Broadway Subway Project

Environmental and Socio-economic Review

December 27, 2019

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Project Overview

The BC Ministry of Transportation and Infrastructure (MOTI) is delivering an extension of SkyTrain's Millennium Line from VCC-Clark Station to a new terminus at Broadway and Arbutus Street, in Vancouver, British Columbia (BC). The 5.7-kilometre Broadway Subway (the "Project") will include 700 metres of elevated track through False Creek Flats in Vancouver with the remaining Project Alignment (the Alignment) being underground. The Project will add one new underground station at Great Northern Way, and five new underground stations along Broadway at Main, Cambie, Oak, Granville, and Arbutus streets to serve the important and growing Broadway Corridor.

The Broadway Corridor is BC's second largest employment centre. It is home to Western Canada's largest hospital, an emerging innovation hub, and hundreds of businesses and residences. As the busiest bus route in Canada and the United States, the existing 99 B-Line service can no longer meet current and anticipated demand. The Project will replace the 99 B-Line bus service between Commercial Drive and Arbutus Street with the 99 B-Line bus service continuing from Arbutus Street to the University of British Columbia.

When operational, the Project will provide a number of important benefits, including:

- Providing significant benefits to transit riders in the form of increased capacity, travel time savings, greater reliability, and improved customer experience
- Improving transportation options and economic development potential
- Filling a critical gap in the regional transit network, thereby easing congestion at other transfer points
- Utilizing a grade-separated (mostly underground) right of way to improve reliability and eliminate conflicts with other vehicle traffic, bicycles, and pedestrians
- Reducing greenhouse gas emissions by reducing automotive vehicle kilometres travelled (VKT) and replacing diesel bus B-Line service with electric SkyTrain service and
- Improving affordability by enabling greater mobility at reduced cost for residents across the region and encouraging transit-oriented urban development and housing availability

The $2.83-billion Project is largely funded by the Government of British Columbia, with contributions from the Government of Canada and City of Vancouver. The Project is part of the rapid transit program in the Metro Vancouver's Mayors' Council 10-Year Investment Plan Phase 2.

Construction of the Project, for which funding was announced on September 4, 2018, is expected to commence in 2020 with the new subway opening in 2025. Project components and activities include:

- 700-metre elevated guideway that will extend from VCC-Clark Station to a tunnel portal adjacent to Emily Carr University of Art + Design
- Five-kilometre tunnel from Emily Carr University of Art + Design, mainly under Broadway, to Arbutus Street
- Six underground SkyTrain stations
- Bus loop integrated with the Arbutus station
- Landscaping
- Acquisition of private, City, and TransLink properties for Project construction and operation
- Site preparation, and utility relocation and improvements
- Power, control, and communication systems
- Testing and commissioning

Construction of the Project will be by a Design-Build-Finance Contractor, which will be responsible for designing, building, and financing the construction of the Project. During Project construction, MOTI will audit Project construction to verify that the Contractor adheres to regulatory and contractual requirements.

Once operational, the Broadway Subway will be seamlessly integrated with Metro Vancouver's transit network and operated and maintained by TransLink.

Environmental and Socio-Economic Review Process

During Project planning, engagement with the Canadian Environmental Assessment Agency and the BC Environmental Assessment Office confirmed that the Project does not exceed regulatory thresholds that would require an environmental assessment under federal or provincial environmental legislation.

An Environmental and Socio-Economic Review (ESR) process was instead undertaken to provide a clear and transparent approach for involving Indigenous groups, the public, stakeholders, and government agencies in identifying potential Project-related effects, and approaches to avoiding or mitigating such effects.

The development of the ESR process was supported by consultation and engagement on the scope of issues to be considered as well as the methods for assessing potential effects on environmental and socio-economic values during Project construction and operation.

The key objectives of the ESR are to:

- Demonstrate the Project's commitment to protecting environmental and socio-economic values
- Identify potential Project-related effects on environmental and socio-economic values and approaches for avoiding or mitigating effects to protect such values
- Provide opportunities for Indigenous groups, government agencies, stakeholders and the public to participate in the identification and review of environmental and socio-economic values and mitigation measures during the Project

The findings of the ESR will be used to support development of environmental protection measures and requirements intended to protect environmental and socio-economic values during construction and operation of the Project.

The ESR was supported by engagement with the public, business and community groups, health care service providers, cycling groups, educational institutions, and nearby businesses and residents, as well as government agencies and elected officials. Engagement activities included workshops with stakeholders and residents adjacent to station locations to discuss neighbourhood specific interests.

Indigenous Consultation

The Project is located within the asserted traditional territories of Musqueam Indian Band, Squamish Nation and Tsleil-Waututh Nation. The Sto:Lo Nation, Sto:Lo Tribal Council, and Hul'qumi'num Treaty Group have also asserted their interests within or near the Project.

Indigenous consultation with Musqueam Indian Band, Squamish Nation and Tsleil-Waututh Nation began in summer 2017. Consultation with Indigenous groups has focused on sharing of Project-related information, determining specific preferences and details with respect to consultation activities, identifying Project-related concerns, interests and issues, and providing information and obtaining input on Project-related benefits such as cultural recognition and Project participation. It has also included obtaining input from Indigenous groups regarding the potential for the Project to affect their Aboriginal Interests and identifying potential measures to avoid or mitigate any potential effects on those Interests.

Indigenous consultation activities have included meetings, letters and emails and the sharing of information on the Project and the content, and conclusions, of the ESR. Information obtained through Indigenous consultation activities was used to inform Project planning including approaches to mitigating potential Project-related effects. In addition, Indigenous consultation activities have supported important dialogue regarding the Project's location, in the traditional territories of Indigenous groups, and opportunities for cultural recognition during future stages of the Project.

Additionally, Indigenous groups have participated in environmental and archaeological field work.

Public Engagement

Public and stakeholder engagement has been underway since December 2016. Public engagement activities have included engagement with the City of Vancouver, provincial and federal government officials, interested groups and organizations, residents, businesses and other key partners, to raise awareness about the Project, gather input from interested parties, and respond to Project-related inquiries.

In 2016–2017, through two phases of engagement and ongoing communication and outreach, public and stakeholder engagement focused on sharing Project-related information, identifying initial concerns, interests, and issues around design and construction, and obtaining input on future engagement activities. The Project also engaged the public and stakeholders on design elements inside and outside stations, as well as construction-related concerns and potential mitigations.

The Project has engaged with these key audiences in a diverse range of ways including meetings, workshops, presentations, open houses, the Project website, social media, and written communications.

A high level of support for the Project resulted from the engagement activities. Key issues raised by the public included:

- Construction-related effects on traffic
- Access to businesses during construction
- Station design
- Noise and vibration
- Air quality
- Management of contaminated sites
- Location of the stations and subsequent impact on neighbourhood character, housing, and business viability
- Location of the Arbutus bus loop
- Access considerations for persons with disabilities

ESR Scope and Methods

The following environmental and socio-economic values (Review Elements) are addressed in the ESR:

- Transportation and Access
- Housing and Property
- Archaeological and Heritage Resources
- Noise
- Vibration

- Air Quality and Greenhouse Gases (GHGs)
- Contaminated Sites and Excavated Materials
- Electric and Magnetic Fields (EMF)
- Aquatic Resources
- Vegetation and Wildlife Resources

The general methodology for the evaluation of potential effects on the Review Elements included:

- Describing existing conditions for each Review Element, supported by the collection of baseline data
- Identifying potential effects to each Review Element, within specified boundaries, as a result of interaction between Review Elements and Project activities and physical works
- Identifying measures to avoid or limit potential effects on Review Elements during construction and operation

Key Findings of the Environmental and Socio-Economic Review

Existing environmental and socio-economic conditions in the Review Area are consistent with the highly developed and urban setting in which the Project is located and include:

- Limited natural habitat values (i.e., wildlife and fish habitat)
- Physical conditions (i.e., noise, water quality, air quality, site contamination) within generally acceptable limits but reflective of the high levels of development and human activity that occur in the Review Area
- Socio-economic conditions that reflect the importance of the Review Area in supporting employment, housing, transportation infrastructure, and access to community services and amenities, including healthcare for local and regional residents

As activities that will be undertaken to construct the Project are similar to those used for typical development projects, well-established best management practices can be effectively applied to avoid or limit potential effects on the Review Elements.

The following sections summarize ESR findings for each Review Element including:

- Existing conditions
- Potential effects of the Project
- How potential effects will be mitigated during construction and operation

Traffic and Transportation

The Broadway Corridor is a major urban transportation corridor for transit, trucks and general-purpose traffic with high volumes of pedestrians. The Project will reduce future travel times, make transit travel more reliable, and increase transit capacity along the Broadway Corridor by three times on opening day with the capacity for more riders in future. The Project will also support planned growth and economic development in the area.

Construction of the Project has the potential to result in changes to transportation and access. Substantial steps are being taken during Project planning to maintain mobility and access and keep people and commerce moving during construction, including:

- Relocating some bus routes to alternative routes; Route 9 and 99 will be prioritized on Broadway to maintain service levels
- Maintaining four lanes of traffic throughout most of the corridor
- Working closely with health care facilities, businesses, institutions, and other stakeholders, to maintain access during construction and allow ongoing client access
- Working closely with emergency service providers to prioritize critical emergency vehicles and limit restrictions on available routes
- Developing and implementing traffic management plans that will include active and ongoing engagement and communication with local businesses and residents
- Advancing a Business Relations Program to inform, engage, and involve businesses in effectively addressing construction-related disruptions

These measures are anticipated to reduce Project-related effects on transportation and access during construction; however, there will continue to be construction-phase effects including longer travels times, changes in existing pedestrian and cycling routes, and a reduction in on-street parking. Limiting these effects will require extensive and ongoing collaboration between the Project, City of Vancouver, TransLink, emergency services, and key stakeholders.

Housing

The Review Area is already substantially developed for high density residential and office uses. The Project is expected to increase market interest in new multi-family and office development along the Corridor, and could result in some shifting of investment from other parts of the City. This is anticipated to increase total housing stock and the supply of employment space along the Corridor. While the Project may result in some shifting of development from other parts of Vancouver, it is anticipated that the overall pace of development across the City and Metro Vancouver will not be affected.

Building on lessons learned from past transit developments in Metro Vancouver, the City has initiated a Broadway land use planning process, the Broadway Plan. The 30-year Plan will focus on opportunities to integrate new housing, jobs, and amenities around the Broadway Subway and will address the need for:

- Increased job space
- Deepening housing affordability
- Limiting displacement of existing tenants
- New or improved connections
- Improved parks and public spaces
- New and renewed public amenities

The City is also taking additional steps to address housing availability and affordability in the Broadway Corridor including:

- Initiatives focused on increasing rental housing stock
- Implementation of the Development Contribution Expectation[1] to limit speculation
- The Making Room housing program which provides increased diversity of housing options in low-density areas
- The False Creek South Neighbourhood Planning Program which includes objectives related to increase housing capacity and choice

Archaeological and Heritage Resources

The Review Area contains some areas with high archaeological potential, including those associated with historic stream locations and the historic shoreline of False Creek. In addition, the Review Area includes properties identified by the City of Vancouver as heritage buildings. Project construction has the potential to affect archaeological resources (during excavation or tunnelling) and heritage buildings (with minor cracking of drywall or the exterior building envelope due to construction-related ground vibration). Potential Project effects will be avoided or limited as follows:

- Requiring development and implementation of an Archaeological and Heritage Management Plan to avoid or mitigate construction-related effects on archaeological or heritage resources. The Plan will include working with Indigenous groups to:
  - Conduct field studies to identify archaeological sites that may exist
  - Avoid or mitigate effects to archaeological or heritage sites in accordance with the *Heritage Conservation Act* and provincial guidance

[1] The Development Contribution Expectation (DCE) Policy is a City of Vancouver policy that was developed to limit land value speculation in areas undergoing community planning (i.e., the Broadway Plan planning area) by adding clarity to land acquisition decisions and allowing purchasers to factor in the costs of required amenities when rezoning or density bonusing occurs.

  - Develop and implement protocols for addressing archaeological and heritage resources that may be unexpectedly encountered during Project construction.
- Requiring development and implementation of a Noise and Vibration Management Plan to avoid or limit construction-related vibration effects on buildings, including heritage buildings, adjacent to the Project

During the operational phase of the Project, no effects on Archaeological and Heritage Resources are expected. With the implementation of the proposed mitigation measures, Project effects on Archaeological and Heritage Resources are expected to be effectively mitigated.

Noise

The Review Area has ambient noise levels typical of a busy urban environment, with the dominant noise source being road traffic. Construction of the Project, including station construction and construction-related traffic, is anticipated to contribute additional sources of noise. Sources of noise associated with the operational phase of the Project will include train operation (primarily underground) as well as station infrastructure such as ventilation and communications systems. Potential Project noise effects (e.g., change in noise levels) will be mitigated as follows:

- Requiring development and implementation of a Noise and Vibration Management Plan to mitigate Project-related noise on adjacent areas. The Plan will include best management practices such as:
  - Providing advance notice to residents regarding Project-related noise and proposed mitigation
  - Enhanced mitigation measures for nighttime work
  - Selecting construction equipment with noise control features
  - Noise monitoring to evaluate the effectiveness of mitigation

During the construction phase, elevated noise levels are predicted in areas adjacent to construction sites though noise levels are predicted to be below the noise thresholds of the City of Vancouver noise bylaw.

Elevated noise levels anticipated during the operation phase will be limited to above-ground sections of the Alignment and can be reduced through mitigation integrated into the design of the Project.
During operations, monitoring of noise and addressing noise concerns will be undertaken in accordance with the British Columbia Rapid Transit Company (BCRTC) Operations Environmental Management Plan (BCRTC 2019).

Vibration

Existing vibration levels near the Alignment are typical of a busy urban environment, with sources of vibration coming primarily from road traffic and construction activities. Construction activities including tunnelling, and station and guideway construction could result in vibration effects on adjacent areas, including affecting the operation of sensitive equipment, disturbing activities in adjacent buildings (e.g., shaking, rattling), and causing damage to adjacent structures. Operation of the Project has the potential to generate vibration associated with train operation.

Potential vibration-related Project effects will be mitigated as follows:

- Requiring development and implementation of a Noise and Vibration Management Plan to limit the effects of Project-related vibrations during construction on the local community and sensitive receptors such as medical services facilities. The Plan will include best management practices such as:
  - Modelling anticipated vibration based on the final design and construction methods
  - Developing site-specific vibration mitigation measures based with input from potentially-affected property owners and residents
  - Using construction methods and equipment that limit vibration levels
  - Conducting pre- and post-construction building assessments, and monitoring vibrations during construction
  - Identifying windows of time to avoid construction activities that cause substantial vibration
  - Incorporating vibration-reducing features into the design of train tracks

During construction, vibration levels may temporarily exceed existing vibration levels in localized areas (e.g., station construction areas); however, with appropriate mitigation measures, and monitoring, such potential effects are expected to be effectively mitigated.

During the operational phase of the Project, potential effects from vibrations will be mitigated by applying relevant vibration-related procedures from BCRTC's Operational Environmental Management Plan. With the implementation of the proposed mitigation measures, Project effects on Vibration are expected to be effectively mitigated.

Air Quality and Greenhouse Gases

Air quality in the Review Area and in the Lower Fraser Valley airshed is generally good and has improved in recent decades, though air emissions from the transportation sector continue to be a significant component of overall air emissions in the region. By encouraging a shift towards more sustainable modes of transportation, the Project will help to maintain air quality in a growing region and reduce GHG emissions. During construction, equipment and vehicles will generate emissions of fugitive dust, air contaminants, and greenhouse gases (GHGs). These potential Project-related effects will be mitigated as follows:

- Requiring development and implementation of an Air Quality and Greenhouse Gas Management Plan to manage air emissions from construction activities. The Plan will include best management practices such as:
  - Using water spray to keep dust down at excavations and on construction routes
  - Using construction fleet vehicles that meet engine emission bylaws, and regularly maintaining the vehicles
  - Using low-sulphur fuel and implementing a no-idling policy

Operation of the Project, which is supported by electrical power, will generate negligible emissions of air contaminants. Emissions of air contaminants generated by the operation of vehicles and equipment required to support operations, can be avoided or mitigated through the application of procedures described in BCRTC's Operational Environmental Management Plan.

With implementation of the proposed mitigation measures, construction-related Project effects on Air Quality and Greenhouse Gases are expected to be effectively mitigated, with negligible changes in air quality and GHGs. When operational, the Project will result in a net reduction in local and regional emissions of air contaminants and GHGs by reducing the number of vehicle kilometres driven by transit buses and passenger vehicles in the Broadway corridor.

Contaminated Sites and Excavated Materials

The Review Area includes some areas with site contamination, associated with historic development and land use, that may be encountered during station construction and tunnelling. The Project has the potential to result in the release of contaminants from contaminated soils or groundwater encountered during construction. Excavation and tunnelling will also generate large quantities of uncontaminated soil and rock that will need to be transported outside the Alignment for beneficial reuse or disposal. In addition, construction of the Project will require the demolition of some existing structures and will generate construction and demolition waste, some of which may include hazardous materials such as asbestos which may be present in older buildings.

Potential Project effects related to contaminated sites and excavated materials will be mitigated as follows:

- Requiring development and implementation of a Contaminated Sites and Excavated Materials Management Plan to maintain compliance with BC's Contaminated Sites Regulation. The Plan will include best management practices such as:
  - Sampling soil and groundwater in areas of planned excavation to determine disposal requirements
  - Describing contingency procedures to follow if a contaminated site is encountered or an accidental release occurs during construction
  - Managing and disposing of uncontaminated and contaminated soil, rock, and groundwater in accordance with provincial laws and regulations
- Requiring development and implementation of a Construction and Demolition Waste Management Plan to manage non-hazardous construction and demolition waste and a Hazardous Materials Management Plan to manage hazardous waste (e.g., asbestos or PCBs from demolished buildings).
- Excavated soil and bedrock will be taken off-site and relocated in accordance with provincial soil relocation requirements, going to beneficial reuse where such reuse can be identified and is cost-effective
- During the operational phase, the minor risk of site contamination will be effectively addressed by applying procedures (e.g., spill response procedures) described in BCRTC's Operational Environmental Management Plan

With implementation of the proposed mitigation measures, Project effects related to Contaminated Sites and Excavated Materials are expected to be effectively mitigated.

Electric and Magnetic Fields (EMFs)

Electric and Magnetic Fields (EMFs) are physical fields produced by electrically charged objects, such as power lines. Elevated levels of EMF can affect the operation of electronic devices, including personal electronics and medical devices such as pacemakers.

Many sources of EMF, typical of urban environments, currently exist along the Alignment and include household electronics, electrical power lines, vehicles, and cellphone towers. Project-related sources of EMFs will include equipment used during construction as well as the electrified track, trains, and systems used to support operations.

Project-related EMFs will be limited by selecting and locating equipment in ways that reduce EMFs at the source and create adequate distance between EMF sources and receptors (e.g., sensitive electronic equipment). As a result of measures to address EMF considerations during Project design:

- Project-related EMFs will meet applicable regulations and guidelines and be similar to those from existing SkyTrain lines
- Project-related EMFs are not expected to cause electromagnetic interference with personal electronics, wheelchairs, personal medical devices such as pacemakers, or other electronics
- Sensitive medical devices in hospitals and medical facilities along the Alignment will not be affected by Project-related EMFs
- Project-related equipment (e.g., communications equipment) will meet Industry Canada standards for electromagnetic compatibility and is not expected to interfere with AM/FM communications or other electronic systems and devices

With the implementation of the proposed mitigation measures, effects from Project-related EMFs are expected to be effectively mitigated.

Aquatic Resources

The Project has limited potential to impact aquatic resources as the Alignment does not directly cross any surface watercourses, although it does cross several culverted historic watercourses. The closest waterbody is False Creek, which receives roadway runoff from the Review Area via the storm water and combined sewer systems. Project construction activities have the potential to affect water quality and aquatic resources by releasing contaminants or sediment into storm drains and thus into False Creek. These potential Project effects will be mitigated as follows:

- Requiring the development and implementation of a Surface Erosion Prevention and Sediment Control Plan and a Water and Sediment Quality Management Plan, with best management practices such as:
  - Implementing measures to control erosion and sedimentation such as covering stockpiles and locating them away from storm drains and using settling tanks to reduce sediment load consistent with environmental bylaws and regulations, before discharging construction water to storm sewers
  - Monitoring water quality for key parameters such as turbidity, total suspended solids, pH, temperature, and hydrocarbons
  - Testing water before allowing its discharge to the sewer system

- Requiring the development and implementation of a Spill Prevention and Emergency Response Plan to respond to accidental spills with best management practices such as:
  - Having spill response materials on the Project site to quickly respond to accidental spills
  - Training Project personnel in spill response procedures
  - Establishing spill reporting requirements
- Applying BCRTC's Operational Environmental Management Plan (e.g., storage of hazardous materials, spill response, liquid waste management)

With the implementation of the proposed mitigation measures, potential Project effects on Aquatic Resources are expected to be effectively mitigated.

Vegetation and Wildlife Resources

The Project area has limited wildlife habitat and no identified species of concern. Vegetation along the Alignment consists of sparse bushes and street trees, which provide marginal wildlife habitat.
Project construction activities, such as clearing and grubbing of undeveloped sites, have the potential to impact existing habitat and wildlife. These potential Project effects will be mitigated as follows:

- Requiring development and implementation of a Vegetation and Wildlife Management Plan to reduce or avoid impacts on wildlife and wildlife habitat, including best management practices such as:
  - Retaining street trees where possible and replacing them where they must be removed
  - Avoiding effects on migratory birds by clearing trees and bushes outside their breeding period or protecting active nests
  - Controlling invasive species using best management practices from the Invasive Species Council of BC
  - Using City of Vancouver design guidelines for bird-friendly structures and for the use of native plant species in landscaping

During the operational phase of the Project, physical barriers will prevent wildlife from accessing Project infrastructure, so effects on wildlife are expected to be negligible. With the implementation of the proposed mitigation measures, Project effects on Vegetation and Wildlife Resources are expected to be effectively mitigated.

Accidents and Malfunctions

SkyTrain has been operating in Metro Vancouver for over 30 years, and TransLink's SkyTrain operator has established procedures to avoid and respond to accidents and malfunctions (e.g., fires, spills, seismic activity, extreme weather) as part of its SkyTrain Control Centre Operations Manual. The operator will conduct regular maintenance of its equipment and infrastructure to reduce the likelihood of potential accidents and malfunctions.

The likelihood, consequence and risk of accidents or malfunction associated with the existing infrastructure continues to be low and the Project will be designed and constructed with features to limit the likelihood and consequence of events. Examples of design measures that will be integrated into the Project to reduce health and safety risks include:

- Station exits and movement corridors to facilitate emergency evacuations
- Drainage infrastructure to prevent flooding of the tracks
- Infrastructure constructed to design standards for fire suppression and response
- Backup systems to allow for the operation of ventilation, lighting, and communications systems during emergencies

Environmental Management Plans

During construction of the Project, a Construction Environmental Management Plan (CEMP) will be in place to mitigate the potential effects of construction activities on Review Elements. The CEMP will be designed and implemented by the Contractor and will be required to comply with applicable environmental laws, regulations, licences, permits, and approvals. The CEMP will comprise the following component plans:

- Air Quality and Greenhouse Gas Management Plan
- Archaeological and Heritage Management Plan
- Construction and Demolition Waste Management Plan
- Contaminated Sites and Excavated Materials Management Plan
- Hazardous Materials Management Plan
- Noise and Vibration Management Plan
- Spill Prevention and Emergency Response Plan
- Surface Erosion Prevention and Sediment Control Plan
- Vegetation and Wildlife Management Plan

During Project construction, MOTI will audit the Contractor's implementation of the CEMP. Auditing of the delivery of the CEMP will be supported by weekly, monthly, and annual environmental reports developed by the Contractor and submitted to MOTI.

During the operational phase of the Project, BCRTC will be responsible for operating the Project and managing environmental issues associated with operation as guided by BCRTC's Operational Environmental Management Plan.

Conclusion

When operational, the Project will provide a number of important benefits including:

- Providing significant benefits to transit riders in the form of increased capacity, travel time savings, greater reliability, and improved customer experience
- Improving transportation options and economic development potential
- Filling a critical gap in the regional transit network, thereby easing congestion at other transfer points
- Utilizing a grade-separated (mostly underground) right of way to improve reliability and eliminate conflicts with other vehicle traffic, bicycles, and pedestrians
- Reducing greenhouse gas emissions by reducing automotive vehicle kilometres travelled (VKT) and replacing diesel bus B-Line service with electric SkyTrain service and
- Improving affordability by enabling greater mobility at reduced cost for residents across the region and encouraging transit-oriented urban development and housing availability

While Project construction activities have the potential to impact environmental and socio-economic conditions in the Broadway Corridor, the ESR process has identified measures that will be taken to avoid or limit temporary construction-phase effects on values such as noise, air quality, contaminated sites, fish and wildlife habitat, and water quality.

While Project construction will result in temporary increases in congestion in some areas, a broad suite of actions will be undertaken to maintain continued, efficient movement of transit, commercial and commuter traffic, cyclists and pedestrians through the Corridor during construction. In addition, the Project will engage with businesses to proactively address potential construction-related disruption.

As a result of careful planning, that draws on past experience in building and operating transit infrastructure, potential effects on environmental and community values during construction will be effectively mitigated.

Once operational, the Project will result in reduced bus and passenger-vehicle traffic on Broadway and facilitate a shift towards more sustainable modes of transportation. Existing transportation infrastructure, including roadways, and other transit services, will continue to operate as they do currently.

During operation, Project infrastructure will be operated by TransLink and guided by existing systems that are in place on the existing Millennium Line to proactively address potential effects on environmental and socio-economic values that could occur. Existing TransLink systems are also in place to avoid and respond to accidents that could occur during operation.

Abbreviations

AAQO	ambient air quality objective
AOA	Archaeological Overview Assessment
BAU	Business as Usual
BC	British Columbia
BCEAA	British Columbia *Environmental Assessment Act*
BCRTC	British Columbia Rapid Transit Company
BIA	business improvement area
CAC	criteria air contaminant
CEA Agency	Canadian Environmental Assessment Agency
CEAA	*Canadian Environmental Assessment Act*
CEMP	Construction Environmental Management Plan
CEMP	Construction Environmental Management Plan
CSR	Contaminated Sites Regulations
dB	decibel
DBF	Design-Build-Finance

DCE	development contribution expectation
EAO	Environmental Assessment Office
EMA	*Environmental Management Act*
EMF	electro-magnetic field
EMF	Electric and Magnetic Field
EMI	electromagnetic interference
EMP	Environmental Management Plan
ESR	Environmental and Socio-Economic Review
FTA	Federal Transit Administration
GHG	greenhouse gas
GHz	gigahertz
GWP	global warming potential
HCA	*Heritage Conservation Act*
ICES	International Committee for Electromagnetic Safety
IMO	International Marine Organization
mG	milligauss

MOECCS	Ministry of Environment and Climate Change Strategy
MOTI	Ministry of Transportation and Infrastructure
MVRD	Metro Vancouver Regional District
NFPA	National Fire Protection Association
PFR	preliminary field reconnaissance
PPV	Peak Particle Velocity
RFP	request for proposal
RFQ	request for qualification
SPA	Supportive Policy Agreement
TBM	tunnel-boring machine
TDG	Transportation of Dangerous Goods
TDR	Technical Data Report
TOR	Terms of Reference
UBC	University of British Columbia
US FTA	United States Federal Transit
USDOT	US Department of Transportation

V/m	volts per metre
VGH	Vancouver General Hospital
VKT	vehicle kilometres travelled
VOC	volatile organic compound
YVR	Vancouver International Airport

1 INTRODUCTION

The Ministry of Transportation and Infrastructure (MOTI) is undertaking the development of the Broadway Subway Project (the Project), to meet current and future ridership demands along the Broadway Corridor in Vancouver, British Columbia (BC). The Project will be funded by the Province of British Columbia, with contributions from the Government of Canada and the City of Vancouver.

The Project will extend the existing Millennium Line SkyTrain by 5.7 km from the current terminus at the VCC-Clark SkyTrain Station to a new terminal station located at West Broadway and Arbutus Street. Construction of the Project is anticipated to begin in 2020, and is expected to be in operation in 2025.

The Project will be fully integrated with existing SkyTrain systems in Metro Vancouver and extend the Millennium Line to provide rapid transit service along the Broadway Corridor as well as enhance regional transit connectivity. The Broadway Subway will be operated and maintained by TransLink.

While the Project does not require environmental approval under federal or provincial environmental legislation, the Project undertook an Environmental and Socio-Economic Review (ESR) to support Project planning and provide for the protection of environmental and socio-economic values. The objectives of the ESR are to:

- Demonstrate the Project's commitment to advancing a Project that protects the environmental and socio-economic values associated with the Project
- Provide a clear and transparent mechanism for identifying potential Project-related effects on environmental and socio-economic values and approaches for protecting such values
- Provide opportunities for Indigenous groups, the public, stakeholders, and government agencies to provide input on the scope of issues to be reviewed and approaches for protecting environmental and socio-economic values

Additional information on the ESR process is provided in Section 1.4 (Environmental Regulatory Requirements) and Section 6 (Review Scope and Methods).

Section 1 of the ESR provides background information on the Project including:

- Project location
- Project need and context
- Project planning
- Environmental regulatory requirements

1.1 Project Location

The Project will extend between the eastern terminus, at the existing VCC-Clark Station, and the western terminus at Arbutus Street. Starting at the VCC-Clark Station, a 700 m elevated guideway will run westward towards the new underground station at Great Northern Way. From Great Northern Way Station, the Project Alignment (the Alignment) continues underground to the station located at Broadway and Main Street. The remainder of the Alignment travels west, under Broadway, to a new terminus and transit exchange at Arbutus Street, with connections to the 99 B-Line, and bus routes 9 and 14, providing access to the University of British Columbia (UBC) Point Grey Campus.

The Project will include six new underground stations, as illustrated in Figure 1-1, located near the major north/south arterials adjacent to the Alignment.

Figure 1-1: Broadway Subway Project Location

1.2 Project Need and Context

The Broadway Corridor, between Victoria Drive in the east to UBC in the west, has been identified as a priority area for public transportation improvements in Metro Vancouver (Metro Vancouver 2011, TransLink 2013). Current challenges in the Broadway Corridor that would be addressed through implementation of the Project include:

- **Achieving economic development potential:** Central Broadway is the second largest business centre and employment area in BC, with the largest hospital in Western Canada (Vancouver General Hospital [VGH]) and an emerging tech sector. The Project will address the lack of rapid transit in the Broadway Corridor which currently creates challenges to attracting and retaining employment opportunities as well as addressing traffic congestion that limits economic development.
- **Improving capacity, reliability, and travel times of transit services:** The Project will significantly improve transit service in the Broadway Corridor by helping to meet demand currently not met with the 99 B-Line express bus service. In 2016, the ridership of the 99 B-Line was 17,288,000 passengers over the entire year, and it was overcrowded for 33% of its revenue hours. Currently, over half a million passengers are passed by every year because 99 B-Line buses are full.
- **Addressing gaps and bottlenecks in the rapid transit network:** The Project will eliminate the need for Expo and Millennium Line passengers, destined for Richmond or Vancouver International Airport (YVR), to go downtown to connect to the Canada Line. Currently, this gap between the Millennium/Expo and Canada Lines exacerbates congestion on the most overcrowded segment of the SkyTrain system (Figure 1-2).
- **Meeting mode share and environmental targets:** Currently, approximately 59% of all trips in the central part of the Broadway Corridor are made by automobile. The Project will make important contributions towards achieving local and regional sustainable transportation targets. The City of Vancouver aims for half of all trips in the City to occur by sustainable modes (transit, walking, cycling) by 2020 and two thirds by 2040. Metro Vancouver and TransLink aim for half of all trips in the Region to occur by sustainable modes by 2045. Shifting to sustainable modes of transportation also contributes to meeting provincial climate change targets.
- **Addressing local and regional housing challenges**: The Metro Vancouver Housing and Transportation Cost Burden Study (Metro Vancouver 2015) identified that the combined cost of housing and transportation represents between 40 and 67 percent of pre-tax income for households. By providing enhanced access to the regional rapid transit network, the Project will facilitate improved access to a greater diversity of housing options including connecting suburban communities with a major employment center.

Figure 1-2: Existing Rapid Transit Network—Gaps and Bottlenecks

1.3 Project History and Planning

In support of Project planning, provincial and municipal governments have consulted extensively on potential alternative technology and alignment options for rapid transit along the Broadway Corridor. These planning processes considered a variety of options for the Project, including the following:

- Rapid transit technology (e.g., SkyTrain vs. light rail transit)
- Terminal station for Phase 1 (i.e., alignment extending to UBC or stopping at a location further east)

The UBC Line Rapid Transit Study was conducted between 2009 and 2011 by TransLink, the Province, and five partners (the City of Vancouver, Metro Vancouver Regional District, UBC, the University Endowment Lands, and Musqueam Indian Band), and it considered 200 technology and alignment options.

At the conclusion of the UBC Line Rapid Transit Study, the top three rapid transit technology options were identified for comparison against "business as usual" (i.e., continuation of electric and diesel bus service including the 99 B-Line). As summarized in Table 1.3-1, rail rapid transit, through extension of the existing SkyTrain system, was chosen as the preferred rapid transit technology to address transportation needs along the Broadway Corridor (MOTI 2018).

Table 1.3-1: Rapid Transit Technology Alternatives

Evaluation Criteria	Business as Usual (Electric and Diesel Bus Service)	Rail Rapid Transit (SkyTrain)	Light Rail Transit	Combination of Rail Rapid Transit and Light Rail Transit
Transportation	No change from current	Significantly better	Better	Significantly better
Financial	No change from current	Same as "business as usual"	Same as "business as usual"	Same as "business as usual"
Environment	No change from current	Significantly better	Better	Better
Urban Development	No change from current	Better	Better	Better
Economic Development	No change from current	Significantly better	Better	Better
Social Community	No change from current	Significantly better	Better	Better
Deliverability (affordability not considered)	No change from current	Significantly better	Same as "business as usual"	Same as "business as usual"
Selection	Not Preferred	Preferred	Not Preferred	Not Preferred

In its 10-year investment vision, the Mayor's Council on Regional Transportation indicated a preference for phased delivery of rapid transit in the Broadway Corridor taking into account the results of the UBC Line Rapid Transit Study, as well as regional transit planning priorities. Based on a consideration of technical, cost and operational considerations, the preferred location for the Phase 1 terminus was determined to be Arbutus Street. The Arbutus Street location, for the eastern Phase 1 terminus, was determined to most effectively accommodate integration with a truncated B-Line system while still addressing the most critical transit gap along the Broadway Corridor (MOTI 2017).

1.4 Environmental Regulatory Requirements

During Project planning, the BC Environmental Assessment Office (EAO) and the Canadian Environmental Assessment Agency (CEA Agency) confirmed that due to the nature of the physical works, the Project does not require an environmental assessment under the federal *Canadian Environmental Assessment Act, 2012* (CEAA 2012) or the British Columbia *Environmental Assessment Act* (BCEAA 2002).

The requirement for environmental permits, that may be required to support construction and operation of the Project, will be confirmed and obtained by the Contractor following final design of the Project.

1.5 ESR Process

As noted above, the Project is not subject to a formal environmental assessment process. However, recognizing the importance of advancing the Project in a way that protects environmental and community values in the corridor, the Project chose to undertake an ESR of the Project.

The purpose of the ESR is to provide a transparent approach for involving the public, Indigenous groups, and government agencies in identifying potential Project-related effects on environmental, social, and economic values, and approaches to mitigating such effects and enhancing Project benefits. Information obtained through the ESR process will be used to guide future planning, construction and operational activities in a way that avoids or limits potential Project-related effects.

The scope of the ESR was defined through the development of the Terms of Reference (MOTI 2018) document. Feedback on the ESR process and the draft TOR was obtained from the public and Indigenous groups through a review and comment period in the Fall of 2017 (MOTI 2018). The TOR identified aspects of the biophysical and socioeconomic environment, termed “Review Elements”, to be reviewed as well as the methods for carrying out the review.

2 PROJECT DESCRIPTION

The Broadway Subway extends the existing Millennium Line alignment by 5.7 kilometres between the existing VCC-Clark Station and the new terminus at Broadway and Arbutus Street. The six underground stations, and approximately 5 kilometres of tunnel, will be connected to the existing Millennium Line by 700 metres of elevated guideway between the Emily Carr University of Art + Design to the VCC/Clark Station. This section of the ESR provides an overview of the Project including:

- Project components
- Project construction activities and construction schedule
- Procurement approach
- Operational phase activities

2.1 Project Components

Table 2.1-1 summarizes the principal components of the Project, which include an elevated guideway and tunnel, stations, and power, control and communication systems. These are further described in Sections 2.1.1 through 2.1.4.

Once operational, the Project infrastructure will be seamlessly integrated with the existing SkyTrain network and support the same vehicles used elsewhere on the Millennium Line. Additional cars will be required to support passenger service on the Broadway Subway Project and will be delivered by TransLink as a separate project.

Project delivery does not include components that support the existing SkyTrain network, such as SkyTrain vehicles (Section 2.1.5), or ancillary infrastructure requirements such as a storage yard or maintenance facilities.

Table 2.1-1: Physical Components of the Project

Project Feature	Components
Tunnel	• Underground SkyTrain tunnel from approximately the north-west corner of the Emily Carr University of Art + Design campus to Broadway and Arbutus Street
Stations	• Six fully accessible underground stations located at: – Great Northern Way and Thornton Streets (Great Northern Way station) – Main Street and Broadway (Mount Pleasant station) – Cambie Street and Broadway (Broadway–City Hall station) – Laurel Street and Broadway (Fairview–VGH station) – Granville Street and Broadway (South Granville station) – Arbutus Street and Broadway (Arbutus station)
Elevated Guideway	• 700 metres of elevated track located south of the False Creek Flats Rail Yards and north of the Emily Carr University of Art + Design campus, connecting the tunnel with VCC-Clark Station.
Power, control, communications, safety, and security systems	• Extension and upgrade of the SkyTrain operating systems.

2.1.1 Tunnel

From a location adjacent to the north-west corner of the Emily Carr University of Art + Design campus, SkyTrain cars will travel underground through a bored or mined tunnel, or pair of side-by-side tunnels. The tunnel(s) will be approximately 15 metres (50 feet) underground, except at Cambie Street where it will pass below the existing Canada Line tunnel.

2.1.2 Elevated Guideway

The Project will include a section of elevated guideway extending approximately 700 m westward from the existing terminus of the Millennium Line at VCC-Clark Station, to an underground tunnel north-west of the Emily Carr University of Art + Design campus.

2.1.3 Stations

The Project will include six underground stations (see Figure 1-1). The new stations include underground platforms sized for the longest SkyTrain trains with access to platforms provided by fully accessible elevators, stairs and up and down escalators. Stations are spaced at approximately 1-kilometre intervals, within a five to six minute walk of all destinations along Broadway. Figure 2-1 presents a typical station design.

The Broadway–City Hall Station at Cambie Street and Broadway will provide a direct passenger connection between the Millennium Line and Canada Line. The station at Arbutus Street and Broadway will include a bus exchange, enabling passengers to connect directly to the 99 B-Line bus service to UBC. General station features are summarized in Table 2.1-2.

Table 2.1-2: Broadway Subway Project Station Features

	Bus Connections	Canada Line Connection	Proximity to Bike Routes and Greenway	Bicycle Parkade	Universal Accessibility
Great Northern Way	✓		✓	✓	✓
Mount Pleasant	✓		✓		✓
Broadway-City Hall	✓	✓	✓	✓[2]	✓
Fairview-VGH	✓		✓		✓
South Granville	✓		✓		✓
Arbutus	✓		✓	✓	✓

Figure 2-1 shows the typical station layout, based on renderings for the Great Northern Way and Fairview-VGH stations; Figure 2-2 shows the conceptual layout of the transit exchange adjacent to the Arbutus Station.

[2] Bicycle parkade will be developed by the City of Vancouver as part of the future Vancouver City Hall development directly adjacent to the Broadway City Hall station.

Figure 2-1: **Typical Broadway Subway Station Layout: Great Northern Way and Fairview-VGH**

Figure 2-2: Conceptual Layout of Transit Exchange at Arbutus Station

2.1.4 SkyTrain Operating Systems

Power, control, and communications systems for the Project will be integrated with those supporting the existing Millennium Line. Systems will include automatic train control, communications, central control room and equipment, supervisory control and data acquisition, power distribution and back-up power, guideway equipment, and station equipment. A 12.5 KV loop will be required to feed the power substations and tunnel boring machine. Work associated with the construction of the 12.5 KV loop will be conducted by BC Hydro. The scope of work to be conducted by BC Hydro, which involves trenching (i.e., approximately 1 m in depth) and the installation of power cables adjacent to Project-related infrastructure (i.e., at Main, Laurel and Arbutus Street stations), is considered as site preparation and utility relocation activities (Section 2.3.1.2) within the ESR.

Section 9.4.1 of the ESR provides an overview of an environmental management plan developed by BC Hydro to support such works and to avoid or limit potential Project-related effects on environmental values and potential archaeology and heritage resources.

2.1.5 SkyTrain Vehicles

The Project will operate the same passenger trains used elsewhere on the SkyTrain system.
The SkyTrain fleet consists of various vehicle types, ranging in passenger capacity from approximately 80 persons per car to 167 persons per car. Vehicles, along with the associated maintenance, storage and operating facilities, will be procured independently from the Project as part of a series of SkyTrain system capacity enhancement projects delivered by TransLink.

2.2 Procurement and Construction

Construction of the Project will be advanced following a Design-Build-Finance (DBF) delivery model; Following this procurement model, a Contractor will be selected to design, build and finance construction of the Project. Following construction and commissioning, the Project will be operated and maintained by the British Columbia Rapid Transit Company (BCRTC), which is a wholly owned operating subsidiary of TransLink.

Following the DBF procurement approach, the Contractor will be responsible for design and construction of the Project based on design and performance requirements developed by the Project team. The design and performance requirements include key Project elements (e.g., number and location of stations), that must be constructed as well as technical requirements (i.e., operating requirements of infrastructure that the final design must provide for) that must be met by the Contractor.

The competitive selection process for selecting the DBF Contractor will include two stages: a request for qualifications (RFQ) stage and a request for proposals (RFP) stage. RFQ respondents will be evaluated based on the strength and relevance of their experience and capability as demonstrated through previous projects.

It is anticipated that a short-list of three proponents will be chosen through the RFQ process and invited to submit a proposal in response to the RFP. Following completion of the procurement process, the successful proponent will finalize the design and proceed with construction. During Project construction, the MOTI Project team will oversee the delivery of the Project to verify that the Contractor complies with contractual requirements.

2.3 Project Activities

This section describes the activities that will occur during construction (see Section 2.3.1), operation (see Section 2.3.2), and decommissioning (see Section 2.3.3) of the Project. Figure 2-3 outlines the preliminary Project schedule. The Project is currently in the pre-procurement planning and engineering stage, which includes engagement, design, and review activities to be completed prior to commencement of construction.

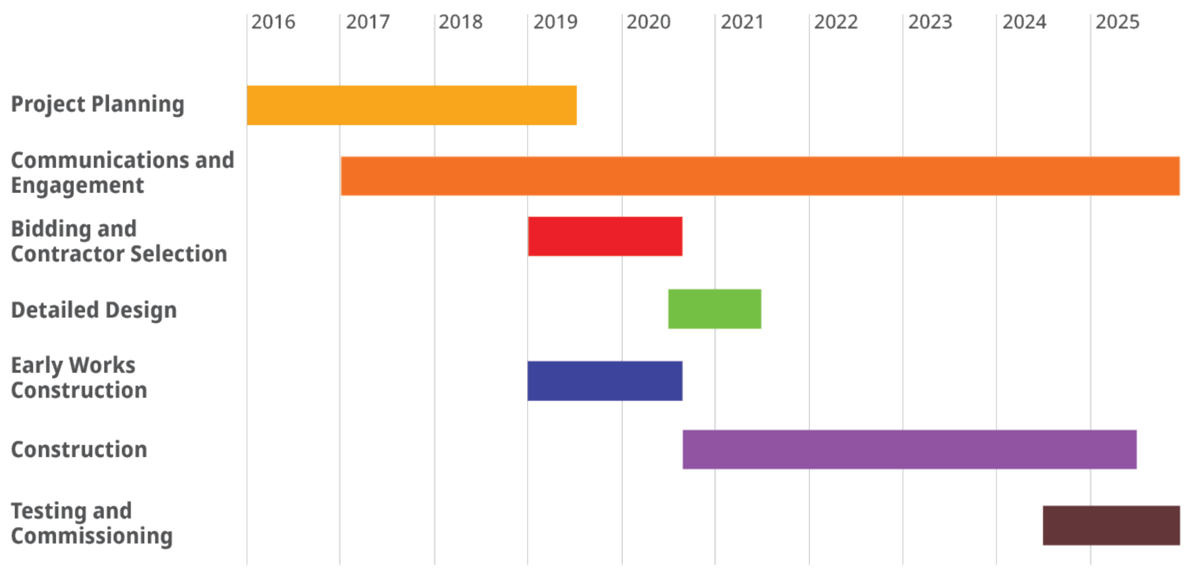

Figure 2-3: Broadway Subway Project Schedule

2.3.1 Construction

The main construction activities associated with the Project are summarized in Table 2.3-1 and described in further detail in the following sections.

Table 2.3-1: Construction Activities

Category	Components
Property requirements and land access	• Securing access to property required to support construction of the Project, including station locations
Site preparation and utility relocation	• Site preparation including clearing and grading, ground improvement, demolition, and set up of temporary facilities such as equipment and material storage areas • Relocation of utilities (e.g., electricity, telecommunications, municipal utilities)
Elevated guideway construction	• Construction of the elevated guideway
Tunnel construction	• Tunnel excavation, tunnel lining, track supply/install, and excavation of stations and ancillary facilities • Disposal and/or reuse of excavated materials
Station construction	• Underground and above-ground components of station structural concrete works, and installation of underground components and systems (e.g., rails, power systems, ventilation) • Disposal and/or reuse of excavated materials) • Architectural finishes including all non-structural components of the stations including the headhouse design and construction
Commissioning and start-up	• Testing and commissioning for all elements of the system, including electrical and mechanical systems, fixed facilities, and SkyTrain vehicles

2.3.1.1 Property Requirements and Land Access

In order to advance the Project, MOTI will be undertaking work to secure property required to support construction of the proposed infrastructure. Where acquisition of land is required, the acquisition process will follow established processes used by MOTI in meeting property requirements for other similar infrastructure developments.

2.3.1.2 Site Preparation and Utility Relocation

Site preparation will include clearing and grading, ground improvement, demolition of existing buildings, and development and set up of temporary facilities such as equipment and material storage areas. Site preparation works may also include, as required, work to remediate existing site contamination as well as management of hazardous materials that may be contained in existing structures that need to be demolished to support Project construction.

Some utilities will be installed and/or relocated to allow for construction of the Project. In some cases, utility relocations will be advanced prior to the selection of the construction Contractor in order to expedite the construction schedule. Examples of such utilities include water and wastewater lines, BC Hydro infrastructure, as well as telecommunications infrastructure.

2.3.1.3 Elevated Guideway Construction

Construction of the guideway is anticipated to involve transportation of girders to the site, pouring of concrete piers, installation of anchor bolts and bearings, and erection of the girders using a high capacity crane. During the construction process, the girders may be temporarily stored at site until they are lifted into position.

2.3.1.4 Tunnel Construction

Tunnel construction will include activities required to excavate materials and install tunnel related infrastructure including: tunnel lining, track supply/installation, and excavation of stations and ancillary facilities. The Contractor will be required to conduct the tunneling underground, except at stations and areas requiring special track-work. The Contractor will use a tunnel boring machine and/or other tunnel mining techniques to mine or bore the tunnel. Surface disruption will only be allowed at stations and the locations of special trackwork.

Construction of the tunnel will be initiated from the eastern end of the Alignment with the tunnel portal located on the north side of Great Northern Way. Excavated material from tunnel construction will be transported off-site for disposal or beneficial reuse. A traffic management plan will be in place to manage construction-related traffic in all areas of the Alignment including adjacent to the tunnel portal.

Given the large volume of materials to be excavated, it is anticipated that tunnel construction activities will require extended construction hours, including some nighttime work. As part of Project planning, the Project team is working with the City of Vancouver to identify daytime and nighttime noise thresholds that will guide the management of construction-related noise associated with tunnel construction. In addition, as identified in Section 7.5 (Noise), the Construction Contractor will develop and implement a Noise and Vibration Management Plan to limit construction-related disturbance on adjacent properties. Development and implementation of the Noise and Vibration Management Plan will be supported by engagement with local residents and businesses.

2.3.1.5 Station Construction

Station construction activities include the construction of underground and above-ground components of station structural concrete works, installation of underground components and systems (e.g., rails, power systems, ventilation), and architectural finishes, constructed and installed subsequent to station excavation works. Similar to tunneling, station excavation will involve the removal of excavated material by truck to off-site areas for beneficial reuse or disposal.

The construction of stations will require refinements to existing transportation systems in order to accommodate construction works. Section 7.2 (Transportation and Access) provides an overview of steps that will be taken to limit effects on existing transportation activities in the Broadway Corridor during construction.

Finalization of detailed stations designs will be supported by engagement with the City of Vancouver and BCRTC to confirm that station designs align with technical operational requirements, and integrate with adjacent transportation infrastructure (i.e., cycling, road and pedestrian traffic) as well as City of Vancouver considerations (i.e., integration with adjacent land uses, public amenities, landscaping). Finalization of detailed station designs will also include opportunities for engagement and input from key stakeholders and the general public.

2.3.1.6 Commissioning and Start-up

Following the construction of Project components described above, the Contractor will undertake a period of testing and commissioning for all elements of the system, including electrical and mechanical systems, fixed facilities, and SkyTrain vehicles.

The commissioning period, which will include the active participation of BCRTC, will be undertaken to confirm that Project elements are constructed and operated in compliance with contractual requirements prior to handover of the infrastructure to BCRTC.

2.3.2 Operations

The main activities during the operations phase are operation of the Skytrain (see Section 2.3.2.1), and stations (see Section 2.3.2.2), as well as maintenance (i.e., tracks, stations, rail vehicles etc.), administration, and security (see Section 2.3.2.3).

The Project will be operated and maintained by the BCRTC, which operates and maintains the existing Expo and Millennium Lines.

2.3.2.1 SkyTrain Operation

SkyTrain operations on the Broadway Subway will be integrated with the remainder of the Millennium Line. Current SkyTrain frequency on the Millennium Line ranges from 3–4 minutes during peak hours to 8–10 minutes late at night. The Millennium Line currently operates between approximately 5 am and 1 am.

During operating hours, SkyTrain attendants will be assigned to monitor station conditions and assist passengers as needed. As the Project will be integrated with the existing SkyTrain system, stations will be divided into Fair Paid Zones, with entry through fare gates compatible with the Compass Card system. Stations will be accessible, with elevator and escalator access.

2.3.2.2 Maintenance, Administration, Security

Maintenance, administration, and security for the Broadway Subway will be integrated with the existing SkyTrain systems, with BCRTC responsible for system security once the Project is in operation. This will include maintenance of security systems at stations (e.g., rolling grilles at station entrances, and access card readers for equipment rooms), the elevated and underground guideway (e.g., guideway intrusion detection systems), and SkyTrain attendants who will staff the station platforms and rail vehicles.

2.3.2.3 Integration with Other Modes of Transportation

Once operational, the Project will replace some bus services operating along Broadway. Most notably, the 99 B-Line bus will operate between UBC and the new station at Arbutus Street rather than between UBC and the Commercial/Broadway Station. TransLink's Route 9 bus will continue to operate on Broadway. Figure 2-4 shows the anticipated integration of the Project with other bus routes in the area. Figure 2-5 shows the conceptual layout of the station at Cambie Street that will be integrated with the Canada Line Broadway-City Hall station.

Figure 2-4: Proposed Transit Integration

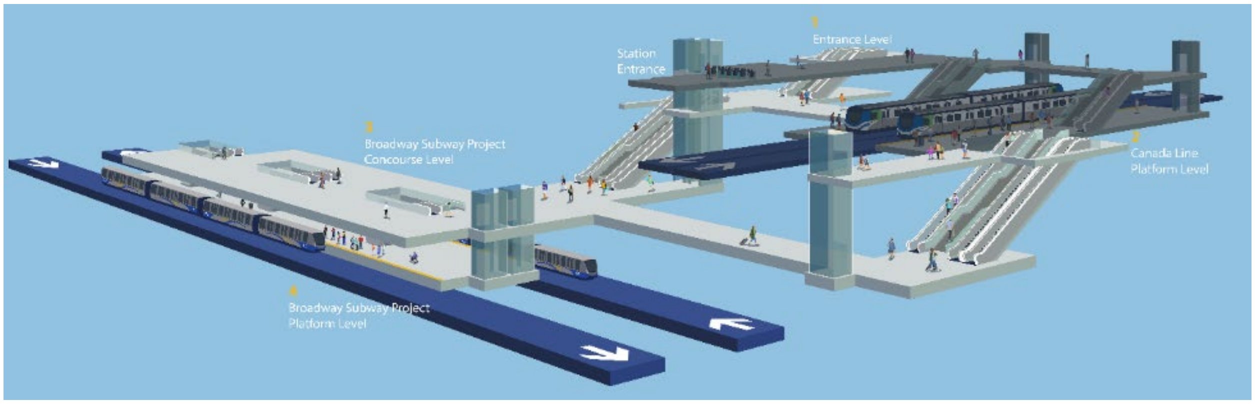

Figure 2-5: Broadway Subway/Canada Line Transit Integration

The Project's station locations are adjacent to key bicycle routes across the city, such as the Central Valley Greenway, 10th Avenue, Ontario Street, Cambie Street, and the Arbutus Greenway.
The conceptual design includes bicycle storage facilities at the following stations: Great Northern Way, Main, Cambie, and Arbutus.

2.3.3 Decommissioning

The SkyTrain system has been operating in Vancouver for over thirty years, and with regular maintenance it can be operated indefinitely. As such, there are no plans for Project decommissioning.

3 PROJECT BENEFITS

The Broadway Subway Project (the Project) is anticipated to result in a number of both short and long-term benefits that will be felt at local, regional and provincial levels. This section provides an overview of Project-related benefits including transportation, social and community, economic, and environmental benefits.

3.1 Transportation Benefits

The Project, once operational, will result in a number of transportation-related benefits which are anticipated to increase over time, as ridership grows. The anticipated benefits, discussed in more detail in Sections 3.1.1 to 3.1.6, include the following:

- **Improved transit access on the Broadway Corridor**—The Broadway Corridor is the second largest employment area in BC. The Project will allow for transit access to the Corridor, making it easier for people to access jobs and do business.
- **Transit-related travel-time savings and reliability**—The Broadway Subway will move transit riders through the Corridor faster and more efficiently, providing travel time reliability for customers. The Project will save transit riders up to 30 minutes per day in travel time for travel between Commercial-Broadway and UBC.
- **Increased transit ridership**—The current demand for transit exceeds the current capacity of existing bus services. On opening day, the Broadway Subway will have room for three times as many people as the current 99 B-Line service, with trains arriving every three minutes during peak hours.
- **Improved regional transit connectivity**—The Project is an extension of the Millennium Line and will provide direct regional access to the Broadway Corridor, a direct connection to the Canada Line, and improved regional transit connectivity.
- **Improved safety**—Underground rapid transit infrastructure that both reduces congestion and reduces transit vehicles along the Broadway Corridor is expected to result in improved road safety.
- **Improved transportation choice**—The Broadway Subway stations will be designed to facilitate multi-modal access. The stations will be designed to enable pedestrian, cycling and bus connections providing people with a combination of ways to access and travel through the Corridor.

3.1.1 Improved Transit Access

The Project has been designed to address a critical gap in the regional transit network and is anticipated to deliver long-term benefits to residents, businesses, and institutions near the Alignment once operational, through increased transit access for employees, employers, customers, tourists and other visitors, medical patients, students, and residents. Specific benefits associated with improved transit accessibility include:

- **Transit access supporting planned growth**—The Project will result in an increased number of residents in the Broadway Corridor living within 800 m of rapid transit MOTI 2018). In 2011 the number of residents living within 800 m of rapid transit was 28,000; this is anticipated to reach 37,000 by 2045, not including potential for increased density (MOTI 2018).
- **Improved access to key business areas**—Business areas, including the Great Northern Way Campus, False Creek Flats Tech and Media Hub, Mount Pleasant Industrial Zone, Medical Precinct, and South Granville Shopping Area will benefit from improved access for workers and customers. Employment in these areas is predicted to increase from 35,000 jobs (2011) within 800 m of rapid transit to 66,000 by 2045 (MOTI 2018).

3.1.2 Transit-related Travel Time Savings and Reliability

By extending the existing SkyTrain system, the Project will provide more reliable transit travel times when compared to the existing B-Line bus or passenger vehicle travel along the Broadway Corridor (MOTI 2018). Some of the benefits related to transit-related travel-time savings and improved reliability include the following:

- **Improved rapid transit efficiency/reduced transit congestion**—Once the Project is operational, transfers between Canada Lines will no longer need to take place downtown. Expo Line passengers will be able to transfer to the west-bound Millennium Line at Commercial Drive Station, and transfer to the Canada Line at the planned station at Broadway and Cambie. Such changes will reduce transit congestion and transfers at the existing Commercial-Broadway Station, and reduce passenger volumes on the Expo Line between Commercial-Broadway and Main Street-Science World Stations (MOTI 2018).
- **Reduced transit travel times**—Transit travel times during operation (2030) are anticipated to be less than half the amount of time when compared to without the Project (i.e., Business as Usual (BAU), for travel from Commercial-Broadway Station to the planned station at Broadway and Arbutus. The Project will save transit riders up to 30 minutes per day in travel time for travel between Commercial-Broadway and UBC. The total travel time reliability[3] benefit in dollars is estimated to be $410 million (MOTI 2018).

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[3] These are the cost savings associated with reduced travel time on the Project when compared to road travel modes, largely.

Travel times are expected to be reliable for the Broadway Subway while increased traffic congestion would likely further reduce the relative performance of bus transit times (MOTI 2018). The Project is expected to provide sufficient capacity to meet forecasted demand through to at least 2045 (MOTI 2018).

Travel times on the Project are anticipated to be substantially less than BAU scenarios. For travel from Commercial-Broadway Station to various destinations, see Table 3.1-1. Travel times during peak periods are projected to remain the same from 2030 to 2045 as the system is designed to accommodate for projected increases to ridership levels over this period. Travel times for 2030 and 2045 are therefore shown under a single heading.

Table 3.1-1: Travel Times under Project and Business as Usual (BAU) Scenarios

	BAU		Broadway Subway
	2030	2045	2030/2045
UBC	44	50	33–37
Vancouver Airport	38	40	33
City Hall	11	14	6
Oak Street	13	17	8
Granville Street	17	21	9
Arbutus Street	22	28	11

3.1.3 Increased Transit Ridership

The new Broadway Subway Project will provide faster and more reliable service from VCC-Clark to Arbutus than B-Line service or car. This will create an anticipated ≤55% increase in ridership by 2050, representing 167,000 to 191,000 daily passengers, as compared to ongoing B-Line service or car trips if the subway was not built (MOTI 2018).

3.1.4 Improved Regional Connectivity

The Project will connect downtown Vancouver, Vancouver International Airport, Richmond (via the Canada Line); East Vancouver, Burnaby, and Surrey (via the Expo Line); and East Vancouver, Burnaby, and Coquitlam Port Moody (via the existing Millennium Line).

The Project will provide system continuity with the existing SkyTrain system by integrating transfer to the Canada Line and 99 B-Line bus services west of Arbutus (MOTI 2018).

3.1.5 Improved Safety

The Project is anticipated to reduce the number of vehicle kilometres travelled (VKT) in Metro Vancouver by 2045 (MOTI 2018). This anticipated reduction in vehicle traffic, including reduced bus traffic along the existing Broadway Corridor, is expected to contribute to improved traffic safety conditions. In addition, goods movement may also benefit from decreased cars and buses on designated truck routes.

As an underground system, the Project will contribute to improvements in traffic safety conditions along the Alignment both by removing some vehicle traffic (i.e., buses) from existing roads and shifting commuter-pedestrian traffic away from an active roadway.

As a result of reduced vehicle kilometres travelled, the Project will result in an estimated $72 million reduction in collision-related costs region-wide (MOTI 2018). This will assist in achieving traffic safety targets set out in Vancouver's 2040 Transportation.

3.1.6 Improved Transportation Choice

The Project will provide areas along the Alignment that are currently only served by bus, with access to rail rapid transit. At the same time, residents, students, and employees in the area will still have access to bus services along the Alignment. For persons with disabilities, those travelling with bicycles, or other considerations, rail rapid transit may represent a more accessible mode of transit compared to busses.

All stations will be located adjacent to key bicycle routes connecting the Broadway Corridor to other parts of Vancouver and beyond, such as the Central Valley Greenway, 10th Avenue, Ontario Street, Cambie Street, and the Arbutus Greenway. Provision of bicycle parkades at Great Northern Way, and Arbutus Street stations, and the planned bicycle parkade that will be part of the future City of Vancouver development adjacent to Broadway City Hall, is anticipated to facilitate integration of these modes of transportation and increase transportation options.

3.2 Social and Community Benefits

3.2.1 Support for Regional and Local Planning

The Project will support implementation of a number of regional and local land use, regional growth and transportation plans and progress towards related goals and objectives.

3.2.1.1 Regional Growth Strategy (Metro Vancouver 2040)

The Regional Growth Strategy for Metro Vancouver identified the extension of rapid transit along the Broadway Corridor as a priority under regional land use objectives (Metro Vancouver 2011a). Growth of compact urban areas, with access to sustainable transportation choices, are also key goals of the Strategy. The Strategy suggests focusing growth in areas served by frequent transit, with specific reference to the Broadway Corridor.

3.2.1.2 City of Vancouver 2040 Transportation Plan

In 2013, the City of Vancouver adopted the 2040 Transportation Plan which includes policies to advance new and improved rapid transit. The plan identified the Broadway Corridor (Victoria Drive to UBC) as a major gap in the regional transit network and as a focus area for rail-based underground rapid transit (City of Vancouver 2012).

The plan includes direction for land use to support sustainable transportation choices, including prioritizing dense and diverse development in areas served by rapid transit, discouraging private automobile use, and establishing trip generating entities (e.g., schools, employment centres, shopping districts) along current and future rapid transit corridors. The following key targets were set:

- By 2020: half of all trips on foot, bicycle, or transit (achieved in 2016)
- By 2040: two-thirds of all trips on foot, bicycle, or transit
- By 2020: reduce vehicle kilometres travelled by 20%
- By 2040: zero traffic-related fatalities

The Project is expected to contribute to achievement of these goals by increasing the proportion of trips made by transit and other sustainable modes, reducing vehicle kilometres travelled, and by improving traffic safety conditions along the Alignment.

3.2.1.3 City of Vancouver Greenest City and Renewable City Action Plans

The Greenest City Action Plan addresses three main areas of focus: zero carbon, zero waste, and healthy ecosystems (City of Vancouver 2018a). The Renewable City Action Plan has a goal of sourcing 100% of the City’s energy needs from renewable sources by 2050 (City of Vancouver 2018b). Implementation of the Project will support the movement towards zero carbon and renewable energy sources by increasing access to rapid transit, encouraging public transit, walking and cycling, and by reducing reliance on fossil fuels.

3.2.2 Housing Availability and Access

The Housing Vancouver Strategy includes actions to increase affordable housing along the Broadway Corridor and near future station areas by planning for the expansion of rapid transit (City of Vancouver 2018c). The City of Vancouver has started a new planning process for Broadway (the Broadway Plan) as one action to facilitate implementation of the Strategy. The Broadway Plan will focus on the integration of housing with future rapid transit stations along the Broadway Corridor. In June 2018, Vancouver City Council approved an interim rezoning policy and a development contribution expectation (DCE) policy created to reduce land speculation (City of Vancouver 2018d).

Studies have assessed housing and transportation costs in the Metro Vancouver region and found that for the Vancouver sub-region, housing and transportation costs accounted for 39% of owner household median income, and 45% of renter household median income (Metro Vancouver 2015b). Households living in areas well-served by rapid transit spend less on transportation costs. Further development of rapid transit is an important factor in providing owners and renters with more affordable and sustainable transportation options (Metro Vancouver 2015b).

The Project is anticipated to improve mobility for approximately 75% of non-market housing units within a 400 m distance from the Alignment. The Project is also expected to encourage new transit-oriented development and contribute to increasing housing stock along the Alignment and near stations.

3.3 Economic Benefits

3.3.1 Construction Phase

The total capital cost for the Project, including planning, construction, and financing, is estimated at $2.827 billion (MOTI, 2018). Construction-related expenditures are expected to result in substantial opportunities for local and regional businesses involved in providing support to the construction of the Project.

Based on the total capital cost of the Project, direct, indirect, and induced employment is anticipated to provide economic benefits through the following pathways:

- Direct and indirect employment (13,450 jobs) through Project expenditures on labour and through Project purchases of equipment, materials, goods, and services from local and/or regional businesses during construction and operations (MOTI 2018)
- Induced employment through direct or indirect employee purchase of consumer goods and services from local and/or regional businesses

3.3.2 Operations Phase

Once the Project is operational, the 99 B-Line will be truncated at Arbutus Street, resulting in a reduction of 48,800 bus operating hours annually, starting in 2030 through to 2045 (MOTI 2018). Over the 30-year evaluation period considered, this represents a reduction of 1.5 million bus operating hours (MOTI 2018).

The total travel time reliability (dependability of travel times on the Project compared to alternative modes) benefit in dollars is estimated to be $410 (MOTI 2018). The equivalent of $218 million is estimated as a monetary benefit from reduced bus pass-ups (MOTI 2018). The greatest source of economic benefit is expected from journey time savings (travel time savings incurred by existing and new transit users) and is estimated at $1.926 billion [over the lifetime of the Project (MOTI 2018)].

Reduced vehicle kilometres travelled as derived from expected mode shift is expected to result in auto-operating cost savings of $77 million and collision cost savings of $72 million (2017 dollars [MOTI 2018]).

In addition to the range of estimated economic benefits noted above, the Project is anticipated to result in additional economic benefits that have not been estimated or monetized. These include:

- **Enhanced economic efficiency**—The concentration of economic activity from densified urban development can serve to enhance economic efficiency in the local and regional economy by: lowering costs due to shorter travel times between commercial properties and greater access to a wider source of labour.
- **Employment benefits**—It is anticipated that the Project will increase the attractiveness of employment opportunities located along the Broadway Corridor due to the presence of rapid transit. It is currently estimated that the Project will directly and indirectly generate 13,450 new jobs (MOTI 2018).
- **Regional Competitiveness**—The Project is anticipated to increase the overall competitiveness of the Region helping to attract talent and businesses to the Corridor particularly for the health sciences and technology sectors with resultant benefits for the residents and economy of the Region (MOTI 2018).

3.4 Environmental Benefits

The investment in transit infrastructure associated with the Project is expected to benefit the environment by contributing to local, regional, and provincial air quality goals. Air quality benefits are anticipated as a result of increased transit use both within the Broadway Corridor and regionally. Such increased rapid transit use, coupled with reduced reliance on automobile use and fewer busses on the Broadway Corridor, is anticipated to lead to reductions in common air contaminants and greenhouse gas (GHG) emissions.

The Project's effect on air quality is expected to be particularly significant because the Broadway Corridor is one of the most densely developed areas in Metro Vancouver, and second largest employment centre in BC (MOTI 2018), with substantial transportation demands.

Regional goals for improved air quality and GHG management include Metro Vancouver's Regional Growth Strategy which includes a goal to "protect the environment and respond to climate change impacts" (Metro Vancouver 2011a). Metro Vancouver's Integrated Air Quality and GHG Management Plan includes a goal to improve the region's visual air quality while acknowledging Metro Vancouver's opportunity to contribute to global climate targets by reducing regional GHG emissions (Metro Vancouver 2011b).

