Health Impact Assessment (HIA) of the George Massey Tunnel Replacement Project

Prepared on behalf of:

British Columbia Ministry of Transportation and Infrastructure

Vancouver, British Columbia

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Habitat
HEALTH IMPACT CONSULTING

Executive Summary

Key Messages

- As a result of the Project, health benefits are expected in the areas of exposure to airborne contaminants; greenhouse gas emissions; active and public transportation; traffic safety; connectivity and access; emergency response; and economic considerations.
- Project construction may result in temporary air quality, noise, and recreational and park access impacts. These impacts will be effectively mitigated to avoid health impacts.
- Overall, the Project is anticipated to improve health equity by providing disadvantaged groups with better access to reliable transportation options.
- Future Project-related engagement with Aboriginal Groups represents an important opportunity to address health-related interests specific to Aboriginal Groups that have been identified in the health impact assessment.

The Ministry of Transportation and Infrastructure (Ministry) has proposed replacing the George Massey Tunnel (Tunnel) with a new bridge that will span the South Arm of the Fraser River. The George Massey Tunnel Replacement Project (the Project) also will include several upgrades to the Highway 99 corridor in Delta and Richmond, improve several interchanges, provide transit/HOV upgrades, and increase cycling and pedestrian infrastructure.

A health impact assessment (HIA) was undertaken by Habitat Health Impact Consulting on behalf of the Ministry to examine potential beneficial and adverse health effects related to the Project. In recent years there has been increased interest among the public, governments and health authorities in the use of health impact assessments (HIAs) for assessing health considerations associated with various development projects in B.C. and other jurisdictions. In general terms, an HIA is used as a planning tool and provides a framework for considering the way in which the planning and development of community infrastructure may influence health in either positive or adverse ways. The use of HIA as a planning tool for the Metro Vancouver region is described in *Health Impact Assessment of Transportation and Land Use Planning Activities Guidebook*, a recent guidance document developed for the Metro Vancouver region.

The figure below illustrates the conceptual framework behind HIA and how land use planning activities and the development of community infrastructure can influence a broad range of human health outcomes.

Considering previous planning and consultation work that had been done to support Project development, and the work done in support of the environmental assessment for the Project, it was determined that a desktop HIA would be an appropriate level of assessment. The Project HIA followed the standard process for health impact assessment outlined in multiple reference documents: screening; scoping; assessment and analysis; development of recommendations; reporting; and monitoring and evaluation.

This HIA relied on the reported results of stakeholder engagement activities that have been undertaken for the Project over the last three years with both the general public and with specific municipal, Aboriginal, professional and community-based organizations. In addition, the scope of the HIA was directly reviewed by the Vancouver Costal Health and the Fraser Health Authorities, as well as with select Aboriginal Groups. Comments from all of these reviewers informed the HIA approach. Additional engagement with emergency responders was undertaken to support HIA development.

Eleven health interest areas emerged from the scoping process; these are shown in Table 1. In addition to assessing the effects of the Project on the general population for each of these 11 health interests, the HIA also paid specific consideration to how effects might be experienced by vulnerable populations and by Aboriginal populations.

Overall, the effects of the Project are expected to be positive and to result in beneficial health effects in Delta, Richmond, as well as other communities in Metro Vancouver. While there is a range of possible negative health effects that could arise from this project, these occur primarily during the construction phase, are temporary, and for the most part will be effectively mitigated.

Table 1: Effect characterization for each health interest areas examined within the HIA

	Direction	Size / distribution of population affected	Magnitude	Likelihood	Equity considerations	Confidence
Exposure to Airborne Contaminants	Positive	Medium	Medium/ high	Likely	Improvement	High
Noise	Mixed	Medium	Low	Likely	No equity effect	High
Food and Water Consumption	Neutral	Small	Low	Possible	Adverse	Medium
GHG Emissions	Positive	Large	Low	Likely	No equity effect	Medium
Active and Public Transportation	Positive	Medium	Medium/high	Likely	Improvement	High
Traffic Safety	Positive	Medium	Medium to high	Likely	No equity effects	Medium
Connectivity and Access	Positive	Medium	Medium	Likely	Improvement	Medium
Emergency Response	Positive	Small	High	Likely	No equity effect	High
Safety and Security	Neutral to positive	Medium	High	Low	No equity effect	High
Economic Health Effects	Positive	Large	Medium	Likely	Improvement	Medium
Recreation and Parks	Mixed	Large	Medium	Likely	No equity effect	Medium

The HIA identified recommendations in the areas of Active and Public Transportation, Traffic Safety, Emergency Response, Safety and Security, and Economic Health Effects. These recommendations were intended to supplement the mitigation measures already planned as part of the Project (discussed in the Application Information Requirements (approved on May 24, 2016)*, and to further ensure that adverse health outcomes would be avoided and potential health benefits would be enhanced. The Ministry has accepted these recommendations, and they now comprise part of the planned mitigations described in the Application.

* http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_document_430_40443.html

Acronyms & Abbreviations

%HA	Percent highly annoyed
BC / B.C.	British Columbia
BCEAA	British Columbia Environmental Assessment Act
BCEHS	BC Emergency Health Services
c/mvk	Collisions per million vehicle kilometers
CH_4	Methane
CO_2	Carbon dioxide
dBA	A-weighted decibels
EA	Environmental assessment
FN	First Nations
GHG	Greenhouse gas
HIA	Health impact assessment
HOV	High-occupancy vehicle
LAA	Local assessment area
Ministry	The British Columbia Ministry of Transportation and Infrastructure
N_20	Nitrous oxide
PM	Particulate matter
Project	George Massey Tunnel Replacement Project
RQ	Risk quotient
tunnel	George Massey Tunnel

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1. BACKGROUND & CONTEXT

1.1 Purpose of this Report

The Ministry of Transportation and Infrastructure (Ministry) has proposed replacing the George Massey Tunnel (Tunnel) with a new bridge that will span the South Arm of the Fraser River. The George Massey Tunnel Replacement Project (the Project) also will include several upgrades to the Highway 99 corridor in Delta and Richmond, improve several interchanges, provide transit/HOV upgrades, and increase cycling and pedestrian infrastructure. While population health considerations associated with the Project have been identified as part of Project planning and the design of mitigations, such health considerations have previously not been presented as a stand-alone health-focused study.

This report comprises a health impact assessment (HIA) that brings together health-related information and analysis to help the Ministry and local stakeholders understand how construction and operation of the proposed Project, including Tunnel decommissioning, could affect the health of residents who live or work in the vicinity of the Project or in areas affected by it.

This HIA considers health broadly, meaning that a broad suite of health-related outcomes and supports have been included; and that both potential adverse effects and potential health benefits are considered. The approach to the HIA was based on stakeholder feedback to ensure that local health values were integrated into the HIA analysis.

1.2 The Project

In service since 1959, the Tunnel is an important link in the transportation system for the Metro Vancouver region, the lower mainland, and the province of British Columbia as a whole. The Tunnel accommodates an average of 80,000 vehicles each day and connects to key gateways that fuel the national, provincial and regional economies.

Over recent years concerns have been raised about safety and traffic congestion in and near the Tunnel. As a result, the Government of B.C. initiated a planning and consultation process in 2012 and, after evaluation of a number of options, it was determined that a new bridge and other improvements to the Highway 99 corridor, was the most appropriate and most-supported option for replacing the Tunnel.[4, 5]

Consultation activities identified the following six goals:

- **Reduce congestion** – Improve travel times and reliability for all users.
- **Improve safety** – This includes improving traffic and seismic safety, as well as emergency response capabilities.
- **Support trade and commerce** – Improve access to local businesses and gateway facilities, and improve travel time reliability for goods movers and service providers.
- **Support increased transit on the Highway 99 corridor** – Provide dedicated transit/HOV lanes on the new bridge to improve travel time reliability and add capacity for long-term transit improvements.

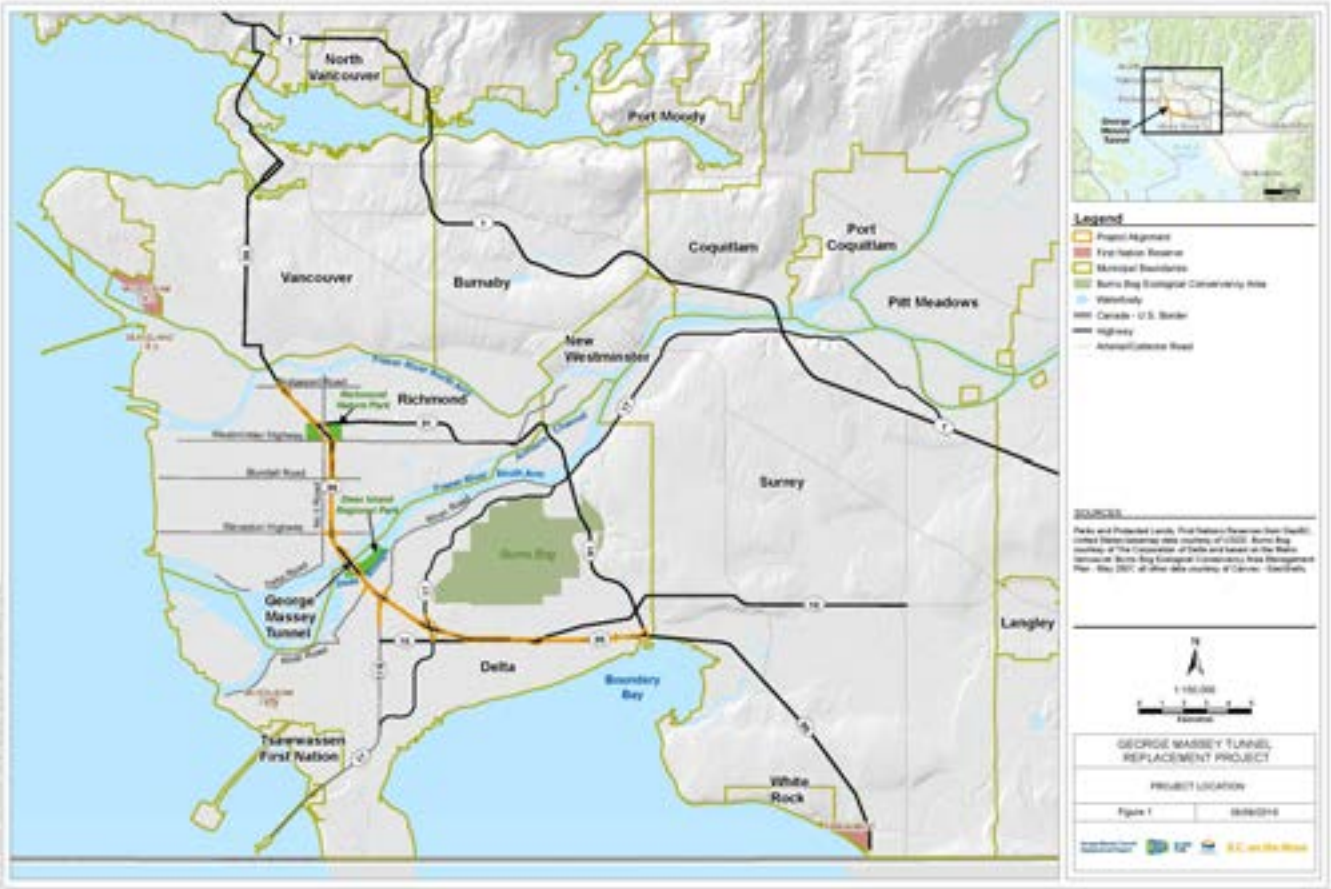
- **Support options for pedestrians and cyclists** – Provide a multi-use pathway on the new bridge to connect cycling and pedestrian corridors in Richmond and Delta.
- **Enhance the environment** – Enhance the environment under the new bridge and in the Project right-of-way on Deas Island.

In order to best achieve these goals, it was determined that a bridge should replace the Tunnel. Key features of the Project that have been considered in this HIA include the following:

- The replacement bridge will have eight general traffic lanes plus two dedicated transit/high occupancy vehicle (HOV) lanes, as compared with the Tunnel, which has four travel lanes with a counterflow system that provides three lanes in the morning and afternoon peak period direction.
- The Project includes improvements to several interchanges along Highway 99 in addition to widening the Highway to accommodate 50 kilometers of dedicated HOV lanes.
- Multi-use pathways will be included as part of the Project scope to provide improved access for cyclists and pedestrians and connect with the existing cycling and pedestrian networks on either side.
- Proposed interchange improvements include replacing the Westminster Highway, Steveston Highway and Highway 17A interchanges. Transit improvements include bus stops, including pedestrian and cyclist access, which will be integrated within the Steveston and Highway 17A interchanges.
- Highway 99 will be upgraded to modern engineering standards to increase safety.
- The new bridge will be built to modern seismic standards.
- Noise walls, or other noise mitigation measures, will be provided at applicable locations along the highway.
- The new bridge will be funded at least in part through user tolls.
- Subject to environmental approvals, construction is expected to begin in 2017, with the new bridge completed by 2022.

The Ministry has published extensive documentation describing the Project, as well as the planning and consultation process that has taken place over the last three years. This information is available online at **masseytunnel.ca.**

Figure 1: Project Location



1.3 The EA Process

Under the *B.C. Environmental Assessment Act* (*BCEAA*), proposed major projects, such as large transportation projects, must undergo an Environmental Assessment (EA). EA is a process that provides opportunity for reviewing proposed projects in order to assess potential impacts. This process involves engagement and consultation with stakeholders, Aboriginal Groups, permitting agencies and the public, and an array of technical studies. The Proponent, which in this case is the Ministry, submits an Application that describes the Project, its potential effects, and mitigation strategies. The review of the Application assists government in determining whether the Project should be approved and, if so, what conditions of approval might be appropriate.

The EA process considers environmental, economic, social, health and heritage values potentially affected by the Project.[6] Overall Project planning, including obtaining environmental approvals is typically supported by various stand-alone technical studies that may be conducted as appropriate. This HIA has been undertaken to support overall Project planning and, while it draws on information presented in the Application including the Project Description, it provides a separate consideration of the Project through a health lens.

2. ABOUT HEALTH IMPACT ASSESSMENT

2.1 What does "Health" mean?

Most contemporary definitions of health acknowledge that good health is different than merely an absence of disease, and that it incorporates physical, mental, and social well-being.[7] Healthy people are able to cope with everyday activities and to adapt to their surroundings.

Health is influenced by where people live, the state of their environment, their income and education levels, their jobs, as well as their relationships with friends, family and the larger community. These critical factors are often called '**health determinants'** (or determinants of health) because of their roles in shaping health of individuals and communities. Some health determinants are related to individual behaviours (e.g. smoking, eating healthy foods, or using seatbelts). Other health determinants are more closely tied to the physical environment (e.g. air and water quality, subsistence resources), activities under the control of institutions (e.g. public utilities, land use, access to alcohol and tobacco), working conditions (e.g. jobs, income), or the social environment (e.g. social, emotional, cultural, and religious supports). Genetics is also a contributor. Figure 2 shows a graphical representation of health determinants, and illustrates how different factors work together and interact to shape the health of individuals and communities.

Figure 2: A graphic representation of the determinants of health.

Source: Dahlgren and Whitehead (1991)[8]

The way that health determinants interact with each other contributes to **health outcomes** that are ultimately experienced by individuals, such as acute illness (e.g. gastrointestinal disease), chronic illness (e.g. hypertension), mental health status (e.g. depression or anxiety) and injuries or trauma (e.g. broken bones or concussion).

Another important concept implicit in contemporary definitions of health is '**health equity'**. Health equity refers to the way in which the supports and outcomes of good health are distributed across the

population. Health inequity occurs when there are unfair or avoidable differences in the distribution of diseases between population groups due to differences in access to health services and/or a healthy environment.[9] This concept is premised on the assumption that equity is achieved when all people have a fair opportunity to attain their full health potential.[10]

This HIA uses a broad definition of health, focusing on the proposed Project's potential effects on health determinants. It also considers how potential effects may be distributed amongst the population and whether health inequities may be exacerbated or lessened as a result.

2.2 What is HIA?

Health Impact Assessment (HIA) is a process that identifies how a specific policy, project or program could affect health determinants and health outcomes in human communities, and how those effects may be distributed within the population.

The purpose of HIA is to provide information to assist in decision-making, with an ultimate goal of enhancing the health benefits of the policy, project or program and mitigating potential harms.

Many resources and guidebooks are available that outline the basic steps of HIA. Figure 3 shows the HIA process as outlined in the *Health Impact Assessment of Transportation and Land Use Planning Activities Guidebook*,[11] (the Guidebook) developed Metro Vancouver, in collaboration with a number of regional and provincial agencies including regional health authorities, to integrate health considerations into infrastructure planning and development.

Figure 3: The HIA Process

Source: Metro Vancouver (2015)[11]

As described in the Guidebook and in other HIA toolkits and resources,[12] the HIA process consists of the following steps:

1. **Screening:** In this step, the proposed project is evaluated to determine whether conducting an HIA is appropriate and feasible, and whether it will add value to the decision-making process.

2. **Scoping:** Scoping is about planning the HIA. In this step, the approach for the HIA is determined (i.e. desktop, intermediate or comprehensive), the HIA team is created, the health effects to be assessed are established, the geographic and temporal boundaries established, the stakeholders identified, and the HIA work plan developed.

3. **Assessment and analysis:** In this step, the potential health effects of the proposed project are identified and characterized. A baseline community health profile is created, and a variety of quantitative and qualitative data are collected. An informed judgment of potential health effects is made based on available information, analysis, expertise and experience.

4. **Recommendations:** Based on the outcomes of the analysis, recommendations to mitigate potential adverse effects and enhance potential health benefits are identified.

5. **Reporting:** The results of the HIA are reported to stakeholders and decision-makers.

6. **Monitoring and evaluation:** In this final step, indicators are used to gauge the progress and outcomes of the project. The evaluation process helps determine whether or not the recommendations in the HIA are having the desired effects on health-related outcomes.

The way in which the HIA for this Project has approached each of these steps is described in **Section 3 Methods**.

3. METHODS

3.1 Screening

The EA that has been undertaken for the Project considers human health with a primary focus on exposure to airborne contaminants and noise. However, the actual health implications of the Project are broader in scope than these two areas.

Several stakeholders, primarily consisting of local health authorities, noticed this discrepancy in the representation of health within the Project. Due to the wide range of possible effects including potential benefits, both Vancouver Coastal Health and Fraser Health advocated for undertaking a project-focused HIA to provide a holistic consideration of health. In this context, the Ministry chose to conduct a HIA as a complement to the EA and other project-related planning work. Considering previous planning and consultation activities that have been undertaken to support Project development, and the work done in support of the environmental assessment process, it was determined that a **desktop HIA** would be an appropriate level of assessment.

3.2 Scope of the HIA

Health Interests

The Ministry's stakeholder consultation activities informed the scope of the HIA. While official consultation for the EA process began in January 2016, the Ministry had been engaging with a range of stakeholder groups to support Project planning over a period of almost three years. Results of consultation were used to develop the scope of the HIA. More specifically, the identification of health interests drew on several consultation sources: stakeholder consultation reports, consultation with Metro Vancouver, Delta, Richmond and other communities, and consultation with Aboriginal communities. There was also direct input from local health authorities on the proposed scope of the HIA. HIA authors additionally drew on their own expertise from similar infrastructure projects to populate any gaps in the scope of health interests.

Twelve health interests emerged from the scoping process, shown in Table 2. These have been grouped in the table under the five categories suggested by the Metro Vancouver HIA Guidebook:

- Physical Environment,
- Built Environment,
- Community and Social Factors,
- Livelihood Factors, and
- Lifestyle Factors.

The potential effects identified during construction and operations shown in Table 2 are speculative and represent the interests to be examined during the HIA assessment rather than the actual findings of the HIA. **Section 6.12 Tolling** also includes a discussion of the road tolling aspect of the Project.

Table 2: Health interests scoped for the HIA

Health Interest	Potential effects during construction (to be assessed)	Potential effects during operations (to be assessed)	Health outcomes that could be affected (to be assessed)
Physical Environment			
1. Exposure to Airborne Contaminants	• Cardiorespiratory effects, from dust and emissions due to construction and equipment	• Changes to health outcomes related to reduced emissions from reduced congestion-related idling • Changes in regional air quality due to traffic pattern changes	Cardiorespiratory health outcomes Additional health outcomes associated with airborne contaminants
2. Noise	• Construction-related noise	• Road traffic noise	Annoyance, sleep disturbance, speech comprehension
3. Food and Water Consumption	• Contamination of food sources via construction activities	• Changes to drinking water quality and security (e.g., water supply and infrastructure) • Changes to food (fish, agriculture) quality or acceptability • Exposure to contaminants via food/water sources • Changes to agricultural land production capability	Health considerations associated with changes in air quality/water quality
4. GHG Emissions	• NA	• Changes to emissions from a reduction in congestion-related idling • Changes to emissions from increases in traffic volumes or vehicle kilometers travelled	Climate change-considerations associated with construction and operation of the Project
Built Environment			
5. Active and Public Transportation	• Temporary restrictions of some routes leading to decreased walking/cycling • Effects on access to public transportation	• Change in walking and cycling conditions • Changes on access to public transportation	Physical activity, weight, metabolic outcomes, stress and equity
6. Traffic Safety	• Traffic diversions and change	• Change in traffic safety • Change in pedestrian and cyclist injuries due to increased walking/cycling • Changes in traffic accidents	Injury and fatality as well as stress and mental well-being
Social and Community Factors			
7. Connectivity and Access	• Social connectivity and community cohesion	• Changes in travel time • Changes in social connectivity and community cohesion • Changes in accessibility to services for low-access groups	Stress and mental well-being as well as care and management of health conditions
8. Emergency Response	• Emergency response times	• Changes in emergency response times	Health outcomes related to timely medical treatment

9. Safety and Security	• NA	• Suicide attempts • High-risk populations congregating at the base of the new bridge • Seismic stability compared with current Tunnel	Injury and mental well-being
Livelihood Factors			
10. Economic Health Effects	• Construction-related employment and contracts • Temporary impacts on access to local businesses • Limitations on movements of goods or services	• "Economic benefits" shown in EAC • Changes in access to employment opportunities "across the bridge" • Changes with respect to access to affordable housing • Health care costs associated with changes in chronic disease or injury	Multiple aspects of physical and mental well-being
Lifestyle Factors			
11. Recreation and Parks	• Temporary impacts to parks experience	• Changes in connectivity to park and recreation areas • Changes to park experience	Physical activity, weight, stress and mental well-being

Geographic Boundaries

HIAs include a requirement to define the geographic boundary that will be used to describe the spatial area in which health effects are considered. For an HIA, this means considering who could most likely be affected and what geographic area would include such individuals. The geographic boundaries for the HIA for the Project have been developed on an issue-by-issue basis in order to most appropriately capture the different effects of topics ranging from air quality to recreation and parks. Geographic boundaries were selected through considering existing boundaries used within relevant sections of the Application, input given by health authorities and identification of the overall population that would most likely experience health effects.

