

Technical Report**NOISE AT WORK ASSESSMENT FOR BAKERLOO LINE TRAIN OPERATORS**

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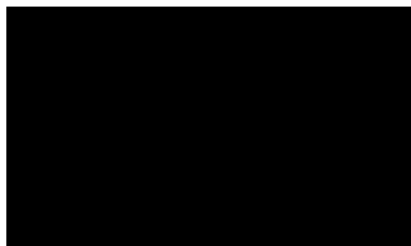
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1. Introduction

The noise and vibration team in Technical Services was asked to measure noise levels in accordance with The Control of Noise at Work Regulations 2005 for train operators on the Bakerloo line and to identify track sections where the noise levels were high.

2. Summary of the Control of Noise at Work Regulations 2005

The aim of the regulations is to protect persons against risk to their health and safety arising from exposure to noise at work. The general aspiration of the regulations is to reduce noise levels for all employees to as low a level as reasonably practicable. The following duties are placed on an employer:

- assessment of employees' risk and periodic review of the risks (this can include noise measurements),
- implementation of controls to eliminate the risk or reduce it to as low as possible (by either reducing the noise levels or exposure time),
- provision of personal hearing protectors as appropriate to the exposure level determined,
- health surveillance as appropriate, and
- provision of information, instruction and training to employees at risk.

The regulations define noise exposure limit values and action values. These are provided in Table 1.

Table 1 – Noise exposure limit values and action values

	Daily Personal Noise Exposure $L_{EP,d}$	Peak Sound Pressure L_{Cpeak}
Lower Exposure Action Values	80 dB(A)	135 dB(C)
Upper Exposure Action Values	85 dB(A)	137 dB(C)
Exposure Limit Values	87 dB(A)	140 dB(C)

The equation used to calculate a daily personal noise exposure, $L_{EP,d}$ is defined as

$$L_{EP,d} = L_{Aeq,Te} + 10 \log \left(\frac{T_e}{T_0} \right)$$

where,

$L_{Aeq,Te}$ is the equivalent continuous A-weighted sound pressure level,

T_e is the duration of exposure to the noise, in seconds, and

T_0 is the reference duration of 8 hours (28,800 seconds).

Hearing protection should only be considered when organisational and technical methods to reduce noise levels to as low as possible have been found not to be reasonably practical. In such circumstances employees exposed to levels at or above the lower action values shall be advised of the risks and personal hearing protectors shall be made available to them.

Employees who are exposed to levels at or above the upper action values must be provided with personal hearing protectors by their employer and the employer is required to enforce their mandatory use.

The employer must ensure that employees are not exposed to noise above the exposure limit values, which includes allowing the employer to take into account the noise reduction provided by hearing protection.

3. Measurements and Results

The LU HSE team asked Technical Services to carry out the monitoring of train operator's noise levels for the Bakerloo line. This was to ensure that train operator noise exposure is minimised and controlled in line with the Control of Noise at Work Regulations 2005.

A train operator's daily noise exposure level is a log average of all the noise levels he/she is exposed to throughout an 8 hour shift. If the amount of time spent at high noise levels can



be reduced either by reducing the noise levels or exposure time this will reduce the daily noise exposure level. The highest noise levels a train operator is exposed to are when he/she is in the cab and the train is moving. These cab noise levels can be broken down into inter-station noise levels.

The measurements were carried out on the 14 and 15th January 2020 using one handheld sound level meter (SLM), with the microphone located next to the driver's most exposed ear. The details regarding the meter can be found in Appendix A. Each direction was measured multiple times in randomly selected cabs.

The average levels for all cab runs are presented in the tables below. These measurements start when the train starts moving at the start station and finish when the train comes to rest at the end station. These overall levels do not include the dwell time spent at stations, i.e. noise exposure is likely to be lower if rest periods and dwell times are included.

Table 2 – Interstation noise levels for the northbound road between Elephant & Castle and Harrow & Wealdstone

Interstation Section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	A-Weighted Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1000	2000	4000	8000
Elephant & Castle to Lambeth North	77	115	57	66	72	73	67	65	60	50
Lambeth North to Waterloo	77	117	57	66	72	73	68	66	66	52
Waterloo to Embankment	76	112	57	68	70	71	69	66	60	51
Embankment to Charing Cross	73	113	54	65	68	67	66	65	59	49
Charing Cross to Piccadilly Circus	76	112	56	65	72	73	66	63	58	49
Piccadilly Circus to Oxford Circus	78	117	56	68	74	73	68	66	62	52
Oxford Circus to Regent's Park	76	115	55	66	70	72	68	66	66	51
Regent's Park to Baker Street	82	114	59	71	78	79	74	69	62	49
Baker Street to Marylebone	74	114	56	65	69	69	67	66	61	53
Marylebone to Edgware Road	75	114	59	66	69	69	67	66	61	51
Edgware Road to Paddington	79	115	56	65	68	77	69	69	62	52
Paddington to Warwick Avenue	75	112	55	63	68	72	68	65	60	50
Warwick Avenue to Maida Vale	76	113	49	60	70	73	69	65	59	49
Maida Vale to Kilburn Park	73	114	49	59	64	69	67	65	59	49
Kilburn Park to Queen's Park	71	113	51	60	65	65	65	62	58	51
Queen's Park to Kensal Green	70	115	51	61	62	63	63	63	59	50
Kensal Green to Willesden Junction	73	112	58	66	67	67	65	64	60	51
Willesden Junction to Harlesden	73	119	54	65	66	66	66	65	60	52
Harlesden to Stonebridge Park	70	116	52	58	61	64	64	63	58	51
Stonebridge Park to Wembley Central	72	115	52	65	66	66	65	63	58	51
Wembley Central to North Wembley	70	116	50	57	61	64	64	64	58	51
North Wembley to South Kenton	70	112	48	56	61	64	64	63	58	49
South Kenton to Kenton	71	112	51	58	61	65	66	66	57	47
Kenton to Harrow & Wealdstone	71	115	50	59	63	66	65	63	59	51
Harrow & Wealdstone to sidings	72	115	47	59	58	62	66	64	60	51



