Our ref: NIA/7491/17/7603/v1/Lidl Mapplewell

15th December 2017

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Dear Sirs

NOISE IMPACT ASSESSMENT FOR A PROPOSED LIDL FOOD STORE AT FORMER WILLIAM FREEMAN SITE, LAND EAST OF A61 WAKEFIELD ROAD, MAPPLEWELL, BARNSLEY, S71 3LT

1.00 INTRODUCTION

1.01 Environmental Noise Solutions Ltd (ENS) has been commissioned by Lidl UK GmbH to undertake a noise impact assessment for a proposed Lidl food store at the former William Freeman site at land to the east of the A61 Wakefield Road, Mapplewell, Barnsley (the site).

1.02 The objectives of the noise impact assessment were to:

- Measure the baseline noise levels at the site during representative periods of the daytime, evening and night time
- Assess the potential impact of the proposed food store with reference to the National Planning Policy Framework Planning Practice Guidance on Noise and other guidelines
- Provide recommendations for structural and management controls, as necessary, to protect the noise amenity of the nearest (existing and proposed) residential dwellings

1.03 This report details the methodology and results of the assessment and has been prepared to accompany a planning application to be submitted to Barnsley MBC.

1.04 This report has been prepared for Lidl UK GmbH for the sole purpose described above and no extended duty of care to any third party is implied or offered. Third parties making reference to the report should consult Lidl UK GmbH and ENS as to the extent to which the findings may be appropriate for their use.

1.05 A glossary of acoustic terms used in the main body of the text is contained in Appendix 1.

2.00 APPLICATION SITE SETTING AND PROPOSED DEVELOPMENT

2.01 Roughly rectangular in shape, the application site is bound by (see Appendix 2):

- Open land to the north (note: earmarked as proposed residential in future)
- A nursery school to the south
- Open land to the east
- The A61 Wakefield Road to the west (residential dwellings on opposite side of road)

2.02 The proposed development consists of a new Lidl food store with 136 car parking spaces. The proposed store opening hours are 0800 to 2200 hours (6 consecutive hours between 1000 and 1800 hours on Sundays). The proposed delivery hours are 0700 to 2300 hours.

2.03 In order to meet the refrigeration and comfort cooling requirements, the plant compound has:

- 2 x Hauser Heat Pumps rated at 45 dB(A) at 10 metres per unit (these units operate from one hour prior to store opening to 30 minutes prior to store closing i.e. 0700 to 2130 hours)
- 2 x Hauser Low Noise Floor Mounted Dry Coolers rated at 37 dB(A) at 10 metres per unit (these units operate 24/7)

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3.00 BASELINE NOISE SURVEY

3.01 In order to determine the baseline noise levels at the application site, noise surveys were undertaken on Monday 7th August through to the early hours of Tuesday 8th August 2017. For the purpose of the assessment, the following noise monitoring positions were adopted:

- MP1 was located towards the north western corner of the proposed Lidl food store site circa 10 metres from Wakefield Road kerb
- MP1A was located towards the south western corner of the proposed Lidl food store site circa 10 metres from Wakefield Road kerb
- MP2 was located on the northern boundary circa 45 metres from Wakefield Road (representative of car parking on northern boundary furthest from road)
- MP3 was located towards the north eastern corner of the proposed Lidl food store (representative of the proposed delivery bay and plant compound)
- MP3A was located towards the south eastern corner of the proposed Lidl food store

3.02 Noise measurements were undertaken using a Bruel & Kjaer 2250 Type 1 integrating sound level meters. Measurements consisted of A–weighted broadband parameters, together with linear octave band L_{eq} levels. Weather conditions throughout the surveys were appropriate for monitoring. The following table contains a summary of the noise measurement data

