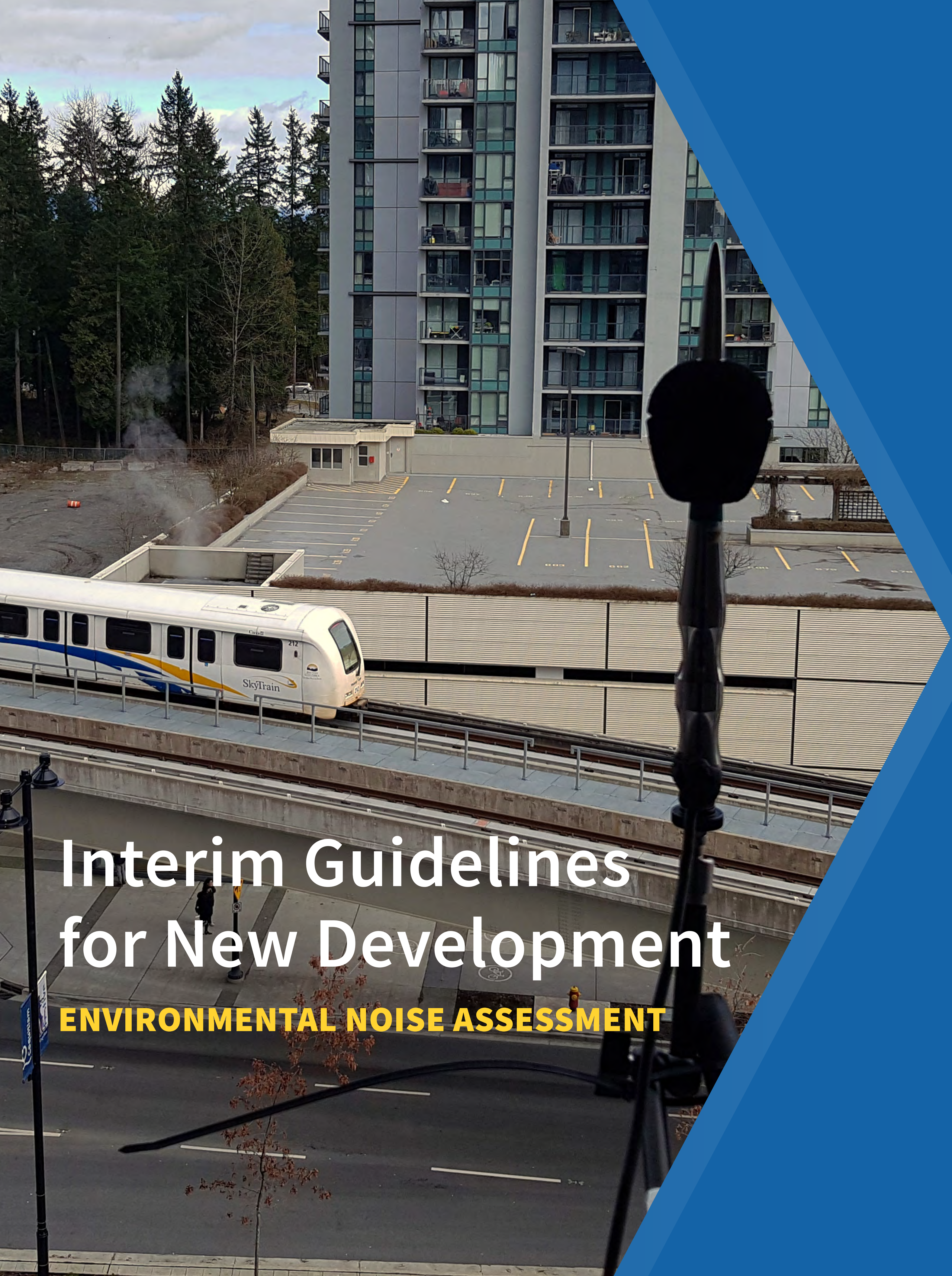

Interim Guidelines for New Development

ENVIRONMENTAL NOISE ASSESSMENT

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ENVIRONMENTAL NOISE ASSESSMENT

TRANS LINK

Prepared for TransLink by

BKL

BKL Consultants Ltd.
bkl.ca
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List of Abbreviations

Abbreviation/Acronym	Definition
ANC	Association of Noise Consultants
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BKL	BKL Consultants Ltd.
BSI	British Standards Institute
CIEH	Chartered Institute of Environmental Health
CMHC	Canada Mortgage and Housing Corporation
CRTN	Calculation of Road Traffic Noise
dB	decibel
dBA	A-weighted decibel
EGBC	Engineers and Geoscientists British Columbia
FCM	Federation of Canadian Municipalities
Hz	hertz
IEC	International Electrotechnical Commission
INCE	Institute of Noise Control Engineering
IOA	Institute of Acoustics
ISO	International Organization for Standardization
km	kilometre
L_{AE}	A-weighted sound exposure level
L_{eq}	A-weighted equivalent sound level
L_{eq24}	A-weighted 24-hour equivalent sound level
L_{Amax}, L_{Fmax}	A-weighted, fast time constant, maximum sound level
LRT	Light Rail Transit
NCAC	National Council of Acoustical Consultants
NRC	National Research Council of Canada
OITC	Outdoor to Indoor Transmission Class
RAC	Railway Association of Canada
s	second
STC	Sound Transmission Class
STD	standard deviation
TL	Sound Transmission Loss
TransLink	South Coast British Columbia Transportation Authority
WHO	World Health Organization

1

1 Introduction

Research shows that environmental noise has potential to create adverse effects on human health. TransLink hired BKL Consultants Ltd. (BKL) to develop professional practice guidelines (the Guidelines) for assessing environmental noise at proposed noise-sensitive developments. The Guidelines outline a three-stage approach to establish when and how environmental noise assessments should be performed, and are meant to assist municipalities, developers, and designers as they plan for and address environmental noise.

The Guidelines are for informational purposes only. Administration of an environmental noise guideline for new developments is outside of TransLink's remit. Consultation with developers, acoustical practitioners, and others is recommended.

1–1 Background

In 2018 TransLink commissioned a SkyTrain noise study in response to noise concerns raised by residents. The study recommended investigations into the feasibility and effectiveness of various mitigation measures, mostly relating to SkyTrain operation and maintenance practices. One recommendation was to develop an acoustical guideline for new residential developments near SkyTrain. The study also identified a need to integrate noise control measures with ventilation and thermal comfort in new residential developments. Consultation with municipal planning staff confirmed the need for such a guideline, provided it address all environmental noise sources potentially affecting new developments.