Table 3 presents the geographic boundaries that are used in this HIA.

Table 3: Populations of concern and corresponding geographic boundaries

Health Area	Population of interest from a health perspective	HIA geographic boundaries
Exposure to Airborne Contaminants	Residents who could experience changed exposure to air contaminants at the bridge or along the highway	A one-kilometre zone around the Project alignment.
Noise	Residents who could be exposed to increased noise levels at the bridge or along the highway.	500 m from either side of the Project alignment, except in the vicinity of the new bridge where it extends 1,600 m from either side of the Project alignment.
Food and Water Consumption	Consumers of food and water that could be affected by the Project. Water would be related to impacts on city water sources, whereas food sources would include fish and agricultural sources.	Municipalities of Richmond and Delta (west of Highway 91), and the Tsawwassen First Nation, including a one-kilometer boundary downstream and 500 m in upland areas of the Project alignment in the Fraser River.
GHG Emissions	Residents within the Fraser Valley airshed.	The lower Fraser Valley airshed, which is bounded to the north by North Vancouver, to the east by Hope, and to the south by the Cascade Mountains in Washington State.
Active and Public Transportation	Current and potential future walkers, bikers, and users of public transportation.	Municipalities of Richmond and Delta (west of Highway 91), South Surrey, and the Tsawwassen First Nation, including water access.
Traffic Safety	Drivers, cyclists and pedestrians using the Tunnel/bridge, and the Highway 99 corridor.	The Project alignment plus a 500-m surrounding buffer.
Connectivity and Access	Populations living, working, and using the municipalities and services on either side of the Tunnel, who frequently use the Tunnel.	Municipalities of Richmond, Delta and South Surrey.
Emergency Response	Population that could receive emergency services and response, where responders are travelling on the future bridge.	Municipalities of Richmond and Delta (west of Highway 91), and the Tsawwassen First Nation
Safety and Security	Residents of communities near the Project alignment.	Municipalities of Richmond and Delta (west of Highway 91), and the Tsawwassen First Nation
Economic Health Effects	Business owners/employees in the nearby municipalities, (Delta and Richmond), as well as businesses who rely on the Tunnel and the surrounding area for transportation or goods.	Metro Vancouver boundary.
Recreation and Parks	Users of parks near the Project alignment.	Major parks and recreation areas within the Municipalities of Richmond and Delta: • Richmond Nature Park • Deas Island Regional Park • Ernie Burnett Park

Temporal Boundaries

The HIA has selected a temporal boundary for this Project as follows:

- **Construction:** 2017 to 2022 (followed by decommissioning of the Tunnel for approximately one year).
- **Operations:** The operation of the bridge will continue for decades, and the assessment of several of the health interests are influenced by traffic forecasts into the future (e.g., 2031 and 2045). For many topics, modeling has been undertaken up to the year 2031 (e.g., air quality, noise) as local and regional development policies and plans beyond this point are less reliable in predicting future conditions.

3.3 Technical Data Sources

Stakeholder Involvement

This HIA relied on the reported results of stakeholder engagement activities that have been undertaken about the Project over the last three years with both the general public and with specific municipal, Aboriginal, professional and community-based organizations.

In addition, the scope of the HIA was directly reviewed by the Ministry and by the Vancouver Costal Health and the Fraser Health Authorities, as well as with select Aboriginal Groups, and their comments informed the HIA approach.

Additional stakeholder involvement that took place for the HIA, comprised a meeting and additional phone conversations between the HIA team and key emergency responders to help fill specific gaps around interests related to emergency response, safety and security. These meetings also helped supplement the traffic safety assessment.

Technical Works Supporting the HIA

The HIA also drew on a range of technical studies and data that have been developed by the Ministry to inform the Project. These included the results of the human health risk assessment presented in *Section 7.1 Human Health* of the Application and studies undertaken to support Project planning that are available on the Project website such as traffic and collision data reports. Additionally, the HIA team drew on sections of the Application being undertaken including those addressing subject areas such as fish and fish habitat, land use, noise, and air quality. HIA authors also reviewed draft management plans that have been developed, as part of the Application, to mitigate potential project-related effects.[b]

3.4 Effect Characterization

The assessment of each health interest draws on both qualitative and quantitative sources (where available) to describe the likely effects of the Project. Based on this analysis, each health effect is characterized using a number of standard parameters. These are:

[b] References to other sections within the HIA are indicated in bold font, while references to sections of the Application are indicated in italicized font with section numbers included.

- Direction
- Size and distribution of population potentially affected
- Magnitude
- Likelihood
- Equity considerations
- Confidence for the effect

Definitions for these parameters, in addition to what constitutes a high, medium or low effect, are shown in Table 4.

Table 4: Effect characterization parameters and definitions

Parameter	Rating	Definition
Direction	**Positive**	A beneficial or desirable change
	Adverse	An adverse or undesirable change
	Mixed	Both beneficial and adverse effects may occur
Size / Distribution	**Small (limited)**	Effects mainly occur in close proximity to the Project site/activities
	Medium (localized)	Effects mainly occur within the population boundary (population affected will be defined)
	Large	Effects extend beyond the population boundary (population affected will be defined)
Magnitude*	**Low**	Causes/reverses effects that can be quickly and easily managed or do not require treatment
	Medium	Has the potential to cause/reverse effects that necessitate treatment or medical management and are reversible
	High	Has the potential to cause/reverse effects that are chronic, irreversible or life-threatening
Likelihood	**Unlikely**	There is little potential for the effect to occur as a result this Project
	Possible	The effect may occur, but is not common in similar projects of this type
	Likely	The effect commonly occurs in projects of this type
Equity Considerations	**Improvement**	Has the potential to disproportionately and positively affect subpopulations that are disadvantaged (populations affected will be defined)
	Adverse	Has the potential to disproportionately and negatively affect subpopulations that are disadvantaged (populations affected will be defined)
	No equity effect	The effect is not likely to disproportionately affect disadvantaged populations
Confidence	**Low**	Evidence for this anticipated effect is limited
	Medium	There is some evidence for this effect; however, there are also gaps in available evidence
	High	The quality of evidence for this anticipated effect is high

Note: *Magnitude can be characterized for both positive and negative health effects. For positive health effects, this would **reverse** health problems, while negative health effects would **cause** health issues.

3.5 Approach to Recommendations

Based on the findings from the assessment, the HIA identifies recommendations for enhancing and protecting public health in the context of advancing the Project. These recommendations, which include both mitigation measures for specific effects as well consultation on specific topics during future stages of project planning, have been integrated into appropriate sections of the Application.

3.6 Limitations and Gaps

While this HIA uses the best information available, there still remain a number of limitations in the assessment.

- For many of the health areas discussed in this HIA, there is little evidence-based literature that quantifies the health changes associated with changes in the biophysical or social environment that is applicable to this Project.

- Most health outcomes are multi-factorial; that is, they are influenced by a wide variety of causes, and changes in health outcomes can rarely be confidently credited to a single factor. For HIA, this means that a future change in health outcomes compared to current conditions cannot be easily connected to activities of the Project or to any other single source.

- The desktop approach used for this HIA relied primarily on previous stakeholder engagement that had been conducted for the Project.

- Much of the data that is available to describe health conditions in the study area, such as the *My Health My Community* survey and data provided by Statistics Canada, is only available for a geographic area that is much larger than the study area. As a result, it is not possible to identify the extent to which this data may be representative of the populations specifically affected by the Project.

4. COMMUNITY PROFILE

4.1 Community Overview

Metro Vancouver is a region that consists of multiple municipalities, each of which has unique characteristics. This section provides an overview of Metro Vancouver, as well as the two municipalities where the key Project elements are located: the City of Richmond and the Corporation of Delta.

Metro Vancouver

Metro Vancouver is a regional district on B.C.'s Pacific Coast comprised of 23 local authorities, including 21 municipalities, one treaty First Nation, and one electoral area. Although the region is urban – with a current population of 2.3 million people and counting – only a third of its total area of 2,865 square kilometres is designated as such; the remaining two-thirds of the land is made up of forests, alpine areas, wetlands, marshes, streams, rivers, estuaries, and agricultural lands. Metro Vancouver has committed to ensuring that urban development is contained as the region moves into future development. This commitment, made within the *Metro Vancouver 2040: Shaping our Future* regional growth strategy, not only reinforces the protection of natural areas, but will also enhance the efficiency of core services and transit in Metro Vancouver.[13]

City of Richmond

The City of Richmond is one of Metro Vancouver's constituent communities. It is comprised of one main island and a series of smaller islands located at the mouth of the Fraser River.[14] In the 1990s, the city experienced significant population increase and continues to grow as a multi-ethnic urban centre. While Statistics Canada placed the population at 189,305 in 2011,[15] the City of Richmond more recently estimated the population to be 213,891 people as of 2014.[16] As of 2011, 70 per cent of Richmond's population identified as a visible minority, the highest proportion of any municipality in the province.[17] Additionally, 60 per cent of Richmond's population are of Chinese or South Asian ancestry.[16] The City of Richmond also has the highest life expectancy in all of Canada; its residents live 84.1 years on average. Its economy is highly varied, including services, retail, tourism, technology, manufacturing, airport services, aviation, agriculture, fishing, and government sectors.[14]

Richmond consists of a blend of residential and commercial property, agricultural lands, industrial parks, waterways, and public amenities, including parks, trails, cycling routes, as well as arts, culture and heritage facilities, and the Richmond Hospital. The community is connected to the mainland via two provincial highways (Highway 91 and Highway 99), a rapid transit line, and two railway lines, and also contains two international seaports as well as the Vancouver International Airport.[14] Overall, the municipality relies more heavily than others in the area on cars for daily commuting, rather than biking, walking, or public transit.[18]

Corporation of Delta

Bordered by the Fraser River to the North and the United States to the South, Delta has approximately 100,000 residents.[13] The Corporation of Delta is itself comprised of three communities: Ladner, Tsawwassen, and North Delta.[19] It is a prosperous municipality, with an average household

income that is 30 per cent higher than the Canadian average, and also has a reputation for being safe, quiet, and clean. Although it has a strong farming and agricultural background, the municipality is currently one of the fastest growing industrial areas in the Metro Vancouver region; Annacis Island Industrial Park and Tilbury Industrial Park – two of Vancouver's top four business parks – are located in Delta and are home to aerospace, manufacturing, distribution, and high-tech businesses.[19, 20]

Delta has a vast array of public facilities, including the Boundary Bay airport, a museum and archives, libraries, waterfront parks, trails, cycling paths, and the Delta Hospital.[19]

4.2 Community Demographics

Demographic data for the City of Richmond, the Corporation of Delta, the region of Metro Vancouver, the province of B.C. and Canada as a whole are outlined in Table 5. In comparison to Metro Vancouver overall, Richmond has a higher population density, while Delta is far less densely populated than either Richmond or Metro Vancouver. As of 2011, Richmond also had nearly double the number of residents in comparison to Delta.

Over 40 per cent of the population in both Richmond and Delta are children and seniors, meaning that a substantial proportion of both municipalities is comprised of people who have higher levels of susceptibility to health challenges.

Both Aboriginal and immigrant populations contribute to community cultural diversity, and while Richmond, Delta, and Metro Vancouver all have lower percentages of Aboriginal residents in comparison to B.C. and Canada, the proportion of immigrants in these communities is considerably higher than for the province or the country.

Table 5: Community Demographics, 2011

	City of Richmond	Corporation of Delta	Metro Vancouver	British Columbia	Canada
POPULATION					
Total population	189,305	98,745	2,280,700	4,324,455	32,852,325
Population density per km^2	1,473.5	554.4	802.5	4.8	3.7
AGE					
Median age	42.1	42.8	40.2	41.9	40.6
Children (ages 19 and under)	27.7%	32.5%	28.3%	28.4%	30.3%
Seniors (ages 65 and over)	13.7%	15.7%	13.7%	15.9%	15.1%
ABORIGINAL IDENTITY					
Population Aboriginal identity	1.0%	2.3%	2.3%	5.4%	4.4%
BIRTHPLACE					
Population born in Canada*	42%	67%	64%	--	--

Sources: National Household Survey Profile (2011)[15]; My Health My Community (2014)[18, 21]
Notes: *Data from 2014

4.3 Social and Economic Indicators

Indicators for income, employment, education, and home ownership are shown in Table 6. These indicators comprise important determinants of health, as they contribute to independence, purchasing power, and social and economic resilience. The table shows that individuals and families in Delta are on average more affluent than their regional, provincial, and national counterparts. Contributing to this relative affluence is Delta's high rate of employment and a low percentage of the population that is not in the labour force (i.e. people who are not employed and who are not seeking employment).

Although Richmond residents report incomes that are lower than the Canadian average – and 38 per cent of its population earns less than $40,000 annually – a slightly higher proportion of Richmond's population has completed a postsecondary education than in Delta. Residents in both municipalities are more likely than their Canadian counterparts to live in homes that they own rather than in rented properties or band housing. Home ownership, which encourages social cohesion and civic participation in the community, has positive impacts on health.

Table 6: Social and Economic Indicators, 2011

	City of Richmond	Corporation of Delta	Metro Vancouver	British Columbia	Canada
HOUSEHOLD INCOME					
After-tax income					
Median after-tax individual income of population 15 years and over	$22,599	$30,510	$26,796	$26,842	$27,334
Median couple-only family after-tax income	$59,987	$71,697	$67,106	$62,765	$59,975
Median couple-with-children family after-tax income	$73,963	$95,687	$84,771	$83,510	$83,801
Median lone-parent family after-tax income	$39,950	$50,585	$42,648	$40,646	$42,401
Income brackets					
Under $40,000*	38%	22%	32%	-	-
$40,000 to $79,999*	27%	29%	28%	-	-
$80,000 to $119,999*	19%	25%	21%	-	-
$120,000 and above*	16%	24%	19%	-	-
EMPLOYMENT					
Employed	57.3%	62.0%	61.4%	59.6%	60.9%
Unemployed	4.4%	4.1%	4.7%	5.0%	5.1%
Not in the labour force	38.3%	33.9%	33.9%	35.4%	34.0%
EDUCATION					
No certificate, diploma or degree	14.2%	15.7%	14.6%	16.7%	20.1%
High school diploma or equivalent	27.9%	29.7%	26.8%	27.7%	25.6%
Postsecondary certificate, diploma, or degree	57.9%	54.6%	58.6%	55.6%	54.3%
HOME OWNERSHIP					
People living in a home they own	77.1%	81.0%	65.5%	70.0%	69.0%
People living in a home they rent	22.9%	19.0%	34.5%	29.8%	30.6%
People living in band housing	0.0%	0.0%	0.0%	0.2%	0.4%

Sources: National Household Survey Profile (2011)[15]; My Health My Community (2014)[18, 21]
Notes: *Data from 2014

4.4 Health Indicators

Data for key health indicators, for Metro Vancouver, Richmond and Delta, are presented in Table 7. *Self-rated general health* describes the self-reported health status of respondents. Based on the results of the *My Health My Community* survey conducted among residents of Metro Vancouver, Richmond residents consider themselves to be less healthy than do residents of Metro Vancouver overall. In Delta, on the other hand, residents were more likely to rate their general and mental health as excellent or very good in comparison to those in the region as a whole. However, health outcome data show that Delta residents actually had higher reported rates of obesity, diabetes, high blood pressure, heart disease, and multiple chronic conditions than residents in Richmond, despite higher self-reported health status (Table 7).

In addition, Delta's residents were more likely than those in Richmond to engage in unhealthy lifestyle behaviours (e.g., smoking, alcohol consumption); however, they were also more likely to partake in healthy lifestyle choices (e.g., food choices and regular physical activity). While stress rates in Delta are on par with those in the Metro Vancouver region overall, Richmond residents report considerably lower rates of extreme stress.

Access to primary care is relatively good in both municipalities; a higher proportion of residents in both Richmond and Delta report having family physicians than do residents in the Metro Vancouver region.

The all-cause standardized mortality ratio indicates that in both Richmond and Delta, fewer people die prematurely per year than in B.C. overall. Likewise, the average life expectancy in both municipalities is higher than for the province as a whole.[22]

It should be noted that for all of these indicators, the observed differences may not reach statistical significance.

Table 7: Health Indicators, 2014

	City of Richmond	Corporation of Delta	Metro Vancouver
HEALTH STATUS			
Self-rated general health (excellent/very good)	41.5%	51.0%	48.5%
Self-rated mental health (excellent/very good)	52.4%	61.6%	56.5%
Obese (BMI 30+)	16.9%	26.6%	21.7%
Diabetes	8.4%	9.8%	7.7%
Hypertension	20.2%	21.0%	17.9%
Heart disease	4.7%	7.2%	4.7%
Multiple chronic conditions	8.6%	10.7%	7.9%
Cancer (lung, breast, prostate, or colorectal)	3.1%	2.8%	2.9%
LIFESTYLE			
Binge drinking (1+ times/month)	15.0%	19.8%	20.7%
Smoker (daily/occasional)	7.8%	8.7%	10.6%
Physical activity (150+ minutes/week)	37.5%	46.0%	44.1%
Fruit and vegetable intake (5+ servings/day)	20.9%	25.0%	24.9%
Stress (extremely/quite stressed)	13.9%	17.9%	17.8%
PRIMARY CARE ACCESS			
Have a family physician	87.1%	90.7%	83.1%
Visited a healthcare professional (past 12 months)	79.8%	84.4%	80.4%
MORTALITY			
All-cause standardized mortality ratio, relative to provincial population (2007-2011)*	0.74	0.92	-
LIFE EXPECTANCY			
Life expectancy at birth (2007-2011)*	84.1	83.0	-

Sources: My Health My Community (2014)[18, 21]; British Columbia Vital Statistics Agency (2011)[23]
Note: *Data from 2011

4.5 Health Care Services

Health care in B.C. is provided through the B.C. Ministry of Health, which organizes service delivery through six health authorities. Richmond falls under the Vancouver Coastal Health Authority while in Delta health care service is delivered through the Fraser Health Authority. The First Nations Health Authority assumed responsibility for the health and well-being of Aboriginals in the province in 2013, making it their goal to successfully address health disparities between Aboriginals and non-Aboriginals in B.C. through collaboration and coordination with the Ministry of Health and Regional Health Authorities.[1]

In the City of Richmond, the Vancouver Coastal Health Authority delivers healthcare through the Richmond Hospital. However, the municipality's aging and growing population has put a strain on the hospital's resources; although it has the highest hospital bed efficiency rate in the province, it currently has the lowest number of beds per capita, and its infrastructure is aging.[24] The hospital currently has 200 beds and provides emergency, ambulatory care, diagnostics, intensive care, coronary care, maternity, psychiatry, and surgery services.[25]

In the Corporation of Delta, long wait times and delayed service for emergency response – in part due to the municipality's large land area – have caused concern, leading to the training of firefighters as Emergency Medical Responders.[26] Access to primary care in Delta is particularly high, with over 90 per cent of the population reporting access to a family physician.[21] The Delta Hospital has 58 acute care beds as well as 92 residential care beds. As a primary care community hospital, it is the first point of contact for preventing, diagnosing, and treating patients, and provides some specialized care.[27]

4.6 Aboriginal Groups

Project planning involved consultation and engagement with 13 Aboriginal Groups identified during the environmental assessment process as having potential interests in the Project. These include:

- Cowichan Tribes
- Halalt First Nation
- Katzie First Nation
- Kwantlen First Nation
- Lake Cowichan First Nation
- Lyackson First Nation
- Musqueam Indian Band
- Penelakut Tribe
    - Hwilitsum
- Semiahmoo First Nation
- Squamish Nation
- Stz'uminus First Nation
- Tsawwassen First Nation
- Tsleil-Waututh Nation

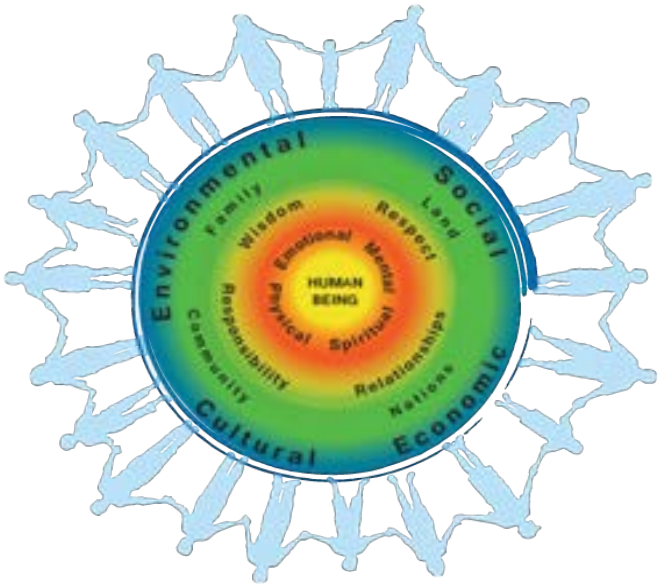
For the purposes of this HIA the health of Aboriginal Groups is considered differently than other individuals and communities in Canada. This has been done for a number of reasons.

For many Aboriginal Groups, "health" is a concept that is holistic and centers on the interconnectedness of land, water, culture and identity.[28] For many, these factors cannot be considered separate from one another. A quotation that illustrates this concept is shown below, originally published in the *BC First Nations and Aboriginal People's Mental Wellness and Substance Use 10 Year Plan*.[29]

> "*To live in wellness means striving to be in balance, within self (Body, Mind, Spirit and Emotion), with others (Family & Community), with the Spirit World and with the land (nature). If there is an imbalance in any of these areas there is stress on our overall system. In time this stress causes illness and it can be physical illness, mental/emotional illness (such as depression), or spiritual illness.*"

A new health and wellness model was launched at the *Gathering Wisdom for a Shared Journey Forum*, hosted by the B.C. First Nations Health Council in the summer of 2013. Drawing on these traditional ideas and concepts, the new health and wellness model involves spiritual, emotional, mental and physical aspects of health and how one must understand and maintain balance of the four elements. The model also incorporates healing practices, including holistic and natural medicines; and spiritual and emotional counsel from an Aboriginal perspective. This wellness model is shown in Figure 4. While health continues to be highly individual, this figure gives an idea of how health can be shaped in a way that is specific to Aboriginal Groups.

