Ministry of Transportation and Infrastructure
BRITISH COLUMBIA

# HIGHWAY 1/99 NORTH SHORE CORRIDOR STUDY: LYNN VALLEY ROAD TO HORSESHOE BAY

## Technical Report

October 2021

PARSONS

# TABLE OF CONTENTS

PARSONS

# EXECUTIVE SUMMARY

The Highway 1/99 North Shore Corridor Study: Lynn Valley Road to Horseshoe Bay undertook a high-level assessment of current and anticipated future travel patterns along the subject highway corridor. Key challenges with respect to multi-modal mobility and safety for corridor users were identified, and then several potential opportunities for improvements were explored, both along the corridor and at interchanges.

## E1 Study Area and Context

The highway is a four-lane facility (with a short six-lane section) that features full access control and free-flow conditions; entries to and exits from the highway occur only at 13 interchanges/access points along the corridor. The highway passes through three municipalities (the District of North Vancouver, the City of North Vancouver and the District of West Vancouver) and the traditional territories of three Indigenous groups (Musqueam Indian Band, Squamish Nation and Tsleil-Waututh Nation). The majority of the segment of the highway running through West Vancouver is co-signed as Highway 99, as this segment of highway also facilitates connectivity with the Lions Gate Bridge (via Marine Drive and Taylor Way) to the south and the Sea to Sky Highway to the north. Two bus services run along segments of the highway within the District of West Vancouver, although eight interchanges include transit service travelling across the highway. On-corridor shoulder cycling is permitted between Capilano Road and Horseshoe Bay. In addition to sidewalk facilities across the highway at all interchanges and a protected cycling lane on southbound Lynn Valley Road, dedicated active transportation corridor crossings are provided at five locations, with one additional such crossing planned at Casano Drive. The extents of the Study Area are illustrated in ***Figure E.1***.

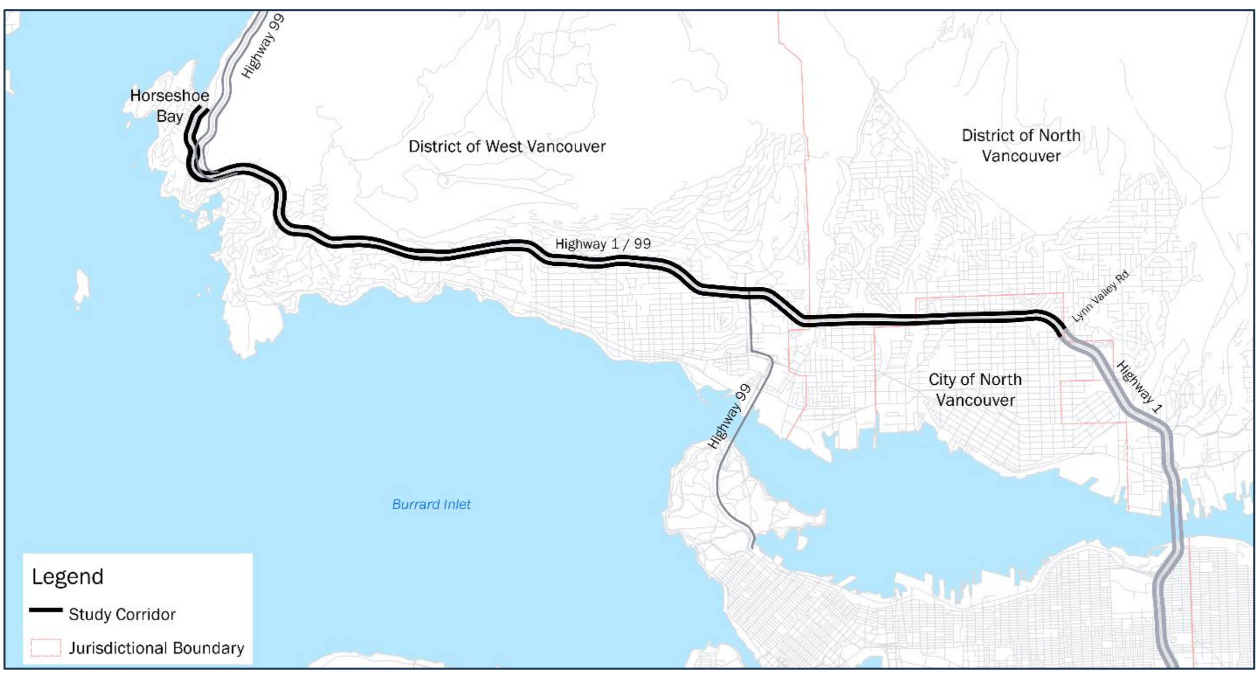


**Figure E.1: Highway Corridor Study Area**

## E.2 Study Purpose

The BC Ministry of Transportation and Infrastructure (BC MoTI) is currently delivering the $200 million Highway 1 Lower Lynn Improvements project, which is upgrading several interchanges at the north end of the Ironworkers Memorial Bridge. This project is intended to improve multi-modal safety and mobility, improve traffic flow during peak times, provide improved local street network connectivity, reduce collisions through geometric improvements to highway facilities, and provide new walking, cycling and transit infrastructure.

Notwithstanding these ongoing improvements, the remainder of the Highway 1 corridor on the North Shore from Lynn Valley Road to Horseshoe Bay has not been the subject of any focused corridor-level studies since the completion of the free-flow corridor in the mid-1990s. Therefore, the purpose of this study is to provide a high-level assessment of the long-term needs of the remainder of the corridor and to explore potential opportunities for improvements with respect to active transportation and transit and highway safety and operations. By outlining what potential improvements BC MoTI may consider implementing over the next 30 years, the study outcomes will be considered in future local, regional and provincial planning exercises. Therefore, at this point in time, there are no specific plans to undertake further improvements to the highway corridor beyond the currently underway Lower Lynn Improvements project.

## E.3 Study Process

The study involved a high-level technical assessment of multi-modal mobility and safety to identify existing and anticipated future conditions and challenges along the corridor. Mobility analysis was undertaken using the Regional Transportation Model, a travel demand modelling tool that incorporates information on existing land use, transportation infrastructure and trip-making behaviour. Population on the North Shore is anticipated to increase by 35%–40% over the next 30 years; based on assumed future land uses and population growth, as well as changes to the transportation network, the model forecasts future travel patterns over a 30-year planning horizon (i.e., year 2050) and can also be used to assess how travel patterns would change in response to new infrastructure. Road safety analysis was primarily undertaken through a review of the observed collision history along the corridor. Based on the findings of this multi-modal mobility and safety analysis, several areas along the highway corridor were identified for development and high-level evaluation of improvement opportunities. Specific improvement opportunities are discussed further in Section E.5.

## E.4 Study Engagement

In conjunction with technical analysis, the study team also conducted engagement with the three North Shore municipalities (the City of North Vancouver, the District of North Vancouver and the District of West Vancouver), TransLink, the three Indigenous groups whose traditional territories the study corridor is located within (Squamish Nation, Tsleil-Waututh Nation and Musqueam Indian Band) and the HUB cycling advocacy group. Input was also received from BC Ferries with respect to the potential changes to traffic patterns that may emerge as a result of long-term upgrades at the Horseshoe Bay ferry terminal. A range of feedback was received from these study partners and stakeholders, and was incorporated into the study in several different ways:

- **Issues identification:** Input was received from study partners and stakeholders with respect to the identification of multi-modal mobility and safety issues on the study corridor. In some cases, this input validated the findings of the technical analysis; in other cases, input provided the study team with further context to more fully understand issues that were initially identified through the technical analysis. Finally, in other cases, feedback brought attention to other issues that were not captured by the study team through the initial technical analysis. The study team was also directed to previous reports or materials prepared by study partners and stakeholders; these materials were subsequently reviewed for further information.
- **Development of improvement opportunities:** Input from study partners and stakeholders was used to support both the generation and refinements of potential improvement opportunities. In some cases, the scope of the improvement opportunities was updated to explicitly incorporate suggested refinements. In other cases, feedback regarding potential refinements or variations of an improvement opportunity that would require more detailed investigation was not explicitly incorporated into the improvement opportunity, but instead documented as a key consideration for any further design development, refinement and assessment. It is also acknowledged that the study did not seek to address every issue identified along the study corridor, and that feedback was also received regarding the need for improvements at other locations along the highway corridor in addition to those areas for which improvement opportunities were developed as part of this study.
- **Evaluation of improvement opportunities:** The study undertook a high-level evaluation of the potential benefits and impacts of the improvement opportunities. Several study partners and stakeholders explicitly noted their support for promoting sustainable transportation modes, reducing greenhouse gas emissions and improving regional air quality. Feedback also highlighted the need for further assessment of the potential environmental and archaeological implications of the improvement opportunities, and the importance of any eventual projects achieving a net environmental gain. This feedback has been documented as a key consideration for any further concept development, refinement and assessment.
- **Other carry-forward considerations:** Most “next steps” feedback from study partners and stakeholders related to either further scope refinements to specific improvement opportunities or further investigation of potential benefits and the impacts of these improvement opportunities. However, at a broader level, feedback was also received from some groups with respect to interest in opportunities for increased cultural visibility/recognition along the corridor, as well as interest in contracting opportunities, should any of the improvement opportunities (or any other potential improvements along the corridor) be implemented in the future.

## E.5 Potential Improvement Opportunities

Several improvement opportunities to address the identified challenges were developed and evaluated with high-level quantitative and qualitative indicators, and then subsequently refined in response to feedback received through the engagement process. Potential improvements have been organized into on-corridor improvement opportunities and interchange improvement opportunities. These opportunities are intended to address one or more issues related to active transportation, transit and/or highway safety and operations.

## On-Corridor Improvement Opportunities

On-corridor improvements are focused on providing more people-moving capacity along the eastern portion of the highway corridor study area (roughly between Capilano River and Lynn Valley Road), where volumes and congestion levels are greatest. Three potential approaches to increase people-moving capacity were identified: a bus-on-shoulder system, high-occupancy vehicle (HOV) lanes and general-purpose lanes. These concepts are described below:

- **Bus-On-Shoulder System:** This concept would provide an on-corridor bus service and transit priority measures via a bus-on-shoulder system. Based on discussion with TransLink, for the purposes of conducting an exploratory analysis, the bus service was assumed to be an extension of the existing Route 222 service between Metrotown and Phibbs Exchange that would provide stops at Capilano Road and Lonsdale Avenue. A stop at Lynn Valley Road was also investigated, but would likely require modifications to the interchange (as noted below in the discussion of interchange improvement opportunities). From an active transportation perspective, it is anticipated that this concept could be developed to address cycling barriers at the Capilano Road and Westview Drive interchanges to facilitate on-corridor cycling connectivity between these two interchanges, where the parallel municipal cycling network is less developed due to the presence of Mosquito Creek and Mackay Creek. This includes maintaining the existing pathway on the south side of the highway between Pemberton Avenue and Westview Drive, as well as further enhancements to connectivity, and potentially new connectivity on the north side of the highway. From a transit perspective, this concept would provide an on-corridor transit service with a travel time advantage over private vehicle modes (particularly if the bus-on-shoulder system was extended to Phibbs Exchange) and enable transit service on the highway corridor to overcome some of the challenges the corridor otherwise faces with respect to facilitating transit ridership, and would create an increase in use of sustainable transportation modes on the North Shore. Stop placement would need to be carefully considered in order to ensure easy access on/off the highway for buses, as well as high-quality pedestrian access and waiting environments. This concept is not anticipated to significantly decrease travel times for other highway users; rather, the primary transportation benefit of this concept would be to increase overall people-moving capacity and access between different parts of the region by providing an alternative to a passenger vehicle.
- **HOV Lanes:** This concept would provide an additional lane in each direction for high-occupancy vehicles (i.e., 2+ occupants), and would also include the Route 222 transit service described above. In the existing six-lane segment of the highway near Westview Drive/Lonsdale Avenue, the HOV lane would be facilitated by repurposing an existing general-purpose lane. Similar to the previous concept, this concept would facilitate cycling connectivity between Capilano Road and Westview Drive, and would provide transit with a travel time advantage over private vehicles, although to a lesser extent than the bus-on-shoulder system. By enabling transit service and providing a faster dedicated travel lane for high-occupancy vehicles, the HOV lane concept provides the greatest potential for increasing total person-throughput capacity on the study corridor. Although this concept improves mobility, the lack of continuity of the HOV system to run further east from the study area across Burrard Inlet could introduce a traffic operations challenge. The technical feasibility of an outside-lane HOV configuration, which facilitates transit service, would need to be further investigated if this concept were to be pursued further.
- **Additional General-Purpose Lanes:** This concept would convert the existing four-lane sections of the corridor between Taylor Way and Lynn Valley Road to six lanes. Active transportation provisions would be similar to the previous two concepts; no provision for transit service is included in this concept. This

concept would increase highway corridor passenger vehicle trips, some of which are rerouted from the municipal road network, resulting in both increased and reduced traffic volumes on various municipal roads. Mobility benefits for this concept would be relatively evenly split between local trips within the North Shore and longer-distance regional trips. A key challenge of this concept is that it could exacerbate eastbound queuing and travel times for trips across Burrard Inlet. Further analysis would be required to confirm potential mobility benefits as well as to ensure alignment with the CleanBC strategy and the *Roadmap to 2030* plan if this concept were to be pursued further.

•

## Interchange Improvement Opportunities

Several interchanges were identified as areas of focus for investigation of improvement opportunities. These interchanges are shown in ***Figure E.2***.

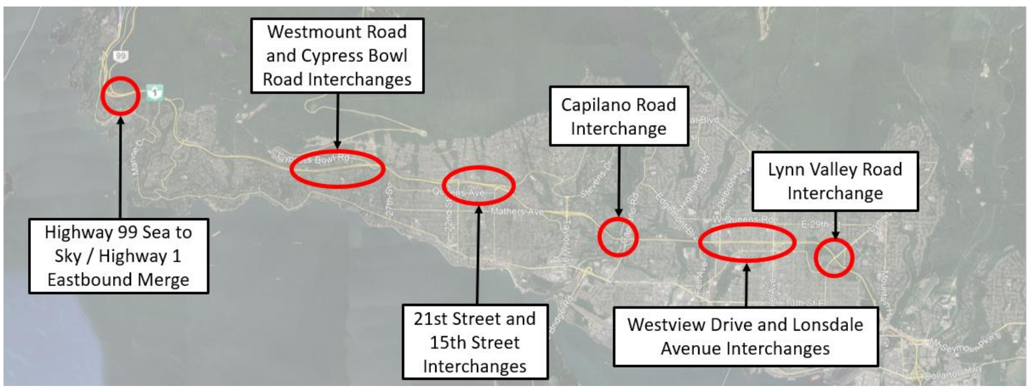


Figure E.2: Interchanges Identified for Investigation of Improvement Opportunities

A high-level summary of the improvement opportunities at each of these interchanges is provided below:

- **Capilano Road Interchange:** This concept would provide wider walking and cycling facilities across the river, address cycling conflicts with eastbound ramp traffic and enable cycling facilities on Capilano Road underneath the highway. From a transit perspective, the concept would provide a shoulder on the bridge(s) in each direction wide enough to future-proof the bridge to accommodate use as a future bus-on-shoulder facility. The concept would also address safety challenges on the westbound on-ramp, the eastbound off-ramp and the horizontal curvature on the west side of the bridge, and facilitate local/intra-municipal travel.
- **Lynn Valley Road Interchange:** This concept would complete the cycling connectivity on Lynn Valley Road, and enable an on-corridor bus service to stop at Lynn Valley Road. The concept would also address safety challenges on the westbound on-ramp and the eastbound off-ramp.
- **21$^{st}$ Street and 15$^{th}$ Street Interchanges:** This smaller-scale concept would extend the 21$^{st}$ Street Interchange eastbound on-ramp beyond the 15$^{th}$ Street off-ramp in order to address weaving issues between these two interchanges.
- **Westview Drive and Lonsdale Avenue Interchanges:** This concept would provide a new multi-modal overpass across Highway 1 at St. Georges Avenue, which would provide a new cross-highway walking and cycling connection, provide increased flexibility for reconfiguring Lonsdale Avenue in the future (e.g., to support improved transit service and/or improvements to walking and cycling conditions), and would

provide an alternate route for local traffic to cross the highway, which could in turn enable signals at Westview Drive and Lonsdale Avenue Interchange to provide increased priority to interchange ramp movements, rather than cross-highway movements.

