Technical Report 19

Ambient Vibration Assessment Report

NZ TRANSPORT AGENCY
WAKA KOTAHI

MacKays to Peka Peka Expressway

Revision History

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-	James Whitlock	For internal review	8 August 2011
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Document Acceptance

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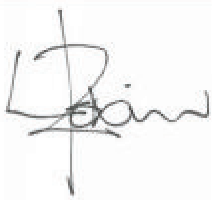
Prepared by	James Whitlock (Marshall Day Acoustics)		23 November 2011
Reviewed by	Curt Robinson (Marshall Day Acoustics)		15 December 2011
Approved by	Siiri Wilkening		15 December 2011
on behalf of	Marshall Day Acoustics		

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Appendices

1 Executive summary

Marshall Day Acoustics (MDA) has undertaken ambient vibration monitoring in the vicinity of the MacKays Crossing to Peka Peka proposed Expressway alignment. The survey results will be used as reference for the assessment of vibration effects in Technical Report 18, Volume 3 of the AEE.

The results showed that ambient vibration levels in the vicinity of the proposed Expressway are generally below the threshold of perception. Most residents did not perceive any traffic-induced vibrations in their home, and those who said they had on the odd occasion were not disturbed by them.

Vibration peaks adjacent to the existing SH1 route were more frequently above the threshold of perception, and average vibration levels were noticeably higher than at sites adjacent to the proposed Expressway. The occupants of these buildings could readily feel vibrations from traffic and trains but were generally not disturbed by them, having become somewhat habituated.

2 Introduction

This report provides a summary of ambient vibration level surveys undertaken for the MacKays to Peka Peka Expressway Project (the Project). The results are intended to provide:

- An understanding of the ambient vibration levels in the community adjacent to the proposed route prior to the implementation of the Project, and
- Reference vibration levels on dwellings adjacent to the existing SH1 route

This report will enable the assessment of vibration effects of the Project by providing a base level with which predicted future operation vibration levels can be compared.

A glossary of terms is included in Appendix 19.A.

3 Survey details

3.1 Survey locations

Ambient vibration levels were determined by measurement at selected representative sites, as follows:

Nine sites in the vicinity of the Project alignment:

- 115 Leinster Avenue
- 88 Raumati Road
- 55 Milne Drive
- 1/100 Kāpiti Road
- 22 Chilton Drive
- 155 Otaihanga Road
- 28 Puriri Road
- 164 Te Moana Road
- 20 Peka Peka Road.

Four sites adjacent to the existing SH1 route:

- 158 Main Road
- 170 Main Road
- 174 Main Road
- 216 Main Road.

All survey locations are indicated on the aerial photo in Appendix 19.B.

Data obtained at the nine sites adjacent to the Project are intended to provide baseline data for assessment of the Project effects, whereas data from the 'existing SH1 sites' provide a useful reference of vibration levels experienced by dwellings close to a high-volume road.

The Main Road sites were chosen to be in areas of peaty soil, and be directly adjacent to existing SH1. Peaty soils and sand/sandy soils are widespread along the Project alignment. Ground vibrations are readily transmitted in peat (refer to Technical Report 18, Volume 3), so areas with peaty soils are of particular interest.

The existing SH1 route has a variation of surface types (ranging from chip seal to Open Grade Porous Asphalt (OGPA), some of which (as seen during site visits) are relatively dilapidated compared with the proposed Expressway's surface, which ensures a worst-case assessment of traffic vibration, in ground conditions which are relevant to the Project.

4 Survey methodology

4.1 Instrumentation

At each survey location the ambient vibration levels were measured using one of two Instantel Minimate seismographic loggers[1] with two tri-axial geophones. The geophones were mounted generally in accordance with ISO 4866:2010 (refer glossary in Appendix 19.A), with one mounted on the dwelling structure and the other on the ground.

The logger continuously measured tri-axial peak particle velocity (PPV) data in both geophones, and recorded the highest value from each geophone every 15 minutes. The survey period ranged between 3 and 8 days.

4.1.1 Sensitivity limitations

The quoted measurement range for the Instantel instruments is 0 – 254 mm/s. However the instruments' 'zero' is limited by the sensitivity of the geophone and electrical interference in the cable and instrument.

Analysis of the measured data indicates that both Instantel monitors can measure vibration levels as low as 0.08 – 0.14 mm/s, depending on the geophone.

As stated in Section 4.3, the threshold of perceptibility in the most sensitive situations is 0.14 mm/s PPV. The vibration loggers, therefore, recorded vibration levels below the value of perceptibility. Although it was not possible to measure vibration values less than 0.08 mm/s, these events would be irrelevant as they would not be felt.

4.2 Transducer location

The construction of the dwelling involved in the survey varied widely so the transducer location was somewhat site-specific.

At sites with timber sub-floor on piles (e.g. 115 Leinster Avenue) the dwelling transducer was fixed as close as possible to the subfloor perimeter, and the ground transducer placed in the ground with ground-spikes and sandbagged. These sites are more susceptible to significant vibration readings on the dwelling transducer as a result of floor vibrations from occupant activities i.e. walking, closing doors, dropping objects, stereo use etc.

[1] 1) Instantel Minimate Pro6 (S/N MP12633) with 2 tri-axial geophones (S/N SD12580, SD12581)
2) Instantel Minimate Plus (S/N BE9167) with 2 tri-axial geophones (S/N BG8325, BG8326)

At sites with poured concrete slab foundations (e.g. 55 Milne Drive), the dwelling transducer was placed on a concrete footing or terrace and sandbagged, whilst the ground transducer was fixed in an adjacent area of soft ground with ground spikes and sandbagged.

Some sites (e.g. 1/100 Kāpiti Road) had piled foundations with no practical access point to the sub-floor area. In these cases the dwelling transducer was placed on an external concrete patio and sandbagged, with the ground transducer fixed in an adjacent area of soft ground with ground spikes and sandbagged.

4.3 Threshold of perceptibility

British Standard BS 5228-2:2009, Annex B states that construction vibration levels become perceptible between 0.14 and 0.3 mm/s PPV, however one's limit depends on the situation.

Table B.1 of the Standard states that 0.3 mm/s PPV might be "just perceptible in residential environments", so for the purposes of this assessment, this is taken as the perception threshold.

The table also states that at 0.14 mm/s PPV, construction vibration "might be just perceptible in the most sensitive situations", which is interpreted as specialist laboratory-type environments, and that at 1 mm/s PPV, complaint would be expected unless prior warning and explanation has been given to residents.

5 Results

5.1 Survey sheets

Data from the site surveys has been plotted and summarised in survey sheets attached in Appendix 19.C.

Each sheet provides a description of the site location, distance to the closest major road, the equipment installed and brief comments on the equipment setup at that site.

Vibration data is provided in graph form, showing the time traces of PPV values on both the dwelling and ground. This allows a direct visual comparison between dwelling and ground vibration levels, and any distinct spikes can be analysed to assess whether they originated on the ground or dwelling structure (i.e. whichever is the higher).

Two specific vibration values are also given, as follows:

- Mean uncontaminated dwelling PPV – this is the arithmetic average of the dwelling data, once data affected by occupant movement, rain and/or earthquakes (see Section 4.1.1 below) has been removed

- Maximum dwelling PPV – this is the highest vibration peak measured by the dwelling transducer, regardless of its origin

Both these values relate to the dwelling data because the vibration levels on the house structure are most relevant to the assessment. The ground measurement essentially acts as a filter to eliminate non-ambient data from the dwelling data and in the sites near the existing SH1 indicates the transfer function of traffic vibration, via peat, into the dwelling structure.

5.1.1 Rain and earthquake data

Rain and earthquakes are two natural events which have the potential to produce readings in the vibration data.

Rain droplets generate vibration on and around the transducers if they are not under cover (notwithstanding the sandbag which provides significant attenuation).

Rain data for the measurement period was obtained from the NIWA Paraparaumu Airport rain gauge, via the NIWA CliFlo database. Periods of rain are indicated on the survey sheets. In many cases (e.g. 55 Milne Drive) there is a clear correlation between the periods of rain and the ground data.

Four minor earthquakes (magnitude 3 – 4) occurred in the general area during the measurement period. Data on these was obtained from www.geonet.org and the events have been indicated on the relevant survey sheets. They can be seen to correlate with distinct peaks of varying magnitude in both the dwelling and ground data.

