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ADDITIONAL NOISE SURVEY & ASSESSMENT

Acoustics Report 2122/R02a
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1. Introduction

This acoustic report details additional noise surveys and analysis of the commercial wingwalking events operated by AeroSuperBatics at Rendcomb airfield; Figure 1.

The findings are to be considered in conjunction with our initial noise impact assessment of the wingwalking activities is documented in our report M2122/R01b dated 16/8/21.

The report is divided into the following sections:

Section 2: Noise Criteria

Section 3: Noise Survey

Section 4: Findings

Section 5: Conclusion

Appendix A: Calibration Certificates

2. Noise Criteria

This additional review of the noise impact of the wingwalking flights has considered the following published guidance.

2.1 Noise Nuisance

Section 79(6) of the Environmental Protection Act 1990, as amended, specifically exempts aircraft noise from the general noise nuisance controls which exist under that legislation. This is the case, irrespective of whether an airfield in question is small and unlicensed or a major UK airport.

2.2 National Planning Policy Framework (NPPF)

NPPF (2019) sets out the Government's planning policies for England and how these are expected to be applied.

The framework states (among other commitments) that the planning system should contribute to and enhance the natural and local environment by *"Preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability".*

The express inclusion of noise in the NPPF means that it is a material planning consideration for local planning decisions.

With regard to noise paragraph 180 of the NPPF document states that planning policies and decisions should aim to:

> mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life
>
> identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason

2.3 Noise Policy Statement for England (NPSE)

The Noise Policy Statement for England (NPSE) launched in March 2010 states the long-term vision of Government noise policy is to *"promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development".*

The aims of NPSE, through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development are to:

Avoid significant adverse impacts on health and quality of life;

Mitigate and minimise adverse impacts on health and quality of life;

Where possible, contribute to the improvement of health and quality of life.

NPSE provides the following categories to aid the identification of potential impact of noise:

NOEL (No Observed Effect Level): This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.

LOAEL (Lowest Observed Adverse Effect Level): This is the level above which adverse effects on health and quality of life can be detected.

SOAEL (Significant Observed Adverse Effect Level): This is the level above which significant adverse effects on health and quality of life occur.

It should be highlighted that NPSE does not provide noise limits or threshold associated with the above effect level categories.

2.4 Civil Aviation Authority (CAA)

The CAA provides a number of studies and documents covering the assessment and impact of aircraft noise.

For the assessment of aircraft noise CAA provides the following measurement parameters:

Maximum sound level ($L_{Amax,S}$): The simplest measure of a noise event such as the over-flight of an aircraft is the maximum sound level recorded. The measurements of L_{Amax} should be undertaken with the meter set to the 'slow' response. L_{Amax} measurements do not take into account the duration of the noise event and therefore cannot be taken to be representative of the disturbance due to the entire noise event. However, they are useful in reviewing potential sleep disturbance during the night (WHO advises that regular maximum noise levels above L_{Amax} 42dB can lead to sleep disturbance). They are also often reported as they are easier to measure and are considered simpler for the lay person to understand.

Sound Exposure Level (SEL): The SEL of an aircraft noise event is the sound level of a one second burst of steady noise that contains the same total A-weighted sound energy as the whole event. In other words, it is the dBA value that would be measured if the entire event energy were uniformly compressed into a reference time of one second.

Most of the sound energy recorded from an aircraft is concentrated in the highest sound levels. For a constant level sound event, the SEL increases by 3 dB if the duration is doubled, because the energy is doubled. As most aircraft noise events have durations significantly greater than the reference time of one second, their SEL values are invariably numerically greater than L_{Amax} values, typically by around 10 dB.

L_{Aeq}: L_{Aeq} can be defined as the hypothetical steady sound, which contains the same sound energy as the actual variable sound, over a defined measurement period, T. As aircraft noise is composed of individual noise events, L_{eq} can be expressed in terms of the number of events N that occur during the measurement period T, and their logarithmic average Sound Exposure Level (SEL): L_{eq} = Average SEL + 10 x log (N) – 10 x log10 (T)

Perceived Noise Level (PNL): The PNL is used to capture the complex signature of aircraft noise and enable a review of potential for 'annoying' characteristics. It's use is typically limited to the review of jet and propeller driven heavy aircraft and heavy helicopters.

2.5 Department for Transport

The Department of Transport's 'Air Navigation Guidance (2017)' document advises that for the purposes of assessing noise impacts of airspace changes, the government has set threshold for LOAEL of $L_{Aeq,16hr}$ 51dB for daytime noise and $L_{Aeq,8hr}$ 45dB for night time noise. Note that we have been informed that these threshold levels are for the aircraft generated noise alone i.e., they do not include the contribution of environmental noise.

The document also advises that for communities with aircraft noise below the LOAEL threshold, the number of overflights that exceed 65dB (N65) during the day may also be worthy of consideration. Note that it is not defined if the 65dB is a $L_{Amax,S}$ or L_{Aeq} value (for the assessment we have reviewed the $L_{Amax,S}$ values) and no guidance is provided on suitable measurement durations (informs on the frequency of events) or acceptable range of N65.

With regard to AONB the document comments that there are no legislative requirements with overflying. However, it does advise avoiding over-flight of more densely populated areas below 7,000 feet in order to minimise the number of people potentially adversely affected by aircraft noise.

2.6 IEMA Guidelines for Environmental Noise Impact Assessments

The Institute of Environmental Management & Assessment (IEMA) document Guidelines for Environmental Noise Impact Assessment (2014) provides descriptors for noise effects based on the change in sound level and sensitivity of the receptor; Table 1

Table 1. IEMA guideline effect descriptors

Effect Descriptor	Change in sound level
Very substantial	Greater than 10 dB L_{Aeq} change in sound level perceived at a receptor of great sensitivity to noise
Substantial	Greater than 5 dB L_{Aeq} change in sound level at a noise-sensitive receptor, or a 5 to 9.9dB L_{Aeq} change in sound level at a receptor of great sensitivity to noise
Moderate	A 3 to 4.9 dB L_{Aeq} change in sound level at a sensitive or highly sensitive noise receptor, or a greater than 5 dB L_{Aeq} change in sound level at a receptor of some sensitivity
Slight	A 3 to 4.9 dB L_{Aeq} change in sound level at a receptor of some sensitivity
Non/Not significant	Less than 2.9 dB L_{Aeq} change in sound level and/or all receptors are of negligible sensitivity to noise or marginal to the some of influence of the proposals

3. Noise Survey

Table 2. Survey details					
Date	Day	Weather	Wind speed, m/s; Table 3		Wind direction
		Precipitation	Highest	Median	
30/06/2021	Wednesday	Dry	1.3	0.7	N
23/09/2022	Friday	Dry	2.5	0.5	N
23/10/2022	Saturday	Dry	5.0	2.3	N
13/10/2022	Thursday	Dry	0.9	0.0	N
14/10/2022	Friday	Dry	1.8	0.0	SW
18/10/2022	Tuesday	Dry	4.4	3.0	E
22/10/2022	Saturday	Dry	1.7	0.9	SW
Noise monitors: Position 1: Brüel & Kjær Type 2260 Positions 3 & 4: Brüel & Kjær Type 2238 Spot measurements (Positions 1 - 4): Brüel & Kjær Type 2260 Noise monitor calibrated before and after the survey using a Brüel & Kjær Type 4230 calibrator with no deviations found Unmanned monitors configured to measure consecutive 1 minute samples of noise All noise measurements are free-field. Weather station: Weather station: Kestrel type 4500 Configuration: Configured to measure the average wind speed and temperature over consecutive 10-minute periods					

Figure 1 provides an aerial view with the measurement locations identified, whilst Figure 2 shows the setting of the monitors.

The survey results are provided in:

Figures 3 – 7: unmanned measurements made at Positions 1, 3 and 4, with the periods of wingwalking flights highlighted. Note that AeroSuperBatics are not required to keep flight logs; the wingwalker flights were identified by analysis of data and observation.

