Reuter Associates LLC
CONSULTANTS IN ACOUSTICS

10 Vaughan Mall, Suite 201A
Portsmouth, NH 03801
603-430-2081

Prescott Park Arts Festival
Sound Level Monitoring Report
June 18, 2017 – July 16, 2017

Prepared by
Eric L. Reuter, INCE Bd. Cert.
for
The City of Portsmouth, NH

Introduction

Reuter Associates, LLC is under contract with the City of Portsmouth, NH to provide various services related sound management in Prescott Park, including the monitoring of sound levels during events at the city-owned facility. The Prescott Park Arts Festival, a non-profit arts and education organization, is the principal tenant of the Park, and presents musical theater, concerts, and other events throughout the summer season.

For several years, sound levels from events at Prescott Park have generated noise complaints from the surrounding neighborhood. While some efforts have been made to quantify noise impacts, the data collected during previous seasons have been insufficient to provide guidance on mitigation. Further, the Festival's efforts to monitor event sound levels during events have been hindered by lack of proper equipment and trained operators.

In addition to monitoring sound levels, services in this engagement also include the administration of a third-party review of the design, installation, and condition of the sound reinforcement system to result in recommendations for maintaining adequate coverage of audience areas while mitigating offsite impacts. Following this review, a calibrated sound measurements will be performed to better understand the relationship between the on-site sound production and off-site sound levels.

The two goals for monitoring sound levels throughout the season are to maintain consistency in sound level emission between events (both theater and concerts) and to create a continuous record of sound levels for the entire season. These data, along with input from the surrounding community, will be used to develop mitigation strategies for future seasons.

To support these goals, a sound monitoring system has been installed at Prescott Park. This system continuously monitors and records the sound pressure level at a fixed outdoor microphone, and provides visual feedback in real time to the sound engineer in the form of an arrangement of lights that provide a warning when sound levels exceed preset thresholds. By observing the lights during performances, the sound engineer is easily able to maintain sound levels that are consistent throughout the performance, across performances, and even across multiple engineers.

Terminology

Measurement and analysis of sound is a complex subject with a good deal of proprietary terminology. The definitions below are intended to help clarify the contents of this report, but are by no means comprehensive.

Decibel (dB)– Sound pressure is a fluctuation above and below the steady-state atmospheric pressure, and is typically measured in pascals (force/area). However, humans perceive changes in sound pressure on a logarithmic scale rather than a linear scale. To generate equal intervals of change in perceived loudness, exponential increases in pressure are necessary. As such, instead of comparing sound pressures in pascals, a pair of sound pressure measurements can be compared using the decibel scale, which provides a consistent measure of perceived change in amplitude between the measured values. For reference, a change of 3 dB is considered the just noticeable difference (JND) for humans, 5 dB represents a clearly audible change, and 10 dB is perceived by most people to be twice (or half) as loud.

Sound Pressure Level (SPL) - The decibel is, by definition, a comparative measure. However, it has been adapted for use as an absolute measure of sound level by comparing a measured pressure to the threshold of human hearing. This is known as sound pressure level (SPL). Sound level meters measure sound pressure level directly, and the reported value represent the amplitude (loudness) of the sound relative to the threshold of hearing.

Frequency Weighting – While sound pressure level is based on the threshold of human hearing, the threshold of hearing is frequency dependent. In simple terms, the threshold of hearing for low (bass) frequencies is much higher (requiring more SPL) than that for higher frequencies (such as speech). Human hearing acuity is frequency-dependent throughout the dynamic range (soft to loud) of hearing. Measuring overall sound pressure level without any regard for relative acuity at different frequencies yields meaningless data when the goal is to assess human perception and response.

To correct for this, weighting curves are applied to measured data before calculating the overall level. These filters compensate for relative acuity. Two such curves are in common use: A-weighting and C-weighting. A-weighting de-emphasizes low (bass) frequencies more than C-weighting, and is used in nearly all assessment of noise impacts. C-weighting is used in a few specific applications, among them monitoring of outdoor concert noise with significant low-frequency content.

When sound pressure level is measured with frequency weighting applied, the dB is followed by a letter indicating the weighting, i.e. **dBA** or **dBC**. If no weighting has been used, this it indicated by using dBZ, for “zero weighting”, but this is unusual.

Equivalent Sound Level (Leq or L_{EQ}) – Sound pressure level fluctuates rapidly. If levels are to be measured over time, an interval of time must be chosen for each discrete measurement. However small this interval, sound pressure level will likely have fluctuated somewhat within the interval. The equivalent sound level is the theoretical constant sound pressure level that would contain the same amount of energy as the actual fluctuating level. It is therefore considered an energy average. To avoid the

necessary exponential math, it is easiest to think of Leq as the average sound level during the interval.

If Leq is measured at a particular interval, these data can be used to calculate the Leq of any longer interval, provided the data are continuous. For example, a 1-minute Leq can be calculated from sixty 1-second Leq values. A 24-hour Leq can be calculated from 24 1-hour Leq values (or 86,400 1-second values).

While other statistics are often calculated to analyze the nature of fluctuating sound levels, Leq has been shown to be most useful in predicting annoyance and other impacts on humans from noise in the environment. It is therefore the only metric used in this study.

Sound Level Limits

Appropriate limits for sound pressure levels from events at Prescott Park have not been established formally. However, in order to achieve the goal of consistency across performances, it was necessary to choose initial limits for the current season.

Prescott Park Arts Festival has been using a limit of 90 dBA at front of house for several seasons. However, the equipment and staff constraints did not allow for constant monitoring or enforcement. This limit is known to have been exceeded frequently. Because of this, no meaningful correlation can be drawn between this limit and community reactions from previous seasons.

When mixing live music, the sound reinforcement system (the loudspeakers, amplifiers, and other associated components) must be able to overcome the direct sound emanating from the instruments on stage. If it is not possible to accomplish this, the engineer will not have control over the mix. For a full band with drums and guitar amplifiers onstage, this level is routinely in the 85 to 90 dBA range at a distance comparable to the front of house location at Prescott Park. For this reason, the existing limit of 90 dBA has been maintained.

As noted in the Terminology section above, C-weighting (dBC) is sometimes used for monitoring of live music. C-weighting is more sensitive to low frequencies (bass, etc.) than A-weighting, and C-weighted levels are typically higher than A-weighted levels for rock/pop music. C-weighting may be useful for some of the concerts staged at the park, but A-weighting is more appropriate for musical theater and lightly orchestrated folk and similar music, which makes up much of the summer schedule. For these reasons, A-weighting has been used for monitoring and feedback. This may be revisited in the future, depending on the data collected this season.

Visual Feedback

The sound level monitor at Prescott Park continuously measures and logs 1-second Leq values. These data are used in real time to calculate longer Leq values, and to control the stoplight-style visual feedback system.

Sound pressure levels associated with music fluctuate rapidly, making it somewhat impractical to use the nearly instantaneous 1-second Leq to monitor the overall sound level of a performance. A longer Leq is more useful. This can be described as a sliding average, or smoothing function. This is used for the first level of warning, the yellow light.

The red light is used to warn of instantaneous levels that exceed a higher threshold, indicating a more severe exceedance of the limit.

The triggers for the lights have been set as follows:

Green – neither condition below is true (target sound level range)
Yellow – 10-second Leq exceeds 90 dBA
Red – 1-second Leq exceeds 95 dBA

Sound engineers have been instructed to respond as follows:

Yellow – Gradually reduce overall level until green illuminates.
Red – Immediately reduce overall level by at least 5 dB until green illuminates.

Under most circumstances, the yellow light will already have been on if the red light comes on, but there are situations where both could illuminate simultaneously.

Based on the data measured to date and informal feedback from sound engineers using the system, it appears that the visual feedback is working well. With few exceptions, event sound levels have been remarkably consistent.

Event Data

The attached Appendix A provides plots of sound levels versus time from 6 pm to midnight for each night between June 18, 2017 and July 16, 2017. Nights without events have been included for clarity and comparison.

Each plot presents data measured between 6 pm and 12 am. The lines plotted are both A-weighted sound pressure level in 1-minute intervals, as plotting six hours of data in 1-second intervals makes the plot difficult to interpret. The 1-second data are available for further analysis.

1-minute Leq – The Leq over the minute ending at the data point
Maximum 1-second Leq – The maximum 1-second Leq measured during this minute

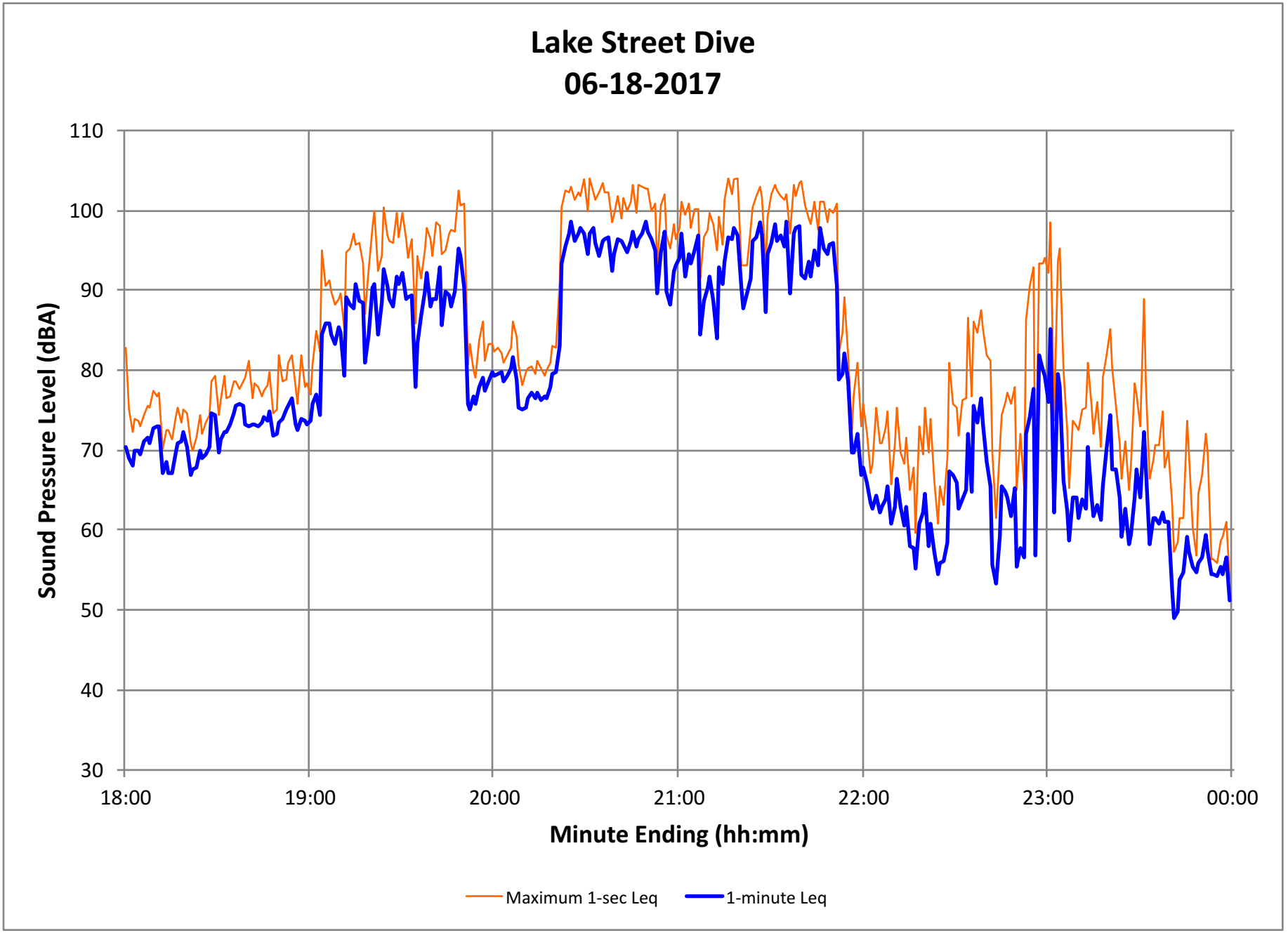
As annoyance is known to correlate with Leq, the 1-minute Leq is the more useful of these. However, the maximum 1-second Leq during each minute provides a better indicator of whether the 95-dBA red lamp was illuminated.