Figure 4: First Nations Perspective on Health and Wellness



Source: First Nations Health Authority, (2016)[1]

Another reason to consider the health of Aboriginal Groups distinctly is because the factors that influence health among Aboriginal Groups may be different than those for other subsets of the general population.

For all Canadians, the social, economic and physical environments that we live within play a strong role in determining health. These social, economic and environmental factors are referred to as 'health determinants'. Although the health of all people can be affected by some of the same things, such as having access to income, nutritious food, safe housing and clean air and water, there are unique determinants for Aboriginal Groups that speak to the different ways that these communities may experience health.[28] Determinants of health that have been identified by the National Aboriginal Health Organization[30] and are specific to an understanding of health in an Aboriginal context in Canada are:

- Colonization
- Globalization
- Migration
- Cultural continuity
- Territory
- Access
- Poverty
- Self-determination

It is important to recognize that all health determinants are highly interconnected in how they affect the health of individuals and communities. They interact together, and are often outside the control of an individual person.

A further reason to consider the health of Aboriginal Groups distinctly is because historically, there has been a gap between the health status of Aboriginal Groups and non-Aboriginal Groups in Canada (see **Section 4.7 Aboriginal Groups** in the Community Profile). While that gap has substantially improved over the last few decades, there are still large strides to be made.[31]

The planning and development of projects such as this Project have the potential to contribute to positive health and wellness, but may also result in adverse impacts where the health of Aboriginal Groups may not be fully considered. Therefore, it is important to understand how Project activities could specifically interact with the factors that work together to shape positive health among Aboriginal Groups.

Throughout the assessment sections of this HIA, the potential for the Project to disproportionately or uniquely affect Aboriginal Groups is discussed. Following the submission of the HIA, and as part of the ongoing Aboriginal Consultation program for the Project, Aboriginal Groups may provide feedback on the findings and conclusions of the assessment. The environmental assessment undertaken under *BCEAA* will consider potential effects to a range of values not specifically linked to health that will be of interest to Aboriginal Groups. Concerns beyond the scope of the HIA will be addressed through the Aboriginal Consultation program for the Project.

4.7 Vulnerable Populations

Vulnerable populations include those people who are more likely than others to suffer adverse health effects. Biological factors (e.g. age), social constructs (e.g. gender, ethnicity), material conditions (e.g. employment, income), or exposure to harmful environments (e.g. populations in certain areas) can all contribute to the vulnerability of a particular group.[12] In a wider sense, a vulnerable population is any population that is "at elevated risk of suffering harm as the result of one or more" factors.[32]

Vulnerable populations in the Canadian context often include Aboriginal peoples; people living in poverty; immigrants and temporary workers; refugees; people with disabilities; people who are gender and sexually diverse; people experiencing homelessness or lack of affordable housing; people with low literacy skills; and people living in poor, rural or remote communities.[33]

This definition is also relevant in the Project context, though in both Richmond and Delta, the majority of these vulnerable groups do not represent a substantial proportion of the population. For instance, homelessness is less of a concern in Richmond and Delta than for other municipalities in the Metro Vancouver region.[34]

On the other hand, the elderly represent a considerable, and growing, vulnerable group in both Richmond and Delta. Indeed, the population is aging in both municipalities; between the 2011 Census and the 2014 *My Health My Community* survey, Richmond's population aged 65 and over grew from nearly 14 per cent to 17 per cent, while in Delta it grew from under 16 per cent to 19 per cent.[15, 18, 21] Moreover, Richmond has nearly double the percentage of private households with an after-tax annual income of less than $20,000 than Delta (15.4% for the former versus 8.7% for the latter), as well as a higher proportion of the population with a postsecondary education.[15] Again, these statistics likely point to the large proportion of elderly retirees in Richmond, as do various health indicators such as the higher rates of self-reported health issues and slightly higher cancer rates.

5. SUMMARY OF FINDINGS

Section 6 presents the analysis of effects and associated mitigations for each of the 11 health interest areas. The table below summarizes these findings. Key highlights of the assessment include the following:

- As a result of the Project, health benefits are expected in the areas of exposure to airborne contaminants; greenhouse gas emissions; active and public transportation; traffic safety; safety and security; connectivity and access; emergency response; and economic considerations.
- Project construction may result in temporary air quality, noise, and recreational and park access impacts. These impacts will be effectively mitigated to avoid health impacts.
- Overall, the Project is anticipated to improve health equity by providing disadvantaged groups with better access to reliable transportation options.
- Aboriginal Groups and individuals will experience the same benefits from the Project as the general population. Ongoing engagement with Aboriginal Groups will be key to ensuring that these groups and individuals do not disproportionately experience adverse effects.

Table 8: Characterization of Health Interests Assessed in the HIA

	Direction	Size of population affected	Magnitude	Likelihood	Equity considerations	Confidence
Exposure to Airborne Contaminants	Positive	Medium	Medium/ high	Likely	Improvement	High
Noise	Mixed	Medium	Low	Likely	No equity effect	High
Food and Water Consumption	Neutral	Small	Low	Possible	Adverse	Medium
GHG Emissions	Positive	Large	Low	Likely	No equity effect	Medium
Active & Public Transportation	Positive	Medium	Medium/high	Likely	Improvement	High
Traffic Safety	Positive	Medium	Medium to high	Likely	No equity effects	Medium
Connectivity and Access	Positive	Medium	Medium	Likely	Improvement	Medium
Emergency Response	Positive	Small	High	Likely	No equity effect	High
Safety and Security	Neutral to positive	Medium	High	Low	No equity effect	High
Economic Health Effects	Positive	Large	Medium	Likely	Improvement	Medium
Recreation and Parks	Mixed	Large	Medium	Likely	No equity effect	Medium

6. TOPIC-SPECIFIC FINDINGS & RECOMMENDATIONS

6.1 Exposure to Airborne Contaminants

Why is exposure to Airborne Contaminants a health interest?

Airborne contaminants refers to chemical substances that either don't occur naturally in the air, or that are present in unusually high concentrations. Examples of airborne contaminants include particulate matter (dust, smoke), diesel emissions from machinery, exhaust from cars, and waste product from incinerators. Exposure to airborne contaminants may induce adverse respiratory health effects such as asthma, chronic bronchitis, and decreased pulmonary function as well as cardiovascular events, increased hospital admissions, and increased mortality.[35] Whether or not any health problems occur from exposure depends on factors that include the nature of the contaminant substance, the amount of exposure, and the sensitivity of the person who comes in contact with the contaminant.

How was exposure to Airborne Contaminants assessed?

Section 7.1 Human Health of the Application presents the results of a human health risk assessment that evaluated the potential risk from exposure to Project-related airborne contaminants. A summary of results from this assessment is presented below. No further analysis of contaminant exposure was conducted for the HIA; rather, the results from the human health risk assessment are presented in this HIA report so that all health-related information appears in one place.

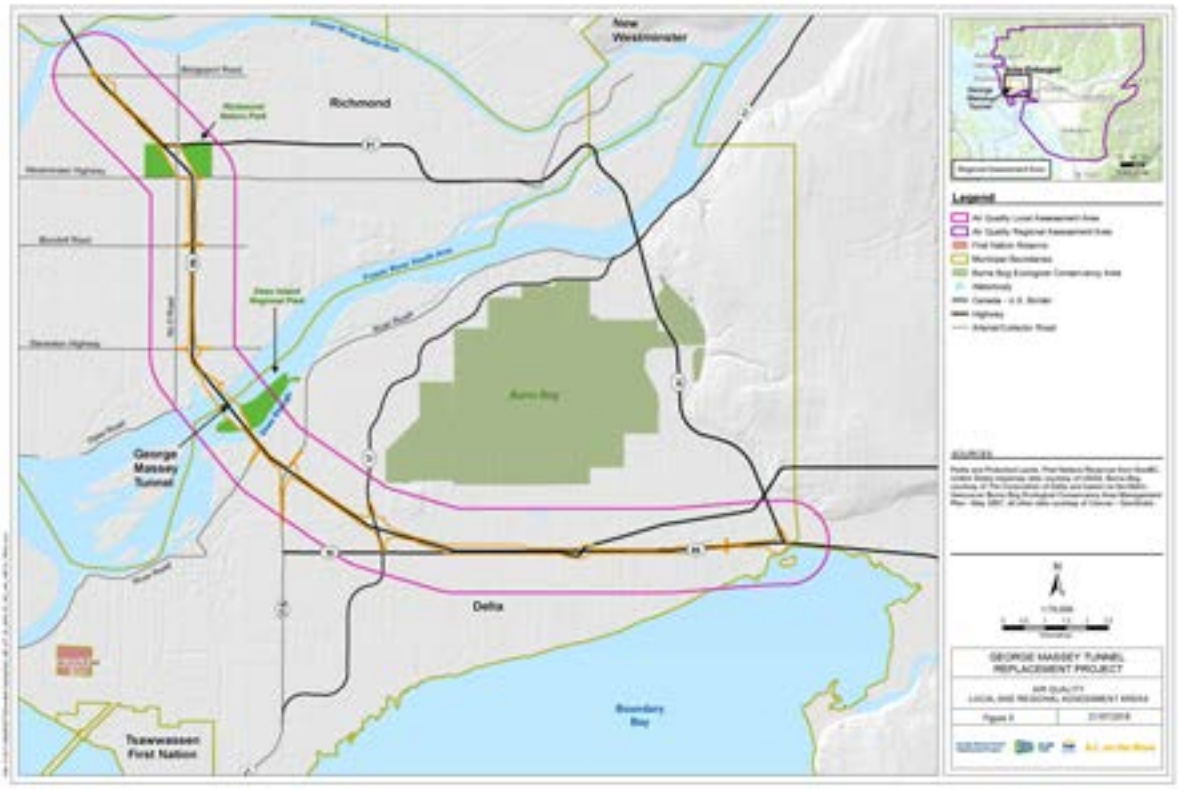
Air quality assessment work undertaken to support the environmental assessment process was supported by the modeling of air quality across the study area (Figure 5). These locations were selected as representative of areas where people may spend extended periods of time and included residences, school and learning settings, medical/care facilities, places of worship, parks, and agricultural lands situated near the Project. More information about the selection of geographic boundaries, receptor locations and the air quality modeling approach can be found in *Section 4.9 Air Quality* of the Application.

The human health risk assessment undertaken in support of the environmental assessment compared the estimated level of each air contaminant against health-based exposure limits developed by regulatory agencies including the Agency for Toxic Substances and Disease Registry, the B.C. Ministry of Environment, Health Canada, the International Agency for Research on Cancer, Metro Vancouver, the United States Environmental Protection Agency, and the World Health Organization.

For each air contaminant, a Risk Quotient (RQ) was calculated. The RQ compares the measured concentration of the substance with published maximum exposure limits.

- Where the RQ is less than 1.0, it means that the concentration of the substance is lower than the permitted upper limit.
- Where the RQ is greater than 1.0, it means that the concentration of the substance in the air is higher than the permitted upper limit.

Figure 5: Air Quality Local and Regional Assessment Area



Source: George Massey Tunnel Replacement Project Application Information Requirements (May 24, 2016)

What do we know about existing conditions for Airborne Contaminants?

Air quality studies undertaken to support the environmental assessment process assessed changes in specific air contaminants, including those that are of concern in terms of both acute and chronic inhalation exposure. Table 9 below, which is taken from *Section 7.0* of the Application (*Appendix B*), shows modeled 2011 air quality for chemicals of concern for acute inhalation. The table presents data for three areas: across the LAA, at the "maximum point of impingement" (MPOI) for Delta, and at the MPOI for Richmond. Maximum point of impingement refers to the location in Delta or Richmond where the highest air concentrations are predicted to occur. The MPOIs, in this case, were locations within five to 15 metres of the road at either entrance to the Tunnel.

The table shows that for most chemical substances, the RQ values are far below 1.0, meaning that the concentration of these substances in the air is below the regulatory limits. However, RQ values are higher than 1.0—in other words, higher than the regulatory threshold—for some substances in some locations. The RQ values higher than 1.0 are bolded in the table, and comprise PM_{10} and respiratory irritants in the Delta and Richmond MPOIs.

It should be noted that RQ values over 1.0 do not mean there is necessarily a health risk for some or all people; the RQ modeling is based on conservative assumptions (i.e., greater exposure periods than would likely occur) and results in an over-estimate of potential risk.

Table 9: Existing (2011) air quality conditions for residences: substances of concern for acute inhalation.

Chemical / Substance	Duration of exposure	Across LAA	Delta MPOI	Richmond MPOI
Carbon monoxide	1 hour	0.5	1.0	1.0
	8 hours	0.5	1.0	0.9
Nitrogen dioxide	1 hour	0.8	0.8	0.8
Sulphur dioxide	10 minutes	0.1	0.1	0.1
	1 hour	0.1	0.2	0.2
Ammonia	1 hour	0.1	0.2	0.2
PM_{10}	24 hours	0.9	**2.0**	**2.0**
$PM_{2.5}$	24 hours	0.7	1.0	1.0
Acetaldehyde	1 hour	0.02	0.05	0.05
Acrolein	1 hour	0.3	0.7	0.7
Benzene	1 hour	0.03	0.1	0.1
1,3-butadiene	1 hour	0.003	0.01	0.01
	24 hours	0.04	0.08	0.07
Formaldehyde	1 hour	0.3	0.7	0.6
Naphthalene	1 hour	0.001	0.003	0.003
Eye irritants[1]	1 hour	0.6	**2.0**	**2.0**
Respiratory irritants[2]	1 hour	0.9	1.0	1.0

Notes: Values in **bold**: RQ >1.0
[1] Combined one-hour RQ values for ammonia, acrolein, formaldehyde, and naphthalene
[2] Combined one-hour RQ values for ammonia, acetaldehyde, naphthalene, nitrogen dioxide, and sulphur dioxide
Source: Adapted from the Application

Table 10, also taken from *Section 7.0* of the Application (*Appendix B*), shows RQ values for a number of chemicals for which chronic inhalation is a concern for health endpoints. None of these chemicals had a risk quotient above 1.0.

Table 10: Existing (2011) air quality conditions for residences: substances of concern for chronic inhalation

Chemical	Residences within the LAA
NO_2	1
SO_2	0.1
Ammonia	0.01
DPM	0.2
PM_{10}	0.9
$PM_{2.5}$	0.9
Acetaldehyde	0.005
Acrolein	0.03
Benzene	0.1
1,3-butadiene	0.1
Formaldehyde	0.2
Naphthalene	0.1
Nasal irritants[a]	0.4

Notes: Values in **bold**: RQ >1.0
[a] Combined annual RQ values for acetaldehyde, acrolein, formaldehyde, and naphthalene
Source: Reproduced from the Application

What are the potential effects of the Project?

Construction

As described in *Section 7.1 Human Health* of the Application, during construction, the diesel-powered equipment used for building the bridge will be the primary source of air emissions. Emissions from diesel engines vary substantially from engine to engine, and have also changed over time with new technologies. Improved diesel fuel and newer diesel technologies have been linked with substantially fewer harmful emissions and fewer health effects.[36]

The human health risk assessment undertaken in support of the environmental assessment determined that potential health risks as a result of temporary exposure to construction emissions are unlikely to occur, as the Project will implement best management practices for vehicle and equipment operation (see **Mitigation Measures** below).

Operations

Once the bridge is open for use, air quality is expected to improve compared to current conditions. This improvement stems from two sources:

- First, the new bridge will allow for better dispersion of vehicle emissions because it is elevated above ground level.
- Second, the new bridge will reduce emissions at specific locations by alleviating congestion and allowing vehicles to drive at highway speeds.

The human health risk assessment undertaken in support of the environmental assessment developed estimates of contaminant exposure for residences and for recreational users of the area for the future for the year 2031, both with and without the Project in place. Results are discussed below.

Exposure to air emissions at residences

Table 11, taken from *Section 7.0* of the Application (*Appendix B),* shows the estimated exposure to substances that may cause acute inhalation responses. The table shows three different time points (existing 2011 conditions; the year 2031 without the Project; and the year 2031 with the Project).

As shown in the table, for both future scenarios there is a reduction in the amount of most air contaminants, primarily due to improvements in vehicle technology, and the predicted exposure is, for many substances, far below the maximum allowed. However, the improvement is much greater with the Project than without the Project.

Table 11: Acute Inhalation Risk Quotients – Residential

		Existing conditions (2011)			Future (2031) WITHOUT Project			Future (2031) WITH Project		
Chemical / Substance	**Duration of exposure**	**LAA**	**Delta MPOI**	**Richmond MPOI**	**LAA**	**Delta MPOI**	**Richmond MPOI**	**LAA**	**Delta MPOI**	**Richmond MPOI**
Carbon monoxide	1 hour	0.5	1.0	1.0	0.4	1.0	1.0	0.5	0.8	0.8
	8 hours	0.5	1.0	0.9	0.4	0.9	0.8	0.4	0.6	0.6
Nitrogen dioxide	1 hour	0.8	0.8	0.8	0.7	0.8	0.8	0.7	0.7	0.7
Sulphur dioxide	10 minutes	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.06	0.06
	1 hour	0.1	0.2	0.2	0.1	0.2	0.2	0.1	0.09	0.09
Ammonia	1 hour	0.1	0.2	0.2	0.1	0.2	0.2	0.03	0.06	0.06
PM_{10}	24 hours	0.9	**2.0**	**2.0**	0.9	**2.0**	**2.0**	0.8	1.0	1.0
$PM_{2.5}$	24 hours	0.7	1.0	1.0	0.7	1.0	1.0	0.6	0.8	0.8
Acetaldehyde	1 hour	0.02	0.05	0.05	0.02	0.03	0.03	0.02	0.01	0.01
Acrolein	1 hour	0.3	0.7	0.7	0.2	0.4	0.4	0.1	0.08	0.08
Benzene	1 hour	0.03	0.1	0.1	0.02	0.06	0.06	0.02	0.03	0.03
1,3-butadiene	1 hour	0.003	0.01	0.01	0.002	0.005	0.005	0.002	0.003	0.003
	24 hours	0.04	0.08	0.07	0.04	0.05	0.05	0.04	0.04	0.04
Formaldehyde	1 hour	0.3	0.7	0.6	0.2	0.5	0.5	0.1	0.1	0.1
Naphthalene	1 hour	0.001	0.003	0.003	0.001	0.002	0.002	0.001	0.001	0.001
Eye irritants[a]	1 hour	0.6	**2.0**	**2.0**	0.5	1.0	1.0	0.3	0.3	0.3
Respiratory irritants[b]	1 hour	0.9	1.0	1.0	0.9	1.0	1.0	0.8	0.9	0.9

Notes: Values in **bold**: RQ > 1.0

[a] Combined one-hour RQ values for ammonia, acrolein, formaldehyde, and naphthalene

[b] Combined one-hour RQ values for ammonia, acetaldehyde, naphthalene, nitrogen dioxide, and sulphur dioxide

Source: Adapted from the Application

Table 12 shows the RQ for substances that are of concern for chronic exposure. Projections are given for existing conditions, future without the Project, and future with the Project for the LAA as a whole. The table shows that without the Project, the RQ for some substances will decrease (e.g., benzene, NO_2) but others will remain the same (e.g., PM_{10}, ammonia, 1,3-butadiene). With the Project, however, the RQ for all substances is lower than or unchanged from existing values, and lower than established thresholds that are protective of human health.

Table 12: Chronic Inhalation Risk Quotients– Residences

Chemical	Existing (2011)	Future (2031) without Project	Future (2031) with Project
NO_2	1.0	0.7	0.6
SO_2	0.1	0.1	0.1
Ammonia	0.01	0.01	0.01
DPM	0.2	0.1	0.1
PM_{10}	0.9	0.9	0.8
$PM_{2.5}$	0.9	0.9	0.8
Acetaldehyde	0.005	0.005	0.005
Acrolein	0.03	0.03	0.02
Benzene	0.1	0.1	0.1
1,3-butadiene	0.1	0.1	0.1
Formaldehyde	0.2	0.2	0.2
Naphthalene	0.1	0.1	0.1
Nasal irritants [a]	0.4	0.4	0.3

Notes: Values in **bold**: RQ >1.0
[a] Combined annual RQ values for acetaldehyde, acrolein, formaldehyde, and naphthalene
Source: Adapted from the Application

Cancer risk is considered separately from other chronic health effects. Table 13 shows the RQ for substances that have the potential to cause cancer. As with the substances above, all RQs are far below 1.0, meaning that the predicted exposure with the Project in place will be far below the limits set for these chemicals by agencies such as Health Canada, the United States Environmental Protection Agency, and the California Office of Environmental Health Hazard Assessment. While it must be noted that for carcinogenic (cancer-causing) substances, there is considered to be no threshold below which exposure is 'safe' (i.e., no dose that is considered to be risk-free), predicted exposure to these chemicals is lower with the Project in place than without it.

Table 13: Chronic Inhalation Risk Quotients for Carcinogenic Effects

Chemical	Residential Receptors
Acetaldehyde	0.006
Benzene	0.05
1,3-butadiene	0.02
Formaldehyde	0.01
Napthalene	0.08
Benzo[a]pyrene	0.08
DPM	0.2
Leukemia [a]	0.2
Lung tumours [b]	0.02
Nasal tumours [c]	0.006

Notes: [a] Combined annual RQ values for 1,3-butadiene and benzene
[b] Combined annual RQ values for benzo[a]pyrene and DPM
[c] Combined annual RQ values for acetaldehyde, formaldehyde, and naphthalene

Source: Reproduced from the Application

Exposure to air emissions among recreational users

For people who could be exposed to airborne contaminants while using the Project area recreationally, Table 14 shows the predicted RQ for the same contaminants of concern. As with exposure for residents, both future scenarios show a reduction in exposure to chemical substances, and the predicted reduction in exposure is greater with the Project than without.

