Nuisance Dog Barking Investigation

3 Elouera Crescent, North Toontown 5014
Final Report – 5678-01

NoiseNet Operations Pty Ltd ABN: 26 624 212 175		Customer Name:	City of Toontown
noisenet.com.au		Report Number:	Sample5678-01
P: 1800 266 479		Issue Date:	15/07/2024
Customer Ref No.:	Not Provided	Monitoring Type:	Single Monitor
Property Type:	Residential House		
Property Address:	3 Elouera Crescent, North Toontown 5014		
Property Code:	5014_sample5678	Report Issue:	Final Report
Compiled By:	Jake Donovan-Parker	Reviewed By	Jonathan South

1 OBJECTIVE

NoiseNet was commissioned by City of Toontown to investigate a suspected excessively barking dog at 27 Futurama Drive, North Toontown 5014 (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 noise at the monitoring position,
2) The date and time when 1) occurs,
3) The frequency and durations of 1), and
4) The direction of arrival 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, 27 Futurama Drive, North Toontown 5014 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 (3 Elouera Crescent, North Toontown 5014). See Figure 1 for details.

To gather data and recordings of dog barking at the target property, a NoiseNet hybrid noise monitor (capable of determining the durations of nuisance noises as well as the direction from which the sound is coming from) was installed at 3 Elouera Crescent, North Toontown 5014, located east of the target address. For further details on the monitoring location, refer to Figure 1 and Section 2.2.

2.2 NOISE MONITORING

A NoiseNet Pinpoint smart noise monitor (S/N: 5204) was installed on the corner post of a veranda on the western part of 3 Elouera Crescent, North Toontown 5014, approximately 1.5 metres above ground level and 4 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 habitable areas, while minimising the impact of other noise sources in the area which include general residential noise and noise from a nearby railway station and churches. The positioning of the monitor also permitted the angular capability of the noise monitor to determine the direction of arival of the dog noise.

The noise monitor recorded noise between 2:05 pm on the 28th of May 2024 and 2:30 pm on the 14th of June 2024, and was calibrated prior to shipment to the installing authority to ensure accuracy (decibel level and date/time) before installation. Data from this period has been used to confirm directional sources.

Refer to Section A.1 and 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, complainant property, surrounding residents and noise monitoring location.

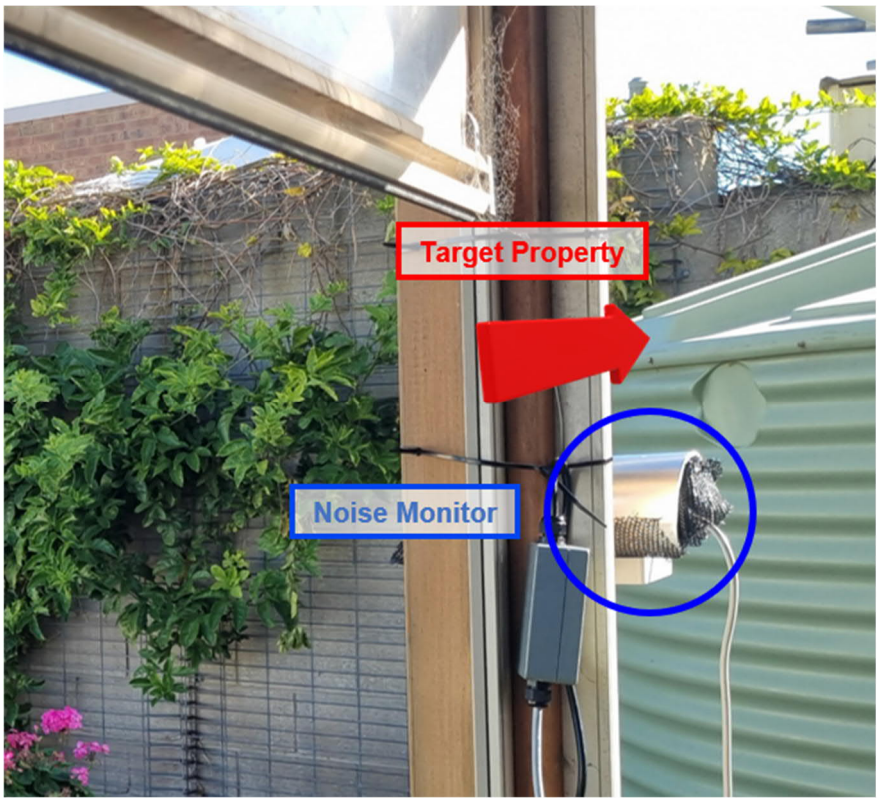

Figure 2 - Noise monitor location, in situ.