The Project will also contribute to advancing the Province BC's Climate Action Plan which identifies targets for reducing GHGs by 33% by 2020 and by 80% by 2050 from 2007 levels (Province of BC 2008). Both the Climate Action Plan and the Climate Leadership Plan (Province of BC 2016) identified communities with sustainable transportation options as important participants in reaching the Province's GHG targets. Similarly, the Project is expected to contribute to the advancement of the City of Vancouver's Greenest City Action Plan, which includes reducing community GHGs by 33% by 2020 from 2007 levels (including through the reduction of transportation fuel use), and improving transit such that it is fast, frequent, reliable, and accessible (City of Vancouver 2018a).

4 INDIGENOUS CONSULTATION

The Province (MOTI) is committed to involving Indigenous groups in the planning and delivery of the Broadway Subway Project (the Project). This section of the Environmental and Socio-Economic Review (ESR) describes the approach for engagement and consultation with Indigenous groups regarding the Project and summarizes the process undertaken to:

- Establish effective and respectful working relationships
- Provide Project-related and environmental review information to Indigenous groups
- Provide opportunities for Indigenous groups to review and comment on ESR related documents
- Obtain feedback from Indigenous groups regarding the ESR process
- Identify and respond to issues or concerns raised by participating Indigenous groups regarding the ESR process

This section also describes engagement activities supporting the ESR process, including summaries of:

- Past and planned engagement activities with Indigenous groups
- Key issues and concerns raised by Indigenous groups regarding the Project and the ESR process along with MOTI's responses to those issues and concerns
- How feedback from participating Indigenous groups influenced the ESR including proposed mitigation measures supporting construction and operation of the Project

4.1 Principles and Guidelines for Indigenous Consultation

MOTI encourages and supports cultural awareness and diversity and recognizes the importance and relevance of the rights and interests of Indigenous groups. MOTI acknowledges that Indigenous people have the right to practice and protect their unique cultures, identities, traditions, and customs. MOTI also recognizes and respects that certain sites, places, landscapes, traditional practices, and beliefs can have deep cultural and spiritual significance for Indigenous communities.

Throughout the ESR process, the Project endeavored to undertake early and frequent engagement with Indigenous groups. Through the activities summarized in this section, the Project has worked to establish and maintain open and transparent relationships to support effective consultation while at the same time working to resolve issues or concerns raised by Indigenous groups in a meaningful and timely manner.

4.2 Identification of Potentially Affected Indigenous Groups

The Province's Consultation Area Database was utilized to identify Indigenous groups potentially affected by the Project. The Project is located in the traditional territory of the Musqueam Indian Band (Musqueam), Tsleil-Waututh Nation (Tsleil-Waututh) and Squamish Nation (Squamish).

Project consultation with Indigenous groups began in November 2016. The Project team (i.e., formerly TransLink, now MOTI) has engaged directly with Musqueam, Squamish and Tsleil-Waututh Nations through face-to-face meetings and ongoing correspondence.

In addition, the following tribal councils, treaty groups, and associations, located outside of Metro Vancouver, have reported that they, or one or more of their member groups, have interests in the area where the Project is located. As such, Project information has also been shared with these Indigenous groups throughout the Project planning phase:

- Hul'qumi'num Treaty Group
- Stó:lō Nation
- Stó:lō Tribal Council

4.3 Summary of Past and Planned Consultation Activities

In June 2014, the Metro Vancouver Mayors' Council on Regional Transportation shared a 30-year regional transportation vision and a ten-year plan to guide investments to keep Metro Vancouver moving with the Mayors' Council Plan including the Project as a priority investment. Approval for Project planning was provided in November 2016, following which communications with Indigenous groups were initiated.

4.3.1 Summary of Indigenous Consultation

This section summarizes Indigenous consultation activities undertaken for the Project between November 2016 and October 2019.

Indigenous groups were consulted through four stages of consultation. Consultation has included formal letters to Indigenous groups outlining the Project activities undertaken and planned, key information, deliverables and anticipated schedule.

Meetings with the Musqueam, Tsleil-Waututh and Squamish Nations have been undertaken and are ongoing. Meetings have provided opportunities to share information about the Project, address any concerns related to Aboriginal Interests and discuss opportunities for Project-related benefits, including cultural recognition and continued participation. Information has also been shared by way of letters, phone and emails to Indigenous groups. During these consultation activities, the Project has:

- Shared information about the Project to appropriately inform and engage Indigenous groups early in the Project activities and related studies
- Made funding available to Indigenous groups to support their involvement in Project consultation and the ESR review
- Sought comments on the draft ESR Terms of Reference (TOR), the draft sections of the ESR, and supporting technical reports
- Provided opportunities to discuss and identify Project-related issues and interests

- Considered comments from Indigenous groups on the ESR process and report prior to finalizing key documentation
- Extended invitations to participate in the archaeological preliminary field reconnaissance program
- Extended invitations to participate in environmental fieldwork.
- Documented and responded to issues raised by Indigenous groups during consultation
- Obtained input from Indigenous groups in relation to the Project's procurement process, in particular, requirements of the Contractor related to employment and contracting opportunities
- Included Indigenous groups in procurement-related activities
- Made funding available to support the negotiation of a Project Agreement
- Met with Indigenous groups to discuss a Project Agreement

4.3.1.1 Project-related Consultation Program:

The Project has implemented a multi-year, three-stage consultation and engagement program summarized as follows:

- **Stage 1:** Project Introduction (November 2016 to April 2017)—this initial stage introduced the Project team to Indigenous groups, provided an overview of the Project and sought input on Project-related Aboriginal Interests and desired participation in future engagement activities. During this stage, meetings were held with Musqueam and Tsleil-Waututh and included discussions related to Aboriginal Interests in Project-related consultation.
- **Stage 2:** Consultation on the Environmental and Socio-economic Review process (May–October 2017)—the second stage of consultation was focused on providing updated Project status information, introducing the ESR process (e.g., environmental evaluation overview and initial findings of identified environmental Review Elements). During this phase meetings were held with Musqueam and Tsleil-Waututh and a copy of the Initial Environmental Summary Report was shared with Indigenous groups.
- **Stage 3:** Project Environmental and Socio-economic Review (October 2017–October 2019)—
  The Project team shared the draft ESR TOR with Musqueam, Tsleil-Waututh and Squamish Nations in October–November 2017, for review and comment. Comments received from participating Indigenous groups were taken into consideration when finalizing the TOR; direct responses were provided to participating Indigenous groups along with the final TOR.
  - Beginning in June 2018, draft sections of the ESR report were submitted to Musqueam and Tsleil-Waututh for review and comment. Comments received from participating Indigenous groups were taken into consideration when finalizing the ESR. Direct responses were provided to the participating Indigenous groups along with the final ESR report.
  - Musqueam, Tsleil-Waututh and Squamish were invited to participate in the Archaeological Preliminary Field Reconnaissance for the Project. In May 2018, Inlailawatash Limited Partnership completed an Archaeology Overview Assessment.

- Inlailwatash undertook additional archaeological work, building on the Archaeological Overview Assessment (2018). The Addendum to the Archaeological Overview Assessment (2019) was informed by additional detail regarding the property requirements of the Project and allowed for refining the findings, and recommendations, of the Archaeological Overview Assessment (AOA).
- In September 2019 an Archaeological Impact Assessment, under *Heritage Conservation Act* Permit 2019-0237, was undertaken near the eastern terminus of the Project near the proposed Great Northern Way station.
- Inlailawatash Limited Partnership oversaw archaeological monitoring that was required as a part of the contaminated sites investigations for the Project, and outreached to Musqueam, Squamish and Tsleil-Waututh Nation to arrange for participation in archaeological monitoring activities.
- Updated Project documents were shared with Indigenous groups including the updated Terms of Reference for the ESR, the updated ESR, and Technical Data Reports.
- Representatives from Musqueam, Squamish and Tsleil-Waututh participated in environmental field work
- The Project hosted a business to business event for Indigenous groups' partnerships and businesses, including member-owned businesses, to meet with Proponents.
- The Project team invited representatives from Musqueam, Squamish, and Tsleil-Waututh Nations to participate in the opening of the Broadway Subway Project community office.

4.4 Issues and Interests Identified by Indigenous Groups During Review of ESR TOR

Key issues and interests raised by Indigenous groups during review of the draft ESR TOR focused on the following range of topics including:

- Opportunities for Indigenous groups to review and comment on the review process, Review Elements, and documents
- Consideration of historical streams
- Project design and incorporation of vegetation and habitat
- Effects to archaeological and heritage resources
- Housing costs
- Transit accessibility and costs
- Environmental mitigation and protection measures

Following review of the draft TOR by Indigenous groups, and taking into account specific comments from Indigenous groups, the following changes to the ESR TOR were made:

- The candidate Socio-economic Review Element was split into three distinct Review Elements: Traffic and Transportation; Housing, Residential Properties and Commercial Businesses; and Community and Emergency Services. These were later refined to the two Review Elements presented in the ESR: Transportation and Access (which includes community and emergency services) and Housing and Property

- The language for the Review Indicators for the assessment of Archaeological and Heritage Resources was revised to more clearly include potentially-affected sites
- The TOR was revised to include a statement that applicable heritage permits, including permits issued by Indigenous groups, will be sought for the assessment of Archaeological and Heritage Resources
- Aquatic Resources was added as a Review Element
- A consideration of the fisheries values of historical streams was included in the review of Aquatic Resources
- Vegetation and Wildlife Resources was added as a Review Element

Where comments did not result in a change to the TOR, written responses to Musqueam and Tsleil-Waututh were provided through comment tracking tables to explain the rationale for why changes were not made.

4.5 Key Issues and Interests Raised by Indigenous Groups During Review of the ESR

This section summarizes issues raised by Musqueam and Tsleil-Waututh during review of the ESR and the Project team's responses to comments and issues identified by Indigenous groups. Key issues and interests identified by Musqueam and Tsleil-Waututh during review of the ESR related to:

- Consideration of and approach to assessing cumulative effects
- Consideration of climate change and GHGs as a stand-alone Review Element
- Concern with reliance on desktop surveys rather than field-based surveys to characterize existing biophysical conditions
- Effects on aquatic resources including consideration of historical streams in the review
- Indigenous groups' participation in the management of sites with archaeological potential
- Effects on urban wildlife from Project-related noise and vibration
- Incorporation of green space including tree retention and/or replacement into the Project design
- Potential effects of EMFs on human health and the health of wildlife
- Providing opportunities for Indigenous groups to review, comment and provide input on the Construction Environmental Management Plan (CEMP)
- Providing opportunities for Indigenous groups to participate in environmental monitoring during Project construction
- Communication with Indigenous groups in the event of spills and/or incidents during Project construction

The majority of comments were responded to directly through tracking tables with MOTI providing written responses to the respective Indigenous groups. Changes made to the ESR, as a result of review and comments are summarized below by applicable ESR section.

4.5.1 Review Scope and Methods

Within the Review Scope and Methods section, language describing review indicators for Archaeological and Heritage Resources was revised from: “number and description of archaeological sites altered as a result of Project activities” to “inventory of potentially affected archaeological sites and description of potential alterations; and from “number and description of heritage sites altered as a result of Project activities” to “inventory of potentially affected heritage sites and description of potential alterations”. This change was also made in the Archaeological and Heritage Resources chapter.

4.5.2 Environmental and Socio-Economic Setting

Within the Environmental and Socio-Economic Setting section, a correction was made regarding population (from “greater than 630,000” to “631,486”), and additional information on general demographics was included.

4.5.3 Archaeological and Heritage Resources

The Archaeological and Heritage Resources chapter of the ESR was updated to list the Aboriginal groups and Tribal Groups with asserted territory that overlaps with the Project.

With respect to consultation with Indigenous groups, a commitment was added to consult with the Musqueam, Tsleil-Waututh and Squamish in the development of the Chance Find Procedure for the Project, as well as a commitment to develop and implement the Chance Find Procedure with the inclusion of applicable Indigenous group procedures and policies.

Stemming from the recommendations made by Inlailawatash in the AOA, the ESR was revised to include commitment to: conducting an Archaeological Impact Assessment once Project design is complete; conducting subsurface sampling of undeveloped lots within areas of archaeological potential; and monitoring subsurface mechanical excavation from 0–10 m below surface in areas within 50 m of historic streams and/or drainages.

4.5.4 Air Quality and Greenhouse Gases

The ESR was revised to include a discussion of how Project-related reductions in GHG emissions align with key federal, provincial and local/regional climate change initiatives.

4.5.5 Noise and Vibration

Wording in the Noise and Vibration chapter of the ESR was revised to clarify that there are no plans to decommission the Project and noise and vibration effects, associated with decommissioning are not considered in the ESR.

4.5.6 Aquatic Resources

Water quality parameters associated with assessing potential changes in water quality were revised to include temperature and turbidity. Further, a statement was added regarding water collection systems and their use in preventing or limiting unplanned discharges to the stormwater system during construction.

4.5.7 Vegetation and Wildlife Resources

The Vegetation and Wildlife Resources section was revised to include a commitment to consider the inclusion of planted walls and columns within the stations.

4.5.8 Environmental Management Plans

The ESR text was modified to acknowledge that the Indigenous groups involved in the review process will have a role in approving the Archaeological and Heritage Management Plan and specific actions that may be taken during implementation of the Plan.

Text pertaining to specific objectives was clarified regarding: communication with Indigenous groups, as well as with other relevant orders of government in the event of spills above regulatory thresholds; monitoring the effectiveness of the Sediment Prevention and Sediment Control Plan; and long-term avoidance of the spread and establishment of invasive plants.

4.6 Ongoing Consultation

The Project team is committed to continuing to work with the Musqueam, Squamish and Tsleil-Waututh Nations to ensure their ongoing involvement in the Project. The Project team is actively engaged in discussion with the Musqueam, Squamish and Tsleil-Waututh Nations regarding Project Agreements. Continued participation of Indigenous groups in the Project includes, but is not limited to the following opportunities:

- Involvement in the archaeological component (including monitoring)
- Review of the Construction Environmental Management Plan and other Project-related information
- Contracting and employment through the Project's Contractor
- Indigenous cultural recognition

As the Project advances through procurement and construction, the Project team will continue to share Project-related information with Indigenous groups (i.e. construction updates, milestones), facilitate their continued involvement in key Project components of interest (i.e. monitoring), address any Project-related concerns that may potentially affect their identified Interests, and ensure commitments to Indigenous groups are met.

4.7 Summary of Indigenous Consultation on Environmental and Socio-economic Review

Consultation with Musqueam Indian Band, Squamish Nation and Tsleil-Waututh Nation is ongoing. Indigenous group review and comment on the draft TOR and draft ESR, provided important and valuable input into the conduct of the ESR.

5 PUBLIC ENGAGEMENT AND INFORMATION DISTRIBUTION

5.1 Introduction

Planning for rapid transit along Broadway has been underway since 2009 and has been supported by significant public engagement. Through such engagement, TransLink, in collaboration with the City of Vancouver, Government of BC and other key partners, has raised awareness about the Project, gathered input from interested parties, and responded to Project-related inquiries.

During Project planning to date, public engagement has focused on providing the public, businesses and residents, property owners, students, and other stakeholders with the opportunity to be informed and provide input regarding:

- The technology, route, and Alignment selection of the Project through the University of British Columbia (UBC) Line Rapid Transit Study, i.e., Alternatives Analysis Study (Steer Davies Gleave 2012) that analyzed a range of rapid transit options for the Corridor
- Construction-related effects of building the Broadway Subway Project on environmental, social and economic values of the Review Area
- Operations-related effects of the Broadway Subway Project

This section of the ESR describes engagement activities that have taken place to support Project planning and which have informed the conduct of the ESR, and includes:

- Description of local governments, residents, property owners, and other rights holders who are potentially affected by the Project
- A summary of past and planned engagement activities with governments, stakeholders and the general public
- A summary of key issues and interests raised regarding the Project through the ESR process, along with the responses to those comments

Information regarding the Project-related engagement activities with affected Indigenous groups can be found in Section 4 (Indigenous Consultation) of the ESR.

5.2 Background Information

This section identifies stakeholders who will potentially be affected by, or may have an interest in, the construction and operation of the Project.

5.2.1 Stakeholder Identification

The Project's engagement program has been designed to reach a wide variety of stakeholders and the public. Since 2009, the Project team has been working to identify, meet with and keep informed a broad list of stakeholders who may be interested in or affected by the Project.

Key audiences include government agencies and organizations who have a policy, planning, or regulatory interest in the Project. Key audiences also include individuals and organizations, who may be affected by the Project, and/or those with an interest in the Project, such as advocacy and decision-making organizations, nearby businesses, and nearby residents. Key audiences also include individuals and organizations who may have a broader interest in the Project but are not directly affected by it.

The following list identifies key stakeholder groups who have been invited to participate and/or have actively participated in engagement activities to date. Table 5.2-1 provides an overview of feedback from engagement with key stakeholders.

Government Agencies:

- Provincial
  - Ministry of Transportation and Infrastructure
  - Ministry of Municipal Affairs and Housing
- Federal
  - Ministry of Infrastructure and Communities

Provincial and Federal Elected Officials:

- Federal Members of Parliament (MP)
  - MP Vancouver Granville
  - MP Vancouver East
  - MP Vancouver Quadra
- Provincial Members of the Legislative Assembly (MLA)
  - MLA Vancouver-Point Grey
  - MLA Vancouver-Mount Pleasant
  - MLA Vancouver-Fairview
  - MLA Vancouver-False Creek
  - MLA Vancouver-Quilchena

Local Elected Officials and Governments:

- Local and Regional Government Staff, Council and Organizations
  - Mayors' Council, mayors and staff
  - City of Vancouver, staff and Council
  - Metro Vancouver, staff
  - Vancouver Coastal Health, staff
  - Vancouver School Board, staff

Other interested Groups and Organizations:

- Academic Institutions, including
  - University of British Columbia
  - UBC Campus + Community Planning
  - University Endowment Lands
  - UBC Alma Mater Society
  - Graduate Student Society
  - Vancouver Community College
  - Emily Carr University of Art + Design
  - Vancouver Community College
  - Student's Union of Vancouver Community College
  - B.C. School Trustees Association
  - St. Xavier School
  - St. Augustine's Elementary School
  - St. John's School
  - Century International School
  - Fraser Academy
  - Little Sorbonne Language School
- Advisory Groups
  - City of Vancouver Persons with Disabilities Advisory Committee
  - City of Vancouver Seniors' Advisory Committee
  - City of Vancouver Women's Advisory Committee
  - City of Vancouver Active Transportation Policy Council
  - Urban Indigenous Peoples' Advisory Committee
  - City of Vancouver Children, Youth and Families Advisory Committee
  - City of Vancouver Transportation 2040 Stakeholder Advisory Group
  - TransLink User Advisory Group
  - Vancouver City Planning Commission

- Businesses and business organizations, including:
  - business owners and operators within the Review Area
  - BC Chamber of Commerce
  - Greater Vancouver Board of Trade
  - Vancouver Economic Commissions
  - BC Trucking Association
  - Vancouver Airport Authority (YVR)
  - Tourism Vancouver
  - Commercial Drive BIA
  - Mount Pleasant BIA
  - Cambie Village BIA
  - West Broadway BIA
  - South Granville BIA
  - West Point Grey BIA
  - Great Northern Way Trust
  - BC Tech Association
  - BC Innovation Hub
- Community Associations, Neighbourhood Houses, and Inclusion advocates
- CMHC
- Transportation advocates
  - Putting Pedestrians First
  - Vancouver Public Space Network
  - Cycling BC
  - BC Cycling Coalition
  - HUB Cycling
  - Mobi Bike Share
  - Better Environmentally Sound Transportation (BEST)
  - Car share companies
- Developers and development groups
- Environmental and naturalist organizations, including:
  - David Suzuki Foundation
  - Environmental Youth Alliance

- Health
  - Vancouver Coastal Health and Fraser Health
  - Vancouver General Hospital
  - Lower Mainland Facilities Management
  - VGH Research Institute
  - BC Cancer Agency
  - BC Ambulance Service
  - BC Arthritis Society
  - BC Centre for Hip Health and Mobility
  - Heart and Stroke Foundation
- Public Safety
  - Vancouver Police Department
  - Community Policing
- Members of the public

Table 5.2-1 identifies the key audiences, their potential interests, and primary engagement activities.

Table 5.2-1: Summary of Key Audiences and Interests

Audience	Potential Interests	Primary Engagement Activities
Federal Government	Alignment with its strategic goals in the Investing in Canada Plan to build strong cities through investments in public transit and reduce traffic congestion and commuting times that impact a healthy economy, environment, and society.	Ongoing briefings.
Provincial Government	Alignment with its strategic goals on infrastructure investment, climate change, and affordable housing.	Ongoing briefings
TransLink	Alignment with its strategic and corporate goals in the Mayors' Vision and TransLink investment plans, as well as bus operation continuity during construction, and seamless integration of the Project with the regional network in operation.	Ongoing briefings
City of Vancouver	Alignment with strategic and corporate goals, in the Greenest city Action Plan, Transportation 2040, corridor and area planning, permitting, and standards.	Ongoing briefings staff-to-staff Project-level involvement.
Educational Institutions	Alignment with strategic and corporate goals, as well as safety and access during construction, including noise, vibration, light, dust, and traffic impacts. Access to UBC Point Grey Campus during construction and improving access during operations. Safety of students and pick-up drop off access for schools near the Project Alignment during construction.	Notification via formal letter/email to provide update on Project. Invitations to attend stakeholder workshops, open houses; briefings by Project team as required.
Industry Goods Movement	Broadway is part of the major road network, and key goods movement corridor. Construction and operation impacts on traffic flow and traffic changes are of interest.	Notification via formal letter/email. Invitation to attend stakeholder workshops; regional stakeholder workshops and presentations.
Healthcare Institutions	Construction and operations impact of vibration, noise, air quality, electrical/sewer disruption, as well as patient, visitor, and 24-hr staff access (transit, parking), and Emergency Room access.	Notification via formal letter/email with follow-up calls. Invitation to attend stakeholder workshops, sector-specific meetings.
Business Representatives	Construction and operation impacts to traffic flow, perceived/actual loss of business short- and long-term, access (sidewalk, patio, parking, transit interruption), business visibility (for customer access and security) and construction impacts (noise, vibration, air quality); long-term benefits for improved regional access.	Notification via postcard/email. Invitation to attend stakeholder workshops, open houses; dedicated business engagement program.

Table 5.2-1: Summary of Key Audiences and Interests

Audience	Potential Interests	Primary Engagement Activities
Small business, social services, arts	Construction and operation impacts on traffic flow, access (sidewalk, patio, parking, transit interruption), perceptions of safety, and construction impacts (noise, vibration, air quality).	Notification via postcard/email. Invitation to attend stakeholder workshops, open houses.
Community Associations	Construction and operation impacts on property values and related tax increase, safety, sinkholes, access, parking, street traffic, noise/light/dust; interest in streetscape design, station entrances, and landscaping.	Notification via email. Invitation to attend stakeholder workshops, open houses, briefings.
Nearby Residents	Construction and operation impacts on property values and related tax increases, safety, sinkholes, access, parking, street traffic, noise/light/dust; interest in streetscape design, station entrances, and landscaping.	Notification via formal letter/email. Invitation to attend open houses (stakeholder workshops if adjacent to the Alignment).
First Responders and Emergency Service Providers	Construction and operation impacts on emergency access; interest in safety streetscape design, station entrances, and landscaping; interest in safety aspects of construction, including for people with disabilities.	Notification via email. Invitation to attend stakeholder workshops, open houses.
Environmental Advocacy Groups	Construction methods/impacts; interest in remediation and potential impacts associated with brownfields.	Notification via email. Invitation to attend stakeholder workshops, open houses.
Development Advocacy Groups	Development opportunities along the Alignment; potential development restrictions in terms of form or timing.	Notification via email. Invitation to attend stakeholder workshops, open houses.
Transportation Advocacy Groups	Construction and operation impacts to access to bike lanes and transit; bike connections, amenities, streetscape design, partnerships, Project benefits; potential service disruption; business opportunities, partnerships.	Notification via email. Invitation to attend stakeholder workshops, open houses.
Multicultural Advocacy Groups	Communications and engagement opportunities in other languages as appropriate; engagement opportunities are welcoming and culturally appropriate.	Notification via email. Invitation to attend stakeholder workshops, open houses.
Disability & Accessibility Groups	Interest in streetscape design, station designs including washrooms, and landscaping; service disruption, accessibility during construction and operation.	Notification via email. Invitation to attend stakeholder workshops, open houses.
Interested Publics	Support for the Project; construction and operations impact; affordable housing impacts.	Notification via print/online advertising, street team postcard, posters, website, and online Invitation to attend open houses.

5.2.2 Engagement Tools

Project communications and engagement activities included in-person workshops and meetings, open house events, printed materials, and online information and questionnaires.

5.2.3 Public Notification of Engagement Activities

The following public notification tools were used to raise awareness of public engagement opportunities:

- **MOTI, TransLink and City of Vancouver websites**
- **Email notification:** TransLink Listens panelists, Talk Vancouver panelists, and Project email list, Buzzer Blog, and Greenest City email list
- **MOTI, TransLink and the City of Vancouver social media accounts:** including Facebook and Twitter
- **TransLink "Next Bus" text feature**
- **Print advertisements:** 24 Hours/Metro, Georgia Straight, Vancouver Courier (Vancouver Matters advertisement)
- **Posters** Placed at local businesses and community centres, handed out at events
- **Postcards / Letters:** Mailed to people in the Arbutus and Great Northern Way areas
- **Postcards:** Distributed by street teams during morning and evening peak hours at Commercial-Broadway Station, Broadway-City Hall Station, Granville Street at Broadway, and VCC-Clark Station, handed out at events
- **Signage at High-Traffic Areas:** A-frame sign during public events in high-traffic sidewalk areas near the event to encourage drop-in visits

5.2.4 Issues Management Tools

The following issues management tools were used to collect, inventory, and manage Project-related issues and interests that were identified through public communications and engagement activities:

- **Stakeholder tracking:** A database record of communications efforts and issues and interests raised by stakeholders and the public
- **Online monitoring:** A daily scan of media, social media, blogs, etc. for issues pertaining to the Project to identify key issues and support Project planning
- **Phone:** Information provided to customer service call centre
- **Project address and email:** A Project-specific physical address and email address to receive questions, comments, feedback, and concerns
- **Polling:** A baseline, and annual poll, was undertaken to measure progress against the communications and engagement objectives

5.2.5 Face to Face Engagement

A number of in-person engagement mechanisms were used to support stakeholder and public engagement during Project planning. These included:

- **TransLink, City of Vancouver, Metro Vancouver & Province meetings:** Project updates at existing Mayors' Council and other meetings.
- **Stakeholder workshops and meetings**: Six workshops and nineteen meetings to obtain focused stakeholder feedback in geographic areas along the line. Designed for groups of 12 to 50 people.
- **Open houses for general public:** Six open houses for the general public. Included a presentation, poster boards, and handouts as required. Feedback gathered via online questionnaires and at the open house events through a paper questionnaire and directly on the poster boards.

Please see Table 5.3-1, Table 5.3-2, and Table 5.3-3 for more specific information about the stakeholder workshops, meetings, and open houses.

5.2.6 Public Reference Material

Reference materials that were made available to the public and stakeholders, via in-person meetings or on-line, to support communications and engagement activities included the following:

- **Website and updates:** Project website (i.e., Project website and City of Vancouver website) with information including: Project description, work done to date, Project timeline, Project location (map), anticipated benefits and potential impacts, contact information, sign up for email updates
- **Frequently Asked Questions (FAQ):** A FAQ webpage on the Project website that focuses on the Project timeline, anticipated benefits, and construction impacts
- **Info sheets with information on the Project route, timeline, anticipated benefits and potential impacts considered in the ESR made available at Stakeholder events.**
- **PowerPoint Presentation:** PowerPoint presentations used to support general, and stakeholder specific, engagement activities
- **Poster boards for Open House:** Poster boards to support stakeholder workshops and open houses
- **Handouts:** Handouts for participants, including an explanation of the ESR process
- **Questionnaire/Feedback Form:** A short and primarily quantitative online and paper questionnaire to identify and gather feedback on important issues
- **Engagement Summary Report:** Summarize communications and engagement activities, feedback, and committed follow-up after each stage of engagement (three engagement stages) (City of Vancouver and TransLink 2017a,b; Modus 2017a,b).

5.3 Engagement History

TransLink's Transport 2040 strategy identified rapid transit along Broadway as a key part of Metro Vancouver's transit needs. In 2008, recognizing the importance of Metro Vancouver's transit needs, the Province of British Columbia included rapid transit along Broadway to UBC as part of its Provincial Transit Plan and provided funding to initiate a multiple account evaluation of rapid transit alternatives for Broadway. The following provides a brief summary of Project-related engagement to-date and supports a more detailed description of more recent engagement activities, including those supporting completion of the ESR, presented in Section 5.4.

5.3.1 Phase 1: Alternatives Analysis Study, 2009–2013

In 2009, TransLink, and the Province, in partnership with the City of Vancouver, UBC, University Endowment Lands, Musqueam Indian Band, and Metro Vancouver, launched Phase 1 of the UBC Line Rapid Transit Study (Alternatives Analysis Study; Steer Davies Gleave 2012) to identify options for addressing transit needs along Broadway. Phase 1 of the study was supported by a comprehensive engagement program to inform and seek input from local residents, businesses, UBC representatives, and local and regional stakeholders. Development of the Study considered more than 170 route and technology combinations based on three rapid transit technologies, bus rapid transit, light rail rapid transit, and rail rapid transit (including SkyTrain).

The Phase 1 engagement program included open house events, 17 stakeholder engagement sessions, five community workshops, three webinars, and a robust online information and engagement program. The program resulted in more than 400 workshop attendees, 2,300 questionnaire responses, and 240 comments submitted online.

Based on an assessment of technical options, and in consideration of feedback received from stakeholder engagement, Phase 1 of the study identified a shortlist of seven rapid transit alternatives evaluated against more than 65 detailed measures of associated benefits and impacts.

During Phase 2 of the study, TransLink and the study partners conducted broad public and stakeholder engagement on these shortlisted alternatives from spring 2010 to late 2011 through four in-person workshops, an online webinar, seven small group meetings and two drop-in sessions. Approximately 540 people participated in these events. Workshop minutes were recorded, and input was received and tracked through more than 1,500 feedback questionnaires submitted.

Additional feedback was gathered via the TransLink Listens survey, a statistically-significant online advisory panel of more than 1,800 regional residents. Comments on the Buzzer blog posts and direct correspondence were also recorded. A Multiple Account Evaluation was used, along with public and stakeholder engagement, to evaluate each of the seven options. The results of Phase 2 of the study found that the Rail Rapid Transit (SkyTrain) option was the highest ranked alternative in every category but that three options were worth advancing for further consideration (Light Rail Transit, a combination of Light Rail Transit and Rail Rapid Transit [SkyTrain] and Rail Rapid Transit [SkyTrain]).

5.3.2 Phase 2: Mayors' Council Vision and Pre-construction Funding, 2014

In February 2014, the Minister of Transportation and Infrastructure asked the Metro Vancouver Mayors' Council on Regional Transportation to confirm its transportation vision and to clarify the costs, priorities, and phasing for investments and actions. This resulted in the 10-Year Vision for Metro Vancouver Transportation, which includes rapid transit to UBC as a priority investment to be delivered in two phases: the first extending the Millennium Line westward from its current terminus at VCC-Clark Station to Arbutus Street, and the second expanding rapid transit to UBC at a later date.

5.3.3 Phase 3: Pre-construction Planning, 2016 to 2018

On November 23, 2016, the Mayors' Council and TransLink's Board of Directors reviewed and approved Phase One of the 10-Year Vision. The approval of Phase One included funding for pre-construction planning and engagement on the Broadway Extension to Arbutus Street.

In December 2016 after receiving senior government and regional funding to allow pre-construction planning to begin, TransLink and the City of Vancouver re-engaged with stakeholders and the public to raise awareness of the route and technology selected as part of the UBC Rapid Transit Study, build support for the Project, and gather input on opportunities and constraints to inform the procurement process.

TransLink and the City of Vancouver designed a three-stage engagement process to:

- Re-engage the public and stakeholders
- Inform and support the conduct of the ESR
- Support design and construction principles to support Project procurement

The overall objectives of the Pre-Construction Engagement Program are to:

- **Provide information about the Project and opportunities to provide input**—This includes building awareness of the Project, responding to questions, and giving people an opportunity to provide feedback. Supporting activities include maintaining a Project website with current and background information, inviting and responding to enquiries, attending presentations and community meetings on request and convening meetings of stakeholders, as appropriate.

- **Integrate stakeholder input into Project design and construction principles**—This includes encouraging dialogue and information exchange on Project design and construction topics and gathering input to understand areas of interest and concern. Such dialogue also supports the identification of ways to mitigate potential Project effects during future stages of the Project (i.e., design, procurement, construction).
- **Support the ESR process**—This includes providing information about the environmental, economic, heritage, health, and social conditions in the Project area, potential Project- related effects, and mitigation measures that could be used to address such effects. This also includes tracking public input, and communicating to the public how public comments will be addressed in the ESR.

5.3.4 Stage 1—Re-engagement

Stage 1 re-engagement took place from December 2016 through March 2017, with the primary purpose to inform stakeholders within the Review Area and the greater public about:

- The Alignment
- General station locations
- Technology choice
- Work that the Project team has done to-date

Engagement activities also presented an opportunity to hear general comments and questions about the Project.

The objectives of Stage 1 engagement, were to:

- **Inform**:
  - Re-engage with stakeholders previously involved in the UBC Line Rapid Transit Study
  - Provide an update on the status of Project planning, including the preferred route and technology and how they were chosen
  - Maintain communications with stakeholders and the general public during geotechnical investigation activities
- **Consult:**
  - Gather stakeholder and public feedback on Project opportunities and challenges

Stage 1 engagement activities included three stakeholder meetings and three open houses (hosted by TransLink and the City of Vancouver), an online and paper questionnaire, and a region-wide telephone poll.

A total of 71 stakeholders attended two stakeholder presentations in December 2016 and mid-January 2017 and over 400 members of the public attended three open houses in late January/early February 2017.

A region wide telephone poll conducted in early 2017 reached 800 respondents in Metro Vancouver and 145 respondents within 800 metres of proposed stations. More than 3,700 respondents completed the paper or online questionnaire, representing an 82% completion rate.

Stage 1 activities are summarized in Table 5.3-1.

Table 5.3-1: Summary of Stage 1 Engagement Activities

Date	Stakeholder Type	Engagement Activity
12 December 2016	City of Vancouver advisory group	Transportation 2040 Stakeholder Advisory Group
19 January 2017	Business, Development	Stakeholder Workshop
19 January 2017	Education, Safety, Residents	Stakeholder Workshop
28 January 2017	General public	Public Open House
31 January 2017	General public	Public Open House
01 February 2017	General public	Public Open House
January 2017	General public	Region-Wide Telephone Poll (Mustel Group)
23 January 2017 to 13 February 2017	General public	Online Survey (Talk Vancouver and TransLink Listens)

5.3.5 Stage 2—Design Engagement

Stage 2 engagement (design engagement) took place from April 2017 through August 2017 with the primary purpose to inform people about the work that the Project Team has done to date and seek feedback from stakeholders within the Review Area and the greater public about potential construction effects and mitigation, and design guidelines inside and outside the stations. Engagement activities also presented an opportunity to hear general comments and questions about the Project.

The objectives of this phase were to:

- **Refine & Communicate Project Definition:**
  - Provide general information about construction methods and requirements
  - Receive feedback from general public
- **Develop Design Principles:**
  - Share information on design considerations for inside and outside stations
  - Share information that the Project is being designed for capacity increases needed to match future ridership and a future potential extension to UBC
  - Seek general public input on design considerations and inter-modal connection
- **Construction Management Strategies:**
  - Share information on potential construction management strategies
  - Seek general public input on construction management strategies

- **Share General Project Updates:**
  - Communicate which issues, throughout the engagement processes, will be explored in Stage 3

In Stage 2, information about the Project was shared and input sought on construction management strategies and station design principles. This was done through 11 stakeholder meetings, four stakeholder workshops, three public open houses, and an online and paper questionnaire.

During Stage 2 engagement, 71 stakeholders attended four stakeholder workshops in mid- to late-June 2017, and 876 members of the general public attended three open houses in late-June 2017. In addition, 3050 members of the public completed the questionnaire – either online or by completing hard-copies at engagement events.

Table 5.3-2 summarizes Stage 2 engagement activities.

Table 5.3-2: Summary of Stage 2 Engagement Activities

Date	Stakeholder	Stakeholder Type	Engagement Activity
24 May 2017	Joint Business Improvement Associations	Region-wide business interests	Stakeholder Presentation with questions and answers
07 June 2017	Vancouver City Planning Commission	City of Vancouver	Stakeholder Presentation with questions and answers
07 June 2017	Active Transportation Policy Council	Transportation Advocacy Groups	Stakeholder Presentation with questions and answers
08 June 2017	Transportation 2040 Stakeholder Advisory Group	Transportation Advocacy Groups	Stakeholder Presentation with questions and answers
09 June 2017	Health Precinct	Healthcare facilities	Stakeholder Presentation with questions and answers
13 June 2017	Persons with Disabilities Advisory Committee (Transportation Sub-Committee)	Disability & Accessibility Groups	Stakeholder Presentation with questions and answers
16 June 2017	Seniors' Advisory Committee	Community Associations, Interested Publics	Stakeholder Presentation with questions and answers
22 June 2017	TransLink Users Advisory Committee	TransLink	Stakeholder Presentation with questions and answers
26 June 2017	Downtown Vancouver Business Improvement Association	Region-wide business interests	Stakeholder Presentation with questions and answers
17 July 2017	Urban Aboriginal People's Advisory Committee	Indigenous groups	Stakeholder Presentation with questions and answers
20 July 2017	Children, Youth and Families Advisory Committee	Community Associations, Interested Publics	Stakeholder Presentation with questions and answers
21 July 2017	Great Northern Way Workshop	Great Northern Way area landowners	Stakeholder Workshop
21 July 2017	Arbutus Workshop	Arbutus area residents and businesses	Stakeholder Workshop

Table 5.3-2: Summary of Stage 2 Engagement Activities

Date	Stakeholder	Stakeholder Type	Engagement Activity
22 July 2017	General Workshop #1	Alignment-wide businesses, employers, and residents	Stakeholder Workshop
22 July 2017	General Workshop #2	Alignment-wide businesses, employers, and residents	Stakeholder Workshop
24 June 2017	Open House #1	Alignment-wide businesses, employers, and residents	Public Open House
27 June 2017	Open House #2	Alignment-wide businesses, employers, and residents	Public Open House
28 June 2017	Open House #3	Alignment-wide businesses, employers, and residents	Public Open House

5.3.6 Stage 3—ESR Terms of Reference and Mitigation Engagement

Stage 3 (ESR) engagement was initiated in September 2017. The purpose of Stage 3 engagement was to inform people about the work that the Project has done to date and seek feedback from stakeholders along the Alignment and the greater public on the ESR Terms of Reference (TOR), and environmental, social, economic values along the Alignment.

Feedback was sought to confirm the scope of Review Elements to be considered in the ESR as presented in the draft TOR for the ESR. In addition, input was sought on construction and operation effects on specific Review Elements including socio-economic, noise and vibration, contaminated sites, air and water quality, electro-magnetic field (EMF), and heritage and archaeological.

Input on Review Elements, obtained during Stage 3, included feedback on the extent and nature of potential effects as well as mitigation that could be applied to avoid or mitigate effects on Review Elements during construction and operational phases of the Project.

The objectives of Stage 3 engagement are:

- **Engage stakeholders and raise awareness:** Ongoing public awareness and communications
- **Inform the ESR process:** Present the ESR TOR and gather key stakeholder feedback; use this information to inform finalizing the ESR TOR, the conduct of the ESR process, and identification of potential mitigation strategies to address potential effects on Review Elements.
- **Communicate the results of the ESR:** Present a summary of the key findings of the ESR (i.e., extent and nature of potential effects) and proposed mitigation strategies for addressing potential effects on Review Elements.
- **"Close the loop" on Project design and construction management strategies:** Share additional information on key design elements and construction approaches for the Project.

- Provide information on the procurement process and future engagement opportunities during Project delivery

The Project team participated in 7 meetings to gather feedback on the ESR TOR as well as collect information to support the conduct of the ESR. During these meetings, the Project team shared work-to-date on noise and vibration studies, answered questions, and discussed topics of interest to participants.

Engagement with stakeholders and the public continued through 2018 to share the findings of the ESR, mitigation strategies, and additional details on key elements of the Project.

Table 5.3-3 summarizes Stage 3 engagement activities to date.

Table 5.3-3: Summary of Stage 3 Engagement Activities

Date	Stakeholder	Stakeholder Type	Engagement Activity
October 19, 2017	Greater Vancouver Board of Trade	Region-wide business interests	Presentation with questions and answers
October 23, 2017	Mayor's Forum on Project Construction Mitigation Strategies. Participants included representatives from Business Improvement Associations, strata management organizations, City advisory committees, such as Seniors and People with Disabilities, and business owners.	Alignment-wide businesses, employers, and residents	Presentation with questions and answers
November 22, 2017	Emily Carr University of Art + Design, Great Northern Way Trust, PCI, ONNI, Great Northern Way Co-op, St. Francis Xavier School	Great Northern Way area landowners	Presentation with questions and answers
November 23, 2017	Lower Mainland Facilities Management, Vancouver Coastal Health, Fraser Health, BC Cancer Agency	Health precinct facilities	Presentation with questions and answers
December 14, 2017	Arbutus area residents and businesses	Arbutus area residents and businesses	Presentation with questions and answers
December 19, 2017	City of Vancouver's Business and Community Advisory Group	Alignment-wide businesses, employers, and residents	Presentation with questions and answers
February 22, 2018	Arbutus area residents and businesses	Arbutus area residents and businesses	Presentation with questions and answers

5.4 Identified Issues and interests

Table 5.4-1 provides a summary of key issues and interests identified during the engagement process to date, and the Project’s response.

Table 5.4-1: Summary of Key Issues Identified during Public Engagement

Interest	Identified Issue	Response
Project Design and Construction Methods		
Project routing	Consider alternate routes to reduce congestion on Broadway during construction and operations, such as W 10th Avenue or W 16th Avenue.	• The Alternative Analysis Study (Steer Davies Gleave 2012) considered more than 200 technology, route, and Alignment options for rapid transit from Commercial-Broadway Station to UBC • Section 2 (Project Description) of the ESR includes an overview of options considered during Project planning
Terminus station at Arbutus and phasing the extension to UBC	There is interest in the Project extending to UBC to reduce bus traffic between Arbutus and UBC, to avoid the development of a student train-bus exchange at Arbutus, and to provide improved travel for students along the Broadway to W 10th Avenue corridor.	• Metro Vancouver Mayors' Council on Regional Transportation 10-Year Vision prioritizes rapid transit along Broadway in two phases. The first phase is the Broadway Extension of the Millennium Line to Arbutus to be delivered within ten years. A future phase of investment would include rapid transit to UBC. • Section 2 (Project Description) of the ESR includes an overview of various options that were considered during Project planning
Tunnel excavation method	Concerns that the Project may be constructed using a cut and cover method rather than a tunneled/mined method, which is the proposed reference method.	• The Broadway Extension will be tunneled with alternative methods of construction limited to specified locations including stations. • Section 2 (Project Description) of the ESR includes information on construction methods and approaches
Station design	The Project should be built in consideration of projected population growth in the Lower Mainland and build large stations.	• The Project has been designed to account for future ridership forecasts, and includes platforms designed to accommodate projected population demands
Station design for person with disabilities	Questions raised about plans for designing stations that are accessible for disabled riders.	• Stations will be designed to modern accessibility standards and in accordance with TransLink's guidelines, similar to the station upgrades at Main Street and Commercial-Broadway Station, as well as the Evergreen Line, including: – Elevators, ramps, and escalators – Way-finding – Integration with HandyDART service • The Project has, and will continue to, seek feedback on design considerations from the Access Transit Users' Advisory Committee to understand accessibility considerations and requirements.

Table 5.4-1: Summary of Key Issues Identified during Public Engagement

Interest	Identified Issue	Response
Socio-economics/ Business and Community		
Project funding	Questions were raised about how the Project will be funded.	• The Government of Canada, Government of British Columbia, and Mayors' Council have reached agreement on the full Phase 2 Mayors' Vision, which includes the Project. Public consultation is now underway to confirm the regional share. • The Project business case and senior government funding for the Project have been confirmed.
Project leads	Clarity sought regarding relationship between the City of Vancouver and TransLink.	• In September 2018, MOTI confirmed deliver of the Project with support from the City of Vancouver and TransLink. • The City of Vancouver will provide use of certain properties and relevant street rights-of-way for construction of the Project.
Effects on businesses	Potential that businesses will be adversely affected during construction due to a change in access to store fronts, parking availability, and customer avoidance.	• The Project team recognizes the importance of business continuity during construction. The Project is developing a full business continuity plan that considers construction, traffic management, parking, access. • A Community Office opened in September 2019.
Compensation for lost business	Small business owners should be compensated for lost business during the construction phase.	
Traffic flow	Construction activities during peak commuting hours could slow traffic flow.	• Details on construction schedule, including hours of work, will be developed with consideration of the City of Vancouver's bylaw requirements.
Housing	Residents are concerned that housing costs will increase following development of the Project.	• The City of Vancouver committed to a comprehensive review and update of its land use policies and transportation networks near the planned Broadway Extension stations once the line is fully funded. Residents will have input to the City's long-term, land use vision for the amenities and infrastructure to support the area, as well as the long-term, multi-modal transportation needs in the Review Area.

Table 5.4-1: Summary of Key Issues Identified during Public Engagement

Interest	Identified Issue	Response
Project communication	The Project should develop a system for notifying stakeholders (e.g., local businesses, residents, medical community) regarding construction activities and for receiving feedback from affected parties.	• The Project team recognizes the importance of ongoing construction communications and engagement with impacted stakeholders. The Project is developing a robust communications and engagement protocol to keep the lines of communications open with local businesses, medical community, residents, and the public.
Access during construction	Concerns regarding pedestrian access, including access for disabled persons, and traffic to businesses, residents, and along Broadway in general, during construction.	• The Project team recognizes the importance of maintaining business continuity during construction and mitigating potential construction effects. The Project is developing a full business continuity plan that considers construction, traffic management, parking, access, and a store-front liaison office to serve local businesses, the community, and public.
Parking during construction	Clarification on parking plans, including compensation plans for lost parking spaces during construction.	• Technical work is underway to support construction phase planning. This work will support traffic management activities, including parking needs, that will take place during construction. • Section 7.2 (Traffic and Transportation) of the ESR provides an analysis of potential construction effects on traffic and transportation and options for mitigating potential effects.
Pollution and Emissions		
Greenhouse gas emissions	Change in greenhouse gas emissions due to construction and operation of the Project and clarification on how greenhouse gases are measured.	• Section 7.7 (Air Quality and Greenhouse Gases) of the ESR describes potential air emissions (including GHGs) from Project construction and operation activities.
Air quality	Concerns that air quality will be reduced during construction due to dust, vehicle idling, other particulates.	• Section 7.7 (Air Quality and Greenhouse Gases) of the ESR quantifies air emissions from construction and identifies mitigation measures to avoid or reduce potential Project-related effects on Air Quality.
Electromagnetic waves	Concern regarding electromagnetic field effects during the operation phase and clarification on mitigation measures that will be applied to reduce effects on humans, electric powered vehicles, and medical equipment.	• Section 7.9 (Electric and Magnetic Fields) of the ESR includes a review of potential effects of construction and operation of the Project, including change in EMF levels as a result of Project activities. • According to Health Canada guidelines, anticipated levels of EMF associated with the Project are below thresholds where pre-cautionary measures are required.

Table 5.4-1: Summary of Key Issues Identified during Public Engagement

Interest	Identified Issue	Response
Effects of noise and vibration on residents and buildings during construction and operation	Concern that noise and vibrations during construction and train operation will disturb local residents and may damage building foundations or geotechnical integrity.	• Section 7.5 (Noise) and Section 7.6 (Vibration) of the ESR provide a review of potential change in noise and vibration levels in the vicinity of the Project footprint during construction and operation of the Project. • Sections 7.5 (Noise) and 7.6 (Vibration) of the ESR identify mitigation and management measures to avoid or reduce potential effects. • Details regarding construction schedule, including hours of work will be developed with the City of Vancouver, in consideration of City bylaw requirements.
Effects of vibration on medical and educational facilities and equipment	Vancouver General Hospital, BC Cancer Agency, and Emily Carr University of Art + Design expressed concerns that sensitive equipment could be disrupted due to noise and vibration during construction and operation of the Project.	• Section 7.5 (Noise) and Section 7.6 (Vibration) of the ESR evaluates potential noise and vibration effects on buildings, including medical facilities, education institutions, and residences. • The evaluation of noise and vibration will take into account thresholds for medical equipment use. • The review will identify mitigation and management measures to avoid or reduce potential effects.
Waste disposal	Concern regarding the amount of waste that will be produced during construction.	• Section 7.8 (Contaminated Sites and Excavated Materials) of the ESR includes a review of potential effects of Project-related disposal of waste and excavated materials, and identifies mitigation and management measures to avoid or reduce potential effects.
Environmental and Heritage Resources		
Archaeology	TransLink should develop a plan for unexpected archaeological finds during excavation and boring activities.	• The archaeological and heritage resources review for the Project follows provincial requirements guidelines as well as input received from Indigenous groups. • Mitigation measures will include chance find procedures for addressing unexpected heritage sites during Project construction.

Table 5.4-1: Summary of Key Issues Identified during Public Engagement

Interest	Identified Issue	Response
Environmental contamination	TransLink should develop a plan to manage and clean up contaminants, should they be discovered during construction.	• Contaminated soil encountered during Project construction will be managed according to the BC Contaminated Site Regulations. • Section 7.8 (Contaminated Sites and Excavated Materials) of the ESR includes a review of potential effects of construction activities on the release of contaminants from contaminated soils or water. • The evaluation presented in the ESR will include information on the potential for contaminated soil and groundwater to be encountered as part of construction.
Aquatic resources	Locations of watercourses, including historic watercourses, should be considered in the review.	• Flow from historic watercourses have been piped or culverted and now run beneath the City's road network. • The Project is not expected to affect freshwater fish habitat. • Potential effects associated with Project-related discharges into the municipal storm sewer system are discussed in Section 7.10 (Aquatic Resources) of the ESR. This section includes mitigation and management measures to avoid or reduce the likelihood of sediment-laden discharges entering the storm sewer system.

5.5 2019 and Planned Future Engagement

In the summer of 2019, Project representatives went door-to-door and floor-to-floor along Broadway, 8th Avenue, 10th Avenue and cross streets between Kingsway and Vine to speak with local business managers and owners about their needs and interests. The Project continues to gather information to learn more about access, customers, product or services, and communications preferences.

In Fall 2019, the Project opened a Community Office at 1212 West Broadway to provide information and engage with local businesses and community members. The Project also hosted a series of three Open Houses, eight pop-up events and online information including a feedback form to provide information about the project, procurement and construction timeline, station locations, community and business relations and potential mitigation measures, and seek public feedback.

Throughout and beyond the pre-construction phase, the Project will continue to engage with the public and stakeholders, including maintaining the Project website and Community Office, and attending meetings and presentations.

The Project will also continue to consult and engage with stakeholders and the public as the Project moves into, and through, construction. Communications and engagement activities will include, but are not limited to:

- Providing Project update opportunities, through in-person, email, online at the Project website, and at the Community Office
- Responding to public and stakeholder enquiries
- Engaging with residents, community, business and medical groups

6 ENVIRONMENTAL AND SOCIO-ECONOMIC REVIEW SCOPE AND METHODS

This section of the Environmental and Socio-economic Review (ESR) describes the methods used to support the assessment of potential effects of the Project on environmental and socio-economic values within the Project area (see Section 7). Information presented in this section of the ESR report includes the methods used to:

- Select the environmental and socio-economic aspects to be assessed in the review (referred to as "Review Elements")
- Define the scope of assessment for Review Elements
- Describe existing conditions for Review Elements
- Identify Project interactions and assess the potential effects of the Project on Review Elements
- Identify mitigation measures to avoid or limit potential Project-related effects
- Discuss results of the review for each Review Elements including the effectiveness of proposed mitigation

Any refinements to the methods outlined in this section, to support the assessment of a specific Review Element, are provided in the relevant Review Element subsection of Section 7.

Methods for addressing and describing existing conditions specific to each of the Review Elements are described in Section 6.3.

6.1 Selection of Review Elements

Review Elements were selected to focus the assessment on aspects of the biophysical and socio-economic environment that are considered important or of value, and that may be affected by the Project. This was done by considering the following:

- Relevant environmental policies, regulations, or guidance
- Potential for Project-related effects
- Potential effects that have been assessed in similar projects (e.g., Evergreen Line, Canada Line)
- Interests and issues identified by Indigenous groups, government agencies, stakeholders, and the public

Feedback on the candidate Review Elements was obtained from the public and Indigenous groups through review and comment provided on the draft Terms of Reference (TOR) for the ESR, which was undertaken in the Fall of 2017. Following the comment period revisions were made to the draft TOR to reflect input obtained.

Key changes that were made to the TOR following the review and comment period include:

- The candidate Socio-economic Review Element was split into multiple Review Elements: Transportation and Access and Housing and Property. This refinement was made to allow for a focused consideration of potential effects associated with these specific aspects of the socio-economic environment.
- Aquatic Resources and Vegetation and Wildlife Resources have been included as Review Elements

The selected Review Elements, as per the final TOR, are as follows:

- Transportation and Access
- Housing and Property
- Archaeological and Heritage Resources
- Noise
- Vibration
- Air Quality and Greenhouse Gases
- Contaminated Sites and Excavated Materials
- Electric and Magnetic Fields (EMF)
- Aquatic Resources
- Vegetation and Wildlife Resources

Section 7 of the ESR assesses potential effects on each of these Review Elements following the approach outlined in Sections 6.2 through 6.7.

6.2 Scope of Review Element Assessment

This section of the ESR describes the methods for determining the scope of assessment of potential effects on each Review Element. The Review Element assessments in Section 7 outline the specific scope of the assessment for each Review Element.

6.2.1 Regulatory and Policy Setting

For each Review Element, the assessment outlines relevant regulatory requirements, policy, and guidance for the assessment of potential effects. This may include municipal, provincial, federal, and/or Indigenous considerations that are relevant to the management of the Review Element.

6.2.2 Engagement Input Supporting the Assessment

Sections 4 (Indigenous Consultation) and 5 (Public Engagement and Information Distribution) of the ESR describe information collected through consultation with Indigenous groups and engagement with government agencies, stakeholders, and community members. The Review Element assessments in Section 7 (Assessment of Potential Effects) describe how this information has been used to inform the scoping of the assessment and any relevant analyses.

6.2.3 Identification of Potential Effects and Indicators

For each Review Element, the assessment identifies potential effects that could result from the Project and that are of interest to regulators, public, stakeholders and Indigenous groups. These effects are measured using “indicators” that represent types of changes that could occur, relative to current conditions. The indicators enable quantitative or qualitative description of the potential changes to the Review Elements.

The draft TOR proposed potential effects and indicators for each Review Element included in the assessment, in consideration of information and concerns identified through consultation activities. Input was solicited from the public and Indigenous groups during the Fall 2017 review period. This input was incorporated into the final TOR and is summarized in Table 6.2-1.

Table 6.2-1: Potential Effects and Indicators

Review Element	Potential Effect	Indicators
Transportation and Access	Effects on existing transportation systems (e.g., road traffic, pedestrians, cyclists).	• Roadway description (e.g., number of lanes, traffic flow characteristics) • Change in parking • Change in vehicle volume (vehicles/day, vehicles-km travelled) • Transit (travel time, ridership) • Pedestrian/cyclist information mobility
Housing and Property	Effects on housing, residential properties and commercial businesses	• Change in access to properties • Population change • Number and type of residential properties affected by the Project • Housing availability • Number of businesses potentially affected and description of potential effects
Archaeological and Heritage Resources	Alterations to archaeological site contents or context (known and unknown)	• Inventory of potentially affected archaeological sites, description of potential alterations, and impacts of such alterations
	Alterations to heritage buildings, landscapes, or other sites of heritage value (known and unknown)	• Inventory of potentially affected heritage sites and description of potential alterations
Noise	Change in noise levels during construction and operation	• Predicted noise level during construction and operation phases quantified using following parameters: • Daytime and nighttime equivalent sound level (Ld and Ln) in dBA • Hourly equivalent sound level (Leq (1 hour)) in dBA • Day-Night sound level (Ldn) in dBA • 24-hour equivalent sound level (Leq (24 hours)) in dBA
Vibration	Change in vibration levels during construction and operation	• Predicted ground vibration levels during construction and operation phases quantified using the following parameters: • Peak particle velocity (PPV) in mm/s • Root mean square (RMS) velocity in mm/s

Table 6.2-1: Potential Effects and Indicators

Review Element	Potential Effect	Indicators
Air Quality and Greenhouse Gases	Project-related changes in emissions of CACs and changes in ambient air quality	• Changes to release of CACs (SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$, O_3, VOCs) as an indicator of changes in ambient CAC concentrations
	Project-related changes in emissions of greenhouse gases (GHGs) within the regional airshed	• Changes to release of GHGs (CO_2, CH_4, N_2O, reported as CO_{2e})
Contaminated Sites and Excavated Materials	Release of contaminants from contaminated soils or water encountered during construction	• Existence and location of contaminated sites • Nature of contaminated materials
EMF	Human health considerations associated with EMF levels	• Electric field (V/m) • Magnetic field (mG)
Aquatic Resources	Project-related effects on water quality	• Presence of water quality contaminants including Total Suspended Solids that effect habitat quality for aquatic resources
Vegetation and Wildlife Resources	Direct and indirect effects on vegetation, wildlife and wildlife habitat	• Change in the presence of species of management concern, abundance or quality of wildlife habitat and habitat features • Change in vegetated areas including the number and type of trees • Potential for injury or mortality risk to wildlife

6.2.4 Assessment Boundaries

The Review Element assessments presented in Section 7 incorporate spatial and temporal boundaries as described below.

Spatial boundaries encompass areas with higher potential for adverse effects. The draft TOR outlined proposed spatial boundaries by Review Element. This was subject to review and comment by the public and Indigenous groups. Input received was integrated into the final TOR and is presented by Review Element in Table 6.2-2.

Table 6.2-2: Review Elements and Spatial Boundaries

Review Element	Spatial Boundaries	Rationale
Traffic and Transportation	Area bounded by major roads adjacent to the Broadway Corridor within the City of Vancouver	Represents an area large enough to establish context for estimating Project effects relative to existing conditions and where Project-related activities could be attributed to a direct, predictable, and measurable change to Transportation and Access.
Housing, Residential Properties, and Commercial Businesses	Area bounded by major roads adjacent to the Broadway Corridor within the City of Vancouver	Represents an area large enough to establish context for estimating Project effects relative to existing conditions and where Project-related activities could be attributed to a direct, predictable, and measurable change to Housing and Property.
Archaeological and Heritage Resources	Within 100 m of the Alignment	Representative of the area where direct and indirect Project effects (e.g., ground disturbance) could potentially affect archaeological and heritage resources.
Noise	Within 300 m of the Alignment	Represents the area that encompasses the nearest receptor location to the Alignment.
Vibration	Within 300 m of the Alignment	Represents the area that encompasses the nearest receptor location to the Alignment.
Air Quality and Greenhouse Gases	City of Vancouver Lower Fraser Valley (LFV) airshed is considered the regional boundary	The City of Vancouver was selected because this is the smallest spatial boundary for which an emission inventory is available for analysis. Air emissions from Vancouver will disperse into the Lower Fraser Valley airshed, which is considered as the regional spatial extent for this analysis.
Contaminated Sites	Within 100 m of Alignment	Represents an area where it is possible that existing contamination at neighbouring properties could migrate to the Alignment through soil and/or groundwater.
EMF	Within 100 m of Alignment	Based on the EMF strengths generated by the Project, 100 m is the furthest distance that electromagnetic interference with other systems can reasonably be expected.
Aquatic Resources	Watercourses located within 50 m of Alignment, and waterbodies that receive project-related runoff	The 50-m buffer is to evaluate watercourses, including riparian habitat, that fall within the area of potential influence of construction activities. The waterbodies receiving Project-related runoff are included to evaluate potential for downstream effects.
Vegetation and Wildlife Resources	Within 100 m of Alignment	Represents the area where direct and indirect Project effects (e.g., vegetation clearing, sensory disturbance from noise, vibration, and light) could potentially affect vegetation and wildlife resources.

Temporal boundaries provide the timeframe within which potential effects are assessed in relation to Project phases and activities. Temporal boundaries are based on the timing and duration of Project activities (i.e., during construction and operation) that may interact with a Review Element. Based on the current Project schedule, the temporal boundaries for the assessment are as follows:

- **Construction**: An approximately 5-year construction period starting in 2020
- **Operation**: Beginning in 2025 and operating on an ongoing basis

6.3 Existing Conditions

The description of existing conditions specific to each Review Element is based on data collected during desktop review and, where applicable, field programs. Where information is available, pre-Project conditions are described to provide context for the assessment of specific Review Elements.
The description of existing conditions is guided by the spatial boundary established for each Review Element (see Table 6.2-2).

6.4 Project Interactions

The assessment evaluates the potential interactions between each Review Element and Project activities and physical works. These potential interactions are outlined by Project phase in Table 6.4-1.

Table 6.4-1: Potential Project Interactions with Review Elements

Project Activities and Physical Works	Transportation and Access	Housing and Property	Archaeology and Heritage Resources	Noise	Vibration	Air Quality and Greenhouse Gases	Contaminated Sites & Excavated Materials	Electric and Magnetic Fields	Aquatic Resources	Vegetation and Wildlife Resources
Construction										
Property acquisition	-	✓	-	-	-	-	-	-	-	-
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	✓	✓	✓	✓	✓	✓	✓	-	✓	✓
Elevated guideway construction	✓	✓	✓	✓	✓	-	✓	-	✓	✓
Tunnel and station excavation	✓	✓	✓	✓	✓	-	✓	-	✓	✓
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	✓	✓	-	✓	✓	-	-	-	✓	✓
Vehicle traffic (e.g., road use and construction traffic)	✓	✓	-	✓	✓	✓	✓	-	✓	-
Management and disposal of waste and excavated materials	-	-	-	-	-	-	✓	-	✓	-
Commissioning and start-up	✓	-	-	-	-	-	-	-	-	-
Operation										
Train operation, including wayside and power	✓	-	-	✓	✓	✓	-	✓	-	-
Station operation	-	✓	-	✓	-	-	-	-	-	-
Train maintenance, administration, transit police	-	✓	-	-	-	-	-	-	✓	-

Where it is determined that interactions may result in potential effects, they are carried forward to the Review Element assessments in Section 7. These interactions are then further refined to focus on the specific potential effect(s).

The Review Element assessments presented in Section 7 begin with a brief description of the mechanism by which a Project activity or physical work could affect a Review Element. Project effect mechanisms are provided for each Project phase, where applicable. Where activities and physical works are not anticipated to interact with the Review Element in a manner resulting in a potential effect, justification is provided.

For interactions between a Review Element and the Project that may cause a potential effect, the assessment proceeds with identifying appropriate mitigation measures (see Section 6.5), and discussing the Project effects (see Section 6.6) following the application of these mitigation measures.

6.5 Mitigation Measures

The Review Element assessments in Section 7 identify Project- and site-specific, industry-standard mitigation measures, that can be applied, to avoid or reduce the potential effects of the Project on Review Element. Such measures may include planning and design approaches, in addition to the application of management practices, to avoid or reduce potential Project-related effects. A summary of mitigation measures is provided in Appendix A.

During construction of the Project, the Contractor may employ mitigation measures identified in the ESR, to avoid or limit potential effects on Review Elements, but will also have the flexibility to utilize other means of mitigation that may be more effective and better aligned with the specific design and construction methods being used.

Section 9 (Environmental Management Plans) describes mechanisms that the Project team will employ, during the construction phase, such that the Contractor complies with contractual and regulatory requirements related to avoiding or limiting potential effects to the Review Elements considered in the ESR.

6.6 Discussion of Review Results

The Review Element assessments in Section 7 include an analysis of effects on each Review Element anticipated to result from interactions with Project activities or physical works. The analysis is supported by the use of applicable analytical methods. Relevant criteria such as magnitude, geographical extent, and duration are used to describe the effects. Where effects cannot be characterized quantitatively, they are discussed qualitatively.

This section also discusses the effectiveness of mitigation measures in managing potential effects and outlines any recommendations for ongoing monitoring or management requirements, as appropriate. The discussion of review results, for specific Review Elements, may also include reference to applicable environmental management plans as described in Section 9 (Environmental Management Plans) of the ESR.

6.7 Conclusion

The conclusion section provides a concise summary of the conclusions of the Review Element review.

7 ASSESSMENT OF POTENTIAL EFFECTS

The Environmental and Socio-Economic Review (ESR) includes an assessment of environmental and socio-economic effects based on selected Review Elements identified herein. The assessment of each Review Element will be conducted following the methods specified in Section 6.

7.1 Environmental and Socio-economic Setting

This section of the ESR describes the environmental and socio-economic setting for the Broadway Subway Project (the Project), including an overview of the geographical and biophysical features, built environment, and land use in the vicinity of the Alignment. Detailed baseline information is provided in each Review Element subsection.

7.1.1 Geographic and Physical Setting

The Project will be located in the City of Vancouver, British Columbia (BC) from the existing Millennium Line VCC-Clark Station to a new terminus at Arbutus Street and West Broadway (Figure 1-1 in Section 1).

The Project is located on lands within the asserted traditional territories of the Musqueam Indian Band and the Squamish and Tsleil-Waututh Nations. The Sto:Lo Nation, Sto:Lo Tribal Council, and Hul'qumi'num Treaty Group have also asserted that they, or one or more of their member Indigenous groups, have interests within, or in proximity to, the Alignment (see Section 4 [Indigenous Consultation]).

The above ground section of the Alignment between the existing VCC-Clark Station and Great Northern Way crosses the relatively flat terrain (i.e., change in ground surface elevation of 2 m) of the False Creek Flats, with an increase in elevation as the Alignment moves west of Great Northern Way. Surface elevations along the underground portion of the Alignment vary from approximately 22 m near the station at Cambie Street, to approximately 48 m near Alder Street (Golder Associates Ltd. 2017). The section of the Alignment located in the False Creek Flats area near Great Northern Way was previously reclaimed by filling. Soils and underlying conditions vary along the Alignment, and include granular soils and fill, loose silty sand, sand, silt clay, and dense till-like soils. Bedrock is primarily sedimentary sandstone, encountered at a range of approximately 3–19 m below ground surface (Golder Associates Ltd. 2017).

7.1.2 Biophysical Setting

Areas within and adjacent to the Alignment are highly modified and developed and consist of buildings, roadways, sidewalks, and parking areas. The following provides an overview of biophysical conditions within, and adjacent, to the Alignment.

7.1.2.1 Vegetation and Wildlife Resources

Given that the Alignment is in a highly developed urban area, the study area contains limited natural vegetation and wildlife habitat. Vegetation that does exist along the above-ground section of the Alignment consists predominantly of deciduous trees and shrubs and provides suitable habitat for common urban bird species (e.g., song sparrow [*Melospiza melodia*], spotted towhee [*Pipilo maculatus*], and northwestern crow [*Corvus caurinus*]), as well as other urban wildlife (e.g., raccoon, striped skunk [*Mephitis mephitis*]). There are no known occurrences of provincially Blue- or Red-listed vegetation or wildlife species within or adjacent to the Alignment (Province of British Columbia 2017a, b).

7.1.2.2 Aquatic Resources

The Alignment does not cross any surface watercourses (e.g., streams, ditches, ponds, wetlands) (Province of British Columbia 2017a). The nearest waterbody is the marine environment of False Creek, located 400 m north of the Alignment. Historically, several streams crossed the proposed Alignment flowing north into False Creek (Vancouver Public Aquarium Association 1987). Due to historic urban development, existing surface watercourses within the Review Area were diverted and are contained within the underground storm water and sewer system.

7.1.2.3 Air Quality and Greenhouse Gases

Regional air quality for common air contaminants in the Review Area is considered good and has improved in recent decades due to numerous airshed management and planning initiatives. In 2010 36% of Metro Vancouver's greenhouse gas emissions were from transportation sources (i.e., light and heavy-duty vehicles) (Metro Vancouver 2013). In 2013, there were no exceedances of the Metro Vancouver ambient air quality objectives at the Vancouver-Kitsilano or Richmond Airport stations (Metro Vancouver 2014). In 2014, concentrations of ambient carbon monoxide and nitrogen dioxide in the Lower Fraser Valley airshed did not exceed ambient air quality objectives.

