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RBA ACOUSTICS

FORMER NESTLE FACTORY, HAYES (AUS)

Vibration Assessment

Reference: 8231.RP02.VIB.1
Prepared: 27 July 2021
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Vibration Assessment

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Prepared: 27 July 2021

Revision	Comment	Date	Prepared By	Approved By
0	First issue of report	30 June 2018	Callum Brewer	Alex J Wyatt
1	Site description updated for AUS	27 July 2021	Callum Brewer	Alex J Wyatt

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1.0 INTRODUCTION

The re-development of the former Nestle factory site in Hayes is proposed.

Ref.1331/APP/2019/2314
Development of 4No. new buildings comprising residential units (in addition to those approved under planning permission ref.1331/APP/2017/1883) a basement extension to Block B, flexible commercial uses (Class E) and associated landscaping, access, car parking and other engineering works.
Approved 28/06/2019

The site is located on ground with a railway embankment running along the north-western site boundary. Hayes and Harlington station is located towards the north-west of the site.

RBA Acoustics has been commissioned to undertake a vibration survey in order to ascertain whether the proposed dwellings to the north of site are likely to be affected by train induced vibration, either in the form of tactile vibration or re-radiated noise.

This report presents the results of the vibration survey undertaken at the site and associated BS 6472 assessment and conclusions.

2.0 ASSESSMENT CRITERIA

It is necessary to consider two sets of criteria when assessing train-induced vibration and its potential impact on dwellings. Not only will the disturbance be perceived as tactile vibration, but the vibration may also result in structure-borne re-radiated noise.

When assessing vibration and re-radiated noise levels generated by either surface or underground train movements, reference should be made to the following guidelines.

2.1 Vibration

BS 6472-1:2008 "Guide to Evaluation of Human Exposure to Vibration in Buildings Part 1: Vibration sources other than blasting" provides guidance on predicting human response to vibration in buildings over the frequency range 0.5Hz to 80Hz.

BS 6472 is based on the evaluation of vibration measurements with regards to adverse comment from occupants, rather than criteria relating to health and safety or structural damage.

In terms of assessing what impact the perceptibility of structure-borne vibration has on a person the standard promotes the use of the vibration dose value (VDV). The VDV determines an overall dose value accounting for intermittent, impulsive or continuous vibration experienced by a person and rates the level in terms of subjective response. Table 1 details the relationship between vibration dose and human annoyance:

Table 1 – VDV Values

Place and Time	Low probability of adverse comment ($m/s^{-1.75}$)	Adverse comment possible ($m/s^{-1.75}$)	Adverse comment probable ($m/s^{-1.75}$)
Residential Buildings 16h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential Buildings 8h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

The above values can be used for both vertical and horizontal vibration, provided that they are calculated according to the appropriate frequency weightings.

Perception

Additional guidance in BS 6472-1:2008 is given on the thresholds of perception of continuous whole-body vibration. Although it is recognised that thresholds vary widely among individuals the standard defines broad categories of thresholds of perception; as stated below:

Approximately half the people in a typical population, when standing or seated, can perceive a vertical weighted peak acceleration of 0.015m/s^2. The weighting used is W_b. A quarter of the people would perceive a vibration of 0.01m/s^2 peak, but the least sensitive quarter would only be able to detect a vibration of 0.02m/s^2 peak or more. Perception thresholds are slightly higher for vibration duration of less than about 1s.

2.2 Re-Radiated Noise

There are no specific UK or international standards that define when ground borne noise becomes significant. As a result there are no formal criteria against which assessment of ground borne noise inside residential buildings can readily be made.

It is commonly accepted that vibration levels resulting in re-radiated noise levels of up to 35dBA $L_{max(s)}$ should not result in nuisance or complaints, whilst levels above 40dBA $L_{max(s)}$ will make complaints likely. $L_{max(s)}$ re-radiated noise levels between 35dBA and 40dBA are considered perceptible but not a cause of complaint.

In addition, recent rail transit systems (Jubilee Line Extension, Crossrail and Channel Tunnel Rail Link) have adopted a re-radiated noise criterion of 40dBA $L_{max(s)}$ for residential buildings potentially affected by train induced vibration in order to ensure a low degree of impact.

We would therefore advise a 40dBA $L_{max(s)}$ criterion be adopted for the residential areas in order to ensure minimal likelihood of complaint from re-radiated noise.

N.B. The proposed development will also be affected by airborne noise intrusion (as the rail lines are overground) where a criterion of 45dBA $L_{max(f)}$ has been adopted.

3.0 TRAIN MOVEMENTS

During our time on site four different types of trains were noted.

Low to Medium speed commuter trains with an approximate frequency of 26 trains an hour in either direction were noted. Some of these commuter trains also stopped at Hayes and Harlington Station.

Medium to High speed electric passenger train passbys were also noted with an approximate frequency of 12 trains an hour in either direction. These passenger trains did not stop at Hayes and Harlington Station.

In addition, Medium to High speed diesel passenger train passbys were also noted with an approximate frequency of 6 trains an hour in either direction. These diesel trains did not stop at Hayes and Harlington Station.

During our time on site diesel freight train passbys were noted with an approximate frequency of 2 trains an hour in either direction. These freight trains did not stop at Hayes and Harlington Station.

From our on-site observations and review of the train timetables, an average of 45-50 train passbys per hour are expected to occur during the daytime period (07:00-23:00 hours).

Upon reviewing the train timetables for the night-time period (23:00-23:00 hours), a reduced number of train passbys are noted to occur. Typically 20 train passbys per hour are expected to occur during the night-time period.

4.0 VIBRATION MEASUREMENTS

4.1 Instrumentation

Full details of the equipment used are provided in Appendix B.

The accelerometers were calibrated both prior to and on completion of the survey with no calibration drifts observed.

4.2 Methodology

Site-wide vibration measurements were undertaken for a number of train movements at two measurement positions on 12 January 2018. The positions are described in detail below:

Position 1: Measurements were undertaken on a steel block bonded to existing concrete hardstanding on site. This location was to the centre of the northern site boundary, approximately 27m from the nearest elevated railway track.