- **Westmount Road and Cypress Bowl Road Interchanges:** This concept would upgrade the Westmount Road Interchange to provide improved walking and cycling connectivity across the highway, provide a potential approach for on-corridor transit to service this area (in the event that a transit service to this area is implemented in the future), and provide efficient access to and from new developments on the north side of the highway.
- **Highway 99 Sea to Sky/Highway 1 Eastbound Merge:** This smaller-scale concept would provide automated warning flashers or dynamic message signage on Highway 99 southbound, upstream of the merge point, to warn users of the surge in ferry traffic volumes, to suggest shifting to the inside lane and to facilitate smoother merging.

## E.6 Next Steps

This high-level study outlined a range of potential long-term improvement opportunities for the highway corridor in general as well as several key interchanges. The study establishes the range of potential improvements BC MoTI may consider implementing in the long-term future, which in turn provides a basis for local and regional transportation agencies to continue their own strategic transportation planning activities to address local and sub-regional needs. Several specific areas of interest have been identified as requiring further consideration by these other agencies, including:

- On-corridor improvement opportunities should be considered in conjunction with the findings from the Integrated North Shore Transportation Planning Project (INSTPP) process and follow-up initiatives. It is noted that INSTPP did not identify increased capacity as the first step in addressing congestion; rather, INSTPP highlighted an opportunity to first focus on demand management measures (which include some, but not all, of the opportunities identified in this study). Furthermore, even within the context of infrastructure/capacity-oriented improvement opportunities, consideration will need to be given to assessing the compatibility of these on-corridor improvement opportunities with other regional transportation initiatives to improve mobility for the North Shore (e.g., Burrard Inlet Rapid Transit), which are currently the subject of separate planning studies.
- For any improvement opportunities involving new transit service, further work would be required by TransLink to validate and further assess the assumptions, feasibility, performance and cost of such a service. The feasibility of continuing the bus-on-shoulder system between Lynn Valley Road and Phibbs Exchange would also need to be confirmed.
- In the event that either an HOV or additional general-purpose lane were to be further contemplated, further assessment would be required to assess the potential impacts against the generated benefits.
- The study highlights several opportunities to improve active transportation connectivity both along and across the highway corridor. Consideration of these opportunities by municipal and regional transportation agencies is required to ensure the ongoing development of an active transportation network that provides seamless connectivity and consistent quality of facilities across the North Shore.

- With respect to potential interchange opportunities, coordination is required with local and regional government agencies to guide transportation and land use/development planning adjacent to the interchanges to ensure compatibility with potential future interchange footprints.
- For all improvement opportunities outlined herein, further development, investigation, engagement and evaluation across a range of financial, transportation, social, environmental, archaeological and economic criteria are required prior to proceeding towards implementation.

A potential phasing strategy has been developed that, subject to the considerations noted above with respect to further technical investigation and engagement, organizes potential improvements into short-term, medium-term and long-term timelines. Opportunities were assigned to these time frames based on concept complexity, interdependency with other initiatives, and anticipated costs. In some cases, interchanges that were categorized as long-term opportunities feature elements that could be implemented in the short term to provide an interim benefit while still being broadly compatible with longer-term improvements. The proposed phasing strategy is as follows:

- Short-Term:
    - Lynn Valley Road Interchange: Westbound and Eastbound On-Ramp Extensions.
    - Capilano Road Interchange: North Side Active Transportation Improvements.
    - Westview Drive Interchange: Eastbound Off-Ramp Shoulder Cycling Extension.
    - Westview Drive Interchange: Westview Drive and 23rd Street Signal Coordination.
    - Highway 99 Sea to Sky/Highway 1 Eastbound Merge.
    - On-Corridor: Active Transportation Improvements between Westview Drive and Pemberton Avenue.
    - Caulfeild Westbound Ramp Terminal Intersection Improvements.
    - Taylor Way Interchange Cycling Improvements.
    - 21st Street and 15 Street Interchanges Improvements.
- Medium-Term:
    - Lynn Valley Road Interchange: Eastbound Off-Ramp Extension.
    - Lonsdale Avenue Interchange: Active Transportation Improvements.
    - St. Georges Avenue Overpass.
- Long-Term:
    - On-Corridor Transit Service with Bus-on-Shoulder.
    - Lynn Valley Road Interchange: Transit Elements.
    - Capilano Road Interchange: Bridge Twinning.
    - Westmount Road Interchange: East-facing Ramps and Road Connection.

# 1. INTRODUCTION

The Highway 1/99 North Shore Corridor Study: Lynn Valley Road to Horseshoe Bay is a high-level strategic transportation planning assessment of the long-term needs of the highway corridor, often referred to as the Upper Levels Highway, between Lynn Valley Road and Horseshoe Bay.

## 1.1 Study Area

The Upper Levels Highway passes through three municipalities (the District of North Vancouver, the City of North Vancouver and the District of West Vancouver) and the traditional territories of three Indigenous groups (Musqueam Indian Band, Squamish Nation and Tsleil-Waututh Nation). The majority of the segment of the highway running through West Vancouver is co-signed as Highway 99, as this segment of highway also facilitates connectivity with the Lions Gate Bridge (via Marine Drive and Taylor Way) to the south and the Sea to Sky Highway (Highway 99) to the north.

A map of the study corridor is provided in ***Figure 1.1***.

