

Executive Summary

These are the results of nearly six months of continuous sound measurements away from and near industrial wind turbines (IWT's) at five locations in Grey Highlands, ON, Canada. The measurement protocol was designed to allow for corrections to account for wind induced noise resulting in findings that are directly comparable to the MOE tables. The results indicate that for three IWT sites studied, the recorded sound pressure levels (SPL's) exceeded MOE's noise limits a majority of the time for non-participating receptors outside the minimum distance of 550 m and outside the 40 dBA SPL contours calculated by consultants engaged by the wind developers.¹ The other two sites were used to measure background noise levels.

For a summary of the study, please review Figures 1 -3 on pages 2 – 4. A more detailed discussion is provided below.

Results for Figures 1- 3

The first three plots on pages 2 - 4 summarise the noise problems for three Plateau sites, namely Receptors 96, 104 and 263. In the bottom graph for each figure, the MOE noise limit is shown as a **RED** plot based on 40 dBA up to 6 m/s wind speed at 10m and then ramped up to 51 dBA at 10 m/s wind speed **plus** the background noise as measured at a Grey Highlands - Brewster Lake site. An equation was fitted to the background noise at Brewster Lake and added to the MOE limit which is for the IWT contribution only. The equation for background noise is

$$\text{SPL (dBA)} = 24.503 + 2.475 * (10 \text{ m wind speed})$$

¹ It is assumed the reader has a working knowledge of the MOE WT noise guidelines.

This SPL is the best fit of all sound sources at Brewster Lake so adding the background noise results in conservative values in MOE's favour.

In the bottom graph for each figure, the MOE IWT noise limit plus background noise is subtracted from the measured SPL and shown as the **BLUE** plot. This plot shows the extent of the non-compliance of the IWT with the MOE allowable limit with the percent of time this limit is exceeded in the text box.

Discussion

Ideally, extraneous noise from tractors, airplanes, cars, trucks, lawn mowers and all other sources of noise other than nature and wind turbines are excluded from the analysis. So the percentage of time that the turbines measured exceed the MOE limit is an approximation and possibly a little higher than actually occurred if the peaks along the (black) dBA plot in the lower graph are caused by extraneous noise and not the IWT's. However, it is also quite possible that (some of) the peaks are IWT noise. But given that even the low points along the dBA plot are above the MOE allowable limit, the problem seems clearly defined. I.e. even if the peaks are not IWT noise, the average SPL (noise) is still too high.

It is apparent, just by a visual inspection of these graphs alone, that the MOE allowable limits are exceeded a great deal of the time at close distances as well as at a distance of 1.4 km. This is marked by periods of continuous exceedence in the very bottom solid **BLUE** plot.

This suggests that the model used by the MOE to predict sound pressure levels substantially under-estimates wind turbine noise.

This implies the problem is general, and not confined to the test site.

More detailed information on how Figures 1 – 3 were derived follows on pages 5 -24. A map with IWT and receptor locations is given on p. 5.

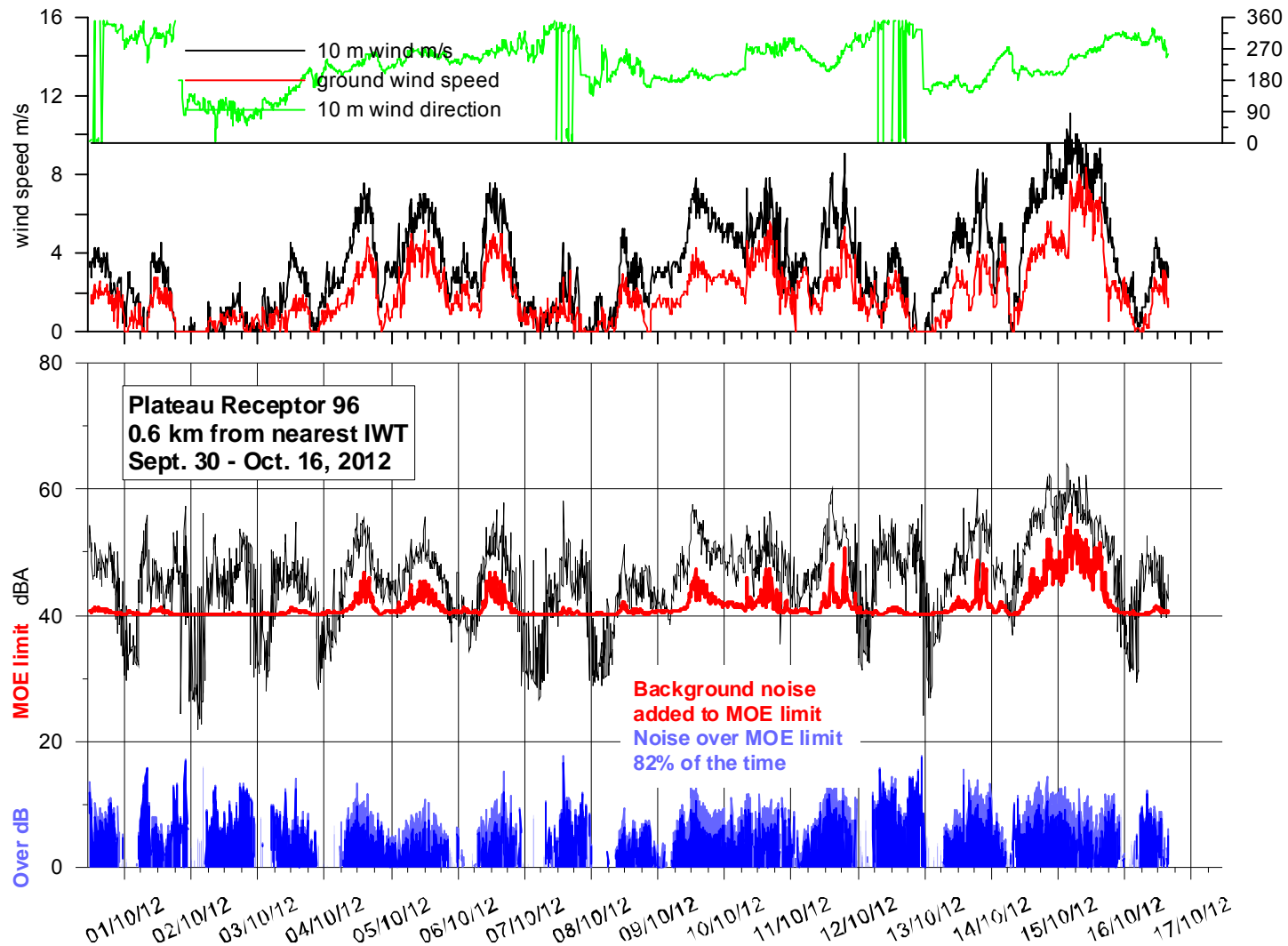


Figure 1 - This figure is a summary of the data for one IPC - Plateau Project receptor location (#96) in Grey Highlands, Ontario. The location is to the south of a group of wind turbines. The top graph in green is the (compass) wind direction. The plots below are the 10 m wind speed in black and the ground wind speed in red in m/s. The bottom graph has 3 variables plotted. The black line is the A-weighted (dBA) sound pressure level (SPL). The red line is the MOE limit obtained by adding the background noise (from the Brewster Lake site) to the MOE IWT noise limit. The bottom plot in blue is the amount by which the MOE noise limits are exceeded. In this location, the limits are exceeded every day except periods during some nights between midnight and 6 am. During the night, when the 10 m wind speed is over about 4 m/s the night time limit is exceeded as well.

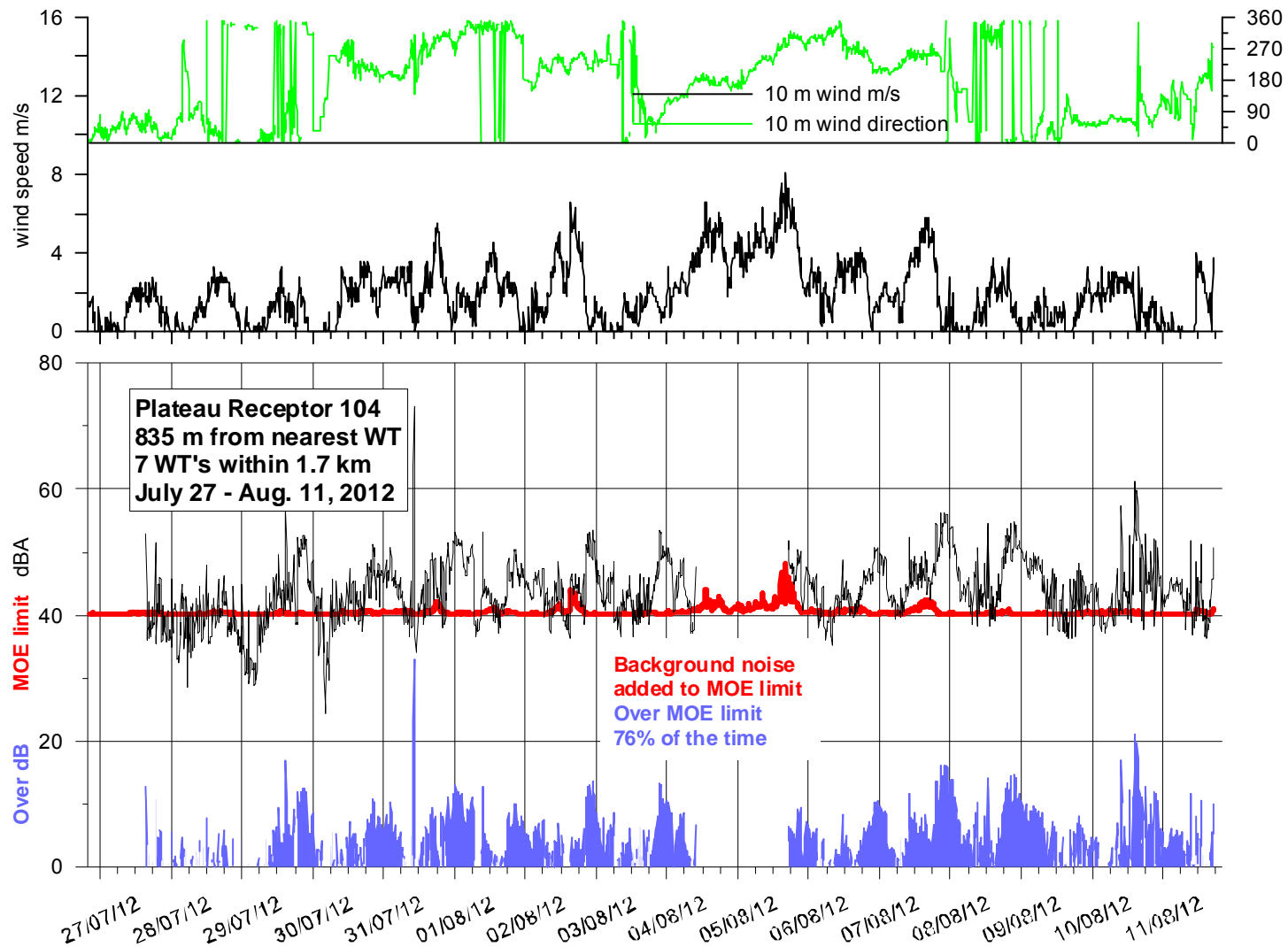


Figure 2 - This figure is a summary of the data for one IPC - Plateau Project receptor location (#104) in Grey Highlands, Ontario. The plots have the same meaning as in Figure 1. The location is in the centre of a group of seven wind turbines, all within a distance of 1.7 km. The nearest IWT is a little further away than at receptor #96 (835 m.). The IWT's are reported to be very loud at this location.

