11 NOISE AND VIBRATION

11.1 Introduction

11.1.1 Summary

This chapter describes the noise and vibration impacts and effects considered likely to arise from the development of the Scheme.

The existing baseline noise conditions at the site and surroundings are established via a combined survey and modelling approach. The likely noise and vibration impacts during the construction and operational phases are identified, and possible effects on human receptors assessed. A mitigation strategy is proposed where deemed necessary or appropriate, and the residual effects of the Scheme presented.

A glossary of relevant noise and vibration terminology is presented in Appendix H.1, which is included in the ES Volume 3. A list of abbreviations used in the chapter can be found at the beginning of this Volume.

11.1.2 Scoping

The Environmental Scoping Report for the Scheme included an outline of the proposed approach to assessing potential effects of noise and vibration. The Scoping Report highlighted relevant guidance, and addressed the methodology for the baseline survey, prediction modelling, impact assessment, mitigation and residual effects, which has been adopted as described in Section 11.2.

11.1.3 Scheme and Site Description

The Scheme is described in detail in Chapter 2 of this volume of the ES.

The Scheme would pass through a range of noise environments, including rural areas currently subject to relatively low levels of environmental noise, and areas on or near existing arterial roads, with higher levels of road traffic and neighbourhood activity noise.

11.2 Legislation and Policy Context

11.2.1 European

(Environmental Noise) *Directive 2002/49/EC*

Commonly known as the Environmental Noise Directive (European Parliament and the Council of the European Union, 2002)[11.1], this legislation requires signatory member states, including the UK, to establish laws to enact the preparation of noise action plans to map, assess and reduce environmental noise affecting the population. Part of the action plan implemented by the Welsh Government involves the identification of Priority Areas within which action taken to reduce noise will be focused. Two Priority Areas are identified within the vicinity of the Scheme: a corridor running along the existing A487 between the Goat Roundabout and a point around 1km north of Bontnewydd, and a smaller zone around the intersection of the existing A487 and the A4085 in Caernarfon (Welsh Government, 2013).

11.2.2 National

Environmental Noise (Wales) Regulations 2006

The Environmental Noise (Wales) Regulations (2006) implement the requirements of EU Directive 2002/49/EC within national legislation.

Noise Insulation (Amendment) Regulations (NIR) 1975, 1988

The NIR as amended , provide the framework to determine the entitlement to noise insulation treatment at eligible buildings (i.e. dwellings and other building used for residential purposes within 300m of the nearest point on the new or altered highway) subject to road traffic noise. All of the following three conditions must be met for a property to be considered eligible:

- The combined expected maximum noise traffic level, i.e. the 'relevant noise level' from the new or altered highway together with any other traffic in the vicinity must not be less than the 'specified noise level', 68 dB $L_{A10,18h}$;
- The relevant noise level must be at least 1 dB more than the 'prevailing noise level', i.e. from the total traffic noise existing before the works to construct or improve the highway were begun; and,
- The contribution to the increase in the relevant noise level from the new or altered highway must be at least 1 dB.

The noise levels are assessed at a reception point located 1 metre in front of the most exposed façade part of an external window or door of an eligible room. Traffic flows used in the calculations should be the maximum expected in a period of 15 years after opening to traffic. The predictions are normally undertaken using the Annual Average Weekday Traffic (AAWT) flow.

Control of Pollution Act (CoPA) 1974

Section 60 of the CoPA (The Control of Pollution Act, 1974)[11.6] empowers local authorities to control noise disturbance caused by construction works.

Section 61 of the CoPA provides construction site operators with the opportunity to apply for consent to the works, subject to an agreed programme and suitable measures to control noise. If the operator is granted consent under Section 61, and is carrying out the work in accordance with the prior consent notice, this provides a valid legal defence against action taken under Section 60.

Planning Policy Wales (PPW) Edition 8 2016

PPW addresses the policy approach of the Welsh Government to environmental noise, including from road traffic. In particular, Chapter 8: Transport paragraph 8.5.7 states:

> *"Great care must be taken to minimise the adverse impacts of new transport infrastructure, or improvements to existing infrastructure, on the natural, historic and built environment and on local communities, where neighbourhood severance should especially be avoided. Routes should make the best use of existing landforms and other landscape features to reduce noise and visual effects, subject to safety and other environmental considerations. Where no other alternative routes or options are practicable,*

transport infrastructure schemes should provide mitigation measures to minimise the impacts caused by their construction and operation."

Technical Advice Note 11 (TAN11) Noise 1997

TAN11: Noise sets out specific guidance relating to development affected by, or generating, environmental noise. Annex B provides advice on assessing noise from road traffic, referring assessors to the guidance in the Calculation of Road Traffic Noise and the Design Manual for Roads and Bridges, both of which are discussed further below.

11.2.3 Local

The Gwynedd Unitary Development Plan 2001-2016 (Gwynedd Council, 2001)[11.10] presents the current adopted local planning policies applicable within the region. Policy CH25 – *New Roads and Road Improvements* states:

Proposals for improvements to existing roads and for new sections of roads will be approved provided there is sufficient justification for the development on economic and public safety grounds and that there will be no unacceptable environmental effects. Developers must prove that other options have been considered and that the scheme with the least environmental impact has been chosen and that all the following criteria can be met:

1. *that the improvement/new road scheme reflects the road's status in the defined road hierarchy;*
2. *that the design reduces the danger of accidents for road users;*
3. *that the design incorporates measures that encourages journeys by public transport and reflects the needs of cyclists and pedestrians;*
4. *that the scheme is acceptable in terms of its impact on the community;*
5. *that the scale and design of the proposed development is suitable for the location;*
6. *that every practical effort is made to ensure that the development will not cause significant harm to the landscape, the coast, biodiversity, or historic areas/ features, particularly within or near designated areas;*
7. *that appropriate measures are included to reduce the risk of injury or death as a result of collisions between vehicles and wildlife;*
8. *that the development will not cause significant harm to the amenities of neighbouring residents or sensitive uses; and*
9. *that the proposal incorporates adequate measures to mitigate the effects of the scheme.*

Of these criteria, nos. 5, 8 and 9 are relevant to this chapter. Impacts on the wider community, landscape, cultural heritage and biodiversity, which might incorporate some consideration of noise, are addressed within the ES Chapters 6 (Cultural

Heritage), 7 (Landscape), 8 (Nature Conservation) and 13 (Community and Private Assets).

11.3 Methodology

11.3.1 Relevant Guidance

Design Manual for Roads and Bridges (DMRB)

DMRB provides wide-ranging guidance on the design and impact assessment for road development schemes in the UK.

Scope of DMRB Assessment
Volume 11 Section 3 Part 7 (Revision 1) of DMRB (Highways Agency, Transport Scotland, Welsh Assembly Government & The Dept for Regional Development Northern Ireland, 2011)[11.11] advises on the appropriate scope of the noise and vibration impact assessment. The procedure outlines three proportionate levels of assessment: a) scoping, b) simple and c) detailed. The scoping assessment would normally be carried out at the options appraisal phase to determine whether there is a need for further noise and vibration impact assessment.

Following the scoping stage, selection of the appropriate level of impact assessment depends on the following noise level threshold criteria:

- A permanent change in magnitude of 1 dB $L_{A10,18h}$ in the short term (i.e. on the scheme opening);
- A permanent change in magnitude of 3 dB $L_{A10,18h}$ in the long term (i.e. between opening and future assessment years); and
- The predicted night-time noise level $L_{night,outside}$ is greater than 55dB in any scenario *and* is expected to change by at least 3 dB in the long-term.

A simple assessment is undertaken when the threshold values above are not expected to be exceeded. A detailed assessment will be appropriate when the thresholds are expected to be exceeded at the assessed receptors, as is the case with this scheme.

Detailed DMRB assessment
In a detailed assessment, the short-term scheme impacts are derived by comparing the 'Do Minimum' scenario (i.e. without the scheme) in the 'opening year'[11], with the 'Do Something' scenario in the same year. The long-term impacts are derived by comparing 'Do Minimum' scenario in the opening year with the 'Do Something' scenario in the 'design year', which is taken to mean the year within 15 years of the opening year when the greatest traffic flows associated with the scheme are predicted. To complete the assessment, a comparison is also made between the Do Minimum Opening year with the Do Minimum Design year. The abbreviations used in this ES for each scenario are as follows:

[11] It should be noted that the DMRB text actually refers to this assessment year as the '*baseline year*'. To avoid confusion for the purpose of this ES, the terminology used is 'opening year', and 'baseline year' is reserved for an assessment year specified prior to the scheme opening. This is in order to make an explicit connection between the noise assessment prediction model and the 'baseline survey', the data from which is used for comparison with the model output from a 'baseline year' prediction.

- Do Minimum Opening (year): DMO
- Do Something Opening (year): DSO
- Do Minimum Design (year): DMD
- Do Something Design (year): DSD

DMRB: Study Area

DMRB sets out a process by which the area for study is defined. The following steps are followed:

i. Designate the start and end points of the physical works associated with the Scheme;

ii. Identify the existing routes that are being bypassed or improved, and any proposed new routes, between the identified start and end points;

iii. Define a one kilometre boundary from the carriageway edge of the routes identified in ii;

iv. Define the 'calculation area' as the area within 600m of the carriageway edge of all routes identified in ii, and within 600m of the carriageway edge of any 'affected routes' falling within the boundary defined in iii;

v. Identify any 'affected routes' outside the boundary defined in iii; and

vi. Add to the calculation area an area within 50m of the carriageway edge of routes identified in v.

An affected route is defined as a road with the possibility of a change in the $L_{A10,18h}$ noise level of 1 dB or more in the short-term, or 3 dB or more in the long-term (i.e. corresponding to minor impacts or greater – see impact criteria set out below).

This process has been used to determine the overall area for calculation and assessment of operational noise impacts around the Scheme.

The study area required for assessment of entitlement under the NIRs is restricted to dwellings or other buildings used for residential purposes within 300m of the carriageway edge of the new or altered road, and consequently is completely encompassed by the DMRB calculation area. The study areas used for the assessment are shown in Volume 2, Figure 11.1.

DMRB: Impact criteria

The magnitude of impacts is assessed against the criteria for the short term and long term as outlined in Tables 11.3.1 and 11.3.2. The tables show an important distinction between short and long-term impacts: in the long term, the impact of an equivalent change in noise level is considered to be reduced in magnitude compared with the short-term. It should also be noted that the current version of DMRB requires night-time noise impacts to be considered in the long term only, for receptors subject to predicted levels equal to or greater than 55 dB L_{night}.

Table 11.3.1: DMRB Criteria for Magnitude of Operational Daytime Road Noise Impacts in the Short Term

Noise Change (in $L_{A10,18h}$), dB	Magnitude of Impact
0	No Change
0.1 - 0.9	Negligible
1 - 2.9	Minor
3 - 4.9	Moderate
5+	Major

Table 11.3.2: DMRB Criteria for Magnitude of Operational Day or Night-time Road Noise Impacts in the Long Term

Noise Change (in $L_{A10,18h}$ or L_{night}), dB	Magnitude of Impact
0	No Change
0.1 - 2.9	Negligible
3 - 4.9	Minor
5 - 9.9	Moderate
10+	Major

DMRB: Road Noise Nuisance

A limitation of an assessment of changes in noise level is that it does not consider the effect of the absolute levels expected at a receptor; this is considered within DMRB by assessing overall road traffic 'noise nuisance' changes expected as a result of the Scheme, in terms of percentages of people bothered very much or quite a lot by road noise.

