Contractor

Forth Crossing Bridge Constructors

HOCHTIEF Solutions
American Bridge International
DRAGADOS
Morrison Construction

Project

FORTH REPLACEMENT CROSSING

Document title

VIBRATION MONITORING REPORT

FEBRUARY 2012 TO APRIL 2012

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Contents

Appendices:

INTRODUCTION

1.1. In accordance with the Code of Construction Practice (CoCP) and Noise and Vibration Management Plan, FCBC have risk assessed all construction activities through the PCNV process.

1.2. During the preparation of the PCNVs, assessment/prediction of vibration levels showed that no plant or equipment used, or construction activity carried out was envisaged to induce any level of vibration at receptors that would exceed threshold levels of vibration in the CoCP. This assessment/prediction was confirmed by means of permanent vibration monitoring.

2. MONITORING SUMMARY

2.1. Due to the location and sensitivity of vibration monitoring equipment, the exceedances presented in the graphs included in the appendices of this report do not represent levels generated by construction, but rather show local interference around the monitoring equipment. This can include doors being slammed or movement close to the location of the Vibrock causing elevated vibration levels.

2.2. According to the BS5228-2 (2009) there is hardly any documented proof of actual damage to structures or their finishes, and damage resulting solely from well-controlled construction and demolition vibrations is rare. There are many other mechanisms which cause damage, especially in decorative finishes, and it is often incorrectly concluded that vibrations from construction and demolition sites are to blame. It is not possible to ascertain the exact cause of vibration, though it is possible to rule out construction as a cause on an activity basis.

2.3. The works carried out in each construction area as well as vibration assessments of the works are summarised in Appendix A.

2.4. Due to the distance between the works and the receptors and the methods of working the risk of damage to structures or nuisance to the residents due to vibration is highly unlikely.

2.5. The number of exceedances during construction are shown in Table 1 below.

Table 1- Exceedances of thresholds set out in the COCP

February

Location	PPV Exceedance		VDV Exceedance	
	Continuous (5 mm.s^{-1})	*Intermittent (10 mm.s^{-1})*	*Day (0.4 m.s$^{-1.75}$)*	*Night (0.2 m.s$^{-1.75}$)*
Clufflat Brae	1	8	0	0
5 Linn Mill	3	6	1	2
Barracks East	0	0	0	0
Barracks West	0	0	0	0
Butlaw Fisheries	1	0	0	0
Dundas Home Farm	1	0	1	2
Echline	0	1	0	0
Inchgarvie Lodge	0	0	0	0
Springfield	0	1	4	26
Tigh ni Grian	2	2	0	0
Whinnyhill	1	10	0	0

March

Location	PPV Exceedance		VDV Exceedance	
	Continuous (5 mm.s^{-1})	*Intermittent (10 mm.s^{-1})*	*Day (0.4 m.s$^{-1.75}$)*	*Night (0.2 m.s$^{-1.75}$)*
Clufflat Brae	4	22	0	0
5 Linn Mill	4	9	3	20
Butlaw Fisheries	0	0	0	0
Dundas Home Farm	0	0	0	1
Echline	0	1	0	0
Inchgarvie Lodge	1	2	1	0
Springfield	2	2	3	28
Tigh ni Grian	4	4	0	0
Newton	0	12	6	13
Scotstoun	0	1	0	0
Whinnyhill	0	12	0	0

April

Location	PPV Exceedance		VDV Exceedance	
	Continuous (5 mm.s^{-1})	*Intermittent (10 mm.s^{-1})*	*Day (0.4 m.s$^{-1.75}$)*	*Night (0.2 m.s$^{-1.75}$)*
Clufflat Brae	3	19	0	15
5 Linn Mill	2	7	0	0
Barracks West	0	0	0	0
Butlaw Fisheries	0	0	0	0
Dundas Home Farm	1	0	0	1
Echline	0	1	0	0
Inchgarvie Lodge	1	1	0	0
Springfield	0	0	0	0
Tigh ni Grian	8	5	0	0
Newton	0	21	12	19
Scotstoun	1	1	1	0
Whinnyhill	5	12	0	0

2.6. Peak Particle Velocity (PPV) is used to measure vibration through a solid surface. When a vibration is measured, the point at which the measurement takes place can be considered to have a particle velocity. This particle vibration will take place in three dimensions (x, y and z).

2.7. The Peak Particle Velocity is the highest velocity that is recorded during a particular event, and as such is appropriate for the measurement of activities such as blasting and piling. The thresholds for the Forth Replacement Crossing are 5 $mm.s^{-1}$ for continuous construction (e.g. piling) and 10 $mm.s^{-1}$ for intermittent construction (i.e. blasting).

2.8. These thresholds are set to protect against building damage. For this monitoring period, all the exceedances have been investigated thoroughly and seem to be generated due to standalone, instantaneous events most probably as a result of unknown local interferences. There was no construction activity within 300m of the receptors which could cause such exceedances.

2.9. Vibration Dose Value (VDV) is a metric used in vibration monitoring. It is calculated by taking the fourth root of the integral of the fourth power of acceleration after it has been frequency-weighted. The frequency-weighted acceleration is measured in $m.s^{-2}$ and the time period over which the VDV is measured is in seconds. This yields VDVs in $m.s^{-1.75}$

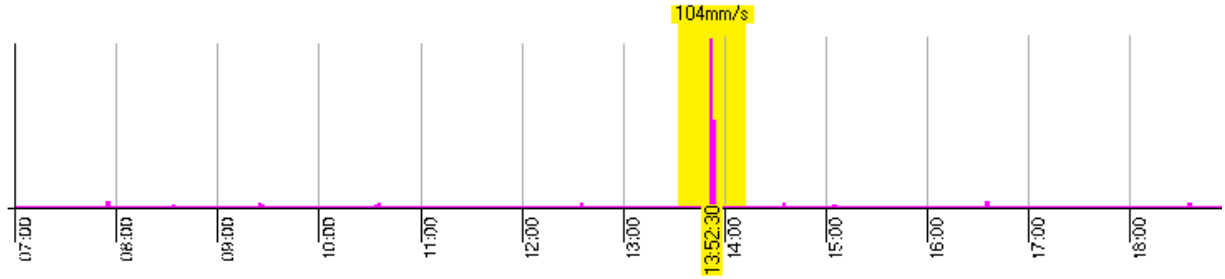
2.10. During the monitoring period, vibratory rollers were used intermittently at several locations around the site in the construction of haul roads. Due to the distances of the rollers away from any receptors none of the exceedances in VDV levels can be associated with the use of vibratory rollers.

2.11. In addition, detailed investigation of all exceedances (i.e. review of PPV levels over 30 seconds periods) has shown that each resulted from isolated, non-construction related events, which occurred adjacent to the transducer. Below is an example of one of such investigation, an exceedance of 104

mm.s^{-1}, which occurred on 23/11/11. As can be seen, this was an isolated event which appears to be due to sources other than construction activities.

Calibrate by: SEP 12

Ev 011			
Cont	Max	Time	Date
Event	104mm/s	13:52:30	23/11/11
Hour 1	.725mm/s	07:54:10	23/11/11
Hour 2	.275mm/s	08:34:10	23/11/11
Hour 3	.400mm/s	09:25:10	23/11/11
Hour 4	.425mm/s	10:34:50	23/11/11
Hour 5	.175mm/s	11:00:10	23/11/11
Hour 6	.600mm/s	12:35:00	23/11/11
Hour 7	104mm/s	13:52:30	23/11/11
Hour 8	.475mm/s	14:35:10	23/11/11
Hour 9	.325mm/s	15:05:30	23/11/11



2.12. Within the Appendix B, there are short gaps of missing data in the PPV and VDV graphs. These occurred as a result of:

- The occasional relocation of Vibrocks for rock blasts; or
- Short power cuts, causing the Vibrock to power down until manually reset; or
- Vibrocks being sent back to the supplier for emergency maintenance, as data could not be retrieved.

3. Conclusion

3.1. Considering the distance between construction works and the above receptors, and the methods of working utilised, the risk of damage to structures or nuisance to residents resulting from vibration is highly unlikely.

3.2. Due to the location and sensitivity of vibration monitoring equipment, the exceedances presented in the graphs included in the appendices of this report do not represent levels generated by construction, but rather show local interference around the monitoring equipment. This may include, for example, the slamming of doors or other movements nearby the monitoring equipment location, which result in elevated vibration levels.

APPENDIX A – VIBRATION ASSESSMENTS OF RELEVANT PCNVs

Butlaw Fisheries				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0002	Feb 12 to Apr 12	Marine-based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data exists for 182m but the vibration levels based on the historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum duration to reduce any exposure.

Butlaw Fisheries				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0011	Feb 12 to Apr 12	Main Crossing-Bridge Works Area	1. S7 Foundation – Construction of S7 foundation 2. S8 Foundation – Construction of S8 foundation 3. N2 Foundation – Construction of N2 foundation including drilling shot holes for blasting. 4. Construction of Working Platform at S6 as well as Construction of S6 foundation.	PPV: Nearest property to the works is Inchgarvie House which is an average 64m from foundation S8. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

Butlaw Fisheries				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0019	Feb 12 to Apr 12	Beamer Rock blast & excavation	1. Blasting works 2. Excavation and disposal of loosened rock	Butlaw Fisheries - 0.2mm.s^{-1} Tigh-na-Grian - 0.4mm.s^{-1} Port Edgar Barracks - 0.2mm.s^{-1} Forth Rd Bridge North Tower - 0.8mm.s^{-1}

Barracks West				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0002	Feb 12 to Apr 12	Marine-based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data exists for 182m but the vibration levels based on the historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum duration to reduce any exposure.

Barracks West				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0011	Feb 12 to Apr 12	Main Crossing-Bridge Works Area	1. S7 Foundation – Construction of S7 foundation 2. S8 Foundation – Construction of S8 foundation 3. N2 Foundation – Construction of N2 foundation including drilling shot holes for blasting. 4. Construction of Working Platform at S6 as well as Construction of S6 foundation.	PPV: Nearest property to the works is Inchgarvie House which is an average 64m from foundation S8. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

Barracks West				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0019	Feb 12 to Apr 12	Beamer Rock blast & excavation	1. Blasting works 2. Excavation and disposal of loosened rock	Butlaw Fisheries - 0.2mm.s^{-1} Tigh-na-Grian - 0.4mm.s^{-1} Port Edgar Barracks - 0.2mm.s^{-1} Forth Rd Bridge North Tower - 0.8mm.s^{-1}

Barracks East				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0002	Feb 12 to Apr 12	Marine-based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data exists for 182m but the vibration levels based on the historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum duration to reduce any exposure.

Barracks East				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0011	Feb 12 to Apr 12	Main Crossing-Bridge Works Area	1. S7 Foundation – Construction of S7 foundation 2. S8 Foundation – Construction of S8 foundation 3. N2 Foundation – Construction of N2 foundation including drilling shot holes for blasting. 4. Construction of Working Platform at S6 as well as Construction of S6 foundation.	PPV: Nearest property to the works is Inchgarvie House which is an average 64m from foundation S8. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

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PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0011	Feb 12 to Apr 12	Main Crossing-Bridge Works	1.S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation 2. S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation 3. N2 Foundation –Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting.	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0019	Feb 12 to Apr 12	Beamer Rock blast & excavation	1. Blasting works 2. Excavation and disposal of loosened rock	Butlaw Fisheries - 0.2mm.s^{-1} Tigh-na-Grian - 0.4mm.s^{-1} Port Edgar Barracks - 0.2mm.s^{-1} Forth Rd Bridge North Tower - 0.8mm.s^{-1}

Inchgarvie House				
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PCNV0002	Feb 12 to Apr 12	Marine-based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data exists for 182m but the vibration levels based on the historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum duration to reduce any exposure.
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Inchgarvie House				
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PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0021	Feb 12 to Apr 12	Earthworks	1. Earthworks – cut and fill operations including excavation and deposition of rock 2. Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway 3. Road work operations 4. Utility diversions – electric, water, sewerage, gas, BT 5. Site Clearance	PPV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect

Inchgarvie House				
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				on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

Linn Mill				
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PCNV0002	Feb 12 to Apr 12	Marine-based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data exists for 182m but the

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Linn Mill				
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Clufflat Brae				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0011	Feb 12 to Apr 12	Main Crossing-Bridge Works	1.S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation 2. S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation 3. N2 Foundation –Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting.	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0021	Feb 12 to Apr 12	Earthworks	1. Earthworks – cut and fill operations including excavation and deposition of rock 2. Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway 3. Road work operations	PPV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest

Clufflat Brae				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
			4. Utility diversions – electric, water, sewerage, gas, BT 5. Site Clearance	levels of vibration are likely to be generated by the vibratory roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

Springfield				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0011	Jan 12	Main Crossing-Bridge Works	1.S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation 2. S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation 3. N2 Foundation –Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting.	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0021	Feb 12 to Apr 12	Earthworks	1. Earthworks – cut and fill operations including excavation and deposition of rock 2. Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway 3. Road work operations 4. Utility diversions – electric, water, sewerage, gas, BT 5. Site Clearance	PPV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect

Springfield				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
				on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

Echline				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0011	Jan 12	Main Crossing-Bridge Works	1.S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation2. S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation3. N2 Foundation – Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting.	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0021	Feb 12 to Apr 12	Earthworks	1. Earthworks – cut and fill operations including excavation and deposition of rock	PPV: Nearest property to the works is Inchgarvie House which is

Echline				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
			2. Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway 3. Road work operations 4. Utility diversions – electric, water, sewerage, gas, BT 5. Site Clearance	an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

Dundas Home Farm				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0021	Feb 12 to Apr 12	Earthworks	1. Earthworks – cut and fill operations including excavation and deposition of rock 2. Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway 3. Road work operations 4. Utility diversions – electric, water, sewerage, gas, BT 5. Site Clearance	PPV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

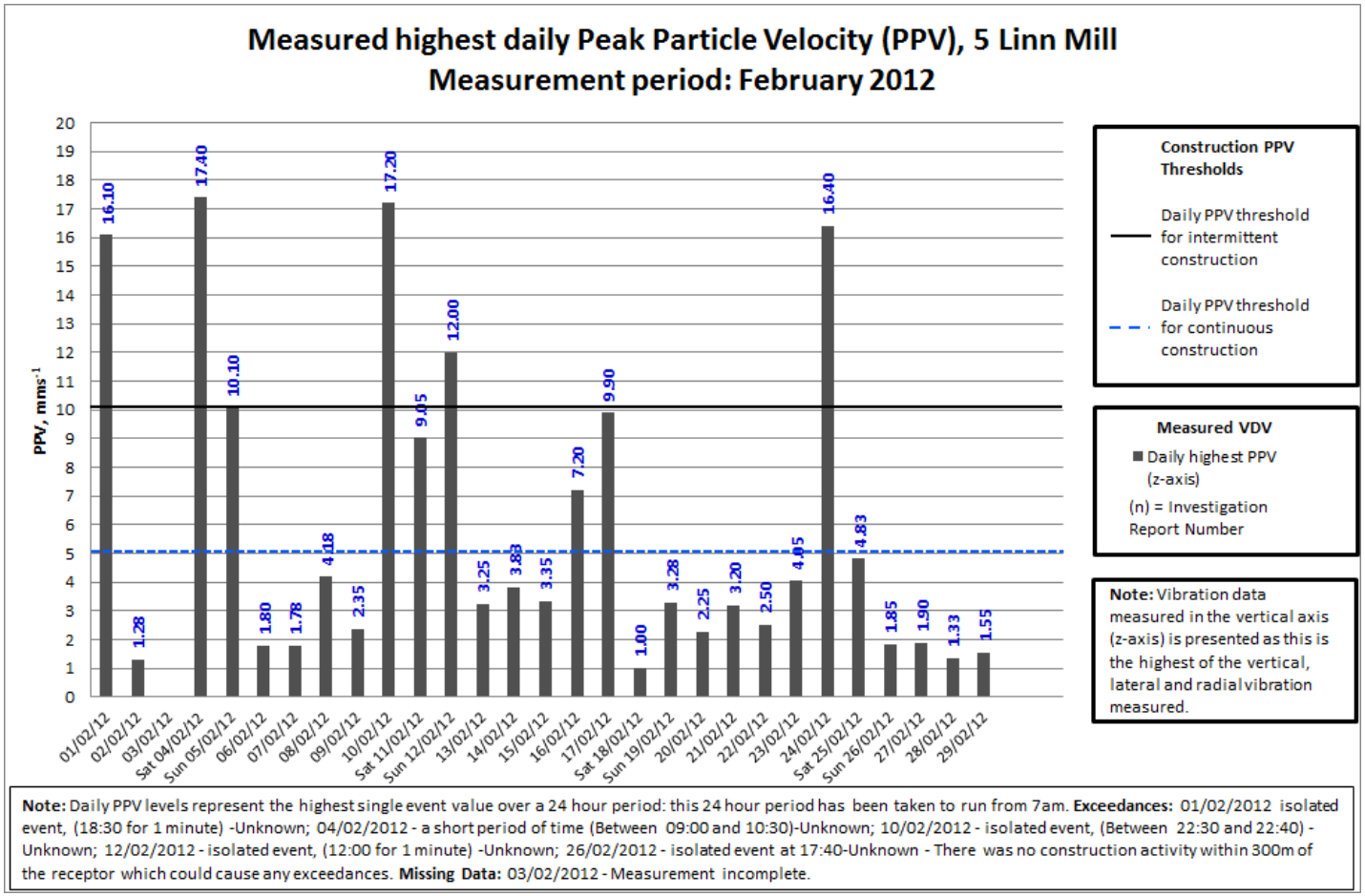
Tigh-ni Grian				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
PCNV0002	Feb 12 to Apr 12	Marine-based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data exists for 182m but the vibration levels based on the historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum duration to reduce any exposure.
PCNV0010	Jan 12 to Jun 12	North 1 Works	Drilling Shot Holes; Removal of Blasted Rock; Structure; Filling; Removal of Blasted Rock; Soil Mixing; Piled Embankment; Sewer Diversions; Working Platform; Ground Improvement.	The equipment to be used in these activities do not generate appreciable levels of vibration, also the distances to the closest occupied receptors are over 300m so therefore no assessment has been undertaken.
PCNV0011	Jan 12	Main Crossing-Bridge Works	1.S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation 2. S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-

Tigh-ni Grian				
Relevant PCNV No.	**Relevant Date**	**PCNV Name**	**Particulars of works to be carried out**	**Vibration Assessment**
			3. N2 Foundation –Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting.	standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0019	Feb 12 to Apr 12	Beamer Rock blast & excavation	1. Blasting works 2. Excavation and disposal of loosened rock	Butlaw Fisheries - 0.2mm.s^{-1} Tigh-na-Grian - 0.4mm.s^{-1} Port Edgar Barracks - 0.2mm.s^{-1} Forth Rd Bridge North Tower - 0.8mm.s^{-1}

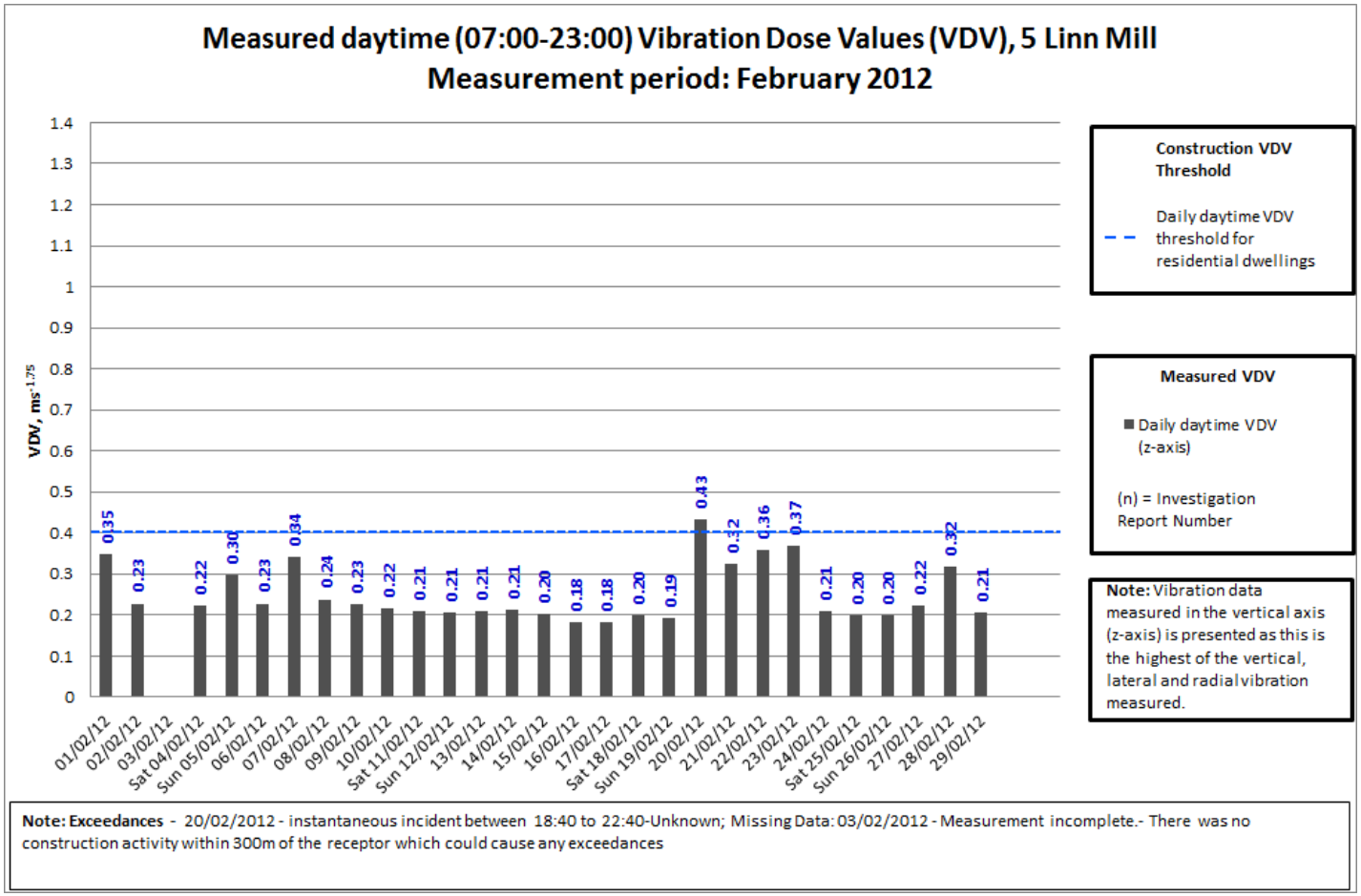
Forth Crossing Bridge Constructors
HOCHTIEF Solutions
American Bridge International
DRAGADOS
Morrison Construction

APPENDIX B – VIBRATION GRAPHS

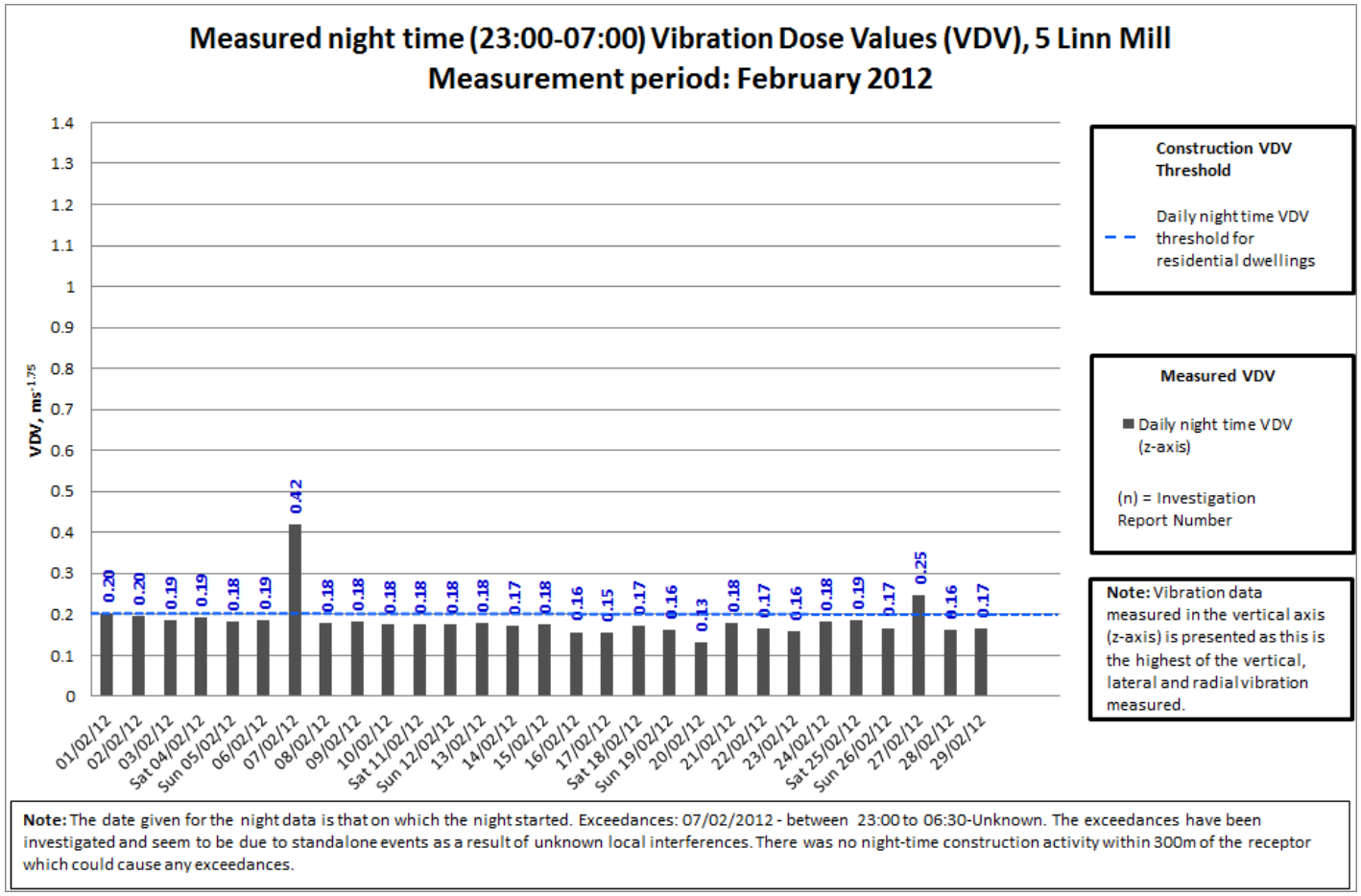
PPV at 5 Linn Mill – February 2012



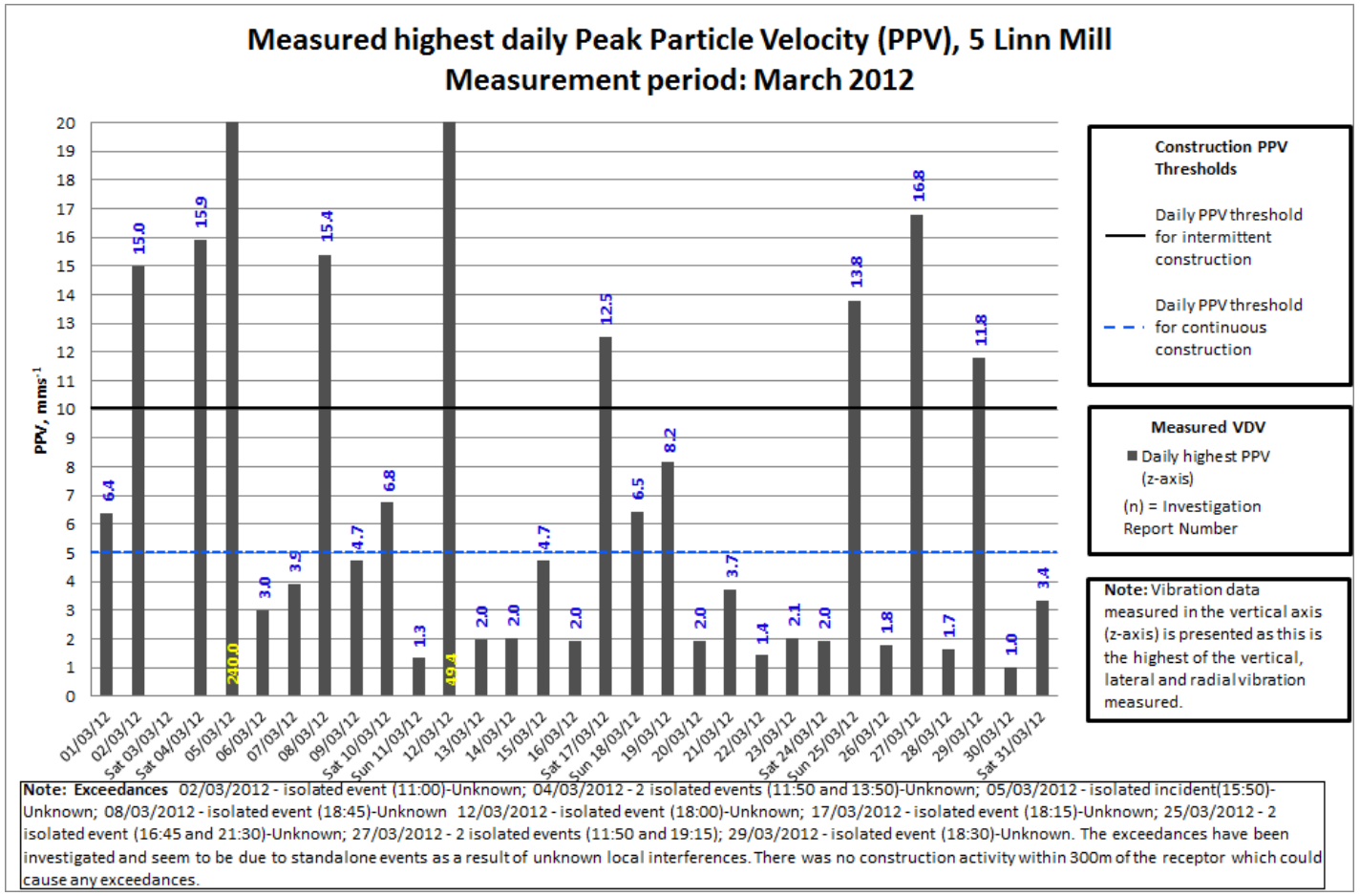
Daytime VDV at 5 Linn Mill – February 2012



Night-time VDV at 5 Linn Mill – February 2012

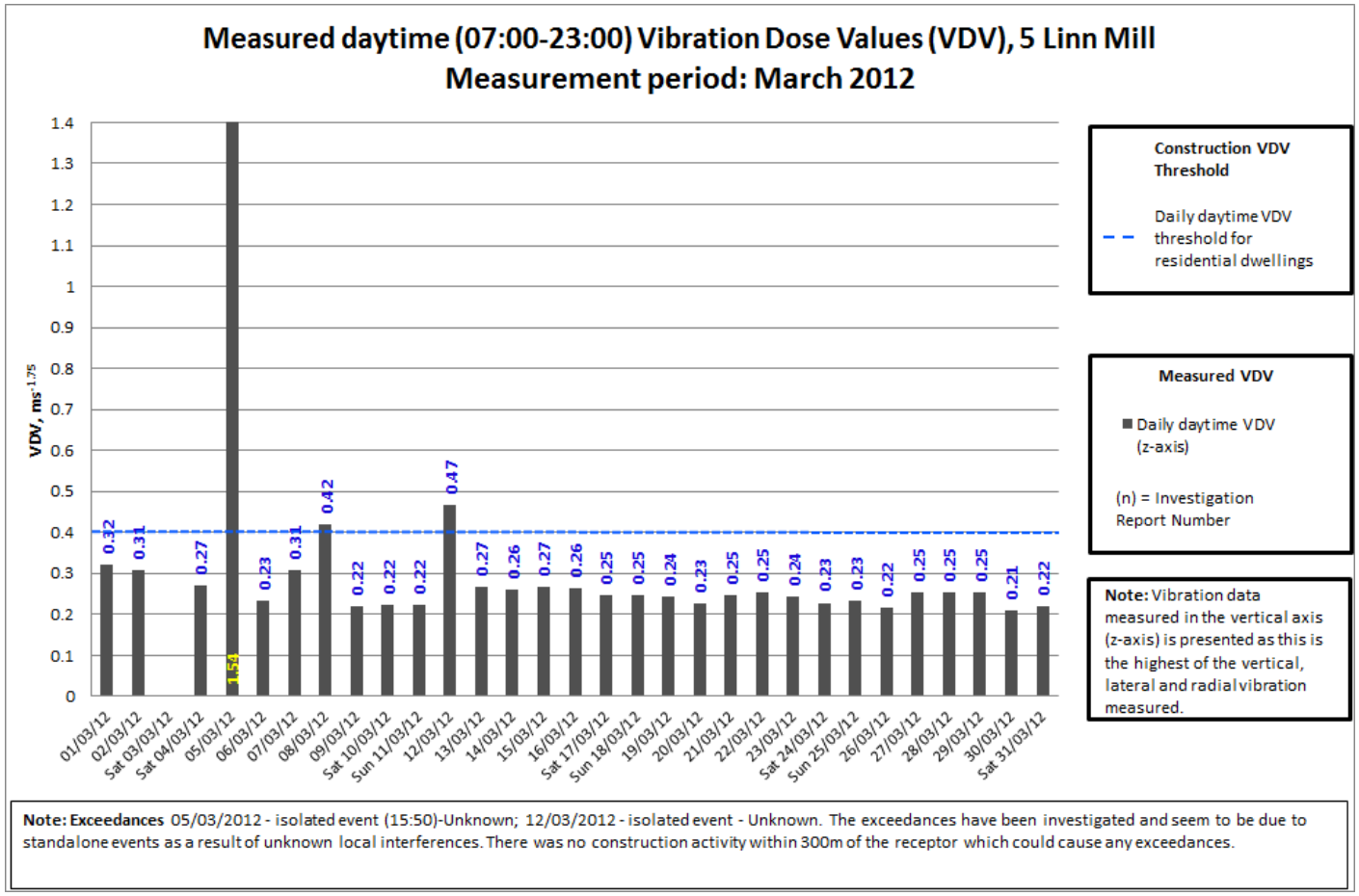


PPV at 5 Linn Mill – March 2012

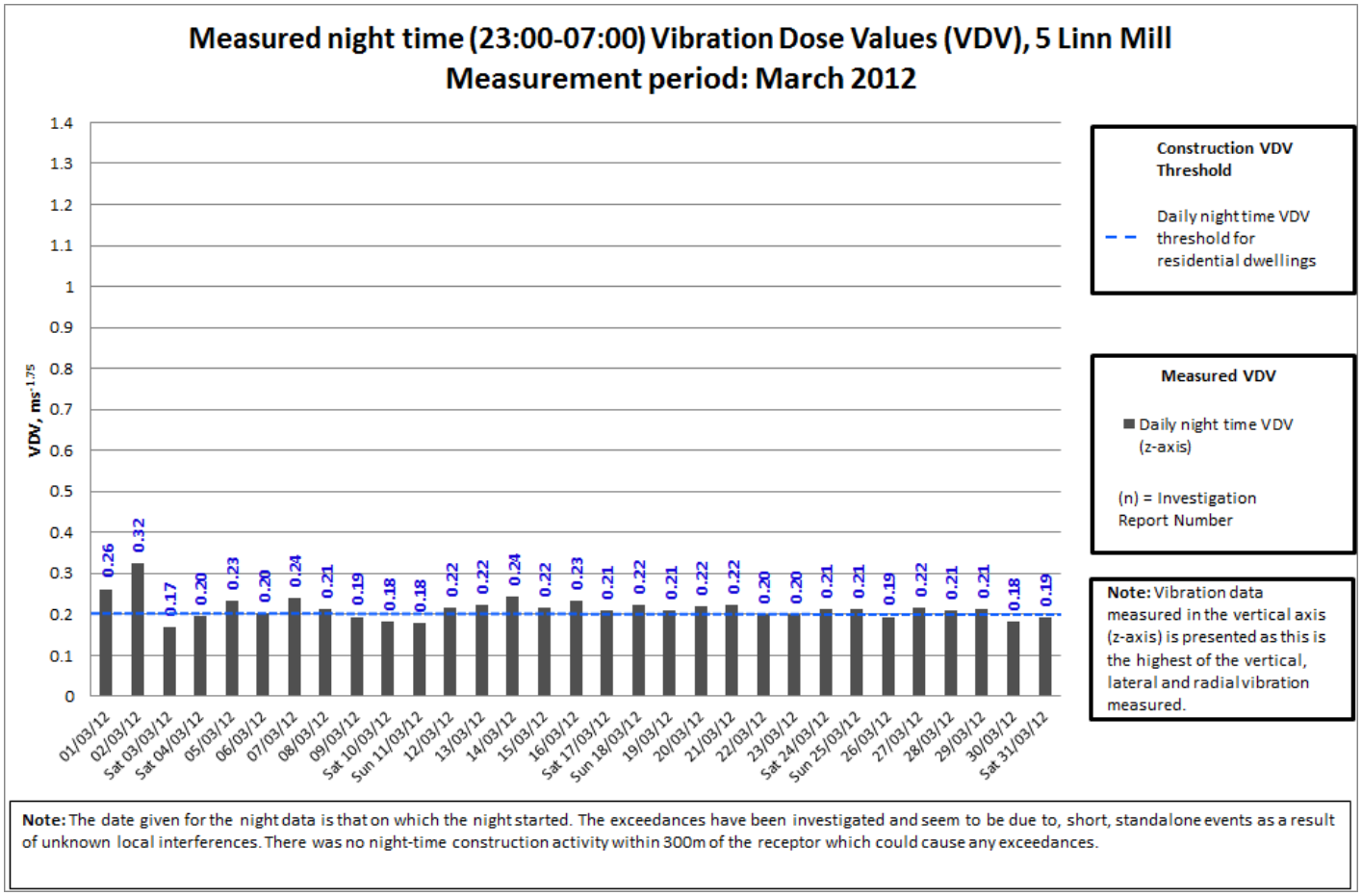


Note: Exceedances 02/03/2012 - isolated event (11:00)-Unknown; 04/03/2012 - 2 isolated events (11:50 and 13:50)-Unknown; 05/03/2012 - isolated incident(15:50)-Unknown; 08/03/2012 - isolated event (18:45)-Unknown 12/03/2012 - isolated event (18:00)-Unknown; 17/03/2012 - isolated event (18:15)-Unknown; 25/03/2012 - 2 isolated event (16:45 and 21:30)-Unknown; 27/03/2012 - 2 isolated events (11:50 and 19:15); 29/03/2012 - isolated event (18:30)-Unknown. The exceedances have been investigated and seem to be due to standalone events as a result of unknown local interferences. There was no construction activity within 300m of the receptor which could cause any exceedances.

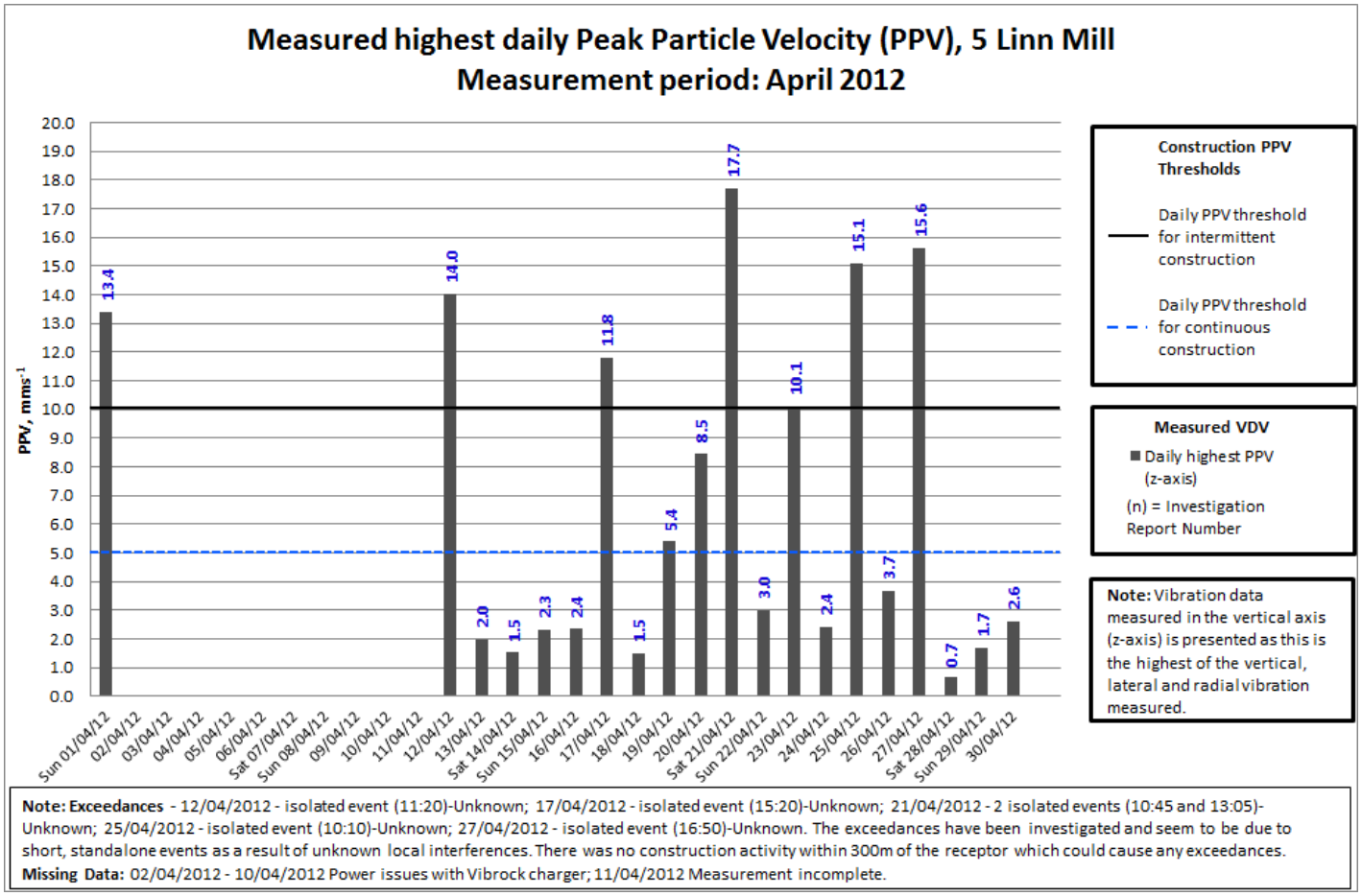
Daytime VDV at 5 Linn Mill – March 2012



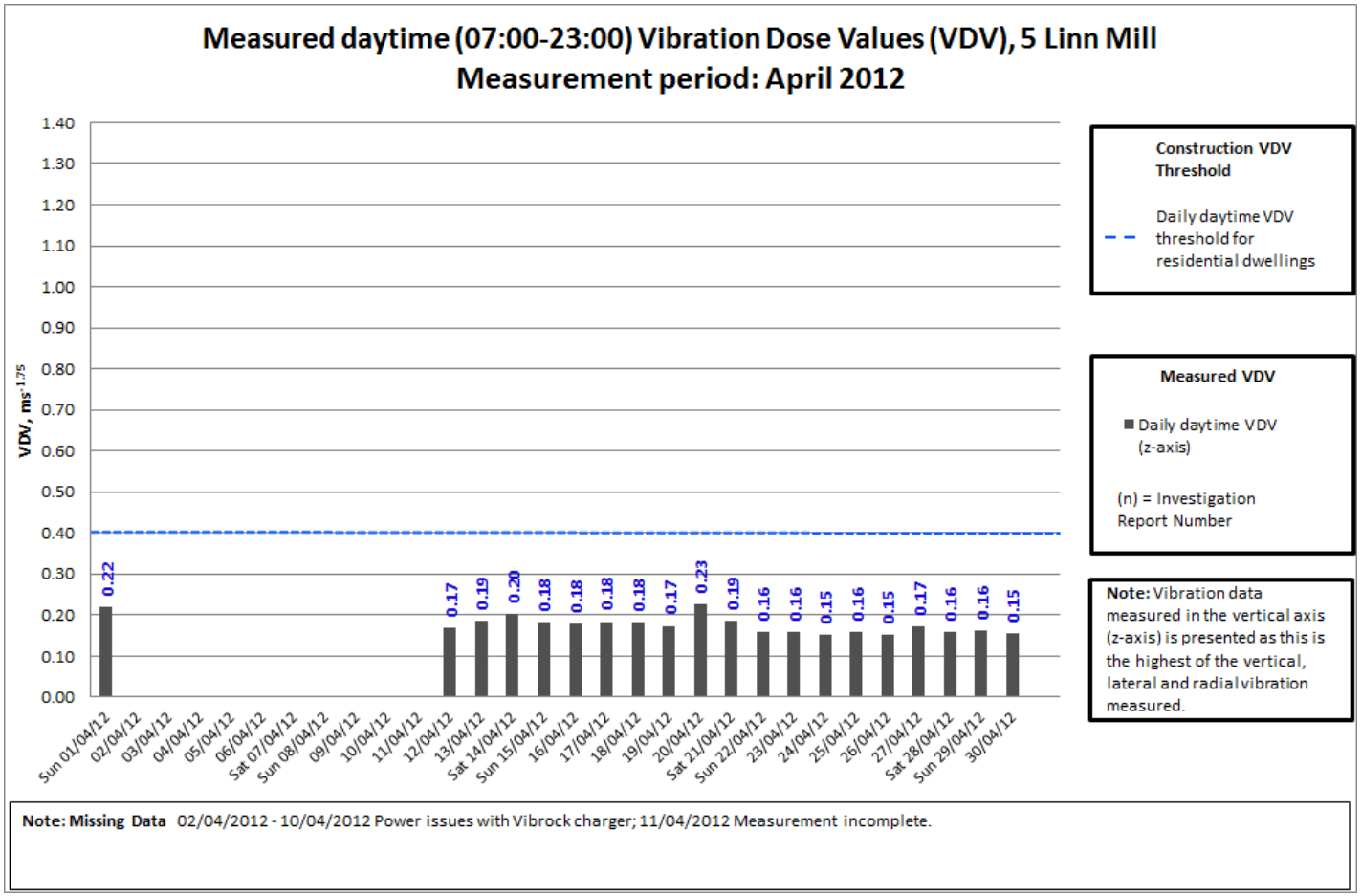
Night-time VDV at 5 Linn Mill – March 2012



