PARTX/

DCC PLAN 0017/17
COMP. REC.17/10/18

APPENDIX E

SANDY BROWN

Consultants in Acoustics, Noise & Vibration

PARTX/
DCC PLAN 0017/17
COMP. REC.17/10/18

16301-R03-B

27 June 2017

New Children's Hospital

Noise and vibration monitoring plan

55 Charterhouse Street, London EC1M 6HA [illegible]
[illegible] Sackville Street, Manchester [illegible]
[illegible] Walker Street, Edinburgh [illegible]
87 Caroline Street, Birmingham [illegible]

post@sandybrown.com
www.sandybrown.com

Sandy Brown Associates LLP
Registered in England & Wales No. [illegible]
Registered Office: [illegible] London [illegible]

Version	Date	Comments	Author	Reviewer
A	27 Jun 17		Daryl Prasad	Jason Swan
B	27 Jun 17	Updated with BAM comments	Daryl Prasad	Jason Swan

Contents

1 Introduction

Sandy Brown Associates LLP (Sandy Brown) has been commissioned by BAM Contractors to develop a Noise and Vibration Monitoring Plan (NVMP) as part of the main contract works for the New Children's Hospital (NCH) project. The proposed site is to be located within an area of the existing St James Hospital in Dublin.

Guidance for the noise and vibration monitoring is set out in the Main Contract *Structural specification: Conditions surveys, monitoring and instrumentation* NPH-C-OCSC-CD-SP-2028-007 dated 2 June 2017. The specification calls for BAM Contractors to appoint a Surveying, Instrumentation and Monitoring Subcontractor (SIMS) to develop the noise and vibration monitoring plan.

It should be noted that the specification also covers movement which is beyond our expertise and we assume this portion of the works will be undertaken by a separate subcontractor.

This document outlines the noise and vibration specification requirements, monitoring criteria, technical details of the proposed monitoring equipment and our relevant experience in this type of work.

2 Specification

2.1 Equipment

The specification calls for a noise and vibration monitoring system capable of:

- Real-time monitoring
- Tablet and smart phone friendly: Android, iPhone, Google Chrome, Internet Explorer, Firefox, Safari
- Real time alerts via SMS and email, including level exceedance, tamper detection and battery levels
- Website charting, download of raw data and audio/video playback of exceedances,
- Automatic online report generation
- Secure, long term data storage
- Powered by battery, mains power and/or solar-panel dependent on location
- Robust, weather resistant case (withstands heat, rain and extreme wind conditions)
- Sound level meter options
- Noise-source triangulation and display when multiple devices are used in concert
- Local data storage for areas with possibly no or poor network signal.

The Noise Monitoring Terminals (NMT) need to be capable of:

- Logging of two concurrent periods, e.g. 15-minute & hourly
- Daily CIC automated calibrations
- E-mail alert on threshold exceedance
- E-mail alert on low battery and low memory
- Remote access to measured data, and
- Live display of noise levels.

Vibration monitoring stations should continually log vibration levels using the Peak Particle Velocity parameter (PPV, mm/s) in the X, Y and Z directions, in accordance with BS ISO 4866: 2010: *Mechanical vibration and shock - Vibration of fixed structures - Guidelines for the measurement of vibrations and evaluation of their effects on structures*.

It should be noted that noise triangulation is not strictly possible however the noise monitors can be synchronized by GPS to allow for a detailed analysis of the measured signals. Multiple markers can be assigned to allow for post processing of the time history to detect the disturbing source from the sum of all other noises sources.

2.2 Criteria

2.2.1 Noise

The relevant noise limits included in the specification are reproduced in Table 1. These are assumed to be assessed at the nearest residential properties.

Table 1 Construction noise criteria at residential receiver

Period over which criteria applies		Noise impact criterion ($L_{Aeq,1hr}$)
Monday to Friday	Day: 07:00 to 19:00	70 dB
	Evening: 19:00 to 22:00	60 dB*
	Night: 22:00 to 07:00	The higher of 45dB or the ambient level*
Saturday: Day: 08:00 to 14:00 (work outside these hours no higher than 45 dB or ambient noise level)		65 dB
Sundays and Bank Holidays*: Day: 08:00 to 14:00		60 dB*

Note * Construction activity at these times, other than that required for emergency works, will require the explicit permission of the relevant local authority.

In addition, an internal noise limit of 45dB $L_{Aeq,1hr}$ will be required for construction noise intrusion in all hospital and clinical buildings.

2.2.2 Vibration

The construction vibration limits, at the nearest sensitive and residential receivers, are taken from DIN 4150-3:1992 *Structural vibration – the effects of vibration on structures*. The criteria is assumed to be Line 3 from DIN 4150 and are reproduced in Table 2.

