46	51	46	44	48	39	30	40	44	42	45	45	41	47
NSL2	53	39	49	53	41	46	53	43	53	44	31	43	43	33	44	45	34	41	46	35	45
NSL3	50	41	52	48	42	48	51	43	51	50	40	48	46	39	49	48	35	45	49	42	50
NSL4	44	39	46	49	40	52	46	41	47	45	39	48	48	39	47	43	37	44	58	35	60
NSL5	49	41	51	54	38	53	53	42	52	59	41	60	67	42	70	60	34	55	57	36	50

Evening Results

Year		2010			2011			2012			2013			2014			2015			2016	
Monitoring location	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10
B1													62	57	59	54	52	55	51	48	54
B2													50	49	51	52	51	53	54	53	55
B3													46	45	47	60	59	60	58	58	59
B4													42	38	42	38	29	36	44	34	43
B5													42	41	44	52	45	51	43	34	40
B6													59	56	61	54	51	54	53	51	55
B7													37	35	38	46	43	45	35	31	37
B8													35	31	38	39	36	41	35	30	37
B9													45	33	47	45	33	45	37	32	38
NSL1										52	48	52	46	38	48	34	30	37	48	46	49
NSL2										49	39	51	50	35	48	45	33	42	47	42	48
NSL3										43	36	46	44	36	47	50	41	52	49	39	50
NSL4										54	33	52	41	39	42	47	39	46	36	30	38
NSL5										45	35	40	57	31	49	52	34	47	57	35	55

Night time Results

Year		2010			2011			2012			2013			2014			2015			2016	
Monitoring location	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10	LAEQ	LA90	LA10
B1	63	61	65	58	55	59	66	64	67	56	53	58	59	53	62	62	55	63	54	47	57
B2	51	50	52	58	57	59	51	50	52	53	53	54	50	49	51	53	52	53	55	54	56
B3	48	27	38	32	29	34	52	36	41	59	58	59	42	37	40	60	59	60	59	58	59
B4	38	28	40	53	32	43	36	35	37	36	34	38	37	35	38	41	35	39	38	33	38
B5	40	37	40	34	32	36	30	27	30	41	37	43	42	39	43	42	41	44	38	38	43
B6	48	46	48	65	64	66	51	50	52	47	46	47	57	55	59	53	51	54	51	50	53
B7	41	36	40	34	32	35	30	28	36	37	35	38	38	34	39	39	36	41	36	32	38
B8				36	33	38	36	28	32	40	37	42	33	30	35	38	35	40	39	36	42
B9	35	20	38	33	25	33	53	45	55	35	29	33	36	27	33	41	21	40	37	28	39
NSL1	38	30	39	33	30	35	44	39	43	47	42	50	43	41	43	35	30	35	50	49	52
NSL2	34	23	37	42	30	37	46	34	38	38	36	40	34	31	35	41	34	42	37	31	39
NSL3	36	17	35	46	32	51	37	34	39	38	33	40	29	24	32	38	21	42	42	29	45
NSL4	44	26	37	54	37	45	46	32	37	43	34	41	41	39	42	43	37	42	34	29	36
NSL5	36	21	38	35	27	38	39	34	38	37	33	36	32	26	32	37	23	37	54	30	40

Attachment 6
Ambient Air Monitoring Locations

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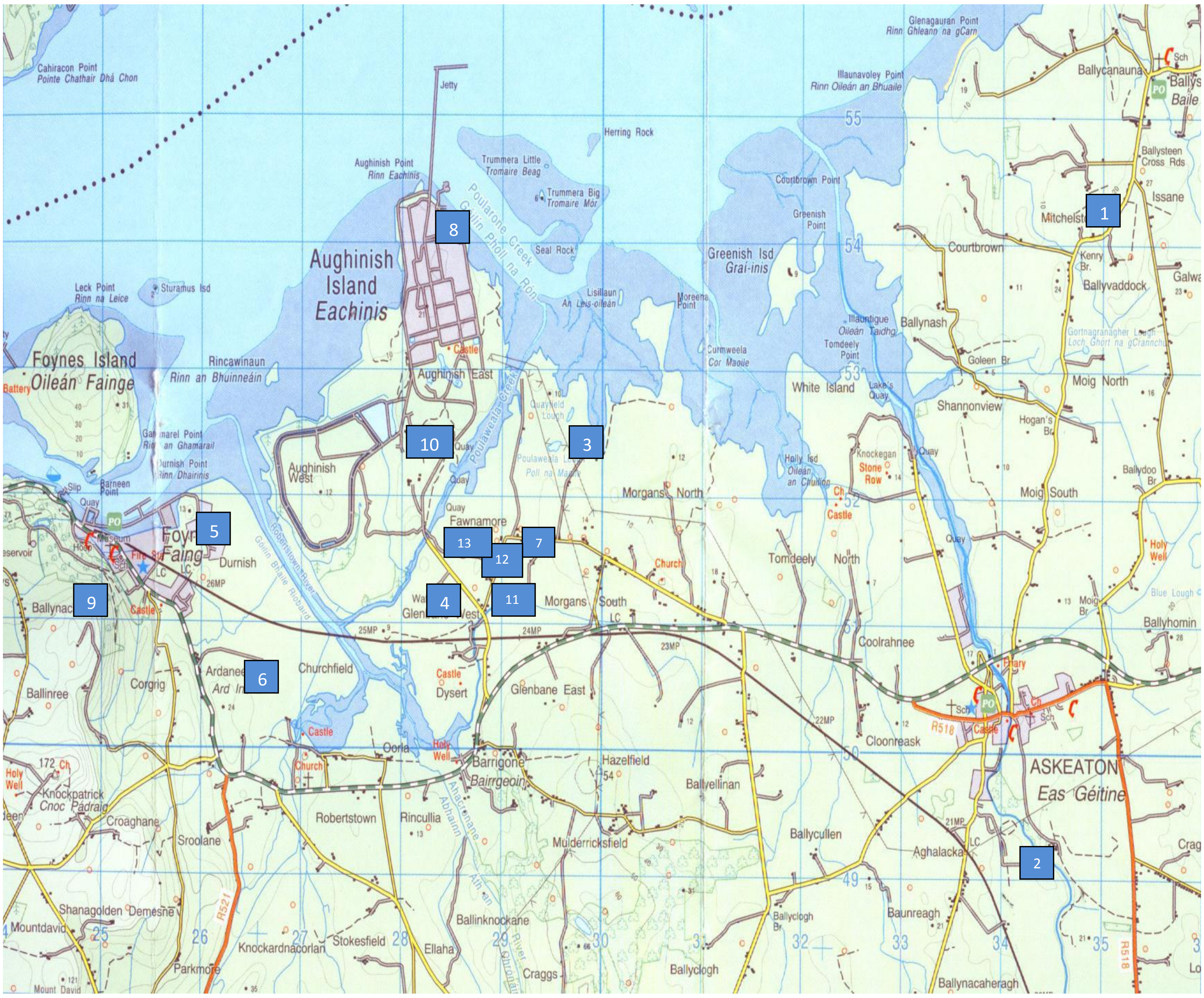

Parameter	1 Ballysteen (Kennericks)	2 Askeaton (Deel intake)	3 Morgans Nth (Keanes)	4 WTP (LCC)	5 Foynes (LCC Reservoir)	6 Creeves (Morans)	7 Fawnamore (Fitzsimons)	8 A23 North	9 BRDA (P Stack)	10 Foynes Port	11 Cronin	12 Sullivan	13 Ford (DG#33)
PM10 (continuous)	Osiris			Osiris	Osiris			Osiris	Osiris				
PM2.5 (continuous)	Osiris			Osiris	Osiris			Osiris	Osiris				
Deposited dust (monthly)			Dust Gauge (DG#29)				Dust Gauge (DG#30)				Dust Gauge (DG#31)	Dust Gauge (DG#32)	Dust Gauge (DG#33)
Sox (continuous)	Continuous				Continuous								
Sox (monthly)	Diffusion tube x2	Diffusion tube	Diffusion tube	Diffusion tube	Diffusion tube x2	Diffusion tube	Diffusion tube	Diffusion tube		Diffusion tube			

Attachment 7
BRDA Operational Plan & Safety Manual

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RUSAL Aughinish

IE Licence P0035-06

Bauxite Residue Disposal Area

Operational Plan and Safety Manual

Prepared by: P O'Loughlin Date: 12.10.04	Approval Date Env Co-ord:	Reference No. BRDA OP001	Issue 1
Revised by: BRDA Eng Kevin McMahon Date 14.10.15	BRDA Eng:		Rev. 7

Bauxite Residue Disposal Area (BRDA)

Operational Plan & Safety Manual

Contents

1. Introduction

The Bauxite Residue Disposal Area (BRDA) is a dedicated extractive waste facility, owned, developed and operated by RUSAL Aughinish Ltd for the permanent disposal of specific bauxite and process residues generated within the alumina extraction plant.

This Operational Plan and Safety Manual is structured to facilitate a clear presentation of relevant information as required by Conditions 8.4.10, 8.4.11 and 8.4.12 of the Industrial Emissions (IE) licence. It includes all relevant data for the effective operation, health and safety management, monitoring long-term planning and aftercare of the BRDA. It demonstrates that the BRDA operations are in accordance with best management practices, the health and safety and environmental policies of RUSAL Aughinish Ltd and the IE Licence.

2. Site Management and Responsibilities

The Technical and Knowledge Management Manager has overall responsibility for the operation of the Bauxite Residue Disposal Area (BRDA). See Rusal Aughinish Organisational Chart'

The BRDA is referred to as Area 54 (A54). The BRDA Operations Engineer has functional and administrative responsibility for the management of the BRDA including the health and safety management of the BRDA.

Placement of trucked residue material within the BRDA is undertaken by Murphy International Ltd. (MIL) under a Site Process Materials Handling (SPMH) Contract.

MIL are also contracted to operate the mud farming equipment to amphiroll and grade the entire pumped residue in the BRDA disposed under the Mud Farming contract.

The BRDA Operations Team has overall responsibility for technical developments in the residue production and the co-ordination of day to day operations and maintenance.

The BRDA Operations Team includes:

- BRDA Operations Engineer.
- BRDA Consultant Engineer
- SPMH & Mud Farming Contractor
- BRDA Site Monitor

The BRDA Consultant Engineer has functional responsibility for all technical developments within the BRDA area and advises the BRDA Operations Team.

The SPMH & Mud Farming Contractor is responsible for all disposal area operations and maintenance as per contract.

The BRDA Site Monitor advises on a daily basis the appropriate residue disposal locations and monitors the capacity of the individual cells within the BRDA and checks the progress of mud deposition and advises on equipment tasks for mud farming activities.

All queries from members of the public are managed by the Human Resources (HR) Manager.

All liaison with and queries from the EPA concerning BRDA aspects are managed by the Environmental Coordinator.

The Aughinish Health and Safety Co-ordinator supports the BRDA health and safety management as per the BRDA Safety Policy and Condition 9.0 of the IE licence (in particular Condition 9.4.2).

2.1 Operation of the BRDA

The day-to-day operation activities of the BRDA are carried out by the SPMH & Mud Farming Contractor. Under this contract, Murphy International Ltd. (the Contractor) has responsibility for the following:

- Collection, transport and placement of all process plant residues at the BRDA.
- Maintenance and organisation of red mud placement operations.
- Reporting of waste quantities deposited to the BRDA to the Environmental Dept.
- Organisation and development of all landfill operations and maintenance, including construction of internal access roads.
- Mud farming by amphirolling and grading of all red mud residue in the cells within the BRDA and the internal and perimeter drainage works associated with surface water drainage from the areas being amphirolled for maximum drying and compaction of the red mud residue.
- Organisation and implementation of all internal storage developments within the BRDA, including perimeter rockfill construction.
- Organisation, implementation and maintenance of environmental protection measures inside the BRDA.

The responsibilities of the BRDA Operations Team include:

1. Patrolling and liaising with the SPMH & Mud Farming Contractor on discharge points to be operated. Assessing the vulnerability of dusting and liaising with contractor on appropriate measures to suppress it.
2. Advising the Local 2 *Control Room Operator (CRO)* to operate the dust suppression sprinkler system with water as and when required.
3. Submitting job tickets for any maintenance work required.
4. Formulation of medium and longer-term operating strategies.
5. The BRDA Operations Team with support from the Engineering Dept. manages the construction of rockfill embankments on the perimeter of the residue disposal areas.

2.2 Control of Mud Quality

The Local 2 (L2) CRO is responsible for monitoring mud slurry throughput and mud line pressure.

