DGL-01
DESIGN GUIDELINE
NOISE AND VIBRATION MITIGATION

VERSION 1.1 NOVEMBER 2021




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1 INTRODUCTION

1.1 GUIDELINE OBJECTIVES

This guideline is focused on the architecture, landscape and urban design strategies that can be used to address the community impacts arising out of the expansion of transit infrastructure and services. This document is intended to serve as a reference for Metrolinx teams and their consultants in support of the community engagement, design, and project implementation processes.

The requirement for noise and vibration mitigation is determined as part of the Environmental Assessment (EA) process. The implementation of recommended noise and vibration mitigation strategies shall follow applicable Metrolinx policies and standards. The specifications for noise barriers will be developed as part of a detailed design phase of a project.

This document is a resource to help guide the interpretation and adaptation of Metrolinx policies and standards to suit the programmatic and site-specific requirements of the project.

1.1.1 Standardized Approach to Community Impacts

Metrolinx continues to strive to deliver a consistent approach to addressing community concerns related to project impacts. The objective is to bring greater consistency to community consultation and decision making. A clearly defined framework allows Metrolinx to be proactive in addressing community impacts and formalizes the mitigation options to bring a consistent approach to community consultation and decision-making.

Figure 1: GO Transit locomotive

Figure 2: Advanced Light Rapid Transit (ALRT) vehicle

The purpose of the guidelines:

- set expectations with communities and assist in communication
- provide a framework for requirements and decisions making
- act as a tool for the Community Engagement and Communications teams
- provide guidance to project teams in managing outcomes
- manage the quality and consistency of outcomes

1.1.2 NOISE IMPACTS AND VEHICLE TYPES

These guidelines are applicable to locations impacted by non-stationary noise sources such as trains, LRT, and buses. Diesel locomotives, electric locomotives, subways, light rail vehicles, and buses each have different noise profiles and require distinct responses to noise and vibration impacts.

Vehicle Types

- Diesel locomotives and bi-level passenger rail cars
- Electrified locomotives and/or Electric Multiple Units (EMU)
- Automated Light Rail Transit (ALRT)
- Light Rail Transit (LRT) vehicles
- TTC T1 rapid transit rolling stock (heavy rail)
- Buses

1.2 COMMUNITY BENEFITS

A key principle used in the determination of community benefits: the mitigation should be commensurate to the negative consequences that arise fromof Metrolinx activities (for example, noise and/or vibration impacts)

The concept of equity as it applies community benefits should be considered in terms of the type and magnitude of the negative impacts arising from Metrolinx activities. The impacts of new infrastructure and increased services are not uniform across the region; therefor, the provision of community benefits need not be equivalent in all locations.

The fact that some locations experience a significantly greater negative impacts is the reason why there is an option for "special conditions" for linear infrastructure projects. The assessment of community benefits is to be carried out on a case by case basis using a robust multi-criteria options analysis process.

1.2.1 Exceptional Conditions

Metrolinx may consider enhanced mitigating design solutions for locations experiencing significant negative impacts that are considered both a unique and extreme condition within the network, or:

- represent locations that carry a high degree of reputation risk to Metrolinx; or
- represent locations where issues of social equity are to be addressed.

2 DECISION MAKING CRITERIA

2.1 PROCESS

With respect to communities, there are a number of criteria that informing the types of remedial action that Metrolinx might undertake to address project impacts. Options analysis is one of the key tools used in the decision making process.

2.1.1 Optioneering: Multi-criteria Decision Analysis

Note: refer to Appendix A for a sample Multi-criteria Design Analysis Table

Decision making criteria include:

- Environmental Assessment (EA) Requirement
- Metrolinx Guidelines, Policies, and Standards
- Adjacent Land Use(s) and Built Form
- Responsiveness to Urban Design Considerations
- Addresses Reputational Risks
- Exceptional Conditions
- Third Party Scope Requests
- Supports Municipal Planning and/or Urban Design Objectives
- Procurement Model
- Variation/Change to Contract
- Project Phase / Project Risk
- Cost Estimate / Cost Delta
- Maintenance/Lifecycle Costs
- Summary/Recommendation

2.1.2 Noise Barrier Specific Design Criteria

Decision making criteria include:

- the recommendations coming out of the EA noise and vibration studies
- the spatial relationship between source and receptor
- local topography and built form

2.1.3 Adjacent Land Categories

Land use is a key criteria in determining what type of mitigation strategies that may be considered for a specific location. These strategies may include noise barriers, retaining walls, crash barriers, vegetative screening, murals, or a combination thereof.

