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Towards a Good Practice Guide for Implementing CNOSSOS-EU in Ireland

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Government of Ireland

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- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

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EPA RESEARCH PROGRAMME 2021–2030

Towards a Good Practice Guide for Implementing CNOSSOS-EU in Ireland

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EPA Research Report

Prepared for the Environmental Protection Agency

by

University College Dublin and Trinity College Dublin

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This report is based on research carried out/data from 1 February 2018 to 1 May 2020. It does not reflect more recent policy developments relevant to R4 strategic noise mapping, such as the revisions to CNOSSOS-EU by means of a delegated directive amending Annex II of Directive 2002/49/EC, and the revised EEA Reportnet 3 reporting mechanism as a result of Regulation (EU) 2019/1010.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

The Noise-Adapt (Ireland) project aims to provide transitional needs assessment and guidance for adapting to CNOSSOS-EU (Common Noise Assessment Methods in Europe) in the Irish context for road and rail sources, including the administration of the standardised approach for population exposure estimation under CNOSSOS-EU. The objective of this document is to inform guidance for implementation of the European Union Environmental Noise Directive (END) under the CNOSSOS-EU approach. This document is primarily targeted at practitioners charged with implementing the noise mapping requirements of the END under CNOSSOS-EU.

The guide includes a data needs section for road and rail sources, as well as recommendations for data input where Irish data are unavailable. In the context of road sources within agglomerations, the new CNOSSOS-EU classification system is outlined. In order to categorise heavy vehicles into categories 2 and 3, additional traffic count exercises are necessary. However, if this is not possible, sensitivity analyses suggest that heavy vehicle flow information may be equally split into two categories. Furthermore, it is recommended that category 4 vehicles be incorporated into the category 1 classification in the Irish context. This recommendation is based on sensitivity analyses and the minimal proportion of category 4 vehicles present in the Irish fleet. In relation to average speed, if such data cannot be acquired, sensitivity analyses indicate that the speed limit may be utilised in the Irish context. Finally, in relation to the identification of traffic light and roundabout junctions, sensitivity analyses based on direct measurements indicate that applying a correction coefficient model for traffic light and roundabout intersections does not improve the accuracy of results [i.e. results are within a 2 dB(A) threshold]. Therefore, the Noise-Adapt project considers that it is acceptable not to apply correction coefficients for traffic light and roundabout intersections at the current time since their application does not improve the accuracy of results. This alleviates the requirement to identify traffic light and roundabout junctions within agglomerations.

The primary aim of this document is to provide a fully accessible, step-by-step manual for practitioners undertaking the strategic noise mapping process by providing practical examples and using explanatory visuals that can be referred to during each step (where possible) of the process. In this respect, the road and rail sources calculation using commercial software is outlined, as well as instructions regarding the generation of strategic noise maps using data interpolation, and guidance regarding the estimation of population exposure under CNOSSOS-EU. In determining the number of inhabitants of a building, European Commission Directive (EU) 2015/996 L168/92-3 recommends that, where data on the number of inhabitants are available and the number of inhabitants is known for entities larger than a building, such as districts (e.g. Central Statistics Office Small Area Population Statistics data), estimations should be based on the volume of the building.

The fundamental objective of this report is to support relevant authorities by providing strong evidence-based analysis and instruction on how to implement strategic noise mapping under CNOSSOS-EU from 2022 onwards. It is hoped that this report achieves this objective by the presentation of detailed guidance tailored specifically towards practitioners.

1 Introduction

1.1 Overview of the Noise-Adapt Project

The Noise-Adapt (Ireland) project aims to identify Ireland's adaptation needs for transitioning to the CNOSSOS-EU (Common Noise Assessment Methods in Europe) standardised noise calculation method and the standardised approach for population exposure estimation based on European Commission Directive (EU) 2015/996 of 19 May 2015 (EU, 2015). In doing so, the project has reviewed existing noise mapping procedures in Ireland relative to the needs of calculation and exposure estimation under the new CNOSSOS-EU approach. Furthermore, existing policies and legislative and guidance documents have been reviewed with a view to recommending changes for new guidance associated with strategic noise mapping under CNOSSOS-EU.

The project comprises four interrelated work packages (WPs) as follows:

- WP 1 – transitioning to CNOSSOS-EU;
- WP 2 – strategic noise mapping using CNOSSOS-EU;
- WP 3 – reanalysing past strategic noise mapping data;
- WP 4 – good practice guide and final project report.[1]

The specific objectives of the study are:

- to provide a data needs/gaps assessment for adapting to CNOSSOS-EU in the Irish context for road and rail (WP 1);[2]
- to assess CNOSSOS-EU methodology limitations that are likely to impede the successful implementation of the CNOSSOS-EU transition (WP 1);
- to test the CNOSSOS-EU method within an Irish city (Dublin) and along a major road outside an agglomeration to assess its suitability/shortcomings for Ireland, including issues related to the point-to-point propagation under CNOSSOS-EU (WP 2);
- to explore the applicability of the CNOSSOS-EU method for estimating population exposure in Ireland (WP 2);
- to reassess past strategic noise mapping data and population exposure estimates using CNOSSOS-EU (WP 3);
- to develop practitioner guidance for future strategic noise mapping rounds using CNOSSOS-EU (WP 4);
- to assess the suitability of existing noise policy/legislation in the light of transitioning to CNOSSOS-EU (WP 4).

The purpose of this report is to provide the final work package (WP 4), which consists of a national guidance document supporting the transition to CNOSSOS-EU approaches under the Environmental Noise Directive (END) (EU, 2002), informed by a high-quality data analysis coupled with policy and practice recommendations to integrate and embed environmental noise pollution issues within various policy domains.

Developing strong practice guidance has the potential to aid better practice and reshape it in a manner that maximises the possibility of protecting citizens' health and well-being and quality of life more generally. CNOSSOS-EU establishes a harmonised and consistent approach to assessing noise levels for all European Union (EU) Member States (MSs), and will provide Irish authorities with the opportunity to review implementation of the END and address any areas where improvement may be necessary.

1 See *Transitioning to Strategic Noise Mapping under CNOSSOS-EU (Noise-Adapt)* (full report), available to download at http://www.noisemapping.ie/useful-outputs.html

2 See *Data Needs Assessment and Recommendations for Transitioning to CNOSSOS-EU* (full report), available to download at http://www.noisemapping.ie/useful-outputs.html

1.2 Structure of Guidance

The following section outlines the background and objectives of the CNOSSOS-EU methodology, including its statutory requirements.

- Chapter 2 provides an overview of the strategic noise mapping process.
- Chapter 3 describes the development of data specifications and the production of datasets.
- Chapter 4 outlines CNOSSOS-EU transitioning needs and recommendations in relation to road sources.
- Chapter 5 outlines CNOSSOS-EU transitioning needs and recommendations in relation to rail sources.
- Chapter 6 demonstrates step-by-step guidance regarding how road sources should be calculated in commercial software.
- Chapter 7 demonstrates step-by-step guidance regarding how rail sources should be calculated in commercial software.
- Chapter 8 provides step-by-step guidance on the generation of strategic noise maps (SNMs) using spatial interpolation.
- Chapter 9 provides step-by-step guidance on the estimation of population exposure under CNOSSOS-EU and the assignment of noise levels and population to buildings.
- Chapter 10 outlines reporting requirements necessary for submission of data generated from the strategic noise mapping process.
- Chapter 11 provides concluding comments on the guidance document, outlining its primary objective and purpose.

1.3 Guidance and the Use of Software

The following document contains guidance regarding the use of noise calculation geographic information system (GIS) and data management software applications to perform the strategic noise mapping process. Predictor-LimA is used for noise calculation, ArcGIS ArcMap is utilised as a GIS and Microsoft Access is utilised for data management. Note, however, that the guidance document does not recommend specific software, and other comparable software applications may be utilised where appropriate. Furthermore, the guidance provided is fully translatable to most noise calculation software, any GIS environment and any data management platform. Ultimately, the choice of software is a decision for the responsible authority.

1.4 Responsible Authorities

In relation to policy issues, the responsible authority is the Department of the Environment, Climate and Communications. The Irish Environmental Protection Agency (EPA) is responsible for reporting to the European Commission in order that relevant strategic noise mapping and noise action planning timelines are met. According to the Environmental Noise Regulations 2018 (Government of Ireland, 2018), the EPA's functions are to:

- exercise general supervision over the functions and actions of noise-mapping bodies and noise action planning authorities;
- provide guidance or advice to such bodies and authorities.

It is important to note that, under Irish legislation transposing the END, a distinction is made between strategic noise-mapping bodies and noise action planning authorities. Strategic noise-mapping bodies produce SNMs on behalf of the relevant noise action planning authority. Although the vast majority of mapping bodies are also engaged in action planning (e.g. Dublin City Council – DCC), this is not always the case for all organisations; for example, Transport Infrastructure Ireland (TII) is responsible for the noise mapping of major national roads, but is not involved in action planning, because it is not a designated action planning authority under Irish legislation.

In the context of the Dublin agglomeration, the responsible authorities in relation to the strategic noise mapping process are:

- DCC;
- South Dublin County Council;
- Dún Laoghaire–Rathdown County Council;
- Fingal County Council.

In the context of the Cork agglomeration, the responsible authorities in relation to the strategic noise mapping process are:

- Cork City Council;
- Cork County Council.

In the context of the Limerick agglomeration, the responsible authorities in relation to the strategic noise mapping process are:

- Limerick City Council;
- Limerick County Council.

In the context of major railways, the responsible authorities in relation to the strategic noise mapping process are:

- Irish Rail/Iarnród Éireann for all heavy rail networks;
- TII for all light tram rail networks (i.e. Luas in Dublin city).

In the context of major roads with more than 3 million passages per annum, the responsible authorities in relation to the strategic noise mapping process are:

- TII for classified national roads;
- local authorities for non-national roads.

2 Strategic Noise Mapping under CNOSSOS-EU

2.1 The Environmental Noise Directive and Noise Mapping

In 1996, the European Commission published the Green Paper on Future Noise Policy (EC, 1996) in order to initiate debate around the possibility of developing an environmental noise abatement policy within the EU and, ultimately, to serve as the basis for future legislative proposals. Clearly delineating noise as a pollutant, the document proposed a new framework for noise policy, calling for a directive aimed at harmonising methods of assessing noise exposure across Europe, with the objective of facilitating an open exchange of information across the EU. The document outlined a proposal for noise mapping in order to achieve such objectives and for the provision of information on noise exposure to the wider public. Ultimately, the document aimed to make noise abatement a higher priority in European policymaking.

In 2002, European Commission Directive 2002/49/EC (EU, 2002), known as the END, was adapted into EU law, and MSs became legally obligated to generate SNMs and action plans every 5 years. This legal obligation is necessary so that that new legislation can be tendered and strategies concerning noise abatement are supported and, ultimately, to protect public health. Accordingly, since 2007, EU MSs have been legally obligated to undertake strategic noise mapping every 5 years for all agglomerations with over 100,000 inhabitants, for all roads with over 3 million vehicle passages per annum, for all railways with more than 30,000 passages per annum and for airports with over 50,000 movements per annum. Once generated, these maps can inform action planning strategies aimed at mitigating noise at problem hotspots and identifying and conserving quiet area locations. SNMs and associated noise action planning strategies are fundamental tools for the general public to access and ascertain levels of population exposure to noise in areas of interest.

2.1.1 The case of Ireland

The END has been transposed into Irish national legislation via the European Communities (Environmental Noise) Regulations 2018 [Statutory Instrument (S.I.) 549/2018; Government of Ireland, 2018]. This statutory document transposes the European Commission Directive 2002/49/EC relating to the assessment and management of environmental noise, as amended by European Commission Directive (EU) 2015/996, which establishes common noise assessment methods, replacing Annex II of European Commission Directive 2002/49/EC. The regulations identify those authorities responsible for the development of noise maps and action plans, and outline the role of the Irish EPA in acting as the national authority in supervising and guiding the various noise mapping bodies and action planning authorities.

In accordance with Article 14 of the END, the EPA is also responsible for submitting the required deliverable information to the European Commission in a timely manner. At the national level, the development of noise maps in Ireland has been driven by communication between the various noise mapping bodies and guidance received from the EPA through various meetings, workshops, presentations and documentation. In 2009, the EPA issued guidance notes on noise mapping and action planning (EPA, 2009a,b) aimed at assisting the development of noise maps for delivery during the second phase of noise mapping in 2012. Subsequent guidance was also issued in 2011 (EPA, 2011) and updates were provided in 2017 (EPA, 2017). It is expected that these guidance documents will be updated for CNOSSOS-EU implementation.[3]

2.2 CNOSSOS-EU

Since the publication of the Green Paper on Future Noise Policy in 1996 (EC, 1996), it has been recognised that a common approach for assessing noise levels must be implemented as a matter of

3 Available at http://www.epa.ie/pubs/advice/noisemapping/ (accessed 12 March 2021).

priority in order to improve the effectiveness of the END. Accordingly, the European Commission endorsed the development of CNOSSOS-EU as a standardised noise modelling approach in 2009 in collaboration with the European Environment Agency (EEA), the European Aviation Safety Agency (EASA), the World Health Organization (WHO) Europe and approximately 150 noise experts (Licitra and Ascari, 2018). These developments were presented in a Joint Research Centre Reference report in 2012 (Kephalopoulos *et al*., 2012), which was superseded by the publication of the European Commission Directive (EU) 2015/996 (EU, 2015), representing the legal framework for the implementation of prospective rounds of strategic noise mapping under the END. As such, all EU MSs are obligated to transition from previous national-level assessment methods to the new CNOSSOS-EU standardised methodology. This methodology is to be applied for the fourth round of strategic noise mapping in 2022.

The CNOSSOS-EU method presents a standardised framework for the strategic noise mapping process through the establishment of noise emission terms for road and rail, aircraft, and industrial sources; terms for the assessment of attenuation due to propagation; and terms for the assessment of population exposure. Source models for road and rail were originally developed from the Harmonoise and IMAGINE (Improved Methods for the Assessment of the Generic Impact of Noise in the Environment) projects, whereas propagation models for road, rail and industrial sources were developed from the NMPB 2008 French model. The EEA is preparing the END-INSPIRE noise data model documentation, which aims to update the current data model to fulfil both the END and the INSPIRE Directive. The aircraft source and propagation models were developed in line with the European Civil Aviation Conference 29 (ECAC 29), whereas the assessment of population exposure was developed from the German method for determining the number of people exposed to environmental noise (*Vorläufige Berechnungsmethode zur Ermittlung der Belastetenzahlen durch Umgebungslärm*; VBEB) (Umweltbundesamt, 2007). The CNOSSOS-EU method itself represents the calculation of noise in a frequency band from 125 Hz to 4 kHz for road and rail sources, from 63 Hz to 4 kHz for industrial noise, and from 50 Hz to 10 kHz for aircraft sources (EU, 2015). In general, the CNOSSOS-EU model functions by dividing physical noise sources into corresponding point sources, determining the applicable path of propagation between the point source and the receiver, and generating point-to-point estimations for each path of propagation (Umweltbundesamt, 2007).

2.3 Strategic Noise Mapping

The formal definition of an SNM, as outlined in the END, is “a map designed for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for such an area” (EU, 2002, p. 14). It is important to note the difference between noise mapping and strategic noise mapping; the latter is more definitive, as it pertains to criteria outlined by the END. Generally, noise mapping can be defined as the acoustic representation of a geographic region that is primarily concerned with the presentation of noise levels. Strategic noise mapping, on the other hand, while incorporating the presentation of noise levels, is associated with the mapping and estimation of population exposure to noise. Because it has many separate, yet interrelated, components, strategic noise mapping is better understood in terms of a process, rather than a singular output (Murphy and King, 2014). The most common form of SNM involves the calculation of noise levels of respective sources to receiver points along a systematic grid located over the territory under analysis. These maps use relevant input data and noise modelling methodologies that have, to date, differed between EU MSs, but which, with the introduction of CNOSSOS-EU, have become standardised. Input data primarily consist of information related to annual traffic flow with respect to road, rail and aircraft, as well as vehicle type and speed, road surface and rail type, and stationary or mobile sources with respect to industry. Other input data relate to building dimension, including height, terrain geometry and ground cover, and to barriers and bridges. Maps are usually generated using commercially available software programs that apply embedded algorithms for relevant sources of noise emission and propagation standards applicable in each EU MS. Once generated, these maps can inform action planning strategies aimed at mitigating noise at problem hotspots and identifying and conserving quiet area locations within agglomerations. SNMs and associated noise action planning strategies function as important interactive tools for the general public to

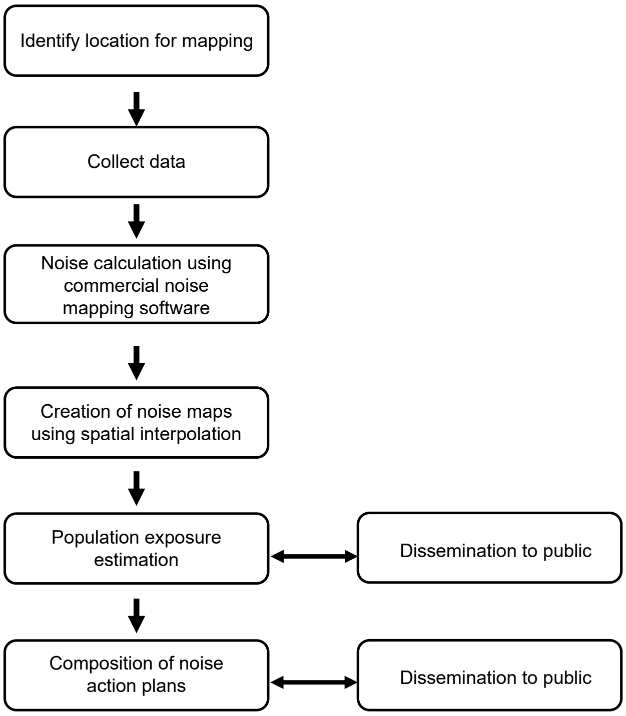


Figure 2.1. Strategic noise mapping.

access and ascertain levels of population exposure to noise in areas of interest. Figure 2.1 outlines the various stages involved in the strategic noise mapping process.

2.4 The Purpose of Strategic Noise Mapping

The primary purposes of the strategic noise mapping process are:

- to provide the European Commission with a strategic estimation of the extent of population exposure to levels of noise from transport sources across the EU in order to inform the development of future noise policy in Europe;
- to provide information to the general public and decision-makers on the level of population exposure to noise locally, nationally and internationally;
- to develop noise action plan strategies informed by the estimation of population exposure statistics in order to mitigate environmental noise where required, and where levels of exposure are deemed likely to incur negative health impacts on the affected population;
- to identify and preserve the integrity of quiet areas within agglomerations.

3 Development of Data Specifications and Production of Datasets[4]

It is important to note that, in the Irish context, datasets used in previous rounds of strategic noise mapping may be used and modified in accordance with changes that have taken place between rounds. This applies to building, barrier and bridge datasets, whereby previous datasets may be used and modified to take account of any additional construction that has taken place in the intervening period. In the case of contour lines and ground cover, previous datasets may be used without modification unless a more accurate dataset is identified.

3.1 Development of Data Specifications

3.1.1 Overview

In order to be able to develop the datasets required for a three-dimensional (3D) model environment to support the assessment of noise from roads and railways, it is first necessary to develop a dataset specification. A specification is based on the various features contained within a noise model and on the object definitions required by the noise calculation software to be used within the project for the specific method of assessment being used.

The data requirements for strategic noise mapping are categorised as follows:

- road sources input data;
- railway sources input data;
- population exposure input data (required to analyse the noise exposure from the results of noise propagation calculation);
- noise model output data.

3.1.2 Input data requirements for the three-dimensional model pathway environment

The road and rail calculation methods require similar information for the definition of the 3D propagation pathway, even though the source information required is unique for each calculation method. The similarity of the datasets required for defining the acoustic pathway can allow for the development of a single unified 3D model environment within which the various noise emission sources are located and propagation to the receivers is assessed. This approach is the basic premise of popular commercial noise-mapping software tools, which enable a variety of noise sources to exist within a single 3D terrain environment. The elements that make up the 3D model environment include:

- digital ground model, consisting of:
  - equal height contour lines;
  - embankment edges;
  - escarpment edges;
  - bridges;
- buildings:
  - polygon objects describing all building footprints within the model;
- ground cover:
  - polygon objects defining areas of acoustically absorbent or reflective ground cover;
- barriers:
  - polyline objects defining barriers such as walls or fences considered to have potential noise-attenuating effects;
- meteorology information on long-term annual average for calendar year under analysis:
  - air temperature;
  - air humidity;
  - air pressure.

4 Sections 3.1 to 3.3 rely heavily on *EPA Guidance Note for Strategic Noise Mapping for the Environmental Noise Regulations (Version 2)* (EPA, 2011; Chapters 6, 7 and 8). The text has been updated where appropriate.

3.1.3 Input data requirements for assessment of road traffic noise

The information required for the source emission model for road traffic under CNOSSOS-EU is as follows:

- traffic volume according to categories 1, 2 and 3, and mean vehicle speed (or speed limit), expressed as annual hourly average day, evening and night traffic flows:
  - road centreline;
  - road classification;
  - road identification (ID);
  - road surface type;
  - road gradient;
  - average speed/speed limit.

3.1.4 Input data requirements for assessment of railway noise

The information required for the source emission model for the rail traffic under CNOSSOS-EU is as follows:

- track data requirements:
  - rail centreline location between the two railheads;
  - track type and support structure;
  - rail roughness;
  - impact noise (location and frequency of joints and switches);
  - bridge location and type;
  - track curvature;
- vehicle data requirements:
  - annual average day, evening and night traffic flows per vehicle type;
  - vehicle type (potentially multiple types per train; e.g. locomotive, self-propelled, hauled);
  - operational speed per vehicle type;
  - vehicle running condition (constant speed or idling);
  - structure transfer;
  - generation of custom vehicle profile catalogue (brake type, wheel measure, number of axles, length, etc.).

3.1.5 Input data requirements for population exposure assessment

The information required includes:

- GeoDirectory[5] "Buildings" table;
- Small Area Population Statistics (SAPS) from Central Statistics Office (CSO) census data.

3.2 Generation of Datasets

3.2.1 Process

As previously stated, in the Irish context the majority of datasets have already been created and will only need to be updated in accordance with new information. However, where new datasets are required to be generated, this will involve an initial collection of the raw GIS, electronic and paper datasets. It is then necessary to collate and catalogue the information available and carry out an audit. The audit process will provide a gap analysis highlighting any data shortcomings, and an indication of the processing requirements of the data. The general areas addressed at this point are:

- an appraisal of the available data, examining issues such as:
  - coverage, resolution, accuracy, attributes, maintenance regime, format, metadata, fitness for purpose;
- a gap analysis to result in details of the data required that are not currently available, and mechanisms for the completion of the input datasets;
- the documentation and appraisal of licence conditions of each of the available datasets to confirm that they may be used within the noise mapping project. Some of the licensing issues that should be considered may include:
  - current and future intellectual property rights (IPRs), residual IPRs, use for what purpose and restrictions on other users and subcontractors, maintenance of data, duration of licence term, residual rights after expiry, internet access, public availability.

5 See https://www.geodirectory.ie/ (accessed 17 February 2021).

Following the appraisal, gap analysis and resolution of licensing issues, the input datasets need to be completed in line with the approved approach. This could be via a number of different routes:

- extended licensing of existing datasets for additional coverage or improved currency;
- data-capture programs to fill gaps in the available datasets;
- interpolation or processing of raw datasets to produce relevant derived data products.

The European Commission Working Group Assessment of Exposure to Noise *Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure* (version 2) (WG-AEN GPG v2) (WG-AEN, 2007) presents a number of toolkits that provide a series of options for sources of genuine data or guidance on interpolation or use of default datasets. Many WG-AEN GPG v2 toolkits provide quantified accuracy statements, where the impact on the acoustic quality of the results is indicated alongside the description of the option in order for the quality of the strategic noise mapping to be estimated. In general, it is recommended that the best approach available, with the lowest uncertainty, should be used. Where interpolation or default values are used, following the use of WG-AEN GPG v2 toolkits, it is recommended that a review is undertaken to investigate other potential sources of data, and balance the relevant costs and benefits of these sources.

3.2.2 Ordnance Survey Ireland datasets

A wide range of mapping products is available for use within strategic noise mapping. Some of these may be available under existing licensing schemes with suppliers; others may require additional licensing to be taken out. Some of the datasets that may prove useful include the following:

- Ordnance Survey Ireland (OSi) PRIME2. Contains all the data that were previously managed in:
  - OSi large-scale database;
    - 1:1000 scale in urban areas;
    - 1:2500 in suburban areas;
    - 1:5000 in rural areas;
  - OSi boundaries;
    - county, electoral division and townland boundaries;
  - small-scale dataset (Ireland core/Discovery);
  - address database;
- OSi high-resolution orthophotography;
  - 25 cm per pixel;
- OSi light detection and ranging (LiDAR);
  - laser-scanned remote sensing height or elevation data;
  - 2 m postings in urban areas;
  - 10 m postings in rural areas;
- OSi discovery height data;
  - 10 m gridded digital terrain model (DTM).

3.2.3 Base model – digital ground model

The foundation of the 3D model environment is the DTM, describing the ground elevation across the mapping area. DTMs are generally available in three formats:

- points;
  - regular grids derived from orthophotography;
  - higher resolution regular or irregular grids derived from LiDAR survey;
- breaklines;
  - 3D polylines that describe “edges” or transitions in terrain gradient, derived from orthophotography (Ordnance Survey of Northern Ireland enhanced DTM product is an example);
- contours;
  - equal height ground contours provided as two-dimensional (2D) polylines with a height attribute;
  - OSi LiDAR 1 m contour datasets.

Point datasets generally need processing in order to produce breakline or contour line datasets; however, these can be of a higher resolution than generally available contour datasets. Noise mapping calculation involves the assessment of source to receiver propagation paths, which is inherently searching for edges (of buildings, embankments, cuttings, etc.) to break the direct line of sight and provide screening. For this reason, experience with breakline products has generally produced efficient noise models. In general, the higher the resolution of the source dataset, the better the quality of the resulting ground model. This conclusion is demonstrated within the quantified accuracy statements in WG-AEN GPG v2 for Toolkits 7, 11 and 12.

3.2.4 Base model – buildings

The buildings dataset is an important layer for the development of a 3D noise model. For noise mapping in Ireland, buildings may be identified within the OSi PRIME2 product by querying the feature codes. Most noise mapping software systems require 2.5D closed vector polygon building objects; this is a 2D vector polygon with a height attribute.

There are typically a number of issues that can arise when preparing buildings datasets. They are as follows:

- Polyline buildings. OSi PRIME2 may be delivered in Drawing Interface Format (DXF), AutoCAD Drawing Database (DWG) format or National Transfer Format (NTF). It is good practice to check and confirm polygon integrity in a GIS.
- Building polygons split across tiles. This is where individual building footprints cross tile boundaries. Buildings may not be supplied as a single polygon, but rather as separate polygon objects split along the tile boundaries.
- Incorrect feature code classifications. Instances can arise where buildings do not have the relevant feature code, or other objects have been attributed with the buildings' feature code. These types of issues can be difficult to identify unless the buildings in question are large, or manual checking is undertaken against aerial photography.
- Height data. OSi PRIME2 is supplied as a 2D dataset, without height data. Buildings need to be 3D objects and are often set with a single height attribute. The height data may be derived from detailed LiDAR datasets, detailed site surveys or field surveys of the numbers of storeys or estimated building heights. WG-AEN GPG v2 Toolkit 15 provides guidance on the impact on accuracy of the various approaches.

3.2.5 Base model – topography and ground/land cover

For Ireland, there are three widely available datasets that could be utilised for developing the ground cover dataset. These are:

- OSi PRIME2. This dataset consists of 1:1000, 1:2500 or 1:5000 scale vector mapping. Areas of acoustically soft ground may be identified and extracted for use in the noise mapping.
- OSi Digi City. This dataset consists of 1:15,000 scale raster mapping. Large areas of acoustically soft ground may be identified and carried through into the mapping.
- OSi LiDAR. LiDAR is a remote sensing technology that uses laser scanning to collect height or elevation data. Our LiDAR data are supplied in Irish Grid (IG) and Irish Transverse Mercator (ITM) in ASCII (American Standard Code for Information Interchange) file format, with postings of 2 m (although this is not exclusively the case) and a minimum vertical accuracy of 25 cm. The final outputs from the point cloud are either a DTM or a digital surface model. For technical reasons, LiDAR data may not be available in all areas of the country.
- CORINE (Coordination of Information on the Environment).

The EEA's CORINE Land Cover 2000 dataset is a European-wide vector land parcel product derived from satellite imagery raster to vector (R2V) processing. The CORINE dataset was developed in the framework of the CORINE programme to establish a computerised inventory on land cover. The dataset was used for making environmental policy and other policies, including regional development and agriculture policies. For noise calculation, the dataset can be used to provide information on the land cover distribution. The various classes of land cover need to be reviewed and a value, or G factor, of acoustic ground absorption assigned to each as an attribute.