7.1.2.4 Noise and Vibration

The acoustic environment at monitored locations along the Alignment is typical of a busy urban environment. Road traffic (i.e., passerby traffic, air brakes, horns, backup alarms, engine starts) is the dominant noise source, with passerby/parked trucks, first responder vehicles, and rail locomotives producing the loudest sound levels. Vibration sources and levels along the Alignment are typical of a busy urban environment, and include vibration from road traffic, rail traffic, and haul trucks.

7.1.3 Socio-economic Setting

The following sections provide information on population and demographics, labour force and educational attainment, and housing and land use for the City of Vancouver.

7.1.3.1 Population and Demographics

The City of Vancouver is within the Metro Vancouver Regional District (formerly the Greater Vancouver Regional District), which includes 21 municipalities, one Treaty First Nation, and one Electoral Area. The City of Vancouver covers 115 km^2 and in 2016 had a population of 631,486 (51% female, 49% male), roughly one-quarter of the population of Metro Vancouver (Statistics Canada, 2017). In 2016, an estimated 13,905 persons identified as being of Aboriginal Identity (Statistics Canada, 2017). By 2041, it is expected that the population of the City of Vancouver will increase by approximately 25% (Metro Vancouver 2011).

In 2016, 11.2% of the City of Vancouver's population was below the age of 15, 73.3% between the ages of 15 and 64 (21.5% between the age of 15 and 29, 24.5% between the age 30 and 44, 27.3% between the age of 45 and 64), and 15.2% aged 65 years and older (13.0% between the ages of 65 and 85, and 2.2% aged 85 years and older; Statistics Canada 2017). The average and median age of the population of the City of Vancouver in 2016 was 41.6 years and 39.9 years respectively (Statistics Canada 2017).

Approximately 25.7% of the population residing in the City of Vancouver speaks a non-official language regularly at home (Statistics Canada, 2017). The most common first language spoken at home other than English is Cantonese (37.7%) followed by Mandarin (18.8%), Tagalog, Punjabi, Vietnamese, Spanish, and Korean (all less than 6%) (Statistics Canada, 2017).

7.1.3.2 Labour Force and Educational Attainment

The labor force participation rate (the percent of the population actively employed or seeking employment) for the City of Vancouver in 2016 was 67.7% (Statistics Canada 2017). The unemployment rate for Vancouver in 2016 was 5.6% (Statistics Canada 2017). In 2016, occupational employment was greatest in 'sales and service', 'business, finance and administration', and 'education, law, social, community, and government services'. Combined, these three occupational classifications accounted for 53.0% of total employment in the City of Vancouver (Statistics Canada 2017).

In 2016, 87.4% of the population of the City of Vancouver (aged 15 years and older) had successfully completed formal education at or above the secondary (high) school diploma level (Statistics Canada 2017). In terms of the highest certificate, diploma, or degree attained, 24.2% of the population held a secondary (high) school diploma or equivalent, 4.8% an apprenticeship or trades certificate or diploma, 14.9% a college or other non-university certificate or diploma, 3.5% a university certificate or diploma below the bachelor level, and 40.0% a university certificate, diploma, or degree at or above the bachelor level (Statistics Canada 2017).

7.1.3.3 Housing and Land Use

Within the broader context of the Indigenous territorial interests references above (Section 7.1.1), the Alignment runs east-west through the communities of Grandview-Woodlands, False Creek Flats (Strathcona), Mount Pleasant, Fairview, and Kitsilano. Properties in these communities include commercial, residential, and mixed-use buildings (i.e., retail on lower levels and residential on upper levels), light- and heavy-industrial areas, Vancouver General Hospital, and the Port of Metro Vancouver facilities (City of Vancouver 2017c).

Recently-approved land use plans for the communities of Grandview-Woodlands, Mount Pleasant, and False Creek Flats have incorporated policies to support increased development and density. The Grandview-Woodland Community Plan prioritizes the creation of additional affordable housing (i.e., market and non-market housing units), improvements to pedestrian safety, and cycling network and safety improvements (City of Vancouver 2017a). The Mount Pleasant Community Plan focuses on developing cycling and pedestrian routes, revitalizing the Broadway East area, and addressing gaps and future needs for childcare, cultural spaces, and affordable housing (City of Vancouver 2010). The primary focus of the False Creek Flats Area Plan is to intensify employment while preserving valuable industrial land through development of new rental housing opportunities for students and local employers, new walking and cycling paths (over rail lines) to improve connections, and accommodation of the future site for St. Paul’s Hospital and Health Campus (City of Vancouver 2017b).

Land use planning for the Broadway Corridor is centered around supporting transportation network reliability to improve quality of life and address environmental and economic issues. The City of Vancouver’s Broadway Plan (City of Vancouver 2018a) will address increased job space, housing affordability, new or improved connections, improved parks and public spaces, and public amenities.

The Project runs near Vancouver General Hospital, which is the largest hospital in Western Canada, one of the largest medical research institutes in Canada, and the only Level 1 Trauma Centre in BC (VGH & UBC Hospital Foundation 2018). The Project also runs near two BC Cancer Agency Vancouver Centre locations which provide chemotherapy, radiotherapy, surgery, and oncology consultations.
Two Vancouver Fire and Rescue Services firehalls are located along the Alignment in the Mount Pleasant and Fairview communities, while the headquarters of the Vancouver Police Department are located in Mount Pleasant and the Kitsilano-Fairview Community Policing Centre is located in Fairview.

There are seven public schools, nine private schools, and two post-secondary institutions located within the Review Area. Several post-secondary institutions, including Vancouver Community College and Emily Carr University of Art + Design, as well as professional training centres and continuing studies institutions are located along the Alignment.

There are 18 parks located within the Review Area. The closest park to the Alignment, Guelph Park, is approximately 1 ha in size and includes a playground, tennis courts, and fields (City of Vancouver 2018b). The remaining 17 parks are all located more than 100 m from the Alignment. There is one community centre located within the Review Area: Mount Pleasant Community Centre. The community centre includes a gym and climbing wall, fitness centre, dance studio, multi-purpose rooms, outdoor space, a public library, child development centre, and café (Mount Pleasant Community Centre 2018).

Retail centers along the Alignment include the South Granville shopping district and Granville Island, which provide residents with access to grocery stores, banks, fitness centres, restaurants, and professional services. There are artist studios and galleries, low-rise commercial properties, and mixed-use developments along Great Northern Way. There are several low-, mid-, and high-rise commercial properties and mixed-use retail properties along West Broadway between Main Street and Arbutus Street, as well as commercial development, mid- and high-rise hotels, and comprehensive development between Cambie Street and Oak Street.

7.2 Transportation and Access

This section of the Environmental and Socio-Economic Review (ESR) evaluates Project-related changes in transportation and access. Changes to transportation and access from Project activities are evaluated relative to existing conditions for the Review Area.

Given that the Project is anticipated to address existing transportation and access challenges in the Broadway Corridor the assessment presented in this section focuses primarily on potential construction phase considerations.

The assessment of potential effects on transportation and access, during Project construction, has been undertaken in parallel with Project planning, to mitigate effects on transportation and access during construction as much as possible. This iterative planning and assessment process, which was supported by traffic modelling, assisted with identifying potential effects to transportation and access during construction and evaluating mitigation approaches.

The primary objective guiding this approach to planning and assessment was to mitigate effects on transportation[4] and access considerations during construction, including: emergency vehicles, transit, access for business, trucks, general-purpose road traffic, pedestrians and cyclists.

Transportation related benefits of the Project are discussed in Section 3 (Project Benefits).
Section 7.2.4.2 (Operations) discusses potential refinements to existing transportation infrastructure that may be required to accommodate the Project.

Key information provided to support the assessment of Transportation and Access includes:

- Rationale for selection of Transportation and Access as a Review Element
- Methods used to review potential effects of Project activities in the context of regulatory requirements and policy applicable to this Review Element
- Existing conditions for transportation and access within the Review Area
- A summary of Project components and activities that may interact with transportation and access
- A description of mitigation measures to limit or avoid effects on transportation and access during construction
- A discussion of review results and conclusions

[4] The terms “transportation” and “traffic” are defined to be inclusive of all modes of transportation and user groups (i.e., emergency vehicles, transit, commercial and passenger vehicles, pedestrians and cyclists). Reference to traffic management plans. discussed in the ESR, are also inclusive of the same modes and user groups.

7.2.1 Rationale for Selection as a Review Element

Transportation and Access was selected as a Review Element because Project activities during construction are expected to affect transportation infrastructure, transportation, and access, which are of interest to stakeholders and the public. The review of potential effects on Transportation and Access, which focuses on potential construction phase effects, was conducted based on the indicators presented in Table 7.2-1 and the Terms of Reference.

Table 7.2-1: Potential Effects and Indicators for Transportation and Access

Potential Effects	Project Effects Mechanisms	Indicators	Rationale for Selection of Indicators
Change in transportation	• Project construction will result in temporary changes to existing transportation infrastructure (e.g., number of lanes, traffic signals) • Project construction will result in increased congestion for on road vehicles during construction.	• Transit (travel time, ridership) • Pedestrian/cyclist mobility • Safety • Motor vehicle travel times	• Project construction is expected to affect travel times for all modes • Importance of identifying and mitigating potential transportation-related safety risks during construction • Project construction has the potential to affect access for emergency service providers
Change in access	• Project construction has the potential to temporarily change access to residential, commercial, and institutional properties in the Broadway Corridor	• Change in access to residential and commercial properties • Change in access for emergency services vehicles • Access to parking	• Project construction has the potential to change access to some properties along in the Corridor • Project has potential to change access for emergency service providers • The Project may adversely affect parking access and supply

7.2.2 Review Scope for Transportation and Access

7.2.2.1 Regulatory and Policy Setting

Legislation, regulations, and policies that frame the evaluation of the Transportation and Access Review Element are presented in Table 7.2-2.

Table 7.2-2: Regulatory Setting for Transportation and Access

Responsible Agencies	Law, Regulation, Policy	Description	Potential Project Applicability
TransLink	Regional Transportation Strategy Strategic Framework	A long-term strategy which helps guide transportation decisions in Metro Vancouver over the next 30 years by establishing goals, principles, strategies, and key initiatives.	The Project is aligned with and supports the Plan.
Mayors' Council of Metro Vancouver	Regional Mayors' Council Vision for Regional Transportation Investment	A plan for investments in public transit, major roads, cycling and walking infrastructure in Metro Vancouver over the next 10 years.	The Project is aligned with and included in the Mayor's Vision.
City of Vancouver	2040 Transportation Plan	A long-term strategic vision for Vancouver to help guide transportation and land use decisions, and public investments in the future. The Plan includes long-term targets, high-level policies, and specific action to achieve set targets.	The Project is aligned with and supports the Plan.
City of Vancouver	Street & Traffic By-law No. 2849	Regulates traffic, the use of streets, and the size and weight of vehicles that are permitted to travel on Vancouver streets.	Guides traffic management measures during construction.
TransLink	TransLink Bus Infrastructure Design Guidelines	Sets comprehensive guidelines related to the planning and design of transit infrastructure.	Provides guidance should bus routes or stops require relocation.
City of Vancouver	Transportation Design Guidelines: All Ages and Abilities Cycling Routes	A guideline providing 10 general rules to consider when designing or designating a route as all-ages-and-abilities (AAA).	Provides guidance should an AAA bike route require detours.
City of Vancouver	Design Criteria Manual	Design guidelines for transportation and utilities in Vancouver.	Provides guidance for lane widths and other design elements during construction.

Table 7.2-2: Regulatory Setting for Transportation and Access

Responsible Agencies	Law, Regulation, Policy	Description	Potential Project Applicability
BC Ministry of Transportation & Infrastructure (MOTI)	2015 Interim Traffic Management Manual for Work on Roadways	Outlines fundamental principles and guidelines for traffic management and traffic control with the goal of safe and efficient movement of road users through a work zone and safety of workers.	Provides guidance to traffic management plans and application of traffic control standards during construction.
MOTI	Manual of Standard Traffic Signs and Pavement Markings	Sets standards for design and application of traffic signs.	Traffic sign standards must be followed during construction.

The Regional Transportation Strategy Strategic Framework (adopted by TransLink in 2013) identified the Broadway Corridor[5] as a regional rapid transit corridor (TransLink, 2018a), with the Broadway Subway Project recommended as a transportation priority in the Regional Mayors' Council Vision for Regional Transportation Investment (2015).

The City of Vancouver adopted the 2040 Transportation Plan in 2013, which included policies to advance new and improved rapid transit and identified the Broadway Corridor as a major gap in the regional transit network and as a focus area for rail-based underground rapid transit (Vancouver, 2012). The plan includes direction for land use to support sustainable transportation choices, including prioritizing for dense and diverse development in areas served by rapid transit and establishing trip generating entities (e.g., schools, employment centres, shopping districts) along current and future rapid transit corridors.

The Broadway Subway is a key part of the rapid transit program in the Mayors' Investment Plan and has received funding support from the Governments of Canada and British Columbia, and City of Vancouver as follows:

- Government of Canada: $888.4 million
- Government of British Columbia: $1.82 billion
- City of Vancouver: $99.8 million (in-kind land contribution)

7.2.2.2 Engagement Input Supporting the Assessment

The assessment of Transportation and Access was informed by input received during engagement with public stakeholders and consultation with Indigenous groups. Key comments received during public engagement, related to Transportation and Access during construction, include:

- Increased traffic in neighbourhoods
- Changes to bus services
- Preservation of bike lanes
- Road congestion
- Accessibility to businesses, residences, schools, hospitals, and other facilities
- Prohibiting construction-related vehicles from parking in residential areas

Engagement also identified operational-phase interest including:

- Multi-modal transit integration during operations
- Safety and security

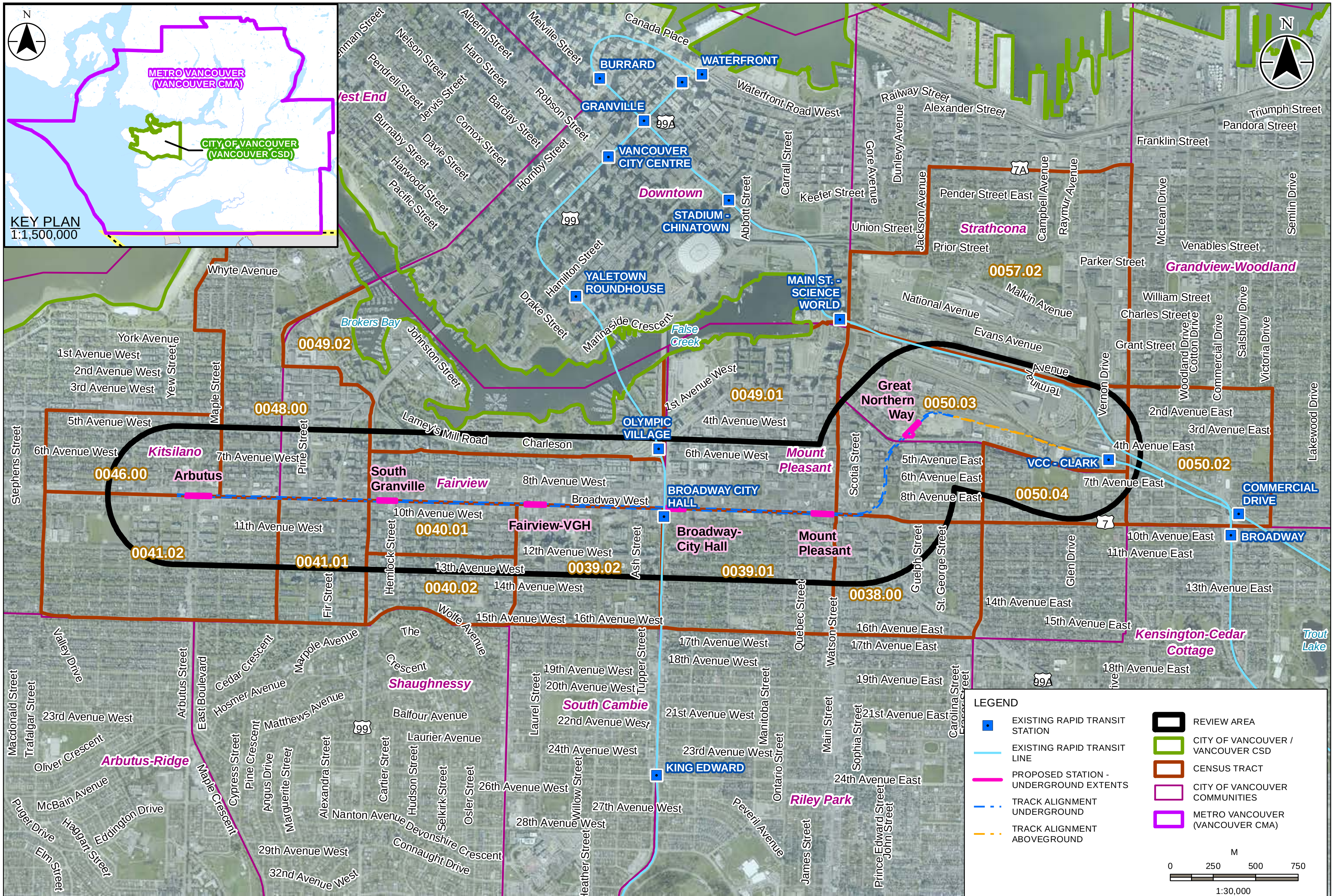
5 segment of Broadway from Victoria Drive to the University of British Columbia

7.2.2.3 Selection of Effects and Indicators

Table 7.2-1 outlines the potential Project effects on Transportation and Access and summarizes the Project effect mechanisms and indicators used to assess the potential effect. The effect mechanisms identified in this table are described in more detail in Section 7.2.4 (Project Interactions). The use of indicators facilitates the qualitative or quantitative measurement of potential effects.

7.2.2.4 Boundaries

The spatial boundary of the Review Area for Transportation and Access includes neighbourhoods and travel routes within Vancouver that are within 400 m of the Project as shown in Figure 7.2-1. The Review Area represents the spatial extent within which Project-related activities could result in effects on Transportation and Access during Project construction.



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BROADWAY SUBWAY PROJECT

Stantec

BROADWAY SUBWAY PROJECT

TRANSPORTATION AND ACCESS REVIEW AREA

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7.2.2.5 Methods

Information on existing Transportation and Access conditions to support the review of Transportation and Access was primarily obtained from public sources (e.g., Statistics Canada, City of Vancouver), public engagement summaries, interviews with key personnel involved in recent rapid transit projects in the Lower Mainland, and traffic studies prepared for the Project. Information was also obtained through a review of studies and assessments of similar rapid transit projects in Metro Vancouver (e.g., Canada Line and Evergreen Line).

Potential construction-related effects were evaluated by considering how construction activities (e.g., station construction, construction related truck traffic etc.) may affect mobility and access within the Broadway Corridor. As noted in Section 7.2, the evaluation was supported by traffic modelling that takes into account historical and forecast traffic information, volumes for existing and expected road use during construction.

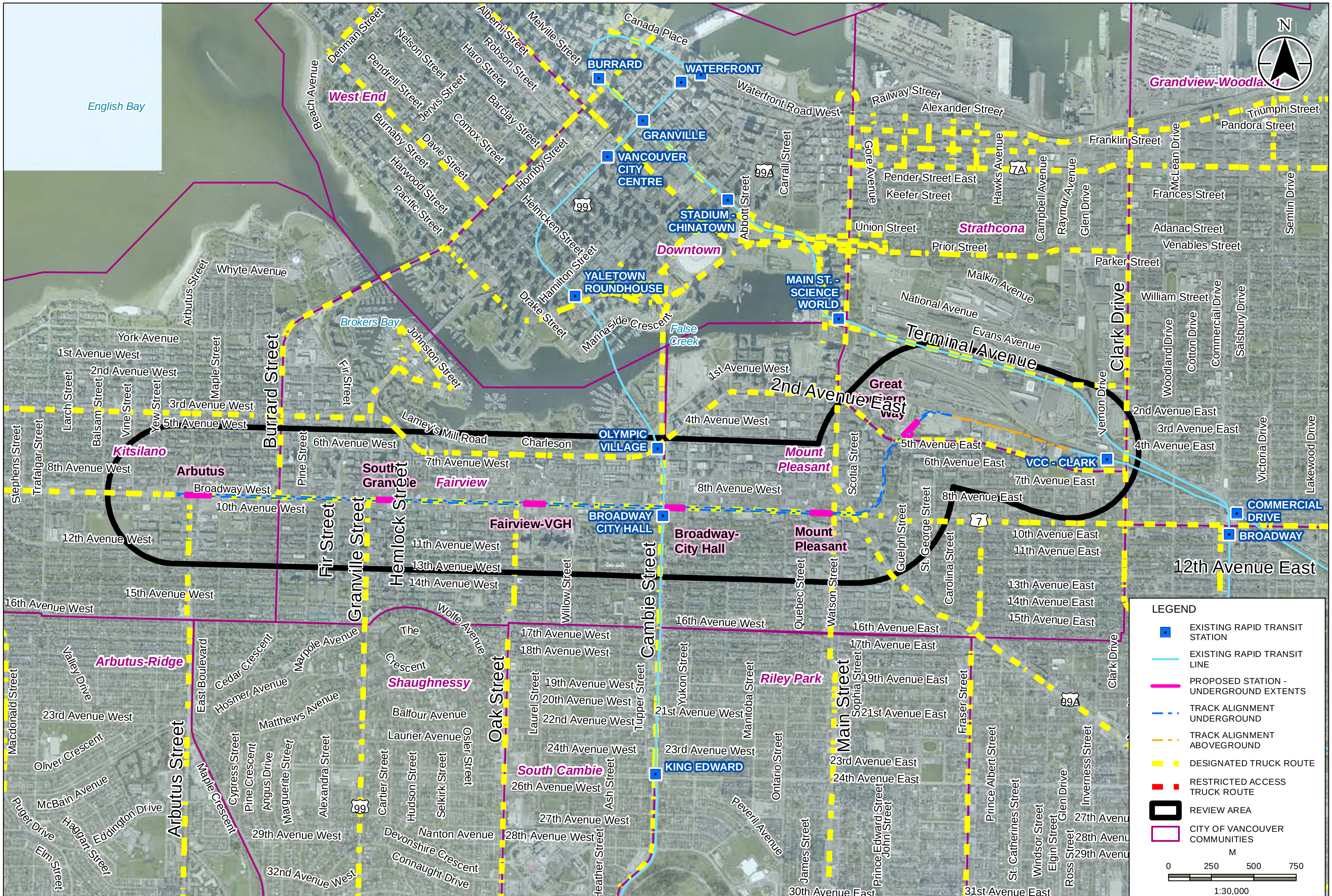
7.2.3 Existing Conditions

The following sections provide information on transportation infrastructure in the Review Area as well as existing conditions with respect to current use by different transportation modes and access requirements.

7.2.3.1 Transportation Infrastructure

Road Network

Major roads within the Review Area are shown on Figure 7.2-2. There are three main East-West travel corridors within the Review Area between VCC-Clark and Arbutus-Broadway as shown on Figure 7.2-2 (Great Northern Way/2nd Avenue, Broadway, 12th Avenue). Key north-south routes intersecting the Review Area include Clark Street, Main Street, Cambie Street, Oak Street, Granville Street, Burrard Street, and Arbutus Street. Traffic modelling, undertaken to support construction planning, focused on the Broadway Corridor where the biggest traffic impacts are expected.



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MAJOR ROADS AND TRUCK ROUTES IN THE REVIEW AREA

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Truck Routes

Approximately 800 trucks travel along Broadway between 8:00 am and 8:00 pm each day, making it one of the busiest designated trucking routes for goods movement in Vancouver (MOTI 2018). Other truck routes that intersect the Alignment include Kingsway, Main Street, Cambie Street, Oak Street, Granville Street, Burrard Street, and Arbutus Street (Vancouver 2017a).

Parking

Metered parking is currently only available during off-peak hours along Broadway and most major north-south roads of the Alignment. Great Northern Way has some areas with no parking restrictions, and some limited to two hours between 9:00 am and 6:00 pm Monday to Friday. Residential parking permit zones are common on local roads near the proposed stations. In addition, there is substantial commercial off-street parking available throughout the Review Area.

Public Transit Infrastructure

The Review Area is serviced with rapid transit by the Canada Line SkyTrain at the Broadway-City Hall station and by the Millennium Line SkyTrain at VCC-Clark station. The Review Area is also served by a number of bus routes (see Figure 7.2-3). The curb lanes in the Review Area along Broadway, in both eastbound and westbound directions, typically operate as bus only lanes during the morning and evening peak periods.

SOURCE: TransLink 2018

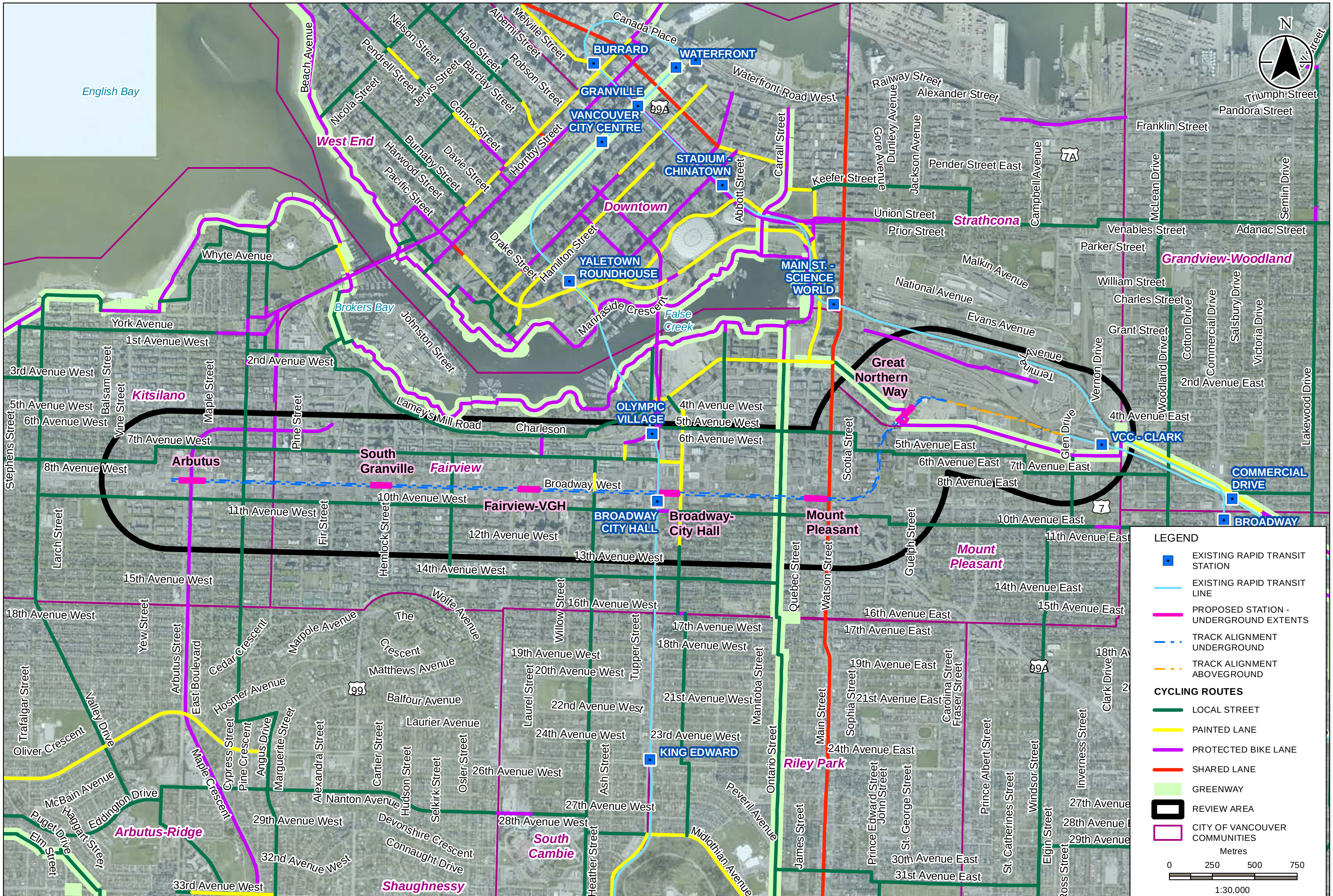
Figure 7.2-3: Transit Network, Centre on the Review Area

The segment of Broadway from Commercial Drive to Alma Street is classified as part of the 'frequent transit network'.

The 'frequent transit network' classification is identified by TransLink on routes with transit service at least every 15 minutes every day, beginning at 6:00 am on weekdays, 7:00 am on Saturdays, and 8:00 am on Sundays, and runs until 9:00 pm every day (TransLink 2018b). Several other roads intersecting Broadway are also classified as part of the frequent transit network, including Arbutus Street, Granville Street, Oak Street, Cambie Street, Main Street, Fraser Street, and Knight Street/Clark Drive.

Cycling

Key cycling routes in the Review Area include: 10th Avenue, Ontario Street, Heather Street, Yukon Street, Cypress Street, 7th Avenue, the Central Valley Greenway, the BC Parkway and the Arbutus Greenway (Figure 7.2-4). The Central Valley Greenway, which runs along 2nd Avenue and Great Northern Way, connects to another regional cycling route (the BC Parkway) just past the Commercial-Broadway SkyTrain station.



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BROADWAY SUBWAY PROJECT

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BROADWAY SUBWAY PROJECT

BIKEWAYS AND GREENWAYS IN THE REVIEW AREA

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7.2.3.2 Transportation Demand and Travel Times

The Broadway Corridor is one of the busiest transportation corridors in the City of Vancouver and supports significant transportation modes including road, transit and pedestrian use, as well as parallel and crossing bike routes. This section provides an overview of travel demand, by mode, including information on volumes of vehicle and transit traffic and existing travel times.

Information obtained through Statistics Canada, which surveyed commuting habits within the City of Vancouver (Table 7.2-3), illustrates commuting modes for the employed workforce between the Review Area and the City of Vancouver and shows that within the Review Area approximately 59% of people took public transit, walked, or cycled to work in 2016. The proportion of people in the Review Area relying on personal motor vehicles for transportation to work (41.1%) was less than the city average.

The Statistics Canada data also shows growth in the use of transit, cycling and walking between 2011–2016 that parallel decreases in the use of personal motor vehicles for commuting. This trend occurred even with existing transit systems within the Corridor operating at maximum capacity and suggests latent transit demand that would be supported by the Project and the opportunity to further shift to more sustainable modes of commuting.

While transit vehicles make up a relatively small proportion of the total vehicle fleet that uses the Broadway Corridor, they move a substantial number of people. Including routes 14, 16 and 17 that travel part of their routes on Broadway, more than 100,000 transit riders travel in the Corridor each day. Based on 2017 Bus Service Performance Review, 56,000 people per day rode route 99 with 22,700 riding route 9 for a total of close to 79,000 per day during weekdays.

Table 7.2-3: Mode of Transport for Commuting to Work—City of Vancouver and Review Area, 2011 and 2016

Mode of Transportation	City of Vancouver		Review Area	
	2011 Trips (% of total)	2016 Trips (% of total)	2011 Trips (% of total)	2016 Trips (% of total)
Car, truck or van—as a driver	48.0%	45.4%	39.2%	38.7%
Car, truck or van—as a passenger	3.6%	3.6%	2.5%	2.4%
Public transit	30.0%	29.7%	33.8%	30.4%
Walked	12.5%	13.7%	15.3%	16.5%
Bicycle	4.4%	6.1%	7.5%	10.4%
Other	1.6%	1.4%	1.7%	1.6%

NOTE:
* 25% sample data
SOURCE:
Statistics Canada 2017b, 2013.

Motor Vehicles

Traffic count data at locations along Broadway was collected to support planning for traffic management that will be required during Project construction. East-West traffic volumes ranged from 25,500 vehicles/day to 32,200 vehicles/day during the week, and up to 27,200 vehicles/day on the weekend (Table 7.2-4) Peak traffic volumes occur during the AM and PM rush hours. Weekday traffic along the Broadway Corridor ranged from approximately 1,800 to 2,400 vehicles/hour during the AM peak period, and from 2,000 to 2,500 vehicles/hour during the PM peak period.

Table 7.2-4: East-West Weekday and Weekend Traffic Counts, 2017

Location	Weekday ADT		
	Eastbound	**Westbound**	**Two-way**
West of Main Street	15,100	17,100	32,200
East of Cambie Street	17,300	14,400	31,700
West of Oak Street	13,200	15,400	28,600
West of Granville Street	14,400	11,100	25,600
East of Arbutus Street	12,600	12,900	25,500

Heavy truck traffic ranged from 15 to 40 trucks per hour, whereas light truck traffic ranged from 90 to 160 vehicles per hour, which is in the order of 3% of the total intersection volumes (Stantec 2019). Truck volumes were observed to be higher in the midday period compared to AM/PM peak periods on weekdays (Stantec 2019).

Travel time surveys were conducted as part of data collection for the traffic modelling for the Project. Survey findings show that the travel time along the Broadway Corridor varied from 11 minutes to 19 minutes (Stantec 2019). Eastbound travel times were observed to be the longest during the weekday PM peak (3:00 pm to 6:00 pm; Stantec 2019). Westbound travel times were observed to be the longest during the weekday midday peak (11:00 am to 1:00 pm) and the Saturday peak (12:00 pm to 4:30 pm; Stantec 2019).

Public Transit

Table 7.2-5 summarizes bus ridership for bus routes travelling through the Review Area.

Table 7.2-5: Bus Route Ridership in the Review Area

Bus Route Name	Route one-way trip distance (km)	Daily Volume Mon-Fri
B-Line (99)	12.4	55,700
Boundary/Broadway Station/Granville/Alma (9)	9.0	22,200
Hastings/Downtown/UBC (14)	12.7	16,450
29th Avenue Station/Arbutus (16)	16.7	21,850
Downtown/Oak (17)	9.6	9,000
UBC/Downtown (22)	8.6	5,740
Waterfront Station/False Creek South	6.6	4,400
VCC-Clark Station/UBC (34)	11.5	9,750
SOURCE: TransLink 2016a.		

Travel time surveys were conducted for bus routes along Broadway (Stantec 2019). Buses on routes 9 and 99 travel along Broadway, from Commercial Drive to Arbutus Street. Routes 14, 16, and 17, which collectively have an average volume of daily of over 47,000 passengers, pass through the Broadway Corridor and serve primarily north-south bus service.

The 99 B-Line is the busiest bus route in Metro Vancouver. During peak periods, the 99 B-Line operates on a three-minute headway. Even then, 99 B-Line busses are overcrowded one-third of the time, with some transit riders being passed up by full buses (MOTI 2018). Travel times from Commercial Drive to UBC on the 99 B-Line can vary by up to 15 minutes (MOTI 2018).

Rapid transit lines associated with the Review Area carry substantial passenger volumes and the Project is anticipated to facilitate further growth in rapid transit passenger volumes as some passenger volumes shifts from bus to rapid transit service. Table 7.2-6 provides average daily station entries for rapid transit stations within the Project Corridor. In 2016, Commercial-Broadway was the second busiest SkyTrain station, with 24,100 average daily weekday entries (TransLink 2016b).

Table 7.2-6: Rail Rapid Transit Service, 2016

RRT Line	Review Area Stations	Average daily station entries (Mon-Fri)
Canada Line	**All Canada Line Stations (16)**	**138,700**
	Broadway-City Hall	14,400
Millennium & Expo Lines	**All Millennium and Expo Line Stations (38)**	**315,900**
	Commercial-Broadway	24,100
	Main Street—Science World	13,100
	VCC-Clark	3,000
SOURCE: TransLink 2016b.		

Pedestrian Traffic

Pedestrian count data collected at six key intersections along the Broadway Corridor shows that the intersection of Broadway and Cambie Street experienced the heaviest pedestrian volumes with overall pedestrian intersection volume at 5,000 pedestrians per hour in the PM peak period (Stantec 2019). This high activity is influenced by the proximity to the Broadway City Hall Canada Line Station. The intersection of Broadway and Granville Street was the second busiest intersection for pedestrians, followed by Broadway at Main Street (Stantec 2019).

Cycling

In 2016, 50% of all trips in the Review Area were made by foot, bicycle, or public transit (Vancouver 2017c) with 10.4% of trips to work made by bicycle (Statistics Canada 2017b).

Table 7.2-7 shows estimated average daily cyclists counts on cyclist routes along the Alignment. Values are based on manual cyclists counts undertaken in the spring and summer of 2017, and then adjusted based on measurements taken from a permanent counter at Clark and 10th Ave. The busiest location for cyclists both eastbound and westbound is at 10th and Alder, near Vancouver Hospital (City of Vancouver 2017).

Table 7.2-7: Adjusted Bicycle Counts along Alignment

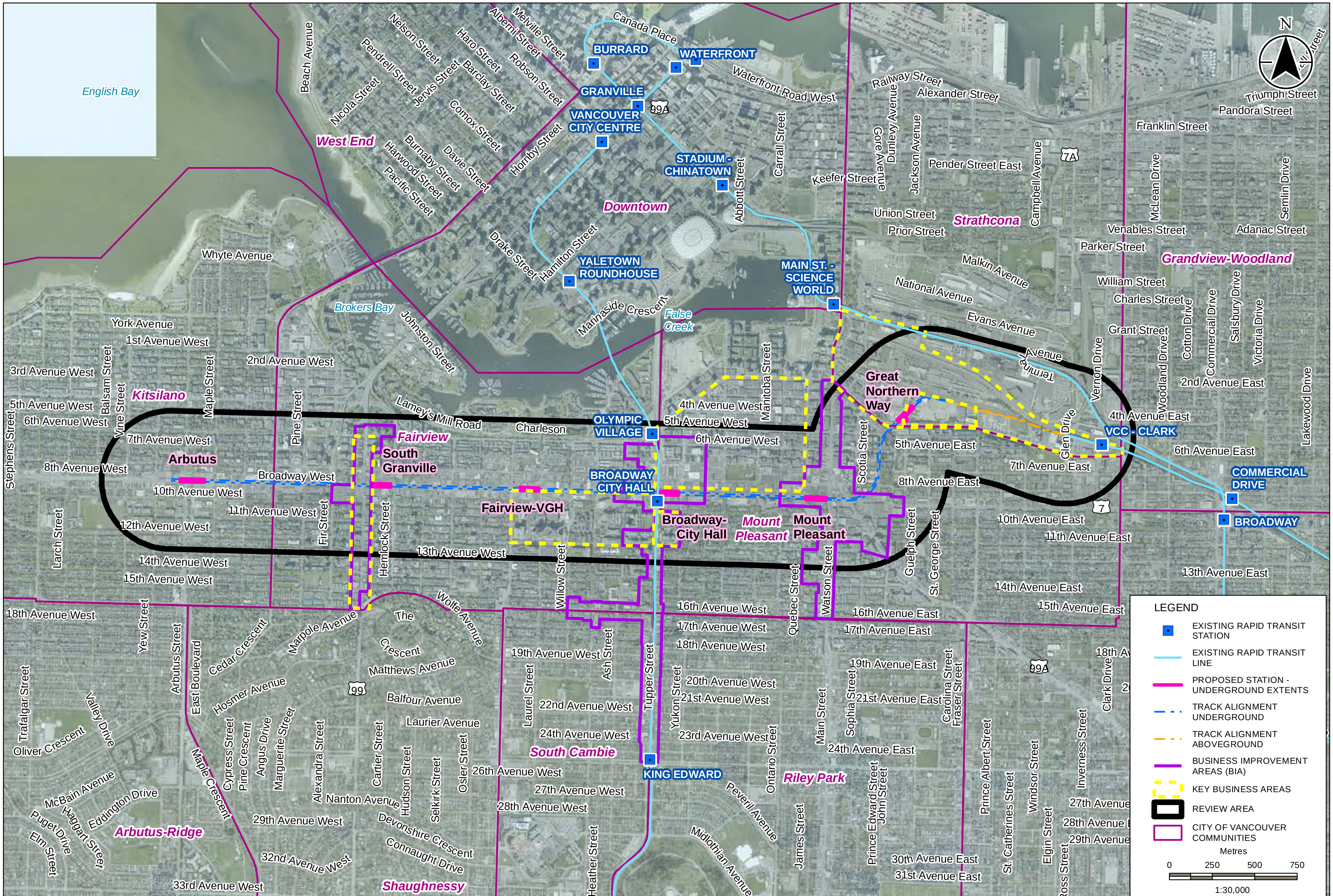
Name	Eastbound ADT	Westbound ADT
W 5th Ave & Yukon	200–700	250–850
7th Ave & Alder	200–700	150–550
7th Ave & Arbutus Greenway	150–550	200–650
7th Ave & Cypress	200–600	150–550
7th Ave & Yukon	100–350	150–400
800 W 7th Ave	250–900	300–900
2100 W 7th Ave	300–1000	200–700
10th Ave & Alder	550–1750	450–1450
10th Ave & Arbutus Greenway	200–700	200–650
10th Ave & Cypress	400–1250	300–950
SOURCE: City of Vancouver 2017		

7.2.3.3 Access

The Broadway Corridor is home to more than 105,000 jobs and by 2045 is anticipated to accommodate 133,000 jobs (MOTI 2018). Forty percent of Vancouver's health care businesses and 25% of technology businesses are located along the Broadway Corridor (MOTI 2018). Maintenance of property access during construction is an important consideration for those that live, work, and operate businesses along the Broadway Corridor.

There are 22 business improvement areas (BIAs) in Vancouver (City of Vancouver 2018a). Business improvement areas are managed by commercial property owners and their tenants to improve and promote their businesses, beautify surrounding neighborhoods and streets, and promote tourism (City of Vancouver 2018a). Three BIAs overlap the Review Area, including the South Granville BIA, Cambie Village BIA, and Mount Pleasant BIA (see Figure 7.2-5).

The second largest public-sector employer in Metro Vancouver in 2015 was Vancouver Coastal Health (Business in Vancouver 2016). Figure 7.2-6 shows the locations of major medical and healthcare facilities within the Review Area. These include Vancouver General Hospital and the British Columbia Cancer Agency. The University of British Columbia, (the third largest public-sector employer in Metro Vancouver in 2015) is located west of the Review Area.



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BROADWAY SUBWAY PROJECT

Stantec

BROADWAY SUBWAY PROJECT

KEY BUSINESS AREAS
IN THE REVIEW AREA

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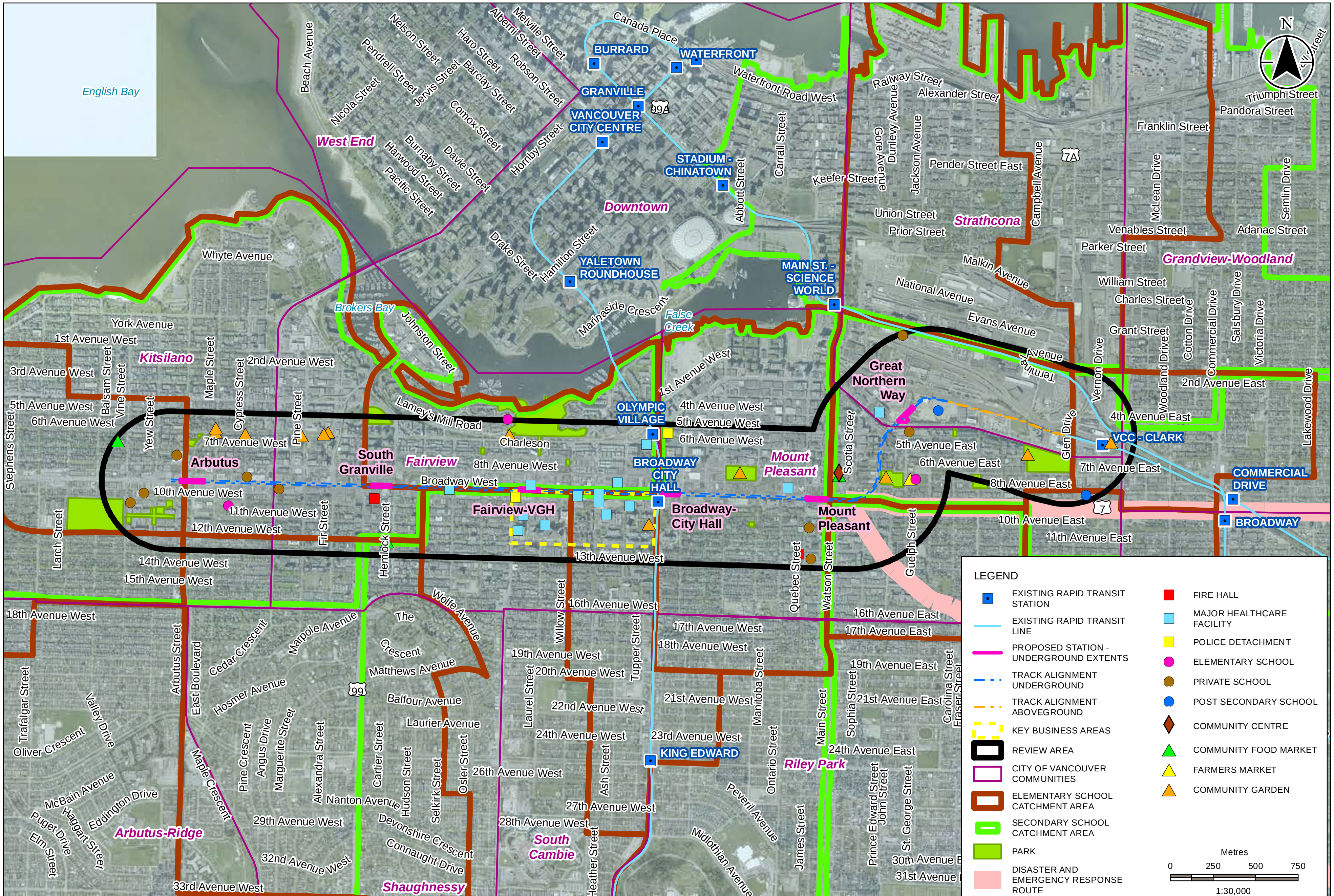
DATE 17-11-29			
SHEET NO.	FIGURE 7.2-5		



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BROADWAY SUBWAY PROJECT

Stantec

BROADWAY SUBWAY PROJECT

EMERGENCY, HEALTH AND COMMUNITY INFRASTRUCTURE AND SERVICES N THE REVIEW AREA

SCALE 1:30,000
DATE 17-11-29
CONTRACT NO.
SUB CONSULTANT PROJECT NO. 115814099
SHEET NO.

FIGURE 7.2-6

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Commercial and Residential Buildings

The Review Area is characterized by low- to mid-rise commercial buildings, low- to mid-rise residential, light industrial, institutional, with few high-rise developments. Table 7.2-8 provides an overview of the commercial property and residential housing along the Alignment.

Table 7.2-8: Overview of Commercial Property / Residential Housing Mix Along the Alignment

Segment	Type of properties
VCC-Clark Station to Great Northern Way)	Primarily light industrial, commercial, and educational.
Great Northern Way to Main Street	Light industrial, education, multi-family residential, greenspace, commercial, and comprehensive development.
Main Street to Cambie Street	Comprehensive development (mid-rise), commercial, and light industrial.
Cambie Street to Oak Street	Commercial (low, mid, and high-rise), comprehensive development, high-rise commercial, tourism (accommodation), hospital and health precinct.
Oak Street to Granville Street	Commercial (low, mid, and high-rise), comprehensive development, light industrial.
Granville Street to Arbutus Street	Commercial (low, mid, high rise), comprehensive development, light industrial.

Vehicular access points (driveways, parkade entrances, alleyways, etc.) to properties are present along Broadway. Some of these access points are critical for traffic circulation, parking, goods delivery, and access to properties. Most buildings fronting Broadway can be accessed by parallel lanes at the rear of the property. Most properties along Broadway are accessed at street level from the sidewalk by pedestrians, including transit users, and cyclists. Some properties have stairs, elevators, or escalators from a street level access point in order to enter the business or residence.

Healthcare and Emergency Responders

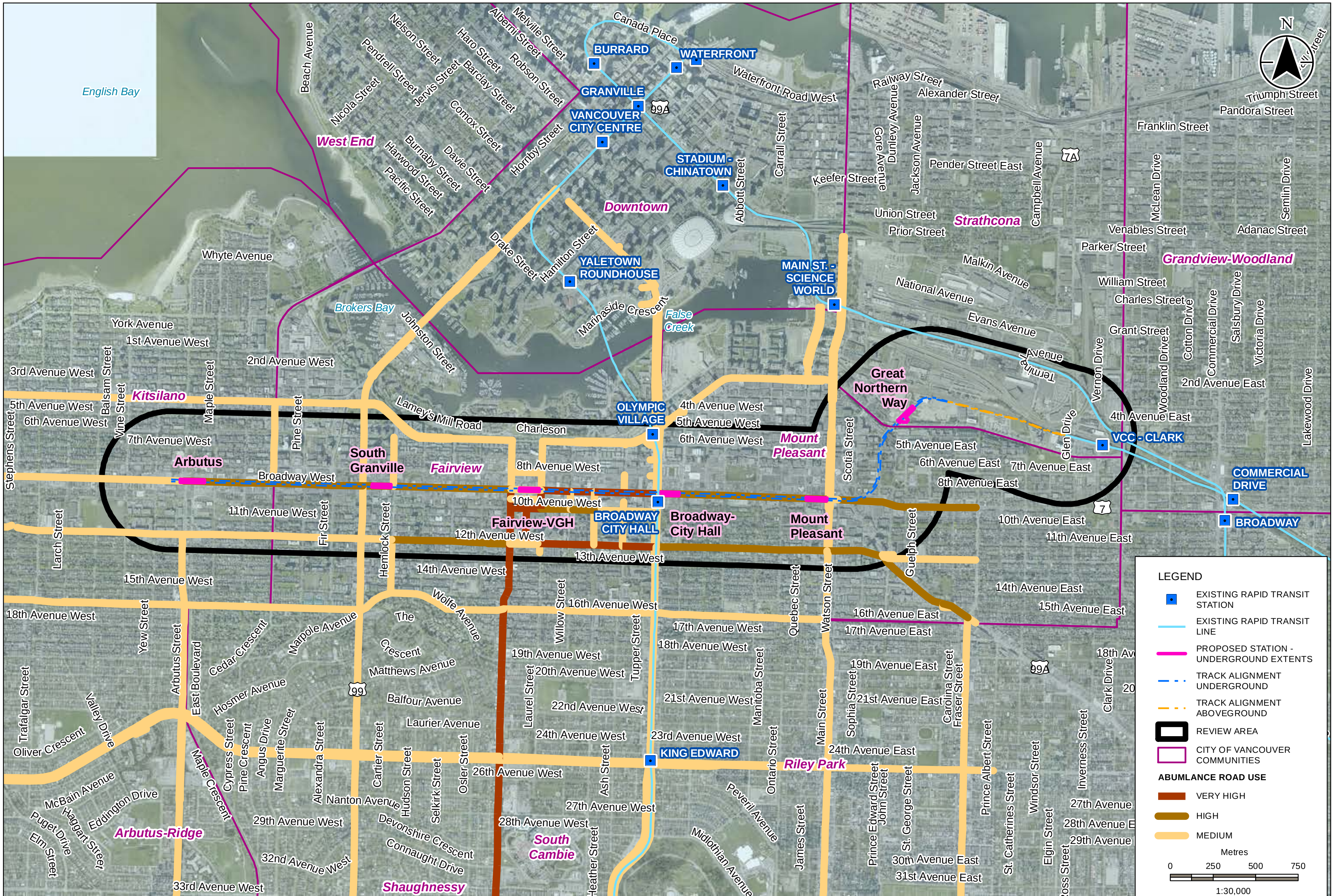
Some roads in the Review Area are utilized heavily by ambulances transporting patients to Vancouver General Hospital (VGH). These roads include Oak Street, West Broadway, West 12th Avenue, West 10th Avenue, Laurel Street, Cambie Street, Willow and Heather and Kingsway (BC EHS 2018). Roads used heavily by ambulances when not transporting patients also include segments of Main Street, Arbutus Street, Burrard Street, and East 7th Avenue (BC EHS 2018).

There are two firehalls located within the Review Area (Figure 7.2-6), the No. 4 Hall at 1475 West 10th Avenue (at Granville) and the No. 3 Hall at 2801 Quebec Street (near 12th Ave). Headquarters of the Vancouver Police Department (2120 Cambie Street) and the Kitsilano Community Policing Centre (1687 Broadway) are also located within the Review Area (Figure 7.2-7).

Disaster Routes

Disaster response routes are pre-identified transportation routes for emergency responders (fire, police, ambulance, and military vehicles) to use during a disaster or emergency. The Review Area overlaps two municipal disaster routes (Figure 7.2-7). One municipal disaster response route connects with Highway 1A and the other connects with Highway 7A (Vancouver 2018a).

The construction Contractor will be required to maintain emergency routes curing construction.



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BROADWAY SUBWAY PROJECT

Stantec

BROADWAY SUBWAY PROJECT

EMERGENCY VEHICLE ACCESS ROUTES TO VANCOUVER GENERAL HOSPTIAL WHEN TRANSPORTING PATIENTS

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SUB CONSULTANT PROJECT NO. 115814099
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Schools, Parks, and Community Centres

Two post-secondary institutions are located within the Review Area: Emily Carr University of Art + Design (520 East 1st Avenue) and Vancouver Community College (1155 East Broadway). Emily Carr University of Art + Design can be accessed by car and on foot from Great Northern Way, Carolina Street, and Thornton Street. Vancouver Community College can be accessed at multiple spots on East Broadway, Glen Drive, East 7th Avenue, and Keith Drive. Parking lots can be accessed from East 7th between Keith Drive and Glen Drive.

There are seven public schools and nine private schools located within the Review Area (see Figure 7.3-2). Saint Francis Xavier is located at 482 Great Northern Way with off street parking and drop-off only accessible from Great Northern Way east of Brunswick Street. Alternate pedestrian access is available.

There is one community centre located within the Review Area: Mount Pleasant Community Centre located at 1 Kingsway (see Figure 7.2-6). There are 18 parks located in the Review Area (see Figure 7.2-6). The closest park to the Alignment is Guelph Park (2390 Brunswick Street).

7.2.4 Project Interactions

Project activities that may interact with the Transportation and Access Review Element, during construction and operation, are indicated by check marks in Table 7.2-9. Section 7.2.5 describes measures that have been taken, during Project planning, to avoid or limit potential effects on Transportation and Access during construction.

Table 7.2-9: Potential Project Interactions with Transportation and Access

Project Activities and Physical Works	Potential Effects	
	Change in Transportation	**Change in Access**
Construction		
Property acquisition	-	✓
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	✓	✓
Elevated guideway construction	✓	✓
Tunnel and station excavation	✓	✓
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	✓	✓
Vehicle traffic (e.g., road use and construction traffic)	✓	✓
Management and disposal of waste and excavated materials	-	-
Commissioning and start-up	-	-
Operation		
Train operation, including wayside and power	✓	✓
Station operation	✓	✓
Train maintenance, administration, transit police	-	-
NOTES: ✓ Potential interactions that may cause an effect - No anticipated interaction		

7.2.4.1 Construction

In general, construction activities noted above are expected to result in increased congestion and travel times for all modes during construction. As a result of increased congestion, some activities have the potential to impact mobility, travel time reliability and access along the Broadway Corridor. Mitigation measures described in Section 7.2.5, will be undertaken in order to avoid or limit construction-related effects on traffic and access.

7.2.4.2 Operation

Following construction, roadways and traffic infrastructure are anticipated to generally operate in the same manner as they do currently. A new off-street transit exchange at Arbutus Street will accommodate route 99 buses travelling between Arbutus Street and UBC.

7.2.5 Mitigation Measures

Mitigation measures that may be employed to avoid or reduce effects on transportation infrastructure, transportation modes, and access during Project construction are discussed below and are provided in Table 7.2-10. Mitigation measures have been developed based on best practices used for comparable transportation projects in Metro Vancouver to limit or avoid adverse effects on transportation and access during construction and operation.

The assessment of potential effects on transportation and access has been undertaken in parallel with Project planning. This iterative planning and assessment process, which was supported by traffic modelling, has included the identification of measures, provided in Table 7.2-10, to mitigate potential adverse effects on transportation and access.

In addition to mitigation measures specific to transportation and access, provided in Table 7.2-10, the following aspects of the Project, including design and construction will also mitigate effects on transportation and access:

- Tunnel excavation using mining and boring methods to limit top-down construction
- Limiting the extent of excavations to station locations and cross overs

As noted in Section 9 (Environmental Management Plans), the Contractor will confirm the final mitigation approaches to support the Traffic Management Plan. This approach will allow for mitigation measures that are aligned with the detailed design and construction approach developed by the Contractor.

Table 7.2-10: Mitigation Measures for Transportation and Access

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.2-1	Develop and implement a Traffic Management Plan for the construction phase, that considers all road users (e.g., transit users and busses, drivers, cyclists, and pedestrians, including those with disabilities). The Traffic Management Plan will include: • A Traffic Control Plans for all construction activities with the potential to impact traffic along the Alignment. • An Incident Management Plan with procedures for responding to unplanned events or incidents. • A Public Information Plan with procedures to notify the City of Vancouver, TransLink, transit operators, emergency response agencies, media, stakeholders, adjacent property owners, and the travelling public, of any scheduled or unscheduled activities affecting traffic. • A Bus Management Plan identifying all bus routes to be accommodated, how bus operations will be prioritized, how and where bus stops will be relocated, and associated pedestrian access, transfer, and waiting areas. • A Truck Management Plan identifying how Project-related trucks will be managed during construction including routes to be followed, entry and egress points, truck classifications, truck staging areas. The Truck Management Plan will include measures to ensure that emergency vehicle access and safety are given the highest priority.	Construction	Contractor	Contractual Requirement
7.2-2	A Bus Management Plan identifying all bus routes to be accommodated, how bus operations will be prioritized, how and where bus stops will be relocated, and associated pedestrian access, transfer, and waiting areas. Note: this Plan is separate from the Contractor Traffic Management Plan	Construction	TransLink	Supportive Measure
7.2-3	Implement temporary changes to bus operations in the Broadway Corridor during construction including: • Re-routing buses that primarily travel the north south direction and only travel along the Broadway Corridor for short sections, including the Route 14, 16, and 17, off the Broadway Corridor. • Keeping routes 9 and 99 on the Broadway Corridor to continue to serve major destinations and adding additional buses to maintain existing service levels.	Construction	TransLink / Coast Mountain Bus Company	Supportive Measure
7.2-4	Undertake modifications to road infrastructure, on both the Broadway Corridor and on adjacent routes, to improve the flow of traffic during construction. Some of these modifications will include parking regulation changes, and intersection signal timing/phasing.	Construction	City of Vancouver	Supportive Measure
7.2-5	Maintain existing cycling routes throughout construction, including the Central Valley Greenway and Arbutus Greenway, or identify direct and intuitive alternate routes.	Construction	Contractor	Contractual Requirement
7.2-6	Maintain existing emergency routes within the Project site or relocate the emergency routes in the vicinity of the Project site in consultation with and subject to the approval of the relevant Emergency Response Agencies.	Construction	Contractor	Contractual Requirement
7.2-7	The Province will engage with stakeholders, with support from the City of Vancouver and the Contractor, to build and foster relationships to manage construction-related disruption, increasing predictability for business operations.	Construction	Province, City of Vancouver, Contractor	Supportive Measure

7.2.6 Discussion of Review Results

Some Project activities have the potential to impact to travel and access in the Review Area. This section discusses the potential for Project-related effects on Transportation and Access due to Project-related activities.

7.2.6.1 Maintaining Mobility and Accommodating Transportation Demand

Construction

During construction, mobility along the Broadway Corridor for all modes of transportation will be temporarily affected as a result of increased congestion arising from a reduced number of lanes as well as increased construction related traffic. However, a number of mitigation measures have been identified that will serve to limit such effects during the construction period.

Project Design/Construction Approach

The majority of the Alignment will be located within a tunnel, which will be excavated using underground excavation techniques. Therefore, direct impacts on roadway infrastructure will be limited to the extent possible.

From VCC-Clark Station to the tunnel portal at Great Northern Way, 700 m of elevated guideway will be constructed. In this area, construction will generally occur off major roadways, with only minor changes in traffic circulation and parking along Great Northern Way.

Maintenance of Emergency Services Vehicle Movements

During construction, access to emergency health care facilities and emergency services will be maintained or equivalent alternate access created. Emergency response vehicles will be prioritized above all other motorized modes to avoid delays in emergency response.

Prioritizing Transit

Recognizing the important role of transit in the Broadway Corridor, in terms of efficiently moving large numbers of commuters, and anticipating increased congestion during construction, a number of refinements will be made to prioritize east-west transit traffic. Routes 14 (UBC), 16 (Arbutus), and 17 (Oak) buses are primarily north south transit routes and will be re-routed off the Broadway Corridor (see Figure 7.2-8) to reduce potential delays by avoiding travel through construction areas. Routes 9 and

99 will remain on the Broadway Corridor to serve major destinations and additional buses will be added in order to maintain existing service levels.

A Bus Management Plan will identify methods to prioritize transit buses over all other motorized modes, except emergency response vehicles. Methods for prioritization may include the use of bus queue jumper lanes at intersections, curbside bus lanes, traffic control persons to assist buses to merge into traffic, bus signal priority at signalized intersections, etc. (Figure 7.2-8).

More detailed refinements to transit services in the Broadway Corridor, including bus stop relocations will be identified in the individual Traffic Control Plans. Access to the Canada Line station will be maintained throughout construction.

Figure 7.2-8: **Bus Route Relocations during Project Construction**

Early communication about transit changes will be made available on TransLink's website. Signage will also be posted at bus stops to provide advance notice about changes to bus service. Maps will be made available online to indicate changes to bus routes in addition to TransLink's regular communication with customers.

Even with mitigation measures, it is anticipated that transit travel times will increase during construction due to concentrated vehicle volumes on Broadway. Other East-West routes running parallel to Broadway may experience increased ridership should transit users, not destined for Broadway, choose an alternate route. Bus service and ridership on parallel routes to Broadway will be monitored as part of normal operations by TransLink during construction to optimize transit service to meet changing demand.

Maintaining Traffic Operations on Broadway

During construction lane availability will be managed to provide as efficient as possible traffic movements for all traffic modes on the Broadway Corridor. In general, four lanes (i.e., 2 in each of the east-bound and west-bound directions) will remain open in the construction areas. Drivers for destinations outside the Broadway Corridor will be encouraged to use other routes or take transit in order to limit traffic demand in the Corridor during construction.

Active Traffic Management

In order to limit congestion and maintain access to public, commercial and residential properties, a Traffic Management Plan will be developed and implemented during Project construction. Development of the Traffic Management Plan will be supported by engagement with the City of Vancouver, TransLink and key stakeholders including emergency services, business associations, schools and community service organizations.

The Traffic Management Plan will include measures for actively managing traffic as well as provisions for communicating changes to transit, road, pedestrian and cycling infrastructure required as part of the Project.

Focus on Safety

Monitoring of traffic collisions during construction will be undertaken to verify that current safety levels are maintained. Where traffic safety concerns are noted, refinements will be made to the existing Traffic Management Plan and/or existing infrastructure to address the issue.

Managing Construction-related Traffic

A truck management plan will be implemented to mitigate the potential impact of construction traffic on other roadway users including not permitting Project workers to park within 1 km of the Project site. Construction-related truck traffic will be required to follow existing by-laws and follow designated truck routes to access construction sites.

Maintaining Pedestrian and Cyclist Mobility

Proactive planning to avoid effects to pedestrian and cycling infrastructure, will avoid most adverse effects on pedestrian and bike traffic during construction. While some parts of bike routes and pedestrian walkways may not be as direct as under existing conditions, effects on overall travel times are expected to be limited.

Cyclist passage and access to designated cyclist routes, including on Ontario Street, Yukon Street, Heather Street, Cypress Street, 10th Avenue and 7th Avenue will be maintained to reduce potential disruption to cyclists. Pedestrian and cyclist mobility may be restricted at station excavation and construction areas for safety. At these locations, detours and diversion routes will be provided to safely move pedestrians and cyclists around work zones.

The Central Valley Greenway and Arbutus Greenways may be rerouted in areas adjacent to station construction but will continue to meet City of Vancouver's AAA bike facility classification. This will help to maintain cyclist mobility by providing safe and accessible alternate route.

Changes in pedestrian and cyclist mobility will be developed and communicated as part of the Traffic Management Plan and include signage and advance notice about changes to cycling and pedestrian routes. Wheelchair accessibility will be maintained.

Operation

By substantially increasing transit capacity, removing the 99 B-Line bus between Commercial Drive and Arbutus Street, and attracting more drivers out of their cars, the Project is expected to improve traffic operations for transit users, private vehicle use, and commercial traffic supporting local businesses.

Once the Project is complete, road infrastructure, is generally anticipated to return to pre-construction conditions though the operation of the new off-street Arbutus Transit Exchange will result in some roadway refinements near Broadway and Arbutus. Such refinements may include changes in traffic signals to allow route 99 buses to turn on and off Broadway.

The Project has been designed to integrate with key local cycling routes (including the Central Valley Greenway and the Arbutus Greenway) with the Great Northern Way and Arbutus stations including bicycle parkades. In addition, the planned City of Vancouver development, adjacent to the Broadway-City Hall station, will also include a bicycle parkade.

Passenger and cyclist safety within the stations will be managed using similar measures already in place at existing SkyTrain stations.

Summary

During construction, motor vehicle traffic in the Corridor is anticipated to experience travel time delays due to increased traffic congestion at certain times of the day. This is anticipated to be heightened around station construction areas. Traffic will be managed within the Corridor in order to prioritize emergency and transit vehicles and additional steps will be taken to move some north / south transit routes off of Broadway during construction.

With mitigation measures, cyclist and pedestrian mobility and travel times are not expected to be adversely affected by construction. Monitoring of traffic collisions during construction will be undertaken to verify that current safety levels are maintained.

During operation, the Project will result in improved transit, truck, and motor vehicle operations on the Broadway Corridor and integrate effectively with pedestrian and cyclist routes.

7.2.6.2 Maintaining Access

Construction

The Broadway Corridor serves a large number of commercial and institutional operations (i.e., schools and hospitals) that clients, support services, and employees need to access throughout Project construction. As well, the Corridor is home to residents that require access to their homes during this period. As such, Project planning has identified mitigation measures that will serve to maintain access to these groups throughout construction.

Maintaining Access for Emergency Services and Health Care Facilities

The Public Information Plan that will support delivery of the Traffic Management Plan will inform stakeholders, including emergency service providers and healthcare facilities, of current and planned changes to roadways, traffic, and transportation during Project construction and will ensure that key interests, such as emergency service providers and care providers, are aware of alternate access that is in place during construction.

During development of the Traffic Management Plan, in consultation with the City of Vancouver and emergency responders, two existing municipal disaster response routes, or alternate routes, will be maintained throughout construction. Such access planning will allow for the maintenance of sufficient response routes in the event of a local or regional disaster.

Business Engagement during Construction

A program to engage and involve businesses along the Broadway Corridor will be developed to build working relationships with local businesses, and to identify and mitigate construction-related disruptions to business during construction. Key objectives of the program will be to help increase predictability for business operations and maintain public awareness.

A Community Office within the corridor was opened in September 2019, in advance of construction, to serve as source for information and direct connection with the Project team. Local business and community stakeholders will also have opportunities to provide input on access to businesses, construction and traffic management plans, parking, and other construction and traffic-related issues and opportunities. Additionally, ongoing feedback mechanisms will be available to engage businesses on ways to limit construction-related effects to access during construction.

Maintaining Access to Residential and Commercial Properties

During Project construction, residential and commercial properties within the Review Area, specifically those fronting the station construction areas, elevated guideway, laydown/staging areas, and trolley bus reroute areas, may experience temporary changes in access and parking. As well, on-street parking on both sides of Broadway will be temporarily removed during construction. Existing or alternate sidewalk and vehicular access to businesses and residences will be maintained during construction.

Traffic access near station construction sites may be temporarily affected during station excavation and construction due to lane and parking restrictions. To limit disruption for traffic supporting local businesses (i.e., pick up/drop off of goods, access for service providers) during station construction, consultation with local businesses, healthcare facilities, and the City of Vancouver will be undertaken to identify mitigation measures to be included in the Traffic Management Plan.

