June 9, 2015

Mr. Russell Jennings
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Subject: Proposed Sports and Campground Complex – Charlton, MA
Updates to Environmental Sound Study

Dear Mr. Jennings,

This letter and attachments supplement our previous report to you dated March 6, 2015.

Introduction

Sunset City Inc. (Sunset City) proposes to construct and operate an outdoor Sports and Campground Complex (the Complex) in Charlton, MA. A portion of the proposed Complex is to include a motocross practice track and race track.

In connection with the Town of Charlton Site Plan Review process, Sunset City has retained Cavanaugh Tocci Associates, Inc. (CTA) Consultants in Acoustics to evaluate potential environmental sound levels produced by the proposed Complex.

During the course of the Site Plan Review process, the Town of Charlton has retained Graves Engineering Inc. (Graves) to provide general engineering review services and Harris Miller Miller & Hanson Inc. (HMMH) to provide acoustical Peer Review services.

CTA's evaluation is summarized in our original March 6, 2015 report and is extensively supplemented in this current report. The supplemental evaluation has included interaction and cooperation with Graves, HMMH, and the Office of Town Planner, Town of Charlton, MA. Our interactions with these offices since the submittal of our March 6, 2015 report, have enhanced the acoustical evaluation that is summarized in this current report.

The evaluation has included extensive measurements of existing ambient sound levels at locations surrounding the Complex project site (including additional locations suggested by HMMH), measurements of sound produced by motocross bikes (observed and corroborated by HMMH), computer modeling of future sound levels at locations surrounding the Complex project site, comparisons between existing measured and estimated future sound levels, and an evaluation of future sound levels in accordance with applicable noise regulations.

The primary purposes of this current supplemental report are to:

- Summarize the additional sound monitoring conducted during April and May 2015
- Update the corresponding Massachusetts Department of Environmental Protection (MassDEP) sound level limits.
- Present the results of updated computer modeling based on sound measurements of motocross bikes conducted on/near the project site, and attended by both CTA and HMMH.

Additional Sound Monitoring

Our initial sound monitoring at locations adjacent/near to residential properties in the vicinity of the project site was conducted during February 2015, and was summarized in our March 6, 2015 report.

In response to the suggestion of HMMH following peer review of our March 6, 2015 report, we conducted a second round of sound monitoring at an expanded number of locations during late-April into early-May 2015.

Figure 1 is an aerial photograph annotated to show the boundaries of the Complex property, as well as the town line between Sturbridge, MA and Charlton, MA. Shown in Figure 1 are locations where sound measurements of existing ambient conditions were conducted (SM1 – SM8), and the locations of representative residential receptors evaluated in our acoustical computer modeling of the Complex (R1 – R14) and referred to throughout this report. The locations that were included in our March 2015 report have been shown with grey shading. The locations added in the revised study appear without shading.

Sound Monitoring Locations

The locations selected for the additional sound monitoring during April/May include the three locations that were monitored previously in February (SM1 – SM3); a long-term monitor was also placed at SM4, which in our previous study had been a short-term measurement location. In addition to the four previous sound monitoring locations, four additional locations as suggested by HMMH were included in the second round of sound monitoring.

The sound monitoring locations are summarized as follows:

- SM1 was near the eastern terminus of Ladd Road, close to an operating farm owned by the project proponent, and approximately 3000 feet from Interstate 90.
- SM2 was along Brookfield Road, approximately between North Sullivan Road and Massachusetts Route 49.
- SM3 was near the eastern property line, approximately 2500 feet south of SM2.
- SM4 was near the residence at the southern terminus of Ladd Road, on property which has recently been acquired by the project proponent.
- SM5 was set back approximately 850 feet from Brookfield Road, near the southern border of the Sydney Circle residential development.
- SM6 was along North Sullivan Road, near the northeast corner of Upper Sibley Pond.
- SM7 was along Ladd Road, approximately 550 feet east of County Route 49. This location is also analogous to the sound level at residential receptors with a similar setback on the west side of Route 49.
- SM8 was set back approximately 300 feet from Brookfield Road, near the southern edge of the residential backyard.

Continuous Monitoring Data

To identify typical trends in existing ambient environmental sound levels, and to quantify time varying ambient sound levels in the community, continuous sound monitoring was performed at locations SM1 through SM8. The continuous monitors were installed for an approximate 7-day period beginning Tuesday April 28, 2015.

For the continuous measurements, sound levels were monitored using data-logging sound level meters outfitted with ½ inch electret microphones and windscreens. The specific instruments used were Rion model NL-31 (SM1 – SM4: A-weight only), Rion model NL-52 (SM5, SM6, SM8: spectral), and Larson Davis model 831 (SM7: spectral). The instruments were calibrated before the measurement period using a Larson Davis CAL-250 acoustical calibrator.

During the measurements, the sound monitor microphone support struts were mounted on tree branches at locations approximately 5 to 6 feet above the ground. These instruments and their use conform to ANSI S1.4 for Type 1 (ISO 61672 for class 1) precision sound measurement instrumentation, and have calibration certificates traceable to the National Institute of Standards and Technology (NIST).

For this study, the sound monitors were programmed to record the following one-hour A-weighted environmental noise descriptors:

- Maximum and minimum sound levels (L_{Amax}, L_{Amin})
- Percentile sound levels (L_{A99}, L_{A90}, L_{A50}, L_{A10}, L_{A01})
- Equivalent sound level (L_{Aeq})

Attached Figures 2a – 2h present a series of measured hourly ambient sound levels at the continuous monitoring locations. The battery packs of the sound monitors installed at SM5, SM6 and SM8 did not provide sufficient power for the full one-week monitoring interval, and as such automatically terminated data collection after approximately 4 days of measurements (the 4 days of data collected by these three monitors prior to automatic shutdown are fully valid).

Environmental Conditions during Sound Monitoring

During the 1-week monitoring period of the supplemental Spring 2015 sound study, wind directions were highly variable, with speeds generally between 1 and 20 mph. There was only one minor precipitation event (rain) which occurred on Thursday, April 30. In local forests, it was observed that most deciduous trees were leaved, and that local soils were fully thawed.

It should be noted that sound propagation over long distances (e.g. greater than 1000 feet) is significantly influenced by meteorological effects. The effects are further complicated by local variations in wind direction and speed. As suggested by the Peer Reviewer, references to meteorological data in this report have been based on weather data measured and reported from weather station KORH (Worcester Regional Airport), which is the closest professional weather station of which we are aware. Weather data described in this study are as reported by Weather Underground[1].

[1] http://www.wunderground.com/weather-forecast/zmw:01602.3.99999

Insect Sound in Sound Monitoring Data

It is believed that insect noise may have contributed to some of the background sound levels measured during the second round of sound monitoring (Spring 2015). Sound produced by insects in the eastern United States is typically found in octave bands from approximately 2 kHz and greater. In order to minimize the effects of insect sound in the ambient sound monitoring data, we have re-calculated the A-weighted sound levels measured at SM5 – SM8 for the octave bands ranging from 31.5 Hz to 1 kHz.

On the basis of the review of insect sound, it is our opinion that it may be appropriate to deduct 2 dBA from the ambient sound monitoring data in order to account for insect contributions. The data presented in Table 1 below have been adjusted for insect sound as described above, which has the effect of <u>lowering</u> the reported ambient A-weighted sound levels.

Limits for Sunset City Complex Sound

Table 1 presents a summary of measured ambient sound levels at SM1 – SM8, as well as corresponding sound level limits developed on the basis of the MassDEP Policy.