Table 3.1 – Baseline Noise Measurement Data

Position	Date	Time	L_{Aeq} (dB)	L_{A90} (dB)	L_{A10} (dB)	L_{A1} (dB)	Comment
MP1	07/08/17	1152–1216	63	46	67	71	Ambient (L_{Aeq}) is A61 Wakefield Road Background (L_{A90}) is urban & distant traffic
MP1	07/08/17	1339–1415	64	47	68	73	
MP1	07/08/17	2144–2216	59	41	64	69	
MP1	07/08/17	2340–0016	57	32	52	69	
MP1	08/08/17	0138–0208	54	30	48	68	
Daytime ambient and background noise level 63 to 64 dB L_{Aeq} and 46 to 47 dB L_{A90}, respectively Evening ambient and background noise level 59 dB L_{Aeq} and 41 dB L_{A90}, respectively Night time ambient and background noise level 54 to 57 dB L_{Aeq} and 30 to 32 dB L_{A90}, respectively							
MP1A	07/08/17	1342–1412	63	47	67	72	As above
Comparable to MP1							
MP2	07/08/17	1154–1218	54	46	57	62	As above
Comparison of LA10 with MP1 indicates point source propagation (6 dB doubling) from centre of A61 Wakefield Road							
MP3	07/08/17	1105–1131	51	47	53	55	Distant traffic
MP3	07/08/17	1220–1335	51	47	54	56	
MP3	07/08/17	2111–2141	47	42	49	53	
MP3	07/08/17	2220–2300	44	39	47	52	
MP3	07/08/17	2300–2335	42	33	45	50	
MP3	08/08/17	0020–0100	40	32	44	50	
MP3	08/08/17	0100–0135	40	30	44	50	
Daytime ambient and background noise level 51 dB L_{Aeq} and 47 dB L_{A90}, respectively Evening ambient and background noise level 44 to 47 dB L_{Aeq} and 39 to 42 dB L_{A90}, respectively Night time ambient and background noise level 40 to 42 dB L_{Aeq} and 30 to 33 dB L_{A90}, respectively							
MP3A	07/08/17	1223–1332	50	47	54	56	Distant traffic
Comparable to MP3							

3.04 The baseline ambient and background noise levels are considered wholly commensurate with the site setting.

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4.00 NOISE IMPACT ASSESSMENT CRITERIA

4.01 In terms of noise impact assessment criteria, Paragraph 123 of the National Planning Policy Framework states that planning policies and decisions should aim to '*avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development'.*

4.02 Planning Practice Guidance specifically dealing with noise was uploaded to the Government's Planning Portal in March 2014 as an accompaniment to the National Planning Policy Framework. This guidance is summarised herein.

4.03 The guidance states that noise needs to be considered when new developments may create additional noise. Whilst noise can override other planning concerns, neither the Noise Policy Statement for England nor the National Planning Policy Framework (which reflects the Noise Policy Statement for England) expects noise to be considered in isolation, separately from the economic, social and other environmental dimensions of proposed development.

4.04 In order to determine noise impact, local planning authorities' plan-making and decision taking should take account of the acoustic environment and in doing so consider:

- Whether or not a significant adverse effect is occurring or likely to occur
- Whether or not an adverse effect is occurring or likely to occur, and
- Whether or not a good standard of amenity can be achieved

4.05 In line with the Explanatory Note of the Noise Policy Statement for England, this would include identifying whether the overall effect of the noise exposure is, or would be, above or below the significant observed adverse effect level and the lowest observed adverse effect level for the given situation.

4.06 In terms of Observed Effect Levels:

- No Observed Adverse Effect Level (NOAEL) – This is the level of noise exposure below which no effect at all on health or quality of life can be detected
- Lowest Observed Adverse Effect Level (LOAEL) – This is the level of noise exposure above which adverse effects on health and quality of life can be detected, and
- Significant Observed Adverse Effect Level (SOAEL) – This is the level of noise exposure above which significant adverse effects on health and quality of life occur

4.07 At the lowest extreme, when noise is not noticeable, there is by definition no effect. As the noise exposure increases, it will cross the no observed effect level as it becomes noticeable. However, the noise has no adverse effect so long as the exposure is such that it does not cause any change in behaviour or attitude. The noise can slightly affect the acoustic character of an area but not to the extent there is a perceived change in quality of life. If the noise exposure is at this level no specific measures are required to manage the acoustic environment.

