



Contractor



Forth Crossing Bridge Constructors

HOCHTIEF Solutions
American Bridge International
DRAGADOS
Morrison Construction

Project **FORTH REPLACEMENT CROSSING**

Document title

**VIBRATION MONITORING REPORT
AUG 2012 TO OCT 2012**

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Contents

- 1. Introduction**
- 2. Monitoring Summary**
- 3. Conclusion**

Appendices:

Appendix A: Vibration Assessments of Relevant PCNVs

Appendix B: PPV and VDV Graphs

Appendix C: Certificates of Calibrations of the VIBROCKs

1. 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

August

Location	PPV Exceedance		VDV Exceedance	
	<i>Continuous (5 mm.s⁻¹)</i>	<i>Intermittent (10 mm.s⁻¹)</i>	<i>Day (0.4 m.s^{-1.75})</i>	<i>Night (0.2 m.s^{-1.75})</i>
Clufflat Brae	2	3	0	0
5 Linn Mill	4	13	1	0
Butlaw Fisheries	0	1	1	0
Dundas Home Farm	0	0	0	1
Echline	1	0	0	0
Inchgarvie Lodge	0	1	0	0
Springfield	1	2	11	28
Newton	1	6	3	8
Scotstoun	2	8	1	0
Whinnyhill	6	10	0	16

September

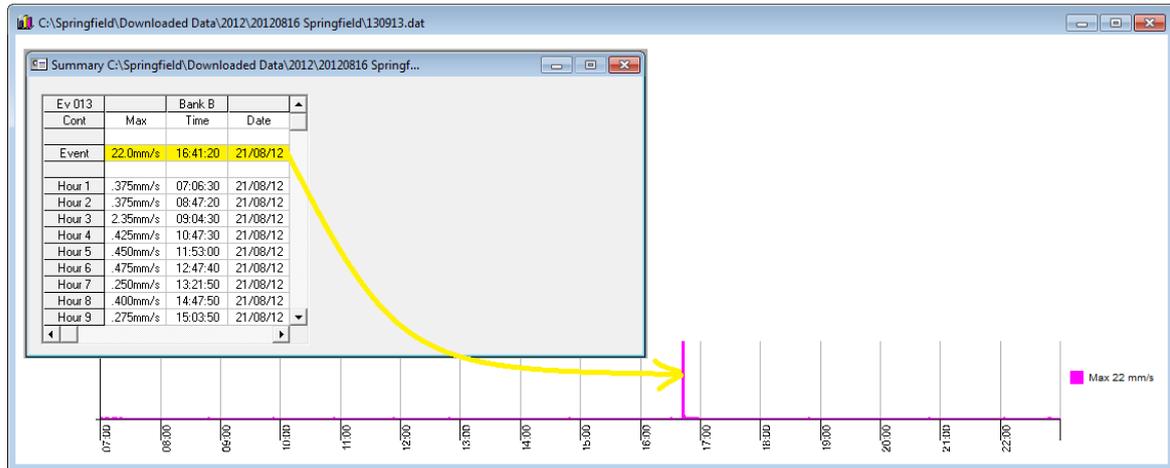
Location	PPV Exceedance		VDV Exceedance	
	<i>Continuous (5 mm.s⁻¹)</i>	<i>Intermittent (10 mm.s⁻¹)</i>	<i>Day (0.4 m.s^{-1.75})</i>	<i>Night (0.2 m.s^{-1.75})</i>
Clufflat Brae	4	6	2	13
5 Linn Mill	0	2	0	0
Butlaw Fisheries	0	0	0	0
Dundas Home Farm	0	0	0	5
Inchgarvie Lodge	0	0	0	0
Springfield	0	0	12	29
Newton	3	27	2	13
Whinnyhill	4	4	1	16

October

Location	PPV Exceedance		VDV Exceedance	
	<i>Continuous (5 mm.s⁻¹)</i>	<i>Intermittent (10 mm.s⁻¹)</i>	<i>Day (0.4 m.s^{-1.75})</i>	<i>Night (0.2 m.s^{-1.75})</i>
Clufflat Brae	0	18	4	23
Butlaw Fisheries	0	0	0	0
Dundas Home Farm	1	0	0	6
Inchgarvie Lodge	1	0	0	0
Springfield	3	1	28	31
Tigh-Ni-Grian	3	4	0	1
Scotstoun	0	0	0	0
Echline	1	0	0	0
Whinnyhill	3	3	2	26

- 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 VDV in $\text{m.s}^{-1.75}$.
- 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 22

mm.s⁻¹, which occurred on 21/08/12. As can be seen, this was an isolated event which appears to be due to sources other than construction activities.



2.1. 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
PCNV-00011	Aug 12 to Oct 12	Land Based Piers	<ol style="list-style-type: none"> 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. 	<p>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 generate appreciable levels of vibration due to the distance from the closest receptor. Equipment to be used in all other activities does not generate appreciable levels of vibration and therefore no assessment has been undertaken.</p> <p>VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefore 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.</p>

Butlaw Fisheries				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00014	Aug 12 to Sept 12	Dredging Works	<p>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 S5 and 50,000 cu m from the northern tower and pier N1.</p> <p>The dredging will be completed by the following plant:</p> <ul style="list-style-type: none"> • 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.
PCNV-00020	Aug 12 to Oct 12	Marine Foundation Works	Construction of the foundations for S1 to S5, N1 and the North, Central and South Towers.	Due to the distance between the works and the nearest sensitive properties and the method of working renders the risk of damage to structures due to vibration as highly unlikely.
PCNV-00021	Aug 12 to Oct 12	South Earthworks	<ol style="list-style-type: none"> 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 	<p>PPV:</p> <p>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 generate appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities does not generate appreciable levels of vibration and therefore no assessment has been undertaken.</p>

Butlaw Fisheries				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
				<p>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.</p>

Inchgarvie Lodge				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00011	Aug 12 to Oct 12	Land Based Piers	<ol style="list-style-type: none"> 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. 	<p>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 generate appreciable levels of vibration due to the distance from the closest receptor. Equipment to be used in all other activities does not generate appreciable levels of vibration and therefore no assessment has been undertaken.</p> <p>VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefore 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.</p>

Inchgarvie Lodge				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00014	Aug 12 to Sept 12	Dredging Works	<p>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.</p> <p>The dredging will be completed by the following plant:</p> <ul style="list-style-type: none"> • 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.
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PCNV-00021	Aug 12 to Oct 12	South Earthworks	<ol style="list-style-type: none"> 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 	<p>PPV:</p> <p>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 generate appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities does not generate appreciable levels of</p>

Inchgarvie Lodge				
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Linn Mill, Clufflat Brae				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00011	Aug 12 to Oct 12	Land Based Piers	<ol style="list-style-type: none"> 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. 	<p>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 generate appreciable levels of vibration due to the distance from the closest receptor. Equipment to be used in all other activities does not generate appreciable levels of vibration and therefore no assessment has been undertaken.</p> <p>VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefore 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.</p>

Linn Mill, Clufflat Brae				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00014	Aug 12 to Sept 12	Dredging Works	<p>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.</p> <p>The dredging will be completed by the following plant:</p> <ul style="list-style-type: none"> • 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.
PCNV-00020	Aug 12 to Oct 12	Marine Foundation Works	Construction of the foundations for S1 to S5, N1 and the North, Central and South Towers.	Due to the distance between the works and the nearest sensitive properties and the method of working renders the risk of damage to structures due to vibration as highly unlikely.
PCNV-00021	Aug 12 to Oct 12	South Earthworks	<ol style="list-style-type: none"> 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 	<p>PPV:</p> <p>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 generate appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities does not generate appreciable levels of</p>

Linn Mill, Clufflat Brae				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
				<p>vibration and therefore no assessment has been undertaken.</p> <p>VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefore 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.</p>

Springfield, Echline				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00008 (Mod02 & 04)	Aug 12 to Oct 12	Construction of BP Protection Works	Extension to the programme of PCNV-0008 with the addition of Construction of BP Protection Works. These works are to allow BP Specialist Works to be carried out on the Oil Line.	As per PCNV-00008 Section 8, all equipment to be used in these activities does not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV-00021	Aug 12 to Oct 12	South Earthworks	<ol style="list-style-type: none"> 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 	<p>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 generate appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities does not generate appreciable levels of vibration and therefore no assessment has been undertaken.</p> <p>VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefore 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.</p>

Dundas Home Farm				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00008 (Mod02 & 04)	Aug 12 to Oct 12	Construction of BP Protection Works	Extension to the programme of PCNV-0008 with the addition of Construction of BP Protection Works. These works are to allow BP Specialist Works to be carried out on the Oil Line.	As per PCNV-00008 Section 8, all equipment to be used in these activities does not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV-00021	Aug 12 to Oct 12	South Earthworks	<ol style="list-style-type: none"> 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 	<p>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 generate appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities does not generate appreciable levels of vibration and therefore no assessment has been undertaken.</p> <p>VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefore 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.</p>

Tigh-Ni-Grian				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00010	Aug 12 to Oct 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.
PCNV-00011	Aug 12 to Oct 12	Land Based Piers	<ol style="list-style-type: none"> 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. 	<p>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 does not generate appreciable levels of vibration and therefore no assessment has been undertaken.</p> <p>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</p>

Tigh-Ni-Grian				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
				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.
PCNV-00014	Aug 12 to Sept 12	Dredging Works	<p>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.</p> <p>The dredging will be completed by the following plant:</p> <ul style="list-style-type: none"> • 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.
PCNV-00015	Aug 12 to Oct 12	Blasting North Network	<p>4 blasts at St Margaret's Hope</p> <ul style="list-style-type: none"> • Traffic Management • Loading of the explosives. • Firing of the explosives to create a blast at St Margaret's Hope. 	<p>A protective vibration level of less than $10\text{mm}\cdot\text{s}^{-1}$ has been maintained for the Queensferry Hotel. Queensferry Hotel has been identified as the only occupied receptor to be within sufficient distance to be effected by blasting at St Margaret's Hope.</p> <p>A review of sensitive properties and structures identifies the following closest receptors to St Margaret's Hope: Radar Station, Admiralty House, St Margaret's Hope Lodge, Queensferry Hotel.</p> <p>These receptors are deemed to conservatively protect other structures further away. Vibration monitors for air over pressure and ground vibration have been installed at each location.</p>

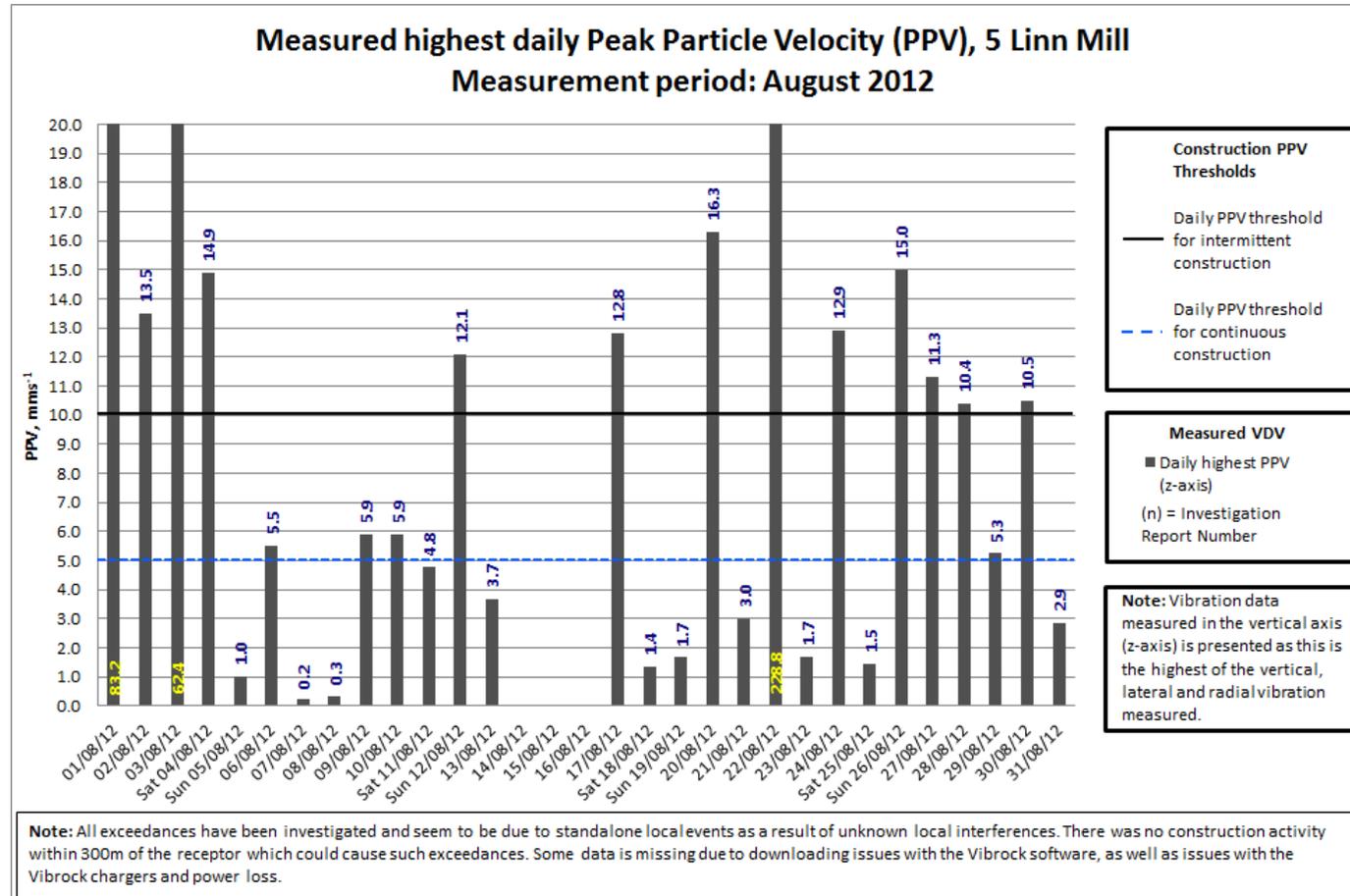
Tigh-Ni-Grian				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00020	Aug 12 to Oct 12	Marine Foundation Works	Construction of the foundations for S1 to S5, N1 and the North, Central and South Towers.	Due to the distance between the works and the nearest sensitive properties and the method of working renders the risk of damage to structures due to vibration as highly unlikely.

Whinny Hill				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV-00010	Aug 12 to Oct 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.
PCNV-00011	Aug 12 to Oct 12	Land Based Piers	<ol style="list-style-type: none"> 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. 	<p>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 generate appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities does not generate appreciable levels of vibration and therefore no assessment has been undertaken.</p> <p>VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefore 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</p>

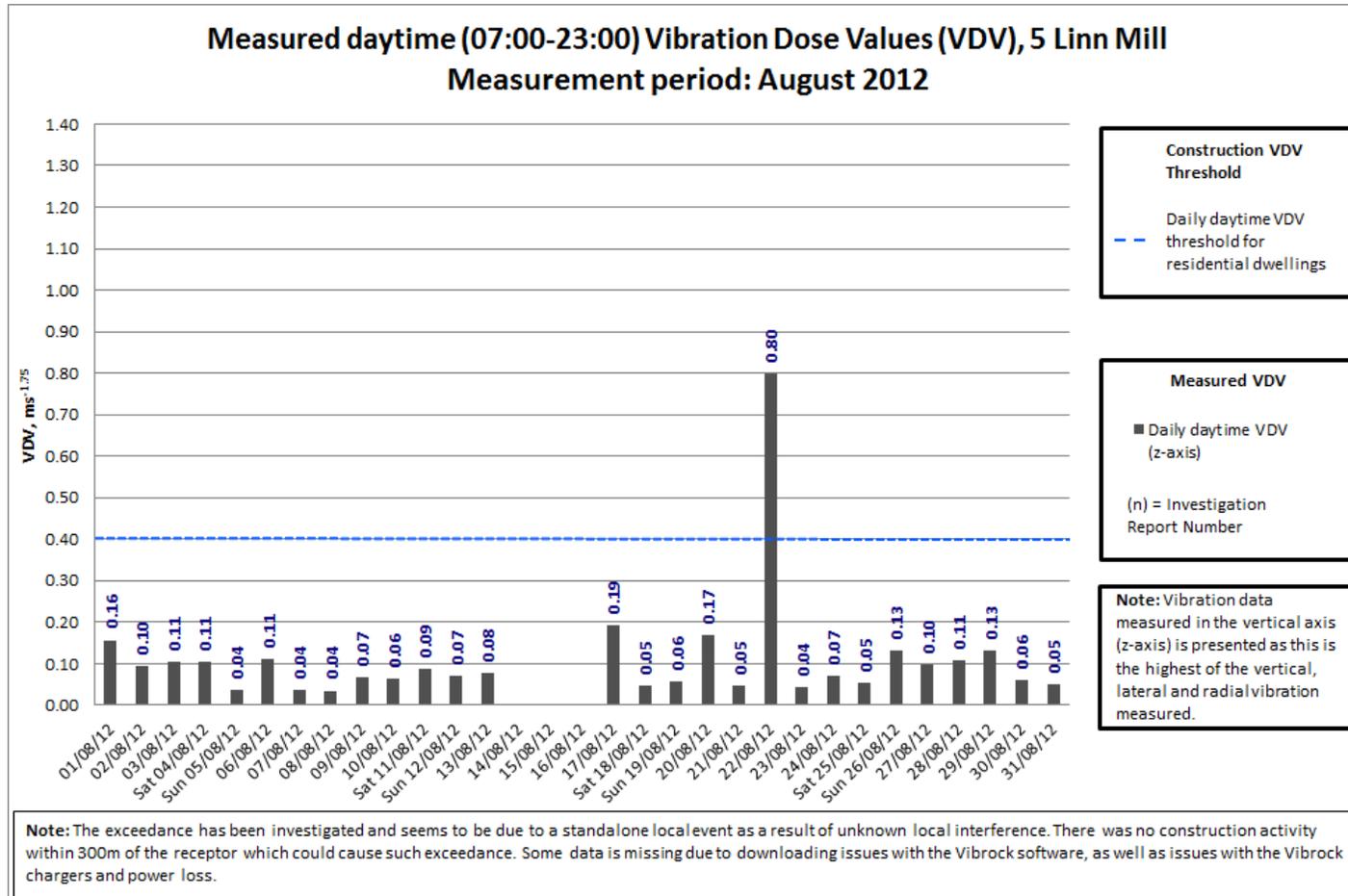
Whinny Hill				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
				Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.
PCNV-00015	Aug 12 to Oct 12	Blasting North Network	4 blasts at St Margaret's Hope <ul style="list-style-type: none"> • Traffic Management • Loading of the explosives. • Firing of the explosives to create a blast at St Margret's Hope. 	<p>A protective vibration level of less than $10\text{mm}\cdot\text{s}^{-1}$ has been maintained for the Queensferry Hotel. Queensferry Hotel has been identified as the only occupied receptor to be within sufficient distance to be effected by blasting at St Margret's Hope.</p> <p>A review of sensitive properties and structures identifies the following closest receptors to St Margret's Hope: Radar Station, Admiralty House, St Margaret's Hope Lodge, Queensferry Hotel.</p> <p>These receptors are deemed to conservatively protect other structures further away. Vibration monitors for air over pressure and ground vibration have been installed at each location.</p>

APPENDIX B – VIBRATION GRAPHS

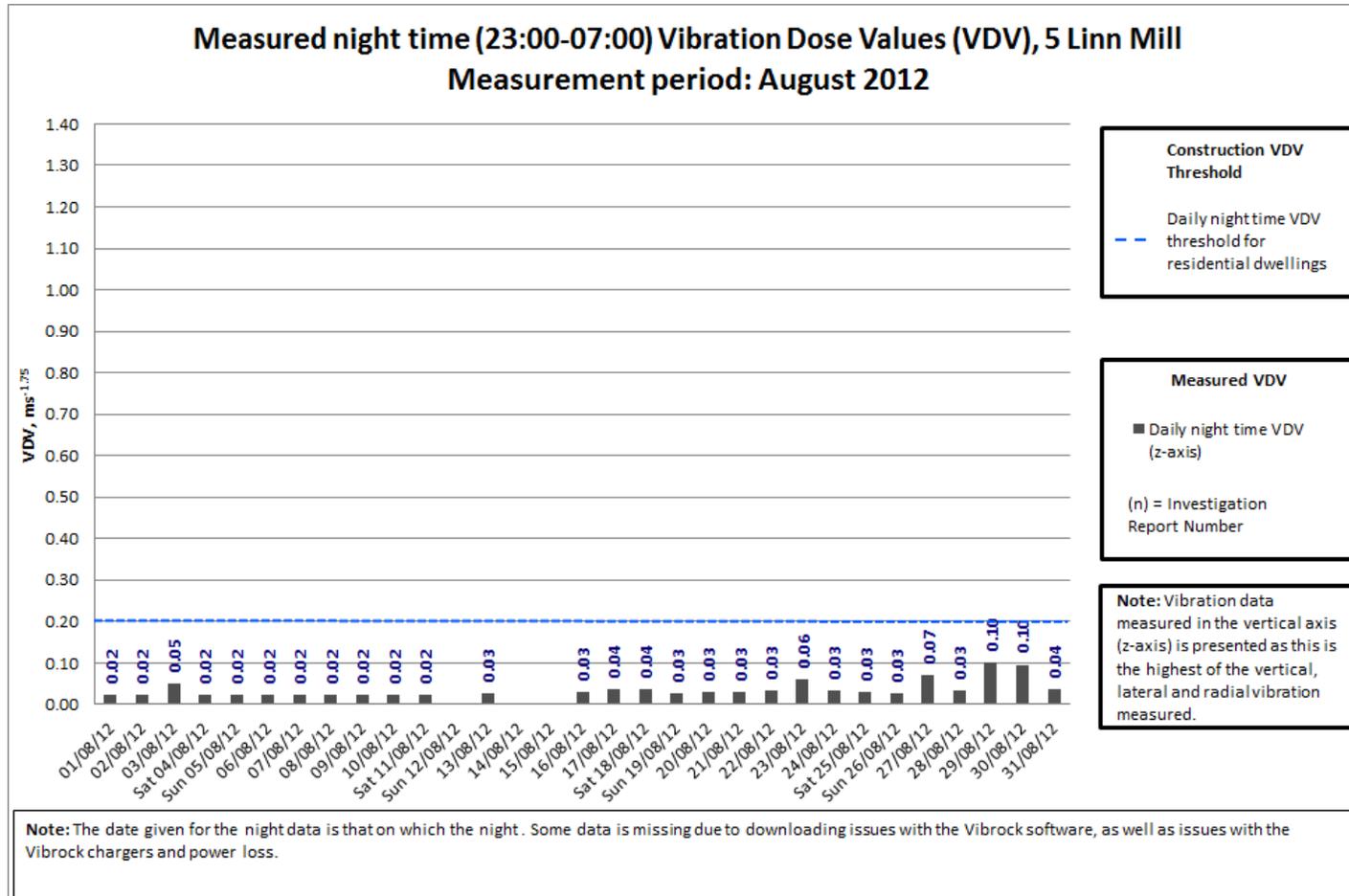
PPV at Linn Mill – August 2012



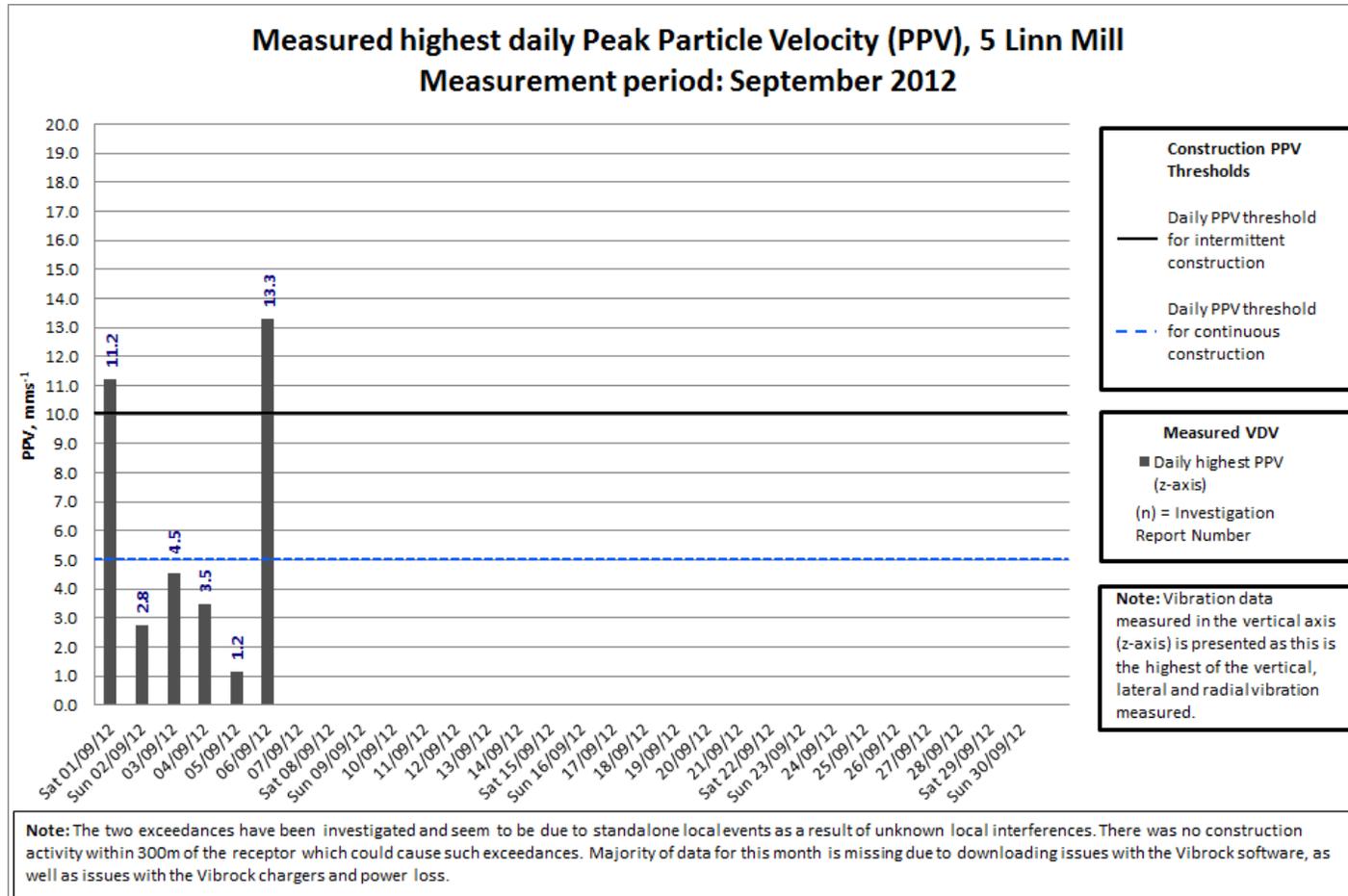
Daytime VDV at Linn Mill – August 2012



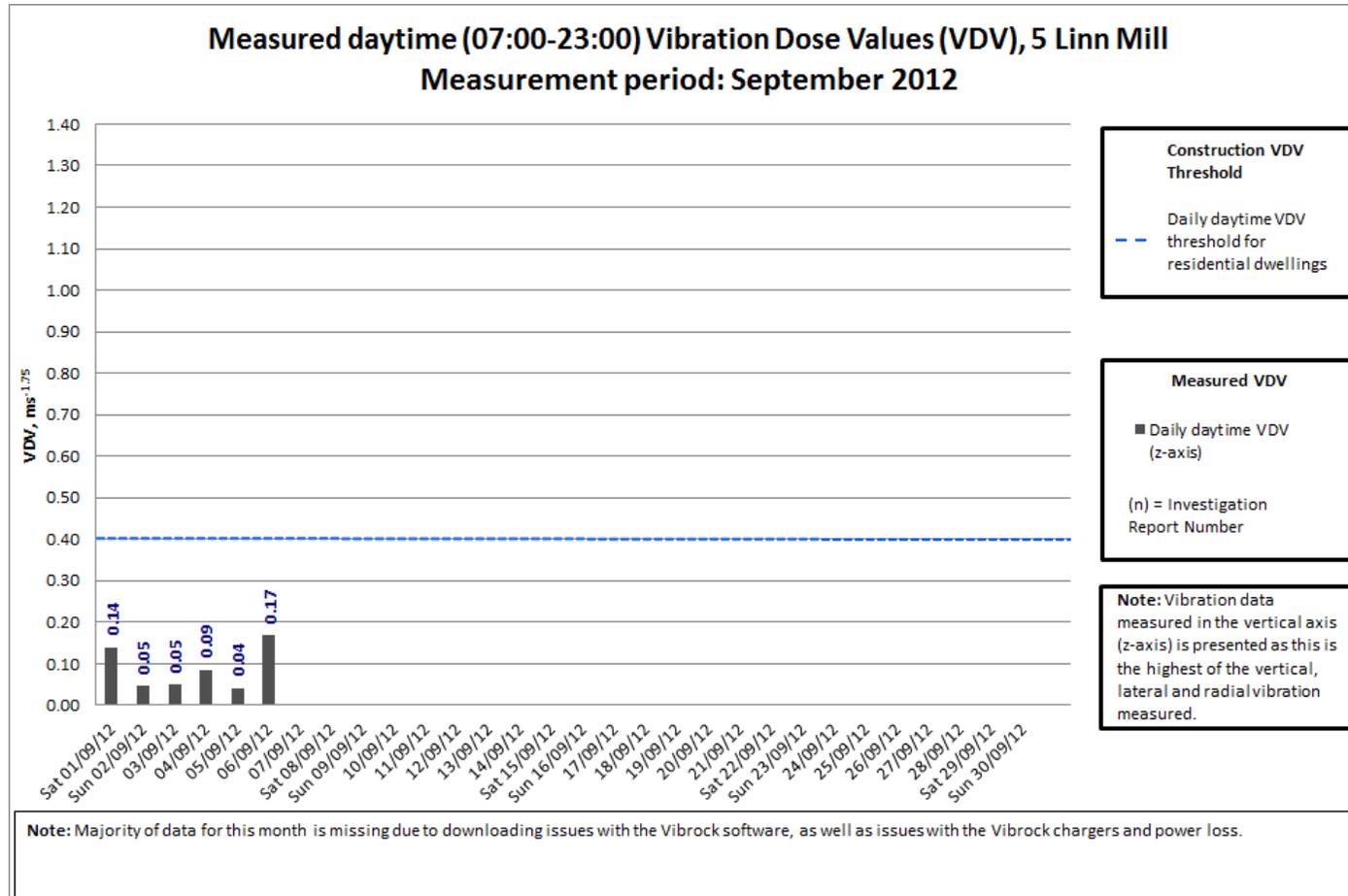
Night-time VDV at Linn Mill – August 2012



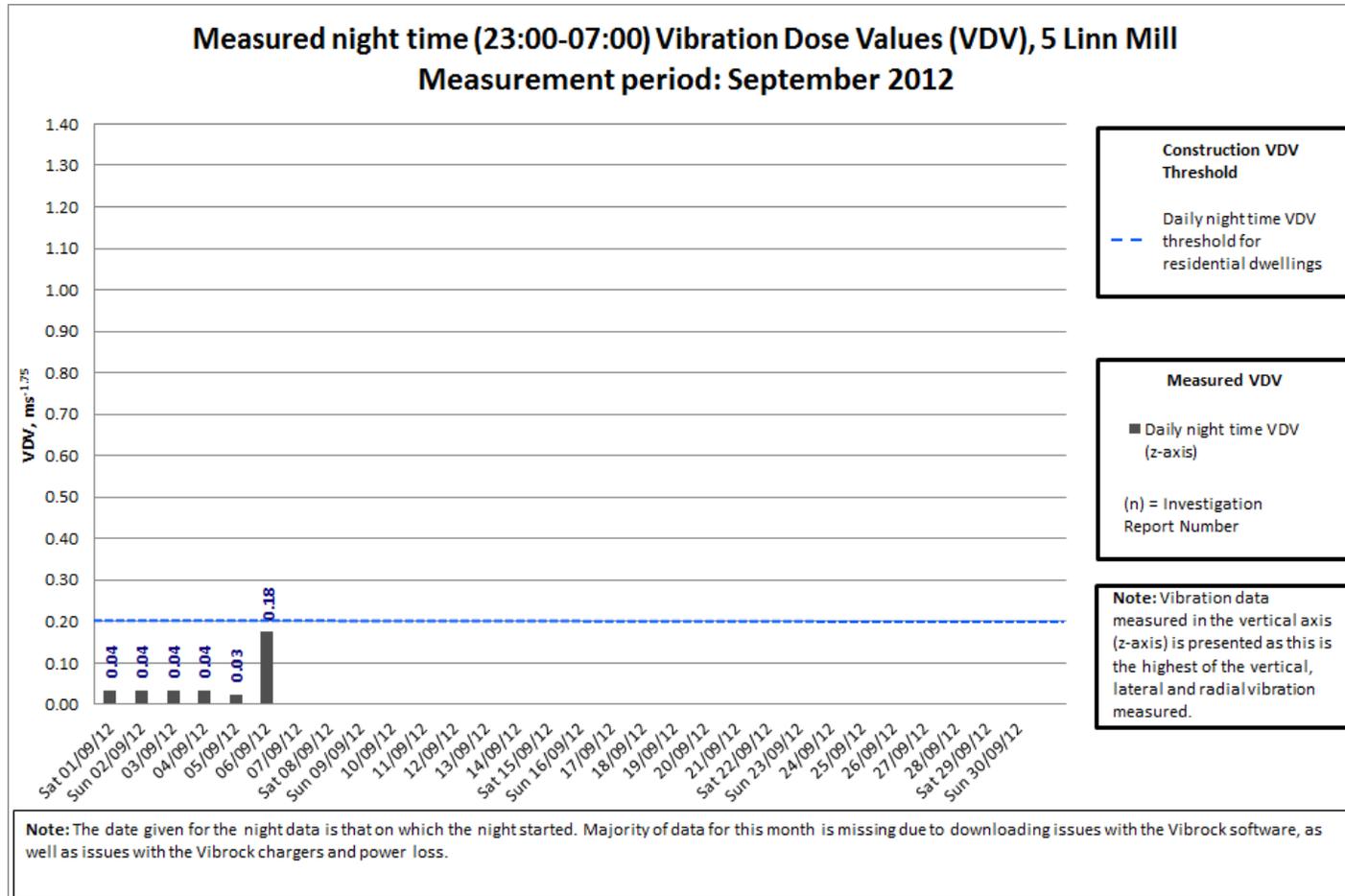
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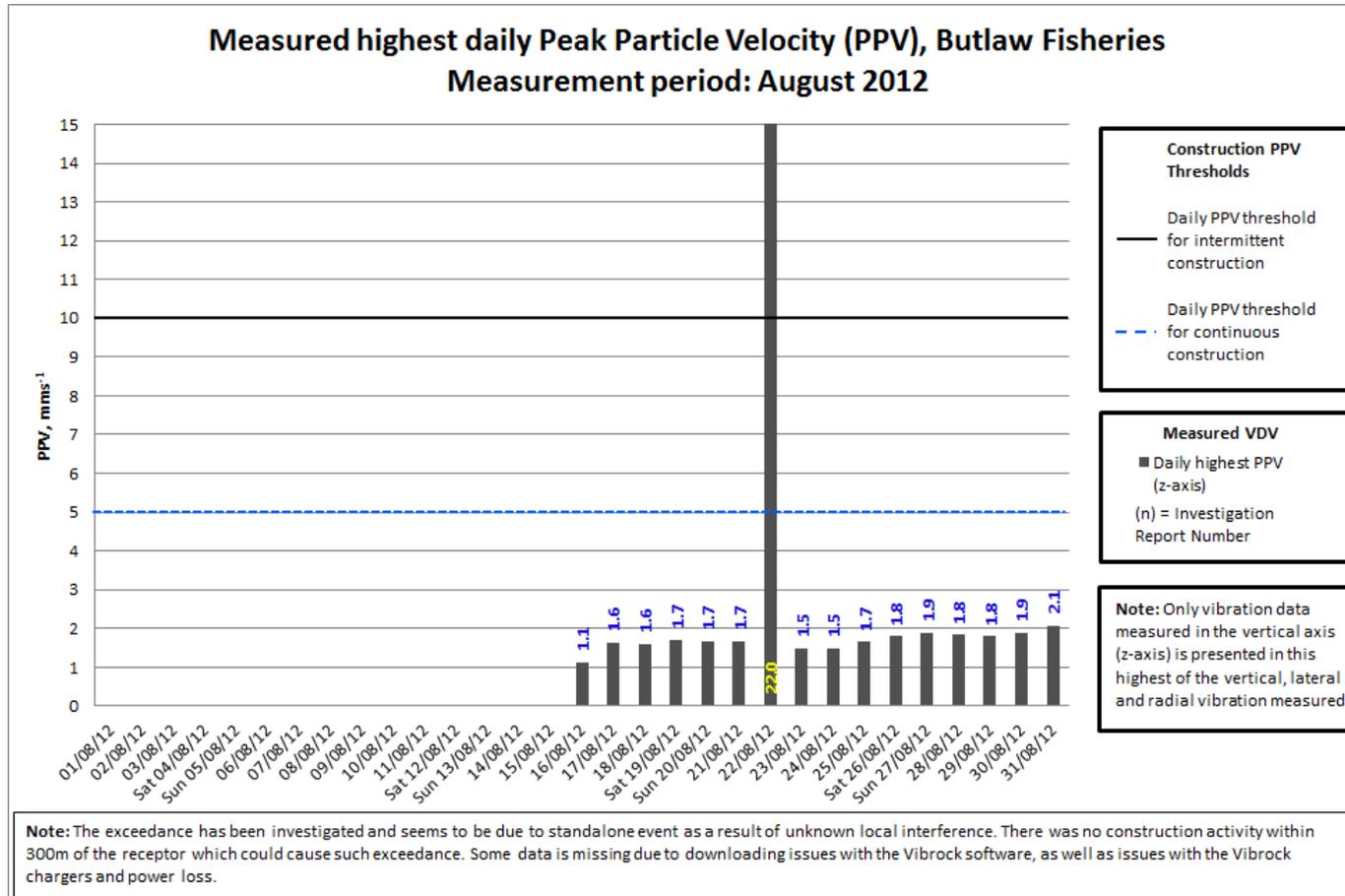
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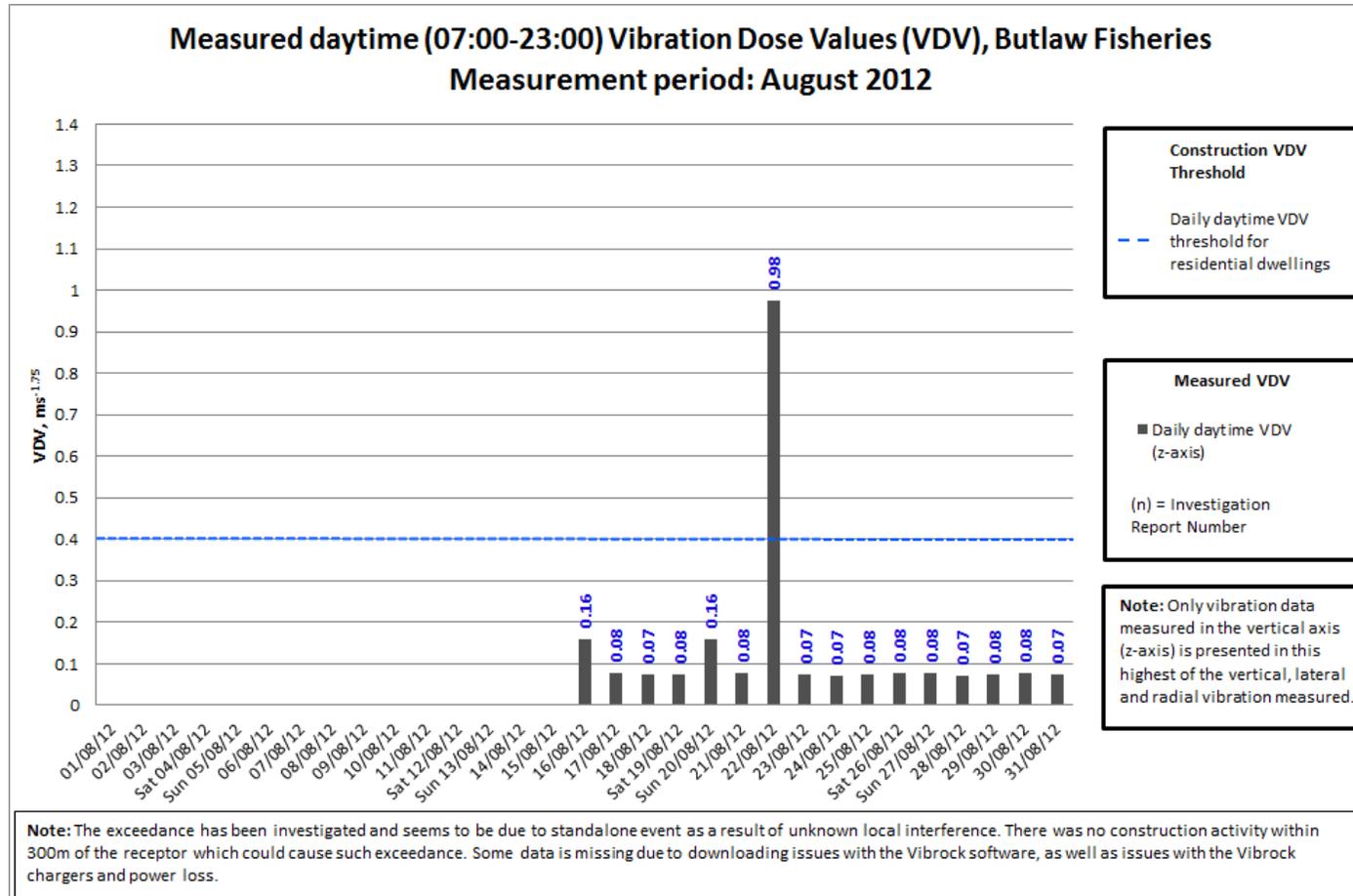
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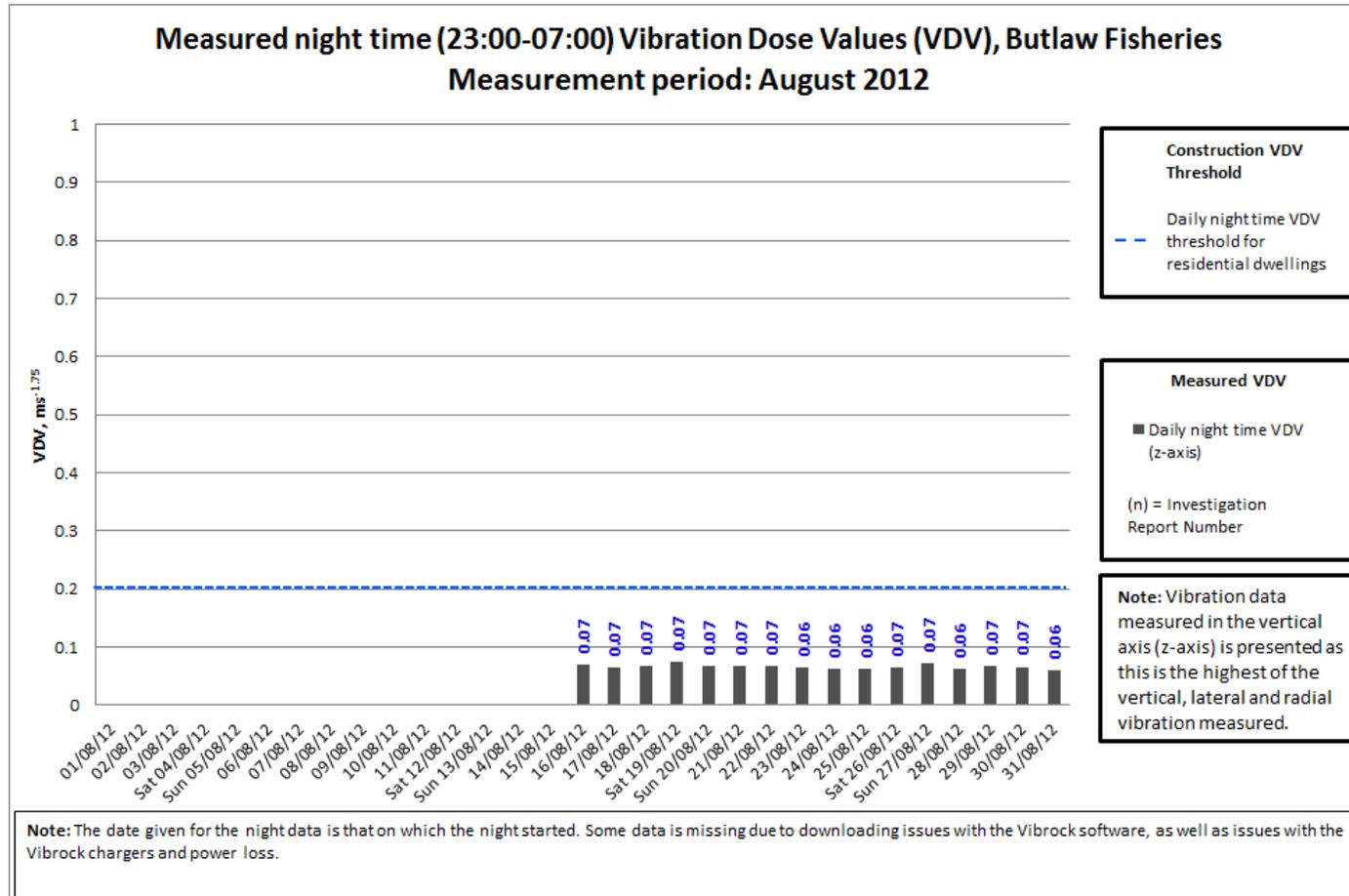
PPV at Butlaw Fisheries – August 2012