Table 4: The measured $L_{Amax,S}$ and SEL of example wingwalking and other aircraft

Figure 8: provides the 1/3 octave band measurements of example wingwalking and other aircraft flights.

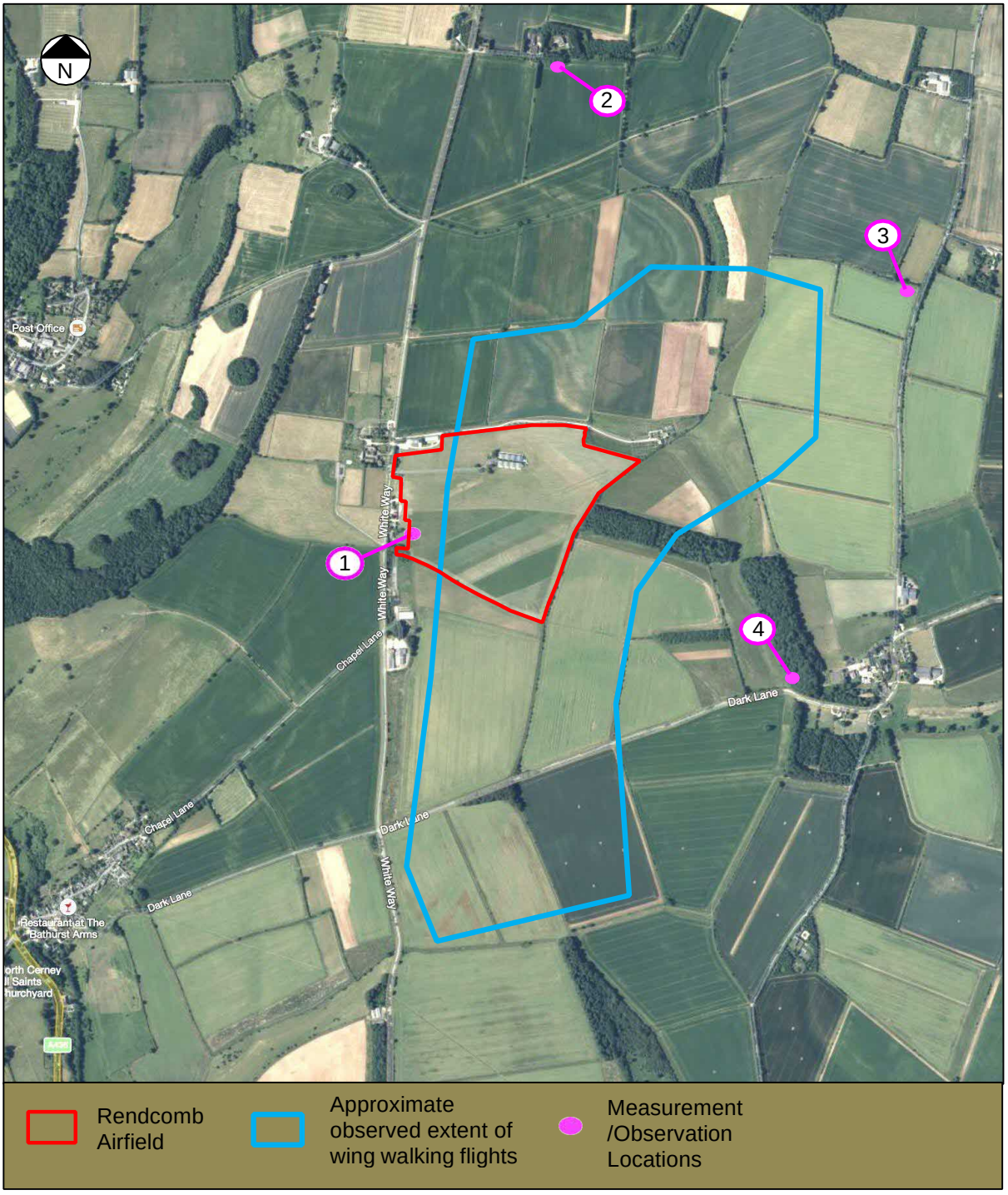

Figure 1. Aerial view (source: ww.google.com) showing Rendcomb Airfield, survey measurement and observation locations and observed approximate extent of wingwalking flights

Position 1 (view from the monitor looking east toward a taxing wingwalker)

Position 3 (looking south-west)

Position 4 (looking east)

Figure 2. Photos of the settings of noise monitor Positions 1, 3 and 4

Table 3. Weather station data

Time	Fri	Sat	Thurs	Fri	Tues	Sat
	23/09/2022	23/10/2022	13/10/2022	14/10/2022	18/10/2022	22/10/2022
	Wind Speed, m/s					
09:00	0.0	0.0		0.0		
09:10	0.0	0.0		0.0		
09:20	0.0	0.0	0.0	0.0		1.3
09:30	0.0	1.1	0.0	0.0		0.0
09:40	0.0	1.1	0.0	0.0		0.0
09:50	0.8	1.2	0.0	0.0		0.9
10:00	2.5	0.0	0.0	0.6		0.6
10:10	0.0	1.6	0.0	0.7		0.7
10:20	0.9	2.5	0.0	0.5		1.0
10:30	0.0	1.5	0.0	0.0		1.3
10:40	0.5	1.3	0.0	0.0		0.6
10:50	0.5	1.2	0.0	0.6		0.5
11:00	0.0	2.5	0.0	0.0		0.0
11:10	0.7	1.2	0.8	0.0	3.0	0.9
11:20	1.5	2.8	0.0	0.0	2.9	0.6
11:30	0.0	2.1	0.0	0.0	3.3	1.7
11:40	0.8	0.4	0.0	0.5	3.0	1.4
11:50	0.0	1.9	0.0	0.0	2.3	0.4
12:00	0.0	0.8	0.0	0.4	3.6	1.1
12:10	0.6	2.6	0.0	1.0	1.9	1.3
12:20	1.5	1.8	0.0	0.4	2.7	1.7
12:30	0.0	1.5	0.9	0.0	3.0	1.4
12:40	0.9	3.0	0.0	1.0	3.3	1.4
12:50	0.4	2.2	0.0	0.0	2.4	1.4
13:00	0.6	1.9	0.0	0.8	3.9	0.7
13:10	0.7	1.7	0.8	0.6	1.7	1.0
13:20	1.5	2.5	0.0	0.0	3.5	0.7
13:30	1.2	2.1	0.0	0.0	4.4	0.5
13:40	0.7	2.6	0.0	1.1	4.1	1.1
13:50	0.0	1.6	0.0	0.3	2.6	1.0
14:00	0.4	3.8	0.0	0.4	4.0	0.9
14:10	0.4	2.6	0.0	0.0	2.3	0.9
14:20	2.1	2.2	0.7	0.0	3.3	1.3
14:30	0.0	3.8	0.0	1.8	2.5	0.8
14:40	1.0	2.8	0.0	1.4	1.3	0.9
14:50	0.4	1.6	0.0	0.0	2.6	1.4
15:00	0.0	3.0	0.0	0.4	1.2	0.0
15:10	1.1	3.1	0.0	0.0	3.1	
15:20	0.3	3.2	0.0	1.3	1.8	
15:30	0.4	3.0	0.0	1.1		
15:40	0.0	2.5	0.6	0.6		
15:50	0.8	4.2	0.0	0.0		
16:00	0.9	3.7	0.0	0.5		
16:10	0.9	2.9	0.0	0.0		
16:20	0.0	5.0	0.0	0.9		
16:30	2.0	2.2	0.0	0.0		
16:40	1.7	2.8	0.0	1.0		
16:50	1.9	2.4	0.0	0.0		
17:00	1.9	2.3	0.0	0.5		
17:10	0.5	2.3	0.0	0.7		
17:20	0.0	2.7	0.0	0.0		
17:30	0.8	2.4	0.0	0.0		
17:40	0.0	2.7	0.0	0.0		
17:50	1.1	2.5	0.0	0.0		
Max	2.5	5.0	0.9	1.8	4.4	1.7
Median	0.5	2.3	0.0	0.0	3.0	0.9

