EARL:

Noise and Vibration

Briefing Note

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Prepared by: Paul Maddock and Aileen McLuckie

CONTENTS

1 INTRODUCTION

This Briefing Note has been prepared to outline how noise and vibration is being assessed in relation to the proposed Edinburgh Airport Rail Link (EARL)

It should be noted that the assessment of the impacts of noise and vibration from the construction and operational activities of EARL have not yet been finalised (at the time of writing) and the impacts outlined here are preliminary only; the full assessment will be completed in January 2005.

1.1 ABOUT ERM

As part of the Technical Adviser team, Environmental Resources Management (ERM) has been appointed by Scott Wilson Halcrow Joint Venture for, and on behalf of, Transport Initiatives Edinburgh Ltd. (tie) to undertake an Environmental Impact Assessment (EIA), in accordance with the EIA Regulations [1], of the proposed new Edinburgh Airport Rail Link (EARL). An Environmental Statement (ES) will be produced to accompany the Bill to the Scottish Parliament which will present the findings of the EIA.

1.2 WHAT IS NOISE?

The terms "sound" and "noise" tend to be used interchangeably, but noise can be defined as unwanted sound. Your neighbour may enjoy the sound of his music at 2am but you would be disturbed by the noise.

Sound is a normal and desirable part of life. However, when noise is imposed on people (such as from industry, construction or transportation) it can lead to disturbance, annoyance and other undesirable effects.

(1) Environmental Impact Assessment (Scotland) Regulations 1999 (SI 1999 No 1).

It is relatively straightforward to physically measure sound with a sound level meter, but it is a different matter to quantify the sound in terms of how noisy it is perceived to be and the effects it may cause.

For this reason ERM draw on various standards and guidelines that relate a measured noise level to the effect it is likely to have. These guidelines are generally based on large scale social surveys that have produced accepted, all be it approximate, relationships between noise level and effect.

1.3 AN EXPLANATION OF NOISE LEVELS

Noise is measured and quantified using decibels (dB). This scale is logarithmic, which means that noise levels do not add up or change according to simple linear arithmetic. For example, any two equal noise sources added together give only an increase of 3dB higher than the individual levels (e.g. 60 dB + 60 dB = 63 dB, not 120 dB). This represents what happens in practice when two equal sounds coincide; the ear perceives only a slight increase in noise and not a doubling. The following table illustrates examples of noise levels.

Table 1.1 Examples of Noise Levels on the Decibel Scale

Noise Level dB(A)*	Typical noise source / example
0	Threshold of hearing (lowest sound an average person could hear)
30	Quiet bedroom at night
40	Whispered conversation at 2 metres
50	Conversational speech at 1 metre
60	Busy general office
70	Loud radio indoors
80	Lorry at 30 kph at 7 metres
90	Lawnmower at 1 metre

**The dB(A) scale is a particular way of measuring the different frequencies in sound designed to match how the human ear works, called 'A'-weighting.*

The way human hearing works is conveniently similar to the logarithmic changes in noise.

- An increase of 1 dB in noise levels cannot usually be heard (possible in 'laboratory' conditions).
- An increase of 3 dB is generally accepted as the smallest change that is noticeable in ordinary conditions.
- An increase of 5dB is clearly perceptible.
- An increase of 10dB seems to be twice as loud.

1.4 HOW IS NOISE MEASURED?

1.4.1 Introduction

There is a little more to the measurement of noise than pointing a sound level meter and taking a reading. Because noise tends to vary over time, we need to find a way of measuring it in a manner which represents the variation in noise level that also reflects people's perception of how noisy it is. Over the years a number of different ways to measure noise (metrics or parameters) have been developed as the best ways of representing different types of noise sources (single events, industry, road traffic, railway, aircraft etc). Those relevant to the EARL proposal are introduced below.

Measurement Parameters

$L_{Aeq,\,T}$

This metric is called the continuous equivalent sound level. It is a widely used noise parameter that represents a varying noise level by calculating the constant noise level that would have the same energy content over the measurement time period. The letter 'A' denotes that 'A'-weighting has been used and 'eq' indicates that an equivalent level has been calculated. Hence, L_{Aeq} is the A-weighted equivalent continuous sound level, measured over time period 'T'.

