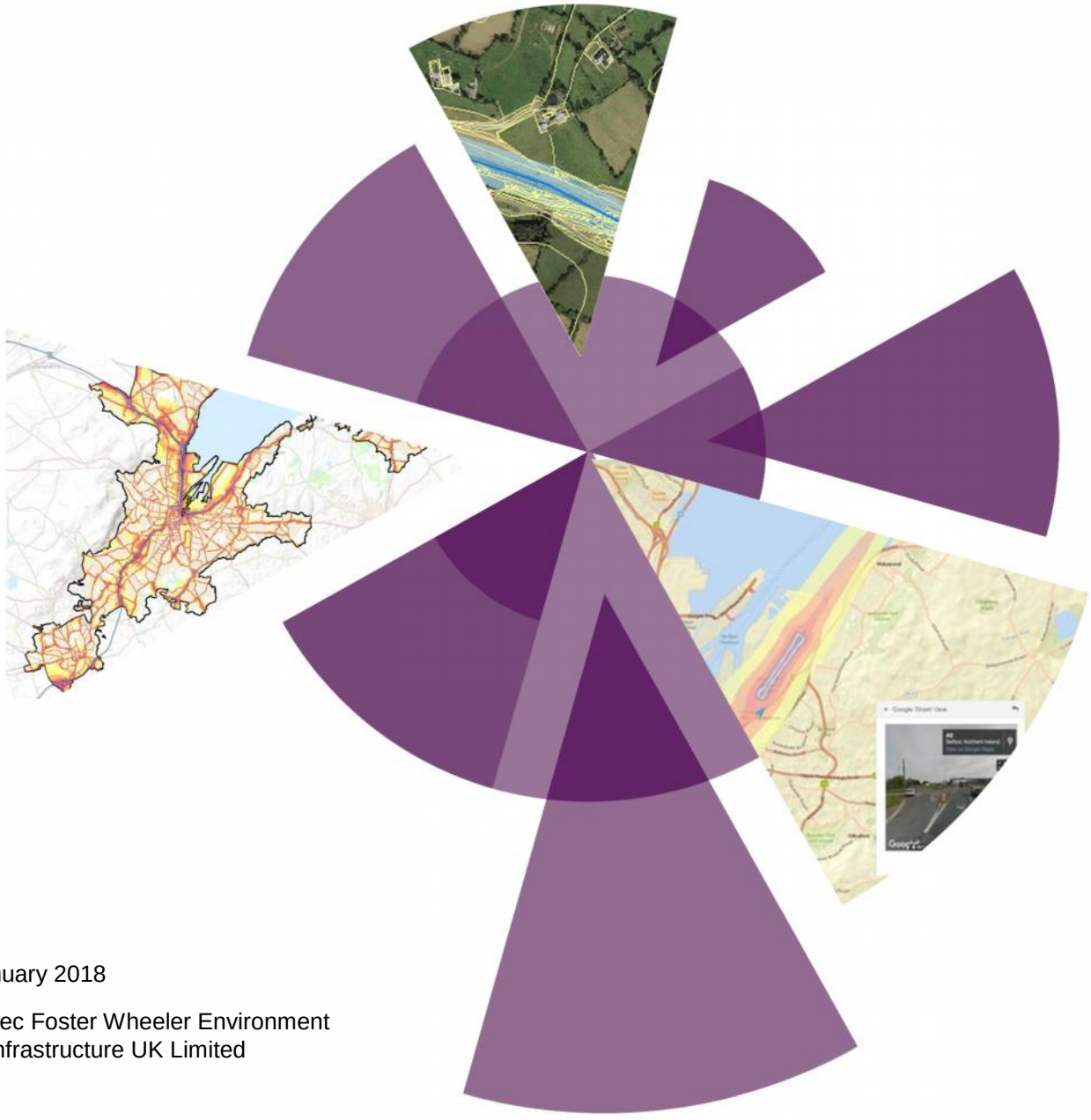
Department of Agriculture, Environment and Rural Affairs – Northern Ireland

Noise Mapping and Action Planning Contract Round 3 - 2016/2017

Summary Report - Final



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1	Final Version	29/11/2017
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Executive summary

Purpose of this report

In September 2016, Amec Foster Wheeler were commissioned by the Northern Ireland Department of Agriculture, Environment and Rural Affairs (DAERA) to prepare strategic noise maps to fulfil Northern Ireland reporting responsibilities under the third reporting round of the Environmental Noise Directive (END).

The commission was undertaken on behalf of Belfast City Airport, Belfast International Airport, DAERA, the Department of Infrastructure, and Translink. These organisations are the competent authorities under the definitions outlined in the END.

Within the commission, Amec Foster Wheeler have prepared updated strategic noise maps, associated population exposure analysis and supplementary reports as required under the Regulations, the Directive and the European Environment Agency (EEA) Environmental Noise Directive Reporting Mechanism (ENDRM).

The maps and reports will enable Northern Ireland to report the results of the mapping to the European Commission, with this document being one of seven report deliverables produced for DAERA and the competent authorities.

The key purpose of this report is to summarise the methods used to develop the Round 3 maps and to present, in one place, the final Round 3 area and population analysis results for each of the individual noise sources which are required to be mapped for the END.

The report also includes the mapping and analysis results for the Round 3 consolidated maps, an output which was produced from the individual layers and is a key deliverable under the requirements of the END.

Contents

Gossary

Term	Definition
Agglomeration	Major Continuous Urban Area as set out within the Regulations
AMEC	AMEC Environment and Infrastructure UK Limited
ArcGIS	GIS software package produced by ESRI
ASL	Above Sea Level
Attribute Data	A trait, quality, or property describing a geographical feature, e.g. vehicle flow or building height
Attributing (Data)	The linking of attribute data to spatial geometric data
BCA	Belfast City Airport
BIA	Belfast International Airport
CORINE land cover 2012	Coordination of Information for the Environment (CORINE) land cover dataset last produced the UK in 2012
CRN	The Calculation of Railway Noise 1995. The railway prediction methodology published by the UK Department of Transport.
CRTN	The Calculation of Road Traffic Noise 1988. The road traffic prediction methodology published by the UK Department of Transport.
Data	Data comprises information required to generate the outputs specified, and the results specified
dB	Decibel
DAERA	Department of Agriculture, Environment and Rural Affairs
DEM	Digital Elevation Model
DoE	Department of Environment
DSM	Digital Surface Model
DTM	Digital Terrain Model
DWG/DXF	Autodesk Autocad Drawing (DWG) or Data Exchange File (DXF) format
EC	European Commission
EEA	European Environment Agency
EIONET	EIONET is a partnership network of the European Environment Agency (EEA) and its member and cooperating countries. The network supports the collection and organisation of data and the development and dissemination of information concerning Europe's environment
END	Environmental Noise Directive (2002/49/EC)
ENDRM	Environmental Noise Directive Reporting Mechanism
ENDRM DF4_8	Environmental Noise Directive Reporting Mechanism Data Flow 4_8
ESRI	Environmental Systems Research Institute
FDMI	Final Modified Data Inputs

Term	Definition
GIS	Geographic Information System
INM	Integrated Noise Model
Irish National Grid (ING)	The official spatial referencing system of Ireland
ISO	International Standards Organisation
KML/KMZ	Keyhole Markup Language (KML) is used to express geographic annotation and visualization within Internet-based, two-dimensional maps and three-dimensional Earth browsers. The file format is used within Google Earth and many GIS software packages.
Land Cover Map 2007 / LCM2007	CEH Land Cover Map 2007 depicting 23 individual land use classes across the UK.
LimA	Software product produced by Stapelfeldt for calculating noise levels
Metadata	Descriptive information summarising data
NTF	Ordnance Survey National Transfer Format
NISRA	Northern Ireland Statistics and Research Agency
Noise Bands	Areas lying between contours of the following levels (dB): L_{den} <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >74 L_d <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >74 L_e <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >74 L_n <50, 50 – 54, 55 – 59, 60 – 64, 65 – 69, >69
Noise Levels	Free-field values of L_{den} L_d, L_e, L_n, and $L_{A10,18h}$ at a height of 4m above local ground level
Noise Level - L_d - Daytime	L_d (or L_{day}) = $L_{Aeq,12h}$(07:00 to 19:00)
Noise Level - L_e - Evening	L_e (or $L_{evening}$) = $L_{Aeq,4h}$(19:00 to 23:00)
Noise Level - L_n - Night	L_n (or L_{night}) = $L_{Aeq,8h}$(23:00 to 07:00)
Noise Level - L_{den} – Day/Evening/Night	A noise rating indicator based upon Ld. Le and Ln as follows: $L_{den} = 10 * lg\ 1/24 \{12 * 10^{((L_{day})/10)} + 4 * 10^{((L_{evening}+5)/10)} + 8 * 10^{((L_{night}+10)/10)}\}$
Noise Level – $L_{A10,18h}$	$L_{A10,18h} = L_{A10,18h}$ (06:00 to 24:00)
Noise Mapping (Input) Data	Two broad categories: (1) Spatial (e.g. road centre lines, building outlines). (2) Attribute (e.g. vehicle flow, building height – assigned to specific spatial data)
Noise Mapping Software	Computer program that calculates required noise levels based on relevant input data
Noise Model	All the input data collated and held within a computer program to enable noise levels to be calculated.
Noise Model File	The (proprietary software specific) project file(s) comprising the noise model
Output Data	The noise outputs generated by the noise model
OSNI	Ordnance Survey of Northern Ireland
Processing Data	Any form of manipulation, correction, adjustment factoring, correcting, or other adjustment of data to make it fit for purpose. (Includes operations sometimes referred to as 'cleaning' of data)
QA	Quality Assurance

Term	Definition
Round One	Round One noise modelling for the European Noise Directive (Northern Ireland) - 2007
Round Two	Round Two noise modelling for the European Noise Directive (Northern Ireland) - 2012
Round Three	Round Three noise modelling for the European Noise Directive (Northern Ireland) - 2017
Shapefile	ESRI proprietary GIS dataset format. Contains both geometry to define features, and associated alphanumeric attribute information.
Spatial (Input) Data	Information about the location, shape, and relationships among geographic features, for example road centre lines and buildings.
Translink	The main public transport service provider for Northern Ireland
WG - AEN	Working Group – Assessment of Exposure to Noise

1. Introduction

1.1 Background

EU Noise Directive

The EU Directive 2002/49/EC on the management and assessment of environmental noise, commonly referred to as the Environmental Noise Directive (END), has provided a driving force behind noise mapping and action planning within the European Community.

The aim of the END is to provide a common approach across the European Union to avoid, prevent and reduce on a prioritised basis the harmful effects of exposure to environmental noise from transportation and industrial sources. The Directive imposes a requirement on to Member States to:

- inform the public about environmental noise and its effects;
- produce strategic noise maps for the following areas:
  - agglomerations;
  - major roads;
  - major railways; and
  - major airports.
- produce Action Plans (based on the results of the noise mapping exercises) to manage and reduce environmental noise where necessary and to preserve environmental noise quality where it is good.

The qualification of such sources and agglomerations are summarised in Table 1.1 below which highlights the differing requirements of the first and subsequent rounds of mapping and action planning.

Table 1.1 Thresholds stipulated by the END directive

	First Round Threshold	Thresholds for Subsequent Rounds of Mapping
Major Roads	≥ 6 million vehicles / year	≥ 6 million vehicles / year; and ≥ 3 million vehicles / year and < 6 million vehicles / year
Major Railways	≥ 60,000 trains / year	≥ 60,000 trains / year; and ≥ 30,000 trains / year and < 60,000 trains / year
Major Airports	≥ 50,000 movements / year	≥ 50,000 movements / year
Agglomerations[1]	≥ 250,000 inhabitants	≥ 250,000 inhabitants; and ≥ 100,000 and < 250,000 inhabitants

1 For agglomerations all sources of transportation and industry affecting noise levels within agglomerations are to be considered

The END requires Member States (MS) to produce 'strategic noise maps' and complete noise action plans over a 5-year rolling cycle. The first round of noise mapping and action planning required MS to produce noise maps and where relevant have them approved by Competent Authorities by 30 June 2007, with Noise Action Plans required for the same areas by 18 July 2008. For the current third round (R3) the equivalent deadlines are 30 June 2017 for strategic noise maps, and 18 July 2018 for noise action plans.

In preparing the noise maps, the END prescribes clarity on the 'assessment methods' that can be used to produce the noise maps in Annex II. This allows MS to adopt existing 'national methods' or 'recommended interim methods'.

END reporting requirements

Under the END, it is responsibility of MS to report information from the strategic noise maps and summaries of the Action Plans to the European Commission within 6 months of these respective dates. Following submission, the Commission collates all information reported by MS and uses it to support a publication on the implementation of the END for the European Parliament and the Council and to support the publication of information for the public. This process is achieved through the Environmental Noise Directive Report Mechanism (ENDRM) which is managed by the European Environment Agency (EEA).

The END stipulates that the noise mapping and action planning process is taken forward on a five-yearly rolling programme. This led to reporting on the second round of mapping to be completed by 30 December 2012, with updated action plans reported by 18 January 2014.

Due to the change in the thresholds between the first and second rounds as described in Table 2.1 above, the extents of the noise maps were much larger for R2 than for R1. This was highlighted in the technical reports which were delivered at the end of R2.