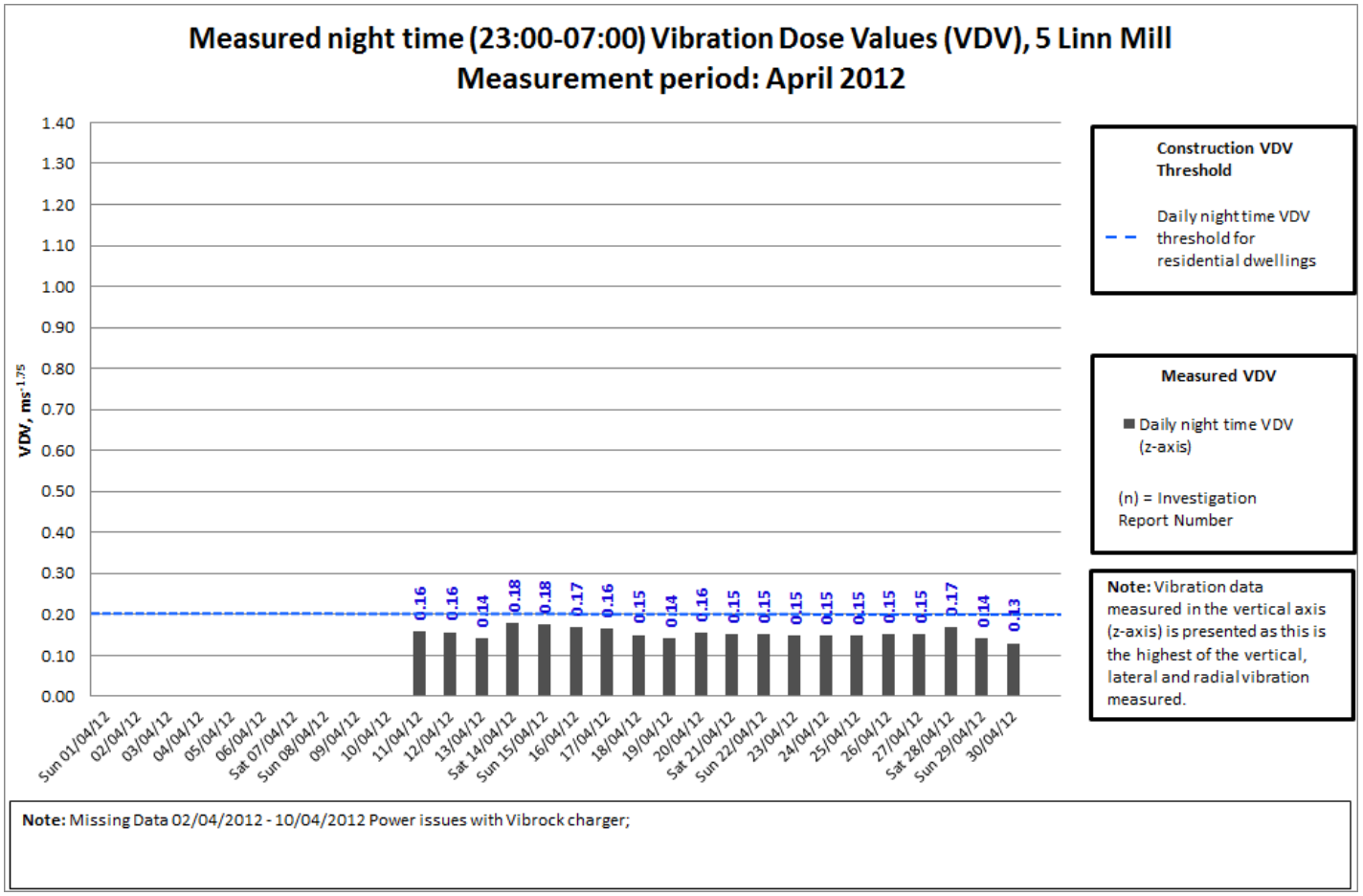
PPV at 5 Linn Mill – April 2012



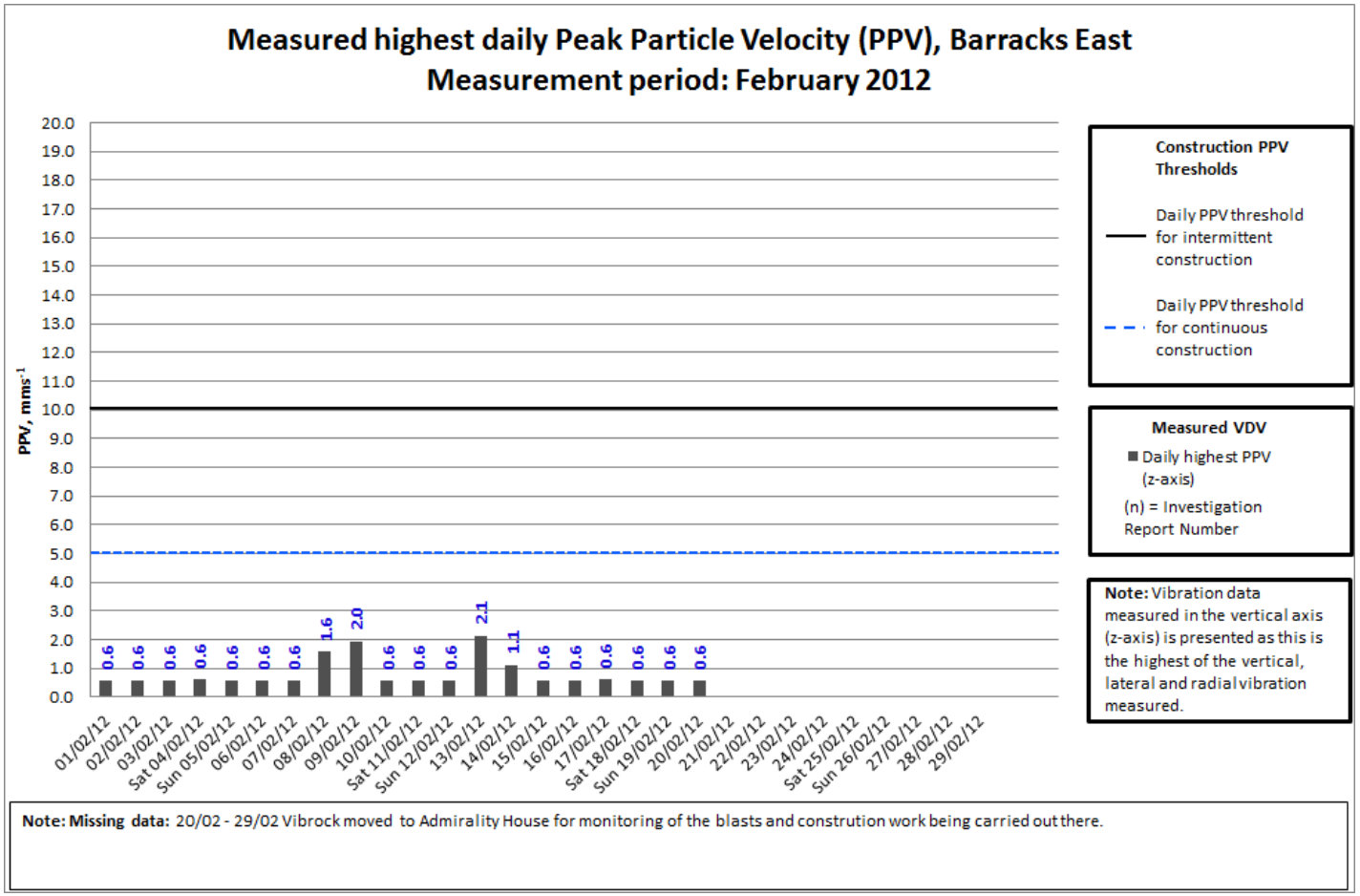
Daytime VDV at 5 Linn Mill – April 2012



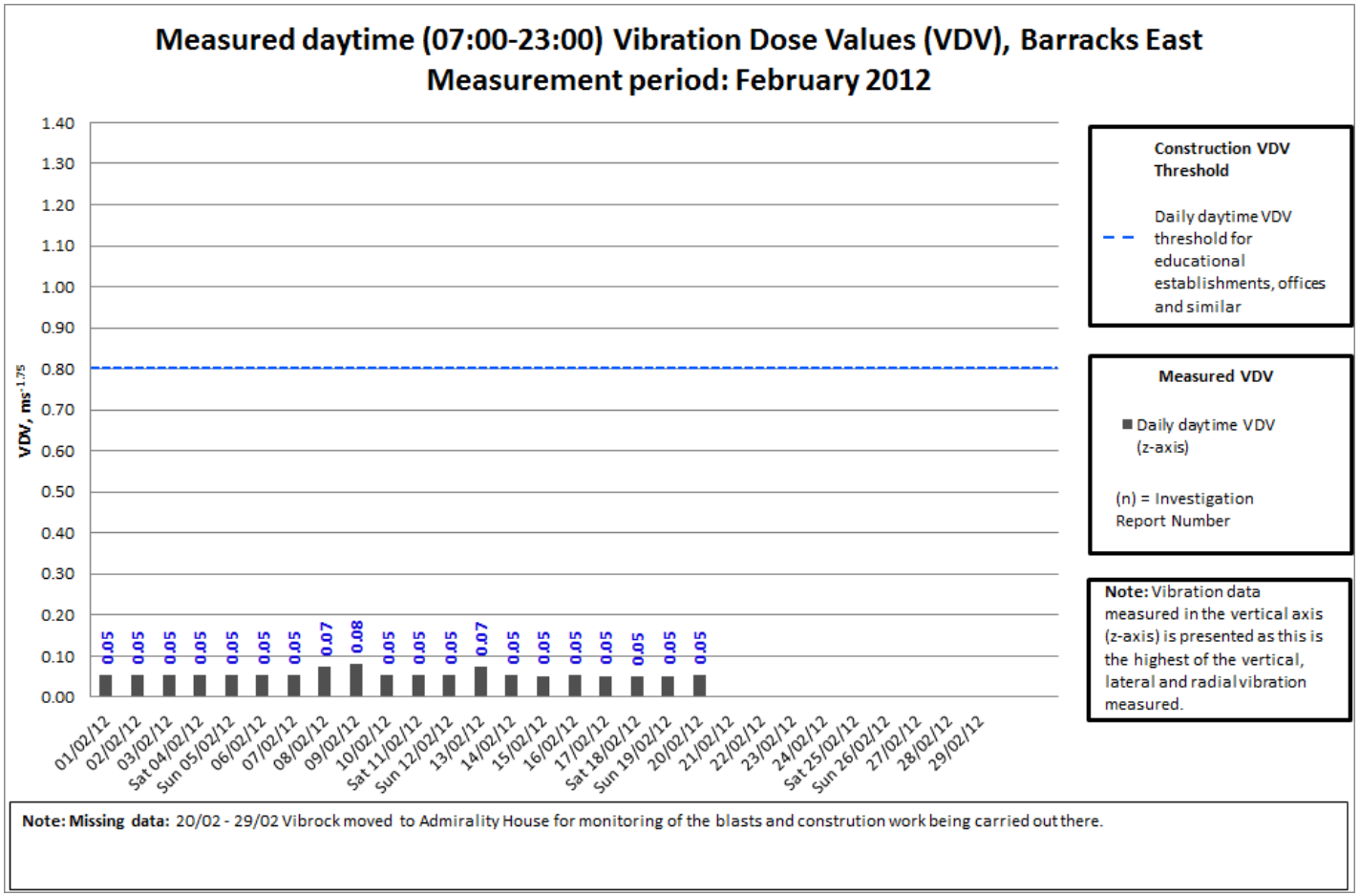
Night-time VDV at 5 Linn Mill – April 2012



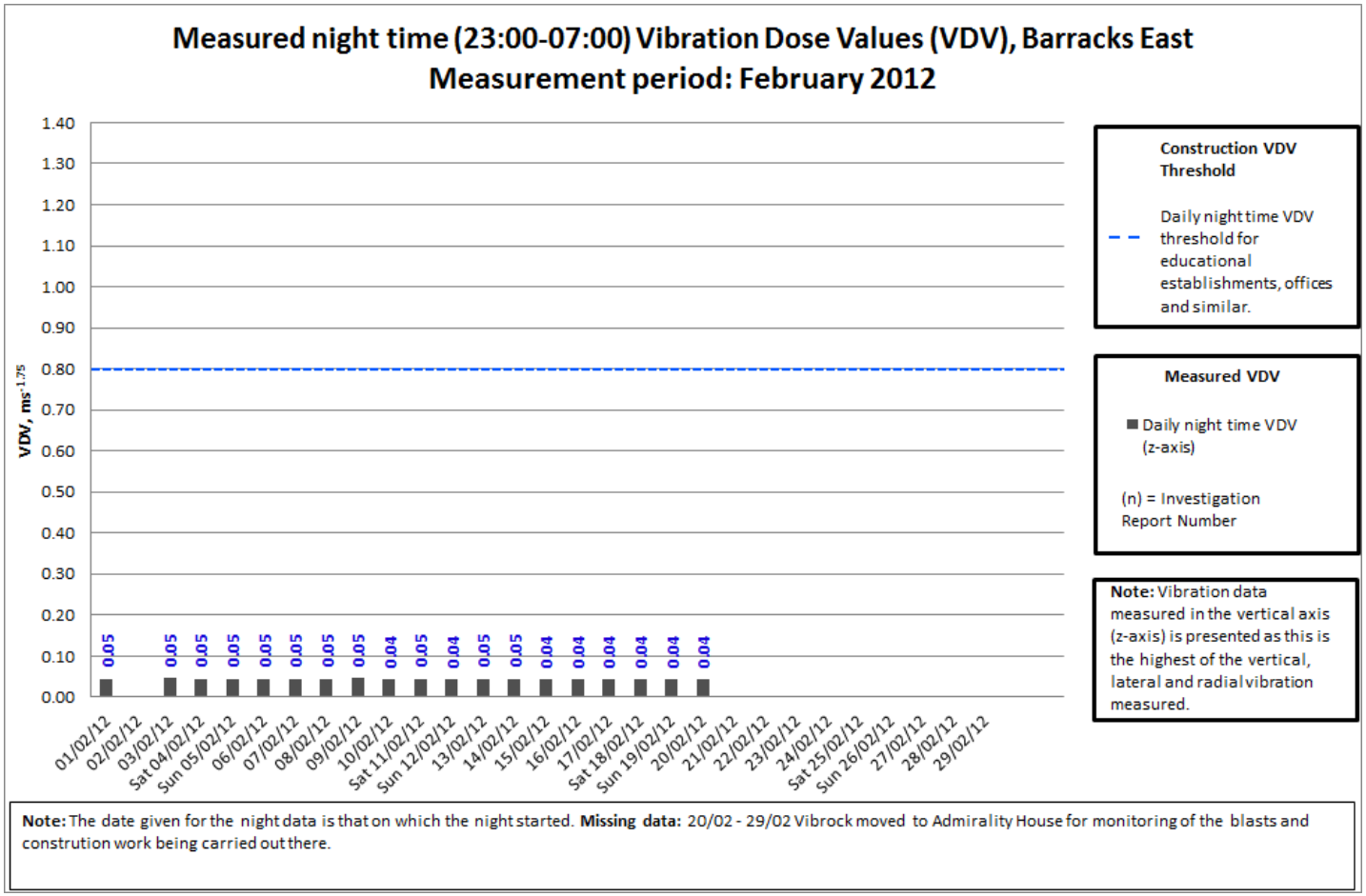
PPV at Barracks East – February 2012



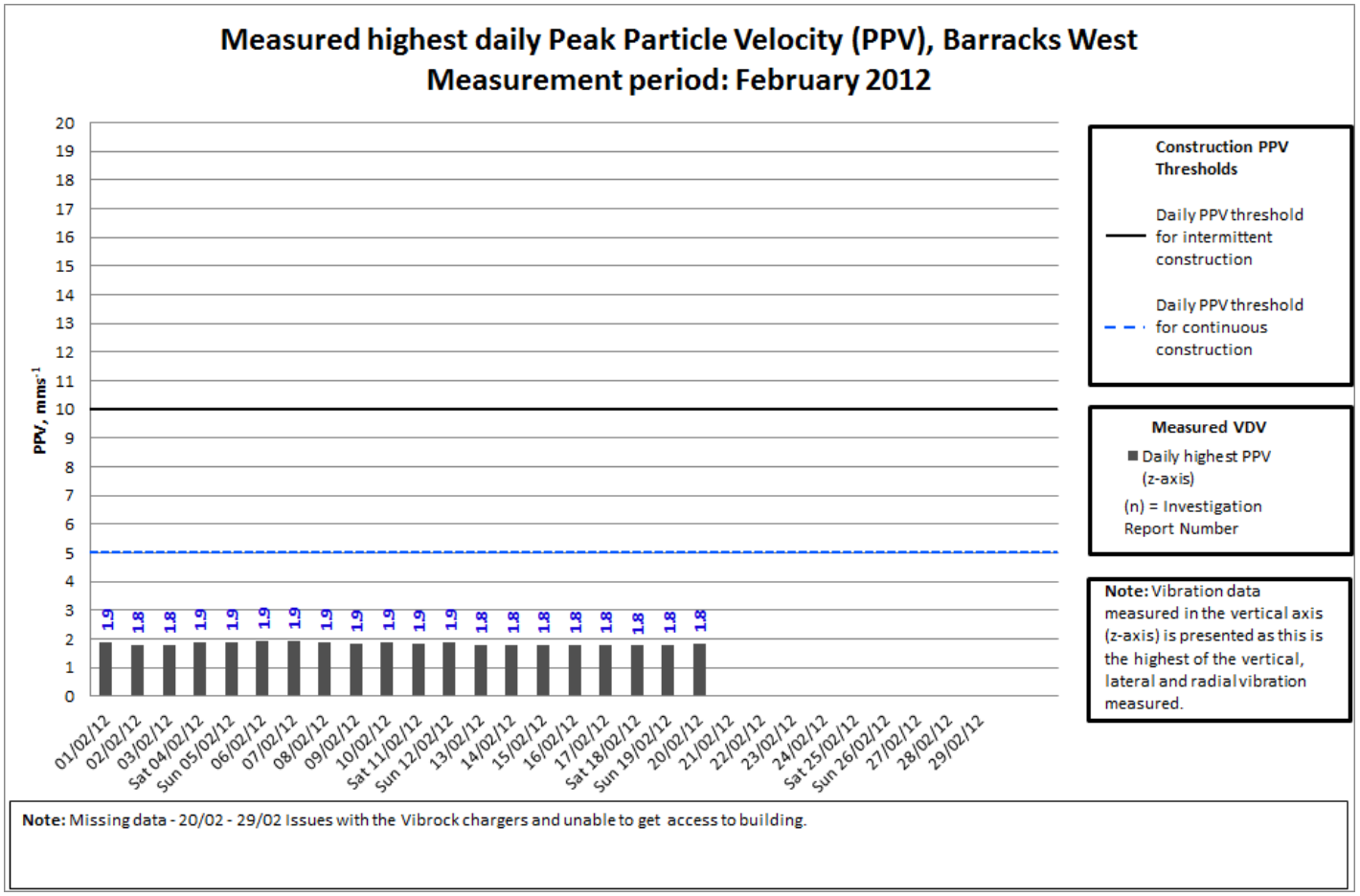
Daytime VDV at Barracks East – February 2012



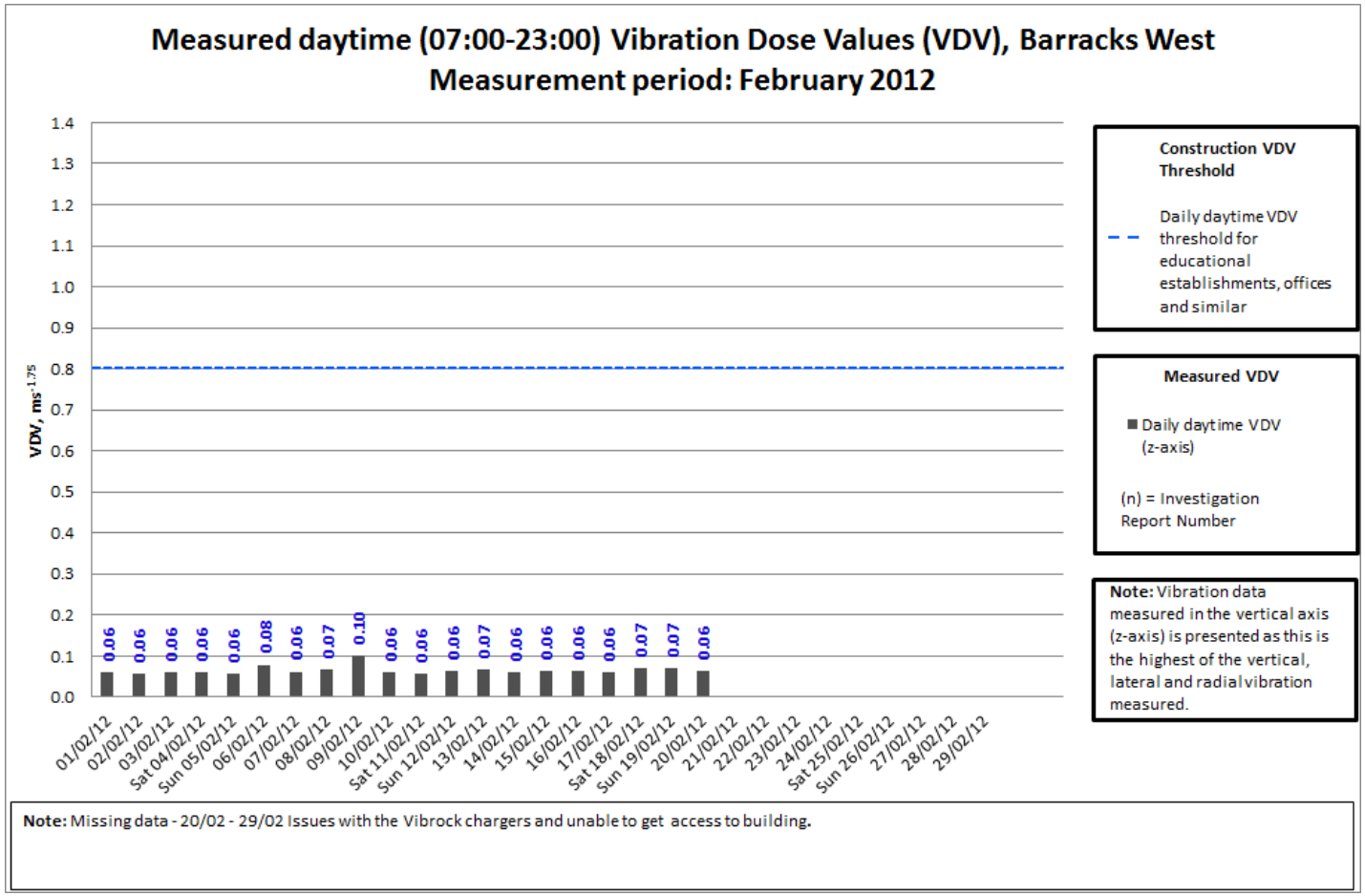
Night-time VDV at Barracks East – February 2012



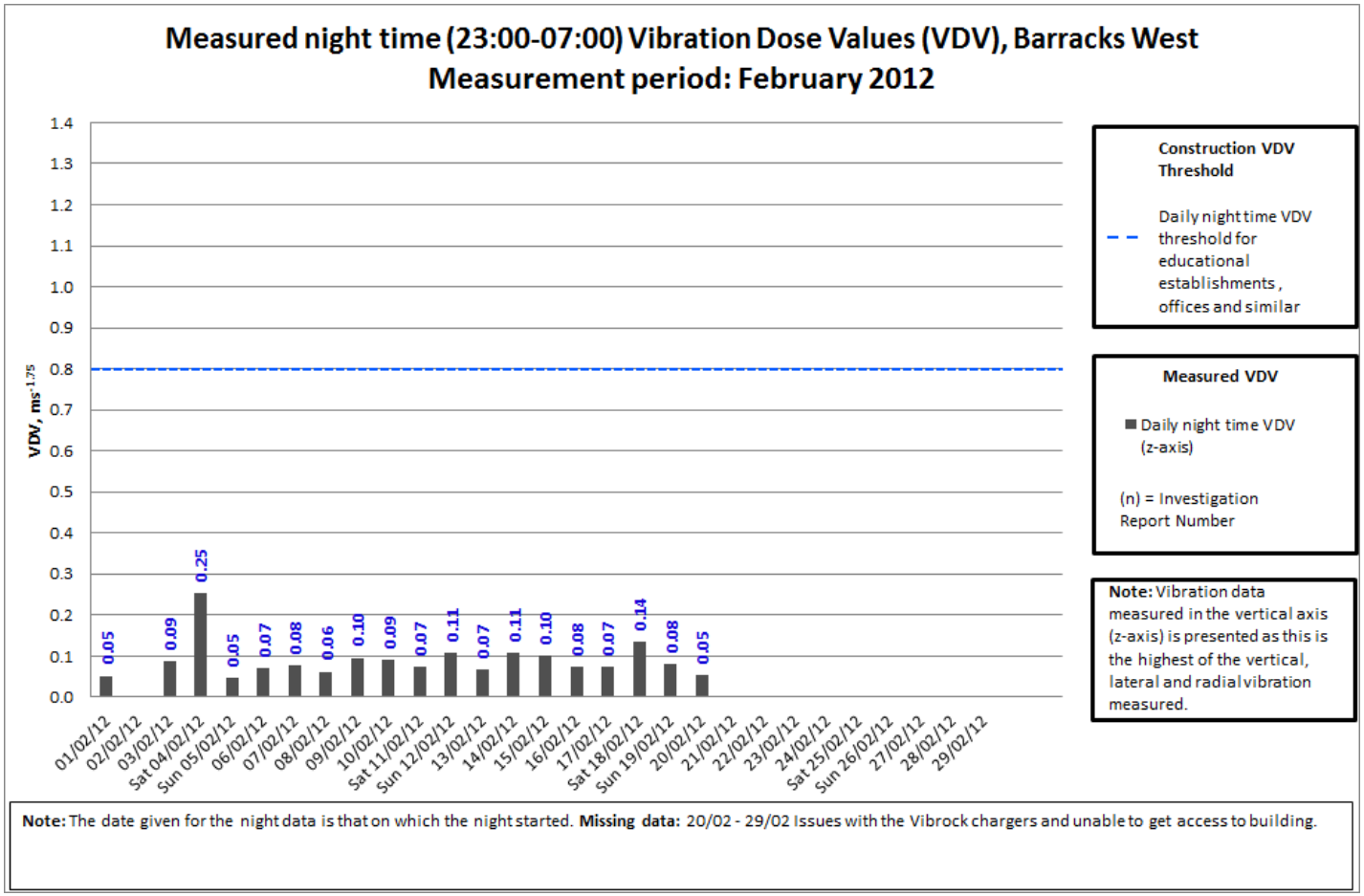
PPV at Barracks West – February 2012



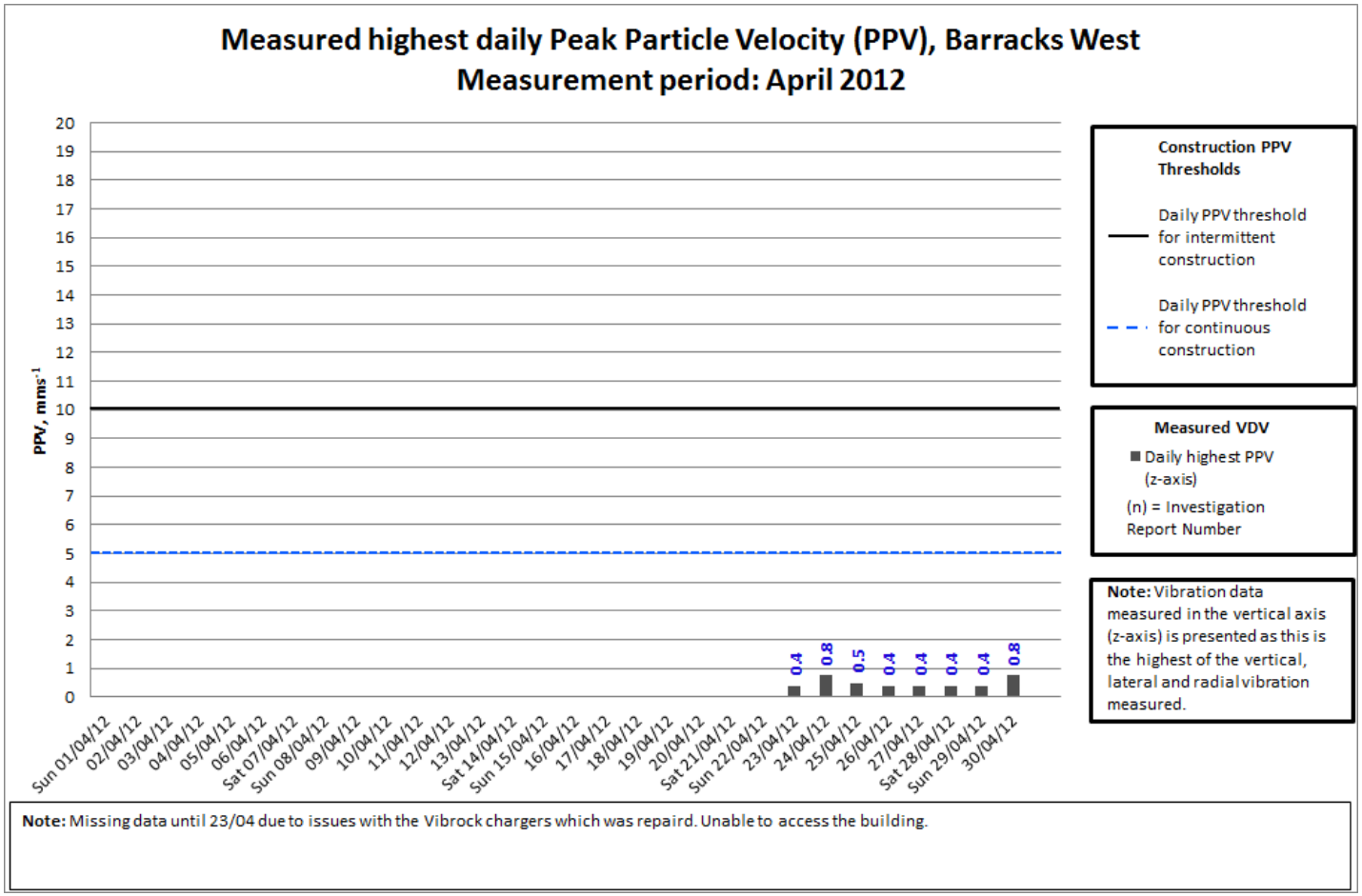
Daytime VDV at Barracks West – February 2012



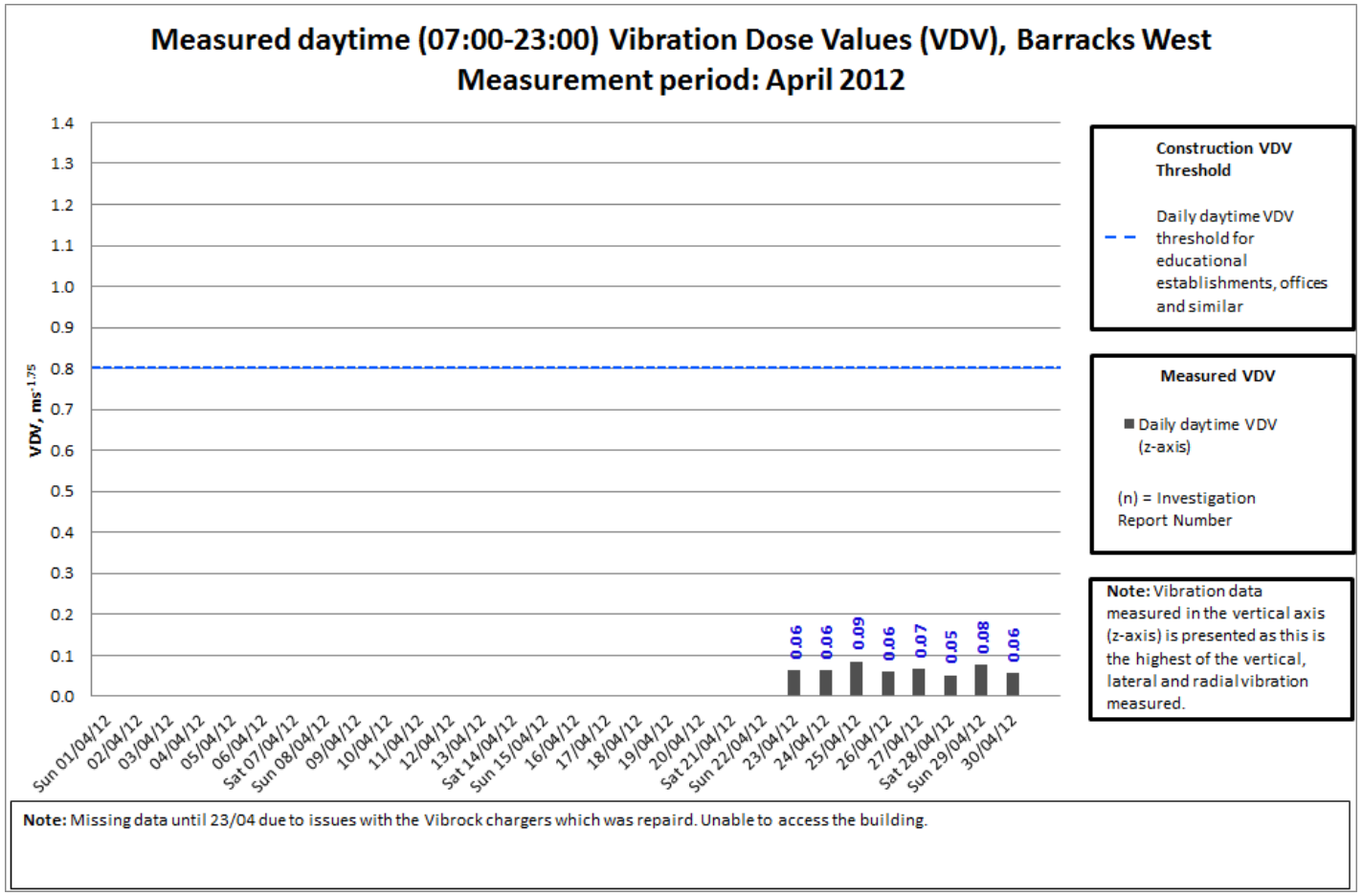
Night-time VDV at Barracks West – February 2012



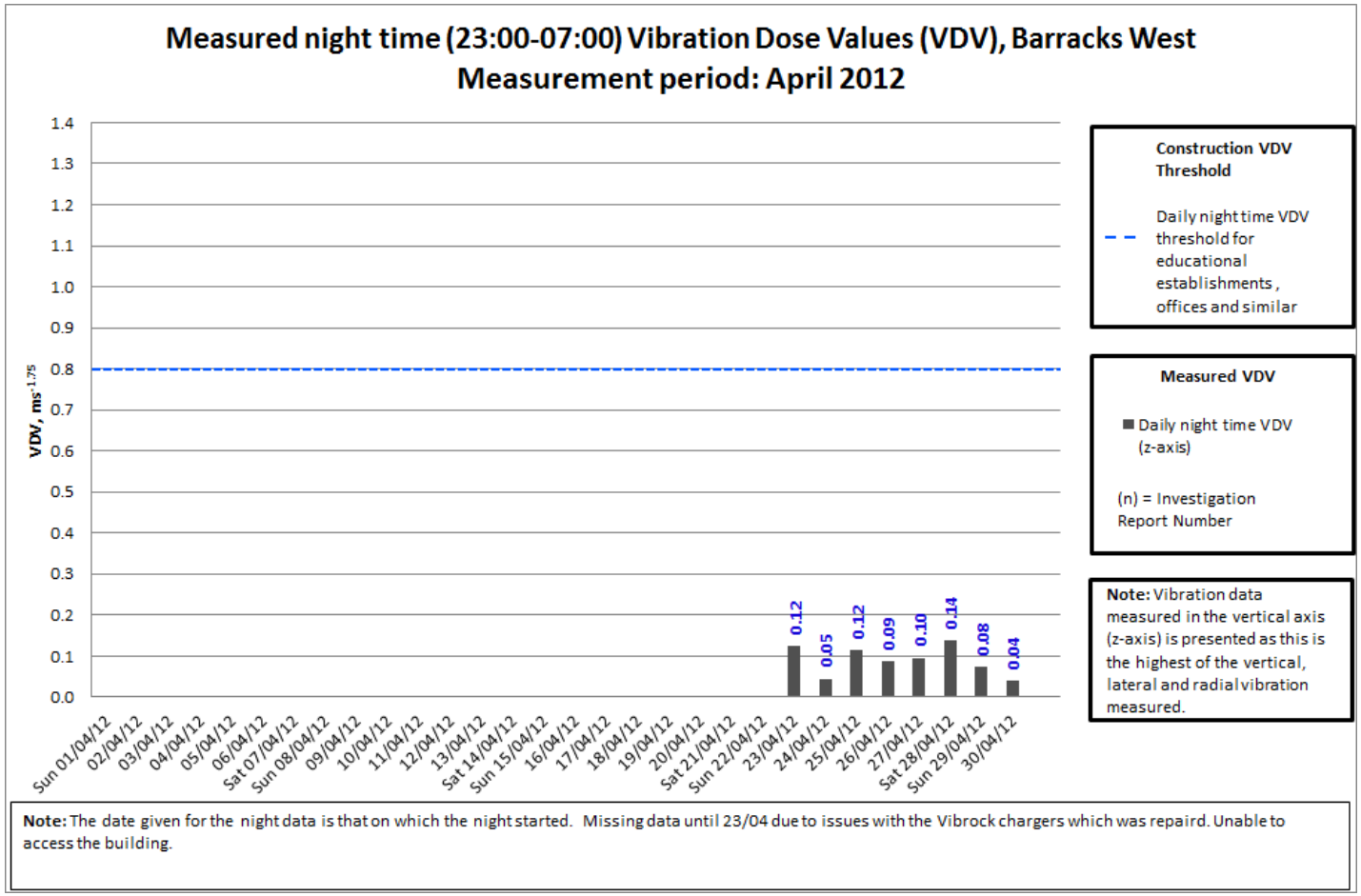
PPV at Barracks West – April 2012



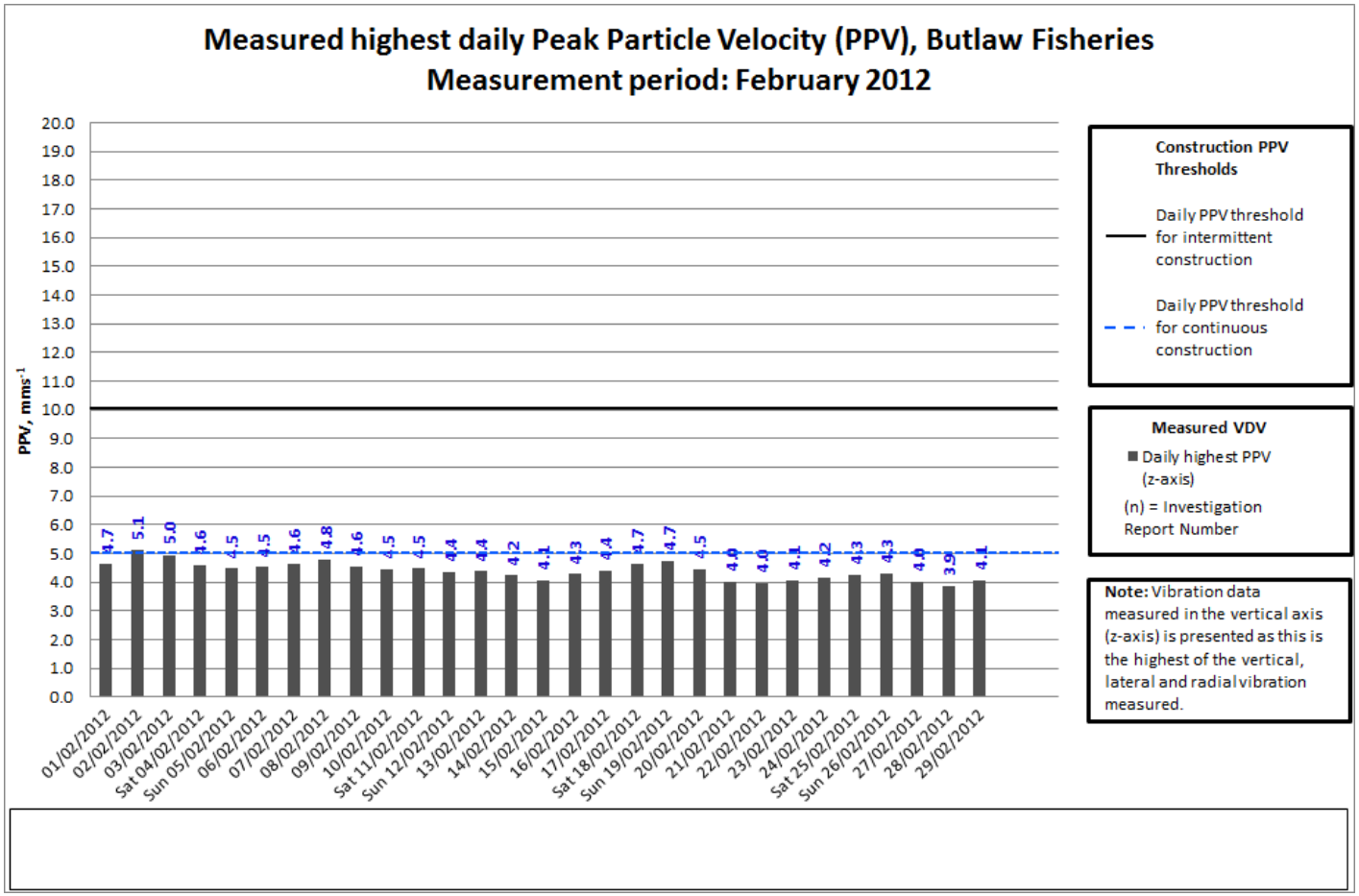
Daytime VDV at Barracks West – April 2012



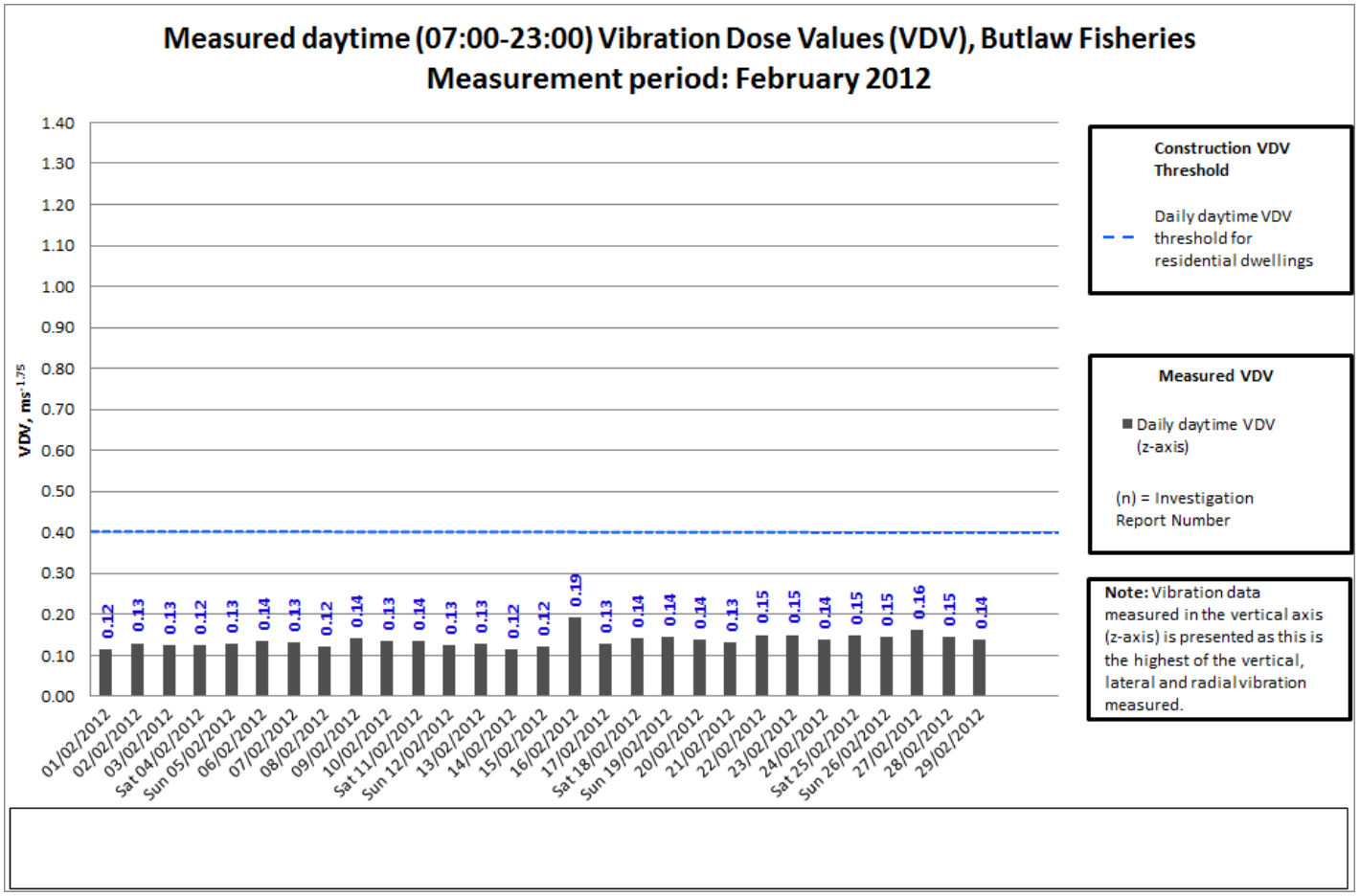
Night-time VDV at Barracks West – April 2012



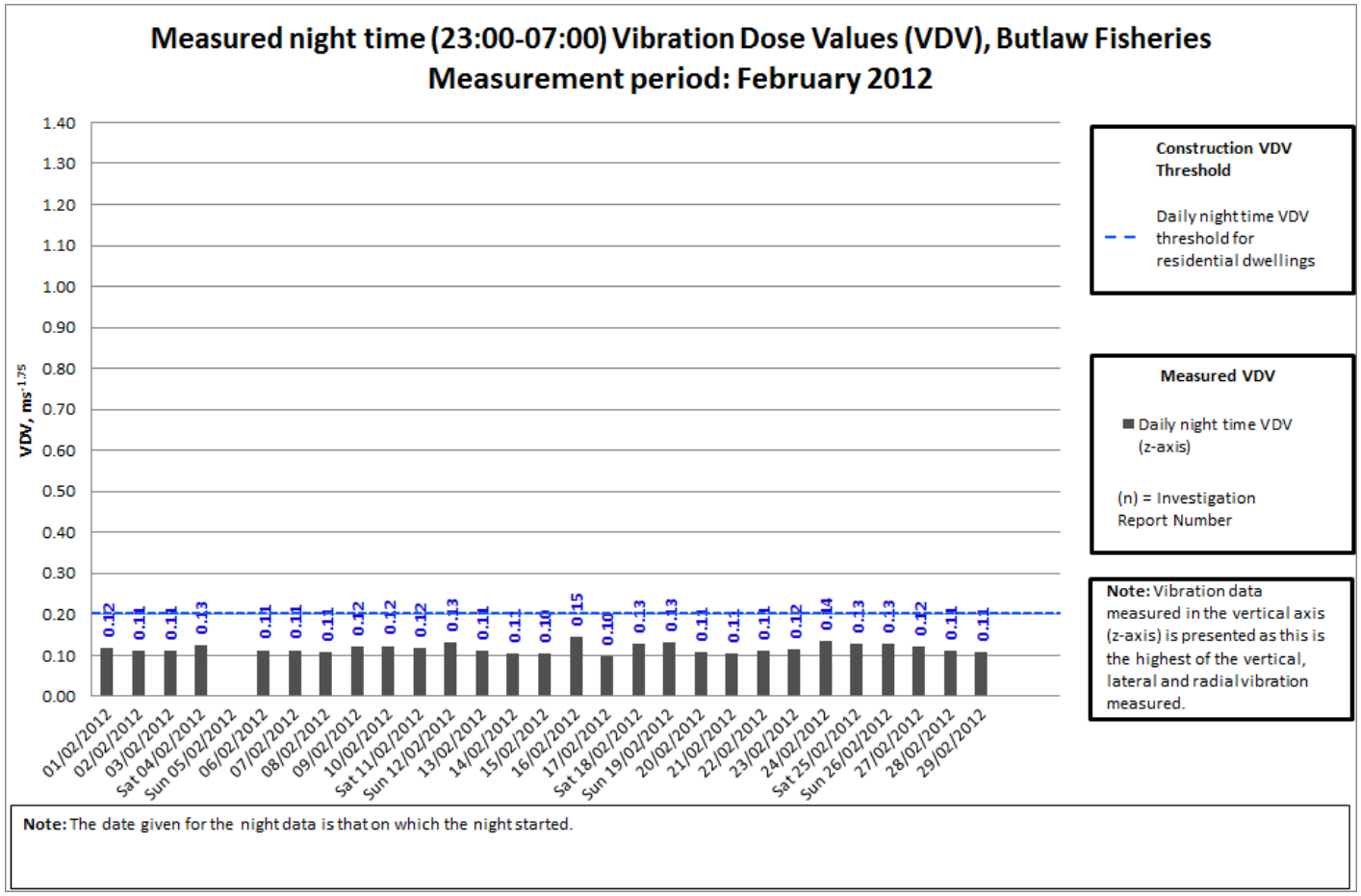
PPV at Butlaw Fisheries – February 2012



Daytime VDV at Butlaw Fisheries – February 2012

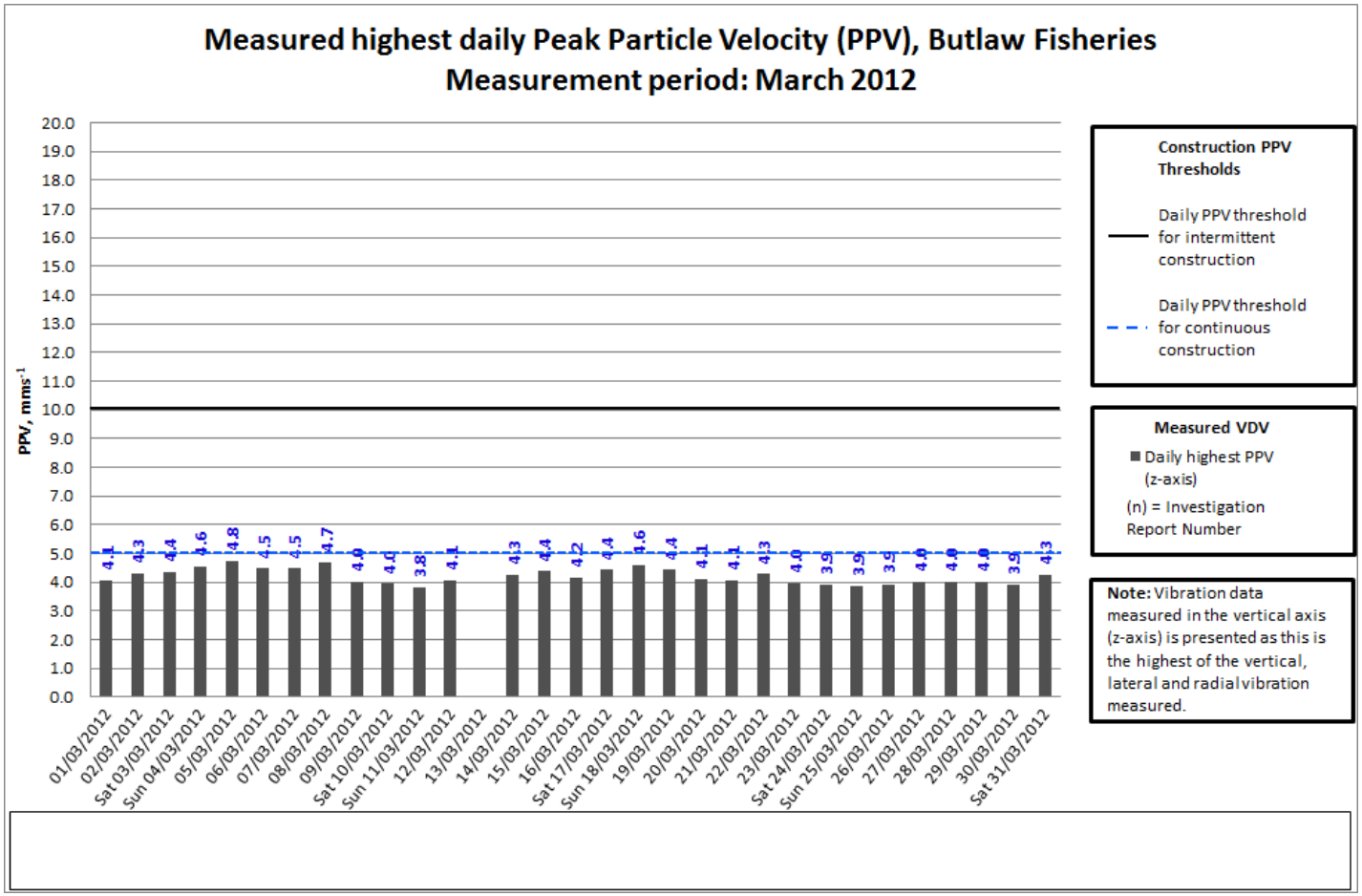


Night-time VDV at Butlaw Fisheries – February 2012

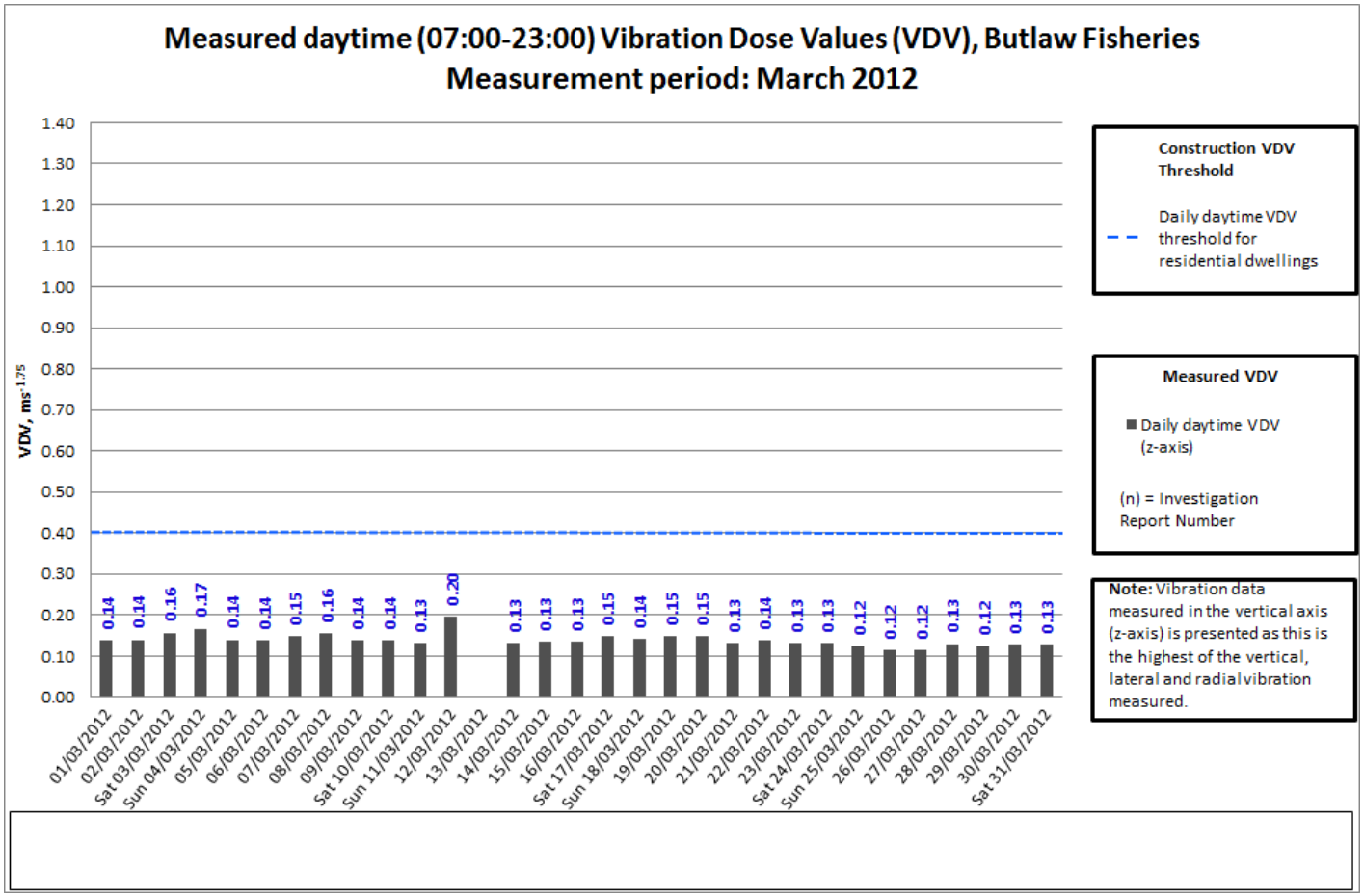


Forth Crossing Bridge Constructors
HOCHTIEF Solutions
American Bridge International
DRAGADOS
Morrison Construction