3 CRITERIA

Noise from barking dogs is managed in City of Toontown under Dog and Cat Management Act 1995, Section 45A(5) which details criteria for nuisance barking as follows:

> A person who owns or is responsible for the control of a dog is guilty of an offence if the dog (either alone or together with other dogs, whether or not in the same ownership) creates a noise, by barking or otherwise, which persistently occurs or continues to such a degree or extent that it unreasonably interferes with the peace, comfort or convenience of a person.

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. Verify correct identification of dog noise events.
3. Determine the duration of do noise events.
4. 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 City of Toontown, 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 hybrid noise monitor gathers data, (audio recordings and A weighted decibel levels) via a calibrated certified microphone, which is analysed in a number of steps to give insights on the timing and duration of audible dog barks.

The same steps are used to analyse data gathered from the directional microphone on the hybrid noise monitor to give insights on the direction and of the dog barking. Full details of the noise monitor can be found in Section A.1 and 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.3 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 two or more animals as follows:

Animal Identifier	Description	Estimated Contribution to Barking (Indicative Only)
Animal 1	Mid-low pitched bark, usually heard a short to moderate distance from the monitor. Animal 1 can sound similar to Animal 2.	70%
Animal 2	Mid pitched bark, usually heard a moderate distance from the monitor. Animal 2 can sound similar to Animal 1.	20%
Other Barking	Other barking not distinguished as Animal 1 (usually distant/quiet barking).	10%

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

Filename	Animals heard in file
Animal 1 2024-05-28T15_21_42+0930.wav	Animal 1 only.
Animal 1 2024-06-02T14_42_39+0930.wav	Animal 1 only.
Animal 2 2024-05-28T15_26_02+0930.wav	Animal 2 only.
Animal 2 2024-05-28T15_09_13+0930.wav	Animal 2 only.
Animal 1 Animal 2 2024-05-28T15_57_04+0930.wav	Animal 1 and Animal 2.
Animal 2 Animal 1 2024-06-02T14_03_42+0930.wav	Animal 2 and Animal 1.
Animal 1 Other Barking 2024-05-28T16_20_18+0930.wav	Animal 1 and other barking.

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 0.3-0.8 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.

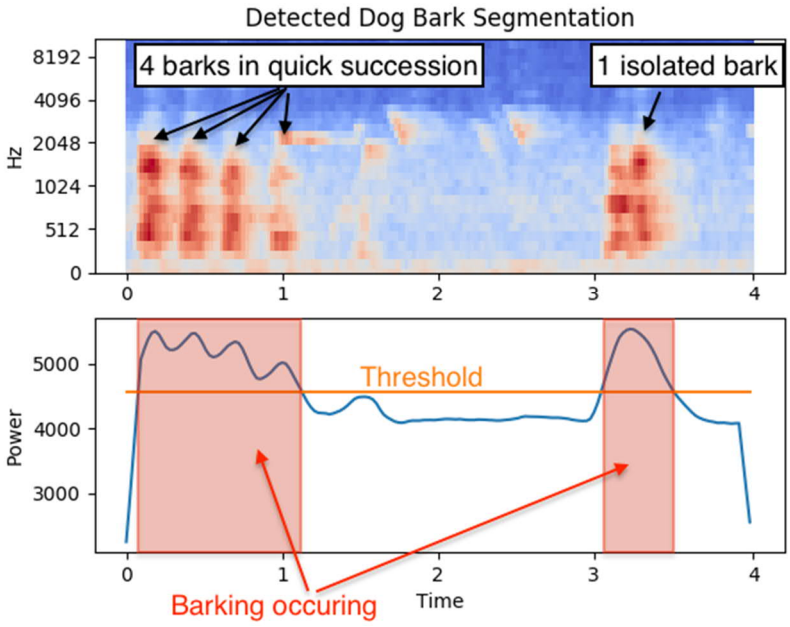

Figure 3 – Example bark duration extraction. This snippet has 1.47 seconds of dog barking.

