Nuisance Dog Barking Investigation

12 Sharp Street, Bracken Gully 6232

Final Report – Sample1234-01

NoiseNet Operations Pty Ltd ABN: 26 624 212 175 noisenet.com.au P: 1800 266 479		Customer Name: Report Number: Issue Date:	Shire of Dardanup Sample1234-01 2/4/2024
Customer Ref No.:	1716668	Monitoring Type:	Single Monitor
Property Type:	Residential House		
Property Address:	12 Sharp Street, Bracken Gully 6232		
Property Code:	6232_sample1234	Report Issue:	Final Report
Compiled By:	Jake Donovan-Parker	Reviewed By	Jonathan South

1 OBJECTIVE

NoiseNet was commissioned by Shire of Dardanup to investigate a suspected excessively barking dog at 14 Sharp Street, Bracken Gully 6232 (referred to as the Target Property).

To facilitate the investigation, unattended noise monitoring was conducted using proprietary NoiseNet technology, with the gathered data analysed using specialised techniques to ascertain;

1) Instances of audible dog barking, howling or whining (dog noises) at the monitoring position,
2) The date and time when 1) occurs, and
3) The frequency and durations of 1).

Results of the analysis are compared to relevant criteria and legislation for the job locality, and conclusions drawn as to periods of criteria exceedance.

2 SITE CONTEXT AND MONITORING LOCATION

2.1 SITE DESCRIPTION

The target property, 14 Sharp Street, Bracken Gully 6232 is located in a primarily residential area. Noise from one animal (referred to as the target dog) on the target property has been reported as a nuisance and impacting the complainant's property (12 Sharp Street, Bracken Gully 6232). See Figure 1 for details.

To gather data and recordings of dog barking impacting the complainant property, a noise monitor was installed at 12 Sharp Street, Bracken Gully 6232, located east of the target address. For further details on the monitoring location, refer to Section 2.2.

2.2 NOISE MONITORING

A NoiseNet noise monitor (S/N: 4281) was installed on a support pole under a water tank on the western side of 12 Sharp Street, Bracken Gully 6232, approximately 1.5 metres above ground level and 1.5 metres from the Target Property (refer to Figure 1 and Figure 2).

The monitoring position was chosen to allow clear measurement of dog barking as it affects external areas of the host property, while minimising the impact of other noise sources in the area which include traffic and general residential noise.

The noise monitor recorded noise between 1:00 pm on the 29th of February 2024 and 3:00 pm on the 7th of March 2024, and was calibrated prior to shipment to the installing authority to ensure accuracy (decibel level and date/time) before installation.

Refer to Section A.2 for further information regarding NoiseNet noise monitoring equipment.

Where possible, the unattended noise monitoring was conducted in accordance with *Department of Environment and Heritage Protection EM1107* and *AS1055:1997* guidelines[1].

[1]The guidelines focus on methodology ensuring accurate measures of sound level in decibels (dB). As the criteria and methodology used in this report are based on noise classification, audibility and duration, a number of recommendations (particularly concerning reflecting surfaces and weather considerations) are disregarded in favour of a more representative monitoring location.

