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Assessing Noise Impacts from Surface Transportation Projects in Canada

Kaarina STIFF
Transport Canada
Ottawa, Ontario, Canada
stiffk@tc.gc.ca

1.0 ABSTRACT

This report provides an overview of current issues concerning the assessment of noise impacts from transportation projects under federal environmental assessment (EA) legislation in Canada. It provides an overview of noise assessment methodology, and highlights key challenges that Canadian practitioners are facing in adopting appropriate project thresholds for transportation-related noise increases. This report draws extensively on a report commissioned by Transport Canada, prepared by RWDI Air Inc., titled "Recommendations for a National Approach to Assessing Noise Impacts from Transportation Projects". Copies of this report are available upon request.

2.0 CONTEXT

Transport Canada is responsible for ensuring that an environmental assessment is carried out for projects that it supports with certain approvals, including federal funding for transportation projects. The provision of federal funding means an environmental assessment under the *Canadian Environmental Assessment Act* (CEAA) must be completed before the project can proceed.

The definition of "environmental effects" under CEAA includes any change that the project may cause in the environment. The definition also includes any potential human health impacts that may result from an environmental effect. Potential increases in noise are among the effects that must be considered in the EA process.

The main focus of environmental assessments under CEAA is to determine the "significance" of the environmental effects. Projects that are likely to have significant adverse environmental effects must either be referred to a review panel or mediator for further assessment, or responsible authorities may not support the projects. Significance is generally defined on an assessment-by-assessment basis, and varies for each environmental component. Defining significance in the context of noise impacts has been particularly challenging for transportation projects in recent years.

3.0 BACKGROUND ON NOISE ANALYSIS

Sound is a dynamic, fluctuating pressure, in a fluid medium such as air, other gases, or liquids such as water. These fluctuations are transmitted by pressure waves through the medium from the source to the receiver. For most engineering purposes, the primary interest is with sound waves in air, with human beings as the receptor. Noise is defined as *unwanted sound*. These terms are often used interchangeably.

Sound pressure level is what humans experience as sound. Sound waves create small fluctuations around the normal atmospheric pressure. These pressure fluctuations come into contact with eardrums and create the sensation of sound. Sound pressure is measured in decibels.

Road and rail transportation noise sources tend to be broadband in nature, having roughly equal sound energy in many octave bands. Heavy rail traffic and heavy truck traffic may produce noise in lower frequencies.

The A-Weighting network was developed to correspond to how humans hear low to medium levels of noise. The A-Weighting is the most frequently used scheme, and the majority of noise guidelines are expressed in A-Weighted decibel values, denoted as "dBA" levels.

People experience a wide range of sound levels in their daily activities. Sound levels from 40 to 65 dBA are generally considered to be in the *faint to moderate* range. The vast majority of the outdoor noise environment, even within the busiest city cores, will lie within this area. Sound levels from 65 to 90 are generally perceived as *loud*. This area includes very noisy commercial and industrial spaces. Sound levels greater than 90 dB are generally considered to be *very loud to deafening*, and could potentially result in hearing damage (RWDI, 2006).

Transportation noise events, which vary with time, can also be considered in terms of their maximum noise level (Lmax) during a vehicle pass-by, as shown below:

Table 1 - Typical Pass-By Noise Levels at 15 m from Noise Source

Event	**Range of Noise Levels (dBA) at 15 m**
Semi-Trailer Trucks	75 – 85
Aircraft	69 – 85 [1]
Conventional Light Rapid Transit	72 – 80 [2]
Large Trucks	71 – 78
Street Motorcycle	76
Diesel or Natural Gas Bus	70 – 78
Trolley Bus	69 – 73
Small Motorcycle	67
General Busy Auto Traffic	66 – 70
Individual Automobiles	63 – 69

Notes: *Source*: BKL Consultants Ltd.
[1] Aircraft flyover not at 15 m distance
[2] Based on data provided for the Calgary, Edmonton and Portland LRT systems.

4.0 MEASURING NOISE LEVELS

In Canada, long-term human responses to noise from transportation projects are typically evaluated using energy equivalent sound exposure levels (Leq values), in A-Weighted decibels (Leq values in dBA), including adjustments to account for particularly annoying characteristics of the sounds being analyzed.