Maintaining Access to Educational and Community Services

Project construction has the potential to affect access to schools and other community amenities (including parks and community centres) in the Review Area, especially for locations near station construction sites. Emily Carr University of Art + Design and St. Francis Xavier School may experience changes in access during construction. Potential disruptions during construction are anticipated to be reduced through early planning, consultation, notifications, and signs for road users.

Operation

It is anticipated that there will be designated parking spaces for transit police and transit service vehicles near station areas.

Summary

With mitigation, residential and commercial properties within the Review Area, specifically those fronting the active construction areas, are anticipated to experience temporary changes in access during Project construction. With identified mitigation measures to limit the duration and frequency of access disruptions, provide alternate access, and enable effective communication regarding access changes, access for existing users will be provided throughout construction. Maintaining access during construction will require active and ongoing dialogue between the Contractor and key stakeholders including City of Vancouver, emergency services providers, businesses, educational and community services and residents.

Once operational, the Project is not anticipated to result in any adverse impacts on access as most Project infrastructure is underground and will not intersect with access to residential, commercial, or institutional properties.

7.2.7 Conclusion

The Broadway Corridor is a major urban transportation corridor that supports high volumes of transit, general purpose road traffic, pedestrians and cyclists and is experiencing growing challenges with respect to increased congestion and travel times. The Corridor is also an important commercial center with a significant business and service presence. Advancing the Broadway Subway Project will result in substantial transportation-related benefits by improving future travel times and supporting planned growth and economic development.

Recognizing the importance of the Corridor—to the movement of people and goods, and the operation of businesses and services located in the Project area—substantial effort will be taken during construction to maintain mobility and access and help keep businesses operating. Such efforts include:

- **Maintaining Emergency Access**—Working closely with emergency service providers to limit restrictions on available routes, develop alternate routes, and prioritize emergency vehicle mobility throughout construction.
- **Prioritizing Transit**—Some buses will be relocated to alternative routes and routes 9 and 99 will be prioritized on Broadway to maintain service levels.
- **Supporting Commuter/Commercial Traffic**—Maintaining four lanes of traffic throughout most of the corridor, and identifying alternative parking to maintain vehicular traffic flow.
- **Maintaining Access**—Working closely with businesses, health care facilities and schools, to maintain access during construction and allow them to maintain existing operations and serve their clients.

- **Traffic Management**—Developing and implementing traffic management plans, supported by ongoing engagement with local businesses and communities, to actively manage traffic within the Corridor.
- **Business Engagement**—The Province, City of Vancouver and Contractor will advance a Business Engagement Program to engage businesses and find ways to limit construction-related disruptions.

While the range of measures noted above will help to reduce Project-related effects on transportation and access during construction, there will be construction-phase effects that cannot be fully mitigated. Depending on the time of day, travel times for both general-purpose traffic and transit will be longer than are currently experienced. In some locations, even with the measures proposed, there will be temporary changes in existing pedestrian routes, and overall reduction in parking.

Addressing these challenges will require extensive and ongoing collaboration between the Project, City of Vancouver, TransLink, Emergency Services, and key stakeholders to keep people and goods moving, and businesses operating, through the construction phase.

7.3 Housing and Property

This section of the ESR discusses Project-related changes to housing and property. Potential changes to housing and property as a result of Project-related activities are discussed relative to existing information available for the Review Area and City of Vancouver.

This section considers potential effects on housing availability and affordability related to the development of the Project. Because such effects are related to potential changes in development patterns, the evaluation considers potential effects associated with the operation phase of the Project only.

Unlike other Review Elements considered in the ESR, changes to housing and properties are primarily influenced by factors outside of the scope of the Project including existing housing demand as well as City policies and plans that govern land use and development. As such, the review of housing and properties focuses on incremental changes that may occur as a result of the construction of the Project. Measures to address potential Project-related effects on housing focus on initiatives advanced by the City of Vancouver who have jurisdiction over policies and plans related to land use and development.

Key information provided to support the assessment of Housing and Property include:

- Rationale for selection as a Review Element
- Methods used to review potential effects of Project activities in the context of regulatory requirements and policy applicable to this Review Element
- Existing conditions within the Review Area
- A summary of Project components and activities that may interact with this review element
- A description of mitigation measures to limit or avoid effects on housing and property
- A discussion of review results and conclusions

7.3.1 Rationale for Selection as a Review Element

Housing and Property was selected as a Review Element because Project activities may affect land use, housing stocks and affordability, and because of its importance to stakeholders, Indigenous groups, and the public.

7.3.2 Review Scope for Housing and Property

7.3.2.1 Regulatory and Policy Setting

The City of Vancouver is primarily responsible for property-related policy and development planning within its borders. City of Vancouver policies and plans that shape property development within neighbourhoods along the Alignment are identified in Table 7.3-1. Additional information, including details of recently approved land use plans for Grandview-Woodlands, Mount Pleasant, and False Creek Flats, are provided in Stantec 2019.

Table 7.3-1: City of Vancouver Policies and Plans related to Housing and Property

Responsible Agency	Law, Regulation, Policy	Description
City of Vancouver	The Vancouver Charter	Grants the City additional powers and freedoms compared to other provincial municipalities including statutory immunity to building regulation and ability to: impose unique building code requirements; prohibit businesses or business activities, unique planning and land use tools; and impose special development levies.
City of Vancouver	Housing Vancouver Strategy	The City's 10-year housing strategy to retain and grow the supply of affordable housing, prioritizing a shift to the "right supply" of housing that is affordable to local incomes
City of Vancouver	Broadway Plan	In June 2018 City Council approved the Terms of Reference for a two-year Broadway planning process. The Plan will focus on opportunities to integrate "new housing, jobs, and amenities with future transit", and address the need for additional affordable housing.
City of Vancouver	Development Contribution Expectation (DCE) Policy	Intended to limit land value speculation in areas undergoing community planning by adding clarity to land acquisition decisions and allowing purchasers to factor in the costs of required amenities when rezoning or density bonusing occurs.
City of Vancouver	Metro Core Jobs and Economy Land Use Plan	The goal of the Plan is to ensure that there is enough development and transportation capacity to accommodate future job growth and economic activity in the Metro Core – including the Broadway Corridor
City of Vancouver	Rental Housing Stock Official Development Plan (ODP)	Protects existing rental housing by requiring redevelopment projects in certain zoning districts to replace converted or demolished rental units. Works alongside the *Tenant Relocation and Protection Policy* which assists tenants displaced by redevelopment.
City of Vancouver	Employment Lands and Economy Review	A long-range land use policy plan to ensure an appropriate supply of land for businesses/jobs to support future economic growth including in the Broadway Corridor. Began in 2018 and will conclude in 2020.

Table 7.3-1: City of Vancouver Policies and Plans related to Housing and Property

Responsible Agency	Law, Regulation, Policy	Description
City of Vancouver	Mount Pleasant Community Plan	Aims at guiding development in the neighbourhood over the next 30 years and covers land use, urban design, housing, economic development, parks, public realm, transportation, community amenities, heritage and culture.
City of Vancouver	False Creek Flats Plan	Aims at maintaining space for "core and back-of-house industrial functions essential to a healthy, sustainable and completed city", and for increasing employment opportunities, particularly in the sciences and innovation, and food and service industries (Coriolis 2018).
City of Vancouver	Tenant Relocation and Protection Policy	Provides support and financial compensation to renters affected by redevelopment. The policy supplements existing protections for renters provided in the BC *Residential Tenancy Act*.
City of Vancouver	False Creek South Neighbourhood Planning Program	The Program will set the foundation for long-term planning in False Creek South. One of the ten principles is to increase housing capacity and choice, including affordable options (City of Vancouver 2018d).

7.3.2.2 Engagement Input Supporting the Assessment

The assessment of Housing and Property was informed by input received during stakeholder engagement processes including those focused on obtaining feedback on the development of the Terms of Reference. Key comments received during public engagement focused on:

- Neighbourhoods and housing (land use planning, speculation, housing availability)
- Business viability in the long term (affordable commercial space)

Additional information on Indigenous consultation and public engagement are provided in ESR Sections 4 and 5, respectively.

7.3.2.3 Selection of Effects and Indicators

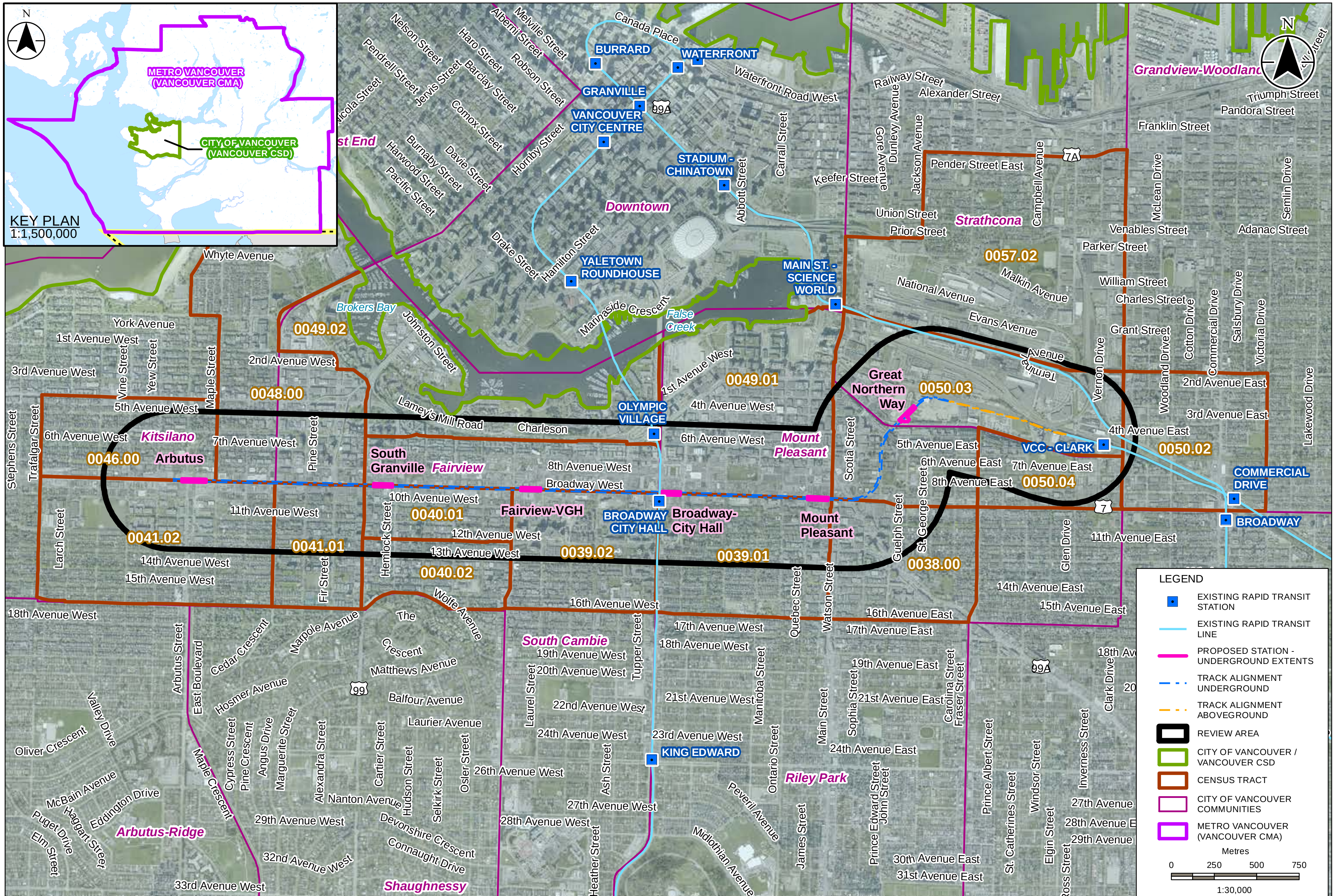
Table 7.3-2 defines the potential Project-related effects on Housing and Property and summarizes the Project effect mechanisms and indicators used to assess the potential effect. The effect mechanisms identified in this table are described in more detail in Section 7.3.4 (Project Interactions). The use of indicators facilitates the qualitative or quantitative measurement of potential effects.

Table 7.3-2: Potential Effects and Review Indicators for Housing and Property

Potential Effects	Project Effects Mechanisms	Indicators	Rationale for Selection
Change in housing and property	• Project has the potential to induce new development and redevelopment of existing housing stock along the Alignment and near station areas • Project has the potential to result in changes to property values	• Population change • Net change in types of commercial and residential properties • Housing availability and cost metrics	• The Project may affect land use, housing stock and affordability

7.3.2.4 Boundaries

The spatial boundary of the Review Area for the Housing and Property Review Element comprises communities within Vancouver that are within 400 m of the Project, which aligns with a commonly used walking distance standard used for transit planning (Figure 7.3-1) (Human Transit 2018). Studies have shown that property-related effects from rapid transit development, such as changes in development patterns, tend to be more prominent nearer to the alignments and stations (CMHC 2009; Human Transit 2018). In some cases, Project effects may extend beyond 400 m, particularly with respect to changes in the pace of development in other areas (Coriolis 2018) and are discussed at the neighborhood, city, and regional level. However, it is anticipated that the more prominent effects will largely be felt within 400 m of the Alignment.



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HOUSING AND PROPERTY REVIEW AREA

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7.3.3 Existing Conditions

7.3.3.1 Methods

Information on existing housing and property conditions for the Review Area, City of Vancouver, and Metro Vancouver was primarily obtained from public sources (e.g., Statistics Canada), public feedback and engagement summaries, information on City of Vancouver programs and policies, and comprehensive studies prepared for the Project.

Statistical socio-economic information for the Review Area is based on census tracts and is presented in the Socio-Economic Technical Data Report prepared in support of the ESR (Stantec 2019). Information was also obtained through a review of studies and assessments of similar rapid transit projects in Metro Vancouver (e.g., Canada Line and Evergreen Line).

7.3.3.2 Review of Existing Conditions

Population and Income

The population of the Metro Vancouver Regional District (MVRD) in 2016 was 2,463,431 (4.6% increase from 2011) and is expected to reach 3,443,000 by 2041 (Metro Vancouver 2015a). Vancouver represents approximately one-quarter of MVRD's population and grew at the same rate as the MVRD between 2011 and 2016. By 2041, the number of dwelling units in the City of Vancouver is anticipated to increase approximately 17% from 2016 levels (Vancouver 2017a).

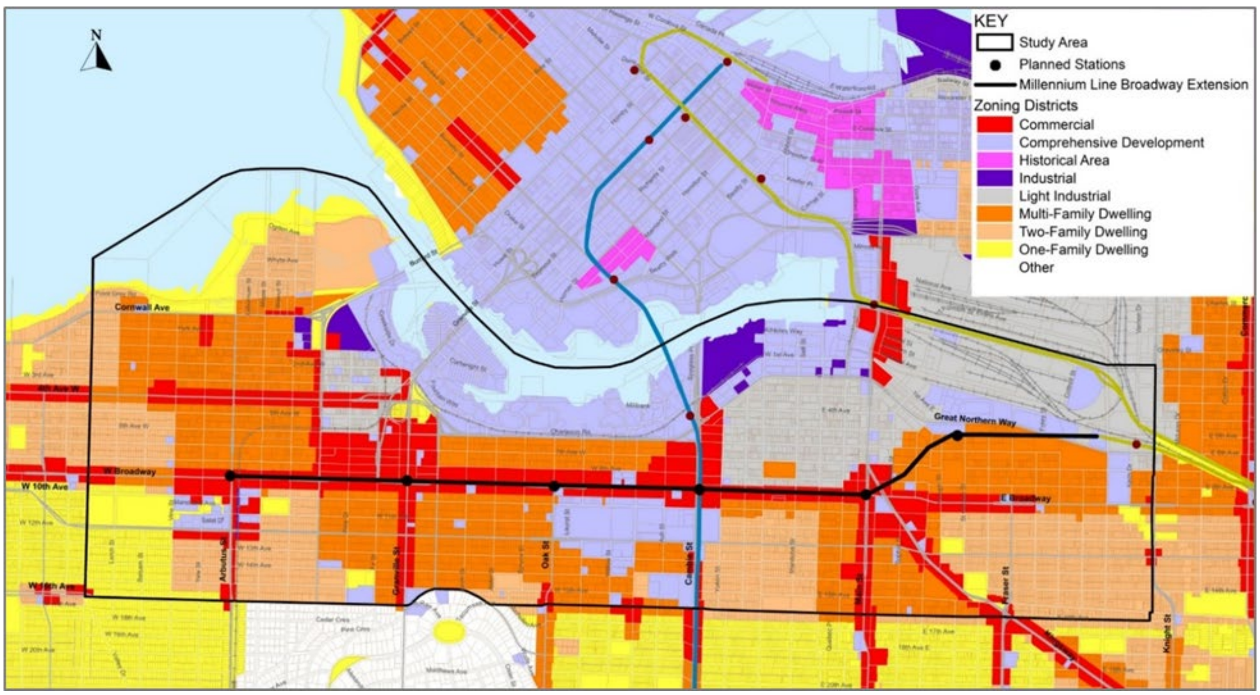
Average after-tax household income in 2015 for the Review Area was $68,830, 9.0% less than average household income in the City of Vancouver ($76,249). Median after-tax income of households in 2015 for the Review Area was $55,698 and $56,908 for the City of Vancouver (Statistics Canada 2017a and 2017b).

Rapid transit projects, when combined with supportive land use policies, often induce high density development. Between 2001 and 2011, areas near future Evergreen Line SkyTrain stations experienced a 51% increase in population compared to an average population increase of 16% across Metro Vancouver (South Coast BC Transportation Authority Police Service 2014). This increase in population was a result of increased residential development densities, a trend also experienced around the Canada Line SkyTrain stations (South Coast BC Transportation Authority Police Service 2014).

Land Use along the Alignment

The Review Area overlaps six sub-areas: False Creek Flats, Mount Pleasant Employment area, Burrard Slopes Industrial area, Commercial corridors, Uptown Office District, and residential neighbourhoods (Coriolis 2018).

The Review Area is characterized by low- to mid-rise commercial and mixed-use buildings; low- to mid-rise residential; light industrial; institutional, including post-secondary educational institutions, City Hall Campus, and Vancouver General Hospital, with few high-rise developments. Generalized zoning directly along the Alignment includes light industrial, commercial, comprehensive development, and multi-family dwelling (Figure 7.3-2). Two-family dwelling and one-family dwelling zoning is also present within a 400 metre buffer of the Alignment.



SOURCE: Coriolis Consulting Corp using MapInfo and City of Vancouver Open Data.

Figure 7.3-2: Generalized Zoning along the Alignment and within the City of Vancouver

Table 7.3-3 provides an overview of the residential housing and commercial property mix fronting the Alignment. Additional detail on residential properties and housing is provided in the following sections.

Table 7.3-3: Overview of Commercial Property / Residential Housing Mix in the Review Area

Segment	Type of properties
VCC-Clark Station to Great Northern Way)	Primarily light industrial, commercial, and educational.
Great Northern Way to Main Street	Light industrial, educational, low to mid rise multi-family residential (much of which is protected by the RHS ODP), greenspace, commercial, and mixed use (midrise) development.
Main Street to Cambie Street	Mixed use (mid-rise), low-rise multi-family residential, commercial, and light industrial.
Cambie Street to Oak Street	Commercial (low, mid, and high-rise), mixed use (mid to high rise), institutional, multifamily residential,(low and midrise) , tourism (short-term accommodation).
Oak Street to Granville Street	Commercial (low, mid, and high-rise), mixed use (mid-rise), multifamily residential (low to midrise rental—much is protected by the RHS ODP), and light industrial.
Granville Street to Arbutus Street	Commercial (low, mid, high rise), mixed use (midrise), multifamily residential (rental areas protected by RHS ODP as well as strata), duplex and single family residential, and light industrial.

The Corridor includes residential neighbourhoods along the Alignment both north and south of Broadway Much of this land is zoned and developed for multifamily residential (medium and higher density); however, there are areas zoned for single detached and duplex as well, containing approximately 360 single-family zoned lots and approximately 2,700 two-family zoned lots (Coriolis 2018).

Residential Properties

Housing Stock

In 2016, there were 283,915 households in the City of Vancouver, of which 18.1% (51,495) were located in the Review Area. Overall, 47% of Vancouver residents owned their homes while 40% of Review Area residents were homeowners (Statistics Canada 2017a and b). The remainder of households are classified as renters.

There were 309,418 dwelling units in Vancouver in 2016. By 2041, the number of dwelling units in the City of Vancouver is anticipated to increase approximately 17% from 2016 levels (Vancouver 2017a). In 2016, there were a total of 62,000 private dwelling units in the Review Area and 94% of these units were occupied (Statistics Canada 2017a).

The Review Area accounts for approximately 30% of the City's total stock of purpose-built rental housing; much of this rental stock is old and is low to medium density (Coriolis 2018). The Alignment overlaps three rental market survey zones defined by Canada Mortgage and Housing Corporation: zones 4 (South Granville/Oak), 5 (Kitsilano/Point grey), and 8 (Mount Pleasant/ Renfrew heights). Rental market characteristics within these areas are summarized in Table 7.3-4.

Table 7.3-4: Rental Market Characteristics, 2016

	Zone 4 (South Granville/Oak)	Zone 5 (Kitsilano/Point Grey)	Zone 8 (Mount Pleasant/ Renfrew Heights)
Vacancy rates (2016)	0.7%	0.8%	1.2%
Private apartment average rent	$1,355	$1,391	$1,147
Number of private apartments	7,765	7,198	6,377
% change in rent 2015-16	7.6%	8.7%	7.5%
SOURCE: CMHC, 2016.			

Housing Starts and Completions

In 2016, the majority (approximately 85%) of residential building permits in the City of Vancouver were for apartment units, the remainder were largely for single dwelling units (BC Stats 2017). Housing starts in Vancouver 2016 (9,759) were more than double the housing starts in 2015 (City of Vancouver 2017b).

From 2012-2016, rental units have accounted for 23% of housing starts. Rental housing starts set a record in 2016 with approximately 3,200 new rental units added in Vancouver (CMHC 2016). However, few purpose-built rentals are three or more bedrooms suitable for families while vacancy rates for family-sized units hover around zero (City of Vancouver 2017a). In 2016, Mount Pleasant/Renfrew Heights had the most housing starts and completions (811 and 2 respectively). In 2017, Kitsilano/Point Grey had the most housing starts (184), and Mount Pleasant/Renfrew Heights had the most completions (29).

Housing Affordability

The provincial government and the City of Vancouver have both established affordable housing as a priority issue. As an example, the City of Vancouver's Housing Vancouver Strategy (Table 7.3-1) is focused on achieving the right supply of affordable housing, relative to local incomes, to maintain household diversity.

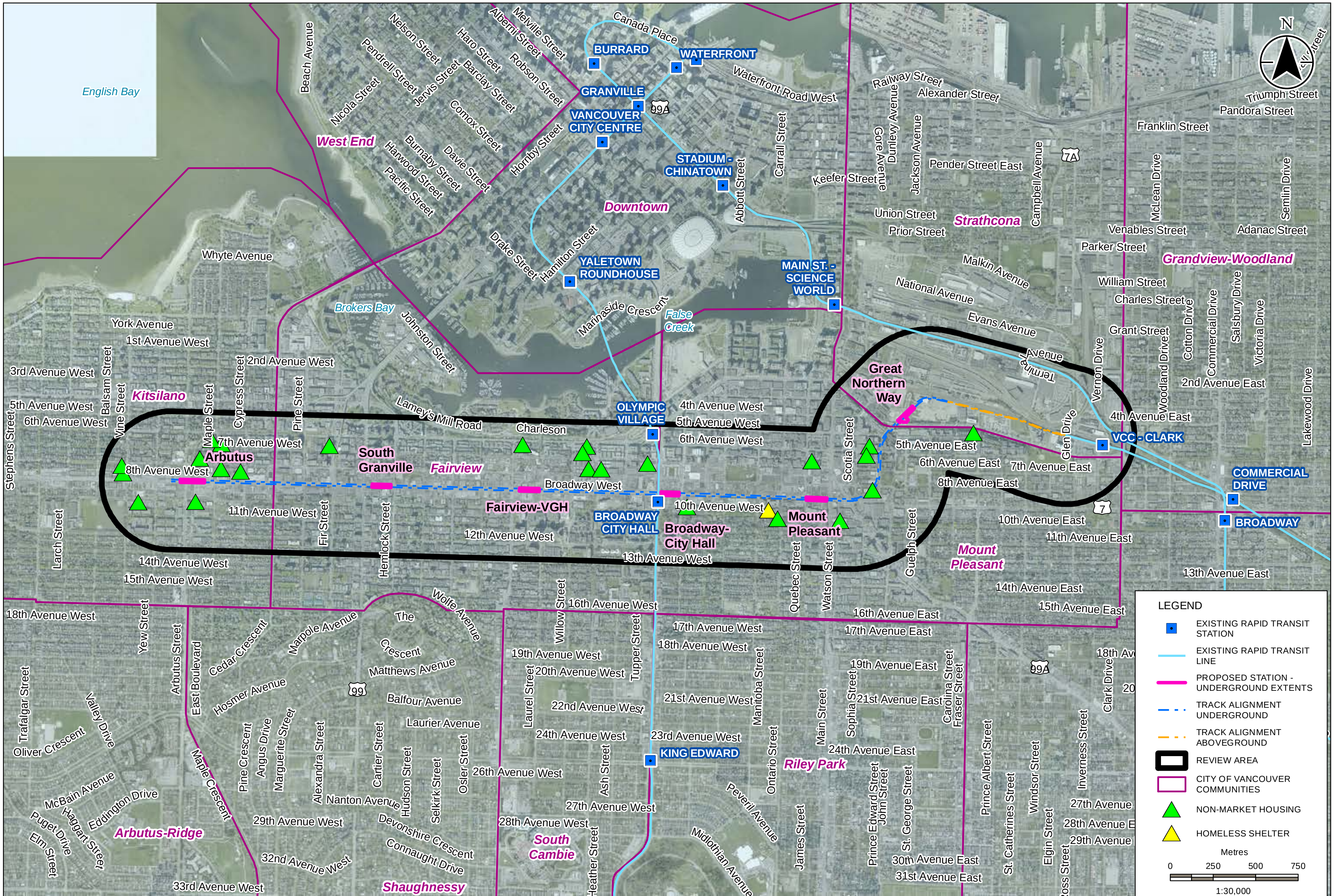
One indicator of housing affordability used in the City of Vancouver is ‘core housing need’. A household is considered to be ‘in core housing need’ if its housing does not meet at least one of the adequacy, affordability or suitability standards and the household would have to spend 30% or more of pre-tax income to pay median rent of alternative local housing that meets all three housing standards (Statistics Canada 2016). The rate of core housing need in the City of Vancouver has decreased from 2011 (20.4%) and 2006 (20.6%) levels to 19.8% in 2016, representing a total of 51,400 households considered to be in core housing need (Statistics Canada 2016). The majority of households (46,990) cited ‘unaffordability’ as at least one of the reasons they were in core housing need (Statistics Canada 2016). The rate of unaffordable housing (percent of households spending more than 30% of household income on housing) for owner households in 2016 was 27.8%, and 44.3% for renter-households (Statistics Canada, 2016).

Local and regional studies have assessed housing and transportation costs in the Metro Vancouver region and found that for the Vancouver sub-region, housing and transportation costs accounted for 39% of owner household median income, and 45% of renter household median income (Metro Vancouver 2015b). Transportation costs for owners and renters were reported as the same, while owners spend nearly 50% more on housing than renters (Metro Vancouver 2015b). Owners and renters in the Vancouver sub-region realize some of the highest housing costs compared to the rest of Metro Vancouver (Metro Vancouver 2015b). Households living in areas well-served by rapid transit spend less on transportation costs. A single zone transit pass (includes all of City of Vancouver and UBC) costs $93 monthly or $1,116 annually. This is substantially less than average annual costs to own and operate a vehicle [$8,900 (Metro Vancouver 2015b)].

Non-market housing

In 2017, the City of Vancouver had 25,623 non-market (e.g., subsidized) housing units (Vancouver 2017a). Non-market housing locations are depicted on Figure 7.3-3. There are 24 buildings (1,000 units) offering non-market housing[6] within 400 m of the Alignment. Approximately 32.5% of these units are studio/bachelor apartments, 32.8% are one bedrooms, 21.8% are two bedrooms, 12.1% are three bedrooms, and 0.8% are four bedrooms. Approximately 36% (4,008 households) of Metro Vancouver residents on social housing wait lists in 2017 lived in Vancouver.

[6] Non-market housing identified in Figure 7.3-3 does not include housing units associated with non-profit projects and Co-op housing.



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7.3.4 Project Interactions

Project activities that may interact with the Housing and Property Review Element are indicated by check marks in Table 7.3-5. Based on the general design and construction approach described in Section 2 (Project Description), construction activities are not anticipated to affect availability and affordability of housing and property, because the Project will be built mainly underground with limited property requirements to support the construction of stations.

Project operation may affect housing and property through changes in land use, development patterns, property values, and housing availability and affordability. Section 7.3.5 discusses measures that have been undertaken, primarily by the City of Vancouver, in anticipation of how the addition of rapid transit to the Corridor will influence land use and development.

Table 7.3-5: Potential Project Interactions and Effects on Housing and Property

	Potential Effects
Project Activities and Physical Works	**Change in Housing and Property**
Construction	
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	-
Elevated guideway construction	-
Tunnel and station excavation	-
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	-
Vehicle traffic (e.g., road use and construction traffic)	-
Management and disposal of waste and excavated materials	-
Commissioning and start-up	-
Operation	
Train operation, including wayside and power	✓
Station operation	✓
Train maintenance, administration, transit police	-

7.3.5 Mitigation Measures

Given the integrated nature of land use planning and the development of transportation infrastructure, the City of Vancouver has been, and remains, an important partner in the planning and delivery of the Project. City plans and programs that will address housing availability and affordability in neighbourhoods along and near the Alignment include:

- Implementation of the Development Contribution Expectation Policy in order to limit speculation in the Broadway Corridor.
- **Housing Vancouver Strategy**—a comprehensive city-wide strategy to retain existing affordable housing and facilitate the construction of new affordable housing affordable to local incomes. Specific strategies that may be applied include:
  - Rental unit replacement requirements
  - Rental only-zoning
  - Density bonuses/rezoning/inclusionary zoning
  - Land sales and below market rates
  - Community Amenity Contribution requirements during up-zoning

  The Housing Vancouver Strategy is a City-wide initiative. To the extent that specific strategies are applied along the Broadway Corridor, it is intended that they will help address housing affordability within this area.
- **Vancouver Plan**—The City has begun a process to create a strategic, long-term plan for Vancouver that will address, among other issues, long-term land use and housing affordability.
- **Broadway Plan**—The City has begun development of the Broadway Plan, with the objective to “co-ordinate transit-supportive land use, affordable housing policies, job space, transportation connectivity, and public realm design with the rapid transit project.” The planning process is intended to: create additional affordable housing and rental housing opportunities close to transit while preserving and mitigating displacement of existing renters; increase the amount of job space; and enhance local shopping areas (Coriolis 2018).
- **False Creek Flats Plan**—This Plan, which was approved in May 2017, will support the development of emerging and innovative industries, including digital business, health care, and food services. The plan also introduces some new opportunities for residential development (Coriolis 2018). The Broadway Subway Project will integrate within this plan in the vicinity between VCC-Clark Station and the new station at Great Northern Way and Thornton Ave.
- **False Creek South Neighbourhood Planning Program**—Most of the land along the south shore of False Creek, between Cambie Street Bridge and Burrard Street Bridge is owned by the City and developed for multifamily residences on long-term leases. In May 2018, the City adopted a Provisional Vision Statement and Guiding Planning Principles that include an objective of increasing housing capacity in this area including new affordable housing options (Coriolis 2018).

In June 2018 the City of Vancouver and TransLink signed a Supportive Policy Agreement (SPA) with respect to the Project. Within the SPA, TransLink and the City of Vancouver “affirm their commitment to advancing the principles of the Transit-Oriented Communities Design Guidelines in the planning, design, and implementation of the Project (City of Vancouver and TransLink 2018). The SPA identifies the following principles to guide transit-oriented development along the Project Corridor:

- The coordination of land use and transportation, focusing on high demand destinations along the Project Corridor
- The creation of a pedestrian- and bicycle-friendly street network to support transit use
- The design of a public realm accessible to people of all ages and abilities, whether they be walking, cycling, using transit, pushing a stroller, or using a mobility device
- The concentration of homes, jobs, and key activities within a short walk of the stops for the Project at a level appropriate to support the transit investment
- The provision of diverse land uses and housing types, tenures and price points
- The use of travel-demand management measures like parking pricing to promote walking, cycling and transit in the Project corridor (City of Vancouver and TransLink 2018)

Under the SPA the City will develop and adopt an affordable housing strategy for the Project corridor, under the context of the Housing Vancouver Strategy, which will “outline affordable housing targets by location, housing type, target income and tenure.” TransLink will collaborate with the City and the Province in the development of the Affordable Housing Strategy by providing technical information and analysis to the planning process (City of Vancouver and TransLink 2018).

7.3.6 Discussion of Review Results

This section discusses the potential for Project-related effects on housing and property during Project operation. The potential for Project-related effects is evaluated by examining the potential influence of Project operations on anticipated trends in housing as reflected in key housing and property indicators.

7.3.6.1 Residential Properties Affected by the Project

Population Growth and Changing Development Patterns

The Project, in concert with a complementary area plan, will assist in accommodating planned population growth, jobs and development density along the Alignment. Once implemented, the Broadway Plan, facilitated by the SPA between the City and TransLink, will include direction for land use to support sustainable transportation choices. This includes prioritizing for dense and diverse development in areas served by rapid transit and enhancing and enabling trip-generating entities (e.g., schools, employment centres, shopping districts) along rapid transit corridors.

The Project is likely to make redevelopment of existing lower density residential properties more attractive to property development companies when coupled with increased available zoning densities. However, rather than increase the pace of development in the City, it is anticipated that the Project will influence the distribution of development within parts of Metro Vancouver (Coriolis 2018). As such, some of the development that would otherwise occur in other parts of the City of Vancouver or elsewhere in the region may shift to the Broadway Corridor.

Housing and Residential Property Values

The Project has the potential to contribute to increases in property values. Speculation, in the anticipation of rapid transit development, has been shown in some instances to increase property values prior to projects becoming operational (Ferguson 1984; Schiff 2012). A study examining property value changes prior to, during, and after the development of the Canada Line found that properties perceived to have high development potential, within 500 m of proposed stations, were purchased at a premium of approximately 5–7% (Schiff 2012). Property speculation was observed to be strongest following the announcement of a final investment decision of that project (December 2004), and with the announcement of project completion (January 2009). The City has already approved a DCE Policy that aims to curb land speculation in advance of the Broadway Plan and delivery of the Broadway Subway Project.

Housing Affordability

Through changes in property value and induced development, the Project could contribute to changes in the availability of affordable housing. Recent studies completed on transit-oriented affordable housing have found that affordable rental housing is in low supply, largely because affordable rents do not cover land and development costs, especially near rapid transit (Metro Vancouver 2017). The City of Vancouver has recently approved the Housing Vancouver Strategy which includes protecting and renewing existing affordable housing as well as ambitious affordable housing targets with a focus on locating new affordable housing units.

Additionally, in accordance with the SPA, the City, through the Broadway Planning process, will identity approaches to enable new purpose-built rental housing and non-market housing, and to enhance tenant protections. The City will work with the Province and TransLink to implement measures under the Housing Vancouver Strategy, the Broadway Plan and the SPA to facilitate an increase in affordable housing options and ensure strong tenant protections and supports in order to limit the impacts of displacement on existing residents resulting from land use changes along the Project Alignment. Such measures are intended to assist in mitigating potential increases on housing values that may be associated with the Project.

By delivering convenient, low cost, rapid transit service, the Project could improve the overall cost of living of households along the Alignment. An estimated 74% of non-market housing units in the Review Area are currently not served by rapid transit. To the extent that households are able to reduce private vehicle use, the Project will have a positive impact on cost of living due to higher costs of operating a private vehicle compared to using transit.

7.3.6.2 Commercial Properties Affected by the Project

The Broadway Corridor is the second largest employment centre in BC. Project operation is expected to benefit commercial properties in a variety of ways. Key business areas will be connected via efficient, reliable, rapid transit. The Project will deliver long-term benefits to businesses along the corridor, once operational, through enhanced transit access along Broadway, for customers and employees, as well as increased density and development. Increased foot traffic resulting from accessible transit will likely contribute to increased local spending.

Commercial properties located in the immediate vicinity (less than 150 m) of rapid transit stations may experience increases in property value (Ferguson 1984; Schiff 2012; KPMG 2013). Rapid transit will improve local and regional connections and may increase desirability, staff accessibility, and increased rents and/or property tax payments.

The Project may facilitate commercial redevelopment within the Review Area, because of improved locational attributes (i.e., better transit service) and increasing employment intensity in the area.
Some types of businesses (e.g., light industrial or low-rise commercial) may face pressure to relocate as new commercial and industrial developments progress. For example, the landlords of older light industrial and low-rise commercial buildings that are located on parcels zoned for higher density employment generating uses may be incentivized by developers to sell their properties. The availability of lower-rent older retail space may decline; this could result in a shift in the composition of retail areas (Coriolis 2018). Commercial businesses may experience increased business activity with revenues which could potentially offset increases in property taxes and leasing costs. However, some businesses may not be able to increase revenues and could be pressured to re-locate to lower cost commercial space elsewhere in the City or Metro Vancouver region.

7.3.7 Conclusion

Communities along the Alignment, and in particular along Broadway, have historically experienced high density residential and office development, due to their central location within transportation corridors, and proximity to major institutions including City Hall, Vancouver Hospital, and UBC. By providing high quality rapid transit service, the Project is expected to facilitate further residential and commercial development within this area and could result in some shifting of development interest from other parts of Vancouver.

The Project is expected to facilitate transit-oriented development, particularly in areas near stations. However, because many of these areas are already substantially built up, changes caused by the Project are anticipated to be incremental.

Land values may increase in the Broadway Subway Corridor due to speculation about future allowable densities, and could present additional challenges to housing affordability. In anticipation of such challenges, the City has introduced the DCE policy with a goal of limiting speculation within the corridor. Residential and commercial rents could also increase due to proximity of the new Broadway Subway, resulting in some changes in the composition of residential and commercial areas.
To address this potential effect, the City of Vancouver, working with the Province, and TransLink will implement measures under the Housing Vancouver Strategy, the Broadway Plan, and the SPA to facilitate an increase in affordable housing options, allow for strong tenant protections and supports, and encourage job space along the Alignment. The Project will also provide an affordable rapid transit option to area residents and employees, and to the extent that this reduces private automobile usage, will lower household transportation costs, thus positively contributing to overall cost of living.

7.4 Archaeological and Heritage Resources

This section of the Environmental and Socio-economic Review (ESR) evaluates Project activities with the potential to affect Archaeological and Heritage Resources. The Archaeological and Heritage Resources Review Element includes archaeological and heritage sites as defined under British Columbia (BC) *Heritage Conservation Act* (HCA) and Vancouver Charter.

Key information provided to support the assessment of Archaeological and Heritage Resources includes:

- Rationale for the selection of Archaeological and Heritage Resources as a Review Element
- Relevant legislation and policy applicable to protecting Archaeological and Heritage Resources
- Identification of potential Project effects and indicators
- Existing conditions for Archaeological and Heritage Resources within the spatial boundaries of Project assessment
- Potential Project interactions with Archaeological and Heritage Resources
- Mitigation measures to avoid, or reduce, potential effects on Archaeological and Heritage Resources
- A discussion of review results and conclusions

7.4.1 Rationale for Selection as a Review Element

Archaeological and Heritage Resources were selected as a Review Element because, if present, they are susceptible to alteration from certain Project activities, and archaeological and heritage sites are protected from alterations by the BC HCA. Additionally, the City of Vancouver has the ability under the Vancouver Charter to protect heritage properties through designation bylaws and these properties cannot be altered without the appropriate municipal approvals. Archaeological and heritage sites within the Review Area may have cultural significance to local Indigenous groups on whose traditional territories the Project is located (e.g., Musqueam Indian Band, Tsleil-Waututh Nation, and Squamish Nation) and the protection of these resources was identified as being important during both the Indigenous consultation and public engagement phases.

7.4.2 Review Scope for Archaeological and Heritage Resources

7.4.2.1 Regulatory and Policy Setting

The following legislation and bylaws provide the regulatory framework within which Archaeological and Heritage Resources in the City of Vancouver are managed (see Table 7.4-1).

Table 7.4-1: Regulatory Setting for Archaeological and Heritage Resources

Responsible Agency	Law, Regulation, Policy	Description	Potential Project Applicability
Archaeology Branch, Ministry of Forests, Lands, Natural Resource Operations and Rural Development	*Heritage Conservation Act*	Prohibits alteration of archaeological sites except as authorized under permit	Project activities that involve ground disturbance have the potential to alter archaeological sites, if/where present
Heritage Branch, Ministry of Forests, Lands, Natural Resource Operations and Rural Development	*Heritage Conservation Act*	Prohibits alteration of non-archaeological heritage sites and heritage objects[7] except as authorized under permit	Project activities that involve ground disturbance and/or result in vibration have the potential to alter heritage sites, if/where present
City of Vancouver	Vancouver Charter	Provides City with the authority to protect significant heritage sites from alterations	Project activities that have the potential to alter designated heritage sites, if/where present
City of Vancouver	Heritage Bylaw No.4837	Allows for protection of heritage designated properties	Project activities that involve alteration of heritage designated properties
City of Vancouver	Heritage Revitalization Agreement Bylaw 7771	Enables the City to negotiate agreements with landowners that require preservation of the property's heritage features in exchange for variances on other city regulations	Project activities that have the potential to alter heritage features protected under Heritage Revitalization Agreement Bylaw 7771

In addition to provincial and local government legislation and policy guiding the assessment and protection of heritage resources, some Indigenous groups have established permitting processes focusing on archaeology and heritage assessments in their traditional territories. As a best practice, Inlailawatash Limited Partnership (Inlailawatash) applied for heritage investigation permits from Musqueam Indian Band, Squamish Nation, and Tsleil-Waututh Nation prior to conducting an AOA, on behalf of the Project team, in support of Project planning and the ESR (Inlailawatash 2018). Subsequent to completion of the AOA, Inlailawatash provided refined recommendations based on additional geotechnical, Project location and areas of archaeological potential that became available (Inlailawatash 2019).

[7] The HCA defines "heritage site" as "whether designated or not, personal property that has heritage value to British Columbia, a community or an aboriginal people"; and defines "heritage object" as "whether designated or not, land, including land covered by water, that has heritage value to British Columbia, a community of an aboriginal people".

British Columbia *Heritage Conservation Act*—In BC, heritage resources are managed in accordance with the legal requirements and conditions set forth in the HCA. The HCA defines "heritage site" to mean "whether designated or not, land, including land covered by water, that has heritage value to British Columbia, a community, or an aboriginal people". This broad definition encompasses a variety of resource types including archaeological sites and historical sites, as well as other places, such as spiritual sites, which may not contain evidence of human activity. For the purposes of this ESR, the assessment focuses on heritage resources that are legally protected by the HCA.

The HCA extends automatic legal protection to archaeological sites if they pre-date AD 1846 or are of unknown age but may pre-date AD 1846. Burial sites and Indigenous rock art sites are automatically protected, regardless of age. Though not automatically protected under the HCA, post-AD 1846 Indigenous heritage sites may be protected under the HCA under agreement with Indigenous groups. Historical sites that postdate AD 1846 are generally not protected by the HCA, except where designated as a 'Provincial heritage site' under section 9 of the *Act*. "Heritage value" is defined in the HCA as the "historical, cultural, aesthetic, scientific or educational worth or usefulness of a site or object". Designated heritage sites are defined as sites with historical, paleontological, and/or architectural significance which have been designated as heritage sites, either provincially through the HCA, or in the City of Vancouver through provisions under the Vancouver Charter.

The Archaeology Branch of the British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development has authority over the archaeological assessment and review process. Under the HCA, the Archaeology Branch is responsible for deciding whether permits can be issued to allow development to take place within protected sites and has established standards, policies, and guidelines to regulate the archaeological assessment process. The Heritage Branch of the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development has authority over post-1846 heritage sites and heritage objects as defined in the HCA.

Vancouver Charter—The Vancouver Charter provides City of Vancouver Council with the authority to protect heritage property through heritage designation bylaws. Alterations must be approved through the municipal permitting process. The City legally enacted the Vancouver Heritage Register in 1986, which is the officially-recognized list of property and features with historical, cultural, aesthetic, scientific, or educational value in the City. Changes to protected heritage property are administered under the Heritage Procedures Bylaw and associated bylaws for heritage protection. Not all sites listed on the Vancouver Heritage Register have heritage designation, so a property listed on the register is not necessarily subject to the permit process.

Heritage properties can include buildings, structures, lands and features of buildings or affixed to the land (e.g. landscaping). Protection occurs through Council designation of property through heritage bylaws, heritage revitalization agreements or section 219 covenants under the *Land Title Act*. Under Heritage Bylaw No. 4837 there are two categories of heritage designations. Buildings, structures, and lands listed on Schedule "A" of the bylaw are protected in entirety from alteration, while Schedule "B" includes buildings or structures for which specific features are protected from alteration.

Prior to altering a designated building or feature, a heritage alteration permit is required from the City of Vancouver Director of Planning.

Designation may also be legally secured through Heritage Revitalization Agreement Bylaw No. 7771, or through restrictive covenants.

7.4.2.2 Consultation and Engagement Input Supporting the Assessment

The Terms of Reference for the ESR, which guided the assessment of effects on Archaeological and Heritage Resources, was informed by Project team consultation with Indigenous groups and engagement with the public.

Comments received during the consultation and public engagement phase are provided in Section 5.5 and include comments noting that archaeological and heritage sites could be encountered during construction and that steps should be taken to avoid effects on such sites. This input has been addressed through the completion of an AOA which identifies areas within the Alignment with archaeological potential and mitigation measures to guide the management and protection of Archaeological and Heritage Resources that may be encountered during construction. Information in the AOA report (Inlailawatash, 2018) was used to inform the evaluation of Archaeological and Heritage Resources presented in this section of the ESR.

An important outcome of the Project team's consultation with Indigenous groups was the decision to engage Inlailawatash to complete the AOA and preliminary field reconnaissance (PFR) for the Project. Inlailawatash is a business owned by the Tsleil-Waututh Nation, who are one of the Coast Salish First Nation communities in whose traditional territories the Project is located. As part of the AOA/PFR process, Inlailawatash applied for heritage investigation permits from Musqueam, Tsleil-Waututh and Squamish Nations, and representatives from Tsleil-Waututh and Squamish participated in the PFR field work. Additionally, Musqueam Indian Band provided place name information for the AOA report (Inlailawatash 2018).

7.4.2.3 Selection of Effects and Review Indicators

Table 7.4-2 lists potential Project effects on Archaeological and Heritage Resources and provides a summary of the effects mechanisms and review indicators used to assess the potential effects. Project effects mechanisms are presented in this table to show the linkage between the Review Element and the potential effect. Review indicators facilitate qualitative or quantitative measurement of potential effects.

The AOA determined that there was no potential for culturally modified trees predating 1846 AD within 100 m of the Alignment (Inlailawatash 2018, page 25) and potential Project effects on culturally modified trees are not considered in the scope of the assessment.

Table 7.4-2: Potential Effects and Review Indicators for Archaeological and Heritage Resources

Potential Effects	Project Effects Mechanisms	Review Indicators	Rationale for Selection
Alteration of archaeological sites	• Any Project activities involving ground disturbance have the potential to effect archaeological sites, if/where present	• Inventory of previously recorded archaeological sites, description of potential alterations, and impacts of such alterations • Presence of locations with high archaeological potential	• Regulatory requirements (automatic protection of archaeological sites under the HCA)
Alteration of heritage sites	• Site specific depending on identified heritage values and nature of Project-related activity on heritage properties	• Inventory of potentially affected heritage sites and description of potential alterations	• Regulatory requirements under the City Heritage Procedures Bylaw and Bylaws No. 4837 and 7771

7.4.2.4 Boundaries

The Review Area for the assessment of potential effects of the Project on Archaeological and Heritage Resources is a 100 m offset from the centerline of the Alignment.

The temporal boundary used in this assessment is the construction phase (i.e., 2020 to 2025).

7.4.3 Existing Conditions

This section summarizes the existing conditions and the methods used, to support the assessment of Archaeological and Heritage Resources within the Review Area.

7.4.3.1 Methods

The following describes methods used in support of identifying both archaeological and heritage resources in the Project Area.

Archaeology

An AOA of the Review Area was undertaken to gather information on baseline conditions for Archaeological and Heritage Resources (Inlailawatash 2018). The AOA was conducted in accordance with the Province's AOA standards and guidelines, and the terms and conditions of heritage investigation permits issued by the Musqueam Indian Band, Squamish Nation, and Tsleil-Waututh Nation.

The AOA evaluated archaeological site distribution and potential in the Review Area. The assessment consisted of a desk-based literature review and compilation of existing historical knowledge about recorded archaeological site locations, historical Indigenous land-use and place names, and environmental features in areas likely to influence archaeological site location.

As part of the AOA, a PFR was conducted for the Review Area. The PFR was carried out on February 16, 2018 by Inlailawatash archaeologists, and field representatives from Tsleil-Waututh Nation and Squamish Nation. The methods consisted of a pedestrian survey along the length of the corridor to visually assess the surficial landscape, including landforms and the shorelines that may have the potential to contain archaeological resources. The information from the AOA and PFR was used to create an archaeological potential model of where archaeological sites could be expected to be located.

Following the completion of work to finalize the land and property requirements of the Project, Inlailawatash undertook an additional desktop review of areas with high archaeological potential within the Review Area (Inlailawatash, 2019). The additional review focused on those areas of high archaeological potential that, based on more detailed design and property information, overlap with the confirmed property requirements of the Project and where Project-related ground-disturbance (i.e., within 1–10 metres depth) may occur.

Heritage

In order to identify existing heritage buildings and features within the Project Area, searches of the Vancouver Heritage Register and VanMap online application were undertaken to confirm the location and status of heritage properties in the Review Area.

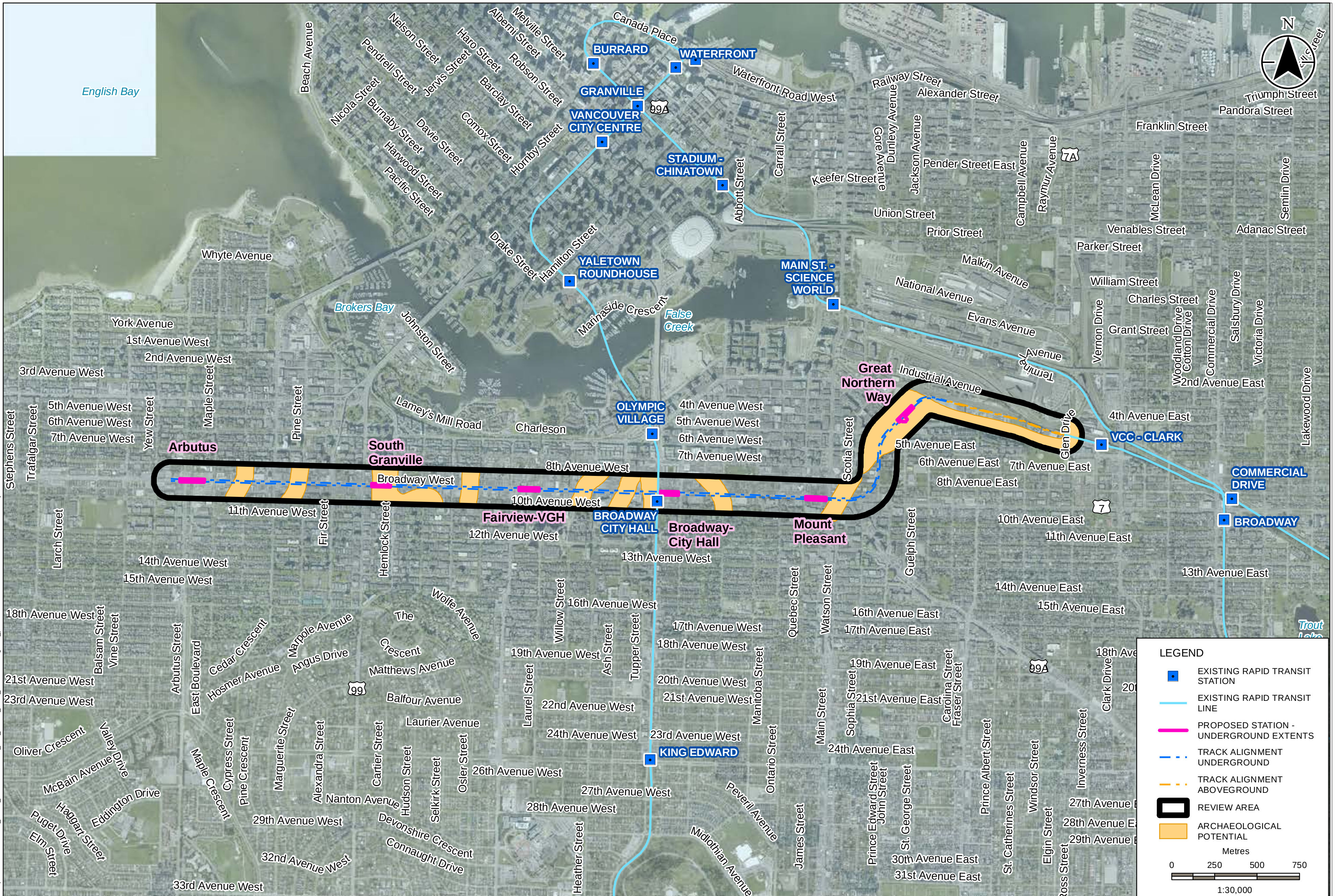
7.4.3.2 Review of Baseline Conditions

Recorded Archaeological Sites

There are no archaeological sites listed on the Archaeology Branch's Remote Access to Archeological Data database within the Review Area. However, six archaeological sites are listed in the Remote Access to Archeological Data database as being located within two kilometres of the Review Area.

Locations with Archaeological Potential

The AOA identified 10 locations of archaeological potential within the Review Area. These locations correspond with the pre-industrial shoreline of False Creek, as well as nine locations associated with historic streams (Figure 7.4-1).



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APPROVAL	INIT	YY-MM-DD DATE

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BROADWAY SUBWAY PROJECT

Stantec

BROADWAY SUBWAY PROJECT

AREAS OF ARCHAEOLOGICAL POTENTIAL

SCALE 1:30,000	CONTRACT NO.	SUB CONSULTANT PROJECT NO. 115814099
DATE 17-11-29		
SHEET NO.	FIGURE 7.4-1	

Listed Heritage Properties

The Vancouver Charter defines heritage properties as those that have been identified as having heritage character or heritage value, by Council's delegate, even if not listed on a register. Currently, there are five properties listed on the Vancouver Heritage Register that face streets that the Alignment will follow:

- 1490 West Broadway—the "Dick Building"
- 1154 West Broadway—the "BowMac Sign"
- 301-307 West Broadway—low rise commercial building ("Clydemont Centre")
- 151-189 East Broadway—the "Lee Building"
- 2490 Main Street—the "Bank of Montreal"

While no Project-related modifications to these properties are under consideration, two of these properties are subject to protection under the City Heritage Bylaws and would require heritage alteration permits if alterations were proposed. The "Dick Building" at 1490 West Broadway is a Schedule A designated heritage property under Bylaw No. 4837; and the "BowMac Sign" at 1154 West Broadway (Borden number DhRs-348) is subject to Heritage Revitalization Agreement Bylaw No. 7771.

7.4.4 Project Interactions

Project activities and physical works that may interact with Archaeological and Heritage Resources are identified in Table 7.4-3. Potential interactions are indicated by check marks and are discussed in greater detail below. Justification for non-interactions that are not assessed are provided following the table below.

Table 7.4-3: Potential Project Interactions and Effects on Archaeological and Heritage Resources

Project Activities and Physical Works	Potential Effects	
	Alteration of Archaeological Sites	Alteration of Heritage Sites
Construction		
Property acquisition	-	-
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	✓	✓
Elevated guideway construction	✓	-
Tunnel and station excavation	✓	✓
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	✓	✓
Vehicle traffic (e.g., road use and construction traffic)	-	-
Management and disposal of waste and excavated materials	✓	-
Commissioning and start-up	-	-
Operation		
Train operation, including wayside and power	-	-
Station operation	-	-
Train maintenance, administration, transit police	-	-

7.4.4.1 Archaeological Resources

Based on the Project Description (Section 2), construction activities that could affect archaeological resources would include ground disturbing activities associated with site preparation, guideway construction, tunnel and station excavation, station construction, and management and disposal of waste and excavated material.

Ground disturbing activities that take place beneath post-glacial sediments (i.e., tunnel excavation) will not affect archaeological resources because these deeper deposits predate the known arrival of humans to the area. In addition, ground disturbing activities within imported materials (e.g., fill, asphalt) are unlikely to affect archaeological resources because intact archaeological deposits are not found in imported, disturbed materials.

Based on the results of the AOA, construction activities have the potential to affect archaeological resources through ground disturbance in 10 locations with archaeological potential.

Other Project activities are expected to have no measurable interaction with archaeological resources as they will not result in ground disturbance.

7.4.4.2 Heritage Buildings and Features

Project activities that could result in potential effects on City of Vancouver designated heritage buildings and features include site preparation, tunnel and station excavation, and station construction.
These activities have the potential to result in indirect effects on buildings, including heritage properties (e.g., minor cracking of drywall and/or exterior envelope) as a result of ground vibration generated by construction works. A more detailed consideration of potential vibration effects within the Project Area, and measures for addressing such effects during construction, are presented in Section 7.6 (Vibration).

7.4.5 Mitigation Measures

To avoid or mitigate potential Project-related effects on archaeological resources, mitigation measures, such as those identified in Table 7.4-4, will be included in the Archaeology and Heritage Management Plan to be developed by the Contractor prior to construction. Section 9 (Environmental Management Plans) provides additional information on how environmental management plans will be developed and implemented.

The mitigation measures identified in Table 7.4-4 were developed based on best practices for Archaeological and Heritage Resources and a review of applicable legislation and policy and are consistent with the recommendations of the AOA.

As noted in Section 9 (Environmental Management Plans), the Contractor will confirm the final mitigation approaches to support the Archaeology and Heritage Management Plan. This approach will allow for mitigation measures that are aligned with the detailed design and construction approach developed by the Contractor.

7.4.5.1 Archaeological Resources

Prior to construction, the Contractor will identify detailed mitigation for avoiding or limiting potential effects on archaeological resources that may be identified in the Project Area. The detailed mitigation measures will be informed by the final design and construction method selected by the Contractor. The mitigation measures will focus on the protection of archaeological and heritage resources during futures stages of Project development, including detailed design and construction. The Plan will include specific measures, identified in Table 7.4-4, such as:

- Additional investigation in areas with archaeological potential during property acquisition and/or following detailed design (e.g., Archaeological Impact Assessment)

- Monitoring of subsurface disturbance from 0-10 m below surface in areas of historical stream drainages, where appropriate (e.g., based on detailed Project design)
- Subsurface sampling of undeveloped lots within areas of archaeological potential
- Protocols for addressing archaeological and heritage resources that may be unexpectedly encountered during Project construction

7.4.5.2 Heritage Buildings and Features

With respect to measures to avoid or mitigate potential vibration effects on City of Vancouver designated heritage buildings, Section 7.6 (Vibration) identifies activities that will be taken to monitor and address potential vibration effects. Specifically, the Contractor will be required to develop and implement a Noise and Vibration Management Plan that includes provisions for monitoring construction-related vibration and mitigation to avoid and/or mitigate potential vibration effects on adjacent buildings and vibration-sensitive activities (e.g., operation of sensitive equipment in medical and health facilities as well as commercial / educational facilities).

The Noise and Vibration Management Plan will include a requirement to conduct pre-construction condition surveys of existing structures in order to identify, and repair, minor building damage that could result from construction-related vibration. The Project will work with the City of Vancouver, in the development and implementation of the Noise and Vibration Management Plan, to verify that proposed mitigation is consistent with City of Vancouver Heritage bylaws.

Table 7.4-4: Mitigation Measures for Archaeological and Heritage Resources

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.4-1	Develop and implement an Archaeology and Heritage Management Plan, for the construction phase, that identifies measures to protect archaeological and heritage resources. The Archaeology and Heritage Management Plan will include measures for protecting archeology and heritage resources in the Project areas including: • Specific best practices to ensure archaeological resources are managed in compliance with the Heritage Conservation Act (HCA) • The Identification of areas with archaeological potential requiring additional investigation (i.e., Archaeological Impact Assessment) during property acquisition and/or following detailed design. • Monitoring of subsurface disturbance in areas of historical stream drainages, where appropriate (i.e., based on detailed Project design)	Construction	Contractor	Contractual Requirement
7.4-2	Undertake targeted archaeological field studies (e.g., an archaeological impact assessment) as recommended (i.e., in the AOA) to assess or monitor ground-altering developments within areas of archaeological potential identified in the AOA so that archaeological sites, if present, are appropriately managed.	Construction	Province and Contractor	Contractual Requirement
7.4-3	Mitigate effects to archaeological and heritage sites (if any) identified during the archaeological assessments for the Project in accordance with the HCA and provincial guidance.	Construction	Contractor	Contractual Requirement
7.4-4	An Archaeological and Heritage Resources Chance Find Procedure will be developed in advance of construction and implemented in the event that previously unidentified archaeological or heritage resources are encountered during Project construction.	Construction	Contractor	Contractual Requirement

7.4.6 Discussion of Review Results

The proposed mitigation measures, including additional targeted archaeological field studies and avoidance or mitigation of any archaeological sites, are predicted to be effective at avoiding Project-related effects on archaeological resources. Consequently, no effects on archaeological sites are expected. Additional mitigation measures, including further review of areas of high archaeological potential, will be implemented where appropriate to further limit potential effects to archaeological resources.

Based on additional review work undertaken by Inlailawatash (2019), MOTI has initiated an Archaeological Impact Assessment to be undertaken, in advance of construction, to confirm the presence/absence of archaeological resources in the vicinity of Great Northern Way. This area is considered to have the highest archaeological potential within the known property requirements of the Project, given its proximity to the historical shoreline of False Creek prior to the area being infilled during historic development. Undertaking such work, in advance of detailed design and construction, will provide greater certainty regarding sub-surface conditions and help guide avoidance measures in the event that archaeological resources are confirmed to be present.

As the Project does not directly overlap any properties with heritage buildings, no loss of City of Vancouver designated heritage buildings is anticipated. There is the potential for some indirect effects on heritage buildings as a result of construction-related vibration.

The development and implementation of a Noise and Vibration Management Plan, described in Section 7.6 (Vibration) will include requirements for monitoring and mitigating potential effects on buildings arising from construction-related vibration. Measures typically included in vibration management plans are commonly employed, to avoid or mitigate potential effects on buildings caused by construction related vibration, and have been demonstrated to be effective in avoiding or limiting such effects.

7.4.7 Conclusion

With the implementation of mitigation measures outlined above there are no anticipated Project effects on Archaeological and Heritage Resources. Detailed, Project-specific mitigation measures to be used by the Contractor, will be confirmed prior to construction in discussion with the appropriate agencies including the City of Vancouver and Ministry of Forests, Lands, Natural Resource Operations and Rural Development (Archaeology Branch and Heritage Branch).

Where appropriate, additional archaeological field studies are being advanced in areas of archaeological potential identified in the AOA. Such work will provide greater certainty regarding sub-surface conditions and will help guide avoidance measures in the event that archaeological resources are confirmed to be present. Any archaeological sites identified during the studies will be managed in accordance with provincial regulations and in consultation with participating Indigenous groups.

Potential effects to heritage buildings will be limited to potential vibration effects which can be effectively mitigated through the application of a Project-specific Noise and Vibration Management Plan.

7.5 Noise

This section of the Environmental and Socio-economic Review (ESR) evaluates Project-related effects on changes in existing noise levels. Project-specific noise is quantified relative to existing conditions as well as applicable guidelines and policies to determine potential effects of Project activities on the noise Review Element.

Project construction activities that could affect existing noise levels mainly relate to the use of construction equipment and vehicles. Operational activities that could affect existing noise levels are limited to train operation on the above ground section of the guideway and station operation (i.e., noise from ventilation system of underground stations) and maintenance (e.g., track maintenance).

Key information provided to support the assessment Noise includes:

- Rationale for selection of noise as a Review Element
- Methods used to review potential effects of Project activities in the context of applicable guidelines and policies applicable to this Review Element
- Existing conditions near the Alignment
- Summary of Project components and physical activities that may interact with this Review Element
- Proposed mitigation measures to limit, or reduce, potential effects on the Review Element
- Review of Project effects on the Review Element, specific to Project construction and operation

7.5.1 Rationale for Selection as a Review Element

Noise was selected as a Review Element because Project construction and operation activities are expected to create noise. For the purpose of this assessment, noise is defined as unwanted sound that has the potential to affect the health and well-being of people. Only environmental noise experienced outdoors is assessed and noise potentially experienced by passengers on trains is not part of this assessment.

7.5.2 Review Scope for Noise

7.5.2.1 Regulatory and Policy Setting

This section summarizes noise terminology (descriptors) relative to key regulatory guidance documents applicable to the Noise Review Element. The key regulatory guidance documents are presented in Table 7.5-1. Details on how the regulatory and policy documents have been applied are provided in the Noise Technical Data Report (TDR; Stantec 2019).

Table 7.5-1: Regulatory Setting for Noise

<table>
<tr><th>Agency</th><th>Policy</th><th>Environmental Noise Descriptors</th><th>Applicable Criteria</th></tr>
<tr><td rowspan="2">The City of Vancouver</td><td rowspan="2">Noise Control Bylaw No. 6555, Zoning Map.</td><td rowspan="2">L_{eq}(3 min) daytime & nighttime limits</td><td>Day:
60 dBA—quiet zone
70 dBA—intermediate or activity zone
85 dBA—construction site boundary</td></tr>
<tr><td>Night:
55 dBA—quiet zone
65 dBA—intermediate or activity zone</td></tr>
<tr><td>United States Federal Transit Administration</td><td>Transit Noise and Vibration Assessment Guideline (May 2006)</td><td>Difference in Pre-Project and Post-Project Noise Level, L_{dn}(dBA) or L_{eq}(h).1</td><td>3 possible impact levels:
No Impact
Moderate Impact
Severe Impact</td></tr>
</table>

Noise Terminology

The acoustic environment is quantified in terms of the energy equivalent sound levels (L_{eq}). The L_{eq} may be quantified by different time periods such as, hourly (L_{eq}(h)), daytime (L_d), nighttime (L_n), and the day-night equivalent sound level (L_{dn}). In general, a L_{eq} value describes a receiver's average sound level from all events over a specified time period.

The parameters L_d and L_n are the equivalent sound levels established for the daytime (07:00 am to 10:00 pm) and nighttime (10:00 pm to 07:00 am) periods. The L_{dn} is a 24-hour day-night equivalent sound level calculated using L_n and L_d, with a 10 decibel (dB) penalty (addition of 10 dB) applied to the L_n. As a result, the L_{dn} value can be higher than the L_d and L_n values.

The above descriptors are based on A-weighted sound pressure levels. The A-weighting sound pressure levels account for the relative loudness perceived by the human ear by frequency bands. The use of these parameters permits the description of time-varying acoustic environments as single numbers. See Figure 7.5-1 for example sound pressure levels.