Table 3 – Interstation noise levels for the southbound road between Harrow & Wealdstone and Elephant & Castle

Interstation Section	L _{Aeq} dB(A)	L _{cpeak} dB(C)	A-Weighted Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1000	2000	4000	8000
Sidings to Harrow & Wealdstone	72	115	46	55	60	59	67	65	60	51
Harrow & Wealdstone to Kenton	72	115	54	61	64	66	67	65	62	52
Kenton to South Kenton	71	113	55	60	63	65	66	64	61	50
South Kenton to North Wembley	71	115	53	59	63	64	67	64	60	50
North Wembley to Wembley Central	72	113	55	61	63	66	68	66	62	52
Wembley Central to Stonebridge Park	75	114	56	66	70	70	68	67	61	50
Stonebridge Park to Harlesden	72	113	56	62	66	66	67	64	60	50
Harlesden to Willesden Junction	74	113	57	65	69	68	67	64	59	49
Willesden Junction to Kensal Green	76	116	58	70	71	70	67	64	60	51
Kensal Green to Queen's Park	70	115	51	60	63	64	66	62	60	50
Queen's Park to Kilburn Park	76	115	55	63	68	72	71	66	62	53
Kilburn Park to Maida Vale	76	114	54	63	68	72	70	66	60	53
Maida Vale to Warwick Avenue	77	112	51	61	68	74	72	66	61	54
Warwick Avenue to Paddington	77	115	55	65	71	73	71	66	62	54
Paddington to Edgware Road	81	116	60	71	76	77	73	68	63	54
Edgware Road to Marylebone	77	114	54	63	70	73	70	67	63	55
Marylebone to Baker Street	75	117	52	62	67	69	68	66	63	63
Baker Street to Regent's Park	79	113	55	66	74	75	71	66	61	51
Regent's Park to Oxford Circus	76	118	52	63	70	72	70	69	62	54
Oxford Circus to Piccadilly Circus	77	116	56	65	70	73	72	66	62	53
Piccadilly Circus to Charing Cross	76	112	51	63	69	73	69	68	60	49
Charing Cross to Embankment	74	115	53	62	67	68	69	67	63	57
Embankment to Waterloo	78	114	59	71	73	74	70	67	63	54
Waterloo to Lambeth North	77	118	55	65	70	73	70	67	63	55
Lambeth North to Elephant & Castle	76	113	55	63	69	71	70	66	62	57

Charts 1 and 2 show the average weighted noise levels of all runs on each inter-station section in a graphical representation. These values are taken from Tables 2 and 3. Levels at stations are not shown since these were more a result of other sources rather than operating the train.



Chart 1 - Average weighted noise levels on the Bakerloo northbound road, between Elephant & Castle and Harrow & Wealdstone