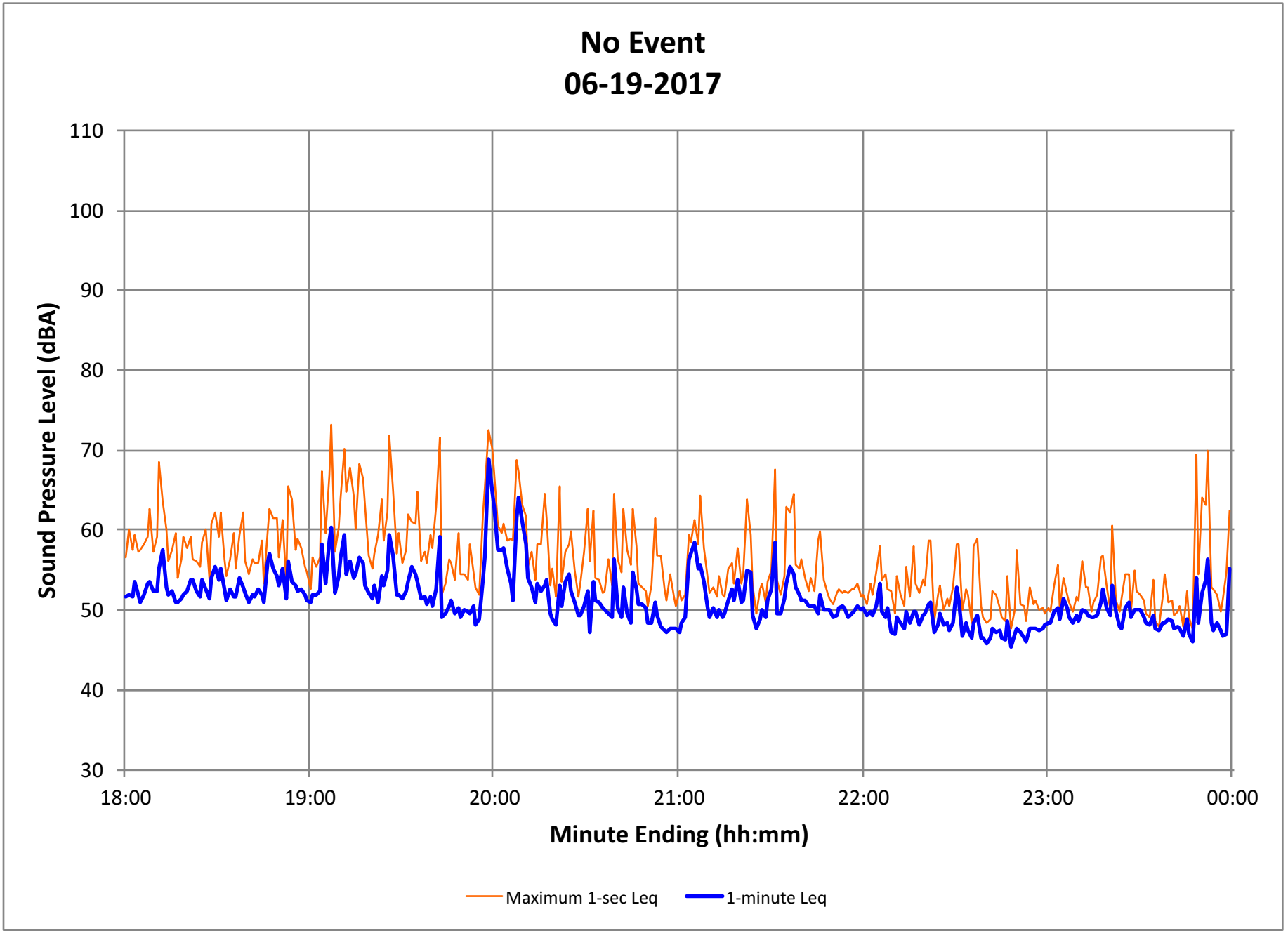
Event Notes

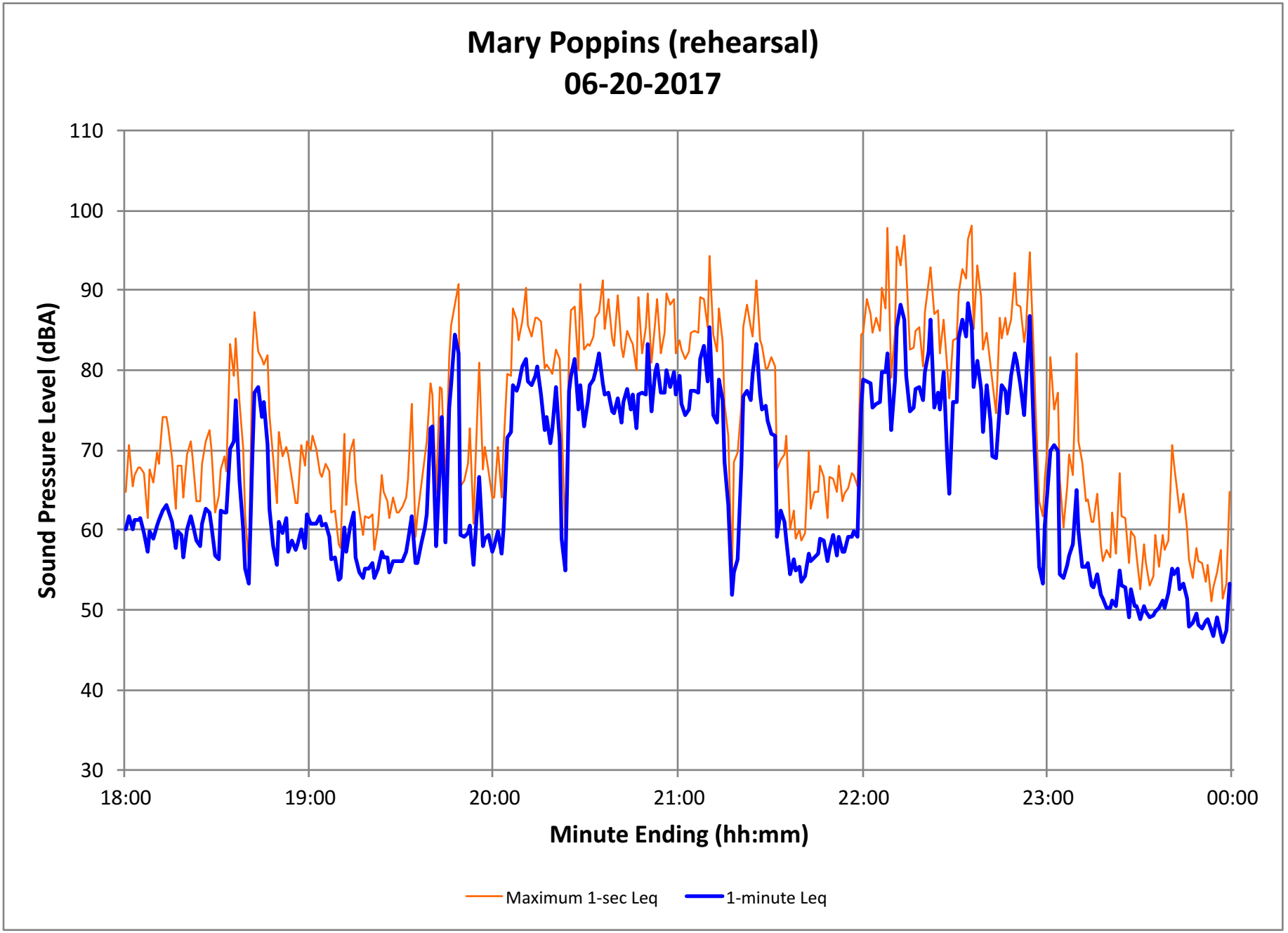
It should be noted that the visual feedback system was not yet operational for the first event of the season, Lake Street Dive (June 18th). Levels during that performance were much higher than any of the events after the system was installed.

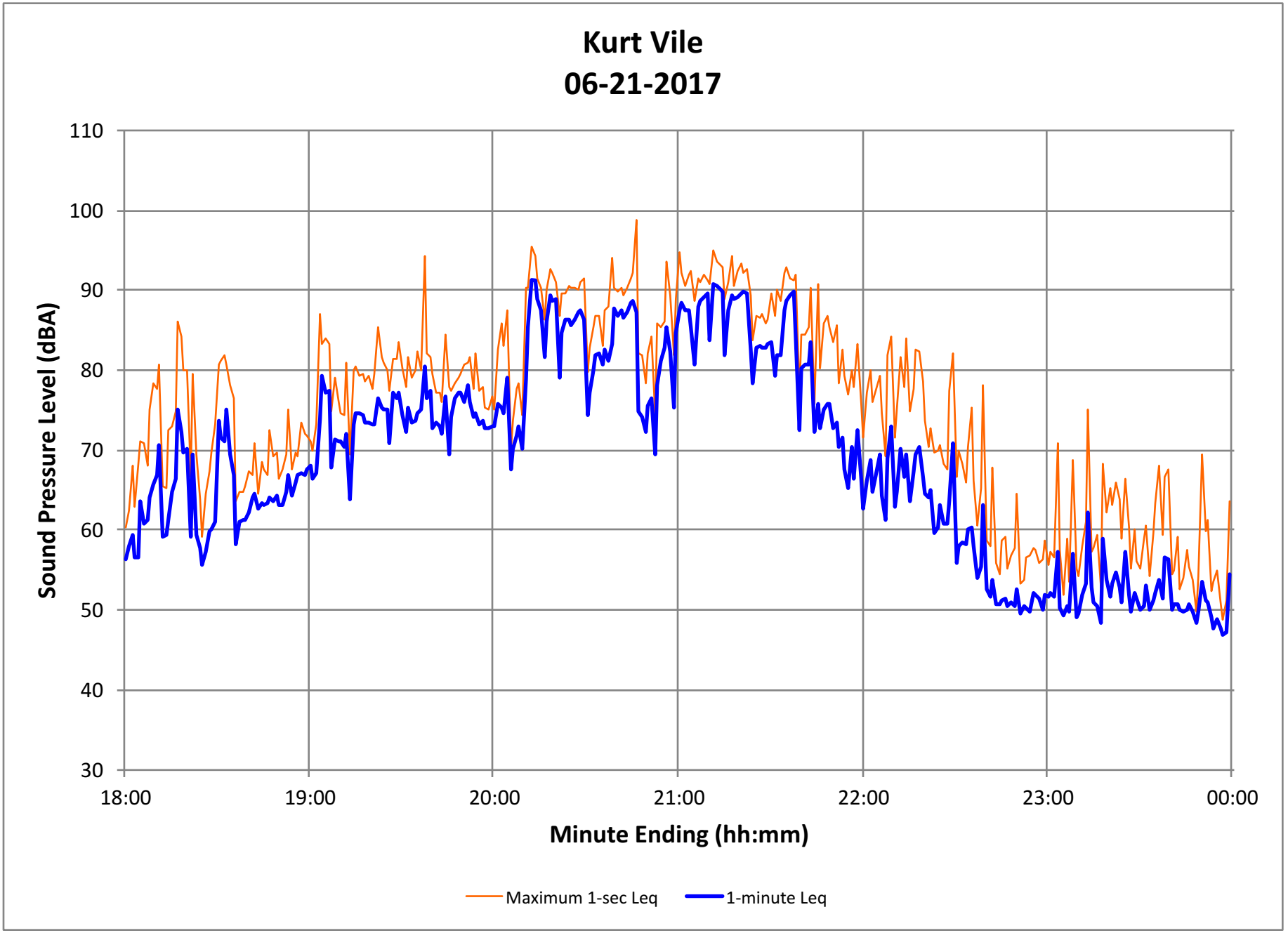
The only other event during this timeframe with significant exceedances of the limit (1-minute Leq over 90 dBA) was Gillian Welch (July 1st). I was not present for this performance, but have discussed it with Festival sound personnel. I was told that the guest sound engineer was cooperative, and it is unclear why levels got so high at the end of the performance.

