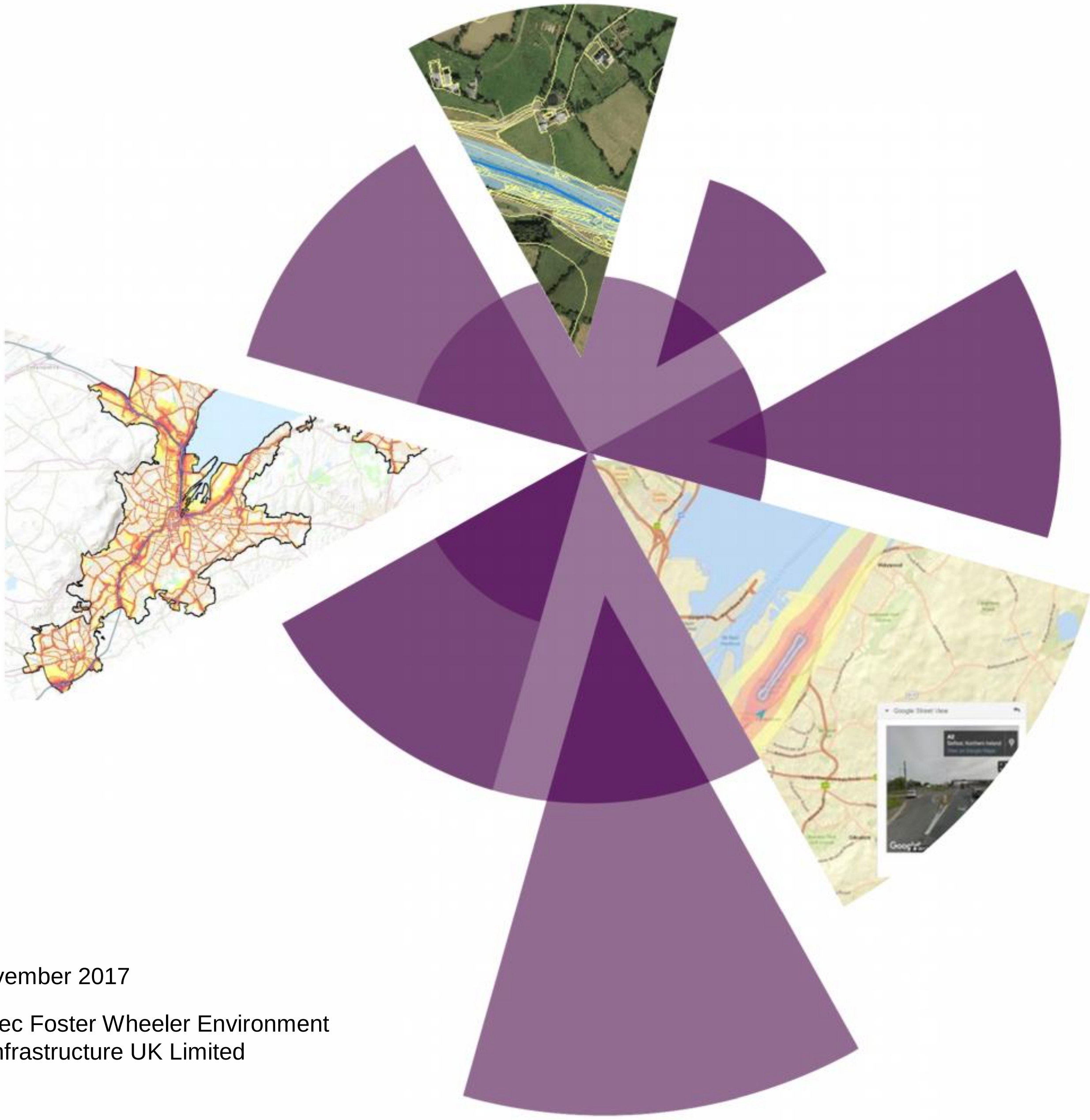
Department of Agriculture, Environment and Rural Affairs – Northern Ireland

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

Railway Modelling Report - Final



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Amec Foster Wheeler Environment
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Report for

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1	Draft Version	08/11/2017
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Executive summary

Purpose of this report

This report has been produced for the purpose of documenting the processes which have been adopted to develop the railway noise dataset used within Round Three of noise mapping within Northern Ireland under the Environmental Noise Regulations (Northern Ireland) 2006. The results of the noise mapping process are also presented at the end of the report.

This document aims to give the Northern Ireland Department of Agriculture, Environment and Rural Affairs (DAERA) a full understanding of the model development process including data capturing and processing, development of the railway noise dataset and related QA procedures.

The report begins with providing an introduction to the requirements of the mapping exercise (Section 1) and outlining the extents of the Round Three data capture areas (Section 2). This provides the setting for the specific calculation methods used to develop the Round Three railways maps (Section 3) and the data requirements needed to develop the final noise model maps (Section 4).

The report then outlines the work which has been undertaken to update and improve the railways source datasets (Sections 5 and 6). This includes preparation of input data covering the geographical location of the railway centrelines; number of overall rail movements; number of diesel locomotives on full power; location and configuration of bridges and elevated tracks; type of rolling stock; overall train and line speeds; track types and support structures.

The processes used to QA the final railway source and emission datasets produced are discussed in detail in Section 7 of the report. These includes highlighting the automated and manual checks which were completed to ensure that the final datasets are both ‘fit for purpose’ and optimised for the final modelling exercise.

In Section 8 of the report, the discussion covers the final calculation and processing settings which have been used to run the LimA modelling environment. This includes providing further details of the efficiency settings, calculation settings; and computational environment used in the modelling processes. The section concludes by outlining the post-processing steps which have been adopted to produce the final modelling outputs.

The final sections of the report (Sections 9 and 10) detail the preliminary results of railway noise exposure analysis. This includes providing area analysis of the different noise levels alongside the more detailed analysis of population and dwelling noise exposure. This provides the context for the final Section (Section 11) which provides an assessment of the key differences between the outputs of the Round 2 and Round 3 mapping exercises.

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 noise 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 six report deliverables produced for DAERA.

The key purpose of this report is to detail the data sources and processes which have been to develop the railway source dataset used in the development of the END R3 railway noise models and maps. 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.

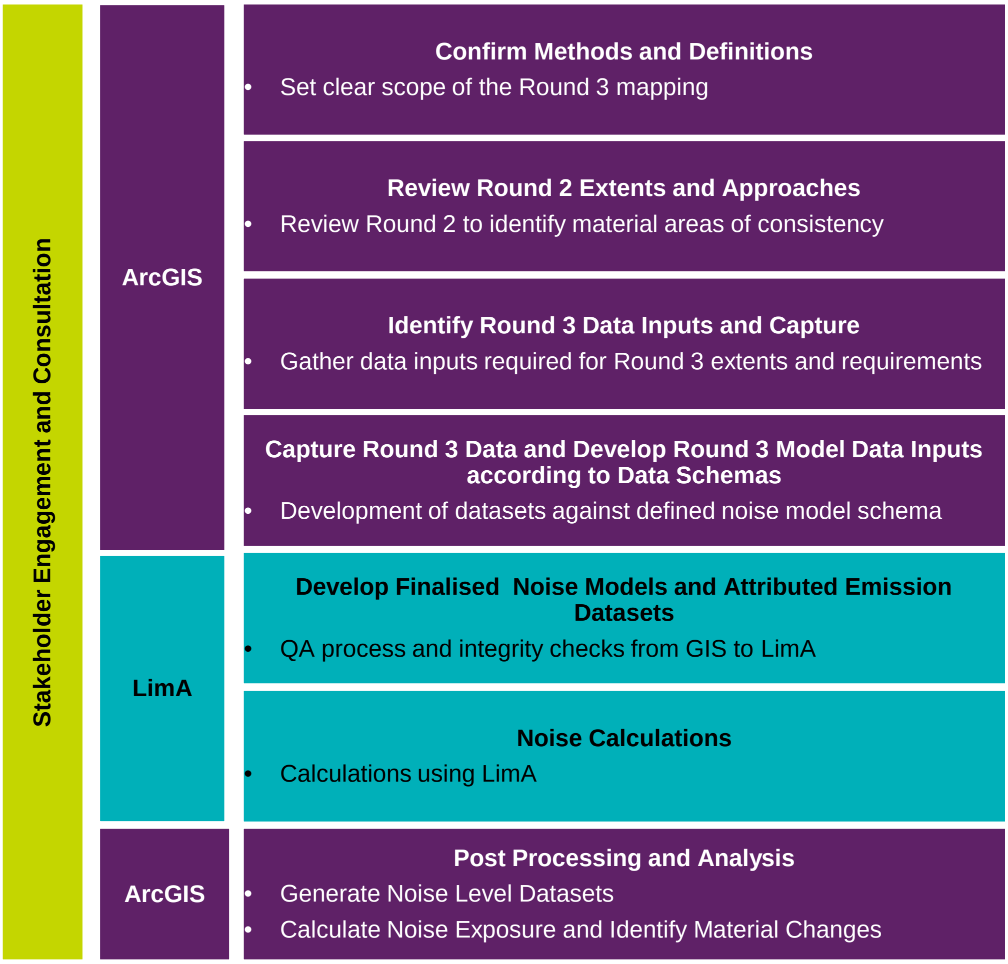
The aim and scope of Stage 2 was:

- 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 Railways modelling extents – Northern Ireland

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 2.1.

Tables 2.1 and 2.2 provide a summary of the extent of railways and data capture areas used for the Round Two and Round Three mapping exercises. This information shows that there have been slight increases in the size of the railway data capture areas between Round Two and Round Three, and this reflects alterations in the extent of the agglomeration since 2012.

Table 2.2 also shows that there has been no change in the overall length of railways modelled in Northern Ireland between R2 and R3.

Table 2.1 Agglomeration and major railways – 3km data capture area extent

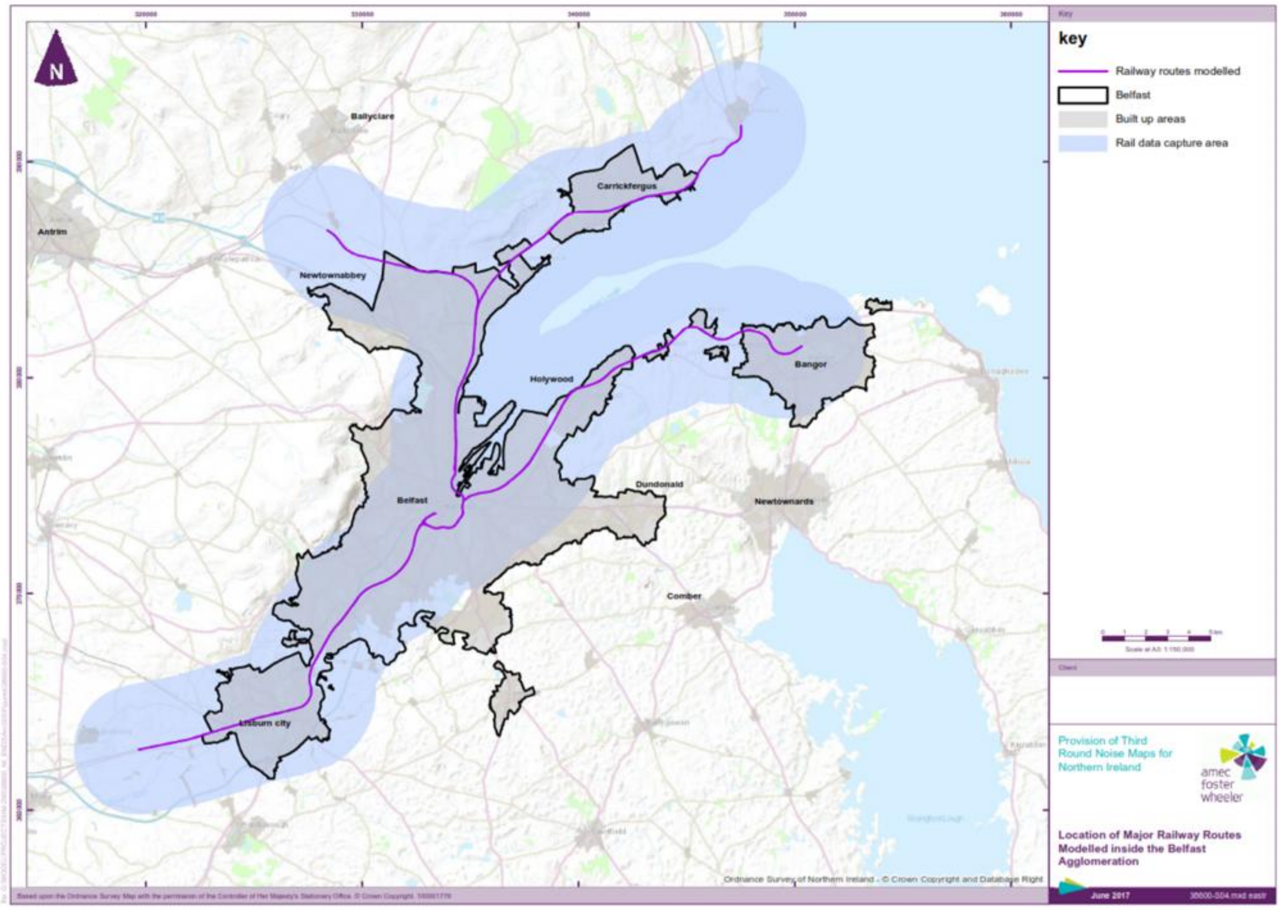
Noise Source	Round One (km^2)	Round Two (km^2)	Round Three (km^2)	Percentage increase from Round Two
Agglomeration	596	596	618	3.7%
Major railways (outside the Belfast agglomeration	-	-	-	0%
Total area	596	596	618	2.7%

Table 2.2 Agglomeration and major railways - length of railways modelled in data capture areas

Noise Source	Round One (km)	Round Two (km)	Round Three (km)	Percentage increase from Round Two
All railways modelled inside the Belfast agglomeration	148	148	148	0%
Major railways (outside the Belfast agglomeration	-	-	-	0%
Total length	148	148	148	0%

The geographical extent of the major railways, and railways within the Belfast Agglomeration, modelled in Round Three are shown in Plate 2.1.

Plate 2.1 Major railways, agglomeration railways and data capture area modelled in Round 3



3. Calculation methods used for Round Three

Under the Regulations the assessment method prescribed for the mapping of railway traffic noise sources is set out in schedule 2, as outlined in Table 3.1. For Round One and Two, the methods outlined in Schedule 2 were adopted and/or supplemented by additional guidance.

Table 3.1 Methods of assessment as outlined in Schedule 2 of the Regulations (Railways)

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).*

For railway noise, the assessment for Round One and Round Two was undertaken with reference to the following:

- 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 regarding noise emissions and railway roughness corrections for the Northern Irish rail fleet as provided by DeltaRail during Round One.

For Round Three, there is no requirement to alter the method adopted for Rounds One and Two. It was also concluded that the adopted method outlined above remains relevant to the delivery of the strategic noise maps under the Regulations.

For Round Three, the noise calculation assessment method described in this section has been used to inform data requirements and identify any additional data capture requirements.

3.1 Software methods

For Round One and Round Two, noise mapping of 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.

4. Dataset specification and requirements

4.1 Developing the dataset specification

The development of the railway traffic noise source emission model dataset has been undertaken with the aim of developing and finalising “Final Modified Data Inputs” (FMDIs) in accordance with a data specification satisfying the requirements of the assessment method and software environments.

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)

This report concentrates on the development of the railways source noise emission dataset. Development of the noise propagation dataset is discussed in the accompanying Northern Ireland Round Three Noise Mapping 3D modelling report. It is recommended that this report is read in conjunction with the 3D propagation model report.

For Round One and Two, a dataset specification was developed for the railway noise emission dataset which was designed to function with the selected 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 dataset specification is provided in full in Appendix A.

In order to populate this dataset, a list of data requirements was developed. These data requirements are outlined in Section 4.2.

4.2 Data requirements

In order to develop the railway traffic noise emission dataset to specification, the following data requirements were formulated. These data requirements are identical to those developed in Round One and Round Two and include:

- Rail centreline geometry
  - between the two railheads
  - one per rail line
  - plan accuracy to within 1.5m in urban areas
  - plan accuracy to within 3.0m in rural areas
  - in any case should not cross the “top of embankment” or “bottom of cutting” polylines
  - section accuracy to within 0.5m
- Total vehicle volume of all vehicles along centreline
  - Annual average day, evening and night 18 hours and 6 hours traffic flow
- Diesel Locomotives on Full Power
  - Locations where diesel locomotives are normally on full power
- Bridges and elevated tracks
  - Location and type of bridge or track support

- Type of rolling stock
  - Matched to CRN categories
- Train speed
  - For each type of rolling stock
- Track type and support
  - Where jointed, slab or continuously welded
  - How supported
- Maximum line speed
  - Per track
- Acoustic Track Quality (ATQ)
  - Per track.

Table 4.1 Railway noise emission dataset requirements

Input		Spatial Reference	Object Type	Unit	Validated Range
Rail centre line geometry		Vector	Polylines	Metre (m)	n/a
Train flow		n/a	n/a	n/a	n/a
Track type/track support structure		n/a	n/a	n/a	n/a
Rolling Stock		n/a	n/a	n/a	n/a
Speed	Diesel locomotive on full power Rail Vehicle Speed	n/a	n/a	n/a	n/a
Number of vehicles comprising train		n/a	n/a	Number Integer	*1-50 Vehicles
Bridge/ballast correction		n/a	n/a	NA	n/a
Rail roughness / ATQ		n/a	n/a	dB(A)	n/a
Rail grinding		n/a	n/a	n/a	n/a

* Range of values displaced within the tables and charts of Calculation of Railway Noise (Department of Transport, 13th July 1995, HMSO);

4.3 Reviewing the Round Two dataset

At the start of the project, a data review questionnaire was prepared and submitted to Translink. The purpose of this questionnaire was to understand whether there had been any changes in the agglomeration and major railway networks in Northern Ireland that may influence the Round Three data capture and results and also to assist with the review process.

A detailed review of the Round Two railway datasets was also undertaken at the start of the project. The key focus of this review was to assess the ability of using the Round Two dataset as the basis for creating an updated road source layer for the Round Three modelling exercise, and whether or not data sources could be improved upon or further refined for Round Three.

Table 4.2 presents a summary of the key outcomes of the data questionnaire and review of the Round Two railway dataset by the Amec Foster Wheeler team.

Table 4.2 Review of the Round Two dataset

Data Input	Round Two Data Source	Round Two Coverage relevant for Round Three Mapping	Changes from Round 2 due to improved or altered data
Rail Centrelines	OSNI LargeScale	Yes	No
Total Movements	Schedules	Yes	Yes
Diesel Locomotives on Full Power	Train Drivers	Yes	Yes
Elevated Track Locations/ Bridges	Various	Yes	Yes
Rolling Stock	Schedules / Engineering	Yes	Yes
Train Speed	Speed Limits and Recorded Tran Speeds	Yes	No
Track Type and Support	Various	Yes	No
Rail Roughness	Informed Assumption	Yes	Yes

The following section outlines the specific datasets and processing tasks undertaken to develop the final railways source layer used to develop the Round Three maps.

5. Railways source dataset – spatial attributes

5.1 Railway centrelines

For Round One and Round Two, railway centrelines were derived from the OSNI LargeScale digital mapping product. An initial review of the railway line features within the OSNI LargeScale digital mapping product showed that there had been no fundamental changes to the location and extent of the railway network in Northern Ireland between 2011 and 2016. The data questionnaire responses by Translink also confirmed that:

- There has been no additional rail lines laid in Northern Ireland since 2011;
- No disused or closed railway lines had reopened;
- There had been no light rail schemes in Northern Ireland which may affect noise levels in the Belfast Agglomerations or could be considered as Major Railway; and
- No new stations had opened since 2011.

Based on these responses, it was determined by the project team that the derived Round Two railway centrelines could be used as basis for modelling Round Three noise emissions as there has been no fundamental changes to the extents under consideration between rounds.

5.2 Rail movements

Rail movement data is required by the assessment method in order calculate noise emission levels from the total number and type of rail vehicles operating on a section of the rail network. The total number of rail passages, in terms of trains, is also required in order to determine whether a rail route qualifies above the major railway threshold of 30,000 passages per annum.

In order to be compliant with the Regulations, vehicle movements are required for the following five separate time periods:

- Day (0700 – 1900hrs)
- Evening (1900 – 2300hrs)
- Night (2300 – 0700hrs)
- 18 Hour UK Day (0600 – 0000hrs)
- 6 Hour UK Night (0000 – 0600hrs)

For the second round, Translink derived annual passenger vehicle movements for each route on the Northern Ireland rail network from timetables representative of 2016. Vehicle passenger movements were provided in two directions and were assigned to a specific rolling stock with further details of the typical train make up i.e. number and type of vehicle units comprising the train. Additional information regarding the number of engineering movements to and from Translink's York Road and Fortwilliam depots, and for the number of 'out of service' passenger trains were also provided and modelled.

As part of the review process, the project team raised the following queries with Translink.

- Has there been any change in timetabling between 2011 and 2016 that would materially affect the number of rail movements?
- Are there any new or additional services from 2011 which are now effective in 2016?

- Has there been any change in train services since 2011 which are now effective in 2016 which may affect the number of stopping and terminal services?
- Has there been any change in the rolling stock services that are operated on any of the services identified modelled in Round Two i.e. are new trains operating the services?
- Are all of the passenger services in Round Two still operating?
- Has there been any change in the engineering movements and rail engineering vehicles since 2011?

Following these queries, Translink issued a set of revised rail vehicle passenger movements representative of 2016, as outlined in Appendix B. These vehicles movements were based on schedules and took into considerations developments throughout 2016. This included the consideration of the introduction of 20 Class 4000 trains which have replaced seven Class 450 trains across the Translink network.

From the review process, Translink confirmed that the ‘out of service’ passenger train movements and engineering movements used in Round Two were still applicable to Round Three.

5.3 Diesel locomotives on full power

For Round One, the location of where diesel locomotives are on Full Power was provided by Translink. This information was sourced from information recorded/provided by individual locomotive drivers. Two locations in the Lisburn area were identified as being where full power was required. These locations were apparent from the Round One FMDI GIS railway noise emission dataset as being locations where the L_FP attribute was set to a value of 1. This approach was confirmed for Round Two.

For the Round Three exercise, it is understood that there have not been any significant changes to signalling or rolling stock which would potentially require further review of these locations or identify any further locations. As such the locations obtained from the Round Two FMDI’s were adopted for Round Three.

5.4 Bridges and elevated tracks

For Round One and Two, bridges and elevated tracks were identified from a variety of sources including analysis of digital mapping data, aerial photography, the Translink Bridge Inventory and a field survey used to verify the locations of bridges from other sources of data. These were reviewed and updated during Round Two.

Translink also supplied two additional GIS datasets showing the recorded position of over-line and under-line bridge or crossing (culvert) features. This data was reviewed in detail during the work undertaken to update and improve the 3D-model used in the LimA model. A majority of the features were excluded from the final model as they related to minor footbridge or culverts features which would have no material impact upon the resulting noise maps.

In the end, eight new bridge features relating to the Translink data were captured and added the existing bridges captured for Round 2. Full details are provided in the accompanying 3D ground model report.

5.5 Type of rolling dtock

A key data requirement of the CRN calculation methodology is the consideration of the noise emissions from the various train vehicles making up movements on a section of track. For Round Two, information regarding rolling stock was provided by Translink in the form of movements schedules. As part of the data review questionnaire, the project team asked Translink whether there had been any new rolling stock that had entered service on their network in 2016 in comparison to Round Two.

Table 5.1 presents a summary of the technical details of each train operating on the Northern Irish rail network.

Table 5.1 Overview of Northern Ireland rail fleet

Rail Vehicle	Maximum Speed	Horse Power	Propulsion	Braking System	Used Between (R1)	Used Between (R2)	Used Between (R2)
Class 110 Locomotive	90mph (144kmh)	2475bhp	Diesel	Tread	GVS – Newry	Retired	Retired
Class 201 Locomotive	90mph (144kmh)	3200bhp	Diesel	Disc	Belfast – Dublin	Belfast – Dublin	Belfast – Dublin
Mark IIf/IIb Coaches	70mph (112kmh)	n/a	n/a	Tread	GVS – Newry	Retired	Retired
Enterprise Loco Hauled Carriage	90mph (144kmh)	n/a	n/a	Disc	Belfast - Dublin	Belfast – Dublin	Belfast – Dublin
Class 450	70mph (112kmh)	560bhp	Diesel-Electric	Tread	Belfast – Bangor Belfast – Portadown Belfast – Larne	Belfast – Larne	Retired
Class 3000	90mph (144kmh)	Unknown	Diesel	Disc	Bangor – Portadown Belfast – Londonderry	Bangor – Portadown Belfast – Londonderry	Bangor – Portadown Belfast – Londonderry
Class 4000	90mph (144kmh)	530hp	Diesel	Disc	-	Belfast – Larne	Belfast – Larne
Class 80	70mph (112kmh)	560bhp	Diesel-Electric	Tread	All lines (maintenance)	All lines (maintenance)	All lines (maintenance)
Tampers:							
Plasser 07-16 Plasser 08 Plasser 08-16 SP4	- - -	402 hp 402 hp 805 hp	Diesel	Tread	All lines (maintenance)	All lines (maintenance)	All lines (maintenance)
Ballast and Hopper Wagons:							
HTA Wagons	75 mph (121 kmh)	n/a	n/a	-	All lines (maintenance)	All lines (maintenance)	All lines (maintenance)

5.6 Train and line speeds

Train speed is an important input for calculating railway noise emissions. The CRN calculation method requires that train speed is provided per train and rail vehicle and that this speed is provided at all locations along the railway line.

For Round Two, train speed information was captured from:

- Permanent speed restrictions which obtained from annotated paper maps marked against mileposts; and
- Actual train speed obtained from the data recorder of a Class 3000 train.

During Round Two, Translink confirmed that the speed of Class 3000 trains on any of its routes would provide a good representation for other train movements due to operational procedures. Where the data obtained from the Class 3000 did not cover sections of the rail network, Translink confirmed that speed restrictions should be used instead. From reviewing the Round 1 FMDIs, actual speeds obtained from the Class 3000 trains were present within the L_VEL attribute whereas speed restrictions were identified within the L_VAD attribute.

The project team raised the approach adopted during R1 and R2 with Translink through the data questionnaire and Translink confirmed that this data would be applicable for R3 mapping. The L_VAD and L_VEL values and spatial locations from R2 have therefore been subsequently adopted for R3.

5.7 Track type and support structure

CRN allows for railway noise emissions to be corrected depending upon track type and support structures. Different railway track types and supports can comparatively enhance and indeed reduce noise emissions. Understanding the location and type of track, bridges, points and switches is therefore a key requirement when calculating railway noise emissions.

During R1 and R2, this information was captured through a series of meetings with Translink and from information held within their bridge inventory. Virtual techniques including aerial imagery was also employed to confirm the location and type of various support structures.

For R1 and R2, all railway lines were modelled as Continuous Welded Rail (CWR) on a Ballast track bed. This followed confirmation from Translink that the majority of the rail network in the vicinity of Belfast is, if not all, CWR laid on ballast. This characteristic was confirmed by Translink at the start of R3.

As part of the data questionnaire, the project team also asked Translink to identify any new or replacement bridges on the Northern Irish network. Translink confirmed that there had been no new or replaced railway bridges on the network since R2. On this basis, the project team identified that the content of the L_TT (track type) and L_TS (track support) was still current for R3 mapping and on this basis, the content of the L_TT and L_TS attributes was adopted.

The location of tunnels was also reviewed, and the R1 FMDI checked to ensure that the tunnels were modelled appropriately by disabling noise emissions.

6. Railways source dataset – emission attributes

This section of the report presents the development of the R2 railway noise emission dataset using the information captured and adopted as outlined in Section 5. The calculation of railway noise emissions has been undertaken using a specially developed railway noise emission geo-processing and database script developed in the Python programming environment. The follow section details specific information which is relevant to the calculation of railway noise emissions using this script.