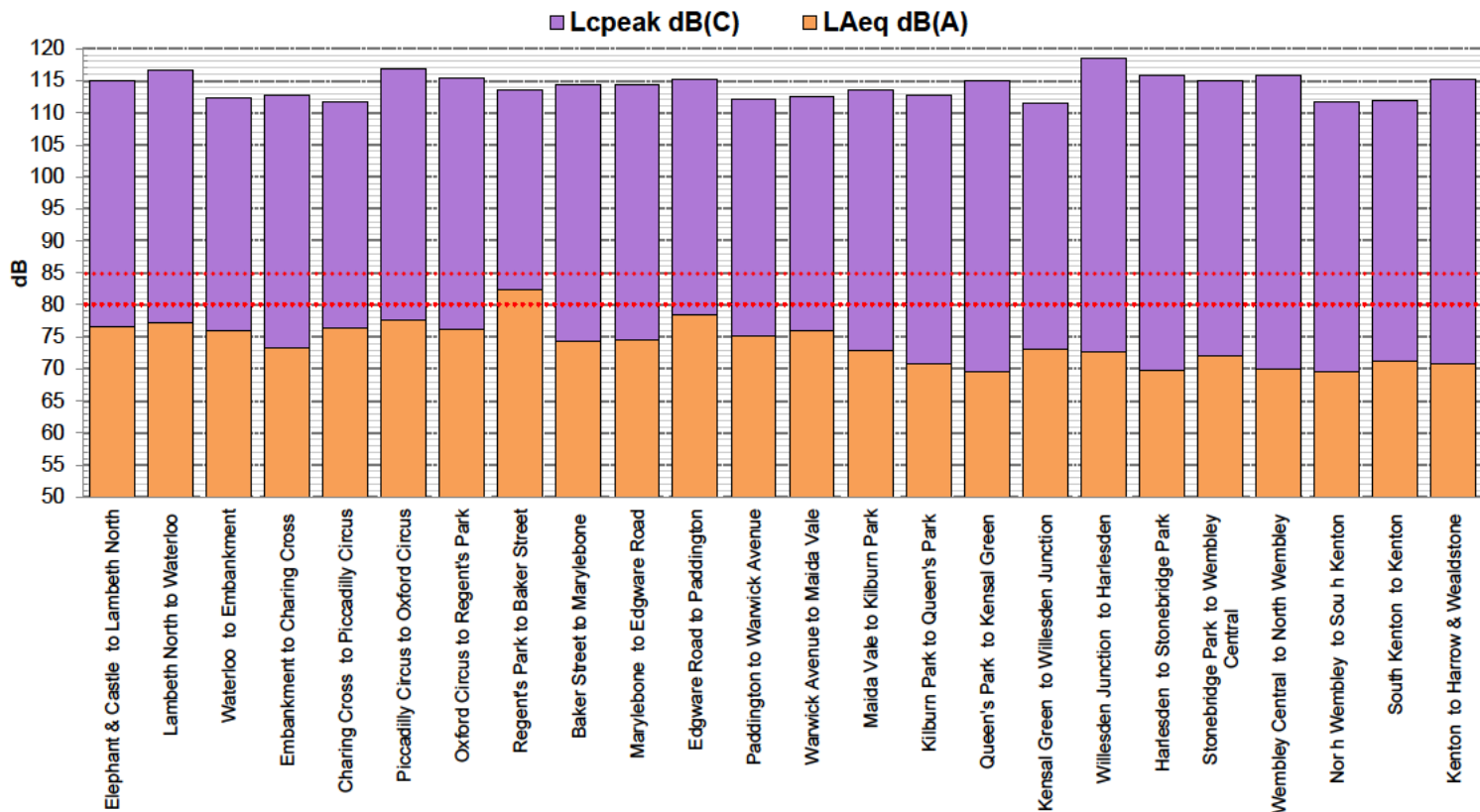
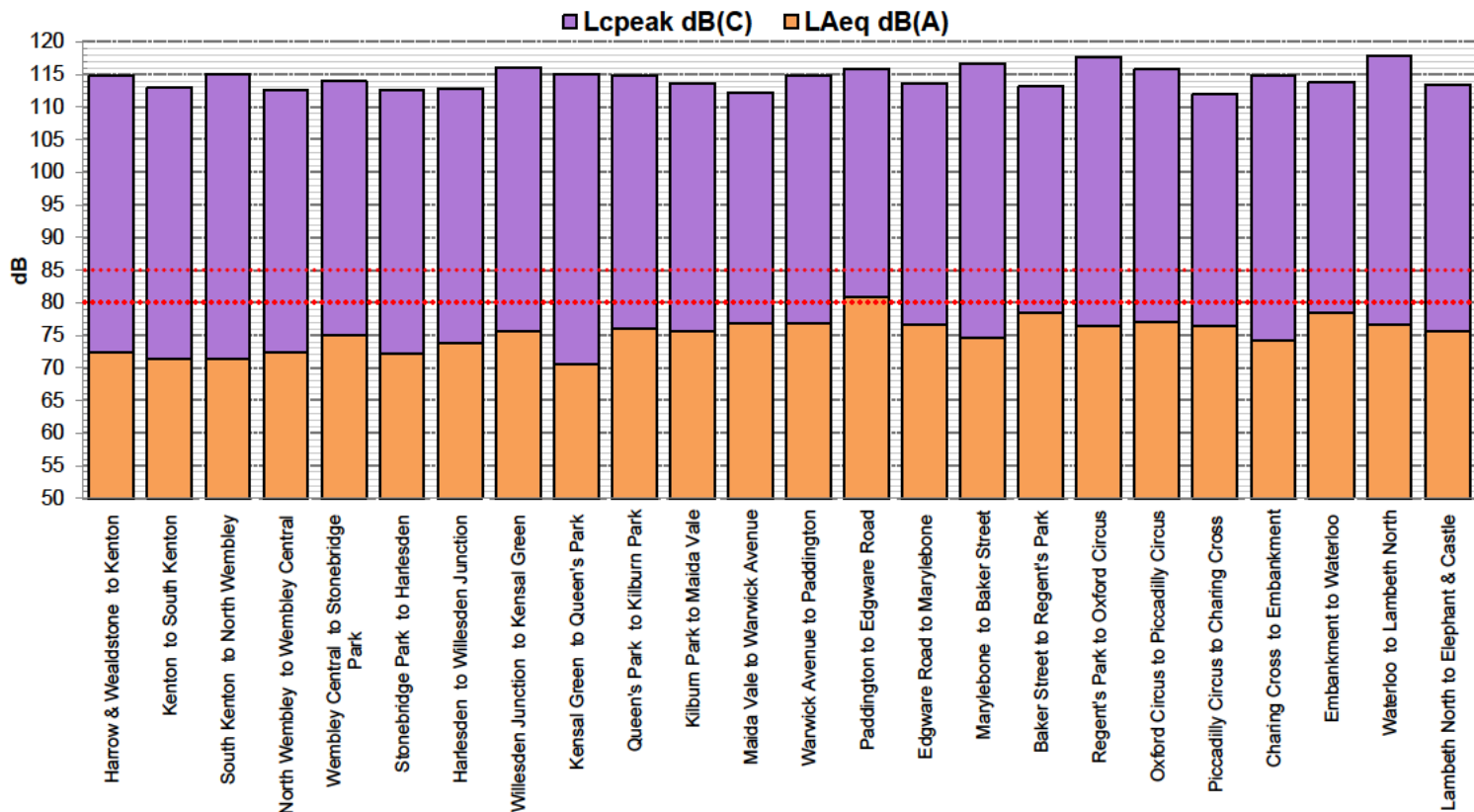