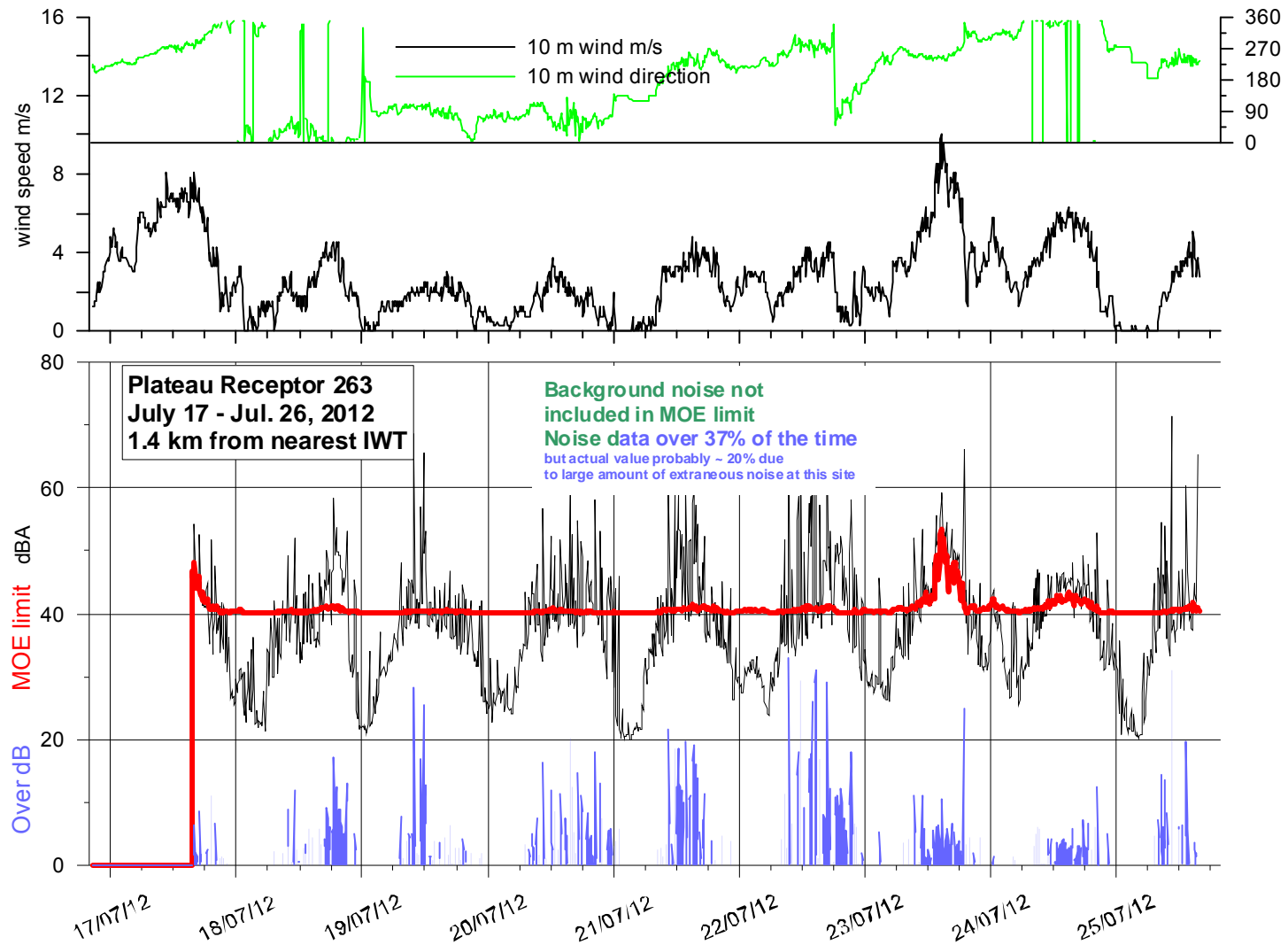
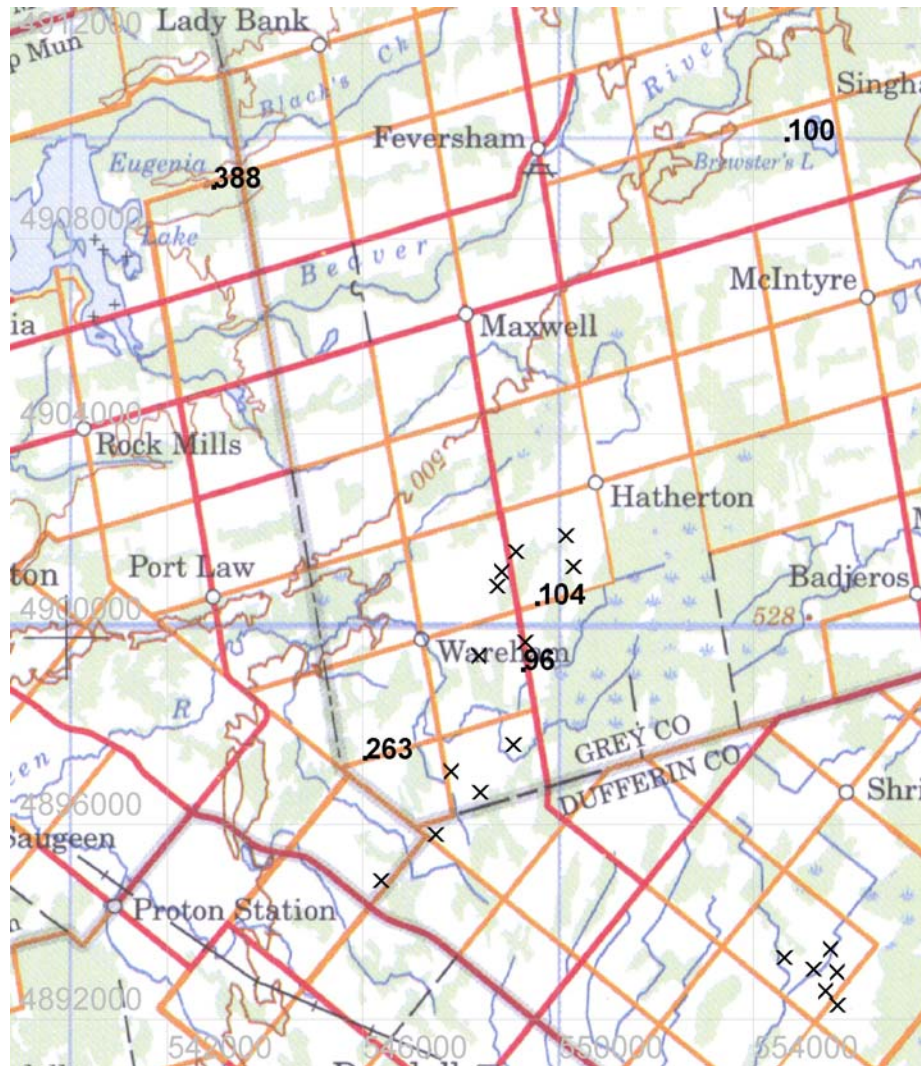


Figure 3 - This figure is a summary of the data for one IPC - Plateau Project receptor location (# 263) in Grey Highlands, Ontario. The plots have the same meaning as in Fig. 1. The location is approximately 1.4 km from the nearest IWT. The IWT's generally be cannot be heard (i.e. differentiated from other noise) at this location although the SPL is a higher than at the background site.

Location map



Rock Hill is 388; Brewster Lake is 100; X is IWT; road spacing = 2 km

Comparison with other studies

Kaliski. K. and E. Duncan: "Propagation Modeling Parameters for Wind Power Projects". Sound and Vibration. Dec. 2008. Pp. 12-16.

Kaliski & Duncan show a 5 dB underestimation of IWT SPL for a New England wind farm. They suggest the reason for the under-

estimation is that the source is not ground based but elevated and that the assumption that sound is absorbed by the ground is not correct:

"While the ISO 9613-2 methodology specifically recommends spectral ground attenuation for flat or constant-slope terrain with $G=1$, in this case, it underestimated the sound levels. This may be due to the height of the hub (80 m) as compared with typical noise sources. That is, the sound waves may not significantly interact with the ground over that distance. It may also be due to the fact that sound from wind turbines comes not from a single point – we assumed a single point at hub height – but is more likely to be similar to a circular area source. Finally, wind turbines often operate with wind speeds that are higher than ISO 9613-2 recommends. The combination of higher wind speeds and an elevated noise source may result in greater downward refraction".

Cameron Hall, Senior Environmental Officer, Guelph District Officer, MOE: "Memorandum dated April 9, 2010 to Jan Glasco:

Mr. Hall notes in his memo that the +/- 3dB error possible with the use of ISO 9613-2 and the +/- 2 dB error (Melancthon) can result in a +/- 5dB error in predicted IWT noise.

[The +/- 3 dB error in the model is taken directly from ISO 9613-2].

William K.G. Palmer. "Review of Enbridge Ontario Wind Power Compliance With Ministry of the Environment Certificate of Approval (Air) Noise". Report submitted to Mr. R. Campbell, District Manager, Owen Sound District Office, SW Region, Ministry of Environment, Ontario. January 2011.

Mr. Palmer reviewed two reports by Valcoustics on noise studies performed for Enbridge Ontario Wind Power, the operator of a wind farm in Bruce County, Ontario and found that for wind speeds under 6 m/s the sound level exceeded the predicted value more than 50% of the time at midnight, and in fact on more than 25% of the nights was more than 3 dBA above the predicted value even while the 10 metre wind speed was below 6 m/sec.

Applicability of the model

In the SCOPE of ISO 9613-2 “Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation”:

‘This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground-based noise sources. It does not apply to sound from aircraft in flight, or to blast waves from mining, military or similar operations.’

ISO 9613-2 is an empirical model. In general, empirical models should not be used outside the range of the data that was used in their development.

In table 5 of ISO 9613-2 the estimated accuracy for broadband noise is given for a mean source height of up to 30 m, suggesting that the error is unknown outside this range. This implies that the model was not calibrated for noise sources above 30 m from the ground.

Given that IWT noise is generated between approximately 50 and 150 m above the ground, thus well outside the intended use of ISO 9613-2, we can expect greater uncertainty in the model’s prediction.

In addition to these shortcomings, the MOE criteria, of using a ground attenuation factor (GAF) of 0.7 (or 1.0 by one consultant!), a temperature of 10C and RH of 70%, are clearly non conservative in winter months, and under predict the sound at distances of 1000 to 1500 m by some 3 dBA compared to a more typical winter value of a GAF of 0.2, a temperature of minus 10C and a RH of 90% in the winter.

Even a winter GAF of 0.2 may be too high as suggested by Kaliski & Duncan who suggest 0.0 as a more appropriate value as the sound can travel from the source to the receptor in a straight line unimpeded or unaffected by the ground.

The writer knows of no instance in Engineering where a safety factor is not applied – especially when an empirical model is used outside its intended range .

In the writer’s own field of water resources modelling, a normal requirement is for the proponent of a project to calibrate and validate any model being used that impacts the safety and well-being of the public.

Disclaimer:

The principal investigator while **not** a trained acoustician is a Distinguished Professor Emeritus of Civil and Environmental Engineering at the University of Waterloo, Ontario, Canada. He holds a PhD in Civil Engineering (Water Resources) and is registered as a Professional Engineer in Ontario and a Fellow of the American Society of Civil Engineers.

The data presented herein are for information and discussion purposes only and are not to be relied upon in any particular situation without express written consent by the author. Based on a general understanding of the subject, the author believes that the model and parameters used to predict SPLs near IWT’s result in an under estimation of IWT noise. **Please make your own assessment of this data set.**

This work is **not** sealed.

I welcome your comments or questions.

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Acknowledgement:

The equipment was bought through an NSERC Discovery Grant and my own resources. No other financial support was received.

Grey Highlands Sound Measurements: Raw data.

Dec. 11/12

. The results are presented in three parts for each location:

- 1) Figures 1 – 3, 7 & 10: Time series of the sound pressure levels (SPL's) in A weighted dBA along with the 10m wind speed in m/s and wind direction as well as ground wind speed and direction for the later measurements only.
- 2) The A weighted SPL in dBA covering all data versus 10 m wind speed
- 3) The A weighted SPL in dBA versus 10 m wind speed for night time 1-5 am only.

The first two sets of (3 part) results are for locations more than 9 km from the nearest IWT for two locations respectively. The first is near Rock Hill at the intersection of Conc. 10 and the Artemesia-Osprey Townline. The second is just west of Brewster Lake. The lines fitted on these plots reappear as background noise in the subsequent plots for locations near IWT's.

On each SPL versus time plot (Figs. 1-3), the MOE allowable IWT noise **plus** the background noise is shown as a red line . For the recorded SPL versus 10 m wind speed plots below, the green lines are the MOE IWT noise limits while the red lines are the MOE limits **plus** the background noise.

The instrument used was the Norsonic NOR140 Sound Analyser http://www.norsonic.no/en/products/sound_level_meters/sound_analyser_nor140/Nor140+Sound+Analyser.9UFRjQYk.ips Detailed specifications are in the Appendix.

The instrument was calibrated before and after each setup. The change in calibration was less than 0.2 dB for a calibration level of 104 dB over each two week period. The sound meter was calibrated with a Sinus model 511E 1kHz Calibrator EIC 942 (1988) Class 1L.

A standard 60 mm acoustic foam primary wind screen supplied with the sound meter was used on the microphone. The microphone was sheltered from rain and other elements by a 21" X 36" X 30" (0.5 X 0.61 X 0.76 m) wire crate covered with burlap fixed tight to avoid flapping sounds (Fig. 4). The crate was covered by two layers of plywood with a sheet metal drip tray in between. A foam covering was contemplated but it has been found by others that an enclosure of 1 inch acoustical foam can reduce measured dBA values by 2 to 3 dB. While this microphone protection is not required by MOE requirements, it is useful to protect the microphone from the elements that might otherwise interfere with the measurements or damage the hardware. The burlap is very open and easily allows sound to pass through.

The setup on the trailer has the advantage of having a consistent setup from one location to another and can be used in any kind of weather. Placing the microphone in a sheltered location instead of the 4.5 m height as required by the MOE is even more important to reduce unwanted wind noise on the rig & the windscreens. This can also prevent problems from temporary setups. For example, a recently observed MOE field site exhibited a loud noise emanating from the microphone support similar to wind noise in the rigging of a sailboat in high wind.