Measurement Location	**Model Receptors**	**Daytime ambient, $L_{A90,1\text{-hr.}}$ [dBA]**[1, 2, 5]	**MassDEP Limit [dBA]**
SM1	n/a[3, 4]	30	40
SM2	R6 – R8	37	47
SM3	n/a[4]	32	42
SM4	R10	50	60
SM5	R2 – R4, R13	38	48
SM6	R1, R14	41	51
SM7	R9, R11 – R12	36	46
SM8	R5	36	46

[1] Arithmetic average of minimum daily $L_{A90,1\text{-hr.}}$ sound levels measured between 8:00 AM to 8:00 PM (proposed Complex operating hours).

[2] Based on continuous sound monitoring gathered at noted location.

[3] The nearest residential receptor is the home and farm of the project proponent.

[4] This location was included for consistency with our previous report. New monitor locations appear to be located closer to this residence.

[5] All ambient sound levels reported in Table 1 reduced by 2 dB to discount effects of insect sound.

Table 1. Summary of measured ambient sound levels and corresponding MassDEP sound level limits
Sunset City Sports and Campground Complex (Charlton, MA)

Updated Facility Sound Assessment

Acoustic Modeling Methodology

Sound levels associated with motocross practice and racing at the Complex have been calculated using CadnaA environmental sound modeling software (Version 4.5.147, 32-bit, DataKustic GmbH). The CadnaA sound modeling software uses algorithms and procedures described in International Standard *ISO 9613-2:1996 Acoustics - Attenuation of sound during propagation outdoors – Part 2: General method of calculation*. The methodology described in this standard provides estimates of sound levels for meteorological conditions that are favorable to the propagation of sound (receptor downwind from source, with a wind speed of between 1 and 5 m/s). This methodology is also valid for sound propagation under well-developed moderate ground-based temperature inversions, which commonly occur on clear calm nights.

Receptor sound levels were calculated using the following factors:

- Source sound power level (in octave bands)
- Distances between source and receptor locations (geometric divergence)
- Atmospheric absorption (10°C and 70% relative humidity)
- Reflections from building and barrier structures
- Screening by obstacles such as topographic contours and earthen berms
- Attenuation by foliage and ground effects

Acoustic Modeling Scenario

In order to describe the variable configuration of motocross motorcycles operating on the proposed track, we have placed 20 individual point sources at equal spacing along the track perimeter. This configuration is typical of motocross operations for the majority of the time in which the track is expected to operate.

Sunset City Complex Sound Sources

The primary source of Complex sound considered in this analysis is that produced by multiple motocross bikes as they race around a dirt track. The source sound power of these bikes was determined through sound pressure level measurements conducted on the Complex site, observed and corroborated by the Peer Reviewer. These measurements were conducted on May 21, 2015, and were generally in accordance with Appendix I of Subparts D and E of 40 CFR Part 205[2].

As recommended in 40 CFR Part 205, passby sound pressure levels produced by individual motocross bikes operating at open throttle were measured at a distance of 50 feet. Sound measurements were conducted simultaneously on both sides of a designated travel lane, and each bike was measured a minimum of three full-throttle passby events. The average of each passby L_{max} sound level was reported for both sides of the travel lane, and the greater of these two were used to determine the average sound power of a motocross bike operating at open throttle. As with the measurements, this method of reporting data is generally in accordance with the 40 CFR Part 205 method. The sound power level was calculated using adjustments for hemispherical divergence over a reflective ground plane.

[2] Typical USEPA F-76a Test Procedure for determining vehicle sound emissions

Sunset City Complex Sound Level Estimates

Hourly L_{eq}

As with many environmental sound sources, sound emissions from the Complex will vary considerably over time. As such, L_{eq} sound levels are appropriate descriptors with which to assess the acoustic impact of Complex sound, as these descriptors evaluate the overall sound energy produced by track operations. In our analysis of L_{eq} sound levels, we have assumed that there would be four 10-minute motocross races during a one-hour interval, with periods of relative quiet interspersed between. Because the Complex will operate approximately 40 minutes in a given hour (i.e. 60 minutes), it is appropriate to reduce the receiver sound level by $10 \times \log_{10}(60/40) \cong 1.8$ [dB] in order to calculate the hourly L_{eq}.

The energy-average Complex sound level for a one-hour period ($L_{Aeq,\ 1\text{-hr.}}$) has been compared to the MassDEP sound level limits discussed above ($L_{A90,\ 1\text{-hr.}}$); this comparison is presented in Table 2a below. The values included in Table 2a have been reduced by approximately 1.8 dB in order to produce an hourly L_{eq}, as described above.

Description	A-weighted sound level [dBA]													
	R1	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*R9*	*R10*	*R11*	*R12*	*R13*	*R14*
Sunset City $L_{Aeq,\ 1\text{-hr.}}$	43	44	40	40	40	43	42	39	42	43	41	40	39	46
MassDEP limit [1]	51	48	48	48	46	47	47	47	46	60	46	46	48	51

[1] Based on average of daily minimum $L_{A90,\ 1\text{-hr.}}$ sound levels measured between 8:00 AM and 8:00 PM over entire monitoring interval (weekdays and weekends)

Table 2a. Hourly energy-average sound levels produced by motocross activity – as designed (no noise control measures) Sunset City Sports and Campground Complex (Charlton, MA)

Instantaneous Sound Level

It is often considered good technical practice to compare noise statistics of similar duration; for example the 1-hour ambient sound level might robustly be compared to the 1-hour motocross source level (as has been presented in Table 2a). That said, community reaction to intrusive noise is typically based on the sound level which occurs at a defined moment in time, as opposed to statistical descriptions of sound spread over e.g. an hour. With this in mind, the motocross sound levels included in Table 2b have not been reduced to compensate for the duration of operation. These “instantaneous” levels have been compared to the MassDEP sound level limits.

Description	A-weighted sound level [dBA]													
	R1	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*R9*	*R10*	*R11*	*R12*	*R13*	*R14*
Sunset City L_A	45	45	42	41	42	45	44	41	43	45	43	42	41	47
MassDEP limit [1]	51	48	48	48	46	47	47	47	46	60	46	46	48	51

[1] Based on average of daily minimum $L_{A90,\ 1\text{-hr.}}$ sound levels measured between 8:00 AM and 8:00 PM over entire monitoring interval (weekdays and weekends)

Table 2b. Typical “instantaneous” sound levels expected during motocross activity – as designed (no noise control measures) Sunset City Sports and Campground Complex (Charlton, MA)

Conclusion

CTA has completed a review of environmental sound associated with the proposed Sunset City Sports and Campground Complex. This review has included a survey of applicable noise regulations, baseline acoustic survey, and computer modeling to estimate future sound levels at nearest residential receptors. In response to the Town's Peer Reviewer, the environmental sound evaluation has also included a second round of community sound monitoring, as well as additional detailed sound measurements of operating motocross bikes in order to refine the sound power inputs used in the computer model.

On the basis of this review, it has been concluded that proposed Complex sound levels will comply with the applicable MassDEP noise regulation. Based on the inherent variability of meteorological conditions, there may be some times during the day that the Complex would be audible, and others during which the Complex would be inaudible.

It is important to note that during a "live demonstration" with a dozen motocross bikes operating on the proposed Complex property (motocross bikes were circling a large cleared horse-pasture area, that is located in the near vicinity of the proposed Complex practice/race motocross tracks locations, to simulate practice/race track operating conditions) numerous people associated with the Town of Charlton Peer Review process travelled to residential-area locations surrounding the Complex project site and conducted informal "listening evaluations" at the residential locations, while the motocross bikes were operating.

It is our understanding that the people conducting these informal listening tests included the Peer Reviewer, and two Charlton Planning Board members.