- Heritage Conservation Districts (HCD)
- Institutional and Public Buildings
- Commercial
- Residential
- Recreational
- Open Space
- Industrial
- Agricultural

3 IMPACT IDENTIFICATION

3.1 IMPACTS

Mitigation strategies are selected based on the different noise profiles and vibration impacts, each requiring its own distinct response.

Types of noise and vibration impacts:

1. Temporary construction noise and vibration impacts
2. Permanent noise and vibration impacts resulting from service and operations

3.2 VIBRATION

3.2.1 Factors Influencing Vibration Levels

There are many factors that influence vibration levels, including:

- Soil type and conditions
- Rail condition
- Wheel condition
- Speed of vehicle
- Weight of vehicle
- Suspension system of vehicle
- Track bed (concrete, ballast, etc.)
- Distance between source and receiver

3.2.2 Vibration Mitigation Measures

- Mitigation measures include track fixation, rail dampening, ballast mats, locomotive specifications and modifications, and electric multiple unit (EMU) specifications
- Limit hours of operation for certain high impact construction activities (e.g. auger cast piles)

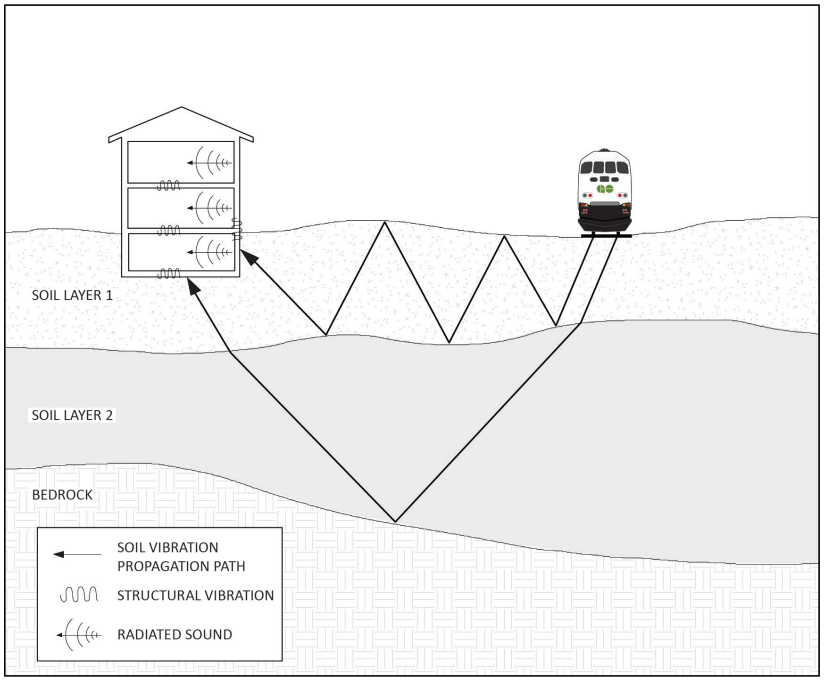


Figure 3: Vibration impacts illustration

3.3 NOISE

3.3.1 Temporary Construction Noise Impacts

Mitigation measures include:

- Control noise at source
- Prescribe operational measures to mitigate the impacts of construction noise and vibration.

3.3.2 Permanent Noise Impacts

The requirement for noise and vibration mitigation is determined as part of the Environmental Assessment (EA) process. The implementation of recommended noise and vibration mitigation strategies shall follow applicable Metrolinx policies and standards. The specifications for noise barriers will be developed as part of a detailed design phase of a project.