In addition to these datasets, there is also the guidance provided within WG-AEN GPG v2 Toolkit 13. It is recommended that all available sources are investigated and tests undertaken within the noise mapping software to assess the relative complexity of the datasets, impact on processing time and any difference in calculated noise level that occurs through using the different products.

3.2.6 Base model – barriers

The WG-AEN GPG v2 has quantified accuracy statements for WG-AEN GPG v2 toolkits for road traffic and railway noise calculations. The importance of correctly identifying the height attributes of potential screening objects in the vicinity of road and railway corridors is clearly stated within the WG-AEN GPG v2 toolkits and the commendations for data quality, particularly relating to the edges of cuttings and the tops of barriers. The inclusion of noise barriers within the models influences the calculation results; the noise barriers are also relevant within the process of noise action planning. It is therefore recommended that the noise model should include noise barrier information, where possible, in the vicinity of road, rail and industrial sources within the agglomeration, and in the vicinity of major sources outside the agglomeration. OSi data and orthophotography are not currently of sufficient resolution to enable consistent identification of these features. Therefore, a field survey is recommended as an appropriate means of capturing barrier data. WG-AEN GPG v2 Toolkit 14 provides guidance on the means by which barrier heights may be assessed and WG-AEN GPG v2 Toolkit 16 provides guidance on setting sound absorption coefficients. They also provide quantified accuracy statements to demonstrate the impact on the uncertainty of the calculated results.

In the context of Luas light rail system and national roads outside agglomerations, information regarding the geometry of barriers may be obtained from TII databases. In terms of the horizontal position of noise barriers, TII reports that construction contract protocol depends on a maximum horizontal tolerance of ±15 mm to road source, with a <0.3 m margin of error in relation to barrier height. Therefore, recorded dimensions are relatively accurate. In other contexts, information on noise barriers and other non-acoustic barriers (e.g. walls) may be acquired using field surveys or aerial photography analysis. In this regard, datasets are available for previous rounds of SNM and may be updated accordingly.

3.2.7 Base model – bridges

Bridge objects are required to carry and support 2.5D road and rail emission lines over cuttings or junctions within some of the commercial noise mapping software systems. Bridges are not explicitly identified within OSi data products and therefore bridge datasets may need to be manually created. It is recommended that bridge locations, relative heights and orientations are initially identified from field surveys and aerial photography investigation. In the context of rail sources, Irish Rail and TII (Luas Tram Rail) have these required datasets. This may then be followed by manual ground model checking and bridge structure digitisation in accordance with the dataset specification.

3.2.8 Base model – meteorology

Meteorology data are required for the assessment of road and rail sources. In general, three pieces of meteorology data are required in order to satisfy the data requirements of the methods. These are:

1. air temperature;
2. air humidity;
3. air pressure.

As the noise level assessment is undertaken on the basis of a long-term annual average, the meteorology data are required as an annual average. Annual metrological information for any location can be acquired from 1 of 25 Met Éireann weather observation stations located across the country and available online. For CNOSSOS-EU modelling, annual averages pertaining to temperature, atmospheric pressure and humidity are required.

3.2.9 Road traffic noise modelling

The road traffic model is built using road centrelines, which should generally be midpoint between the two opposing carriageways for a standard two-way road, or the centre of the carriageway for a one-way road. The noise mapping software should then use the centreline location. The road centrelines are available from OSi. The road centreline objects are attributed with information on the road surface, velocity and vehicle composition. The road centreline object must be split each time one of these attributes changes to ensure that the information is accurate.

The road surface data are required for each road section and may be captured by close proximity measurements (CPXs) or statistical pass-by measurements. WG-AEN GPG v2 Toolkit 5 provides guidance on the range of methods available, along with quantified accuracy statements associated with the use of each method. The road gradient may normally be derived from interfacing the road centrelines with the terrain model. For each road section, traffic flow data are required for three vehicle categories in the Irish context [light vehicles, medium–heavy vehicles and heavy vehicles (HVs)], for the three time periods: day, evening and night. For each time period, it is also necessary to know the average speed of each vehicle type.

WG-AEN GPG v2 Toolkits 2, 3 and 4 and NANR 93[6] provide guidance on the methods available for determining input data for road traffic flow, average traffic speed and composition of traffic. They also provide quantified data accuracy guidelines to help illustrate the potential impact on calculation uncertainty associated with the various options. Traffic flow data may be provided from manual or automated traffic counts, traffic flow models such as the National Transport Authority (NTA) model, or traffic forecasting models. Care needs to be taken in consolidating these various sources, as they may hold data in different formats, including 24 hours, 18 hours, annual average daily traffic, a.m. peak, p.m. peak, off-peak, weekday, weekend, 7 day, etc. It is commonly required to apply factors to flows to provide a common base situation and undertake linking of traffic flow data to the road centreline geometry. It is recommended that traffic counts undertaken in the future have regard to the requirements of strategic noise mapping to help prepare the required data in a suitable format, at least in the vehicle categories and time periods required by the calculations.

Traffic speed information may be available from traffic forecasting models or from journey time databases. In the absence of other speed data, it is common practice to use the speed limit of the road section as a basis for setting a default mean vehicle speed. Alternatively, it may be possible to drive the network with global positioning system (GPS) logging equipment to estimate vehicle speeds.

3.2.10 Railway noise modelling

The information required for modelling the railway sources is predominantly related to the trains and the track. The track-related information is commonly held by the infrastructure management section, whereas the train information is often held by the train operations section. The rail centrelines are to be modelled as the location of the emission and this is generally midpoint between the two railheads of the line. Rail centrelines may be acquired from the infrastructure departments of Irish Rail and TII. Information on physical aspects of the railway line are also required, and are assigned as attributes to the rail centreline:

- track type and support structure;
- rail roughness;
- impact noise (location and frequency of joints and switches);
- bridge location and type;
- track curvature.

When these attributes change, the rail centreline will need to be segmented at the point of change in attribute. For each section of rail centreline, it is required to assign the train movements that use the track. The number of train movements is required per vehicle type and per time period (day, evening and night) on an annual average basis. For each vehicle type, for each time period, it is also necessary to know the average operational speed over the section of track and the running condition of the vehicle. Some of this information may be available from train timetables, train network modelling systems or trackside train sensing systems. Some of this information, such as the classification data needed to profile each vehicle type, may need to be captured through interviews with personnel from the various train operation sections. Data such as brake type, wheel measure, number of axles and length should be attainable from the various vehicle data specification documents.

At the present time, the CNOSSOS-EU database contains a relatively small example of predefined vehicle categories based on the rolling stock commonly in service across Europe. It is not necessarily the case that these categories equate to the rail vehicles in service in Ireland. This leaves the Noise Management Board (NMB) with a choice of either selecting the predefined vehicle categories that appear to approximate those in the Irish context or developing a national dataset of vehicle emission categories suitable for use with CNOSSOS-EU. It is at the practitioner's discretion to decide whether

6 Department for Environment, Food and Rural Affairs (Defra) Research Project NANR 93, available at http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=13248&FromSearch=Y&Publisher=1&SearchText=wg-aen&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description (accessed 10 March 2021).

or not the default vehicle categories referenced within the CNOSSOS-EU database are sufficiently representative of the Irish fleet. It must be noted that, at the current time, these are estimates based on the Extrium project[7] for the Directorate-General for Environment and have not been validated. All rail vehicles classified within the RMR (*Reken- en Meetvoorschrift Railverkeerslawaai* – Railway Noise Modelling Method) 1996 interim method are represented in most noise prediction software packages within the CNOSSOS-EU database; therefore, if these have been deemed appropriate in the past, it is possible to translate the RMR classification to CNOSSOS-EU. However, some modifications to the rail vehicle classification catalogue may still be required; for instance, the Luas Light Rail Tram consists of multiple bogies that cannot be detached and therefore the relevant vehicle category parameters (i.e. number of axles and length) need to be tuned in order to account for this.

3.2.11 Data capture through field survey

It is recommended that, where possible, data gaps are filled through the undertaking of a field survey to capture data. The type of information captured by a field survey could include noise barriers in the following locations: alongside major roads, alongside railways, and adjacent to industrial sites. Location and relative height should also be determined for the following:

- road surface type: categories as per the assessment method;
- additional road and rail information: junctions, bridges, flyovers, underpasses and tunnels.

3.3 Development of Datasets within a Geographic Information System Environment

3.3.1 General GIS datasets

The following list sets out a review of the typical problems associated with the use of generic GIS datasets within noise modelling:

- Fractured link data. Road and rail centrelines datasets can often suffer from fractured link–node models, with a series of polylines describing one flow link. To simplify the model, reduce errors and increase calculation speeds; the concatenation of the links should often be investigated.
- Gradient correction. The correct assessment of gradient often requires the “draping” of the road/rail centreline onto the underlying DTM. This process should always be managed, rather than left to automatic interpretation, during the calculation run, as small links within polylines can result in localised excess gradient.
- Road/rail structure geometry. Cuttings, embankments and flyovers can be constructed from the linear polyline features received from the OSi load. This enables the simple construction of complex 3D geometry in order to accurately deal with road structures. Bridges can also be automatically generated from road axis data, even using 3D road polyline objects.
- Ground height definitions. Ground and model object height definitions can be managed in a variety of different formats: relative, absolute, single point, 3D polylines, triangulated irregular network (TIN) and meshes.

3.3.2 Base model – digital ground model

An accurate ground model is important in developing an effective noise model. It is necessary for the determination of the bare ground surface and the assessment of relative building heights, especially within detailed urban areas. The key components of an optimised digital ground model for noise modelling are as follows:

- The model should contain a series of equal height contour lines.
- The model should contain 3D polylines to describe the edges of features such as cuttings and embankments that would act as screens to sound propagation.
- The model should also contain bridges to carry road and rail emission lines over cuttings or junctions. These elements need to be economically described within the dataset, with a minimum of redundant nodes, and provide a degree of spatial accuracy that affects the acoustic accuracy of the results at or below a level

7 See http://www.extrium.co.uk/index.html (accessed 17 February 2021).

equivalent to the other datasets. Some types of data optimisation pre-processing steps that could be normally carried out are:

- Line smoothing, which uses an algorithm to remove redundant node information (within a tolerance of, say, 0.5 or 1 m horizontal displacement). This can be an important factor for improving model performance without loss of overall model accuracy and, hence, enabling the production of effective noise models.
- Editing of the ground contour model in the agglomerations often needs to have been carried out; this requires the editing/removal of spurious contours and/or the addition of key bridge features. This process concentrates on acoustically important features that are not well defined by the available contour data. These include bridge overpasses and underpasses and cuttings located on/near principal road and rail routes.

3.3.3 Base model – buildings

In addition to the ground model, the buildings layer is one of the most important layers necessary for the development of an accurate and effective noise model. There are a number of issues relevant to noise modelling that can typically arise within building datasets. These aspects are discussed below.

Building height

Building height attribution can present issues such as:

- lack of real building height data;
- zero-height buildings;
- excessively high buildings;
- inconsistencies in building heights along terraces.

Building objects located on road or rail features

Extensive previous work with OSi PRIME2, OS Land Line and OS Master Map suggests that there can often be issues with objects in the buildings layer being located across the road or rail emission lines, and broken road and rail centrelines that do not extend below bridges. When developing a buildings layer, checks are often required to identify and correct features such as those below, which often find themselves in the buildings theme:

- footbridges between buildings;
- footbridges over rivers;
- footbridges over roads and railways;
- electricity pylons;
- elevated road signs.

Although these represent a small number of objects, the presence of these features can introduce noticeable error into the final noise maps. Caution does need to be exercised, however, as sometimes buildings do correctly straddle road or railway emission lines, so they cannot all be removed without due consideration.

3.3.4 Base model – ground/land cover

There are several potential sources for ground cover information that may be applicable.

- The CORINE dataset. This is a 1:100,000 scale European-wide digital land cover product derived from Landsat Thematic Mapper imagery. The minimum size of a CORINE land parcel is 25 ha.
- The vegetation database contained within the OSi PRIME2 product. Vegetation depiction is more detailed than that of the CORINE dataset, with boundaries accurate to ±0.4 m, a minimum area of 0.1 ha, a minimum width of 5 m and a vegetation type indicator in the form of spatially associated symbology.
- Generation of a new land cover dataset from aerial photography. Recent experience with OSi PRIME2- and OSi Master Map-derived datasets has raised issues regarding the complexity of the raw dataset in the context of noise propagation modelling. Test calculations have also indicated that the simplified CORINE dataset can be used within agglomerations with very little change in calculated noise level.

3.3.5 Base model – barriers

The WG-AEN GPG v2 presents quantified accuracy statements for road traffic noise calculations. One of the key outcomes was an understanding of the importance of correctly identifying the height attributes of potential screening objects in the vicinity of the road corridor, particularly the edges of cuttings, or the tops of barriers. As noted previously, the inclusion of noise barriers within the model will not only influence the calculated results, but is also relevant within the process of noise action planning. As such, a fit-for-purpose noise model would normally need to have noise barrier information suitable for the calculation of road, rail, industry and port noise within the agglomerations, and in the vicinity of major roads and railways outside agglomerations.

3.3.6 Noise source layer – roads

Although the ground model, buildings and ground cover data layers are key components of the noise modelling process, spatially accurate and populated source term information (i.e. road traffic flow and condition data) is crucial to the development of an effective noise map to meet the purposes of the END. There are a number of issues relating to the use of generalised GIS datasets for road traffic noise sources, as discussed in this section.

Road traffic flows

Gaining access to road traffic flow parameters for all the required roads can be problematic. In the absence of such information, default values may be assigned to the input datasets. One potential approach for determining default values could be that outlined in the WG AEN GPG v2 Toolkit 2, Tool 5, to assess assumed traffic flow levels using a graduated approach.

Other road attributes

In addition to road traffic flow, there are several additional attribute fields that will be important to the effective development of road noise maps within the agglomeration areas and the strategic road corridors. These are:

- road surface type;
- road gradient;
- average speed/speed limit; and
- vehicle category.

Height attribute

An efficient road layer will also contain information on the relative height of each road segment. This is particularly important for road sections that cross bridge features. The attribution is normally the result of GIS processing to create and attribute correctly road segments that either traverse a bridge or follow ground contours. Using the output of the cutting process, a manual exercise is typically required to correctly assign attribute values to each of the road segments.

Geometry

As discussed in WG-AEN GPG v2, available road traffic network models that hold information on vehicle flows and speeds are often based on a link-node format where nodes may be located in approximately relevant geometrical locations such as junctions, whereas the links are generally straight lines between the nodes, unlike real roads. An example is shown in Figure 3.1. In this situation, it is necessary to overlay the traffic flow information from the geometrically inaccurate flow model onto the geometrically accurate road centreline dataset. This is normally a semi-automated method that may require a high level of manual intervention and checking.

3.3.7 Noise source layer – railways

The OSi rail centreline data contain both individual railheads (a pair of parallel polylines per track) and a route centreline (one polyline at the centre of the route corridor, irrespective of how many tracks there are). There are a number of issues relating to the use of generalised GIS datasets for rail noise sources, which are discussed in this section.

Figure 3.1. An example of an accurate digital road network model (brown) and an inaccurate road traffic network model (green). Source: based on WG-AEN (2007, p. 19).

Track curvature

Previous rail models did not factor track curvature into the model calculation parameters. This will be a new requirement for the 2022 round of strategic noise mapping. Track radius information can be acquired directly from the track departments of Irish Rail and TII. This information is reported to be highly accurate.

Rail roughness

The acquisition of accurate rail roughness values can prove problematic across a large network. Rail roughness has a significant effect on the noise emission values and therefore roughness or corrugation surveys should be conducted to better understand the contributions to emissions. Where this proves to be too labour intensive or there is insufficient budget to complete this, an "average network" value may be selected.

Bridges and impact noise

It is known that augmentation of rolling noise levels can occur when trains pass over different types of track, joints/switches or structures such as bridges. This augmentation is also related to the type of locomotive and rolling stock, and to the train speed. Impact noise and other resultants of changes to track type also have a significant effect on noise emission levels; therefore, their position, frequency and type should be rigorously checked.

Height attribute

An efficient railway layer will also contain information on the relative height of each rail segment. This is particularly important for railway sections that cross bridge features. The attribution is normally the result of GIS processing to create and attribute correctly rail segments that either traverse a bridge or follow ground contours. Using the output of the cutting process, a manual exercise is typically required to correctly assign attribute values to each of the rail segments.

3.4 CNOSSOS-EU Templates for Road and Rail

3.4.1 Road sources

The following items may be populated in the attribute table (i.e. dBASE file) of respective road polyline shapefiles intended for importation into a noise propagation software package for CNOSSOS-EU calculation (see tables in Figure 3.2).

- IDENT – road segment identifier, e.g. primary or secondary network;
- DESCR – name of the road segment, e.g. Dorset Street Upper;
- HDEF – values for height definition may be selected from within the software;
  - 0 – relative height, with the height of the item being relative in regard to the calculated terrain level;
- GRADIENT – gradient of road segment;

IDENT	DESCR	ISOH	IOSM	HDEF	GRADIENT	Surface

Q_1_1	V_1_1	Q_1_2	V_1_2	Q_1_3	V_1_3	Q_1_4	V_1_4	Fstud_1

Q_2_1	V_2_1	Q_2_2	V_2_2	Q_2_3	V_2_3	Q_2_4	V_2_4	Fstud_2

Q_3_1	V_3_1	Q_3_2	V_3_2	Q_3_3	V_3_3	Q_3_4	V_3_4	Fstud_3

Figure 3.2. Road sources attributes. Source: WG-AEN (2007).

- Surface – road surface type [for Ireland, the Dutch classification SMA-NL8 (SMA, stone mastic asphalt)– i.e. R-n105-sma-nl8 – may be selected for the current time; code = 5];
- Q_1_1 – hourly traffic flow of category 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V_1_1 – average speed of category 1 vehicles representing L_{day}/speed limit;
- Q_1_2 – hourly traffic flow of category 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V_1_2 – average speed of category 1 vehicles representing $L_{evening}$/speed limit;
- Q_1_3 – hourly traffic flow of category 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V_1_3 – average speed of category 1 vehicles representing L_{night}/speed limit;
- Q_2_1 – hourly traffic flow of category 2 vehicles representing L_{day};
- V_2_1 – average speed of category 2 vehicles representing L_{day}/speed limit;
- Q_2_2 – hourly traffic flow of category 2 vehicles representing $L_{evening}$;
- V_2_2 – average speed of category 2 vehicles representing $L_{evening}$/speed limit;
- Q_2_3 – hourly traffic flow of category 2 vehicles representing L_{night};
- V_2_3 – average speed of category 2 vehicles representing L_{night}/speed limit;
- Q_3_1 – hourly traffic flow of category 3 vehicles representing L_{day};
- V_3_1 – average speed of category 3 vehicles representing L_{day}/speed limit;
- Q_3_2 – hourly traffic flow of category 3 vehicles representing $L_{evening}$;
- V_3_2 – average speed of category 3 vehicles representing $L_{evening}$/speed limit;
- Q_3_3 – hourly traffic flow of category 3 vehicles representing L_{night};
- V_3_3 – average speed of category 3 vehicles representing L_{night}/speed limit.

3.4.2 Rail sources

The following items may be populated in the attribute table (i.e. dBASE file) of the rail polyline shapefiles intended for importation into a noise propagation software package for CNOSSOS-EU calculation (see tables in Figure 3.3).

- IDENT – rail segment identifier;
- DESCR – name of the rail segment;
- HDEF – values for height definition should be selected from the following:
  - 1 – absolute height. The height of the item (above the fixed 0-level) is the entered value. The height of the item above terrain level is the entered absolute height minus the calculated terrain level.
  - 0 – relative height. The height of the item is relative in regard to the calculated terrain level.
  - 2 – relative to item directly below. The entered height will be added with the highest height of the items directly below. In case there is no item directly below, the height of the item is relative with regard to the calculated terrain level.
  - 3 – user defined. Two values have to be entered. The first value is the terrain height; the second value is the height of the item above the terrain level. This option is equal to the implemented method in Predictor-LimA version 4.
- TRAIN1 – train type (for Ireland one of the CNOSSOS-EU categories should be used);
- RC1 – running condition of the vehicle (constant speed or idling);
- Q1_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V1_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T1_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q1_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V1_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T1_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q1_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V1_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T1_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- TRAIN2 – train type (for Ireland one of the CNOSSOS-EU categories should be used);
- RC2 – running condition of the vehicle (constant speed or idling);
- Q2_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);

IDENT	DESCR	ISOH	IOSM	HDEF

TRAIN1	RC1	Q1_P1	V1_P1	T1_P1	Q1_P2	V1_P2	T1_P2	Q1_P3
V1_P3	**T1_P3**	**Q1_P4**	**V1_P4**	**T1_P4**				

TRAIN2	RC2	Q2_P1	V2_P1	T2_P1	Q2_P2	V2_P2	T2_P2	Q2_P3
V2_P3	**T2_P3**	**Q2_P4**	**V2_P4**	**T2_P4**				

TRAIN3	RC3	Q3_P1	V3_P1	T3_P1	Q3_P2	V3_P2	T3_P2	Q3_P3
V3_P3	**T3_P3**	**Q3_P4**	**V3_P4**	**T3_P4**				

TRAIN4	RC4	Q4_P1	V4_P1	T4_P1	Q4_P2	V4_P2	T4_P2	Q4_P3
V4_P3	**T4_P3**	**Q4_P4**	**V4_P4**	**T4_P4**				

TRAIN5	RC5	Q5_P1	V5_P1	T5_P1	Q5_P2	V5_P2	T5_P2	Q5_P3
V5_P3	**T5_P3**	**Q5_P4**	**V5_P4**	**T5_P4**				

RCURVE	TRACK	STRUCT	ROUGH	IMPACT	BRIDGE

Figure 3.3. Rail sources attributes.

- V2_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T2_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q2_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V2_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T2_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q2_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V2_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T2_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- TRAIN3 – train type (for Ireland one of the CNOSSOS-EU categories should be used);
- RC3 – running condition of the vehicle (constant speed or idling);
- Q3_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V3_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T3_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q3_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);

- V3_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T3_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q3_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V3_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T3_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- TRAIN4 – train type (for Ireland one of the CNOSSOS-EU categories should be used);
- RC4 – running condition of the vehicle (constant speed or idling);
- Q4_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V4_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T4_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q4_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V4_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T4_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q4_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V4_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T4_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- TRAIN5 – train type (for Ireland one of the CNOSSOS-EU categories should be used);
- RC5 – running condition of the vehicle (constant speed or idling);
- Q5_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V5_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T5_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q5_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V5_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T5_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q5_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V5_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T5_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- RCURVE curve radius in metres;
- TRACK – track transfer (classifies the track construction);
- STRUCT – structure transfer;
- ROUGH – rail roughness;
- IMPACT – impact noise [relates to amplified rail sources (e.g. rail joint, single switch)];
- BRIDGE – bridge constant.

4 Modelling Road Sources under CNOSSOS-EU: Data Needs Assessment and Recommendations

4.1 Identify Areas to Be Mapped

EU MSs have been charged with the legal obligation to produce SNMs every 5 years for all agglomerations with over 100,000 inhabitants, and for all roads with over 3 million vehicle passages per annum.

4.1.1 Areas to be mapped

In order for road sources that are under investigation to be accurately calculated, it is important to consider input data from areas beyond the boundary of the measured source. Such areas are referred to as buffer zones. The Noise-Adapt project recommends that parameters regarding fetching radius and buffer zone correspond, and that all local authority areas within agglomerations use a standardised buffer zone and fetching radius parameter.

> For future rounds of strategic noise mapping, and in the context of Irish agglomerations, the Noise-Adapt project recommends setting the buffer zone to a minimum of 1000 m and also setting the fetching radius at 1000 m.[8]

4.2 Data Collection

Primary data collection requirements for road sources include:

- annual traffic flow;
- vehicle classification under CNOSSOS-EU;
- average speed per vehicle class;
- road centreline;
- road surface type.

Input data primarily consist of information related to annual traffic flow in respect to road and rail, as well as vehicle type and speed, road surface and rail type. Other input data relate to building dimension, including height, terrain geometry and ground cover, as well as to barriers and bridges. In some cases, data may not be available for certain input parameters. In such cases, default input values and assumptions are acceptable "if the collection of real data is associated with disproportionately high costs" (EU, 2015, p. 5).

4.2.1. Annual traffic flow

Under the CNOSSOS-EU methodology, traffic flow data will be required separately for day, evening and night periods.[9]

Within agglomerations

Within agglomerations, DCC, for example, uses the Sydney Coordinated Adaptive Traffic System (SCATS) to estimate the total volume of road traffic at 1100 junctions across the city, covering an area of 122 km². Total traffic volume is calculated every 15 minutes over a 24-hour period. In previous rounds of strategic noise mapping, DCC has used annual survey counts at 33 key locations across the city in order to estimate the percentage of HVs. For strategic noise mapping, average hourly values over the survey period from 07:00 to 19:00 are applied as a percentage to each hour of the SCATS data for an 18-hour period, on which, historically, the Calculation of Road Traffic Noise (CRTN) L10 18Hr calculations were based. The previously utilised CRTN method was based on 18-hour traffic flows. Under the CNOSSOS-EU methodology, such estimations must be applied to a 24-hour cycle. According to the EPA, all four Dublin local authorities have access to SCATS. Cork City Council and Cork County Council have TII count data and historical count site data, which were used to supplement the round 2 traffic data. Most, if not all, of the local authorities also need to extrapolate, gap fill and extend the actual traffic data available in

8 If the model is not tiled it may be necessary to set the fetching radius to 125% of the buffer zone.

9 If data are unavailable for day/evening/night periods and/or for 24-hour cycles, consult TII (TII, 2016).

order to have traffic flow data to complete the road network included in the round 3 noise models.

Figure 4.1 illustrates the distribution of the SCATS system across the Dublin agglomeration. It shows how the system is extensive across the Dublin city local authority area. In the Dún Laoghaire–Rathdown area, data are available along major routes; however, in South Dublin and Fingal, the SCATS system is poorly represented in relative terms.

Outside agglomerations

Outside agglomerations, TII provides hourly traffic counts at 328 traffic counters for all national road networks. Data are publicly available to download from https://www.nratrafficdata.ie/c2/gmapbasic.asp?sgid=ZvyVmXU8jBt9PJE$c7Uxt6 (accessed 22 January 2020). If count data are unavailable for non-national roads, they may be estimated using field count surveys.

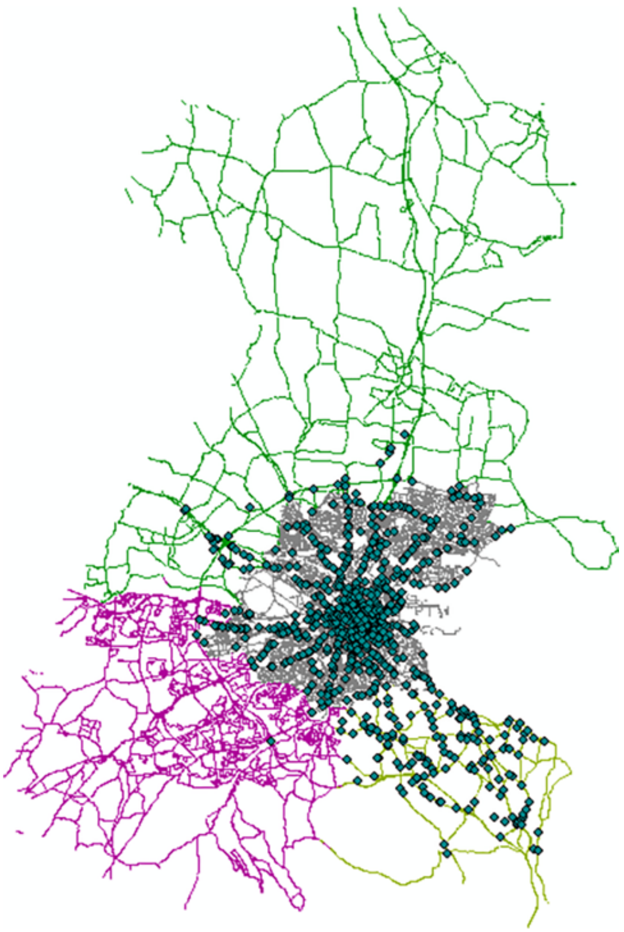


Figure 4.1. SCATS distribution across the Dublin agglomeration. Road polylines are based on round 3 data supplied by local authorities. SCATS point data were acquired online from https://data.gov.ie/dataset/scats-sites-coordinates (accessed 17 May 2020).

4.2.2 Vehicle classification under CNOSSOS-EU

The UK CRTN 1998 methodology used for strategic noise mapping in Ireland from 2007 to 2017 applied two vehicle categories: one for light vehicles and one for HVs. By way of contrast, the CNOSSOS-EU methodology applies five vehicle categories. The fifth vehicle classification is prospective, as the proportion of hybrid or electric vehicles on European roads is currently insignificant.