4.08 As the exposure increases further, it crosses the lowest observed adverse effect level boundary above which the noise starts to cause small changes in behaviour and attitude, for example, having to turn up the volume on the television or needing to speak more loudly to be heard. The noise therefore starts to have an adverse effect and consideration needs to be given to mitigating and minimising those effects (taking account of the economic and social benefits being derived from the activity causing the noise).

4.09 Increasing noise exposure will at some point cause the significant observed adverse effect level boundary to be crossed. Above this level the noise causes a material change in behaviour such as keeping windows closed for most of the time or avoiding certain activities during periods when the noise is present. If the exposure is above this level the planning process should be used to avoid this effect occurring, by use of appropriate mitigation such as by altering the design and layout. Such decisions must be made taking account of the economic and social benefit of the activity causing the noise, but it is undesirable for such exposure to be caused.

4.10 At the highest extreme, noise exposure would cause extensive and sustained changes in behaviour without an ability to mitigate the effect of noise. The impacts on health and quality of life are such that regardless of the benefits of the activity causing the noise, this situation should be prevented from occurring.

4.11 The following table summarises noise exposure hierarchy, based on likely average response.

Table 4.1 – Noise Exposure Hierarchy

Perception	Examples of Outcomes	Increasing Effect Level	Action
No Observed Adverse Effect Level (NOAEL)			
Not Noticeable	No Effect	No Observed Effect	No specific measures required
Noticeable and not intrusive	Noise can be heard, but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a perceived change in the quality of life.	No Observed Adverse Effect	No specific measures required
Lowest Observed Adverse Effect Level (LOAEL)			
Noticeable and intrusive	Noise can be heard and causes small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life.	Observed Adverse Effect	Mitigate and reduce to a minimum
Significant Observed Adverse Effect Level (SOAEL)			
Noticeable and disruptive	The noise causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant Observed Adverse Effect	Avoid
Noticeable and very disruptive	Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory	Unacceptable Adverse Effect	Prevent

4.12 The subjective nature of noise means that there is not a simple relationship between noise levels and the impact on those affected. This will depend on how various factors combine in any particular situation. These factors include:

- The source and absolute level of the noise together with the time of day it occurs
- **For non-continuous sources of noise, the number of noise events, and the frequency and pattern of occurrence of the noise**
- The spectral content of the noise (i.e. whether or not the noise contains particular high or low frequency content) and the general character of the noise (i.e. whether or not the noise contains particular tonal characteristics or other particular features)
- The local acoustic character of the area

4.13 In addition, further useful contextual guidance is provided in

- British Standard 4142:2014 'Methods for Rating and Assessing Industrial and Commercial Sound' (BS 4142)
- World Health Organisation Guidelines for Community Noise (1999)
- World Health Organisation Guidelines for Night Noise in Europe (2009)

4.14 With respect to a new noise-sensitive receptor being introduced to an environment already experiencing or that will at a future time experience, industrial and/or commercial sound, BS 4142 states:

Where a new noise-sensitive receptor is introduced and there is extant industrial and/or commercial sound, it ought to be recognized that the industrial and/or commercial sound forms a component of the acoustic environment. In such circumstances other guidance and criteria in addition to or alternative to this standard can also inform the appropriateness of both introducing a new noise-sensitive receptor and the extent of required noise mitigation.

4.15 With respect to a new specific sound source being commissioned in an area with an existing noise-sensitive receptor, BS 4142 states:

The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs'.

Typically, the greater this difference, the greater the magnitude of the impact. For example:

- *A difference of around +10 dB or more is likely to be an indication of a significant adverse impact,* ***depending on the context***
- *A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the* ***context***
- *The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact,* ***depending on the context***

Adverse impacts include, but are not limited to, annoyance and sleep disturbance. Not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact.

