UPM

SHOTTON MILL

Noise Investigation

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CONFIDENTIAL

UPM

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Noise Investigation

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1 INTRODUCTION

WSP UK Ltd has been commissioned by UPM to investigate the validity and potential cause of noise complaints alleged to be originating from UPM's Shotton site.

The complaints, which started in Aug 2019, have been lodged directly with UPM by the residents of a dwelling **[TEXT REDACTED].**

The complaints relate to noise disturbance allegedly caused by UPM operations at its paper mill site in Shotton, but as the UPM site itself is very large and is located within a very large industrial area, there are many other noise sources present which also have the potential to cause disturbance.

To date it has not been conclusively determined by either UPM, Natural Resource Wales or the complainant, which (if any) items of UPM plant are contributing to the alleged disturbance, nor has it been determined if the UPM site is indeed a source of the disturbance(s).

The purpose of this assessment is to provide information about an initial noise survey undertaken at the complainants' property to determine both the level and tonal content of the noise giving rise to the complaints, and about attended surveys undertaken at the UPM site with a view to determining the potential sources of the noise causing complaints.

The report necessarily uses some specialist acoustic related terminology, and to assist the reader a glossary of terms is included in Appendix A.

2 ENVIRONMENTAL NOISE SURVEY

Prior to the noise surveys being undertaken, WSP spoke directly to the residents on the phone and in person to establish details of the noise disturbances. A series of questions were asked about the noise, when it occurs, who can hear it, and where it can be heard etc.

The property from which the complaints originate comprises a **[TEXT REDACTED]** dwelling occupied by **[TEXT REDACTED]. [TEXT REDACTED].** The dwelling is situated **[TEXT REDACTED]** relative the village **[TEXT REDACTED]** and relative to the UPM site (~5m ASL). **[TEXT REDACTED]**. The main points established from the initial interview (which was conducted on 13th November 2019) with **[TEXT REDACTED]** were as follows:

- The noise has been heard since **[TEXT REDACTED]** moved into the property in **[TEXT REDACTED]**
- The noise is described as a humming, like that heard just after a jet aeroplane has passed overhead
- Generally, the disturbing noise is worst at night when road traffic noise is noticeably reduced
- The noise is heard most in the conservatory and the main bedroom of the house
- The noise is seemingly linked to wind direction, with south westerly winds leading to the most disturbing periods and north easterly winds resulting in no significant disturbances
- It was originally considered to be coming from the new Parc Adfer site, but after having been **[TEXT REDACTED]** of this site and told it was not operational at the time the complaints started, **[TEXT REDACTED]** no longer suspect the Parc Adfer site as the source
- No specific measures have been taken to avoid being disturbed by the noise, but it has prevented guests being invited to the house due to the degree of annoyance it causes

2.1 MEASUREMENT LOCATIONS

Following the interview, potential internal and external noise survey locations were discussed with a view to determining where the disturbing noise could best be measured on the complainants' premises. The following measurement locations were agreed as appropriate:

- **Measurement Location 1** – Outside, on the **[TEXT REDACTED]** accessed off the main bedroom of the house. The location was chosen to best represent the external noise environment to the dwelling. The microphone was mounted on a tripod approx. 1.5m above the floor of the **[TEXT REDACTED]** in a free field position. The sound level meter at this location measured noise levels continuously.
- **Measurement Location 2 –** Inside the main bedroom of the house at first floor level, in front of the **[TEXT REDACTED]** (ML1). The microphone was mounted on a tripod approx. 1m high and was equipped with a remote-control button which **[TEXT REDACTED]** were asked to press at times when the disturbing noise was audible. Upon depressing the remote control, the sound level meter recorded 2mins of audio signal.

In order to determine how the noise levels at the house compare to noise levels closer to the UPM site at times when disturbances were logged, a further measurement location was also used as follows:

- **Measurement Location 3** – On the northern boundary of the UPM site at the approximate midpoint. The microphone was mounted on a tripod approx. 1.5m above the ground.

The dominant noise sources at this location were generally all from within the UPM site, but also included road traffic on both the adjacent Weighbridge Road and the distant road network. This location was chosen after having been around the site to look at the noise sources present, during which it was noted that most of the significant noise sources on the site are at roof level. There were not considered to be any ground level locations where all the roof level sources significantly contributed to the noise environment, and all the potential roof locations would have been biased towards a particular source.

2.2 SURVEY DETAILS

The survey at ML1 and ML2 was undertaken from Wednesday 13th November until Tuesday 26th November 2019, and whilst the sound level meter at ML3 was installed for the same period, its battery ran out on the evening of 14th November.

At each location, during the continuous noise measurements the overall L_{Aeq}, and third octave band L_{eq} values were captured.

[TEXT REDACTED] were also given a log sheet and were asked to keep a log of the times at which the disturbing noise occurred, when the button at ML2 was pressed, how long it lasted for, and its severity on a scale of 1 to 10 (1 being minimal disturbance, 10 being severely disturbing). This was to be filled in for a period of several days, or until such a time as several instances of noise disturbance had occurred.

In addition to the longer-term measurements made at ML1-ML3, short term source measurements were undertaken over two attended on-site surveys, close to numerous noises sources on the paper mill site. The first survey was undertaken on Wednesday 13th November 2019. The second survey was undertaken on Thursday 6th February 2020.

All of the noise sources measured were emitting continuous, non-cyclical noise, therefore enablingvery short term (1min) measurements to be representative. Audio signal was also recorded, to enable narrow band analysis to later be undertaken for comparison with the measurements at ML1.

It should be noted that the source measurements were undertaken when there was no reported noise disturbance by **[TEXT REDACTED]**. Despite this, the source noise survey was still completed as UPM informed WSP that the site operates constantly with no plant switching on/off periodically, which would rule out the possibility of the noise not being present due to a noise source not being operational.

The sources/locations measured on 13th November 2019 were:

- Area outside Boiler house on green.
- Adjacent to compressor tanks next to office block
- Louvre on Boiler 7 roof
- Chimney on Boiler 7 roof
- In front of drum pulper back door
- In front of MRF doors
- Roof of RCF3, near stair opening
- RCF3 roof Loc1
- RCF3 roof Loc2
- RCF3 roof Loc3

- RCF3 roof Loc4
- RCF3 adjacent to drum roller (internal)
- In front of the oil store near northern boundary.

The sources/locations measured on 6th February 2020 were:

- All powered fans on RCF3 roof
- Fan 1 on RCF3 roof at 45Hz inverter frequency
- Fan 1 on RCF3 roof at 49Hz inverter frequency
- Fan 1 on RCF3 roof at 50Hz inverter frequency
- Fan 1 on RCF3 roof at 52Hz inverter frequency
- Disc filter fan on RCF3 roof
- Air intake vents on RCF3 roof
- Open exhaust point on RCF3 roof
- All Exhaust points on PM2 roof
- Air intake on PM2 roof
- Boiler outlet points above boiler7
- Internal measurement of RCF3 ▪ Internal measurement of PM2

All locations were outside unless otherwise noted.

A plan showing the measurement locations ML1-ML3, and on-site measurements, together with the general location of the UPM site relative to **[TEXT REDACTED]** dwelling is included in Appendix B.

The details of the measurement equipment used during the noise surveys are presented in Table 2.1 and Table 2.2.