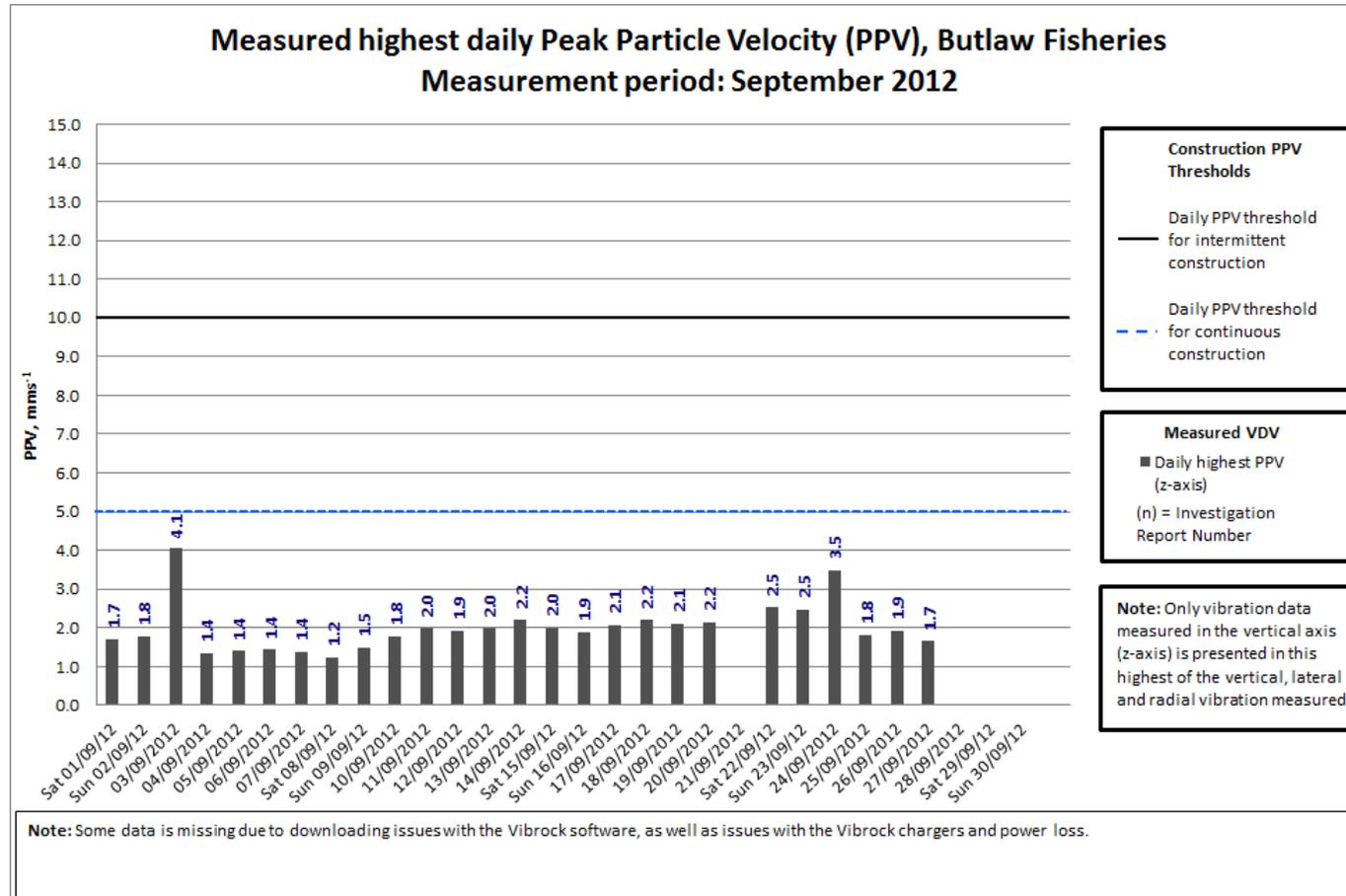
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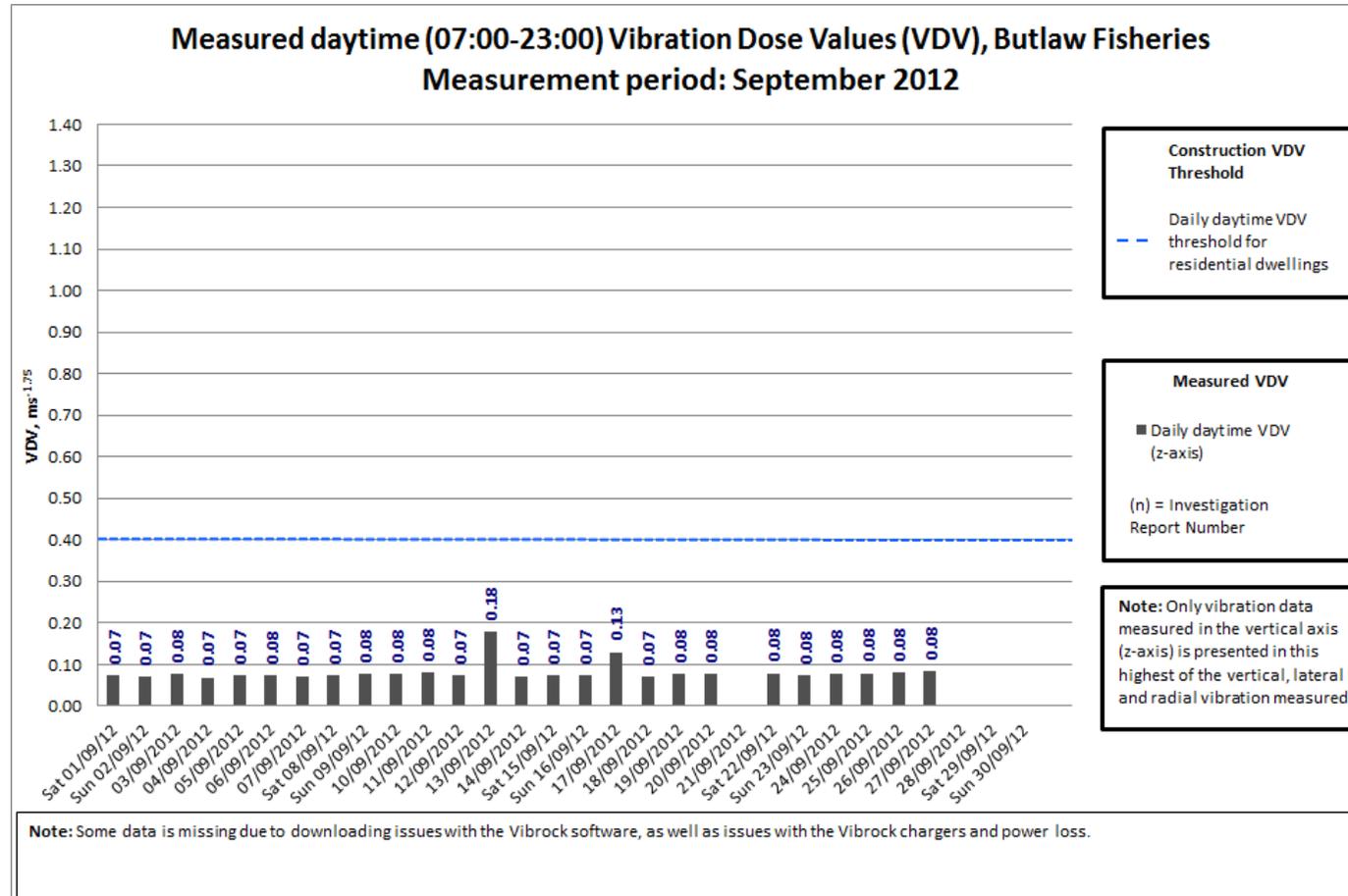
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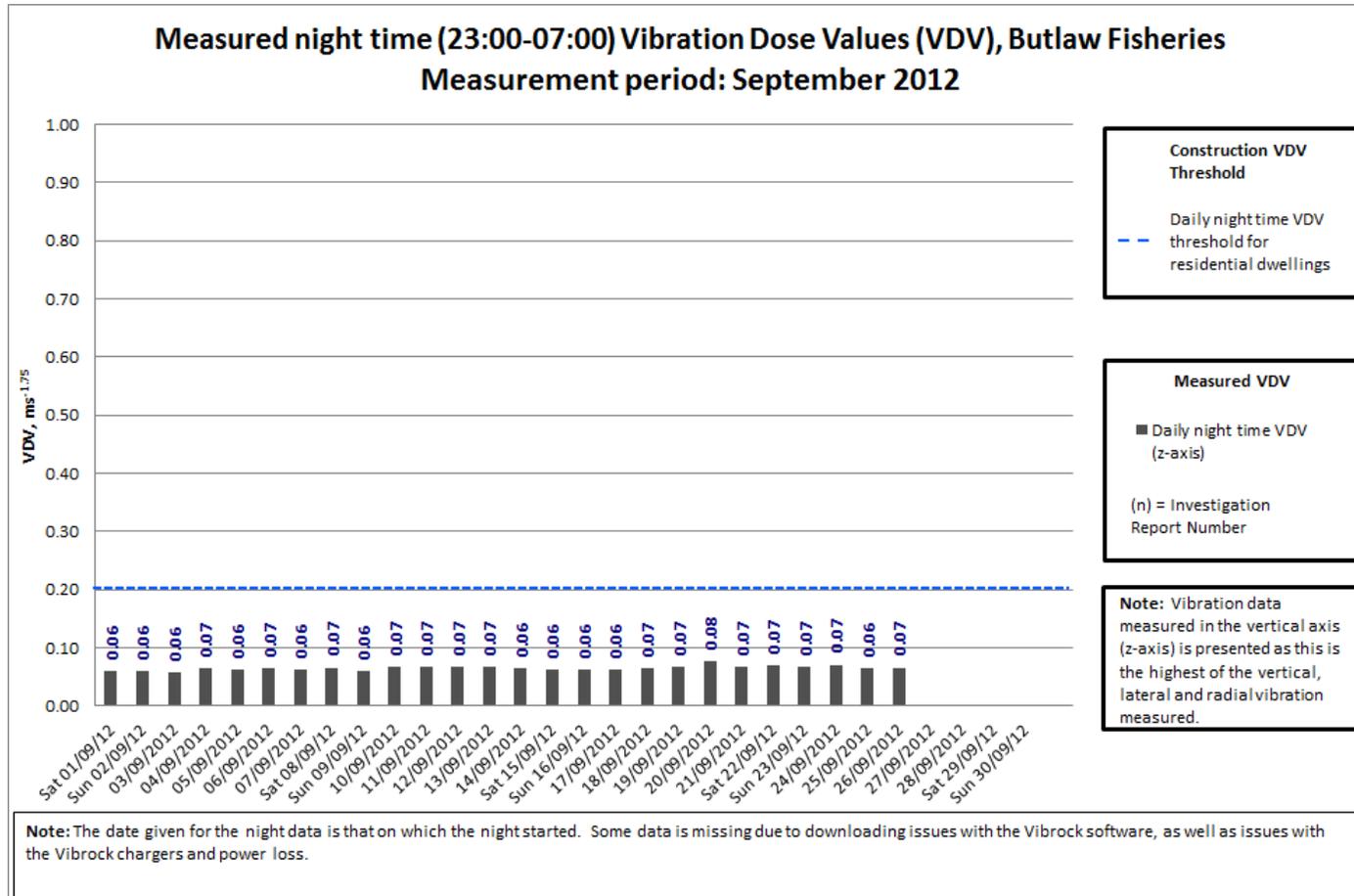
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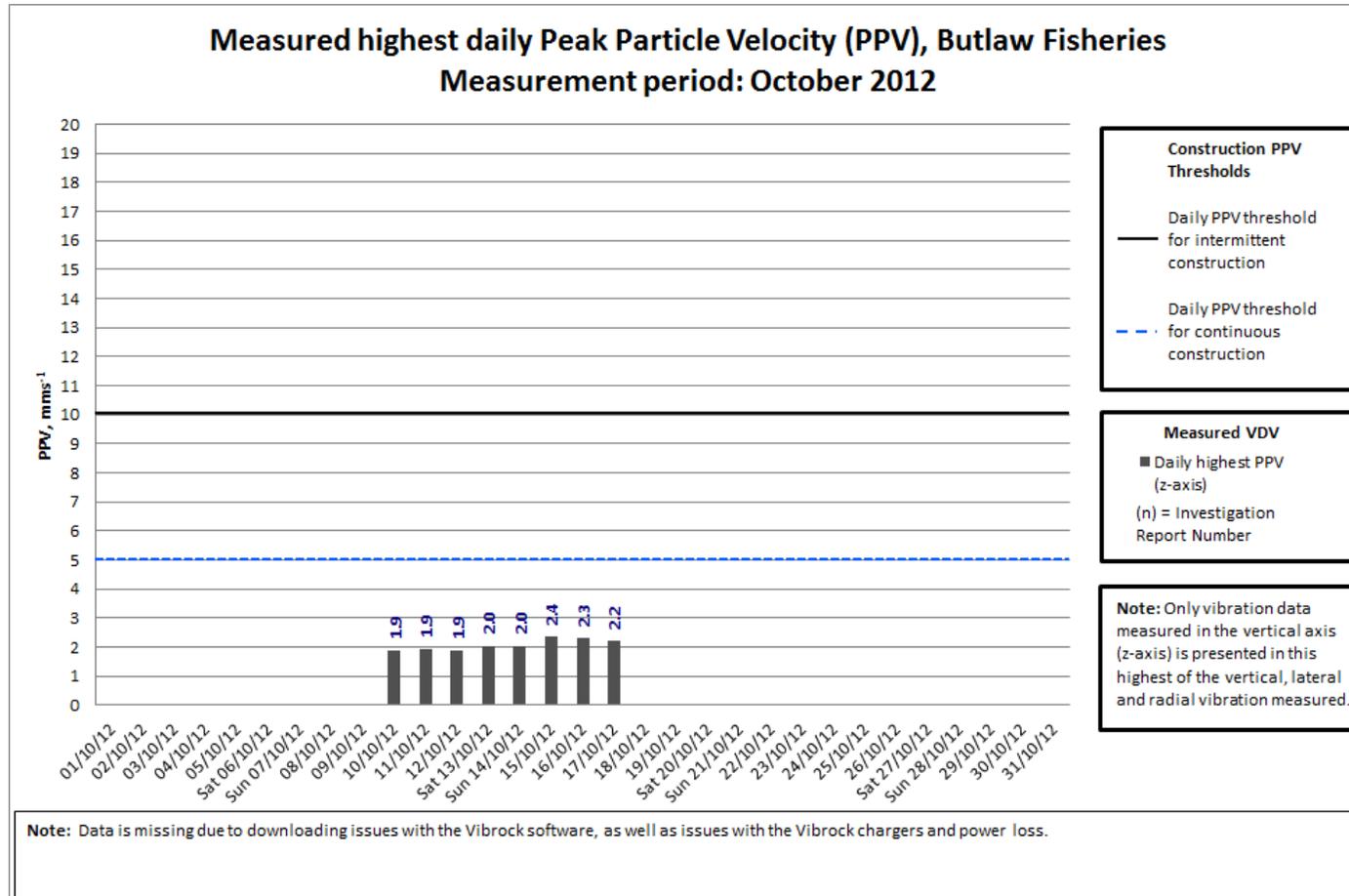
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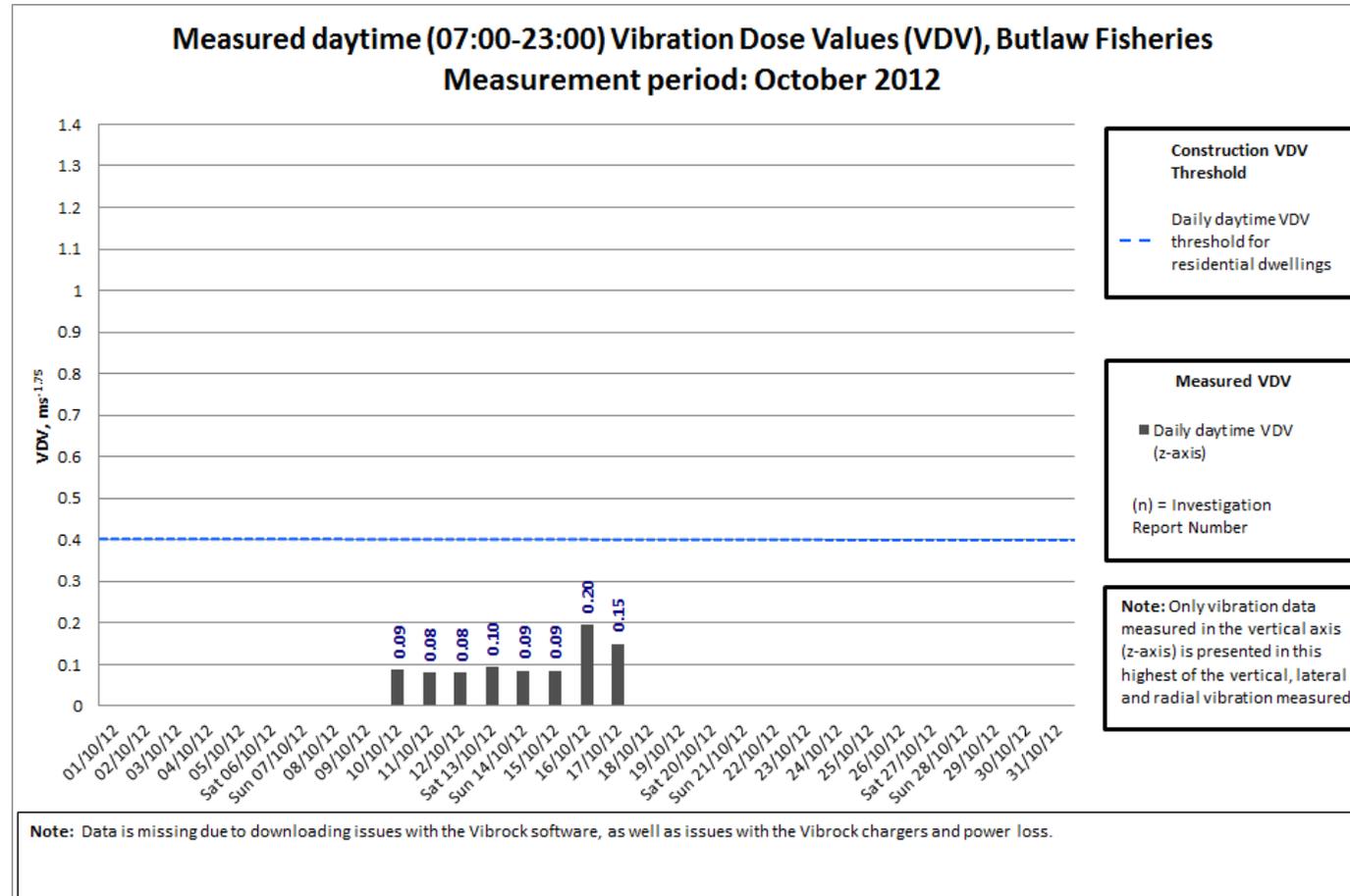
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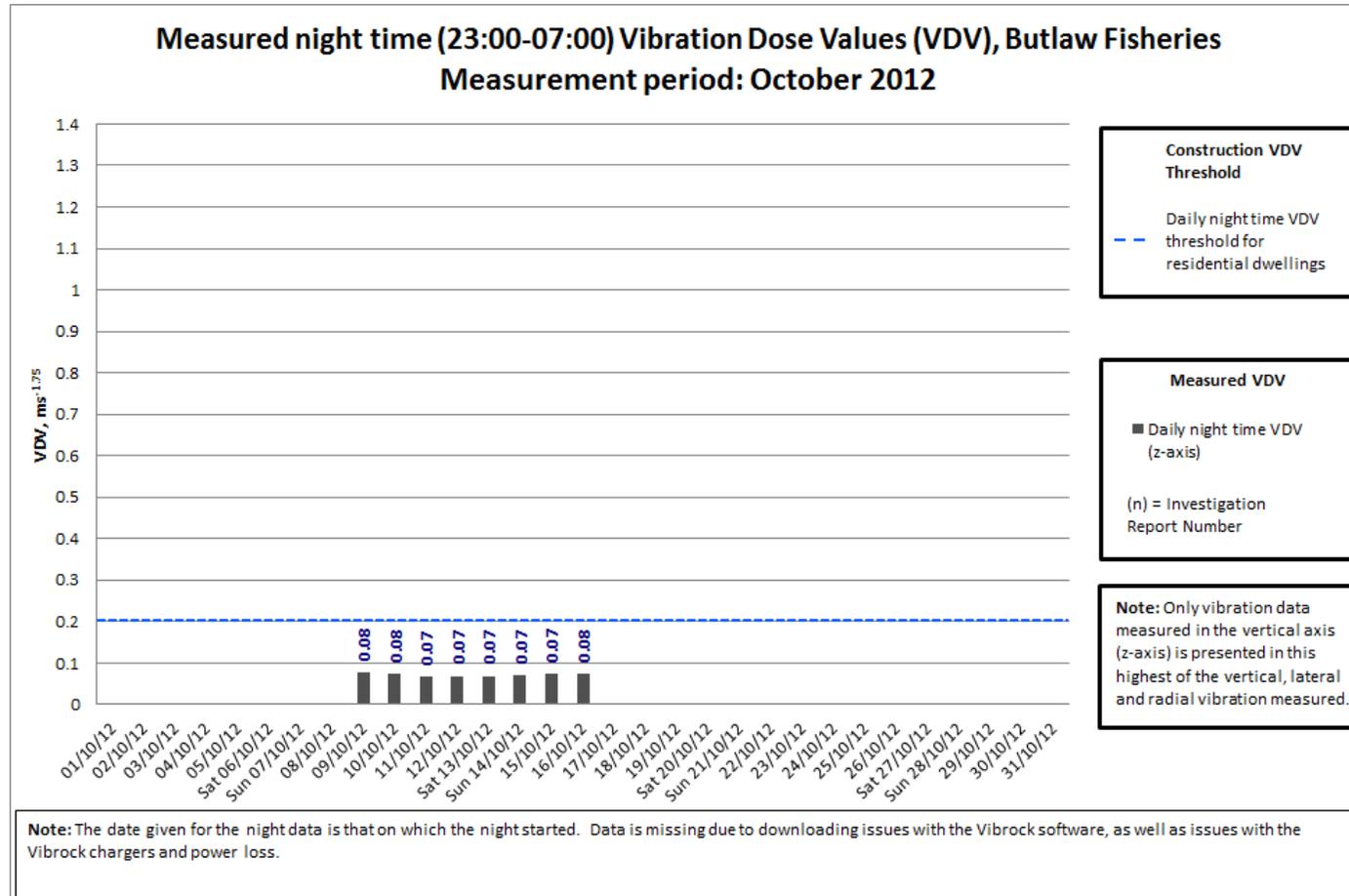
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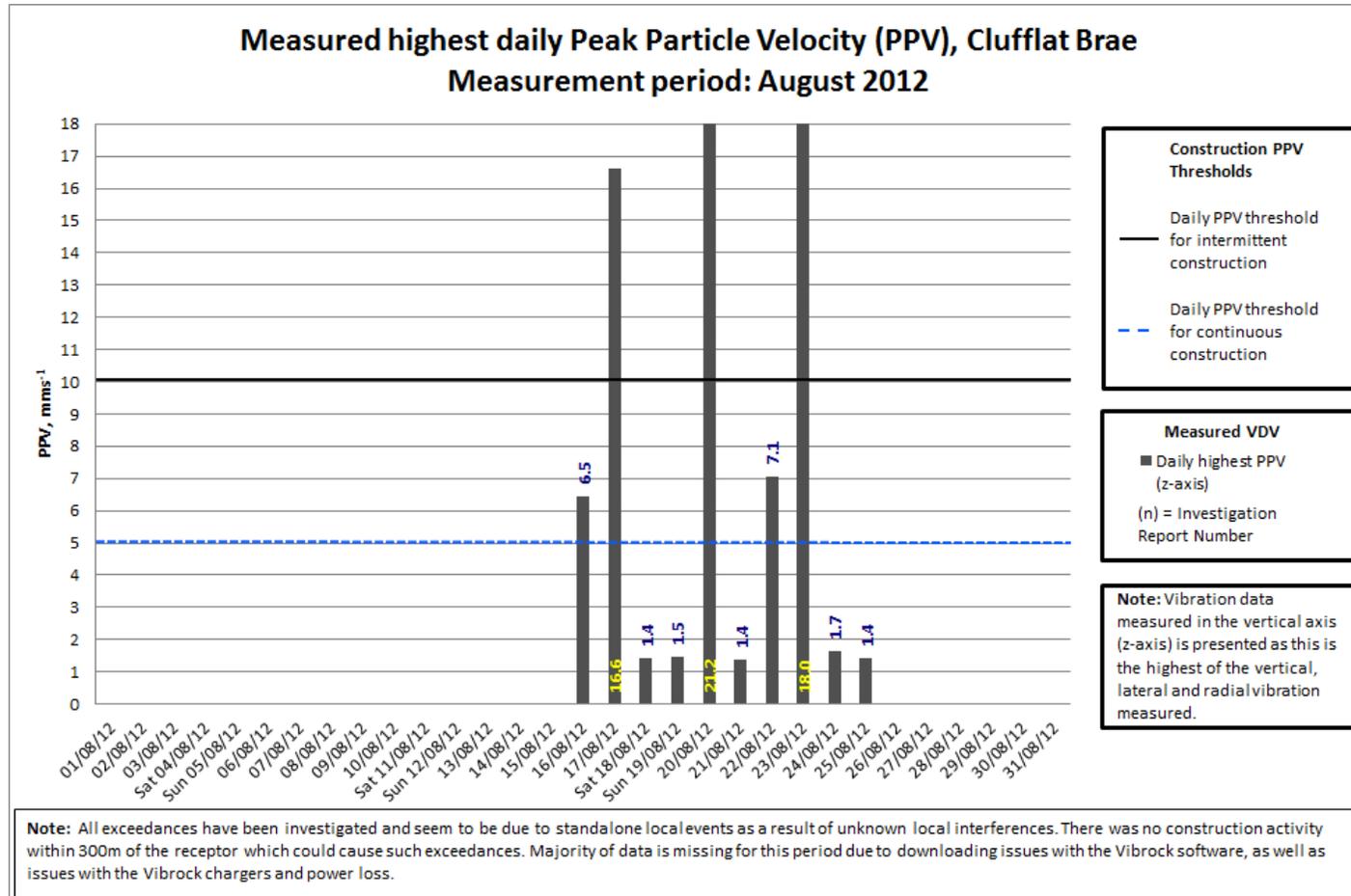
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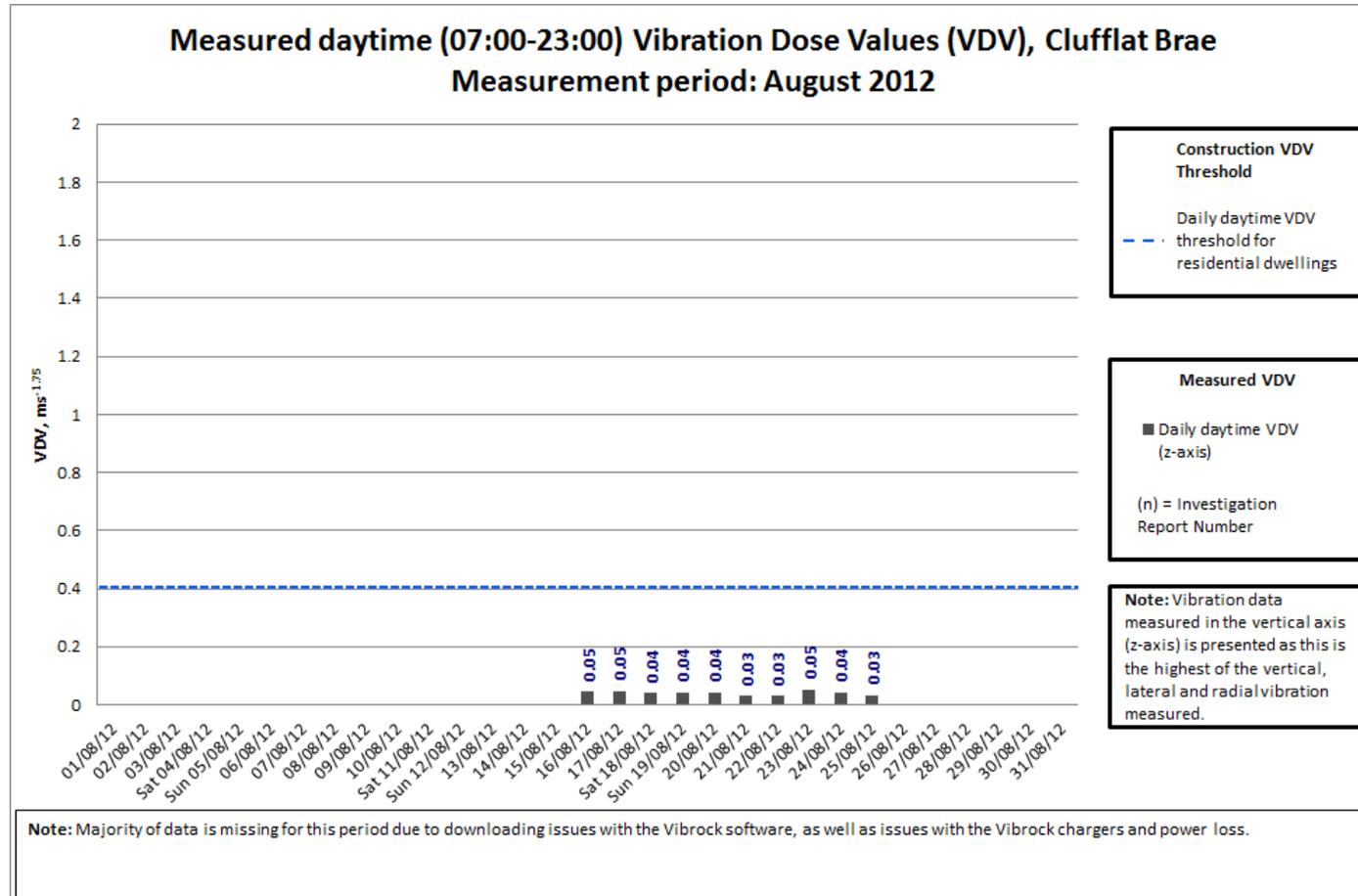
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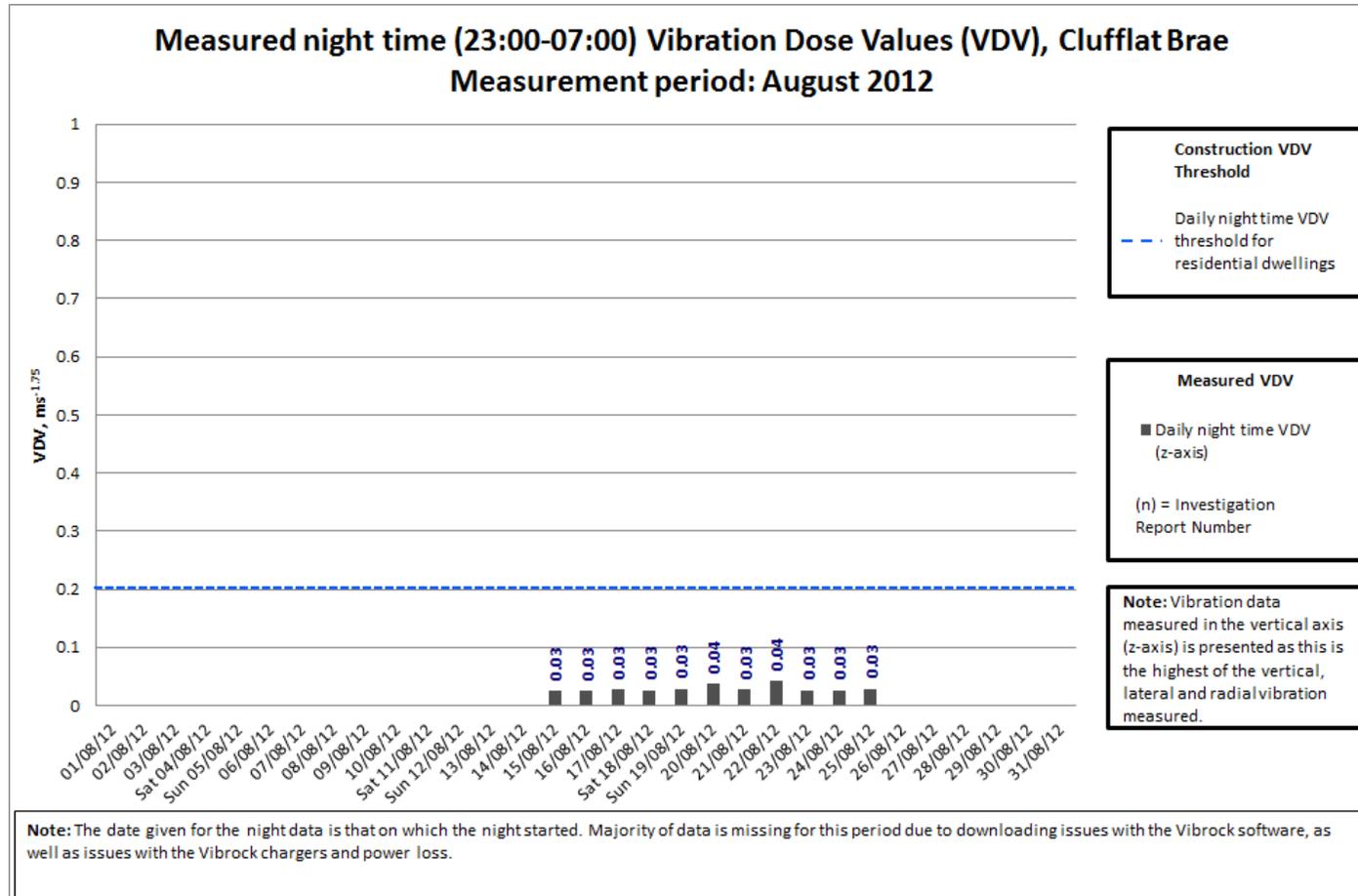
PPV at Cufflat Brae – August 2012