In keeping with the cycle set by the END, the third round of noise mapping and action planning is now required. The thresholds set by the END will remain unchanged between this coming third round and the previous second round. This means that the majority of the sources and agglomerations considered in R2 will need to be reconsidered for R3. Any new agglomerations or major sources may need to be mapped if these have relocated or have increased to beyond the thresholds since the second round.

The END is very clear in Article 7(5) that as part of the cycle that

"The strategic noise maps shall be reviewed, and revised, if necessary, at least every 5 years…"

As such, the preparation of the third round strategic noise maps can, if necessary, be based upon a review and subsequent revision of the second round mapping. This forms a key component of the approach, processes and methods used to deliver the R3 noise mapping.

Implementation of the regulations in Northern Ireland

The Environmental Noise Regulations (Northern Ireland) 2006 (referred hereon in as the "Regulations") set out the requirements and responsibilities associated with the production of strategic noise maps and action plans as defined by European Directive 2002/49/EC (referred hereon in as the "Directive").

The Regulations also set out the Competent Authorities who have been made responsible for producing noise maps and action plans. These authorities are:

- Road noise – Department of Infrastructure;
- Railway noise – Translink;
- George Best Belfast City Airport noise - George Best Belfast City Airport;
- Belfast International Airport noise - Belfast International Airport; and
- Industrial noise – Northern Ireland Environment Agency.

The regulations also identify the Department of Agriculture, Environment and Rural Affairs (DAERA) (formerly the Department of Environment (DoE)) as the named Authority responsible for overseeing the implementation of the Regulations. This role includes active engagement with the individual competent authorities and the management of the delivery project on behalf of the Competent Authorities.

1.2 Purpose of this report

In September 2016, Amec Foster Wheeler were commissioned to prepare noise maps for the Component Authorities reporting directly to DAERA. As part of the commission, Amec Foster Wheeler have prepared noise maps, all associated population exposure data and supplementary reports as required under the Regulations, the Directive and the EEA ENDRM. The maps and reports will enable Northern Ireland to report the results of the mapping to the European Commission. The following document is one of seven report deliverables produced for DAERA.

The key purpose of this report is to outline the methods used to develop the Round 3 maps and to present, in one place, the final Round 3 area and population analysis results. The report also includes the mapping and analysis results for the Round 3 consolidated maps, an output which was produced from the individual layers and is a key deliverable under the requirements of the END.

Full details of the individual data layers produced are detailed later in the remainder of this report.

The Round Three mapping contract was delivered in two stages. Stage 1 was undertaken to the following scope:

- Review of the necessary Competent Authority data to ensure completeness (including a data Quality Assurance);
- Appraisal of data provided by DoE (and other stakeholders) with gaps identified with Quality Assuring of the data.
- Identification of gaps in order to define any further information requirements;
- Modifying and/or collecting further information through contractor survey (data cleaning and manipulation);
- Collation of the data into relevant datasets; and
- Preparation of Stage 1 report.

The following tasks were undertaken within Stage 1 of the contract:

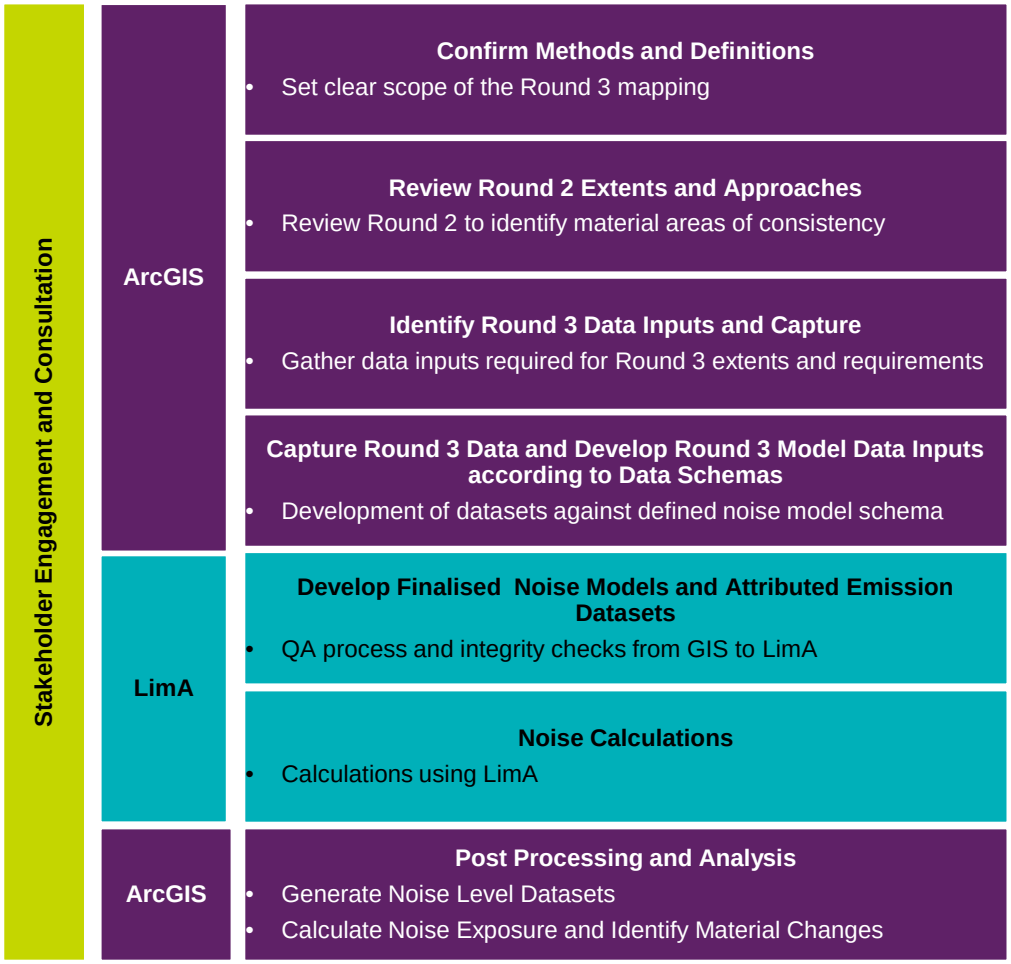
- Descriptions of the processes and approaches adopted for the collection, collation, validation, verification, integration and creation of the noise model;
- Description of the datasets to be generated;
- Detailed description of the noise modelling methodology to be applied to each noise source;
- Acceptable approximations and simplifications where appropriate;
- Software to be used (notably noise model and GIS software environments);
- Efficiency settings; and
- Storage and backup of electronic data.

The aim and scope of Stage 2 was:

- the development of digital noise models based upon the FMDIs developed during Stage 1;
- the production of third round noise maps including consolidated noise maps of road, rail, airport and industrial noise within the Belfast Agglomeration;
- generation of datasets identifying the total areas and populations within noise level bands as required by the Regulations and the Directive; and
- provision of suitable Environmental Noise Directive Report Mechanism (ENDRM) Data Flow 4_8 (DF4_8) reporting and associated technical reports for submission to the Commission through the EIONET.

The key stages of the process are summarised below in Plate 1.1.

Plate 1.1 Generalised approach to R3 mapping



2. Data capture extents

Under the Environmental Noise Regulations (Northern Ireland) 2006, Round Three noise maps must encompass the following:

- Major roads with more than 3 million vehicle passages per year;
- Major railways with more than 30,000 passages per year;
- Major airports; and
- Agglomerations (including road, railway, industrial and airport noise sources) with more than 100,000 inhabitants.

The remainder of this section details the extent of the Round Three data capture area for each of the noise sources.

2.1 Agglomeration modelling extent

The only agglomeration considered in Round Three is the Belfast agglomeration, as defined in the Regulations.

The Belfast agglomeration is presented in Plate 2.1 and has an area of 209.4km^2. This represents an 11km^2 increase on Round Two and reflects both changes in the definition of the Agglomeration following the 2011 census and creation of new housing developments on the edge of Belfast since 2011. The new agglomeration includes all areas modelled at Round 2 plus the new development areas.

It should also be noted that the 2015 population for the Belfast agglomeration is 597,419 and exceeds the required END threshold of 100,000.

A review of potential agglomerations qualifying for Round Three was also been undertaken for completeness. Data obtained from the Northern Ireland Statistics and Research Agency (NISRA) for 2015 shows that the second largest urban area in Northern Ireland is the Derry Urban Area. The Derry Urban Area has a population of 91,602 and therefore falls below the 100,000 threshold. The Derry Urban Area has therefore not been mapped in Round Three.

Using the Belfast agglomeration as a basis, the Round Three data capture extent was created. This was developed by applying a 3km corridor around the boundary of the Belfast agglomeration and subsequently clipped against the Northern Ireland coastline. The resulting data capture area is shown in Plate 2.1.

2.2 Airport modelling extents

At the start of the Round Two, contact was established between AMEC and Belfast City and Belfast International Airports. Subsequent discussions with representatives of the airports confirmed that there have not been any significant physical changes or changes to airspace or runway operations at either airport since 2011. The location of the two airports is shown on Plate 2.1.

2.3 Industry modelling extents

Under the Directive, there is a requirement to assess noise from industrial sources affecting areas within agglomerations.

A detailed review of relevant industrial sites in Belfast was undertaken in the form of a spatial cataloguing exercise. The key stages of the processing task were:

- Manual review of updated PPC GIS data provided by DAERA in November 2016. This review was undertaken using a mixture of Google Earth, Google StreetView, and detailed OSNI Aerial imagery;
- Capture of an additional 62 industrial sites within the Port/harbour areas using a hardcopy A1 plan provided by the Ports Authority and additional review of sites using Google Earth, Google StreetView, and detailed OSNI Aerial imagery; and
- Digitisation of the location of three additional waste sites, which were not included in the latest list of PPC sites, but which were identified by DAERA as needing to be modelled in Round Three.

The final outcome of this work was the creation of a dataset of 170 industrial sites within Belfast agglomeration and the surrounding area. These are shown in Plate 2.2.

2.4 Roads modelling extents

The extents of major roads within Northern Ireland have been based on an assessment of roads which are likely to exceed the 3 million vehicle movement threshold as set out in the Regulations. Within Round Three, a number of core data sources have been used identify the major roads to be mapped. These sources were:

- Automatic Traffic Counters (ATC) – ATCs available within Road Service's C2 database were used to identify a majority of the roads which exceed the 3 million vehicle movement threshold in terms of Annual Average Daily Traffic (AADT);
- Temporary Counters (TC) – selected temporary counter information was also extracted from the Road's Service C2 database and used to establish additional roads estimated to exceed the 3 million vehicle movements threshold;
- Belfast Traffic Surveys undertaken in November/December 2015 by Atkins; and
- Data concerning expected road traffic flows provided for the creation of the END Round Two.

The extents to which the above data sources apply to sections of roads was based on the location of counters, road configurations, local knowledge and derivation techniques.

Analysis of these sources highlighted that there was 7% increase in the length of roads modelled from Round 2. The extent of roads modelled is presented in Plate 2.3. This change relates to subtle changes in the extent of the Belfast Agglomeration and for main roads, the improved representation of dual carriageways and inclusion of additional road segments which now meet the requirement of the END.

2.5 Railways modelling extents

At the start of the Round Three, Translink confirmed that there had been no major changes to the railway network in Northern Ireland since 2012 and that all of Northern Ireland's major rail network falls within the Belfast Agglomeration. As a consequence, the stretches of rail network mapped and considered during the second round have been used as the basis for the data capture process. Following railway movement data obtained from Translink, the major railway extents have been confirmed. This has confirmed that Northern Ireland's major railways are located in and around the Belfast Agglomeration. The extent of Northern Ireland's major railway network is shown in Plate 2.4.