Detailed surveys have been carried out into people's responses to different sources of noise and these have been used to define which noise metrics provide good relationships with perceived noisiness. The EC Directive on the

Assessment and Management of Environmental Noise, for example, advocates $L_{Aeq, Period}$ for all types of transportation noise.

It is important to appreciate that whilst L_{Aeq} does give a measure of the accumulated noise over a period of time it is not like a conventional (arithmetic) average. It is in fact a logarithmic average. The effect of this is to give a high weighting to high noise levels even if they are relatively short lived or infrequent peaks.

The difference between arithmetic and logarithmic (L_{Aeq}) averaging can be illustrated by considering the average age of a class of 30 children and their teacher. Suppose the children are 5 years old and the teacher is 40 years old. The arithmetic average age is just 6, whereas the logarithmic (L_{eq}) average is 16. This partly explains why L_{eq} has been found to be a good indicator of the effects of noise that comprise a series of varying signals over a period of time, such as railway noise.

An L_{Aeq} can be calculated over different time periods depending on the characteristics of the noise and how people are exposed to it. If the noise is steady, a relatively short measurement period will be sufficient to characterise it. If it fluctuates randomly or has cyclical elements, then a longer measurement period will be required to obtain a representative sample. Some standards specify a measurement period, but 10 to 15 minutes is often adequate to obtain repeatable results.

L_{AMax}

This is a measure of the 'peak' in a varying sound signal and is the maximum A-weighted noise level, L_{Amax}. For train noise, it is the highest level experienced when the vehicle passes directly in front of the receptor location.

2 NOISE IMPACTS

2.1 INTRODUCTION

Noise is being considered from two sources; firstly from the construction of the rail link, and secondly from operational noise from trains.

2.2 CONSTRUCTION NOISE

Construction contractors should aim to use the Best Practicable Means to ensure noise from construction activities does not cause disturbance. Noise from construction will be managed by strict criteria (noise limits) derived using relevant, recognised national and international guidance which will be enforced by the Local Authority under the Control of Pollution Act 1974. ERM will outline in the EIA the standards that should be met during construction, and the following requirements generally apply.

- A noise criterion of 70 dB $L_{Aeq, 12\ hour}$ is adopted for the assessment of daytime impacts.

- Noise impacts will occur at lower noise levels at night. Noise levels below 45 dB $L_{Aeq, 1\ hour}$ or below the existing ambient (i.e. measured) $L_{Aeq, 1hr}$ are unlikely to give rise to significant noise impacts in terms of sleep disturbance at night. This is adopted as the assessment criterion for night-time assessment. In practice any night-time working will be discussed in detail with Local Authorities before works start. Local authorities have powers under the Control of Pollution Act 1974 to control noise from construction sites. These powers do not refer to fixed noise limits but instead allow for the enforcement of 'best practicable means' to reduce or counteract the effects of the noise.

- Plant, equipment and construction methods should be employed which have the lowest practicable noise output.

- Permitted operating hours will be agreed with the Local Authority to minimise the duration of any noise impact, and where night-time construction is required, stricter criteria is usually applied.

- Construction contractors will have to work closely with the Local Authority in assessing construction noise prior to the start of work in line with the best practice given in British Standard BS 5228 "Noise Control on Construction and Open Sites" at each worksite. This will identify where there may be potential noise impacts on local receptors.

- Where potential noise impacts at local receptors have been identified, then specific noise control measures will have to be put in place to ensure a criterion is being met. This can be achieved in numerous ways, for example, selecting and using silenced plant or equipment, using noise barriers, working between certain hours only, minimising the duration of the noise etc.

To date, information on specific construction activities are not available to carry out preliminary calculations, however these are expected early in the 2005. Once received, ERM will be able to calculate the noise impacts from construction and formulate appropriate noise control regimes which will be reported in the EIA.

2.3 OPERATIONAL NOISE

Operational noise will occur from the passing of trains. Noise from new railway developments is often assessed in two ways:

- by comparing the levels of noise that are expected to be generated against absolute noise standards, such as those that indicate likely annoyance of disturbance with everyday activities; and / or

- by considering the change in ambient noise that will occur with the development in operation.