Periods of rain and earthquake events have been excluded from the 'mean uncontaminated dwelling PPV' values.

5.2 Resident survey

After the survey period, the resident of each survey location (with the exception of 115 Leinster Avenue, as directed by the Project team[2]) was contacted by phone to thank them for their involvement and briefly discuss their experience of vibration in their home. They were asked:

5.2.1.1 Do you regularly feel any vibrations in your dwelling?

5.2.1.2 If yes, what would you attribute them to?

5.2.1.3 If yes, are you bothered or disturbed by them (i.e. sleep disturbance)?

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[2] This Report refers to the Project team as carrying out works on behalf of and as contracted by the NZTA. The NZTA is the requiring authority and the consent holder

The majority response was that no vibrations are felt in the dwelling. Those who said they occasionally felt earthquakes, heavy vehicles or other members of the household moving around, said they were not bothered or disturbed by these events.

5.3 Results – sites near Project alignment

The results of these measurements show that the ambient vibration environment due to existing traffic is low - the mean uncontaminated dwelling PPV values did not exceed the perception threshold (0.3 mm/s PPV) at any site.

Furthermore, most residents felt no traffic vibration in their homes and those that did on occasion, were not disturbed by it.

The following Sections 4.3.1 – 4.3.9 contain descriptions of the surveys and relevant findings for each site.

5.3.1 115 Leinster Avenue

This dwelling has a timber sub-structure on piles; the dwelling geophone recorded pronounced vibration levels on the dwelling which are largely uncorrelated with the ground vibration data. The peaks in the dwelling data generally reduce during the night-time period (11.00 pm to 5.00am) i.e. when the occupants are asleep.

The mean uncontaminated dwelling PPV was 0.17 mm/s which is below the threshold of human perception of 0.3 mm/s PPV for a residential receiver (refer Section 3.3).

5.3.2 88 Raumati Road

Access to an ideal dwelling transducer location was difficult at this site. The chosen location was the concrete parapet of a sub-floor access point, directly adjacent to the ground transducer. The foundation type is unknown, but presumed to be timber with plastered brick perimeter.

There were several high magnitude spikes measured by the ground transducer. These are not shown in dwelling transducer trace so, considering the close proximity of the two transducers, these were most likely due to some local disturbance of the ground transducer by a person or animal.

In general the data shows no distinct correlation either between the two transducers, or in the day-to-day levels. In the dwelling data there are consistent occupant-generated vibrations with a 2 day period mid-survey where there was little or no activity indicating the occupants were away, however during this period there are still several of the ground peaks mentioned above.

The mean uncontaminated dwelling PPV was 0.09 mm/s, which corroborates the residents' statement that they feel no traffic vibration.

5.3.3 55 Milne Drive

This dwelling had a poured concrete foundation, so there is little influence from occupant activity on the dwelling transducer.

Peaks in the dwelling data generally correspond to higher peaks in the ground data, indicating the source of vibration is outside. However, these peaks are generally inconsistent and occur sporadically. This does not align with a traffic vibration profile, which would typically be smoother, so is more likely due to local disturbance of both geophones by a person or animal, and the peak is higher in the ground data because of the soft ground.

There were several periods of rain and 3 earthquake events, which have been removed from the mean uncontaminated dwelling PPV, which was 0.09 mm/s

5.3.4 1/100 Kāpiti Road

There was a very close correlation between the dwelling and ground results at this location, with practically every peak showing in both traces at similar magnitudes.

There is an apparent rise in measured levels during the daytime. This may be due to heavy traffic on Kāpiti Road, which is one of the busiest roads in the area, but the activity generally continues through the night, which is not typical for heavy traffic.

Notwithstanding this, the levels are generally below the threshold of perception with the odd period of sustained higher levels such as daytime on 18th May.

The mean uncontaminated dwelling PPV was 0.2 mm/s and the residents stated that they feel no vibration. The foundation type is unknown, but presumed to be timber with plastered block or brick perimeter.

5.3.5 22 Chilton Drive

This dwelling is understood to have been unoccupied during the measurement period. However, the measurements are contrary to this claim. The dwelling data shows the typical diurnal variation of an occupied dwelling albeit at very low levels i.e. activity in daytime hours (0600 – 2200) which drops away to the instrument noise floor in the night-time period.

There are also regular daily peaks in the ground data around 0600 and 1800 hrs, which do not appear in the dwelling data. These would be due to some local disturbance of the ground transducer. Overall the levels are low (mean uncontaminated dwelling PPV of 0.09 mm/s) with only the odd peak above the perception threshold.

5.3.6 155 Otaihanga Road

Little vibration activity was measured at this site. The two traces tend towards the noise floor of the instrumentation – note that the noisefloor of the ground transducer was slightly higher than that of the dwelling transducer. There is generally some activity in both transducers during the daytime but few peaks are above the perception threshold.

One resident at this address considers herself to be particularly vibration sensitive stating she can sometimes feel house vibrations, but attributes them to earthquakes. Traffic was described as being heard but not felt.

The mean uncontaminated dwelling PPV value was 0.13 mm/s. This value is higher than at some other sites but is due to the noise-floor.

5.3.7 28 Puriri Road

This site demonstrated the highest consistent peaks in the dwelling data, of all the measured sites. These can be clearly attributed to occupant-generated vibration as the dwelling has a timber sub-structure (and is therefore susceptible to high readings on the dwelling) and there is significantly less activity between 0000 – 0600 hours when the occupants are likely to be asleep.

It is noted that the peaks seen in the ground data are likely to be from the same source, transferred into the ground through the piles.

As such, the mean uncontaminated dwelling PPV of 0.09 mm/s is calculated from a diminished dataset. This value corresponds to the residents' subjective comment that they often hear, but not feel, heavy traffic on Puriri Road.

5.3.8 164 Te Moana Road

This site has a timber sub-structure, and so the dwelling data dominates the readings – although not to the same extent as at 28 Puriri Road.

Interestingly, the dwelling data shows no sign of dropping off during the night-time period (similar to 100 Kāpiti Road) however the dwelling and ground data are not as closely correlated. It is unlikely that the continual dwelling activity is due to the residents (unless their working arrangements are such that somebody is active in the dwelling at all times). The readings could be due to an item of equipment which operates through the night.

Notwithstanding this, it is clear that the dwelling data is not generated by traffic as the ground data rarely shows vibrations above 0.2 mm/s PPV, and the dwelling data is consistently higher. The mean uncontaminated dwelling PPV value was 0.19 mm/s and the residents said they feel no vibration.

5.3.9 20 Peka Peka Road

The results here are similar to 155 Otaihanga Road – consistent but low-level vibration in both transducers during the daytime period, with few peaks above the perception threshold.

The dwelling is some distance (130 metres) from the closest major road, so traffic vibration is unlikely. The residents stated they have felt dwelling vibration on occasion (3 – 4 times), which they generally attribute to earthquakes, however they have noticed the odd large truck on Peka Peka Road. There were numerous periods of rain and 3 earthquake events which have been removed from the mean uncontaminated dwelling PPV value, which was 0.16 mm/s.

5.4 Results – sites near existing SH1 route

There is a clear increase in activity in the ground data of all existing SH1 sites, when compared with the sites adjacent to the Project alignment and this increase is attributed to traffic on existing SH1. The mean uncontaminated dwelling PPV values are also higher than for any of the sites near the Project alignment.

In two of the four locations (158A and 216 Main Rd), the average ground data value was higher than the average dwelling data value and in the other two, it was within 5%. This clearly indicates that vibration from external sources (i.e. traffic, trains etc) is the predominant vibration source.

Some of the ground data also shows a slight hump during the day as the traffic volume waxes and wanes, indicating that traffic is the primary vibration source for these data (notwithstanding the effects of local disturbance from residents).

The Kāpiti rail line runs parallel to existing SH1 on the opposite side to the dwellings, approximately 10 metres from the road edge. The Metlink timetable (www.metlink.org.nz) indicates there are 79 passenger trains per weekday on that line – one train every 14 minutes on average. It is not practical to filter out train data from the traces, considering influence from traffic vibration and the possibility of timetable inconsistencies etc., so the measured vibration levels will include vibration from trains also.

The mean uncontaminated dwelling PPV values at the SH1 sites were equal or higher than at sites adjacent to the proposed Expressway, and the number of peaks above the perception threshold was noticeably higher. Three of the four sites showed mean uncontaminated dwelling PPV values above the perception threshold.