Chart 2 – Average weighted noise levels, on the Bakerloo southbound road, between Harrow & Wealdstone and Elephant & Castle





The main differences between measurements on the same day are differences in the measured cabs, as each run is on a different train. The track condition on the same day is very unlikely to change. Other things that could affect the results are train speed, radio announcements and driver's talking on the radio and stops at signals.

The calculated daily noise exposure level for train operators is based on the noise level at ear level and is a log average of all the inter-station sections travelled as well as the noise when stopped at signals. The noise level during breaks and stops as well as the noise level at stations are ignored in this report, as these levels are considerably lower when compared to the cab noise levels when the train is moving.

Tables 2 and 3, show that **only two** inter-station sections **reached and exceeded 80dB L_{Aeq}**. In addition, **none** of the inter-station sections **exceeded 85dB L_{Aeq}**.

The two inter-station sections with the highest noise levels for each of the measured directions are shown below.

- **Northbound** – Regent's Park to Baker Street and Edgware Road to Paddington
- **Southbound** – Paddington to Edgware Road and Baker Street to Regent's Park

4. Daily Exposure L_{EP,d} Levels

The daily exposure L_{EP,d} levels for train operators of the Bakerloo line, found in table 4, were based on the train operator duties. The duty books, Elephant & Castle and Harrow & Wealdstone all apply from 15th December 2019 (working Timetable 45).

The calculations were based on a sample of 30 duties. These were representative of the spread of duration of the different duties and the different start and end points of the runs. The duties selected ranged between 4 to 8h in duration.

In order to calculate the L_{EP,d} of each trip, they were partitioned into inter-station sections. Each inter-station exposure level was calculated based on the average value of all runs and the average time between stations taken from all runs.

To obtain the total exposure level, all the partial exposures comprised in a specific duty were added, and a L_{EP,d} exposure level was achieved. The table below shows the total duration of the duties chosen for the analysis.

Table 4– Duration of the duties chosen for the daily exposure calculations

Duty	Duty duration (hours:minutes)	Driving time (hours:minutes)	L _{EP,d} dB(A)	Duty	Duty duration (hours:minutes)	Driving time (hours:minutes)	L _{EP,d} dB(A)
101	6:21	2:50	72	001	6:45	3:20	72
102	6:12	2:37	71	002	7:28	3:41	73
103 (Mon-Thu)	5:54	1:36	70	003	6:43	3:18	72
103 (Fri)	6:08	1:36	70	004 (Mon,Wed&Fri)	6:39	3:20	72
104 (Mon-Wed & Fri)	5:47	2:41	71	004 (Tue&Thu)	6:39	3:20	72
104 (Thu)	6:25	3:19	72	005	5:04	2:38	71
105	6:00	2:48	70	006	4:12	1:58	71
106	7:36	3:29	73	007	7:08	3:57	73
107	7:33	3:39	73	008	6:50	3:21	73
108	5:25	1:57	70	009	7:14	3:36	72
109	7:28	3:28	72	010	6:58	3:36	73
110	7:35	3:28	72	011	7:18	3:57	73
111	4:28	2:19	71	012	7:38	3:58	73
112	7:58	4:38	73	013	8:00	4:40	74
113	5:11	2:10	71	014	5:58	2:59	72



