

Vibration Impact Assessment

Newman Main Line Vibration Levels from Train Pass-bys RGP 5 Project

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1 INTRODUCTION

As part of the environmental studies for the BHP Billiton Iron Ore (BHPIO) Chichester Deviation project, a new species of trap door spider has been discovered in the areas of the proposed alignment. This type of spider is believed to be sensitive to ground-borne vibrations.

To establish a baseline against which to assess potential impact to these spiders, an assessment of the ground-borne vibration levels associated with freight trains operating on the Newman main line has been undertaken. The assessment provides typical vibration levels and the expected attenuation of the vibration energy with distance from the railway.

Although we are not aware of any criteria for spider disturbance from ground-borne vibration, some discussion is provided on possible impact areas.

2 DEFINITIONS

RMS

The root mean square level. This is used to represent the average level of a wave form such as vibration.

Vibration Velocity Level

The RMS velocity of a vibration source over a specified time period. Units are mm/s.

Decibel – Vibration Levels

The decibel (dB) describes the vibration velocity level in manageable numbers. It is a logarithmic scale referenced to 10^{-6} mm/s.

Peak Velocity

Level of vibration velocity measured as a non root mean square (r.m.s.) quantity in millimetres per second (mm/s).

3 METHODOLOGY

Vibration levels were measured at each location using a 100mv/g accelerometer magnetically connected to a metal stake that was driven 200mm into the ground. The accelerometer output was connected to a SVAN model 946A or a SVAN model 948 vibration analyser. The analysers were set to sample the vibration levels (z-direction) every 125 milliseconds and to log the results at one second intervals.

For each train pass-by, two measurements were made. One measurement was made at a control distance from the rail and the other at a different distance. This methodology was used to obtain a reliable relationship between vibration level and distance from the rail.

Three different terrains were chosen. These were:

- ❑ Flat ground. Where the land did not rise or fall as the distance from the railway increased. This has been found to have spider habitats;
- ❑ Rail in Cut. Where the land rose sharply from approximately 10m from the edge of rail. This is a known spider habitat; and
- ❑ Rail on fill. Where the land falls away sharply from approximately five metres from the railway. This is not a known spider habitat but provides variation to the other two terrains.

4 RESULTS

4.1 Typical Vibration Values

The results of the vibration measurements at the chosen locations are provided below. For measurement locations close to the railway, the train dominates the overall levels and therefore the vibration level can be easily assessed. Typical overall vibration velocity levels at 5 and 20 metres from the railway are provided below in *Figures 4.1 to 4.4*. The charts show the measured average, maximum and peak levels at one-second intervals. For human response to vibration, the average levels are used as this correlates with the reaction time of humans to detect vibration levels. The peak levels are often used to determine the likelihood of damage to buildings.

It should be noted that the figures are provided in both mm/s and decibels. Decibels are calculated using the formula $20 \log_{10}(\text{measured velocity level}/\text{ref velocity level})$. They are used as they provide numbers that are easier to use.