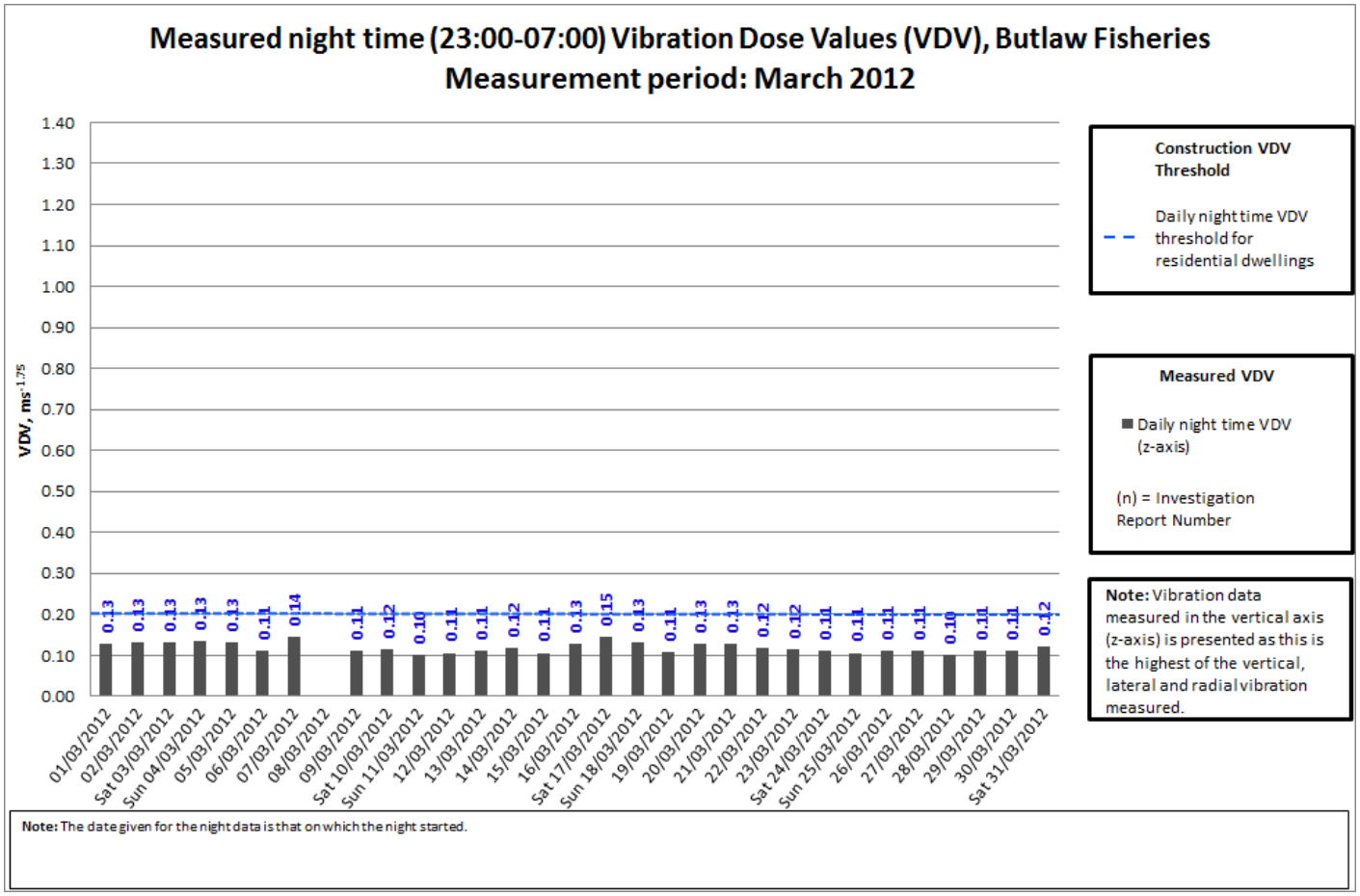
PPV at Butlaw Fisheries – March 2012



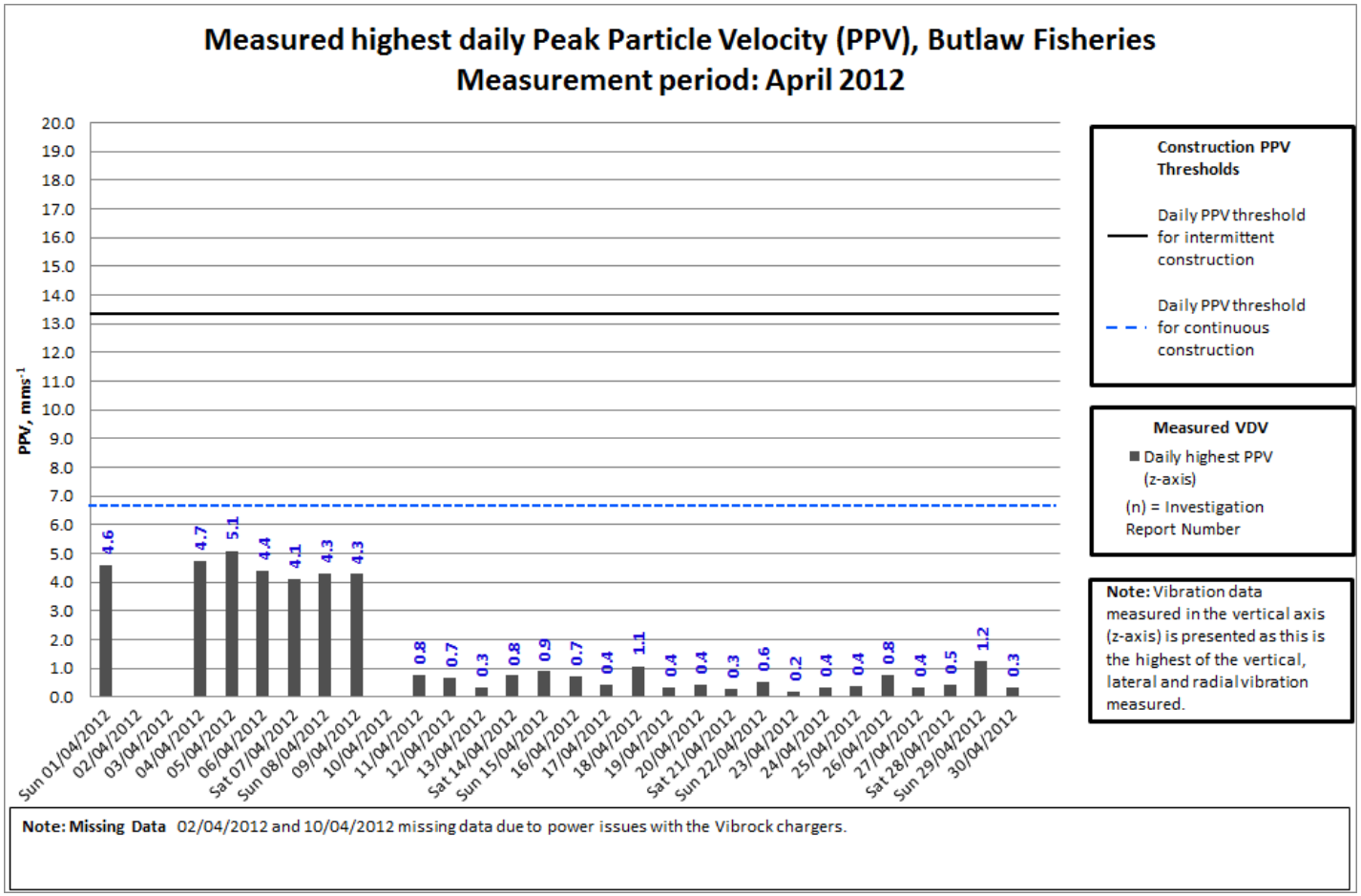
Daytime VDV at Butlaw Fisheries – March 2012



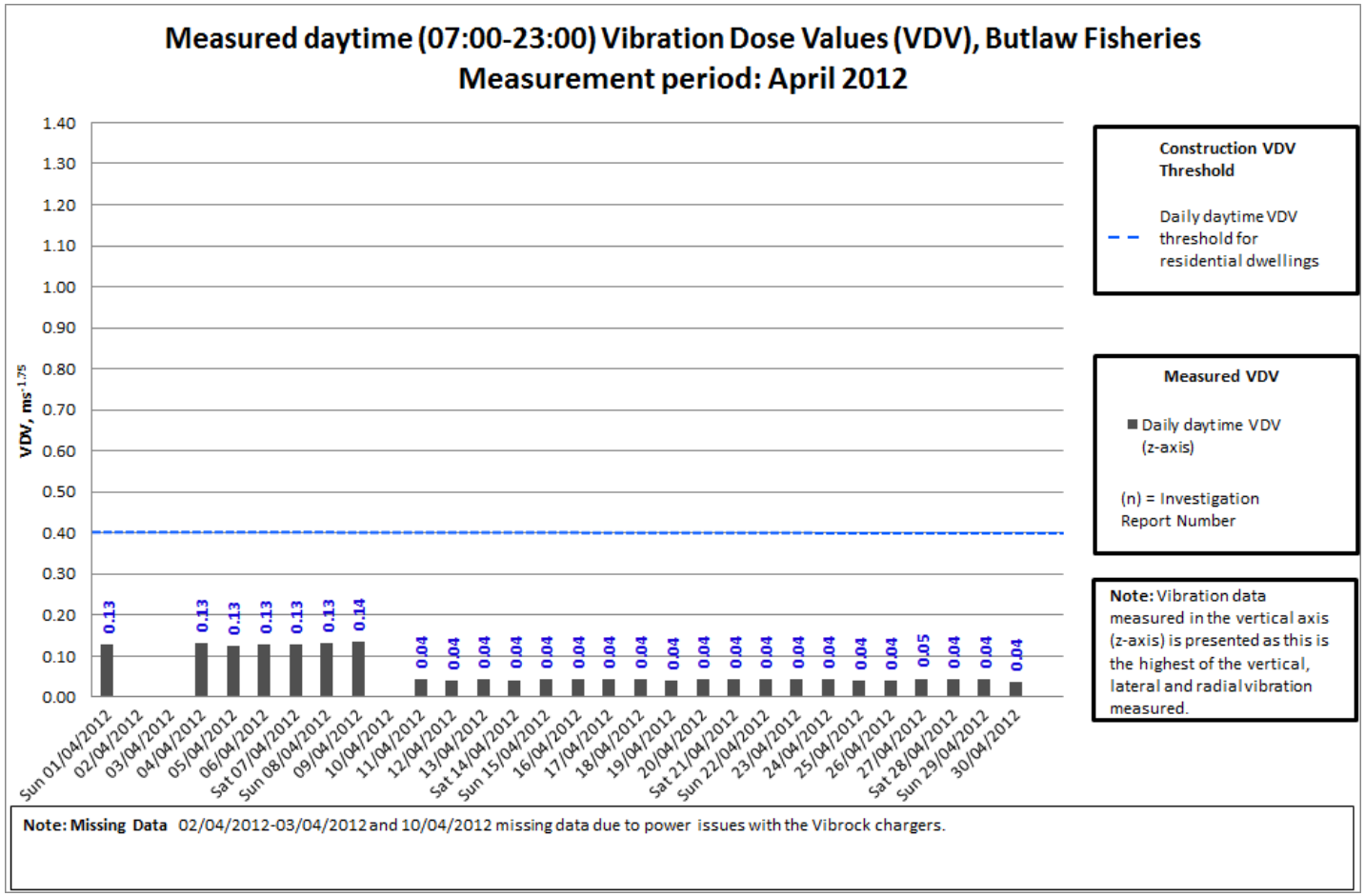
Night-time VDV at Butlaw Fisheries – March 2012



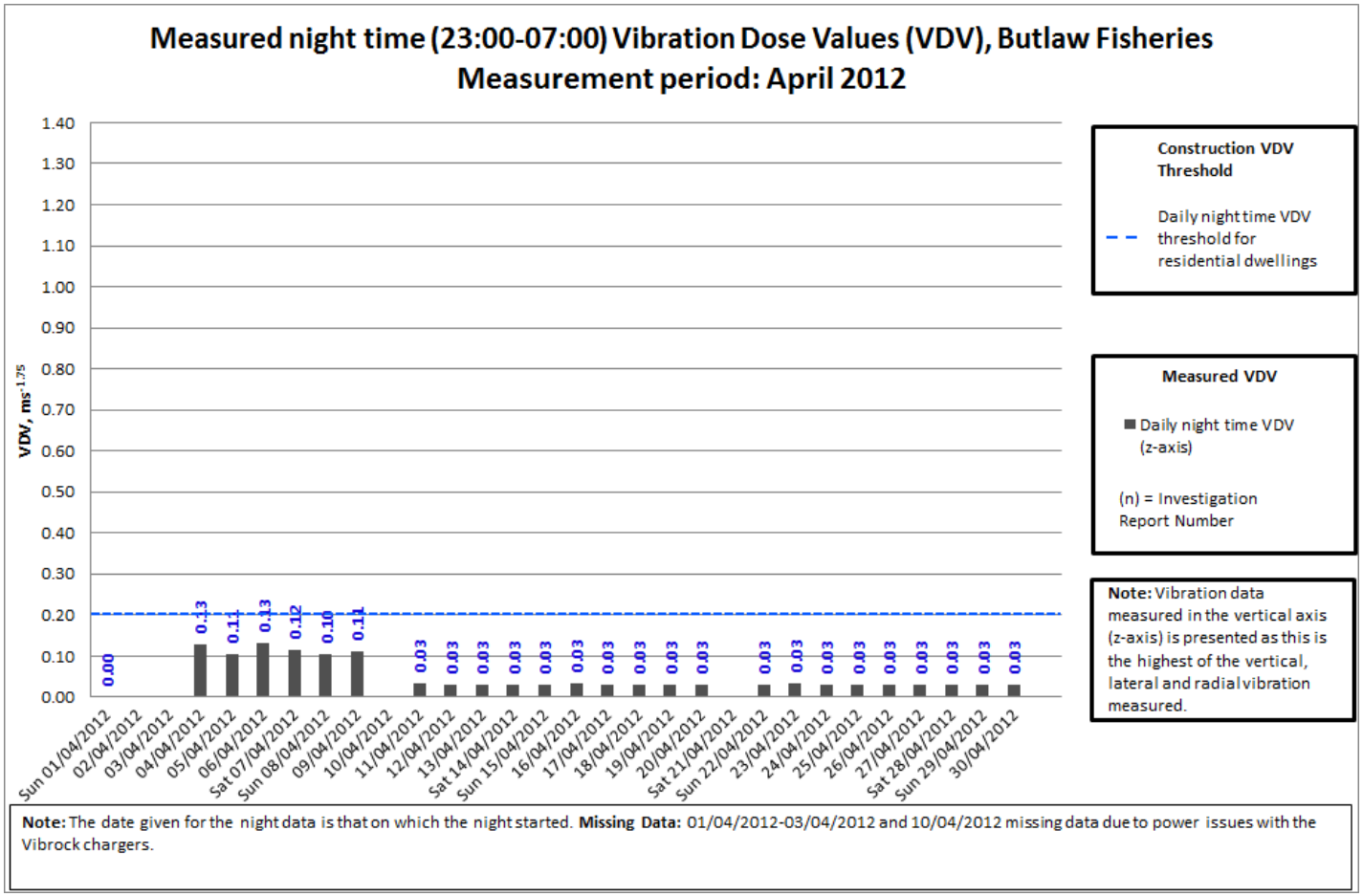
PPV at Butlaw Fisheries – April 2012



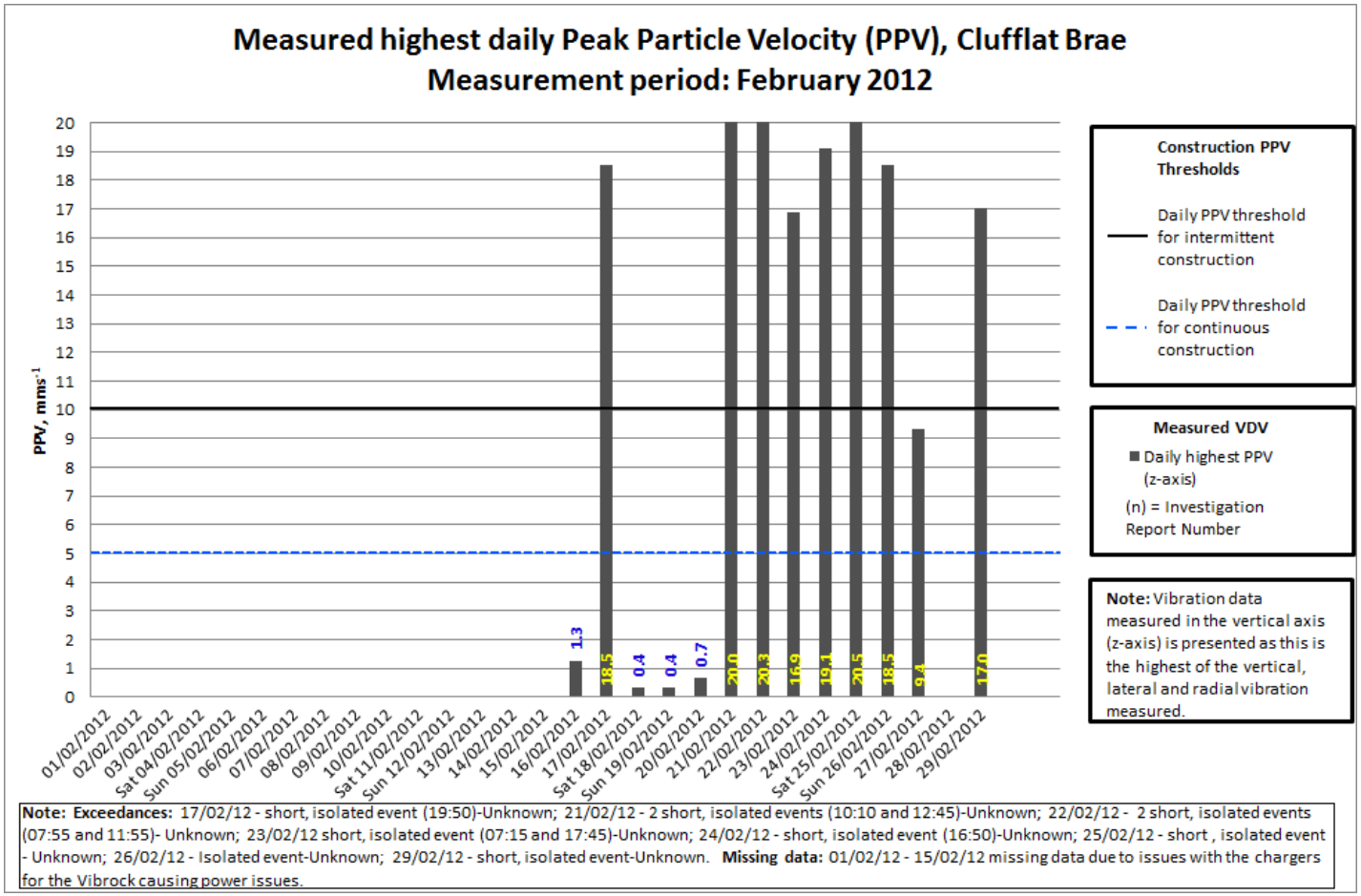
Daytime VDV at Butlaw Fisheries – April 2012



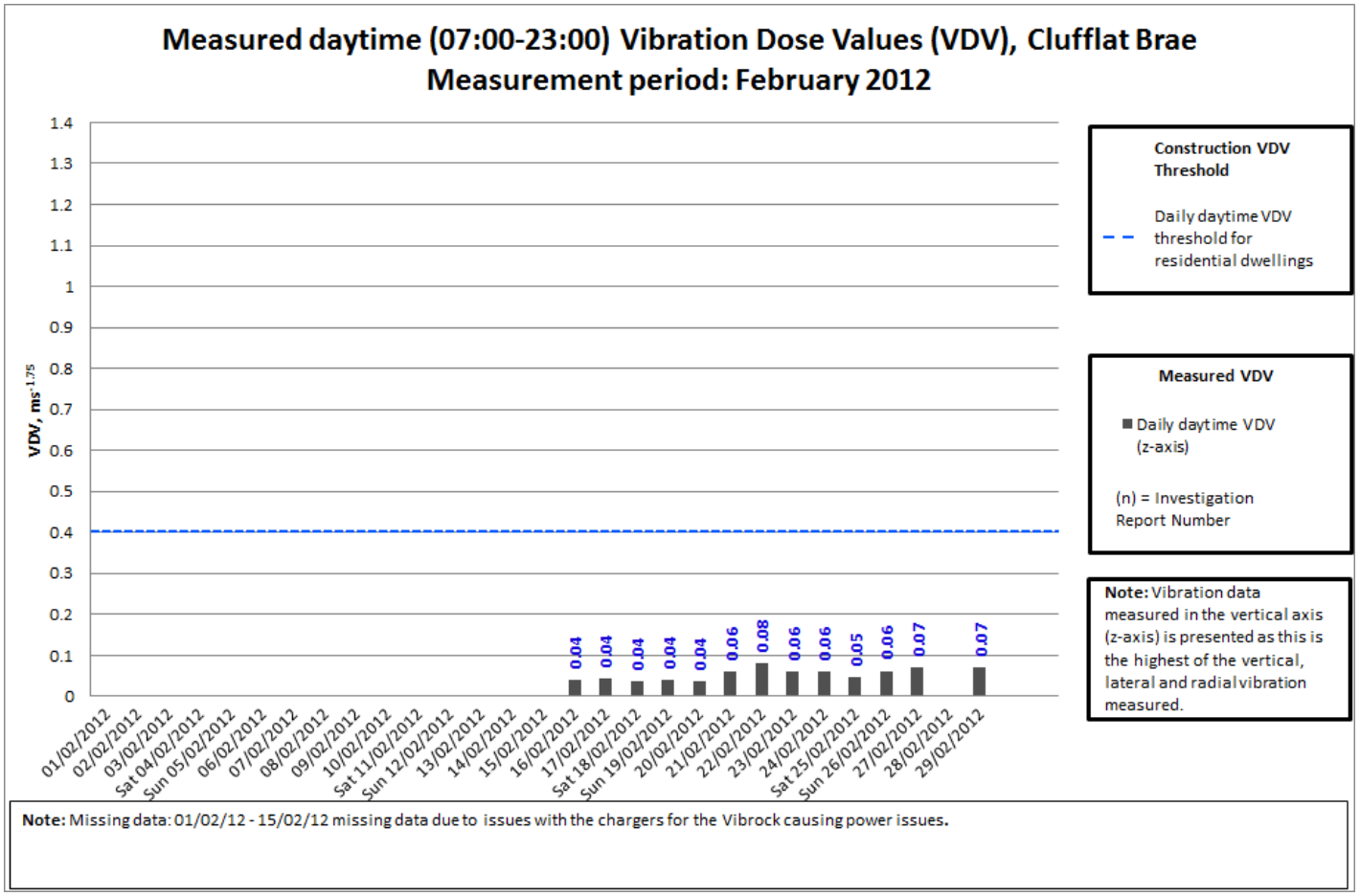
Night-time VDV at Butlaw Fisheries – April 2012



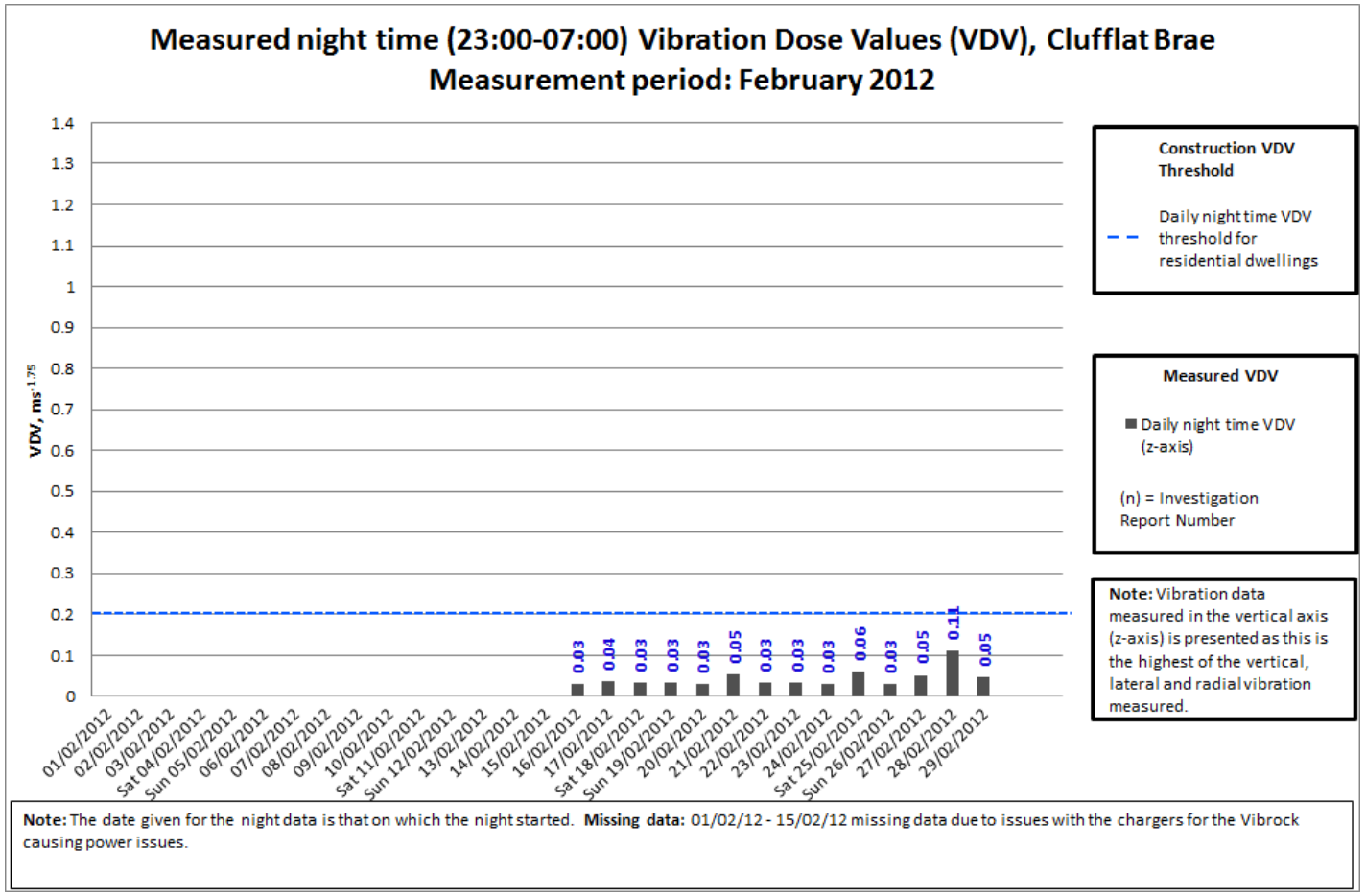
PPV at Cufflat Brae – February 2012



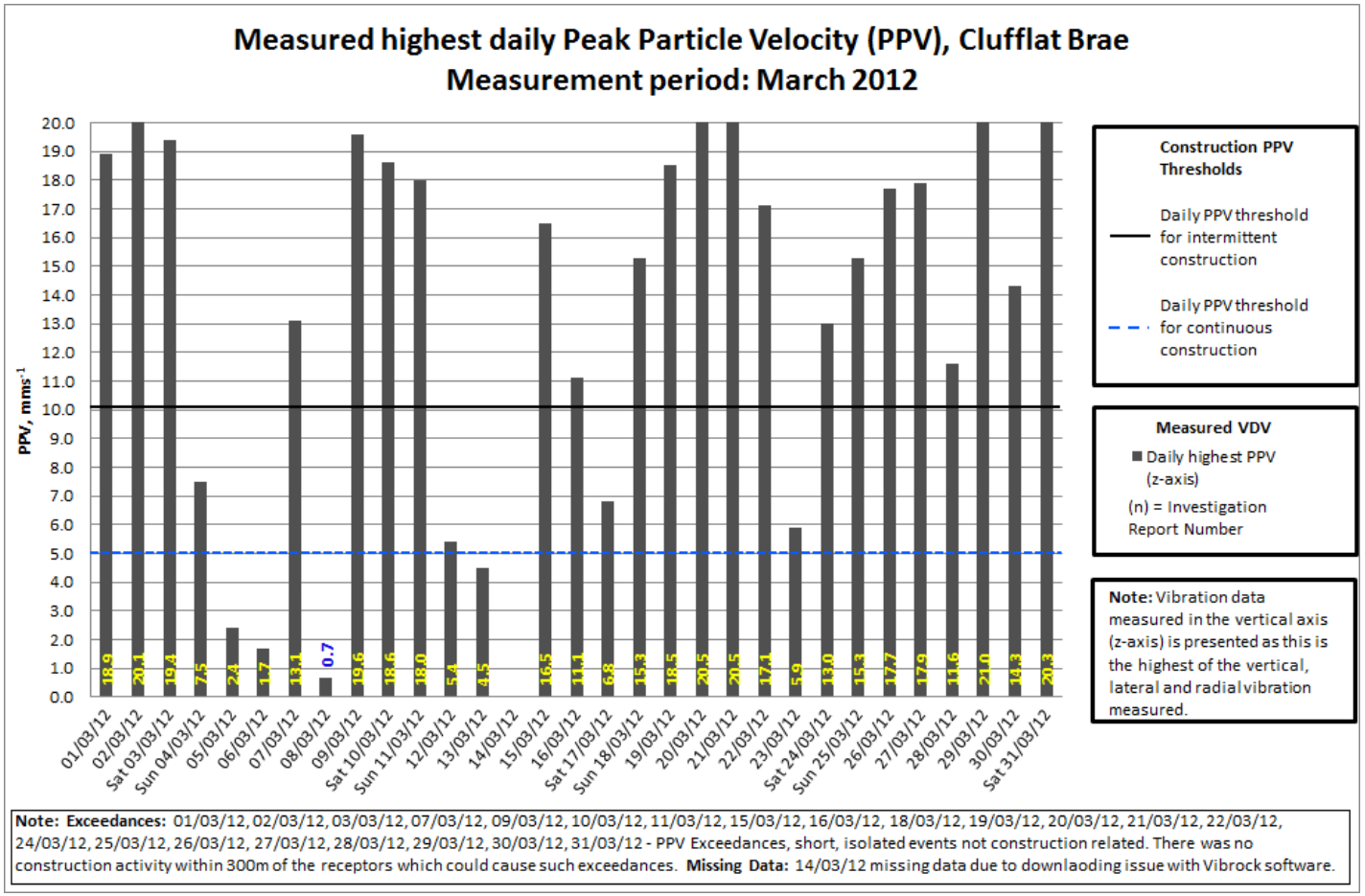
Daytime VDV at Cufflat Brae – February 2012



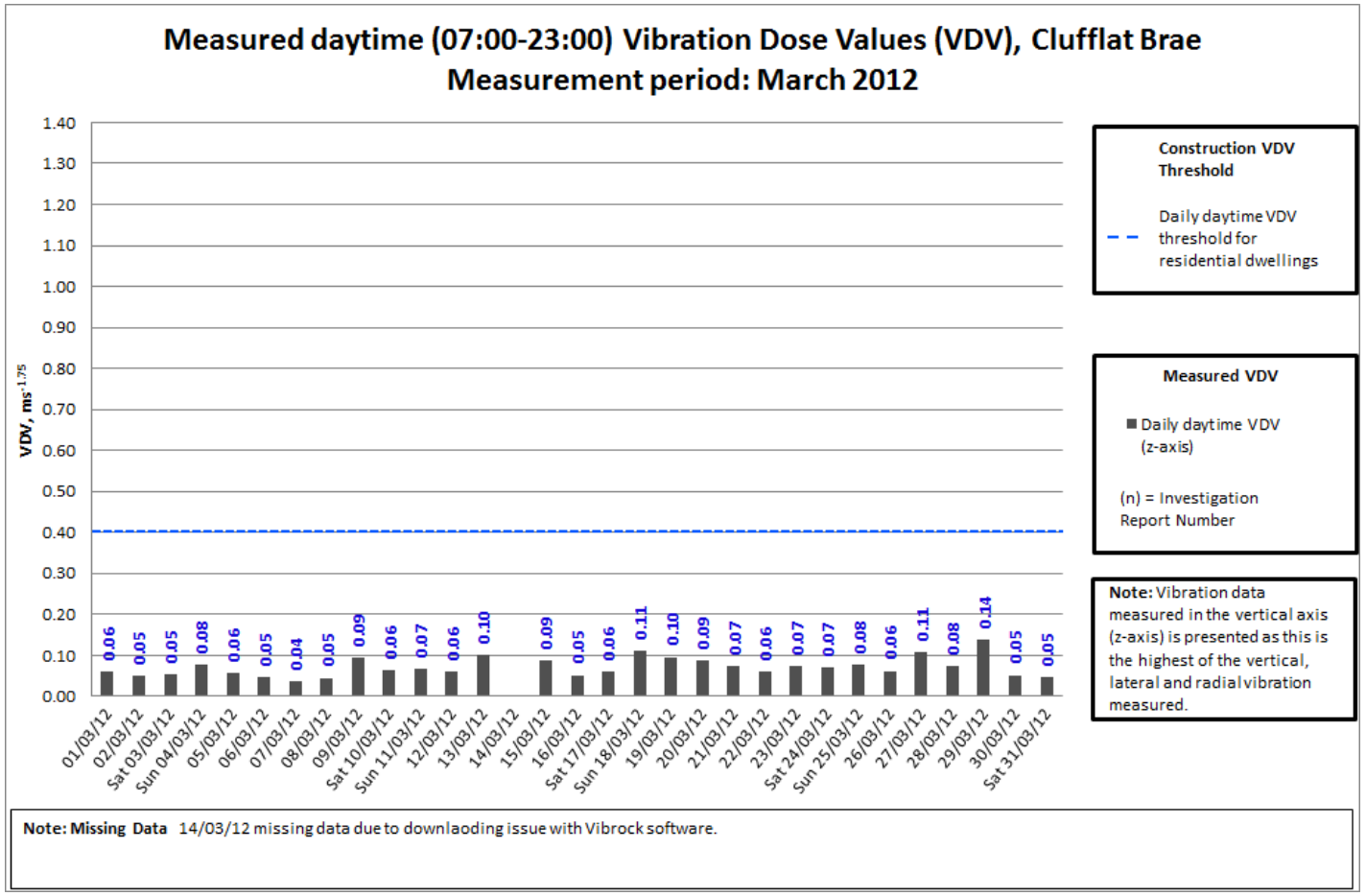
Night-time VDV at Cufflat Brae – February 2012



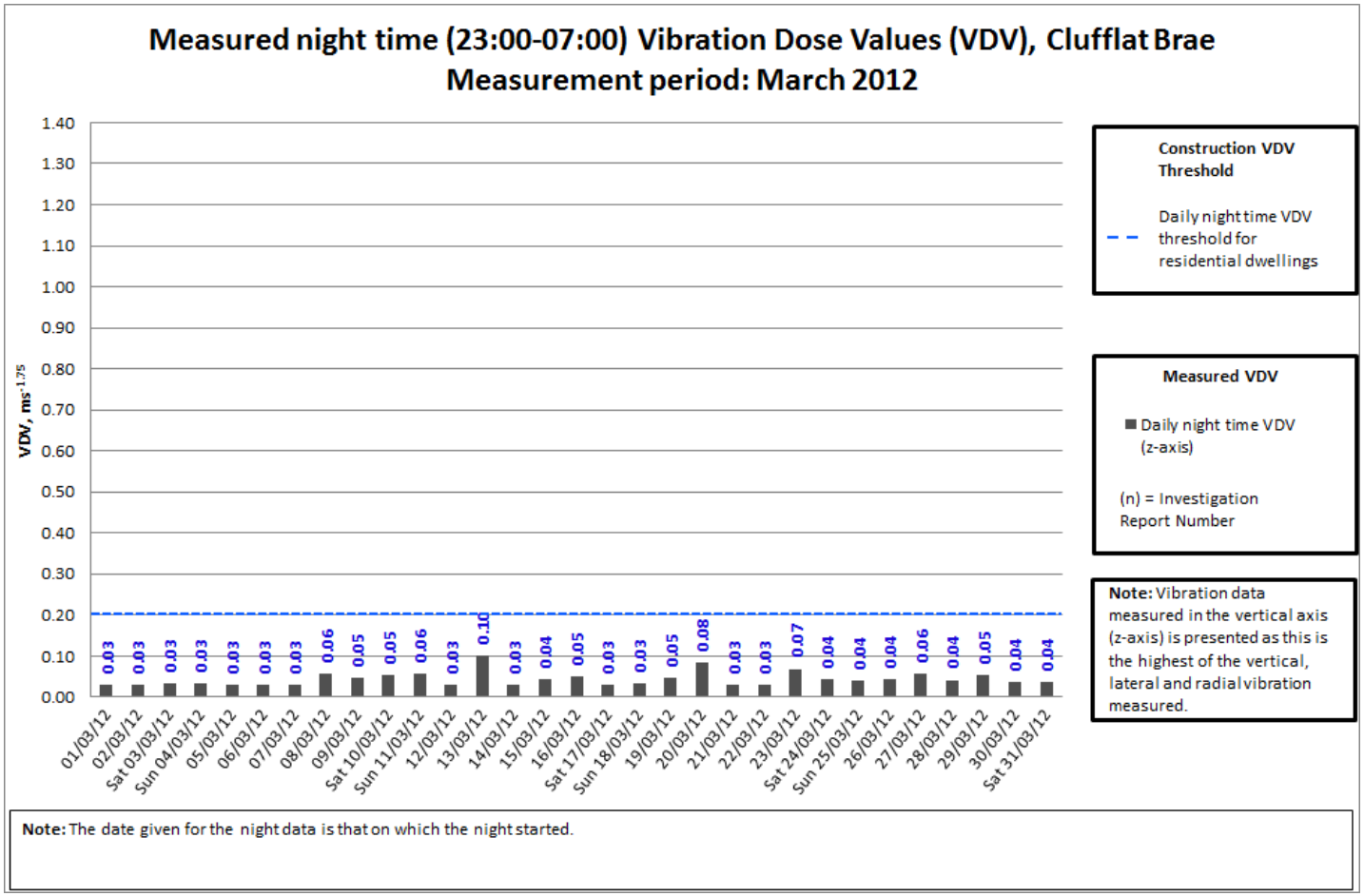
PPV at Cufflat Brae – March 2012



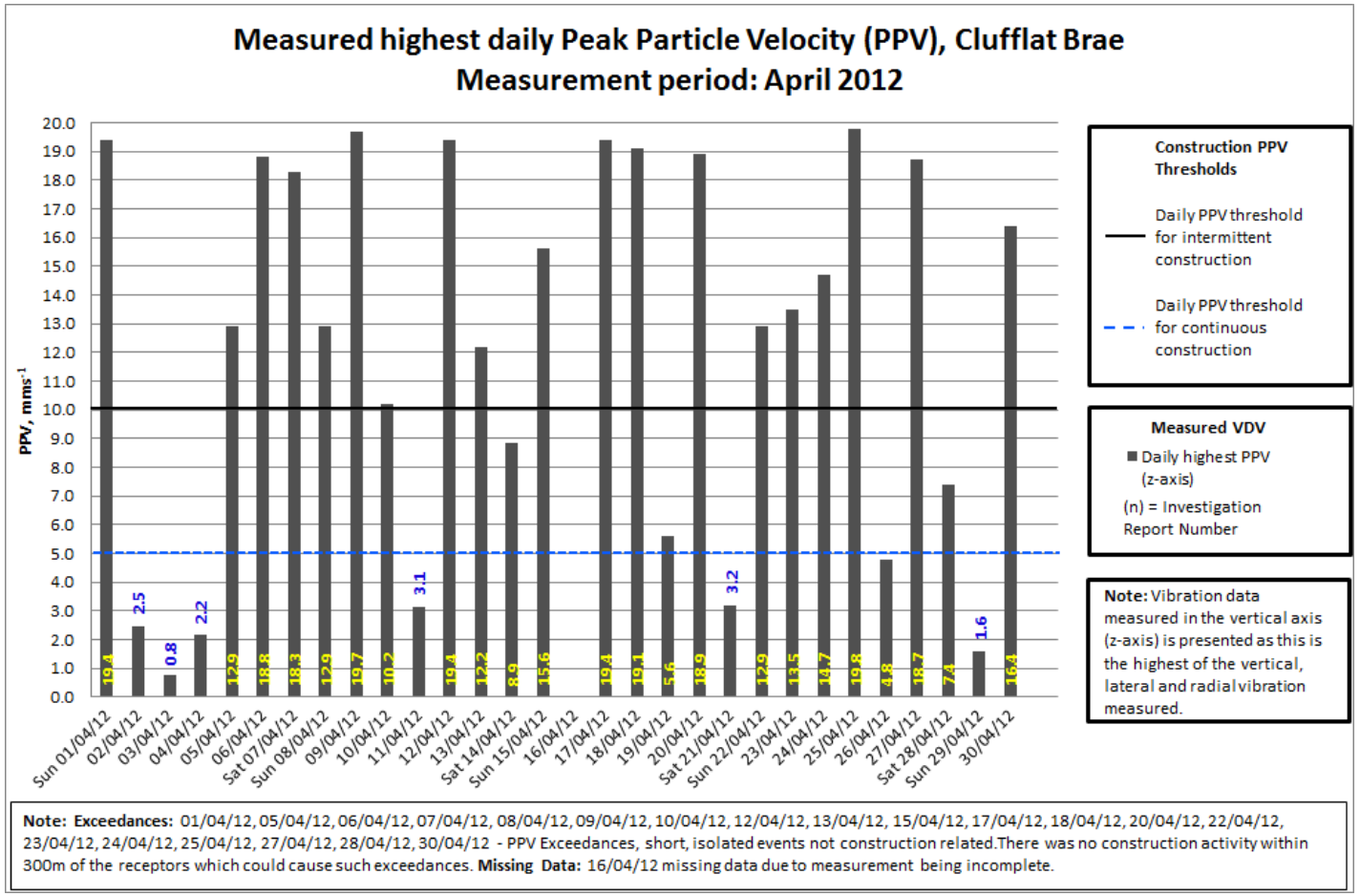
Daytime VDV at Cufflat Brae – March 2012



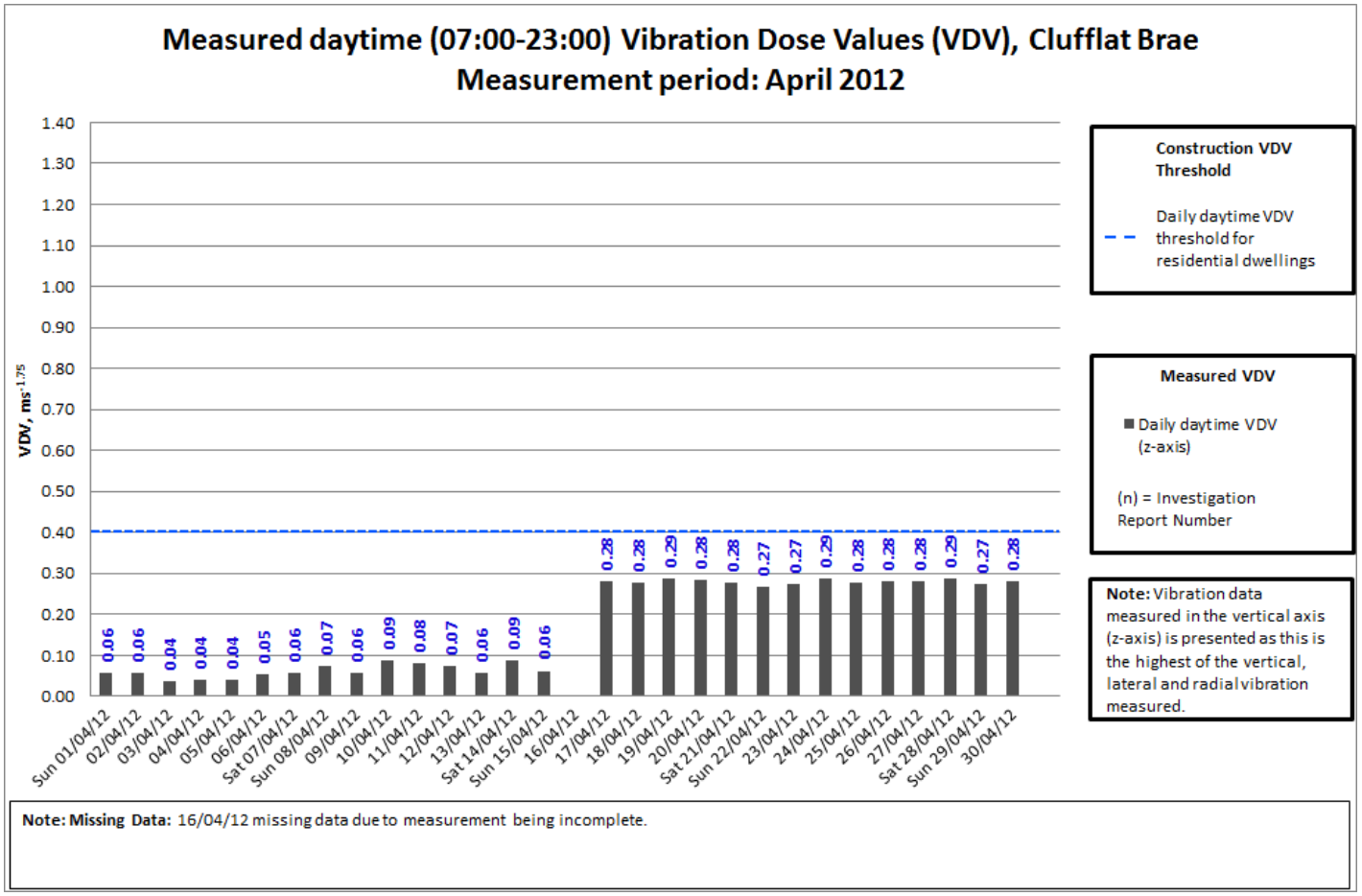
Night-time VDV at Cufflat Brae – March 2012