1–2 Scope

The Guidelines have been developed as a tool for assessing and addressing environmental noise impacts at sites proposed for new noise-sensitive developments. They do not address

- potential impacts on existing or approved noise-sensitive developments due to proposed projects (such as new roads or rail lines);
- noise sources that are a part of a proposed development (e.g., rooftop mechanical units) that may affect other properties; or
- noise transmission between rooms within a new development.

While Appendix A lists common technical terms, the Guidelines are intended for acoustical practitioners and assume an advanced level of knowledge in acoustics. The Guidelines were developed to be flexible with respect to potential solutions to address potential noise issues.

The Guidelines outline applicable projects, appropriate noise criteria, and the standard of professional practice for Acoustical Professionals conducting noise intrusion assessments. However, because, for example, SkyTrain noise levels can vary due to train and rail conditions, following the Guidelines does not guarantee the noise exposure levels at new developments.

The Guidelines address only acoustical requirements. Where closed windows are used to mitigate noise ingress, spaces should be designed and constructed to achieve thermal comfort standards outlined in the latest edition of ASHRAE 55 *Thermal Environmental Conditions for Human Occupancy*. This study should be conducted by a qualified professional and submitted as a supplementary report.

1–3 Normative References

In developing the Guidelines, BKL has relied on national and international standards and guidelines for reference, as summarized in Appendix B, in addition to its own experience performing similar studies for residential and commercial development projects. Appendix C provides example results with the Guidelines' acoustical criteria compared to the Canada Mortgage and Housing Corporation (CMHC) criteria. Please note that the Guidelines address only the acoustical requirements with respect to environmental noise. Other requirements should be examined for compatibility.

The following standards are indispensable for the Guideline's application. The latest edition of each referenced document (including any amendments) applies.

- *IEC 60942 Electroacoustics – Sound calibrators*
- *IEC 61260-1 Electroacoustics – Octave-band and fractional-octave-band filters – Part 1: Specifications*
- *IEC 61672-1 Electroacoustics – Sound level meters – Part 1: Specifications*
- *ISO 1996-2 Acoustics - Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels*
- *ISO 12354-3 Building acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 3: Airborne sound insulation against outdoor sound*

2

2 Applicable Projects

Environmental noise intrusion assessments should be performed for noise-sensitive developments that meet any of the criteria described in Table 2.1 below.

Table 2.1: Criteria for Applicable Projects

Noise Source	Criteria: One of the Following Must Be True:
Rail Traffic	Development is adjacent to or across the street from a rail right-of-way
	Development is within 100 metres of a rail line right-of-way with any point on any facade having direct line of sight* to the top of the guideway or track
Road Traffic	Development has direct line of sight to the road and is within 100 metres of a road carrying more than 15,000 vehicles per day
Aircraft Traffic	Development is located in an area where the Noise Exposure Forecast (NEF), as published by the airport authority, is NEF 25 or greater
Industrial Activities	Development is adjacent to or across the street from industrial-zoned property

**Only solid objects that break the line of sight to the entire railway should be considered as sufficient barriers to reduce noise such that a study would not be required.*

◀ ***Table 2.1:*** *Criteria for noise-sensitive developments.*

Noise-sensitive developments include the following building types:

- buildings with residential use;
- places of worship;
- hospitals; and
- educational facilities (including child care centres).

In the Guidelines, such developments are known as Applicable Projects.

Where there is potential for vibration impact (typically within 30 metres for residential developments in proximity to rail lines), the criteria and procedures outlined in the Federation of Canadian Municipalities (FCM) and the Railway Association of Canada (RAC) *Guidelines for New Development in Proximity to Railway Operations* (2013) should be followed, with calculation methods following the US Department of Transportation Federal Transit Administration, Transit Noise and Vibration Impact Assessment Manual (2018).

3 Acoustical Professional Minimum Qualifications

Environmental noise assessment for new developments is a multidisciplinary field that requires specific education, training, and experience associated with acoustics, as well as architectural and mechanical systems. The reports prepared following the Guidelines should be authored by a professional acoustical engineer licensed with Engineers and Geoscientists British Columbia and certified by membership with a recognized acoustical association that assesses the qualifications of its members. Suitable organizations include the following:

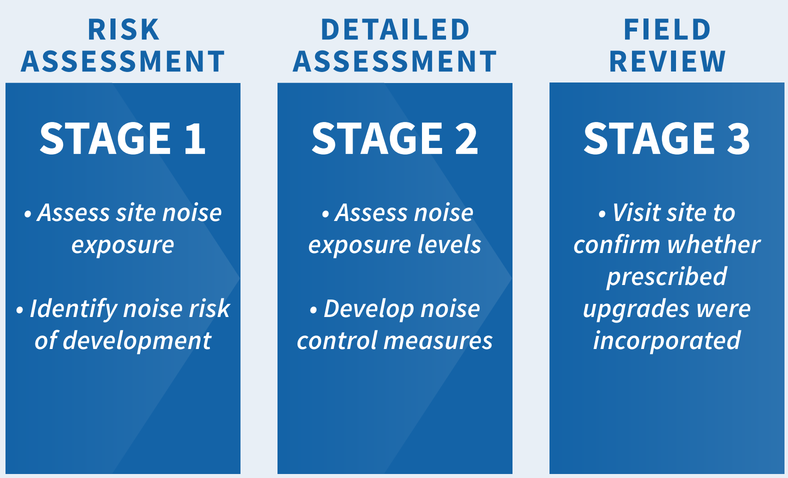
- Institute of Acoustics (IOA);
- Institute of Noise Control Engineers (INCE); or
- National Council of Acoustical Consultants (NCAC).

In the Guidelines, a professional who meets these qualifications is referred to as an Acoustical Professional.

4 Approach Framework

The Guidelines outline a three-stage approach to address environmental noise at Applicable Projects:

Figure 4.1: Overall Approach



◀ ***Figure 4.1:*** *The Guidelines apply a three-stage approach to assess environmental noise at Applicable Projects.*

For Stage 1, when a full architectural and mechanical design has not yet been developed, an Acoustical Professional should prepare a report identifying the noise risk of the proposed development. That is, the report should identify how difficult it will be to meet the noise criteria and state whether noise control measures are necessary. This assessment should meet the full requirements of Sections 5.1, 5.2, and 5.3 of the Guidelines. No further assessment is required if the noise risk is found to be negligible.

▲ *A bus unloads passengers at a stop in Coquitlam (Photo: TransLink)*

Where the noise risk is not negligible, and once the full architectural and mechanical design has been developed, the Stage 2 assessment should be performed to fully design and prescribe the noise control measures required to meet the noise criteria.

