Weaver Residence Wind Turbine Noise Assessment

February-March, 2013

By

Nicholas Kouwen

This report outlines the findings of an informal wind turbine noise assessment at the Weaver residence at 7624 Wellington Road 12 just south of Arthur, ON.

The Weaver property abuts the 22.92 MW Conestogo Wind Farm in Mapleton Township near Arthur, ON. The wind farm consists of 9 Siemens AG2.3 MW IWT's and 1 Siemens AG 2.221 MW wind turbine. A location diagram is located in Appendix A. The Weaver residence is shown as receptor 65 where the "**worst case**" IWT sound levels were predicted to be 39.2 dBA by the proponent.

The investigation suggests that the IWT generated noise does not comply with the MOE noise guidelines ~50% of the time and that SPL's are above the predicted "worst case" ~59% of the time.

A journal of the quality of life and health problems experienced by the occupants of the home is attached as Appendix B.

Methodology

The equipment and methodology for the study is the same as that described in detail in my Grey Highlands 2012 Wind Turbine Noise Survey[1].

In the following part of the report, the results are paired for the two sites shown in Fig's 1 & 2. Figure 1 shows the microphone location at the Weaver residence while Figure 2 shows the microphone location as a similar background site, approximately 10 km from the nearest IWT.

There are four separate comparisons:

1) The time series of the A weighted sound pressure levels (SPL's) (dBA) along with the 10m wind speed in m/s and wind direction as well as ground wind speed.

2) The A weighted SPL (dBA) covering all data versus 10 m wind speed.

3) The A weighted SPL (dBA) versus 10 m wind speed for night time 1-5 am only.

4) The L50 versus 10m wind speed.

Unweighted SPL's (dBZ) are also plotted.

In the following report, the MOE noise limits are those in NPC-232 "Sound level limits for stationary sources in Class 1 & 2 Areas (Rural)"

When referring to the MOE protocol for determining compliance NPC-103 "Compliance Protocol for Wind Turbine noise" the methodology in this protocol is noted but is replaced by the more objective and workable approach adopted herein.

[1] http://docs.wind-watch.org/Grey_Highlands_Plateau_Noise_20130131.pdf

Figure 1 – Noise measurement location at the Weaver residence near Arthur, ON. 723 m away from the nearest IWT. Nearby: ONSET Wind Speed/Direction Smart Sensor model S-WCA-M003 with Onset HOBO Micro Station logger model E348-H21-002. Also, a tipping bucket rain gauge is co-located with the wind sensors. Microphone locations are situated in sheltered areas. Location: N4847853 E534398

Figure 2 - Background noise location & setup: in a small clearing east of Eugenia Lake, Grey Highlands. ON. This site was chosen to be closely comparable to the Weaver location near Arthur. The microphone is located in a burlap wrapped wire crate on a trailer. Location: N4909221 E542872

Equipment

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 Grey Highlands Noise Report.

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 the data acquisition period. The sound meter was calibrated with a Sinus model 511E 1kH 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 (Figs 1 & 2). 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[2] 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 has an open weave that 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, at MOE noise monitoring station near Clear Creek and Underwood, Ontario, loud noise emanated from the microphone support towers and rigging similar to wind noise in the rigging of a sailboat in high wind. This noise was louder than any noise from trees or the nearby IWT's when standing beside the towers.

The 10 m wind speed and direction was recorded at a nearby open site using an Onset Wind Speed Smart Sensor model S-WSA-M003; an ONSET Wind Direction Smart Sensor model S-WDA-M003; and an Onset HOBO U30 data logger model E348-U30-NRC-000-05-S100-000.

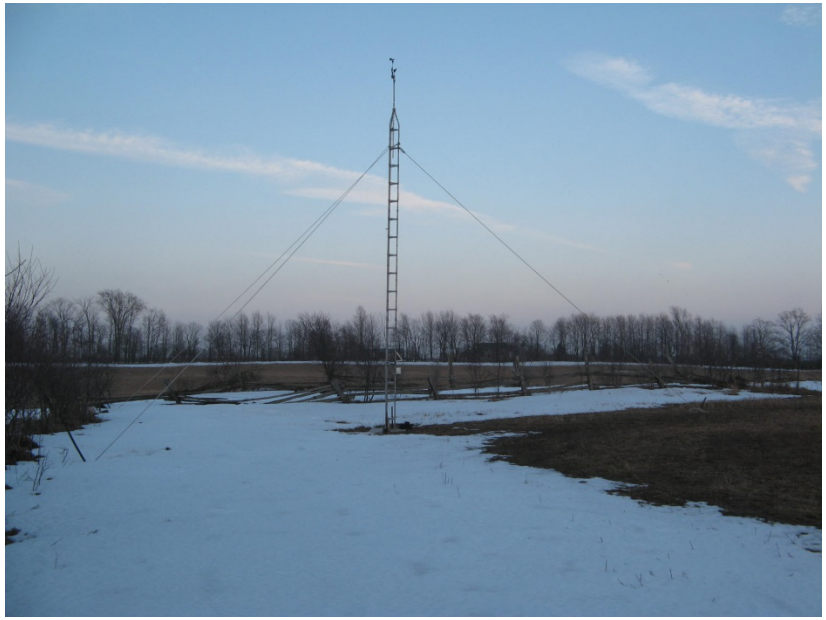

Figure 3 – 10 m wind speed and direction tower.

Wind tower locations:

Arthur site: N4849259 E535649

Rock Hill site: N4907462 E543572

[2] Personal communication with Mr. Bill Palmer.

Contact Information and disclaimer

The writer is **not** a trained acoustician. He is a Distinguished Professor Emeritus of Civil and Environmental Engineering at the University of Waterloo, Ontario, Canada and holds a PhD in Civil Engineering (Eco-hydraulics), is registered as a professional engineer in Ontario and is 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 writer. Based on a general understanding of the subject, the writer believes that the model and parameters used to predict SPLs near IWT's result in an under estimation of IWT noise and that the MOE noise guidelines are routinely exceeded at the Weaver residence.

Please make your own assessment of this data set.

This work is **not** sealed.

I welcome your comments or questions.

