

DEVELOPMENT OF A METHODOLOGY TO EVALUATE ENVIRONMENTAL NOISE BASELINE LEVELS AND ESTABLISH ENVIRONMENTAL QUALITY OBJECTIVES FOR NOISE IN RELATIVELY QUIET AREAS.

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1. INTRODUCTION

This paper describes the first comprehensive scientific study undertaken in Ireland to monitor the soundscape of relatively untouched or wilderness areas over time. The research aims to establish comprehensive baseline data for relative quiet areas (as defined in the proposed EU Environmental Noise Directive) by carrying out extensive noise monitoring programmes throughout Ireland. The monitored data will be utilised to elaborate on and recommend environmental quality objectives (EQOs) and Environmental Quality Standards (EQSs) for noise in relation to relatively quiet areas. In addition anthropogenic noise modelling will be undertaken at representative sites, and integrated within a Geographic information system (GIS). The capabilities of this system will allow for strategic environmental assessment for noise and provide an integrated environmental planning methodology for noise control.

2. RELATIVE QUIETNESS

There is no such thing as 'absolute' quietness in the environment. Natural quietness is normally taken to be the absence of anthropogenic noise, or extreme levels of natural noise, such as high level wind noise. Relative quietness then implies a degree of quietness relative to some other level of noise. In busy conurbations where ambient noise levels might exceed 70 dB(A) due to transport and industrial activities, a level of 50 dB(A) in a suburban area might be said to be relatively quiet. On the other hand, 50 dB(A) would be considered to be rather loud in a rural context.

There is then, no strict definition of 'relative quietness'. However the term 'relatively quiet area' has been considered in the proposed Directive and it is suggested that relative quietness relates to noise levels unaffected by transport, industry and recreational activity. A definition is given below.

The proposed Directive defines a "Relatively Quiet Area in the open country" as "An area, delimited by national or regional competent authority that is undisturbed by noise from traffic, industry or recreational activities and where natural quiet can be enjoyed." (Commission of the European Communities, 2000)

2.1 Relatively quiet areas in other countries

The Sixth Environment Action Programme of the European Community "Environment 2010: Our Future, Our Choice" identified four priority areas upon which environmental policy will focus. One area was "Natural resources", which would apply to relatively quiet areas.

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There are five key approaches –

- Ensure the implementation of existing environmental legislation;
 - Integrate environmental concerns into all relevant policy areas;
 - Work closely with business and consumers to identify solutions;
 - Ensure better and more accessible information on the environment for citizens;
 - Develop a more environmentally conscious attitude towards land use.
- (EU Commission, 2000)

The proposed Directive and the Action programme above will require member states to take action to protect relatively quiet areas. Work to date indicates that there is relatively little information from other European countries on research concerning the establishment and preservation of RQAs.

Action plans generally are aimed at reducing relatively high ambient noise levels rather than preserving relatively low levels. Perhaps this is due to the fact that Ireland is in a relatively unique position historically of having a limited number of major conurbation's and low population densities in large areas of the country, with resultant low levels of anthropogenic noise. This provides the opportunity to allocate resources to protect quietness rather than to the reduction of high ambient noise levels.

2.2 Identifying and Monitoring Relatively Quiet Areas

The Environmental Protection Agency (EPA) has sought to establish baseline data for relatively quiet areas in order to establish the baseline noise environment in Ireland. In a previous report entitled 'Establishing rigorous methods for definition and monitoring of relatively quiet areas' certain criteria were decided upon, which should characterise Relatively Quiet Areas.

2.3 Characteristics of a relatively quiet area

- Rural environment
- $L_{A,90}$ level of less than 30 dB for a total of at least 1 hour in any given day-time period (0700-1900) or evening period (1900-2300)
- $L_{A,90}$ level of less than 30 dB for a total of at least 3 hours in any given night-time period (2300-0700hrs)
- At least 1 km from any urban centre with a population greater than 1,000
- At least 5 km from any urban centre with a population greater than 5,000
- At least 10 km from any urban centre with a population greater than 10,000
- At least 1 km from local industry (e.g. grain drying facility, nursery, small factory)
- At least 5 km from major industry (e.g. large factory, industrial estate)
- At least 1 km from a National Primary road
- At least 2 km from a Dual carriageway or motorway
- At least 5 km from the normal departure/arrival flight path of any airport with more than 10 flights in any given 24-hour period
- At least 1 km from a railway line in regular use (i.e. more than 10 scheduled trains in any given 24-hour period)

It was considered that in some circumstances, minimum distances specified above were not be sufficient to ensure that measured noise levels are not affected by external sources in very quiet locations. The following specifications should ensure that external noise does not affect measurements.