6.1 Rail centrelines emission objects

The R2 FMDIs were adopted as the R2 rail centreline emission objects. No modifications were made to these objects. The adoption of the R2 FMDIs ensured that railway noise emissions in Northern Ireland continue to be modelled at track level rather than route level. Track level modelling is more accurate than route level modelling as a track level model considered all railway lines within a given rail corridor or route. This approach is also compliant with CRN. Route level modelling simplifies the railway by assuming that all railway movements within a given route occur on a single rail centreline. This approach has previously been adopted in England, Wales and Scotland and can result in uncertainties where rail corridors are wide.

6.2 Assigning rail movements to rail centrelines

The assignment of rail movements to the rail centrelines was undertaken using relational database techniques. For each rail movement provided by Translink, a unique ID was assigned in terms of a 'J_ID' or 'Journey ID'. The unique J_ID for the core rail movements is presented in Appendix B and is incorporated within the information provided by Translink.

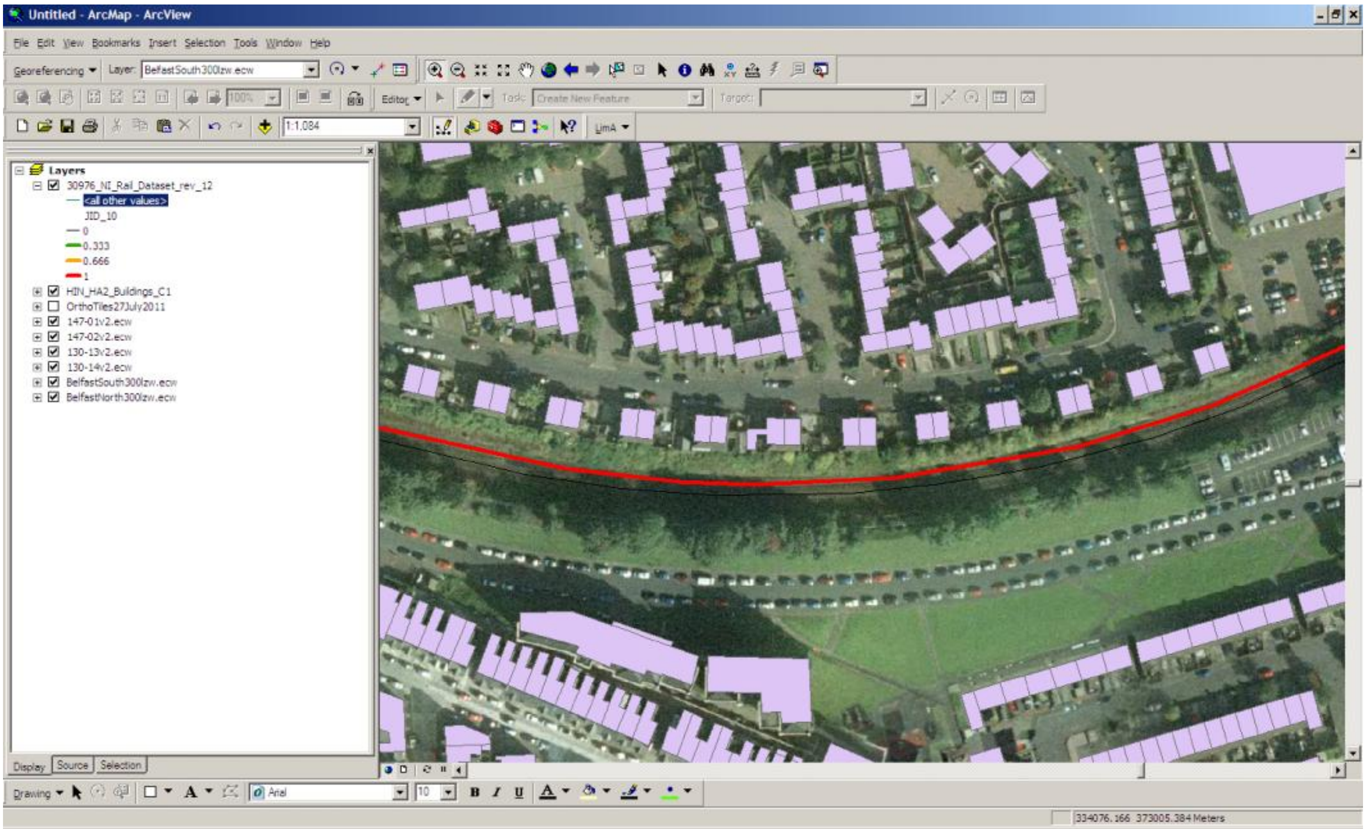
Using GIS, each rail centreline was assigned a 'J_ID' value between 0 and 1 to reflect the proportion of movements of a journey operating on a certain track. For majority of cases, this J_ID was assigned to either 0 or 1. In some instances, such as stations, the J_ID was set to reflect a spread of movements across tracks and platforms. Using a database scripting, details of the journey, including the number of movements and rail vehicle details could be obtained for the purposes of rail emission calculations.

The assignment of movements, and any associated assumptions, in terms of the J_ID is discussed in the following sections for general sections of railway; stations and depots.

General rail movements

For general rail movements between stations, the assignment process adopted a default assumption that trains run on the left-hand track in their direction of travel. Plate 6.1 presents an example of this assumption for a passenger service movement between Great Victoria Street and Belfast Central.

Plate 6.1 Example of left hand direction of travel



Red line shows the modelled rail emissions between Great Victoria Street and Belfast Central. The red line is modelled on the left-hand track assuming that the direction of travel is always on the left-hand line.

It should be noted that for the majority of the railway lines considered by the mapping, the J_ID was assigned to either 0 or 1 to reflect all or none of the movements operating on the line. In some scenarios, notably beyond terminating stations, the J_ID has been set to a value reflecting the number of trains carrying on past a station and the number that terminate at the station. This is discussed further in the following section.

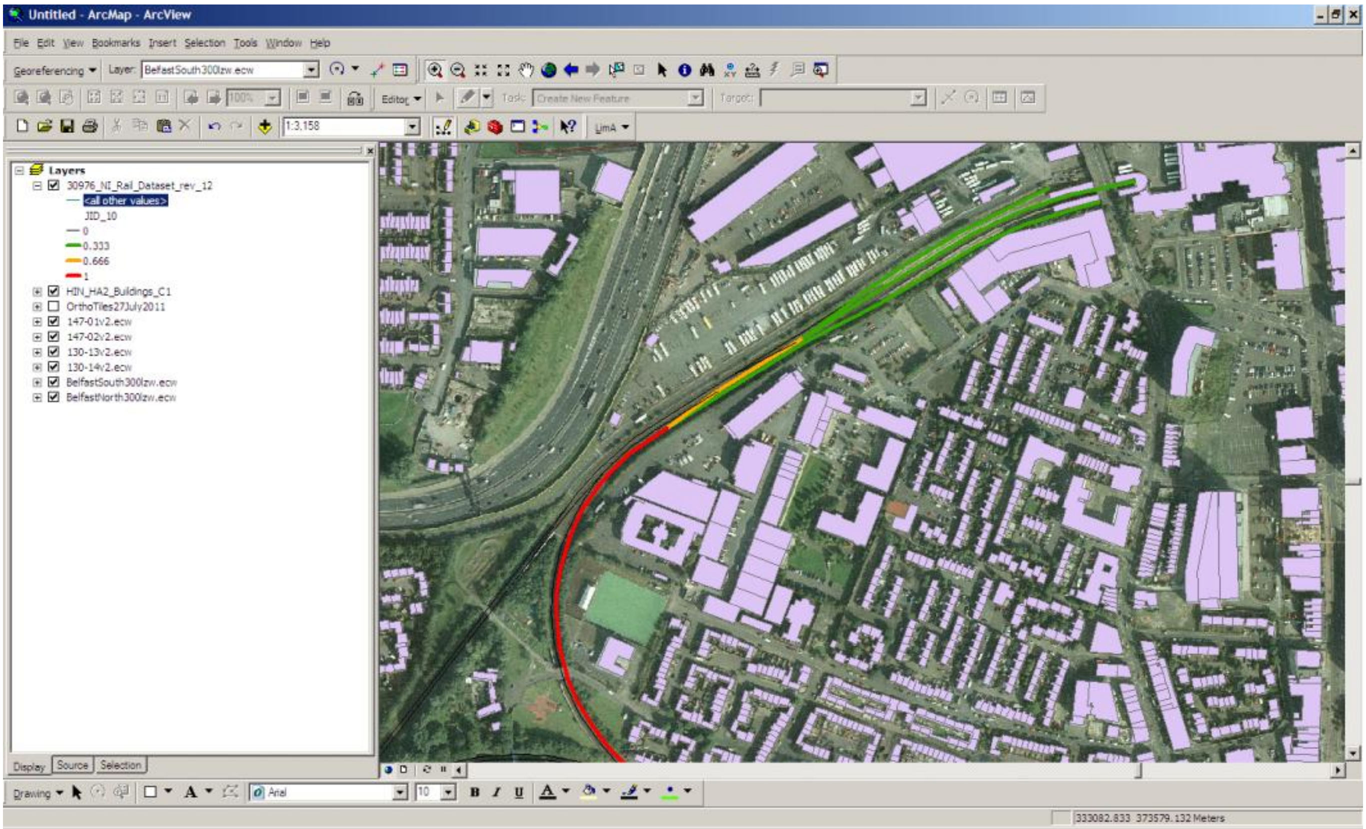
Stations

For R1, three options were considered for the modelling of train movements into and out of stations:

- Option 1 – model only two centrelines into and out of stations;
- Option 2 – Proportion movements into and out of stations by service type; and
- Option 3 – average total services across all available platforms into and out of stations.

Following discussions with Translink, it was decided that Option 2 was most appropriate for the modelling of the railways in Northern Ireland. Subsequent guidance was provided by Translink relating to the allocation of railway movements across platforms. This guidance has been reviewed and confirmed by Translink as appropriate for modelling in R3. An example of the application of the Option 2 approach is provided below in Plate 6.2.

Plate 6.2 Example of J_ID attribution at Great Victoria Street station



The example shows the distribution of railway movements by J_ID into platforms at Great Victoria Street Station. The green lines assume that 33% of the movements will be allocated across these platforms. The orange line assumes that 66% of the movements will be allocated. The red line assumes that 100% of the movements will be allocated to the line.

For stations outside the Belfast agglomeration it has been necessary to carefully review the modelling to confirm the extent of major rail. This has involved consideration of the number of trains terminating and continuing past Carrickfergus and Lisburn stations.

Further information regarding the number of terminating trains at these stations has been used in combination with information regarding the modelling of platforms. This appends the information provided by Translink during R2 and is presented in Appendix C.

Depots

In R2, the York Road and Fortwilliam Depots were modelled using guidance provided by Translink on the allocation of movements to and from the depot. The approach to modelling routes in and out of the depots has been retained from R3.

Further details of modelling the movements in and out of the two depots are outlined in Appendix C.

6.3 Modelling of rail vehicles

Total vehicle movements

The CRN method requires that all train movements be considered in terms of railway vehicles (or 'bogies') in order to calculate noise emissions. This means, for example, that a single train comprising of a locomotive and eight carriages is modelled in terms of noise emission from the locomotive and each of its eight carriages. In the case of multiple unit trains, a single multiple unit train is modelled in terms of number of units it comprises.

Movement data provided by Translink for passenger movements, out-of service passenger trains, engineering movements and terminating services were provided in terms of trains. This approach is appropriate for determining the extent of major rail as the Regulation requires the consideration of the 'number of train passages' which must be considered at route level. For the mapping of railway noise in Northern Ireland, the approach adopted by the project team and the methodology outlined in CRN requires railway vehicles to be modelled at track level. To this end, Translink provided details of the typical composition of the trains outlined in the movements provided. In addition, Translink also outlined the routes which the trains are operating.

Using the information provided, the project team developed a look-up table which linked the trains provided in the movement data to the number of various vehicles they comprised. This look-up table was expanded to contain additional information relevant to the calculation of railway noise emissions that is intrinsic to the type of railway vehicles. This is discussed further in the following sections.

6.4 Railway vehicle noise emission data

As discussed in Section 6.3, the project team developed a look-up table which linked the various trains outlined in the movements provided by Translink to the number of railway vehicles they each comprised. This look-up table was extended to include details relevant to the calculation of noise emissions from each rail vehicle. These details included:

- Maximum vehicle speed;
- Rail vehicle emission factors for rolling noise, fan noise and diesel on-power noise; and
- Railway roughness.

Maximum vehicle speeds

Maximum vehicles speeds were taken from technical specification for each of the rail vehicles identified within the data provided by Translink. The importance of maximum speeds is to ensure that rail vehicles are not modelled above their maximum operating speed. In the calculation of noise emissions, the speed obtained from the rail centreline is cross checked against the maximum operating speed. Where the speed obtained from the line is higher than the operating speed, the trains maximum speed is used within the calculation of the noise emissions.

Rail vehicle noise emission factors

The adapted version of CRN used within the mapping considered noise emissions from three noise sources on a train. Each rail vehicle considered has emission factors for the sources that change between vehicles to differentiate their noise emission characteristics. These sources are as follows:

- **Rolling Noise** – this is noise from the rail-wheel interface and is modelled at the railhead;
- **Diesel Locomotive (Full Power)** – this is noise generated at the exhaust of a diesel locomotive when at full power. This noise source only applies for diesel locomotives when at full power and is modelled

at 4m. When this source is modelled, the rolling noise from the diesel locomotive is excluded from the calculation;

- **Fan Noise** – this is the noise source generated by the fans from Class 373 Eurostar trains and was included for the purposes of modelling a specific characteristic of the Eurostar as part of the Channel Tunnel Rail Link (CTRL). This source is modelled at a height of 2m above the railhead. The specific nature of this source means that it not relevant to the noise mapping exercises undertaken for Northern Ireland.

During R1 and R2, emission factors for Rolling Noise and Diesel Locomotive (full power) noise sources were obtained from Deltarail. This information has been retained for R3.

For R1 and R2, the modelling of wagons and hoppers associated with engineering movements was undertaken with the assumption that half of these vehicles would be full and the other half empty. This is due to the emission factors for rolling noise for these vehicles differing due to loading. This assumption has been retained for R3.

Railhead roughness

Rolling noise is the dominant component of railway noise over a large speed range. Railhead roughness is a significant factor in the rolling noise emissions from by the railways. The core calculation methodology within CRN assumes that trains with smooth wheels are operating on smooth, unperforated lines. Railway roughness occurs when a train vehicles wheel locks during breaking and flat spots. Rail vehicles with tread brakes are much more prone to flat spotting than disc-braked vehicles and for this reason, rolling noise emissions tend to be much lower for disc-braked vehicles. Flat spotting is generally associated with cast-iron tread brakes rather than the latest composite types which tend result in similar rolling noise components as disc-braked vehicles.

In general, flat spotting results in two effects:

- increased rolling noise emissions due to the flat spot interacting with the railhead; and
- general increases in rolling noise emissions for rail vehicles with smooth wheel interacting with resultant perforations in the railhead.

Research has indicated that railhead roughness can account for increases of up to 20 dB(A) in rolling noise emissions in comparison to the methodology outlined in CRN. The adapted version of CRN used for the mapping Northern Ireland accounts for Railhead Roughness using guidance provided to Defra by Deltarail.

As outlined above, railway roughness affects rolling noise emission at the railhead and through the wheel-railhead interaction. When considering emissions factors for railhead roughness, the wheel roughness characteristics of the rail vehicles must be considered in combination with the railhead roughness of the track. To this end, it is necessary for rail vehicles to be considered in terms of whether their wheels are ‘rough’ or ‘smooth’ and to what extent their wheels interact with the roughness of the track, otherwise known as gradient. This information has been adopted from R2.

Final railway noise emission look-up table

Table 6.1 presents the railway vehicle noise emission data adopted for the mapping. The table presents the railway vehicle emission data described in the previous sections for each railway vehicle modelling in R3.

Please note that Class 110, Mark IIf/IIb Coaches and Class 450 train vehicles are now retired and are therefore not included as a vehicle type within the Round 3 mapping exercise.

Table 6.1 Final railway noise emission look-up table

V_ID (Vehicle ID)	Train Vehicle	Maximum Vehicle Speed	Wheel Condition	Gradient	Rolling Noise Emission Factor	Diesel Locomotive (Full Power) Emission Factor
01	Class 110 Locomotive*	90mph (144kmh)	Smooth	0.64	13.0 dB	-5.0 dB
02	Class 201Locomotive	90mph (144kmh)	Smooth	0.64	13.0 dB	-13.0 dB
03	Mark IIf/IIb Coaches*	70mph (112kmh)	Rough	0.73	14.8 dB	n/a
04	Enterprise Loco Hauled Carriage	90mph (144kmh)	Smooth	1.00	6.0 dB	n/a
05	Class 450*	70mph (112kmh)	Rough	0.40	16.1 dB	n/a
06	Class 3000	90mph (144kmh)	Smooth	0.90	7.6 dB	n/a
07	Class 4000	90mph (144kmh)	Smooth	0.90	7.6 dB	n/a
08	Class 80	70mph (112kmh)	Rough	0.40	16.1 dB	n/a
Tamper & Liner:						
09	Plasser 07-16					
10	Plasser 08	n/a	Rough	0.70	12.0 dB	n/a
11	Plasser 08-16 SP4					
Ballast and Hopper Wagons:						
12	HTA Wagons (Loaded)	75mph (121kmh)	Smooth	0.90	7.1 dB	n/a
13	HTA Wagons (Empty)	75mph (121kmh)	Smooth	0.68	10.4 dB	n/a

Note * = Vehicle type which is now retired

6.5 Diesel locomotives on full power

As discussed earlier in this section, CRN considers a separate noise source and set of emission factors for diesel locomotives that are on full power. For the purposes of noise mapping, an understanding of where diesel locomotives are at full power is required. As discussed earlier in this section, Translink confirmed that the location of diesel locomotives using full power remains the same as that in R2 and as such the locations obtained from the R2 FMDIs as outlined in the L_FP attribute have been adopted.

For the purposes of calculation railway noise emissions, where the L_FP attribute stored on the railway centrelines is set to 1, diesel locomotives are considered as being on full power and railway noise emissions for these vehicles are calculated accordingly.

6.6 Track type and support structure

As discussed earlier in this section, Translink have confirmed that track type and support structures have not changed from R2 and therefore the information held within the L_TT and L_TS attributes in the R2 FMDIs can be retained for R3.

Track type and support only effects rolling noise emissions. The L_TT and L_TS attributes are indexed to lookup tables for the various rolling noise source corrections offered by CRN for the track type and support structures considered by the method. Table 6.2 and Table 6.3 presents these lookup tables for track support and type respectively as considered by CRN.

Table 6.2 Support structure rolling noise correction look-up table

L_TS	Material	Structure Type[1]	Correction to Rolling Noise Emissions (dB)
01	Concrete	Bridge	+1 dB
02		Viaduct	+1 dB
03	Steel	Generic	+4 dB
04		Box Girder (with rails fitted directly girder and orthotropic slab). Rail Bearer and cross and lattice girder	+9 dB

[1] Descriptions from CRN

Table 6.3 Track type rolling noise correction look-up table

L_TT	Track Type Description[1]	Correction to Rolling Noise Emissions (dB)
01	Continuously Welded Rail (CWR) on Concrete Sleepers and Ballast	0 dB
02	Continuously Welded Rail (CWR) on Timber Sleepers and Ballast	0 dB
03	Jointed Track (18.3m lengths).	+2.5 dB
04	Points and Crossings	+2.0 dB

[1] Descriptions from CRN

For the purposes of calculating noise emissions, the corrections outlined in Table 6.2 and 6.3 are obtained from the L_TS and L_TT attributes on the rail centrelines and then applied to rolling noise emissions. It should be noted that corrections for support structure and track type are arithmetically summed before being applied to rolling noise emissions.

Crossings, points and switches

Crossings, points and switches were considered in R2 by setting the L_TT attribute to a value of 4 in the location of these features. Although the location of these features has not changed since R2, these were reviewed prior to the calculation of emissions.

6.7 Train and line speeds

Train vehicle speed is a key component in the modelling of railway noise emissions. This is reflected in CRN models where rolling noise emissions increase with increasing rail vehicles speeds. In the case of diesel locomotive (full power) noise sources, emissions decrease within increasing speeds.

Using information provided by Translink, it was confirmed that the same rail vehicle and line speed assumptions adopted for R2 were applicable for R3. This information is held within the L_VEL and L_VAD attributes within the R1 FMDIs. Additional information relating to speed, in the form of maximum rail vehicle speeds, is also stored in the railway vehicle noise emission look-up table outlined in Table 6.1.

For the purposes of calculating noise railway noise emissions, speed has been handled as follows:

- The calculation script checks for an entry in the L_VEL and L_VAD attributes. Where a speed is present within the L_VEL attribute, this indicates a measured train speed for the line is available and is adopted. Where no L_VEL speed is available, this indicates that no measured speed information is available and the line speed stored within the L_VAD attribute is adopted;
- The L_VEL or L_VAD speed is checked against the maximum speeds of the rail vehicles. Where the maximum speed of the rail vehicle is lower than L_VEL or L_VAD, the speed adopted for the calculation of emissions is set at the maximum rail vehicle speed otherwise the L_VEL or L_VAD speed is adopted for the calculation.

This approach is compliant with the approaches and guidance outlined in the WG-AEN GPG2 Toolkit 9 from Defra research project NANR 208 as outlined in Plate 6.3 below.

Plate 6.3 WG-AEN GPGv2 Toolkit 9 guidance for the modelling of train speeds

Toolkit 9: Train (or tram) speed			
Method	complexity	accuracy	cost
Reliable train speeds are **available from the owner of the tracks**	△	< 0.5 dB	△
Reliable train speeds are **available from the operators of the trains**	◇	< 0.5 dB	⬠
Measure train speeds	⬡	< 0.5 dB	⬡
Use timetables and distances to calculate an average speed (may not be possible for freight trains)	⬠	2 dB	⬠
Take the minimum of the following two values: • maximum train speed • maximum track speed	◇	2 dB	◇

It should be noted that this approach within the calculation of emissions reflects the accuracy and hierarchy of the methods outlined in Toolkit 9.

Assumptions and rules within L_VAD and L_VEL Attributes

The L_VAD attribute considered maximum line speeds as provided by Translink during R2. The data considered within this attribute is subject to rules and assumptions. This includes a minimum modelling speed of 20 kmh^{-1} as this speed is the lowest permissible within the CRN method. This assumption mainly effects stations and platforms, and has been retained for R3. For completeness, it should also be noted that the measured speeds stored within L_VEL attribute as taken from the Class 3000 data recorders during R1 have also been restricted to a minimum speed of 20 kmh^{-1}.

6.8 Rail roughness

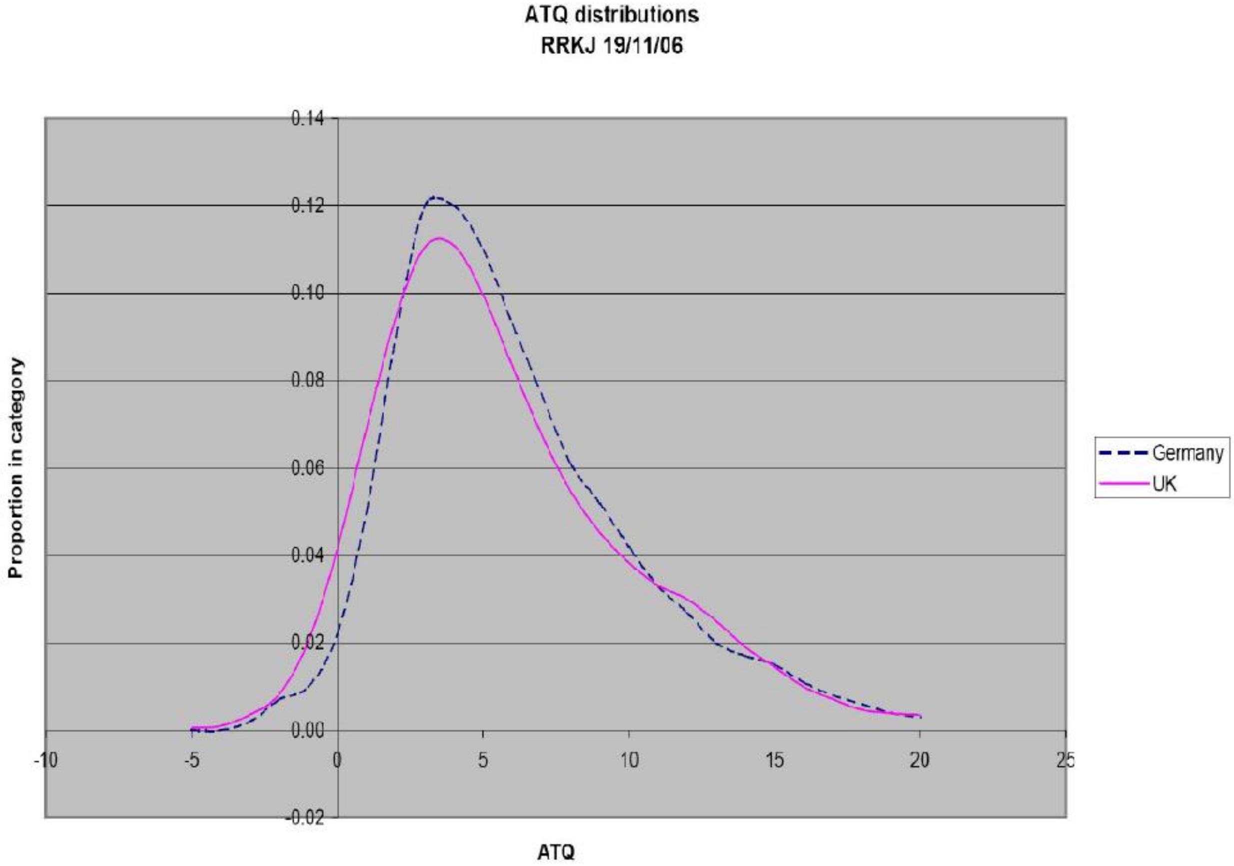
As discussed in Section 6.5, railhead roughness is a combination of direct and indirect effects through the flat-spotting of rail vehicle wheels. Although railhead roughness is considered for rail vehicles, some consideration must also be given to the roughness of the rail. This consideration is given through the concept of Acoustic Track Quality (ATQ).

ATQ was developed by Deltarail through their study of the influence of railway roughness upon railway noise levels and emissions. ATQ aims to quantify railway roughness against the core assumption within CRN that a railhead is smooth. The ATQ is measured in decibels (dB). Where ATQ is equal to 0 dB, this reflects the core assumption of CRN. Where the ATQ of a track is higher than 0 dB, this reflects a track which produces more noise that the core CRN assumption. Conversely, where the ATQ is less than 0 dB, this reflects a track which performs better than the core assumption in CRN and produces lower noise emissions.

Through measurements undertaken by Deltarail, ATQ has been found to vary from around -5 dB for very smooth track to around +20 dB for rough perforated tracks. For a smooth wheeled vehicle, this results in changes in rolling noise emissions directly proportional to the ATQ of the track i.e. rolling noise are increased or decreased by value of the ATQ. For rough wheeled vehicles, the relationship between rolling noise emissions and ATQ is more complex in that the effects of wheel roughness upon noise emission become more dominant when the railhead is smooth. Deltarail have developed equations to calculate the correction due to railhead roughness for rough wheeled vehicles.

To fully consider railhead roughness, it is preferable to determine the ATQ of all modelled tracks. However, this information was not available in R1 and required the development of an assumption relationship based upon a measured distribution of ATQ obtained from Deltarail. This distribution is shown in Plate 6.4.

Plate 6.4 Measured distribution of ATQ as reviewed in R1



Based upon the information presented in Plate 6.4, a ATQ value of 4 dB was applied for all rail lines in Northern Ireland during R1 and R2.