It is our further understanding that motorcycle sound was either barely audible or inaudible at each/all of the off-site "listening test" receptor locations at surrounding residential properties.

In particular, the Peer Reviewer witnessed all of our motocross bike sound level measurements, conducted corroborating measurements of his own during our measurements; and witnessed and listened to motocross bike activities on-site, and conducted listening tests at multiple residential locations off-site during the motocross bike activities.

It has been a pleasure providing these services to Sunset City LLC. Please don't hesitate to contact us if we can provide any further information.

Yours Sincerely,
CAVANAUGH TOCCI ASSOCIATES, INC.

Brion G. Koning

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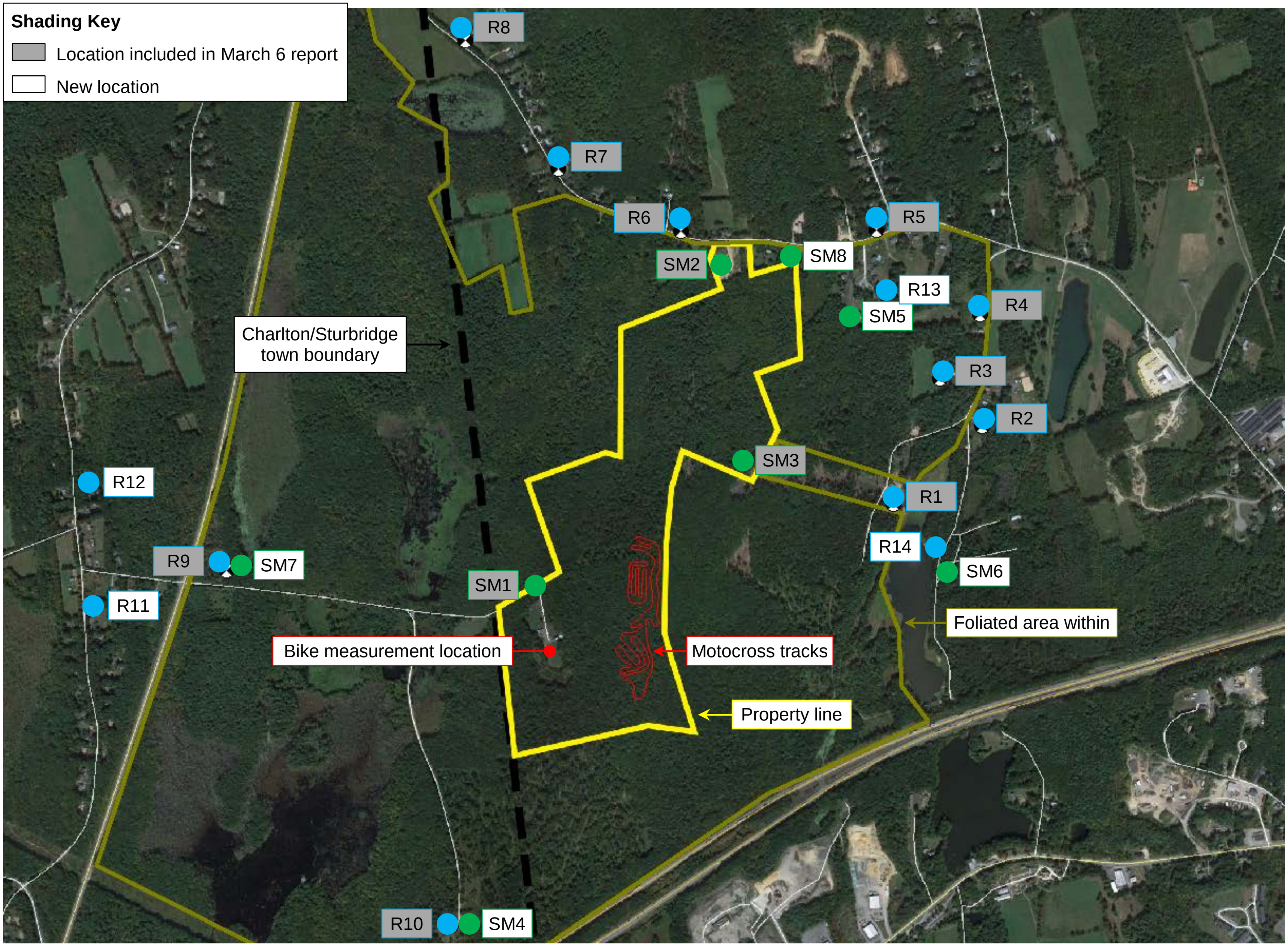
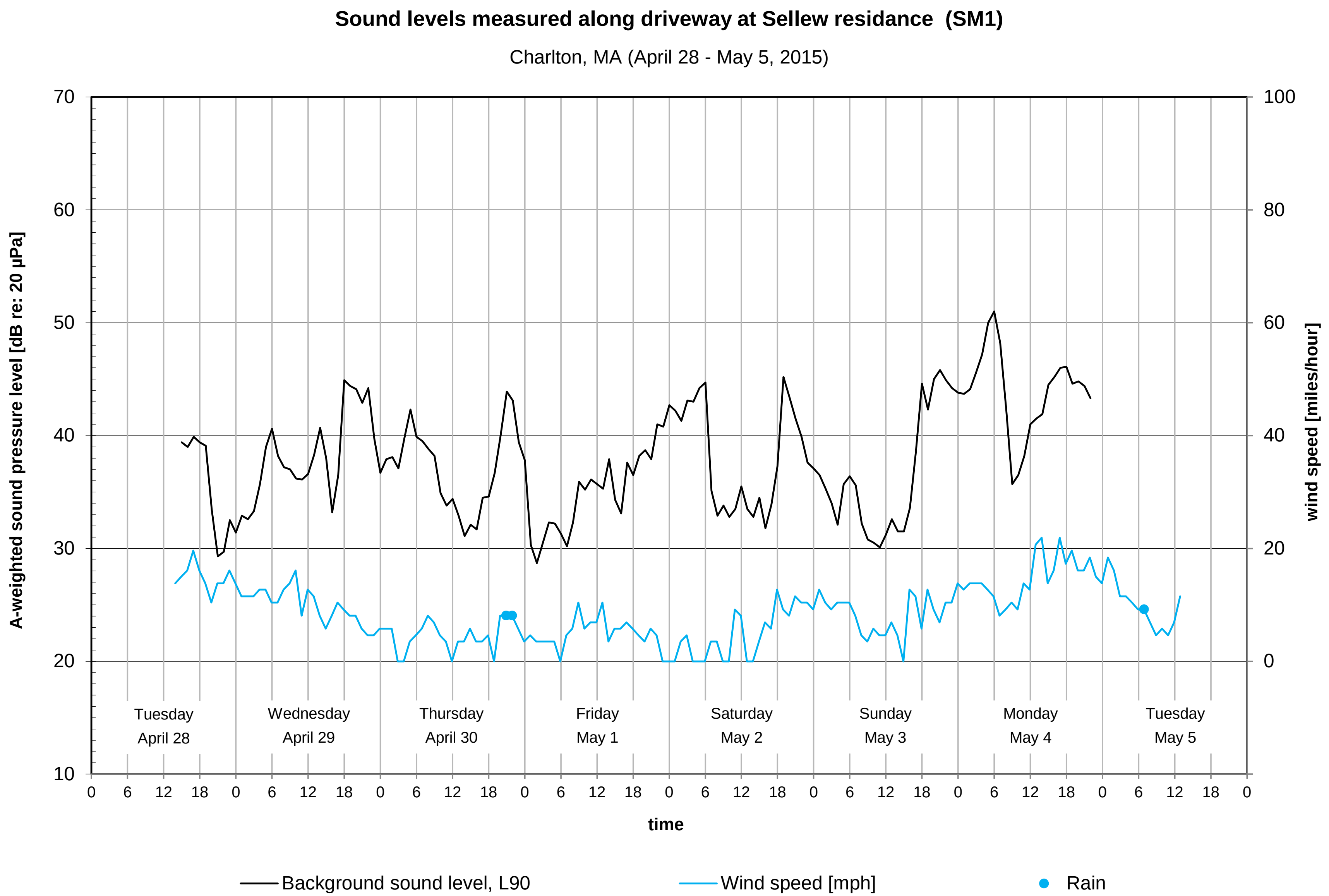