Figure 4

Background noise location & setup: in middle of a clearing west of Brewster Lake, Grey Highlands. ON. It is located 500 m from the nearest road. The microphone can be seen on a tripod in a burlap wrapped wire crate on a trailer. Nearby: ONSET Wind Speed/Direction Smart Sensor model S-WCA-M003 with Onset HOBO Micro Station logger model E348-H21-002. All microphone locations situated in sheltered areas as much as possible.



Figure 5

10 m wind speed and direction sensors near Plateau receptor 263 in Grey Highlands. IWT is visible just to the left of the tower. Onset Wind Speed Smart Sensor model S-WSA-M003; ONSET Wind Direction Smart Sensor model S-WDA-M003; with Onset HOBO U30 data logger model E348-U30-NRC-000-05-S100-000.

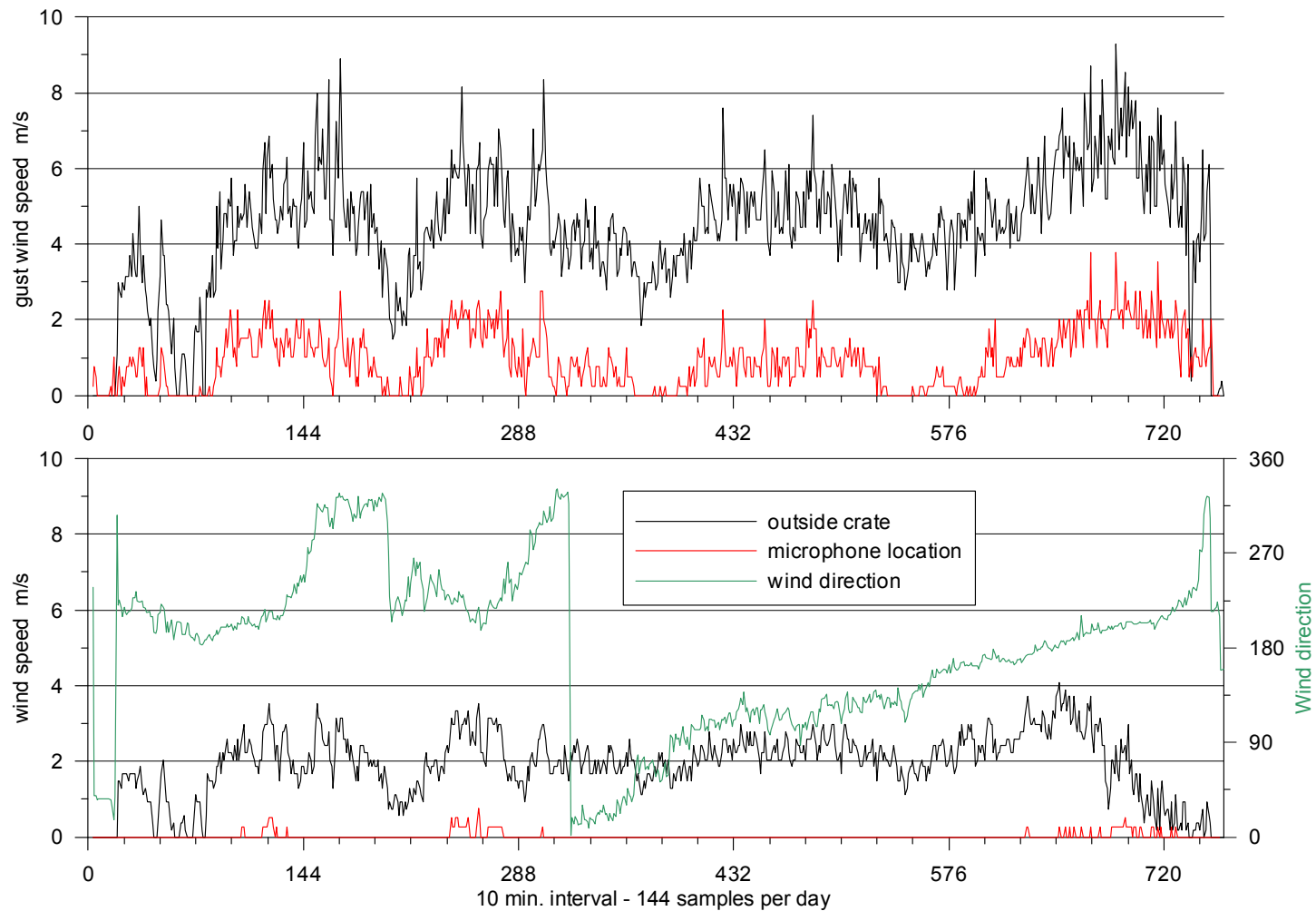


Figure 6 – Effect of wire and burlap enclosure on wind acting on the microphone

This graph shows that the air movement inside the housing, a burlap covered wire crate, is below the sensitivity of the anemometer located at the normal microphone location most of the time for all incident wind directions. Even when the 10 min. - average wind speed outside the crate is over 2 m/s, the wind speed inside does not exceed .5 m/s. Thus wind induced noise on the microphone should virtually be non-existent. Some wind induced noise on the crate may still be present.

Throughout this set of graphs, it should be kept in mind that the setup is the same for all locations, both near and far from IWT's so it can be reasonably argued that the excess noise near IWT's is due to noise produced by them.

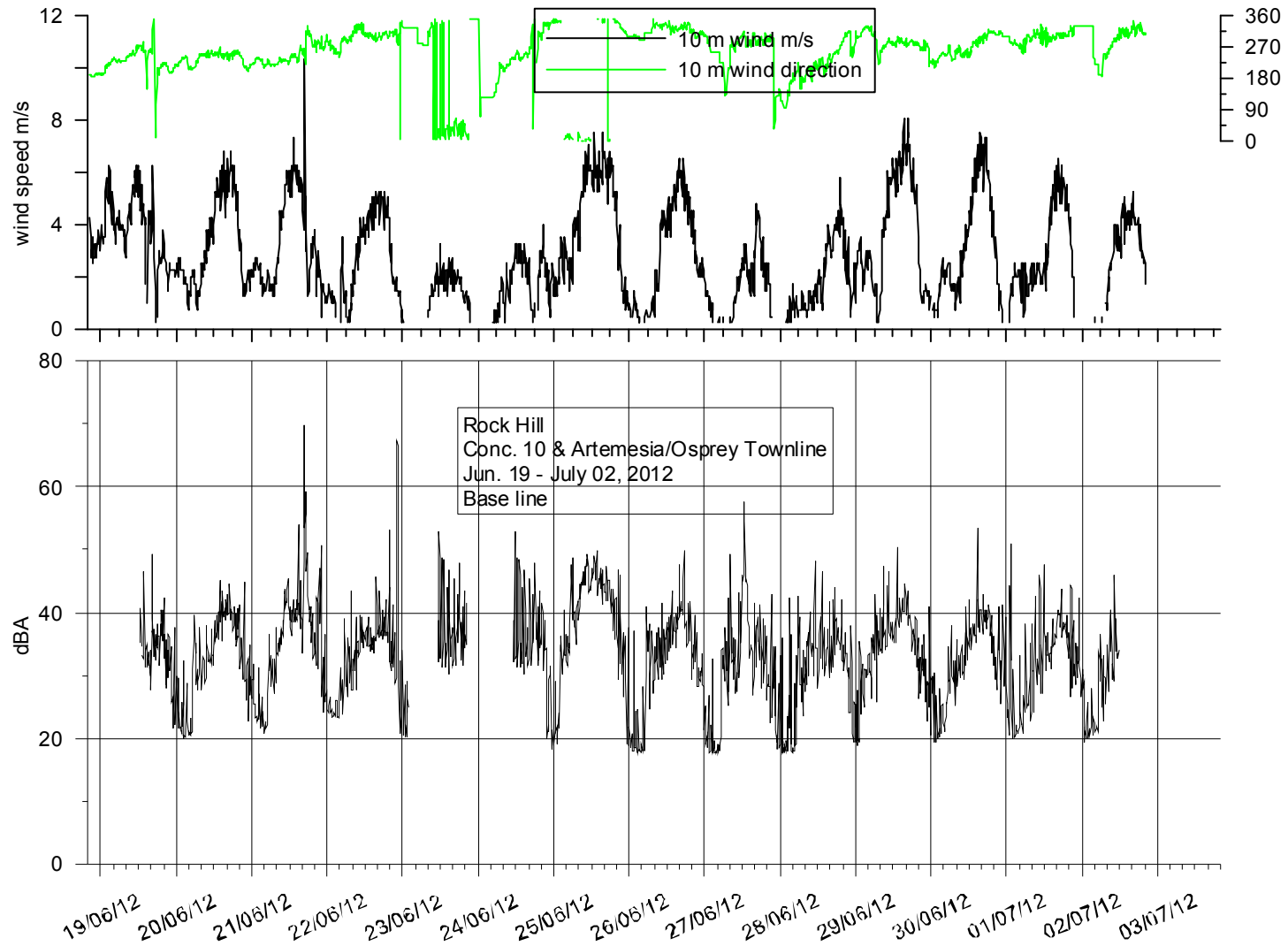


Figure 7 – Rock Hill: Background SPL

These data were measured in a small clearing in a mixed maple & cedar bush just east of Eugenia Lake in Grey Highlands. Night time SPL's are in the low 20 dBA range with some nights under 20 dBA. These were summer time data with relatively low wind speeds.

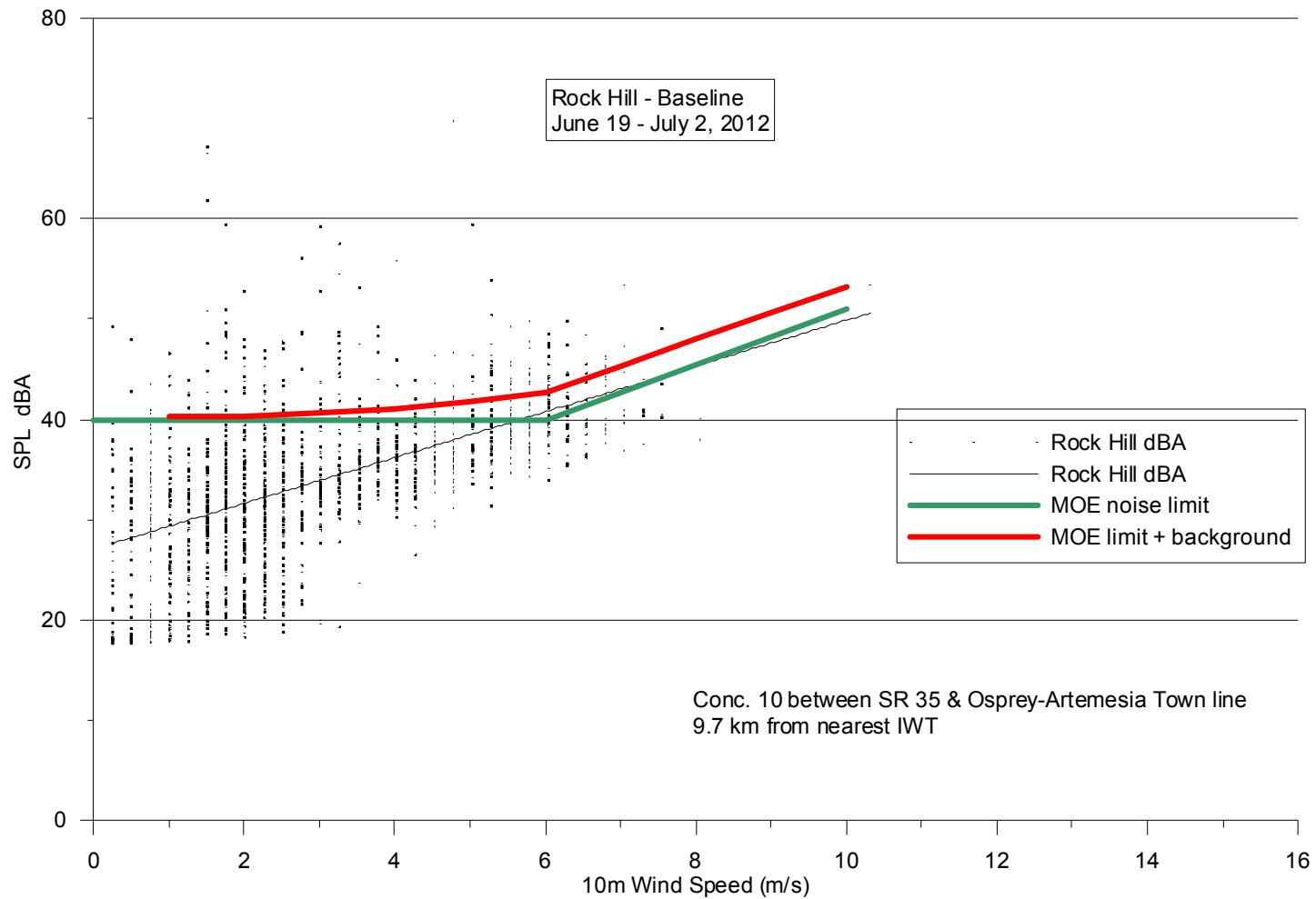


Figure 8 – Rock Hill: Background SPL

This is the same data set as presented in the previous time series plot in Fig. 7. These data include all extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. The best fit line (black) is based on all measurements including the extraneous noise. The lower envelope of the plotted points is thus the real ‘natural noise only’ background noise resulting from those 10 minute samples when no man-made noise was present. The green line is the MOE allowable IWT noise while the red line is obtained by adding the background noise to the MOE allowable IWT noise. These lines are shown to show the magnitude of the background noise levels relative to the MOE limits. These lines are shown in subsequent plots.