As part of the data review questionnaire, Translink confirmed that ATQ has not been captured prior to the R3 mapping exercise and that assumptions used during R2 should be applied to R3. Although the project team are aware of companies who can directly measure ATQ, capture of this data would be extremely costly to undertake and was therefore ruled out as a possibility in the R3 mapping exercise. The ATQ value of 4 dB during R1 and R2 was therefore applied for R3 within the L_ATQ attribute field.

6.9 Source segmentation

To calculate railway noise emissions, it was necessary to segment the railway noise centrelines to reflect changes in the input parameters that lead to changes to in railway emission levels. Much of this segmentation was already present within R2FMDIs however, in some locations, additional segmentation has been required. Plate 6.5 presents the concept of source segmentation with respect to the various input parameters required for the calculation of emissions. The project team have undertaken this segmentation within the ArcGIS environment.

Plate 6.5 Railway emission source segmentation

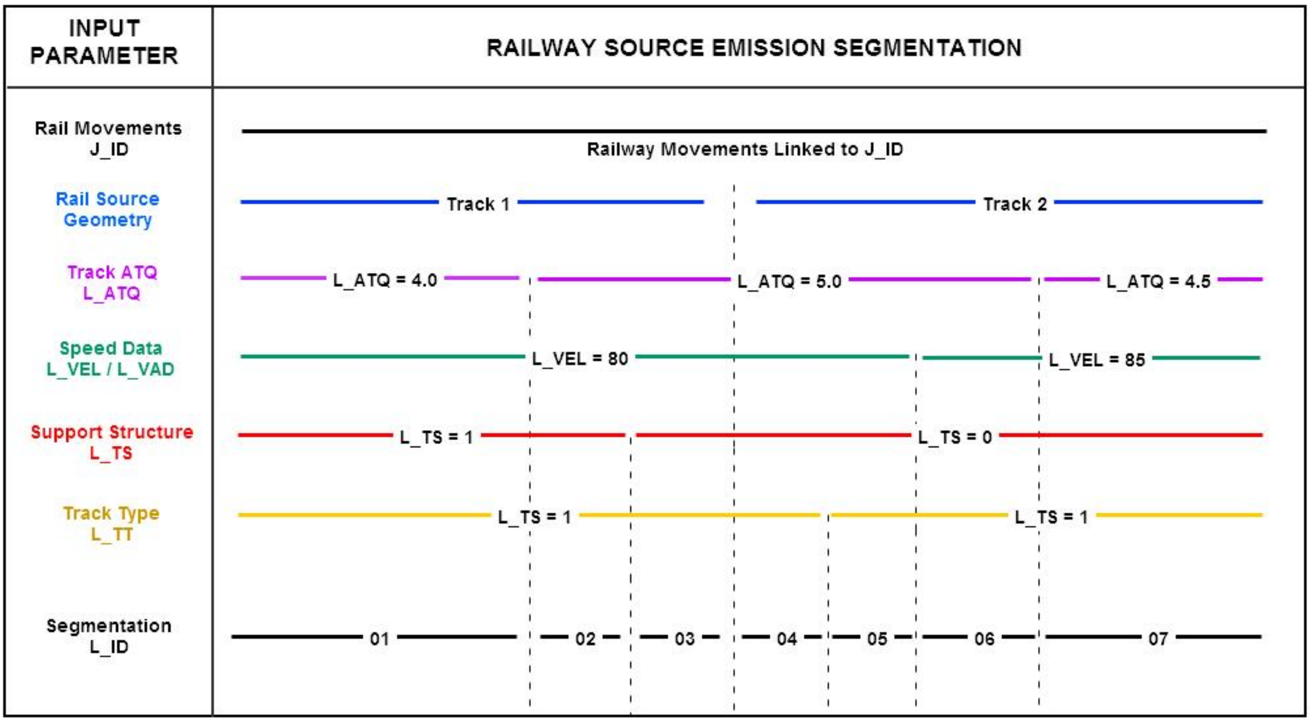


Plate 6.5 shows that the resultant emission source segmented according to the changes in the emission input data is referenced against a unique ID stored within the L_ID attribute. The resulting segmented railway noise emission line can then be used to calculate railway noise emissions.

6.10 Calculation of railway noise emissions

As stated previously, the calculation of railway noise emissions has been undertaken using a geo-processing and database script developed in the Python programming environment. This script is designed to read in the segmented source emission geometry and source emission attributes, perform the calculation of railway noise emission in accordance with adapted CRN and populate the emission attributes on the rail emission geometry. As part of the process the script reads data from the lookup tables outlined in this section to ensure that each rail vehicles, track type and support structure is handled correctly within the calculation. Plate 6.6 presents an overview of the process of calculating the railway noise emissions using the script.

As part of the scripting process, information regarding the total number of train passages is also reported against routes to allow the extent of major rail to be confirmed and determined. The script also checks for inputs which do not match values in any of the look-up tables. Any blank or missing values are also reported so that any potential errors are identified before the calculation commences. Plate 6.7 presents an illustration of the populated emission objects and the Python scripting.

Upon completion of the calculation of emission, the BRT source emission dataset was reviewed before being signed off as complete.

Plate 6.6 Process diagram for the calculation of railway noise emissions

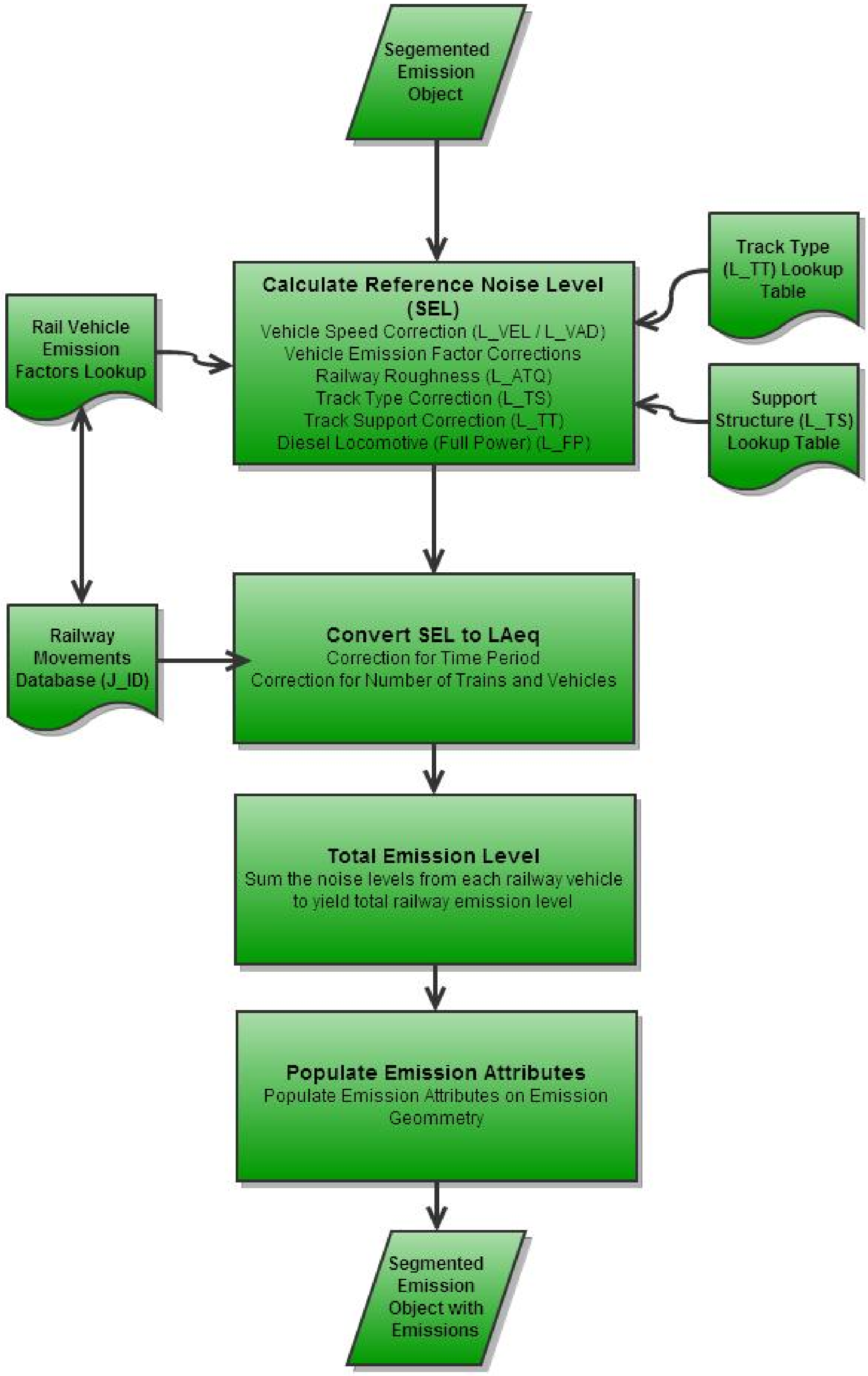
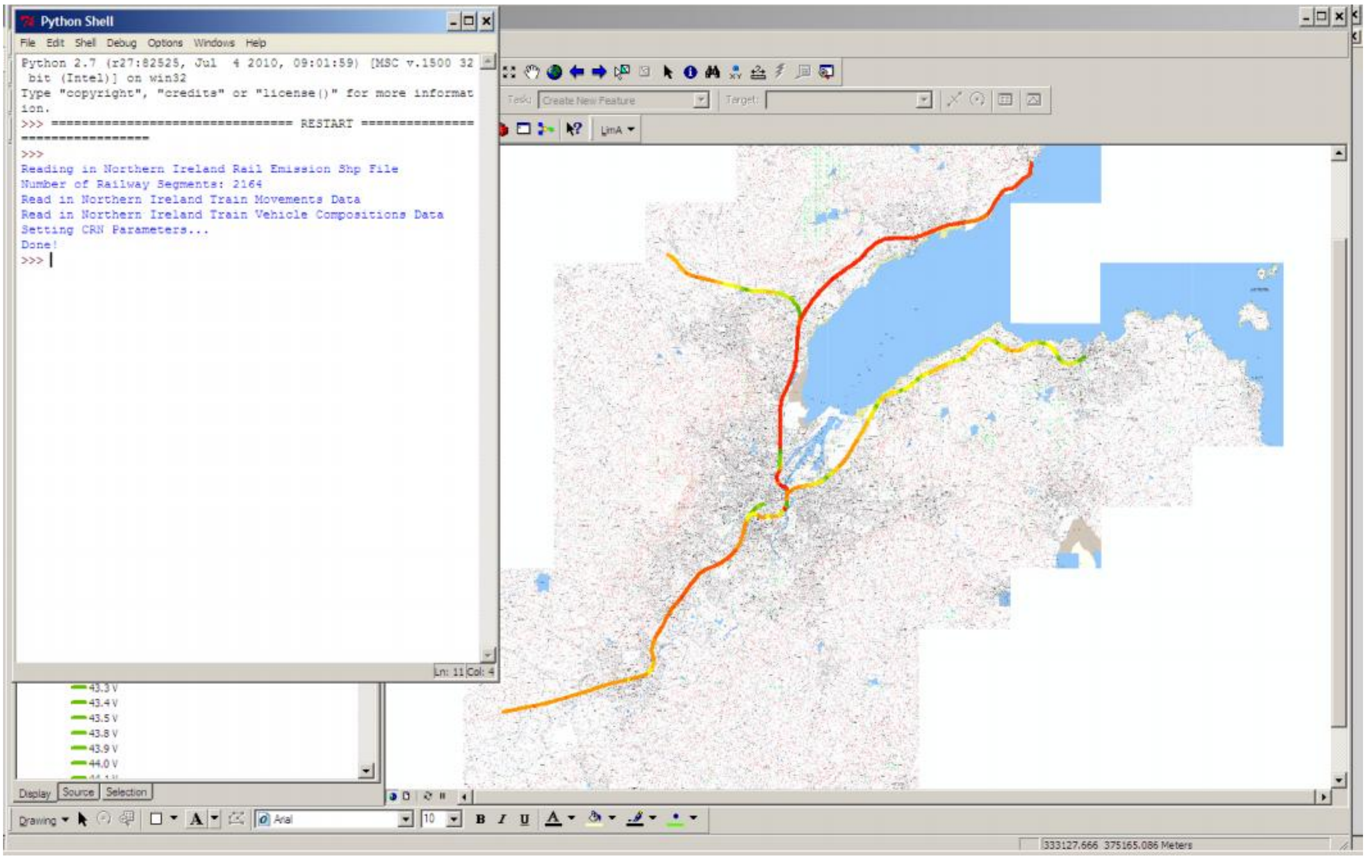


Plate 6.7 View of the emission calculation in ArcGIS and populated rail emission objects



7. Quality assurance

7.1 Introduction

This section details the Quality Assurance procedures implemented to enable the effective modelling of railway noise sources. As discussed in this report, the railway source dataset was developed in the GIS environment in accordance with the required LimA object dataset schema. This approach was taken to reduce the processing required within the LimA software environment, and seeks to ensure that datasets are in compliance with the LimA software.

The Quality Assurance of the Round Three datasets marked the transition from the GIS environment to the LimA software environment and also marked the beginning of Stage 2 of the project. The QA procedures aimed to identify whether the various GIS datasets (including the railway source dataset and the 3D modelling environment) had been developed to specification. It also aimed to ensure that calculations would run without error and that any issues encountered with the 3D modelling layers were identified before calculation and corrected as required.

The QA procedures adopted by the project team broadly reflect those implemented for Round Three with all QA procedures undertaken with the assistance of electronic proformas. These proformas ensure that all steps within each stage of the QA procedures are adhered to in sequence and are correctly implemented. The proformas also allow version control, file paths and corrective actions to be formally issued between the noise calculation and GIS teams. Plate 7.1 presents an example proforma.

Plate 7.1 Example QA proforma

Stage 3A QA - Integrity Checks in LimA Modelling Env.

Project Title	Northern Ireland Third Round Noise Mapping
Project Number	38600
Project Sub-Area	_AreaA
LimA Server Project Path	\\emanlima1\LimAjobs\38600\DATA

Note: Scroll over the QA Check to review checking requirements. Perform Checks from Left to Right

Shapefile Data Inputs								
Data Layer	File	CHECK 1 OK?	CHECK 2 OK?	CHECK 4 OK?	CHECK 7 OK?	Renumber ELEs	SAVE	Pass / Fail?
~~HIN_HA1~~	~~No Data Layer for Project Sub-Area~~		n/a		n/a			
HIN_HA2	\\emanlima1\LimAjobs\38600\DATA_AreaA\MODEL\HIN_HA2_AreaA_HIN_HA2	Yes	Yes	Yes	n/a	Yes	Yes	Pass
HIN_HA4	\\emanlima1\LimAjobs\38600\DATA_AreaA\MODEL\HIN_HA4_AreaA_HIN_HA4	Yes	n/a	Yes	n/a	Yes	Yes	Pass
HIN_HA7	\\emanlima1\LimAjobs\38600\DATA_AreaA\MODEL\HIN_HA7_AreaA_HIN_HA7	Yes	Yes	Yes	Yes	Yes	Yes	Pass
GEL	\\emanlima1\LimAjobs\38600\DATA_AreaA\MODEL\GEL_AreaA_GEL_02.BNA	Yes	n/a	Yes	n/a	Yes	Yes	Pass
~~BRL~~	~~No Data Layer for Project Sub-Area~~		n/a		n/a			
~~RDL~~	~~No Data Layer for Project Sub-Area~~		n/a		n/a			
~~IND~~	~~No Data Layer for Project Sub-Area~~				n/a			

Corrective Actions		Description
Data Layer	File Path	
~~HIN_HA1~~	~~No Data Layer for Project Sub-Area~~	
HIN_HA2	\\emanlima1\LimAjobs\38600\DATA_AreaA\SOURCE\HIN_HA2_AreaA_HIN_HA	No edits required - saved as rev2
HIN_HA4	\\emanlima1\LimAjobs\38600\DATA_AreaA\SOURCE\HIN_HA4_AreaA_HIN_HA	No edits required - saved as rev2
HIN_HA7	\\emanlima1\LimAjobs\38600\DATA_AreaA\SOURCE\HIN_HA7_AreaA_HIN_HA	Incorrect bridge geometry on ID 32, 37 - corrected in rev2
GEL	\\emanlima1\LimAjobs\38600\DATA_AreaA\SOURCE\GEL_AreaA_GEL_02.SHI	No errors - all checks completed

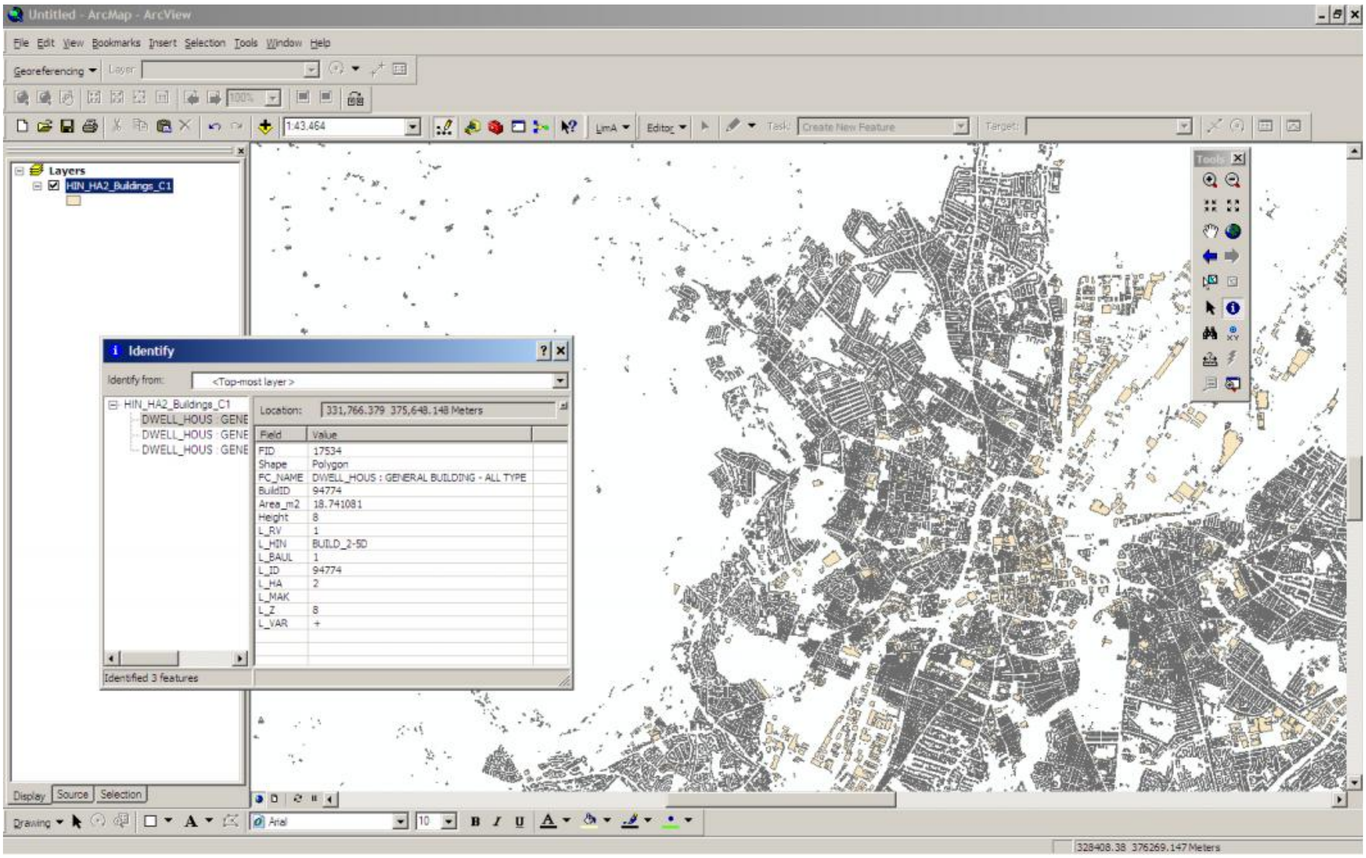
The QA procedure comprised a four-stage process. The first three stages of the QA procedure were implemented on a layer by layer basis. The final stage of the QA procedure required the interaction of all 3D modelling layers ensuring that the noise model was correctly compiled.

7.2 Stage 1 of the QA process

Stage 1 of the QA procedure was a check of the datasets in the GIS environment by a member of the noise calculation team prior to import into the LimA environment, see Plate 7.2. The purpose of this stage was to ensure that the data had been correctly prepared in terms of spatial extent, object type and attribution and was generally suitable to be imported into the LimA environment.

These checks were applied to both the updated R3 road source layer and the revised Round Three ground model data layers.

Plate 7.2 GIS dataset checking in ArcGIS prior to import into LimA

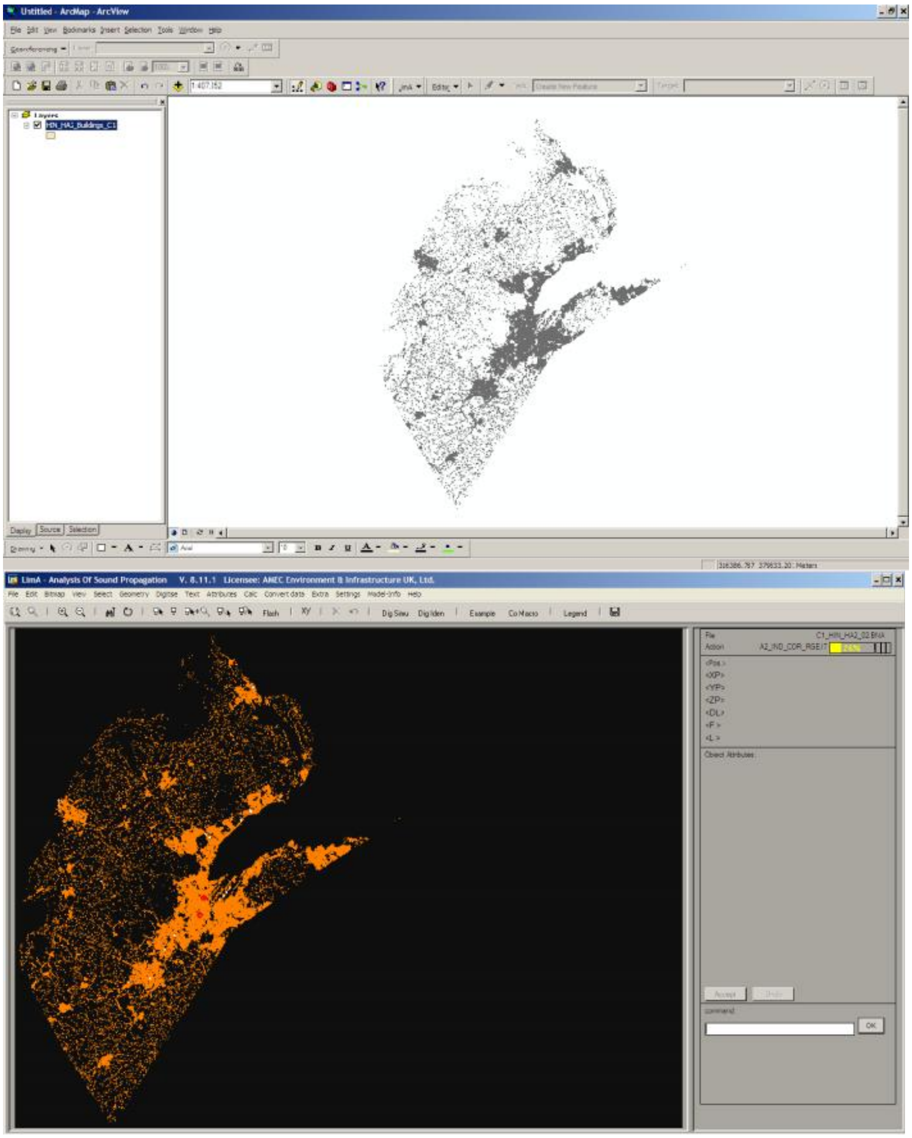


7.3 Stage 2 of the QA process

Stage 2 of the QA procedure imported of the GIS model layers into the LimA environment. All data was exported from the GIS environment in Shapefile format and imported into the LimA environment to the software's proprietary BNA file format. The import process was a one-to-one conversion and is illustrated in Plate 7.3. This means that all objects in GIS must be stored as single features and should have unique identification numbers. As part of the importation, LimA warned of any objects which did not meet this requirement or had significant non-compliant topographies.

The QA process in Stage 2 required the documentation of any errors during importation and feedback to the GIS project team when any errors were encountered, along with corrective actions.

Plate 7.3 Data in ArcGIS and LimA environments



7.4 Stage 3A of the QA process

Stage 3A incorporated the testing of the imported datasets within the LimA modeling environment. The LimA modeling environment has several built-in check procedures which look for topographic and attribution issues and/or errors. Each type of 3D modeling layer underwent a different series of checks. For example, bridge objects had a check designed specifically for their object type.

Once imported the QA procedure required each LimA modeling object (e.g. bridge, building etc.) to undergo a series of checks. These checks included:

- Object integrity checks (i.e. does the object meet its topographic definitions);
- Attribution checks (i.e. are the attributes populated appropriately);
- Object definitions checks; and
- Duplicable object checks.

Where errors were identified by the check procedures, LimA marked the objects for correction. Depending upon the number of corrections required the QA procedures allowed these to be undertaken within LimA or alternatively passed back to the GIS team for corrective action. Any amendments were documented within the proformas.

7.5 Stage 3B of the QA process

Stage 3B of the QA procedure reflected those undertaken in Stage 3A except these checks were undertaken within the LimA calculation environment. Each layer was subjected to LimA's 'Model Check' procedure. When performed on a layer-by-layer basis, this check highlights any object attribution or topographic errors that were not highlighted within the LimA modelling environment. These included:

- Incorrect object attribution (i.e. are the attributes populated appropriately);
- Duplicable object checks; and
- Incorrect or incompatible topographies (e.g. polylines with incomparable vertex spacing).

The checks undertaken as part of LimA's 'Model Check' function were more rigorous that than those undertaken in Stage 3A within the LimA modeling environment. These checks ensured that each model layer was error free prior to Stage 4.

7.6 Stage 4 of the QA process

Stage 4 was the most involved stage of the QA process. Stage 4 was a QA of the interaction of all the various datasets comprising the noise model. The Stage 4 QA process was broken into several small stages as outlined in Table 7.1.

Table 7.1 Tests undertaken in Stage 4 of the QA process

Test	Model Layers	Description
T1	HIN HA 4, GEL, HIN HA 7	Bridges interact correctly with the DTM
T2	HIN HA 4, GEL, HIN HA 2	Buildings interact correctly with the DTM
T3	HIN HA 4, GEL, HIN HA 1	Barriers interact correctly with the DTM
T4	HIN HA 4, GEL, HIN HA 2, HIN HA 7, HIN HA 1, TOP	Bridge, Barrier and Building interact correctly with the DTM and Ground Cover
T5	As T4 and Noise Source Dataset	Check Complete Ground Model interaction with Noise Sources

Each test culminated in a complete QA of the ground model within the LimA calculation environment using the 'Model Check' feature.

In Test T1, the noise calculation team reviewed the digitisation of each bridge and their 3D positioning. Each bridge was reviewed in 3D and corrected if necessary. Bridges which were incorrectly digitised were automatically flagged by the LimA calculation core however incorrect position was not. A manual check was therefore the only means of ensuring that bridges were correctly modelled.

In Test T2, the 'Model Check' functions evaluated the height of flat topped buildings, based on the relative height of the building and the height of the terrain at the start point of the building object. The key output of the check was the identification of buildings which had relative heights which fell below the surrounding terrain. This was possible in locations where buildings were located on sloping terrain.

Where this occurred, it was necessary to reposition the start point of the building object to another location which ensured that the top of the building object was above the terrain at all locations. For Round One, these errors had to be correctly manually. For Round Two and Three, an automated solution was used to correct the start position of the building objects where the building falls below the terrain.