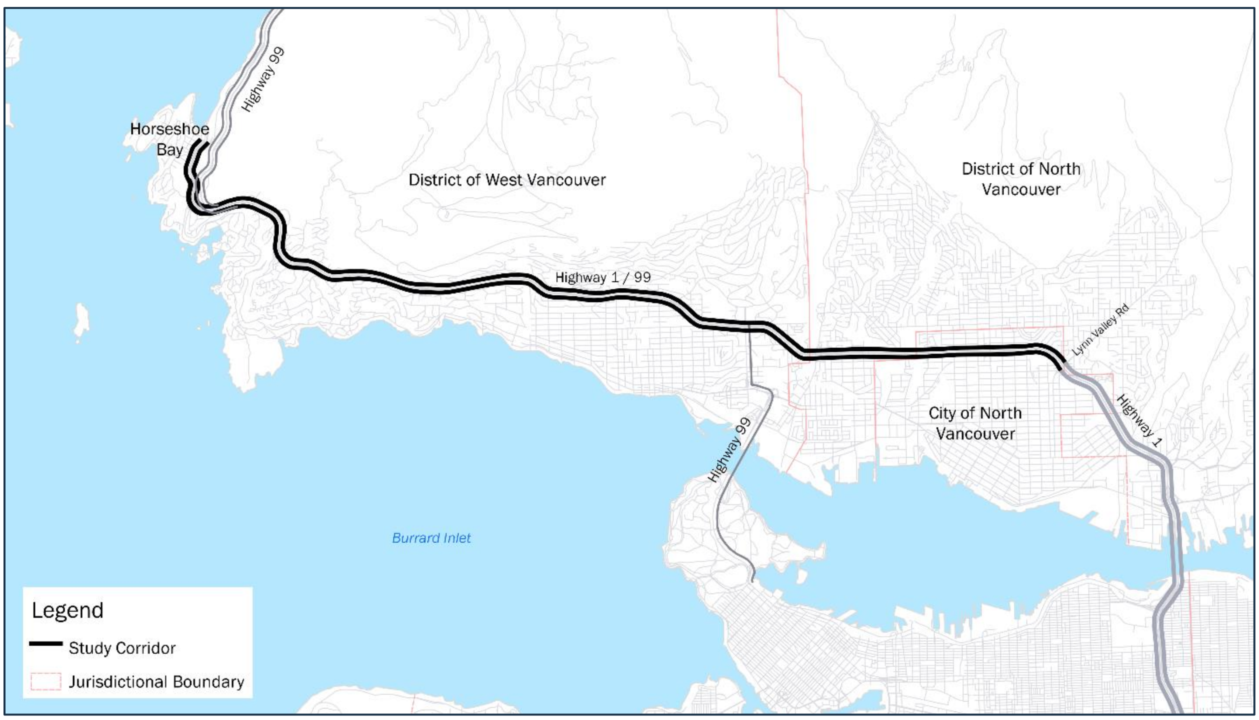


**Figure 1.1: Study Corridor**

This study made use of a regional travel demand modelling tool to assess travel patterns and highway operations in the context of overall regional trip-making. As such, travel patterns to and from key connecting corridors (Highway 1 through the Lower Lynn area and across the Ironworkers Memorial Bridge, Taylor Way and the Lions Gate Bridge, the Sea to Sky Corridor, etc.) are captured in the analysis. However, from the perspective of identifying issues and generating potential mitigation measures, the scope of the study is limited to the defined segment of Highway 1/99 between Lynn Valley Road and Horseshoe Bay.

## 1.2 Study Objectives

The objectives of this planning study are to:

- Undertake a high-level assessment of the current and anticipated future corridor performance by forecasting out to year 2050.
- Based on the outcomes of the current and future performance assessments, develop and evaluate the feasibility of a range of potential improvement opportunities, including shoulder-running bus lanes, highway widening and lane allocation, on-corridor provisions for active transportation, footprint requirements for new or reconfigured interchanges, and other potential improvements.
- Develop documentation of various improvement opportunities on the North Shore that can provide reference material during the design development phase of potential future projects, with a focus on potential design interdependencies with other improvement opportunities.

## 1.3 Report Organization

This reporting for the Highway 1/99 North Shore Corridor Study: Lynn Valley Road to Horseshoe Bay is organized as follows:

- **Section 2: Problem Definition** conducts an issues identification process based on a review of previous reports, the engagement process with study partners and stakeholders, and a technical assessment of corridor-level mobility, network-level mobility and road safety.
- **Section 3: Potential On-Corridor Improvement Opportunities**, which, based on the findings of the issues identification process, develops and undertakes a high-level evaluation of three potential approaches to improve multi-modal mobility along the eastern portion of the study corridor (i.e., Capilano River to Lynn Valley).
- **Section 4: Potential Interchange Improvement Opportunities**, which, based on the findings of the issues identification process, develops and undertakes a high-level evaluation of potential improvements at several interchanges throughout the corridor to address a variety of mobility and safety challenges.
- **Section 5: Prioritization and Phasing** provides an overall summary of the evaluation results and potential next steps.

# 2. PROBLEM DEFINITION

This section provides an assessment of existing and anticipated future conditions along the study corridor, culminating in the identification of key multi-modal operations and safety performance issues for which mitigation options will be developed. This section is structured as follows:

- Section 2.1 provides an overview of existing (physical) infrastructure along the corridor.
- Section 2.2 provides a review of previous studies.
- Section 2.3 provides an assessment of some key factors that are broadly influencing travel patterns in the study corridor.
- Section 2.4 provides a technical assessment of mobility along the study corridor.
- Section 2.5 provides a technical assessment of mobility at sub-regional/network levels.
- Section 2.6 provides a technical assessment of road safety and collision history.
- Section 2.7 provides a review of feedback received through the engagement process.
- Section 2.8 provides a summary of the key issues and challenges in the corridor.

## 2.1 Existing Infrastructure

The highway is a four-lane facility (with a short six-lane section) and features full access control and free-flow conditions; entries to and exits from the highway occur only at 13 interchanges/access points along the corridor. The following provides a brief description of the highway characteristics with respect to horizontal and vertical geometry, laning and cross-sections, posted speeds, on-corridor transit, on-corridor cycling infrastructure, highway access and cross-corridor facilities (i.e., interchanges), other cross-corridor walking and cycling facilities, and bridge structures.

### 2.1.1 Geometry

The horizontal geometry of Highway 1/99 across the North Shore runs in a generally east-west direction and is typically set 1 to 2 kilometres up the hillside from the northern shoreline of Burrard Inlet. The eastern portion of the study corridor through the District of North Vancouver and City of North Vancouver is generally a straight east-west alignment with few horizontal curvatures other than in the immediate vicinity of the Lynn Valley Road Interchange. In contrast, the western portion of the study corridor through the District of West Vancouver is slightly more winding, particularly where the highway runs near the base of Cypress Mountain. The sharpest horizontal curvature is located within the District of West Vancouver just west of the Capilano River, and features a radius of approximately 200 metres, which provides for a design speed of 70 km/h (assuming a superelevation of 0.04 m/m).

With respect to vertical geometry, within the eastern portion of the study corridor, the highway generally runs on a downhill grade towards the west, beginning with a high point of approximately 160 metres above sea level just west of the Lynn Valley Interchange (at the top of the "cut"[1]) to a low point of approximately 45 metres near the Capilano River. Within the western portion of the study corridor, slopes are more varied, with the highway running from 45 metres at the Capilano River to a high point of approximately 170 metres between the 21st Street Interchange and Cypress Bowl Road Interchange, and then ultimately descending almost to sea level at the Horseshoe Bay ferry terminal.

There are several areas along the study corridor where extended uphill grades can create impacts on traffic operations, particularly for trucks or other heavy vehicles. In the eastbound direction, these uphill grades include:

- From the Horseshoe Bay ferry terminal to the Highway 99 Sea to Sky Merge, where grades average approximately 7.2% for a distance of 1.7 kilometres.
- From the Eagle Creek Bridge structure to the Caulfeild Interchange, where grades average approximately 4.5% for a distance of 1.1 kilometres.
- From the Westmount Road Interchange to the Cypress Bowl Road Interchange, where grades average approximately 4.5% for a distance of 1.2 kilometres.
- From the Westview Drive Interchange to the Lonsdale Avenue Interchange, where grades average approximately 5.3% for a distance of 600 metres.
- Beginning at the Lonsdale Avenue Interchange, where grades average approximately 4.8% for a distance of 700 metres.

In the westbound direction, these uphill grades include:

- From the Capilano River to the Taylor Way Interchange, where grades average approximately 4.5% for a distance of 600 metres.
- From the Taylor Way Interchange to the 15th Street/Cross Creek Road Interchange, where grades average approximately 5.7% for a distance of 1.2 kilometres.

### 2.1.2 Laning and Cross-Section

The highway mainline primarily features two general-purpose mainline lanes in each direction, with the following exceptions:

- In the vicinity of the Westview Drive Interchange and Lonsdale Avenue Interchange, the cross-section expands to six mainline lanes for a distance of approximately 1.3 kilometres. The east-facing ramps at Westview Drive Interchange and the west-facing ramps at Lonsdale Avenue Interchange are configured as auxiliary lanes and briefly expand the cross-section to eight lanes.
- In the westbound direction from the Taylor Way Interchange to the 15th Street/Cross Creek Road Interchange, the westbound on-ramp from Taylor Way runs for approximately 1.3 kilometres, which is beyond the off-ramp diverge location for the 15th Street/Cross Creek Road Interchange. As such, the

[1] The "cut" is the nickname for a segment of the highway between the Lynn Valley Road Interchange and the Mountain Highway Interchange that features an extended downhill grade in the eastbound direction (and, by extension, an extended uphill grade in the westbound direction).

on-ramp lane acts as a *de facto* climbing lane up the approximately 5.5% grade between the two interchanges.

- In the westbound direction near the bridge over Nelson Creek, three lanes are provided, although the third lane is in effect an extended off-ramp/ferry toll plaza queuing lane for the major fork that spits the highway between Highway 99 (Sea to Sky Corridor) and the Horseshoe Bay ferry terminal and village.