This was reflected in the comments from occupants who all stated they regularly felt dwelling vibrations, attributing them to traffic and trains, but were either not disturbed by them or had become habituated (and therefore desensitized) to them. One site was used as an office and the occupant stated she would not choose to live there.

The following Sections 4.4.1 – 4.4.4 contain descriptions of the surveys and relevant findings for each site.

5.4.1 158A Main Road

The results at 158A Main Road show a strong correlation between the two traces, which is expected with poured concrete foundations. This site is used as an office and the occupant says the vibrations from trains and trucks are noticeable, and are such that she would not choose to live there.

This response corroborates the dwelling data which shows frequent peaks above the residential perception threshold and a mean uncontaminated dwelling PPV of 0.35 mm/s. This value is lower than the ground data mean PPV (with the contaminated data also removed for consistency) of 0.4 mm/s, indicating traffic and/or trains are the major vibration source(s).

There were two earthquake events one of which was the widely publicised magnitude 6.5 quake centred near Lake Taupo - this clearly identifiable in both the ground and dwelling data at 3.36pm on 5th July.

5.4.2 170 Main Road

This site has a timber sub-structure, so there are more distinctive peaks in the dwelling data than for 158A Main Road. There are the same consistent low-mid level peaks in both traces, but generally at a lower level than at 158A resulting in a lower mean uncontaminated dwelling PPV of 0.28mm/s. This is most likely a result of the increased distance to the carriageway i.e. 9 metres further. There are a greater number of distinct peaks in the dwelling data, but these are deemed to be occupant-generated and have been removed from the mean.

The occupant said he feels vibrations from trucks and trains but is not disturbed, having become habituated to them.

The same two earthquake events described in the 158 Main Road discussion above were seen here also and they, along with periods of rain were removed from the average calculation.

5.4.3 174 Main Road

This site also has a timber sub-structure, but the perimeter plate was not accessible so the dwelling transducer was fixed to a bearer adjacent to a pile. As a result there are many more high-level peaks in the dwelling data during the daytime period, when the occupants were active.

These occupant-generated peaks dominate the trace, and have been removed from the dataset resulting in a mean uncontaminated dwelling PPV of 0.33 mm/s. This is a higher value than at 170 Main Road, despite being 12 metres further from the road, which could be symptomatic of the dwelling transducer position, or different ground conditions.

There were no earthquakes, but periods of rain have been removed from the dataset.

The occupant said he feels vibrations from trucks and trains but is not disturbed by them.

5.4.4 216 Main Road

The ground data at this site was more dominant than for the other SH1 sites, showing higher peaks and a higher mean uncontaminated PPV value (0.28 mm/s on the ground, compared with 0.2 mm/s on the dwelling). Some of these may be due to occupant and or local vehicle movement, as the two transducers were located near the garage entrance.

The occupants said they feel vibrations and attribute them to trucks and trains, and are occasionally woken by an early morning freight train. There is a regular weekday peak or around 0.4 mm/s in the traces just after midnight which may be due to this train event.

6 Conclusion

A comprehensive ambient vibration assessment has been undertaken in the vicinity of the proposed Expressway, and the existing SH1 route. Vibration levels were measured on the dwelling structure and ground underneath/adjacent to the dwelling at each site. The occupants of each site were also contacted and asked to give their impression of existing vibration levels in their homes.

Vibration data measured on the dwelling structures are most relevant to the assessment because they represent the levels experienced by the occupants. Vibrations caused by occupant activities (footsteps, moving/dropping objects etc.) were filtered by assessing the diurnal variation and comparing the dwelling and ground data. Additionally, vibration caused by rainfall and earthquakes were removed from the data as far as practicable.

For sites near the proposed Expressway, the results show that the ambient vibration environment due to existing traffic is low - the mean uncontaminated dwelling PPV values did not exceed the perception threshold (0.3 mm/s PPV) at any site. Furthermore, most residents felt no traffic vibration in their homes and those that did were not disturbed by it.

For sites adjacent to the existing SH1 route, the mean uncontaminated dwelling PPV values were higher than at sites adjacent to the proposed Expressway and the number of peaks above the perception threshold was noticeably higher. Three of the four sites showed mean uncontaminated dwelling PPV values above the perception threshold.

This was reflected in the comments from occupants who all stated they regularly felt dwelling vibrations, attributing them to traffic and trains, but were either not disturbed by them or had become habituated (and therefore desensitized) to them. One site was used as an office and the occupant stated she would not choose to live there.

It is noted that the road seal on the proposed Expressway will be a higher grade seal (OGPA) than the existing SH1 route (chip seal), so lower vibration levels would be expected for equivalent dwellings adjacent to the completed proposed Expressway.

7 Reference

Whitlock, J. "Assessment of Vibration Effects": Technical Report 18, Volume 3 of the MacKays to Peka Peka Expressway Project AEE.

9 Appendix 19.A - Glossary of Terminology

Ambient vibration	Ambient vibration is the vibration at a given location that is due to any and all sources of vibration in the vicinity. In a typical dwelling it includes but is not limited to local traffic, footfalls in the dwelling, door slamming, dropping heavy objects etc. The measurement methodology has been designed to eliminate occupant-generated vibration events.
BS 5228-2:2009	British Standard BS 5228-2:2009 *"Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration"*, British Standards Institute, 2009
Coupling Loss	The reduction in vibration energy across the interface between the ground and a building structure.
Geophone	Measurement transducer which measures vibration velocity. Usually tri-axial.
Ground spikes	100mm steel spikes, 3 of which are screwfixed into the base of each geophone. Used when installing geophone in a relatively soft medium like soil or clay. Generally used in conjunction with sandbag to ensure the geophone is well coupled to the surface.
ISO 4866:2010	International Standard ISO 4866:2010 *"Mechanical vibration and shock – Vibration of fixed structures – Guidelines for the measurement of vibrations and evaluation of their effects on structures"*, International Organisation for Standardisation, 2010
Longitudinal Axis	Vibration axis in the horizontal plane, where the vibration movement is parallel to the direction of the source i.e. forward and back
Noise-floor	The noise floor of a measurement device is an underlying signal generated by the device's electronic components, meaning it cannot measure an absolute zero level. For measurements in low vibration environments, the recorded data may show the noise-floor rather than a real vibration signal, because any actual vibration is too low for that device to measure.

OGPA	Open Grade Porous Asphalt. A low noise, low vibration road surface proposed in places for the Project alignment
PPV	Peak Particle Velocity. Standard metric for building damage assessments. Units are mm/s
Sandbag	Used to weigh down geophones to ensure consistent contact with the measurement surface during vibration monitoring
Sensitive receivers	Buildings and/or occupants of buildings for which vibration effects should considered due to their proximity to vibration sources and/or particular sensitivity to vibration (i.e. sleep disturbance). Building damage is the primary concern for the construction phase, whereas the comfort of building occupants is the primary concern for the operation phase
Threshold of perception	British Standard BS 5228-2:2009, Table B.1 states a range of vibration perception between 0.14 and 0.3 mm/s PPV. The criteria in Table B.1 of the standard states that 0.3 mm/s PPV might just be perceptible in residential environments.
Transfer function	The change (usually a reduction) in vibration magnitude as the energy transfers from the ground into a building structure.
Transverse Axis	Vibration axis in the horizontal plane, where the vibration movement is perpendicular to the direction of the source i.e. side to side
Tri-axial	Measures vibration in all three axes (longitudinal, transverse and vertical) simultaneously
Vertical Axis	Vibration axis in the vertical plane where the vibration movement is perpendicular to the ground surface i.e. up and down
Vibration	A ground-borne or structure-borne acoustic signal.