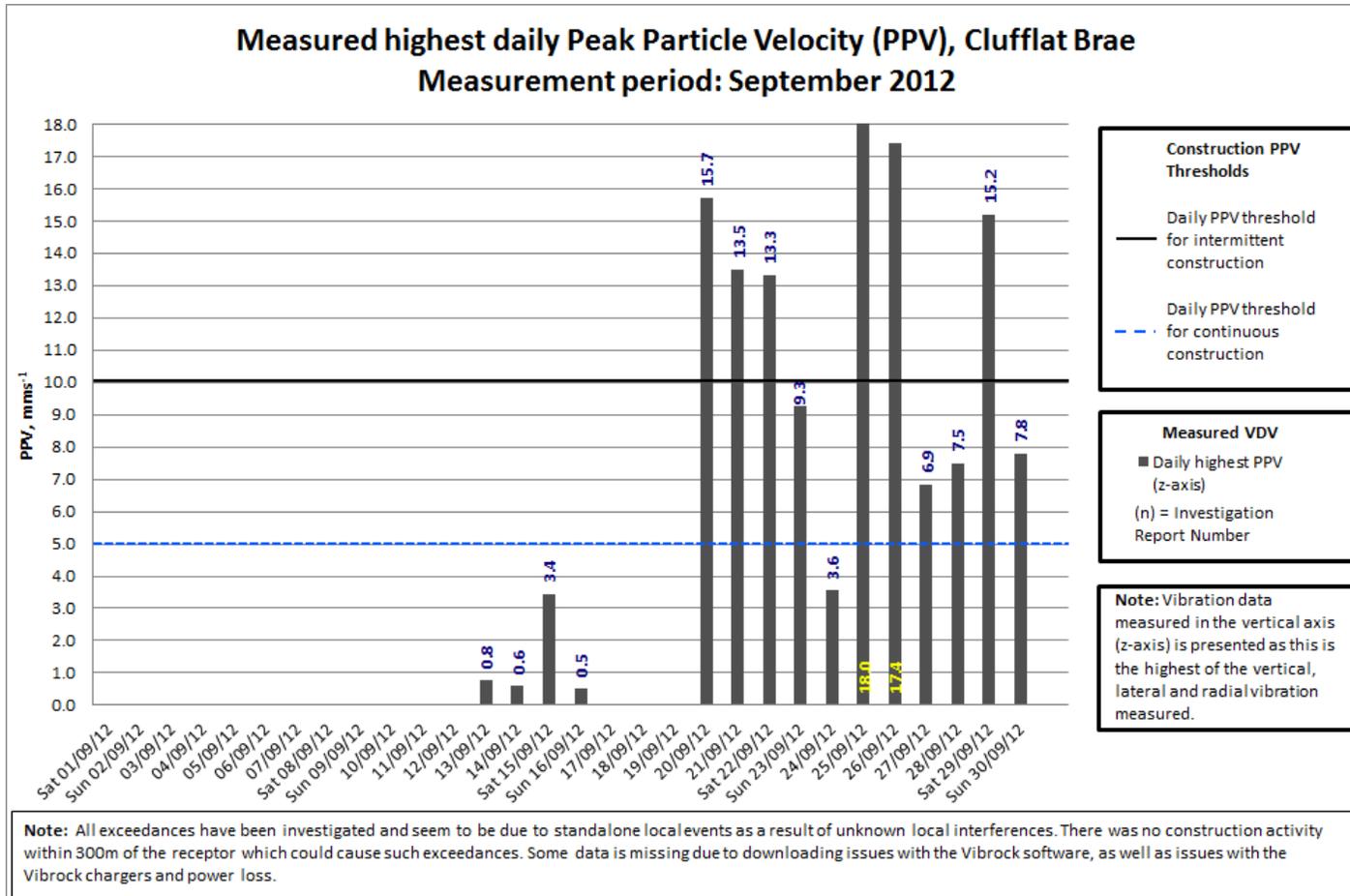
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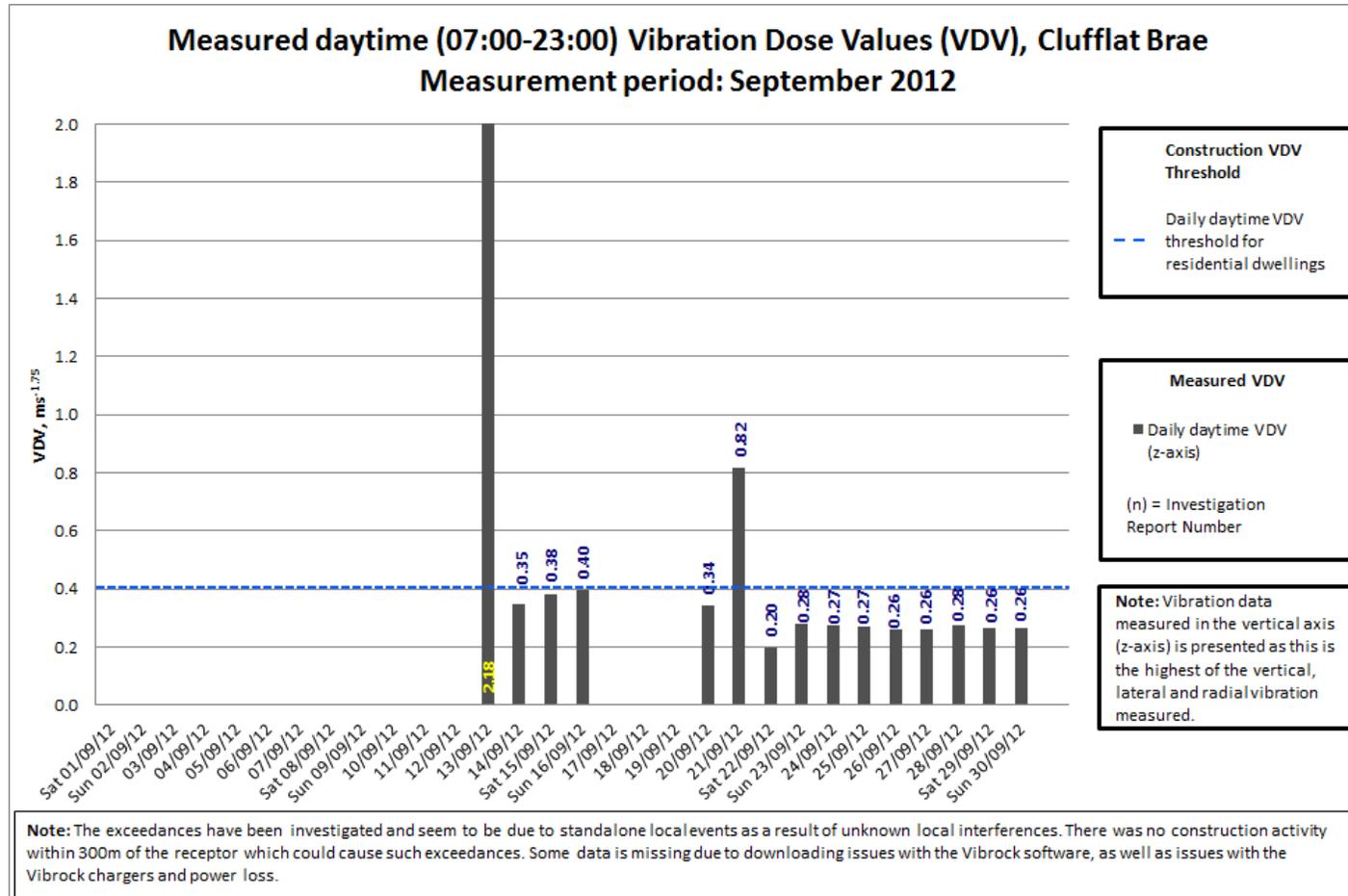
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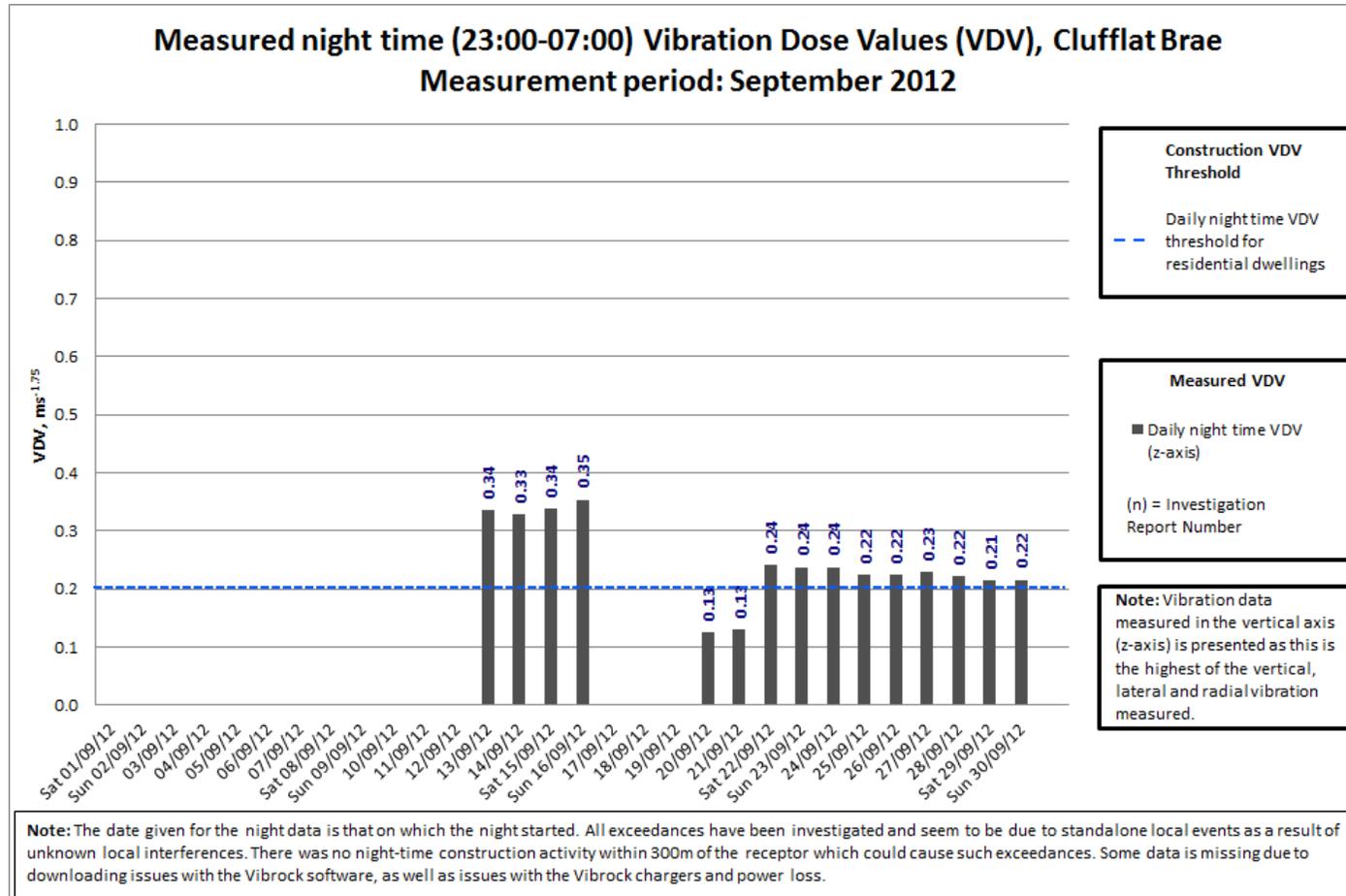
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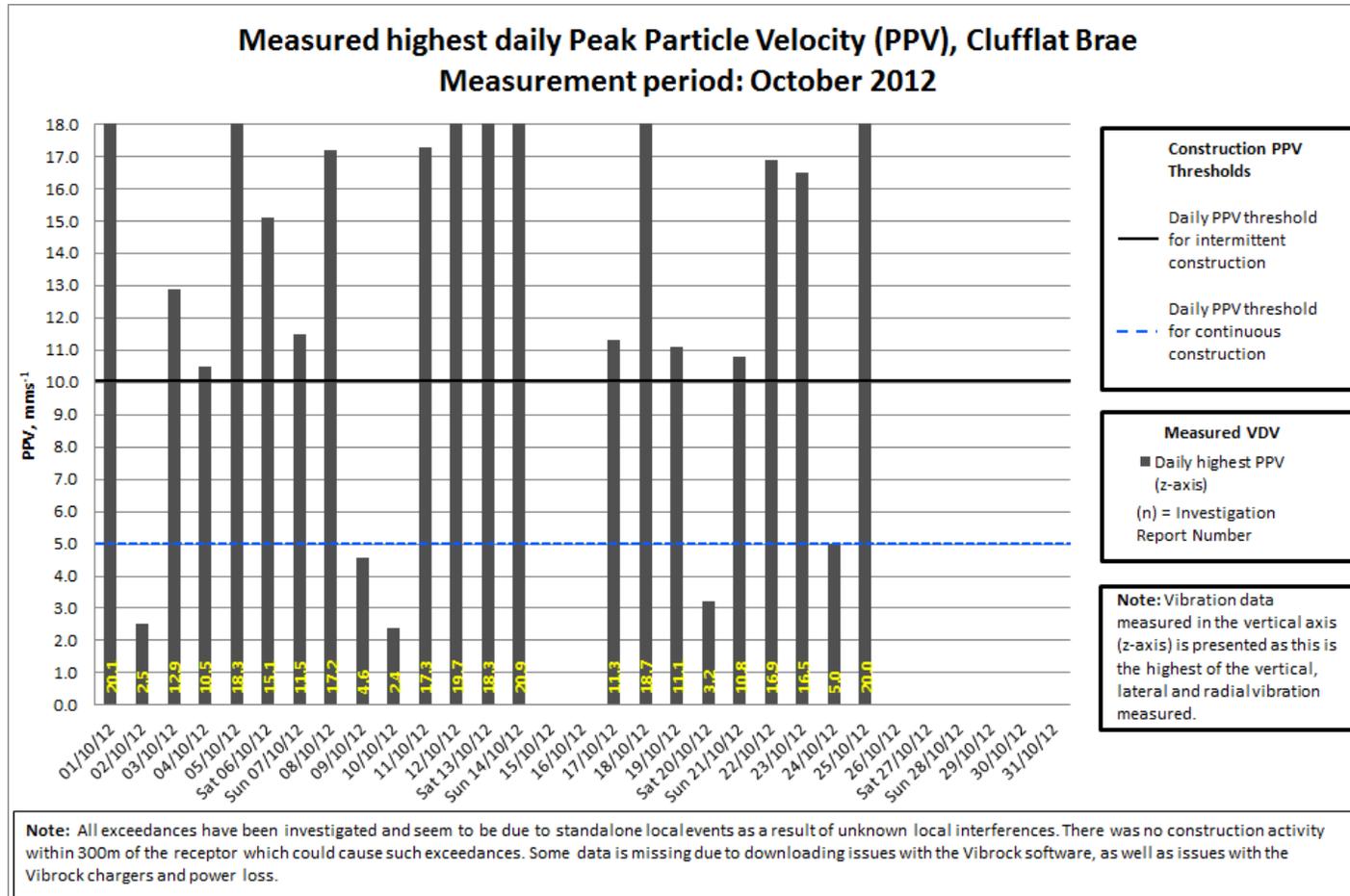
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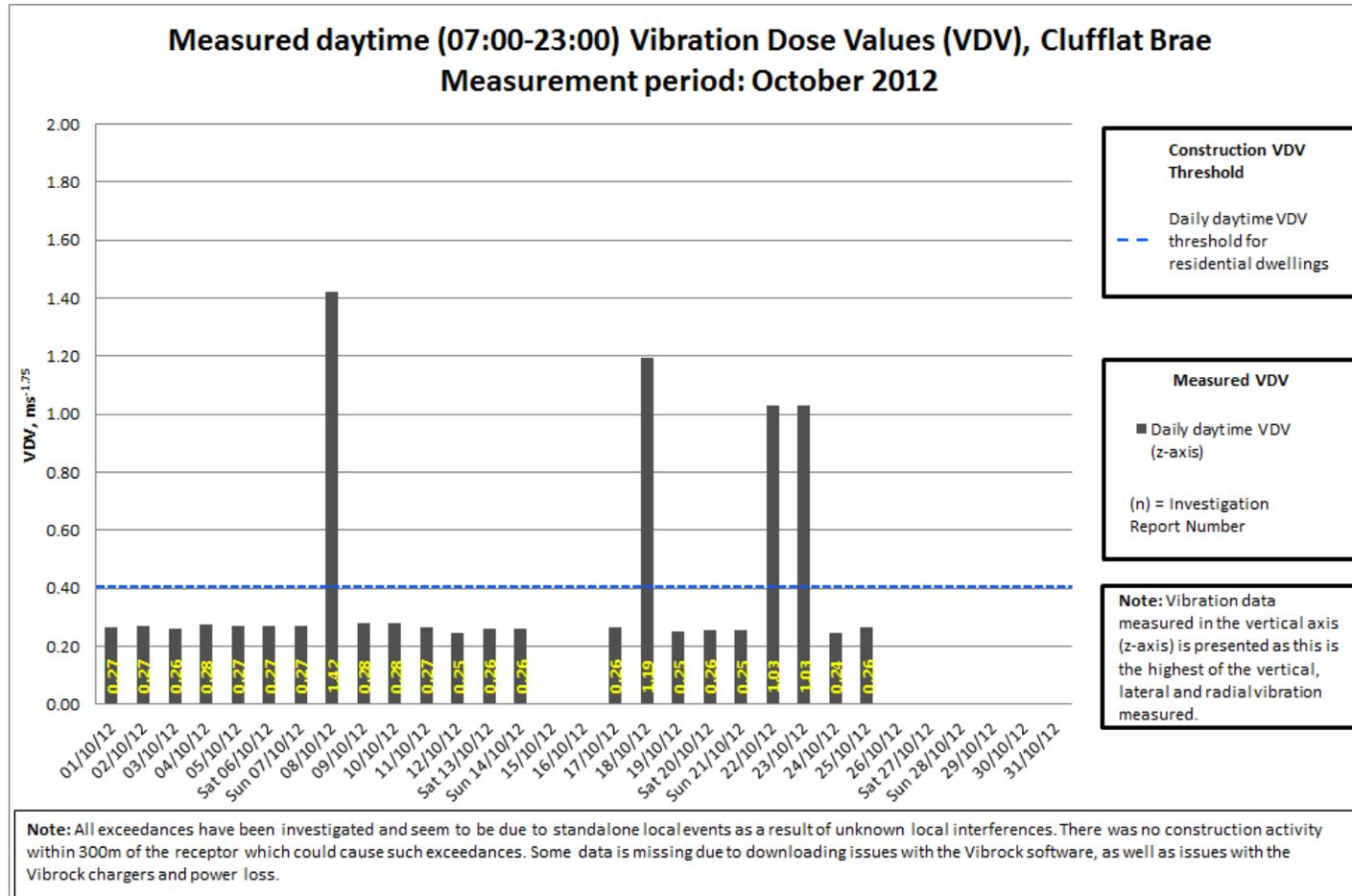
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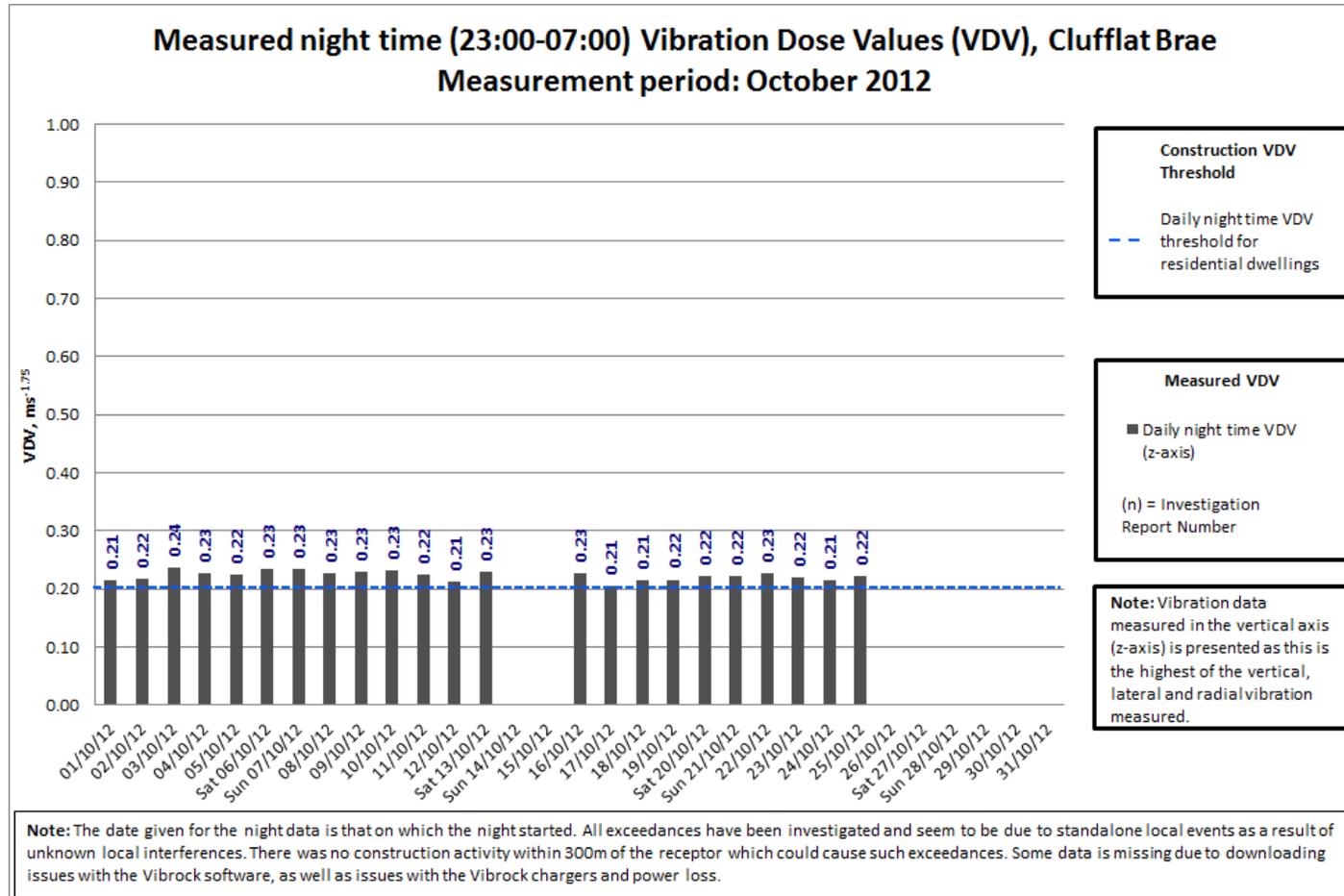
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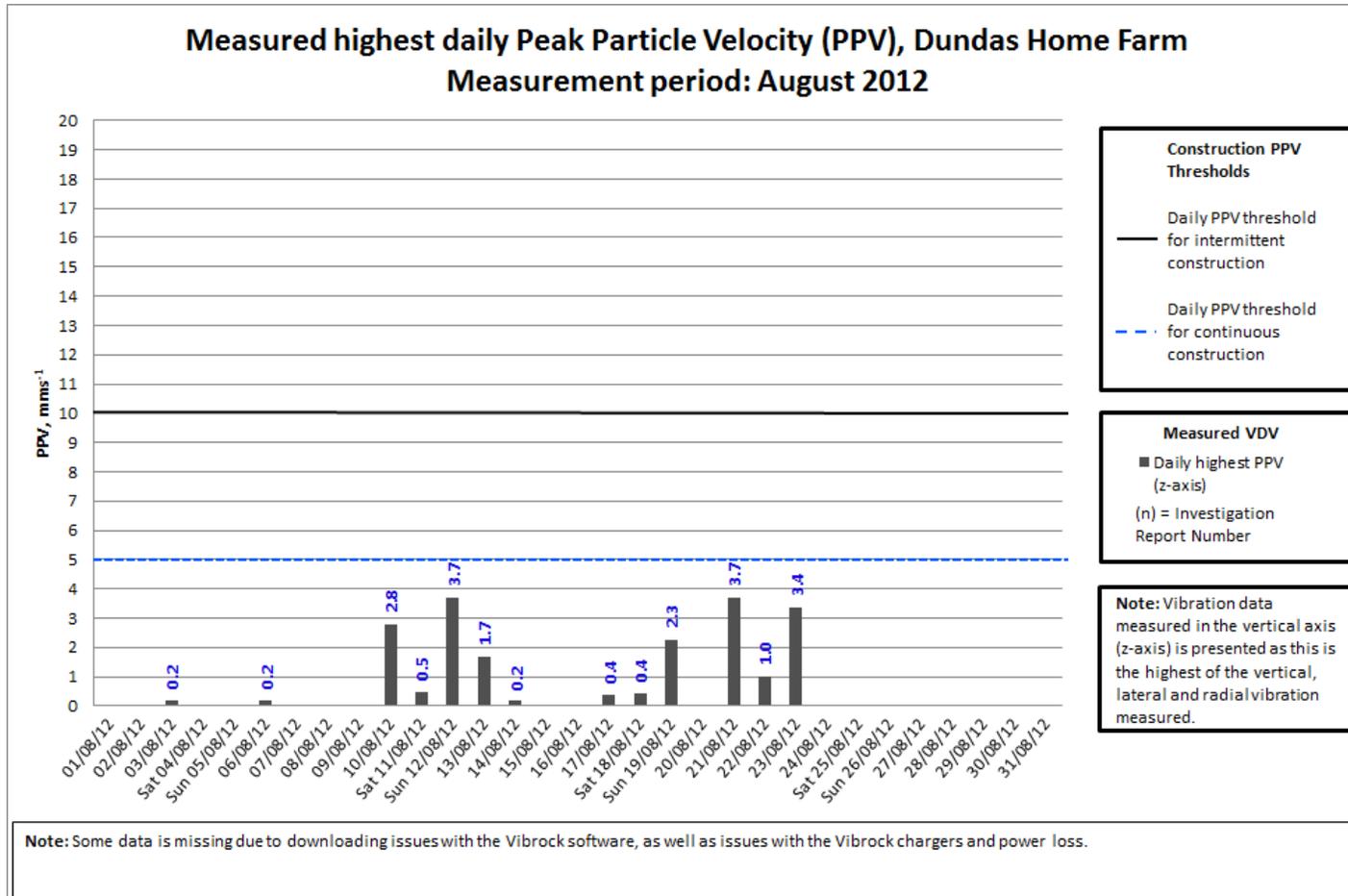
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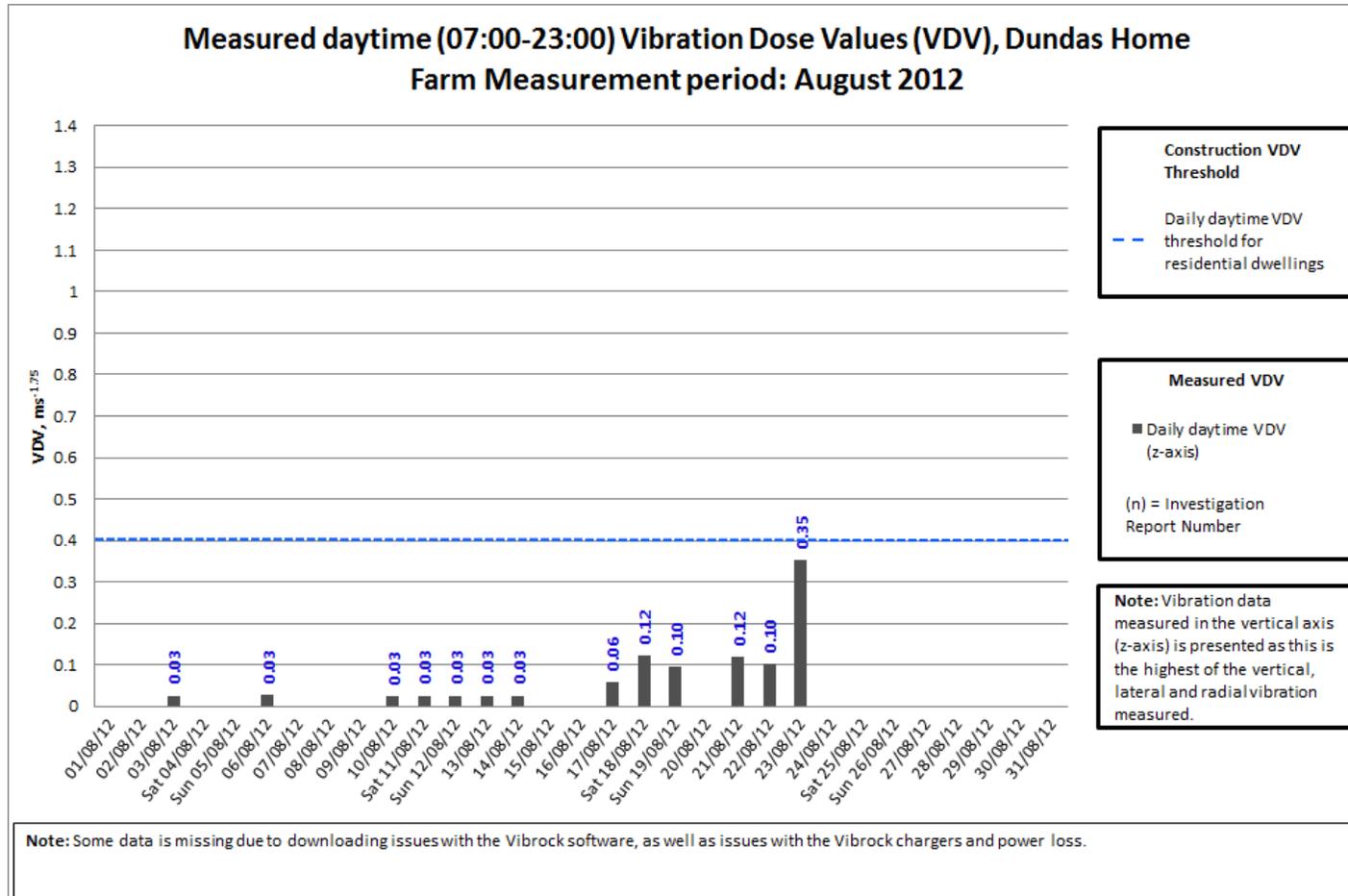
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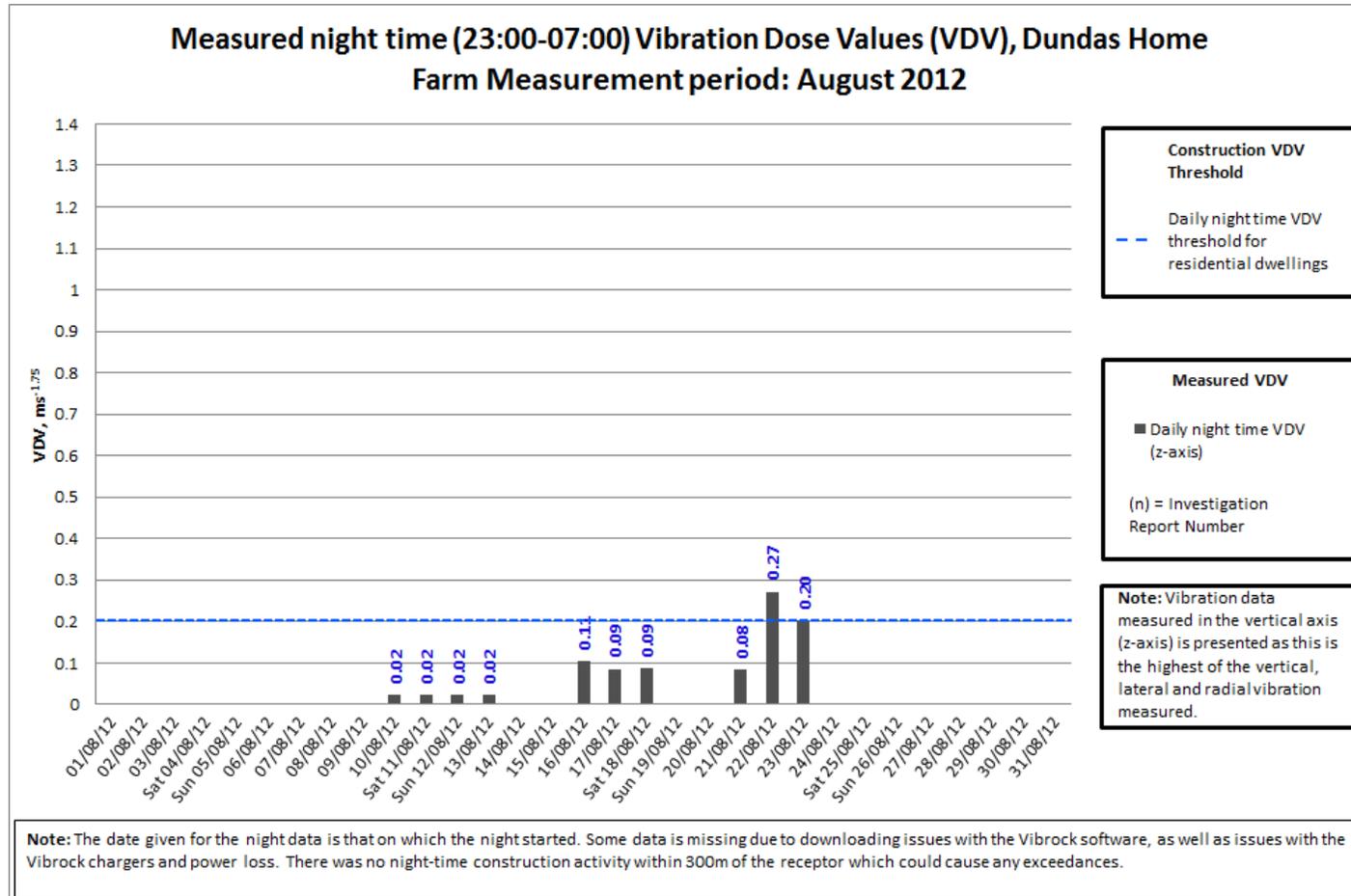
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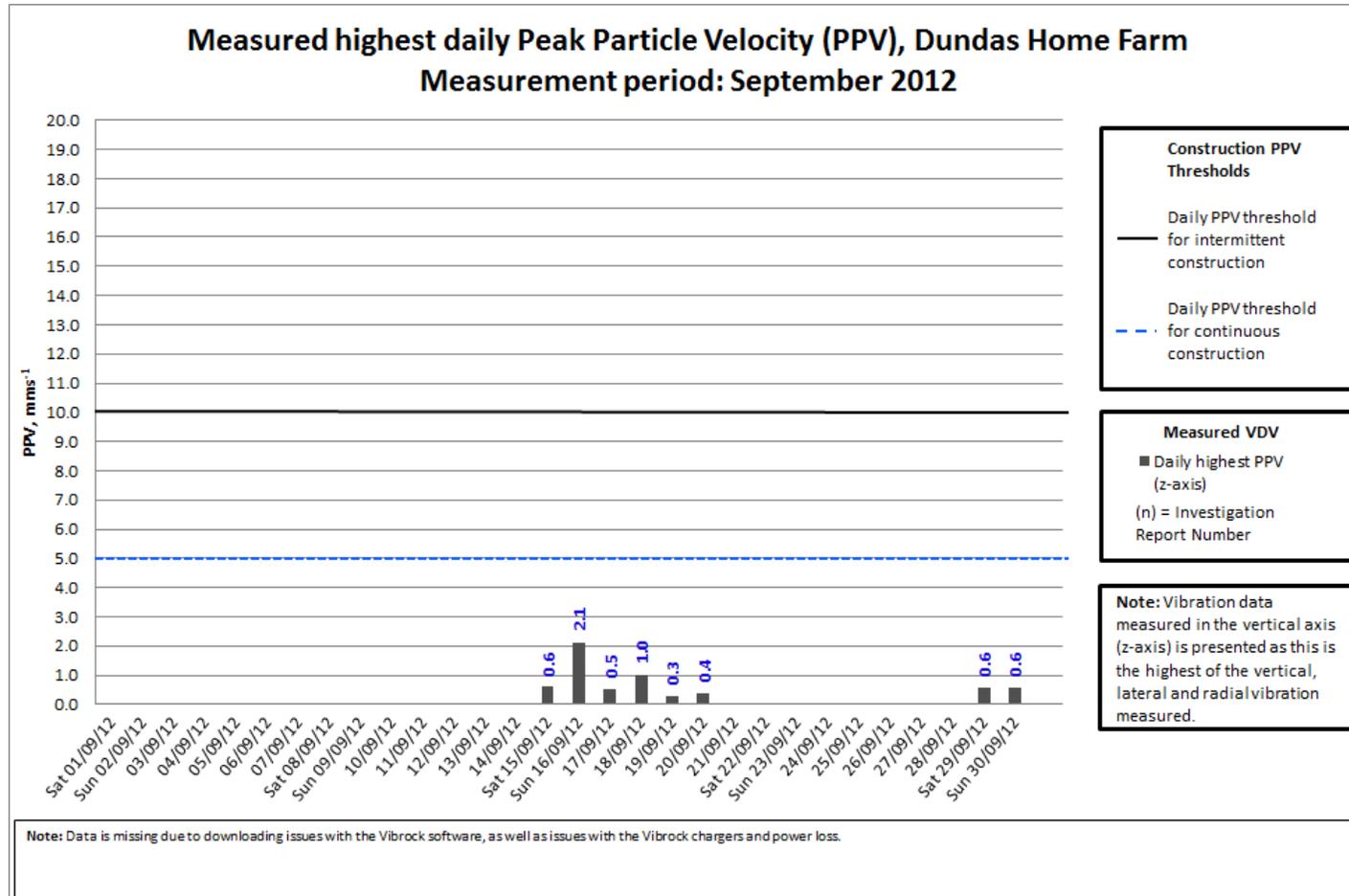
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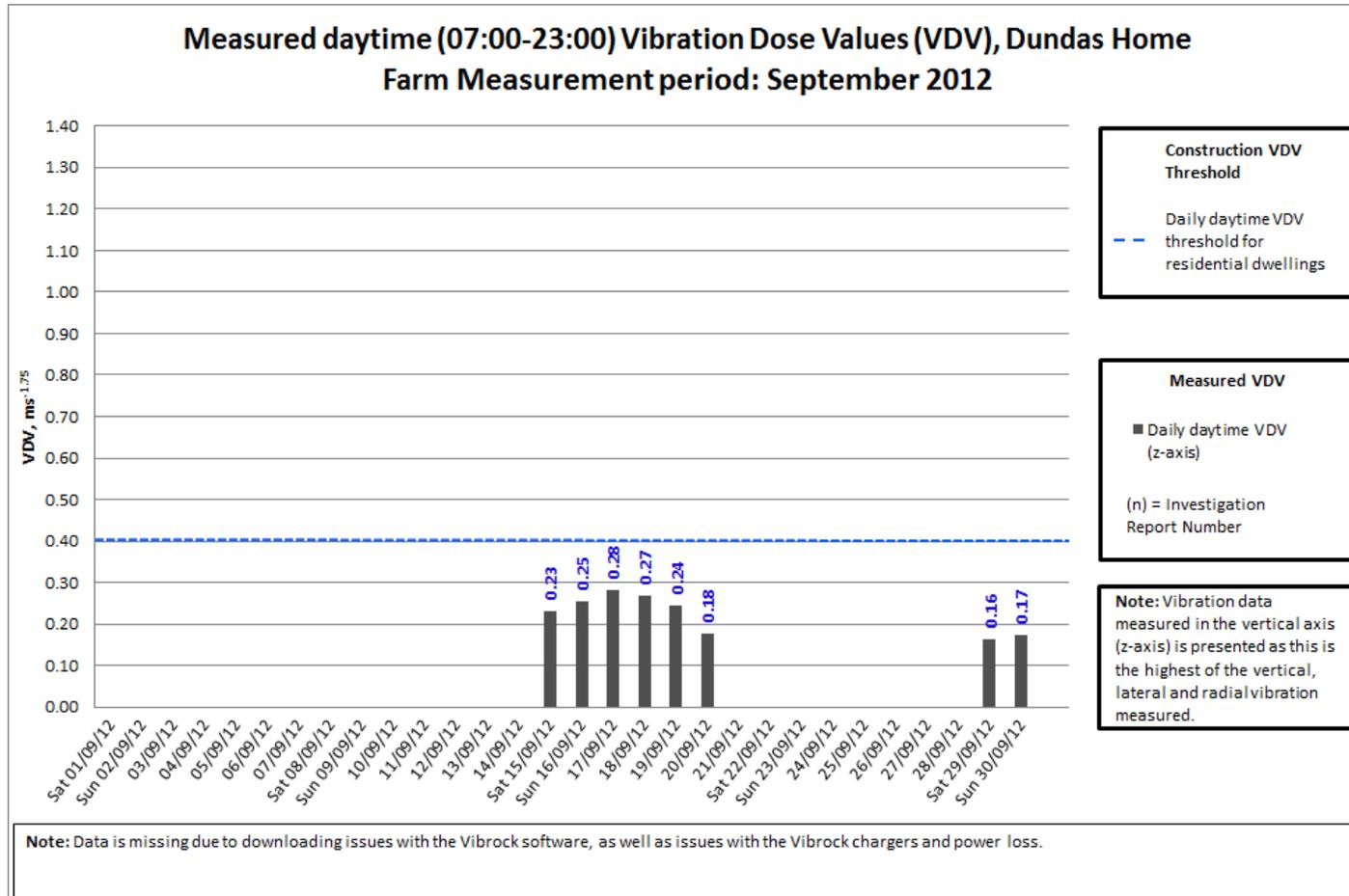
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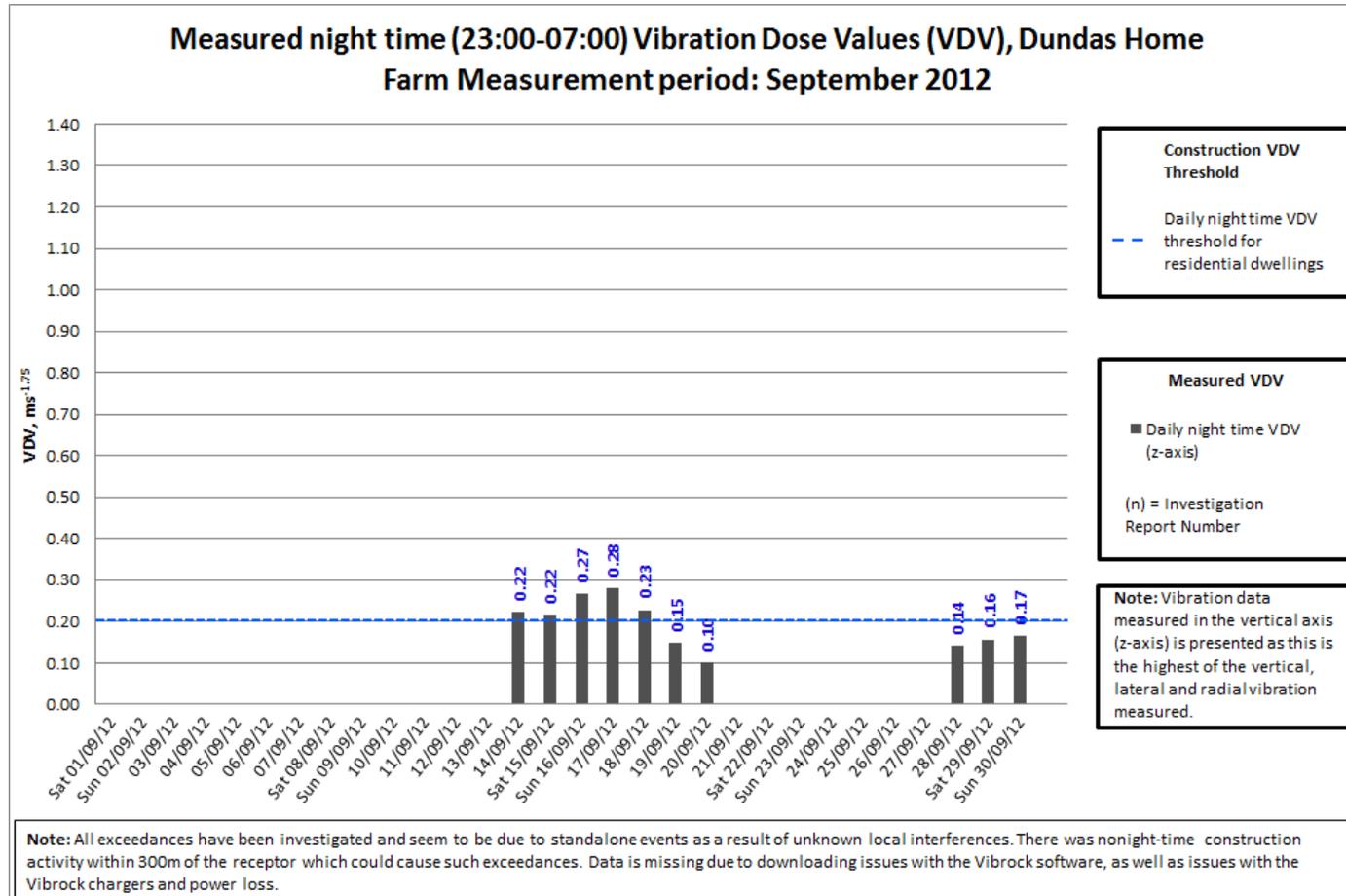
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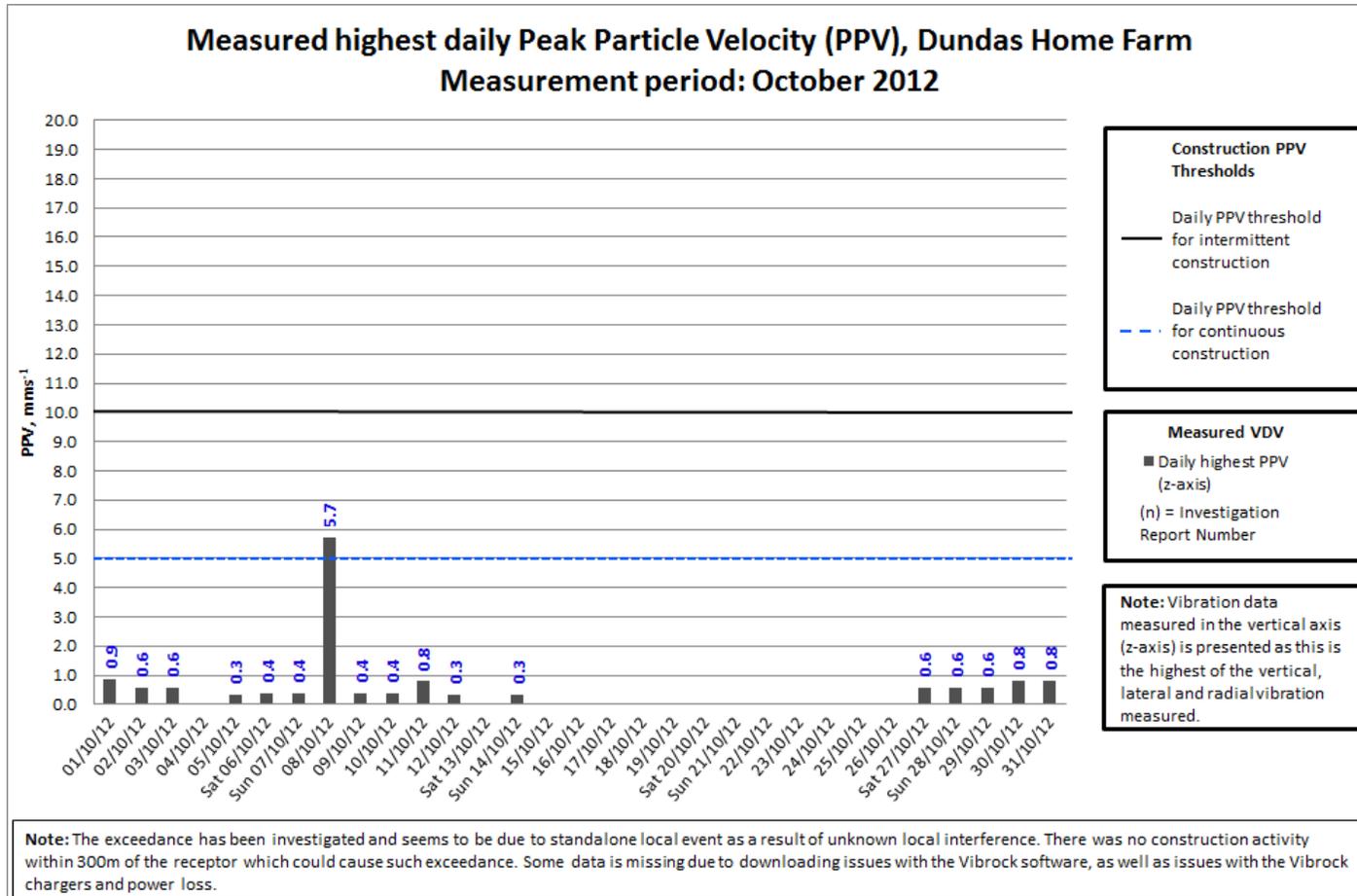
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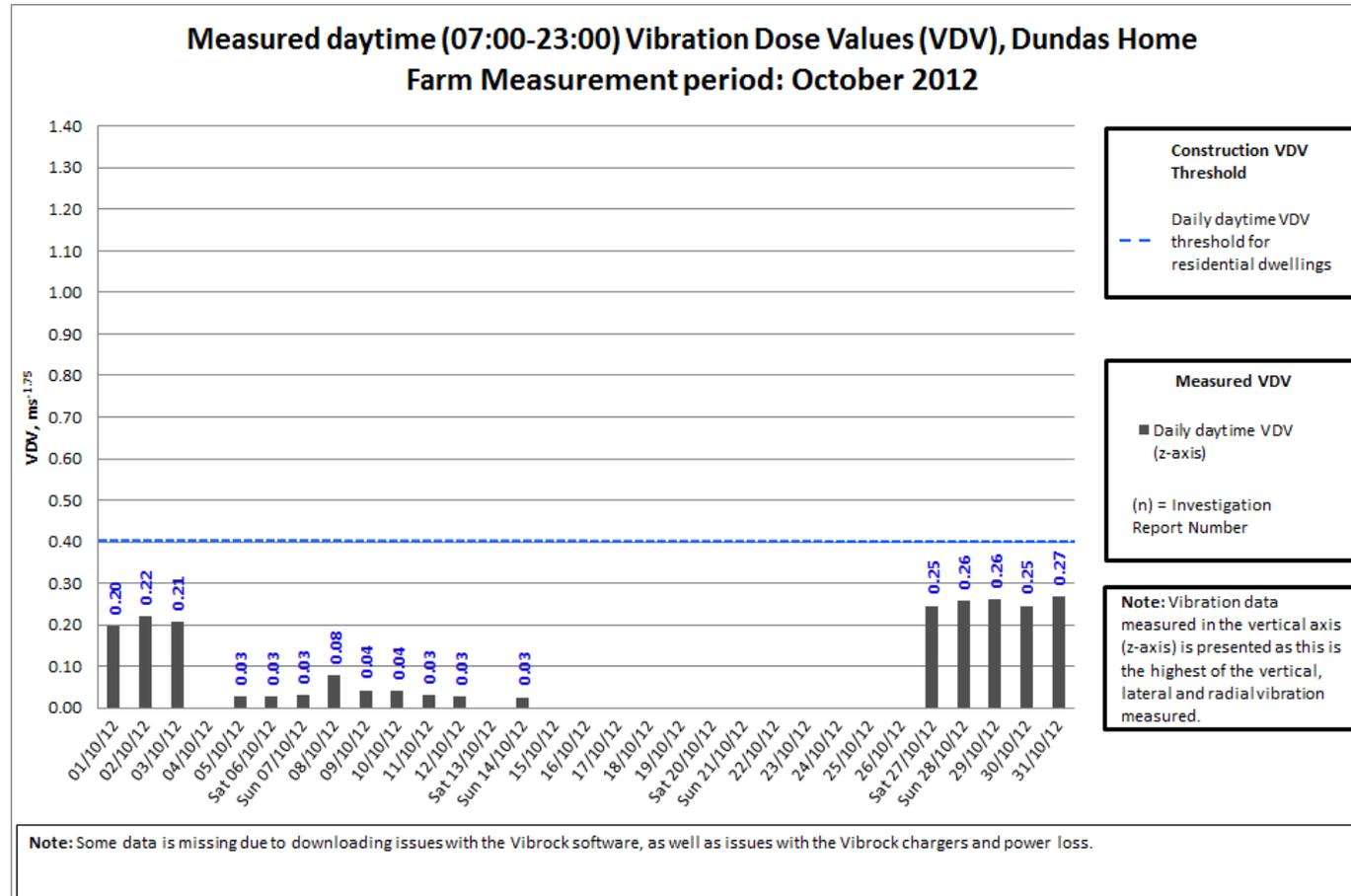
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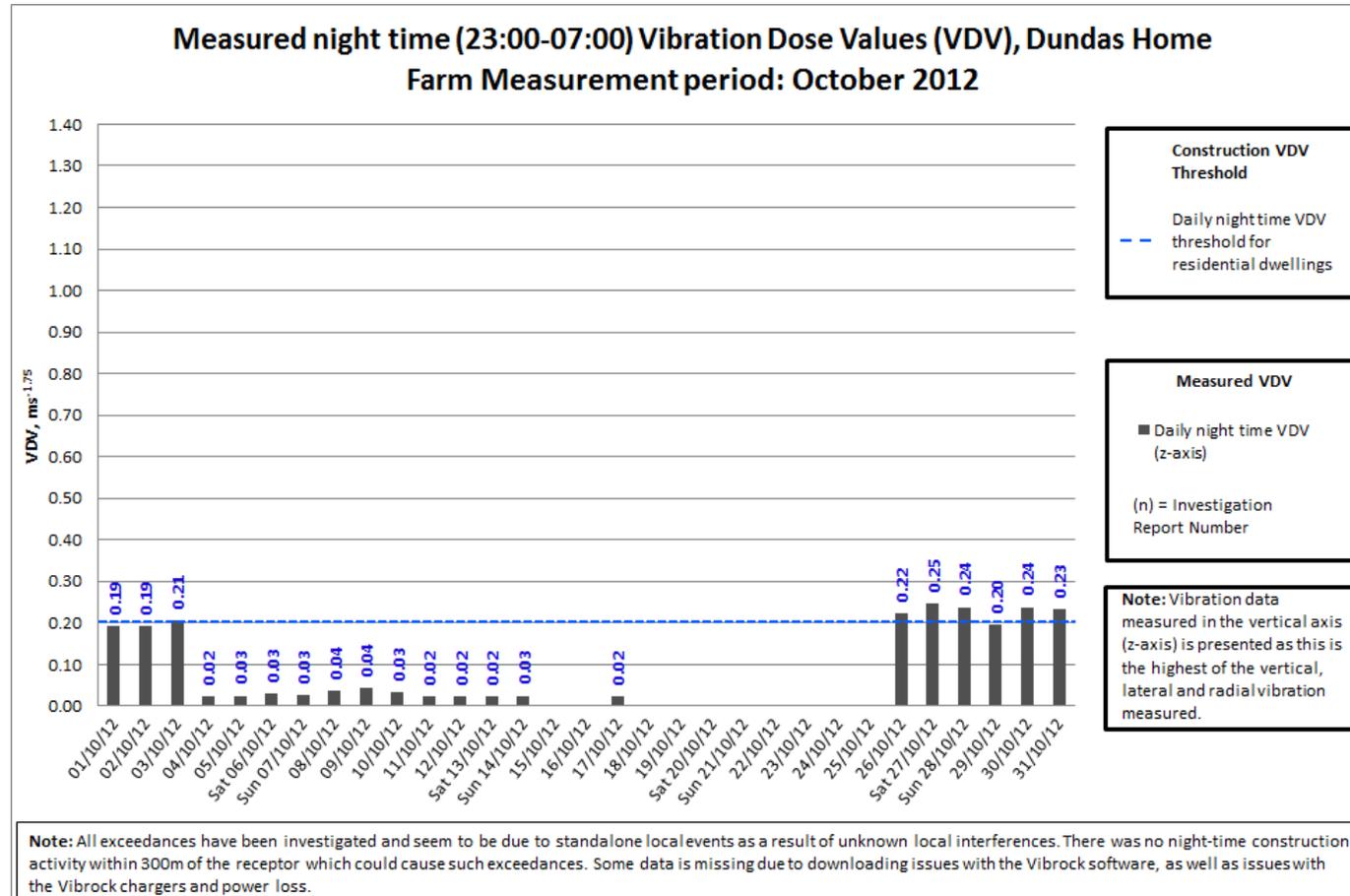
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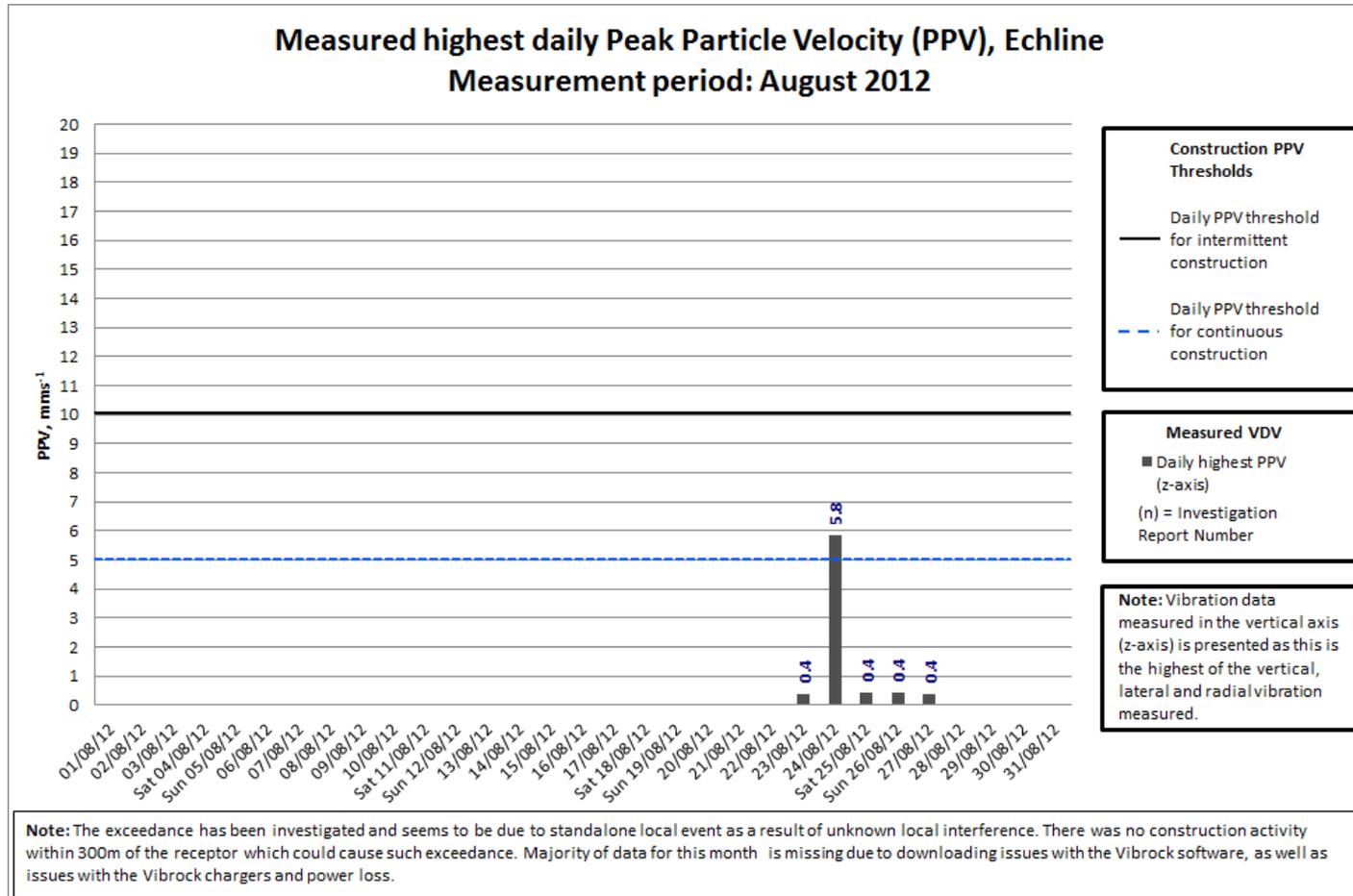
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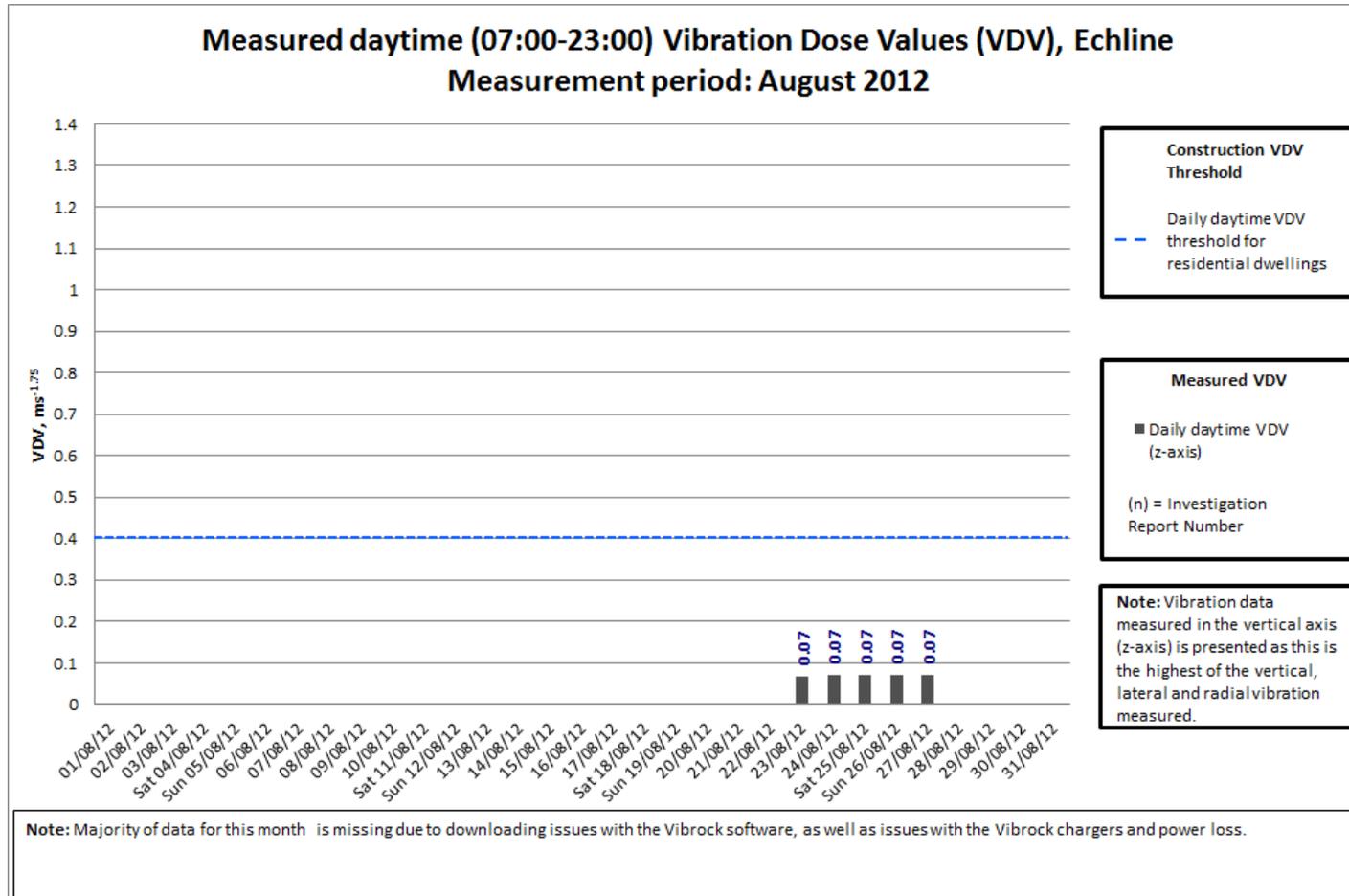
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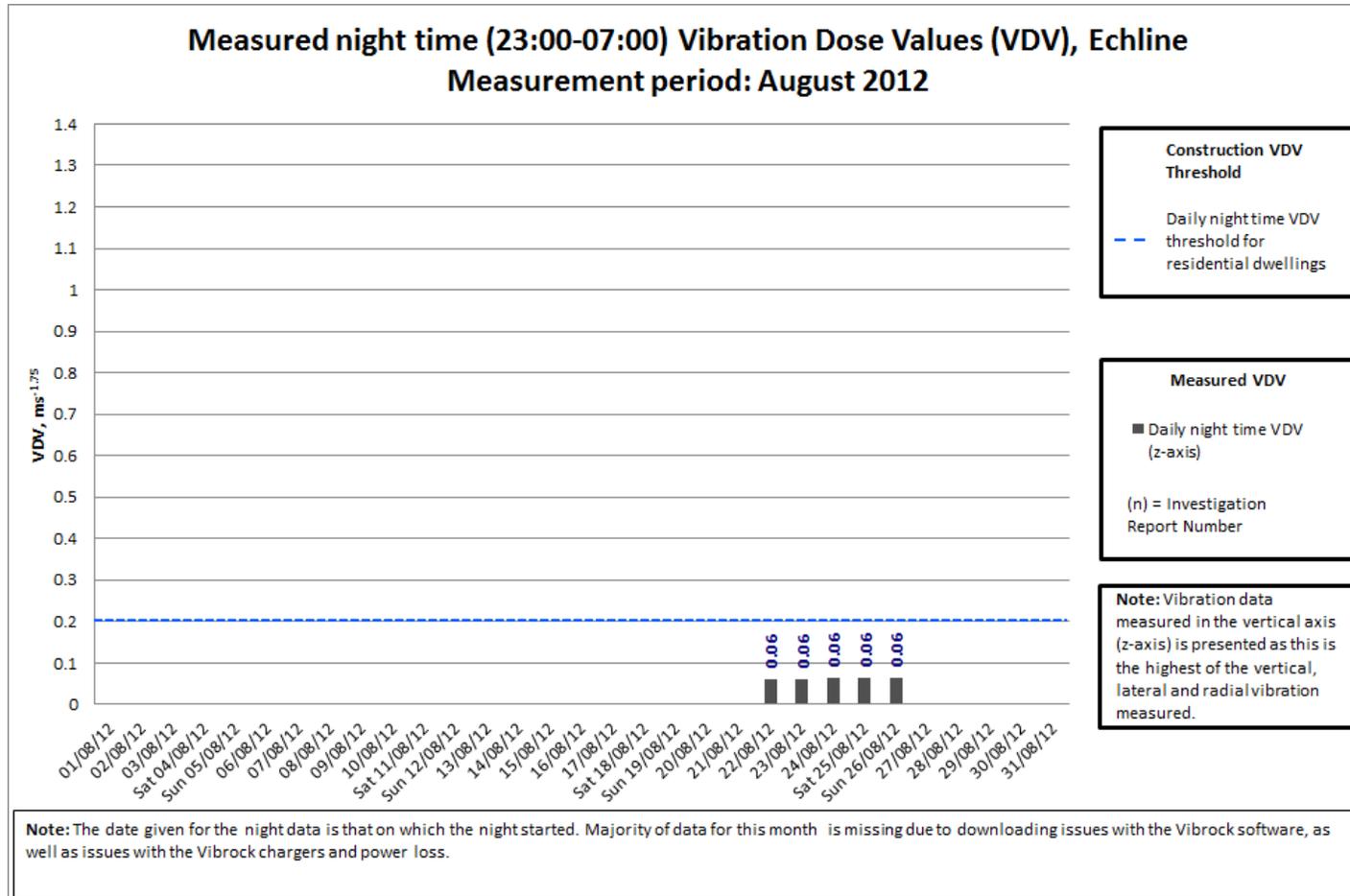
PPV at Echline – August 2012