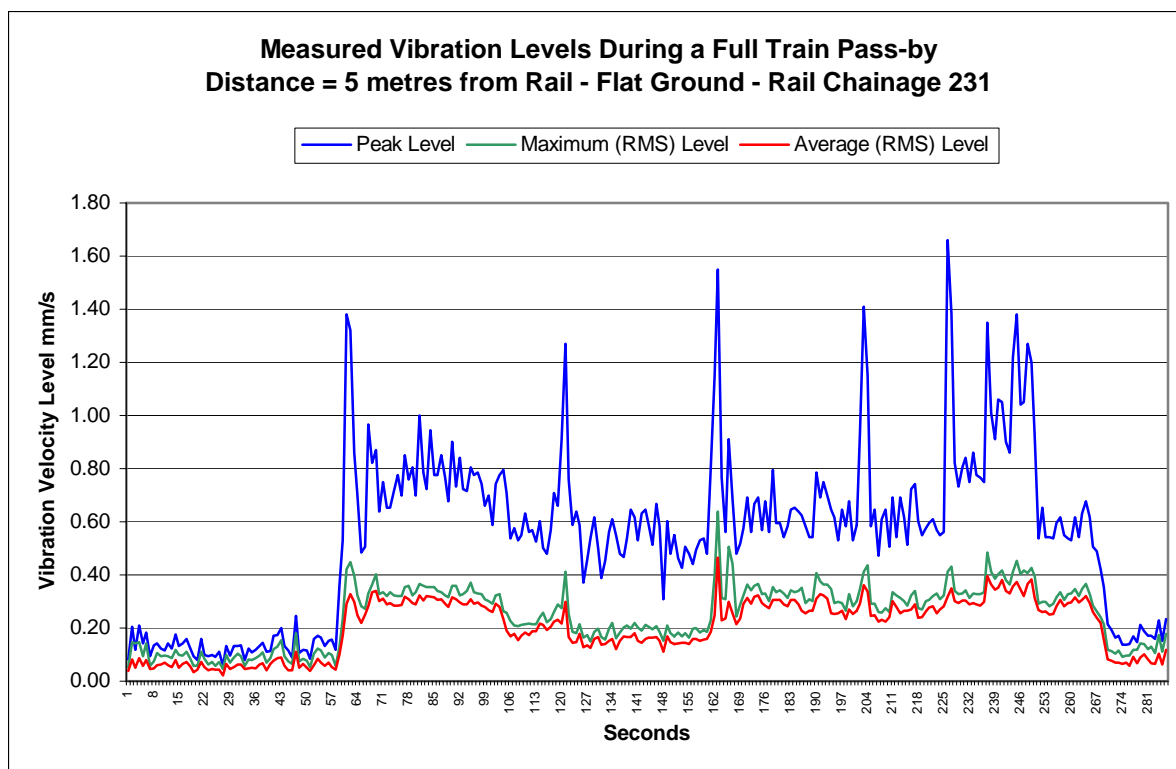


Figure 4.1 Vibration Levels at 5 metres from the rail on Flat Ground in mm/s

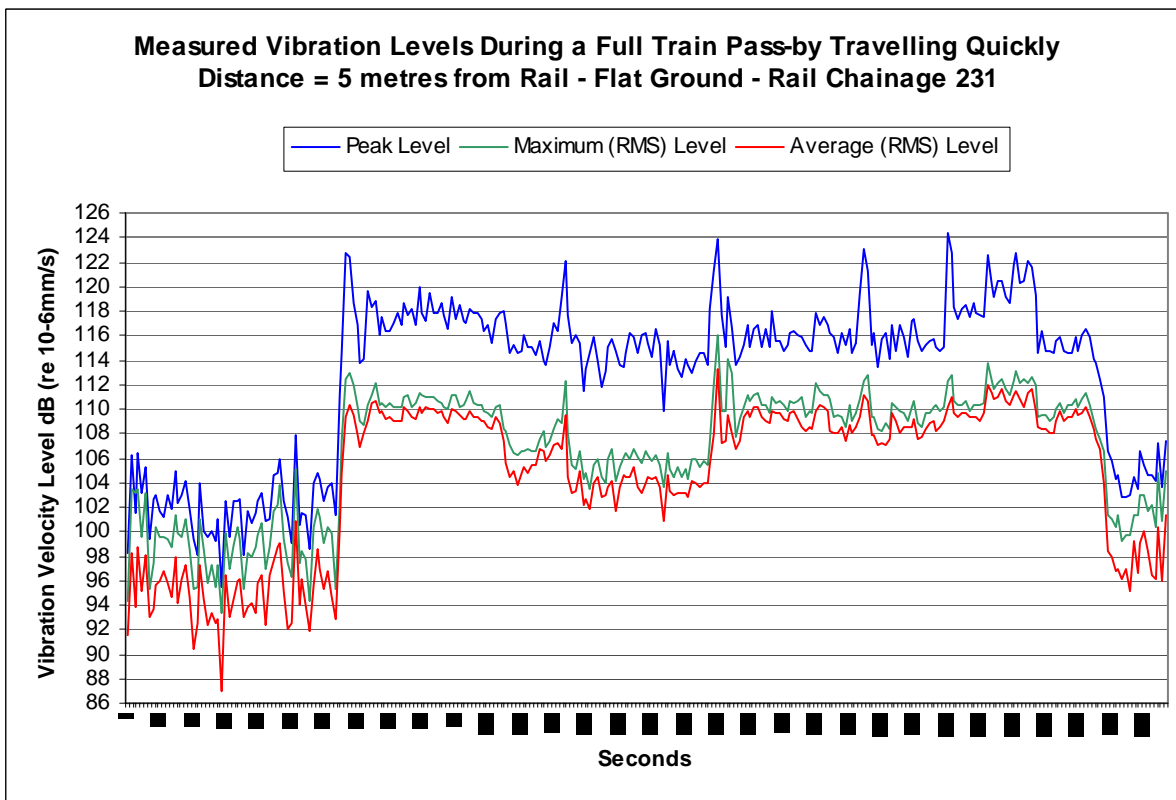


Figure 4.2 Vibration Levels at 5 metres from the rail on Flat Ground in dB

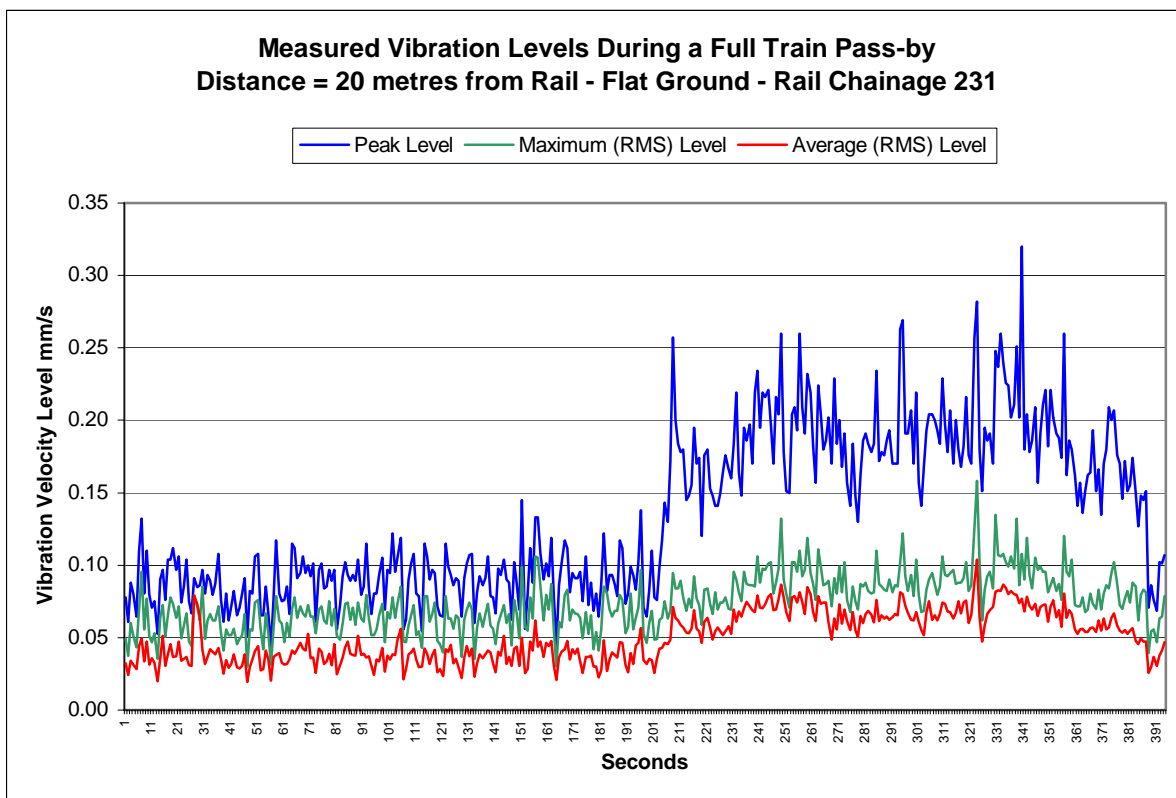
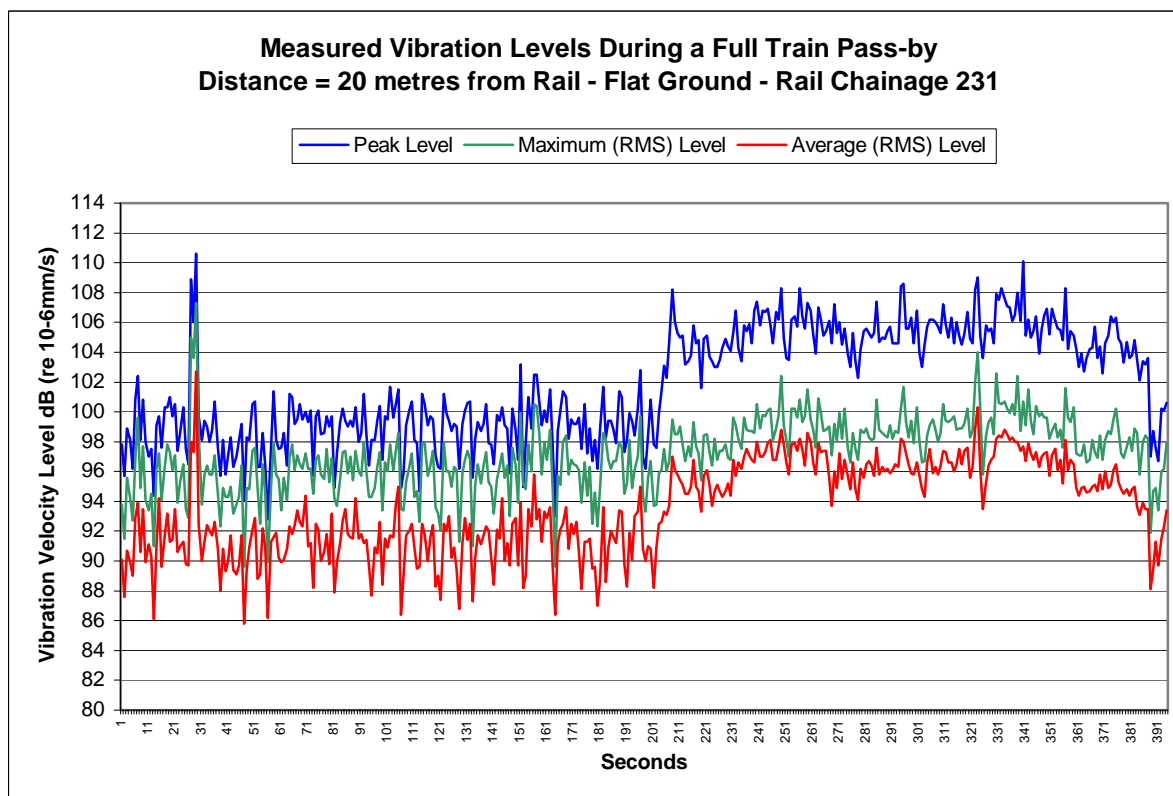


Figure 4.3 Vibration Levels at 20 metres from the rail on Flat Ground in mm/s



For measurements at distances greater than 20 metres from the railway, the overall level becomes less reliable as relatively high background vibration levels at the low frequency range (0.8 to 1.25Hz) can influence the overall level. To calculate the reduction in vibration levels over distance, we have considered a single frequency in the frequency range that we know to be dominant for train pass-bys. The frequency range for train pass-bys is typically dominant between 40 to 100 Hz. We have therefore selected the 63 Hz band as being representative of the vibration from the trains.

The following sections show the measured and overall average vibration level at various distances from the track. As different train types, wagon loading and speed can affect the vibration levels; for each train pass-by, two measurement locations were used simultaneously. The first location was at a fixed (control) distance, with the second being at a different distance.

From these results the reduction in vibration from the train over distance, in decibels, has been determined. The results are grouped in the three types of topography selected, being: flat ground; railway in cut (slope); and railway on fill.

4.2 Results for Flat Ground Vibration Measurements

These measurements were undertaken at the rail chainage 231 location and represents flat ground that does not rise or fall as the distance from the railway increases

