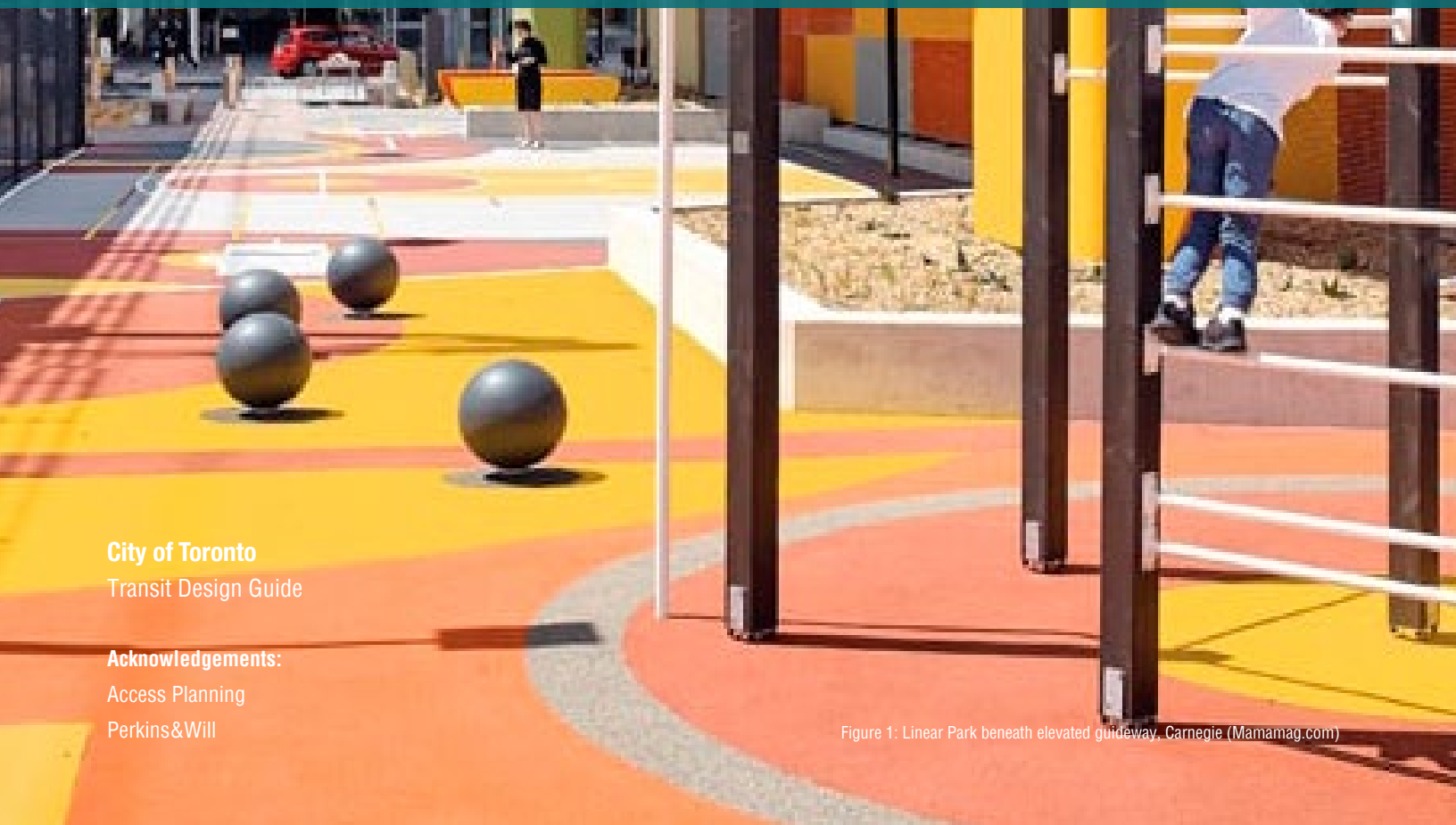
Elevated Guideways



City of Toronto
Transit Design Guide

Acknowledgements:
Access Planning
Perkins&Will

Figure 1: Linear Park beneath elevated guideway, Carnegie (Mamamag.com)

1.0 INTRODUCTION

1.1 Definition

Elevated guideways are sections of track infrastructure between stations that are raised above grade or street level. A series of factors influence the layout and resulting guideway type, including:

- Context and urban fabric in which it is located (right-of-way width, elevation, built-up, parks or open space, natural areas (e.g., valleys, floodplain), urban or suburban).
- Alignment of guideway to its surrounding context, such as adjacent networks of streets and blocks (parallel, intersecting, etc.).
- Adjacency of the guideway to other corridors such as highways, rail tracks, or natural features such as ravines or linear parks.
- Visibility of the guideway from the surrounding public realm.

Components of an elevated guideway include:

- **Guideway:** The track and concrete structure on which a transit vehicle travels.
- **Emergency walkway:** A narrow walkway alongside the guideway for emergency egress or access.
- **Guards, Barriers or Railings:** For added safety requirements, guards, barriers, or railing elements / features installed along the edge of the guideway and required to meet established safety standards.
- **Underpass:** The open-air space directly beneath the guideway structure.
- **Piers and columns:** Vertical structure that supports the load of the horizontal span of the guideway.
- **Bents:** Bents come in a variety of configurations including "T" and "Y" shaped bents. For example, straddle bents are composed of a large beam that is held up by columns on either side, used instead of a regular central pier when a roadway runs under the guideway.
- **Foundation:** The structure that supports the guideway into the earth.