The L2 Process Operator (PO) is responsible for sampling, field patrols, filter checks, pump checks, filter washing and mud line pressure control. The L2 PO has responsibility for tasks associated with mud slurry washing, vacuum filtration, mud filter cake reslurrying and mud pumping operations.

The L2 Process Engineer is responsible for monitoring and achieving all long-term trends and process targets in the Mud Filtration Area (Area 34).

2.3 Management of Surface Water Inventory – Water Management

The L2 CRO is responsible for monitoring pond and channels levels, inventory and stream distribution. The CRO records any non-compliance in the L2 Log and reports these to the Shift Plant Facilitator (SPF). The SPF reports any non-compliance in the shift log. The L2 PO is responsible for sampling, field valve set up and field patrols.

2.4 Pond Cleanouts and Inspection

The L2 Process Engineer and Facilitator are responsible for deciding when a clean-out may commence. Pond sludge is pumped to the effluent clarifier for recycling to the plant. The BRDA Operations Team decides where the remaining 'non-pumpable' bauxite residue sludge is disposed in the BRDA.

The Environmental Engineer is responsible for reviewing clean-out operations and to advice on environmental control measures as necessary.

The L2 CRO is responsible for monitoring any condensate flows to the West Pond or its associated drainage trenches. The L2 PO is responsible for monitoring pumping from the Liquid Waste Pond during a normal clean-out. The L2 Environmental Facilitator is responsible for inspection of ponds.

The Engineering Department is responsible for monitoring and overseeing any repairs to the pond liners or concrete.

2.5 Dust Emissions Control

The BRDA Operations Team is responsible for ensuring that no dusting occurs on the BRDA and to take the necessary measures to prevent dusting. These measures include ensuring the sprinkling system is applied appropriately to damp down potential fugitive dust emissions at all times.

The SPMH & Mud Farming Contractor is responsible for the maintenance, filling and operation of all mobile water sprayers and the maintenance and vertical spool lifting of permanently installed sprinkler systems.

The BRDA operation engineer, SPM Management Contractor and BRDA Monitor maintains a watching brief for the meteorological conditions which favour dusting and are responsible for communicating this to the L2 CRO and L2 Equipment Facilitator on a daily basis.

2.6 Emergency Response

In the event of a dusting emergency, any member of the BRDA Operations team detecting the event is responsible for directly notifying the SPF and L2 CRO. Depending on the response required, the SPM Management Contractor has responsibility for requesting assistance, organising all dust suppression resources and ensuring that the BRDA Dusting Prevention and Control (SWM 2026) is implemented.

3. Waste Analysis

3.1 Waste Origin and Composition

All bauxite-derived solid and sludge residues (‘Extractive Waste’) arising from alumina production at the plant are deposited in the BRDA in accordance with IE Licence conditions. Almost all the solid residue material arises from the initial caustic digestion of the bauxite ore. After exiting the bauxite digesters, the bauxite residue is segregated into two fractions, the fine red mud fraction, representing approximately 93% of the total and the coarse fraction, known as process sand, representing the other 7%.

Together these represent about 97% of the total process residue from the plant. The remaining proportion comprises salt cake; from a salting-out liquor purification process and other process wastes including sand, scale, sludge’s and construction and demolition waste. Table 1 below lists the waste types approved by the EPA for placement within the BRDA.

Table 1 Approved Waste Types

Waste Stream	Source	EWC Code
Red Mud	Residue from bauxite processing	01 03 09
Process Sand	Residue from bauxite processing	01 03 99
Salt Cake	By-product of production process	01 03 07
Lime Grits	Lime slaking rejects	01 03 99
Process Scales & Sludge’s	Scale & sludge from vessel cleanouts & cleanout of plant effluent storage ponds	01 03 99
*Recovered Concrete Rubble	Construction & demolition. Used for roadway/embankment construction within the BRDA	17 01 01
*Recovered Refractory Material	Calciner & boiler unit maintenance. Used for roadway/embankment construction within the BRDA	16 11 04
*Recovered Miscellaneous Materials	Process contaminated materials. E.g. cooling tower packing and waste insulation. Used for internal roadway construction within BRDA	Depending on type of plastic fill

***In accordance with IE Condition 8.4.29, recovered materials may be deposited in the BRDA.**

The red mud is subject to counter-current washing to reduce the concentration of entrained caustic before being de-watered in vacuum drum filters and pumped as *high density* slurry to the BRDA.

The coarser process sand fraction is delivered to the storage area *by road truck*. Salt cake, lime grits, refractory and scale that are trucked to the BRDA, are confined to specific areas within the existing BRDA.

Accumulated sludge's from process ponds are also deposited within the BRDA.

Table 2 shows the classification of the main process residues disposed of to the BRDA.

Table 2 Process Residues deposited in the BRDA

Waste Stream	European Waste Catalogue Code	Hazardous/ Non-Hazardous (EWC Classification)	Approximate % of Total Residue Deposited
Bauxite Residue (Red Mud & Sand)	01 03 09	Non-Hazardous	88%
Process Waste	01 03 99	Non-Hazardous	9%
Lime Grits	01 03 99	Non-Hazardous	1%
Salt Cake	01 03 07	Hazardous	2%

3.2 Waste Quantities

Data on waste composition and quantities is collected in accordance with IE Licence conditions and is included in Annual Environmental Reports (AER's) to the EPA.

3.3 Physical Properties

The red mud residue is pumped from the Vacuum Filtration area (Local 2) to the BRDA as slurry with solids content of between 55% and 60%. Once the mud has been discharged it begins to dry, with water removal through "bleeding", surface evaporation and mud farming. Samples indicate that after an average 'maturing period' of 3 to 6 months for mud layer of 0.3 to 0.6m thick, a solid's content of around 70% is achieved.

Particle size analyses of red mud indicate that the material is largely silt size, with 90% of the particles smaller than 63 microns and 30% finer than 2 microns. The permeability of the mud is correspondingly very low and has been assessed to be in the range 1×10^{-7} to 1×10^{-8}m/sec. The specific gravity of the dry mud solids is 3.47.

The process sand is graded medium sand having 95%, 60% and 5% of the particles smaller than 1000, 500 and 100 µm respectively. The permeability of the process sand is estimated to be about 1000 times greater than the permeability of the red mud.

Salt cake is deposited as a 70% solids filter cake.

3.4 Mineral Composition

The principal constituents of the red mud solids (expressed as the oxides) are iron oxide (Fe_2O_3), aluminium oxide (Al_2O_3) and titanium dioxide (TiO_2).

Red mud is analysed as per Schedule C4 of the licence.

Salt cake consists of the organic degradation products from humates in the bauxite, including sodium carbonate, sodium sulphate and sodium oxalate.

4. Operational Principles

The following summarises the key operating principles for the BRDA:

1. The BRDA accepts only those residues described in and permitted by the current IE Licence.

2. The red mud is pumped to the BRDA at optimum solids and deposited in layers to maximise maturing by drying, consolidation and mud farming to optimise overall storage capacity of the BRDA.

3. The approach to the placement of red mud is based on mud farming as described in Section 5 and in SWM 2022. (Link SWM 2022)

4. Storage capacity is developed within the BRDA by construction of rockfill embankments around the BRDA using upstream embankment construction where the underlying red mud supports the upper rockfill embankment.

5. The overall stability of the upstream rockfill core mud retention terraces around the perimeter of the BRDA is determined by routine monitoring of pore pressures in the mud and movement in the inclinometers and by site investigations at frequency determined by the designers to assess by continuous penetration testing the strength of the red mud and underlying estuarine soil.

6. The soda content of the red mud and other residues being deposited is minimised to optimise soda recovery in the plant and to minimise environmental liabilities associated with the BRDA. The soda content of the red mud is further reduced using the mud farming/atmospheric carbonation process.

7. The integrity of all HDPE geomembranes for environmental protection is maintained. No mobile equipment is permitted to contact geomembrane directly.

8. The runoff water is directed to and collected in a perimeter channel and pumped back to the plant for treatment as described in Section 8.0.

9. The surface water inventories in the perimeter channel and adjacent Storm Water Pond (SWP) are minimised to targets listed in SWM 2011 and pumping capacities are maximised as practicably as possible to ensure that there is sufficient operational freeboard for major rainfall events.

10. Water sprinkling dust suppression system is used over the entire red mud and process sand surfaces to prevent dusting.

11. The downstream toe drains, external watercourses and groundwater observation wells are routinely inspected and sampled in accordance with IE conditions.

12. All incidents, whether of an environmental or health and safety nature are reported and investigated to ensure that any necessary remedial action is taken and to prevent any re-occurrence of the incident.

5. Waste Handling and Placement

The BRDA is a dedicated and engineered facility for the placement of specific process residues as detailed below.

5.1 Red Mud

The majority of red mud slurry is pumped from the Mud Filtration Building in A34 to the BRDA at generally greater than 58% solids. A small proportion of low solids red mud slurry, collected from the maintenance turnaround cleaning of the mud settling and washing tanks, is trucked to the BRDA by the Contractor and deposited on existing red mud surfaces.

The red mud including low solids red mud is matured through surface evaporation and the mud farming process as described in section 5.8.

The handling of red mud is covered by section 6.25 of the Waste Management Manual (WM001)
The placement of red mud within the BRDA is controlled by the procedures:
SWM 2022: Area 54A Operation of the BRDA; (Link SWM 2022) and
SWM 2009: Minimise Mud Soda Losses and Maximise Mud Density to the BRDA. (Link SWM 2009)

5.2 Process Sand

Process sand is the quartzite fraction of the bauxite residue. This is washed as effectively as possible to remove all leachable soda and in particular to extract all leachable sodium aluminate which could potentially contain product (refer to SWM 2006 Area 27A Operation). (Link SWM 2006). Process sand is trucked by the Contractor from Area 27 to the BRDA. The handling of process sand is covered by section 6.28 of the Waste Management Manual (WM001)

5.3 Salt Cake

Salt cake is produced in the liquor purification/oxalate removal area of the process plant (A65). The liquor is purified through the precipitation of impurities that occur when the process liquor is concentrated. These impurities are removed as a filter cake, consisting principally of sodium compounds with carbonate, sulphate, oxalate, fluoride and chloride. Salt Cake is trucked from A65 to the BRDA. The handling of salt cake is covered by section 6.27 of the Waste Management Manual (WM001)

Salt cake is classified as a hazardous waste and is deposited within a composite lined cell in the BRDA as per condition 8.4.5 of the IE licence. The design details and construction quality assurance plans for the cell have been agreed with the Agency.

5.4 Lime Grits

These are the insoluble clinker cores of the burnt limestone cobbles dissolved in the lime slaking plant within the process. These are trucked from the process plant to the BRDA by the Contractor and are used as road surfacing materials.

The handling of lime grits is covered under Section 6.15 of the plant Waste Management Manual (WM001)

5.5 Process Scale

Process scale consists of hydrated sodium aluminium silicate sometimes combined with bauxite residues, removed from the interiors of process tanks, vessels and pipes during routine and turnaround maintenance activities in the process plant. All such scales are trucked by the Contractor to the BRDA and deposited on the existing red mud surfaces or on compacted process sand areas.

The handling of scale is covered under Section 6.24 of the plant Waste Management Manual (WM001)

5.6 Transport and Placement of Wastes

The BRDA is operated under the SPM Management Contract by Murphy International Ltd. who has overall responsibility for the collection, transportation, and placement of waste. The contract extends to maintenance and resourcing of all equipment, including vehicles, which operate within the BRDA, including environmental control equipment for dust suppression.

All residues are either pumped or trucked in specified skips or dumpers to the BRDA area. All drivers are trained to ensure that only wastes permitted for disposal in the BRDA should be contained in the designated skips. If other waste streams are contained in the skips these skips will not be removed for disposal. Drivers are also trained on checking and handling of leachate which may arise.

All trucked residues are transported to the BRDA area on a network of internal access roads.

Trucked residues must be deposited on a layer of matured red mud. Process sand may be deposited directly onto red mud surfaces provided mechanical plant is confined to adjacent engineered designed and supervised access roads or the mobile plant is moving on a layer of compacted process sand.

5.7 Relevant Standard Operational Procedures

In addition to the sections of the SPM Management Contract and the Waste Management Manual listed above, the following standard operating procedures (standard work methods) deal with the operation of the BRDA:

Table 3 Relevant SWM's

Procedure Number	Link	Purpose
SWM 2006	Link SWM 2006	Area 27A Operation
SWM 2009	Link SWM 2009	Minimise Mud Soda Losses and Maximise Mud Density
SWM 2017	Link SWM 2011	Water Management
SWM 2017	Link SWM 2017	Pond Cleanouts and Inspections
SWM 2022	Link SWM 2022	Area 54 Operation of the BRDA
SWM 2026	Link SWM 2026	BRDA Dust Prevention and Control

5.8 Mud Farming Process

5.8.1 General Approach

Red mud deposited on the BRDA is processed by "mud farming". Mud is deposited in separate drying bays or cells in the BRDA constructed using mud bunds or nominal boundaries as detailed on 54-G-1130 (see Appendix 1).