A good acoustical design process should be followed (Grimwood et al. 2017). Good acoustical design involves taking an integrated approach to assessing the noise requirements of the project. The process may be iterative and could involve other professionals. Proportionate to the scale of development and noise risk of the project, the design process should include the following steps:

- Consider options for planning the site or building layout.
- Incorporate noise barriers as part of the proposed development or outside the proposed development to screen the development from the most significant noise sources.
- Consider the orientation of the proposed building(s) and locations of most noise-sensitive spaces.
- Select construction types and methods to mitigate noise to acceptable levels.
- Examine the effect of noise control measures on thermal comfort, ventilation, health and safety, cost, etc.
- Determine the viability of alternative solutions.
- Assess outdoor amenity noise.

A Stage 3 assessment should be performed once the specified construction upgrades have been installed. A consultant under the direct supervision of an Acoustical Professional should perform a site visit to randomly inspect multiple units. That Acoustical Professional should prepare a report to confirm that the Stage 2 report recommendations were incorporated into the construction of the development.

5 Municipality Requirements

For Applicable Projects, municipalities could consider requiring deliverables during the following phases of the development process:

5–1 Early Development Permitting Phases

At the earliest opportunity, during Rezoning, Preliminary Plan Approval, or Development Permit applications, the Stage 1 assessment should be performed and included with the relevant permit application.

5–2 Building Permit Phase

The Stage 2 assessment should be performed and included with the building permit application.

5–3 Occupancy Permit Phase

Where a Stage 2 report required construction upgrades, a Stage 3 assessment should be performed and included with the occupancy permit application to confirm whether these upgrades were constructed.

6 Stage 1: Risk Assessment

Figure 6.1 below provides a step-by-step overview for performing a noise risk assessment. Each step is detailed in the sections that follow (section numbers in parentheses). The general sequences of stages and project design elements are as follows:

Figure 6.1: Risk Assessment

Identify Existing Noise Sources (6.1)

Identify Future Noise Sources (6.2)

Measure Existing Site Noise Exposure (6.3)

Predict Future Site Noise Exposure Level (6.4)

Identify Risk Level (6.5)

Prepare Risk Assessment Report (6.6)

◀ ***Figure 6.1:*** *A step-by-step overview for performing a noise risk assessment. Each step is detailed in the sections that follow (section numbers in parentheses).*

6–1 Identify Existing Noise Sources

A site visit should be performed to determine all existing noise sources and identify any unique characteristics affecting noise levels.

- Location-specific factors affecting SkyTrain and other rail noise include
  - inbound and outbound speeds;
  - accelerating or decelerating areas;
  - curve radii;
  - crossing of switches;
  - rail conditions;
  - presence of parapet barriers and/or guideway centreline barriers; and
  - proximity to stations and electrical or mechanical services buildings.
- Location-specific factors affecting road traffic noise include
  - traffic volumes;
  - average vehicle speeds;
  - percentage of heavy vehicles;
  - accelerating or decelerating areas;
  - proximity to bus stops; and
  - road surface type, condition and gradients.

- Location-specific factors affecting aircraft traffic noise include
  - proximity to flight paths;
  - runway use;
  - flight direction (take-off versus landing); and
  - mix of aircraft types.
- Location-specific factors affecting industrial noise include
  - regulations governing allowable noise (e.g., municipal bylaws);
  - equipment sound power levels;
  - operating conditions;
  - local sound reflecting and shielding elements; and
  - sound source directivity.

6–2 Identify Future Noise Sources

Noise levels should be corrected to assess the noise exposure 10 years in the future. Traffic growth should be estimated based on traffic projections. Any planned expansion to SkyTrain, roads, etc., should be included in the assessment using available data on projected noise levels.

6–3 Measure Existing Site Noise Exposure

On-site noise measurements should be undertaken to assess the site noise exposure. All sound measurements should meet ISO 1996-2 requirements. Adjustments to measured levels may be required depending on measurement timing, duration, and location, as detailed below.

6–3–1 Equipment and Calibration

The acoustical instrumentation system should conform to Class 1 requirements as defined by IEC 61672-1. Frequency analysis should meet the requirements of a Class 1 filter as specified in IEC 61260-1. Ideally, the system should be capable of recording audio files (e.g., wav or mp3 file formats) to assist in identifying noise events after the measurements have been completed. Windscreens should always be used during outdoor measurements and should be clean, dry, and in good condition.

To ensure a standard of accuracy and consistency, all sound instrumentation should be calibrated using a Class 1 sound calibrator in accordance with IEC 60942 before and after each series of measurements has been taken.

6–3–2 Measurement Timing

The intent of the measurement is to represent the annual-average noise environment. A weekday measurement is considered acceptable when the site is dominated by road or rail noise. Professional judgement should be used in other cases.

Varying rail conditions can significantly affect measurement results. For SkyTrain noise, TransLink is available to confirm if the current condition of the track is representative of the typical condition. If the track is expected to be noisier than the annual average, then this level may also be used for the acoustical design.

Care should be taken to avoid negative environmental effects on measurement quality due to excessive wind or rain.

6–3–3 Measurement Duration

For SkyTrain noise, a 24-hour measurement should be performed and a full nighttime period should be reviewed to determine the 10th noisiest event. Alternatively, a short-term measurement can be performed with statistical analysis, assuming normal (Gaussian) distribution, to determine appropriate L_{eq} and L_{Fmax}.

For road traffic noise, a 24-hour measurement should also be performed, since varying traffic conditions usually make scaling the result of a short-term measurement unreliable. If a 24-hour measurement is impractical, short-term noise measurements and analysis following the Calculation of Road Traffic Noise (CRTN) shorthand method should be used (Department of Transport Welsh Office 1988, Abbott and Nelson 2002). Professional judgement should be used in other cases.

For aircraft noise, a 24-hour measurement should also be performed. However, aircraft noise varies day to day, so a 24-hour measurement would not necessarily represent annual-average noise levels. Hence, the airport authority should be contacted to obtain annual noise data collected at the nearest noise monitoring terminal so that adjustments can be made to the measurements to calculate annual average noise levels.

For industrial operations, a 24-hour measurement should be performed if operations have the potential to vary throughout the day. If the operation schedule of each source is understood, perform short-term noise measurements and calculations to determine the representative noise levels.

6–3–4 Measurement Location

Microphone location(s) should be chosen to best capture the highest noise exposure at the proposed development. Multiple measurement locations may be necessary where there is varying exposure or more than one dominant noise source.