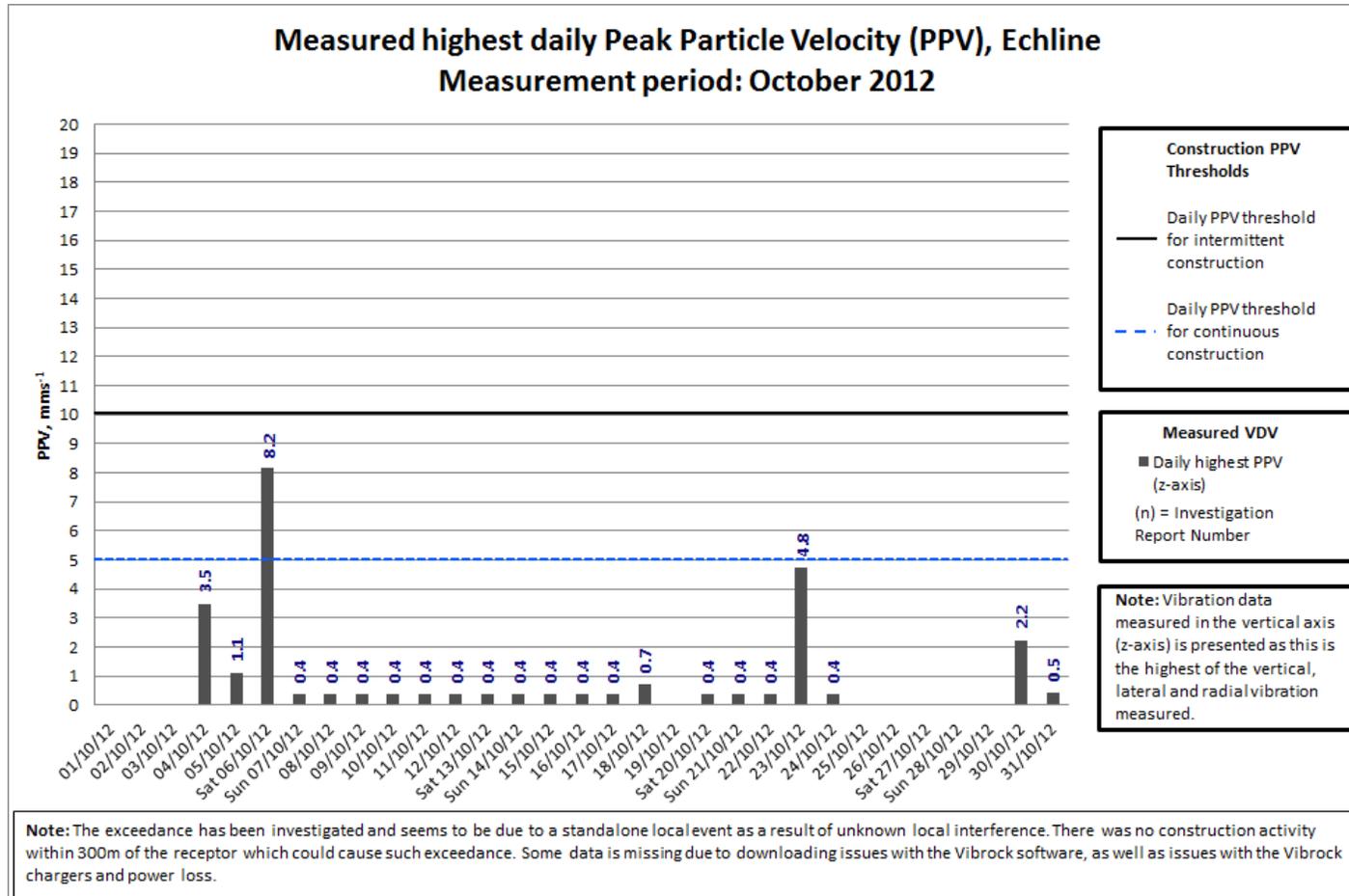
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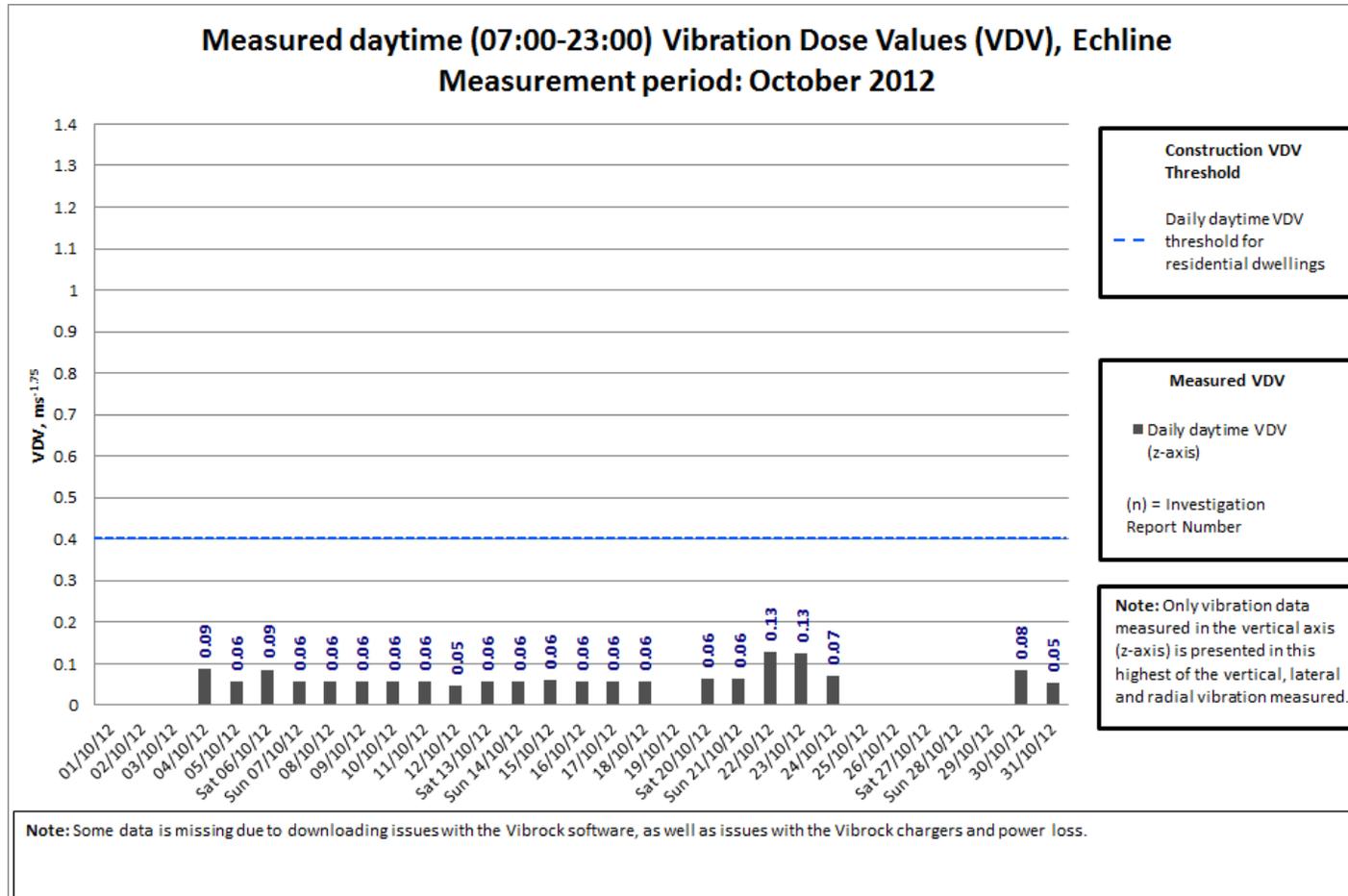
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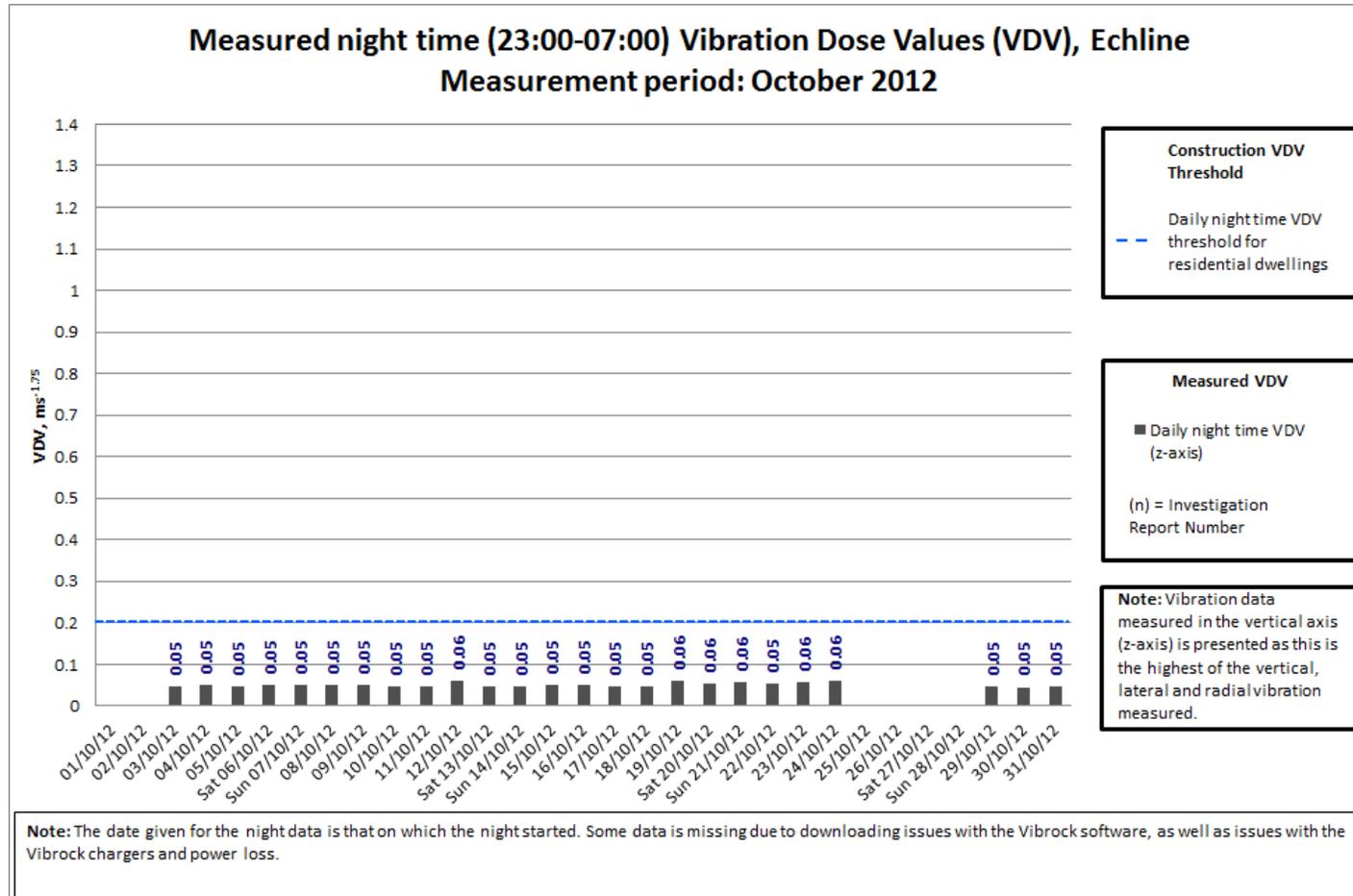
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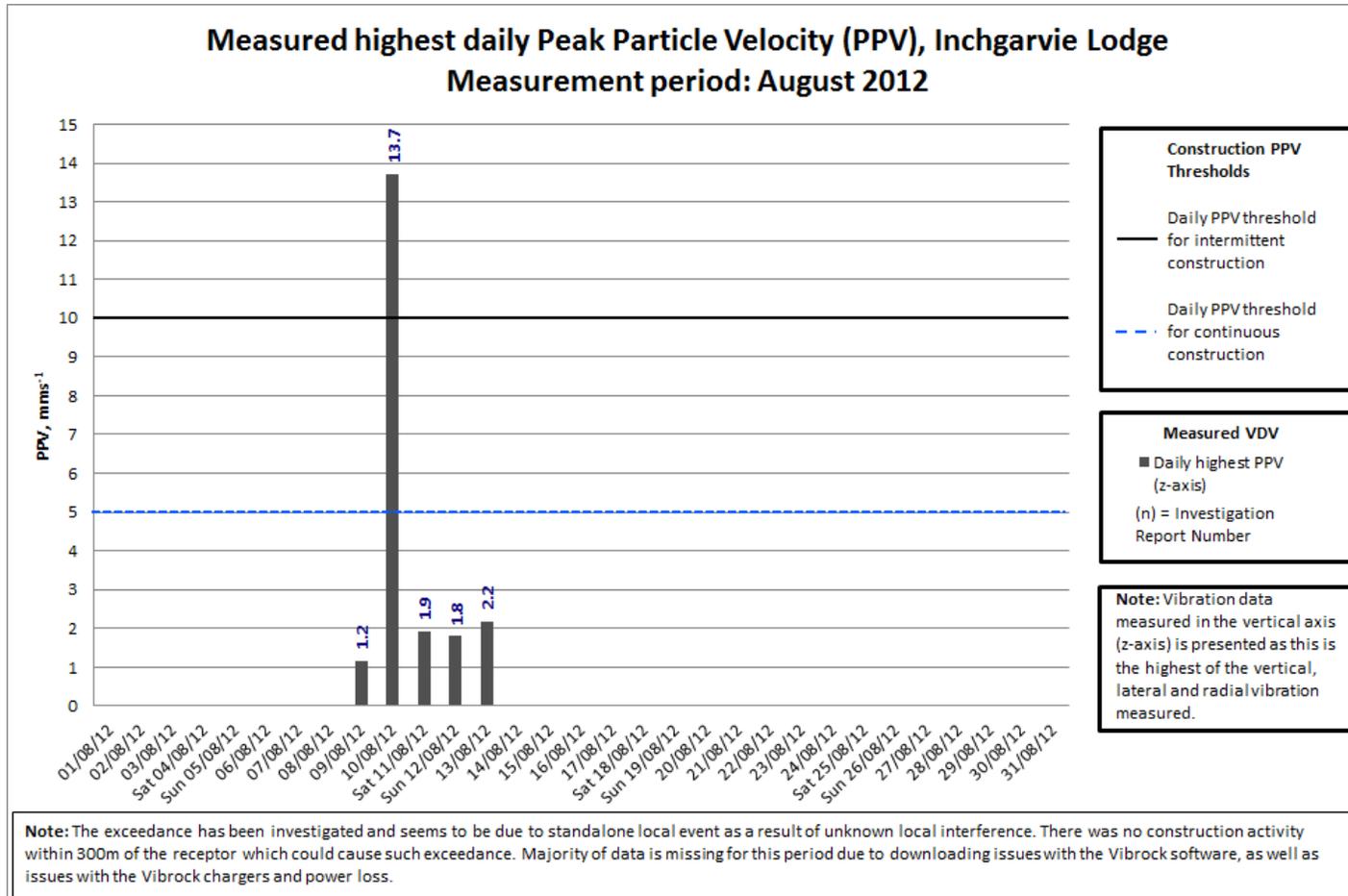
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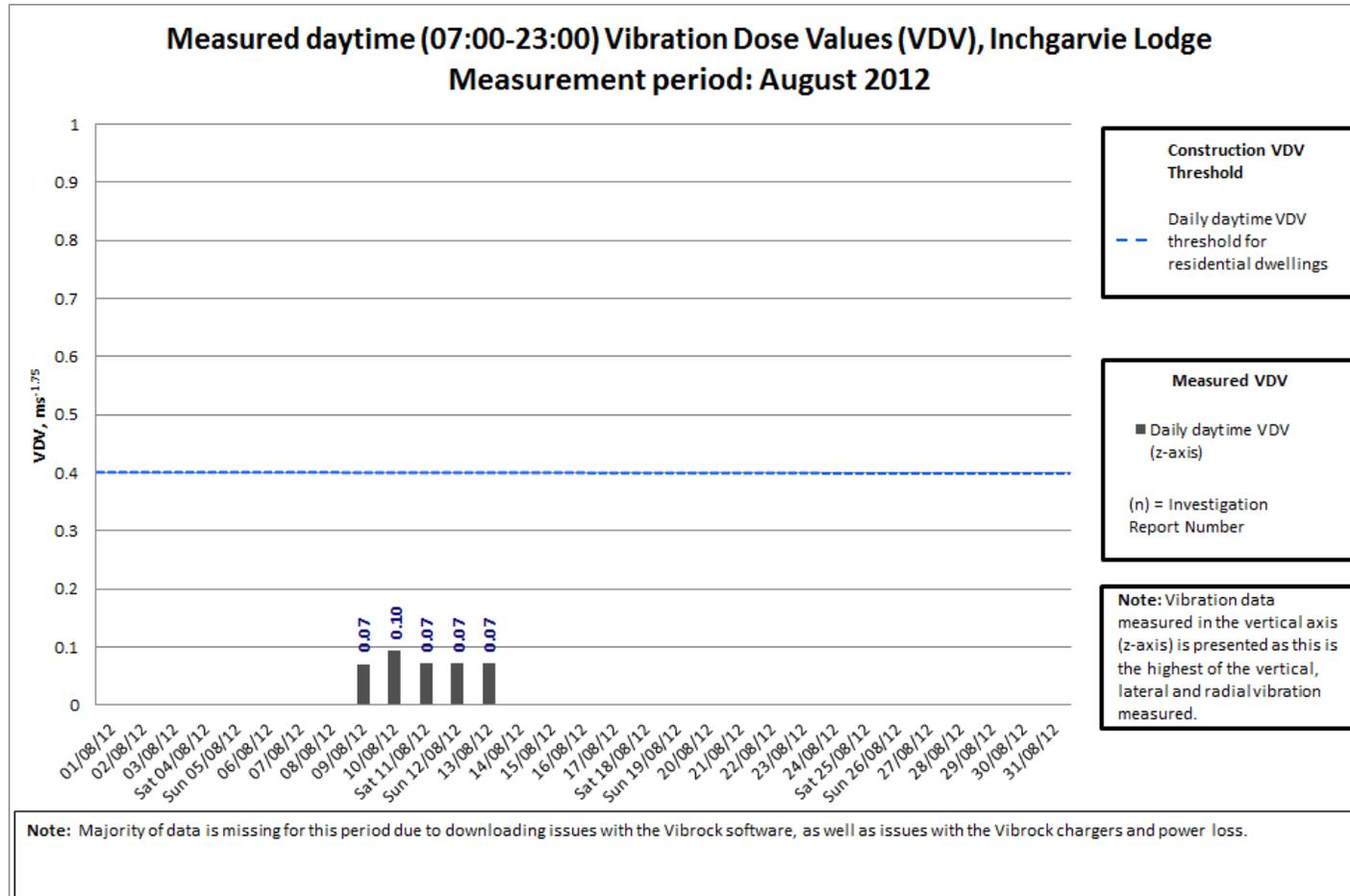
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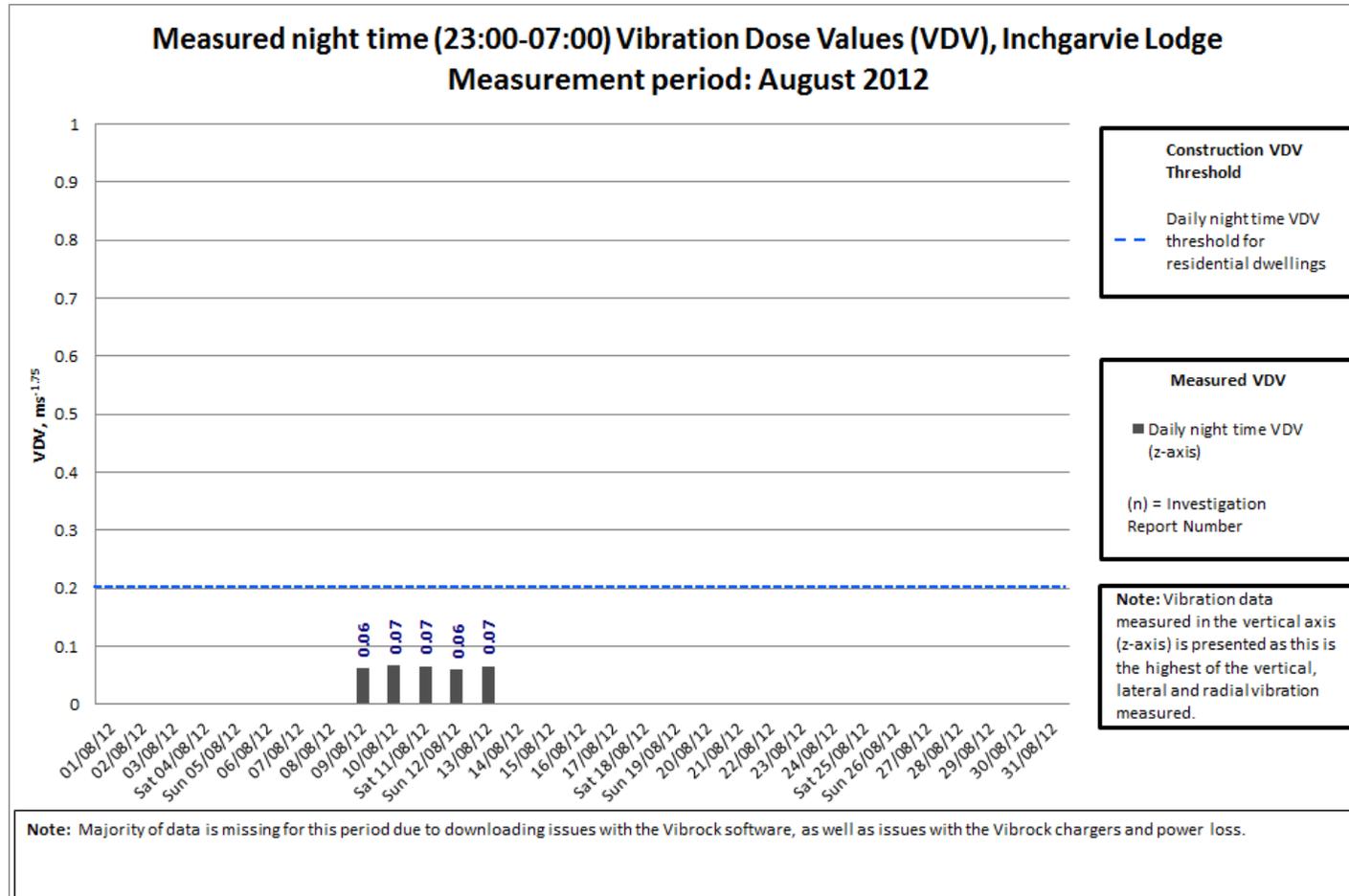
PPV at Inchgarvie Lodge – August 2012