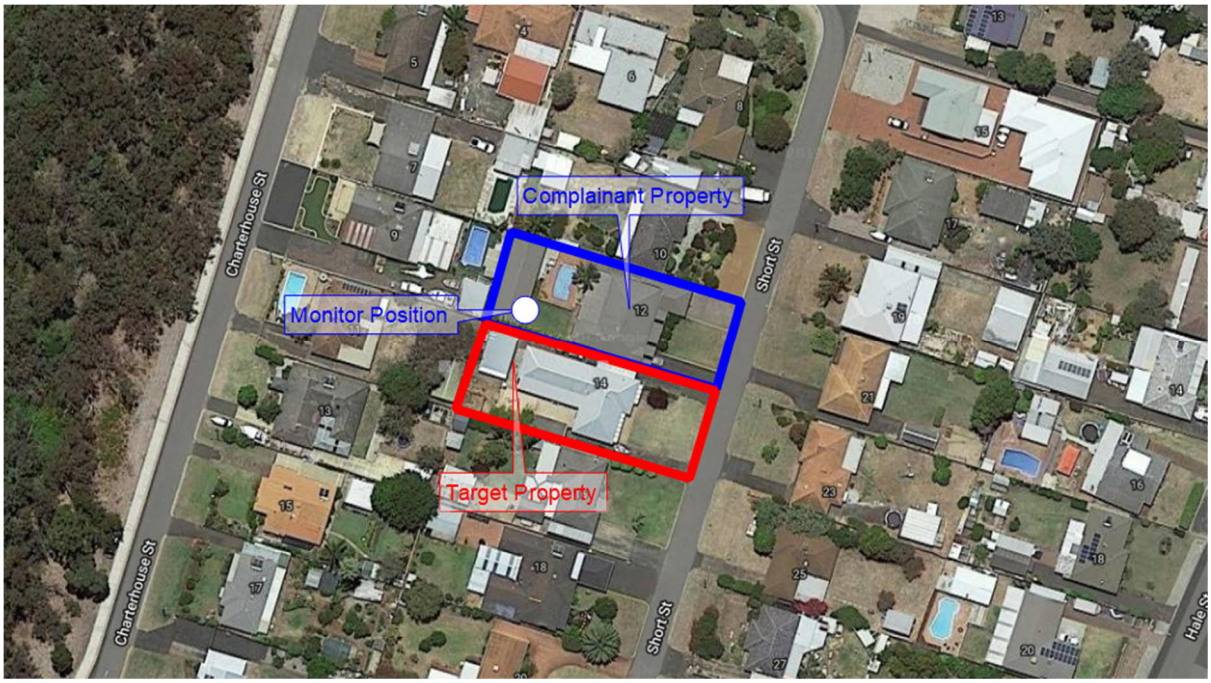

Figure 1 - Target property, surrounding residents and noise monitoring location.

Figure 2 - Noise monitor location, in situ.

3 CRITERIA

Noise from barking dogs is managed in Shire of Dardanup under Dog Act 1976, Division 4 Section 38(1) which details criteria for nuisance barking as follows:

For the purposes of this section, a dog is a nuisance if the dog —

a. *makes a noise, by barking or otherwise, that persistently occurs or continues to such a degree or extent that it unreasonably interferes with the peace, comfort or convenience of any person in any place; or*
b. *is shown to be allowed to behave consistently in a manner contrary to the general interest of the community; or*
c. *makes a noise, by barking or otherwise, that exceeds —*
    i. *a prescribed noise level measured by a prescribed method over a prescribed period of time; or*
    ii. *a prescribed number of times of occurrence during or over a prescribed period of time.*

To assist in interpreting the gathered data, further context is given to the results by comparing to a quantitative dog barking nuisance criterion, as implemented extensively in other Councils. The legislation states;

A dog is considered to be creating a noise nuisance if:

- *It barks/howls for more than a total of 6 minutes in any one hour period between 7am and 10pm on any day;*
- *It barks/howls for more than a total of 3 minutes in any 30 minute period between 10pm and 7am on any day.*

To assess levels of dog barking at the target property to these criteria, the general methodology followed is:

1. Automatically identify and tag times when dog noises are measured by the device.
2. Distinguish between noises from separate dogs, and isolate the target dog
3. Verify correct identification of dog noise events.
4. Determine the duration of the noise events from the target dog.
5. Compare durations to the relevant limits set by the above legislation.

Full details of the methodology can be found in Section 4 below.

As results in this report are compared to criteria which are not in effect in Shire of Dardanup, it is up to the discretion of the assessing officer and council to ascertain whether the barking constitutes a nuisance under their legislation.

4 ANALYSIS METHODOLOGY

The noise monitor gathers data, (audio recordings and A weighted decibel levels) via a calibrated microphone, which is analysed in a number of steps to give insights on the timing and duration of audible dog barks. Full details of the noise monitor can be found in Section A.2.

4.1 DOG BARK IDENTIFICATION

To efficiently analyse the large amount of data gathered by the monitor, automated tools are utilised to reduce and largely remove the amount of listening required by human operators. The aim of these tools is to identify, with accuracy, times when a bark, howl or whine is recorded by the noise monitor. Each step of the identification process is described in Sections 4.1.1 to 4.1.3.

4.1.1 AUTOMATED NOISE EVENT DETECTION

The background noise level LA_{90} is determined over a rolling time window, and is used to establish a baseline for significant and insignificant noises. If a given four seconds has a noise level significantly above the background level, a ‘noise event’ is deemed to have occurred. Each of these noise events are extracted as a recorded ‘snippet’, which contain only the most significant and impactful noises.

