USING ‘REVERSE’ NOISE CONTOURS TO MANAGE CONSTRUCTION NOISE – A CONTRACTOR’S EXPERIENCE

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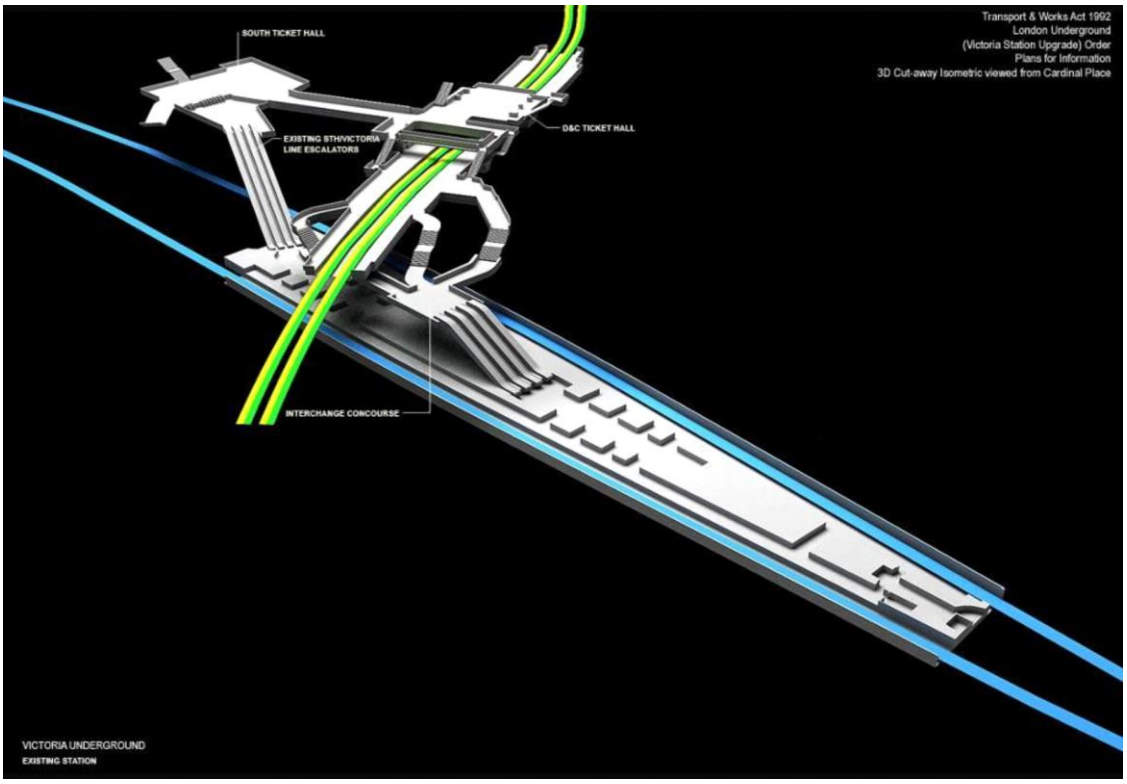
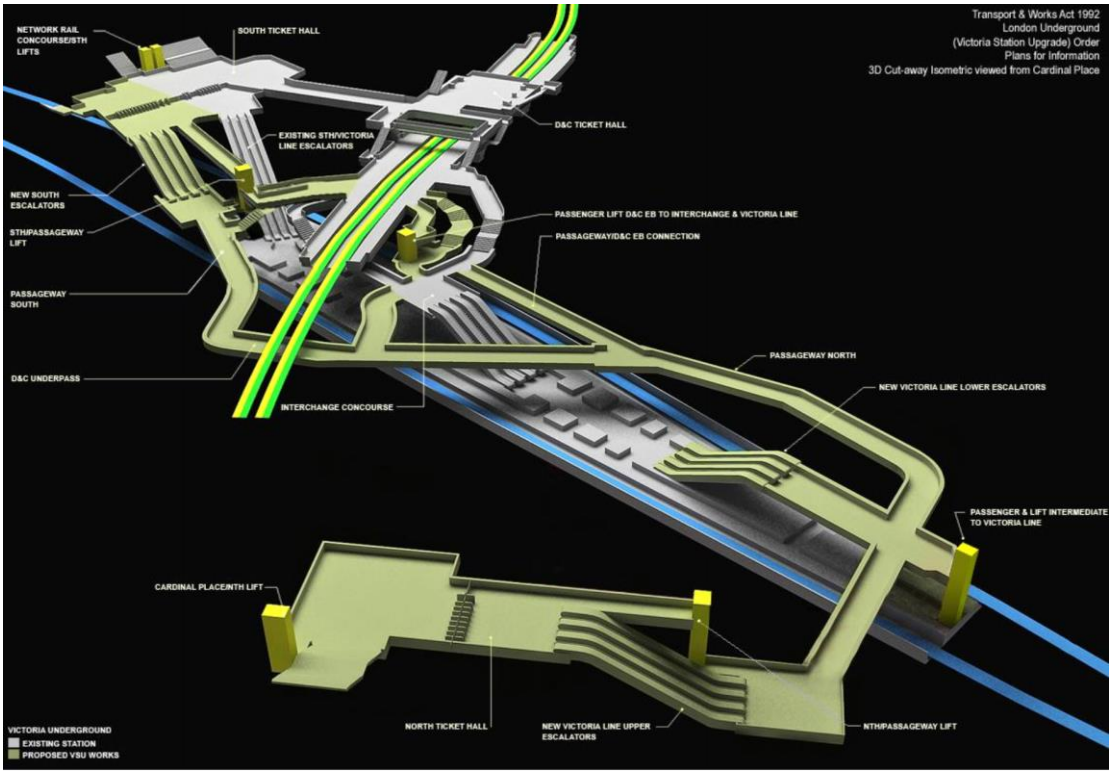
ABSTRACT