Table 2 Construction vibration criteria at sensitive and residential receiver

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of:		
Less than 10 Hz	10 to 50 Hz	50 – 100 Hz
3 mm/s	3-8 mm/s	8-10 mm/s

In addition to above construction vibration limits are also provided for the nearby clinical buildings. These are specified in weighted acceleration although the weighting is undefined. The criteria appears to be derived from BS 6472:1992 *Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)* and would correspond to the base curve for building vibration in the z-axis.

The acceleration criteria is reproduced in Table 3 below. We have also included the BS 6472:1992 curve number and the corresponding values for z-axis building vibration in PPV.

Table 3 Construction vibration criteria for clinical buildings

Location	BS 6472 curve	Frequency weighted acceleration	PPV
Operating theatres, precision laboratories, audiometric testing booths	1	0.005 m/s^2	0.141 mm/s
Wards	2	0.01 m/s^2	0.242 mm/s
General Laboratories, treatment areas	4	0.02 m/s^2	0.484 mm/s
Offices, Consulting Rooms	8	0.04 m/s^2	0.968 mm/s

Criteria to protect underground structures has been set as per BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open sites –Part 2: Vibration.*

This recommends vibration limits as:

- Maximum P.P.V for intermittent or transient vibrations – 10 mm/s, and
- Maximum P.P.V for continuous vibrations – 5 mm/s.

3 Instrumentation and monitoring plan

The nearest sensitive receivers will be the:

- surrounding residents, and
- the St James Hospital (SJH).

Below details the proposed equipment and monitoring methodology.

3.1 Baseline monitoring

Baseline monitoring has been undertaken as part of the enabling works.

Noise levels from road traffic on Brookfield/South Circular Road is already high and in some instances was exceeding the noise limits. Noise limits were increased to $L_{Aeq,1hr}$ 73 dB to avoid false alerts.

Baseline noise and vibration was also undertaken within the existing SJH. These are detailed in our report 16301-R02-A *National Paediatric Hospital - St James Hospital baseline monitoring* dated 27 January 2017. Depending on location both the noise and vibration criteria were exceeded on a regular basis from internal activities. Higher noise and vibration limits were recommended to avoid alerts from internal activities.

Given the high levels of internal noise within the SJH it may be more appropriate to locate the noise monitors outside. This needs to be agreed with the Engineer.

It is recommended that the baseline levels from the monitors are reviewed and limits adjusted where appropriate.

3.2 Installation

The monitoring equipment will be installed by suitably qualified personal.

All of the components will be checked in the laboratory, tested and preconfigured prior to arrival to site.

All signal cables will be checked onsite. Power and batteries will be checked on installation. Communications will also be checked.

Vibration transducers will be fixed in accordance with BS ISO 5348:1998 *Mechanical vibration and shock. Mechanical mounting of accelerometers.*

3.3 Commissioning

All of the monitoring equipment will be appropriately commissioned. This will include:

- a check of the calibration by a hand held calibrator/exciter (where the transducers allow)
- verification of channel numbering and labelling
- verification of the alarm triggering process, and
- verification of remote access for data retrieval.

3.4 Calibration

All instrumentation will be appropriately calibrated in an accredited facility prior to installation. The equipment will be ensured to be within its valid calibration period during the course of the monitoring.

Should the equipment need to be sent off for calibration throughout the course of the monitoring it would be swapped with a suitable replacement. This will need to be agreed, however it is envisaged this will take place outside of construction hours. This should therefore not impact on the vibration monitoring from construction activities.

3.5 Monitoring locations

We have proposed monitoring locations based on the various phases of the works. The monitoring locations have been proposed to:

- protect nearby residences
- protect nearby hospital.

The monitoring locations within the St James Hospital are assumed to be in similar locations as for the enabling works.

The proposed monitoring locations are shown on the marked-up drawing in Appendix A.

3.6 Proposed equipment

3.6.1 Noise

Noise monitoring will be undertaken with 01dB Cube sound level meters as shown in Figure 1.

Figure 1 01dB Cube

The meters will be housed in a weatherproof envirnomental case and be used with an external outdoor microphone kit (as shown in Figure 2). The units can be powered from batteries or solar panels although it is envisaged mains power will be made available at each of the monitoring stations.

Figure 2 Outdoor microphone kit

The meters feature an automatic calibration feature. When the meter detects a stable calibration level, it automatically starts the calibration procedure. At the end of this procedure, the instrument indicates the new calculated sensitivity and prompts the user for validation, repeat or rejection of the calibration. Information provided is stored and added up to the historical data of the instrument.

