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TECHNICAL REPORT

DEAL GROUND, BRACONDALE, NORWICH

Environmental Noise Assessment

Adrian James Acoustics Document Control Sheet

Report prepared for:	Serruys Property Company Ltd SPC House Atlas Works Norwich Road Lenwade Norfolk NR9 5SN
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QA Control

Rev	Date	Author	Checked by	Approved by
-	26 May 2023	Gary Percival MIOA	Andy Thompson MIOA	Andy Thompson MIOA
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Revision History

Rev	Details

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1 INTRODUCTION

1.1 Background

We have been appointed by Serruys Property Company Ltd to carry out an environmental noise assessment in relation to a proposed mixed use residential and commercial development on land known as the Deal Ground, Bracondale, Norwich.

Outline planning permission for regeneration of the site was originally granted in 2013 by Norwich City Council (NCC) and South Norfolk District Council (SNDC), partly based on a previous noise assessment carried out by Loven Acoustics in 2012. The site straddles the boundary between both Councils and the original planning approval reference numbers are 12/00875/O (NCC) and 2011/0152/O (SNDC), respectively.

The outline planning permission describes a residential led *"mixed development consisting of a maximum of 670 dwellings; a local centre comprising commercial uses (A1/A2/A3): a restaurant/dining quarter and public house (A3/A4); demolition of buildings on the May Gurney site (excluding the former public house); an access bridge over the River Yare; new access road; car parking; flood risk management measures; landscape measures inc earthworks to form new swales and other biodiversity enhancements including the re-use of the Grade II Listed brick Kiln for use by bats."*

In accordance with the original planning approvals, detailed reserved matters plans must be submitted before July 12, 2023. A new Environmental Impact Assessment (EIA) has been carried out to support the reserved matters application(s) and a scoping opinion was sought from both Councils to confirm the required scope of the EIA (NCC reference number 22/01225/EIA2 and SNDC reference number 2022/1847).

Based on this scoping opinion, we understand that noise and vibration were scoped out of the EIA. However, the outline planning approvals contain conditions relating to noise (NCC condition 11c and SNDC condition 8c, respectively). These both state:

> *"Notwithstanding the illustrative materials submitted with the application, the detailed site layout within the Marsh Reach/Wensum Riverside areas and the appearance, internal room layout, and glazing and ventilation specifications shall be informed by the need to mitigate the impact of noise from adjacent sources, in particular the asphalt plant/rail head, in order to ensure satisfactory levels of amenity for future residents. Mitigation should be informed by the Noise and Vibration Report dated 19 October 2012, updated and revised where necessary."*

The purpose of the assessment documented in this report is to provide the necessary details to meet this condition. As per the condition, the assessment is primarily focused on the Marsh Reach/Wensum Riverside areas of the development (see Section 4 of this report for more details). However, for completeness we have also assessed the potential impact of road traffic noise on the part of the site known as *'May Gurney'*.

It is important to note, however, that this is not a planning requirement and was carried out for good acoustic design purposes only. The assessment is mainly focused on the potential noise impact on the *'Marsh Reach/Wensum Riverside'* areas from the following sources:

- The rail sidings, aggregates depot and asphalt plant to the west of the site which is currently operated by Tarmac;
- The Trowse Rail Bridge in the north-western corner of the site; and
- Crown Point Rail Depot to the north, across the river Yare.

The first two of these sources were established as being of particular concern during the initial 2012 noise assessment. The Crown Point Rail Depot was highlighted by Network Rail as a potential noise source during the EIA scoping consultation process.

We discussed the scope and methodology for the assessment with Richard Divey (Public Protection Officer at NCC) and Alex Grimmer (Environmental Management Officer at SNDC, now South Norfolk and Broadland District Council) in February 2023.

Further details of this consultation are presented in Section 2.3.

The primary aims of the assessment are:

1. To confirm that the rail sidings, Trowse Rail Bridge and Crown Point Rail Depot are the main sources of noise affecting the site;
2. To quantify typical noise levels produced by those sources; and
3. To identify the acoustic measures necessary to ensure that acoustically appropriate conditions can be provided for residents.

1.2 Information used in this report

The report is based on the following drawings by Stolon Studio.

Drawing No	Revision	Title
055-S3-SK02	A	May Gurney, Units
055-S3-SK03	A	Marsh Reach Unit Plan
055-S3-SK04	A	Wensum Riverside Unit Plan
055-S3-SK05	B	Overall Unit Plan
055-S3-SK06	B	Building Heights
055-S3-SK07	-	Massing 01
055-S3-SK08	-	Massing 02
055-S3-SK09	-	Massing 03
055-S3-SK10	C	Overall Sketch Plan
055-S3-SK11	C	May Gurney Block Plan
055-S3-SK12	C	Marsh Reach Block Plan
055-S3-SK13	C	Wensum Riverside Block Plan

Table 1 – Project drawings used in the assessment

2 PLANNING POLICY

2.1 National Planning Policy Framework

The latest version of the National Planning Policy Framework (NPPF) was released in February 2019 and was last updated in July 2021

The NPPF does not set out quantitative criteria for assessing noise affecting proposed developments, but in paragraph 174 states that planning policies and decisions should actively contribute to the enhancement of the natural and local environment by:

> *"preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability."*

According to paragraph 185, planning policies and decisions should also ensure new development is appropriate for its location, particularly considering the likely effects on health and living conditions. Planning policy and decision makers should aim to:

> *"mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life".*

The *'agent of change principle'* has been part of the NPPF since the July 2018 revision. This principle means that a person or business (i.e. the agent) introducing a new land use is responsible for managing the impact of that change. Paragraph 187 states:

> *"Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of development permitted after they were established. Where the operation of an existing business or community facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or 'agent of change') should be required to provide suitable mitigation before the development has been completed."*

The NPPF also promotes *"good design"* (including good acoustic design) as a means of ensuring that development creates high quality, sustainable buildings, and places. Paragraph 124 states that *"good design is a key aspect of sustainable development"*.

2.2 Local planning policy

2.2.1 Norwich City Council

NCC's Development Management Policy '*DM2 – Amenity*' set out the Council's policy on noise affecting future occupiers of proposed development:

> *"Future occupiers Development will only be permitted where:*
>
> *a) it provides for a high standard of amenity, satisfactory living and working conditions, adequate protection from noise and pollution and adequate levels of light and outlook for future occupiers; and b) such a standard can be achieved and maintained without preventing or unreasonably restricting the continued operation of established authorised uses and activities on adjacent sites. To ensure that residential dwellings are designed to meet the demands of everyday life, adequate internal space must be provided and would normally be expected to exceed the City Council's indicative minimum guidelines for internal space standards."*

2.2.2 South Norfolk and Broadland District Council

The SNDC Development Management Policies Document was released in October 2015 as part of the South Norfolk Local Plan. Policy DM 3.13 states that:

> *"(1) Development should ensure a reasonable standard of amenity reflecting the character of the local area. In all cases particular regard will be paid to avoiding:*
>
> *c. Introduction of incompatible neighbouring uses in terms of noise, odour, vibration, air, dusts, insects, artificial light pollution and other such nuisances."*

2.3 Local authority consultation

We discussed the scope and methodology for the assessment with Richard Divey (Public Protection Officer at NCC) and Alex Grimmer (Environmental Management Officer at SNDC, now South Norfolk and Broadland District Council) in February 2023.

It was agreed during this consultation that, in line with the conditions attached to the outline planning approval, a reserved matters submission should primarily be focused on delivery/unloading activities at the rail sidings/railhead/asphalt plant to the west, and on noise produced by trains passing across the Trowse Rail Bridge to the north-west (the rail bridge is of steel construction and as a result rattles as trains pass across it).

It was also agreed that we would assess the potential noise impact of activities at the Crown Point rail depot (north of the site, on the north bank of the River Wensum) in line with the consultation response from Network Rail provided during the EIA scoping.

It was also confirmed that road traffic noise (mainly on Bracondale) is only likely to be significant in areas near to the road, and that any assessment of the implications of road traffic noise is for good acoustic design purposes only and is not a planning requirement.

The technical methodology/criteria established in 2013 for all noise sources are:

- Internal noise levels in habitable rooms of the new dwellings would be assessed using the guidance provided in BS 8233:1999 *'Sound insulation and noise reduction for buildings. Code of practice'* (since superseded by BS 8233:*2014 'Guidance on sound insulation and noise reduction for buildings'*) and the guidance in the World Health Organisation (WHO) *'Guidelines for community noise'* (1999).
- External amenity areas assessed using the same WHO guidelines.

It was agreed that it is appropriate for the same technical methodology/criteria to be used for this assessment. Further details of the guidance are provided in Section 3.

During consultation we also set out proposed approach for measurement/prediction:

- Road traffic – predicted based on future transport projections for Bracondale.
- Tarmac railhead/rail sidings – attended survey(s) to measure typical noise levels from delivery/unloading activities (and from the asphalt plant if this can be measured, though this was expected to be much quieter than rail activities).
- Trowse rail bridge (and Crown Point Rail Depot) – unattended monitoring in the north-west/north of the site over at least 3-5 days to confirm average/maximum noise levels from trains passing over the bridge, as well as from the rail depot.

We also proposed to measure noise levels from general rail traffic near the west boundary, north of the railhead, though this was not specifically requested.

Details of our noise survey methodology/results are provided in Section 6 of this report.

Based on our initial site inspection prior to the assessment, we considered that an assessment focused on the above should be enough to adequately inform mitigation requirements. In 2020 the Carrow Works site (formerly Colman's and Unilever) was sold to a developer, essentially removing another potentially significant noise source.

3 TECHNICAL STANDARDS AND GUIDANCE

3.1 BS 8233:2014

British Standard 8233:2014 *'Guidance on sound insulation and noise reduction for dwellings'* (BS 8233) provides guideline limits for ambient noise levels inside dwellings.

BS 8233 suggests the following internal ambient noise levels for dwellings:

Activity	Location	07:00 to 23:00hrs	23:00 to 07:00hrs
Resting	Living room	35 dB $L_{Aeq,16\ hour}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16\ hour}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16\ hour}$	30 dB $L_{Aeq,8\ hour}$

Table 2 - Internal Ambient noise levels for dwellings (Table 4 of BS 8233:2014)

Note 4 of Section 7.7.2 of BS8233 states:

> *"Regular individual noise events (for example, scheduled aircraft or passing trains) can cause sleep disturbance. A guideline value may be set in terms of SEL or $L_{Amax,F}$ depending on the character and number of events per night. Sporadic noise events could require separate values."*

Note 5 states:

> *"If relying on closed windows to meet the guide values, there needs to be appropriate alternative ventilation that does not compromise the façade insulation or the resulting noise level."*

Note 7 states:

> *"Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved."*

Section 7.7.3.2 of BS 8233 recommends that noise levels in external amenity areas should ideally not exceed 50 dB $L_{Aeq,T}$ and that 55 dB $L_{Aeq,T}$ should be considered as an upper limit. However, BS8233 also accepts that these guideline values are not achievable in all circumstances where development might be desirable.

3.2 World Health Organisation guidance

The WHO *'Guidelines for community noise'* were published in 1999 and remain the most relevant WHO guidance in relation to appropriate noise levels inside dwellings. The guidance recommends internal ambient noise levels not exceeding 35 dB $L_{Aeq,16hr}$ during the day (07:00-23:00hrs) and 30 dB $L_{Aeq,8hr}$ at night (23:00-07:00hrs). This is consistent with the guidance in Table 4 of BS 8233, as reproduced in Table 2.

The WHO guidelines also recommend that *"noise exceeding 45dB $L_{AF,max}$ should be limited, if possible"* and 45 dB $L_{AF,max}$ is commonly adopted as a limit for bedrooms. The WHO guidelines also refer to 1991 research by Vallet and Vernet recommending that levels should not exceed 45 dB more than 10-15 times a night to protect sleep.

The WHO guidance for outdoor *"living"* (amenity) areas is also consistent with BS 8233, with daytime average noise levels between 50-55 dB $L_{Aeq,T}$ representing the levels at which annoyance would normally range between *"moderate"* and *"serious"*.

3.3 Building Regulations Part O

Part O of Schedule 1 to the Building Regulations 2010 came into effect on the 22 June 2022. The requirements are summarised in Approved Document O (ADO) and apply to new residential buildings, including residential care homes, halls of residence and other accommodation for children over 5. Communal rooms and common spaces of buildings containing more than one residential unit also fall within the scope of ADO.

Requirement O1(2)(a) is met in a new residential building if the building's overheating mitigation strategy takes account of several factors, including noise levels at night.

If noise at night is an issue, it is less likely that windows would be opened by occupants to mitigate overheating. Therefore, for residential buildings where external night-time noise may be an issue, the overheating mitigation strategy should take account of the likelihood that windows will be closed during sleeping hours (23:00 hrs to 07:00 hrs).

According to ADO, bedroom windows are likely to be closed during sleeping hours if noise within bedrooms exceeds the following limits:

- 40 dB $L_{Aeq,T}$, averaged over 8 hours (between 11pm and 7am).
- 55 dB L_{AFmax}, more than 10 times a night (between 11pm and 7am).

The ADO requirements for night-time noise and overheating are based on guidance in the *'Acoustics, Ventilation and Overheating: Residential Design Guide'* (AVO), 2020. Details of the guidance on overheating contained in the AVO guide are provided below.

3.4 The Acoustics, Ventilation and Overheating Guide

The Acoustics, Ventilation and Overheating (AVO) Guide was produced jointly by the Association of Noise Consultants (ANC) and Institute of Acoustics (IoA) in 2020 and is intended to be used in the planning, development, design, and commissioning of new dwellings. It recommends an approach considering the interdependence of provisions for acoustics, ventilation, and overheating. Application of the AVO Guide is intended to form part of a good acoustic design process, as described in The Professional Practice Guidance on Planning and Noise (ProPG) which was published in May 2017.

The AVO Guide is intended for new residential developments that will be exposed predominantly to airborne sound from transportation sources, and to internal sound produced by mechanical services serving the proposed residential properties. Other sources of noise, such as noise from industrial, commercial or entertainment premises, and of ground-borne noise and vibration, are outside the scope of the AVO Guide.

3.4.1 Overheating risk - noise from transportation sources

The AVO Guide proposes a two-level assessment procedure for assessing the risk of adverse noise impact alongside the risk of overheating.

Level 1 is a site risk assessment based on external noise levels and the assumption that opening windows would be the primary means of mitigating overheating. Based on the Level 1 indication of risk, a subsequent Level 2 assessment may be required.

The AVO guidance for a Level 1 site risk assessment is reproduced in Figure 1.