The five vehicle classifications under CNOSSOS-EU are as follows:

1. light motor vehicles – passenger cars, delivery vans < 3.5 tonnes, sport utility vehicles, multi-purpose vehicles, trailers and caravans;
2. medium–heavy vehicles – delivery vans > 3.5 tonnes, buses, touring cars, etc., and vehicles with two axles and twin tyre mounting on rear axle;
3. HVs – heavy-duty vehicles, touring cars, buses and vehicles with three or more axles;
4. powered two-wheelers – (1) mopeds, tricycles or quads < 50 cc and (2) motorcycles, tricycles or quads > 50 cc;
5. open category – the development of vehicles using electric traction (either hybrid electric vehicles or totally electric). Currently there are no data available for such vehicles in Europe.

Within agglomerations

In order to categorise HVs into categories 2 and 3, additional and specifically tailored traffic count exercises must be conducted. In order to ascertain the priority of such an exercise, the Noise-Adapt project performed sensitivity analyses for scenarios where the proportion of HVs was well above average in the context of Dublin city (i.e. 10% HVs). It was found that categorising HVs into various proportions (i.e. 50/50, 30/70, 70/30) and at various velocities did not significantly change the total road source emission value. For example, at a velocity of 50 km/h and

60 km/h, the estimated emission value between HVs categorised by 50/50 to 30/70 showed an average differential of just 0.3 decibel(A) [dB(A)], and those categorised by 50/50 to 70/30 showed an average differential of –0.2 dB(A), at six receiver points (see Appendix 1, Table A1.2).

> Therefore, if accurate categorisation is not possible, the Noise-Adapt project recommends that current HV flow information may be equally separated into two categories (i.e. 50/50).

This recommendation is supported by European Commission guidelines (EC, 2010, p. 39).

Regarding category 4 vehicles, sensitivity analyses were performed in a scenario whereby 5% of total traffic flow was represented by motorcycles. The results indicated that category 4 vehicles had a negligible effect on the total road source emission value. For example, at a velocity of 50 km/h and 60 km/h, with and without category 4 vehicles included, results showed an average differential of just 0.1 dB(A) and 0.1 dB(A), respectively, at six receiver points (see Appendix 1, Table A1.3).

> Therefore, if data are not available for category 4 vehicles, the Noise-Adapt project recommends that the category may be excluded in the Irish context, particularly considering that category 4 vehicles represent a minimal proportion of vehicles in the Irish fleet.[10]

This recommendation is also supported by European Commission guidelines (EC, 2010, p. 39).

Outside agglomerations

Outside agglomerations, TII's vehicle classification system is based on a EURO 6 (plus motorbike) classification scheme. Vehicle classification is based on a number of factors that traffic counters are capable of measuring. These measured factors include vehicle length, chassis code and vehicle profiling. Combined, the system is commonly known as a loop profiling classifier. The system measures each factor, compares it with a preset classification table and bins the vehicle into a particular category. For the most part, classification is not based on weight; it is primarily based on length.

Currently, vehicles are categorised under the following class headings:

1. MBIKE – motorbikes;
2. CAR – passenger cars and small goods vehicles;
3. LGV – large goods vehicles;
4. BUS – buses, including minibuses;
5. HGV_RIG – heavy goods vehicles with rigid trailers;
6. HGV_ART – heavy goods vehicles with articulated trailers;
7. CARAVAN – caravans.

With this classification system there are limits on the accuracy of certain classes given the wide variety of vehicles in transit at any given time. However, the TII Strategic Transport Planning Department reports that it can supply data on national roads in line with the CNOSSOS-EU classification system.

4.2.3 Average speed

Within agglomerations

According to European Commission Directive (EU) 2015/996, the average speed per vehicle category should be used in the estimation of road source emission values (EU, 2015, pp. 7–8). In the context of agglomerations, Dublin and Cork do not currently operate speed monitoring systems. In order to record average speed, a network of vehicle speed monitors would have to be installed in each agglomeration in Ireland. In order to ascertain the priority of such an implementation, sensitivity analyses were performed utilising a number of velocity scenarios in a case study area within Dublin city. It was found that altering the velocity of vehicles did not significantly change the total road source emission

10 According to figures from the CSO (2017), a total of 63,474 new category 4 vehicles (1.77% of total vehicle registration) were registered in Ireland between 1997 and 2017.

value. For example, at velocities of 44 km/h to 50 km/h and 50 km/h to 60 km/h, the estimated total emission value resulted in differentials of just 0.4 dB(A) and 0.8 dB(A), respectively, at six receiver points (see Appendix 1, Table A1.4). In this respect it must be noted that European Commission Directive (EU) 2015/996 also states that “if local measurement data is unavailable the maximum legal speed for the vehicle category shall be used” (EU, 2015, p. 8).

> Therefore, in the Irish context, the Noise-Adapt project considers it acceptable to use the signposted speed limit within agglomerations as a measure of vehicle speed per vehicle category if average speed cannot be accurately quantified.

Outside agglomerations

Vehicle speed is an output of the TII’s traffic monitoring unit and it should therefore should be utilised for roads outside agglomerations

4.2.4 Identification of traffic light and roundabout junctions

According to European Commission Directive (EU) 2015/996 2.2.5, “before and after crossings with traffic lights and roundabouts a correction shall be applied for the effect of acceleration and deceleration” (EU, 2015, p. 11). Before such correction terms are applied, the first task for practitioners is to identify the various intersection types in each agglomeration. Such spatial identification is a particularly resource-intensive exercise, and it was therefore considered prudent to ascertain the evidence base for applying such measures. This was achieved by way of a direct measurement campaign performed at a single-lane traffic light intersection and a single-lane roundabout intersection within Dublin city in order to examine the margin of error involved in applying, and not applying, correction coefficients for each intersection to the CNOSSOS-EU model. Results from both experiments indicated that the CNOSSOS-EU model converges closely with measurement data when the correction coefficients for traffic light and roundabout intersections are removed. For example, in relation to the traffic light intersection experiment, the results indicated that the CNOSSOS-EU model overestimated by an average of 1.5 dB(A) when correction coefficients were applied, whereas the model overestimated by an average of 0.1 dB(A) when correction coefficients were removed (see Appendix 1, Table A1.9). Likewise, with respect to the roundabout intersection experiment, the CNOSSOS-EU model was found to overestimate by an average of 1.5 dB(A) when correction coefficients were applied, whereas the model overestimated by 1.4 dB(A) when correction coefficients were removed (see Appendix 1, Table A1.10) For a full description of experimental set-up please see *Transitioning to Strategic Noise Mapping under CNOSSOS-EU (Noise-Adapt)* (full report), available at http://www.noisemapping.ie/useful-outputs.html. This indicates that applying correction coefficients to traffic light and roundabout intersections does not improve the accuracy of results. These results are applicable to representative road typologies (e.g. primary roads). Results may not be applicable for unrepresentative road typologies (e.g. no through roads). However, the latter typology is not relevant for such an application.

> Therefore, the Noise-Adapt project recommends that it is acceptable not to apply correction coefficients for traffic light and roundabout intersections at the current time, as their application does not improve the accuracy of results. This alleviates the requirement to identify traffic light and roundabout junctions within agglomerations.

4.2.5 Road surface type

The current version of the CNOSSOS-EU database contains a table of the following 15 road surface coefficients αi, m and βm based on the Dutch road calculation method (see EU, 2015, pp. 126–127):

1. 0 – reference road surface;
2. nl01 – one-layer permeable concrete (*zeer open asfaltbeton* – zoab);
3. nl02 – two-layer zoab;
4. ni03 – two-layer zoab (fine);
5. nl04 – sma-nl5;
6. nl05 – sma-nl8;

Table 4.1. CNOSSOS-EU road surface sensitivity analysis – R108 medium–heavy traffic flow analysis LA_{eq} dB(A)

Measurement points	nl01	nl02	nl03	nl04	nl05	nl06	nl07	nl08	nl09	nl10	nl11	nl12	nl13	nl14
1	72.1	68.2	65.9	71.2	71.9	73.4	72	72.5	74.6	74	77.3	71.3	69.8	68.5
2	72.1	68.2	66	71.2	72	73.4	72	72.6	74.6	74	77.4	71.4	69.8	68.5
3	72.2	68.3	66	71.2	72	73.5	72.2	72.6	74.7	74.1	77.4	71.4	69.8	68.6
4	72.5	68.6	66.4	71.6	72.4	73.8	72.4	73	75	74.4	77.8	71.8	70.2	69

Note: shading denotes most appropriate road surface type.

7. nl06 – brushed down concrete;
8. nl07 – optimised brushed down concrete;
9. nl08 – fine-broomed concrete;
10. nl09 – worked surface;
11. nl10 – hard elements in herringbone;
12. nl11 – hard elements not in herringbone;
13. nl12 – quiet hard elements;
14. nl13 – thin layer a;
15. nl14 – thin layer b.

The Noise-Adapt project considers road surface type nl05 – sma-nl8 as most appropriate in the Irish context relative to other road types within the currently available CNOSSOS-EU database.

Table 4.1 describes a number of sensitivity analyses performed at four receiver points and based on the Dutch classification table. These sensitivity analyses indicate that results for road surface type nl05 converge closely with those for nl01, nl04, nl06, nl07, nl08, nl10, nl12 and nl13. On the other hand, results diverge between nl05 and nl02, nl03, nl09, nl11 and nl14. Considering the data that are currently available, and which are based solely on the Dutch classification table, and considering the sensitivity analysis in Table 4.1, the Noise-Adapt project recommends that nl05 – sma-nl8 road surfaces types are appropriate until such a time that more specific local information becomes available. Practitioners may wish to apply Irish-specific road surface corrections, for which upcoming guidance is expected to be delivered, whereby rolling α and β values based on CPX measurements and statistical pass-by testing are generated. This process requires the translation of current road categories to spectral α and β coefficient octave bands and would involve applying pre-existing data that measure the interaction of physical parameters and noise emission (Olsen, 2015). TII is aiming to undertake this work in 2020/2021.

5 Modelling Rail Sources under CNOSSOS-EU: Data Needs Assessment and Recommendations

5.1 Identify Area to Be Mapped

EU MSs have been charged with the legal obligation to produce SNMs every 5 years for all railways with more than 30,000 passages per annum.

5.1.1 Areas to be mapped

In order for rail sources under investigation to be accurately calculated it is important to consider input data from areas beyond the boundary of the measured source. As mentioned in relation to road sources, such exterior areas are often referred to as buffer zones. The Noise-Adapt project recommends that parameters regarding fetching radius and buffer zone correspond, and that all noise mapping bodies use a standardised buffer zone and fetching radius parameter common to all local authority areas. For future rounds of strategic noise mapping, in the context of both within agglomerations and outside agglomerations, it is recommended to set the buffer zone to a minimum of between 750 and 1000 m and also setting the fetching radius to 750 to 1000 m. Finally, it is important to ensure that all shapefile data, particularly buildings, correspond to the SAPS area location surrounding the rail sources to ensure that an accurate estimation of population, based on building perimeter, can be accomplished.

5.2 Data Collection

The primary data collection requirements for rail sources are as follows:

1. rail centreline location;
2. track transfer;
3. structure transfer;
4. rail roughness;
5. impact noise;
6. bridge constant;
7. track curvature;
8. rail vehicle type under CNOSSOS-EU;
9. vehicle length;
10. number of axles;
11. number of rail vehicles;
12. operational speed per rail vehicle;
13. running condition.

Input data primarily consist of information related to annual traffic flow, vehicle type and speed, and rail surface and type. Other input data relate to building dimension, including height, terrain geometry and ground cover, as well as to barriers and bridges. As is the case for road sources, default input values and assumptions are accepted “if the collection of real data is associated with disproportionately high costs” (EU, 2015, p. 5).

5.2.1 Track properties

Track property input data are held by the infrastructure departments of Irish Rail and TII (Luas Tram Rail). Such data include rail centrelines, which are determined as the midpoint between the two railheads of the source line. Physical aspects of rail tracks are assigned as attributes of the rail centreline. Where attributes alter, the rail centreline is segmented at the point of change and relevant track parameters are assigned.

Rail centreline location

Rail centrelines can be acquired from data used by TII and Irish Rail in previous rounds of strategic noise mapping and modified for any new track or track changes. Values for rail height can be generated through the integration of rail polylines onto a terrain model within a noise mapping software environment.

Track transfer

TII and Irish Rail have categorised relevant sections of track in accordance with the Dutch RMR standard for rail noise. Although the current version of the CNOSSOS-EU database contains varying track base types, not all are present in some noise modelling software packages. Predictor-LimA has 10 analogous track types to choose from, namely (1) empty track transfer function, (2) minimum (min), (3) maximum (max), (4) mono-block sleeper on soft rail pad, (5) mono-block sleeper on medium stiffness rail pad, (6) mono-block sleeper on hard rail pad, (7) bi-block sleeper on soft rail pad, (8) bi-block sleeper on medium stiffness rail pad, (9) bi-block sleeper on hard rail pad and (10) wooden sleeper. According to TII and Irish Rail, in the context of both the Luas Tram Rail and Irish Rail networks, ballasted track types would be most accurately represented by (6) "mono-block sleeper on hard rail pad". In the context of Luas Tram Rail, there are numerous track types that are not represented within the currently available CNOSSOS-EU database, namely embedded track and slab track. Results from a sensitivity analysis indicated that selecting parameters for "mono-block sleepers on soft rail pad" resulted in a 1–1.5 dB(A) emission increase when compared with "mono-block sleepers on hard rail pads" (see Appendix 1, Table A1.5).

Therefore, in the absence of the required parameters within the CNOSSOS-EU model (present in the RMR model), the Noise-Adapt project recommends that, for the scenario of embedded and slab track sections, the parameter of "mono-block sleeper on soft rail pad" is selected.

Future versions of noise prediction software may include a larger updated catalogue. Additionally, TII plans to undertake research in the area of identifying and classifying track properties (namely slab and embedded track) for the Irish context in relation to the Luas network.

Structure transfer

Data are not currently collected for vehicle or structure transfer parameters in the Irish context. According to Thompson (2008), superstructure noise emission from rail vehicles had negligible contributions in terms of wayside noise when compared with the dominant source at the wheel/rail region. Sensitivity analyses also determined that, apart from imputation of the "maximum" parameter within the noise prediction software, all other parameters were found to produce identical rail source emission results (see Appendix 1, Table A1.6). Therefore, it may not be considered feasible to conduct the necessary surveys in order to ascertain structure transfer parameters in the Irish context unless desired.

For the present time, the Noise-Adapt project recommends that the "CNOSSOS-EU default" parameter is used with respect to structure transfer.

Rail roughness

As stated in WG-AEN GPG v2, "The difference in sound emission from well-maintained rails and wheels to similar but poorly maintained rails can be 10 dB or more. Consequently, it is of great importance to establish and use the correct data on rail conditions" (WG-AEN, 2007, p. 26). In relation to rail roughness, under the CNOSSOS model, the five available parameters are (1) empty rail roughness, (2) min, (3) max, (4) EN ISO (International Organization for Standardization) 3095:2013 and (5) average network. Sensitivity analysis demonstrated that the "average network" rail roughness parameter is 1.5 dB(A) higher than the EN ISO 3095:2013 parameter. The most accurate approach in the allocation of rail roughness values for modelling is to conduct experiments to best capture track roughness for various sections of track. In the absence of these data, it is recommended that the "average network" parameter be selected, as it is most representative of the Irish Rail network. However, this parameter may not be suitable for particular track sections and, thus, alternative parameters may need to be applied where appropriate (e.g. in sections where roughness is known to be particularly problematic). In the context of the Luas Tram Rail network, periodic corrugation surveys have shown the default upper limit curve for rail roughness within EN ISO 3095:2013 to be well exceeded in many Irish locations. Therefore, in such cases it is necessary to create a custom rail roughness parameter for use within the XML (extensible markup language) rail track catalogue for the case of the Luas Light Rail network.

Impact noise

Information regarding the location of impact noise generated from vehicles passing over crossings, switches and rail joints may be obtained from TII and Irish Rail databases. This is a new requirement under CNOSSOS-EU. The presence of a single crossing, switch or joint can be the most dominant contribution to rolling noise, as has been observed through sensitivity analysis using noise prediction software (see Appendix 1, Table A1.8). The noise prediction software package offers four parameters, namely (1) empty impact noise, (2) min, (3) max and (4) single switch/joint/crossing/100 m. It should be noted that the CNOSSOS-EU model provides an additional rail roughness element based on joint density per length of track. It is possible to account for the additional number of discontinuities per 100 m by the addition of $10^{\log(n)}$, where *n* is the number of discontinuities, at all wavelengths to the database default spectrum "single switch/joint/crossing/100 m" (Paviotti *et al.*, 2015). This can be achieved by modifying the default rail track XML catalogue or by adhering to the recommendation outlined in Paviotti *et al.*'s impact noise look-up table. This table describes how sections of track with jointless rails should be allocated the parameter of "min". For sections of track with one or two joints or discontinuities per 100 m the parameter for "single switch/joint/crossing/100 m" is recommended, whereas for sections of track with more than two joints or discontinuities per 100 m the "max" value is recommended (see Paviotti *et al.*, 2015). Finally, it should be noted that future software updates may be provided to allow better usability of this parameter.

Bridge constant

Information regarding bridge type and location may be obtained from TII and Irish Rail databases. The CNOSSOS-EU database offers five categories for bridge constant, namely (1) empty bridge constant, (2) min, (3) max, (4) predominantly concrete or masonry bridges with any track form and (5) predominantly steel bridges with ballasted track.

> For the Irish context the Noise-Adapt project recommends inputting the relevant bridge constant where applicable with classification data acquired from the aforementioned datasets. For the majority of rail track where no bridge is present, the "empty bridge constant" category should be applied.

Track curvature

The CNOSSOS-EU model recommends the application of 8 dB(A) for a track curve radius less than 300 m, and 5 dB(A) for a track curve radius between 300 m and 500 m. Previous strategic noise mapping rounds did not factor squeal as a result of track curvature into the source models.

> It is recommended that the appropriate track curvature is applied for all of the Irish Rail network where a curve with less than 500 m is present.

The application of the 8 dB(A) and 5 dB(A) (flat spectrum) refers to heavy rail only. For the case of the Luas Light Rail Network, vehicles use onboard lubrication systems to mitigate squeal emission. Additionally, trams tend to squeal only in curves with radii that are much less than for heavy rail (Verheijen and van Beek, 2019). As recommended in Verheijen and van Beek (2019), a more suitable application of squeal for light rail vehicles would be a 5 dB(A) (flat spectrum) penalty applied to track curves with radii less than 200 m, and no squeal penalty applied to track curves with radii greater than 200 m. It has been noted that, for the case of the Luas Light Rail network, the presence of squeal owing to the curve radius of track section is an issue on only some curved track sections, whereas other curved track sections of the same radius have been observed to exhibit no additional noise owing to squeal. This can possibly be attributed to variations in track design and construction methods implemented over the Red and Green line networks. On account of this phenomenon, and the limited number of curves across the Luas network, it is deemed practicable to undertake direct measurements and compile site-specific data relating to the contribution of squeal to rail source emission.

5.2.2 Vehicle properties

Data regarding vehicle property values can be obtained from train operators in Irish Rail and TII (Luas Tram Rail). In relation to this, vehicle movements are required to be assigned to respective sections of track. The number of vehicle movements is required per vehicle category, and annual average hourly information is required per time period for the following: L_{day}, $L_{evening}$, L_{night} and L_{den}. For each vehicle category and time period, operation vehicle speed over each section of track must also be ascertained. The number of vehicle carriages and vehicle operating conditions (i.e. constant speed or idling) must also be determined. Such information may be acquired from train timetables, train network modelling systems and/or from trackside train sensing systems. The CNOSSOS-EU database currently contains a limited set of vehicle categories. Different software packages, such as Predictor-LimA, have expanded the CNOSSOS-EU calculation method database to include converted previous RMR classification.

> However, as these unverified converted classification categories may not accurately equate with vehicles operating within the Irish fleet, it is recommended that a review be conducted and a modified analogous rail vehicle XML catalogue created to best represent the Irish fleet in its entirety.

It has been noted that TII plans to undertake testing of the Irish fleet in 2020. Various European Committee for Standardization (CEN) standards are being developed in an effort to create harmonised methods for the measurement and classification of rail vehicles; some include EN ISO 3095:2013 and EN 15610:2019. With this in mind, it was outlined in a letter report from the Dutch National Institute for Public Health and the Environment in 2019 (Kok and van Beek, 2019) that the European Commission will take the initiative in creating guidance documents in response to a lack of vehicle type database information under the CNOSSOS-EU methodology.

Rail vehicle type under CNOSSOS-EU

Directive (EU) 2015/996 L 168/12 (EU, 2015, p. 12) states that a vehicle is defined as "any single railway subunit of a train (typically a locomotive, a self-propelled coach, a hauled coach or a freight wagon) that can be moved independently and can be detached from the rest of the train". However, in the case of vehicle subunits that are part of a non-detachable set (e.g. which share a single bogie), they should be grouped as a single vehicle for the purpose of calculation. It must be emphasised that descriptors are defined as, and correspond to, the properties of respective vehicles. This affects the acoustic directional sound power per metre length of the equivalent source line modelled. Previously, Ireland had used the RMR train classification to map the Irish fleet for suitable model conditions. Table 5.1 outlines potential vehicle identification and categorisation for both RMR and the new CNOSSOS-EU method with respect to the Irish fleet.

CNOSSOS-EU classification has allowed for further granularity in relation to the newly split categories for diesel multiple units (DMUs) and InterCity Railcars (ICRs) with respect to the Irish Rail fleet. The noise prediction software allocates preset values for each vehicle type, whereby further customisation (e.g. number of axles, length of vehicle) is possible through the modification of catalogue XML files for both rail vehicle and track.

For each of the 20 vehicle classifications within the CNOSSOS-EU database, it is possible to modify the following descriptors and parameters within the vehicle XML catalogue file:

Table 5.1. Rail vehicle type CNOSSOS-EU/RMR-1996

Irish fleet	CNOSSOS-EU train category	SNM rounds 1–3 RMR train category
DART EMUs	10	8
DMUs	8	6
ICRs	19	6
Mk4s	14	3
Freight	15	4
Luas Tram	20	7

DART, Dublin Area Rapid Transit; DMU, diesel multiple unit; EMU, electric multiple unit; ICR, InterCity Railcar; Mk4, Mark IV InterCity train.

1. ID = unique identification of the vehicle;
2. Code = vehicle code short description (informative);
3. Description = vehicle type long description (informative);
4. P_mech = power in kilowatts (informative);
5. V_max = max speed in kilometres per hour (informative);
6. Weight = weight in tonnes (informative);
7. Length = length in metres;
8. Axles = number of axles;
9. WheelDiameter = in millimetres (informative);
10. WheelDiameterCode = diameter in millimetres (large, medium, small) (informative);
11. WheelMeasure = wheel measures (none, wheelDampers, screens, other) (informative);
12. BrakeCode = brake type (castIronBlock, compositeBlock, disk) (informative);
13. Load = load in kilonewton (informative);
14. RefTransfer = reference to table "VehicleTransfer";
15. RefContact = reference to table "ContactFilter";
16. RefRoughness = reference to table "WheelRoughness";
17. RefTraction = reference to table "TractionNoise";
18. RefAerodynamic = reference to table "AeroDynamicNoise".

Although analogous settings for train types are available within a CNOSSOS-EU default vehicle XML catalogue (automatically generated when a new model is created), the Noise-Adapt project recommends that a modified rail vehicle XML catalogue is created to better represent the Irish fleet in its entirety. The parameters required to be tuned for each vehicle classification include vehicle type, number of axles per vehicle, brake type and wheel measure.

To acquire these data, it may be necessary to undertake direct measurement campaigns for the varying rolling stock within the Irish context. Efforts are being made by working group CEN/TC 256/WG3[11] to create harmonised standards that outline appropriate measurement methods that can be used to more accurately categorise vehicle types.

Vehicle length

The average rail vehicle length per category should be imputed into the CNOSSOS-EU modified vehicle XML catalogue under the relevant classification categories. In the context of Luas Tram Rail, a second category identical to category 20 should be created to mirror all the values except the train length and number of axles. This should be completed in order to correctly model the Citadis 401/402 trams (length = 45 m/axles = 8) relative to the Citadis 502 trams (length = 55 m/axles = 10).

Number of axles

As mentioned previously, the number of axles per vehicle should be imputed to the CNOSSOS-EU modified vehicle XML catalogue under the relevant classification categories.

Number of rail vehicles

The number of vehicle types should be imputed for each track section, for each time period and on an annual average basis (i.e. L_{day}, $L_{evening}$, L_{night} and L_{den}). The noise prediction software implementation of the CNOSSOS-EU model stipulates hourly average number of vehicles of each type. This information can be obtained from timetable data provided by train operators from Irish Rail and TII.

Operation speed per rail vehicle

Average vehicle speed measured as kilometres per hour should be imputed for each vehicle type, for each track section, for each time period and on an annual average basis (i.e. L_{day}, $L_{evening}$, L_{night} and L_{den}). These data can be obtained from train operators from

11 Non-exclusive relevant standards within WG3; EN 15610:2019 – Rail and wheel roughness measurement related to noise generation; EN ISO 3095:2013 – Measurement of noise emitted by rail-bound vehicles.

Irish Rail and TII, as well as from datasets used for previous rounds of strategic noise mapping.

Running condition

Parameters associated with running condition within the noise prediction software currently include (1) constant speed, (2) accelerating, (3) decelerating and (4) idling. However, it should be noted that Commission Directive (EU) 2015/996 L 168/21 (EU, 2015, p. 21) accounts only for parameter inputs relating to constant speed or idling.

> The Noise-Adapt project recommends that the relevant running condition (i.e. constant speed or idling) is applied to all modelled vehicles per section of track in the Irish fleet.

Round 3 SNM railway shapefile data for running condition and operating speed per vehicle per section of track have sufficient resolution at present.

6 Road Source Calculation Using Commercial Software

6.1 Importing Data

Once all relevant information has been collected, the data should be inputted into a noise calculation software program. Once a project has been created within the software program, the first step is to import all relevant data in order to generate a noise map within the software application (see Figure 6.1). On the “File” menu a number of import options are available, including “Shape file”, “MapInfo file” and “Text file”. In previous rounds of strategic noise mapping, Irish authorities have utilised Esri shapefiles.

When importing shapefiles, it must be specified which item type the shapefile is referring to. In the Irish context, local authorities should primarily be dealing with the following item types: (1) roads, (2) buildings, (3) height lines, (4) ground regions, (5) barriers and (6) bridges (see Figure 6.2).

Once an item type is specified, file attributes (i.e. “File Field”) should be matched to the analogous “Item Field” within the noise calculation software (see Figure 6.3). If file attributes are labelled under the same headings as noise calculation software, “Item Field” label attributes are automatically attached; if file attributes are labelled under different headings, then attributes must be attached manually.

Road shapefile polylines for CNOSSOS-EU modelling should contain the following information:

- IDENT – road segment identifier;
- DESCR – name of the road segment;
- HDEF values for height definition, which should be selected from the following:
  - 1 – absolute height. The height of the item (above the fixed 0-level) is the entered value. The height of the item above terrain level is the entered absolute height minus the calculated terrain level.
  - 0 – relative height. The height of the item is relative to the calculated terrain level.
  - 2 – relative to item directly below. The entered height will be added with the highest height of the items directly below. In case there is no item directly below, the height of the item is relative with regard to the calculated terrain level.
  - 3 – user defined. Two values must be entered. The first value is the terrain height; the second value is the height of the item above the terrain level.
- GRADIENT – gradient of road segment;
- Jtype – not applicable;
- Jdist – not applicable;

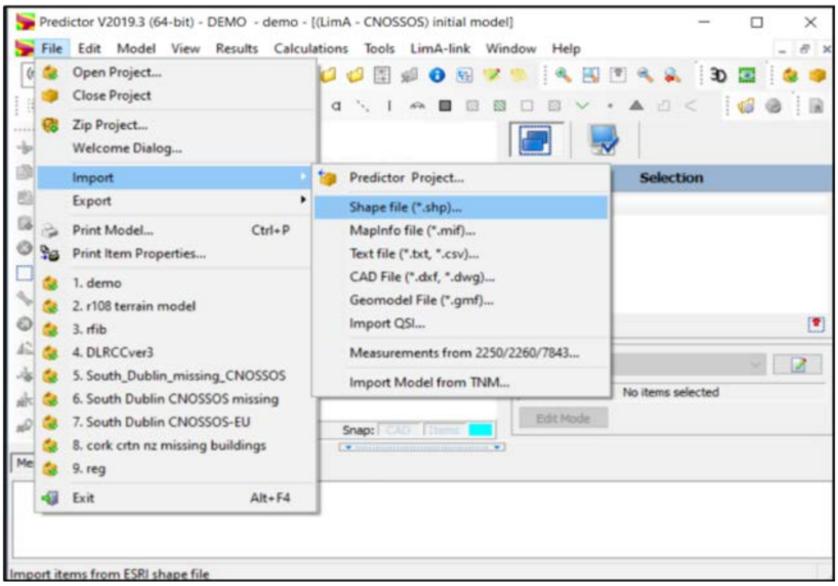


Figure 6.1. Importing data.