There are no special lane designations (e.g., transit only, high-occupancy vehicle) provided anywhere along the length of the corridor.

The current laning is graphically shown in ***Figure 2.1***.

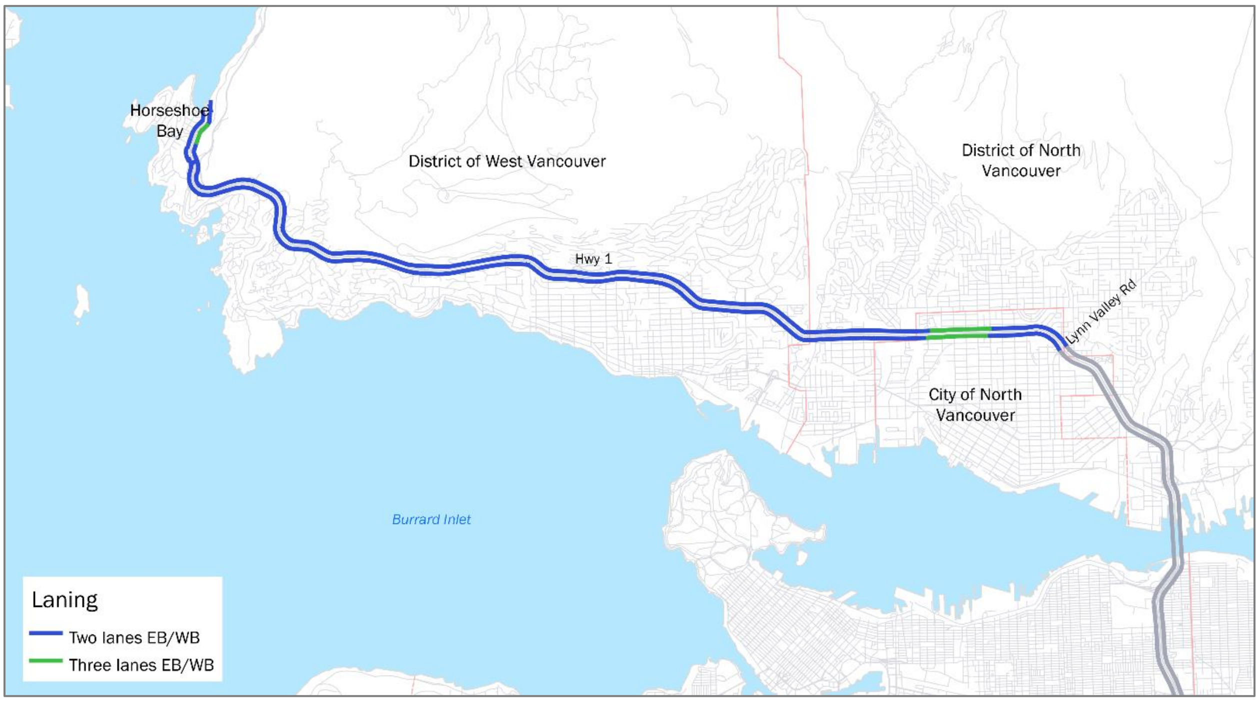


Figure 2.1: Current Vehicular Laning Along the Study Corridor

Additional cross-sectional elements, such as provision of a median and the width of inside and outside shoulders, are variable along the length of the corridor. In general, outside shoulders through the western portion of the study corridor (i.e., West Vancouver) are generally in the range of 2.5 metres to 3 metres wide, although both wider and narrower shoulder segments exist in places. Of particular note, the Capilano River Bridge does not feature any outside shoulders, and the bridge over Nelson Creek also features narrower shoulders (roughly 1.5 metres). The latter structure featured wider shoulders until the highway cross-section was reconfigured in 2009 as part of the major fork to/from the Highway 99 Sea to Sky Corridor. Outside shoulders through the eastern portion of the study corridor (i.e., the District of North Vancouver and City of North Vancouver) are generally in the range of 2.0 metres to 2.5 metres wide, although both wider and narrower shoulder segments exist in places.

Inside shoulder widths typically range from 0.6 metres to 1.0 metre along much of the corridor, with a few major exceptions:

- The section of the highway through the Westview Drive and Lonsdale Avenue Interchange was constructed in the early 1990s and features more modern highway geometry. In this area, shoulder widths are typically in the range of 1.5 metres to 2 metres.
- In some cases, the highway features a wide median and/or a split grade; this is often a result of topography or interchange design (e.g., the 21st Street Interchange and the Taylor Way Interchange).

### 2.1.3 Posted Speed

The posted speed limit along the corridor ranges from 90 km/h on the western portion of the corridor to 80 km/h on the eastern portion. Specifically:

- In the eastbound direction, the posted speed limit is 60 km/h upon leaving the Horseshoe Bay ferry terminal and rises to 80 km/h just beyond the Marine Drive overhead structure, and then to 90 km/h near the Eagle Creek bridge structure. The posted speed limit remains at 90 km/h for approximately 11 kilometres until it transitions to 80 km/h approximately 700 metres east of the Taylor Way Interchange, and then remains at 80 km/h for the next 6 kilometres until the Lynn Valley Road Interchange. Approximately 200 metres downstream of the transition to 80 km/h, an advisory speed limit of 60 km/h is provided immediately prior to the sharp horizontal curvature on the west side of the Capilano River Bridge. Shortly beyond the eastern boundary of the study area at the Lynn Valley Road Interchange, the posted speed limit drops to 70 km/h.
- In the westbound direction, the posted speed limit transitions from 80 km/h to 90 km/h at the 11th Street pedestrian overpass structure located approximately 700 metres west of the Taylor Way Interchange. At the major fork with the Highway 99 Sea to Sky Corridor, the posted speed limit on the Highway 1 "off-ramp" drops to 50 km/h.

The current posted speeds are shown in ***Figure 2.2***.