Examples of noises which would likely be disregarded as background noise are air-conditioning/mechanical plant, crickets and distant traffic. Foreground sounds likely to be extracted as snippets include close proximity dog barking, bird calls or other impulsive and loud noises.

4.1.2 AUTOMATED SPECTRAL FINGERPRINT ANALYSIS

Each snippet is then automatically classified as either containing a “dog noise” (bark, howl or whine), or “non dog noise”, by comparing the spectral “fingerprint” of the snippet in question and a database of spectral fingerprints from many different noise sources. The comparison and classification method is conducted using various machine learning algorithms and techniques, which groups snippets into the closest matching category.

Refer to Section A.1 for further details

4.1.3 MANUAL VERIFICATION

A manual verification step is introduced to ensure the automated steps are achieving sufficient accuracy. Operators are given a randomized selection of 4 second audio snippets, observing the spectral fingerprint and listening to the audio. The operator then assigns an appropriate category to the snippet, which is compared to the category the automated processes had assigned. In this way, the amount of false positive and false negative identifications of dog noises is quantified.

If accuracy is deemed insufficient, the operator tagged data is fed back into the system, allowing the automated detection of dog noises to be improved for a particular situation. For example, the system may initially tend to provide “false alarms” on dog noises, perhaps falsely identifying frog noises as dog barking. The operator correctly identifies the frog noise as background noise, and the system is retrained, and re-run, providing a more accurate classification of different noises. The manual verification, re-classification, and re-analyse step can be performed as many times as deemed necessary to obtain the most accurate result possible.

4.2 IDENTIFICATION OF DIFFERENT ANIMALS

Once dog noises have been identified with sufficient accuracy, NoiseNet aims to provide additional information regarding the different types of barking observed at the property, and an estimate of amount of different animals responsible for the barking. This estimate can then be reviewed by council officers or the complainant to ascertain whether the observed barking is representative of the barking usually experienced on the property.

Depending on the surrounding acoustic environment, it may be clear that the target animals are responsible for the majority of measured barking, while other situations may have barking observed from many different animals which are potentially irrelevant to the analysis (e.g. occasional barking from a nearby dog which is not a nuisance). This report provides indicative measures of the animals contributing to barking based on random sampling of data across the period of monitoring. This should be taken as a guideline only.

In this case, dog barking was identified from one or more distinct animals as follows:

Animal Identifier	Description	Estimated Contribution to Barking (Indicative Only)
Animal 1	Mid pitched bark, usually heard a short distance from the monitor. Animal 1 varies the pitch of its bark often.	>90%
Other Barking	Other barking not distinguished as Animal 1.	<10%

A selection of audio files have also been provided to assist in identifying the different animals.

Filename	Animals heard in file
Animal 1 2024-03-05T15_28_26+1000.wav	Animal 1 only (showing pitch range).
Animal 1 2024-03-04T13_13_10+1000.wav	Animal 1 only (showing pitch range).
Animal 1 2024-03-01T13_46_14+1000.wav	Animal 1 only.
Animal 1 2024-03-04T12_42_53+1000.wav	Animal 1 only.
Animal 1 2024-03-04T12_57_27+1000.wav	Animal 1 only.
Animal 1 Other Barking 2024-03-01T08_15_24+1000.wav	Animal 1 in the foreground and other barking heard in the background.

At this stage, it is not known which of these animals is the target animal. If required, additional identification of barks may be completed by council or complainant, and data re-analysed. All data presented in this report represents all dog barks measured at the monitor, and is agnostic of source animal.

4.3 DETERMINATION OF DOG NOISE DURATION

The specific determination of barking duration or continuous barking is left largely undefined by relevant legislation, with no strict methodology in place. Typical processes used by council officers may include listening in the field and estimating durations, or stopwatch timing from recordings.

For this analysis, automated tools and processes are used to determine the duration of dog noises measured by the monitor.

A spectrogram is generated for snippets which are deemed to contain dog noises, which provides information in both the frequency and time domain. As the frequency content of dog noises occurs within a relatively predictable set of frequencies, observing the energy content within these bands can show exactly when dog barking is occurring within the snippet.

The “start time” of a bark is deemed when the instantaneous sound energy rises above a threshold level, and the “stop time” when it falls below, with the duration of dog noise as the difference between the start and stop times. Operators also verify that the threshold level is set appropriately for the types of dog noises measured by the monitor. Using this method, isolated barks are typically logged as approximately 0.4-0.8 seconds (depending on the bark characteristics), with multiple barks in quick succession logged as a longer duration. Refer to Figure 3 for a visual explanation.