At a time when the demand to extend the life of existing infrastructure is high, the challenge of managing the noise impact of construction works in urban environments needs fresh thinking. The upgrade of one of London’s busiest underground stations has led to the formulation of processes which are easily transferrable to future projects, delivering both financial and reputational benefits. Real-time monitoring of noise provides teams with valuable time to react to, and mitigate, any possible issues, in order to maintain relationships with local stakeholders. In addition, through reversing traditional methods of monitoring noise and tracking audible noise outwardly from key receptors, a robust process is produced to ensure that both noise and programme requirements can be met.

1. INTRODUCTION

Victoria Station Upgrade (VSU) is a £700m Transport for London (TfL) ‘programme’ of work to upgrade one of London’s busiest underground stations. It is located at the centre of a major transport interchange between Victoria Underground Station, National Rail Station and Bus Terminus; weaved around a dense population of residents and stakeholders, which include two of the Capital’s longstanding, and heritage-listed, theatres.





Figures 1 & 2 Existing station layout and the additional infrastructure that the VSU project will bring

The passenger-handling capacity of the station is in urgent need of improvement, with current numbers at over 82m passenger journeys a year and this set to rise to 100m by 2020. The upgrade will extend the life of the station by approximately 75 years through doubling the size of the existing ticket hall, providing an additional ticket hall, constructing approximately 300m of tunnels to link the two and providing step-free access into the station.

The work requires buildings to be demolished and shafts to be sunk, from which the new passenger access tunnels are driven. Large excavations are also needed for the ticket hall works.

The current construction project is undertaken by a Joint Venture between Taylor Woodrow and BAM Nuttall Ltd (TWBN) and commenced in July 2011, with completion scheduled for 2018.

Figure 3 VSU Tunnelling compound showing cut and cover worksite, from the roof of the Victoria Palace Theatre

The location of the project has meant that the management of noise has been a constant focus in order to strike the balance between delivering an efficient programme of works and minimising the impact on local stakeholders.

Section 61 of the Control of Pollution Act 1974[1] allows contractors to apply to the Local Authority for 'Prior Consent' for noise generating activities during the construction phase of a development. This prompts a bi-annual submission by VSU to the City of Westminster which is reviewed to take account of the progression of the phases of construction. It contains noise limits which have been agreed for various locations throughout the site that VSU must adhere to. In addition VSU has two local Third Party Legal Agreements in relation to noise with the Victoria Palace Theatre and the Apollo Victoria Theatre.

The agreements cover the theatres' evening performances, from Monday through to Saturday and the matinee performances on Wednesday, Thursday and Saturday.

Failure to work within the agreed noise levels could have serious legal and financial consequences on the project, and could also ruin relationships that have been built with local stakeholders.

2. REVIEW OF EXISTING METHODOLOGIES

The main guidance for the management of noise relating to construction activities is BS 5228 Code of practice for noise and vibration control on construction and open sites Part 1: Noise[2]. The standard sets out general control measures, supported by reference details of expected noise levels

arising from various construction activities and plant equipment. Section 8 of the Standard, 'Control of Noise' discusses the need to mitigate noise impact and it is only Section 8.4, 'Noise Control Targets' which details a need to apply monitoring to ascertain whether the resultant noise from construction activity meets the anticipated noise levels.

It is considered that whilst this approach provides an initial basis to establish what the potential noise levels may be, in practice it is a reactive approach and does not truly take into account the varying nature of the activity and the impact of background noise levels. Applying such a reactive technique on the VSU project would have been detrimental to stakeholder relations and given rise to complaint.