DMRB; Night-time metric

DMRB advises that the L_{night} metric can be estimated using conversion formulae derived in research conducted by TRL on behalf of DEFRA (Abbott, P. et al, 2002)[11.12]; 'Method 3' has been applied in this assessment.

DMRB: Airborne Vibration Nuisance

For receptors located relatively near busy roads, airborne vibration can also cause annoyance. This is treated similarly within DMRB as for airborne noise nuisance.

DMRB: Groundborne Vibration

Significant levels of groundborne vibration from road traffic would only normally occur at relatively close ranges to heavy vehicles travelling at speed over discontinuities in the road surfaces. DMRB refers to TRL research (Watts, 1990)[11.13], which provides a means to make estimates of this range, but for reasonably accurate estimations, detailed knowledge of soil types and composition is needed, as propagation of groundborne vibration is highly variable and heavily dependent on mechanical wave properties in the medium. Nonetheless, by making reasonable worst-case assumptions of input parameters it can be shown that there would be no significant adverse effects expected from groundborne vibration at the receptor ranges involved with the Scheme.

DMRB: Sensitive receptors

DMRB provides examples to assist in defining 'sensitive receptors' for the purpose of impact assessment: dwellings, hospitals, schools, community facilities, important natural outdoor areas (SSSIs, AONBs etc.) and public rights of way.

This section of the ES restricts itself to assessment of the noise impacts on dwellings, schools, hospitals and community buildings including medical centres and places of worship; wider noise impacts on cultural heritage, landscape, community and biodiversity are considered in the ES chapters 6 (Cultural Heritage), 7 (Landscape), 8 (Nature Conservation) and 13 (Community and Private Assets).

It should be noted that noise sensitive receptors (NSRs) included in the assessment correspond to existing properties; there is no requirement to estimate future changes in population and associated speculative impacts.

DMRB: Road surface
Annex 4 provides guidance on the use of low-noise/thin surfacing systems for new and existing roads. For new roads it states:

> *Where new carriageways are to be constructed and a thin surfacing system used, or where an existing surface is to be replaced with a thin surfacing system, a -3.5 dB(A) correction should be assumed for the thin surface system…unless any information is available regarding the specific surface to be installed. This advice applies to roads where the mean traffic speed is ≥75 km/h. Where the mean traffic speed is <75 km/h, a -1 dB(A) surface correction should be applied to a new low-noise surface.*

In this case the Scheme design incorporates a 'thin surface course system' (TSCS) with reduced noise generation. Accordingly, the correction for this surface type has been applied in the modelling calculations. The low-noise road surfacing on the Scheme is also discussed in Section 11.6. All existing roads have been assumed to comprise standard surfaces, and no further adjustments have therefore been applied.

DMRB: CRTN Shortened survey procedure
Annex 4 also confirms that the Shortened Measurement Procedure outlined in CRTN remains statistically valid to estimate road traffic noise levels over the 18 hour period 0600-0000hrs.

DMRB: Study area
The procedure detailed in DMRB for defining the area of assessment around a new scheme is outlined in Section 11.2.5

Calculation of Road Traffic Noise (CRTN) 1988

The CRTN memorandum (Department of Transport, Welsh Office, 1988)[11.9] describes a methodology to predict the road traffic noise at a given distance from the highway.

The methodology takes into account intervening ground cover, road configuration and road layout. The calculation assumes typical moderately adverse noise propagation conditions. Noise levels are presented in terms of the noise descriptor $L_{A10,18h}$; the A-weighted noise level exceeded for 10% of the time within the period 0600-2400hrs.

The main variables used in the calculation of the traffic noise level are:

- the AAWT flow for the 18-hour period 0600-2400hrs;

- the mean traffic speed;
- the proportion of heavy vehicles;
- the type of road surface;
- the road gradient;
- the distance of the receptor from the road;
- screening by obstacles; and,
- the nature of the ground cover between the road and the receptor(s).

Section III of the memorandum also provides guidance on a measurement method. This includes a shortened procedure for determining estimations of road traffic noise levels over the full 18-hour period: measurements of L_{A10} are made over any three consecutive hours between 1000hrs and 1700hrs and arithmetically averaged. An estimated $L_{A10,18h}$ value can then be calculated by subtracting 1 dB from the result.

Welsh Transport Planning and Appraisal Guidance (WelTAG) 2008

WelTAG (Welsh Government, 2008)[11.14] provides a means for appraising overall costs and benefits of proposed transportation infrastructure, including those associated with the effects of noise.

WelTAG makes references to the online Transport Appraisal Guidance (WebTAG) used in England (Department for Transport, 2014)[11.15], which has recently undergone changes to the appraisal methodology relevant to noise. However, the changes in approach have not yet been adopted by the Welsh Government, and so the WelTAG appraisal method applied in this ES chapter remains as described in the original guidance.

The two stages of the WelTAG appraisal for noise comprise:

1. Estimation of the population annoyed by road traffic noise with and without the scheme, using the $L_{Aeq,18hr}$ (0600-0000hrs) metric; and
2. Determination of a monetised value of the cost of noise with and without the scheme, in terms of the equivalent value of the willingness of households to avoid the noise over the appraisal period.

This method for monetisation is based on changes in the market values of dwellings exposed to the noise, and considers 2014 prices as published by DEFRA (Department for Environment, Food & Rural Affairs, 2014)[11.16]. Road noise levels are calculated using the CRTN method described above, and a standard -2.5 dB relationship used to convert the predicted $L_{A10,18hr}$ levels into the $L_{Aeq,18hr}$ required for the appraisal. The national average household size of 2.3 has been applied according to the data from the 2011 census (Office for National Statistics, 2013)[11.17].

BS 5228:2009+A1 Code of practice for noise and vibration control on construction and open sites

BS 5228 Parts 1 and 2 (BSI, 2009a)[11.18] (2009b)[11.19] respectively give recommendations on noise and vibration control relating to construction activities. The standard provides advice on prediction methods, noise measurements and assessment for potential impacts, as well as guidance on methods of mitigation and management.

Construction noise levels can be predicted using the BS 5228-1 methodology, which takes account of source noise levels via an extensive database of measurements, and considers the site-specific propagation, screening and reflection effects as well as operational considerations such as the duration of activities.

Construction noise limits are specific to each scheme, and are normally agreed in consultation with the local authority, prior to carrying out specific activities. These limits take many factors into account, including the nature of the works, the times and durations of the activities, and the sensitivities of the closest receptors. The limits are expressed as an average level for a period of time (averaged over the working period), and so it is possible that peak levels are in excess of the average levels. The 'ABC' method for determining the thresholds for potential significant effects takes into account the expected change in the ambient noise level at a receptor. Categories of threshold values are assigned to daytime, evening/weekends and night-time depending on the existing noise climate, as shown in Table 11.3.3.

Table 11.3.3: BS 5228-1 Thresholds for Significance of Construction Noise Impacts

Evaluation Period	Assessment Category (dB $L_{Aeq,T}$)		
	A	B	C
Night-time (23:00-07:00)	45	50	55
Evening and Weekends*	55	60	65
Daytime (07:00-19:00)	65	70	75

* 19:00-23:00 weekdays, 13:00-23:00 Saturdays and 07:00-23:00 Sundays.

Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.

Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as Category A values.

Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than Category A values.

A potential significant effect is indicated if the $L_{Aeq,T}$ noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level.

If the ambient noise level exceeds the Category C threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq,T}$ noise level for the period increases by more than 3 dB due to site noise.

BS 5228-1 also suggests threshold trigger levels and associated durations of impact beyond which the site operator should consider offering noise insulation or temporary rehousing to occupants of affected dwellings, as shown in Table 11.3.4. It is important

to note that these thresholds represent good practice guidance and do not comprise official binding regulatory mechanisms as equivalent to the Noise Insulation Regulations (1975)[11.4] (1988)[11.5], although the Land Compensation Act (1973)[11.20] provides a means for properties to claim rights to statutory compensation for adverse environmental impacts, including from temporary construction works.

Table 11.3.4: BS 5228-1 Thresholds for Potential Offers of Noise Insulation or Temporary Rehousing Due to Significant Adverse Construction Noise Impacts

Days	Time Period	Averaging Time, *T*	Noise Insulation Threshold Level, dB $L_{Aeq,T}$
Mon - Fri	0700-0800hrs	1h	70
	0800-1800hrs	10h	75
	1800-1900hrs	1h	70
	1900-2200hrs	3h	65
	2200-0700hrs	1h	55
Saturday	0700-0800hrs	1h	70
	0800-1300hrs	5h	75
	1300-1400hrs	1h	70
	1400-2200hrs	3h	65
	2200-0700hrs	1h	55
Sunday / public holiday	0700-2100hrs	1h	65
	2100-0700hrs	1h	55

It may be appropriate to offer noise insulation (or reasonable costs) where the construction noise level is expected to exceed the greater of:

- the threshold values above; or
- 5 dB above the pre-works ambient noise level,

for a period of 10 or more days of working in any 15 consecutive days, or for more than 40 days in any 6-month period.

It may be appropriate to offer temporary rehousing (or reasonable costs) where the construction noise level is expected to exceed the greater of:

- 10 dB above the noise insulation threshold values; or
- 10 dB above the pre-works ambient noise level.

for the same duration.

Vibration levels can be estimated using empirical formulae from BS 5228-2; these can be used to predict impacts from significant vibration-generating activity, such as piling, carried out in near proximity to receptors. Criteria for assessing the impacts of vibration are given as shown in Table 11.2.3.

Table 11.3.5: BS 5228-2 Guidance on Effects of Construction Vibration Impacts on Human Receptors

Vibration Peak Particle Velocity, mms^{-1}	Effect
0.14	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3	Vibration might be just perceptible in residential environments.
1.0	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10.0	Vibration is likely to be intolerable for any more than a very brief exposure to this level.
Single or infrequent occurrences of these levels do not necessarily correspond to the stated effect in every case. The values are provided to give an initial indication of potential effects, and where these values are routinely measured or expected then an assessment in accordance with BS 6472-1 or BS 6472-2 (BSI, 2008) might be appropriate to determine whether the time varying exposure is likely to give rise to any degree of adverse comment	

Guidance is also given in BS 5228-2 on vibration magnitudes likely to cause damage to buildings. It would be highly unusual for normal construction processes to generate vibration of sufficient magnitude to cause building damage; as shown in Table 11.3.6, the thresholds for cosmetic damage are considerably higher than those that would cause significant disturbance for most people and so impacts on human receptors are typically the determining criteria for assessing construction vibration.