Position 2: Measurements were undertaken on a steel block bonded to existing concrete hardstanding on site. This location was to the north-western site boundary, approximately 30m from the nearest elevated railway track.

The approximate locations of the vibration measurement positions are shown on the Site Plan in Figure 1 in Appendix C.

Vertical and horizontal axis measurements were undertaken at all positions. Horizontal axis measurements were undertaken perpendicular to the railway tracks.

5.0 RESULTS

The ground-borne vibration levels for a number train passbys have been analysed into third-octave bands and the data summarised on the attached graphs. Graphs 1 – 4 present the maximum (rms) vertical vibration levels measured at each position for the individual train passbys. Graphs 5 – 8 present the maximum (rms) horizontal vibration levels measured at each position for the individual train passbys.

6.0 PREDICTION ASSUMPTIONS

Vibration levels presented in Graphs 1-8 are as measured on the existing concrete hardstanding. In order to estimate the resultant vibration levels and re-radiated noise levels within the building we have made the following assumptions:

6.1 Prediction Procedures

Our calculations have been based on the following:

(i) Empirical prediction procedures as detailed within the following references:

- "A Prediction Procedure for Rail Transportation Ground-borne Noise and Vibration" – Nelson and Saurenman : Transportation Research Record 1143.

- "Handbook of Urban Rail Noise and Vibration Control" – Nelson, Saurenman, Wilson : US Department of Commerce – National Technical Information Services – February 1982.

(ii) Previous research undertaken by RBA Acoustics on building response to ground-borne vibration within a variety of different building frame types.

6.2 Drawings

Our assessment has been based on the layouts and building types detailed in the Stage 3 Drawings provided by dmfk architects and Makower architects.

6.3 Proposed Building Structures

We have based our assessment on the following information received from dmfk architects, Makower architects, Hydrok structural engineers, Gravity structural engineers and Barratt Homes.

Substructure

All blocks to be constructed on concrete raft foundations.

Superstructure

Superstructure will be formed from an RC frame for all blocks.

Should this information change during the course of the design RBA Acoustics should be notified.

7.0 PREDICTED LEVELS OF VIBRATION & RE-RADIATED NOISE

7.1 Tactile Vibration – Vibration Dose Values (VDVs)

Table 2 details the predicted Vibration Dose Values (VDVs) for both the daytime and night-time periods. Levels have been predicted within the first suspended residential floor slabs, which are generally acknowledged as having the highest levels of vibration. Only the vertical axis has been considered as the floor structures will vibrate predominantly in this axis.

Table 2 – Predicted $Vdv_{b,Day}$ And $Vdv_{b,Night}$

Measurement Position	Period	Vertical VDV ($m/s^{-1.75}$)	BS 6472	
			Low Probability of Adverse Comment ($m/s^{-1.75}$)	Adverse comment possible ($m/s^{-1.75}$)
1	Day	0.05	0.2 – 0.4	0.4 - 0.8
	Night	0.04	0.1 – 0.2	0.2 - 0.4
2	Day	0.05	0.2 – 0.4	0.4 - 0.8
	Night	0.04	0.1 – 0.2	0.2 - 0.4

Please note that vibration levels would typically decrease as one moves up through the building.

Our calculations indicate that the Vibration Dose Values associated with train movements during both the day and night-time periods fall below the threshold of "low probability of adverse comment" for Positions 1 and 2.

Please note that there is a general consensus that the night time VDV range of 0.1-0.2 is considered to be overly relaxed and recent technical forums have presented a number of case studies where lower VDV values have resulted in complaints as the vibration was clearly perceptible by residents.

7.2 Perception Values

Worst-case vertical weighted peak acceleration levels were measured as $0.011m/s^2$.

As can be seen, peak acceleration values recorded at Positions 1 and 2 are marginally above the $0.01m/s^2$ value which indicates that worst-case train vibration may potentially be perceptible to some residents although this is not considered to be sufficient to warrant any mitigation measures.

7.3 Re-Radiated Noise Levels

Table 4 presents the range of predicted re-radiated $L_{max(s)}$ noise levels from train passbys.

Table 4 – Predicted Re-Radiated Noise Levels

Measurement Position	Noise Levels (dBA)	Proposed Criterion (dBA)
1	19-36	40
2	11-34	40

Please note that re-radiated noise levels would typically decrease as one moves up through the building by between 1dB and 3dB per floor level.

7.4 Discussion

Appropriate levels of re-radiated noise, tactile vibrations and perception levels are predicted to be experienced in blocks located within the proximity of the railway embankment. Therefore we would consider that vibration mitigation measures will not be required.

8.0 CONCLUSIONS

Detailed vibration measurements have been undertaken at the former Nestle factory site in Hayes.

The vibration measurements have been analysed on an empirical basis to yield likely levels of tactile vibration and re-radiated noise within the proposed residential blocks and houses.

Our predictions indicate that building isolation will not be required for any of the blocks.

Appendix A - Acoustic Terminology

dB	Decibel - Used as a measurement of sound pressure level. It is the logarithmic ratio of the noise being assessed to a standard reference level.
Peak to peak	This values gives the total excursion of the oscillation about the zero datum. The unit is often used where the vibratory displacement of a component is critical for maximum stress or mechanical clearance calculations.
Peak	This value gives the maximum excursion of the oscillation above or below the zero datum. This value is useful for indicating the level of short duration shocks.
r.m.s.	This value gives the root mean square of the time history over a specific time interval (time constant). This value is useful for indicating the energy content of the vibration.
VDV	Vibration Dose Value (VDV) is a measure of vibration exposure recommended in BS6472-1:2008 'Guide to evaluation of human exposure to vibration in buildings' for assessing the severity of impulsive and intermittent vibration. It involves analysing the vibration signal using a "fourth power" time dependency, as opposed to the more usual "second power" time dependency used to produce the more familiar r.m.s. values used in noise measurement. A definition of VDV is: the fourth root of the integral, over the measurement period, of the fourth power of the frequency-weighted time-varying acceleration. An important feature of this time dependency is that it places greater emphasis on magnitude than on duration, as compared to r.m.s. measurements, so that, for example, a two-fold increase (or decrease) in vibration magnitude is equivalent to a 16-fold increase (or decrease) in the duration of the vibration. It is measured in $m/s^{1.75}$
$L_{max,T}$	The instantaneous maximum sound pressure level which occurred during the measurement period, T. It is commonly used to measure the effect of very short duration bursts of noise, such as for example sudden bangs, shouts, car horns, emergency sirens, etc., which audibly stand out from the general level of, say, traffic noise, but because of their very short duration, maybe only a very small fraction of a second, may not have any effect on the L_{eq} value.