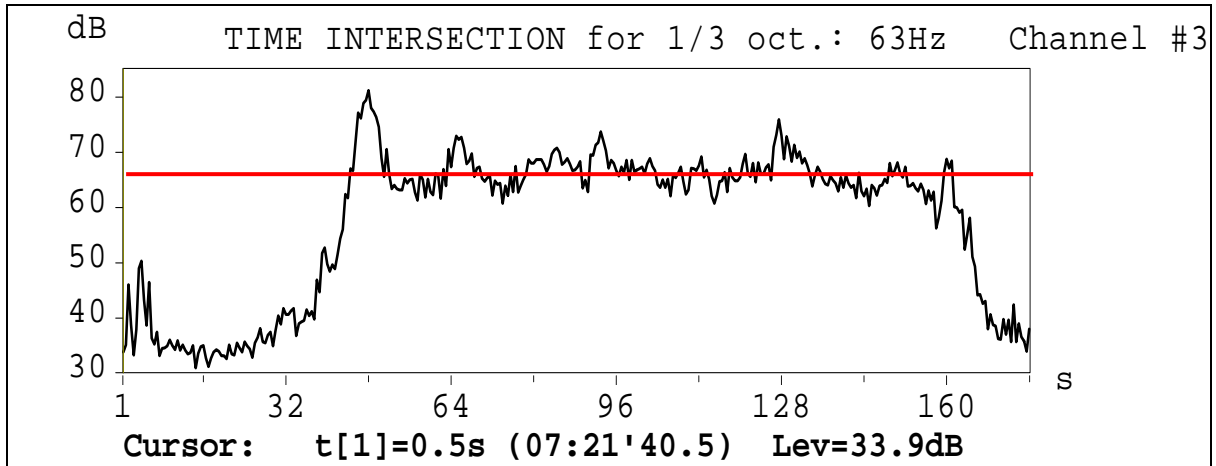


Figure 4.5 Measurement at 20m from Railway (Control) - Full Train

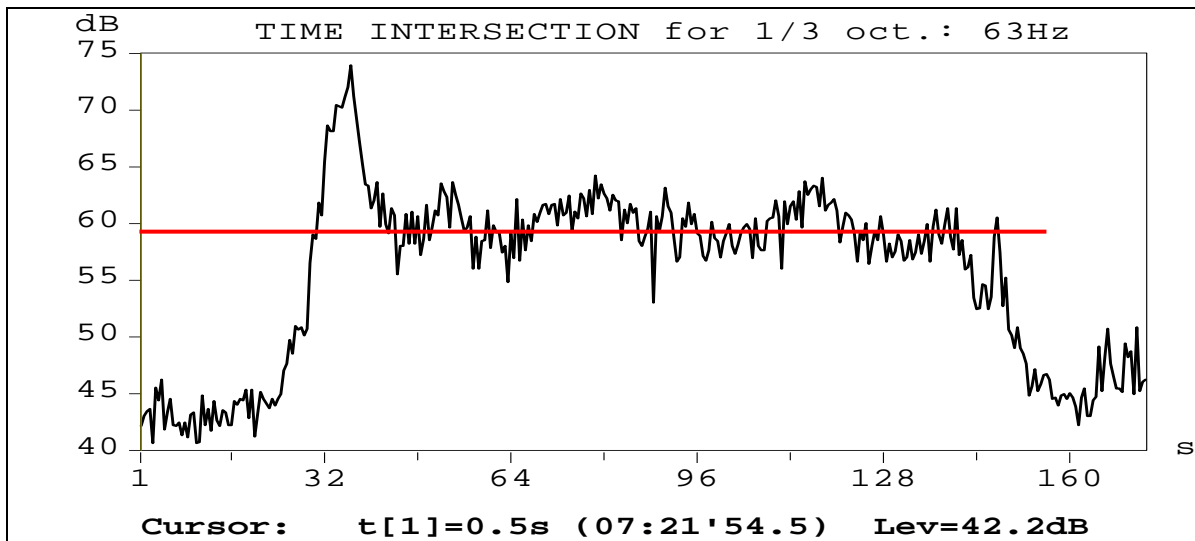


Figure 4.6 Measurement at 30m from Railway - Full Train

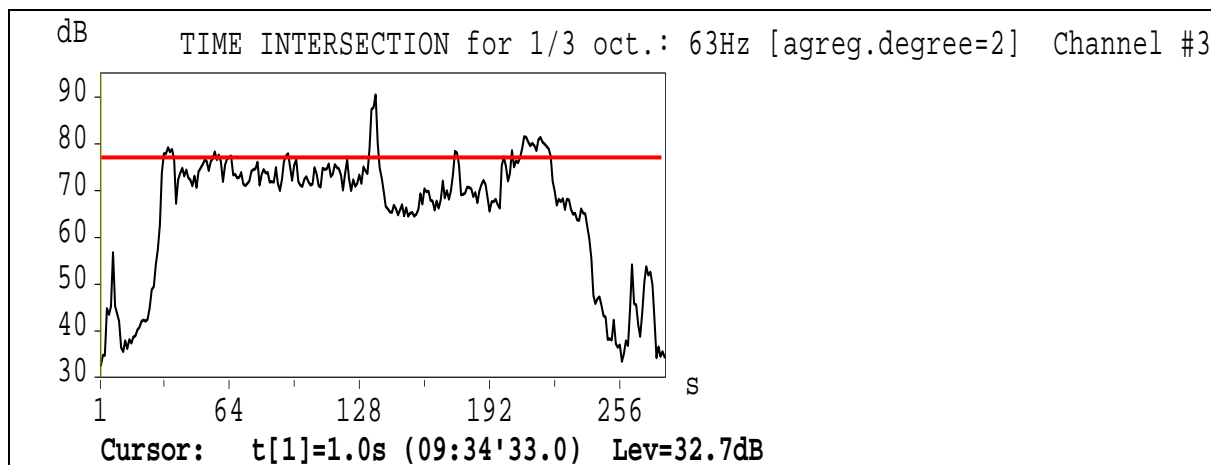


Figure 4.7 Measurement at 20m from Railway (Control) - Full Train

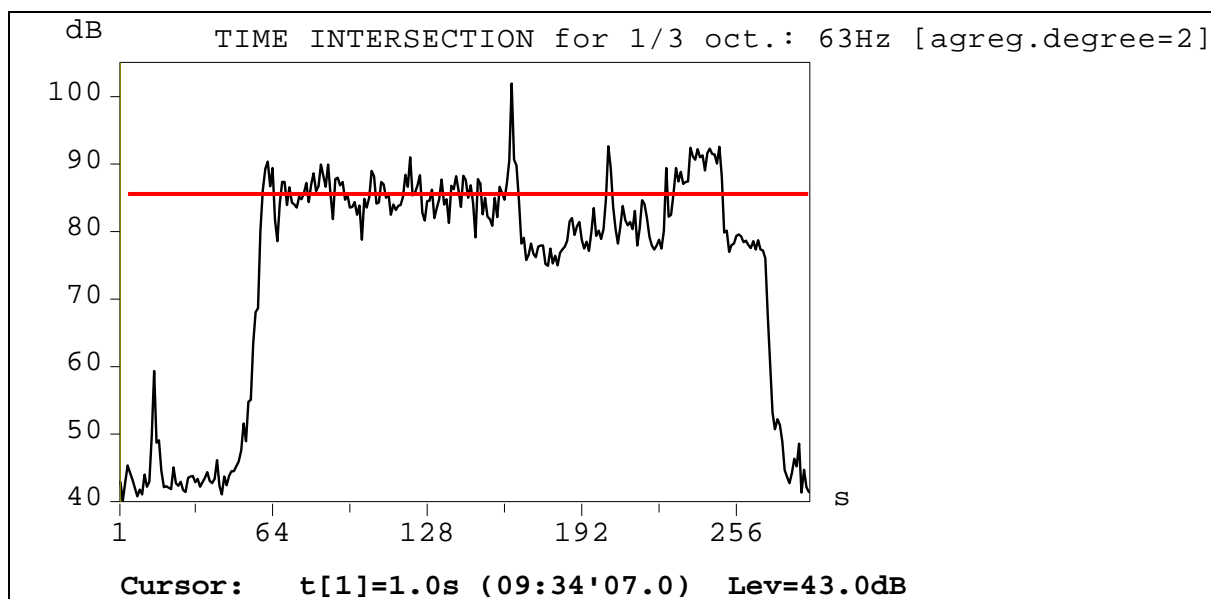


Figure 4.8 Measurement at 5m from Railway - Full Train

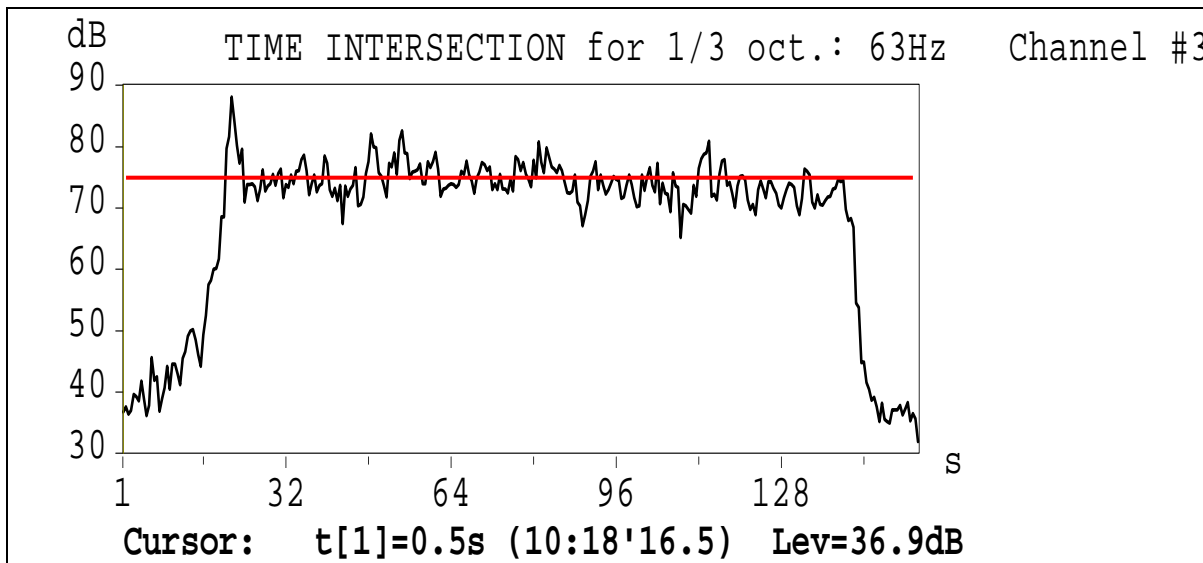


Figure 4.9 Measurement at 20m from Railway (Control) - Empty Train

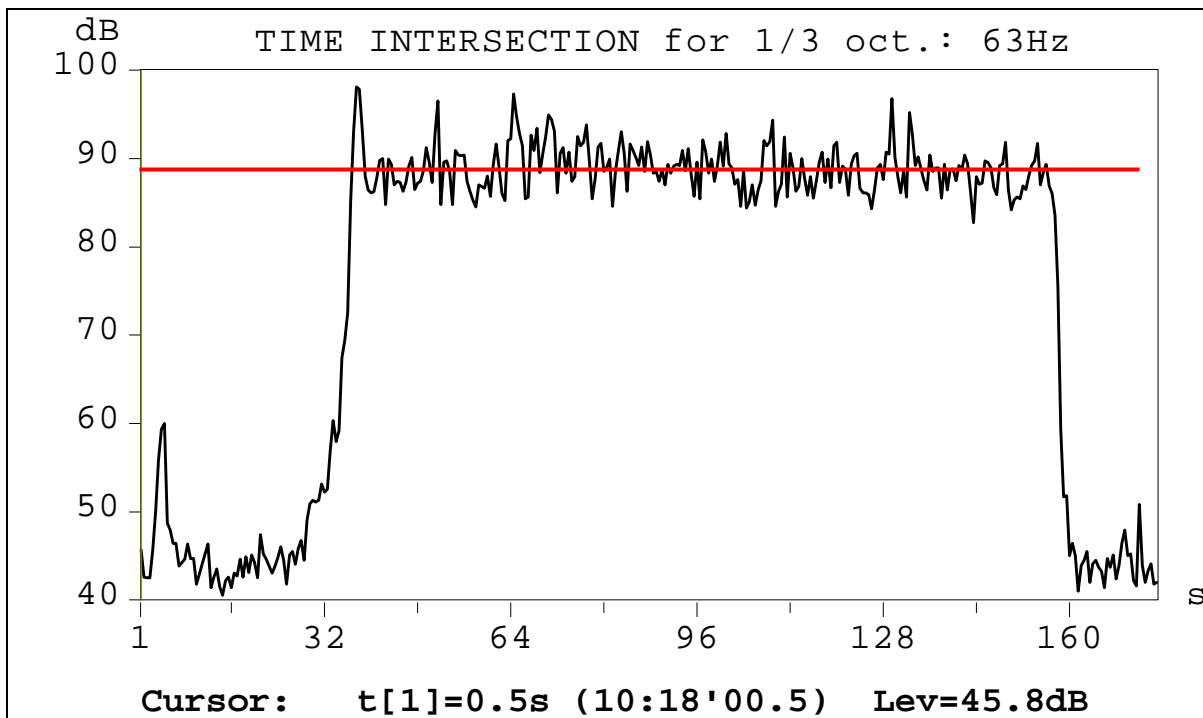


Figure 4.10 Measurement at 5m from Railway - Empty Train

4.3 Results for Railway in Cut

These measurements were undertaken at the rail chainage 212 location and represents land that rises sharply from approximately 10m from the edge of rail. This is a known spider habitat.