10 Appendix 19.B - Ambient Vibration Measurement Locations

11 Appendix 19.C - Survey Sheets

11.1 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location: 115 Leinster Avenue

Project Sector: 1

Date: 6 – 9 April 2011

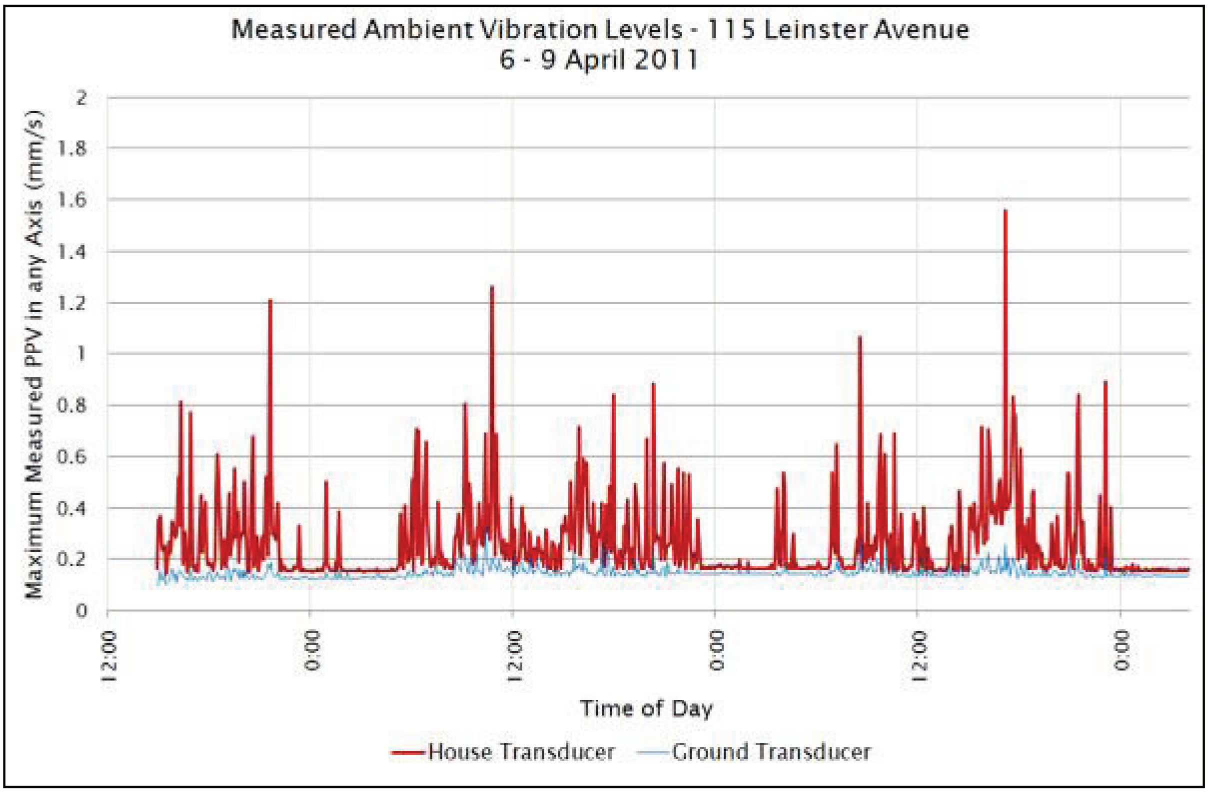
Distance to major road: 105 metres from existing SH1

Equipment: Instantel Minimate Pro6

Maximum dwelling PPV: 1.56 mm/s

Mean uncontaminated dwelling PPV: 0.17 mm/s

Setup comment: Timber pile foundations. One geophone was tied to the outer end of a timber sub-floor bearer, the other was placed on the ground beneath the dwelling.

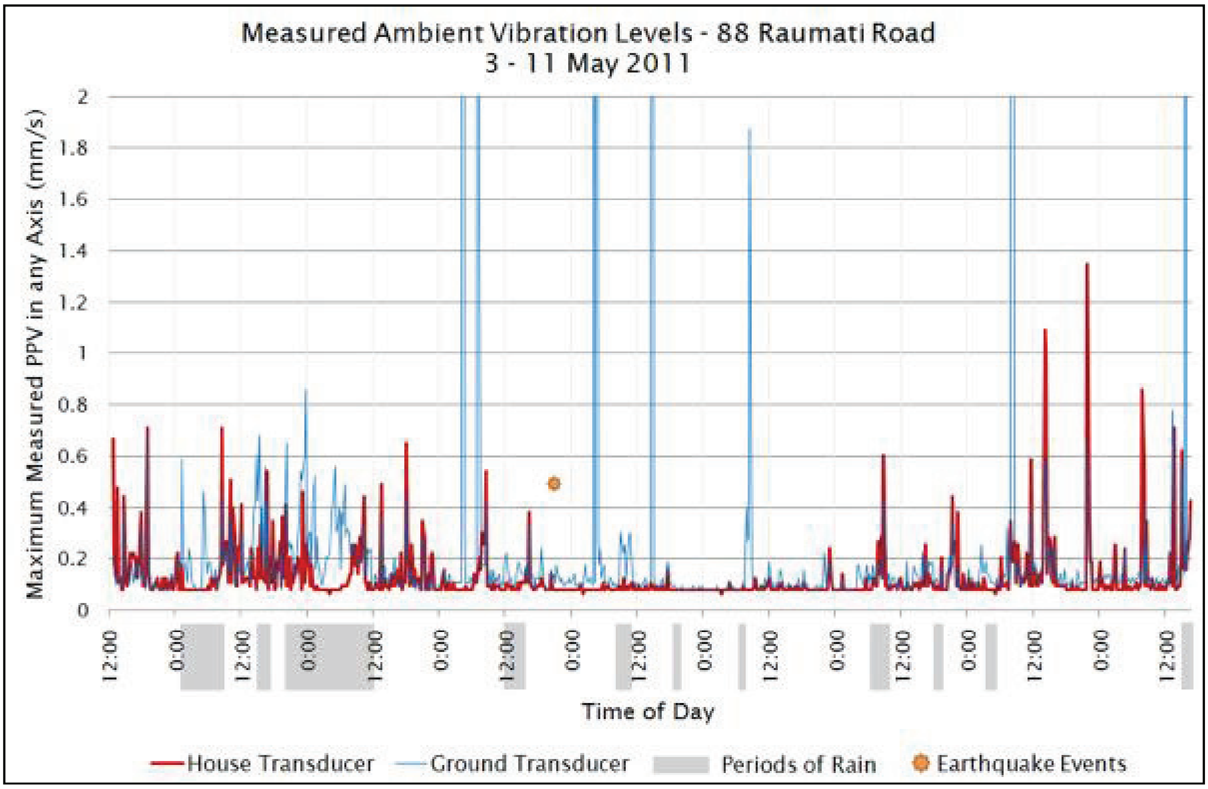


11.2 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location:	88 Raumati Road
Project Sector:	1
Date:	3 – 11 May 2011
Distance to major road:	30 m from Raumati Road
Equipment:	Instantel Minimate Plus

Maximum dwelling PPV:	1.35 mm/s
Mean uncontaminated dwelling PPV:	0.09 mm/s

Setup comment: Dwelling transducer placed on concrete parapet of sub-floor access point and sandbagged. Ground transducer placed in lawn immediately adjacent, with ground spikes, and sandbagged.