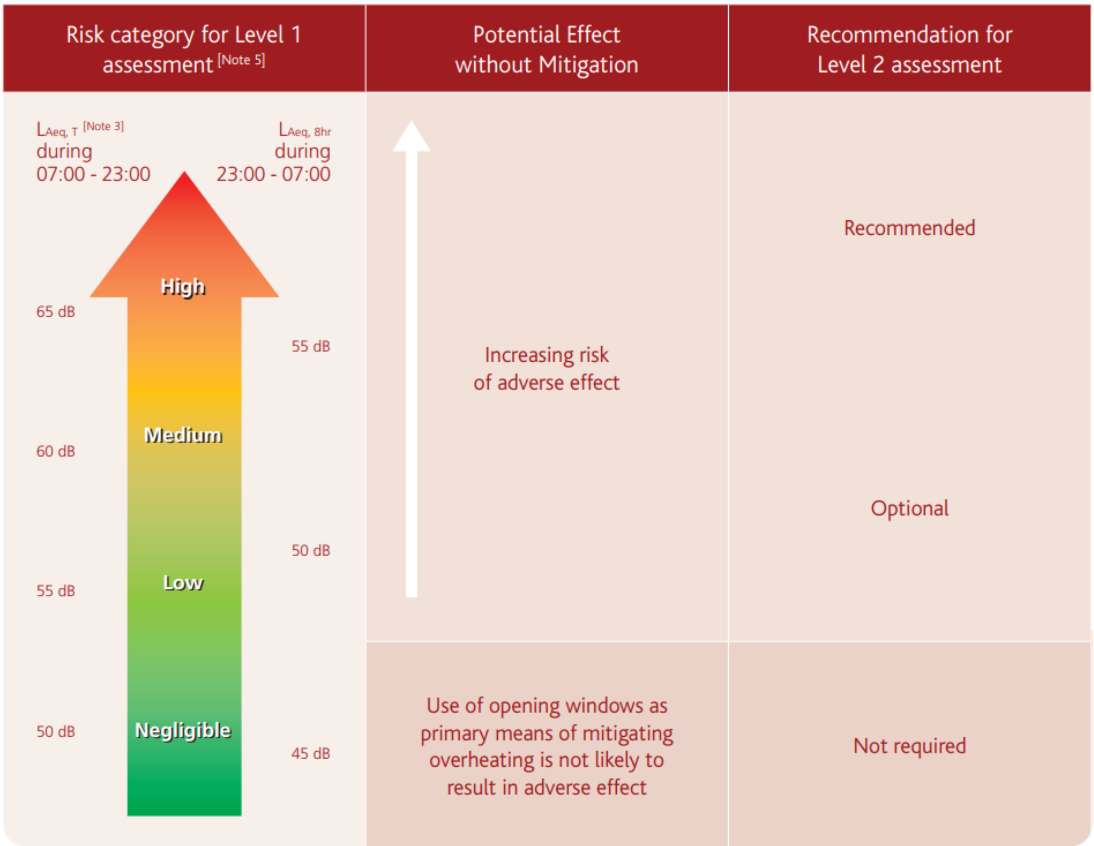

Figure 1 – Guidance for Level 1 site risk assessment of noise from transport sources

The noise levels suggested are based on a steady road traffic noise source but may be adapted for other types of transport. All levels are external free-field noise levels.

Additionally, if external free-field maximum noise levels *"normally"* exceed 78 dB L_{AFmax} at night (between 23:00 hrs and 07:00 hrs), a Level 2 assessment is recommended.

To evaluate the site risk category, The AVO Guide recommends that all three aspects of external noise exposure (daytime, night-time, and individual noise events) should be evaluated, and the highest risk category for any of the three aspects then applies.

If the Level 1 site risk assessment indicates that a Level 2 assessment is required, this should assess potential adverse effects in dwellings based on the internal ambient noise levels during the overheating condition (assuming that windows are open as mitigation), and how frequently/for what duration the overheating condition may occur.

For a Level 2 assessment, the AVO Guide suggests that internal ambient noise levels up to 50 dB $L_{Aeq,16hr}$ (daytime) and 42 dB(A) $L_{Aeq,8hr}$ (night-time), and internal maximum noise levels not *"normally"* exceeding 65 dB L_{AFMax} (night-time) may be acceptable.

The AVO Guide provides qualitative guidance on the combined effect of the internal ambient noise level during the overheating condition and the duration of overheating situations. This takes the form of an *'AVO Diagram'* as reproduced in Figure 2.

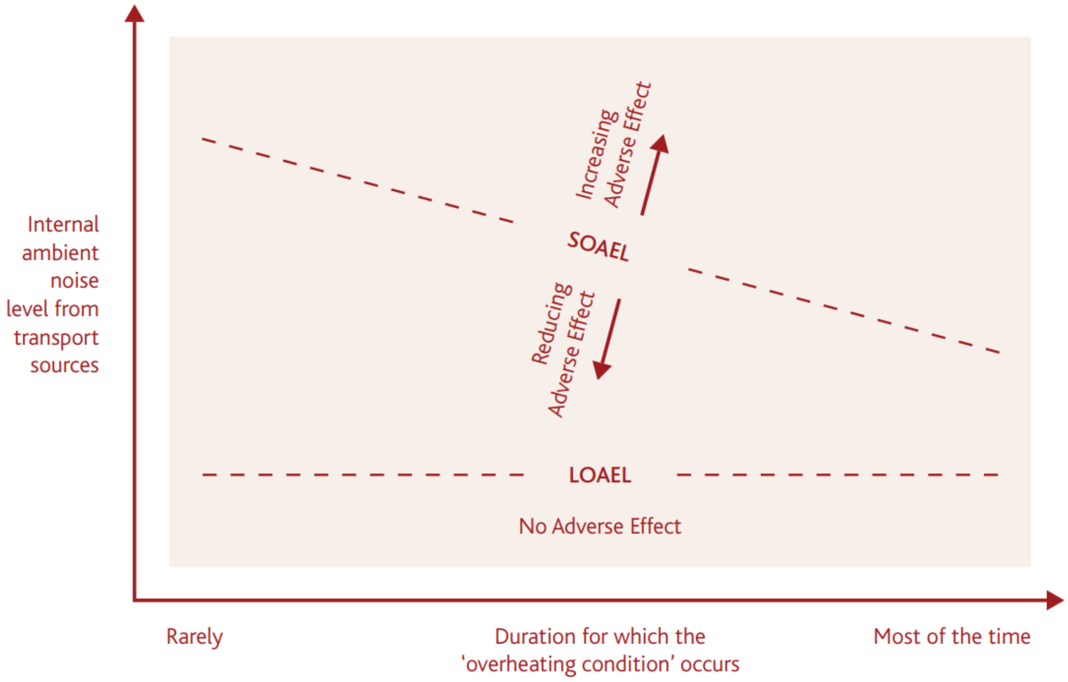

Figure 2 – Qualitative guidance on combined effects for a Level 2 AVO assessment

Therefore, for a Level 2 assessment to be completed, an overheating risk assessment would need to be carried out by a suitably qualified building services engineer, firstly to identify if any of the proposed dwellings may be at risk of overheating, and secondly to predict how frequently and for what duration the overheating conditions may occur.

3.4.2 Internal noise from mechanical services

The AVO Guide provides recommended indoor ambient noise levels for mechanical ventilation systems operating in accordance with Approved Document F of the Building Regulations, during overheating conditions. These limits are reproduced in Table 3.

Possible system or design solution	Desirable upper internal ambient noise levels from mechanical services	Desirable NR level from mechanical services
Ventilative cooling or comfort cooling	Bedrooms: ⩽ 30 dB $L_{Aeq,T}$ Living / Dining Rooms: ⩽ 35 dB $L_{Aeq,T}$	Bedrooms: ⩽ NR 24 dB Living / Dining Rooms: ⩽ NR 29 dB

Note 1 – NR limits assume that $L_{Aeq,T}$ = 6 = NR in the absence of strong low frequency noise

Table 3 – AVO Guide recommended noise limits for mechanical services (cooling)

Higher noise levels (e.g. 5 or 10 dB higher) are typically likely to be acceptable where rapid changes to the cooling or ventilation rates quickly improve the thermal comfort. Lower noise levels may also be appropriate for some types of residential development.

4 DESCRIPTION OF PROPOSED DEVELOPMENT SITE

4.1 Site overview

The proposed development site forms part of the wider area identified as part of the East Norwich regeneration plan. The site boundaries are shown in Figure 3.

The site straddles the boundaries of Norwich City Council and South Norfolk Council.

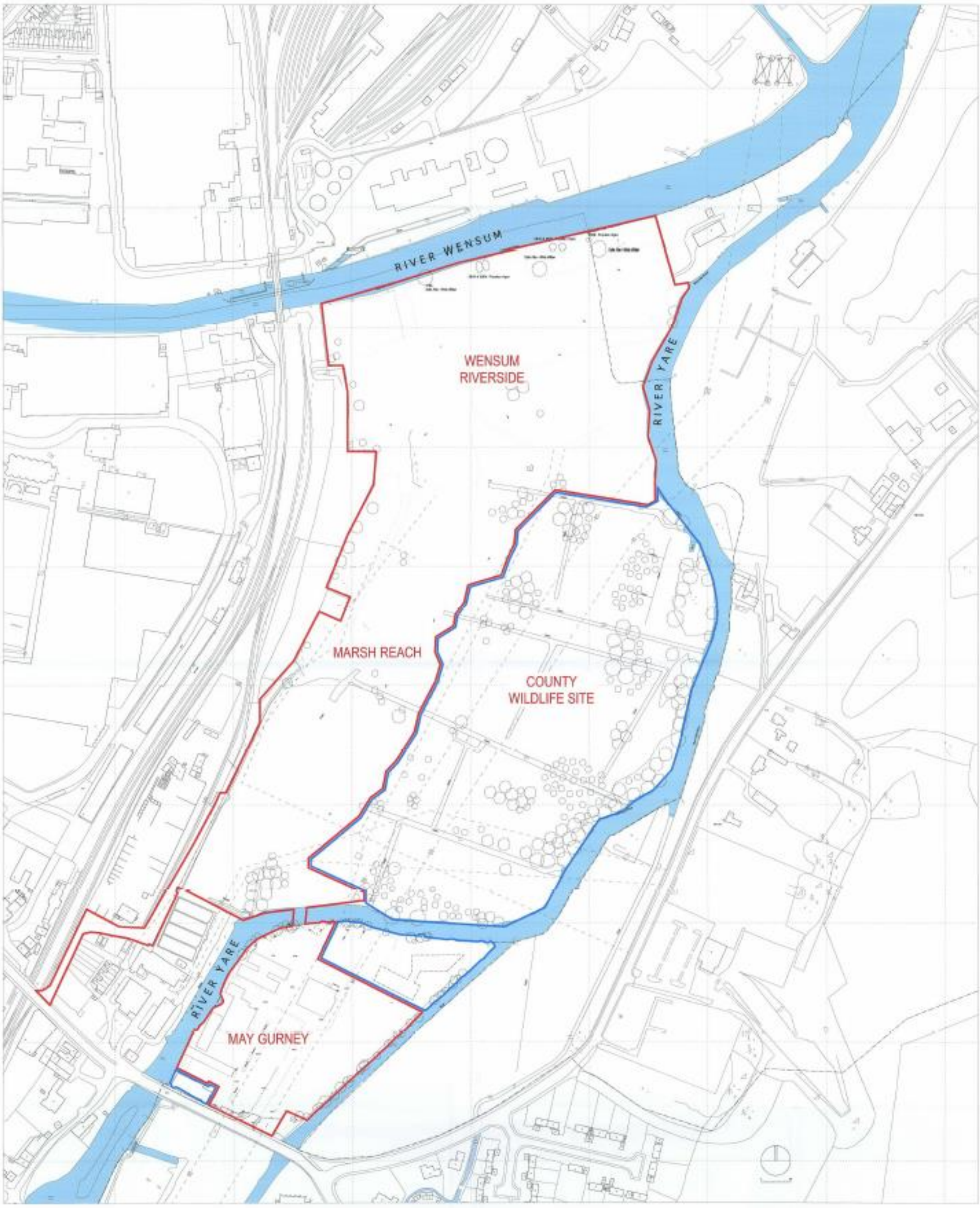

Figure 3 – Red line plan showing the boundaries of the proposed development site

As shown in Figure 3, most of the site, known as the Deal Ground, lies to the east of the Norwich to London Liverpool Street railway line, to the south of the River Wensum and west of the River Yare, effectively forming a self-contained island of land.

To the south and east of the River Yare, a smaller parcel of land, known as the May Gurney site, runs through to the public highway of Bracondale to the south and is enclosed to the east by trees and hedging adjacent to a tributary of the River Yare.

The Deal Ground was historically used as a timber yard in association with the nearby Colman's Works (which was sold to a developer in 2020) and contains hard-surfacing where previous industrial buildings have been removed at the northern end and along the western side, with the rest undeveloped and covered with self-seeded vegetation.

The May Gurney site is mostly covered with hardstanding remaining from removed industrial buildings, with an existing landscape/tree belt along the eastern boundary.

4.2 Trowse Depot

The south-western corner of the Deal Ground sits adjacent to rail sidings and a railhead which are part of an aggregates depot and asphalt plant, which is herein referred to as the Trowse Depot and currently operated by Tarmac. The location is shown below.

Figure 4 – Aerial photograph showing the location of the Trowse Depot © Google 2023

In 2011 Norfolk County Council granted full planning permission for the continued use of Trowse Depot for storage/distribution of aggregates, and for asphalt manufacture, with no defined end date (Norfolk County Council planning reference C/4/2010/4003). Several conditions were also attached to the planning approval, including some which are relevant to the assessment documented in this report, as follows:

- Condition 3 required the installation of a *"solid boundary treatment of 2.5m in height or as high as the existing boundary treatment, whichever is the higher… along the eastern boundary of the site"*. From our various site inspections and surveys of the site this appears to be a solid concrete wall 2.5 m high.
- Condition 7 stipulates that no operations covered by the approval shall take place on Sundays or public holidays, or other than during the following periods:
  - 05:00 hrs – 17:00 hrs Monday to Saturday.

  No bitumen deliveries or collections are permitted before 07:00 hrs on any day.
- Condition 8 sets noise emissions for the site, which currently apply as follows:
  - 50 dB $L_{Aeq,12\ hours}$ and 55 dB $L_{Aeq,1\ hour}$ between 07:00 - 17:00 hrs Monday to Saturday and 50 dB $L_{Aeq,1\ hour}$ at any other time, when measured at the southern boundary of the site.
  - 67 dB $L_{Aeq,12\ hours}$ and 73 dB $L_{Aeq,1\ hour}$ between 07:00 - 17:00 hrs Monday to Saturday and 63 dB $L_{Aeq,1\ hour}$ at any other time, when measured 1 m inside the eastern boundary of the southern yard.
  - 75 dB $L_{Aeq,12\ hours}$ and 78 dB $L_{Aeq,1\ hour}$ between 07:00 - 17:00 hrs Monday to Saturday, when measured 1 m inside the eastern boundary of the northern yard.
- Condition 9 requires that any current or replacement plant must be enclosed with sound insulation material in accordance with a scheme to be agreed in writing with the County Planning Authority prior to the installation of said plant.

We also understand that a temporary variation of the ongoing planning approval was permitted in April 2017 to extend the operational hours of the Trowse Depot to support the construction of the Norwich Distributor Road (NDR), but that this ended at the end of 2018, after which the previous hours restrictions then came back into effect.

Further details regarding significant noise-generating operations at the site, and the typical noise emissions associated with those operations, are provided in Section 6.2.

4.3 Trowse Rail Bridge

Trowse Bridge is a single-track swing railway bridge which was reconstructed in 1987 to carry the electrified Great Eastern Main Line over the River Wensum.

The bridge is of steel construction, and it was identified during the noise assessments carried out for the outline planning application for the Deal Ground development that the bridge produces a loud clattering sound when trains pass over it. Further details of our measurements of trains passing over the rail bridge are provided in Section 6.3.