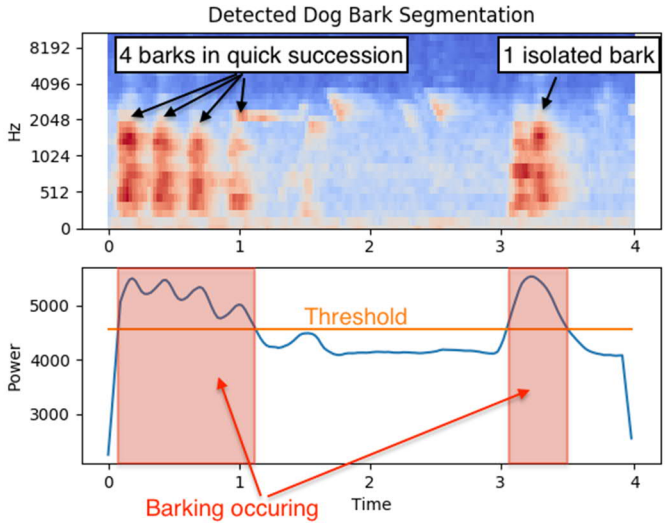

Figure 3 – Example bark duration extraction. This snippet has 1.47 seconds of dog barking.

The durations of dog noises are then tallied within the relevant 60 minute or 30 minute window (depending on the time of day) for a measure of the total duration of barking within that time period. The time periods begin either “on-the-hour” or “on-the-half-hour” as necessary and are not selectively chosen to manipulate results in any way.

Given the undefined nature of bark duration calculations for technical analysis, NoiseNet are willing to re-analyse data based on different definitions of duration, provided a clear and unambiguous definition of barking is given.

4.4 ACCURACY

Under ideal circumstances, our methods can very reliably distinguish dog barks and dog noises from other general noise events such as birds, talking, gates/doors opening and closing and objects falling. However, every job presents an entirely unique acoustic environment, with dogs and other noises that have never been classified by our system before. Even though every job is held to rigorous internal quality assurances, the automation techniques used can never be 100% accurate, and the possibility of false positive and false negative bark identification exists. This means that quoted results may differ from actual durations of dog barking occurring at the property.

We strongly encourage independent verification checks and result validation from complainants and/or councils, particularly in the event of borderline exceedance cases or likely legal action.

5 RESULTS

Using the methods described in Section 4.1, instances of dog noises were successfully extracted and identified from data gathered by the noise monitor over the monitoring period.

The logic in Section 4.3 was then applied to find the total duration of dog noises, with results shown in Figure 4. Table 1 shows the same durations for the daytime (7am-10pm) and night-time (10pm-7am) periods, with solid red cells indicating a breach of criteria detailed in Section 3, and other colours indicating an implied level of nuisance in line with these limits.