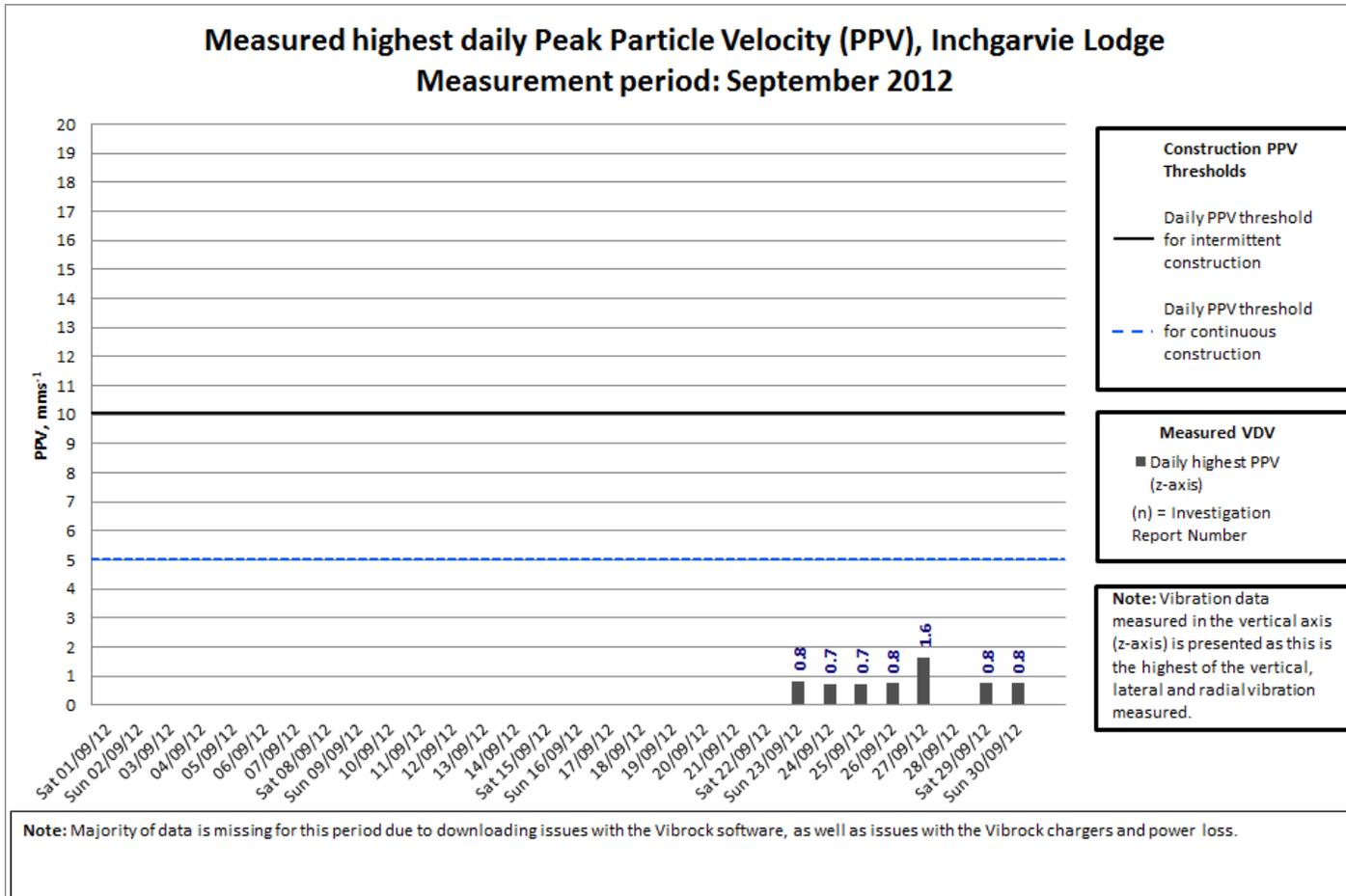
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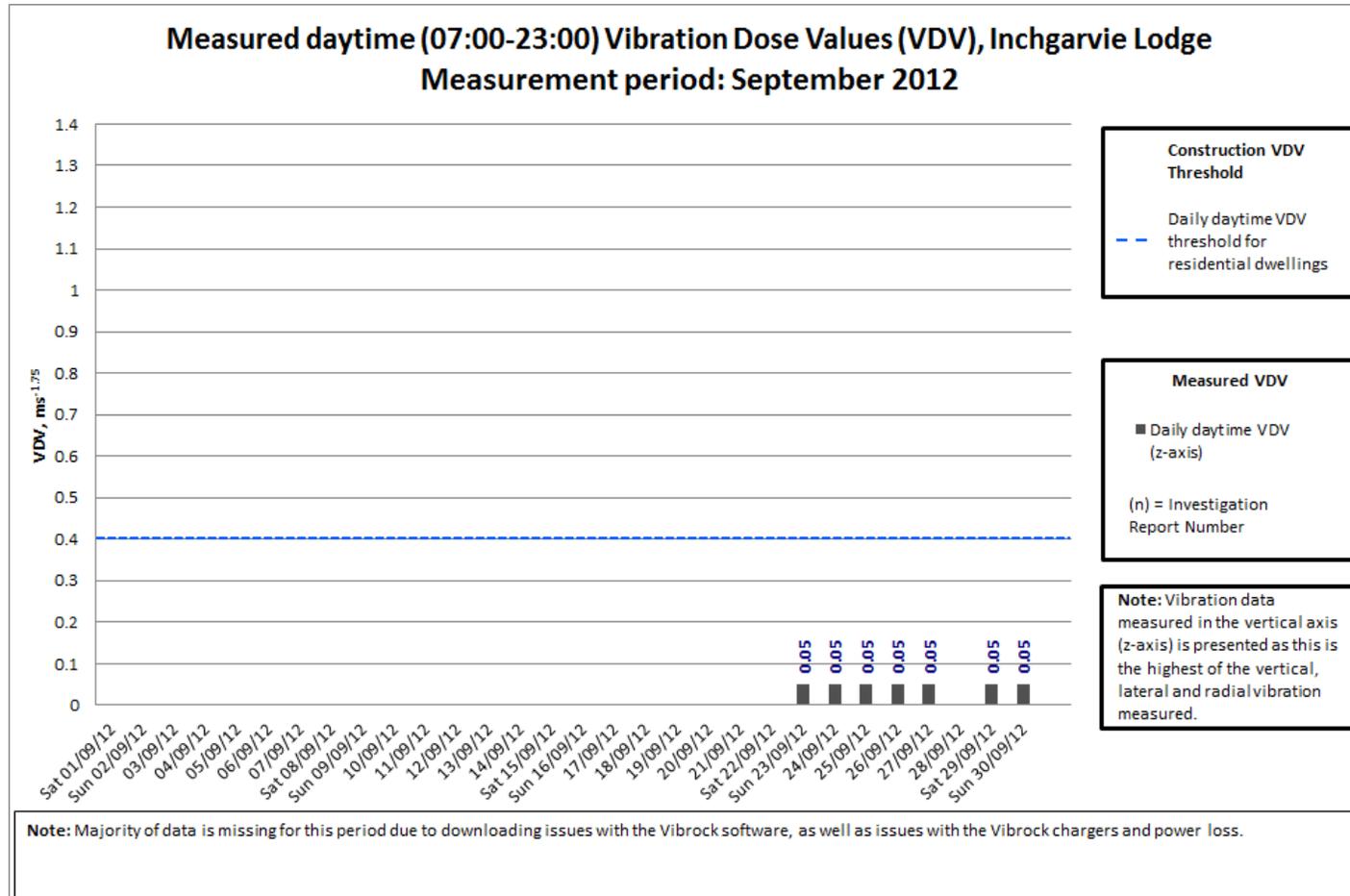
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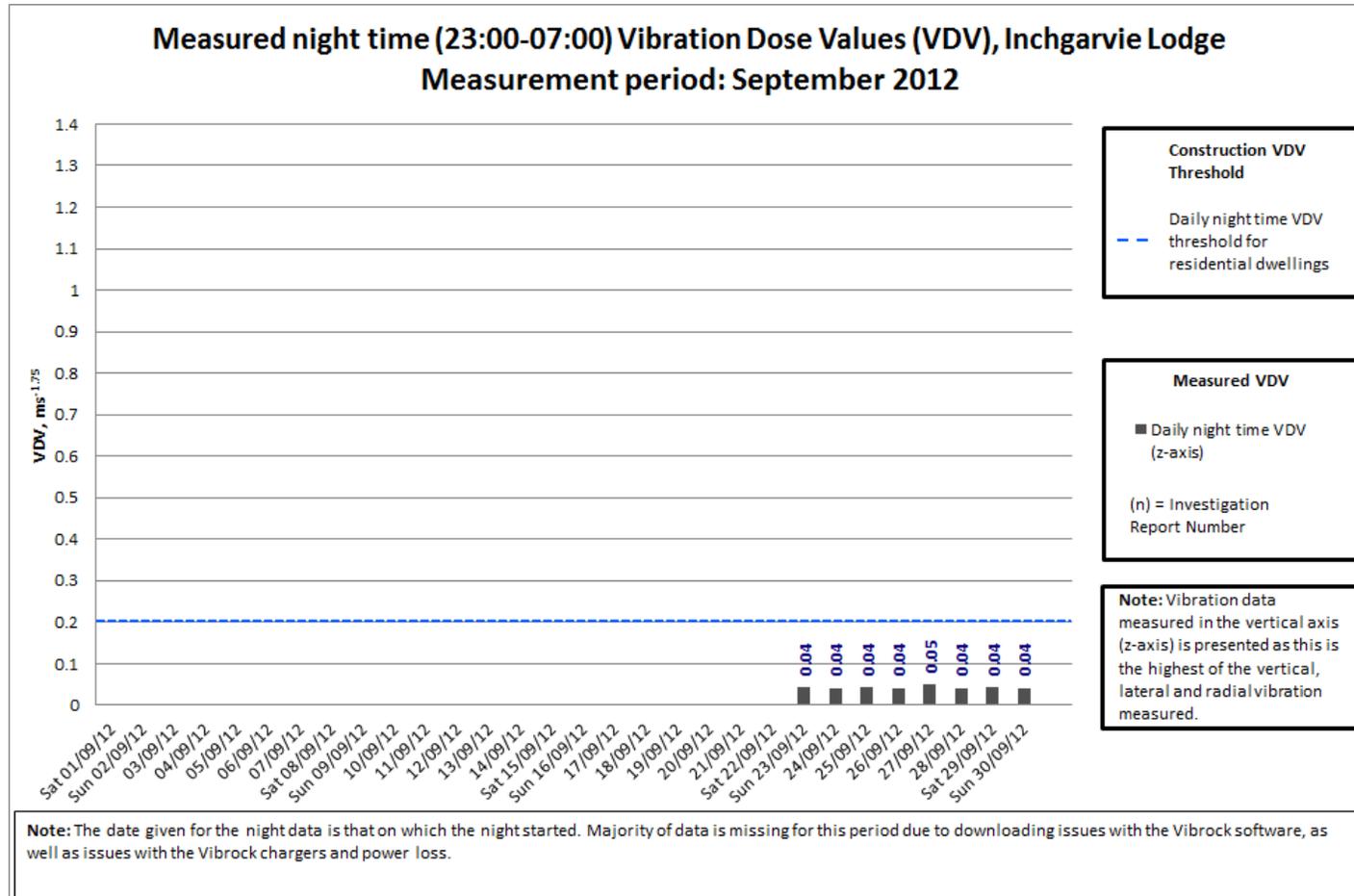
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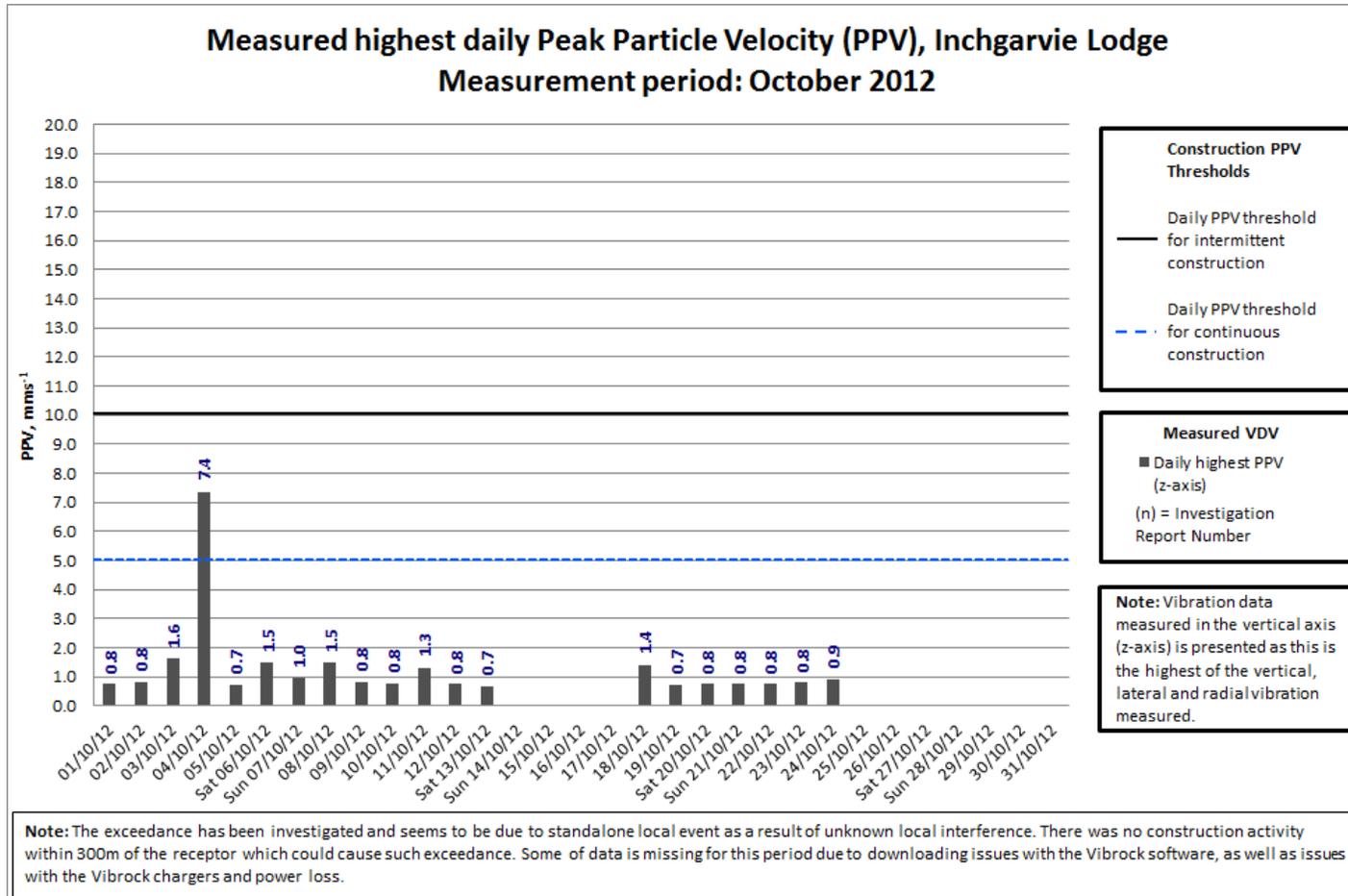
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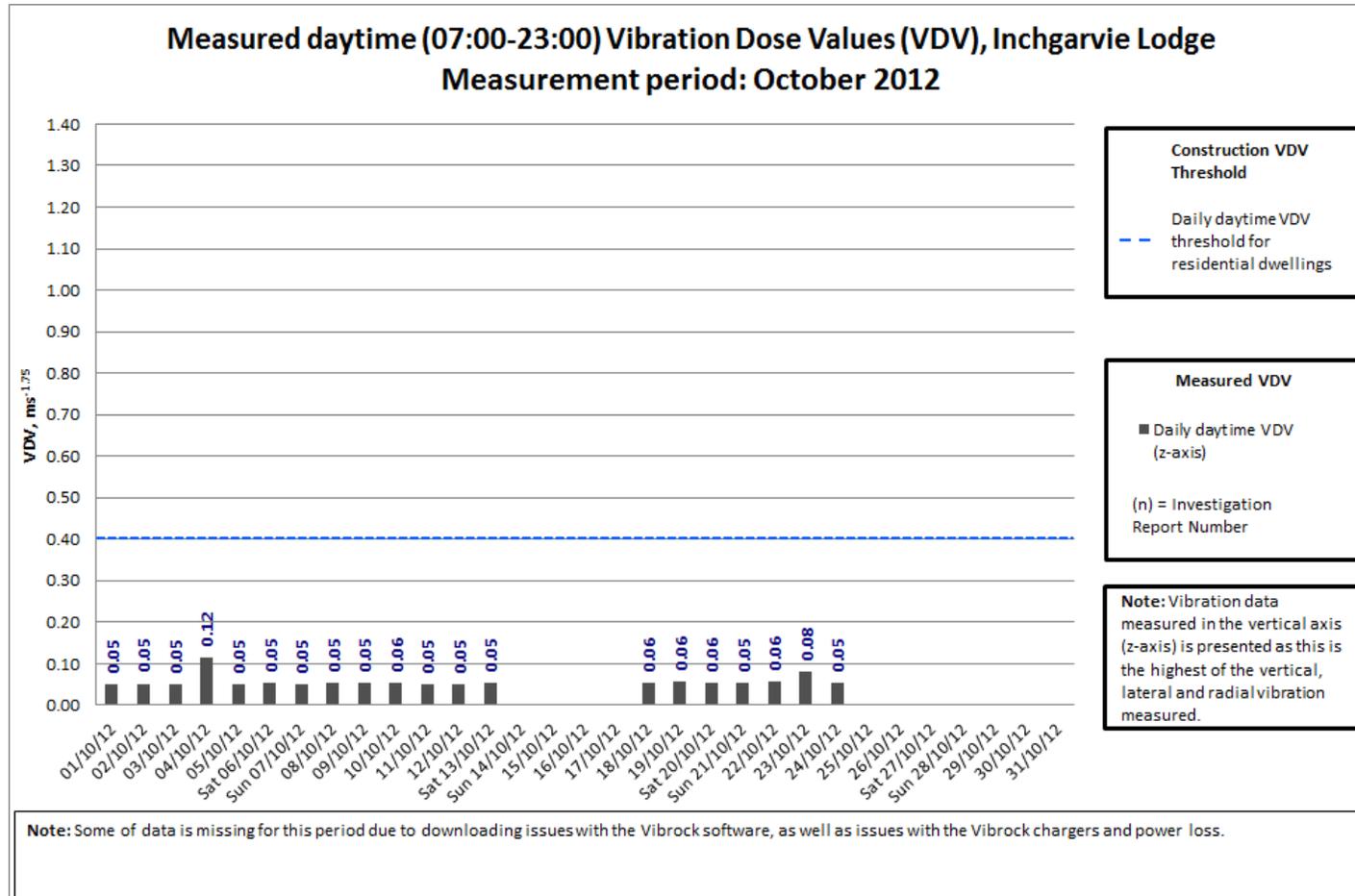
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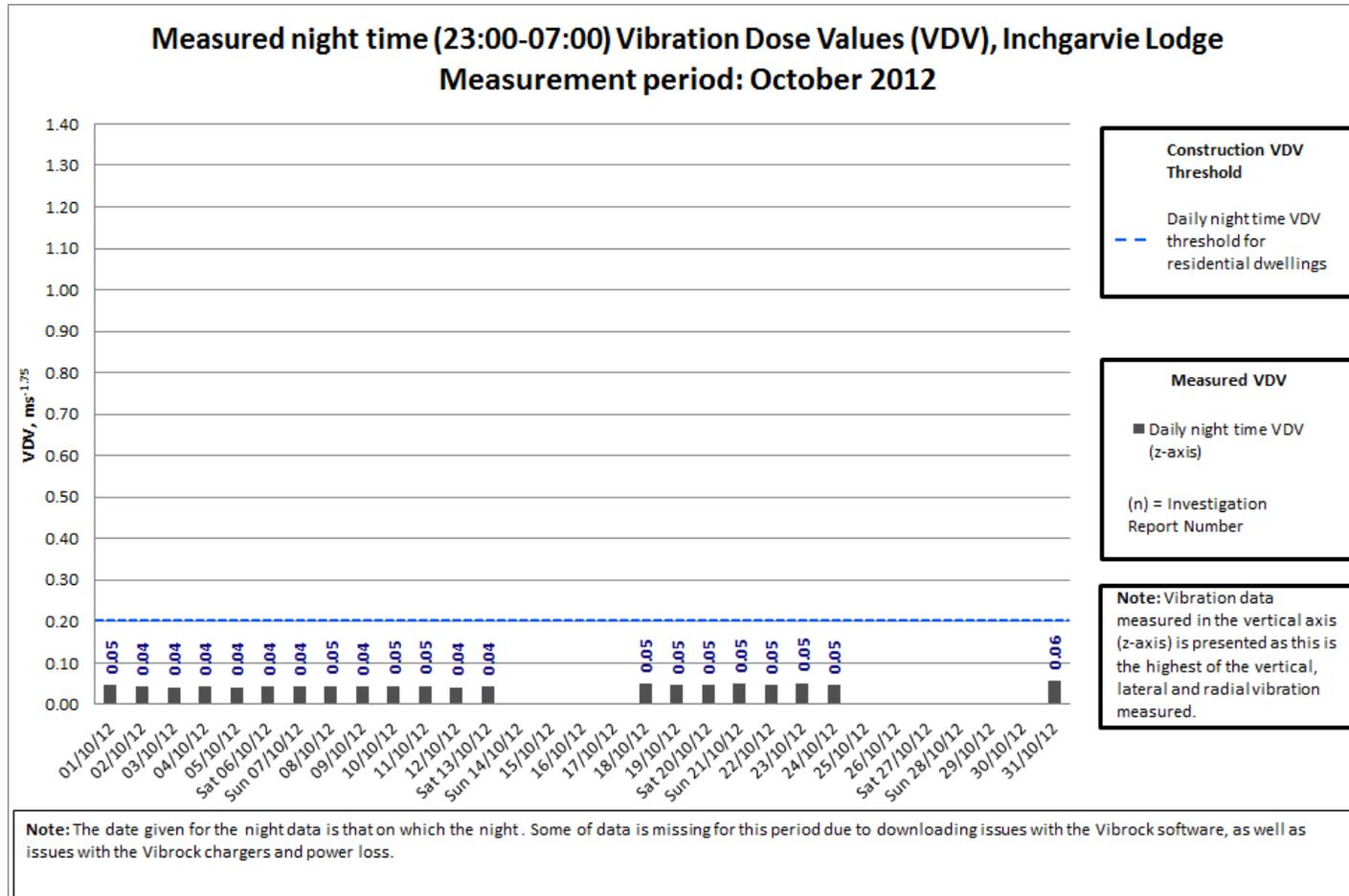
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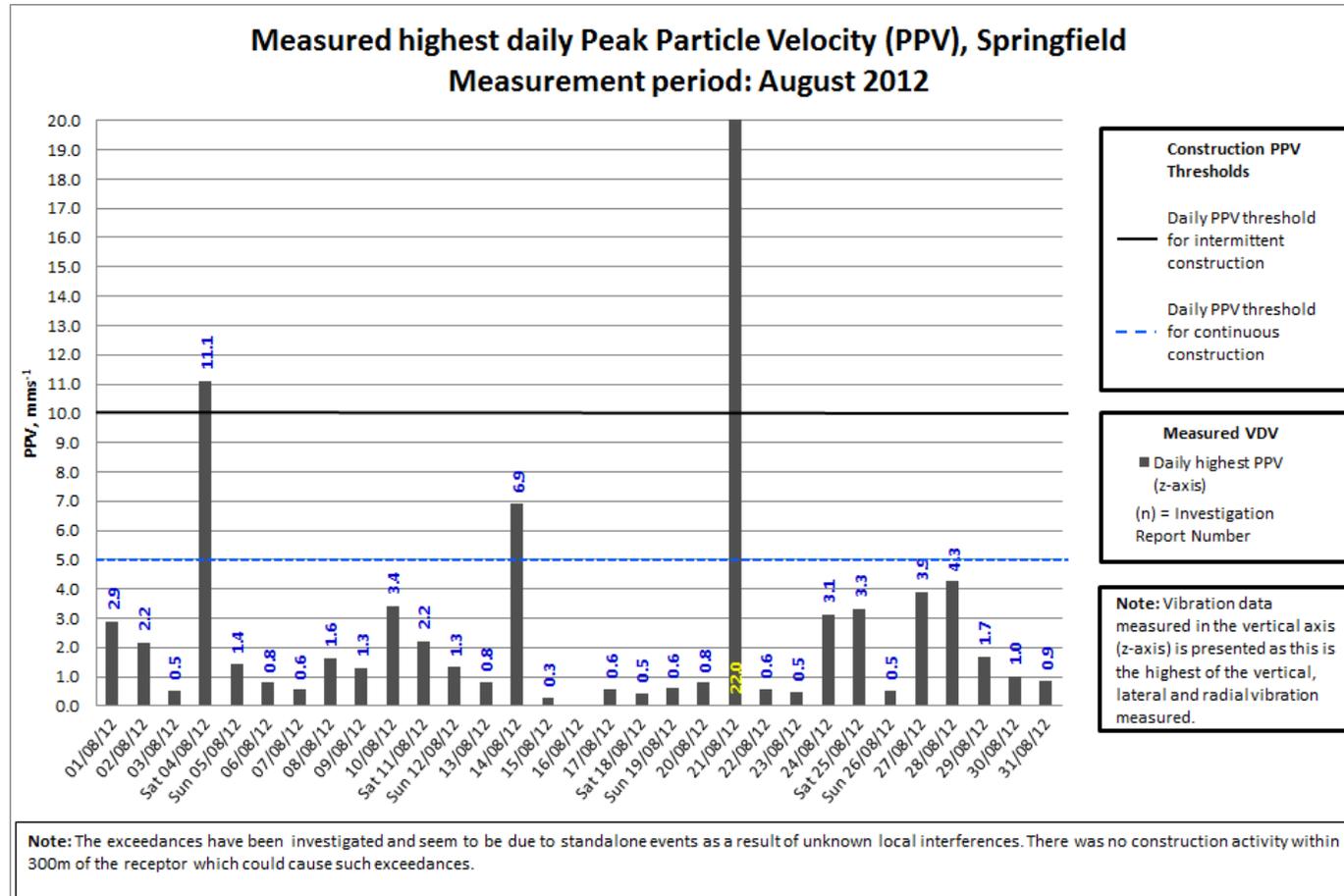
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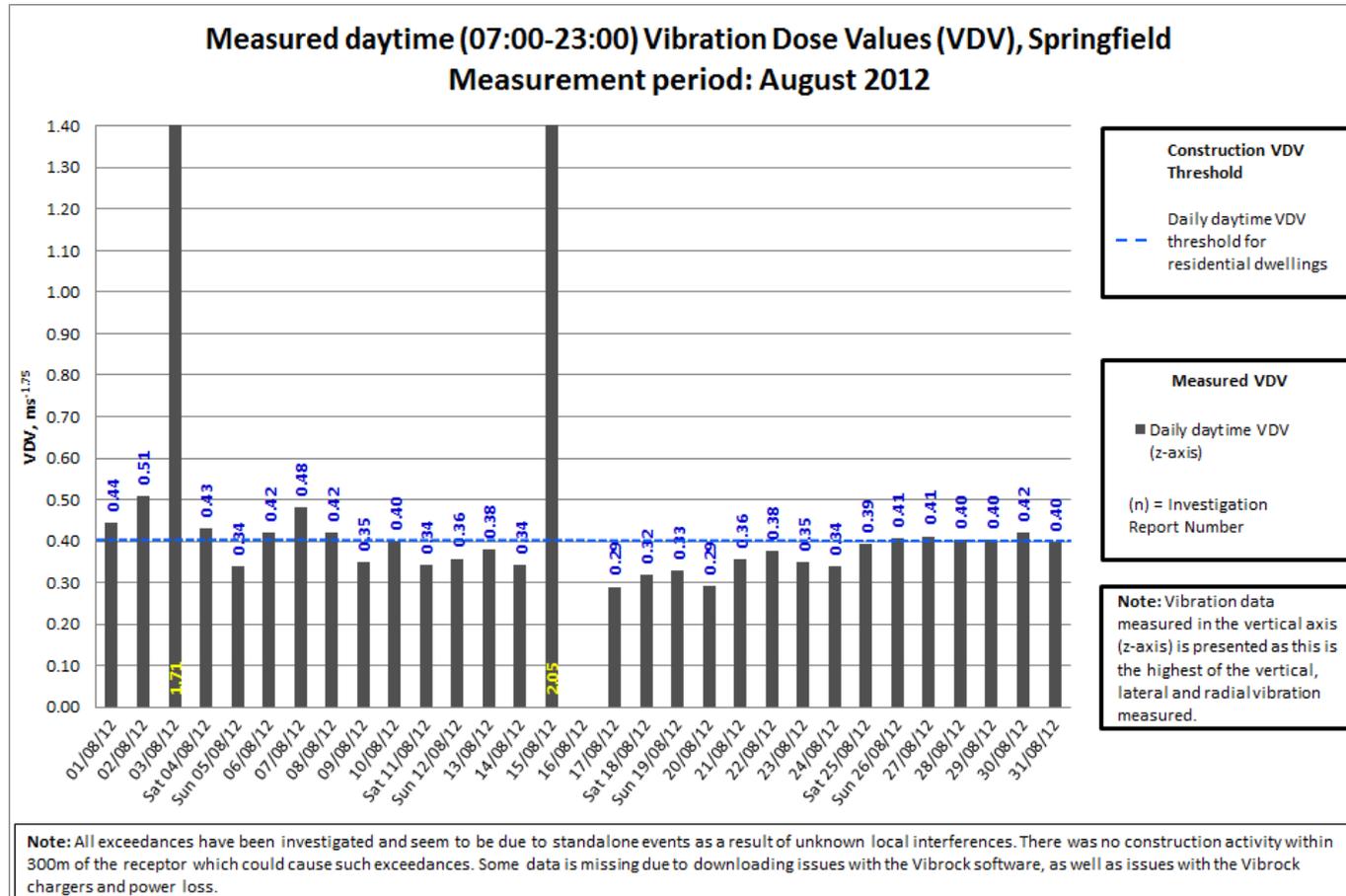
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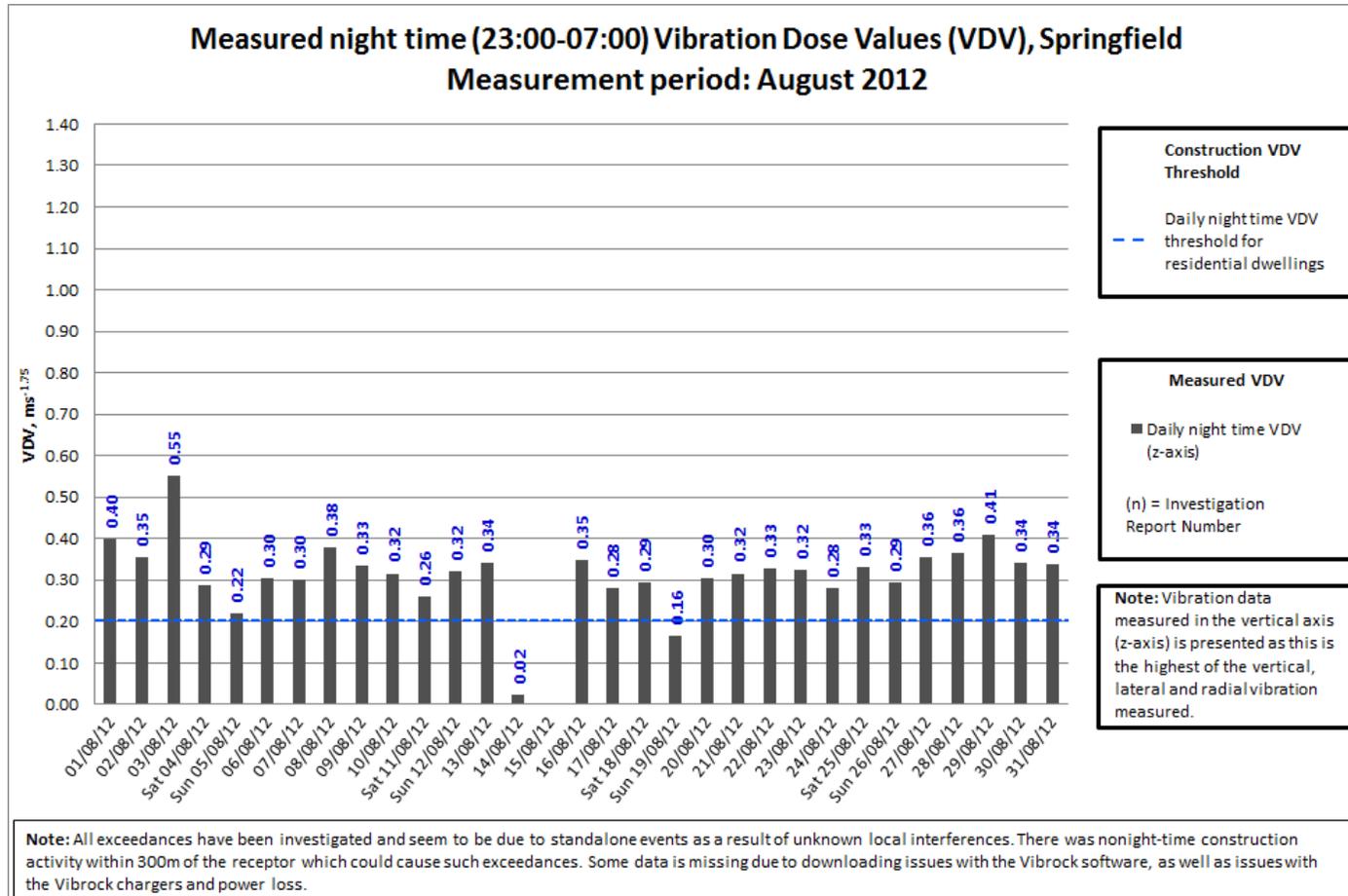
PPV at Springfield – August 2012