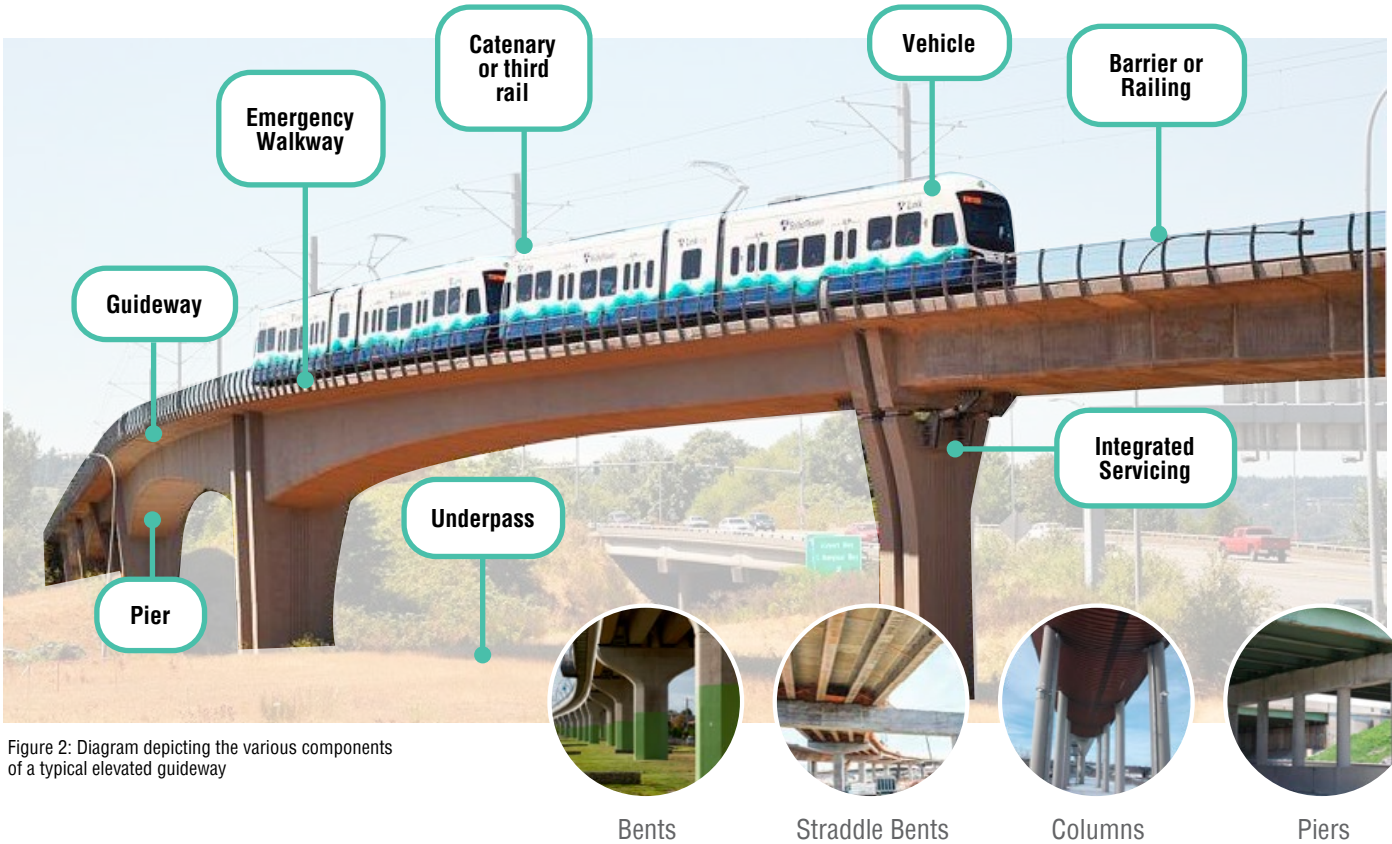


Figure 2: Diagram depicting the various components of a typical elevated guideway

1.2 Areas of Influence

In the context of elevated guideways, the areas of influence can be defined as follows:

Zone 1: Includes the neighbouring public and private properties that will be physically and visually impacted by the guideway, such as, adjacent streets, buildings, parks, and natural areas (e.g., ravines and floodplains). While limited work may occur in zone 1 during the capital transit project, this zone is still impacted by the intervention in zones 2 and 3. Therefore, it is essential that mitigation of potential impacts in zone 1 are carefully considered during the early phases of the project, while the alignment is being determined. Opportunities for the delivery of public realm improvements and amenities in coordination with the guideway should be sought in the early phases.

Zone 2: Includes the guideway structure, guards, as well as any public realm interventions under the guideway. The long-term maintenance and jurisdiction governing the space under guideways will have an impact on the design of these spaces and its influence on zone 1. Zone 2 is typically the scope of work delivered as part of the capital transit project.

Zone 3: Includes the track, overhead catenary system, track lighting and other track elements related to the selected transit technology. This zone is generally outside the scope of these guidelines; nonetheless, this Guide includes guidance regarding the alignment of the line, as it impacts the other zones.

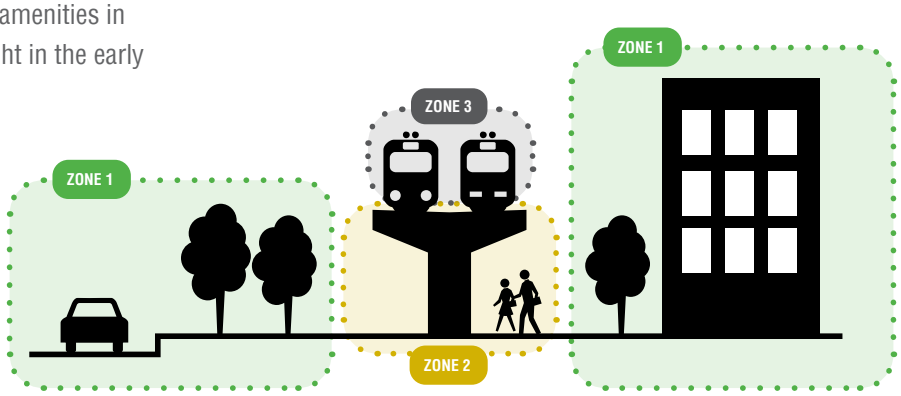


Figure 3: (Right) Cross-section depicting how the areas of influence apply to elevated guideways

Figure 4: (Below) Annotated photograph depicting how the areas of influence apply to elevated guideways

1.3 Applications of Elevated Guideways

Several applications of Elevated Guideway have been identified, based on factors such as the locational alignment or the nature of the surrounding context. Each of these have different considerations and impacts on adjacent infrastructure, development, and/or public realm.