Plate 2.1 Belfast agglomeration including Belfast City and International Airports and major roads

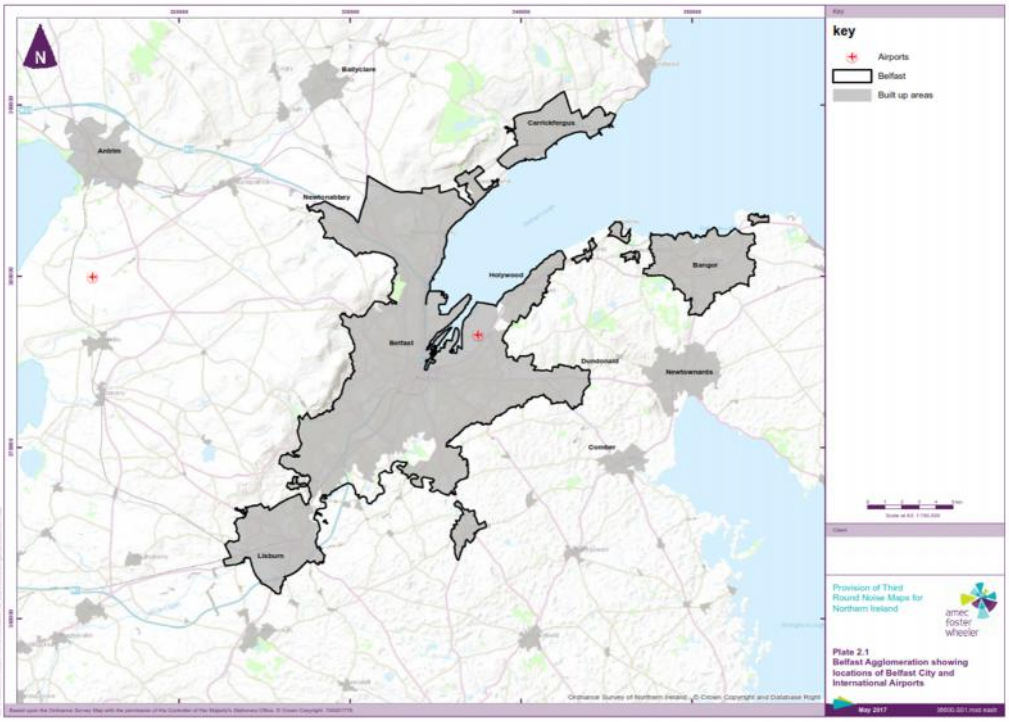


Plate 2.2 Industrial sites modelled within the Belfast agglomeration

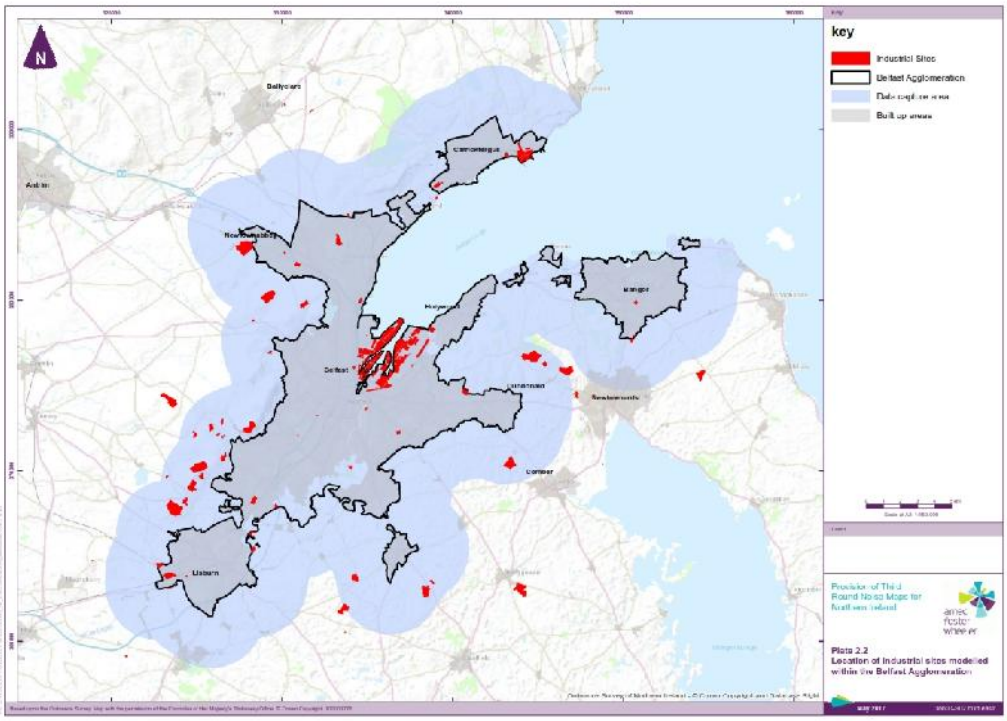


Plate 2.3 Major roads and data capture area modelled in Round 3

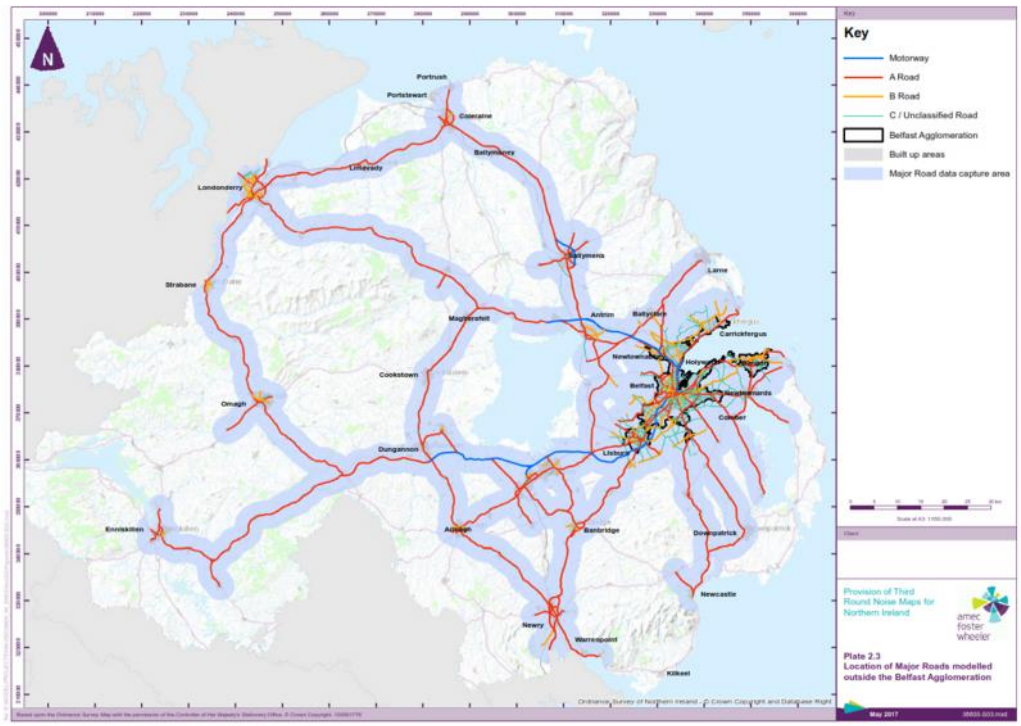
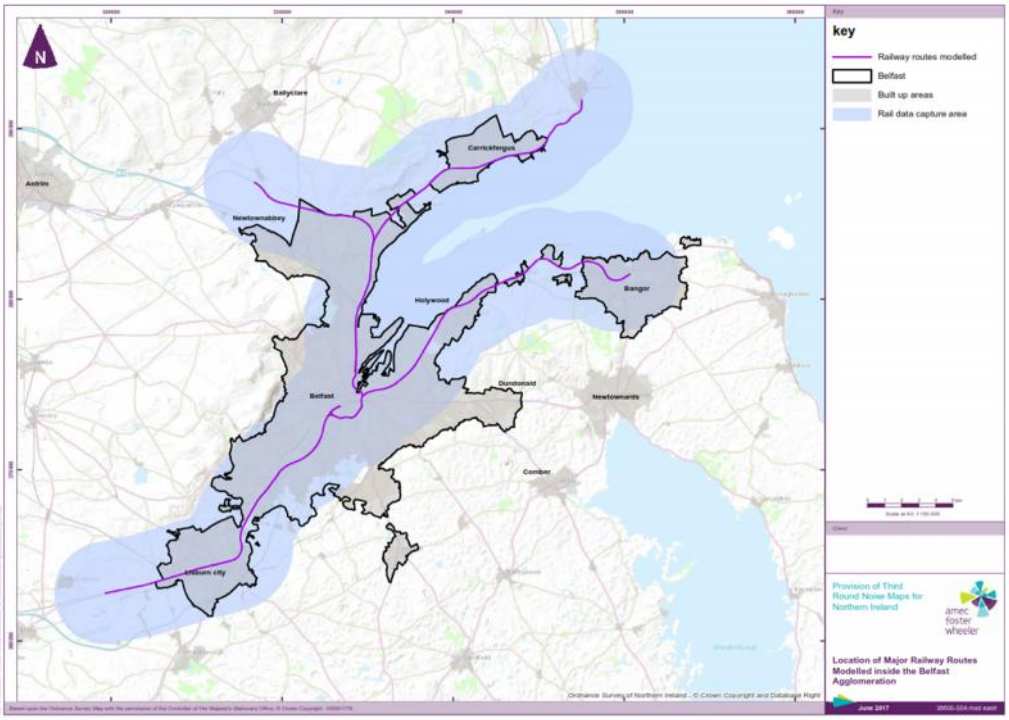


Plate 2.4 Major railways, agglomeration railways and data capture area modelled in Round 3



3. Calculation methods used for Round Three

3.1 Introduction

To calculate noise levels at a specific location or receptor, the following must be established:

- The level of noise being generated at source (i.e. the noise emissions);
- The attenuation of noise levels during propagation from source to receiver (i.e. the propagation).

The 3D model environment is used to establish the various attenuations during the propagation of noise from source to receiver and as such the 3D model environment is a noise propagation dataset. The preparation of noise emission datasets are reported in separate reports delivered under this contract.

For Round One and Two, dataset specifications were developed for the calculation methods and software environments. As there has been no change in the calculation methods or software environments employed in Round Three, the FMDI dataset specifications have been retained from Round Two. The specifications are presented in full at the end of each of the individual modelling reports.

3.2 Propagation Datasets

Due to the similarities in the information required in the calculation of the propagation of road traffic, railway and industrial noise, it is best practice in noise mapping to produce a single 3D model environment which can facilitate calculations of each noise source. This best practice was implemented during Round One and has been carried forward into Round Two.

Within the noise modelling software, the following datasets comprise the propagation dataset:

- **Buildings Dataset** – this dataset defines the location and the height of buildings;
- **Digital Terrain Model (DTM) Dataset** – this dataset is used to define the height and profile of the terrain upon which other objects are located. The DTM dataset can comprise of the following element:
  - Spot Heights –data representing the height of the terrain at a point;
  - Contour Lines – data presenting areas of terrain with equal height;
  - Break Lines – vector information representing the height of the terrain at specific features.
- **Barriers Dataset –** this dataset defines the location and the height of any noise barriers (i.e. barriers that present an obstacle to noise propagation);
- **Bridges Dataset –** this dataset present the location of bridges;
- **Ground Cover Dataset** – this dataset is used to define the acoustic absorbency of the ground over which noise propagates from source to receiver;
- **Meteorological Dataset** – this dataset defines the average annual meteorological conditions for parameters such as temperature, humidity and wind direction.

Full data specifications and GIS processing steps used to generate each of the individual datasets comprising the 3D model are provided in the Round Three 3D modelling report. The FMDI data specifications are designed to

work both within the ArcGIS and LimA software environments. Both software environments are also capable of handling point, polyline and polygon objects and can process heights and elevations in several different formats.

The FMDI dataset specifications have ultimately been driven by the requirements of the LimA noise modelling environment. This means that cartographic, object and object attribution rules required within the LimA environment have been reciprocated within the ArcGIS environment.

3.3 Noise Calculation Methods

The key assessment methods prescribed for the mapping of road traffic, railway and industrial noise sources under END are detailed in schedule 2 of the Environmental Noise Regulations (Northern Ireland) 2006 and are reproduced in Table 3.1 of this report. These methods have been used for END Round 1, 2 and 3 and where relevant have been supplemented by additional guidance. Further details of the approaches used are outlined below.

For road traffic noise, the Round Three assessment was undertaken with reference to:

- Roads: Calculation of Road Traffic Noise (CRTN) (UK) – adapted version comprising:
  - Department of Transport publication, *'Calculation of Road Traffic Noise'*, HMSO, 1988 ISBN 0115508473; and
  - Defra, Method for Converting the UK Road Traffic Noise Index LA10,18h to the EU Noise Indices for Road Noise Mapping, st/05/91/AGG04442, 24th January 2006.

Table 3.1 Assessment methods as outlined in Schedule 2 of the Regulations (Road, Rail, Airport and Industry)

Assessment method for road traffic noise indicators

6. For road traffic noise indicators the assessment method "Calculation of road traffic noise" (Department of Transport, 7 June 1988, HMSO)(b) shall be used, adapted using the report "Method for converting the UK traffic noise index LA10,18h to EU noise indices for road noise mapping" (DEFRA, 24 January 2006)(c).

Assessment method for railway noise indicators

7. For railway noise indicators the assessment methods—

(a) "Calculation of railway noise" (Department of Transport, 13th July 1995, HMSO)(d); and

(b) (in relation to railways to which it is expressed to apply) "Calculation of railway noise 1995 Supplement No. 1 Procedure for the calculation of noise from Eurostar trains class 373" (Department for Transport, 20 October 1996, Stationery Office)(e);

shall be used, adapted as shown in Figure 6.5 of the report "Rail and wheel roughness – implications for noise mapping based on the Calculation of Railway Noise procedures" (DEFRA March 2004)(f).

Assessment methods for aircraft noise indicators

8. For aircraft noise indicators the assessment method "Report on Standard Method of Computing Noise Contours around Civil Airports" (Second Edition, European Civil Aviation Conference, 2–3 July 1997)(g) shall be used in accordance with paragraph 2.4 of the Annex in the Recommendation.

Assessment methods for industrial noise indicators and port noise indicators

9.—(1) For industrial noise indicators and port noise indicators the propagation assessment method described in "ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of Calculation" (International Standards Organisation, 1996) (a) shall be used in accordance with paragraph 2.5 of the Annex in the Recommendation.