BS 5228 Part 1 Annex F 'Estimating Noise from sites' provides an element of initial guidance in establishing noise levels, but it is considered that it falls short in providing a robust mechanism to ensure that the noise associated with the activity will be controlled to ensure that any locally agreed noise level will not be exceeded. In effect, the Standard gives guidance to provide a resultant sound level, L_{Aeq} (equivalent continuous level), however, it does not explain how to correlate this back to a noise limit.

Furthermore, establishing the noise levels prior to works does not factor in the impact of atmospheric conditions, time of day, the impact of adjacent development projects and the evolution and progression of the construction project, highlighting the need for the measurement of noise to be on a continual basis.

If we applied such an inflexible approach to the measurement and management of noise at VSU, we would be in a situation where work activities would have to cease during any of the theatre performances, having massive implications on the construction programme.

3. TOOLS DEVELOPED TO ENABLE IMPLEMENTATION

In order to establish an accurate noise monitoring system, a 24/7 web based data monitoring tool was developed in conjunction with Site Engineering Surveys Ltd (SES) and NoiseMap Ltd. The noise feed from each of the six Rion NL-32 noise monitors is sent via broadband modem to provide a real time record of the current measured level at the receptor. This real time continual monitoring provides accurate noise level data at each monitoring receptor around the VSU worksite, to ensure that agreed noise limits are not exceeded.

Comprehensive noise modelling was undertaken by NoiseMap Ltd to formulate the agreed noise limits for each receptor as detailed in the Section 61 agreement. The software is written such that if the resultant noise approaches the noise limits, an amber alarm is triggered. A text message is sent detailing which monitoring receptor has been triggered, the measured noise level, and the remaining time at which the activity can continue before the noise level will be exceeded and a red alarm will be triggered to give notification of an exceedance.

The VSU noise monitoring system has provided a proactive tool for use by project foremen, agents, engineers and subcontractors. It ensures that activities which may generate high levels of noise can be monitored in real-time and effectively managed.

Whilst this approach ensures compliance for the works that have been modelled against noise limits within the Section 61 agreement, it does not fully cater for ensuring compliance with the more stringent noise levels contained within the Third Party agreements with the Victoria Palace Theatre and the Apollo Victoria Theatre.

4. MONITORING AND COMPLIANCE

In addition to the development of the VSU noise monitoring system, TWBN and NoiseMap Ltd devised a reverse contour noise monitoring procedure to allow work to continue through both the Victoria Palace Theatre and Apollo Victoria Theatre performances, otherwise known as the 'Quiet Time', without breaching the Third Party Legal Agreement.

Two factors combine to determine the noise levels experienced at each theatre façade; the noise output of the plant and its distance from the theatre, and so a noise limit reverse contour map (see Figure 4) was developed for each theatre. This included setting 'Quiet Time' Third Party only triggers to 3 noise monitoring stations to ensure that noise limits would be observed.