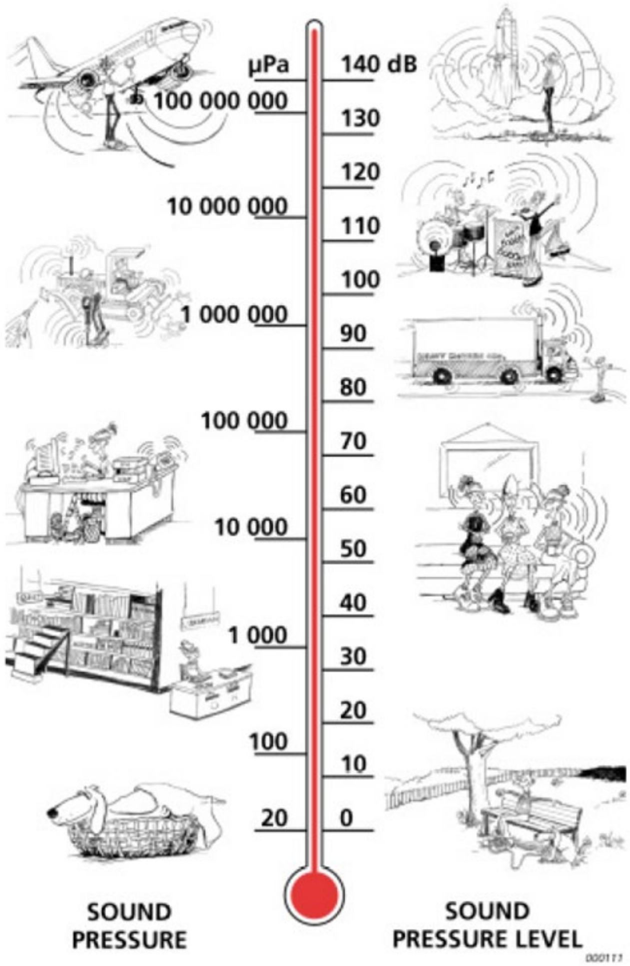


Figure 7.5-1: Typical Sound Pressure Levels Examples (Bruel and Kjaer 2000)

Municipal Codes

The City of Vancouver Noise Control Bylaw No. 6555 (City of Vancouver 2016) prescribes different noise limits for various zones within the city (quiet zone, intermediate zone, event zone and activity zone). Zones reflect specific land-use districts. The majority of the Broadway area is categorized as zone C-3A, which is considered an intermediate zone, no districts within the review boundary are considered as part of the event zone.

L_{eq}(3 min) daytime limits vary from 60 decibels, A-weighed (dBA) for the quiet zone to 70 dBA for the intermediate and the activity zone. L_{eq}(3 min) nighttime limits vary from 55dBA for the quiet zone to 65 dBA for the intermediate and the activity zone. Construction activities are exempt from receptor zone noise limits. Construction noise is limited to L_{eq}(3 min) 85 dBA at the property line of the parcel of land where the construction is taking place, that is nearest to the point of reception of the sound or noise. The bylaw also prescribes time periods during which construction noise is not acceptable. Construction activity will be necessary outside of these prescribed periods and will be discussed in consultation with the City of Vancouver.

Transit Noise Specific Guidance

The United States Federal Transit (US FTA) transit noise and vibration impact assessment document FTA-VA-90-1003-06 (May 2006; “FTA guideline”) has been selected as a guideline for assessing operational noise impact on the basis that it was developed for assessment of transit, including light rail, and has been used in previous assessments of noise on SkyTrain projects. The FTA guideline procedure and criteria are very similar to the BC Ministry of Transportation and Infrastructure (MOTI) Noise Policy which is used for assessing traffic-related noise on provincial highways.

The FTA guideline uses the pre-Project and post-Project day-night sound levels (L_{dn}) as well as the land use category to determine the noise impact of the Project (see Table 7.5-2). Three levels of noise impact are possible: “no impact”, “moderate impact”, or “severe impact”. Potential effects of train noise during Project operation are assessed using the FTA guideline. These specifics are outlined in the Noise TDR (Stantec 2019).

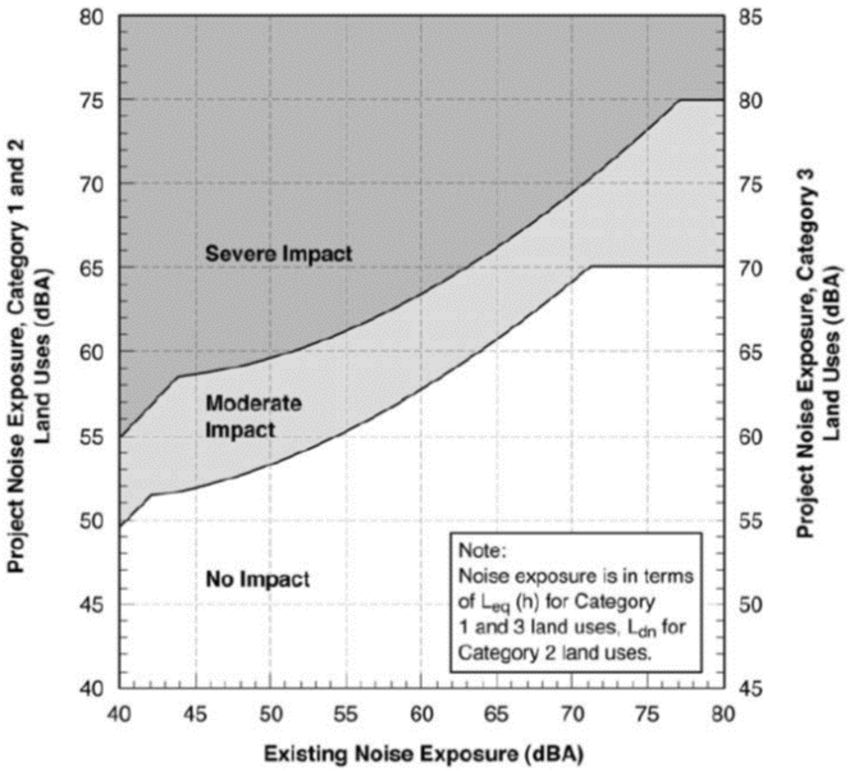


Figure 7.5-2: US FTA Transit Noise Impact Threshold Graph

7.5.2.2 Engagement Input Supporting the Assessment

The development of the TOR and this assessment was influenced by consultation with members of the Technical Review Group and the public. The composition of the Technical Review Group included, amongst others: City of Vancouver, Metro Vancouver, Vancouver General Hospital, Cancer Agency, Jack Bell Research Centre and Emily Carr University of Art + Design. A summary of the topics and key information and concerns that TransLink received during the public consultation phase is provided in Section 5 and for noise specific in Table 7.5-2.

Table 7.5-2: Summary of Key Noise Issues Identified during Public Engagement

Identified Issue	Response
Concern that noise during construction and train operation will disturb local residents.	• Section 7.5 (Noise) of the ESR provides a review of potential change in noise levels in the vicinity of the Project footprint during construction and operation of the Project. • Sections 7.5 (Noise) identifies mitigation and management measures to avoid or reduce potential effects. • Details regarding construction schedule, including hours of work, will be developed in consultation with the City of Vancouver, in consideration of City bylaw requirements. • All nighttime work will be case-specific and include notification with residents and businesses and identification of mitigation to limit disturbance.
Vancouver General Hospital, BC Cancer Agency, and Emily Carr University of Art + Design expressed concerns that sensitive equipment could be disrupted due to noise and vibration during construction and operation of the Project.	• Section 7.5 (Noise) of the ESR evaluates potential noise effects on buildings, including medical facilities, education institutions, and residences. • Review will identify mitigation and management measures to avoid or reduce potential effects.

7.5.2.3 Selection of Effects and Review Indicators

Table 7.5-3 lists the potential Project effects on noise. The table summarizes Project effect mechanisms and indicators used to assess the potential effects. Project effect mechanisms define the link between the Review Element and the potential effect and are described in more detail in Section 7.5.4 (Project Interactions).

Indicators listed below identify specific parameters used to measure and assess potential effects quantitatively. The key issues and concerns pertaining to the noise Review Element are potential effects from Project activities that may result in a change in existing conditions. A change (or increase) in the existing noise levels can become a source of annoyance to human receptors and can affect their quality of life considerations.

Table 7.5-3: Potential Effects and Review Indicators for Noise

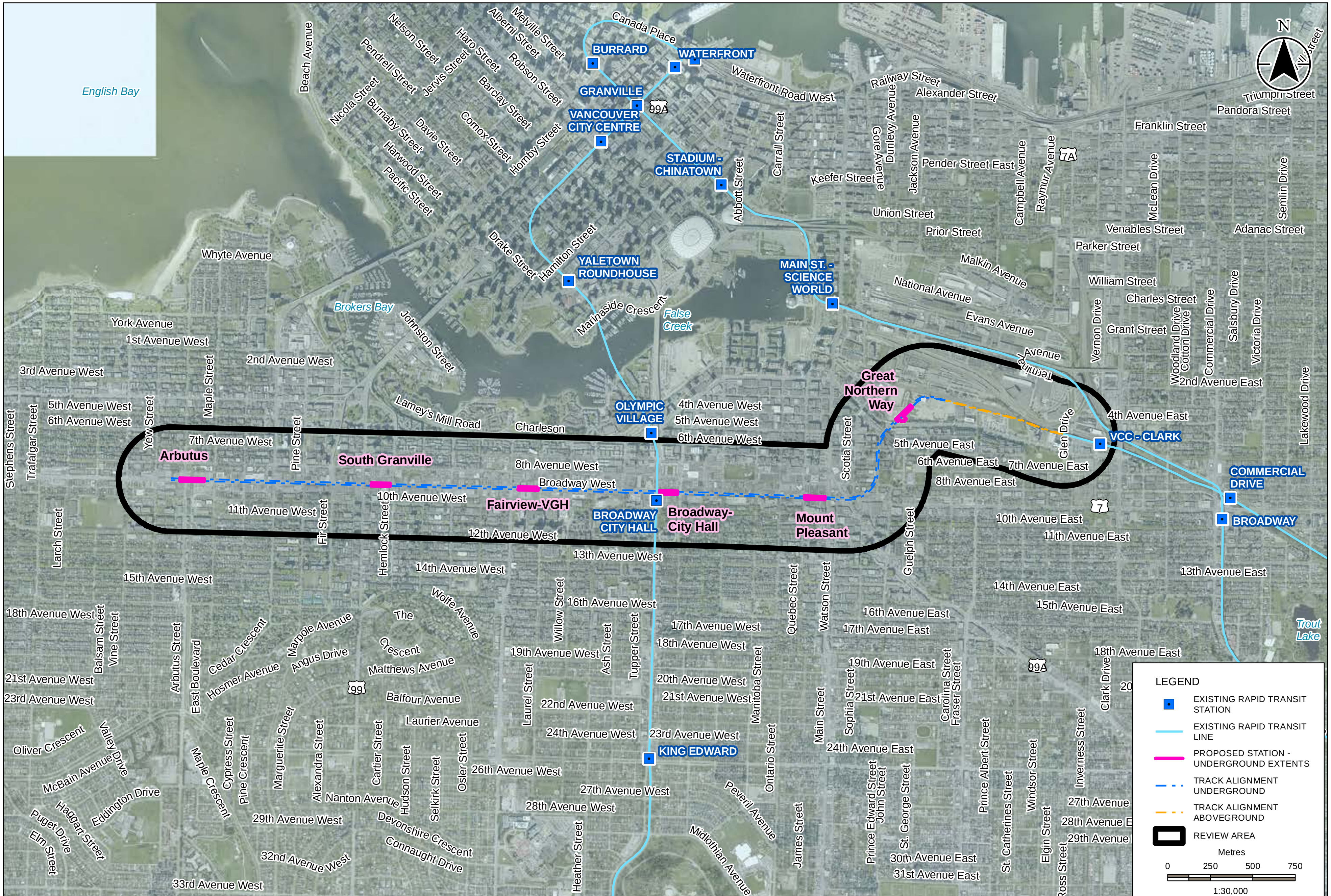
Potential Effects	Project Effects Mechanisms	Indicators	Rationale for Selection
Change in noise levels	Project noise emissions during construction and operation phases	Predicted noise levels during construction and operation phases, quantified using following parameters: • Overall equivalent continuous A- weighted (dBA) daytime and nighttime sound level (L_d and L_n) • A-weighted (dBA) daytime and nighttime equivalent sound level (L_{dn})	• Municipal and provincial or international noise guidelines or guidance

7.5.2.4 Boundaries

The Review Area is a 300 m buffer around the Alignment. Within the Review Area, the assessment of noise effects focuses on 35 representatives, above ground, noise-sensitive receptors along the Alignment and surrounding the stations. Noise sensitive receptors at a greater distance are less likely to be affected by Project noise given the surrounding urban setting and existing noise sources. See Figure 7.5-4 for the location of the representative noise sensitive receptors included in this assessment. Also refer to the Noise TDR (Stantec 2019) for a more detailed description of the noise sensitive receptors.

The temporal boundaries for this assessment include:

- Construction—Anticipated to commence in 2020 and be completed in 2025. Although construction is anticipated to take about six years, individual construction activities will vary in location and duration.
- Operations—Minimum 30 years after commissioning (2025 forward).



DESIGNED	INIT	YY-MM-DD DATE
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CHECKED	INIT	YY-MM-DD DATE
APPROVAL	INIT	YY-MM-DD DATE

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Rev. PC 215.9mm x 279.4mm METRIC

BROADWAY SUBWAY PROJECT

Stantec

BROADWAY SUBWAY PROJECT

NOISE REVIEW AREA

SCALE 1:30,000
DATE 17-11-29
CONTRACT NO.
SUB CONSULTANT PROJECT NO. 115814099
SHEET NO.

FIGURE 7.5-3

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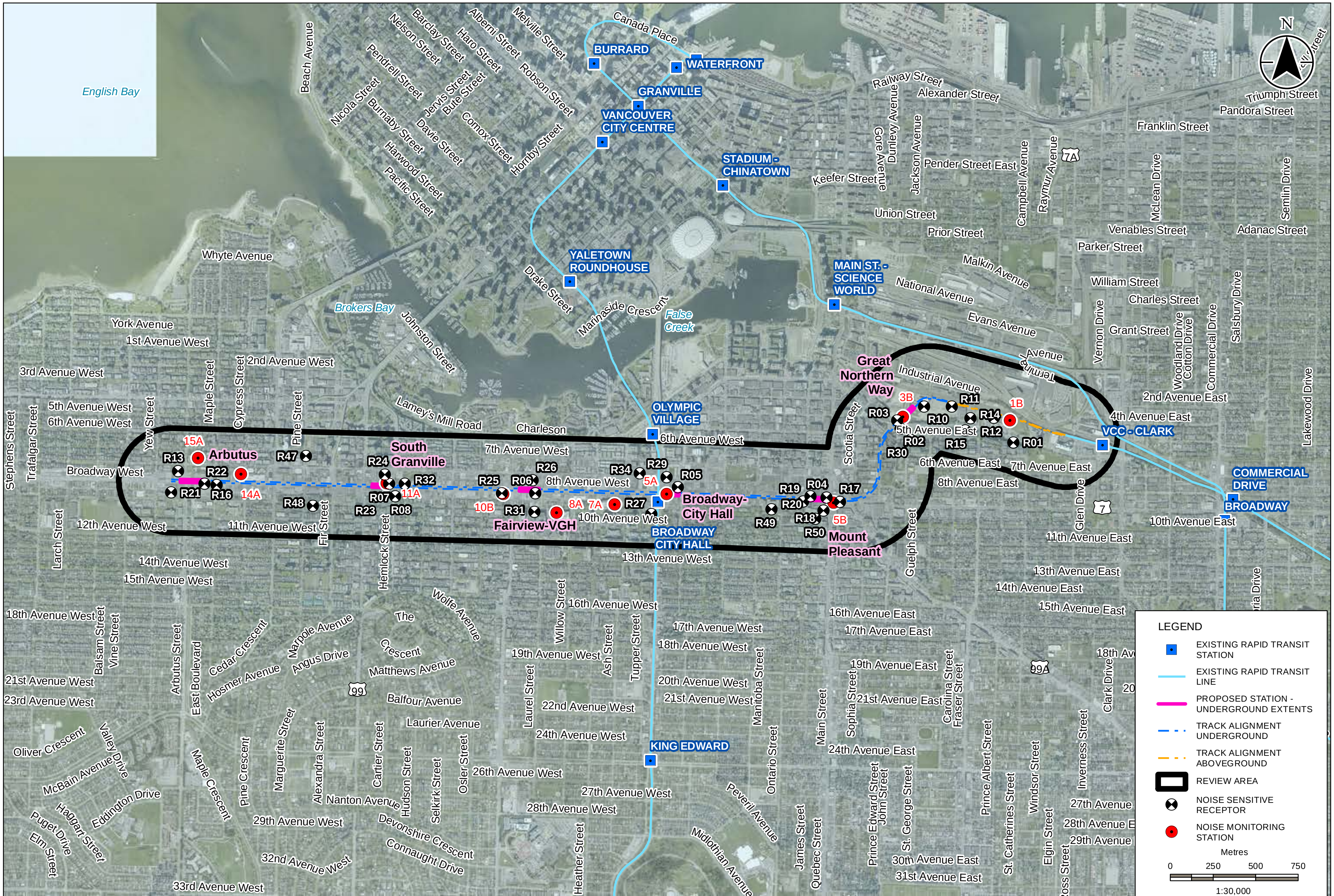

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APPROVAL	INIT	YY-MM-DD DATE

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BROADWAY SUBWAY PROJECT

Stantec

BROADWAY SUBWAY PROJECT

LOCATION OF NOISE SENSITIVE RECEPTORS AND NOISE MONITORING STATIONS

SCALE 1:30,000	CONTRACT NO.	SUB CONSULTANT PROJECT NO.	115814099
DATE 17-11-29			
SHEET NO.		FIGURE 7.5-4	

7.5.3 Existing Conditions

This section summarizes the existing conditions used in this assessment as well as the methods applied to establish the existing conditions. A description of existing acoustic conditions allows a characterization of the interaction between the Project and the acoustic environment. It also places the Project effects into context with acoustic conditions in the region.

7.5.3.1 Methods

The Project will be located in an urban area that includes densely-populated residential neighbourhoods, commercial districts, businesses, medical facilities, as well as recreational and educational facilities. Existing conditions noise monitoring was undertaken at 10 locations along the Alignment considered to be representative of the local acoustic environment (see Figure 7.5-4 for the measurement locations). The measured noise values from the noise monitoring were then used to describe existing conditions for the potentially affected 35 representative noise sensitive receptors in this assessment.

Noise monitoring was conducted at each location for 24-hours to 48-hours on weekdays only. Bruel & Kjaer (B&K) type 1 integrating sound level meters were used for the measurements. Additional technical methods (e.g., locations descriptions, equipment, analysis approach) specific to this program are provided in the Noise TDR (Stantec 2019).

7.5.3.2 Existing Conditions Results

The monitoring results indicate that the acoustic environment at monitored locations is typical of a busy urban environment, with road traffic (i.e., passerby traffic, air brakes, horns, backup alarms, engine starts) being the dominant noise source. The loudest sources included passerby/parked trucks, first responder vehicles, and rail locomotives.

Measured L_d levels at most monitoring locations along West Broadway were in the high 50s to low 70s dBA. Measured nighttime L_n values were in the mid-50s to mid-60s dBA. Lowest L_{dn} values were measured at 7A (near West 10th Avenue and Heather Street) of 60.8 dBA and highest L_{dn} values at 5A (near West Broadway and Cambie) of 75.2 dBA (see Table 7.5-4). Data collected from this monitoring program were used to inform noise modelling. Site-specific results and key findings are presented in the Noise TDR (Stantec 2019).

Table 7.5-4: Existing Conditions Noise Results

Site ID	Nearest Main Cross Streets	Measured Sound Level (dBA)			Characteristics of Existing Noise Conditions	Approximate Distance to the center of the Alignment (m)
		L_d	L_n	L_{dn}		
1B	Foley Street and Finning Way	64.2	59.9	67.0	Road traffic, rail traffic, use of haul truck parking lot and minimal air traffic.	15
3B	Thornton Way and Great Northern Way	61.5	54.6	63.0	Road traffic, first responder vehicles and minimal air traffic	3
5A*	Cambie Street and West Broadway	72.5	67.6	72.2 (75.2)	Busy road traffic, first responder vehicles, buses, truck parking nearby.	2
5B	Main Street and West Broadway	68.8	65.4	72.5	Busy road traffic, first responder vehicles, use of public parking lot and pedestrians.	18
7A	West 10th Avenue and Heather Street	56.8	53.8	60.8	Road traffic, first responder vehicles and some air traffic.	72
8A*	West 10th Avenue and Willow Street	59.5	54.3	62.0	Road traffic and some air traffic.	129
10B*	West Broadway and Oak Street	65.4	57.7	66.4	Busy road traffic, first responder vehicles, some air traffic and daytime construction activities.	27
11A*	West Broadway and Hemlock Street	66.3	60.2	68.0	Busy road traffic, first responder vehicles, daytime construction activities, pedestrians, and some air traffic.	17
14A*	West Broadway and Cypress Street	59.7	54.8	62.4	Road traffic, first responder vehicles, and HVAC use on nearby roof.	48
15A	West 8th Avenue and Arbutus Street	58.7	53.4	63.0	Road traffic, some construction activities, school activities, and pedestrians.	136

NOTE:

* Measurement results for location 8A, 10B, 11A, 14A are considered conservative as the meter was set up on building lips and or roofs and is hence slightly removed from noise sources at street level resulting in quieter measurements. Location 5A was set up through a window on the third floor, close to the reflecting surface of the building wall. This might have impacted the measured sound level resulting in a louder measurement. As a correction and to maintain conservative estimates of the existing condition sound levels a -3dB correction has been applied to the measured sound levels at 5A, the L_{dn} has hence been reset to 72.2 dBA. This is considered a more conservative approach as a lower existing sound level will result in a higher change or noise effect in the assessment.

7.5.4 Project Interactions

The general design and construction approach described in Section 2 (Project Description) was used to determine project interactions that could affect Noise. Project components and physical activities that may interact with the Noise Review Element through the identified potential effects are described in Table 7.5-5. Potential interactions are indicated by check marks and are discussed in detail below in the context of effects mechanisms, standard- and Project-specific mitigation, and Project effects. Justification for excluding certain activities from further assessment (i.e., insubstantial contributions, non-interactions) are provided in the subsections after the table. The justifications are based on professional judgement relative to the Project setting and existing conditions.

Table 7.5-5: Potential Project Interactions and Effects on Noise

Project Activities and Physical Works	Potential Effects
	Change in noise levels
Construction	
Property acquisition	-
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	✓
Elevated guideway construction	✓
Tunnel and station excavation	✓
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	✓
Vehicle traffic (e.g., road use and construction traffic)	✓
Management and disposal of waste and excavated materials	-
Commissioning and start-up	-
Operation	
Train operation, including wayside and power	✓
Station operation	✓
Train maintenance, administration, transit police	-

NOTES:
✓ Potential interactions that may cause an effect to the Review Element
- No or negligible potential for interaction to result in an effect to the Review Element

7.5.4.1 Construction

Construction activities that could change the Noise Review Element include site preparation, elevated guideway construction, tunnel and station excavation, station construction and vehicle traffic (e.g., vehicles used to support construction activities).

For the purposes of this review, the construction phase includes the commissioning and warranty period (i.e., 1 year [duration to be determined]) following substantial completion of construction.

Some activities associated with Project construction will result in noise but are considered negligible in the context of existing surroundings. These activities are not assessed quantitatively in the Project effects section. These activities include:

- Property acquisition
- Management and disposal of waste and excavated materials
- Project commissioning and start up activities (as this is considered transient in nature and short term per location)

7.5.4.2 Operation

Operation activities that could change the Noise Review Element include train and station operation (i.e., train noise, ventilation systems, and track maintenance).

Train maintenance (e.g., taking trains off the tracks and conducting maintenance offsite) and associated activities during Project operation can result in noise but are considered temporary and relatively short-term in the context of existing surroundings. Proposed mitigation measures and the existing BCRTC Operations Environmental Management Plan will be in place to avoid or limit effects associated with train maintenance. Given this, the overall contribution of train maintenance to noise levels is considered negligible and is not quantified in this report.

7.5.5 Mitigation Measures

Mitigation measures to limit or reduce effects from Project-related noise are summarized in Table 7.5-6. Mitigation measures will be included in the Noise and Vibration Management Plan that supports Project construction. Further, Table 7.5-6 outlines Project design features that may be integrated into the design and implemented during construction, where determined to be required (as Project design advances), to attenuate operational noise.

As noted in Section 9 (Environmental Management Plans), the Contractor will confirm the final mitigation approaches to support the Noise and Vibration Management Plan. This approach will allow for mitigation measures that are aligned with the detailed design and construction approach developed by the Contractor.

During construction, MOTI will regularly audit the implementation of the Contractor's environmental management program to assess, and ensure, compliance with contractual requirements related to the management of construction-related noise.

Table 7.5-6: Mitigation Measures for Noise

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.5-1	Develop and implement a Noise and Vibration Management Plan, for the construction phase, to manage construction-related noise. The Noise and Vibration Management Plan will include measures for managing noise during construction including: • Allowable hours of work (day and nighttime). • Measures for the management of noise during daytime and nighttime construction activity. • The identification of the type, location, and duration of construction activities anticipated to generate construction noise. • Requirements for communication with the public regarding any construction noise, as well as procedures for responding to any noise complaints. The Project will adhere to the notification requirements that are included in the Project Agreement. • Site-specific measures to mitigate noise impacts to nearby noise sensitive receptors. • Measures for monitoring noise and the effectiveness of mitigation during construction. Training will be undertaken to support the implementation of the Noise and Vibration Management Plan	Construction	**Contractor**	**Contractual Requirement**
7.5-2	Where noise mitigations are to be implemented (i.e., during nighttime construction activities), consult with potentially affected residents and property owners about the suggested mitigation measures prior to construction start.	Construction	Contractor	Contractual Requirement
7.5-3	Install permanent noise barriers and/or parapet noise barriers where warranted (e.g., along sections of elevated guideway and near the portal).	Construction	Contractor	Contractual Requirement
7.5-4	Based on monitoring during the commissioning and warranty period, apply mitigation to the tunnel near the portal as required to mitigate noise during train operations.	Construction	Contractor	Contractual Requirement
7.5-5	Transport excavated materials through the tunnel where feasible to reduce Project truck traffic on city streets.	Construction	Contractor	Best Management Practice
7.5-6	Implement best management practices to mitigate construction noise including, but not limited to the following: • Select construction equipment or processes that have additional noise control features added, such as better mufflers, enclosures, or other exhaust silencers. • Take advantage of natural and constructed features (e.g., material stockpiles, temporary site buildings) on the edge of the right-of-way, or at the property line of affected noise sensitive receptors. • Avoid dropping materials from a height. • Schedule periods of respite in the case of unavoidable maximum noise level events (e.g., vibratory piling). • Schedule truck movements to avoid residential streets and place site vehicle entrances away from residences and other sensitive receptors. • Avoid clustering of equipment near residences, sensitive receptors, or large reflecting surfaces, and maintain as much distance as possible. • Avoid idling of equipment if not in use. • Where more than one equipment type can be selected for a specific task, with similar efficiency, select the quietest (e.g., hydraulic splitters as alternatives to rock-breaking work methods, hydraulic or electric powered equipment instead of diesel or gas-fired equipment). • Carry out regular maintenance on equipment, especially exhaust systems. • Operate equipment at minimum engine speed, where feasible, while maintaining effective operation. • Use of temporary noise barriers near above-ground construction (e.g., portal/tunneling and surface activities near Great Northern Way and Thornton Street). • Limit the need for reversing alarms and consider alternatives to the typical “beeper” alarms, like broadband alarms.	Construction	Contractor	Best Management Practices
7.5-7	When noisy construction activities (e.g., pile driving, diesel generators) are forecasted to potentially affect adjacent residents and properties, the following will be provided to potentially affected stakeholders in advance of the work: • Description of the work locations • Description of the construction activities and sources of noise, as well as anticipated noise levels • Rationale for the work • Anticipated duration of the work • Description of mitigation measures planned • Information regarding timing and location of neighborhood meetings to discuss issues	Construction	Contractor	Contractual Requirement

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.5-8	Implement a Noise and Vibration Management Plan for operations and maintenance, that includes monitoring at existing condition locations within the first year after substantial completion of construction (e.g., during the commissioning and warranty period), to assess if impacts and mitigation measures are accurate and effective, or to identify locations that warrant additional noise-attenuation measures. The Noise and Vibration Management Plan will also include a noise complaint resolution procedure to address noise concerns in a timely manner. Based on noise monitoring conducted within the first year after substantial completion of construction, TransLink will work with the Contractor to identify and implement noise-attenuation measures where needed.	Operation	TransLink / Coast Mountain Bus Company	Standard Operating Procedure
7.5-9	Operation best practices will strive to follow the BCRTC Operations Environmental Management Plan (BCRTC 2019). Further, operational noise will be managed by adhering to TransLink noise specifications, regarding: • Paging and bell signaling systems for public announcements. • Acoustical design considerations for ancillary systems (e.g., transformers) • Maintenance of guideway track to limit operational noise (e.g., wheel squeal) • Acoustical measures for ventilation shafts at underground stations • During testing and commissioning, sound levels should not exceed 75 dBA 15 m away from trains operating Train operating noise levels at 50 metres from the centre of the track should not exceed: 68 dBA when trains are stationary and 75 dBA when trains are moving (BCRTC 2019).	Operation	TransLink / Coast Mountain Bus Company	Standard Operating Procedure
7.5-10	Operation of the bus loop near the Arbutus Station will be guided by the Operations Environmental Management Plan (BCRTC 2019) to remain in compliance with Noise Control Bylaw No. 6555.	Operation	TransLink / Coast Mountain Bus Company	Standard Operating Procedure

7.5.6 Discussion of Review Results

Project activities during construction and operation will create noise as noted in Section 7.5.4. This section discusses noise effects during both phases in comparison to regulatory guidance and existing noise values. Effects during construction are assessed in Section 7.5.6.1. Effects during operations are presented in Section 7.5.6.2.

In this review, noise modelling used the Cadna/A software (Version 2017 DataKustik 2017), which incorporates ISO 9613 algorithms. Model settings and assumptions are provided in the Noise TDR (Stantec 2019). If the modelled results (not including mitigation measures) are in compliance with applicable noise guidance, the noise effect is considered to be acceptable. Otherwise, mitigation measures are recommended to manage the sound level so that the noise effect complies with the established limits (see Table 7.5-6).

7.5.6.1 Construction

Project construction will include above-ground construction, portal/tunneling, and station box construction activities. A total of six stations are proposed along the Alignment which will include a 700 m elevated guideway and a 5 km tunnel (see Figure 7.5-1). Construction activities will rely on a fleet of equipment including on-road and off-road vehicles.

To assess potential effects of Project construction on existing acoustic conditions, modelling was used to quantify noise generated from:

- Above-ground construction (section of elevated guideway between VCC-Clark and the portal entry)
- Portal/tunneling (surface activities near Great Northern Way and Thornton Street and tunnelling of the remainder of the underground Alignment, including removal of spoils)
- Station box construction (six discrete locations along Alignment)

Noise modelling was based on daytime activity only and does not take into account nighttime work.

To support the modelling of predicted construction phase noise, a generic fleet inventory was established based on other similar-type projects (i.e., Evergreen). Construction details are provided in the Noise TDR (Stantec 2019). This information formed the basis for subsequent noise modelling to quantify Project effects from construction activities.

Noise levels generated from construction activities were predicted at various noise sensitive receptors and compared against the City of Vancouver Noise Bylaw. Based on modelling, construction noise is not expected to exceed the City of Vancouver Bylaw limit of 85 dBA Leq (3 min) at any of the receptor locations or at the extents of station construction areas.

Table 7.5-1: Predicted Project Construction Noise Levels

Receptor	City of Vancouver Construction Threshold L_{eq}(3 min)	Estimated Noise Contribution from Construction (dBA) Daytime (L_{eq}[3 min])[1]
R01	85	57.8
R02	85	75.6
R03	85	82.0
R04	85	84.8
R05	85	77.3
R06	85	82.9
R07	85	83.6
R08	85	70.5
R10	85	78.1
R11	85	83.4
R12	85	67.2
R13	85	71.7
R14	85	67.3
R15	85	59.6
R16	85	83.9
R17	85	70.5
R18	85	69.3
R19	85	75.8
R20	85	84.5
R21	85	59.6
R22	85	69.9
R23	85	55.8
R24	85	62.3
R25	85	69.1
R26	85	70.0
R27	85	63.7
R28	85	69.1
R29	85	68.7
R30	85	63.9
R31	85	57.1
R32	85	69.4

Table 7.5-1: Predicted Project Construction Noise Levels

Receptor	City of Vancouver Construction Threshold L_{eq}(3 min)	Estimated Noise Contribution from Construction (dBA) Daytime (L_{eq}[3 min])[1]
R33	85	58.9
R34	85	56.5
R47	85	55.9
R48	85	56.5
R49	85	56.0
R50	85	54.4

While the City of Vancouver Bylaw limit is not anticipated to be exceeded, construction will result in elevated noise levels in some areas of the Alignment during construction. In order to mitigate construction-related noise, the Construction Contractor will be required to develop and implement a Noise and Vibration Management Plan that will define specific measures intended to mitigate construction-related noise. As such, the predicted construction noise levels presented do not include the application of mitigation measures.

7.5.6.2 Operation

The Project will extend existing SkyTrain Millennium Line train operations from VCC-Clark Station to Arbutus Street and include a 700 m, partly elevated guideway, a 5 km tunnel and six stations (see Figure 7.5-1). Operation activities that could change the Noise Review Element include train and station operation (i.e., train noise and noise from ventilation systems).

Noise modelling was performed to estimate the operation sound levels near the Project right-of-way relative to the City of Vancouver Bylaw and US FTA Transit Administration thresholds. To assess potential effects of Project operations on existing acoustic conditions, modelling was used to quantify noise generated from:

- Ventilation noise of station boxes
- Above ground train noise

Sound levels from stations sources (i.e., ventilation systems) were predicted at various noise-sensitive receptors and compared against the City of Vancouver Noise Bylaw. Predicted noise levels were below the City of Vancouver noise thresholds at all receptors (Daytime L_{eq} (3 min) of 60 or 70 dBA, Nightime L_{eq} (3 min) of 55 or 65 dBA depending on noise zone) with the assumption that noise from ventilation shafts will be mitigated with acoustical treatment to reach compliance with the Noise Bylaw, in a manner consistent with previous SkyTrain projects.

Sound levels from train movement for the 700 m above-ground stretch of the Project right-of-way, including noise from the tunnel opening, were predicted at nine noise sensitive receptors and compared against the US FTA Transit Administration thresholds. These nine receptors were considered representative of the area and most likely to be affected by noise from the above-ground rails/tunnel opening. Other noise sensitive receptors considered in this assessment are located further away (i.e., more than 300 m) and will not be impacted by the train noise.

Of nine receptor locations considered, seven were at the "moderate impact" level and two (i.e., a future residential development and Emily Carr University of Art + Design) showed "severe impact" (see Table 7.5-6). The "moderate" to "severe" impact locations are immediately adjacent to the above ground rail section near Great Northern Way (Stantec 2019).

Table 7.5-7: Predicted Project Operation Train Noise Levels compared to the US Federal Transit Administration guideline impact thresholds

Receptor [1]	Land Use Category per US FTA Guideline[2]	Pre-Project Sound Level	Project Only Sound Level	Post-Project Sound Level	Post-Project and Pre-Project Difference (dBA)	US FTA Impact Level
		L_{dn} or L_{eq} (h) (dBA)	L_{dn} or L_d (dBA)	L_{dn} or L_{eq} (h) (dBA)		
R01	2	67.0	60.8	67.9	0.9	severe
R02	3	66.1	41.4	66.1	0.0	moderate
R03	2	63.0	52.6	63.4	0.4	moderate
R10	3	66.1	50.2	66.2	0.1	moderate
R11	3	68.9	64.0	70.1	1.2	moderate
R12	2	67.0	68.8	71.0	4.0	severe
R14	3	68.9	59.4	69.4	0.5	moderate
R15	2	63.0	55.8	63.8	0.8	moderate
R30	2	60.8	46.8	61.0	0.2	moderate

NOTES:

1 Only representative receptors that are affected by above ground train noise sources are listed.

2 Day-Night Sound Level (Ldn) is used for Category 2 land use. Highest 1Hr Leq (h) is used for Category3 land use.

As prescribed by the US FTA guideline, locations where noise impacts are assessed "severe" demonstrate a compelling need for noise mitigation. Noise mitigation measures (e.g., noise barriers) will be incorporated in the design of the Project as required, as guided by noise modelling as well as noise monitoring during commissioning. Such mitigation is anticipated to address noise levels in areas with "severe" ratings. "Moderate" impact is defined as a change which is noticeable, but may not be sufficient to cause strong, adverse reactions from the community. The need for noise mitigation in areas of "moderate" impact should be considered in conjunction with factors such as the number of sites affected, increase over existing sound levels, noise sensitivity of the property, effectiveness of possible mitigation measures, community views on the Project, and cost.

7.5.7 Conclusion

The predicted conclusions from this noise assessment are as follows:

- Elevated noise levels are expected during the construction phase but are predicted to be below the noise thresholds of the City of Vancouver noise Bylaw.
- A Noise and Vibration Management Plan, including measures to avoid or mitigate construction-related noise, will be developed and implemented to limit construction phase noise.
- Elevated noise levels are expected during the operation phase though will be limited to above-ground sections of the Alignment adjacent to Great Northern Way. Substation ventilation shaft noise can be adequately attenuated to reach noise levels below the noise thresholds of the City of Vancouver noise Bylaw.
- When compared to FTA thresholds, predicted noise levels during operation for two of nine receptors fall within the “severe” category. For such receptors, noise mitigation measures (e.g., noise barriers) will be incorporated into the design phase of the Project as required to reduce noise levels during operation. Noise modelling following detailed design, and monitoring during Project commissioning and the warranty period, will guide the implementation of operational phase noise mitigation.
- Mitigation undertaken during design and construction are intended to reduce noise levels classified as “severe” during operations; further, these measures will reduce operational phase noise levels such that they are within City of Vancouver Bylaw limits.
- During operations (after the warranty period), BCRTC is responsible for the monitoring of noise, and for addressing noise concerns, in accordance with the BCRTC Operations Environmental Management Plan (BCRTC 2019).

7.6 Vibration

This section of the Environmental and Socio-economic Review (ESR) evaluates Project-related changes in vibration. Potential Project-related vibration effects are assessed relative to existing baseline vibration levels in the Project area and vibration thresholds defined in the Federal Transit Administration (FTA), Transit Noise and Vibration Impact Assessment Report (FTA 2006).

Project construction activities that could affect vibration levels relate mainly to the use of heavy construction equipment for construction of the tunnel, stations, and elevated guideway. Operational activities that could affect vibration levels relate mainly to trains passing through the underground tunnels and over the elevated guideway portion of the Project.

Key information provided to support the assessment of Vibration includes:

- Rationale for selection of Vibration as a Review Element
- Methods used to review potential Project effects in the context of applicable guidelines and policies
- Existing baseline conditions around the Alignment
- Summary of Project components and physical activities that may interact with this Review Element
- Proposed mitigation measures to avoid, or reduce, potential effects of the Review Element
- Discussion of review results and conclusions

7.6.1 Rationale for Selection as a Review Element

Vibration was selected as a Review Element because Project construction and operation activities are expected to generate vibrations. These vibrations will be transmitted radially (i.e., horizontally and vertically) through soil and bedrock towards nearby buildings and infrastructure. Effects of ground-based vibrations may include damage to structures, interference with sensitive equipment, and disturbance to building occupants.

7.6.2 Review Scope for Vibration

7.6.2.1 Regulatory and Policy Setting

There are no municipal or provincial regulations or codes for vibration that apply to the Project. As no applicable Canadian codes and guidance for vibration levels have been identified, the following guidelines from the United States have been applied in the review:

- Transit Noise and Vibration Impact Assessment (FTA 2016)
- Transportation and Construction Vibration Guidance Manual (CalTrans 2013)

Metrics associated with vibration thresholds adopted for this review are the Peak Particle Velocity (PPV) and root mean square velocity (V_{rms}). These metrics are used to describe the potential for a range of effects related to sensitive structures and buildings, human disturbance, and sensitive equipment located in the vicinity of the Alignment (Table 7.6-1).

Thresholds for disturbance to building occupants and interference with sensitive equipment are typically provided in terms of V_{rms}. Comparing V_{rms} to PPV requires the use of a crest factor to convert between units of measure. A crest factor of 4 (FTA 2006) is used to compare estimated PPVs to thresholds in V_{rms} using the formula: PPV = 4 * V_{rms}, where the crest factor is the ratio of the peak value of a waveform to the V_{rms}.

Table 7.6-1: Damage and Disturbance Thresholds for Vibration

Threshold		Description	PPV (mm/s)	V_{rms} (mm/s)
Potential Damage to Buildings	Damage to reinforced-concrete steel or timber (no plaster)	Cosmetic or structural damage. Cosmetic damage can be expected at PPVs of 12.7 mm/s, with increasing risk of structural damage at higher PPVs.	> 12.7	> 3.18*
	Damage to engineered concrete and masonry (no plaster)	Cosmetic or structural damage. Cosmetic damage can be expected at PPVs of 7.6 mm/s, with increasing risk of structural damage at higher PPVs.	> 7.6	> 1.91*
	Damage to non-engineered timber and masonry building	Cosmetic or structural damage. Cosmetic damage can be expected at PPVs of 5.1 mm/s, with increasing risk of structural damage at higher PPVs.	> 5.1	> 1.27*
	Damage to buildings extremely susceptible to vibration damage	Cosmetic or structural damage. Cosmetic damage can be expected at PPVs of 3 mm/s with increasing risk of structural damage at higher PPVs.	> 3	> 0.76*

Table 7.6-1: Damage and Disturbance Thresholds for Vibration

Threshold		Description	PPV (mm/s)	V_{rms} (mm/s)
Potential Human Perception and Sensitive Equipment Interference	Disturbance at institutional land uses with primary daytime use	This category includes schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference	> 0.57*	> 0.14
	Disturbance at residences and buildings where people normally sleep	This category covers residential land uses and any buildings where people sleep, such as hotels and hospitals	> 0.40*	> 0.10
	Disturbance at buildings where vibration would interfere with interior operations/equipment	This category covers facilities where vibration would interfere with building operations, such as vibration-sensitive research and manufacturing, and hospitals with vibration-sensitive equipment. Levels may be well below those associated with human annoyance.	> 0.18*	> 0.05

NOTES:
* Value estimated using a crest factor of 4 (FTA, 2006)

Actual vibration levels to cause disturbance may be higher than the thresholds in this table, as baseline vibration levels are often higher than the disturbance thresholds considered here.

With the threshold for potential effects defined, vibration calculations were undertaken to estimate the distance from specific Project activities within which vibration effects may occur. This distance, defined as the vibration threshold contour, identifies where certain vibration thresholds may be exceeded. Details on how the guidelines and thresholds are applied, in the context of the assessment of potential vibration effects, are provided in the Vibration Technical Data Report (Stantec 2019).

7.6.2.2 Engagement Input Supporting the Assessment

The assessment of vibration effects was informed by input received during stakeholder engagement processes including those focused on obtaining feedback on the development of the Terms of Reference. Key issues identified during public engagement are presented below.

Table 7.6-2: Summary of Key Vibration Issues Identified during Public Engagement

Identified Issue	Response
Concern that vibrations during construction and train operation will disturb local residents and may damage building foundations or geotechnical integrity.	• Section 7.6 (Vibration) of the ESR provides a review of potential change in vibration levels in the vicinity of the Project footprint during construction and operation. • Mitigation measures to avoid or reduce potential effects are described in this ESR.
Vancouver General Hospital, BC Cancer Agency, and Emily Carr University of Art + Design expressed concerns that sensitive equipment could be disrupted due to vibration during construction and operation of the Project.	• Baseline vibration monitoring was undertaken at locations identified by Vancouver General Hospital, BC Cancer Agency, and Emily Carr University of Art + Design. • Section 7.6 (Vibration) of the ESR evaluates potential vibration effects to sensitive equipment. • Mitigation measures are identified to avoid or reduce potential effects.

7.6.2.3 Selection of Effects and Review Indicators

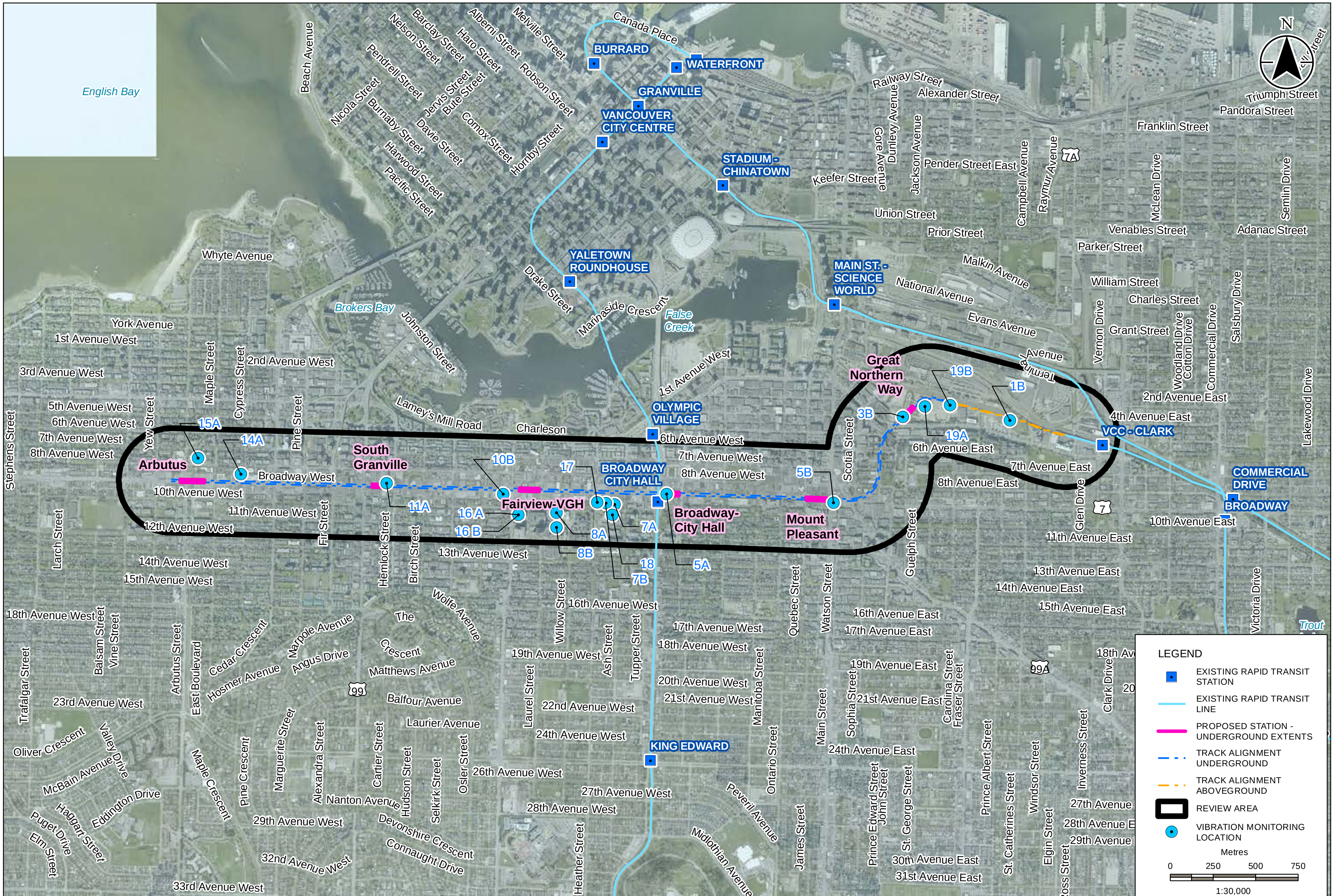
Table 7.6-3 lists potential Project-related vibration effects. The table summarizes Project effect mechanisms and indicators used to assess the potential effects. Project effect mechanisms define the link between the Review Element and the potential effect and are described in more detail in Section 7.6.4 (Project Interactions). The indicators listed in Table 7.6-3 identify specific parameters used to measure and assess potential effects qualitatively or quantitatively.

Table 7.6-3: Potential Effects and Indicators for Vibration

Potential Effects	Potential Effects Mechanism	Indicators	Rationale for Selection of Indicators
Change in vibration levels	Ground-borne vibration during construction and operations causing damage to buildings or disturbance of building occupants/activities.	Estimated ground vibration levels during construction and operation phases quantified using the following parameters: • PPV in mm/s • V_{rms} in mm/s	• PPV and V_{rms} are standard metrics by which vibration effects are measured and assessed. • Indicators are associated with relevant and recognized vibration impact assessment guideline documents (FTA 2006, CalTrans 2013).

7.6.2.4 Boundaries

The Review Area (spatial boundary) applied in this report for Vibration is a 300-m buffer centered on the Alignment (Figure 7.6-1), representing a preliminary area in which potential vibrations are anticipated to be concentrated. Temporal boundaries include the construction (currently anticipated in year 2019 to 2025) and operation (currently anticipated in year 2025 forward) phases.



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BROADWAY SUBWAY PROJECT

VIBRATION REVIEW AREA AND MONITORING LOCATIONS

SCALE	1:30,000	CONTRACT NO.	SUB CONSULTANT PROJECT NO.	115814099
DATE	17-11-29			
SHEET NO.		FIGURE 7.6-1		

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7.6.3 Existing Conditions

This section summarizes the methods used to describe existing vibration baseline conditions to support a comparison with estimated conditions during construction and operation.

7.6.3.1 Methods

Baseline vibration monitoring was undertaken at 18 locations (Figure 7.6-1) along the Alignment considered to be representative of locations where construction and/or operational vibration may affect adjacent receptors. Vibration monitoring was conducted for 24-hours at 14 locations and for 48-hours at four of the locations, during weekdays only. Instantel Blastmate III and Micromate transducer instrumentation with three geophones were used to determine PPV. Additional technical details related to the equipment and data analysis specific to this baseline monitoring program are provided in the Vibration Technical Data Report (Stantec 2019).

7.6.3.2 Baseline Conditions

The vibration environment at monitored locations is typical of a busy urban environment, with baseline vibration conditions influenced by road traffic, construction activities, equipment operation, and pedestrian traffic. The maximum recorded PPV at the 18 locations ranged from 0.095 to 0.905 mm/s which falls within the range where vibration may be perceivable by building occupants (Stantec 2018).

Vibration monitoring included nine sensitive locations near the Alignment including facilities associated with the Vancouver General Hospital (VGH), BC Cancer Agency, BC Cancer Research, and the Emily Carr University of Art + Design. Vibration at these locations was assumed to be predominately influenced by road traffic, pedestrian traffic and mechanical/electrical room equipment. Maximum indoor vibration levels at these locations ranged from 0.071 to 0.413 mm/s PPV. Values at the low end of this range are at the limit of perception and adequate for the operation of some sensitive equipment, while values at the high end of the range exceed the threshold considered herein for interference with the operation of sensitive equipment (PPV of 0.18 mm/s).

Table 7.6-4: Vibration Monitoring Locations and Results

Location ID	Location	Distance to Project Centerline (m)	Setting Description	Characteristics of baseline vibration	Maximum PPV (mm/s)
1B	Foley Street and Finning Way	12	Open space surrounded by medium density residential, haul truck parking, high density office space and active railway.	Road traffic, rail traffic, use of haul truck parking lot traffic.	0.631
3B	Thornton Way and Great Northern Way	3	Medium density residential area adjacent to a school and mixed office and commercial use.	Road traffic, rail traffic, construction activities.	0.476
5A	Cambie Street and West Broadway Avenue	6	Medium to high density residential area mixed with dense commercial and office space along a major traffic roadway.	Busy road traffic, buses, truck parking nearby.	0.110
5B	Main Street and West Broadway Avenue	12	High density commercial and office area at a major traffic intersection.	Busy road traffic, use of public parking lot and pedestrians.	0.709
7A	W 10 Avenue and Heather Street	65	Empty lot surrounded by low to high density office space.	Road traffic.	0.166
7B*	675 W 10 Avenue	60	Basement of Cancer Agency Building	Road traffic, facility mechanical equipment.	0.126
8A*	W 11 Avenue between Willow Street and Oak Street	123	Medium density residential area mixed with high density office buildings.	Busy road traffic, and daytime construction activities.	0.619
8B*	W 11 Avenue between Willow Street and Oak Street	209	Inside MRI Area of Centennial Pavilion	Road traffic, facility mechanical equipment within mechanical room.	0.221
10B	West Broadway Avenue and Oak Street	21	High density residential mixed with high density commercial and office space along a major traffic roadway.	Busy road traffic, and daytime construction activities.	0.492
11A	W 11 Avenue between Heather Street and Oak Street	11	High density commercial and office space along a major traffic roadway.	Busy road traffic, daytime construction activities.	0.286

Table 7.6-4: Vibration Monitoring Locations and Results

Location ID	Location	Distance to Project Centerline (m)	Setting Description	Characteristics of baseline vibration	Maximum PPV (mm/s)
14A	West Broadway Avenue and Cypress Street	41	High density commercial and office space along a major traffic roadway.	Road traffic, facility mechanical equipment within mechanical room.	0.619
15A	West Broadway Avenue and Arbutus Street	131	Medium density residential mixed with two schools and commercial space.	Road traffic, some construction activities, school activities, and pedestrians.	0.905
16A*	Oak Street between 10 Avenue and 12 Avenue	141	Inside basement of Jack Bell Research Centre	Road traffic, electrical equipment within electrical room.	0.142
16B*	Oak Street between 10 Avenue and 12 Avenue	141	Outside of Jack Bell Research Centre	Road traffic and pedestrian traffic.	0.460
17*	675 West 10th Avenue	56	BC Cancer Research Centre	Pedestrian traffic inside building	0.190
18*	600 W 10th Avenue	126	BC Cancer Agency	Pedestrian traffic inside building	0.0952
19A*	520 E 1st Avenue	37	Emily Carr University of Art + Design theatre and lecture hall	Pedestrian traffic inside building	0.413
19B*	520 E 1st Avenue	15	Emily Carr University of Art + Design motion capture studio	Pedestrian traffic inside building	0.159

NOTE:
* Denotes sensitive location

7.6.4 Project Interactions

Potential change in vibration levels caused by Project components and physical activities are described in Table 7.6-5. Potential interactions are indicated by check marks and are discussed in detail below in the context of effects mechanisms, standard- and Project-specific mitigation, and Project effects.

Table 7.6-5: Potential Project Interactions and Effects on Vibration

Project Activities and Physical Works	Potential Effects
	Change in vibration levels
Construction	
Property acquisition	-
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	✓
Elevated guideway construction	✓
Tunnel and station excavation	✓
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	✓
Vehicle traffic (e.g., road use and construction traffic)	✓
Management and disposal of waste and excavated materials	-
Commissioning and start-up	✓
Operation	
Train operation, including wayside and power	✓
Station operation	-
Train maintenance, administration, transit police	-
NOTES: ✓ Potential interactions that may cause an effect. - Not applicable. Project activities do not cause vibrations	

The review of potential effects completed for Vibration is based on a conservative scenario (i.e., includes the use of tunnel-boring machines (TBM) and surface drilling equipment such as pile drivers and hydraulic breakers, and makes assumptions regarding means and methods of construction and geotechnical conditions). Further details on the assumed construction fleet is provided in the Vibration Technical Data Report (Stantec 2019). Given the nature of the work, it is currently unknown whether or not pile drivers will be used to support construction; as such, the assumption that pile drivers would be used overestimates the likely extent and nature of vibration effects that would be anticipated.

7.6.4.1 Construction

Construction activities that could result in a change in vibration level include tunnel excavation, station excavation, station construction and elevated guideway construction. Ground-based vibration effects can include noticeable movement of building floors, shaking of items on shelves, rattling of windows, disturbance to sensitive equipment such as certain electronics or vibration-sensitive equipment that is not adequately dampened, and potentially audible noise. Vibration-related damage may include cosmetic damage such as minor cracking of non- structural components, or structural-related damage at higher levels.

Site preparation and construction vehicle traffic, will cause vibration of lower magnitude than for excavation activities, and are not quantified in this review. Property acquisition and management and disposal of waste and excavated activities will cause no or negligible vibration. Project commissioning, which will occur during the construction phase of the Project, is anticipated to have the potential for vibration effects similar to those during Project operation.

7.6.4.2 Operation

Operation activities that could result in a change (increase) in vibration level are limited to train operation. Ground-based vibration effects from transit trains traveling along steel rail emit vibrations through the rail, ballast, and concrete, propagating though the soil or rock and into nearby structures. Vibration effects can include noticeable movement of building floors, shaking of items on shelves, rattling of windows, disturbance to sensitive equipment such as certain electronics or vibration-sensitive equipment that is not adequately dampened, and potentially audible noise. Train and track maintenance activities associated with Project operation will result in vibrations but are considered negligible and are not quantified in this review.

Operation activities that will not interact with the Vibration Review Element include station operation, administration, and transit police, and are not considered further.

7.6.5 Mitigation Measures

To avoid or mitigate vibration effects during construction, mitigation measures, such as those identified in Table 7.6-6, will be included in a Noise and Vibration Management Plan to be developed by the Contractor prior to Project construction.

The mitigation measures identified in Table 7.6-6 represent best practices for managing potential vibration effects and are consistent with relevant guideline documents. As noted in Section 9 (Environmental Management Plans), the Contractor will confirm the final mitigation approaches to support the Noise and Vibration Management Plan. This approach will allow for mitigation measures that are aligned with the detailed design and construction approach developed by the Contractor.

During design and construction, the Contractor will be responsible for modelling vibration levels (i.e., updated vibration modelling that is informed by the final Project design and the specific construction methods selected by the Contractor), conducting a pre-construction condition assessment (where appropriate), and establishing zones of influence within which potential effects will be further refined. The Contractor will also be responsible for responding to and managing effects, where the condition of a building is determined to have changed as a result of Project-related vibration.

During the operational phase, British Columbia Rapid Transit Company Ltd.'s (BCRTC) existing Operations Environmental Management Plan (BCRTC 2019) will guide actions that may be required to mitigate potential vibration effects during operation. Mitigation measures contained within the Plan have been effectively applied to support management of noise and vibration associated with existing infrastructure including the Expo Line, Millennium Line, and Evergreen Extension.

Table 7.6-6: Mitigation Measures for Vibration

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.6-1	Develop and implement a Noise and Vibration Management Plan, for the construction phase, to manage potential vibration effects on adjacent properties. The Noise and Vibration Management Plan will include measures to assist in assessing and addressing vibration effects including: • Specific best practices to avoid or limit vibration effects during construction • Measures for conducting pre- and post-construction surveys of structures along the Alignment to assist in monitoring potential Project-related damage • Measures for monitoring vibration, and the effectiveness of mitigation, during construction • Notification procedures for potentially high vibration construction works • Procedures for engaging with adjacent properties on construction works that have the potential to disrupt vibration sensitive equipment and activities	Construction	Contractor	Contractual Requirement
7.6-2	Through engagement with local residents and business, identify windows of time for avoiding construction activities that are significant sources of vibration.	Construction	Contractor	Best Management Practice
7.6-3	Develop and implement a program for communicating with stakeholders on the monitoring and management of construction-related noise and vibration issues.	Construction	Contractor	Contractual Requirement
7.6-4	Use of ballast mats to reduce ground-borne vibration associated with on-site movement and management of excavated materials.	Construction	Contractor	Best Management Practice
7.6-5	Where appropriate, trackwork design will incorporate vibration-reducing features (e.g., double-tie design, double-ended pocket tracks or crossovers, floating slabs, ballast mats, resilience fasteners).	Design/Construction	Contractor	Best Management Practice
7.6-6	Use construction methods and equipment that limit vibration levels, where feasible.	Construction	Contractor	Best Management Practice
7.6-7	Implement BCRTC's existing Operations Environmental Management Plan with respect to mitigating potential vibration effects.	Operation	TransLink / Coast Mountain Bus Company	Standard Operating Procedure

7.6.6 Discussion of Review Results

This section discusses estimated changes in Project-related vibration levels during both construction and operational phases.

Estimated vibration levels, during construction and operations, presented in the following sections, draw on and summarize detailed technical analysis presented in the Vibration Technical Data Report. (Stantec 2019).

The estimates of Project-related vibration during construction assume the use of vibration-intensive equipment and excavation methods and do not take into account potential reductions in vibration effects from the application of the mitigation measures described in Table 7.6-1. The Contractor will be responsible for assessing vibration levels, based on the final Project design and the confirmed construction methods, and applying appropriate mitigation measures based on the results of their assessment.

Project-induced vibration is unlikely to affect buildings, sensitive equipment, or building occupants where estimated vibration levels are below vibration thresholds (Table 7.6-1), even where such levels may exceed existing baseline conditions.

Further, the potential impact of estimated changes in vibration levels during construction and operation should be considered in the context of baseline (existing) vibration conditions. In some cases, existing vibration levels are greater than some disturbance thresholds (i.e., nine of 14 monitoring locations (Table 7.6-4) exceed the 0.40 mm/s threshold (Table 7.6-1) for “disturbance at residences and buildings where people normally sleep”). Where existing vibration levels exceed an applicable threshold, receptors can be affected by the additional vibration-inducing construction activity depending upon the site-specific parameters in addition to the increase in vibration.

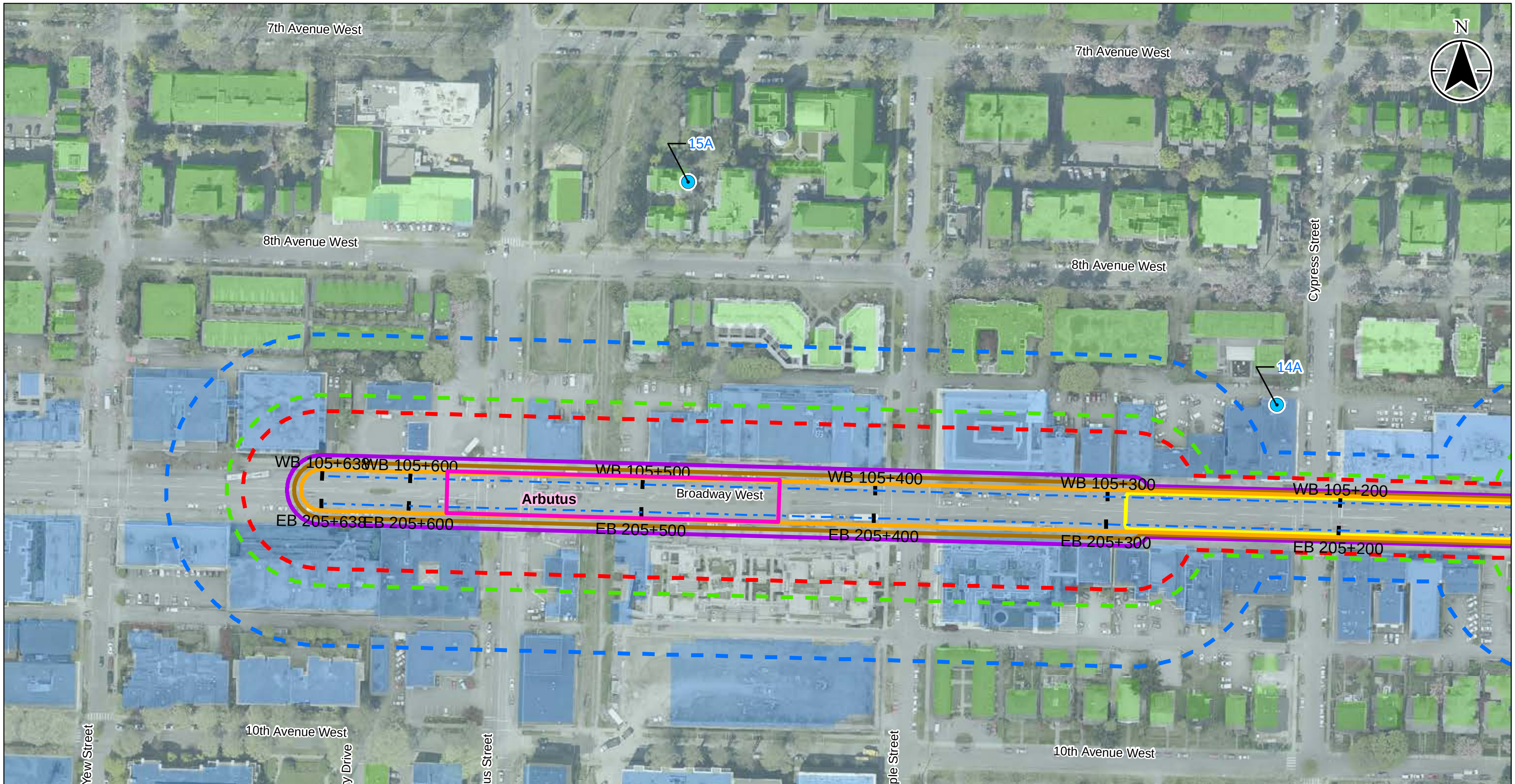
7.6.6.1 Construction

Construction vibration levels were estimated based on an assumed construction fleet, developed from similar projects, including the Evergreen Line. Further details on the assumed construction fleet is provided in the Vibration Technical Data Report (Stantec 2019). Vibration levels (PPV_{equip}) associated with station and elevated guideway construction were derived from Caltrans (2013). Of the various potential construction methods considered in this preliminary assessment, impact pile drivers are expected to create the greatest vibration.

To assess potential effects of Project construction on existing surroundings, vibration calculations were used to quantify vibrations from:

- Tunneling (underground boring activities)
- Station excavation (six locations along the Alignment)
- Elevated guideway (vibration from foundation construction near Great Northern Way)

Vibration calculations were used to determine threshold contours along the Alignment (Stantec 2019). GIS analysis was then undertaken to estimate the number of buildings that would be included in each contour. The threshold values reflect FTA guidelines (2006) for general vibration assessments (summarized in Section 7.6.2.1). The buildings were assessed by using City of Vancouver data (City of Vancouver 2018) with residential, industrial, and commercial zoning types. Table 7.6-6 shows the number of buildings that are located within damage and disturbance threshold distances for various construction activities. An example contour plot is provided in Figure 7.6-2 showing the vibration contour thresholds along the Alignment (Stantec 2019).



NOTES:

1. THRESHOLD CONTOURS ARE BASED OFF AN ASSUMED ROCK COVER OF 13M ABOVE THE TUNNEL CROWN. ACTUAL ROCK COVER VARIES ACROSS THE TUNNEL PROFILE.
2. THRESHOLD VALUES FOR DISTURBANCE TO BUILDING OCCUPANTS AND INTERIOR OPERATIONS ARE OFTEN LESS THAN VIBRATION LEVELS RECORDED DURING THE BASELINE STUDY. THEREFORE, ACTUAL DISTURBANCE CONTOURS MAY BE LESS EXPANSIVE THAN SHOWN HERE.
3. MAP SHOWS ESTIMATED VIBRATION THRESHOLD CONTOURS FOR TBM TUNNELLING ACTIVITY ONLY.
4. ACTUAL VIBRATIONS WILL DEPEND ON CONTRACTOR'S MEANS AND METHODS, ACTUAL GROUND CONDITIONS, AND CHARACTERISTICS OF THE INDIVIDUAL STRUCTURES. SEE SECTION 6.5 FOR ADDITIONAL LIMITATIONS REGARDING THESE CONTOUR MAPS.

LEGEND

- EXISTING RAPID TRANSIT STATION
- EXISTING RAPID TRANSIT LINE
- PROPOSED STATION - UNDERGROUND EXTENTS
- TRACK ALIGNMENT UNDERGROUND
- TRACK ALIGNMENT ABOVEGROUND
- VIBRATION MONITORING STATION
- DAMAGE TO REINFORCED-CONCRETE, STEEL, OR TIMBER (NO PLASTER) (PPV OF 12.7 mm/s)
- DAMAGE TO ENGINEERED CONCRETE AND MASONRY (NO PLASTER) (PPV OF 7.6 mm/s)
- DAMAGE NON-ENGINEERED TIMBER AND MASONRY BUILDING (PPV OF 5.1 mm/s)
- DAMAGE TO BUILDINGS EXTREMELY SUSCEPTIBLE TO VIBRATION DAMAGE (PPV OF 3 mm/s)
- DISTURBANCE TO INSTITUTIONAL LAND USES WITH PRIMARY DAYTIME USE (PPV OF 0.57 mm/s)
- DISTURBANCE TO RESIDENCES AND BUILDINGS WHERE PEOPLE NORMALLY SLEEP (PPV OF 0.40 mm/s)
- DISTURBANCE TO BUILDINGS WHERE VIBRATION WOULD INTERFERE WITH INTERIOR OPERATIONS (PPV OF 0.18 mm/s)

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APPROVAL	INIT	YY-MM-DD DATE

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BROADWAY SUBWAY PROJECT

ZONING CATEGORY
- COMMERCIAL
- INDUSTRIAL
- RESIDENTIAL

Stantec

BROADWAY SUBWAY PROJECT

EXAMPLE VIBRATION REVIEW ELEMENT CONTOUR PLOT

SCALE 1:2,500	CONTRACT NO.	SUB CONSULTANT PROJECT NO.	115814099
DATE 17-11-29			
SHEET NO.		FIGURE 7.6-2	

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Station Construction

Depending on the construction methodology used, station construction has the potential to cause damage and/or disturbance to some buildings based upon this preliminary assessment. Based on estimated vibration levels during construction between buildings within 35 m of the assumed station excavation areas are within a contour where PPV could exceed 3.0 mm/s (Vibration Technical Data Report. Stantec 2019). In such areas, buildings that are considered “extremely susceptible to vibration” would be at risk of damage during construction. However, a detailed assessment of the condition of existing structures has not been undertaken at this stage of the Project. As such, it is unknown how many buildings might be considered “extremely susceptible to vibration”. Nevertheless, where construction-related vibration has the potential to cause damage or disturbance, alternative equipment and excavation methods can be used, which would result in lower vibration levels.