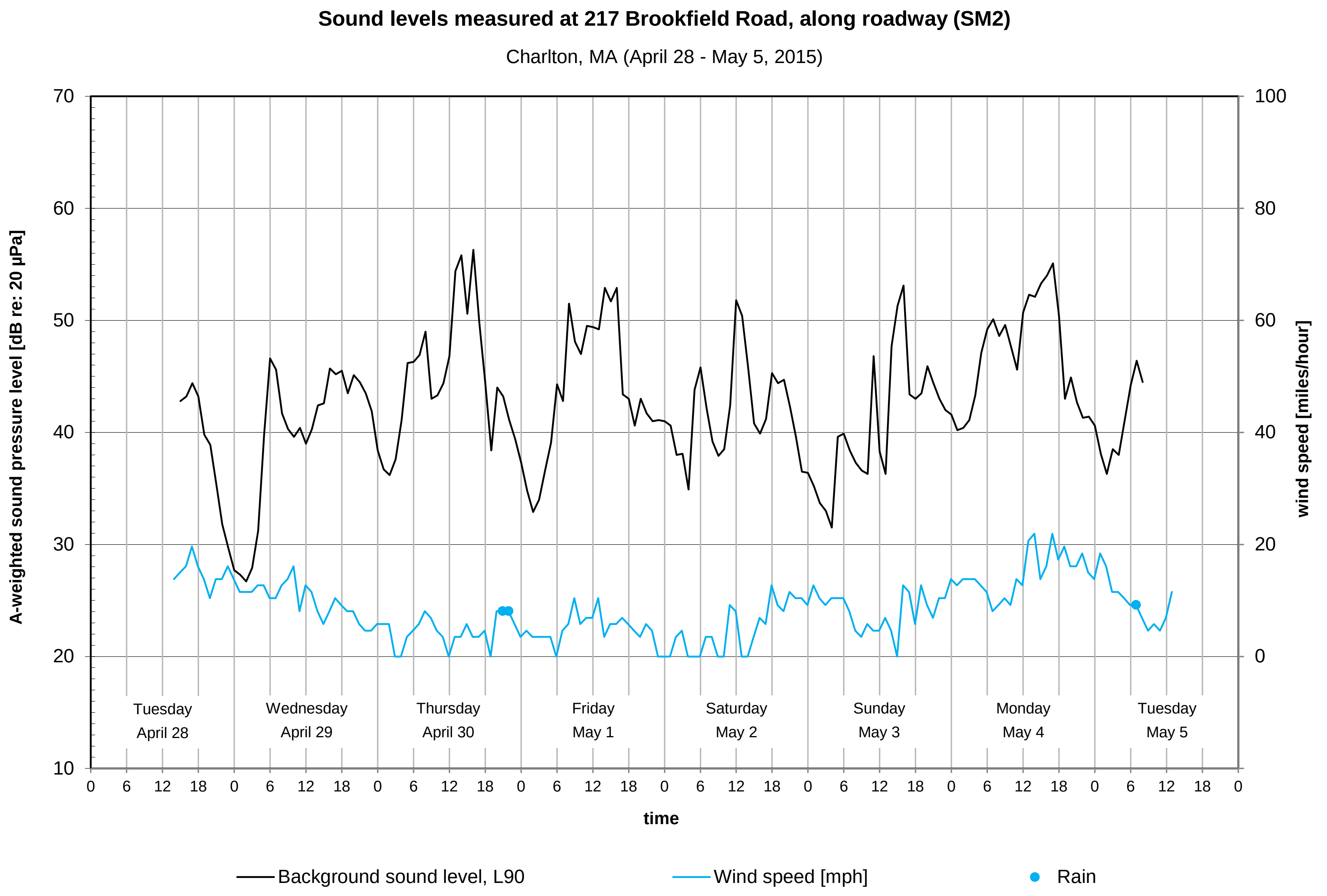
Figure 1. Complex overview showing location of sound measurements (SM1 – SM8, green) and computer model receptors (R1 – R14, blue)
Sunset City Sports and Campground Complex (Charlton, MA)



R0

Figure 2a. Sound monitoring data measured at SM1 (as measured, no insect correction)
Sunset City Sports and Campground Complex (Charlton, MA)

cta



R5

Figure 2b. Sound monitoring data measured at SM2 (as measured, no insect correction)
Sunset City Sports and Campground Complex (Charlton, MA)

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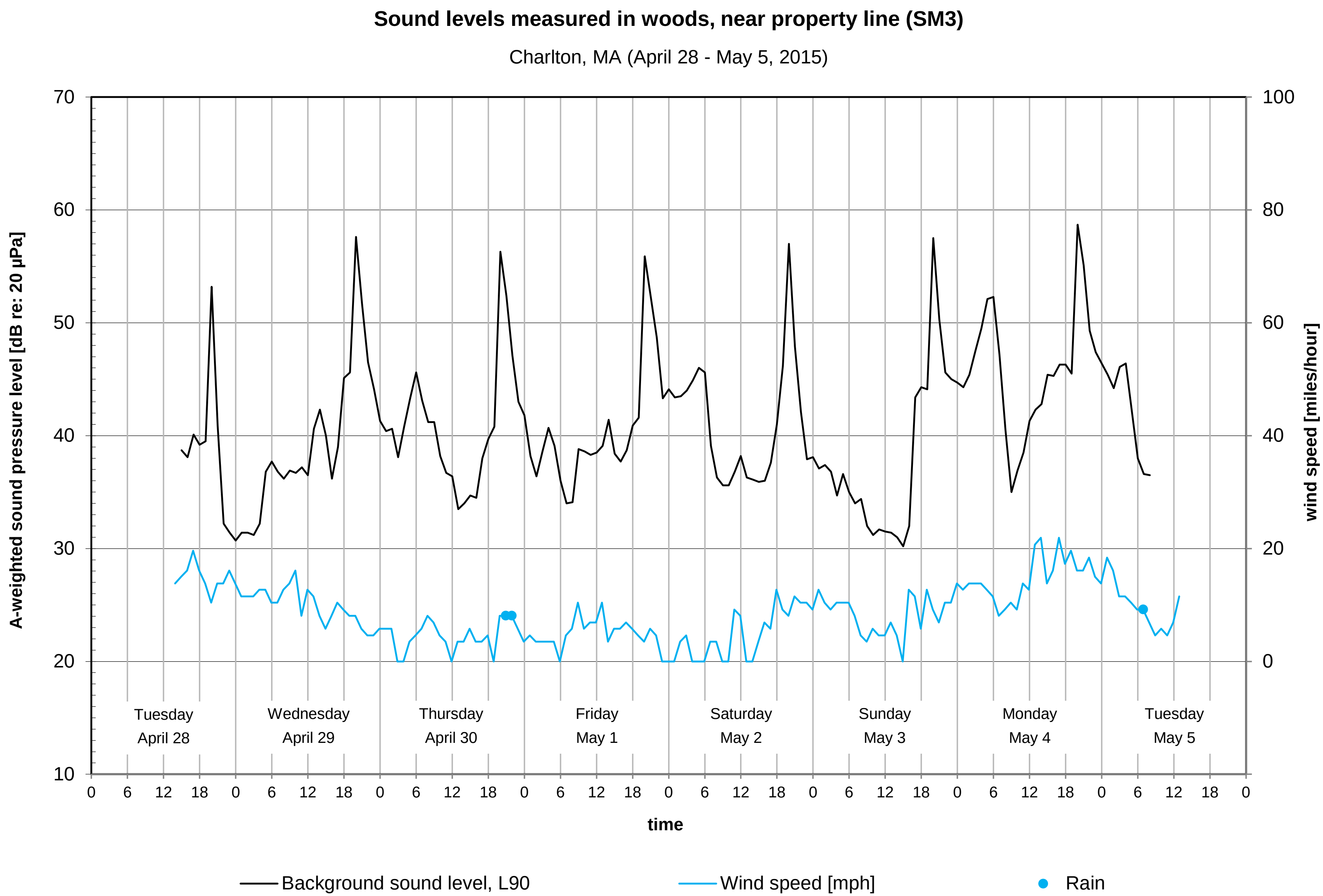