For Test T3, each barrier was reviewed in 3D to ensure that it is correctly aligned with respect to the DTM. Where alignments appeared incorrect, these were corrected within the software. Where barriers were positioned on bridges, these were also reviewed to ensure that they sat correctly on the bridge structure and the adjoining terrain. Each barrier was reviewed in 3D and corrected as appropriate.

For Test T4, all ground model layers were interacted together. The output from the LimA 'Model Check' function was reviewed to ensure that the interaction of objects did not result in any additional errors. Areas were selected from the model and 3D views generated which were reviewed manually. These areas were selected in the location of bridges and barriers.

7.7 LimA version QA

The round Two strategic noise mapping of railways was undertaken using LimA version 8.11. In preparation for the Round Three strategic noise mapping test calculations were run using a part of the Round Two model in Belfast with v8.11 and the current LimA v11.2.

The test model held a 7 x 7 km section of Belfast, near to the port and BCA, as shown in Plate 7.4. The calculation area was the central 3 x 3 km area shown. The same R2 model data was loaded and run in LimA v8.11 and LimA v11.2, using the same calculation settings, on the same computer hardware.

Following the completion of the calculations, the v8.11 grid results were subtracted from the v11.2 results and the difference results analysed.

For the railway calculation according to CRN, across the 75,021 grid points considered, the mean level difference was 0.03 dB, and range calculated in accordance with ISO 17534 & DIN 45687 had a 0.1 quantile of -0.00 dB and 0.9 Quantile of 0.0 dB. The distribution of level difference is shown in Plate 7.5.

The results of this testing indicate that the use of the current version of LimA v11.2 for the Round Three strategic noise mapping will not introduce any significant variance into the R3 results compared to the R2 results.

Plate 7.4 7 x 7 km area used for LimA testing

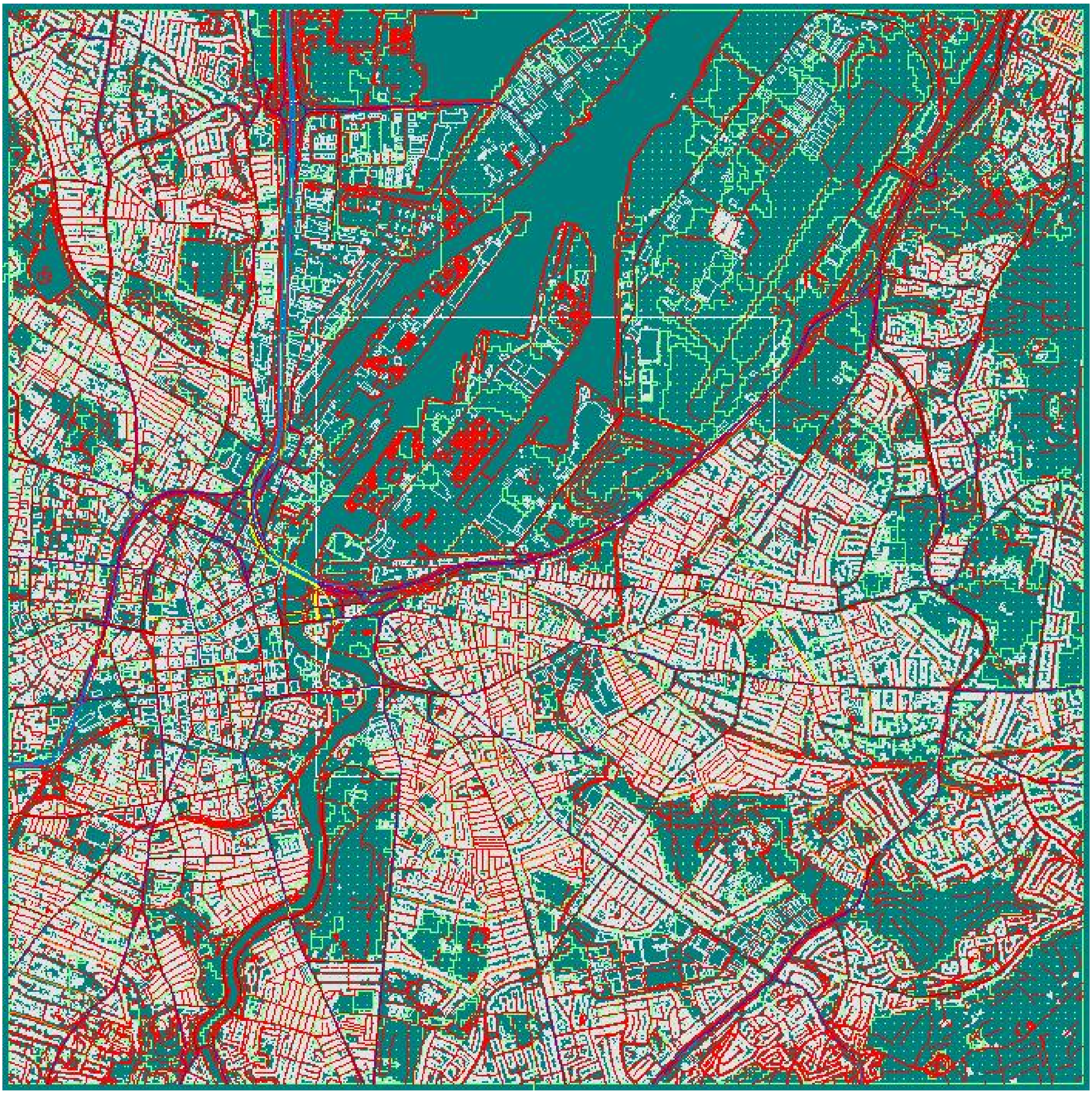
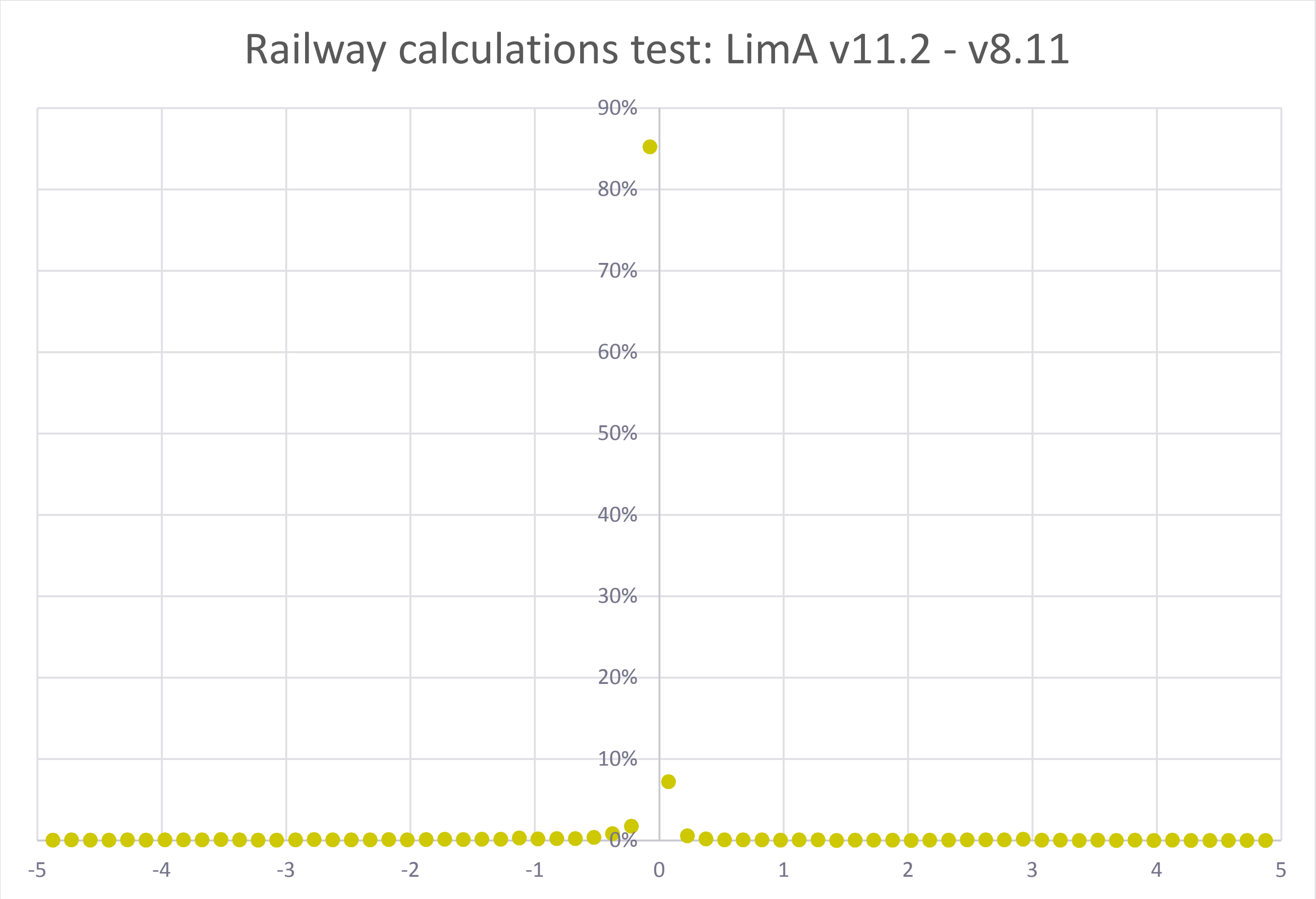


Plate 7.5 Distribution of level difference



8. Noise level calculations

Section 8 details the approach to the noise level calculations for the assessment of railway noise in Northern Ireland. The noise calculations are a culmination of the railway source emission datasets and the 3D modelling datasets which facilitate the propagation of noise from the point of emission into the environment and to the receptors.

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 for the calculations. Some calculation settings simply determine how many calculations should be undertaken and to what resolution these should occur. Other calculation settings require the user to determine how certain elements of a calculation method are handled whilst other calculation settings are used to derive efficiencies in the overall calculation process. All these settings combine to determine the computational load of the calculations and the compliance of the calculations with the various assessment methodologies.

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 the calculated noise levels to remain compliant with the assessment method without introducing excessive uncertainties.

8.1 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 railway noise during Round One and Round Two. This testing studied the effect of the settings upon noise levels above 55 dB L_{den} and 45 dB L_{night} thresholds i.e. those 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 noise level results.

The project team have reviewed these settings against the settings currently available within the LimA calculation environment. This review has confirmed that there are no new settings or modifications to the settings testing during R1 and R2. Project policy has therefore been to retain the efficiency settings adopted in Round One and Round Two for Round Three.

There are several advantages to retaining the same efficiency settings for Round Three, namely consistency within the calculations. Efficiency settings can introduce uncertainties therefore changes in these settings between Round Two and Round Three may mask any actual changes in noise levels between Round Two and Round Three. As such, in order to identify any real change in noise levels between Round Two and Round Three, two sets of calculations would be required using Round Two efficiency settings and any new settings adopted for Round Three. It is the view of the project team that the settings adopted for Round Two should be retained until the introduction of the new Common Method set out in EU Directive 996/2015 during Round Four in 2022. The new common assessment method is likely to require a review of all calculation efficiency and compliance settings.

8.2 Calculation settings

Table 8.1 presents an overview of the calculation settings adopted for the calculation of railway noise in Northern Ireland. These settings were retained from the Round One and Round Two modelling exercises.

Table 8.1 Railway Calculation Settings

Setting	Setting Type	Description	Setting in Round Three
Grid Resolution	Calculation Grid Definition	Defined by the Regulations and Directive as 10m. This setting defined the distance between grid points in the calculation grid.	10m
Calculation Height	Calculation Grid Definition	This setting defines the calculation height of each point within the calculation grid. The Regulations and Directive define calculation height at 4m relative to the ground.	4m
Reflection Order	Compliance	Reflection order is the number of reflections considered in any given source to receiver propagation.	1
Reflection Distance	Compliance	Reflection distance is the distance at which reflections from reflective objects are considered to effect noise levels at receivers. There is no guidance in CRN as to what distances reflections should be considered. For Round One, a value of 50m was adopted as this is the upper rounded value of reflections considered in the example calculations within the appendices of CRN.	50m
Dynamic Error Margin	Efficiency	Dynamic error margin is the maximum uncertainty allowed within any calculation. The setting functions by estimating the influence of a noise source at a receiver through performing a simple noise distance attenuation. Where the influence is considered not to materially affect noise levels at the receiver, the source is discounted. Where the source is considered to affect noise levels, a full propagation calculation is undertaken for the source.	On – 3 dB
Simplify Propagation Analysis	Efficiency	When turned off, each propagation path assessed by LimA is considered in full with all obstacles (i.e. buildings and barriers) assessed in terms of their screening potential. When turned on, obstacles that are located a reasonable distance from the source and receiver are discounted as these are least likely to have any screening potential.	On
Eliminate Inner Walls	Efficiency	When activated, this setting instructs the LimA calculation core to ignore the effect of any walls of buildings that are identical i.e. the walls between buildings in a terrace.	Off
Source Search Radius	Efficiency & Compliance	This setting limits the distance from a receiver point at which noise sources are considered for calculation.	1500m

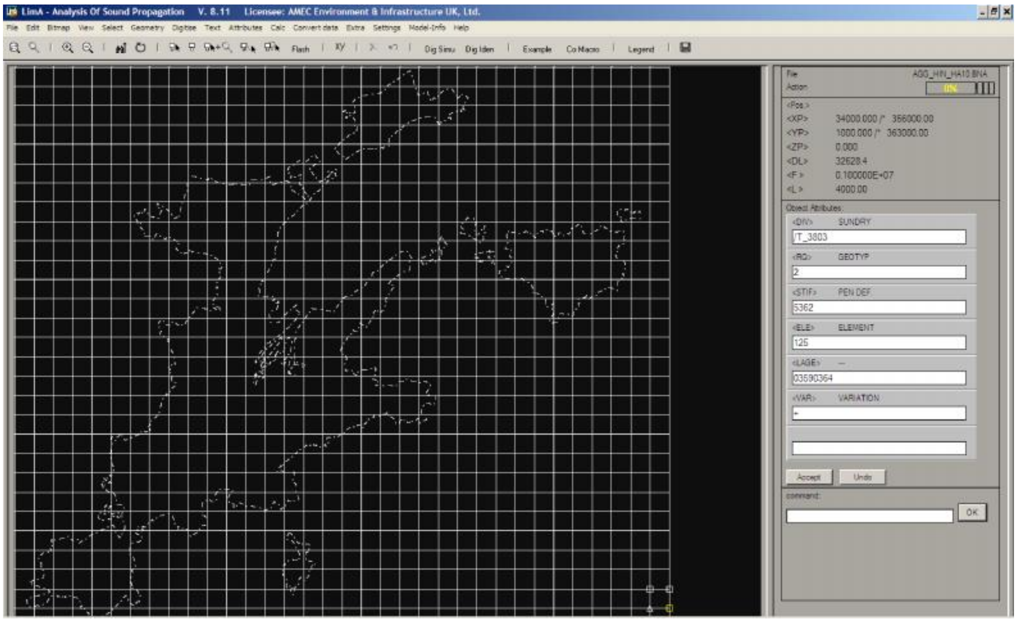
8.3 Distributed calculation

In addition to efficiency settings, calculations can be made quicker through distributing calculations across hardware and computer processors. Additional savings in calculation time can also be found through the optimisation of the hardware environment.

Calculation tiling

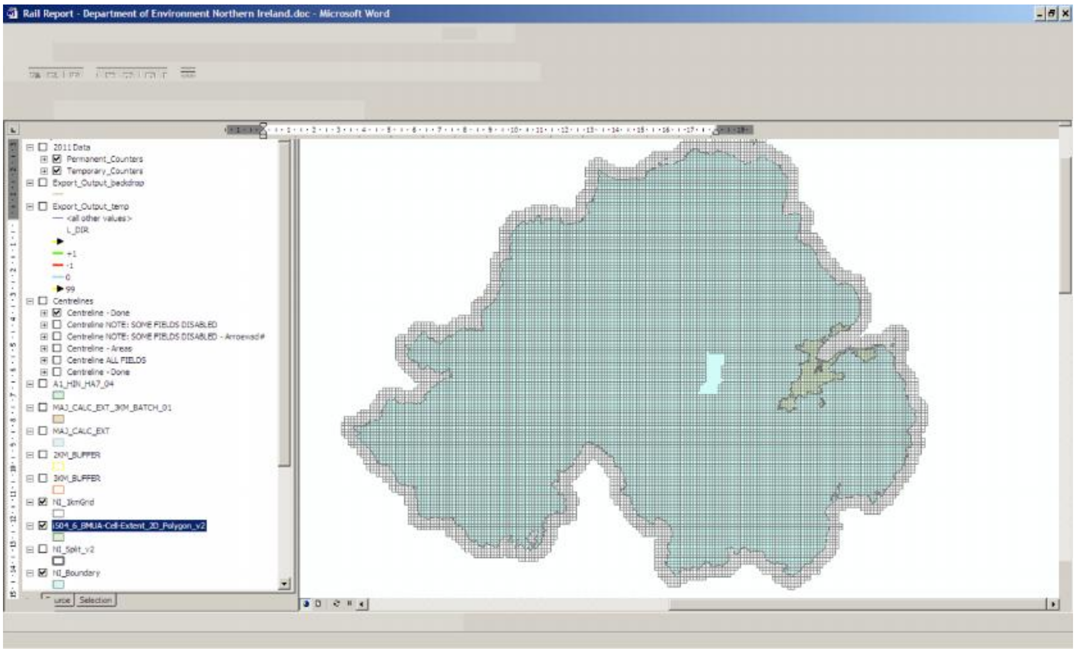
The primary method of distributing calculations within the LimA software environment is through the use of its 'Tiling' functionality. This is illustrated in Plate 8.1. The tiling function allows a large model and calculation area to be segmented into a series of smaller areas which can be calculated on a number of processors and across several computers at once. Plate 8.1 shows an example of calculation tiling for calculation within Belfast agglomeration. The plate shows that calculation area is broken up into a grid of calculation tiles which can be distributed for calculation. The size of these tiles can be specified within the tiling function however it has been previously demonstrated that 1km by 1km calculation tiles result in quicker calculation times than larger tiles due to the amount of modelling information read and processed by the calculation core.

Plate 8.1 Example of Tiling Function within the Belfast Agglomeration



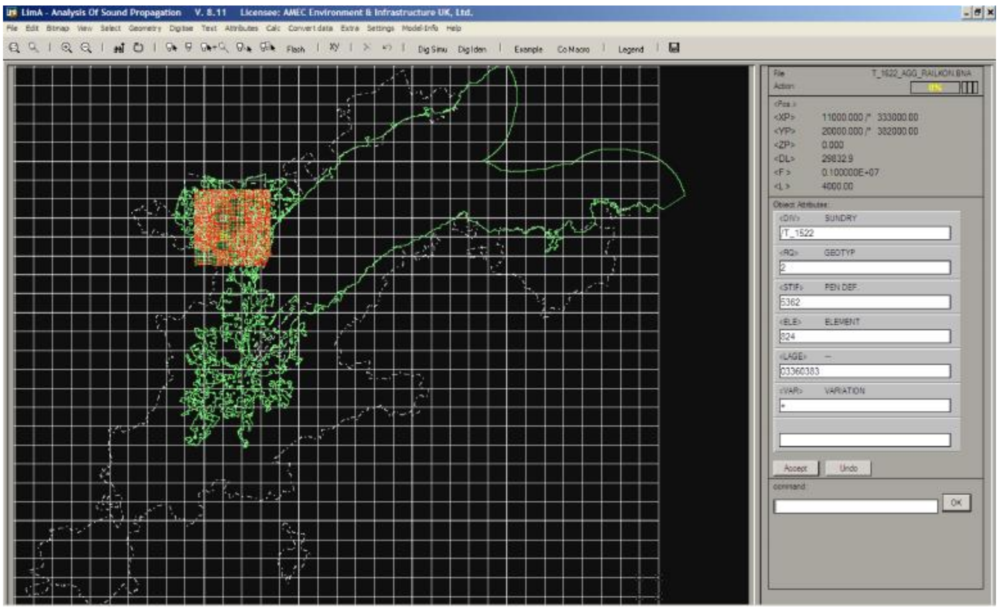
The use of tiling has not been limited to the calculations. Many aspects of the project have been undertaken with respect to the grid lines that are formed through the tiling function. For example, queries raised during the modelling of the major road network have been flagged by calculation tile to allow calculations in other locations to be undertaken away from areas which are still waiting to be resolved. To this extent, the project team have developed a tiling grid which covers Northern Ireland to facilitate the management of the modelling and calculations. This grid is shown below in Plate 8.2.

Plate 8.2 National tiling grid



Prior to calculation, LimA creates a series of calculation instruction files and results folders for each calculation tile. The instruction files tell the LimA calculation core to read in only the model data that is relevant to calculations within the tile. This is defined at the calculation extents plus the distance defined by the source search distance calculation setting. This approach ensures that only the modelling data required to calculate noise levels within the calculation tile is read into the LimA calculation core. An example of this is presented in Plate 8.3. The instruction files also instruct the calculation core to only calculate noise levels within the tile.

Plate 8.3 LimA tiling example



The key advantage of the LimA tiling function is:

- **Reduced calculation times** through the distribution of calculations and through efficient use of model data during calculations; and
- **Redundancy** – tiling calculations can be restarted and models revised on a tile by tile basis allowing calculations to revised or started in the event of model errors or hardware failure.

Calculation servers

LimA manages calculations using its LimAserver management software. The management software allows the automation of calculations. Hardware is allocated a LimA calculation core per processor. When a tiling calculation is started, calculation run files are copied to a 'Global Spool' folder. The LimAserver management software reads the Global Spool folder for run files and then reviews whether any LimA calculation cores are available. When a calculation core is available, the LimAserver software copies the run file to the available core and starts the calculation accordingly. The LimAserver software can manage processors on a single hardware device or on many devices that are distributed across a network.

The LimA server management software ensures that calculations are continuous. The server system is also designed to identify and report if any calculation tiles have fatal errors.

Hardware

AMEC has two dedicated noise calculation servers comprising a total of 44 available calculation cores. These machines are optimised for calculations using the LimA calculation core and were acquired with processors with high floating point performances. Optimisations of these servers have been undertaken in terms of physical memory allocation to ensure that calculations can occur almost entirely within the Random Access Memory (RAM).

8.4 Post processing and output grids

The LimA tiling function and calculation cores produce results grids for each calculation tile as well as the indicators defined during calculation, namely the day, evening and night time periods. In order to simplify the assessment of population exposure, it is necessary to join together each of the tiled results grids into a single grid representative of the area under assessment. In addition, the calculation core is currently restricted to the computation of certain noise indicators. As such, the process of post processing the output grids must also be configured to enable the calculation of additional noise indicators, namely the $L_{Aeq,\ 16hr}$ and the L_{den}. In order to produce the final grid results for all the required noise indicators, a two-stage process was undertaken, the first in LimA and the second in GIS.

Calculation output files

The first stage of the post processing script is to check each of the output files produced by each calculation tile. The purpose of this stage is to ensure that each tile within the calculation area has been calculated and that there are no error messages, failed calculations or warnings. Although errors and warnings are covered by the QA process, errors and warnings can result from the clipping process which is undertaken by the LimA calculation core during tiling.

In the event of any errors, warnings or incomplete calculations, the post processing script halts and produces a message to enable further investigation.

Combining the tile results, interpolating within buildings and export to GIS

The next stage of the post processing routine is undertaken using LimA_9.exe which enables a single step procedure to achieve three parts of the process, namely:

- Combining the individual tile results files into a single results dataset;
- Interpolating results within buildings; and
- Exporting the grid results to GIS files.

In order to combine the tile results a list of the tile results files is generated and read by LimA_9.exe, which then load all the files into memory as one large results dataset.

To enable population exposure, a seamless results grid is required. During calculation, LimA reports default values where noise level grid points are located within buildings. The LimA_9 module has a function to interpolate noise levels within buildings using noise levels immediate to their extents. This process through the results data held in memory.

The interpolated noise level results grids are then exported as ESRI ASCII Grid (ASC) format files as listed in Table 8.2.

Table 8.2 Noise indicators required under contract

Indicator	Type	Description	Incumbent Within	Produced During
LPED	Agglomeration	Annual Average 12-hour daytime noise level (0700-1900hrs)	Regulations	Calculation
LPEE	Agglomeration	Annual Average 4-hour evening noise level (1900-2300hrs)	Regulations	Calculation
LPEN	Agglomeration	Annual Average 8-hour night-time noise level (2300-0700hrs)	Regulations, END and NI Planning Policy Guidance	Calculation
L18H	Agglomeration	Annual Average 18-hour daytime noise level (0600-0000hrs)	Regulations	Calculation
L6HN	Agglomeration	Annual Average 6-hour night-time noise level (0600-0000hrs)	Regulations	Calculation
M_LPED	Major Rail	Annual Average 12-hour daytime noise level (0700-1900hrs)	Regulations	Calculation
M_LPEE	Major Rail	Annual Average 4-hour evening noise level (1900-2300hrs)	Regulations	Calculation
M_LPEN	Major Rail	Annual Average 8-hour night-time noise level (2300-0700hrs)	Regulations, END and NI Planning Policy Guidance	Calculation
M_L18H	Major Rail	Annual Average 18-hour daytime noise level (0600-0000hrs)	Regulations	Calculation
M_L6HN	Major Rail	Annual Average 6-hour night-time noise level (0600-0000hrs)	Regulations	Calculation

Calculation of additional noise indicators

As discussed, the LimA calculation does not currently calculate all of the noise indicators required under this contract during the primary calculation run. Following the export of the L_{day}, $L_{evening}$ and L_{night} results to GIS files, the additional noise indicators have been calculated in GIS under the second stage of post processing as detailed in Table 8.3.

Table 8.3 Additional noise indicators required under contract

Indicator	Type	Description	Incumbent Within	Produced During
LDEN	Agglomeration	Annual Average Day-Evening-Night Noise Rating Level (24-hour)	Regulations and END	Post-processing
L16H	Agglomeration	Annual Average 16-hour daytime noise level (0700-2300hrs)	Regulations and NI Planning Policy Guidance	Post-processing
M_LDEN	Major Rail	Annual Average Day-Evening-Night Noise Rating Level (24-hour)	Regulations and END	Post-processing
M_L16H	Major Rail	Annual Average 16-hour daytime noise level (0700-2300hrs)	Regulations and NI Planning Policy Guidance	Post-processing

The LDEN and L16H indicators were generated as part of the GIS post-processing routine. The formula used for L_{den} was:

$$L_{den} = 10\log\left[\left(\frac{1}{24}\right)\times\left(12\times 10^{\frac{L_{day}}{10}} + 4\times 10^{\frac{L_{eve}+5}{10}} + 8\times 10^{\frac{L_{night}+10}{10}}\right)\right]$$

The formula used for L16HR ($L_{Aeq,\,16hr}$) was:

$$L_{Aeq,16hr} = 10\log\left[\left(\frac{12}{16}\times 10^{\frac{L_{day}}{10}}\right)+\left(\frac{4}{16}\times 10^{\frac{L_{eve}}{10}}\right)\right]$$

9. Area calculations

The first post processing step that was undertaken on the raw continuous output noise grids was a reclassification of the grids into bands. The reclassification bands used are outlined in Table 9.1.

Table 9.1 Noise bands used to reclassify output grids

Noise Level Result	Noise Bands					
$L_{Aeq,\ 16\ hour}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{Aeq,\ 18\ hour}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
L_{den}	< 50	50-54	55-59	60-64	65-69	70-74	>=75
L_{day}	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{evening}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
L_{night}	< 45	45-49	50-54	55-59	60-64	65-69	>=70
$L_{Aeq,\ 6\ hour}$	< 45	45-49	50-54	55-59	60-64	65-69	>=70

The geometric area of the noise bands for each of the bands was calculated with all individual and total area values summarised to the nearest 0.1km^2.