The meters have built-in charge injection calibration to check the entire measurement chain including the microphone. The tests are multi-frequency set at 1000, 2000, 4000 Hz with two additional user-defined frequencies.

General specifications are as follows:

- IEC-61672 Class-1
- PRE22 preamplifier
- Gras 40CD microphone
- Integrated Wi-Fi/3G modem for remote operation and automatic data retrieval
- Integrated GPS antenna for precise localisation and synchronisation
- Internal battery with operating time of 60 hours (Duo) or 24 hours (Cube)
- SD card of up to 128 GB
- Capable of measuring a multitude of parameters including: L_{eq}, L_p, 1/1 or 1/3 octave spectrum, Fast/Slow time weightings.
- Indicators may be measured and stored on the basis of an integration period (IP) of 20 ms (minimum) to 3600 s (maximum) in 5 ms steps.

3.6.2 Vibration

External

External vibration monitoring will be undertaken using 01dB Orion vibration monitor as shown in Figure 3.

The Orion has an integrated tri-axial accelerometer and undertakes real-time integration to simultaneously measure acceleration and velocity. As well as the three internal vibration channels it can also accept 3 external vibration channels to allow for connection of different transducers.

It includes five integrated standards and includes the appropriate frequency weightings for DIN 4150-3 and BS 5228.

The Orion can be mounted horizontally or vertically and includes an integrated spirit level for easy leveling.

PPV will be sampled at 1 second intervals with peak frequency detection at 5 second intervals.

Orion's specifications are as follows:

- Sensitivity 500 mV/g
- Noise floor 25 µg
- Strong casing waterproof to IP65
- Robust connectors
- Internal battery life of 30 hours
- 3G modem
- Wi-Fi access point
- Ethernet
- GPS

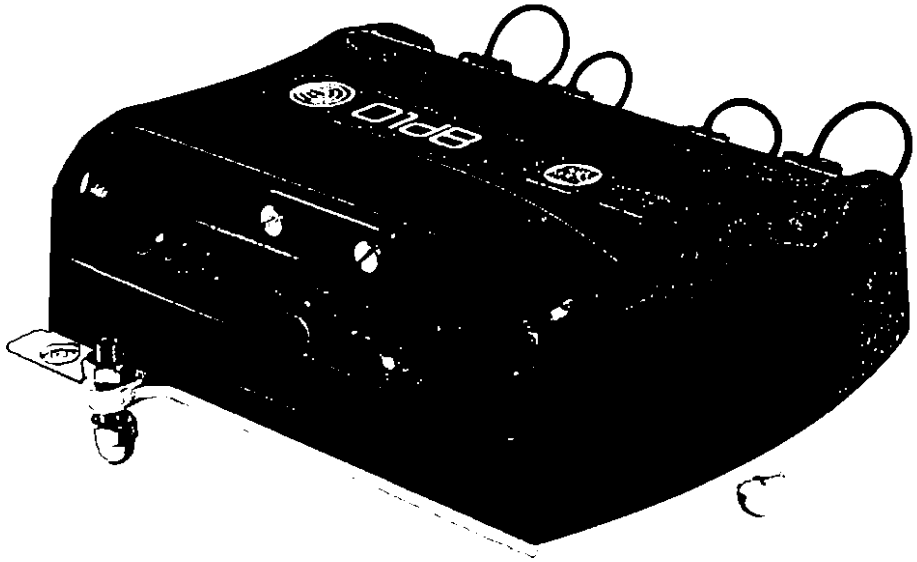
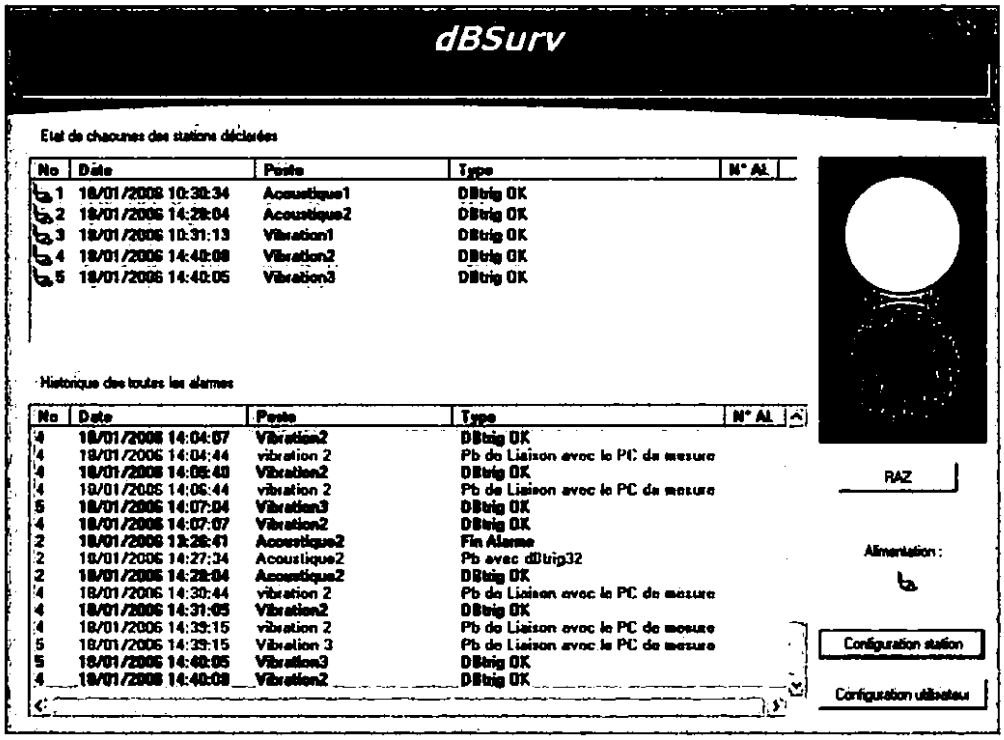