Table 2.1 Noise Measurement Equipment During Survey Period 13th November to 26th November 2019

Location	Equipment Description	Manufacturer & Type No.	Serial No.	Calibration Due Date
ML1	Sound Level Meter	01 dB-Metravib DUO	10594	28 February 2021
	Pre-amplifier	01 dB Metravib PRE 22	1507076	
	Microphone	GRAS 40CD	224313	
	Calibrator	01 dB-Stell CAL 21	34924020	26 September 2020
ML2	Sound Level Meter	01dB-METRAVIB Solo Master	65806	02 November 2021
	Pre-amplifier	01dB-Stell PRE 21 S	16461	
	Microphone	Microtech Gefell GmbH MCE212	166412	

	Calibrator	01dB-Metravib Cal 21	34323904	03 September 2020
ML3 and on-site	Sound Level Meter	01 dB-Metravib DUO	10329	10 October 2020
ML3 and on-site	Pre-amplifier	01 dB Metravib PRE 22	10261	10 October 2020
ML3 and on-site	Microphone	GRAS 40CD	231588	10 October 2020
ML3 and on-site	Calibrator	01 dB-Stell CAL 21	34134164	14 October 2020

Table 2.2 Noise Measurement Equipment During Survey Period 6th February 2020

Location	Equipment Description	Manufacturer & Type No.	Serial No.	Calibration Due Date
External Measurements	Sound Level Meter	01 dB-Metravib CUBE	10621	15 May 2021
External Measurements	Pre-amplifier	01 dB Metravib PRE 22	10635	15 May 2021
External Measurements	Microphone	GRAS 40CD	207269	15 May 2021
External Measurements	Calibrator	01 dB-Metravib CAL 21	35293349	27 September 2020
Internal Measurements	Sound Level Meter	01dB-METRAVIB CUBE	10629	08 March 2020
Internal Measurements	Pre-amplifier	01dB-Stell PRE 22	1610680	08 March 2020
Internal Measurements	Microphone	GRAS 40CD	288092	08 March 2020
Internal Measurements	Calibrator	01dB-Metravib Cal 21	34344462	27 March 2020

All sound level meters were calibrated prior to and upon completion of the survey. No calibration drifts were found to have occurred.

During the long-term survey period a weather station was also installed in the garden of **[TEXT REDACTED]**, which among other parameters measured wind direction.

3 SURVEY RESULTS

3.1 NOISE LOG

During the survey **[TEXT REDACTED]** were asked to make a log of the time when the disturbing noise could be heard and also to rate the level of disturbance for each occurrence on a scale of 1 to 10. For each of these log entries, it was requested that the remote trigger on the sound level meter at ML1 was pressed in order to capture the noise disturbance on the sound level meter.

The log provided is replicated in Table 3.1.

Table 3.1 Noise Log Completed by [TEXT REDACTED]

Date	Time	Disturbance Rating	Comments
16/11/19	22:57	1	Wind from WNW. Detected noise due to low level outside only. Interesting to see if equipment detects this. Temp approx. 8ºC. Only mention this as we weren't expecting to hear anything from this wind direction. I didn't switch on monitor inside as noise mainly outside.
17/11/19	-	-	-
18/11/19	22:42	6	Recorded open door. Constant noise. Temp 4ºC. Wind from south.
	22:44	6	Repeated with door open.
	22:54	5	Closed door. Inside for comparison.
19/11/19	00:32	7/8	Outside very noisy
	00:34	7/8	Inside similar
	00:38	7/8	Inside similar
	07:05	7/8	Outside very noisy on waking up and through morning
	22:52	8/9	Similar to last night. Very noisy outside
	22:58	8/9	Repeated. As above. Outside
	22:59	7/8	Inside. As above.

20/11/19	19:00	5/6	Outside quite windy so noise intermittent.

22/11/19	09:20	5/6	Outside typical of morning noise (could be combined with some traffic noise)
	14:28	5/6	Outside
	23:13	2/3	Outside quite low but still evident despite eastly wind direction
24/11/19	10:05	4/5	Noise evident outside Sunday morning (no rush hour traffic) SSE wind
Date	**Time**	**Disturbance Rating**	**Comments**
	16:09	4/5	Sunday late PM Noise evident outside SSE
	20:58	6/7	Evening noise quite loud outside SSE
	21:00	5/6	Outside constant low resonance
	22:38	6/7	As previous.
	22:42	6/7	Not at its loudest inside but going to bed and constant noise makes things difficult
25/11/19	09:30	4	Early morning noise outside
	09:33	3/4	Inside noise
	09:55	4/5	Outside steady noise typical of what we get most days when prevailing wind is evident during day.
	20:11	8/9	Outside combined with church bells but very loud rumble
	23:04	8/9	Constant noise as earlier rumble.

Summary: Wind direction for large parts of survey has been opposite to prevailing winds seen during the summer months when noise was at its worst. Colder temperatures and some blustery winds/storms keep noise lower than it would otherwise be. Survey shows worst noise when winds are from a generally south direction.

It should be noted that although the microphone was installed inside the bedroom, it was moved outside by the complainant for some of the measurements and/or the door to the **[TEXT REDACTED]** was opened, as indicated in the noise log. These periods have still been analysed but treated as external measurements. Noise tones present in outdoor measurements would not always necessarily be expected to be present inside due to the specific sound insulation properties of the building.

3.2 AUDIO RECORDINGS AND NARROW BAND ANALYSIS OF DISTURBING PERIODS

To determine the tonal noise components present in noise at the complainants' dwelling during periods when a disturbance was logged, the audio recordings made at ML2 have been subject to narrow band frequency analysis, which has enabled the identification of tones present within each measurement with a resolution (bandwidth) of 2.3Hz.

Figures C.1 and C.2 in Appendix C show the results of the narrow band analysis for frequencies from 0Hz to 500Hz. Frequencies above 500Hz were also measured but have not been considered in detail due to the description of the noise disturbance and the subjective opinion after having listened to the recordings, which suggest a lower frequency noise to be the source.

From Figures C.1 and C.2 it can be seen that there are several prominent tones common across measurements made at ML1. The most significant and commonly occurring of these are annotated on the Figures at **82.8 Hz**, **150 Hz, 162 Hz, 196 Hz and 225 Hz,** of which **82.8 Hz** and **150 Hz** are the most significant. All of these tones are present within the indoor and outdoor measurements made at times when a disturbance was reported which goes some way to eliminating the possibility of an internal noise (within the dwelling) being the source.

Other significant tones noted to be present in the external measurements, are at **235 Hz** and **296 Hz.** Whilst these could be contributing to the external disturbances, the measured data does not suggest they are a component of the internally disturbing noise(s).

In addition to the narrow band analysis the recordings have been listened to by WSP staff, and from a subjective point of view, listening to the recordings corroborates the presence and description of the noise disturbances. This is particularly apparent from the external recordings.

3.3 SOURCE MEASUREMENTS

Further narrow band frequency analysis has been carried out on the noise measurements taken close to the UPM noise sources. Most of the noise sources profiled are shown to have very complex tonal components over a wide range of frequencies. Figure C.3 shows the results from each position, with the tones identified at ML1/ML2 overlaid. A site map of measurement positions on 6th February is shown in Appendix B

As shown on Figure C.6, the **82 Hz** tone has been measured at all positions on the western half of the PM2 roof. The tone is most prominent at position P7 next to the short cylindrical exhaust chimney. As no visible powered fan unit is attached to this exhaust point, it is considered that the noise is emanating from the process below and breaking out through the chimney. The difference in measured frequency is thought to be due to slight changes in operational conditions.

During the attended survey on 13th November, only one of the source measurements is shown to have a significant tonal component around **150 Hz**, which is the measurement location in front of one of the louvres on the roof of Boiler 7 building, where a peak at **148.8 Hz** is noted. It should be noted that a tone of **90 Hz** was measured on 6th February at the same position, which was not present in the previous survey, suggesting different operating conditions of the plant. A tone of **147 Hz** was measured from the Disc Filter Exhaust point on the RCF3 roof, but this was at a much lower level than other sources on site.