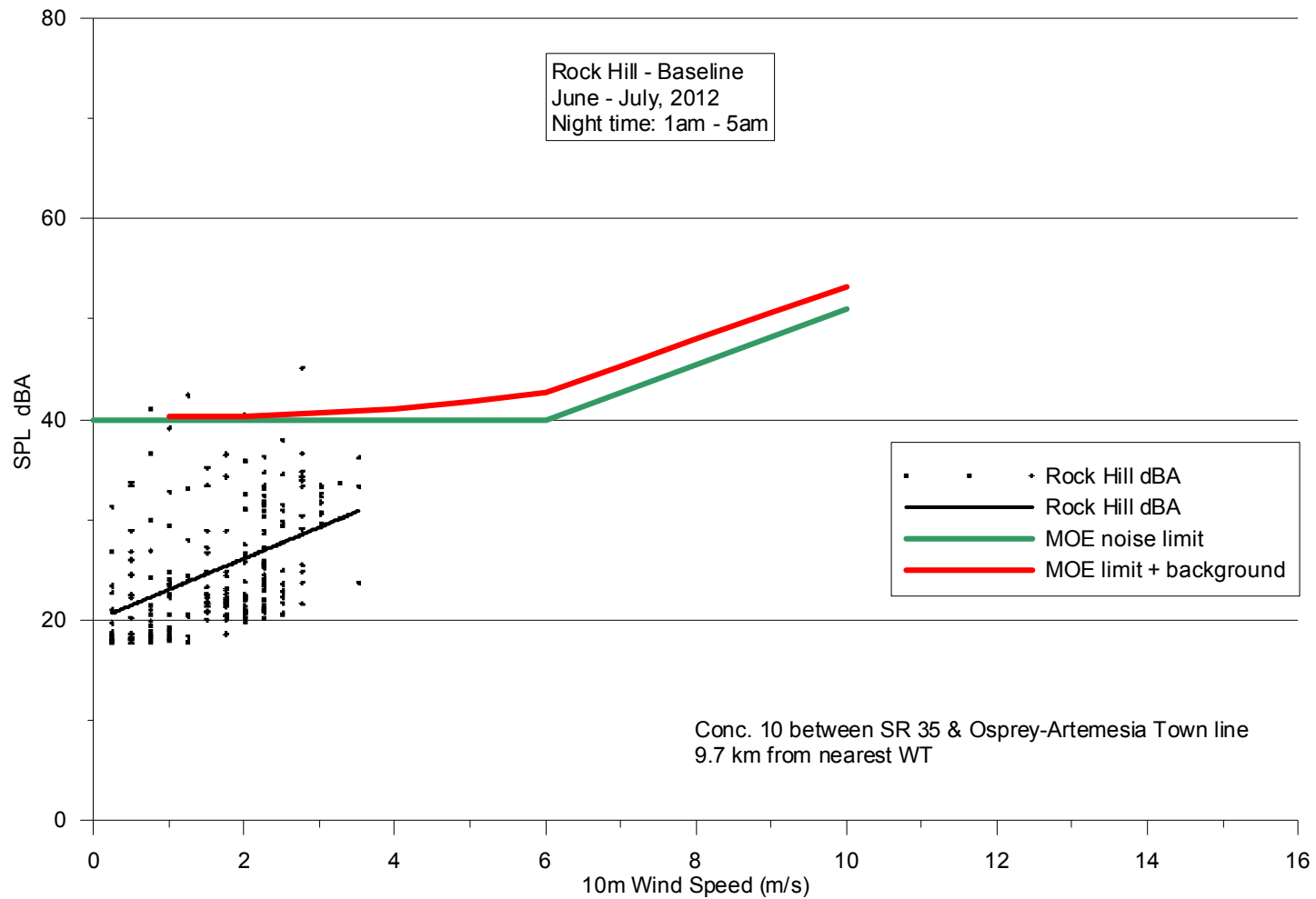


Figure 9 – Rock Hill: Background SPL – night time only 1 – 5 am

This is the same data set as presented in the previous time series plot in Fig. 7 and SPL versus 10 m wind in Fig. 8 but are for night time 1 – 5 am only. These data include all extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. but during this period, sources of such extraneous noise are very limited. As for Fig. 8, the best fit line in Fig. 9 is based on all measurements including the extraneous noise. The lower envelope of the plotted points is thus the real background ‘natural noise only’ resulting from those 10 minute samples when no man-made noise was present. This is a very quiet location.

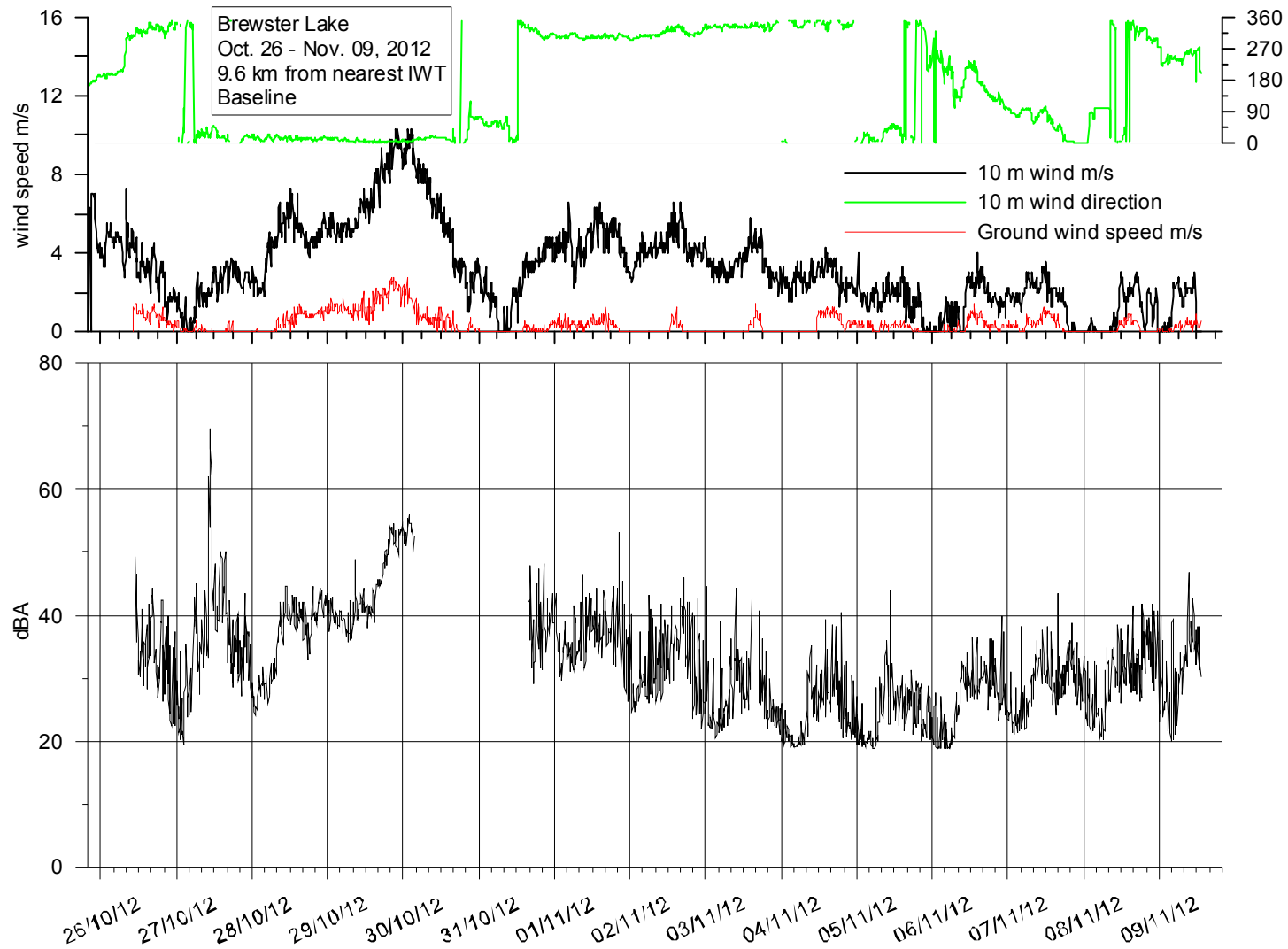


Figure 10 – Brewster Lake site: background SPL

These data were measured in the clearing shown in Fig. 4 just west of Brewster Lake in Grey Highlands, ON. 9.6 km away from the nearest IWT. Night time SPL's are in the low 20 dBA range with some nights under 20 dBA. The gap in the data was due to a power outage due to remnants of hurricane Sandy. The ground level wind speed is very low in this clearing resulting in minimal impact on the SPL's. These data are used as the background SPL's for locations near IWT's in Figs. 1 – 3.

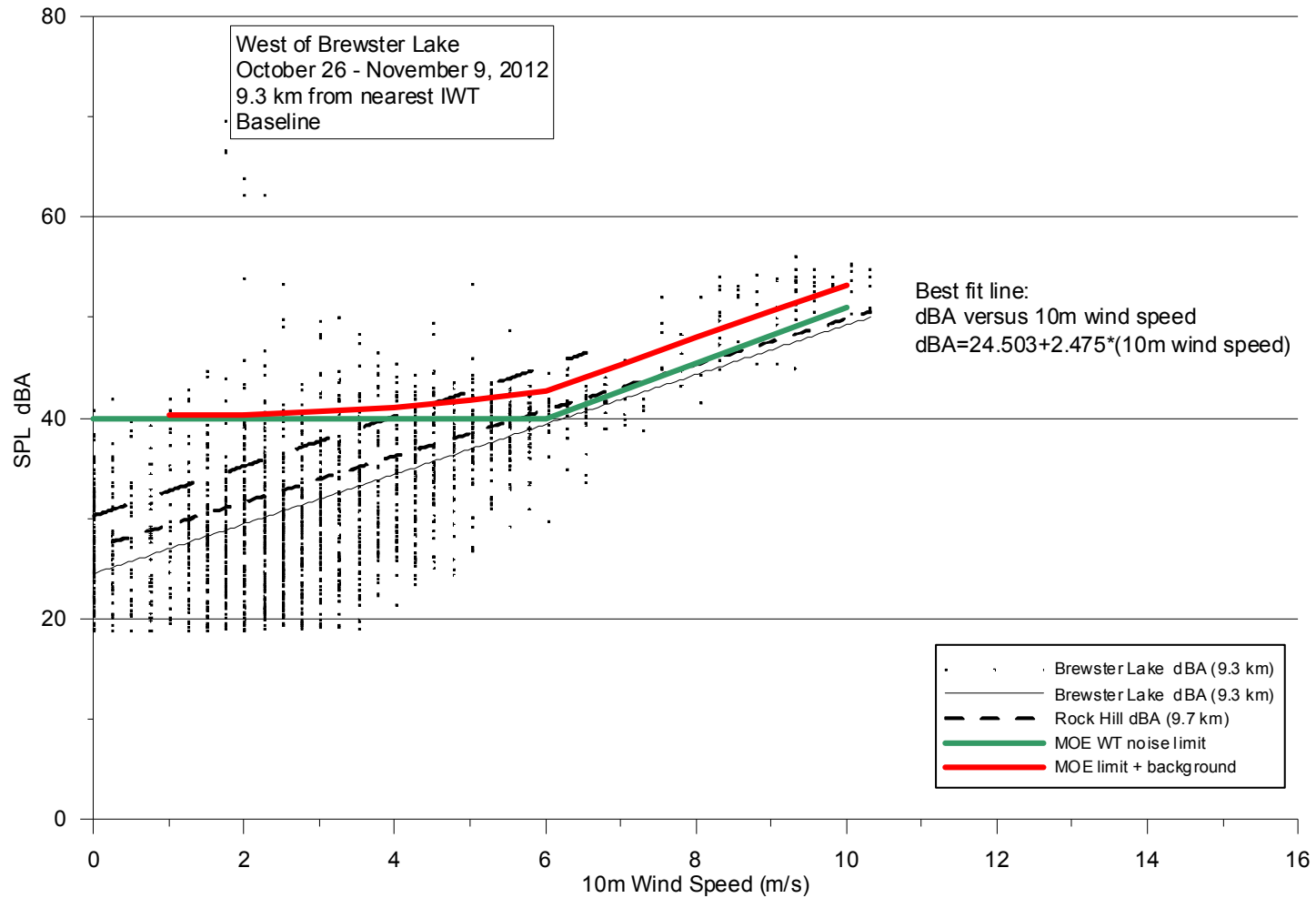


Figure 11 – Brewster Lake site: background SPL

This is the same data set as presented in the previous time series plot in Fig. 10. These data include all extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. The best fit line is based on all measurements including the extraneous noise. The lower envelope of the plotted points is thus the real ‘natural noise only’ background noise resulting from those 10 minute samples when no man-made noise was present. The solid black line is the best fit for the Brewster Lake site. The short-dashed lines are the best-fit lines for Rock Hill as in Fig. 8. The long-dashed line is also for the Brewster Lake locations but earlier in the summer when there was more human activity in the area. The Rock Hill and Brewster Lake background SPL’s agree quite well.