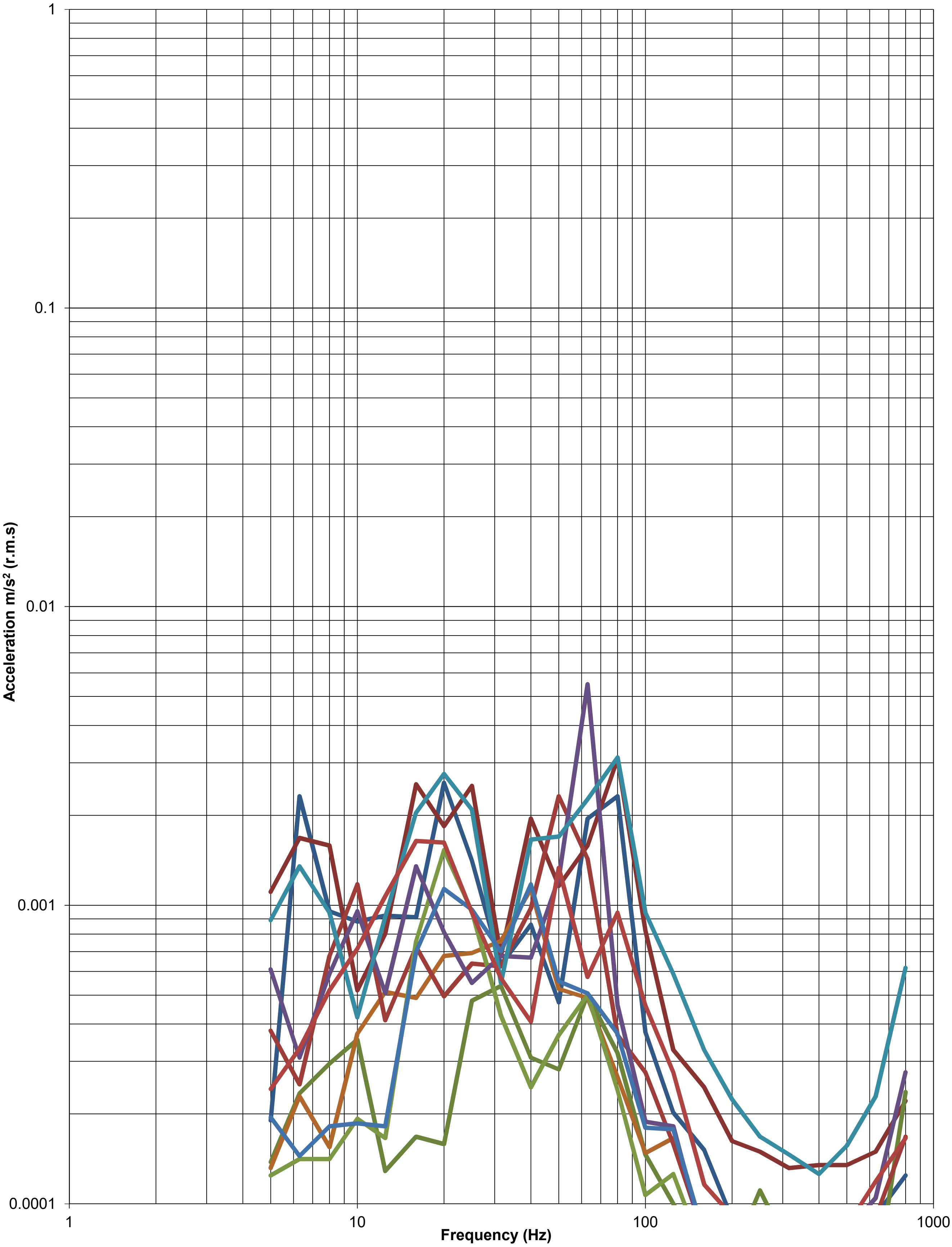
Appendix B - Instrumentation

The following equipment was used for the measurements

Manufacturer	Model Type	Serial No.	Calibration	
			Certificate No.	Expiry Date
01dB A&V Measurement System	Symphonie	01743	1608450	31 August 2018
DJB Accelerometer	A/121/V	1213	1608446	30 August 2018
DJB Accelerometer	A/121/V	1264	1608447	30 August 2018
AP Vibration Calibrator	AT01	2003	1608448	30 August 2018