A screw-propelled amphirol (photo below) is used to plough the mud in the drying cells on a regular basis to accelerate and improve the natural drying process and densify the residue. This process is also used to maximise the atmospheric carbonation of the red mud residue by increasing the caustic soda / CO_2 interface contact.

This process continues until the increasing density of the mud residue reduces the effectiveness of the amphirol. A low ground pressure swamp dozer is then used to level the drying cell and reconstruct the cell walls.

Plate 1 Amphirol used for mud farming

5.8.2 Operations

The BRDA Mud Farming operation consists of the following tasks:

- Residue Planning
- Filling the Drying Cells
- Drainage Management
- Mud Farming

Each of these systems is described below:

Residue Planning

The Phase 1 and 2 BRDAs have been subdivided into approximately *46* separate drying cells as detailed in the attached drawing 54-G-1130 (Appendix 1). Signs identifying each cell number as detailed on 54-G-1130 have been installed on the perimeter of the BRDA.

Mud is pumped to the drying cells via pipelines connected to the Phase 1 Central Discharge Platform or Phase 2 Southern Platform. A total of 19 separate discharge points have been installed on the pipelines to facilitate the filling of the drying cells in Phase 1 & 2 as detailed on 54-G-1130.

Each discharge point is flushed before a period of non-usage (i.e. > 1 week) to prevent line restrictions and blockages. Mud Points 1 to 10 and 15 to 19 are flushed from the Central Discharge Platform and Southern Discharge Platform respectively using the recycled water. Mud Points 11 to 14 are flushed by injecting process condensate into the suction of the Area 34 Mud Pumps.

The BRDA Operations Team meets weekly and identifies the storage area required for the following week's production and associated mud farming, drainage and maintenance activities.

Outer embankment walls are constructed in a timely manner, to ensure that residue storage area is available on a medium term (quarterly) basis in the BRDA.

A weekly residue plan is issued each week, on BPI, to Local 2 and the SPF's detailing the *mud placement* plan for the week. This plan details mud valve changes and alternatives in the event of pipeline maintenance requirements or valve problems.

Filling the Drying Cells

A 400mm – 500mm deep layer is filled into each drying cell in 200 – 250mm mud layers. A *pipe* is installed on each discharge point to allow the mud to be spread evenly across the cell.

Each cell is inspected in advance by the SPM Management Contractor to identify, repair and raise sprinkler pipes as necessary.

Cell filling is monitored by the BRDA Operations Team from 8am - 4.30pm Mon - Fri.

Cell filling is monitored by the L2 Process Operator and SPF's during the evenings / nights and at the weekends to ensure that filling is occurring according to the weekly residue plan.

Drainage Management

Drainage from the drying cells will initially be assisted by the long reach excavator to free the "bleed" liquor and rainfall from the cell. The Amphirol will then complete an initial plough of the cell.

During this period the excavator will be required to maintain the drainage channels particularly around the embankment walls.

Additional drainage may also be required to eliminate areas of standing water at the perimeter of the BRDA.

Mud Farming

Mud farming commences after mud deposition has ceased, initial drainage completed and the red mud has sufficient stiffness to support the amphirol. A daily inspection of all drying cells is undertaken by the BRDA Site Monitor for BRDA Operations Team.

The amphirol continues to make passes over the mud cells every 3-7 days until the indentations in the mud reduce to < 5 – 10 mm. The cells perimeter walls are then re-built using a low ground pressure bulldozer with perimeter walls approximately 800mm - 900mm in height using mature mud.

Atmospheric Carbonation

If following pH testing of the amphirolled residue indicates that the pH is greater than 11.5, then further atmospheric carbonation of the residue is required. This atmospheric carbonation process commences immediately after the mud farming process has been completed. The mature red mud is initially ploughed to break up the compacted red mud surface. The ploughed red mud is then further reduced in size by harrowing to maximize the exposure of the caustic soda in the mud to atmospheric carbon dioxide.

The mud is then repeatedly harrowed on a daily basis until the pH is gradually reduced from the initial pH until the pH is < 11.5.

In the event of a heavy rain forecast, the mud is rolled to seal the mud surface and prevent water ingress.

Further details are provided in SWM 2022 Area 54 Operation of BRDA.

6. Safety Management

6.1 BRDA Safety Organisation & Structural Stability

The organisational structure including safety responsibilities are set out in Chapter 2 above.

The Plant Health & Safety Policy covers plant wide safety management and includes the requirements of IE Licence Condition 9.4.3.

The Health, Safety and Environmental Security of the BRDA is managed to ensure that:

a. Personnel are protected from particular hazards such as perimeter water filled drains and soft slurry associated with the BRDA
b. That the overall structure of the BRDA is geotechnically stable.

Personnel safety is managed by routine risk assessment of tasks and fixed controls to ensure that all risks are identified in accordance with the Aughinish Safety Management System. For example, there are crash barriers around the main perimeter roads for fall protection, there are life buoys located around open drain perimeters as well as crash barriers in case personnel accidentally fall into ponds. There is specialist mobile plant that can safely travel on soft mud slurry. These Risk Assessments are available. BRDA Risk Assessments

The overall geotechnical stability of the BRDA is examined routinely and reported annually through the Annual BRDA Review in accordance with Schedule C7 of the IE Licence.

It was also reviewed in detail as part of the 2013 “Risk Assessment and Breakout Study” which was an update of the 2006 study (referred to in Condition 8.4.16 of the IE Licence). The revised report was submitted to the EPA in March 2013 in accordance with Condition 8.4.30. The revised report takes account of the improved stability of the BRDA brought about by the implementation of ‘mud farming’ in March 2009. The result of mud farming has been to increase the undrained shear strength of the red mud and this has been incorporated in the updated stability analyses for the red mud placed above stages 7/8 in Phase 1 BRDA and all the stages of Phase 2 BRDA. Mud farming has increased the stability of the side slopes significantly on the upper levels of Phase 1, thus reducing the *already negligibly low* probability of failure and the ability of the material to mobilise. In addition, as the facility is raised, the effective stress (self-weight) on the red mud increases which consolidates stiffens and, in turn, increases the red mud strength.

The most important hazards identified by the risk assessment which indicated negligible to highly improbable risk, are in order of priority:

1) Displacement of alkaline water in the PIC as a result of wave surge without breaching the embankment wall and indirectly displacement of the alkaline untreated water in the SWP and the treated water in the LWP based on a future sea level rise up to year 2200. At present current *sea level the risk of this is much less than stated above.*

2) Slope failure of the containment walls for the SWP, LWP, and the Outer Perimeter Wall under static load conditions;

3) Containment failure from the year 2200 wave surge into the PIC. This negligible to highly improbable risk is not such an important hazard at the current sea level.

The study recommended that following procedures/actions be undertaken to alleviate the identified risks or mitigate the consequences: The recommendations have been actioned as follows

Break-study recommendation	**Implemented by**
Avoid pore pressure build up in the residue	Quarterly monitoring of pore pressure is being undertaken by Golder Associates. No issues to date.
Ensure undrained shear strength of residue is sufficient to support the BRDA structures	Monitor the strength by CPT testing as required by the designers. Major Site Investigation undertaken in 2014. Mud strength more than adequate.
Avoid water collecting in some specific perimeter channels on east side.	Ensure gradient in place to drain specific channels as needed.
Install piezometers and inclinometers to monitor stability.	All instruments installed and monitored quarterly.
Provide erosion protection to outer wall.	Installed around the Phase 1 and Phase 2 Outer walls as required. Will be installed around the base of the SWP and LWP at plant closure.
Secure locking mechanism to be installed to prevent spillage to Robertstown River.	Penstock valve installed in 2014 and operation tested for BRDA Emergency Response exercise in 2015.
Regularly inspect the integrity of the flood tidal defence berm	Currently repairs are being considered for an exposed part of this berm.

Other management measures which are already in place include:

- Visual inspection of the facilities indicates no signs of distress in the walls.
- The outer & inner perimeter walls, the storm water and liquid waste ponds are inspected quarterly and annually are performing in accordance with the design.
- Overflow pipes have been constructed to connect the Phase 2 BRDA perimeter channel to the Phase 1 BRDA perimeter channel.
- Two additional submersible pumps have been installed adjacent to the PIC 1 sump area to pump the Phase 1 PIC back to the Storm Water Pond.
- The original PIC 1 pump has a valve tee connection to facilitate filling of the Storm Water Pond so that with the two new dedicated pumps, there is a large measure of equipment flexibility to discharge water from the PIC to either the SWP or the Effluent treatment plant.
- AAL have their own electricity generating station providing a very reliable supply to the plant and ancillary structures such as the pumps servicing the PIC, SWP and LWP. Electricians provide 24 hour coverage for emergencies resulting from electrical outages or breakdowns.

6.2 Emergency Preparedness Plan

The plant wide Emergency Preparedness Plan and the specific BRDA Emergency Response Procedures have been submitted to the EPA in accordance with Condition 9.4.4. These are an integral part of the overall Plant Safety Management System and are available online via the Aughinish intranet. The External Emergency Plan for the BRDA (EEP) was published by Limerick County Council in September 2013 and is available on their website www.lcc.ie. The adequacy of the external plans will be reviewed annually with the Principal Response Agencies (LCC (Environment and Fire Service), HSE and An Garda Siochana). Further details of the emergency preparedness and response procedures are provided in Chapter 7.

6.3 Classification of BRDA

The BRDA has been classified as a Category A facility under the Extractive Waste Directive. The basis for this classification is the environmental sensitivity of the Special Area of Conservation lands and estuarine habitats adjacent to the BRDA.

6.4 BRDA Dam Wall Design and Construction

Section 6.0 of the 2013 'BRDA Risk Assessment and Breakout Study' submitted to the Agency details the design and construction standards under-pinning the structural integrity of the BRDA.

6.4.1 General

The design of the Phase 1, Phase 1 Extension and Phase 2 BRDA are similar although some modifications were made for the Phase 2 BRDA based on the on-going performance of the facility. The key components of the BRDA are:

- Low Permeability Outer Perimeter Embankment Wall;
- Permeable Inner Perimeter Embankment Wall;
- Perimeter Interceptor Channel;
- Composite Lined System Throughout the Phase 1 Extension and Phase 2 BRDA;
- Stage Raises;
- Upper level bench to reduce the overall side slopes from 6H:1V to 6.3H:1V; and

The storm water pond and liquid waste pond were raised to accommodate runoff from both Phases 1 and 2 BRDA.

The Phase 1 extension and the Phase 2 BRDA has been completely composite lined and surrounded by a perimeter interceptor channel which is formed by constructing the outer and inner perimeter embankment walls. The Phase 1 and Phase 2 channels connect on the western section of the facilities. The Phase 1 and Phase 2 facilities will also be merged in the future.

The ground level within the footprint of the Phase 1 BRDA and varies typically between 0 m AMSL to 14 m AMSL. Phase 2 BRDA varies from 0 m AMSL to 14 m AMSL and therefore future raising and merging of the stack walls will need to accommodate these changes of elevations.

The overall slope is 6.3H:1V consisting of a lower slope of 6H:1V and an upper slope of 6H:1V. An upper level bench, approximately 28m wide separates the two slopes. Where the previous sludge pond was located in the southern section of Phase 1, the wall has been realigned and steepened to approximately 4H:1V and wick drains installed.

Unlike conventional tailings facilities or water retaining dams, the BRDA retains little to no surface water on the red mud. The red mud is discharged as a paste from several near central discharge points to form a dome which typically has the apex some 6m to 8m above the perimeter stack wall elevation. The structure is raised by constructing perimeter walls on the red mud by the upstream method which involves the construction of a series of retaining bunds upstream of the toe of the BRDA facility and so forming a supporting face to the overall structure. As previously stated, the slope of the stack wall or face of the storage facility is 6H:1V for the upper and lower slopes which reduces to an overall slope of 6.3H:1V when the width of the upper level bench has been included.