Where the initial estimate of the impact needs to be modified due to the context, take all pertinent factors into consideration, including the absolute level of sound. For a given difference between the rating level and the background sound level, the magnitude of the overall impact might be greater for an acoustic environment where the residual sound level is high than for an acoustic environment where the residual sound level is low. ***Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night.***

4.16 The World Health Organisation's Guidelines for Community Noise (1999) state '*At night, sound pressure levels at the outside façades of the living spaces should not exceed 45 dB L_{Aeq} and 60 dB L_{AFMax}, so that people may sleep with bedroom windows open. These values have been obtained by assuming that the noise reduction from outside to inside with the window partly open is 15 decibels.'*

4.17 The World Health Organisation's Night Noise Guidelines Europe (2009) state '*An external noise level of 40 dB $L_{Aeq\ (2300–0700)}$ represents the Lowest Observed Adverse Effect Level.*'

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5.00 NOISE IMPACT OF THE PROPOSED LIDL FOOD STORE

5.01 The principal noise sources potentially associated with the proposed Lidl food store are considered to be:

- Noise associated with HGV deliveries
- Noise associated with fixed external plant
- Noise associated with the customer car park

5.02 The following sections of the noise impact assessment discuss the potential noise impacts of the above activities on the amenity of the nearest (existing and proposed) residential dwellings.

Noise Associated with HGV Deliveries

5.03 The delivery process involves a HGV reversing into the delivery bay, where it is guided into a docking enclosure and a delivery plate is lowered into the rear of the HGV. The unloading of the HGV then takes place without the need for ramps or lifts, due to the rear of the trailer being level with the delivery area.

5.04 The delivery yard is to be located at the north eastern corner of the proposed Lidl food store and the principal noise source associated with deliveries is that of palleted goods being moved over the delivery plate.

5.05 Measurements have previously been undertaken by ENS at numerous Lidl food stores with delivery noise levels up to 58 dB $L_{Aeq\ (15\ minutes)}$ consistently measured at a distance of 10 metres to the delivery plate with a direct line of sight to the unloading operations during a HGV delivery.

5.06 The layout of the proposed Lidl food store (see Appendix 2) is such that the delivery plate (over which palleted goods are moved by electric pallet truck from the back of the HGV into the store; it is this movement that creates the principal noise associated with a delivery) is wholly and significantly screened from the proposed residential development to the north by the store itself (namely the back of house storage area), whilst potential flanking sound transmission is also controlled by the provision of the acoustic fence around the plant compound.

5.07 Based on experience at other Lidl stores where the nearest residential dwellings are located to the rear of the delivery area, delivery noise is attenuated to such a degree that it does not exhibit any acoustic characteristics (such as impulsivity) and, as a consequence, an acoustic correction (penalty) is not justified.

5.08 The attenuation by the building is calculated as circa 27 dB(A) in accordance with Maekawa and 23 dB(A) in accordance with Kurze. Notwithstanding this, the general guiding principles of IS0 9613-2 Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method Calculation, state that the barrier attenuation should not be taken to be greater than 20 decibels.

5.09 This degree of attenuation is considered realistic given that British Standard 5228:2009-1 Code of Practice for Noise Control of Construction and Open Sites 1 states '*In the absence of spectral data, as a working approximation, if there is a barrier or other topographic feature between the source and the receiving position, assume an approximate attenuation of 5 dB when the top of the plant is just visible to the receiver over the noise barrier, and of 10 dB when the noise screen completely hides the sources from the receiver. High topographical features and specifically designed and positioned noise barriers could provide greater attenuation*.'

5.10 The resultant delivery noise level at the nearest proposed residential dwellings (located circa 20 metes from the delivery bay) is therefore calculated as circa 32 dB $L_{Ar,T}$. This is well below the daytime and evening background noise level in the locality of the delivery bay.

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5.11 In accordance with BS 4142 this is considered to indicate the delivery noise having a low impact, **depending on the context.** In terms of context, it is noteworthy that: a) deliveries are proposed during 0700 to 2300 hours only (no night time deliveries); b) deliveries would typically be expected once or twice a day (hence the frequency of deliveries is relatively low); c) a delivery typically lasts circa 45 to 60 minutes in total (hence the duration of deliveries is relatively low); d) good external noise levels would be maintained from delivery noise; and e) good internal noise levels would be maintained from delivery noise, even with partially open windows.