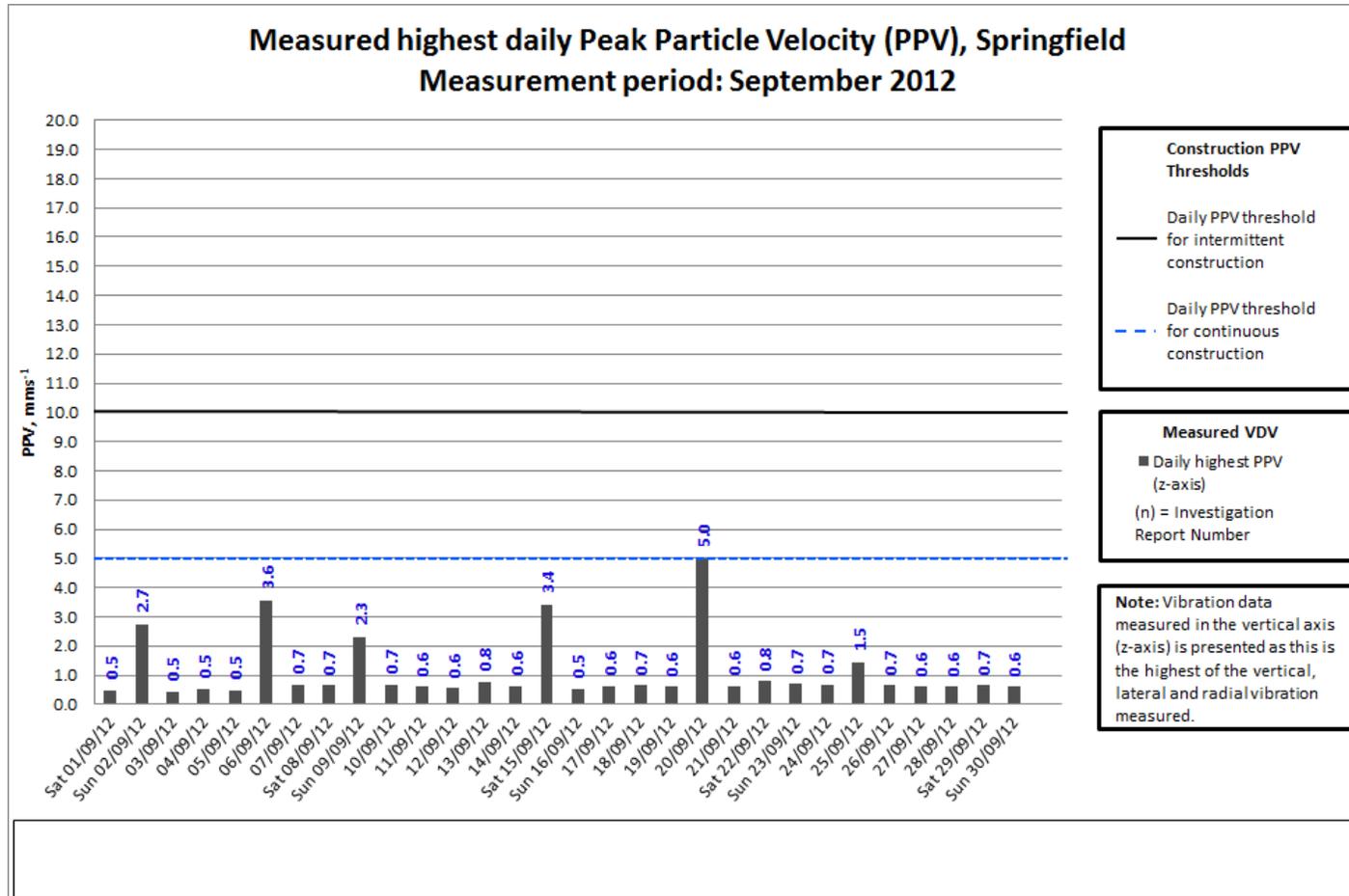
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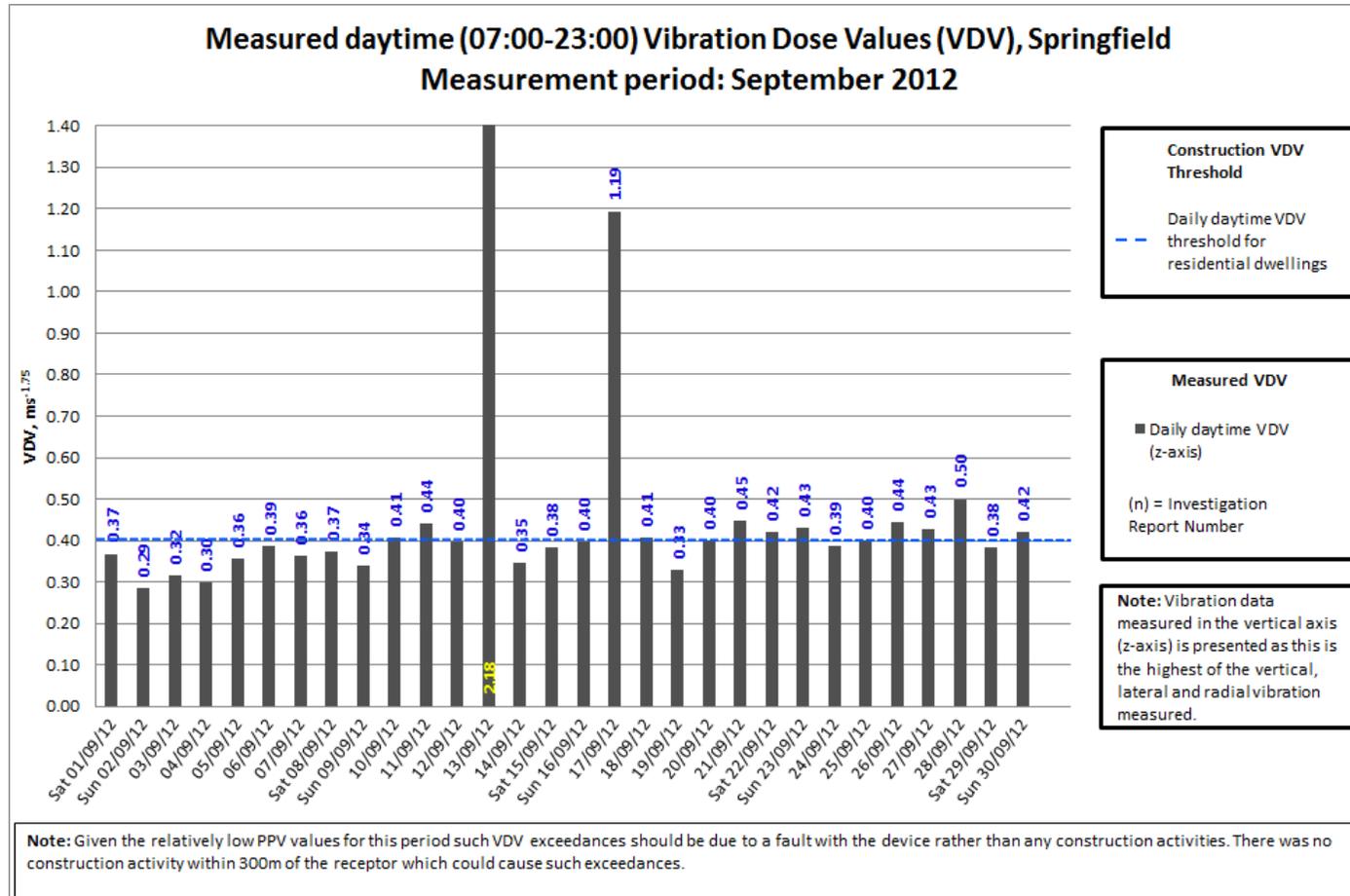
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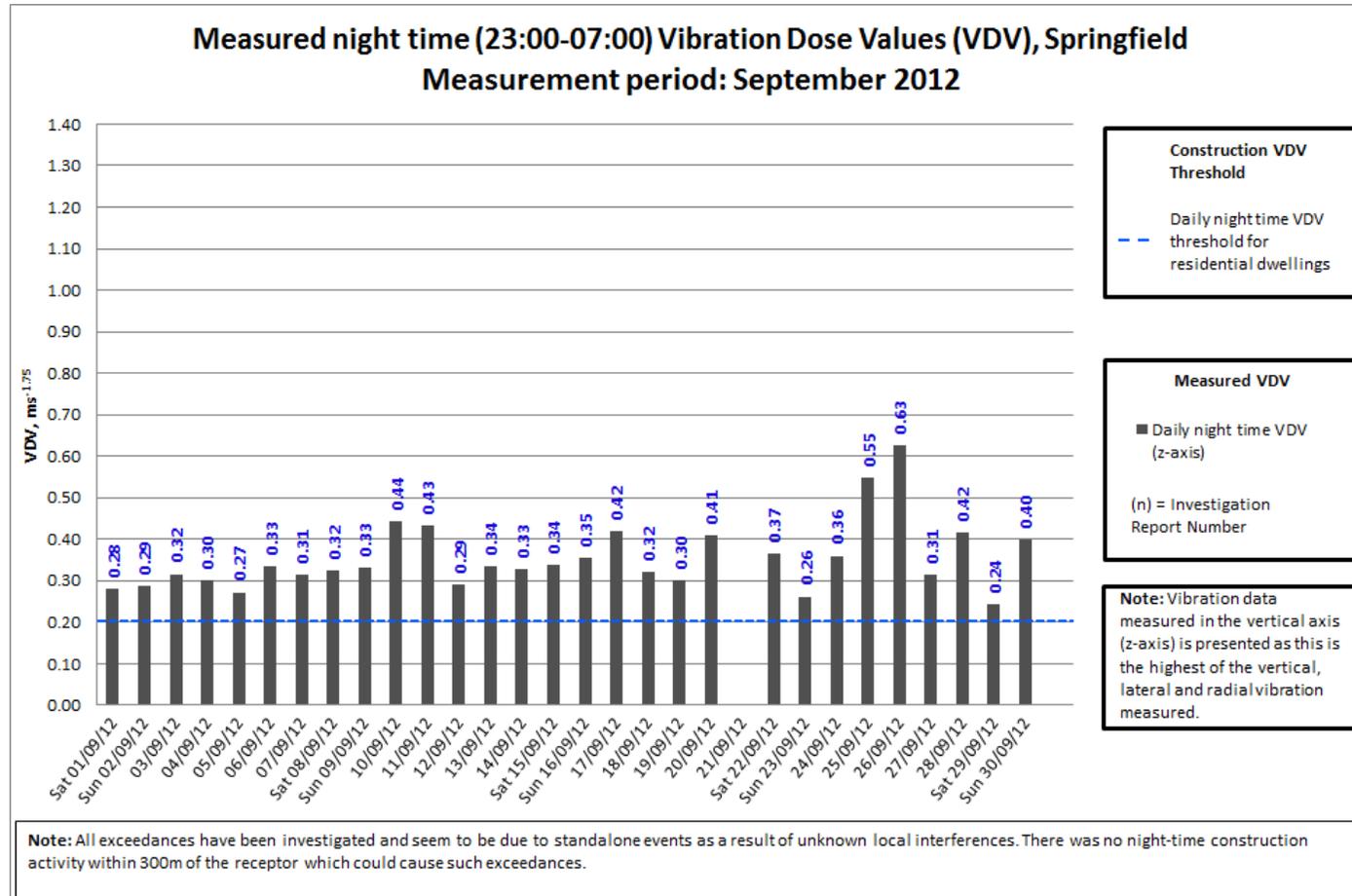
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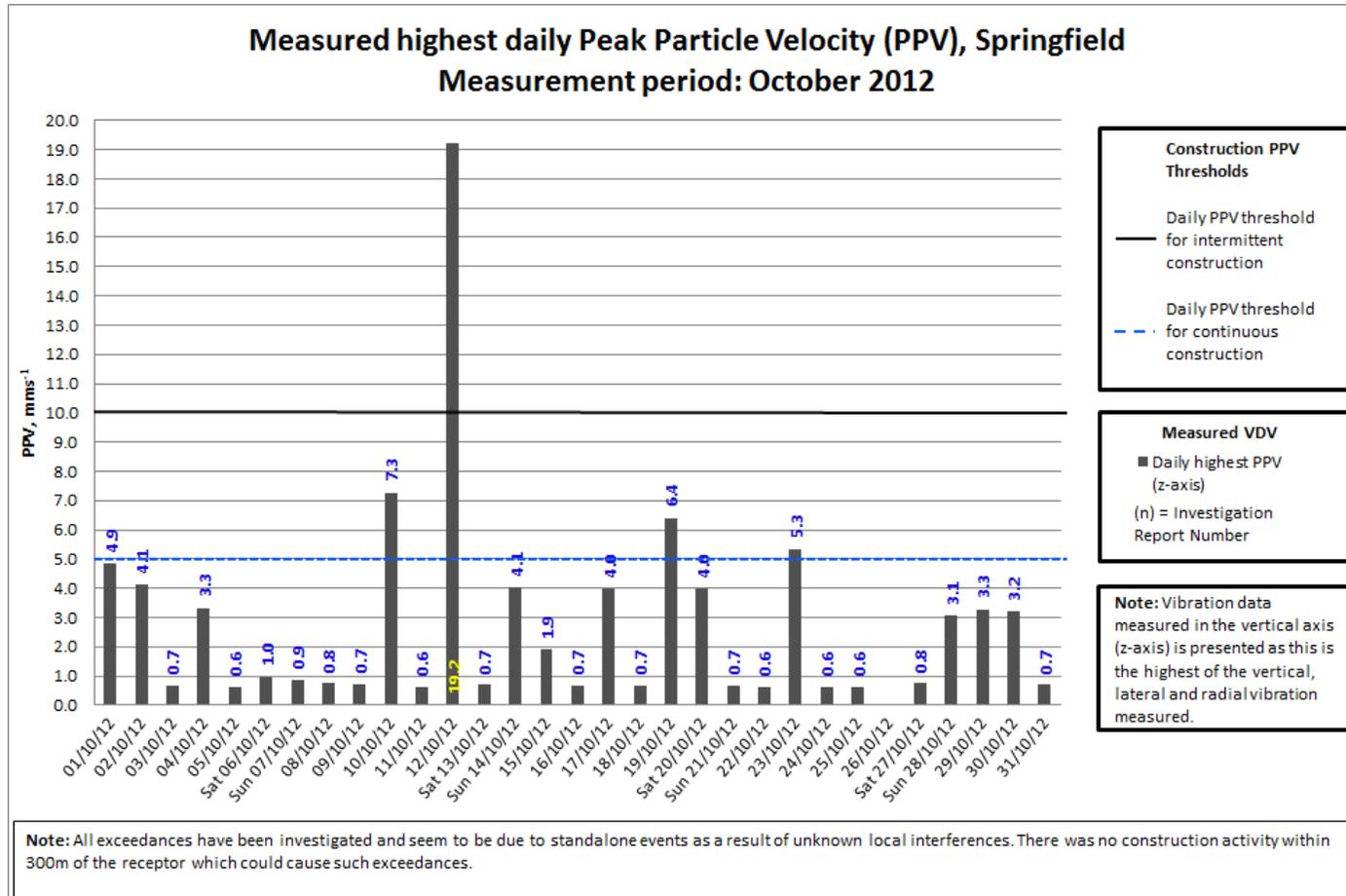
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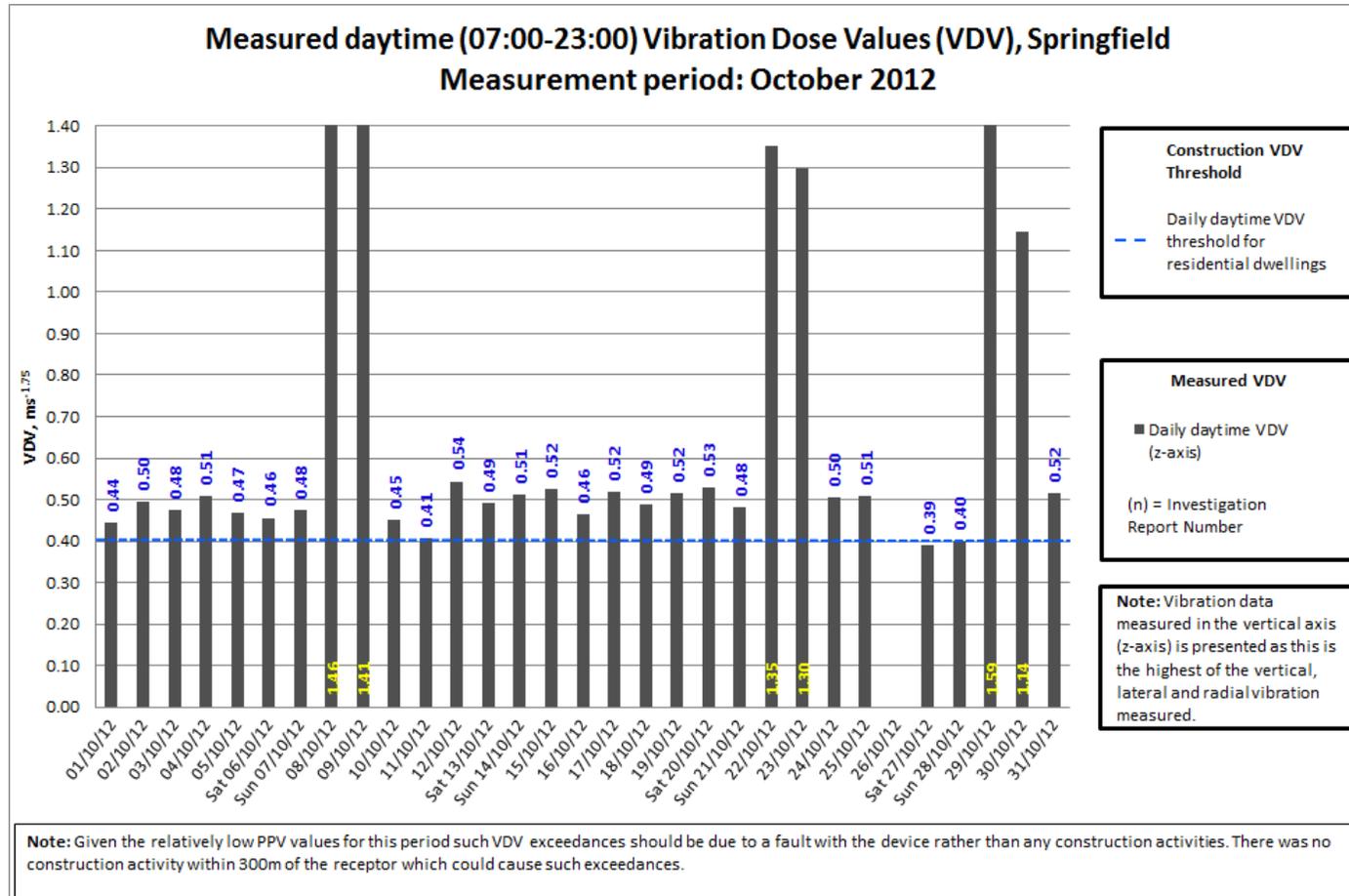
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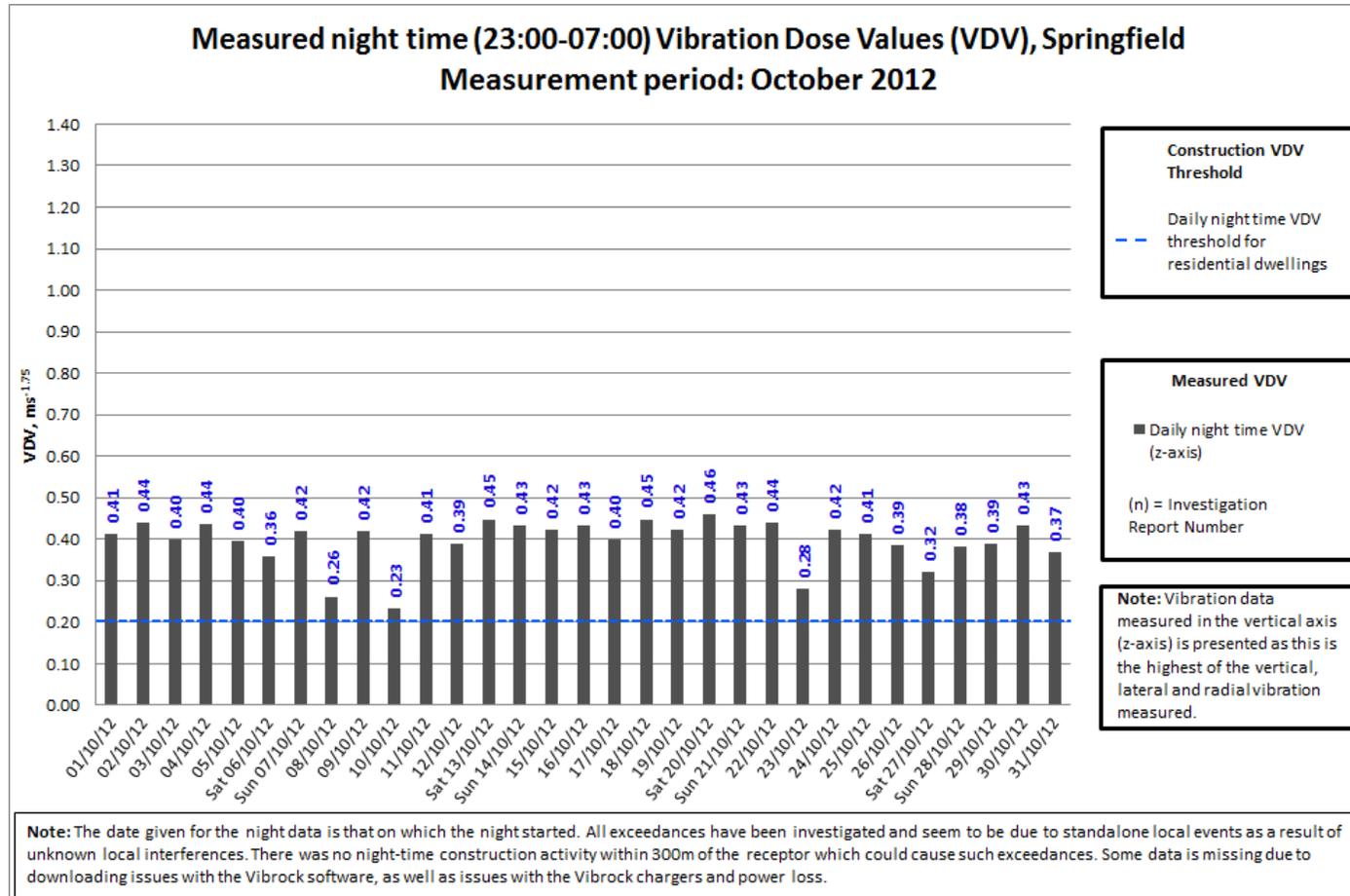
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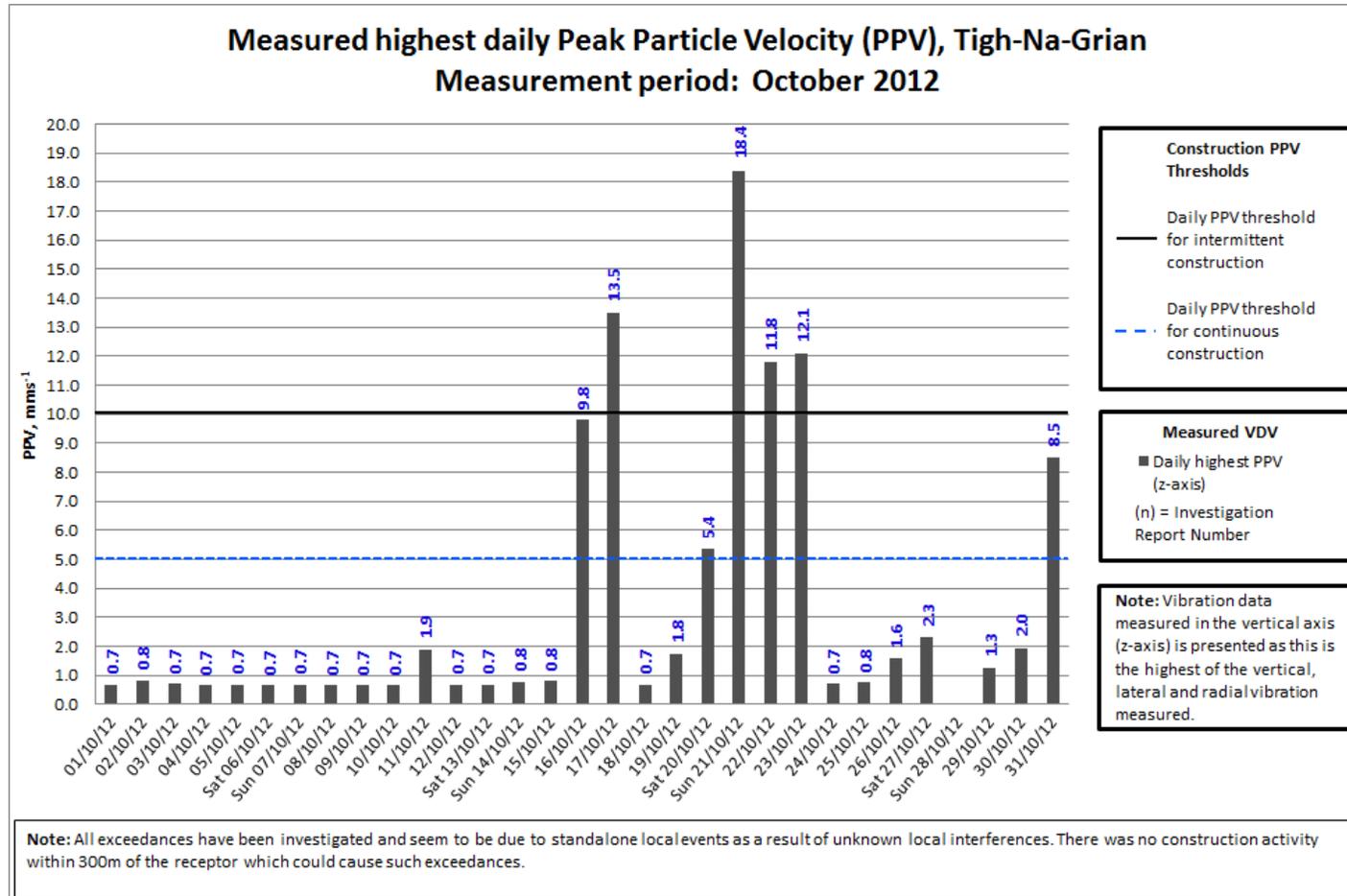
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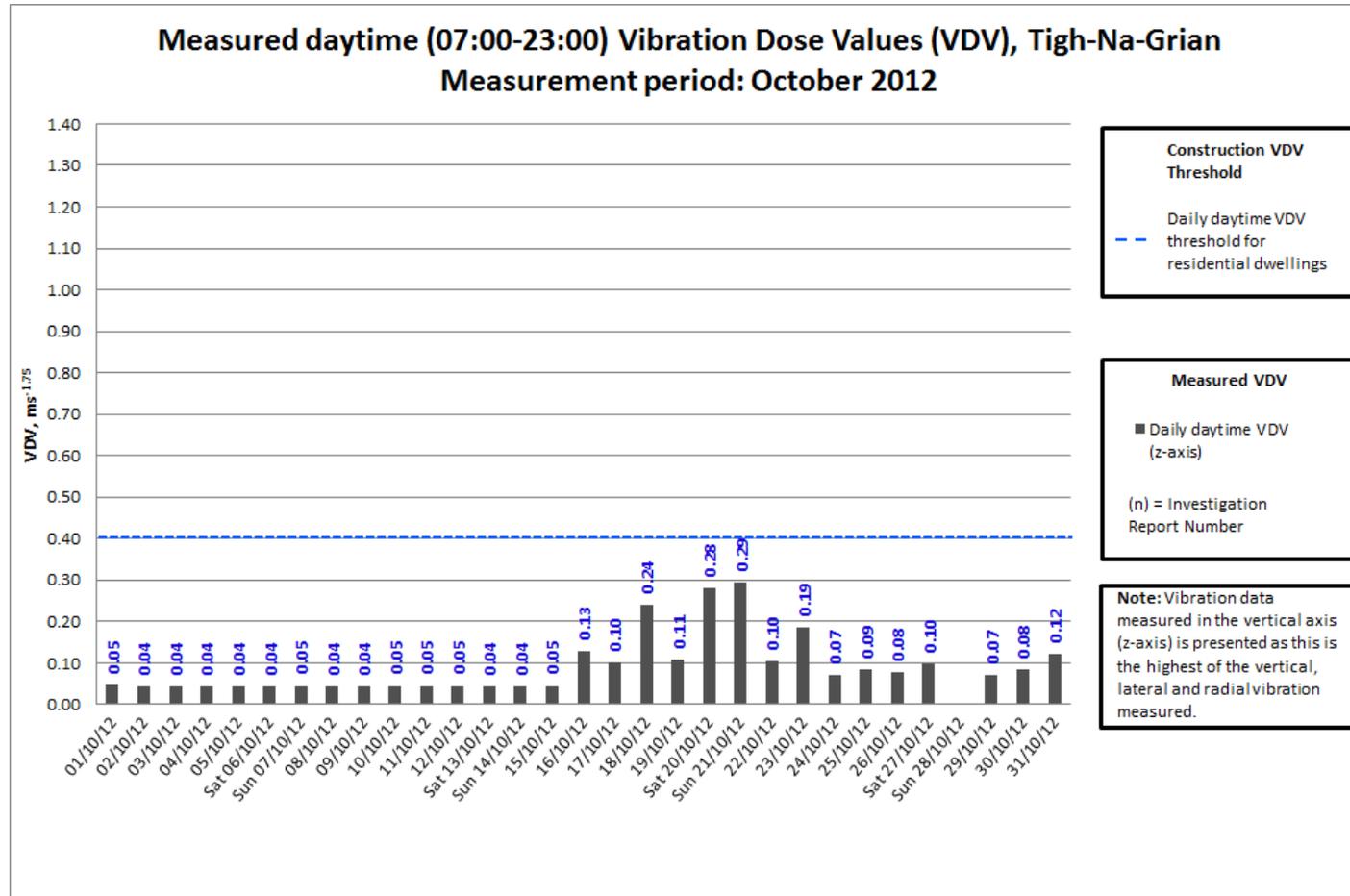
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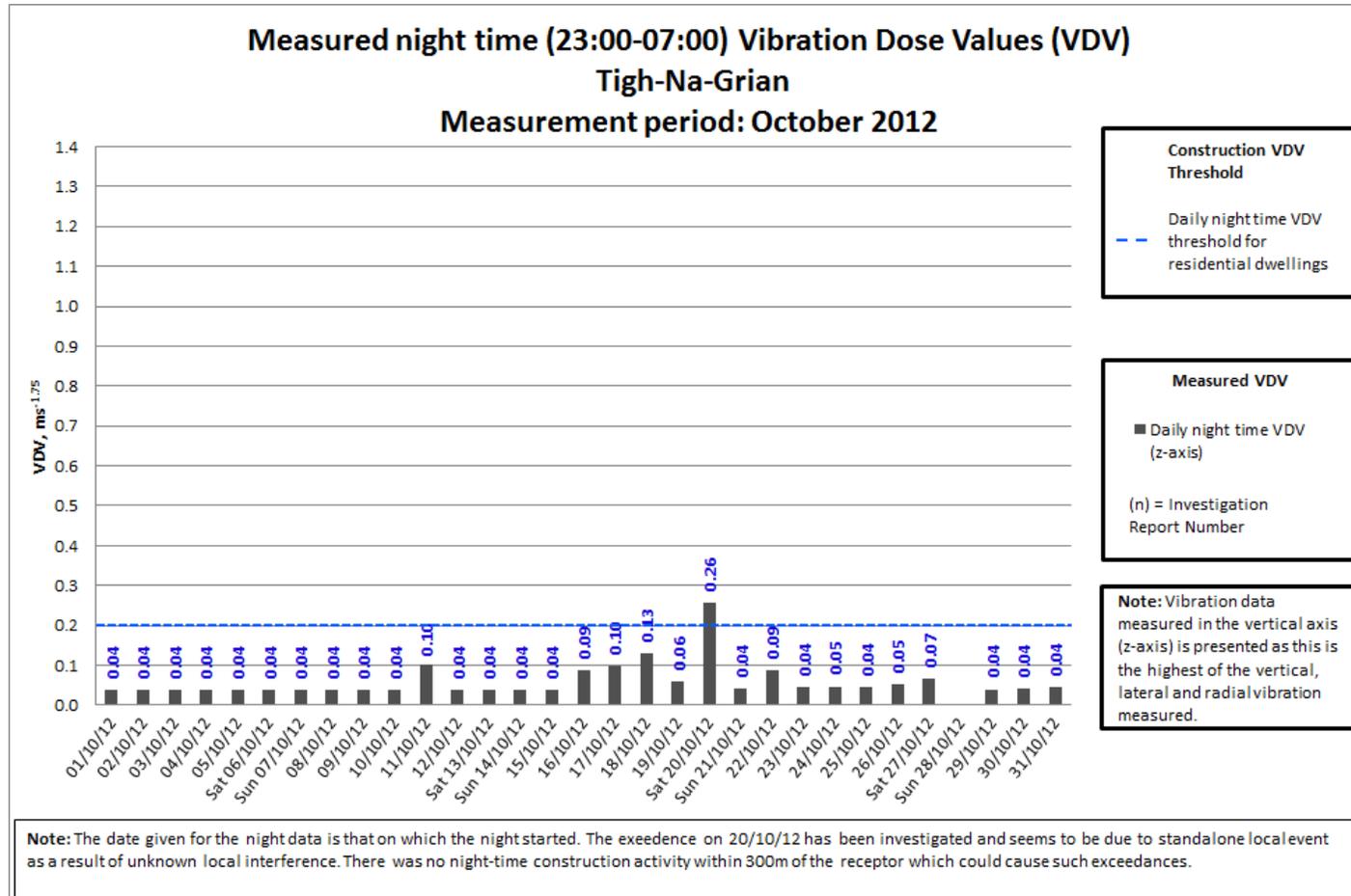
PPV at Tigh-Na-Grian – October 2012