Measuring SkyTrain noise may require more planning due to the high variation of noise with height. For example, BKL has measured an average increase of 11 dBA when increasing the microphone height from below the guideway to above the guideway. Similarly, BKL has measured an average increase of 7 dBA when increasing the microphone height from the same level as the guideway to above the guideway. Therefore, where the proposed development includes buildings with direct line of sight to the top of the SkyTrain guideway, the noise measurements should be taken well above the guideway, for example, using a man lift, to measure the exposure directly.

6–3–5 Data Analysis

The measurements should be reviewed to ensure that non-representative events (e.g., birds close to the microphone or other irregular events) are excluded from the evaluation.

The following parameters should be calculated:

- Daytime (7 am to 11 pm) equivalent sound pressure level (L_d);
- Nighttime (11 pm to 7 am) equivalent sound pressure level (L_n); and
- Where regular individual noise events occur, nighttime (11 pm to 7 am) maximum fast-time-weighted sound pressure level (L_{Fmax}) of the 10th noisiest event.

▲ *SkyTrain noise measurements should be taken well above the guideway (Photo: BKL)*

Regular individual noise events are noticeably loud events that occur more than 10 times per night, such as SkyTrain passbys, heavy rail traffic on a busy rail line, or frequent delivery truck traffic on an otherwise quiet road. Road traffic on a busy road should not be assessed using the L_{Fmax} metric.

The A-weighted equivalent sound level, abbreviated L_{eq}, is commonly used to indicate the average sound level over a period of time. The L_{eq} represents the steady level of sound that would contain the same amount of sound energy as the actual time-varying sound level.

The A-weighted, fast time constant, maximum sound level, abbreviated L_{Fmax} is a measurement of the highest sound level that occurs during an event. The representative L_{Fmax} is the 10th noisiest L_{Fmax} that is expected to occur during each nighttime period. An appropriate alternate criterion should be proposed when the current or future frequency of a regular noise event is fewer than 10 times per night.

If the SkyTrain noise measurement duration was less than 24 hours, a statistical analysis should be used to estimate the expected level of the 10th noisiest event in a night. Based on previous measurements performed by BKL, the standard deviation of SkyTrain passby sound exposure levels (L_{EA}) and L_{Fmax} is approximately 2 dBA. Therefore, the upper bound of the L_{Fmax} of the 10th noisiest event can be estimated (to a 95% confidence interval) using the following formula:

Where N is the number of trains measured, P is the (10/M) x 100th percentile

$$L_{Fmax,\ representative} = P + \frac{4}{\sqrt{N}}$$

noisiest L_{Fmax} measured, and M is the expected number of trains per night. For example, if only one train were measured, then the L_{Fmax} should be adjusted upwards by 4 dBA to obtain the representative level.

For L_{eq} calculations based on limited measurement data, the same method may be used to correct for uncertainty by substituting L_{EA} for L_{Fmax} in the above formula. For noise sources other than SkyTrain, where the standard deviation is known, a similar equation may be derived for the representative L_{Fmax}.

6–4 Predict Future Site Noise Exposure

The results from Section 6.3.5 should be adjusted to represent the typical worst-case noise exposure level for the entire development site, considering the likely changes affecting the site and potential building facade locations and heights, with operating conditions adjusted to 10 years in the future. Any location adjustments from the measured noise exposure level should be determined in accordance with ISO 1996-2 as detailed in Section 7.2.2.

For aircraft noise, the airport authority should be contacted to obtain annual noise data collected at the nearest noise monitoring terminal so that adjustments can be made to the measured L_{Fmax} noise levels to estimate annual average levels.

6–5 Identify Noise Risk Level

The noise risk level of the site should be selected using the highest risk result from the three noise level parameters that apply to the development (see Table 7.1). Figure 6 2 outlines the risk levels and parameters.

Figure 6.2: Noise Risk Level Categories

Risk level	L_d	L_n	L_{Fmax}
HIGH RISK	> 70 dBA	> 65 dBA	> 80 dBA
MEDIUM RISK	= 60–70 dBA	= 55–65 dBA	= 70–80 dBA
LOW RISK	= 50–60 dBA	= 45–55 dBA	= 60–70 dBA
NEGLIGIBLE RISK	< 50 dBA	< 45 dBA	< 60 dBA

◀ ***Figure 6.2:*** *The noise risk level of the site should be selected using the highest risk result from the three noise level parameters.*

For example, a residential site with future projected typical worst-case noise exposure of L_d 56 dBA, L_n 44 dBA, and L_{Fmax} 75 dBA would be judged to be a medium risk site.

6–6 Prepare Risk Assessment Report

The purpose of the noise risk assessment report is to identify the expected difficulty in meeting the target noise levels and need for noise control measures; and confirm that the developer, designer, and the Acoustical Professional are in agreement.

The report should at a minimum include

- a statement demonstrating that the Acoustical Professional is suitably qualified and experienced, and has complied with the Guidelines;
- all assumptions as required by, and in addition to, the Guidelines;
- a description of the noise sources;
- a description of the development site including the topography, potential building geometry, ground cover and condition, and locations of sound sources including each source's height above ground;
- a figure showing all measurement positions on a map;
- a photograph showing microphones as set up;
- the time, day, year, and location of the measurements;
- the instrumentation used (i.e., models and serial numbers) and calibration results;
- the measurement time intervals;
- a description of the weather conditions during the measurements;
- a description of any non-representative sound and procedures used to correct for contamination by non-representative sound;
- a description of any adjustments made to the measured sound levels;
- a description of any noise modelling performed including prediction standard and calculation settings;
- the predicted typical worst case exposure levels;
- level of uncertainty and any adjustments required to address uncertainty;
- justifications for any deviations from the Guidelines;

- confirmation that the EGBC Quality Management Guidelines have been followed in completing the study;
- the noise risk level of the site; and
- the use of the professional EGBC seal by the Acoustical Professional.

7 Stage 2: Detailed Assessment

For risk levels that aren't negligible, a detailed assessment should be performed once the major architectural and mechanical details have been developed. The assessment should be proportionate to the identified noise risk and the scale of the development. Figure 7.1 below provides a step-by-step overview for performing a Detailed Assessment. Each step is detailed in the sections that follow (section numbers in parentheses). The general sequences of stages and project design elements for the noise study are as follows:

Figure 7.1: Detailed Assessment Process Overview

Select Acoustical Criteria (7.1)

Determine Outdoor Amenity and Facade Noise Exposure Levels (7.2)

Determine Indoor Noise Levels and Sound Insulation Requirements (7.3)

Identify and Design Appropriate Noise Control Measures (7.4)

Identify Other Relevant Issues (7.5)

Prepare Detailed Assessment Report (7.6)

◀ ***Figure 7.1:*** *Step-by-step overview for performing a noise risk assessment. Each step is detailed in the sections that follow (section numbers in parentheses).*

7–1 Select Acoustical Criteria

The following table summarizes the target noise levels for different noise-sensitive uses.