R4

Figure 2c. Sound monitoring data measured at SM3 (as measured, no insect correction)
Sunset City Sports and Campground Complex (Charlton, MA)

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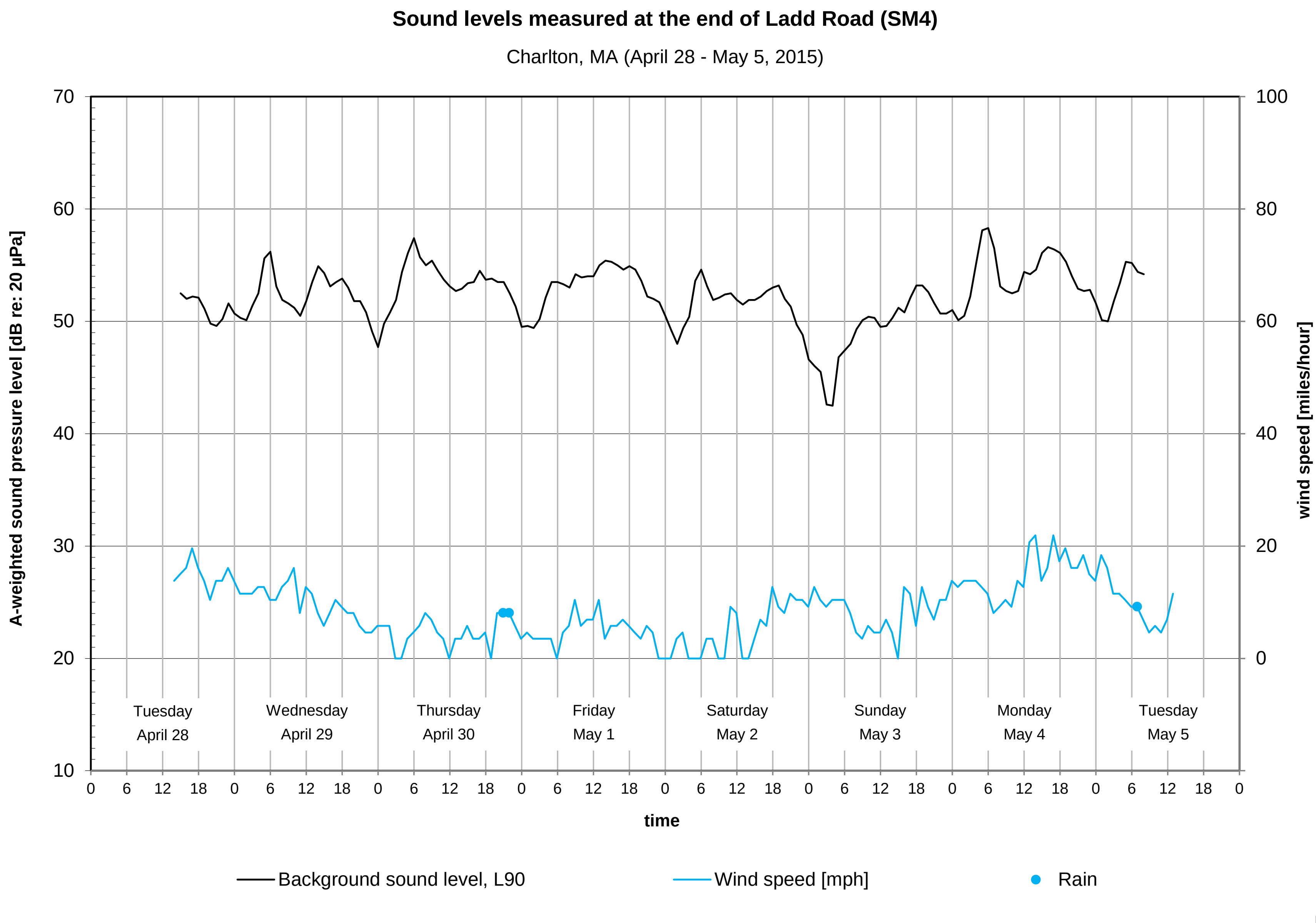

Figure 2d. Sound monitoring data measured at SM4 (as measured, no insect correction)
Sunset City Sports and Campground Complex (Charlton, MA)