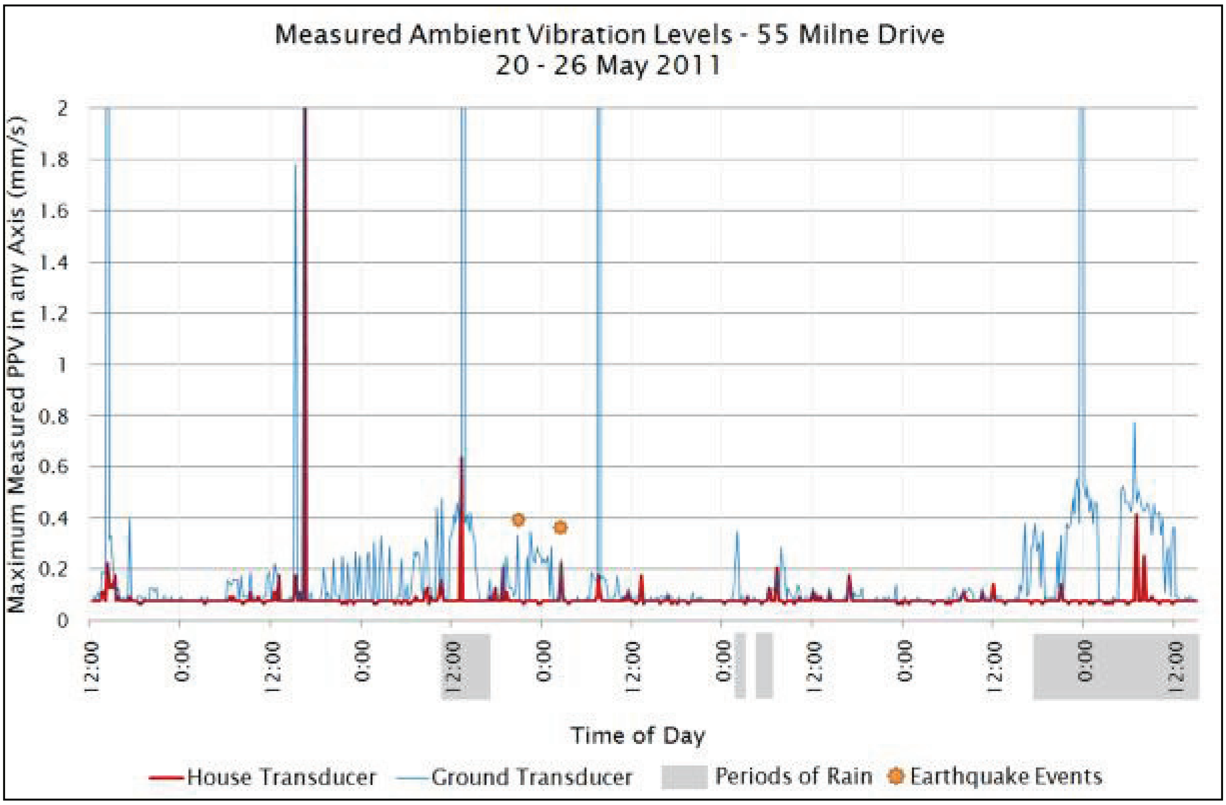


11.3 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location:	55 Milne Drive
Project Sector:	2
Date:	20 - 26 May 2011
Distance to major road:	15 m from Milne Drive
Equipment:	Instantel Minimate Plus

Maximum dwelling PPV:	2.06 mm/s
Mean uncontaminated dwelling PPV:	0.09 mm/s

Setup comment: Dwelling transducer placed on exposed aggregate patio attached to house and sandbagged. Ground transducer placed in adjacent lawn with ground spikes and sandbagged.

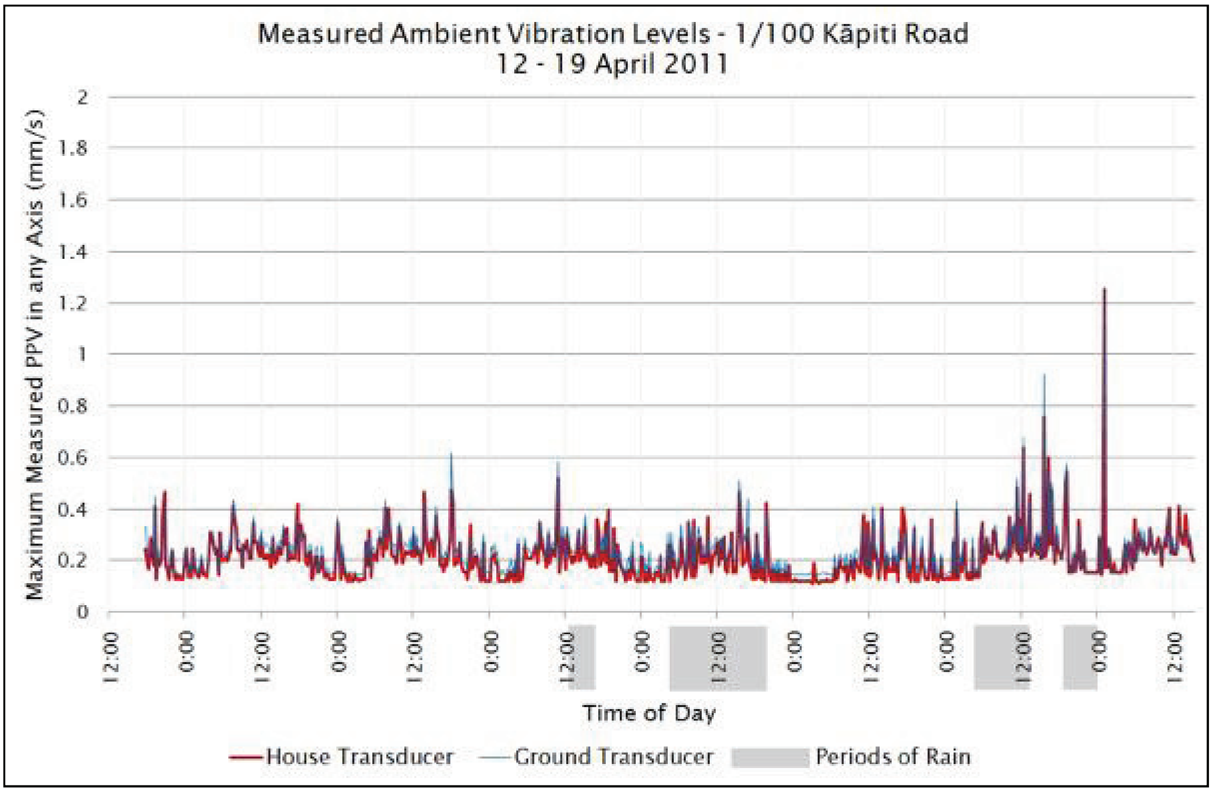


11.4 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

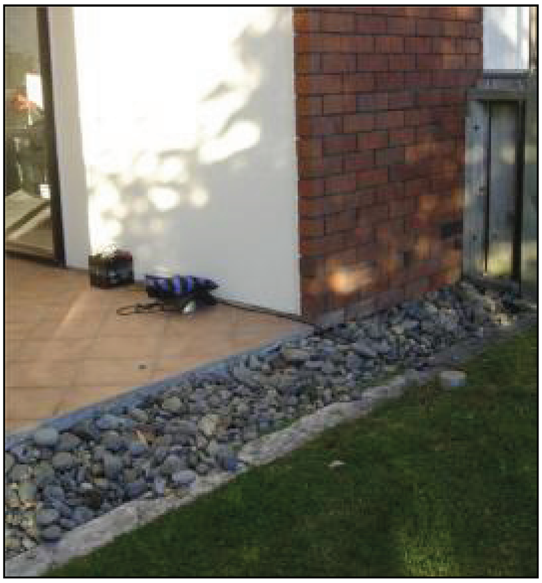
Location:	1/100 Kāpiti Road
Project Sector:	2
Date:	12 – 19 April 2011
Distance to major road:	60 m from Kāpiti Road
Equipment:	Instantel Minimate Pro6

Maximum dwelling PPV:	1.25 mm/s
Mean uncontaminated dwelling PPV:	0.20 mm/s

Setup comment: Presumed pile foundations, but no access to the under-floor area. Dwelling transducer placed on concrete patio (attached to house) and sandbagged. Ground transducer placed in adjacent garden with ground spikes and sandbagged.