The location of Trowse Rail Bridge is indicated in the aerial photograph in Figure 5 and the rail bridge is seen from the north-west corner of the site in the photo in Figure 6.

Figure 5 – Annotated aerial photograph of Trowse Rail Bridge Location © Google 2023

Figure 6 – Photograph of Trowse Rail Bridge taken from north-west corner of the site

4.4 Crown Point Depot

Crown Point Depot is a train maintenance depot, constructed in 1982 and refurbished in 2018. It is located on the northern bank of the River Wensum, approximately 100m from the south bank of the River Wensum (i.e. the northern development boundary).

The location of Crown Point Depot relative to the development site is shown below.

Figure 7 – Aerial photograph showing location of Crown Point Depot © Google 2023

5 DESCRIPTION OF THE PROPOSED DEVELOPMENT

As described in Section 4, the proposed development can generally be considered in terms of three main areas:

- The northern section, known as Wensum Riverside (or Wensum Edge);
- The middle section, alongside the Trowse Depot and the County Wildlife Site, known as Marsh Reach (or Fen Village); and
- The southern section, known as May Gurney (or Yare Newton).

The development is residential led and most of the commercial uses would form part of a new public square and dining quarters within the Wensum Riverside area, though the May Gurney area would include a commercial unit. There would also be green open space, children's play areas, and new pedestrian/cycle bridges across the river.

Further details of the main development areas are provided in turn below.

5.1 Description of Wensum Riverside development area

The Wensum Riverside development area, whilst residential led, includes the largest commercial component. The new public square and dining quarters would be in the north-west corner of this area, closest to the Trowse Rail Bridge. Some of the buildings in this area would be up to eight storeys high - the tallest buildings in the development.

The commercial uses in this area would be on the ground floor of these buildings, with residential units situated on the floors above. Figure 8 shows where the blocks with commercial units would be located (shown in red). Common areas/ancillary facilities are shown in grey, and all other areas are buildings that would just be residential use.

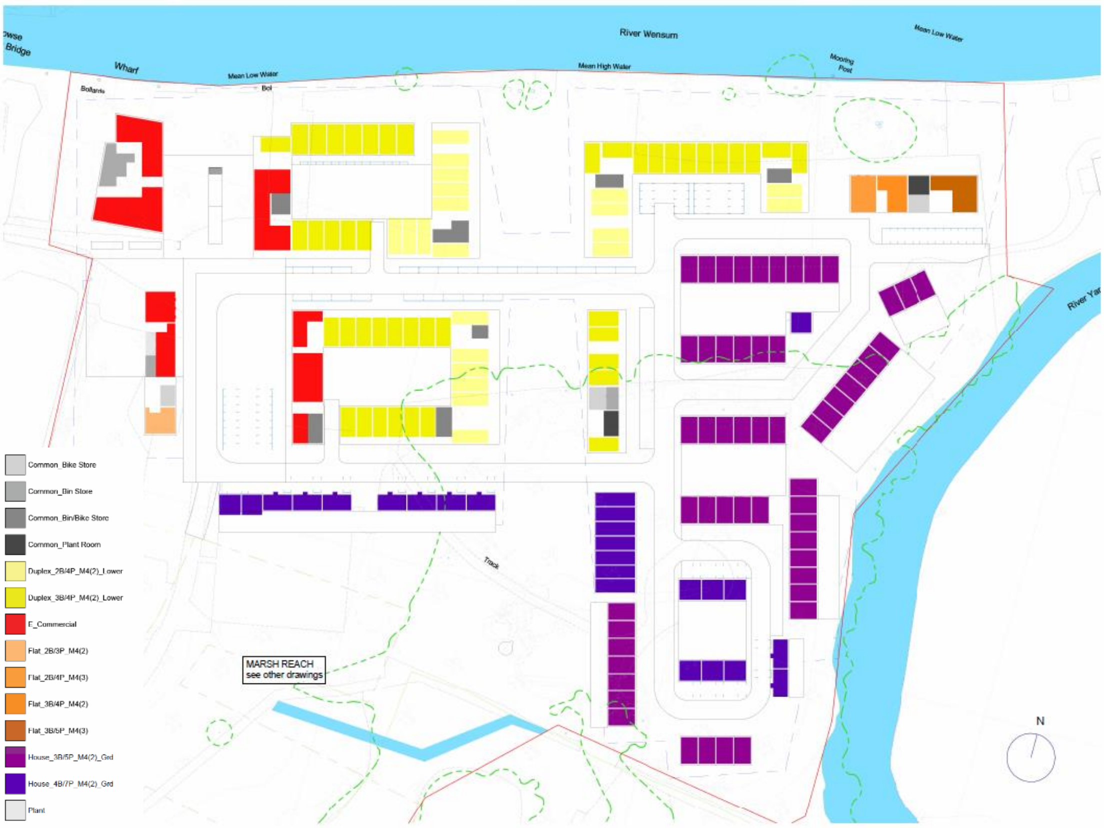

Figure 8 – Extract from Wensum Riverside Unit Plan

The larger blocks in the Wensum Riverside area would be numbered, and it is relevant to note this numbering as some of these blocks are specifically referred to in this assessment. An extract of the Overall Sketch Plan showing this is shown in Figure 9.

Figure 9 – Extract from Overall Sketch Plan showing Wensum Riverside area

Figure 10 shows the building massing area of this area, seen from across the River Wensum to the north. It can be seen from this where the tallest buildings would be along the river edge and in the north-west corner of the Wensum Riverside area.

Figure 10 – Extract from Massing Plan showing building heights in Wensum Riverside

Figure 11 is an extract from the proposed Building Heights drawings, showing in more detail the specific height of buildings proposed in the Wensum Riverside area.

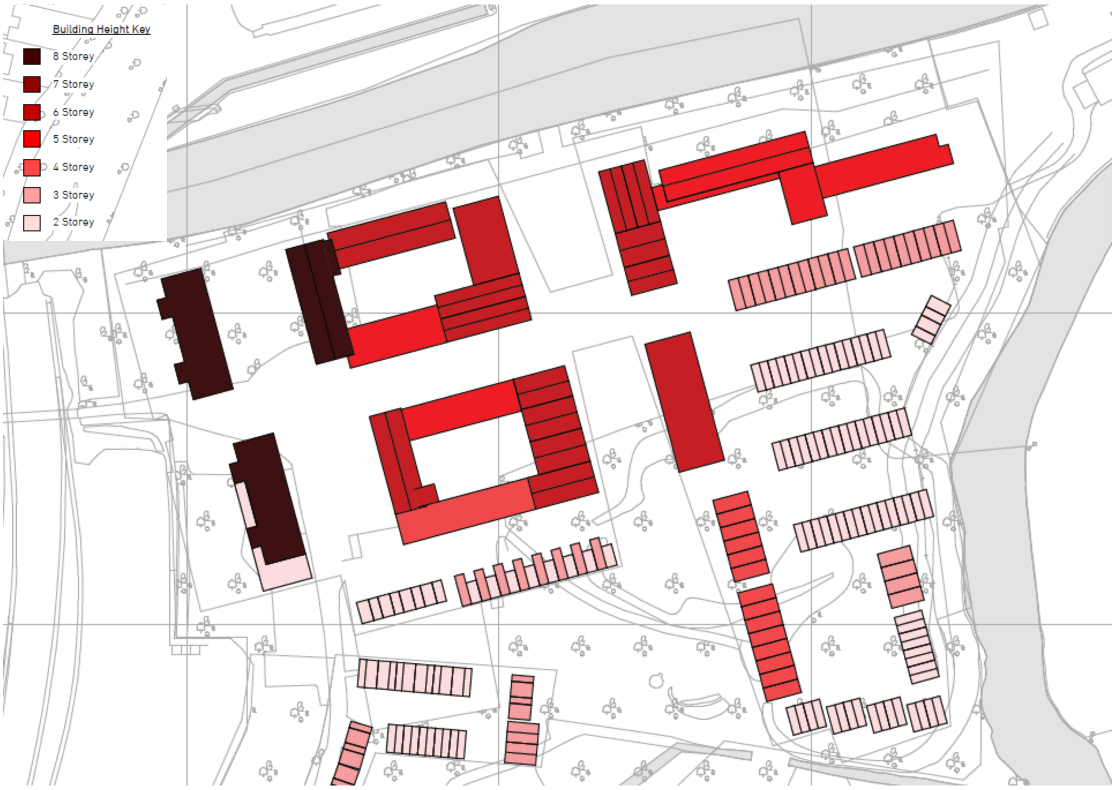

Figure 11 –Building Heights plan showing Wensum Riverside building heights

5.2 Description of Marsh Reach development area

The Marsh Reach development area would be entirely comprised of residential units and associated ancillary facilities. Residents living in the south-west corner of this area would be those closest to the Trowse Depot (as discussed in Section 5.2 of this report).

Building heights would also be much lower than in the Wensum Riverside area, with all buildings being between 2-3 storeys. This is shown in Figure 12 and Figure 13.

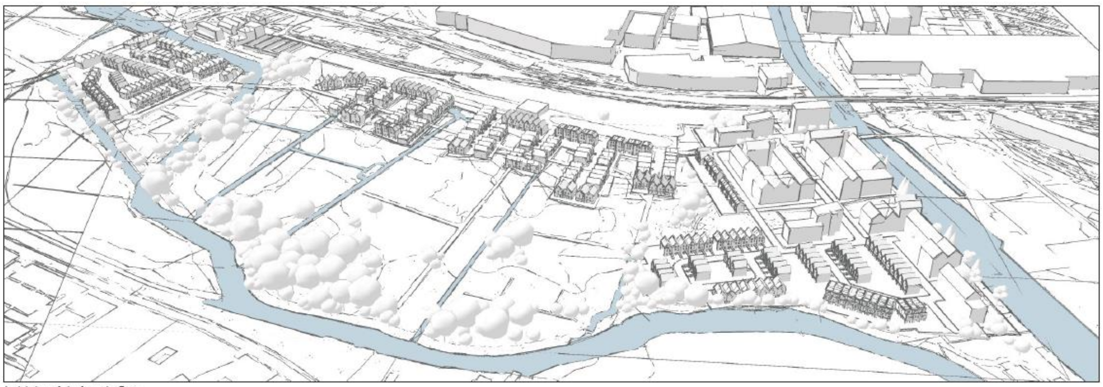

Figure 12 – Extract from Massing Plan showing building heights in Marsh Reach area

Figure 13 – Building Heights plan showing Marsh Reach building heights

5.3 Description of May Gurney development area

The May Gurney development area would also be mostly residential led, although the most southerly block nearest to the road (Bracondale) would have a commercial unit situated on the ground floor, with residential units above. The proposed building uses for the May Gurney development area are shown in the Unit Plan in Figure 14.

All the buildings within this area would be two storeys high, as shown in Figure 15.

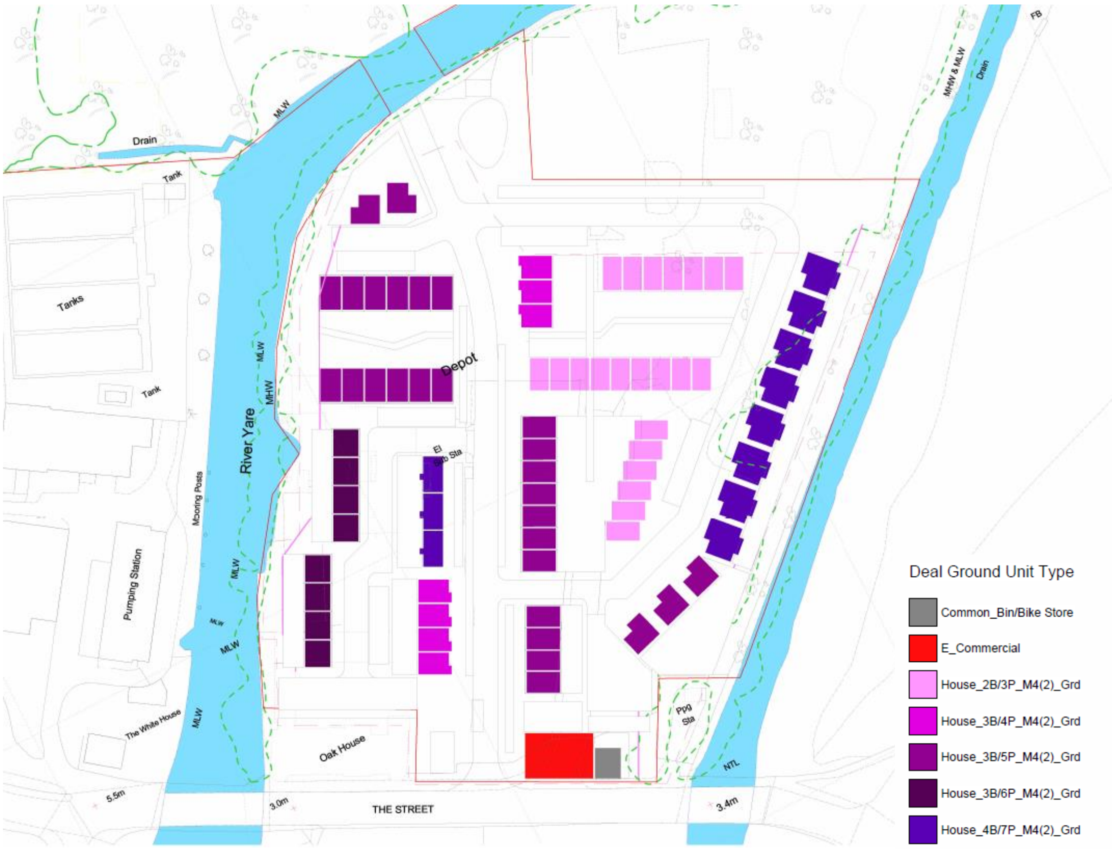

Figure 14 – Extract from May Gurney Unit Plan

Figure 15 – Building Heights plan showing May Gurney building heights

6 SITE NOISE SURVEY

6.1 Introduction

We carried out two noise surveys on the development site as part of this assessment.

The first was an attended noise survey at Trowse Depot to measure noise levels at the location of the nearest proposed residential building to the railhead during a delivery.

The second was an unattended noise survey at three locations around the west and north site boundaries to measure typical ambient and maximum noise levels from all relevant sources, but particularly from rail activity on the Great Eastern Main Line to the west, Trowse Rail Bridge to the north-west, and at Crown Point Depot to the north.

Each of these surveys is discussed in turn below in Sections 6.2 and 6.3, respectively.

6.2 Attended survey

6.2.1 Survey methodology

Following discussions with a representative of Tarmac who helped us to coordinate the survey to align with a typical aggregates delivery, we carried out an attended noise survey between approximately 07:00 hrs and 12:00 hrs on Wednesday 15 March 2023.

We measured at a single position representative of the nearest façade of the nearest proposed residential building in the south-west corner of the Marsh Reach area.

Figure 16 – Attended measurement position relative to Trowse Depot southern yard

A photograph of the measurement position looking west towards Trowse Depot (with the boundary wall, mechanical conveyor, and asphalt plant visible) is shown below.

Figure 17 – Photograph of attended measurement position P1 looking to the west

Details of the measurement instruments and calibration are provided in Appendix B.