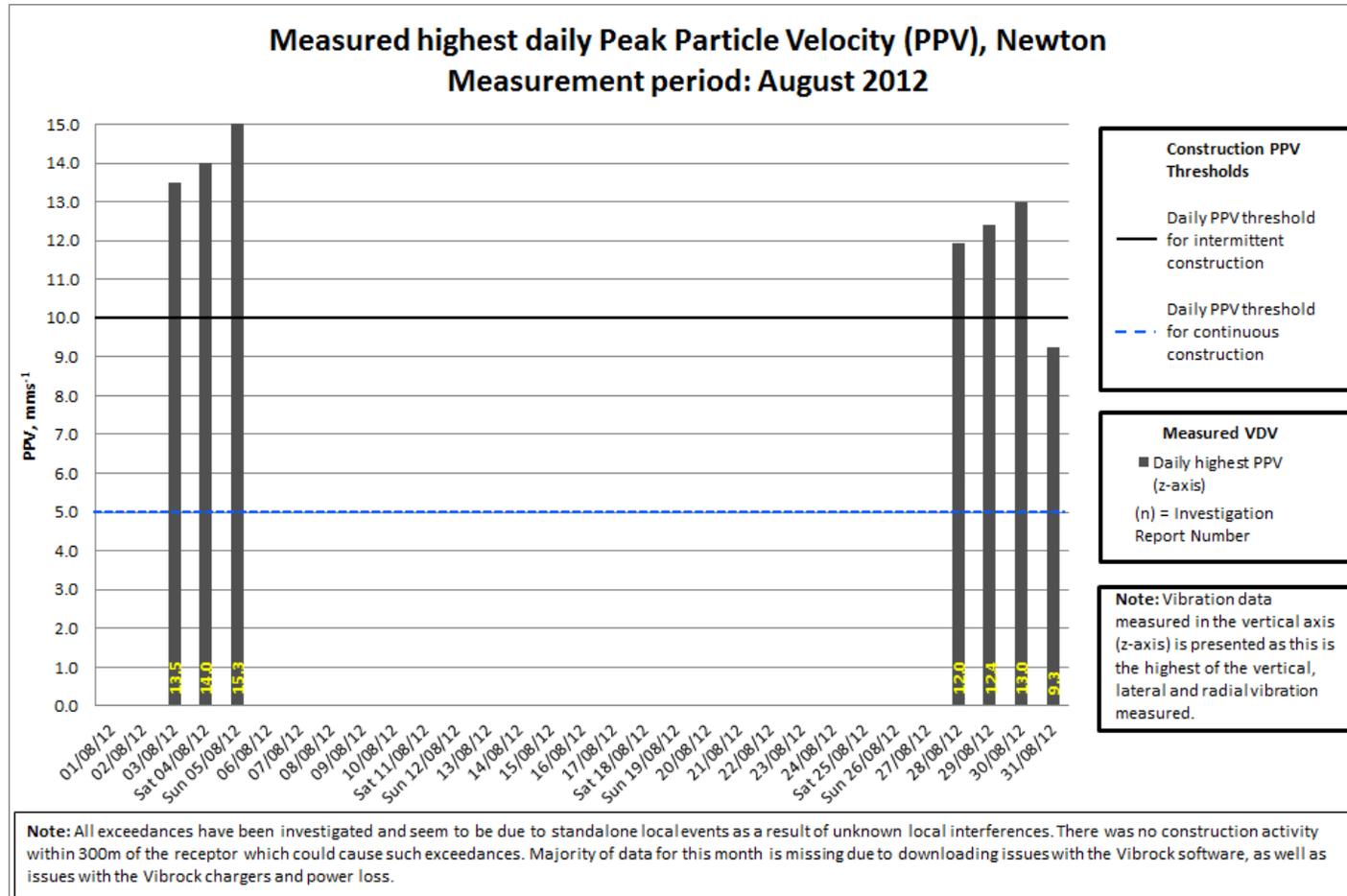
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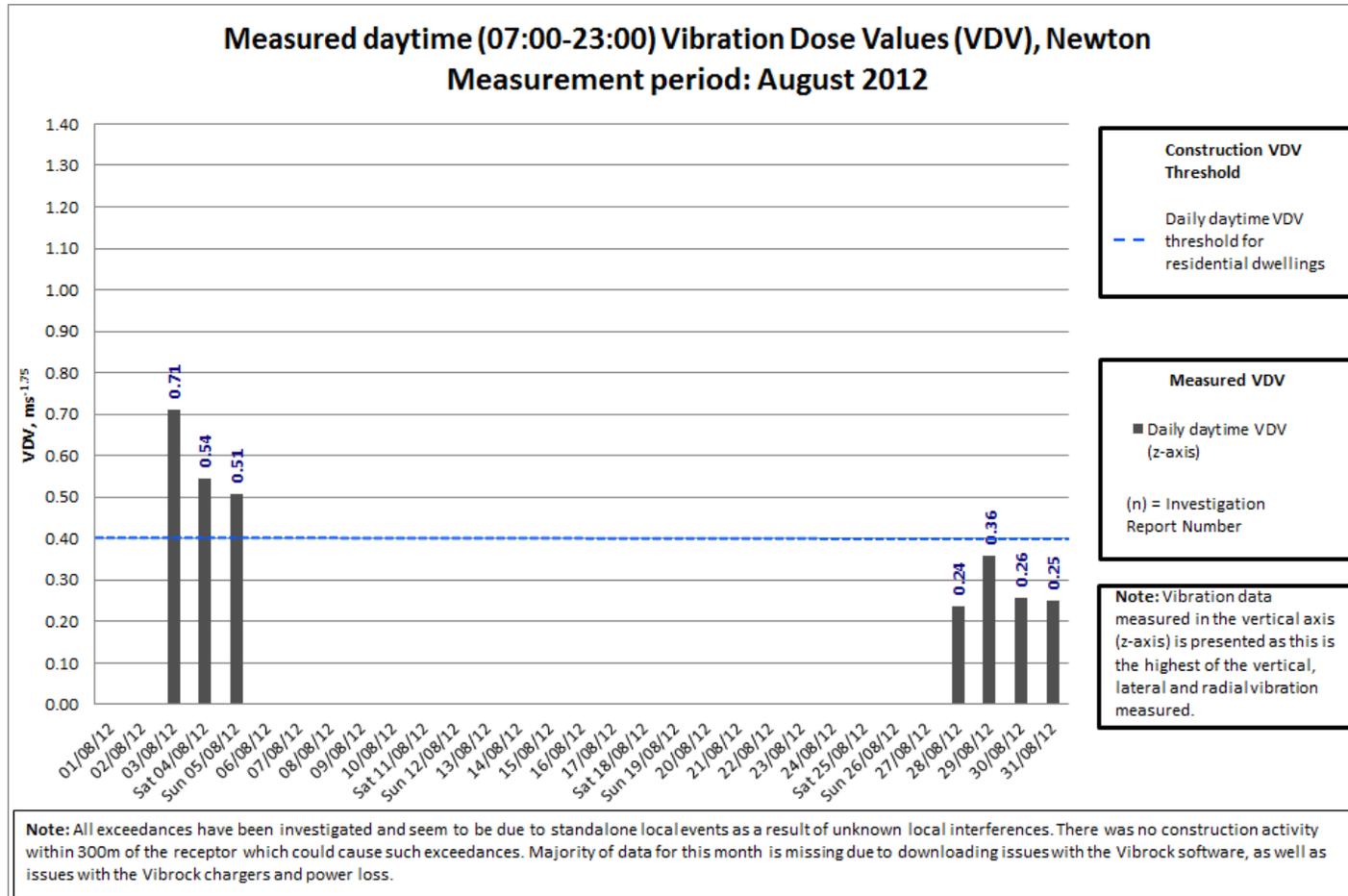
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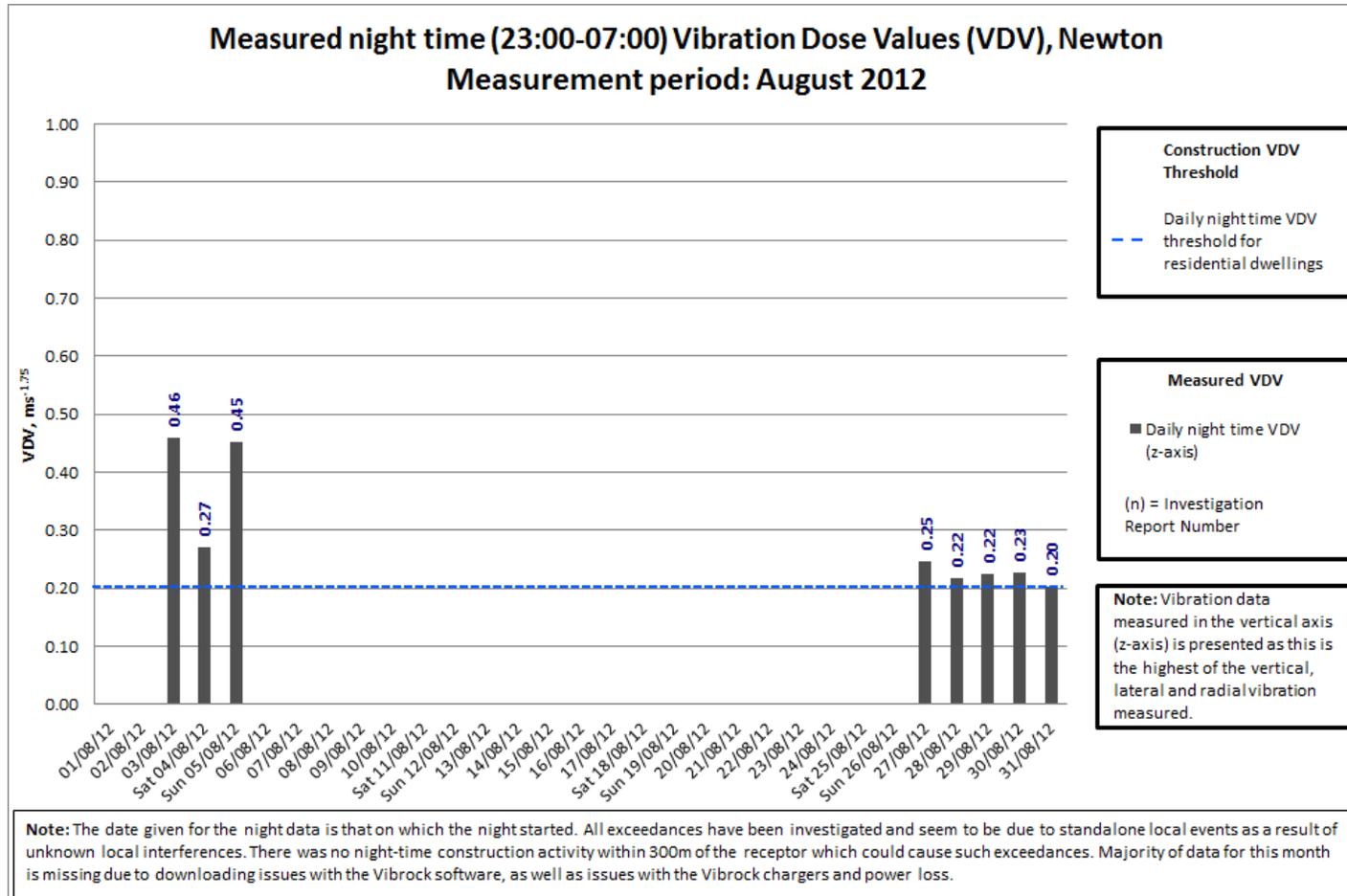
PPV at Newton – August 2012



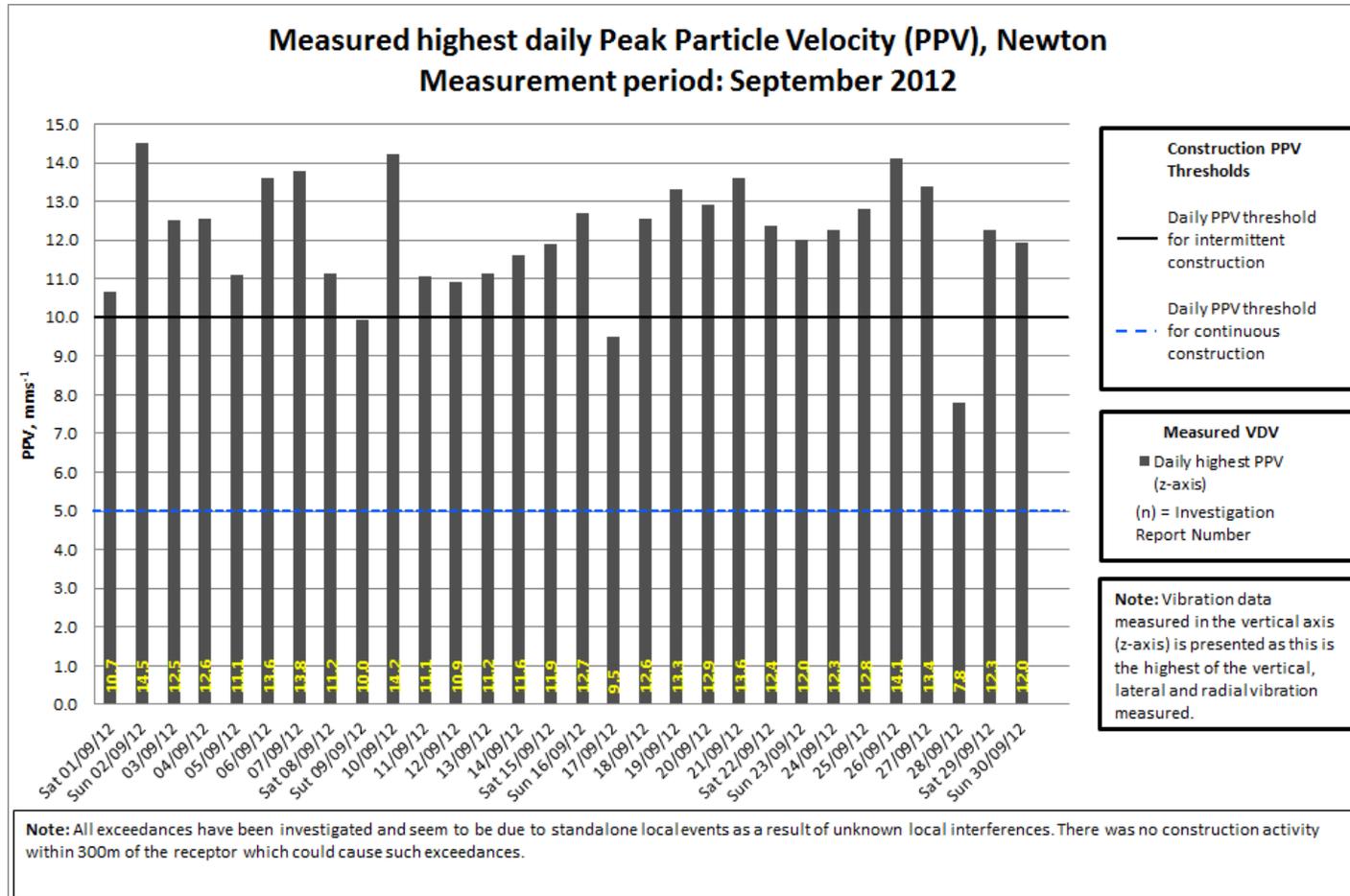
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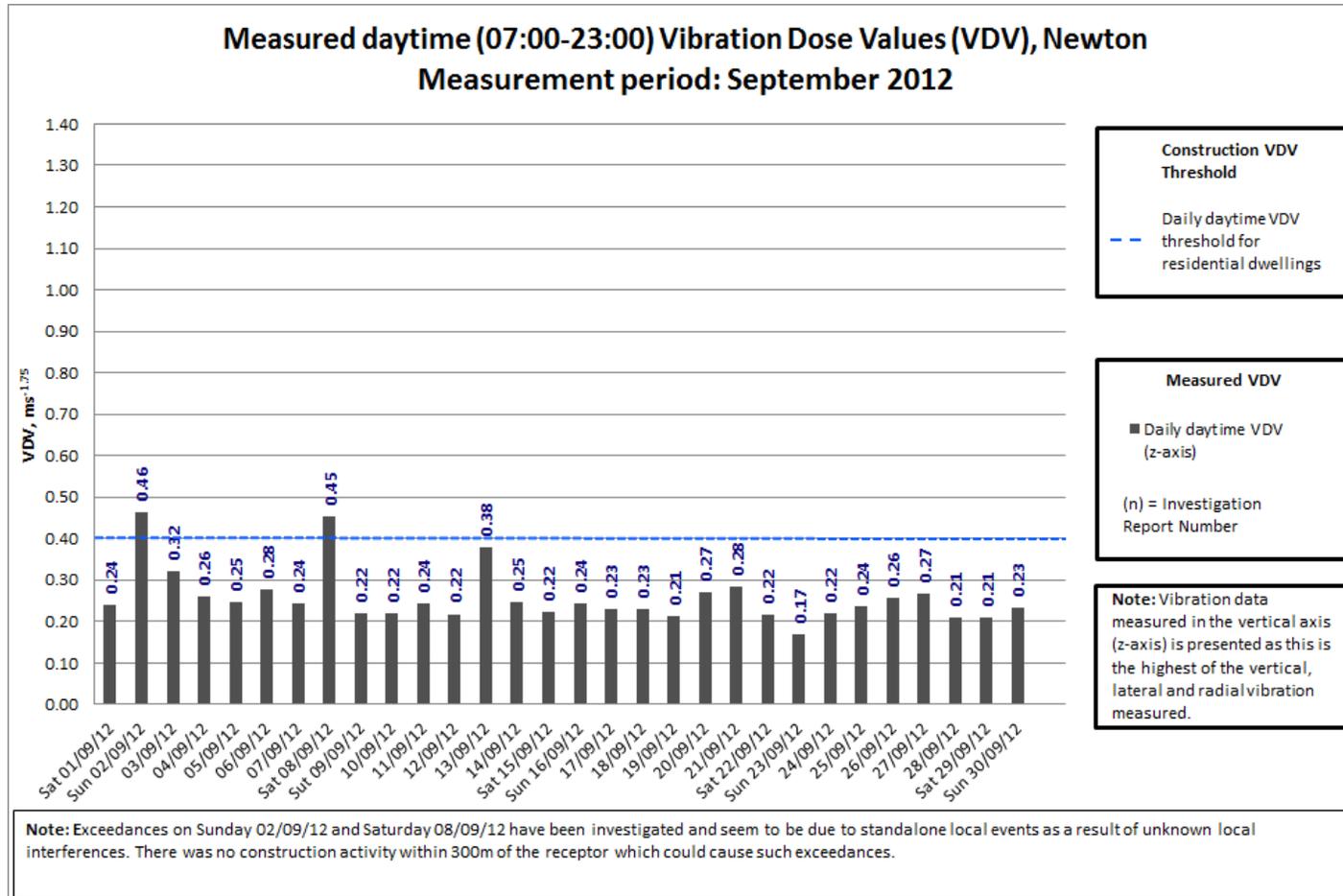
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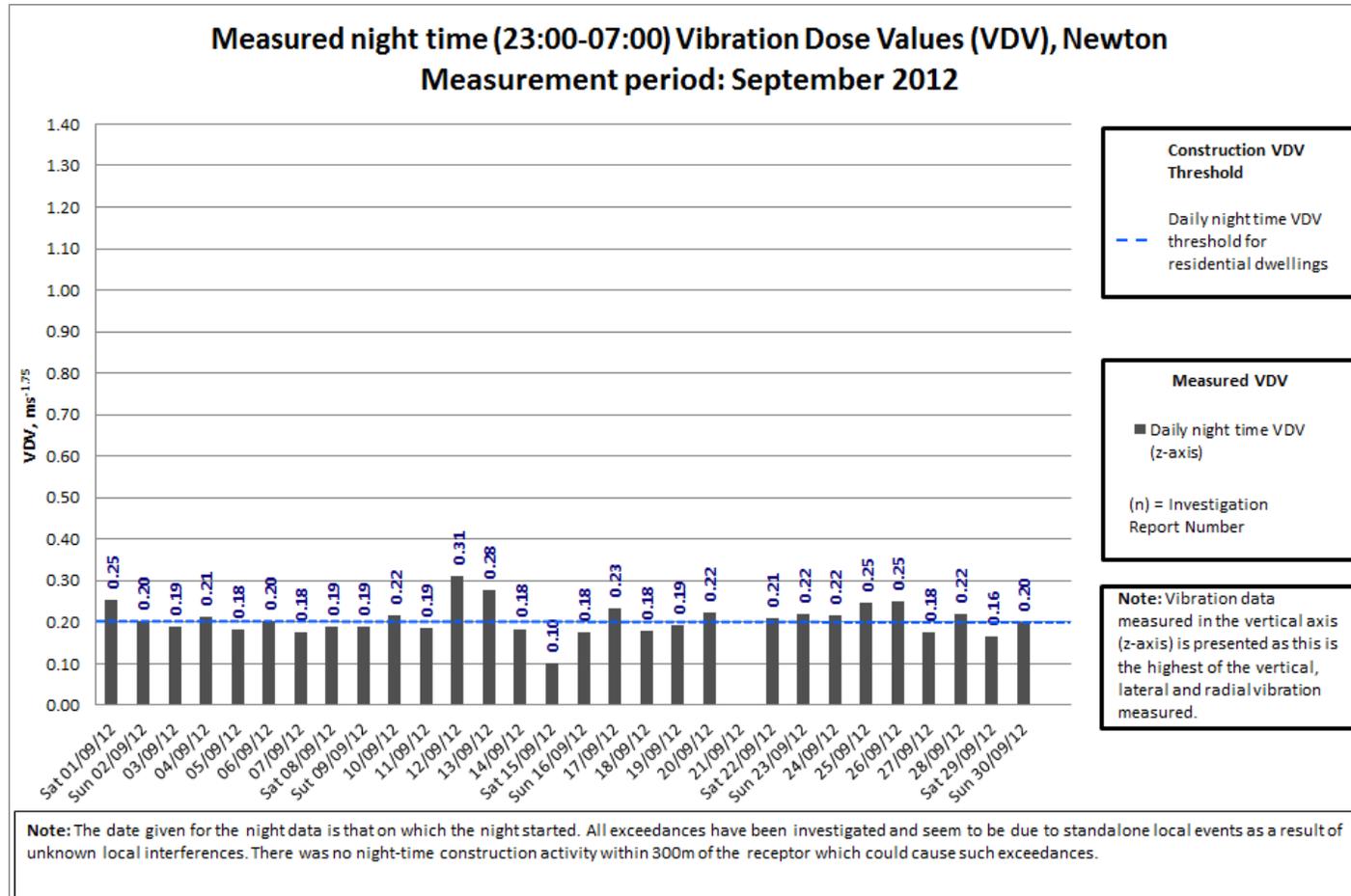
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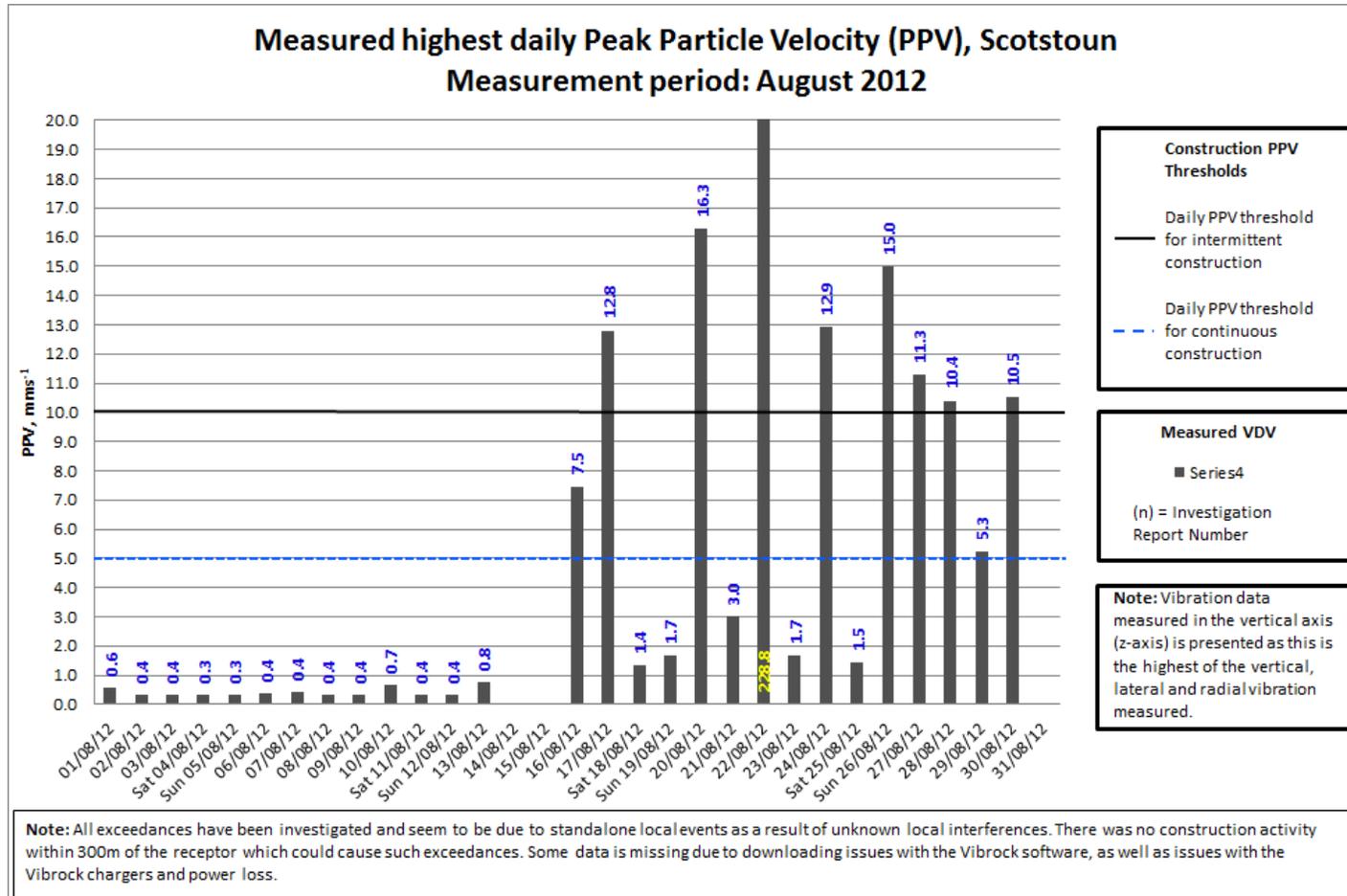
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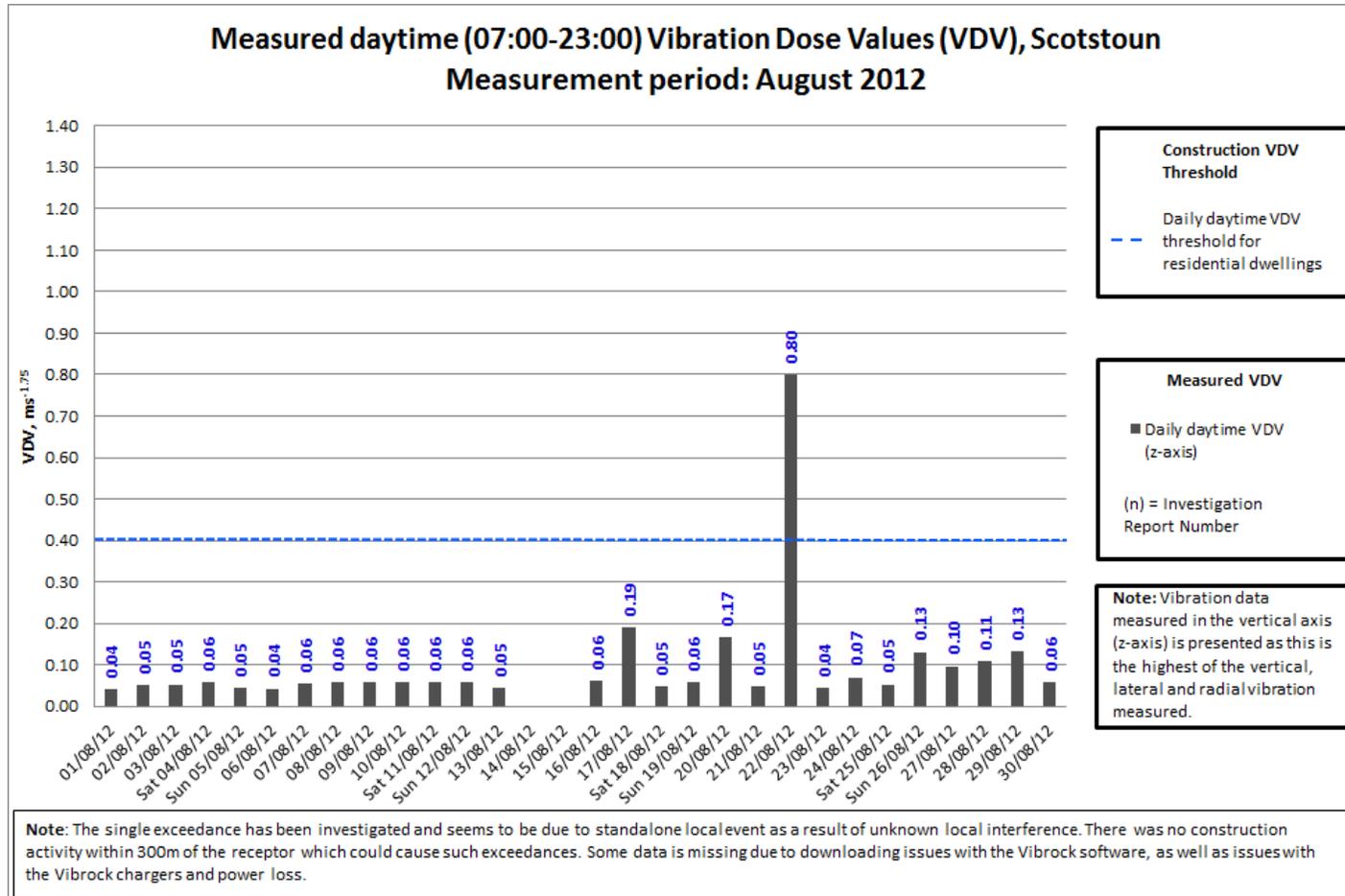
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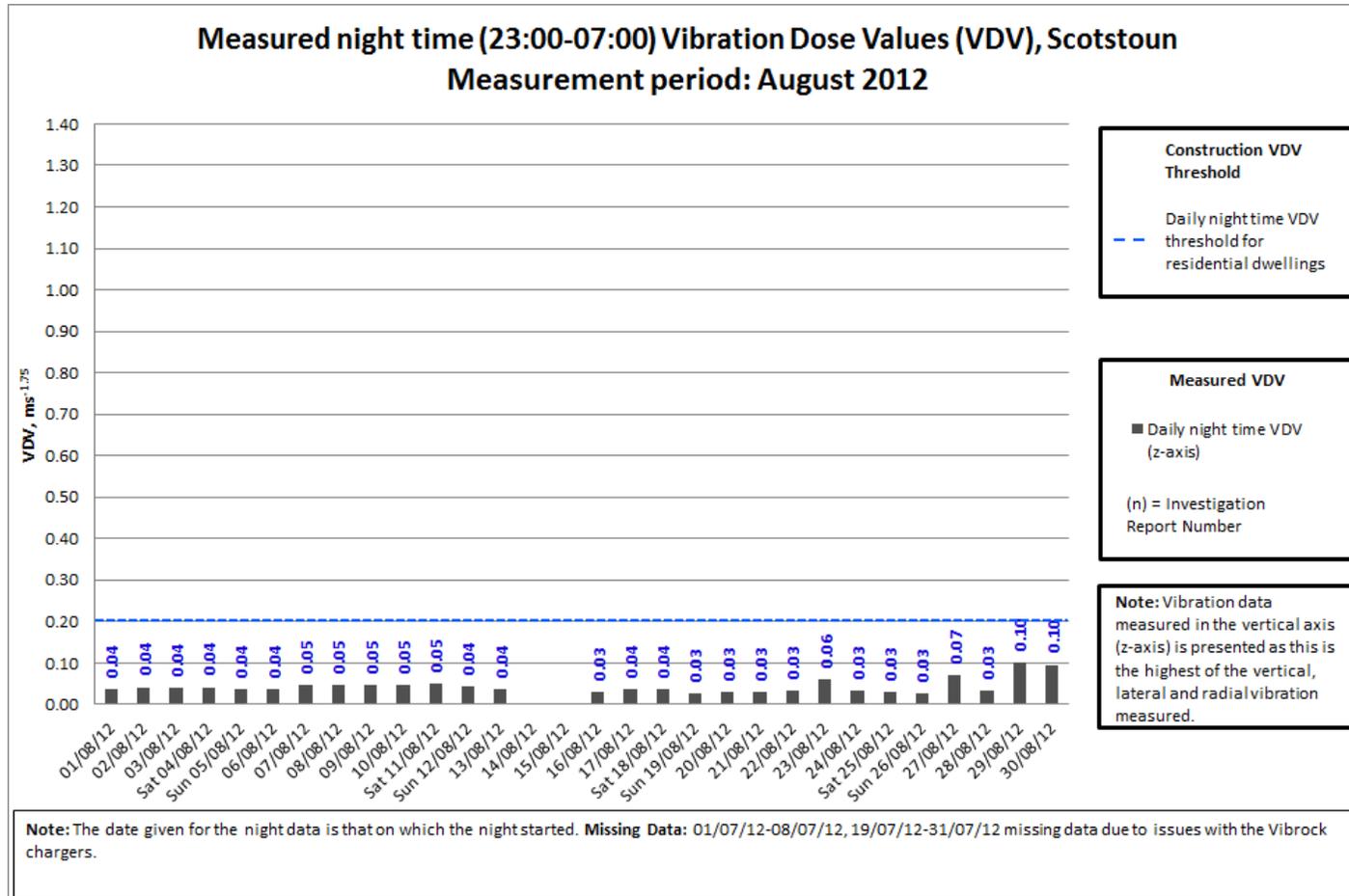
PPV at Scotstoun – August 2012



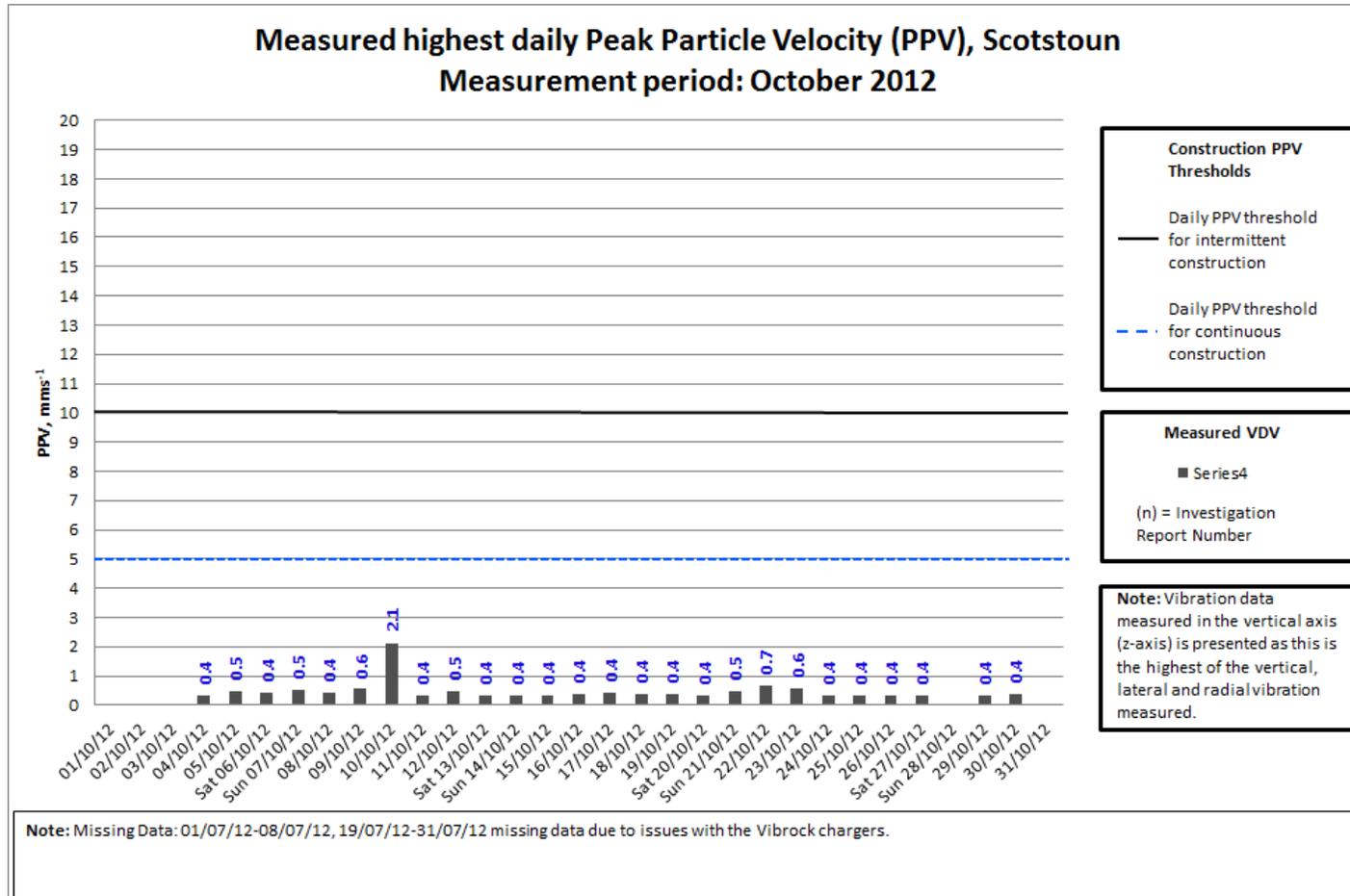
Daytime VDV at Scotstoun – August 2012



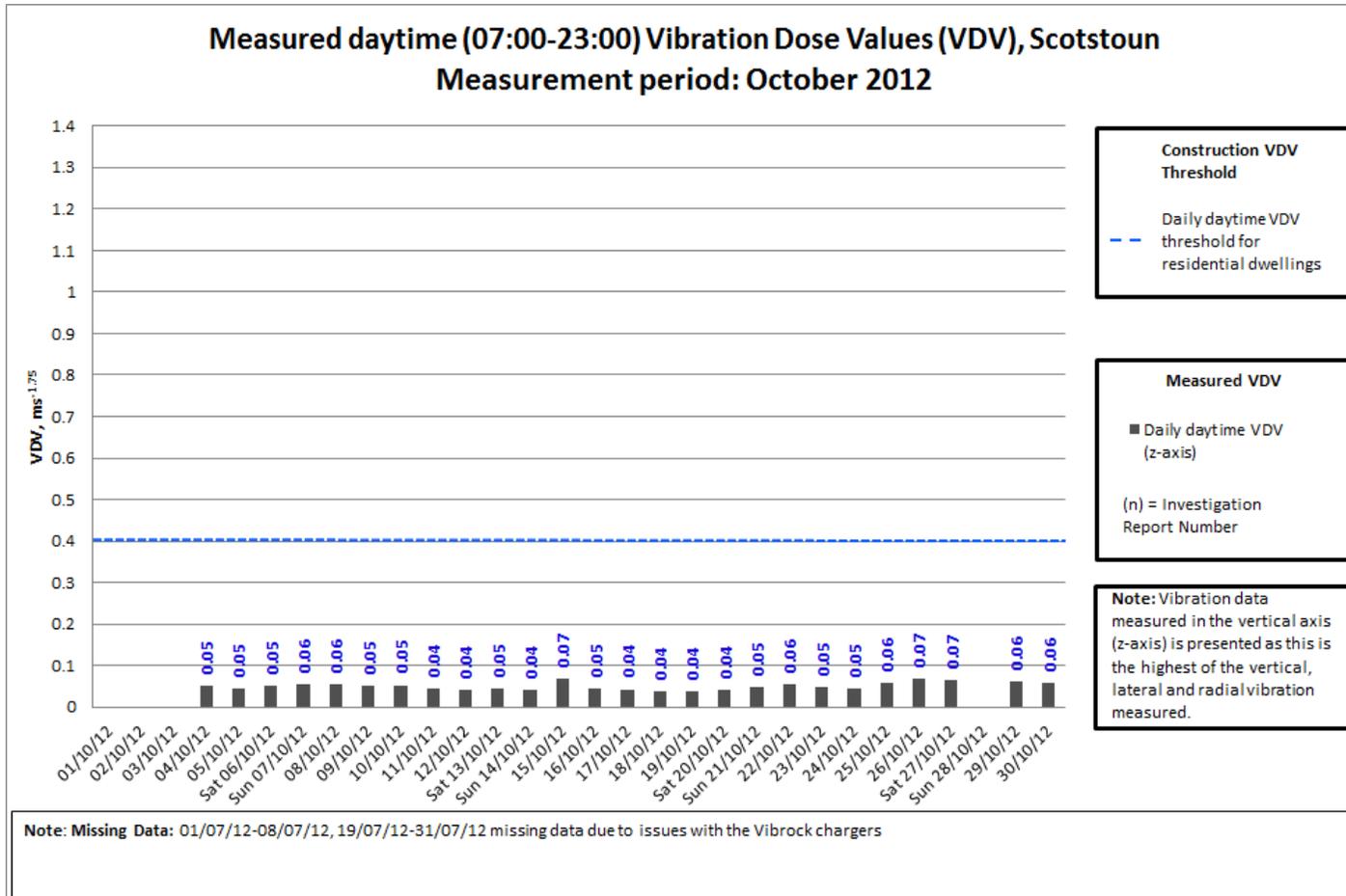
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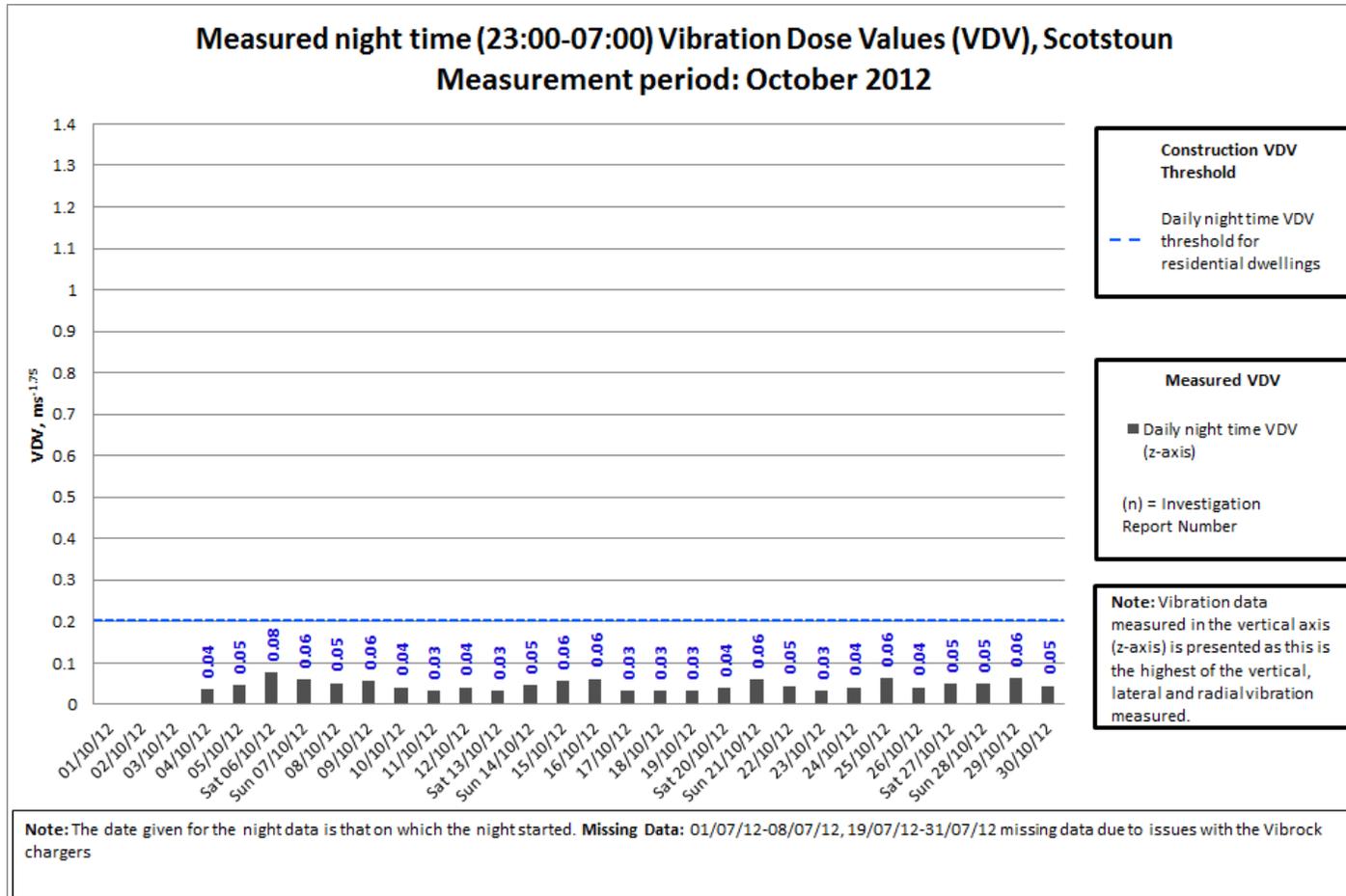
PPV at Scotstoun – October 2012