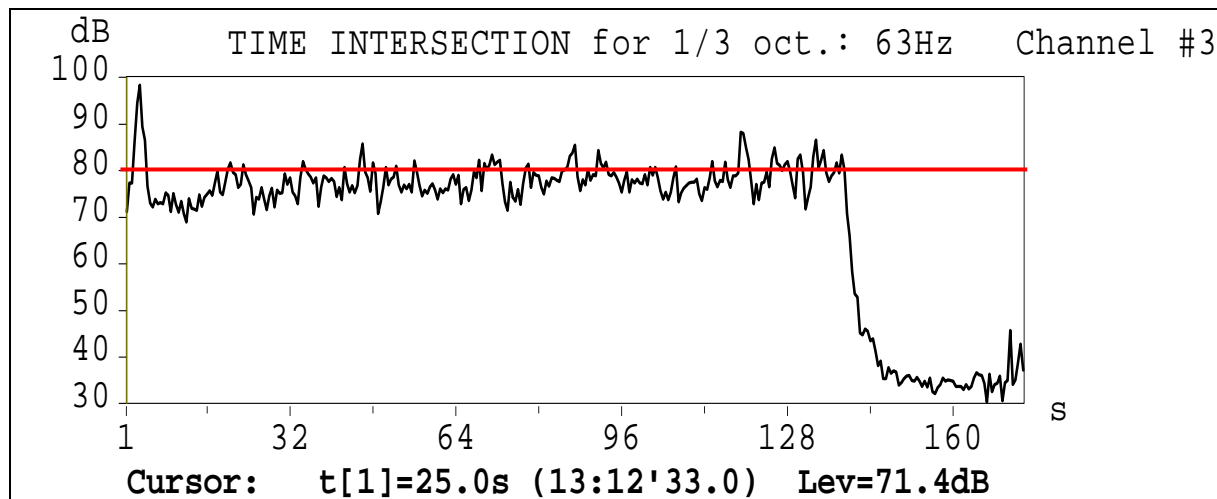


Figure 4.11 Measurement at 10m from Railway (Control) - Full Train

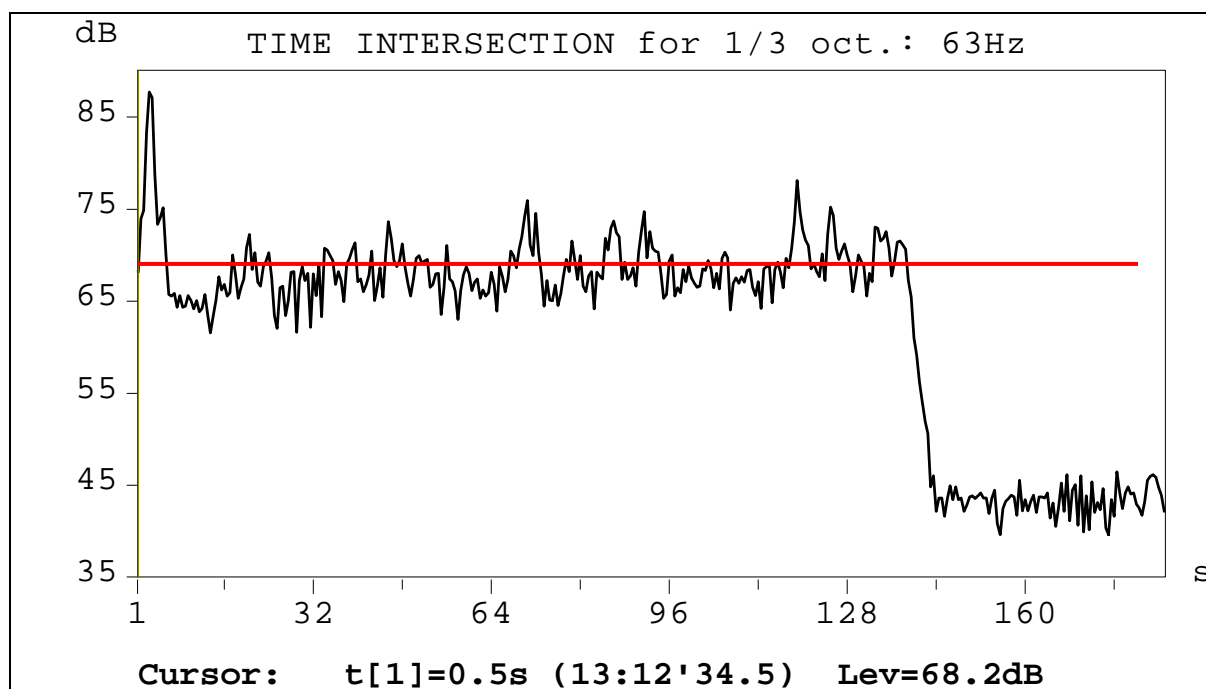


Figure 4.12 Measurement at 20m from Railway - Full Train

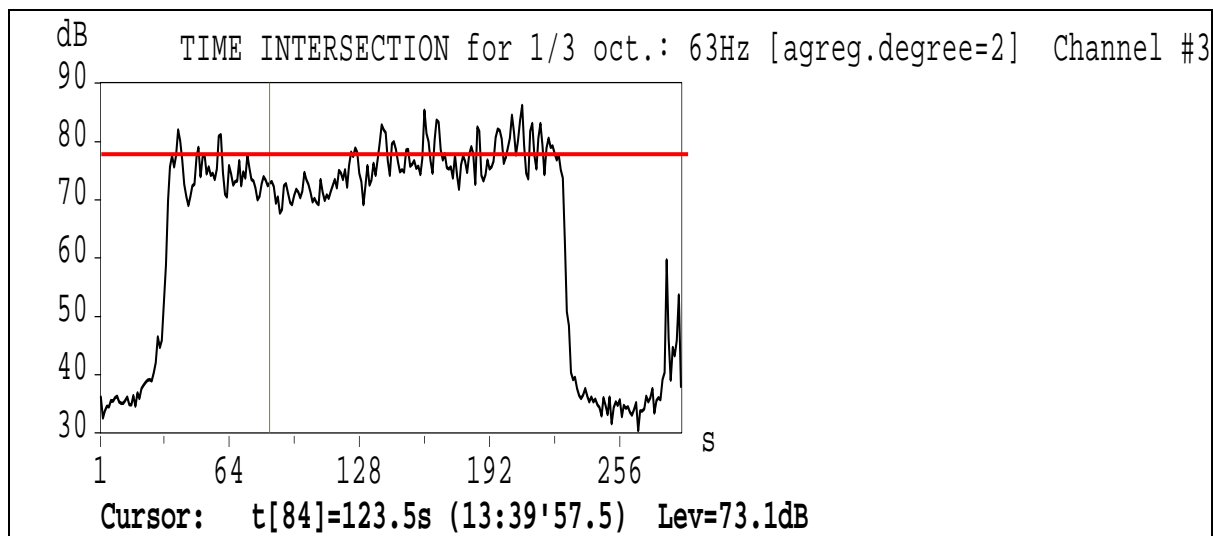


Figure 4.13 Measurement at 10m from Railway (Control) - Empty Train

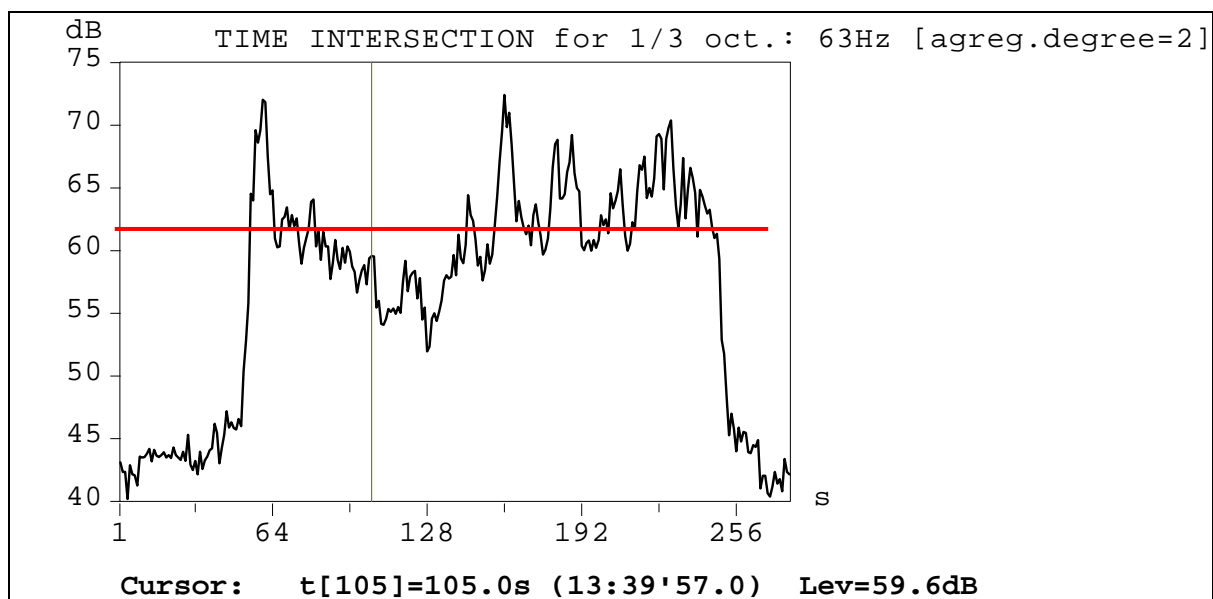


Figure 4.14 Measurement at 30m from Railway - Empty Train

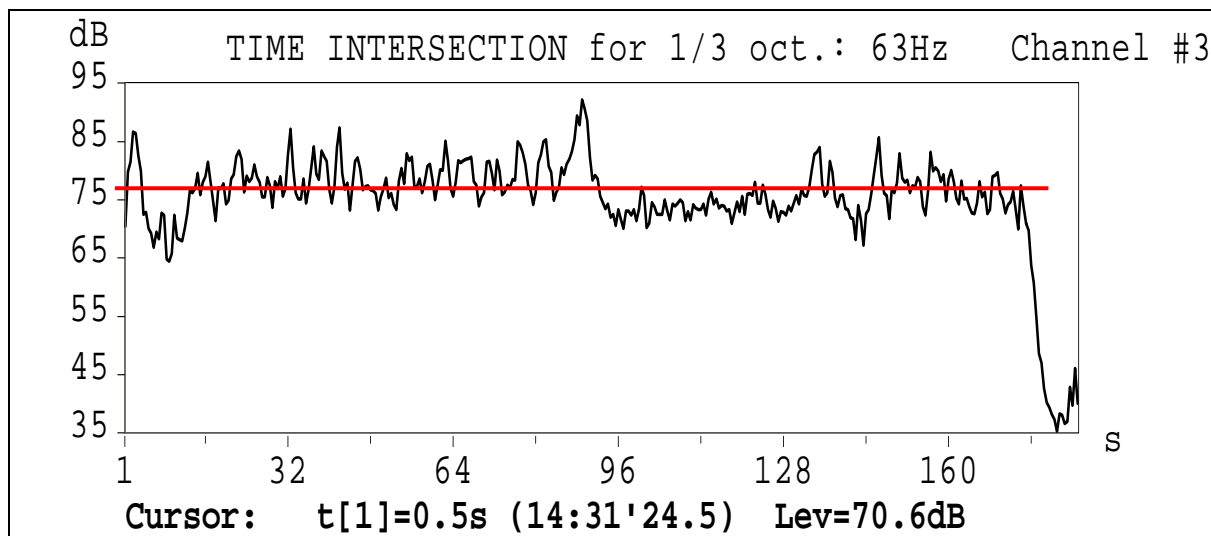


Figure 4.15 Measurement at 10m from Railway (Control) - Empty Train