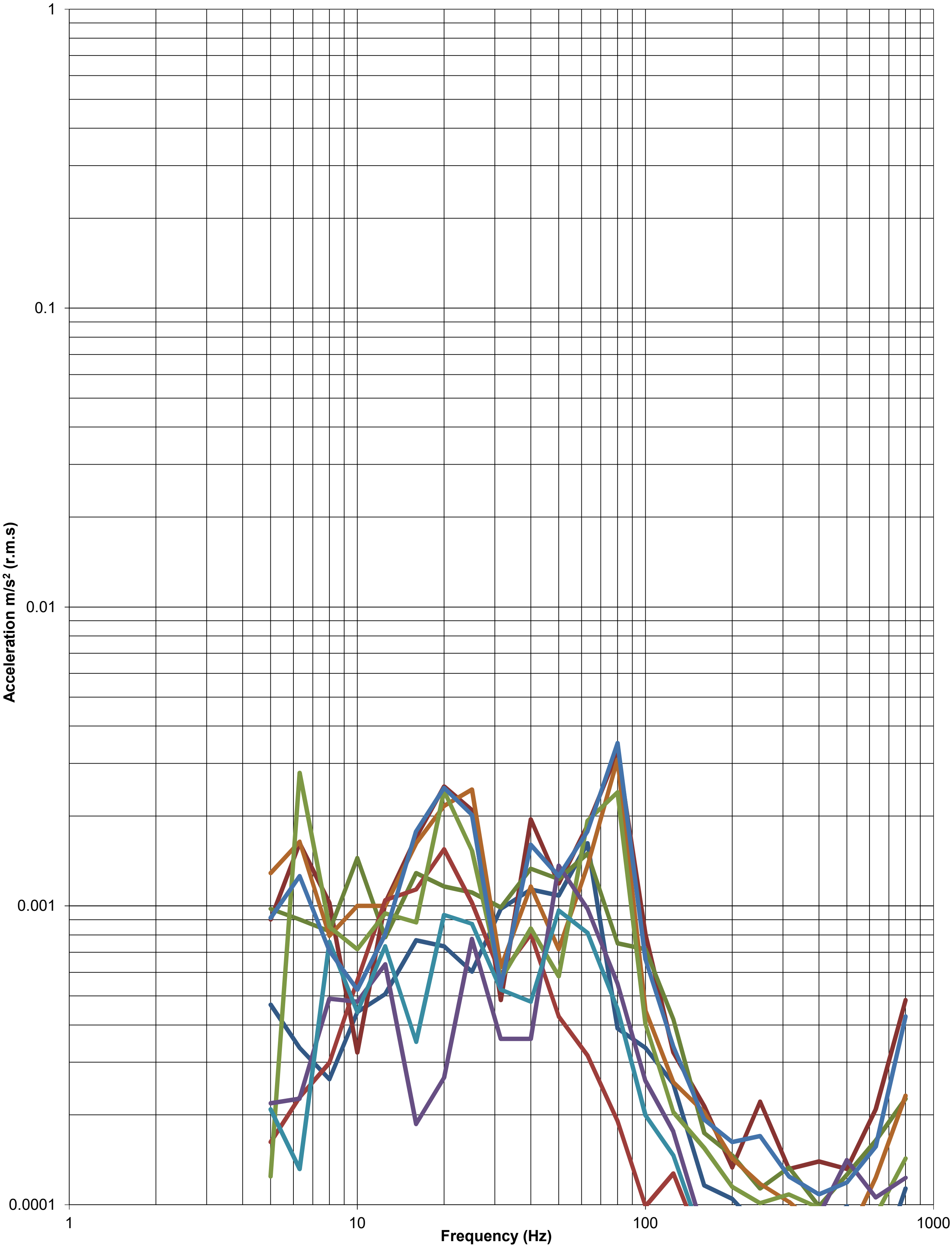
Appendix C – Graphs and Site Plans

Address: Former Nestle Factory, Hayes
Position: VP1
Vertical Axis



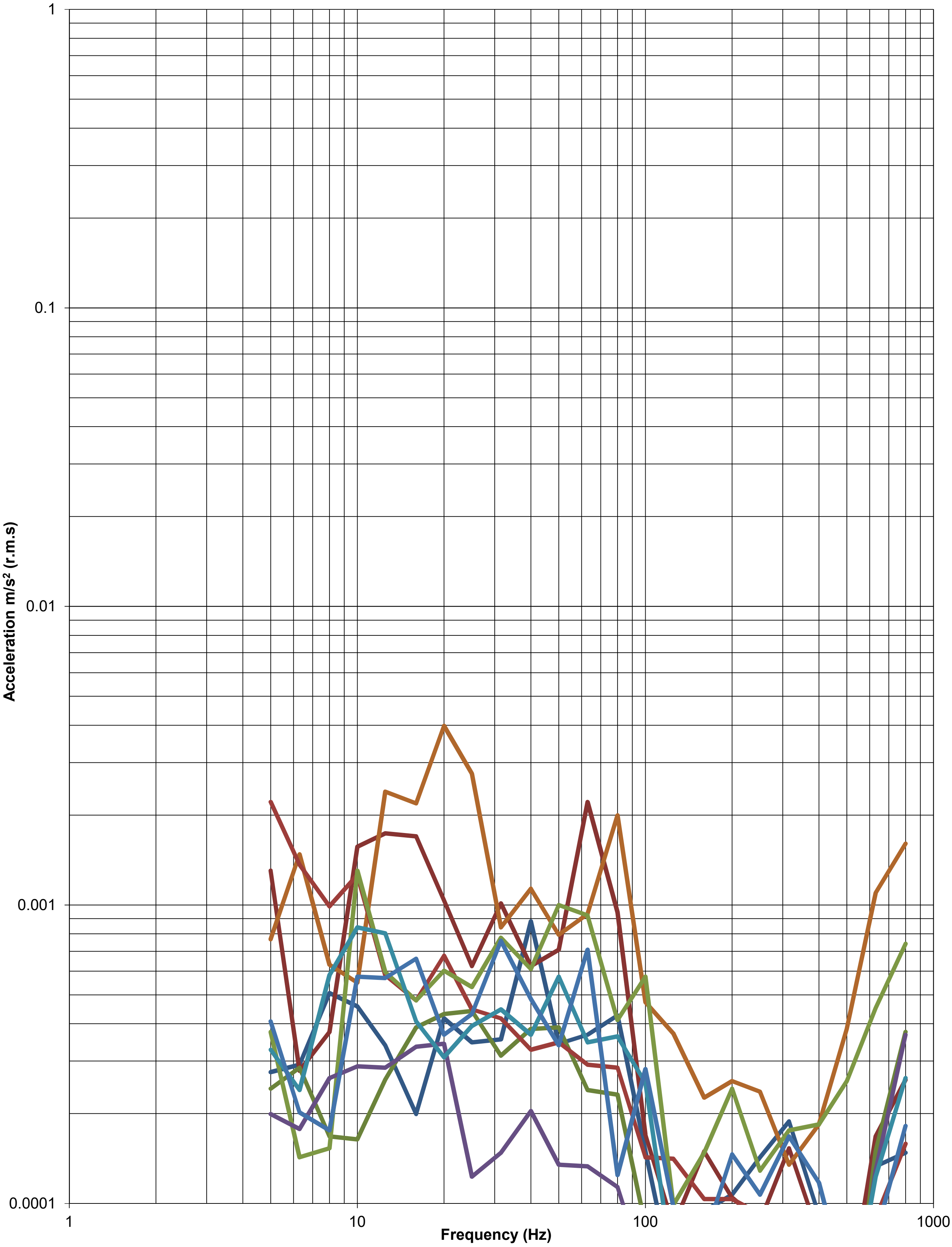
Graph 1

Address: Former Nestle Factory, Hayes