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 DIRECTIONAL DATA PRESENTATION

When displaying results from the directional analysis, data points are plotted on a polar chart, which allows for visualisation of both azimuth and elevation of the noise source in the one chart. An example of the polar chart is given in Figure 4, wherein the blue data point occurs at an angle of approximately 50 degrees azimuthal angle and 60 degrees elevation angle and the red data point occurs at an angle of approximately 225 degrees azimuthal angle and 15 degrees elevation angle. Sources with low elevation angle occur towards the outer edges of the plot, and sources with higher elevation angles appear closer to the centre of the plot. If we imagine the sound direction of arrival being plotted on the surface of a sphere, at the appropriate azimuth and elevation angles, the polar plot is the equivalent of looking directly down on that sphere from above. A limitation of the noise monitor is that noise cannot be determined as occurring uniquely above or below – i.e an elevation angle of 45 degrees may indicate a direction of arrival of 45 degrees above the horizontal, or 45 degrees below the horizontal.

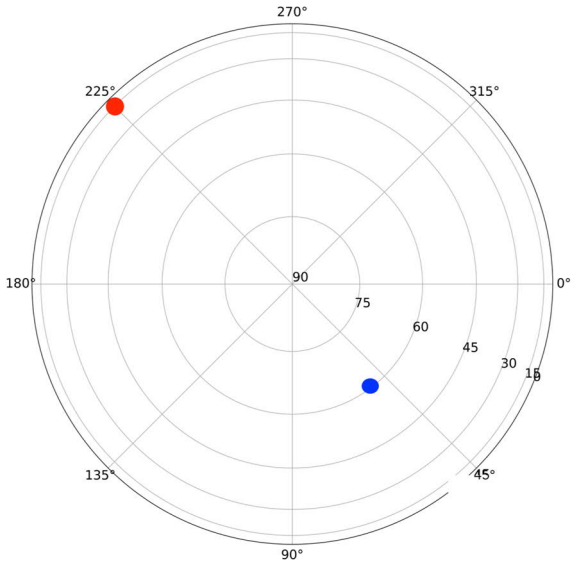

Figure 4 –Example polar chart. The blue data point occurs at an angle of approximately 50 degrees azimuthal angle and 60 degrees elevation angle. The red data point occurs at an angle of approximately 225 degrees azimuthal angle and 15 degrees elevation angle.

Directional data may also be presented on the polar chart as a heat map, with different colours indicating the amount of noise arriving from a certain azimuthal angle. For example, the heatmap in Figure 5 shows that most noise originated from the 75-90 degree direction, and the second most noise coming from the 180-200 degree direction. Blue/Purple colours indicate directions were little/noise noise was observed. Information regarding elevation angle is typically discarded when generating and interpreting these plots.

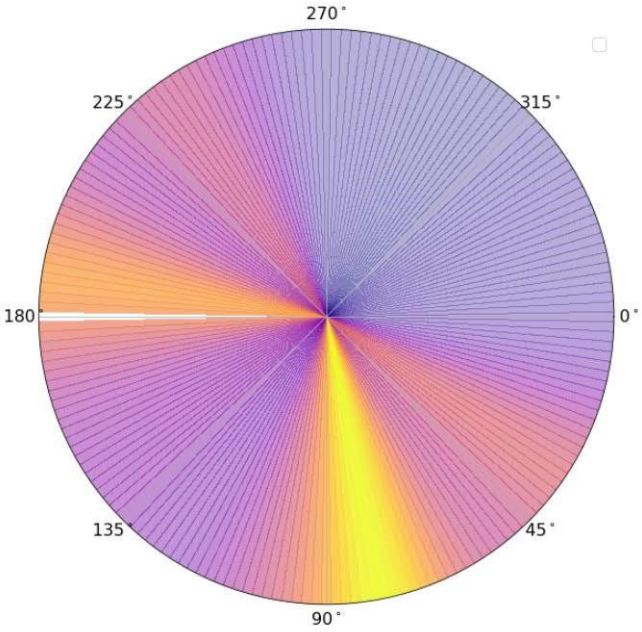

Figure 5 - Example heat map (not related to this job). The most noise is measured in the 75-90 degree azimuthal direction, with the second most measured in the 180-200 degree direction.

Heat maps may be displayed with the underlying data points plotted as well, to give additional insight into the dataset.