Table 7.1: Target Interior Noise Levels

Building Type	Space Type	Time Period	Target Noise Level (dBA)
Residential	Bedrooms	11 pm – 7 am	L_{eq} 35
		11 pm – 7 am	L_{Fmax} 45*
	Living/Dining rooms	7 am – 11 pm	L_{eq} 40
	Outdoor amenity areas	7 am – 11 pm	L_{eq} 55
Educational	Classrooms	7 am – 11 pm	L_{eq} 40
	Outdoor amenity areas	7 am – 11 pm	L_{eq} 55
Places of Worship	Worship spaces	7 am – 11 pm	L_{eq} 40
Hospitals	Wards	11 pm – 7 am	L_{eq} 35
	Other noise-sensitive areas	7 am – 11 pm	L_{eq} 40

**Applies to regular individual noise events only (See 6-3-5)*

◀ ***Table 7.1:*** *Target noise levels for different noise-sensitive uses*

The L_{eq} and L_{Fmax} target noise levels are based on annual average data; they should normally be achieved in typical conditions, but do not have to be achieved in all situations such as occasional events.

All airborne and structure-borne noise sources, including ventilation paths for natural or forced-air ventilation, should be included. Typically, windows need to be closed to meet these targets. The targets should be met accounting for all changes expected to occur up to 10 years from the date of the assessment.

7–2 Determine the Outdoor Amenity and Facade Noise Exposure Levels

Outdoor amenity and facade noise exposure levels for the proposed development should be determined in accordance with ISO 1996-2.

7–2–1 Identify Receivers

Outdoor amenity spaces, such as a rear yard or podium common area, should be included in the assessment at a height of 1.5 metres above the amenity area elevation. Balconies do not need to be included as outdoor amenity spaces.

Facade noise exposure levels should be predicted at the mid-point height of the floors with noise-sensitive uses and should include the rooms with the greatest potential to be affected by noise, e.g., corner bedrooms with exposure to noise on two sides of the room.

Corrections for shielding from balconies and other facade shape corrections should be in accordance with ISO 12354 Part 3.

7–2–2 Calculate Sound Propagation

Noise predictions at facade locations (other than the measurement locations) should account for the following acoustical factors:

- Divergence
- Ground effect
- Shielding from topography
- Shielding from solid obstacles
- Reflections

A recognized standard, such as ISO 9613-2 (1996), should be used to accurately determine these effects. Calculations should be performed in octave bands where frequency-dependent effects are possible. A temperature of 10 C and relative humidity of 80 per cent, representing average weather conditions in Greater Vancouver, should be assumed.

7–3 Determine Indoor Noise Levels

Interior noise levels should be calculated according to ISO 12354 Part 3 using octave or 1/3 octave band calculations. Broadband calculations are not acceptable. Important considerations are detailed below.

7–3–1 Identify Rooms Requiring Assessment

Based on the predicted facade noise exposure levels, rooms that potentially exceed the criteria should be identified for assessed. In general, all rooms with a noise exposure of more than 10 dBA above the criteria should be assessed.

7–3–2 Noise Spectral Shape

The assumed frequency content of the noise source can greatly affect the assessment results. A site-specific noise source spectrum should be obtained from the site noise measurement results. When this is not possible, a frequency spectrum from another similar site may be used.

7–3–3 Reverberation Time

Per ISO 12354 Part 3, a reverberation time of 0.5 seconds should be assumed across all frequency bands for all rooms. Reverberation times should not be predicted because they depend on furnishings, which are unknown during the design stage.

7–3–4 Flanking Transmission

Per ISO 12354 Part 3, flanking noise is not normally important for the calculation of outdoor-to-indoor noise. However, the National Research Council (NRC) of Canada has found flanking noise to be significant in some outdoor-to-indoor situations with lightweight construction. The Acoustical Professional is responsible to determine whether flanking noise should be included in the assessment.

7–3–5 Ventilation

The acoustical criteria are normally met only with windows closed, which sometimes requires that alternative ventilation schemes be developed. All ventilation paths through the building envelope should be included in the analysis. The ventilation design should be requested from the mechanical consultant to ensure sound insulation of building elements such as trickle vents above sliding glass doors are taken into account.

◀A SkyTrain arrives at a station (Photo: Diego Mazz / Unsplash)

7–3–6 Sound Insulation Data

Frequency-dependent sound insulation data for the Applicable Project's walls, windows, doors, ventilation, and other elements must be used in assessing the indoor noise level. This information can be determined using the conservative data published in ISO 12354-3, or data from manufacturer's tests, acoustical software, or field tests. It is the responsibility of the Acoustical Professional to ensure that the sound insulation data is representative of the proposed element.

For example, the following considerations should be made:

Figure 7.2: Sound Insulation Data Considerations

IF USING TEST DATA

- Do not use results from tests that are not representative of actual constructions, e.g., glazings without window frames, walls with resilient channels without bridging effects for window frames, etc.
- Consider if results are manufacturer specific and make that clear in the report, e.g., these results are only valid for X Series of Y Brand Windows.
- Ensure that the frames, seals, and other elements of the tested system are equivalent to the specified system.

IF USING PREDICTED DATA

- Correct test data results using acoustical theory to be more representative of the actual constructions, e.g., reduced window stiffness due to larger pane size.
- Ensure that predicted data are calibrated to test results of a similar construction. Limit difference between test data and predicted data to 10 dB in any 1/3 octave band.
- Where the construction does not use the same frame and seals as the reference tested element (i.e., for windows/doors), or the change in configuration is expected to change the OITC rating by more than 3 points, then either:
  a) Test the system after construction by conducting a 24-hour measurement in an affected room to demonstrate compliance with the criterion; or
  b) Adjust the predicted performance of the element downwards by 3 dB.