Figure 5: CTrain and the downtown Calgary skyline (Photo Credit: Shutterstock)

Figure 6: Hawaii Authority for Rapid Transportation (HART) light metro system, Honolulu (Photo Credit: Catherine Cruz, HPR)

Off-Street

This application refers to transit lines where the guideway is located away from a roadway, such as in between the rear or sides of properties. In practice, this typology typically occurs when there is an existing easement in place, thus located adjacent to or on top of other infrastructure.

In some instances, guideways may be located approximately above the third floor of surrounding buildings. This application is only appropriate for areas of transition, such as when the transit line is required to cross over significant infrastructure or parks and open space areas.

Middle of the Street

This application refers to transit lines where the guideway is located in the centre of the right-of-way, with vehicular traffic lanes under and/or along both sides. This typology is only appropriate for streets with an existing wide right-of-way.

Figure 7: Hague Randstad Rail, Netherlands (Photo Credit: ArchDaily)

Parallel to the Street

This application refers to transit lines where the guideway is located above and alongside the roadway, following the road infrastructure in a parallel configuration. This application typically requires a street with a wide right-of-way, or where sufficient land can be acquired parallel to the right-of-way.

Figure 8: Djerring Trail, Victoria, Australia (Photo Credit: Bazza, Australia247)

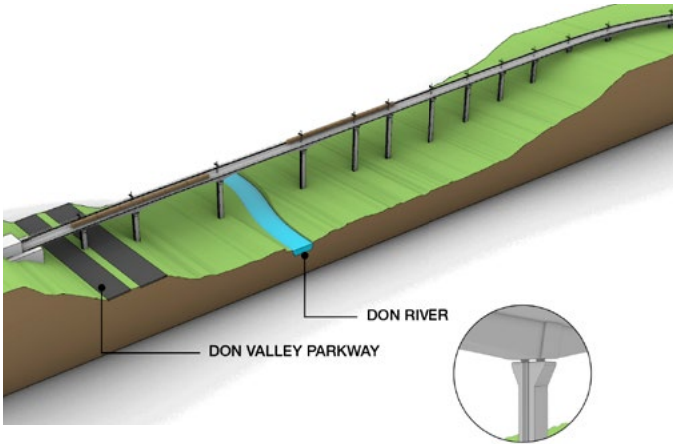


Figure 9: Illustration demonstrating elevated rail going through ravine and natural area, Ontario Line (Photo Credit: Metrolinx)

Parks, Open Space, and Utility Corridors

This application refers to transit lines where the guideway runs through parks and open space, utility corridors, and/or trails. In some cases, guideways within utility corridors interface with recreational facilities, programming, off-leash areas and community gardens. Protection and enhancement of these public uses should be prioritized during planning and design to minimize impacts on community assets.

This application should generally be avoided. However, if required, align guideway to minimize the impact on parkland, trails and mature tree canopy. Avoid street widenings.

The goal should be to maximize park and open space usage, existing programming and user interaction through appropriate treatment of the underside of the guideways (engaging or passive). Final treatment on columns can include creepers, vines, green walls, etc., while mitigating overall environmental and ecological impacts. Surface drainage and other debris that may fall off the elevated guideway should be managed through the design.

Natural Areas

This application refers to transit lines where the guideway passes through a ravine, floodplain, natural heritage areas or other protected natural areas.

This application should generally be avoided to prevent any negative ecological impacts and should only be considered for punctual crossings when other options have proven unfeasible.

Figure 10: Mass Transit Railway (MTR) elevated system above other rail infrastructure, Hong Kong (Reddit)

Above other Infrastructure

This application refers to transit lines where the guideway is located above other transport infrastructure, such as other rail corridors, bridges, or roadways.

This application is only appropriate for areas with an existing corridor that aligns with the proposed guideway. This typology can be considered only if there is sufficient and appropriate space and impacts of height and access can be accommodated

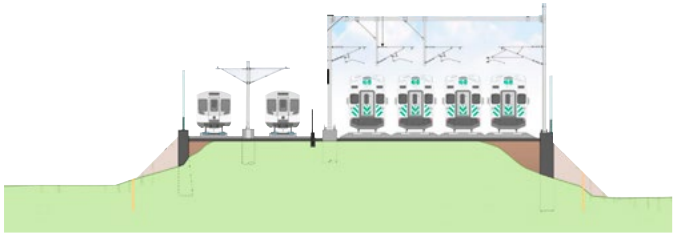


Figure 11: Cross section of rail line on embankment, Ontario Line (Metrolinx)

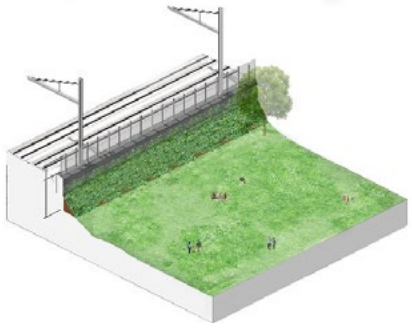


Figure 12: Conceptual rendering of rail line on embankment, with retaining wall adjacent to open space, Ontario Line (Metrolinx)

Embankment

This application refers to transit lines where the guideway is located above an embankment (an artificially raised section of the terrain).