Table 11.3.6: BS 5228-2 Thresholds for Building Cosmetic Damage Due to Transient Vibration

Building structure type	Component Peak Particle Velocity in specific frequency range of predominant pulse, mms^{-1}	
	4 to 15 Hz	≥ 15 Hz
Industrial / heavy commercial – reinforced or framed	≥ 50.0	
Residential / light commercial – unreinforced or light framed	≥ 15.0 at 4 Hz, increasing to ≥ 20.0 at 15 Hz	≥ 20.0 at 4 Hz, increasing to ≥ 50.0 at 40 Hz and above
Values referred to are at the base of the building For unreinforced or light framed buildings, a maximum displacement of 0.6 mm (zero to peak) at frequencies below 4 Hz should not be exceeded		

BS 6472-2:2008 Guide to evaluation of human exposure to vibration in buildings. Part 2. Blast-induced vibration

For blast-induced vibration, BS 6472-2 (BSI, 2008b)[11.22] gives guideline limits for specific operations deemed to ensure a 'low probability of adverse comment', as shown in Table 11.3.7.

Table 11.3.7: BS 6472-2 Guidance on Maximum Magnitudes of Blast Vibration at Human Receptors Deemed to Ensure a Low Probability of Adverse Comment

Place	Time	Peak Particle Velocity limit for up to 3 events per day*, mms^{-1}
Residential	Daytime, Mon-Fri 0800-1800hrs, Sat 0800-1300hrs Night-time 2300-0700hrs Other times	≤ 6.0 to 10.0** ≤ 2.0 ≤ 4.5
Offices or workshops†	Any	≤ 14.0

*For operations exceeding 3 vibration events per day, the limits should be multiplied by a modifying factor F depending on the number of events N, and the blast duration T (in seconds): $F = 1.7N^{0.5}T^{-d}$

where the exponent d is 0 for $T < 1$, 0.32 for wooden floors or 1.22 for concrete floors (for $T > 1$).

**Within residential properties people exhibit a wide variation of tolerance to vibration. Specific values are dependent upon social and cultural factors, psychological attitudes and the expected degree of intrusion. In practice the lower limit should be used with the higher limit being justified on a case-by-case basis.

†Critical working areas where delicate tasks impose more stringent criteria than human comfort are not considered.

The limits given do not consider cumulative impacts from structure-borne noise.

A blast vibration 'event' is defined as an occurrence exceeding the greater of 0.5 mms^{-1} PPV or the background vibration.

A concern with blasting operations is air overpressure, which can induce secondary vibrations in lightweight structural elements. It is acknowledged in BS 6472-2 that prediction of air overpressure from blasting is "*almost impossible*"; therefore it is typically necessary for trial blasts to be undertaken to examine the likelihood of significant adverse effects. Criteria for air overpressure effects can be found in BS 5228-1, as shown in Table 11.3.8.

Table 11.3.8: BS 5228-1 Guidance on Effects of Blast-Induced Air Overpressure

Air overpressure level, dB(Z)	Effect
≥ 120	Above the threshold of perception
≥ 150	Poorly mounted windows may crack
≥ 170	Most windows will crack

In general for blasting operations, BS 5228-1 advises close cooperation between the operator, the local planning authority (LPA) and the affected community (BSI, 2009a)[11.18]:

"*Blasting can be an emotive issue for residents... Good liaison between operator and residents is essential to prevent unnecessary anxiety. Wherever possible, the operator should inform each resident of the proposed times of blasting and of any deviation from this programme in advance of the operations.*

On each day that blasting takes place it should be restricted as far as practicable to regular periods."

11.3.2 Consultation

During the assessment process, consultation has been undertaken with Gwynedd Council Environmental Health Department (GCEHD) to discuss and agree the methodology. The main points from the consultation are summarised in Table 11.3.9.

Table 11.3.9: Summary of Local Authority Consultation

Date	Consultation / query	Outcome / response
18/06/2015	Request issued by the JV Team for comment from GCEHD on proposed survey methodology and measurement locations (e-mail and telephone).	Confirmation received from GCEHD of acceptability of the adopted methodology (telephone).
13/07/2015	Request from GCEHD for precise coordinates of measurement locations (telephone).	Coordinates provided by the JV Team (e-mail).
13/07/2015	Concern raised by GCEHD on risk of groundborne vibration impacts from the new bypass on existing residents (telephone).	Response issued by the JV Team referring to DMRB guidance and TRL research study; operational groundborne vibration is not considered to be a significant concern for the Scheme (e-mail).
24/08/2015	Query raised by GCEHD about inclusion of permanent operator-owned dwellings located on Glan Gwna Holiday Park site (telephone).	Confirmation by the JV Team that 3 permanent dwellings within the site were initially included in the impact assessment on the basis of received information, subsequently increased to 4 (e-mail).
24/08/2015	Request from GCEHD for ES Scoping Report (telephone).	Access to Scoping Report provided by the JV Team (e-mail).
30/11/2015	Request issued by the JV Team for GCEHD to review key-stage 3 study area and comment on receptors identified for assessment in list and diagrammatically (e-mail and telephone).	No comments received.

11.3.3 Baseline Noise Survey

Prior to conducting the baseline survey, GCEHD were requested to comment on the details of the proposed methodology. A detailed description of the survey methodology employed can be found in the Baseline Survey Report, included in Volume 3, Appendix H.3; a brief summary is outlined in Section 11.4 below.

11.3.4 Noise Prediction Model

The potential impacts arising from the operation of the Scheme have been determined according to the DMRB method using a 3D computer prediction model. The model implements the calculation algorithms from CRTN, incorporating additional requirements from DMRB.

The model has been generated using Ordnance Survey Mastermap and Terrain 50 topographical data, combined with more detailed alignment data for the Scheme itself. An AddressBase Plus layer has been added to include identified NSRs located within the calculation area; a total of 6,002 NSRs have been included in the model. The NSRs identified have been verified by the JV Team and are listed in Volume 3, Appendix H.2. Façade noise levels have been calculated for each NSR at 1m from the first floor façade, including an adjustment of +2.5 dB to account for sound energy reflected by the façade.

The source data for the CRTN calculations are taken from outputs of the traffic model provided by the JV Team. The traffic flows and road links incorporated into the noise model are shown in Volume 3, Appendix H.4.

The model has also been used to calculate worst-case construction noise impacts according to the BS 5228 method. The construction noise sources were input in line with the construction works information provided by the JV Team, which is outlined in Section 11.5 below.

11.3.5 Effects Significance Criteria

Guidance on assessing environmental noise impacts can be found in the Institute of Environmental Management and Assessment Guidelines for Environmental Noise Impact Assessment (IEMA, 2014)[11.23]. The significance of environmental noise effects should consider the magnitude and duration of the impact, the sensitivity or importance of the receptor, and the likely responses to the effect, in terms of changes to human behaviour or suitability of buildings for the intended use. This assessment is focused on residential and other sensitive receptors (OSRs) as described above; for simplicity these are all considered to have 'high' sensitivity to noise and vibration. The criteria used in the assessment have been selected in consideration of the potential effects on human health.

Construction effects

For construction noise and vibration, the adverse effects may be potentially significant based on impact magnitude, but would be temporary and could also be of relatively limited duration, in which case the possible implications of mitigation for prolonging exposure, albeit at lower impact levels, should also be borne in mind.

The following significance criteria for construction noise and vibration have been adopted for the assessment, based on the guidance in BS 5228.

Table 11.3.10: Adopted Adverse Construction Noise Effects Significance Criteria

Impact Criterion	Impact Magnitude	Description of Potential Effects	Adverse Effects Significance	Action
Level at NSR below ABC threshold during works	Negligible	Potential for some disruption to outdoor amenity, but unlikely to cause serious concern for temporary works.	Insignificant	Accept: inform LPA and NSRs
Level at NSR exceeds ABC threshold during works	Minor	Temporarily disruptive to outdoor or indoor amenity; may induce annoyance.	Slight	Mitigate: use best practicable means to reduce and minimise impacts / duration, and inform LPA and NSRs
Level at NSR exceeds ABC thresholds by 10 dB, or noise insulation guideline thresholds and durations	Moderate	Disruptive to indoor amenity; occupants take action to reduce noise, e.g. keeping windows shut; potential to generate serious annoyance and complaints.	Significant	
Level at NSR exceeds temporary rehousing guideline thresholds and durations	Major	Likely to be intolerable for any prolonged period; potentially disruptive to sleep indoors; complaints from occupants.	Substantial	Mitigate: avoid /prevent exposure

Table 11.3.11: Adopted Adverse Construction Vibration (Non-Blasting) Effects Significance Criteria

Impact Criterion, component PPV, mms^{-1}	Impact Magnitude	Description of Potential Effects	Adverse Effects Significance	Action
< 0.3 mms^{-1}	Negligible	Unlikely to be perceived.	Insignificant	Accept: inform LPA and NSRs
≥ 0.3 and < 1.0	Minor	Unlikely to generate serious annoyance, provided duration is limited and receptors are informed.	Slight	Mitigate: minimise impacts / duration, and inform LPA and NSRs
≥ 1.0 and < 10.0	Moderate	Increasingly likely to generate serious annoyance and complaints.	Significant	
≥ 10.0	Major	Likely to be intolerable for any prolonged period; complaints from affected receptors.	Substantial	Mitigate: avoid /prevent exposure

A need for rock extraction on the Scheme has been identified for areas near to the Plas Menai roundabout, where a proposed cutting is likely to require the Scheme route to interface with existing layers of rock. The required extent, scope and methodology of these works is not yet known and details are not available for this ES. The approach could incorporate ripping or blasting techniques, or a combination thereof. Suitable criteria for blasting vibration and air overpressure are found in BS 6472-2 and BS 5228-1 respectively, as shown in Tables 11.3.7 and 11.3.8 above.

Operational effects

The significance criteria for operational noise effects used in the assessment are shown in Tables 11.3.12 and 11.3.13.

Table 11.3.12: Adopted Operational Noise Change Effects Significance Criteria

DMRB Impact Magnitude	Description of Potential Effects	Effects Significance
Negligible	Unlikely to be a noticeable change.	Insignificant
Minor	A perceptible but small change in noise level, unlikely to result in significant beneficial or adverse effects.	Slight
Moderate	Likely to be noticeable; receptors may feel reduced (beneficial) or increased (adverse) annoyance due to road traffic.	Significant
Major	Likely to result in substantial changes to the noise environment; receptors may alter their behaviour due to significantly lower (beneficial) or higher (adverse) levels of road noise and associated annoyance.	Substantial

Table 11.3.13: Adopted Operational Airborne Noise and Vibration Nuisance Effects Significance Criteria

DMRB Nuisance Change %	Description of Potential Effects	Effects Significance
<10%	An increasing proportion of people are likely to experience reductions (beneficial) or increases (adverse) in nuisance caused by road traffic noise and airborne vibration.	Insignificant
10 – 20%		Slight
20 – 40%		Significant
> 40%		Substantial

11.4 Baseline Conditions

11.4.1 Survey Details

The baseline noise survey including methodology is reported in Volume 3, Appendix H.3. In conducting the survey, reference was made to the guidance in CRTN and BS 7445 (BSI, 1991-2003)[11.24]. The survey was conducted over two periods: 22nd – 26th June 2015, and 8th – 9th September 2015 and incorporated short-term and long-term monitoring at a total of nine locations. The baseline survey positions can be viewed in Volume 2, Figure 11.2, and geo-referenced location coordinates are included in Volume 3, Appendix H.3.