11.5 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results



Location: 22 Chilton Drive

Project Sector: 2

Date: 12 – 19 April 2011

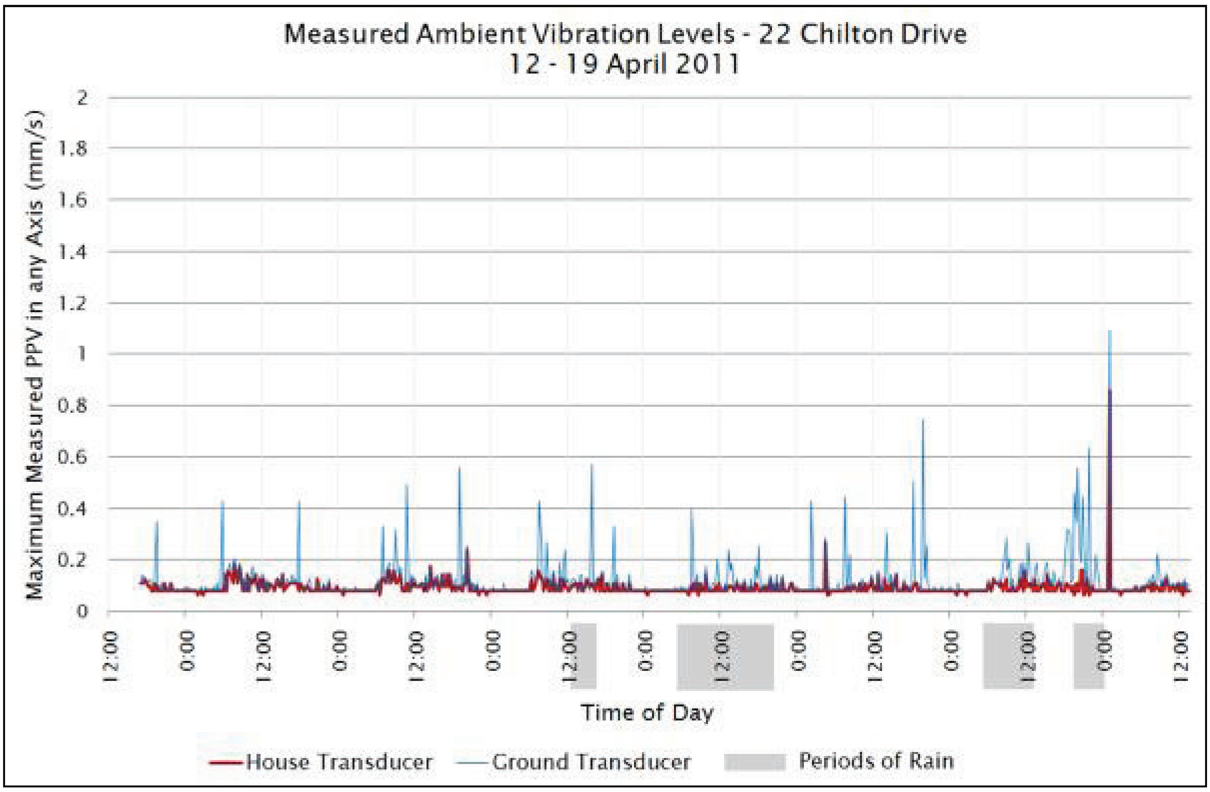
Distance to major road: 45 m from Mazengarb Rd

Equipment: Instantel Minimate Plus

Maximum dwelling PPV: 0.86 mm/s

Mean uncontaminated dwelling PPV: 0.09 mm/s

Setup comment: Poured concrete foundations. Dwelling transducer placed on tiled patio (attached to house) and sandbagged. Ground transducer placed in adjacent lawn with ground spikes and sandbagged.

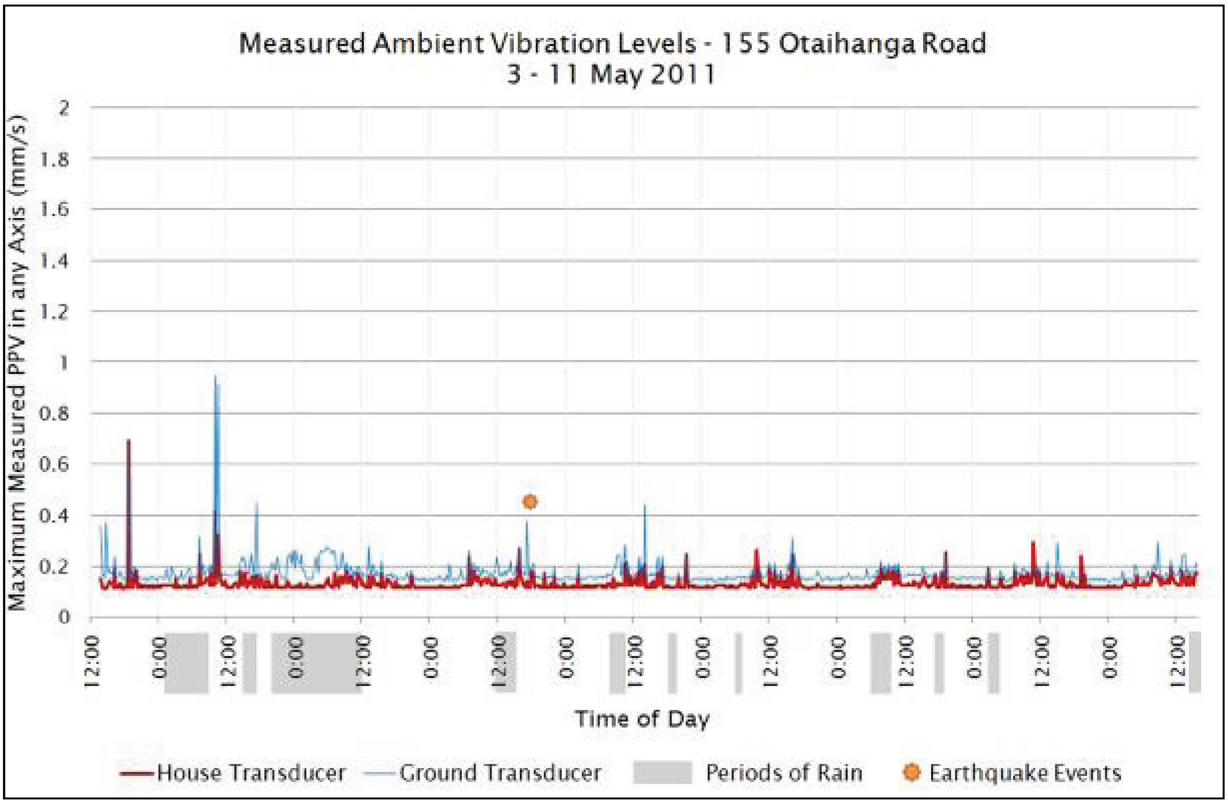


11.6 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location:	155 Otaihanga Road
Project Sector:	3
Date:	3 -11 May 2011
Distance to major road:	85 m from Otaihanga Rd
Equipment:	Instantel Minimate Pro6

Maximum dwelling PPV:	0.69 mm/s
Mean uncontaminated dwelling PPV:	0.13 mm/s

Setup comment: Dwelling transducer placed on edge of poured concrete foundation and sandbagged. Ground transducer placed in adjacent lawn with ground spikes and sandbagged.

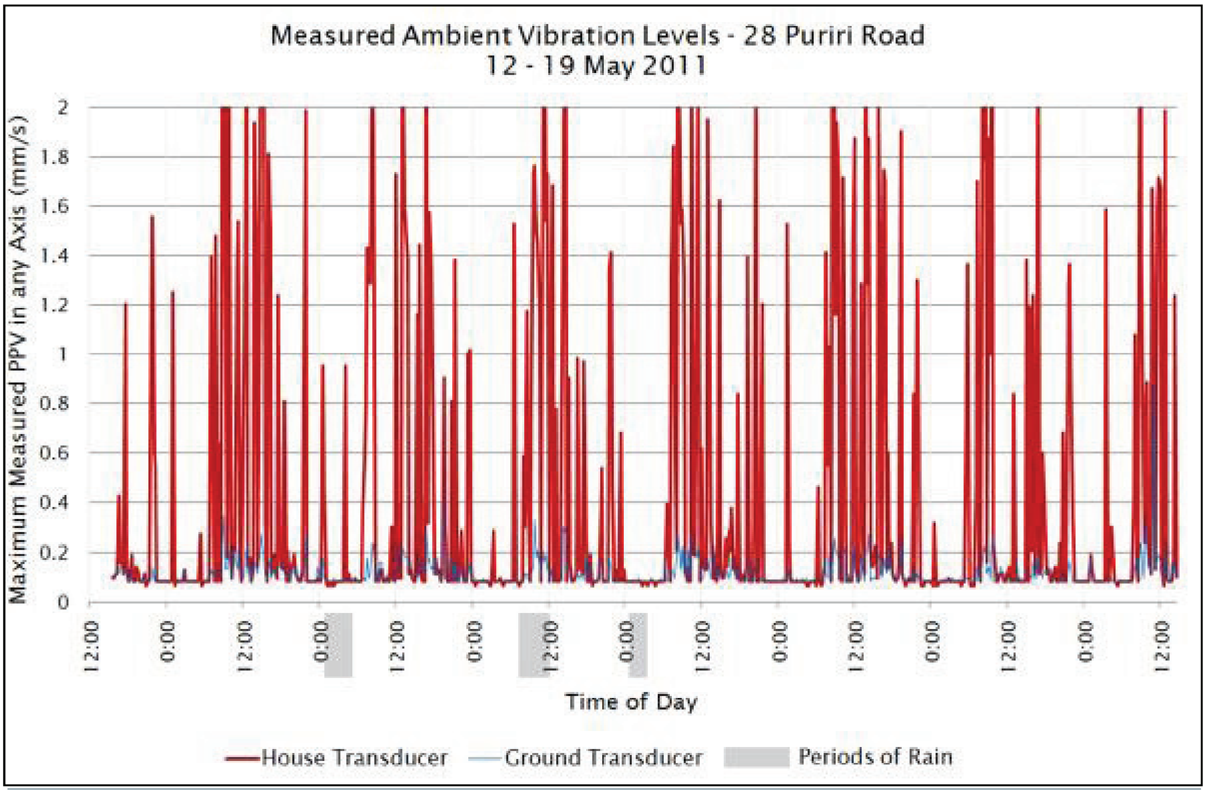


11.7 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location:	28 Puriri Road
Project Sector:	3
Date:	12 - 19 May 2011
Distance to major road:	420 m from Te Moana Rd
Equipment:	Instantel Minimate Plus

Maximum dwelling PPV:	3.79 mm/s
Mean uncontaminated dwelling PPV:	0.09 mm/s

Setup comment: Dwelling transducer fixed to floor joist with cable ties. Ground transducer placed in ground under dwelling with ground spikes and sandbagged.