3.3.3 Controlling Noise at Source

Mitigation measures include:

- continuously welded rail
- resiliency supported rail ties
- high grade rail fasteners and rail dampers
- regular wheel maintenance
- locomotive specifications and modifications
- electric multiple unit (EMU) specifications

Operational measures to control noise at source include:

- reduce frequency and duration of idling vehicles
- adjusting station approach and departure speeds or setting (especially for diesel locomotives)

3.3.4 Noise Barriers

The requirement for noise barriers is typically established during the EA process.

The noise and vibration studies typically outline recommendations for noise barriers including:

- a high level feasibility assessment
- locations where noise barriers are required
- extents of noise barriers
- required barrier heights

3.3.5 Effectiveness of Noise Barriers in Built-up Areas

In some areas noise barriers are not technically effective (for example at rail crossings or when people live in tall buildings in units much higher than a noise wall or on bridges that cannot support the weight of a noise wall).

3.3.6 Wildlife Protection

- Noise barriers have the potential to impede the movement of wildlife between different habitats
- The EA process will identify any environmental obligations regarding protection for wildlife movement within Metrolinx rail corridors.

4 MITIGATION STRATEGIES

4.1 NOISE BARRIERS: SYSTEMS AND FUNCTIONS

Noise barriers systems are made up of an interchangeable components (a kit-of-parts) that can be assembled to in a multitude of different ways to suit the noise mitigation requirements and local context.

4.1.1 Post and Panel Noise Barrier systems

The kit of parts that make up a post and panel noise barrier system include:

- Steel or concrete H posts
- Reflective noise barrier panels
- Absorptive noise barrier panels
- Transparent noise barrier panels.

4.1.2 Reflective Noise Barrier Panels

- Materials can include precast panels, metal clad panels, transparent panels. Refer to Figure 1 for more information on each material.

4.1.3 Absorptive Noise Barrier Panels

- Barriers should be constructed of an absorptive material to prevent increasing sound levels through reflection, particularly when receptors are located on both sides of a transportation corridor
- Unless otherwise specified, noise barrier panels shall meet the requirements for an absorptive finish as outlined in the noise and vibration studies
- Materials can include precast panels, perforated metal clad panels
- Note: repeated coating of panels to mitigate graffiti will reduce the sound absorptive functionality of the barrier over time

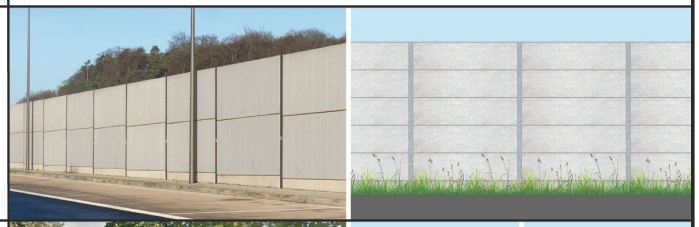
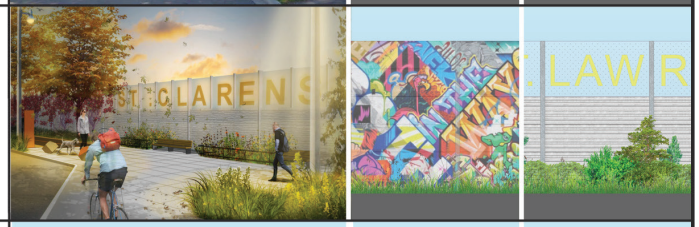
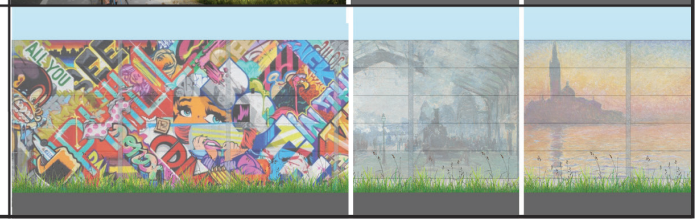
4.1.4 Transparent Noise Barrier Panels