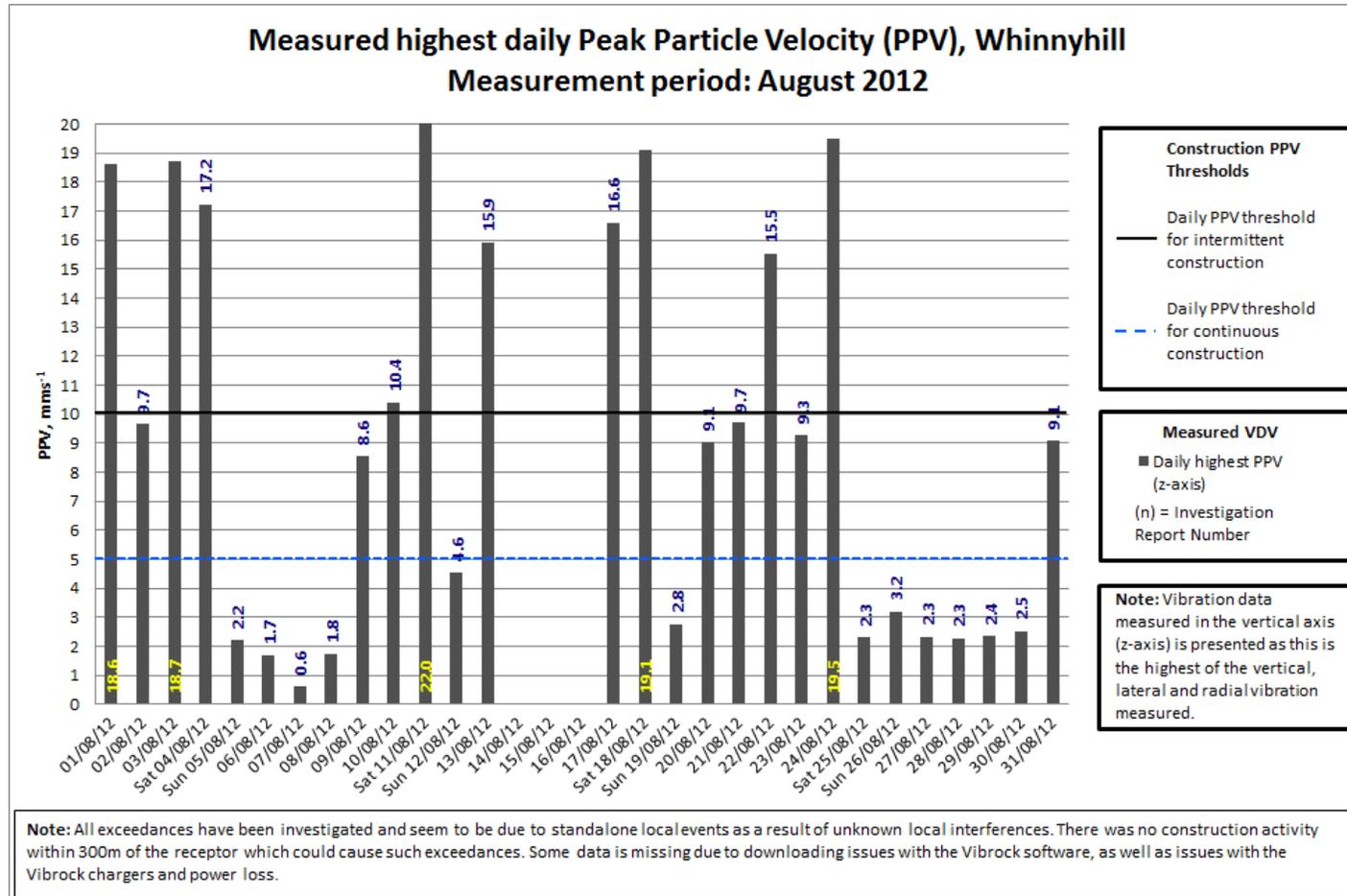
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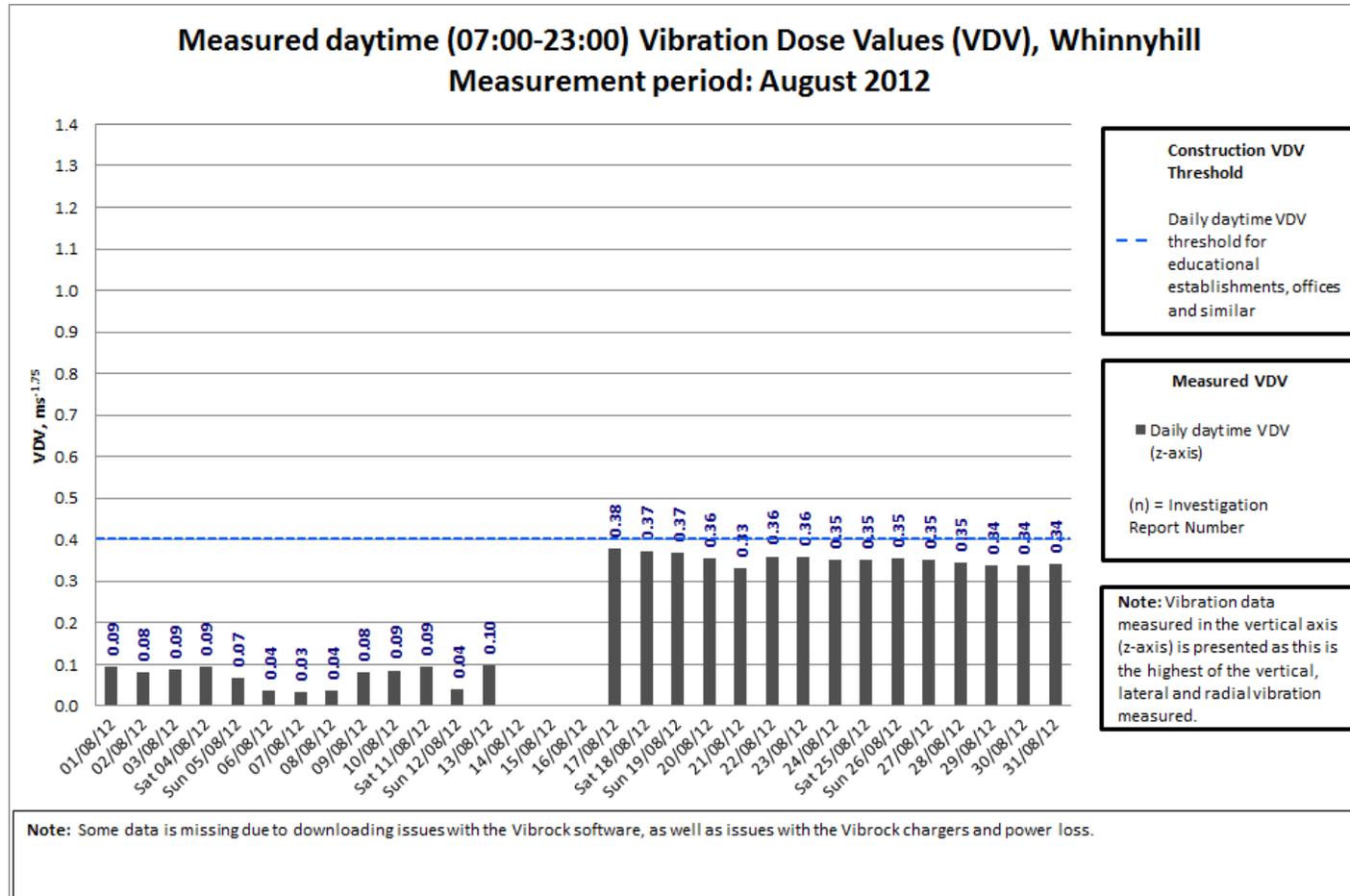
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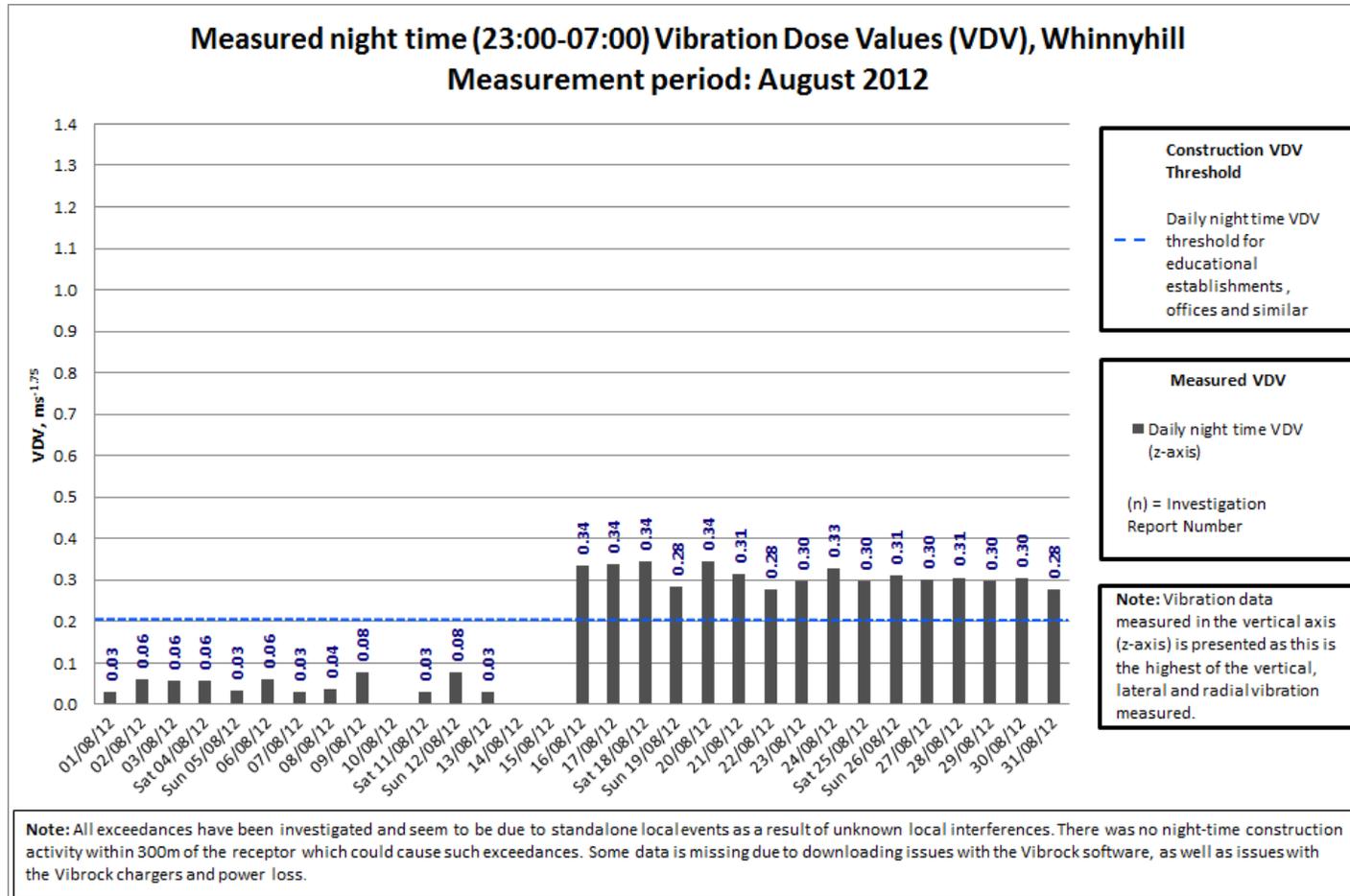
PPV at Whinnyhill – August 2012



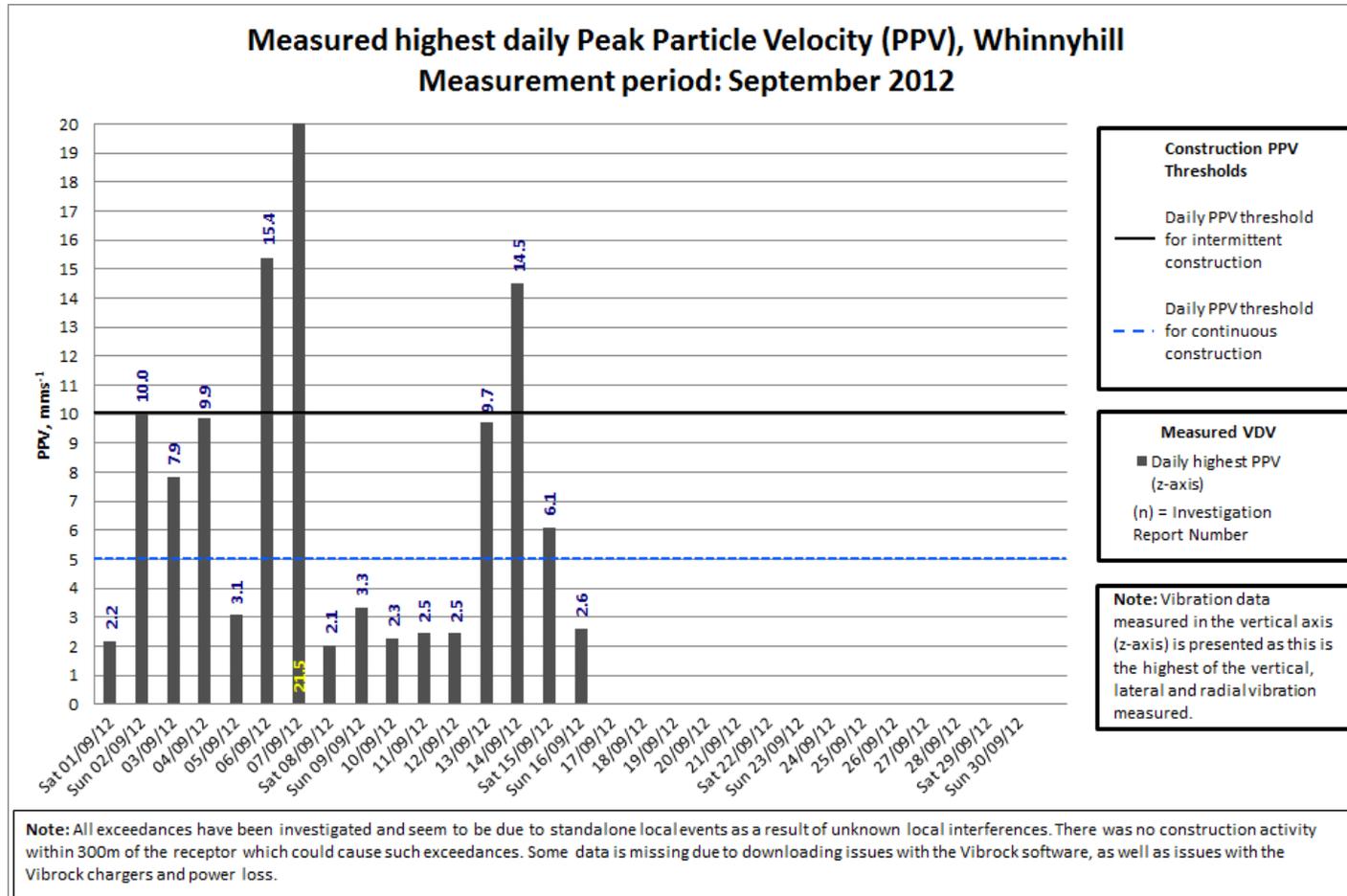
Daytime VDV at Whinnyhill – August 2012



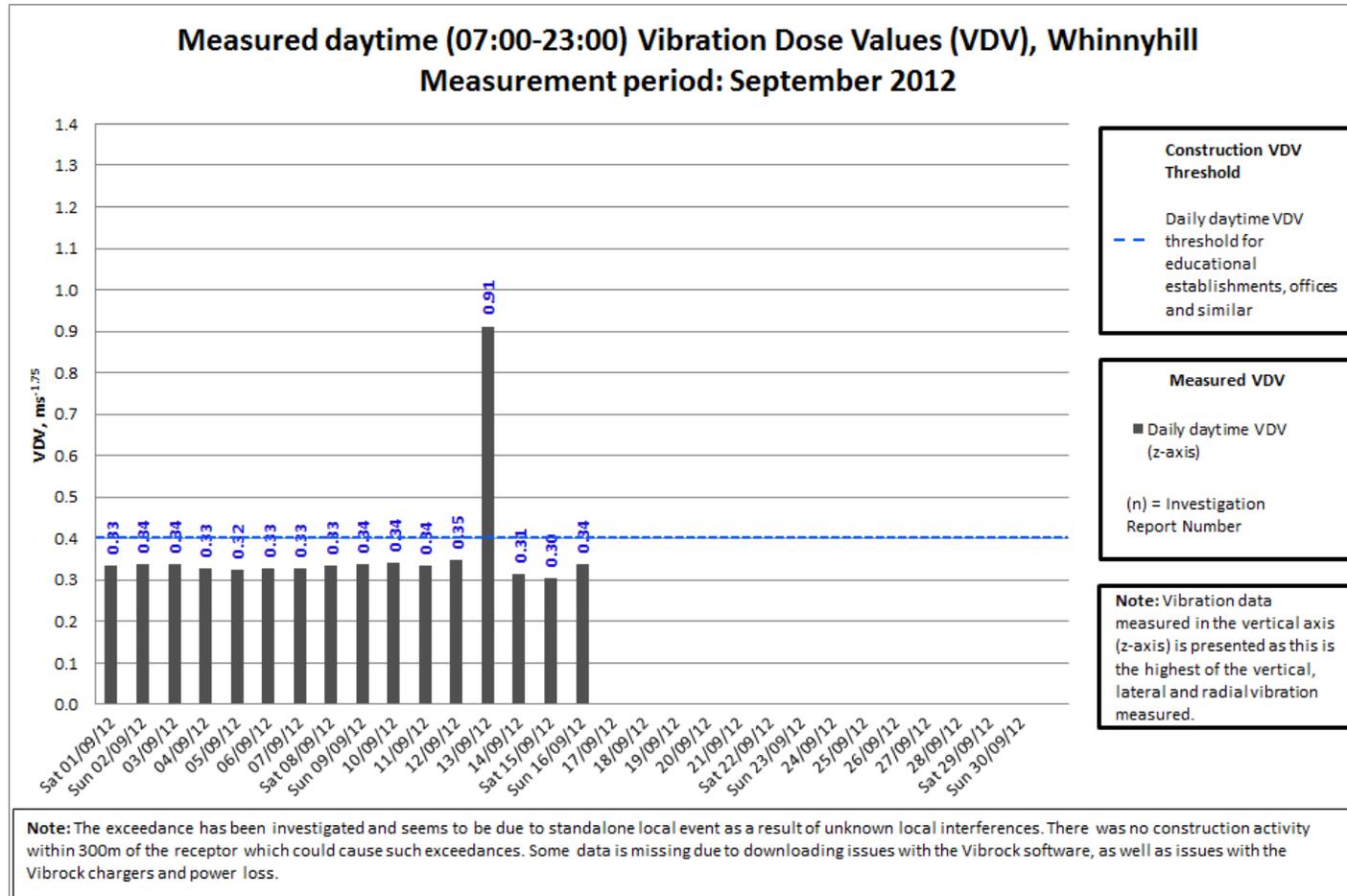
Night-time VDV at Whinnyhill – August 2012



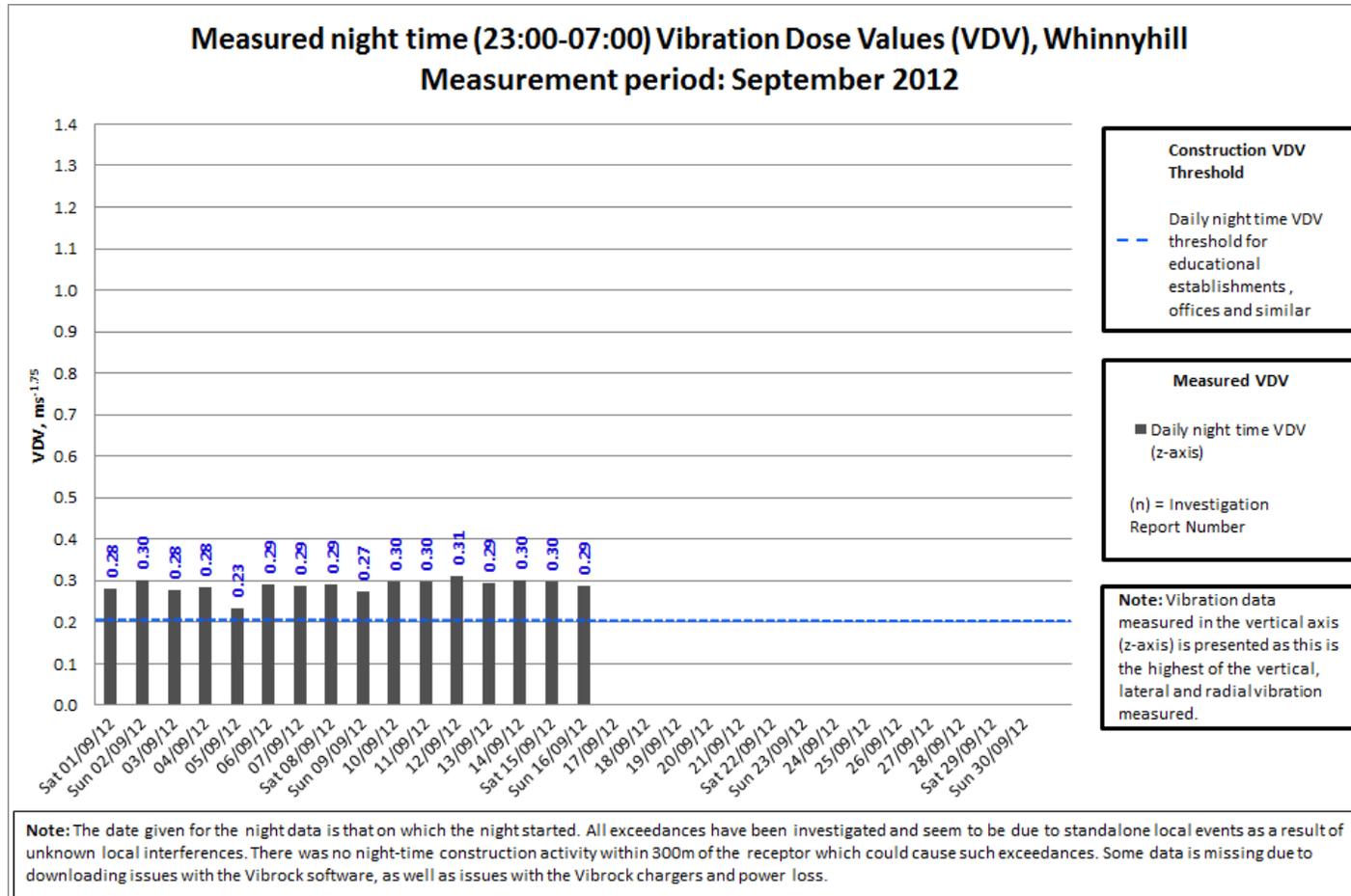
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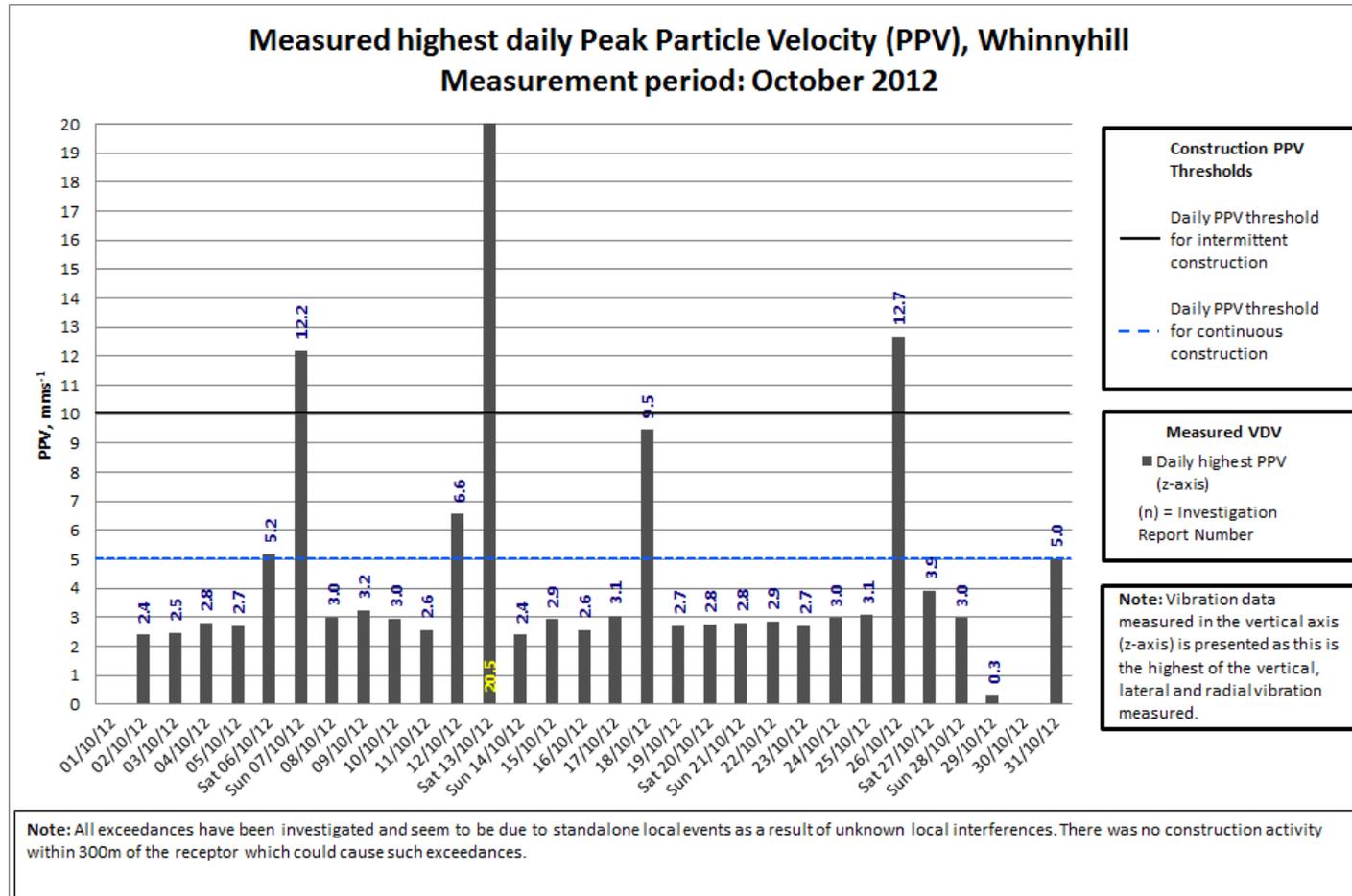
Daytime VDV at Whinnyhill – September 2012



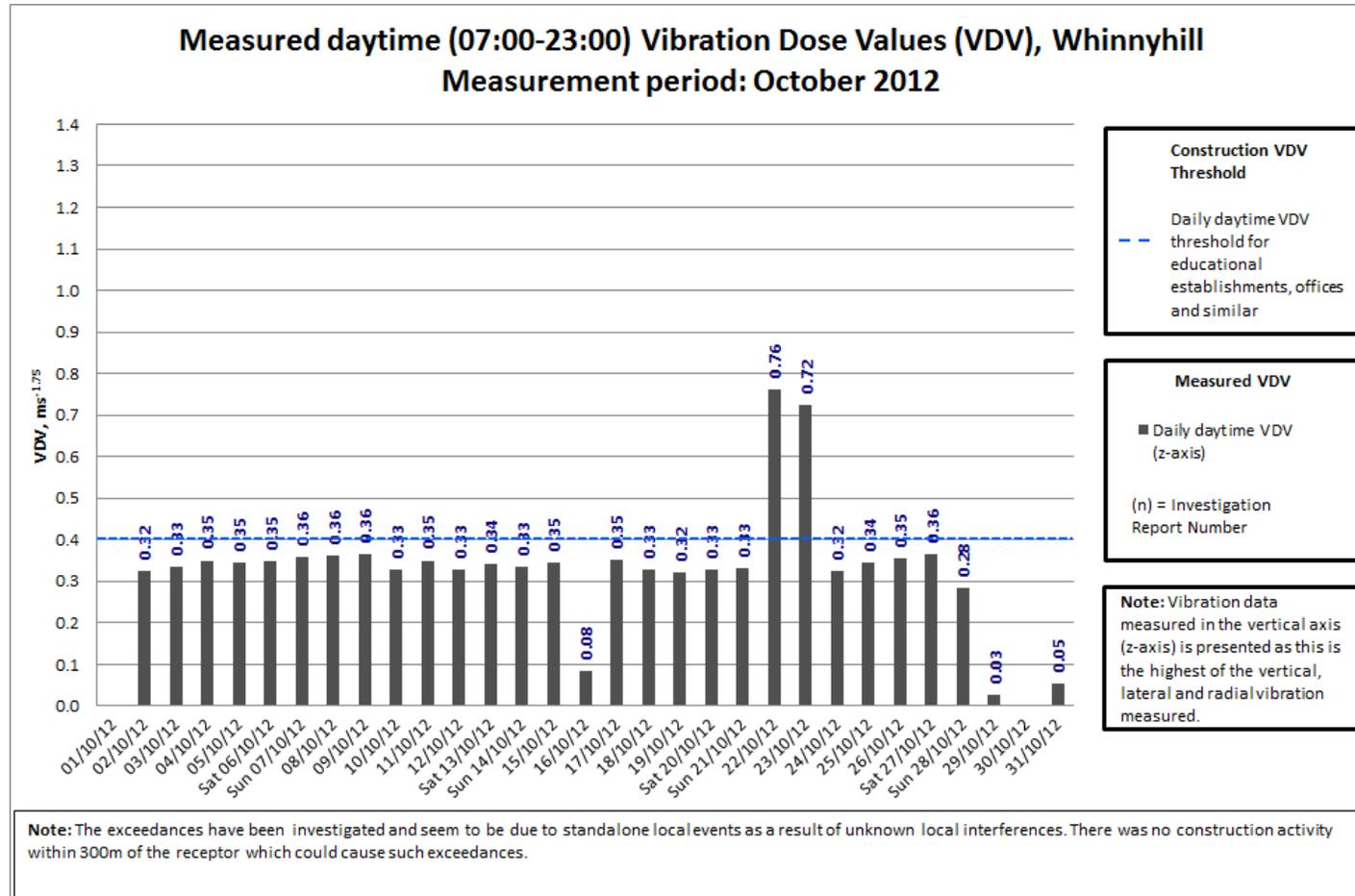
Night-time VDV at Whinnyhill – September 2012



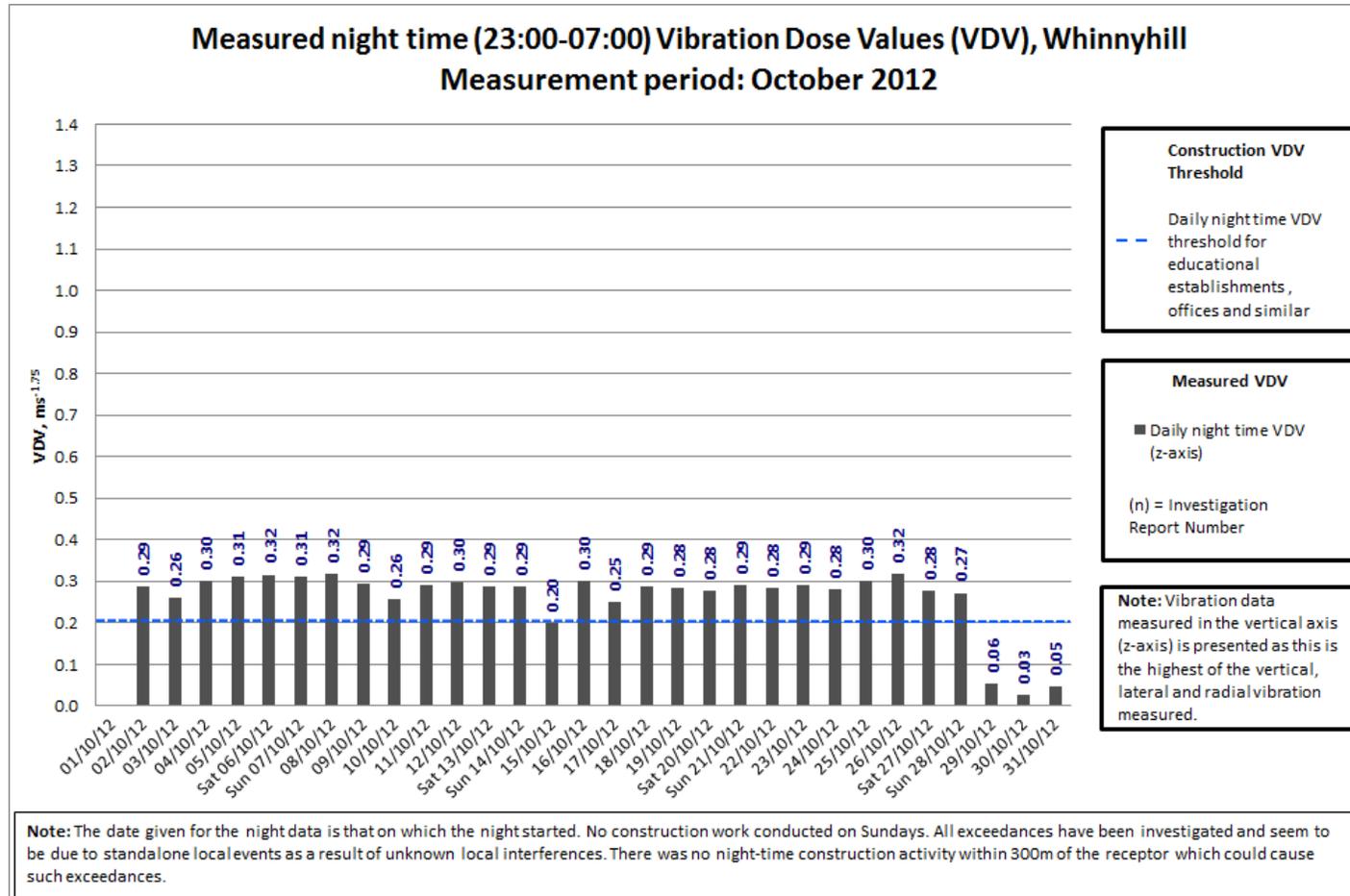
PPV at Whinnyhill – October 2012



Daytime VDV at Whinnyhill – October 2012



Night-time VDV at Whinnyhill – October 2012



APPENDIX C – VIBROCK CALIBRATION CERTIFICATES

CALIBRATION CERTIFICATE

08121562

CALIBRATION CERTIFICATE NO.: _____

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	$\pm 5\%$	$\pm 5\%$	X $\pm 5\%$
Peak Particle Velocity V	$\pm 5\%$	$\pm 5\%$	Y $\pm 5\%$
Peak Particle Velocity T	$\pm 5\%$	$\pm 5\%$	Z $\pm 5\%$

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

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

CERTIFIED BY: _____

14TH AUGUST 2012

DATE: _____

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
Email: vibrock@vibrock.com
Web: www.vibrock.com



CALIBRATION CERTIFICATE

08121563

CALIBRATION CERTIFICATE NO.: _____

Forth Crossing Bridge Constructors

CLIENT: _____

V901-GSM

INSTRUMENT TYPE: _____

1563

SERIAL NUMBER: _____

14TH AUGUST 2012

CALIBRATION DATE: _____

DENNIS LORD

CALIBRATED BY: _____

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: _____

14TH AUGUST 2012

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Web: www.vibroock.com



VIBROCK

CALIBRATION CERTIFICATE

08121564

CALIBRATION CERTIFICATE NO.: _____
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: _____

14TH AUGUST 2012

DATE: _____

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Web: www.vibrock.com



VIBROCK

VibroRock

CALIBRATION CERTIFICATE

08121565

CALIBRATION CERTIFICATE NO.: _____

Forth Crossing Bridge Constructors

CLIENT: _____

V901-GSM

INSTRUMENT TYPE: _____

1565

SERIAL NUMBER: _____

14TH AUGUST 2012

CALIBRATION DATE: _____

DENNIS LORD

CALIBRATED BY: _____

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: _____

14TH AUGUST 2012

DATE: _____

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Web: www.vibroock.com



VIBROCK

Vibroock

CALIBRATION CERTIFICATE

08121567

CALIBRATION CERTIFICATE NO.:

Forth Crossing Bridge Constructors

CLIENT:

V901-GSM

INSTRUMENT TYPE:

1567

SERIAL NUMBER:

14TH AUGUST 2012

CALIBRATION DATE:

DENNIS LORD

CALIBRATED BY:

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	$\pm 5\%$	$\pm 5\%$	X $\pm 5\%$
Peak Particle Velocity V	$\pm 5\%$	$\pm 5\%$	Y $\pm 5\%$
Peak Particle Velocity T	$\pm 5\%$	$\pm 5\%$	Z $\pm 5\%$

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted $\frac{N/A}{dB(Lin)}$

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

CERTIFIED BY:

14TH AUGUST 2012

DATE:

THIS CERTIFICATE IS VALID FOR 12 MONTHS

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Web: www.vibroock.com



VIBROCK

CALIBRATION CERTIFICATE

08121568

CALIBRATION CERTIFICATE NO.: _____
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	$\pm 5\%$	$\pm 5\%$	X $\pm 5\%$
Peak Particle Velocity V	$\pm 5\%$	$\pm 5\%$	Y $\pm 5\%$
Peak Particle Velocity T	$\pm 5\%$	$\pm 5\%$	Z $\pm 5\%$

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

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

CERTIFIED BY:



14TH AUGUST 2012

DATE:

THIS CERTIFICATE IS VALID FOR 12 MONTHS

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Web: www.vibroock.com



VIBROCK

Vibroock

CALIBRATION CERTIFICATE

08121569

CALIBRATION CERTIFICATE NO.: _____

Forth Crossing Bridge Constructors

CLIENT: _____

V901-GSM

INSTRUMENT TYPE: _____

1569

SERIAL NUMBER: _____

14TH AUGUST 2012

CALIBRATION DATE: _____

DENNIS LORD

CALIBRATED BY: _____

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	$\pm 5\%$	$\pm 5\%$	X $\pm 5\%$
Peak Particle Velocity V	$\pm 5\%$	$\pm 5\%$	Y $\pm 5\%$
Peak Particle Velocity T	$\pm 5\%$	$\pm 5\%$	Z $\pm 5\%$

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

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

CERTIFIED BY: _____

14TH AUGUST 2012

DATE: _____

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Web: www.vibroock.com



VIBROCK

Vibro

CALIBRATION CERTIFICATE

08121570

CALIBRATION CERTIFICATE NO.: _____
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	$\pm 5\%$	$\pm 5\%$	X $\pm 5\%$
Peak Particle Velocity V	$\pm 5\%$	$\pm 5\%$	Y $\pm 5\%$
Peak Particle Velocity T	$\pm 5\%$	$\pm 5\%$	Z $\pm 5\%$

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

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

CERTIFIED BY:

14TH AUGUST 2012

DATE:

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Email: vibrock@vibrolock.com
Web: www.vibrolock.com



CALIBRATION CERTIFICATE

08121571

CALIBRATION CERTIFICATE NO.: _____

Forth Crossing Bridge Constructors

CLIENT: _____

V901-GSM

INSTRUMENT TYPE: _____

1571

SERIAL NUMBER: _____

14TH AUGUST 2012

CALIBRATION DATE: _____

DENNIS LORD

CALIBRATED BY: _____

CALIBRATION ACCURACY:-

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

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

**WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY
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CERTIFIED BY: _____

14TH AUGUST 2012

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VIBROCK

CALIBRATION CERTIFICATE

08121572

CALIBRATION CERTIFICATE NO.: _____

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	$\pm 5\%$	$\pm 5\%$	X $\pm 5\%$
Peak Particle Velocity V	$\pm 5\%$	$\pm 5\%$	Y $\pm 5\%$
Peak Particle Velocity T	$\pm 5\%$	$\pm 5\%$	Z $\pm 5\%$

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

**WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY
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CERTIFIED BY:



14TH AUGUST 2012

DATE:

THIS CERTIFICATE IS VALID FOR 12 MONTHS

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Email: vibrock@vibrock.com

Web: www.vibrock.com



VIBROCK

CALIBRATION CERTIFICATE

08121612

CALIBRATION CERTIFICATE NO.: _____

Forth Crossing Bridge Constructors

CLIENT: _____

V901-GSM

INSTRUMENT TYPE: _____

1612

SERIAL NUMBER: _____

14TH AUGUST 2012

CALIBRATION DATE: _____

DENNIS LORD

CALIBRATED BY: _____

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
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CERTIFIED BY: _____

14TH AUGUST 2012

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VIBROCK

CALIBRATION CERTIFICATE

08121613

CALIBRATION CERTIFICATE NO.: _____

Forth Crossing Bridge Constructors

CLIENT: _____

V901-GSM

INSTRUMENT TYPE: _____

1613

SERIAL NUMBER: _____

14TH AUGUST 2012

CALIBRATION DATE: _____

DENNIS LORD

CALIBRATED BY: _____

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	$\pm 5\%$	$\pm 5\%$	X $\pm 5\%$
Peak Particle Velocity V	$\pm 5\%$	$\pm 5\%$	Y $\pm 5\%$
Peak Particle Velocity T	$\pm 5\%$	$\pm 5\%$	Z $\pm 5\%$

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

**WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY
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CERTIFIED BY: _____

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