Smaller tonal peaks also show in various other results at **148.8 Hz** and **150 Hz** but at a level at least around 10 dB lower than the louvre on the roof of Boiler 7. It is unknown if the tone is originating from the louvres on the roof of Boiler 7 or if the large chimney adjacent to the boiler is the source of this tone. This tone was not present during the attended measurements on 6th February 2020 at any position on the Boiler 7 roof or PM2 roof.

The measurement in front of the louvres also shows very strong tones at **300 Hz** and **295 Hz**, which are also apparent in the other measurement on the same roof which was selected to best represent chimney noise. However, the height difference between the chimney opening and the roof resulted in the microphone being significantly off- axis with respect to the chimney discharge and therefore exposed to much reduced chimney noise. As a result, it is not possible to determine with any certainly whether the louvres or the chimney are the source of the **295 Hz** and **300 Hz** tones. These tones were present at this location in both attended surveys.

The measurements undertaken at various positions on the roof of the RCF3 all contain the same strong tonal component at **162 Hz**, which emanated from the cylindrical roof vents providing ventilation to the drum hall beneath. From investigation of the fans, it has been shown that the 162 Hz component of noise arises from blade passes by the exit nozzle of the fan.

The only measurement locations where tonal peaks are present at close to **196 Hz** are the ground level areas in front of the oil store and boiler buildings where a **200 Hz** peak is shown. These locations are approximately opposite each other on the north and south sides of the main building in the centre of the site, and both were influenced by noise from sources (vents) on the roof of this building. The results from both locations also show less significant peaks at **225 Hz**.

The results from in front of the oil store loading door also show a noise tone at **235 Hz** to be present.

It should also be noted that in general, all of the noise levels measured on site are shown to be relatively low in amplitude when compared to the noise levels measured at **[TEXT REDACTED]**, even when distance attenuation of sound is taken into account.

3.4 MEASURED NOISE LEVELS

The noise levels measured at ML2 are shown in Fig C.4 in Appendix C. The plot incorporates L_{Aeq} noise levels together with L_{eq} levels for the third octave frequency bands closest to the tonal components noted to be present in the recordings made at ML1. The chart also includes blue areas indicating the times when disturbances were reported (i.e. when a recording at ML1 was made), and shows the corresponding wind direction measured from the garden of **[TEXT REDACTED]**

As can be seen from the chart, there appears to be a reasonably strong link between wind direction, noise, and reported disturbances. For the first 45 days of the survey there were no significant disturbances reported by **[TEXT REDACTED]**, and during this time the noise levels in each frequency band are generally shown to fluctuate both throughout the daytime period and at night when they drop significantly.

During these first few days the wind direction was generally from the east and east north east, or west and south west.

On 18th November, the disturbing noise was reported as starting to occur. At this time, it can be seen that measured noise levels start to increase whilst also becoming steadier particularly at night when the lowest values are not as low as on previous days. At this time the wind direction is shown to have changed to predominantly south to south easterly directions (i.e. from the Dee Industrial Park).

4 ANALYSIS AND DISCUSSION

4.1 ORIGINS OF THE NOISE DISTURBANCE

Following analysis of the data measured during the survey, and particularly the data presented in this report, there are several points to note, which go some way to confirming where the noise disturbance originates. These points are:

- The results of the narrow band frequency analysis on the measurement data captured at ML1 indicate various strong tonal components present. Inside the dwelling, these are at **82.8 Hz 150 Hz**, **162 Hz** and **196 Hz**, with **82.8 Hz** and **150 Hz** seemingly being the most significant.

- The tones found to be present inside are all also found to be present outside (when the microphone was moved outside). Also noted to be present outside, however, are additional tones at **235 Hz** and **296/300 Hz**. Whilst these are present inside, they are not considered to be 'strong' on account of their overall levels being similar to the level of noise in other adjacent frequency bands.

- The tones mentioned above are noted to be present in all instances of noise disturbances being reported and therefore are the most likely to be the cause of the disturbances.

- The measurements at ML2 were predominantly taken either with the external doors open or with the microphone outside, and as such the data set of internal noise levels is somewhat limited. Notwithstanding this lack of data, it is assumed that the main tones causing internal disturbances are **82.8 Hz, 150 Hz**, **162 Hz,** and **196 Hz**, and the main tones causing the external disturbances are the same plus **235 Hz** and **296/300 Hz**.

- Noise levels measured in the garden of **[TEXT REDACTED]** are shown to increase and become less variable at times when the wind direction is southerly and south easterly. This is true for the overall L_{Aeq} noise level and noise levels in the third octave bands containing the tones identified above. This supports the hypothesis that the source of the noise disturbances is within the Deeside Industrial Estate, especially when considering there are no other noise sources known to be present in the intervening area.

- Analysis of source noise measurements undertaken close to some of UPM's noise sources suggest there are some noise sources within UPM's site which are emitting noise at or close to the disturbing frequencies. These are as follows:

  - 82 Hz Exhaust on PM2 roof
  - 150 Hz Boiler 7 roof louvres and/or chimney
  - 162 Hz RCF3 roof fans
  - 196 Hz Roof mounted plant on top of main site building
  - 225 Hz Roof mounted plant on top of main site building
  - 235 Hz Roof mounted plant on top of main site building *(external disturbance only)*
  - 296 Hz Boiler 7 louvre and/or chimney *(external disturbance only)*
  - 300 Hz Boiler 7 louvre and/or chimney *(external disturbance only)*

- The matches between the tones present in noise from the on-site sources and those measured at **[TEXT REDACTED]**, provide strong evidence that they are the cause of the respective disturbing tones. However, based on the amplitude of the noises emitted at the site combined with the expected level of attenuation provided by the **[TEXT REDACTED]** km separation distance, a higher noise level would be expected to have been measured at ML2 and ML1. The amplitude of noise measured at **[TEXT REDACTED]** would suggest that the noise sources were closer than the UPM site.

- This suggests that either the sources on the UPM site in this case do not emit constant noise and/or were not operating at maximum volume during the survey (the noise was not present at

[TEXT REDACTED]), or the wind is having a significant effect on not only noise propagation, but also perhaps noise generation (e.g. altering the air velocity of air from the louvres).

- Despite the unexpectedly low amplitude of the noise tones, it is not considered likely that a different industrial noise source is responsible because in this case all other potential sources are at last a similar distance away. It is therefore reasonable to assume based on the tonal matching alone, that the UPM noise sources listed above are a significant factor in the noise disturbances reported.

4.2 MITIGATION

If it is considered necessary to reduce noise emitted by the Shotton Mill site, mitigation measures could be considered. This section provides a summary of measures that could be feasible from an acoustic point of view. However, it is acknowledged that in considering what the Best Available Techniques may be for managing noise, consideration must be given to practical aspects (such as impacts on space or the operation of items of equipment at the facility), and financial impacts (including the outlay to implement the measures as well as any costs associated with maintenance or operations).

Consideration has been given to the potential means of mitigating the noise, assuming that it is produced by the UPM site, as follows:

- When considering mitigation of any noise sources, it is always preferable to consider treating a noise source 'at source' first.

- In the case of the RCF3 roof vents, noise is due to fan blades passing the exit nozzle of the chimney and causing a pipe resonance. It would be possible to reduce this noise by reducing the speed of the fans. Fan 1 of the roof has an inverter fitted and so changing the fan speed is possible. The implications of changing the fan speed on its operation would need to be investigated to decide whether this is feasible. Measurements of several fan speeds shows that at lower speeds the overall L_{Aeq} levels are reduced, and the 162 Hz component is eliminated. It should be noted that harmonics (i.e. multiples) of the blade pass frequency are still present in the noise, albeit at lower levels. Measurements are shown as R11 to R14 of Figure C.5 in Appendix C.