Table 14: Acute Inhalation Risk Quotients – Recreational Receptors

Chemical / Substance	Duration of exposure	Existing (2011)	Future (2031) without Project	Future (2031) with Project
Carbon monoxide	1 hour	0.4	0.4	0.4
	8 hours	0.4	0.4	0.3
Nitrogen dioxide	1 hour	0.8	0.7	0.7
Sulphur dioxide	10 minutes	0.1	0.1	0.04
	1 hour	0.1	0.1	0.1
Ammonia	1 hour	0.1	0.05	0.03
PM_{10}	24 hours	0.7	0.7	0.7
$PM_{2.5}$	24 hours	0.6	0.6	0.5
Acetaldehyde	1 hour	0.02	0.02	0.02
Acrolein	1 hour	0.2	0.2	0.1
Benzene	1 hour	0.03	0.02	0.01
1,3-butadiene	1 hour	0.003	0.002	0.001
	24 hours	0.04	0.03	0.03
Formaldehyde	1 hour	0.3	0.2	0.1
Naphthalene	1 hour	0.001	0.001	0.001
Eye irritants[a]	1 hour	0.5	0.4	0.3
Respiratory irritants[b]	1 hour	0.9	0.9	0.8

Notes: Values in **bold**: RQ >1.0
[a] Combined one-hour RQ values for ammonia, acrolein, formaldehyde, and naphthalene
[b] Combined one-hour RQ values for ammonia, acetaldehyde, naphthalene, nitrogen dioxide, and sulphur dioxide

Source: Adapted from the Application

Vulnerable populations

Not all people are equally susceptible to the effects of exposure to airborne contaminants. Children, the elderly, and people with pre-existing respiratory or cardiorespiratory disease are more likely to experience adverse consequences from exposure to airborne contaminants. The conservative modeling approach used for the assessment above therefore used additional assumptions to over-estimate, rather than underestimate, potential risk.

This Project contributes to health equity, as vulnerable populations are most likely to realize the health benefits of future decreases in air contaminant levels.

What is planned to address potential health effects?

As noted in *Section 7.1 Human Health* of the Application, mitigation measures to address potential changes in air quality are focused on the construction phase as, once operational, the Project is predicted to result in improvements in air quality relative to existing conditions. Specific mitigation measures to be applied during construction will be finalized once detailed construction methods and schedules are developed. A Construction Environmental Management Plan will be developed prior to the start of construction that focuses on minimizing construction-related air emissions.

Conclusions about exposure to Airborne Contaminants

Key Findings
• Air quality will improve in the future across the Local Assessment Area, both with and without the Project. However, improvements are greater with the Project. • The predicted human exposure to air contaminants will be far below the thresholds that have been set for specific substances; therefore, no adverse effects are predicted. • Vulnerable populations, including children, the elderly, and those with chronic respiratory problems, will derive the most benefit. • During the Construction phase, there is the potential for Project-related equipment to temporarily generate diesel emissions. The Project will implement best management practices for vehicle and equipment operation to minimize exposure to these emissions.

During construction, best management practices to control emissions will minimize human health concerns. During operations, the direction of the effect is **positive**. The size of the effect is **medium**, affecting the entire study population, although the most substantial effects will be seen closest to the roadways. There is potential for the improvement to avoid health effects that would be characterized as **medium to high magnitude**. The effect is characterized as **likely**, as air quality improvement is almost certain to occur as a result of the Project. There are **equity improvements**, as those most likely to experience benefit are vulnerable populations. The confidence in this prediction is **high**.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity	Confidence
Exposure to airborne contaminants	Positive	Medium	Medium/ high	Likely	Improvement	High

6.2 Noise

Why is Noise a health interest?

Excessive noise in or adjacent to communities can lead to annoyance and adverse health impacts.[37] Exposure to noise is also associated with interference with oral and written communication, sleep disturbance, cardiovascular disease, and cognitive impairment in children.[37, 38] Children, seniors and people with chronic illness tend to be more sensitive to noise disturbances.[39]

There are no regulatory standards, or federal/provincial guidance to assess acceptable community noise levels from a health perspective. There are, however, a number of different measures that have been developed or adapted by Health Canada used to identify problematic community noise levels.

- The first is "percent highly annoyed" or %HA. This estimates the percent of the community that will become highly annoyed based on modeled noise predictions. Health Canada has identified a threshold of 6.5% of the community being highly annoyed as a health-based criterion in its reviews of environmental assessments to indicate the potential severity of project-related noise effects.
- A second measure used by Health Canada is sleep disturbance. For continuous noise, Health Canada suggests an indoor nighttime sound level (Ln) of 30 A- weighted decibels (dBA) as a threshold for sleep disturbance, or an outdoor Ln of 45 dBA (assumed there will be a loss of 15 dBA when sound travels from outdoors to indoors.
- The third measure used by Health Canada is interference with speech comprehension or learning. Health Canada (2011 (draft)) advises that background indoor sound levels for continuous noise be maintained below 40 dBA to sustain adequate speech comprehension. For effective outdoor speech comprehension, Health Canada advises that background outdoor sound levels be kept below 55 dBA for continuous noise.

What do we know about existing conditions for Noise?

A comprehensive noise assessment, which is presented as part of *Section 7.1 Human Health* of the Application has been undertaken to support the environmental assessment of the Project. The following information summarizes existing conditions in the Highway 99 corridor.

- The Project is located in an area where ambient noise levels are generally high, dominated by noise from traffic on Highway 99. Other sources contributing to the noise environment, but to a lesser degree, include local traffic and activities, trains, aircraft, marine, and agriculture-related activities. Changes in the noise environments in the vicinity of the Project, in recent decades, have largely been due to regional traffic volume growth on Highway 99 and, to a lesser degree, on connecting roadways.
- To characterize the existing noise environment, noise measurements were collected in 2013 and 2014 at select noise-sensitive locations along the Project alignment. These locations are considered to be representative of areas where noise levels are expected to be highest.
- Existing (measured) average daytime sound levels (expressed as Ld) ranged from 45.9 to 71.8 decibels (dBA) and exceeded the noise threshold for the ability to maintain adequate

speech comprehension (55 dBA) at 24 (77 per cent) of the receptor locations. Existing (measured) nighttime sound levels (Ln) ranged from 41.3 to 67.8 dBA. The threshold for sleep disturbance (45 dBA outdoors, equivalent to 30 dBA indoors with windows closed) was exceeded at 20 of 22 receptor sites (91 per cent) where Ln was measured. In terms of annoyance, community annoyance is greatest within a few hundred metres of Highway 99, and decreases with increasing distance from the highway.

What are the potential effects of the Project?

To understand how noise from the Project could influence human health outcomes, the human health risk assessment undertaken to support the assessment of health, presented in Section 7.1 Human Health of the Application, compared modeled noise to thresholds of effects for adverse changes in human health for health indicators including annoyance, sleep disturbance, and speech interference, to gauge whether the noise effects would be acceptable.

Construction

Based on work done to support the environmental assessment of the Project it is understood that, during the construction phase, there will be temporary noise generated during site preparation and construction activities, including clearing and grubbing, excavation, building of retaining walls and structures, grading, asphalt paving and pile driving.

Table 15 shows current and construction-phase predicted noise levels for a number of sensitive locations within the study area and compares these levels with guidelines for percent highly annoyed, sleep disturbance and speech comprehension.

During the Project construction phase, the change in %HA from existing (2013) conditions is predicted to range from -9.2 to 45.4%, under maximum predicted noise levels without mitigation. At 24 of 31 noise sensitive locations that were assessed, this predicted change in %HA value exceeded the Health Canada threshold of 6.5%, beyond which Health Canada advises that noise mitigation measures should be considered. As this noise is associated with Project construction only, the annoyance effects are not anticipated to last beyond the construction phase.

The human health risk assessment undertaken to support the environmental assessment process estimated that the modelled nighttime sound level (L_n) during Project construction, without mitigation, was predicted to exceed the sleep disturbance threshold of 45 dBA outdoors at 29 of 31 noise-sensitive locations that were assessed. However, for the majority of these locations, the existing noise environment already exceeds the L_n threshold. Only a small number of locations are expected to experience perceptible increases in nighttime noise related to the Project that may affect sleep quality.

Finally, based on noise modelling undertaken to support the environmental assessment process, modelled daytime sound levels (L_d), without mitigation, are predicted to exceed the speech comprehension guideline of 55 dBA outdoors at 33 of 42 receptor sites. By comparison, under existing (2013) conditions, the L_d exceeds the speech comprehension guideline at 23 of 32 measured receptor sites.

Table 15: Modelled noise level, percent highly annoyed, sleep disturbance and speech interference (pre-mitigation), from the Application

Site No.	Noise Sensitive Receptor Location	Land Use	Existing (2013) Noise Levels (dBA)			Maximum Construction Noise Levels (dBA)			Change in %HA	Exceeds %HA limit	Exceeds sleep disturbance limit	Exceeds speech comprehension limit
			L_{dn}	L_d	L_n	L_{dn}	L_d	L_n				
2	22 Capella Garden, 9731 Capella Drive, Richmond, B.C.	Residential	72.2	-	64.5	81	76	75	27.7	Yes	Yes	Yes
3	10168 Caithcart Road, Richmond, B.C.	Residential	69.7	-	61.4	75	69	68		Yes	Yes	Yes
4	9 Florence Estates, 10411 Hall Avenue, Richmond,B.C.	Residential	72	-	63.8	83	77	77	34.6	Yes	Yes	Yes
4a	Richmond Estates, 10511, Kilby Drive, Richmond, B.C.	Residential	70.1	-	63	82	77	76	36.3	Yes	Yes	Yes
4b	10333 Bryson Drive, Richmond, B.C.	Residential	68.8	-	58.1	84	79	78	45.4	Yes	Yes	Yes
5	4591 Dallyn Road, Richmond, B.C.	Residential	68.7	-	60.8	79	73	73	29.8	Yes	Yes	Yes
6	11600 Dewsbury Drive, Richmond, B.C.	Residential	74.1	-	67.1	80	74	74	19	Yes	Yes	Yes
7	12260 Old Westminster Highway	Residential	67.0	63.7	59.9	76	71	70	23.5	Yes	Yes	Yes
7a	Richmond Nature Park, 11851 Westminster Hwy, Richmond	Park	-	58.0	-	-	56	-	-	-	-	Yes
8	12250 Old Westminster Highway, Richmond	Residential	64.2	61.1	56.9	74	68	67	22	Yes	Yes	Yes
9	12431 Blundell Road, Richmond	Daycare	72.5	66.9	65.9	79	73	73	20.3	Yes	Yes	Yes
9	12431 Blundell Road, Richmond	Daycare	70.4	67.8	62.8	79	73	73	25.9	Yes	Yes	Yes
10	12280 Blundell Road, Richmond	Daycare	67.3	64.5	59.9	78	73	72	29.4	Yes	Yes	Yes
10a	Mosque, 12300 Blundell Road, Richmond	Worship	-	71.8	-	-	76	-	-	-	-	Yes
10b	School, 12300 Blundell Road, Richmond	School	-	71.0	-	-	74	-	-	-	-	Yes
10c	Ling Yen Mountain Temple, 10060 No. 5 Road, Richmond	Worship	-	61.7	-	-	62	-	-	-	-	Yes
11	10640 No. 5 Road, Richmond	Residential	65.7	62.6	58.3	76	70	70	25.8	Yes	Yes	Yes
11a	11551 Dyke Road, Richmond	Park	-	46.4	-	-	37	-	-	-	-	No
12	12900 Steveston Highway, Richmond	Commercial	-	67.7	-	-	63	-	-	-	-	Yes

12a	13060 Steveston Highway, Richmond	Residential	59.3	59.2	49.4	57	51	51	-1.8	No	Yes	Yes
13	103-14100 Riverport Way, Richmond	Multi-family	61.9	58.4	54.5	39	33	33	-9.2	No	No	No
14	12951 Rice Mill Road, Richmond	Residential	63.1	57.5	56.5	74	68	67	23.5	Yes	Yes	Yes
15	12 River Woods, 6105 River Road, Delta	Multi-family	68.4	64.2	61.5	80	74	73	33.7	Yes	Yes	Yes
15a	Central, Deas Island Regional Park, Delta	Park	-	53.9	-	-	69	-	-	-	-	Yes
15b	River Watch, 6251 River Road, Delta	Multi-family	59.7	56.7	52.3	64	58	57	5.0	No	Yes	Yes
15c	Town & Country Inn, 6005 Highway 17A, Delta	Hotel	70.1	65.6	63.2	79	73	72	26.6	Yes	Yes	Yes
16	37 Woodward Landing, 5300 Admiral Way, Delta	Multi-family	57.6	53.6	50.6	55	49	48	-1.6	No	Yes	No
16a	East of Parking, Deas Island Regional Park, Delta	Park	-	46.4	-	-	42	-	-	-	-	No
16b	Captain's Cove Marina, 6100 Ferry Road, Ladner	Multi-family	66.8	61.8	60.1	80	74	74	36.9	Yes	Yes	Yes
17	5954 River Road, Ladner	Residential	67.6	64.4	60.3	75	69	68	19.2	Yes	Yes	Yes
17a	Burr House, Deas Island Regional Park, Delta	Park	-	46.7	-	-	37	-	-	-	-	No
17b	First Fork, Deas Island Regional Park, Delta	Park	-	45.9	-	-	54	-	-	-	-	No
17c	Second Fork, Deas Island Regional Park, Delta	Park	-	46	-	-	53	-	-	-	-	No
18	Ernie Burnett Park, 5400 Ferry Road, Ladner	Residential	51.5	51.7	41.3	41	36	35	-2.0	No	No	No
19	5631 64th Street, Delta	Residential	57.4	56.3	48.7	73	67	67	26.2	Yes	Yes	Yes
20	8640 Ladner Trunk Road, Delta	Residential	67.5	65.2	59.8	76	70	69	22.5	Yes	Yes	Yes
20a	4714 96 Street, Delta	Residential	53.6	52.8	44.6	67	62	61	13.9	Yes	Yes	Yes
21	Delta View Life Enrichment Centre, Delta	Multi-family	75.0	71.8	67.8	83	77	76	25.8	Yes	Yes	Yes
22	Delta View Life Enrichment Centre, Delta	Multi-family	74.5	70.4	67.4	83	77	76	27.3	Yes	Yes	Yes
23	4779 104th Street, Delta, B.C.	Residential	69.1	-	61.7	80	74	74	32.2	Yes	Yes	Yes
24	4949 112th Street, Delta, B.C.	Residential	73.7	-	67.3	75	69	68	3.9	No	Yes	Yes
24a	5054 112th Street, Delta, B.C.	Residential	75.5	-	69.7	60	54	53	31.6	No	Yes	No

Operations

With the mitigation measures that are currently planned during the operations phase, the Project is anticipated to reduce noise levels by 4 to 8 dBA below current (2013) levels at most locations. This will improve the overall sound environment within the study area and reduce the likelihood and severity of any health effects that may currently be associated with existing noise levels.

The %HA will be reduced at all location compared with (2013) conditions. The predicted decrease in %HA varies from approximately 2 to 20 %HA, with most locations predicted to have reductions of 10 to 20 %HA.

In terms of sleep disturbance, the Project with mitigation is predicted to reduce Ln noise levels by 3 to 10 dBA below existing levels. This will significantly improve the nighttime noise environment. However, even with mitigation, the sleep disturbance threshold of Ln 45 dBA will be exceeded at many receptor locations.

There will be two locations (places of worship) that are predicted to have levels of noise that exceed the outdoor speech comprehension threshold of Ld 55 dBA. Additionally, one school is predicted to have Ld levels higher than the Ld 50 dBA threshold for learning environments. However, these predicted sound levels are still less than existing noise levels.

What is planned to address potential health effects?

Metro Vancouver does not have noise bylaws or regulations for construction noise. While the City of Richmond and Corporation of Delta have noise bylaws that impose time constraints and a maximum noise level on construction activities, such bylaws do not apply to the highway right-of-way. However, mitigation measures consistent with the Ministry's 2014 Noise Policy are proposed to avoid or minimize potential Project-related increase in noise levels at noise sensitive locations.

A Noise Management Plan will be developed to mitigate construction phase noise to the extent possible. The plan will include noise abatement measures to avoid or minimize disruption to nearby areas. Best practices will be used to reduce noise created by machinery used during construction to the extent possible. The Ministry will also develop and implement a community communications and engagement program to inform potentially affected communities of construction schedules and activities that may create temporary increases in noise. This program will use a range of communication methods such as: signage, a telephone line, web-based updates and communications, newspaper ads, or direct consultation.

Planned mitigation for Project operations include the application of a combination of measures outlined in the Ministry's noise policy at affected noise receptors. As a result of the application of such measures, traffic-related noise during Project operation is not expected to have an impact on human health.

Conclusions about Noise

Key Findings
• During the construction phase, there will be temporary noise generated during site preparation and construction activities. A limited number of locations in Richmond and Delta may temporarily experience perceptible increases in daytime noise. • During operations, vehicles will remain the primary source of noise. Planned mitigation for Project operations include the potential application of a combination of measures, as appropriate for specific sites. • With the application of mitigation, ambient noise levels during operation are expected to be lower than current levels–on average by 4 dBA at residences and 1.5 dBA at schools and places of worship. • As a result of the application of such measures, traffic-related noise during Project operation is not expected to have an impact on human health.

The direction of the Project noise effect is **mixed**: there will be temporary adverse effects on noise-related health outcomes during the construction phase that will be experienced at some locations. With mitigation, during the operations phase, noise levels will be below current levels at most receptor sites. The size of the effect is **medium**, affecting the entire study population, although the most substantial effects will be seen closest to the roadways. The magnitude of the effects on health can best be characterized as **low**. The effect is characterized as **likely**, as it is based on robust modeling. There are not likely to be health equity impacts, as vulnerable groups are not more likely to disproportionately experience adverse effects. The confidence in this prediction is **high,** with the acknowledgement that areas of uncertainty remain.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity	Confidence
Exposure to airborne contaminants	Mixed	Medium	Low	Likely	No equity effect	High

6.3 Food and Water Consumption

Why is Food and Water Consumption a health interest?

Healthy diets help to prevent disease and promote better health.[40] For Aboriginal Groups, subsistence food sources are important for maintaining a healthy diet, and have been linked with lower rates of conditions such as obesity, diabetes, heart disease and stroke as well as supporting other aspects of

culture and community.[41] Similarly, access to a safe, steady water supply is essential to support health and prevent disease.

There are several areas relevant to food and water consumption that have been raised during public and stakeholder engagement for the Project: agricultural productivity, quality and availability of fish as a food source, potential effects of a spill of hazardous materials; and effects on drinking water security.

What do we know about existing conditions for Food and Water Consumption?

Agricultural Productivity

Richmond and Delta, as well as the wider Metro Vancouver region, host a large amount of agriculture. In Metro Vancouver, 22 per cent of land is designated for agricultural use (Figure 6). Of this agricultural land, 15 per cent lies within Delta, while 9 per cent lies within Richmond.[42] Many types of fruits or vegetables in B.C. are grown in Metro Vancouver, including cranberries, green and wax beans, blueberries and potatoes. Livestock are also raised on this farming land.[42] Farming not only provides an important food source, but also contributes to the local economy and the cultural identity of the region.

Figure 6: Agricultural land in Metro Vancouver

Source: Metro Vancouver (2014)[42]

Fish Quality, Access and Acceptability

The South Arm and the mouth of the Fraser River are important locations for subsistence and commercial fishing. Fish species that are commonly harvested within this region include Pacific salmon, sturgeon, eulachon, trout and char. Sampling conducted in support of fisheries and water quality assessments supporting the environmental assessment of the Project, indicates that habitat (i.e.,

water and sediment quality) in the Project area that supports fish populations would be considered "clean" relative to most regulatory standards and guidelines and that there is no evidence that fish currently caught in the Project area would not be safe for consumption.

Numerous recreational and subsistence fishers use the South Arm of the Fraser River. While some individuals use boats, casting from shore is more popular, with salmon being the main target as a food source. Some popular locations for fishing include Deas Island Park, Ladner boat launch, other locations in Deas Slough, and along the shoreline near the Tunnel extending downstream to the river mouth. The river mouth is particularly popular during salmon runs. In addition to recreational and sport users, there are several Aboriginal Groups who fish in the area between the Port Mann Bridge in Burnaby and the Strait of Georgia. .

Aboriginal Groups in B.C. have indicated that fishing is an important factor for wellness, and that access to traditional foods is important for maintaining a nutritious diet.[43] Such foods tend to be more nutrient-dense than market foods, leading to better overall health.[44] Despite the enduring importance of fish, marine invertebrates and marine vegetation as a food source, a number of Aboriginal Groups in the area have indicated that the consumption of these resources is below desired levels. This is due in part to lessened availability of a number of species, and in part to the perception that some of these food sources have high and unhealthy levels of contamination.[45]

Spill of Hazardous Materials

As specified in the *Tunnel Transportation of Dangerous Goods Regulation,* a section of the *Transportation Act* in B.C., dangerous goods—comprising substances that could cause a spill, fire or explosion that would have human health impacts—are not allowed in the Tunnel without special permitting.[46] As a result, the Alex Fraser Bridge/Highway 91 has become one of the top routes for transporting these goods in Metro Vancouver,[47] while Highway 99 is not.

Drinking Water Supply

Water service in the Metro Vancouver area is currently secure. In general, domestic groundwater use adjacent to the Project alignment is limited, with only four supply wells within 600 m of the Project alignment, as drinking water within Richmond and Delta are supplied by the municipal water supply network.[48]

Metro Vancouver's water is sourced from the Capilano, Seymour and Coquitlam watersheds, none of which are within or near to the Project alignment.[49] However, the Lulu Island and Delta water main is approximately 600m downstream of the Tunnel and provides communities in Delta as well as other southern communities with water. As such, drinking water supply to such communities is unlikely to be affected by the Project.

What are the potential effects of the Project?

Agricultural Productivity

It is anticipated that the Project will result in no net loss of farmland. While the Project will occupy approximately 20 ha of existing agricultural land, the Ministry has identified surplus lands that will be made available for farming at various locations along the alignment. Therefore, agricultural productivity is not expected to decrease and may in fact increase.

In terms of the safety of agricultural foods in the area, the human health risk assessment conducted to support the environmental assessment of the Project included a multimedia analysis to identify how the Project could affect humans through consumption of food sources that are raised or grown in the region. This analysis included the potential for ingestion of plants (root vegetables and above-ground plants), ingestion of milk from dairy cows, ingestion of livestock feeding on soil and plants (cows, pigs, and chickens) and ingestion of eggs from chickens feeding on soil and plants.