6.4.2 Outer Perimeter Embankment Wall

This structure forms the outer wall of the Perimeter Interceptor Channel and is the main access road around the facility and is designed with a crest width of 5 m. The upstream and downstream side slopes vary depending on the foundation materials the structure is placed on. The structures founded on the estuarine soils are typically 4H:1V for Phase 1 and 3H:1V for Phase 2. These are found on the northern and western flanks of Phase 1 BRDA and the western and southern flanks of the Phase 2 BRDA. The structures founded on the glacial tills are typically 4H:1V for Phase 1 and 2H:1V for Phase 2. These are found on the southern flank of Phase 1 BRDA and the south eastern flank of Phase 2 BRDA. The Outer Perimeter Dam (Embankment) Wall has been constructed to an elevation of 5m AMSL.

Along the central section of the southern flank of the Phase 2 BRDA, the Outer Perimeter Embankment Wall is constructed in cut with a side slope of 2H:1V and a crest elevation of 5 m AMSL

6.4.3 Inner Perimeter Embankment Wall

This structure forms the inner wall of the Perimeter Interceptor Channel and is constructed with a crest width of approximately 4.5 m. The upstream and downstream side slopes vary depending on the foundation materials the structure is placed on. The structure founded on the estuarine soils and glacial tills has been constructed with upstream and downstream side slopes of 2H:1V. These structures are located on the northern, western and southern flanks. For these cases, the crest elevation is at 4.5 m AMSL.

Along the central section of the southern flank of the Phase 2 BRDA, the Inner Perimeter Embankment Wall has been constructed in a cut and the rockfill embankment wall and founded on glacial till. In this area, the side slopes are constructed at 2H:1V in order to align with the two embankments constructed on the estuarine soils either side of the cut.

Where the Inner Embankment Wall is founded on limestone along the south eastern flank of the Phase 2 BRDA, the side slopes have been steepened to 3H:2V.

6.4.4 Perimeter Interceptor Channel

The Perimeter Interceptor Channel collects all the runoff from the BRDA facility and seepage from the red mud. It is formed by the construction of the Outer and Inner Perimeter Embankment Walls which are discussed above.

For much of its length and for all the northern, western and southern flanks, the Perimeter Interceptor Channel has a top width of 25 m and a minimum base width of 4 m. The storage capacity of the perimeters channels and storm water pond is listed in Water Management SWM Link SWM 2011

6.4.5 Stage Raise

The method of raising the perimeter wall retaining the red mud is by the upstream method which involves constructing on previously deposited red mud. The red mud is farmed and allowed to mature for as long as possible (minimum 3 months) prior to placing the next layer. The success of this method of stage raising is very much dependent on the design of the facility and its on-going performance of red mud dewatering, drying and consolidation which to date is satisfactory and this process has been enhanced since 2009 by the introduction of red mud farming.

The performance of the facility, which is compared to the design criteria, is determined from a comprehensive geotechnical monitoring system within the stack wall together with an intrusive site investigation carried out prior to subsequent raising of the perimeter walls.

6.4.6 Upper Level Bench

The upper level bench is installed when the stack wall is raised to an elevation of 16 m AMSL (Stage 6) after the red mud has been deposited inside the Stage 5 wall at a maximum elevation of 14 m AMSL. The width of the bench is approximately 28m. The bench improves stability of the slope and with suitable drainage measures installed, allows the downstream slopes of the first 5 stage raises to be rehabilitated.

6.5 Salt Cake Cell

Salt cake is classified as a hazardous waste and is deposited within a composite lined cell (geosynthetic clay liner and 2 mm high density polyethylene liner) in the BRDA as per condition 8.4.5 and 8.4.10(v) of the IE licence. The composite lined cell is located on approximately 12 metres of low permeability matured red mud. There is no hydraulic connection between the composite lined cell and the rest of the BRDA . The design details and construction quality assurance plans for the cell have been agreed with the Agency.
The Salt Cake cell was constructed in 2012 and commissioned in 2013.

The Closure Details for the salt cake cell are included in the BRDA part of the overall Plant Decommissioning and Residuals Plan in accordance with IE Licence condition 10.2. In summary a double plastic HDPE liner will be placed over the cell at closure to seal in the salt cake . A drainage layer and subsoil and topsoil will be placed over the plastic liner and the surface will be vegetated with grass.

6.6 Hydrology

No water is stored on the BRDA itself as it is a sloping surface for stack residue. The surface water and leachate is stored in the Perimeter Interceptor Channel. Surface water is also stored in the Storm Water Pond.

6.6.1 Storm Water Pond

The function of the storm water pond (SWP) is to collect storm runoff from the surface of the BRDA via the Perimeter Interceptor Channel and pump the alkaline water to the effluent treatment plants or back to the alumina plant as recycled pond water for various uses.

The volumes retained by the SWP is listed in the Water Management SWM Link SWM 2011

The current crest elevation of the SWP is 6.0 m Above Mean Sea Level (AMSL) on the external wall with the Bird Sanctuary and the internal dividing walls between the SWP and the LWP and between the SWP and central access ramp. The internal wall between the SWP and the PIC is also at an elevation of 6.0 mAMSL.

The SWP was raised and relined in 2007 with a composite lining using a combination of geosynthetic clay liner (GCL) and processed glacial till on the side slopes overlain by 2mm high density polyethylene (HDPE) liner.

The BRDA Water Management SWM Link SWM 2011 developed in accordance with IE Licence Condition 8.4.23 sets targets for water inventory at different times of the year. Adherence to these targets will ensure that sufficient space is available for storm water management in winter months. At the same time they will ensure that sufficient water inventory is available for dust prevention in summer months.

6.7 Environment

Environmental monitoring is undertaken as per Condition 8.4.10(xv) and Schedules C4 (Waste), C2 (Effluent and Surface Water), C6 (Ambient Air) and C8 (Groundwater).

The Environmental Monitoring Programme examines the composition of materials disposed in the BRDA and the treated effluent discharged to the adjacent Shannon Estuary. It also monitors groundwater and surface water quality and dust deposition at strategic locations around the BRDA which have been agreed with the EPA.

Geotechnical and other monitoring of the stability of the BRDA are undertaken as per Schedule C7. This addresses quarterly monitoring of piezometric pressure and movement in the residue. Taken together with site investigations using continuous penetrating testing they characterize the geotechnical stability of the BRDA. All these monitoring data are input to the overall Annual Review undertaken by Golder Associates as required by Schedule C7.

7. Emergency Procedures

The management of emergencies is coordinated by a fully resourced and trained plant security team who are on site 24 hours per day, 365 days per year.

The overall plant Emergency Response Plan and procedures covers activities in the BRDA. The plant Emergency Response Plan deals with emergency preparedness, planning, response and co-ordination in the case of significant emergencies or incidents at the plant. The defined categories of emergency include environmental emergencies and emergencies which may have to potential to lead to environmental

In the event of an emergency, the organisation of safety and emergency response is co-ordinated and located centrally at the security gatehouse. Roles and responsibilities are detailed in the Plant Emergency Response Plan.

Each area of the plant also has specific Emergency Procedures relevant to the area. The emergency procedures addressing the BRDA are:

P007.02.019	BRDA Containment Emergency Response (Link to Procedure)
P007.02.012	Dust Emergency in the BRDA BRDA Dust Emergency
SWM 2026	BRDA Dust Prevention and control (Link SWM 2026)
P007.02.017	BRDA High Wind Procedure (Link to Procedure)
P007.02.018	Severe Frost Conditions (Link to Procedure)

7.1 BRDA Containment Emergency Response

The release of red mud from the red mud has been assessed as negligible to highly improbable. However although assessed in probability as a very unlikely event, the most significant type of emergency at the BRDA would be a release of alkaline water from one of the water retaining structures (such as the Perimeter Channel Embankments, Storm Water Pond or Liquid Waste Pond). In the event of such a failure, elevated pH water and/or mud would carry over into the lands north and west of the BRDA. All of this land is drained by a watercourse known as the OPW Channel which discharges through a single flap valve into the Robertstown River (to prevent reverse flow from river/estuary). In the event of such a failure the area Emergency Procedure P007.02.019 would be activated as well as the Plant Emergency Response Plan. The area Emergency Procedure details the actions to be taken including closing off the *penstock* valve between the OPW Channel and the Robertstown River to contain the spillage. The Plant Emergency Response Plan deals with call out of additional people and resources as well as Notification of the incident/accident to the Principal Response Agencies which may trigger activation of the BRDA External Emergency Plan.

7.2 Dust Control

The main environmental emergency which can arise in the BRDA is dusting. It is classified as an emergency and is subject to formalised emergency response procedures. The BRDA Team has defined responsibilities in the event of dusting. These responsibilities extend from prevention to response through:

- Review of meteorological conditions
- Preventative damping of BRDA
- Maintenance of equipment
- Operation of sprinklers, bowsers
- Resourcing emergency response
- Communication with RUSAL Aughinish personnel in an emergency response
- Ensuring that relevant SWM's and Emergency Response Procedures are followed

Historical evidence shows that incidents of fugitive dust generation occur under the effects of the following:

- Wind speeds in excess of 10 mph
- Freezing (<0C) or very warm (>20C) temperatures
- Dry air-conditions, i.e. low humidity

The primary objective in management of disposal operations at the BRDA is to prevent the formation of conditions where fugitive dust generation can occur.

7.2.1 Dust Prevention and Response Measures

The following fugitive dust prevention and response measures are implemented at the BRDA. Refer to SWM 2026 (Link SWM 2026)

1. Minimise mud flat area exposed to dusting risk by ploughing the mud surfaces via the mud farming process.

2. Keep mud flats in service (i.e. wet) as long as possible to limit areas of potential dusting.

3. Water spray (dust suppression) sprinkler system installed to ensure 100% coverage over red mud areas.

4. Ensure bowser units are available to transport and discharge water from the Liquid Waste Pond (LWP).

5. Bowsers should be left filled at the Liquid Waste Pond outside of normal business hours when BRDA Operations indicate that significant potential for dusting exists. If taken to be used elsewhere on site, must be returned cleaned to the Liquid Waste Pond and filled with water.

8. Surface Water Management and Protection

The BRDA is bounded by the River Shannon, the Robertstown River and Poulaweala Creek. The River Shannon is tidal at RUSAL Aughinish with a range of over 5m (spring tides).

Surface water runoff due to rainfall from the Phase 1 BRDA discharges to Perimeter Interceptor Channel 1 (PIC 1). PIC 1 runs along the entire northern, western and southern perimeter of the Phase 1 BRDA.

Similarly, surface water runoff due to rainfall from the Phase 2 BRDA discharges to Perimeter Interceptor Channel 2 (PIC 2). PIC 2 runs along the western and southern perimeter of the Phase 2 BRDA.

PIC 2 is pumped into PIC 1 using a submersible pump with a capacity of $600m^3/hr$.

The runoff water is pumped from PIC 1 to the Storm Water Pond (SWP), located in the north-eastern corner of the BRDA (adjacent to the Liquid Waste Pond) via two submersible pumps each with a capacity of $600m^3/hr$ ($1,200m^3/hr$ total).

Two pumps are installed in the SWP to recycle surface water to the plant and to the effluent treatment system with a capacity of $450m^3/hr$ each.

Surface water runoff is also recycled to the plant from PIC 1 by a submersible pump with a capacity in excess of $800m^3/hr$. Surface water is treated in an effluent clarification system before ultimately being discharged to the River Shannon.

Short term heavy rainfall events in the BRDA are accommodated in the Perimeter Interceptor Channels (PIC 1 & PIC 2), Storm Water Pond (SWP) which have the storage capacities listed in Water Management SWM: Link SWM 2011

This design storage capacity is sufficient to ensure a 1 in 200 year rainfall event can be safely managed within the system, while allowing treated effluent discharges to remain within daily flow limits (1,250 m^3/hr, 30,000 m^3/day) as specified in the IE Licence (Schedule B.2).

9. Groundwater Management and Protection

Aughinish Island is hydro-geologically isolated from the mainland and can be regarded as an independent groundwater body.

The BRDA is underlain by two geologically dissimilar components. The northern part of the Phase 1 BRDA is generally underlain by low conductivity estuarine deposits, which are subject to saline intrusion (into the groundwater). The original plant BRDA was developed directly on this material. The eastern part of the Phase 1 BRDA is underlain by limestone bedrock. This section of the BRDA is sealed within 1.0mm and 2.0mm thick HDPE sheets, on 600mm of screened glacial till.

The Phase 2 BRDA is underlain by estuarine deposits on the west side and by limestone bedrock on the eastern side. The Phase 2 BRDA is sealed within 1.5mm and 2.0mm thick HDPE sheets, on a layer of geosynthetic clay liner (GCL).