- Where treatment of the source is not considered possible or feasible, the most effective mitigation option would likely be to introduce an element of attenuation to all of the ventilation ducts in the building. This could be in the form of attenuators inside the building at roof level directly connected to the vents as they exit the roof. The feasibility of this option would need to consider the practical and financial impacts, and may require further acoustic assessment to produce specifications for each attenuator.

- These principles of incorporating attenuators could also apply to the roof ventilation on Boiler 7 and on the PM2 roof.

- Further survey work needs to be carried out to give further confidence about the specific noise source(s) responsible for the 150 Hz tone. This is especially important for the chimney and louvres above Boiler 7 building in order to determine if one of these two sources can be eliminated as a source.

5 CONCLUSION

WSP has undertaken an investigation in noise disturbances reported by residents of a residential property to the north of UPM Shotton paper mill site. This investigation has included detailed noise surveys and has received direct input from the complainants as to when, during the survey, the noise disturbances occurred.

The results of the various noise measurements undertaken are considered to provide strong evidence that up to seven tones are contributing to disturbances outside the house, between two and five of which are leading to disturbances inside the house.

A source noise survey on UPM's site provides evidence to suggest that the disturbing tones are being emitted from noise sources on the UPM site, all of which are located on roofs.

Further work is recommended in relation to 300 Hz tone sources to be able to more accurately determine the specific plant emitting the tones. It is thought this tone is being produced by the large chimney stack.

It is likely that mitigation of all the identified sources will be possible, if not at source, by the addition of attenuation to the roof mounted ventilation points, or by reducing fan speeds of powered ventilation points. Further assessment is required to determine whether mitigation is necessary, cost effective and practical.

Appendix A

GLOSSARY OF ACOUSTIC TERMS

Noise is defined as unwanted sound. Human ears are able to respond to sound in the frequency range 20 Hz (deep bass) to 20,000 Hz (high treble) and over the audible range of 0 dB (the threshold of perception) to 140 dB (the threshold of pain). The ear does not respond equally to different frequencies of the same magnitude, but is more responsive to mid-frequencies than to lower or higher frequencies. To quantify noise in a manner that approximates the response of the human ear, a weighting mechanism is used. This reduces the importance of lower and higher frequencies, in a similar manner to the human ear.

Furthermore, the perception of noise may be determined by a number of other factors, which may not necessarily be acoustic. In general, the impact of noise depends upon its level, the margin by which it exceeds the background level, its character and its variation over a given period of time. In some cases, the time of day and other acoustic features such as tonality or impulsiveness may be important, as may the disposition of the affected individual. Any assessment of noise should give due consideration to all of these factors when assessing the significance of a noise source.

The most widely used weighting mechanism that best corresponds to the response of the human ear is the 'A'-weighting scale. This is widely used for environmental noise measurement, and the levels are denoted as dB(A) or L_{Aeq}, L_{A90} etc, according to the parameter being measured.

The decibel scale is logarithmic rather than linear, and hence a 3 dB increase in sound level represents a doubling of the sound energy present. Judgement of sound is subjective, but as a general guide a 10 dB(A) increase can be taken to represent a doubling of loudness, whilst an increase in the order of 3 dB(A) is generally regarded as the minimum difference needed to perceive a change under normal listening conditions.

An indication of the range of sound levels commonly found in the environment is given in the following table.

Typical sound levels found in the environment

Typical Sound Level	Example Location
0 dB(A)	Threshold of hearing
20 to 30 dB(A)	Quiet bedroom at night
30 to 40dB(A)	Living room during the day
40 to 50 dB(A)	Typical office
50 to 60 dB(A)	Inside a car
60 to 70 dB(A)	Typical high street
70 to 90 dB(A)	Inside factory
100 to 110 dB(A)	Burglar alarm at 1m away
110 to 130 dB(A)	Jet aircraft on take off
140 dB(A)	Threshold of pain

Glossary of Terms

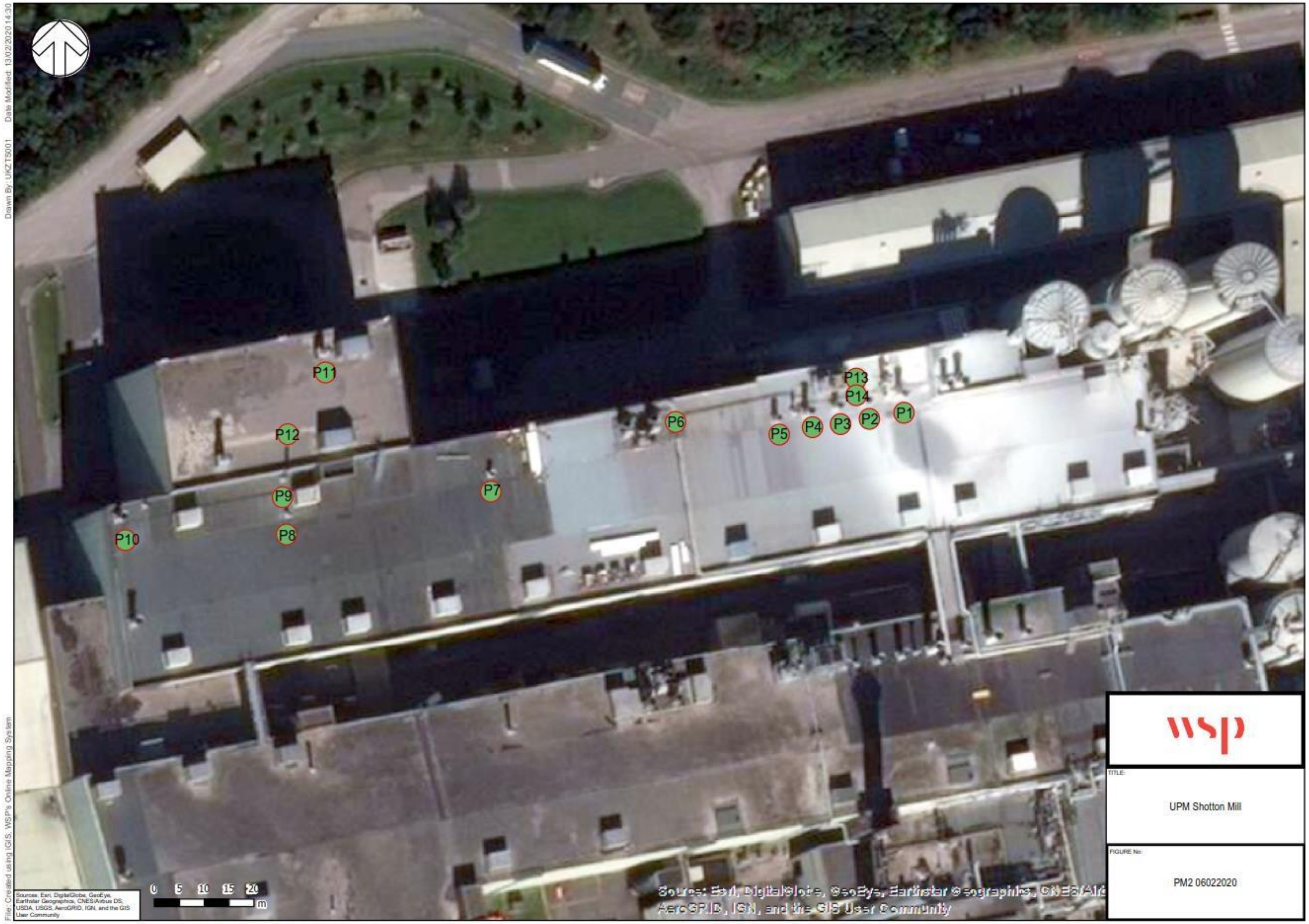
Term	Description
dB (decibel)	The scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure (2x10-5Pa).
$L_{EP,d}$	The daily personal noise exposure level. This is the hypothetical steady sound pressure level which, if sustained for 8 hours, would give the same acoustic energy dose as received from the actual sound pressure levels at the work place during the actual time spent at the workplace during one day.
L_{Cpeak}	C-weighted Peak Sound Pressure Level. This is the maximum sound pressure level within a given measurement period.
$L_{Aeq,T}$	LAeq is defined as the notional steady sound level which, over a stated period of time (T), would contain the same amount of acoustical energy as the A - weighted fluctuating sound measured over that period.
L_{Amax}	LAmax is the maximum A - weighted sound pressure level recorded over the period stated. LAmax is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the overall Leq noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L_{10} and L_{90}	If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The Ln indices are used for this purpose, and the term refers to the level exceeded for n% of the time. Hence L10 is the level exceeded for 10% of the time and as such can be regarded as the 'average maximum level'. Similarly, L90 is the 'average minimum level' and is often used to describe the background noise. It is common practice to use the L10 index to describe traffic noise.
Free-field Level	A sound field determined at a point away from reflective surfaces other than the ground with no significant contributions due to sound from other reflective surfaces. Generally as measured outside and away from buildings.
Fast	A time weighting used in the root mean square section of a sound level meter with a 125millisecond time constant.
Slow	A time weighting used in the root mean square section of a sound level meter with a 1000millisecond time constant.
Ambient Noise Level	The all-encompassing noise level measured in LAeq,T. The Ambient Noise Level incorporates background sounds as well as the industrial source noise under consideration.
Residual Noise Level	The Ambient Noise Level in the absence of the industrial source noise under consideration, measured in LAeq,T.