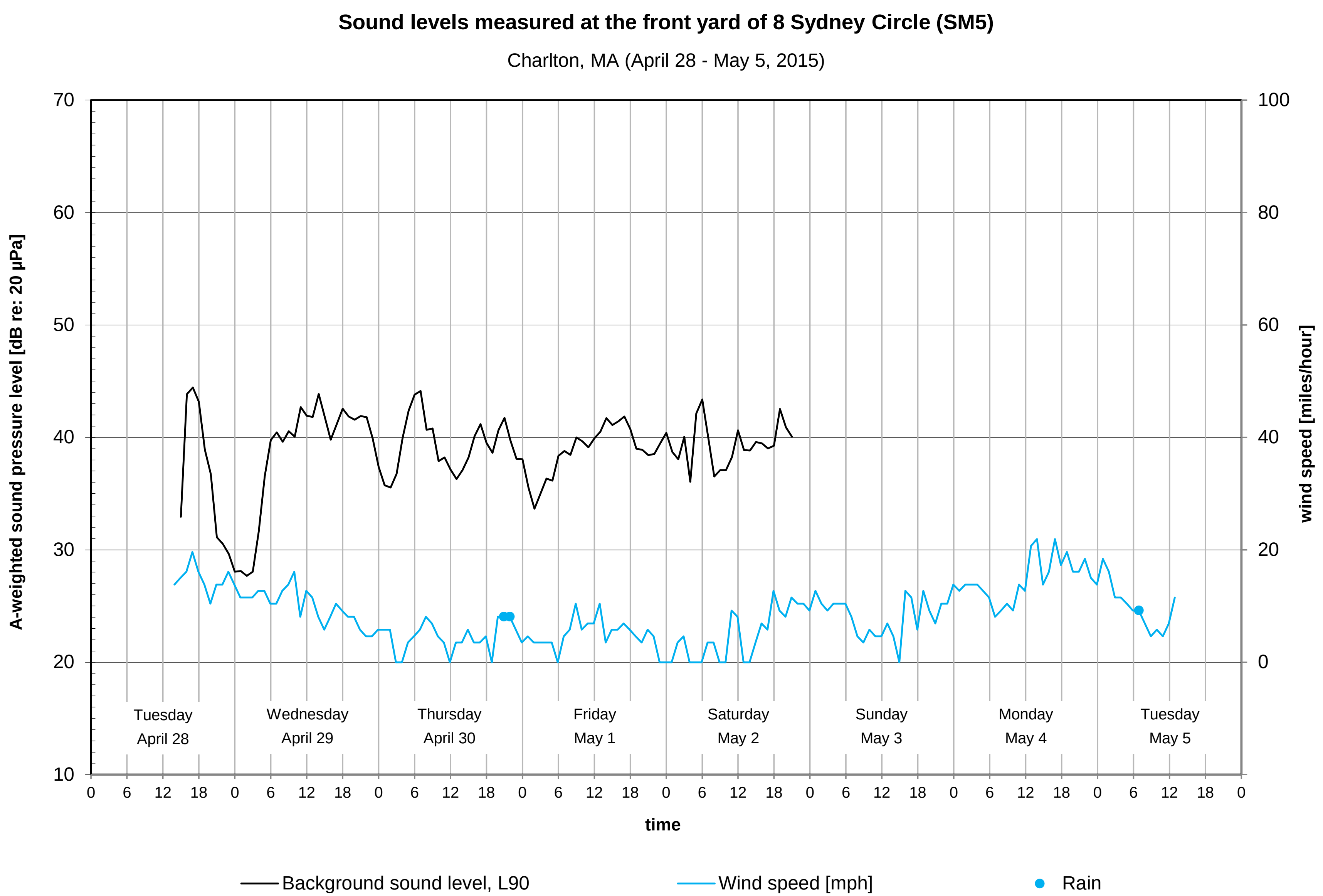

Figure 2e. Sound monitoring data measured at SM5 (with insect correction: truncation above 1 kHz OB)
Sunset City Sports and Campground Complex (Charlton, MA)

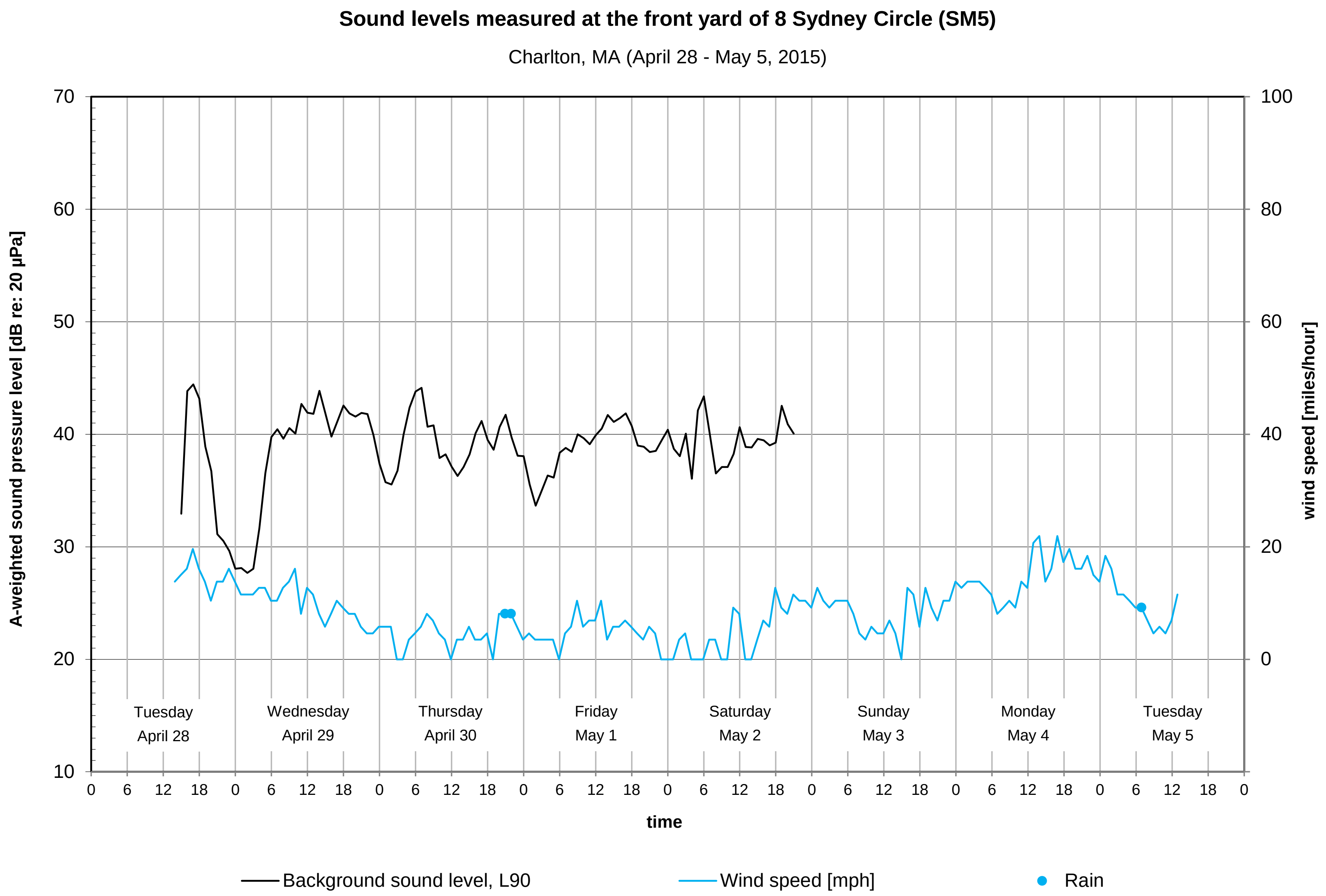

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Figure 2f. Sound monitoring data measured at SM6 (with insect correction: truncation above 1 kHz OB)
Sunset City Sports and Campground Complex (Charlton, MA)