(2) Suitable noise emission data (input data) for "ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation" can be obtained either from measurements carried out in accordance with one of the following methods:

(a) "Acoustics. Determination of sound power levels of multisource industrial plants for evaluation of sound pressure levels in the environment. Engineering method" (BS ISO 8297:1994, British Standards Institute)(b);

(b) "Acoustics. Determination of sound power levels of noise sources using sound pressure. Engineering method in an essentially free field over a reflecting plane" (BS EN ISO 3744:1995, British Standards Institute)(c);

(c) "Acoustics. Determination of sound power levels of noise sources using sound pressure. Survey method using an enveloping measurement surface over a reflecting plane" (BS EN ISO 3746:1996, British Standards Institute)(d);

or by using Toolkit 10 of the "Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure Version 2, Position Paper Final Draft" (European Commission Working Group Assessment of Exposure to Noise, 13 January 2006)(e).

For railway noise, the assessment for Round Three was undertaken with reference to:

- Railways: Calculation of Railway Noise (CRN) (UK) - adapted version comprising:
- Calculation of Railway Noise (Department of Transport, 13th July 1995, HMSO);
- Calculation of Railway Noise 1995 Supplement No. 1 Procedure for the calculation of noise from Eurostar trains class 373" (Department for Transport, 20th October 1996, Stationery Office);
- "Rail and wheel roughness – implications for noise mapping based on the Calculation of Railway Noise procedure" (Defra, March 2004);
- "Additional railway noise source terms for "Calculation of Railway Noise 1995" (Defra, May 2004); and

Supplementary information from Round One regarding noise emissions and railway roughness corrections for the Northern Irish rail fleet as provided by DeltaRail was also used.

For airport noise, the assessment for Round One was undertaken with reference to the *"Report on Standard Method of Computing Noise Contours around Civil Airports"* (Second Edition) as implemented in the Federal Aviation Administrations (FAA) Integrated Noise Model (INM) version 6.2. For the Round Two, the method prescribed for airport noise is as described in *"Report on Standard Method of Computing Noise Contours around Civil Airports"* (Third Edition) as implemented in INM version 7 onwards.

The main change between the Second and Third Edition of the method is the inclusion of additional functions and attenuations for bank angles, and the inclusion of new flight procedures and updated thrust reverser components. These changes do not however effect the requirements of the method in relation to 3D modelling and only terrain and geo-positioning information are required from the 3D modelling dataset.

For industrial noise, the Round Three assessment was undertaken with reference to:

- ISO 9613 Interim is described within the following documents:
  - ISO 9613-2: 'Acoustics — Attenuation of sound propagation outdoors, Part 2: General method of calculation';
  - Commission Recommended Adaptations from 2003/613/EC; and
  - The source noise levels used within the calculations should be derived via a methodology in line with the WG-AEN GPGv2 Toolkit 10.

For Round Three, there is no requirement to alter or amend the methods adopted for Round One or Two. It has also been concluded that the adopted versions outlined above remain relevant to the delivery of the strategic noise maps under the Regulations.

For Round Three, the noise calculation assessment methods described in this section were used and have informed the preparation of the 3D modelling dataset.

3.4 Software methods

For Round One and Round Two, noise mapping of industrial sources, roads and railway traffic noise sources was prepared using the LimA noise modelling package with geo-processing and analysis undertaken with the ESRI ArcGIS software environment.

For Round Three both software environments have been retained. The LimA version that has been adopted for Round Three is version 11.2.

Following discussions with Stapelfeldt Ingenieurgesellschaft mbH, developers of the LimA noise mapping software, it is understood that there have been no significant modifications to the implementation of the core CRN methodologies between versions 8.1 and 11.2.

For Round 3, the noise modelling for airports was undertaken using the US Federal Aviation Administration's (FAA) Integrated Noise Model (INM) version 7.0d. It should be noted that for Round 2, INM v.7b was used. However, both v7.0d and 7.0b are derived from the same methodology prescribed in ECAC.CEAC Doc 29[1] (2005). The main change between v7.0b and version v.7.0d are database modifications to the noise-power-distance (NPD) curves for some aircraft and the addition of newer aircraft types.

[1] ECAC Doc.29 4th Edition, 2016

4. Dataset specification and requirements

The means by which these calculations are undertaken and indeed the accuracy of these calculations can vary significantly depending upon choices made in the settings of the calculations. Some calculation settings simply determine how many calculations should be undertaken and to what resolution these should occur to. Other calculation settings require the user to determine how certain elements of a calculation method are handled whilst other calculations settings are used to derive efficiencies in the calculation process. All these settings combine to determine the computational load of the calculations and the compliance of the calculations with the various assessment methods.

Strategic noise mapping under the Directive and the Regulations is clear in terms of the area and resolution of the calculations. Therefore, in order to ensure that calculations are undertaken in a compliant but efficient manner, consideration must be given to settings and calculation technique which allow calculations to be efficient yet allow calculated noise levels to retain compliance with the assessment method without introducing excessive uncertainties.

4.1 Efficiency settings

Efficiency settings are designed to reduce the computational load of a noise calculation by either reducing the number of calculations required or by reducing the complexity of each calculation. This is achieved by settings which instruct the calculation core to ignore or discount certain noise sources or aspects of the calculation. As outlined above, although efficiency settings have advantages in reducing the computation load and time of the calculations, they can introduce uncertainties into the calculated noise levels. As a rule of thumb, a slower calculation is likely to introduce less uncertainty than a faster one.

Efficiency settings can be applied separately or in combination with each other. A series of efficiency settings were tested for the calculation of road traffic noise during Round One. The testing studied the effect of the setting upon noise levels above 55 dB Lden and 50 dB Lnight thresholds requiring reporting of population exposure under the Directive. The testing was comprehensive and demonstrated that a combination of settings could result in significant benefits in calculation times whilst introducing low levels of uncertainty into the final results.

The project team have reviewed these settings against the settings currently available within the LimA and INM calculation environments. This review has confirmed that there are no new settings or modifications to the settings testing during Round One. Project policy has therefore been to retain the efficiency settings adopted for Round One and Two within Round 3.

There are several advantages to retaining the efficiency settings from Round One to Round Two, namely consistency within the calculations. Efficiency settings can introduce uncertainties; therefore changes in these settings may mask any actual changes in noise levels between individual mapping rounds.

It is the view of the project team that the settings adopted for Round One should therefore be retained in perpetuity until the introduction of any new assessment method. Any new assessment method is likely to require a review of all calculation efficiency and compliance settings.

4.2 Calculation process and creation of output files

A majority of the calculations performed for Round Three was undertaken using the LimAserver management software. The management software allows the automation of calculations, with hardware allocated a LimA calculation core per processor. LimAserver management software was used to manage AMEC's two dedicated noise calculation servers comprising a total of 44 available calculation cores.

The noise calculations produced using LimA were subject to a series of processing steps. This processing was designed to ensure the accuracy of the results and to provide outputs in a suitable format for subsequent analysis work. The processing steps performed were:

- Combining the tiled model results to a single model results dataset;
- Calculation of additional noise indicators (including $L_{Aeq\ 16\ hour}$ and/ or L_{den}) from the standard L_{day}, $L_{evening}$ and L_{night} produced by LimA or IMN;
- Use of LimA to interpolate results beneath building footprints to replace default values;
- Refinements to the final calculated results grids. This included that there are no calculated noise level falls below a minimum value of 15 dB(A); and ensuring that all noise levels within the calculations areas have values; and
- Export of the noise level results grids to the ESRI ASCII Grid (ASC) format.

The noise assessments for the two airports within the project, namely Belfast International Airport and George Best Belfast City Airport, were undertaken using FAA Integrated Noise Model (INM) v7.0b software. This was used to model the flight movements of aircraft operating in and out of the airports, and generated a grid of receptors noise results at 100 m spacing.

5. Post processing and analysis

The preparation of the final Round Three outputs (including final GIS noise datasets, report and exposure analysis) required a number of additional post processing steps to be undertaken. These steps included:

- Import of the raw ASCII noise model calculations to create a series of ESRI grids;
- GIS processing of each of the raw noise model grids to create classified grid results in 5 dB bands. This is required to meet the specific reporting requirements of the END;
- Development of a GIS model to evaluate the area (km^2) exposed within each of the 5 dB noise level bands from each of the noise sources and each END reporting indicator;
- Creation of a residential building dataset using detailed OSNI large scale digital data as an input for the dwelling and population exposure assessment;
- GIS based analysis to assess the number of residential buildings exposed within each of the 5 dB noise level bands from each of the noise sources, for each of the assessed indicators;
- GIS based analysis using enhanced address datasets and 2015 census estimates to estimate the number of people within dwellings exposed within each of the 5 dB noise level bands from each of the noise sources, for each of the assessed indicators; Further details of the population datasets used are presented in Section 6;
- Production of noise level indicator maps presenting the results of the noise assessment as 5 dB bands within the project extent. Examples of these maps are provided below in Plates 5.1 to 5.8;
- Production of final reports covering the project and the work undertaken; and
- Population of the EC Electronic Noise Data Reporting Mechanism (ENDRM) for submission of DF4 results to the Commission.

A summary of the key results are provided in the following sections. Further information is provided in the technical reports which have been prepared for each noise source considered in the Round Three study.