Measurements were taken in the free field, with the microphone installed on a tripod approximately 1.2 m above ground height. This location (and the nearest proposed residential façade) was approximately 40 m from the east boundary or Trowse Depot.

6.2.2 Weather conditions

It was cold during the survey, particularly early on, with average temperatures ranging between approximately -1°c at 07:00 hrs and 8°c at 12:00 hrs. Temperature inversion effects can sometimes occur during very cold conditions, but this tends to only affect sound propagation over relatively long distances (>1 km) so was unlikely in this case.

Average wind speeds ranged from 3-5 m/s which is suitable for acoustic measurement.

There was no rain, with some fog during the early hours, clearing through the morning.

6.2.3 General observations

When we started our measurements at around 07:15 hrs there was no train present but the mechanical conveyor (which carries aggregates deposited at the railhead to the storage areas) was already running. This provided an opportunity to measure the typical noise levels from the conveyor in isolation (which are reported in Table 4).

The asphalt delivery started at approximately 09:00 hrs and this continued until around 11:45 hrs when we ended our survey. The train sounded its horn on approach, and then 8 cars of asphalt were unloaded at the railhead. The aggregates were deposited from the bottom of each car and carried on the conveyor to the storage area. There were a further 9 cars to be unloaded at the point we ended our survey, but we expected the noise levels from this to be very similar to the first 8 cars we measured.

Generally speaking, the delivery we measured was not particularly loud as the trains were very slow moving and the stockpiles onto which the asphalt were deposited were already somewhat full, so no material was deposited directly onto the hardstanding.

Some photographs taken during the delivery are shown in Figure 18 and Figure 19.

Figure 18 shows the diesel locomotive reversing along the sidings into the railhead, shunting the first 8 cars into position ready to be unloaded.

Figure 18 – Photograph of diesel locomotive shunting cars into position for delivery

Figure 19 shows some of the first 8 cars in position at the railhead during the delivery. When this photo was taken, a steady flow of asphalt was moving along the conveyor, and the hopper emptying material onto the stockpile from the conveyor can be seen.

Figure 19 – Photograph of cars at railhead during delivery and hopper dropping asphalt

6.2.4 Measurement results

The A-weighted maximum, minimum, average and background sound levels measured between 07:15 - 08:45 hrs are summarised in Table 4. The ambient and background sound levels during this period were typically dictated by the mechanical conveyor (as is evident from the relative consistency between the measured $L_{Aeq,15min}$ and $L_{AF90,15min}$).

Maximum sound levels during this period were dictated by a range of sources including trains on the Great Eastern Main Line, activity at Trowse Depot, and nature (birdsong).

Start time	End time	Maximum sound pressure level	Minimum sound pressure level	Average sound pressure level	Background sound pressure level
(hh:mm:ss)	(hh:mm:ss)	(dB L_{AFmax})	(dB L_{AFmin})	(dB $L_{Aeq,15min}$)	(dB $L_{AF90,15min}$)
07:15:50	07:30:50	67.6	56.4	59.4	58.2
07:30:50	07:45:50	68.0	57.0	59.1	58.1
07:45:50	08:00:50	64.5	54.2	58.4	56.0
08:00:50	08:15:50	71.1	53.6	56.5	54.7
08:15:50	08:30:50	61.8	53.6	55.3	54.5
08:30:50	08:45:50	73.0	53.7	56.1	54.8

Table 4 – Measured sound levels from conveyor only at attended position P1

The 1/1 octave-band and overall A-weighted average sound levels from the conveyer was also calculated from the logarithmic average of all the 15-minute measurements.

Linear average sound pressure level at 1/1 octave-band centre frequency, dB $L_{Aeq,15min}$									Overall dB $L_{Aeq,15min}$
63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	
66.6	62.5	53.0	56.8	53.0	46.2	40.9	31.8	21.3	57.6

Table 5 – 1/1 octave-band average sound levels from conveyer at position P1

The A-weighted maximum, minimum, average and background sound levels measured between 09:01 - 11:46 hrs are summarised in Table 4. The ambient and background sound levels were typically dictated by sources associated with the aggregate delivery at the railhead, i.e. diesel locomotive engines, cars being shunted in and out of position, materials being deposited onto and from the conveyor, and the conveyor itself running.

Maximum sound levels during this period were dictated by a range of sources, some of which were associated with the delivery (notably including a train horn producing a maximum sound level of 78 dB L_{AFmax}) and some of which were not, including noise trains on the Great Eastern Main Line, activity at Trowse Depot, and nature (birdsong).

Start time	End time	Maximum sound pressure level	Minimum sound pressure level	Average sound pressure level	Background sound pressure level
(hh:mm:ss)	(hh:mm:ss)	(dB L_{AFmax})	(dB L_{AFmin})	(dB $L_{Aeq,15min}$)	(dB $L_{AF90,15min}$)
09:01:32	09:16:32	67.3	54.3	57.9	56.2
09:16:32	09:31:32	77.9	56.6	58.9	57.6
09:31:32	09:46:32	68.7	56.8	58.9	57.7
09:46:32	10:01:32	70.4	56.9	59.3	58.2
10:01:32	10:16:32	66.5	56.1	58.2	57.2
10:16:32	10:31:32	71.3	55.7	58.4	57.0
10:31:32	10:46:32	69.2	55.0	57.8	56.5
10:46:32	11:01:32	68.1	55.0	57.4	56.1
11:01:32	11:16:32	71.0	52.2	58.3	56.6
11:16:32	11:31:32	70.7	55.2	59.2	56.6
11:31:32	11:46:32	67.2	54.5	57.3	55.8

Table 6 – Measured sound levels from delivery activity at attended position P1

The 1/1 octave-band and overall A-weighted average sound levels during the delivery was also calculated from the logarithmic average of all the 15-minute measurements.

Linear average sound pressure level at 1/1 octave-band centre frequency, dB $L_{Aeq,15min}$									Overall dB $L_{Aeq,15min}$
63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	
64.8	65.4	61.6	51.8	54.3	53.6	50.0	52.2	39.6	58.9

Table 7 – 1/1 octave-band average sound levels from delivery activity at position P1

6.3 Unattended noise survey

6.3.1 Survey methodology

Our unattended noise survey involved noise monitors at three locations around the west and north boundaries of the site, primarily with the aim of measuring typical sound levels from trains on the Great Eastern Main Line passing over Trowse Rail Bridge and along the track parallel with the western site boundary, but also to measure any noise produced by Crown Point Rail Depot and identify any other significant noise sources.

The three measurement positions are identified as follows:

- U1 – In the north-western corner of the site, approximately 40 m from the bridge
- U2 – Along the northern site boundary, adjacent to the river and approximately 150 m from Crown Point Rail Depot (we consulted Network Rail prior to the survey to confirm that the depot would be operating typically during the survey).
- U3 – On the western site boundary, adjacent to the northern yard of Trowse Depot and approximately 50 m to the east of the Great Eastern Main Line.

An annotated aerial photo of the unattended survey locations is shown in Figure 20.

Figure 20 – Aerial photo showing unattended measurement positions © Google 2023

Details of the measurement instruments and calibration are provided in Appendix B.

Measurements were taken in the free-field conditions. At U1 and U2 the microphone was installed on a floor stand approximately 1.2 m above local ground height. At U3 the microphone was fixed to a fence on the boundary, approximately 1 m above the top of the fence and with a line of sight to both the northern yard and railway lines.

6.3.2 Weather conditions

Weather data for the unattended survey was taken from published data from Norwich Weather Centre (via https://www.timeanddate.com/weather/uk/norwich/historic).

Weather conditions were generally considered suitable for acoustic measurement with average temperatures typically ranging between -2°C and 17°C and very little rainfall.

The exception was during the day on Saturday 1 April when there was some heavy rain, but this did not seem to significantly affect the measured sound levels due to the dominance of railway sources unaffected by the rain (as described in Section 6.3.3).

Temperature inversion effects can sometimes occur during very cold conditions, but this tends to only affect sound propagation over relatively long distances (>1 km) so was unlikely to be an issue here as the dominant sound sources were closer than this.

Average wind speeds did not typically exceed 5 m/s during the survey.

6.3.3 General observations

Ambient and maximum sound levels at all three unattended measurement positions were typically dominated by train noise, with trains passing over Trowse Rail Bridge being by far the dominant noise source – particularly at position U1. Other significant sources of ambient noise included occasional vehicles associated with the sailing club to the east (which is accessed through the site), aircraft, and natural sounds (birdsong).

From analysis of the audio and statistical data we also identified several train horns at night, especially at U3. Distant plant noise was sometimes identified in the early morning at U3 which we consider likely to be from the conveyor and/or asphalt plant at Trowse Depot. Very little other activity associated with Trowse Depot was identified.

Noise from Crown Point Depot was not distinctly audible at any position at any time. We consulted Network Rail prior to the survey to confirm that the depot would be operating typically during the survey, and our assessment is based on that assumption.

Measured ambient and maximum sound levels were highest at U1 and lowest at U3, which reflects the dominance of noise from trains passing over Trowse Rail Bridge.

6.3.4 Measurement results

The measured 16-hour daytime ($L_{Aeq,0700-2300hrs}$) and 8-hour night-time ($L_{Aeq,2300-0700hrs}$) average noise levels have been calculated and are summarised in Table 8.

Date	Daytime dB $L_{Aeq,0700-2300hrs}$			Night-Time dB $L_{Aeq,2300-0700hrs}$		
	U1	U2	U3	U1	U2	U3
30/03/2023	63.0	56.9	57.7	56.9	57.7	52.1
31/03/2023	61.7	57.3	56.4	57.3	56.4	53.4
01/04/2023	62.0	53.4	56.3	53.4	56.3	48.7
02/04/2023	61.2	58.9	54.9	58.9	54.9	53.0
03/04/2023	62.8	58.6	56.0	58.6	56.0	53.2
04/04/2023	62.1	58.4	56.0	58.4	56.0	52.8
05/04/2023	63.0	56.7	57.3	56.7	57.3	51.2
06/04/2023	62.8	58	56.3			
Logarithmic Average	62.2	57.5	56.2	57.5	56.2	52.3

Note: Periods in green were less than the complete 16-hours.

Table 8 – Summary of unattended noise measurement results

Maximum sound levels at night were typically dictated by trains on the Great Eastern Main Line, and particularly on the Trowse Rail Bridge (and occasional train horns).

In accordance with the WHO guidance that maximum noise levels should not normally exceed 45 dB L_{AFmax} in bedrooms more than 10-15 times per night, we have calculated the maximum sound level exceeded no more than 10 times per night on average.

Maximum sound level typically exceeded no more than 10 times per night (dB L_{AFmax})		
U1	U2	U3
82	76	71

Table 9 - Maximum sound level typically exceeded no more than 10 times per night

7 NOISE MODELLING

7.1 Noise modelling methodology

We created a 3D noise model using CadnaA software to predict sound propagation around the site from each significant noise source. The calculation methodology from ISO 9613-2 *'Attenuation of sound during propagation outdoors'* was adopted for this.

ISO 9613-2 sets out an engineering method for calculating the attenuation of sound during propagation outdoors to predict downwind environmental noise levels at distance from a variety of sources. As well as accounting for the distance between each source and receiver, the ISO 9613-2 method also includes the following factors:

A. Geometrical divergence, A_{div}

Accounts for spherical spreading in the free field from a point sound source.

B. Atmospheric absorption, A_{atm}

Depends primarily on the frequency of the sound, the ambient temperature and relative humidity of the air.

C. Ground effect, A_{gr}

Mainly the result of sound reflected by the ground surface interfering with the sound propagating directly from source to receiver.

D. Screening by obstacles, A_{bar}

Screening obstacles (often called barriers) must have a closed surface (without large cracks or gaps) and have a surface density of at least 10 kg/m^2.

E. Reflections

Reflections off horizontal or vertical surfaces (such as the facades of buildings) which can increase the sound pressure levels at the receiver.

F. Meteorological correction, C_{met}

Only applied where local meteorological conditions vary from those which are favourable to propagation for several months or a year. This is rarely applied.

ISO 9613-2 has a calculation tolerance of +/- 3 dB.

Table 10 sets out the main configuration settings from our CadnaA model which define the correction factors applied according to the ISO 9613-2 calculation method.

Atmospheric absorption	Ambient temperature	10 °C
	Relative humidity	70 %
Ground effect	Default ground absorption	1.00 (soft ground)
	Roads and hardstanding	0.00 (hard ground)
Surface reflection and absorption	Concrete barriers (Trowse Depot)	Absorption coefficient: 0.00
	Buildings	Absorption coefficient: 0.00
	Number of reflections calculated	5

Table 10 – ISO 9613-2 correction configurations applied in the CadnaA model

7.2 Input data and calibration

7.2.1 Trowse Depot

Noise sources associated with Trowse Depot were calibrated based on the attended survey results summarised in Section 6.2. 1/1 octave-band spectra and A-weighted levels were input based on the measurement data at A1 for the following scenarios:

A. Conveyor only (before 07:00 hrs, dB $L_{Aeq,T}$)

B. Conveyor and typical delivery activities (after 07:00 hrs, dB $L_{Aeq,T}$)

7.2.2 Trowse Rail Bridge

Based on the survey results summarised in Section 0, maximum rather than average sound levels from trains passing over Trowse Rail Bridge are most likely to dictate the potential noise impact (and therefore the acoustic design of noise-sensitive buildings).

A typical train pass event on the bridge was input as a point source and calibrated to the typical night-time maximum sound level exceeded no more than 10 times per night at each unattended measurement position. The calibration was precisely accurate at position U1 and within 0.5 dB at the other two unattended positions (U2 and U3).

7.2.3 Road traffic noise

Road traffic noise on Bracondale and The Street was calculated using the methodology set out in the 1988 Department for Transport (Welsh Office) document 'Calculation of Road Traffic Noise' (CRTN) based on future traffic flow projects provided by Odyssey:

	18hr AADT (vehicles)		HGV%		Average Speed (mph)	
	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
			2023			
Bracondale (west of Site Access)	1944	1832	11%	10%	30.6	28.9
The Street (east of Site Access)	1944	1803	12%	7%	24.8	24.9
			2036			
Bracondale (west of Site Access)	2203	2076	11%	10%	-	-
The Street (east of Site Access)	2202	2043	12%	7%	-	-
			Development			
Bracondale (west of Site Access)	1538	1471	0%	0%	-	-
The Street (east of Site Access)	46	0	0%	0%	-	-
			2036 + Development			
Bracondale (west of Site Access)	3741	3547	11%	10%	-	-
The Street (east of Site Access)	2249	2043	12%	7%	-	-

Figure 21 – Future traffic flow projection data provided by Odyssey

Road traffic noise is a secondary element of the assessment (as it is not considered a planning requirement) so was not included in our survey. The typical road traffic noise spectrum given in BS EN 1793-3 'Road traffic noise reducing devices' (1998) was therefore used to calibrate the model, as per the guidance in Section 6.2.1 of BS 8233.

7.2.4 Development layout

Once the model was accurately calibrated for each of the relevant noise sources as described above, we then added the proposed development layout (including buildings and roads) to the model using the development drawings in Table 1 of this report.

7.3 Results

Noise maps of the predicted sound propagation around the proposed development for each of the three scenarios described in Section 7.2 are provided in Appendix C.