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- At least 3km from Urban areas with a population >1000 people.
- At least 10km from any urban areas with a population of > 5,000 people.
- At least 15km from any urban areas with a population > 10,000 people.
- At least 3km from any local industry
- At least 10km from any major industry centre
- At least 5 km from any National primary route
- At least 7.5 km from any Motorway or Dual Carriageway (as recommended in EU studies)

In addition to minimum distance criteria the following factors should also be taken into account: -

- Topography, elevation and land use including flight paths, wind direction and rural activities.
- It would be advantageous to include a selection of ecological habitats and land uses at varying elevations.
- Special consideration should be given to special areas of conservation and places of high amenity value with regard to their natural soundscape.
- It would be advantageous to consider the variation between traffic flow on National Primary Routes along the high density population East coast and the low density population on the western side of the country.

In assessing the various acoustic soundscapes of relatively quiet areas in Ireland many different landscapes will be studied.

1. Mountain, rolling hill and open valley landscape,
2. Flat lowland landscapes in the midlands,
3. Coastal landscapes
4. Inland waterway influenced landscapes,

The soundscape will be directly related to the meteorological conditions and presence of wildlife and in certain landscapes with low wind speeds > 4m/s above average baseline noise levels will exist without the presence of anthropogenic noise. Such sites would still be classified as relatively quiet areas.

In selecting suitable sites the following conditions generally apply:

- Low population density
- Low agricultural productivity (away from intensive farming)
- Good network of minor roads/tracks to facilitate accessibility and noise mapping.

The reference level of $L_{A,90}$ 30 dB(A) is largely site specific depending on the natural environment, landuse, aspect, elevation and concentration of wildlife.

2.4 Management and preservation of Relatively Quiet Areas

Sustainable development means that we have to introduce accountable noise abatement development programmes and related noise monitoring systems to continuously assess and inform on whether one is making progress or not. By using the Best Available Information (BAI) to support the improvements in the acoustical environment and to deliver reliable, objective and comparable information on the acoustical environment at a European, National and Local level.

The management and prediction of environmental noise requires accurate and adequate information of the sound power levels within the RQA. The distribution and variety of noise sources in an area will make the determination of exact sound power level of the acoustic environment very difficult. The noise sources will generally be of organic nature in origin. In order to maintain the ambient noise levels in the environment within the limits prescribed by the any proposed national standards, the land use plans for area will have to be acoustically designed.

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The reasons for preservation of relatively quiet areas are threefold, firstly to protect areas for people to enjoy solitude, secondly to preserve the aural footprint and characteristics of an area and thirdly to protect biodiversity. The integration of a Geographic Information System (GIS) will help to monitor, review and inform the public on the acoustic environment in a manner that is more understandable. It will relate noise measurements of the geographic locations and assist in the public understanding of the environment using the Best Available Technology.

3. METHODOLOGY TO EVALUATE ENVIRONMENTAL NOISE LEVELS

The project will be executed in the following manner:

- Identify 15 sites in the Irish countryside as reference locations for the assessment of the baseline noise environment.
- Develop an extensive database of the soundscape or acoustic quality of the environment in each location through monitoring and noise data analysis.
- Undertake baseline noise mapping for each of the fifteen reference sites utilising GIS technology. The noise mapping will provide a visual representation of the noise profile at a given geographical location, which can be used to identify the boundaries of Relatively Quiet Areas.
- Evaluate the status of Relatively Quiet Areas in Ireland.
- Undertake modelling of anthropogenic noise, based on monitored and/or noise database values, at four of the reference sites representative of different rural conditions in Ireland. Integrate the model results with GIS to provide detailed impact maps to demonstrate the technique. This will provide the authorities involved in policy making with the necessary information to assist in the development of policies and plans for noise abatement and control in Relatively Quiet Areas (RQA) both locally, regionally and nationally.
- Develop and propose comprehensive environmental quality objectives [EQOs] and additional EQSs where considered necessary for the complete achievement of the proposed EQOs, based on the data gathered during the monitoring and modelling tasks above.