Specific Noise Level	The noise level measured in LAeq,T attributed to the industrial noise source under consideration alone.
Background Noise Level	The noise level in the absence of the industrial source noise under consideration, measured in LA90.

Appendix B

SITE LOCATION PLAN [REDACTED]


R15
R5
R7
R6
R4
R8
R11-14
R1, R10
R3
R2
R16
0 5 10 15 20 m
Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Air
AeroGRID, IGN, and the GIS User Community
TITLE:
UPM Shotton Mill
FIGURE No:
RCF3 06022020


P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
0 5 10 15 20 m
Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Air
AeroGRID, IGN, and the GIS User Community
TITLE:
UPM Shotton Mill
FIGURE No:
PM2 06022020
File: Created using IGIS, WSP's Online Mapping System
Drawn By: UKZTS001
Date Modified: 13/02/2020 14:30


File: Created using iGIS, WSP's Online Mapping System
Drawn By: UKZTS001
Date Modified: 13/02/2020 14:38
B2
B1
Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0 5 10 15 20 m
wsp
TITLE:
UPM Shotton Mill
FIGURE No:
Boiler 7 06022020

Appendix C

NARROW BAND FREQUENCY ANALYSIS AND MEASURED NOISE LEVELS

Figure C.1 Narrow band frequency analysis for internal noise measurements at ML2

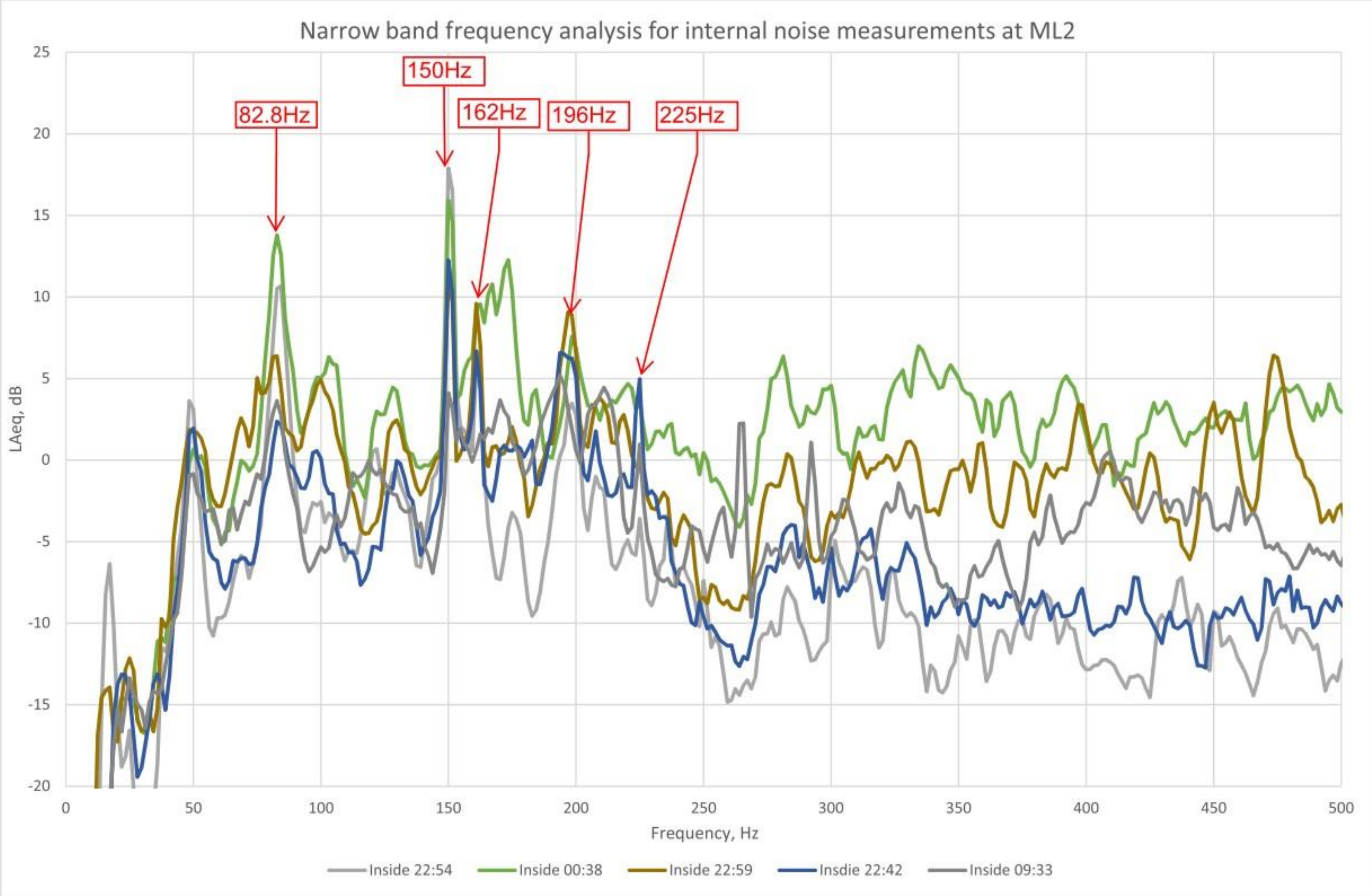


Figure C.2 Narrow band frequency analysis for external noise measurements at ML2 (i.e. using ML1 measurement equipment)