Plate 5.1 Round Three - Agglomeration - Belfast City Airport L_{den} map

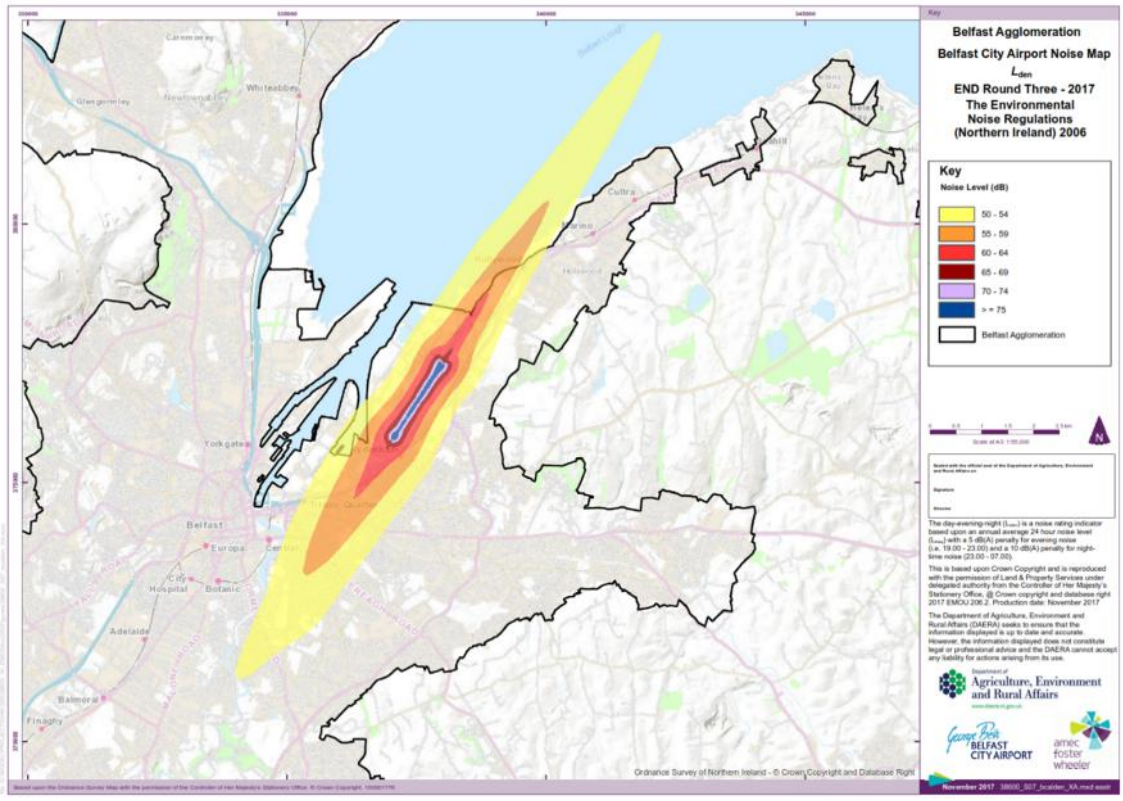


Plate 5.2 Round Three - Agglomeration - Industry City Airport L_{den} map

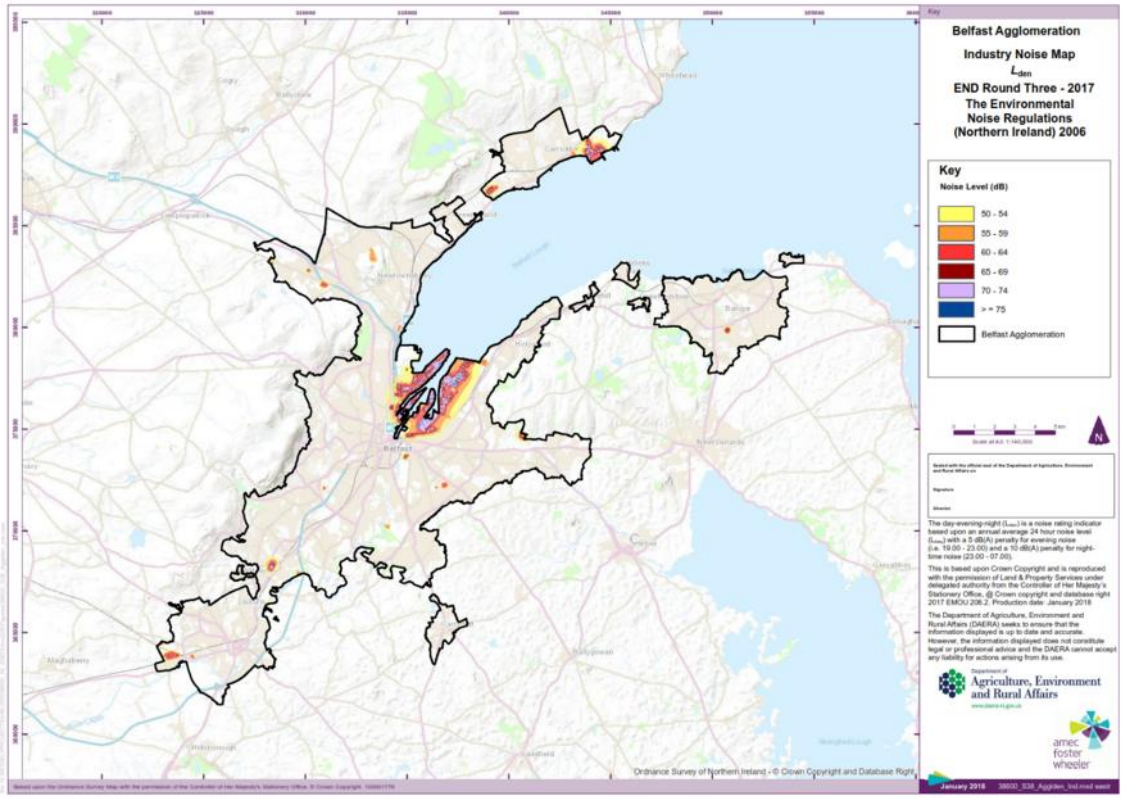


Plate 5.3 Round Three - Agglomeration Railway L_{den} map

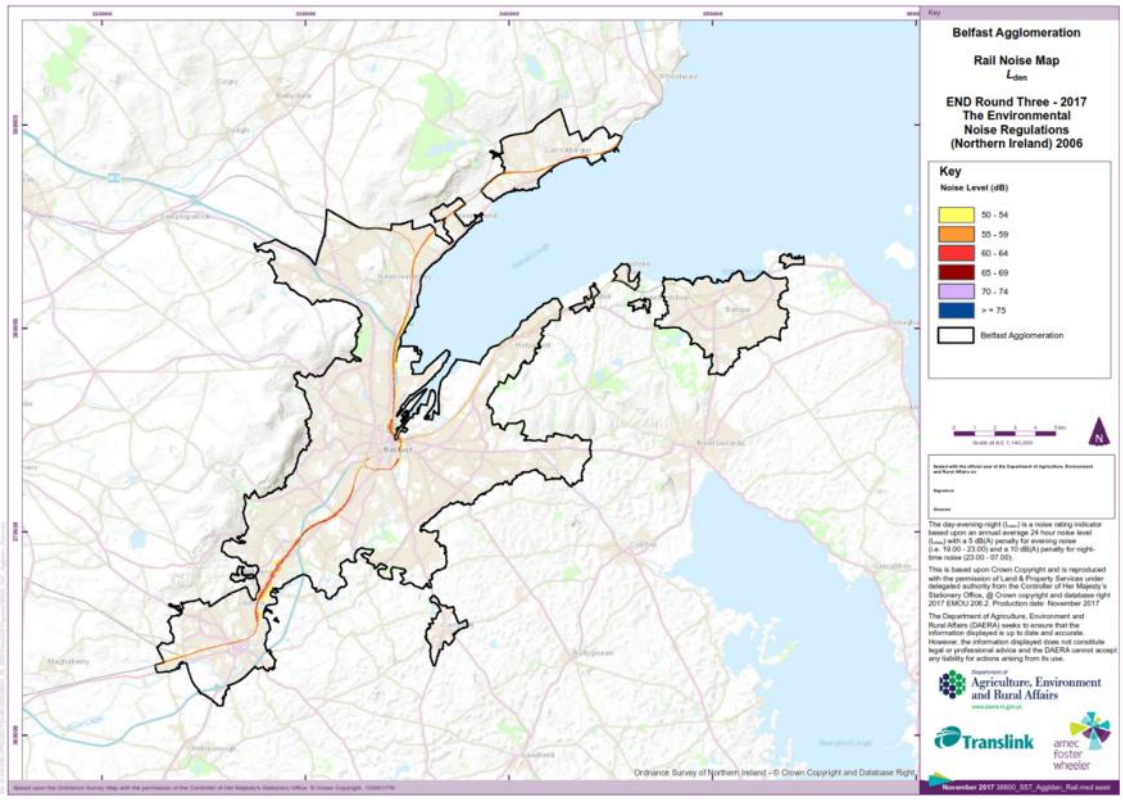


Plate 5.4 Round Three - Agglomeration Roads L_{den} map

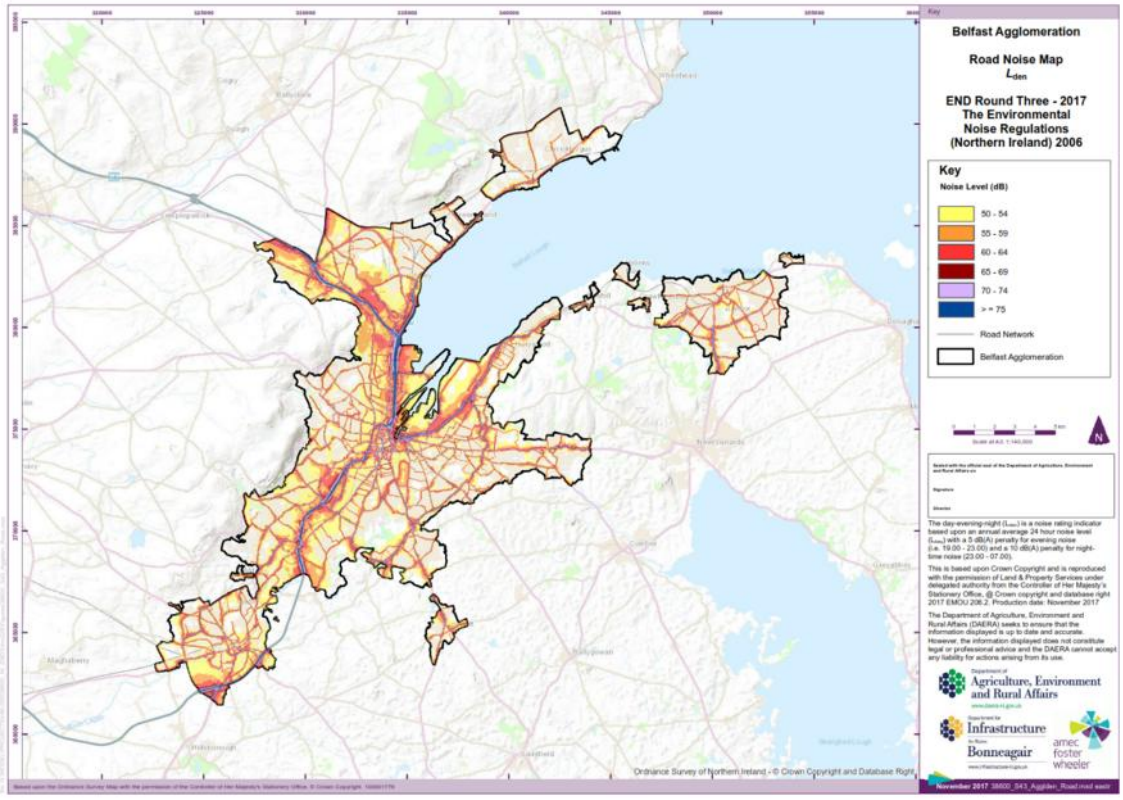


Plate 5.5 Round Three - Agglomeration Consolidated L_{den} map

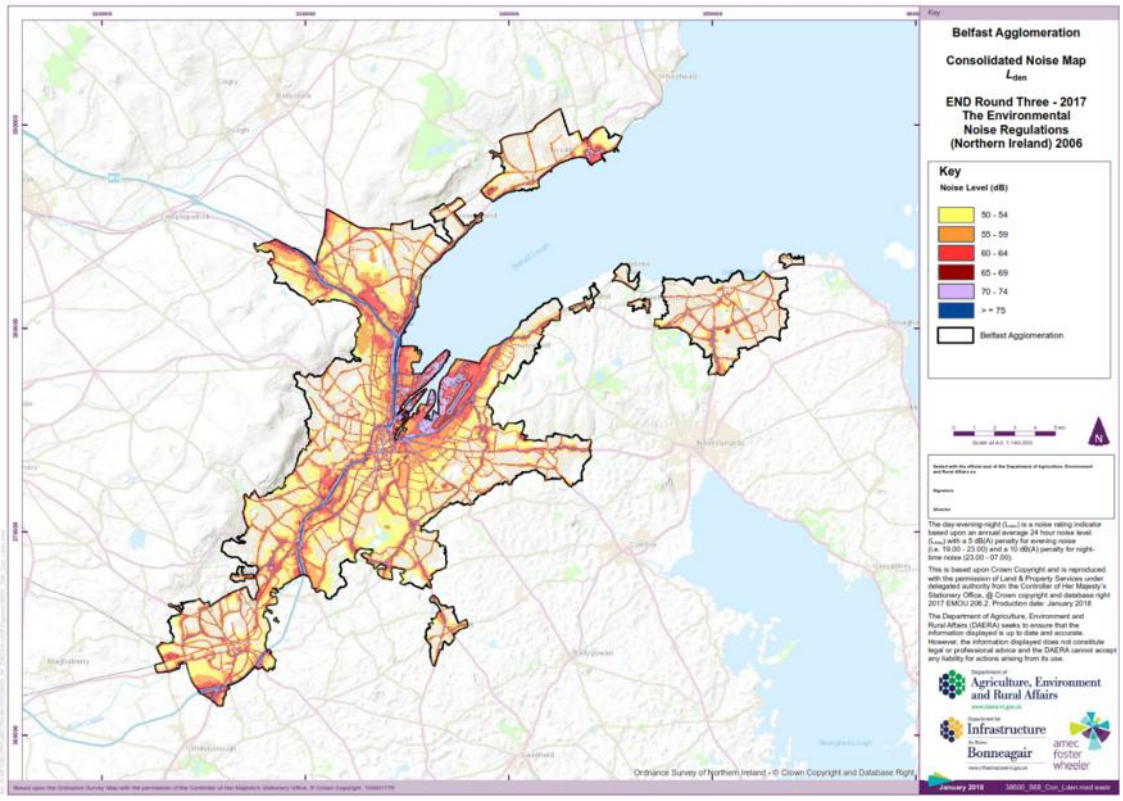


Plate 5.6 Round Three - Belfast International Airport L_{den} map

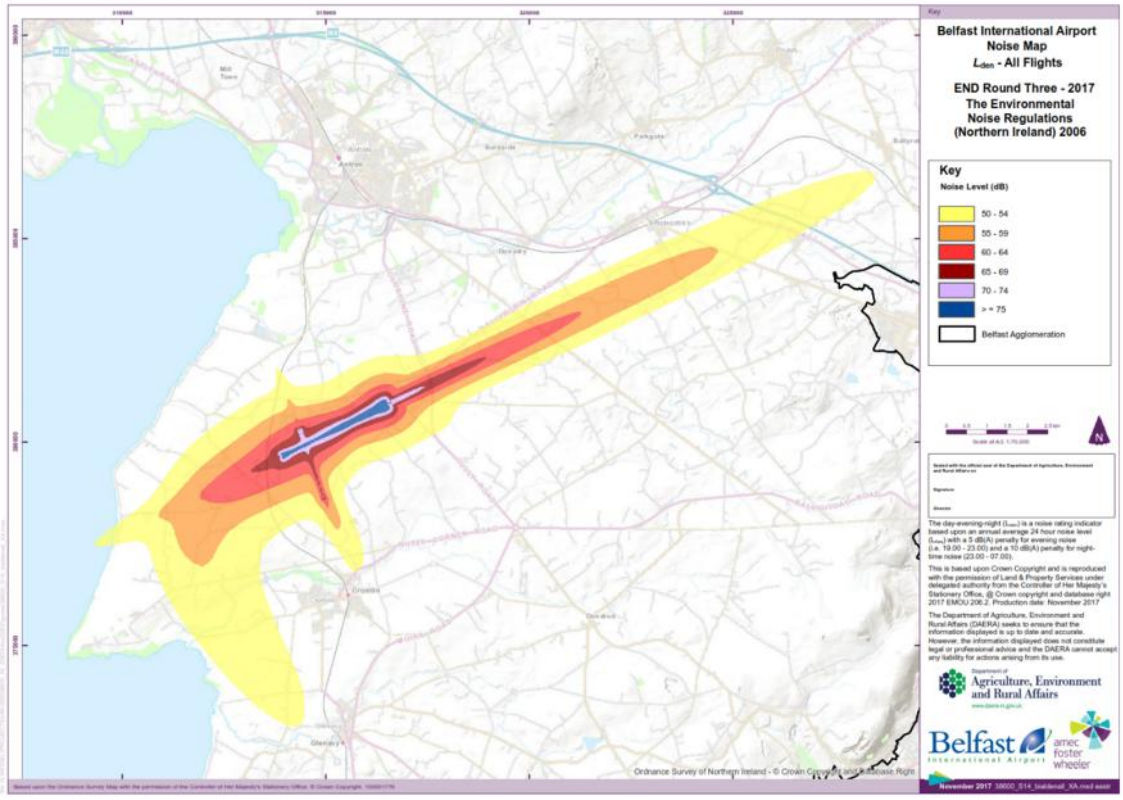


Plate 5.7 Round Three - Major Railway L_{den} map

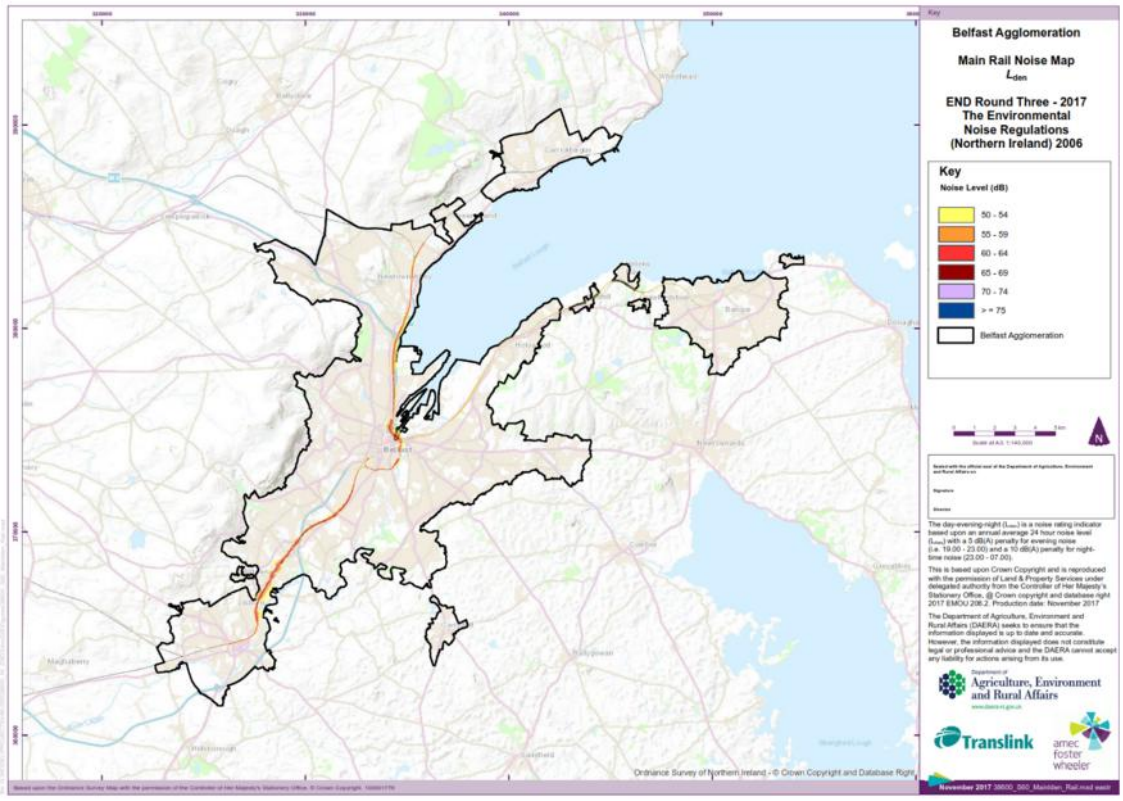
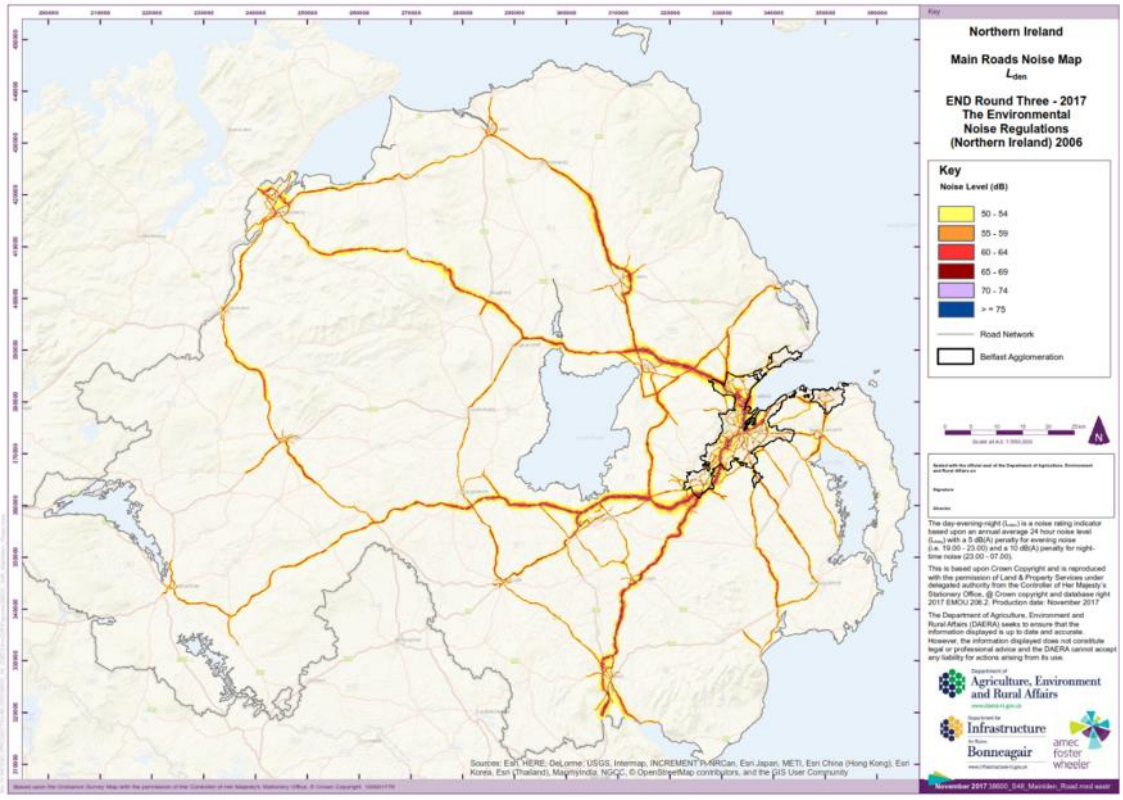


Plate 5.8 Round Three - Major Roads L_{den} map



6. Population exposure and analysis

6.1 Population exposure methodology

Annex VI of the END states that a population exposure assessment is required as an output of the END noise mapping process and that the results of this assessment need to be reported to the European Commission (EC). Annex VI also states that the estimated number of people (in hundreds) living in dwellings that are exposed to noise are to be calculated for the various scenarios mapped. There is no definition of a 'dwelling' in the END although the term is used within Article 3 (q), Annex I (1), Annex III, Annex IV (1) and Annex VI (1.5, 1.6) and (2.5, 2.6).

Four primary datasets were used within the population exposure assessment developed in the Round Three study. The datasets used were:

- Detailed individual building polygons recorded in the 2016 version of the OSNI large scale mapping[2]. However, it is important to note that the date of the imagery used to update the detailed OSNI mapping varies from 2013-2015. Further information is provided in the accompanying Round Three Ground model report.
- The OSNI Pointer dataset which provides details of the residential, public-use and commercial classifications of individual buildings across Northern Ireland[3]. The Pointer data set is described by OSNI as the primary address database for Northern Ireland and is maintained by Land & Property Services (LPS), with input from Local Councils and Royal Mail. This dataset was supplied to Amec Foster Wheeler in September 2016 and contains records until this date.
- Geographical boundary file for the 4537 Small Areas (SAs) which were introduced in Northern Ireland after the 2011 Census[4]. Small Areas are generally created by amalgamating 2011 Census Output Areas which were built from clusters of adjacent postcodes. This is the smallest spatial unit for which annual population estimates are produced for Northern Ireland – see below, and
- Northern Ireland Statistics and Research Agency 2015 population estimates for the 4,537 census small areas (SAs) across Northern Ireland[5]. The total estimated usual resident population across these areas was 1,828,971. This represents a 3% increase in population from Round 2.

The key steps used to create the final population dataset used in the population exposure assessment are summarised below. This builds upon the methodology adopted for Round Two but introduces a more robust approach to the assessment of the number of residential addresses within individual buildings and ultimately the distribution of population across residential buildings in Northern Ireland.

Step A - Assessment of the number of addresses in each residential building object

- A1 - Identification of all individual buildings within the OSNI large scale dataset which were either defined by OSNI as being residential and/or a mixed function building containing at least one residential address as defined in the OSNI Pointer dataset. The total number of residential building objects was 774,424.
- A2 – GIS query run to identify all built residential property addresses within the LPS Pointer dataset. The criteria used for selection is shown in Table 6.1. Please note that the number of

[2] https://www.nidirect.gov.uk/articles/large-scale-vector