Figure 3 01dB Orion

3.6.3 Monitoring server

Remote monitoring is undertaken by remote server operating dBSurv. dBSurv allows for the management of all alarms of the noise and vibration monitoring system. It also enables the transfer of information relevant for decision making, e-mails, phone calls, SMS to the relevant person(s). dBSurv also sends the data to the WebMonitoring interface (described in the Section 3.6.5).

Figure 4 dBSurv screenshot



dB Surv provides predefined alarms both on levels as well as the condition of the operating system, for example:

- exceedances of the trigger thresholds
- electrical power supply failure
- battery level, and
- status of the network connection between the central computer and each station.

If an alarm is triggered then it will be configured to:

- code the trigger in the measurement file that allows displaying them on time histories and
- send SMS and e-mails to one or several recipients.

The server is equipped with a UPS to ensure operation in the event of a power failure. Alarms will also be issued if there are any faults detected in the system.

Similar monitoring systems as proposed have been successfully been used on many projects, including the Louvre and British Museum which was to protect artefacts from construction vibration.

3.6.4 Alerts

Trigger values for alerts have been defined in the specification as green, amber and red value as follows:

Table 4 Alert trigger values

	Green	Amber	Red
Noise	50% of maximum	75% of maximum	Maximum noise limit
Vibration	50% of maximum within frequency range	75% of maximum within frequency range	Maximum vibration limit

The trigger values for noise will need to be agreed as they are unclear. 50 % by value (ie 35 dB from 70 dB) would be far too low and result in numerous un-necessary alerts. 50% by sound pressure would be a 3 dB reduction ie 67 dB which would be considered too close to the maximum value. We would recommend an amber alert be set to -5 dB of the maximum noise limit.

The green alert could be set to -10dB of the maximum noise criteria, however experience would say this would result in a large number of alerts that are 'OK to proceed'. Consideration should be given to whether or not the green alerts are practical.

Should the trigger thresholds be reached then the system will issue alerts (SMS and/or email) to predefined persons.

An example of the alert sent by dBSurv, via SMS, would be as follows:

Alarm: **Amber threshold**
Network: NCH
Station: St James Hospital
Point: V2 Vertical
Line: OK
Power: Mains
System: OK
Frame date: 26/09/2017 11:39:13

This will detail the type of alarm, the location and which transducer triggered the alarm. It will also indicate the status of the system.

Line OK means that the network communication is working. Power Mains means that the system is correctly powered and System OK means that the network system is working.

3.6.5 Web monitoring

Web monitoring will be provided by the 01dB WebMonitoring. WebMonitoring is a customizable website which will display of measurement data, real-time alarms, and periodic system checks.

Real-time readings will be displayed on a Google Map image including colour coding to represent the green, amber and red triggers (see Figure 5) in real time. It also indicates the number of alarms registered since the latest acknowledgment.

When alarms are acknowledged, comments will be added by the contractor for each alarm to as to the reason of the exceedance. The alarm is recorded in the database. Any comments entered will be reproduced in the reports available for each measurement point.Red triggers will stay highlighted until cleared.