- Transparent panels should only be used when the noise and vibration studies performed as part of the EA indicate that reflective barrier will meet the specified performance requirements
- Transparent panels are typically utilized for bridges and elevated road or rail applications or where minimizing visual impacts is important
- Transparent panels are used where views to landmarks or significant landscapes is desirable
- Transparent panels can also be used in locations where buildings are located directly adjacent to a noise barrier to preserve access to natural light and sky views
- Where transparent panels are used in conjunction with other panels types, they should be located at 3.0m above grade or higher in order to minimize risk of graffiti and tagging
- Note: transparent panels shall come complete with bird-deterring markings

Table 1: Noise Barrier Panel Types

Category	Benefits	Disbenefits	Recommendation
Precast Panels	• Very durable and low maintenance • Can be used where reflective or absorptive noise barriers are required • **Unless otherwise specified the rail corridor face of the precast panels meet the requirements of an absorptive noise barrier** • **Note:** sound absorption is determined in part by the porosity of the material (sound absorptive aggregates, fibrous materials) • Patterned concrete surfaces have higher sound absorption qualities than smooth surfaces • Best option for graffiti management • Options for wall surface patterns (Reference *DS-16 Concrete Wall Surface Patterns*) • Suitable substrate for murals (specify smooth finish, do not apply anti-graffiti coatings)	• Not suitable for bridges and elevated guideways • Only suitable for ground-mounted noise barriers	• Recommended for general use
Metal Clad Panels	• Durable • Weight (easier installation) • Suitable for structure-mounted noise barrier solutions (bridges, elevated guideways, retaining walls) • Can be used where reflective or absorptive noise barriers are required (specify perforated panels where sound absorption is required) • Post and panel prefinishing options available (solid colours and painted textures)	• Graffiti management and removal processes involving the application of chemicals followed by power-washing is labour intensive • Less impact resistant than precast panels • Not suitable for bridges and elevated guideways (unless the structure is engineered to accommodate the loading) • Not a suitable substrate for murals	• Recommended for locations where loading on structures is an issue • Post and panel prefinishing options available (solid colours and painted textures)
Transparent Panels	• Minimizes visual impacts of noise barriers • Weight • Suitable for structure-mounted noise barrier solutions (bridges, elevated guideways, retaining walls)	• Graffiti management: graffiti removal results in permanent damage to transparent (acrylic) panels • Not a suitable substrate for murals	• Recommended for locations where loading on structures is an issue • Recommended where minimizing visual impacts of noise barriers is important

Figure 4: Noise Barriers Categories

Category	Noise Barrier Options	Illustrations
1	**Base Noise Barriers** • Base design specification • Meets commitment outcomes from the Environmental Assessment process • Noise barriers must be technically, administratively, operationally and economically feasible	
2	**Aesthetically Enhanced Noise Barriers** • Enhanced features to mitigate negative visual impacts • Extended palette of noise barrier components (enhanced design specifications) to counter significant visual impacts in sensitive locations • Meets all the requirements of the Base Design Specification	
3	**Third Party Scope Requests** • Response to third party scope requests (assessed on a case by case basis) • The objective is to support specific third party requests and/or municipal planning and urban design objectives • Meets all the requirements of the Base Design Specification	
4	**Murals & Public Art Treatments** • Public art or murals applied as a surface treatment to noise walls • Public art or mural projects are typically procured, implemented, and maintained by municipalities or other third parties • Meets all the requirements of the Base Design Specification	

5 NOISE BARRIER CATEGORIES

5.1 NOISE BARRIER CATEGORIES

The noise barrier typologies (Figure 4) are based on a number of criteria including adjacent land uses. These typologies employ different components of a post and panel system to achieve their design objectives.