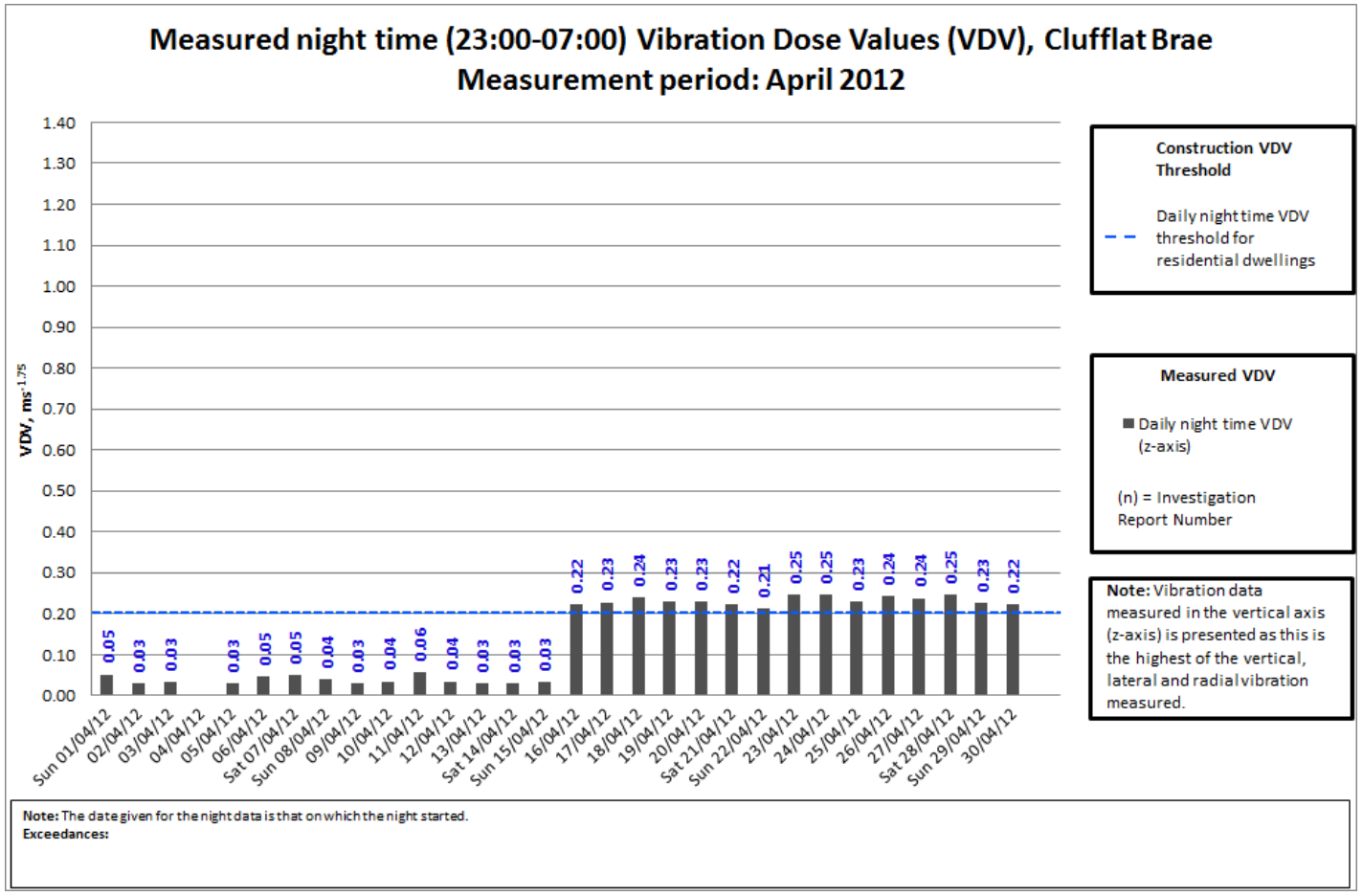
PPV at Cufflat Brae – April 2012



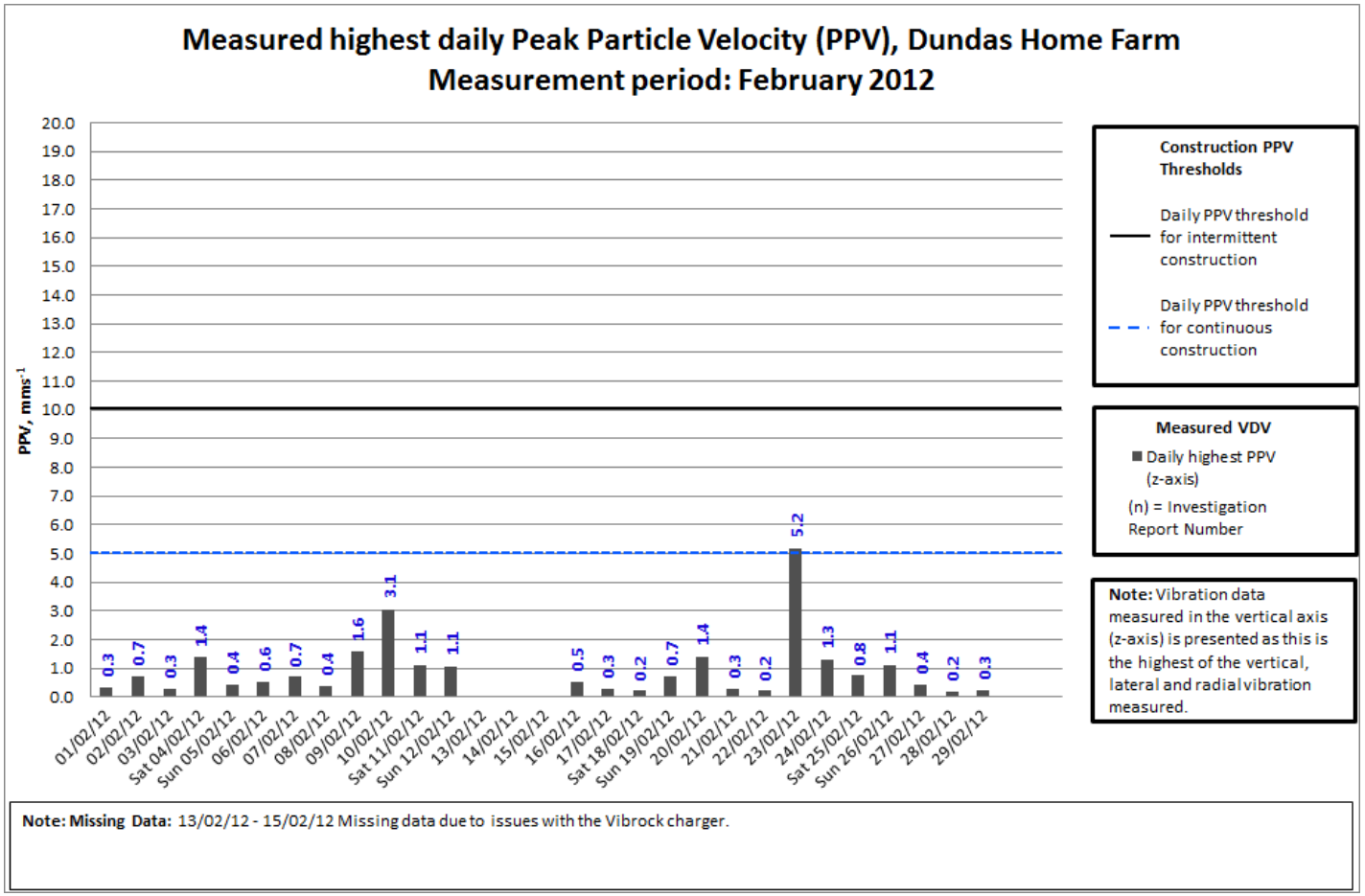
Daytime VDV at Cufflat Brae – April 2012



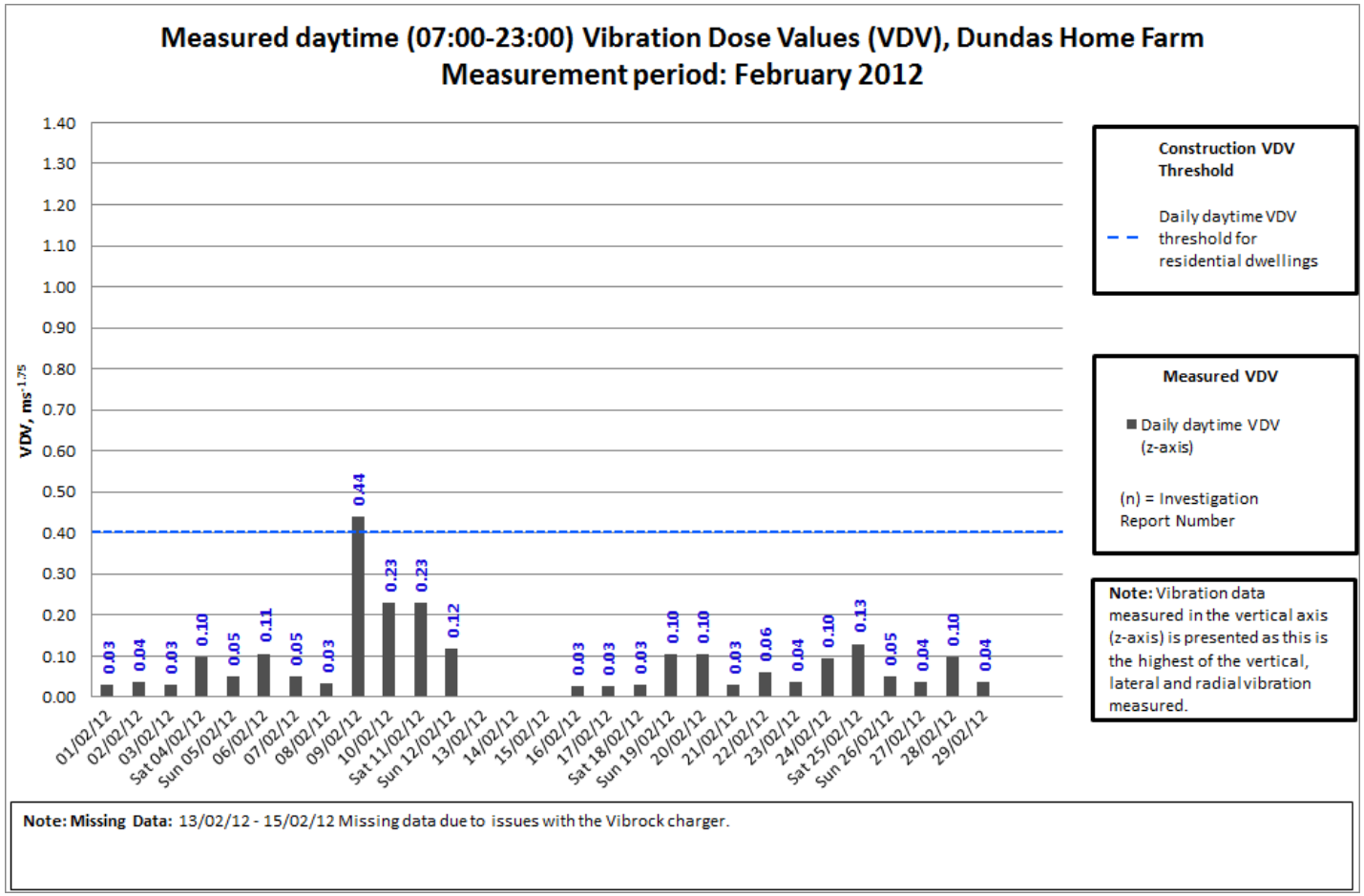
Night-time VDV at Cufflat Brae – April 2012



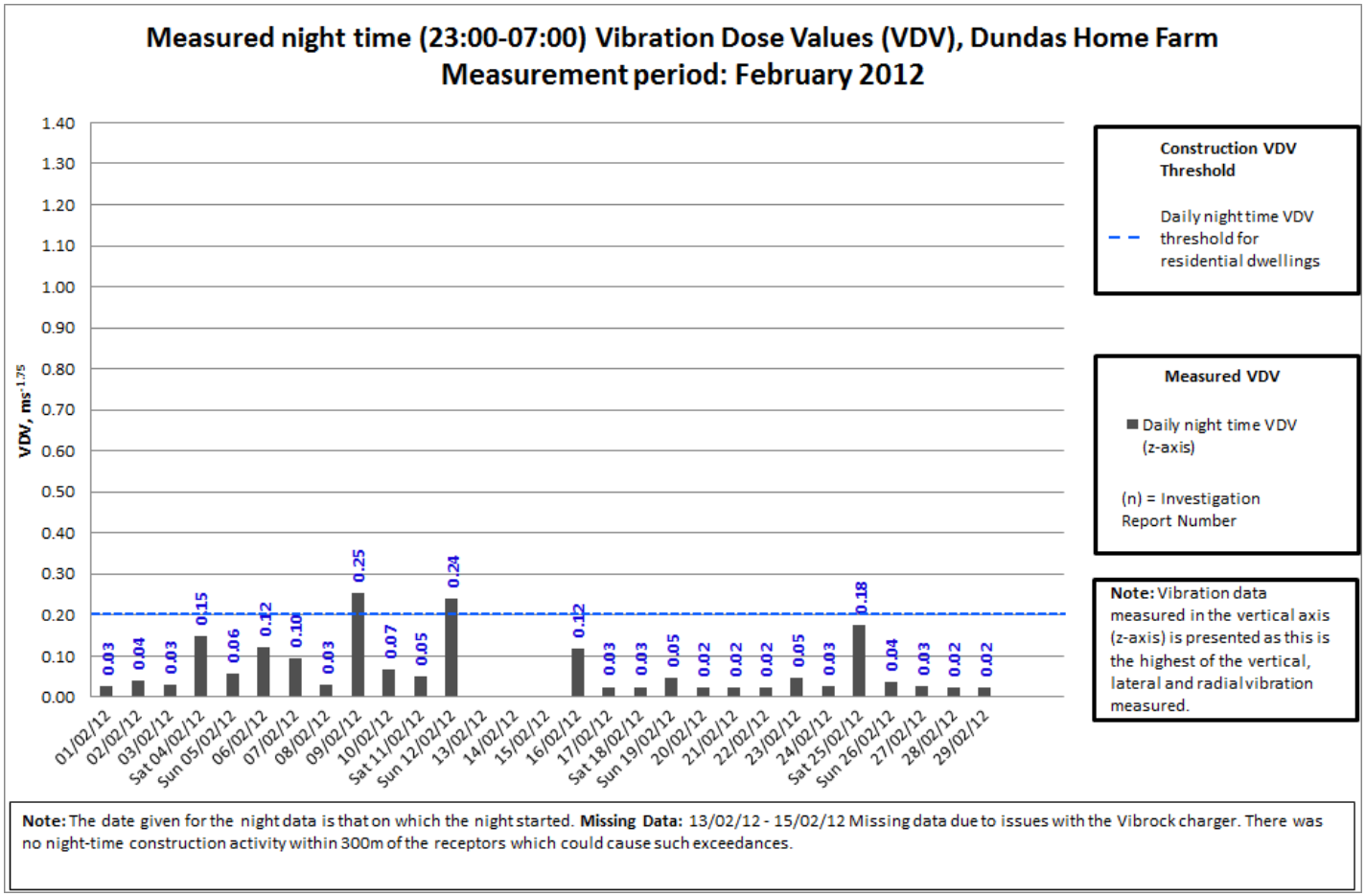
PPV at Dundas Home Farm – February 2012



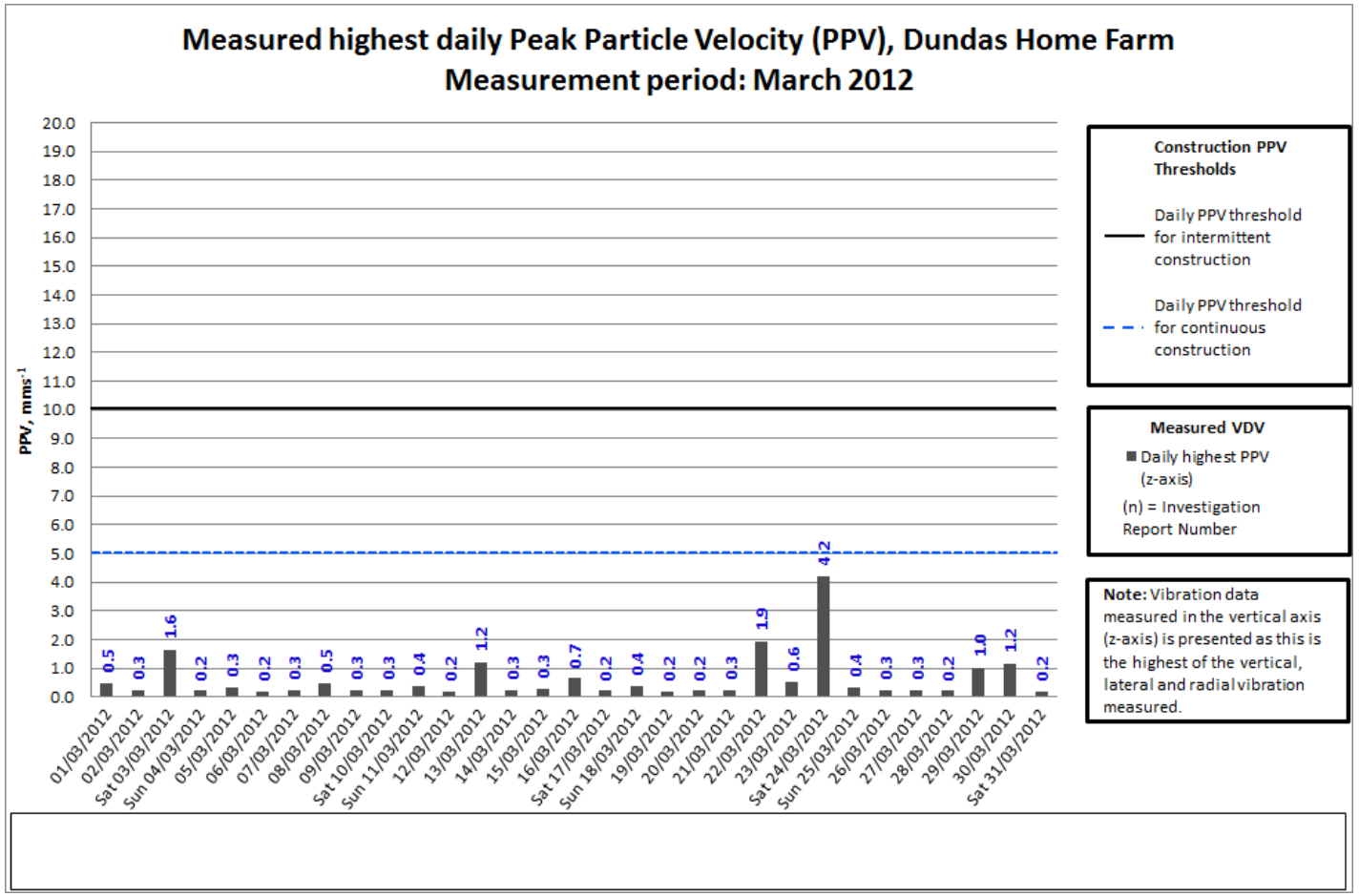
Daytime VDV at Dundas Home Farm – February 2012



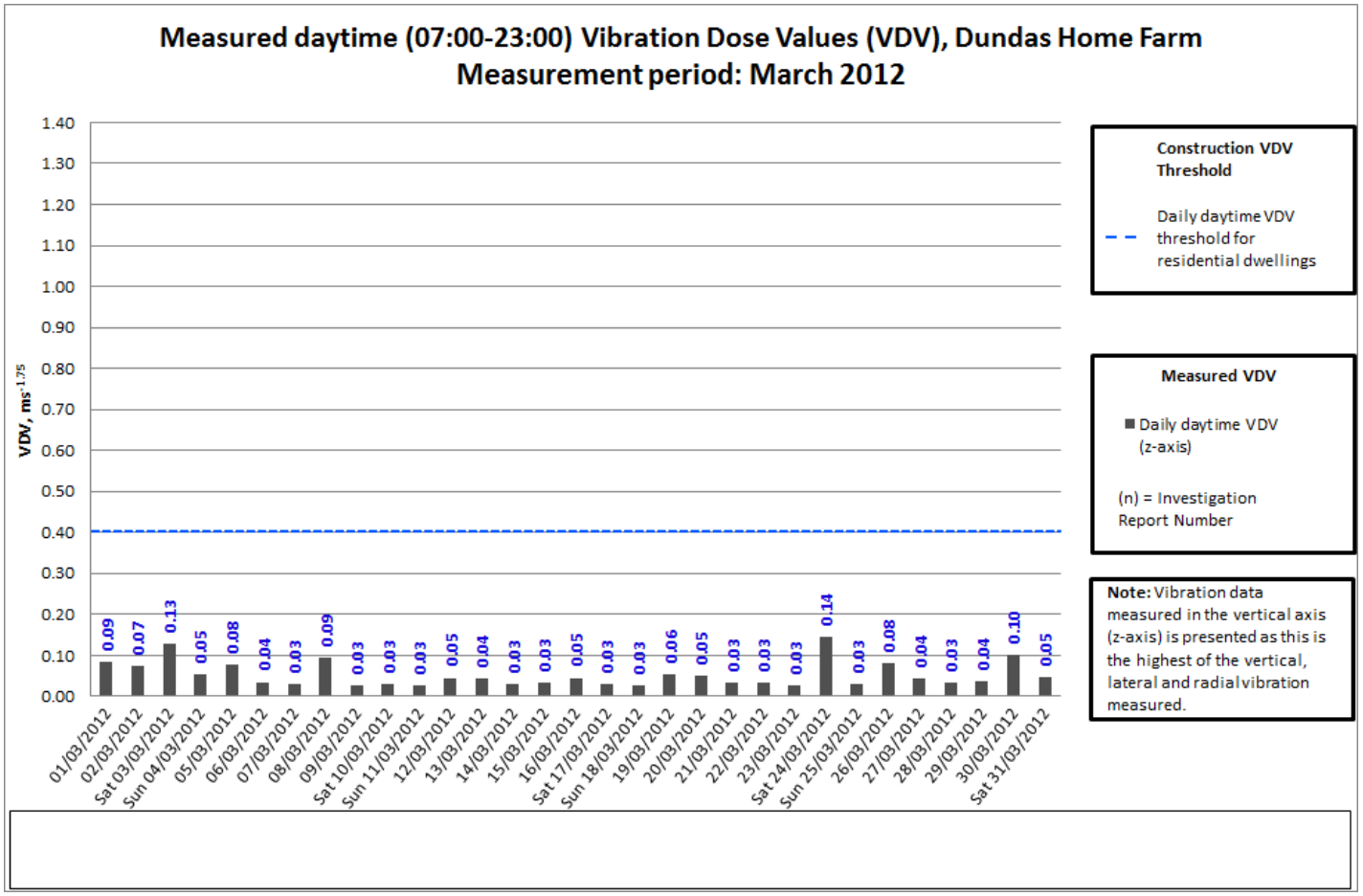
Night-time VDV at Dundas Home Farm – February 2012



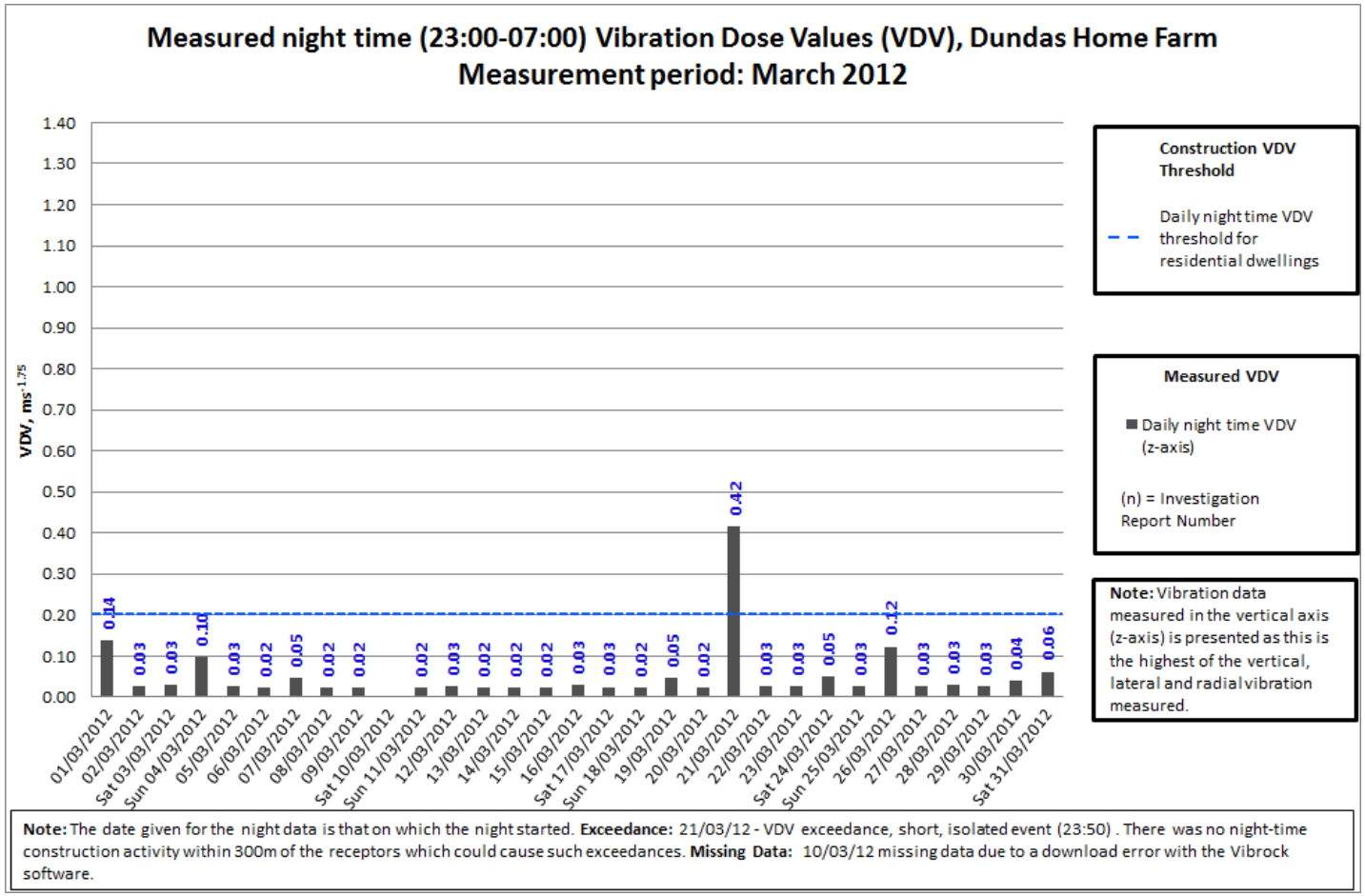
PPV at Dundas Home Farm – March 2012



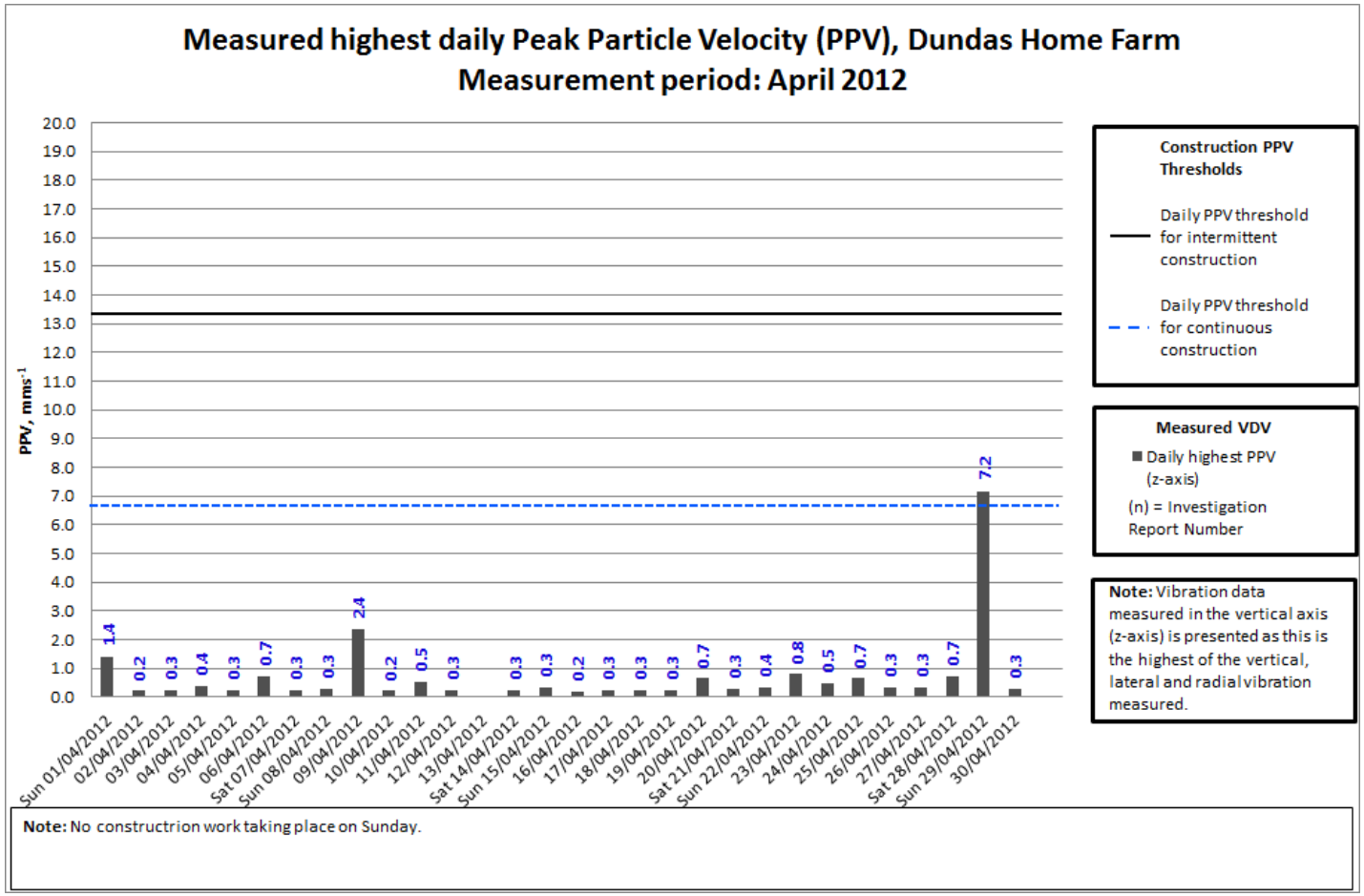
Daytime VDV at Dundas Home Farm – March 2012



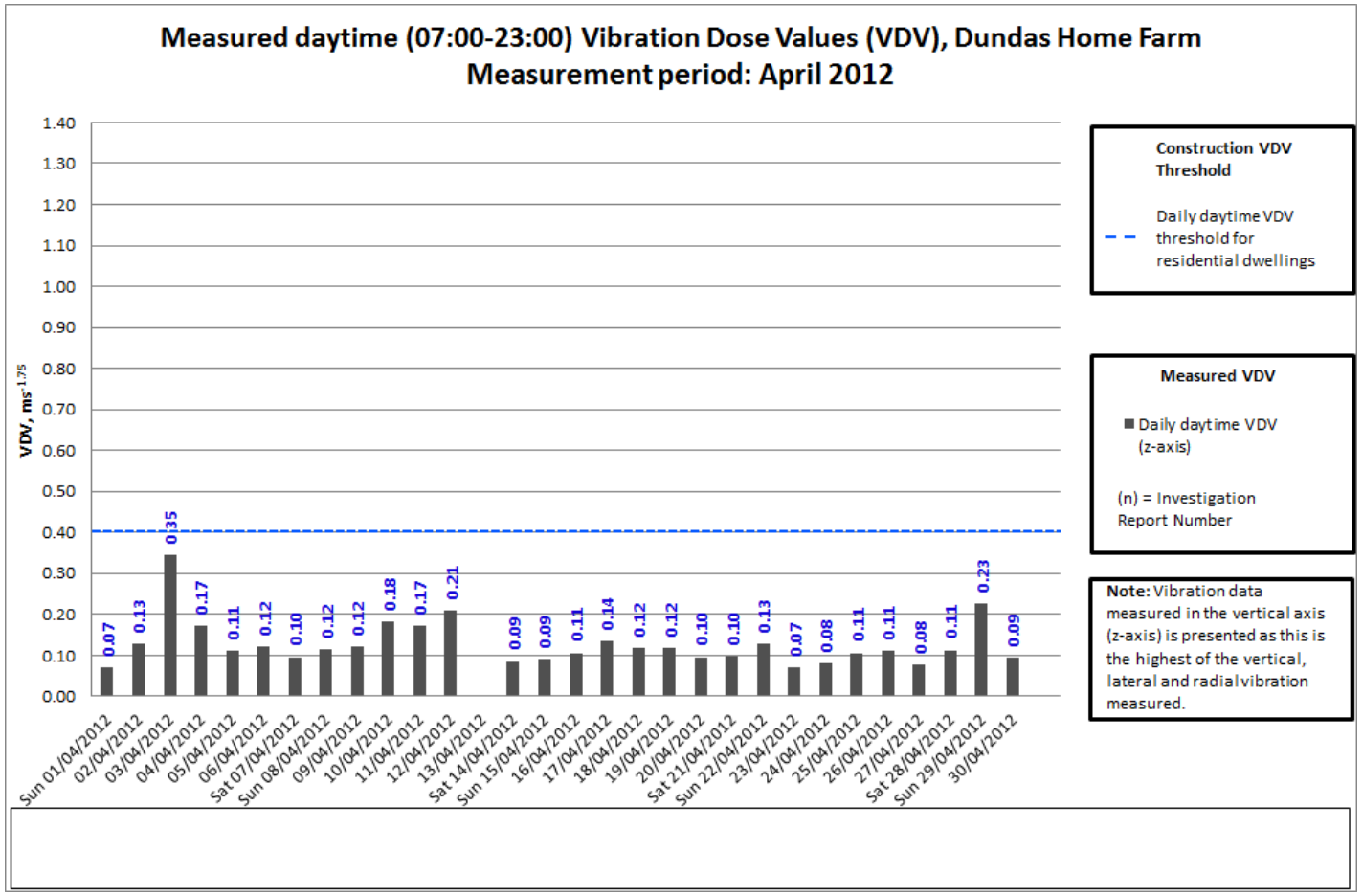
Night-time VDV at Dundas Home Farm – March 2012



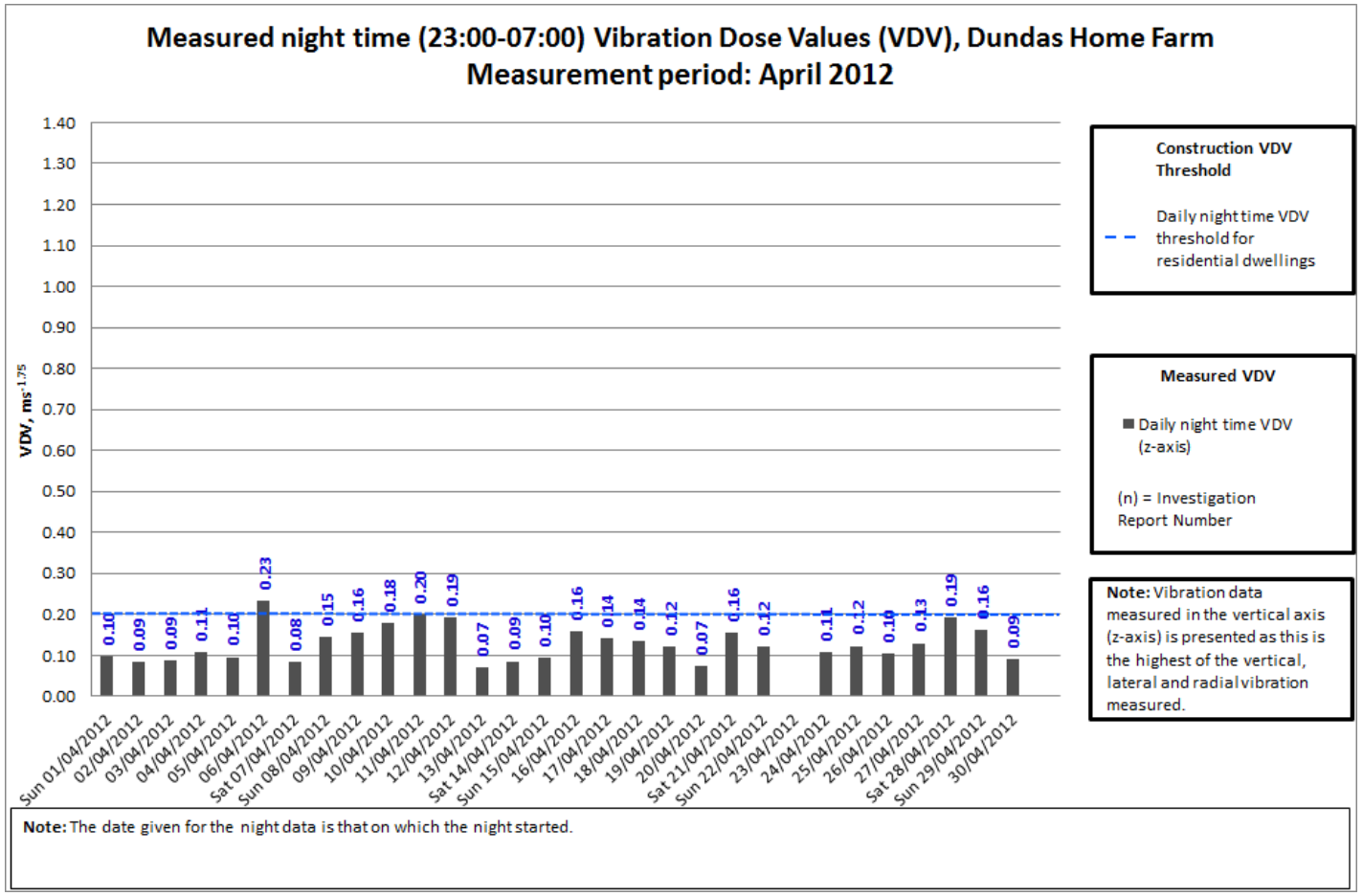
PPV at Dundas Home Farm – April 2012



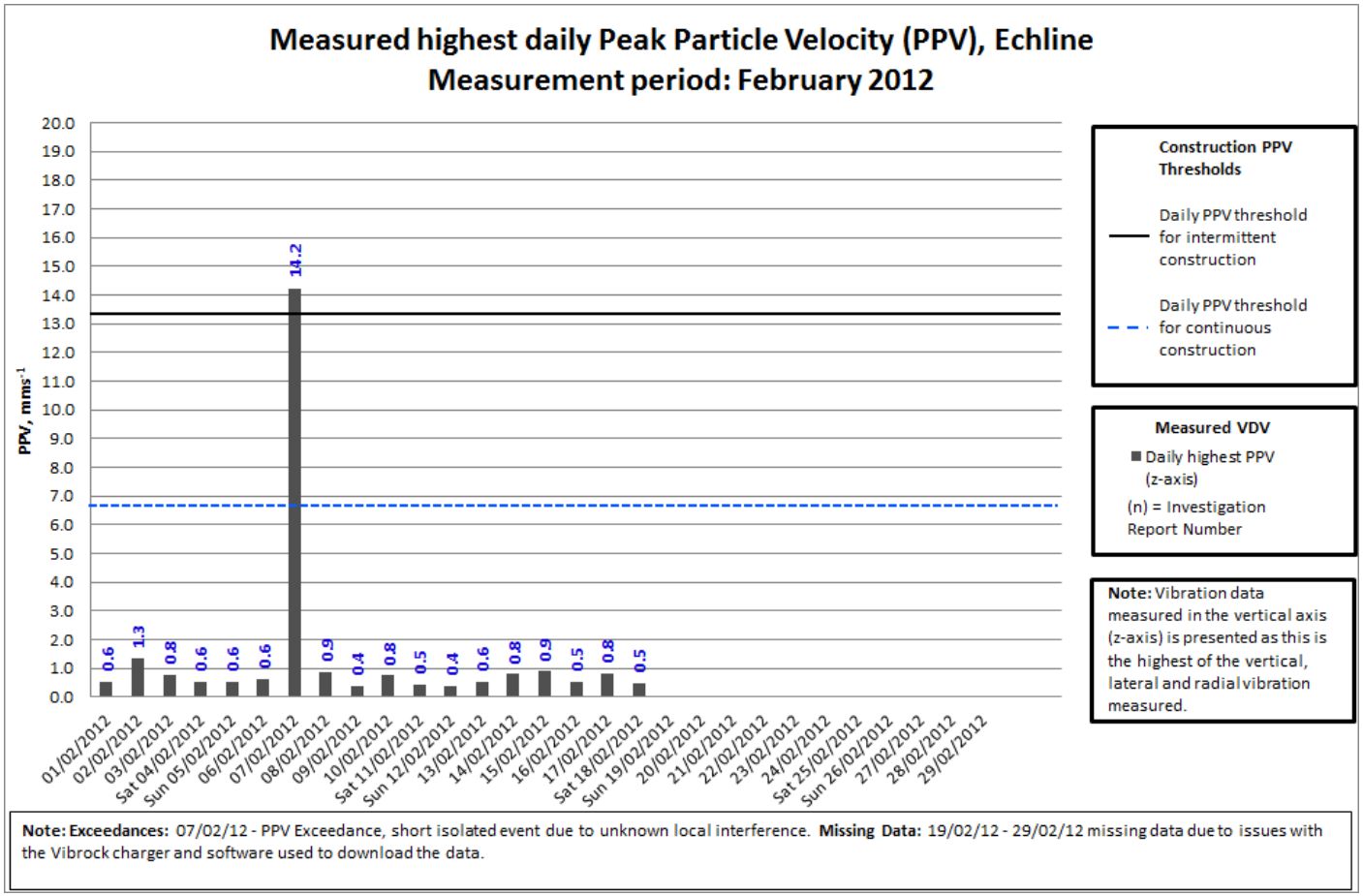
Daytime VDV at Dundas Home Farm – April 2012



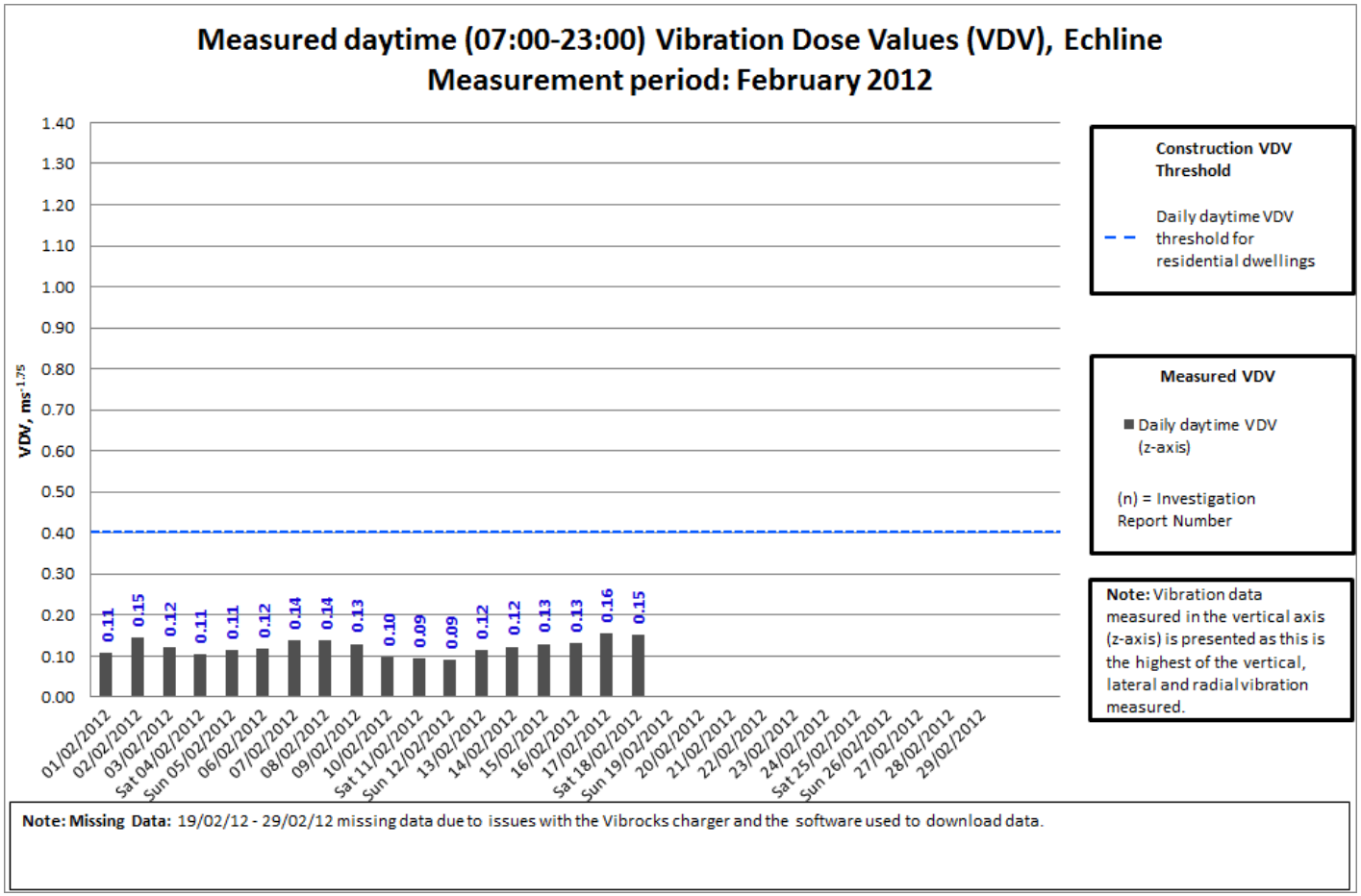
Night-time VDV at Dundas Home Farm – April 2012



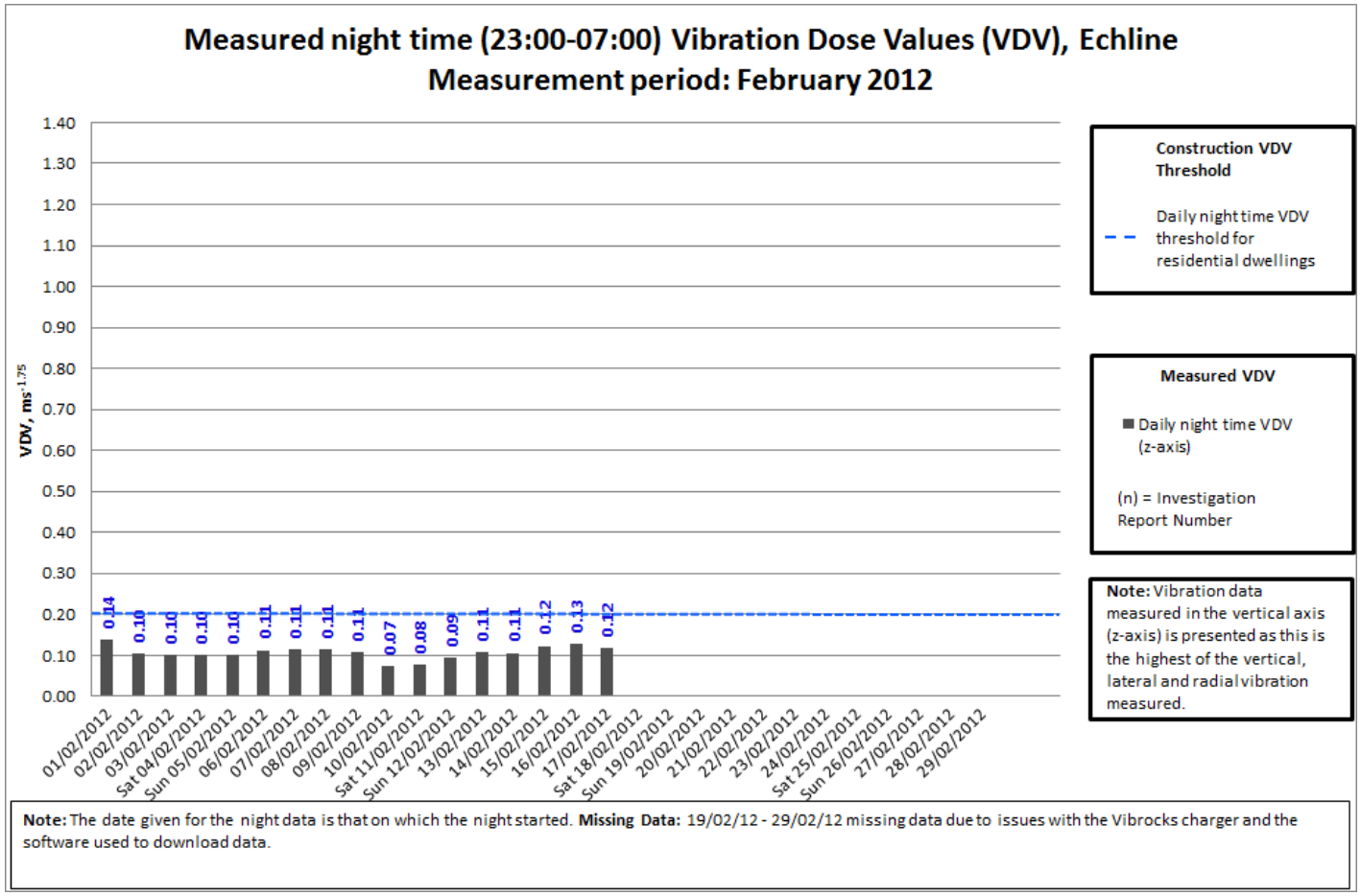
PPV at Echline – February 2012



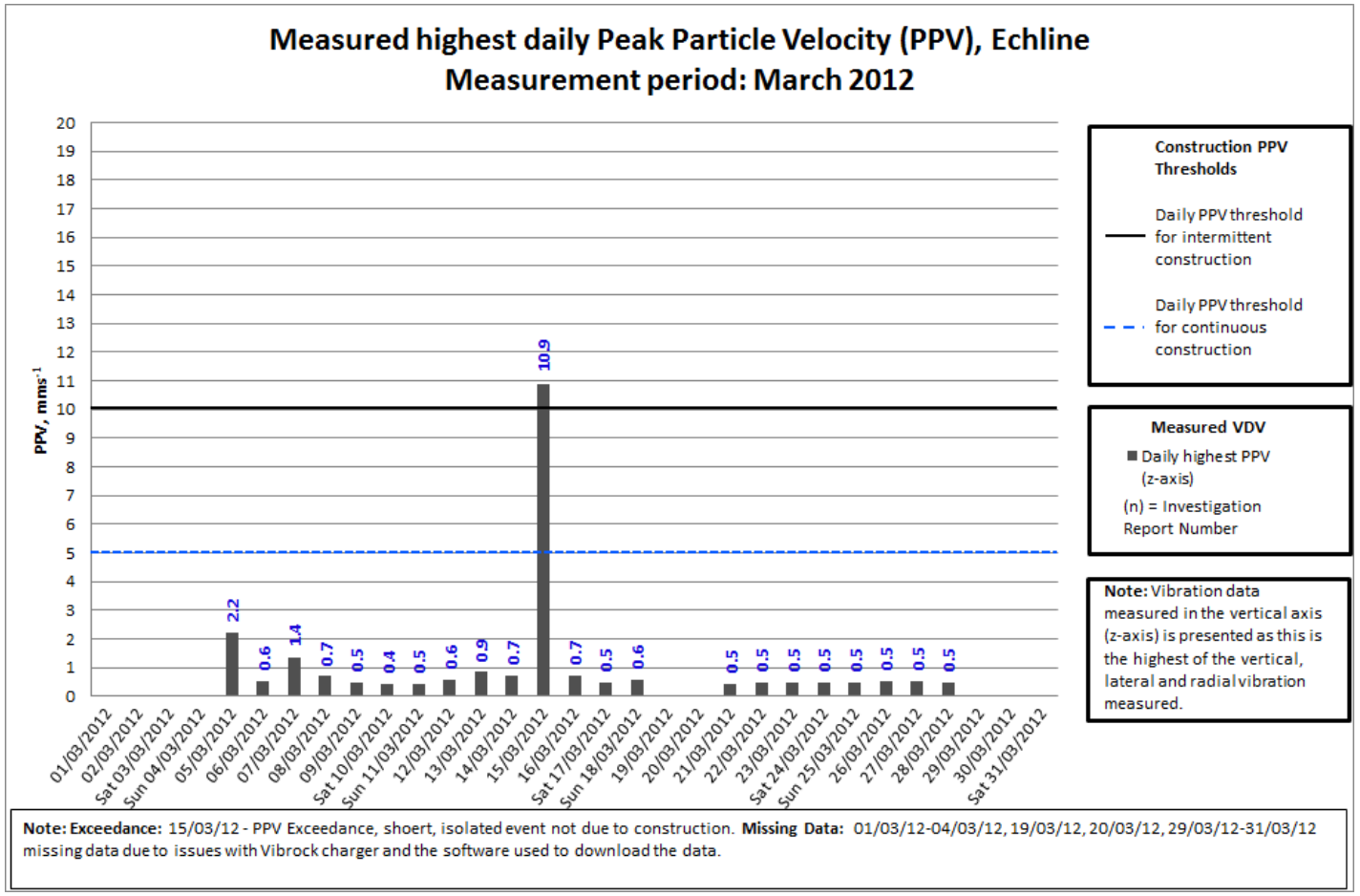
Daytime VDV at Echline – February 2012



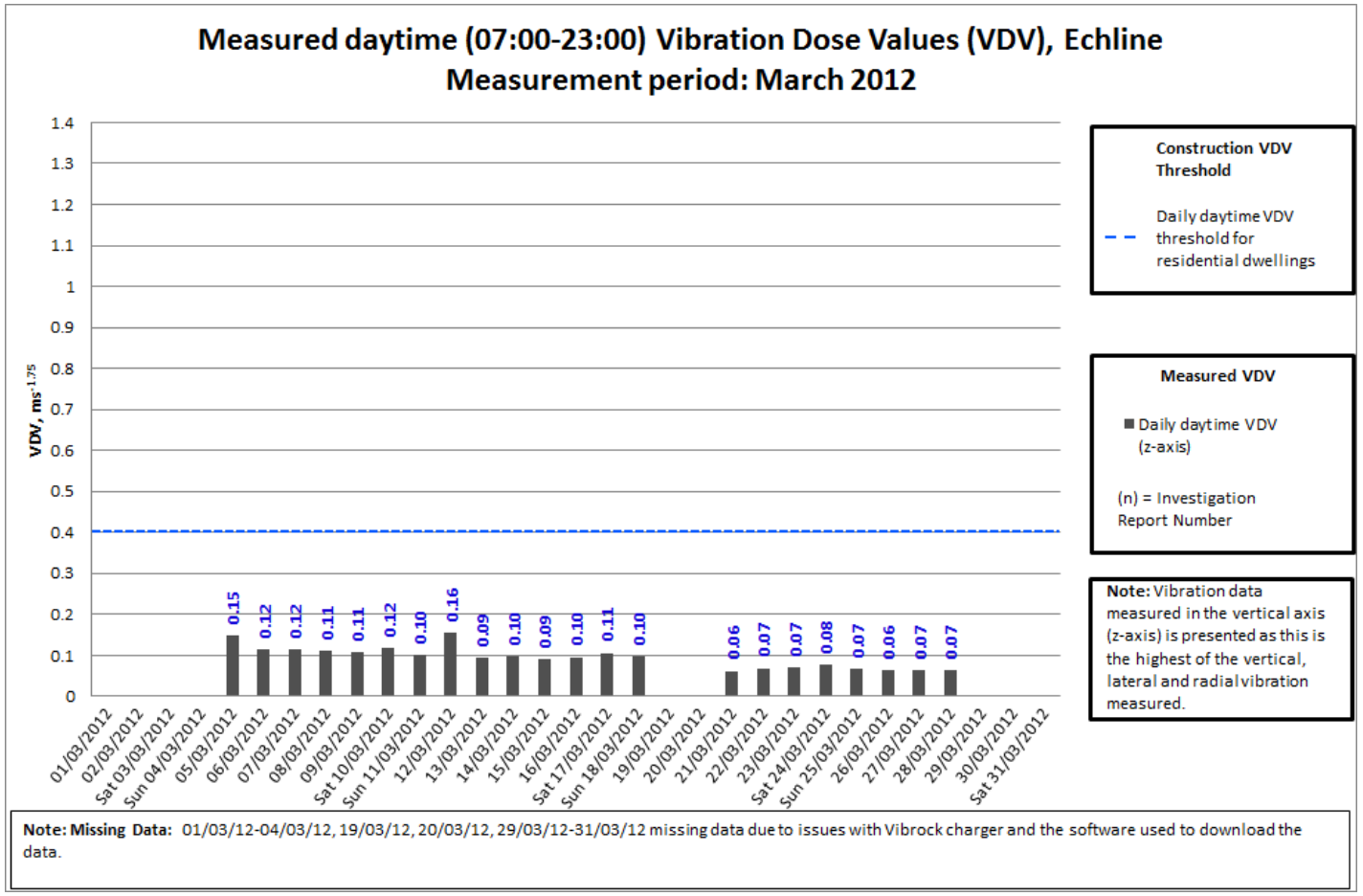
Night-time VDV at Echline – February 2012