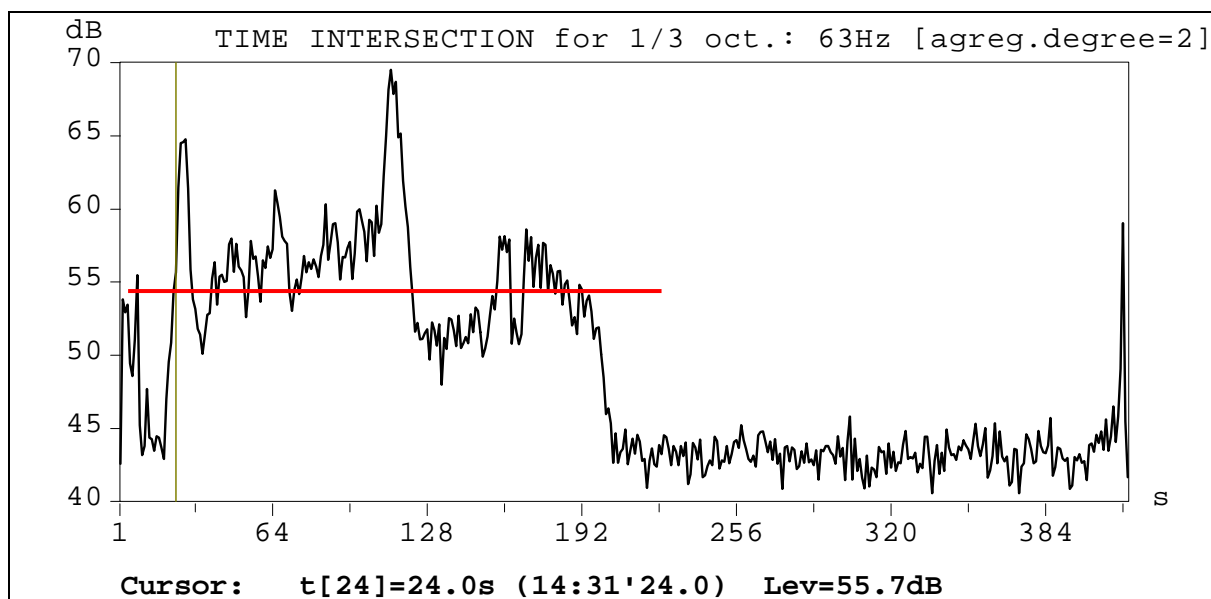


Figure 4.16 Measurement at 50m from Railway - Empty Train

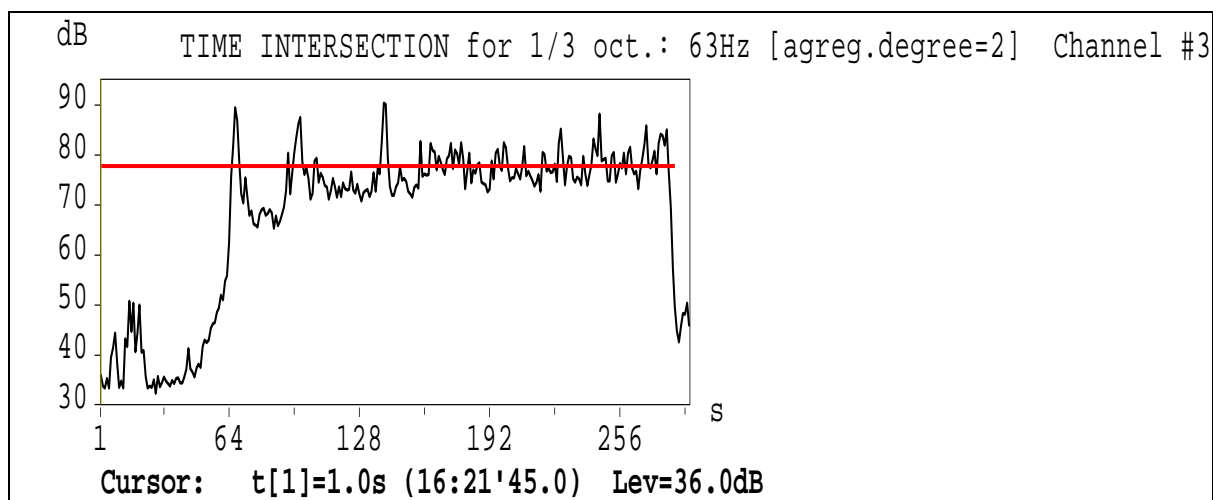


Figure 4.17 Measurement at 10m from Railway (Control) - Full Train

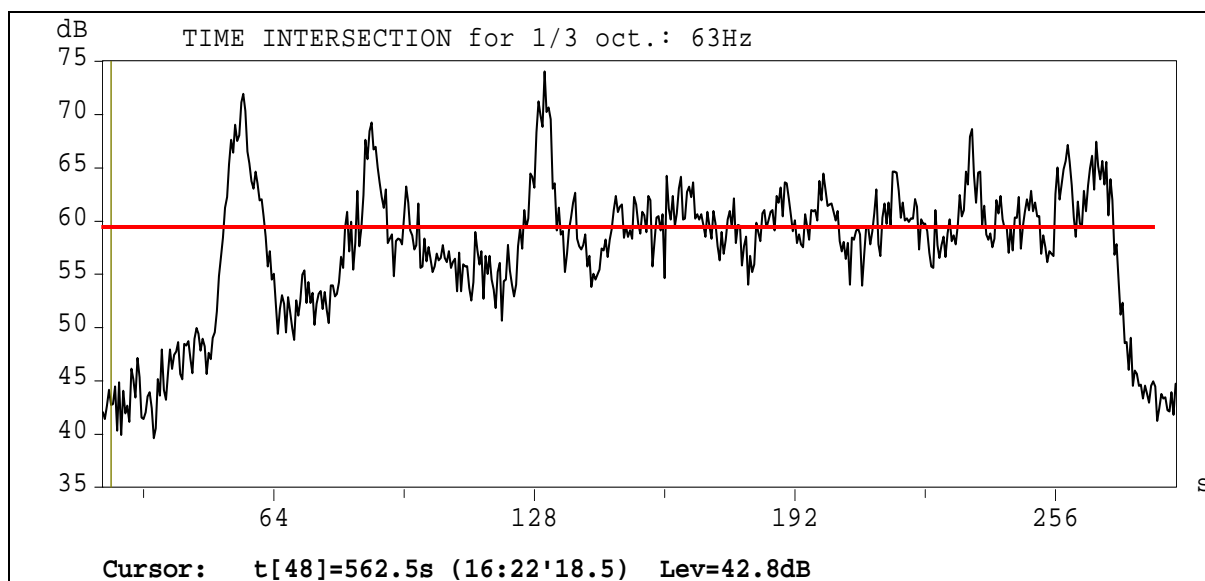


Figure 4.18 Measurement at 40m from Railway - Full Train

4.4 Results for Railway on Fill (North of Shaw Siding)

These measurements were undertaken at the rail chainage 227 and represent land that falls away sharply from approximately five metres from the railway.