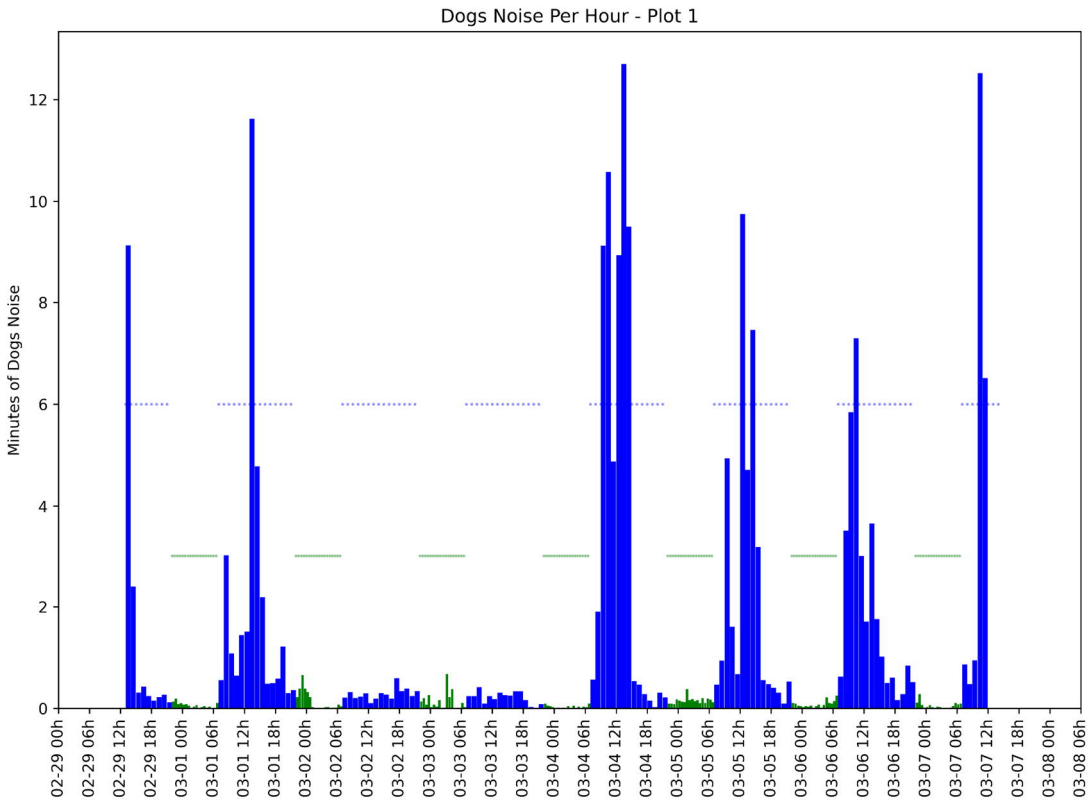

Figure 4 - Total duration (minutes) of dog noise per hour (blue, 7am-10pm) or half-hour (green, 10pm-7am).

Max of Value	Date							
Period Commencing	29/02/24	01/03/24	02/03/24	03/03/24	04/03/24	05/03/24	06/03/24	07/03/24
00:00		0:04	0:19	0:01	0:00	0:09	0:01	0:02
00:30		0:05	0:14	0:04	0:01	0:08	0:03	0:04
01:00		0:03	0:01	0:02	0:00	0:07	0:02	0:01
01:30		0:00	0:00	0:10	0:01	0:23	0:03	0:00
02:00		0:02	0:01	0:00	0:00	0:10	0:01	0:02
02:30		0:04	0:00	0:01	0:03	0:11	0:03	0:01
03:00		0:00	0:00	0:41	0:00	0:09	0:04	0:01
03:30		0:01	0:01	0:13	0:03	0:10	0:01	0:01
04:00		0:03	0:02	0:23	0:00	0:06	0:04	0:00
04:30		0:01	0:00	0:00	0:02	0:12	0:13	0:01
05:00		0:02	0:01	0:01	0:01	0:06	0:06	0:03
05:30		0:00	0:01	0:00	0:02	0:12	0:05	0:07
06:00		0:00	0:04	0:06	0:02	0:10	0:08	0:05
06:30		0:07	0:02	0:02	0:06	0:07	0:15	0:06
07:00		0:33	0:12	0:14	0:34	0:28	0:38	0:52
08:00		3:01	0:19	0:15	1:54	0:56	3:30	0:29
09:00		1:05	0:12	0:25	9:07	4:56	5:51	0:57
10:00		0:39	0:14	0:06	10:35	1:36	7:18	12:31
11:00		1:26	0:18	0:14	4:52	0:40	3:00	6:31
12:00		1:31	0:06	0:11	8:55	9:45	1:42	
13:00	9:07	11:37	0:12	0:18	12:42	4:43	3:38	
14:00	2:24	4:47	0:18	0:16	9:29	7:28	1:45	
15:00	0:19	2:11	0:16	0:15	0:32	3:11	1:01	
16:00	0:26	0:29	0:11	0:20	0:28	0:34	0:30	
17:00	0:15	0:30	0:35	0:20	0:17	0:29	0:36	
18:00	0:09	0:35	0:20	0:10	0:09	0:24	0:10	
19:00	0:13	1:13	0:23	0:02	0:01	0:18	0:17	
20:00	0:16	0:18	0:15	0:01	0:18	0:06	0:50	
21:00	0:07	0:22	0:21	0:05	0:13	0:32	0:31	
22:00	0:08	0:13	0:08	0:05	0:06	0:06	0:07	
22:30	0:12	0:23	0:12	0:04	0:06	0:06	0:17	
23:00	0:05	0:39	0:04	0:03	0:05	0:03	0:04	
23:30	0:06	0:23	0:16	0:01	0:11	0:03	0:01	
Day Exceedances	1	1	0	0	5	2	1	2
Night Exceedances	0	0	0	0	0	0	0	0
Total Exceedances	1	1	0	0	5	2	1	2

Table 1 – Minutes:Seconds of dog noise per hour between 7am and 10pm, and per half hour between for 10pm and 7am, for each monitored day. Time of day represents the start of the 60 or 30 minute period (e.g 7am-8am), with red cells indicating exceedance of the 6 minute day or 3 minute night nuisance criteria.