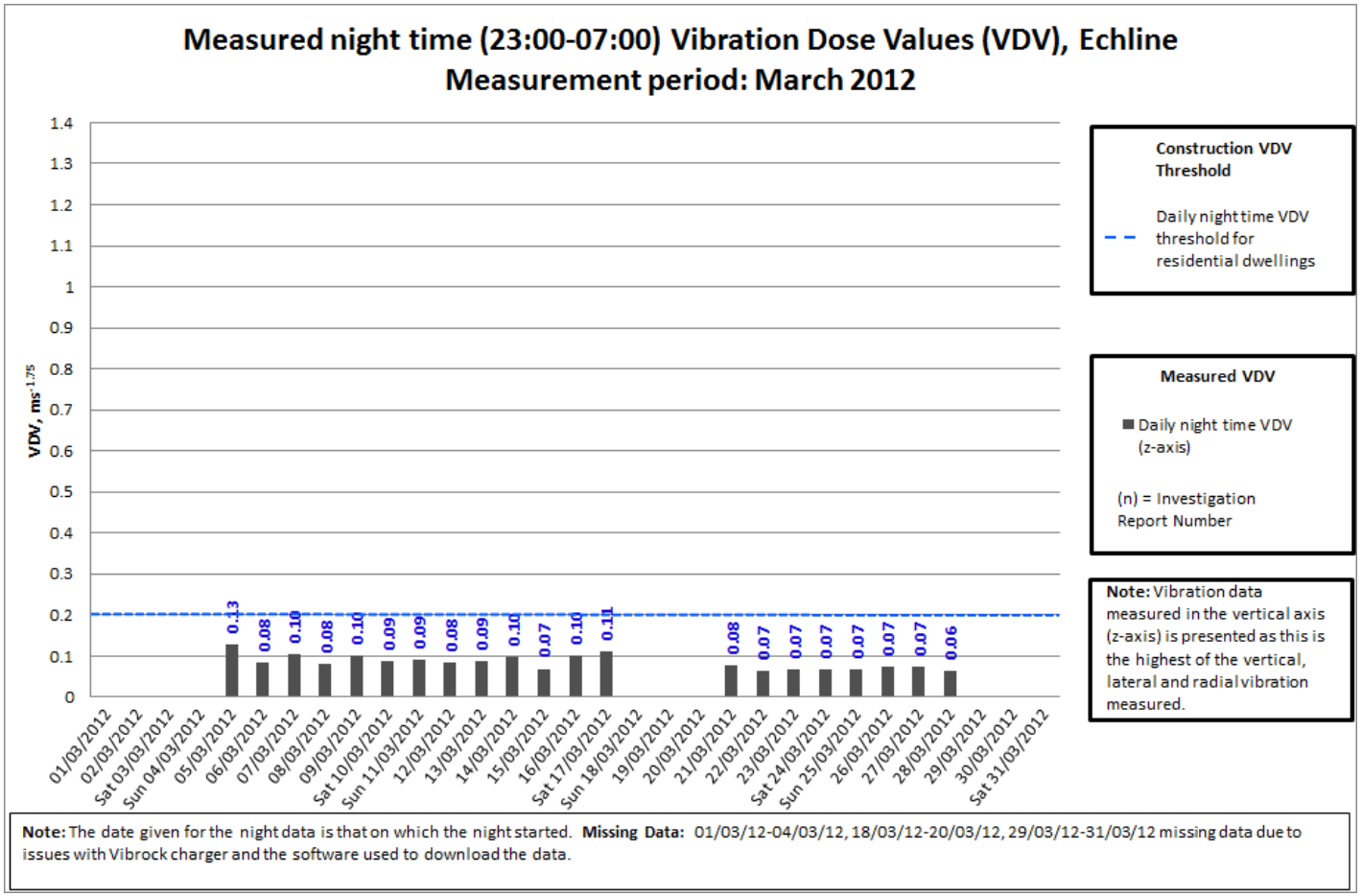
PPV at Echline – March 2012



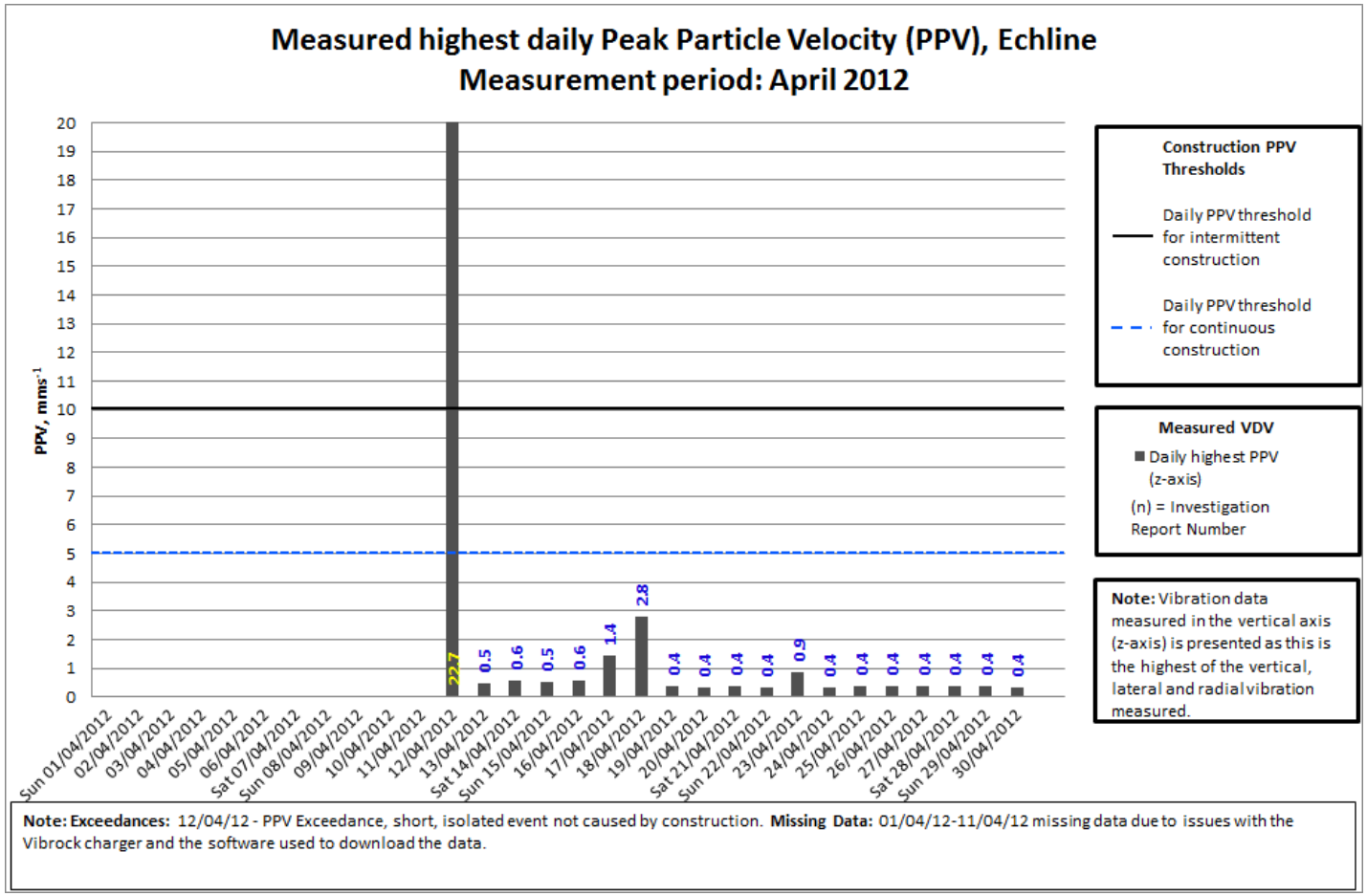
Daytime VDV at Echline – March 2012



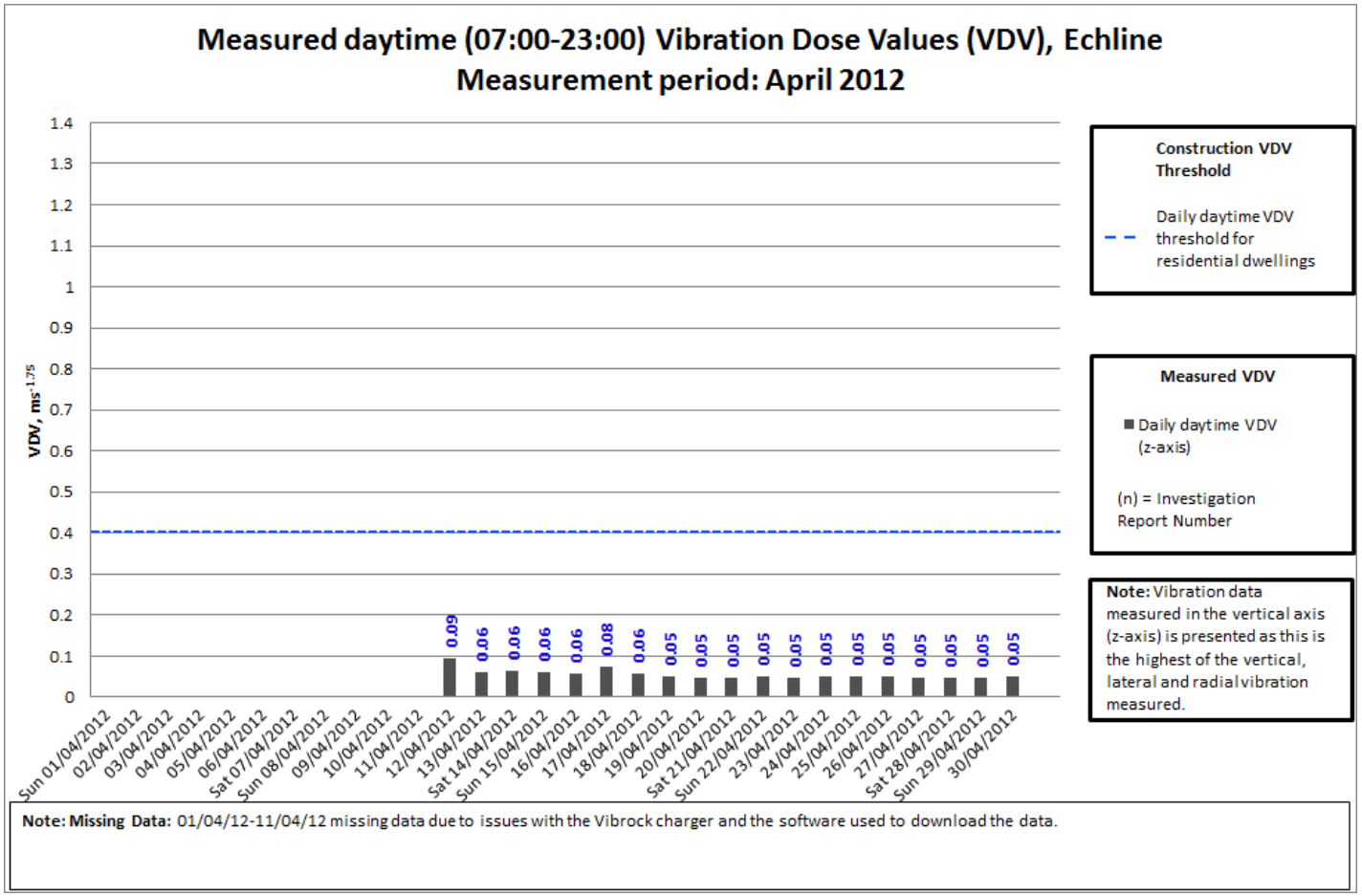
Night-time VDV at Echline – March 2012



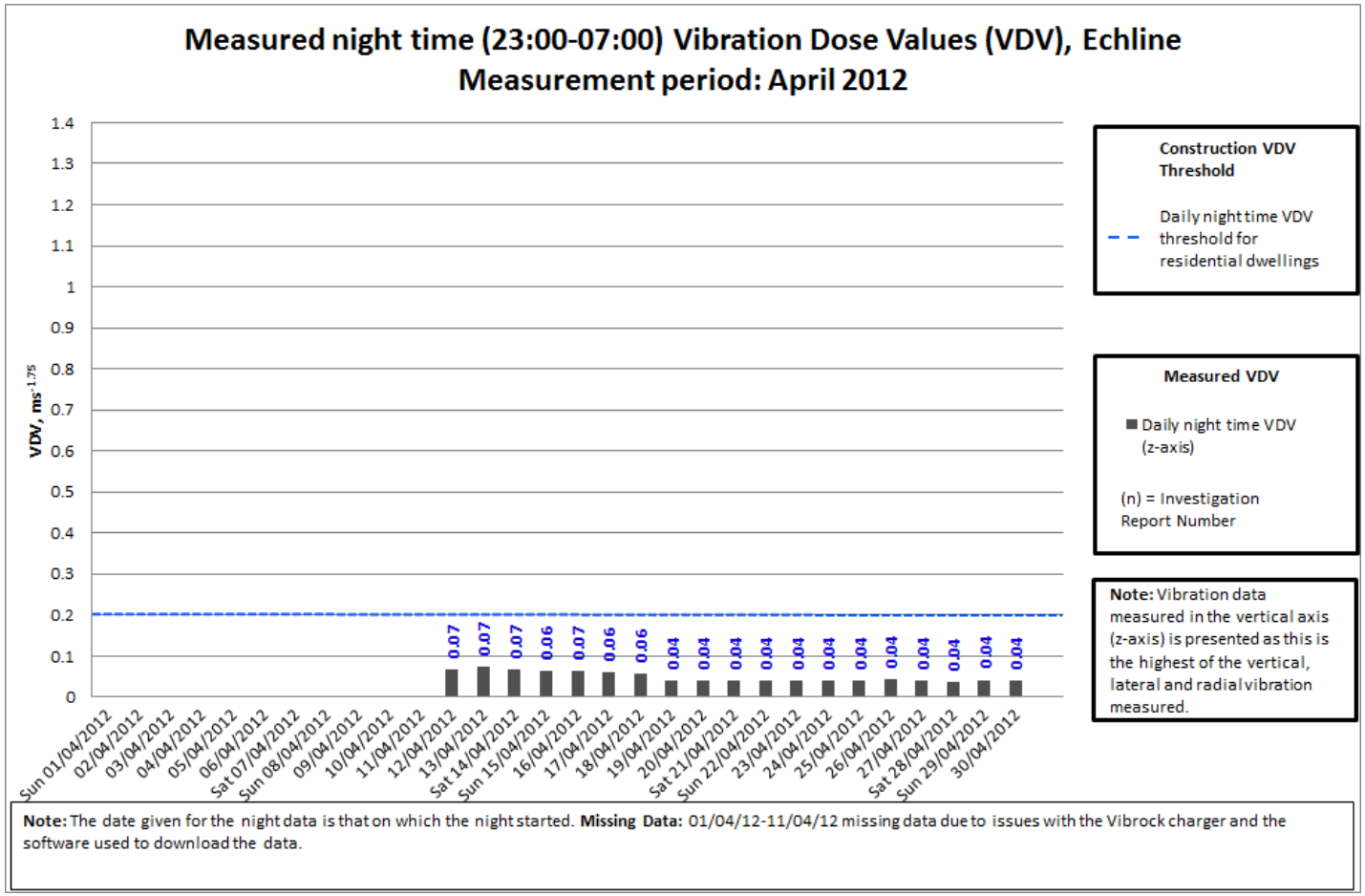
PPV at Echline – April 2012



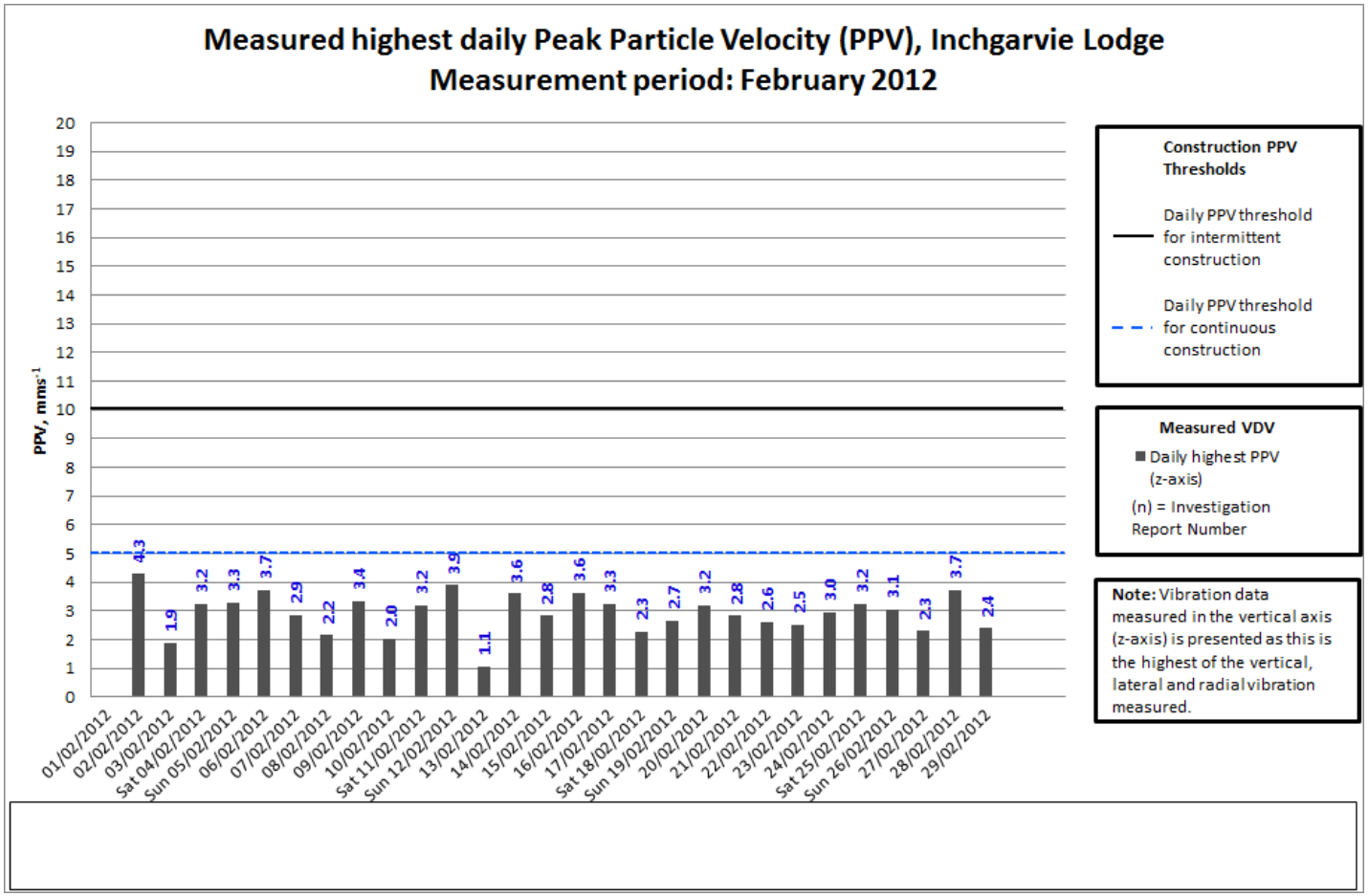
Daytime VDV at Echline – April 2012



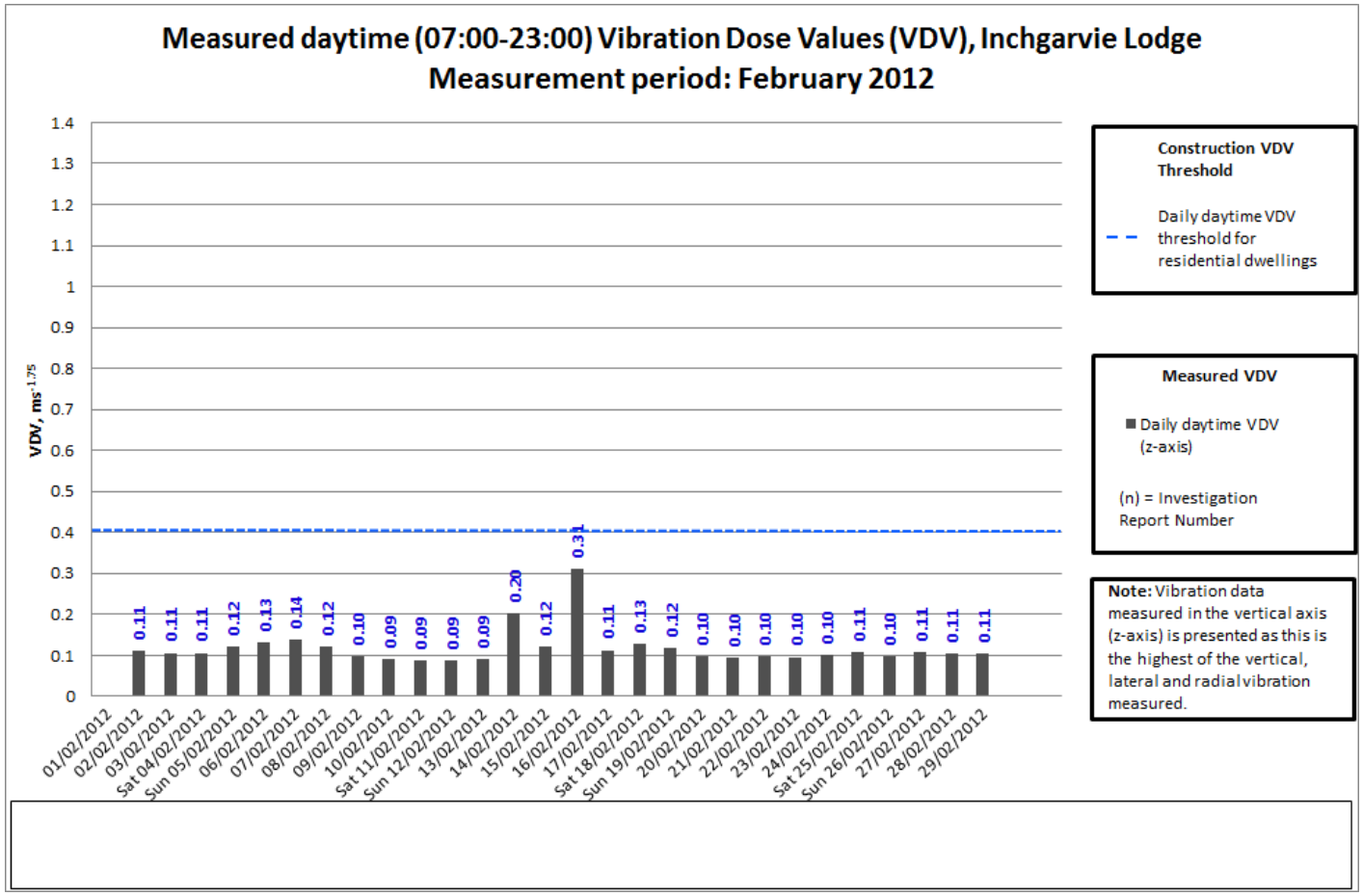
Night-time VDV at Echline – April 2012



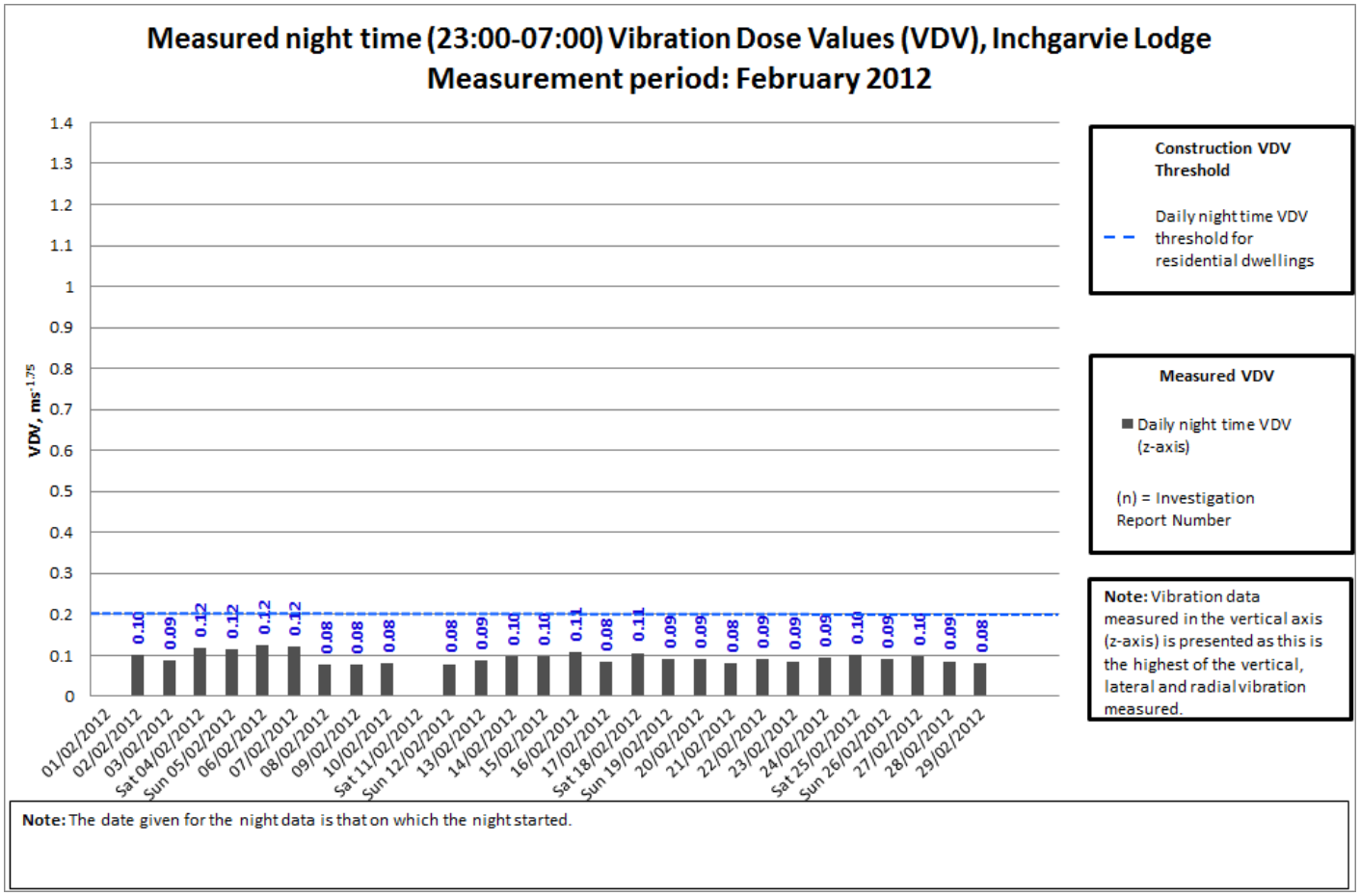
PPV at Inchgarvie Lodge – February 2012



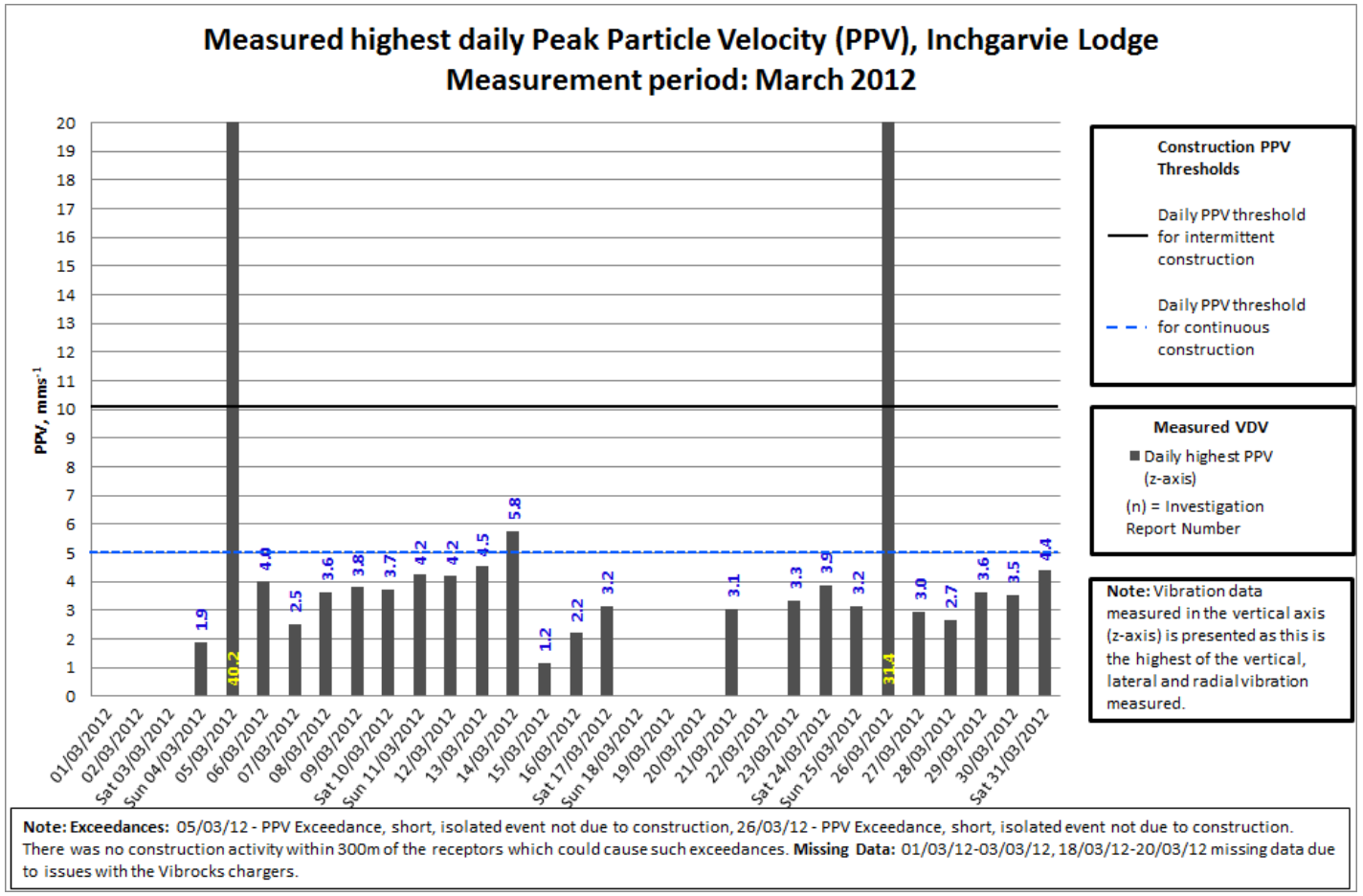
Daytime VDV at Inchgarvie Lodge – February 2012



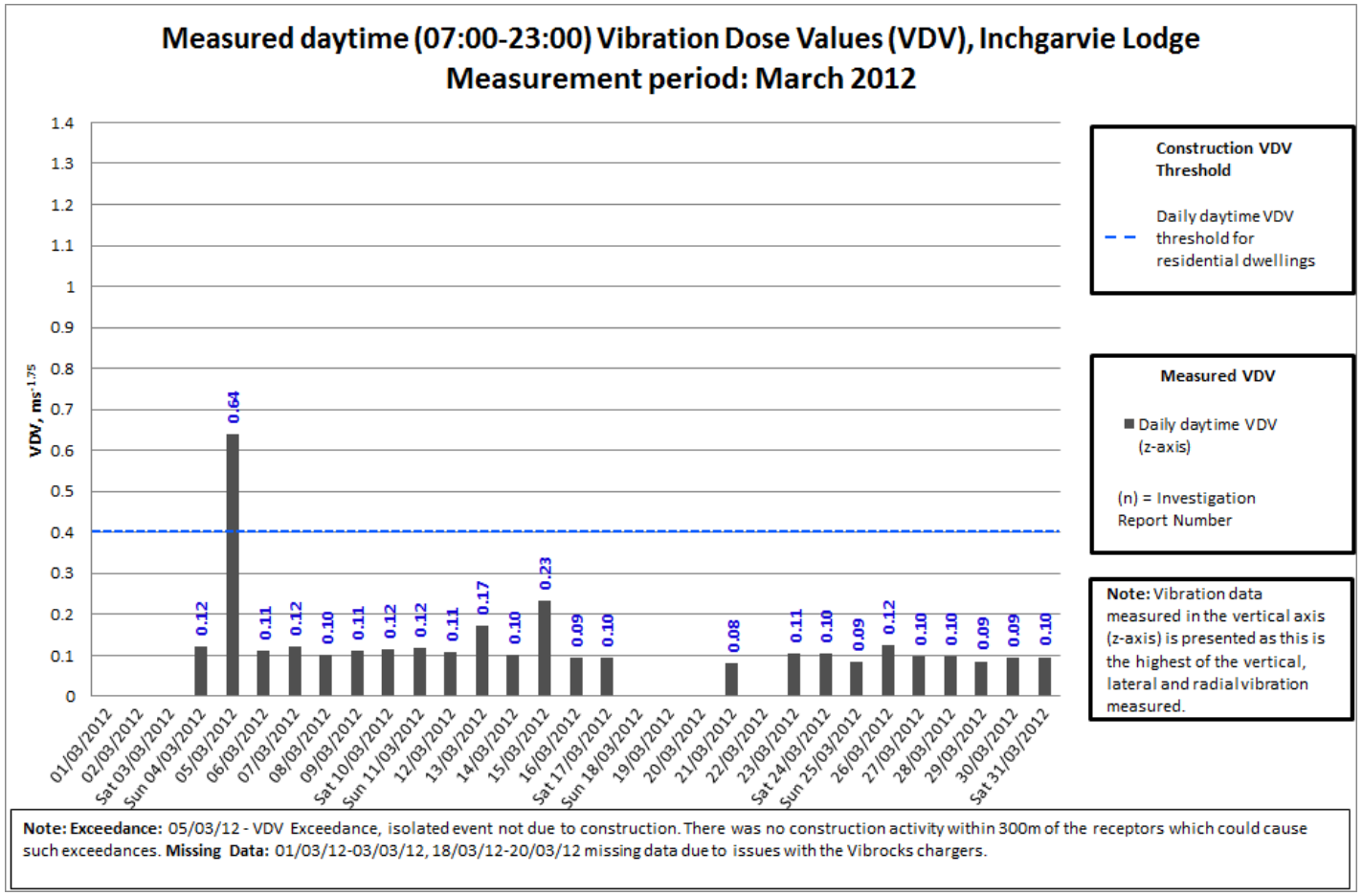
Night-time VDV at Inchgarvie Lodge – February 2012



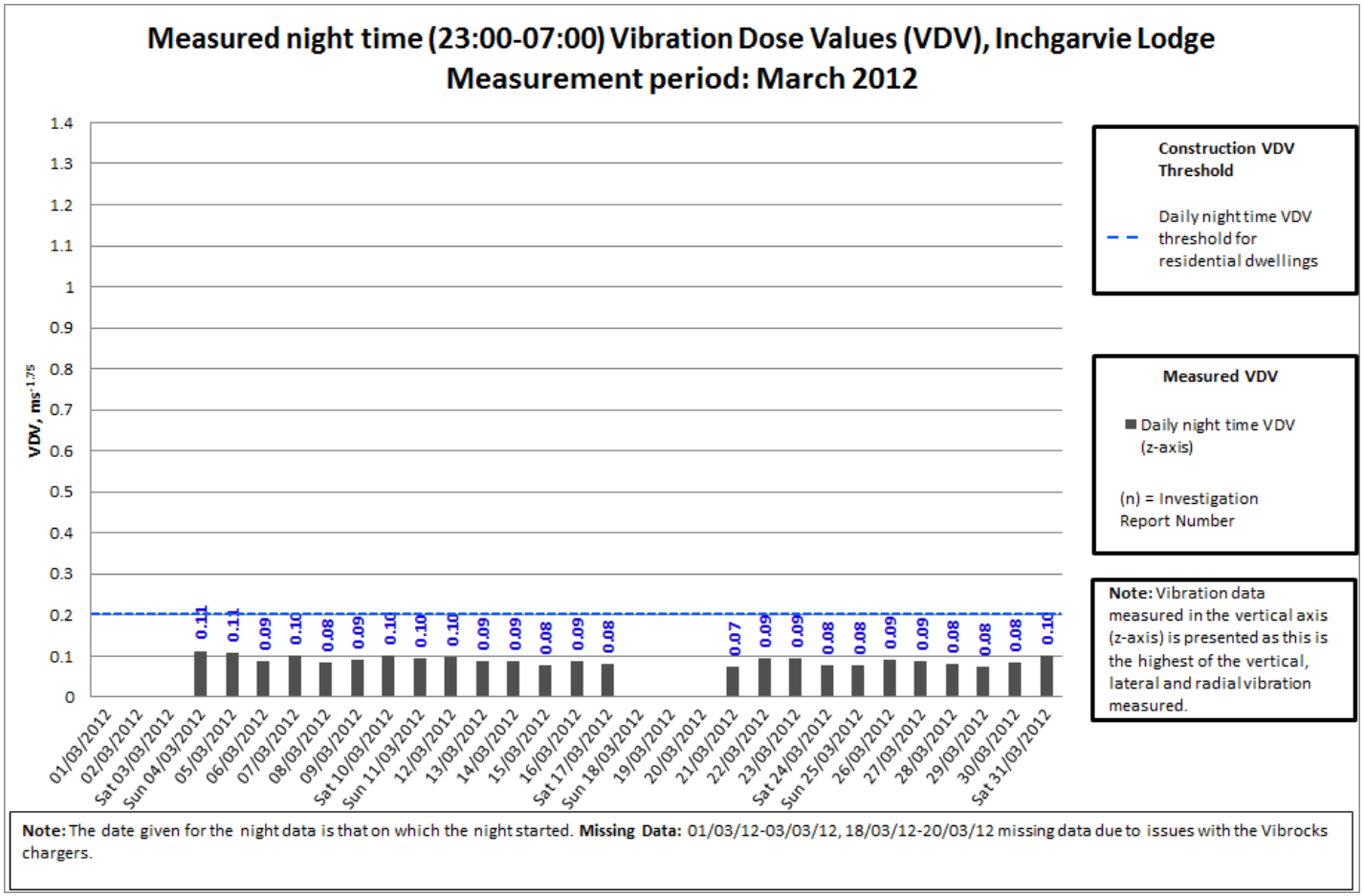
PPV at Inchgarvie Lodge – March 2012



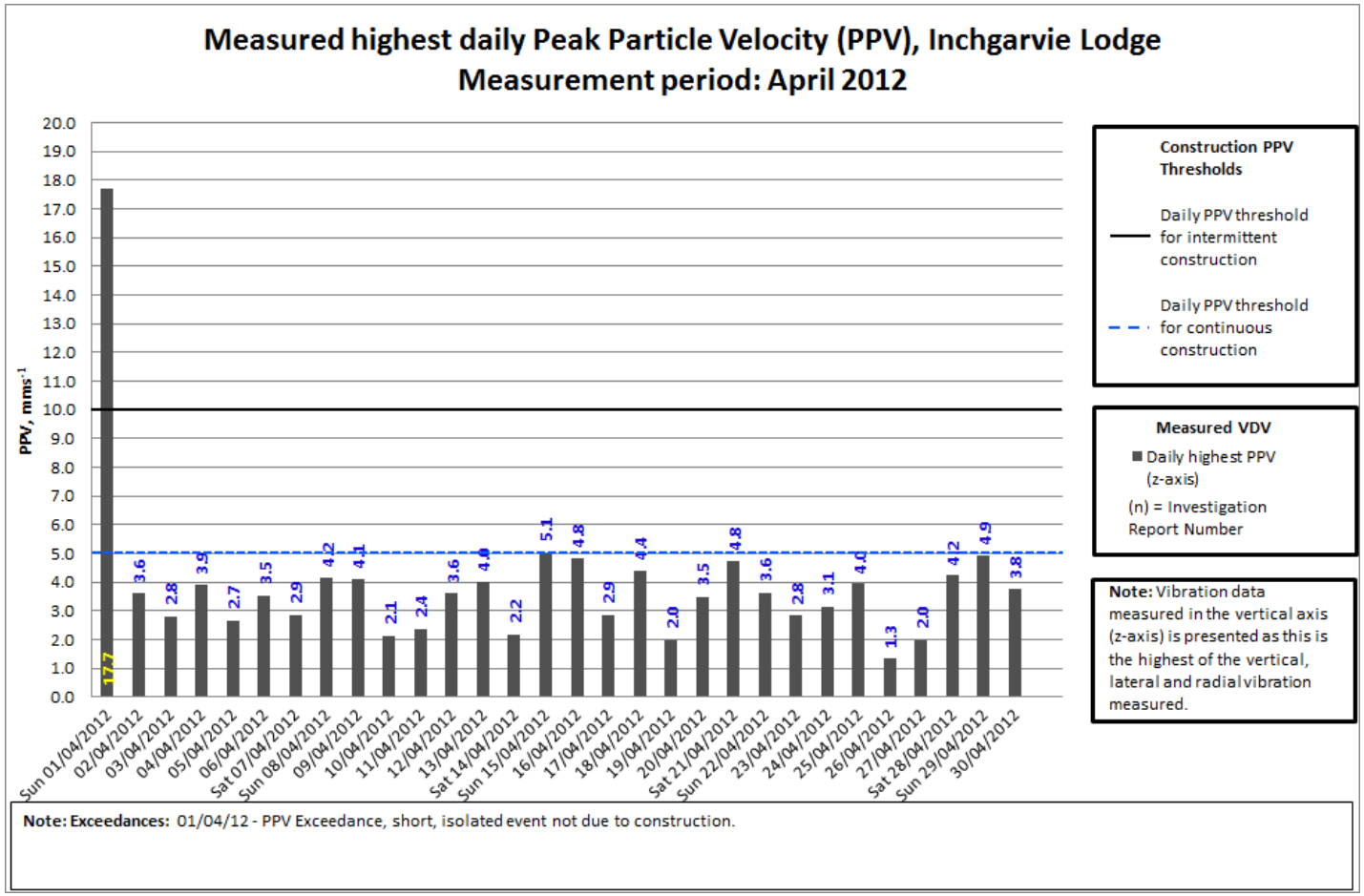
Daytime VDV at Inchgarvie Lodge – March 2012



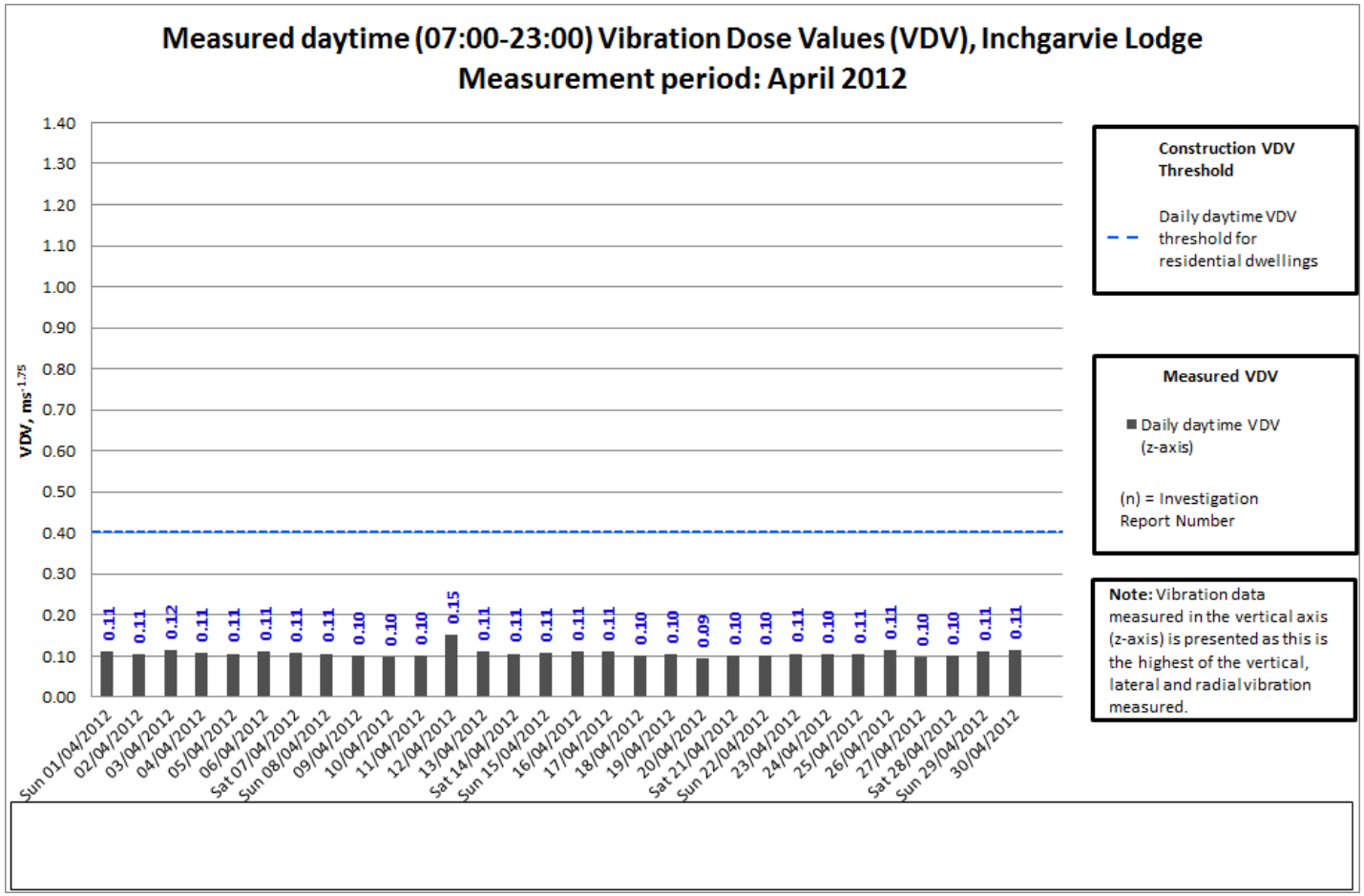
Night-time VDV at Inchgarvie Lodge – March 2012