The results of the human health risk assessment undertaken for the Project indicates that for all contaminants, the risk of exposure decreases in 2031 with or without the Project, and that with the Project, exposure risk decreases even more in 2031 as compared to without the Project. Therefore, the Project is not anticipated to result in health impacts associated with increased contaminants in local agricultural production, and will instead decrease the risk of exposure to harmful contaminants via food sources, which in the long term could be positive for health.

Fish Quality, Access and Acceptability

Comments and questions about impacts to fish and fish habitat were prominent among interests raised by stakeholders during public engagement.[50] Specific interests that health authorities or Aboriginal Groups raised include:

- The potential for decreases in numbers of fish or loss of fish habitat
- The potential effects on fish of cumulative developments including but not limited to the Project
- The potential for contamination of fish (and its resulting unsuitability as a food source).

Potential effects of the Project on fish (salmon, sturgeon, eulachon, trout and char) and fish habitat that have been identified in studies supporting the environmental assessment of the Project conclude that potential effects on fish, as a result of Project construction activities including Tunnel removal, can be effectively mitigated. This conclusion is supported by work that has been undertaken during Project planning including a design that avoids or minimizes effects on fish and fish habitat. Key design elements of the Project include, a clear span structure across the Fraser River, with no direct run-off from the bridge to the river. In addition, fisheries productivity will be maintained or improved through the creation of on-site high-value fish habitat to offset effects of Project components with small areas along the edges of Deas and Green sloughs.

Based on these conclusions, there is unlikely to be an adverse impact on the availability of fish as a food source resulting from the Project.

Finally, the quality of fish as a food source was cited as a potential concern. The human health risk assessment undertaken to support the environmental assessment of the Project did not examine the potential for human exposure to contaminants via fish sources; however, water quality studies undertaken indicate that while localized disturbance of sediments is expected to occur during construction, it is unlikely that chemical change in water quality will occur. For the main channel of the Fraser River South Arm, there are insufficient concentrations of hazardous materials to create an accumulation of contaminants at a level that would be of concern from a human health (consumption) perspective. For Deas Slough, the use of sediment containment structures during construction will prevent potential adverse effects to sediment and water quality in the slough due to re-suspension. As a

result, there is no evidence to suggest that the Project will result in increases of human exposure from consumed fish.

Nonetheless, there remains the potential for some fish consumers to perceive that that Project construction and decommissioning activities could result in contamination of fish as a food source and reduce fish quality. Particularly among Aboriginal Groups who are heavily reliant on marine food resources in this area, this perception could adversely affect nutritious diets, if it results in decreased fishing and fish consumption.

Spill of Hazardous Materials

Once the bridge is open, hazardous materials will be allowed to cross. This will result in the introduction of dangerous good movements at the crossing as well as a potential increase in the Highway 99 corridor between Highway 91 in Delta and Bridgeport Road.

It should be noted that dangerous goods trucking in Canada tends to be safe. A review of dangerous goods trucking found that incidents on highways are infrequent, at 0.27 per 10,000 shipments.[51] Of all incidents, over half (54 per cent) were minor that involved little or no environmental damage.[51] This means that probability of an accident is low, and even if it were to occur, that it is likely to result in minor or no health impacts. One of the most problematic concerns, however, would be a spill of dangerous goods into the Fraser River. However, there would be no additional risk compared to other bridges along B.C. Highways, and any spill would be subject to provincial standards, of which there are specific plans set out in the *BC Hazardous Material Response Plan.*[52]

An accidental release of hazardous materials during construction could occur during refuelling, from machinery leaks, or from the malfunction of a containment facility. Typically, such spills are minor and contained to less than a few litres. Work done to support the environmental assessment of the Project indicates that there is a low chance that a spill of hazardous materials would reach sensitive habitat including the Fraser River, or create a noticeable effect over background conditions. Therefore, from a human health risk perspective this Project does not pose any risk that should be deemed high-risk or unacceptable.

From a public health perspective it is plausible that a hazardous materials spill could result in concerns among some individuals about exposure to contamination. This could lead to avoidance among Aboriginal Groups and other people who rely on fishing for food, and creating health equity concerns. Historically spills have caused avoidance of subsistence foods (e.g. fish or other marine food sources like crab), in particular among Indigenous populations.[53] This possibility emphasizes the need for strong risk planning and communication in the case of such an event.

Drinking Water Supply

Concerns have been expressed that Tunnel removal could result in disruption to the Lulu Island-Delta water main, which would affect the water supply of communities within Delta. However, hydraulic modeling undertaken to support Project planning predicts that the removal of the Tunnel will not result in disruption to this water main. Regardless, the Ministry is committed to monitoring the integrity of the river bed near the water main until it can be ensured that there will be no adverse effects from Tunnel decommissioning. As such, Delta residents are not expected to experience any impacts on drinking water quality.

As noted previously, domestic groundwater use adjacent to the Project alignment is limited, with only four supply wells within 600 m of the Project alignment, and drinking water within Richmond and Delta is supplied by the municipal water supply network.[48] Given the distance from the Project alignment, no effects on local water supply wells is anticipated.

What is planned to address potential health effects?

Fish Quality, Access and Acceptability

There are extensive planned mitigations to avoid effects to fish and fish habitat. The bridge design itself includes a clear span across the Fraser River, to reduce impacts in the river. Other ways that potential effects will be minimized include highway design considerations to manage storm water run-off during operations, a Construction Environmental Management Plan and an Environmental Management Plan during operations to avoid effects to fish and fish habitat through the application of mitigation including timing windows for construction as well as other measures to address potential effects on water quality and underwater noise.

The Project also proposes to restore aquatic habitat and riparian habitat in Green Slough and Deas Slough. Details on proposed restoration works will be described within a Fish and Fish Habitat Management Plan that will be developed in consultation with the Ministry of Forests, Lands and Natural Resource Operations (FLNR), and Fisheries and Oceans Canada (DFO) and will identify opportunities to maintain or improve the productivity of commercial, recreational and Aboriginal fisheries.

Spill of Hazardous Materials

There are several mitigations planned that will reduce the likelihood of a spill occurring, and will reduce impacts in the case that a spill did occur. An Emergency Response and Spill Contingency Plan will be developed, and measures will meet all applicable standards, including personnel training and instruction on spill prevention and management.

In addition, the HIA identified the following measures to mitigate adverse effects on health and enhance potential health benefits. These additional measures have been incorporated into the Application.

- Communications protocols to engage key stakeholders, including Aboriginal Groups, will be built into emergency and spill response plans to be developed.
- Information from environmental monitoring programs will be shared to confirm water quality and sediment composition in the event that a spill occurs.

Drinking Water Supply

The Ministry will work with municipal water service to minimize potential disruptions.[54] Mitigations are planned in order to monitor the Lulu Island-Delta water main and includes coordination with Metro Vancouver through future stages of Project development and ongoing monitoring to ensure the integrity of the water main. As noted above, no effects are anticipated on the small number of water supply wells that exist, the closest of which is 600 m from the Project alignment.

Conclusions about Food and Water Consumption

Key Findings

- Through avoiding the loss of agricultural land and addressing site specific effects, agricultural production is not anticipated to be adversely affected by the Project.
- Project-related decreases in air contaminants during operations will help to reduce the risk of exposure to contaminants, via consumption of locally grown food, in the future.
- Through measures to protect fish and fish habitat, in Project design and construction planning, the Project is not expected to affect the quality or availability of fish for consumption.
- In the event of a spill, concerns could result regarding exposure to contamination and lead to avoidance among people who rely on fishing for food, including Aboriginal Groups.
- Potential concerns about the quality of fish or other marine resources can be addressed through communicating the results of Project-related environmental monitoring programs. This will benefit Aboriginal Groups who rely more heavily than other populations on access to fish as an important component of their diet.
- Through measures to monitor potential changes in river hydraulics following Tunnel decommissioning potential effects to the Lulu Island-Delta water main can be avoided and, drinking water availability will remain secure during all stages of the Project.

The effects on food and water consumption range are characterized as **neutral,** with observable effects not anticipated. The size of this effect will be **small**, mainly limited to a one-kilometre boundary around the Project alignment. The magnitude of health effects is expected to be **low,** and the likelihood of effects occurring is **possible.** There is the possibility for an **adverse health equity effect**, through the potential for some individuals—in particular Aboriginal populations—to avoid consuming fish where there are concerns of contamination arising from Project activities including Tunnel decommissioning. There is a **medium** level of confidence that these effects will occur.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity	Confidence
Food and Water Consumption	Neutral	Small	Low	Possible	Adverse	Medium

6.4 Greenhouse Gas Emissions

Why are GHG Emissions a health interest?

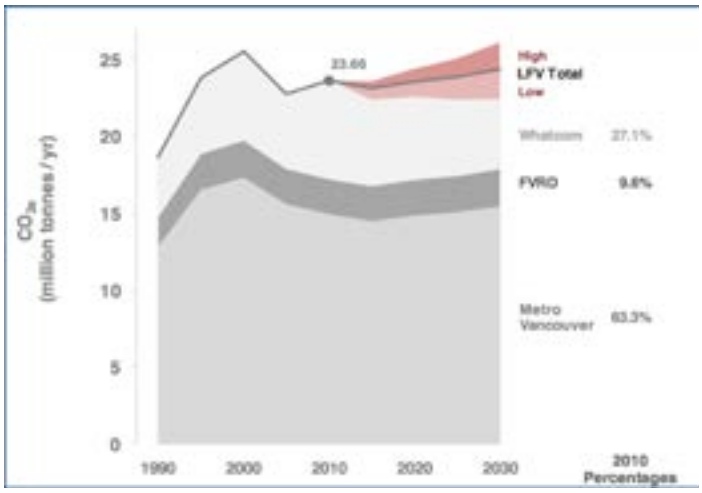
Greenhouse gas (GHG) emissions, such as carbon dioxide (CO_2), black carbon, methane (CH_4) and nitrous oxide (N_20), are drivers of climate change.[55] Climate change has the potential to adversely impact health through risks posed by high temperatures, extreme weather events, and changes in patterns of infection.[56] Climate change can also affect the social and environmental determinants of health: clean air, safe drinking water, sufficient food and secure shelter.[56]

What do we know about existing conditions for GHG Emissions?

Emission Trends

In 2013, Metro Vancouver released the *2010 Lower Fraser Valley Air Emissions Inventory and Forecast and Backcast*.[3] The study area included virtually the entire Metro Vancouver Region, the southwestern portion of the Fraser Valley Regional District (FVRD), and Whatcom County in Washington State (collectively referred to as the Lower Fraser Valley or LFR). According to the report, GHG emissions increased steadily between 1990 and 2000 in Metro Vancouver, with some reductions in 2010 (Figure 7); these were attributed to reduced production at an electric power plant, and some reduction in fuel consumption which may have been attributed to rising fuel costs.[3] In 2010, light-duty vehicles, industry and heating were found to be the major sources of GHG emissions in the Lower Fraser Valley area.[3]

Figure 7: Greenhouse Gas Emissions Trends



Source: Metro Vancouver (2013)[3]

Data on GHG emissions are also available at the municipal level via the Community Energy and Emissions Inventory, which tracks GHG emissions from three sources: buildings, on-road transportation and solid waste.[57] In 2010, 55 per cent of emissions from these sources were attributed to on-road transportation in Richmond,[57] compared to 59 per cent of emissions in Delta.[58] The total percentage attributable to on-road transportation emissions for B.C. was 58 per cent.[58]

Idling

Current traffic conditions at the Tunnel are associated with a substantial amount of congestion-related idling. Congestion-related delays of up to 50 minutes have been recorded for northbound traffic weekday afternoons, and up to 22 minutes for southbound traffic weekday mornings.[59]

What are the potential effects of the Project?

Construction

During Project construction, GHG emissions potentially could increase temporarily if construction activities impede the flow of traffic and increase the time vehicles spend idling. While there are some residential and mixed-use areas adjacent to the Project alignment in Richmond and Delta, especially near the interchange upgrades and along the south shore of Deas Slough, that are anticipated to experience periodic delays in access due to traffic controls, traffic management plans will minimize idling and delays.

The precise contribution of GHG emissions from construction-related vehicles is not yet known because the fleet of vehicles and equipment has not been finalized. However, it is anticipated that the equipment fleet used on the Project will be similar to those used on previous transportation infrastructure projects in the region. In addition, GHG emissions related to machinery use during construction will be temporary and represent a negligible addition to regional GHG emissions.

Operation

When the bridge is complete in 2022, the average commuter will save about 25 to 35 minutes a day.[54] As traffic-related congestion and idling are addressed, emissions per vehicle will decrease for most GHGs. The resulting decrease in emissions will be partially offset by an increase in the total number of vehicles in the LAA due to improved flow and continued population growth.

Table 16 summarizes the emissions of GHGs and black carbon for the 2031 traffic scenarios both with and without the Project and concludes that:

- Effects on air quality during Project construction will be minimized through implementation of recognized mitigation measures and best management practices that have proven to be effective on other transportation projects
- With or without the Project, there will be a decrease in all GHGs between 2011 and 2031, except CH_4 during operations. The decrease is driven by the introduction of newer engine technologies that provide for better fuel efficiency and subsequent reductions in most other vehicle emissions.
- For CO_2, emissions decline more with the Project than without. For CH_4, NO_2 and black carbon, emissions are lower without the Project. This is because the emission per vehicle does not decrease enough to outweigh the increase in traffic volumes. The increase in CH4 emissions, with the Project, mirrors the predicted trend in Metro Vancouver's 2010 emissions inventory and forecast.

Table 16: Greenhouse Gas and Black Carbon Emission for the Three Modelled Scenarios

Pollutant	2011 Existing Roads Emissions (tonnes/yr)	2031 Emissions (tonnes/yr)		Change from 2011 (%)		Change from Without Project Scenario in 2031 (%)
		Without Project	With Project	Without Project	With Project	
CO_2	147,797.6	132,126.9	126,948.4	-11	-14	-4
CH_4	12.2	15.4	15.7	25.6	28.5	2
N_2O	8.0	3.5	3.7	-55.8	-54.1	4
Black carbon	4.1	1.1	1.2	-72	-70	7
CO_2-e (20-year)	164,114.2	137,925.0	133,053.7	-16.0	-18.9	-4
CO_2-e (100-year)	154,184.7	134,599.2	129,539.2	-12.7	-16.0	-4

Source: Greenhouse Gas Evaluation

These small increases in CH_4, N_2O and black carbon with the Project as compared to without the Project represent the maximum expected increase. While not reflected in estimates of future air emissions, If future traffic volume is reduced by the uptake of active or public forms of transportation supported by the Project, as described in **Section 6.5 Active and Public Transportation**, the Project may result in additional GHG emissions reductions .

What is planned to address potential health effects?

Air Quality and Dust Control Management Plan

Air quality mitigation measures specific to the Project will be finalized as the specific construction approach (including equipment) is confirmed. At such a time, the Contractor responsible for construction will develop and implement a detailed Air Quality and Dust Control Management Plan that includes project-specific measures to avoid or minimize construction-related point-source air emissions.

Measures for Vehicle Emissions during Project Operations

Since most pollutants from vehicle emissions show a declining trend when comparing the 2031 scenario with the Project to the 2031 scenario without the Project (see *Section 4.9 Air Quality* in the Application), the implementation of mitigation measures for vehicle emissions is not considered necessary. However, to address potential minimal incremental air quality exceedances during Project operation, the following mitigation measures are proposed:

- Design and manage the Project to ensure optimum traffic flow conditions;
- Include strategies designed to result in more efficient use of transportation resources within the Highway 99 corridor, including transit routes, bicycle routes, and integration with other transit systems (in consultation with local government).

Conclusions about GHG Emissions

Key Findings
• Reducing current congestion at the Tunnel will result in reductions in GHGs that occur as a result of congestion-related idling. • GHG emissions may further decrease during operation of the bridge if traffic volume is reduced by the uptake of active or public forms of transportation.

The Project-related effects on GHG emissions are likely to have an overall **positive** effect during Project operations, although there is a possibility for temporary increases in GHG during the construction phase. The overall effect is characterized as **large**, since GHG emissions can affect health on a global scale and of **low** magnitude. The effects are **likely** to occur, and are not anticipated to directly affect disadvantaged populations in the local study area. The confidence in these effects is **medium**.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity	Confidence
GHG Emissions	Positive	Large	Low	Likely	No equity effect	Medium

6.5 Active and Public Transportation

Why is Active and Public Transportation a health interest?

Active transportation refers to any form of human-powered transportation, although it most often refers to walking and cycling.[60, 61] Compared to people who rely on driving, people who use active modes of transportation tend to engage in more physical activity and experience a wide range of health benefits. These can include improved cardiovascular fitness, mental health, and quality of life, as well as reductions in obesity and chronic disease.[61] Use of public transportation can be associated with increased active transportation, reduced traffic collisions, pollution reduction and increase access to services and healthy foods.[62]

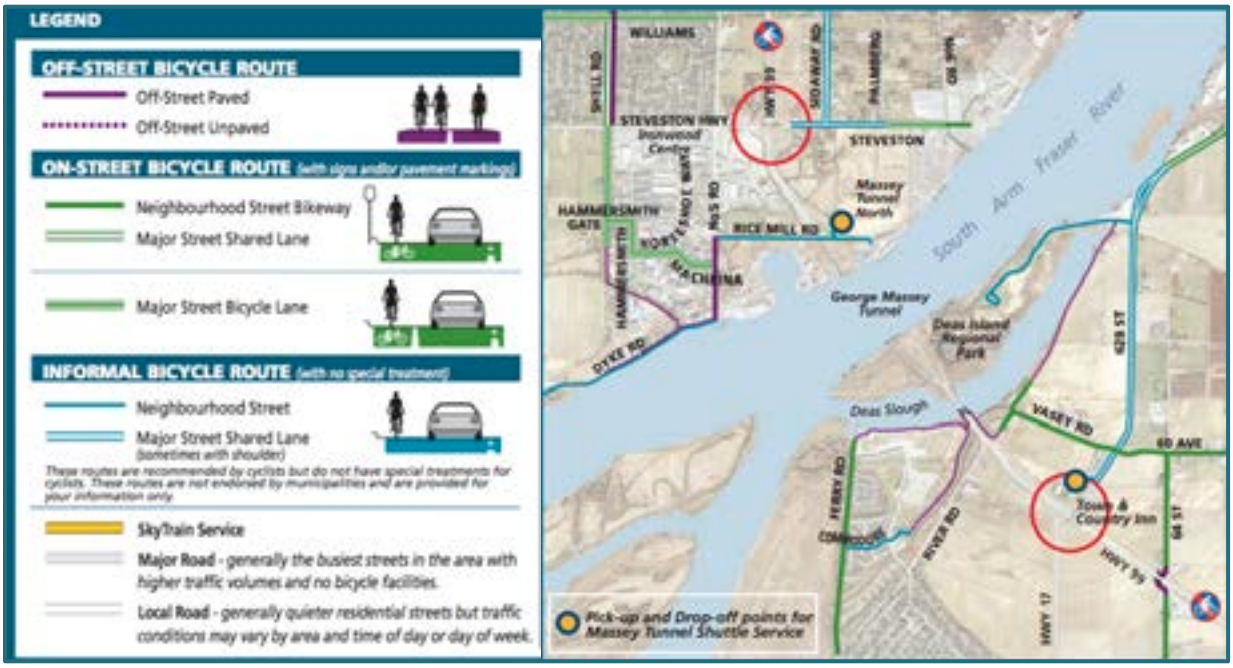
What do we know about existing conditions for Active and Public Transportation?

Active Transportation

Currently, there are no cycling and walking paths through the Tunnel. There is, however, a bike shuttle that operates through the Tunnel. In 2014, the shuttle carried on average 30 people per day, with higher demand in the summer.[59] It does not run on weekends in the winter, but during spring,

summer and fall the shuttle runs roughly once every hour from 6 a.m. to 6 p.m.[63] On both sides of the Tunnel, Highway 99 is a no-cycling zone. While cyclists can also use the TransLink bus system to cross the river, each bus holds only two bikes.[63] For pedestrians, there are walking paths on either side of the Tunnel; however, pedestrians are not able to walk through the Tunnel.

Figure 8: Existing bike routes and options near the Tunnel and Highway 99. Large red circles indicate zones of caution.



Source: Richmond Cycling and Trail Map[64]

The *My Health My Community* survey, conducted in 2013-2014, described residents' perceptions of a number of factors that enable or discourage active transportation. A supportive surrounding environment can enable active transportation, for example: through having amenities close enough to walk/cycle to, walking/bike paths, and having separation from traffic. Table 17 shows survey results for these active transportation indicators in Ladner, Tsawwassen and Delta. In all three areas, a high proportion of people report conditions that facilitate active transportation: nearby amenities, lanes/pathways, and little traffic. These observations are echoed in a high percentage of people reporting they see 'a lot of people' walking or biking.

Table 17: Current community health indicators related to active transportation in Delta, 2013-2014

	Ladner	Tsawwassen	Delta	Lower Mainland*
Amenities within walking/cycling distance	77%	69%	66%	67%
Lanes/pathways for cyclists & walking	53%	55%	55%	67%
See a lot of people walking/biking	79%	87%	71%	70%
Traffic in the area makes walking difficult	14%	16%	21%	25%
Utilitarian walking - 30+ min/day	30%	23%	27%	34%

Source: My Health, My Community Atlas, 2016 [65]
Note: Survey includes Metro Vancouver, as well as Fraser Valley and Costal Rural communities. See https://www.myhealthmycommunity.org/Results/CommunityProfiles.aspx for specific information about communities represented.

The City of Richmond highlights that Richmond is flat and ideal for cycling, and as such encourages the use of active transportation.[66] In Richmond, most communities report having nearby amenities that are within walking and cycling distance, and also report having cycling and walking pathways. The main exception is Hamilton / East Richmond / Fraser Lands, where respondents report that traffic can make walking and cycling difficult, and also report having few amenities within a walking or cycling distance.

Table 18: Current active transportation in Richmond, 2013-2014, based on individual responses from the *My Health My Community* survey

	Steveston	Seafair	Blundell	Sea Island / Thompson	City Centre	Broadmoor	Gilmore / Shellmont	Bridgeport / East Cambie / West Cambie	Hamilton / East Richmond / Fraser Lands	Richmond	Lower Mainland
Amenities within walking / cycling distance	78%	65%	68%	53%	85%	69%	55%	54%	19%	69%	67%
Lanes / pathways for cyclists & walking	85%	88%	70%	80%	71%	69%	74%	49%	57%	72%	67%
See a lot of people walking / biking	85%	79%	53%	70%	65%	58%	67%	41%	45%	65%	70%
Traffic in the area makes walking difficult	12%	16%	21%	14%	35%	24%	29%	21%	29%	23%	25%
Utilitarian walking - 30+ min/day	30%	28%	40%	35%	44%	32%	34%	28%	30%	37%	34%

Source: My Health, My Community Atlas, 2016 [65]
Note: Survey includes Metro Vancouver, as well as Fraser Valley and Costal Rural communities. See https://www.myhealthmycommunity.org/Results/CommunityProfiles.aspx for specific information about communities represented.