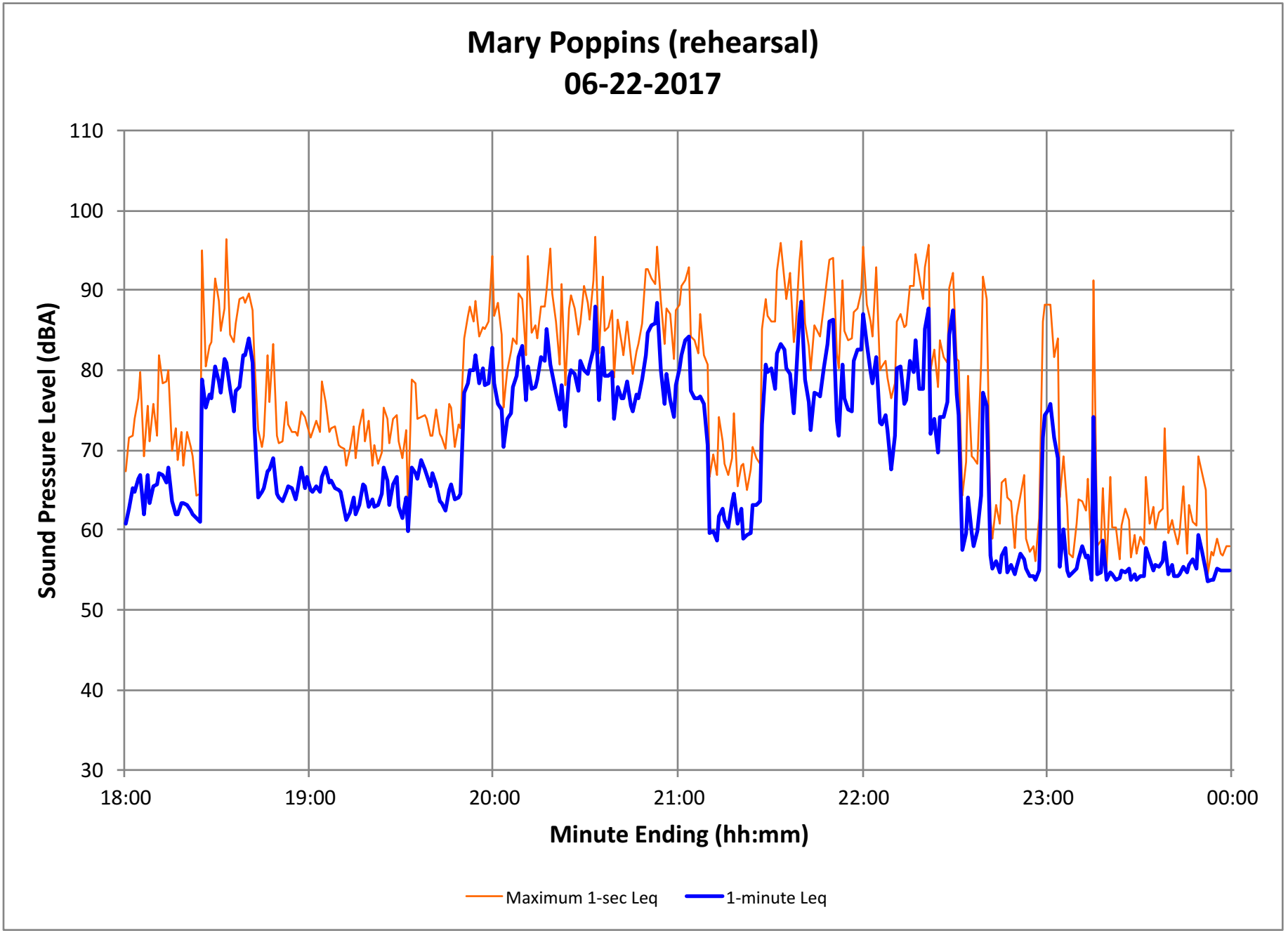
Appendix A
Sound Monitor Data

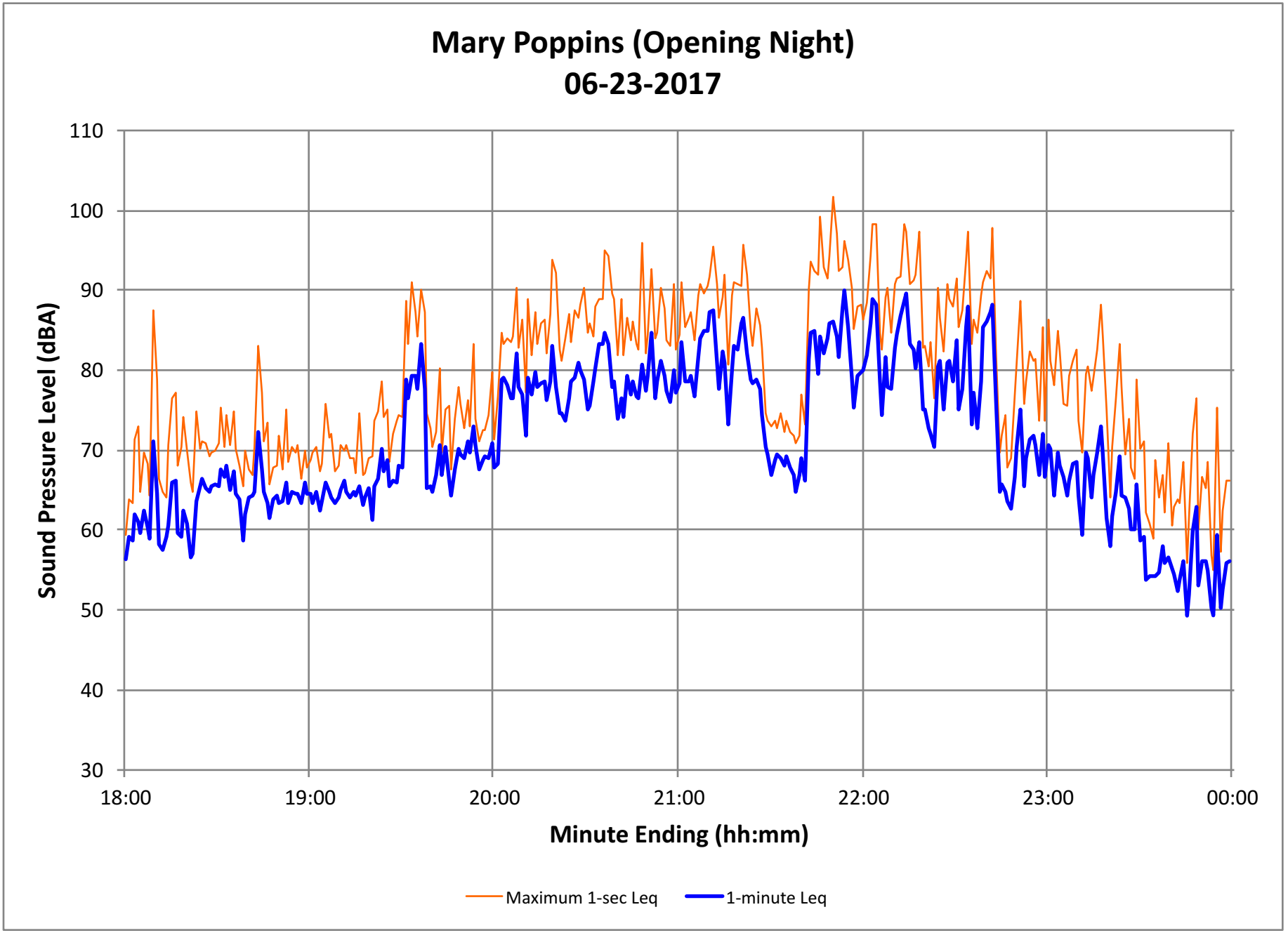

Lake Street Dive
06-18-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

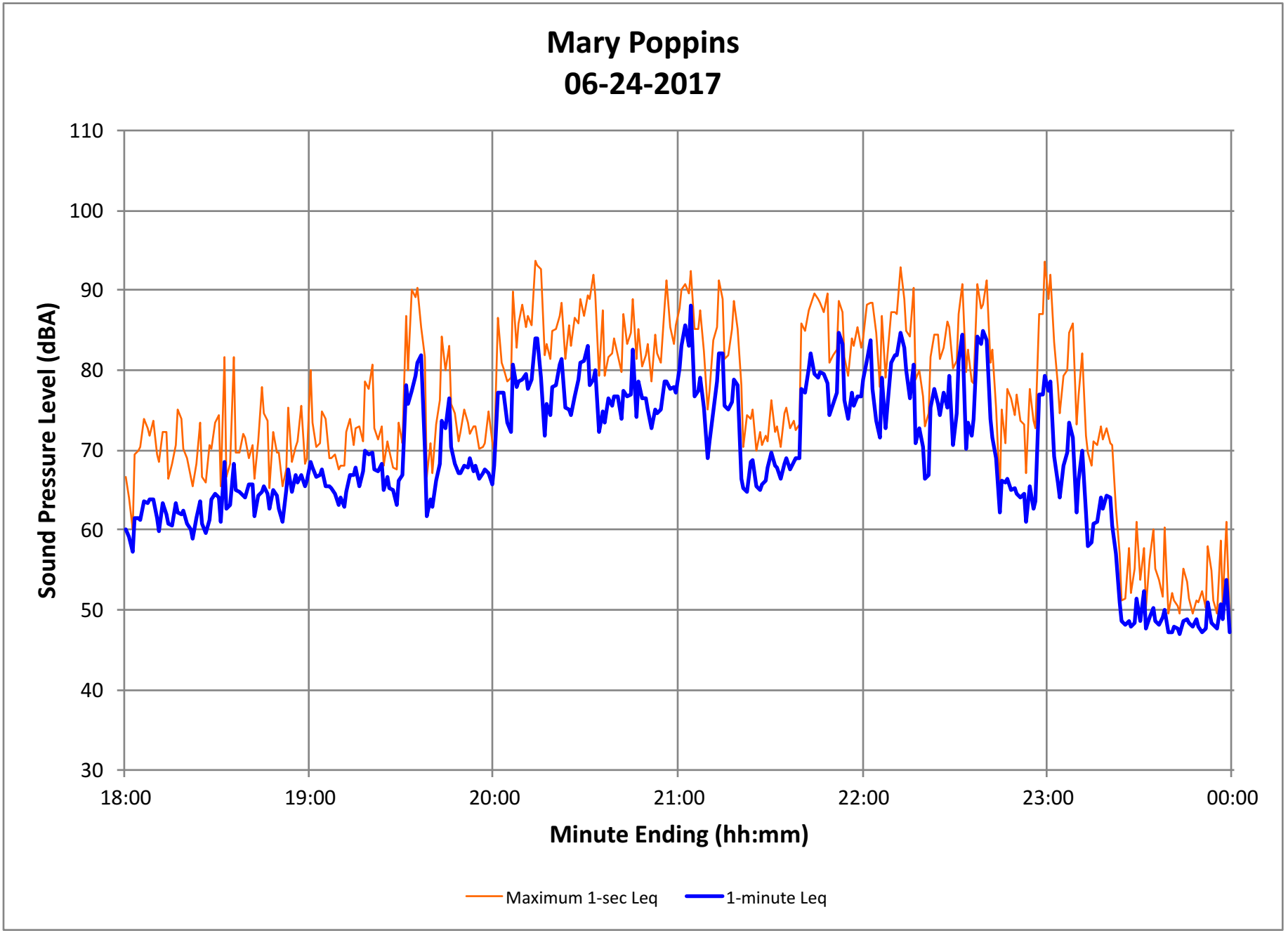

No Event
06-19-2017
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

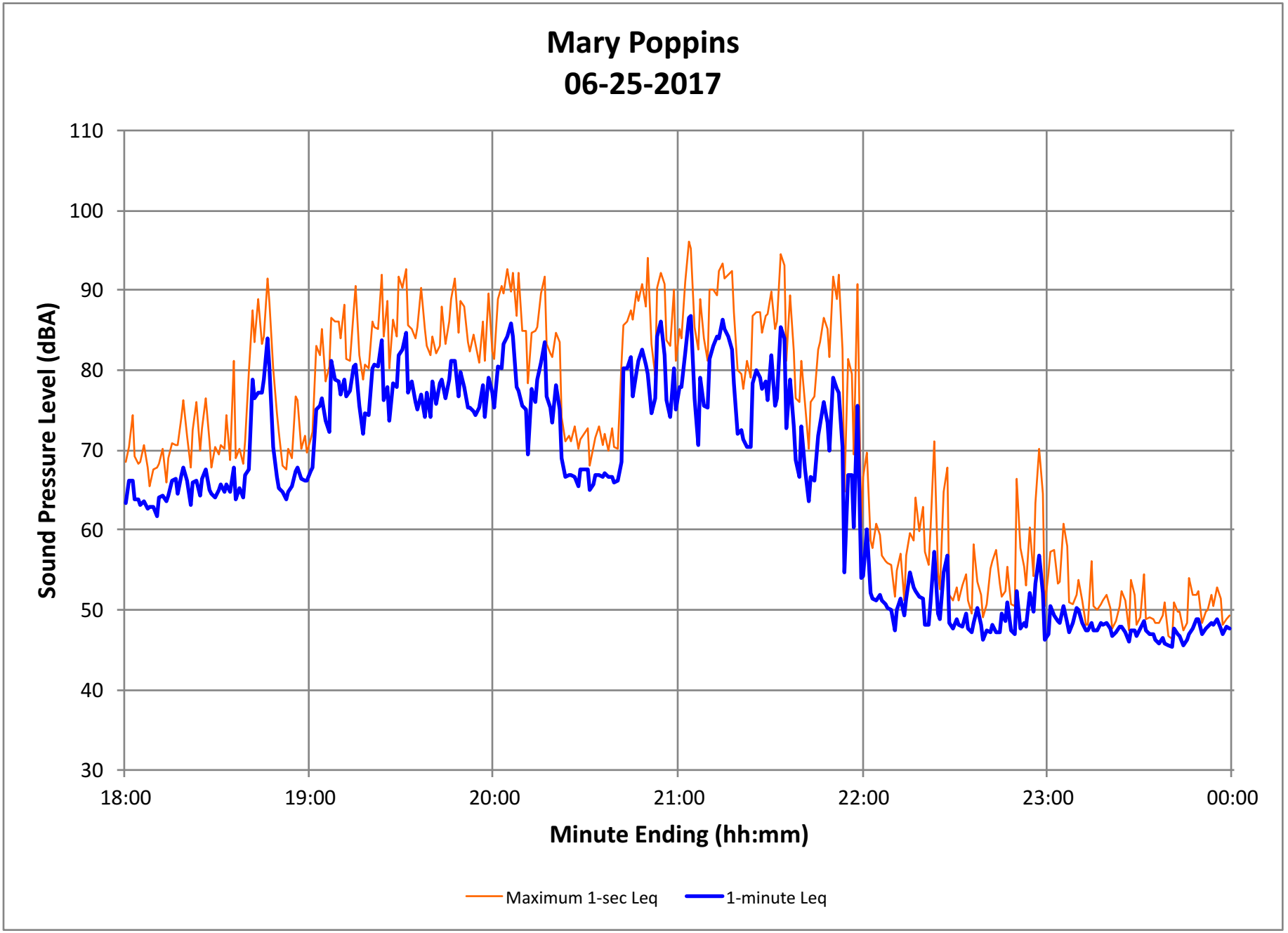

Mary Poppins (rehearsal)
06-20-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

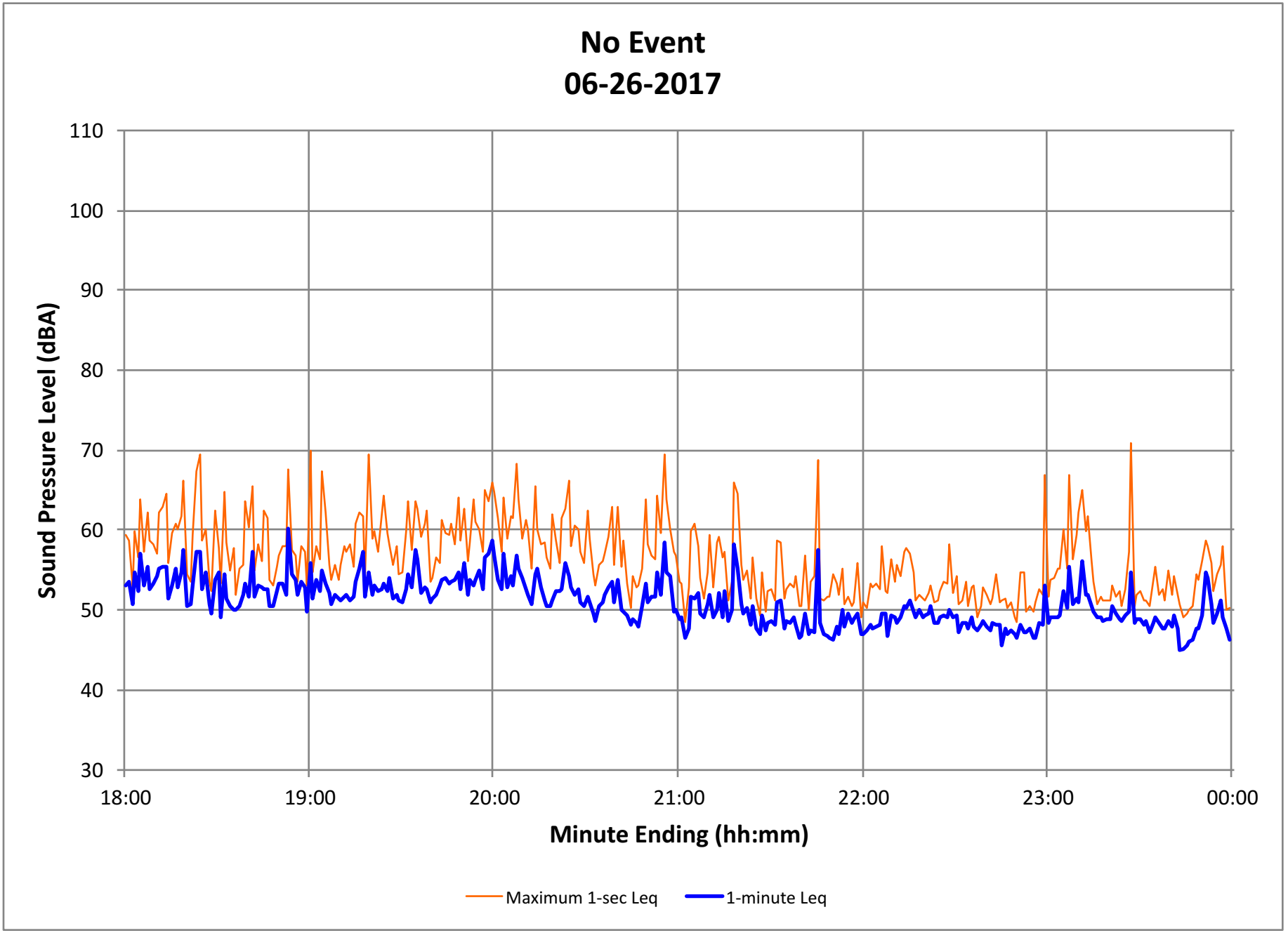

Kurt Vile
06-21-2017
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

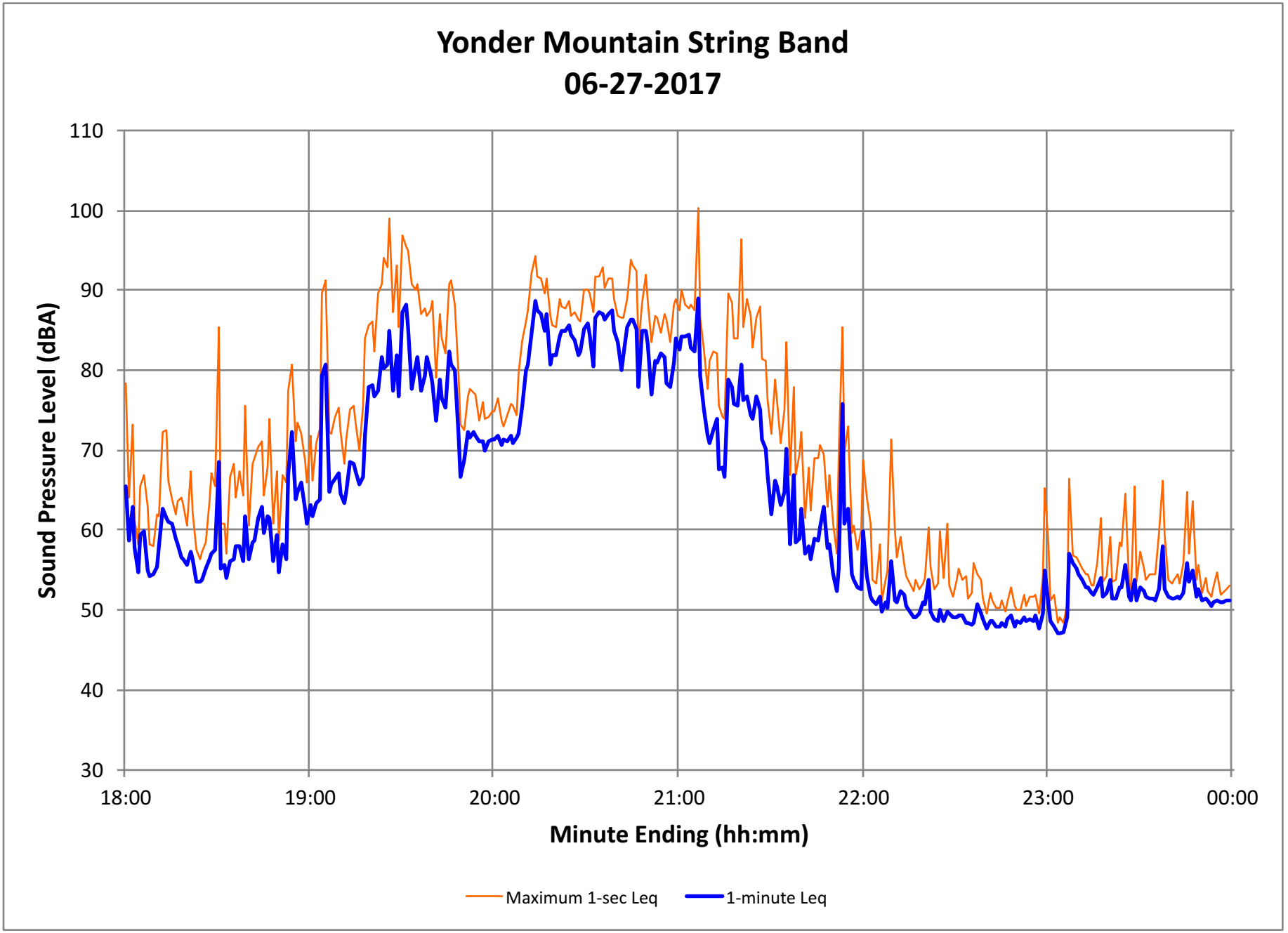

Mary Poppins (rehearsal)
06-22-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