N. Kouwen.
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Acknowledgement:

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

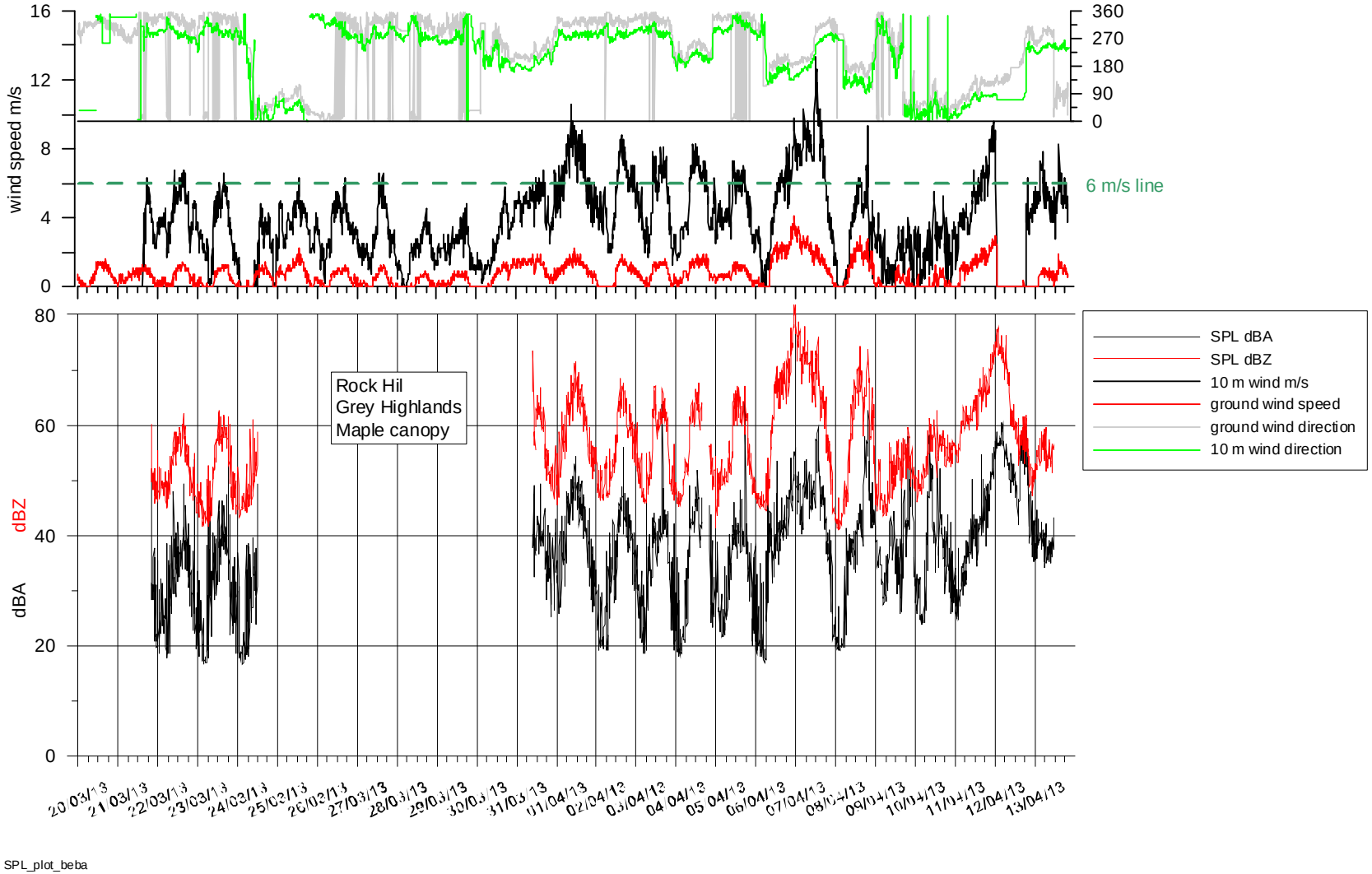


Figure 4 – This baseline data set is near Rock Hill at the intersection of Conc. 10 and the Artemesia-Osprey Townline in Grey Highlands. The lines fitted on these data reappear as background noise in Figures 5 and 6 for the Arthur location near IWT's. The break in the data was due to a stoppage of the noise analyser that went un-noticed for a week.

In the bottom plot, the black line is the A-weighted SPL (dBA), the red trace is the unweighted SPL in (dBZ). The top graph is the 10 m wind speed in black, the ground wind speed near the microphone is in red, the 10 m wind direction in green and the wind direction at the microphone in grey.

On April 12, 2013, the freezing rain prevented the anemometer from recording the wind speed. In the SPL versus wind speed plots that follow, this data has been clipped. One notable feature of this graph are the very low night-time SPL's that are lacking in the next plots.

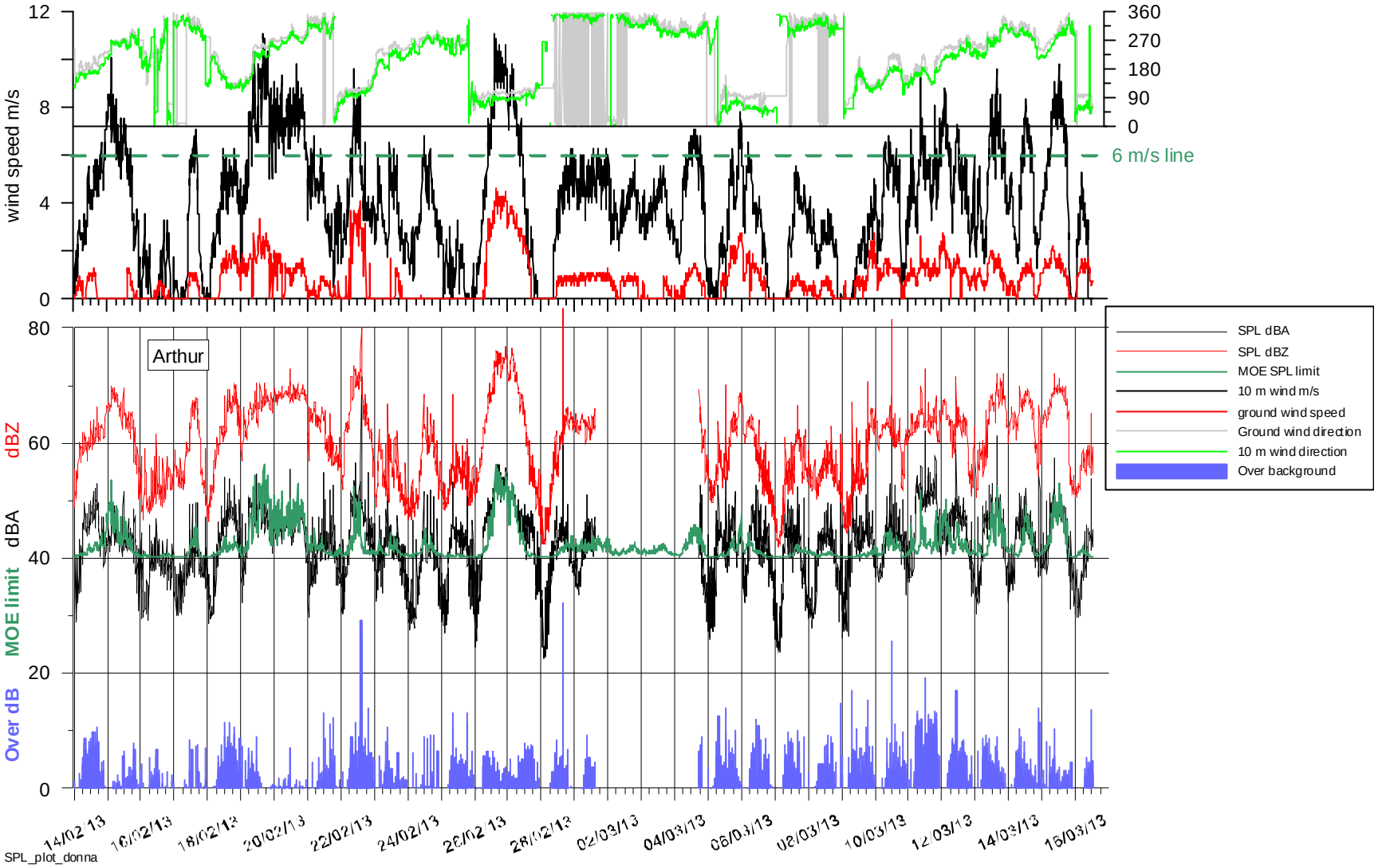


Figure 5 – This is the time series for the Arthur location near 10 ~ 2.2 MW IWT's. The colour scheme is the same as in Fig. 4. Two traces have been added in the bottom plot: the green line represents the MOE allowable SPL based on 40 dBA for 10 m wind speeds up to 6 m/s and ramping up from there to 51 dBA at 10 m/s **plus** Rock Hill background noise. This MOE allowable limit is then subtracted from the recorded A-weighted SPL to give the blue bar graph along the bottom axis. The blue plot shows the amount of time **(50%)** and the magnitude of the non-compliance with the MOE guidelines. This methodology might be critiqued due to the inclusion of traffic noise in the recorded SPL. It is acknowledged that this approach may over estimate both the duration and magnitude of the non-compliance. The use of L50 may correct this problem. Please see a more detailed description of the MOE compliance criteria in the text with Fig. 8.