Extensive environmental noise monitoring over a twelve month period will be undertaken throughout Ireland. Monitoring sites include a selection of ecological habitats; special consideration is given to natural heritage areas (NHA's), special protection areas (SPA's), Ramsar sites and places of high amenity value with regard to their natural soundscape. Reference locations were selected geographically around the country to include as many diverse and regionally separated reference sites as possible. Four principle acoustic landscapes will be assessed:

- *Mountain, rolling hill and open valley landscape*
- *Flat lowland landscapes in the midlands*
- *Coastal landscapes*
- *Inland waterway influenced landscapes*

The selection of representative relatively quiet areas (RQA) for inclusion in the study will include a number of ecological habitats and land uses at varying elevations. Special consideration was given to special areas of conservation and places of high amenity value with regard to their natural soundscape.

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3.1 Monitoring of RQA Sites

Fifteen reference sites will be monitored for a period of one year. Each reference site shall be monitored on four separate or individual occasions within that period. Monitoring will comprise of 24 hr integrated real time noise and meteorological monitoring.

Monitoring at all sites will include a minimum of one fixed reference monitor and up to three portable units. Monitoring will be undertaken at between seven and twenty sites within the greater boundaries of the acoustic landscape. This is required to generate meaningful basic noise contours of the area, any fewer sites would be of little value to the investigation.

Noise measurements shall be undertaken at specific locations simultaneously. A control site shall be established, the LD 870 integrated noise and meteorological monitoring instrumentation shall be set up, calibration checked and set for continuous real time monitoring at 15min time intervals. This location will remain fixed during the monitoring period. In all instances noise monitoring equipment will be time synchronized and calibrated prior to and after monitoring and calibration records kept for further reference. Monitoring shall be undertaken in accordance with best practices and ISO1996:1982 Acoustics- Description and measurement of Environmental Noise.

Monitoring methodologies and procedures shall take into account the EPA commissioned report "*Establishing Rigorous Methods for Definition and Monitoring of Relatively Quiet Areas*".

Of the fifteen reference sites to be monitored, four were selected for more intensive monitoring to facilitate monitoring and modelling of anthropogenic noise. At all reference locations monitoring shall be undertaken with respect to seasonal variation, landscape variation and meteorological influences. It is recommended that the recording periods should in part represent meteorological conditions experienced in Ireland; including periods of calm with low ambient noise levels (windspeeds 1-5 km/sec), and periods of moderate to high wind speeds with elevated ambient noise levels (windspeeds 5 -10km/sec).

One precision digital audio tape minidisk recorder with outdoor microphone will be utilised to monitor the acoustic soundscape and record ambient and anthropogenic noise sources at representative selected sites for further reference purposes. All of the noise monitoring points will be geo-referenced by global satellite positioning using a GPS monitor and marked/identified for further reference.

In addition various meteorological conditions such as precipitation, frost, snowfall, drought, etc should all be considered for further investigation. It is intended wherever possible to plan and undertake the monitoring programmes when meteorological conditions are most suitable ie. low wind speeds and dry conditions.

3.2 Monitoring Parameters

Particular values recorded during the noise survey shall be the equivalent continuous sound level (Leq), maximum noise level (Lmax), the 10% (L10), 90% (L90) and %95 (L95) percentile levels. These values will represent the extremes of the range recorded for over the recording time period. The measurement time intervals will be set to 15 minutes and one hour intervals, history period one minute and history period units one second. The sound level meter set to frequency weighting "A" and detector response to "Fast". Simultaneous wind speed and direction measurements shall be undertaken at the control site to facilitate in data interpretation.

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3.3 Data analysis, and basic noise mapping (data preparation for GIS)

Following the monitoring fieldwork carried out at each site, the data files shall be exported into standard spreadsheet format and each individual file saved in a logical, coded format and additional backups of data performed. Standard operating procedures shall be followed at all times to prevent data loss, file corruption or mislabelling of data files.