Position: VP1
Vertical Axis



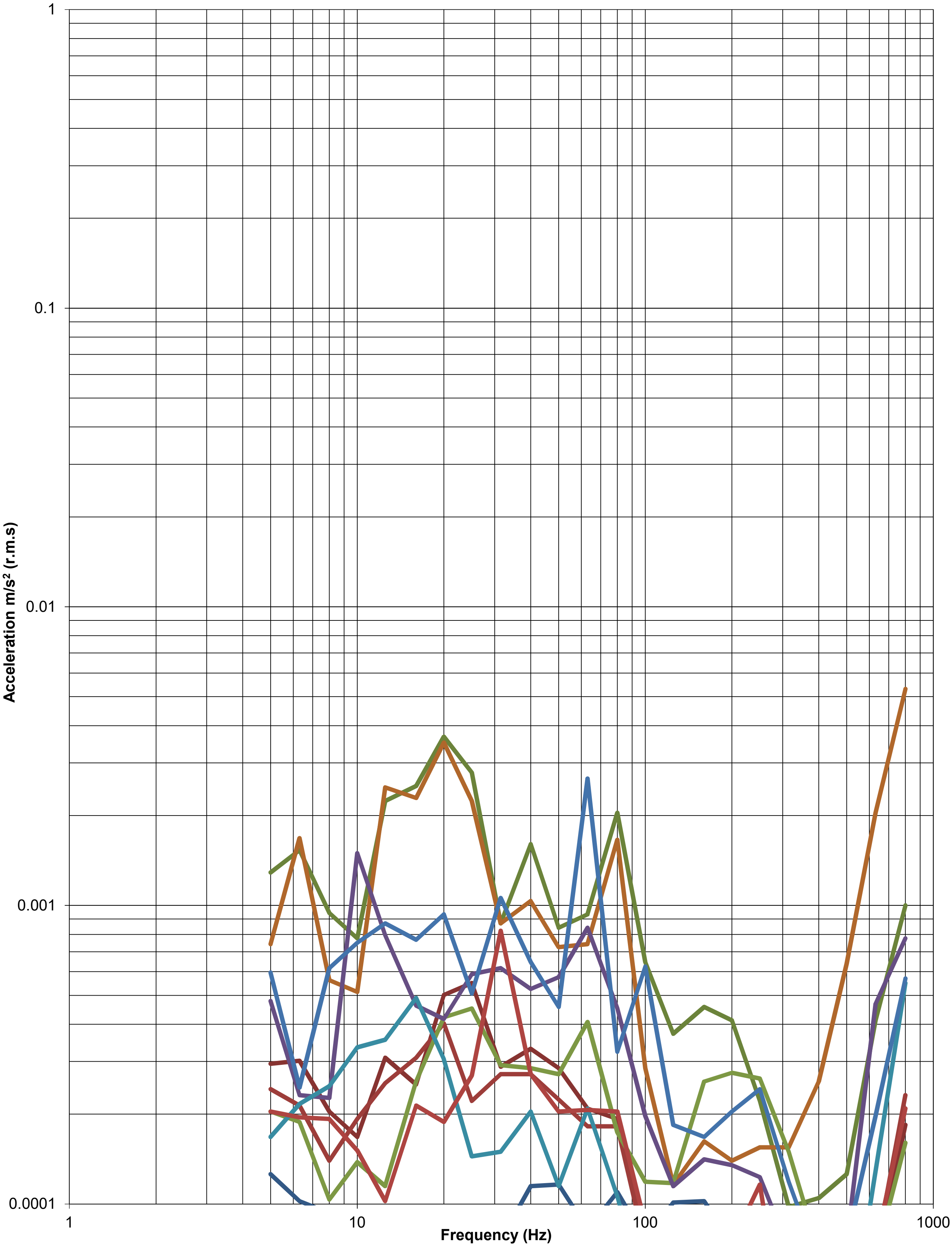
Graph 2

Address: Former Nestle Factory, Hayes
Position: VP2
Vertical Axis



Graph 3

Address: Former Nestle Factory, Hayes
Position: VP2
Vertical Axis