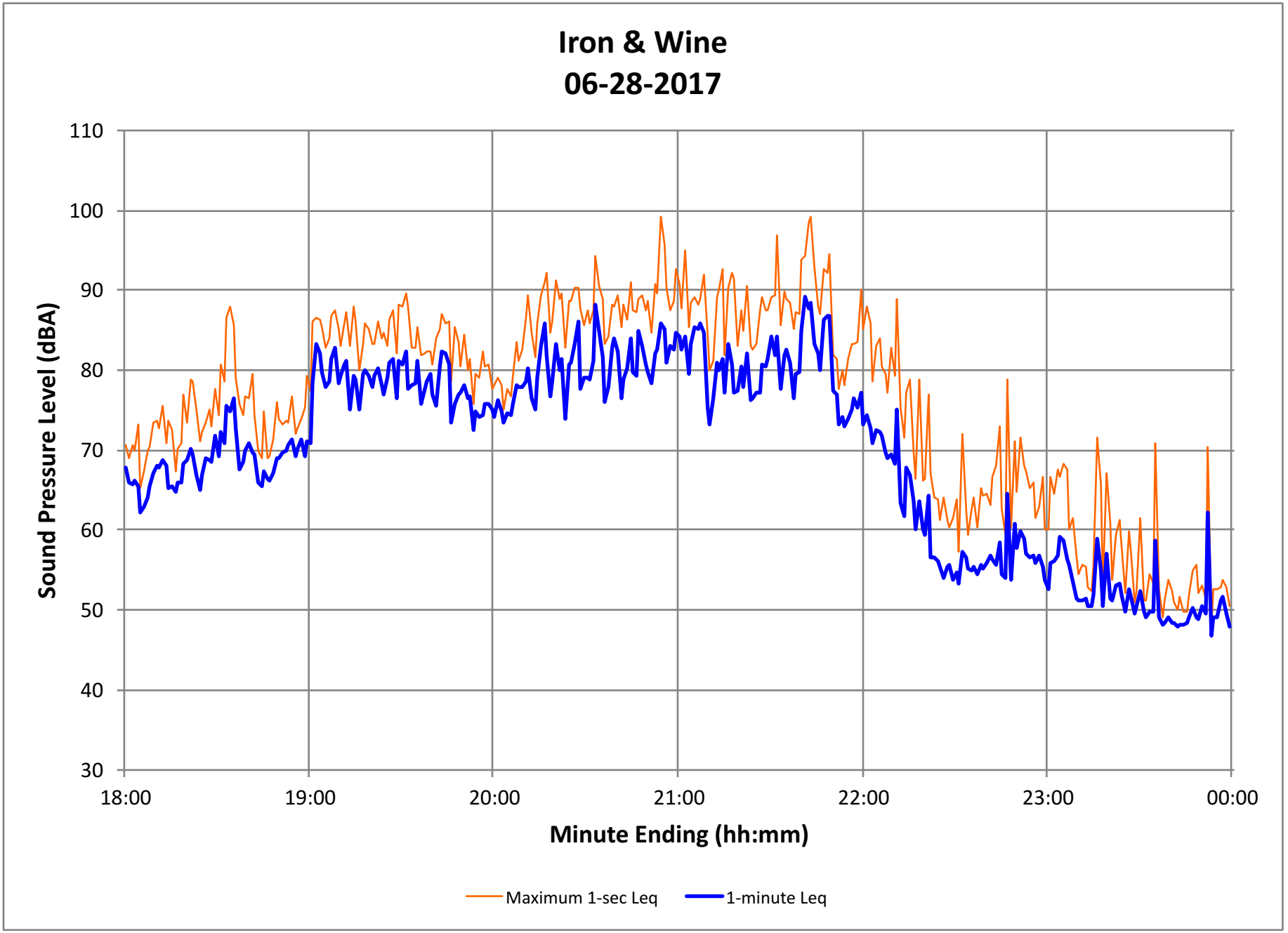

Mary Poppins (Opening Night)
06-23-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