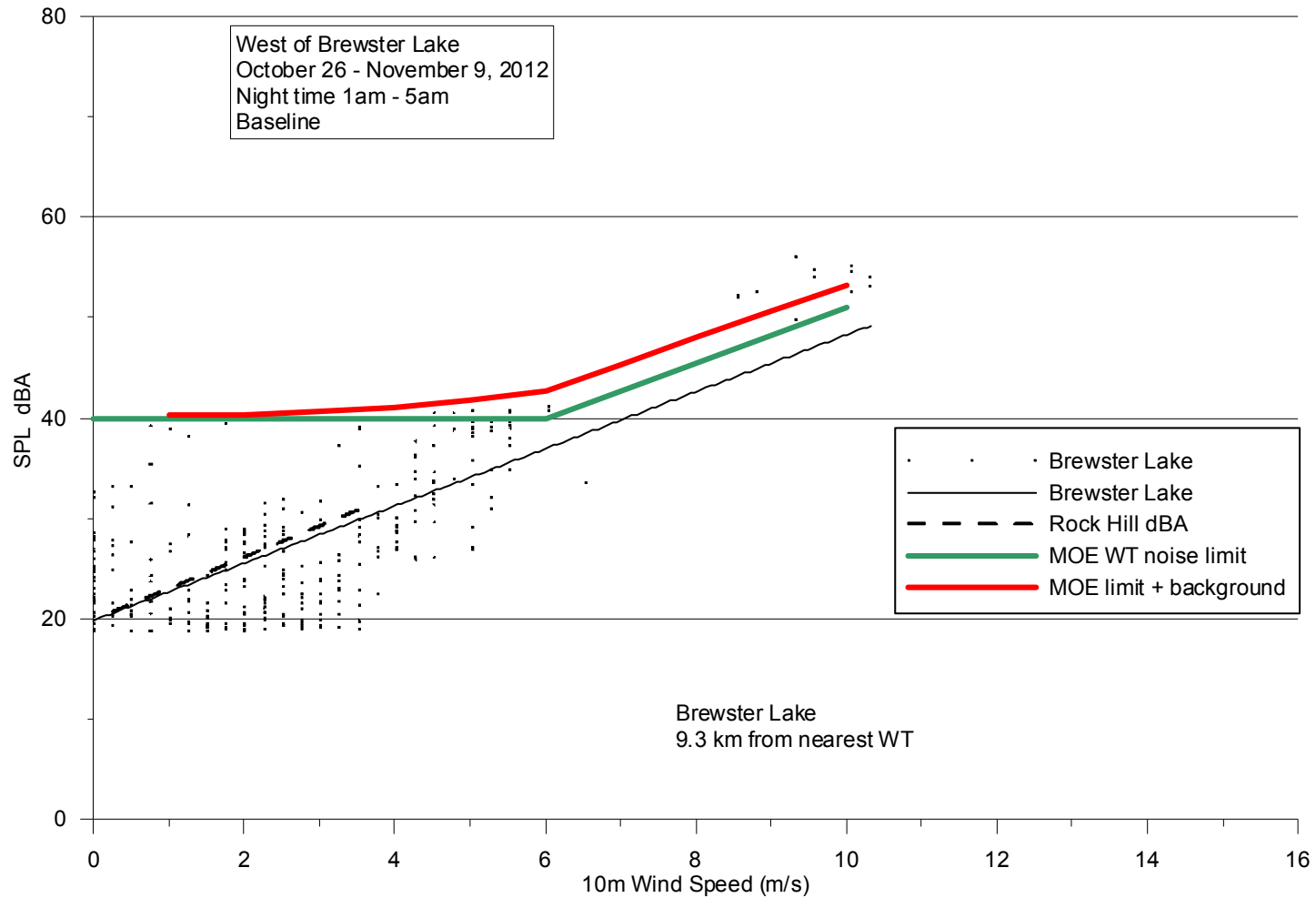


Figure 12 – Brewster Lake site: background SPL – night time only 1 – 5 am.

This is the same data set as presented in the previous time series plot in Fig. 10 and SPL versus wind in Fig. 11 but are for night time 1 – 5 am only. These data include all extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. but during this period, sources of such extraneous noise are very limited. As for Fig. 11, the best fit line is based on all measurements including the extraneous noise. The lower envelope of the plotted points is thus the real 'natural noise only' background noise resulting from those 10 minute samples when no man-made noise was present. This is a very quiet location.

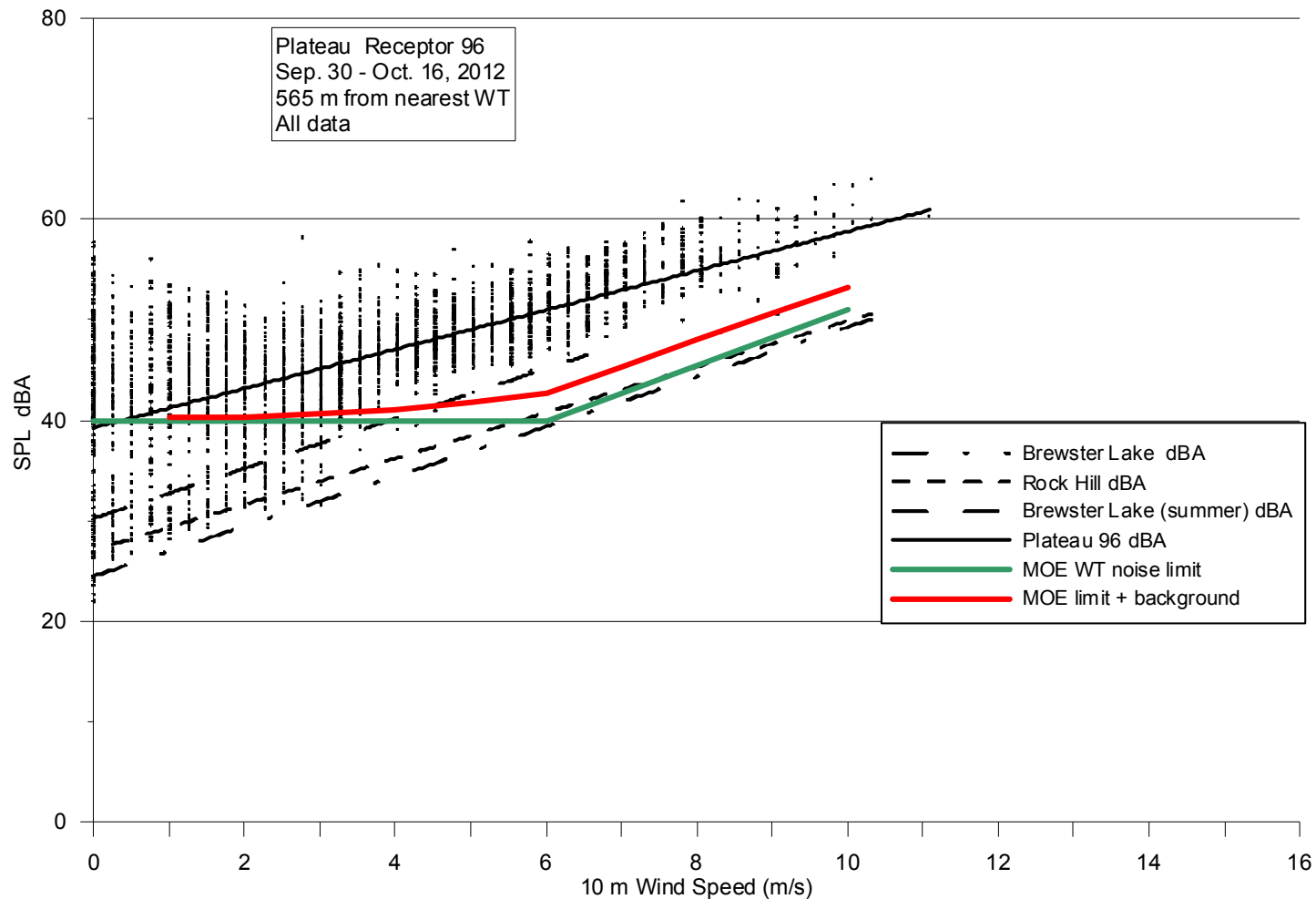


Figure 13 – Plateau receptor 96

This is the same data set as presented in the time series plot in Fig. 1. These data include all extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. The best fit line is based on all measurements including the extraneous noise.

The broken lines are the SPL's for the sites away from the IWT's indicating a 10 – 15 dB increase of the SPL's over the background noise. It is not possible to differentiate between the extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. and the noise generated by the IWT's. However, the non-IWT non-natural sound is present in both the background and the receptor sites so the increase can be attributed to the IWT's. From this plot it is apparent that the IWT noise exceeds the MOE limits. Fig. 1 presents a more complete picture of the amount of time and magnitude of this exceedence at this site.

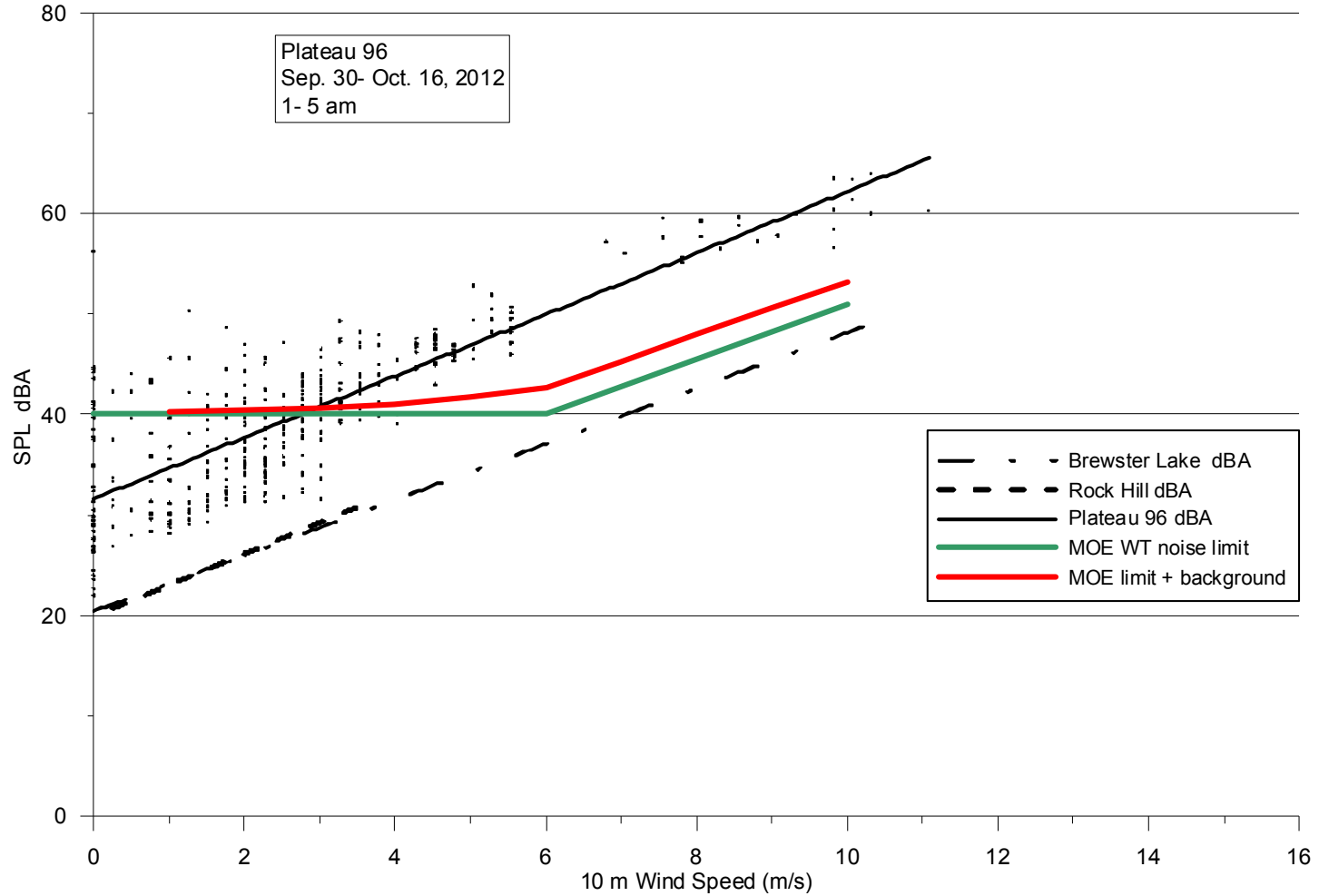


Figure 14 – Plateau receptor 96 – night time only 1 – 5 am.