The results for railway noise sources are shown in Tables 9.2 and 9.3, with an examples of the railway map output (L_{den}) provided in Plates 9.1 and 9.2. The detailed noise maps are presented in Appendix D.

In viewing these values, it is important to note that there has been an 11km sq (5.5%) increase in the area of the defined agglomeration area. This global change must be considered fully when trying to make direct comparisons of area extents, dwelling numbers and population estimates produced for Round 2.

Table 9.2 Agglomeration Railways - area of noise bands in km²

Noise Level (dB)	LAeq, 16 hour	LAeq, 18 hour	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}	LAeq, 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 9.3 Major Railways - area of noise bands in km²

Noise Level (dB)	LAeq, 16 hour	LAeq, 18 hour	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}	LAeq, 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**

Plate 9.1 Round Three railways noise map example – Belfast Agglomeration L_{den}

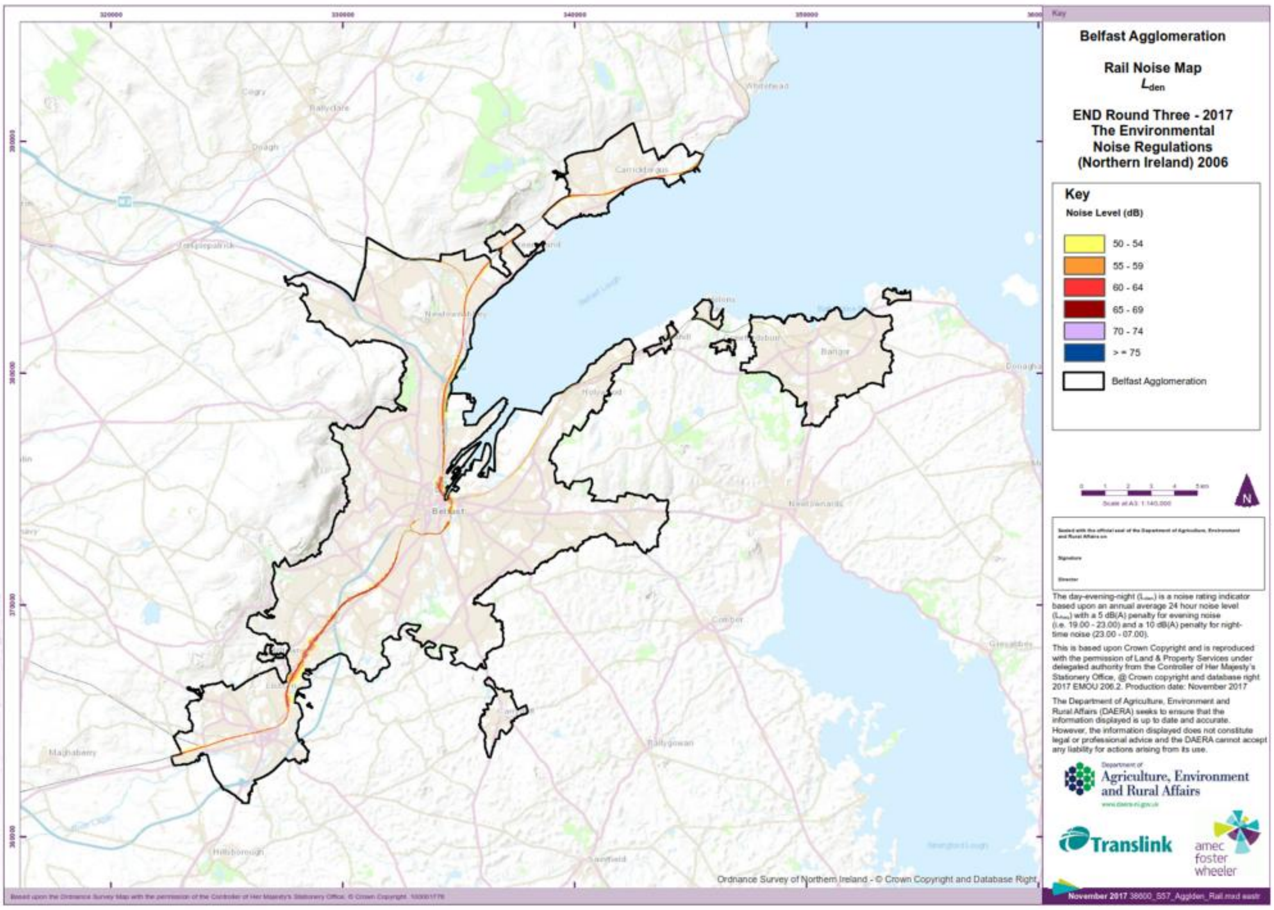
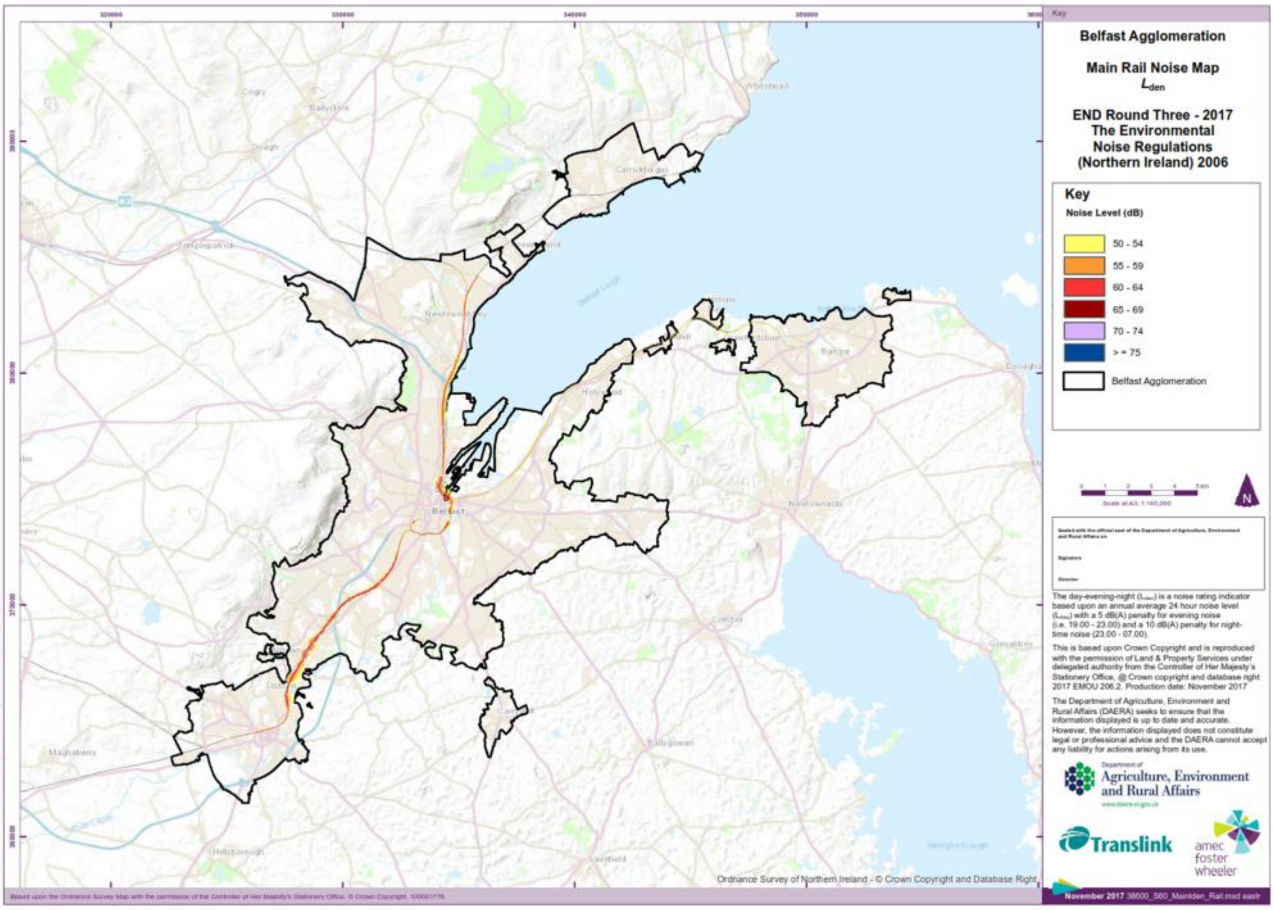


Plate 9.2 Round Three railways noise map example – Major Railway L_{den}



10. Population exposure and analysis

10.1 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[1]. 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[2]. 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[3]. 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[4]. 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 10.1. Please note that the number of records for A2

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

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

Table 10.1 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.

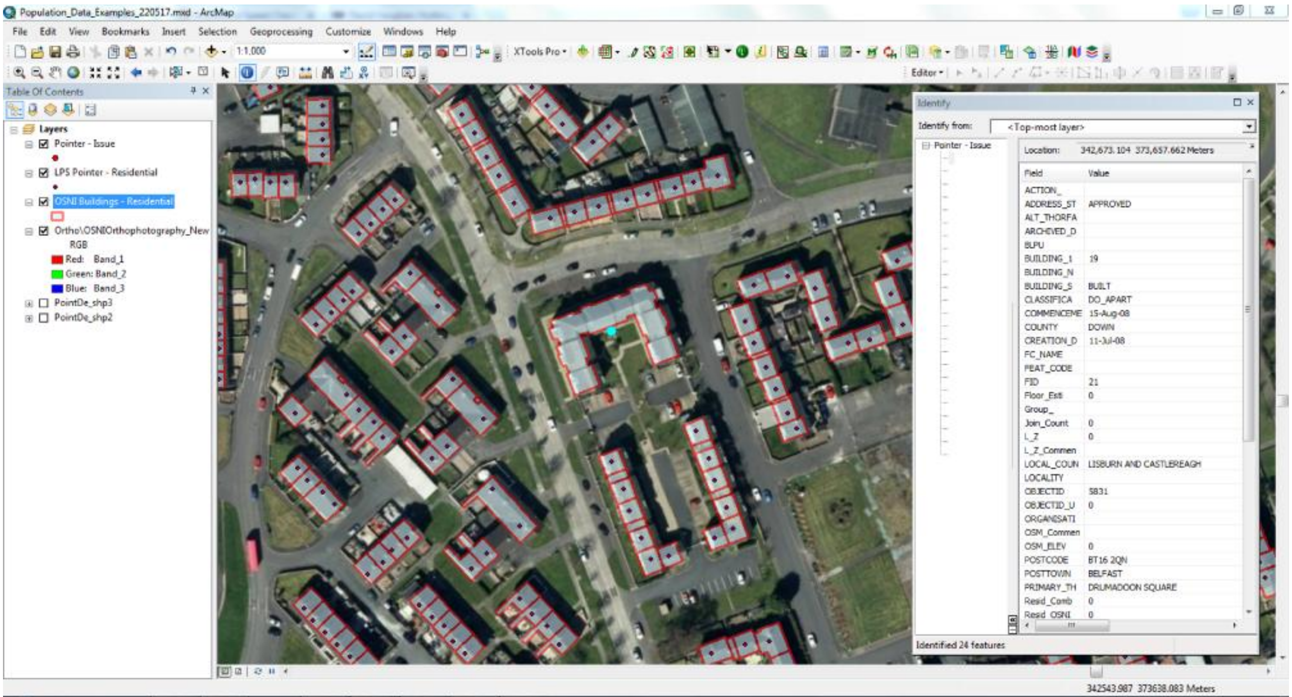
As per the assumptions used in the Round One and Round Two studies, Annex I (1) of the END indicates that noise exposure assessments should be at the most exposed façade. The most exposed façade is defined as the external wall facing onto and nearest to the specific noise source. For the purposes of 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 10.2.

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 10.1, 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 10.1 Spatial mismatch between the LSP Pointer and OSNI building data



10.2 Railways - population exposure analysis

An estimate of the number of dwellings and population exposed to railway traffic noise sources in the Belfast Agglomeration are provided below in Tables 10.2 and Table 10.3. Major rail results are presented in Table 10.4 and 10.5. These results have been produced using the methodology described in Section 10.1 above.

Table 10.2 Agglomeration Railways - Buildings

Noise Level (dB)	LAeq, 16 hour	LAeq, 18 hour	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}	LAeq, 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 10.3 Agglomeration Railways – Population

Noise Level (dB)	LAeq, 16 hour	LAeq, 18 hour	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}	LAeq, 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**

Table 10.4 Major Railways - Buildings

Noise Level (dB)	LAeq, 16 hour	LAeq, 18 hour	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}	LAeq, 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 10.5 Major Railways - Population

Noise Level (dB)	LAeq, 16 hour	LAeq, 18 hour	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}	LAeq, 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**

10.3 Railways - ENDRM reporting

There is a requirement to report exposure assessments to the EC in order to comply with END. The EEA ENDRM consists of six core Data Flows which cover the reporting requirements under the END. The results of the strategic noise mapping, including the population and the dwelling exposure statistics are reported via Data Flow 4_8.

The results from this round were entered into the relevant Data Flow 4_8 data tables that are available from the EEA (http://dd.eionet.europa.eu/datasets/2906). For the agglomeration railways report, the relevant table reference is DF4_8_Agg_Rl (Agglomeration - Railways). Additional spatial datasets have been projected into ETRS89 Lambert Azimuthal Equal Area 52N 10E grid in line with EEA guidance (www.eionet.europa.eu/gis/).

It is important to note that only certain elements (mandatory fields) in Data Flow 4_8 are required to be reported and these fields are detailed below in Tables 10.6 and 10.7.

Table 10.6 ENDRM mandatory fields for Table DF4_8_Agg_Rail

Required Reporting Element	Description
*ReportingEntityUniqueCode	
Lden5559	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
Lden6064	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
Lden6569	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 65-69 dB(A), 4 m above the ground and on the most exposed façade.
Lden7074	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 70-74 dB(A), 4 m above the ground and on the most exposed façade.
Lden75	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
Lden5559FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 55-59 dB(A), 4 m above the ground and on the most exposed façade
Lden6064FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 60-64 dB(A), 4 m above the ground and on the most exposed façade
Lden6569FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 65-59 dB(A), 4 m above the ground and on the most exposed façade
Lden7074FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 70-74 dB(A), 4 m above the ground and on the most exposed façade
Lden75FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
Lnight5054	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 50-54 dB(A), 4 m above the ground and on the most exposed façade.
Lnight5559	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
Lnight6064	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
Lnight6569	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 65-69 dB(A), 4 m above the ground and on the most exposed façade.
Lnight70	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight >70 dB(A), 4 m above the ground and on the most exposed façade

Required Reporting Element	Description
Lnight5054FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 50-54 dB(A), 4 m above the ground and on the most exposed façade.
Lnight5559FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 55-59 dB(A), 4 m above the ground and on the most exposed façade
Lnight6064FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 60-64 dB(A), 4 m above the ground and on the most exposed façade
Lnight6569FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 65-69 dB(A), 4 m above the ground and on the most exposed façade
Lnight70FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source >70 dB(A), 4 m above the ground and on the most exposed façade.
ComputationAndMeasurementMethodsReportDetails	The full name of the report, the author/publisher and date of production.

Table 10.7 ENDRM Mandatory Fields for Tables DF4_8_MRail

Required Reporting Element	Description
*ReportingEntityUniqueCode	A single character Unique code assigned by the Member State to each Reporting Entity.
Lden5559	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
Lden6064	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
Lden6569	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden between 65-69 dB(A), 4 m above the ground and on the most exposed façade.
Lden7074	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden between 70-74 dB(A), 4 m above the ground and on the most exposed façade.
Lden75	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
Lnight5054	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 50-54 dB(A), 4 m above the ground and on the most exposed façade
Lnight5559	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 55-59 dB(A), 4 m above the ground and on the most exposed façade
Lnight6064	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 60-64 dB(A), 4 m above the ground and on the most exposed façade
Lnight6569	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 65-69 dB(A), 4 m above the ground and on the most exposed façade
Lnight70	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
AreaExposedToLden55IncludingAgglomerations	The estimated total area (in km2) exposed to values of Lden higher than 55 dB. The area must include agglomerations.
AreaExposedToLden65IncludingAgglomerations	The estimated total area (in km2) exposed to values of Lden higher than 65 dB. The area must include agglomerations.
AreaExposedToLden75IncludingAgglomerations	The estimated total area (in km2) exposed to values of Lden higher than 75 dB. The area must include agglomerations.
Lden55IncludingAgglomerations	The estimated total number of people (rounded to the nearest hundred) exposed to values of Lden higher than 55 dB. The number of people must include agglomerations.
Lden65IncludingAgglomerations	The estimated total number of people (rounded to the nearest hundred) exposed to values of Lden higher than 65 dB. The number of people must include agglomerations.
Lden75IncludingAgglomerations	The estimated total number of people (rounded to the nearest hundred) exposed to values of Lden higher than 75 dB. The number of people must include agglomerations.
DwellingsExposedToLden55IncludingAgglomerations	The estimated total number of dwellings (rounded to the nearest hundred) exposed to values of Lden higher than 55 dB. The number of dwellings must include agglomerations.

DwellingsExposedToLden65IncludingAgglomerations	The estimated total number of dwellings (rounded to the nearest hundred) exposed to values of Lden higher than 65 dB. The number of dwellings must include agglomerations.
DwellingsExposedToLden75IncludingAgglomerations	The estimated total number of dwellings (rounded to the nearest hundred) exposed to values of Lden higher than 75 dB. The number of dwellings must include agglomerations.
ComputationAndMeasurementMethodsReportDetails	Computation and measurement methods report details

11. Discussion and Conclusions

The final section of this report provides an overview of the key features of the Round Three maps highlighting how the maps have changed from Round Two. This review provides an introduction to a consideration of the factors which have contributed to the structure of the Round Three railway maps and the outcomes of the dwelling and population analysis. These factors include the changes in the extent of the agglomeration, railway source datasets; geometry of the railway network; changes in the 3D propagation model; and improvements in population data used for Round Three.

11.1 Key observations

Analysis of the Round Three agglomeration and major railway maps has highlighted the following key observations. The general observations noted below apply to both agglomeration and major rail given there very similar geographical extents.

- In global terms, the geographical extent of areas mapped above 55dB has reduced significantly for the L_{day}, L_{eve}, L_{den} and $L_{Aeq,\ 16\ hour}$ indicators between Round Two and Three. This changes is evident across the network but particularly noticeable across the Belfast – Carrickfergus line. This reflects both changes in train stock (i.e. removal of 450 classes and replacement with the quieter 4000 class trains) across the network and changes in movement profiles;
- The total geographical extent of areas mapped above 50dB has remained largely unchanged for the L_{night} indicators between Round Two and Round Three. These are some differences in total areas assigned to individual 5dB upper bands but these changes are relatively small;
- There have been a similar level of reduction in the estimated number of dwellings above 55dB for each of day related noise indicators and a small increase in the number of dwellings identified in the 45-49 and 50-54 noise bands for L_{night};
- The amount of population estimated to be living in areas exceeding 55dB for rail noise remains relatively low when compared to other noise sources (road and aircraft). This reflects the relative small geographical footprint of the noise contours for agglomeration and major railways;
- For most of the indicators ($L_{Aeq,\ 16\ hour}$, L_{den}, L_{day} and L_{eve}), the level of population living in areas exceeding 60dB remains relatively low (<2000) with both small and negative changes when compared to Round 2 estimates. These changes reflect both changes in the noise maps and also the enhanced method for the allocation of population to individual building objects in Round 3; and
- The relatively small geographical areas of the railway noise contours means that the results are sensitive to changes in the extent of noise bands; the final spatial distribution of residential buildings (including specifically any new developments) and revisions to the methods used to model population at Round 3. The impact of factors are discussed in more detail below.

11.2 Factors contributing to the Round Three maps

The following section provides further information regarding the factors which have contributed to the Round Three noise maps and the related population analysis. These are grouped into changes in the road source data; 3D propagation model and the population data. All of these factors will contribute to overall and localised changes evident in the maps.

Changes in the railway source data

There have been a number of changes to the railway source data between Round Two and Round Three which have contributed to the spatial composition of the noise maps and ultimately the area, dwelling and population results presented in this report. These improvements have included an update of train vehicle database to remove older 450 class trains and replace these with newer quieter 4000 trains.

We have estimated that this change alone will have led to a variable reduction of 2.5-8.5dB in the core day and evening source emission values used in the LimA model. This change coupled with changes in overall movements contribute to the overall reduction in noise levels represented in the final L_{day}, $L_{Aeq, 16\ hour}$, L_{eve} and L_{den} indicator maps. In contrast, the changes in train rolling stock (i.e. replacement of 450 with 4000 class trains) has only a limited impact upon the calculation of the night based emission values used in the models.

The combination of these changes all contribute to localised differences in the final Round 3 maps produced.

Changes to the 3D propagation model

Changes in the topography and terrain datasets within the 3D model will have also contributed to localised changes in the calculated noise exposure. For example, the demolition and construction of buildings between Round Two and Round Three will significantly affect noise propagation and population exposure. In addition, any fundamental changes or recapturing of terrain by OSNI can also result in change in propagation and the resultant noise level and subsequent population exposure.

The delivery of the population analysis has also highlighted a number of larger apartment developments which have been built in Belfast since Round Two. Examples include several developments along the Queens Road. These new developments will both alter the propagation of noise, and also result in changes in the number of dwellings and population exposed to different noise levels. This issue is covered in more detail below.

Changes to the population model

All elements of the population model have been updated for Round Three. The key changes included in the revised model and population analysis methods are:

- replacement of 2011 population estimates with 2015 population estimate data using the new census Small Area data structure;
- improving the methods used to identify residential buildings in the OSNI and Pointer dataset. This work has included the improved removal of smaller artefact objects (i.e. linked garages, annexes) which are tagged by OSNI as residential objects but could lead to over-representation of dwelling numbers in the population analysis;
- improving the methods used to evaluate the number of delivery addresses within multi-occupancy buildings. This includes improving the assessment of larger multi-functional buildings which may have both residential and commercial uses;
- the increase (5.5%) in the extent of the agglomeration between Round Two and Three means that it is difficult to make direct comparisons between the Round Two and Three analysis results.

Each of these factors will contribute to the final composition of the railway maps and the related outcomes of the population analysis for Round Three.

Appendix A
Railway dataset specifications

Table A.1 BRT Object Overview

Layer Overview	Spatial Reference	Object Dimensions	Elevation Reference	Elevation Reference Position	Elevation Definition	Unit	LimA Object Type
BRT CRN Railway Noise Emission Polyline	Vector	2.5D Polyline	Relative	Relative	Varies per object	Metre (m)	**BRL**

Note: BRT polyline objects should not have vertices with a separation distances less than 0.05m.

Table A.2 BRT Object Specification

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_BRT	Railway Name	String	Data Input	Default Value	RAIL_2D	None
				Max. Length	20	
L_ID	Unique ID Number	String	Data Input	Unique ID		None
				Max. Length	20	
L_RQ	Geometry Type	Integer	Data Input	Default Value	1	None
				Max. Length	4	
L_PD	18-hour Rolling Noise Emission Level (CRN $L_{Aeq, 0600-0000hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PN	6-hour Rolling Noise Emission Level (CRN $L_{Aeq, 0000-0600hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PED	12-hour Daytime Rolling Noise Emission Level (CRN $L_{Aeq, 0700-1900hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	

Table A.2 (continued) BRT Object Specification

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_PEE	4-hour Evening Rolling Noise Emission Level (CRN $L_{Aeq,\ 1900\text{-}2300hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEN	8-hour Evening Rolling Noise Emission Level (CRN $L_{Aeq,\ 2300\text{-}0700hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PDD	18-hour Diesel Full Power Noise Emission Level (CRN $L_{Aeq,\ 0600\text{-}0000hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PDN	6-hour Diesel Full Power Noise Emission Level (CRN $L_{Aeq,\ 0000\text{-}0600hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEDD	12-hour Daytime Diesel Full Power Noise Emission Level (CRN $L_{Aeq,\ 0700\text{-}1900hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEDE	4-hour Evening Diesel Full Power Noise Emission Level (CRN $L_{Aeq,\ 1900\text{-}2300hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEDN	8-hour Evening Diesel Full Power Noise Emission Level (CRN $L_{Aeq,\ 2300\text{-}0700hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PFD	18-hour Rolling Noise Emission Level (CRN $L_{Aeq,\ 0600\text{-}0000hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PFN	6-hour Fan Noise Emission Level (CRN $L_{Aeq,\ 0000\text{-}0600hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEFD	12-hour Daytime Fan Noise Emission Level (CRN $L_{Aeq,\ 0700\text{-}1900hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	

Table A.2 (continued) BRT Object Specification

<table>
<tr><th>Field/ Attribute Name</th><th>Full Description</th><th>Data Type</th><th>Status</th><th colspan="2">Properties</th><th>Special Values</th></tr>
<tr><td rowspan="3">L_PEFE</td><td rowspan="3">4-hour Evening Fan Noise Emission Level
(CRN $L_{Aeq,\ 1900\text{-}2300hrs}$)</td><td rowspan="3">String</td><td rowspan="3">Calculated</td><td>Default Value</td><td>0 V</td><td rowspan="3">None</td></tr>
<tr><td>Precision</td><td>1 d.p.</td></tr>
<tr><td>Max. Length</td><td>6</td></tr>
<tr><td rowspan="3">L_PEFN</td><td rowspan="3">8-hour Evening Fan Noise Emission Level
(CRN $L_{Aeq,\ 2300\text{-}0700hrs}$)</td><td rowspan="3">String</td><td rowspan="3">Calculated</td><td>Default Value</td><td>0 V</td><td rowspan="3">None</td></tr>
<tr><td>Precision</td><td>1 d.p.</td></tr>
<tr><td>Max. Length</td><td>6</td></tr>
<tr><td rowspan="5">L_Z</td><td rowspan="5">Height of Object in AMSL</td><td rowspan="5">String</td><td rowspan="5">Calculated</td><td>Default Value</td><td>8.00</td><td rowspan="5">None</td></tr>
<tr><td>Min Value.</td><td>0.00</td></tr>
<tr><td>Max Value</td><td>9999.99</td></tr>
<tr><td>Precision</td><td>2 dp</td></tr>
<tr><td>Max. Length</td><td>10</td></tr>
<tr><td rowspan="2">L_TT</td><td rowspan="2">Track Type</td><td rowspan="2">Integer</td><td rowspan="2">Data Input</td><td>Default Value</td><td>8.00</td><td rowspan="2">1: CWR + Concrete Slp
2: CWR + Timber Slip
3: Jointed Track
4: Switch or Crossing
5: Slab Track</td></tr>
<tr><td>Max. Length</td><td>10</td></tr>
<tr><td rowspan="2">L_TS</td><td rowspan="2">Support Structure</td><td rowspan="2">Integer</td><td rowspan="2">Data Input</td><td>Default Value</td><td>8.00</td><td rowspan="2">0: No Support
1: Concrete Bridge
2: Stone Bridge
3: Brick Bridge
4: Steel Bridge
5: Steel Box Girder Bridge</td></tr>
<tr><td>Max. Length</td><td>10</td></tr>
<tr><td rowspan="2">L_ATQ</td><td rowspan="2">Acoustic Track Quality of Railheads</td><td rowspan="2">Floating Point</td><td rowspan="2">Data Input</td><td>Default Value</td><td>4 dB</td><td rowspan="2">None</td></tr>
<tr><td>Max. Length</td><td>10</td></tr>
<tr><td rowspan="2">L_VEL</td><td rowspan="2">Measured speed profile</td><td rowspan="2">Floating Point</td><td rowspan="2">Data Input</td><td>Default Value</td><td>0</td><td rowspan="2">None</td></tr>
<tr><td>Max. Length</td><td>6</td></tr>
<tr><td rowspan="3">L_VAD</td><td rowspan="3">Maximum Line Speed</td><td rowspan="3">Floating Point</td><td rowspan="3">Data Input</td><td>Default Value</td><td>0</td><td rowspan="3">None</td></tr>
<tr><td>Precision</td><td>1 d.p.</td></tr>
<tr><td>Max. Length</td><td>5</td></tr>
</table>