[3] https://www.nidirect.gov.uk/publications/pointer-technical-specification
[4] https://www.nisra.gov.uk/support/geography/northern-ireland-small-areas
[5] https://www.nisra.gov.uk/publications/2015-mid-year-population-estimates-small-areas

records for A2 was larger than A1 due to the presence of buildings with multiple addresses (e.g. apartments and flats).

Table 6.1 Criteria for selection of LPS Pointer data

Classification	Address Status	Used in development of the population dataset	No of LSP Pointer records
Domestic (DO_)	Approved	Yes	757,064
Domestic (DO_)	Provisional, Candidate, Historical or Rejected	No	112,361
Non_Domestic (ND_) or Null	All values	No	87,075
Total			956,500

- A3 - GIS tool used to count the number of completed domestic residential "built" LPS Pointer address within each OSNI building object identified in Step A1. This number ranged from 1 (majority of buildings) to 282 (large apartment type buildings). It should also be noted that the analysis only considered LPS Pointer records which had a confirmed Address Status of "Approved", which effectively means a completed building rather than a building under construction.

Step B - Assessment of population per address for each Small Area in Northern Ireland

- B1 – GIS tool used to spatial join the 2015 population estimates to each of the 4,537 census small areas (SAs);
- B2 - GIS spatial join tool used to assign the Small Area (SA) reference code to each of the buildings identified in Step A1. This was achieved using the centroid of the building object.
- B3 – GIS aggregation tool used to count the total number of residential address in each of the 4,537 Small Areas across Northern Ireland; and
- B4 – Final estimate of a population per address calculated by dividing the 2015 population estimate by the total number of address in each of the 4257 Small Areas across Northern Ireland.

Step C - Estimating a total population for each residential building in Northern Ireland

- A final estimate of population in each residential building was calculated by multiply the number of individual residential addresses in the building (Step A3) by the estimate of population per address (Step B4).

These final estimates were subject to a final set of QA checks to ensure a representative distribution of the population of 1,828,971 recorded by the NISRA in the 2015 population estimate dataset. The mean Round 3 population value per residential building was 2.36.

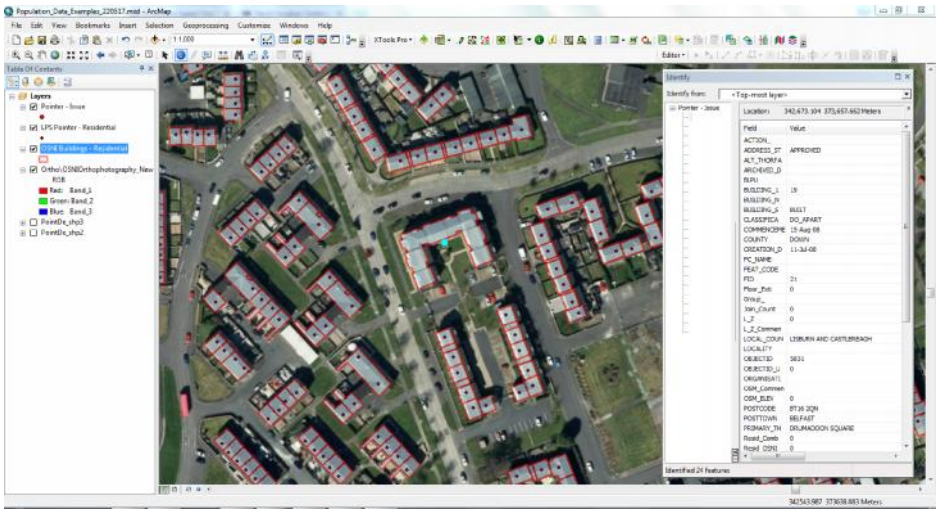
As per the assumptions used in the Round One and Round Two studies, Annex I (1) of the END indicates that noise exposure assessments should be at the most exposed façade. The most exposed façade is defined as the external wall facing onto and nearest to the specific noise source. For the purposes of this assessment the highest overall value assigned to a dwelling is to be considered the most exposed façade as per recommendations set out within the WG-AEN Good Practice Guide v2.

To calculate the level of exposure the residential dwelling building extents were intersected with the reclassified noise grids using an automated GIS processing script. From this process, the number of dwellings and the number of people exposed in the required 5dB END noise intervals were calculated. The results of this analysis are presented in Section 6.2.

In reviewing the final exposure results, it is important to consider the various factors which influence the final exposure analysis. These factors include: improvements in the calculation of populations for buildings with multiple dwellings; differences in the age of the OSNI building, LPS Pointer and NIRAS population datasets used in the analysis; changes and improvements in the OS Pointer address dataset since Round Two; and the remaining limitations of the OSNI Pointer address dataset. These limitations include the absence of an attribute code to distinguish communal residences (i.e. student residence, army living accommodation) from standard residential accommodation, and potential mis-alignment of Pointer records in relation to the OSNI detailed large scale mapping.