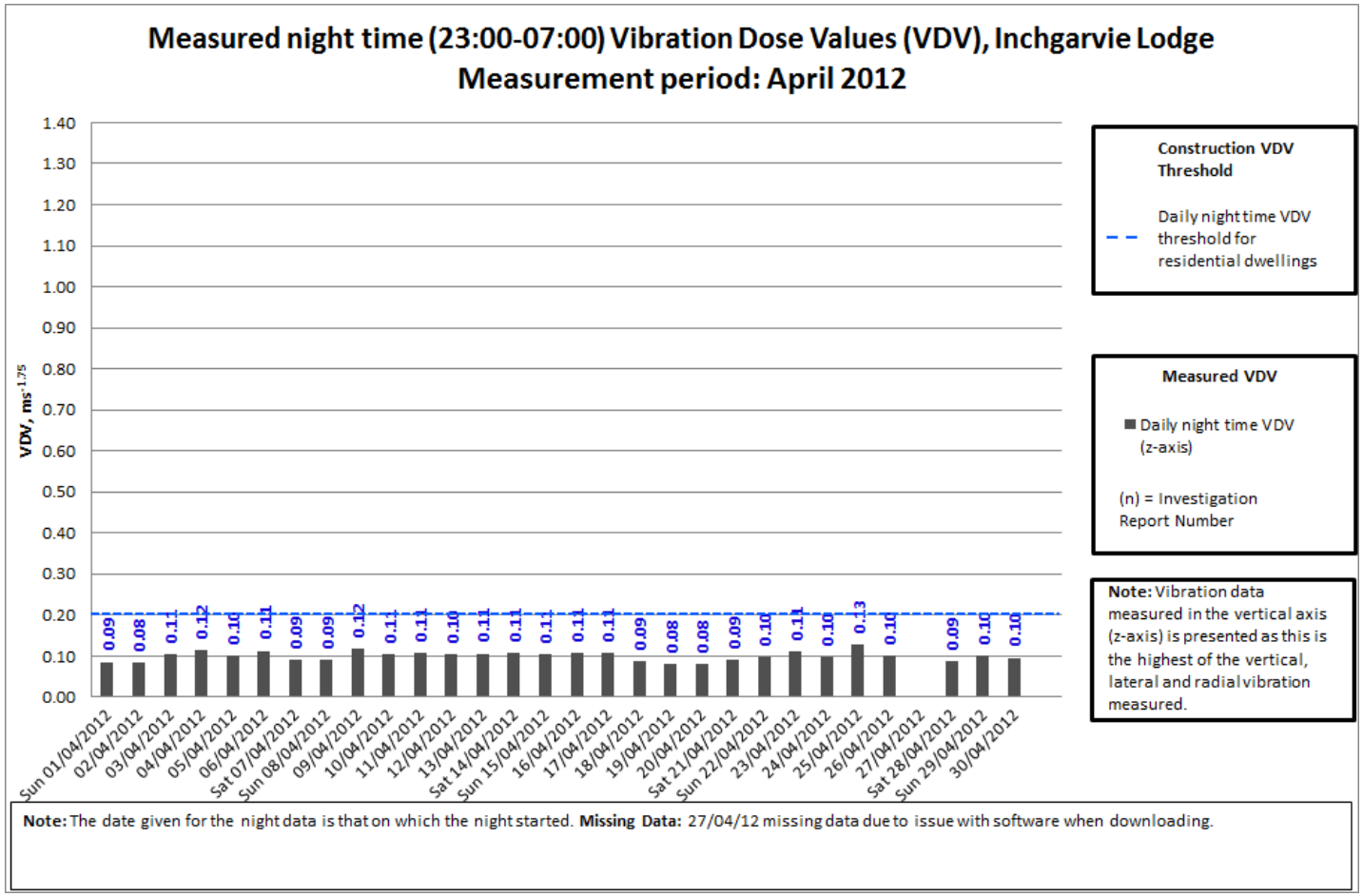
PPV at Inchgarvie Lodge – April 2012



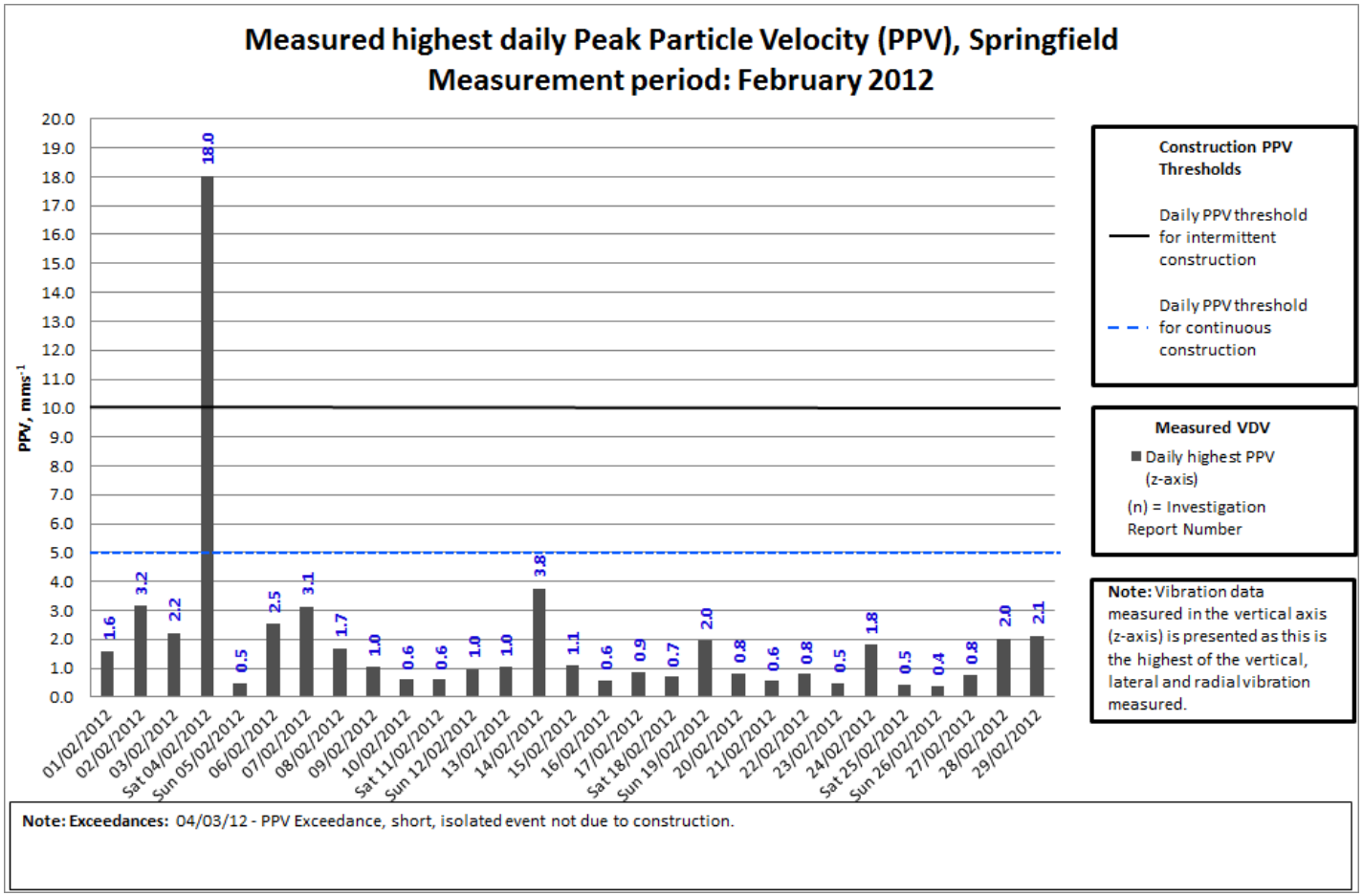
Daytime VDV at Inchgarvie Lodge – April 2012



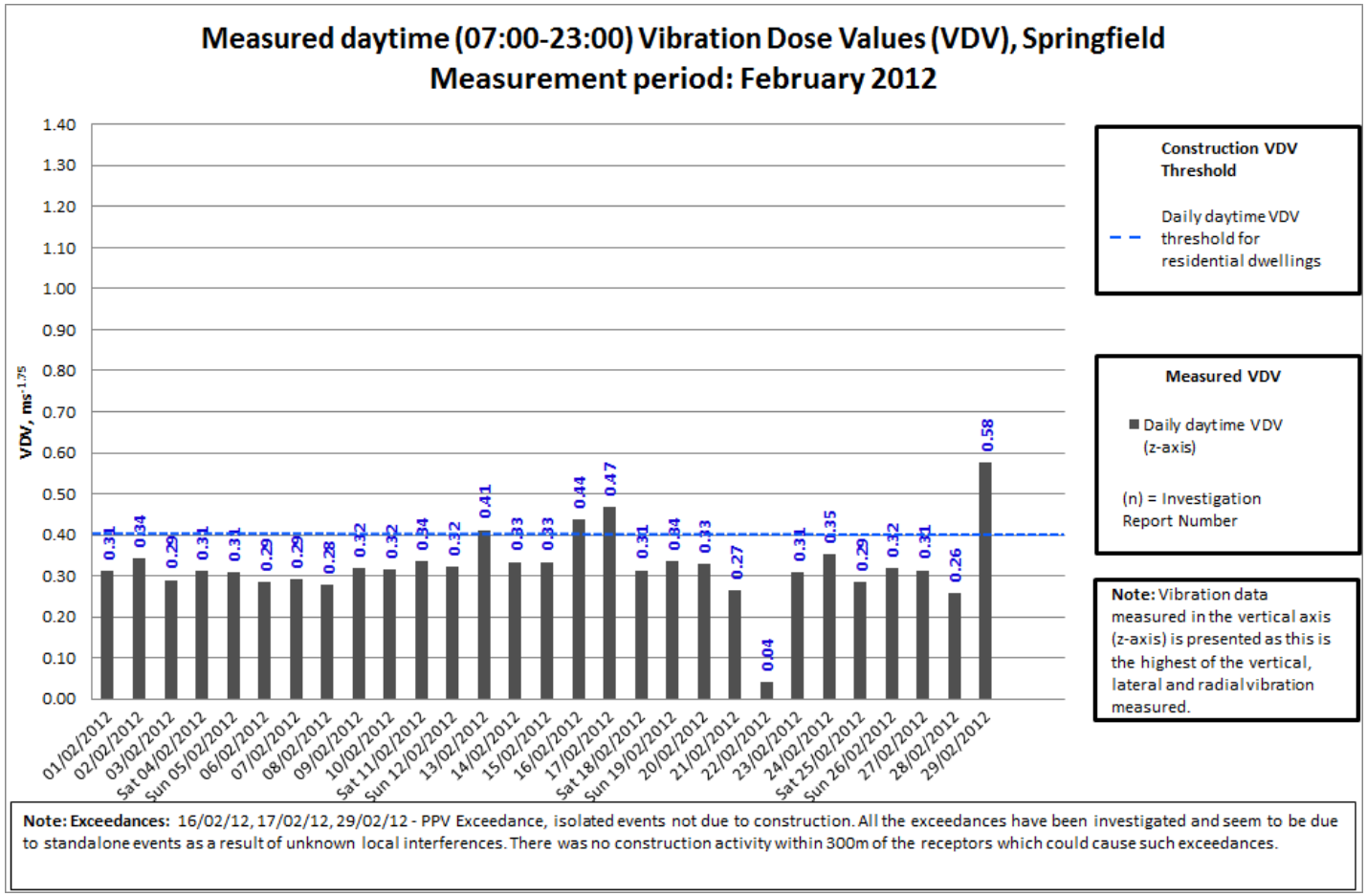
Night-time VDV at Inchgarvie Lodge – April 2012



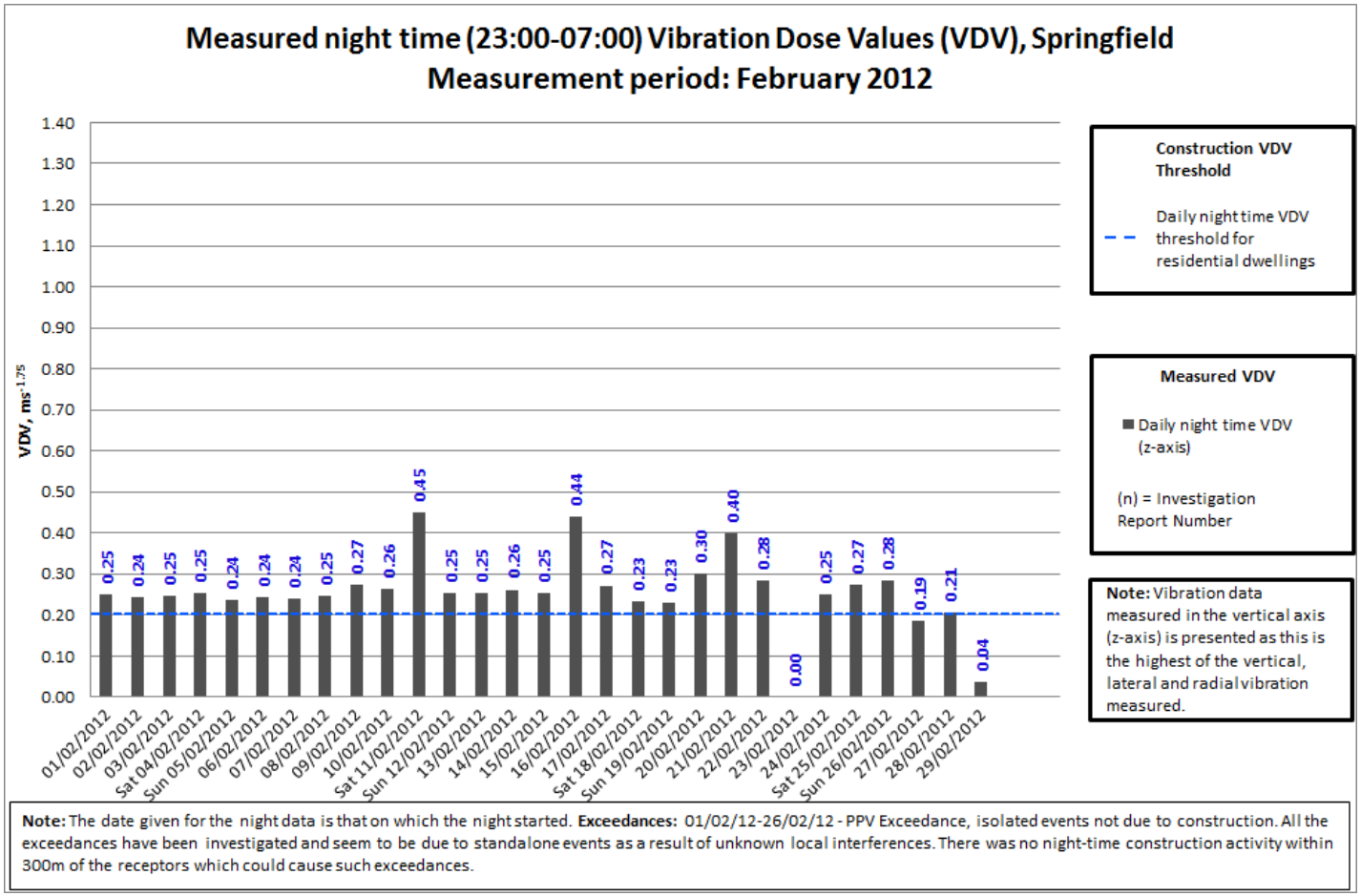
PPV at Springfield – February 2012



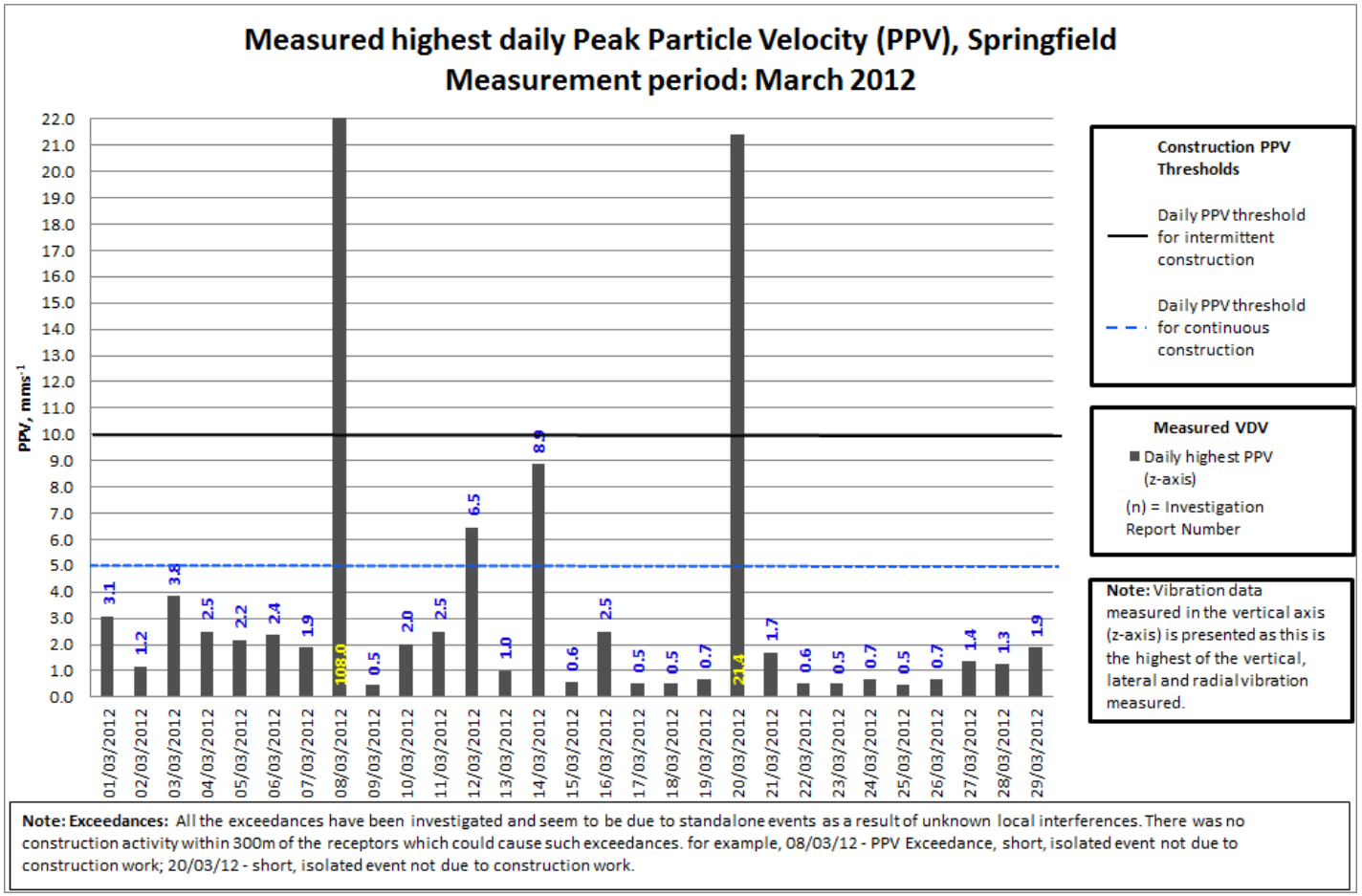
Daytime VDV at Springfield – February 2012



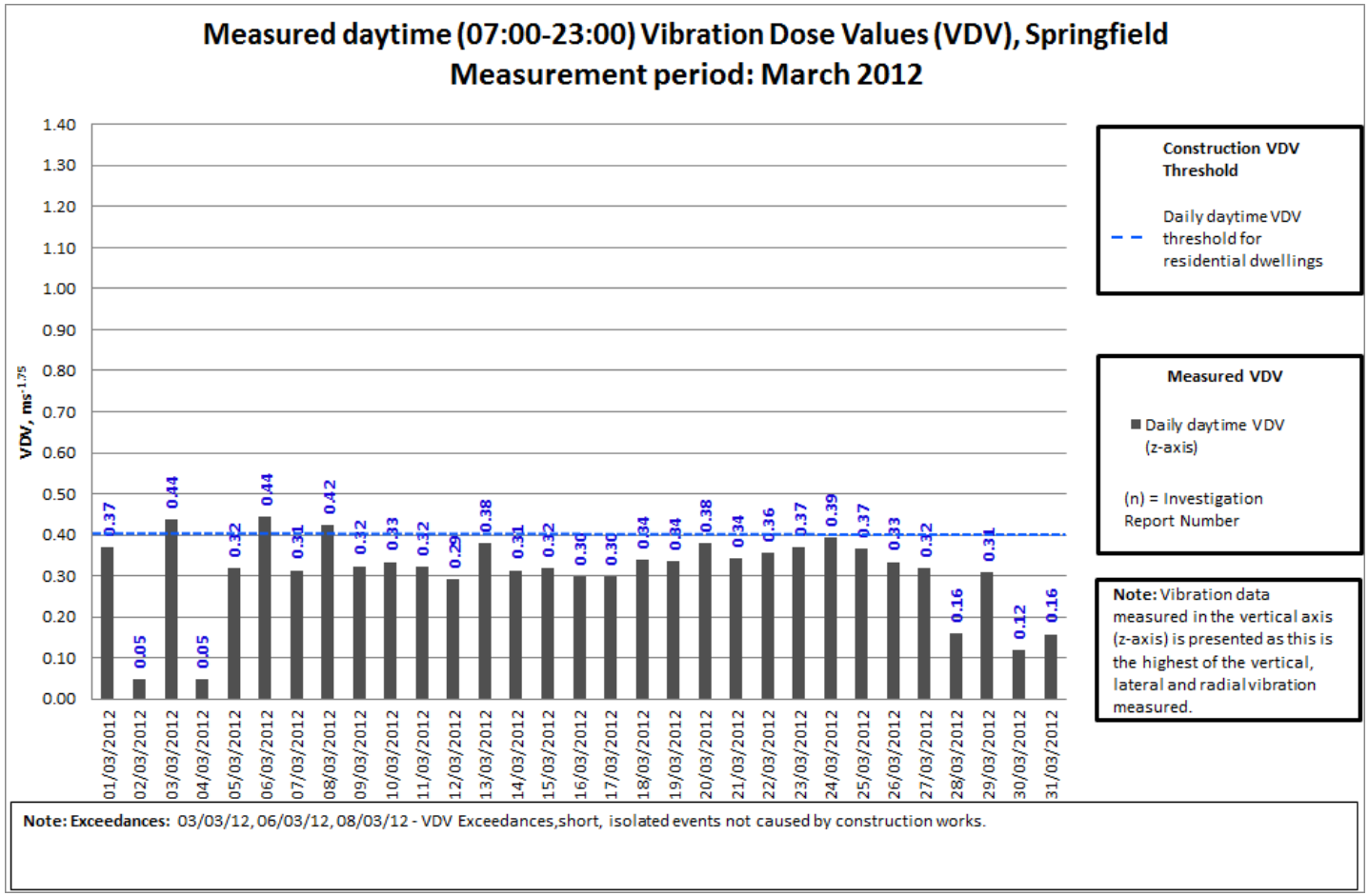
Night-time VDV at Springfield – February 2012



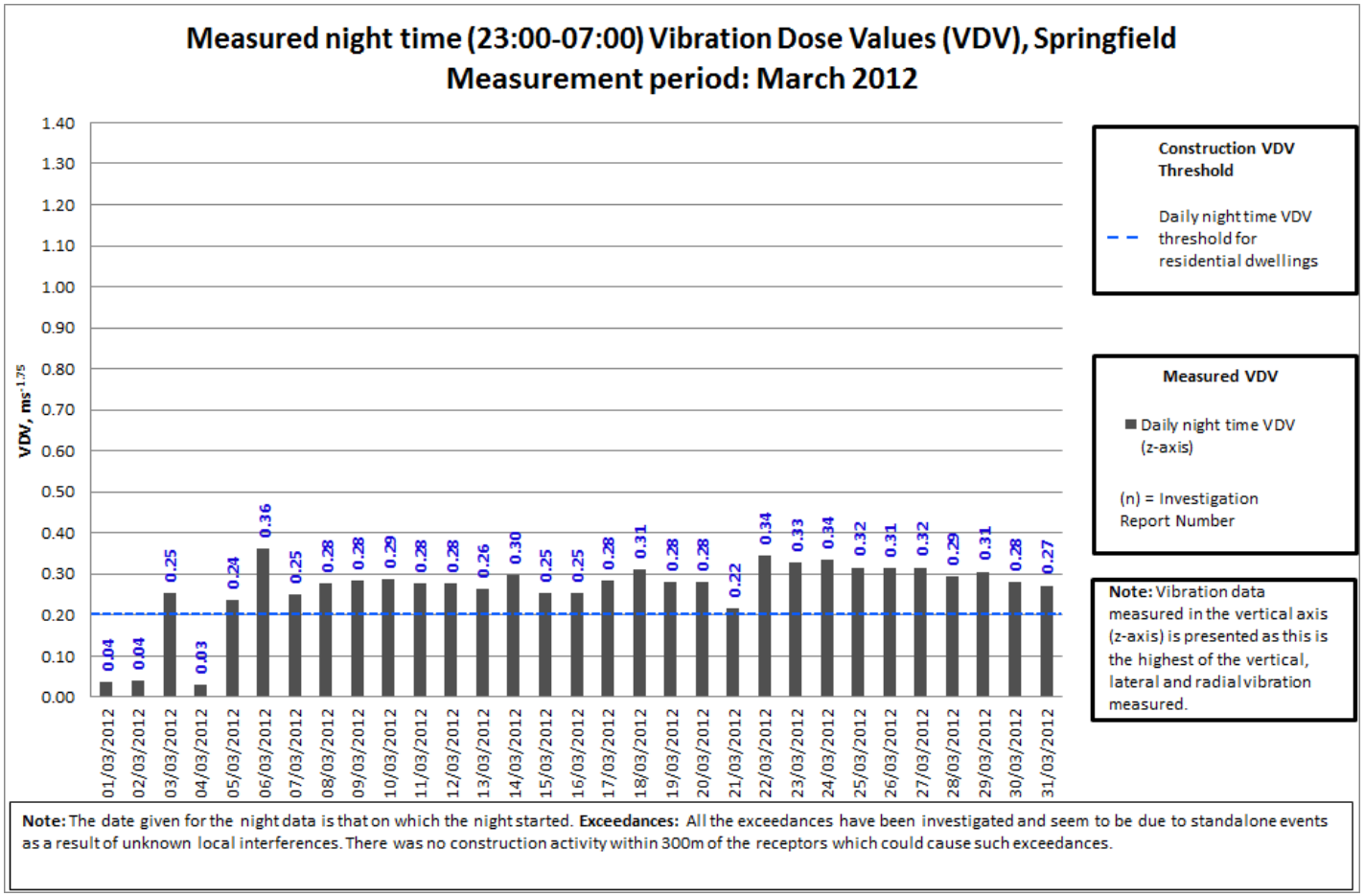
PPV at Springfield – March 2012



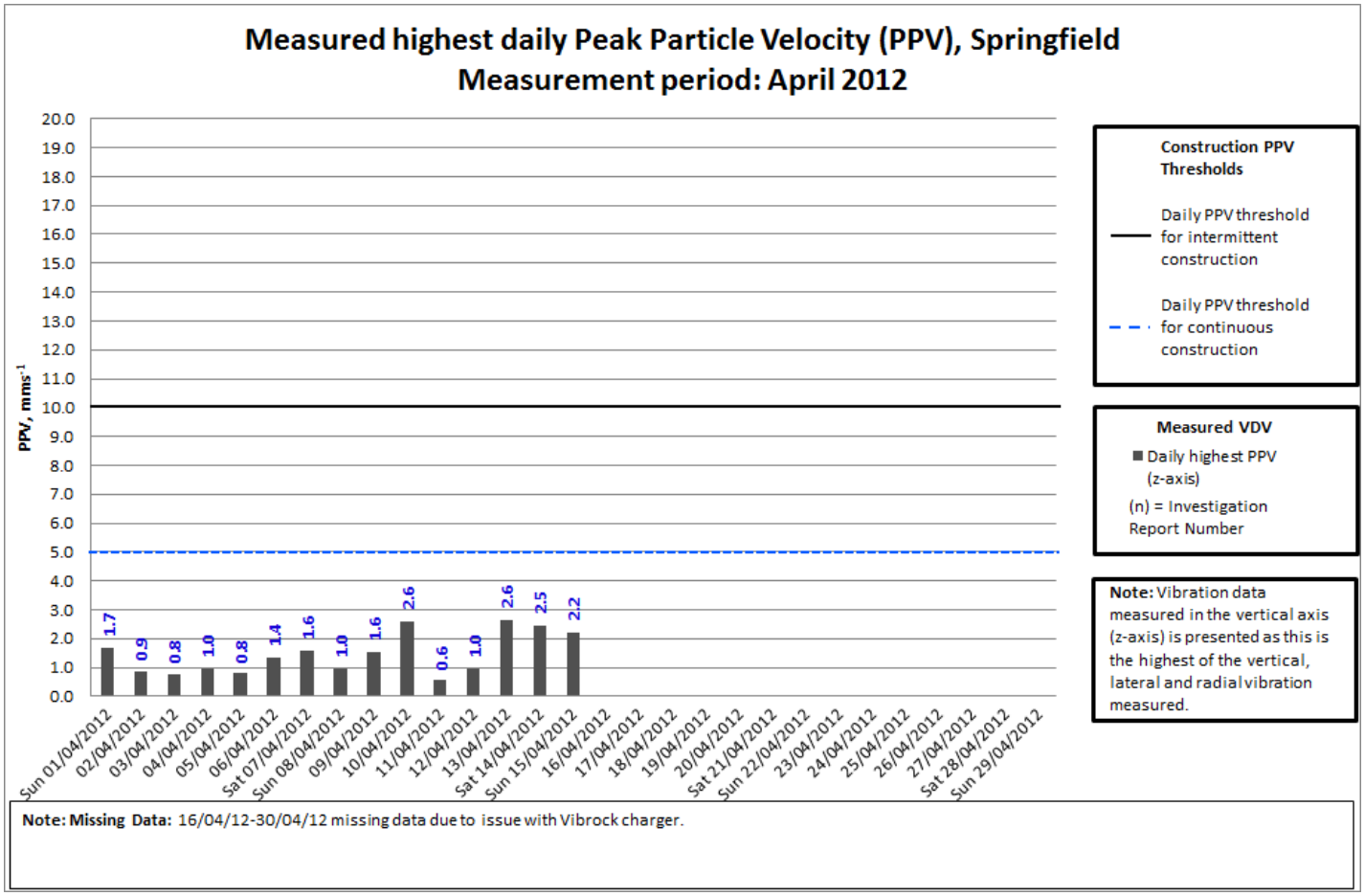
Daytime VDV at Springfield – March 2012



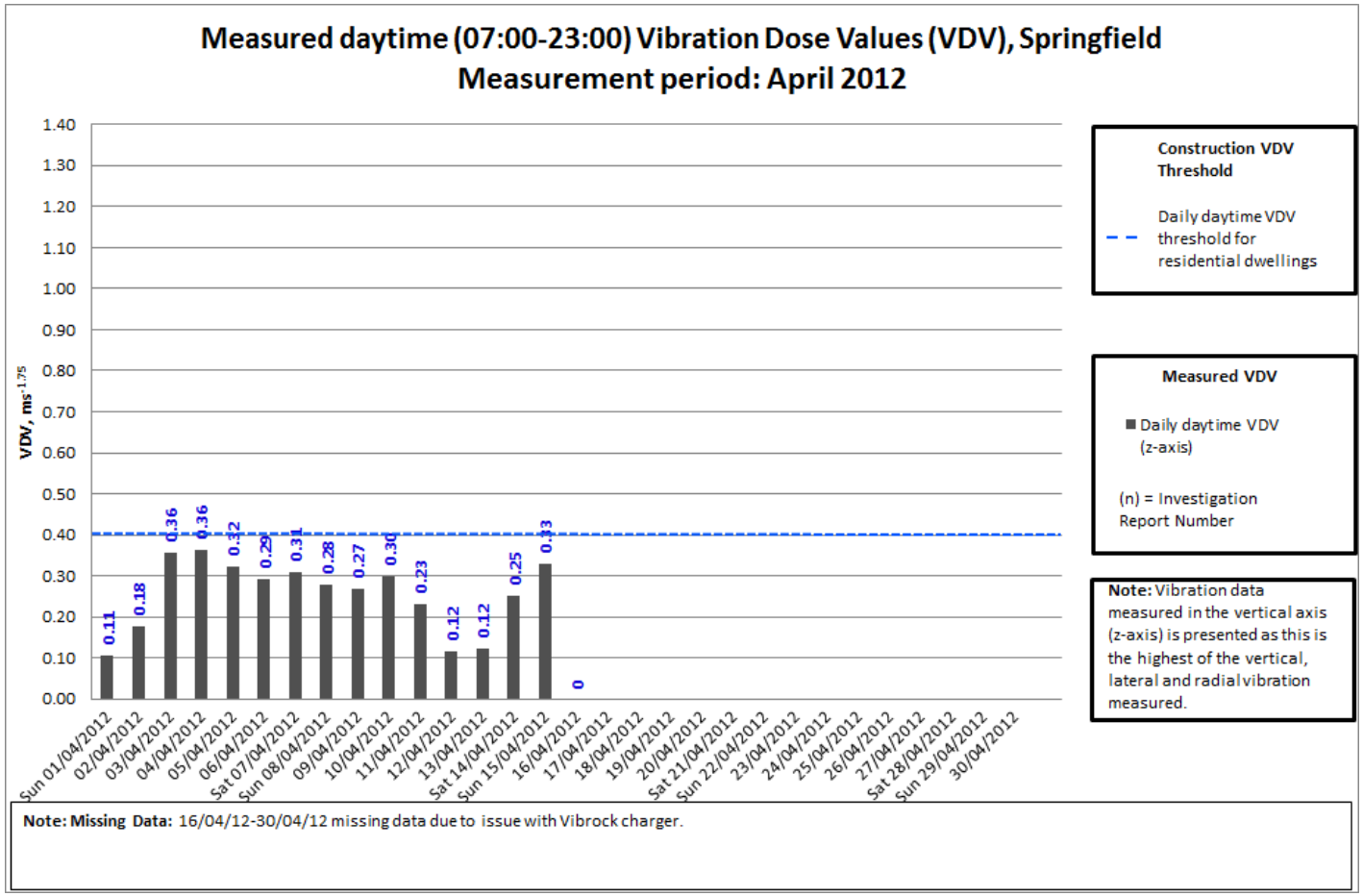
Night-time VDV at Springfield – March 2012



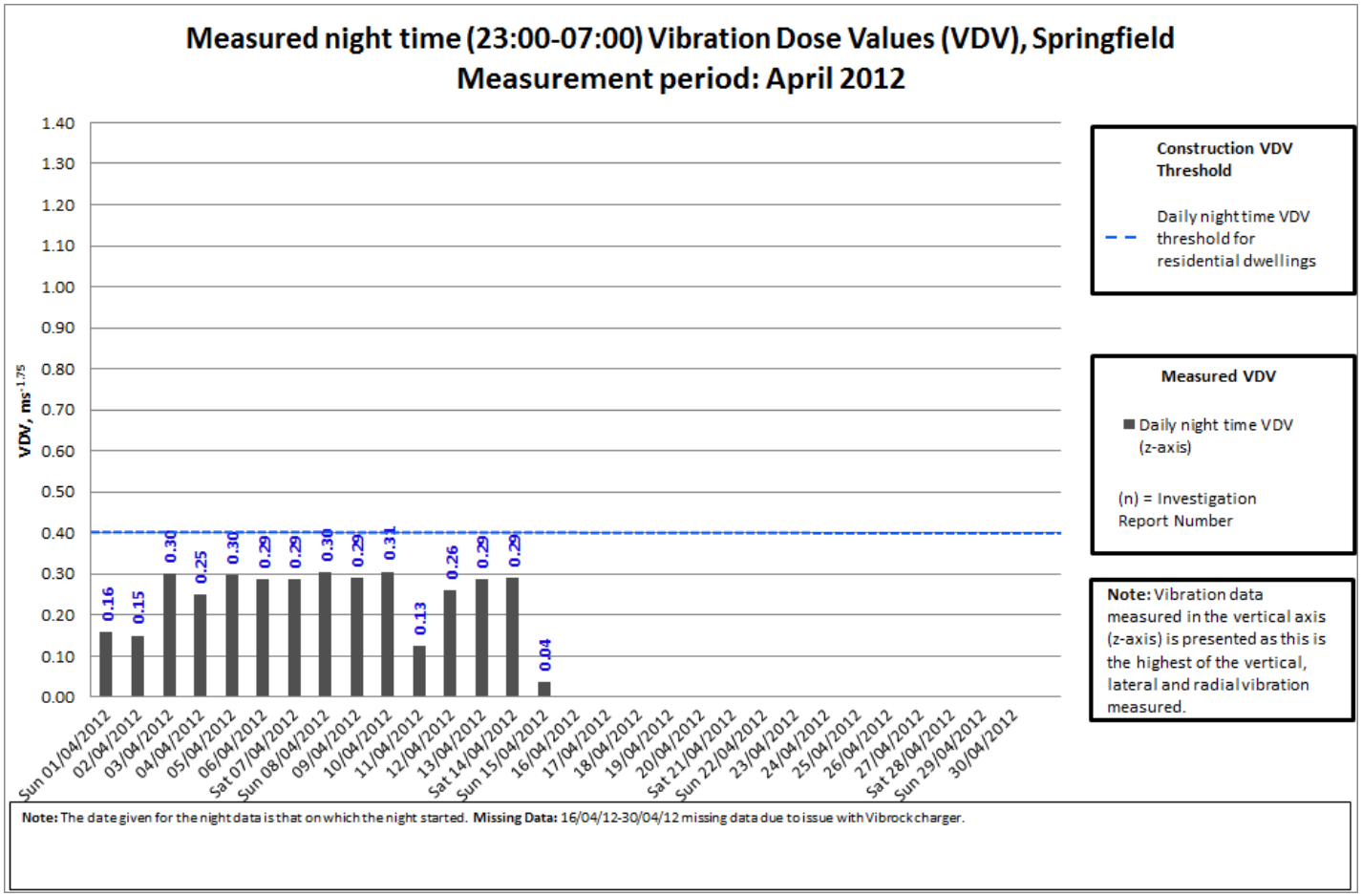
PPV at Springfield – April 2012



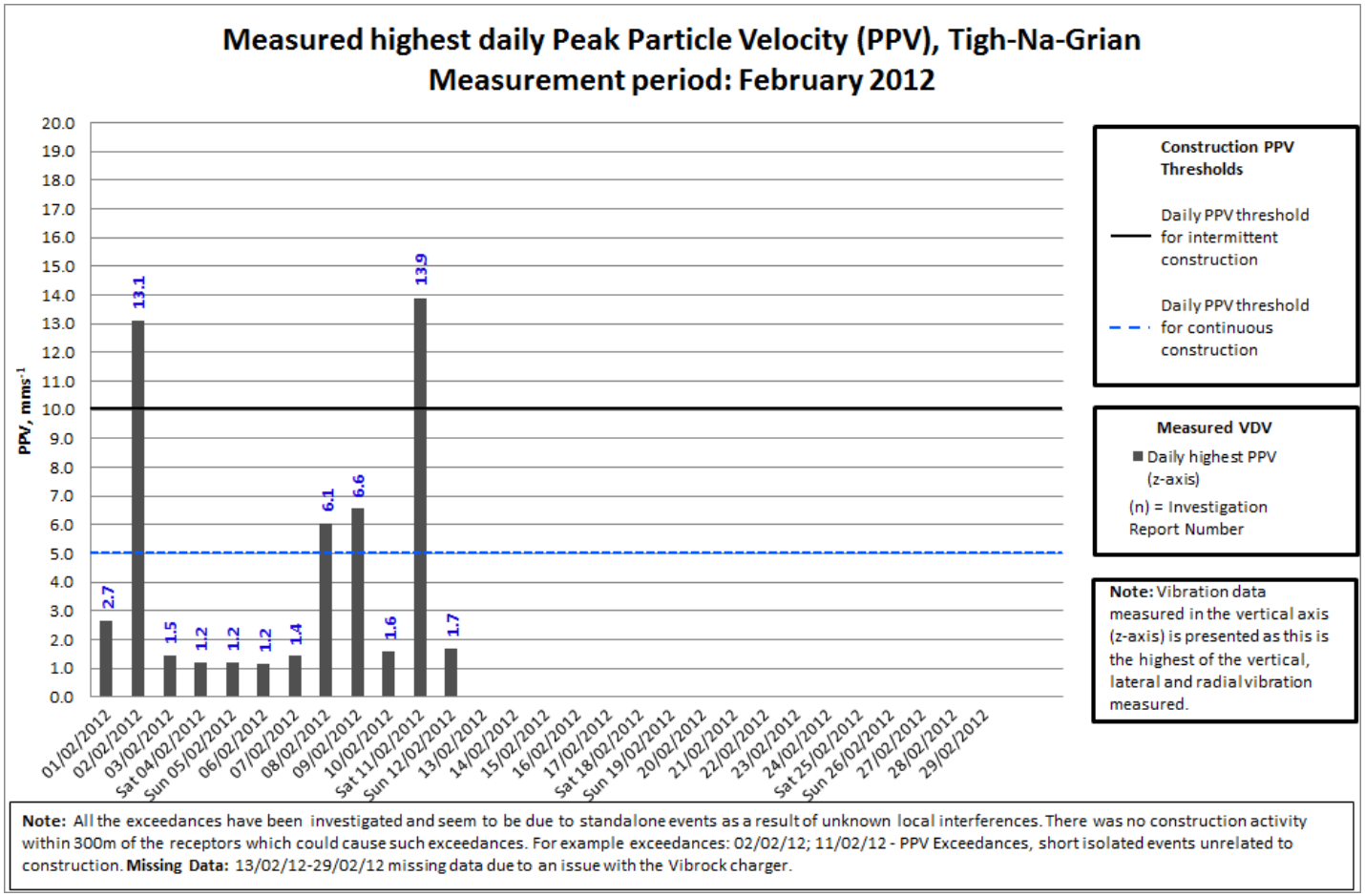
Daytime VDV at Springfield – April 2012



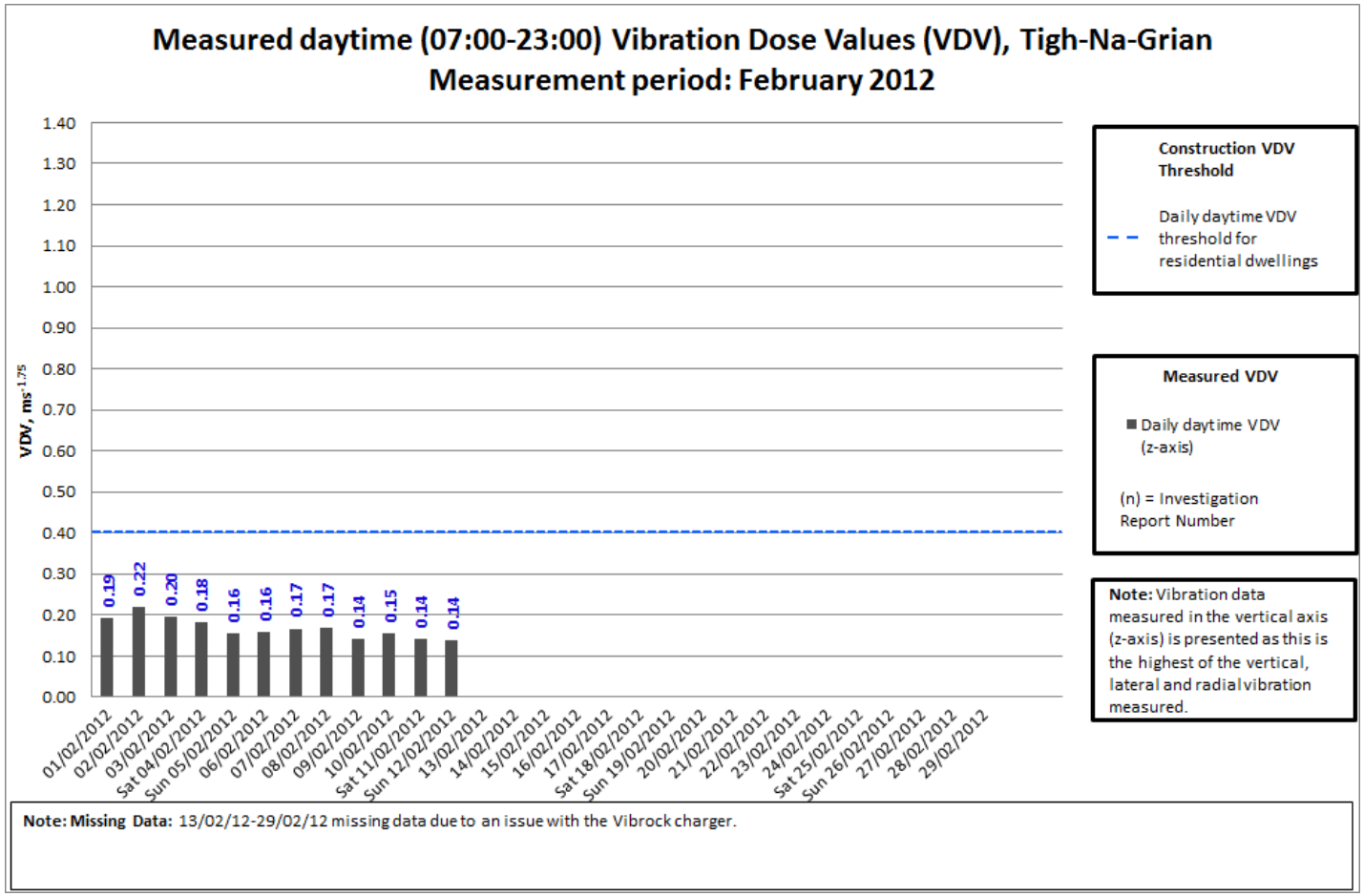
Night-time VDV at Springfield – April 2012



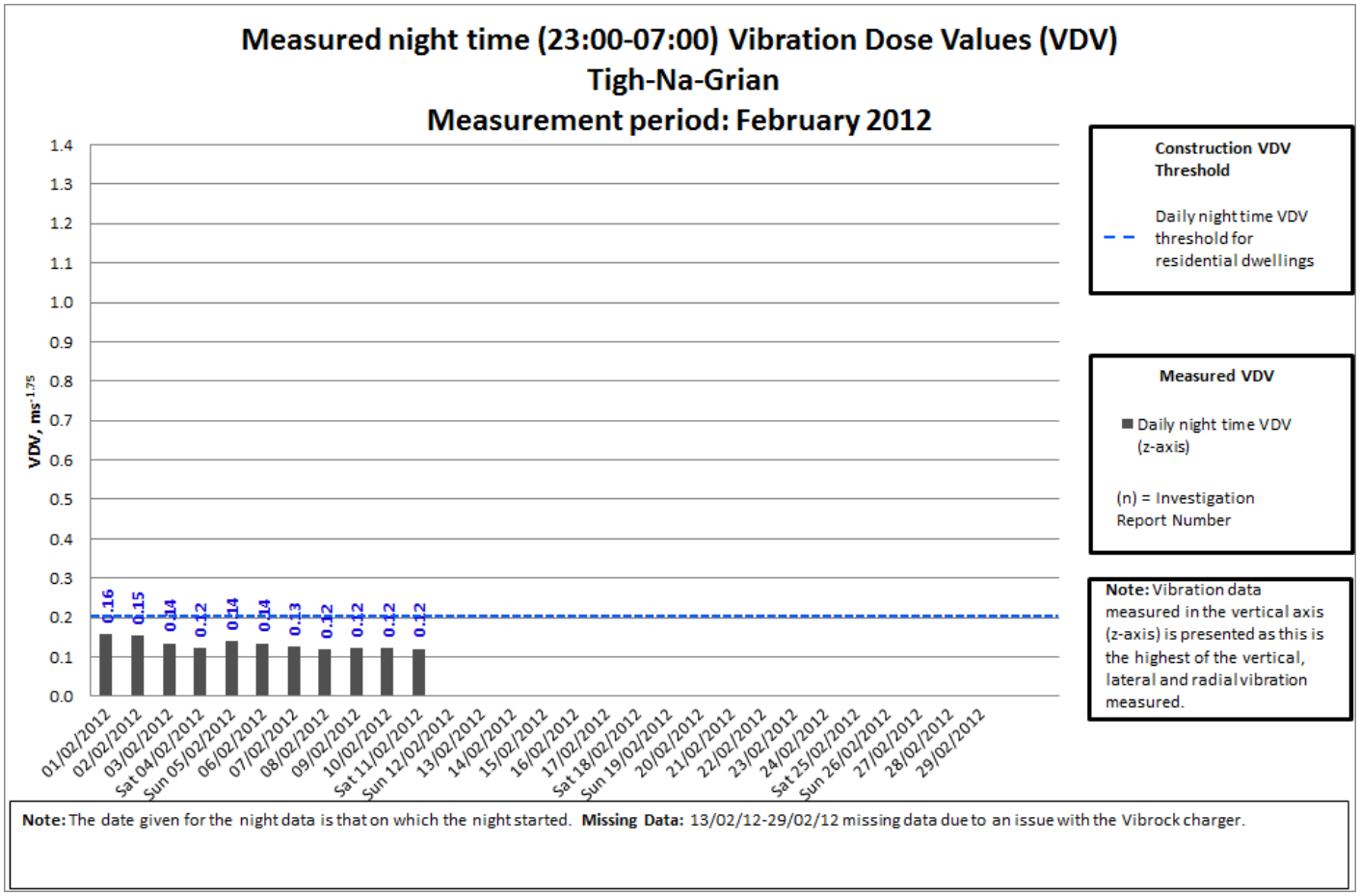
PPV at Tigh-Na-Grian – February 2012



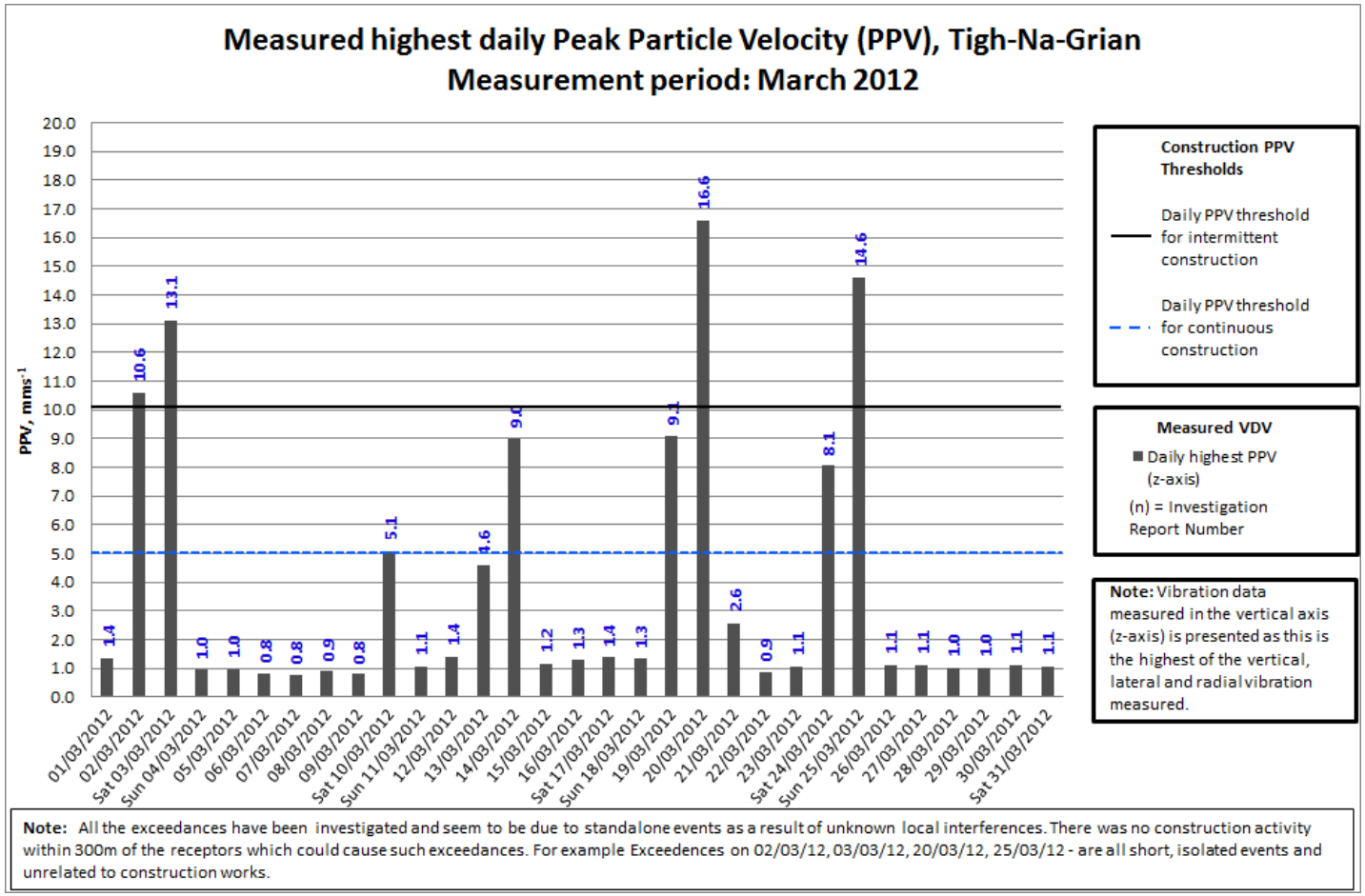
Daytime VDV at Tigh-Na-Grian – February 2012