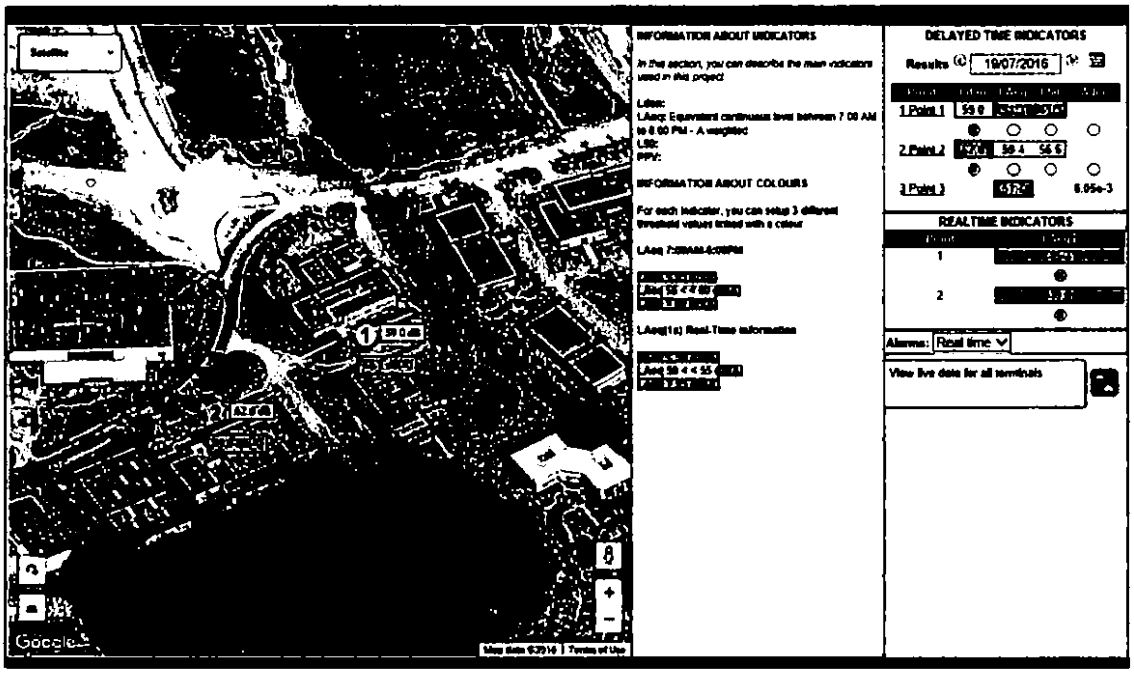


Figure 5 WebMonitoring levels and colour coded triggers

Data from the monitoring stations are stored locally in 1 second intervals and which is uploaded to the monitoring servers at predefined intervals. The server then processes the measured 1 second data into predefined intervals. An example showing both 15 minute and 1 hour intervals is shown in Figure 6.

It is also capable of presenting the triggers for each of the predefined periods (eg 1 hour) as a heat map which is also shown in Figure 7. This shows an overview of the alert status over the monitoring period.

Realtime 1 second interval data may be veiwed from each instrument. This data is 'streamed' directly from the instrument. An example of this is shown in Figure 7.