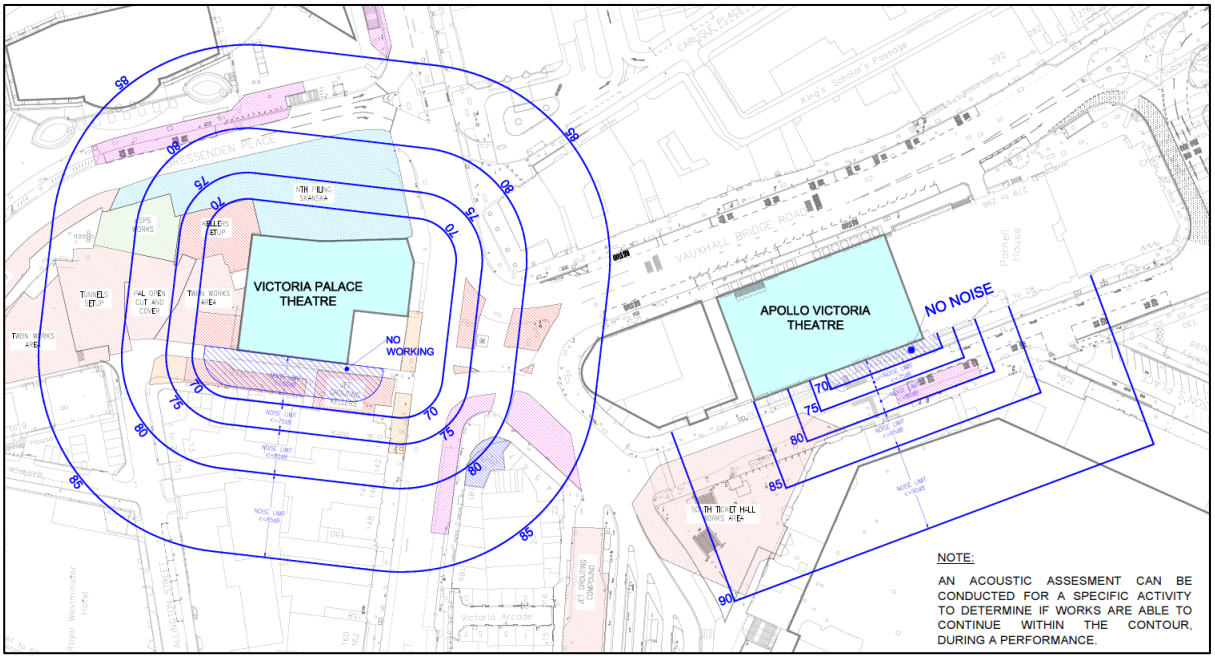


Figure 4 VSU Noise Limit Contour Map – Victoria Palace Theatre & Apollo Victoria Theatre

In order ensure that the necessary controls are in place for works during theatre performances, teams have to obtain a Working through a Performance/Rehearsal Permit.

To assess an activity, the location of works is marked on the contour map (Figure 4) and six monitoring points A, B, C, D, E and F are marked around the works at equal distance, 5m from the activity. At each position, measurements of two sets of one-minute L_{Aeq} readings are taken. An attended field assessment form is used to note any other sounds, other than the works being monitored, including calibration drift, temperature weather and time of day. For each measurement, the logarithmic average is taken to establish the sound level around the activity and the distance is then adjusted from 5m to 10m to give the final noise output for the works. The measured noise level is then plotted on the reverse noise contour map and if it is within the contour limit, then the permit is signed off and the works can proceed.

Importantly, the works undertaken must not differ from the activity measured and upon which the permit is based, i.e. no additional equipment can be used and equipment cannot be substituted for other items of the same type. This is specifically with reference to hand breakers, which have a broad variation on noise level across the equipment range. In all circumstances, the worst case scenario is taken without the deployment of any measures such as acoustic blankets to mitigate the noise impact.

In certain exceptional circumstances, manufacturer's sound power level figures are used and a theoretical resultant noise at 10 metres calculated.

The procedure is applied to all proposed VSU activities during the 'Quiet Time' period. To avoid causing a noise nuisance, only works that have been field assessed and obtained a valid signed/approved permit, are allowed to continue through a theatre performance.

Figure 5 VSU South Ticket Hall expansion worksite showing location of Apollo Victoria Theatre

Figure 6 VSU North Ticket Hall East worksite showing location of Victoria Palace Theatre

Figure 7 VSU Little Ben and Victoria Street worksites showing location of Victoria Palace Theatre

On approaching the 'Quiet Time' period, a siren sounds on each section of works 10 minutes before a performance commences. A red beacon (Figure 8) continues to flash during the performance,

which serves as a reminder to site operatives that a performance is taking place at the theatre. Noise levels are then monitored in real-time via the VSU noise monitoring system.

Figure 8 VSU Quiet Time beacon

This procedure has been in place at VSU for almost three years and has given confidence to theatre staff that our works are managed effectively during their performances. Development of this proactive system has ensured that noise is managed more effectively and given site personnel a better appreciation of noise nuisance in construction. It has protected the interest of the theatres whilst preventing a significant impact on the delivery of the works programme, allowing works to continue through performances both day and night and delivering cost savings of around £1.5m.

5. BENEFITS OF THE SYSTEM

There are a number of significant benefits which the application of the reverse noise contour mapping has provided;
Continuation of construction works during theatre matinee performances and the continued 24/7 operation of surface mounted tunnel ancillary plant without intrusion. This has in turn eliminated potential delays to the project programme.

- Effective control of noise which has reduced and ultimately eliminated complaint.
- Improved stakeholder confidence in the control of noise across the project as a whole.

- Raised level of awareness of the noise impact of construction activities being undertaken amongst project staff, foreman, supervisors and labourers. This sense of ownership across the project team has been a significant factor in the effective management and control of noise.

6. SUMMARY

The VSU noise monitoring system has been reliable, informative and successful in preventing any serious Section 61 and Third Party exceedances. It has provided the project team with an essential tool to plan works and manage noise, with the key feature of providing advanced warning of potential exceedances to allow staff to mitigate against these.

The system has added value to the project, allowing work to continue in an extremely sensitive area, where it would otherwise be impeded by working around theatre performances, residential and commercial establishments.

In conclusion, it is considered that the method applied for the measurement, monitoring and control of noise arising on the Victoria Station Upgrade has provided a robust model which has proved to be effective in the management of construction noise.

7. REFERENCES

1. The Control of Pollution Act 1974
2. BS 5228 Code of practice for noise and vibration control on construction and open sites Part 1: Noise