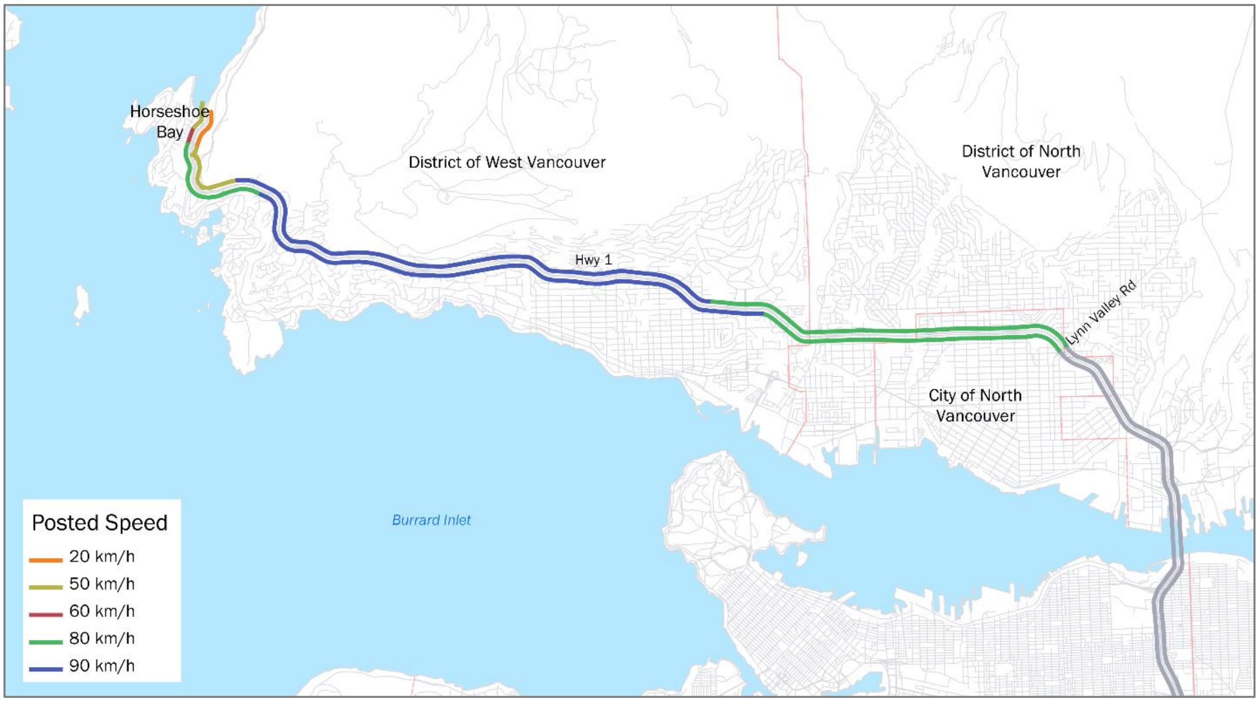


Figure 2.2: Current Posted Speed Limits Along the Study Corridor

### 2.1.4 On-Corridor Transit

Two bus services run along the highway corridor. The Route 257 Horseshoe Bay Express that connects the Horseshoe Bay ferry terminal to the Park Royal Shopping Centre and downtown Vancouver operates on the highway for approximately 11 kilometres between the ferry terminal and the 15th Street/Cross Creek Road Interchange; Route 262 Brunswick/Caulfeild runs along the highway for approximately 4 kilometres between the Caulfeild Interchange and Horseshoe Bay. Existing transit services are described further in Section 2.5.2.

### 2.1.5 On-Corridor Cycling Infrastructure

Shoulder cycling is permitted on an approximately 14-kilometre-long segment of Highway 1 from the Horseshoe Bay ferry terminal to Capilano Road. Other than an approximately 1.5-kilometre-long segment of Highway 99 near the US border, this is the only instance of shoulder cycling being permitted on a Schedule 1 highway in Metro Vancouver. As noted previously, shoulder widths along the corridor are variable, but generally range from 2.5 metres to 3 metres.

People cycling along the highway shoulders may interact with vehicles at each on-ramp and off-ramp. In some cases, signage is provided to direct cyclists to cross from the ramp shoulder to the gore area at off-ramps, and from the gore area to the ramp shoulder at on-ramps; people cycling must yield to vehicles and wait for a gap in the traffic stream at both ramps. In other cases, cyclists must exit via the off-ramp, pass through the ramp terminal intersection, and then rejoin the highway via the on-ramp.

A map of the section of the highway where shoulder cycling is permitted is shown graphically in ***Figure 2.3***.

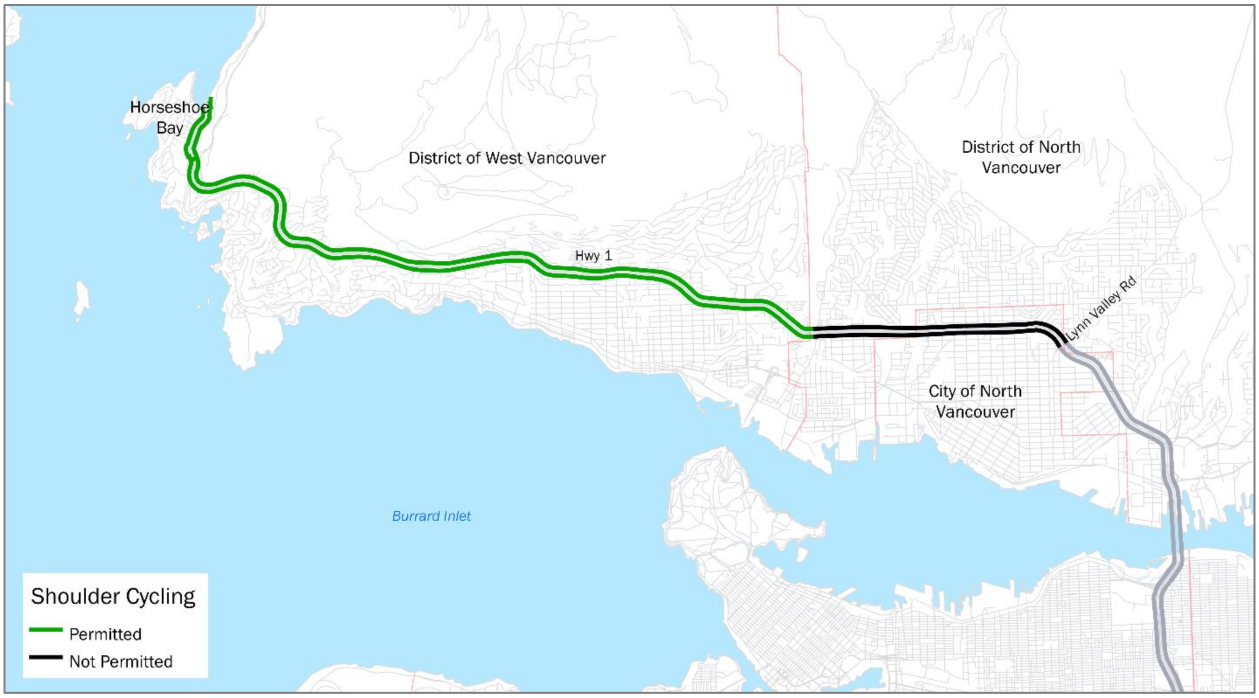


Figure 2.3: Permitted Shoulder Cycling Along Study Corridor

In addition to shoulder cycling, two segments of the highway corridor feature barrier-separated parallel pathways within the highway right-of-way. These include a bidirectional multi-use path on the north side of the highway just west of the Capilano River near Hugo Ray Park, and also on the south side of the highway corridor between Pemberton Avenue (which is just east of the Capilano Road Interchange) and the Westview Drive Interchange.

### 2.1.6 Interchanges

The study corridor is entirely free-flow and fully access-controlled; there are no signalized intersections nor any direct private accesses along the corridor and therefore all entries and exits from the corridor are via interchanges. There are 12 full-movement interchanges along the study corridor, plus one additional right-in/right-out access for the westbound direction only. The interchanges located along the study corridor are summarized in ***Table 2.1***, along with the following supplementary information:

- Distance from previous interchange (i.e., interchange spacing), which is intended to provide a general indication of access to/from the highway throughout the North Shore.[2]
- Type of interchange.
- Configuration of the highway with respect to the cross street (i.e., whether the highway passes overtop the cross street, or vice versa).
- Existing traffic controls on the interchange ramp terminal intersections.
- Cross-street walking facilities, cycling facilities and transit services.

[2] These spacing measurements do not reflect the distances between on-ramp merge and off-ramp diverge areas, and therefore are not necessarily intended to provide an indication of the potential for traffic operations issues (e.g., weaving).

Table 2.1: Summary of Existing Interchanges

| Intersecting Street | Distance from Previous Interchange | Type of Interchange | Configuration with Cross Street | Ramp Terminal Traffic Control | Cross-Street Walking Facilities | Cross-Street Cycling Facilities | Cross-Street Transit Services | Notes |
|---|---|---|---|---|---|---|---|---|
| **Eagleridge Drive** | 1.5 km (from Keith Road signalized intersection within BC Ferries Horseshoe Bay ferry terminal) | Split Diamond | Highway beneath cross street | **Westbound:** Roundabout<br>**Eastbound:** Stop-controlled | Sidewalk on northbound (i.e., east) side only; relatively narrow | None | None | |
| **Highway 99 Sea to Sky Corridor** | 0.4 km | Major Fork | Not applicable | Not applicable. | Not applicable | Not applicable | None | |
| **Caulfeild Interchange (at Headland Drive/Westport Road)** | 2.1 km | Split Diamond | Highway beneath cross street | **Westbound:** Stop-controlled<br>**Eastbound:** Stop-controlled | Sidewalk on northbound (i.e., east) side only; relatively narrow | None | Route 262, Route 263 | The Caulfeild Interchange acts as the U-turn route for trips between the Highway 99 Sea to Sky Corridor and the Horseshoe Bay ferry terminal |
| **Westmount Drive** | 2.6 km | Diamond | Highway beneath cross street | **Westbound:** Yield-controlled<br>**Eastbound:** Stop-controlled | Sidewalk on southbound (i.e., west) side only; relatively narrow | None | None | |
| **Cypress Bowl Road** | 1.6 km | Diamond | Highway beneath cross street | **Westbound:** Stop-controlled | Sidewalk on southbound (i.e., west) side only; relatively narrow | None | None | |