Since the directional noise monitor provides information on the direction of arrival, the actual noise source may be located at any physical location which is in the same direction (we generally cannot resolve the distance to the noise source. As such, care must be taken on interpreting any polar charts overlaid on physical floorplans or photographs, because noise sources are not necessarily located at locations denoted on the image. All care and explanation will be given where such images are presented.

4.5 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.

Accuracy of direction of arrival is typically around 7 degrees variation in azimuthal accuracy, and variations in elevation angle are approximately 5-7 degrees at low angles, and 10 -15 degrees at higher elevations. When two or more noises occur simultaneously or in quick succession, accuracy of directional information may further be reduced or misreported. Additionally, the effect of reflections and reverberation within enclosed spaces may cause the direction of arrival of sound sources to be incorrectly resolved.

These limitations concerning direction of arrival information require that a statistical approach in used when presenting and interpreting directional analysis. Heatmaps, and the distribution of contributing noises should be considered in preference to the location of individual sound events.

All analyses are supported with manual quality assurance and validation of the data presented. We encourage independent verification checks and result validation from complainants and/or

council staff, particularly in the event of borderline exceedances cases or likely legal action. Having corroborating information to back up our findings and to provide further context and interpretation to our results will build a much stronger case than just relying on our data alone.

5 RESULTS

5.1 DOG BARKING FREQUENCY AND DURATIONS

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 6. 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.