◀ ***Figure 7.2:*** *Sound insulation data considerations*

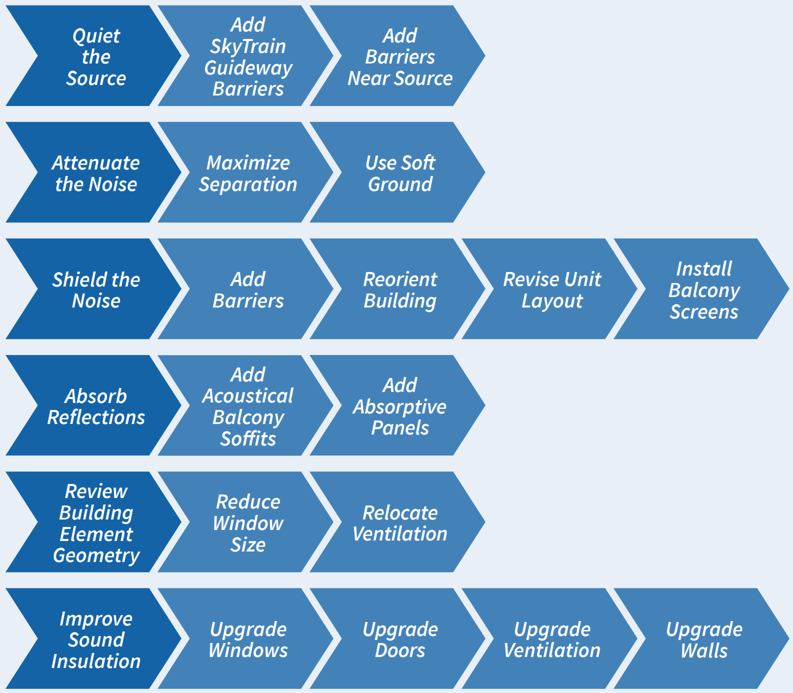
7–3–7 Identify Internal Sound Insulation Requirements

Once the indoor noise levels are predicted for the proposed building elements, these levels can be compared to the applicable acoustical criteria to determine the noise reduction targets.

7–4 Develop Appropriate Noise Control Measures

Requiring closed windows is typically the first noise control measure used to reduce indoor noise levels. Figure 7.3 below outlines additional noise control measures:

Figure 7.3: Potential Noise Control Measures



◀ ***Figure 7.3:*** *Potential noise control measures*

More than one method may be needed to satisfy the criteria. Calculations to determine noise reductions should meet the requirements outlined in Sections 7.2 and 7.3 above. Walls with resilient clips or channels should generally be avoided due to flanking, bridging and install issues. The practicality of implementing the acoustical design and achieving nominal performance should be considered.

◀ *TransLink's commuter train, the West Coast Express, stands ready to embark (Photo: TransLink)*

7–5 Identify Other Relevant Issues

7–5–1 Thermal Environmental Conditions for Human Occupancy

While the Guidelines address only acoustical requirements, where closed windows are required to mitigate noise ingress, spaces should be designed and constructed to achieve thermal comfort standards outlined in the latest edition of ASHRAE 55 *Thermal Environmental Conditions for Human Occupancy*. This study should be conducted by a suitably qualified professional and submitted as a supplementary report.

7–5–2 Practicality of Noise Mitigation Measures

In some cases, it may not be practical to achieve the target noise levels at all locations. In particular, for noise levels in outdoor amenity areas:

- Noise levels exceeding the noise level targets should be accepted as long as they have been designed to be as low as practicable;
- The outdoor amenity area noise assessment could evaluate whether or not each amenity area is intrinsic to the overall design in order to rate the importance of meeting the target noise level;
- The outdoor amenity area noise assessment could evaluate the need to provide access to an outdoor amenity area meeting the target noise level (i.e., with minimal speech interference) considering the type of development and occupants;
- The impact of noise levels exceeding the target level may be reduced if the occupants have access to

  » an enclosed balcony;
  » a room on a relatively quiet facade with openable windows;
  » another outdoor amenity space that does meet the target level; or
  » a relatively quiet public space within a 5-minute walking distance.

Where internal target noise levels are difficult to achieve at all units, it may be appropriate to consider the municipality's wider planner objectives for the area, which may have unintended acoustical consequences, and the noise sensitivity of the likely occupants of the development.

7–6 Prepare the Detailed Assessment Report

The purpose of the detailed assessment report is to demonstrate

- that a good acoustical design process was followed;
- whether the relevant target noise levels can be met; and
- that the developer, designer, and the Acoustical Professional are in agreement.

The report should at a minimum include

- the information required for the Stage 1 report;
- the date of the architectural and mechanical design drawings being used for the assessment;
- the predicted outdoor amenity noise exposure levels and components, including partial sound levels contributing to the exposure levels;
- the predicted facade noise exposure levels and components, including partial sound levels contributing to the exposure levels, and clearly specifying whether facade noise exposure calculations are free-field, 2 metre, or flush-facade values;
- whether closed windows are required to meet the criteria and confirming

the need for a supplemental thermal comfort assessment;
- full details of the design measures and minimum facade construction specifications needed to meet the targets at all units;
- any other relevant non-acoustical issues and the recommended approach to address them;
- the level of uncertainty and any adjustments required to address uncertainty;
- justifications for any deviations from the Guidelines;
- confirmation that the EGBC Quality Management Guidelines have been followed in completing the study;
- an opinion statement from the Acoustical Professional as to whether the development will meet the target noise levels;
- the use of the professional EGBC seal by the Acoustical Professional; and
- for medium and high risk sites, a sample calculation of the room that is predicted to have the worst-case indoor noise exposure level.

8

8 Stage 3: Field Review

The Stage 3 field review should be performed once the detailed assessment report's specified construction upgrades have been installed. A consultant under the direct supervision of an Acoustical Professional should perform a site visit to randomly inspect multiple units. The number of units to inspect should be selected by the Acoustical Professional to be proportionate to the identified noise risk and the scale of the development. The Acoustical Professional should prepare a report outlining the details of the field review and confirming whether the Stage 2 report recommendations were incorporated into the construction of the development.

9

9 Quality Assurance

9–1 Quality Assurance Program

The Acoustical Professional should ensure that the following EGBC Quality Management Guidelines are followed:

- Direct Supervision;
- Documented Checks of Engineering and Geoscience Work;
- Retention of Project Documentation; and
- Use of Seal.

9–2 Uncertainty

Sources of error should be considered in the assessment, including whether to apply factors of safety to more accurately predict in-situ noise levels. Levels of uncertainty in the measurement due to the number of events measured and/or meteorological conditions should also be assessed.

9–3 Peer Review

In accordance with the EGBC Code of Ethics, peer reviewers must make every effort to inform the Acoustical Professional when providing a third-party review. Peer reviews should check calculations and assumptions against the Guidelines.