Table 4. Spot measurement data (free-field)					
Position	Duration	$L_{Amax,S}$ dB	SEL dB	Aircraft	Notes
Wingwalking Flights					
1	03:26	77.9	89.3	Boeing Stearman	Taxing + take off
1	01:34	79.9	88.9	Boeing Stearman	Taxing + take off
1	02:45	77.8	88.9	Boeing Stearman	Taxing + take off + circling over airfield
1	00:28	70.4	78.9	Boeing Stearman	Fly pass mid airfield
1	00:35	70.0	77.3	Boeing Stearman	Fly pass mid airfield
1	02:05	76.5	87.3	Boeing Stearman	2 plane: fly passes + circling over airfield + stunts (sharp up and down)
1	02:14	71.0	81.3	Boeing Stearman	Fly pass near Position 1
1	00:46	74.9	81.9	Boeing Stearman	Fly pass near Position 1
1	00:36	71.5	79.0	Boeing Stearman	Fly pass mid airfield
1	00:45	66.9	76.7	Boeing Stearman	Fly pass mid airfield
1	00:35	71.2	78.3	Boeing Stearman	Fly pass mid airfield
1	00:37	71.8	79.2	Boeing Stearman	Fly pass mid airfield
1	00:43	70.0	78.3	Boeing Stearman	Fly pass mid airfield
2	00:36	58.0	65.7	Boeing Stearman	Banking at northern extent of the flight area
2	00:46	65.0	74.9	Boeing Stearman	Banking at northern extent of the flight area
2	01:10	66.7	76.4	Boeing Stearman	Banking at northern extent of the flight area
2	00:51	61.6	68.9	Boeing Stearman	Banking at northern extent of the flight area
3	01:19	66.6	76.5	Boeing Stearman	Fly pass at western edge of flight area
3	00:41	64.4	72.1	Boeing Stearman	Fly pass at western edge of flight area
3	00:34	66.8	76.7	Boeing Stearman	Fly pass at western edge of flight area
3	00:43	60.1	69.4	Boeing Stearman	Fly pass at western edge of flight area + stunts (sharp up/down)
3	00:39	61.0	70.9	Boeing Stearman	Fly pass at western edge of flight area + stunts (sharp up/down)
3	00:45	60.0	68.1	Boeing Stearman	Fly pass at western edge of flight area + stunts (sharp up/down)
3	00:46	56.5	66.3	Boeing Stearman	Banking at western edge of flight area to turn toward airfield
3	00:36	62.6	70.3	Boeing Stearman	Banking at western edge of flight area to turn toward airfield
3	00:41	54.9	60.9	Boeing Stearman	Banking at western edge of flight area to turn toward airfield
3	00:31	64.7	72.4	Boeing Stearman	Banking at western edge of flight area to turn toward airfield
3	00:36	51.7	61.2	Boeing Stearman	Banking at western edge of flight area to turn toward airfield
3	00:47	54.6	63.7	Boeing Stearman	Banking at western edge of flight area to turn toward airfield
4	00:41	65.9	71.5	Boeing Stearman	Banking to turn toward airfield
4	00:49	62.8	67.3	Boeing Stearman	Fly pass at western flight area
4	00:42	62.3	68.5	Boeing Stearman	Fly pass at western flight area
4	00:46	63.5	66.6	Boeing Stearman	Banking to turn toward airfield
4	00:47	66.2	74.7	Boeing Stearman	2 planes: fly pass at western flight area
4	00:44	62.2	70.4	Boeing Stearman	Fly pass at western flight area
4	00:43	63.7	70.3	Boeing Stearman	Fly pass at western flight area
4	00:40	60.0	66.8	Boeing Stearman	Fly pass at western flight area
4	00:51	68.6	76.7	Boeing Stearman	Fly pass at western flight area
Non-wingwalking aircraft					
3	00:46	49.6	60.3	Light single propeller plane	High level fly pass
3	00:52	66.9	76.6	Light single propeller plane	Low level fly pass
3	00:48	58.1	65.7	Light single propeller plane	Low level fly pass + circling
3	01:13	59.4	70.0	Light single propeller plane	High level fly pass
3	01:07	57.8	71.2	Light single propeller plane	Low level fly pass + stunts (loop the loop over airfield)
3	00:49	49.4	58.6	Light single propeller plane	High level fly pass
3	00:55	54.0	64.9	Light single propeller plane	High level fly pass
3	00:48	58.9	69.5	Light single propeller plane	High level fly pass
3	00:54	48.2	59.6	Light single propeller plane	High level fly pass
3	00:57	74.0	83.8	Helicopter	Mid level fly pass
3	01:01	62.9	76.3	Helicopter	Mid level fly pass
3	00:59	55.0	66.8	Military plane (4 propeller)	High level fly pass
3	00:51	72.1	82.2	Military plane (4 propeller)	High level fly pass
4	00:54	59.7	70.5	Light single propeller plane	Mid level fly pass
4	00:49	60.2	65.6	Light single propeller plane	Mid level fly pass
4	00:43	59.9	67.3	Light single propeller plane	Mid level fly pass