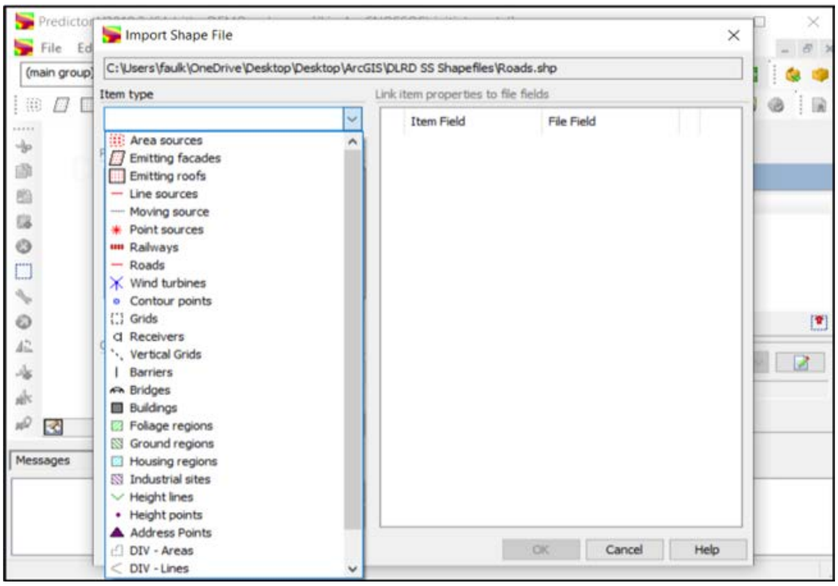


Figure 6.2. Importing data – item type.

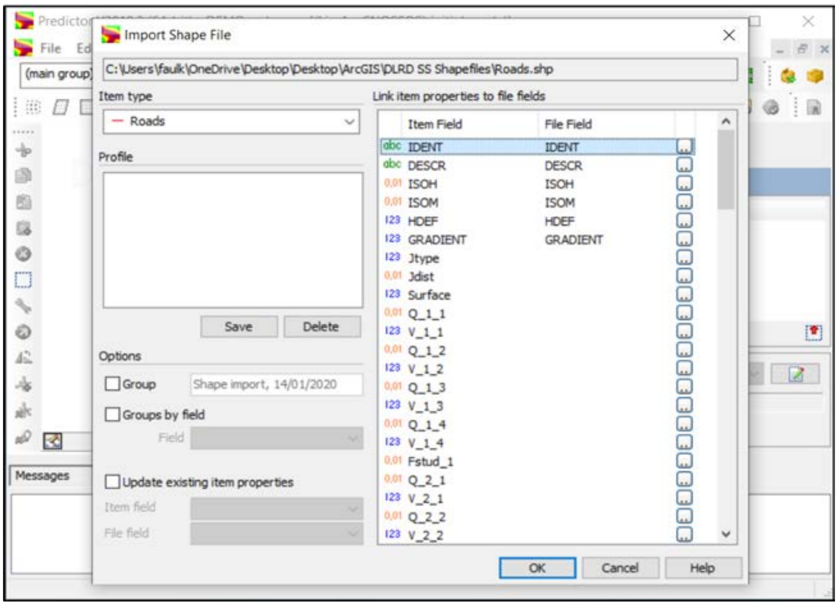


Figure 6.3. Importing data – file field.

- surface – road surface type [for Ireland, the Dutch classification SMA-NL8 (i.e. R-n105-sma-nl8) may be selected for the current time];
- Q_1_1 – hourly traffic flow of category 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V_1_1 – average speed of category 1 vehicles representing L_{day}/speed limit;
- Q_1_2 – hourly traffic flow of category 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V_1_2 – average speed of category 1 vehicles representing $L_{evening}$/speed limit;
- Q_1_3 – hourly traffic flow of category 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V_1_3 – average speed of category 1 vehicles representing L_{night}/speed limit;
- Fstud_1 – not applicable;
- Q_2_1 – hourly traffic flow of category 2 vehicles representing L_{day};
- V_2_1 – average speed of category 2 vehicles representing L_{day}/speed limit.;
- Q_2_2 – hourly traffic flow of category 2 vehicles representing $L_{evening}$;

- V_2_2 – average speed of category 2 vehicles representing $L_{evening}$/speed limit;
- Q_2_3 – hourly traffic flow of category 2 vehicles representing L_{night};
- V_2_3 – average speed of category 2 vehicles representing L_{night}/speed limit;
- Fstud_2 – not applicable;
- Q_3_1 – hourly traffic flow of category 3 vehicles representing L_{day};
- V_3_1 – average speed of category 3 vehicles representing L_{day}/speed limit;
- Q_3_2 – hourly traffic flow of category 3 vehicles representing $L_{evening}$;
- V_3_2 – average speed of category 3 vehicles representing $L_{evening}$/speed limit;
- Q_3_3 – hourly traffic flow of category 3 vehicles representing L_{night};
- V_3_3 – average speed of category 3 vehicles representing L_{night}/speed limit;
- Fstud_3 – not applicable.

Building shapefile polylgons for CNOSSOS-EU modelling should contain the following information:

- IDENT – building identifier;
- DESCR – description or name of building;
- HEIGHT – height of building;
- GRNDLVL – terrain level of building (if buildings are entered using "absolute heights" there is no need to apply GRNDLVL);
- HDEF – height definition of building:
  - 1 – absolute height. The height of the item (above the fixed 0-level) is the entered value. The height of the item above terrain level is the entered absolute height minus the calculated terrain level.

Height line shapefile polylines for CNOSSOS-EU modelling should contain the following information:

- IDENT – contour line identifier;
- DESCR – description of contour line;
- ISOH – ISO height of contour line.

Ground region shapefile polylgons for CNOSSOS-EU modelling should contain the following information:

- IDENT – ground region identifier;
- DESCR – description of ground region;
- GRND – ground factor G values should be imported; however, if this is not possible, then ground type should be selected from the following default options:
  - 0.0 – A – very soft (snow- or moss-like);
  - 0.01 – B – soft forest floor (short, dense heather-like or thick moss);
  - 0.02 – C – uncompacted loose ground (turf, grass, loose soil);
  - 0.03 – D – normal uncompacted ground (forest floors, pasture field);
  - 0.30 – E – compacted field and gravel (compacted lawns, park area);
  - 0.70 – F – compacted dense ground (gravel road, parking lot, ISO 10844);
  - 0.99 – G – hard surfaces (most normal asphalt, concrete);
  - 1.00 – H – very hard and dense surfaces (dense asphalt, concrete, water).

Barrier shapefile polylines for CNOSSOS-EU modelling should contain the following information:

- IDENT – barrier structure or device identifier;
- DESCR – description of barrier structure or device;
- HDEF – height definition of barrier:
  - 1 – absolute height. The height of the item (above the fixed 0-level) is the entered value. The height of the item above terrain level is the entered absolute height minus the calculated terrain level.

Bridge shapefile polygons for CNOSSOS-EU modelling should contain the following information:

- IDENT – bridge identifier;
- DESCR – description of bridge;
- HDEF – height definition of bridge:
  - 1 – absolute height. The height of the item (above the fixed 0-level) is the entered value. The height of the item above terrain level is the entered absolute height minus the calculated terrain level.

6.2 Assigning Grid Points for Strategic Noise Mapping

Once input data have been imported into the noise calculation software, the process of calculating an SNM can begin. In the "Edit" menu, enter "Add Item" and select "Grid", ensuring that "Grids" and

"Grid points" are selected in "Display Options" (see Figure 6.4).

When drawing the calculation grid, right-click the mouse to choose which format the grid should be generated in. The grid should cover the entire area to be calculated. Once the grid has been generated, enter the "Properties" menu in the "Grid" dialogue menu. The *Good Practice Guide for Strategic Noise Mapping* (WG-AEN, 2008) recommends that the distance between grid points be no more than 10 m × 10 m (see Figure 6.5).

6.3 Assigning Receiver Points to the Façades of Buildings for Estimation of Population Exposure

Once input data have been imported into the noise calculation software, the process of assigning receiver points to the façades of buildings can commence. Note

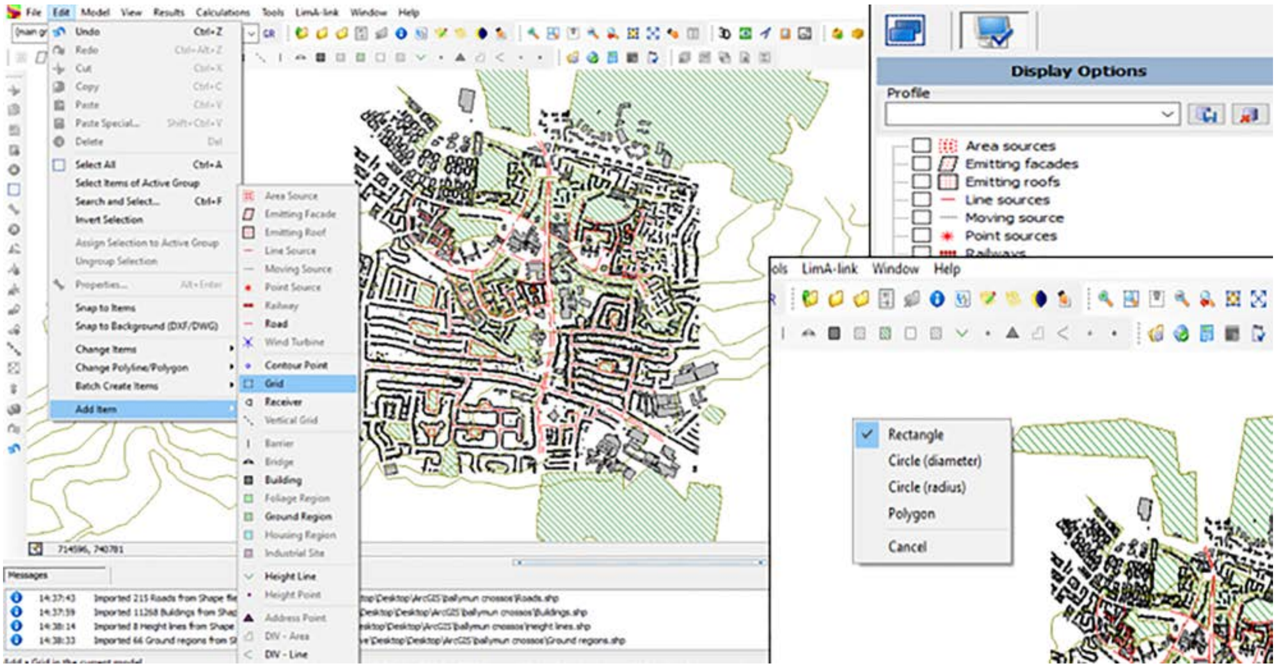


Figure 6.4. Assigning grids.

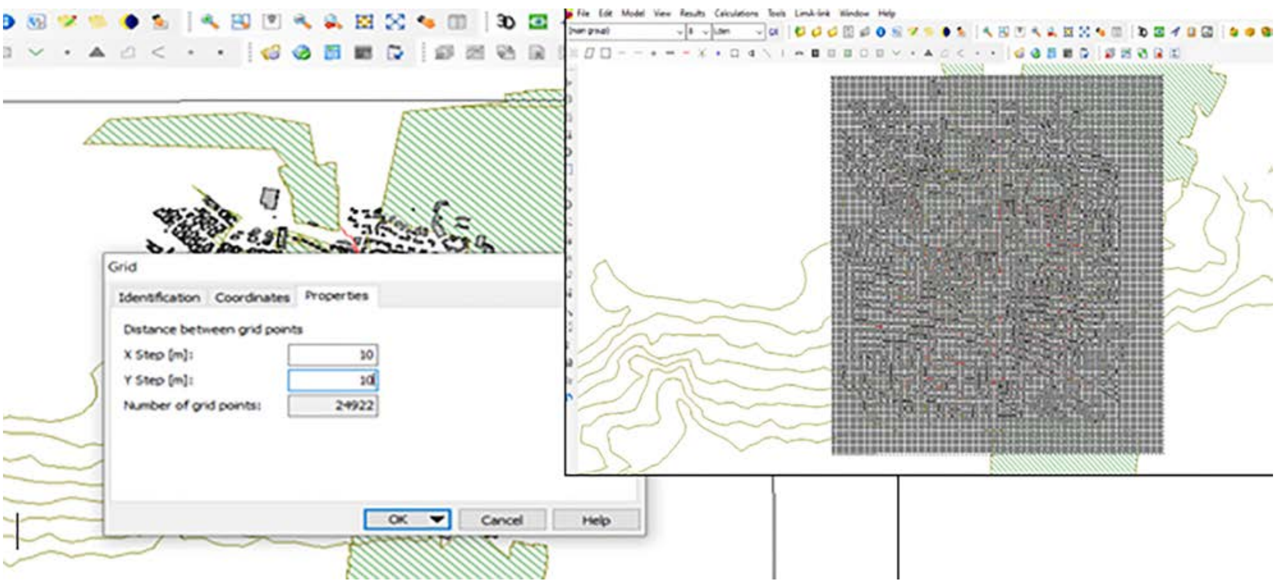


Figure 6.5. Grid properties.

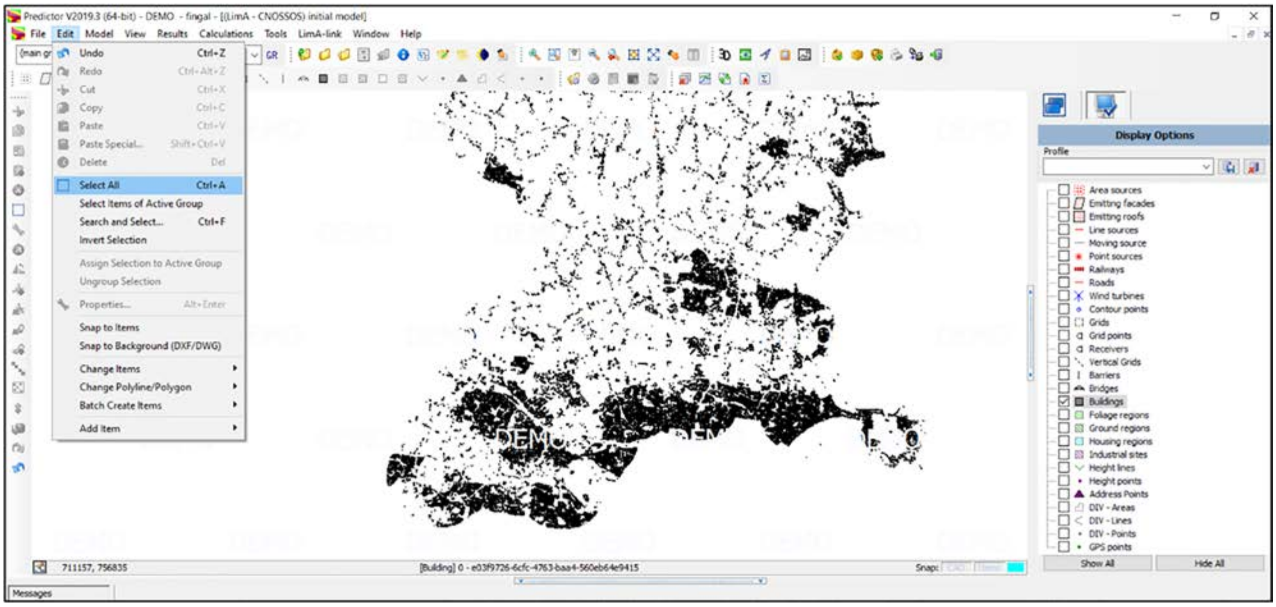


Figure 6.6. Assigning receivers.

that grid point calculation and building receiver point calculation may be performed separately to reduce the possibility of human error in post-processing and to reduce calculation time. On the right-hand column of the software interface, select “Display Options” and deselect all profiles except “Buildings” (see Figure 6.6). Once the “Buildings” profile is the only visible shapefile in the project, select all buildings by entering the “Edit” menu and choosing “Select All” (see Figure 6.6).

Once the entire shapefile is selected, enter “Batch Create Items” and select “Receivers at Façades” to assign receiver points to building façades (see Figure 6.7).

Following this step, the “Create Receivers at Facades” dialogue menu will open. Before creating receiver points, two options must be modified: (1) height definition must be set to “Relative height” and (2) the CNOSSOS-EU method must be set in accordance with the horizontal distance between receivers around the building and the minimum façade length. The Noise-Adapt project recommends that “Cnossos-EU, case 2a” be applied in the Irish context (see Figure 6.8). In this regard, building segments are considered separately, with a receiver being placed in the middle of each segment. Once these steps have been taken, the software will automatically generate receiver points at the façade of every selected building.

It is important to note that, in order to reduce calculation time, receivers may be attached to the

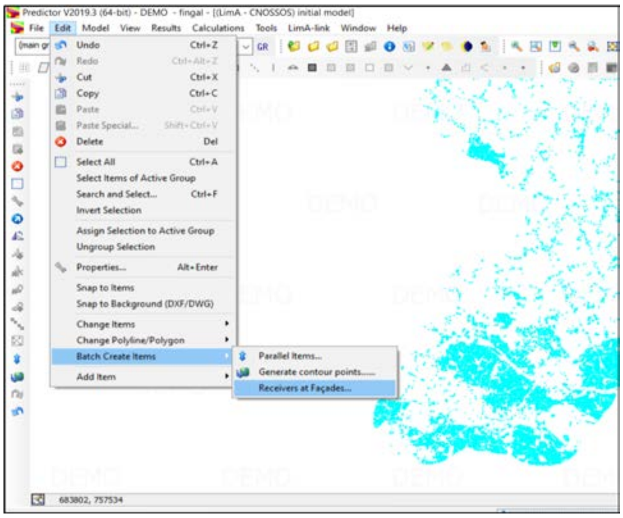


Figure 6.7. Selecting receivers.

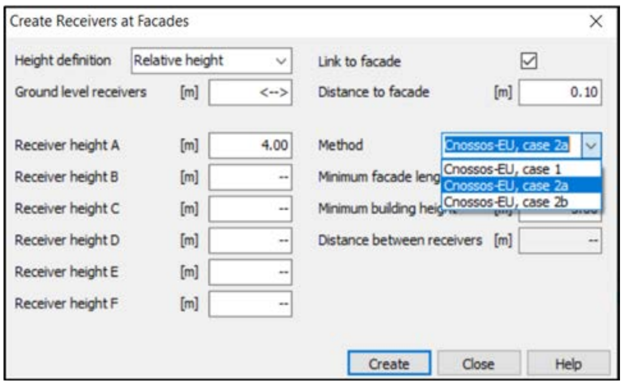


Figure 6.8. Creating receivers.

building shapefile that has been clipped to the local authority boundary in a GIS prior to importation. This means that receivers are not attached to buildings in the buffer zone area. Once receivers have been attached, the clipped building shapefile can be selected and deleted, and the baseline building shapefile that includes the local authority buffer zone area may then be imported into the model. After this process receivers will align only with buildings in the local authority area.

6.4 Model Calculation

Under the “Calculations” menu, click “Settings” (see Figure 6.9).

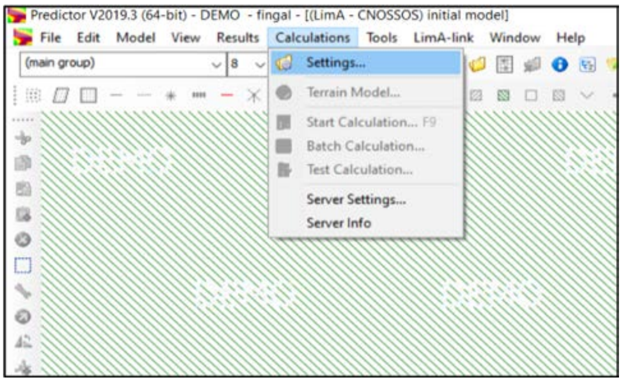


Figure 6.9. Calculation settings.

In the “Calculation Settings” menu, a number of attributes may be modified. The “Fetching radius” for modelling should be set to the same parameter as the buffer zone. For Irish agglomerations, the Noise-Adapt project recommends setting the buffer zone to a minimum of 1000 m and also setting the fetching radius at 1000 m. Meteorological information may also be entered here, including “Average temperature” in Celsius, “Temperature” in Kelvin, “Pressure” and “Air humidity”. “Studded tyres” should be set to “0” for the Irish context.

Before calculation can proceed, it is necessary to tile the model into various components. The number of tiles appropriate for each model is dependent on the density of the model. The smaller the tile size that is generated, the faster the calculation will proceed. To proceed, enter the “Model” menu and select “Tile Model” (see Figure 6.10).

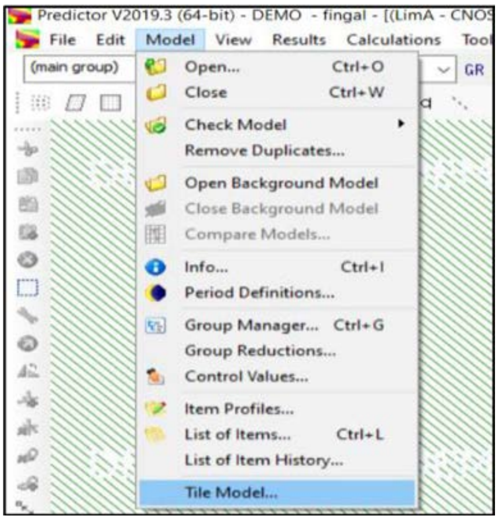


Figure 6.10. Tiling models.

In the “Tile Model” dialogue menu it is necessary to set the “Tile Size”, as well as the “Buffer” zone that will surround each tile (see Figure 6.11). Parameters for the buffer zone should be the same as those set for the baseline model buffer zone and fetching radius.

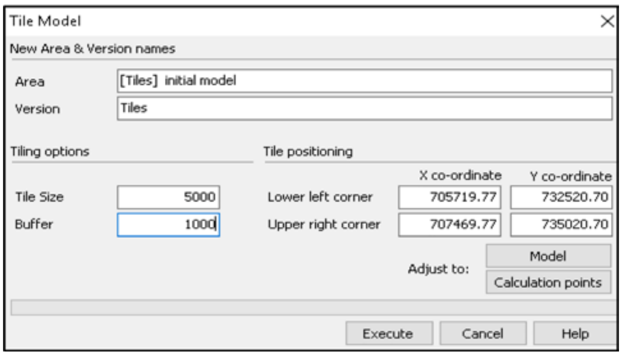


Figure 6.11. Tile parameters.

Once propagation calculation is complete, grid point results should be exported into a GIS environment in order to generate a SNM using spatial interpolation (see Chapter 8). Building receiver point results should be exported into a GIS environment in order to perform population exposure estimation (see Chapter 9). Results may be exported by selecting the “Batch Export Point Results” function within the baseline (i.e. non-tiled) model (see Figure 6.12). Grid point and receiver point results should be exported separately.[12]

12 Predictor-LimA V2021 will enable the importation of calculated results back into the main model. Therefore, the batch export function will not be required for this version.

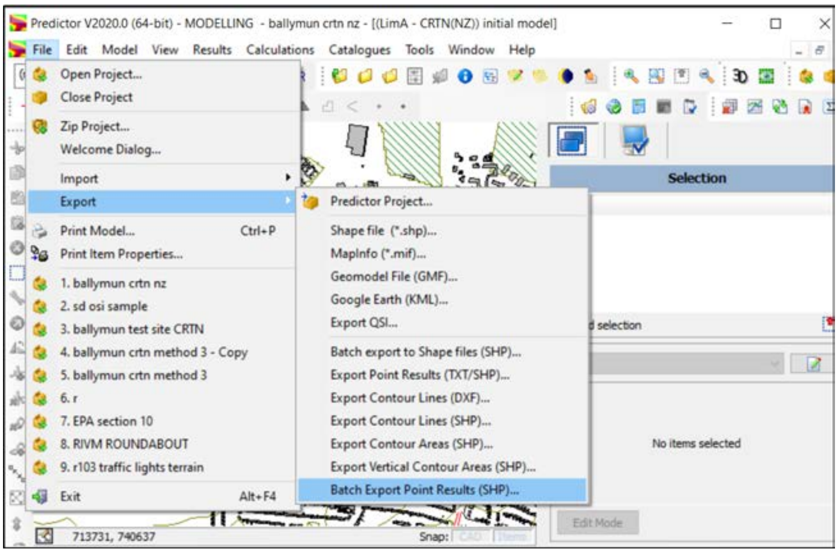


Figure 6.12. Exporting results.

6.5 Computational Time for the Calculation of Noise Levels at Building Façades

Compared with previous modelling under CRTN, it is expected that modelling under CNOSSOS-EU will take approximately 2.6 times longer to complete. For example, on an eight-core system:[13]

- a Dublin city CRTN model was computed in 51 hours, whereas the CNOSSOS-EU model was computed in 134 hours;
- a South Dublin CRTN model was computed in 13 hours, whereas the CNOSSOS-EU model was computed in 36 hours;
- a Dún Laoghaire–Rathdown CRTN model was computed in 16 hours, whereas the CNOSSOS-EU model was computed in 40 hours;
- a Fingal CRTN model was computed in 14 hours, whereas the CNOSSOS-EU model was computed in 37 hours;
- a Cork CRTN model was computed in 6 hours, whereas the CNOSSOS-EU model was computed in 16 hours.

It must be emphasised that these timeframes refer exclusively to the time taken for an eight-core operating system to compute the models.

13 Processor: Intel(R) Xeon(R) W-2145 CPU @ 3.70 GHz; RAM: 32.0 GB.

7 Rail Sources Calculation Using Commercial Software

7.1 Importing Data[14]

Railway shapefile polylines for CNOSSOS-EU modelling should contain the following information:

- IDENT – rail segment identifier;
- DESCR – name of the rail segment;
- HDEF – height definition. Values for height definition should be selected from the following:
  - 1 – absolute height. The height of the item (above the fixed 0-level) is the entered value. The height of the item above terrain level is the entered absolute height minus the calculated terrain level.
  - 0 – relative height. The height of the item is relative in regard to the calculated terrain level.
  - 2 – relative to item directly below. The entered height will be added with the highest height of the items directly below. In case there is no item directly below, the height of the item is relative with regard to the calculated terrain level.
  - 3 – user defined. Two values have to be entered. The first value is terrain height; the second value is the height of the item above the terrain level. This option is equal to the implemented method in Predictor-LimA version 4.
- TRAIN1 – train type (for Ireland, one of the CNOSSOS-EU categories outlined in Table 5.1 should be used);
- RC1 – running condition of the vehicle (constant speed, accelerating, decelerating or idling);
- Q1_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V1_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T1_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q1_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V1_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T1_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q1_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V1_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T1_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- TRAIN2 – train type (for Ireland, one of the CNOSSOS-EU categories outlined in Table 5.1 should be used);
- RC2 – running condition of the vehicle (constant speed, accelerating, decelerating or idling);
- Q2_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V2_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T2_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q2_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V2_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T2_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q2_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V2_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T2_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- TRAIN3 – train type (for Ireland, one of the CNOSSOS-EU categories outlined in Table 5.1 should be used);
- RC3 – running condition of the vehicle (constant speed, accelerating, decelerating or idling);
- Q3_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V3_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T3_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q3_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);

14 For the import of data, please refer to section 6.1.

- V3_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T3_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q3_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V3_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T3_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- TRAIN4 – train type (for Ireland, one of the CNOSSOS-EU categories outlined in Table 5.1);
- RC4 – running condition of the vehicle (constant speed, accelerating, decelerating or idling);
- Q4_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V4_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T4_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q4_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V4_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T4_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q4_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V4_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T4_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- TRAIN5 – train type (for Ireland one of the CNOSSOS-EU categories outlined in Table 5.1);
- RC5 – running condition of the vehicle (constant speed, accelerating, decelerating or idling);
- Q5_P1 – hourly traffic flow of train type 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V5_P1 – average speed of train type 1 vehicles representing L_{day}/operational speed – tram checks;
- T5_P1 – idling time of train type 1 vehicles representing L_{day}/time spent at stations;
- Q5_P2 – hourly traffic flow of train type 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V5_P2 – average speed of train type 1 vehicles representing $L_{evening}$/speed limit;
- T5_P2 – idling time of category 1 vehicles representing $L_{evening}$/time spent at stations;
- Q5_P3 – hourly traffic flow of train type 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V5_P3 – average speed of train type 1 vehicles representing L_{night}/speed limit;
- T5_P3 – idling time of train type 1 vehicles representing L_{night}/time spent at stations;
- RCURVE – curve radius in metres;
- TRACK – track transfer (classifies the track construction);
- STRUCT – structure transfer;
- ROUGH – rail roughness;
- IMPACT – impact noise; relates to amplified rail sources (e.g. rail joint, single switch);
- BRIDGE – bridge constant.