9.1 Groundwater Seepage Controls

The original northern part of the BRDA was developed over an extensive deposit of low hydraulic conductivity estuarine soil. In addition, the upstream slope of the outer wall around the BRDA and the SWP was sealed with a composite liner consisting of a 750 mm thick compacted glacial till fill covered with a 2.0 mm thick HDPE liner anchored in the estuarine soil along the toe of the Outer wall. In addition, all areas along the toes of the Outer wall where the estuarine soil thickness is less than 4.0 m (applies to the BRDA) or where glacial till or rock outcrop (applies to the SWP) was encountered, were sealed with 2mm thick smooth HDPE liner. All runoff reporting to the open drainage ditch is stored in the Perimeter Interceptor Channel.

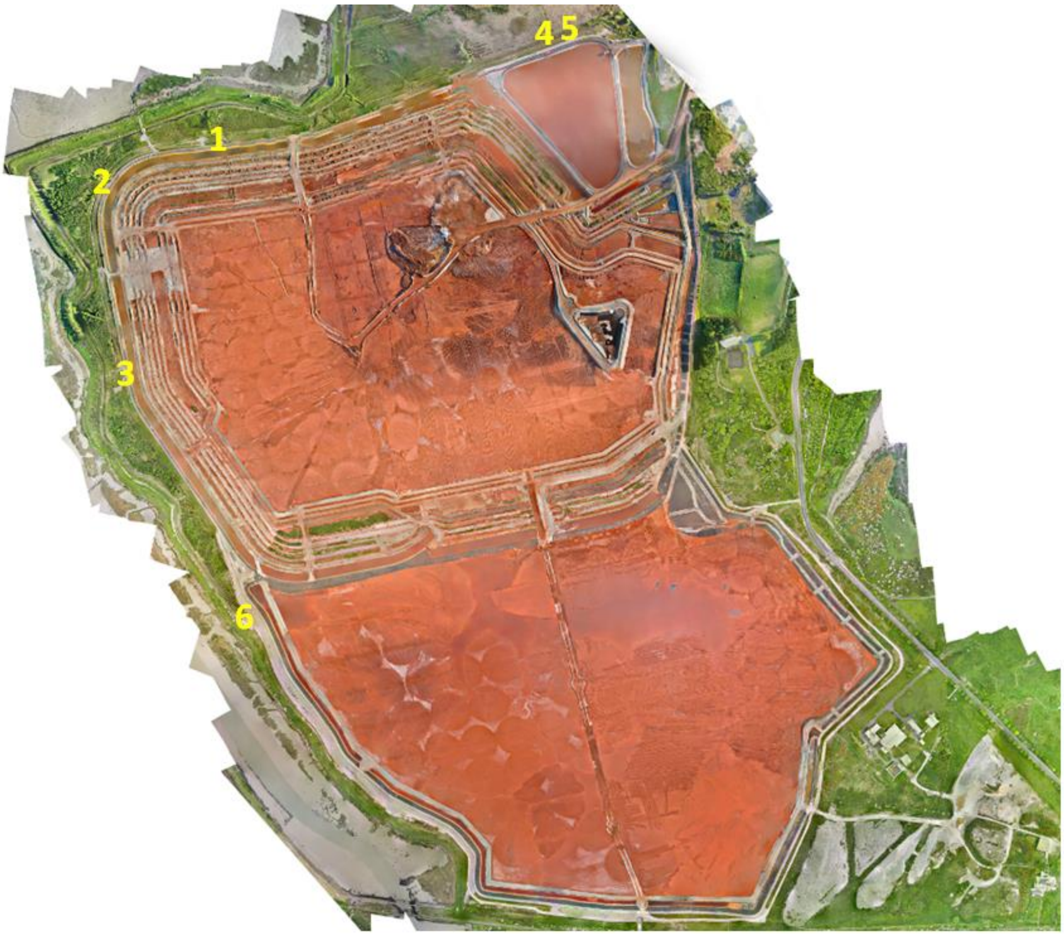
The extended eastern part of the Phase 1 BRDA is sealed with 1.0 and 2.0 mm thick HDPE sheets. Beneath the HDPE sheets, the subgrade consists of a series of mineral varying from 300mm to 600mm thick depending on the subgrade.

9.2 Seepage/Leakage Management and Control

The following seepage and leakage control systems are in place and reported as seepage recovery and monitoring locations as per submission to the EPA in January 2015.

Ref. No. (Fig. 1)	Location	Monitoring parameters	Monitoring Frequency
1	Toe Drain 1 Pumping	pH, Soda, Conductivity	Monthly
2	Toe Drain 2 Pumping	pH, Soda, Conductivity	Monthly
3	Toe Drain 3 Pumping	pH, Soda, Conductivity	Monthly
4	Monitoring Borehole 4 upstream of North East Drain	pH, Soda, Conductivity	Monthly
5	Monitoring Borehole 5 upstream of North East Drain	pH, Soda, Conductivity	Monthly
6	Robertstown Gate	pH, Soda, Conductivity	Monthly

Figure 1: BRDA Proposed Seepage Monitoring Locations



10. Leachate Management and Disposal

The BRDA does not generate leachate in the conventional sense of the term (as applied to waste disposal) due to:

a) The bauxite process residues placed within the BRDA are inorganic and do not degrade.

b) The red mud on placement and maturation has hydraulic conductivity values of the order of 1x10-8 m/sec. Accordingly, recharge and downward movement of liquid into the waste (through precipitation) does not occur.

Although there is no positive leachate collection system in place, bleed water from the red mud is collected in the perimeter channel and returned to the plant for treatment and licensed discharge.

11. Development Programme

All of the principal elements of the Phase 1 and Phase 2 BRDA have been constructed and commissioned in the period 2007 to 2013.
The future development programme for the BRDA consists of

- Routine Stage Raising of the Perimeter Stage Raise walls as per existing design.
- Routine landscaping of the downstream side of future Perimeter stage raise walls as per existing Interim Restoration and Landscaping undertaken in 2013.
- Raising of the existing Salt Cake Cell as per design submitted and agreed with the EPA in 2011.
- Routine Raising of sprinklers and mud discharge pipes in the BRDA as per existing practice.
- Routine raising of the drainage wall on the east side of the Phase 2 BRDA as per Golder Associates design.

12. Life Expectancy

The existing Phase 1 BRDA consists of the original BRDA and the Phase 1 extension, which have been merged since 1999. As the rate of placement is a direct function of production activity, the life expectancy of the BRDA will be reduced with increasing levels of production.

Following the commissioning of the Phase 2 BRDA in 2011, the life expectancy of the combined Phase 1 and 2 BRDAs has been increased by 21 years until mid-year 2032, based on current production levels and residue generation levels. This is reviewed each year as part of the AER. Further details are provided in the AER.

13. Restoration

A Decommissioning and Closure Plan for the site was prepared by SRK Consulting Ltd. and Enviroplan Services Ltd in 1999 – this included proposals for the restoration and aftercare of the BRDA. The Plan was submitted to the Agency as part of the first plant AER in 1999. A revised plan taking into account the Phase 2 extension to the BRDA was submitted in 2005 as part of the application for a revised IE Licence. The plan is updated annually and the most recent update was submitted to the EPA in December 2010.

Based on research undertaken to date, the BRDA perimeter side slopes have been rehabilitated in the interim (2013) and it is proposed that, following final closure of the facility, a surface vegetation cover will be established over the farmed and neutralised residue to ensure physical and chemical stabilisation of the stored bauxite residues.

Establishment of vegetation on the bauxite residues stored at the BRDA has been successfully demonstrated by greenhouse and field trials carried out in conjunction with the University of Limerick. To achieve this, amendment of the red mud residue (using gypsum, compost nutrient, fertilisers and process sand) is required and an understanding of the basic physical and chemical principles for reclaiming alkaline residues must be established. Considerable attention has been focused on the testing and measures that can be used to ensure appropriate surface soil conditions are present which will promote successful vegetation establishment and surface rehabilitation of the BRDA while controlling costs.

Engineering proposals to address the drainage, seepage, control of storm water and surface run-off from the BRDA both in the interim and following final closure of the facility have been investigated and designed by AAL's consultant Golder Associates.

13.1 Closure and Restoration Programme

Closure will involve utilisation of those techniques that have been proven in operations, or demonstrated in field trials, which have the greatest potential to achieve the performance criteria for air, soil, surface water and groundwater. A key element of this closure plan will be the rehabilitation cover for the BRDA. Because of the variety of residues within the BRDA, there are several different surface treatments which will be necessary in order to ensure that performance criteria are achieved following closure.

The BRDA will be rehabilitated to ensure physical and chemical stabilisation of the red mud. The amended soil (red mud mixed with process sand, gypsum and compost) will be seeded with a grassland seed mixture, and fertiliser applied by broadcast spreader. AAL propose to achieve self-sustaining vegetation cover after a period of five years.

Works will be implemented to ensure that a suitable drainage system is established on the rehabilitated BRDA. Engineered surface water drainage berms will be created to allow for stormwater drainage. Careful supervision will be provided during final mud deposition on the BRDA to ensure the surface topography remains consistent for the construction of a system to direct surface water and lateral seepage safely off the BRDA.

The maintenance of efficient surface water drainage from the BRDA, avoiding as far as possible soil erosion into the perimeter channel, will contribute to the improvement of water quality after closure. With time, it is expected that rainwater flushing and wet-dry cycles in the surface layers of the BRDA, will improve water quality so that runoff and seepage can be discharged without treatment.

13.2 Interim Restoration

As part of the extension of the BRDA, an interim restoration plan was put in place to provide for intermediate cover of the perimeter embankment slopes as the height of the area is increased. This involved the installation in the Phase 1 BRDA of a radial collector drain at 100 metre intervals just below the operating upper stage raise wall, which intercepts and drains surface water from the dome of the BRDA in a controlled manner down to the Perimeter Interceptor Channel. Construction of this drain was completed in 2012 in advance of the Phase 1 landscaping works in 2013. The horizontal benches on each of the Stage Lifts on the north and west sides of the Phase 1 BRDA were graded and shaped in 2013 with a drainage medium and topsoil added and grass and trees were planted . The wide stage 5 to stage 6 bench was also restored and grass was planted. Therefore these 2013 works were the first part of interim restoration of the BRDA.

14. Aftercare Management

14.1 Aftercare Monitoring

Success of surface re-vegetation (which will be critical in meeting requirements for control of fugitive dust and valuable in the limitation of subsurface seepage and the maintenance of geotechnical stability) will be measured on the basis of vegetation and soil biological surveys. These surveys will be conducted annually until Year 5 upon which time it is anticipated that the re-vegetation programme will be deemed successful. Should the five-year objective not be met, AAL will identify the measures that it will undertake to improve the performance of the cover.

At closure, the water sprinkler system will continue for a limited period, particularly throughout any periods of leaching and weathering, until surface rehabilitation by a vegetated surface cover is established. The long-term suppression of fugitive dust will be achieved by the vegetation cover with sufficient density to retain the residue.

Water treatment will no longer be considered necessary when the pH in the Perimeter Interceptor Channel (PIC) is maintained at less than or equal to pH 9 with a Total Suspended Solids (TSS) of less than 50 mg/l for 90% of the samples taken over a 12-month period. Following attainment of water quality objectives for a one-year period without treatment, the water management system will be decommissioned. The PIC and the SWP can then be *modified* (with spillway and sluice constructions) to allow for direct discharge to the Shannon Estuary via the Robertstown River. It is anticipated that this can be achieved within five years post-closure. A trial constructed wetland (reed bed) cell was installed in 2013 with its aim to receive alkaline BRDA leachate and reduce its pH. Implementation of this technique on a larger scale will be considered with a view to future inclusion in the Aughinish closure plan. Monitoring of surface water quality and groundwater quality in the vicinity of the BRDA will continue for a period of up to 30 years post closure.

To monitor geotechnical stability, for five years after the closure of the BRDA, AAL will conduct periodic monitoring of subsoil moisture, to demonstrate that the suction head for the upper subsoil layers is being maintained, or reduced, as a result of the rehabilitation measures.

14.2 Final Land Use

The preferred land-use option for the BRDA, based on current knowledge of the chemistry and biology of the sown grassland cover, is to develop the area for nature conservation. A section of AAL land to the north of the BRDA has already been developed as a Bird Sanctuary, so the development of a nature conservation area is in keeping with AAL land conservation practices. The bird sanctuary management has been featured and reported on by organisations such as the Birdwatch Ireland since its development in 1981.

The choice of end-use is also in line with procedures in the 2009 EU BREF on Tailings Management where it states in Table 4.5 that *'rehabilitation is such that the ultimate land use is optimised and is compatible with the surrounding area and the requirements of* *the local community'*.

Lands adjacent to the AAL facility are subject to EU and national environmental designations and the sensitivity of these environmental receptors, particularly in the key areas of surface and groundwater quality, have been taken into account in the design of the BRDA restoration and aftercare process.