Figure 3. Friday & Saturday 23-24/9/22 survey data survey

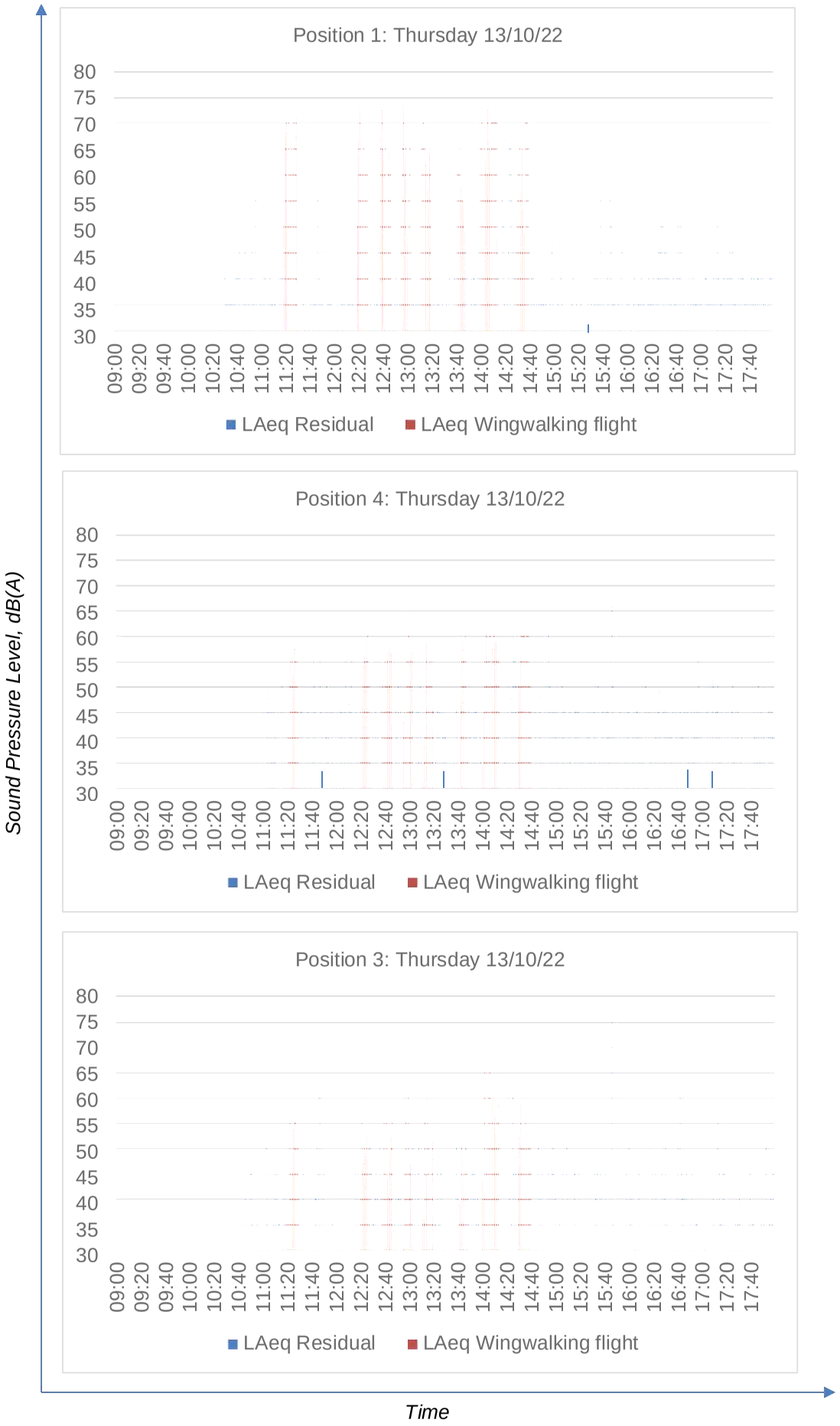

Figure 4. Thursday 13/10/22 survey data

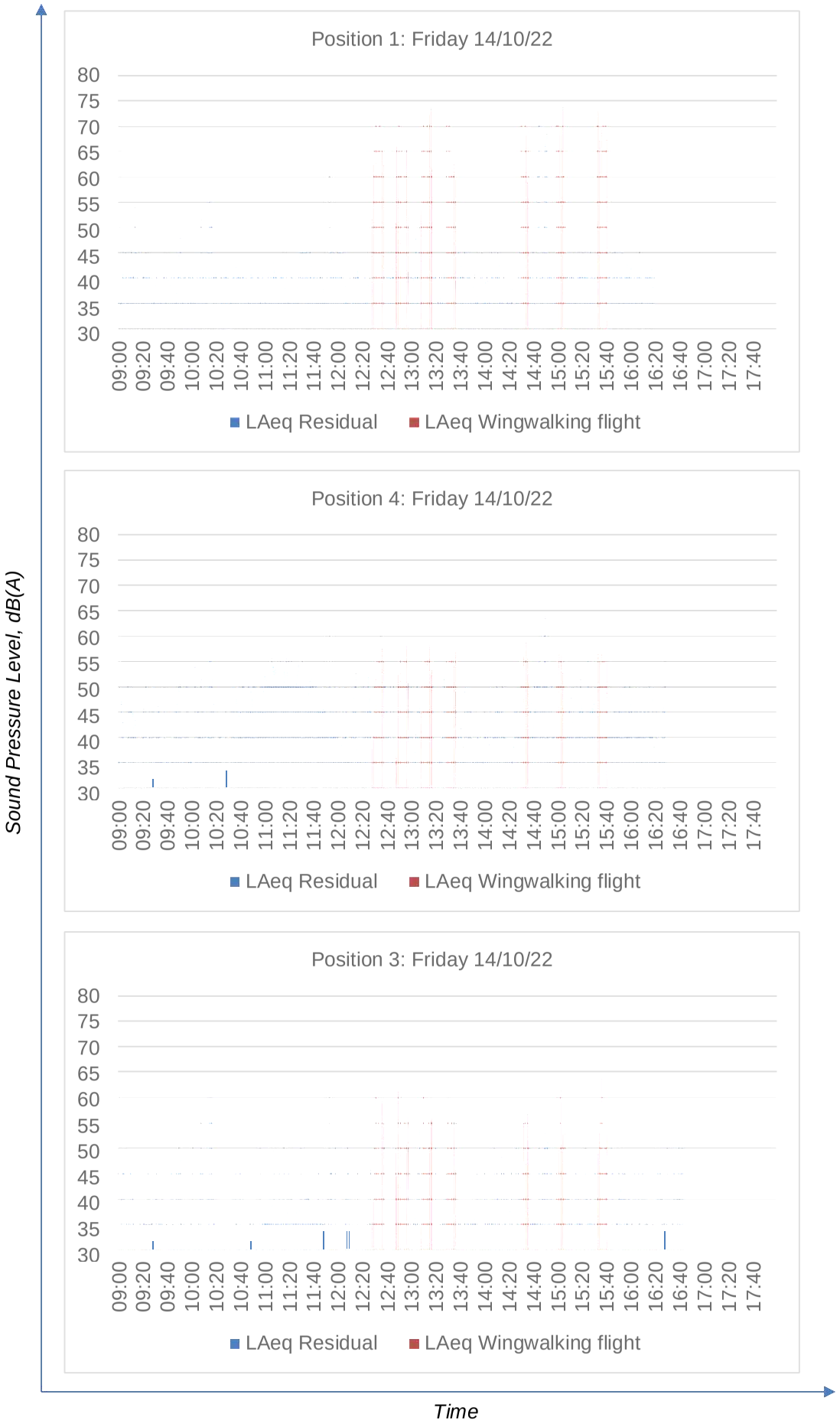

Figure 5. Friday 14/10/22 survey data

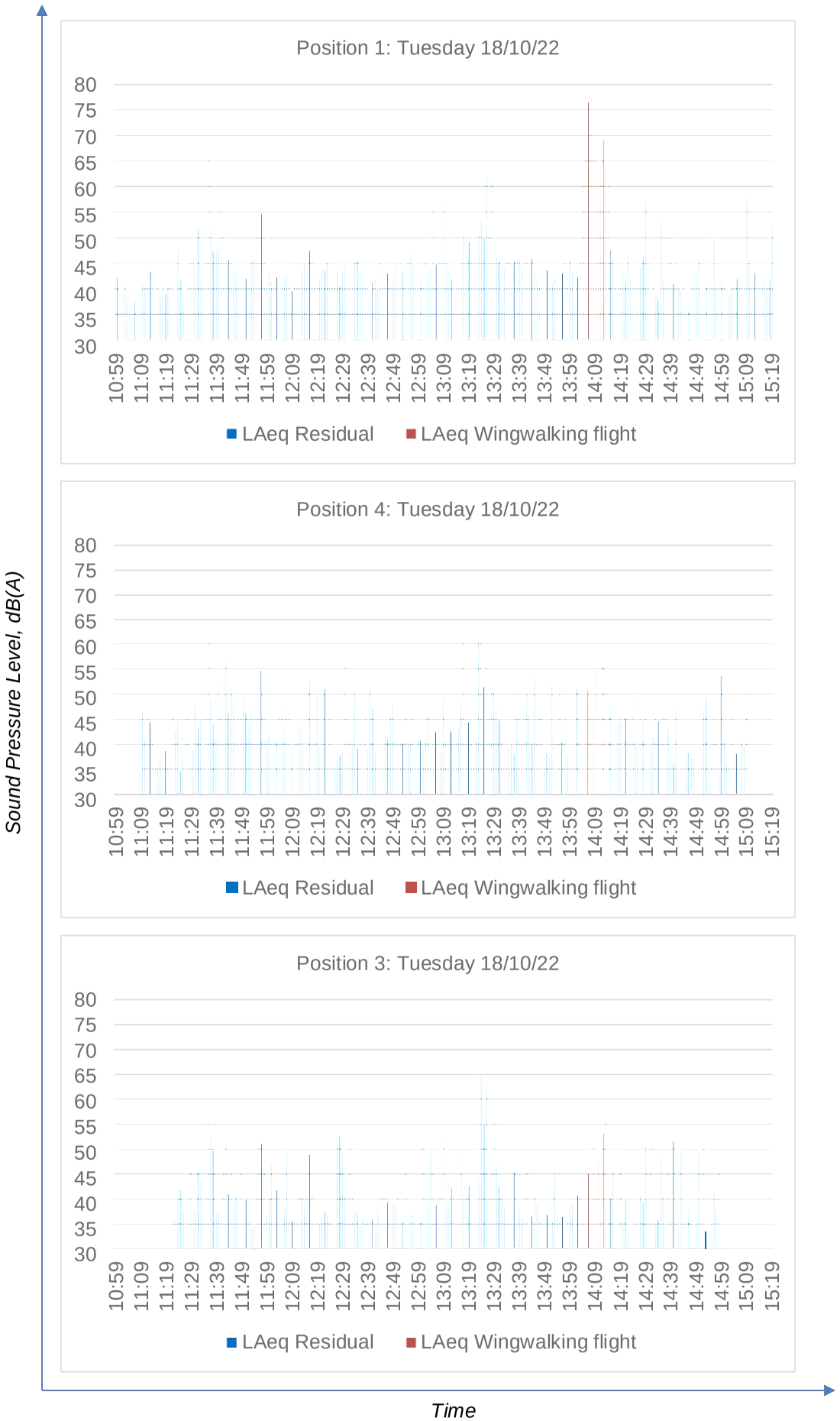