| Intersecting Street | Distance from Previous Interchange | Type of Interchange | Configuration with Cross Street | Ramp Terminal Traffic Control | Cross-Street Walking Facilities | Cross-Street Cycling Facilities | Cross-Street Transit Services | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | **Eastbound:** Stop-controlled | | | | |
| **21st Street** | 2.1 km | Diamond | Highway above cross street | **Westbound:** Signalized (off-ramp) Yield-controlled (on-ramp)<br>**Eastbound:** Stop-controlled (off-ramp) Yield-controlled (on-ramp) | Sidewalk on southbound (i.e., west) side only; relatively narrow | None | Route 256 | West-facing ramps are separated from the main interchange. Specifically, the westbound on-ramp is located along Skilift Road approximately 600 metres west of the rest of the interchange. Similarly, the eastbound off-ramp connects to 22nd Street, and requires approximately 400 metres of travel on local streets (22nd Street and Queens Avenue) to reach 21st Street. |
| **15th Street/Cross Creek Road** | 0.9 km | Diamond | Highway above cross street | **Westbound:** Signalized<br>**Eastbound:** Stop-controlled | Sidewalk on southbound (i.e., west) side only; relatively narrow | None | Route 257 (as part of movement on/off the highway) | |
| **Taylor Way** | 1.7 km | Diamond | Highway above cross street | **Westbound:** Signalized<br>**Eastbound:** Signalized | Sidewalks on both sides; relatively narrow | None | Route 254 | |
| **Capilano Road** | 1.5 km | Parclo AB | Highway above cross street | **Westbound:** Signalized | Sidewalks on both sides; relatively narrow | None | Route 236, Route 246, Route 247 | |

| Intersecting Street | Distance from Previous Interchange | Type of Interchange | Configuration with Cross Street | Ramp Terminal Traffic Control | Cross-Street Walking Facilities | Cross-Street Cycling Facilities | Cross-Street Transit Services | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | **Eastbound:** Signalized | | | | |
| **Lloyd Avenue (westbound only)** | 0.9 km | Right-in/ right-out | Not applicable | **Westbound:** Stop-controlled<br>**Eastbound:** Not applicable | Not applicable; Lloyd Avenue does not connect across highway corridor | Not applicable; Lloyd Avenue does not connect across highway corridor | None | |
| **Westview Drive** | 1.2 km (for eastbound direction from Lloyd Avenue)<br><br>2.1 km (for eastbound direction from Capilano Road) | Tight Urban Diamond | Highway beneath cross street | **Westbound:** Signalized<br>**Eastbound:** Signalized | Sidewalks on both sides; relatively narrow | None | Route 249 | Considered a tight urban diamond due to limited spacing between ramp terminal intersections |
| **Lonsdale Avenue** | 1.2 km | Tight Urban Diamond | Highway beneath cross street | **Westbound:** Signalized<br>**Eastbound:** Signalized | Sidewalks on both sides; relatively narrow | None | Route 229, Route 230, Route 232, Route 241, Route 242 | Considered a tight urban diamond due to limited spacing between ramp terminal intersections |
| **Lynn Valley Road** | 1.5 km<br><br>Downstream interchange (Mountain Highway) is | Diamond (westbound)/Parclo B2 (eastbound) | Highway above cross street | **Westbound:** Yield-controlled (off-ramp) Yield-controlled (on-ramp) | Sidewalks on both sides; relatively narrow. Southbound direction sidewalk has adjacent | Southbound direction has protected cycling lane | Route 228, Route 255 | Westbound off-ramp is located along William Avenue, and connects to an intersection with Lynn Valley Road approximately |

| Intersecting Street | Distance from Previous Interchange | Type of Interchange | Configuration with Cross Street | Ramp Terminal Traffic Control | Cross-Street Walking Facilities | Cross-Street Cycling Facilities | Cross-Street Transit Services | Notes |
|---|---|---|---|---|---|---|---|---|
| | at a distance of 1.9 km | | | **Eastbound:** Signalized | protected cycling lane. | | | 250 metres away from the main interchange |

In addition to the interchanges, there is one roadway (Edgemont Boulevard, located between the Capilano Road Interchange and the Westview Drive Interchange) that crosses the highway corridor as an overpass but does not provide any connectivity to and from the highway. The Edgemont Boulevard overpass provides sidewalks on both sides, but does not have any specific provisions for cycling.

### 2.1.7 Additional Cross-Corridor Pedestrian Sidewalks, Cycling Infrastructure and Pathways

In addition to the walking and cycling facilities provided at interchanges (and on the Edgemont Boulevard overpass) that were described above in ***Table 2.1***, the highway corridor includes several additional crossing opportunities for active modes. These additional opportunities are as follows:

- **26th Street/Chairlift, District of West Vancouver:** An overpass is provided at 26th Street, roughly halfway between the Cypress Bowl Road Interchange and the 21st Street Interchange. The overpass does not require people cycling to dismount, although the loop ramps on the south side of the span feature steep grades and tight horizontal curvatures, which may prove challenging for some riders.
- **11th Street, District of West Vancouver:** An overpass is provided at 11th Street, roughly halfway between the 15th Street/Cross Creek Road Interchange and the Taylor Way Interchange Drive and Lonsdale Avenue. The overpass does not require people cycling to dismount, although the loop ramps on the south side of the span feature steep grades and tight horizontal curvatures, which may prove challenging for some riders.
- **Philip Avenue, District of North Vancouver:** An underpass/culvert is provided at Philip Avenue, just east of the Capilano Road Interchange. The underpass requires people cycling to dismount.
- **Pemberton Avenue, District of North Vancouver:** An overpass is provided at Pemberton Avenue, slightly further east of the Capilano Road Interchange. The overpass does not require people cycling to dismount, although the loop ramps at either side of the span feature steep grades and tight horizontal curvatures, which may prove challenging for some riders.
- **Jones Avenue, City of North Vancouver:** A overpass is provided at Jones Avenue, roughly halfway between the Westview Drive Interchange and Lonsdale Avenue Interchange. The overpass requires people cycling to dismount.
- **Casano Drive, City of North Vancouver:** Just beyond the eastern boundary of the study area, the City of North Vancouver plans to construct the Casano-Loutet overpass across the highway in 2021. The overpass incorporates modern design standards that are intended to accommodate users of all ages and abilities, including a wide path, limited/gentle grades (facilitated by gradual/sweeping curves to accommodate changes in elevation), lighting to improve safety (and perception thereof), and benches for people to rest.

### 2.1.8 Structures

BC MoTI maintains an online database for all structures on the provincial highway system. Based on the information reviewed, there are 25 bridge structures located along the study corridor. These structures, running west to east, are summarized in ***Table 2.2***.