8 ACOUSTIC DESIGN ASSESSMENT

8.1 Objectives

The development should provide the best practicable standards of acoustic amenity. *ProPG: Planning and Noise* (2017) recommends assessing four elements in parallel:

Element 1: Demonstrating a *"Good Acoustic Design Process"*

Element 2: Observing internal *"Noise Level Guidelines"*

Element 3: Undertaking an *"External Amenity Area Noise Assessment"*

Element 4: Consideration of *"Other Relevant Issues"*

8.2 Element 1 – *"Good Acoustic Design"*

A preferred hierarchy of strategies constituting a *"Good Acoustic Design Process"* for mitigating noise impacts (and comments regarding this specific case) is set out below:

- **Reducing noise at source;**

  In this case there is limited scope for the developer to reduce noise at source, as the noise produced by each source is outside the control of the developer.

- **Providing *'buffer'* zones to limit noise exposure.**

  The proposed layout already includes buffer zones to limit the noise exposure, particularly for the Marsh Reach development area where there is a buffer zone of approximately 40 m between the boundary of Trowse Depot and the nearest proposed residential buildings. For Trowse Rail Bridge the setback distance to the nearest residential units is approximately 55 m. For road traffic noise, the nearest proposed residential building is relatively close (approximately 10 m) but this is only one residential unit above the commercial unit facing the road, and the next nearest residential units are approximately 30 m away, with most residential buildings in this area being substantially further away from the road.

- **Reducing noise propagation across site (e.g. through the use of barriers);**

  The potential for noise barriers in this case is inherently limited. For Trowse Rail Bridge, the barrier would need to be on the bridge itself to be effective at reducing noise levels at the upper floors of the nearest residential building, which is unlikely to be practicable. For Trowse Depot, there is already a 2.5 m high concrete barrier around the storage area (which is a planning requirement) and a much taller barrier on the development site is unlikely to be practicable and/or visually acceptable. For the May Gurney development area, a barrier would need to be tall and located along the edge of the road to be effective, which again is considered unlikely to be practicable and/or visually acceptable.

- **Developing the layout of the site to optimise acoustic protection (e.g. through the use of *'barrier'* blocks to help further limit noise propagation and the use of courtyard style development to protect external amenity areas);**

  The use of barrier blocks has already been considered in the proposed layout, particularly in the Wensum Riverside area, where the tall blocks nearest to the rail bridge would be very effective at reducing noise propagation to other blocks in this area (as can clearly be seen from the noise map in Figure 35). For the Marsh Reach area, the nearest residential buildings are relatively low density but would still provide screening to blocks further away, which is also the case for the May Gurney area (the nearest block would screen those further away).

- **Building orientation/internal arrangement (e.g. locating non habitable rooms on 'noisier' facades and sensitive areas on acoustically screened facades);**

  Considering the layout and general design principles of the development, it is unlikely to be practicable in this case to avoid having any habitable rooms on the most sensitive façades. This is not necessarily an issue provided that acceptable internal noise levels can still be achieved (see Section 8.3).

- **Providing sound insulation through appropriate specification of the external building envelope and providing alternative means of ventilation and/or cooling if acceptable internal noise levels cannot be achieved if windows are open.**

  Achieving acceptable acoustic amenity by relying on closed windows should always be the last option, and good acoustic design should be the priority. For the reasons above we consider that this applies here. Recommendations for external building envelope sound insulation are set out in Section 8.3.

8.3 Element 2 – Internal *"Noise Level Guidelines"*

8.3.1 Guideline internal noise criteria

Internal noise levels should meet the levels set out in Section 3 of this report.

These levels are summarised below:

- 35 dB $L_{Aeq,16hr}$ daytime
- 30 dB $L_{Aeq,8hr}$ night-time
- 45 dB $L_{AF,max}$ night-time (bedrooms only)

8.3.2 Building envelope sound insulation

Based on the noise survey results and modelling, we have calculated the minimum airborne sound insulation requirements of the external building envelope to reduce noise from the various dominant noise sources to acceptable internal levels. For Trowse Rail Bridge, the night-time L_{AFmax} is expected to dictate the overall building envelope requirements. For Trowse Depot and road traffic noise, the daytime and night-time average ($L_{Aeq,T}$) sound levels are likely to dictate the overall requirements.

Provided that acceptable internal sound levels are achieved for these parameters, it is expected that internal sound levels for other relevant parameters would be acceptable.

Quantitative sound reduction performance requirements are presented below as 1/1 octave-band sound reduction index (R) values. Specified products shall provide evidence of compliance in accordance with BS EN ISO 101040-2:2010 and shall be rated in general accordance with BS EN ISO 717-1:1998, or an approved equivalent.

Where available, we have used drawings to determine the exact dimensions of façades and internal spaces and have used these as the basis for the calculations. For other buildings/areas, we have used the following typical internal and external dimensions:

Living areas:

- Room dimensions – 4.0 m x 5.0 m x 2.5 m
- Façade area – 10.0 m^2
- Glazing area – 2.0 m^2

Bedrooms:

- Room dimensions - 3.5 m x 4.0 m x 2.5 m
- Façade area – 7.5 m^2
- Glazing area – 1.2 m^2

The recommended sound insulation measures should be applied as follows:

- **System 1** is to be applied to habitable rooms on façades highlighted in red. This has the most stringent acoustic requirements.
- **System 2** is to be applied to habitable rooms on façades highlighted in blue.
- **System 3** applies to all other façades with no coloured line.

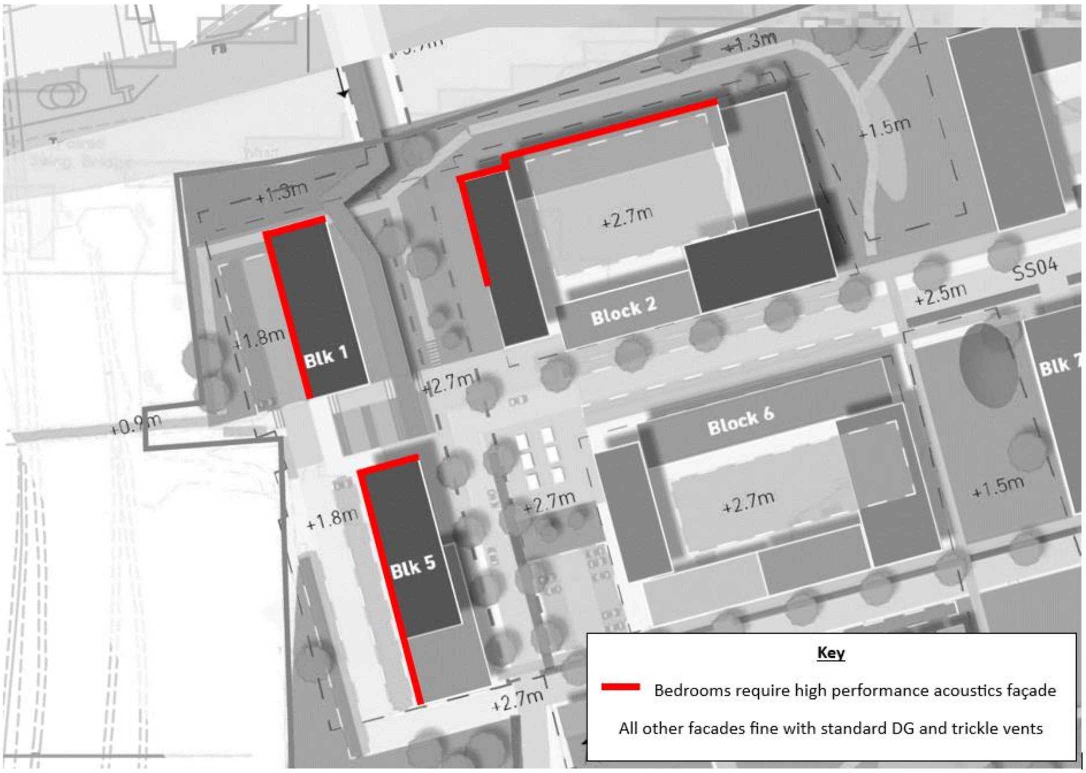

Figure 22 – Façades where System 1 building envelope sound insulation applies

Figure 23 – Façades where System 1 building envelope sound insulation applies

Note: Building envelope recommendations for Marsh Reach assume that the dominant noise source (Trowse Depot) is present through the entire 16-hour day/8-hour night-time assessment period. This will not be the case, so this is considered to provide robust protection.

8.3.3 External wall constructions

External facades must achieve the minimum sound reduction (R) values in Table 11.

<table>
<tr><th rowspan="2">System</th><th rowspan="2">Element</th><th colspan="8">Linear 1/1 Octave-Band Centre Frequency, Hz</th><th rowspan="2">R_w</th></tr>
<tr><th>63</th><th>125</th><th>250</th><th>500</th><th>1000</th><th>2000</th><th>4000</th><th>8000</th></tr>
<tr><td>1</td><td rowspan="3">Façade
Minimum R, dB</td><td>37</td><td>41</td><td>45</td><td>45</td><td>54</td><td>58</td><td>60</td><td>60</td><td>52</td></tr>
<tr><td>2</td><td rowspan="2">14</td><td rowspan="2">17</td><td rowspan="2">31</td><td rowspan="2">40</td><td rowspan="2">48</td><td rowspan="2">46</td><td rowspan="2">56</td><td rowspan="2">56</td><td rowspan="2">40</td></tr>
<tr><td>3</td></tr>
</table>

Table 11 - Recommended minimum R values for facade walls of proposed buildings

In practice, the System 1 performance in Table 11 should be easily achievable using any typical masonry cavity constructions (e.g. brick/cavity/block or block/cavity/block) but would also be achievable using acoustically enhanced lightweight constructions.

For Systems 2 and 3, most lightweight constructions should be sufficient. Ultimately, any type of wall construction can be used provided it achieves the target performance.

8.3.4 Roof

To ensure the roof is not a weakness in the building envelope, we recommend that the roof construction (including loft space) combined with ceilings to all habitable rooms achieve an overall weighted sound reduction index (SRI) matching that of the façades.

8.3.5 Glazing

We expect the recommended internal noise levels should be achievable in living rooms and bedrooms when windows are closed provided that the glazing achieves the minimum 1/1 octave-band sound reduction values shown in Table 12.

<table>
<tr><th rowspan="2">System</th><th rowspan="2">Element
(minimum R, dB)</th><th colspan="8">Linear 1/1 Octave-Band Centre Frequency, Hz</th><th rowspan="2">R_w</th></tr>
<tr><th>63</th><th>125</th><th>250</th><th>500</th><th>1000</th><th>2000</th><th>4000</th><th>8000</th></tr>
<tr><td rowspan="2">1</td><td>Bedroom windows</td><td>22</td><td>27</td><td>29</td><td>36</td><td>41</td><td>42</td><td>52</td><td>58</td><td>39</td></tr>
<tr><td>Living area windows</td><td rowspan="5">18</td><td rowspan="5">24</td><td rowspan="5">20</td><td rowspan="5">25</td><td rowspan="5">35</td><td rowspan="5">38</td><td rowspan="5">35</td><td rowspan="5">38</td><td rowspan="5">31</td></tr>
<tr><td rowspan="2">2</td><td>Bedroom windows</td></tr>
<tr><td>Living area windows</td></tr>
<tr><td rowspan="2">3</td><td>Bedroom windows</td></tr>
<tr><td>Living area windows</td></tr>
</table>

Table 12 - Recommended minimum R values for windows

The R values for System 1 bedrooms should be achievable with acoustically upgraded double glazing (our calculations were based on 10-12-6.4mm (PVB laminate) glazing).

The R values for all other glazing should be achievable using standard thermal double glazing, but ultimately any glazing can be used that achieves the minimum values.

8.4 Ventilation

8.4.1 General principles

It is beyond the scope of our appointment to assess the suitability and/or adequacy of ventilation methods, including overheating relief, which should be the responsibility of a suitably qualified mechanical engineer. We have therefore set out general acoustic principles for façade ventilation and can advise on detailed proposals if required.

Whole-dwelling ventilation (as defined in Part F of The Building Regulations but often referred to as background ventilation) is typically provided by either passive (i.e. trickle ventilators) or mechanical (i.e. Mechanical Ventilation with Heat Recovery) means.

If passive (i.e. trickle through frame and/or through wall) vents are used, then then the acoustic performance of these vents also needs to be considered. This is discussed in Section 8.4.2. If mechanical background ventilation is used, then there is less potential for noise break-in via ventilation apertures, although internally generated ventilation noise might need to be considered (this is discussed in Section 8.4.4).

Windows should typically always be openable for rapid or purge ventilation. Residents would not normally prioritise noise control over purge ventilation, but if windows need to remain open for extended periods for rapid ventilation and/or to prevent overheating, then other ventilation/cooling methods (e.g. mechanical ventilation) may be required.

In many areas of the site (particularly along the northern and western and southern boundaries where façades would be most exposed to the highest sound levels), the internal criteria would not be achieved with windows open assuming a reduction of approximately 15 dB(A) across a typical partially open window (per BS 8233 guidance).

It will therefore be important that whatever ventilation method is used, it provides adequate ventilation during rapid ventilation conditions and that habitable rooms in areas most exposed to noise are not at significant risk of overheating (which might result in residents being forced to open windows at the expense of acoustic amenity). Overheating noise risk and relevant advice are discussed in Section 8.4.5 of this report.

8.4.2 Passive whole-dwelling ventilation

Passive ventilators should provide the below minimum values in in the *'open'* position:

<table>
<tr><th>System</th><th>Location</th><th>1 no. ventilator</th><th>2 no. ventilators</th><th>3 no. ventilators</th><th>4 no. ventilators</th></tr>
<tr><td rowspan="2">1</td><td>Bedroom</td><td>44</td><td>47</td><td>49</td><td>50</td></tr>
<tr><td>Living area</td><td rowspan="3">35</td><td rowspan="3">38</td><td rowspan="3">40</td><td rowspan="3">41</td></tr>
<tr><td rowspan="2">2</td><td>Bedroom</td></tr>
<tr><td>Living area</td></tr>
<tr><td rowspan="2">3</td><td>Bedroom</td><td>31</td><td>34</td><td>36</td><td>37</td></tr>
<tr><td>Living area</td><td>28</td><td>31</td><td>33</td><td>34</td></tr>
</table>

Table 13 – Recommended minimum $D_{ne,w}$ values for habitable rooms

The highest passive ventilator performance values (System 1 bedrooms) should be achievable using high-performance acoustic ventilators (our calculations were based on manufacturer's data provided by Greenwood). System 1 living areas and all System 2 areas) should be achievable using acoustically upgraded ventilators (our calculations were based on a Titon SF3300 ventilator with canopy and 25mm spacer). System 3 (all other areas) should be achievable using standard (hit and miss) trickle ventilators.

Ultimately, any passive ventilator can be used if it achieves the minimum performance.

8.4.3 Mechanical whole-dwelling ventilation

Mechanical ventilation may be used, such as an MVHR system with attenuated intake and outlet ducts or through-wall acoustically attenuated air supply units, such as the Titon Sonair F+. This would probably require further acoustic specification depending on the system chosen and we can provide further guidance on this matter if required.