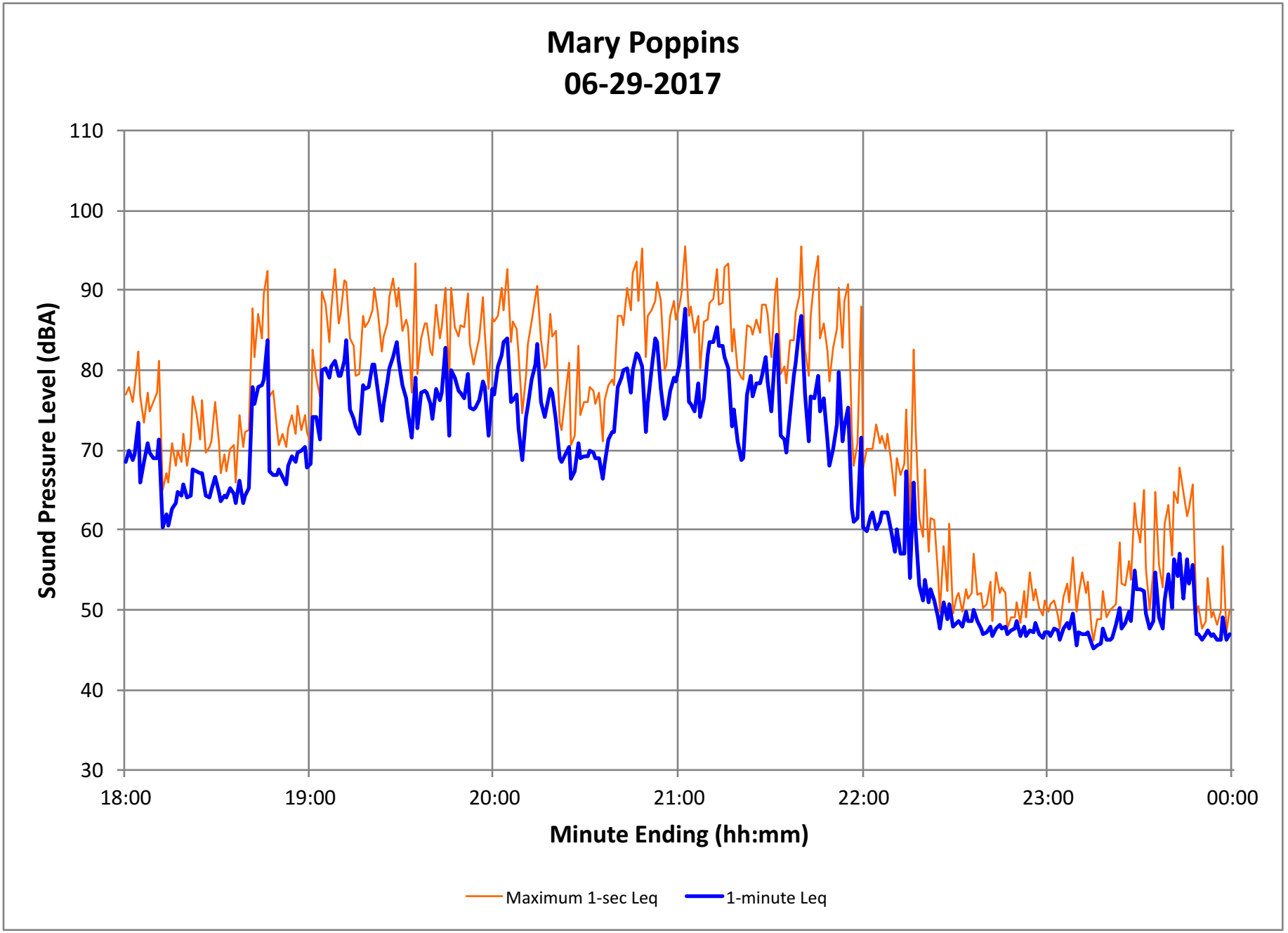

Mary Poppins
06-24-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

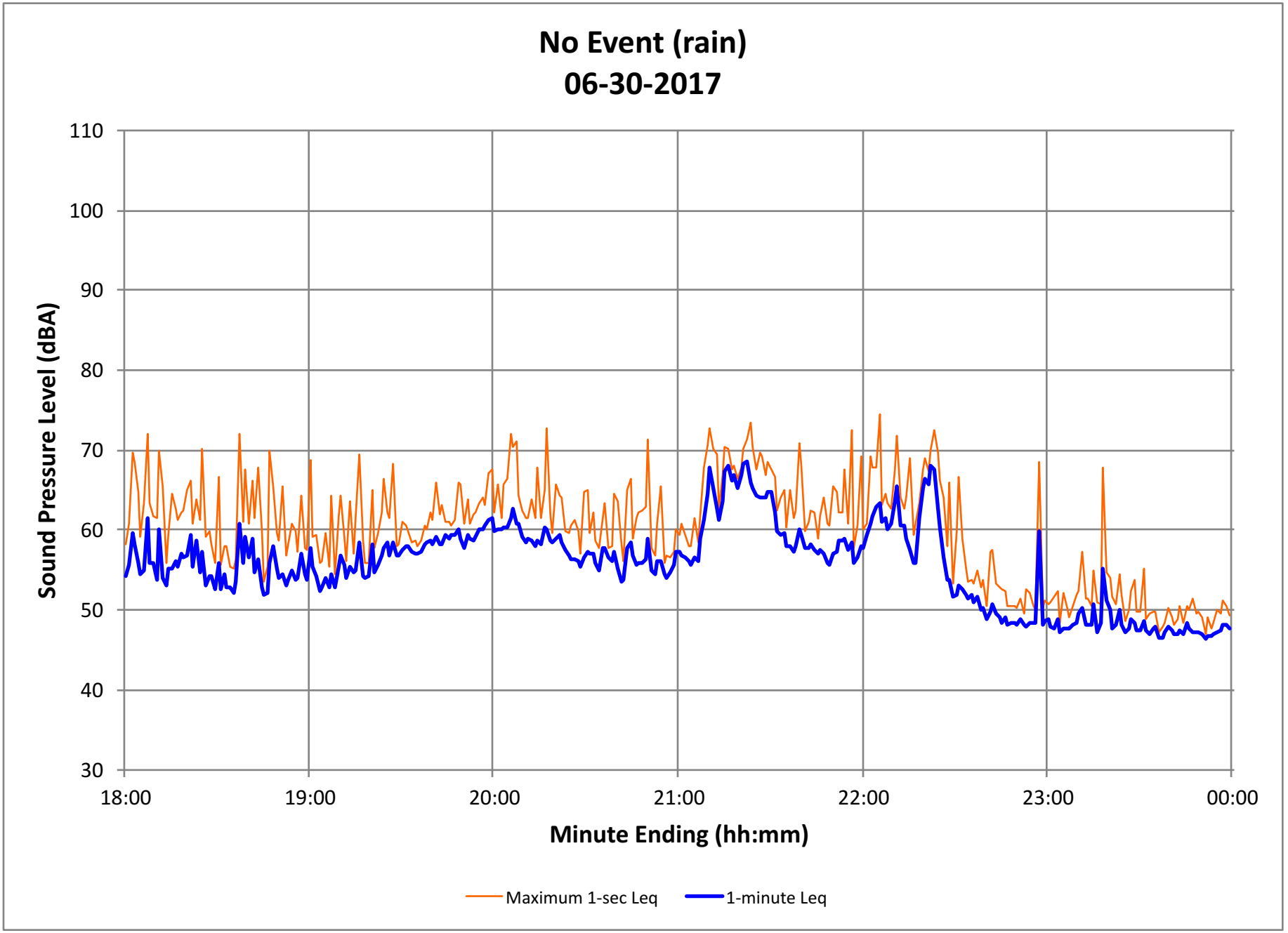

Mary Poppins
06-25-2017
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

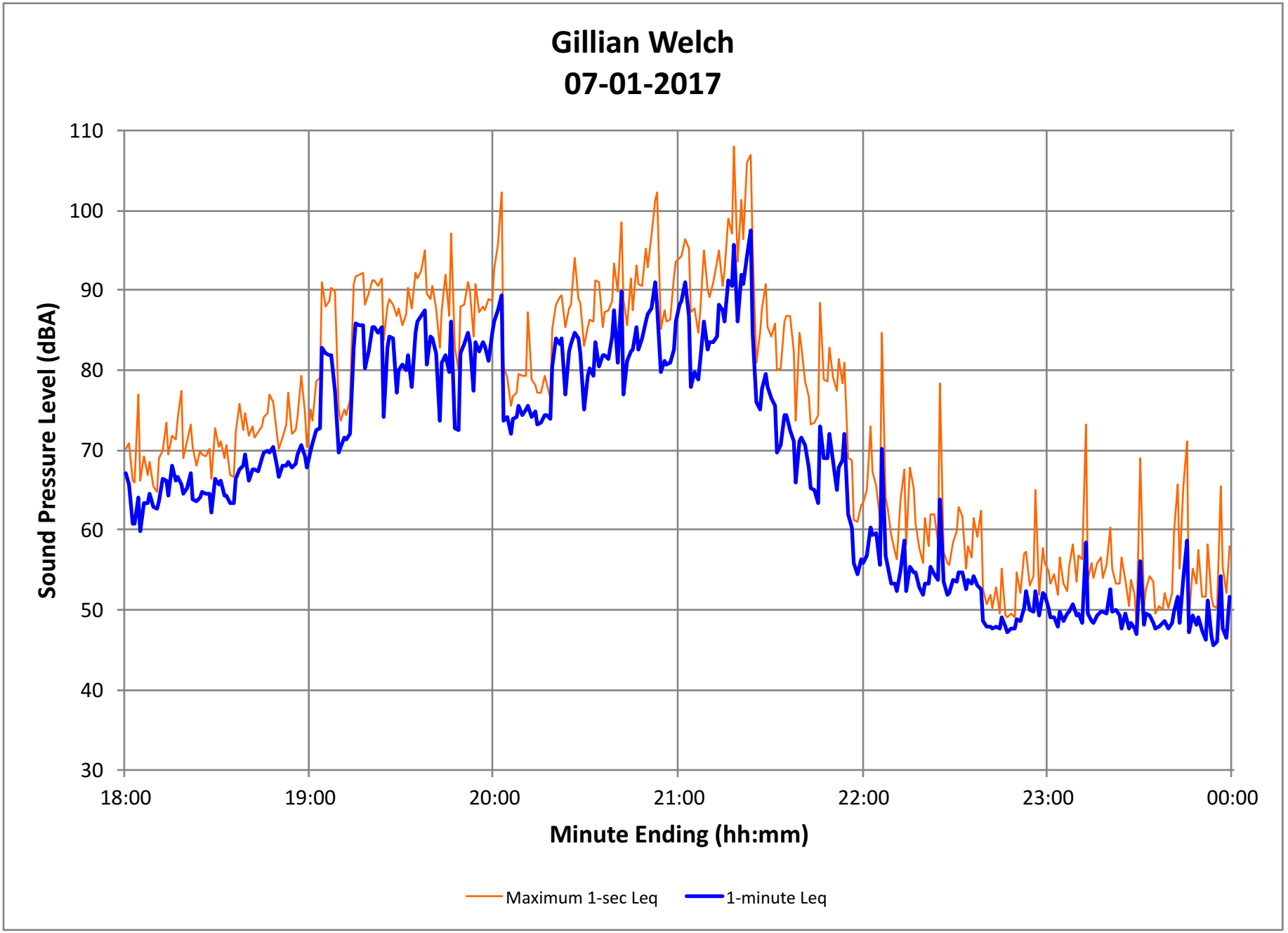

No Event
06-26-2017
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

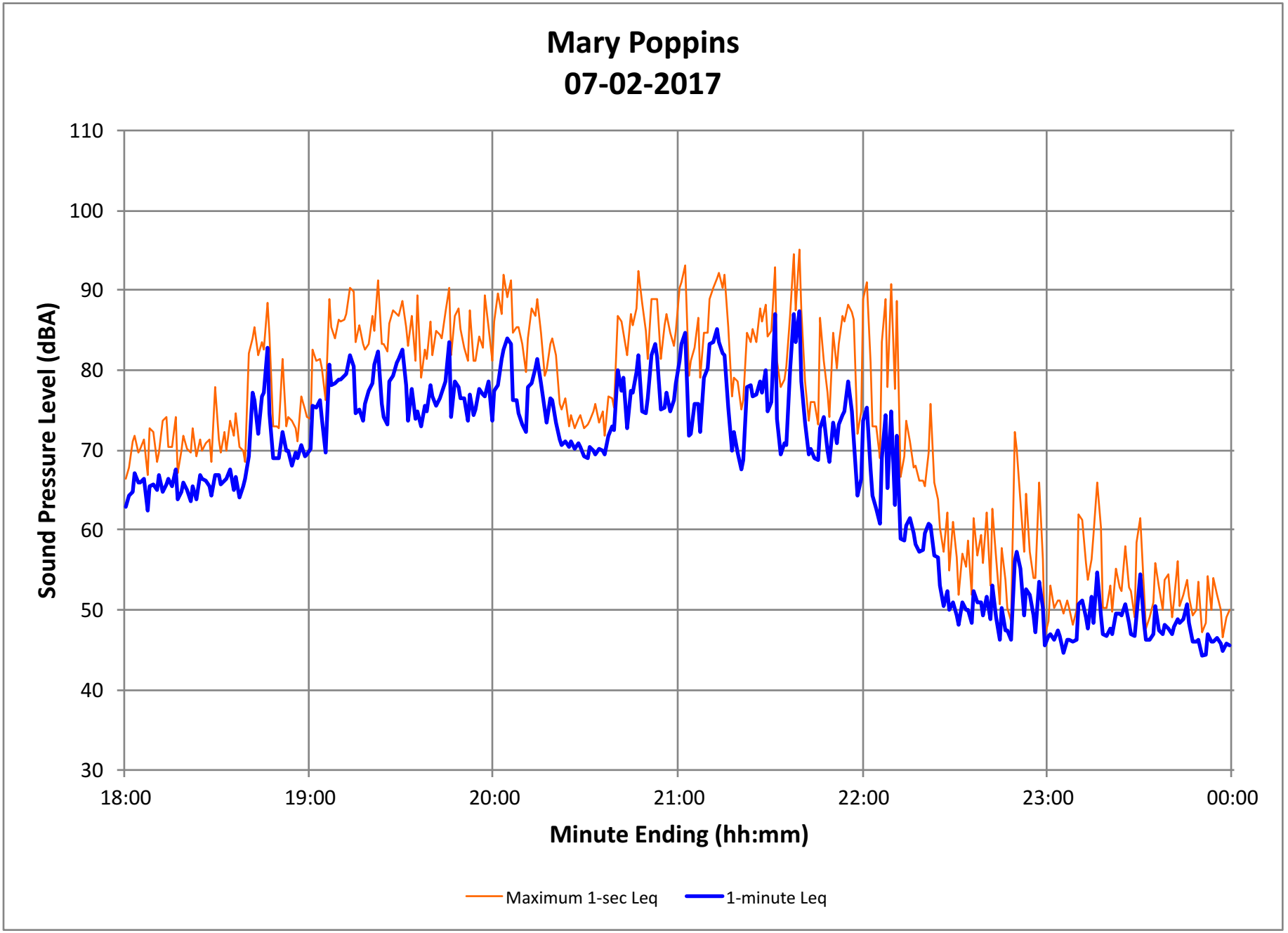

Yonder Mountain String Band
06-27-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