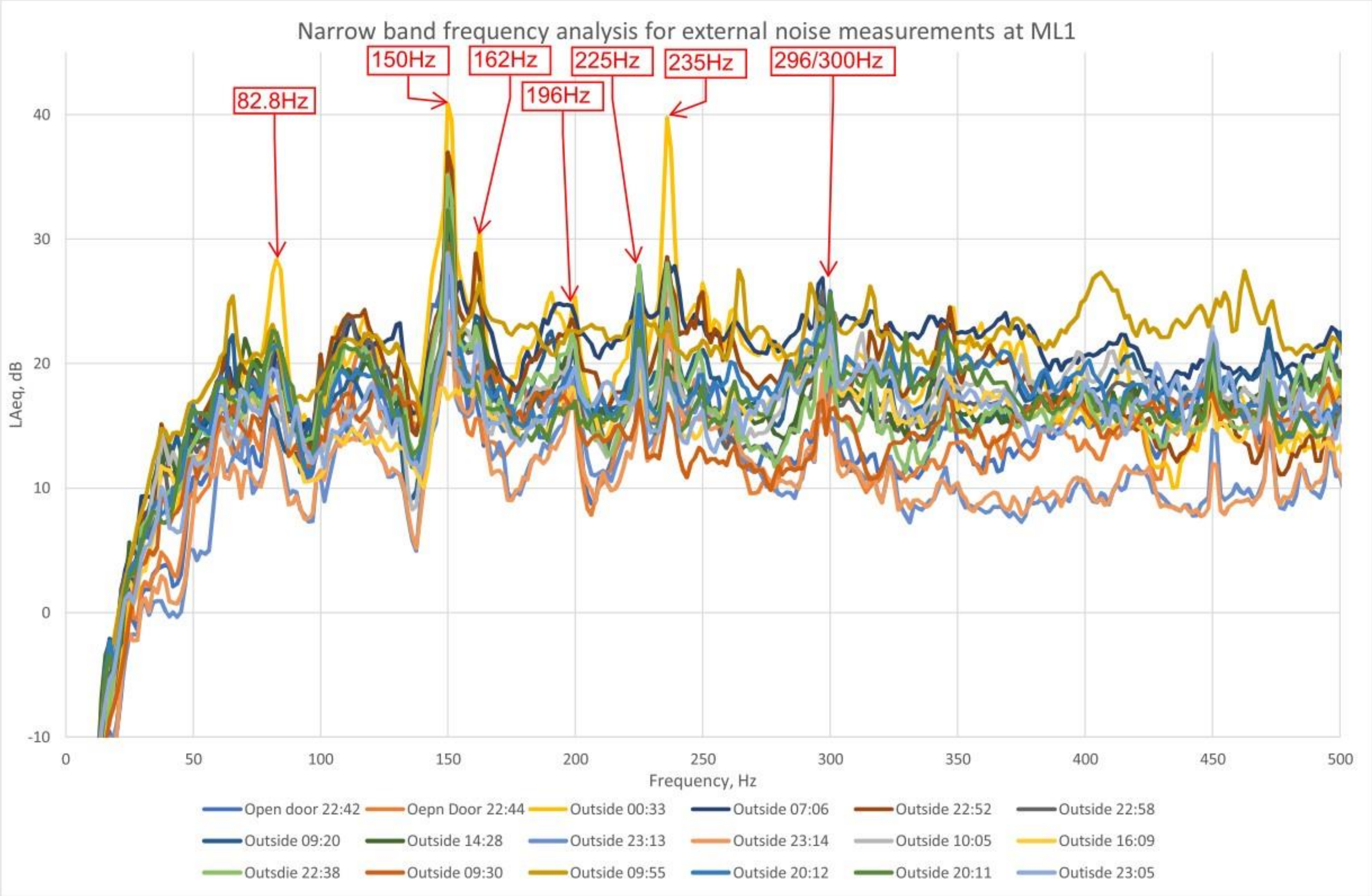


Figure C.3 Narrow band frequency analysis for on site source noise measurements.