The purpose of the survey was to provide data for inter-comparison with the model calculations, and to obtain indicative ambient noise levels at properties remote from existing roads (and therefore unlikely to have local noise environments dictated by road noise).

The 'Shortened Measurement Procedure' described in CRTN was adopted at six locations (ML1 to ML6) adjacent to the A487, A4085, A4086 and B4366 routes. Three one-hour measurements were undertaken at each of the locations between 10:00 and 17:00 hours. These measurements were undertaken to compare the results with outputs from the road noise prediction model.

Long-term monitoring was also undertaken at three residential properties (ML7 to ML9) over periods of 24-72 hours. Measurements were continuously logged at 15-minute intervals. These measurements were undertaken to provide typical ambient noise levels for properties likely to be affected by construction noise.

Calibrated measurement equipment was used throughout, conforming to the Class 1 specifications of BS 61672-1 (BSI, 2003)[11.25].

Weather conditions in the local area were tracked during the surveys using on-site observations and local monitoring stations, with no adverse conditions noted.

Key results from the baseline survey are summarised in Table 11.4.1 and Table 11.4.2.

Table 11.4.1Summary of Short-Term Baseline Noise Survey Results

Date	Location ref.	Description	Derived $L_{A10,18hr}$ at 10m, dB
22/06/15	ML1	A487 South	77.2
23/06/15	ML2	A487 Fford Bont Saint	68.9
25/11/15	ML3	A4085	66.5
24/06/15	ML4	A4086	71.0
24/06/15	ML5	B4366	69.5
23/06/15	ML6	A487 Fford Bangor	70.2

Table 11.4.2: Summary **of Long-Term Baseline Noise Survey Results**

Date	Location ref.	Description	Lowest typical measured ambient levels $L_{Aeq,T}$			
			16hr Day (0700-2300hrs)	12hr day (0700-1900hrs)	4hr eve (1900-2300hrs)	8hr night (2300-0700hrs)
22/06/15 – 25/06/15	ML7	Gwynfryn, Llanfaglan	44	44	41	38
23/06/15 – 25/06/15	ML8	Bryn Eglwys, Caeathro	49	50	40	35
08/09/15 – 09/09/15	ML9	The Glyn, Penybryn Road, Caeathro	46	47	43	36

It can be seen that the levels recorded in Table 11.4.2 are relatively consistent (in view of the 2.5 km distance between the Llanfaglan and Caethro properties), and can be considered representative of the lowest typical levels expected around rural and semi-rural areas, remotely located from the existing main roads in the area.

The traffic model used to provide the projected flow data for the Scheme has been used to obtain traffic volumes for the baseline year 2015. This data has been inserted into the noise prediction model and used to calculate existing road noise levels at the short-term survey locations, for inter-comparison of the noise model and baseline data. The results of the comparison are shown in Table 11.4.3.

Table 11.4.3.: Comparison of Baseline Survey and Baseline Model

Location ref.	Survey Derived Level $L_{A10,18hr}$ at 10m, dB	Model Predicted Level $L_{A10,18hr}$ at 10m, dB
ML1	77	73
ML2	69	71
ML3	67	64
ML4	71	71
ML5	70	69
ML6	70	71

11.5 Predicted Environmental Effects (without mitigation)

11.5.1 Construction Noise

The construction phase of the Scheme is projected over 23 months beginning near the start of 2017. The works have been divided into six chainage links covering the extent of the Scheme, as shown in Table 11.5.1.

Table 11.5.1: Chainage Links for Construction Works

Chainage	Description
0-1800	Goat Roundabout tie in to Afon Gwyrfai Viaduct
1801-3500	Afon Gwyrfai Viaduct to Meifod Roundabout
3501-5300	Meifod Roundabout to A4085 Waunfawr Road
5301-6400	A4085 Waunfawr Road to Cibyn Roundabout
6401-8400	Cibyn Roundabout to Bethel Roundabout
8401-9800	Bethel Roundabout to Plas Menai Roundabout

The main phases of activity required at each link have been identified by the JV Team, together with specific plant items and predicted worst-case operational requirements (i.e. equipment operational and diurnial activity patterns). The work phases have been examined, and five periods have been identified that represent the peak simultaneous noisy activity expected at each chainage link, as shown in Table 11.4.2. A chart illustrating the projected work phases and the peak assessment periods is included in Volume 3, Appendix H.5.

Table 11.5.2: Peak Construction Work Stages Assessed

Stage	Week Commencement (from start of works)	Duration of Peak Period Simultaneous Activity, weeks	Planned Simultaneous Activities
1	WK6	2	Site clearance; fencing and landscaping
2	WK18	2	Earthworks; structures; rock excavation and processing; kerbs, footways, paved areas
3	WK32	1	Earthworks; structures; rock processing; drainage and ducts; piling; fencing and landscaping
4	WK41	1	Earthworks; structures; rock excavation and processing; drainage and ducts; piling; fencing and landscaping
5	WK59	1	Earthworks; structures; drainage and ducts; fencing and landscaping; kerbs, footways, paved areas

The details of specific noise-generating activities required for each stage at all chainage links are set out in Volume 3, Appendix H.5. Source noise levels for equipment have been selected from the BS 5228-1 database along with proportional ‘on-times’ (percentage operation per shift) based on the information provided by the JV Team. This information has been used to build a noise prediction model following the calculation approach set out in BS 5228-1. To simplify the wide array of possible combinations of simultaneous activities and locations relative to the most exposed receptors, the assessment has been narrowed to focus on the worst-case situations

that could potentially arise, i.e. a period in which all the equipment identified for a particular activity is being operated at positions near the works site boundary closest to the most exposed receptor. In reality, although such situations might arise temporarily, the duration would be limited as equipment would be operating across various locations. An exception is made in the case of works associated with a specific discrete structure, such as a bridge or viaduct, for which the works would naturally take place at or close to the central position of the structure, and this is reflected in the calculations.

The standard working hours proposed have also been provided by the JV Team, understood to be 0700-1900hrs Monday to Friday and 0700-1700hrs Saturday. In addition to the working day hours, the construction plan includes some planned night-time working at specific links, which have been assessed separately against the night-time thresholds.

Receptors have been selected as the nearest and most exposed to the works locations, in order to represent the worst-case impacts that could occur for NSRs in their vicinity. The addresses and location plans for each noise assessment receptor are shown in Volume 3, Appendix H.5. 'ABC' threshold categories have been assigned by estimating the day and night-time ambient noise levels for each receptor using the baseline noise prediction model; this approach is likely to slightly underestimate ambient levels for receptors located far from existing roads, i.e. resulting in more stringent thresholds. Where appropriate, the derived noise levels have also been compared with the ambient levels measured during the baseline survey.

The predicted worst-case unmitigated construction impacts at the most exposed receivers for each peak stage and link are found in Volume 3, Appendix H.5 and the associated significance of adverse effects summarised in Table 11.5.3.

Table 11.5.3: Potential Unmitigated Construction Noise Adverse Effects Significance

Chainage	Receptor ref.	Significance of Potential Adverse Effects, 1: Substantial; 2: Significant; 3: Slight; 4: Insignificant								
		Period 1	Period 2		Period 3		Period 4		Period 5	
		Day (only)	Day	Night	Day	Night	Day	Night	Day	Night
0-1800	C1	1	2	3	2	N/A	2	3	2	3
0-1800	C2	1	2	4	2	N/A	2	4	2	4
0-1800	C3	4	4	4	4	N/A	4	4	4	4
0-1800	C4	2	4	4	4	N/A	4	4	4	4
0-1800	C5	3	4	4	4	N/A	4	4	4	4
1801-3400	C6	1	4	N/A	2	N/A	1	4	1	4
1801-3400	C7	2	4	N/A	3	N/A	3	3	3	3
1801-3400	C8	2	4	N/A	2	N/A	2	3	2	3
3401 - 5300	C9	2	3	4	2	4	2	4	2	N/A
3401 - 5300	C10	3	3	3	3	3	3	3	3	N/A
3401 - 5300	C11	2	2	4	2	4	2	4	2	N/A
5301 - 6400	C12	4	4	N/A	4	N/A	4	N/A	4	N/A
6401 - 8400	C13	2	2	4	3	N/A	4	N/A	4	N/A
6401 - 8400	C14	2	4	4	4	N/A	4	N/A	4	N/A

Table 11.5.3: Potential Unmitigated Construction Noise Adverse Effects Significance

Chainage	Receptor ref.	Significance of Potential Adverse Effects, 1: Substantial; 2: Significant; 3: Slight; 4: Insignificant								
		Period 1	Period 2		Period 3		Period 4		Period 5	
		Day (only)	Day	Night	Day	Night	Day	Night	Day	Night
6401 - 8400	C15	4	4	3	4	N/A	4	N/A	4	N/A
8401 - 9800	C16	1	1	4	1	4	1	4	1	4
8401 - 9800	C17	1	1	4	1	4	1	4	1	4
8401 - 9800	C18	3	3	4	4	4	4	4	4	4
8401 - 9800	C19	4	4	4	4	4	4	4	4	4
8401 - 9800	C20	4	4	4	4	4	4	4	4	4

The summary of potential effects in Table 11.5.3 shows that:

- Unmitigated worst-case construction noise impacts would be expected to have significant adverse effects at the most exposed receptors, some of which could be substantial; and
- Planned night-time activities, which comprise works to new structures, are considered unlikely to generate significant adverse effects.

The greatest adverse construction noise impacts would be expected for receptors near to site clearance and earthworks activities, which at times would involve use of particularly noisy equipment such as chainsaws and wood chippers. Mitigation of the noisy activities will be necessary, and will need to achieve significantly reduced levels of impact. Proposed mitigation measures are outlined in section 11.6.

11.5.2 Construction Vibration

The most significant vibration impacts (other than blasting) would be expected to be generated during piling and roadworks activities involving vibratory rollers. Using source data from BS 5228-2, calculations have been carried out to estimate the potential adverse vibration effects arising from use of the following machinery:

- Hydraulic hammer piling rig operated at locations of new structures with 50kJ maximum impact energy per blow; and
- Vibratory rollers, two heavy ride-on units operating simultaneously along the Scheme alignment.

Based on the predicted vibration impacts shown in Volume 3, Appendix H.5, potential adverse effects are summarised in Table 11.5.4 (negligible effects have been excluded).

Table 11.5.4: Summary of Potential Adverse Construction Vibration Effects

Adverse Effect Significance	Number of Receptors Affected
Slight	237
Significant	10
Substantial	0

The receptors identified as potentially subject to significant adverse effects are listed in Appendix H.5 (Volume 3), along with estimations of the worst-case vibration levels and the dominant source at each. Possible mitigation measures are described in Section 11.6.