15. Environmental Monitoring Programme

RUSAL Aughinish undertakes extensive monitoring of environmental quality (air, water, groundwater, dust and noise) in the vicinity of both the plant and BRDA in accordance with the requirements of our IE.

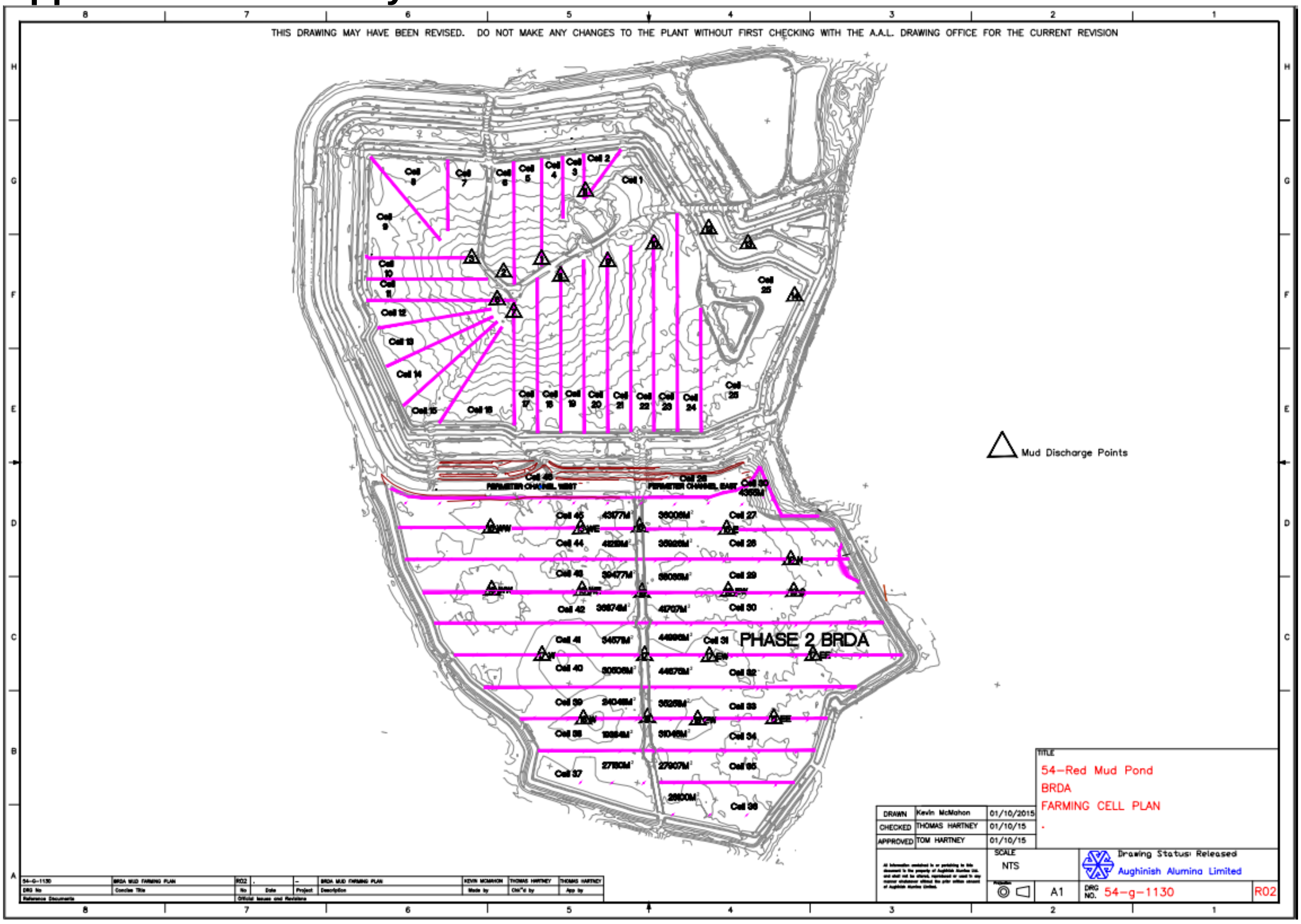
This monitoring, which is undertaken by qualified and experienced Environmental Technicians is detailed in SWM 0003 IEL Compliance and Environmental Performance Monitoring and Reporting. SWM0003

figuEnvironmental Monitoring in the BRDA

Environmental Media	Monitoring Location	Analysis Undertaken	Frequency
Surface Water	OPW Channel Mangans Lough	pH, Conductivity, Soda	Monthly
Groundwater	BRDA Observation Wells (OW's)	pH, Conductivity, Total Alkalinity, Fluoride, Chloride, Soda, Heavy Metals	Quarterly
Air – Fugitive Dust	Dust Gauges at perimeter of BRDA	Dust Deposition	Monthly
Noise	Boundary Locations around BRDA: North Shore (B5), East of East Ridge (B4)	Sound Pressure Level, L_{AEQ}, L_{A10}, L_{A90}	Annually
Waste	Red Mud, Sand, Salt Cake, Leachate	pH, Dry Matter, Alkalinity, Chloride, Fluoride, Soda, Metals	Monthly

In addition to the above, RUSAL Aughinish maintain a weather station between the plant and the BRDA for measurement of wind speed, direction and temperature. This data is fed back to the plant Process Information (PI) System.

Appendix 1 BRDA Layout



Attachment 8
BRDA Annual Review Report Executive Summary

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February 2017

PHASE 1 & 2 BRDA

Phase 1 & 2 BRDA Aughinish 2016 Annual Safety Inspection and Stability Assessment

Submitted to:
Aughinish Alumina Ltd
Aughinish Island
Askeaton
County Limerick
Ireland

REPORT

Report Number. 1524750.500/A.0

Distribution:

Aughinish Alumina Ltd - 1 copy (pdf)
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Executive Summary

Golder Associates were commissioned by Aughinish Alumina Ltd (AAL) to prepare this report to facilitate licensee compliance with Appendix C7 condition of license IED P0035-06 namely 'the annual review' for the Bauxite Residue Disposal Area (BRDA). This stability evaluation summarises the monitoring results from the Casagrande piezometers, the inclinometers and extensometers, the visual inspection of the facilities and assesses the stability of the BRDA, the inner and outer perimeter walls forming the perimeter interceptor channel (PIC), the storm water pond (SWP) and liquid waste pond (LWP).

The Phase 1 BRDA is formed from two facilities, the original Phase 1 BRDA, covering an area of 72 ha and the Phase 1 BRDA extension covering an area of 32 ha. The Phase 1 extension is lined with a HDPE geomembrane while the original Phase 1 relies on the low permeability of the estuarine soils to minimise seepage from the base of the facility, plus the inherent low permeability of the red mud itself. Phase 2 BRDA covers an area of approximately 80 Ha and was commissioned in 2011. It is currently receiving the majority of the red mud generated.

The initial design for the Phase 1 BRDA facility was to provide storage to the year 2009 based on the facility constructed to Stage 7 (elevation 18 m AMSL), which equates to a central elevation of 27.5 m AMSL or 26 m above original ground level. A site investigation and design report was presented to AAL (References 2.1 to 2.4) proposing to raise the facility in three more stages (Stages 8, 9 and 10), resulting in a maximum perimeter elevation of 24 m and a central elevation of 32 m AMSL.

AAL have successfully raised the stack wall for Phase 1 to above Stage 8 and in numerous sections to Stages 9 and to Stage 10. For Phase 2, they have constructed Stage 1 and in places ready to commence construction of Stage 2.

The key components of the BRDA are:

- Low Permeability Outer Perimeter Embankment Wall;
- Permeable Inner Perimeter Embankment Wall;
- Perimeter Interceptor Channel;
- Composite Lined System Throughout the Phase 1 Extension and Phase 2 BRDA;
- Stage Raises; and
- Upper level bench to reduce the overall side slopes from 6H:1V to 6.3H:1V.

The Phase 1 and the new Phase 2 BRDA are surrounded by a perimeter interceptor channel which is formed by constructing the outer and inner perimeter embankment walls. Surface water collected in the perimeter interceptor channel is pumped back to the plant or into the storm water pond during storm events. The Phase 1 and Phase 2 channels connect on the western section of the facilities. The Phase 1 and Phase 2 facilities are being progressively merged.

Treated water is pumped from the treatment plant and into the liquid waste pond prior to discharge into the River Shannon.

Unlike conventional tailings facilities or water retaining dams, the BRDA retains little to no surface water on the red mud surface. The red mud is discharged as a paste from several near central discharge points to form a dome which typically has the apex some 6 m to 8 m above the perimeter stack wall elevation. The structure is raised by constructing perimeter walls on the red mud by the upstream method. This procedure involves the construction of a series of retaining bunds upstream of the toe of the BRDA facility and so forming a supporting face to the overall structure.

The final elevation of the perimeter stack wall will be 24 m AMSL and the highest elevation of stacked residue will be 32 m AMSL, or some 30 m above ground level.

From the results of the Phase 1 BRDA monitoring of the inclinometers, extensometers and piezometers together with the 2014 CPT testing, it is apparent that the stack wall of the BRDA is stable at the current elevations with a factor of safety above 2 and the facility is performing in accordance with the design. No additional site investigation work has been undertaken on Phase 1 since there has been little rise in the structure since the 2014 CPT campaign as the majority of red mud is discharged into Phase 2. It is anticipated that additional site work will be undertaken when the majority of the structure is at Stage 10.

CPT testing and instrumentation of the Phase 2 BRDA will be undertaken when the walls have been upstream raised to Stage 4 at an approximate elevation of 12m AMSL.

The outer and inner perimeter walls, the storm water and liquid waste ponds are performing in accordance with the design.

Visual inspection of the facilities indicates no signs of distress in the walls.

Where seepages emanating from the Phase 1 BRDA perimeter interceptor channel are intercepted, the flow rate should be monitored to determine any changes in flow rate. The water level of the perimeter interceptor channel should also be measured.

The volume of any red mud retained in the perimeter interceptor channel should be estimated/surveyed and checked against design calculations to ensure sufficient flood storage is available and the freeboard can be maintained. It should be noted that the red mud has the ability to throttle seepage emanating from defects in the geomembrane forming the lining system in the perimeter interceptor channel so it would be preferable to leave some red mud at the base. It would also be difficult to remove the red mud from the channel without potentially damaging the lining.

AAL have their own power generating station providing a very reliable supply to the plant and ancillary structures such as the pumps servicing the PIC, SWP and LWP. Electricians provide 24 hour coverage for emergencies resulting from electrical outages or breakdowns.

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Attachment 9
BRDA Closure Demonstration Cell Area Report

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Closure Demonstration Cell Restoration

Based on results and observations from residue research field trials the Closure Demonstration Cell was amended as per the developed restoration technique (ie. process sand, gypsum, organic matter, and fertiliser) in spring 2013 and seeded.

Surface residue (0-10 cm) pH, EC and ESP indicates improvement in residue properties following amendment, seeding and subsequent soil development

Vegetation analysis for first, third and fourth year's growth is shown below. As previously found, amendment procedure resulted in sufficient macro nutrient supply and there was no evidence of excessive uptake of elements associated with bauxite residue (e.g aluminium or sodium). Decline is herbage N content previously observed in the third year was improved for 2016 and indicates establishment of N cycling within the soil/ plant system. Other restored residue areas on the BRDA that are 18+ years old exhibit similar N content.
Further decline in herbage Na content in the fourth year has also been previously recorded on restored residue sites and is indicative of further improvement of the residue as a soil medium.

Herbage and soil analysis will continue as per '*Ecological Monitoring of Restoration Success'* programme below.