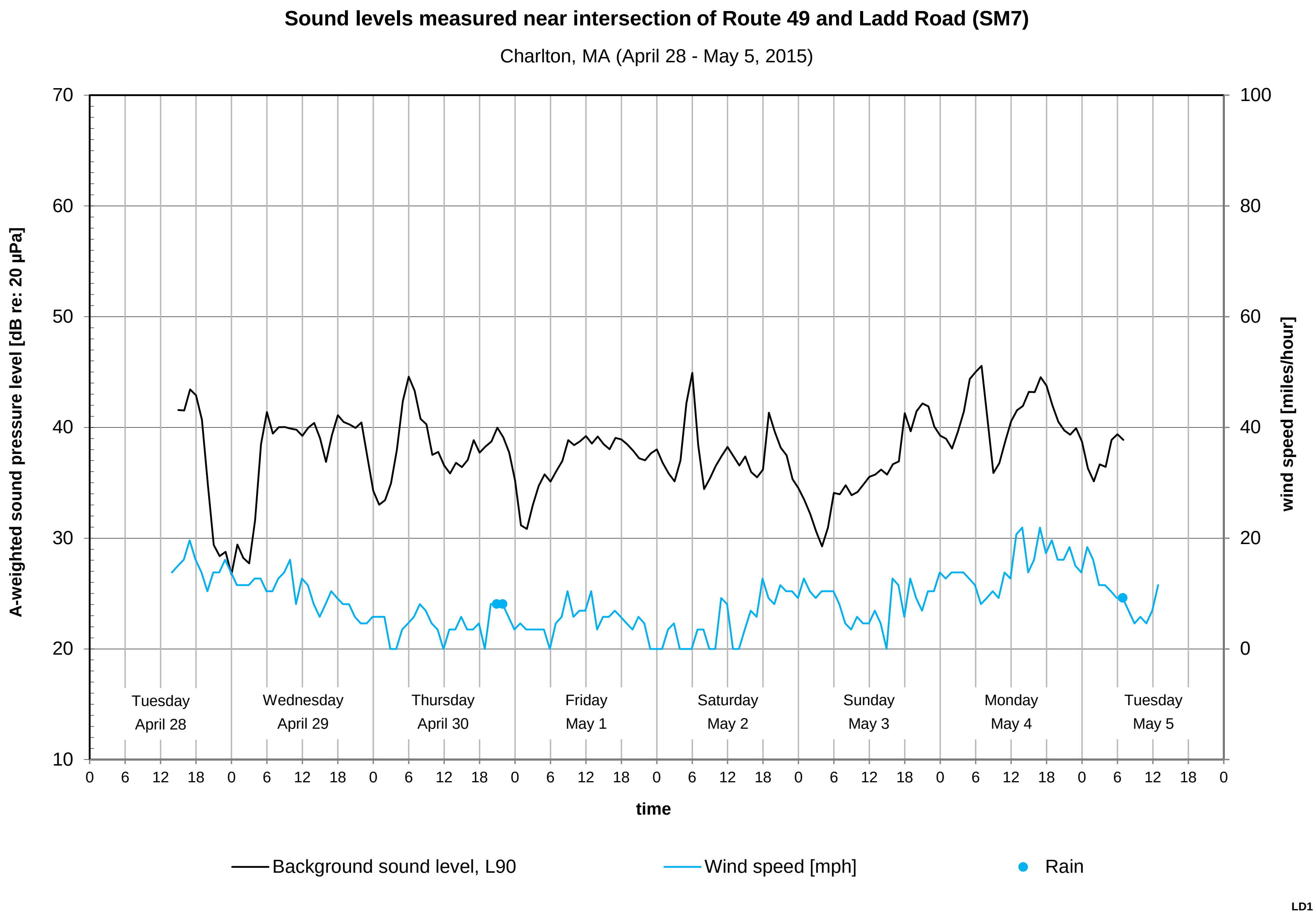

Figure 2g. Sound monitoring data measured at SM7 (with insect correction: truncation above 1 kHz OB)
Sunset City Sports and Campground Complex (Charlton, MA)

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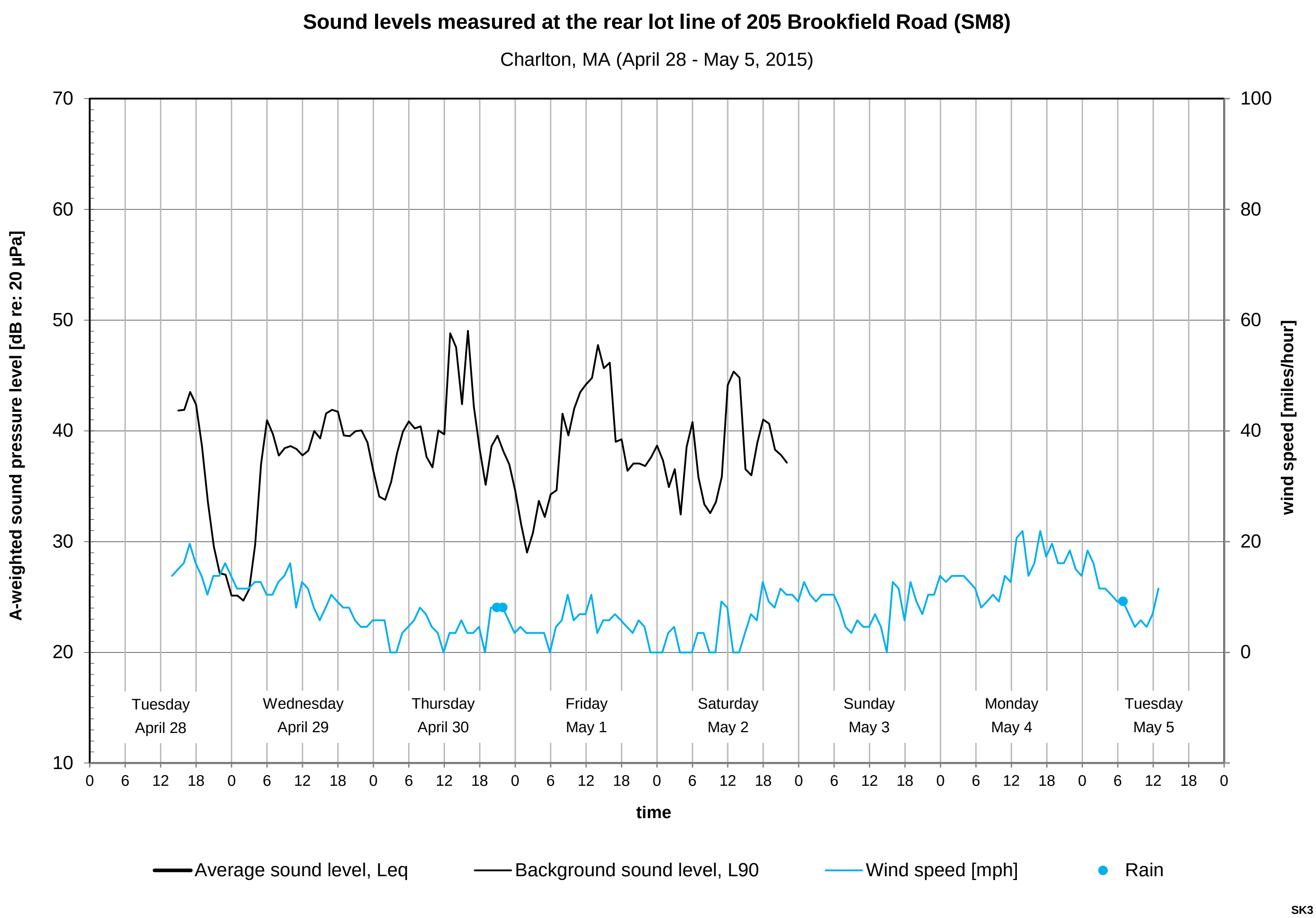

Figure 2h. Sound monitoring data measured at SM8 (with insect correction: truncation above 1 kHz OB)
Sunset City Sports and Campground Complex (Charlton, MA)

Appendix A

Sound Measurement Terminology

Sound Measurement Terminology

In order to quantify the amplitude, frequency, and temporal characteristics of sound, various acoustical descriptors are used. The following is an introduction to acoustic terminology that is used in this report.

Sound Level

Sound levels are typically quantified using a logarithmic decibel (dB) scale. The use of a logarithmic scale helps to compress the wide range of human sensitivity to sound amplitude into a scale that ranges from approximately 0 to 180 dB. Note however, that the use of the logarithmic scale prevents simple arithmetic operations when combining the cumulative impact of sources. For example, two sources of equal sound level operated simultaneously results in a combined sound level that is only 3 dB higher than if only one source was operated alone. An important feature of the human perception of continuous sound is that an increase or decrease in sound pressure level by 3 dB or less is barely perceptible, and an increase or decrease by 10 dB is perceived as a doubling or halving of noise level.

A-weighting

Generally, the sensitivity of human hearing is restricted to the frequency range of 20 Hz to 20,000 Hz. However, the human ear is most sensitive to sound in the 500 Hz to 5,000 Hz frequency range. Above and below this range, the ear becomes progressively less sensitive. To account for this feature of human hearing, sound level meters incorporate filtering of acoustic signals that corresponds to the varying sensitivity of the human ear to sound at different frequencies. This filtering is called A-weighting. Sound level measurements that are obtained using this filtering are referred to as “A-weighted sound levels” and are signified by the identifier, dBA. A-weighted sound levels are widely used for evaluating human exposure to environmental sounds. To help place A-weighted sound levels in perspective, Figure A-1 contains a scale showing typical sound levels for common interior and environmental sound sources.