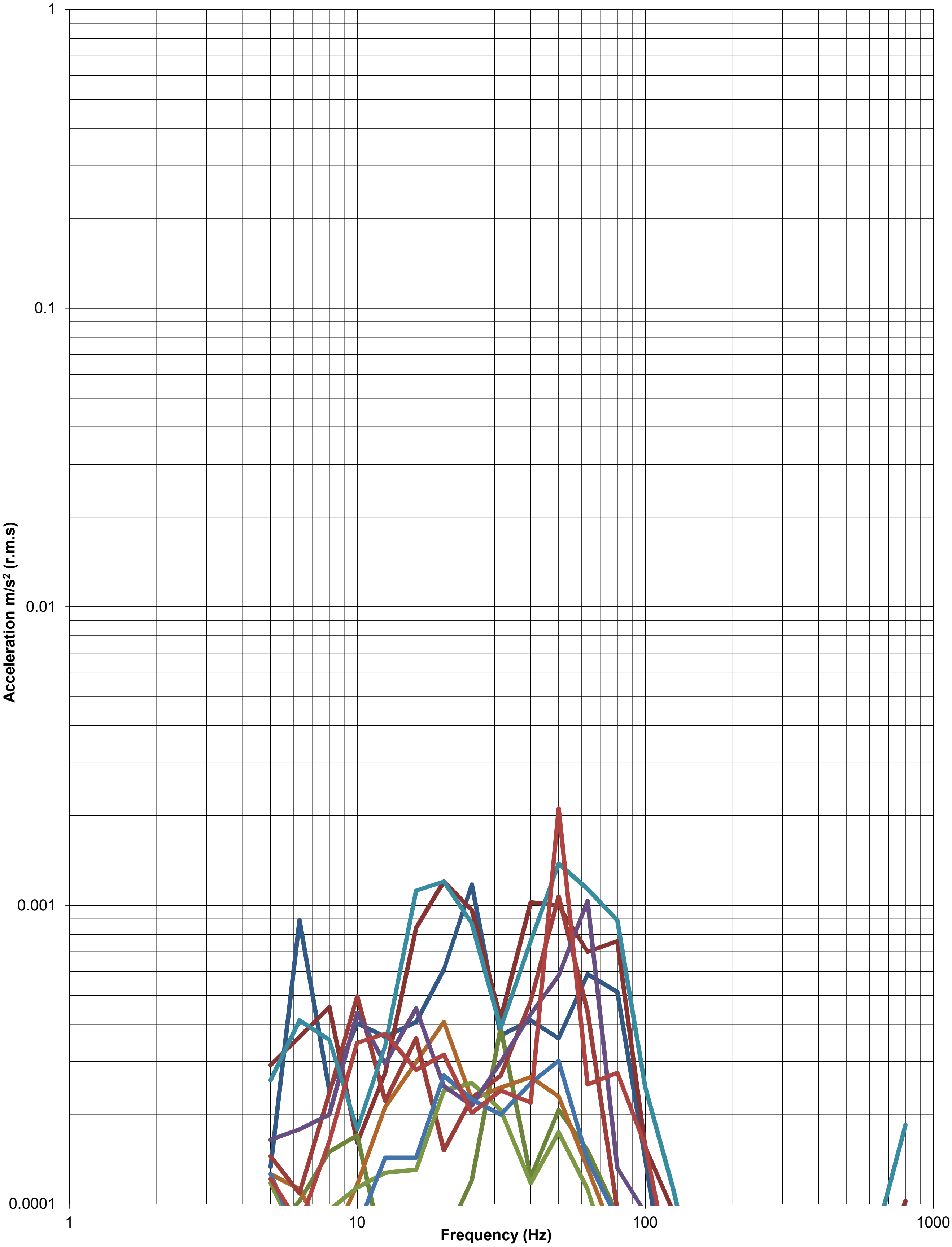


Graph 4

Address: Former Nestle Factory, Hayes

Position: VP1

Horizontal Axis

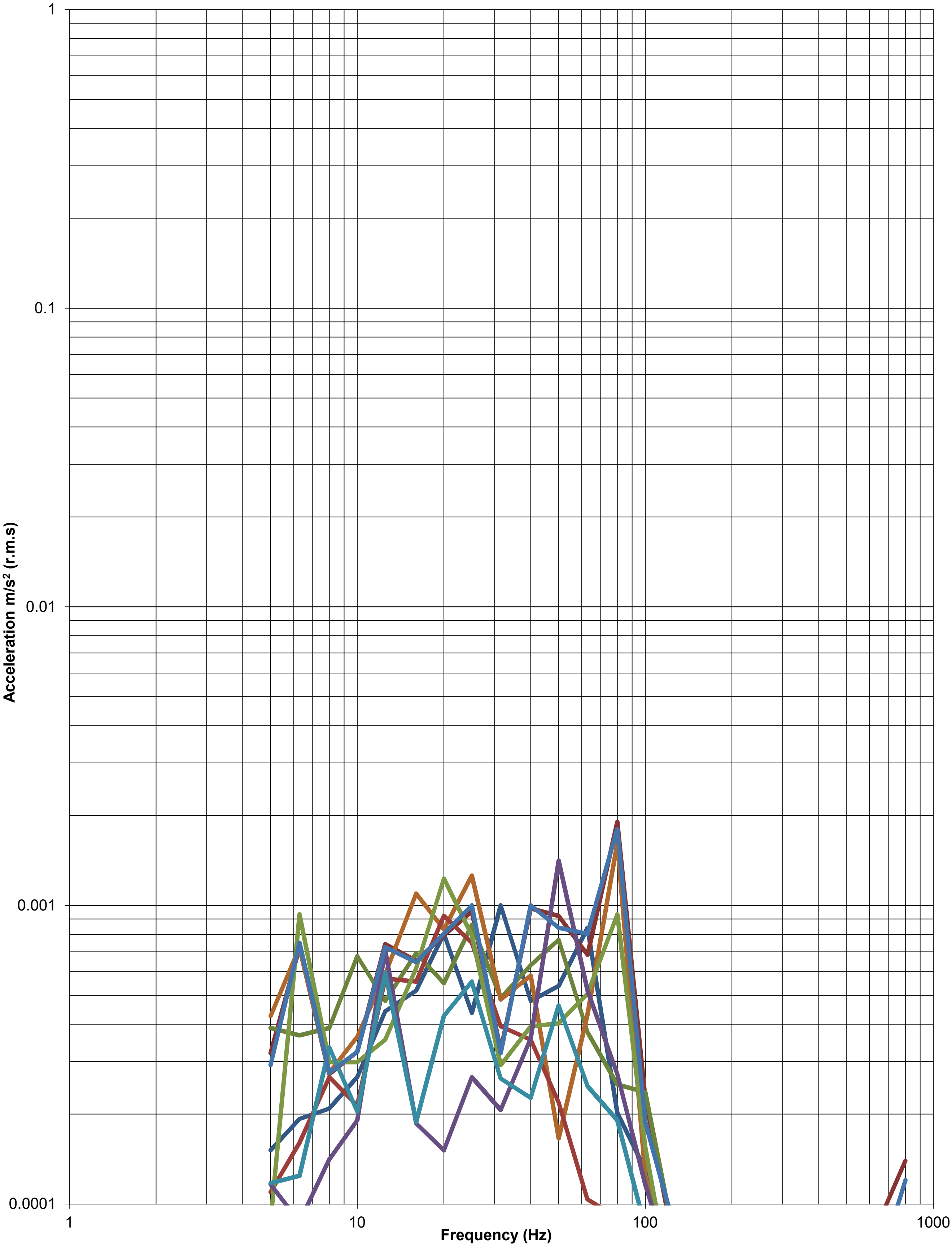


Graph 5

Address: Former Nestle Factory, Hayes

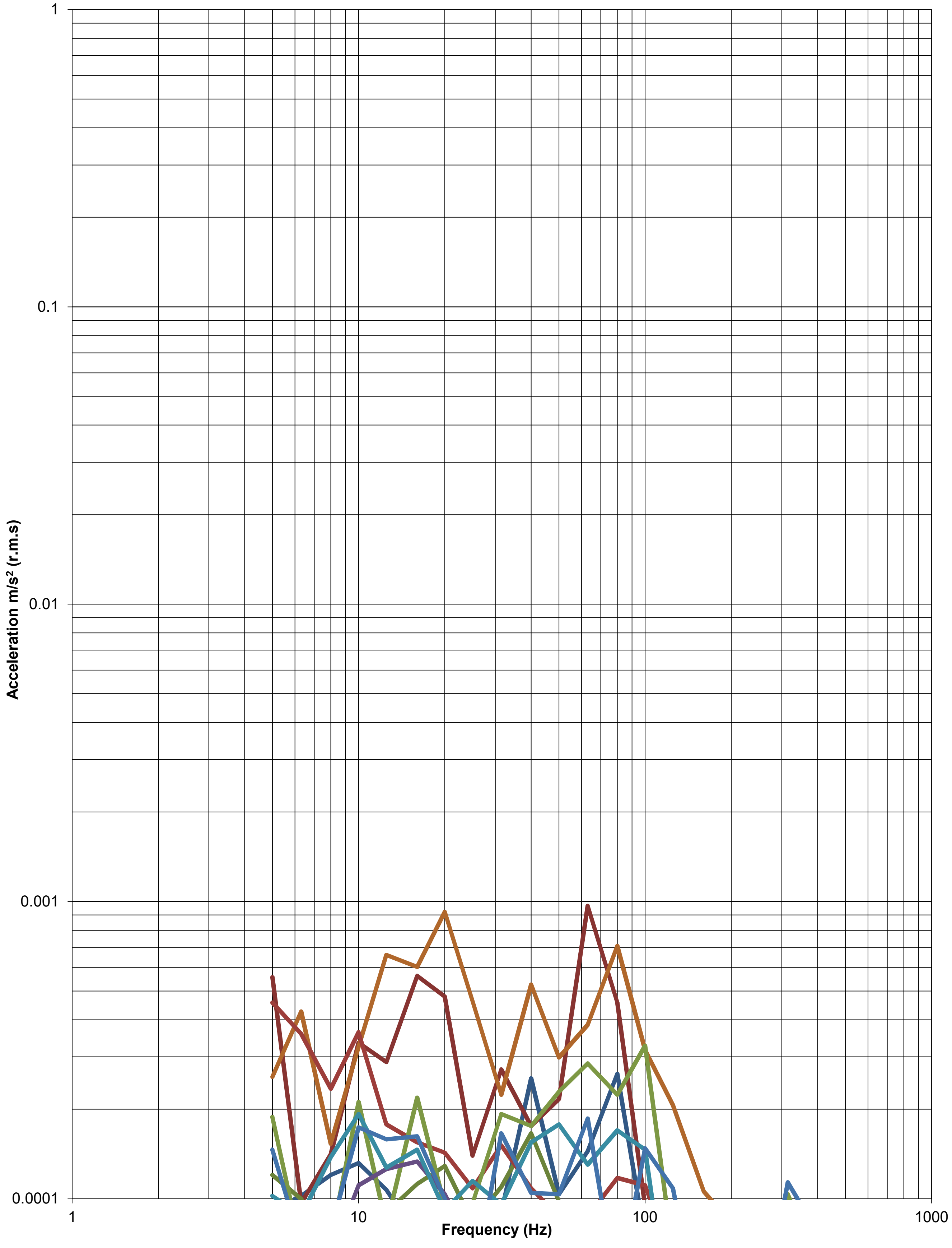