7.2 Vehicle Type Data

Currently, vehicle type data (i.e. TRAIN 1–5) can be derived from the noise prediction software CNOSSOS-EU database and is analogous to categories 8, 10, 14, 15 and 19 in the context of Irish Rail and category 20 in the context of Luas Tram Rail. When there is more than one vehicle type per section of track, these data should be entered accordingly (e.g. TRAIN 2–5). It is important to note that Predictor-LimA software is limited to imputation of five trains per section of track. Currently, the Irish fleet should be adequately represented within the five categories mentioned previously. In the event of additional train types joining the Irish fleet, it will be necessary to liaise with a Predictor-LimA support team to expand the functionality of the software package. The list of vehicle type data currently available within the noise prediction software database, under the CNOSSOS-EU calculation method, is as follows:[15]

- 0 – empty vehicle definition;
- 1 – example vehicle 1;
- 2 – example vehicle 2;
- 3 – diesel locomotive;
- 4 – diesel locomotive;
- 5 – diesel locomotive;
- 6 – diesel locomotive;
- 7 – diesel locomotive;
- *8 – DMU (Diesel Multiple Unit);*
- 9 – electric locomotive (eloco);
- *10 – EMU (Electric Multiple Unit);*
- 11 – block braked passenger;

15 Vehicle type data in italic are those applicable to the Irish fleet.

- 12 – ICM-III (Intercity Materieel-III), ICR trailer, SNCF (Société nationale des chemins de fer français) passenger, TEE (Trans Europ Express);
- 13 – ICR 1700 (Intercity Rail 1700), DDM-1 1800 (DubbelDeksMaterieel-1 1800 locomotive), Belgian locomotives;
- *14 – disc braked passenger trains;*
- *15 – block braked freight trains variable l and number of axles;*
- 16 – Diesel Engine 1 (DE1), DE2, DE3;
- 17 – 2200, 2300 locomotives;
- 18 – 2400, 2500 locomotives;
- *19 – diesel trains with disc brakes;*
- *20 – disc braked urban subway and rapid tram trains;*
- 21 – ICM IV, IRM (InterRegioMaterieel);
- 22 – DDM 2/3;
- 23 – TGV PBA (*Train à Grande Vitesse* Paris–Brussels–Amsterdam – intercity high-speed rail service) type, power car;
- 24 – TGV PBA type, trailer car adjacent to power car;
- 25 – TGV PBA types, other trailer cars;
- 26 – ICE-3 (Intercity Express-3) type assuming no wheel dampers.

In the context of the Irish Rail network, vehicle type data should be entered as follows (see Figure 7.1):

- TRAIN1 = 14 disc braked passenger trains (RMR category 3);
- TRAIN2 = 15 block braked freight trains variable l and number of axles (RMS category 4);
- TRAIN3 = 8 dmu (ns dm 90 dmu) (RMR category 6);
- TRAIN4 = 19 diesel trains with disc brakes (RMR category 6);
- TRAIN5 = 10 emu (ns mat 64 emu) (RRM category 8).

In the context of the Luas Tram Rail network, it is currently necessary to enter data for only one vehicle type (see Figure 7.2):

- TRAIN1 = 20 disc braked urban subway and rapid tram trains.

7.3 Operating Condition

The possible operating conditions of each vehicle type (i.e. RC1–5) are as follows:

- constant;
- accelerating;
- decelerating;
- idling.

As noted in the section "Running conditions" (in section 5.2.2), the CNOSSOS-EU model takes only a parameter input of constant speed or idling and therefore the parameters for acceleration and deceleration can be ignored. For the majority of rail source lines, operating conditions would be expected to be set at "constant" (see Figure 7.1), whereas in the proximity of stations, road crossings and light

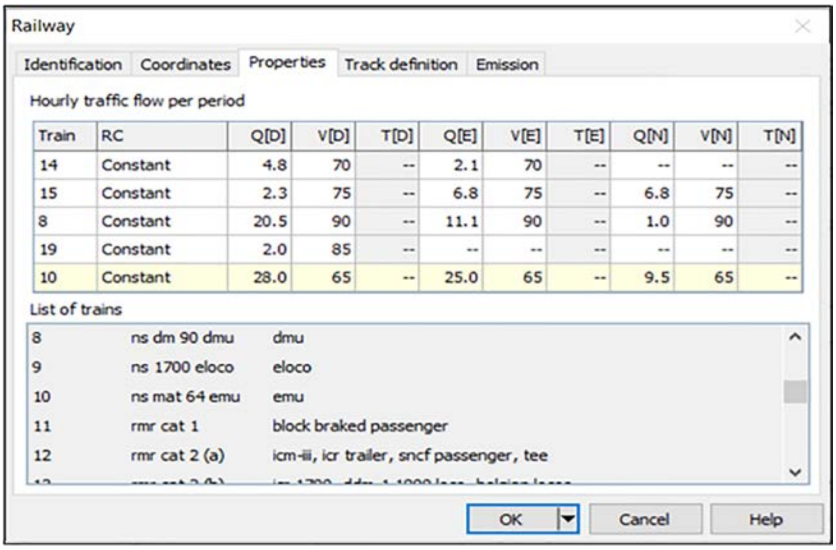


Figure 7.1. Railway properties – Irish Rail.

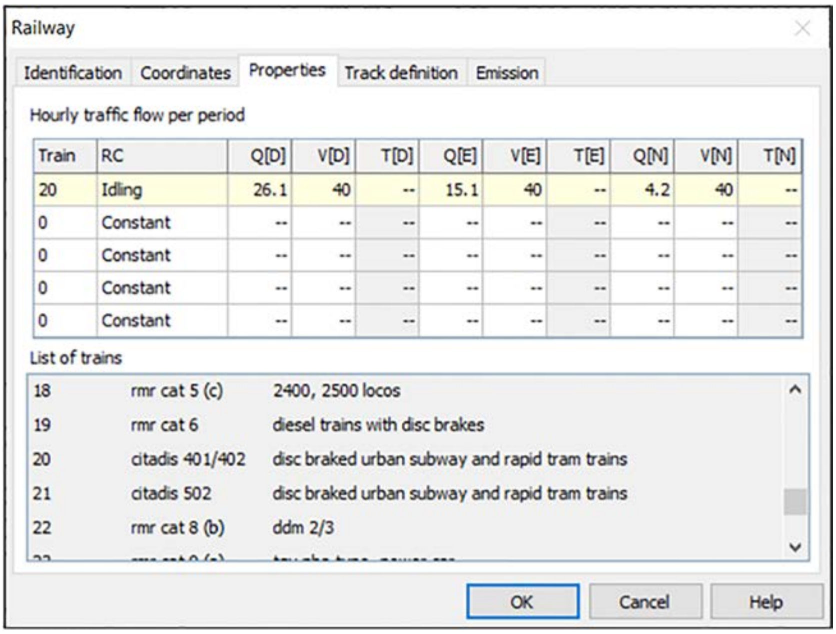


Figure 7.2. Railway properties – Luas Tram Rail.

junctions, etc., operating conditions may be set to "idling" (see Figure 7.2).

7.4 Hourly Quantity of Vehicles and Average Speed

- Q1_P1 – hourly traffic flow of Train 1 vehicles representing L_{day} (i.e. 07:00–19:00);
- V1_P1 – average speed of Train 1 vehicles representing L_{day};
- Q1_P2 – hourly traffic flow of Train 1 vehicles representing $L_{evening}$ (i.e. 19:00–23:00);
- V1_P2 – average speed of Train 1 vehicles representing $L_{evening}$;
- Q1_P3 – hourly traffic flow of Train 1 vehicles representing L_{night} (i.e. 23:00–07:00);
- V1_P3 – average speed of Train 1 vehicles representing L_{night}.

7.5 Track Curvature

The track curvature (i.e. RCURVE) of each track section should be entered in metres. The CNOSSOS-EU model applies an 8 dB(A) correction for a curve radius less than 300 m and a 5 dB(A) correction for a curve radius between 300 and 500 m. For the Irish Rail network, a section of track of at least 50 m located at the centre of the curve should be selected and the proper radius allocated. For a curve radius greater than 500 m, no track curvature value need be applied. For the Luas Tram network, until further work is conducted to measure the squeal noise contribution as a result of track curvature at various locations across the Red and Green line Luas network, no track curvature should be applied (as mentioned in "Track curvature" in section 5.2.1). This is subject to change as on site surveys are conducted.

7.6 Track Type

Currently, track type data (i.e. TRACK) can be derived from the Predictor-LimA CNOSSOS-EU database and are analogous to category 5 in the context of Irish Rail. As mentioned in section 5.2.1, it is not yet possible to represent embedded or slab track sections present on the Luas Tram network with the current list of available parameters. With this in mind, in the context of Luas Tram Rail category 3 is recommended in the absence of embedded or slab track options. The list of track type categories currently available within the Predictor-LimA CNOSSOS-EU database is as follows:[16]

- 0 – empty track transfer function;
- 1 – min;

16 Track type categories in italic are those applicable to the Irish fleet.

- 2 – max;
- *3 – mono-block sleeper on soft rail pad*;
- 4 – mono-block sleeper on medium stiffness rail pad;
- *5 – mono-block sleeper on hard rail pad*;
- 6 – bi-block sleeper on soft rail pad;
- 7 – bi-block sleeper on medium stiffness rail pad;
- 8 – bi-block sleeper on hard rail pad;
- 9 – wooden sleepers.

In the context of the Irish Rail network, track type data should be entered as follows (see Figure 7.3):

- TRACK = 5 mono-block sleeper on hard rail pad.

In the context of the Luas Tram Rail network, track type data should be entered as follows (see Figure 7.4):

- TRACK = 3 mono-block sleeper on soft rail pad;
- TRACK = 5 mono-block sleeper on hard rail pad;

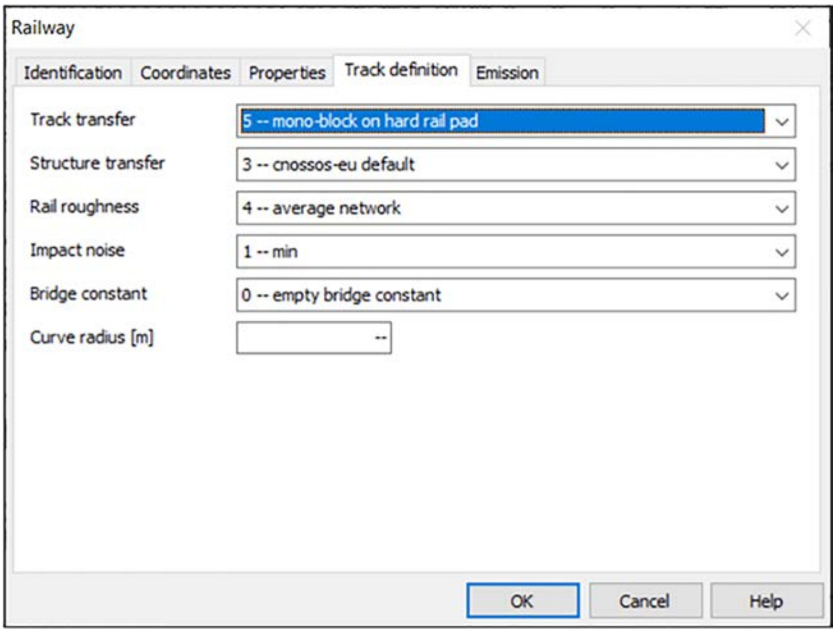


Figure 7.3. Track definition – Irish Rail.

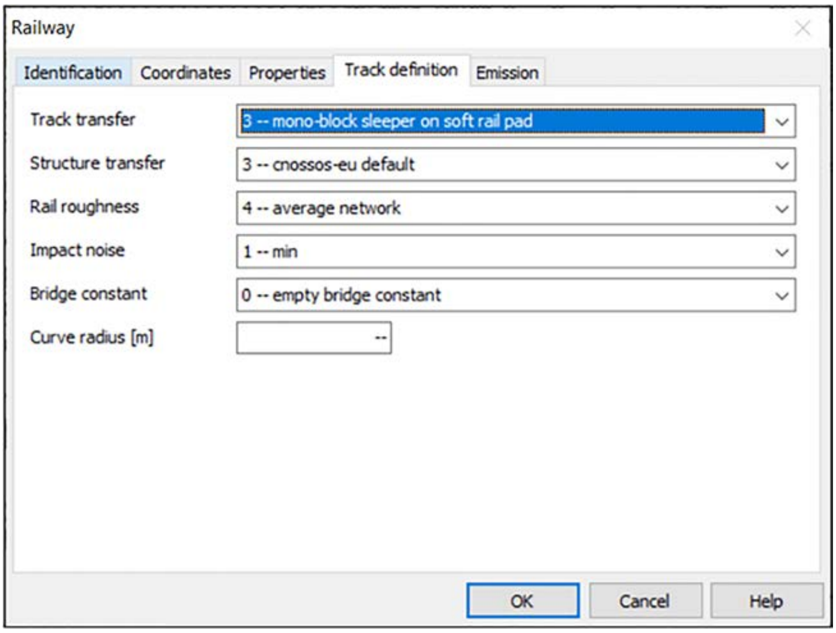


Figure 7.4. Track definition – Luas Tram Rail.

7.7 Structure Transfer

Structure transfer function (i.e. STRUCT) can be derived from the CNOSSOS-EU database. In the Irish context it is recommended to apply “3 – cnossos-eu default” for both the Irish Rail and Luas Tram Rail networks. The list of structure transfer values available within the Predictor-LimA CNOSSOS-EU database is as follows:

- 0 – empty superstructure transfer function;
- 1 – min;
- 2 – max;
- 3 – cnossos-eu default.

7.8 Rail Roughness

Rail roughness (i.e. ROUGH) can be derived from the CNOSSOS-EU database. In the Irish context it is recommended to apply “4 – average network” for both Irish Rail and Luas Light Rail networks until further research is conducted. The list of rail roughness values available within the Predictor-LimA CNOSSOS-EU database is as follows:

- 0 – empty rail roughness;
- 1 – min;
- 2 – max;
- 3 – EN ISO 3095 2013;
- 4 – average network.

7.9 Impact Noise at Crossings

Values from the impact noise at crossings (i.e. IMPACT) can be derived from the CNOSSOS-EU database. For the majority of track sections, the value “1 – min” can be applied to both Irish Rail and Luas Tram Rail networks where jointless track is present. Where a single joint, switch or crossing is present over a 100 m length of track, the value “3 – single switch/joint/crossing/100 m” can be applied. Finally, where a track section with more than two joints per 100 m is present, the value “2 – max” can be applied. The list of impact noise values available within the Predictor-LimA CNOSSOS-EU database is as follows:

- 0 – empty impact;
- 1 – min;
- 2 – max;
- 3 – single switch/joint/crossing/100 m.

7.10 Bridge Type

Values for bridge type can also be derived from the CNOSSOS-EU database. In the Irish context, values for “3 – predominantly concrete or masonry bridges with any track form” or “4 – predominantly steel bridges with ballasted track” should be applied where appropriate for both Irish Rail and Luas Tram Rail networks. The list of bridge type values available within the CNOSSOS-EU database is as follows:

- 0 – empty bridge constant;
- 1 – min;
- 2 – max;
- 3 – predominantly concrete or masonry bridges with any track form;
- 4 – predominantly steel bridges with ballasted track.

In relation to building, height line, ground region, barrier and bridge shapefiles, refer to section 6.1. In relation to assignment of grid points for strategic noise mapping, refer to section 6.2. In relation to assignment of receiver points to building façades, refer to section 6.3. In relation to model calculation, refer to section 6.4.

8 Generation of Strategic Noise Maps Using Spatial Interpolation

As recommended by the WG-AEN (2007), noise maps should be presented in a GIS environment. A GIS provides enhanced data management and spatial functionality facilities. For creating SNMs, the Noise-Adapt project recommends that “nearest neighbour” interpolation be applied, as it is the most mathematically appropriate linear interpolation approach to use in the application of uniform grids (see Murphy and King, 2010).

To generate an SNM, all relevant shapefiles should be imported into the GIS environment. Following this, the first task is to remove grid points that fall beyond the boundary of the model. This is necessary because these grid points will distort results. To remove these grid points, enter the “Editor” menu in the GIS and select “Start Editing” (see Figure 8.1), then select the grid point result shapefile you wish to edit (see Figure 8.2).

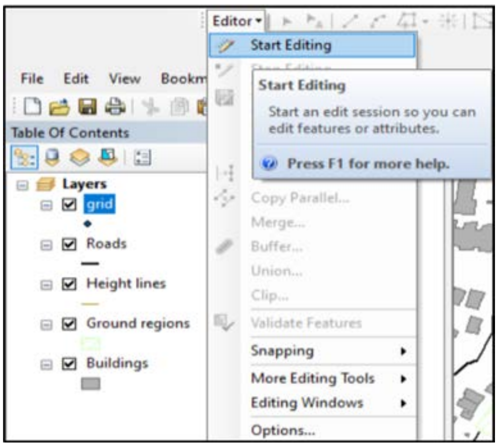


Figure 8.1. Editing shapefiles.

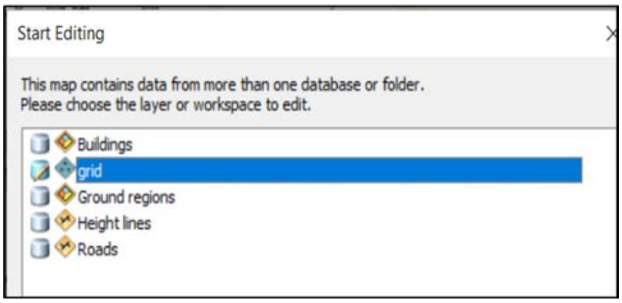


Figure 8.2. Editing grid shapefiles.

In the “Table Option” menu enter “Select by Attributes” (see Figure 8.3), and in the dialogue menu select the “Ground Height” attribute (i.e. GROUNDH) (see Figure 8.4). Select the grid points to be removed by entering [“GROUNDH” = 0] as illustrated in Figure 8.5.

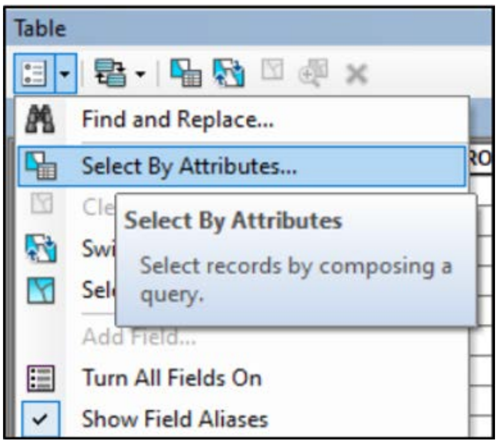


Figure 8.3. Select by attributes.

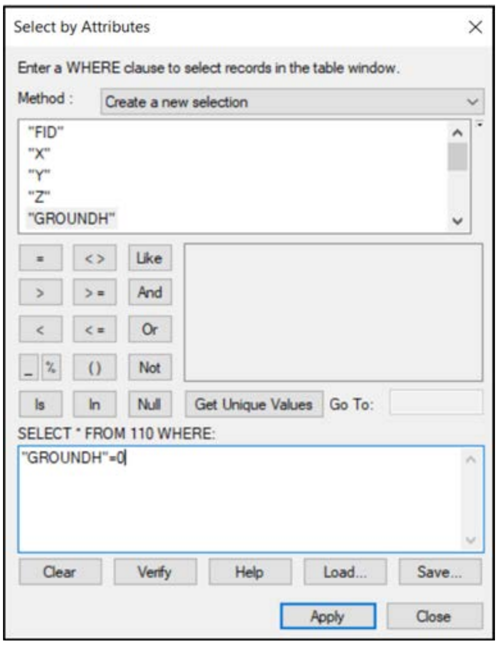


Figure 8.4. Attribute value.

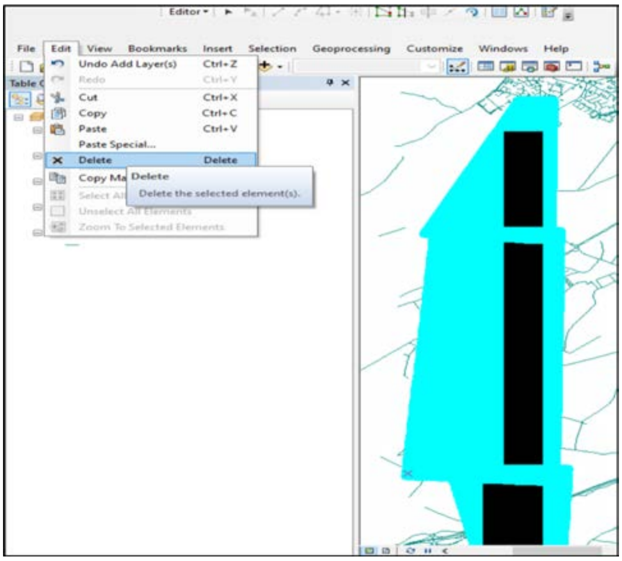


Figure 8.5. Deleting selection.

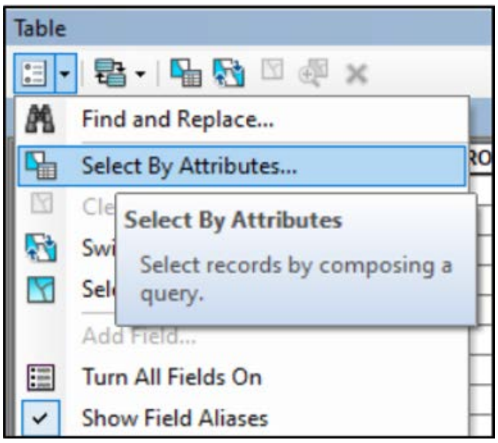


Figure 8.7. Select attributes.

Once missing value result points have been selected, they should be deleted from the model.

The next task is to remove grid points that fall within the boundary of building polygons. This is necessary because grid points, as with receivers, are placed at a height of 4 m above terrain level; consequently, grid points falling within building polygons create errors within noise predictor software and therefore exhibit missing values (i.e. –200 or –250). Such missing values will distort the display of noise contours within the SNM and must therefore be removed. To remove these missing values, enter the “Editor” menu and select “Start Editing” (see Figure 8.6).

In the “Table Option” menu, enter “Select By Attributes” (see Figure 8.7) and within the dialogue menu select the noise level attribute (e.g. 24H) = the missing value (i.e. –200) (see Figure 8.8). Once missing value result points have been selected they should be deleted from the model (see Figure 8.9). Ensure that the edit session is closed before proceeding.

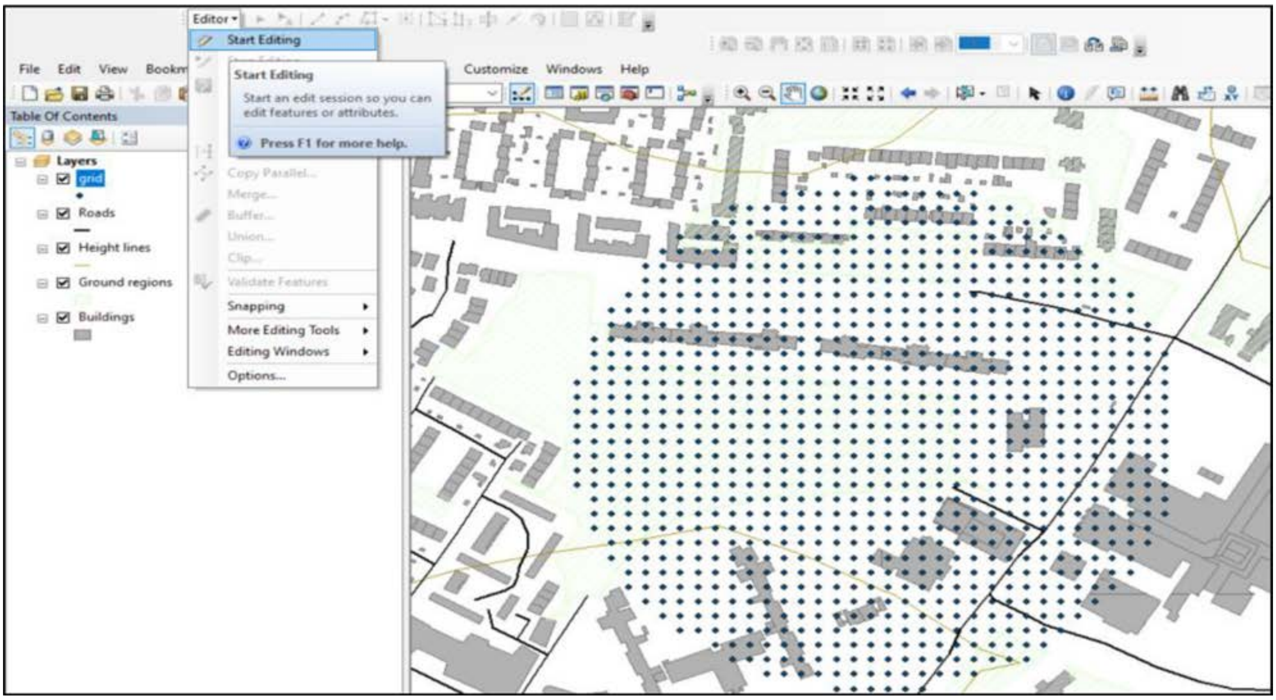


Figure 8.6. Select by attributes – missing values.

Figure 8.8. Deletion criteria.

In order to perform spatial interpolation in GIS, enter the “Toolbox” menu and select “Spatial Analyst Tools” and “Interpolation”, and, finally, select ”Natural Neighbor” as the interpolation technique (see Figure 8.10). Enter the grid point results shapefile into “Input point features” and enter the value you wish to calculate (e.g. L_{den}, L_{night}) into “z value field” (see Figure 8.10).

Once the interpolation process is complete, a raster shapefile of sound contours will be generated and added to the GIS interface. In “Layer Properties”, enter the “Symbology” tab, select “Classified”, and enter the appropriate number of “Classes” required (e.g. 6 for ≤54, 55–59, 60–64, 65–69, 70–74, ≥75). To classify values to the desired noise band level, enter the “Toolbox” menu, select “Reclass”, and, finally, “Reclassify”. Reclassify values according to the desired noise band level (see Figure 8.11).

The colour palette should represent the long-established ISO standard for the presentation of acoustics graphics (ISO 1996-2:1987; see ISO, 1987) outlined in Tables 8.1 and 8.2, and illustrated in Figure 8.12.

In the “Table of Contents” dialogue menu, double-click on the desired colour symbol to open the colour palette and select “More Colours”. In the “Colour Selector” dialogue menu, the R G B values described in Tables 8.1 and 8.2 may be entered (see Figure 8.12).

It is recommended that colour bands are semi-transparent to ensure that base maps remain partly visible, so that orientation and identification of location remain intact. To perform this procedure in GIS, enter the “Customise” menu and select “Toolbars” and

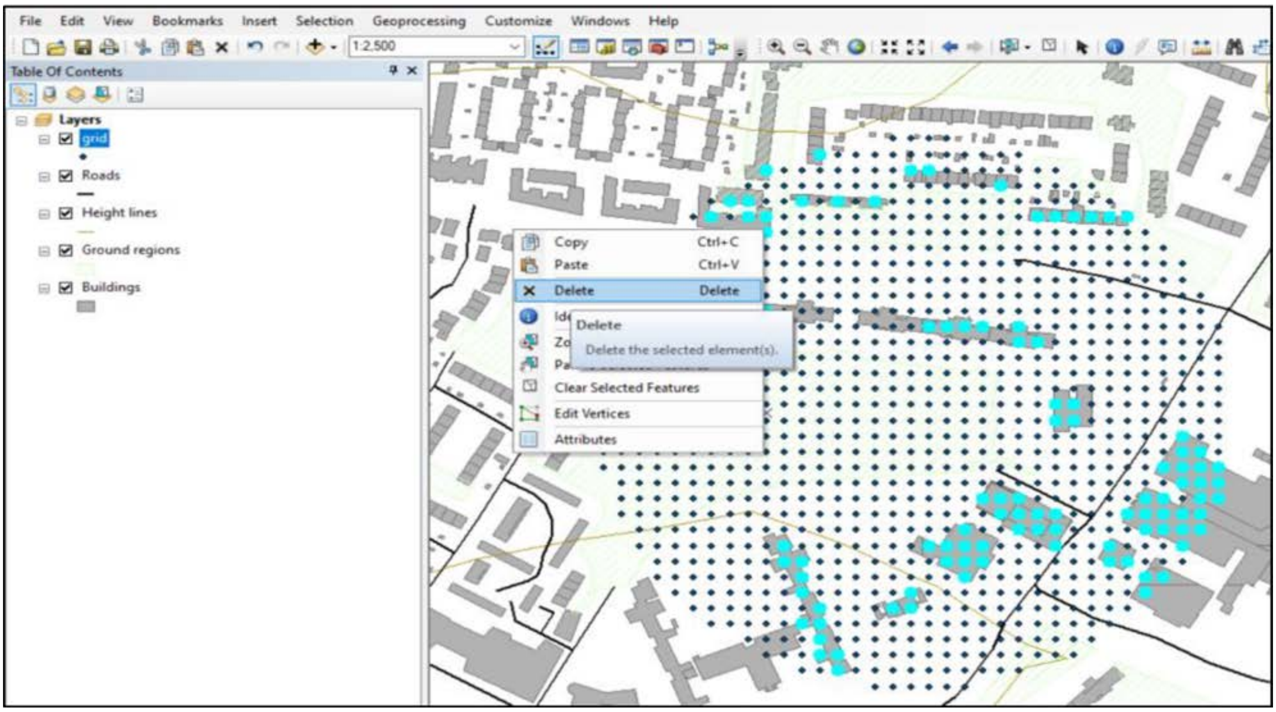


Figure 8.9. Delete selection.