5.1.1 Base Design Specification (Type NB-1)

Selection criteria

- Meets the commitment outcomes of the Environment Assessment (EA) or Transit Project Assessment Process (TPAP)

Specifications

- Solid panels (precast concrete or metal clad panels)
- Acoustically absorptive panels, both faces
- Smooth finish to panel surface unless otherwise specified

Adjacent land uses

- Industrial, Transportation, Open Space

5.1.2 Negative Visual Impact Mitigation, Aesthetically Enhanced (Type NB-2 and NB-4)

Selection criteria

- Specifications to counter significant negative visual impacts in sensitive locations
- Case by case design specifications to be selected from the noise barrier kit of parts

Specifications

- Acoustically absorptive panels, both faces
- Patterned panel finish, both faces

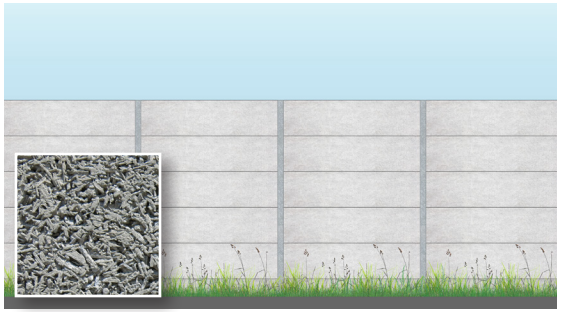


Figure 4: Base design specification for noise barriers

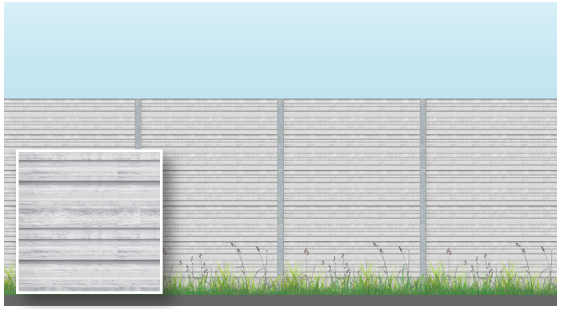


Figure 5: Noise barrier panels with patterned wall surface pattern

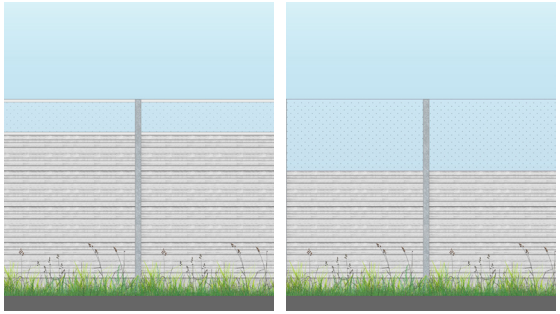


Figure 6: Noise barriers with a combination of opaque and transparent panels

- Option for transparent panels at higher elevations to minimize the visual impacts of the noise barrier (reference figures 4 and 5)
    - Confirmation that the noise barrier performs as per the recommendations of the EA is required if transparent panels are used
    - Transparent panels are typically installed at higher elevations (+2.7m) to minimize risk of graffiti and tagging

Adjacent land uses

- Institutional and Public Buildings, Commercial, Residential, Recreational
- Enhanced design specifications may include remedial landscape and planting strategies and other community benefits determined on a case-by-case basis

The benefits of vegetative screening

The purpose of vegetative screening is to mitigate negative visual impacts along transportation corridors due new services and construction

The primary benefits of vegetative screening include:

- restoration of naturalized habitats along Metrolinx rail corridors and the softening of the "hard edges" along rail corridors
- the application of the techniques of camouflage to minimize the visual impacts of rail corridors and linear infrastructure
- deterrence of tagging and graffiti

5.1.3 Third Party Scope Requests, Custom Enhanced (Type NB-3)

Selection criteria:

- Enhanced design specifications to support regional or municipal planning and urban design objectives

Figure 7: Example of a third party scope request to support a municipal urban design objective

Figure 8: Design specifications may include special graphics and landscape treatments

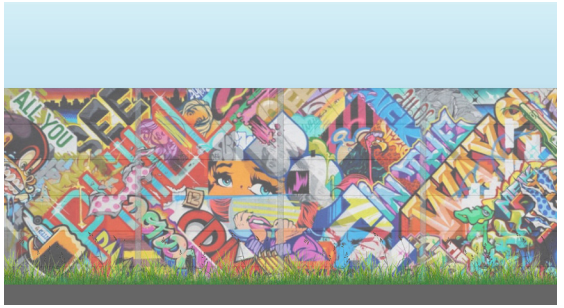


Figure 9: Third party requests may also entail reservation of specific locations on noise and retaining walls for mural programs