Figure 6. Tuesday 18/10/22 survey data

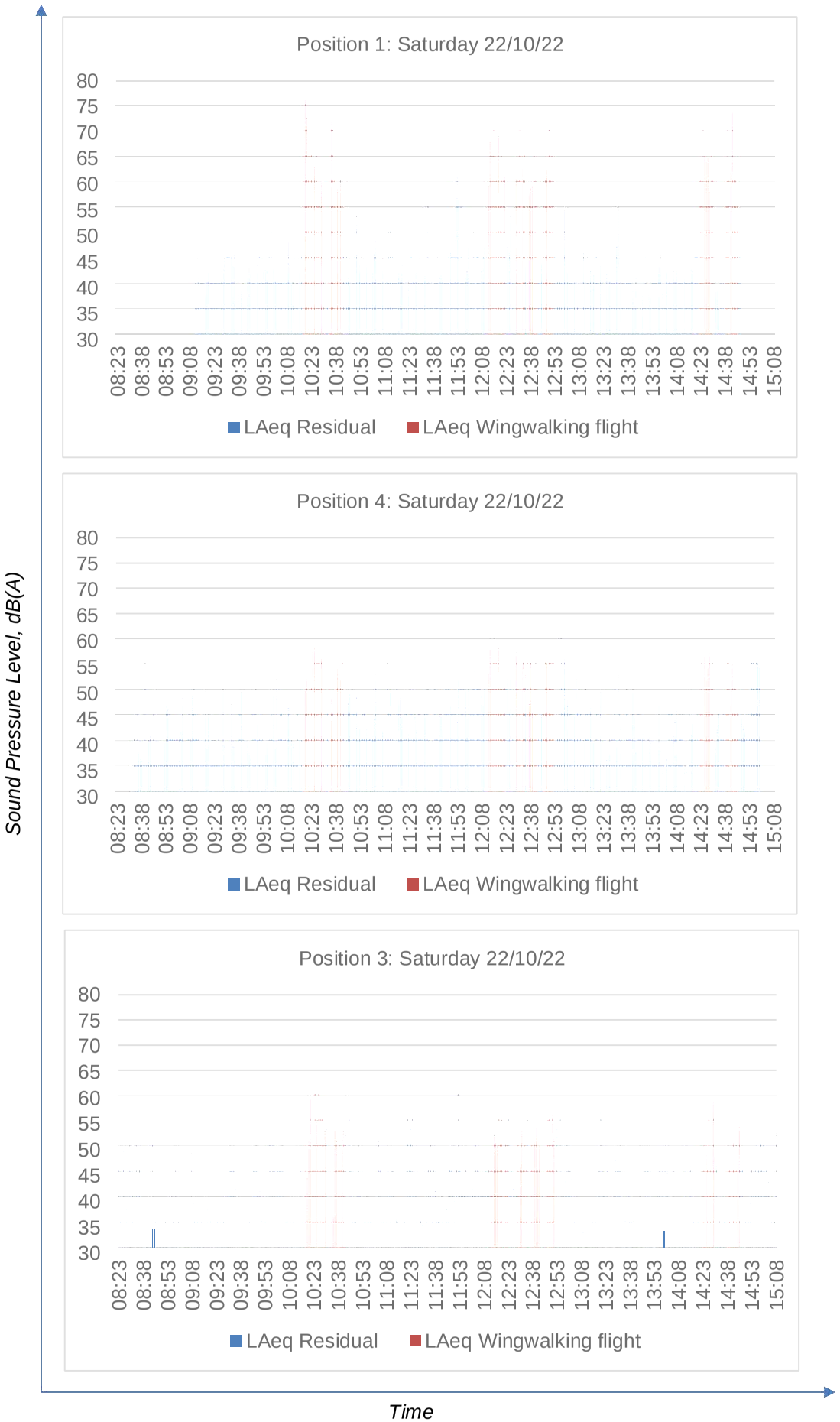

Figure 7. Saturday 22/10/22 survey data

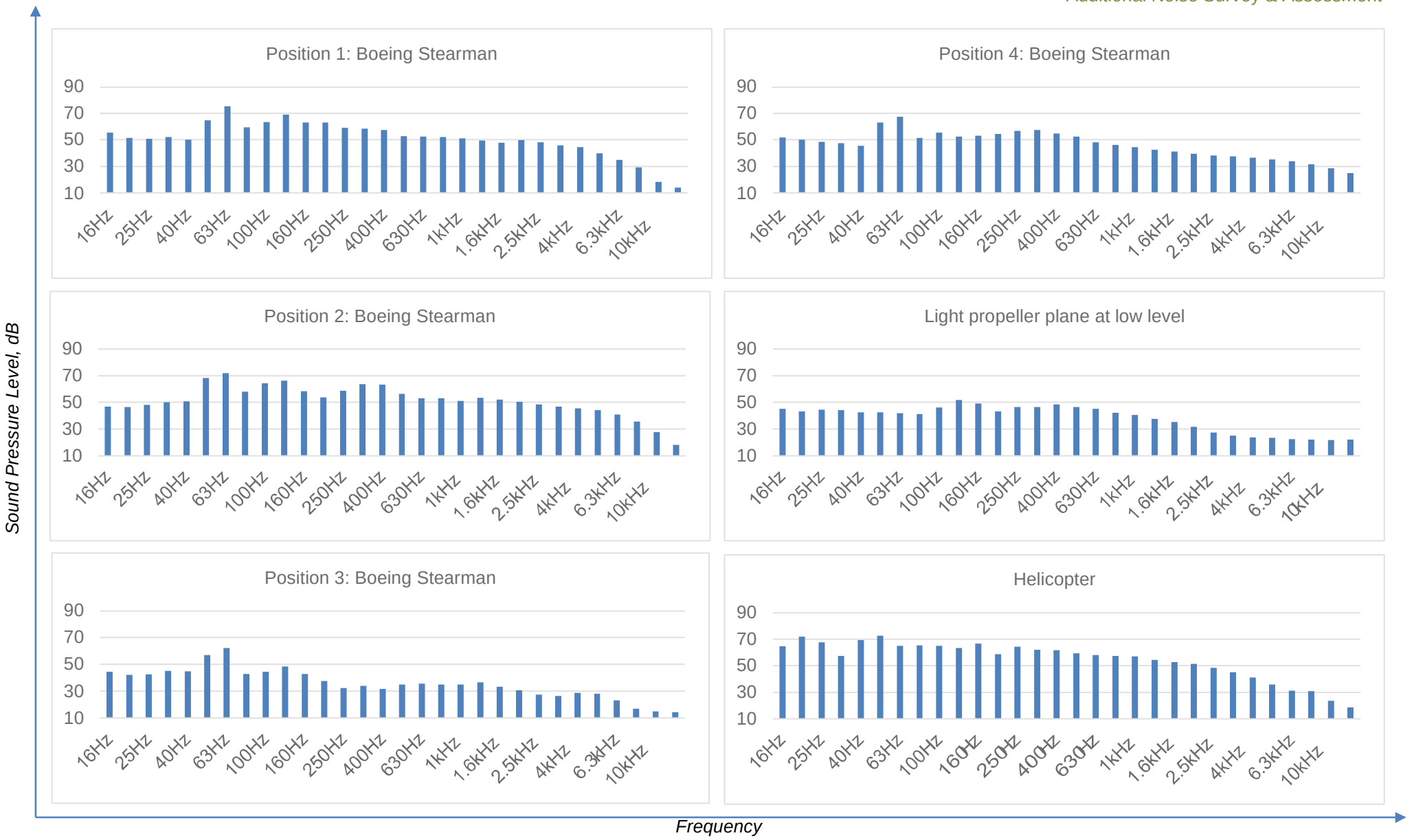

Table 8. 1/3 octave band measurements of example wingwalker/other aircraft flights