Table A.2 (continued) BRT Object Specification

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_MAJ	Major or Non-Major Rail Section	Integer	Data Input	Max. Length	3	0: Non-Major 1: Major
L_VAR	Calculation variant	String	Data Input	Default Value	+	-
				Max. Length	20	
J_ID01 - 99	Movements Allocation Factor	Floating Point	Data Input	Default Value	1	None
				Max. Length	1	
				Range	0 - 1	

Appendix B
Round Three – Railway Movements

Table B.1 Round Three - Modelling Passenger Movements

J_ID	Train	Movements Provided By	Line	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	18-Hour (0600-0000hrs)
JID_01	Class 3000	Train	Bangor-Portadown	Bangor - Belfast Central		13373	10474	2333	566	13373
JID_02	Class 3000	Train	Bangor-Portadown	Bangor - Belfast Central		1530	1530	0	0	1530
JID_03	Class 3000	Train	Bangor-Portadown	Belfast Central - GVS		13883	10880	2640	363	13883
JID_04	Class 3000	Train	Bangor-Portadown	GVS - Lisburn		11022	8127	2074	821	12752
JID_05	Class 3000	Train	Bangor-Portadown	GVS - Lisburn		2295	2295	0	0	2251
JID_06	Class 3000	Train	Bangor-Portadown	GVS - Lisburn		1972	1972	0	0	1972
JID_07	Class 3000	Train	Bangor-Poradown	GVS - Lisburn		311	311	0	0	311
JID_08	Class 3000	Train	Bangor-Portadown	Belfast Central - Bangor		1020	1020	0	0	1020
JID_09	Class 3000	Train	Bangor-Portadown	Belfast Central - Bangor		1785	1785	0	0	1785
JID_10	Class 3000	Train	Bangor-Portadown	GVS - Central		13684	10988	2541	311	13684
JID_11	Class 3000	Train	Bangor-Portadown	Lisburn - GVS	80% of these movements occur before Lisburn based on terminating service data showing around 20% originate at Lisburn.	4267	4367	0	0	0

Table B.1 (continued) Round Three - Modelling Passenger Movements

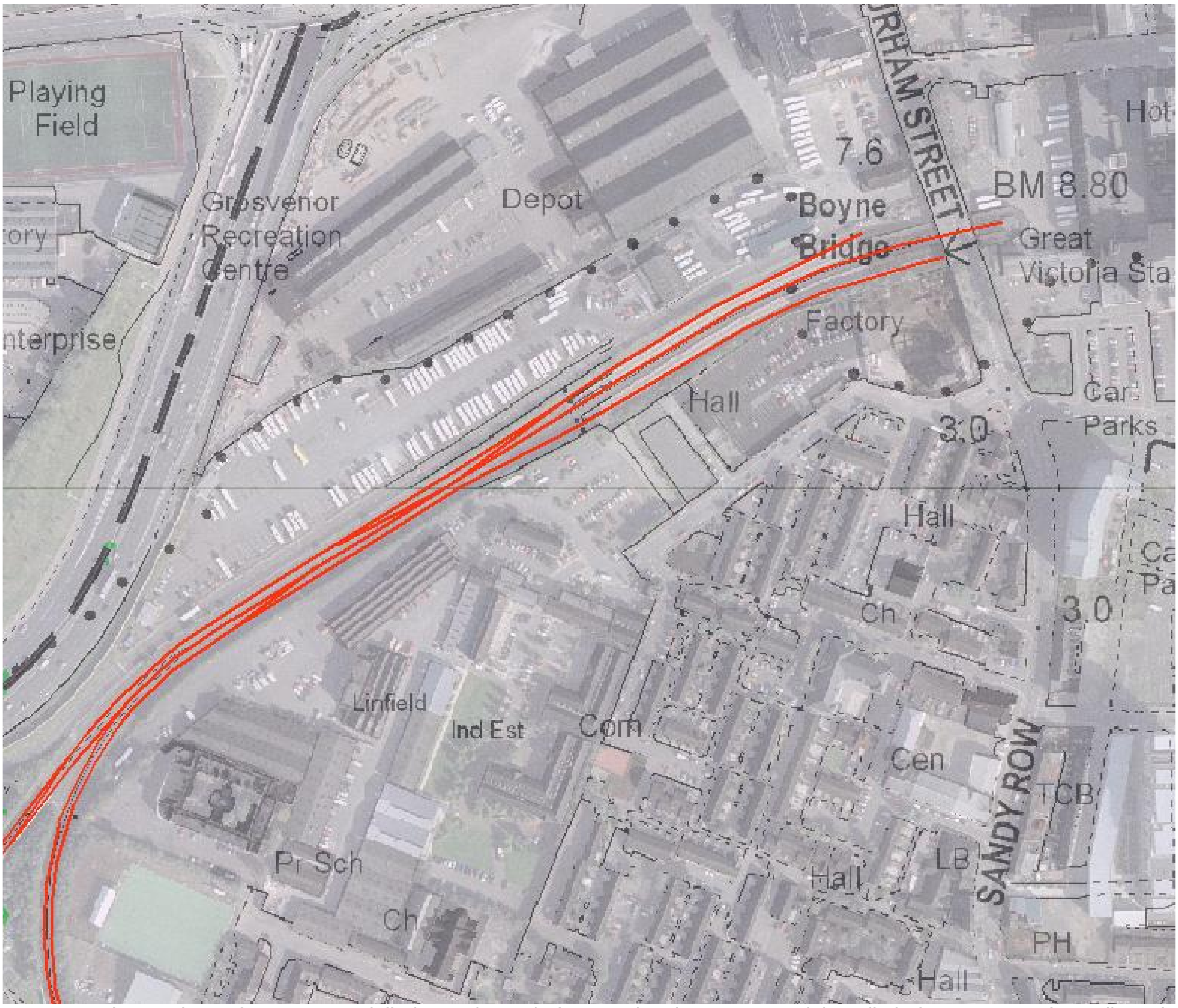
J_ID	Train	Movements Provided By	Line	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	18-Hour (0600-0000hrs)
JID_12	Class 3000	Train	Bangor-Portadown	Lisburn - GVS	70% of these movements occur before Lisburn based on terminating service data showing around 30% originate at Lisburn	11756	9564	2074	678	0
JID_13	Class 4000	Train	Belfast – Carrickfergus	Central - Carrickfergus	Terminating movements show around 75% continue past Carrick	11363	8773	1456	1134	298
JID_14	Class 4000	Train	Belfast - Carrickfergus	Central - Carrickfergus	Terminating movements show around 22% terminate at Carrickfergus	0	0	0	0	0
JID_15	Class 4000	Train	Belfast - Carrickfergus	Central - Carrickfergus		11363	8773	1456	1134	0
JID_16	Class 4000	Train	Belfast - Carrickferg	GVS - Central	Around 40% of movements terminate at Central with 60% continuing past Central to Carrickfergus	10313	8036	1344	933	0
JID_17	Class 4000	Train	Belfast – Carrickfergus	Carrickfergus - Central	Around 75% of the movements originate before Carrickfergus due to 25% shown to terminate at Carrickfergus when heading north	11022	8326	2074	622	0
JID_18	Class 4000	Train	Belfast - Carrickfergus	Carrickfergus - Central	Around 78% of the movements originate before Carrickfergus due to 22% shown to terminate at Carrickfergus when heading north	765	765	0	0	0
JID_19	Class 4000	Train	Belfast – Carrickfergus	Carrickfergus - Central		0	0	0	0	0
JID_20	Class 4000	Train	Belfast - Carrickfergus	Central - GVS		10141	8173	1968	0	0

Table B.1 (continued) Round Three - Modelling Passenger Movements

J_ID	Train	Movements Provided By	Line	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	6-Hour (0000-0600hrs)	18-Hour (0600-0000hrs)
JID_21	Class 3000	Train	Belfast - Londonderry	Central - Antrim		6417	4710	1237	510	0	6417
JID_22	Class 3000	Train	Belfast - Londonderry	GVS - Central (LY)		6162	4507	1412	255	0	6162
JID_23	Class 3000	Train	Belfast - Londonderry	Antrim - Central (LY)		6417	4455	1962	0	458	6417
JID_24	Class 3000	Train	Belfast - Londonderry	Central - GVS (LY)		6110	4830	1442	0	0	6110
JID_25	Enterprise	Vehicle	Belfast - Dublin	Central - Dublin		2748	2074	363	311	0	2748
JID_26	Enterprise	Vehicle	Belfast - Dublin	Dublin - Central		2748	1733	674	311	0	2748

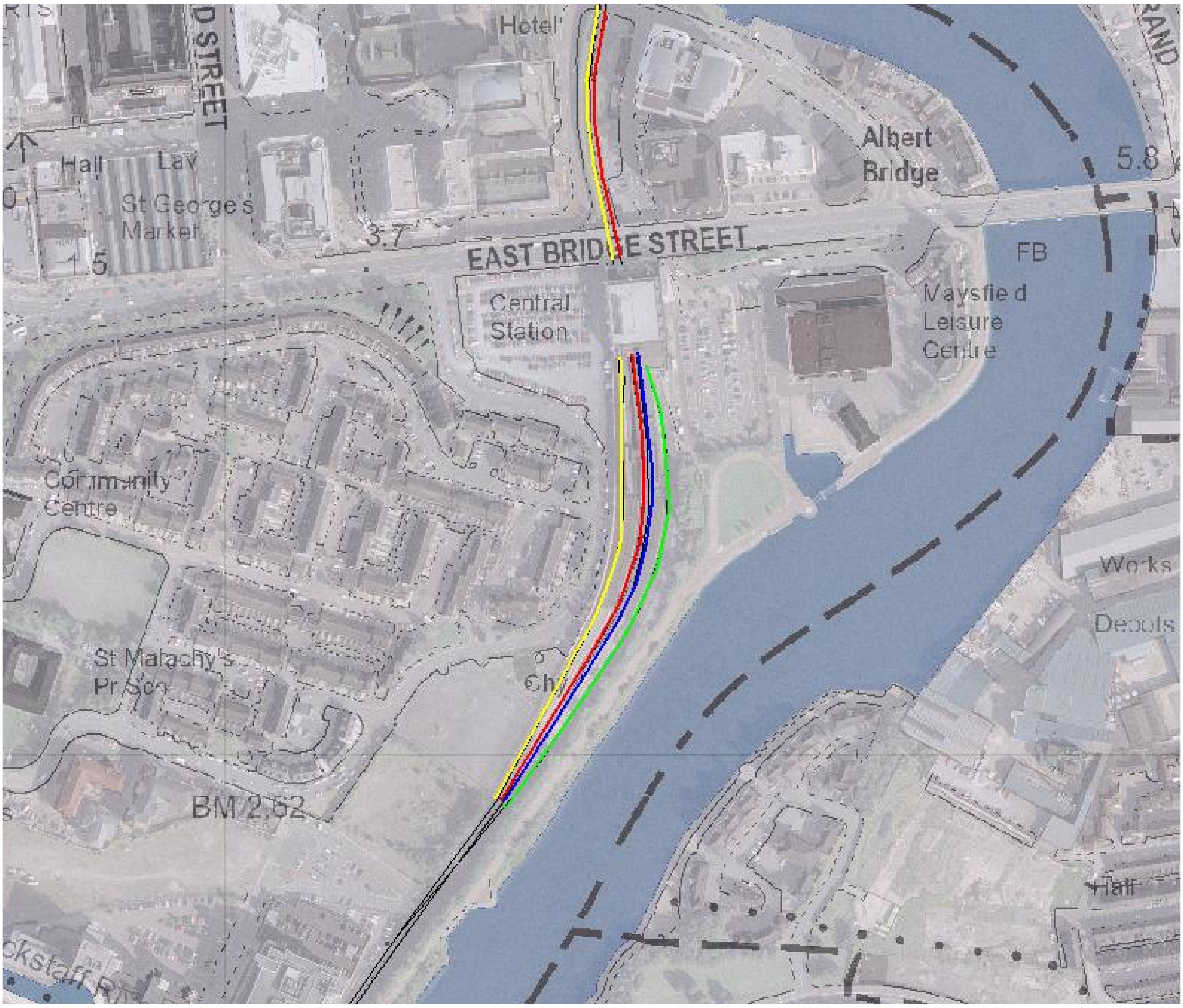
Appendix C
Stations and Depots

Great Victoria Street



Movements into and out of GVS are modelled onto three platforms. It has been assumed that all platforms are used equally and that a third of all train movement and services into and out of the stations are allocated over each of the modelled platforms.

Belfast Central



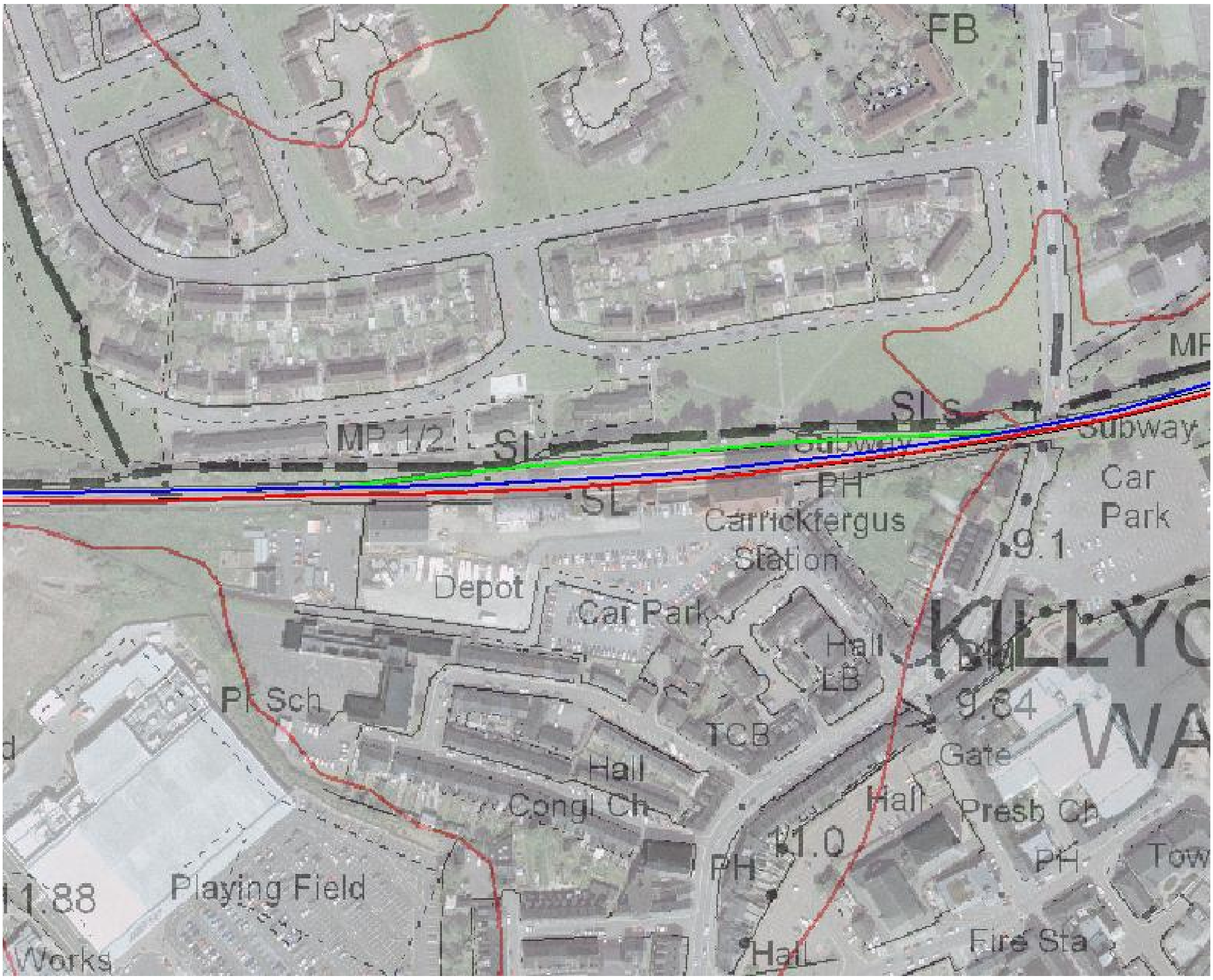
Yellow line models all heading from and to Bangor, Larne and Londonderry.

Red line models all services to and from Londonderry and Bangor.

Blue and Green line models equally model all terminating services terminating at GVS and heading back to Belfast Central

Blue line models Dublin Enterprise Services terminating and departing at and from Belfast Central

Carrickfergus



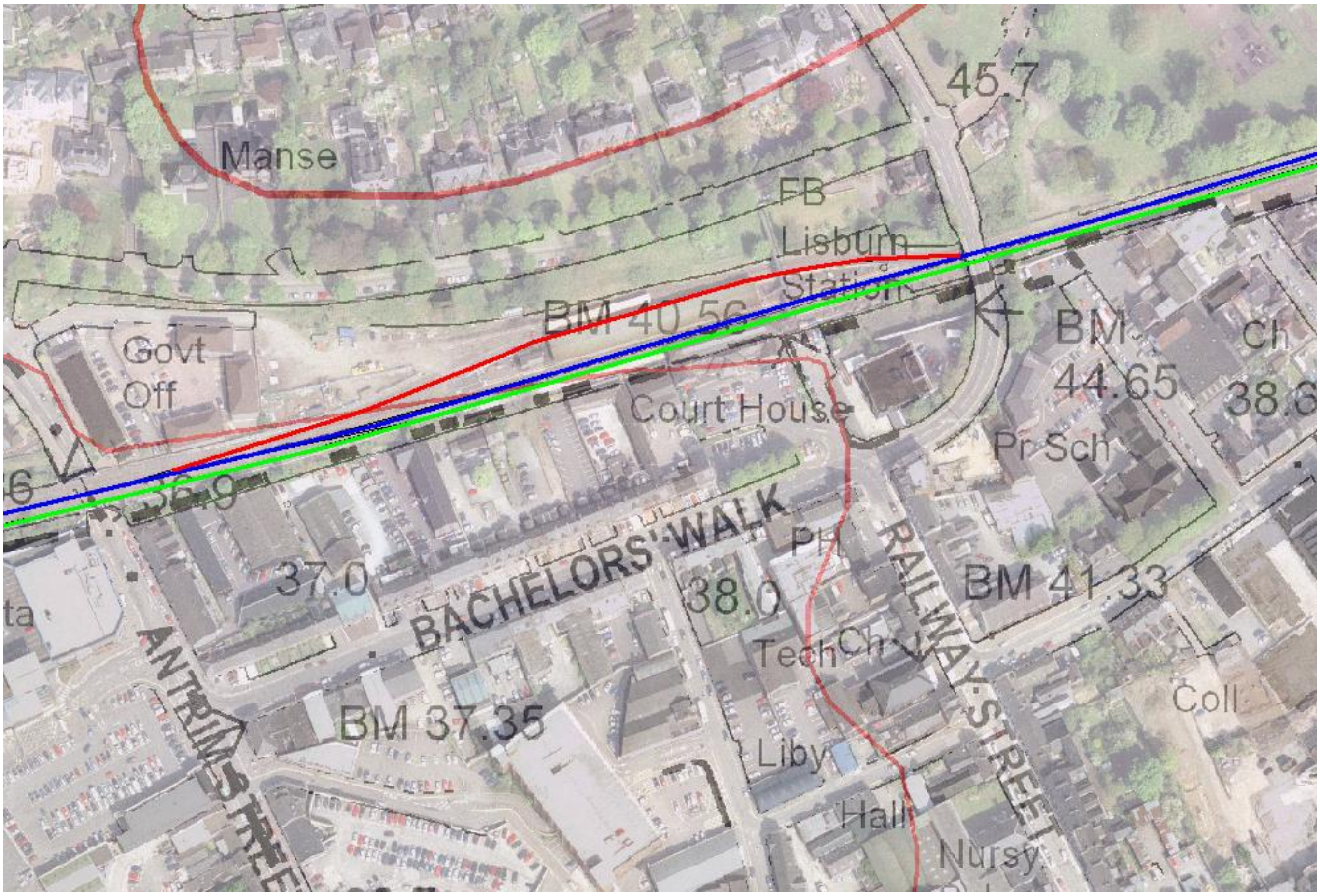
Red line is used to model services stopping at and passing through Carrickfergus towards Belfast

Blue line is used to model services stopping at and passing through Carrickfergus from Belfast

Green line models services terminating at or originating from Carrickfergus.

Note: Data provided by Translink during Round Two indicates that around 20-25% of services terminate at Carrickfergus. The data shows that a corresponding 75-80% of services continue through Carrickfergus or originate before Carrickfergus.

Lisburn

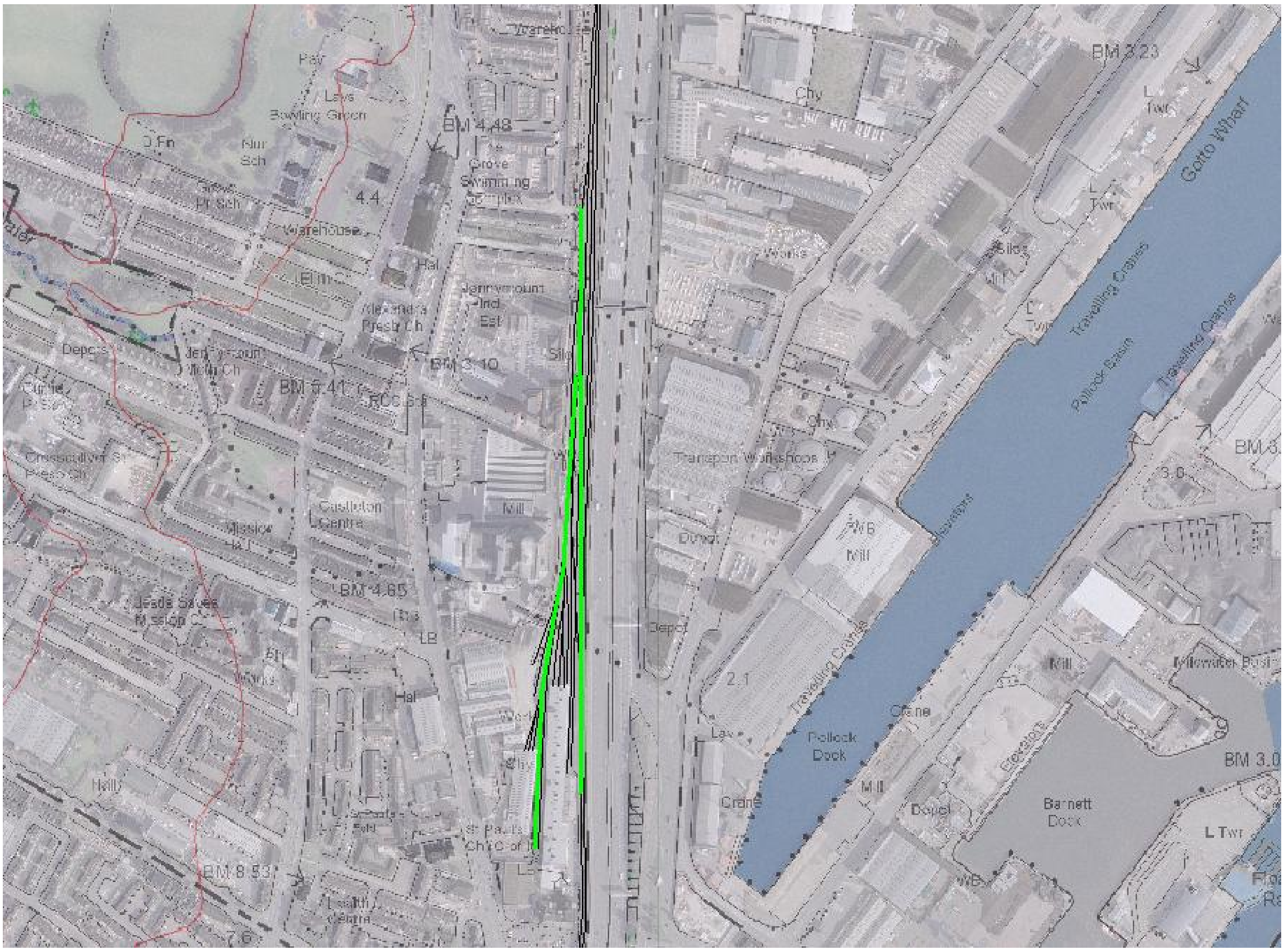


Green and Red lines model services passing through and stopping at Lisburn.

Red line models services that terminate at or originate from Lisburn.

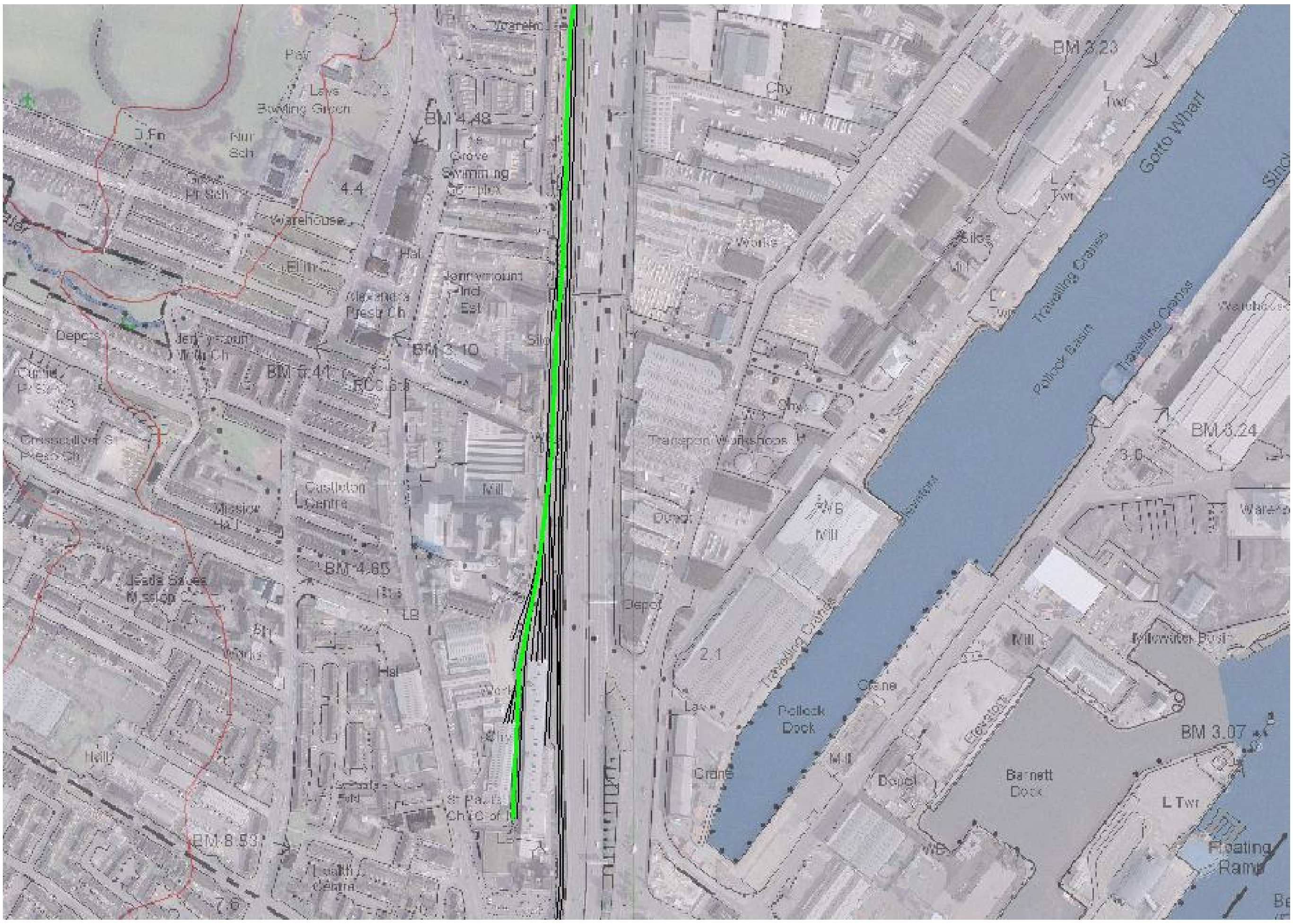
Note: Data provided by Translink for Round Two indicates that 70-80% of movements originate before or travel beyond Lisburn station. The remaining 20-30% terminates or originates at Lisburn.