Sound levels in the ambient environment vary each instant. In a downtown urban environment, the background noise is formed by an "urban hum", composed of noise from distant road traffic and commercial sources. As traffic passes near a receptor, the instantaneous sound level may increase as a vehicle approaches, and then decrease as it passes and travels farther away. The energy equivalent sound exposure level (Leq) is the average sound level over the same period of time with same acoustical energy as the actual environment (i.e., it is the average of the sound energy measured over a time period T). For transportation noise impact analyses, the following durations are typically used:

Table 2 - Durations used for transportation noise impact assessment

Leq (24h)	The sound exposure level over then entire 24-hour day
Leq Day Leq (16h)	Leq (15h), from 7 a.m. to 10 p.m., or from 7 a.m. to 11 a.m.
Leq Night Leq (8h)	Either Leq (9h), from 10 p.m. to 7 a.m., or from 11 p.m. to 7 a.m.
Ldn	A special Leq (24h) value with a 10 dB night-time penalty applied to overnight sound levels (10pm to 7am)

Leq (24h) values are typically used for examining impacts of transportation noise sources with small changes in sound exposure levels over the 24-hour day. For example, freeway noise levels are generally consistent over the 24-hour day. Therefore, for freeways, there is little difference between Leq (24h) values and the corresponding Leq Day and Leq Night values.

Leq Day values, which cover the AM-peak and PM-peak travel periods, are generally used for examining the impacts of non-freeway highways and municipal arterial roadways. The vast majority of noise associated with these sources is concentrated in the daytime hours, when typically, 85% to 90% of the daily road traffic will occur. Thus, if reasonable sound levels occur during the daytime (and appropriate guideline limits are met), they will also occur (and be met) at night.

To account for increased annoyance with noise overnight in a single value, the U.S. Environmental Protection Agency (U.S. EPA) developed the Ldn metric, which is a variation of the Leq (24h) with a +10 dB night-time penalty. Ldn values and a related metric, the day-evening-night level (Lden) are also used in some European guidelines. Ldn values are not typically used in Canadian provincial jurisdictions in evaluating transportation noise. Instead, guideline limits for separate Leq Day and Leq Night periods are generally used. Some transportation noise sources may have significant traffic levels occurring overnight. For example, freight rail traffic in heavily used corridors can be shifted to over-night periods, with daytime track use being reserved for freight switcher traffic and passenger traffic. In situations such as this, an assessment of both daytime and nighttime noise impacts may be considered appropriate (RWDI, 2006).

4.1 Assessing noise impacts from transportation projects

As noted earlier, noise impacts from transportation projects must be assessed in order to comply with the CEAA, which also requires consideration of the effect on human health that are caused by a change in the environment. In some cases, a project may also be subject to an environmental assessment by another jurisdiction, such as a provincial government.

In this regard, a key objective of the CEAA process is to promote cooperation between federal and provincial governments, and to harmonize assessment requirements where environmental assessments are required under both Provincial and Federal authorities. Under the *Canada-Wide Accord on Environmental Harmonization* and the *Sub-agreement on Environmental Assessment*, bilateral agreements are in place between the federal government and several provinces, to prevent unnecessary duplication of effort, consistent with the principle that a project should only undergo a single assessment.

It should be noted that provincial governments implement a large number of projects to which Transport Canada contributes funds, and many of those undergo a coordinated federal-provincial assessment.

Under CEAA, the central test is whether a project is likely to cause significant adverse environmental effects. More specifically, this means that Transport Canada must determine whether:

- the environmental effects are adverse;
- the adverse environmental effects are significant; and
- the significant adverse environmental effects are likely.

This determination directly affects whether Transport Canada can take a course of action with respect to the project, such as providing federal funding, or whether further review is needed through mediation or a panel review. All decisions about whether or not projects are likely to cause adverse environmental effects must be supported by findings based on the requirements set out in the Act (Canadian Environmental Assessment Agency, 1994).

The definitions of "environment" and "environmental effect" are the starting point for this test. The definitions of *environment* and *environmental effect* under CEAA are as follows:

"**Environment**" means the components of the Earth, and includes:

a) *Land, water and air, including all layers of the atmosphere;*
b) *All organic and inorganic matter and living organisms; and*
c) *The interacting natural systems that include components referred to in paragraphs (a) and (b).*

"**Environmental effect**" means, with respect to a project:

a) *Any change that the project may cause in the environment, including any change it may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of the Species at Risk Act,* *b) Any effect of any such change referred to in paragraph (a) on*

- *(i) Health and socio-economic conditions,*
- *(ii) Physical and cultural heritage,*
- *(iii) The current use of lands and resources for traditional purposes by aboriginal persons, or*
- *(iv) Any structure, site or thing that is of historical, archaeological, paleontological or architectural significance, or*

c) Any change to the project that may be caused by the environment,

Whether any such change or effect occurs within or outside Canada.

Practitioners must apply different sets of criteria to determine whether the environmental effect is adverse, significant, and likely.