6 FINDINGS

Over the monitored period, there were twelve instances of criteria exceedance during the day time period (ranging from 6m:31s to 12m:42s and occurring between 9:00 am and 3:00 pm) and zero instances of criteria exceedance during the night time period.

Barking during the day time period varied day to day, with most days having episodes of consecutive high to extreme duration barking lasting up to 6 hours and some days having very low amounts of barking. The episodes of high to extreme duration barking occurred between 9:00 am and 3:00 pm and sometimes were proceeded and/or followed by a period of moderate duration barking at 8:00 am and/or 3:00 pm. Barking outside these times was low.

Barking during the night time period was low.

7 CONCLUSION

A NoiseNet noise monitor was installed at 12 Sharp Street, Bracken Gully 6232 to investigate a potential nuisance barking dog at 14 Sharp Street, Bracken Gully 6232. Analysis of recordings and data gathered by the monitor identified instances of dog barking, howling or whining believed to (within the limitation described in this report) originate from the target dog on the target property.

The duration of the dog noises were tallied and compared to relevant nuisance criteria, revealing tweleve instances where barking exceeded day time criteria and zero instances of exceeding night time criteria.

As results in this report are compared to criteria which are not in effect in Shire of Dardanup, it is up to the discretion of the assessing officer and council to ascertain whether the barking constitutes a nuisance under their legislation.

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Jake Donovan-Parker	Jonathan South
	

A.1 DOG NOISE IDENTIFICATION DETAIL METHODOLOGY

This section describes in detail the methods used to automatically identify dog noises (barks, howls or whines) from the recorded audio.

Describing and categorising a wide variety of sound and noise is something a human can do remarkably quickly, subconsciously, and almost continuously on a day to day basis. As such, they are the often the “gold standard” for deciding what particular source created a noise. However, using humans to categorise sounds within a long duration recording is very time consuming process; at the quickest it can be done at a one-to-one speed, an hour recording could take an hour or more to categorise.

Using automated techniques is an obvious solution, but comes with a troublesome problem; How does a computer know what source created a sound? This question is a topic of extensive current research in Machine Learning and Artificial Intelligence. NoiseNet is on the cutting edge of this research into sound identification and categorisation, striving for accuracy, speed and solutions to real-world problems.

Machines can ‘learn’ to categorise sound in much the same way a human would. We expose them to a huge database of different sounds, which already have the correct category associated with them. Then, when a new sound needs to be categorised, the software compares it against the known database and looks for the closest match it can find.

Specifically, an individual sound is broken down into identifying markers, called features (this step is known as feature extraction). NoiseNet uses the spectral content of a sound as the identifying features, hence referring to the ‘spectral fingerprint’ of a sound. For example, a visual representation of the spectral fingerprint of a typical dog bark is shown in Figure 5. In contrast, the spectral fingerprint of a bird call is shown in Figure 6. There are immediate differences which are able to be discerned by both human inspection and by the computers learning processes, such as longer, lower pitched dog barks compared with the shorter, higher pitch vocalisations of the bird call. The features are also apparent in foreground noise, compared to background noise, allowing for identification of sounds in a complex sound environment.

While there are a vast number of variations of dog and other noises, there are both subtle and obvious similarities in spectral fingerprints within each category. It is here that computers excel at observing the subtle differences in features, and allocating a category to an unknown sound.

While there can be confounding factors in categorisation, e.g. two sounds occurring simultaneously or previously uncategorised sounds, these can be identified (low certainty classifications), correctly categorised by manual listening, and the model re-run. This is the method that NoiseNet uses to ensure the highest accuracy and most appropriate analysis for each specific job.