11.5.3 Construction Blasting

Blasting operations are expected to be necessary to remove rock from the alignment cutting near to the Plas Menai roundabout (chainage link 8401–9800). The nearest residential receptors are located at ranges of around 150-200 m. The extent and techniques required have not yet been established and a quantitative analysis is considered unlikely to yield realistic or useful information. The adverse effects of blasting would be expected to be at least approaching significance, but can be suitably controlled using measures outlined in Section 11.5. Receptors potentially affected by blasting may include commercial buildings with vibration sensitive equipment, and a quantitative assessment will be necessary prior to commencing with the works, once required details have been established.

11.5.4 Operational Noise and Vibration

The potential effects of unmitigated operation of the Scheme have been evaluated during the design development. As a result, the mitigation strategy described in section 11.6 has been integrated into the fundamental Scheme design. The predicted effects of the mitigated Scheme are detailed in section 11.7.

11.6 Proposed Mitigation

11.6.1 Construction Noise and Vibration

A detailed scheme of mitigation for construction noise impacts will be drawn up as part of a Construction Environmental Management Plan (CEMP), at the appropriate time, i.e. alongside the preparation of a full and detailed construction programme. BS 5228 provides guidance on appropriate methods of noise and vibration control. Specific measures for the CEMP include:

- The appropriate selection of plant, construction methods and programming: only plant conforming with or better than relevant national or international standards, directives or recommendations on noise or vibration emissions will be used. Construction plant will be maintained in good condition with regards to minimising noise output and workers exposed to harmful noise and vibration;

- Construction plant will be appropriately operated and maintained, having regard to the manufacturer's written recommendations or using other suitable

operation and maintenance programmes which reduce noise and vibration emissions. All vehicles and plant will be switched off when not in use;

- Design and use of site hoardings and screens, where necessary, to provide acoustic screening at the earliest opportunity. Where practicable, gates will not be located opposite buildings containing noise sensitive receptors;
- Choice of routes and programming for the transport of construction materials, spoil and personnel to reduce the risk of increased noise and vibration impacts due to the construction of the project;
- Vehicle and mechanical plant used for the purpose of the works should be fitted with effective exhaust silencers, to be maintained in good working order and operated in such a manner as to minimise noise emissions. Plant items that comply with the relevant EU/UK noise limits applicable to that equipment will be used;
- The positioning of construction plant and activities to minimise noise at sensitive locations;
- Equipment that breaks concrete by munching or similar, rather than by percussion, will be used as far as is practicable;
- The use of mufflers on pneumatic tools;
- Where practicable, rotary drills actuated by hydraulic or electrical power will be used for excavating hard materials;
- The use of non-reciprocating construction plant where ever practicable;
- The use, where necessary, of effective sound reducing enclosures; and
- Information provision and communication with local communities, including forewarning of especially noisy works expected in the area and expected durations.

Details of specific noise mitigation such as silencers and enclosures will be provided in the CEMP. The approach to controlling temporary construction noise and vibration impacts should employ an approach based on Best Practicable Means (BPM), which would include measures such as those set out above. It is recommended that local and boundary screening is considered wherever necessary to reduce adverse impacts. It is expected that temporary noise barriers or enclosures in combination with the implementation of BPMs could provide approximate maximum noise attenuation of up to 20 dB throughout noisy activities.

It should also be noted that the spatial distribution of noisy activities and machinery around the works site will generally result in lower noise impacts than have been predicted using the worst-case approach adopted.

Piling vibration impacts can be significantly reduced by use of piling techniques such as rotary boring. Suitable piling processes depend on the makeup of the ground and this will be investigated fully during preparation of the CEMP.

Vibratory rollers used during the roadworks can be mitigated by equipment selection (i.e. lower-powered units) and by careful planning (e.g. limiting operations at areas very close to nearby receptors). Both these measures would typically prolong works duration however, and this must be weighed against a potentially higher impact over a shorter period.

11.6.2 Construction Blasting

Effects from blasting operations will be controlled with the following measures:

- A detailed assessment of residential and non-residential sensitive receptors will be undertaken;
- A plan of works specifying techniques, locations, detonation depths and maximum charge sizes will be devised to minimise adverse effects as far as practicable and included in the CEMP;
- Blasting operations will only take place within strictly specified periods and limited numbers of detonations that will be agreed with the LPA and communicated to the local community; and
- The likelihood of blasting impacts causing disturbance to receptors will be compared with the criteria give in BS 6472-2 (see Table 11-5) or other criteria suitable to the identified receptor (e.g. buildings with vibration sensitive equipment may have lower thresholds for significant effects).

11.6.3 Operational Noise and Vibration

A detailed appraisal of feasibility for operational mitigation measures has been carried out. It was established that the use of a thin course surfacing system with low-noise properties would provide a significant impact reduction (see DMRB guidance in section 11.3) for receptor properties adversely affected by the Scheme operation. On this basis it was decided that a low-noise TSCS would be used over the full length of the bypass, and a rated surface road noise reduction of at least -3.5 dB will form part of the construction specification.

In addition, the alignment of the Scheme has been optimised in consideration of noise, by ensuring the Scheme passes as far from existing NSRs as possible within the constraints of land use and need for crossings and structures. The land available for cuttings offering screening for noise along the Scheme route has been utilised.

The noise reduction benefits of noise barriers (earth bunding and / or acoustic fencing) have been assessed against the potential environmental and wider scheme impacts of implementing such mitigation.

The assessment considered the extent and specification of the noise barriers required to reduce noise impacts at significantly affected NSRs along the scheme. The potential impact (positive or negative) on the environment of constructing these barriers has been considered against each of the environmental topics considered in this ES. The potential wider impacts on scheme design, land take and cost have also been considered.

The appraisal concluded that the negative impacts on the environment and wider scheme of the noise barriers outweighed the noise reduction benefits provided by

them. Therefore further mitigation measures in the form of noise barriers have been ruled out.

11.7 Residual Environmental Effects (following mitigation)

11.7.1 Construction Noise and Vibration

The significance of residual adverse construction noise effects including maximum mitigation is summarised in Table 11.7.1.

Table 11.7.1: Potential Residual Construction Noise Adverse Effects Significance

Chainage	Receptor ref.	Significance of Potential Adverse Effects, 1: Substantial; 2: Significant; 3: Slight; 4: Insignificant								
		Period 1	Period 2		Period 3		Period 4		Period 5	
		Day (only)	Day	Night	Day	Night	Day	Night	Day	Night
0-1800	C1	3	4	4	4	N/A	4	4	4	4
0-1800	C2	3	4	4	4	N/A	4	4	4	4
0-1800	C3	4	4	4	4	N/A	4	4	4	4
0-1800	C4	4	4	4	4	N/A	4	4	4	4
0-1800	C5	4	4	4	4	N/A	4	4	4	4
1801-3400	C6	4	4	N/A	4	N/A	4	N/A	4	N/A
1801-3400	C7	4	4	N/A	4	N/A	4	4	4	4
1801-3400	C8	4	4	N/A	4	N/A	4	N/A	4	N/A
3401 - 5300	C9	4	4	4	4	4	4	4	4	N/A
3401 - 5300	C10	4	4	4	4	4	4	4	4	N/A
3401 - 5300	C11	4	4	4	4	4	4	4	4	N/A
5301 - 6400	C12	4	4	N/A	4	N/A	4	N/A	4	N/A
6401 - 8400	C13	4	4	4	4	N/A	4	N/A	4	N/A
6401 - 8400	C14	4	4	4	4	N/A	4	N/A	4	N/A
6401 - 8400	C15	4	4	4	4	N/A	4	N/A	4	N/A
8401 - 9800	C16	2	2	4	2	4	2	4	2	4
8401 - 9800	C17	4	4	4	4	4	4	4	4	4
8401 - 9800	C18	4	4	4	4	4	4	4	4	4
8401 - 9800	C19	4	4	4	4	4	4	4	4	4
8401 - 9800	C20	4	4	4	4	4	4	4	4	4

Table 11.7.1 shows that with the maximum expected mitigation, the majority of the most-exposed receptors would be anticipated to be subject to insignificant or slight adverse effects. The exception is at one property, Tydden Hen (ID: C16, chainage link 8401-9800) located at the side of the existing B4366, part of which would be realigned as part of the Scheme works. It can be seen from the associated C16 location diagram in Volume 3, Appendix H.5 that the property is a single dwelling situated at the very edge of the realignment section, and is over 200 m away from the main works that would take place along the Scheme alignment and the associated realignment of the un-named road connecting the A4086 and the existing A487. The main noisy activities impacting directly on this property would comprise the

earthworks and roadworks necessary to realign the B4366, and significant adverse effects would be temporary and limited in duration.

Slight adverse effects are also anticipated for two single dwellings along chainage link 0-1800, Parc (ID: C1) and Morogoro (ID: C2). The noisiest activities here are expected to be the site clearance and earthworks. These activities are expected to last for a few days in close proximity to Parc, and a few weeks near Morogoro. Careful consideration of mitigation will be needed, especially the use of temporary barriers to minimise disruption, wherever possible.

Receptors expected to be significantly adversely affected by construction vibration are identified in Appendix H.5 (Volume 3). Most of the impacts depend on the technique for piling used in the construction of structure S109 (Pont Ceriw Overbridge), which will be established during preparation of the CEMP. It may be possible to reduce the effects by using a lower impact energy hammer pile, or an alternative piling technique. However, the expected worst-case impacts from hammer piling are predicted to be no more than around 1 to 1.6 mms^{-1} PPV, which are at the lower end of significance. BS 5228-2 advises that for vibration events of magnitude around 1 mms^{-1},

> "*It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.*"

It is anticipated that with careful planning and communication, the CEMP will provide sufficient means to control adverse effects of vibration.

Construction Blasting

Residual effects of blasting may be potentially significant, but of very limited duration. It is expected that blasting effects can be effectively managed by suitable design of the works and cooperation with the LPA and local community.

11.7.2 Operational Noise and Vibration

DMRB Detailed Impact Assessment

Table 11.7.2 below presents the road noise impacts expected in the long-term if the Scheme does not proceed, i.e. values representing changes in noise expected due to traffic flows on existing roads over the 15-year assessment period. A corresponding noise impact contour map is shown in Volume 2, Figure 11.3.

Table 11.7.2: Long-term Road Noise Impact – No Scheme

Scenario/Comparison: Do Minimum in 2018 opening year vs. Do Minimum in 2033 design year (DMD-DMO)					
Impact; change in noise level			Daytime $L_{A10,18h}$ (0600-0000hrs)		Night-time L_{night} (2300-0700hrs)
			Number of Dwellings	Number of other sensitive receptors	Number of dwellings (≥55 dB only)
Adverse; Increase in noise level, dB	Negligible	0.1 - 2.9	5908	77	884
	Minor	3 - 4.9	0	0	0
	Moderate	5 - 9.9	0	0	0
	Major	10 +	0	0	0
No Change		0	70	6	0
Beneficial; Decrease in noise level, dB	Negligible	0.1 - 2.9	11	0	0
	Minor	3 - 4.9	0	0	0
	Moderate	5 - 9.9	0	0	0
	Major	10 +	0	0	0
Totals			5925	77	884

The results in Table 11.7.2 show that long-term road noise impacts are expected to stay largely at their current magnitude in the absence of the Scheme; most NSRs may experience an increase in noise, but the increases are not expected to be significant.