The most common way of determining whether the environmental effects are *adverse* is to compare the quality of the environment before the project with the predicted quality of the environment with the project in place, using relevant criteria. This approach requires information on baseline environmental conditions.

Similarly, the most common method of determining whether the adverse environmental effects of a project are *significant* is to use environmental standards, guidelines, or objectives. If the level of an adverse environmental effect is less than the standard, guideline, or objective, it may be insignificant. If, on the other hand, it exceeds the standard, guideline, or objective, it may be significant. Where no such threshold standards or guidelines exist, other methods, such as risk assessment, may need to be applied. Criteria for determining significance include:

- magnitude;
- geographic extent;
- duration and frequency;
- irreversibility;
- ecological context.

If there are no relevant environmental standards, guidelines, or objectives and quantitative risk assessment is not possible, other methods and approaches must be used. In many cases, practitioners use a qualitative approach based on best professional judgment.

Criteria for determining likelihood include

- probability of occurrence;
- scientific uncertainty.

Where quantitative methods cannot be applied, practitioners may also use a qualitative approach based on professional judgment (Canadian Environmental Assessment Agency, 1994).

4.2 Assessing the significance of noise impacts

In an environmental assessment context, Canadian jurisdictions tend to measure noise impacts based on absolute increases in noise. There are no national standards in place, but several provinces have established guidelines, standards or protocols that must be followed in order to secure provincial approvals. For example, in Ontario, noise mitigation must be considered if a project will cause a noise increase of 5 dB or more. These provincial protocols have traditionally been used to assist federal authorities in determining the significance of noise impacts in the federal EA process under CEAA.

Through the assessment processes for individual transportation projects, it has been suggested that measuring the significance of noise impacts using absolute increases in noise may not be the most effective way to account for potential human health effects of increased noise. Consideration has been given to using the methodology described in Annex D of ISO 1996-1:2003(E), (Acoustics – Description, measurement and assessment of environmental noise). This method is commonly referred to as the 'percent highly annoyed' approach. However, a number of practitioners have raised technical and practical concerns about this approach, because of its implications in the context of the determining significance under CEAA.

4.3 "Percent highly annoyed" approach

Annex D of ISO 1996-1:2003(E) provides a method that may be used to estimate the long-term annoyance response of communities to road traffic noise. This approach is based on calculating the percentage of people who are likely to be highly annoyed by increased noise exposure, which is determined using an algorithm derived from a collection of community surveys on noise exposure. It has been suggested that this method may do a better job of addressing the human health element of noise impacts because it is based on a community's dose-response reaction to increases in noise. The approach is also referred to as the "Schultz curve", based on work done by Theodore J. Schultz in the 1970s to establish a relationship between the percentage of a population expressing high annoyance to aircraft, road traffic and railway noise and the corresponding A-weighted day/night sound level.

In brief, as the existing the ambient conditions becomes louder, a smaller increase in noise is required to generate an increase in the percent highly annoyed. The onset of a severe impact has been characterized as when the percent highly annoyed reaches 6.5% or higher. Thus, quieter noise environments would accept higher increases in noise, while noisier environments would accept very little increase in noise.

Although this approach seems to have been successfully adopted in some other jurisdictions, many practitioners are concerned that the significance framework under CEAA makes this approach inappropriate for application in the federal EA process.

4.4 Issues for determining significance under CEAA

As described above, a finding of significant adverse environmental effects under CEAA means that the federal government may not support a project. Alternatively, the project must be referred for further assessment by a mediator or review panel. This process is generally only applied to very large projects or projects in extremely sensitive environments, and typically results in lengthy project delays.

In contrast, use of ‘percent highly annoyed’ in other jurisdictions is not associated with “go / no-go” decision. Rather, the threshold represents the point at which mitigation measures must be considered. For example, where noise mitigation is not possible or successful, the United States Federal Transit Administration (FTA) has the flexibility under the National Environmental Policy Act (NEPA) to consider what alternatives exist, and whether all reasonable steps for mitigation have been identified. Based on the particular circumstances, a project may still proceed if it is considered appropriate.

> “While NEPA provides broad direction, a more explicit statutory basis for mitigating adverse noise impacts is contained in the Federal Transit Laws. Before approving a construction grant under section 5309, FTA must make a finding that ‘… (ii) the preservation and enhancement of the environment, and the interest of the community in which a project is located, were considered; and (iii) no adverse environmental effect is likely to result from the project, or no feasible and prudent alternative to the effect exists and all reasonable steps have been taken to minimize the effect.” (49 U.S.C. 5324 (b)(3)).” (United States Federal Transit Authority, 1995.)