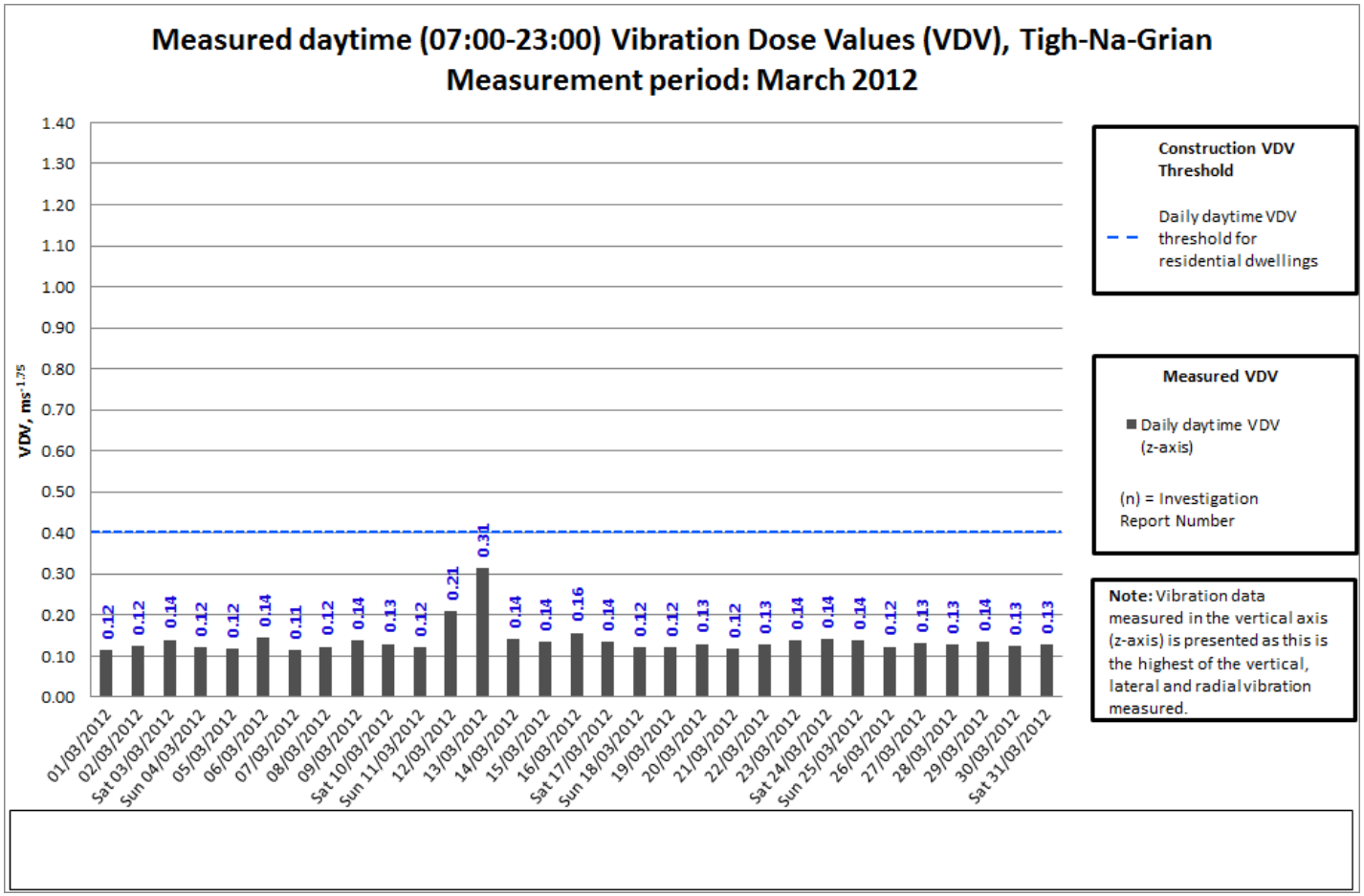
Night-time VDV at Tigh-Na-Grian – February 2012



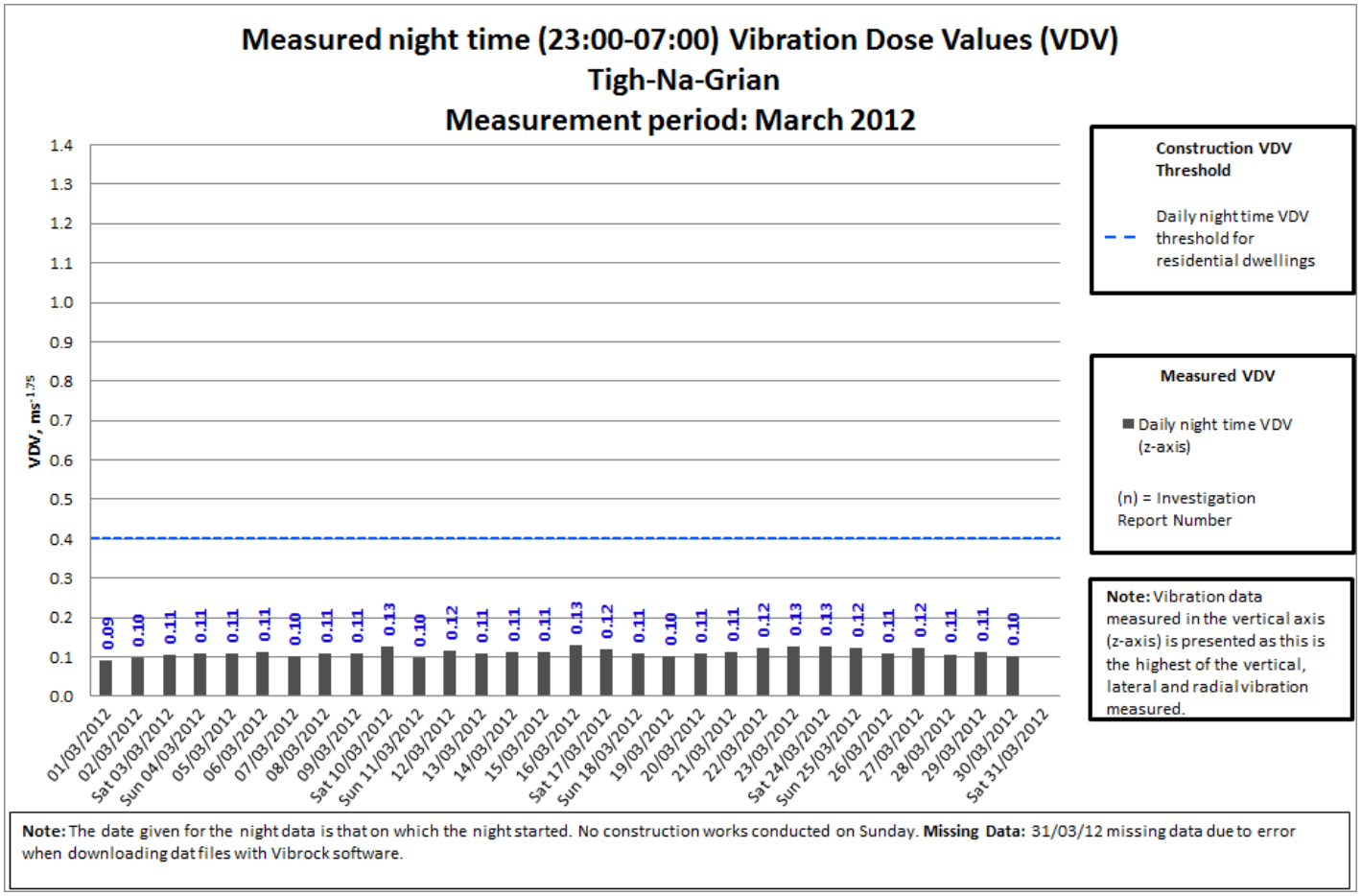
PPV at Tigh-Na-Grian – March 2012



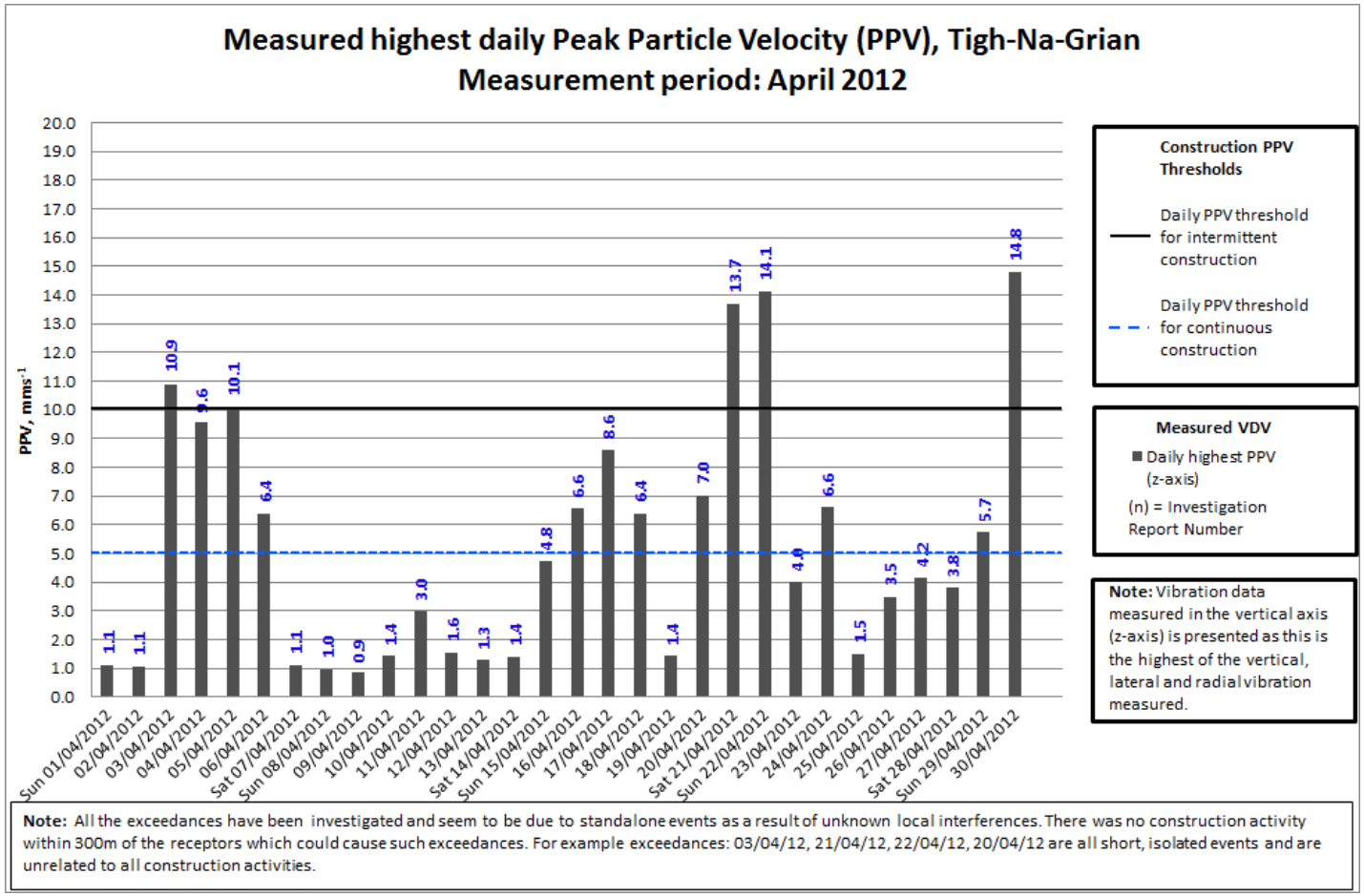
Daytime VDV at Tigh-Na-Grian – March 2012



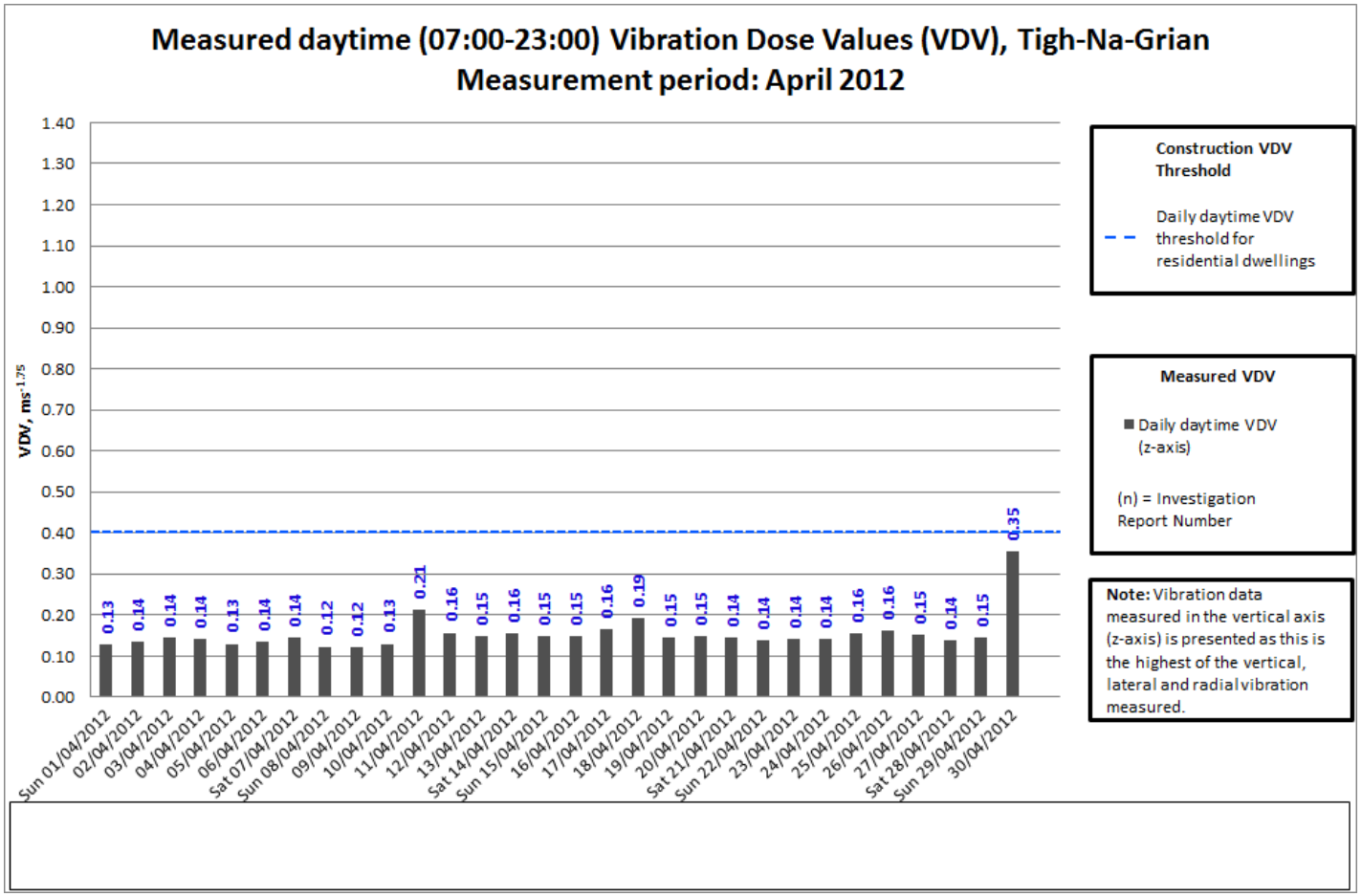
Night-time VDV at Tigh-Na-Grian – March 2012



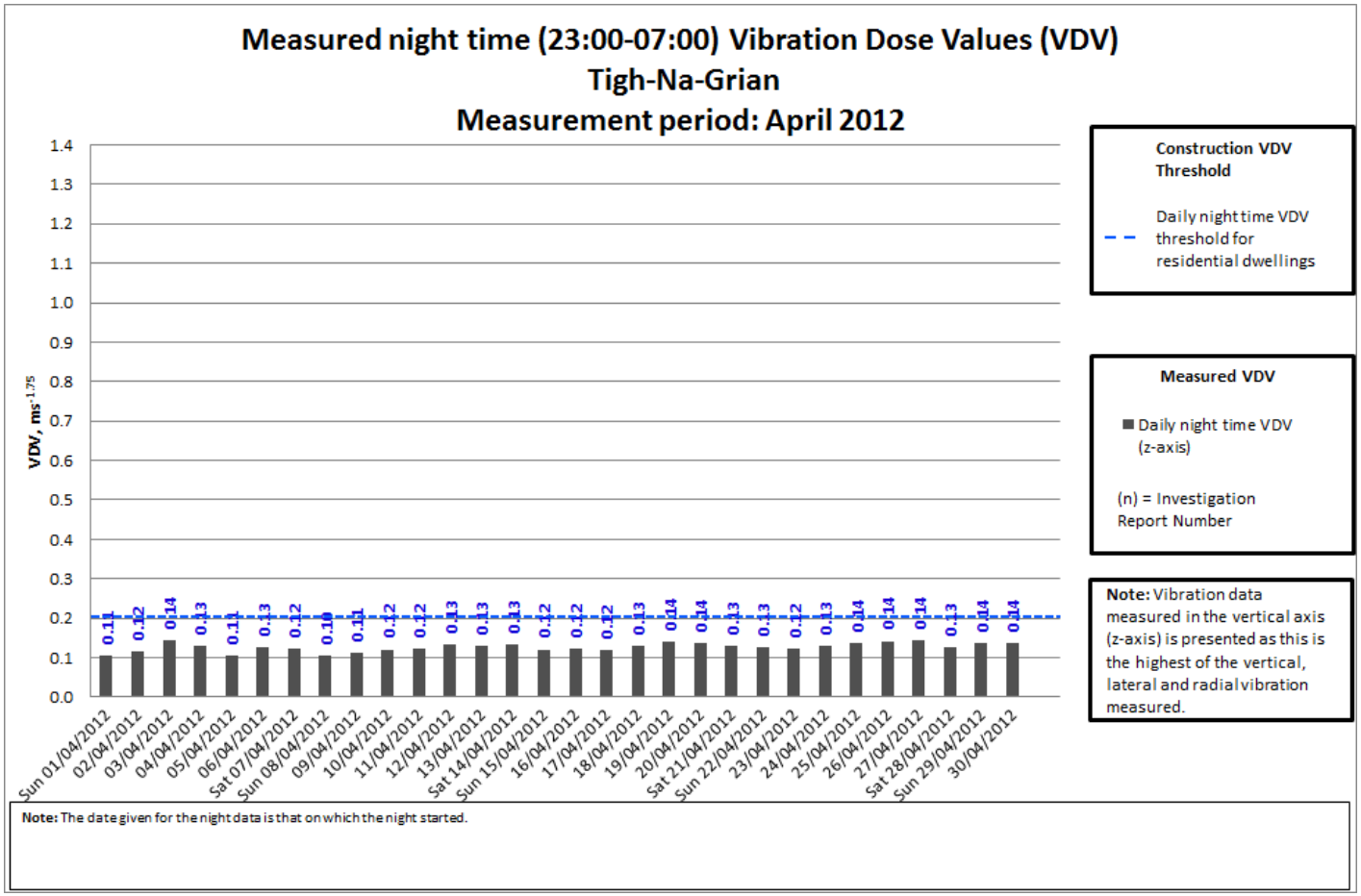
PPV at Tigh-Na-Grian – April 2012



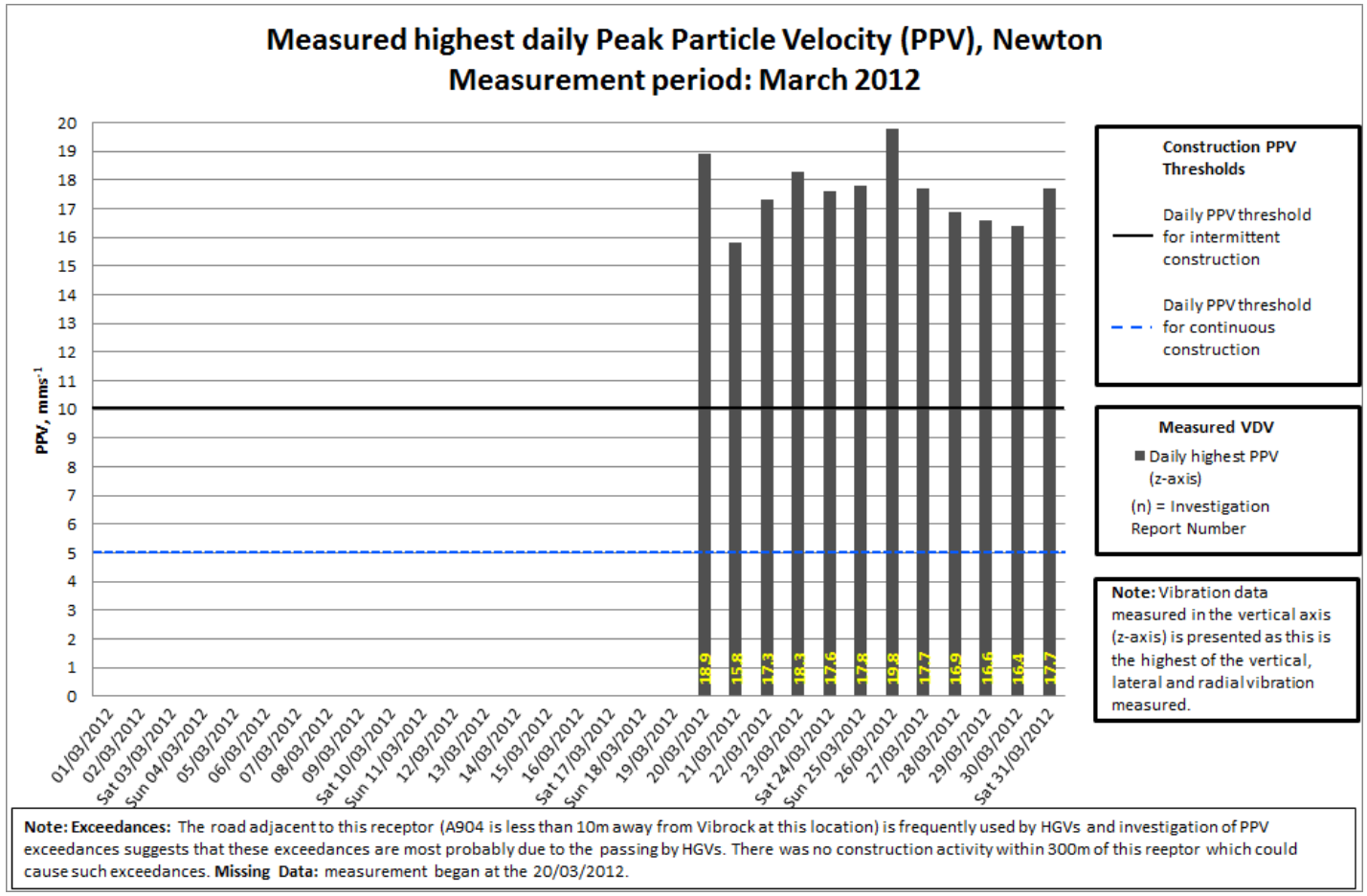
Daytime VDV at Tigh-Na-Grian – April 2012



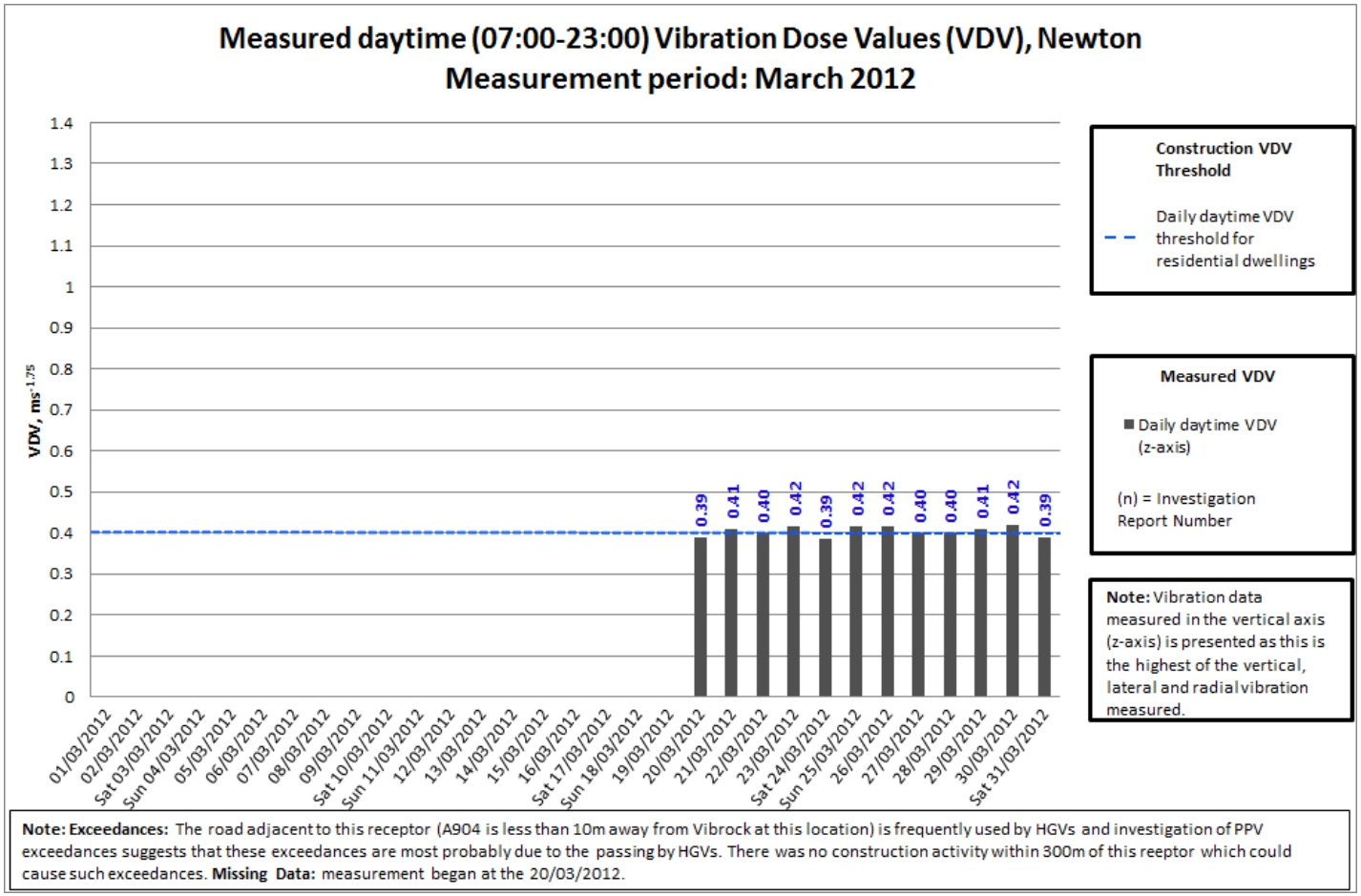
Night-time VDV at Tigh-Na-Grian – April 2012