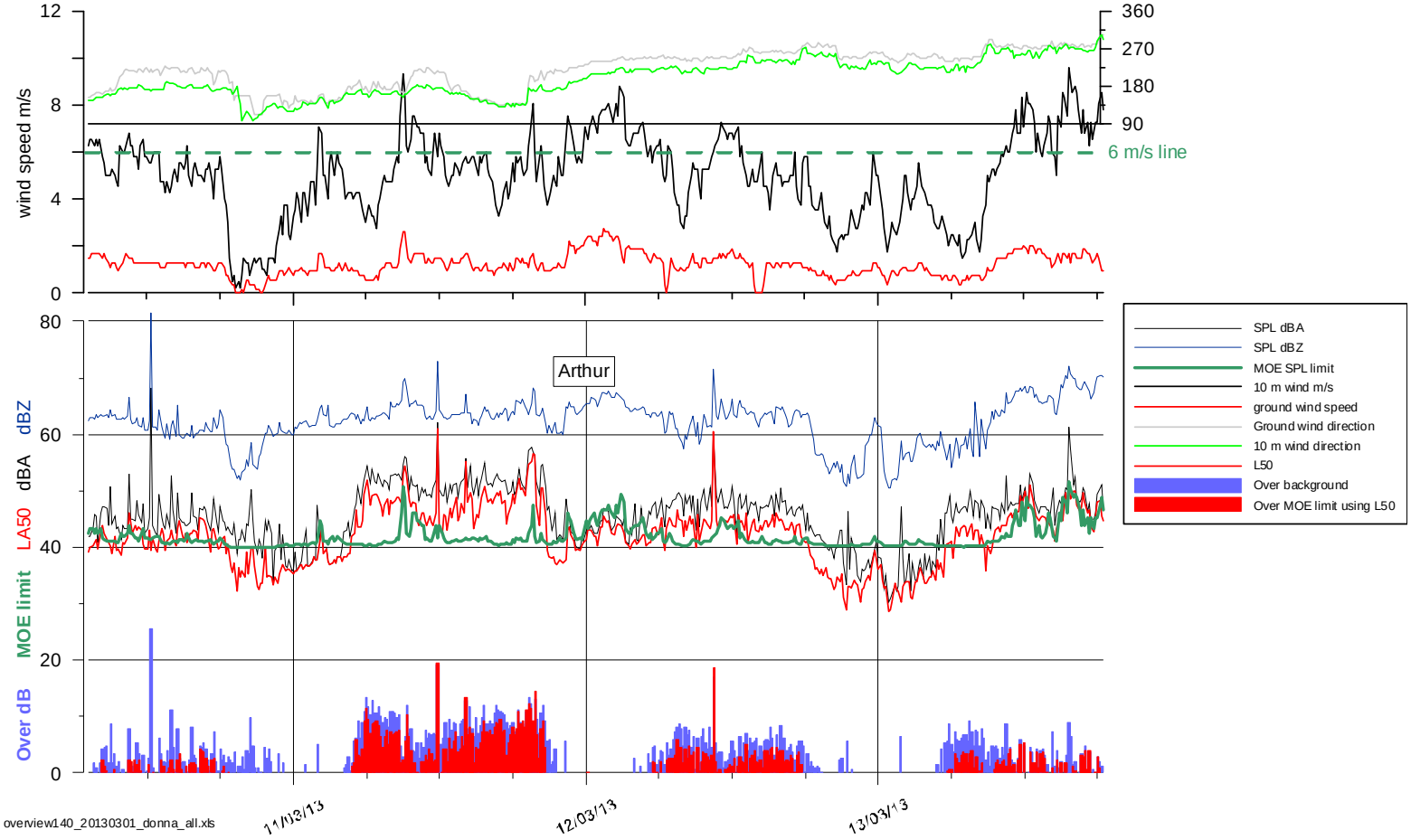


Figure 6 – Detailed record for March 10 – 13, 2013 at the Weaver residence. As noted above, subtracting the MOE limit from the A-weighted SPL may over-estimate the degree of non-compliance with the MOE noise limit. Instead of using the Leq, the L50 can also be used. The L50 value is the median SPL in each 10 minute record. Generally, it was observed that loud traffic noise was not present more than 50% of the time and thus L50 is only the IWT generated noise that is present to raise the SPL level above that of the background site for the same 10 m wind speed. In the bottom graph, the L50 is plotted as a red line and when the MOE limit (green line) is subtracted from the L50, the red bar graph results along the bottom axis. Compared to the blue non-compliance graph as in Fig. 5 (reproduced here), the duration and magnitude are lower as expected **but even the L50 exceeds the MOE allowable noise 24% of the time.** Figure 7 will show the entire record. Figure 6 shows the futility of the MOE approach to determining compliance – i.e. by listening to sporadic recordings to see if IWT noise can be heard over the background noise when the measured SPL is over 40 dBA. It is for the most part impossible to distinguish IWT noise from background noise by simply occasionally listening to recordings for "selected" times. **A long term record is obviously required for a proper assessment.**