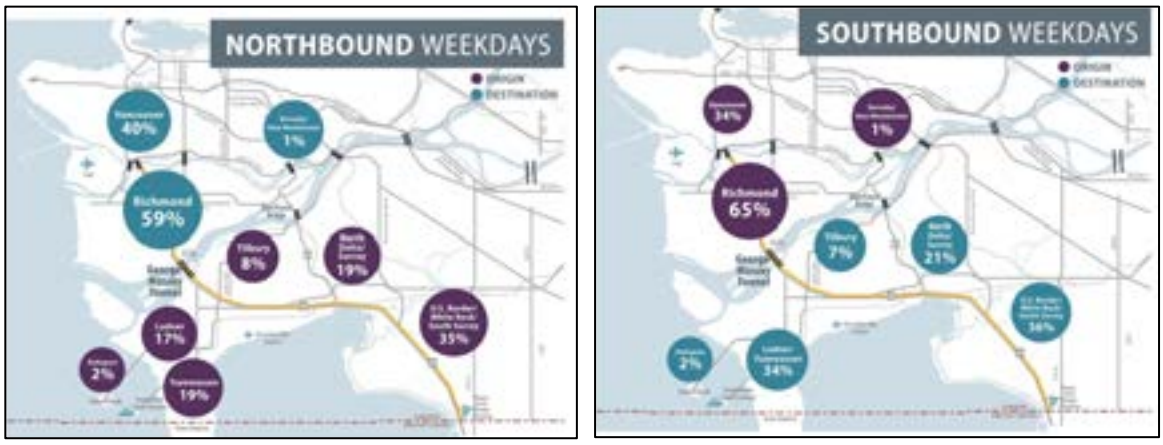
Not surprisingly, areas in Richmond with higher population density also correspond to the locations where active transportation is more often used.[67] Also notable is that almost 35 per cent of respondents in the city center in Richmond find that traffic can make walking and cycling difficult, compared to 23 per cent for the Richmond average. According to the *Healthy Richmond 2012 Final Report*, only six per cent of adults in Richmond commute to work by walking, whereas two per cent bike to work.[68] This report highlights that encouraging healthy living, including physical activity, is a priority for Richmond. Additionally, in terms of trips within Richmond, in 2008 83 per cent of trips were reported to be taken by car with only one per cent by bike; the target goal set in the Official City of Richmond Community Plan is 10 per cent of trips by bike.[69]

Public Transportation

Currently, nine bus routes use the Tunnel. This is more than any other route that crosses the Fraser River.[59] On average, there are 595 buses travelling across the Tunnel per day, carrying 10,535 people. In Delta, 16 per cent of people report using public transit to commute.[65] In Richmond, there is greater reliance on public transit with 22 per cent of people reporting using this method of transportation for their commute.[65] Figure 9 displays the destination and origin of Tunnel users on a weekday. This figure shows that Tunnel users mainly originate from Delta, including North Delta, Ladner and Tsawwassen, as well as South Surrey and surrounding areas near the Canada-U.S. border such as White Rock. While this figure does not separate out public transit from private vehicles, approximately 60 per cent of trips during morning rush hour to downtown Vancouver from South Surrey and South Delta are on public transit.[59] Within the Tunnel, transit only accounts for one per cent of traffic in morning rush hour heading northbound across the Tunnel, yet carries 17 per cent of all travelers during this time.[59]

Highway 99 is a major transit route in Richmond, with high demand at all times of the day.[69] Currently, public transit on Highway 99 faces congestion associated with the Tunnel and sections of Highway 99 between Bridgeport Road and Highway 91 in Delta. It has been estimated that transit users can experience 30 minute delays between King George Boulevard in Surrey to Bridgeport Road in Richmond.[2] Transit-related congestion is generally due to congestion bottlenecks at Bridgeport Road, high-peak demand at Bridgeport Station, difficulties with entry and exit on Highway 99 at Steveston Highway, and general congestion on Highway 99 at the 17A intersection.[70] It should also be noted that currently the transit/HOV lanes are not at capacity.[59] This data suggests there is currently room for greater transit and HOV use along this route. Currently, travel time reliability remains one of the largest barriers preventing transit ridership, in addition to frequency of service, and accessing the final location of the trip where transit may not be as direct.[70]

Figure 9: Origins and destinations for a typical weekday in 2014



Source: Ministry of Transportation and Infrastructure (2015)[59]

What are the potential effects of the Project?

This Project will improve both active and public transportation, specifically during the operations period and even past the temporal boundary of 2031. Improvement of infrastructure for these modes to promote increased use comprises a key part of the Official Community Plans for the Corporation of Delta and the City of Richmond, as well as TransLink's Regional Transportation strategy.[53, 69, 71]

Active Transportation

A key aspect of the Project that is expected to facilitate a positive effect on active transportation is the addition of multi-use pathways associated with the bridge, and other project components, that will connect Steveston Highway in Richmond, and River Road South in Delta. The Project will include a pathway on each side of the bridge that will be usable throughout the year. These pathways will replace the current shuttle system, providing incentive for more people to engage in cycling or walking as a part of their commute as well as to be more active for recreational purposes. Enhancement of cycling and pedestrian infrastructure provides the greatest opportunity with respect to providing a viable alternative to shorter trips. In 2010, in Richmond 62 per cent of residents commuted a distance under 10 kilometers[57] and in Delta, 41 per cent of residents experienced a commute of less than 10 kilometers.[58]

In addition to encouraging more cycling and walking, the proposed infrastructure improvements will also provide for improved safety conditions by providing greater separation between cyclists, pedestrians and vehicle traffic.

Currently, the Highway 99 and Steveston Highway Interchange is highly congested with high rates of collisions.[69] The proposed Project will replace this interchange as well as others, and improve cycling and walking paths and improve transit access. In Richmond, current plans include a multi-use pathway that will connect Odlin Road, a current cycling route in Richmond, with the Shell Road Greenway for users heading south towards the bridge. Multi-use pathways will also be built along the proposed overpasses at Westminster Highway and Blundell Road. In addition, the Steveston Highway interchange will include a multi-use pathway that will allow users to remain separated from road traffic, while also being able to access the integrated transit stop located between northbound and

southbound lanes of Highway 99. This interchange will also provide connections to new multi-use pathways to access Rice Mill Road/Dyke Trail and the pathways on both sides of the new bridge.

In Delta, improvements that will benefit cyclists include a connection between pathways on each side of the new bridge to access the Millennium Trail, as well as River Road and Vasey Road. The connection at Vasey Road allows users to access Highway 17A, and 64th Street, which are also popular for cyclists in Delta. The Highway 17A interchange will also provide a separated multi-use pathway through the interchange, as well as access to Highway 17A and 62B Street. Like the pathway at Steveston Highway, this will also have access to an integrated transit stop between northbound and southbound lanes, which is separated from vehicle traffic. Finally, overpasses at Matthews Interchange (Ladner Trunk Road) and 112 Street will also include multi-use pathways.

The Project cycling improvements provide considerably safer alternatives than existing routes due to the emphasis on grade-separated multi-use pathways where practical, especially at the Steveston and Highway 17A interchanges. Cycling improvements that connect with shoulder cycling lanes are for routes that are already used by cyclists. Currently, all pathways are being designed with safety as a major focus in order to promote active transportation, and in doing so has considered the input of cycling and active transportation stakeholder groups.

It is noted that some existing bike routes near the proposed bridge and interchanges do not have a separated bike lane and could be a safety risk and deterrent for cycling.[61, 72] For example, in Delta, 62B Street is a major shared lane, as is Steveston Highway in Richmond. To fully realize the benefits of Project related cycling improvements, it will be important to consider these aspects and work with stakeholders such as municipalities to integrate the cycling network and continue to promote cycling and cyclist safety.

Increasing options for safe, active transportation may contribute to improved health equity. While transit is already a viable option, the multi-use pathways will increase options for crossing the river for individuals without access to a car. This may increase access to services and employment opportunities for lower income residents.

Public Transportation

The Project is expected to have positive impacts on public transportation. Planned activities that are expected to improve use of public transportation include:

- Dedicated transit/HOV lanes between Bridgeport Road in Richmond and Highway 91 in Delta, including across the new bridge.
- New transit-only ramp at Bridgeport Road.
- Integrated transit stops within the new Steveston Highway and Highway 17A interchanges, accessible by safe and convenient walkways.
- Replace the Westminster Highway interchange to more efficiently accommodate all existing connections.

Without the Project, it is expected that transit delays during the morning rush hour in the year 2045 could be as long as 45 minutes (Figure 10). However, with the proposed infrastructure improvements, future travel times would be reduced while allowing for additional bus service.[2] This will make public transportation a more efficient and accessible option.

Increased use of public transport can also occur alongside increased active transport, as people walk, cycle or use other means to reach transit stops.[3] The addition of safe and convenient walkways at interchanges will help to support access to transit.

Improvements to public transit can also have beneficial effects for disadvantaged or vulnerable populations. Better public transit has been associated with increased access to medical services and healthy foods, and as a result could have positive impacts on equity. However, the addition of a transit lane and better interchanges are only one aspect of improving transit. Figure 10 shows TransLink plans to increase bus services, and the Project will support these transit upgrades by reducing travel times while allowing for greater capacity, and making it easier for individuals to use public transit in the study area.[73] In addition, the design of the bridge can accommodate future rapid transit.

As previously noted, frequency and reliability are currently barriers that limit some individuals from taking public transit. However, the Project design has several considerations that should allow for improved frequency and reliability. The transit/HOV lane will be located on the left-most (inside) lane of the bridge and Highway 99 in each direction. Transit exchanges will be located in the middle of the highway, between northbound and southbound lanes allowing easier merging and improved reliability.

Figure 10: Transit volume and delay projections in Highway 99 corridor

Source: Ministry of Transportation and Infrastructure (2015) [2]

Translink has plans to improve future transit capacity. These include upgrades to the existing bus network as well as facility upgrades along the Project alignment, as well as region-wide plans, such as increasing bus frequency. The Project will support these transit upgrades and make it easier for individuals to use public transit in the study area.[73]

Reduced access to public and active transportation during construction

Stakeholder and community engagement for the Project has identified concern regarding the potential for reduced access to public and active transportation during the construction phase of the Project. The Ministry has indicated that bridge construction will include extensive traffic management and construction staging to ensure public and worker safety and keep all traffic including cars, trucks, buses, and cyclists, moving efficiently on Highway 99 with minimal disruption.[54]

Construction traffic can pose a hazard to cyclists. The Construction Traffic Management Plan that will be developed for the Project will outline the way in which safe movement of all traffic (including cyclists) will be maintained through the Project corridor and will include provisions for managing construction traffic in the Project corridor.

What is planned to address potential health effects?

For the construction phase, a Construction Traffic Management Plan will be developed to address potential congestion and delays and to ensure public safety and efficient movement of traffic on Highway 99 and adjacent local road networks. The Construction Traffic Management Plan will be developed with input from local governments and key user groups and will be supported by communication strategies to keep all users of the existing facilities informed about construction works and steps being taken to avoid delays. Traffic management will involve detour routes with appropriate signage, transition zones, buffer areas and use of traffic control personnel. Ongoing engagement with active transportation groups will assist in developing and implementing temporary changes in cyclist or pedestrian routes safely and efficiently.

During the operation phase, the Project is not expected to have negative impacts on active and public transportation and therefore no mitigation is planned.

The HIA reinforced the following measures to mitigate adverse effects on health and enhance potential health benefits. These measures are reflected in the Application.

- Future engagement with the City of Richmond and the Corporation of Delta on the final design of improvements to cycling networks including safety considerations.
- Ensure the bike shuttle service remains in operation during construction.
- Future engagement with key stakeholders on the development and implementation of the Construction Traffic Management Plan.
- Engagement with TransLink during future Project planning to ensure continued access to transit stops during construction and communicate changes in access to users.
- Monitoring pedestrian and cyclist use of the bridge during the operational phase to measure changes in active transportation.

Conclusions about Active and Public Transportation

Key Findings
• The Project includes elements that will improve both active and public transportation options once in operation and make public transportation more efficient and accessible. • Construction phase effects on traffic can be mitigated to prevent access and safety problems for active and public transportation. • The addition of multi-use pathways across the new bridge and interchanges will improve options for active transportation locally and regionally and will also improve safety for users. • Increased options for safe active and public transportation may contribute to improved health equity. Improvements to public transit can also have beneficial effects for disadvantaged or vulnerable populations. • Monitoring of the use of the multi-use paths will be undertaken to confirm Project

objectives have been met and make further operational refinements if required.

- Better public transit has been associated with increased access to medical services and healthy foods, and as a result could have positive impacts on health equity.
- Future Project-related engagement, will provide opportunities for local governments and other key stakeholders to provide input on the final design of multi-use paths that are part of the Project.
- The Ministry will work with Translink and local governments to ensure that current levels of active transportation and transit service is maintained through the construction period.

This Project will support increased access and opportunities for public and active transportation and the effects are characterized as positive. It is noted however, that with increased numbers of cyclists comes the potential for increased cyclist injury. There will be a **medium size of effect**, with active transportation effects being felt by those within South Delta and Richmond, whereas public transportation effects will also include communities of North Delta, South Surrey and White Rock. Health effects associated with use of active and public transportation are of **medium** magnitude and, while rare, would include accidents involving pedestrians or cyclists. The effects on active and public transportation, including those that will improve health are **likely**. The Project also has the potential to improve **equity**. There is a **high** confidence in these conclusions.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity Considerations	Confidence
Active & Public Transportation	Positive	Medium	Medium/high	Likely	Improvement	High

6.6 Traffic Safety

Why is Traffic Safety a health interest?

Although traffic safety in B.C. has improved over the years,[74] motor vehicle traffic collisions continue to represent a leading cause of injury and death across all ages.[75] Pedestrians and cyclists are particularly vulnerable road users, as they are unprotected by any vehicle structure in the event of a collision.[76] This section discusses vehicle collisions generally; interests specific to pedestrians and cyclists are further explored in **Section 6.5: Active and Public Transportation** in this HIA.

What do we know about existing conditions for Traffic Safety?

Currently, the Tunnel as well as the interchanges at Steveston Highway, Highway 17A and Westminster Highway have safety issues. Over the five-year period of 2008-2012, 6,024 collisions

occurred on Highway 99 and adjacent intersections, with approximately 37 per cent of collisions resulting in injury or fatality.[77]

The expected average rate of collisions on a specific roadway stretch can be calculated as the number of collisions per million vehicle kilometers (c/mvk). Highway 99 is characterized as an 'urban-freeway-divided-4 lane+' (UFD4) road. For a UFD4 road, the expected collision rate is 0.3 c/mvk.[77] While most segments of Highway 99 between the Highway 91 and Bridgeport Road intersections have collision rates below the provincial average, the stretch of road that includes the Tunnel as well as Steveston Highway, and Highway 17A has much higher collision rates (indicated in Table 19 in bold) surpassing the average rate for this type of road.

Table 19: Collision rate along segments of Highway 99 from 2008-2012

	Serpentine River (Surrey) to Highway 17A	Highway 17A to Steveston Highway (Tunnel and adjacent intersections)	Steveston Highway to Oak Street Bridge
Collisions per million vehicle kilometers travelled			
Northbound	0.11	**0.6**	0.24
Southbound	0.14	0.28	0.18
Northbound and Southbound	0.13	**0.44**	0.21

Source: Delcan (2015)[77]

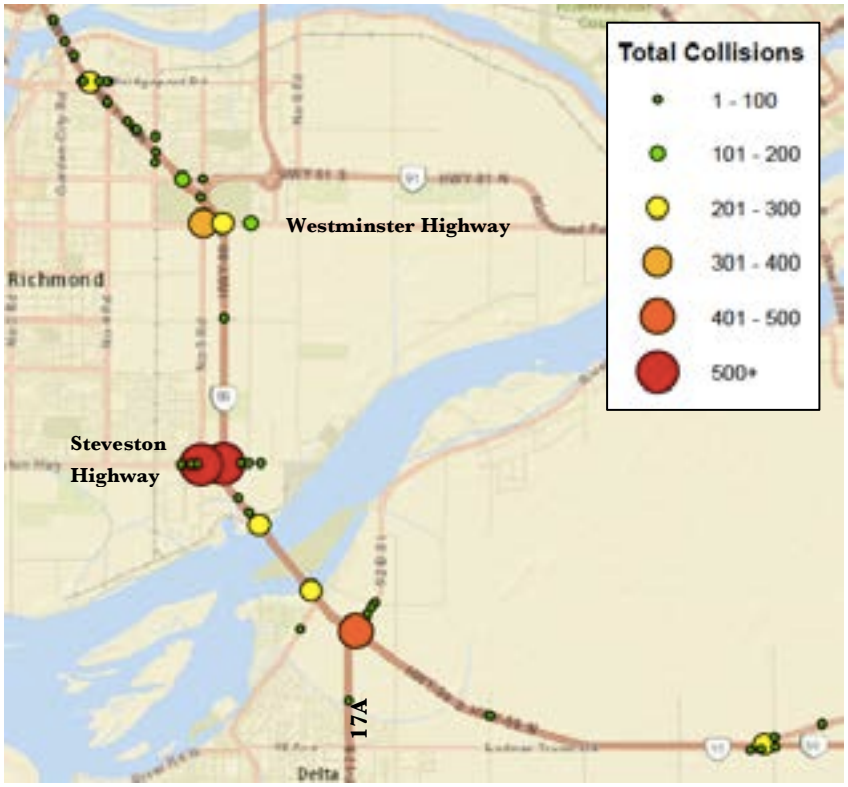
Table 20 shows the locations where collisions most commonly occurred between 2008 and 2012 along with the cumulative number of collisions at each. This information is represented graphically in Figure 11. In the span of the Tunnel itself, almost half of 279 reported collisions (49%) resulted in injury or fatality.[77]

Table 20: Top 10 collision locations on Highway 99 and adjacent intersections

Location	Number of Collisions (2008-2012 combined)
Highway 99 at Steveston Highway Interchange	625
Steveston Highway at No. 5 Road	545
Highway 99 at Highway 17A Interchange	491
No. 5 Road at Westminster Highway	352
152 Street at 32 Avenue	321
George Massey Tunnel Mid Span	278
Highway 10 at Highway 99 Interchange	257
Highway 99 at King George Boulevard Interchange	252
Bridgeport Road On-ramp to Highway 99 NB	221
Highway 99 SB Off-ramp to Ladner	215

Source: Delcan, (2015)[77]

Figure 11: Location and number of collisions along the Highway 99 Corridor



Source: Delcan, (2015)[77]

An additional traffic safety risk is related to the current counterflow lanes. Emergency responders engaged for the HIA indicated that during counterflow times, there are no barriers in the Tunnel between north and south bound lanes, and due to narrow lanes, vehicles drifting even a few inches can result in head-on collisions.

What are the potential effects of the Project?

The Project will have substantial positive effects on traffic safety, and it is expected that there will be a decrease in traffic accidents and associated injury.

Construction

During construction traffic diversions and lane closures are expected; however, this is not likely to result in increased accidents, and may in fact have the opposite effect as evidenced during the construction of the Port Mann Highway 1 Project. During construction, there were decreased vehicle speeds as well increased management of traffic through lane separation, signage, and traffic control personnel which was accompanied by a decrease in collisions. It is expected that construction of highway improvements on Highway 99, supported by a similar traffic management program, would yield a similar effect.

Operations

Once the bridge is operational, several of its features are expected to reduce the high collision rates in this area of Highway 99. These include reduced congestion; no counterflow system, and enhanced laning to help efficiently manage merging traffic including heavy trucks.

Interchanges will also have improved safety capabilities, with improved merging lanes and fewer traffic signals. This is likely to result in fewer collisions at Steveston Highway, Highway 17A, and Westminster Highway where collisions are currently among the highest in the study area. With such significant reduction in congestion, fewer collisions are projected, which will result in health benefits.

It is noted that similar to other less-congested provincial highways, some of the collisions that do occur could be more severe at free-flow conditions as is anticipated during the operation phase.[78, 79] The Ministry has no plans to change the posted speed limit.

What is planned to address potential health effects?

A central aim of the Project is to improve traffic safety, and so little mitigation is needed or planned. During construction, a Construction Traffic Management Plan will be implemented. There are several measures within this plan; key aspects include detour routes with adequate signage, transition zones, and buffer areas, and use of traffic personnel as appropriate to guide traffic and to monitor the effectiveness of the traffic routes.

In addition to these mitigation measures, the HIA identified the following measures to mitigate adverse effects on health and enhance potential health benefits. These additional measures have been incorporated into the Application.

- The Ministry will work with law enforcement organizations to ensure the design of the Project includes measures that facilitate monitoring and enforcement of speed limits.
- The Ministry will ensure that speed limits during the construction phase are implemented effectively to minimize safety risks to workers and travelers.
- The Ministry will monitor collisions during the operational phase to ensure that safety objectives of the Project – including a anticipated 35% reduction in vehicle collisions - are being met.

Conclusions about Traffic Safety

Key Findings
• Through addressing existing congestion, the Project is expected to result in a decrease in traffic accidents and associated injuries and fatalities. • During construction, there will be reduced speeds which will likely result in reduced collisions. Additional traffic safety considerations during construction will be addressed through a Construction Traffic Management Plan. • The new bridge includes several features that will reduce the high collision rates at the Tunnel including elimination of the need for the current counter-flow system and additional lane capacity that allows for safer merging movements and separation of slower moving traffic. • Monitoring of collision incidence on the improved Highway 99 will be undertaken to confirm project objectives have been met and guide operational refinements if required. • Planned improvements for interchanges will also result in safer merging lanes and modern standards. • Future Project-related engagement will provide opportunities for the Ministry to work with police on planning for monitoring and enforcement of speed limits.