- Specification examples: textured panel finish, full or partial use of transparent panels, customized noise barrier system
- Other selection criteria
  - Requirements listed in a master agreement

Specifications:

- Specifications may include textured panel finish and the selective use of transparent panels
- Third Party Scope Requests may also include solicitations for other community benefits that would be determined on a case-by-case basis

Adjacent land uses:

- Municipal planning and urban design objectives;

5.1.4 Murals and Public Art Treatments (Type NB-1 prepped for mural application)

Selection criteria:

- Murals, bas-reliefs, bespoke surface textures, or other types of public art applied to noise barriers is typically initiated through a third party scope request
- This parties include municipalities, Business Improvement Areas (BIA), non-governmental organizations (NGO), or local community groups

Specifications:

- Smooth surface on barriers and panels acting as a substrate for a mural
- Do not apply anti-graffiti coatings to barriers and panels prior to the installation of the painted mural

Adjacent land uses:

- The adjacent land use is not a primary selection criteria

Figure 10: Enhanced negative impact mitigation measures may be required in a dense urban context

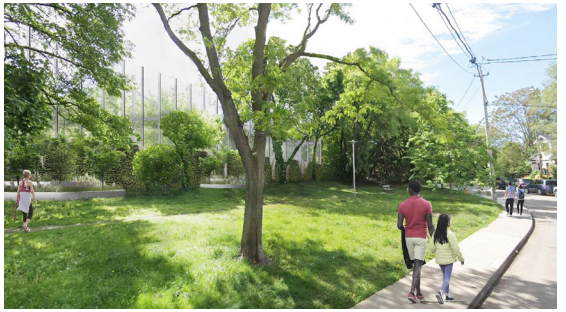


Figure 11: Enhanced negative impact mitigation measures may be required in a dense urban context

Figure 12: Vegetative screening is a key means of mitigating the negative visual impacts of noise barriers in sensitive locations such as parks and residential neighbourhoods

5.1.5 Transparent Panels, Aesthetically Enhanced (Type NB-2 and Type NB-4[X]-BR)

Selection criteria:

- Recommended for locations where loading on structures is an issue
- Transparent noise barriers are also used in locations where structure-mounted solution are required
    - Examples: bridges, elevated guideways, retaining walls).
- Note: transparent panels act as reflective noise barriers and should only be used where the performance criteria meets the noise mitigation requirements as determined through the Environmental Assessment process
- Recommended where minimizing visual impacts of noise barriers is important
- Specification notes:
    - Transparent panels shall come complete with bird-deterring markings
    - These panel types, fabricated from acrylic or polycarbonate, can be pigmented or translucent
    - Translucent panels can be specified where privacy is an issue

Adjacent land uses:

- Locations where significant views are to be protected (including significant landmarks, view corridors)

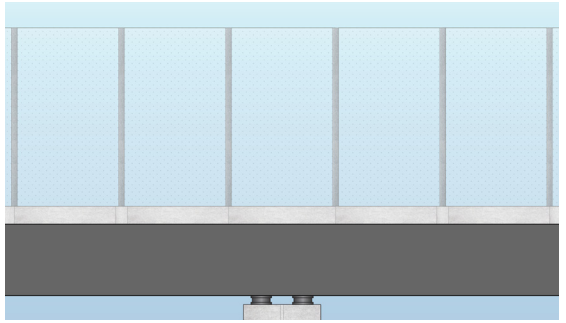


Figure 13: Typical locations for transparent noise barriers include bridges and elevated guideways