The United States Federal Highway Administration uses a similar approach. However, this flexibility does not exist in the CEAA framework, which makes adopting the percent highly annoyed method as a significance threshold very problematic. For example, this approach would mean that projects in areas where noise levels are already elevated could have significant impacts, even if the project-related noise increase is only predicted to be 1 or 2 dBA. In busy urban areas, the mitigation measures that would need to be implemented in order to meet sound level objectives are often not practically achievable, owing to space constraints that prevent the installation of noise barriers or earthen berms.

By contrast, many public infrastructure projects, including highway and transit projects, are proposed because they are needed to reduce congestion in busy urban areas. However, responsible authorities under CEAA do not have the ability to make trade-offs, such as deciding that a significant effect is warranted because of the need for a project; only an assessment by a mediator or review panel has the authority to make such a decision.

As such, adopting the percent highly annoyed approach as a measure of significance in the context of CEAA raises a much broader public policy question about what types of projects the federal government should support. For this reason, it has been suggested that the use of the methodology in this context requires consultation with a range of stakeholders before being implemented.

The “percent highly annoyed” approach also varies considerably from what other jurisdictions in Canada use. This could result in two sets of information requirements for noise assessment, particularly for provincial governments that often have their own protocols that they are obliged to follow. This is inconsistent with the goal of federal-provincial coordination in the EA process, as described earlier.

From a technical perspective, ISO 1996-1 also identified a number of qualifications in the application of this method, which raises additional questions about the appropriateness of using this method in this context. In particular, Annex D indicates that the equation is applicable only to long-term environmental sounds such as the yearly average, and is only applicable to existing situations. As such, concerns have been raised about applying this method to future predicted sound level scenarios.

ISO 1996-1 also indicates that there is great scatter to the date used to create the results in Annex D. In this regard, RWDI indicated that there is a large degree of uncertainty to the annoyance predictions using the method described in Annex D. For example, for a moderate sound level of Ldn 55 dBA, the best case uncertainty in predicting annoyance is +10% / -4%. An increase in sound level to Ldn 65 dBA causes the uncertainty in annoyance prediction to increase to +18% / -7%. Both of these sound levels are typical of many urban areas (RWDI, 2006).

RWDI indicates that these uncertainties are magnified by the uncertainties inherent in measuring and predicting transportation noise levels. At the distances typically encountered, the most state-of-the-art transportation noise models have uncertainties (to 95% confidence intervals) of +/- 1.5 dB. Noise measurements also have uncertainties in the range of 1.5 dB.

Given these uncertainties, and the implications identified above, the appropriateness of this method as a predictive tool is a decision-making process needs to be further investigated.

4.5 Alternative methods of determining significance

In its report, RWDI provided recommendations for an alternative approach to evaluate the significance of noise impacts. Their suggestion follows a two-stage process, starting first with an evaluation as to whether an impact should be considered “substantial”, which is based on the predicted absolute increase in noise as a result of project. If a potential impact is characterized as substantial, the practitioner can then apply a set of criteria to determine whether the impact is “significant”, based on the circumstances of a particular project. The following paragraphs provide additional information on RWDI's recommendations.

RWDI recommended that impacts be assessed based on a comparison between predicted future build sound levels (with the project in place) and future no-build sound levels (where the project does not occur). The design year should be at least ten (10) years into the future, past the completion of construction and start of operation of the project.

Where predictions of future build traffic volumes are not available, the ultimate capacity levels may be conservatively used. Where future no-build traffic volumes are not available, existing traffic volumes may be conservatively used.

For complex urban environments, with multiple road traffic noise sources, measurements of existing conditions may be used to establish no-build conditions. Care must be taken to ensure that a sufficient number of measurement locations are used to characterize the environment near the affected noise sensitive receivers.

RWDI also recommended that noise mitigation measures should be examined where the objective sound levels for the project are exceeded by 5 dB or more. Where installed, the combination of mitigation measures used must be able to provide at least 5 dB of attenuation averaged over the first row of affected receptors. In general, only noise mitigation within the transportation corridor right-of way is acceptable. Where noise mitigation measures are to be applied, the following factors are to be considered:

> *Technical feasibility* – the proposed mitigation measure must be practical, must be able to be implemented, and must be able to provide the required amount of attenuation
>
> *Administrative feasibility* – the mitigation measure must be able to be installed by the project Contractor as part of the project in question, without having to negotiate individual access rights to off-right-of-way properties. The mitigation should be broadly supported by the affected public
>
> *Economic feasibility* – the mitigation measures proposed must not adversely affect project costs.