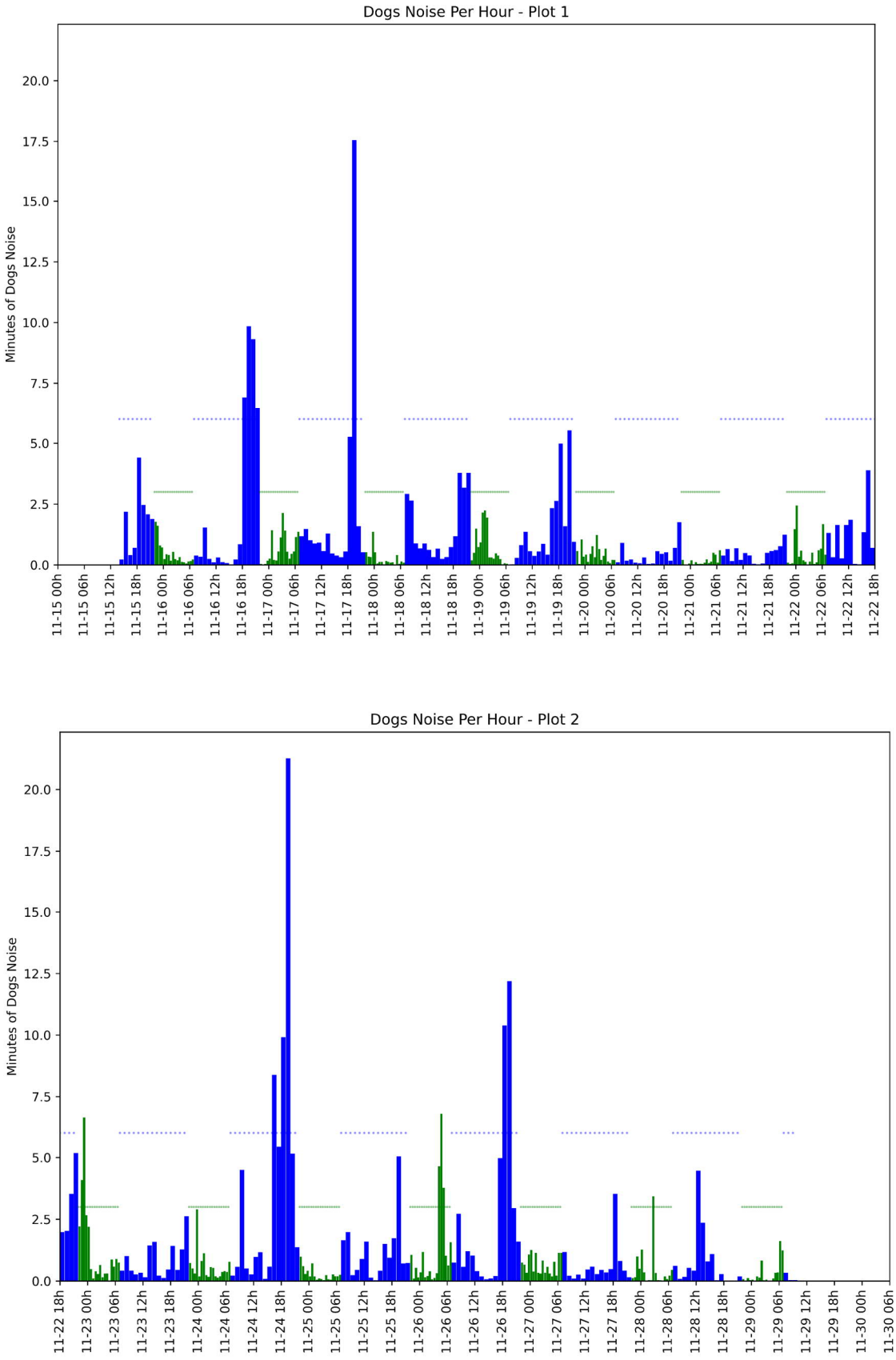

Figure 6 - Total duration (minutes) of dog noise per hour (blue, 7am-10pm) or half-hour (green, 10pm-7am).

Max of Value	Date														
Period Commencing	15/11/22	16/11/22	17/11/22	18/11/22	19/11/22	20/11/22	21/11/22	22/11/22	23/11/22	24/11/22	25/11/22	26/11/22	27/11/22	28/11/22	29/11/22
00:00		0:14	0:16	0:31	0:55	0:25	0:11	2:26	2:12	0:11	0:11	0:21	1:15	1:16	0:03
00:30		0:26	1:25	0:03	2:09	0:07	0:01	0:20	0:29	0:49	0:43	1:11	0:23	0:21	0:01
01:00		0:25	0:13	0:07	2:15	0:27	0:07	0:35	0:06	1:07	0:11	0:09	1:09	0:01	0:11
01:30		0:10	0:11	0:07	1:57	0:46	0:02	0:12	0:23	0:15	0:03	0:12	0:20	0:02	0:08
02:00		0:32	0:33	0:01	0:18	0:19	0:03	0:08	0:17	0:10	0:06	0:24	0:18	0:02	0:50
02:30		0:14	1:08	0:10	0:18	1:14	0:02	0:00	0:39	0:34	0:05	0:04	0:50	3:26	0:02
03:00		0:11	2:08	0:08	0:16	0:39	0:05	0:08	0:09	0:32	0:03	0:08	0:20	0:19	0:03
03:30		0:19	1:25	0:06	0:29	0:12	0:14	0:30	0:18	0:12	0:14	0:19	0:34	0:02	0:01
04:00		0:08	0:33	0:06	0:23	0:22	0:05	0:02	0:18	0:08	0:04	4:39	0:19	0:02	0:01
04:30		0:06	0:15	0:00	0:14	0:40	0:08	0:06	0:01	0:12	0:03	6:48	0:11	0:00	0:06
05:00		0:04	0:27	0:24	0:02	0:08	0:30	0:36	0:52	0:22	0:16	3:46	0:46	0:11	0:20
05:30		0:08	0:33	0:03	0:04	0:05	0:25	0:40	0:35	0:24	0:12	1:01	0:14	0:05	0:20
06:00		0:10	1:09	0:09	0:03	0:12	0:06	1:41	0:53	0:22	0:12	0:38	1:08	0:13	1:37
06:30		0:13	1:22	0:06	0:01	0:12	0:36	0:25	0:45	0:46	0:15	1:34	1:08	0:27	1:15
07:00		0:23	1:11	2:55	0:02	0:06	0:23	1:19	0:25	0:13	1:39	0:45	1:10	0:37	0:20