Table 1. Physico-chemical parameters of surface amended residue (n=5) for 2015-2016

	2015	2016
pH	8.1	8.07
ESP (%)	15	12
EC (ms cm^{-1})		1.81
TKN (%)		0.35

Table 2. Nutrient and elemental analysis for herbage growing in the Closure Demonstration Cell

	2013 (n=10)	2015 (n=5)	2016 (n=5)	Typical Irish grassland range
N (%)	2.34	0.42	0.96	1 – 5
P (%)	0.38	0.38	0.21	0.1 – 0.6
K (%)	3.02	3.3	1.24	2.16 - 4.01
Na	0.61	0.22	0.12	
Ca (%)	0.36	0.43	0.34	0.33 – 0.73
S (%)	0.57	0.52	0.23	0.15 – 0.6
Mg (%)	0.18	0.13	0.09	0.08 – 0.26
Zn (mg /kg)	20	29	17	10-14
Al (mg/kg)	86	32	62	
Cd (mg/kg)	n.d	n.d.	n.d.	

n.d. – not detected

Figure 1. **Soil profile of amended and seeded residue after 3 yrs**

Figure 2. **Amended and seeded residue area after 3 yrs (constructed wetland demonstration area in foreground)**

Ecological Monitoring of Restoration Success

A post-closure monitoring programme has been developed for assessing success of residue restoration in the Closure Plan

This monitoring programme assesses the functioning ability of the restored residue to demonstrate the concept of a self-regulating system. The following ‘Completion criteria’ will be periodically assessed on the trial cell and future restored areas and, where necessary, management intervention implemented. Key components include;

i. Vegetation establishment, survival and succession
ii. Vegetation productivity, sustained growth and structure development;
iii. Soil fauna colonisation and habitat development;
iv. Ecosystem processes such as soil development and nutrient cycling,
v. Colonisation of specific fauna groups that are involved in these processes
vi. Microbiological studies e.g. colonisation by mycorrhizal fungi and microbial biomass
vii. Ecosystem recovery

Attachment 10
BRDA Restoration Works Report by Enrich 2016

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1. Overview of Work Completed

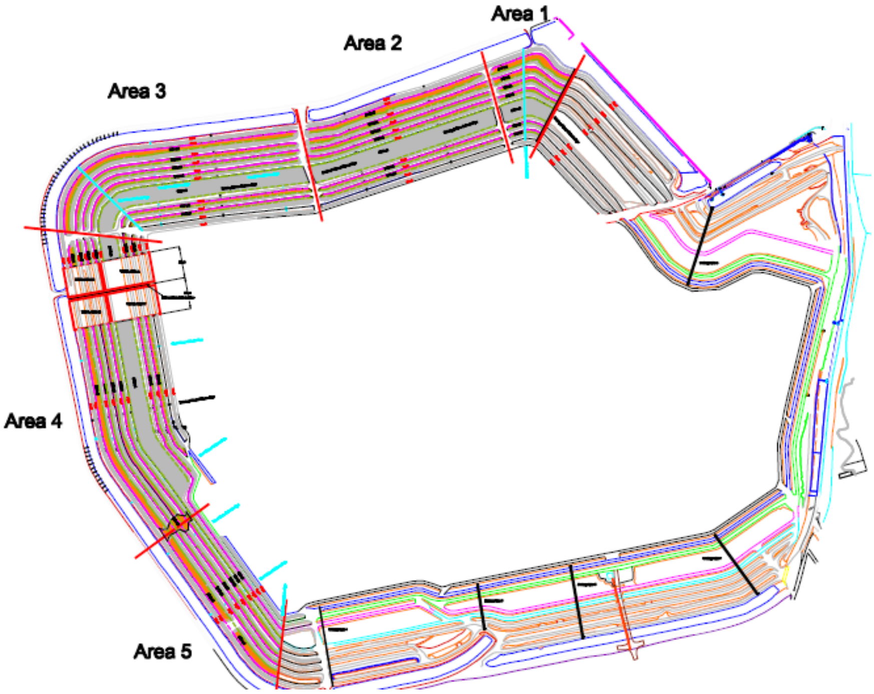


Figure 1: Map of Stage 5 BRDA

1.1 Monitoring- Phase 2

Stage five is being used to provide a visual demonstration that grass can be established and maintained on the amended bauxite residues. Stage five has been divided into two areas for sampling purposes. Given the area and the similarity in result from analysis conducted in 2015, area 1 and area 2 have been amalgamated likewise area 3 and 4.

Table 1: Parameters Analysed in the Manufactured Topsoil

pH	Phosphorus
Electrical Conductivity	Calcium
Sodium	Organic Matter
Magnesium	Potassium
Cation Exchange Capacity	

In order to accurately monitor the natural nutrient recycling both the manufactured topsoil (Table 1) and the grass (Table 2) were analysed for a range of parameters.

Table 2: Chemical Analysis Conducted on Grass

Total Nitrogen DUMAS	Total Calcium	Total Manganese	Total Iron
Total Phosphorus	Total Magnesium	Total Copper	Total Boron
Total Potassium	Total Sulphur	Total Zinc	Total Aluminium

In addition to testing the amended soil, analysis was also conducted on the grass. Leaf analysis is the most accurate method for monitoring plant nutrient levels and detecting any deficiencies. Leaf analysis shows exactly what the plant has successfully absorbed through its root system.

The soil analysis provides information on the levels of nutrients present in the soil, however due to the complex interactions within the soil not all of these are available to the plant.

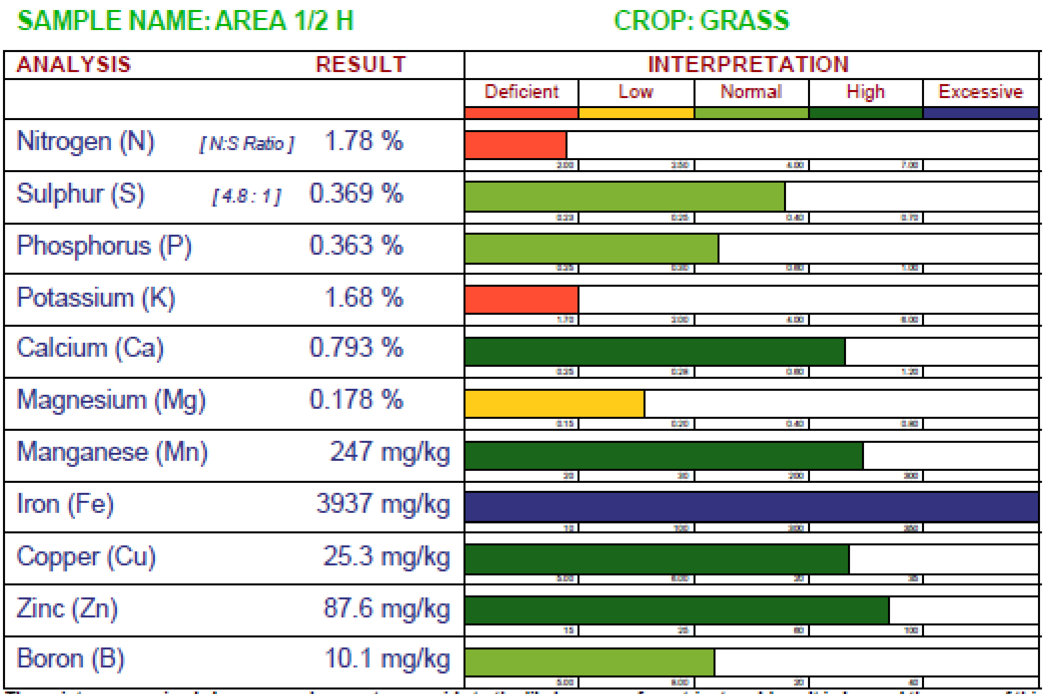
When leaf and soil analysis are looked at together a clear picture can be ascertained about the nutrient recycling and uptake.

2. Results

Table 3 shows the results of the manufactured topsoil.

Parameter	Unit	AREA 1/2	AREA 3/4
pH		6.6	7.9
Phosphorus	mg/l	12.6	21.4
Potassium	mg/l	113	150
Magnesium	mg/l	49	50
Sodium	mg/l	1038	862
Calcium	mg/l	1560	3035
Organic Matter	%	8.5	9.9
Electrical Conductivity	uS/cm	2675	2681
Cation Exchange Capacity	meq/100g	18.2	25.5

Table 4 shows the results of the herbage analysis.



ANALYSIS		RESULT
Nitrogen (N)	[N:S Ratio]	1.78 %
Sulphur (S)	[4.8 : 1]	0.369 %
Phosphorus (P)		0.363 %
Potassium (K)		1.68 %
Calcium (Ca)		0.793 %
Magnesium (Mg)		0.178 %
Manganese (Mn)		247 mg/kg
Iron (Fe)		3937 mg/kg
Copper (Cu)		25.3 mg/kg
Zinc (Zn)		87.6 mg/kg
Boron (B)		10.1 mg/kg

SAMPLE NAME: AREA 3/4 H **CROP: GRASS**

ANALYSIS		RESULT	INTERPRETATION: Deficient / Low / Normal / High / Excessive
Nitrogen (N)	[N:S Ratio]	1.73 %	
Sulphur (S)	[4.9 : 1]	0.351 %	
Phosphorus (P)		0.360 %	
Potassium (K)		1.99 %	
Calcium (Ca)		0.493 %	
Magnesium (Mg)		0.148 %	
Manganese (Mn)		226 mg/kg	
Iron (Fe)		890 mg/kg	
Copper (Cu)		9.90 mg/kg	
Zinc (Zn)		46.2 mg/kg	
Boron (B)		7.90 mg/kg	

Figure 1: Root development August 2016

Figure 2: Grass growth September 2016

4. Discussion

4.1 Discussion of work

As a result of drainage work conducted in 2015, the BRDA is draining freely. The levels of sodium in the soil has reduced due to displacement and leaching. The pH of the soil has dropped as a result of the reduction in sodium.

The reduction of the soils pH has increased the availability of nutrients in the soil. This is demonstrated in the herbage analysis.

The aeration is having a positive impact on root development. Aeration leads to an increase depth of oxygenate allowing the active root zone increase resulting in a larger reservoir of nutrients availability to the grass.

5. Conclusions

The following are the key conclusions:

- The combination of Bauxite residue and customised organic matter is suitable for manufacturing topsoil capable of supporting grass.

- Soil aggregation will occur, increasing the active root zone and the availability of nutrients (*see figure 1*).

- The baseline levels for nutrients in the soil is increasing due to nutrient recycling and the application of customised organic matter

- The pH of the soil is reducing as a result of sodium displacement and improved drainage.

- Aeration is required to ensure that the activate root zone remains aerated, due to compaction a hard pan can develop resulting in restricted movement of the roots limiting the plants access to vital nutrients.

6. Recommendations

The following actions are recommended:

- The grass will require maintenance such as mowing. A mulching mower is recommended as it will evenly distribute the cut grass over the BRDA allowing uniform nutrient recycling.

- The BRDA should be aerated. The purpose of the aeration is to open up the active root zone allowing water and oxygen pass freely.

- Grass and soil analysis to be conducted annually to monitor soil conditions.

- Future Fertilizer applications and/or top dressing with organic material should be determined following an evaluation of the soil and grass analysis

Attachment 11
Constructed Wetland Overview 2016

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Constructed Wetland – 2016

Overview

Bauxite residue from the Bayer process contains residual caustic soda with alkaline leachate of pH > 10.5. Bauxite Residue Disposal Area (BRDA) closure and aftercare plans must address the timeframes required for leachate to reduce to ≤ pH 9.0 so it can be discharged to the receiving environment. A novel approach to ensure that BRDA leachate can be passively treated and made suitable for discharge within a short period (months) of BRDA closure is to incorporate constructed wetland(s) into the Closure Plan. Constructed wetlands are gaining global acceptance by regulators in mine closure. However, little research has been conducted into the using wetlands to treat bauxite residue leachate.

Constructed Wetland - Field Demonstration

In 2012 Aughinish Alumina received funding from its owner UC Rusal and the International Aluminium Association for a four year study programme investigating the use of a constructed wetland to treat residue leachate. A three year field scale demonstration has been in operation since August 2013.

A second phase of the field demonstration commenced in Spring 2015. To determine the effectiveness of wetland technology for low Ca leachate the mixing system was modified to contain de-ionised water for dilution. Results thus far (Figure 1) demonstrate that the constructed wetland can effectively buffer alkalinity of low Ca content residue leachate over a one-year period. A maximum flow rate of 60 l/hr was achieved. As per previous wetland demonstration the component parts of the wetland systems (soil and vegetation) have been periodically sampled and are currently undergoing analysis.