York Road Depot – Trains Entering Depot from Belfast End



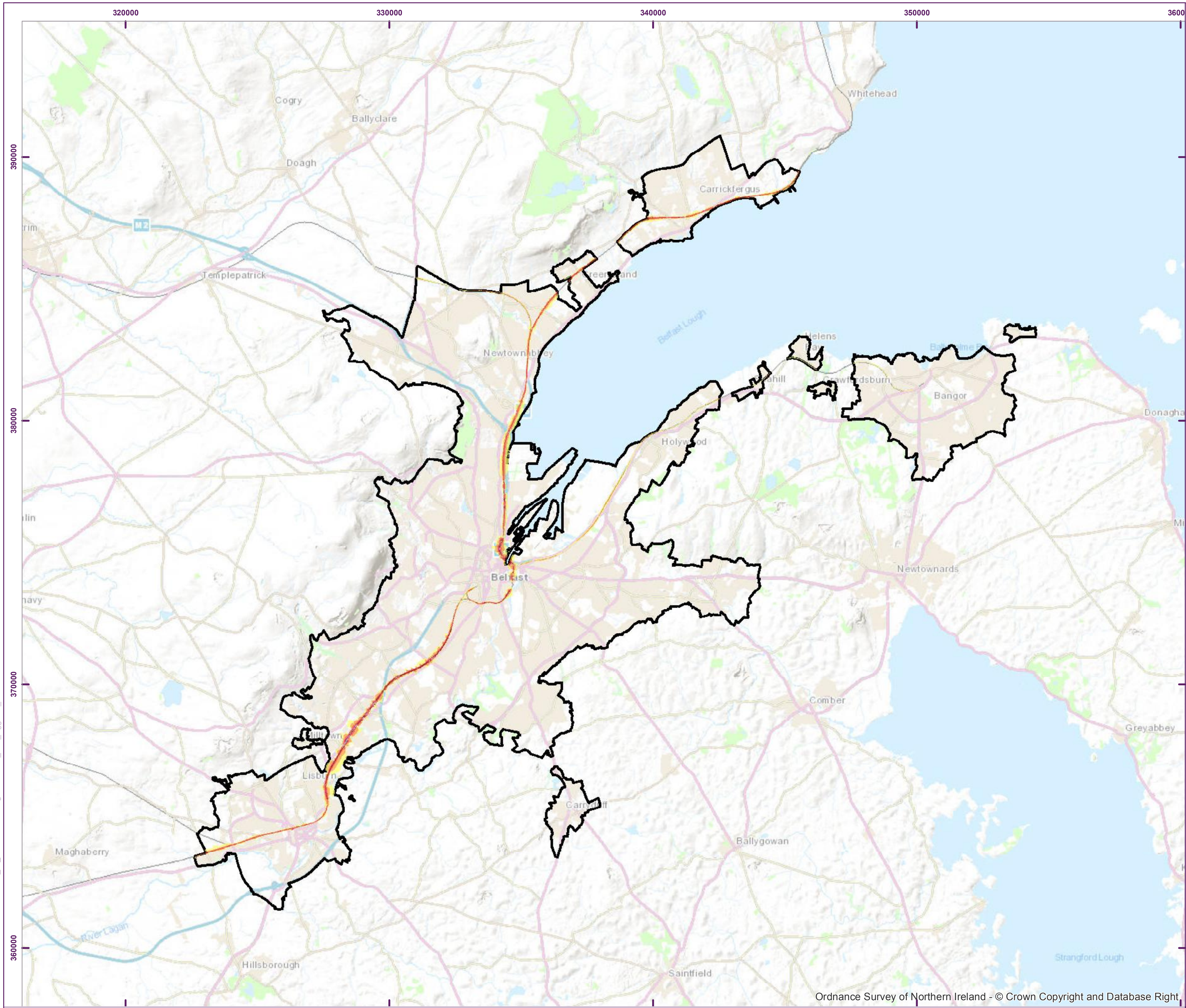
Green line represents trains entering depot from the Belfast end.

York Road Depot – Trains Entering Depot from North



Green line represents train movements entering York Road Depot from the north

Appendix D Round Three Maps



Key

Belfast Agglomeration

Rail 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

N

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Signature

Director

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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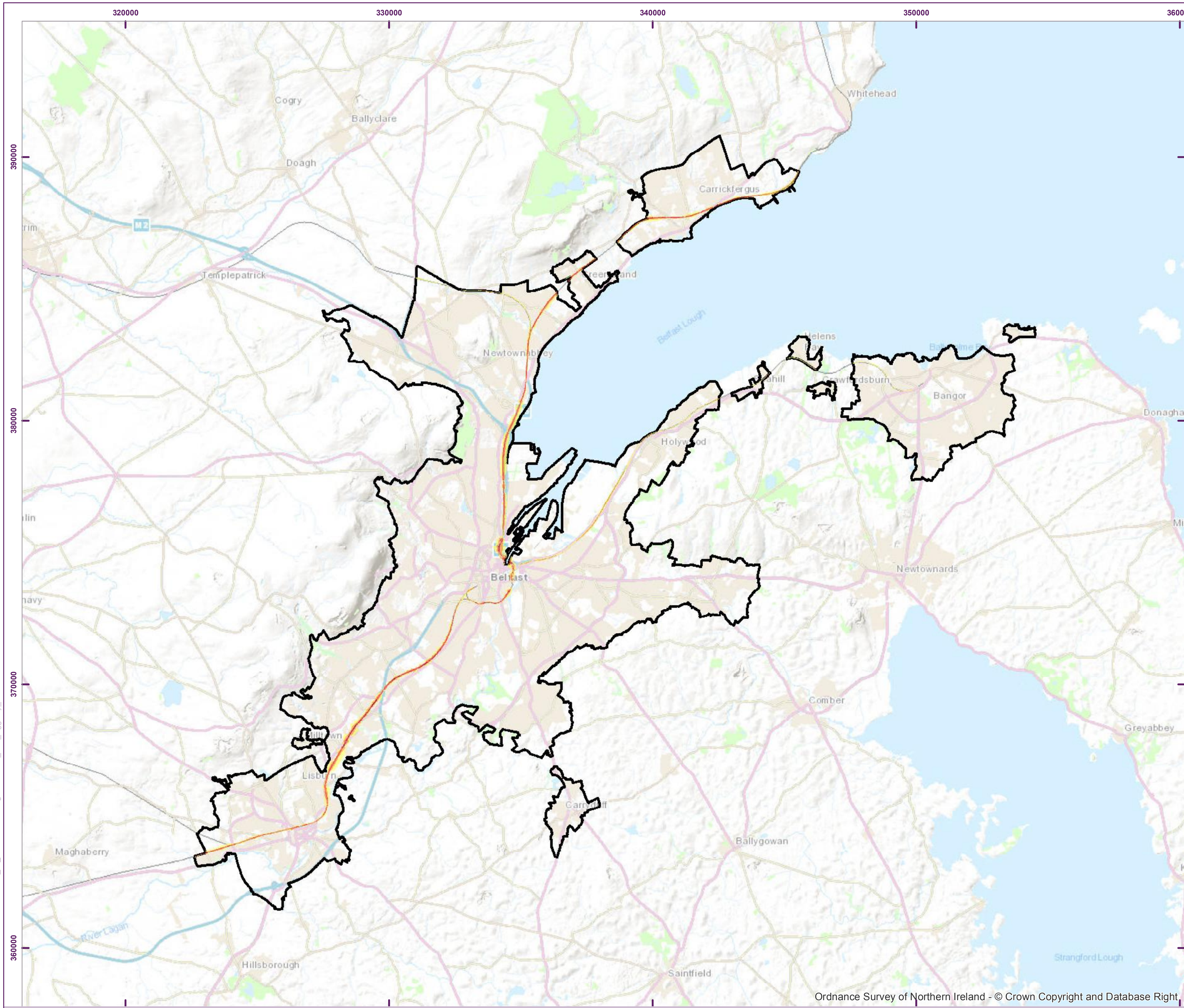
Key

Belfast Agglomeration

Rail 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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Signature

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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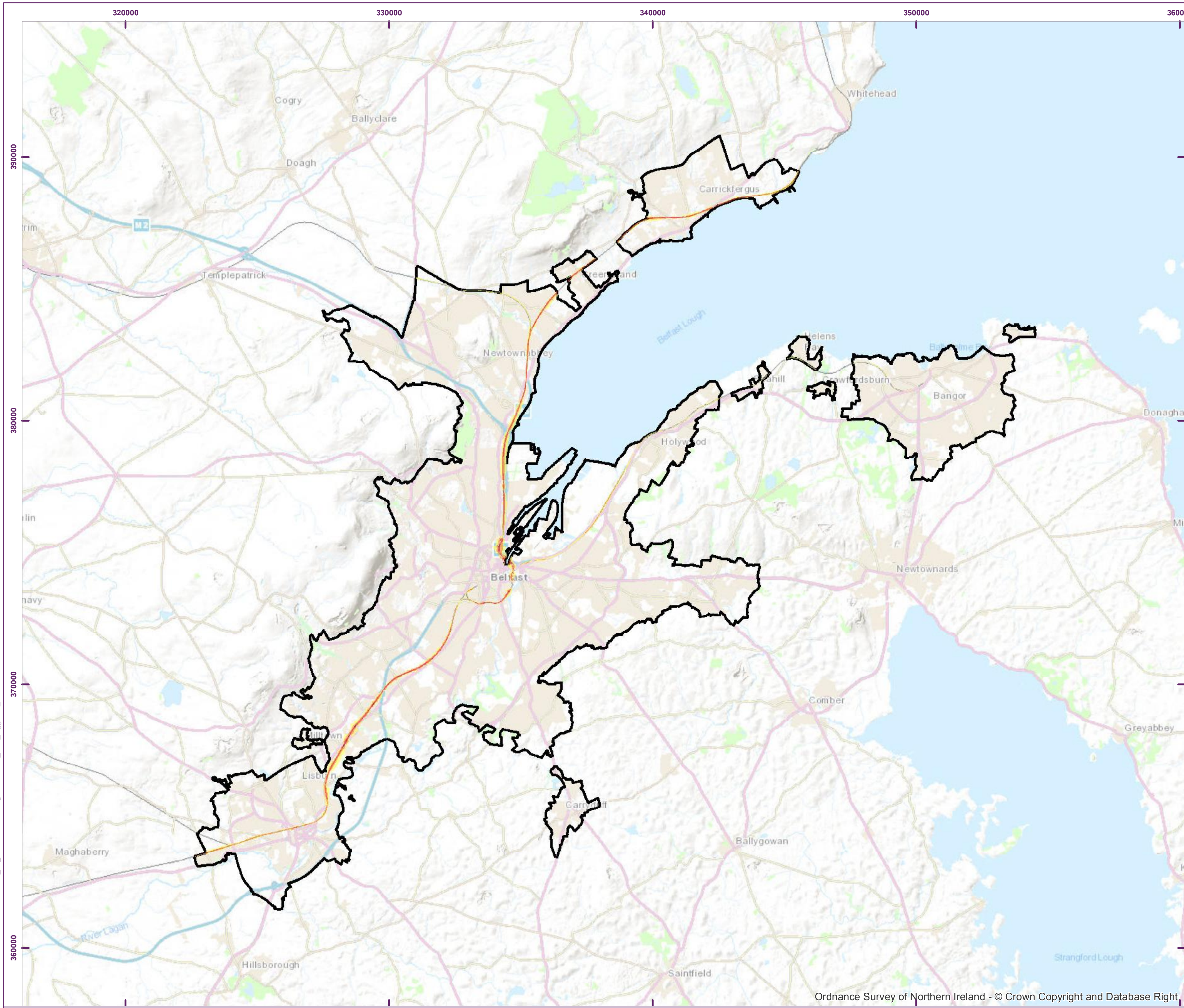

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Key

Belfast Agglomeration

Rail Noise Map

$L_{A10,\,18h}$

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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The $L_{A10,18hr}$ is the mean noise level in dB(A) exceeded for 10% of each hour over the period 06:00 - 24:00 hours.

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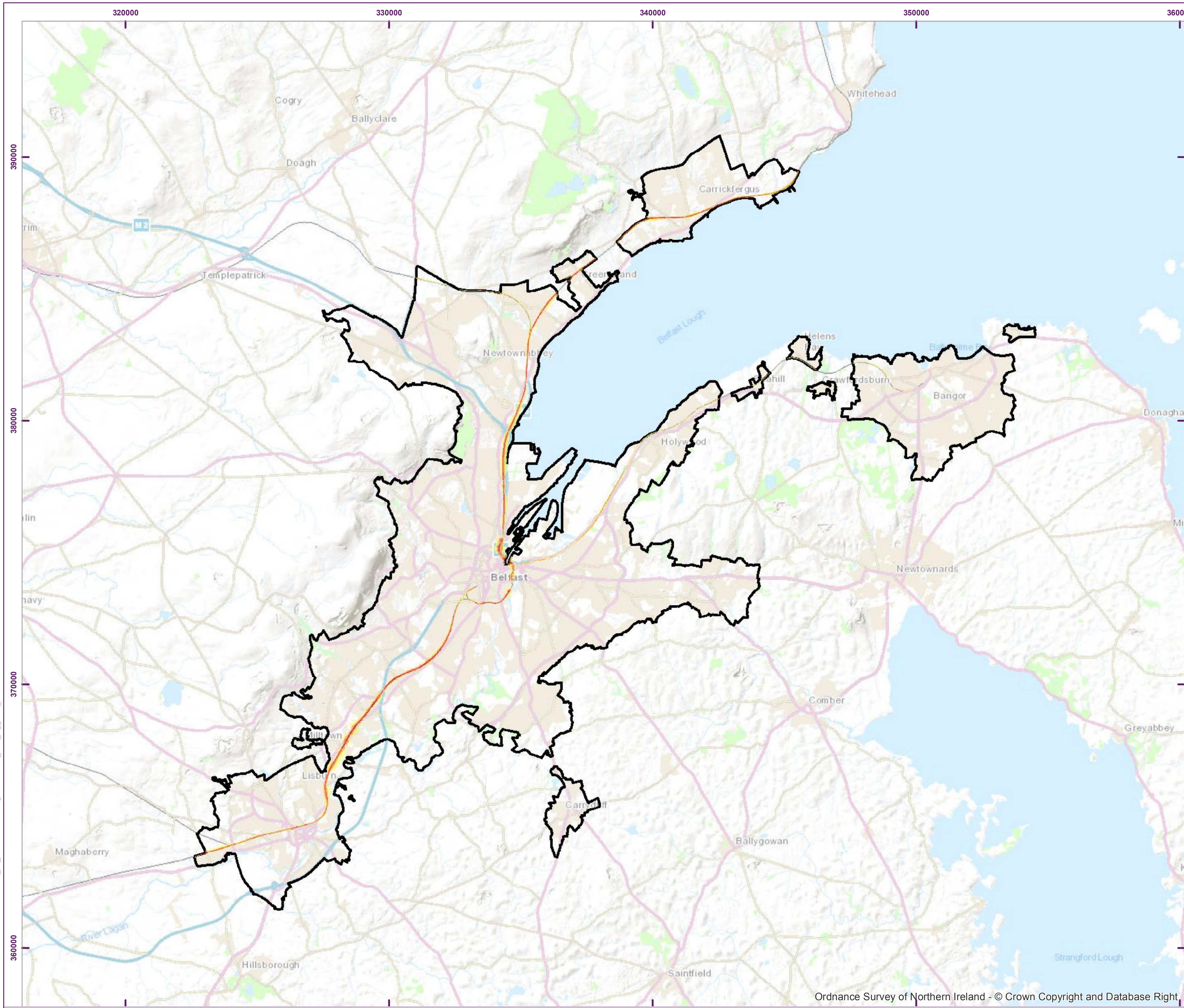
November 2017 38600_S59_Aggl18h_Rail.mxd eastr



Key

Belfast Agglomeration

Rail 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

Scale at A3: 1:140,000

N

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The $L_{aeq,16hr}$ is the equivalent continuous sound level in dB(A) that, over the period 07:00 – 23:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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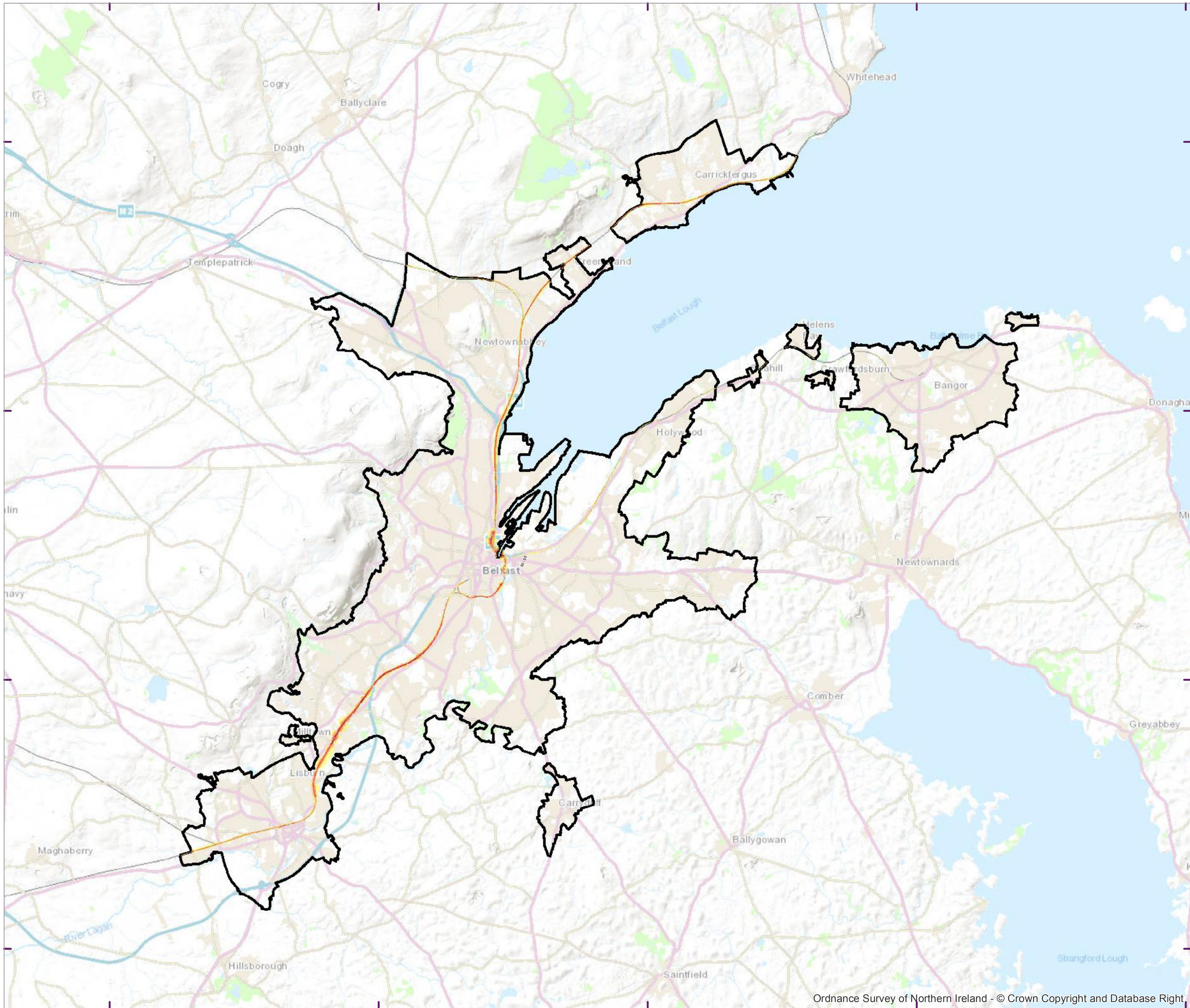

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Key

Belfast Agglomeration

Rail 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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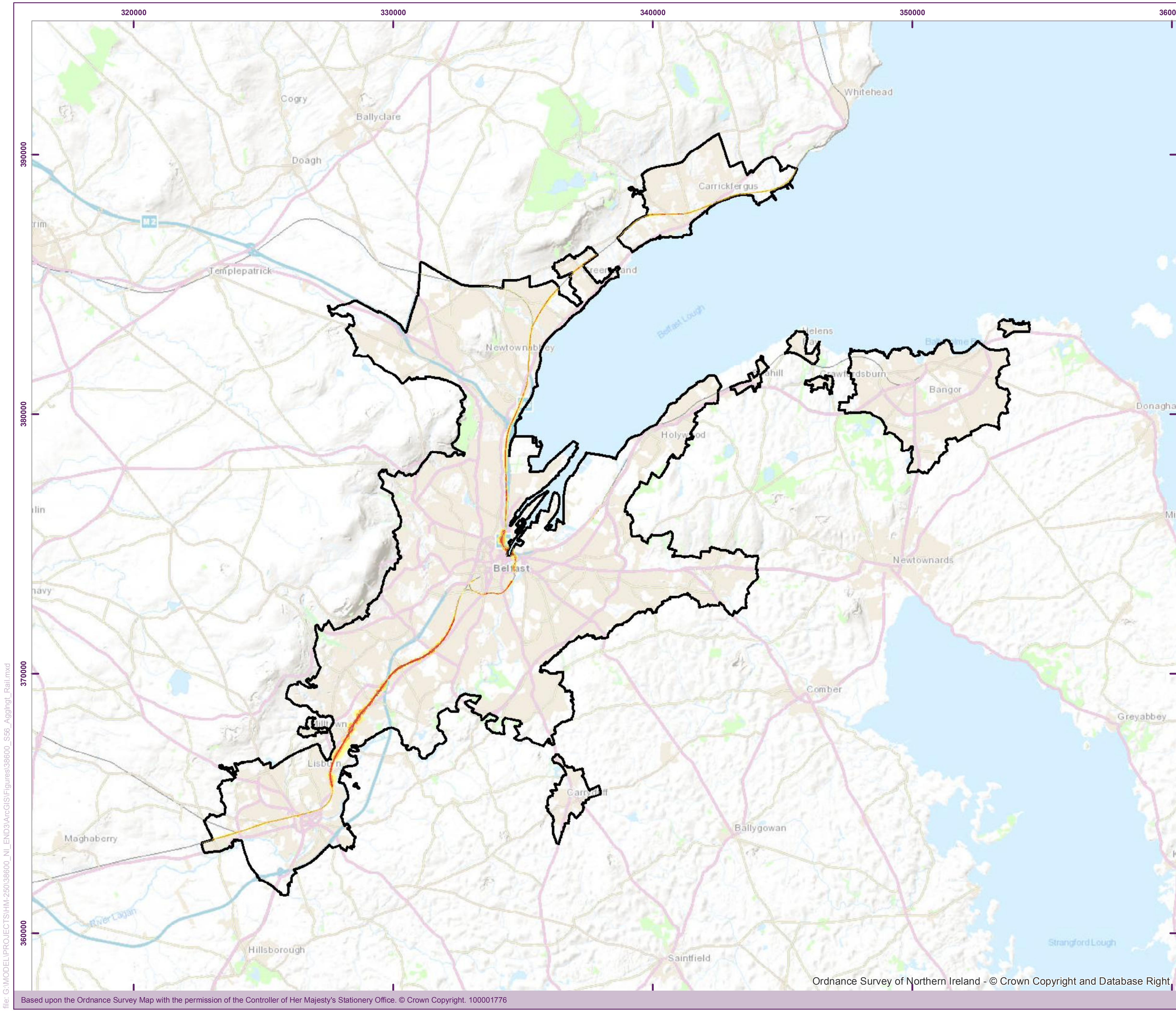

Key

Belfast Agglomeration

Rail Noise Map
L_{night}

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

Key

Noise Level (dB)

(yellow)	45 - 49
(orange)	50 - 54
(red)	55 - 59
(brown)	60 - 64
(lilac)	65 - 69
(blue)	> = 70
(outline)	Belfast Agglomeration

0 1 2 3 4 5 km

Scale at A3: 1:140,000

N

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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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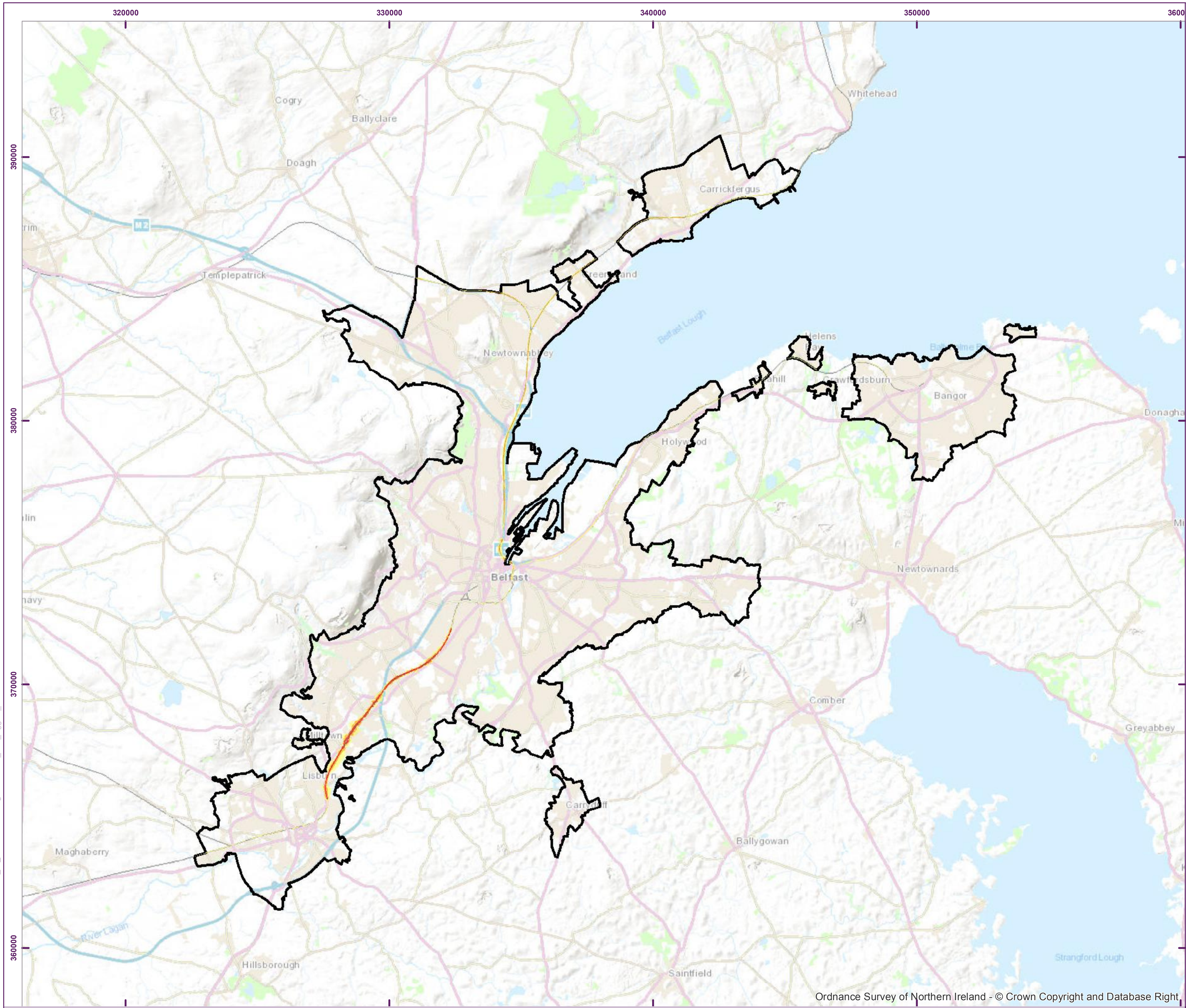