Vibration from station construction could affect residential receptors, particularly if vibration- intensive construction activities occur at night. To limit vibration effects from station construction on residential receptors, efforts will be made to limit vibration-intensive activities to day-time construction hours where possible.

The threshold “disturbance at buildings where buildings would interfere with interior operations/equipment” includes the most buildings, because it is the broadest threshold contour (see Table 7.6-1). However, only a small proportion of the buildings located within this contour are likely to contain equipment that is sensitive to vibration. Based on the preliminary assessment, both the various facilities within the medical precinct (i.e., VGH and adjacent areas), as well as Emily Carr University of Art + Design, are within the sensitive equipment threshold contour for construction.

The application of mitigation measures (i.e., selection of alternative construction methods, vibration monitoring, pre-post construction surveys etc.), as discussed in Section 7.6.6, would reduce the amount of vibration generated and mitigate potential damage or disturbance.

Excavation with Tunnel Boring Machine

Excavation with a TBM may result in some increase in vibration on some structures and building occupants within the Review Area. Of the approximately 440 buildings located within 35 m of the Alignment (the zone where vibration effects could disturb sleep) an estimated 420 to 430 are commercial or institutional, rather than residential (Stantec 2019), suggesting that TBM operations would have a limited effect on residential areas.

TBM operations could affect the operation of sensitive equipment in buildings located within approximately 60 m of the Alignment depending on specific vibration transmission characteristics of the building and baseline vibration levels, among other factors. Buildings where this threshold would be applicable includes the BC Cancer Agency and VGH facilities.

Summary

Construction-related vibration is anticipated to exceed baseline vibration levels along the Alignment in localized areas. The estimates of construction phase vibration are based on the use of equipment that causes the high vibration levels (e.g., impact pile driving), which may not be used during construction. Additionally, vibration generated by the TBM will be temporary, in any given location, as tunnel development proceeds.

As such, for many locations along the Alignment, vibration levels are anticipated to be lower than estimated in this analysis. Depending upon the excavation equipment and method used, the areas at greatest risk of exceeding background vibration levels and vibration thresholds are those where stations are being constructed with vibration-intensive shoring and excavation methods.

Table 7.6-7: Number of Buildings within or Intersected by Thresholds for Construction Vibration

Threshold		Approximate Number of Buildings Within or Intersected by Threshold Contour		
		Excavation with TBM	**Station or Guideway construction using pile drivers**	**Station or Guideway construction using hydraulic breakers**
Potential Damage to Buildings	Damage to reinforced-concrete steel or timber (no plaster)	0	60 to 70	10 to 20
	Damage to engineered concrete and masonry (no plaster)	5 to 15	80 to 90	25 to 35
	Damage to non-engineered timber and masonry building	30 to 40	85 to 95	50 to 60
	Damage to buildings extremely susceptible to vibration damage	150 to 160	120 to 130	70 to 80
Potential Human Reception and Sensitive Equipment Interference	Disturbance at institutional land uses with primary daytime use	400 to 410	770 to 780	220 to 230
	Disturbance at residences and buildings where people normally sleep	430 to 440	1250 to 1260	305 to 315
	Disturbance at buildings where vibration would interfere with interior operations/equipment	680 to 690	4130 to 4140	945 to 955

NOTES:

* Station or Guideway construction based on vibration from impact pile drivers

Values used to estimate damage, disturbance and interference are approximate. Including a building within a contour interval does not guarantee the vibration will affect the building.

Actual vibration levels to cause disturbance may be higher than the thresholds in this table, as baseline vibration levels are often higher than the disturbance thresholds considered here.

7.6.6.2 Operation

Vibration estimates were used to determine vibration threshold contours, during train operation along the extent of the Alignment. The vibration levels associated with rapid transit operation reported in FTA (2006) were used to estimate vibration effects during operation. Although train speed will vary along different points of the Alignment maximum train speed of 80 km/h is assumed across the entire Alignment.

Table 7.6-7 shows the number of buildings that are located within disturbance threshold distances during Project operation. Vibration from train operations is estimated to be potentially too low to result in building damage, even for buildings potentially at risk of such damage.

Operation induced vibration could be a nuisance to residential receptors and/or interfere with the operation of sensitive equipment. However, only 13 of the 342 buildings located within the vibration contour “disturbance at residences and buildings where people normally sleep” are residential. Further, many of these residences are towers, and occupants of higher floors would likely experience less vibration than estimated.

There are approximately 500 buildings located within 40 m of the Alignment (Stantec 2019), which is the threshold for potential interference with sensitive equipment within buildings. However, it is expected that most of these buildings would not house sensitive equipment that could be impacted by vibration.

Vibration from train operations could affect sensitive equipment usage within some of the buildings along Great Northern Way, located immediately adjacent to the Alignment (e.g., Emily Carr University of Art + Design and the QLT Building). Mitigation measures noted in Table 7.6-6 (i.e., vibration dampening design features and vibration monitoring during commission/operation) represent opportunities to address potential vibration from train operations. Medical buildings assessed for vibration effects during operation are located far enough away from the Alignment to not be impacted by vibration.

Table 7.6-8: Number of Buildings within or Intersected by Thresholds for Operation Vibration

Threshold		Total Number of Buildings Within or Intersected by Threshold Contour
Potential Damage to Buildings	Damage to reinforced-concrete steel or timber (no plaster)	0
	Damage to engineered concrete and masonry (no plaster)	0
	Damage to non-engineered timber and masonry building	0
	Damage to buildings extremely susceptible to vibration damage	0
Potential Human Reception and Sensitive Equipment Interference	Disturbance at institutional land uses with primary daytime use	220 to 230
	Disturbance at residences and buildings where people normally sleep	340 to 350
	Disturbance at buildings where vibration would interfere with interior operations/equipment	490 to 500

NOTES:

Values used to estimate damage, disturbance and interference are approximate. Including a building within a contour interval does not guarantee the vibration will affect the building.

Actual vibration levels to cause disturbance may be higher than the thresholds in this table, as baseline vibration levels are often higher than the disturbance thresholds considered here.

7.6.7 Conclusion

Based upon preliminary analysis, Project construction activities will create vibration that may affect nearby structures and building occupants. Such risks can be effectively addressed through the development and application of a Noise and Vibration Management Plan that includes the mitigation measures described in Section 7.6.6.

Application of mitigation measures are considered to be effective in managing vibration risk associated with construction in urban areas and are intended to limit or avoid vibration effects associated with Project construction.

As part of implementing mitigation to address construction-related vibration, the Contractor will update predictive modelling, informed by the final Project design and construction methods that are selected. Based on the findings of such modelling, the Contractor will apply site-specific mitigation that is considered appropriate given the anticipated extent and nature of vibration in specific areas.

Actual vibrations transmitted to buildings will depend on several factors including construction means and methods, actual ground conditions, final track design, the characteristics of the individual buildings along the Alignment, and how efficiently vibration is transferred from the surrounding ground into the structure.

To effectively address potential Project-related vibration effects during construction, the development and implementation of mitigation measures will be supported by engagement with potentially affected property owners and residents.

During the operations phase, estimated vibration levels are not anticipated to exceed existing vibration levels, or thresholds for disturbance to building occupants, for a majority of the buildings in the Review Area. For the limited areas where there may be a risk of operational vibration impacting the operation of sensitive equipment, it is anticipated that the implementation of Project design considerations, and vibration monitoring during commissioning, will mitigate such risk.

7.7 Air Quality and Greenhouse Gases

This section of the Environmental and Socio-economic Review (ESR) evaluates Project-related changes in Air Quality and Greenhouse Gases (GHGs). Air emissions from Project activities are quantified relative to local and regional emissions that have been publicly reported for the City of Vancouver and Metro Vancouver.

Project construction activities that could affect local and regional air quality and GHGs relate mainly to the use of construction equipment and vehicles. Operational activities that could affect local and regional air quality and GHGs relate mainly to reductions in emissions from motor vehicles as a result of increased transit capacity.

Key information provided to support the assessment of Air Quality and GHGs includes:

- Rationale for selection of Air Quality and GHGs as a Review Element
- Methods used to review potential effects of Project activities in the context of applicable legislation and policies applicable to this Review Element
- Existing conditions in the City of Vancouver, Metro Vancouver, and the Lower Fraser Valley
- A summary of Project components and physical activities that may interact with this Review Element.
- A description of mitigation measures to limit or avoid effects to Air Quality and GHGs and comply with relevant legislation and policy
- A discussion of review results and conclusions

7.7.1 Rationale for Selection as a Review Element

Air Quality and Greenhouse Gases (GHGs) were selected as a Review Element because air emissions from construction activities will be released during the construction phase. During the operations phase, the Project is expected to reduce traffic-related air emissions by replacing diesel-fueled buses along the Broadway Corridor with electricity-powered transit and reducing the number of passenger vehicles on the road.

7.7.2 Review Scope for Air Quality and Greenhouse Gases

7.7.2.1 Regulatory and Policy Setting

Under the BC *Environmental Management Act*, Metro Vancouver has been delegated the authority to manage air quality within its district boundaries. Metro Vancouver uses the Integrated Air Quality Management Bylaw No. 1082, 2008 (Metro Vancouver 2008) to manage air emissions within the Lower Fraser Valley airshed. The Integrated Air Quality and Greenhouse Gas Management Plan for Metro Vancouver (Metro Vancouver 2011) aims to address air emissions through an adaptive management approach focused on protecting public health and the environment, improving visual Air Quality and minimizing the region's contribution to global climate change.

Ambient Air Quality Objectives

As part of its mandate, Metro Vancouver established its ambient air quality objectives (AAQO, MV 2016) based on scientific studies to guide airshed management decisions. Substances for which AAQO have been developed are called criteria air contaminants (CACs). Table 7.7-1 summarizes the Metro Vancouver AAQOs for the following CACs: sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), inhalable particulate matter (PM_{10}), respirable particulate matter ($PM_{2.5}$), and ozone (O_3). Ozone is not directly emitted to the atmosphere but is a concern as a secondary air pollutant that may be formed in the atmosphere by reactions with volatile organic compounds (VOCs), NO_2 and sunlight.

Table 7.7-1: Metro Vancouver's Ambient Air Quality Objectives (MV 2016)

Substance	Averaging Time	Ambient Air Quality Objective		Description
		µg/m³	ppb	
SO_2	1-hour	196	75	Sulphur dioxide (SO_2) is a colourless gas with a characteristic pungent sulphur odour. It is produced in combustion processes by the oxidation of sulphur compounds, such as hydrogen sulphide (H_2S), contained in the fuel.
	24-hour	125	48	
	Annual	30	12	
NO_2	1-hour	200	107	Nitrogen dioxide (NO_2) is an orange to reddish gas formed by the oxidation of NO emitted directly by combustion processes, particularly those processes occurring at high temperature and pressure, such as with internal combustion engines.
	Annual	40	22	
CO	1-hour	30,000	26,500	Carbon monoxide (CO) is a colourless, odourless gas, and is a product of incomplete combustion of wood and fossil fuels. Motor vehicles, industrial processes, and forest fires are common sources.
	8-hour	10,000	8,800	

Table 7.7-1: Metro Vancouver's Ambient Air Quality Objectives (MV 2016)

Substance	Averaging Time	Ambient Air Quality Objective		Description
		$\mu g/m^3$	ppb	
PM_{10}	24-hour	50	-	The size classes of PM are referenced to the particle aerodynamic diameters in microns, or micrometres (µm). Inhalable particulate matter (PM_{10}) consists of particles with aerodynamic diameters less than or equal to 10 µm. Respirable particulate matter ($PM_{2.5}$) consists of particles with aerodynamic diameters less than or equal to 2.5 µm.
	Annual	20	-	
$PM_{2.5}$	24-hour	25	-	
	Annual	8(6)	-	
O_3	1-hour	161	82	Ozone is a secondary pollutant, formed as a result of a reaction of oxides of nitrogen and VOCs with sunlight during warm weather.
	8-hour	128	65	
VOCs (Total)	N/A	-	-	Volatile organic compounds (VOCs) are carbon-containing (organic) compounds that readily evaporate into the air under ambient conditions. Many VOCs are of natural origins, including methane. Others may be potentially harmful to the environment, either directly or indirectly as a contributor to ground-level O_3 and smog formation.

Although total VOCs are recognized as air pollutants, there are no AAQOs for total VOCs in British Columbia because of the wide variety of substances grouped under the category of VOCs. Project-related changes in total VOC emissions are considered as VOCs may contribute to the generation of ground level O_3.

Greenhouse Gas Regulatory and Policy Setting

Federal, provincial, and municipal governments have established various policy frameworks and initiatives to reduce GHG emissions. Key legislation, policies, and regulatory guidance documents applicable to this Project are summarized in Table 7.7-2.

Table 7.7-2: Key Legislative, Policy, and Regulatory Guidance Documents Specific to GHGs

Authority	Documentation	Description
Government of Canada	Paris Agreement	During the 2015 COP21 in Paris (UNFCCC 2015), Canada committed to a 30% reduction of national GHG emissions below the 2005 level by 2030. As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), Canada is reporting annual national GHG totals to the UNFCC.
	GHG Emission Reporting Program	Under the Canadian Environmental Protection Act (EC 1999), the GHG Emission Reporting Program requires operators of facilities to report their annual GHG emissions to Environment and Climate Change Canada (ECCC) if their emissions are above 50,000 t carbon dioxide equivalents (CO_2e) per year (ECCC 2017). This reporting threshold is currently under review.
Government of BC	*Greenhouse Gas Industrial Reporting and Control Act*	The Act provides authority for the GHG Emission Reporting Regulation (see below), the GHG Emission Control Regulation, and the GHG Emission Administrative Penalties and Appeals Regulation (Government of BC 2014). This Act also allows for performance standards to be set for industrial facilities or sectors (currently applicable only to liquefied natural gas export facilities).
	Climate Change Accountability Act	This Act sets legislated GHG reduction targets for BC. Under this Act: • By 2030 and for each subsequent calendar year, BC GHGs will be at least 40% less than the level of those emissions in 2007; • By 2040 and for each subsequent calendar year, BC GHGs will be at least 60% less than the level of those emissions in 2007 • By 2050 and for each subsequent calendar year, BC GHGs will be at least 80% less than the level of those emissions in 2007(Government of BC 2007, updated 2018). In support of this Act as well as national and international reporting processes, the Province is consolidating an annual GHG inventory report which feeds into the National Inventory Report. Emissions from Transportation are captured in this report.
	Carbon Tax Act	The *Carbon Tax Act* sets a price on carbon in the form of a provincial carbon tax introduced in 2008. This provides an economy-wide incentive to use less fossil fuel and reduce emissions. It is a broad-based tax that applies to the purchase and subsequent combustion of fuels such as gasoline, diesel, natural gas, heating fuel, propane, and coal (Government of BC 2008).
	Under the Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act	This Act allows the government to set standards for the amount of renewable fuel that must be contained in BC's transportation fuel blends, reduce the carbon intensity of transportation fuels, and meet its commitment to adopt a new low-carbon fuel standard similar to California's.

Table 7.7-2: Key Legislative, Policy, and Regulatory Guidance Documents Specific to GHGs

Authority	Documentation	Description
Metro Vancouver	Integrated Air Quality and Greenhouse Gas Management Plan	The vision of this plan in regard to GHGs is to limit the region's contribution to global climate change. Reduction goals are set to 33% reduction by 2020 from 2007 levels and 80% by 2050, in accordance with the provincial GHG reduction target act (Metro Vancouver 2011). Metro Vancouver specifically identified that reducing GHG emissions from the transportation sector poses a significant opportunity to lower the overall GHG footprint (Metro Vancouver 20111, Metro Vancouver 2014). In 2010 36% of Metro Vancouver's GHG emissions were from transportation sources (i.e., light and heavy-duty vehicles) (Metro Vancouver 2013)
City of Vancouver	Renewable City Strategy	The City of Vancouver's existing climate change and renewable energy targets are to: i) reduce carbon pollution by 33% below 2007 levels by 2020; ii) reduce carbon pollution at least 80% below 2007 levels before 2050; iii) derive 100% of the energy used in Vancouver from renewable sources before 2050 (City of Vancouver 2017)
TransLink	Environmental Sustainability Targets	In 2018, TransLink adopted the following environmental sustainability targets: i) to reduce GHGs by 80% by 2050; and ii) to utilize 100% renewable energy in all operations by 2050 (TransLink 2019)

Substances which have global warming potential (GWP) and are considered in the evaluation of GHGs for the Project, include Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O). Greenhouse gases are often presented as combined units (tonnes) of CO_2 equivalents (t CO_2e). Additional GHG details are provided in Table 7.7-3.

This review considers GHG emissions generated by the construction and operation of the Project. Construction related emissions that are assessed are considered "direct emissions" and include emissions from equipment used to support Project construction. Operational related emissions that are assessed are considered "indirect emissions" and include GHG emissions associated with hydro-electric energy that will be used to support the operation of trains. GHG emissions from vehicles and equipment used to undertake maintenance activities during operation are considered negligible and are not included in the assessment of operational GHG emissions.

Table 7.7-3: GHG Definitions

Substance	Definition
CO_2	CO_2 is a naturally occurring gas (e.g., volcanic eruptions) but is also released by human activities (e.g., by-product of burning fossil fuels, burning of biomass, land use changes, and other industrial processing).
CH_4	CH_4 is a hydrocarbon gas produced through natural sources (e.g., wetlands) and is also the main component of natural gas. It is also produced by human activities (e.g., burning of fossil fuels, fugitive sources, raising livestock, decay of organic waste in landfills). Methane has a higher global warming potential (GWP) than CO_2 but is much less abundant in the atmosphere (GWP of CH_4 is 25).
N_2O	N_2O occurs naturally and from human activities. Nitrous oxide is produced as a by-product of the combustion of fossil fuel and biomass burning as well as during industrial and agricultural activities. Nitrous oxide has the highest GWP of the three GHGs listed here (GWP of N_2O is 298).

7.7.2.2 Engagement Input Supporting the Assessment

The assessment of Air Quality and GHG was informed by input received during stakeholder engagement processes including those focused on obtaining feedback on the development of the TOR. Key issues identified and response to comments obtained during public engagement are presented below (Table 7.7-4).

Table 7.7-4: Summary of Key Air Quality and GHG Issues Identified during Public Engagement

Identified Issue	Response
Air quality will be affected during construction due to construction-related dust and vehicle emissions.	Section 7.7 (Air Quality and Greenhouse Gases) of the ESR quantifies air emissions from construction and identifies mitigation measures to avoid or reduce potential Project-related effects on Air Quality.
Change in greenhouse gas emissions due to construction and operation of the Project and clarification on how greenhouse gases are measured.	Section 7.7 (Air Quality and Greenhouse Gases) of the ESR describes how air emissions from Project construction and operation activities are quantified relative to Metro Vancouver.

7.7.2.3 Selection of Effects and Review Indicators

Table 7.7-5 lists the potential Project effects on air quality and GHGs and summarizes Project effect mechanisms and indicators used to assess the potential effects. Project effect mechanisms define the link between the Review Element and the potential effect and are described in more detail in Section 7.7.4 (Project Interactions). Indicators listed in Table 7.7-5 identify the mechanisms and indicators used to measure and assess potential effects qualitatively or quantitatively.

Table 7.7-5: Potential Effects and Review Indicators for Air Quality and GHG

Potential Effects	Project Effects Mechanisms	Indicator	Rationale for Selection
Project-related changes in emissions of CACs and changes in ambient air quality	Project activities release CACs to the atmosphere (SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$, O_3, VOCs)	Changes to release of CACs (SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs) as an indicator of changes in ambient CAC concentrations	Regulatory agencies (i.e., Metro Vancouver) have established objectives
Project-related changes in emissions of GHGs within the regional airshed	Project activities release GHGs to the atmosphere	Changes to release of GHGs (CO_2, CH_4, N_2O, reported as CO_{2e})	CO_2, CH_4 and N_2O are the primary GHGs that will be released by Project activities

Potential Project effects on CACs and GHG emissions are assessed in the following way:

- Selection of spatial and temporal boundaries forming the Review Area
- Characterization of baseline conditions within the Review Area
  - Existing baseline CAC and GHG emissions from all pollution sources (year 2010)
  - Forecast baseline conditions without the Project (year 2020 and 2030)
  - Existing ambient SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$ and O_3 concentrations
- Characterization of Project contributions to baseline and forecast conditions
  - Total CAC and GHG emissions during construction
  - Total CAC and GHG emission reductions during operation
- Assessment of potential Project-related changes in existing air quality and GHG emissions

7.7.2.4 Boundaries

Spatial Boundaries

The Review Area for Air Quality and GHGs consists of the City of Vancouver. The City of Vancouver was selected because this is the smallest spatial boundary for which an emission inventory is available for analysis.

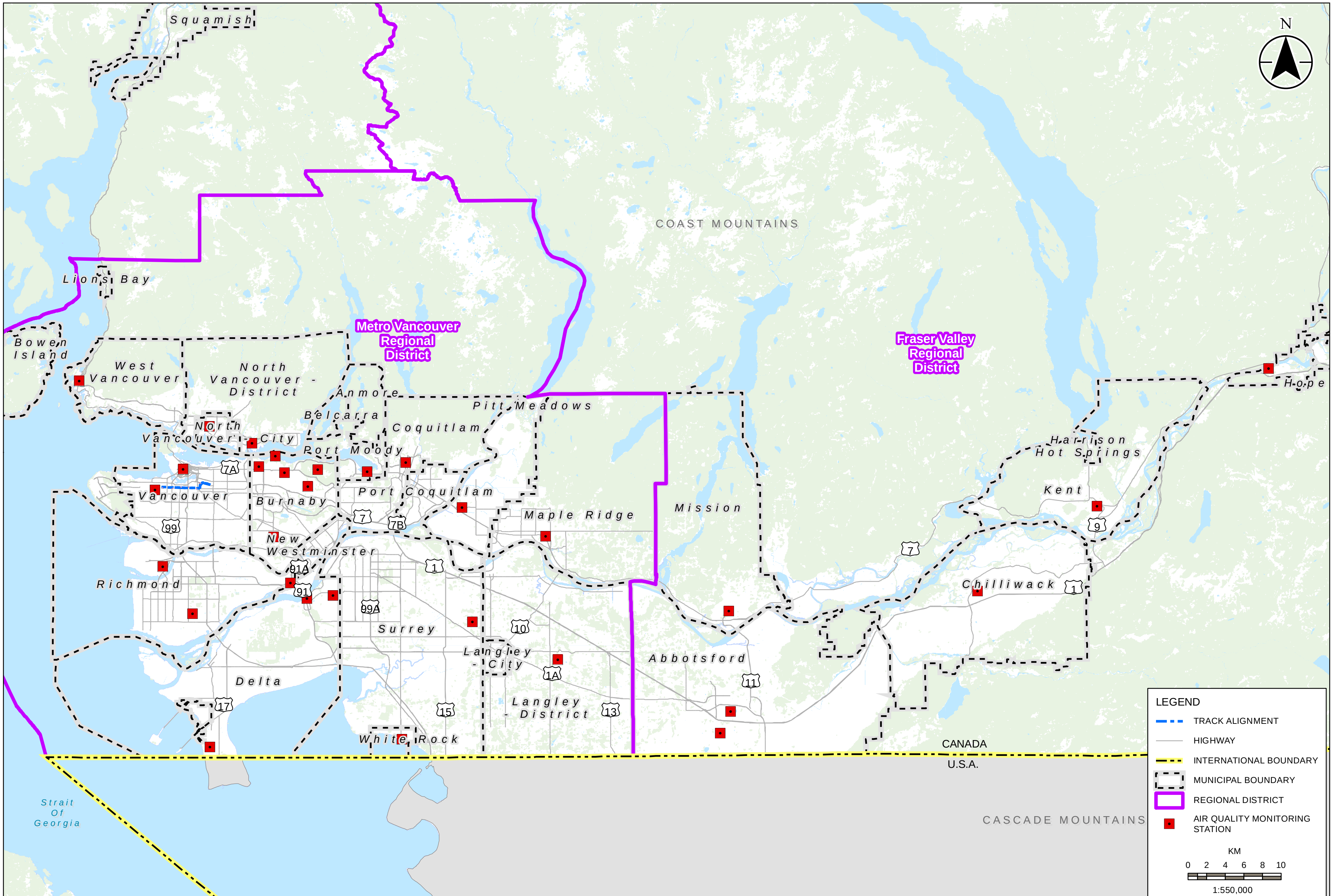
Air emissions from Vancouver contribute to the Lower Fraser Valley airshed. The geographic extent of the airshed includes an area bound by the Coast and Cascade Mountain Range and the Strait of Georgia (see Figure 7.7-1). The Canadian portion of the Lower Fraser Valley airshed extends from Lions Bay to the District of Hope and defines the regional spatial extent of this assessment.

As changes in Project-related emissions within the City of Vancouver are expected to disperse over a wider area including the Lower Fraser Valley airshed, changes in air emissions are reported in the context of both local (the City) and regional (Metro Vancouver) scale.

Temporal Boundaries

The temporal boundaries for this assessment include:

- Construction—Anticipated to commence in 2020 and be completed in 2025
- Operations—Minimum 30 years after commissioning (2025 forward)



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DESIGNED	INIT	YY-MM-DD DATE
DRAWN	INIT	YY-MM-DD DATE
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APPROVAL	INIT	YY-MM-DD DATE

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BROADWAY SUBWAY PROJECT

Stantec

BROADWAY SUBWAY PROJECT

AIR QUALITY AND GREENHOUSE GASES REVIEW ELEMENT SPATIAL BOUNDARIES

SCALE 1:550,000	CONTRACT NO.	SUB CONSULTANT PROJECT NO.	115814099
DATE 17-11-29			
SHEET NO.		FIGURE 7.7-1	

7.7.3 Existing Conditions

Existing air quality and GHG emissions reflect:

- Existing and forecast CAC and GHG emissions from all pollution sources in Metro Vancouver and Vancouver (year 2010, 2020 and 2030) extracted from latest publicly-available emission inventory (pers. comm. Metro Vancouver 2017)
- Existing ambient CAC concentrations (years 2013 and 2014) presented in the latest publicly-available Lower Fraser Valley Air Quality Monitoring Report (Metro Vancouver 2015)

The CAC and GHG emission inventories were obtained from Metro Vancouver and provide an account of total air emissions from all pollution sources for each municipality within its jurisdiction (Metro Vancouver 2017). Metro Vancouver emission inventories include backcast CAC (i.e., SO_2, NO_X, CO, PM_{10}, $PM_{2.5}$) and GHG (i.e., CO_2, CH_4, N_2O, CO_2e) emissions developed by updating past inventories with the current years' methodology and Review Area to allow for a representative comparison of yearly trends.
Metro Vancouver also forecasts emissions in five-year increments as a function of population, economy, employment, kilometres travelled, fuel consumed and future growth. The inventories are grouped into the following categories:

- Mobile sources include on-road (i.e., cars, buses, trucks) and off-road vehicles (i.e., train locomotives, construction equipment, marine vessels, and aircrafts)
- Area sources (e.g., agriculture, vegetation burning, fuel distribution, natural sources, chemical products use, heating, fugitive dust, waste)
- Point sources (e.g., bulk shipping terminals, chemical manufacture, electrical power generation, heating/cogeneration utilities, metal industries, non-metallic mineral processing, paper and allied products, petroleum products, wood products, concrete batch plants).

Metro Vancouver's most recently released backcast CAC and GHG emissions, for the Lower Fraser Valley and associated municipalities is for the year 2010. For the purposes of this assessment, the CAC and GHG emission inventories are provided for year 2010, 2020 and 2030. Emissions for 2010 are considered to describe the baseline (i.e., pre-Project) conditions. Emissions for 2020 describe the anticipated baseline (i.e., without Project-related construction emissions) conditions during construction. The 2030 emissions describe conditions in 2030 when the Project is anticipated to be operational.

7.7.3.1 Regional Climate

This section summarizes the regional climate trends as a function of climate normal data from stations located in Metro Vancouver for the 1981 to 2010 reporting period (ECCC 2017). The information presented provides context to support the assessment of air quality as climactic conditions can influence air quality.

Vancouver has a moderate oceanic climate that is dominated by its proximity to the Pacific Ocean, but also influenced heavily by the Coastal and Cascade Mountain ranges (see Figure 7.7-1). In Vancouver, summers are typically dry, but there is significant rainfall during the rest of the year. Temperatures are generally mild, with average summer maximum daily temperatures of 21°C and average winter minimum temperatures above 0°C. The average annual temperature (at the Vancouver Airport) is 10.4°C.

Vancouver receives most of its precipitation in the form of rain, with an annual average of 1153 mm of rainfall. Precipitation is highly variable throughout Metro Vancouver due to the mountainous topography and can vary from 1,052 mm of rainfall in the Steveston area of Richmond, BC, to 2,351 mm at the Cleveland Dam and 3,735 mm at the Seymour Hatchery, both in North Vancouver. Snow typically falls at least once a year in Vancouver, but large accumulations are infrequent due to the mild winter temperatures. Snow typically accumulates each winter at higher elevations in the surrounding cities such as West Vancouver and North Vancouver.

Weather patterns reflect the influence of the Pacific Ocean and the surrounding topography. The North Pacific Current exerts a moderating influence by carrying warmer water from the western Pacific Ocean eastward to the coast of BC. However, arctic outflow winds can also bring very cold air from the interior of BC and northern Canada. Temperature inversions are common due to the interaction of these contrasting air masses. Winds typically blow from the east during the winter, but from the south and west during the summer. Sea breezes are common and can create large temperature differences between areas near the water and those areas further inland. Wind speeds are typically highest during the winter, and while extreme winds are uncommon, there have been historical storms which caused damage to trees and buildings.

7.7.3.2 Criteria Air Contaminant and Greenhouse Gas Emissions

2010 CAC and GHG Emissions

Total 2010 CAC and GHG emissions for Metro Vancouver and the City of Vancouver are summarized in the Air Quality and Greenhouse Gases Technical Data Report (Air Quality and GHG TDR; Stantec 2019). Vancouver's 2010 SO_2, NO_X and CO emissions are dominated by mobile sources. Most of Vancouver's PM_{10} and $PM_{2.5}$ emissions come from area and point sources. The CO_2 and N_2O emissions come from mobile sources. Area sources contribute the most CH_4 emissions.

2020 CAC and GHG Emissions

Metro Vancouver and Vancouver forecasted CAC and GHG emissions for 2020 are provided in the Air Quality and GHG TDR (Stantec 2019). Vancouver's 2020 SO_2, NO_X and CO emissions remain dominated by mobile sources. The contribution of on-road emissions, specifically NO_x and CO, are forecast to decrease by 2020, due to on-road vehicle emission management, planning, inspections and maintenance. The reductions of SO_2 and PM are predicted to occur due to newly-imposed emission standards for marine vessels by the International Marine Organization (IMO 1997).

The GHG emission forecast for 2020 predicts emissions to be consistent with 2010 estimates due to population and economic growth (MV 2013).

2030 CAC and GHG Emissions

Metro Vancouver and Vancouver forecast CAC and GHG emissions for 2030 are provided in the Air Quality and GHG TDR (Stantec 2019). The NO_x, CO and SO_2 emissions are still dominated by mobile sources and are predicted to level off by 2030.

A slight decline in GHG emissions is predicted for 2030 due to new vehicle engine technology, emissions management and new regulations expected in the future.

7.7.3.3 Ambient CAC Concentrations

Metro Vancouver, in partnership with BC Ministry of Environment and Climate Change Strategy and ECCC, operate and maintain an extensive ambient air monitoring network in the Lower Fraser Valley airshed. Ambient monitoring data is collected, analyzed and reported on an annual basis, with the latest report summarizing Lower Fraser Valley airshed conditions for the 2014 reporting year (MV 2015).

Local and regional ambient SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$, O_3 and VOC concentrations for 2014 are summarized in Table 7.7-6. Local concentrations are based on data from the Vancouver-Kitsilano and Richmond-Airport monitoring stations (locations shown in Figure 7.7-1), considered nearest to the Project and representative of Project conditions. Similarly, regional concentrations reflect a range of concentrations from all Lower Fraser Valley monitoring stations operated by Metro Vancouver during the monitoring period.

Historical ambient CAC concentrations are provided in the table below and discussed in detail in the Air Quality and GHG TDR (Stantec 2019).

Table 7.7-6: Local and Regional Ambient CAC Concentrations (based on 2014 data)

Substance	Averaging Period [e]	Ambient Concentration (µg/m³)		Metro Vancouver AAQO (µg/m³)
		Local [a]	Regional (Lower Fraser Valley airshed [b])	
SO_2	1-hour	39	13–**346**	196
	24-hour	9	5–59	125
	Annual	1.4	0.3–5	30
NO_2	1-hour	86	59–153	200
	Annual	30	11–34	40
CO	1-hour	1,831	670–2,980	30,000
	8-hour	1,477	432–1,611	10,000
PM_{10}	24-hour	33	28–**55**	50
	Annual	11	9–13	20
$PM_{2.5}$	24-hour	23	19–**37**	25
	Annual	6.6	4.6–6.7	8(6)
O_3	1-hour	104	45–**172**	161
	8-hour	96	74–**146**	128
VOCs [c]	24-hour [d]	122	42–694	-
	Annual	37	22–223	-

NOTES:

Bold values identify an exceedance of the Metro Vancouver AAQOs.

a The Vancouver-Kitsilano station operated for a partial year in 2014; therefore 2013 ambient SO_2, NO_2, CO, $PM_{2.5}$ and O_3 concentrations are presented for Vancouver-Kitsilano. Based on past ambient trends and no significant changes in emission sources in the local area, 2013 ambient concentrations are assumed to be representative to those that would have been measured in 2014. For consistency, 2013 ambient PM_{10} and VOC concentrations are provided from Richmond-Airport Station.

b In 2014, Metro Vancouver operated 28 air monitoring stations in the Lower Fraser Valley airshed (MV 2015). These values reflect the range of concentrations observed from available data.

c VOC ambient data for 2014 is not available from Metro Vancouver; therefore, 2013 has been summarized. Based on past ambient trends and no significant changes in emission sources in the regional area, 2013 ambient concentrations are assumed to be representative to those that would have been measured in 2014.

d VOC 24-hour value represents a daily total VOC maximum.

e Metro Vancouver has established AAQOs as a function of specific averaging periods over which the ambient concentration data should be averaged when compared to the objective.

7.7.3.4 Overview of Existing Conditions

Regional air quality for CACs in the Lower Fraser Valley is considered good and has improved in recent decades due to numerous airshed management and planning initiatives. In 2014, ambient CO or NO_2 concentrations did not exceed applicable AAQO at any of the monitoring stations in the Lower Fraser Valley airshed. There were a few recorded exceedances of SO_2, PM_{10} and $PM_{2.5}$ concentrations (MV 2015). Reasons for these exceedances included weather constraints and emission sources within and outside the airshed (i.e., forest fires).

Local air quality for CACs near the Project is also considered good overall. In 2013, there were no exceedances of the Metro Vancouver AAQOs at the Vancouver-Kitsilano or Richmond-Airport stations.

With respect to GHGs, baseline CO_2 and N_2O emissions from 2010 are attributed predominantly to mobile sources. The GHG emission forecast for 2020 predicts emissions to be consistent with 2010 estimates due to population and economic growth (Metro Vancouver 2013). A slight decline in GHG emissions is predicted for 2030 due to new engine technology, emissions management and new regulations expected in the future.

7.7.4 Project Interactions

The general design and construction approach described in Section 2 (Project Description) was used to determine project interactions that could affect Air Quality and GHGs. The potential effects to air quality and GHG caused by Project components and physical activities are described in Table 7.7-7. Potential interactions are indicated by check marks and are discussed in detail below in the context of effects mechanisms, standard- and Project-specific mitigation, and Project effects.

Table 7.7-7: Project Interactions with Air Quality and GHG

Project Activities and Physical Works	Potential Effects	
	Change in ambient CAC concentrations	**Change in quantities of GHGs released to the atmosphere**
Construction		
Property acquisition	-	-
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	✓	✓
Elevated guideway construction	✓	✓
Tunnel and station excavation	✓	✓
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	✓	✓
Vehicle traffic (e.g., road use and construction traffic)	✓	✓
Management and disposal of waste and excavated materials	-	-
Commissioning and start-up	-	-
Operation		
Train operation, including wayside and power	✓	✓
Station operation	-	-
Train maintenance, administration, transit police	-	-
NOTES: ✓ Potential interactions that may cause an effect - Not applicable		

7.7.4.1 Construction

Construction activities that will result in air emissions include the use of heavy equipment and vehicles. Emissions are estimated for a year of peak construction activities and are considered conservative. Activities generating emissions during the other years of construction will be shorter in duration and therefore emissions are assumed to be lower in magnitude. Assumptions on construction equipment, methods and schedule, that have informed estimates of construction-related air emissions, are provided in the Air Quality and GHG TDR (Stantec 2019).

The following activities associated with Project construction will result in air emissions but, in consideration of standard mitigation measures, the magnitude of such emissions is considered negligible, and as such are not quantified in this review:

- Fugitive dust emissions from site preparation, excavation, materials handling and use of roads to transport earth and rock materials
- CAC and GHG emissions from construction traffic and traffic closures/road restrictions during Project construction

Fugitive dust emissions from site preparation, excavation, material handling and vehicle movements are considered negligible for the following reasons:

- The construction activities are transient in nature; therefore, sources of dust will be intermittent and short-term.
- Regional climate is known for significant year-round precipitation thus substantively reducing the potential for fugitive dust emissions (see Section 7.7.3.1).
- The small contribution of Project emissions relative to existing sources of emissions in the City of Vancouver (see Section 7.7.6.1).

Construction activities that will not result in CAC and GHG releases include property acquisition, elevated guideway construction, station construction, waste management, commissioning and start-up because there are no emissions associated with these activities.

7.7.4.2 Operation

Operations activities that could change the CAC and GHG releases include train operation including associated power consumption. The Project is expected to displace diesel powered transit buses (i.e., 99 B-Line) and passenger vehicles particularly along the West Broadway Corridor. The decrease in traffic volumes in the Broadway Corridor is expected to result in decreased CAC and GHG emissions and is quantified below.

The Project will be fully integrated with the existing SkyTrain network in Vancouver and will operate the same trains used on the existing SkyTrain Millennium Line. Trains will operate using electrical power provided by BC Hydro. As such, GHG emissions associated with the generation of electricity provided by BC Hydro are quantified in the review (see Section 7.7.6.2 below).

Some activities associated with Project operation will result in air emissions but are considered negligible and are not considered in this review. These include:

- CAC and GHG emissions from a small fleet of vehicles supporting Project operations
- CAC and GHG emissions from intermittent use of emergency power generators (i.e., to support lighting, communications, air circulation)

- CAC and GHG emissions from station operation, train maintenance, administration and transit police

7.7.5 Mitigation Measures

Examples of the types of mitigation measures that may be employed to avoid or reduce effects from Project-related CAC and GHG emissions during Project construction and operation are summarized in Table 7.7-8. Mitigation measures applied during construction will be included in the Air Quality and Greenhouse Gas Management Plan which will be part of the Construction Environmental Management Plan. With the implementation of mitigation measures identified in Table 7.7-8, potential construction-related effects on existing conditions are expected to be negligible.

As noted in Section 9 (Environmental Management Plans), the Contractor will confirm the final mitigation approaches to support the Air Quality and Greenhouse Gas Management Plan. This approach will allow for mitigation measures that are aligned with the detailed design and construction approach developed by the Contractor.

Management of environmental issues, including air emissions, during operations will be the responsibility of BC Rapid Transit Company Ltd. (BCRTC 2019) and will be guided by its existing Operational Environmental Management Plan.

Table 7.7-8: Mitigation Measures for Air Quality and Greenhouse Gases

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.7-1	Prepare an Air Quality and Greenhouse Gas Management Plan which will include: • Best management practices and mitigation measures to manage construction phase air emissions including the use of low or zero emissions equipment where practical • Air quality monitoring to verify the effectiveness of construction phase air quality mitigation measures	Construction	Contractor	Contractual Requirement
7.7-2	Potential dust emissions will be controlled by applying best management practices which may include: • Using water spray to reduce generation of fugitive dust at excavation sources • Regularly sweeping paved surfaces and roadways to remove build-up sand and dirt • Installing wheel wash stations to eliminate mud track-out issues at active construction sites • Using water trucks on construction routes during dry conditions, where necessary	Construction	Contractor	Best Management Practice
7.7-3	Air emissions from construction equipment will be reduced by applying best management practices which may include: • Construction fleet will meet requirements of Metro Vancouver Non-Road Diesel Engine Emission Regulation Bylaw No. 1161 • Construction fleet will use low-sulfur fuel • Construction fleet will undergo regular tuning and maintenance • A no-idling policy will be implemented	Construction	Contractor	Best Management Practice

7.7.6 Discussion of Review Results

Project CAC and GHG emissions will be released because of construction activities as noted in Section 7.7.4. During the operations phase, the Project is expected to reduce overall CAC and GHG emissions by displacing transit buses and passenger vehicles in the Broadway Corridor. Changes in air quality and GHG emissions during both phases have been assessed in comparison to existing and forecast emissions in the local and regional context.

The effects of Project activities on the air quality and GHG emissions are assessed in the context of CAC emissions (SO_2, NO_X, CO, PM_{10}, $PM_{2.5}$ and VOCs) and GHG emissions (CO_2, CH_4, N_2O as CO_2e).

7.7.6.1 Construction

Project construction is expected to take approximately five to six years, and will include station, portal/tunnel and above-ground construction activities. Construction activities will rely on a fleet of equipment including construction vehicles and equipment. To support this assessment, a typical construction fleet inventory was established based on professional judgement regarding equipment used on other similar transportation-sector construction Projects (i.e., Evergreen Line). Details specific to associated air emissions are provided in the Air Quality and GHG TDR (Stantec 2019) and the Climate Lens report (MOTI 2019).

Table 7.7-9 compares annual estimated Project construction emissions at peak construction to emissions forecast for year 2020 and indicates that air emissions, from construction equipment, will result in small increases in local (Vancouver) and regional (Metro Vancouver) emissions of CACs and GHGs. Such increases in emissions would be temporary in nature and confined to the construction period.

In the context of the City of Vancouver, estimated Project-related CAC emissions would result in between a 0.19% (CO) and 2.52% (NOx) increase in emissions during the construction period. In the context of Metro Vancouver, estimated Project-related CAC emissions would result in between a 0.02% (SO_2) and 0.35% (NOx) increase in annual emissions. Project-related GHG emissions, in the context of the City of Vancouver, would result in a 0.81% increase in local GHG emissions (CO_2e) during the construction period. Project-related GHG emissions would result in a 0.14 % increase in regional (Metro Vancouver) GHG emissions (CO_2e) during the construction period.

With respect to GHG emissions generated during the construction phase, the substantial reduction in GHG emissions that is anticipated during the operational phase (2025–2054) by facilitating a shift towards more sustainable modes of transportation, will offset construction emissions and result in a net overall reduction in GHG emissions.

Table 7.7-9: Annual CAC and GHG Emissions during Construction Relative to City of Vancouver and Metro Vancouver

Parameter	CAC Annual Emissions (tpy)					GHG Annual Emissions (tpy)				
	SO_2	NO_X	CO	PM_{10}	$PM_{2.5}$	VOC	CO_2	CH_4	N_2O	CO_2e
Total construction emissions	0.21	116.22	111.01	6.33	6.13	10.39	22,035	0.63	0.2	22,111
Total emissions in City of Vancouver (2020)	18	4,617	57,401	965	578	N/A[a]	2,716,263	547	138	2,718,495
% Construction emissions in City of Vancouver (2020)	1.16%	2.52%	0.19%	0.66%	1.06%	N/A[a]	0.81%	0.12%	0.15%	0.81%
Total emissions in Metro Vancouver (2020)	1,361	33,181	246,319	6,598	4,127	N/A[a]	15,385,867	16,507	859	16,054,545
% Construction emissions in Metro Vancouver (2020)	0.02%	0.35%	0.05%	0.10%	0.15%	N/A[a]	0.14%	0.004%	0.02%	0.14%

NOTES:

[a] Local and regional VOC emissions are not available for year 2020 (Metro Vancouver 2017)

Existing CAC and GHG conditions in Vancouver and Lower Fraser Valley airshed are good overall with most existing concentrations of CACs found to be consistently below Metro Vancouver AAQOs. With the effective implementation of mitigation measures as outlined above, CAC and GHG emissions from Project construction are unlikely to result in the Metro Vancouver AAQOs being exceeded and will have a negligible influence on local and regional air quality overall.

7.7.6.2 Operation

The potential effects of Project operations on existing air quality and GHG conditions are assessed by quantifying anticipated changes in local and regional CAC and GHG emissions as result of Project-related improvements to transit infrastructure in the Broadway Corridor and the subsequent displacement of diesel buses and reduction in passenger vehicle use. This change is compared to predicted local and regional emission inventories for year 2030 (presented in Section 7.7.3.2) if the Project was not undertaken (i.e., without the Project).

In addition to changes in transportation related emissions, the assessment of GHG emissions associated with Project operation also takes into account indirect GHG emissions (i.e., from electricity generation) associated with train operation are also quantified for year 2030 to gauge the overall effects of Project operations on existing conditions.

Traffic Displacement

The Project is expected to reduce CAC and GHG emissions overall by displacing transit buses and passenger vehicles in the Broadway Corridor, between the SkyTrain VCC-Clark Station and Arbutus Street.

Public transit routes along Broadway accounts for 187,000 daily transit passenger trips with two routes (i.e., 99 B-Line and route 9) using Broadway directly. Once the Project is operational, buses operating the 99 B-Line route will only operate between Arbutus and UBC. Electric trolley buses operating route 9 between UBC and Boundary will continue to operate at a higher frequency to provide local access (i.e., shorter bus stop distances).

In addition to being a major public transit route, Broadway is designated as a truck route for the movement of goods. Truck traffic volumes are expected to be unaffected by the Project, though are anticipated to increase in alignment with local and regional land-use plans.

As discussed in Section 7.2 (Traffic and Transportation) changes in traffic volume in the Broadway Corridor were estimated by Steer Davies Gleave (SDG) using the EMME regional transportation model (RTM) (SDG 2018). Regional modelling was conducted for year 2030 to determine the difference in distance travelled by cars with and without the Project.

Model predictions provided by SDG anticipate that Project operation will reduce regional car travel by 46,740,064 km in year 2030 (SDG 2018). This difference in vehicle kilometres travelled was used to estimate the decrease in CAC and GHG emissions due to Project operation. Since RTM predictions did not include a reduction in diesel bus operation (i.e., 99 B-Line), this estimate is considered conservative and the actual reductions in CAC and GHG emissions are expected to be greater.

To calculate CAC and GHG reductions, the reduction in vehicle kilometres travelled was multiplied by CAC and GHG emissions factors for cars (in units of grams of substance per km travelled) reported by SDG (SDG 2017). CAC and GHG emissions factors and associated emission reductions for year 2030 are summarized in Table 7.7-10; the table compares the change in overall emissions with forecast emissions in the city of Vancouver and Metro Vancouver.

In the context of the City of Vancouver, estimated Project-related CAC emissions would result in between a 0.03% ($PM_{2.5}$) and 0.37% (CO) decrease in emissions. In the context of Metro Vancouver, estimated Project-related CAC emissions would result in between a 0.01% ($PM_{2.5}$) and 0.12% (CO) decrease in emissions.

Project-related GHG emissions, in the context of the City of Vancouver, would result in a 0.22% decrease in emissions. Project-related GHG emissions would result in a 0.06% decrease in regional (Metro Vancouver) GHG emissions. This finding is also comparable to the Climate Lens Report (MOTI 2019) evaluation of expected GHG emissions for 2030. The Evergreen Line Project (TransLink 2010) also found comparable findings with respect to the reduction in CAC and GHG emissions.

Table 7.7-10: Year 2030 Project CAC and GHG Emissions

Parameter	SO_2	NO_X	CO	PM_{10}	$PM_{2.5}$	VOC	CO_2e
Emission Factor (g/km, car only) [a]	0.004	0.28	7.1	0.016	0.007	0.339	201
Change in overall emissions due to Project (tpy)	-0.19	-13.09	-331.85	-0.75	-0.33	-15.84	-9,837
Forecast 2030 emissions in Vancouver (tpy)[b]	100	5,958	89,503	2,081	1,054	N/A	4,433,351
% Change in overall emissions in Vancouver (%)	-0.19%	-0.22%	-0.37%	-0.04%	-0.03%	N/A	-0.22%
Forecast 2030 emissions in Metro Vancouver (tpy)[b]	1,436	31,230	276,884	7,529	4,384	N/A	16,782,011
% Change in overall emissions in Metro Vancouver (%)	-0.01%	-0.04%	-0.12%	-0.01%	-0.01%	N/A	-0.06%

NOTES:

[a] Emission factors apply to cars only for year 2030 (SDG 2017).

[b] Emissions forecast for Metro Vancouver and the city of Vancouver are specific to year 2030. Technical details are presented in the Air Quality and GHG TDR (Stantec 2019).

Indirect GHG Emissions

Broadway Subway trains will draw the required electricity from existing BC Hydro infrastructure and, in doing so, will result in some indirect GHG emissions associated with the different sources of energy available through the BC Hydro grid. Based on publicly available information on GHG emissions associated with energy provided by BC Hydro, indirect GHG emissions from electricity consumption were calculated for the operations of the Project. This approach to calculating GHG emissions during operation of the Project is consistent with the approach adopted on the Evergreen Line Project (TransLink 2010), and is based on the following assumptions:

- Track length is 5.7 km between VCC-Clark station and Arbutus Street
- Trains will operate at an average speed of 40 km/h
- During peak hours (6 h/d, 5 d/week), 20 trains will be in service as per existing Millennium Line statistics (TransLink 2017)
- During off-peak hours (14 h/d, 19 h/Saturdays, 17 h/Sundays), 10 trains will be in service as per existing Millennium Line statistics (TransLink2017)
- Each train will pull four cars on average
- Electricity consumption to operate trains will be 3.5 kilowatt hours per car per kilometre travelled (kWh/car-km) (Evergreen 2010)

With these assumptions, the total annual electricity consumption for the Project is anticipated to be 48,339 megawatt hours. The GHG intensity of electricity consumption is 10.67 kg of CO_2e per kilowatt hour (MOE 2016). As such, the total indirect GHG emissions associated with electricity consumption by Project trains is 516 t CO_2e per year.

The GHG emissions forecasts for 2030 in the City of Vancouver and Metro Vancouver are estimated at a total of 4,433,351 and 16,782,011 t CO_2e (see Table 7.7-9), respectively.

For context, indirect GHG emissions resulting from electricity consumption to operate trains equates to approximately 0.01% of local GHG emissions and 0.003% of regional GHG emissions. Indirect GHG emissions from Project electricity consumption to operate Project trains will be negligible in comparison to local and regional emissions.

Overall Contributions

The reductions in CAC and GHG emissions achieved by displacing traffic along the Broadway Corridor will result in a small reduction in the overall emissions forecast for Vancouver, and the Lower Fraser Valley, for year 2030.

7.7.7 Conclusion

Existing air quality and GHG in Vancouver and the Lower Fraser Valley airshed is good overall. Project construction activities will contribute CAC and GHG emissions to the local (Vancouver) and regional (Lower Fraser Valley airshed) overall emissions. The emissions during construction will be generated over the short-term and will cease once the Project moves into the operations phase. As well, the magnitude of air emissions generated during construction is small, relative to existing sources, and expected to have a negligible effect on overall existing conditions.

During the operations phase, the Project will result in overall reductions in air emissions by displacing public transportation buses and reducing passenger vehicle use in the Broadway Corridor. Limited GHG emissions are expected during Project operation (e.g. indirect emissions from electricity consumption). The substantial reduction in GHG emissions (274,968 t CO_2e) that is anticipated during the operational phase (2025 - 2054) will offset construction emissions (22,111 t CO_2e/year) and result in a net reduction in GHG emissions (Climate Lens report; MOTI 2019). As such, the Project is expected to contribute to achieving progress towards GHG reduction targets associated with local, provincial, and federal government GHG reduction initiatives.

With the implementation of mitigation measures during construction as outlined in Section 7.7.5, Project CAC and GHG emissions are expected to result in negligible changes in air quality and GHG emissions. During operations air quality is anticipated to improve, relative to existing conditions, as Project-related reductions in air emissions are realized.

7.8 Contaminated Sites and Excavated Materials

This section of the Environmental and Socio-economic Review (ESR) evaluates Project-related effects associated with contaminated sites, excavated materials, and management of construction and demolition waste, and outlines standard practices and mitigation measures to manage these activities and limit potential effects.

Key information provided to support the assessment of contaminated sites and excavated materials includes:

- Rationale for selection of Contaminated Sites and Excavated Materials as a Review Element
- Methods used to review potential effects of Project activities in the context of applicable legislation and policies applicable to this Review Element
- Existing conditions for contaminated sites and materials in the Project Area
- A summary of Project components and physical activities that may interact with this Review Element
- A description of mitigation measures to avoid or reduce effects from Project-related activities during construction
- A discussion of review results and conclusions

7.8.1 Rationale for Selection as a Review Element

Contaminated Sites and Excavated Materials was selected as a Review Element because known or suspected contaminated sites may be intersected by construction of the Project. Contamination may be encountered at planned laydown areas, station houses, ventilation shafts and portal locations throughout the Project Area.

In addition to the potential for contaminated materials, the Project will generate uncontaminated excavated material (i.e., soil and rock) that will need to be managed in an appropriate manner.
The construction of the Project will also result in construction and demolition waste, a small amount of which may be considered as hazardous waste, (e.g., PCBs in old equipment, asbestos in building insulation, etc.) that will need to be disposed of in an appropriate manner.

7.8.2 Review Scope for Contaminated Sites and Excavated Materials

This section of the ESR includes:

- A description of the relevant key legislation associated with the management of contaminated soils and groundwater, and hazardous demolition and construction waste
- Summary of key issues, related to the management of contaminated sites and excavated materials, identified during consultation
- Identification of potential Project effects associated with contaminated sites and management of displaced materials, and selection of indicators used to evaluate these potential Project effects
- A description of the spatial and temporal boundaries of the assessment of Contaminated Sites and Excavated Materials Review Element

7.8.2.1 Regulatory and Policy Setting

Key pieces of legislation associated with management of Contaminated Sites and Excavated Materials are presented in Table 7.8-1 and described in the following sections.

Table 7.8-1: Regulatory Setting for Contaminated Sites and Excavated Materials

Responsible Agency	Law, Regulation, Policy	Description	Potential Project Applicability
BC Ministry of Environment and Climate Change Strategy (MOECCS)	*Environmental Management Act* (EMA)	The central anti-pollution law that regulates the introduction of waste into the environment. It sets out general principles for identification, assessment, and remediation of contaminated sites, and the identification, management and disposal of wastes	The principles set out will apply to the management and disposal of contaminated soils and water, hazardous building materials, and other wastes generated during the Project.
BC MOECCS	Contaminated Sites Regulation (CSR)	The enabling regulation of the EMA with respect to contaminated sites. It includes specific legal standards for identification, assessment, and remediation of contaminated sites.	The relocation and disposal of soil and water must be done in compliance with the CSR.
BC MOECCS	Hazardous Waste Regulation (HWR)	Defines practices and methods for handling, transporting and storing/disposing of materials designated as hazardous waste.	Some of the contaminated soils and water displaced by the Project may be considered hazardous waste. Hazardous building materials and other wastes generated by the Project will also be considered hazardous waste.
BC MOECCS	Approved Water Quality Guidelines	A set of science-based levels of physical, biological, and chemical parameters for the protection of specific water uses such as aquatic life, drinking water, and recreation.	Discharges of water from the Project (such as excavation water) that may enter a surficial body of water will be required to comply with these guidelines.
Metro Vancouver (Greater Vancouver Sewerage and Drainage District [GVSDD])	Sewer Use Bylaw No. 299, 2007 Consolidated	Sets out standards to manage the discharge of non-domestic waste to sewers and drains connected to a sewage facility operated by the GVSDD.	Water (such as excavation water) that is to be discharged by the Project to a sanitary sewer must meet the requirements of this bylaw.
City of Vancouver	Sewer and Watercourse By-Law No. 8093	Regulates the disposal of wastewater and storm water and the use of watercourses within the City of Vancouver.	Water (such as excavation water) that is to be discharged by the Project to a storm sewer or a watercourse must meet the requirements of this bylaw.

Table 7.8-1: Regulatory Setting for Contaminated Sites and Excavated Materials

Responsible Agency	Law, Regulation, Policy	Description	Potential Project Applicability
Workers Compensation Board of BC (WorkSafeBC)	Occupational Health and Safety (OHS) Regulation	Contains legal requirements that must be met by all workplaces under the inspection jurisdiction of WorkSafeBC. It includes substance-specific requirements for controlling exposure to materials such as asbestos and lead.	Any work that involves the disturbance of hazardous building materials or other hazardous wastes must be completed in accordance with the requirements set out in this regulation.

The management of contaminated sites in BC is governed by the *Environmental Management Act* (EMA), which is administered by the BC Ministry of Environment and Climate Change Strategy (MOECCS). In BC, a contaminated site is defined as an area of land in which the soil or underlying groundwater, soil vapour, or sediment contains either a hazardous waste or a substance in an amount or concentration that exceeds provincial environmental quality standards or criteria.

Specific provisions are set out in the Contaminated Sites Regulations (CSR; Reg 375/96, including 11 stages of amendments up to BC Reg. 196/2017), which is the enabling regulation of the EMA with respect to contaminated sites. The CSR includes specific legal standards for identification, assessment, and remediation of contaminated sites.

The Hazardous Waste Regulation (HWR; BC Reg. 63/88, including amendments up to BC Reg. 179/2016; formerly the Special Waste Regulation) includes specific legal standards for the identification and management of hazardous waste. This applies to soil, excavation water, and any other materials, such as hazardous building materials and demolition waste, that will be displaced by the Project.

Contamination encountered during construction of the Project will be managed in accordance with the EMA, CSR, and HWR. In the context of the Project, BC MOECC has indicated the Project will not be obligated to determine the geographic bounds of contamination encountered, or remediate such contamination, outside of the construction zone. The assessment and remediation of contamination originating from a site adjacent to the Alignment will remain the responsible party's obligation under the CSR (McCammon 2017, pers. comm.).

During construction, discharge of water from the Project will be managed in accordance with the BC MOECCS Approved Water Quality Guidelines, Metro Vancouver's Sewer Use Bylaw No. 299, and the City of Vancouver's Sewer and Watercourse By-Law No. 8093. Further discussion of water quality is provided in Section 7.10 (Aquatic Resources).

In addition to the BC HWR, hazardous building materials encountered during structure and building demolition will be managed in accordance with the BC Occupational Health and Safety Regulation, and the federal *Transportation of Dangerous Goods Act.*

7.8.2.2 Engagement Input Supporting the Assessment

Engagement with the BC MOECCS during Project planning provided direction with respect to expectations regarding the investigation and management of contaminated materials during construction.

Engagement with the public and consultation with Indigenous groups to date, including input on the ESR Terms of Reference, has identified interest in Review Elements (e.g., aquatic resources and water quality) which may be indirectly affected by the manner in which contaminated sites and excavated materials are managed.

7.8.2.3 Selection of Effects and Review Indicators

Table 7.8-2 lists potential Project effects associated with contaminated sites and excavated material management and summarizes Project effect mechanisms and indicators used to assess the potential effects. Project effect mechanisms define the link between the Review Element and the potential effect and are described in more detail in Section 7.8.4 (Project Interactions). Indicators listed in Table 7.8-2 identify the mechanisms and indicators used to measure and assess potential effects qualitatively or quantitatively.

Table 7.8-2: Potential Effects and Review Indicators for Contaminated Sites and Excavated Materials

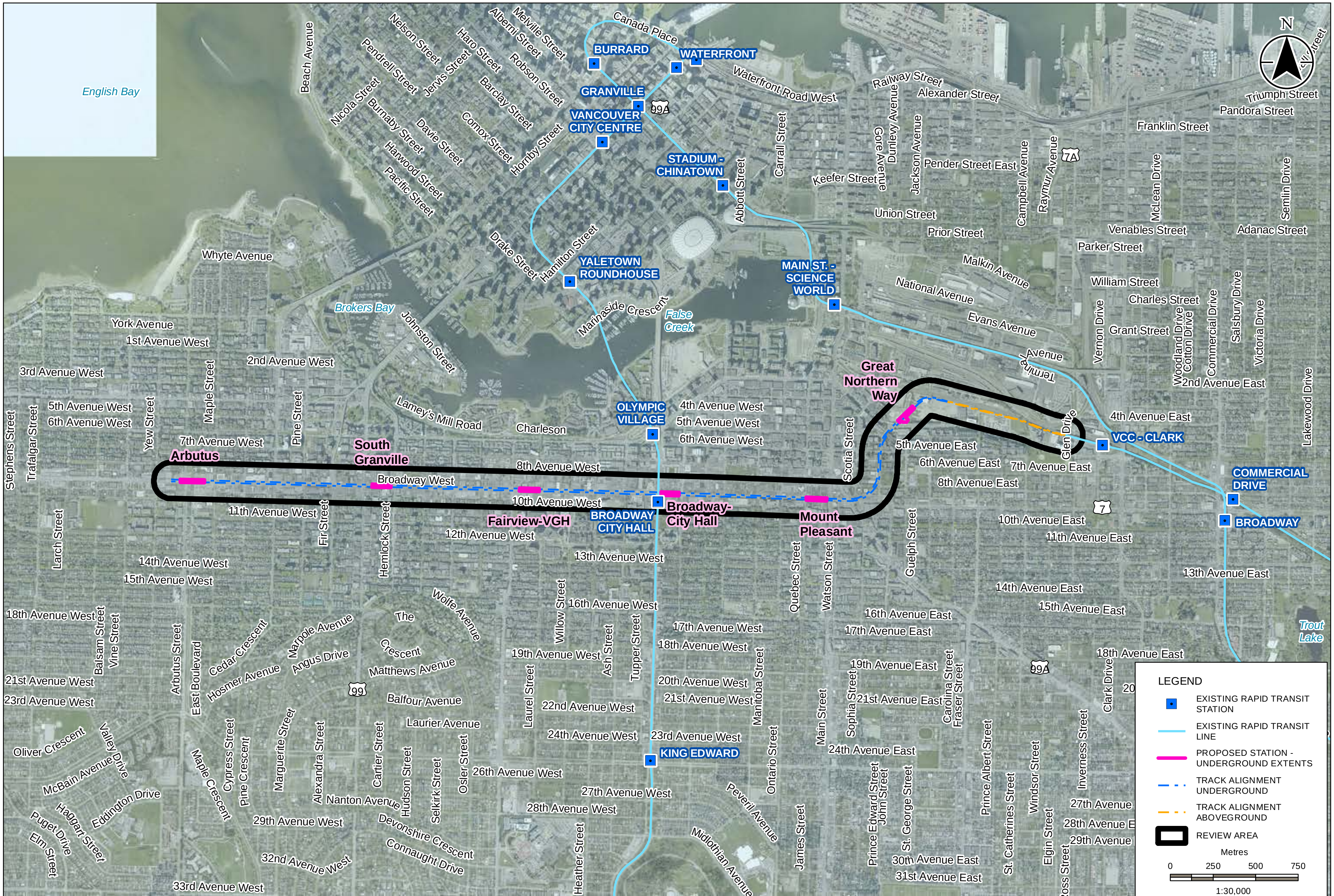
Potential Effects	Project Effects Mechanisms	Indicator	Rationale for Selection
Release of contaminants from contaminated soils or water encountered during construction	Excavation activities may encounter contaminated soil or groundwater, which will require appropriate disposal/discharge.	• Existence and location of contaminated sites • Nature of contaminated materials	The EMA and CSR include standards for the quality of soil and groundwater, to determine whether such materials are contaminated, and requirements for the management and disposal or discharge of contaminated media.

Hazardous materials and non-contaminated excavated materials are included as topics for discussion in this section but have not been identified as resulting in potential effects, because they can be effectively managed through the application of regulatory requirements and/or best practices. Measures to manage hazardous materials and non-contaminated materials disposal are identified in Section 7.8.5.

7.8.2.4 Boundaries

The Review Area for the assessment of potential effects of the Project on Contaminated Sites and Excavated Materials is the area within 100 m of the centerline of the Alignment. This width is considered to be sufficient to capture contaminated sites that may intersect with the Project, while excluding contaminated sites that are further from the Alignment and unlikely to have any influence.

Figure 7.8-1 shows the general Alignment with the Review Area boundary indicated.



DESIGNED	INIT	YY-MM-DD DATE
DRAWN	INIT	YY-MM-DD DATE
CHECKED	INIT	YY-MM-DD DATE
APPROVAL	INIT	YY-MM-DD DATE

RAV-STN-ASIZE-SHEET.dwg
Rev. PC 215.9mm x 279.4mm METRIC

BROADWAY SUBWAY PROJECT

Stantec

BROADWAY SUBWAY PROJECT

CONTAMINATED SITES AND EXCAVATED MATERIALS REVIEW AREA

SCALE 1:30,000	CONTRACT NO.	SUB CONSULTANT PROJECT NO.	115814099
DATE 17-11-29			
SHEET NO.	FIGURE 7.8-1		

7.8.3 Existing Conditions

This section describes existing contaminated sites conditions in the Review Area, and the methods used to establish existing conditions. Technical information presented in this section is drawn from the Contaminated Sites and Excavated Materials Technical Data Report (Stantec 2019).

7.8.3.1 Methods

The methods used to support the collection of existing contaminated sites information included a desk-top review of publicly available information on known, and potential, contaminated sites based on historical land use. The review examined current operations and land uses on properties adjacent to the Alignment as well as a review of historical data of properties adjacent to anticipated Project infrastructure. The information reviewed included, where available, intrusive site investigation reports prepared for the responsible parties and obtained from BC MOECCS.

Commonly called a 'linear Phase 1' assessment, the method is consistent with the initial screening-level assessments defined by the CSR in BC and by the CSA standard Z-768-01. Intrusive site investigations, including sampling of soil, groundwater, or vapour, were not conducted as part of this work.

Based upon known or potential contaminated sites conditions of properties, and the known or potential presence of contaminants and anticipated excavation locations, the risk of encountering contaminated soils or groundwater was evaluated. A risk ranking (i.e., Low Risk, Moderate Risk, or High Risk) was assigned to each station location and laydown site. These rankings are defined as follows:

- **Low-risk** locations are areas where there is no known contamination, or areas where historic activities indicate a low likelihood of contamination being present. These locations may not have been assessed by intrusive site investigation to confirm the absence of contamination.
- **Moderate-risk** locations are areas where there is uncertainty with respect to the presence or absence of contamination, where adjacent known or anticipated contamination is not expected to be encountered by construction (i.e., contamination is expected to be outside of the planned excavation area), or sites where activities indicate a moderate likelihood of contamination may be present but have yet to be assessed by site investigation.
- **High-risk** locations are areas where there is confirmed or anticipated contamination present in planned excavation areas, based on historic or current operations adjacent to the Alignment (or on the station house/laydown property) or information in reviewed publicly-available environmental investigation reports.