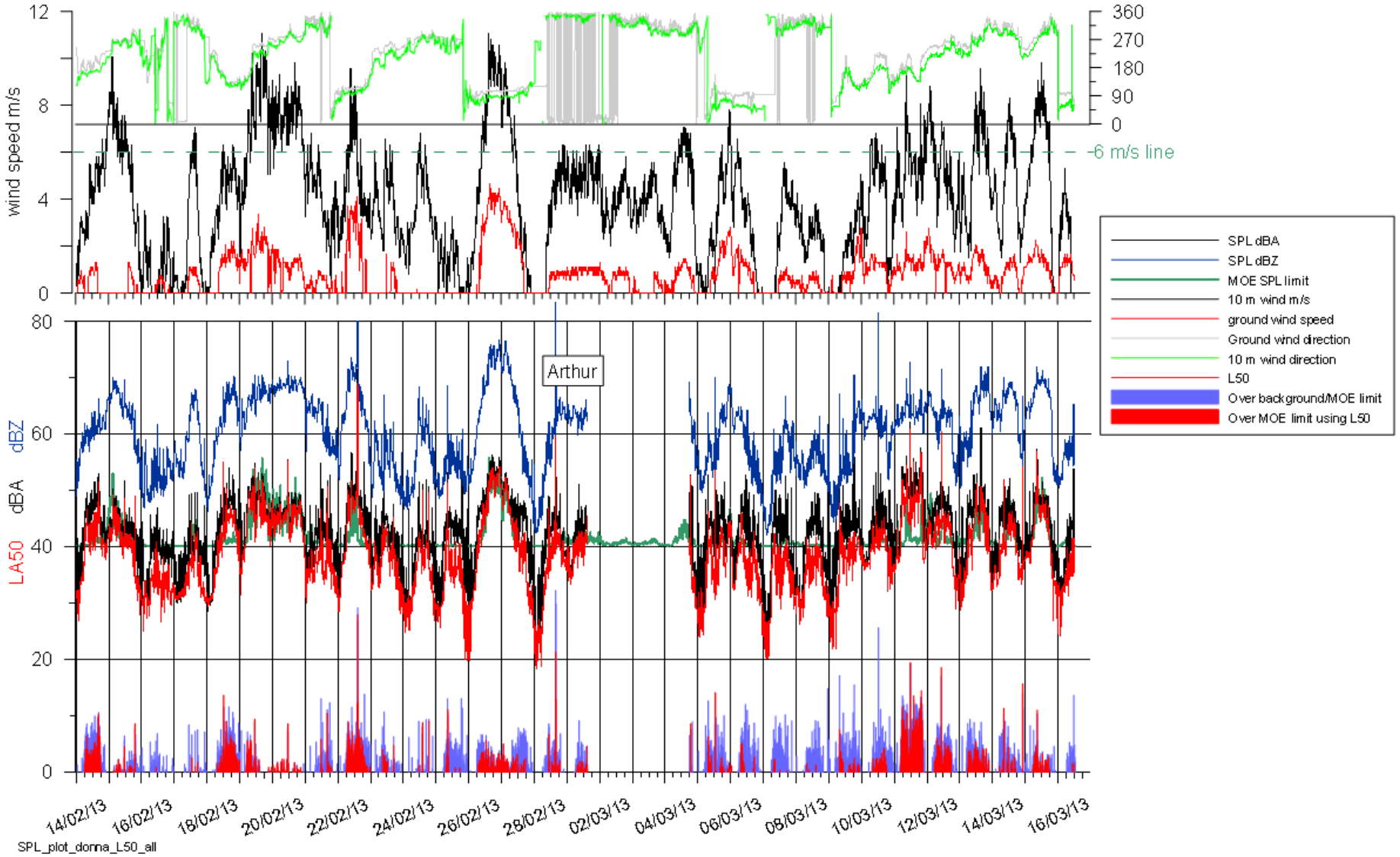


Figure 7 – Full record showing non-compliance using L50. The most notable part of this graph (and on Figs. 5 & 6 as well) **is the lack of quiet nights** compared to the background record in Fig. 4. At the Rock Hill background site, night time noise routinely drops below 20 dBA while at the Arthur IWT site it does not often even go below 30 dBA. **This is a ~10 dBA increase over the conditions normally found at night in rural sites** - a consequence predicted in various noise reports but unappreciated in terms of the resulting hardships**.** In the bottom plot, the green line is the background L50 added to the MOE IWT noise limit.

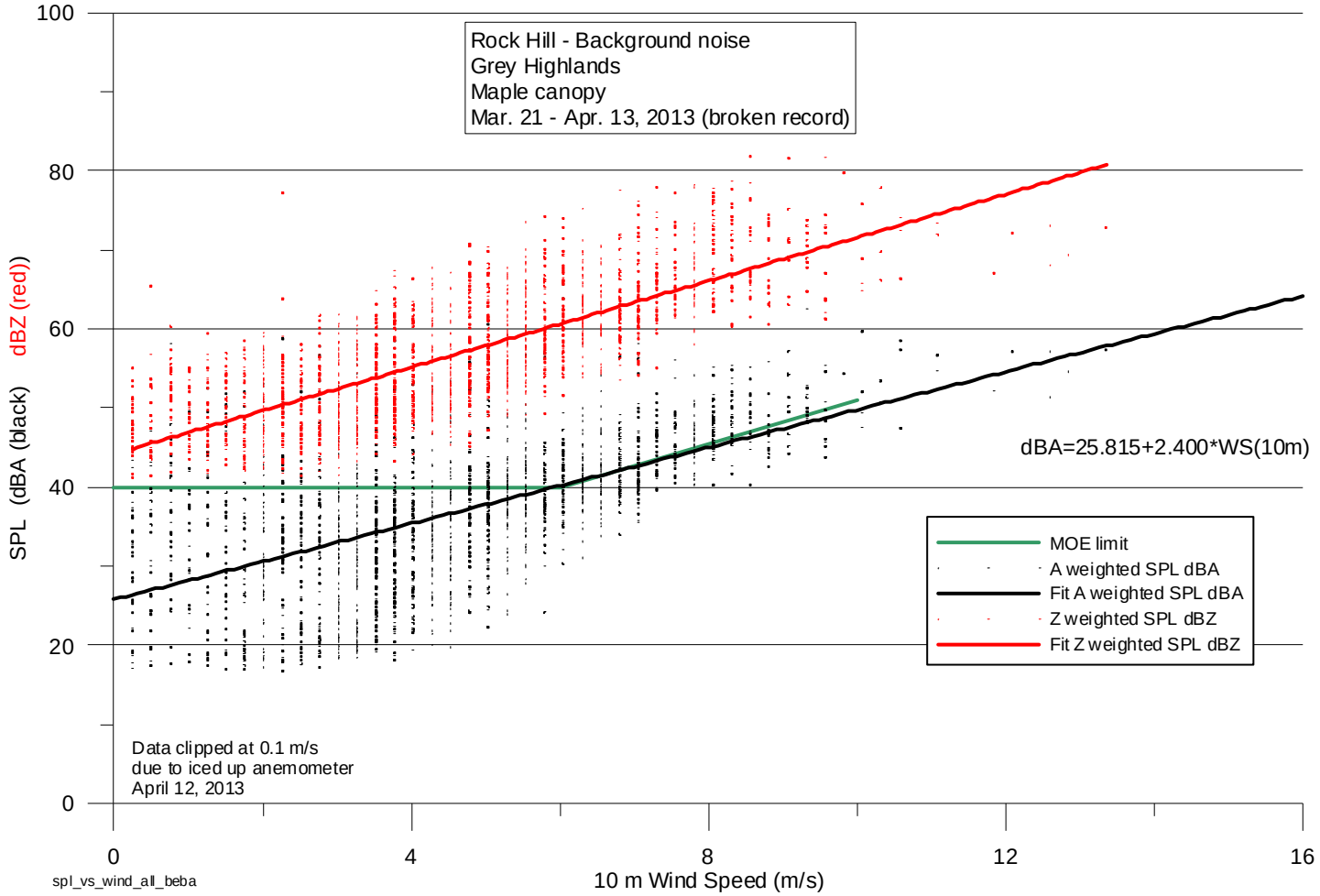


Figure 8 – 10 m wind speed versus SPL for the Rock Hill background site. A linear equation is fitted to the data and in combination with the MOE limit is used to determine non-compliance shown in Fig. 5. If the recorded SPL is over the sum of the green line (MOE limit) and the black fitted line (background noise) the noise limit is exceeded although this approach may over estimate both the duration and magnitude of the non-compliance as noted in the text with Fig. 5. The equation for the linear fitted background SPL is shown in the Fig. 8 and is used to calculate the lower blue bar graph in Fig. 5.