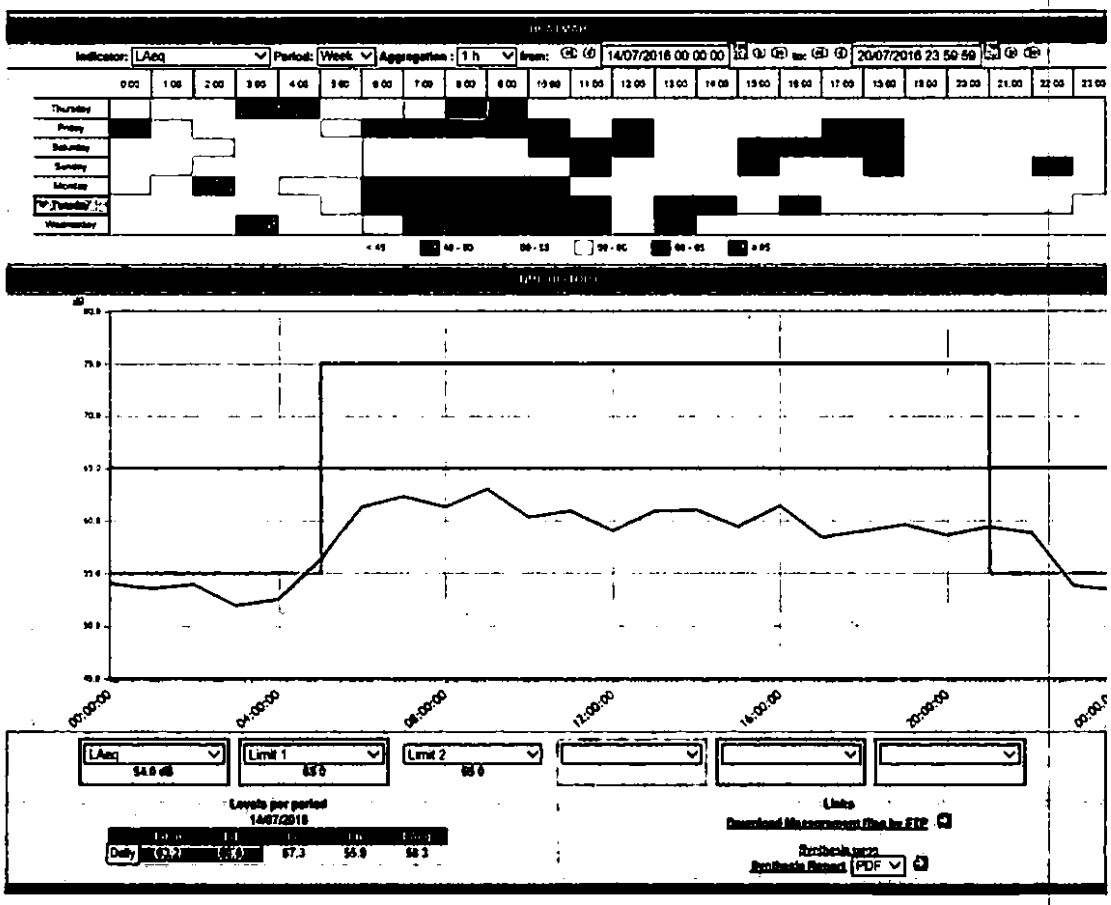


Figure 6 WebMonitoring 1hr and 15 min intervals and heat map

Data collected by the monitoring stations is transferred to the 01dB data-hosting center on a periodic basis. It is stored and backed-up in order to maintain its integrity. Raw data is remotely accessible by FTP.

The website has admin control to allow different users access to different portions of the website as required.

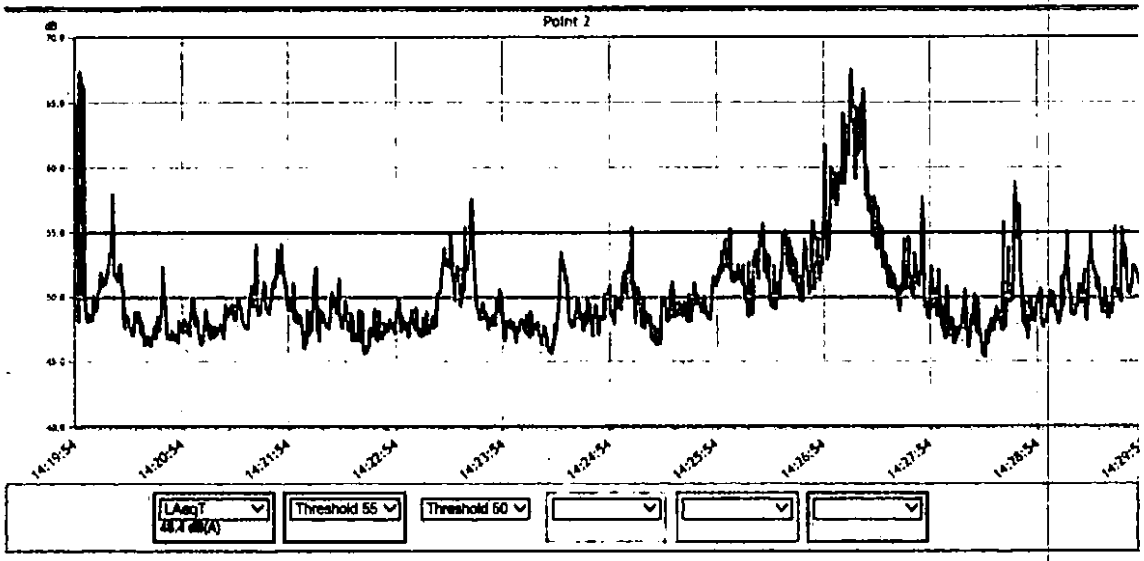


Figure 7 Real-time 1s time history

3.6.6 Site requirements

Liaison with site engineer will be required to determine specific locations for the monitoring equipment and cable routing. Mains power and access to the LAN may be required inside the St James Hospital.

Instructions will be provided to the hospital on how to move the monitors, if required for clinical reasons. We would request a log be kept of such activities so they can be accounted for within the monitoring reports.