5.12 At such levels during the night time, the noise associated with HGV deliveries to the application site therefore represents the No Observed Adverse Effect Level (NOAEL).

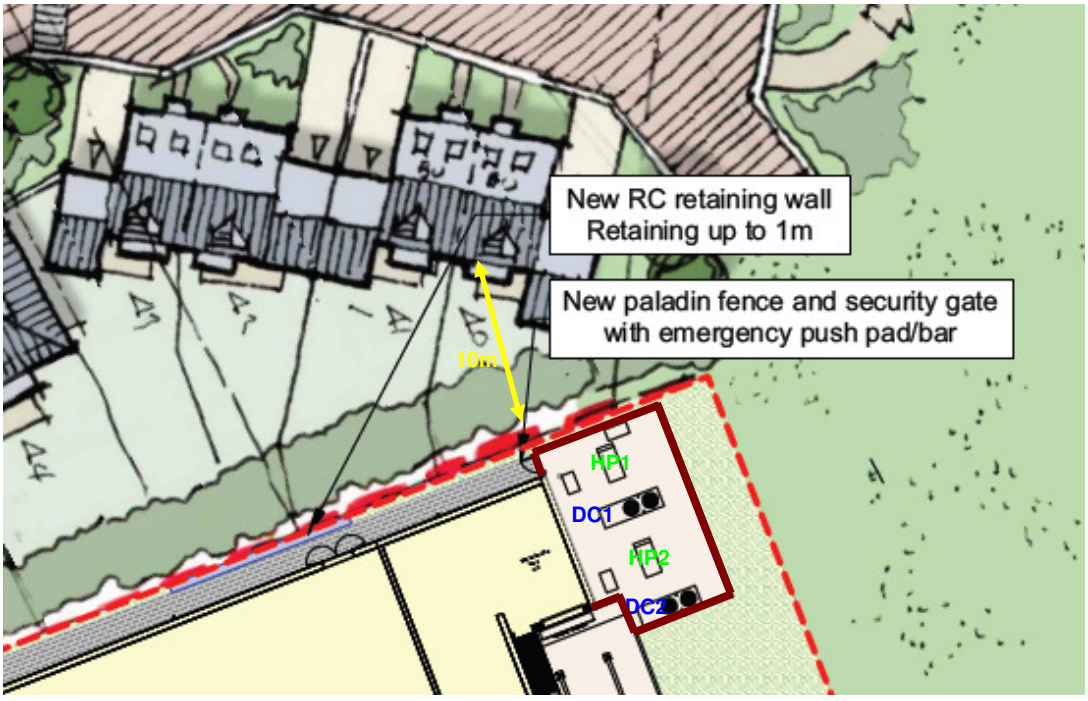
Noise Associated with Fixed External Plant

5.13 In order to meet the refrigeration and comfort cooling requirements of the proposed Lidl food store, it is understood that the following items of plant are required:

- 2 no. Hauser Heat Pumps – noise level per unit of 45 dB(A) at 10 metres (note: these units operate from one hour prior to store opening to 30 minutes prior to store closing (in this case 0700 to 2130 hours))
- 2 no. Hauser Low Noise Floor Mounted Dry Cooler – noise level per unit of 37 dB(A) at 10 metres (note: these units operate 24/7)

5.14 The layout of the plant compound and its relationship to the nearest proposed residential dwelling is illustrated below:

Plate 5.1 – Illustrative Plant Compound



5.15 The resultant noise level at the nearest residential dwelling, both ground floor middle of the garden during the daytime and (worst case) second floor during the night time, are set out in the following tables.