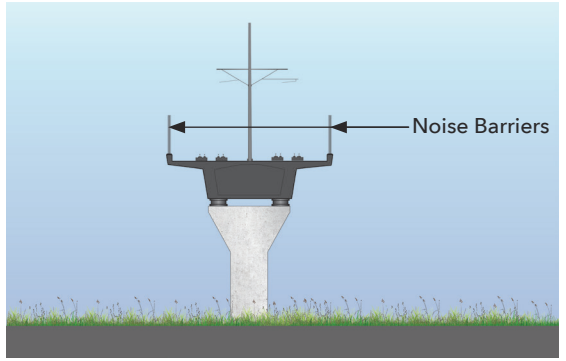


Figure 14: Sections showing location of noise barriers on an elevated guideway

Figure 15: These types of noise barriers available with a transparent, translucent, or pigmented finish

6 NOISE BARRIER END TREATMENT

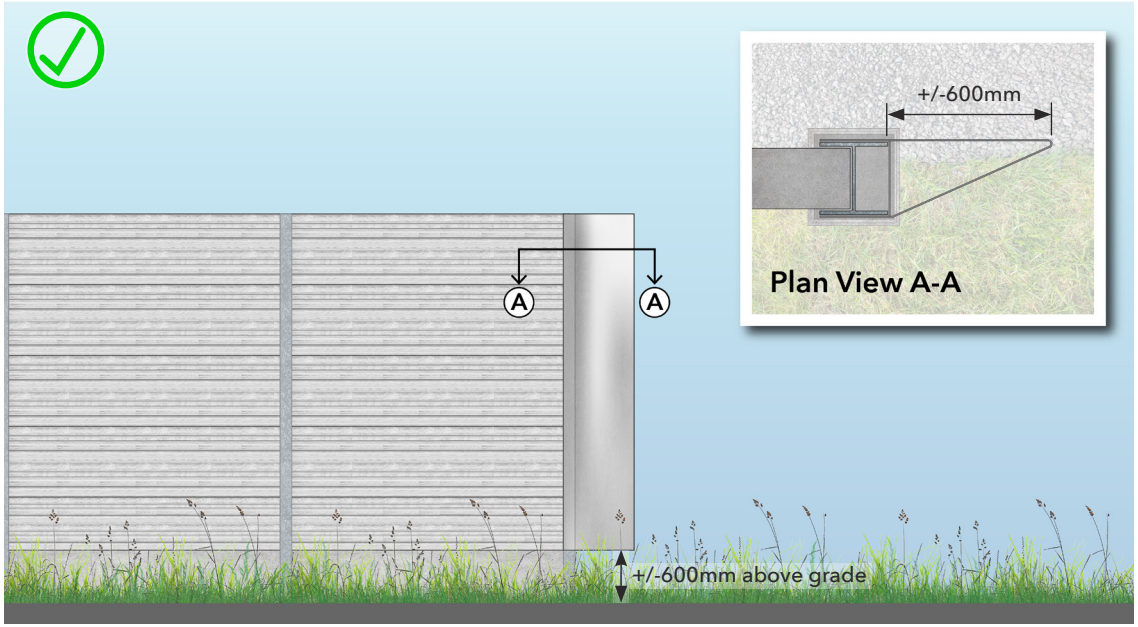


Figure 16: Illustrations showing noise barrier end treatment with custom termination post

6.1 TERMINATION POSTS

The termination of a noise barriers shall be marked by a customized post as illustrated in Figure 15. The custom termination posts should also be used at break in the noise barriers for level grade separations and bridges.

Outline specification for custom termination posts:

- Termination posts may be prefabricated to facilitate speed of installation
- The shaped, or formed, termination panels shall be fabricated from a heavy gauge metal plate formed and welded to the metal post as illustrated in figure 15
- The finish to the shaped metal plate shall match adjacent noise barrier posts