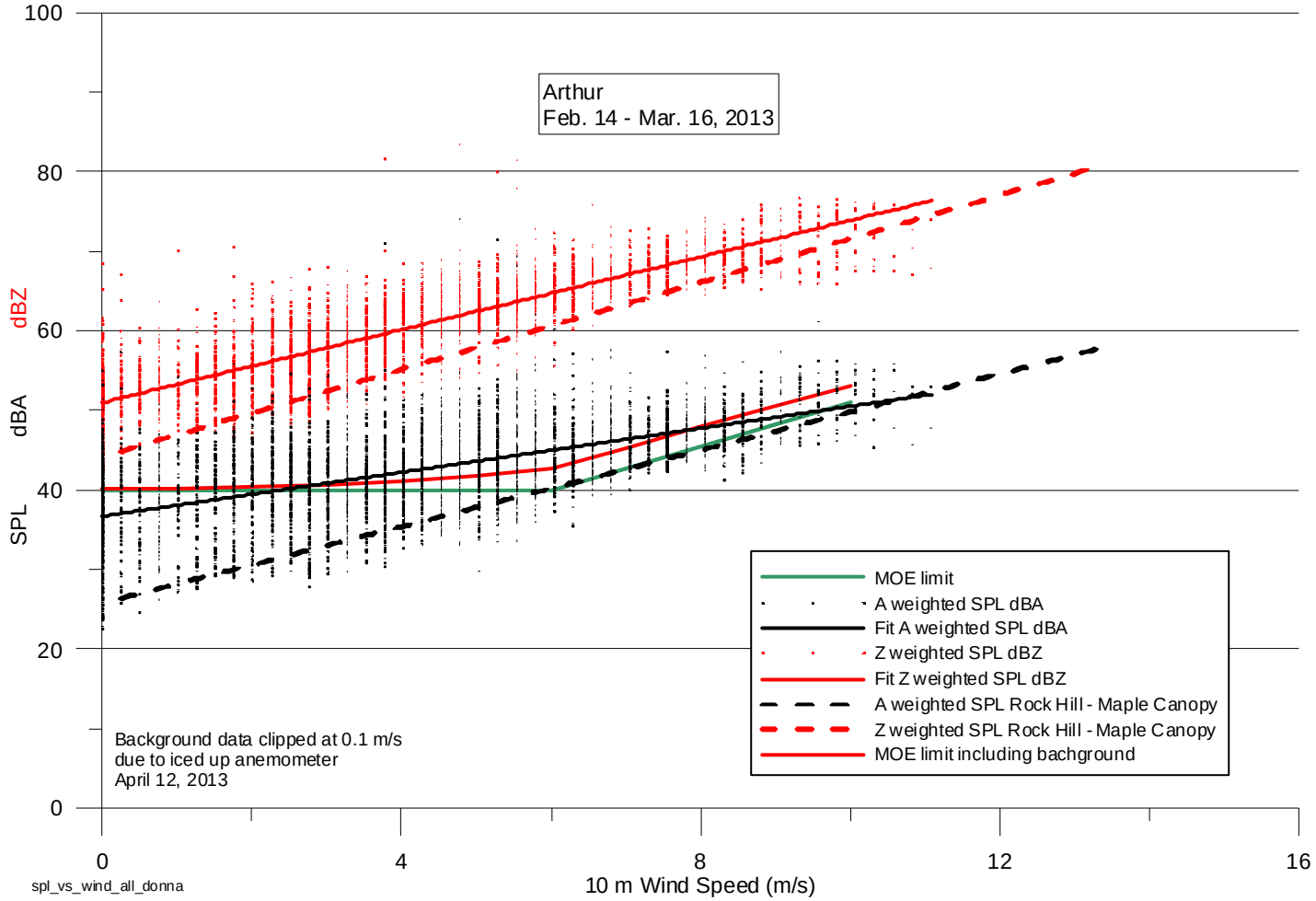


Figure 9 – 10 m wind speed versus SPL for the Arthur IWT site. A linear equation is fitted to the data in Fig. 8 and in combination with the MOE limit is used to determine non-compliance shown in Fig. 5. If the recorded SPL is over the sum of the green line (MOE limit) and the black dashed fitted line (background noise from Fig. 8) the noise limit is exceeded. This approach may over estimate both the duration and magnitude of the non-compliance as noted in the text with Fig. 5 but the use of L50 may be a more robust method to determine compliance in this location due to the traffic noise. The solid black line fitted to the Arthur data is (likely) flatter (i.e. higher at the low wind speed) than the Rock Hill line (dashed black) due to the influence of traffic noise (which does not increase with wind speed).

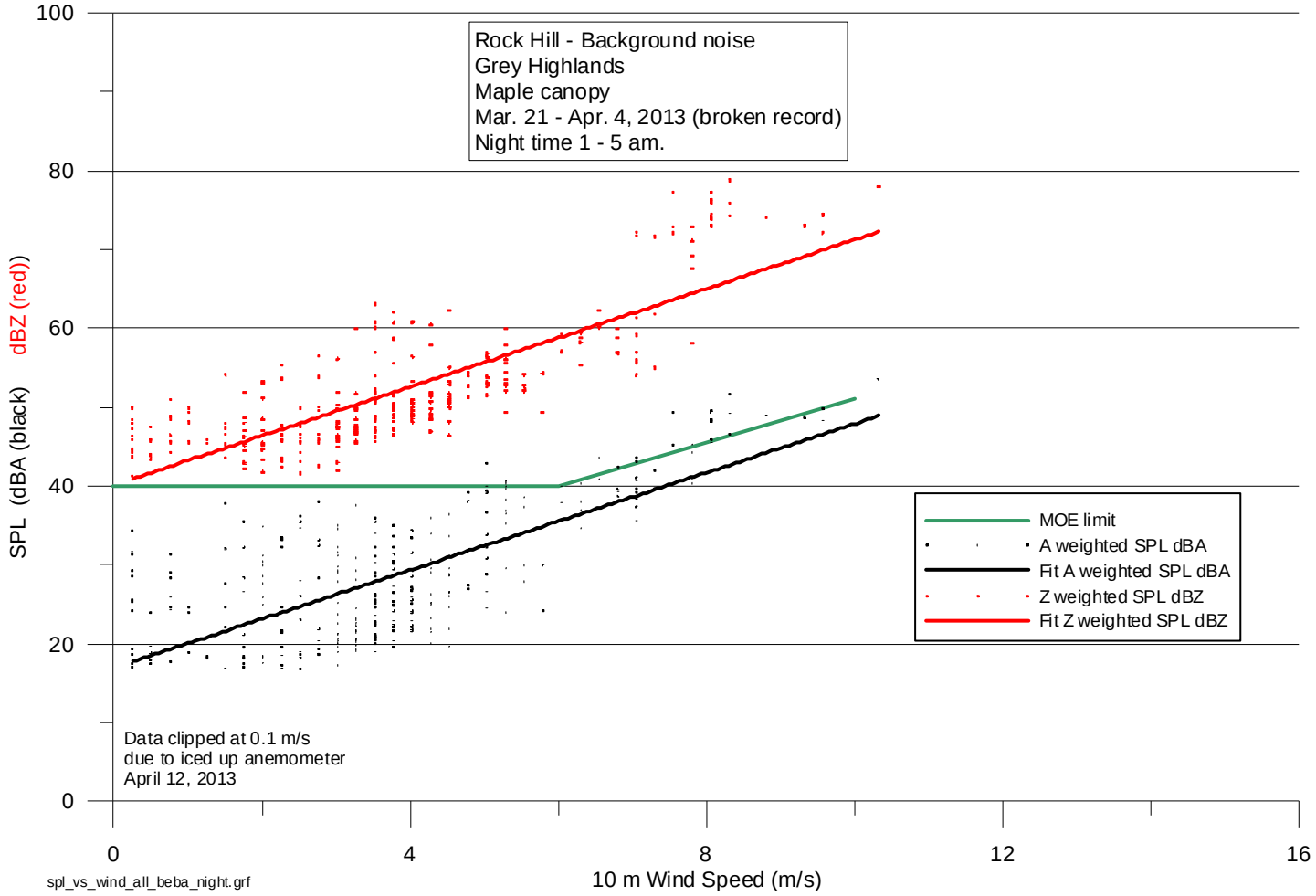


Figure 10 – 10 m wind speed versus SPL for the Rock Hill background site for night time 1-5 am only. The logarithmic sum of the green and black lines is the bottom (curved) red line in Fig. 11.