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Table 5.1 – Cumulative Plant Noise Levels (ground floor, mid-garden)

Plant	Reference Noise Level	Distance to Mid-Garden	Distance Correction	Barrier Correction to Ground Floor	Resultant
Heat Pump 1	45 dB(A) at 10m	6m	+ 3 dB(A)	– 13 dB(A)	35 dB(A)
Heat Pump 2	45 dB(A) at 10m	13m	– 2 dB(A)	– 12 dB(A)	31 dB(A)
Dry Cooler 1	37 dB(A) at 10m	10m	0 dB(A)	– 13 dB(A)	24 dB(A)
Dry Cooler 2	37 dB(A) at 10m	16m	– 4 dB(A)	– 12 dB(A)	21 dB(A)
Cumulative Noise Level circa 37 dB(A) at ground floor (mid garden) due to daytime plant					

Table 5.2 – Cumulative Plant Noise Levels (2nd floor, bedroom façade)

Plant	Reference Noise Level	Distance to Facade	Distance Correction	Barrier Correction to 2nd Floor Facade	Resultant
Dry Cooler 1	37 dB(A) at 10m	16m	– 4 dB(A)	0 dB(A)	33 dB(A)
Dry Cooler 2	37 dB(A) at 10m	22m	– 7 dB(A)	0 dB(A)	30 dB(A)
Cumulative Noise Level circa 35 dB(A) at (worst case) second floor (bedroom façade) due to night time plant					

5.16 The resultant daytime and evening plant noise levels at the nearest residential dwelling (mid garden) are calculated at circa 37 dB(A), which is well below the background noise level.

5.17 In accordance with BS 4142 this is considered to indicate the plant noise having a low impact, **depending on the context.** In terms of context, it is noteworthy that: a) the plant noise is not tonal, it is continuous steady broadband noise; b) very good external noise levels would be maintained from plant noise.

5.18 The resultant night time plant noise levels at the nearest residential dwelling ((worst case) second floor, bedroom façade) are calculated at circa 35 dB(A), which is comparable to the background noise level which ranged from circa 39 to 33 dB (A) between circa 2200 and 0000 hours (note: BS 4142 states '*Among other considerations, diurnal patterns can have a major influence on background sound levels and, for example, the middle of the night can be distinctly different (and potentially of lesser importance) compared to the start or end of the night-time period for sleep purposes).*

5.19 In accordance with BS 4142 this is considered to indicate the plant noise having a low impact, **depending on the context.** In terms of context, it is noteworthy that: a) the plant noise is not tonal, it is continuous steady broadband noise; b) good internal noise levels would be maintained from plant noise, even with partially open windows; and c) the night time plant noise level is well below the 40 dB(A) level which represents the onset of the Lowest Observed Adverse Effect Level (LOAEL) as stipulated by the WHO Night Noise Guidelines for Europe.

5.20 With reference to the National Planning Policy Framework Planning Practice Guidance on Noise, at such levels it is considered that: at the nearest proposed residential dwellings, noise associated with plant could be heard, but would not cause any change in behaviour or attitude or overly affect the acoustic character of the area, and certainly not to an extent such that there was a perceived change in the quality of life. **At such levels, the noise associated with plant at the application site therefore represents the No Observed Adverse Effect Level (NOAEL).**

<u>Noise Associated with Customer Car Park</u>

5.21 The existing ambient noise level at the application site at a location representative of the car parking bays along the northern boundary of the application site (MP2) was circa 54 dB $L_{Aeq,T}$ during the daytime period and (based on measurements at MP1 closer to the road) would be expected to be circa 50 dB $L_{Aeq,T}$ during the evening period.

5.22 Based on previous measurements at food store car parks, the noise level from a row of car parking bays has been measured / calculated as being less than 48 dB $L_{Aeq, T}$ at a distance of 5 metres, which corresponds to less than 42 dB $L_{Aeq, T}$ at a distance of 10 metres.

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5.23 For reference, the nearest proposed residential dwelling (rear façade leading to garden) is circa 10 metres from the nearest car parking bay. It is therefore evident that car park noise will be well below the ambient noise level.