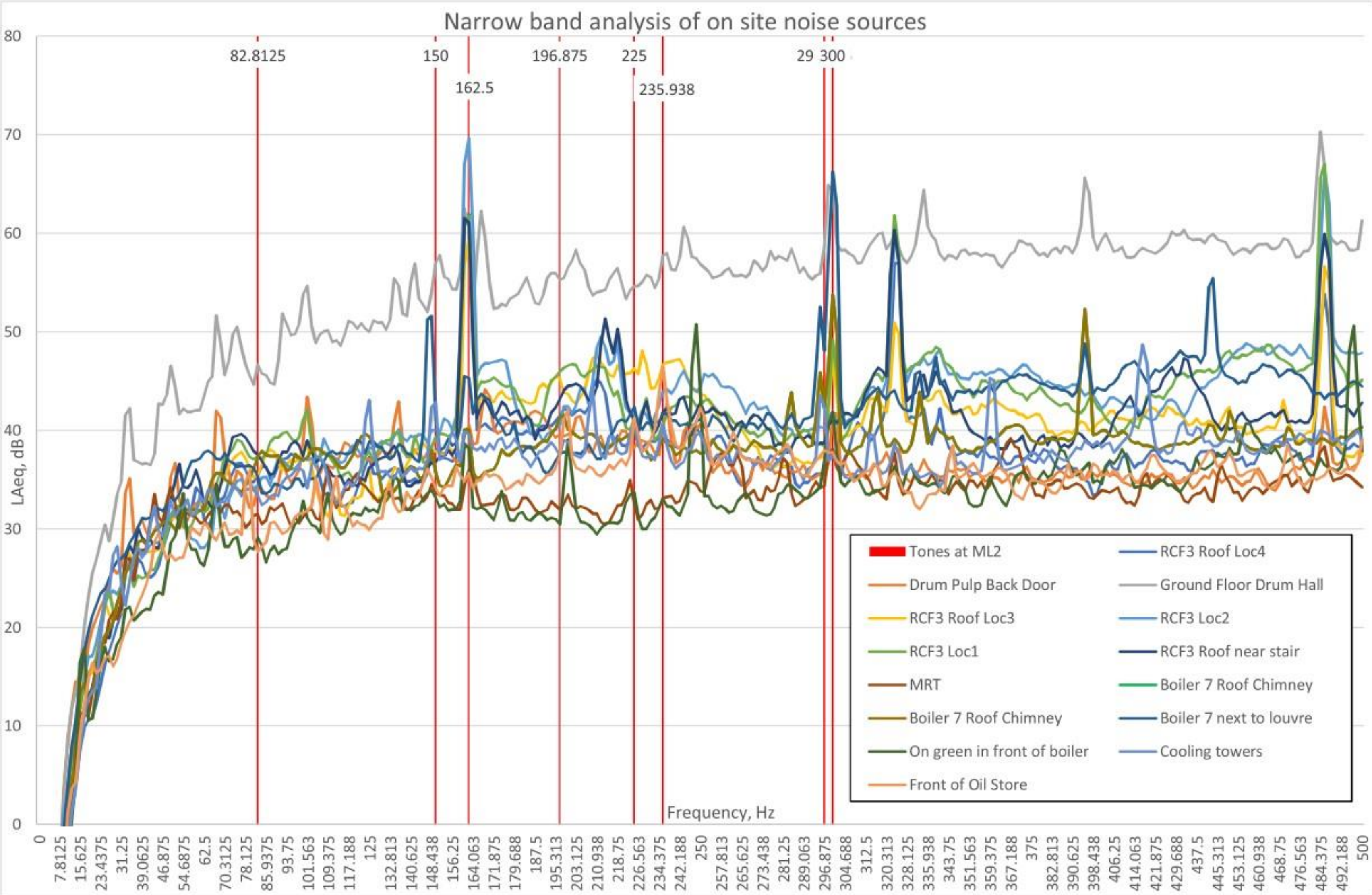
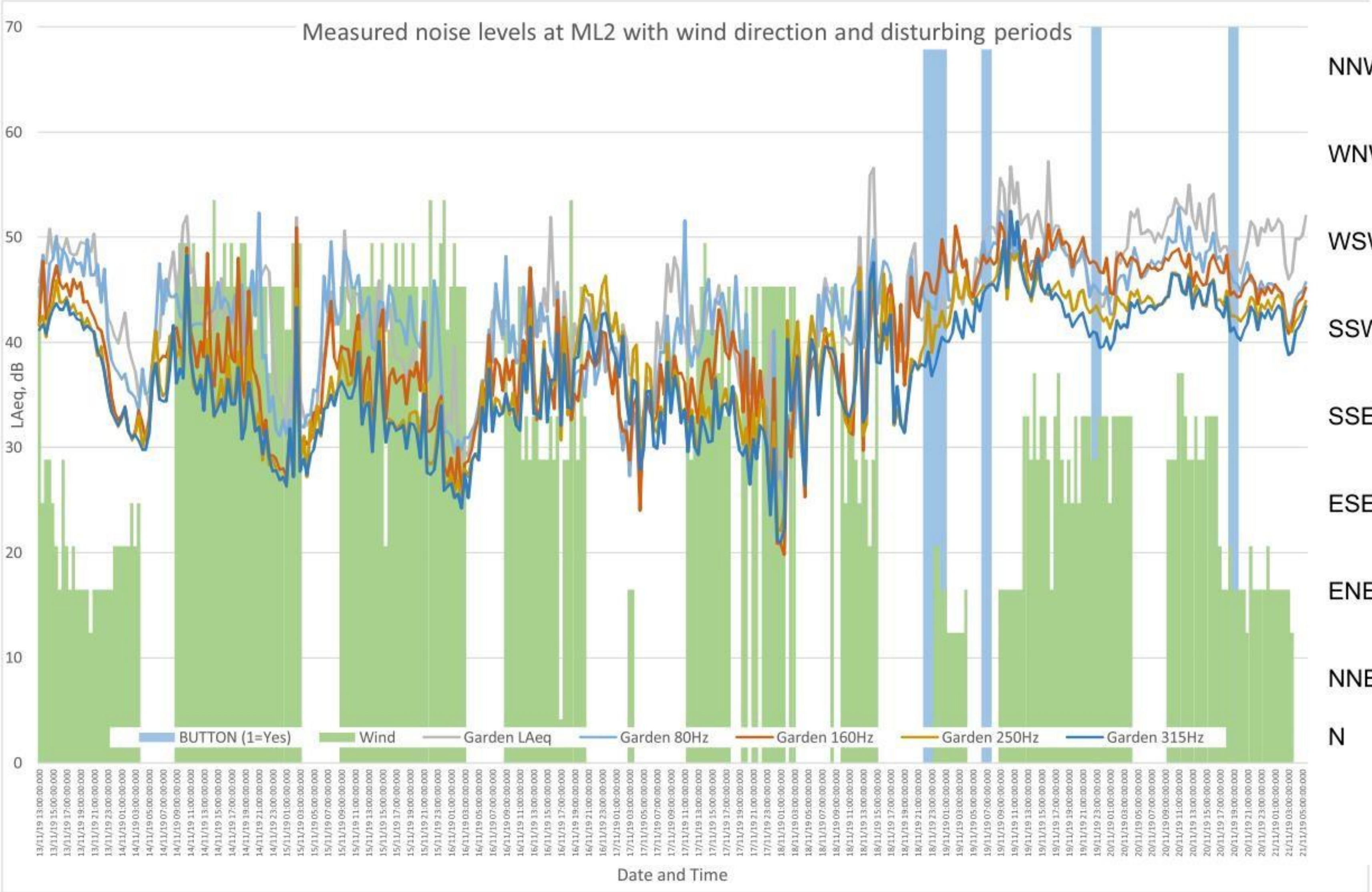
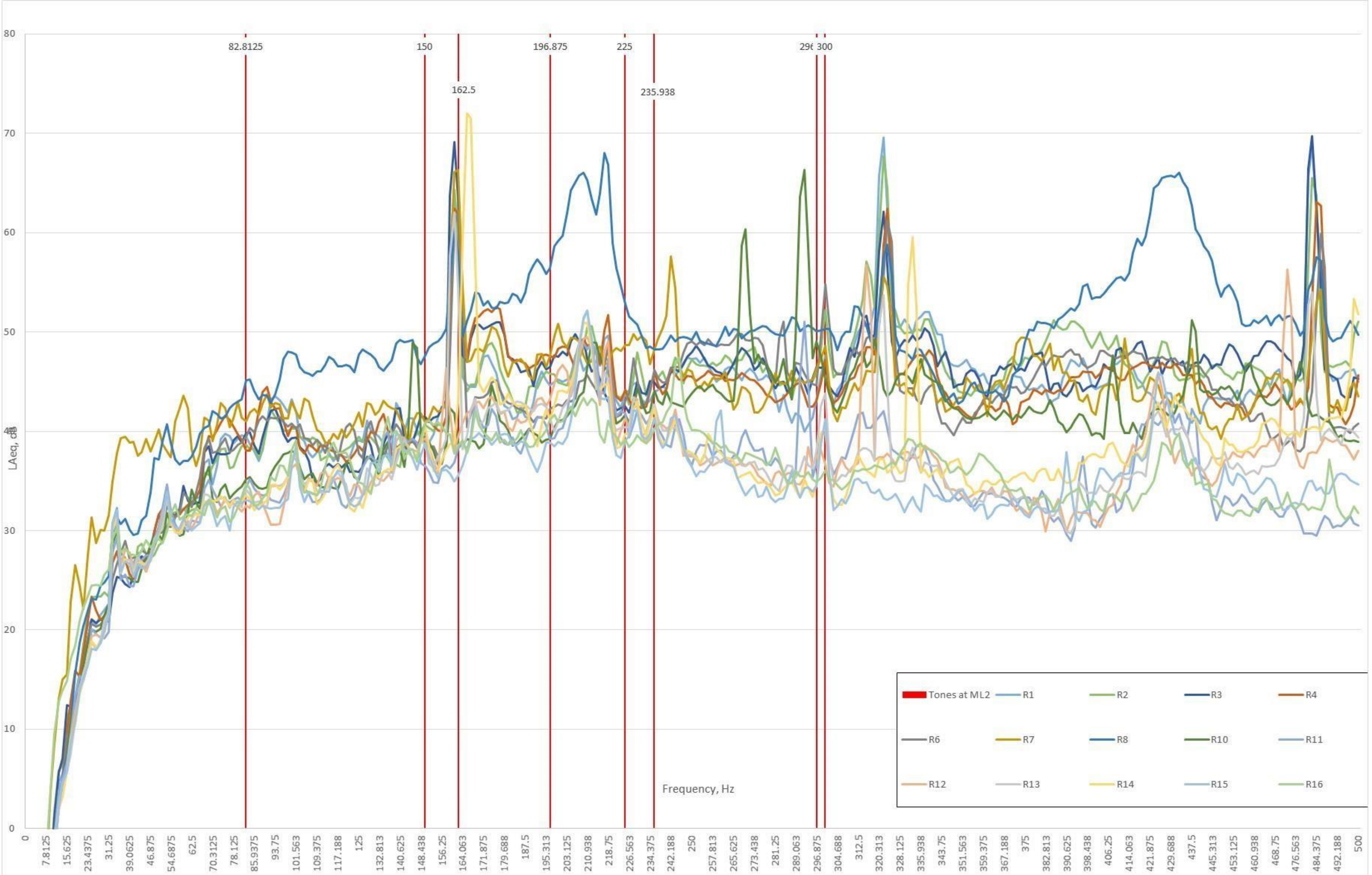