Table 11.7.3 below presents the impacts expected in the short-term due to changes in road noise levels at the Scheme opening year. A corresponding noise impact contour map is shown in Volume 2, Figure 11.4. It should be noted that the contour maps are intended to illustrate the spread of impacts around the Scheme; the contour calculations involve interpolation of noise levels and so should not be used to read off impacts for individual receptors.

Table 11.7.3: Short-term Road Noise Impact – With Scheme

Scenario Comparison: Do Minimum in 2018 opening year vs. Do Something in 2018 opening year (DSO-DMO)				
Impact; change in noise level			Daytime $L_{A10,18h}$ (0600-0000hrs)	
			Number of Dwellings	Number of other sensitive receptors
Adverse; Increase in noise level, dB	Negligible	0.1 - 0.9	338	5
	Minor	1 - 2.9	360	3
	Moderate	3 - 4.9	158	1
	Major	5 +	128	0
No Change		0	70	0
Beneficial;	Negligible	0.1 - 0.9	910	5

Table 11.7.3: Short-term Road Noise Impact – With Scheme

Scenario Comparison: Do Minimum in 2018 opening year vs. Do Something in 2018 opening year (DSO-DMO)				
Impact; change in noise level			Daytime $L_{A10,18h}$ (0600-0000hrs)	
			Number of Dwellings	Number of other sensitive receptors
Decrease in noise level, dB	Minor	1 - 2.9	3062	49
	Moderate	3 - 4.9	556	8
	Major	5 +	343	6
Totals			5925	77

The results in Table 11.7.3 show that, in terms of changes in road noise levels, short term impacts caused by the Scheme are expected to be predominantly beneficial for the majority of receptors; disregarding negligible changes, around two-thirds of the total residential receptors assessed are predicted to experience reductions in road noise levels, with around 15% (899) likely to experience significant or substantial beneficial effects. The Scheme would also be expected to benefit the majority (around 81%, or 63 properties, excluding negligible benefits) of OSRs, with around 18% (14 properties) experiencing significant or substantial beneficial effects due to reduction in noise impacts. The contour map shown in Volume 2, Figure 11.4 indicates that this is due mainly to reductions in impacts around the existing A487, which runs through the relatively densely populated centre of Bontnewydd. Road noise impacts in and around Caernarfon are also expected to be broadly beneficial. The beneficial effects include receptors within the zones identified as Priority Areas for noise action planning by the Welsh Government.

Table 11.7.3 also shows that around 3% (158) and 2% (128) of residential receptors are expected to be subject to significant or substantial adverse effects respectively, in the short term. Figure 11.4 (Volume 2) indicates that these properties are in relatively remote and sparsely populated areas, or at the fringes of Caernarfon, Llandwnda, Llanfaglan and Bontnewydd. One OSR would be expected to be subject to a significant adverse short term effect; this receptor is St Gwyndaf's Church, Caernarfon. Inspection of the overall road noise predicted at this receptor for the opening year scenarios shows that although a moderate impact is expected due to a 4 dB increase in road noise, the absolute level predicted at Scheme opening is 48 dB $L_{A10,18h}$, which is a relatively low level – the World Health Organization advises that few people are annoyed by steady environmental noise levels below around 50-55 dB $L_{Aeq,T}$ during the daytime (WHO, 1999)[11.27], which, for road noise over the 0600-0000hrs period, would be roughly equivalent to an annoyance threshold range of 52.5 – 57.5 dB L_{A10}. Road noise predicted at the Church is significantly lower than this range.

Table 11.7.4 below presents the impacts expected in the long term due to changes in road noise levels between the Scheme opening year and the 15th year. A corresponding noise impact contour map is shown in Volume 2, Figure 11.5.

Table 11.7.4: Long-term Road Noise Impact – With Scheme

Scenario Comparison: Do Minimum in 2018 opening year vs. Do Something in 2033 design year (DSD-DMO)					
Impact; change in noise level			**Daytime $L_{A10,18h}$ (0600-0000hrs)**		**Night-time L_{night} (2300-0700hrs)**
			Number of Dwellings	**Number of other sensitive receptors**	**Number of dwellings (≥55 dB only)**
Adverse; Increase in noise level, dB	Negligible	0.1 - 2.9	1162	11	13
	Minor	3 - 4.9	183	1	0
	Moderate	5 - 9.9	131	0	0
	Major	10 +	34	0	0
No Change		0	70	1	1
Beneficial; Decrease in noise level, dB	Negligible	0.1 - 2.9	3688	54	667
	Minor	3 - 4.9	350	4	86
	Moderate	5 - 9.9	290	6	102
	Major	10 +	17	0	2
Totals			5925	77	871

The results in Table 11.7.4 show that, in terms of changes in daytime road noise levels, the largest proportion (83%) of residential receptors (4,920 dwellings) are expected to experience no change or negligible changes in long term impacts. Disregarding negligible changes, around 11% (657) are expected to be subject to beneficial effects, with around 5% (307) experiencing significant or substantial benefits. Around 13% (10) of the assessed OSRs are expected to benefit from noise change impacts. Figure 11.5 (Volume 2) shows that the expected long term beneficial effects include receptors within the A487 corridor Priority Area identified by Welsh Government for noise action planning. In the night-time, most receptors are expected to be subject to beneficial changes. Around 12% (104) of the assessed receptors (i.e. where night noise levels may exceed 55 dB L_{night} in either scenario) are predicted to experience significant or substantial benefits in terms of night-time noise reduction. No receptors are expected to experience significant adverse effects due to night-time road noise exposure.

Table 11.7.4 also shows that receptors subject to significant adverse effects in the long term (corresponding to moderate impacts from changes in noise level) are reduced slightly compared with the short term, to 2% (or 131 properties). Receptors expected to be subject to substantial adverse effects in the long term (corresponding to major impact from changes in noise level) are reduced to around 0.6% (or 34 properties). Once again, Figure 11.5 (Volume 2) indicates these are generally single dwellings in relatively remote areas, or small clusters of properties on the fringes of Llanfaglan and Bontnewydd.

The results of the road noise nuisance assessment are summarised in Table 11.7.5.

Table 11.7.5: Road Noise Nuisance Changes

Scenario Comparison: Do Minimum in 2018 opening year vs. Do Minimum / Do Something in 2033 design year			
Change in nuisance level		Without Scheme	With Scheme
		Number of Dwellings	Number of Dwellings
Increase in nuisance level	< 10%	5881	499
	10 < 20%	0	264
	20 < 30%	0	383
	30 < 40%	0	223
	> 40%	0	63
No Change	0%	37	207
Decrease in nuisance level	< 10%	7	4078
	10 < 20%	0	158
	20 < 30%	0	50
	30 < 40%	0	0
	> 40%	0	0
Totals		5925	5925

The results in Table 11.7.5 show that, without the Scheme, the majority of people would be expected to experience a small increase in road noise nuisance. With the Scheme, the vast majority (around 72%, or 4,286 NSRs) are predicted to experience a small decrease in nuisance. Around 3% (158) would be expected to experience slight beneficial effects due to reductions in noise nuisance, with around 1% (50 properties) significantly benefitting. Around 10% (606) of the residential receptors are expected to experience a significant adverse effect due to noise nuisance, with around 1% (63 properties) subject to substantial adverse effects.

The results of the airborne vibration nuisance assessment are summarised in Table 11.7.6. For properties where road noise levels are expected to below 58 dB $L_{A10,18h}$, DMRB advises that very few people would be bothered by airborne vibration, and a proportion of 0% can be assumed. Including properties that have an expected 0% annoyed for either with or without the Scheme might give a misleading impression in the results (i.e. large populations with 'no change' in vibration nuisance), therefore these properties are excluded from consideration, as indicated by the totals shown in Table 11.6.6.

Table 11.7.6: Road Airborne Vibration Nuisance Changes

Scenario Comparison: Do Minimum in the opening year vs. Do Minimum / Do Something in the opening / future years			
Change in nuisance level		Without Scheme	With Scheme
		Number of Dwellings	Number of Dwellings
Increase in nuisance level	< 10%	2055	277
	10 < 20%	0	6
	20 < 30%	0	0
	30 < 40%	0	0

Table 11.7.6: Road Airborne Vibration Nuisance Changes

Scenario Comparison: Do Minimum in the opening year vs. Do Minimum / Do Something in the opening / future years			
Change in nuisance level		Without Scheme	With Scheme
		Number of Dwellings	Number of Dwellings
	> 40%	0	0
No Change	0%	52	13
Decrease in nuisance level	< 10%	0	1621
	10 < 20%	0	142
	20 < 30%	0	48
	30 < 40%	0	0
	> 40%	0	0
Totals		2107	2107

The results in Table 11.7.6 indicate that, without the Scheme, most of the residential receptors would be expected to experience small increases in airborne vibration nuisance. With the Scheme, a large proportion is expected to experience reductions in nuisance. Some of these beneficial effects are expected to be significant.

Noise Insulation Regulations Assessment

Noise levels at residential receptors within 300m of the Scheme have been assessed for eligibility for offers of noise insulation under the Regulations; none of the properties are predicted to meet the relevant criteria, and therefore no properties are deemed to be eligible.

WelTAG Appraisal

The estimated total numbers of people annoyed by noise with or without the Scheme, together with the net change in numbers are shown in Table 11.7.7.

Table 11.7.7: Summary of WelTAG Appraisal – Total Numbers and Net Change in People Annoyed by Noise With or Without Scheme

Scenario	Numbers of People Annoyed by Noise
Without Scheme	1726
With Scheme	1419
Net Change	-307

The appraisal shown in Table 11.7.7 shows that is expected to be a net reduction in numbers of people annoyed by noise if the Scheme proceeds. The net present value of the Scheme in terms of monetised noise impacts over a 60-year period is estimated at £19,640,116.

11.7.3 Limitations

As with any assessment of future environmental impacts, the potential noise and vibration effects identified in this chapter are subject to uncertainty. The main sources of uncertainty involved in the noise and vibration assessment include the following:

- Noise and vibration prediction methods
- Assumptions used as inputs to the models, including the validity of the road traffic data
- Variation in the human response to noise and vibration exposure

Measures adopted to minimise the influence of uncertainty on the outcomes of the assessment are described in Volume 3, Appendix H.6.

Variation to human response to noise and vibration exposure is uncontrollable, but the relationships used for the assessment have been derived from recognised national and international guidance.

11.8 Summary and Conclusions

11.8.1 Construction Noise and Vibration Effects

An assessment of potential adverse noise and vibration effects due to construction of the Scheme has been carried out. A worst-case approach to the assessment has been adopted, and potential unmitigated adverse effects would be expected to be substantial at the most exposed receptors. However, with the application of best practicable means control measures via the careful preparation and implementation of a Construction Environmental Management Plan, together with close cooperation with the Local Planning Authority and the affected communities, it is anticipated that noise and vibration from construction works can be adequately mitigated.