Where proposed as a noise control measure, the design of noise barrier walls must consider public access and safety concerns, utility and infrastructure access concerns, and be broadly supported by the affected residents in the area.

RWDI also recommended cautionary upper limits for noise. In particular, predicted future build sound levels, including noise mitigation measures, in excess of Leq (24 h) of 70 dBA or Leq Day / Leq Night of 70 dBA should be considered *substantial*, regardless of future no-build sound levels. Special consideration should be given in evaluating the

CEAA significance11 of project where levels exceed 70 dBA at noise sensitive receivers, including:

- The amount of the excess over 70 dBA
- The change from existing conditions
- The number and nature of affect receptors
- The general community attitude to the project

If noise increases are *substantial* within an area, and noise mitigation is indicated as not feasible, the report should indicate the limiting effect (economic, technical, or administrative).

RWDI also provided recommendations for sound level objectives for highways and arterial roads. The objective sound levels are defined as the higher of the values in the table below, or the future no-build sound levels.

Table 3: Sound Level Objectives

NSR Type	Sound Level Objective at Point of Reception*	
	Day-time Outdoor Living Area (Leq 16h, dBA)	Night-time bedroom window (Leq 8h, dBA)
Residences	55	50
Hospitals	50	50
Schools	55	n/a

Notes: * Or the future no-build sound level, whichever is higher. It should be recognized that in many locations the base sound level objectives in the table are already exceeded. This is typical of busy urban centres, where it may not be possible to achieve these targets. Populations tend to acclimatize to their current noise level. Changes in annoyance due to new or expanded transportation project will depend on the change from existing or "no-build" sound levels. Therefore, the objective levels are referenced to the future no-build or existing ambient conditions.

Changes in sound exposure level between predicted future build and future no-build sound exposures resulting from the proposed transportation facility can be calculated for the selected representative noise sensitive receivers. The magnitude of the noise changes can be ranked according to the following scale:

Table 4: Magnitude of Sound Level Changes

Change in Sound Level (dB)	**Ranking of Change**
<3	Imperceptible
3 to 4	Noticeable
5 to 9	Substantial
>10 and more	Very Substantial

Where predicted future no-build and or future build sound levels are predicted to exceed an Leq Day or Leq Night of 70 dBA, then the noise impact should be deemed to be *substantial*, regardless of the future no-build sound level.

Where future daytime build sound levels exceed the objective levels by 5 dB or more (i.e., result in *substantial* or *very substantial* increases in noise levels), then mitigation should be investigated, and must be applied where feasible. Mitigation where applied must provide at least 5 dB of attenuation averaged over the first row of receptors, and must be technically, economically, and administratively feasible.

For residential receptors, where *substantial* or *very substantial* noise increases will still exist after mitigation measures are applied and/or where mitigation measures are not feasible, then in determining the CEAA significance of the excess, consideration should be given to:

- The amount of the excess,
- The magnitude of the future build sound level,
- The number of affected receptors,
- The nature of the surrounding area,
- The general community attitude towards the project, and
- Other potential project benefits that may mitigate or out-weigh the effect of the increase in noise level.

For hospital or school receptors, where *substantial* or *very substantial* noise increases will still exist after mitigation measures are applied and/or where mitigation measures are not feasible, then in determining the CEAA significance of the excess, consideration should be given to:

- The amount of the excess, and
- Whether windows are kept closed for the vast majority of the year (thus mitigating the noise impact.

In certain situations, and with the agreement of affected provincial and municipal reviewing agencies, off right-of-way noise mitigation such as façade and ventilation upgrades may be considered for these receptors, where technically, economically, and administratively feasible, and in agreement with the owners of the facilities.

The advantage of this approach is that it provides flexibility to evaluate each project based on its specific circumstances, while still providing a level of protection to the community. Although Transport Canada has not formally adopted these recommendations, they demonstrate that there are approaches that are compatible with the CEAA framework, and the department considers them to be a useful starting point for further discussion.

5.0 SUMMARY AND CONCLUSIONS

Although the percent highly annoyed methodology may be helpful in establishing sound level targets or objectives for communities, the method does not appear appropriate to use for evaluating significance under CEAA, because of the lack of flexibility in the environmental assessment framework.

Transport Canada continues to work with other transportation agencies and acoustics experts to better understand how this method might be appropriately applied, and to further explore other options to appropriately assess the significance of noise impacts from surface transportation projects. Cooperation with other agencies and further exploration of best practices in other jurisdictions will be needed in order to develop an approach that fits within the Canadian legislative framework.

6.0 REFERENCES

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