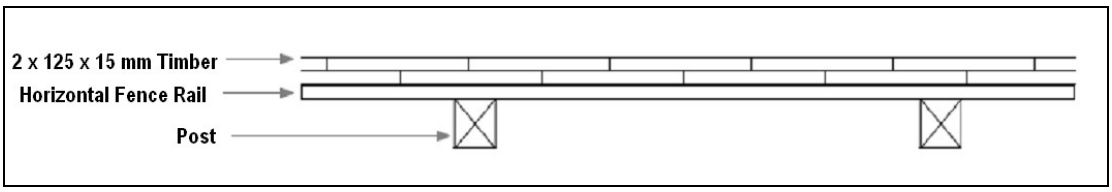
5.24 Notwithstanding this, Lidl UK GmbH is committed to the provision of an 1800 mm high acoustic fence (or an acoustic fence on top of a retaining wall to provide an overall height of 1800 mm) along its northern boundary between car parking areas and the proposed residential development (see Appendix 2).

Acoustic Fencing around Plant Compound and also along (parts of) Northern Boundary

5.25 Acoustic fencing is to be provided (as shown by a brown dashed line in Appendix 2) as follows:

- Overall height of 3000 mm to the plant compound
- Overall height of 1800 mm to the northern boundary of the car park

5.26 The overall mass per unit area of the fence shall be at least 15 kg/m2 and sealed at the ground with a gravel board. The following construction detail is considered appropriate (thicker timber panels can be used if necessary):



6.00 CONCLUSIONS

6.01 A noise impact assessment has been undertaken for a proposed Lidl food store at the former William Freeman site at land to the east of the A61 Wakefield Road, Mapplewell, Barnsley.

6.02 The ambient and background noise climate at the site is attributable to road traffic noise.

6.03 An assessment of the noise impact of the proposed Lidl food store has been undertaken, in line with the National Planning Policy Framework guidelines. Management controls (limitations on opening and delivery hours to the daytime) and structural mitigation measures (3000 mm high acoustic timber fence around the plant compound) have been recommended.

6.04 Provided the recommendations contained within this noise impact assessment are implemented, noise is not considered to represent a constraint to the proposed Lidl food store or the proposed residential development to the north.

I trust the foregoing is sufficient for your needs. Should you have any queries regarding the above, please do not hesitate to contact me.

Yours sincerely

T. Crabb

Thomas Crabb
MIOA, Diploma in Acoustics and Noise Control, MEng (Hons)
Environmental Noise Solutions Limited

Appendix 1
Glossary of Acoustic Terms

Sound Pressure Level (L_p)

The basic unit of sound measurement is the sound pressure level. As the pressures to which the human ear responds can range from 20 µPa to 200 Pa, a linear measurement of sound levels would involve many orders of magnitude. Consequently, the pressures are converted to a logarithmic scale and expressed in decibels (dB) as follows:

$L_p = 20 \log_{10}(p/p_0)$

Where L_p = sound pressure level in dB; p = rms sound pressure in Pa; and p_0 = reference sound pressure (20 µPa).

A-weighting Network

A frequency filtering system in a sound level meter, which approximates under defined conditions the frequency response of the human ear. The A-weighted sound pressure level, expressed in dB(A), has been shown to correlate well with subjective response to noise.

Equivalent continuous A-weighted sound pressure level, $L_{Aeq, T}$

The value of the A-weighted sound pressure level in decibels of continuous steady sound that within a specified time interval, T, has the same mean-square sound pressure as a sound that varies with time. $L_{Aeq, 16h}$ (07:00 to 23:00 hours) and $L_{Aeq, 8h}$ (23:00 to 07:00 hours) are used to qualify daytime and night time noise levels.

$L_{A10, T}$

The A-weighted sound pressure level in decibels exceeded for 10% of the measurement period, T. $L_{A10, 18h}$ is the arithmetic mean of the 18 hourly values from 06:00 to 24:00 hours.

$L_{A90, T}$

The A-weighted sound pressure level of the residual noise in decibels exceeded 90% of a given time interval, T. L_{A90} is typically taken as representative of background noise.

$L_{AF\ max}$

The maximum A-weighted noise level recorded during the measurement period. The subscript 'F' denotes fast time weighting, slow time weighting 'S' is also used.

Sound Exposure Level (SEL or L_{AE})

The energy produced by a discrete noise event averaged over one second, no matter how long the event actually took. This allows for comparison between different noise events which occur over different lengths of time.