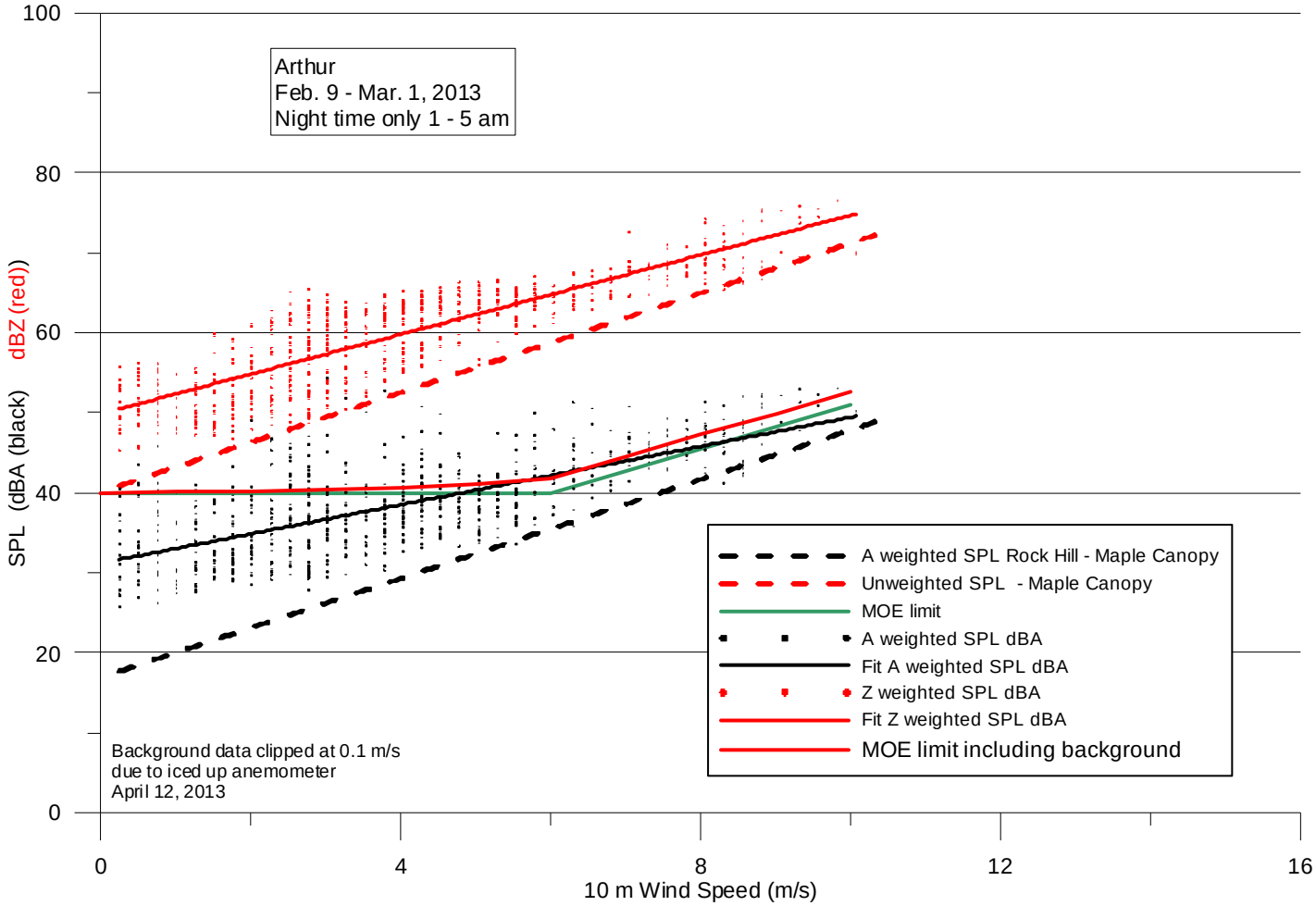


Figure 11 – 10 m wind speed versus SPL for the Arthur IWT site for night time 1-5 am only. Note that we see a strong dependency of the SPL on the 10 m wind speed which is an indication that traffic noise is not influencing the fitted line to a large degree. This shows that at night for wind speeds over ~4 m/s, the MOE limits are often exceeded.

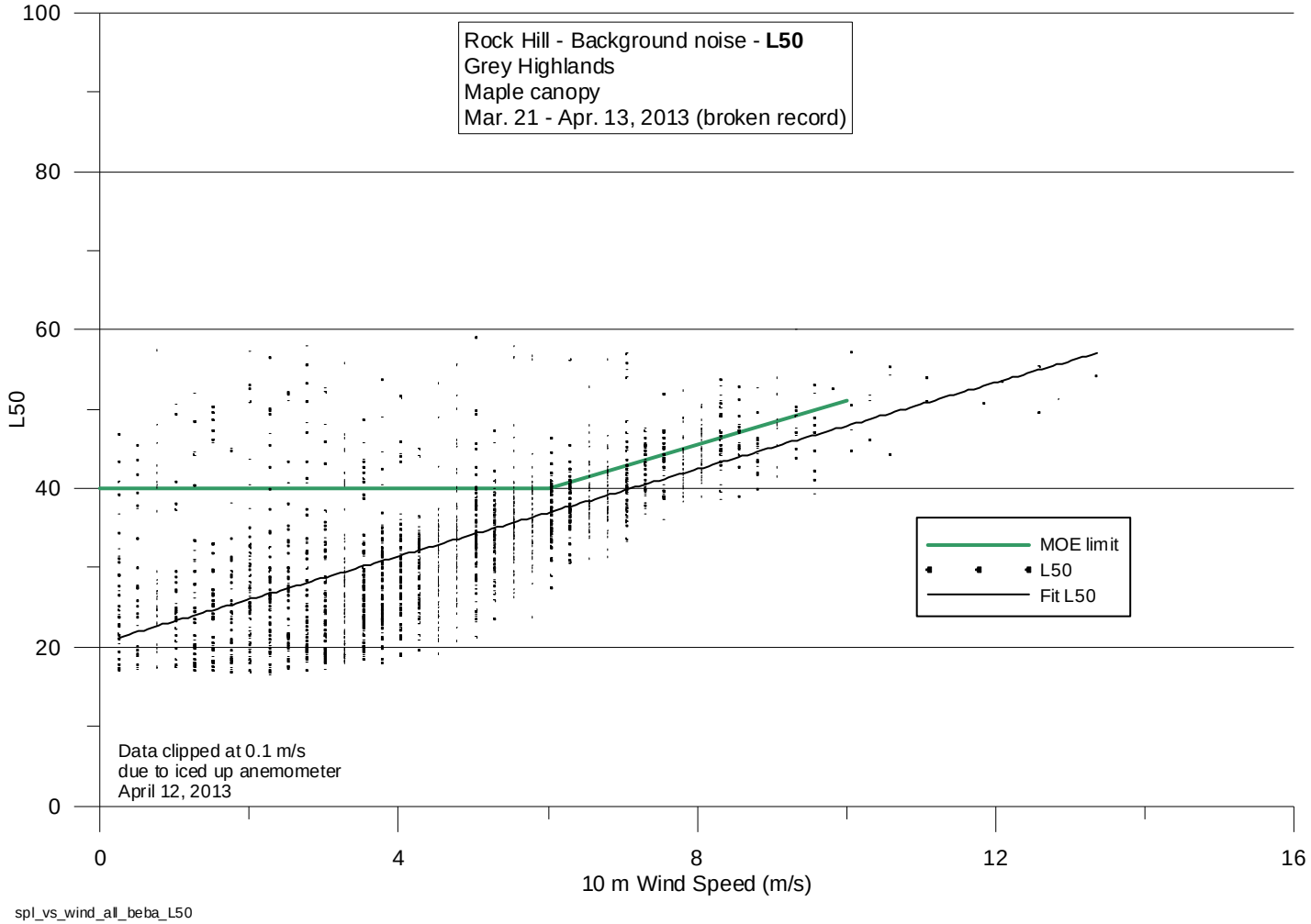


Figure 12 – 10 m wind speed versus **L50** for the Rock Hill background site. The logarithmic sum of the green and black lines (above) is the red curved line in Fig. 13. Any recorded noise above the red line exceeds the MOE limit.