The overall impact of the Project on Traffic Safety will be **positive**, with fewer collision-related injuries and fatalities expected, although there could be a greater proportion of high-severity collisions. The size/distribution of the effect is characterized as **medium**, experienced by drivers along the Project alignment. The magnitude of effect will be **medium to high**. Effects to traffic safety due to the Project are **likely** to occur. The effect is not likely to impact health equity; therefore a characterization of **no equity effects** is assigned. There is a **medium** level of confidence in this characterization.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity	Confidence
Traffic Safety	Positive	Medium	Medium to high	Likely	No equity effects	Medium

6.7 Connectivity and Access

Why is Connectivity and Access a health interest?

Connectivity and access can be important health supports. Logistically, connectivity and access can improve travel time and reliability, enabling access of vital services, including health care services. On a social level, connected communities foster social participation and strong relationships, leading to physical and social well-being.[80, 81]

What do we know about existing conditions for Connectivity and Access?

Stakeholder consultation for the Project demonstrated that there are pre-existing issues with connectivity across the South Arm of the Fraser River and Highway 99. Specific concerns raised by residents and organizations during consultation included:

- Having to cancel or postpone trips – or choose alternate destinations – that would otherwise have been taken due to Tunnel traffic congestion[72]
- Lack of reliable public transit, cycling, and pedestrian routes and calls for the prioritization of these needs[4]
- Poor access across Highway 99 for farmers in Delta, who also get caught in the congestion when accessing other farm plots or market.

Stakeholders also raised the need to consider social connectivity and community resources in the assessment of this Project.

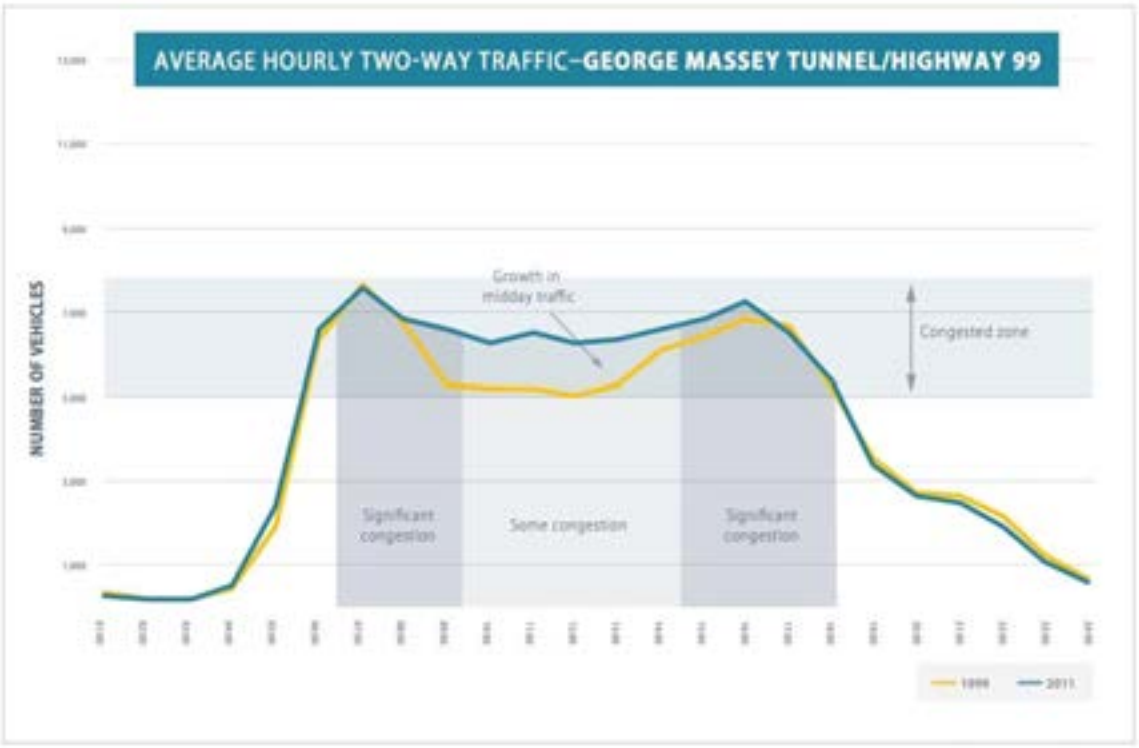
What are the current barriers to connectivity and access?

Traffic congestion is the main barrier faced by residents in Delta, Richmond, Surrey, and other Tunnel users. Congestion prevents people from timely access to services and locations on either side of the Tunnel, and provides uncertainty in reaching these destinations.

Within Delta and Richmond, farmers particularly suffer from congestion, as they attempt to cross Highway 99 and get caught in traffic. Some farmers operate multiple properties that may be on opposite sides of the corridor, and others share equipment with farmers who may be located across Highway 99; congestion makes these transactions difficult and time consuming. It also affects both how farmers get their products to market and how they get to service suppliers.[82]

Figure 12 below illustrates that the corridor currently experiences congestion throughout the day rather than only during rush hour.

Figure 12: Average Traffic - Tunnel/Highway 99



Source: Ministry of Transportation and Infrastructure (2015)[59]

What are the potential effects of the Project?

There are three main aspects of this Project that will directly affect connectivity and access, and thus impact on the health of users of the new infrastructure.

First, the additional lanes at the crossing, including the transit/HOV lanes, will improve travel times for those accessing services, school, work or other locations across the bridge.[53] Shorter commutes have positive effects on social connectivity by increasing the amount of time people have for socializing, and for other activities outside of work.[83]

By ensuring that buses and carpools have a reliable, uncongested route across the Fraser River, more people may choose to use these means of transportation. Since public transit and carpooling are more affordable options than commuting individually by car, the Project will improve equitable access and services. The effects of the Project on public transportation are discussed further in **Section 6.5: Public and Active Transportation.** Increased access to public transportation has health implications related to better connectivity and access; public transit improves access to civic services for the elderly and disabled, providing greater community inclusion.[84]

Second, the multi-use pathways on the bridge will provide year-round access for pedestrians and cyclists, replacing the existing shuttle system as discussed in **Section 6.5** of this HIA.[50, 53] Aside from the direct health benefits of active transport, walking and biking paths will improve both social interaction and equitable access to schools, public services, and recreation for those who do not have

access by car.[85, 86] The bridge's multi-use pathways will, for instance, provide access to and from the BC Ferries Tsawwassen terminal for cyclists, increasing access to Vancouver Island for this growing user group.[53]

Third, the Project will enable the Corporation of Delta to build a River Road connection under Highway 99, improving connectivity within Delta between the Ladner and North Delta communities.[54] People will be able to travel within South Delta more efficiently, without having to use Highway 99. The enhanced mobility that this provides will allow for more economic and social contact, improving agricultural and local community connectivity.

Overall, the effects of the Project on connectivity and access will be positive; there will be more reliable transportation options, access to jobs and services will be improved, getting to school or work will be easier and less stressful, and there will be a higher degree of connectivity between and within communities.[53] With more reliable affordable transportation options including carpooling, public transit, cycling, and walking, people will have more equitable access to travel. This in turn positively affects health by reducing isolation and creating more opportunity for social interaction and physical activity. The Project will also benefit a range of residents, including low-income and the elderly who may currently face extra limitations in travel reliability. This could help to improve health equity.

In the long-term, improvements in connectivity and access between and within these communities will also enhance residents' independence; improvements in how people can reliably travel to and from their homes, schools, places of business, and services will in turn allow them more choice in where they choose to live, study, work, and play, which is an important health benefit.[87]

What is planned to address potential health effects?

The Project will have positive impacts on health due to improvements in community connectivity and access, and as such no mitigations are planned.

Conclusions about Connectivity and Access

Key Findings
• Through the proposed design elements of the Project overall impacts on connectivity and access are anticipated to be positive. • Reduced congestion in the Highway 99 corridor, as a result of the Project will improve travel times and reliability for those accessing services, school, work or other locations. • By addressing existing congestion in the Highway 99 corridor, the Project will support reductions in transit times for those using public transit or carpooling, making these options more attractive to commuters. This will improve equity in access to travel for disadvantaged populations. • The Project will improve access for pedestrians and cyclists, which will support increases in physical activity levels. • By being designed to accommodate future forecasted growth in population and employment in communities south of the Fraser River, the Project will improve connectivity between Richmond and Delta as well as within these municipalities. • The Project will also support improved connectivity for local farm operations.

The Project will have a **positive** effect on health through improving connectivity and access. This effect will be a **medium** size, and will be experienced within the Richmond, Delta and South Surrey communities. This effect will be of a **medium** magnitude, and is considered **likely** to occur. The effect is expected to **improve equity** in the study area. Finally, the confidence for this characterization is **medium**.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity Considerations	Confidence
Connectivity and Access	Positive	Medium	Medium	Likely	Improvement	Medium

6.8 Emergency Response

Why is Emergency Response a health interest?

Emergency response services, including ambulance services, police services and firefighters, are all a part of responding to emergencies and providing critical medical care to individuals experiencing acute health crises. Shorter ambulance response times are associated with improved patient health outcomes for some medical emergencies, including cardiac arrest, respiratory arrest and total airway obstruction.[88, 89] Recent advances in emergency response research have demonstrated that rapid response times are not linked to improved patient outcomes for other health conditions, contrary to long-held belief.[89]

What do we know about existing conditions for Emergency Response?

Emergency Response Times

Emergency health care in B.C. is provided by both the BC Ambulance Service and municipal firefighters.[90] The BC Ambulance Service is a provincial entity falling under the BC Emergency Health Services (BCEHS), and is responsible for pre-hospital care and transportation to and between hospitals. As first responders, municipal firefighters can provide low-level medical and scene support.[90]

Response times tend to be longer in the suburbs compared to Vancouver. In 2014, the median response time for Code 3 ("lights and sirens") calls was 9.9 minutes in Richmond, compared to eight in Vancouver.[91] For Code 2 ("no lights and sirens") calls, the median response time was 16 minutes in Richmond, compared to 14.7 in Vancouver (data not available for Delta).[91]

In the 2016 *Transforming Emergency Health Services Action Plan: A Response to Demand Modelling Study*, the BCEHS established the following response time targets:[92]

- Nine minutes or less 75 per cent of the time for the highest acuity. "Highest acuity" refers to calls classified by BCEHS as "Delta/Echo," such as cardiac arrest, drowning and not breathing, choking and other life-threatening calls.
- Fifteen minutes or less 75 per cent of the time for medium acuity

In 2014, the percentage of incidents where responders arrived within nine minutes in Delta, Richmond and Burnaby was 46 per cent for the highest acuity calls, while 86 per cent of calls were responded to within 10 minutes. For first responders in Metro Vancouver, the nine-minute response percentage was 93 per cent.[93]

Emergency Response in the Tunnel

Accidents in or near the Tunnel occur frequently and often involve simultaneous response from multiple jurisdictions, including from detachments in Delta and Richmond in order to reach these accidents in a timely manner. Emergency responders, including fire, ambulance and police services, have cited challenges in accessing accidents due to congestion, a lack of shoulders, pull-outs, and cameras in the Tunnel that would help identify where the collision is situated. There is no room for emergency vehicles to bypass traffic within the Tunnel. These challenges have health implications for

patients who are being transported and/or for people stuck in traffic who may need medical assistance.

In addition, existing congestion in the Highway 99 corridor, and the Tunnel in particular, increase safety risks for emergency responders accessing and attending the scene of the accident.

What are the potential effects of the Project?

Traffic congestion is one of the primary drivers of the Project and was identified as a leading consideration to consider in developing replacement options during public consultation. With respect to emergency situations, addressing congestion is not only important in terms of getting patients to hospital quickly; it is also relevant in terms of enabling emergency response vehicles to return promptly and without delay to their base station so that they are available to respond to other calls.

Construction

The Construction Traffic Management Plan in *Section 12.2* of the Application outlines strategies and measures to ensure that emergency vehicles can pass through the Project area safely during the construction period. There will also be an Emergency Response Plan, which will complement the Construction Traffic Management Plan to ensure access for emergency vehicles in the event of an incident where emergency vehicle and response personnel require passage to or through the construction site. Emergency responders expressed that further engagement during development of the Construction Traffic Management Plan would help to alleviate construction concerns but noted that it is unlikely that construction-related congestion will add additional challenges with respect to emergency response times given the current congestion.

Operation

The Project will substantially improve emergency response capabilities for local accidents. These improvements will stem from the capacity to help manage traffic and provide better access for first responders during an emergency, reduced traffic congestion on Highway 99 and connecting roads and improved safety conditions for emergency responders, including wider lanes and shoulders. Based on the current available evidence, improved emergency response times and access will improve health outcomes for individuals dependent on quick transfer to a hospital.[89]

What is planned to address potential health effects?

The Ministry will continue to work with first responders and policing agencies to incorporate emergency response considerations into the final design and operating conditions of the Project. These design considerations will include discussion around features such as shoulders, pullouts, U-turn routes, security cameras and other safety features relevant to improving response capabilities and protecting emergency response personnel.

Conclusions about Emergency Response

Key Findings
• By reducing existing congestion in the Highway 99 corridor including the Tunnel the Project will have a positive effect on emergency response. • The design of the bridge will increase traffic safety by addressing congestion, improving interchanges and eliminating the need for the counter-flow which will reduce the number of events for which emergency response is needed. • Future stages of Project-related engagement will provide opportunities for first responders, emergency response agencies and other interests to provide input on emergency response considerations during future design stages. • The bridge is anticipated to substantially improve emergency response capabilities for local accidents. These improvements will stem from the increase in numbers of lanes; reduced traffic congestion; dedicated transit/HOV lanes; and improved safety conditions for emergency responders. • Based on the current available evidence, improved emergency response times will likely improve health outcomes for individuals experiencing acute conditions that require urgent medical attention.

The Project-related effects on emergency response will be **positive** and of **small** size/distribution, being confined to the area localized around the Tunnel and the area immediately including the Project alignment. While the potential effects will be of low magnitude for the majority of (routine) emergency response calls, there is potential **high** magnitude for the small number of immediately life-threatening calls and for the safety of emergency response personnel. The effects are **likely** to occur, and are expected to be **equitable.** The confidence in these conclusions is **high**.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity	Confidence
Emergency response	Positive	Small	High	Likely	No equity effect	High

6.9 Safety and Security

Why is Safety and Security a health interest?

In this section, safety and security are considered in terms of violence – either violent crime or self-inflicted violence (suicide). Violence can result in injury or death and fear of violent crime has been found to adversely impact mental well-being and physical health, both directly and indirectly.[94] Health

may also be affected if people who are worried about crime avoid health-promoting social and physical activities.[95]

What do we know about existing conditions for Safety and Security?

Suicide

In 2011, the B.C. Vital Statistics Agency recorded 426 province-wide deaths due to suicide, ranking twelfth overall as the leading cause of death.[23] Compared to the B.C. provincial average, both the Fraser South Health Service Delivery Area and the Richmond Health Service Delivery Area had lower rates of suicide.[96, 97] Over the 10-year period of 2002-2011, the total number of suicides was 112 in Richmond and 73 in Delta.[98]

Suicide is a health interest of particular concern to many Aboriginal communities in B.C. and across Canada, where rates of suicide can sometimes be much higher than in the non-Aboriginal population. Among the Status Indian population in B.C., suicide deaths were even higher, and comprised the fourth leading cause of death for people under the age of 75 between 2002 and 2006.[99] The total number of suicides in the Fraser Region Aboriginal population between 2007 and part of 2012 was 22; the majority of these suicides occurred in Abbotsford, Hope and Surrey.[100]

An average of 7.6 per cent of all suicide deaths were attributed to jumping during this time period.[98] In Metro Vancouver, the B.C. Coroner's Service has reported that 89 people are known to have died from jumping off bridges between 2009 and 2013.[101]

Safety and Crime

Crime rates in Delta are at historic lows due in large part to a volunteer community policing program (CoPS) that has been in place since 1992; Delta is ranked the thirty-fifth safest community in the country.[102, 103] Likewise, crime rates in Richmond between 2009 and 2011 were low relative to other Metro Vancouver municipalities and the province overall, including rates of violent crime (1.8 offences per 1,000), property crime (5.8 offences per 1,000), and vehicle theft (2.2 offences per 1,000). The main reason for help calls in the city in 2014 was housing and homelessness (29%).[104]

Seismic Event

The Tunnel was built in the 1950s and has been upgraded several times since its original construction, including in 2006 where the connections between Tunnel sections were strengthened. While the likelihood of a seismic event occurring and resulting in Tunnel failure is only 1-in-275 years, this failure rate is far below today's seismic safety standards for similar structures.[53]

What are the potential effects of the Project?

Potential effects related to suicide and crime are not applicable to the Project construction phase.

Suicide

Several bridges in Metro Vancouver have been used as structures for suicide by jumping, and introducing a new bridge into the region introduces the possibility that it may also be used for this purpose. Installing physical barriers to prevent jumping from bridges has been found to be an effective

method of preventing suicide, and usually does not result in a subsequent increase in jumping at other sites or an increase in suicide by other means.[105-107] In 2008, the B.C. Coroner's Service recommended that the Ministry develop a policy to determine when bridges should be outfitted with barriers, and incorporating this policy in the construction of new bridges in B.C.[108] Building on past Ministry experience in addressing suicide risks on bridges as well as the policy recommendation from the B.C. Coroner's Service, the proposed Project design includes safety fencing.

Safety and Crime

Emergency responders and Aboriginal Groups have both reported that the bases of bridges can be popular locations for high-risk populations to create temporary shelters. Populations considered high-risk in this case include the homeless, who often suffer from a range of mental health issues. Emergency responders indicate that there is often a corresponding increase in petty crimes in areas that are within walking distance of such temporary shelters.

It is possible that the base of the new bridge could be used in this manner. Emergency responders theorized that the Richmond side of the bridge would likely be more desirable, due to its proximity to nearby amenities. Emergency responders suggested making the base of the bridge in Richmond less desirable to use as shelter.

It is also important to note that most responders did not view this potential issue as a major concern; while incorporating deterrents into the bridge design would help reduce this potential problem, it was primarily viewed as something that police forces would able to control within their normal course of duty. It is also important to note that the bridge is not likely to create issues of homelessness or crime, but rather provide an alternate and potentially more attractive location in which it would occur.

Seismic Event

The bridge will have a far greater ability to withstand a seismic event than the Tunnel. The likelihood of a seismic event resulting in bridge failure will be 1-in-2,475 years.[53] This greatly reduces the chance of mass injury and mortality from a failure compared with the current Tunnel, and will improve safety into the future. The new bridge will meet the standards set out in the Canadian Bridge Highways Code and will be designed as a lifeline structure, meaning that it will stay standing and operational in a seismic event, and will be used as an emergency route.

What is planned to address potential health effects?

Mitigations that are planned that will affect this health interest of Safety and Security include:

- Safety fencing on the bridge to deter jumping.
- In addition to roadway lighting, lighting will be provided for the multi-use paths and public spaces to meet functional, safety and CPTED (Crime Prevention Through Environmental Design) requirements.

In addition, the HIA identified the following measures to mitigate adverse effects on health and enhance potential health benefits. These additional measures have been incorporated into the Application.

- As design work progresses, the Ministry will work with local governments, emergency response, first responders and policing agencies to address safety fencing and security considerations, including at-risk populations.

Conclusions about Safety and Security

Key Findings
• The installation of safety fencing, included in the Project design, will help to reduce the incidence of suicide. • Emergency responders report that isolated areas, such as the bases of bridges, can attract high-risk populations to create temporary shelters that may be associated with elevated rates of petty crime. • The Project design will include lighting for the multi-use trails and public spaces to meet functional, safety and Crime Prevention Through Environmental Design (CPTED) requirements. • The new bridge will have a far greater ability to withstand a seismic event than the Tunnel. This greatly reduces the chance of injury and mortality from a failure compared with the Tunnel, and will improve safety into the future. • Future Project-related will provide opportunities to work with local governments and other key stakeholders to ensure safety and security considerations are addressed in the design of the Project.

The Project-related effects on Safety and Security are characterized as **neutral** to **positive**, as the bridge will not create new issues of suicide, homelessness or petty crime, and will improve safety in case of a seismic event. Impacts will be of a **medium size** and localized to the study area. The likelihood for impacts to occur is **low**; however, the potential severity of impacts could be of a **high** magnitude, particularly if there was a major earthquake. Planned mitigation is expected to effectively address potential changes, and no equity effects are expected.

Overall, there is good data to inform this assessment and the confidence in these findings are **high**.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity	Confidence
Safety and security	Neutral to positive	Medium	High	Low	No equity effect	High

6.10 Economic Health Effects

Why are Economic Health Effects a health interest?

Employment, income and its distribution are key determinants of health. Employed individuals and those in higher income brackets typically experience better health outcomes with respect to life expectancy, mortality, cardiovascular disease, mental health and child health status.

The Project will support the movement of goods in and out of the region, allow for better access to local businesses, enhance access for local agricultural producers, and provide direct employment during construction. Health effects subsequent to these economic effects are examined below.

What do we know about existing conditions for Economic Health Effects?

Goods Movement

The Fraser River is one of the most important seaways for the Canadian economy, and it has been estimated that the impact of both port and shipping facilities on the Lower Fraser River in 2012 amounted to roughly $4 billion in GDP.[109]

Both the Tunnel and the Alex Fraser Bridge comprise important trucking routes in the region and enable access to key points that support the economy and trade, including Deltaport, Vancouver International Airport, the U.S. border and BC Ferries Tsawwassen Ferry Terminal.[53] On an average weekday, the Alex Fraser Bridge has about 9,000 trucks, and truck traffic experienced five per cent growth between 2008 and 2014. Approximately 7,000 trucks currently use the Tunnel each weekday, growing approximately nine per cent between 2008 and 2014.[59]

Agriculture

Agriculture in Metro Vancouver generated $789 million from the sales of agricultural products in 2010,[42] and provides over half (63 per cent) of regional employment in goods-producing sectors.[110]

Fisheries

Commercial fisheries represent an important economic activity in Metro Vancouver, with a value of $102 million in 2011. Although commercial fishing has decreased in recent years due to a combination of factors including a decrease in the salmon run, it remains an important economic resource.[111]

There are several Aboriginal Groups that participate in commercial fishing in the lower Fraser River, including the Tsawwassen, Musqueam, Qayqayt, Kwikwetlem and Tsleil-Waututh First Nations.

What are the potential effects of the Project?

Project-Related Employment

This Project is expected to provide 9,000 direct jobs during the planning and construction phase,[112] and 8,000 indirect jobs for businesses that support and supply construction activities. This employment

has the potential to improve the health of workers and their families, particularly if the employment is directed towards people who are currently under- or unemployed.