3.6.7 Redundancy

Generally, in our experience, the monitoring systems are rather robust. In the event of a fault the equipment will be replaced as per the specification.

3.6.8 Power

All of the monitoring equipment will have battery back up to ensure operation in the event of a power failure. The monitoring server will also be equipped with an Uninterruptable Power Supply (UPS).

3.6.9 Reporting

Monitoring reports can be automatically generated from the WebMonitoring website. The reports will contain:

- identification of date and location
- graphical time histories of the logged data
- a definition of measuring instrumentation chain, including serial numbers of transducers and all other components
- comments on any significant events, and
- any other information that may be of importance to the data recorded.

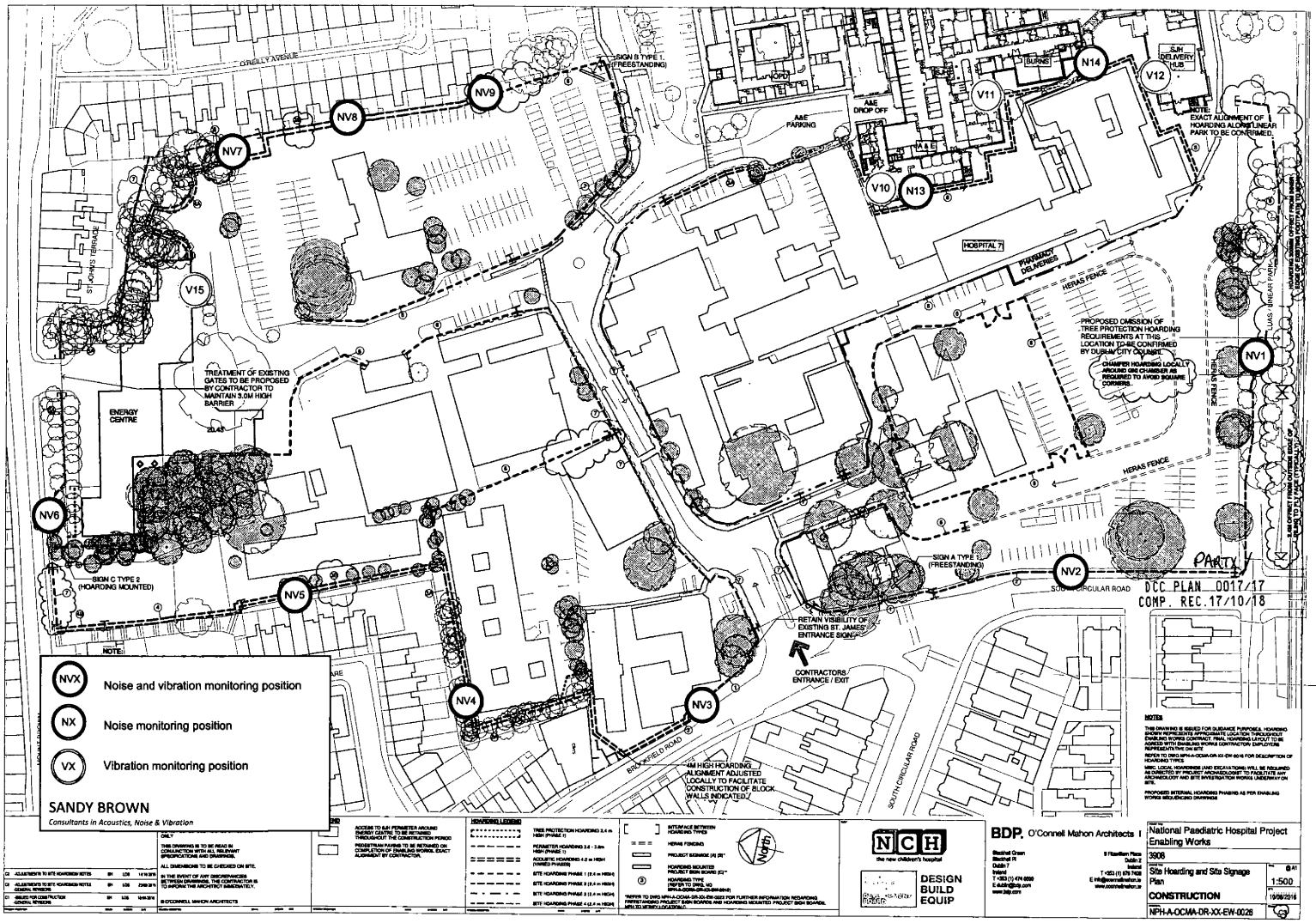
The results of the monitoring will be reviewed as per the monitoring specification. Upon review we will prepare a report to either:

- outline the system is working as normal and the works are lower than the amber trigger levels or
- outline the exceedances, the reason for the exceedance and any remedial or mitigations measures implemented.