Spectral Characteristics – Octave and 1/3 Octave Band Sound Levels

To characterize a sound, it is often necessary to evaluate the frequency distribution of the sound energy. As mentioned before, the frequencies of most interest where human exposure is concerned range between 20 Hz and 20,000 Hz. This frequency range is commonly divided into octave bands, where an octave band is a range of frequencies. Each octave band is referred to by its center frequency and has a bandwidth of one octave (a doubling of frequency). To cover the full range of human hearing, it is necessary to measure sound in 10 separate octave bands. Typically, the lowest frequency band measured has a center frequency of 31.5 Hz. The next frequency band has a center frequency of 63 Hz. This geometric series continues to the highest frequency band that has a center frequency of 16,000 Hz.

A set of octave band sound levels to describe a particular sound is called an octave band spectrum. Covering the full range of hearing, an octave band spectrum would have 10 values, one for each band. Under certain circumstances, more frequency resolution in acoustical data is needed to identify the presence of tonal sounds. A 1/3 octave band spectrum uses filters that divide each octave band into 3 separate frequency bands. Note that octave band and 1/3 octave band sound levels are not usually A-weighted, with their units being dB.

Environmental Noise Descriptors

Sound levels in the environment are continuously fluctuating and it is difficult to quantify these time-varying levels with single number descriptors. Statistical approaches, which use *percentile sound levels* and *equivalent sound levels*, are often used to quantify the temporal characteristics of environmental sound.

Percentile sound levels (L_n) are the sound levels that are exceeded for specific percentages of time within a noise measurement interval. For example if a measurement interval is one hour long, the 50th percentile sound level (L_{50}) is the sound level that is exceeded for 30 minutes of that interval. Common practice is to include the frequency weighting used for the measurement, yielding a compound descriptor such as L_{A50} in the case of the previous example.

- L_{90} is the sound level in dBA exceeded 90 percent of the time during the measurement period. The 90th percentile sound level represents the nominally lowest level reached during the monitoring interval and is typically influenced by sound of relatively low level, but nearly constant duration, such as distant traffic or continuously operating industrial equipment. The L_{90} is often used in standards to quantify the existing background or *residual* sound level.

- L_{50} is the median sound level: the sound level exceeded 50 percent of the time during the measurement period.

- L_{10} is the sound level exceeded only 10 percent of the time. It is close to the maximum level observed during the measurement period. The L_{10} is sometimes called the *intrusive* sound level because it is caused by occasional louder noises like those from passing motor vehicles or aircraft.

By using percentile sound levels, it is possible to characterize the sound environment in terms of the steady-state background sound (L_{90}) and occasional transient sound (L_{10}).

The *equivalent sound level* (L_{eq}) is the energy average of the sound level for the measurement interval. Sounds of low level and long duration, as well as sounds of high level and short duration influence this sound level descriptor.

Noise levels at night generally produce greater annoyance than do the same levels which occur during the day. It is generally agreed that a given level of environmental noise during the day would appear to be 10 dBA louder at night – at least in terms of potential for causing community concern.

The day-night average sound level (L_{dn}) is a 24-hour average A-weighted sound level where a 10 dB “penalty” is applied to sound occurring between the hours of 10:00 P.M. and 7:00 A.M. The 10 dB penalty accounts for the heightened sensitivity of a community to noise occurring at night.

When a steady continuous sound is measured, the L_{10}, L_{50}, L_{90} and L_{eq} are all equal. For a constant sound level, such as from a power plant operating continuously for a 24-hour period, the L_{dn} is approximately 6 dBA higher than the directly measured sound level.

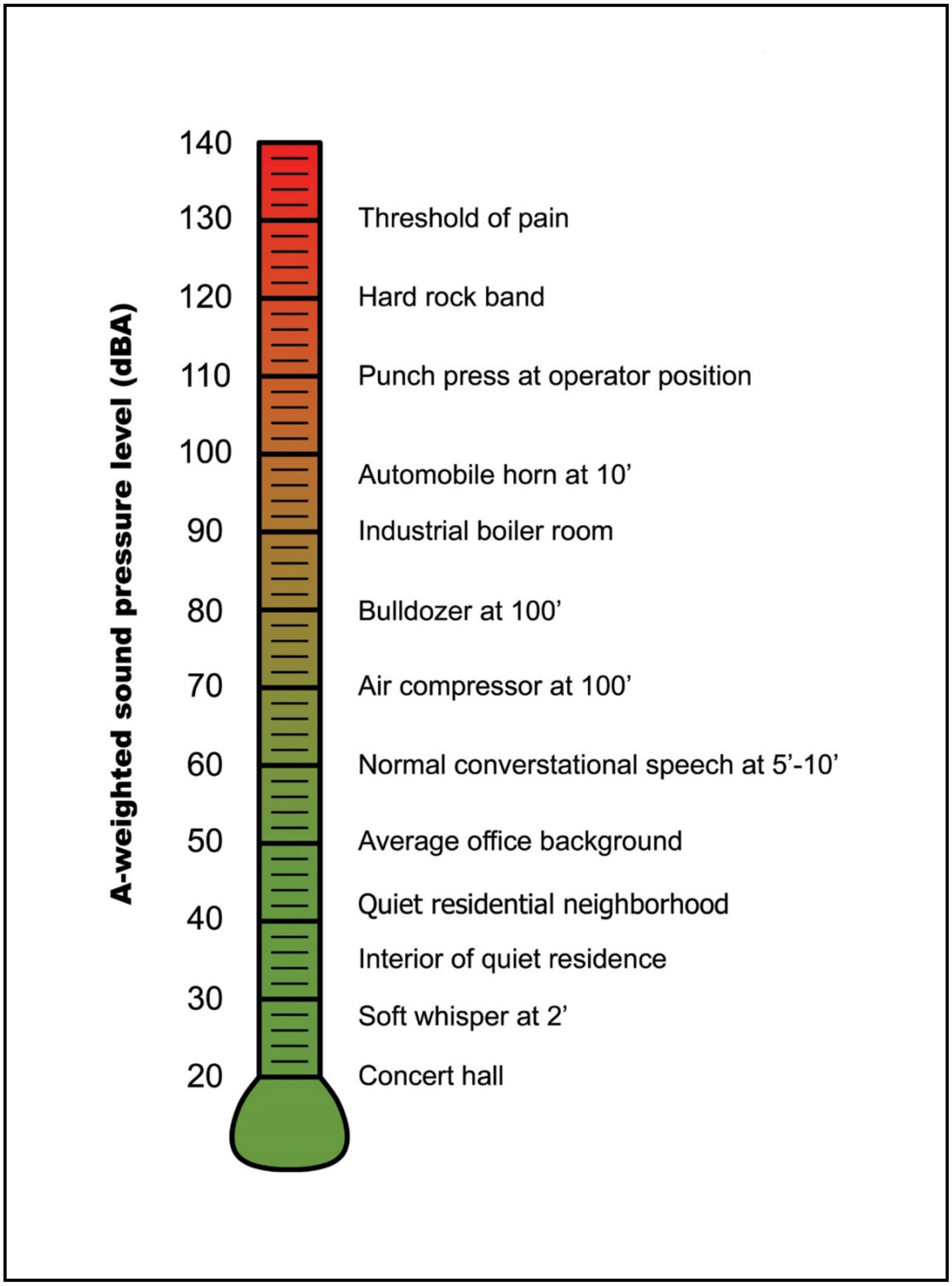

Figure A-1. Typical Sound Levels for Common Interior and Environmental Sources