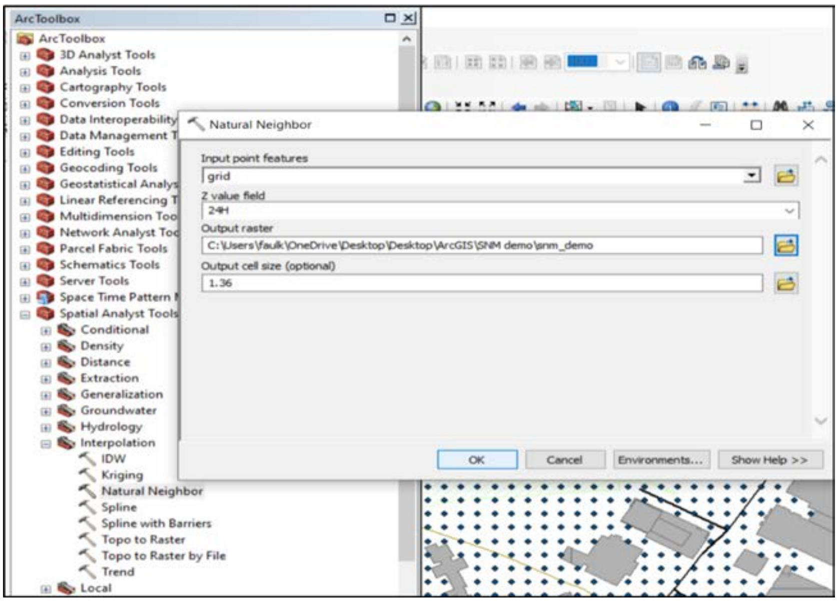


Figure 8.10. Interpolation – Natural Neighbor.

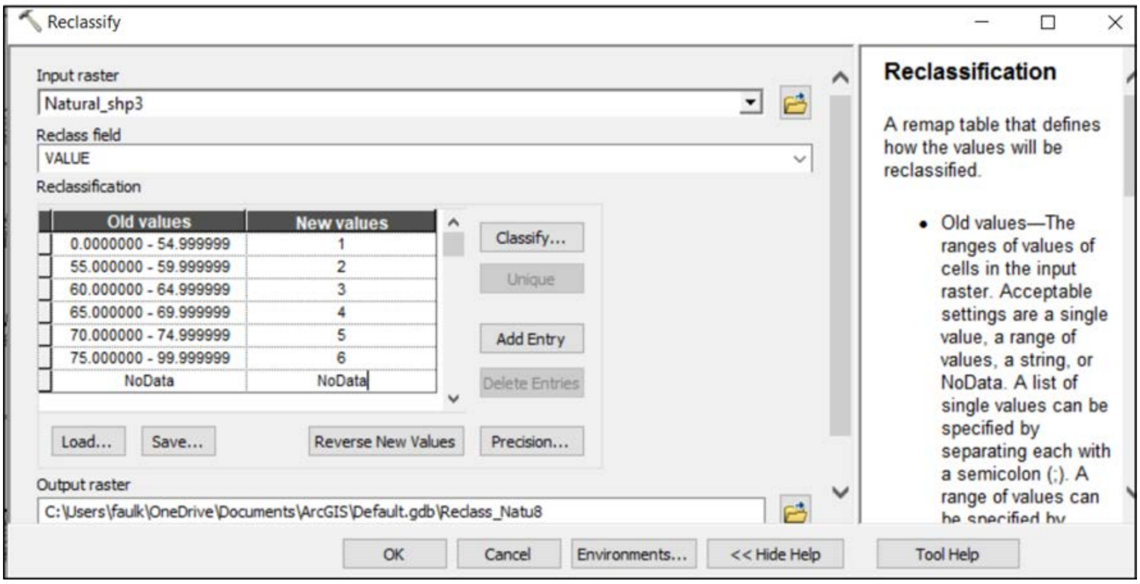


Figure 8.11. Reclassify function.

Table 8.1. ISO 1996-2 colour scheme – L_{den}

dB	Red	Green	Blue
≤54	No colour		
55–59	255	102	0
60–64	255	51	51
65–69	153	0	51
70–74	173	154	214
≥75	0	0	255

Table 8.2. ISO 1996-2 colour scheme – L_{night}

dB	Red	Green	Blue
≤44	No colour		
45–49	255	255	0
50–54	255	199	74
55–59	255	102	0
60–64	255	51	51
65–69	153	0	51
≥70	173	154	214

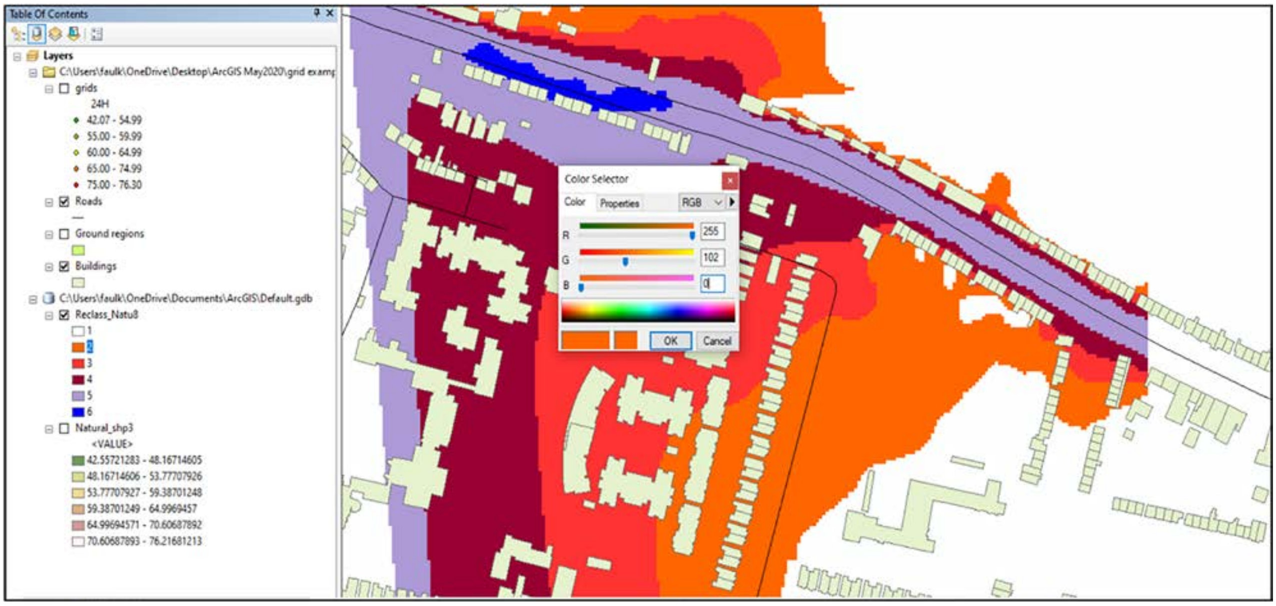


Figure 8.12. Colour selector.

“Effects”. The level of transparency can be adjusted from 0% to 100%.

Alternative colour scheme for able vision and visually impaired viewers

An alternative colour scheme has been proposed by Weninger (2015). If practitioners wish to adopt this alternative colour scheme, then the scheme presented in Table 8.3 should be entered into GIS using the procedure described previously.

Table 8.3. Alternative colour scheme (Weninger, 2015)

dB	Red	Green	Blue
35–39	160	186	191
40–44	184	214	209
45–49	206	228	204
50–54	226	242	191
55–59	243	198	131
60–64	232	126	77
65–69	205	70	62
70–74	161	26	77
75–79	117	8	92
≥80	67	10	74

9 Estimating Population Exposure under CNOSSOS-EU

9.1 Assigning Noise Levels and Population to Buildings

To estimate population exposure to noise, residential dwellings should be identified and calculated noise levels should be applied to buildings. This should be performed in a GIS environment. The first stage in the process is establishing if buildings are residential or non-residential. This information is attainable from the commercially available An Post GeoDirectory database,[17] which contains detailed information on all properties in Ireland and is updated every 6 months. GeoDirectory data are usually supplied in CSV (comma-separated values) format and should be imported using the IRENET95 ITM projected coordinate system. Relevant information contained in this file includes:

- building ID;
- electoral district ID;
- small area ID;
- building use (e.g. residential or commercial);
- whether the building is derelict, vacant, invalid, or under construction;
- total number of residential delivery points indicative of the number of dwelling units;
- projected coordinate system Irish Grid;
- projected coordinate system ITM.

In the GIS, add the GeoDirectory data in a similar manner to which a shapefile would be added. The data are in tabular format; hence, right-click on the data and select “Display XY Data” (see Figure 9.1). On the “Display XY Data” dialogue menu, enter “ITM_EAST” into the “X Field” option and “ITM NORTH” into the “Y Field” option (see Figure 9.2). This process will align point data from the GeoDirectory with the corresponding building polygons.

Depending on particular licensing agreements that authorities may have with An Post GeoDirectory, files may be accessible for locations beyond the area of interest. In such cases all files should be uploaded into the GIS as previously described. Relevant GeoDirectory point shapefiles can then be isolated for analysis using the clip feature in the GIS. Enter the “Geoprocessing” toolbar and select the “Clip” function (see Figure 9.3). In the “Clip” function dialogue menu, enter the GeoDirectory point data shapefiles, which should be labelled “building.csv Events”, into the “Input Features” dialogue menu (see Figure 9.4); these are the data points you may wish to “clip” to your area of interest. Then, enter the area of interest shapefile that you wish the GeoDirectory data to be clipped to (see Figure 9.4). In “Output Feature Class”, select the location and name of this new point shapefile of the area you are interested in (see Figure 9.4).

Once the “GeoDirectory” shapefile has been generated, the shapefile should be spatially joined to the “building” shapefile in order to create a “building GeoDirectory” shapefile. Right-click the “building” shapefile and select “Joins and Relates” then “Join”

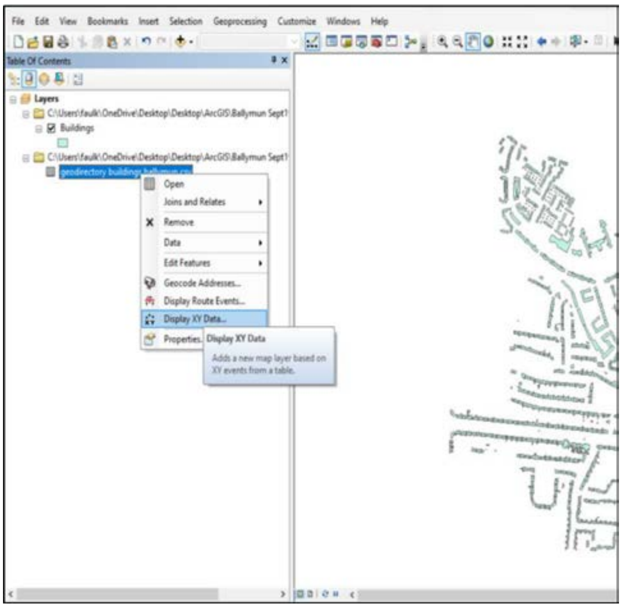


Figure 9.1. Displaying XY data.

17 See https://www.geodirectory.ie/ (accessed 11 March 2021).

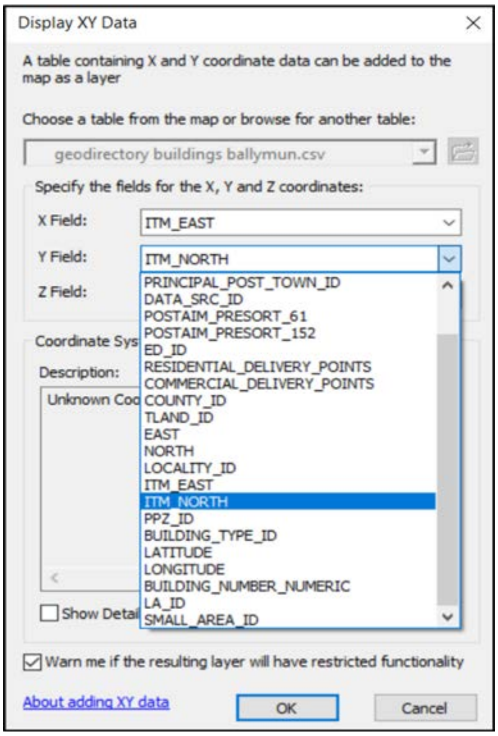


Figure 9.2. Specifying XY data.

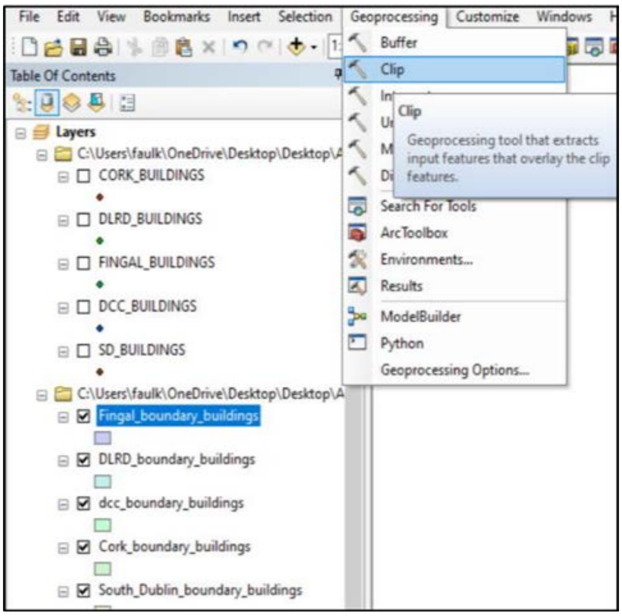


Figure 9.3. Clipping.

to open the “Join Data” dialogue menu, and select the “SUM” numeric attribute[18] (see Figure 9.5).

The next task involves the incorporation of population statistics into the dataset. Census data for SAPS

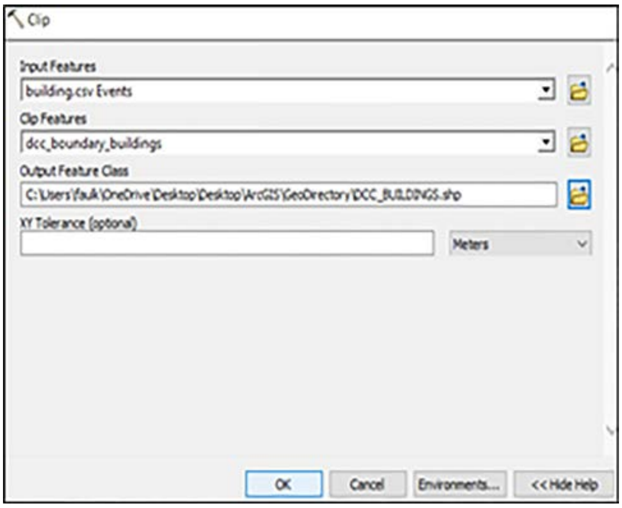


Figure 9.4. Clipping features.

are readily available online from the CSO. SAPS shapefile data can be downloaded from http://census2016geohive.ie (accessed 23 January 2020). This shapefile contains the total population in each Small Area Boundary. Select the area of interest in a GIS. Selection can be made by right-clicking the shapefile and opening the attribute table, then entering the “Select by Attribute” menu and entering the attribute values you wish to apply as selection criteria (see Figure 9.6). Selection can also be performed by manually selecting relevant cells in the attribute table. The selected area of interest can then be exported as a shapefile.

The SAPS area of interest used in this example is the Dún Laoghaire–Rathdown local authority area, which contains the total population of 775 Small Areas (see Figure 9.7).

Finally, the SAPS shapefile can be spatially joined to the “building GeoDirectory” shapefile. Right-click the “building GeoDirectory” shapefile to perform the spatial join and select the second option, “each polygon will be given the attributes ...” (see Figure 9.8). It is important to ensure that the “building GeoDirectory” shapefile is present before the SAPS shapefile is imported into the GIS environment, to ensure accuracy in coordinate alignment.

The next step involves the assignment of noise levels to buildings (i.e. “building GeoDirectory SAPS” shapefile). Once the propagation model has been

18 This provides a sum of residential postal addresses (i.e. number of residential units) per building where more than one GeoDirectory point exists within a building.

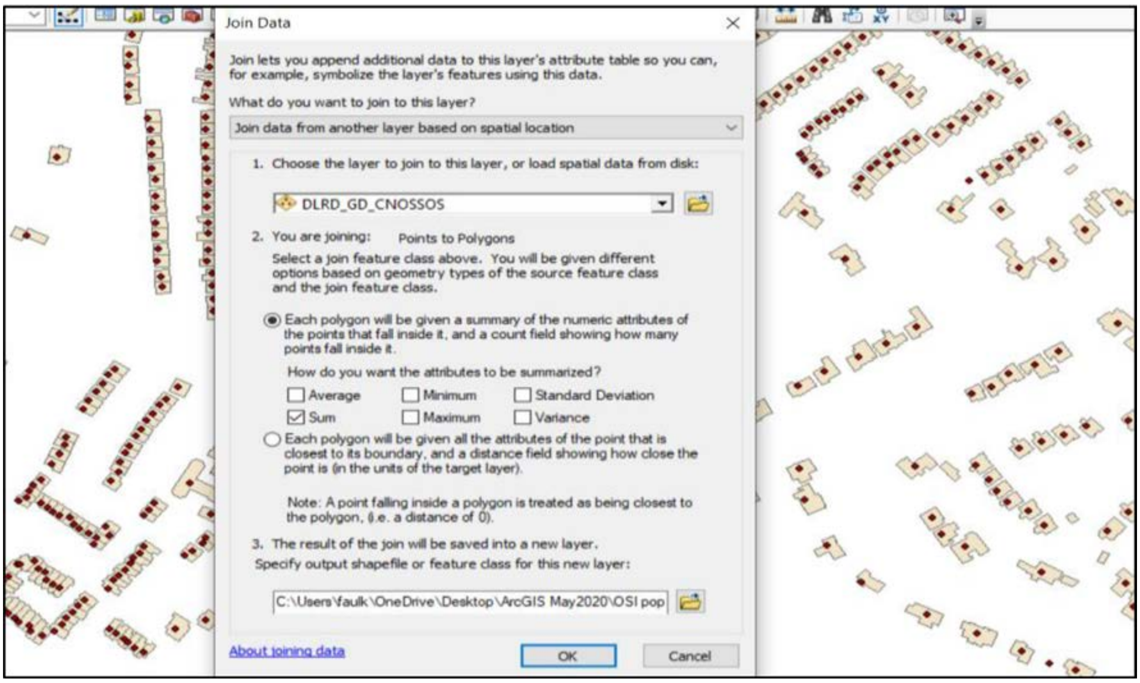


Figure 9.5. Joining data.

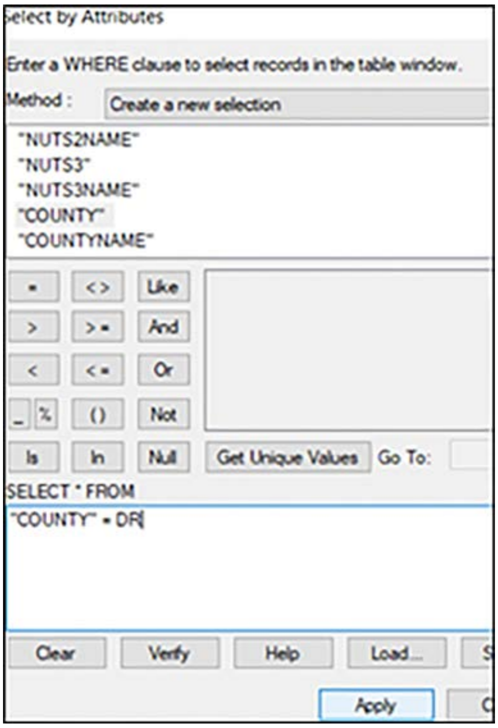


Figure 9.6. Selecting areas.

generated, results should be exported to the GIS environment in order to spatially join the “building GeoDirectory SAPS” shapefile to the point “results” shapefile. However, as receivers are placed 0.1 m in front of the façade of buildings, corresponding point results automatically fall outside the spatial footprint of the building polygons. This means that spatially joining buildings to results is not possible without data manipulation. Therefore, a buffer zone around buildings must be generated in order to allow the spatial join to proceed accurately (see Figures 9.9 and 9.10). In the GIS, enter the “Geoprocessing” menu and select “Buffer”; the building polygon shapefile should be entered as “Input Features” and the “Linear unit” should be set at 0.5 m, which is the minimum distance a GIS platform may allow so that point results fall within the spatial footprint of building polygons (see Figure 9.11).

Once the buffer zone has been created, the “building GeoDirectory SAPS” shapefile can be spatially joined to the point “results” shapefile. Right-click the point “results” shapefile and select “Joins and Relates” and then “Join” to open the “Join Data” dialogue menu (see Figure 9.12). Select the first option, “each point will be given all the attributes of the polygon that: it falls inside” in order to assign all receiver point values to each building (see Figure 9.12). Press “OK” to perform the spatial join and a new “results building GeoDirectory SAPS” shapefile will be created.

The next task is to remove all information regarding non-residential result points. In order to achieve this, enter an “Edit” session in the GIS environment. In the “Selection” toolbar, enter “Select By Attributes” (see Figure 9.13).

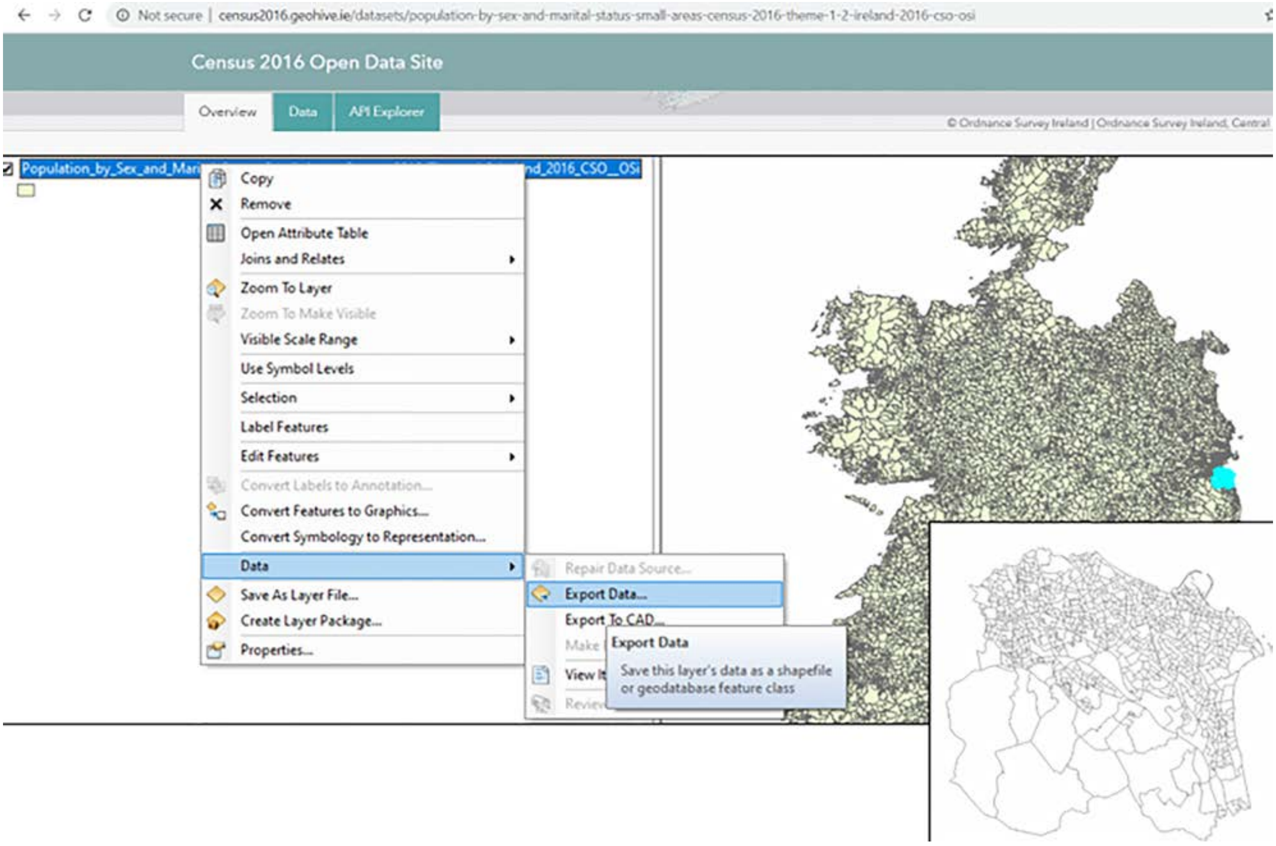


Figure 9.7. Area of interest.

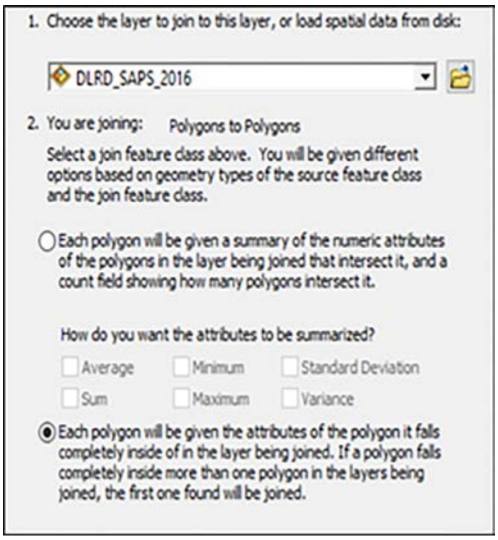


Figure 9.8. Spatial joining.

In relation to derelict, vacant and invalid buildings, and buildings that are under construction (i.e. DERELICT, VACANT, INVALID, UNDER_CONS) such attributes should be selected in the "Select By Attributes" dialogue menu (see Figure 9.14). Once selected, enter, for example, "DERELICT" = "Y" in order to select all data relating to derelict buildings (see Figure 9.14). Once this information is selected it can be deleted from the dataset by selecting the delete function. Follow the same procedure for the vacant and invalid buildings, and buildings under construction (e.g. "VACANT" = "Y"; "INVALID" = "Y"; "UNDER_CONS" = "Y"). Any result point data without a residential postal address should also be deleted (i.e. "RESIDENTIA" = "0"). Finally, any missing values on results points (e.g. –200, –250) should be removed.[19] Close the edit session to save all changes.

When all non-residential information is removed from the dataset, the process of estimating population per household can commence. In determining the number of inhabitants of a building, European Commission Directive (EU) 2015/996 L168/92-3 recommends that, where data on the number of inhabitants are available and the number of inhabitants is known for entities

19 All missing values on results points should be thoroughly investigated, and affected tile models should be re-run if necessary.

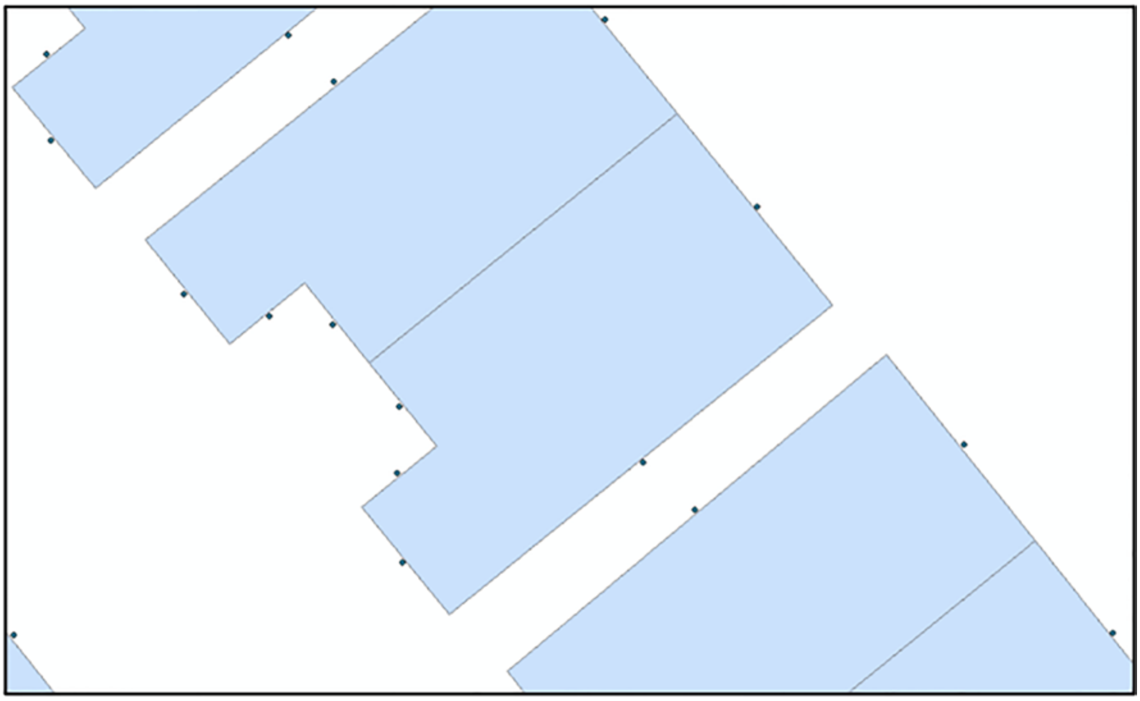


Figure 9.9. Original shapefile.