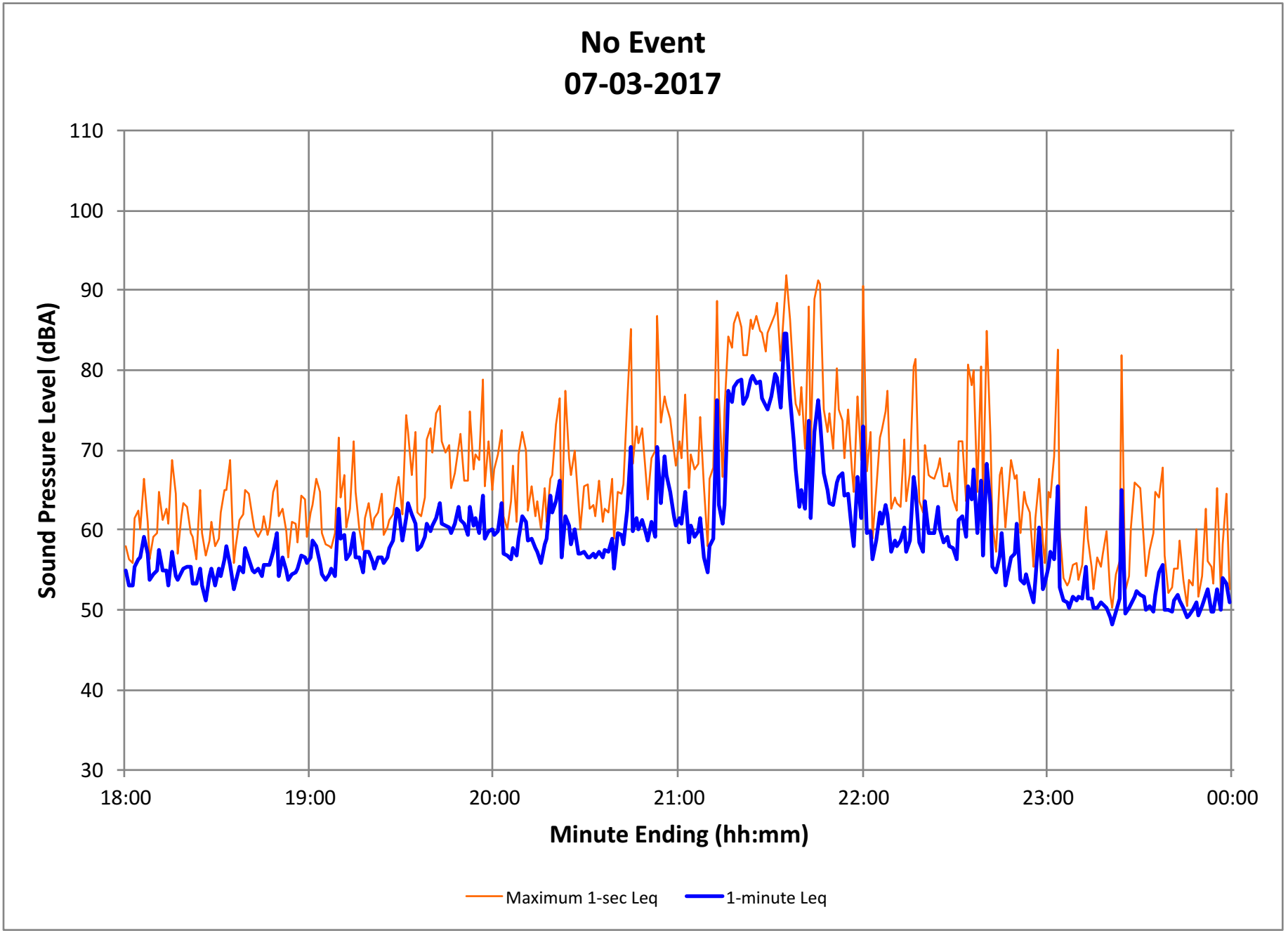

Iron & Wine
06-28-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

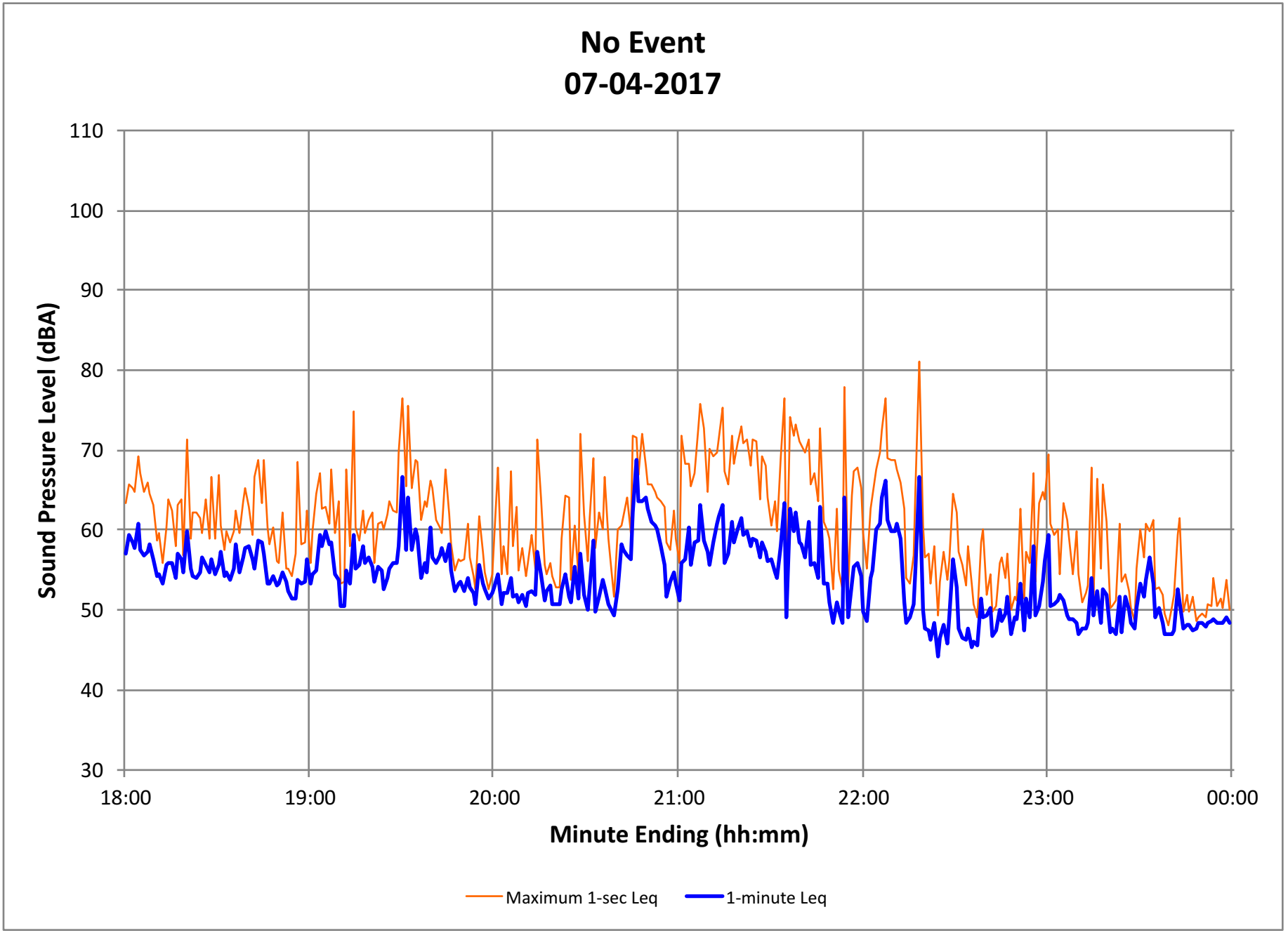

Mary Poppins
06-29-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

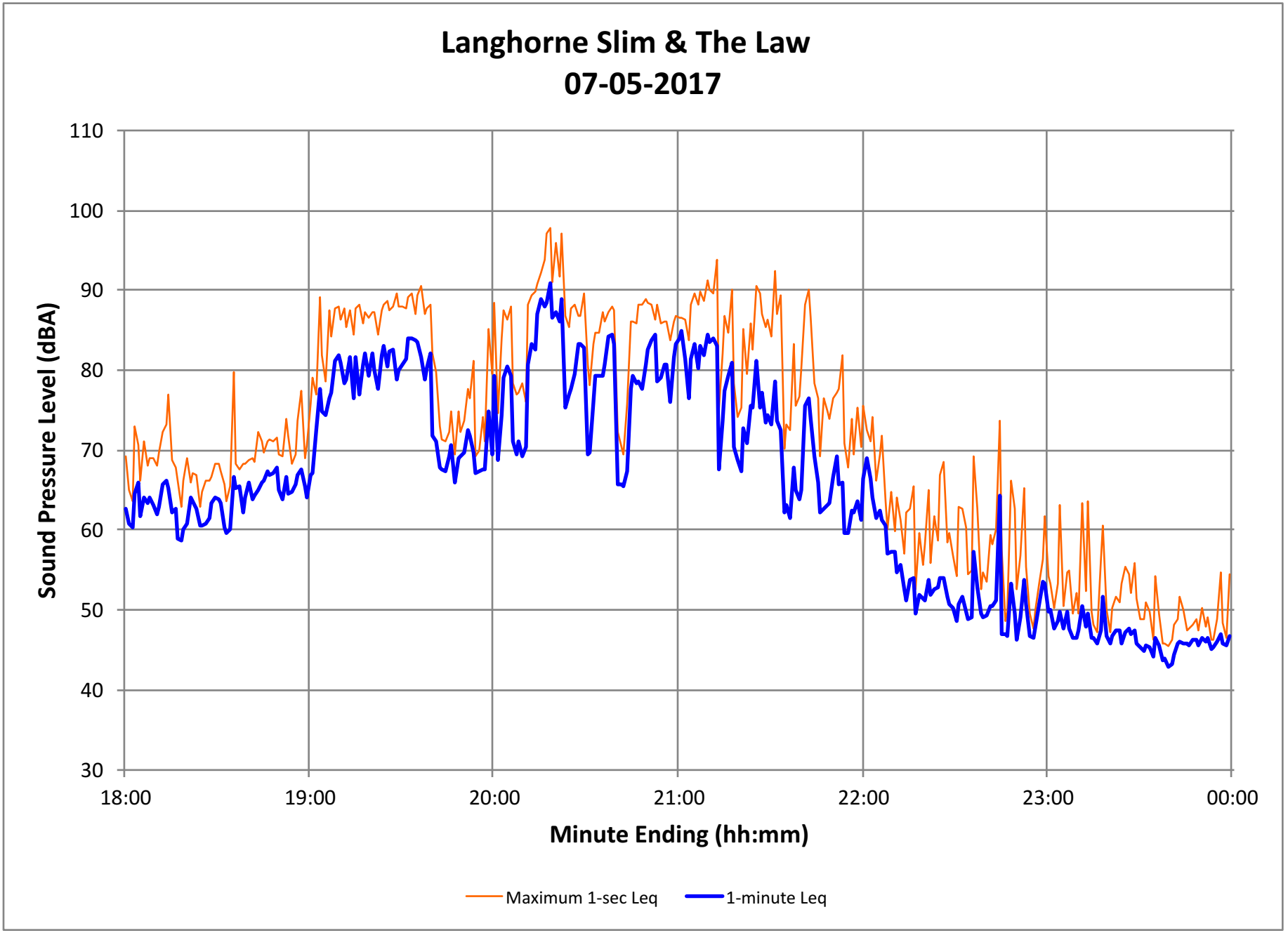

No Event (rain)
06-30-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

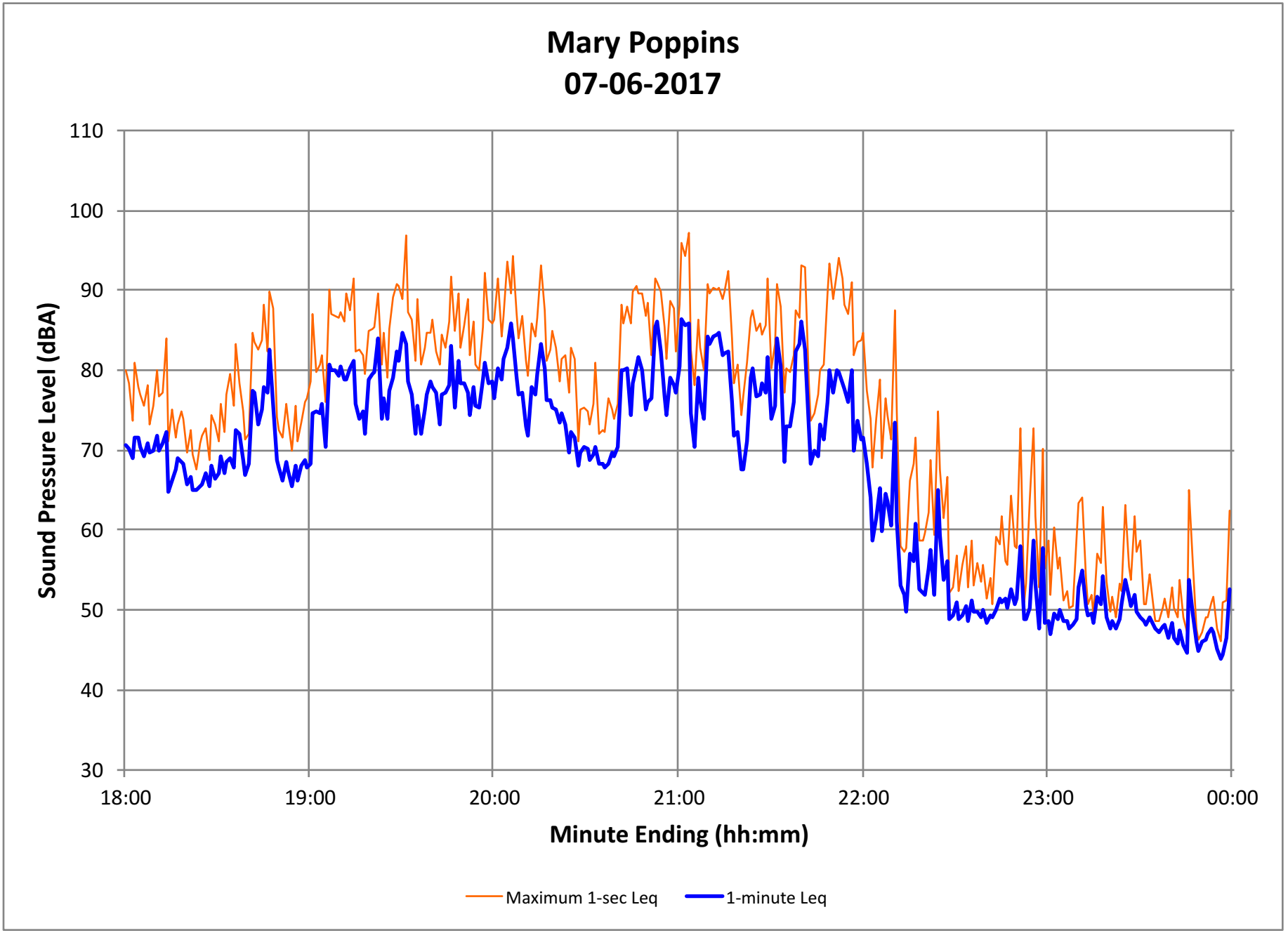

Gillian Welch
07-01-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