11.8 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location: 164 Te Moana Road

Project Sector: 3

Date: 12 - 19 May 2011

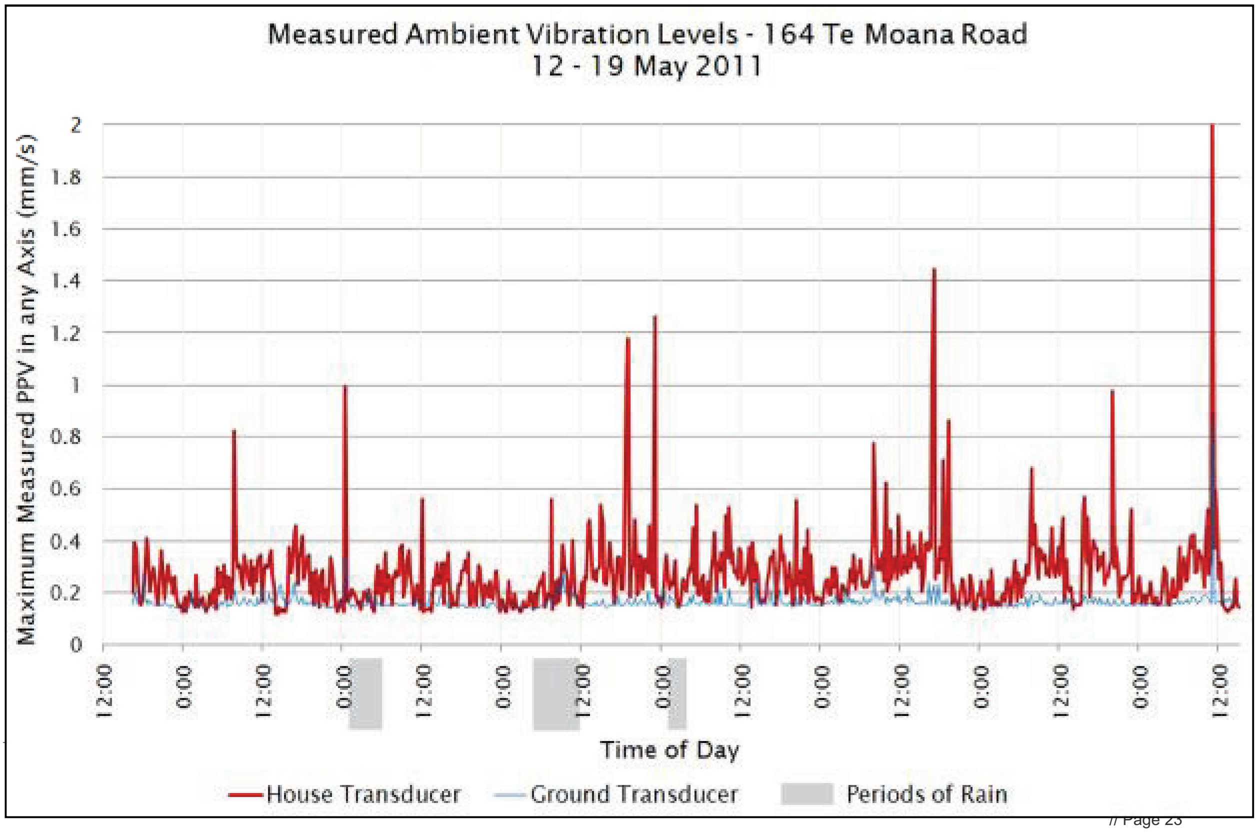
Distance to major road: 20 m from Te Moana Road

Equipment: Instantel Minimate Pro6

Maximum dwelling PPV: 2.05 mm/s

Mean uncontaminated dwelling PPV: 0.19 mm/s

Setup comment: Dwelling transducer fixed to floor joist with cable ties. Ground transducer placed in ground outside with ground spikes and sandbagged.



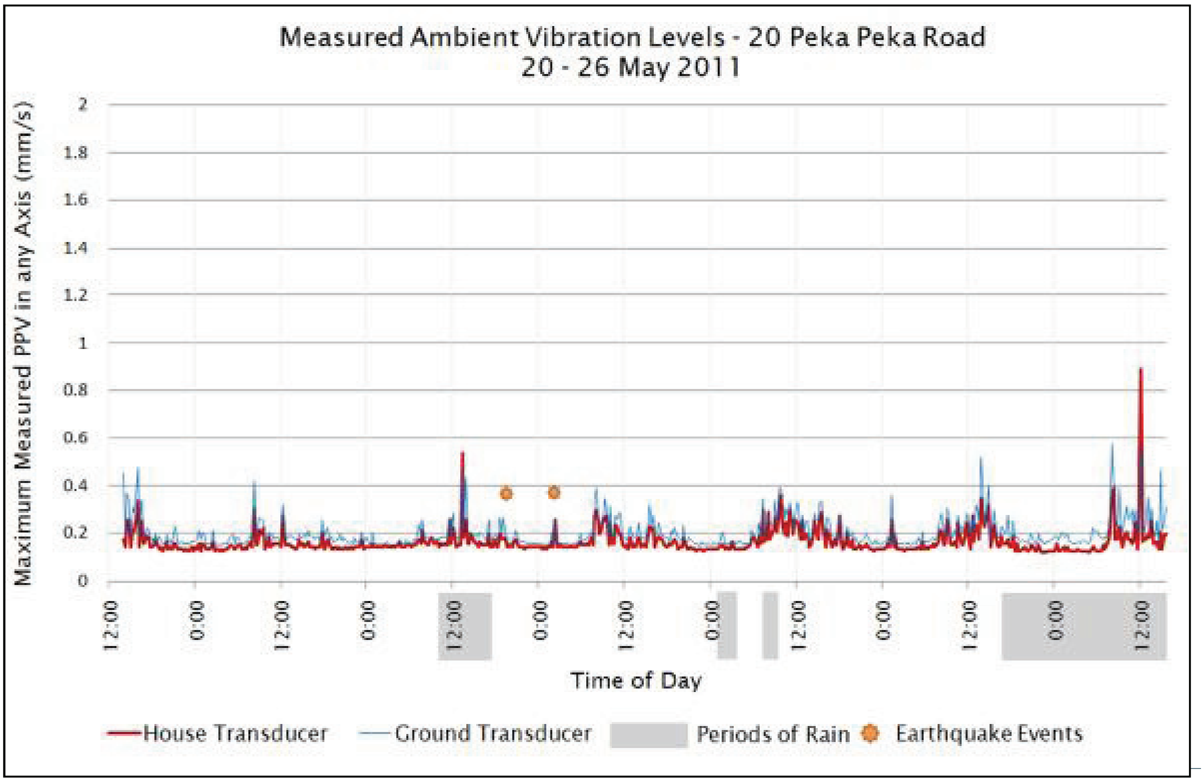
11.9 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location:	20 Peka Peka Road
Project Sector:	4
Date:	20 – 26 May 2011
Distance to major road:	150 m from existing SH1
Equipment:	Instantel Minimate Pro6

Maximum dwelling PPV:	0.9 mm/s
Mean uncontaminated dwelling PPV:	0.16 mm/s

Setup comment: Dwelling transducer placed on concrete footing and sandbagged. Ground transducer placed in ground under dwelling with ground spikes and sandbagged. Note waste pipes close to ground transducer.