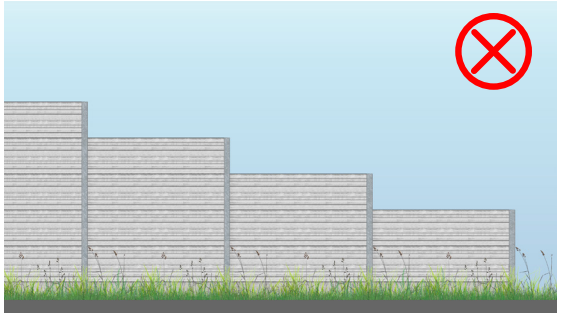


Figure 17: Noise barrier end treatment with stepped panel

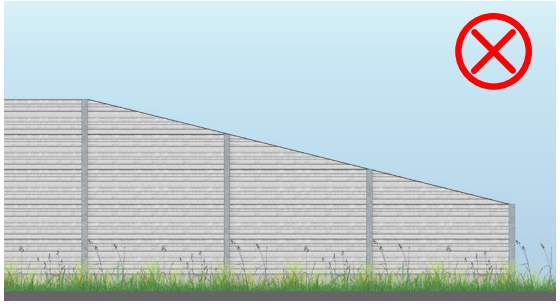


Figure 18: Noise barrier end treatment with sloped panel

Figure 19: Noise barrier end treatment with vegetation marking termination of the structure

7 ALIGNMENT ALONG THE TOP OF NOISE BARRIERS

7.1 SHIFTS IN THE DATUM OF NOISE BARRIERS

- The noise barrier system shall be a post and panel configuration made with prefabricated modular panels resting on a precast concrete base sitting 600 mm (typical) above grade
    - The top of the base panel should align with the bottom of the formed panels attached to the termination posts as illustrated in **figure 15**
- Noise barriers shall be designed so that there are no sections less than 100 meter in length with variable height
- Where topographical changes precipitate shifts in the datum of the noise barrier – a minimum of five adjacent panels must be maintained at each given top of barrier elevation within the 100 meter parameter.

Figure 20: Noise barrier should not look like an accordion when responding to topographical changes

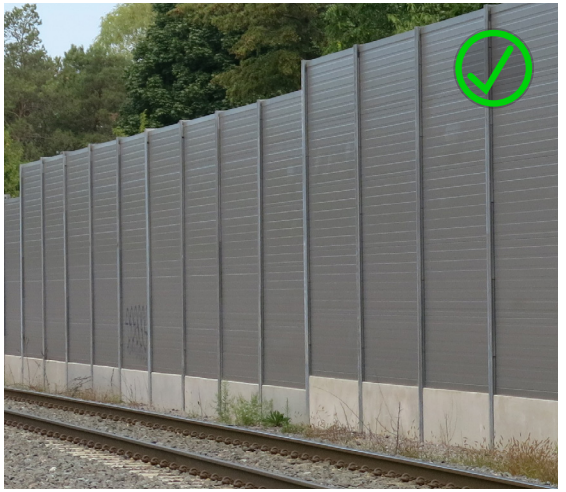


Figure 21: Where topographical changes precipitate shifts in the datum of the noise wall – a minimum of five adjacent panels must be maintained at each given top of barrier elevation

Appendix A: Sample Multi-criteria Design Analysis Table

Multi-criteria Decision Analysis		Better		Worse	
Criteria	**Subject Matter Expert**	**Option A**	**Option B**	**Option C**	**Remarks**
Environmental Assessment Requirement (Y/N)	EPA				A commitment identified in the Environmental Project Report (EPR)
Conforms to Metrolinx Guidelines, Policies, and Standards (Y/N)	All				
Adjacent Land Use(s) and Built Form	EPA, Design Division, Consultant, TA				
Responsive to Urban Design Considerations	Design Division, Consultant, TA				
Addresses Reputational Risks	Community Engagement				An *exceptional condition* is defined as a location where negative impacts are both extreme and unique within the network
Exceptional Conditions	All				
Third Party Scope Requests (Y/N)	Community Engagement, EPA				
Supports Municipal Planning and/or Urban Design Objectives (Y/N/NA)	Design Division, Community Engagement				
Procurement Model	Project Delivery Team				
Variation/Change to Contract (Y/N)	Project Delivery Team				Does change add to project risk?
Project Phase / Project Risk (high, moderate, low)	Project Delivery Team				
Cost Estimate / Cost Delta	Project Delivery Team				
Maintenance/Lifecycle Costs	Project Delivery Team				
Other Criteria (if applicable)	All				
Summary/Recommendation	**All**				

Figure A1: *Sample Multi-criteria Design Analysis Table*