This application is only appropriate for areas where there is already an existing embankment (e.g., for an existing road or transit corridor). This prevents creating new edge conditions or barriers that disrupts the natural areas or impede on pedestrian connections. Where required, this application should be used minimally and always in combination with a true elevated condition (refer to other applications above) to allow for permeability of the public realm, circulation at the ground level or with underpasses and pedestrian tunnels to maintain accessibility and safety.

1.4 Typical Project Delivery

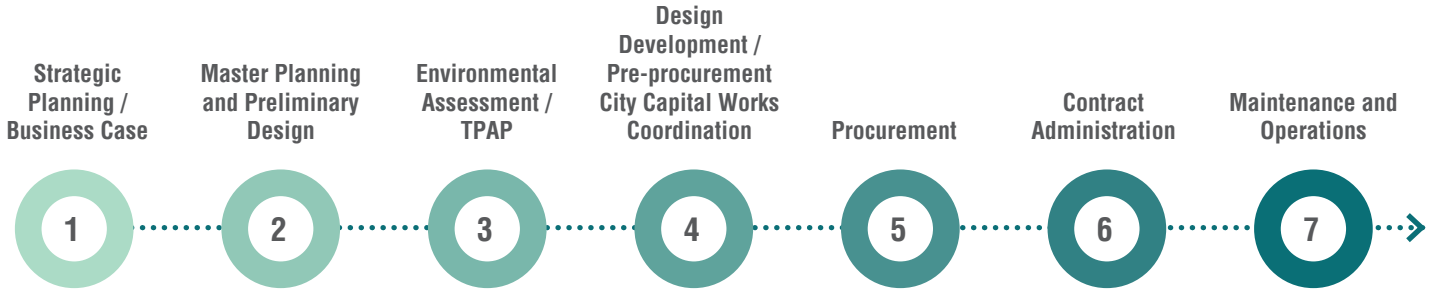


Figure 13: The typical delivery process for transit infrastructure

The selection of an elevated system as the preferred transit solution occurs early on during **Master Planning and Preliminary Design.** While precedents around the world demonstrate that beautiful and well-integrated elevated systems are possible, it brings additional design challenges that must be considered: elements of the system that would otherwise be below-grade are now in plain sight and need to be carefully designed and integrated within the public realm. Additionally, public, Indigenous and accessibility related consultation should be considered during the **Design Development** phase.

For these reasons, it is necessary that the evaluation criteria developed for any **Business Case or Environmental Impact Assessment** takes into consideration all the benefits, opportunities and challenges of an elevated system, including typology, alignment and location. This should include the cost of delivering high quality elevated elements, the investment in the public realm design to integrate the structure, the cost of restoring any impacted built or natural areas as well as the additional operational costs involved in maintaining the structure and associated spaces. A life cycle assessment of the carbon footprint should be part of the Business Case prior to selecting an elevated system as the preferred option.

Obligations surrounding ownership and maintenance responsibilities for spaces beneath guideways should be clarified in the project delivery process. Operations and maintenance for the underpass area should be established during the planning stages to ensure continuity of the public realm and responsibility for maintenance and servicing access.

In the Toronto context, elevated systems are typically packaged with other elements as part of a Public Private Partnership (P3) procurement process. Under these circumstances, it is expected that:

- Guideways will be designed in conjunction with other elements of the transit system, rather than in isolation. The transit agency delivering the project should produce project-specific guidance documents that address overall cohesivity of the design and ensure continuity in identity throughout the transit line. These documents should be part of the procurement documents.
- City of Toronto staff should participate in the preparation of the procurement documents and provide input as per the guidelines included in this document.
- Local transit agencies (e.g. TTC) will have input on special track operations, including switches, crossovers, and pocket tracks. They will accommodate regularly scheduled turnback service for sections experiencing differential demand, run-as-directed service for event surges, critical or strategic segments for perturbation operations, short turn locations to maintain vehicle line operations, and others.
- Public consultation throughout the process should inform project teams on local goals, provide diverse views and feedback, and comment on evolving plans or designs, which should be considered in decision-making.
- Local community artists and groups should be engaged where appropriate and interested, working with relevant

City divisions. This is especially important in equity-seeking communities where such involvement can create opportunities for individual and community benefits.

- Other relevant stakeholders include emergency services as special emergency access and evacuation conditions will apply given the elevated nature of the infrastructure. Adjacent and/or affected property owners should also be engaged throughout the process with many opportunities to be informed and provide feedback.

2.0 EXISTING GUIDANCE

The following is a non-exhaustive, illustrative list of existing guidance and requirements that should be read together with this Guide.

- **Official Plan (3.1.X):** Public realm policies for higher-order transit require transit stations and ancillary infrastructure to provide high-quality architecture, landscape architecture, and urban design. Ancillary elements located, organized and designed to be contextually responsive and limit impacts to public realm and adjacent property.
- **Official Plan 4.3.3:** Development within Parks and Open Space Areas is intended to have only minimal adverse impacts on natural features and functions, and those areas are to be restored and enhanced including existing vegetation and other natural heritage feature.
- **City of Toronto Accessibility Design Guidelines, 1.1.3. Pedestrian Overpasses and Underpasses:** Underpasses should provide accessible and clear paths of travel that are continuous and unobstructed, adhering with maximum slopes.
- **City of Toronto Tree Protection By-Laws:** Provides direction for tree protection and replacement ratios for private and City-owned trees planned for removal.
- **TTC Design Manual, DM-0303-01 Elevated Structures:** Aesthetic considerations inform the guideway form and impact the structural design process. There are opportunities to provide additional guidance on prescribed form and/or direction to minimize the scale of the guideway.
- **TTC Design Manual, DM-0203-01 Property:** Provides guidelines on right-of-way acquisition, with goal of minimizing property acquisition; lower limits only apply where special limiting features exist.
- **MTO Aesthetic Guidelines for Bridges:** Functional clarity and high design excellence is emphasized as key considerations for structures such as elevated guideways. These guidelines also specify pleasing proportions between elevated structures and surrounding context, with a visual impression of lightness.