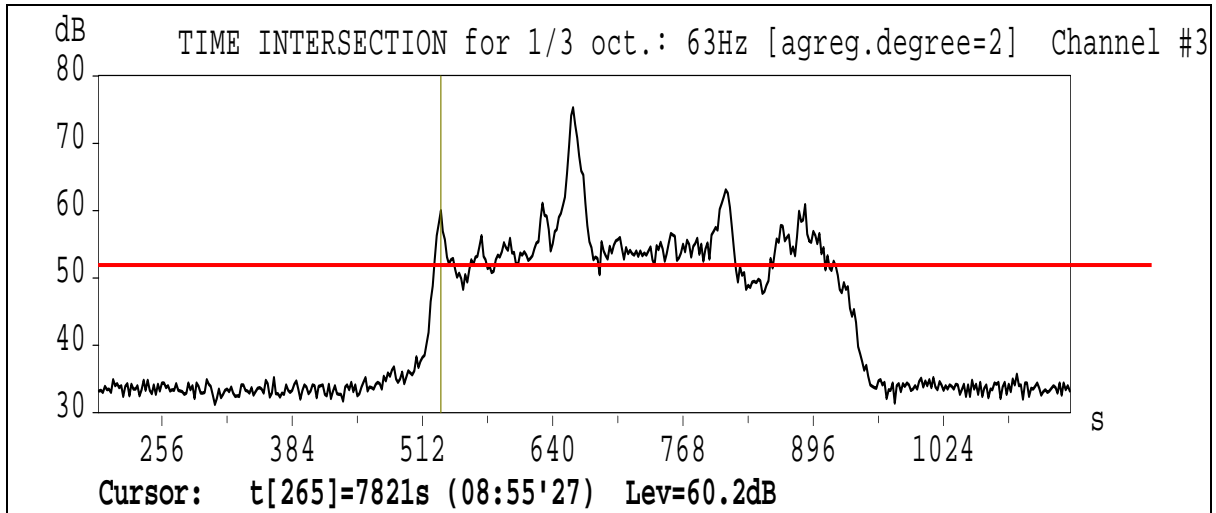


Figure 4.19 Measurement at 24m from Railway (Control) - Full Train

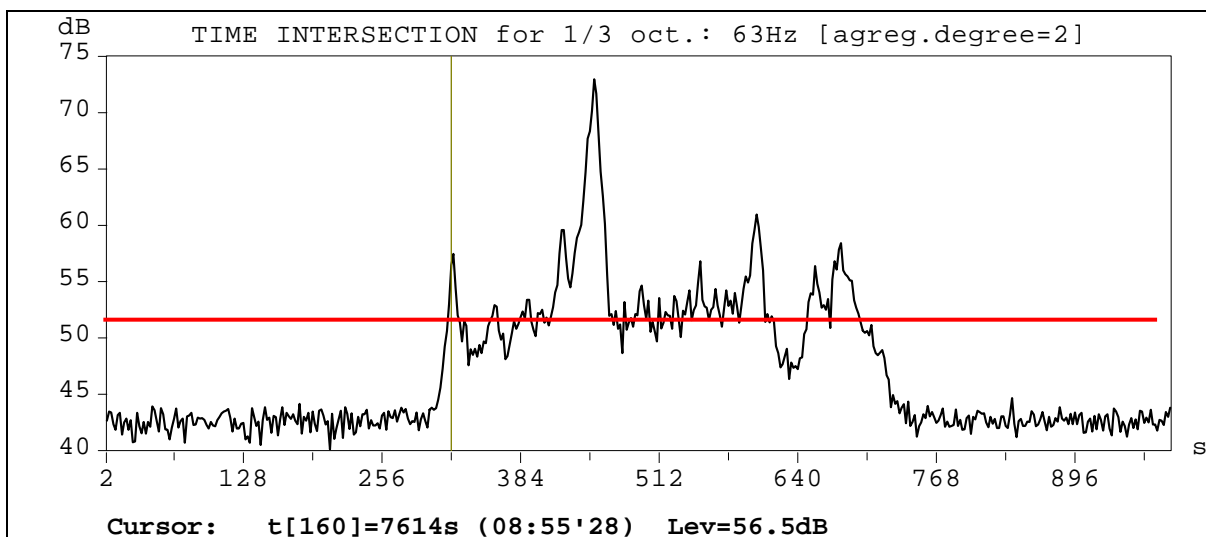


Figure 4.20 Measurement at 44m from Railway - Full Train

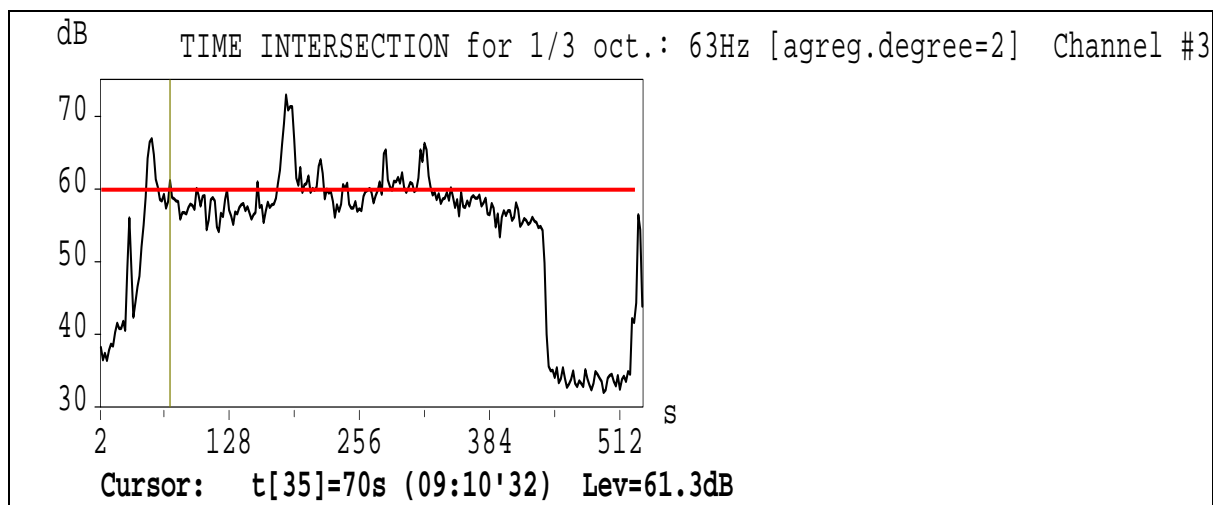


Figure 4.21 Measurement at 24m from Railway (Control) - Full Train

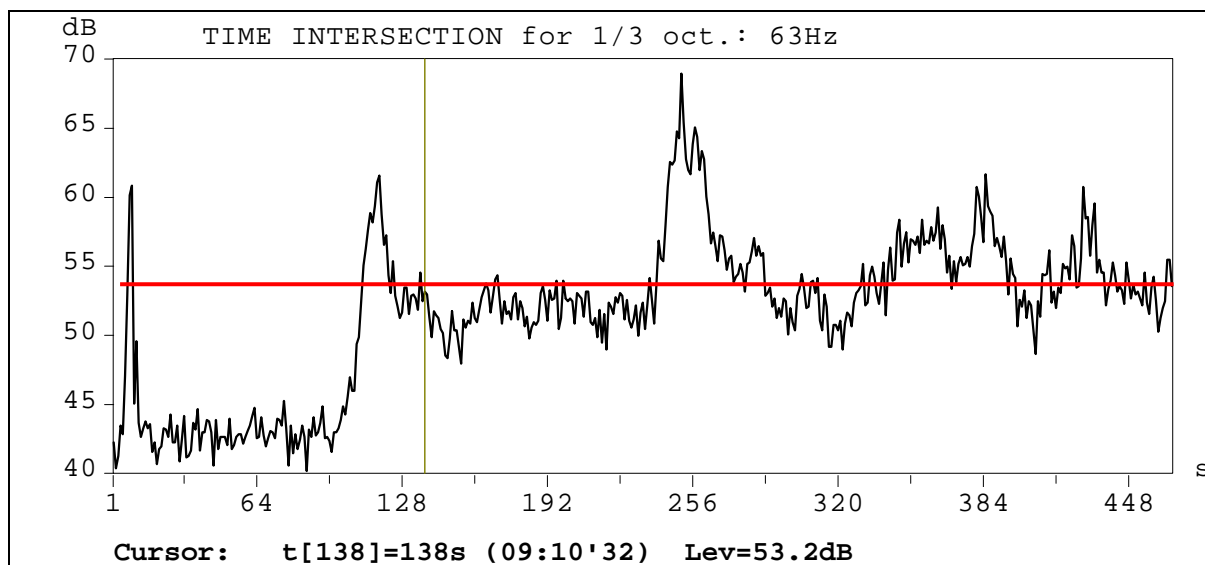


Figure 4.22 Measurement at 44m from Railway - Full Train

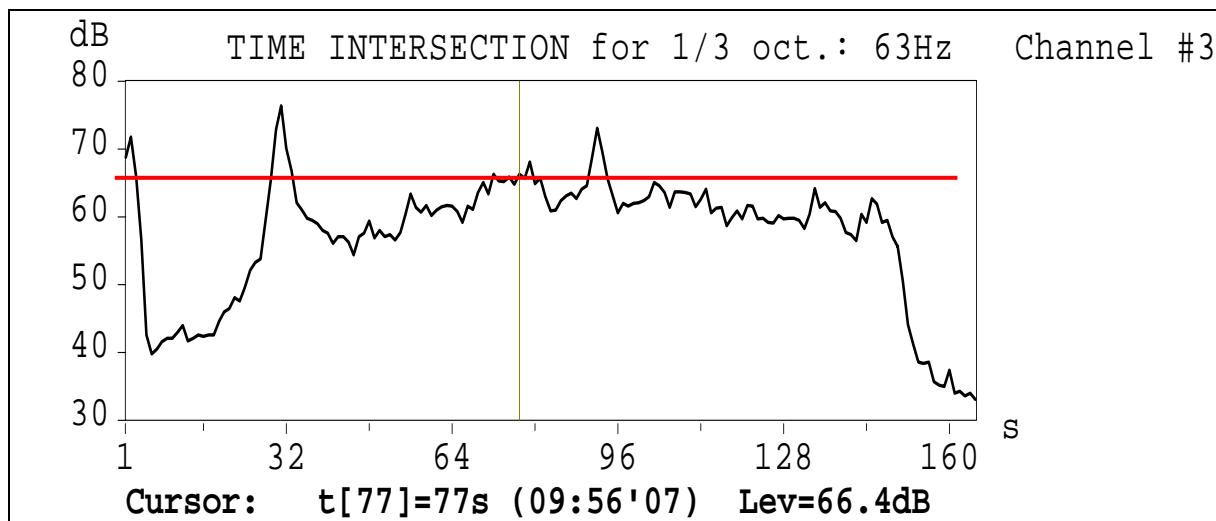


Figure 4.23 Measurement at 24m from Railway (Control) - Empty Train