Weighted Sound Reduction Index (R_W)

Single number quantity which characterises the airborne sound insulation properties of a material or building element over a defined range of frequencies (R_W is used to characterise the insulation of a material or product that has been measured in a laboratory).

Weighted Airborne Sound Insulation ($D_{nT,w}$)

Single number quantity which characterises the airborne sound insulation between rooms.

Appendix 2
Proposed Layout Plan, Noise Monitoring Positions and Boundary Treatments



Appendix 3
Barrier Attenuation Calculations

Heat Pump 1 to Garden

Receiver Height=	1.20
Barrier Height=	3.00
Source Height=	2.30
Source to Barrier=	1.00
Source to Receiver=	6.00

Path difference:		0.4348
SB	BR	SR
1.22	5.31	6.10
SR ang.	SB ang.	Diff ang.
-0.1813	0.6107	0.7920
	x = log(d):	-0.36

Speed of sound =	330

Plot Barrier at Steps of =	0.05

CRTN Barrier Attenuation		
SHADOW ZONE		
CRTN Attenuation =	13	dB

Maekawa Barrier Attenuation			
Freq	LINEAR	Weight	A
31.5	7	-39.4	0
63	8	-25	0
125	10	-16	0
250	12	-9	3
500	15	-3	12
1000	17	0	17
2000	20	1	21
4000	23	1	24
8000	26	-1.1	25

Heat Pump 2 to Garden

Receiver Height=	1.20
Barrier Height=	3.00
Source Height=	2.30
Source to Barrier=	8.00
Source to Receiver=	13.00

Path difference:		0.2982
SB	BR	SR
8.03	5.31	13.05
SR ang.	SB ang.	Diff ang.
-0.0844	0.0873	0.1717
	x = log(d):	-0.53

Speed of sound =	330

Plot Barrier at Steps of =	0.05

CRTN Barrier Attenuation		
SHADOW ZONE		
CRTN Attenuation =	12	dB

Maekawa Barrier Attenuation			
Freq	LINEAR	Weight	A
31.5	6	-39.4	0
63	7	-25	0
125	9	-16	0
250	11	-9	2
500	13	-3	10
1000	16	0	16
2000	19	1	20
4000	22	1	23
8000	25	-1.1	24

Appendix 3
Barrier Attenuation Calculations

Dry Cooler 1 to Garden

Receiver Height=	1.20
Barrier Height=	3.00
Source Height=	1.70
Source to Barrier=	5.00
Source to Receiver=	10.00

Path difference:		0.4679
SB	BR	SR
5.17	5.31	10.01
SR ang.	SB ang.	Diff ang.
-0.0500	0.2544	0.3043
	x = log(d):	-0.33

Speed of sound =	330

Plot Barrier at Steps of =	0.05

CRTN Barrier Attenuation		
SHADOW ZONE		
CRTN Attenuation =	13	dB

Maekawa Barrier Attenuation			
Freq	LINEAR	Weight	A
31.5	7	-39.4	0
63	8	-25	0
125	10	-16	0
250	12	-9	3
500	15	-3	12
1000	18	0	18
2000	21	1	22
4000	24	1	25
8000	27	-1.1	25

Dry Cooler 2 to Garden

Receiver Height=	1.20
Barrier Height=	3.00
Source Height=	1.70
Source to Barrier=	11.00
Source to Receiver=	16.00

Path difference:		0.3829
SB	BR	SR
11.08	5.31	16.01
SR ang.	SB ang.	Diff ang.
-0.0312	0.1176	0.1489
	x = log(d):	-0.42

Speed of sound =	330

Plot Barrier at Steps of =	0.05

CRTN Barrier Attenuation		
SHADOW ZONE		
CRTN Attenuation =	12	dB

Maekawa Barrier Attenuation			
Freq	LINEAR	Weight	A
31.5	6	-39.4	0
63	8	-25	0
125	9	-16	0
250	12	-9	3
500	14	-3	11
1000	17	0	17
2000	20	1	21
4000	23	1	24
8000	26	-1.1	25