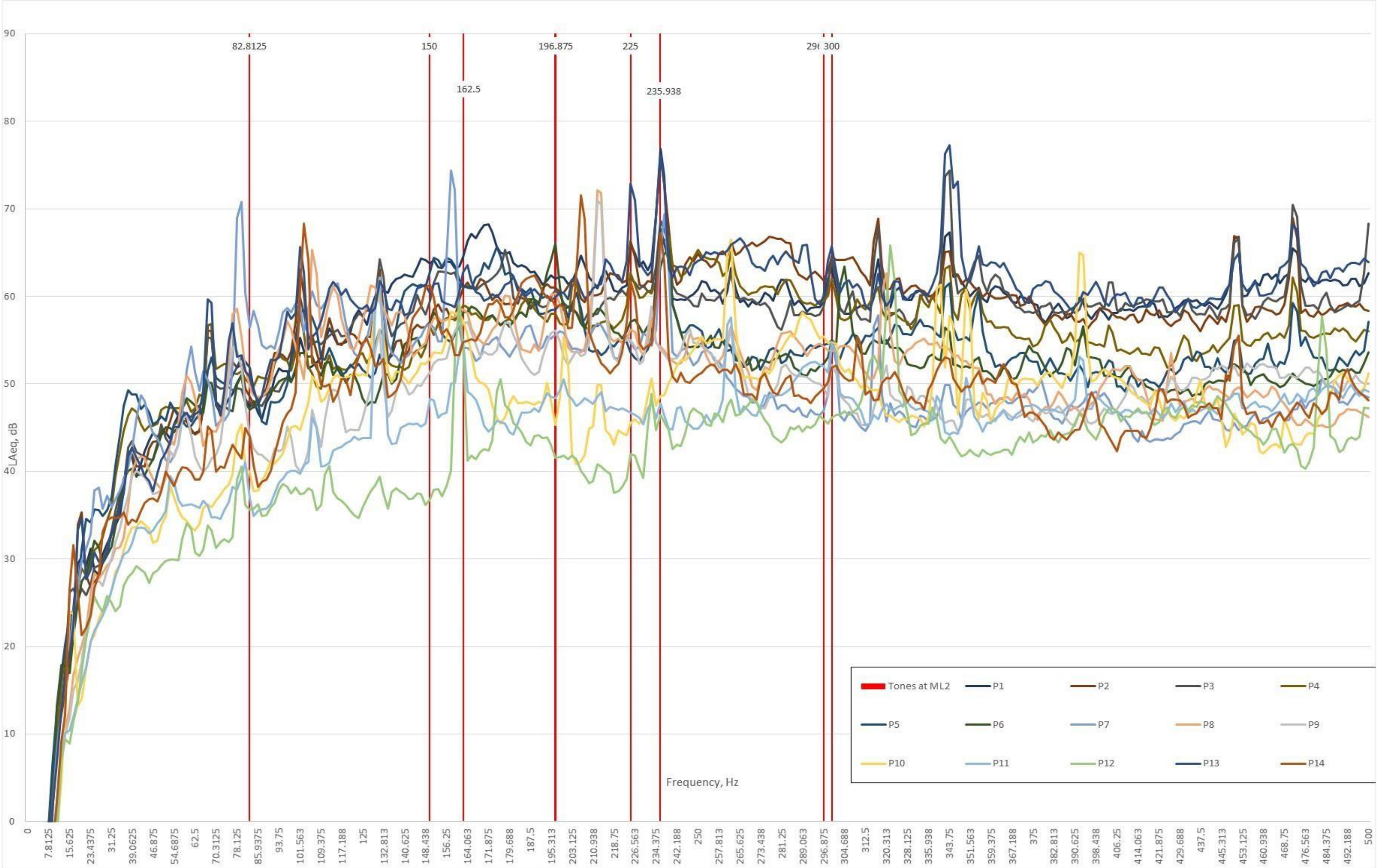
Figure C.4 Measured noise levels at ML2 with wind direction and disturbing periods also shown.



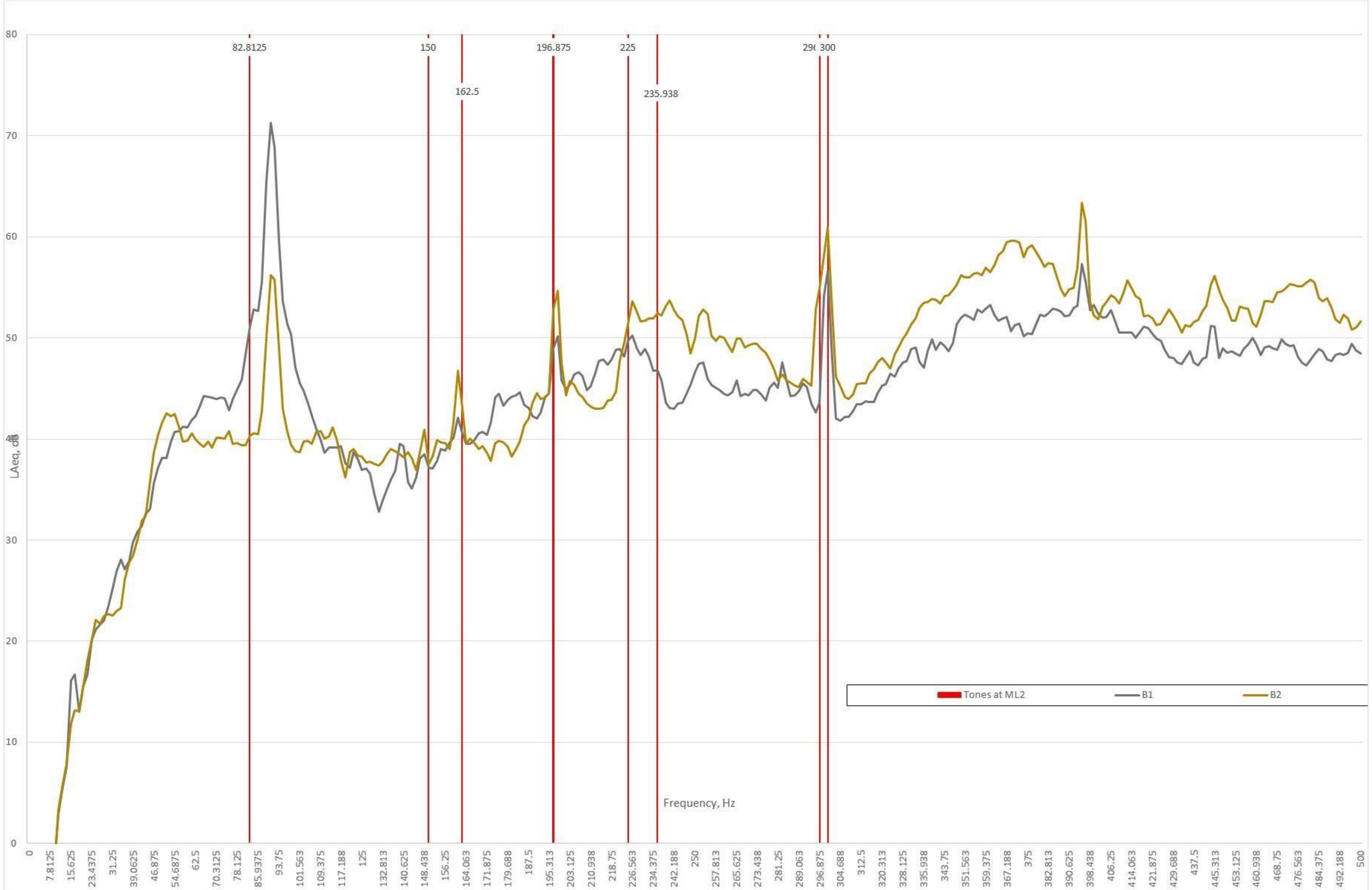
5 Measured noise levels on RCF3 roof on 06/02/2020.



6 Measured noise levels on PM2 roof on 06/02/2020.



7 Measured noise levels on Boiler 7 roof on 06/02/2020.



Appendix D

LIMITATIONS OF REPORT

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