This last issue is illustrated below in Plate 6.1, where the Pointer centroid is located just outside the OSNI building object rather than located within the boundary of the building object. This means that the 24 addresses located at the point location have not been automatically assigned to the adjacent building. Further manual edits where applied to the population database to address this issue in key locations.

Plate 6.1 Spatial mismatch between the LSP Pointer and OSNI building data



The results of the Round 3 population analysis are presented in remainder of this chapter. Please note that all area values have been rounded to the nearest 0.1 km^2 and is also reflected in total area values in the tables.

6.2 Belfast Agglomeration - Belfast City Airport

The Round 3 results for Belfast City Airport are presented in Tables 6.2-6.4.

Table 6.2 Belfast City Airport - area of noise bands in km²

Level (dB))	LAeq, 16 hour	Lden	Lday	Leve	Level (dB)	L_{night}
50-54	9.7	11.3	10.2	8.2	**45-49**	3.5
55-59	3.4	4.3	3.7	2.5	**50-54**	0.9
60-64	0.9	1.2	1.0	0.7	**55-59**	0.3
65-69	0.3	0.4	0.3	0.2	**60-64**	0.2
70-74	0.2	0.2	0.2	0.1	**65-69**	0.1
>75	0.1	0.2	0.1	0.1	**>=70**	0.0
Total	**14.7**	**17.5**	**15.5**	**11.9**	**Total**	**5.1**

Table 6.3 Belfast City Airport - residential buildings

Level (dB)	LAeq, 16 hour	Lden	Lday	Leve	Level (dB)	Lnight
50-54	11,639	12,723	12,099	9,277	**45-49**	4,300
55-59	3,836	5,663	4,560	1,778	**50-54**	
60-64		6			**55-59**	
65-69					**60-64**	
70-74					**65-69**	
>75					**>=70**	
Total	**15,475**	**18,392**	**16,659**	**11,055**	**Total**	**4,300**

Table 6.4 Belfast City Airport - population exposure

Level (dB)	LAeq, 16 hour	Lden	Lday	Leve	Level (dB)	Lnight
50-54	25,959	28,609	26,974	20,715	**45-49**	9,182
55-59	8,389	12,155	9,988	3,844	**50-54**	
60-64		68			**55-59**	
65-69					**60-64**	
70-74					**65-69**	
>75					**>=70**	
Total	**34,348**	**40,832**	**36,962**	**24,558**	**Total**	**9,182**

6.3 Belfast Agglomeration - Industry

The Round 3 results for industrial sites in the Belfast Agglomeration are presented in Tables 6.5-6.7.

Table 6.5 Agglomeration - Industry - area of noise bands in km²

Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	2.8	4.1	2.9	2.6	**45-49**	3.6
55-59	1.9	2.9	1.9	1.4	**50-54**	2.8
60-64	3.9	2.2	4.0	3.2	**55-59**	1.9
65-69	1.1	3.2	1.2	1.1	**60-65**	4.0
70-74	0.0	2.2	0.0	0.0	**65-69**	1.2
>=75		0.2			**>=70**	-
Total	**9.8**	**14.8**	**10.0**	**8.2**	**Total**	**13.5**

Table 6.6 Agglomeration - Industry - residential buildings

Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	72	1,389	97	48	**45-49**	746
55-59	21	160	23	13	**50-54**	97
60-64	7	36	7	1	**55-59**	23
65-69	-	4	-	-	**60-65**	7
70-74	-	3	-	-	**65-69**	
>=75	-	-	-	-	**>=70**	
Total	**100**	**1,592**	**127**	**62**	**Total**	**873**

Table 6.7 Agglomeration - Industry - population exposure

Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	197	3,953	253	131	**45-49**	2,423
55-59	36	392	39	24	**50-54**	253
60-64	13	68	13	1	**55-59**	39
65-69	-	8	-	-	**60-65**	13
70-74	-	5	-	-	**65-69**	
>=75	-	-	-	-	**>=70**	
Total	**246**	**4,426**	**305**	**156**	**Total**	**2,728**

6.4 Belfast Agglomeration - Railway

The Round 3 results for railways in the Belfast Agglomeration are presented in Tables 6.8-6.10.

Table 6.8 Agglomeration Railways - area of noise bands in km²

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{Aeq, 18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}	$L_{Aeq, 6\ hour}$
50-54	2.7	2.6	3.1	2.7	2.4	**45-49**	2.1	2.2
55-59	1.7	1.6	2.0	1.7	1.6	**50-54**	1.6	0.9
60-64	1.0	0.9	1.4	1.1	0.7	**55-59**	0.6	0.4
65-69	0.1		0.4	0.1	0.2	**60-64**	0.2	0.1
70-74			0.1			**65-69**		
>=75						**>=70**		
Total	**5.4**	**5.1**	**7.0**	**5.5**	**5.0**	**Total**	**4.4**	**3.7**

Table 6.9 Agglomeration Railways - residential buildings

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{Aeq, 18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}	$L_{Aeq, 6\ hour}$
50-54	1,158	1,063	1,580	1,178	1,048	**45-49**	974	1,028
55-59	719	741	888	723	789	**50-54**	788	394
60-64	496	370	653	514	367	**55-59**	345	285
65-69	19	8	229	14	27	**60-64**	56	35
70-74			10			**65-69**		
>=75						**>=70**		
Total	**2,392**	**2,182**	**3,360**	**2,429**	**2,231**	**Total**	**2,163**	**1,742**

Table 6.10 Agglomeration Railways - population exposure

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{Aeq, 18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}	$L_{Aeq, 6\ hour}$
50-54	2,872	2,714	4,014	3,092	2,421	**45-49**	2,457	2,571
55-59	1,931	1,765	2,203	1,804	2,262	**50-54**	2,256	1,722
60-64	1,286	1,198	1,682	1,335	965	**55-59**	906	654
65-69	517	313	1,145	502	532	**60-64**	594	281
70-74			41			**65-69**		
>=75						**>=70**		
Total	**6,607**	**5,992**	**9,084**	**6,733**	**6,181**	**Total**	**6,214**	**5,228**

6.5 Belfast Agglomeration - Roads

The Round 3 results for roads in the Belfast Agglomeration are presented in Tables 6.11-6.13.

Table 6.11 Belfast Agglomeration - Roads - area of noise bands in km²

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10, 18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	38.9	47.5	45.5	42.1	24.0	**45-49**	34.1
55-59	23.3	28.7	28.8	25.1	16.7	**50-54**	21.9
60-64	16.2	19.1	19.0	17.2	12.5	**55-59**	15.1
65-69	12.4	13.7	13.7	13.0	8.3	**60-64**	10.6
70-74	7.9	10.3	9.7	8.9	2.2	**65-69**	4.5
>=75	2.3	4.8	4.4	3.1	0.7	**>=70**	2.0
Total	**100.9**	**124.0**	**121.0**	**109.3**	**64.4**	**Total**	**88.2**

Table 6.12 Belfast Agglomeration - Roads - residential buildings

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	40,811	59,177	57,439	46,977	21,662	**45-49**	35,430
55-59	20,600	26,748	27,370	22,002	18,685	**50-54**	22,172
60-64	18,132	18,521	19,209	18,188	16,460	**55-59**	18,112
65-69	16,111	17,380	17,618	17,208	5,573	**60-64**	9,737
70-74	4,590	9,672	7,783	6,290	347	**65-69**	1,867
>=75	124	981	814	343	-	**>=70**	143
Total	**100,368**	**132,479**	**130,233**	**111,008**	**62,727**	**Total**	**87,461**

Table 6.13 Belfast Agglomeration - Roads - population exposure

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	95,997	137,976	134,485	110,367	52,056	**45-49**	84,461
55-59	50,179	64,111	65,687	53,162	47,134	**50-54**	54,529
60-64	45,807	45,754	47,618	45,202	43,358	**55-59**	46,256
65-69	42,781	45,715	46,103	45,985	17,621	**60-64**	27,382
70-74	15,019	28,149	23,242	19,298	1,273	**65-69**	7,245
>=75	468	3,299	3,090	1,140	-	**>=70**	404
Total	**250,250**	**325,004**	**320,225**	**275,153**	**161,441**	**Total**	**220,276**

6.6 Belfast Agglomeration - Consolidated

An additional requirement of the END is the development of consolidated noise maps and subsequent area, residential building and population exposure statistics for the Belfast agglomeration boundary.

In the Round Three assessment, consolidated noise levels for L_{day}, $L_{evening}$ and L_{night} were calculated through logarithmic addition of the assessed noise levels for the roads, railways, industry and Belfast City airport with the Belfast agglomeration. L_{den} was then calculated using the following equation where the consolidated L_{day}, $L_{evening}$ and L_{night} noise grids were used as input datasets.

$$L_{den} = 10\lg\frac{1}{24}\left(12*10^{\frac{L_{day}}{10}} + 4*10^{\frac{L_{evening}+5}{10}} + 8*10^{\frac{L_{night}+10}{10}}\right)$$

This assessment process was achieved using series of python coding within ArcGIS.
Using these methods, five final consolidated maps (L_{day}, $L_{evening}$, L_{night} and L_{den}) were created for the Belfast Agglomeration. These maps are presented in Appendix A.

These maps were then used to develop an estimate of the area, number of dwellings and population exposed to consolidated noise sources in the Belfast agglomeration. These results are provided in Tables 6.14 – 6.16.

Table 6.14 Agglomeration Consolidated - area of noise bands in km²

Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	42.2	49.0	45.7	28.6	**45-49**	35.0
55-59	26.6	31.3	28.4	20.5	**50-54**	24.6
60-64	21.5	22.2	22.3	17.3	**55-59**	17.8
65-69	14.7	17.6	15.5	10.1	**60-64**	15.0
70-74	8.1	12.6	9.2	2.4	**65-69**	6.0
>=75	2.4	4.8	3.2	0.7	**>=70**	2.1
Total	**115.5**	**137.5**	**124.2**	**79.6**	**Total**	**100.5**

Table 6.15 Agglomeration Consolidated - residential buildings

Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	51,110	67,498	57,360	31,241	**45-49**	41,288
55-59	26,118	34,298	28,146	21,867	**50-54**	24,029
60-64	19,007	20,892	19,182	17,071	**55-59**	18,623
65-69	16,228	17,925	17,356	5,687	**60-64**	9,848
70-74	4,613	7,841	6,336	352	**65-69**	1,880
>=75	126	822	352	-	**>=70**	149
Total	**117,202**	**149,276**	**128,732**	**76,218**	**Total**	**95,817**

Table 6.16 Agglomeration Consolidated - population exposure

Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	119,054	156,714	133,520	73,584	**45-49**	96,928
55-59	62,206	80,969	66,462	54,433	**50-54**	59,208
60-64	47,707	51,699	47,482	44,684	**55-59**	47,455
65-69	42,991	46,663	46,208	17,988	**60-64**	27,612
70-74	15,128	23,435	19,532	1,284	**65-69**	7,304
>=75	471	3,105	1,155	-	**>=70**	415
Total	**287,558**	**362,586**	**314,360**	**191,974**	**Total**	**238,921**

6.7 Major airports - Belfast International Airport

The Round 3 results for Belfast International Airport are presented in Tables 6.17-6.19. The results presented are for modelling of commercial flights only.

Table 6.17 Belfast International Airport - area of noise bands in km²

Level (dB)	$L_{Aeq, 16\text{-}hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	13.1	27.2	12.3	15.2	**45-49**	15.3
55-59	5.5	10.8	5.2	6.4	**50-54**	6.9
60-64	2.2	4.6	2.0	2.6	**55-59**	2.7
65-69	0.8	1.7	0.7	1.0	**60-64**	0.9
70-74	0.3	0.6	0.3	0.4	**65-69**	0.4
>75	0.2	0.4	0.2	0.2	**>=70**	0.3
Total	**22.0**	**45.3**	**20.7**	**25.7**	**Total**	**26.3**

Table 6.18 Belfast International Airport - residential buildings

Level (dB)	$L_{Aeq, 16\text{-}hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	505	1,027	408	736	**45-49**	524
55-59	99	281	82	124	**50-54**	115
60-64	13	45	12	19	**55-59**	16
65-69		7			**60-64**	2
70-74					**65-69**	
>75					**>=70**	
Total	**617**	**1,360**	**502**	**879**	**Total**	**657**

Table 6.19 Belfast International Airport - Population

Level (dB)	$L_{Aeq, 16\text{-}hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	1,014	2,023	836	1,428	**45-49**	1,132
55-59	243	631	210	293	**50-54**	296
60-64	33	133	31	52	**55-59**	44
65-69		14			**60-64**	4
70-74					**65-69**	
>75					**>=70**	
Total	**1,290**	**2,801**	**1,077**	**1,772**	**Total**	**1,476**

6.8 Major Railway

The Round 3 results for Major Railways are presented in Tables 6.20-6.22.