8.4.4 Noise levels from mechanical whole-dwelling ventilation

Approved Document F of the Building Regulations (ADF) suggests (not requires) that ambient sound levels in habitable rooms should not exceed 30 dB $L_{Aeq,T}$ with mechanical ventilation (if required) operating at the *'whole dwelling'* ventilation rate.

The AVO Guide suggests that indoor ambient noise levels from mechanical services running in various ADF ventilation conditions should comply with the limits in Table 14.

Based on the AVO guidance, the recommended internal ambient noise level (IANL) and estimated NR values for ADF mechanical ventilation systems are provided below.

ADF Ventilation condition	Possible ADF system or design solution	Desirable internal ambient noise level from mechanical ventilation	Desirable NR level from mechanical ventilation
Whole Dwelling Ventilation	System 3: MEV, minimum low ventilation rates System 4: MVHR, minimum low ventilation rates	Bedrooms: ⩽ 26 dB $L_{Aeq,T}$ Living Rooms: ⩽ 30 dB $L_{Aeq,T}$	Bedrooms: ⩽ NR 20 dB Living Rooms: ⩽ NR 24 dB
Extract Ventilation	System 1: Intermittent extract fans System 3: MEV, minimum high ventilation rates System 4: MVHR, minimum high ventilation rates	Bedrooms: ⩽ 30 dB $L_{Aeq,T}$ Living / Dining Rooms: ⩽ 35 dB $L_{Aeq,T}$ Bathroom / WC / Kitchen: ⩽ 45 dB $L_{Aeq,T}$	Bedrooms: ⩽ NR 24 dB Living / Dining Rooms: ⩽ NR 29 dB Bathroom / WC / Kitchen: ⩽ NR 39 dB
Purge Ventilation	Manually controlled fan exchanging at least 4 air changes per hour	No desirable noise levels are currently recommended	No desirable noise levels are currently recommended

Note 1 – NR limits assume that $L_{Aeq,T}$ = 6 = NR in the absence of strong low frequency noise

Table 14 – AVO Guide recommended noise limits for mechanical ventilation systems

8.4.5 Overheating

The AVO Guide recommends an initial *'site risk assessment'* to identify potential noise issues due to overheating. This is based on external noise levels and the assumption that opening windows would normally be the primary means of mitigating overheating.

Additionally, if external free-field maximum noise levels *"normally"* exceed 78 dB L_{AFmax} at night (between 23:00 hrs and 07:00 hrs), a Level 2 assessment is recommended. *"Normally"* is typically taken to be occurring more than 10-15 times during the night.

We used the CadnaA noise model (see Section 7) to identify areas where the AVO Guide recommends that a Level 2 assessment is recommended. These areas are shown in red in the noise maps presented in Figures 29 through 34.

In summary, these show that the areas/façades where acoustically upgraded building envelope sound insulation is recommended (see Figure 22 and Figure 23) are also the same general areas where a Level 2 assessment is recommended in the AVO Guide.

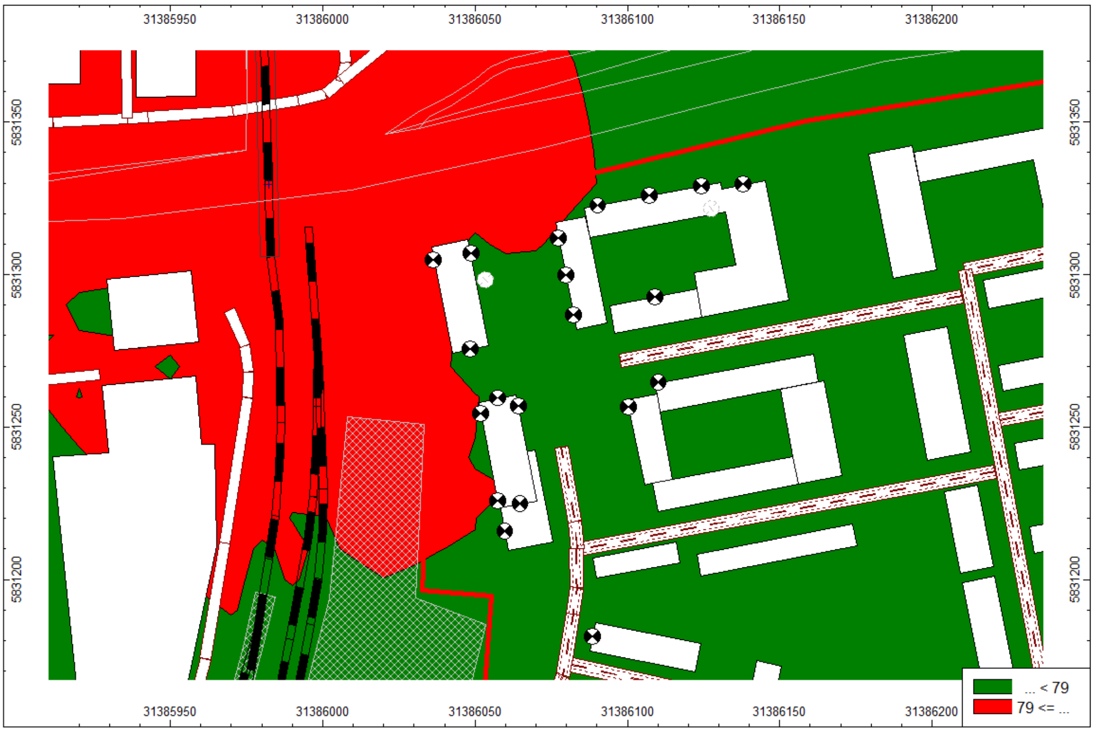

Figure 24 – Wensum Riverside: AVO Guide Level 2 assessment recommended

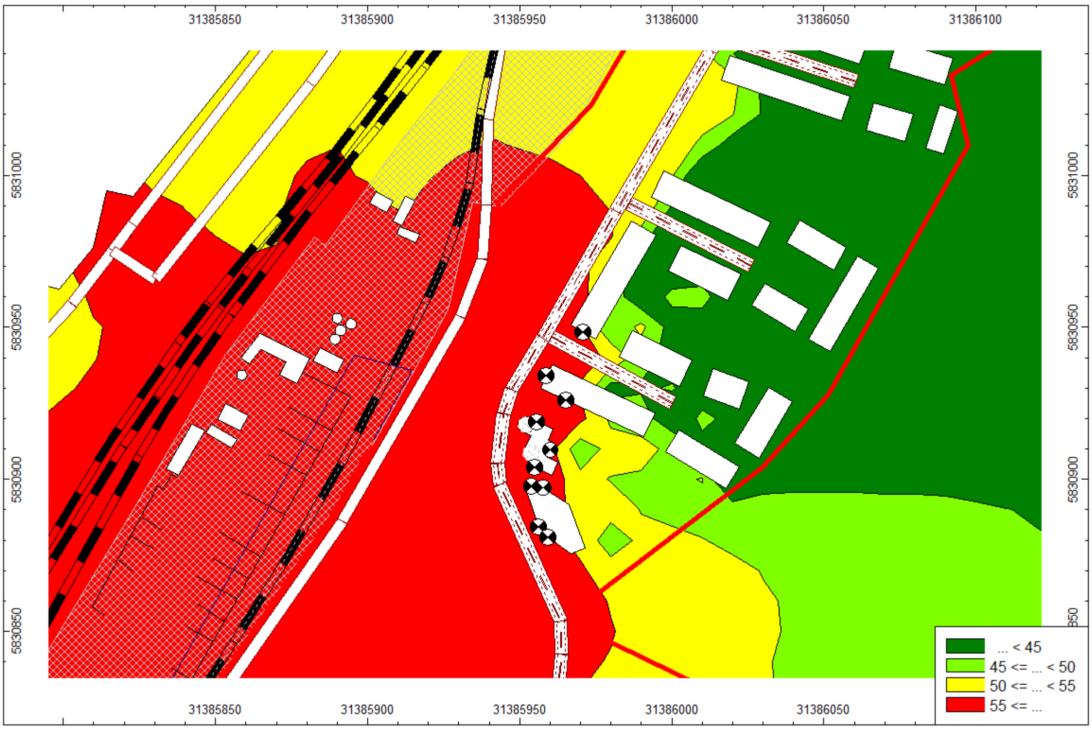

Figure 25 – Marsh Reach: AVO Guide Level 2 assessment recommended (conveyor)

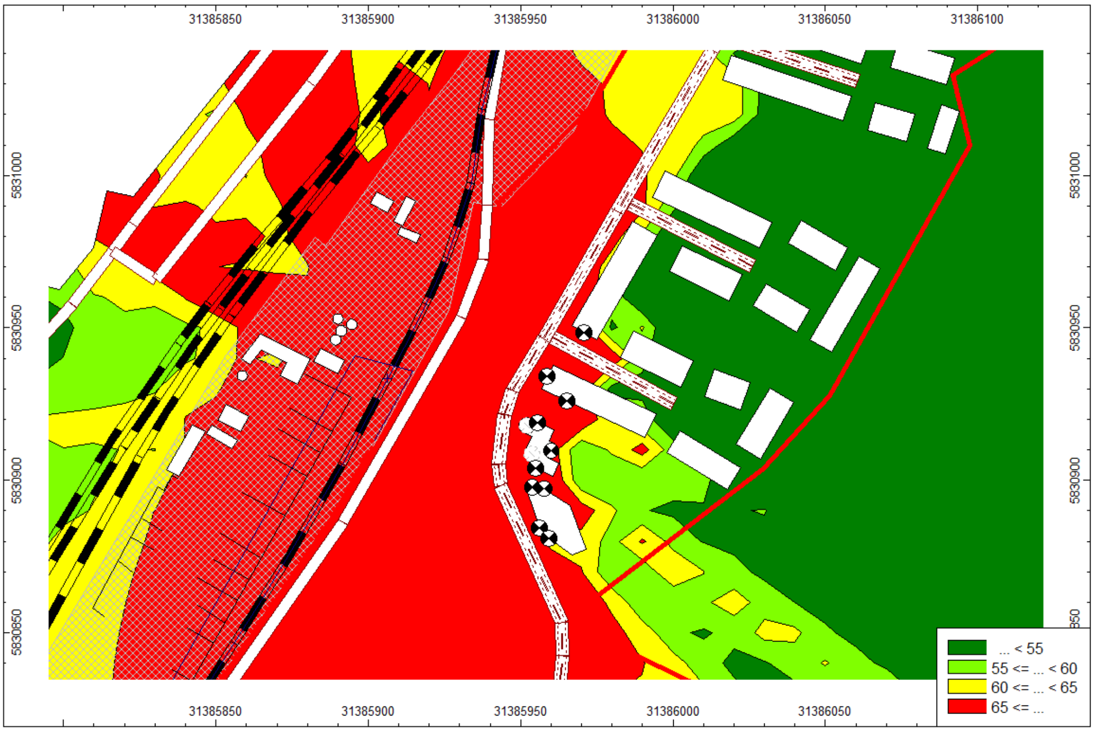

Figure 26 – Marsh Reach: AVO Guide Level 2 assessment recommended (delivery)

Figure 27 – May Gurney: AVO Guide Level 2 assessment recommended (daytime)

Figure 28 – May Gurney: AVO Guide Level 2 assessment recommended (night-time)

Additionally, and as described in Section 3.3, Part O of the Building Regulations also requires that the overheating mitigation strategy for residential buildings should take account of the likelihood that windows will be closed at night if noise levels within bedrooms exceed the limits specified in Section 3 of Approved Document O (ADO).

The areas where predicted night-time L_{AFmax} levels (due to Trowse Rail Bridge) would exceed the ADO limit of 55 dB L_{AFmax} (>10 times per night) are shown in red below.

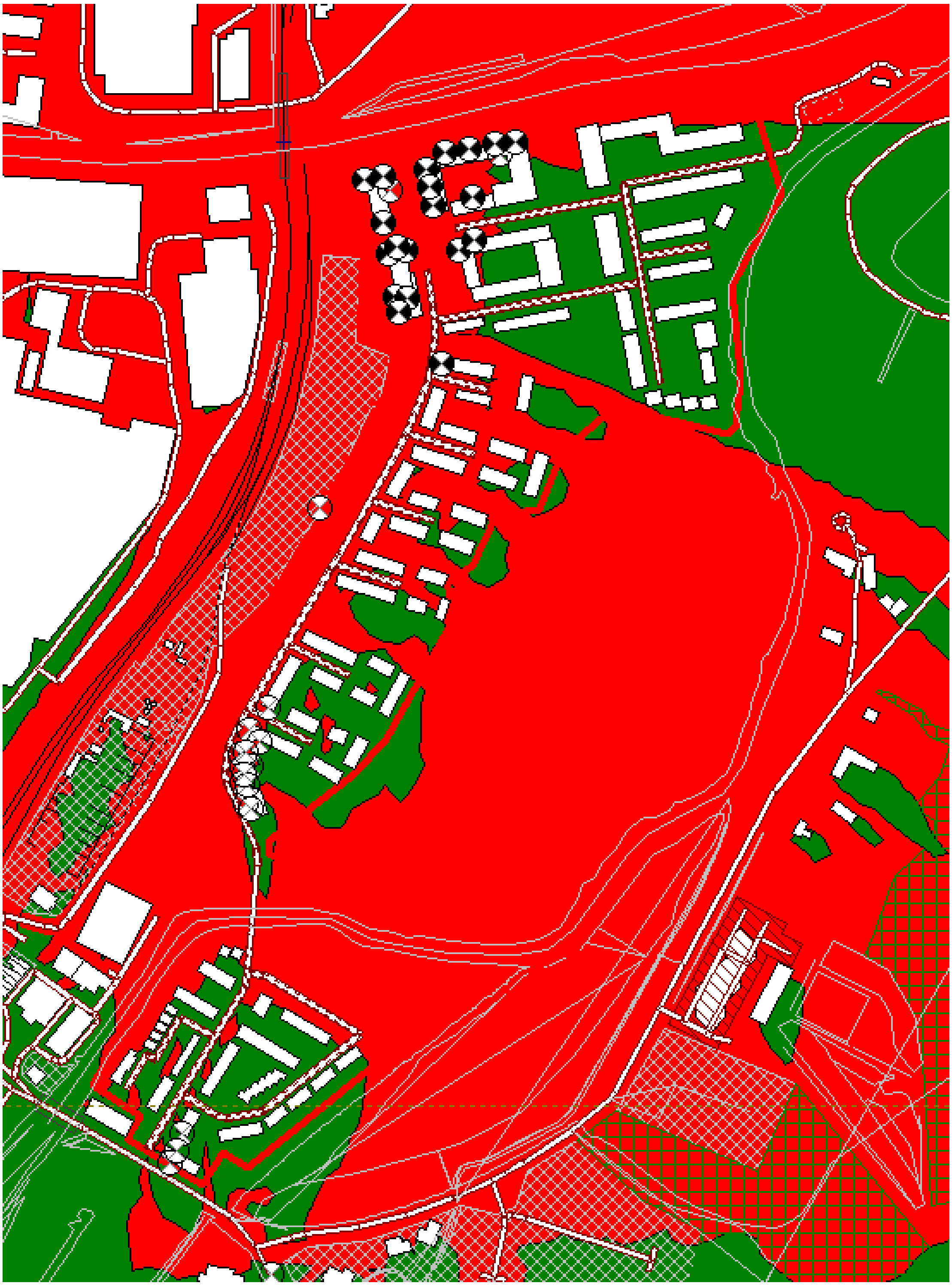

Figure 29 – Noise map showing where night-time L_{AFmax} exceeds ADO criterion

The areas where predicted night-time average noise levels would exceed the ADO criterion of 40 dB L_{night} are shown in red below.