08:00		0:20	1:28	2:38	0:17	0:54	0:39	0:19	1:01	0:34	1:59	2:43	0:13	0:05	0:02
09:00		1:32	1:01	0:53	0:49	0:11	0:10	1:39	0:25	4:30	0:15	0:34	0:06	0:10	0:02
10:00		0:15	0:53	0:41	1:22	0:13	0:41	0:16	0:16	0:30	0:27	1:12	0:16	0:32	
11:00		0:07	0:55	0:53	0:34	0:06	0:12	1:38	0:20	0:16	0:54	1:02	0:06	0:26	
12:00		0:18	0:34	0:37	0:23	0:04	0:30	1:51	0:09	0:58	1:36	0:24	0:28	4:28	
13:00		0:07	1:17	0:20	0:33	0:18	0:23	0:02	1:27	1:10	0:08	0:11	0:35	2:21	
14:00	0:13	0:04	0:28	0:40	0:52	0:02	0:03	0:02	1:35	0:05	0:02	0:04	0:17	0:47	
15:00	2:11	0:01	0:23	0:15	0:25	0:03	0:02	1:20	0:13	0:35	0:25	0:06	0:27	1:06	
16:00	0:24	0:14	0:19	0:19	2:20	0:34	0:03	3:53	0:08	8:23	1:30	0:12	0:21	0:02	
17:00	0:42	0:51	0:33	0:44	2:38	0:27	0:30	0:42	0:28	5:26	0:56	4:58	0:29	0:17	
18:00	4:25	6:54	5:16	1:11	4:59	0:31	0:35	1:58	1:26	9:54	1:44	10:23	3:32	0:01	
19:00	2:28	9:51	17:33	3:47	1:35	0:10	0:37	2:02	0:27	21:16	5:03	12:12	0:48	0:00	
20:00	2:05	9:19	1:36	3:10	5:32	0:42	0:46	3:32	1:17	5:09	0:42	2:57	0:25	0:00	
21:00	1:53	6:28	0:31	3:47	0:57	1:45	1:14	5:11	2:38	1:22	0:44	1:36	0:09	0:11	
22:00	1:47	0:02	0:32	0:12	0:34	0:13	0:06	2:13	0:44	0:59	1:04	0:45	0:07	0:05	
22:30	1:36	0:00	0:21	0:30	0:02	0:01	0:03	4:05	0:31	0:36	0:06	0:40	0:10	0:00	
23:00	0:48	0:02	0:19	1:29	1:03	0:00	0:04	6:39	0:18	0:17	0:32	0:20	1:00	0:07	
23:30	0:43	0:10	1:21	0:44	0:20	0:03	1:28	2:40	2:54	0:25	0:09	1:04	0:30	0:02	
Day Exceedances	0	4	1	0	0	0	0	0	0	3	0	2	0	0	0
Night Exceedances	0	0	0	0	0	0	0	2	0	0	0	3	0	1	0
Total Exceedances	0	4	1	0	0	0	0	2	0	3	0	5	0	1	0