9–4 Design Changes

The accuracy of the risk or detailed assessment may be affected by architectural or mechanical design changes. For medium and high risk sites, calculations should be revised if changes are made to unit layout, building envelope, or ventilation designs.

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A

APPENDIX A GLOSSARY

A-weighting – A standardized filter used to alter the sensitivity of a sound level meter with respect to frequency so that the instrument is less sensitive at low and high frequencies where the human ear is less sensitive. Also written as dBA.

daytime equivalent sound level (Ld) – the equivalent sound level over daytime hours (7 am to 11 pm).

decibel – the standard unit of measurement for sound pressure and sound power levels. It is the unit of level that denotes the ratio between two quantities that are proportional to pressure or power. The decibel is 10 times the logarithm of this ratio. The reference pressure used for airborne sound is 20 µPa, while the typical reference pressure used for underwater sound is 1 µPa. Also written as dB.

equivalent sound pressure level – the steady level that would contain the same amount of energy as the actual time-varying level. Although it is, in a sense, an "average," it is strongly influenced by the noisiest events because they contain the majority of the energy.

frequency – with reference to noise and vibration signals, the number of cycles per second. Hertz (Hz) is the unit of frequency measurement.

frequency spectrum – distribution of frequency components of a noise or vibration signal.

percentile noise level – the noise level exceeded for n% of the measurement time.

maximum sound pressure level – greatest time-weighted and frequency-weighted sound pressure level within a stated interval and expressed in decibels (dB), e.g., the L_{AFmax} is the A-frequency-weighted, F-time-weighted maximum sound pressure level.

metric – measurement parameter or descriptor.

nighttime equivalent sound level (L_n) – the equivalent sound level over the nighttime hours (11 pm to 7 am).

noise-sensitive – space where the intended use may be adversely affected by noise.

octave bands – a standardized set of bands making up a frequency spectrum. The centre frequency of each octave band is twice that of the lower band frequency.

receiver – a noise-sensitive stationary position at which noise levels are received.

sound – the fluctuating motion of air or other elastic medium which can produce the sensation of sound when incident upon the ear.

B

APPENDIX B ACOUSTICAL REFERENCE DOCUMENTS

In addition to the normative references listed in Section 1.5, documents published by the following organizations have been used in the preparation of the Guidelines.

Canada Mortgage and Housing Corporation

The criteria outlined by the Canada Mortgage and Housing Corporation (CMHC) in *Road and Rail Noise: Effects on Housing* (1981) have been commonly used throughout Greater Vancouver but have not been updated since 1981. Regardless, they contain planning guidance that is still relevant to reduce noise impacts.

Federation of Canadian Municipalities and Railway Association of Canada

In 2013, the Federation of Canadian Municipalities (FCM) and the Railway Association of Canada (RAC) jointly published *Guidelines for New Development in Proximity to Railway Operations* (2013). These guidelines specify noise criteria for new residential developments in proximity to freight railway corridors across Canada.

World Health Organization

World Health Organization (WHO) *Community Noise Guidelines* (1999) criteria have been used around the world to develop noise level targets. Page xii of this guideline states:

> *Sleep disturbance from intermittent noise events increases with the maximum noise level. Even if the total equivalent noise level is fairly low, a small number of noise events with a high maximum sound pressure level will affect sleep. Therefore, to avoid sleep disturbance, guidelines for community noise should be expressed in terms of the equivalent sound level of the noise, as well as in terms of maximum noise levels and the number of noise events.*

Furthermore, on page 46 it states:

> *For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{Amax} more than 10–15 times per night (Vallet & Vernet 1991)*

British Standards Institute

British Standard 8233 *Guidance on sound insulation and noise reduction for buildings* (2014) includes limits from the WHO 1999 guidelines and summarizes many considerations that should be made during the design of new buildings.

Association of Noise Consultants (ANC), Institute of Acoustics (IOA), and Chartered Institute of Environmental Health (CIEH)

The *Professional Practice Guidance on Planning & Noise, New Residential Development* (2017) provides comprehensive planning guidance and criteria to address noise.

Australia NSW Planning Department

The Australia NSW *Development Near Rail Corridors and Busy Roads – Interim Guideline* (2008) contains comprehensive planning guidance and acoustical criteria to address noise.

C

APPENDIX C APPLICATION OF CRITERIA TO PAST PROJECTS

The following two examples illustrate potential differences in building upgrades required to meet the acoustical criteria in these Guidelines and in the CMHC manual *Road and Rail Noise: Effects on Housing* (1981).

Description of Site Measurements

Site 1 is a two-storey unoccupied single-family residence in Vancouver. The site is exposed to road traffic noise from East 1st Avenue. The acoustician positioned the outdoor sound meter in the front yard and the indoor sound meter in the corner bedroom suite on the second floor for a period of 24 hours.

Figure C.1, below, shows the measurement location details of each sound meter used at this site. Table C.1 summarizes the results of the measurements.

Figure C.1: Example Measurement Locations, Site 1

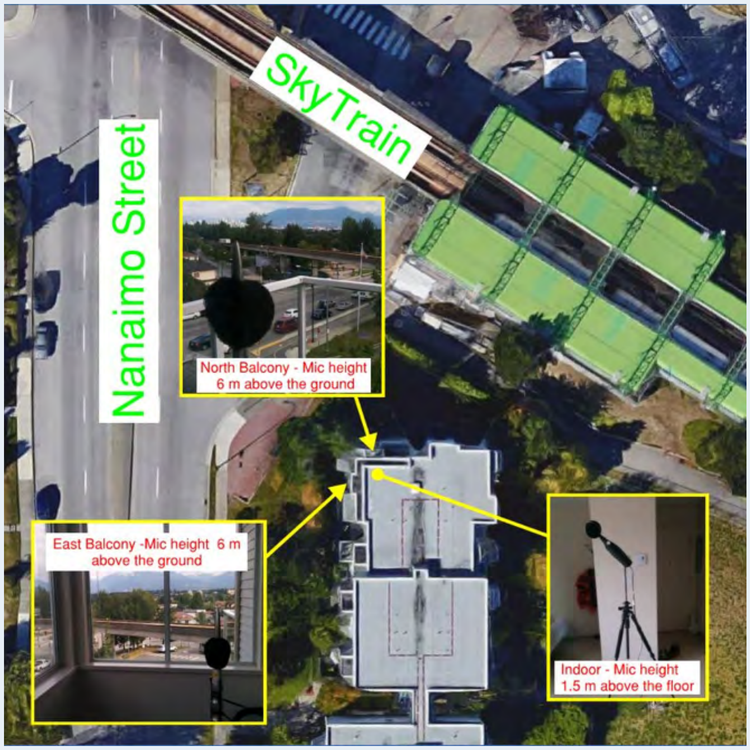
◀ ***Figure C.1:*** *Example measurement locations, Site 1*

Site 2 is a four-storey multi-family apartment building in Vancouver. The site is exposed to rail noise from the Millennium and Expo SkyTrain lines, and road traffic noise from Nanaimo Street. The acoustician assessed the noise exposure at a southeast corner unit on the top floor. One sound meter was positioned on the north balcony facing the SkyTrain guideway for a period of 24 hours; a second sound meter was set up in the west enclosed balcony facing Nanaimo Street for a period of 24 hours; and a third sound meter was placed inside the apartment for 5 hours.