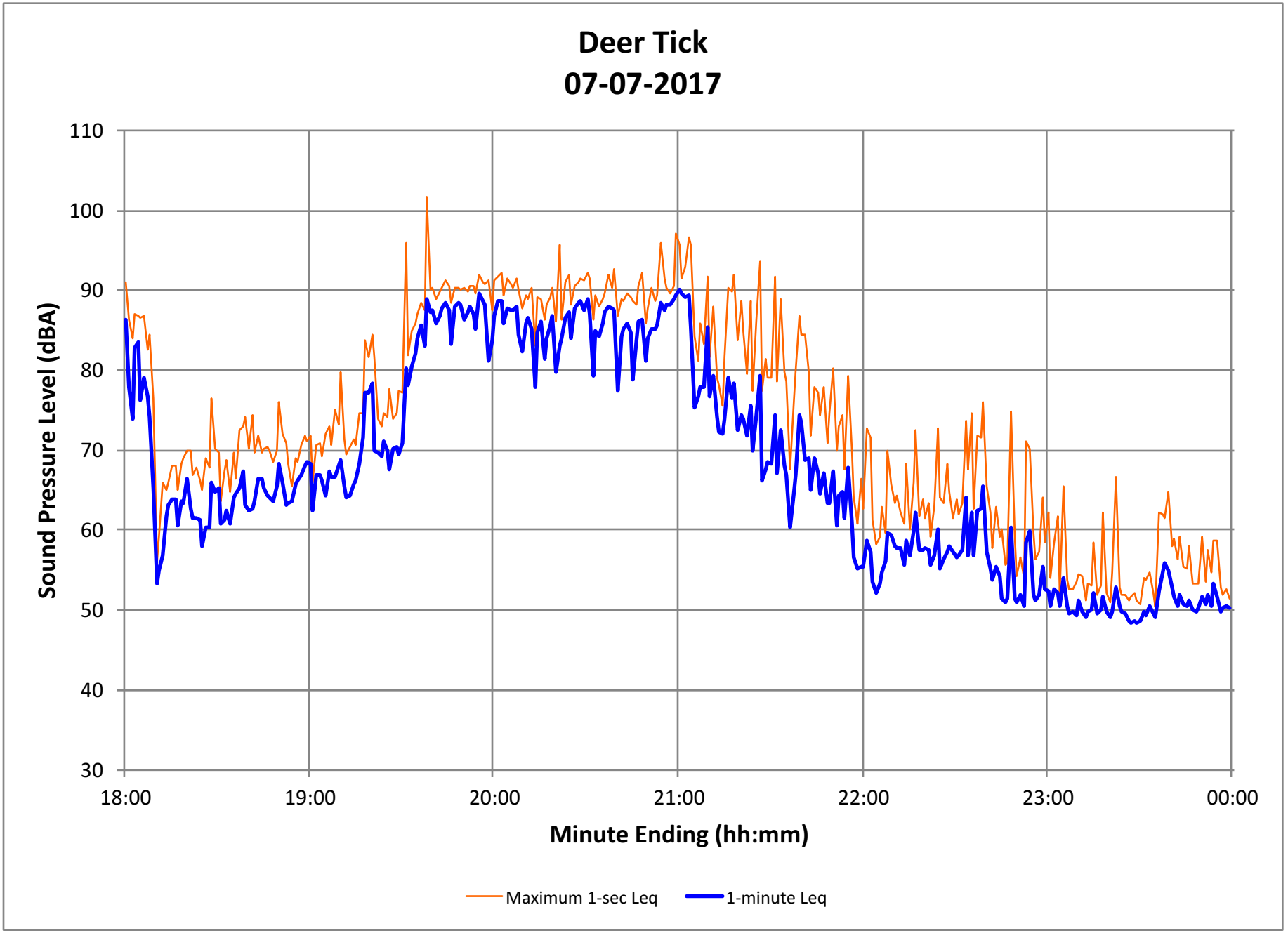

Mary Poppins
07-02-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

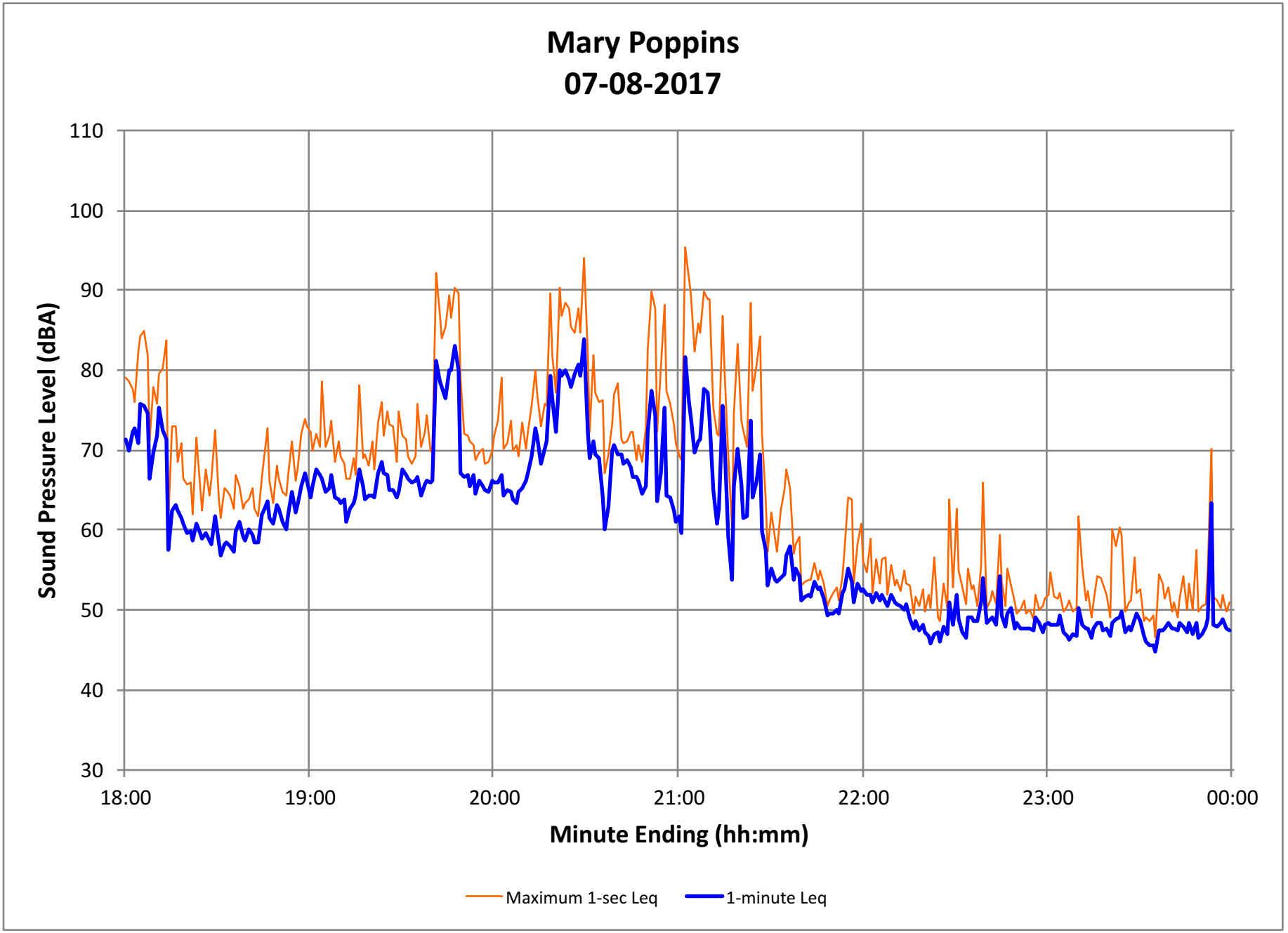

No Event
07-03-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

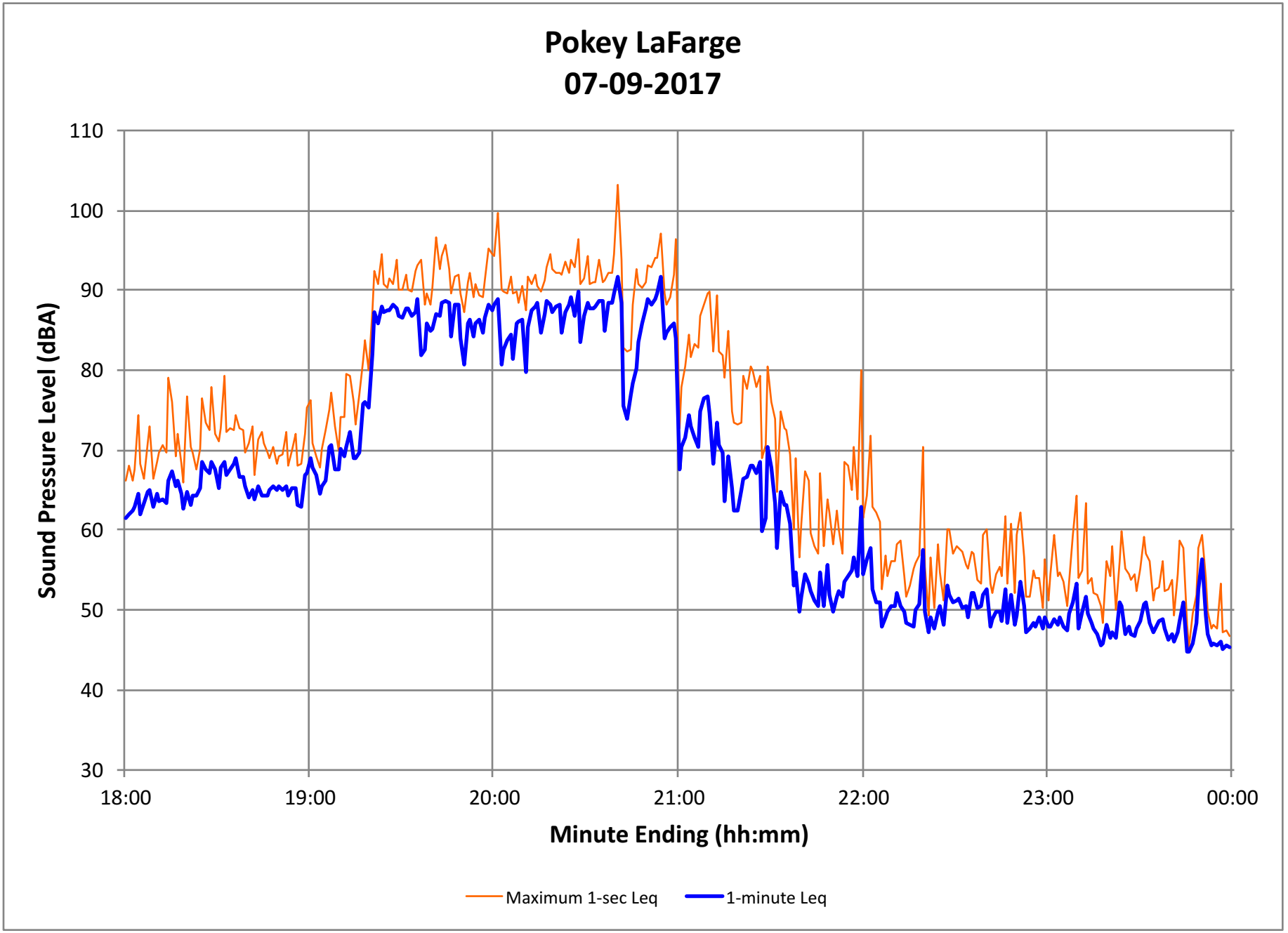

No Event
07-04-2017
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

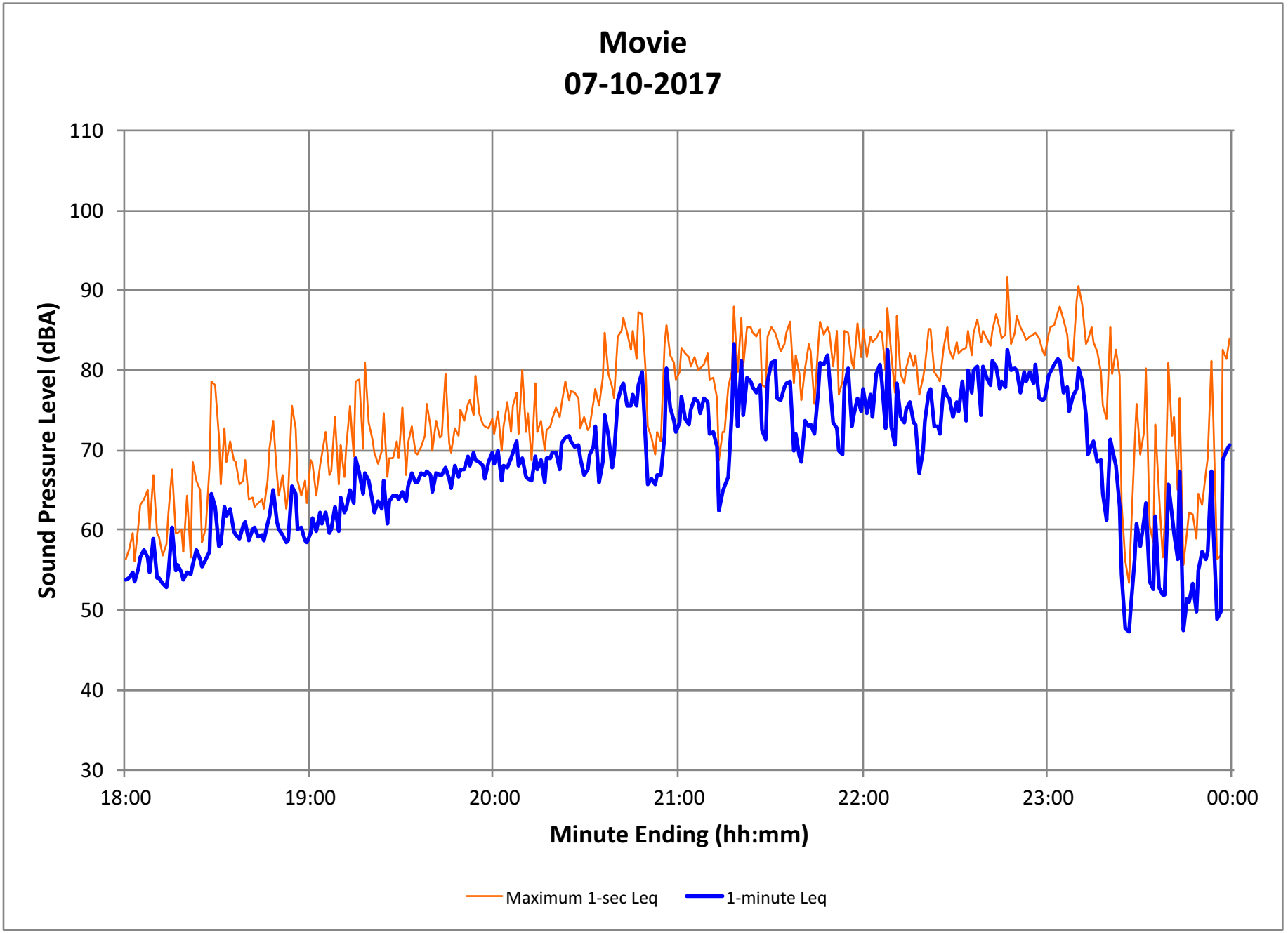

Langhorne Slim & The Law
07-05-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