Each of the approximately 200 sites monitored within the fifteen reference locations are spatially and geographically separate, to illustrate or map acoustic boundaries for an area this data needs to be represented in an informative and scientific manner. Basic, non-GIS noise contour maps will be provided for all sites. In addition, one of the most comprehensive and commonly used GIS packages, ArcView, will be utilised to spatially map or illustrate the acoustic soundscape at four reference sites selected for anthropogenic noise modelling. The use of this data presentation mapping system will greatly assist in the comprehension, interpretation and dissemination of monitored data and will allow for the graphical presentation of numerical result data on site maps.

The digital maps are supplied by the Environmental Protection Agency. The preliminary map preparation work would involve the graphical presentation of the basic noise monitoring data in noise contours for each geographical area. At this stage, the minimum of output from the mapping facility shall include:

- Cartographic presentation of site maps.
- Simple Cartographic maps with overlaid result data of measured noise levels at spot locations
- Graphical presentation of the acoustic soundscape using noise contours at each of the fifteen reference sites.
- Presentation of noise monitoring results in Leq, Lmax, L10 and L90 values in both graphical and tabular format.

In the case of sites selected for anthropogenic noise modelling and GIS impact assessment, each site shall be photographed, the landscape identified and representative images scanned for subsequent reference. Basic vegetation/landuse maps based on field observations shall be prepared for integration into the GIS maps of the area. Thus these maps shall also provide an indication of the various land uses that can be found within a study area.

The main objective is to develop an integrated numerical /GIS model for the prediction of the noise environment for relatively quiet areas in Ireland. The anthropogenic noise source characterisation and modelling results will be presented as overlay contour maps on the baseline GIS maps prepared.

The integrated system will be used for environmental impact assessment and will be provided as a policy tool for use in future planning purposes. The work will be carried out under the following Tasks

1. Develop a noise prediction model based on the Equivalent Acoustic Centre principle for each of the four selected sites, model anthropogenic noise sources and interpret results,
2. Build a detailed GIS data base for each of the four selected sites, to include topographic, geographic, demographic and monitoring station details.. Map and present the monitored and predicted noise environment for the selected RQA's.

The noise analysis and interpretation of the monitored noise data, the GIS integration and modelling, together with the anthropogenic noise modelling will be done in parallel with the monitoring work over the course of the project.

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3.4 Modelling of anthropogenic noise sources

This task will develop an anthropogenic noise source characterisation model, based on the Equivalent Acoustic Centre (EAC) principle, for the four reference sites selected as follows representative locations chosen from the original fifteen sites:

In the application of a noise model and investigating of the influence of anthropogenic noise on RQA a combined Experimental Measurement /Acoustic Database Techniques will be implemented to determine the sound power level of the EAC. the source power model. The models developed for the four reference RQA's will provide the necessary spatial noise data to be interfaced with GIS for detailed environmental assessment and will allow for the modelling of the impact of anthropogenic noise.

This system will further assist the Environmental Protection Agency in assessing and developing strategies for noise control and implementation policies in Ireland. By adding and combining other information (for example population distribution, roads, land use etc) maps of the reference sites will be developed which will display environmental information to support local, regional or national action taken to protect the acoustic environment.

For the purposes of the present model development, the environmental noise level is defined as outlined in ISO1996:1982 Acoustics- Description and measurement of Environmental Noise. It is also assumed that the equivalent continuous sound pressure level (L_{eq}) for a period (15 min periods in this study) at a particular location reflect the quality of the noise environment in that area during that period. The predicted level can be considered as the maximum level that may appear due to the ancillary activities or future planned development.

3.5 Environmental impact assessment in GIS using the modelled anthropogenic noise sources

Monitored Data and the results of anthropogenic noise modelling will be integrated with the site specific topographic data and with other site properties that characterise noise propagation at each of the selected sites. The next stage of the process will involve environmental impact assessment, based on assumed anthropogenic noise sources, in order to evaluate the effect of possible noise encroachment in the RQA's.