According to the MOE method, the background noise is subtracted logarithmically from the recorded SPL and then compared to the green line. This is not possible with the method herein as it would result in having to take logarithms of negative numbers because fitted lines are used instead of paired observations. Comparing the observed values to the logarithmic sum of the background SPL and the MOE limit SPL permits the use of long sequences of data: **i.e. no data needs to be discarded from the analysis.**

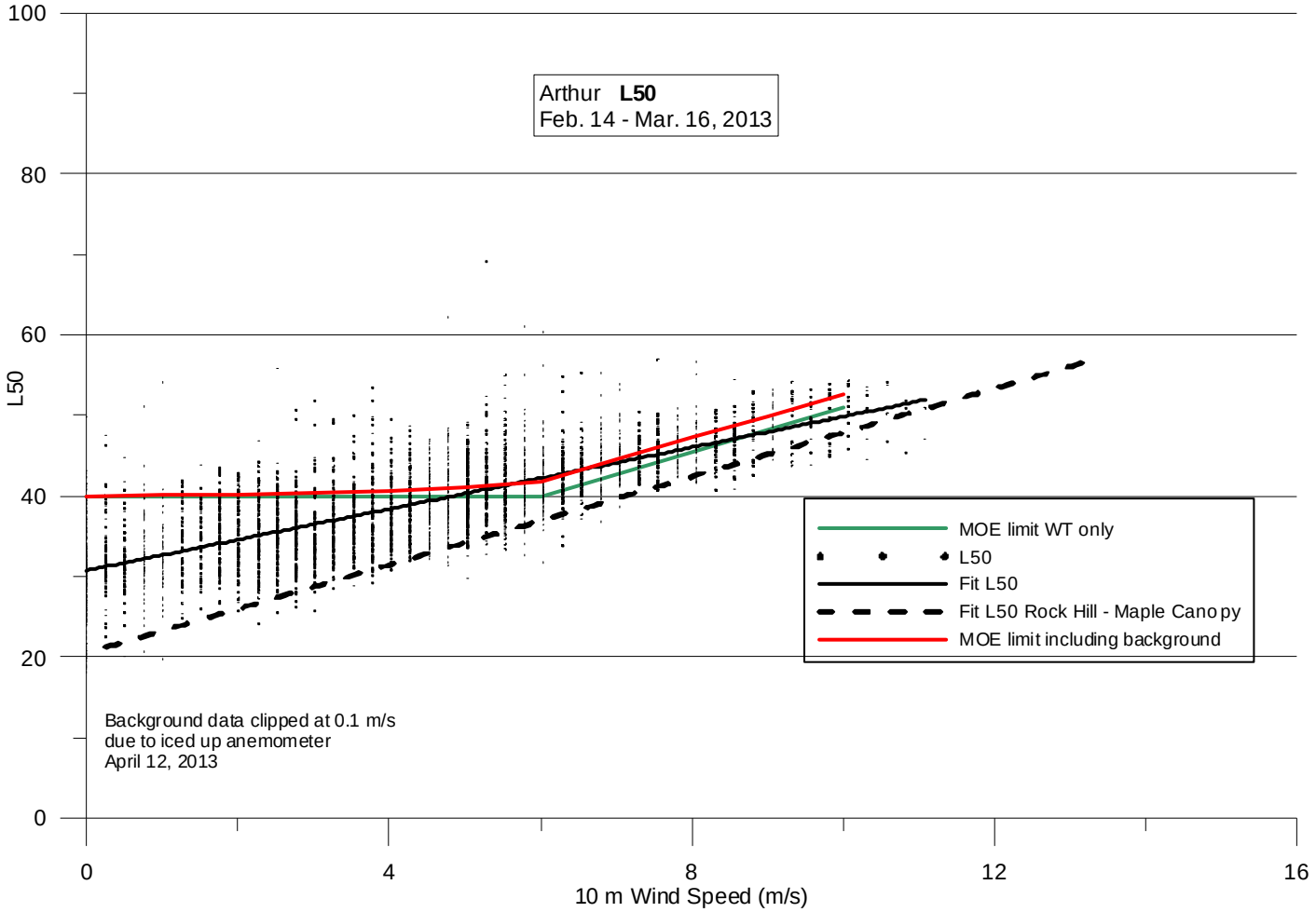


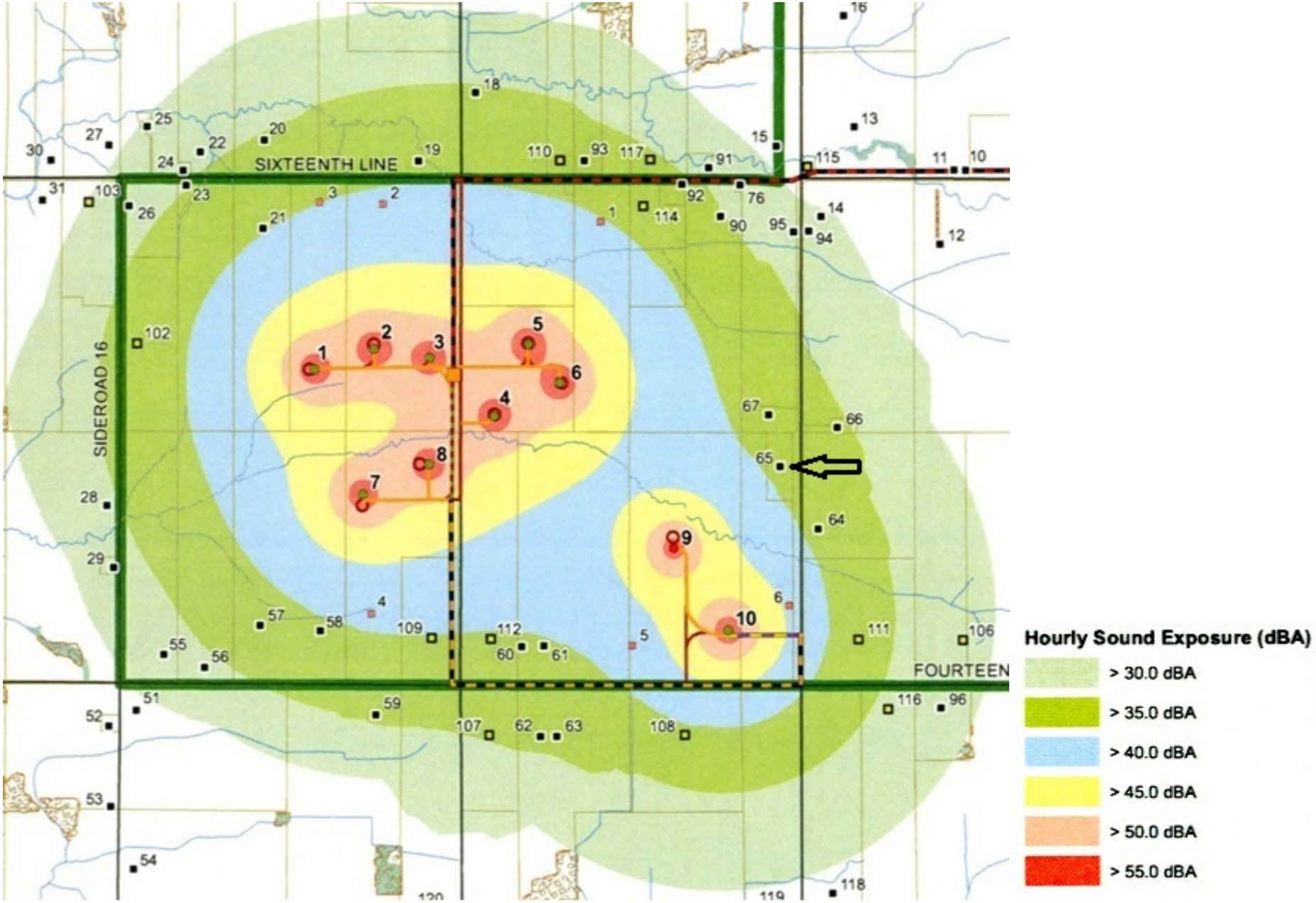
Figure 12 – 10 m wind speed versus **L50** for the Arthur IWT site. As described in the text with Fig. 6. The **L50** is the median A-weighted SPL . The loudest 50% has been removed from the record for both the background and the IWT locations. We can see that the **L50** for the IWT site is substantially higher than the **L50** for the background site with a similar vegetative canopy (Maple forest). We see a very strong dependence with wind speed **which would not be expected if traffic noise dominated the record.**