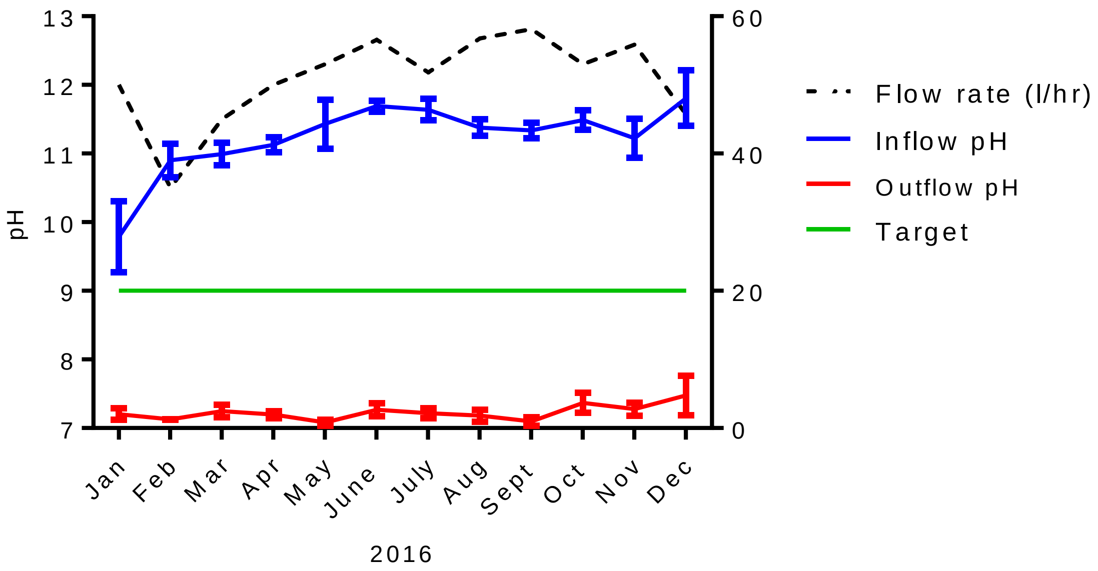

Figure 1. Monthly average pH values of inflow and outflow in constructed wetland treating bauxite residue leachate

Plant growth trials

In order to determine the effects of bauxite residue leachate on soil properties and plant growth a ten week pot experiment was set up using a range of leachate dilutions. Bauxite residue leachate was diluted as indicated below. Pots were filled with compost and planted with freshly transplanted *Phragmites australis*. Following amendment with nutrient additions pot were then inundated with solutions of the differing pH solutions. After 10 weeks the pots were dismantled and soils were analysed for pH, EC and soluble elements. Plants were separated into below and above ground portions and new growth determined by root and shoot length. Elemental concentrations of the plant samples are shown.

Treatment	Dilution factor	Solution pH
1	1:40	11.1
2	1:75	10.4
3	1:100	9.9
4	1:200	9.0
5	1:300	8.8
6	1:400	8.5
Control	------	6.9

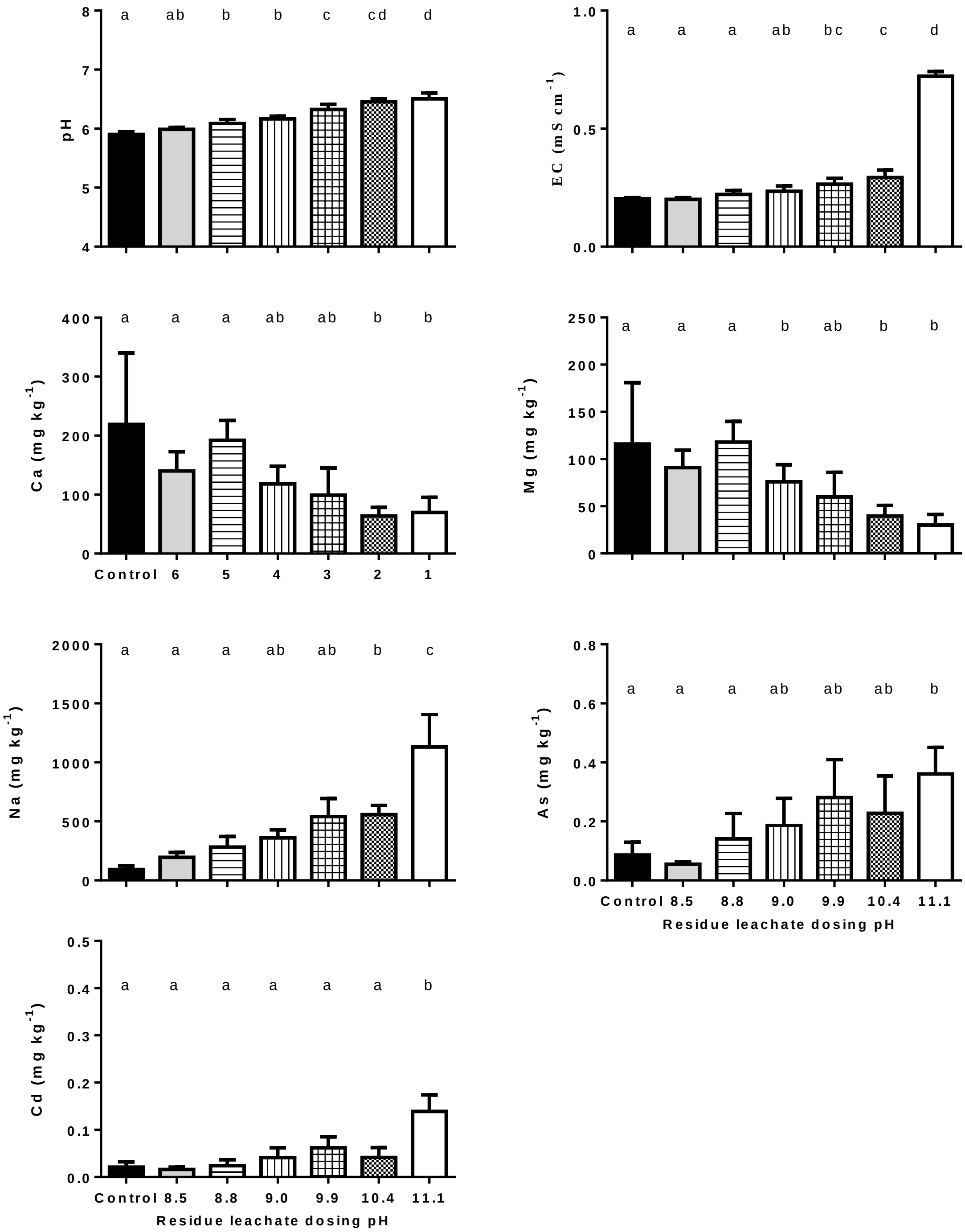

Figure 2. Selected soil physico-chemical parameters after 10 weeks of inundation with residue leachate

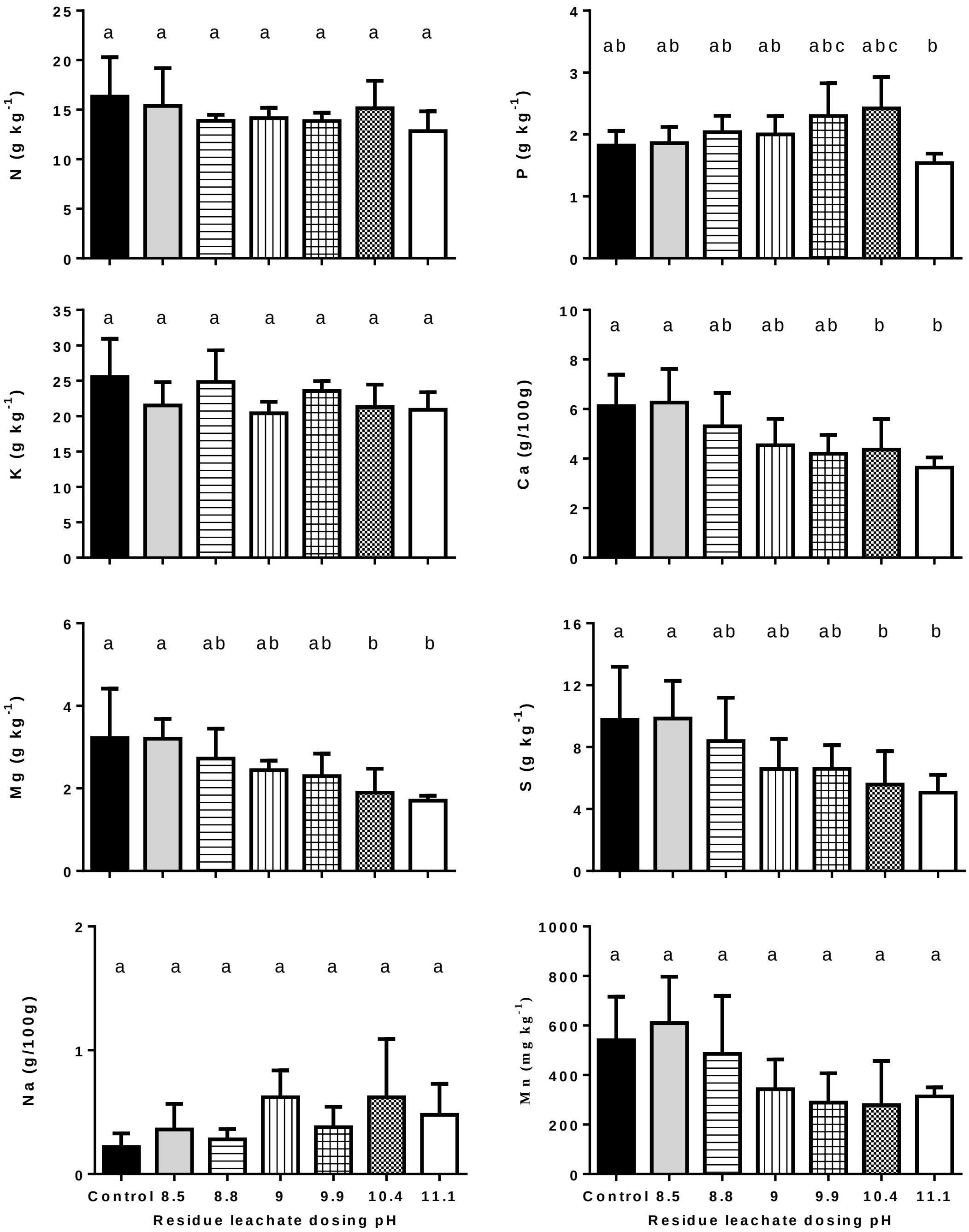

Figure 3. Nutrient and Na content in Phragmites australis aboveground biomass. Means followed by the same letter are not significantly different at $P \leq 0.05$

Although inundation with residue leachate resulted in an increase in soil pH values for all treatments remained below pH 7. In general, increasing amounts of residue leachate resulted in decreased soluble Ca in the soil. Conversely, soil EC and Na levels significantly increased with amount of residue leachate per treatment.

For aboveground biomass samples, increased leachate pH did not result in any significant differences for N, K, Na and Mn content (Fig. 3). Significantly lower values for Ca, Mg, S and Mn were observed with increased residue leachate pH. No treatments displayed nutrient content that was indicative of deficiency levels.

Table 1. Plant growth parameters for *Phragmites australis* and microbial biomass in soil samples (means ± SE, n = 5)

Treatments	**Root Biomass (g/pot)**	**Root length (cm)**	**Shoot Biomass (g/pot)**	**Shoot length (cm)**	**Microbial biomass (µg C/g)**
Control	7.6±1.6a	53±10a	1.3±0.3a	56.4±4.9a	780±152a
pH 8.5	5.8±1.1a	43±7.5a	1.2±0.2a	56.5±9.9a	583±278a
pH 8.8	6.5±1.5a	42±5.7a	1.3±0.2a	56.4±4.8a	604±199a
pH 9.0	8.6±2.6a	36±3.7a	2.2±0.5a	74.2±8.6a	460±376a
pH 9.9	8.5±1.6a	38±5.2a	1.9±0.4a	63.5±6.1a	798±178a
pH 10.4	5.7±1.4a	29±2.3a	1.0±0.3a	48.4±8.1a	900±285a
pH 11.3	7.1±1.0a	32±4.2a	1.9±0.2a	68.7±8.3a	516±145a

Values within a column followed by the same letter are not significantly different at P=0.05

Plant growth in the residue leachate treatments displayed contrasting results. Root length was decreased with increased amount of residue leachate in the treatment but was not significantly different. This trend was not repeated for aboveground (shoot) growth. Biomass yield and elemental content are currently being determined to further understand the impact of residue leachate on plant growth within a constructed wetland system receiving bauxite residue leachate.

Summary

Growth of *P. australis* (below- and aboveground growth and biomass) was not adversely affected in bauxite-residue leachate treatments (pH 8.5–11.1). Whilst some substrate pH, EC and Na content were increased these were not to levels of concern.

Research outputs

Buckley, R., Curtin, T. and Courtney, R. 2016. The potential for constructed wetlands to treat alkaline bauxite residue leachate: laboratory investigations. Environmental Science and Pollution Research, 23:14115-14122.

Higgins, D., Curtin, T., Pawlett, M. and Courtney, R. 2016. The potential for constructed wetlands to treat alkaline bauxite-residue leachate: Phragmites australis growth. Environmental Science and Pollution Research, 23: .24305-24315.