Much of the existing guidance for elevated guideways relates to the objectives of **Urban Integration**, specifically informing place-making and integration of these structures into the public realm. This Guide adds to the guidance with a focus on **User Experience**, **Sustainability and Resilience**, **Intermodal Operations** and **Accountability** with regard to elevated guideways.

3.0 OBJECTIVES

Elevated guideways are a prominent feature of the urban landscape. While their primary purpose is to support the provision of higher-order transit service, they must achieve a number of design objectives to secure benefits to the community beyond transit and mitigate the potentially significant impacts if not well designed.

The following is a summary of the objectives for elevated guideways:

Urban Integration

Elevated guideways should integrate seamlessly with the existing and planned urban context and take advantage of the physical infrastructure to create a sense of place within the public realm; their placement should enhance connectivity rather than create barriers and optimize integration with adjacent new development rather than sterilize development sites.

User Experience

Elevated guideways should allow for a safe, legible, and accessible user experience, benefiting both users of the transit line while not compromising the quality of space for the local community.

Sustainability & Resilience

Elevated guideways should be sustainably designed with low-carbon materials, optimal use of green infrastructure, and increased resilience to climate change.

Intermodal Operations

From a transportation operations perspective, the design of elevated guideways must maximize the benefit to transit service, minimize weather impacts to ensure uninterrupted, reliable service, and avoid conflicts with other modes of travel.

Accountability

Elevated guideway design should consider the entire lifecycle, use of materials and construction methods that account for whole life cost, and foresee the need to accommodate new transit lines, improved service, changes in capacity and new technology. Importantly, the siting, massing and design of elevated guideways should allow for optimization of future overbuild and/or active Transit-Oriented Development (TOD) frontages.

4.0 DESIGN GUIDANCE

Urban Integration

4.1 Urban Integration

1. Plan, locate, design, and build elevated guideways to minimize overlook of adjacent property, shadowing, noise, vibration and visual and physical obstructions at-grade.
2. Design elevated guideways as a key focal point and landmark for the surrounding context where appropriate.
3. Set the height of the elevated guideway to:
    a. Respond to the scale of the street, especially in areas where the guideway is located adjacent to built-up areas.
    b. Ensure clear views at grade up to 2 storeys (minimum 7.5 metres from the existing ground level), while maintaining visibility across the street and adjacent public realm so that the street is perceived as one whole space.
    c. Maximize use of the underpass area and ensure access to sunlight on the public realm below, especially when it includes uses such as natural areas, landscaped or recreational spaces.
4. Establish a fixed datum for the guideway through urban conditions as a way of unifying the design solutions.
5. Plan and design foundations to anticipate future development.
6. Design vertical guideway elements, such as columns and piers:
    a. To be as slender as possible, to reduce both visual and physical obstruction at grade;
    b. With enhanced treatments (e.g. greening, public art, signage, etc.) to improve the experience at the pedestrian level;
    c. To be located with consideration of street elements such as the curb, sidewalk, median, or intersections, to maximize sightlines and pedestrian permeability; and
    d. To be coordinated with the location of existing and planned street trees and other vertical elements such as lighting poles.

Encourage

Figure 14: Richmond-Brighouse Station, Canada Line (Photo Credit: Perkins&Will)

Discourage

Figure 15: Sukhumvit Road, Bangkok, Thailand (Photo Credit: Urban Capture)

7. Minimize the width of the guideway to limit shadowing under the guideway. Alternately, consider splitting the guideway into two, to reduce the extent of areas in full shadow.

8. Design guideway guards and railings to consider visual impact (views and shadows) from street level and impact on noise attenuation. Guideway structures and associated guards and railings should be designed in an integrated fashion.

Figure 17: BART Train guards and railing as integrated part of the guideway's design expression, West Oakland (Photo Credit: Michael Short, The Chronicle)

9. Create connections between new public spaces and existing community amenities along the guideway. Connect to existing active transportation where possible along the elevated guideway to facilitate multi-modal connections, ease of access and to address last mile connectivity.

10. Integrate pedestrian and cyclist transportation modes into the design, such as safe and designated cycling facilities, to promote inter-modal transport.

11. Create a multi-use pathway or trail alongside the transit line to provide open spaces along the planned transit route.

12. Avoid obstructing direct accesses to bus services.

13. Preserve, protect and enhance parks and natural features and functions alongside and under guideways.

14. Design setbacks as an integrated component of the public realm through use of buffers that include street trees and multi-use trails and/or recreational areas.

15. Provide adequate vertical and horizontal setbacks from elevated guideways as appropriate, to:

    a. Respond to both the existing and planned context;

    b. Ensure daylighting of the public realm;

    c. Provide comfortable areas of circulation for pedestrians and cyclists, both surrounding and under the elevated structure; and

    d. Allow for the inspection and maintenance of the structure, while recognizing the objective to plan for efficient and compact urban development.

16. Provide additional horizontal and vertical setbacks for:

    a. Sensitive uses (e.g., hospitals, residential, schools, etc.) with low tolerance to noise and vibration;

    b. Heritage resources and heritage views; and

    c. Parks and Open Space and Natural Areas.

17. Align the guideway away from the sidewalk to the minimum clearance to eliminate the potential falling hazards of particles such as debris, icicles or snow from the fascia to the public on the sidewalk/multi-use pathway (MUP).

18. Minimize use of barriers at-grade, including screening and fencing. When barriers at-grade are required, such as when located along a rail corridor, promote the use of integrated design. Consolidate barriers to avoid inaccessible and unmaintained strips of land between fencing. Determine ownership and maintenance of any barriers during the design phase.

19. Design barriers that are visible from the public realm to be visually engaging, through the use of high-quality, durable materials, and the integration of greening and public art.