Blasting operations would be expected to raise specific concerns, and a detailed plan and assessment of the most appropriate approach and restrictions on scheduled blasts would be needed before embarking on the works. Communities should also be kept informed of scheduled blasting.

11.8.2 Operational Noise and Vibration Effects

The overall effects of the Scheme are expected to be largely beneficial. By reducing flows of traffic on existing roads through relatively densely populated areas such as Bontnewydd and Caernarfon, the majority of receptors considered are expected to be subject to reduced road noise and airborne vibration during both day and night-time. Around 15% of residential receptors, a total of 899 dwellings, are likely to experience significant or substantial beneficial effects in the short-term, reducing to around 5%, or 307 dwellings, in the long term. Other sensitive receptors (i.e. non-residential) are also expected to experience benefits, with around 18% (14 properties) significantly or substantially benefitting in the short-term, reducing to around 8% (6 properties) in the long term.
Many of the receptors likely to benefit from reductions in noise impacts are located within the Priority Areas identified by Welsh Government for noise action planning.

Adverse impacts are expected to affect smaller proportions of the exposed receptors, primarily at the relatively sparsely-populated fringes of Llanfaglan, Llanwnda and Bontnewydd. 5% of residential receptors, or a total of 286 dwellings, are predicted to

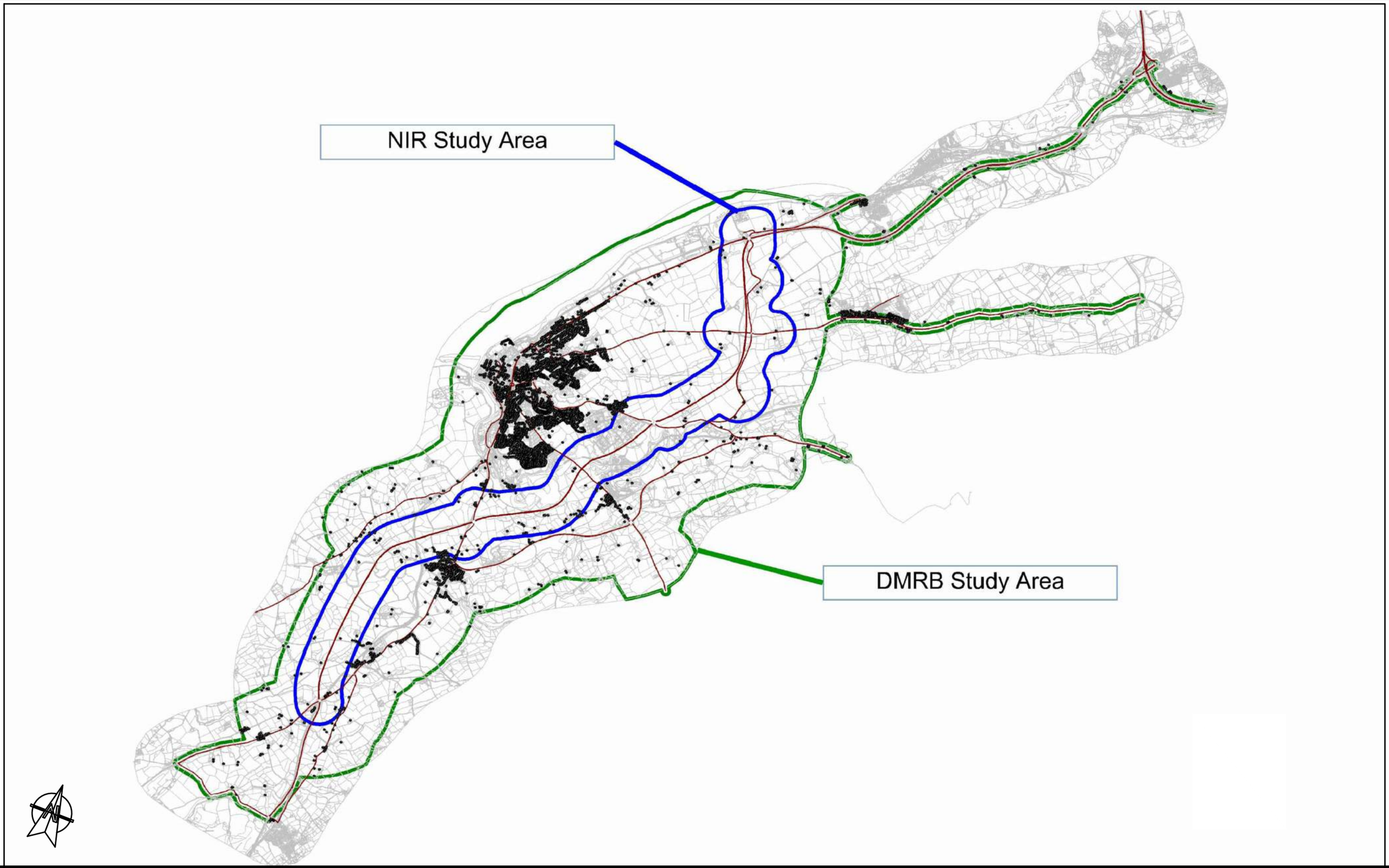
be likely to experience significant or substantial adverse effects in the short term, reducing to less than 3%, or 165 dwellings, in the long term.
Specific mitigation measures incorporated into the Scheme comprise a low-noise road surface system throughout the alignment, the positioning of the alignment, and maximised use of cuttings and embankments/bunding to provide screening. The feasibility of further screening measures (e.g. barrier fencing) has been investigated and ruled out on the basis of other practical considerations and Scheme constraints, including land acquisition, environmental effects and structural requirements.
The assessment of impacts with reference to the Noise Insulation Regulations criteria indicates that no properties are deemed eligible for a statutory offer of noise insulation.

The WelTAG appraisal of noise annoyance and monetisation indicates a net benefit to the Scheme, with a reduction in annoyed persons of approximately 307, and a net present value of £19,640,116.

The main findings of the operational noise assessment are summarised in Table 11.8.1.

Table 11.8.1: Summary of Operational Noise Impact Assessment

Noise Impacts	Affected
Short-term significant/substantial beneficial (DMRB)	899 dwellings 14 other sensitive receptors
Short-term significant/substantial adverse (DMRB)	286 dwellings 1 other sensitive receptor
Long-term significant/substantial beneficial (DMRB)	307 dwellings 6 other sensitive receptors
Long-term significant/substantial adverse (DMRB)	165 dwellings 0 other sensitive receptors
Monetised noise annoyance (WelTAG)	307 fewer dwellings: £19.6m net value



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A487 CAERNARFON AND BONTNEWYDD BYPASS

Noise & Vibration
Noise Model Study Areas

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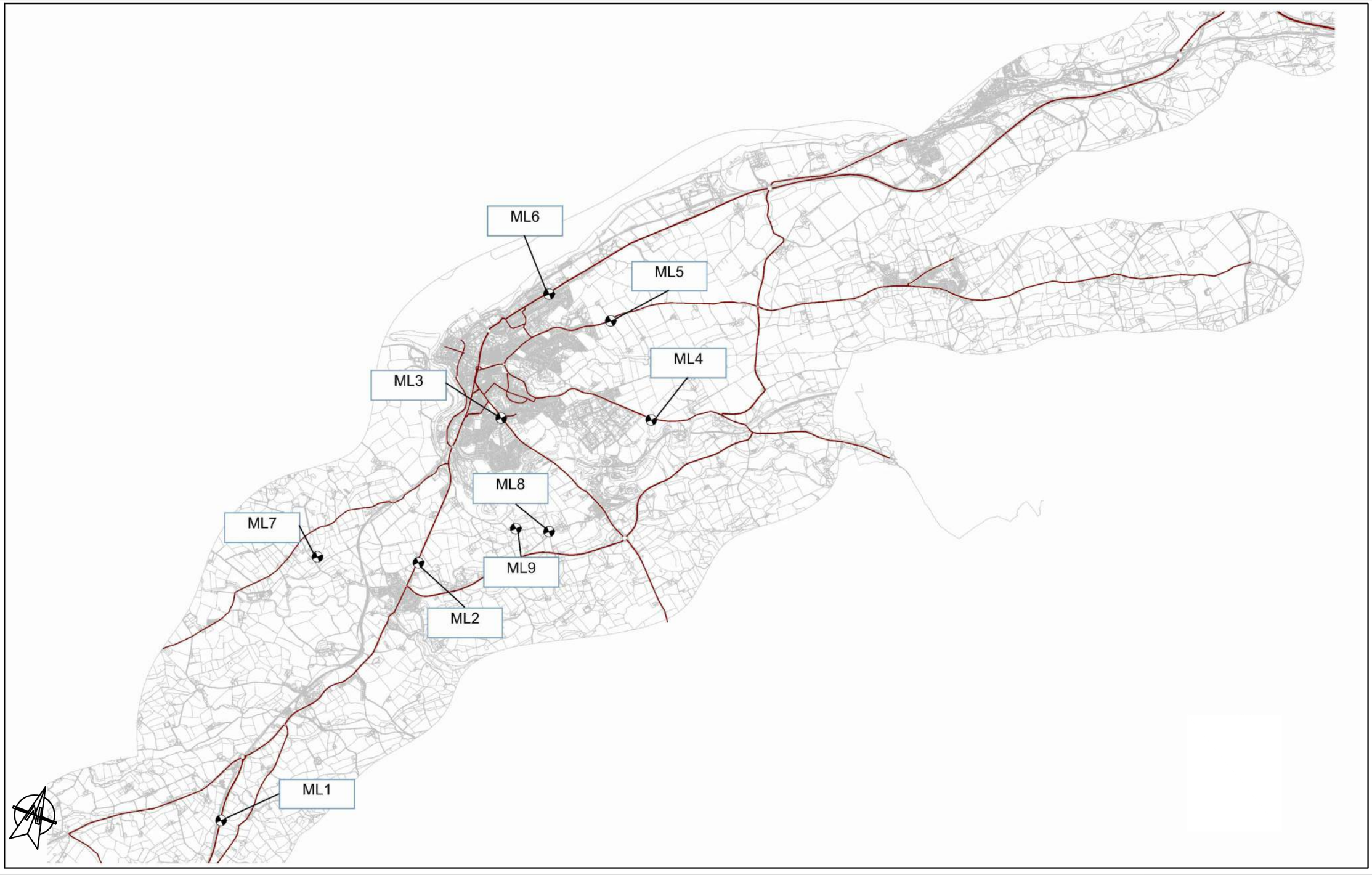

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Noise & Vibration
Baseline Noise Survey Locations