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.

5.2 DOG BARKING DIRECTION OF ARRIVAL

Using the methods described in Section 4, the direction of the dog noises were successfully identified from the data gathered by the directional monitor over the monitoring period.

The accuracy of the detected direction of arrival of sound is dependent on the path the sound takes from the source to the noise monitor. The resolved direction may be influenced by confounding factors such as reflections, barriers and obstacles or simultaneous noise sources. As such, directional results should be interpreted from a statistical standpoint, with the direction of individual noise events considered carefully.

Additionally, in reference to Section 4.4, the reader is reminded that the location where individual data points lie on the satellite imagery is inconsequential, and do not represent an absolute location of the noise source.

Figure 7 displays a heat map supplemented with a scatter plot of triggering snippets of dog noise from the entire monitoring period (small blue dots). The clustering of data points at low elevation angles (towards the outer edge of the polar chart) indicates that dog barking is impinging on the noise monitor from either the same altitude, from reasonably large separation distances, or diffracting over obstructing obstacles similar to the height of the monitor (such as fences or buildings).

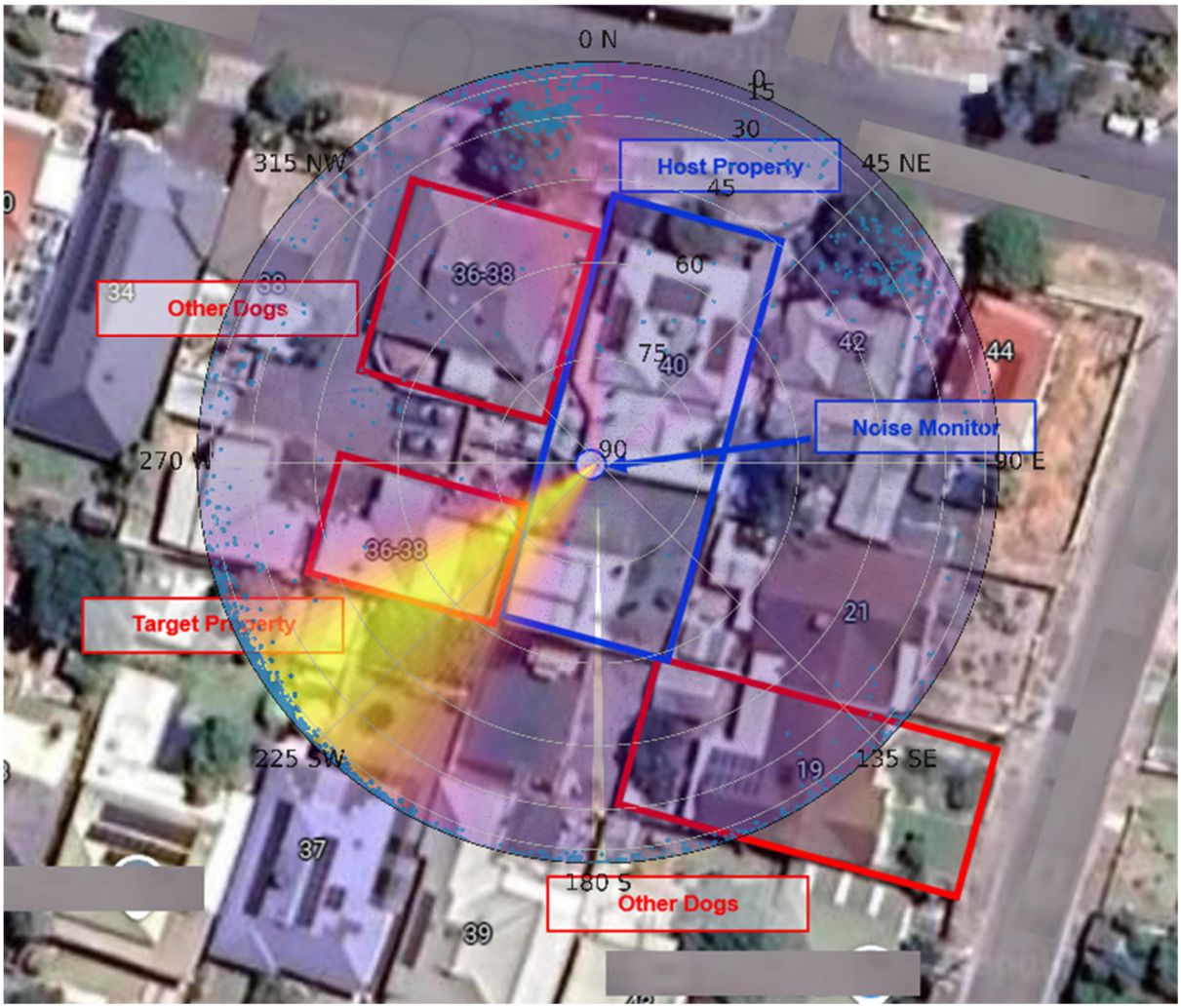

Figure 7 - Overlay heat map and scatter plot of triggering dog noises from across the whole monitoring period.

Figure 8 shows a heat map and scatter plot of a small number of random confirmed dog barking noise events from across the entire monitoring period. Which supports the results in Figure 7.