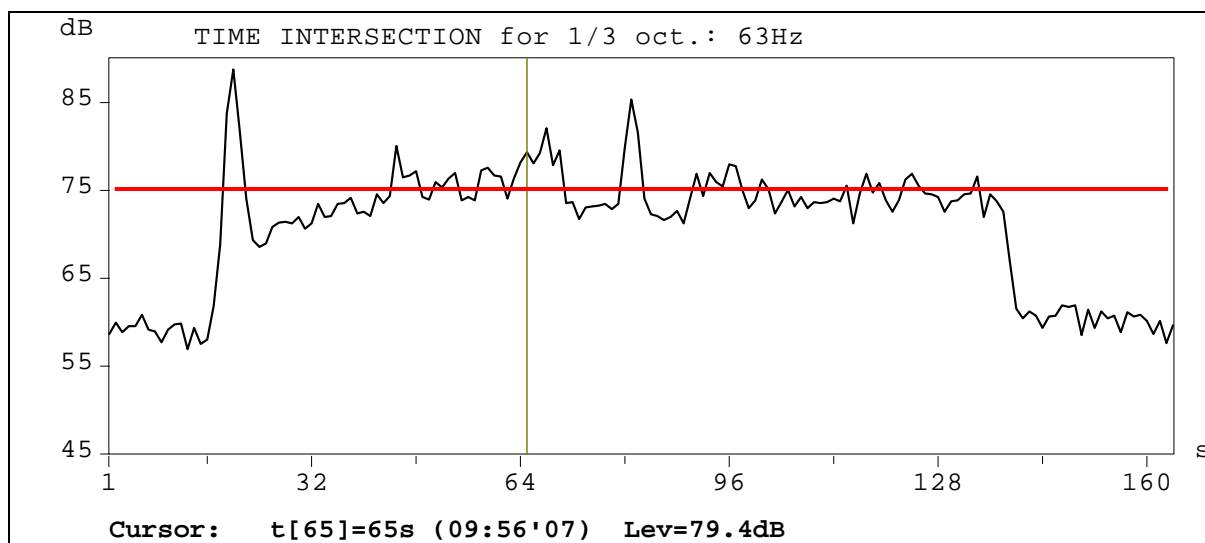


Figure 4.24 Measurement at 12m from Railway - Empty Train

5 DISCUSSION

Analysis of the results shows that there is no significant difference between the three types of topography, in terms of attenuation of vibration energy with distance.

To determine a relationship between vibration level and distance from the railway, the results were plotted and a best-fit logarithmic trend line applied. These results are presented in *Figure 5.1*.

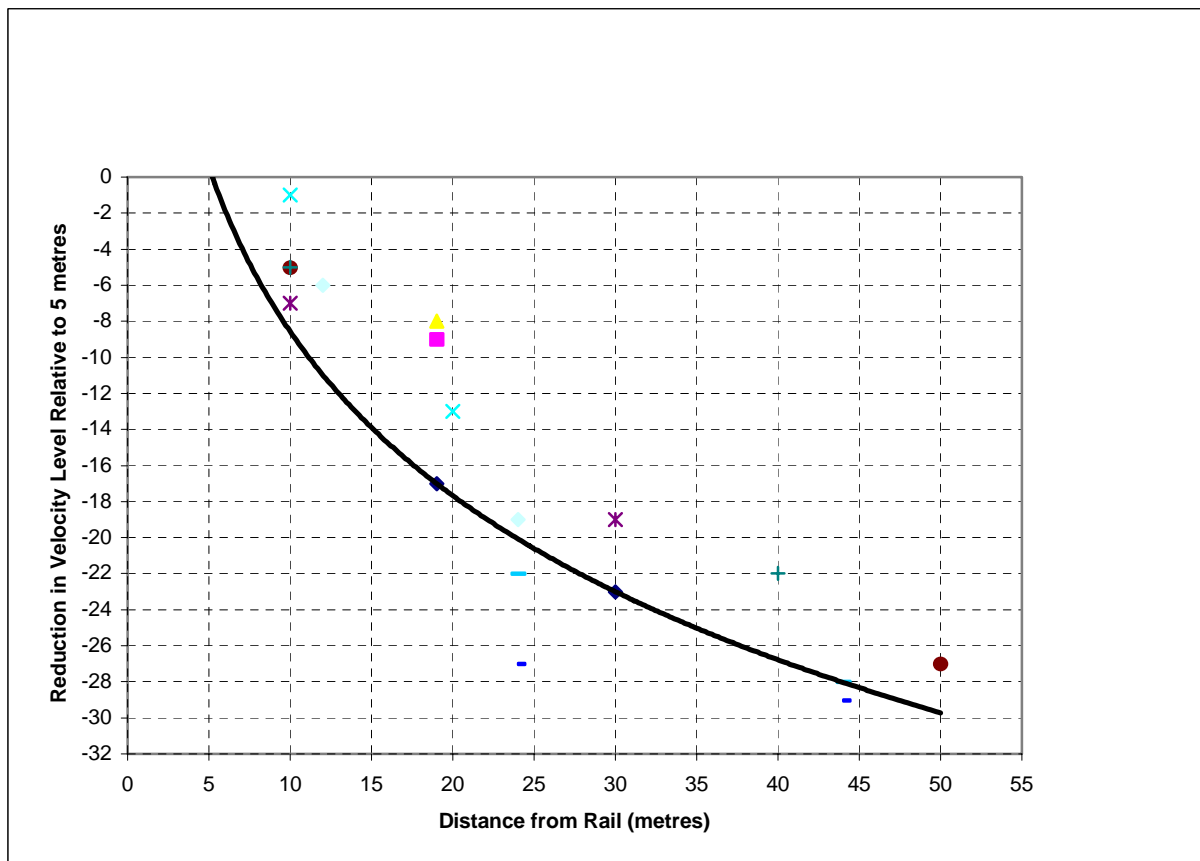
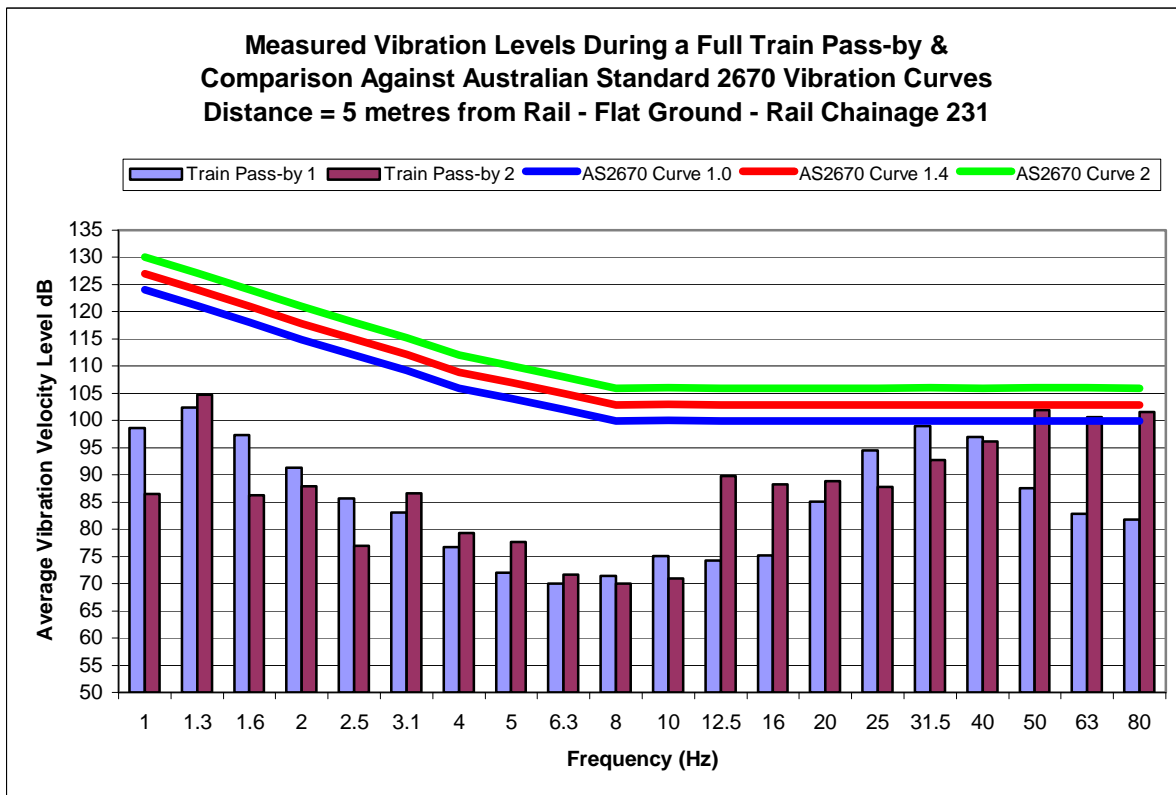