Table 6.20 Major Railways - area of noise bands in km²

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{Aeq, 18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}	$L_{Aeq, 6\ hour}$
50-54	2.2	2.0	2.6	2.3	2.0	**45-49**	1.6	1.8
55-59	1.3	1.1	1.6	1.3	1.1	**50-54**	1.1	0.7
60-64	0.8	0.7	1.0	0.8	0.6	**55-59**	0.6	0.4
65-69	0.1		0.4	0.1	0.2	**60-64**	0.2	0.1
70-74			0.1			**65-69**		
>=75						**>=70**		
Total	**4.4**	**3.9**	**5.6**	**4.5**	**3.8**	**Total**	**3.5**	**3.1**

Table 6.21 Major Railways - residential buildings

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{Aeq, 18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}	$L_{Aeq, 6\ hour}$
50-54	914	764	1,194	913	800	**45-49**	801	735
55-59	574	558	719	590	592	**50-54**	629	385
60-64	340	219	503	351	278	**55-59**	306	254
65-69	15	8	190	12	24	**60-64**	44	29
70-74			9			**65-69**		
>=75						**>=70**		
Total	**1,843**	**1,549**	**2,615**	**1,866**	**1,694**	**Total**	**1,780**	**1,403**

Table 6.22 Major Railways - Population

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{Aeq, 18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}	$L_{Aeq, 6\ hour}$
50-54	2,534	2,240	3,538	2,703	2,125	**45-49**	2,058	735
55-59	1,556	1,306	1,732	1,481	1,683	**50-54**	1,685	385
60-64	899	844	1,372	926	793	**55-59**	948	254
65-69	510	313	807	499	526	**60-64**	569	29
70-74			31			**65-69**		
>=75						**>=70**		
Total	**5,499**	**4,704**	**7,480**	**5,608**	**5,128**	**Total**	**5,260**	**1,403**

6.9 Major Roads

The Round 3 results for Major Roads are presented in Tables 6.23-6.25.

Table 6.23 Major Roads (Northern Ireland) - area of noise bands in km²

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10, 18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	359.8	461.1	462.9	397.1	203.9	**45-49**	313.1
55-59	184.0	244.6	247.1	205.5	102.1	**50-54**	160.3
60-64	91.9	123.0	124.4	102.7	55.8	**55-59**	80.8
65-69	51.8	64.2	64.7	56.0	35.6	**60-64**	46.3
70-74	33.0	41.0	40.3	36.3	13.9	**65-69**	24.9
>=75	12.9	23.7	23.9	16.6	2.8	**>=70**	10.1
Total	**733.4**	**957.7**	**963.4**	**814.1**	**414.2**	**Total**	**635.5**

Table 6.24 Major Roads - residential buildings

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	59,807	85,599	85,978	67,923	30,245	**45-49**	50,966
55-59	26,697	37,177	38,245	30,099	19,958	**50-54**	25,795
60-64	19,772	20,466	21,238	19,804	20,046	**55-59**	21,325
65-69	20,024	20,913	21,063	20,721	10,072	**60-64**	14,325
70-74	7,892	13,612	12,229	9,947	1,426	**65-69**	4,293
>=75	650	2,382	2,387	1,138	79	**>=70**	497
Total	**134,842**	**180,149**	**181,140**	**149,632**	**81,826**	**Total**	**117,201**

Table 6.25 Major Roads (Northern Ireland) - Population

Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}	Level (dB)	L_{night}
50-54	142,643	201,846	203,733	161,792	73,595	**45-49**	122,376
55-59	64,808	89,886	92,478	72,935	49,056	**50-54**	63,148
60-64	48,544	50,433	52,235	48,368	50,210	**55-59**	52,367
65-69	51,456	52,455	52,909	53,084	28,310	**60-64**	37,881
70-74	22,050	36,875	32,994	27,177	3,702	**65-69**	12,983
>=75	1,659	6,357	6,680	2,897	216	**>=70**	1,207
Total	**331,162**	**437,852**	**441,028**	**366,255**	**205,089**	**Total**	**289,963**

Appendix A END Round 3 - Consolidated Maps

320000 330000 340000 350000 3600

390000 380000 370000 360000

Cogry Ballyclare Doagh Templepatrick Whitehead Carrickfergus Greenisland Belfast Lough Helens Bay Holywood Bangor Donaghadee Newtownards Comber Greyabbey Ballygowan Strangford Lough Saintfield Hillsborough Maghaberry River Lagan M2

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Key

Belfast Agglomeration

Consolidated Noise Map
L_{day}

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 1 2 3 4 5 km

Scale at A3: 1:140,000

N

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Director

The L_{day} is the equivalent continuous sound level in dB(A) that, over the period 07:00 – 19:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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390000 380000 370000 360000

Cogry Ballyclare Doagh Whitehead Templepatrick Carrickfergus Greenisland Belfast Lough Helens Bay Holywood Bangor Donaghadee Newtownards Comber Greyabbey Ballygowan Strangford Lough Saintfield Hillsborough Maghaberry River Lagan M2

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Key

Belfast Agglomeration

Consolidated Noise Map
L_{eve}

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 1 2 3 4 5 km

Scale at A3: 1:140,000

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The L_{eve} is the equivalent continuous sound level in dB(A) that, over the period 19:00 – 23:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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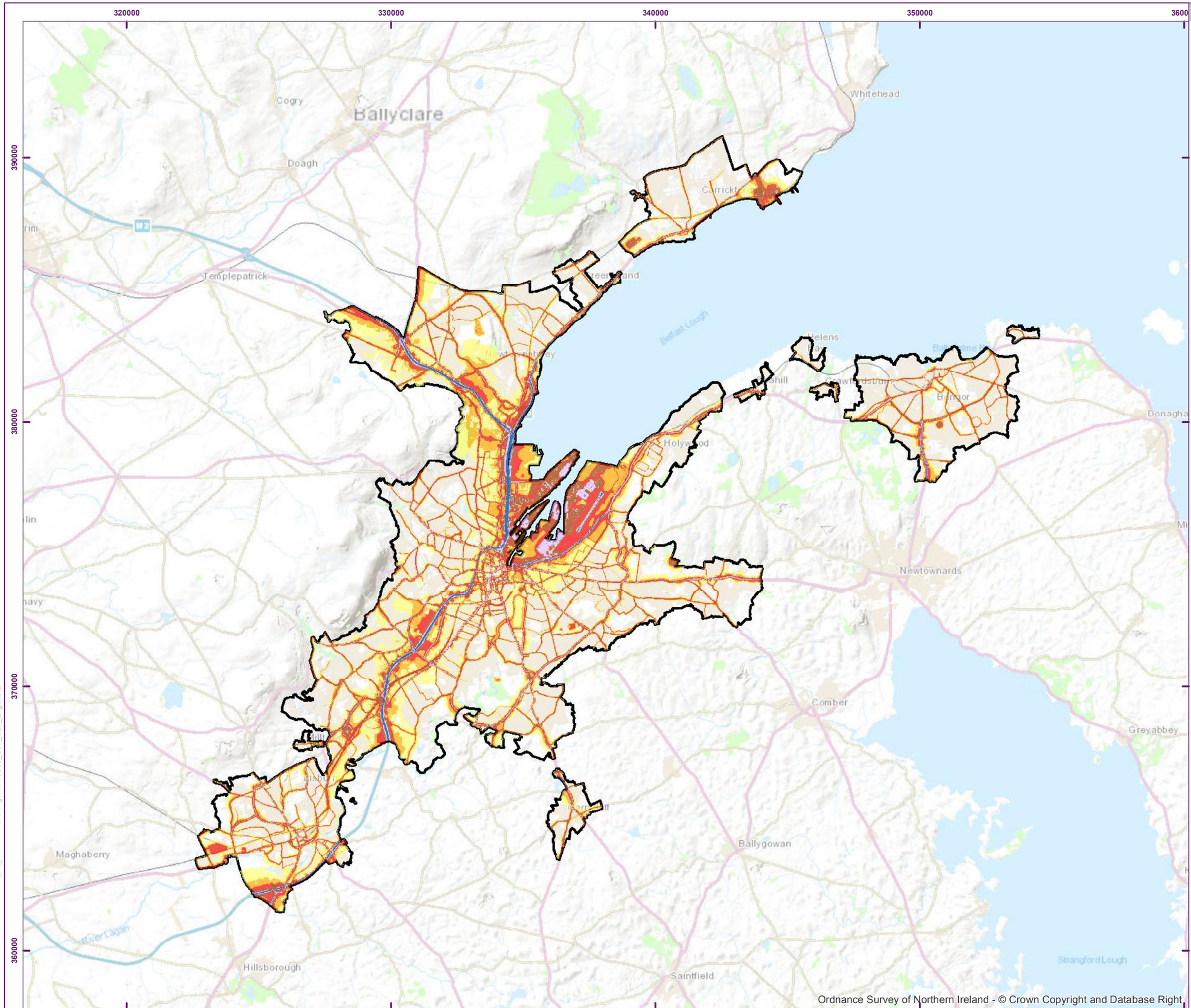

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Key

Belfast Agglomeration

Consolidated Noise Map
L_{night}

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 45 - 49
- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- > = 70
- Belfast Agglomeration

0 1 2 3 4 5 km

Scale at A3: 1:140,000

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The L_{night} is the equivalent continuous sound level in dB(A) that, over the period 23:00 – 07:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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390000 380000 370000 360000

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Key

Belfast Agglomeration

Consolidated Noise Map
L_{den}

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 1 2 3 4 5 km

Scale at A3: 1:140,000

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The day-evening-night (L_{den}) is a noise rating indicator based upon an annual average 24 hour noise level (L_{Aeq}) with a 5 dB(A) penalty for evening noise (i.e. 19.00 - 23.00) and a 10 dB(A) penalty for night-time noise (23.00 - 07.00).

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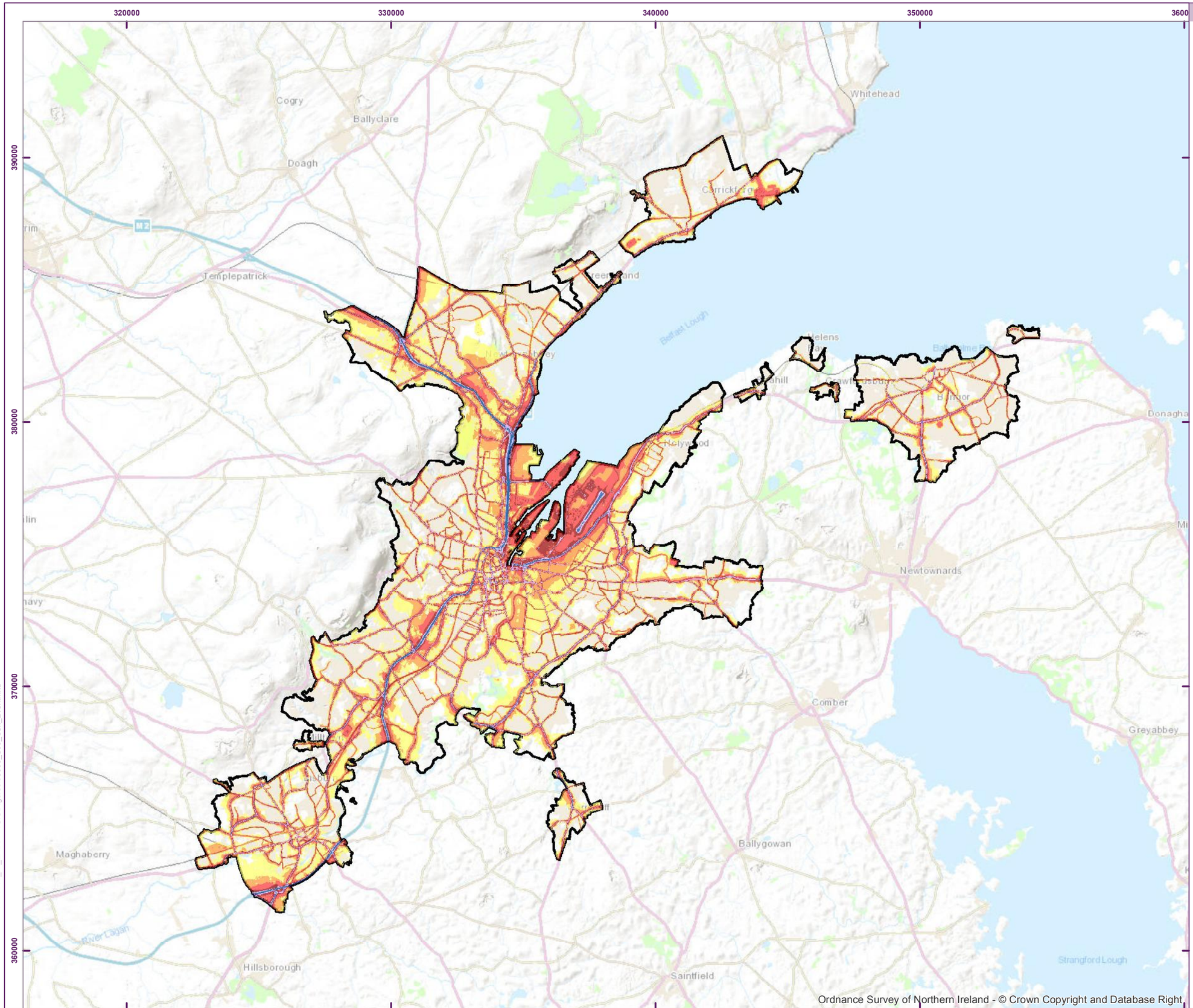

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Key

Belfast Agglomeration

Consolidated Noise Map
$L_{aeq,16h}$

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 1 2 3 4 5 km

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