The red bar graph along the bottom x-axis in Figs. 6 & 7 represent the **L50** values that are located above the logarithmic sum of the MOE limit (green line) and the background noise (solid black line in Fig. 8; broken black line above). **The amount of time that L50 exceeds the MOE noise limit is 24% of the time between February 9 and March 16, 2013**

<u>Given that even the L50 exceeds the MOE guidelines, it is does not seem possible to argue that the MOE noise limits are not exceeded!!!</u>

Appendix A – IWT layout 22.92 MW Conestogo Wind Farm near Arthur, ON.

From Noise Assessment Report by Genivar dated July 4, 2011.



Appendix B - Journal: Donna Weaver

Journal started December 26, 2012 and is ongoing. This extract is the record for the period of time that that the noise measuring equipment was set up at the Weaver residence. [Clarifying comments in square brackets added by NK]

Feb. 15	1:00 Bob restless panic attack. Went for drive. Back home still panicky – left again Restless all afternoon. Went back out. Couldn't work Too distracted.
Feb. 16	2:00 am – earache seems a lot of pressure in the house • Still awake @ 4:00 am Bob having a panic attack; left house; came home left again.
Feb. 17	12:00 Bob having a bad panic attack 2:00 Bob more panic attacks 4:30 Bob pacing; says doesn't know what's wrong; Say he can't explain it. Left house Returned @ 10:00 pm. Feeling better after being out.
Feb. 18	2:00 am Changed bedrooms 1:00 Bob left house – says he feels distracted; can't concentrate. 8:00 pm Bob went out. 11:00 returned – feel better.
Feb. 19	Out all day 8:00 pm Couch vibrating – furnace not going • Bob restless once he got home again • Sat in chair 12:30 Earache starting Pressure building in my head. Bad headache starting
Feb. 21	2:00 Bob having panic attack; says he can't breathe – going to doctor – left house
Feb. 22	Bob doesn't feel well; went for a drive 3:00 am I'm awake with earache; pressure on my head. 2:00 pm Bob restless; doesn't feel well; says he can't concentrate
Sun. Feb. 24	Out 12:00 my ear aching; pressure in my head 9:30 pm. Pressure & ear ache starting
Mon. Feb. 25	Out
Tues. Feb. 26	8:35 am Bob restless again. Doesn't look well. I have headache starting. Petro [dog] rubbing ears on couch 9:00 pm Getting ear ache
Fri. Mar. 1	Bob up at 7:00 restless; went for drive came back; tried to lay down; couldn't; went again. I woke up with a dreadful headache 11:30 am Still have headache 2:30 Bob took pill & went to bed

	6:30 Petro barking 7:00 Bob went out couldn't stay in house
Sat. Mar. 2	Bob distracted; couldn't go back to sleep 2:00 Went out. Went to drug store to get herbal for panic attacks 6:00 Wanted to leave house again
Sun. Mar. 3	2:45 am Turbines noisy 4:00 Bob can't sleep; restless; He woke me up. I have pressure in my head. 5:00 Bob gone for a drive 12:00 Pressure in my ears. Bob finally asleep. This is insanity. 2:00 Bob has to get out of house – went grocery shopping 5:15 Turbines whooshing; very light wind. Just came home. Bob restless already. 6:00 Bob can't stay in house. Has gone for a drive. I'm going to bed – don't feel well. 10:15 pm Pain in ear & headache starting. That feeling of pressure again. 12:30 pm [0:30 the next day] Shaw satellite signal loss but not [the other] Dish network
Mon. Mar. 4	2:15 am Awake with an earache. Turbines noisy. Very little wind. Took sleeping pill. 2:00 Left house returned 4:00 Bob laid down; very restless 7:00 Bob went to [Palmerston hospital] emergency; couldn't breathe panicky. Palmerson. People called worried. **[Bob went to his car dealership before going to the hospital where his brother and a salesman were worried about his condition and wanted to drive him to the hospital but Bob left to go on his own]**
Tues. Mar. 5	8:00 pm earache. – headache starting 11:00 turbines loud – earache starting again
Wed. Mar. 6	3:00 am – wakened up – turbines loud Earaches starting again Bob took sleeping pill. Couldn't get to sleep 3:30 headache starting still awake *Grand daughter here overnight threw up four times Bob up again in night went out at 9:00am came home 12:00 Left 2:00 came home 5:00 Left 7:00 came home @ 9:00 **[Bob & I]** took sleeping pill
Thurs. Mar. 7	Slept in Both of us very tired. Bob left after being up 5:00 Earache started Bob had to leave house 6:00 Came home 8:00 we both had headaches & I had earache. Left house @ 12:30 Ten minutes after being in house my headache & earache started again. Bob for sure has to sleep somewhere else. Company coming for 4 days. Earache & headache took pills – Good sleep
March 8	Started as soon as home not long Bob up – restless 3:00 Left for airport

	7:00 Bob restless; Mark took him for drive
Mar. 9	Out of house most of day. Turbines not running in morning (9&10) Late afternoon. I started earache; Denise said pressure on her temple. Turbines noisy @ night
Mar. 10	Bob up all night; sick @ stomach 1:00 Had to get out of house; went for drive 3:00 he [Bob] went to bed. My earache started both ears; a lot of pressure Turbines facing east – north east 49 revs per min @ 3:15 Company went for another drive
Mar. 11-12	Company out of house a lot 7:05 pm Raining Mar. 12 high wind
Mar. 13	Woke up with headache; didn't get to sleep until 2:30 am! Bob up & down all night
Mar. 14	Bob gone @ 8:00 am-; couldn't sleep • In & out all morning Seemed really disoriented • Went to bed, - going for sleep apnea tests I do <u>not</u> have an ear infection. Both ears clear [doctor visit earlier] 8:34 Have had earache since late afternoon Experienced flicker from Turbine 9 in bedroom today. Will have to pull curtain on window. Couldn't see TV Don't know about rest of house. I was too upset to look. 11:00 pm We both have had headaches; I have too much pressure on my ears Going for a drive. Have to get out of house 10 min out headaches gone 2:00 am returned home Turbines **<u>very</u>** loud 2:20 EARACHE & PRESSURE BACK 2:30 Going to try to sleep
Mar. 15	Out all day; home 1 hr Bob had to leave; gone - came home threw up twice – wants to sleep somewhere else 9:45 Dog growling & barking 10:00 pm Took pill to get some sleep; Bob took pill too
Mar. 16	Turbines really noisy! Bob woke & changes bedrooms I slept until 11:00 am Bob sleep till 12:00 Company this am could feel pressure in the temples Bob had to leave; has been in & out since noon; gone out again 3:30 had company One felt pressure 5:00 Bob home. Tried to sleep 9:45 Left house. Bob couldn't stay