5. Conclusions

- The daily exposure levels presented in Table 4 are a worst-case scenario. If dwell times at stations, meal breaks and time waiting to pick up trains were to be included in the measurements, the overall noise level would reduce, albeit negligibly. As such, the presented exposure levels are **only representative of train operation**.
- The 1972 Tube Stock cab noise is dominated by rolling contact noise. This airborne noise outside the train influences the noise levels inside the cab. There are two methods to reduce the rolling noise in the cab: the noise can be reduced at source and/or the transmission path can be inhibited.
- The transmission path of the airborne rolling noise includes paths through the cab side doors. Reduced cab sealing will increase noise levels. It should be noted that the microphone position during the measurements, was located next to the left hand side ear of the train operator, i.e. the ear most affected by noise, which was closer to the cab door.
- There are sections of the Bakerloo track that have corrugation (high rail roughness). Corrugation increases rolling noise and thus cab noise levels. In addition, resilient track has been installed in certain sections to cope with groundborne noise, which may lead to an increase of in-tunnel noise. However, during all runs, that outcome did not occur.
- Only two inter-station sections reached, or exceeded 80dB L_{Aeq} . In the loudest section, Regent's Park to Baker Street, rail roughness was the cause of the increased noise levels. The section Edgware Road to Paddington also presented a loud squeal on the approach to Paddington, however it did not occur on every run.
- Daily exposure levels are dominated by interstation sections with noise levels below 80dB(A), and no inter-station sections reached or exceeded 85dB L_{Aeq} .
- **All duties presented a daily exposure level below the Lower Exposure Action Value (LEAV)** for continuous noise at an $L_{EP,d}$ of 80dB(A) and as such train operators are not at risk of reaching or exceeding the daily LEAV within an 8-hour working day.
- **All duties presented a daily exposure level below the Upper Exposure Action (UEAV)** for continuous noise at an $L_{EP,d}$ of 85dB(A) and as such train operators are not at risk of reaching or exceeding the daily UEAV within an 8-hour working day.
- If train operators are provided with ear defenders, these should have low attenuation (5-10 dBA) to avoid over-protection, which could lead to train operators having difficulties with communication and hearing warning signals. They may also become isolated from their environment, leading to safety risks.
- **All of the measured inter-station sections measured below the LEAV for impulsive noise**, namely an instantaneous C-weighted peak level (L_{Cpk}) of 135 dB(C). The highest peak level, 119dB(C), was recorded on run 2 between Willesden Junction to Harlesden. Note that through this section, the first and third run showed lower peak levels.

6. References

1. Statutory Instrument 2005 No. 1643. The Control of Noise at Work Regulations 2005.
2. Controlling Noise at Work, Guidance Document L108, Health and Safety Executive 2005.
3. Health and Safety Executive Daily Noise Exposure Calculator
www.hse.gov.uk/noise/dailycalc.xls



APPENDIX A – Equipment Details

Table A.1 – Equipment used for the train operator noise exposure measurements

Item	Make	Model	Serial No.
Sound Level Meter	01dB	Fusion	10758



APPENDIX B – Full Line Testing Results

Table B.1 – Inter-station noise levels for the northbound road between Elephant & Castle and Harrow & Wealdstone

Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave (Hz)							
			63	125	250	500	1000	2000	4000	8000
Elephant & Castle to Lambeth North	76.3	115.1	57.3	65.8	72.2	72.7	65.6	64.4	58.1	49.0
	76.5	114.6	55.0	65.4	73.0	71.9	67.0	65.4	61.2	52.2
	76.8	112.7	57.1	65.4	71.0	73.7	68.8	65.1	59.6	48.9
Lambeth North to Waterloo	76.4	110.4	57.5	65.5	71.2	72.2	67.1	63.3	69.0	48.8
	76.7	116.6	57.4	66.5	70.9	73.0	68.2	67.2	63.1	55.2
	78.3	110.7	57.0	66.2	73.6	74.8	69.0	66.8	60.4	49.4
Waterloo to Embankment	75.1	112.4	58.3	68.7	69.7	70.6	65.7	64.9	58.1	48.6
	76.0	111.3	56.2	67.4	71.0	71.9	68.3	64.6	60.1	51.2
	76.8	110.6	54.9	68.5	70.4	71.8	70.6	67.6	61.7	51.6
Embankment to Charing Cross	73.7	112.8	54.1	65.6	68.6	66.5	65.7	66.6	58.4	49.1
	72.9	111.1	53.3	64.1	67.6	66.6	66.3	63.3	58.0	50.1
	73.3	111.2	53.5	64.7	68.1	66.4	65.7	65.2	59.2	48.9
Charing Cross to Piccadilly Circus	77.1	111.2	56.8	65.6	72.8	74.1	66.5	64.2	59.5	50.4
	77.1	109.7	56.1	65.1	72.7	74.2	67.0	62.1	57.6	48.7
	74.3	111.6	53.6	63.3	68.5	71.1	64.7	63.3	57.3	46.7
Piccadilly Circus to Oxford Circus	77.9	111.0	56.1	67.6	74.2	74.0	67.8	64.7	61.1	49.0
	77.9	116.8	55.6	67.6	73.8	73.4	69.0	66.5	63.4	55.6
	76.9	111.4	55.2	67.3	72.3	72.8	68.5	65.9	60.3	47.2
Oxford Circus to Regent's Park	74.3	111.0	54.6	66.1	69.6	71.5	63.5	62.0	57.3	48.1
	76.8	115.4	53.8	66.4	71.0	72.3	67.0	65.9	69.9	53.2
	76.8	111.1	55.1	65.9	68.0	72.7	70.8	68.5	60.6	48.2
Regent's Park to Baker Street	82.9	111.7	58.7	71.0	78.4	79.8	73.5	71.5	61.6	48.9
	82.7	113.6	59.2	71.4	78.6	79.4	74.2	65.9	60.4	50.1
	81.2	113.1	58.9	70.7	77.0	77.2	73.0	68.8	63.3	48.9
Baker Street to Marylebone	73.7	111.2	56.5	65.4	68.8	69.3	65.1	63.3	57.3	47.3
	74.2	114.3	55.8	64.6	67.9	67.5	67.1	67.4	63.5	56.8
	75.2	111.9	55.5	65.8	69.2	70.1	68.6	66.3	61.4	48.2
Marylebone to Edgware Road	74.4	111.2	58.5	66.6	69.6	69.2	66.2	64.6	58.5	50.1
	74.7	114.4	59.0	66.2	68.8	68.9	67.0	66.4	62.1	52.2
	74.6	111.0	58.6	66.5	69.0	68.6	67.1	66.1	61.2	48.5
Edgware Road to Paddington	75.6	113.2	55.4	65.3	67.1	70.1	65.4	71.7	61.7	49.2
	80.6	115.2	57.1	64.8	68.2	79.3	69.8	67.8	63.0	55.5
	78.0	111.4	56.6	64.8	68.3	76.0	69.3	67.2	61.1	48.7
Paddington to Warwick Avenue	73.7	111.8	54.4	62.7	68.2	69.4	65.9	64.9	58.6	49.5
	75.2	112.0	55.0	63.0	67.9	72.4	68.1	64.6	60.4	51.2
	76.0	109.3	54.6	64.3	67.7	72.8	69.8	66.2	60.8	47.5
Warwick Avenue to Maida Vale	72.7	112.5	48.2	58.6	68.5	68.5	64.4	63.6	56.1	47.0
	77.5	111.9	49.8	59.4	71.3	74.5	70.8	65.6	60.4	51.8
	76.6	110.6	50.1	61.0	69.0	74.5	69.4	65.0	59.1	48.1
Maida Vale to Kilburn Park	67.6	113.6	46.6	55.0	61.0	60.7	61.4	62.1	55.5	47.1
	74.2	112.6	49.2	58.8	64.7	70.5	69.2	65.6	60.8	51.4
	74.3	111.6	51.1	61.4	66.0	70.7	68.1	65.7	60.3	47.1
Kilburn Park to Queen's Park	69.6	110.7	50.9	58.9	63.9	63.3	63.3	61.8	58.1	50.2
	72.3	112.3	53.2	60.5	66.6	66.2	66.4	63.6	60.0	53.3
	70.3	112.7	49.4	60.5	64.5	64.3	64.0	61.0	55.5	43.5
Queen's Park to Kensal Green	69.3	111.2	49.4	60.3	59.7	61.5	63.0	63.6	60.7	50.3
	69.8	115.1	49.3	59.5	61.9	62.0	63.5	64.3	59.4	51.8
	69.7	109.1	52.7	62.3	64.0	63.9	62.5	60.8	55.8	45.5
Kensal Green to Willesden Junction	72.1	111.1	57.7	67.1	66.3	66.2	62.2	62.1	60.4	50.6
	71.0	111.2	57.3	62.5	64.8	64.9	63.2	62.6	59.5	52.0
	75.0	111.5	57.6	67.9	68.8	69.1	67.7	66.0	61.2	50.1
Willesden Junction to Harlesden	69.9	110.2	52.0	63.9	64.2	63.0	61.4	61.7	56.4	47.5
	74.1	118.5	54.6	65.4	67.3	66.1	68.0	67.3	62.5	55.8
	73.3	109.8	56.0	65.6	67.1	67.9	66.3	64.5	58.8	48.2



Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave (Hz)							
			63	125	250	500	1000	2000	4000	8000
Harlesden to Stonebridge Park	68.6	110.9	47.2	56.0	60.0	62.4	62.7	63.4	56.0	45.7
	71.0	115.8	51.1	56.7	61.5	63.8	66.1	64.9	61.4	55.2
	69.4	109.4	54.6	60.5	62.5	64.7	62.7	60.7	54.7	45.4
Stonebridge Park to Wembley Central	71.5	110.2	51.2	63.9	66.8	66.2	62.6	61.7	56.2	46.2
	72.9	115.0	51.7	64.5	66.8	66.3	67.4	64.1	60.7	54.2
	71.6	110.4	53.2	65.6	65.4	66.4	63.9	61.9	55.5	45.1
Wembley Central to North Wembley	69.5	111.7	49.1	56.5	61.9	65.1	62.4	63.3	56.3	46.7
	71.0	115.8	48.3	55.8	60.6	63.6	66.3	65.5	61.1	54.9
	69.1	110.0	52.0	59.3	61.4	64.2	63.2	60.9	54.8	45.4
North Wembley to South Kenton	69.6	111.2	47.0	54.5	61.7	65.4	63.2	63.4	55.9	47.1
	70.8	111.7	47.8	54.7	61.1	64.2	66.3	64.5	61.0	52.2
	67.7	109.0	49.2	57.6	60.8	62.1	61.4	60.4	55.0	45.1
South Kenton to Kenton	68.9	111.9	49.4	56.3	60.9	65.0	62.4	61.0	56.4	46.8
	69.4	105.4	49.9	56.1	61.3	64.4	65.0	60.9	56.0	47.2
	73.5	111.3	53.2	60.1	61.5	65.7	67.9	70.1	58.1	46.1
Kenton to Harrow & Wealdstone	70.7	111.0	49.9	59.0	63.9	66.6	62.9	62.7	58.3	48.5
	72.5	115.2	49.9	58.5	63.9	66.6	67.6	65.6	61.4	54.2
	68.2	110.7	50.0	58.3	61.3	62.8	62.2	60.6	54.0	44.8
Harrow & Wealdstone to sidings	73.0	115.1	48.1	58.9	60.0	63.5	69.5	67.6	63.1	54.9
	70.6	114.0	49.1	62.5	60.3	63.8	66.4	62.8	58.2	47.7

Table B.2 – Inter-station noise levels for the northbound road between Harrow & Wealdstone and Elephant & Castle

Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave (Hz)							
			63	125	250	500	1000	2000	4000	8000
Sidings to Harrow & Wealdstone	73.2	114.9	44.7	53.7	57.1	58.5	70.3	67.8	64.1	55.2
	70.8	110.9	49.8	58.4	63.5	61.8	66.8	64.1	57.6	49.4
Harrow & Wealdstone to Kenton	72.6	112.2	55.3	61.4	64.1	66.7	68.0	64.4	61.2	50.8
	73.7	114.7	54.6	61.6	64.7	66.4	68.1	67.7	65.0	55.5
	70.3	110.8	53.3	60.2	64.2	65.1	64.1	60.8	57.4	47.2
Kenton to South Kenton	72.2	112.7	56.6	61.6	63.3	66.4	67.2	64.4	60.8	50.9
	71.5	112.9	53.0	60.2	62.5	64.7	66.6	64.7	61.8	50.2
	70.0	112.5	53.3	59.2	61.8	64.1	64.8	62.5	58.4	48.3
South Kenton to North Wembley	72.8	111.3	55.8	61.3	63.8	66.6	68.9	64.2	60.8	51.1
	70.5	115.1	48.7	55.4	61.5	60.2	66.7	63.8	61.4	48.5
	70.8	112.9	52.8	58.5	62.3	64.5	65.9	64.4	58.6	49.1
North Wembley to Wembley Central	73.6	112.7	56.3	62.0	64.2	67.9	69.1	65.8	62.3	53.1
	72.4	112.6	54.7	61.2	63.2	65.3	67.2	66.1	63.1	52.0
	71.1	111.3	53.3	59.4	62.9	64.8	65.9	64.5	59.0	48.1
Wembley Central to Stonebridge Park	76.7	114.0	57.8	67.6	70.8	71.8	69.9	67.2	64.1	53.3
	71.6	108.4	53.7	63.4	67.3	67.9	62.3	59.9	56.0	43.4
	75.6	112.3	54.0	67.2	70.7	68.4	68.4	68.6	59.0	49.1
Stonebridge Park to Harlesden	72.6	111.4	57.5	63.2	65.2	66.5	67.7	63.3	60.5	50.2
	72.8	112.7	55.4	61.4	65.7	67.3	66.9	65.0	62.0	51.4
	71.2	110.7	55.1	62.3	65.8	65.1	65.0	61.7	56.5	46.9
Harlesden to Willesden Junction	73.7	112.3	57.2	65.5	68.3	68.4	66.7	63.1	60.0	50.2
	74.5	112.4	56.9	65.3	70.0	69.4	67.2	64.6	58.2	47.9
	73.4	112.8	56.2	65.3	68.4	66.9	66.7	64.0	57.0	48.6
Willessden Junction to Kensal Green	75.4	115.2	58.4	69.5	70.1	69.8	67.9	63.1	59.9	49.6
	75.6	114.3	57.7	69.9	70.3	70.0	67.0	65.2	62.3	53.1
	75.8	116.0	58.0	71.2	71.3	69.3	66.7	63.5	58.2	48.3
Kensal Green to Queen's Park	71.7	112.5	52.0	60.9	64.0	65.8	66.9	62.7	60.7	50.9
	71.2	115.1	50.9	60.0	63.9	64.1	66.7	63.4	59.5	51.9
	67.5	112.5	47.8	58.0	60.1	60.1	61.9	59.3	59.2	44.7
Queen's Park to Kilburn Park	78.3	114.8	55.3	63.7	70.5	74.7	72.3	68.6	65.4	56.3
	73.8	106.5	52.5	60.8	66.1	70.0	68.8	63.7	58.1	45.6
	74.8	112.2	55.2	63.1	67.0	69.8	69.9	65.5	60.6	52.6



Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave (Hz)							
			63	125	250	500	1000	2000	4000	8000
Kilburn Park to Maida Vale	76.4	113.7	51.9	62.6	68.0	73.5	70.3	67.2	61.4	54.3
	74.7	105.2	51.5	61.6	67.2	71.8	68.6	63.8	57.8	44.7
	75.3	111.9	56.6	63.7	67.7	70.6	70.1	65.8	61.3	54.7
Maida Vale to Warwick Avenue	77.4	112.2	51.3	60.9	67.7	74.5	72.3	67.0	62.0	56.9
	76.8	104.7	50.8	59.7	67.2	74.4	70.5	65.7	60.9	48.1
	76.5	111.3	51.6	61.8	67.7	72.8	72.1	65.9	60.1	52.3
Warwick Avenue to Paddington	77.8	114.8	55.2	65.4	71.1	74.5	71.7	66.8	61.9	56.3
	75.4	114.5	53.8	63.9	70.1	70.8	68.8	65.4	61.5	51.4
	76.7	112.5	55.9	66.2	71.2	71.9	71.2	66.3	61.3	50.9
Paddington to Edgware Road	81.3	115.9	59.5	71.1	75.4	78.3	73.9	68.7	63.9	56.6
	78.8	110.3	59.4	70.8	75.0	74.3	69.3	63.8	59.6	47.2
	82.2	113.1	60.4	72.2	77.4	78.4	74.1	70.0	63.8	53.8
Edgware Road to Marylebone	77.1	111.3	53.6	62.5	69.5	75.1	70.3	64.2	59.6	52.3
	76.0	113.6	53.4	62.3	69.9	71.9	70.2	66.3	59.7	48.9
	76.9	113.1	54.2	63.7	69.3	72.4	70.5	69.1	66.5	58.0
Marylebone to Baker Street	75.5	114.0	51.6	60.7	66.6	70.3	67.7	67.2	66.6	67.4
	73.8	116.7	52.3	60.8	68.1	67.8	68.1	66.1	59.5	50.1
	74.0	113.5	52.9	62.8	67.3	68.9	68.7	65.3	60.1	50.3
Baker Street to Regent's Park	79.5	110.0	55.4	65.4	74.3	77.0	71.8	66.0	61.0	51.3
	76.7	107.3	55.3	66.5	72.5	72.8	68.3	62.4	55.8	42.1
	78.9	113.1	55.3	66.5	75.1	74.4	71.1	67.3	62.5	53.9
Regent's Park to Oxford Circus	77.2	112.6	52.2	63.0	68.9	73.8	70.3	70.5	61.3	55.1
	76.0	117.6	50.1	63.4	71.2	70.4	69.5	66.4	63.7	54.0
	75.8	112.4	52.2	63.8	69.3	71.2	69.5	68.8	60.0	49.9
Oxford Circus to Piccadilly Circus	78.1	112.9	58.2	65.6	70.7	75.4	72.4	66.0	61.2	52.6
	76.1	115.8	54.8	65.0	68.1	71.2	71.4	66.7	64.8	54.8
	76.4	111.7	55.4	65.6	69.8	72.7	70.7	64.9	59.3	48.9
Piccadilly Circus to Charing Cross	77.2	109.8	50.5	61.6	68.7	72.8	70.7	71.7	61.6	51.7
	73.4	105.4	51.9	63.6	69.6	69.8	63.9	59.7	54.7	41.4
	77.5	111.9	51.2	62.5	69.3	75.2	68.8	67.0	61.1	50.2
Charing Cross to Embankment	74.5	113.7	52.6	61.1	65.2	69.6	69.5	67.1	62.7	59.3
	74.8	114.9	53.2	61.4	67.5	66.6	69.9	67.9	64.5	56.9
	73.2	111.3	52.7	62.9	66.5	67.7	67.9	64.8	58.4	50.3
Embankment to Waterloo	78.7	112.4	59.6	70.7	71.9	75.5	70.5	68.2	63.1	56.4
	78.1	113.8	58.9	70.7	72.9	72.7	70.7	67.6	63.5	54.6
	78.6	110.9	59.6	71.6	74.1	73.8	70.1	66.2	60.4	49.6
Waterloo to Lambeth North	77.1	114.3	55.0	64.2	69.3	74.7	70.3	66.1	61.7	55.7
	76.2	117.9	53.7	63.3	69.5	70.1	71.0	67.6	65.7	56.5
	76.4	111.4	55.9	65.7	70.9	72.6	68.7	65.7	59.9	50.3
Lambeth North to Elephant & Castle	77.4	113.2	55.7	62.7	69.5	73.6	71.8	68.1	64.6	60.7
	73.4	113.4	53.5	61.2	67.3	67.3	68.8	64.0	59.5	46.4
	74.8	113.0	55.4	64.1	69.7	69.6	67.6	65.1	61.3	51.6

APPENDIX C – PHOTOGRAPHS



Figure C1 – Microphone arrangement during the measurements