Position: VP1

Horizontal Axis



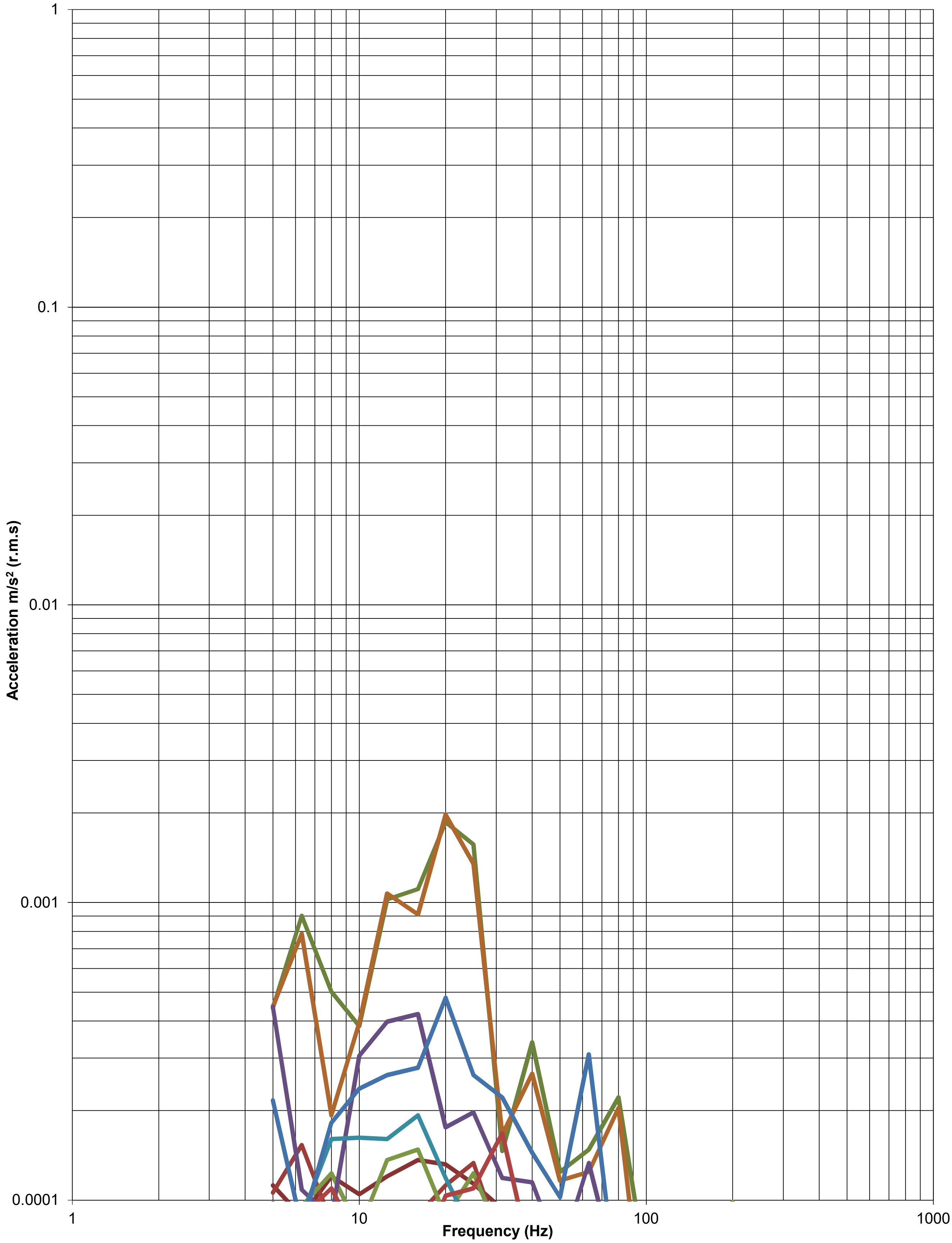
Graph 6

Address: Former Nestle Factory, Hayes
Position: VP2
Horizontal Axis

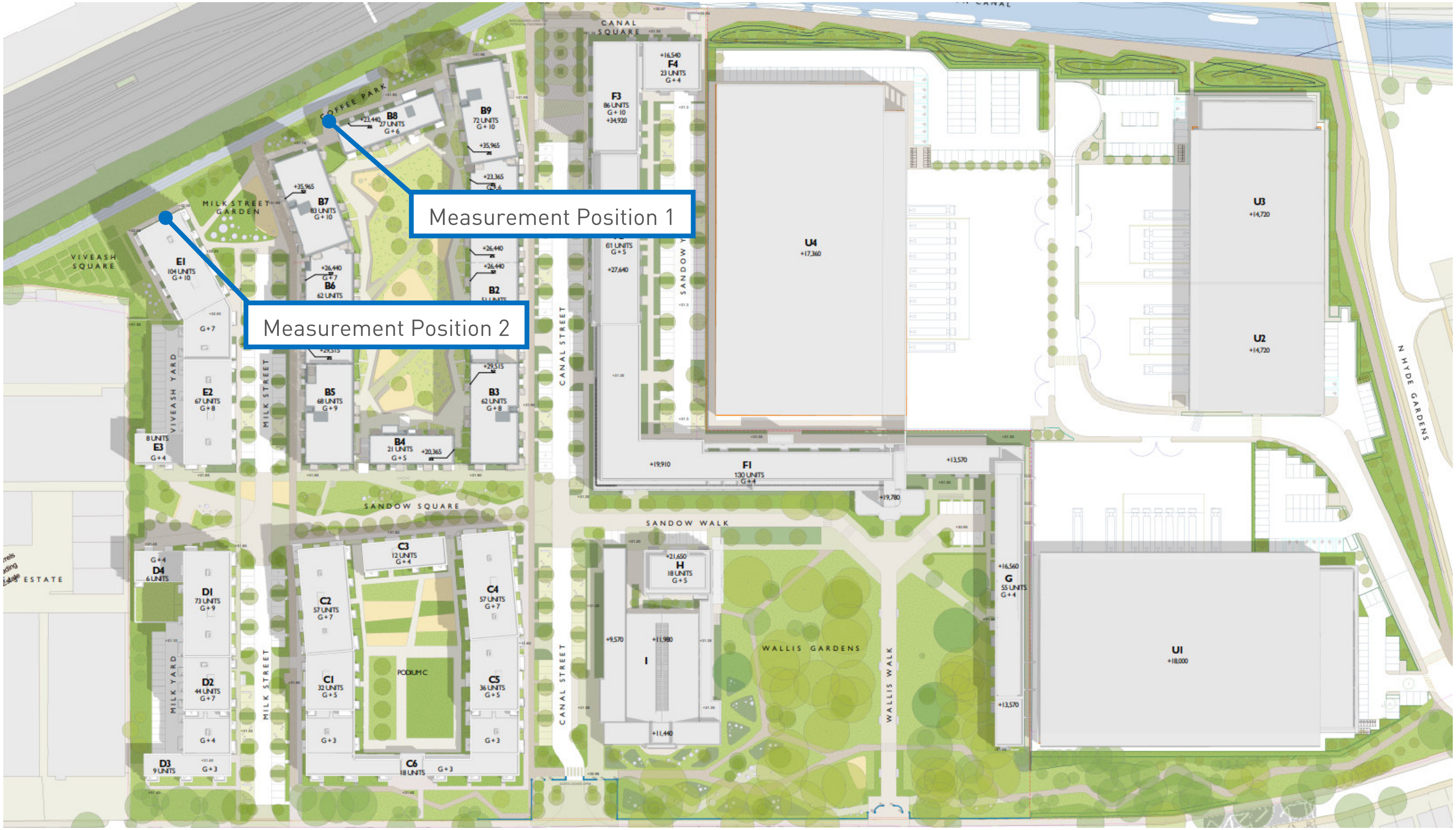


Graph 7

Address: Former Nestle Factory, Hayes
Position: VP2
Horizontal Axis



Graph 8



FORMER NESTLE FACTORY, HAYES (AUS)

Proposed Site Plan Showing Vibration Measurement Positions 1 and 2

Figure 1

27 July 2021

Not to Scale

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