4. Findings

4.1 Survey Observations

During the survey it was observed that:

General noise environment:

- The general environmental noise levels are low, consisting of birdsong, road traffic and non-wingwalking aircraft passes
- The non wingwalking aircraft passes, of which there were approximately 10 per hour, consisted of helicopters, light single propellor planes and large 4 propellor military planes. These were all clearly audible for up to 5-minute durations, in particular the helicopters and low-level light aircraft. A single propellor plane was also observed performing stunts (loop the loop) to the north of the airfield.

Wingwalking flights

- North-easterly take-off from Rendcomb airfield, with the take-off starting adjacent to Position 1 (we understand that the take-off direction varies depending on the wind direction/speed)
- The noise emissions of the Boeing Stearman taxiing/taking-off were at a low level, i.e., just audible, at Positions 2 – 4; at Position 1, which was adjacent to where the wingwalkers started the take-off, the plane was the dominant noise source.
- The noise emissions of landings, which were of short duration, were inaudible at Positions 2 - 4 and had lower noise emissions than fly passes
- The airtime of the wingwalker flights lasted approximately 8minutes
- Noise emissions from the Boeing Stearman engine were characterised by a lower frequency rumble
- The commercial wingwalker flights were conducted within the approximate area identified in Figure 1; there were no instances of a residential over-flight
- At each measurement position the commercial wingwalker flights were only clearly audible for parts of the flight circuit; typically, this resulted in 4 instances up to 1-minute periods of clearly audible plane noise at Positions 2 – 4 and 8 instances at Position 1.

4.2 Aircraft noise characteristics

The spot measurements of the Boeing Stearman's flights confirm that they produce characteristic tonal peaks at the 50Hz and 63Hz frequency bands, which are >10dB above the adjacent frequency bands; see Figure 8. This finding is consistent with the survey observations. It should be highlighted that below 50Hz the noise emissions significantly drop.

The Boeing Stearman did not contain any other identifiable noise characteristics.

The spot measurement of light propeller planes and helicopters identified that:

The light propeller planes have a tonal peak at around 125Hz

Helicopters have tonal peaks at 20Hz, 40Hz, 50Hz and 160Hz

The 1/3 octave band measurements identified that all aircraft included tonality, with the helicopters having the lowest frequency peaks.

4.3 Flight durations

Table 5 provides the total duration of each wingwalking flight, which includes taxing/take-off, air time and landing, during the 6 surveys. The overall average of the 47 flights is 10-minutes, which equates to approximately 8-minutes air time (taxiing/take-off and landing take around 2 minutes).

Table 5. Wingwalker total flight durations

Flight	23/9/22	24/9/22	13/10/22	14/10/22	18/10/22	22/10/22
1	10	9	11	10	11	13
2	15	10	9	11		9
3	12	11	9	10		11
4	10	12	8	8		6
5	11	13	9	7		7
6	8	9	7	8		7
7	11	11	14	9		9
8	8	12	11			8
9	8	9				
10		8				
11		11				
12		10				
13		10				
14		9				
Total Average	10					

4.4 Measured ambient noise levels with and without wingwalker flights

Table 6 provides the measured ambient noise levels with and without the contribution of the wingwalker flights at Positions 1, 3 and 4 over the duration of each survey.

Table 6. Measured L_{Aeq} values at Positions 1, 3 and 4

No. of Flights	Day	Date	Position 1				Position 3				Position 4			
			$L_{Aeq,T}$ dB				$L_{Aeq,T}$ dB				$L_{Aeq,T}$ dB			
			A	B	C	D	A	B	C	D	A	B	C	D
9	Fri	23/9/22					47.4	34.1	47.6	0.2	48.1	42.7	49.2	1.1
14	Sat	24/9/22					46.4	38.1	47.0	0.6	45.1	45.7	48.4	3.3
8	Thurs	13/10/22	47.1	60.4	60.6	13.5	52.6	47.2	53.7	1.1	46.4	49.3	51.1	4.7
7	Fri	14/10/22	50.1	60.4	60.8	10.7	45.2	46.5	48.9	3.7	49.2	46.0	50.9	1.7
1	Tues	18/10/22	48.2	56.5	57.1	8.9	47.7	34.4	47.9	0.2	48.2	34.9	48.4	0.2
8	Sat	22/10/22	46.4	60.1	60.3	13.9	46.5	45.2	48.9	2.4	47.6	47.0	50.3	2.7

A = Residual; excluding wingwalking flights
B = Noise levels during wingwalking flights
C = Residual + wingwalking flights
D = Change in the ambient noise level due to the contribution of the wingwalker flights

As can be seen in Table 6, the identified change in the ambient noise levels and corresponding IEMA effect descriptor ranges between:

Position 1: 8.9 – 13.9dB; 'Substantial' to 'Very substantial'

Position 3: 0.2 – 3.7dB; 'Not significant' to 'slight'

Position 4: 0.2 – 4.7dB; 'Not significant' to 'slight'

It should be noted that a direct correlation between the number of wingwalker flights and increase in ambient noise levels was not identified. This finding highlights that there is a degree of variation in the plane noise emissions on a flight-to-flight basis, which will be due to the manoeuvres being undertaken and exact flight path.

At Positions 3 and 4 the ambient noise levels during the wingwalker flights do not exceed the LOAEL $L_{Aeq,9hr}$ 51 dB threshold. At Position 1 however the LOAEL $L_{Aeq,9hr}$ 51 dB threshold was

consistently exceeded; this is expected as Position 1 was adjacent to the start of the take-off location of the planes, which had a significant impact on the noise emissions.

We consider that context must be taken into consideration when viewing the higher noise emissions at Position 1. The dwellings that this location represents are directly on the western boundary of the airfield, and consequently high plane noise emissions, in particular for take-offs, are inevitable and expected (that be for wingwalkers or other aircraft). The occupiers of these dwellings will be fully aware of their proximity to the airfield and therefore the noise implementations (AeroSuperBatics have been operating wingwalking flights from Rendcomb Airfield for the last 28 years).

We therefore consider the exceedance of the LOAEL threshold is acceptable at Position 1, as it is within context for dwellings bounding a small airfield.

It should also be highlighted that our original survey recorded lower wingwalker noise emissions at the western boundary of the airfield; this was due to a combination of the monitor being located further to the north and the mid-airfield take-off location used by the planes. The noise emissions at the dwellings along the western boundary will therefore vary, with the latest surveys identify the highest expected noise emissions due to the south-west corner take-off location used.

4.5 Calculated wingwalker flight noise emissions

The maximum number of flights proposed for the commercial wingwalking flights is 20 per day.

To establish the aggregate wingwalker noise emissions at Positions 1 – 4 for this worst-case scenario, the noise levels have been calculated using the average measured SEL levels of the clearly audible sections of the commercial wingwalking flights.

For the calculation four periods of clearly audible wingwalking flight noise at Positions 2 – 4 have been assumed between 09:00 – 18:00hrs; at Position 1 eight periods have been used together with a take-off per flight. The calculation is provided in Table 7, which includes the aggregate of the wingwalking noise emissions and environmental noise (logarithmic average of the 6 surveys) and corresponding change in noise level.