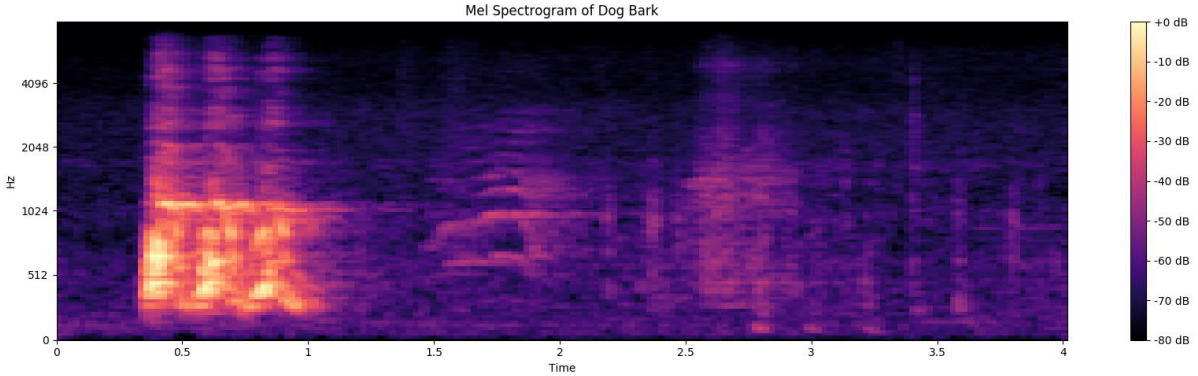

Figure 5 - Typical features (spectral fingerprint) of a dog bark.

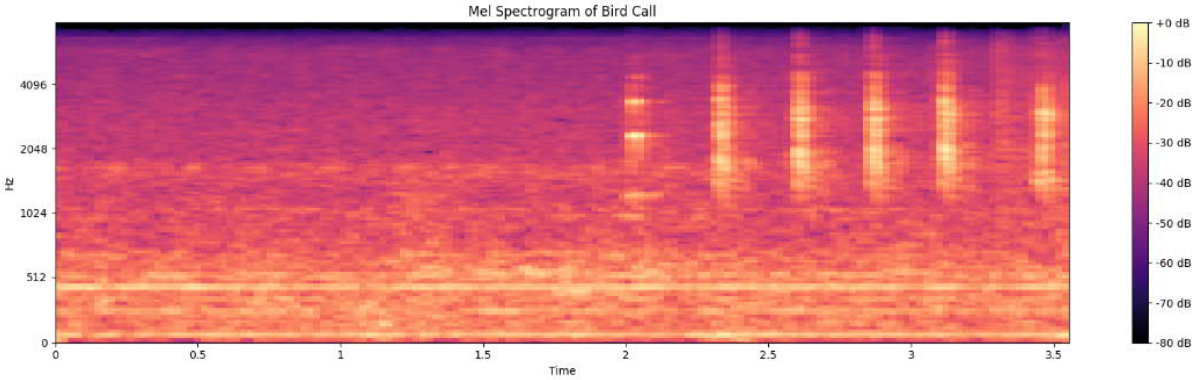

Figure 6 - Typical features (spectral fingerprint) of a bird call.

A.2 NOISE MONITOR DETAILS

NoiseNet uses a custom-built noise monitor for our measurement and analysis, with basic onboard components as follows:

- MEMS microphone (SPH0645), digital I2S connection
- Rapsberry Pi 3B+ micro-computer
- 3G/WiFi wireless communication

Noise data is processed and encrypted on-device, before being transmitted wirelessly to NoiseNet databases. Further processing and analysis is completed on a job specific basis, before being compiled for a client report.

Our noise monitors are designed and built with flexibility, size and low-cost in mind, and with systems in place to provide the benefits of an on-site field technician (sound recognition, spectral and time based analysis, automated data processing), without the associated costs.

To maintain flexibility, our devices are not currently certified to Australian Standard AS IEC 61672.1-2004, which specifies the construction, function and operations of sound measurement devices.

All device components are thoroughly pre-tested in-house for acoustic performance, stability and reliability and have been tested for repeated accurate measurement of:

- descriptors including L_p, L_{eq}, L_n,
- fast response integration time,
- unweighted and A weighting,
- broadband and single octave, between 63Hz and 16kHz
- all of the above to within $\pm$ 3dB, for sound levels between 27dB and 90dB SPL.

Each device is field calibrated using a handheld calibrator before and after each deployment, and operation monitored using the wireless connection throughout the deployment.

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