The reports will also contain a summary of any noise and vibration complaints received, the cause and any remedial action taken.

Appendix A

Proposed monitoring locations


CORBELLY AVENUE
SIGN B TYPE 1 (FREESTANDING)
NV9
NV8
NV7
V15
ST JOHNS TERRACE
TREATMENT OF EXISTING GATES TO BE PROPOSED BY CONTRACTOR TO MAINTAIN 3.0M HIGH BARRIER
ENERGY CENTRE
NV6
SIGN C TYPE 2 (HOARDING MOUNTED)
NV5
NOTE:
NVX Noise and vibration monitoring position
NX Noise monitoring position
VX Vibration monitoring position
SANDY BROWN
Consultants in Acoustics, Noise & Vibration
NV4
NV3
BROOKFIELD ROAD
4M HIGH HOARDING ALIGNMENT ADJUSTED LOCALLY TO FACILITATE CONSTRUCTION OF BLOCK WALLS INDICATED
SOUTH CIRCULAR ROAD
RETAIN VISIBILITY OF EXISTING ST. JAMES' ENTRANCE SIGNS
CONTRACTORS' ENTRANCE / EXIT
SIGN A TYPE 12 (FREESTANDING)
NV2
SOUTH CIRCULAR ROAD
DCC PLAN 0017/17
COMP. REC. 17/10/18
PARTY
NV1
HERAS FENCE
PROPOSED OMISSION OF TREE PROTECTION HOARDING REQUIREMENTS AT THIS LOCATION TO BE CONFIRMED BY DUBLIN CITY COUNCIL
CHAMFER HOARDING LOCALLY AROUND ORE CHAMBER AS REQUIRED TO AVOID SQUARE CORNERS.
HOSPITAL 7
PHARMACY DELIVERIES
A&E PARKING
A&E DROP OFF
OPD
BURNS
N14
V12
V11
V10
N13
SJH DELIVERY HUB
NOTE: EXACT ALIGNMENT OF HOARDING ALONG LINEAR PARK TO BE CONFIRMED.
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10
V11
V12
V13
V14
V15
N13
N14
NOTE:
THIS DRAWING IS ISSUED FOR GUIDANCE PURPOSES. HOARDING ENERGY REPRESENTS APPROXIMATE LOCATION TO ENABLE ENABLING WORKS CONTRACT. FINAL HOARDING LAYOUT TO BE AGREED WITH ENABLING WORKS CONTRACTOR / EMPLOYERS REPRESENTATIVE ON SITE
REFER TO DWG NPH-A-OCMA-DR-XX-EW-0016 FOR DESCRIPTION OF HOARDING TYPES
MISC. LOCAL HOARDINGS (AND EXCAVATIONS) WILL BE REQUIRED AS DIRECTED BY PROJECT ARCHAEOLOGIST TO FACILITATE ANY ARCHAEOLOGY AND SITE INVESTIGATION WORKS UNDERWAY ON SITE.
PROPOSED INTERNAL HOARDING PHASING AS PER ENABLING WORKS SEQUENCING DRAWINGS
HOARDING LEGEND
TREE PROTECTION HOARDING 3.4 m HIGH (PHASE 1)
PERIMETER HOARDING 3.4 - 3.8m HIGH (PHASE 1)
ACOUSTIC HOARDING 4.0 m HIGH (VARIED PHASES)
SITE HOARDING PHASE 1 (2.4 m HIGH)
SITE HOARDING PHASE 2 (2.4 m HIGH)
SITE HOARDING PHASE 2 (4 m HIGH)
SITE HOARDING PHASE 2 (4.8 m HIGH)
INTERFACE BETWEEN HOARDING TYPES
HERAS FENCING
PROJECT SIGNAGE (A) (R)*
HOARDING MOUNTED PROJECT SIGN BOARD (C)*
HOARDING TYPE (REFER TO DWG NO NPH-A-OCMA-DR-XX-EW-0016)
*REFER TO DWG NPH-A-OCMA-DR-XX-EW-0025 FOR FURTHER INFORMATION REGARDING PERIMETER HOARD PROJECT SIGN BOARDS AND HOARDING MOUNTED PROJECT SIGN BOARDS.
NCH
the new children's hospital
DESIGN BUILD EQUIP
BDP. O'Connell Mahon Architects
National Paediatric Hospital Project
Enabling Works
3908
Site Hoarding and Site Signage Plan
1:500
CONSTRUCTION
19/09/2018
NPH-A-OCMA-DR-XX-EW-0026