As can be seen in Table 7, the resultant wingwalker noise emissions do not exceed the LOAEL L_{Aeq} 51dB threshold at Positions 2 – 4. Note that this finding holds true even if the highest measured SEL's are used.

At Position 1 the LOAEL L_{Aeq} 51dB threshold is exceeded by around 9dB.

The change in noise levels is <5dB at Positions 2 – 4 (IEMA 'slight' change in noise level) and >10dB at Position 1 (IEMA 'very substantial' change in noise level)

These findings are consistent with the measured noise emissions presented in Table 6.

Table 7. Calculation of Wingwalking Flight and Aggregate L_{Aeq}

	Pos 1		Pos 2	Pos 3	Pos 4
	Take-off	Flight	Flight	Flight	Flight
SEL average, dB	89	79	73	72	72
No. of audible events	20	160	80	80	80
No. events correction, dB	13	22	19	19	19
Time correction, dB	45.1	45.1	45.1	45.1	45.1
$L_{Aeq,9hr}$ dB	57	56	47	46	46
General environmental noise, $L_{Aeq,9hr}$ dB	48		46	47	49
Aggregate (flight + environmental), $L_{Aeq,9hr}$ dB	60		50	50	51
Change	12		4	3	2

4.6 N65

Table 8 provides the N65 at Positions 1, 3 and 4 during the wingwalking flights for each survey together with the average N65 per flight. Note that the N65 has been determined using the consecutive 1-minute measurements.

Using the established overall average N65 per flight, the total N65 over the 9-hr day period that the wingwalking operates for the proposed maximum of 20 wingwalking flights would be:

Position 1: 101

Position 3: 28

Position 4: 10

Note that a N65 for Position 2 has not been established as long term measurements were not possible due to there being no suitable secure location for a noise monitor. It is expected however that the N65 will be similar to those established at Position 3.

The N65 at Positions 3 and 4 at are not high, being at highest <30 individual events over a 9hr period (based on the maximum of 20 wingwalker flights); to put this into perspective that is less than 30 instances of an individual maximum event that exceeds 65dB over 540 minutes. It should also be highlighted that other aircraft fly passes also resulted in exceedance of $L_{Amax,S}$ 65dB

We therefore consider the relatively low N65 at Positions 3 and 4 (and expected at position 2) to be acceptable.

The significantly higher N65 at Position 1 is predominately due to the take-offs. As already discussed, we consider that this is acceptable when context is taken into account.

Table 8. N65 ($L_{Amax,S}$)

No. of Flights	Day	Date	Position 1		Position 3		Position 4	
			N65		N65		N65	
			Total	Average per flight	Total	Average per flight	Total	Average per flight
9	Fri	23/9/22			5	0.6	2	0.2
14	Sat	24/9/22			7	0.5	21	1.5
8	Thurs	13/10/22	47	5.9	18	2.3	0	0
7	Fri	14/10/22	26	3.7	13	1.9	0	0
1	Tues	18/10/22	7	7	2	2	1	1
8	Sat	22/10/22	28	3.5	9	1.1	3	0.4
Overall average N65 per flight				5.0		1.4		0.5

5. Conclusion

Additional nose surveys over 6 days of wingwalking flights has been conducted to further review the noise emissions of the commercial wingwalking flights at Rendcomb Airfield.

The survey established that the Boeing Stearman, as used for the wingwalking, contained tonal peaks at 50H and 63Hz; this was perceived as a distinctive low frequency rumble. Other aircraft using the air space locally were also identified to have a tonal signature, with Helicopters having a tonal peak as low as 20Hz.

Analysis of the survey data, which had up to 14 flights within a single day, established that at the dwellings to the north, north-east, east and south-east of the airfield the wingwalker noise emissions resulted in:

Compliance with the LOAEL threshold with regard to plane noise

Low N65 values

'Slight' change in noise according to IEMA guidance

These findings hold true for the calculated noise emissions for the proposed maximum of 20 wingwalker flights in any one day (each flight is on average 8-minutes airtime).

For the dwellings along the western boundary of the airfield the wingwalker noise emissions were significantly higher. These higher noise emissions however are considered to be acceptable when taking into consideration context; dwellings directly bounding the airfield will inevitable be exposed to higher plane noise, be that from wingwalker events or other aircraft. The occupiers of these dwellings will be fully aware of their proximity to the airfield and therefore the noise implementations (AeroSuperBatics have been operating wingwalking flights from Rendcomb Airfield for the last 28 years).

The survey established that that there is a degree of variation in the wingwalker noise emissions on a flight-to-flight basis, which will be due to the manoeuvres being undertaken and exact flight path. This does not alter the overall survey findings; there is however potential for a significant reduction in noise emissions for the western dwellings for alternative take-off locations (these are dictated by the weather) than occurred during the additional surveys.

CERTIFICATE OF CALIBRATION

ISSUED BY	Gracey & Associates	BSI CERTIFICATE	FS 25913
DATE OF ISSUE	16 July 2021	CERTIFICATE NUMBER	2021-0702
DATE OF CALIBRATION	16 July 2021		
CALIBRATION INTERVAL	24 months		PAGE 1 OF 1

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TEST ENGINEER [redacted] APPROVING SIGNATORY

Equipment **B&K 2238, s/n: 2428864**
Description Mediator - Type 1, Hottinger Bruel & Kjaer UK Ltd

Customer Matrix Acoustic Design Consultants
Brookfield Coach House, Weston Lane, Bath, BA1 4AG

Standards
BS EN 60651 / BS EN 60804

Conditions

Atmospheric Pressure	102.1 kPa
Temperature	22.4 °C
Relative Humidity	49.6 %

Calibration Reference Sources

Equipment	S/N	Last Cal	Equipment	S/N	Last Cal
Druck DPI 141	479	06-Aug-20	HP 34401	3146A16728	30-Mar-21
Vaisala HMP23	S2430007	03-Aug-20			

Notes

We certify that the above product was duly tested and found to be within the specification at the points measured (except where indicated). Measurements are traceable to reference sources calibrated to National Standards. Where no national or international standards exist, traceability is to standards maintained by the manufacturer. Our Quality Management System has been assessed to comply with BS EN ISO 9001:2015 - BSI Certificate number FS 25913. Tests were carried out in environmental conditions controlled to the extent appropriate to the instrument's specification. All relevant test certificates are available for inspection.
The uncertainties are for a confidence probability of not less than 95%.

CERTIFICATE OF CALIBRATION

ISSUED BY	Gracey & Associates	BSI CERTIFICATE	FS 25913
DATE OF ISSUE	16 July 2021	CERTIFICATE NUMBER	2021-0705
DATE OF CALIBRATION	16 July 2021		
CALIBRATION INTERVAL	24 months		PAGE 1 OF 1

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Equipment **B&K 2238, s/n: 2540985**
Description Mediator - Type 1, Hottinger Bruel & Kjaer UK Ltd

Customer Matrix Acoustic Design Consultants
Brookfield Coach House, Weston Lane, Bath, BA1 4AG

Standards
BS EN 60651 / BS EN 60804

Conditions

Atmospheric Pressure	102.1 kPa
Temperature	22.4 °C
Relative Humidity	49.6 %

Calibration Reference Sources

Equipment	S/N	Last Cal	Equipment	S/N	Last Cal
Druck DPI 141	479	06-Aug-20	HP 34401	3146A16728	30-Mar-21
Vaisala HMP23	S2430007	03-Aug-20			

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The uncertainties are for a confidence probability of not less than 95%.