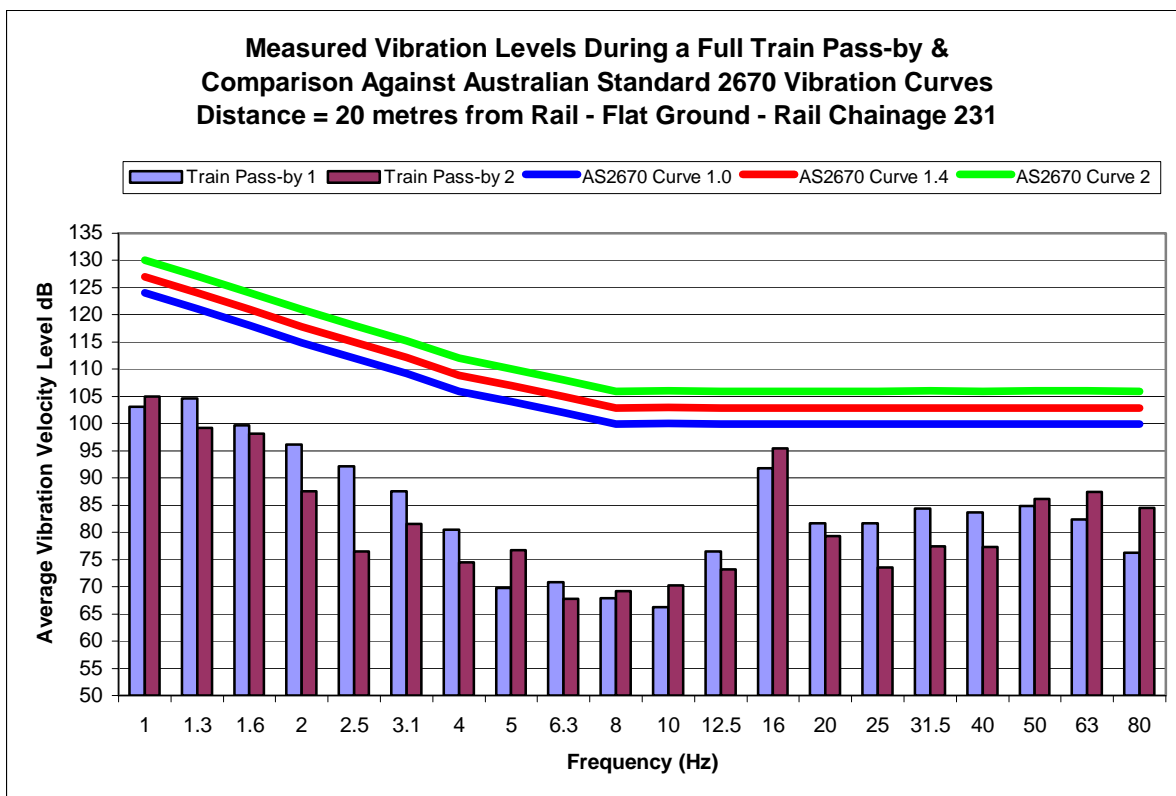
Figure 5.1 Relationship Between Vibration Level and Distance from the Rail

The curve in *Figure 5.1*, suggests that there is a 9 dB reduction per doubling of distance or a $30 \times \log_{10}$ distance relationship.

In addition to the overall vibration level, we have compared the typical (higher) measured levels at 5 metres and 20 metres, to the Australian Standard AS2670.2-1990 *Continuous and shock induced vibration in buildings (1 to 80 Hz)*. AS2670 provides criterion curves that correspond to expected annoyance by humans. The base curve (*Curve 1.0*) is the level where the vibration is unlikely to be perceived by humans and complaints would not be expected. It is also often used as the criterion for sensitive buildings such as hospitals or rooms with sensitive equipment such as electron microscopes. *Curve 1.4* is the night-time criterion often used for railways next for residential premises. Comparisons against the AS2670 curves are provided in *Figures 5.2 and 5.3*.



Figures 5.2 Comparison of Typical (higher) Vibration Levels at 5m to AS 2670



Figures 5.3 Comparison of Typical (higher) Vibration Levels at 20m to AS 2670

The above figures suggest that the vibration level that would be perceptible to humans is restricted to distances closer than 20 metres from the rail during an average train pass-by.

Theories that this new species of trap door spider is disturbed by vibration has resulted from claims that the spider is attracted to the tyres of 4-wheel-drive (4WD) vehicles while they are idling near to their burrows. To determine the level of vibration that a typical 4WD emits, vibration measurements were made near the tyres of the vehicle used to undertake this survey. The results are shown in *Figure 5.4*.

Our calculations suggest that a typical primary frequency for a 6-cylinder 4WD vehicle idling at 500 rpm would be 25 Hz. However, harmonic frequencies in the 50Hz, 100Hz and 200 Hz band could also be dominant as is evident in *Figure 5.4*.

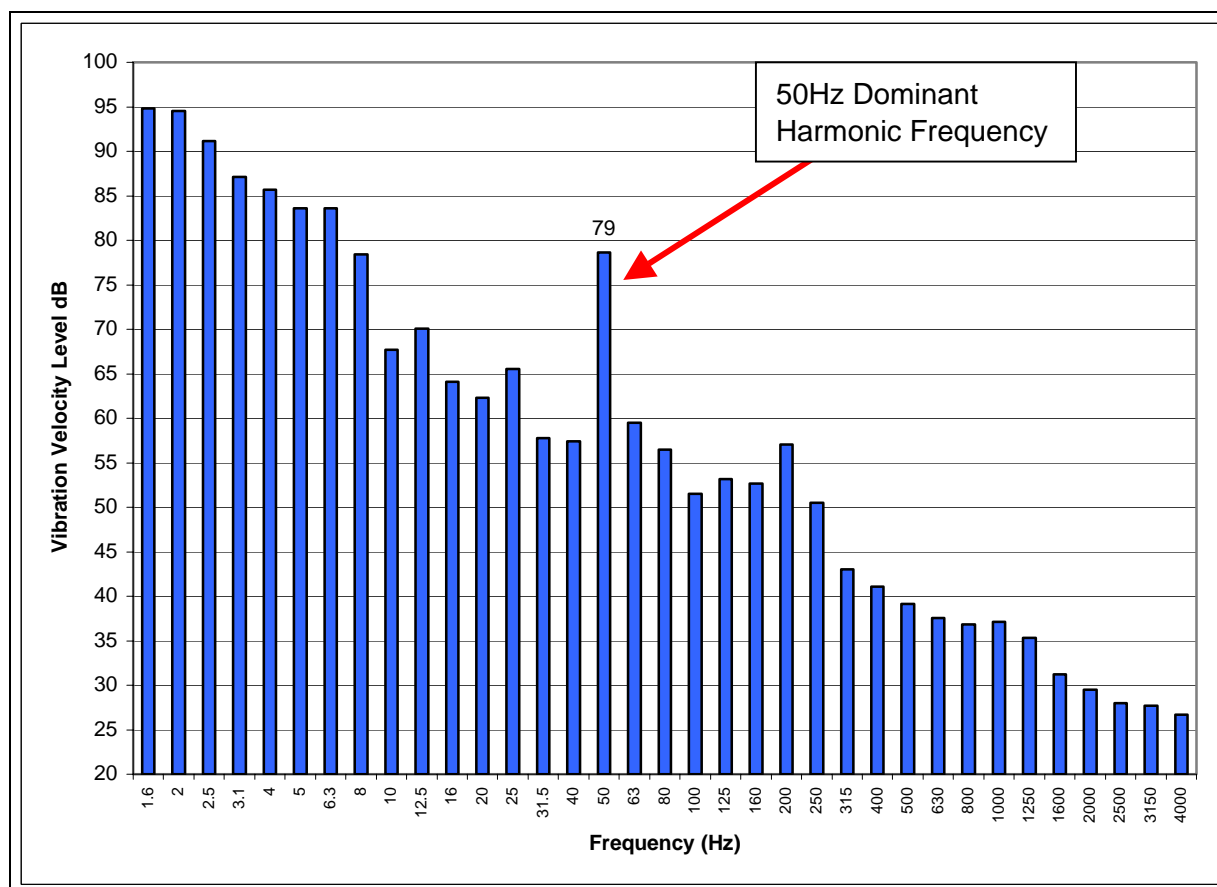


Figure 5.4 Vibration level under the Wheel of an Idling 4WD Vehicle

If we assume the above levels to be the threshold of spider attraction and apply this to the vibration level from the trains at 50 Hz (*Figure 5.3*), we find that for a the higher vibration levels associated with a typical train pass-by, this level occurs at approximately 30m from the railway.

6 CONCLUSION

In the absence of any criteria that relates to the disturbance of this new species of trap door spider, the results of this assessment suggest that spiders may be disturbed within a distance of 30 metres from the railway. Outside of this distance the vibration levels are unlikely to be detected, in terms of human response, and are below the level that would be expected from a typical idling 4WD vehicle.