20. Design barriers to provide opportunities for integrated public art.
21. Use transparent and/or anti-graffiti noise barrier areas to decrease visual pollution for sound barriers.
22. Integrate anti-graffiti measures to noise barriers, visual barriers and transparent screening.
23. Apply graffiti management strategies to enhance perception of safety.
24. Conduct block studies including the areas along the guideway to identify optimal station locations for potential TOD.
25. Protect and anticipate the delivery of future parkland (e.g. base/ultimate condition) where planned around or under the guideway. If a detailed above base park design is not being delivered through the transit project, any parkland conveyance must include current City standards for base park conditions as a minimum requirement.
26. Integrate or connect elevated guideways to planned development.
27. Locate elevated guideways, stations and other associated transit infrastructure at the side or rear of sites to allow for the creation of feasible and desirable development parcels, reserving public street frontages for active uses.

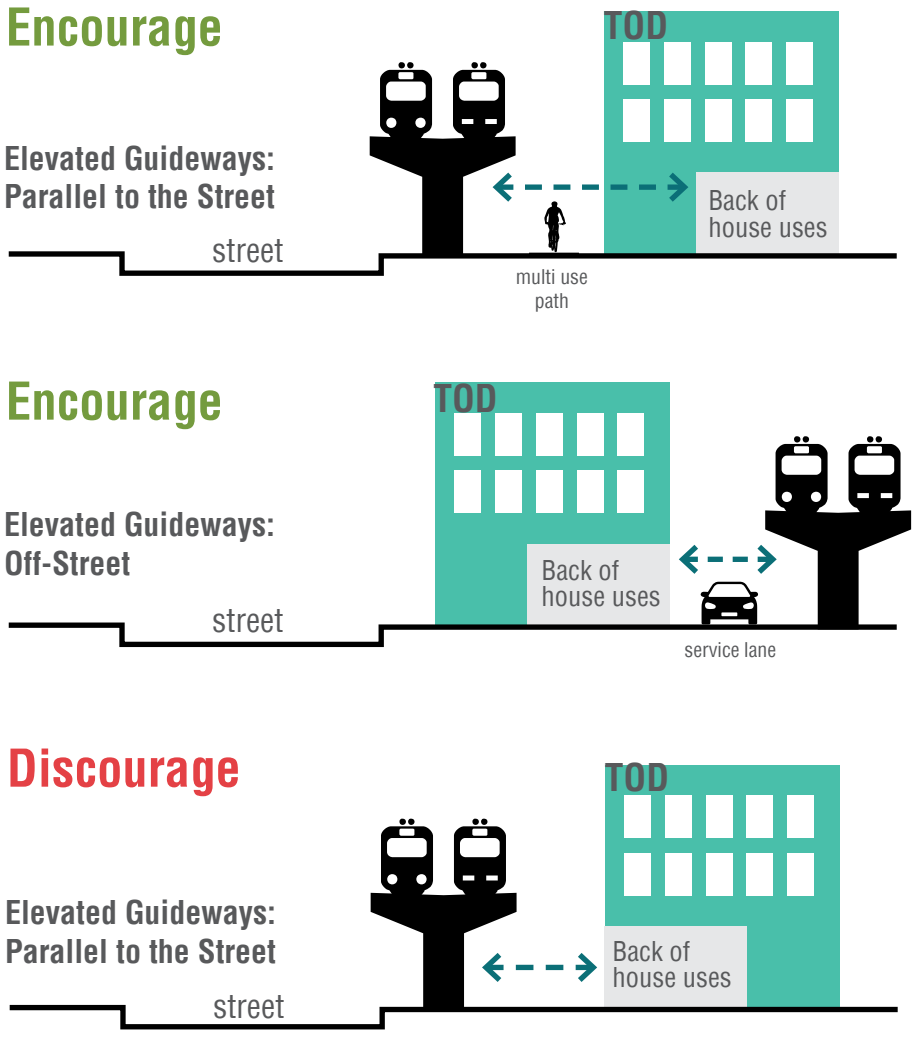


Figure 18: Examples of how TOD can be integrated with different elevated guideway typologies. Teal represents TOD, whereas the grey represents back of house uses

28. Consolidate and design ancillary structures located under guideways with a compact footprint, preferably in proximity to a pier.

29. Design space beneath or adjoining the elevated guideway to support, connect or enhance and respond to public realm context to make the area more attractive, interesting, comfortable and multi-functional through the use of elements such as hardscaped paths, plazas and connections; landscaped areas and planting; multi-use paths; and play or recreational uses.

30. Design the frequency and location of piers to minimize interference with natural heritage systems when a guideway structure is designed to run across a natural feature protected area, such as a ravine.

31. Minimize the loss of mature trees with the design of new infrastructure.

32. Provide three replacement trees as compensation for every tree removed in the construction of the project.

Figure 19: Underpass skate trail and flexible public space beneath the Gardiner Expressway, Toronto (Photo Credit: The Bentway)

Figure 20: Example of Transit Oriented Development (TOD), Marine Gateway, Vancouver (Perkins&Will)

Figure 21: Unique materiality along infrastructure to support adjacent cyclist and pedestrian trail, Melton Highway, Melbourne (Photo Credit: M James Holdings)

Figure 22: Unique materiality and landscaping to support adjacent cyclist and pedestrian trail, Melton Highway, Melbourne (Photo Credit: M James Holdings)

Case Study

Melbourne Skyrail's level crossings removal project – Victoria, Australia

As part of the level crossings removal project where 85 congested crossings are to be removed, new public spaces, or "activation nodes" were created to provide more immediate placemaking. Each one integrates the physical and local culture. For example, one of the new elevated portions incorporated a new Linear Park underneath the elevation of the train tracks from Caulfield to Dandenong and drew on local recreational themes. Over 22 hectares of new public space with various types of sport and exercise equipment to support all users beneath the elevated structure. The height of the guideway is well designed to ensure that at-grade spaces are comfortable. Wayfinding, lighting, furniture and well-proportioned guideway piers allow the space to be visible, safe, and well programmed.