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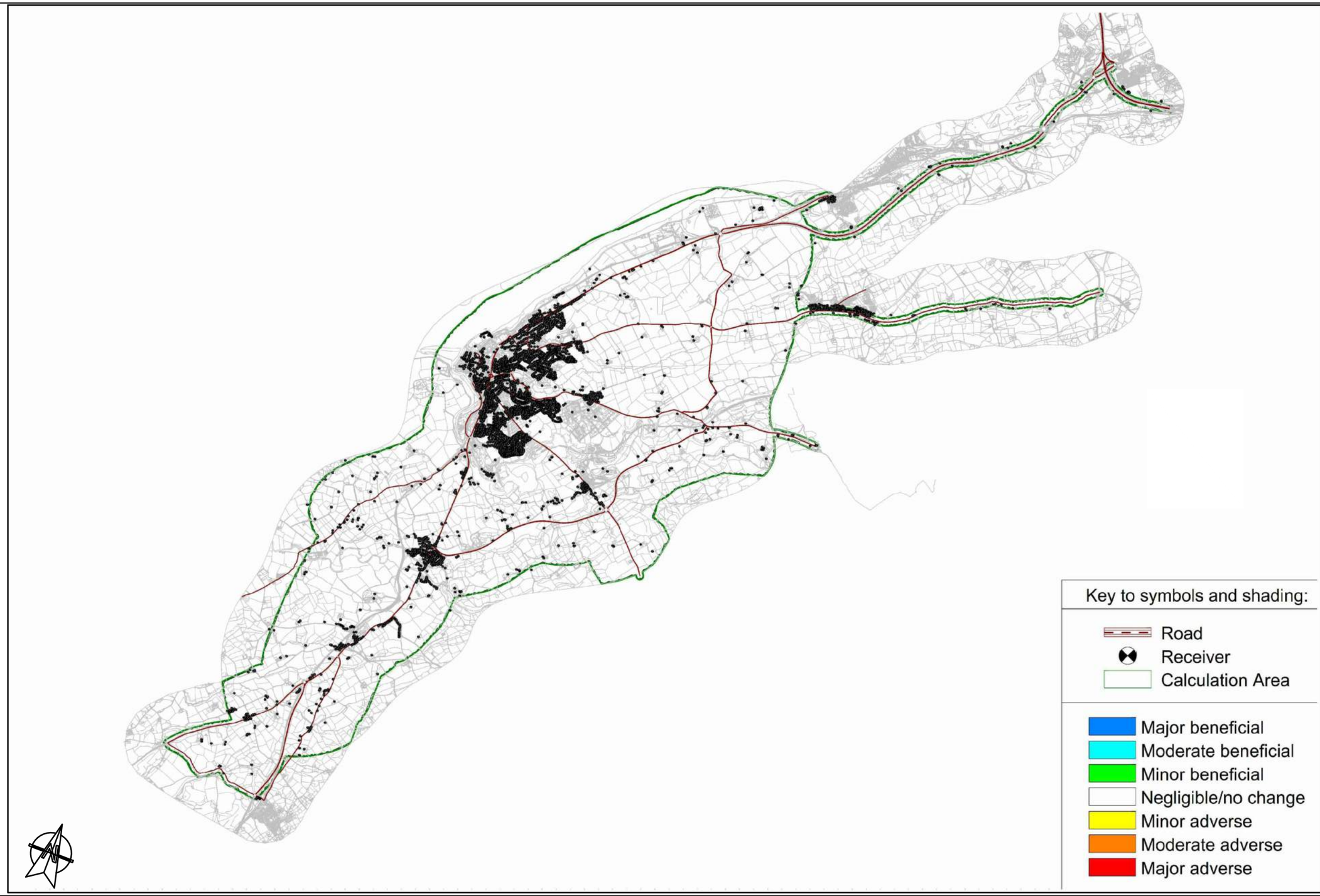

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Noise & Vibration
Noise Model DMRB Long-term Change:
Do Minimum Opening Year 2018 vs
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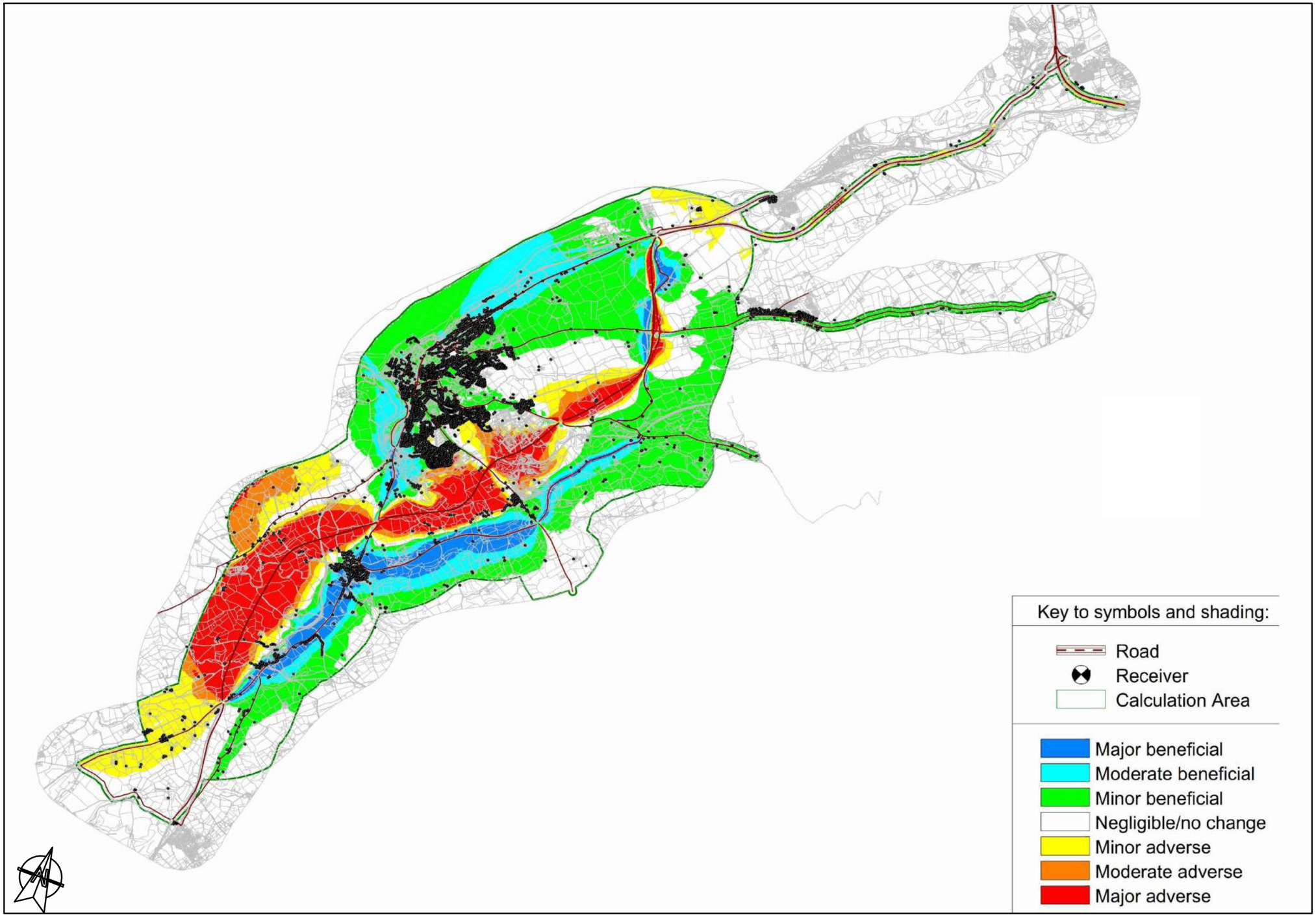

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Noise & Vibration
Noise Model DMRB Short-term Change:
Do Minimum Opening Year 2018 vs
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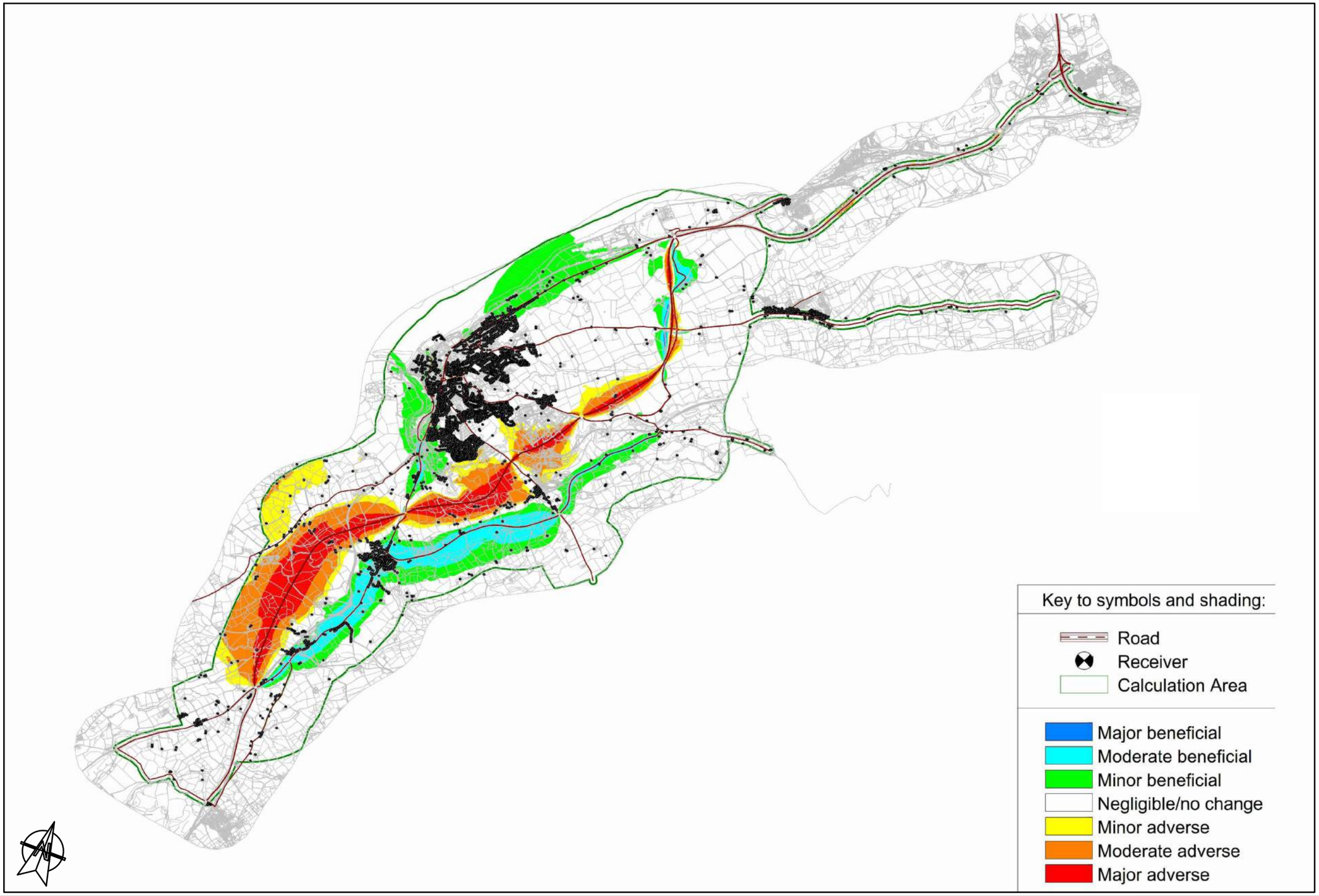

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