Goods Movement

Project construction is not expected to adversely affect marine traffic. However, work undertaken to support the environmental assessment indicates that there will be some interruptions to marine traffic that will limit access at certain times. These interruptions will be restricted to small timing windows, which will not prevent overall goods movement, and especially not to the extent that health could be influenced. Project construction could cause some commercial truck traffic delays, but is unlikely to have substantial effects that would influence health. Once the bridge is in place, marine traffic will not be adversely affected and commercial trucks will experience increased capacity, reduced congestion and improved opportunities to travel at all times of the day rather than just outside of peak periods.

The Project's positive effect of facilitating commercial traffic is expected to support regional growth, employment opportunities and associated positive health effects.

Agriculture

There are a number of ways in which the Project is anticipated to affect agriculture during the construction phase. Mitigation measures built into the Project including relocating utilities and removing and replacing fencing are anticipated to address any adverse effects on farming operations. Additionally, there will be no net loss of farm land; the Project is proposed to occupy approximately 20 ha of existing agricultural land; however, the Ministry has identified surplus land that will be made available for farming at various locations along the alignment. It is noted that Metro Vancouver's regional growth strategy, specifically recommends decreased farm subdivision and fragmentation, as a means to encourage agricultural production.[113]

While the Project will result in removal of narrow segments of land adjacent to Highway 99, individual losses to specific properties will be minor in extent, ranging from 0.01 ha to 2.8 ha on sites that are 0.2 ha to 51.4 ha. For most parcels, this loss of land is considered relatively small and is not expected to substantially change field configurations since the boundary changes occur on the perimeter of fields. Therefore, the impact of the Project on farm configuration is expected to be neutral on the majority of the farm parcels affected, with the exception of three properties.

For those farmers whose lands are affected, there may be impacts stemming either from reduced financial viability or an increase in stress.[114, 115] This effect should be extremely small, if at all, due to the limited number of farms where decreased productivity is possible. Farmers of these lands will also be compensated for losses, if any, which would help alleviate impacts.

Fisheries

Although some constraints on marine vessel movements may occur during construction, the Project is not anticipated to have any major effects on marine traffic movement during construction and no effects during operation as a result of the Project including a clear span bridge with no in-river components. During construction, a Marine Users Group will be convened to provide input into a Marine Access Management Plan that will be developed to reconcile the timing and location of both marine vessel movements and specific construction works. As such, commercial, recreational and aboriginal fisheries will be able to continue during the construction period. As stated above, these

constraints will be brief and mitigated, to prevent adverse health and economic effects. It is therefore unlikely that the Project will result in any negative human health effects. There are also no additional impacts expected on fisheries used by Aboriginal Groups, and mitigation will be applied to ensure continued access for those fisheries.

Economic Growth

It is expected that the southwest area of Metro Vancouver, which includes Richmond, Delta, Surrey, and White Rock, will grow more than 60 per cent between 2006 and 2041. By reducing congestion and improving access, the Project will support economic growth across the region, and increase the viability of local businesses and the employment of residents in these businesses.

This economic support may translate into improved health on a population level because both income and employment are strongly correlated with positive health outcomes. There may also be positive health equity implications if increased access via public or private transportation enables access to a wider range of employment opportunities, or for an individual to choose less costly housing options.

What is planned to address potential health effects?

Impacts on fisheries and marine traffic will be mitigated through a Marine Access Management Plan, which will minimize potential construction-related effects on all marine users and will include communication about water access restrictions. Additionally, marine users have been consulted since 2012 and will continue to be engaged throughout Project construction to identify potential marine use conflicts and solutions. The Ministry will also maintain engagement with Aboriginal Groups that have fisheries in the area to ensure continued access. This will help to communicate schedules and disruptions, and assist the Ministry in planning construction activities to avoid fisheries impacts.

An Agricultural Management Plan also will be developed in line with best management practices, to minimize effects on soil quality, drainage, water quality, irrigation, farm infrastructure and farm operations. Farm parcel boundary changes also are planned to support parcel consolidation to increase farmable area. Productive lands on three farms will be reduced, but will be offset by parcel consolidation on other properties. The Agricultural Land Commission will be involved in consolidation plans.

The HIA identified the following additional measures to mitigate adverse effects on health and enhance potential health benefits. These additional measures have been incorporated into the Application.

- The Ministry will work with Aboriginal Groups with respect to employment, training, business and other opportunities during Project delivery.
- The Ministry will work with individual property owners during the continued design of the Project to minimize property specific effects and implement appropriate mitigation.
- The Ministry will share the results of environmental monitoring undertaken during Project construction with Aboriginal Groups, regulators and key stakeholders.

Conclusions about Economic Health Effects

Key Findings
• Overall, the Project is anticipated to have a positive effect on health in Metro Vancouver, due to positive economic contributions and effects to the local and regional economy. • The operation of the Project will contribute to improved goods movement in the region, as well as the viability of local businesses. This will help support local economic growth and job opportunities, both of which can contribute to positive health and well-being. • The Project will cause minor and temporary constraints to marine traffic and commercial truck traffic during construction, but these will have a negligible effect on the local and regional economies. • Future Project-related engagement will provide for working with adjacent land owners and businesses to avoid impacts to business operations. • Overall it is anticipated that the Project will result in a net gain of agricultural land that can be actively farmed as well as access improvements for local agricultural operations. • The Ministry is currently engaged with Aboriginal Groups with respect to employment, training, and business opportunities during Project delivery.

There are a number of ways in which this Project could have economic health effects, which will result in a range of corresponding health effects that are **positive.** Health effects related to the economy will be **large**, and can benefit the economy across Metro Vancouver. Health effects are expected to be of a **medium** magnitude, and are **likely** to occur. This Project also has the potential to **improve equity** into the future through increased access to employment opportunities for all residents in the southern area of Metro Vancouver. There is a **medium** level of confidence in these characterizations.

	Direction	Size / Distribution	Magnitude	Likelihood	Equity	Confidence
Economic Health Effects	Positive	Large	Medium	Likely	Improvement	Medium

6.11 Recreation and Parks

Why is Recreation and Parks a health interest?

Access to and engagement with natural features of the environment offers numerous health benefits. Experiencing nature is associated with lower levels of stress, anxiety, depression, and chronic disease; and increased levels of concentration and cognitive functioning.[116] Parks are also associated with multiple physical, psychological and social benefits.[117] Parks promote physical activity, which has well-established links with positive physical and mental health outcomes. Park users may also experience psychological benefits with respect to improvements in mood, stress and anxiety. Further, using parks may encourage social interaction, promoting community cohesion and social capital.[117]

What do we know about existing conditions for Recreation and Parks?

Recreational areas and parks in the study area

Three recreational areas and parks were identified by stakeholders as important in the context of the Project:

1. **Richmond Nature Park:** Located at 11851 Westminster Highway in Richmond, this park consists of 200 acres of raised peat bog habitat, five kilometers of walking trails, and an interpretative centre.[118]
2. **Deas Island Regional Park:** Deas Island Regional Park is located on an island in the lower reaches of the Fraser River; it includes the southern entrance to the Tunnel. Managed by Metro Vancouver, this regional park is home to a wide array of recreational opportunities and facilities, including walking and equestrian trails, cycling, tidal fishing, picnic shelters, group camping, three heritage buildings, and Deas Slough and boathouse (Delta Deas Rowing Club).[119]
3. **Ernie Burnett Park:** Located at 5258 Brigantine Road, Ladner, this park features trails, benches and a gazebo.[120]

Park use in the study area

Residents of Metro Vancouver highly value outdoor recreation, and are among the most active of British Columbians. According to the 2011 *Regional Outdoor Recreation Opportunities Study* commissioned by Metro Vancouver and the Fraser Valley Regional District (FVRD), residents of Metro Vancouver used parks and open spaces year-round, with an average of 41 visits per year, as shown in Table 21.[121] Residents of Richmond and Delta (which was grouped together with Surrey and Langley) also made use of parks and open spaces, although at not as high a rate.

Table 21: Average Number of Visits Per Resident to Parks and Open Spaces Per Year, 2011

Region	Warm weather months	Cold weather months	Total
Surrey/Delta/Langley	23	8	31
Richmond	15	7	22
Metro Vancouver	29	12	41

Source: Regional Outdoor Recreation Opportunities Study (2011)[121]

Metro Vancouver collects detailed data on regional park usage, including Deas Island. In 2014, Deas Island had 269,042 visits.[122] It also recorded 2,781 individual campers and 4,072 users of picnic shelters. In addition, Deas Island is a site for educational programs and events; in 2014, it hosted a range of community and school groups and public programs attended by a total of 1,162 individuals.[122]

The *Regional Parks 2013 Visitors Survey* further elaborates on patterns and purposes of usage for Deas Island Regional Park.[123] According to the study, 67 per cent of respondents identified walking as one of their main activities in the park, followed by picnicking (42 per cent), boating (32 per cent), and wildlife/nature viewing (27 per cent). The main reasons for visiting Deas Island Regional Park were access (important to 67 per cent of respondents), exercise (58 per cent), family recreation activities (49 per cent) and solitude (45 per cent). Forty-one per cent of respondents visited the park more than once per week. Although the majority of respondents reported a postal code in the Surrey/Delta/White Rock region, visitors came from as far as Vancouver and the Fraser Valley.[123]

What are the potential effects of the Project?

Potential effects of the Project on recreation and parks stem from constraints on access, disturbances in the natural environment, and changes in visual quality at Deas Island Regional Park. No effects were identified for Richmond Nature Park or Ernie Burnett Park.

Construction

During the construction phase, adverse effects on the quality of the park experience are expected for Deas Slough, which may result in a temporary decrease in physical or recreational activities, which support healthy lifestyles, at Deas Island.

Construction activities may temporarily affect vehicle access or travel in the park. Areas along the south shore of Deas Slough may experience periodic delays due to traffic controls, including the possible rerouting of traffic. If access is affected, park users may be deterred from visiting the park. In 2013, 92 per cent of the visitors to Deas Island arrived by car.[121] Moreover, 25 per cent of Metro Vancouver residents reported they are willing to travel less than one hour to reach their recreation destination, and another 38 per cent would travel one to two hours.[121] If construction activities push travel time over these thresholds, it is possible that some users may be deterred from accessing the park during the construction phase of the Project.

Construction activities may also temporarily restrict access to specific areas of Deas Island Regional Park. Recreational use of the Island Tip Trail is expected to be periodically restricted during bridge construction and Tunnel decommissioning, although the main access to the park, parking areas, boat

launch, beach area, and major trails would not be directly affected. For recreational watercraft located in Deas Slough, periods of restricted access may limit the operations of marinas and water-based recreation programs with shore-based facilities (e.g., rowing club based in Deas Island Regional Park).

Park users situated nearest to construction activities may experience other Project-related disturbances, such as noise, which alter the park experience. For example, noise from heavy equipment and construction vehicles could change the park experience and lead to levels of annoyance, since solitude was the fourth most common (45 per cent of respondents) reason for visiting Deas Island Regional Park.[123] Depending on distance from construction activities, noise in some areas within Deas Island will temporarily exceed the speech comprehension guideline while others will not.

Certain park users may be more affected by annoyance related to increases in noise than others during the construction phase. For example, Deas Island supports a group campground and a number of educational programs and events. Given the social and educational nature of these activities, any construction activities that are perceived to be interfering with socializing, learning, and perhaps even sleeping, can have the potential to cause annoyance. Given the size of the park, varying distances from construction works and the range of recreational activities that take place in Deas Island Regional Park, it is unknown to what extent temporary construction noise might affect park usage overall.

Operation

During the operations phase, both beneficial and adverse effects may be anticipated on the usage of Deas Island Regional Park. On the positive side, reduced traffic congestion may increase park access and use.

The bridge introduces a new, permanent overhead structure to the users of Deas Island Regional Park that did not exist before which may change the feel and experience of the park for some park users though there is no way of knowing the extent to which this may result in a change in park usage.

The bridge also introduces a change in the source and level of noise from the highway, on the users of Deas Island Regional Park that did not exist previously. Based on noise modelling undertaken, it predicted that noise levels during operation will increase by varying degrees dependent on distance from the Highway though will generally remain below thresholds acceptable for residential, educational or institutional facilities under the Ministry's 2014 noise policy (Policy for Assessing and Mitigating Noise Impacts from New and Upgraded Numbered Highways).[124] As previously noted, certain park users may be more impacted by noise, and consequently annoyance, than others such as campers and those attending educational programs and events at Deas Island Regional Park.

It is difficult to determine whether potential changes in park access, disturbances in the natural environment, and changes in visual quality will have an effect on biophysical and mental well-being outcomes, mainly due to the fact that it is unknown whether park users will choose to forego outdoor recreational opportunities altogether, elect to visit different parks, or continue to use parks as previously.

What is planned to address potential health effects?

Park access and enjoyment

Mitigations related to addressing access issues to and within the park will be provided in a Construction Traffic Management Plan and Marine Access Management Plan. Following construction, including removal of the existing portal and road works associated with Highway 99, trails along the southern shoreline on the island will be reconnected and upland areas restored with native vegetation. Additionally, improvements in air quality, resulting from both reducing congestion as well as removing the requirement for Tunnel ventilation, will help to improve the park experience at Deas Island.

Disturbances in the natural environment

As future noise levels during operation within Deas Island Regional Park are not anticipated to exceed levels considered acceptable for residential, educational, or institutional facilities, no mitigation is planned to mitigate the change in noise levels within Deas Island Regional Park. Additionally, given the source of noise (overhead), there are limited means for effectively mitigating traffic noise throughout the Park.

Changes in visual quality

As the Project involves construction of a bridge to replace the Tunnel, changes in visual quality adjacent to the Park are unavoidable. However, design considerations have been incorporated into the Project to ensure that the structure is aesthetically pleasing and blends well with the local and regional landscape. Given the orientation of the bridge (overhead), relative to the Park, there are limited means for effectively mitigating changes in visual quality within the Park and no site specific mitigation has been proposed.

Conclusions about recreation and parks

Key Findings
• Construction activities may deter some park users from using nearby parks (such as Deas Island) as a result of construction related noise and traffic management. • During operations, park usage may increase as existing traffic congestion is addressed and access is improved. • The park experience at Deas Island Regional Park will change as a result of the Project and will include both benefits (i.e., improved air quality, restoration of shoreline, revegetation of areas under the bridge, decreased noise at portals) as well as adverse effects (i.e., shading, overhead noise, visual conditions). • The extent to which the overall change to the recreational experience at Deas Island Regional Park is beneficial or adverse is subjective and will be perceived differently by different users.

In summary, the direction of the effects on recreation and parks will be **mixed** (both beneficial and adverse) and potentially of a **large size** (i.e. Metro Vancouver). Existing park users will only be affected if they decide to avoid parks within the study area and access recreational opportunities further afield. The potential health effects are of **medium** magnitude. While the effects are **possible**, they are **not likely to increase health inequities**. The effects are expected to occur for both the construction and operation phases of the Project, and confidence in this prediction is **low.**

	Direction	Size / Distribution	Magnitude	Likelihood	Equity	Confidence
Recreation and Parks	Mixed	Large	Medium	Likely	No equity effect	Low

6.12 Tolling

The Ministry plans to toll the new bridge to recover Project costs. An electronic, open road toll system similar to that of the Port Mann Bridge will be used as the toll collection mechanism, whereby registered vehicles will be detected as they pass over the bridge, and unregistered vehicle license plate numbers will be captured by camera.[125] Port Mann toll exemptions currently are in place for emergency vehicles, BC Transit and TransLink buses, passenger transportation pool vehicles, taxis, and vehicles of persons with disabilities.[126]

Tolling generates broad interest and discussion and has been a recurring topic in the Project's community and stakeholder activities. During consultation, Richmond residents were more likely to suggest tolling on all bridges at a lower rate, Delta residents were more likely to oppose tolling

altogether, and Vancouver residents overall were more likely to support tolls than residents of other areas. In general, though, most participants who commented about tolling supported it as a funding mechanism and many suggested that a regional tolling policy be put into place.[50]

Currently, open road tolling exists for the Port Mann and Golden Ears bridges in the Metro Vancouver region. TransLink also plans to toll the Pattullo Bridge replacement crossing.

Road tolling can be associated with several potential health impacts, including exposure to contaminants, changes in activity levels due to mode shift, and health/economic inequity.

Exposure to Contaminants

At toll plazas, traffic can be congested due to frequent stopping and idling, causing a small-area increase in airborne contaminants and the potential for increased exposure among road users. However, in the case of the Project there will be no adverse health effects as tolls will be collected electronically while vehicles pass over the bridge without stopping.[127]

Active Transportation and Public Transit

The levying of tolls on roadways has been found to shift users from private vehicles to active transportation and/or public transit.[82, 128-130] The potential benefits of an increase in active/public transit use are described in **Section 6.5** of this report and include reduced traffic collisions, reduced emissions, and increased physical activity. An increase in transit mode share of 5-10% is anticipated as a result of the Project as identified in *Section 5.1 (Traffic)* of the Application.

Health and Economic Inequity

The imposition of tolls may have inequitable impacts on low-income populations.

For users of tolled roadways, research indicates that a larger proportion of a poor household's annual income will go towards tolls than will for a non-poor household and that the cost of tolls will have negative implications for the economic well-being of lower income users.[131]

A recent study on road tolling in Europe found that people who do not want, or cannot afford, to pay road tolls often re-route to non-tolled alternatives; however, in some cases this shift causes an increase in congestion on roads that are not built for high volumes. [132] A free alternative (in this case, the Alex Fraser Bridge) would give lower income drivers the opportunity to avoid the economic burden of tolling as described above, but could expose those drivers to greater vehicle emissions, noise, or stress, as well as contribute to the amount of time spent in traffic.

The provincial authorities have stated that bridges in B.C. cannot be tolled unless there is a non-tolled alternative available. However, Canada's EcoFiscal Commission states that in order to reduce rather than shift congestion, all routes must be tolled; it recommends that tolls be both harmonized across routes and variable depending on traffic patterns (i.e. higher during rush hour and lower during off-peak times). The EcoFiscal Commission has stated that provincial tolling policy should be revisited in order to address this interest.[133]

7. MONITORING AND EVALUATION

7.1 Monitoring Program

As referenced in this HIA, monitoring activities are planned that will help the Ministry and its stakeholders identify how the Project is affecting environmental, social and health outcomes and the effectiveness of mitigation.

A separate monitoring program is not planned for health interests. Rather, health considerations will be addressed through monitoring programs that are already planned. Table 22 and Table 23 present indicators that could be used to better understand potential health changes arising from the Project. These indicators relate primarily to determinants of health such as air quality rather than health outcomes. There are several reasons for this focus on health determinants:

- Since health outcomes are multifactorial, it is difficult to attribute changes in health to one specific infrastructure project;
- Changes in health outcomes can sometimes take years to become noticeable in population health data;
- Health data is usually not available at a level that would be specific to the study areas used within this HIA.

Monitoring social, economic and environmental indicators will yield a much faster and more accurate understanding of changes to health determinants. It should be noted that indicators for monitoring changes in exposure to airborne contaminants and noise are not included in the tables below, as these are addressed specifically within relevant sections of the Application.

Table 22: Potential monitoring indicators for Project-related changes during CONSTRUCTION

Health Area	Key interests to be monitored	Indicators
Food and Water Consumption	• The potential for construction and Tunnel decommissioning activities to affect water mains	• Changes in the condition of the Lulu Island-Delta water main
	• Continued marine access to fisheries • Perceptions around decreased quality or contamination of fish	• Changes in use of fisheries along the Southern Arm of the Fraser Rivers
	• Hazardous materials spills	• Number and volume of construction-related spills
Active and Public Transportation	• Interaction between cyclists and construction traffic	• Accidents involving cyclists
	• Project-related transit interruptions	• Changes in public transit travel-times compared to before the Project construction
Traffic Safety	• Construction activities that could affect the number of traffic accidents	• Average traffic speed along project alignment • Number of traffic accidents along the project alignment
Emergency Response	• Access to incidents for emergency responders	• Feedback from emergency responders on access during construction.
Recreation and Parks	• Park use	• Change in number of users in of Deas Island Park (weekly or monthly)

Table 23: Potential monitoring indicators for Project-related changes during OPERATIONS

Health Area	Key areas to be monitored	Indicators
Food and Water Consumption	• Hazardous materials spills	• Incidents involving dangerous goods
Active and Public Transportation	• Use of active transportation options Safety of people walking and cycling	• Number of cyclists using the multi-use pathways along the bridge per week • Number of pedestrians using the multi-use pathways along the bridge per week • Number of individuals using public transit from Delta, South Surrey, White Rock and Richmond • Change in mode share
Traffic Safety	• Traffic safety along the project alignment • Number of collisions • Severity of collisions	• Number and severity of total collisions along the bridge • Number and severity of collisions at interchanges along Project alignment, including at minimum Steveston and 17A interchanges • Average speeds along the bridge and Highway 99 within Richmond and Delta
Connectivity and Access	• Connectivity and movement in the region	• Travel time between Richmond and Delta during the average weekday • Travel time between Ladner and North Delta
Emergency Response	• Emergency response times and access	• Number of incidents along the bridge • Time spent by emergency responders accessing incidents along the bridge
Safety and Security	• Suicide and intentional self harm	• Number of incidents (including attempts) from the new bridge
	• Petty crime and security	• Number of calls reporting petty crimes within walking distance of the bridge • Reports from emergency responders/policing agencies regarding homeless populations congregating underneath the bridge
Recreation and Parks	• Park usage	• Change in number of users in of Deas Island Park from pre- to post-Project

7.2 Evaluation Plan

Evaluation is part of the HIA process, and is discussed in the Metro Vancouver HIA Guidebook as well as other key HIA resources.[11, 12, 134] The purpose of evaluation is to understand the extent to which the HIA was successful in affecting decision-making about the Project, and whether the results of the HIA were successful in affecting health outcomes.

There are no formal plans for conducting an evaluation of this HIA. However, there is evidence that the conduct of the HIA has informed decision making. Most notably, the HIA identified a series of recommendations in the areas of Active and Public Transportation, Traffic Safety, Emergency Response, Safety and Security, and Economic Health Effects. These recommendations were intended to supplement mitigation measures already planned in the Application, to further ensure that adverse health outcomes would be avoided and potential health benefits would be enhanced and have been integrated as part of the planned mitigation presented in the Application.

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