Figure 23: Bike infrastructure such as racks and bollards provide intermodal connections (Photo Credit: Carnegie Place)

Figure 24: Clearly delineated pedestrian furniture zones at Carnegie Station Linear Park (Photo Credit: SVC)

Figure 25: Guideway is visually permeable. Open spaces allow for opportunities such as public art, spaces for congregation and recreation, and weather protection (Photo Credits: ASPECT Studios)

Figure 26: Guideway structure does not obstruct views surrounding the public space, with minimal shade (Photo Credit: ASPECT Studios)

Figure 27: Consistency in guideway components such as clear and integrated wayfinding (Photo Credit: ASPECT Studios)

Figure 28: Structure maintains access to sunlight, with bright colours for wayfinding (Photo Credit: ASPECT Studios)

4.2 User Experience

1. Provide a high-quality and accessible public realm that fosters intuitive wayfinding and congregation to encourage community interaction.
2. Create visual and built connections to adjacent amenities to maximize accessibility to the larger surrounding context
3. Design and align elevated structures to be visually permeable, complement adjacent structures, and respond to context.
4. Provide multi-use pathways between the guideway and development(s), creating an active space for the development to front onto, where there is a landscaped setback condition.
5. Design elevated guideways to be a simple, light and elegant structures that minimizes the visual impact on surrounding development and public streets.
6. Design the guideway to consider all elements together, including columns, guideway beams, deck and guards, so the guideway is perceived as one unified structure.
7. Design guideway structural elements to:
    a. Avoid excessive monumentality, such as over-designed concrete or over structured elements;
    b. Establish continuous linear forms through the use of horizontal structural elements that avoid abrupt transitions between sections;
    c. Minimize girder depth and number of spans;
    d. Minimize shadows and number of piers by using long span box girder with tapered profile;
    e. Create rhythm by aligning joints between beams, formwork and other reveals in consistent spacing; and
    f. Create one integrated structure by using recessed profiles that conceal construction joints and pipes.
8. Encourage intuitive wayfinding through the architectural treatment of the guideway and surrounding area.
9. Specify materials and/or construction methods that provide mitigation of noise and vibration impacts; cost should be considered during the business case.
10. Avoid dark corners or spaces that may be susceptible to loitering or undesirable activities.
11. Minimize height and opacity of parapet and/or guards, to limit the perception of height of the guideway and shadowing, thus creating a safe, comfortable, and pedestrian-scaled experience, without sacrificing the required safety standards for the guideway design.

Figure 29: Well-proportioned structural elements that still maximize public space and openness, Newtown Interchange, Sydney (Photo Credit: Ross Thornton)

Figure 30: Light and elegant guideway structure, RandstadRail, The Hague, Netherlands (Photo Credit: ZJA)

Case Study
Miami Underline – Miami, Florida

The Miami Underline is a 120-acre project beneath the existing Metrorail guideway, providing new connections to the local transit, walking, and cycling networks and demonstrates the Miami-Dade County's commitment to improving and enhancing connectivity. Additional enhancements such as wayfinding, lighting, and direct access to transportation are made with underpass programming such as gardens, playgrounds, recreational courts, dog parks, and more. Stronger connections have been made to local businesses and encouraged more transit activity for residents and tourists alike.

Figure 31: Public art and multi use pathway beneath the elevated structure (Photo Credits: The Underline, Robin Hill)

Figure 32: Landscaping and wayfinding (Photo Credits: The Underline, Robin Hill)

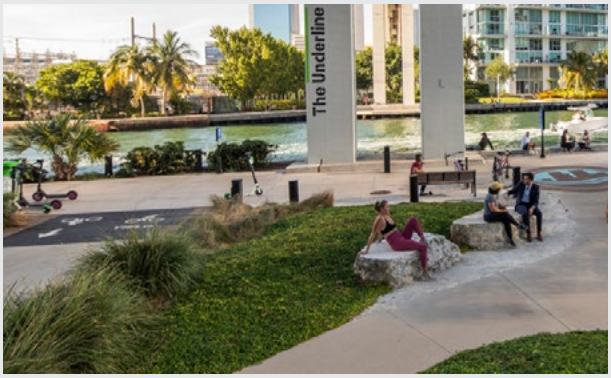


Figure 33: Various multi-modal connections underneath the elevated guideway, connecting to local networks (Photo Credits: The Underline, Robin Hill)

User Experience

12. Design guards to be a feature within the guideway rather than using off-the-shelf products.
13. Avoid intricate design details that may accumulate dust and particulate matter, limiting more intricate expressions to areas of high visibility.
14. Employ high-quality, architectural concrete and limit the use of cast-in-place elements.
15. Apply consistency in materials across elevated guideway components, while exploring the potential to differentiate special areas with material variation.
16. Integrate channels for services (e.g., electrical conduits, rainwater leaders, audio-visual wiring) into structural elements.
17. Design structures to incorporate rainwater drainage, integrating drip edges and recesses along horizontal elements to avoid staining of vertical surfaces.
18. Explore opportunities for greening spaces beyond the street level, including green track and green walls, by:
    a. Selecting low maintenance, native planting species that are low light and drought tolerant for planting around the guideway.
    b. Avoiding spaces that may attract bird nesting.
19. Apply Crime Prevention Through Environmental Design (CPTED) principles in the design of landscaped and other public spaces.
20. Use a lighting approach that is functional and scaled to pedestrians, especially in underpass areas, at access points and paths of travel, to increase feelings of safety and comfort.
21. Integrate lighting with architectural design elements to ensure the entire guideway network is visually cohesive and easily identifiable.
22. Ensure that additional lighting is considered for

programmed areas, such as recreational spaces.