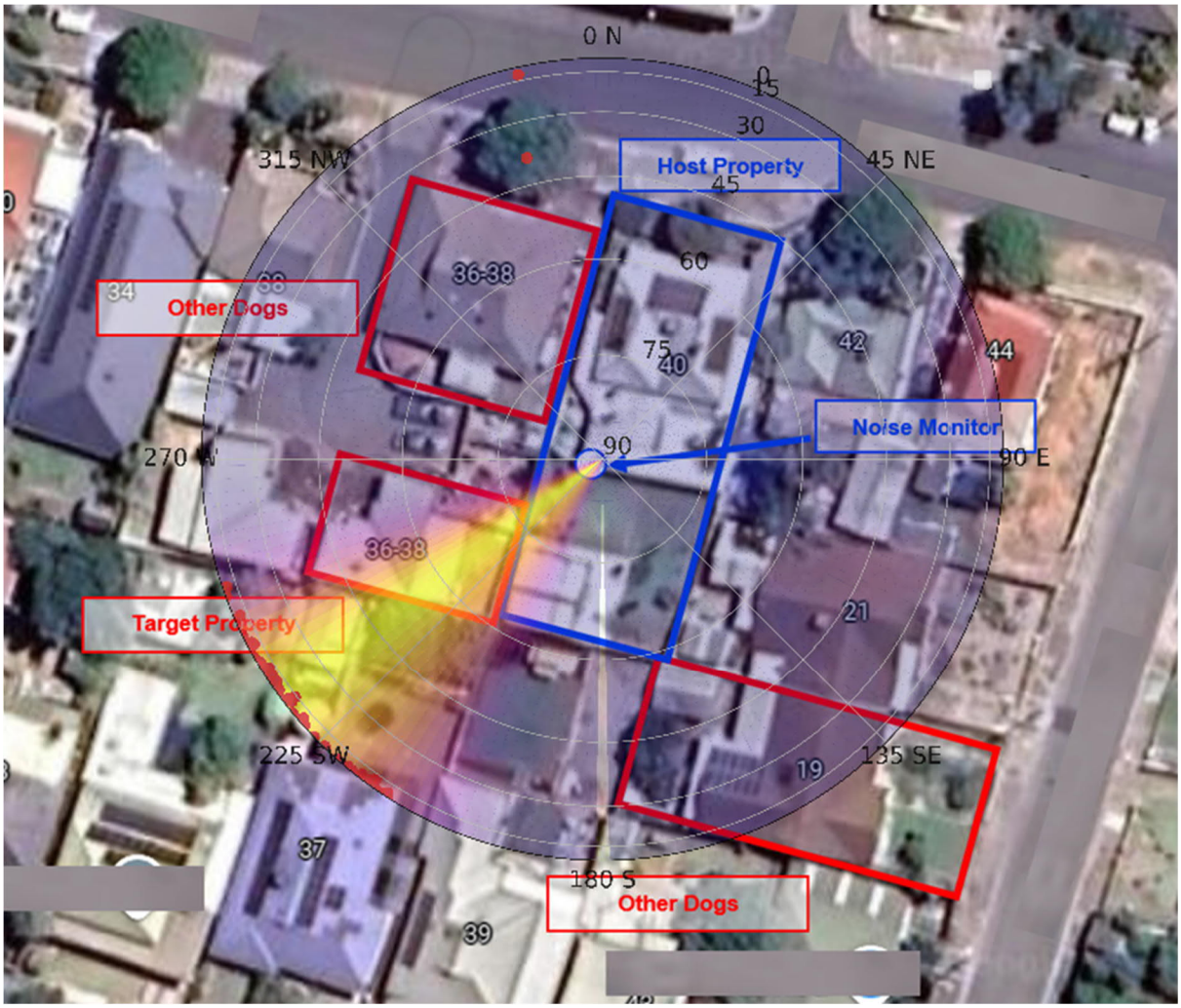

Figure 8 - Overlay heat map and scatter plot of manually tagged random triggering barking from across the whole monitoring period.

6 FINDINGS

Over the monitored period, there were ten instances of criteria exceedance during the day time period (ranging from 6m:23s to 22m:16s and occurring between 4:00 and 10:00 pm) and six instances of criteria exceedance during the night time period (ranging from 3m:26s to 6m:48s occurring at random times throughout the night).

Barking during the day time period was typically low to moderate, with many sporadic periods of high to extreme barking lasting between 1 and 5 hours. These sessions of high to extreme barking occurred on most days.

Barking during the night time period was usually low to moderate, with multiple periods of high to extreme barking occurring on the majority of nights during the monitoring period. This barking would be very disruptive to sleep.

From the directional data analysed and displayed in Figure 7 and Figure 8, it is clear that the majority of the barking is coming from the direction of the Target Property.

7 CONCLUSION

NoiseNet noise monitor was installed at 3 Elouera Crescent, North Toontown 5014 to investigate a potential nuisance barking dog at 27 Futurama Drive, North Toontown 5014 . 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 two 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 City of Toontown, it is up to the discretion of the assessing officer and council to ascertain whether the barking constitutes a nuisance under their legislation.

Compiled By:

Jake Donovan-Parker

Reviewed By:

Jonathan South

A.1 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 3 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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