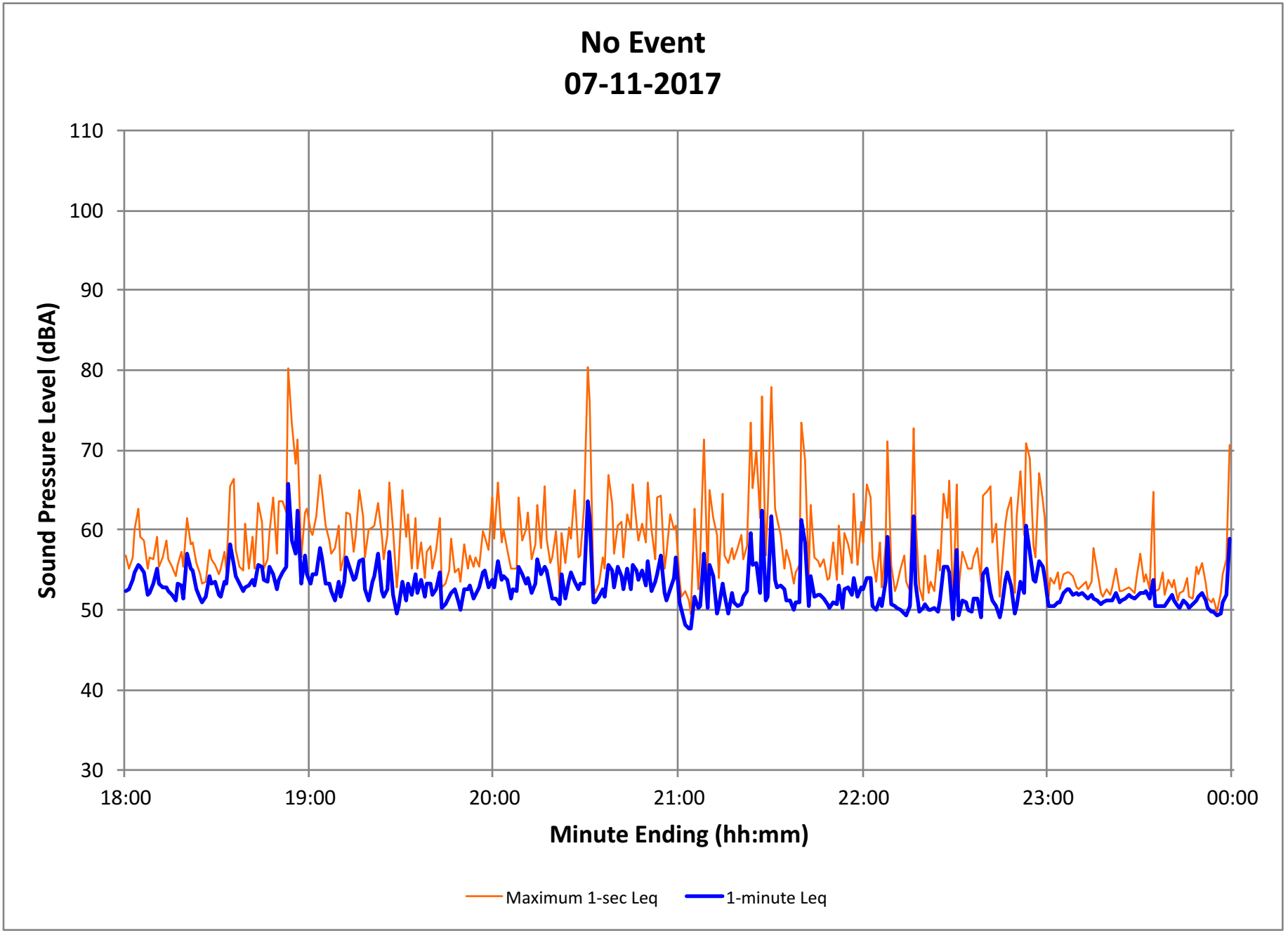

Mary Poppins
07-06-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

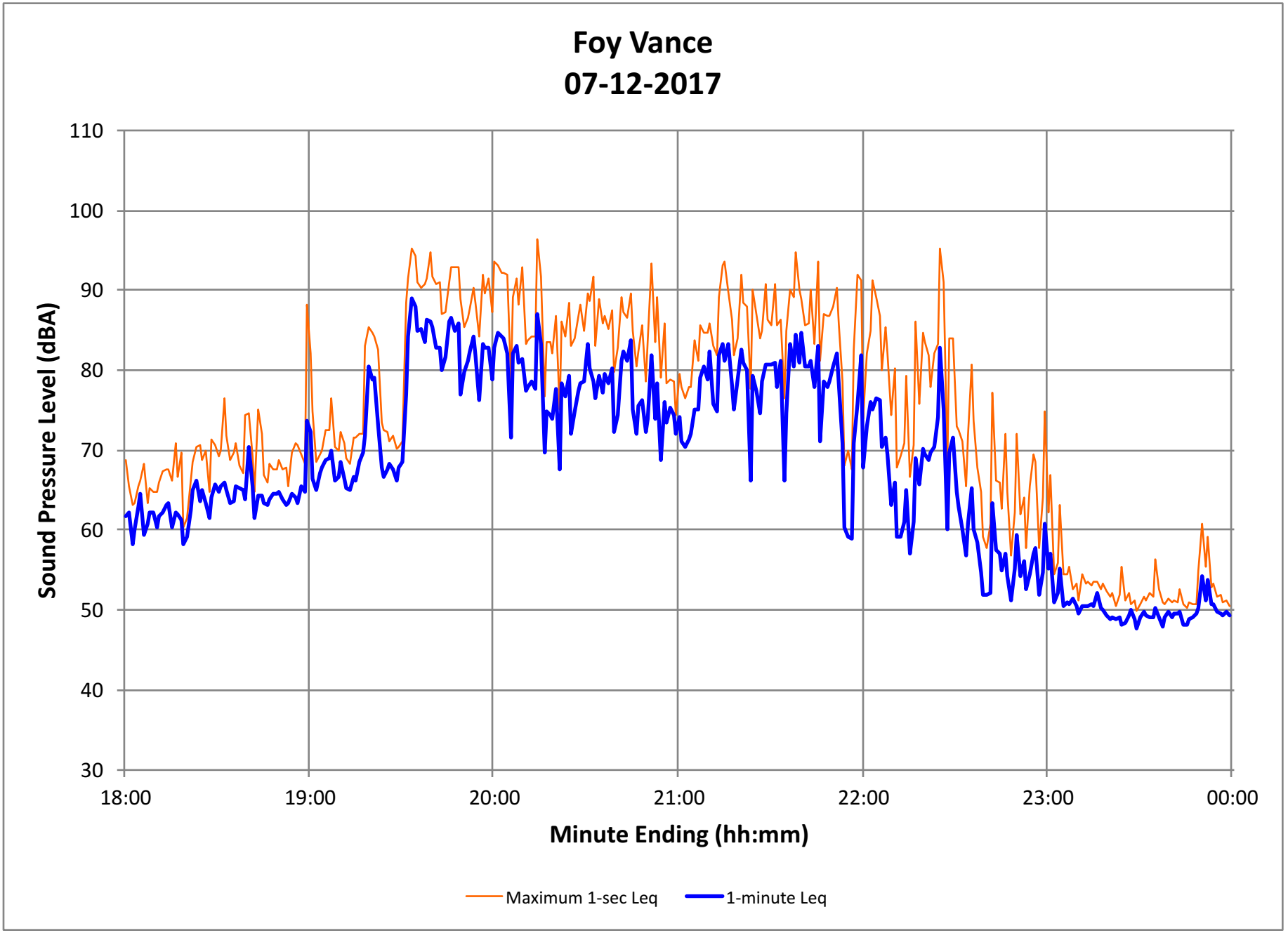

Deer Tick
07-07-2017
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

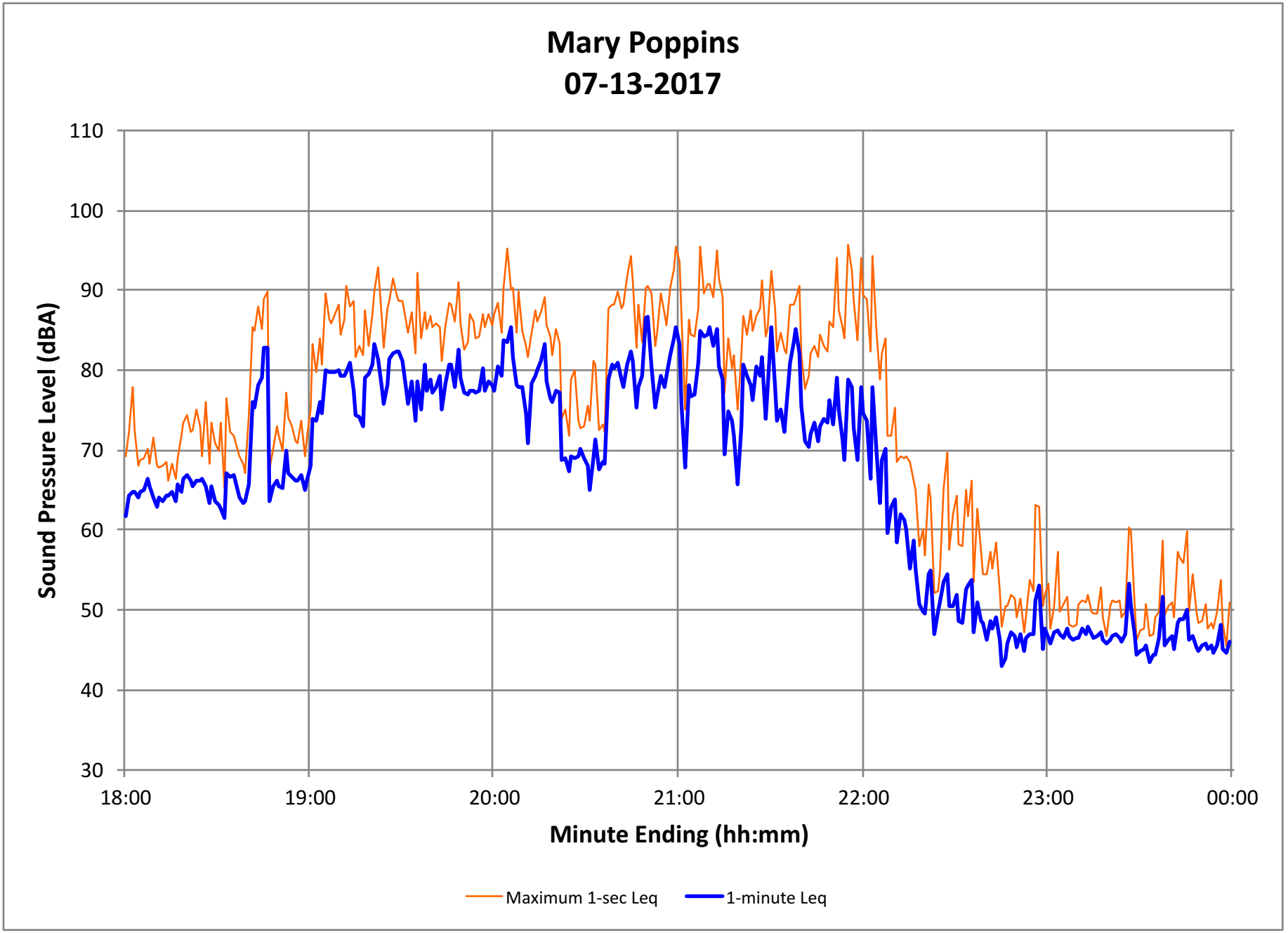

Mary Poppins
07-08-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

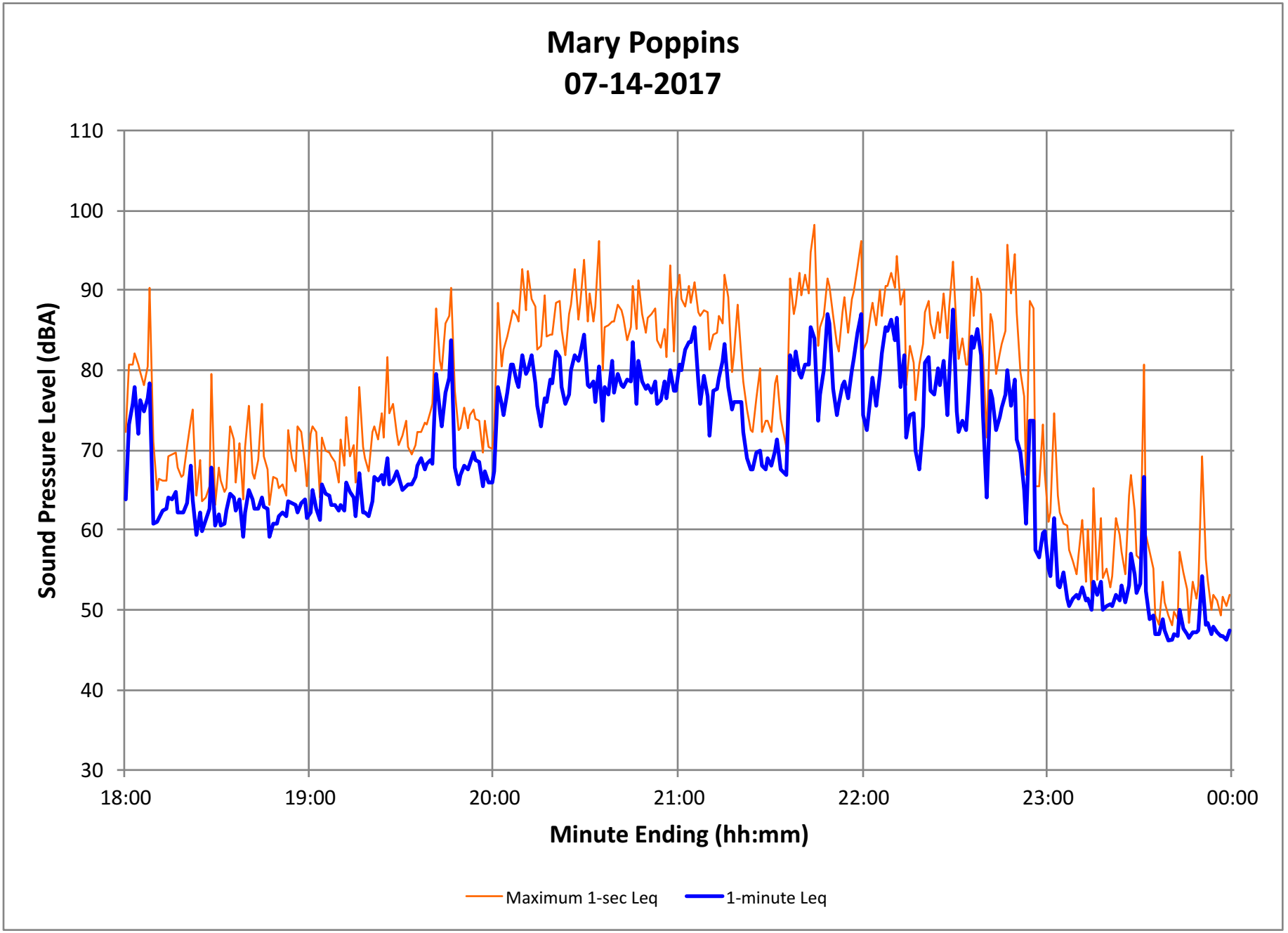

Pokey LaFarge
07-09-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

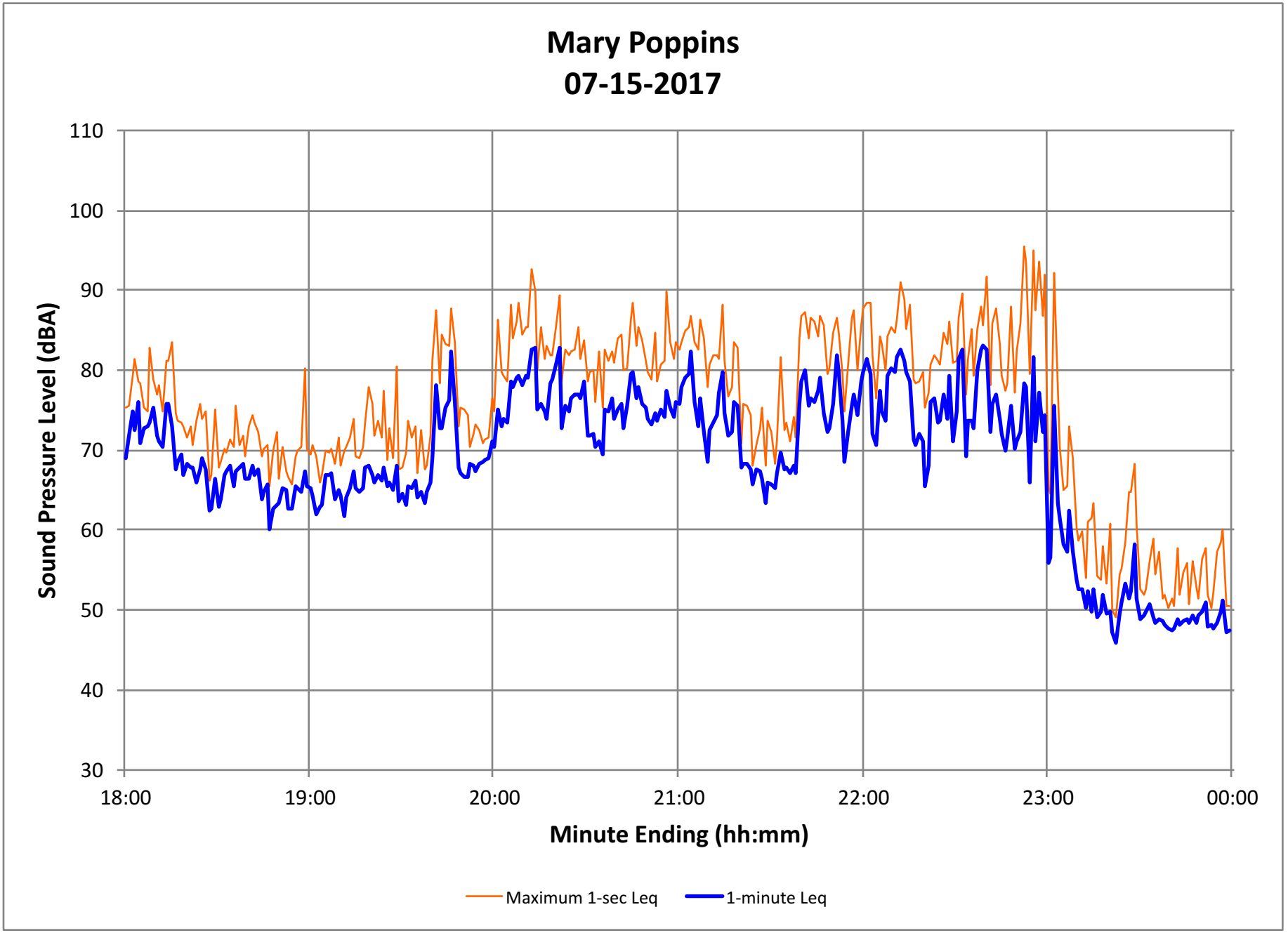

Movie
07-10-2017
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq

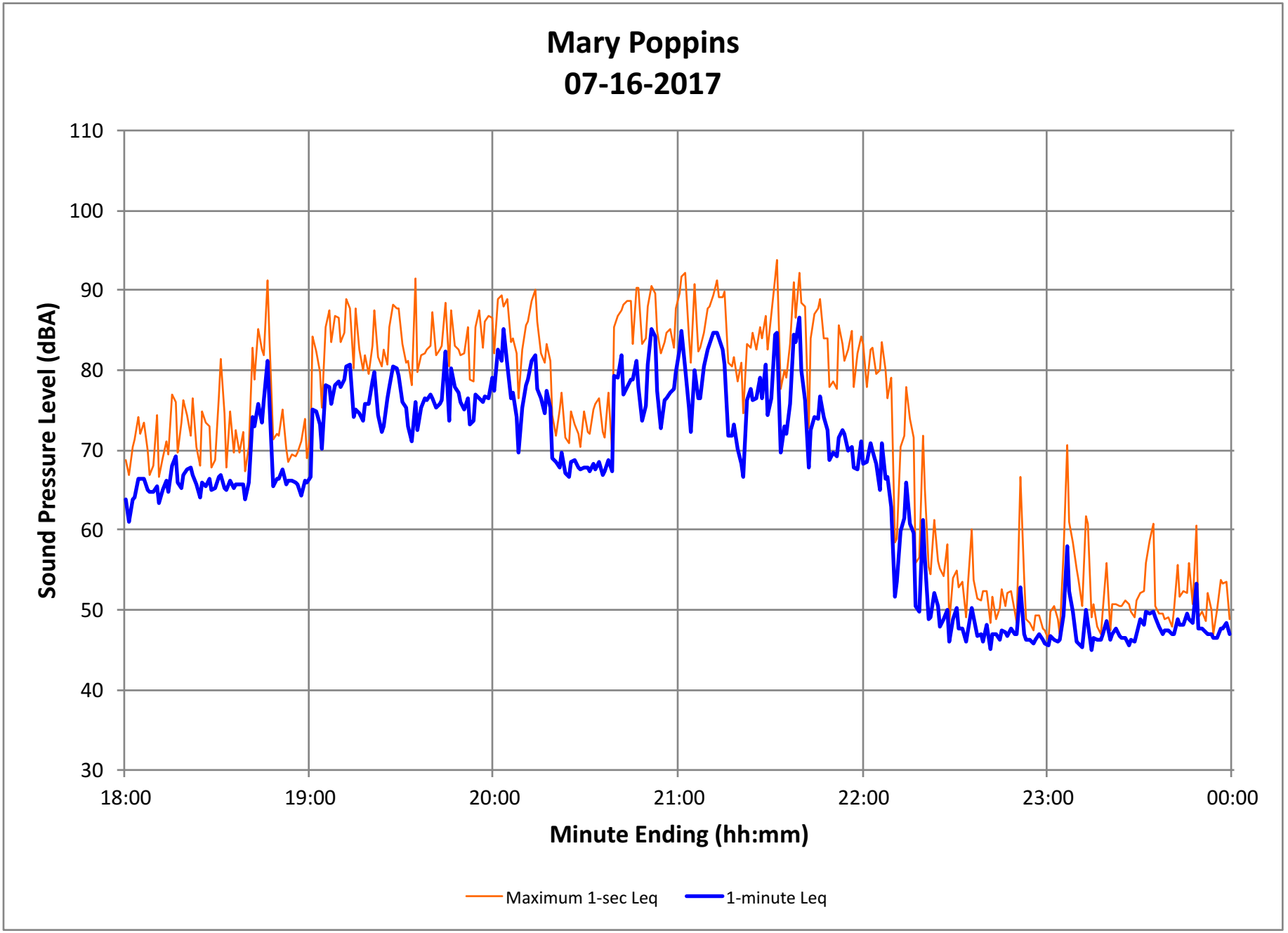

No Event
07-11-2017
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq


Foy Vance
07-12-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq


Mary Poppins
07-13-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq


Mary Poppins
07-14-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq


Mary Poppins
07-15-2017
110
100
90
80
70
60
50
40
30
Sound Pressure Level (dBA)
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq


Mary Poppins
07-16-2017
Sound Pressure Level (dBA)
110
100
90
80
70
60
50
40
30
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Minute Ending (hh:mm)
Maximum 1-sec Leq
1-minute Leq