Figure 30 – Exceedances of ADO Lnight criterion due to conveyor at Trowse Depot

Note: This assumes that the dominant noise source (Trowse Depot) is present through the entire 8-hour night-time assessment period. This is considered a relatively robust approach.

Figure 31 – Exceedances of ADO Lnight criterion in May Gurney due to traffic noise

In conclusion, Part O of the Building Regulations requires that the overheating strategy of most residential buildings in the development should take account of noise at night.

If noise at night is an issue, it is less likely that windows would be opened by occupants to mitigate overheating. Therefore, for residential buildings where external night-time noise may be an issue, the overheating mitigation strategy should take account of the likelihood that windows will be closed during sleeping hours (23:00 hrs to 07:00 hrs).

We have been provided with the overheating assessment recently completed by CBRE (dated June 2023) which is to be submitted as part of the reserved matters application.

In the Executive Summary, the overheating assessment states that:

> *"The assessment identifies those apartments that are at higher risk of overheating. These include units with a larger glazing area, units with S/SW-facing windows, top-floor units receiving higher solar gains, units where cross ventilation is not possible and units with easily accessible windows. A sample of unit types, representing these dwellings, have been assessed against the Part O 2021 overheating criteria.*
>
> *The analysis results show that all the sample rooms, assessed against the DSY1 weather data, comply with the overheating criteria, i.e. during moderately warm summer conditions the risk of overheating is low. The risk of overheating in communal corridors has been also assessed."*

Based on the conclusions of the overheating assessment, we do not consider that any further assessment of overheating noise risk is required because a Level 2 AVO Guide assessment would be focused on any dwellings at risk of overheating (there are none).

The overheating assessment was carried out to demonstrate that the requirements of ADO could be achieved. We consider that noise levels at night have been adequately assessed as part of the overheating mitigation strategy, in full accordance with ADO.

8.5 Element 3 – *"External Amenity Area Noise Assessment"*

Noise levels in external amenity areas should ideally not exceed 50 – 55dB $L_{Aeq,16hr}$.

The proposed development would provide outdoor amenity space as a mixture of private gardens, private balconies, and shared communal areas.

Based on the noise survey and modelling results, daytime average noise levels in most areas would be within the recommended guidelines. There are some areas of the site where noise levels might exceed these guidelines, and these are discussed below:

8.5.1 Wensum Riverside

Based on the unattended noise survey results, daytime average noise levels in areas along the north-west and northern boundaries (particularly those facing Trowse Rail Bridge and/or the Great Eastern Main Line) are likely to be exposed to average noise levels between 54-62 dB $L_{Aeq,16hour}$. It would ultimately be up to residents to decide whether they wish to use these balconies with slightly higher than ideal noise levels.

However, it should also be noted that residents of properties on these façades would also have access to shared communal amenity space in other parts of this area where average noise levels would be much lower (below the 50 dB $L_{Aeq,16h}$ lower guideline).

Furthermore, as discussed in Section 3.1, BS8233 also accepts that these guideline values are not achievable in all circumstances where development might be desirable.

On balance, we expect outdoor acoustic amenity in this area to be broadly acceptable.

8.5.2 *Marsh Reach*

Based on our noise surveys and modelling, we expect daytime average noise levels in some outdoor amenity areas in Marsh Reach to exceed the upper guideline value of 55 dB $L_{Aeq,T}$ when Trowse Depot is operational. These areas are shown in red in the noise maps in Figure 32 and Figure 33. At all other times and in all other areas of Marsh Reach, average noise levels would be likely to be below the guideline values.

Based on our noise model, average noise levels during operation of the conveyor would be between 56-61 dB $L_{Aeq,16hour}$. During a delivery they would be 56-72 $L_{Aeq,16hour}$.

From our discussions with a representative of Tarmac, we understand that deliveries typically occur once every 1-2 weeks at present. Whilst this is not controlled through planning conditions, it does mean that occasions when the nearest properties to the depot would be exposed to the highest average noise levels are relatively infrequent.

In any case, it should also be noted that residents of properties on these façades would also have access to shared communal amenity space in other parts of this area where average noise levels would be much lower (below the 50 dB $L_{Aeq,16h}$ lower guideline).

Furthermore, as discussed in Section 3.1, BS8233 also accepts that these guideline values are not achievable in all circumstances where development might be desirable.

On balance, we expect outdoor acoustic amenity in this area to be broadly acceptable.

Figure 32 – Marsh Reach: Exceedances of 55 dB $L_{Aeq,T}$ with conveyor operating

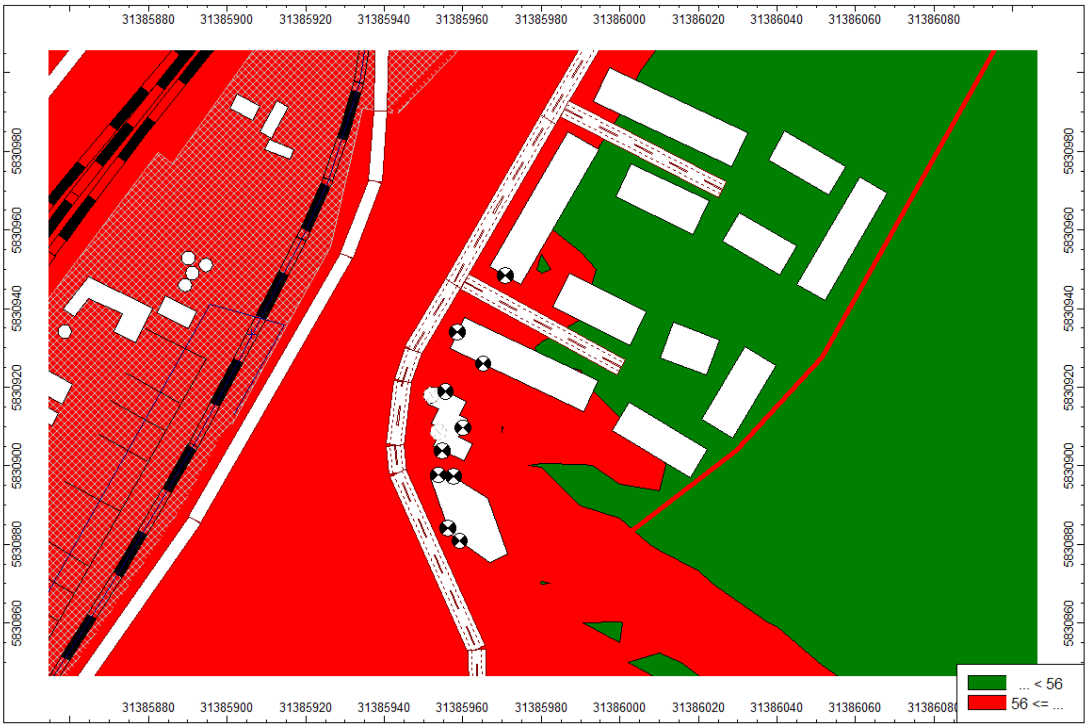

Figure 33 – Marsh Reach: Exceedances of 55 dB $L_{Aeq,T}$ during a rail delivery

8.5.3 May Gurney

Based on our modelling, there is only one façade where daytime average noise levels would exceed the 55 dB $L_{Aeq,T}$ upper guideline value (by up to 5 dB). We understand that dwellings on this façade are proposed to be provided with private balconies.

Areas where the upper guideline is predicted to be exceeded are shown in red below.

Figure 34 – May Gurney: : Exceedances of 55 dB $L_{Aeq,T}$ during the day

However, it should also be noted that residents of properties on these façades would also have access to shared communal amenity space in other parts of this area where average noise levels would be much lower (below the 50 dB $L_{Aeq,16h}$ lower guideline).

Furthermore, as discussed in Section 3.1, BS8233 also accepts that these guideline values are not achievable in all circumstances where development might be desirable.

On balance, we expect outdoor acoustic amenity in this area to be broadly acceptable.

8.6 Element 4 – *"Other Relevant Issues"*

ProPG recommends that *"Other Relevant Issues)* are also considered, including:

- compliance with relevant national and local policy
- magnitude and extent of compliance with ProPG
- likely occupants of the development
- acoustic design versus unintended adverse consequences
- acoustic design versus wider planning objectives

Provided the noise mitigation measures detailed in this report are incorporated into the development design, internal and external noise levels should achieve the relevant acoustic guidelines and therefore acceptable acoustic amenity is likely to be provided.

Therefore, the proposed development would comply with the intentions of both the NPPF, which states that planning policies/decisions should aim to minimise potentially significant adverse impacts on health and/or quality of life, and local planning policy.

9 CONCLUSIONS

- An environmental noise survey at the proposed development site confirmed that the main noise sources affecting residential areas will be trains travelling on the Great Eastern Main Line (and passing over Trowse Rail Bridge, in particular) and from plant and activities Trowse Depot (currently operated by Tarmac). Road traffic noise on Bracondale/The Street has also been considered, although we note that this is not a planning requirement and is addressed to aid in the design.
- Noise from trains passing over Trowse Rail Bridge is most significant, and the maximum noise levels produced by night-time trains should dictate the building envelope requirements for some residential buildings in the Wensum Riverside development area. We have provided recommendations for façades, glazing and ventilation based on night-time maximum noise levels, and, provided these are followed, internal noise levels at all other times should also be acceptable.
- Noise from Trowse Depot is also significant, and average noise levels from both plant and activities associated with deliveries should dictate building envelope requirements in the Marsh Reach area. Planning conditions imposed on the depot require that there are no deliveries before 07:00 hrs so plant noise is the main noise source before this time. We have provided recommendations for the building envelope of relevant buildings/façades in this area, and, provided these are followed, internal noise levels at all other times should also be acceptable.
- Acceptable internal noise levels should be achievable in the May Gurney area using relatively standard (not acoustically upgraded) building envelope elements.
- Our surveys indicated that noise from Crown Point Depot is insignificant in comparison to the above sources and should not affect the development design.
- Good acoustic design principles have generally been followed in the proposed development layout, particularly in terms of the use of buffer zones and the use of buildings nearest to the main noise sources to screen other buildings further away. We do not consider that there is much the developer can to do mitigate noise at source because it would be impractical and/or outside their control.
- Our assessment of overheating noise risk indicates that a Level 2 assessment is recommended according to the AVO Guide, and that noise should be considered in the overheating mitigation strategy. However, The overheating assessment recently completed by CBRE concludes that there is a low risk of overheating in all of the worst-case sample rooms assessed, and we therefore consider that overheating noise risk has already been adequately assessed and mitigated. We also consider that noise levels at night have been adequately considered as part of the overheating mitigation strategy for the development, as required by ADO.
- Daytime average noise levels in outdoor amenity areas should generally comply with relevant guideline criteria. There are predicted to be some exceedances of the upper guideline value at some buildings closest to the main noise sources, but residents in all these areas will have access to other areas (shared outdoor amenity areas) where average noise levels will be much lower. Furthermore, BS 8233 advises that some exceedances of the guidelines may be acceptable where development is desirable and should not necessarily preclude development. On balance we expect outdoor acoustic amenity to be acceptable.
- In conclusion, we expect acceptable levels of acoustic amenity to be achieved provided that the recommendations in this report are followed. If this happens, the development should comply with the noise-related planning conditions imposed on the outline planning approvals issued by NCC and SNDC.

APPENDIX A TECHNICAL TERMS AND UNITS RELEVANT TO THIS REPORT

Decibel (dB) - This is the unit used to measure sound level. The range of human hearing from the quietest detectable sound to the threshold of pain is very large. If a normal linear scale of measurement were used, it would have to range from 20 μPa to 200,000,000 μPa. Using such large figures would be unmanageable and for this reason sound pressure levels are expressed on a logarithmic scale, which corresponds to the almost logarithmic response of the ear and which compresses the range to a manageable 0dB to140dB.

Sound Pressure Level (L_p or SPL) - This is a function of the source and its surroundings and is a measure in decibels of the total instantaneous sound pressure at a point in space. The SPL can vary both in time and in frequency. Different measurement parameters are therefore required to describe the time variation and frequency content of a given sound. These are described below.

Frequency - This refers to the number of complete pressure fluctuations or cycles that occur in one second. Frequency is measured in Hertz (Hz). The rumble of thunder has a low frequency, while a whistle has a high frequency. The sensitivity of the ear varies over the frequency range and is most sensitive between 1KHz and 5KHz.

Octave and One-Third Octave Bands - The human ear is sensitive to sound over a frequency range of approximately 20 Hz to 20,000 Hz and is more sensitive to medium and high frequencies than to low frequencies. To define the frequency content of a sound, the spectrum is divided into frequency bands, the most common of which are octave bands. Each band is referred to by its centre frequency, and the centre frequency of each band is twice that of the band below it. Where it is necessary for a more detailed analysis octave bands may be divided into one-third octave bands.

'**A' Weighting** - The sensitivity of the human ear varies with frequency, some frequencies sound louder than others. The 'A'-weighting curve represents the non-linear frequency response of the human ear and is incorporated in an electronic filter used in sound level meters. Measurements using an 'A'-weighting filter makes the meter more sensitive to the middle range of frequencies, which approximates to the response of the ear and the subjective loudness of the sound. Sound level measurements using 'A'-weighting will include the subscript A, e.g. dB(A).

Statistical Analysis - These figures are normally expressed as LN, where L is the sound pressure level in dB and N is the percentage of the measurement period. The LN figure represents the sound level that is exceeded for that percentage of the measurement period. L_{90} is commonly used to give an indication of the background level or the lowest level during the measurement period. L_{10} may be used to measure road traffic noise.

L_{Amax} - The highest A weighted sound pressure level recorded during the measurement period. The time constant used (Fast or Slow) should be stated.

$L_{eq,T}$ - The equivalent continuous sound level is used to measure sound that varies with time. The $L_{eq,T}$ is the notional equivalent steady sound level, which contains the same acoustic energy as the actual varying sound level over the period of measurement. Because the averaging process used is logarithmic, the $L_{eq,T}$ level tends to be dominated by the higher sound levels measured.