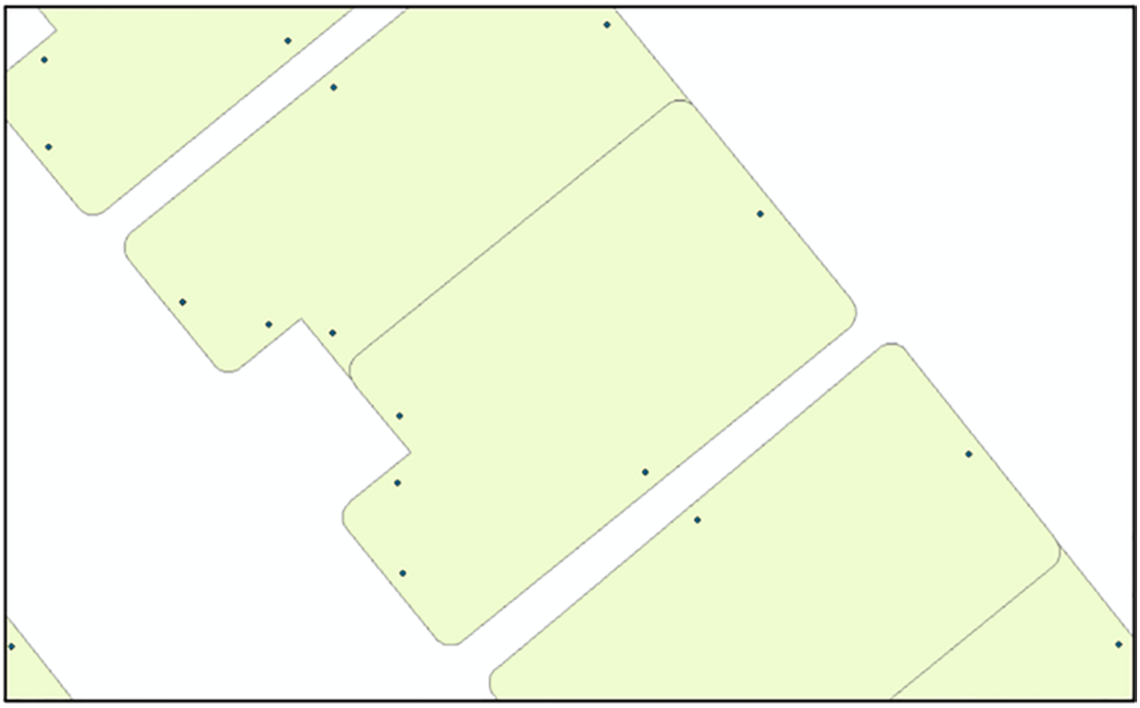


Figure 9.10. Buffered shapefile.

larger than a building, such as districts (e.g. CSO SAPS data), estimations should be based on the volume of the building.[20]

First, in order to generate a count of all receiver points associated with each building, enter the Attribute Table of the "results building GeoDirectory

20 See Commission Directive (EU) 2015/996 L168/93 – "1B: The number of inhabitants is known only for entities larger than a building, e.g. sides of city blocks, city blocks, districts or even an entire municipality. In this case the number of inhabitants of a building is estimated based on the volume of the building".

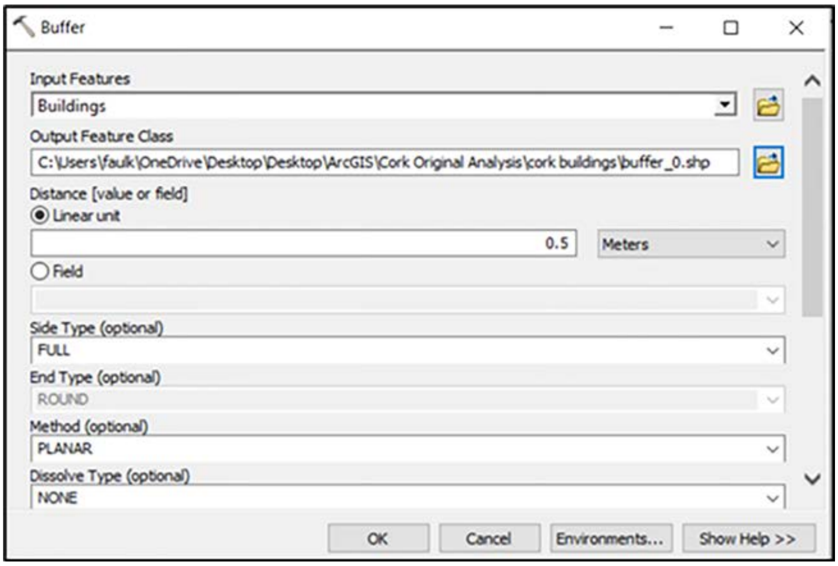


Figure 9.11. Buffering.

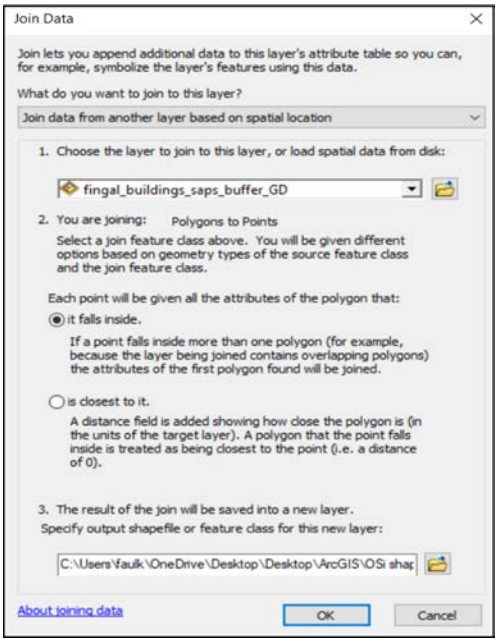


Figure 9.12. Joining results.

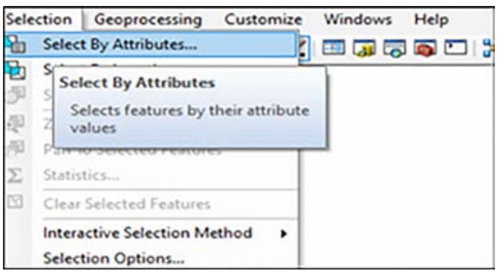


Figure 9.13. Selecting building attributes.

SAPS” shapefile, right-click on any field and select “Summarize” (see Figure 9.15). In the “Summarize” dialogue menu, select the building ID (e.g. “ELMID”) as

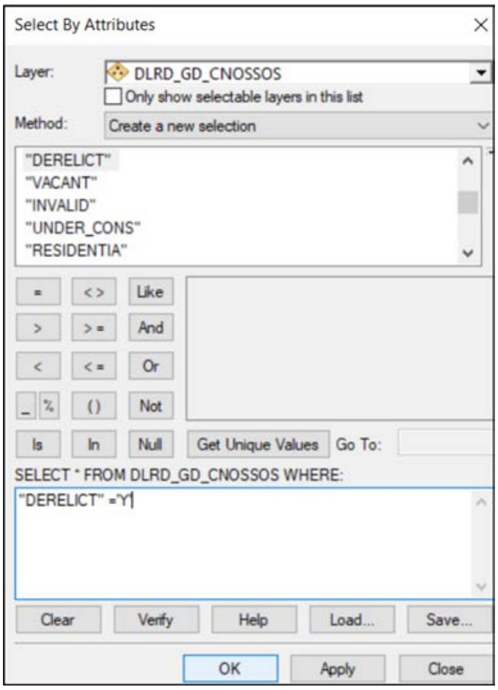


Figure 9.14. Removing building attributes.

the “field to summarize” (see Figure 9.16). In the “Save as type” dialogue menu, select “dBASE Table”. A count of all receiver points associated with each building will be generated in a new summary table. Select “Yes” to add the table to the map.

To add the new count field to the “results building GeoDirectory SAPS” shapefile, perform a spatial join based on values from the Attribute Table (see Figure 9.17). Choose the building ID (e.g. “ELMID”) as the common attribute for the table to be joined

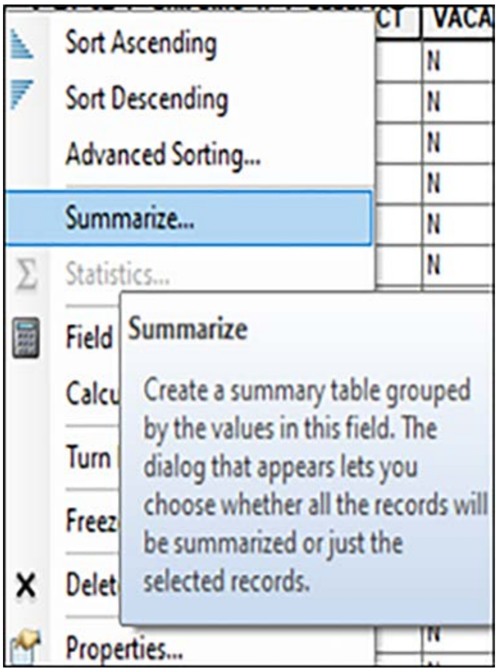


Figure 9.15. Summarise function.

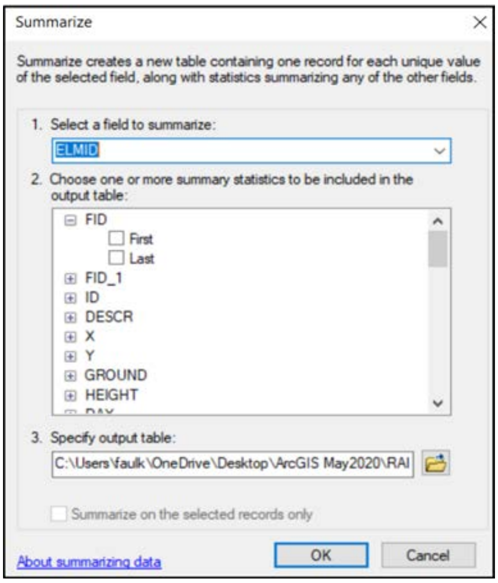


Figure 9.16. Selecting fields to summarise.

(see Figure 9.17). It is important to ensure that, when joining the count table to the "results building GeoDirectory SAPS" shapefile, any variable label that starts with a numerical symbol is replaced with an alphabetical symbol. Shapefile labels should be changed externally within a data management application and imported back into the GIS environment. Once the spatial join is complete, the shapefile should be saved using the "Export" function, so that the new count data are incorporated.

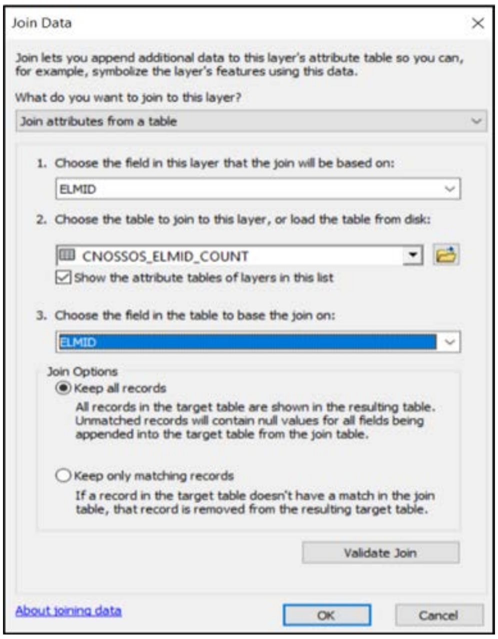


Figure 9.17. Spatial join.

Second, in the GIS environment, open the Attribute Table of the "results building GeoDirectory SAPS" shapefile, enter "Table Options" and select "Add Field" (see Figure 9.18). This new field will represent the volume of each building. Enter an edit session, right-click on the new field to enter the "Field Calculator" (see Figure 9.19), multiply the building perimeter by the associated relative height of the building, and divide by the receiver count data of each building [i.e. ([PERIMETER]*[RELATIVE_HEIGHT]/ELMID)]. This attribute represents the volume of each building, which is standardised in accordance with the number of receiver points associated with the building (see Figure 9.20). Following this computation, close the edit session.

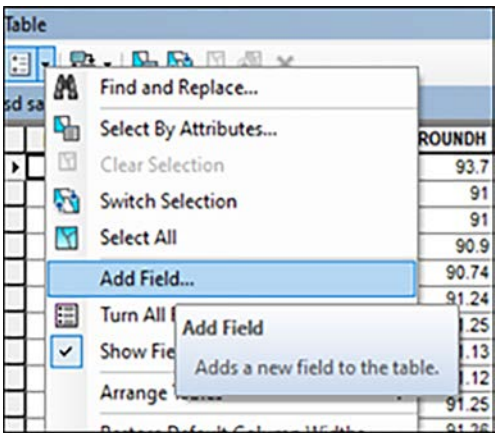


Figure 9.18. Add field.

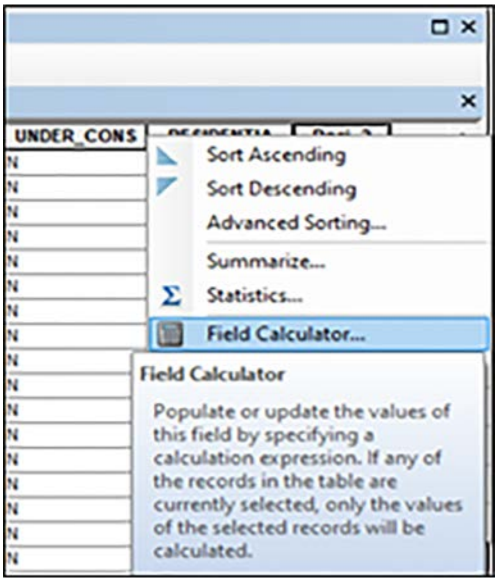


Figure 9.19. Field calculator.

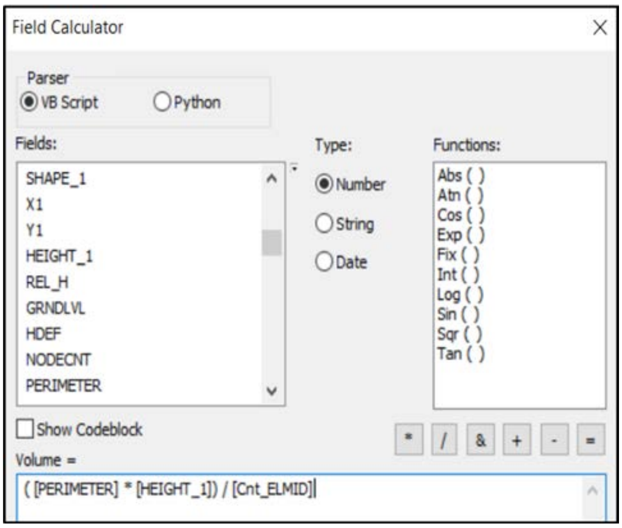


Figure 9.20. Standardising volume.

Third, the building volume attribute should be aggregated according to the SAPS location. Enter the Attribute Table of the “results building GeoDirectory SAPS” shapefile once again, right-click on any field and select “Summarize” (see Figure 9.21). In the “Summarize” dialogue menu, select “GEOGID” as the “field to summarize” and aggregate (i.e. “SUM”) the new building volume attribute (e.g. “Volume”) in order to generate the new aggregated summary table (see Figure 9.22). In the “Save as type” dialogue menu, select “dBASE Table”.

Finally, according to Commission Directive (EU) 2015/996, “only for buildings with floor sizes that

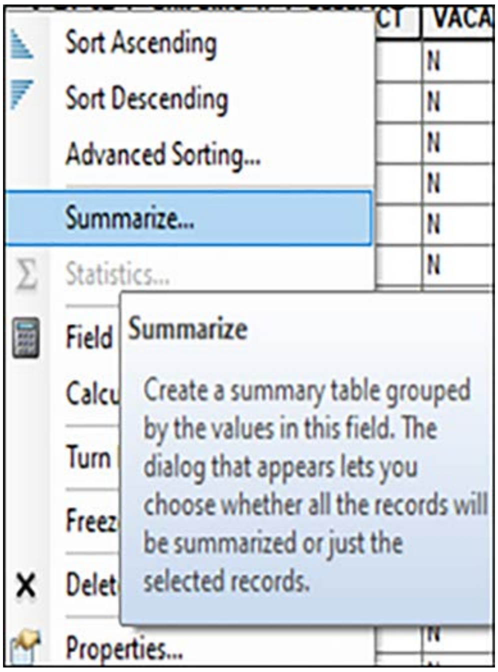


Figure 9.21. Summarising to aggregate.

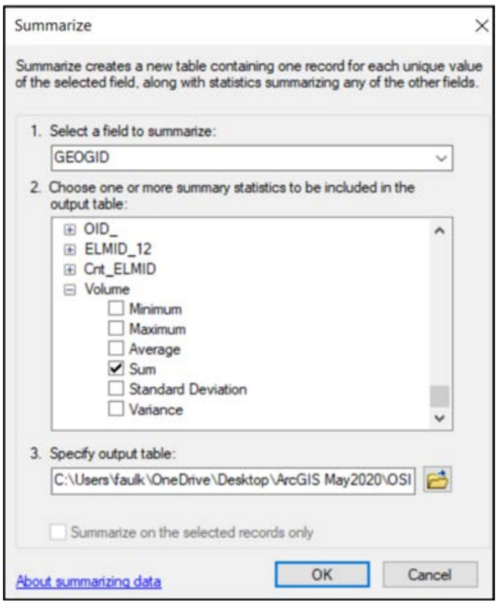


Figure 9.22. Aggregating volume.

indicate a single dwelling per floor level, the most exposed façade noise level is directly used for the statistics and related to the number of inhabitants” (EU, 2015, p. 95). This indicates that, for single dwelling residential buildings, noise levels at the most exposed façade should be used in the estimation of population exposure; hence, a new variable should be generated that represents values at the most exposed façade. Use the summarise function procedure described previously to generate this variable. In the “Summarize” dialogue menu, select a building identification variable (e.g. “ELMID”) as the “field to summarize”, and on the chosen noise indicator select “Maximum” to generate noise levels at the most exposed façade of each building (see Figure 9.23).

Following this procedure, the data are ready for final analysis in an appropriate data management platform. The dBASE file associated with the “building results GeoDirectory” shapefile should be imported into a database software program (see Figure 9.24) and a new query should be created by selecting the “Query Design” menu (see Figure 9.25).

The following variables should be added from the imported dBASE file table (see Figure 9.26):

- building data;
  - Volume – building volume;
  - Volume_Sum – aggregated building volume per SAPS area;
- GeoDirectory data;
  - RESIDENTIA_SUM – number of dwelling units per building;
- Noise level data;
  - F24H – L_{den} value of noise at each receiver;
  - NI – L_{night} value of noise at each receiver;
- SAPS data;
  - GEOGID – geographical identification of each SAPS area;
  - T1_2T – total population in each SAPS area.

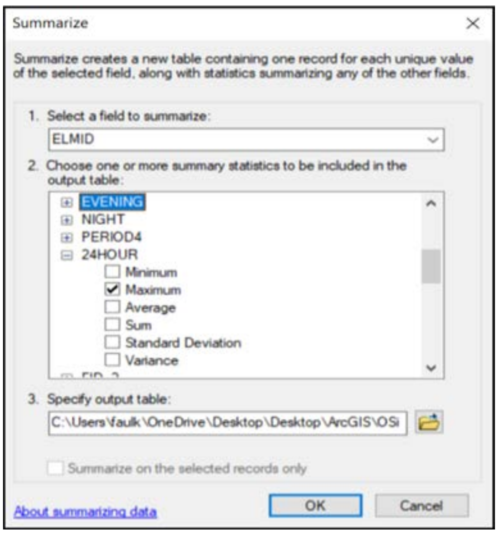


Figure 9.23. Summarising to maximise.

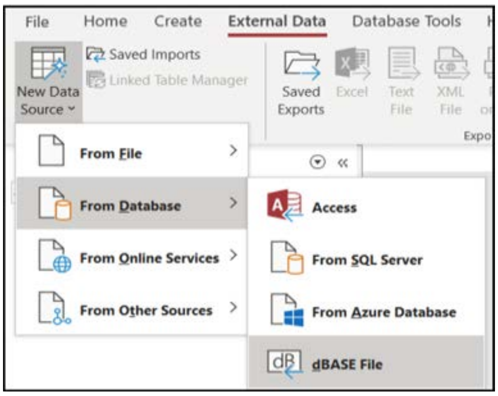


Figure 9.24. Importing dBASE files.

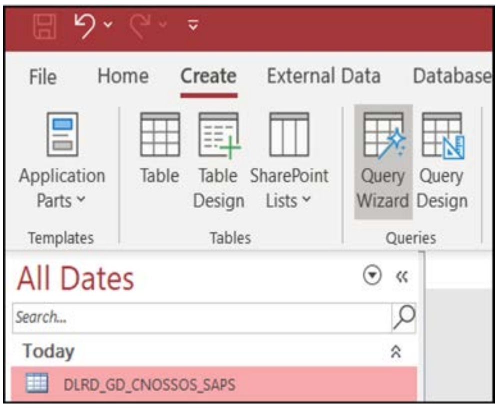


Figure 9.25. Creating queries.

The two summary tables should now be related to the “results building GeoDirectory SAPS” table using common attributes as appropriate, for example SAPS ID (e.g. “GEOGID”) for the aggregated building volume (e.g. “Sum_Volume”), and Building ID (e.g. “ELMID”) for noise at the most exposed façade (e.g. MAX_F24HOU) (see Figure 9.27).

The population per residential dwelling can now be estimated based on the building volume, as recommended in Commission Directive 2015 (EU) 2015/996 L168/93, and the aggregated building volume according to SAPS location. Right-click an empty field in the newly created query table and select “Build” to compute the “population per building” variable (see Figure 9.28). Once the “Expression Builder” dialogue menu has been opened, the population per residential building can be calculated by dividing the aggregated building volume according to SAPS location into the total population living in each SAPS location, multiplied by the building

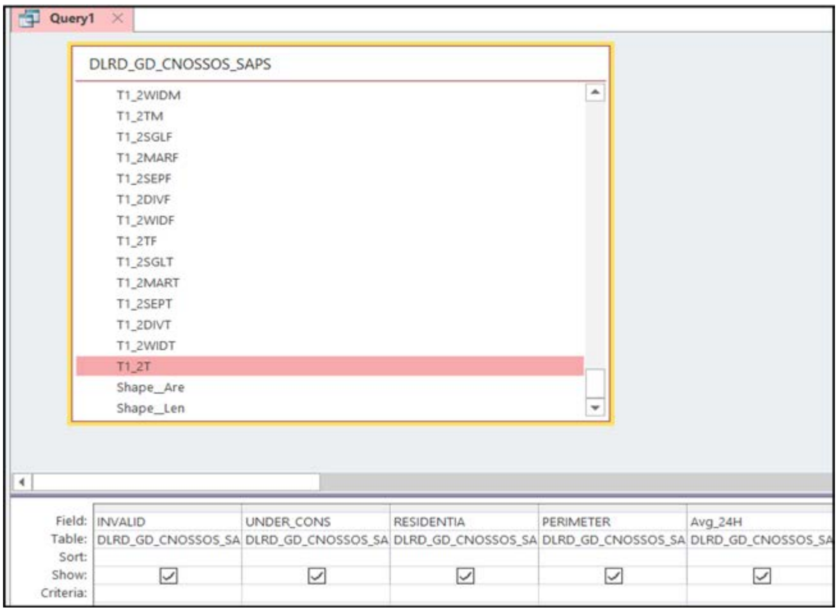


Figure 9.26. Specifying data.

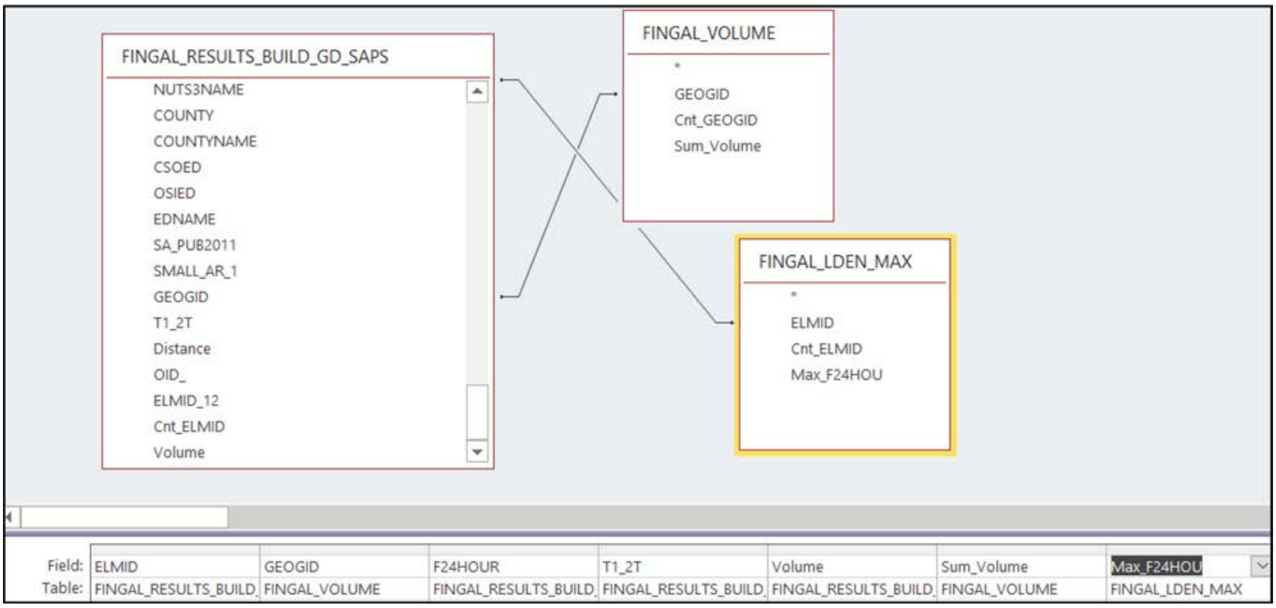


Figure 9.27. Relating tables.

volume [e.g. ([Volume]/[Sum_Volume]) * [T1_2T]] (see Figure 9.29).[21]

Once population per building has been estimated, the next step is to estimate population exposure to each noise band category. In accordance with the END, obligatory 5 dB noise band categories are:

- L_{den} < 55, 55–59, 60–64, 65–69, 70–74, ≥ 75;
- L_{night} < 50, 50–54, 55–59, 60–64, 65–69, ≥ 70.

However, the EEA Electronic Noise Data Reporting Mechanism (ENDRM) has also recommended voluntary reporting thresholds of L_{den} 50–54 dB and L_{night} 45–49 dB noise band categories. Therefore, it is

21 See Commission Directive (EU) 2015/996; L168/93, 2.8.2: $Inh_{building} = \frac{V_{building}}{V_{total}} \times Inh_{total}$.

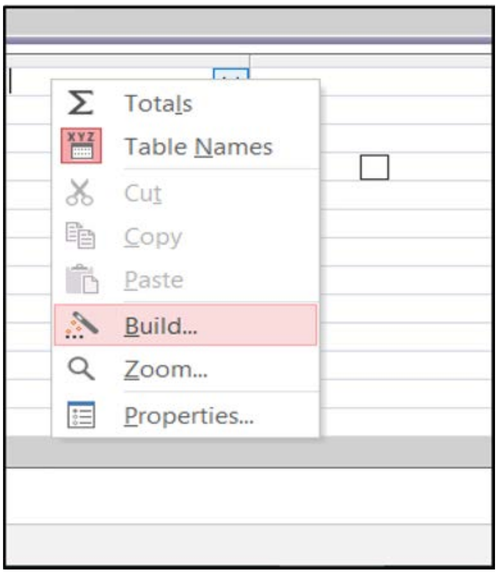


Figure 9.28. Build function.

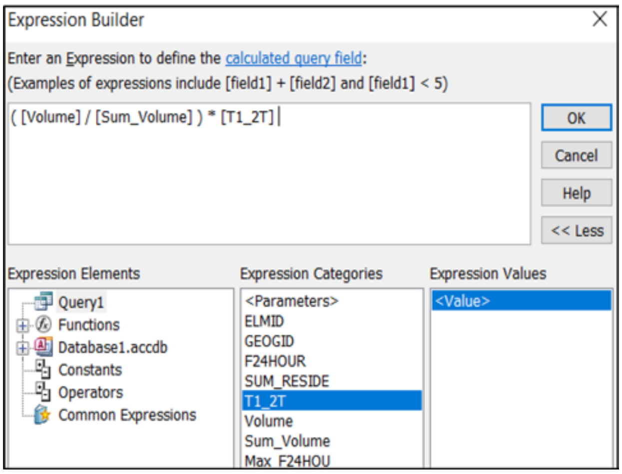


Figure 9.29. Expression builder.

recommended that the following noise band categories be used in the application of population exposure statistics:

- L_{den} < 50, 50–54, 55–59, 60–64, 65–69, 70–74, ≥ 75;
- L_{night} < 40, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, ≥ 70.