7.8.3.2 Review of Existing Conditions

A desktop review of investigation and remediation reports provided by the MOECCS, was completed. The station and laydown were grouped, based on proximity to each other, into 10 “Sites”. Based on the findings of the desktop review, three of the station and laydown yard Sites (i.e., “Arbutus Station House”, “Arbutus Station and Cross-over Tunnel”, and “Great Northern Way Station and Laydown Yard”) are known to have contamination within associated excavation areas. The risk ranking for each grouped station and laydown Site is provided in Table 7.8-3.

Table 7.8-3: Summary of Risk Ranking for Each Station and Laydown Site

Site	Risk Rating
Great Northern Way East Laydown Yard	Moderate
Great Northern Way Laydown Yard, Station, Station House, Emergency Exits/Ventilation Shafts, and Tunnel Construction Excavation	High
Main Street East Laydown Main Street West Laydown	Moderate
Main Street Station House Main Street Emergency Exits/Ventilation Shafts	Moderate
Cambie Street Laydown Cambie Street Station House	Low
Oak Street North Laydown Oak Street South Laydown Oak Street Station	Low
Granville Street Laydown Granville Street Station House Granville Street Station Emergency Exits/Ventilation Shafts	Moderate
Arbutus Street Station House Arbutus Street Station Emergency Exits/Ventilation Shafts	High
Arbutus Street Station and Cross-over Tunnel	High
Arbutus Street Laydown Yards	Moderate

In general terms, some level of contamination is present on some sites adjacent to the Alignment from historical or current land use. In most cases, where contamination has been shown to have migrated onto the Alignment, or is present at the station house or laydown sites, the contamination is expected to be in soil overburden above bedrock and unlikely to be encountered by the tunneling activity. However, contamination in overburden at these sites may be encountered during construction and will require management. There is also a risk of encountering contamination associated with the relocation of buried utilities near the property line of contaminated sites, where utility relocation may be necessary.

7.8.4 Project Interactions

A review of key Project components and activities described in Section 2 (Project Description) was used to determine potential Project interactions with Contaminated Sites and Excavated Materials. The potential interactions between contaminated sites and Project components and physical activities are described in Table 7.8-4 and are discussed in detail below in the context of effects mechanisms, standard- and Project-specific mitigation, and effects.

Table 7.8-4: Potential Project Interactions and Effects on Contaminated Sites and Excavated Materials

Project Activities and Physical Works	Potential Effect
	Release of contaminants from contaminated soils or water encountered during construction
Construction	
Property acquisition	-
Building demolition material salvage and sorting, hazardous building materials removal and management	✓
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	✓
Elevated guideway construction	✓
Tunnel and station excavation	✓
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	-
Vehicle traffic (e.g., road use and construction traffic)	✓
Management and disposal of waste and excavated materials	✓
Commissioning and start-up	-
Operations	
Train operations, including wayside and power	-
Station operations	-
Train maintenance, administration, transit police	-

A risk evaluation was completed based on site specific information collected with respect to the potential to encounter contamination during construction. Three sites were rated as high risk, meaning these were identified as areas where there is a high likelihood of encountering contamination during construction. Five sites were rated as moderate risk of encountering contamination during construction, and two sites were rated as low risk.

Taking into account both construction at specific existing properties, and construction of sub-surface sections of the tunnel, excavated materials that will be generated by the Project will include:

- Overburden (material above the bedrock) consisting of clean and contaminated soil, and miscellaneous fill materials including some containing debris and contamination
- Bedrock consisting of tunnel boring machine spoil and excavated bedrock

It has been estimated that approximately 170,000 m^3 of uncontaminated overburden and 14,000 m^3 of contaminated overburden will be excavated. Tunnel boring spoil from the bedrock tunneling is expected to be approximately 320,000 m^3. Station house excavation material volume from bedrock is expected to be approximately 540,000 m^3.

Excavated materials will require responsible management and disposal or relocation, in accordance with the applicable legislation. Contaminated and uncontaminated materials may be managed at local, out-of-region, or out-of-province facilities. The contractor will be responsible for finding and making arrangements with appropriate disposal facilities or relocation properties, including obtaining any required permits or approvals.

The Project will also require the demolition of existing structures occupying sites required for the Project. The review has identified the potential for hazardous building materials to be present in existing structures on Project properties. These materials include asbestos-containing materials, gypsum wallboard (potentially containing asbestos), equipment containing mercury, equipment containing polychlorinated biphenyls, oil-filled transformers (potentially containing polychlorinated biphenyls), and systems for air conditioning and fire suppression containing ozone depleting substances. These materials will require appropriate management in accordance with the BC Occupational Health and Safety Regulation, the BC HWR, and the federal *Transportation of Dangerous Goods Act* and Regulations as part of building deconstruction, salvage, and demolition.

In addition to hazardous building materials, the demolition of existing structures will generate material, some of which may be reused or recycled, that will require appropriate disposal.

No excavated soil or rock, or demolition and construction waste is expected to be generated during the operations of the Project. Therefore, no Project-related effects with respect to Contaminated Sites and Excavated Materials are anticipated during Project operation.

7.8.5 Mitigation Measures

Prior to construction, the construction contractor will be required to prepare a Contaminated Sites and Excavated Materials Management Plan that will guide the management of excavated material, excavation water, and demolition and construction materials.

Mitigation measures, including best practices anticipated to be used to avoid or reduce effects from Project-related activities during construction, are summarized in Table 7.8-5.

As noted in Section 9 (Environmental Management Plans), the Contractor will confirm the final mitigation approaches to support the Contaminated Sites and Excavated Materials Management Plan, the Construction and Demolition Waste Management Plan, and the Hazardous Materials Management Plan. This approach will allow for mitigation measures that are aligned with the detailed design and construction approach developed by the Contractor.

Table 7.8-5: Mitigation Measures for Contaminated Sites and Excavated Materials

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.8-1	Develop and implement a Contaminated Sites and Excavated Materials Management Plan, for the construction phase, to ensure that contaminated materials are managed in compliance with all applicable regulatory requirements. The Contaminated Sites and Excavated Materials Management Plan will include: • Specific best practices for guiding the assessment and appropriate management of potentially contaminated materials during construction • Locations of known and suspected contamination that maybe encountered during construction • Facilities that will be used for the disposal of contaminated soils and uncontaminated excavated materials • Protocols for soil and groundwater sampling in areas of planned excavation to characterize conditions in order to appropriately plan the excavation and determine disposal requirements • Measures for on-site soil storage including residual material (including tunnel spoil) to avoid erosion and sedimentation • Protocols for the collection of soil samples, from excavation limits, where contamination has been removed	Construction	Contractor	Contractual Requirement
7.8-2	Develop and implement a Hazardous Materials Management Plan and Construction and Demolition Waste Management Plan for the construction phase to ensure such materials are managed in compliance with all applicable regulatory requirements. The Hazardous Materials Management Plan and Construction and Demolition Waste Management Plan will include: • Specific best practices to for identifying and appropriately managing hazardous materials including procedures for storage and disposal • Specific best practices for the appropriate management and disposal of construction and demolition waste	Construction	Contractor	Contractual Requirement
7.8-3	Contaminated materials and hazardous materials will be managed in accordance with relevant regulatory requirements including the EMA, CSR, HWR; WHMIS; and Transportation of Dangerous Goods (TDG).	Construction	Contractor	Contractual Requirement
7.8-4	Emergency and spill response procedures will be developed in accordance with the EMA and CSR to allow for rapid response in the event of spills of fuels and other hazardous materials, and provisions for access/egress of emergency vehicles.	Construction	Contractor	Contractual Requirement
7.8-5	Refueling and maintenance of equipment will be in designated areas to prevent contamination from these activities.	Construction	Contractor	Best Management Practice
7.8-6	Spill response and containment equipment will be kept on the worksite near storage/handling and refueling/maintenance areas.	Construction	Contractor	Contractual Requirement
7.8-7	Use biodegradable hydraulic fluid in construction equipment in order to reduce or avoid soil contamination risk during construction.	Construction	Contractor	Best Management Practice
7.8-8	A register of construction-related hazardous materials (such as fuels, lubricants, and other chemicals) will be maintained and will include information on: • Storage location • Storage requirements • Proper usage • Handling information • Disposal procedures	Construction	Contractor	Contractual Requirement
7.8-9	Surveys of salvageable and hazardous building materials will be undertaken for buildings requiring demolition to ensure appropriate disposal of materials.	Construction	Contractor	Contractual Requirement

7.8.6 Discussion of Review Results

A desktop review was completed to evaluate risk of contamination at each station and laydown yard. Based on the desktop review, two of the planned station and laydown yard Sites are considered to be low-risk for encountering contamination during construction, five of the station and laydown yard Sites are considered to be moderate-risk, and three of the station and laydown yard Sites (i.e., “Arbutus Street Station House”, “Arbutus Street Station and Cross-over Tunnel”, and “Great Northern Way Station and Laydown Yard”) are considered to be high-risk as they are known to have contamination within expected excavation areas. Project construction activities will involve excavation or other ground disturbance at these station and laydown yard Sites and is anticipated to generate some contaminated soils and groundwater. The presence of these contaminated materials in such areas is the result of current and historical activities and not a result of planned Project construction activities.

The majority of excavated soil and rock is not anticipated to be contaminated, leaving several options for beneficial reuse, relocation, or disposal. The construction contractor will be responsible for obtaining, and working in compliance with, the conditions of environmental permits and approvals required to support the disposal of residual excavated materials.

The demolition of existing structures and buildings to build Project-related infrastructure will result in the generation of demolition waste, some of which may include hazardous building materials. The Contractor will be responsible for identifying hazardous building materials and verifying that it is managed and disposed of in an appropriate manner during Project construction.

By adhering to applicable provincial and federal legislation, and applying industry best practices for the management of contaminated soil and water, excavated materials, and demolition and construction waste no Project-related effects are anticipated.

7.8.7 Conclusion

The Project has the potential to result in the release of contaminants from contaminated soils or water encountered during construction; these contaminated materials are the result of current and historical activities. Contaminated soils and water encountered during construction will be managed through the implementation of Contaminated Sites and Excavated Materials Management Plan. The Plan will be developed and implemented by the construction Contractor and will contain best practices, for appropriately managing contaminated soils and water generated by the Project.

Hazardous materials and non-contaminated excavated materials, as well as demolition waste, may be generated during Project construction.

Best practices for effectively managing hazardous materials, non-contaminated excavated materials, and construction and demolition waste will also be described in the Contaminated Site and Excavated Materials Management Plan.

Project-related effects from contaminated sites and excavated materials are not anticipated following the implementation of best management practices and mitigation measures.

7.9 Electric and Magnetic Fields

Electric and Magnetic Fields (EMFs) are physical fields produced by electrically charged objects such as computers, cell phones, household appliances, and lighting.

This section of the Environmental and Socio-economic Review (ESR) identifies sources of Project-related EMFs, such as those produced by trains and the electrified rail that powers the trains, and the potential effects of Project-related EMF changes. Project-related EMF effects that are considered include those resulting from electromagnetic interference (EMI) on electronics and radio communications, precision medical devices (e.g., pacemakers, or EMF-sensitive hospital equipment), and interactions with people.

Key information provided to support the assessment of EMFs include:

- The rationale for selecting EMFs as a Review Element
- The review scope for EMFs, including a description of EMFs and its properties, and EMF standards for EMI and health
- Existing conditions for EMF in the Review Area
- Project interactions that may affect EMFs
- Mitigation measures to avoid or reduce potential Project-related EMF effects
- Discussion of review results and conclusions

7.9.1 Rationale for Selection as a Review Element

Electric and Magnetic Fields were selected as a Review Element because of the potential for Project-related changes in EMF to interact with, and affect the operation of, other electrical systems such as those in electronics (e.g., cell phones, computers, pacemakers) or to result in potential human health effects. Electric and Magnetic Fields also have the potential to interfere with radio communications.

7.9.2 Review Scope for Electric and Magnetic Fields

This section of the ESR includes:

- A description of Electric and Magnetic Fields and their properties
- A description of the relevant industry standards associated with EMF and in light rail transit systems
- Summary of key issues identified during consultation
- Identification of Project-related EMFs and indicators used to evaluate the potential for EMI and health effects
- A description of the spatial and temporal boundaries of the assessment of the Electric and Magnetic Field Review Element

7.9.2.1 Properties of Electric and Magnetic Fields

Electric and Magnetic Fields are physical fields produced by electrically-charged objects, which can affect other electrically charged objects within the field.

An electric field is produced when voltage is applied to electrical conductors and equipment, such as when a lamp is plugged into an electrical socket. Voltage refers to the difference in potential energy between two points. The electric field intensity is measured in volts per metre (V/m). Electric fields can be blocked by conductive materials, which includes most types of common building materials (e.g., wood, concrete, metal), ground materials (e.g., soil, rocks), water and living objects (e.g., trees, and the human body).

Magnetic fields are produced by electrical currents, which is a flow of electrons, such as when a lamp is plugged in and turned on. The magnetic field intensity is measured in milligauss (mG). Unlike electric fields, magnetic fields are unaffected when passing through most types of materials. However, magnetic fields can be redirected away from EMF-sensitive equipment or locations.

When characterizing EMFs, the following characteristics of the EMF field are considered:

- **Field intensity**—Electric and magnetic field intensity at the source can vary depending on the voltage (for electric fields) and current (for magnetic fields). The field intensity declines rapidly with increasing distance from the EMF source. For example, the EMF intensity at 20 m from a source is only 25% of the intensity at 10 m from the source and EMF intensity at 30 m from the source is only about 11% of the intensity at 10 m from the source. The relationship between distance from the EMF source and the field intensity is known as the inverse square law[8].
- **Frequency**—The frequency of an EMF refers to the wave oscillation of the field as shown in Figure 7.9-1. The EMF frequency is measured in Hz and higher frequencies indicate a higher energy state of the field. SkyTrain technology used to operate the Millennium Line will be used on the Project, which operates on direct current. Direct current produces a static, or constant EMF with a frequency of 0 Hz.

  The standard frequency for electrical power in North America is 60 Hz alternating current, and EMFs of this frequency are referred to as extremely low frequencies (ELF; less than 300 Hz). Electric and Magnetic Fields with ELF are found in household wiring and common household electrical items (e.g., lights, computers, televisions). These types of EMFs may be produced by basic electrical systems in Project stations (e.g., lighting, communications system, wiring).

[8] The inverse square law states that the intensity of a specified quantity is inversely proportional to the square of the distance from the source of the physical quantity.

Higher frequencies of non-ionizing EMFs associated with radio wave (ranging in the kilohertz to megahertz) and microwaves (in the range of gigahertz) are not expected to be produced by the Project at an appreciable field intensity that could affect other systems. Ionizing EMFs such as X-rays and gamma rays are not produced by Project activities.

- **Vector**—Electric and Magnetic Fields are vector fields, meaning that the field has a direction at each point in space. Multiple EMFs from different sources interact, and can add together, cancel out, and change the overall field vector, depending on their relative vectors, field intensities and frequencies.

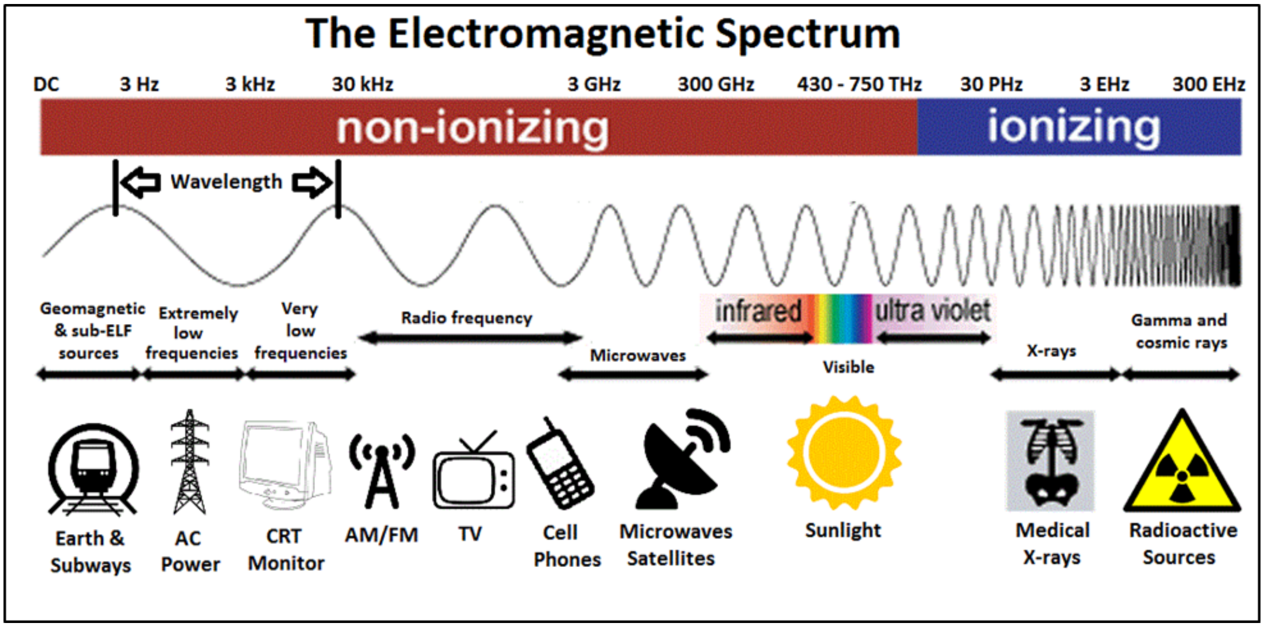


Figure 7.9-1: Electromagnetic Field Frequency Range

7.9.2.2 Regulatory and Policy Setting

Canadian Standards

There are currently no provincial or federal regulations or criteria for EMFs applicable to train systems. Canadian standards listed in Table 7.9-1 guide the design and electrification of railways and associated electrical infrastructure. These standards have been considered during Project planning to ensure that, to the extent possible, EMF emissions from trains and associated infrastructure do not result in EMI with other systems.

International standards applicable to train systems provide guidance on acceptable levels of EMF emissions, and help establish test methods for measuring and monitoring EMFs. International agencies that provide EMF standards for railways and trains include the American Public Transportation Association, European Standards, Institute of Electrical and Electronic Engineers, and the International Electrotechnical Commission.

Table 7.9-1: Standards Applicable to Rail Systems

Regulatory Agency	Standard
Canadian Standards Association	• CSA C22.3 No. 8-M91—Railway Electrification • CAN3-C108.3.1-M84—Canadian Standard for Limits and Measurement of Electromagnetic Noise from AC Power Systems, 0.15-0.30 MHz • CAN/CSA-C22.3 No. 3—Canadian Standard for Electrical Coordination between Power Supply and Communication Conductors • CSA C22.3 No. 6—Principles and Practices of Electrical Coordination between Pipelines and Electric Supply Lines

Health Criteria

Health Canada does not have guidelines or standards for ELF EMFs. However, Health Canada recognizes international exposure guidelines established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP 2009) and the International Committee for Electromagnetic Safety (ICES 2002, 2007) (Health Canada 2015). These agencies have exposure reference levels for EMFs ranging from 0 Hz to 300 gigahertz (GHz).

Table 7.9-2 shows the reference levels applicable to the EMF frequency range that the Project is expected to produce from the electrified fourth rail (0 Hz) and the trains (0 to 3,000 Hz). These reference levels were developed to protect people from possible thermal/heating effects from short-term exposure to high-intensity EMFs. Such high intensity exposures are typically associated with work near highly electrified equipment such as those found at a sub-station or power plant. These reference levels assume an exposure duration comparable to a typical work week (i.e., 8 hours/day, 5 days/week). The public is generally not exposed to EMFs in a typical urban environment that could reach such reference levels for an extended duration.

The links between exposures to ELF EMFs have been extensively reviewed by several scientific agencies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP), International Committee for Electromagnetic Safety (ICES), and the World Health Organization. Based on their reviews, these agencies have concluded that there is no identifiable causal link between exposures to ELF EMF and changes in human health (ICNIRP 1998, ICES 2002, and WHO 2007). Therefore, the ICNIRP and ICES do not provide long-term exposure reference levels for ELFs from low-intensity fields.

This is also the position of Health Canada, which "does not consider that any precautionary measures are needed regarding daily exposures to electromagnetic fields at ELF (i.e., less than 300 Hz)" (Health Canada 2004).

Table 7.9-2: Reference Levels for Whole-Body Exposure to Electromagnetic Fields at 0, 60 and 3,000 Hertz

Regulatory Agency	0 Hertz		60 Hertz		3,000 Hertz	
	Electric Field	Magnetic Field	Electric Field	Magnetic Field	Electric Field	Magnetic Field
ICNIRP	N/A	400,000 mG	4,167 V/m	833 mG	87 V/m	63 mG
ICES	N/A	N/A	5,000 V/m	9,040 mG	N/A	N/A

SOURCES:
ICNIRP (1998). ICNIRP guidelines for limiting exposure to time-varying EMFs (up to 300 GHz).
ICNIRP (2009). Guidelines on Limits of Exposure to Static Magnetic Fields.
ICES (2002). IEEE Standard for Safety Levels with Respect to Human Exposure to EMFs 0 to 3 kHz

Studies regarding the potential health effects from exposure to EMFs at radiofrequencies (i.e., from radio, TV and cell phones) are inconclusive. The most recent animal study on radiofrequency EMFs conducted by the U.S. National Toxicology Program resulted in inconclusive findings (NTP 2018a, 2018b). The conclusions do not definitively demonstrate a health effect, nor do they definitively conclude the absence of a health effect.

The communications system used for the Project may emit some radiofrequency EMFs. When considering high-frequency non-ionizing EMFs in the GHz range from cellular phone towers and radiofrequencies, Health Canada provides exposure guidelines for EMF radio frequencies ranging from 3,000 Hz to 300 GHz (Health Canada 2015). However, the Project mainly produces EMFs in the frequency range of 0 to 3,000 Hz and would not produce radio frequency EMFs at magnitudes that approach these exposure reference levels.

Certain types of high-frequency ionizing EMFs (e.g., ultraviolet radiation, x-rays, and gamma rays) are clearly related to health effects because they cause cellular and genetic damage. However, no ionizing high-frequency EMFs will be produced by the Project and are not further assessed in the ESR.

Other Considerations

The standards and criteria described above do not extend to potential effects and interactions with some types of electronic equipment. For example, precision medical equipment, such as pacemakers, may be sensitive to certain types of EMFs. Electric and magnetic field sensitivity may also vary between pacemaker brands and models. With respect to pacemakers, the American Conference of Governmental Industrial Hygienists recommends an EMF exposure criterion of 1,000 V/m for electric fields and

1,000 mG for magnetic fields (ACGIH 2009). Pacemakers are not likely to be affected by EMFs below these exposure criteria.

7.9.2.3 Engagement Input Supporting the Assessment

Consultation and engagement with the public, regulators and various stakeholders identified comments related to Project-related changes in EMFs. Such comments included those regarding potential health effects on people exposed to EMFs, EMI with other electronics (e.g., pacemakers, personal electronic devices such as cell phones and computers) and sensitive machinery and equipment (e.g., medical equipment at Vancouver General Hospital, British Columbia Cancer Agency and other health institutions), and EMI with AM/FM radio frequencies and other forms of communication. Comments and input regarding EMF informed the selection of potential receptors considered in the assessment of potential EMF effects.

7.9.2.4 Selection of Effects and Indicators

Table 7.9-3 lists the potential Project-related EMF effects and provides a summary of the indicators used to support the assessment of potential effects. Effects mechanisms are described in more detail in Section 7.9.4 (Project Interactions).

Table 7.9-3: Potential Effects and Review Indicators for Electric and Magnetic Fields

Potential Effects	Project Effects Mechanisms	Indicators	Rationale for Selection
Change in EMF levels	• Electric and Magnetic Fields ranging from 0 to 3,000 Hz are generated by the Project's electrical infrastructure (e.g., electrified rail, substations, electrical rooms, trains) during operations	• Electric and magnetic field levels relative to applicable EMF criteria	• Electric and Magnetic Fields generated by the Project's electrical infrastructure may cause EMI with radio communications or other electrical systems. • Address perceived health risks associated with EMF exposure.

7.9.2.5 Boundaries

The spatial Review Area for the assessment of EMFs is 100 m from the centerline of the Alignment. Project-related EMFs beyond 100 m from the Alignment are expected to be negligible and not distinguishable from background levels.

7.9.3 Existing Conditions

The existing conditions for EMFs are defined as the types and ranges of EMFs that typically exist in urban environments, such as along the Alignment and generally within Vancouver. This includes EMFs from a variety of sources, including: common household electronics and appliances (e.g., computer, television, fridge, oven, microwave, lights), electrical wiring, transmission and distribution power lines, vehicles (e.g., cars, buses, trucks), cellular phone towers, and cell phones. The EMF frequencies from these devices vary, as shown in Figure 7.9-1.

Quantifying EMFs in an urban environment is complex due to the ubiquity of EMF in urban areas. Background EMFs from the Earth's electromagnetic field vary but are generally less than 0.65 mG for magnetic fields, and between 100 and 150 V/m for electric fields (Finlay et al. 2010 and WHO 2018). In a household environment, the EMF field intensity of most household appliances at a distance of 30 cm is 10 mG or less for magnetic fields, and 180 V/m or less for electric fields (WHO 2018).

7.9.4 Project Interactions

The key Project components and activities described in Section 2 (Project Description) were used to determine Project interactions that could affect Electric and Magnetic Fields. Project activities and physical works that may result in a change in EMF levels are identified in Table 7.9-4, and indicated by check marks. A change in EMF levels is defined as an increase in EMF above those typically found in urban city environments.

The electrical system infrastructure for the Project will generate EMFs along the Alignment. Such infrastructure includes the trains, electrified fourth rail, generators, substations, alternators, brakes, heating ventilation and air conditioning systems, communications systems, and navigation electronics. The major EMF sources, and the focus of this assessment, include the electrified fourth rail along the track, and the trains themselves. Electric and Magnetic Fields from these sources are expected to include static field EMFs (i.e., EMF frequency of 0 Hz from direct current), and extremely low-frequency EMFs (i.e., EMF frequency of 5 to 3,000 Hz from alternating current).

Electric and Magnetic Fields produced during the construction phase are primarily from vehicles (engine computer and powertrain) and equipment. These sources are similar to those already found along the Alignment such as the engine computers in road vehicles, and they are not further assessed in this assessment because they are similar in their frequencies and field intensities to existing EMF levels.

Initial commissioning and start-up of the Project during construction will produce EMFs at levels that are similar to the operations phase. For the purposes of this assessment, EMFs during commissioning and start-up, and the operations phase are assumed to be a single continuous event.

Table 7.9-4: Potential Project Interactions and Effects on Change in Electric and Magnetic Field Levels

Project Activities and Physical Works	Potential Effects
	Change in Electric and Magnetic Field Levels
Construction	
Property acquisition	-
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	-
Elevated guideway construction	-
Tunnel and station excavation	-
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	✓
Vehicle traffic (e.g., road use and construction traffic)	-
Management and disposal of waste and excavated materials	-
Commissioning and start-up	✓
Operation	
Train operation, including wayside and power	✓
Station operation	✓
Train maintenance, administration, transit police	-

NOTES:
✓ Potential interactions that may cause an effect.
- Not applicable. Project activities do not produce EMFs above those typically found in urban environments.

7.9.5 Mitigation Measures

Mitigation measures to avoid or limit EMFs and EMI are primarily applied during Project design and construction, including the selection of equipment and design of stations. As part of this process, the procurement of equipment (e.g., communications systems and infrastructure within stations) that meets regulatory requirements (e.g., Health Canada exposure guidelines), enables the avoidance of exposure to harmful levels of EMF and EMI.

In addition, the US Department of Transportation (USDOT) provides guidance on the prevention and mitigation of environmental, health, and safety and impacts of EMFs and radiation for electric transit systems (USDOT, undated). Mitigation measures that are typically applied to avoid or limit EMF emissions and EMI with receptors include those presented in Table 7.9-5.

As noted in Section 9 (Environmental Management Plans), the Contractor will confirm the final mitigation approaches to mitigate potential Project-related effects. This approach will allow for final mitigation measures that are best aligned with the detailed design and construction approach developed by the Contractor.

Table 7.9-5: Mitigation Measures for Electric and Magnetic Fields

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.9-1	Use of equipment that meets the available Canadian EMF standards or its equivalent standard by international agencies	Construction	Contractor	Standard Operating Procedure
7.9-2	Apply engineering and design best practices to minimize EMF exposures during operations through: • Station design and layout to optimize the distance between EMF sources (e.g., substations, electrical and mechanical rooms, electrified fourth rail) and receptors (e.g., sensitive electrical or electronic systems, communication systems) • Electrical design and layout of the electrical infrastructure to reduce stray EMFs • Passive engineering controls of infrastructure designed to block electric fields or redirect magnetic fields	Construction	Contractor	Best Management Practice

7.9.6 Discussion of Review Results

7.9.6.1 Change in Electric and Magnetic Field Levels

Mitigation measures described above will reduce the intensity of EMFs in the Review Area by increasing the distance from an EMF source through the design and layout of the station, applying engineering techniques or operational controls to reduce EMFs at the source, or apply passive controls between the source and areas of potential concern that block EMFs.

After the implementation of design mitigations, EMFs generated by the Project are expected to be similar to those produced by existing TransLink lines (i.e., Millennium Line and Expo Line). Magnetic field measurements taken on Expo Line trains over continuous 5-minute intervals showed an EMF bandwidth ranging from 35 to 400 Hz. Magnetic fields ranged from 19 to 58 mG at a height of 1 m from the ground (Takahashi 1993).

The USDOT provides measured and calculated EMFs for urban mass transit systems using linear induction motors, as described by the USDOT (USDOT, 1999). These low-frequency EMFs would range from 0 Hz to 3,000 Hz. The field intensity would be dependent on the distance between a receptor and the EMF source.

Electric field intensity for low-frequency EMFs may reach up to several V/m along the station walkway, less than 10 V/m along the station platform (based on the electric field from the electrified fourth rail in the absence of a train), and approximately 100 to 200 V/m on the train. The electric field intensity reduces when passing through most types of materials (e.g., walls, concrete, ground materials such as soil and rocks, and people). At ground-level along the Alignment and the station entrance, the electric field intensity from the Project will be negligible. Electric field intensity at ground level would be similar to existing EMF conditions associated with urban city environments.

The static magnetic field (0 Hz) produced from the electrified fourth rail will likely be less than 500 mG at the station platform, which is approximately 10 m away from the electrified rail. Extremely low frequency magnetic fields will primarily be at 60 to 3,000 Hz; associated with basic electrical systems in the station. The magnetic field intensity at ELF is expected to be in the range of 10 mG at the station walkways and platforms, which is similar to those experienced by common household electrical items (i.e., <1 to 150 mG) at a distance of one to several feet away from the source. Extremely low frequency magnetic fields on the train are expected to be in the range of 50 mG.

These anticipated EMF levels are well understood from existing TransLink lines and other North American train systems as documented by the US DOT (US DOT, 1999) and EMF monitoring during the start-up and commissioning phase will not be required.

Electric and Magnetic Fields produced by equipment manufactured by third parties (e.g., communications systems, trains) would apply the applicable Industry Canada standards and regulations for those products. These types of equipment are assumed to meet the applicable criteria to mitigate the potential for EMI with communications and radiofrequencies.

Electromagnetic Fields and Health Risk

When considering acute, short-term exposure to Project-related EMFs, the intensity of low-frequency EMFs in the trains, and at the station platform and walkways are expected to be within the ICNIRP reference levels shown in Table 7.9-2.

The public would not be exposed to EMF intensities at durations which would pose a public health concern. There may be intermittent exposure to high-intensity EMFs in close proximity to the electrical rooms and substations, but the exposure duration would be less than the duration for which the ICNIRP reference levels are based upon (i.e., occupational exposures of 8 hours per day, 5 days per week).

When considering long-term EMF exposure, there are no recognized health effects related to exposure to low-intensity, low-frequency EMFs such as those that are produced by the Project, as described in Section 7.9.4.

Based on these factors, there are no anticipated health risks to the public from exposure to Project-related EMFs.

Electromagnetic Compatibility

The Project will produce EMFs at levels that meet the applicable regulations and standards listed in Section 7.9.4, which are intended to maintain electromagnetic compatibility and mitigate the potential for EMI. It is unlikely that Project-related EMFs could interfere with other electrical systems, and AM/FM radio services if the EMFs are within the applicable criteria and standards.

When considering passengers on a train, the potential for low-frequency EMFs to interfere with electronics (e.g., cellphones, smartphones, laptops) is limited. Electromagnetic interference with personal electronics, wheelchairs, and personal medical devices is not expected on the trains, station platform, or station passageways. A review of pacemaker EMF compatibility guides by various pacemaker manufacturers indicates that pacemakers are designed to be compatible with the types of EMFs associated with light rail transit, magnetic levitation trains, and high-speed trains (Boston Scientific 2017, Medtronic 2017, Tikkaja et al. 2013). Electric and Magnetic Fields from the Project are not expected to affect the functionality of other electronics.

When considering sensitive medical devices (e.g., magnetic resonance imaging machines) located in hospitals and medical facilities along the Alignment, the locations of these devices are situated too far from the Alignment (e.g., greater than 100 m) to be affected by Project-related EMFs. Project-related

EMFs are also low-frequency and are unlikely to interfere with high-frequency imaging machines. The Vancouver General Hospital ranges between 100 to 300 m from the Project and Project-related EMFs would be negligible at such distances.

Electric and Magnetic Fields in the radio-frequency range may be produced by communications equipment used in the Project. Industry Canada standards and regulations would apply to these products, which address the potential for electromagnetic compatibility and no EMI is anticipated from the use of communications equipment.

7.9.7 Conclusion

Overall, EMFs from the Project are not expected to interfere with AM/FM radio communications, or other electronic systems and devices as Project-related equipment will meet the applicable regulations and standards intended to maintain electromagnetic compatibility and mitigate the potential for EMI.

Pacemakers and wheelchairs are designed to be compatible with the types of EMFs associated with passenger use of trains and locomotives. Sensitive medical equipment such as magnetic resonance imaging machines at Vancouver General Hospital are further than 100 m from the Project, and EMFs would have reduced to levels that would not interfere with these types of equipment.

With regards to public health, the EMF frequency and intensity produced by the Project are below the acute reference levels indicated by ICNIRP for occupational exposures; chronic exposures to low frequency EMFs are not recognized as a potential health concern by Health Canada or the World Health Organization. Therefore, EMF generated by the Project is not expected to result in increased human health risks.

7.10 Aquatic Resources

Aquatic Resources are valued ecosystem components which provide important ecosystem services including fisheries, ecological diversity, nutrient cycling, and flood and erosion control. Fish and fish habitat, including supporting aquatic species, are protected under the Federal Fisheries Act which prohibits serious harm to fish and fish habitat and the introduction of deleterious substances.

This section of the ESR evaluates Project activities with the potential to affect Aquatic Resources through the introduction of sediment or deleterious substances to nearby watercourses, and outlines standard practices and mitigation measures to manage these activities and limit potential effects.

Key information provided to support the assessment of Aquatic Resources includes:

- Rationale for the selection of Aquatic Resources as a Review Element
- Regulatory requirements and policy applicable to the protection of Aquatic Resources as a Review Element
- Existing conditions for aquatic resources within the Project Area
- A summary of Project components and activities that may interact with Aquatic Resources
- A description of mitigation measures to limit or avoid effects on Aquatic Resources and comply with relevant legislation and policy
- A discussion of review results and conclusions

7.10.1 Rationale for Selection as a Review Element

Aquatic Resources were selected as a Review Element because they are a valued ecosystem component to Indigenous groups, stakeholders, and the public and provide important ecosystem functions. The health of aquatic ecosystems has the potential to be affected by Project activities, primarily through the introduction of sediment or deleterious substances to nearby watercourses.

Project activities that may interact with Aquatic Resources include construction of an elevated guideway, tunnel and station construction, increased vehicle traffic (e.g., construction vehicles, trucks and other support vehicles) during construction, and disposal of excavated materials.

7.10.2 Review Scope for Aquatic Resources

This section of the Aquatic Resources ESR includes:

- A description of the relevant key legislation associated with protection of aquatic species and habitats
- Summary of key issues identified during consultation

- Identification of potential Project effects on Aquatic Resources and selection of indicators used to evaluate these potential Project effects within this Aquatic Resources ESR assessment
- A description of the spatial and temporal boundaries of the Aquatic Resources ESR

7.10.2.1 Regulatory and Policy Setting

Key pieces of legislation associated with management of surface water runoff, protection of freshwater aquatic species, and protection of water quality are presented in Table 7.10-1 and described in the following sections.

Table 7.10-1: Regulatory Setting for Aquatic Resources

Responsible Agency	Law, Regulation, Policy	Description	Potential Project Applicability
Environment and Climate Change Canada	*Fisheries Act*— (Section 36)	Prohibits deposition of deleterious substances into waters frequented by fish	Project activities that have the potential to release chemicals or increase sedimentation into nearby watercourses
BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development	*Water Sustainability Act* (Section 11)	Regulates work in and around streams or other designated waterbodies	Project activities that occur in water or around waterbodies
BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development	*Water Sustainability Act* (Section 6)	Pertains to the diversion of water from a stream or aquifer and states that provincial authorization is required for groundwater use	Project activities that may require diversion of water or use of groundwater
BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development	Water Sustainability Regulation (Schedule A, Item 13)	Pertains to diversion of water; construction dewatering is considered a Miscellaneous Industrial Water Use purpose	Project activities that may required diversion of water
City of Vancouver	Sewer and Watercourse Bylaw No. 8093	Regulates discharge to watercourses and stormwater systems	Project activities that occur near watercourses or stormwater systems
City of Vancouver	Integrated Rainwater Management Plan	This plan treats the City's rainwater as a resource and aims to reduce demand for potable water and restore the role of urban watersheds to support urban and natural ecosystems and provide clean water	Changes to volume and/or quality of rainwater that result from Project activities

Federal Fisheries Act

The federal *Fisheries Act* provides protection to fish and aquatic health. Section 36 of the *Fisheries Act* prohibits deposition of deleterious substance(s) into waters frequented by fish. Deleterious substance includes any substance that, if added to any water, would degrade or alter its quality such that it could be harmful to fish, fish habitat, or the use of fish by people. Under the *Fisheries Act* the term 'fish' includes fish, shellfish and crustaceans and all life stages of these animals (i.e., eggs, sperm, larvae, juveniles, adults). Section 36 of the Act is administered by Environment and Climate Change Canada.

British Columbia *Water Sustainability Act*

The British Columbia *Water Sustainability Act* and its associated regulations are administered by the Ministry of Forests, Lands, Natural Resource Operations, and Rural Development. The *Act* regulates works around a stream, which is defined as any "natural watercourse or source of water supply, whether usually containing water or not, and a lake, river, creek, spring, ravine, swamp and gulch". The *Act* requires an application for a change approval or notification for any "modification to the nature of the stream, including modification of the land, vegetation and natural environment of a stream or the flow of water in a stream", depending on the types of works being conducted.

City of Vancouver Sewer and Watercourse Bylaw No. 8093

The placement or discharge of water and waste into the storm drainage system or watercourse is regulated under Section 3.2 of Bylaw No. 8093 (City of Vancouver 1999). The bylaw outlines criteria for storm water discharges and details the limits for various substances and contaminants that may be directly or indirectly placed or discharged into the storm drainage system or any watercourse. Specific criteria that apply to potential discharges of water or waste from the Project include, but are not limited to, the following:

- Total suspended solids (TSS); content must be 75 mg/L or less
- pH; must be higher than 6.0 and lower than 9.0
- No deleterious substances as defined in Section 34(1) of the federal *Fisheries Act*"
- Grease; must be lower than 15 mg/L
- Liquid or vapour; must have a temperature lower than 40 °C

The City has developed the Erosion and Sediment Control—Large Lot Development Bulletin (City of Vancouver 2017) under Bylaw No. 8093, which identifies requirements and criteria that must be followed during construction projects to reduce the risk of sediment entering the storm sewer system, and is applicable to construction sites that are greater than 1,000 m^2.

7.10.2.2 Engagement Input Supporting the Assessment

The development of the Terms of Reference, and the scope of the assessment of Aquatic Resources, was informed by consultation with Indigenous groups and engagement with the public, municipal governments, and stakeholders. Section 5.5 provides a summary of key issues and interests identified. Key issues identified, and responses to comments obtained related to Aquatic Resources are presented in Table 7.10-2.

Table 7.10-2: Summary of Key Aquatic Resources Issues Identified during Public Engagement

Identified Issue	Response
Locations of watercourses, including historical watercourses, should be considered in the review.	Flows from historical watercourses in the Review Area have been piped or culverted and now run beneath the City's road network. As a result, the Project is not expected to affect aquatic habitat.
Potential effects associated with Project-related discharges into the municipal storm sewer system	The review of Aquatic Resources evaluates potential effects of the Project on the storm sewer system (which drains into local fish-bearing, marine, waterways such as False Creek). The ESR identifies mitigation and avoidance measures to reduce or avoid potential Project-related effects on aquatic habitats.

7.10.2.3 Selection of Effects and Review Indicators

Table 7.10-3 lists the potential Project effects on Aquatic Resources and provides a summary of the Project effect mechanisms and review criteria used to assess potential effects. Effects mechanisms, identified in this table, are described in more detail in Section 7.10.4 (Project Interactions). Review indicators were selected to facilitate qualitative or quantitative measurement of potential effects.

Table 7.10-3: Potential Effects and Review Indicators for Aquatic Resources

Potential Effects	Project Effects Mechanisms	Indicator	Rationale for Selection
Project-related influences on water quality	Project activities may discharge contaminants into the municipal storm sewer system	Presence of water quality contaminants (including TSS), or measure of water quality parameters (e.g., temperature, turbidity, pH) that influence habitat quality for Aquatic Resources.	Regulatory requirements (federal, provincial and municipal) to maintain water quality

7.10.2.4 Boundaries

The spatial boundary for the Aquatic Resources review includes any watercourses located within 50 m of the Alignment and waterbodies that receive Project-related runoff. The temporal boundaries that guide the assessment are construction (year 2020 to 2025) and operations (year 2025 forward) phases (see Figure 7.10-1).

7.10.3 Existing Conditions

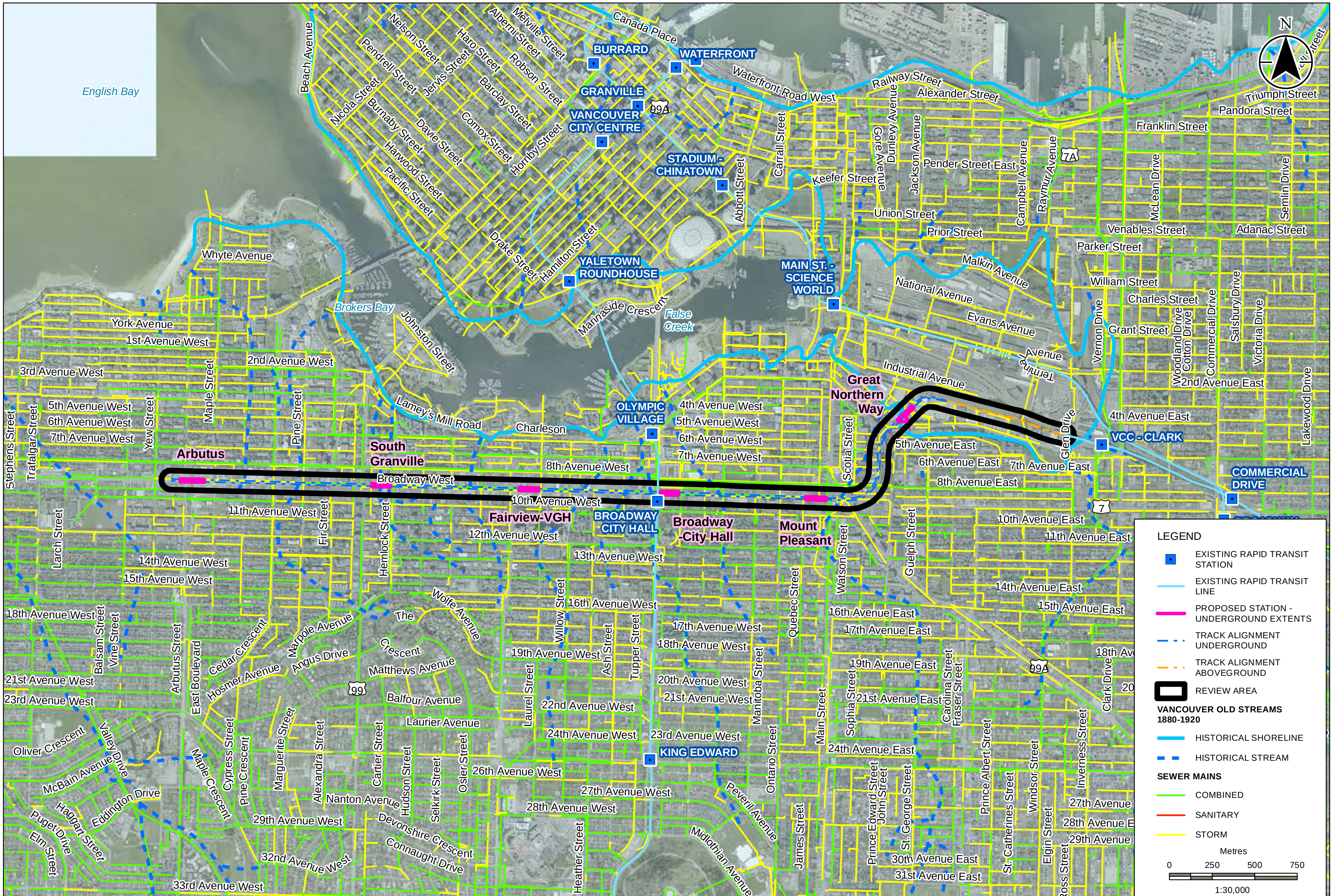
This section summarizes the methods used to identify Aquatic Resources and describes the existing conditions within the spatial boundary for Aquatic Resources.

7.10.3.1 Methods

Information to characterize the existing aquatic habitat within watercourses potentially affected by the Project was gathered and compiled from the following sources:

- Provincial databases (BC Ministry of Environment 2018)
- Spatial data regarding location of current and historical watercourses, as well as storm water and sanitary sewer systems (City of Vancouver 2015)

Field verification of watercourse presence or absence was not conducted.



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AQUATIC RESOURCES REVIEW ELEMENT SPATIAL BOUNDARIES

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SUB CONSULTANT PROJECT NO. 115814099
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7.10.3.2 Review of Existing Conditions

The Project does not cross any surface watercourses (e.g., stream, ditch, pond, wetland) (BC Ministry of Environment 2018; see Figure 7.10-1). The nearest waterbody is False Creek, which is marine habitat that runs parallel to the Alignment, a minimum of 400 m to the north.

Historically, several streams crossed the Alignment and flowed north into False Creek Vancouver Public Aquarium Association 1978). However, urban development, associated with the growth of the City, has resulted in elimination of all surface watercourses in the Review Area with historic stream flows diverted underground within the storm water and combined sewer system which discharge into False Creek (see Figure 7.10-1). Consequently, surface watercourses do not have potential to be affected by the Project.

The environment within the Review Area consists of buildings, roadways, sidewalks, and parking areas. Under existing conditions, roadway contaminants and sediment enter the storm water and combined sewer systems directly. Subsequently, contaminants may enter the marine environment during high flows, discharging through outfalls along the shoreline of False Creek. There are no vegetated areas (greenspaces), permeable surfaces, or ditches in the Review Area that could provide attenuation of storm run-off flows or absorption of contaminants.

7.10.4 Project Interactions

A review of key Project components and activities described in Section 2 (Project Description) was undertaken to determine project interactions that could potentially affect Aquatic Resources. Project components and physical activities that may interact with Aquatic Resources are described in Table 7.10-4. Potential interactions are indicated by check marks and are discussed in greater detail below. Explanation of non-interactions are provided after the table and not assessed further.

Table 7.10-4: Potential Project Interactions and Effects on Aquatic Resources

Project Activities and Physical Works	Potential Effects: Project-related influences on water quality
Construction	
Property acquisition	-
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	✓
Elevated guideway construction	✓
Tunnel and station excavation	✓
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	✓
Vehicle traffic (e.g., road use and construction traffic)	✓
Management and disposal of waste and excavated materials	✓
Commissioning and start-up	-
Operation	
Train operation, including wayside and power	-
Station operation	-
Train maintenance, administration, transit police	-
NOTES: ✓ Potential interactions that may cause an effect - No anticipated interaction	

Project construction activities have the potential to affect Aquatic Resources through changes in water quality. Activities involving active alteration to the environment or using vehicles (i.e., site preparation, tunnel and station excavation, vehicle traffic, and waste/excavated material management) have the potential to interact with Aquatic Resources due to the potential introduction of deleterious substances.

Construction of elevated guideways and stations may increase the potential for sediment, vehicle fluids and fuel, and other chemicals to be deposited on surrounding roadways, which then may be transported via the storm water and combined storm sewer systems to downstream aquatic habitats (i.e., False Creek).

Erosion of stockpiled materials from utility relocations, tunnel excavation, and station excavation may also increase sedimentation and contaminated water run-off entering these systems. Excavation sites may require dewatering, which will require containment and eventual discharge of water, which has the potential also to enter downstream habitats. Increased contaminant and sediment concentrations entering downstream habitats have the potential to affect health of marine organisms (e.g., fish, invertebrates,

and plants) due to changes in water quality that can lead to direct mortality, smothering, decreased foraging success, burial, and habitat avoidance (Bash et al. 2001, DFO 1993).
Water collection systems will be used to prevent or limit unplanned discharges to the existing stormwater system during construction; construction is not anticipated to increase water inputs to the catchment area.

Property acquisition, commissioning and the operational activities are expected to have no measurable interaction with Aquatic Resources due to no or low potential for increased contaminant runoff and spatial separation of Project components (i.e., elevated guideway and underground stations and tunnel) and are not assessed further.

7.10.5 Mitigation Measures

Mitigation measures will be implemented to avoid or reduce potential Project-related discharges of deleterious substances and sediments to downstream local waterways via the storm sewer and combined sewer systems. These measures are described in Table 7.10-5. Such measures will limit the Project's potential effects on water quality, such that water quality parameters remain within thresholds outlined in legislation and policy. Mitigation measures, focused on the protection of Aquatic Resources, will be included in various plans within the Construction Environmental Management Plan for the Project. The identification of mitigation focused on the protection of Aquatic Resources will be guided by the following by the regulatory guidance and criteria:

- Land Development Guidelines for the Protection of Aquatic Habitat (Fisheries and Oceans Canada 1993)
- City of Vancouver Erosion and Sediment Control—Large Lot Development bulletin (City of Vancouver 2017)

As noted in Section 9 (Environmental Management Plans), the Contractor will confirm the final mitigation approaches to support the Surface Erosion Protection and Sediment Control Plan. This approach will allow for mitigation measures that are aligned with the detailed design and construction approach developed by the Contractor.

Table 7.10-5: Mitigation Measures for Aquatic Resources

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.10-1	Develop and implement a Surface Erosion Prevention and Sediment Control Plan for the construction phase, to avoid or limit erosion, sedimentation and potential effects on water quality and aquatic resources. The Surface Erosion Prevention and Sediment Control Plan will include: • Specific best practices to manage sediment and erosion during construction and avoid or limit potential effects on water quality and aquatic resources. • Measures for monitoring the effectiveness of sediment and erosion control mitigation during construction	Construction	Contractor	Contractual Requirement
7.10-2	Erosion and sediment control measures will be implemented to reduce potential for erosion and to reduce risk of release of silt, sediment, sediment-laden water, and other deleterious substances into the storm sewer system.	Construction	Contractor	Contractual Requirement
7.10-3	Water quality monitoring for turbidity, total suspended solids, and pH will be completed prior to discharge.	Construction	Contractor	Best Management Practice
7.10-4	Use sediment settling tanks or ponds to store sediment laden-water allowing it to clarify and remove sediment prior to discharge.	Construction	Contractor	Best Management Practice
7.10-5	Cover and locate stockpiled materials to reduce likelihood of erosion into the storm sewer system.	Construction	Contractor	Best Management Practice
7.10-6	Management excavation waste in compliance with Land Development Guidelines for the Protection of Aquatic Habitat.	Construction	Contractor	Best Management Practice

7.10.6 Discussion of Review Results

Some Project activities, identified in Table 7.10-4, have the potential to cause changes to water quality downstream of the Review Area. This section discusses the potential for effects to Aquatic Resources due to water quality changes as a result of Project-related activities. The potential for Project-related effects is evaluated qualitatively by comparing current conditions with the likelihood and extent of Project-related discharges following implementation of mitigation measures.

Project construction is expected to take approximately five years, including above and below ground excavating activities. Excavation of work areas will involve the presence of additional vehicle traffic, wash stations, and stockpiling of construction materials and excavated materials. Existing conditions (i.e., urban hardscaping reducing surface permeability and increasing roadway runoff into the storm water system) enable roadway contaminants and sedimentation to enter the storm water and combined sewer systems and subsequently the marine environment through marine outfalls. Project activities have the potential to release additional sediment and deleterious substances to the existing surface water run-off, which in turn could adversely affect downstream water quality in the marine environment.

Project design measures will be used to locate vehicle wash stations and material stockpile locations away from storm drain connections and surface water flow pathways (i.e., on slopes and road inclines). The use of erosion and sediment control measures, such as silt curtains, water settling tanks, and covering of excavated materials, will further prevent the likelihood of sediment and contaminants entering these systems. During construction, contact water will be monitored for turbidity, suspended sediments and pH levels, with water retained in settling tanks until sediment concentrations meet discharge guidelines.

Due to the predicted effectiveness of proposed mitigation measures, maintenance of these measures throughout construction, and ongoing monitoring during construction activities, no Project effects are expected on Aquatic Resources.

7.10.7 Conclusion

Potential changes to water quality associated with the release of surface run-off into the storm and combined sewer systems, and subsequently into nearby waterways, from Project-related construction activities will be managed through the implementation of mitigation measures such as those outlined above. Mitigation measures will be fully described in detailed the Construction Environmental Management Plan, to be developed prior to construction. With the effective implementation of best practices, Project-related effects on Aquatic Resources are not anticipated as a result of Project construction.

7.11 Vegetation and Wildlife Resources

This section of the Environmental and Socio-economic Review (ESR) evaluates potential Project-related changes in Vegetation and Wildlife Resources. Project-related effects on Vegetation and Wildlife Resources are qualitatively assessed based on the potential for Project-related activities to interact with existing Vegetation and Wildlife Resources within the Review Area.

The Project has the potential to interact with Vegetation and Wildlife Resources through vegetation clearing, including removal of street trees, and through Project-wildlife conflicts during construction activities and train operation.

Key information provided to support the assessment of Vegetation and Wildlife Resources includes:

- Rationale for the selection of Vegetation and Wildlife Resources as a Review Element
- Relevant legislation and policy applicable to protecting vegetation and wildlife
- Identification of potential Project effects and indicators
- Existing conditions for Vegetation and Wildlife Resources
- Potential Project interactions with Vegetation and Wildlife Resources
- Mitigation measures and industry practices to avoid, or reduce, potential adverse effects on Vegetation and Wildlife Resources
- Discussion of review results and conclusions

7.11.1 Rationale for Selection as a Review Element

The Vegetation and Wildlife Resources Review Element was selected because Project construction and operations may result in the loss or alteration of vegetation and wildlife habitat and could result in potential conflicts with wildlife. The Review Element was also identified as important by regulatory agencies, stakeholders, the public, and Indigenous groups.

The Vegetation and Wildlife Resources Review Element represents vegetation and wildlife species of management concern, associated wildlife habitat (e.g., green space, street trees), and wildlife habitat features (e.g., bird nests, tree cavities used by urban mammals such as raccoon). For the purposes of the ESR, species of management concern include:

- Species at Risk - plant and wildlife species designated as Red- or Blue-listed in British Columbia (BC), or designated as Endangered, Threatened, or Special Concern by either the *Species at Risk Act* or the Committee on the Status of Endangered Wildlife in Canada
- Invasive species - invasive plants or wildlife species and plant species considered to be noxious under the BC *Weed Control Act*

Project construction has the potential to directly interact with vegetation, wildlife habitat, and wildlife species through vegetation clearing around the VCC-Clark Station and other stations where vegetation exists. Project construction could also indirectly affect wildlife resources through sensory (e.g., noise and lighting) disturbance, or changes to attractants (e.g., increased human presence and waste) that could increase the risk of injury or mortality for wildlife.

7.11.2 Review Scope for Vegetation and Wildlife Resources

7.11.2.1 Regulatory and Policy Setting

Key pieces of legislation and policies applicable to the protection of Vegetation and Wildlife Resources are presented in Table 7.11-1 and described in the following sections. Because the Alignment does not support habitat for species designated on Schedule 1 of the *Species at Risk Act*, this legislation is not discussed further.

Table 7.11-1: Regulatory Setting for Vegetation and Wildlife Resources

Responsible Agency	Law, Regulation, Policy	Description	Potential Project Applicability
Environment and Climate Change Canada	*Migratory Birds Convention Act,* 1994	Prohibits the disturbance, destruction, or possession of migratory birds, and their eggs or nests.	Project activities that may result in disturbance to nests, including altering or removing vegetation, as well as accidental injury or mortality.
BC Ministry of Forests, Lands and Natural Resource Operations & Rural Development	*Wildlife Act*	Prohibits the killing, capture, and harassment of native wildlife, except where a permit or regulation allows these activities.	Project activities that may result in disturbance to nests, including altering or removing vegetation, as well as accidental injury or mortality.
	Weed Control Act	Requires land users to control the spread of plants designated as provincially or regionally noxious.	Project activities (e.g., clearing, movement of soil) that may result in the spread of weeds.
City of Vancouver	*Protection of Trees Bylaw 9958*	Requires that trees be retained during construction and protection applied to the subject tree and nearby trees that may be in danger of being damaged.	Project activities (e.g., excavations) that involve ground disturbance have the potential to damage tree roots.

Migratory Birds Convention Act—Migratory birds in Canada are afforded protection through the federal *Migratory Birds Convention Act,* 1994 and Migratory Birds Regulations. The *Migratory Birds Convention Act* applies to species of migratory birds that are identified in Article I of the *Act* and occur on federal, provincial, and private lands. General prohibitions under the *Act* prohibit the disturbance, destruction, or possession of migratory birds, and their eggs or nests.

British Columbia *Wildlife Act*—Management of wildlife in the province of British Columbia occurs primarily through the provincial *Wildlife Act*. Under this legislation, the province manages wildlife populations by regulating and restricting the harvest of individuals. The *Wildlife Act* prohibits the killing, capture, and harassment of native wildlife, except where a permit or regulation allows these activities. Section 34 of the *Wildlife Act* specifically prohibits disturbance or destruction of any bird, eggs, or occupied nests. It is also an offence to destroy the nest of an eagle, peregrine falcon, gyrfalcon, osprey, heron or burrowing owl, regardless of whether it is occupied.

BC *Weed Control Act*—Under the BC *Weed Control Act*, land users are required to control the spread of plants designated as provincially or regionally noxious. Noxious plant species are listed on Schedule A of the Weed Control Regulation.

City of Vancouver Protection of Trees Bylaw 9958—The protection of trees in Vancouver is regulated under the *Protection of Trees Bylaw 9958* (City of Vancouver 2014a). The Bylaw was established to preserve urban tree cover; to regulate and prohibit the cutting, removal and damage of trees; and outline tree cutting permit requirements. Under the Bylaw, trees are to be retained during construction and protection applied to nearby trees (e.g., trees along adjacent streets), unless stipulated in a tree removal permit issued by the City of Vancouver. A development permit is required prior to applying for a tree removal permit.

Section 2.3 of the Bylaw provides a tree removal permit exemption for works that involve construction or maintenance of a public utility in a public utility easement or statutory right-of-way.

7.11.2.2 Engagement Input Supporting the Assessment

Project-related engagement was undertaken to support Project planning including the conduct of the ESR and included engagement with public stakeholders and consultation with Indigenous groups. Feedback on the ESR Terms of Reference, as well as specific comments on the importance of vegetation and landscaping adjacent to stations, has informed the evaluation of potential Project-related effects on Vegetation and Wildlife Resources.

7.11.2.3 Selection of Effects and Indicators

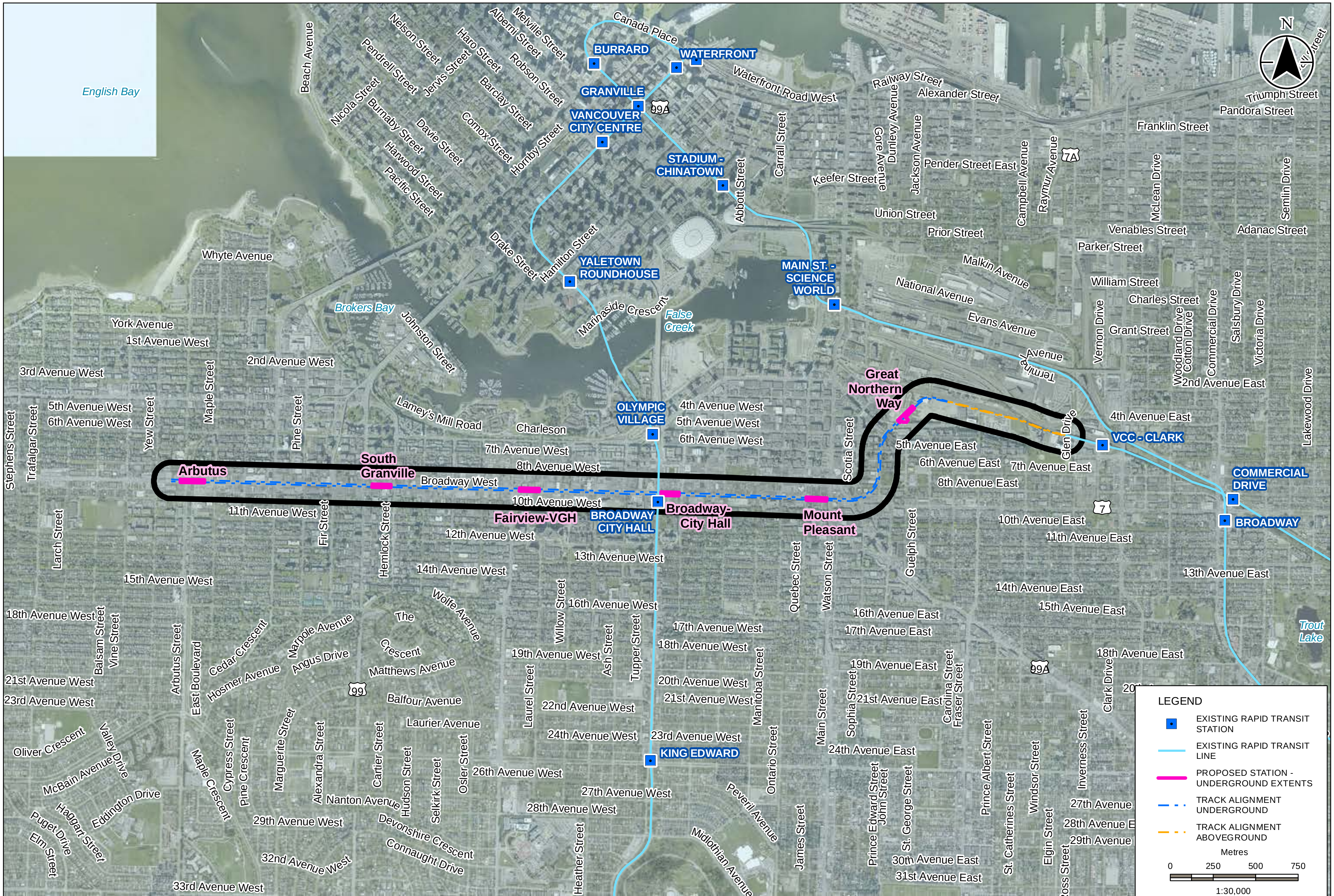
A summary of potential Project effects on the Vegetation and Wildlife Resources Review Element, effect mechanisms, and indicators is provided in Table 7.11-2. Effects mechanisms are described in more detail in Section 7.11.4 (Project Interactions). Indicators enable the qualitative measurement of potential effects.

Table 7.11-2: Potential Effects and Review Indicators for Vegetation and Wildlife Resources

Potential Effects	Project Effect Mechanisms	Indicators	Rationale for Selection
Direct and indirect Project effects on vegetation, wildlife, and wildlife habitat	• Vegetation clearing could remove wildlife habitat or displace wildlife. • Movement of machinery and vehicles during the construction phase could introduce and/or spread invasive species.	Change in the presence of species of management concern, abundance or quality of wildlife habitat and habitat features	Species of management concern are a conservation priority within the province. Change to potential occurrence and locations of invasive species may affect native species and species at risk through competition or displacement. The abundance or quality of wildlife habitat, and/or habitat features provides a measure of the status of urban ecology of the City.
	• Vegetation clearing will result in the direct removal of vegetation.	Change in vegetated areas	The City has established goals to increase the number of trees in Vancouver to provide benefits such as improving air quality and providing easy access to nature for residents and visitors (City of Vancouver 2014b).
	• Vegetation clearing and construction traffic could increase mortality risk to wildlife. • Improper waste management could attract wildlife and increase mortality risk through human-wildlife interactions.	Potential for injury or mortality risk to wildlife	Mortality and disturbance of wildlife due to human activities is recognized as one of the threats to biodiversity in the City and forms part of a goal to protect and enhance biodiversity during development (Vancouver Board of Parks and Recreation 2016).

7.11.2.4 Boundaries

The spatial boundary for the Vegetation and Wildlife Resources review encompasses a 100-m buffer on either side of the Alignment. Temporal boundaries used in this review are the construction (i.e., 2020 to 2025) and operations (i.e., 2025 and onward) phases.



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VEGETATION AND WILDLIFE RESOURCES REVIEW AREA

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7.11.3 Existing Conditions

7.11.3.1 Methods

Baseline information was compiled through a desktop review of existing information and review of air photos. Publicly available online databases were queried to identify occurrences of vegetation and wildlife species of management concern and their habitats (City of Vancouver 2015; BC MFLNRO, 2017; Province of British Columbia 2017a, b).

7.11.3.2 Review of Baseline Conditions

Given that the Alignment is in a highly developed urban area, the study area contains limited natural vegetation and wildlife habitat. The above-ground portion of the Alignment overlaps urban areas with sparse tree cover and provides marginal wildlife habitat values (see Figure 7.11-1). The City of Vancouver's tree database revealed that some street trees in the City's inventory overlap with the Alignment. The stations along the Alignment do not overlap with parks, and their associated wildlife habitat values, and are located within existing developed areas.

Existing green space along the Alignment can provide denning sites and shelter for urban mammals such as raccoon and striped skunk (*Mephitis mephitis*). Urban trees and shrubs can provide nesting habitat for birds. However, given that the trees and shrubs between the VCC-Clark and Great Northern Way stations are predominantly deciduous, nesting opportunities are expected to be limited to common urban bird species (e.g., song sparrow [*Melospiza melodia*], spotted towhee [*Pipilo maculatus*], and northwestern crow [*Corvus caurinus*]).

The desktop review did not reveal occurrence records of species of management concern within the Review Area (BC MFLNRO 2017; Province of British Columbia 2017a, 2017b). Although there are no records of invasive plant or wildlife species within the Review Area, invasive plants and wildlife are likely present given the disturbed urban setting. The Alignment also does not cross any watercourses or wetlands.

7.11.4 Project Interactions

Key Project components and activities, described in Section 2 (Project Description), were reviewed to determine Project interactions that could affect Vegetation and Wildlife Resources. Project activities and physical works that may interact with Vegetation and Wildlife Resources are identified in Table 7.11-3. Potential interactions are indicated by check marks and are discussed in greater detail below. Justification of non-interaction are provided after the table and not assessed further.

Table 7.11-3: Potential Project Interactions and Effects on Vegetation and Wildlife Resources

Project Activities and Physical Works	Potential Effect Direct and indirect Project effects on vegetation, wildlife, and wildlife habitat
Construction	
Property acquisition	-
Site preparation (e.g., clearing, grading, and set up of temporary facilities), and utility relocation	✓
Elevated guideway construction	✓
Tunnel and station excavation	-
Station construction, including underground and above-ground components, installation of underground components, and systems (e.g., rails, power systems, ventilation)	✓
Vehicle traffic (e.g., road use and construction traffic)	✓
Management and disposal of waste and excavated materials	✓
Commissioning and start-up	-
Operation	
Train operation, including wayside and power	✓
Station operation	-
Train maintenance, administration, transit police	-
NOTES: ✓ Potential interactions that may cause an effect. - Not applicable	

Site preparation activities (e.g., clearing, grading) have potential to affect Vegetation and Wildlife Resources directly or indirectly by changing the presence of species of management concern (i.e., species at risk and invasive species), abundance or quality of wildlife habitat and habitat features, vegetated areas, or increasing the potential for injury or mortality risk to wildlife. The Japanese Beetle (a regulated pest) and the Canadian Food Inspection Agency has issued an order for the City of Vancouver which restricts moving plant and soil materials from outside a movement control zone in order avoid the spread of the species which is a threat to the domestic agricultural sector (City of Vancouver, 2019).