This plot is for night time SPL measurements only – between 1 and 5 am. The spread of the data is less as the non – IWT extraneous noise is mostly absent and SPL values in excess of the background SPL's are due to IWT noise. The IWT SPL's exceed the MOE limits by approximately 7-8 dBA for 10 m wind speeds over 6 m/s once the background noise is added to the MOE limits (red line). (Some would argue that the background noise should not be added to the MOE limits as the green line represents the background noise and that it should “hide” the IWT noise. With this approach, the IWT noise is over the MOE limit by some 10 dB).

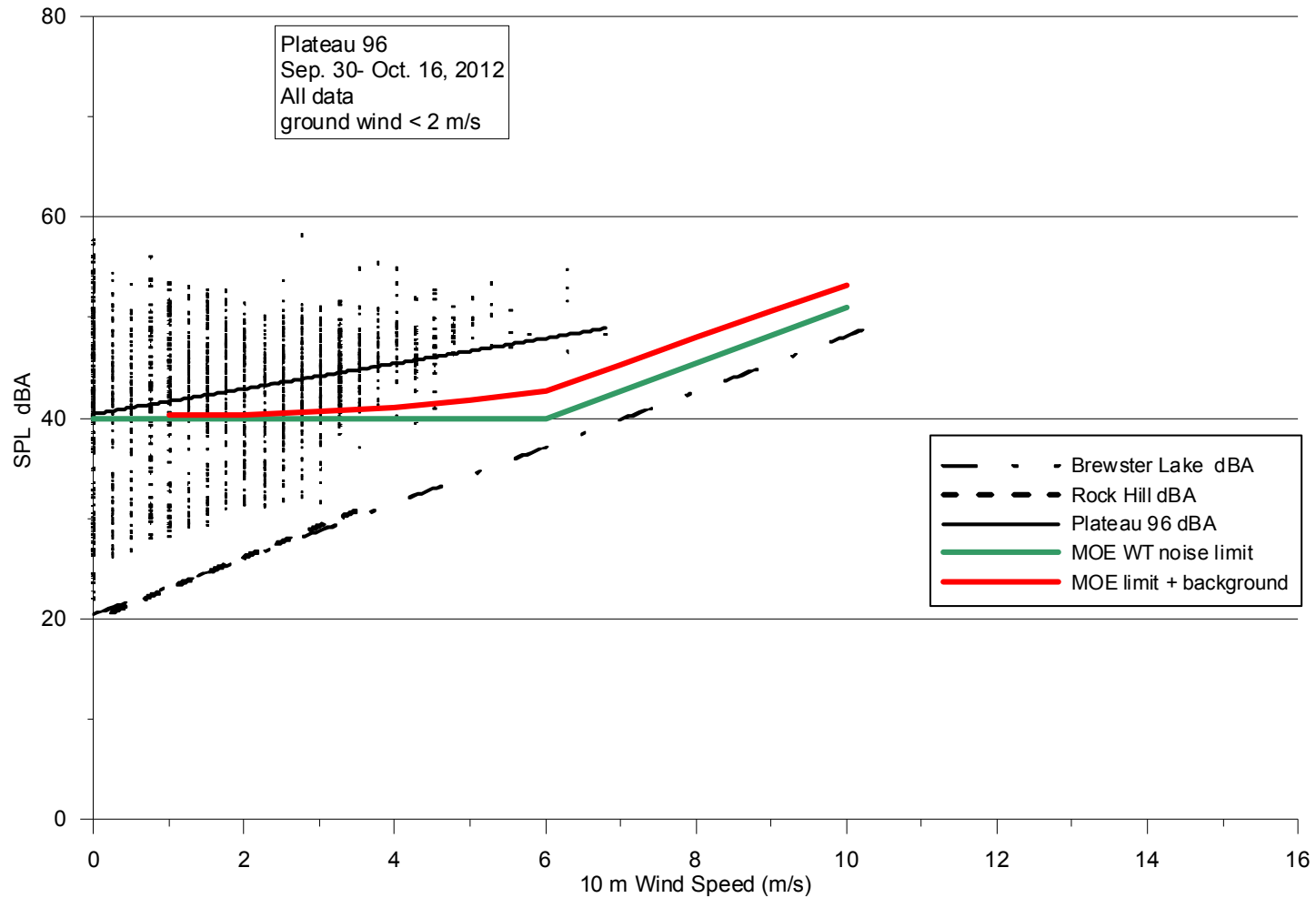


Figure 15 – Plateau receptor 96 – ground wind speed < 2 m/s

This is based on the same data set as presented in Figs. 1 and 13. However, all data for ground wind speed above 2 m/s are **deleted** from the data. This analysis was performed to ensure that SPL's as measured in the burlap covered crate were not artifacts due to wind generated noise by the burlap covered enclosure itself. A visual inspection of the data points in the two plots (Figs. 13 & 15) reveals that the SPL's are not substantially different (and well above MOE limits in both cases) thus validating the experimental setup for this work.

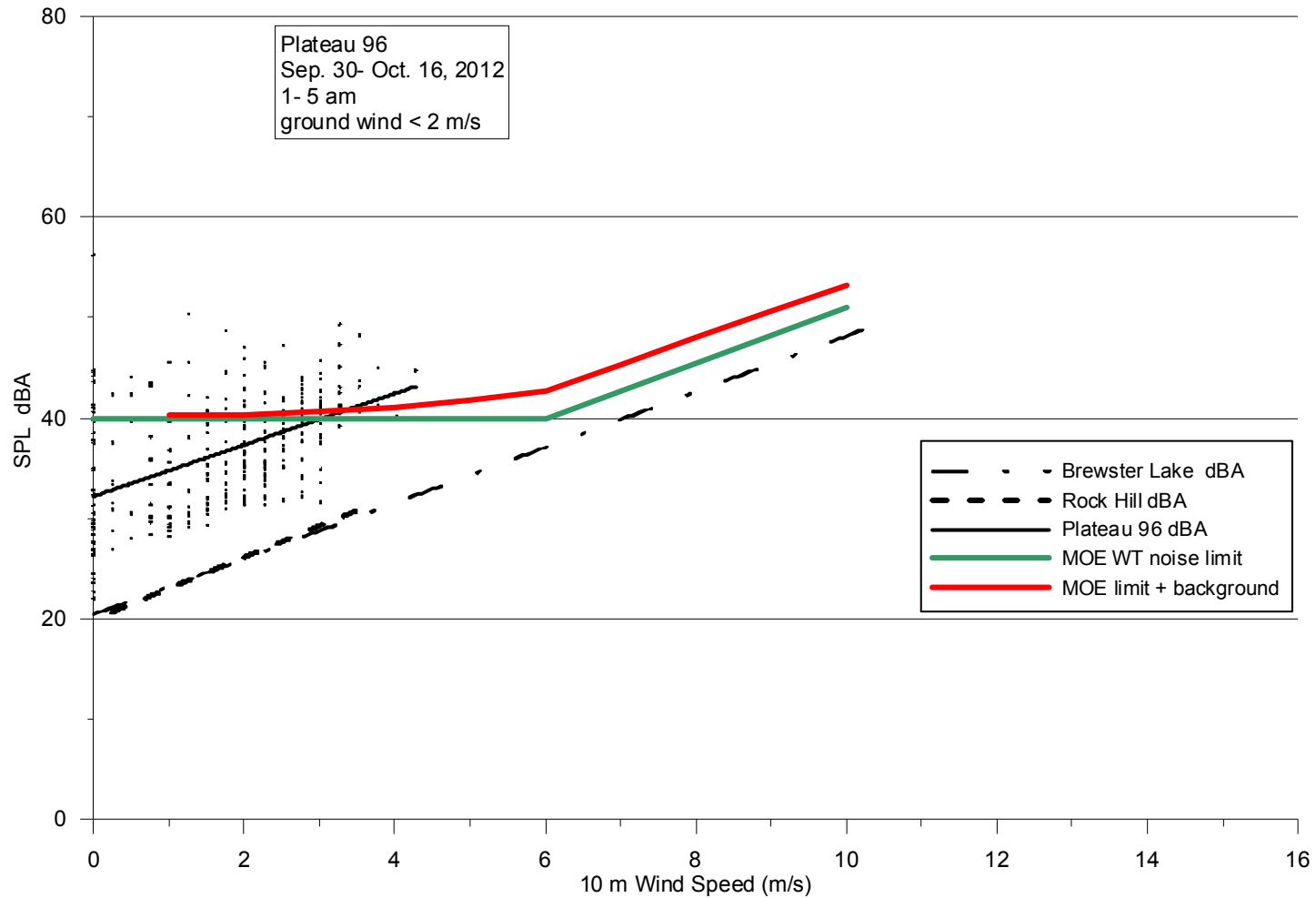


Figure 16 – Plateau receptor 96 – ground wind speed < 2 m/s – night time only 1 – 5 am.

This is based on the same data set as presented in Figs. 1 and 14 but the data are for night time 1 – 5 am only. As for Fig. 15, the data for ground wind speed above 2 m/s are **deleted** from the data. Again, this analysis was performed to ensure that SPL's as measured in the burlap covered crate were not artifacts due to wind generated noise by the burlap covered enclosure itself. A visual inspection of the data points in the two plots (Figs. 14 & 16) reveals that the SPL's are not substantially different thus validating the experimental setup for this work.

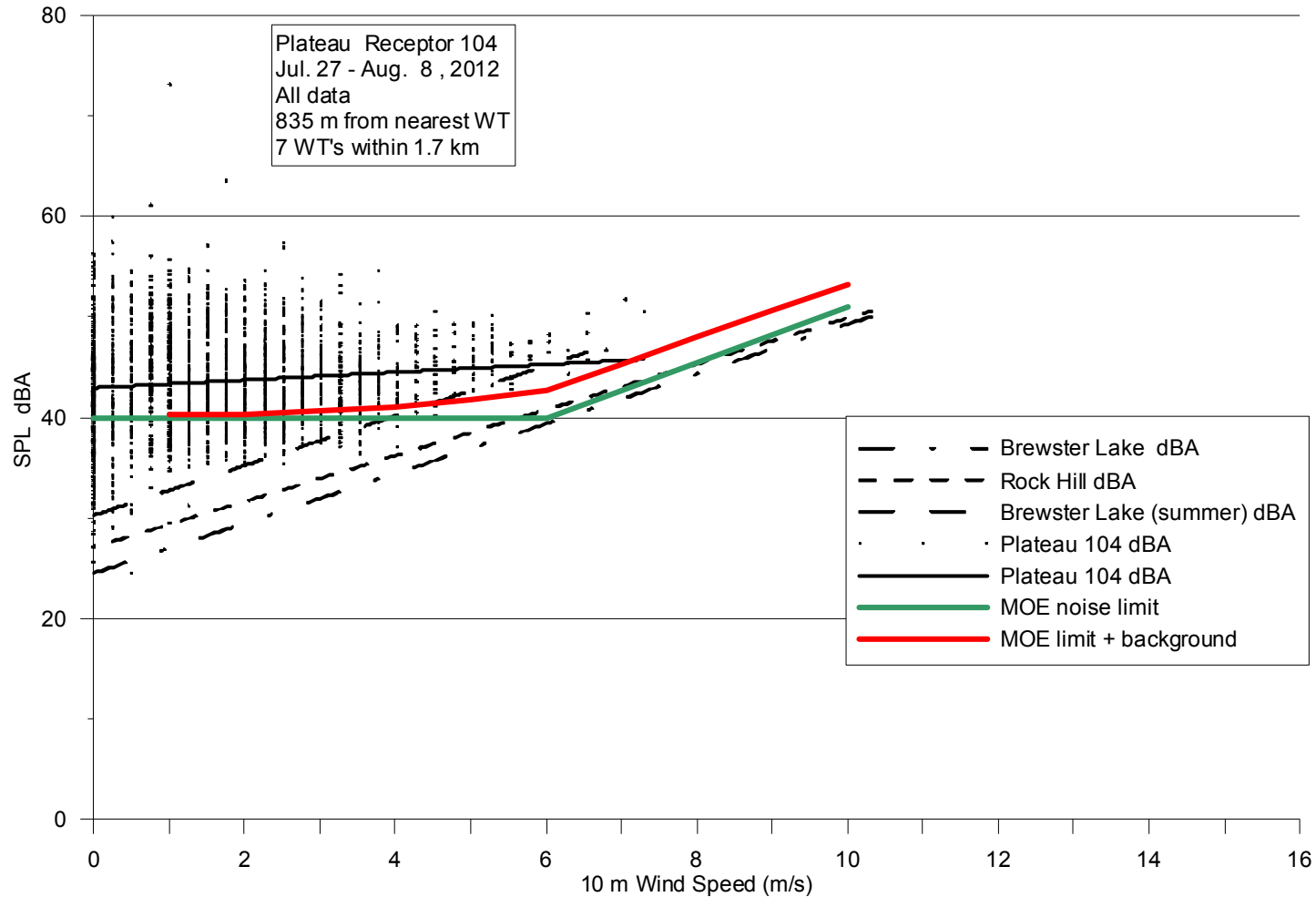


Figure 17 – Plateau receptor 104

This is the same data set as presented in the time series plot in Fig. 2. These data include all extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. The best fit line is based on all measurements including the extraneous noise.