The following free-field standards for absolute (free-field) noise levels can be drawn from PAN 56 [1]:

- Threshold of noise impacts — Day - $L_{Aeq,\ (0700\text{-}2300\ hours)}$ 55 dB; Night - $L_{Aeq,\ (2300\text{-}0700\ hours)}$ 45 dB
- Significant impact — Day - $L_{Aeq,\ (2300\text{-}0700\ hours)}$ 66 dB; Night - $L_{Aeq,\ (2300\text{-}0700\ hours)}$ 59 dB

The guidance given in Planning Advice Note PAN 56, Planning and Noise [2], 1999, and the statutory provisions of the Noise Insulation (Railways and other Guided Transport Systems) Regulations [3] 1996 have been referred to in setting assessment criteria. Although the Noise Insulation Regulations do not apply in Scotland, in England and Wales they indicate a higher noise limit at which receptors are sufficiently affected for noise insulation to be required.

A summary of the noise assessment criteria to be used in the ES is given below.

It should be noted that the threshold levels referred to in PAN 56 are in relation to new housing and are not specifically relevant to new rail development (although they are used for reference). There are no statutory requirements to achieve them, and instead they should be considered generally desirable noise levels.

Noise from the railway will thus fall into one of three cases:

a) below the absolute thresholds;
b) in between the threshold and significant levels; or
c) above significant levels.

The assessment and approach to mitigation used for each of these three cases is as follows.

(1) Planning Advice Note 56 (PAN 56), April 1999, Planning and Noise.
(2) PAN 56 Planning and Noise, Scottish Office, 1999.
(3) Noise Insulations (Railways and Other Guided Systems) Regulations, 1996. England and Wales only.

1. Train noise below threshold criteria – no impact, no mitigation required.

2. Train noise between threshold and significant criteria – impacts depend on baseline noise level, EARL will adopt all reasonable practicable means to reduce noise levels, preferably to below the threshold of impacts.

3. Train noise above significant criteria – severe impacts expected depending on baseline noise level, EARL will adopt all reasonable practicable means to reduce noise levels, including noise insulation if necessary.

Clearly if the level of train noise is below ambient noise, train noise will be less noticeable and impacts are less likely. Hence a second tier of assessment is required in cases 2 and 3.

- In case 2 the predicted level of train noise is added to the measured ambient noise level to establish the change in noise that would be expected, and this is assessed using the significance rating given in the Institute of Acoustics and the Institute of Environmental Management and Assessment's draft guidance on the Assessment of Environmental Noise, April 2002.

- In case 3, an increase of 1dB due to the new noise indicates that the new noise is affecting the total noise level and shows that successful mitigation would have an effect on the total noise levels in the area.

- Maximum pass-by noise levels (L_{Amax}, the instantaneous 'peak' as the train passes) are assessed against the standard for sleep disturbance.

The table below summarises the noise assessment criteria.

Table 1.2 Summary of Noise Assessment Criteria

Predicted Train Noise Level $L_{Aeq, period}$	**Increase in Ambient ($L_{Aeq, period}$) Noise**	**Impact**
Case 1		
Day < 55 dB (0700-2300 hrs)	N / A	No Impact
Night < 45 dB (2300-0700 hrs)	N / A	No Impact
Case 2		
Day	< 1 dB	No impact
> 55 dB (0700-2300 hrs) < 66	1 to 3 dB	Slight impact
dB (0700-2300 hrs).	3 to 5 dB	Moderate impact
	5 to 10 dB	Substantial impact
	>10 dB	Severe impact
Night	< 1 dB	No impact
>45 dB (2300-0700 hrs) < 59 dB	1 to 3 dB	Slight impact
(0700-2300 hrs)	3 to 5 dB	Moderate impact
	5 to 10 dB	Substantial impact
	>10 dB	Severe impact
Case 3		
Day > 66 dB (0700-2300 hrs).	>1 dB	Significant impact
Night > 59 dB (0700-2300 hrs)	>1 dB	Significant impact
LAmax (2300 – 0030 hrs) >82	LAmax < or equal to 82 dB or less than existing	No impact
	LAmax >82 dB, and greater than existing	Significant impact

There is no statutory requirement for mitigation in Case 2 or Case 3, but the Client team is committed to adopting mitigation where it is reasonable to do so and where it is within their powers to do so; *ie* by measures to be taken 'at source', particularly where more significant impacts are predicted

Preliminary baseline noise measurements have been made during daytime and night-time periods at ten locations along the EARL route. These

measurements have been compared against predicted train noise calculations [1] to assess the potential operational noise impact.