Clearing is required to accommodate the short section of elevated guideway and above-ground stations and will result in the removal of some existing vegetation. Vegetation, including street trees and shrubs, provides habitat for wildlife including birds. Indirect effects such as noise and lighting during site preparation could temporarily displace species of management concern (e.g., wildlife species at risk) through avoidance.

Based on the developed setting of the Alignment, it is anticipated that the removal of vegetation that provides substantive habitat value will be negligible. Where there may be a limited need for the temporary removal of street trees (i.e., directly adjacent to some stations), the Project will work with the City of Vancouver to provide replacement trees as part of detailed design and construction plans.

Injury and mortality risk to migratory birds has the potential to occur if site preparation activities occur during the breeding period, which is between March 28 and August 8 in the Lower Mainland (Government of Canada 2017). Vehicle and machinery use during construction of the elevated guideway and excavation and construction of the stations could increase mortality risk for wildlife. Waste and excavated materials may attract wildlife and increase mortality risk for wildlife.

Property acquisition, construction of certain Project components (i.e., tunnel, and stations), and commissioning and start-up do not have potential to interact with Vegetation and Wildlife Resources directly or indirectly. No change related to species of management concern, wildlife habitat and habitat features, or vegetated areas are expected from these activities.

Activities associated with the operation phase are not expected to interact with indicators for Vegetation and Wildlife Resources, other than train operations which could result in injury and mortality risk for wildlife that may end up on the tracks or in the stations.

7.11.5 Mitigation Measures

To avoid or mitigate effects on Vegetation and Wildlife Resources, mitigation measures, such as those identified in Table 7.11-4, will be included in a Vegetation and Wildlife Management Plan to be developed by the Contractor prior to Project construction. Section 9 (Environmental Management Plans) provides additional information on how environmental management plans will be developed and implemented.

The mitigation measures identified in Table 7.11-4 represent best practices for managing potential effects on Vegetation and Wildlife Resources and are consistent with applicable regulatory and policy considerations. As noted in Section 9 (Environmental Management Plans), the Contractor will confirm the final mitigation approaches to support the Vegetation and Wildlife Management Plan. This approach will allow for mitigation measures that are aligned with the design and construction approach developed by the Contractor.

Table 7.11-4: Mitigation Measures for Vegetation and Wildlife Resources

Mitigation Number	Mitigation	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.11-1	Develop and implement a Vegetation and Wildlife Management Plan, for the construction phase, to avoid or limit potential effects on vegetation, wildlife and wildlife habitat. The Vegetation and Wildlife Management Plan will include: • Specific best practices to avoid or limit potential effects on vegetation and wildlife during construction • Specific best practices to guide the management of invasive and/or noxious plants during construction • Procedures to follow when wildlife or wildlife habitat is encountered • Measures for monitoring the effectiveness of vegetation and wildlife mitigation during construction	Construction	Contractor	Contractual Requirement
7.11-2	Avoid vegetation clearing during the breeding period for migratory birds in the Lower Mainland (i.e., March 28 through August 8; Government of Canada 2017. If vegetation clearing cannot be avoided during this period, conduct a pre-clearing bird nest survey to identify and protect active nests.	Construction	Contractor	Contractual Requirement
7.11-3	Avoid or limit vegetation clearing and the removal of trees where possible. Mark Project footprint boundaries on Alignment sheets and with flagging/signage at the work site.	Construction	Contractor	Best Management Practice
7.11-4	Consider guidance, in the Vancouver Bird Strategy and in the *Bird Friendly Design Guidelines* with respect to building and landscape design (City of Vancouver 2014c).	Construction	Contractor	Best Management Practice
7.11-5	Engage a certified arborist to conduct an arborist survey, prior to construction, following guidance associated with the City of Vancouver's Protection of Trees Bylaw 9958 (City of Vancouver 2014a, City of Vancouver 2017).	Construction	Contractor	Best Management Practice
7.11-6	Work with the City of Vancouver to achieve tree relocation and replacement objectives associated with the City of Vancouver's Protection of Trees Bylaw 9958 (City of Vancouver 2014a).	Construction	Contractor	Best Management Practice
7.11-7	Look for opportunities during landscape design to offset the loss of vegetation, including street trees, using native or recommended boulevard plant species (City of Vancouver 2018a, b).	Construction	Contractor	Best Management Practice
7.11-8	Best practices for controlling the spread of noxious weeds and invasive plants will be outlined in the Construction Environmental Management Plan, consistent with guidance from the Invasive Species Council of BC.	Construction	Contractor	Best Management Practice
7.11-9	Follow Canadian Food Inspection Agency Guidance for the moment of plants, plant parts and soil leaving the Japanese beetle regulated areas in Vancouver, British Columbia (Canadian Food Inspection Agency 2019).	Construction	Contractor	Contractual Requirement

7.11.6 Discussion of Review Results

There are no occurrence records of species at risk within the Review Area and it is unlikely that existing habitat within the Review Area could support wildlife or plant species at risk. In addition, site preparation activities will be limited to the above-ground portion of the Alignment between the VCC-Clark and Great Northern Way stations and at station locations along the route. Although there are no records of noxious or invasive species along the Alignment, there is potential for these species to be identified during construction.

As most of the Project involves underground construction, potential effects on vegetated areas (e.g., tree cover, green space) will be limited to the removal of vegetation along a small portion of the overall Alignment. The Project stations are located within developed areas and do not overlap with any parks; however, it is anticipated that some street trees may require temporary removal to accommodate development at station locations. In such cases, the Project will work with the City to offset the removal of street trees.

The potential for injury or mortality of wildlife is expected to occur primarily during the construction phase due to site preparation activities (e.g., vegetation clearing), elevated guideway construction, and station construction. During construction, there will be a change in vehicle traffic due to construction machinery and other Project-related vehicles.

Construction activities may result in increased amounts of waste that could act as attractants to wildlife. However, waste management mitigations developed as part of the Environmental Management Plans (see Section 9) will reduce potential injury or mortality of wildlife by reducing availability to food wastes that could attract wildlife and increase potential for wildlife-human interactions.

No direct effects on amphibians, or other aquatic biota, or their respective habitats are expected to occur because no watercourses or wetlands were identified in the above-ground section of the Alignment.

There is potential for injury or mortality to wildlife during train operations; however, the train will run underground for most of the Alignment and the elevated rail will not be easily accessible to wildlife. As such, Project interactions with wildlife during operations are expected to be negligible.

With the implementation of mitigation measures for reducing Project-related effects on vegetation, wildlife, and wildlife habitat, effects on Vegetation and Wildlife Resources are expected to be negligible.

7.11.7 Conclusion

Project interactions with Vegetation and Wildlife Resources will be limited to vegetation clearing in the above-ground portion of the Alignment and at station locations. A small amount of vegetation will require removal for construction of the Project; however, such vegetation provides limited habitat values for wildlife. With the implementation of identified mitigation measures, potential effects on Vegetation and Wildlife Resources will be effectively mitigated.

8 ACCIDENTS, MALFUNCTIONS, AND NATURAL HAZARDS

8.1 Introduction

The purpose of this section of the Environmental and Socio-economic Review (ESR) is to identify specific accident and malfunction scenarios that are considered reasonably likely to occur during the life of the Project (i.e., construction and operation), the associated public safety risks and the potential effects on the environmental and socio-economic Review Elements. Building on this analysis, this section of the ESR identifies mitigation and response measures to avoid or respond to potential accident and malfunction scenarios.

Information presented in this section of the ESR to support the assessment of Accidents, Malfunctions and Natural Hazards includes:

- **Methods**—A description of the method used to undertake the assessment of potential effects on public safety and the environment resulting from Accidents, Malfunctions and Natural Hazards.
- **Scenario Descriptions**—A description of the events leading to the scenario and the types of risks to public safety and to the Review Elements.
- **Preventative and Response Measures**—A description of the preventative and response measures to the scenarios. Preventative measures are those that reduce the probability of the scenario occurring, while response measures are those that are applied after the scenario has occurred.
- **Potential Effects**—A description of the potential long-term or permanent effects on the Review Elements after response measures have been implemented.
- **Conclusions**—A summary of the accidents, malfunctions, and natural hazards scenarios including the likelihood of the scenario occurring during the life of the Project, the potential consequence to public safety, and the potential effects on the Review Elements.

8.2 Methods

The methods used to support the assessment of accidents and malfunctions include examining specific accident and malfunction scenarios considered to have a reasonable likelihood of occurring during the construction and/or operational phase of the Project, to assist in identifying likely effects and appropriate mitigation/preventative measures.

The scenarios considered include those related to fire, spills, power outages, derailments, earthquakes and extreme weather events. Information supporting the description of scenarios incudes:

- "Worst case" or "probable case" events and the applicable Project stage when such an event could be anticipated to occur
- Identification of preventative measures intended to reduce the likelihood of the event occurring and/or reduce the potential risk to public safety
- Identification of response measures intended to mitigate potential risks to public safety once the event has occurred, including actions to be taken after the event has occurred

Preventative and response measures are discussed primarily in the context of public safety, where the primary objective is to mitigate the potential for serious harm or injury to the public and employees. Many accidents, malfunctions and unplanned events can be prevented or have their effects reduced by pro-active planning, design, maintenance, and mitigation.

The British Columbia Rapid Transit Company (BCRTC) operates and maintains existing SkyTrain lines (i.e., Millennium Line, Expo Line, Evergreen) and has established procedures to respond to accidents, malfunctions, and natural hazards in its SkyTrain Control Centre Operations Manual (BCRTC 2016). These procedures will apply to the transit infrastructure operated as part of the Project. Emergency procedures in the operations manual that are specifically referred to in this section include:

- **Evacuation Strategies (Operations Manual Section 3.03.04)**—Applies when evacuating trains, individual or multiple stations, and buildings.
- **Emergency Shutdown and Evacuation (Code X-Ray) (Operations Manual Section 3.04.16)**—Applies when a safe and orderly full shutdown of the entire mainline is required including all trains, stations, and buildings.
- **Fire (Operations Manual Section 3.04.03)**—Applies when smoke or fire is detected on a train or in a station.
- **Airborne Hazards or Toxic Spills (Operations Manual Section 3.04.08)**—Applies when stations or tunnels are affected by a leak of natural gas, propane, carbon monoxide, smoke, toxic fumes or spills of toxic and flammable liquids.
- **Earthquake response (Operations Manual Section 3.04.13)**—Applies to minor and major earthquakes.
- **Severe Weather (Operations Manual Section 3.04.11)**—Applies to severe wind, rain, and snow events.

These procedures are referred to, as part of the preventative and response measures, where applicable in the context of the accident and malfunction scenarios presented in this section of the ESR.

In addition, pro-active planning to prevent the occurrence of, or respond to, scenarios presented includes the development of the Environmental Management Plans (EMPs) described in Section 9 (e.g., Spill Prevention and Emergency Response Plan, Hazardous Materials Management Plan), and referred to in this section when applicable.

The potential effect of accident and malfunction scenarios on each Review Element is also characterized if there is a long-term or permanent interaction between a Review Element and a specific accident or malfunction scenario.

The likelihood of each scenario occurring, taking into account preventative measures, is characterized (i.e., low, moderate, or high). In addition, the consequence or risk to public safety, after response measures are considered, is also characterized (i.e., negligible, low, moderate, or high).

For this report, accidents and malfunctions are considered as those events caused by equipment malfunction or failure, human error, or natural events.

8.3 Fire

8.3.1 Description of Scenario

During the construction phase, small-scale fires may result from the use of machinery and vehicles, but the likelihood of a fire is low and the risk to public health and safety is negligible since the construction area is not accessible to the public. As such, only major fires that may pose a safety risk to passengers and employees during the operations phase of the Project are considered in this assessment.

A simulated fire scenario was modelled for the operation phase (Jensen Hughes 2017). The simulation included a train fire at the platform level of a station that required the evacuation of passengers. Under this scenario, the evacuation would involve a full evacuation based on the predicted 2045 ridership (i.e., ridership associated with the "design year"). A train fire at the platform level is considered the 'worst case' fire scenario because it exposes passengers to fire and smoke risk and requires the evacuation of passengers on board the incident train and passengers waiting at the platform.

The simulated fire scenario considers the direct risk to public safety from the fire and smoke, as well as indirect risks (e.g., potential injuries during evacuation activities).

8.3.2 Preventative and Response Measures

Preventative and response measures for a fire scenario are intended to either prevent an existing fire from spreading, or to mitigate the risk to public safety by providing and maintaining a means of safe evacuation. These preventative and response measures (e.g., sprinklers, fire suppression equipment, and emergency ventilation systems) are integrated into the design of the station and are described in the following sections.

8.3.2.1 Equipment Maintenance

The primary preventative measure to avoid a train fire is equipment maintenance, including maintenance of the rails, trains, mechanical rooms and electrical rooms. The BCRTC conducts regular maintenance of such infrastructure to reduce the likelihood of a fire resulting from equipment failure.

8.3.2.2 Station Design

The design, layout and construction of each station will incorporate various fire safety considerations. For example, each station is designed with multiple exit routes that allow for a full evacuation within a specified criteria clearance time (i.e., the maximum time for a safe and full evacuation of the station beginning from the station platform). Station platforms will be designed to allow a walking pedestrian flow rate that would meet the criteria clearance time at bottleneck locations such as stairs and escalators. Maintaining the pedestrian flow rate by allowing for adequate personal space is factored into the walkway design to prevent possible panic scenarios.

In addition to design considerations, materials used to construct the stations and trains will also incorporate materials with fire safety properties, such as low flammability, low combustibility and low smoke production, as required by the applicable fire codes.

8.3.2.3 Fire Suppression

To allow for appropriate fire suppression measures to be in place, each station will be designed in accordance with the TransLink Building Code Criteria, which is based on the National Fire Protection Association (NFPA) “Standard for Fixed Guideway Transit and Passenger Rail Systems” (NFPA 130).

Fire suppression infrastructure at each station will include sprinkler systems in non-public areas where there are flammable materials, and in areas identified in conjunction with the Vancouver Fire and Rescue Services, as well as wall hydrants designed and built to applicable municipal code with consideration of the NFPA guidance “Standard for the Installation of Sprinkler Systems” (NFPA 130). Manual fire suppression equipment such as fire extinguishers will be available on trains, and at strategic locations throughout each station including maintenance rooms (e.g., electrical and mechanical rooms). The type of fire extinguisher will vary based on its location and expected application.

8.3.2.4 Fire Emergency Response

The fire response procedures are described in the operations manual (BCRTC 2016). The primary objective is to protect passengers and employees. The incident train will be brought to the next downstream station for passengers to exit. The Duty Manager will assess the fire and select the appropriate response, which may include the initiation of the emergency ventilation system and the evacuation of the station. The emergency ventilation system in the tunnel can be activated by personnel to prevent smoke from back-layering in the direction of the evacuation routes.

Emergency evacuation routes that are secured by a door would have a positive air pressure flow to prevent smoke from entering. Evacuations of the train or station may be supervised by a qualified employee, or unsupervised by giving passengers instructions over the communications system, as described in the operations manual (BCRTC 2016).

8.3.3 Potential Effects

The design measures and emergency response procedures noted above will address public health and safety risks associated with a fire scenario, though some short-term effects on Review Elements would be anticipated. However, it is not anticipated that a train fire, as described above, would result in effects on the long-term viability of the Review Elements.

A train fire will produce some combustion products into the air. However, the volume of combustion products produced would not affect local air quality and would contribute a negligible amount of greenhouse gases. A fire scenario would also result in temporary traffic disruptions for emergency responders to access the incident location, which may also affect access to nearby residential roads and commercial businesses.

8.3.4 Conclusion

The likelihood of a train fire scenario occurring during the life of the Project is considered low. Although regular maintenance can reduce the likelihood of a fire scenario, it cannot eliminate the risk entirely due to spontaneous equipment failure.

The potential risk to public health and safety, should a fire scenario occur, is considered low. The low smoke producing properties of building materials, in combination with planned emergency ventilation systems, would mitigate public safety risk by reducing the likelihood of smoke inhalation by passengers.

Low combustibility and low flammability materials used in the construction of the trains and station would effectively mitigate the risk to public safety from direct exposure to a fire by allowing sufficient time for the train and station to be evacuated before a fire can spread. In addition, station design requirements such as the size and configuration of platforms and exit routes, allows for a rapid evacuation from multiple exit routes within a specified criteria clearance time.

A fire scenario, should one occur, would not result in substantial effects on the Review Elements, beyond short-term emissions of smoke and combustion products, and temporary disruptions to local traffic and access.

8.4 Leaks and Spills

8.4.1 Description of Scenario

During Project construction, potential leaks and spills that could occur would be limited to fuels, oils, lubricants and other substances used to operate machinery and equipment. It is assumed that construction equipment would be refueled off-site, or using a mobile fuel delivery service, and that no large volumes of fuel will be stored on site. As such, it is assumed that leaks of spills that could occur will be small in magnitude (i.e., jerry can under 10 L) with a low likelihood of a large-scale leak or spill.

Leaks and spills of fuels, oils and lubricants are less likely to occur during the operations phase because the trains are powered by electricity. As such, fuels, oils, lubricants, or other substances required during operations would be present in extremely small volumes with very low likelihood of a large-scale leak or spill.

8.4.2 Preventative and Response Measures

The associated risks with small-scale leaks and spills of liquids during construction are effectively managed through the EMPs described in Section 9 (i.e., Spill Prevention and Emergency Response Plan, Hazardous Materials Management Plan).

In the unlikely event of a large leak or spill during operations, that poses a risk to the safety of workers and/or passengers, response measures described in the operations manual (BCRTC 2016) would be followed. These response measures include evacuating passengers and employees from the affected area. The affected area may also be powered down to prevent igniting flammable fumes. Emergency responders may be summoned to investigate the source of the hazard and to provide medical aid to any passengers or employees who are ill from exposure to the hazard.

8.4.3 Potential Effects

The measures noted above will address health and safety risks associated with a potential spill or leak during construction and operations though some short-term effects on Review Elements would be anticipated. However, it is not anticipated that a spill, as described above, would result in effects on the long-term viability of Review Elements.

8.4.4 Conclusion

Accidental leaks and spills that may occur, during both construction and operations, are anticipated to be small in magnitude and represent a negligible risk to human health and safety. Response measures detailed in construction phase EMPs and operational phase BCRTC emergency response guidance documents, are in place to address spills and leaks. Such procedures have been demonstrated to be effective and the potential risk to public health and safety from a leak or spill is considered negligible. While small leaks or spills could result in a short-term effect to specific Review Elements, there are no anticipated long-term effects.

8.5 Power Outage

8.5.1 Description of Scenario

Accident and malfunction scenarios related to power outages are limited to the operations phase of the Project. If there is a power outage in the area during the construction phase of the Project, there would be no risk to the public and construction work would be postponed, where necessary, until power is restored.

A power outage during the operations phase may result in one or more of the following: a loss of primary power along the line causing trains to stall, and/or a loss of power to communications, lighting and emergency systems.

A power outage may be the result of a spontaneous failure in the Project’s electrical infrastructure, or the indirect result of a widespread power outage in the area. The likelihood of a partial or full power outage during the life of the Project is high, and there are many potential causes of a power outage that are beyond the control of the system operator. Power outages may be short-term (e.g., lasting several hours), moderate-term (e.g., lasting up to 24 hours), or long-term (e.g., lasting days) depending on the cause and time required to repair the problem.

8.5.2 Preventative and Response Measures

The primary preventative measure to avoid power outages associated with a malfunction of the Project's electrical infrastructure, is a dual feed power supply, where power is supplied from two separate and independent substations. Provision of two separate and independent power sources will limit power outages to a single substation and will therefore not result in a loss of power to the trains. The secondary preventative measure to avoid a power outage is regular maintenance of Project-related infrastructure.

Response measures to a power outage are dependent on the systems that are affected. The Duty Manager will select the appropriate level of response to the scenario, which may include train and station evacuations, as described in the operations manual (BCRTC 2016).

In general, an evacuation is undertaken if the lighting, communications or emergency systems are affected, if the power outage is expected to be prolonged, or if the number of passengers exceeds the capacity of employees to manage safely. Stations will have an uninterruptible power source to maintain functionality of critical systems (e.g., emergency lighting in the stations and tunnels, and communications), but it does not provide motive power to the trains. Employees can sweep the tunnel for stopped trains and supervise a train evacuation to the nearest station. If a power outage is expected to be prolonged, additional buses could be deployed to address local and regional transit needs.

8.5.3 Potential Effects

The mitigation and response measures noted above will address public health and safety risk associated with a power outage scenario. A power outage may result in short-term disruptions to traffic and transportation, particularly during rush hour. If the outage is expected to be prolonged, additional buses could be deployed to mitigate the effect.

8.5.4 Conclusion

The likelihood of a power outage during the life of the Project is high. However, the risk to public health and safety is negligible. Response measures are dependent on the extent and duration of the power outage and can range from having passengers stay in place (e.g., for stalled trains) to an evacuation of the trains and stations (e.g., if the outage is prolonged or if lighting, communications and emergency systems are affected).

A power outage is not anticipated to result in effects on the Review Elements. Temporary disruptions in traffic and transportation can be mitigated with the deployment of additional buses to meet local and regional transit needs.

8.6 Train Derailment

8.6.1 Description of Scenario

A train derailment scenario applies to Project commissioning and the operations phase of the Project only. Such a scenario could include derailments at rail switch points that are caused by a malfunctioning switch, broken rails or equipment that fails or breaks off and falls onto the tracks. Train derailments associated with high-speed travel on curved sections are considered improbable, since the Alignment is predominantly linear and curved sections are designed for the trains operating speeds. The likelihood of a train derailment is low, based on no previous derailments of trains carrying passengers since the start of SkyTrain operations in 1986.

Accident and malfunction scenarios related to train derailments do not consider acts of vandalism, terrorism or foreign objects falling onto the rails. In the case of objects falling onto the rail, along the 700 m elevated guideway, alarm systems will be triggered, and train operation halted until operations personnel can remove the object. Objects falling onto the rail in the underground tunnel sections are improbable since there is no public access. In the case of objects falling from the station platform, trains would be travelling at low speed as they are either decelerating when approaching the station or accelerating from a stop when departing the station. It is improbable that an object falling onto the tracks from the platform could result in a low-speed derailment since the train is more stable at lower velocities.

8.6.2 Preventative and Response Measures

Preventative measures to mitigate the risk of a train derailment include routine maintenance of the rail, wheels and other equipment (e.g., electrical and mechanical systems at switch points), and rail and track design features.

Routine maintenance may include the use of rail grinders to restore the profile of the rail and remove irregularities, or regular maintenance of mechanical and electrical equipment at switch points.
The proposed right-of-way is mostly linear, which mitigates the risk of derailment associated with operating at high-speeds at curved locations.

In the event of a train derailment, the Duty Manager would be among the initial responders. The Duty Manager will assess the severity of the derailment and public safety risk to determine the level of support from firefighters, ambulance and police. Emergency support needs may include passenger rescue from the incident train and medical services for injured passengers. Although the safety risk to passengers on the station platform would be negligible, evacuation from the station may be required to facilitate the emergency response. Evacuation procedures are described in the operations manual (BCRTC 2016).

8.6.3 Potential Effects

A train derailment is not expected to result in effects on the Review Elements. A train derailment may result in short-term disruptions to traffic and local access at the station used by emergency responders to access the incident location.

8.6.4 Conclusion

The likelihood of a train derailment is low, and historically SkyTrain has had no derailments of trains carrying passengers. Preventative measures including a proposed right-of-way that is mostly linear, along with regular maintenance, will mitigate most of the risk that could lead to a train derailment. However, if a train derails, the risk to public safety is moderate to high for passengers on the incident train, due to the risk of injury and potential logistical difficulty in evacuating injured passengers on the train. Emergency response support from firefighters, ambulance and police will help prevent further risks to public safety. No effects on the Review Elements are anticipated apart from short-term disruptions to traffic and local access at the station used by emergency responders to access the incident location.

8.7 Seismic Activity

8.7.1 Description of Scenario

A seismic event scenario applies to the operations phase of the Project only. Given that the public will not have access to construction sites, it is assumed a seismic event occurring during the construction phase would not result in effects to public safety.

Generally, it is safer to be in an underground tunnel during an earthquake compared to being above ground in a busy, urban setting such as that along the Alignment. Underground tunnels and structures move with the ground, while structures above ground will sway, which may cause the collapse of buildings, trees, power lines and other structures. The tunneled sections of the right-of-way would be constructed with reinforced concrete and provide a safe and stable environment during an earthquake. Passengers along the 700 m above-ground portion of the right-of-way near VCC-Clark Station would be inside a train, which would provide some level of protection from falling objects.

8.7.2 Preventative and Response Measures

Preventative measures for a seismic event are intended to reduce the probability of damage to Project infrastructure and associated injury to workers and passengers. These measures are integrated into the applicable federal building codes that guide the design and construction of the Project (e.g., National Building Code of Canada, Canadian Highway and Bridge Design Code). They include design specifications that require maintenance of structural integrity for a major earthquake, as defined by a 1-in-2,475-year return period seismic event.

The station and the tunnels would be among the safest structures to be in during an earthquake. Examples of design features to mitigate risks to public safety during an earthquake include tunnel sections constructed with reinforced concrete, or roof and wall concrete slabs formed from a single-pour to provide continuity in the tunnel structure and to prevent water ingress.

Earthquake response procedures also include the full shutdown and evacuation of the entire mainline and all stations, as described in the operations manual (BCRTC 2016). The main objective in these procedures is to safely evacuate all passengers from the trains and stations, and to summon appropriate support for trapped or injured passengers. In the event of a major earthquake, a full shutdown is likely required in order to assess the damage to the Project infrastructure and conduct repairs.

8.7.3 Potential Effects

An earthquake or other seismic event is not expected to affect the Project in a manner that results in effects on Review Elements.

8.7.4 Conclusion

The likelihood of a seismic event over the life of the Project, that is of substantial magnitude to merit a response measure, is moderate to high. Design mitigations would make the station and tunnel among the safest structures to be in during an earthquake, and effectively mitigate public safety risks. Trains would be stopped during an earthquake to mitigate the risk of derailment. Following an earthquake, passengers would be evacuated from the tunnels and station and emergency support summoned as appropriate for injured passengers. No effects on the Review Elements are anticipated.

8.8 Extreme Weather Events

8.8.1 Description of Scenario

Extreme weather events include windstorms, heavy rain, or heavy snow. Since the Project infrastructure is primarily underground and is protected from the effects of extreme weather events, this assessment only considers the 700 m aboveground portion of the Project between the VCC-Clark Station to the tunnel portal adjacent to Great Northern Way.

Heavy rain will not affect train safety in the above-ground portions of the Project. The elevated guideway would have adequate drainage to mitigate potential flooding from heavy precipitation. The trains will remain stable during periods of high wind, but objects such as tree branches may blow onto the tracks.

Periods of heavy snow can result in ice formation on the tracks. Ice on the tracks can pose a risk of derailment if it is not removed. The response measures in the event of a derailment are described in Section 8.6. Extreme weather events may also lead to power outages, which are described in Section 8.5.

8.8.2 Preventative and Response Measures

Extreme weather events are naturally occurring and there are no preventative measures for avoiding such scenarios. Project design features include mitigation to prevent flooding of the tracks during periods of heavy precipitation.

Response measures to severe weather events are described in the operations manual (BCRTC 2016). Following such measures, extreme weather events would be monitored through weather forecasts and a weather warning made to all staff and passengers when applicable.

During high wind events, trains can be operated manually at the start of each day to sweep the above-ground portions of the track for foreign objects that may be introduced as a result of extreme weather events (e.g., debris blown onto tracks). The formation of ice on the tracks can be mitigated by keeping the trains running during non-operational hours. The steel on steel contact between the rail and train is sufficient to break the ice buildup.

8.8.3 Potential Effects

An extreme weather event is not expected to affect the Project in a manner that results in effects on the Review Elements. Heavy wind, rain and snow can be effectively mitigated, and there would be no risk to public safety.

8.8.4 Conclusion

The likelihood of an extreme weather event occurring over the life of the Project is high. However, the risk to public and worker safety is negligible. The Project is primarily underground except for a 700 m section near the VCC-Clark Station. Design features will mitigate the effects of heavy rain on the Project. During high wind events, trains can be operated manually at the start of each day to sweep the above-ground portions of the track for foreign objects. Continuously running the trains during periods of heavy snow would effectively prevent ice buildup on the rails. Extreme weather events do not affect the Project in a manner that could result in effects on Review Elements.

8.9 Conclusion

The risk to public and worker health and safety, and the potential effects on the Review Elements were assessed in relation to accidents, malfunctions, and natural hazard scenarios. In addition to EMPs that will address potential accidents and malfunction during construction, BCRTC has existing emergency response procedures in its operations manual to address the above accidents, malfunctions, and extreme weather event scenarios. Considering the preventative measures to avoid or respond to these events, and the demonstrated effectiveness of such measures, the risk to public and worker health and safety is considered to be low.

The Project is designed with mitigation and response measures to address relevant and reasonably foreseeable accidents and malfunctions, that are aimed at avoiding or limiting risks to public health and safety. These mitigation and response measures are also effective in preventing or limiting most types of effects on the Review Elements.

9 ENVIRONMENTAL MANAGEMENT PLANS

This section of the ESR report describes the Construction Environmental Management Plan (CEMP) and accompanying Environmental Management Plans (EMPs; or “component sub-plans”), and supporting processes, that will be developed to support implementation of measures to protect environmental and socio-economic values during construction and operation.

Information presented in this section includes:

- A description of applicable licences, permits and approvals
- An overview of the CEMP and EMPs that should be developed to support the management of environmental issues during construction
- A description of the roles and responsibilities of the Contractor, and MOTI, in developing and implementing the CEMP
- A description of how the CEMP will be implemented in the context of specific construction activities including the use of site- and activity-specific Environmental Work Plans
- An overview of how operational phase environmental and socio-economic considerations will be managed and addressed
- An overview of other Project-related management plans, outside of the scope of the CEMP, that will be developed and implemented to address topics considered in the ESR (e.g., traffic management, safety, etc.)

9.1 Applicable Licences, Permits, and Approvals

A preliminary list of environmental-related licences, permits, and approvals potentially required for construction is provided in Table 9-1. The construction Contractor will be responsible for confirming applicable licences, permits and approvals required for the Project, taking into account the final design and construction methods selected. The construction Contractor will also be responsible for obtaining and working in compliance with all applicable licenses, permits and approvals.

Table 9.1-1: Applicable Environmental Licences, Permits, and Approvals

Legislation	Licence, Permit, or Approval	Regulatory Agency	Description/Activity	Relevant Review Element	Notes
Environmental Management Act Contaminated Sites Regulation	Site Profile, Certificate of Compliance or Notice of Independent Remediation	BC Ministry of Environment and Climate Change Strategy (BC MOECCS)	Where remediation of contaminated materials is undertaken, provide notice to MOECCS	Contaminated Sites	Approval for management and disposal of contaminated materials
Environmental Management Act Petroleum Storage and Distribution Facilities Storm Water Regulation	Fuel Storage Registration	BC MOECCS	If on-site fuel storage is required	Contaminated Sites	Temporary fuel storage
Environmental Management Act	Waste Discharge Permit	BC MOECCS	If excavation dewatering and discharge to sewer or receiving environment is required	Fisheries and Aquatic Resources	Disposal of excavated materials (on land), wastewater discharge, Project air emissions, waste discharges
Heritage Conservation Act	Heritage Inspection Permit Heritage Investigation Permit	BC Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD)	Potential for heritage and archaeology sites along the proposed Alignment	Archaeology and Heritage Resources	Should these permits be required, a qualified, professional archaeologist who is in good standing with the Archaeology Branch will prepare and submit applications.
Heritage Conservation Act	Heritage Inspection Permit Heritage Investigation Permit	FLNRORD Archaeology Branch	Potential for heritage and archaeology sites along the proposed Alignment	Archaeology and Heritage Resources	Should these permits be required, a qualified, professional archaeologist who is in good standing with the Archaeology Branch will prepare and submit applications.
Water Sustainability Act	Water Licence	FLNRORD	Diversion of groundwater for non-domestic use requires a water licence; this may be applicable for the dewatering of work areas should groundwater be encountered	Fisheries and Aquatic Resources / Contaminated Sites	Disposal (dewatering) of groundwater seepage from excavations
First Nations	Heritage investigation permits	Musqueam Indian Band, Squamish Nation, Stó:lō Research and Resource Management Centre, and/or Tsleil-Waututh Nation		Archaeology and Heritage Resources	N/A

9.2 Environmental Management Roles and Responsibilities

This section describes the roles and responsibilities of the Contractor, MOTI (construction phase), and BCRTC in managing environmental issues, identified in the ESR report, associated with the construction and operation of the Project.

9.2.1 Construction Environmental Management

During the construction phase of the Project, the Contractor will be responsible for developing and implementing plans, including the CEMP, for managing all Project-related environmental issues in compliance with relevant regulatory, and contractual requirements.

During construction, MOTI will audit the implementation of the Contractor's environmental management program and, where necessary, take steps to verify compliance with environmental-related regulatory and contractual requirements.

The implementation of the Contractor's environmental management program will be supported by a team of qualified environmental practitioners (QEPs) who will plan and implement work associated with the CEMP. QEPs are qualified and experienced environmental practitioners with an appropriate level of training and experience in their respective field, and in appropriate professional designations (e.g., professional geoscientist, engineer, agrologist, or biologist). The key roles within the Contractor's environmental management team are described in Table 9-2.

Table 9.2-1: Contractor Environmental Management Team

Role	Responsibility
Environmental Manager	• Development, implementation and maintenance of EMPs • Understanding regulatory requirements, mitigation measures, and the other Project commitments described in the EMP(s) • Managing environmental issues associated with the Project on a day-to-day basis, including overseeing the environmental monitoring program • Reporting to MOTI, throughout construction, on implementation of the Project environmental requirements • Communicating with applicable regulatory agencies regarding regulatory requirements • Supporting engagement with participating Indigenous groups during implementation of the Project's environmental program • Authorizing Stop Work orders, if required, to Project personnel for non-compliance with the EMP(s) or CEMP
Environmental Specialists	• Providing specialized advice on discipline-specific environmental issues (e.g., air quality scientist, remediation specialist, wildlife biologist) to support delivery of the Contractor's environmental program.

Implementation of the Contractor's construction phase environmental program, and auditing of implementation by MOTI, will be guided by contractual requirements including:

- General requirements to work in compliance with applicable environmental laws and regulations
- Required skills and experience of members of the Contractor's environmental team
- Contractual requirements related to the management of specific environmental issues
- Contractual requirements related to providing weekly, monthly and annual environmental reports confirming compliance with environmental requirements

9.2.2 Operational Environmental Management

During the operational phase of the Project, BCRTC will be responsible for the operation of the Project. BCRTC currently operates other TransLink rail infrastructure including the Expo and Millennium lines. Section 9.5 outlines BCRT's operational environmental management requirements.

9.3 Construction Environmental Management Plan

Sections 7.2 to 7.11 of the ESR report describe the potential for Project-related construction activities to affect environmental and socio-economic Review Elements as well as mitigation measures to avoid or limit such effects. The purpose of the CEMP is to describe the specific best practices that will be employed by the Contractor, and processes to support their implementation, during Project construction.

The CEMP will include component sub-plans (or EMPs) that focus on specific aspects of environmental management (e.g., noise, sediment and erosion control, air quality, etc.) that need to be managed during construction of the Project.

This section provides a summary of each component sub-plans to be included in the CEMP.

In addition to mitigation measures identified throughout Sections 7.2–7.11, and summarized in Appendix A, the Contractor will have the flexibility to identify other mitigation approaches and best practices, not identified in this report, to mitigate potential Project-related effects. This approach will allow for the selection of mitigation measures that are appropriate and effective in the context of the final design and construction methods selected by the Contractor.

Component sub-plans that will be included within the CEMP for the Project include:

- Air Quality and Greenhouse Gas Management Plan
- Archaeological and Heritage Management Plan
- Construction and Demolition Waste Management Plan
- Contaminated Sites and Excavated Materials Management Plan
- Hazardous Materials Management Plan
- Noise and Vibration Management Plan

- Spill Prevention and Sediment Control Plan
- Surface Erosion Prevention and Sediment Control Plan
- Vegetation and Wildlife Management Plan

It is recommended that each component sub-plan within the CEMP include the following information:

- Purpose, scope, and objective
- Roles and responsibilities
- Project, site orientation, and training requirements
- Summary of mitigation measures and contingency procedures
- Relevant regulatory requirements
- Monitoring and reporting requirements
- General and emergency contacts

9.3.1 Air Quality and Greenhouse Gas Management Plan

The objectives of the Air Quality and Greenhouse Gas Management Plan are to:

- Avoid or reduce effects from Project-related common air contaminants (e.g., sulphur dioxide [SO_2], inhalable particulate matter [PM_{10}]) and greenhouse gas emissions (e.g., carbon dioxide [CO_2], methane [CH_4]) during Project construction
- Describe key performance indicators, best management practices, mitigation measures, and monitoring requirements to be implemented to reduce potential Project-related effects to air quality during construction
- Describe relevant regulatory requirements, such as those under the Sulphur in Diesel Fuel Regulations (SOR/2002-254) and the Metro Vancouver Non-Road Diesel Engine Emission Regulation Bylaw No. 1161.

9.3.2 Archaeological and Heritage Management Plan

The objectives of the Archaeological and Heritage Management Plan are to:

- Reduce potential Project-related effects to archaeological and heritage resources that may be legally protected by the *Heritage Conservation Act* or *Local Government Act*
- Describe a Chance Find Procedure that should include a description of types of archaeological sites and heritage resources that may be discovered in Vancouver and steps to follow if a suspected or confirmed archaeological site or artefact is located during construction.
- Provide a mechanism that allows for Indigenous groups' active involvement in decisions related to the management of potential archaeological resources within the Review Area.

9.3.3 Construction and Demolition Waste Management Plan

The objectives of the Construction Waste Management Plan are to:

- Manage the disposal of non-hazardous construction and demolition waste
- Describe waste reduction measures to be employed during construction such as best practices typically used in urban development projects to support, the recycling and beneficial reuse of materials
- Describe measures to be implemented to manage construction-related waste in a way that avoids effects on environmental and social values
- Describe procedures and best management practices for the proper storage and disposal of construction materials, measures to manage food waste that may attract wildlife, and identify opportunities for reuse of non-hazardous construction materials
- Demonstrate the Project's compliance with the *Environmental Management Act*

9.3.4 Contaminated Sites and Excavated Materials Management Plan

The objectives of the Contaminated Sites and Excavated Material Management Plan are to:

- Manage contaminated sites in compliance with the Contaminated Sites Regulation of the *Environmental Management Act*
- Identify locations of known and potential contaminated sites and site-specific procedures for working in and near known and potential contaminated sites, including, where required, procedures for remediation of contaminated sites
- Describe contingency procedures to follow if an unanticipated contaminated site is encountered or an accidental release occurs during construction, as well as testing and reporting requirements

9.3.5 Hazardous Materials Management Plan

The objectives of the Hazardous Materials Management Plan are to:

- Reduce the risk of a spill or safety incident involving dangerous goods and materials during construction of the Project
- Describe procedures for the transport of dangerous goods and materials, training requirements for Project personnel and contractors, measures for proper inventory and storage of dangerous goods and materials in environmentally sensitive areas, and servicing and inspection requirements for transport and storage equipment
- Describe procedures and best management practices for the identification, abatement, verification, transportation, and disposal of hazardous building materials encountered during the demolition of structures required for the Project

- Demonstrate compliance with the *Transportation of Dangerous Goods Act* and Regulations, *Environmental Management Act*, Hazardous Waste Regulation, the Workplace Hazardous Materials Information System *Workers Compensation Act*, Occupational Health and Safety Regulations, and associated Safe Work Practices.

9.3.6 Noise and Vibration Management Plan

The objectives of the Noise and Vibration Management Plan are to:

- Limit or reduce effects on the local community and sensitive receptors from Project-related unwanted noise and vibration during construction
- Identify information supporting the management of construction-related noise including: a schedule of construction activities and hours, target noise and vibration levels and thresholds, equipment inspection and maintenance requirements, public outreach program, noise monitoring plan, and reporting requirements
- Outline a monitoring component to regularly verify vibration levels at key locations and enable comparison with specific thresholds (e.g., FTA 2006)

9.3.7 Spill Prevention and Emergency Response Plan

The objectives of the Spill Prevention and Emergency Response Plan are to:

- Reduce the potential for an accident or malfunction caused by Project-related activities
- Equip Project personnel with procedures to follow in the event of an accident, malfunction, or natural hazard including incident reporting to local Indigenous groups and relevant regulatory agencies
- Outline a list of materials and equipment to be stored on site (e.g., spill abatement materials, clean-up kits, survival kits) to support emergency response activities
- Outline roles and responsibilities of on-site personnel in the event of an accident or malfunction, training requirements for on-site personnel, spill response procedures, and reporting requirements (including both reporting in accordance with regulatory thresholds, and notification to local Indigenous groups).

9.3.8 Surface Erosion Prevention and Sediment Control Plan

The objectives of the Surface Erosion Prevention and Sediment Control Plan are to:

- Identify construction activities that could lead to soil erosion and discharge of sediment-laden water into Vancouver's storm water system
- Describe measures that should be implemented prior to, and during, construction to manage erosion and stormwater runoff, in order to avoid or limit sedimentation effects to aquatic habitats
- Outline monitoring requirements to verify the effectiveness of mitigation measures to prevent or limit sedimentation associated with Project-related activities
- Demonstrate alignment of Project-related surface erosion prevention and control activities with the City of Vancouver's Erosion and Sediment Control—Large Lot Development Bulletin (City of Vancouver 2017) under Bylaw No. 8093

9.3.9 Vegetation and Wildlife Management Plan

The objectives of the Vegetation Management Plan are to:

- Avoid or reduce Project-related effects on vegetation (e.g., boulevard trees) and prevent or limit the long-term spread and establishment of invasive or noxious plants
- Reduce the risk of the spread of invasive and noxious plants
- Outline steps for Project personnel to follow if invasive or noxious plants are discovered during construction and reporting and re-planting requirements for boulevard trees
- Avoid or reduce Project-related effects on wildlife and wildlife habitat (e.g., nests protected under the *Wildlife Act* or the *Migratory Birds Convention Act*) by outlining procedures to follow if wildlife or a wildlife features is encountered

9.4 Environmental Work Plans

To support implementation of the CEMP, the Contractor will prepare site- and or activity-specific Environmental Work Plans (EWPs), that are consistent with the objectives and mitigation measures contained within the CEMP. Such EWPs will identify site- and/or activity-specific mitigation, monitoring and management activities that are required to avoid or limit potential effects on environmental values associated with the Project.

The EWPs will be submitted to MOTI for review, prior to the commencement of construction activities, and will be adopted by the Contractor when undertaking construction activities related to specific sites and/or activities.

At a minimum, each EWP will:

- Describe the site location applicable to the EWP, the work schedule, and key environmental contacts related to the specific work described in the EWP
- Describe the activities to be undertaken and equipment required to complete the work
- Include a list of applicable permits and authorizations
- Describe training requirements for personnel working on the site
- Identify site and/or activity specific environmental risks including the use of maps or drawings, as appropriate, to identify the presence and location of important environmental features
- Describe mitigation measures to be implemented to avoid or limit environmental effects including maintenance requirements
- Reference applicable regulatory and contractual requirements as well as sections of the CEMP
- Describe the expected and scheduled timing of environmental inspections and specific reporting procedures that should apply
- Include relevant emergency procedures and emergency contact information

9.4.1 BC Hydro Works EMP and Other Utility Works

As noted in Section 2.1.4 (SkyTrain Operating Systems) BC Hydro is undertaking works, related to the Project, which involve installation of a 12.5 KV loop to provide power to support Project construction and operation. In support of such work, and consistent with findings of the ESR, BC Hydro has developed and implemented an EMP to support such construction works (BC Hydro 2018).

The BC Hydro EMP includes best management practices to avoid or limit potential effects, associated with site preparation and utility relocation activities, on the following Review Elements: Archaeological and Heritage Resources (Section 7.4), Contaminated Sites and Excavated Materials (Section 7.8), Aquatic Resources (Section 7.10), Vegetation and Wildlife Resources (Section 7.11), and Accidents and Malfunctions (Section 8.0).

The development of the EMP supporting the above noted works was supported by consultation with relevant Indigenous groups.

Other utility works being completed by other parties (e.g., City of Vancouver) as separate projects but supporting BSP are also supported by EMPs appropriate to their scope and activities (e.g., trolley line upgrades).

9.5 Operational Environmental Management

As noted in Section 9.2.2, BCRTC will be responsible for operation of the Project including managing any environmental issues associated with the operational phase. BCRTC has developed an Operations Environmental Management Plan (BCRTC 2019) that supports the management of environmental considerations associated with the existing Millennium and Expo Lines.

The scope of environmental management considerations addressed in the BCRTC Operations Environmental Management Plan include the following:

- Air Quality and Dust Control Management Plan
- Fuel, Chemicals, and Material Storage and Handling Management Plan
- Health and Safety Management Plan
- Noise and Vibration Management Plan
- Solid and Liquid Waste Management Plan
- Snow Management Plan
- Water and Sediment Quality Management Plan
- Storm Water Management Plan
- Spill and Emergency Response Plan

During future stages of Project development, and prior to the start of operations, the existing BCTRC Operations Management Plan will be reviewed and updated to address any environmental risks that are specific to the operation of the Project and not already addressed in the Operations Environmental Management Plan.

10 SUMMARY AND CONCLUSION

The Project, once operational, will provide faster, more convenient and reliable transit connectivity within the Broadway Corridor as well as improved regional rapid transit connectivity. Such improvements in transit capacity will support implementation of local and regional economic development and land use plans as well as targets for moving towards more sustainable modes of transportation.

Consultation with Indigenous groups, during the conduct of the ESR, has provided important input with respect to identifying potential Project-related effects on Aboriginal Interests, and ways to avoid or mitigate such effects, as well as opportunities for Indigenous group involvement in Project delivery. Such consultation has supported important dialogue on interests such as verifying that archaeological resources within the Project area are protected during Project construction as well as opportunities for cultural recognition during Project delivery.

While Project construction activities have the potential to temporarily impact environmental and socio-economic conditions along the Broadway Corridor, the ESR process has identified measures (Appendix A—Summary of Mitigation) that will be taken to avoid or limit temporary construction-phase effects. Drawing on past experiences in constructing similar infrastructure, the ESR has identified best practices that have been proven effective in avoiding or limiting potential effects on values such as noise and vibration, archaeology, air quality, contaminated sites, vegetation and wildlife habitat, and aquatic resources.

In order to limit construction phase traffic congestion, a broad suite of actions will be undertaken, in collaboration with the City of Vancouver, and local businesses and residents, to maintain efficient movement of transit, emergency service providers, commercial and commuter traffic, cyclists and pedestrians through the Corridor. The development of management plans that address the traffic and access needs of businesses, service providers and residents along the Corridor, will be supported by early and ongoing engagement with those work and live in the Corridor. To support businesses operating through the construction phase, Project delivery will be supported by a Business Engagement Program to inform, engage and involve businesses in effectively addressing construction-related disruptions.

In order to maximize housing-related benefits associated with improved transit capacity in the Corridor, the City of Vancouver, has initiated a Broadway land use planning process to coordinate transit-supportive land use, affordable housing policies, transportation connectivity, and public realm design with the Project. Such measures will allow for planned growth in the Corridor that achieves City of Vancouver objectives including: increased rental housing, more affordable housing, and increased housing choices.

During operation, Project infrastructure will be operated by TransLink and guided by existing systems that are in place on the existing Millennium Line to proactively address potential effects on environmental and community values that could occur. Existing TransLink systems are also in place to avoid and respond to accidents that could occur during operation.

Once operational, the Project will result in reduced bus traffic on Broadway and facilitate a shift towards more sustainable modes of transportation. Existing transportation infrastructure, including roadways, and other transit services, will continue to operate as they do currently.

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Appendix A

Table 1 Broadway Subway Project Environmental and Socio-Economic Review: Summary of Mitigation Measures

Mitigation No.	Mitigation Measure	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.2 Transportation and Access				
7.2-1	Develop and implement a Traffic Management Plan for the construction phase, that considers all road users (e.g., transit users and busses, drivers, cyclists, and pedestrians, including those with disabilities). The Traffic Management Plan will include: • A Traffic Control Plans for all construction activities with the potential to impact traffic along the Alignment • An Incident Management Plan with procedures for responding to unplanned events or incidents • A Public Information Plan with procedures to notify the City of Vancouver, TransLink, transit operators, emergency response agencies, media, stakeholders, adjacent property owners, and the travelling public, of any scheduled or unscheduled activities affecting traffic • A Bus Management Plan identifying all bus routes to be accommodated, how bus operations will be prioritized, how and where bus stops will be relocated, and associated pedestrian access, transfer, and waiting areas • A Truck Management Plan identifying how Project-related trucks will be managed during construction including routes to be followed, entry and egress points, truck classifications, truck staging areas. The Truck Management Plan will include measures to ensure that emergency vehicle access and safety are given the highest priority.	Construction	Contractor	Contractual Requirement
7.2-2	• A Bus Management Plan identifying all bus routes to be accommodated, how bus operations will be prioritized, how and where bus stops will be relocated, and associated pedestrian access, transfer, and waiting areas. Note: this Plan is separate from the Contractor Traffic Management Plan	Construction	TransLink	Supportive Measure
7.2-3	Implement temporary changes to bus operations in the Broadway Corridor during construction including: • Re-routing buses that primarily travel the north south direction and only travel along the Broadway Corridor for short sections, including the Route 14, 16, and 17, off the Broadway Corridor • Keeping routes 9 and 99 on the Broadway Corridor to continue to serve major destinations and adding additional buses to maintain existing service levels	Construction	TransLink / Coast Mountain Bus Company	Supportive Measure
7.2-4	Undertake modifications to road infrastructure, on both the Broadway Corridor and on adjacent routes, to improve the flow of traffic during construction. Some of these modifications will include parking regulation changes, and intersection signal timing/phasing.	Construction	City of Vancouver	Supportive Measure
7.2-5	Maintain existing cycling routes throughout construction, including the Central Valley Greenway and Arbutus Greenway, or identify direct and intuitive alternate routes.	Construction	Contractor	Contractual Requirement
7.2-6	Maintain existing emergency routes within the Project site or relocate the emergency routes in the vicinity of the Project site in consultation with and subject to the approval of the relevant Emergency Response Agencies.	Construction	Contractor	Contractual Requirement
7.2-7	The Province will engage with stakeholders, with support from the City of Vancouver and the Contractor, to build and foster relationships to manage construction-related disruption, increasing predictability for business operations.	Construction	Province, City of Vancouver, Contractor	Supportive Measure
7.3 Housing and Property				
7.3-1	The City of Vancouver, working with the Province and TransLink will implement measures under the Housing Vancouver Strategy, the Broadway Plan, and the Supportive Policies Agreement, to facilitate increased housing options and employment opportunities in the Broadway Corridor. Other complimentary polices and programs being advanced by the City of Vancouver to address housing availability and affordability in the Broadway Corridor include: • Implementation of the Development Contribution Expectation (DCE) Policy in order to limit speculation in the Broadway Corridor • The Vancouver Plan, which will address long-term land use and housing affordability • The False Creek South Neighbourhood Planning Program which includes objectives of increasing housing capacity and choice	Construction/Operation	City of Vancouver, TransLink, Province	Supportive Measures

Mitigation No.	Mitigation Measure	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.4 Archaeological and Heritage Resources				
7.4-1	Develop and implement an Archaeology and Heritage Management Plan, for the construction phase, that identifies measures to protect archaeological and heritage resources. The Archaeology and Heritage Management Plan will include measures for protecting archeology and heritage resources in the Project areas including: • Specific best practices to ensure archaeological resources are managed in compliance with the Heritage Conservation Act (HCA) • The Identification of areas with archaeological potential requiring additional investigation (i.e., Archaeological Impact Assessment) during property acquisition and/or following detailed design • Monitoring of subsurface disturbance in areas of historical stream drainages, where appropriate (i.e., based on detailed Project design)	Construction	Contractor	Contractual Requirement
7.4-2	Undertake targeted archaeological field studies (e.g., an archaeological impact assessment) as recommended (i.e., in the AOA) to assess or monitor ground-altering developments within areas of archaeological potential identified in the AOA so that archaeological sites, if present, are appropriately managed.	Construction	Province and Contractor	Contractual Requirement
7.4-3	Mitigate effects to archaeological and heritage sites (if any) identified during the archaeological assessments for the Project in accordance with the HCA and provincial guidance.	Construction	Contractor	Contractual Requirement
7.4-4	An Archaeological and Heritage Resources Chance Find Procedure will be developed in advance of construction and implemented in the event that previously unidentified archaeological or heritage resources are encountered during Project construction.	Construction	Contractor	Contractual Requirement
7.5 Noise				
7.5-1	Develop and implement a Noise and Vibration Management Plan, for the construction phase, to manage construction-related noise. The Noise and Vibration Management Plan will include measures for managing noise during construction including: • Allowable hours of work (day and nighttime). • Measures for the management of noise during daytime and nighttime construction activity • The identification of the type, location, and duration of construction activities anticipated to generate construction noise • Requirements for communication with the public regarding any construction noise, as well as procedures for responding to any noise complaints. The Project will adhere to the notification requirements that are included in the Project Agreement. • Site-specific measures to mitigate noise impacts to nearby noise sensitive receptors • Measures for monitoring noise and the effectiveness of mitigation during construction • Training will be undertaken to support the implementation of the Noise and Vibration Management Plan	Construction	Contractor	Contractual Requirement
7.5-2	Where noise mitigations are to be implemented (i.e., during nighttime construction activities), consult with potentially affected residents and property owners about the suggested mitigation measures prior to construction start.	Construction	Contractor	Contractual Requirement
7.5-3	Install permanent noise barriers and/or parapet noise barriers where warranted (e.g., along sections of elevated guideway and near the portal).	Construction	Contractor	Contractual Requirement
7.5-4	Based on monitoring during the commissioning and warranty period, apply mitigation to the tunnel near the portal as required to mitigate noise during train operations.	Construction	Contractor	Contractual Requirement
7.5-5	Transport excavated materials through the tunnel where feasible to reduce Project truck traffic on city streets.	Construction	Contractor	Best Management Practice

Mitigation No.	Mitigation Measure	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.5-6	Implement best management practices to mitigate construction noise including, but not limited to the following: • Select construction equipment or processes that have additional noise control features added, such as better mufflers, enclosures, or other exhaust silencers • Take advantage of natural and constructed features (e.g., material stockpiles, temporary site buildings) on the edge of the right-of-way, or at the property line of affected noise sensitive receptors • Avoid dropping materials from a height • Schedule periods of respite in the case of unavoidable maximum noise level events (e.g., vibratory piling). • Schedule truck movements to avoid residential streets and place site vehicle entrances away from residences and other sensitive receptors • Avoid clustering of equipment near residences, sensitive receptors, or large reflecting surfaces, and maintain as much distance as possible • Avoid idling of equipment if not in use • Where more than one equipment type can be selected for a specific task, with similar efficiency, select the quietest (e.g., hydraulic splitters as alternatives to rock-breaking work methods, hydraulic or electric powered equipment instead of diesel or gas-fired equipment) • Carry out regular maintenance on equipment, especially exhaust systems • Operate equipment at minimum engine speed, where feasible, while maintaining effective operation • Use of temporary noise barriers near above-ground construction (e.g., portal/tunneling and surface activities near Great Northern Way and Thornton Street) • Limit the need for reversing alarms and consider alternatives to the typical "beeper" alarms, like broadband alarms	Construction	Contractor	Best Management Practices
7.5-7	When noisy construction activities (e.g., pile driving, diesel generators) are forecasted to potentially affect adjacent residents and properties, the following will be provided to potentially affected stakeholders in advance of the work: • Description of the work locations • Description of the construction activities and sources of noise, as well as anticipated noise levels • Rationale for the work • Anticipated duration of the work • Description of mitigation measures planned • Information regarding timing and location of neighborhood meetings to discuss issues	Construction	Contractor	Contractual Requirement
7.5-8	Implement a Noise and Vibration Management Plan for operations and maintenance, that includes monitoring at existing condition locations within the first year after substantial completion of construction (e.g., during the commissioning and warranty period), to assess if impacts and mitigation measures are accurate and effective, or to identify locations that warrant additional noise-attenuation measures. The Noise and Vibration Management Plan will also include a noise complaint resolution procedure to address noise concerns in a timely manner. Based on noise monitoring conducted within the first year after substantial completion of construction, TransLink will work with the Contractor to identify and implement noise-attenuation measures where needed.	Operation	TransLink / Coast Mountain Bus Company	Standard Operating Procedure
7.5-9	Operation best practices will strive to follow the BCRTC Operations Environmental Management Plan (BCRTC 2019). Further, operational noise will be managed by adhering to TransLink noise specifications, regarding: • Paging and bell signaling systems for public announcements. • Acoustical design considerations for ancillary systems (e.g., transformers) • Maintenance of guideway track to limit operational noise (e.g., wheel squeal) • Acoustical measures for ventilation shafts at underground stations • During testing and commissioning, sound levels should not exceed 75 dBA 15 m away from trains operating • Train operating noise levels at 50 metres from the centre of the track should not exceed: 68 dBA when trains are stationary and 75 dBA when trains are moving (BCRTC 2019)	Operation	TransLink / Coast Mountain Bus Company	Standard Operating Procedure
7.5-10	Operation of the bus loop near the Arbutus Station will be guided by the Operations Environmental Management Plan (BCRTC 2019) to remain in compliance with Noise Control Bylaw No. 6555.	Operation	TransLink / Coast Mountain Bus Company	Standard Operating Procedure
7.6 Vibration				

Mitigation No.	Mitigation Measure	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.6-1	Develop and implement a Noise and Vibration Management Plan, for the construction phase, to manage potential vibration effects on adjacent properties. The Noise and Vibration Management Plan will include measures to assist in assessing and addressing vibration effects including: • Specific best practices to avoid or limit vibration effects during construction • Measures for conducting pre- and post-construction surveys of structures along the Alignment to assist in monitoring potential Project-related damage • Measures for monitoring vibration, and the effectiveness of mitigation, during construction • Notification procedures for potentially high vibration construction works • Procedures for engaging with adjacent properties on construction works that have the potential to disrupt vibration sensitive equipment and activities	Construction	Contractor	Contractual Requirement
7.6-2	Through engagement with local residents and business, identify windows of time for avoiding construction activities that are significant sources of vibration.	Construction	Contractor	Best Management Practice
7.6-3	Develop and implement a program for communicating with stakeholders on the monitoring and management of construction-related noise and vibration issues.	Construction	Contractor	Contractual Requirement
7.6-4	Use of ballast mats to reduce ground-borne vibration associated with on-site movement and management of excavated materials.	Construction	Contractor	Best Management Practice
7.6-5	Where appropriate, trackwork design will incorporate vibration-reducing features (e.g., double-tie design, double-ended pocket tracks or crossovers, floating slabs, ballast mats, resilience fasteners).	Design/Construction	Contractor	Best Management Practice
7.6-6	Use construction methods and equipment that limit vibration levels, where feasible.	Construction	Contractor	Best Management Practice
7.6-7	Implement BCRTC's existing Operations Environmental Management Plan with respect to mitigating potential vibration effects.	Operation	TransLink / Coast Mountain Bus Company	Standard Operating Procedure
7.7 Air Quality and Greenhouse Gases				
7.7-1	Prepare an Air Quality and Greenhouse Gas Management Plan which will include: • Best management practices and mitigation measures to manage construction phase air emissions including the use of low or zero emissions equipment where practical • Air quality monitoring to verify the effectiveness of construction phase air quality mitigation measures	Construction	Contractor	Contractual Requirement
7.7-2	Potential dust emissions will be controlled by applying best management practices which may include: • Using water spray to reduce generation of fugitive dust at excavation sources • Regularly sweeping paved surfaces and roadways to remove build-up sand and dirt • Installing wheel wash stations to eliminate mud track-out issues at active construction sites • Using water trucks on construction routes during dry conditions, where necessary	Construction	Contractor	Best Management Practice
7.7-3	Air emissions from construction equipment will be reduced by applying best management practices which may include: • Construction fleet will meet requirements of Metro Vancouver Non-Road Diesel Engine Emission Regulation Bylaw No. 1161 • Construction fleet will use low-sulfur fuel • Construction fleet will undergo regular tuning and maintenance • A no-idling policy will be implemented	Construction	Contractor	Best Management Practice

Mitigation No.	Mitigation Measure	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.8 Contaminated Sites and Excavated Materials				
7.8-1	Develop and implement a Contaminated Sites and Excavated Materials Management Plan, for the construction phase, to ensure that contaminated materials are managed in compliance with all applicable regulatory requirements. The Contaminated Sites and Excavated Materials Management Plan will include: • Specific best practices for guiding the assessment and appropriate management of potentially contaminated materials during construction • Locations of known and suspected contamination that maybe encountered during construction • Facilities that will be used for the disposal of contaminated soils and uncontaminated excavated materials • Protocols for soil and groundwater sampling in areas of planned excavation to characterize conditions in order to appropriately plan the excavation and determine disposal requirements • Measures for on-site soil storage including residual material (including tunnel spoil) to avoid erosion and sedimentation • Protocols for the collection of soil samples, from excavation limits, where contamination has been removed	Construction	Contractor	Contractual Requirement
7.8-2	Develop and implement a Hazardous Materials Management Plan and Construction and Demolition Waste Management Plan for the construction phase to ensure such materials are managed in compliance with all applicable regulatory requirements. The Hazardous Materials Management Plan and Construction and Demolition Waste Management Plan will include: • Specific best practices to for identifying and appropriately managing hazardous materials including procedures for storage and disposal • Specific best practices for the appropriate management and disposal of construction and demolition waste	Construction	Contractor	Contractual Requirement
7.8-3	Contaminated materials and hazardous materials will be managed in accordance with relevant regulatory requirements including the EMA, CSR, HWR; WHMIS; and Transportation of Dangerous Goods (TDG).	Construction	Contractor	Contractual Requirement
7.8-4	Emergency and spill response procedures will be developed in accordance with the EMA and CSR to allow for rapid response in the event of spills of fuels and other hazardous materials, and provisions for access/egress of emergency vehicles.	Construction	Contractor	Contractual Requirement
7.8-5	Refueling and maintenance of equipment will be in designated areas to prevent contamination from these activities.	Construction	Contractor	Best Management Practice
7.8-6	Spill response and containment equipment will be kept on the worksite near storage/handling and refueling/maintenance areas.	Construction	Contractor	Contractual Requirement
7.8-7	Use biodegradable hydraulic fluid in construction equipment in order to reduce or avoid soil contamination risk during construction.	Construction	Contractor	Best Management Practice
7.8-8	A register of construction-related hazardous materials (such as fuels, lubricants, and other chemicals) will be maintained and will include information on: • Storage location • Storage requirements • Proper usage • Handling information • Disposal procedures	Construction	Contractor	Contractual Requirement
7.8-9	Surveys of salvageable and hazardous building materials will be undertaken for buildings requiring demolition to ensure appropriate disposal of materials.	Construction	Contractor	Contractual Requirement

Mitigation No.	Mitigation Measure	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.9 Electric and Magnetic Fields				
7.9-1	Use of equipment that meets the available Canadian EMF standards or its equivalent standard by international agencies	Construction	Contractor	Standard Operating Procedure
7.9-2	Apply engineering and design best practices to minimize EMF exposures during operations through: • Station design and layout to optimize the distance between EMF sources (e.g., substations, electrical and mechanical rooms, electrified fourth rail) and receptors (e.g., sensitive electrical or electronic systems, communication systems) • Electrical design and layout of the electrical infrastructure to reduce stray EMFs • Passive engineering controls of infrastructure designed to block electric fields or redirect magnetic fields	Construction	Contractor	Best Management Practice
	7.10 Aquatic Resources			
7.10-1	Develop and implement a Surface Erosion Prevention and Sediment Control Plan for the construction phase, to avoid or limit erosion, sedimentation and potential effects on water quality and aquatic resources. The Surface Erosion Prevention and Sediment Control Plan will include: • Specific best practices to manage sediment and erosion during construction and avoid or limit potential effects on water quality and aquatic resources • Measures for monitoring the effectiveness of sediment and erosion control mitigation during construction	Construction	Contractor	Contractual Requirement
7.10-2	Erosion and sediment control measures will be implemented to reduce potential for erosion and to reduce risk of release of silt, sediment, sediment-laden water, and other deleterious substances into the storm sewer system.	Construction	Contractor	Contractual Requirement
7.10-3	Water quality monitoring for turbidity, total suspended solids, and pH will be completed prior to discharge.	Construction	Contractor	Best Management Practice
7.10-4	Use sediment settling tanks or ponds to store sediment laden-water allowing it to clarify and remove sediment prior to discharge.	Construction	Contractor	Best Management Practice
7.10-5	Cover and locate stockpiled materials to reduce likelihood of erosion into the storm sewer system.	Construction	Contractor	Best Management Practice
7.10-6	Management excavation waste in compliance with Land Development Guidelines for the Protection of Aquatic Habitat.	Construction	Contractor	Best Management Practice
	7.11 Vegetation and Wildlife Resources			
7.11-1	Develop and implement a Vegetation and Wildlife Management Plan, for the construction phase, to avoid or limit potential effects on vegetation, wildlife and wildlife habitat. The Vegetation and Wildlife Management Plan will include: • Specific best practices to avoid or limit potential effects on vegetation and wildlife during construction • Specific best practices to guide the management of invasive and/or noxious plants during construction • Procedures to follow when wildlife or wildlife habitat is encountered • Measures for monitoring the effectiveness of vegetation and wildlife mitigation during construction	Construction	Contractor	Contractual Requirement
7.11-2	Avoid vegetation clearing during the breeding period for migratory birds in the Lower Mainland (i.e., March 28 through August 8; Government of Canada 2017. If vegetation clearing cannot be avoided during this period, conduct a pre-clearing bird nest survey to identify and protect active nests.	Construction	Contractor	Contractual Requirement
7.11-3	Avoid or limit vegetation clearing and the removal of trees where possible. Mark Project footprint boundaries on Alignment sheets and with flagging/signage at the work site.	Construction	Contractor	Best Management Practice
7.11-4	Consider guidance, in the Vancouver Bird Strategy and in the *Bird Friendly Design Guidelines* with respect to building and landscape design (City of Vancouver 2014c).	Construction	Contractor	Best Management Practice
7.11-5	Engage a certified arborist to conduct an arborist survey, prior to construction, following guidance associated with the City of Vancouver's Protection of Trees Bylaw 9958 (City of Vancouver 2014a, City of Vancouver 2017).	Construction	Contractor	Best Management Practice
7.11-6	Work with the City of Vancouver to achieve tree relocation and replacement objectives associated with the City of Vancouver's Protection of Trees Bylaw 9958 (City of Vancouver 2014a).	Construction	Contractor	Best Management Practice

Mitigation No.	Mitigation Measure	Project Phase	Delivery	Mitigation Type (Contract Requirement, Best Practice, Supportive Measure, Standard Operating Procedure)
7.11-7	Look for opportunities during landscape design to offset the loss of vegetation, including street trees, using native or recommended boulevard plant species (City of Vancouver 2018a, b).	Construction	Contractor	Best Management Practice
7.11-8	Best practices for controlling the spread of noxious weeds and invasive plants will be outlined in the Construction Environmental Management Plan, consistent with guidance from the Invasive Species Council of BC.	Construction	Contractor	Best Management Practice
7.11-9	Follow Canadian Food Inspection Agency Guidance for the moment of plants, plant parts and soil leaving the Japanese beetle regulated areas in Vancouver, British Columbia (Canadian Food Inspection Agency 2019).	Construction	Contractor	Contractual Requirement