The indoor monitoring period was limited due to the resident's schedule. Further, the fridge compressor was operating at 15-minute intervals; therefore, only half of the measured indoor noise, 2.5 hours, could be attributed to external sources (road and rail noise).

Figure C.2, on the next page, shows the measurement location details of each sound meter used at this site. Table C.1 summarizes the results of the measurements.

Figure C.2: Example Measurement Locations, Site 2



◀ ***Figure C.2:*** *Example measurement locations, Site 2*

Table C.1: Measurement Results

Site	Sound Meter Location	Measurement Duration (hr)	L_{eq} (dBA)	L_d (dBA)	L_n (dBA)	L_{Fmax} (dBA)*	Noise Risk Category	Reverberation Time**
1 - 1341 East 1st Avenue, Vancouver	Outdoor	24	70	71	69	-	High	-
	Indoor	24	42	43	40	-	-	0.75
2 - 4170 Nanaimo Street, Vancouver	North Balcony	24	61	62	58	74	Medium	-
	East Balcony	24	53	55	43	58		0.5
	Indoor	2.5	38	-	-	-	-	0.5

◀ ***Table C.1:*** *Results of example measurements*

** 10th noisiest at night*

*** reverberation time is a measure of a room's liveliness and affects the "build-up" of sound within the room*

Analysis

The construction details for Site 2 were used as indicated on the building permit drawings. Drawings were not available for Site 1 so the construction was observed on site and necessary details were noted. Where exact information could not be obtained, standard practices at the time of construction were assumed.

With this information, the acoustician predicted the interior noise levels and how they would change with additional upgrades to meet the relevant acoustical criteria.

Site 1 was not exposed to regular noise events during the nighttime; therefore, the indoor noise level was not assessed against the proposed L_{Fmax} criteria. For Site 2, there were more than 10 SkyTrain passby events that exceeded 70 dBA L_{Fmax}. Since the L_{Fmax}

exposure exceeded the criteria (74 dBA – 45 dBA = 29 dBA) by a much greater amount than the L_n (58 dBA – 35 dBA = 23 dBA), these SkyTrain passby events were the limiting factor in determining the required upgrades to meet the proposed criteria.

Table C.2 shows the normalized indoor noise levels based on 0.5 second reverberation time at each site.

Table C.2: Measured (Normalized) Indoor Noise Levels

Site	$L_{eq,24hr}$ (dBA)	L_n (dBA)	L_{Fmax} (dBA) 10th noisiest at night
1 - 1341 East 1st Avenue, Vancouver	40	38	-
2 - 4170 Nanaimo Street, Vancouver	35*	-	49*

**extrapolated from measured sound levels during the day*

◀ ***Table C.2:*** *Measured (normalized) indoor noise levels.*

According to the measured indoor levels, the construction upgrades required were determined to meet the acoustical criteria where applicable. Site 1 requires an additional 5 dBA reduction to meet the CMHC criteria and a 3 dBA reduction to meet the interim criteria outlined in this document. Site 2 meets the CMHC criteria, but requires an additional 4 dBA reduction to meet the interim criteria. Table C.3 and Table C.4 list the as-built construction and construction upgrades categorized by building facade component.

Each site would require upgrades to meet the interim criteria. Since it is unlikely that an acoustical assessment was performed at Site 1, this site would require wall and window upgrades in the bedrooms facing East 1st Avenue to meet the CMHC criteria. Site 2, which may have had an acoustical assessment performed during permitting, was assessed to meet the CMHC criteria but would require a heavier sliding glass door and an additional layer of gypsum wallboard to meet the interim criteria. These same construction upgrades would likely be required at the other three units on the north end of the third and fourth storeys.

Please note that this study was limited by the amount of information available concerning the as-built construction at each site, which can vary considerably from the design drawings in some cases.

Table C.3: Building Construction Upgrades for Site 1

Facade Component	Original	Example Upgrades to Meet CMHC Criteria	Example Upgrades to Meet Interim Criteria	Location of Upgrades
Wall	• 3/8" stucco • 1/2" OSB • 2" x 6" wood studs 16" OC • R8 batt insulation • 1/2" gypsum wall board	• 3-1/2" brick • 1/2" OSB • 2" x 6" wood studs 16" OC • R8 batt insulation • 1/2" gypsum wall board	• 3-1/2" brick • 1/2" OSB • 2" x 6" wood studs 16" OC • R8 batt insulation • 1/2" gypsum wall board	Bedroom south and west facades
Window	• Two single-glazed 3 mm slider windows separated by 85 mm airspace	• Two panes of 6 mm glass separated by at least 10 mm airspace (OITC 29)	• One pane of 5 mm glass and one pane of 3 mm glass separated by at least 17 mm airspace (OITC 27)	Bedroom south facade

◀ ***Table C.3:*** *Building upgrades for Site 1*

Table C.4: Building Construction Upgrades for Site 2

Facade Component	Original	Example Upgrades to Meet CMHC Criteria	Example Upgrades to Interim Criteria	Location of Upgrades
Wall	• Vinyl siding • 3/8" exterior-grade GWB over sheathing • R12 batt insulation • 2" x 4" wood studs 16" OC • 1/2" Type X gypsum wall board	• No upgrades required	• Additional layer of 1/2" Type X gypsum wall board	• North facade of 3rd and 4th floor bedrooms facing SkyTrain
Window	• Two panes of 4 mm glass separated by 9 mm airspace in a vinyl casing		• No upgrades required	• n/a
Sliding Glass Door	• Two panes of 4 mm glass separated by 12 mm airspace in a vinyl casing		• Starline sliding glass door with one pane of laminated 6 mm glass and one pane of 4 mm glass separated by at least 9 mm airspace (OITC 29)	• North facade of 3rd and 4th floor bedrooms facing SkyTrain

◀ ***Table C.4:*** *Building upgrades for Site 2*