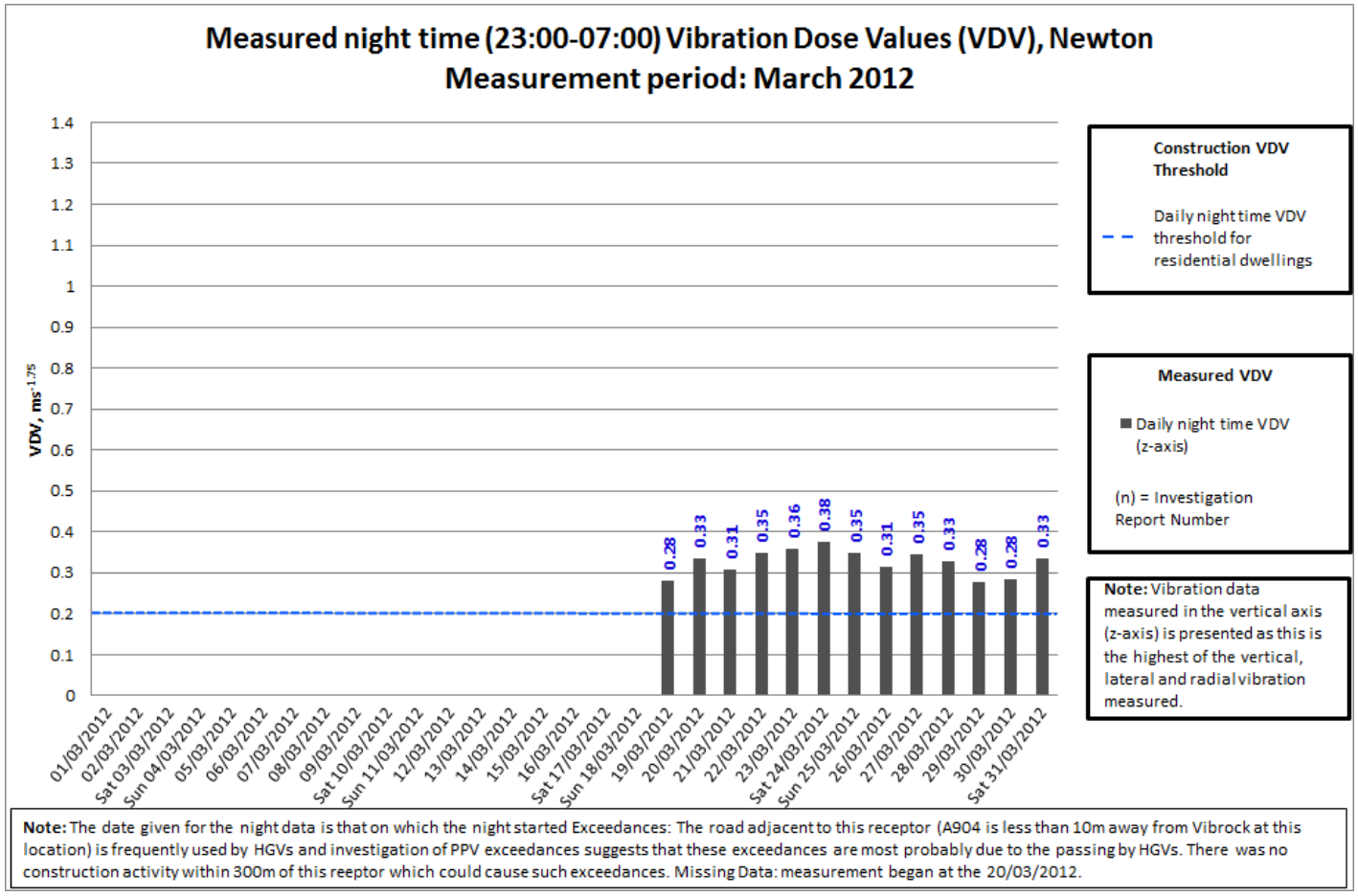
PPV at Newton – March 2012



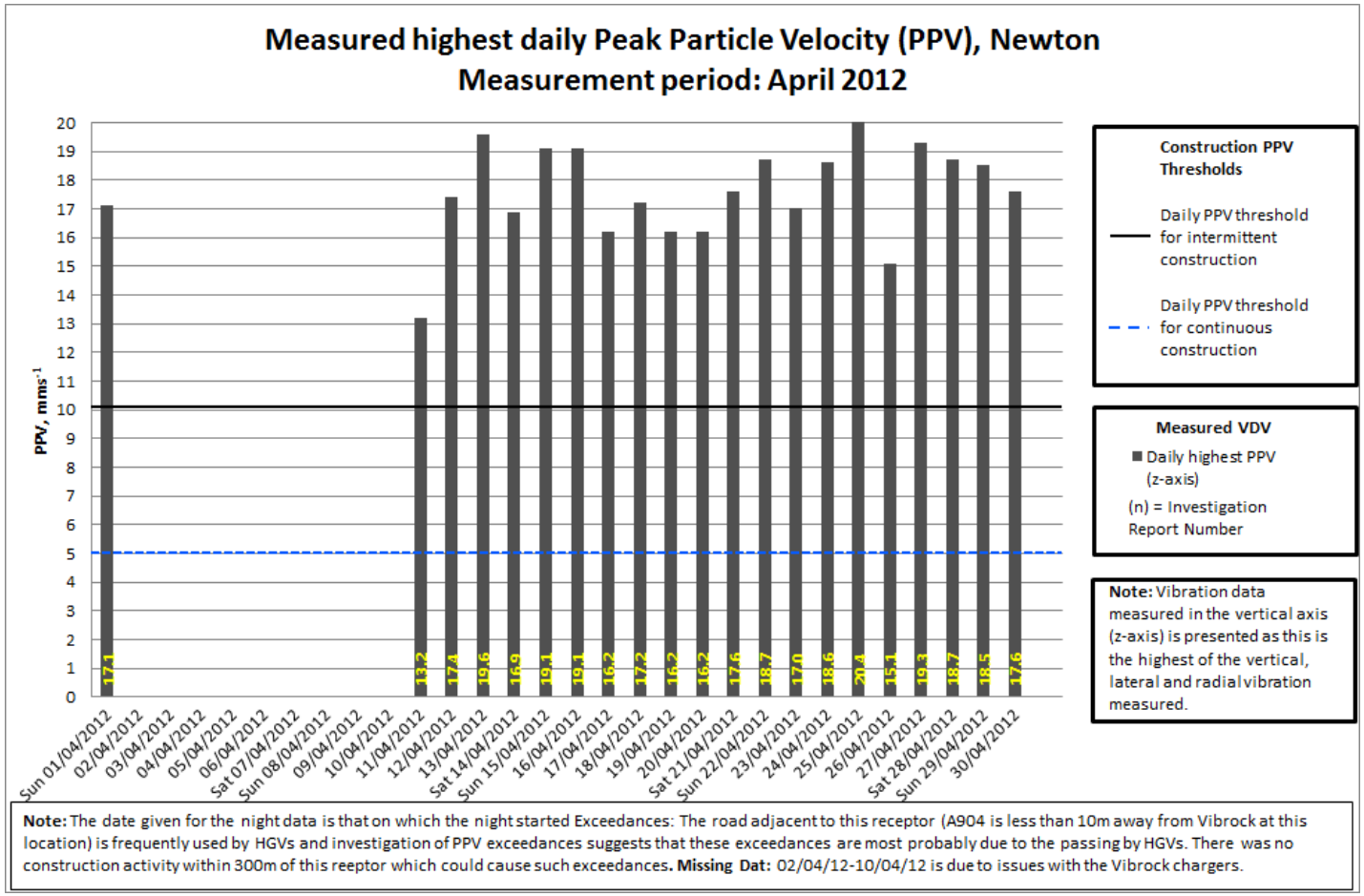
Daytime VDV at Newton – March 2012



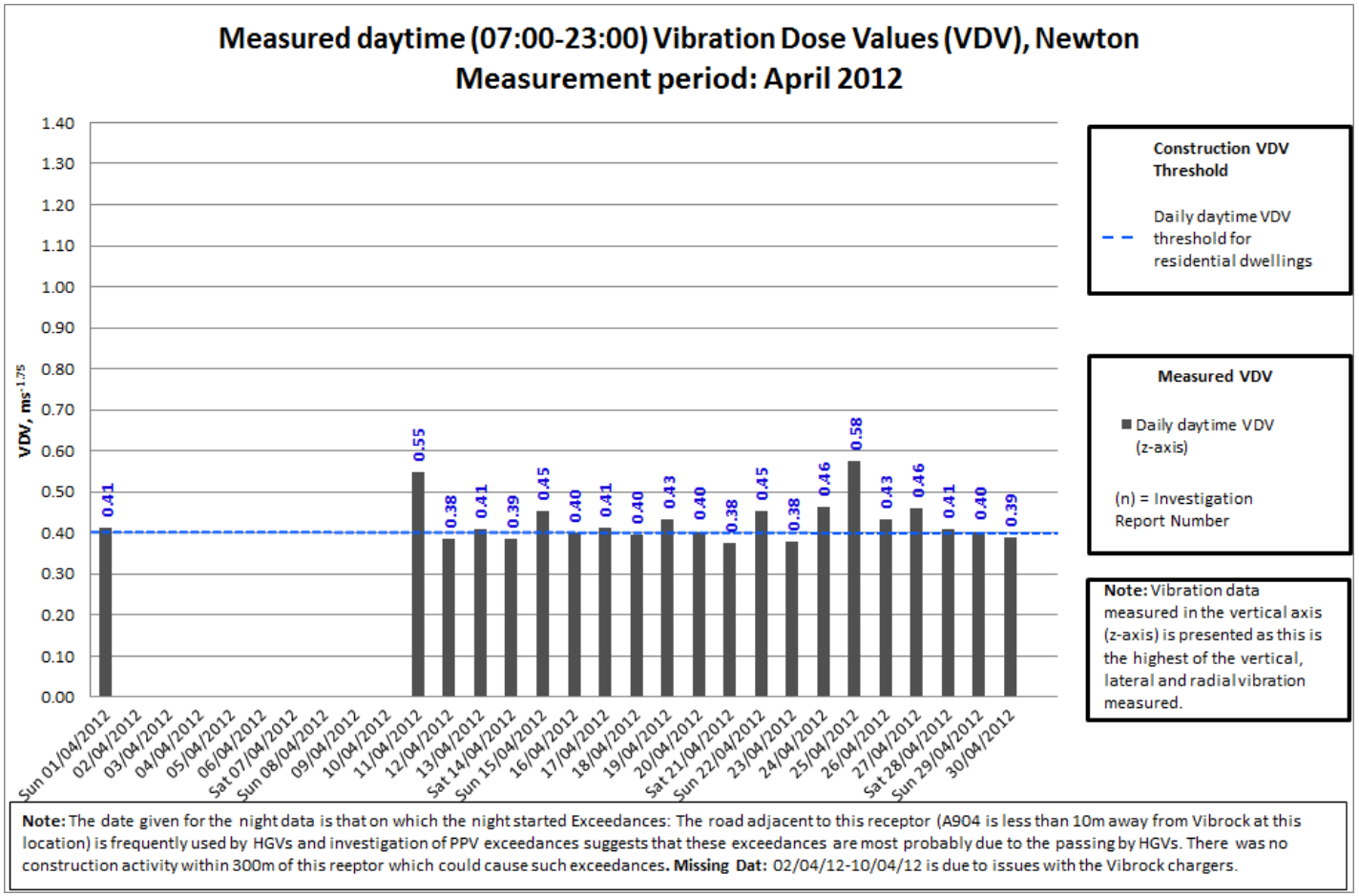
Night-time VDV at Newton – March 2012



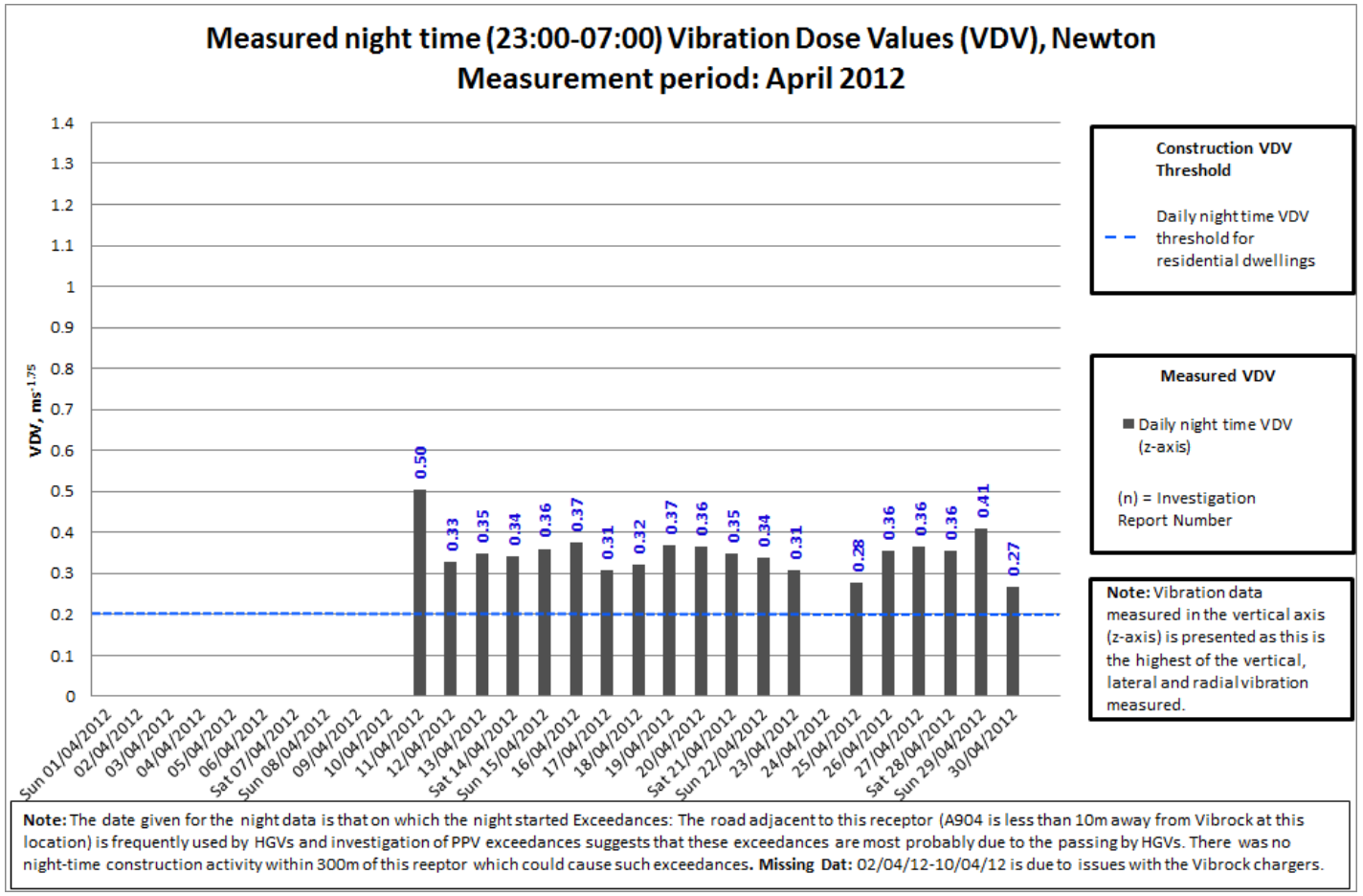
PPV at Newton – April 2012



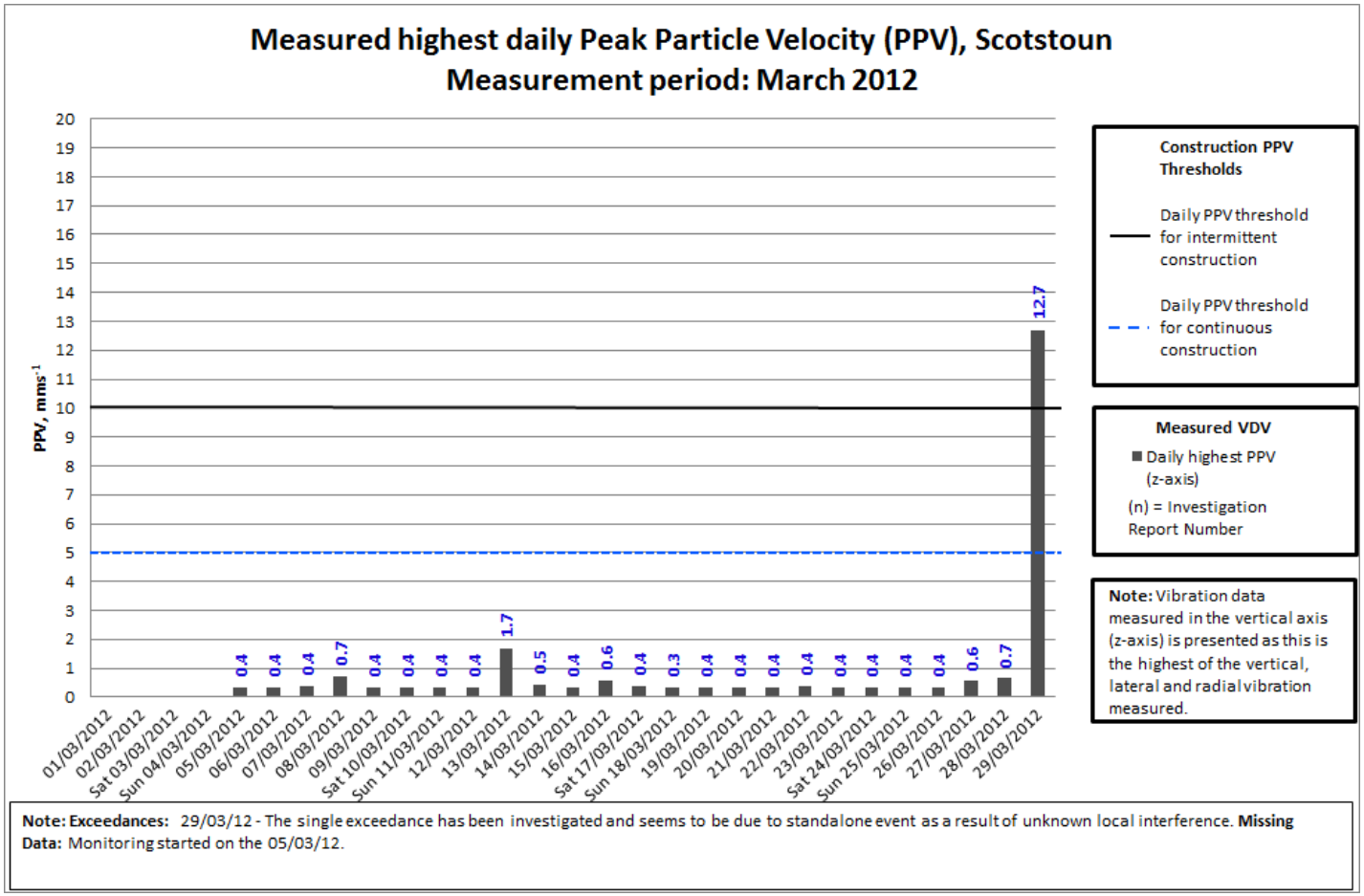
Daytime VDV at Newton – April 2012



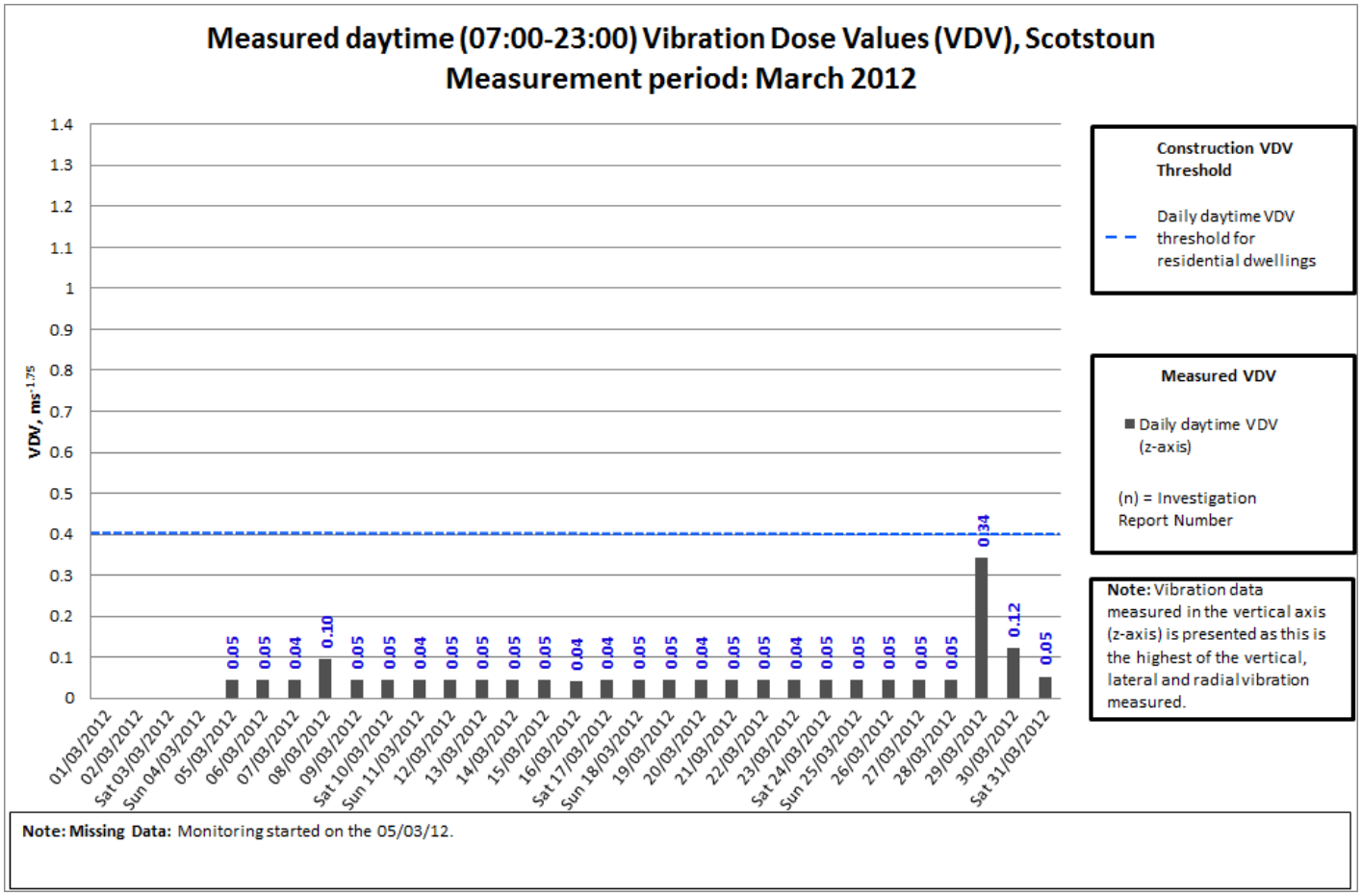
Night-time VDV at Newton – April 2012



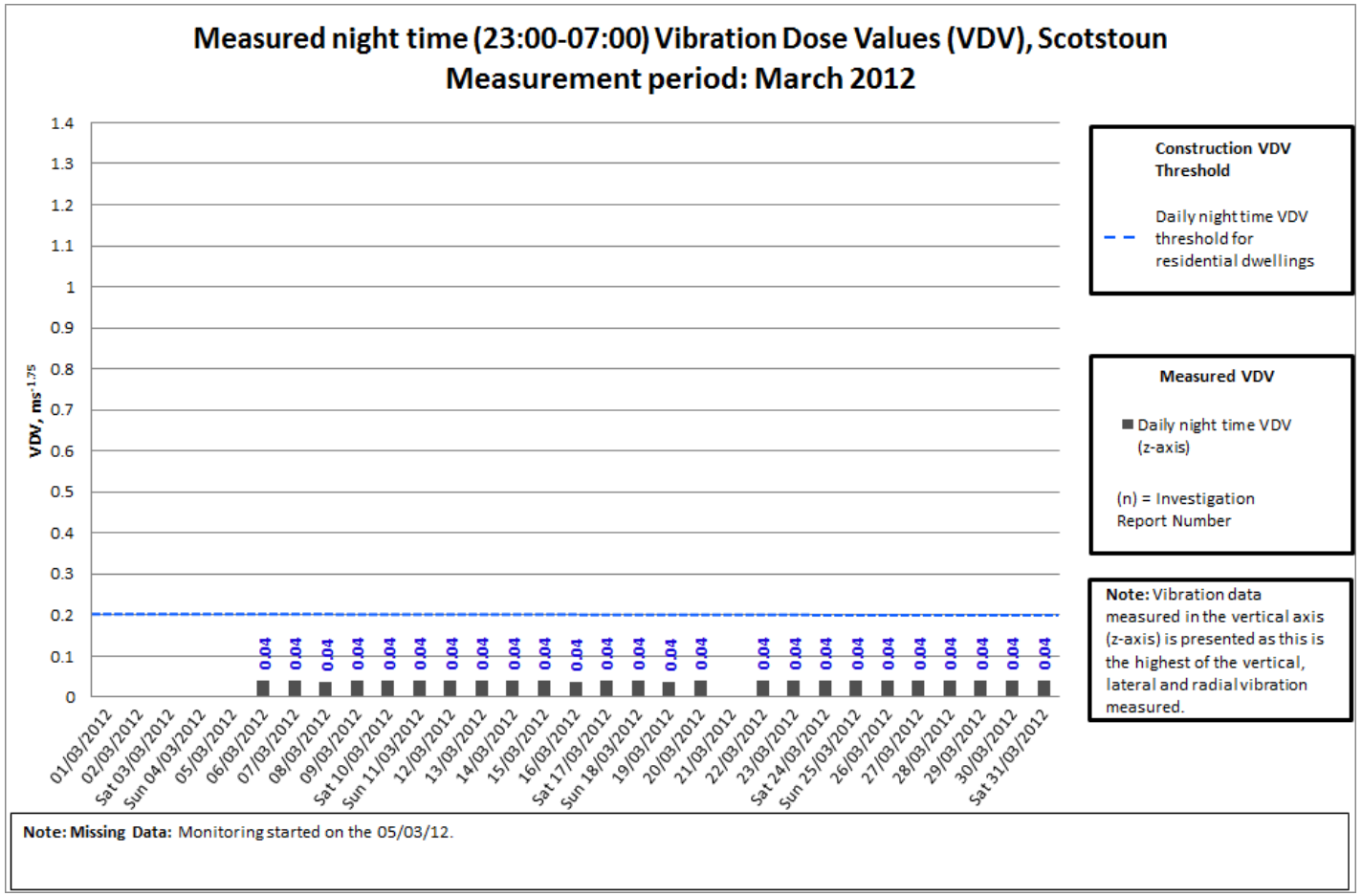
PPV at Scotstoun – March 2012



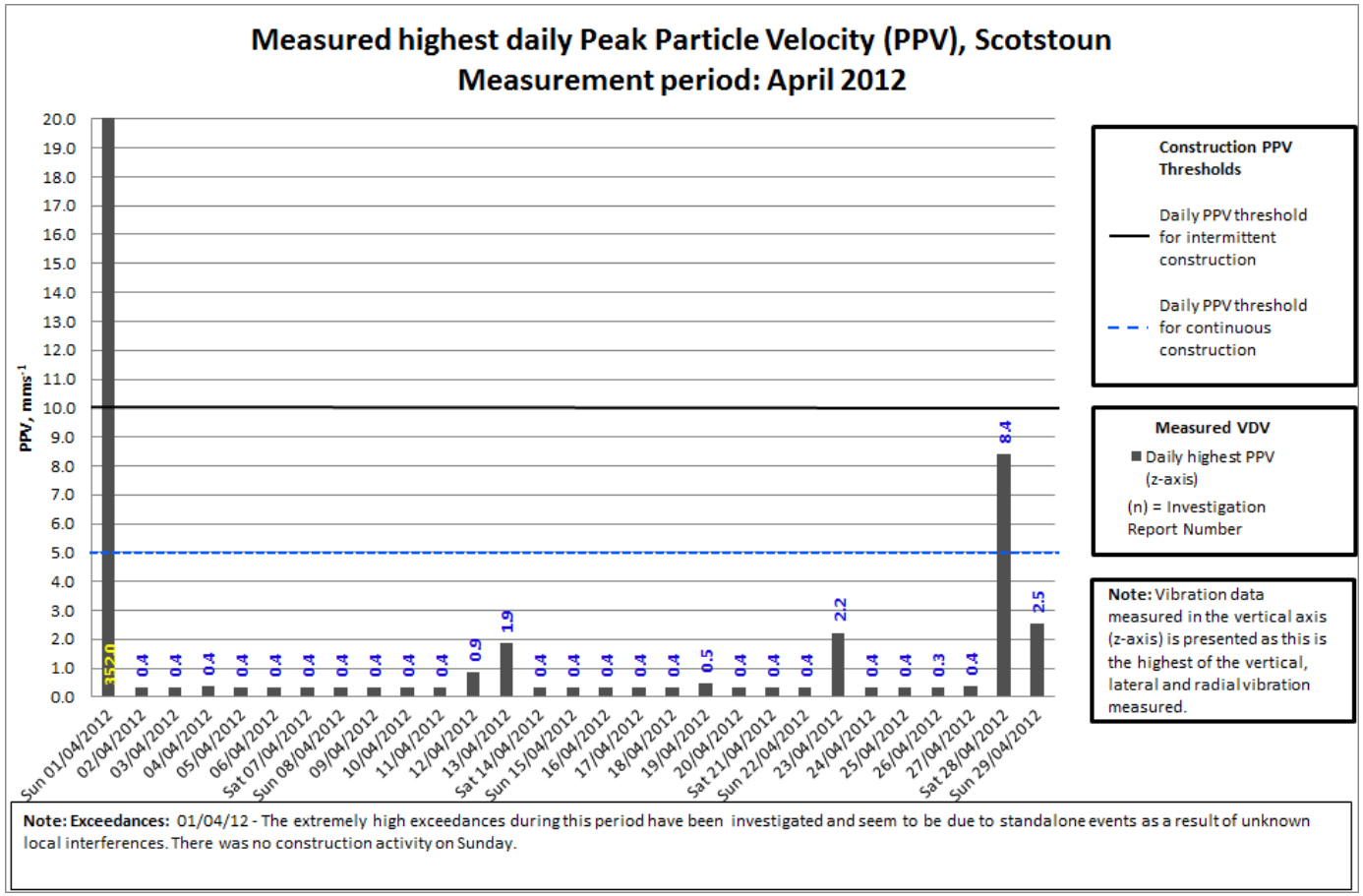
Daytime VDV at Scotstoun – March 2012



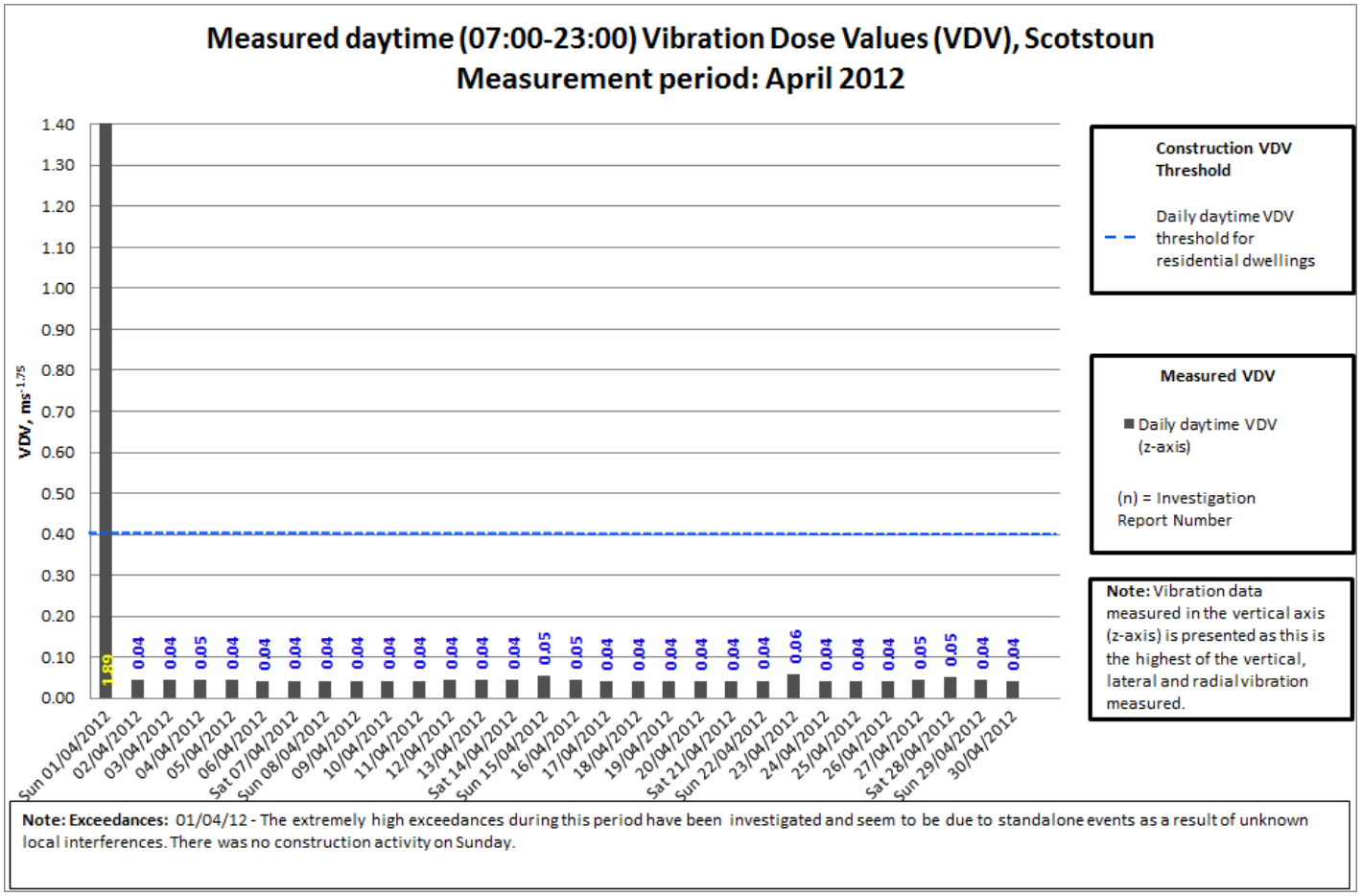
Night-time VDV at Scotstoun – March 2012



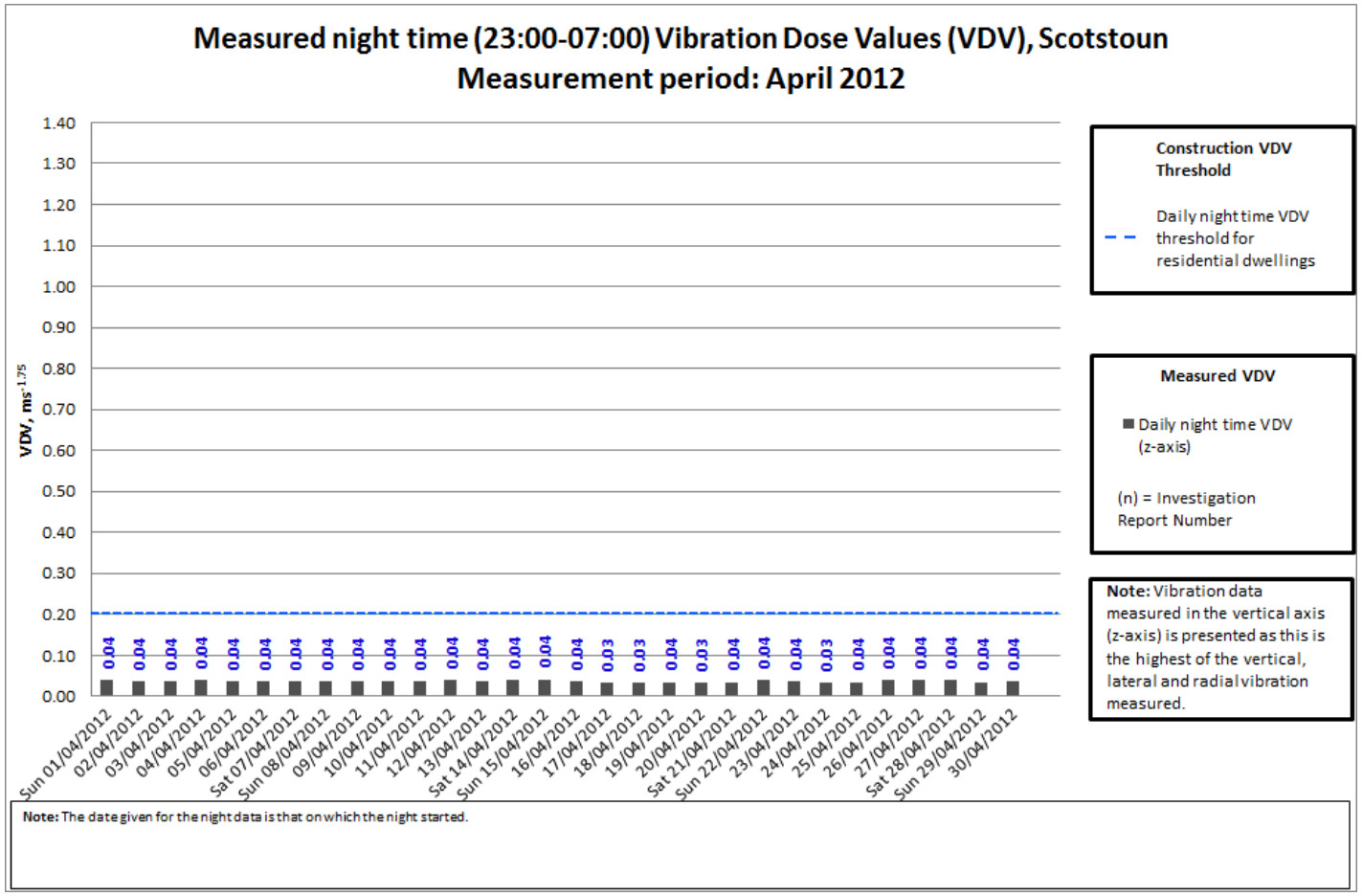
PPV at Scotstoun – April 2012



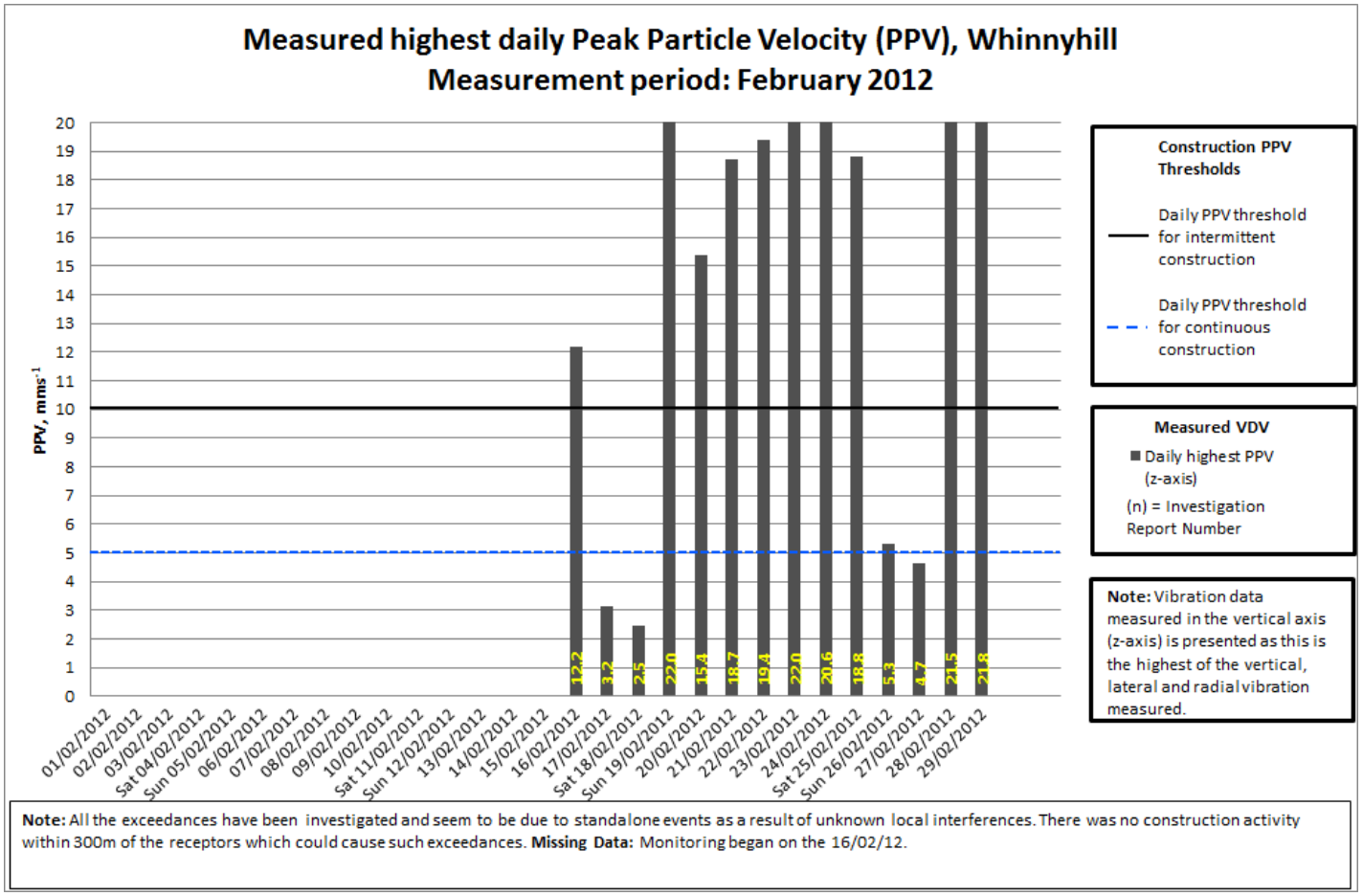
Daytime VDV at Scotstoun – April 2012



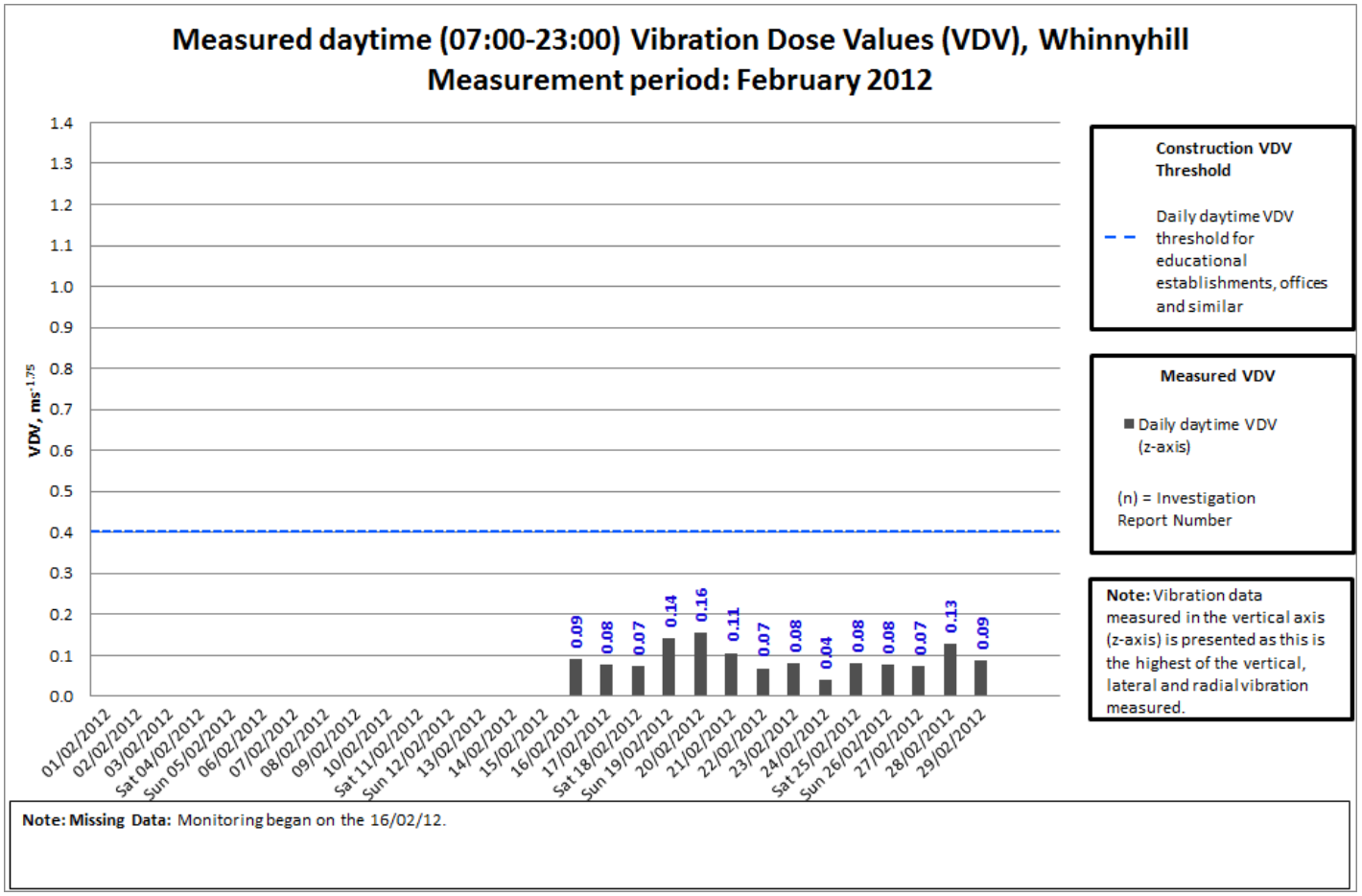
Night-time VDV at Scotstoun – April 2012



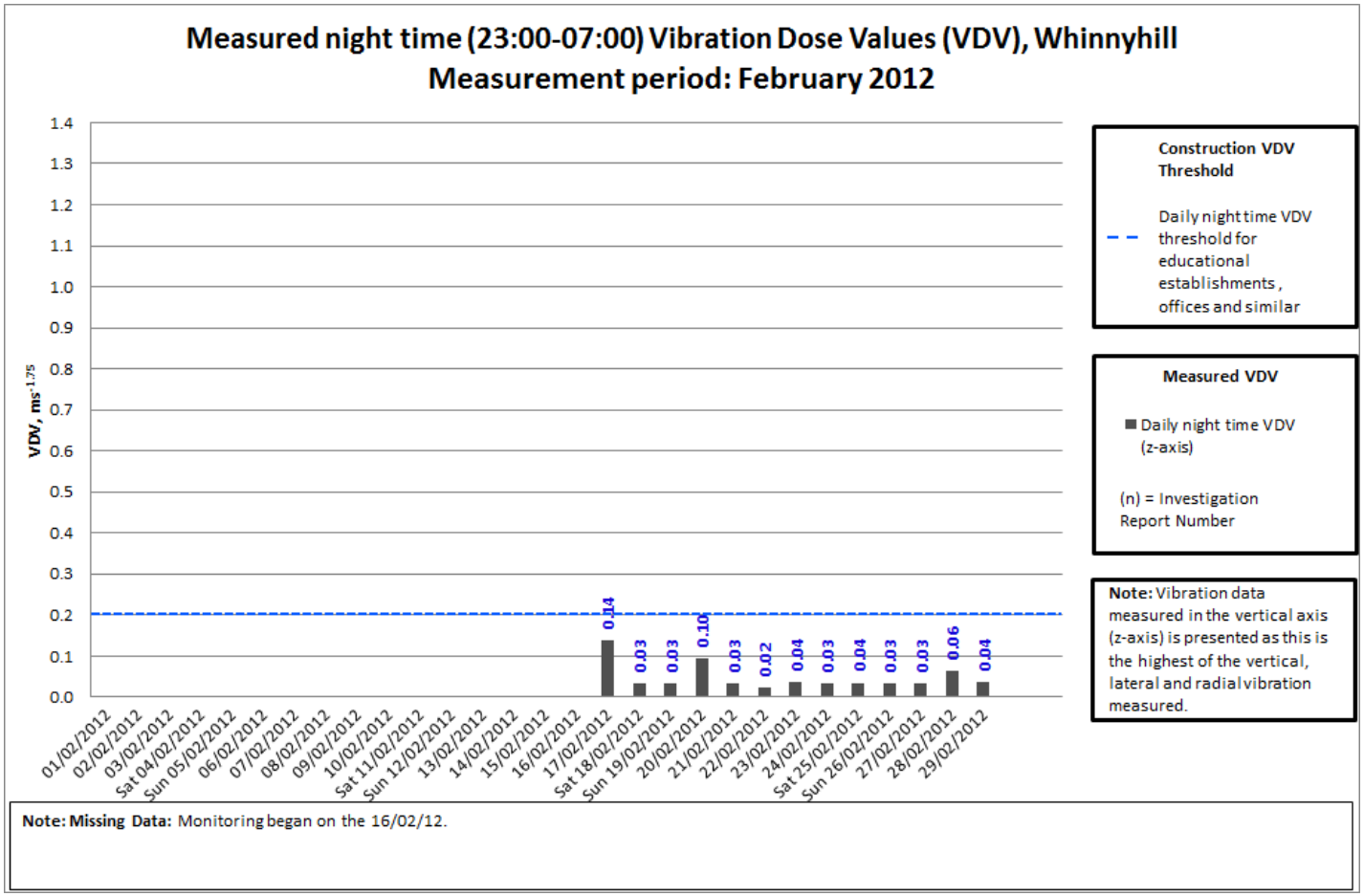
PPV at Whinnyhill – February 2012



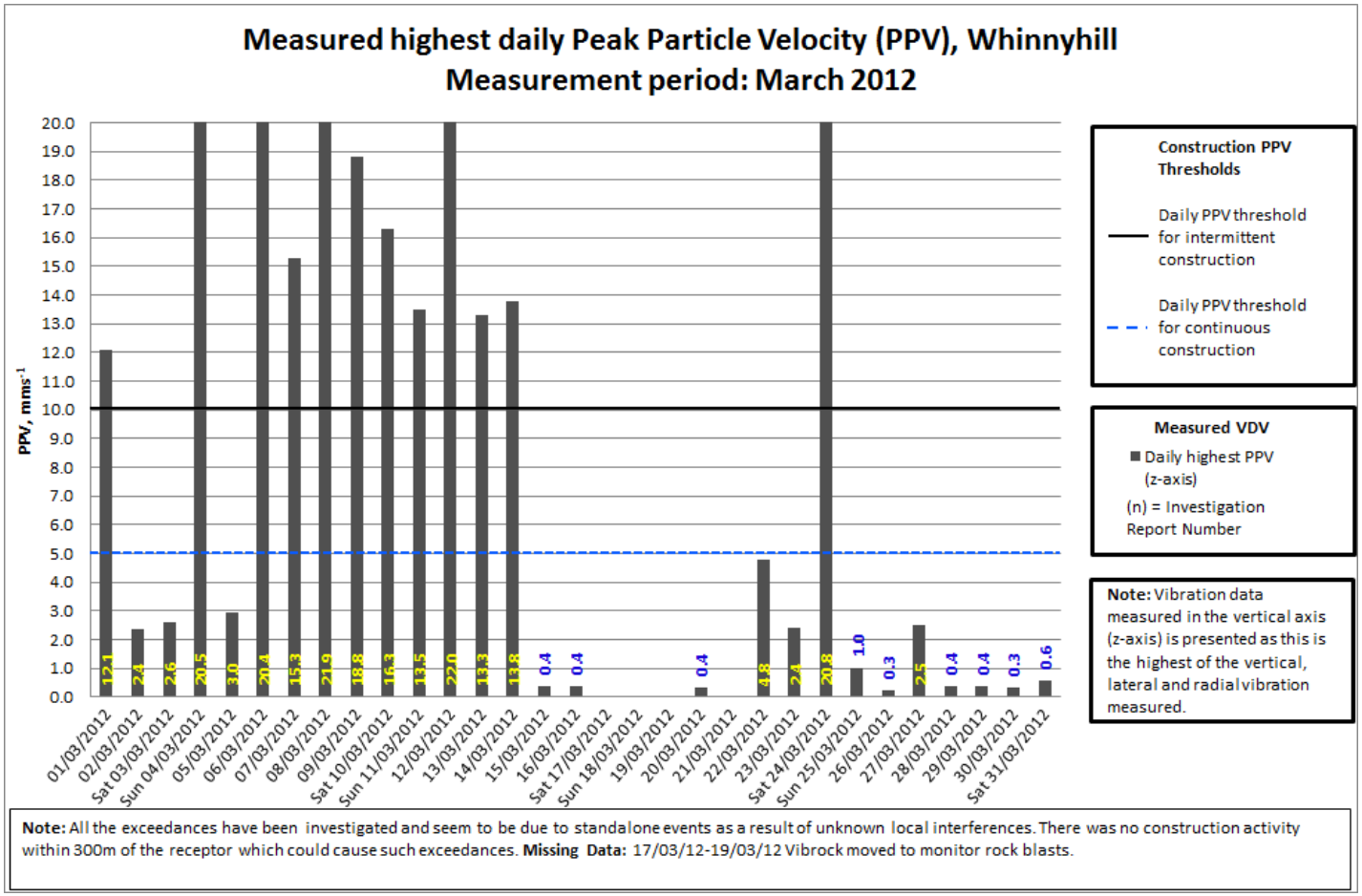
Daytime VDV at Whinnyhill – February 2012



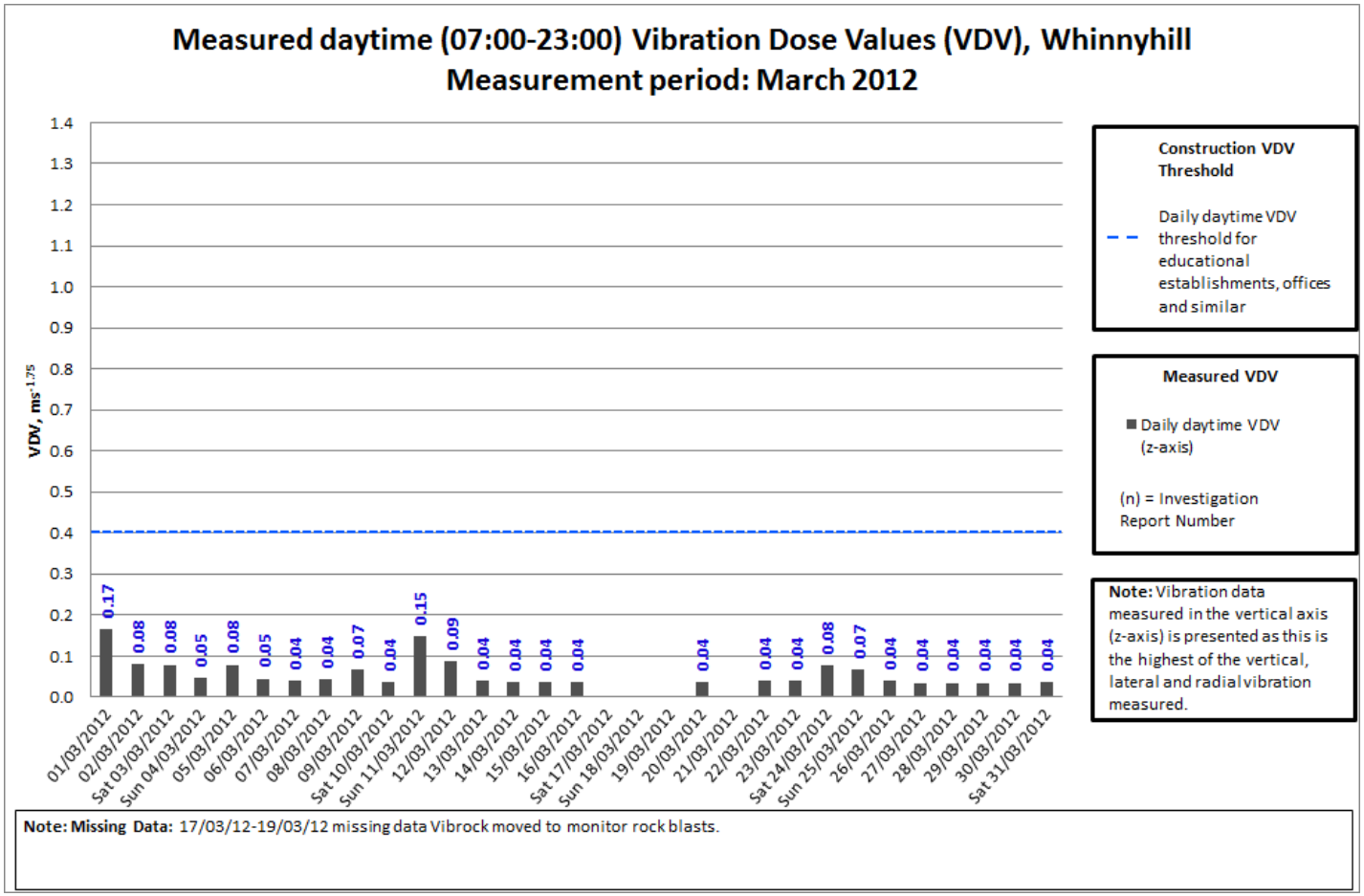
Night-time VDV at Whinnyhill – February 2012



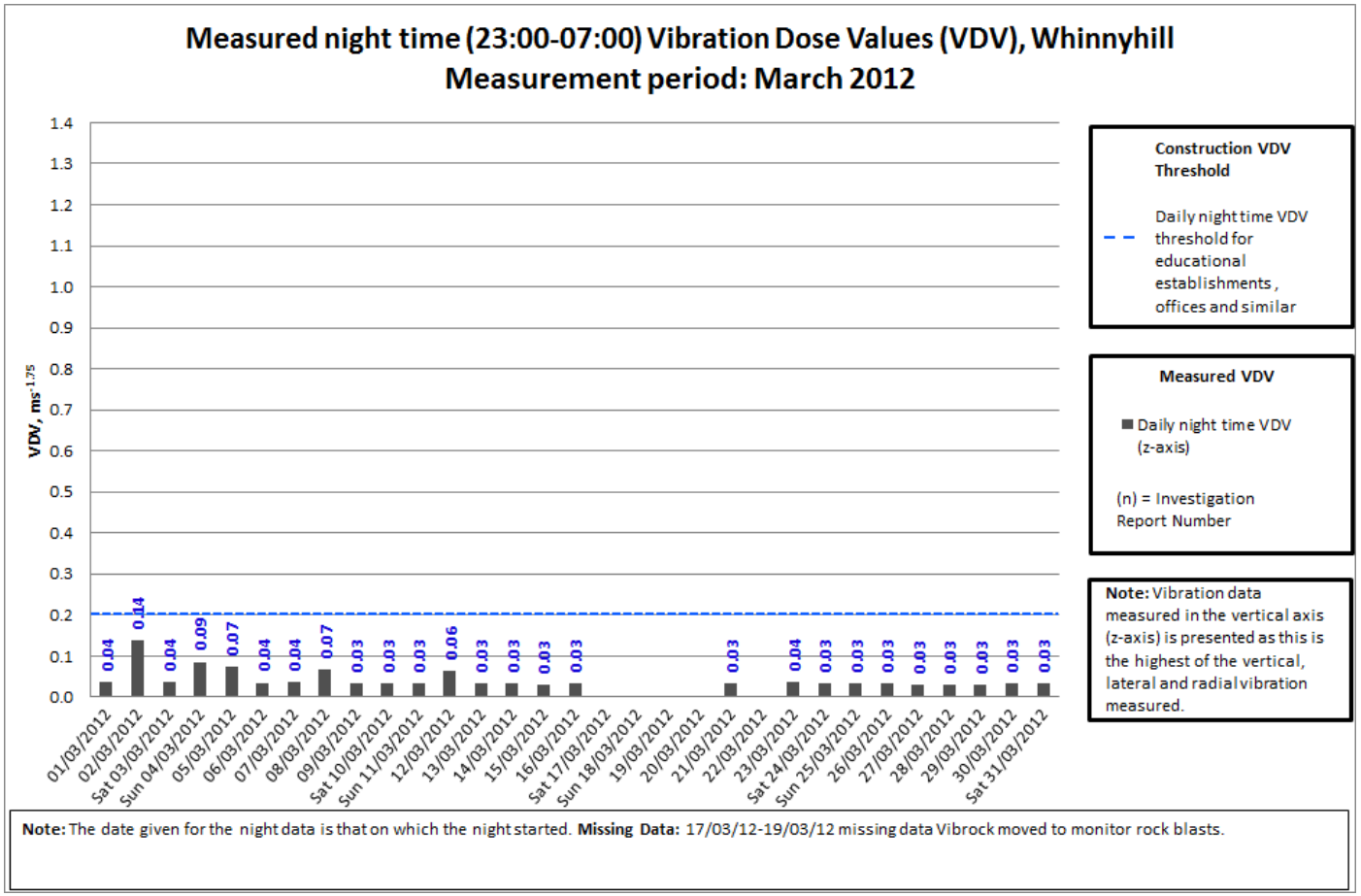
PPV at Whinnyhill – March 2012



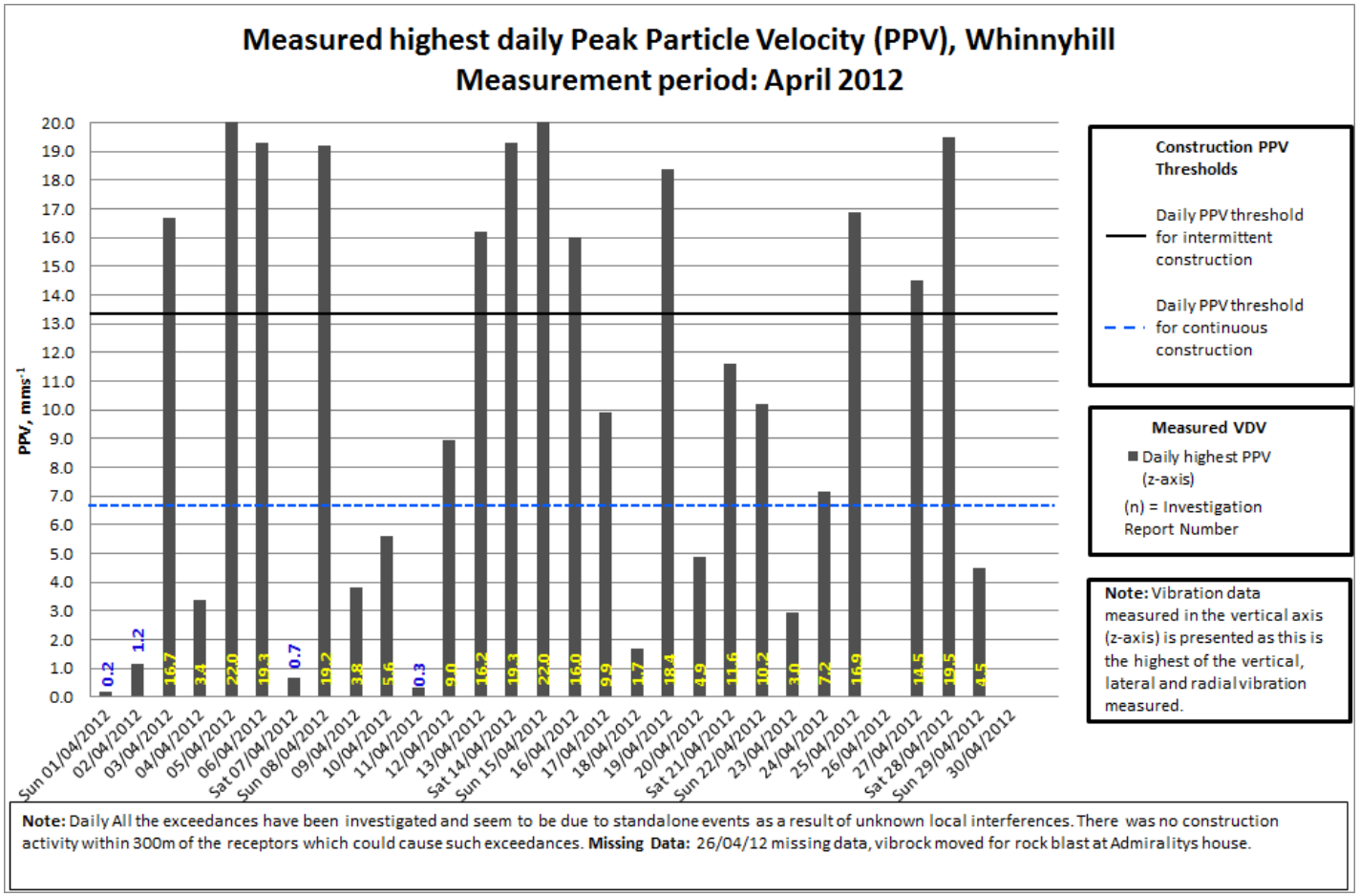
Daytime VDV at Whinnyhill – March 2012



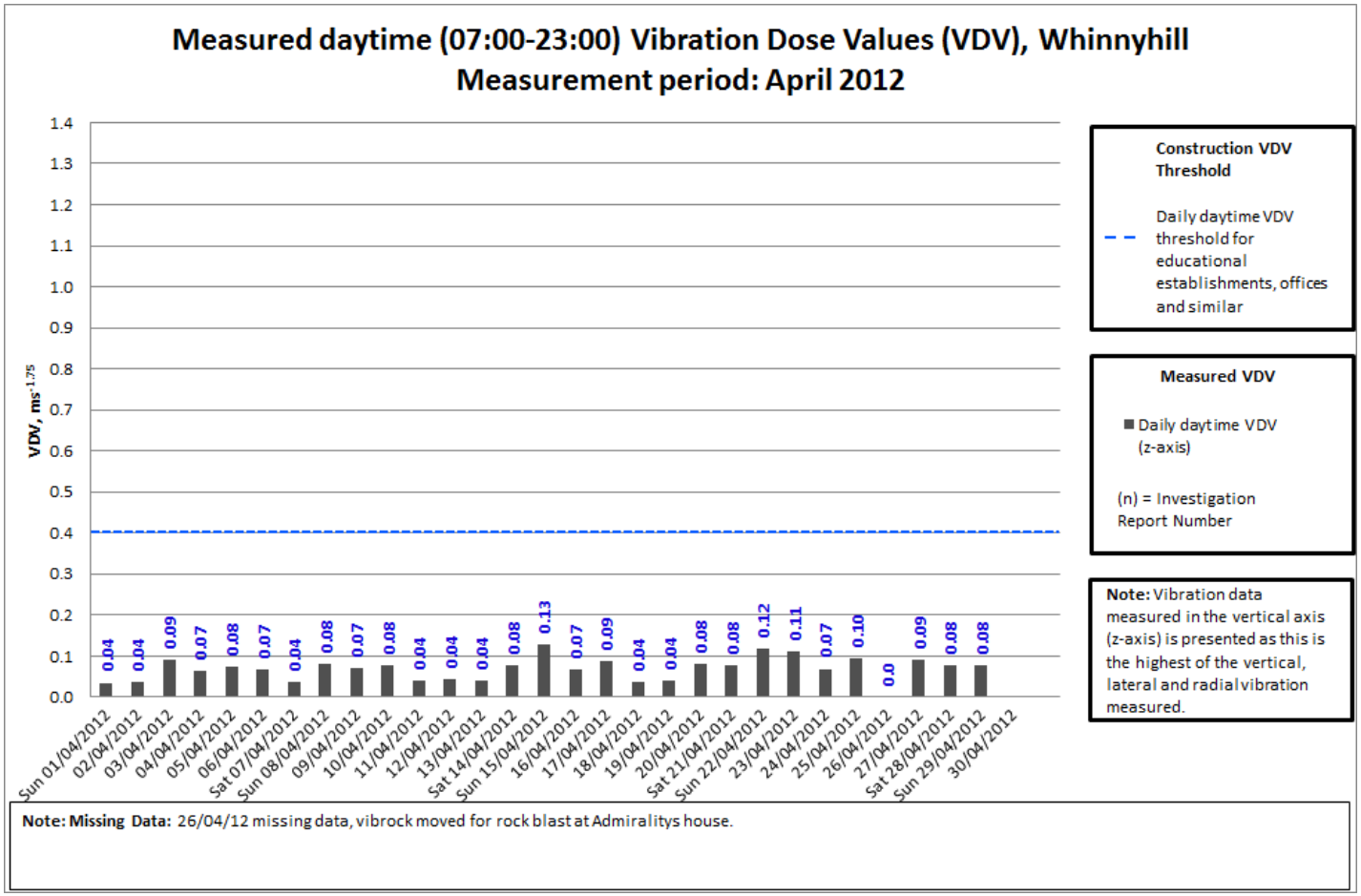
Night-time VDV at Whinnyhill – March 2012



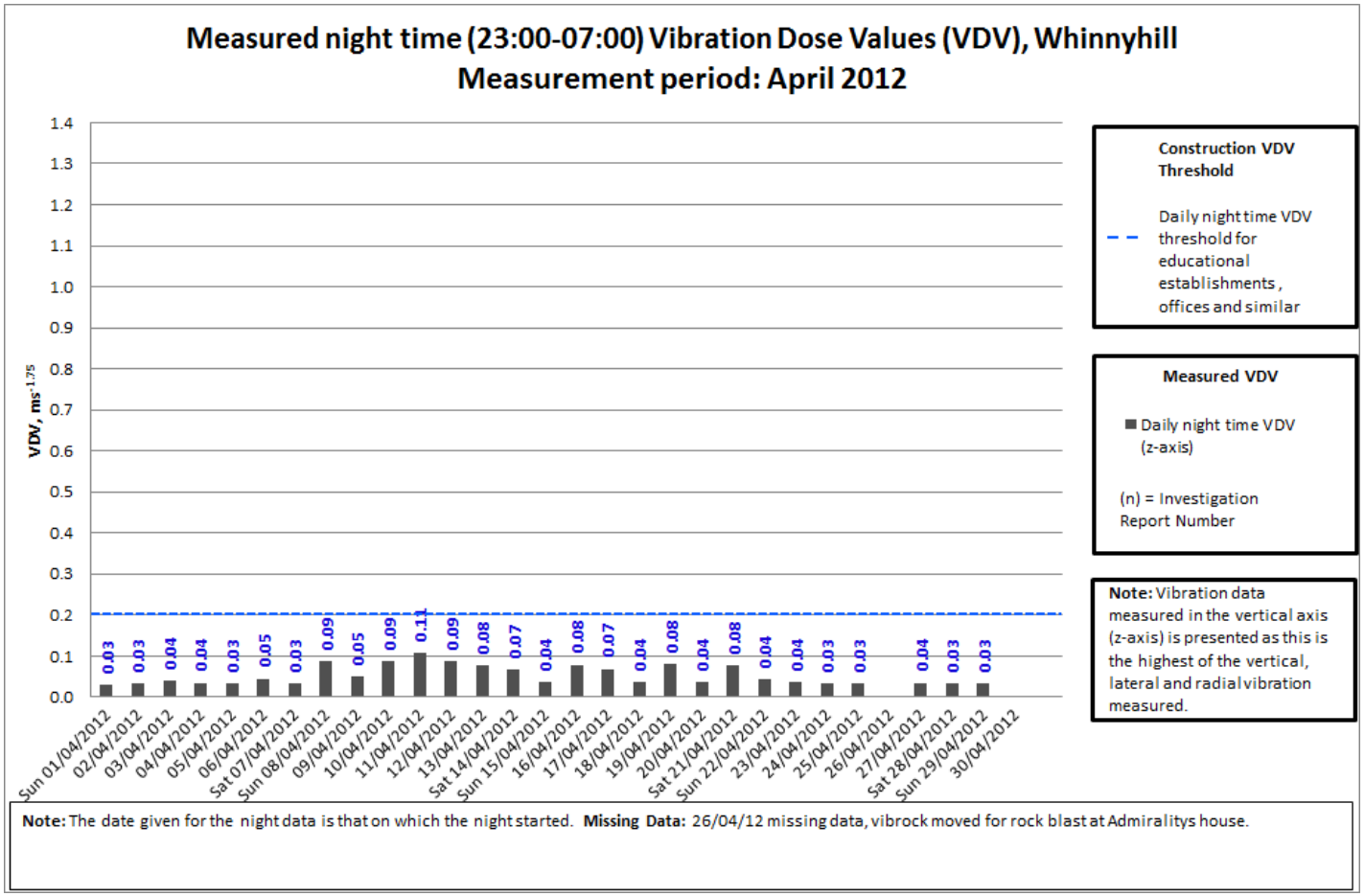
PPV at Whinnyhill – April 2012



Daytime VDV at Whinnyhill – April 2012



Night-time VDV at Whinnyhill – April 2012



APPENDIX C – VIBROCK CALIBRATION CERTIFICATES

CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121562**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1562**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY: 

DATE: **14TH AUGUST 2012**

THIS CERTIFICATE IS VALID FOR 12 MONTHS

The above calibration was carried out using equipment calibrated as follows:-
Pulsar Acoustic Calibrator 100B, serial number 60796, calibrated March 2012
ISO-TECH IFG 100 Oscillator, serial number 300351, calibrated June 2012
Monitran Vibration Meter, serial number 213608, calibrated June 2012
Precision Gold PG012 Multimeter, serial number 09000182, calibrated June 2012

THIS CALIBRATION IS TRACEABLE TO NATIONAL STANDARDS

VIBROCK LIMITED
Shanakiel
Ilkeston Road
Heanor
Derbyshire DE75 7DR
Tel: 01773 711211
Fax: 01773 711311
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Web: www.vibrock.com

VIBROCK

CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121563**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1563**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5%	±5%	X ±5%
Peak Particle Velocity V	±5%	±5%	Y ±5%
Peak Particle Velocity T	±5%	±5%	Z ±5%

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY: 

DATE: **14TH AUGUST 2012**

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CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121564**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1564**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY: 

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CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121565**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1565**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

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VIBROCK

CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121567**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1567**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY: 

DATE: **14TH AUGUST 2012**

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VIBROCK

CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121568**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1568**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY: 

DATE: **14TH AUGUST 2012**

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CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121569**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1569**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

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DATE: **14TH AUGUST 2012**

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CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121570**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1570**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

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CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121571**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1571**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted n/a dB(Lin)

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DATE: **14TH AUGUST 2012**

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CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121572**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1572**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

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CERTIFIED BY: 

DATE: **14TH AUGUST 2012**

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VIBROCK

CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121612**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1612**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

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Heanor
Derbyshire DE75 7DR
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CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: **08121613**

CLIENT: **Forth Crossing Bridge Constructors**

INSTRUMENT TYPE: **V901-GSM**

SERIAL NUMBER: **1613**

CALIBRATION DATE: **14TH AUGUST 2012**

CALIBRATED BY: **DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X ±5 %
Peak Particle Velocity V	±5 %	±5 %	Y ±5 %
Peak Particle Velocity T	±5 %	±5 %	Z ±5 %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

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