The broken lines are the SPL's for the sites away from the IWT's so there is a 5 – 15 dBA increase of the SPL's over the background noise. It is not possible to differentiate between the extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. and the noise generated by the IWT's. However, the non-IWT non-natural sound is present in both the background and the receptor sites so the increase can be attributed to the IWT's. From this plot it is apparent that the IWT noise exceeds the MOE limits. The best fit line (solid black) has too little slope likely due to too much extraneous noise and the lack of higher wind speed during this summer data set. Fig. 2 presents a more complete picture of the amount of time and magnitude of this exceedence.

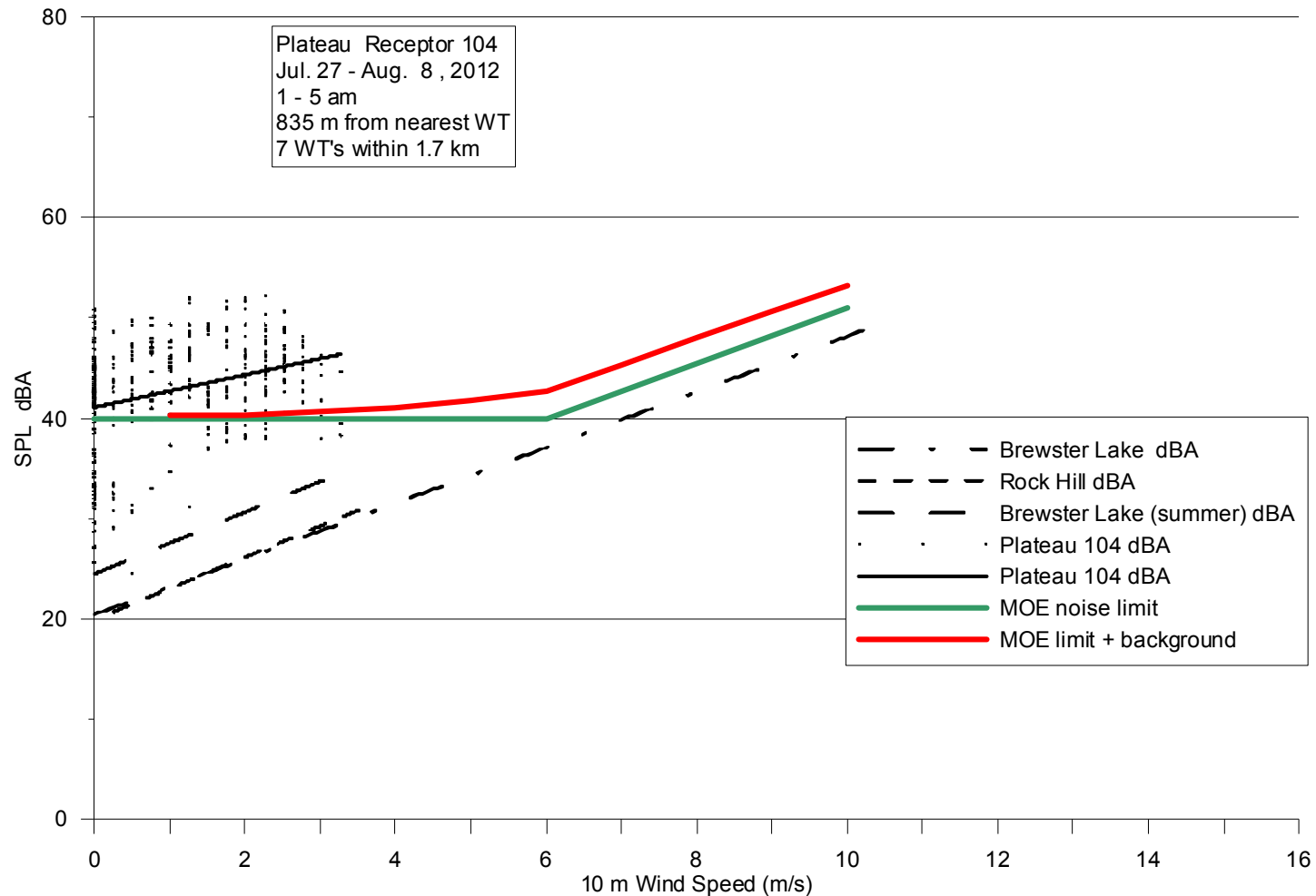


Figure 18 – Plateau receptor 104 – night time only 1 – 5 am.

This plot is for night time SPL measurements only – between 1 and 5 am. The spread of the data is less as the non – IWT extraneous noise is mostly absent and SPL values in excess of the background SPL's are due to IWT noise. The night time IWT SPL's exceed the MOE limits for even very low 10 m wind speeds supporting the observations that the IWT's can be very noisy even at night when there is virtually no ground wind speed. In this location, MOE limits were exceeded every night for two weeks when the IWT's were operating. These data are for summer time conditions (August). No high wind speeds were recorded. These data are during summer nights with very little wind.

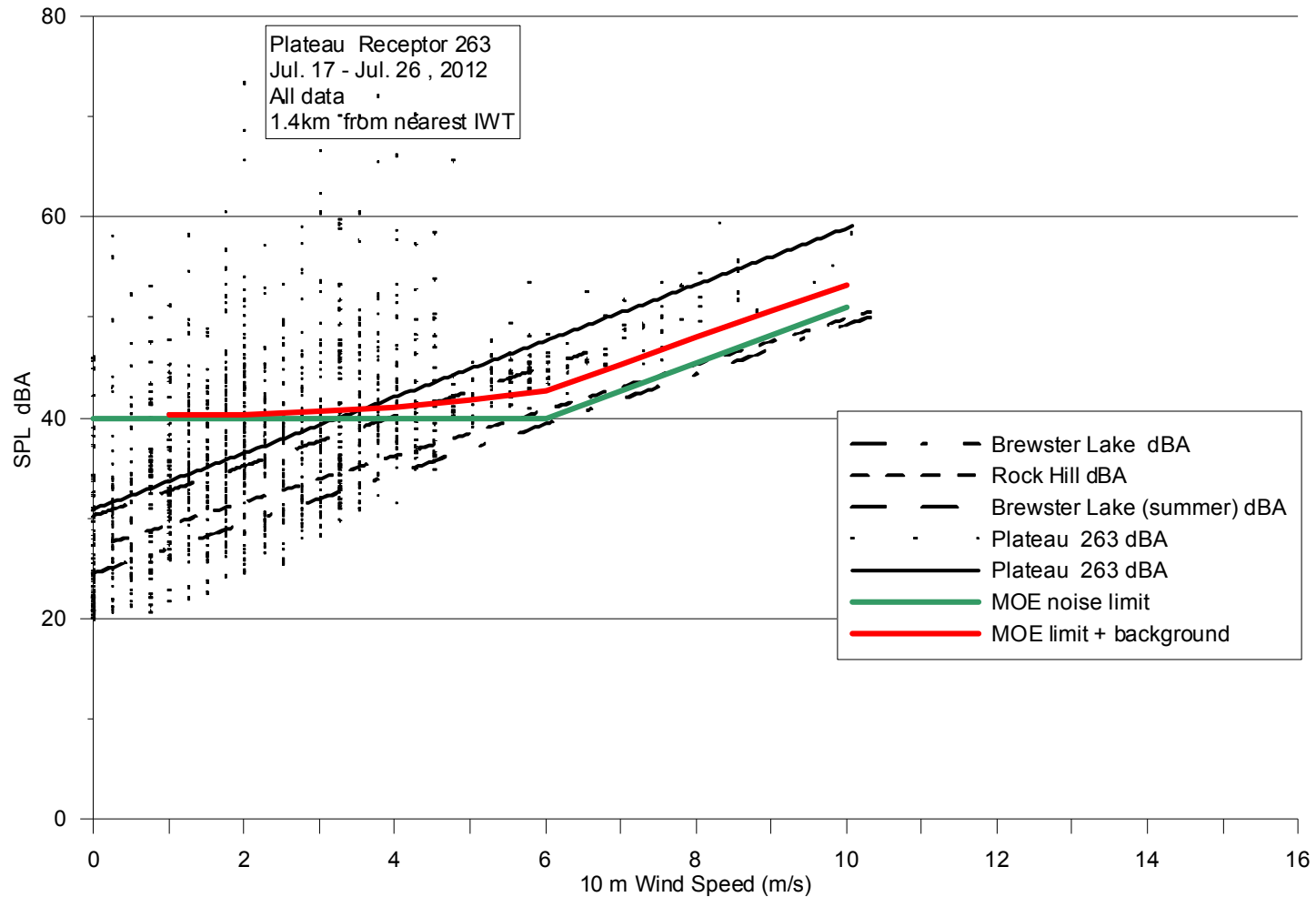


Figure 19 – Plateau receptor 263

This is the same data set as presented in the time series plot in Fig. 3. These data include all extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. The best fit line is based on all measurements including the extraneous noise. The interesting point to note with these data is that even at a distance of 1.4 km from the nearest IWT, the MOE limits are exceeded as shown in Fig. 3. Approximately 7- 8 dB is added to the background noise.

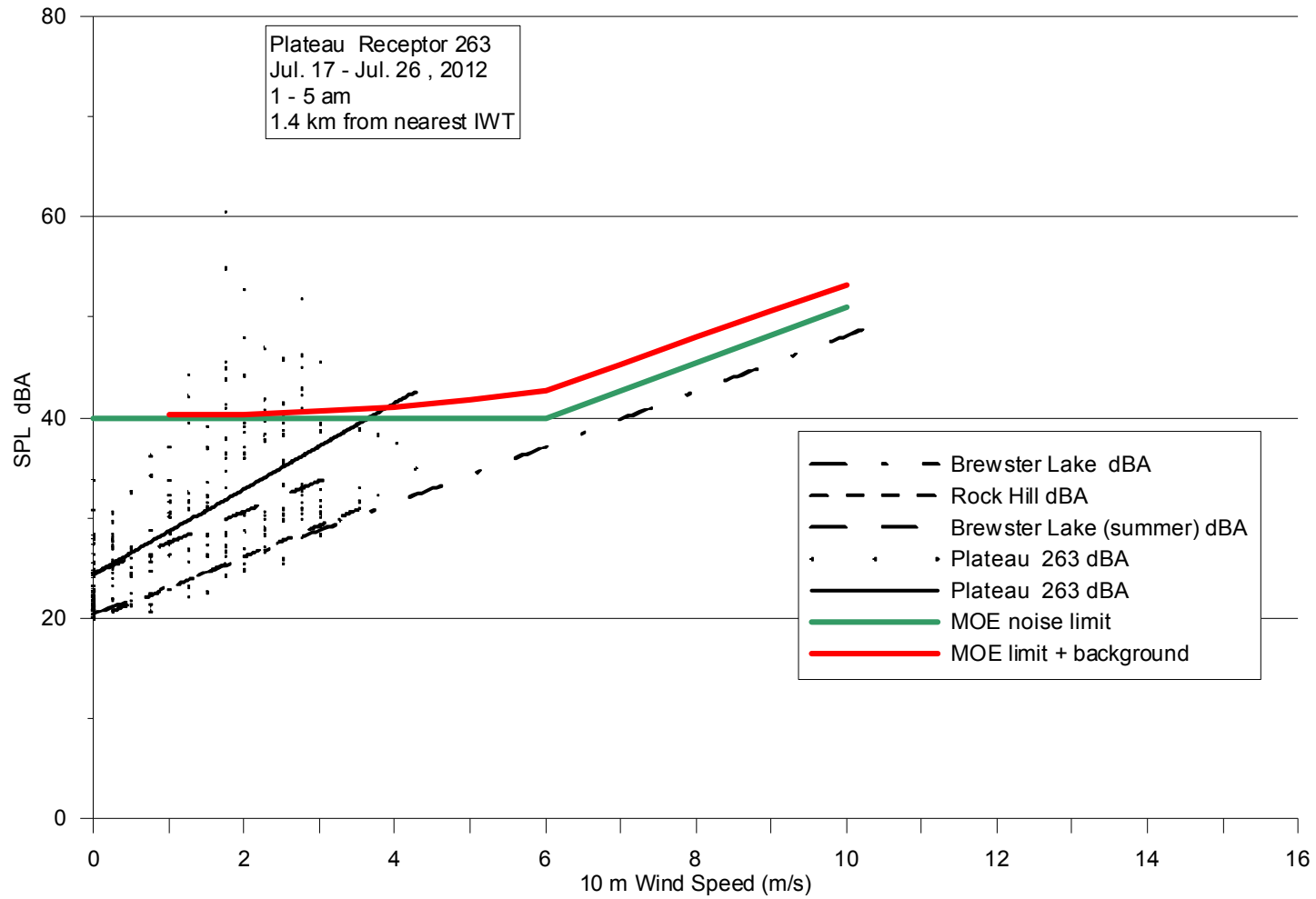


Figure 20 – Plateau receptor 263 – night time only 1 – 5 am.