APPENDIX B MEASURING EQUIPMENT AND CALIBRATION

Job reference and title:	13495 – May Gurney & Deal Ground
Measurement location:	See Section 6.3.1 of this report
Measurement date(s):	Trowse Depot survey: 15/03/2023
	Unattended survey: 30/03/2023 – 06/04/2023

Measuring equipment used:

Equipment description / serial number	Type number	Manufacturer	Date of calibration expiration	Calibration certificate number
Rion VDV / PPV meter				
3-channel vibration meter serial no. 00370025	XV-2P	Rion	02/09/2024	TCRT22/1550
Tri-axial accelerometer serial no. 72424	PV-83C	Rion		
Mounting plate	DIN 45669-2	Rion		
Precision sound level meter serial no. A2A-08643-E0	XL2-TA	NTi Audio	06/07/2024	UK-22-053
Microphone serial no. 9185	MC230	NTi Audio	06/07/2024	UK-22-053
Microphone pre-amplifier serial no. 3489	MA220	Neutrik	06/07/2024	UK-22-053
Microphone calibrator serial no. 25993	NOR-1251	Norsonic	24/11/2024	42584
Precision sound level meter serial no. A2A-10758-E0	XL2-TA	NTi Audio	05/11/2023	39375
Microphone serial no. 6017	MC230	NTi Audio	05/11/2023	39374
Microphone pre-amplifier serial no. 5308	MA220	Neutrik	05/11/2023	39375
Microphone calibrator serial no. 34541	NOR-1251	Norsonic	05/11/2023	39373
Precision sound level meter serial no. A2A-13211-E0	XL2-TA	NTi Audio	08/09/2023	38897
Microphone serial no. A14465	MC230A	NTi Audio	08/09/2023	38896
Microphone pre-amplifier serial no. 6869	MA220	Neutrik	08/09/2023	38896
Microphone calibrator serial no. 9022	CAL200	Larson Davis	08/09/2023	38895

Calibration levels:	A2A-08643-E0 = 114.0 dB @ 1 kHz
	A2A-10758-E0 = 113.9 dB @ 1 kHz
	A2A-13211-E0 = 113.8 dB @ 1 kHz
Persons in charge of measurements:	Martyn Broom AMIOA
	George Moore MIOA
Measurement parameters	1/1 octave band and A-weighted $L_{eq,T}$
	1/1 octave band and A-weighted L_{Fmax}
	Tri-axial peak particle velocity, $mm \cdot s^{-1}$
	Tri-axial vibration dose value, $m \cdot s^{-1.75}$

APPENDIX C CADNAA NOISE PREDICTION MAPS

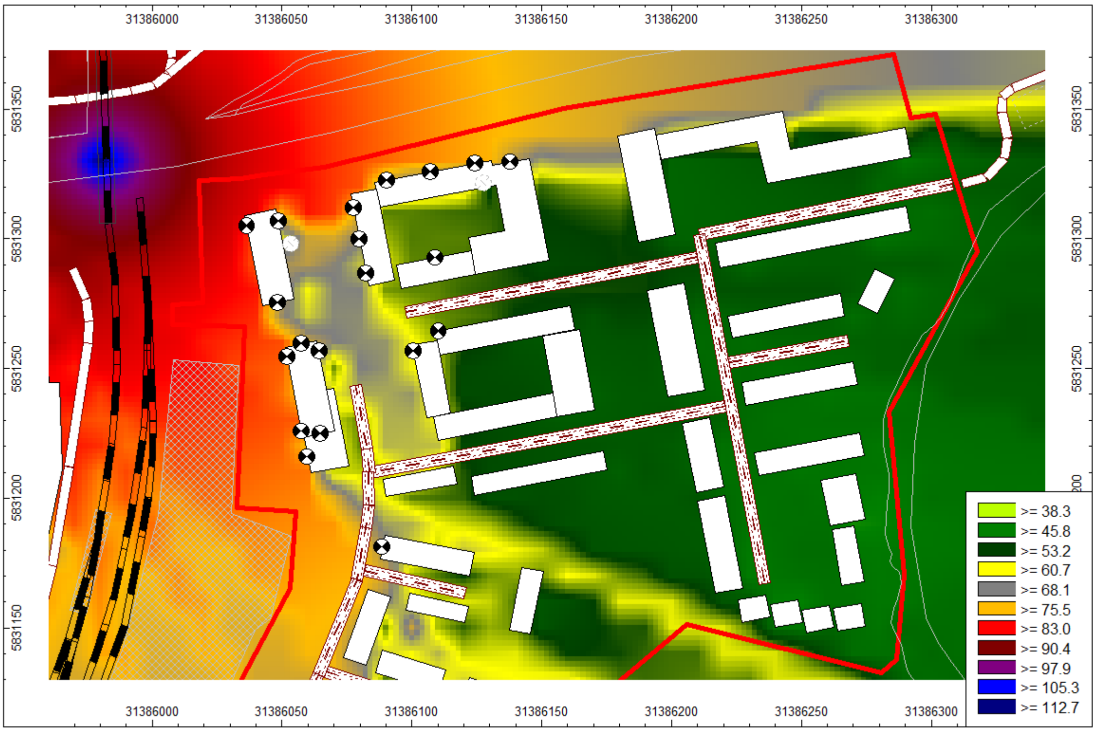

Figure 35 – Noise map for Trowse Rail Bridge (dB L_{AFmax})

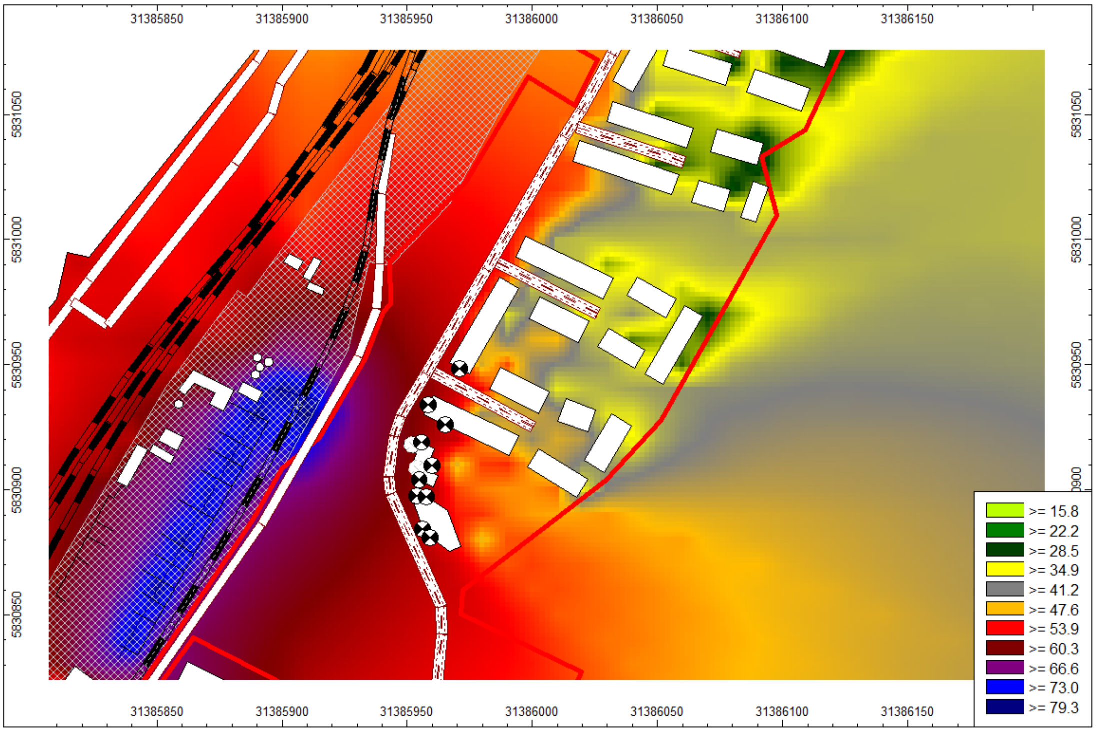

Figure 36 – Noise map for Trowse Depot (conveyor only, dB $L_{Aeq,T}$)

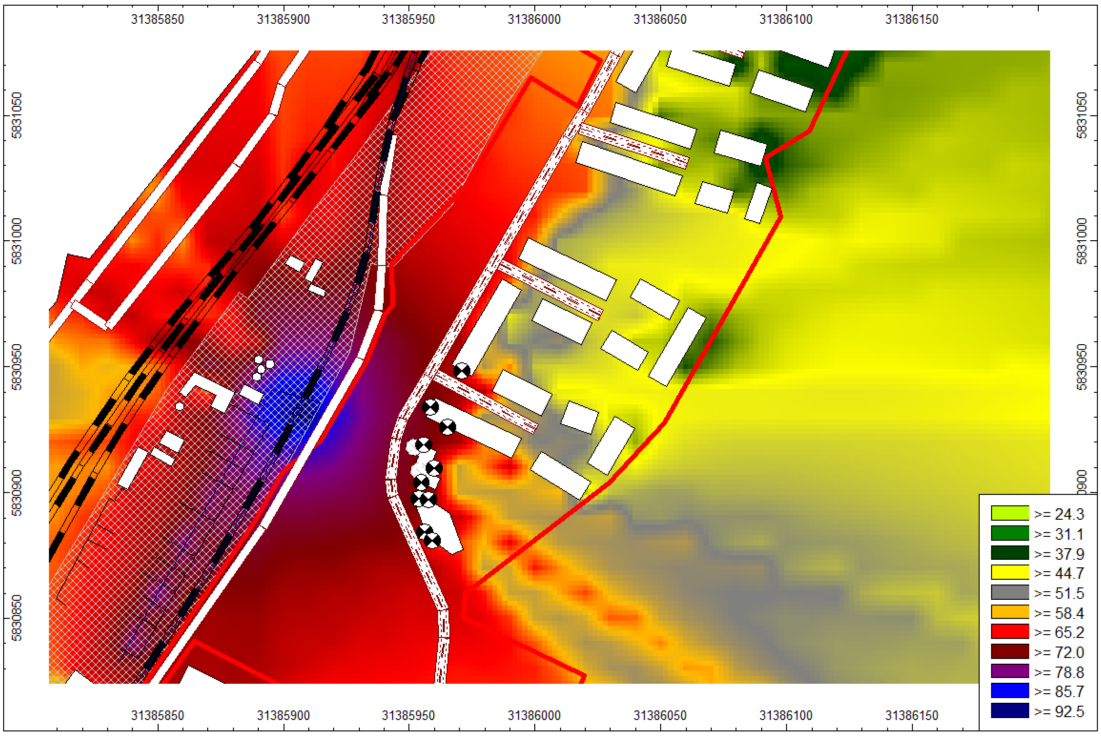

Figure 37 – Noise map for Trowse Depot (conveyor and delivery noise, dB $L_{Aeq,T}$)

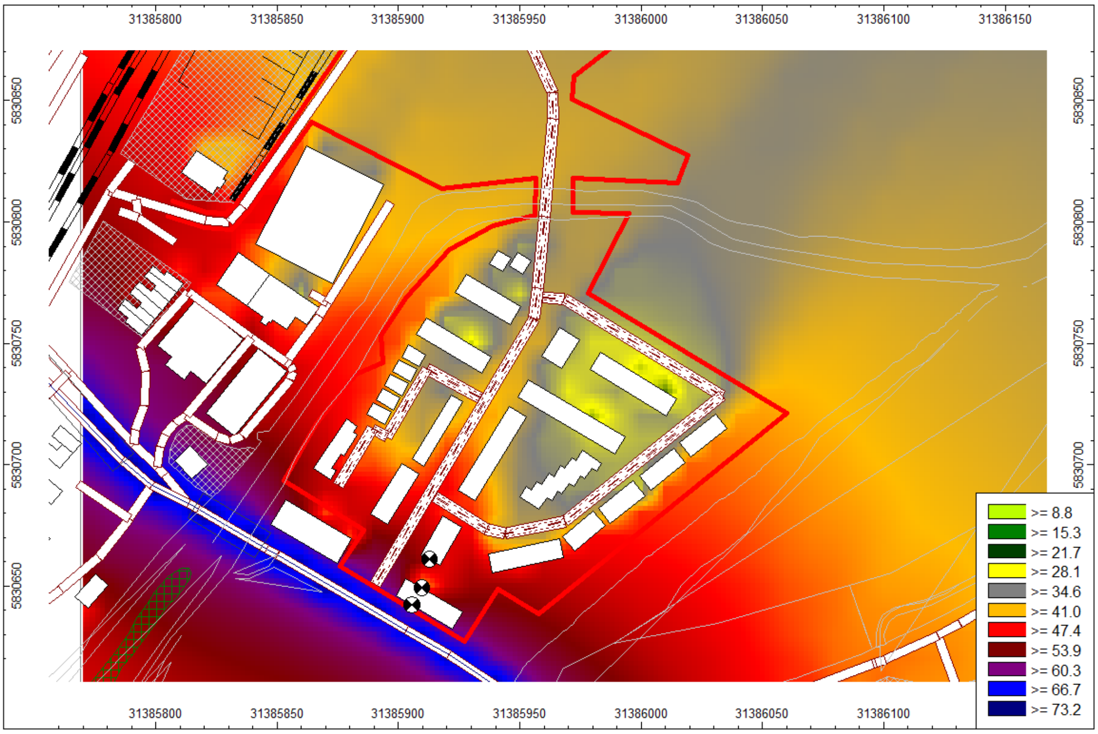

Figure 38 – Road traffic noise (daytime $L_{Aeq,07:00–23:00\ hrs}$)

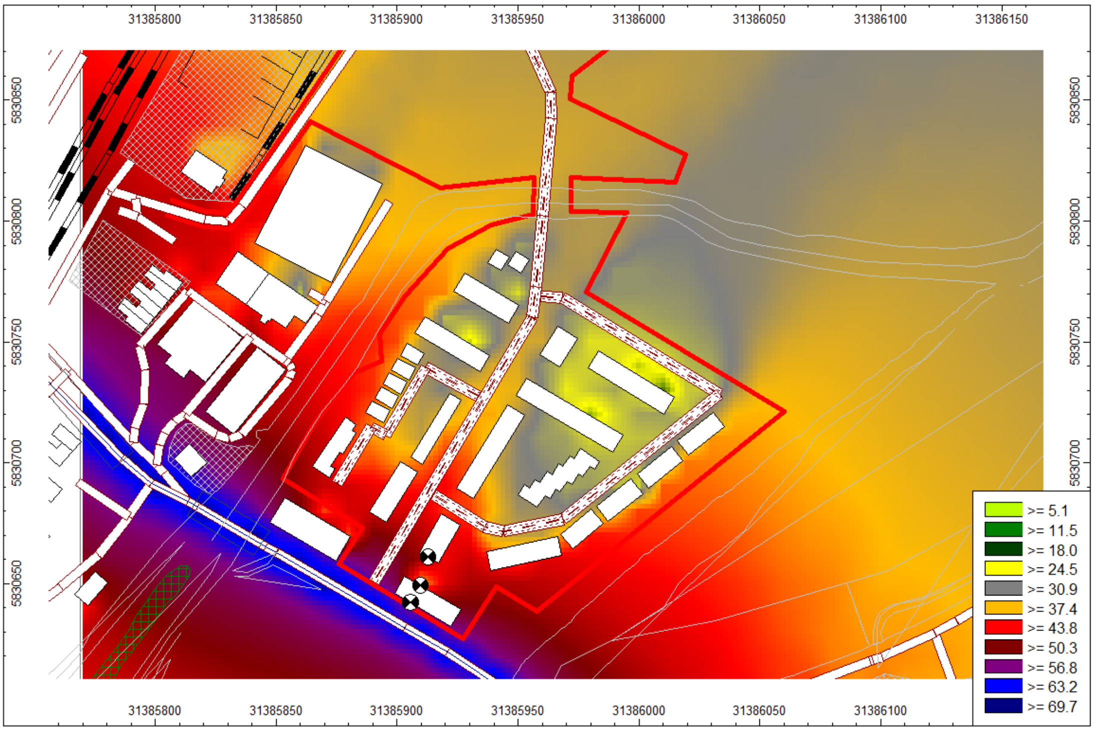

Figure 39 – Road traffic noise (night-time $L_{Aeq,23:00–07:00\ hrs}$)