Noise mapping systems will be developed for representative sites utilising Geographic Information Systems (GIS). The maps will assist in the development of future noise mitigation plans for relatively quiet areas in Ireland and allow for updating of the maps at given intervals.

Through this process, it will become easier to perform cost-benefit analysis of development plans or actions and lead to more sustainable policies. In addition the availability of these maps and further monitoring at each of the selected sites will help establish trends that will test the policies and plans for noise abatement locally, regionally and nationally.

4. PROPOSALS FOR ENVIRONMENTAL QUALITY OBJECTIVES

Existing and proposed environmental quality standards for noise will be considered in the light of the results of the environmental noise monitoring and modelling.

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The flow diagram representing the relationship between the project workpackages is illustrated in Figure 1.

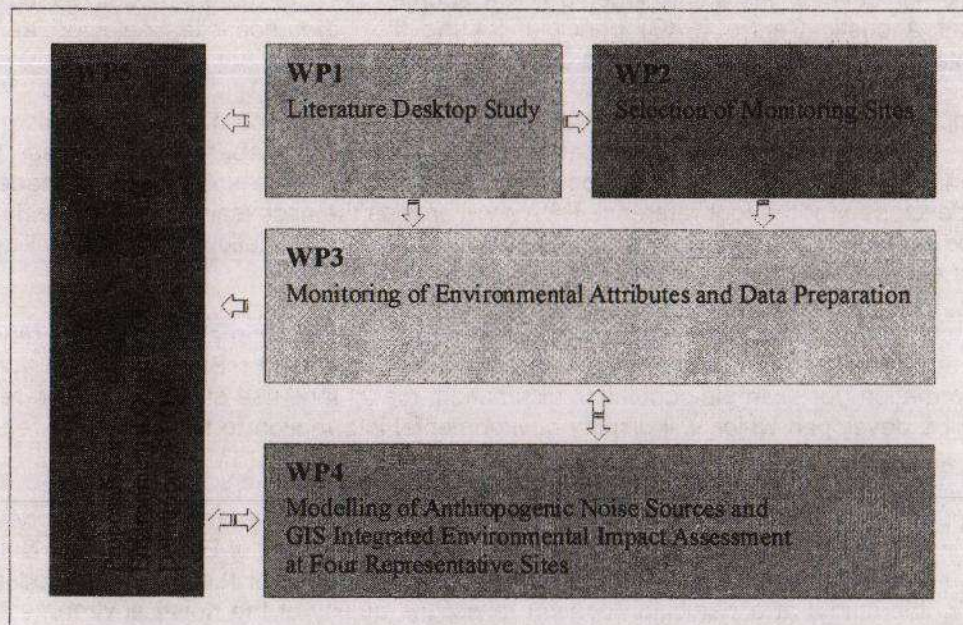


Figure 1. Project flow diagram

A coherent, comprehensive proposal for the definition and assignment of EQOs for the noise compartment will be made. Where no appropriate EQS exists, appropriate standards will be proposed. Proposals will be made for future work for the maintenance of relatively quiet areas in Ireland.

The final report on the state of the acoustic environment in Ireland with reference to Relative Quiet Areas will include the major sources of noise such as road traffic, air traffic, rail traffic, industry and recreational activities. It will identify any problem areas, suggest strategies for noise control and landuse planning in RQA. This study will look at the noise data available and determine the impact of anthropogenic noise on areas of relative quietness.

The report will investigate the impact of noise in relative quiet areas with reference to spatial planning, land use and environmental management. The report will investigate the initiatives undertaken in other European Countries and organisations. A particular focus of the report will be to investigate the impact of further economic development both regionally and otherwise on the acoustic environment. It will review action plans by other member states and suggest comprehensive implementation guidelines for improving the noise environment in Ireland. These issues will have to be critically addressed in order to meet the objectives of the CEC's 5TH Environmental Action Programme on the Environment and Sustainable Development..

In the long term, in order to maintain the noise levels within the limits prescribed by the any proposed national standards, the land use plans for areas will have to be acoustically designed. Anthropogenic noise modelling and its integration within GIS for environmental impact assessment and environmental resource management, will provide an integrated planning methodology focused on sustainable development.