Initial calculations have indicated that there are unlikely to be any adverse noise impacts on properties beyond approximately 100m from the route. Further data is awaited before finalising the calculations, however the more distance between the route and the residents, the less likely they are to experience impacts. Similarly, where the railway will travel in tunnels and in cuttings the impact will be minimised.

Where impacts are identified during the Environmental Impact Assessment mitigation measures will be outlined where practicable to reduce or minimise any significant adverse noise impacts. Both day time and night time impacts will be considered and site details will play an important role in determining the level of noise impacts and the mitigation measures that can realistically be installed.

(1) Department of Transport (1995) "Calculation of Railway Noise"

3 VIBRATION

3.1 INTRODUCTION

Vibration from construction sources will generally be of a temporary nature but the disturbance it causes, if significant, may result in property damage or disturbance. In considering the impact from vibration we must consider two questions.

- What level of vibration will be produced by the proposed construction works?
    - This is dependent on the construction method and how the local geology of the site will propagate the vibration.
- What is the acceptable level of vibration?
    - The appropriate criteria in this instance is British Standard BS 6472: 1992 (1) which provides general guidance on human exposure to building vibration.

The answers to both of the questions are always site specific, although important initial appraisals can be made on the basis of experience from other sites.

3.2 ASSESSMENT OF VIBRATION

The assessment of vibration will follow the guidance set out in British Standard BS 6472. The British Standard provides general guidance on human exposure to building vibration in the frequency range 1 Hz to 80 Hz. The Standard provides methods to assess annoyance for humans together with appropriate measurement methods.

(1) BS 6472: 1992 "Guide to Evaluation of human exposure to vibration in buildings" (1 to 80 Hz).

Groundborne vibration is typically measured in terms of velocity (millimetres per second) or acceleration (metres per second). Where sources are impulsive or intermittent it is the peak particle velocity or acceleration which is measured and this is the maximum value recorded during an event.

Complaints from building occupiers about excessive vibration are normally due to the belief that if the vibration can be felt then it is likely to cause damage. Door closures or footfall within buildings often cause levels well above those measured from the source under investigation.

Complaint levels from occupants of buildings subject to vibration and the acceptable magnitudes, or limits, for building vibration depend upon specific circumstances. The BS 6472 provides data on acceptable levels for human exposure to vibration and for the evaluation of building vibration with respect to annoyance and comfort. These are in the form of 'weighting curves' applicable to different situations. *Table 1.3* and *Table* extracted from BS 6472 below provide indicative criteria where 'adverse comment' may be received due to human exposure to vibration.

Table 1.3 Frequency Weighted r.m.s. Acceleration (m/s^2 r.m.s) Corresponding to a Low Probability of Adverse Comment

Place	**Exposure Periods**				
	16 h	1 h	225 s	14 s	0.9 s
Residential Buildings, day time	0.01 to 0.02	0.02 to 0.04	0.04 to 0.08	0.08 to 0.16	0.16 to 0.32

Table 1.4 Vibration Dose Values ($m/s^{1.75}$) Above Which Various Degrees of Adverse Comment may be Expected in Residential Buildings

Place	**Low Probability of Adverse Comment**	**Adverse Comment Possible**	**Adverse Comment Probable**
Residential Buildings 16 h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential Buildings, 8 h night	0.13	0.26	0.51

3.3 *POSSIBLE IMPACTS*

A review of published data from several mechanised tunnelling sites suggests that the vibration levels are well below damage thresholds over the range of distances of 10m to 100m from the tunnel (depending on ground type). Although vibration levels were found to be perceptible in these studies, the calculated vibration dose values indicate that there was a low probability of 'adverse comment' which is the criteria used in BS 6472.

For homes situated near tunnelling sites, the effects of vibration are therefore dependent on the distance and the type of intervening ground, but generally, if a property is over 100m away then the likelihood of vibration perception from tunnelling works is very unlikely.

Properties closer than 100m to the tunnelling activities may experience vibration impacts but the significance of such impacts will be dependant on the site particulars, including ground conditions. ERM will be assessing the impacts on such properties in detail once construction methodologies have been finalised. While the construction methodology is still being developed, during construction the contractor should be using Best Practicable Means(1) to control vibration to the lowest level practicable and also ensure that any impacts are as temporary as possible.

(1) Defined in Section 72 of the Control of Pollution Act 1974.