This is the same data set as presented in the time series plot in Fig3 and Fig. 19 but for night time 1 – 5 am only. These data include all extraneous noise from traffic, farm machinery, airplanes, lawn mowers etc. These data are for summer time conditions. Night time IWT audible noise does not appear to be a problem at this distance for these low wind speeds.

Appendix: Sound Meter Specifications

ANALOGUE INPUTS

Number of channels: 1

Input connector:

7 pin LEMO connector for Norsonic microphone systems.

Microphone: Nor1225, 1/2", freefield, 50 mV/Pa

Preamplifier: Nor1209 (Normal) or ICP®-type by menu selection.

Preamplifier supply voltage: ±15 volt, max 3 mA

Polarisation voltage:

0 V and 200 V, selectable.

Maximum input signal: ±11 V peak

Preamplifier ICP®:

Supply current: 4mA

Supply voltage: 24V

Input impedance:

>100 kΩ, <650 pF

Measurement range: 0,3 μV - 7Vrms (10 Vpeak) in one range corresponding to -10 dB to 137 dB (140 dB peak) with a microphone sensitivity of 50 mV/Pa. Option 18 shifts the measurement range to 147 dB (150 dB peak) by reducing the microphone sensitivity.

Highpass filter

The input section is equipped with an analogue highpass filter to reduce noise from wind or other sources with frequencies below the frequency range for measurements. The filter is switched on if the limited frequency range is selected (>6,3 Hz).

Filter type: 3rd order HP filter (-3 dB at 3,4 Hz, Butterworth response)

Analogue to digital conversion

The analogue input signal is converted to a digital signal by a multirange sigma-delta converter with an effective sampling frequency of 48 kHz. The anti-aliasing filter is a combination of an analogue and a digital filter.

Frequency weightings

Simultaneous measurement of A and C-weighting or A- and Z-weighting. 1/1 octave band or 1/3 octave

Overall Performance

The Nor140 fulfill the following standards set for sound level meters,

band levels may be measured simultaneously if options providing these weightings are installed.

1/1 octave filters: 0,5 - 16000 Hz, class 1, digital IIR filters, base 10 system (IEC 61260) and ANSI S1.11-2004 Class 1.

1/3 octave filters: 0,4 - 20000 Hz, class 1, digital IIR filters, base 10 system (IEC 61260) and ANSI S1.11-2004 Class 1.

Level detector

Detector type: Digital true rootmean-square (RMS) detection, resolution 0.1 dB which may optionally be increased to 0.01 dB for indicated levels in the range -9.99 to 99.99 dB.

Crest factor capability: The crest factor is only limited by the peak-value of the signal.

Simultaneous measurement of the following functions: SPL, Lmax; Lmin; Leq; LE; Lpeak; LN ; Leq; LEI; LTMx5.

Indication range

The calibration of the instrument allows microphones with sensitivity in the range -84 dB to +15.9 dB relative to 1V/Pa to be applied. The corresponding display range for the indicated sound level is -50 dB to +180 dB.

Self-noise levels

The self-noise is measured with the calibration set to -26.0 dB corresponding to a microphone sensitivity of 50 mV/Pa. For voltage input, the level 0 dB then corresponds to 1μV. Typical values for the self-noise are 5 dB lower than the values stated. Noise measured with 18 pF microphone dummy and microphone preamplifier Nor1209, averaged over 30 s of measurement time:

A-weighted: 13 dB

C-weighted: 15 dB

Z-weighted: 25 dB

1/3 oct: 6.3 Hz to 250 Hz: 10 dB

1/3 oct: 315 Hz to 20 kHz: 5 dB

Noise measured with Nor1225 microphone and preamplifier Nor1209, averaged over 30 s of measurement time:

A-weighted: 18 dB

1/1-octave and 1/3 octave filters:

IEC61672-1:2002 class 1, IEC60651 class 1,

IEC60804 class 1, IEC61260

C-weighted: 22 dB

Z-weighted: 30 dB

1/3 oct: 6.3 Hz to 250 Hz: 15 dB

1/3 oct: 315 Hz to 20 kHz: 10 dB

Power supply

Batteries: 4 cells, IEC LR6, AA-sized

Typical battery life time: up to 14 hours

External DC: 11 - 16V. Power consumption approximately 1.2W depending on selected modes of operation. The mains adapter Nor340 is recommended for use with the instrument. If the external supply falls below 9 V, the instrument will use the internal batteries if available. If the instrument switched itself off due to loss of power, it will automatically switch on and resume normal operation after reapplying the external DC supply.

Display

The display is a monochrome, transreflective LCD graphical display with 160×240 pixels (W×H) with automatic temperature compensation for contrast and viewing angle. Pressing the light key illuminates the display. The light switches off automatically two minutes after the last operation of any key. The bargraph display covers 80 dB which may be scrolled in 10 dB steps to cover the total range.

Signal generator output

Max output voltage: ±10V

Output impedance: <100Ωohm. The output is short-circuit proof to GND and output current is in excess of 3 mA.

Gain accuracy at 1 kHz: ±0.2 dB

Frequency response re. 1 kHz:

±0.5 dB for 20 Hz < f < 20 kHz

AC-out: 3,5 mm stereo jack. Both channels have identical signals driven by two separate amplifiers. Load impedance shall be 16 ohm or more. Output voltage is generated by the 48 kHz DAC based on data from DSP. Full scale on the display bargraph corresponds to 100 mV. **Output impedance:** Less than 10 ohm, AC-coupled 100 μF. class 1, ANSI S1.4-1983 (R2001) with amendment S1.4A-1985 class 1, ANSI S1.43-1997 (R2002) class 1, ANSI S1.11-2004 class 1.

Gain accuracy 1 kHz: ±0,2 dB

Frequency response re. 1 kHz:

±0,5 dB for 20 Hz < f < 20 kHz.

USB interface: USB type 2.0

USB socket: B411

Serial I/O port:

RS232 port, 9600 - 115200 baud.

Digital inputs: 3 pc

Digital outputs: 4 pc

SD Memory Card

The instrument may use SD memory card for storing of setup information, sound recordings and measurement results. SD memory card included in the delivery.

Data storage

Measured data is stored in the internal memory of the sound level meter or on the SD memory card. The internal memory is of the "flash" type retaining the information without battery supply. Approximately 25 Mbyte is available for the data storage.

Environmental condition for operation

Temperature: -10°C to +50°C

Humidity: 5% to 90% RH, dewpoint less than 40°C.

Atmospheric pressure: 85 kPa to 108 kPa.

Environmental condition for storage

Temperature: -30°C to +60°C

Humidity: 5% to 90% RH, dewpoint less than 40°C.

Atmospheric pressure: 50 kPa to 108 kPa.

Dimensions:

Depth: 30 mm, **Width:** 75 mm,

Weight incl. batteries: 410 g

Length, excl. microphone/

preamplifier: 210 mm

Length, incl. microphone/

preamplifier: 292 mm

Some of the feature listed in this leaflet may be optional in certain markets. Contact your local representative or the factory for details.

Norsonic reserve the right to amend any of the information given in this leaflet in order to take advantage of new developments.

Installed options:

Option 1: 1/1-octave real-time filters

- Parallel 1/1-octave real-time filters covering the 0,5 Hz – 16 kHz frequency range
- To enhance readability, the frequency range may be limited to 8Hz - 16 kHz.
- All filters fulfil the IEC 61260 class 1 digital IIR base 10 requirements
- 120 dB “one-range” even in the filter bands
- Results are displayed both graphically and numerically
- A-preweighting feature available on displayed results

When fitted with option 1, the Nor140 can perform real time frequency analysis in octaves covering the frequency bands 0.5 Hz to 16 kHz in one range. A limited frequency range 8 Hz - 16 kHz can be set in order to avoid low frequency noise. A 3 Hz 3rd order high pass filter is then enabled in the analogue input stage to prevent overload due to low frequency noise. The wide frequency range with full dynamic range of more than 120 dB makes the instrument well suited for both vibration and noise measurements

Option 3: 1/3-octave real-time filters

- Parallel 1/3-octave real-time filters covering the 0.4 Hz - 20 kHz frequency range in one span
- All filters fulfil the IEC 61260 class 1 digital IIR base 10 and ANSI S1.11-2004 Class 1 requirements 120 dB “one-range” even in the filter bands
- Results are displayed both graphically and numerically
- A-weighting (pre-weighting) feature available on displayed results

Option 4: Statistical calculation of LN values

- Calculate 7 fixed LN values (L1%, L5%, L10%, L50%, L90%, L95% and L99%)
- Parallel calculation of 1 editable LN value selectable within the range 0.1 – 99.9 %

Meter

Type Sound Analyser Nor-140

Serial no. 1404753

Program version 2.1.405

Id no. 8183935

Microphone

Norsonic Type 1225. Serial No. 149381

Cartridge size ½”

Main Standard IEC 61672 Class 1

IEC 61094-4 type designation WS2F Free-Field

- Statistical calculations based on 0.2 dB class widths covering the entire 130 dB range
- Parallel statistical calculation on both A- and C-/Z-weighted networks
- If real-time filters are installed (option 1 or 3), statistical calculations are available for the individual filter bands as well

Option 4 adds statistical distribution to the Nor140 functionality. There are eight percentiles shown, out of which one is user selectable. The class width is 0.2 dB over the entire 130 dB range.

The statistical distribution calculations employs the F time constant and applies to the spectral weighting networks (A and C or Z) as well as all the individual 1/1 and 1/3-octave filter bands (if applicable). The back-erase feature, which deletes up to the ten most recent seconds of acquired global data prior to a pause upon resuming, updates the statistics buffers as well to maintain consistency.

Option 5: Parallel F, S and I time weightings

- Simultaneous measurement of F, S and I time weightings
- Parallel measurement of three different SPL, Lmin and Lmax functions based on F, S and I time weightings
- Parallel calculation of Leq, Leq,I, LE and LEI functions using no time constant and I time weighting simultaneously
- The parallel measurement using three time weightings is available on both A- and C-/Z-weighted networks

Option 5 enables parallel measurement of all time constants simultaneously. If real time filters are installed, the parallel time weighting functions are available for the individual filter bands as well.

Option 6: Level versus time measurement

- Measures the time “Profile” (level vs. time) of the noise signal with preset time resolution simultaneously with the overall “Global” measurement

- Selection of preset intervals within the 1 second to 199 hours interval range
- Automatic level versus time storage of LAeq, Lmax and LCpeak (or LZpeak)
- Automatic multispectrum storage of Leq and Lmax if option 1 is installed
- Level versus time measurement continues during a paused Global measurement
- Markers identify any pause, stop or continue of the measurement
- Real-time graphical and numerical display of the level versus time results

Automatic markers:

A pause marker is inserted into the time profile in pause mode. A recorder marker is inserted when the instrument is doing a sound recording, and an overload marker is inserted if overload occurs.

Option 8: Sound recording

- Storage of the sound signal itself onto the SD card or the internal memory
- Triggered by an external hand-switch, by a level trigger or by a manual key push
- 8, 16 or 24 bit accuracy
- 12 or 48 kHz sampling
- 0 - 96 dB digital gain
- Reference calibration tone can be added at the beginning of the first recording in a measurement

Option 8 allows storing the sound signal itself onto the SD card or the internal memory.

This option is especially useful for source identification. The sound recording can be triggered by an external hand switch, by a level trigger (requires option 16) or by a manual key push. Several recording formats are supported, ranging from 8, 16 or 24 bit and with sampling rates of 12 or 48 kHz. Using 48 kHz sampling and the stored sound signal may be used for further processing. The Nor140 has a large dynamic range – exceeding 120

Nominal Sensitivity @ 250Hz 50mV/PaFreq. Response +/- 1dB 12.5-10kHz +/- 3dB 3.15 – 20KHz

Self Noise 15 dBA

Calibration:

Sensitivity 47.0 mV/PA

-26.6 dB re. 1 V/Pa

Capacitance 22.8 pF

Calibrator

Manufacturer: Cirrus Research plc

Model Number: CR:511E

Serial no. 035234

dB. This means that if you try to play back the signal on your PC you will – in most cases - hear nothing! To overcome this problem a special digital gain, 0 – 96 dB, can be added to the sound recorded signal without affecting the calibration or measured values. Another useful feature is that you may play a 10 sec reference tone - sine wave, pink or white noise in the beginning of a measurement to set a reference level when later replaying recorded data.

Option 14: FFT measurement mode

- 8000 line FFT analysis with 1.46Hz line resolution
- Covers the 1.46 – 9.6 kHz frequency range
- Both engineering units and dB
- Pre-selection of 1 - 1028571 averages
- Useful when searching on problems with rotating machinery
- Fulfil the requirements for FFT analysis when searching for tonality according to the ISO/DIS 1996-2 Annex C (2005) standard
- Display compression in binary sequence 1 – 64

Option 16 : Trigger

- Trigger the start of a measurement based on the internal clock, level threshold or external TTL signal such as hand switch Nor263A
- Level threshold trigger used in combination with Repeat storage makes an automatic event measurement device
- The audio recording is triggered based on the clock, level threshold or external TTL signal such as hand switch Nor263A

The measurement and audio recording trigger can be set independently of each other. A special pre-trigger feature on the audio recording can be set up to capture the latest seconds of the audio signal prior to the trigger point.