CERTIFICATE OF CALIBRATION

ISSUED BY	Gracey & Associates	BSI CERTIFICATE	FS 25913
DATE OF ISSUE	16 July 2021	CERTIFICATE NUMBER	2021-0706
DATE OF CALIBRATION	16 July 2021		
CALIBRATION INTERVAL	24 months	PAGE 1 OF 2	

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Equipment **B&K 4188, s/n: 2408019**
Description Microphone - 1/2" FF 0V, Hottinger Bruel & Kjaer UK Ltd

Customer Matrix Acoustic Design Consultants
Brookfield Coach House, Weston Lane, Bath, BA1 4AG

Standards
BS EN 61094

Conditions

Atmospheric Pressure	102.0 kPa
Temperature	22.4 °C
Relative Humidity	49.6 %

Calibration Data

Sensitivity -29.2 dB

Calibration Reference Sources

Equipment	S/N	Last Cal	Equipment	S/N	Last Cal
B&K 4134 L	1675305	14-Jul-20	Druck DPI 141	479	06-Aug-20
HP 34401	3146A16728	30-Mar-21	Nor 1253	20848	14-Jul-20
Stanford DS36	33213	17-Aug-20	Vaisala HMP23	S2430007	03-Aug-20

Notes

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The uncertainties are for a confidence probability of not less than 95%.

CERTIFICATE OF CALIBRATION

ISSUED BY	Gracey & Associates	BSI CERTIFICATE	FS 25913
DATE OF ISSUE	16 July 2021	CERTIFICATE NUMBER	2021-0703
DATE OF CALIBRATION	16 July 2021		
CALIBRATION INTERVAL	24 months	PAGE 1 OF 2	

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TEST ENGINEER [redacted] APPROVING SIGNATORY

Equipment **B&K 4188, s/n: 2426929**
Description Microphone - 1/2" FF 0V, Hottinger Bruel & Kjaer UK Ltd

Customer Matrix Acoustic Design Consultants
Brookfield Coach House, Weston Lane, Bath, BA1 4AG

Standards
BS EN 61094

Conditions

Atmospheric Pressure	102.0 kPa
Temperature	22.4 °C
Relative Humidity	49.6 %

Calibration Data

Sensitivity -29.7 dB

Calibration Reference Sources

Equipment	S/N	Last Cal	Equipment	S/N	Last Cal
B&K 4134 L	1675305	14-Jul-20	Druck DPI 141	479	06-Aug-20
HP 34401	3146A16728	30-Mar-21	Nor 1253	20848	14-Jul-20
Stanford DS36	33213	17-Aug-20	Vaisala HMP23	S2430007	03-Aug-20

Notes

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CERTIFICATE OF CONFORMANCE

ISSUED BY	Gracey & Associates	BSI CERTIFICATE	FS 25913
DATE OF ISSUE	16 July 2021	CERTIFICATE NUMBER	2021-0707
DATE OF CALIBRATION	16 July 2021		
CALIBRATION INTERVAL	24 months		PAGE 1 OF 1

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TEST ENGINEER	APPROVING SIGNATORY
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Equipment **B&K ZC 0030, s/n: 2478**
Description Preamplifier - 1/2" - B&K 2238, Hottinger Bruel & Kjaer UK Ltd

Customer Matrix Acoustic Design Consultants
Brookfield Coach House, Weston Lane, Bath, BA1 4AG

Standards
Manufacturer Specifications

Conditions

Atmospheric Pressure	102.8 kPa
Temperature	22.4 °C
Relative Humidity	49.6 %

Calibration Reference Sources

Equipment	S/N	Last Cal	Equipment	S/N	Last Cal
Druck DPI 141	479	06-Aug-20	HP 34401	3146A16728	30-Mar-21
Vaisala HMP23	S2430007	03-Aug-20			

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The uncertainties are for a confidence probability of not less than 95%.

CERTIFICATE OF CONFORMANCE

ISSUED BY	Gracey & Associates	BSI CERTIFICATE	FS 25913
DATE OF ISSUE	16 July 2021	CERTIFICATE NUMBER	2021-0704
DATE OF CALIBRATION	16 July 2021		
CALIBRATION INTERVAL	24 months		PAGE 1 OF 1

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Equipment **B&K ZC 0030, s/n: 4949**
Description Preamplifier - 1/2" - B&K 2238, Hottinger Bruel & Kjaer UK Ltd

Customer Matrix Acoustic Design Consultants
Brookfield Coach House, Weston Lane, Bath, BA1 4AG

Standards
Manufacturer Specifications

Conditions

Atmospheric Pressure	102.8 kPa
Temperature	22.4 °C
Relative Humidity	49.6 %

Calibration Reference Sources

Equipment	S/N	Last Cal	Equipment	S/N	Last Cal
Druck DPI 141	479	06-Aug-20	HP 34401	3146A16728	30-Mar-21
Vaisala HMP23	S2430007	03-Aug-20			

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The uncertainties are for a confidence probability of not less than 95%.

CERTIFICATE OF CALIBRATION

ISSUED BY	Gracey & Associates	BSI CERTIFICATE	FS 25913
DATE OF ISSUE	16 July 2021	CERTIFICATE NUMBER	2021-0710
DATE OF CALIBRATION	16 July 2021		
CALIBRATION INTERVAL	24 months		PAGE 1 OF 1

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Equipment **B&K 2260 B, s/n: 2305168**
Description Investigator, Hottinger Bruel & Kjaer UK Ltd

Customer Matrix Acoustic Design Consultants
Brookfield Coach House, Weston Lane, Bath, BA1 4AG

Standards
BS EN 60651 / BS EN 60804

Conditions

Atmospheric Pressure	102.1 kPa
Temperature	22.4 °C
Relative Humidity	49.6 %

Calibration Reference Sources

Equipment	S/N	Last Cal	Equipment	S/N	Last Cal
Druck DPI 141	479	06-Aug-20	HP 34401	3146A16728	30-Mar-21
Vaisala HMP23	S2430007	03-Aug-20			

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The uncertainties are for a confidence probability of not less than 95%.

CERTIFICATE OF CALIBRATION

ISSUED BY	Gracey & Associates	BSI CERTIFICATE	FS 25913
DATE OF ISSUE	16 July 2021	CERTIFICATE NUMBER	2021-0711
DATE OF CALIBRATION	16 July 2021		
CALIBRATION INTERVAL	24 months		PAGE 1 OF 2

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Equipment **B&K 4189, s/n: 2294181**
Description Microphone - 1/2" FF 0V, Hottinger Bruel & Kjaer UK Ltd

Customer Matrix Acoustic Design Consultants
Brookfield Coach House, Weston Lane, Bath, BA1 4AG

Standards
BS EN 61094

Conditions

Atmospheric Pressure	102.0 kPa
Temperature	22.4 °C
Relative Humidity	49.6 %

Calibration Data

Sensitivity -26.3 dB

Calibration Reference Sources

Equipment	S/N	Last Cal	Equipment	S/N	Last Cal
B&K 4134 L	1675305	14-Jul-20	Druck DPI 141	479	06-Aug-20
HP 34401	3146A16728	30-Mar-21	Nor 1253	20848	14-Jul-20
Stanford DS36	33213	17-Aug-20	Vaisala HMP23	S2430007	03-Aug-20

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The uncertainties are for a confidence probability of not less than 95%.

CERTIFICATE OF CONFORMANCE

ISSUED BY	Gracey & Associates	BSI CERTIFICATE	FS 25913
DATE OF ISSUE	16 July 2021	CERTIFICATE NUMBER	2021-0712
DATE OF CALIBRATION	16 July 2021		
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Equipment **B&K ZC 0026, s/n: 2305168**

Description Preamplifier - 1/2" - B&K 2260, Hottinger Bruel & Kjaer UK Ltd

Customer Matrix Acoustic Design Consultants
Brookfield Coach House, Weston Lane, Bath, BA1 4AG

Standards
Manufacturer Specifications

Conditions

Atmospheric Pressure	102.8 kPa
Temperature	22.4 °C
Relative Humidity	49.6 %

Calibration Reference Sources

Equipment	S/N	Last Cal	Equipment	S/N	Last Cal
Druck DPI 141	479	06-Aug-20	HP 34401	3146A16728	30-Mar-21
Vaisala HMP23	S2430007	03-Aug-20			

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The uncertainties are for a confidence probability of not less than 95%.