23. Minimize the impact of ornamental lighting such as downlights installed at the edge of elevated guideways within light sensitive areas.

24. Avoid light fixtures that may impact or reduce the vertical clearance along pedestrian and cycling paths of travel.

25. Integrate public art, especially in proximity to stations or threshold zones to create a vibrant gateway.

26. Ensure that public art is complementary or responsive to the local context and character.

27. Encourage art installations that take advantage of the scale of the structure and will create an immersive experience.

Figure 34: Integrated retail frontages, Nakameguo, Tokyo (Photo Credit: Web Japan)

4.3 Sustainability and Resilience

1. Propose sustainable design solutions for landscape treatment below and alongside guideways.
2. Consider options for reducing carbon footprint, including but not limited to, the reduction of cementitious materials or the use of carbon-absorptive concrete, low carbon concrete, or self-cleaning concrete.
3. Incorporate structural redundancies that will protect against anticipated natural disasters.
4. Integrate architectural and structural elements to reduce use of excess materials.
5. Design the open space surrounding the guideway to mitigate heat island effect by selecting high albedo surface materials, incorporate trees and manage stormwater runoff by providing ground permeability and Low Impact Development (LID) strategies.
6. Encourage reduction in de-icing requirements, such as through the use of a green track system or weather protection.
7. Include planting under the guideway while allowing for maintenance and operations.
8. Implement best practices in performance-based specifications to maintain and improve air quality.

Figure 35: Vertical gardens installed on piers, Mexico City (Photo Credit: Via Verde)

Figure 36: Vertical gardens were constructed on approximately 1,000 piers all along the guideway and other transit infrastructure, Mexico City (Photo Credit: Via Verde)

4.4 Intermodal Operations

1. Redesign streets accessing and running adjacent to the elevated guideway to ensure they are transit-supportive complete streets that facilitate good pedestrian, cyclist and surface transit access, and facilitate mode shifts to transit and active transportation.
2. Consider increase in risk from a non-fully-enclosed/ protected operating environment as these may require additional maintenance.
3. Design elevated guideways to support operations requirements as set out by the transit agency, such as train capacities, headway, speed, end-to-end travel times, and traction power systems.
4. Identify space and location requirements for operations and maintenance. An Operation and Maintenance agreement should be executed prior to implementation of the final plan.
5. Provide adequate setbacks or lateral clearances around structures to guarantee adequate maintenance access.
6. Consider impacts of seasonality on transit maintenance and operations, such as: tree leaves on tracks; and winter impacts (snow and ice) to design a safe and comfortable experience.
7. Clearly define maintenance boundaries of transit facilities at-grade to all responsible parties involved.

4.5 Accountability

1. Ensure that elevated guideways are aligned with potential for TOD and provide opportunities for future site development.
2. Anticipate and protect for planned capital projects in the planning and design of elevated guideways.
3. Implement planned changes to the design, layout and/or configuration of streets running adjacent to the elevated guideway together with the guideway project to coordinate their design and minimize community disruption.
4. Future-proof for connections to planned active transportation routes.
5. Clarify ownership and maintenance obligations for space under guideways through project delivery process.
6. The design and alignment of the guideway should protect for future stations by considering:
    a. Adjacent and surrounding development parcels and designated growth areas / nodes, coordinated with potential future land uses and multi-modal networks;
    b. Location and orientation of the track to accommodate new platforms and stations, including the provision of flat track, tangent track, separation between tracks and location of crossovers;
    c. Reasonable rough-in of structural infrastructure to accommodate future additions;
    d. Coordination with other infrastructure such as hydro towers or maintenance facilities to optimize potential for future uses; and
    e. The preservation of space within the easement for future transit uses, including the underpass area for ancillary uses or an enhanced public realm.

4.6 Applications Specific Guidance

The guidelines below are specific to the individual applications and to be applied in addition to the general guidelines above.

Off-Street

1. Provide sufficient setbacks around the off-street guideway to mitigate impacts on existing or sensitive land uses and infrastructure to provide access to the guideway for maintenance.
2. Explore opportunities to integrate active transportation networks alongside the transit corridor in off-street guideways, especially where multi-use pathways exist
3. For taller guideways, or "in the sky" applications:
    a. Limit impacts on sky-view, skyline, and significant or heritage views from the public realm.
    b. Consider access to the elevated structure for maintenance and emergency evacuation.

Middle of the Street

4. Design the underpass landscape area to be visually appealing and require little maintenance due to its high visibility in the middle of the street and constraints to access.

Parallel to the Street

5. Deliver high-quality public space along the guideway that acts as buffer between the roadway and adjacent, sensitive development such as residential uses.
6. Ensure a high standard of architectural expression and materials for the guideway structure, given its direct proximity to pedestrian spaces, such as sidewalks along the street.

Parks, Open Space, Utility Corridors and Natural Areas

7. Gain a comprehensive understanding of the proposed impacts through the appropriate environmental studies.
8. Limit the extent of intervention, to protect mature trees, natural areas and their ecological functions through an interactive responsive design process.
9. Limit the degree of temporary and permanent impacts, including the visual and physical scales of the structures, noise or light pollution.
10. Propose ecologically based restorative design solutions for landscape treatment below guideway.
11. Consider the local ecology, with reference to Toronto and Region Conservation Authority standards.
12. Ensure continued functionality and access to park spaces below the guideway and limit disruptions to existing park networks.
13. Avoid disruptions to existing parks operations (permitted and non-permitted facilities) and park network connections.
14. Maintain, restore and enhance areas impacted by surrounding transit infrastructure according to City standards.

Embankment

15. Provide effective and well-designed barriers that significantly reduce noise and vibration impacts.
16. Minimize the footprint and extent of the guideway infrastructure, to reduce disruption to adjacent open spaces or sensitive land uses.