11.10

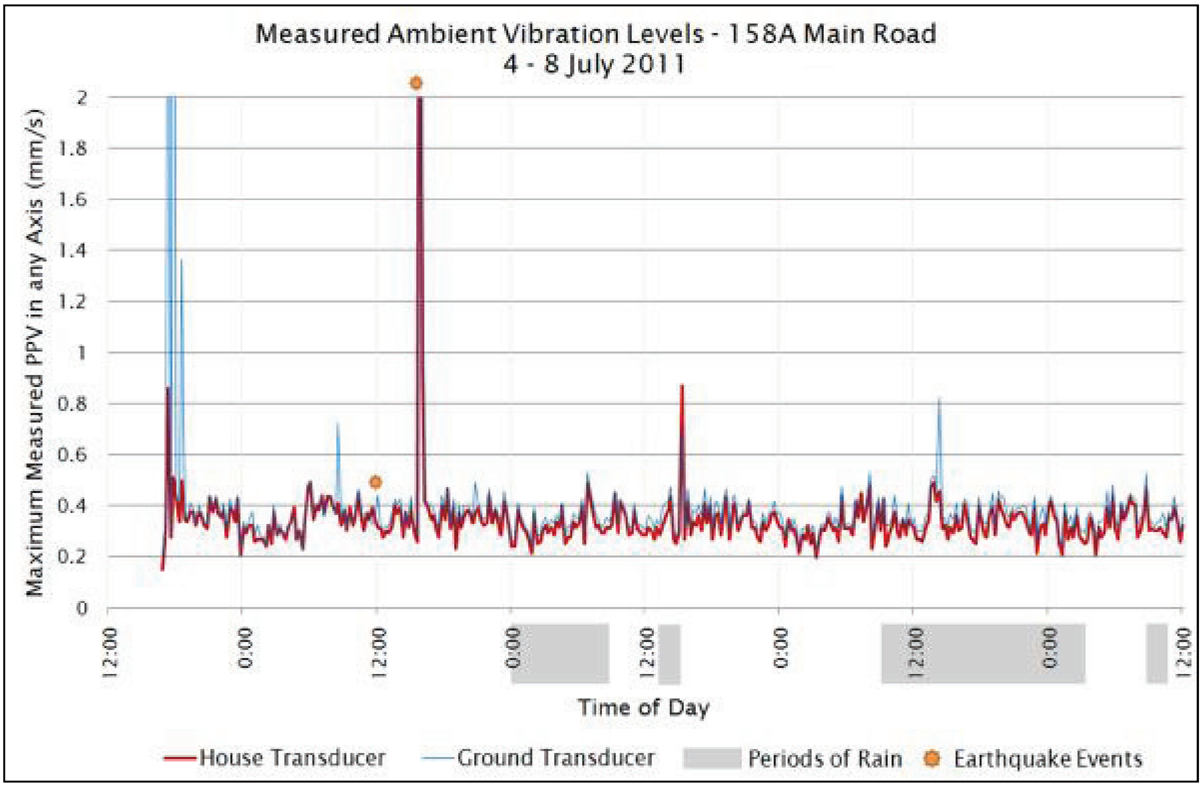


MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location:	158A Main Road (SH1)
Project Sector:	N/A
Date:	4 – 8 July 2011
Distance to major road:	15 m from existing SH1
Equipment:	Instantel Minimate Pro6

Maximum dwelling PPV:	3.38 mm/s
Mean uncontaminated dwelling PPV:	0.35 mm/s

Setup comment: Building is used as an office. 'Dwelling' transducer placed on poured concrete patio at side of building and sandbagged. Ground transducer placed in adjacent ground with ground spikes and sandbagged. Note ground transducer closer to road.



MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location: 170 Main Road (SH1)

Project Sector: N/A

Date: 4 – 8 July 2011

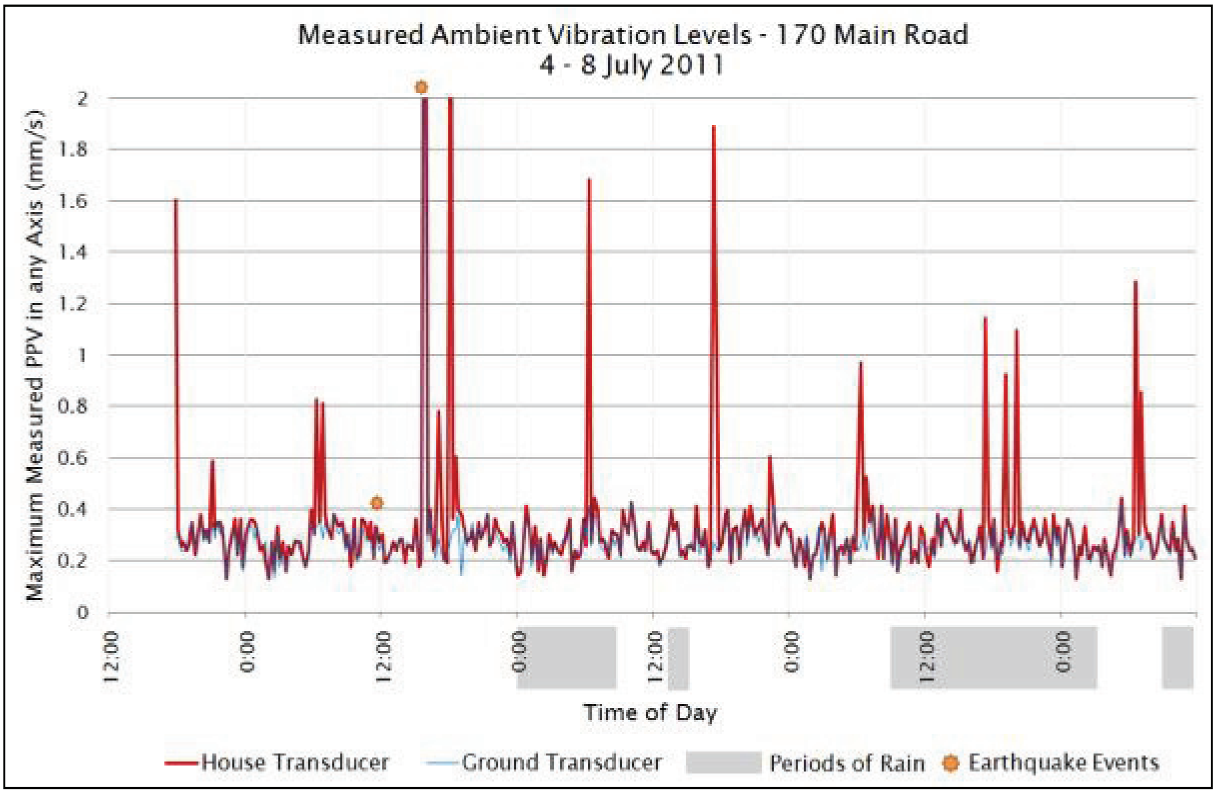
Distance to major road: 24 m from existing SH1

Equipment: Instantel Minimate Plus

Maximum dwelling PPV: 3.76 mm/s

Mean uncontaminated dwelling PPV: 0.28 mm/s

Setup comment: Timber subframe and block perimeter. Dwelling transducer fixed with cable ties and duct tape to floor joist, by intersection with perimeter plate. Ground transducer placed in ground under dwelling with ground spikes and sandbagged.



MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location: 174 Main Road (SH1)

Project Sector: N/A

Date: 11 – 18 July 2011

Distance to major road: 36 m from existing SH1

Equipment: Instantel Minimate Pro6

Maximum dwelling PPV: 8.76 mm/s

Mean uncontaminated dwelling PPV: 0.33 mm/s

Setup comment: Timber subframe. Dwelling transducer fixed with cable ties to floor joist, adjacent to pile. Ground transducer placed in ground under dwelling with ground spikes and sandbagged.

11.13 MACKAYS TO PEKA PEKA - Ambient Vibration Monitoring Results

Location: 216 Main Road (SH1)

Project Sector: N/A

Date: 11 – 18 July 2011

Distance to major road: 30 m from existing SH1

Equipment: Instantel Minimate Plus

Maximum dwelling PPV: 4.60 mm/s

Mean uncontaminated dwelling PPV: 0.20 mm/s

Setup comment: Transducers positioned at entrance to garage. Dwelling transducer placed on concrete floor and sandbagged. Ground transducer placed on ground outside and sandbagged.