Key

Belfast Agglomeration

Rail Noise Map

$L_{aeq, 6hr}$

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

N

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Director

The $L_{Aeq,6hr}$ is the equivalent continuous sound level in dB(A) that, over the period 24:00 – 06:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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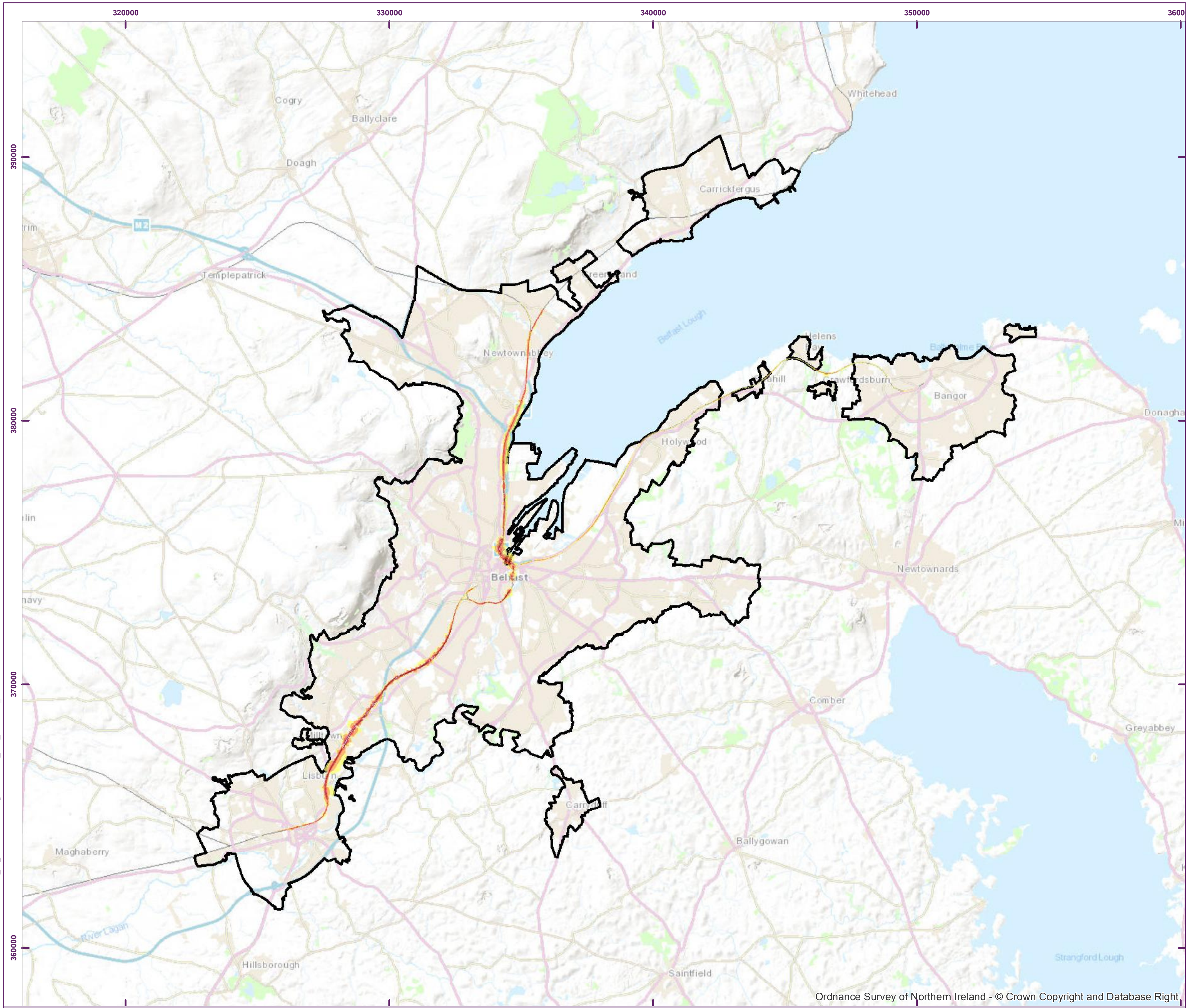

Key

Belfast Agglomeration

Main Rail 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

N

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Signature

Director

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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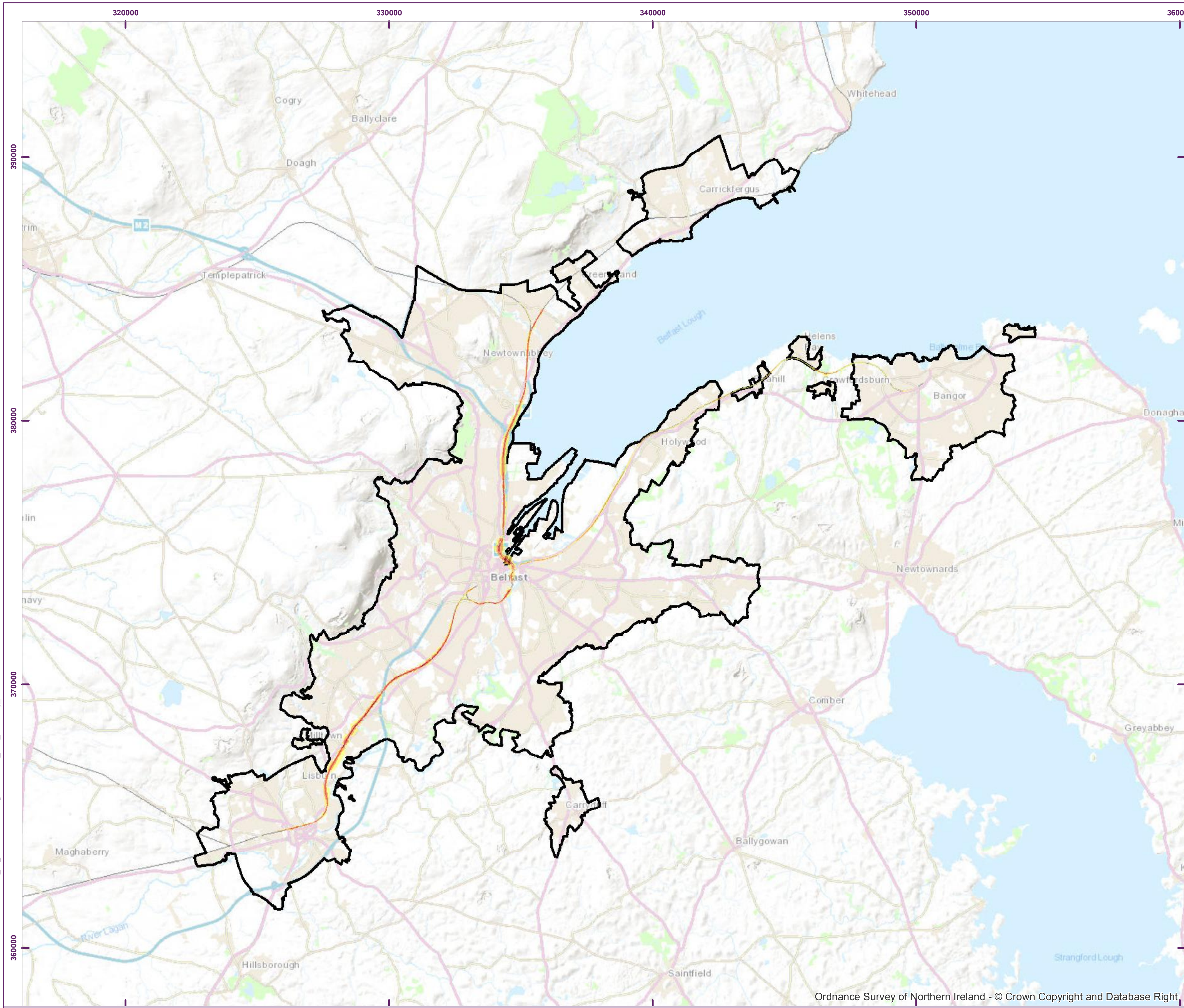

Key

Belfast Agglomeration

Main Rail 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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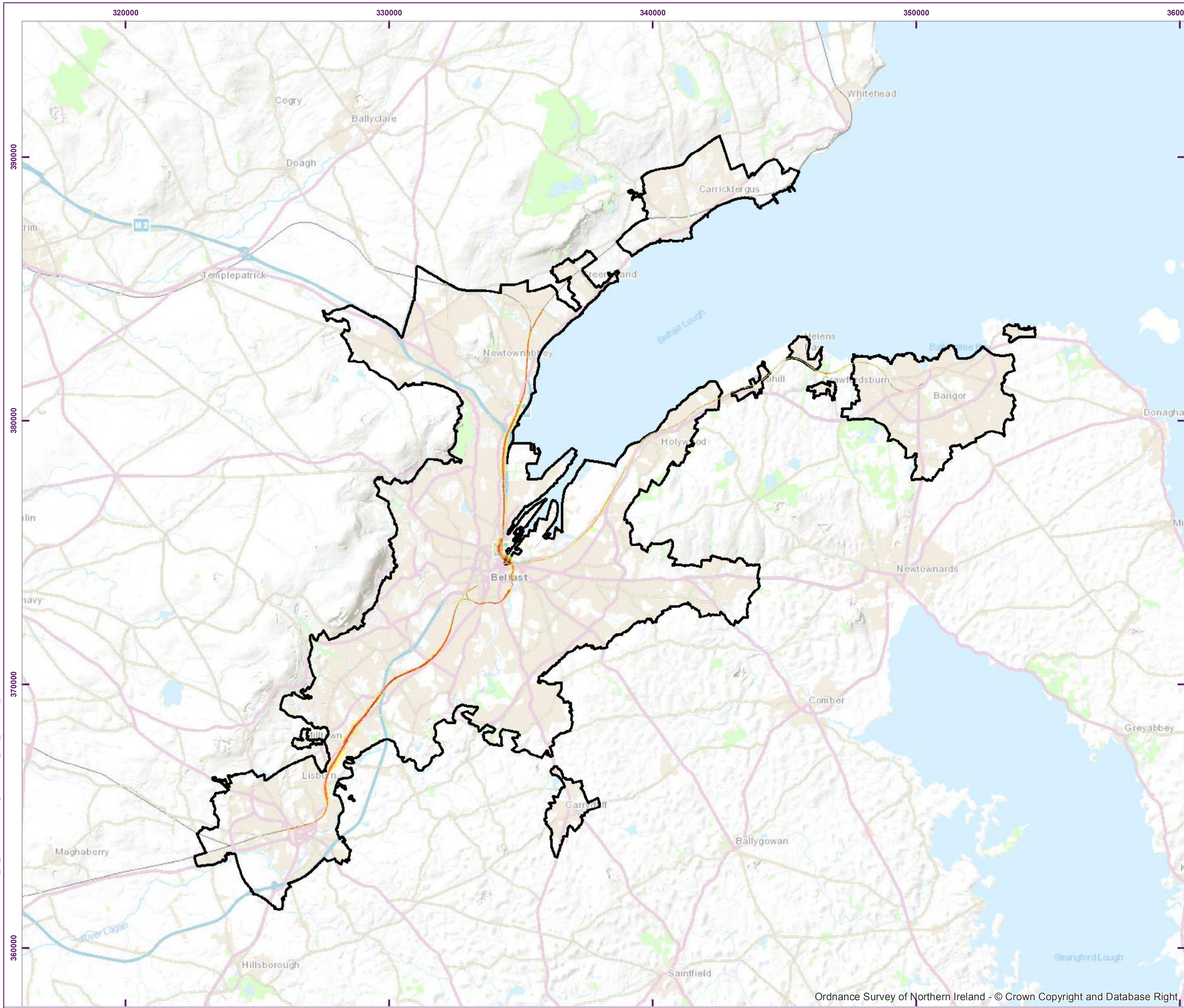

Key

Belfast Agglomeration

Main Rail 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
Scale at A3: 1:140,000

N

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Signature

Director

The $L_{aeq,16hr}$ is the equivalent continuous sound level in dB(A) that, over the period 07:00 – 23:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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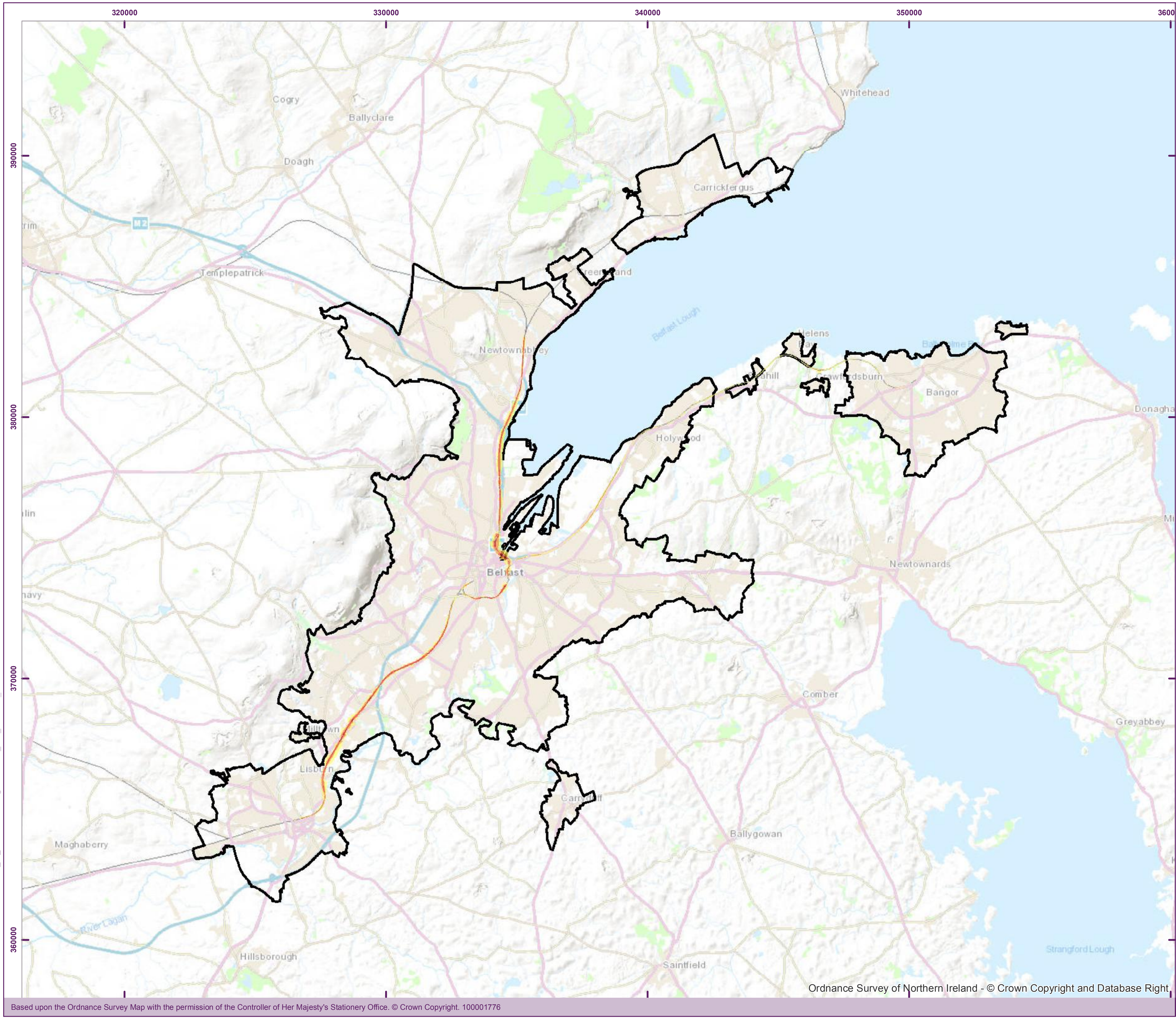

Key

Belfast Agglomeration

Main Rail Noise Map
$L_{A10,\ 18h}$

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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Signature

Director

The $L_{A10,18hr}$ is the mean noise level in dB(A) exceeded for 10% of each hour over the period 06:00 - 24:00 hours.

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Translink

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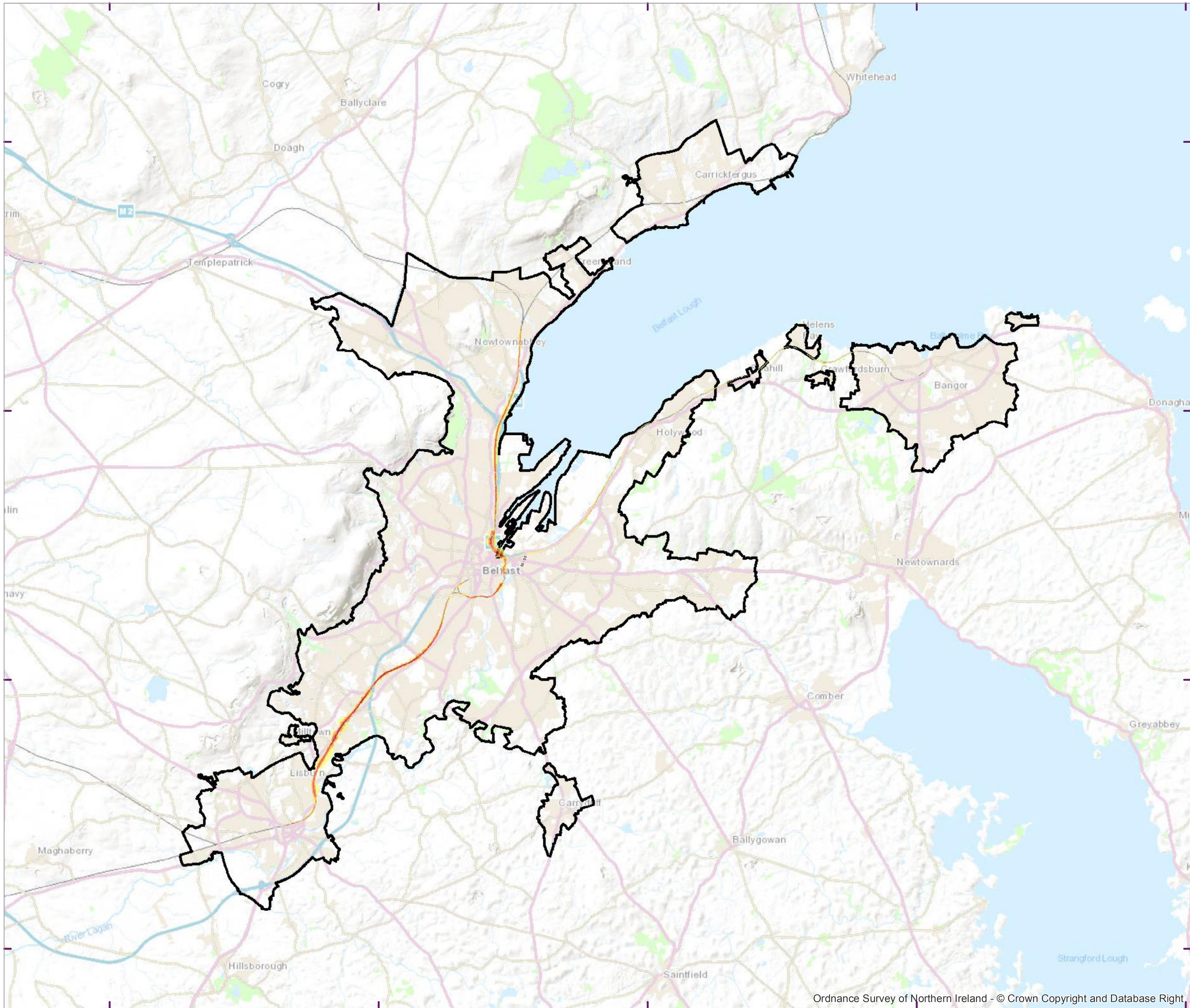
November 2017 38600_S70_MainI18h_Rail.mxd eastr



Key

Belfast Agglomeration

Main Rail 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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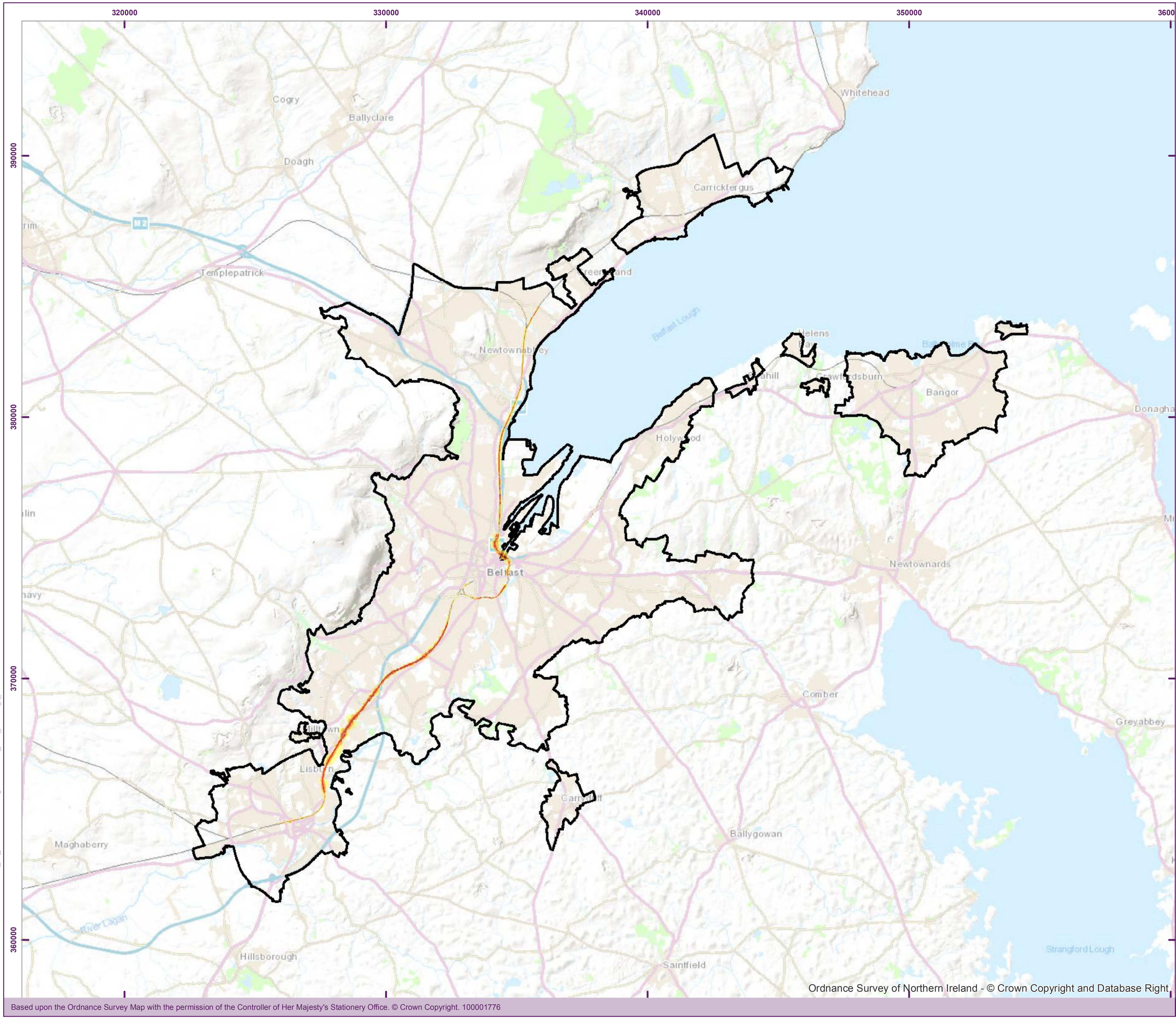

Key

Belfast Agglomeration

Main Rail 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

N

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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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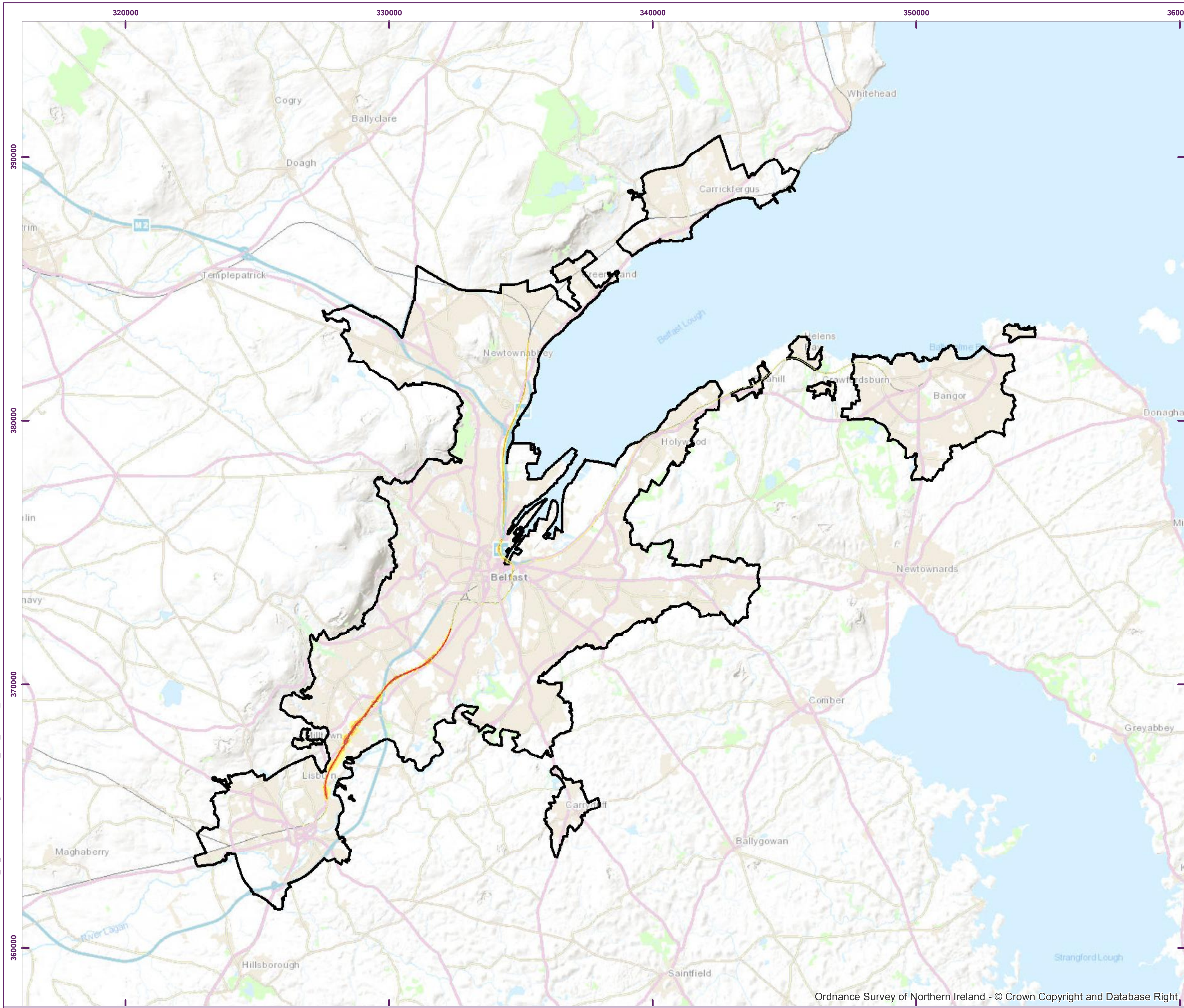

Key

Belfast Agglomeration

Main Rail Noise Map

$L_{aeq, 6hr}$

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

N

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The $L_{Aeq,6hr}$ is the equivalent continuous sound level in dB(A) that, over the period 24:00 – 06:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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