The following noise bands should be used in software applications:

- 0.00–49.99;
- 50.00–54.99;
- 55.00–59.99;
- 60.00–64.99;
- 65.00–69.99;
- 70.00–74.99;
- 75.00–99.99.

To estimate population exposure for single dwelling residential units, enter the value of 1 in the “Criteria” section of the “RESIDENTIA_SUM” variable in order select these units (see Figure 9.30). Once these units have been selected, enter values for the noise band categories into the “Criteria” section, for example “between 0.00 and 54.99” (see Figure 9.31) or “between 55.00 and 59.99” (see Figure 9.32). In this case, the noise band categories for receivers at the most exposed façade are analysed.

Once the correct parameters have been selected, enter “Datasheet View”, select the “Totals” function (see Figure 9.29), and then select the “Sum” function associated with the “population_per_building” variable in order to estimate the total population within the noise band (see Figure 9.33).

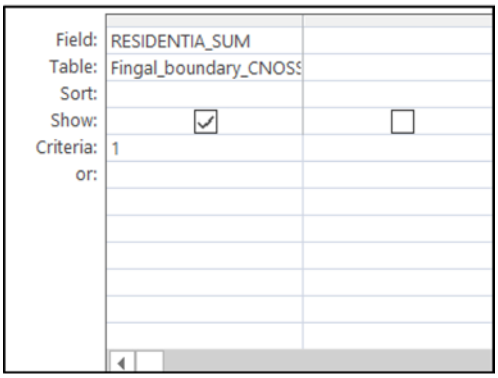


Figure 9.30. Criteria: units.

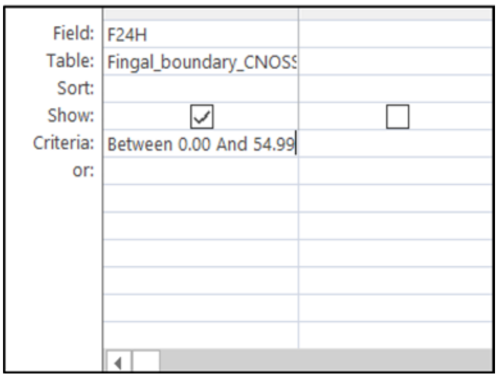


Figure 9.31. Criteria: noise 0–54.99.

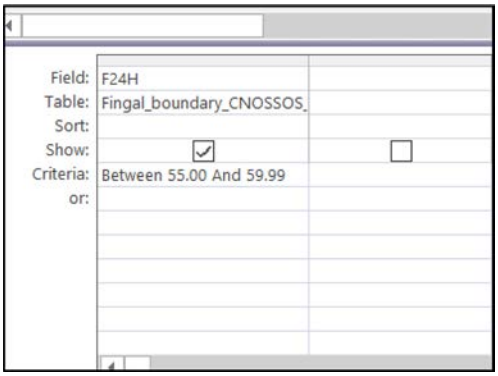


Figure 9.32. Criteria: noise 55–59.99.

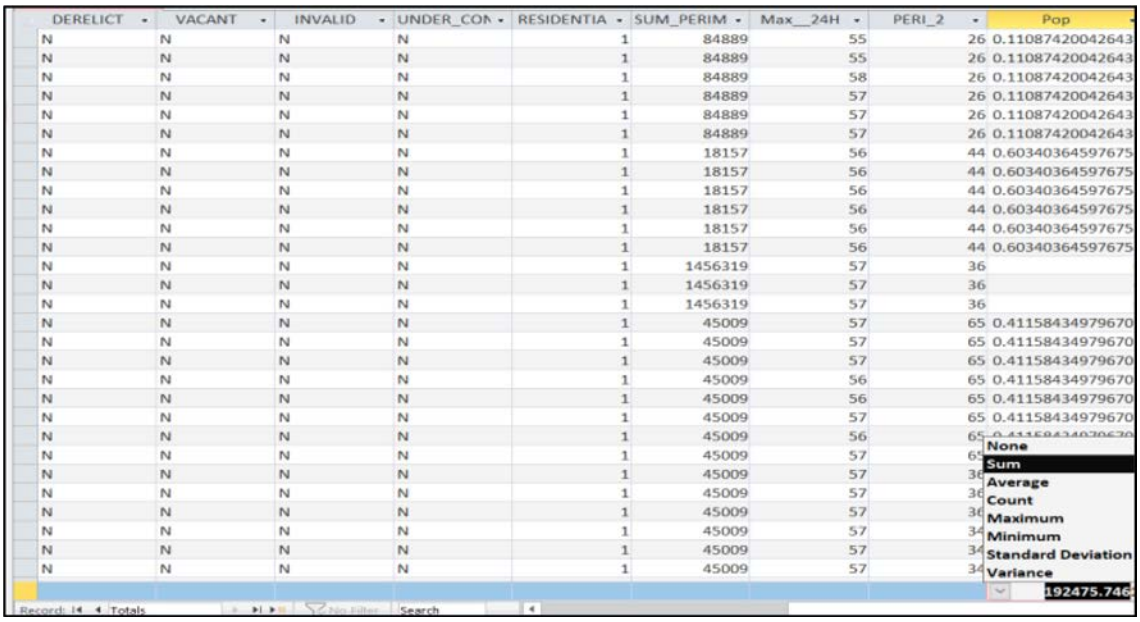
To estimate population exposure for multiple dwelling residential buildings, enter the value of > 1 in the “Criteria” section of the “RESIDENTIA_SUM” variable in order to select these residential units, and follow the procedure described previously. In this case, the noise band categories for all receivers are analysed.

9.2 Special Insulation Against Noise Analysis

Directive 2002/49/EC L189/24 states that “where appropriate” and “where information is available”, population exposure statistics should be submitted for “dwellings that have special insulation against noise”.

9.3 Quiet Façade Analysis

Directive 2002/49/EC L189/24 also states that “where appropriate” and “where information is available”, population exposure statistics should be submitted for quiet façades, “meaning the façade of a dwelling … whereby noise emitted from a specific source, is more than 20 dB lower than at the façade having the highest value of L_{den}” (EU, 2002, p. 24). If it is deemed appropriate to submit such statistics, then values for noise levels at the least exposed façade of buildings should be generated by using the “Summarize” function procedure previously described, whereby “Minimum” is selected along with “Maximum” to produce noise levels at the least exposed and most exposed façades of each building. It can be determined if the least exposed façade of a building is 20 dB lower than the most exposed façade by using a compute function whereby the value at the former is subtracted from the value at the latter (e.g. MAX_24H minus MIN_24H).



DERELICT	VACANT	INVALID	UNDER_CON	RESIDENTIA	SUM_PERIM	Max__24H	PERI_2	Pop
N	N	N	N	1	84889	55	26	0.11087420042643
N	N	N	N	1	84889	55	26	0.11087420042643
N	N	N	N	1	84889	58	26	0.11087420042643
N	N	N	N	1	84889	57	26	0.11087420042643
N	N	N	N	1	84889	57	26	0.11087420042643
N	N	N	N	1	84889	57	26	0.11087420042643
N	N	N	N	1	18157	56	44	0.60340364597675
N	N	N	N	1	18157	56	44	0.60340364597675
N	N	N	N	1	18157	56	44	0.60340364597675
N	N	N	N	1	18157	56	44	0.60340364597675
N	N	N	N	1	18157	56	44	0.60340364597675
N	N	N	N	1	18157	56	44	0.60340364597675
N	N	N	N	1	1456319	57	36	
N	N	N	N	1	1456319	57	36	
N	N	N	N	1	1456319	57	36	
N	N	N	N	1	45009	57	65	0.41158434979670
N	N	N	N	1	45009	57	65	0.41158434979670
N	N	N	N	1	45009	57	65	0.41158434979670
N	N	N	N	1	45009	56	65	0.41158434979670
N	N	N	N	1	45009	56	65	0.41158434979670
N	N	N	N	1	45009	57	65	0.41158434979670
N	N	N	N	1	45009	56	65	[illegible]
N	N	N	N	1	45009	57	6[illegible]	None
N	N	N	N	1	45009	57	3[illegible]	Sum
N	N	N	N	1	45009	57	3[illegible]	Average
N	N	N	N	1	45009	57	3[illegible]	Count Maximum
N	N	N	N	1	45009	57	3[illegible]	Minimum
N	N	N	N	1	45009	57	3[illegible]	Standard Deviation
N	N	N	N	1	45009	57	3[illegible]	Variance
								192475.746

Figure 9.33. Sum function.

10 Reporting Requirements[22]

10.1 Reporting Mechanism

EU MSs are required to submit the results of strategic noise mapping and action planning to the European Commission. It is the responsibility of the EPA, as the designated national authority, to report the results of strategic noise mapping and action planning to the Commission.

To this end, the European Commission has published the recommended ENDRM for reporting under the END, which sets out six Data Flow templates covering the MS reporting obligations in the Directive. The Data Flows cover the first and subsequent implementation rounds of the END. Information on the extent of designated locations is submitted to the Commission using templates derived from Data Flow 1_5 (DF1_5).[23] The information reported under DF1_5 covers the designation of the following:

- agglomerations ≥ 100,000 inhabitants;
- major roads > 3 million vehicles per year;
- major railways > 30,000 trains per year.

Information on the results of the SNMs is submitted using the templates in DF4_8.[24] The information to be reported under DF4_8 covers details of the following:

- agglomerations ≥ 100,000 inhabitants;
- agglomeration railways, including major railways;
- agglomeration roads, including major roads;
- major railways ≥ 30,000 trains per year;
- major roads ≥ 3 million vehicles per year.

The information reported to the European Commission may be updated at any time by the EPA, and thus the NMBs should report to the EPA any changes in information pertinent to this report as the project extents are clarified and confirmed approaching the commencement of the strategic noise mapping projects.

The EIONET Data Dictionary[25] includes:

- technical specification in PDF format;
- reporting template in Microsoft Excel;
- GIS templates in Esri SHP (shapefile) format;
- code lists and schema in XML and CSV formats.

It is recommended that data are reported using the Microsoft Excel and Esri SHP file templates, following the guidance in the specification PDF.

10.2 Information to Be Sent to the EPA

The regulations allow NMBs some scope regarding the use of supplementary noise indicators in addition to the required assessment of L_{den} and L_{night}. The regulations require NMBs to seek prior approval regarding the use of supplementary noise indicators and the data used to undertake strategic noise mapping. In this regard, the NMB should submit a proposal to the EPA for approval. The NMBs are to submit the following to the EPA:

- results of the strategic noise mapping process, in an electronic format to be agreed with the EPA;
- draft strategic noise mapping report;
- supplementary report, not exceeding 10 pages in length.

The designated noise mapping bodies for the agglomerations are to liaise and submit to the EPA a single consolidated set of strategic noise mapping results, a single consolidated draft strategic noise mapping report and a single consolidated short supplementary report, not exceeding 10 pages in length, covering the whole of the agglomeration.

22 This chapter relies heavily on the EPA's *Guidance Note for Strategic Noise Mapping for the Environmental Noise Regulations* (EPA, 2011; Chapter 11). The text has been updated where appropriate.

23 EEA ENDRM DF1_5. Available at http://dd.eionet.europa.eu/datasets/latest/NoiseDirectiveDF1_5 (accessed 3 June 2020).

24 EEA ENDRM DF4_8. Available at http://dd.eionet.europa.eu/datasets/latest/NoiseDirectiveDF4_8 (accessed 3 June 2020).

25 EIONET Data Dictionary for Noise. Available at https://tinyurl.com/y4388px9 (accessed 3 June 2020).

10.2.1 Submission guidance documentation

Submission guidance documentation can be acquired from the following resources:

- DF0: definition of reporting structure;[26]
- DF1_DF5: major roads, major railways, major airports and agglomerations designated by the MS;[27]
- DF2: reporting of competent authorities for SNMs, action plans and data collection;[28]
- DF3: noise limit values in force and associated information;[29]
- DF4_DF8: SNMs for major roads, major railways, major airports and agglomerations;[30]
- DF6_DF9: noise control programmes for major roads, railways, airports and agglomerations;[31]
- Submission of DF7_DF10: noise action plans for major roads, railways, airports and agglomerations;[32]
- European Environment Agency, *Electronic Noise Data Reporting Mechanism: A Handbook for Delivery of Data in Accordance with Directive 2002/49/EC*.[33]

10.3 Information for the Public

Within the context of Regulation S.I. 549/2018 (Government of Ireland, 2018) and the 2002 Directive, SNMs are to serve as a public statement of the extent to which environmental noise currently affects the area covered by the maps, and provide the basis of evidence for the development of noise action plans.

To this end, information for the public on SNMs should be clear and comprehensible, and include a summary setting out the most important points.

Dissemination to the public should be carried out via any appropriate means, including through the use of available information technologies, and should be in accordance with relevant regulations. The results of strategic noise mapping should be made available to the public within 1 month of the date they are finalised. On dissemination, the Directive states that it should be in "accordance with relevant Community legislation, in particular Council Directive 90/313/EEC of 7 June 1990 on the freedom of access to information on the environment", which has subsequently been repealed and replaced by Directive 2003/4/EC of 28 January 2003 on public access to environmental information (EU, 2003).

Regulation S.I. 549/2018 quotes the European Communities Act 1972 (Access to Information on the Environment) Regulations 1998 (S.I. 125/1998) European Communities (Access to Information on the Environment) Regulations 2007, S.I. 133/2007, which transpose Directive 2003/4/EC.

The European Commission Working Group Assessment of Exposure to Noise (WG-AEN) developed a Position Paper, *Presenting Noise Mapping Information to the Public*, in 2008 (WG-AEN, 2008). This provides clear guidance, advice and examples of best practice on how to publish noise mapping information. One important aspect that the paper covers is the need for suitable supporting information and explanation alongside the noise mapping results to ensure that the relevance and context of the results are conveyed.

10.4 Revision

The regulations introduce a continuing obligation on noise mapping bodies to review and, where necessary, revise each SNM every 5 years, or sooner, where requested by the EPA or when a material change in environmental noise in the area concerned triggers a revision of the relevant noise action plan.

NMBs have an obligation to undertake a review of the SNMs and, where necessary, revise them. It is

26 Available at https://cdr.eionet.europa.eu/help/noise/Annex_DF0.pdf (accessed 11 March 2021).

27 Available at https://cdr.eionet.europa.eu/help/noise/Annex_DF1_5_Changes2017.pdf (accessed 11 March 2021).

28 Available at https://cdr.eionet.europa.eu/help/noise/Annex_DF2.pdf (accessed 11 March 2021).

29 Available at https://cdr.eionet.europa.eu/help/noise/Annex_DF3.pdf (accessed 11 March 2021).

30 Available at https://cdr.eionet.europa.eu/help/noise/Annex_DF4_8_Update2018.pdf (accessed 11 March 2021).

31 Available at https://cdr.eionet.europa.eu/help/noise/Annex_DF6_9.pdf (accessed 11 March 2021).

32 Available at https://cdr.eionet.europa.eu/help/noise/Annex_DF7_10_Update2018.pdf (accessed 11 March 2021).

33 Available at https://cdr.eionet.europa.eu/help/noise/Electronic%20Noise%20Data%20Reporting%20Mechanism%2012-2012%20v2017_finaldraft.pdf (accessed 11 March 2021).

recommended that the review comprises consideration of the following aspects:

- Have there been any significant new infrastructure developments (e.g. bridges, bypasses)?
- Have there been any significant new developments (e.g. regeneration or housing developments)?
- Have additional road or railway segments come into the “major” category as a result of the change in traffic flows or flow thresholds?
- Have any major policy decisions caused a noise impact that should be shown in revised maps (e.g. noise action plan measures)?
- Have there been any significant changes to the vehicle fleet (i.e. cars, heavy goods vehicles, rail or tram vehicles)?

When revisions of SNMs are deemed necessary for any of the reasons mentioned, the revised SNMs should be republished and resubmitted to the EPA in line with the approach set out previously.

11 Conclusion

This document aims to provide a guidance manual for future noise mapping rounds under the CNOSSOS-EU approach. This document is essentially a good practice guide for transitioning to CNOSSOS-EU, targeted at practitioners charged with implementing the noise mapping requirements of the END. The guide includes a data needs section for road and rail sources, as well as recommendations for data input where Irish data are unavailable. Developing strong practice guidance for environmental issues has the potential to stop unsustainable practices and reshape practices in a manner that is better for the environment, as well as for the health and well-being of the wider population more generally. The current shift towards the CNOSSOS-EU approach provides Irish authorities with the opportunity for a "reset moment" with respect to how it implements the END, with the potential to be a policy leader in this area. It is the firm aim of this report to assist relevant authorities through the development of strong evidence-based advice on how to implement CNOSSOS-EU from 2022. This report hopes to achieve this aim by the provision of wide-ranging guidance tailored specifically for practitioners.

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Abbreviations

2D	Two-dimensional
3D	Three-dimensional
CNOSSOS-EU	Common Noise Assessment Methods in Europe
CORINE	Coordination of Information on the Environment
CPX	Close proximity measurement
CRTN	Calculation of Road Traffic Noise
CSO	Central Statistics Office
CSV	Comma-separated value
dB(A)	Decibel(A)
DCC	Dublin City Council
DMU	Diesel multiple unit
DTM	Digital terrain model
EEA	European Environment Agency
EMU	Electric multiple unit
END	Environmental Noise Directive
ENDRM	Electronic Noise Data Reporting Mechanism
EPA	Environmental Protection Agency
EU	European Union
GIS	Geographic information system
HV	Heavy vehicle
ICR	InterCity Railcar
ID	Identification
IPR	Intellectual property right
ISO	International Organization for Standardization
ITM	Irish Transverse Mercator
LiDAR	Light Detection and Ranging
max	Maximum
min	Minimum
MS	Member State
NMB	Noise Management Board
OSi	Ordnance Survey Ireland
PBA	Paris–Brussels–Amsterdam
RMR	Dutch Railway Noise Modelling Method (*Reken- en Meetvoorschrift Railverkeerslawaai*)
SAPS	Small Area Population Statistics
SCATS	Sydney Coordinated Adaptive Traffic System
SHP	Shapefile
S.I.	Statutory Instrument
sma (also SMA)	Stone mastic asphalt
SNM	Strategic noise map
TGV	Intercity high-speed rail service (*Train à Grande Vitesse*)
TII	Transport Infrastructure Ireland
WG-AEN GPG v2	Working Group Assessment of Exposure to Noise Good Practice Guide Version 2
WP	Work package
XML	Extensible markup language
zoab	Permeable concrete (*zeer open asfaltbeton*)

Glossary

Decibel(A)	An expression of the relative loudness of sounds in air as perceived by the human ear
L_{day}	Day noise level; the A-weighted, L_{eq} (equivalent noise level) over the 12-hour day period (07:00–19:00). See Directive 2002/49/EC L 189/18
L_{den}	Day–evening–night noise level; the A-weighted, L_{eq} (equivalent noise level) over a whole day, but with a penalty of 10 dB(A) for night-time noise (23:00–07:00) and 5 dB(A) for evening noise (19:00–23:00). See Directive 2002/49/EC L 189/18
$L_{evening}$	Evening noise level; the A-weighted, L_{eq} (equivalent noise level) over the 4-hour evening period (19:00–23:00). See Directive 2002/49/EC L 189/18
L_{night}	Night noise level; the A-weighted, L_{eq} (equivalent noise level) over the 8-hour night period (23:00–07:00). See Directive 2002/49/EC L 189/18

Appendix 1 – Sensitivity Analysis

Table A1.1. Sensitivity analysis – CRTN-TRL vis-à-vis CNOSSOS-EU (medium–heavy traffic flow) in dB(A)

Microphone/ receiver[a]	Sound level meter	CNOSSOS-EU model	CNOSSOS-EU differential	CRTN-TRL method 3	CNOSSOS-EU CRTN-TRL method 3 differential	CRTN-TRL method 2	CNOSSOS-EU CRTN-TRL method 2 differential
Roadside (7.5 m)							
East lane							
5	72.6	71.8	–0.8	70.7	–1.2	69.7	–2.2
6	72.8	71.9	–0.9	70.3	–1.7	69.3	–2.7
7	72.6	71.9	–0.7	70.6	–1.4	69.6	–2.4
8	72.6	72.3	–0.3	71.4	–1	70.4	–2

[a]Except where otherwise stated, all receivers are set at a ground-level height of 1.5 m.
TRL, Transport Research Laboratory.

Table A1.2. Sensitivity analysis – category 2 and 3 vehicles[a] (medium–heavy traffic flow) in dB(A)

Receiver	HV analysis at 50 km/h				
Roadside (7.5 m)	50/50	30/70	Differential	70/30	Differential
1	72.1	72.4	0.3	71.9	–0.2
2	72.1	72.4	0.3	71.9	–0.2
3	72.2	72.4	0.2	71.9	–0.3
4	72.6	72.8	0.2	72.3	–0.3
Propagation (30 m)					
5 (30 m)	67.2	67.5	0.3	67	–0.2
6 (Height = 4 m)	66.2	66.5	0.3	66	–0.2
Receiver	**HV analysis at 60 km/h**				
Roadside (7.5 m)	50/50	30/70	Differential	70/30	Differential
1	72.8	73.1	0.3	72.6	–0.2
2	72.8	73.1	0.3	72.6	–0.2
3	72.9	73.2	0.3	72.6	–0.3
4	73.3	73.6	0.3	73	–0.3
Propagation (30 m)					
5	67.9	68.2	0.3	67.7	–0.2
6 (height = 4 m)	66.9	67.2	0.3	67	0.1

[a]This analysis was performed in a scenario whereby 10% of total traffic flow was represented by HVs. According to Dublin City round 3 data, 88%, 11% and 0.7% of road polylines represent 0%, 1%–10% and 11%–22% of HVs, respectively.

Table A1.3. Sensitivity analysis – category 4 vehicles[a] (medium–heavy traffic flow) in dB(A)

Receiver	Category 4 analysis					
Roadside (7.5 m)	Category 1 no MBIKE at 50 km/h	Category 4 at 50 km/h	Differential	Category 1 no MBIKE at 60 km/h	Category 4 at 60 km/h	Differential
1	70.4	70.6	0.2	71.5	71.5	0
2	70.6	70.6	0	71.5	71.5	0
3	70.6	70.6	0	71.5	71.5	0
4	71	71	0	71.9	71.9	0
Propagation (30 m)						
5	65.6	66	0.4	66.5	66.9	0.4
6 (height = 4 m)	64.7	65	0.3	65.6	65.8	0.2

[a]This analysis was performed in a scenario whereby 5% of total traffic flow was represented by category 4 vehicles. In Ireland, figures from the CSO (CSO, 2017) describe a total of 63,474 (1.77% of total vehicle registration) new category 4 vehicles registered for the period.

Table A1.4. Sensitivity analysis – velocity (medium–heavy traffic flow) in dB(A)

Receiver	Velocity				
Roadside (7.5 m)	44 km/h	50 km/h	Differential	60 km/h	Differential
1	71.9	72.3	0.4	72.7	0.8
2	72	72.4	0.4	72.8	0.8
3	72	72.4	0.4	72.8	0.8
4	72.4	72.8	0.4	73.2	0.8
Propagation (30 m)					
5	65.9	66.3	0.4	66.7	0.8
6 (height = 4 m)	65.7	66.2	0.5	66.3	0.6

Table A1.5. Sensitivity analysis – track type classification CNOSSOS-EU in dB(A)

Track type	Receiver position[a] from centreline		
	1 (7.5 m)	2 (15 m)	3 (30 m)
Empty track transfer function	56	52.5	48.7
Min	56	52.5	48.7
Mono-block sleeper on soft rail pad	59.6	56.1	51.5
Mono-block sleeper on medium stiffness rail pad	58.7	55.2	50.9
Mono-block sleeper on hard rail pad	58.3	54.9	50.6
Bi-block sleeper on soft rail pad	59.5	56	51.4
Bi-block sleeper on medium stiffness rail pad	58.4	54.9	50.7
Bi-block sleeper on hard rail pad	57.8	54.3	50.2
Wooden sleepers	58.7	55.2	50.7

[a]In the context of rail sources, all receivers are set at a height of 1.2 m.

Table A1.6. Sensitivity analysis – structure transfer CNOSSOS-EU in dB(A)

	Structure transfer analysis			
Receiver position	Empty superstructure transfer function	Min	CNOSSOS-EU default	Differential
1 (7.5 m)	59.6	59.6	59.6	0
2 (15 m)	56.1	56.1	56.1	0
3 (30 m)	51.5	51.5	51.5	0

Table A1.7. Sensitivity analysis – rail roughness CNOSSOS-EU in dB(A)

	Rail roughness analysis				
Receiver position	Empty rail roughness	Min	EN ISO 3095:2013	Average network	Differential
1 (7.5 m)	63.8	55.6	57.8	59.6	8.2
2 (15 m)	60.2	52.1	54.3	56.1	4
3 (30 m)	56	47.8	49.9	51.5	3.7

Table A1.8. Sensitivity analysis – impact noise CNOSSOS-EU in dB(A)

	Impact noise analysis			
Receiver position	Empty impact	Min	Single switch/joint/crossing/100 m	Differential
1 (7.5 m)	59.6	59.6	70.1	10.5
2 (15 m)	56.1	56.1	66.6	10.5
3 (30 m)	51.5	51.5	61.1	9.6

Table A1.9. Sensitivity analysis – R103 traffic light intersection analysis LA_{eq} dB(A)

Microphone location	Distance from intersection (m)	Sound level meter	Correction coefficient		Differential	
			Applied	Not applied	Applied	Not applied
1	30	67.8	71.1	68.8	3.3	1.0
2	30	68.1	71.2	68.9	3.1	0.8
3	60	68.7	69.2	68.2	0.5	–0.5
4	90	69.3	68.3	68.2	–1.0	–1.1

Table A1.10. Sensitivity analysis – R103 roundabout intersection analysis LA_{eq} dB(A)

Location	Distance from intersection (m)	Sound level meter	Correction coefficient		Differential	
			Applied	Not applied	Applied	Not applied
1	90	69.5	68.9	69.0	–0.6	–0.5
2	60	68.2	68.6	68.8	0.4	0.6
3	30	66.1	68.4	68.1	2.3	2.0
4	7.5	64.7	69.1	68.2	4.4	3.5

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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Towards a Good Practice Guide for Implementing CNOSSOS-EU in Ireland

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Identifying Pressures

In the European Union (EU), 113 million people are estimated to be exposed to noise pollution from transport sources and that is detrimental to their health and quality of life. Internationally, there is a growing evidence base that links noise from transport sources to health issues, including sleep disturbance, annoyance, heart disease, cognitive impairment, quality of life and mental health and wellbeing. This report addresses noise pollution from transport as a significant environmental pressure and public health concern by providing guidance that assists with the practical implementation of recentrevisions to the Environmental Noise Directive (END; 2002/49/EC). Given that Ireland has a statutory obligation to meet the requirements of the END, this is a strategic national environmental priority. This guide outlines research conducted to assist with the objective of implementing regulations set out in the END and, in doing so, assists with developing future national capacity that contributes towards meeting Ireland's legislative obligations under EU law.

Informing Policy

Internationally, this guide contributes to improving the implementation of the END and utilises the new CNOSSOS-EU (Common Noise Assessment Methods in Europe) methodology from 2019 onwards. This document provides a comprehensive good practice guide for implementing CNOSSOS-EU in Ireland. The aim of the guide is to support the fourth round ofnoise mapping guidance for implementation of the END using the CNOSSOS-EU methodology. The guide is primarily targeted at practitioners charged with implementing the 5-yearly strategic noise mapping requirements of the END. Thus, the guide supports relevant authorities by providing robust analysis and instruction on how to implement strategicnoise mapping under CNOSSOS-EU. The guide is based on research carried out from February 2018 to May 2020. Therefore, it does not reflect some policy developments relevant to the fourth round of strategic noise mapping, such as the anticipated revisions to CNOSSOS-EU by means of a delegated directive amending Annex II of Directive 2002/49/EC, and the revised European Environment Agency (EEA) Reportnet 3 reporting mechanism as a result of Regulation (EU) 2019/1010, introduced in November 2020.

Developing Solutions

The development of strong guidance for implementing environmental legislation has the potential to assist with transitioning to more sustainable environmental practices, which can benefit the health and wellbeing of the wider population. The current shift towards the CNOSSOS-EU methodology for strategic noise mapping provides Irish authorities with the opportunity for a "reset moment" with respect to implementation of the END. In this sense, Ireland has the potential to be a European policy leader in the area. This guide outlines solutions and advice on how to implement thenew CNOSSOS-EU noise modelling and mapping methodology from 2019 onwards. It utilises practical examples and explanatory visuals that can be referred to at each step of the process. In this respect, the guide provides instruction regarding road and rail source calculation using commercial software, the generation of strategic noise maps using data interpolation and the estimation of population exposure under CNOSSOS-EU.

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