Table 2.2: Summary of Existing Bridge Structures

| Structure Name | Type | Approximate Location | Highway/Cross-Street Structure |
|---|---|---|---|
| Horseshoe Bay U/P | Underpass | Marine Drive/Horseshoe Bay Drive | Highway |
| Squamish U/P | Underpass | BC Ferries Horseshoe Bay Toll Booth | Highway |
| Eagleridge Dr U/P | Underpass | Eagleridge Drive | Highway |
| Eagle Bluff Hwy 1 U/P | Underpass | Highway 1 Exit 3 | Highway |
| Nelson Cr | Bridge | Nelson Creek | Highway |
| Westport Rd O/P | Overpass | Westport Road | Cross street |
| Caulfeild Dr U/P | Underpass | Headland Drive/Northwood Drive | Highway |
| Caulfeild Ped Tun | Tunnel | Caulfeild Drive | Cross street |
| Almondel Rd O/P | Overpass | Almondel Road | Cross street |
| Westmount Rd U/P | Underpass | Westmount Road/Wentworth Avenue | Highway |
| Cypress Bowl Rd U/P | Underpass | Cypress Bowl Road | Highway |
| 26th St Ped O/P | Overpass | 26th Street | Cross street |
| 21st St O/P | Overpass | 21st Street | Cross street |
| 15th St O/P | Overpass | 15th Street/Cross Creek Road | Cross street |
| 11th St Ped O/P | Overpass | 11th Street | Cross street |
| Taylor Way O/P | Overpass | Taylor Way | Cross street |
| Capilano Canyon | Bridge | Capilano Road | Highway |
| Keith Rd Ped Tun | Tunnel | Keith Road | Cross street |
| Pemberton Ped O/P | Overpass | Pemberton Avenue | Cross street |
| Edgemont Blvd U/P | Underpass | Edgemont Boulevard | Highway |
| Mosquito Cr | Bridge | Mosquito Creek | Highway |
| Westview U/P | Underpass | Westview Drive | Highway |
| Jones Ave Ped O/P | Overpass | Jones Avenue | Cross street |
| Lonsdale Ave U/P | Underpass | Lonsdale Avenue | Highway |
| Lynn Valley Rd O/P | Overpass | Lynn Valley Road | Cross street |

## 2.2 Review of Previous Studies

The review of previous studies and reports has been used to support the identification of outstanding issues on the highway as well as to provide a basis for both the technical analysis and the engagement process for further discussion and identification of issues. The compiled list of issues is documented in this section.

The review of previous documentation has been separated into two categories:

- BC Ministry of Transportation and Infrastructure (BC MoTI)-generated reports and study documents focusing on publications from BC MoTI (or consultants) that relate either directly or indirectly to the Highway 1/99 corridor.
- Stakeholder-generated reports and studies, primarily focusing on a review of documents from TransLink, the three North Shore municipalities, or other parties that may have ideas or policies relating to the Highway 1/99 corridor.

The study corridor has not been the subject of any focused corridor-level studies since the completion of the free-flow corridor in the mid-1990s. Therefore, the list of previous studies is relatively small, and primarily focuses on studies that either directly relate to only a small part of the corridor or indirectly affect the corridor. The list of studies reviewed in this document includes:

- BC MoTI-Generated Documents:
    - *Highway 1 at Main/Dollarton Interchange Detailed Design Subject: Vissim Model Update for the Reduced 90% Detailed Design – Final Technical Memo* (2019)
    - *Highway 99 Sea to Sky Corridor Study* (2018)
    - *Lower Mainland Highway Information System Dashboard* (2016)
    - *Highway 1 Willingdon Avenue to Lynn Valley Road (2016)*
    - *Lower Lynn Interchanges Options Identification and Evaluation* (2014)
    - *Lions Gate to Highway 1 Connector Planning Study* (2007)
- Stakeholder-Generated Documents:
    - *Integrated North Shore Transportation Planning Project* (2018)
    - TransLink: *North Shore Area Transit Plan* (2012)
    - District of North Vancouver: *Transportation Plan* (2012)
    - District of West Vancouver: *Strategic Transportation Plan* (2010)
    - City of North Vancouver: *Long-Term Transportation Plan* (2008)
    - District of West Vancouver: *Official Community Plan* (2018)
    - *Transportation Impact Study for BC MoTI – Cypress Village – Phase 1 Development Scenario* (2018)
    - *Burrard Inlet Rapid Transit Study: Stage 2 Engineering Review* (2020)

### 2.2.1 Highway 1 at Main/Dollarton Interchange Detailed Design Subject: Vissim Model Update for the Reduced 90% Detailed Design – Final Technical Memo (2019)

The purpose of this memo was to provide guidance for the detailed design of the Lower Lynn Interchanges project.

While outside the study area, the area modelled in this memo is adjacent to the study area. Currently, queues through the Lower Lynn area can extend through the cut to the study area. However, the point-to-point travel times and (lack of) unprocessed vehicles in the VISSIM model outputs imply that the analysis undertaken in this memo found that, in the future, it is not anticipated that queue spillbacks up the cut would affect the study area (i.e., Lynn Valley Interchange and Highway 1 segments further west). Note that this analysis is not necessarily using the same long-term forecasting horizon year (2050) that is being applied for this study.

### 2.2.2 BC MoTI/Resort Municipality of Whistler: Highway 99 Sea to Sky Corridor Study (2018)

This study provides forecasts of vehicle volumes on the Highway 99 Sea to Sky Corridor that can be used to guide refinement of anticipated growth rates in volumes at the external zone on Highway 99 just north of Horseshoe Bay. Using the best information available for this external zone is critical to forecasting of future volumes on the Highway 1 study corridor, particularly in light of the high growth rate of volume on the Highway 99 Sea to Sky Corridor over the past decade.

### 2.2.3 Lower Mainland Highway Information System Dashboard (2016)

The BC MoTI Lower Mainland Highway Information System compiles key highway performance metrics related to traffic volumes, mobility (i.e., vehicle speeds) and road safety (including collision rate, collision severity, collision type, and weather and road surface conditions) into a dashboard tool.

#### TRAFFIC VOLUMES

Traffic volumes are not provided within the study corridor itself and therefore do not provide insight directly. However, the volumes do show that the Ironworkers Memorial Bridge carries roughly double the daily traffic volume of the Lions Gate Bridge. Seasonality effects (i.e., higher summer volumes) are pronounced on the Ironworkers Memorial Bridge and especially on the Highway 99 corridor north of Horseshoe Bay.

#### HIGHWAY SPEEDS

The dashboard results clearly show that eastbound speeds are lower than westbound ones, regardless of the time of day, and that speeds are consistently lower in the Lower Lynn area on the approach to the Ironworkers Memorial Bridge. This suggests that the highway immediately upstream of the bridge and/or the bridge itself are bottlenecks, and that queue spillbacks from this area can cause decreases in speed upstream of this area (e.g., up to Lynn Valley Road Interchange and even beyond, on more congested days). The comparatively higher speeds in the westbound direction likely reflect the fact that the south approach to the Ironworkers Memorial Bridge creates a bottleneck that meters traffic flow into the North Shore. As long as sufficient volumes exit from the highway within the North Shore, the additional vehicles travelling westbound from origins within the North Shore do not create significant increases in congestion.

#### ROAD SAFETY

The Capilano River Interchange, followed by the Lynn Valley Road Interchange, have by far the highest collision frequencies in the study corridor. The area around Mackay Creek and Mosquito Creek appears to have a high collision severity in both directions, as does the segment of Highway between the Caulfeild Interchange and the Westmount Road Interchange.

### 2.2.4 Highway 1 Willingdon Avenue to Lynn Valley Road (2016)

Between 2009 and 2013, substantial upgrades were undertaken on Highway 1 as part of the Port Mann/Highway 1 project. This additional capacity along the corridor was anecdotally found to change congestion conditions, particularly between Lynn Valley Road and Willingdon Avenue. The objective of this study was to undertake a review of traffic operations in the Highway 1 corridor between Lynn Valley Road and Willingdon Avenue, identify any congestion/operational issues, and identify, analyze and recommend potential mitigation measures.

The Lower Lynn Interchanges project has an important relationship to the study corridor, as issues and incidents in the area can have major upstream impacts. The model assessment suggests that the Lower Lynn Interchange project will improve travel, which may help reduce the risk of upstream queuing affecting the study area beginning at Lynn Valley Road. However, this assessment focused on near-term operational analysis, and did not consider a longer-term planning horizon.

### 2.2.5 Lower Lynn Interchanges Options Identification and Evaluation (2014)

The objective of this report was to identify and evaluate potential implementation options for the Lower Lynn Interchanges. This involved a process of issues identification, concept development, concept screening, package development and option evaluation.

While these interchanges are outside the study area, the effects of the Lower Lynn Improvements could be felt further west along the highway (i.e., in the study area). The report acknowledges this, but does not present any analysis outside the Lower Lynn study area. The concepts do not provide any specific references to, or provisions for, transit services along Highway 1 extending west from the Lower Lynn area.

### 2.2.6 Lions Gate to Highway 1 Connector Planning Study (2007)

The purpose of this study was to assess opportunities for improved connectivity between Highway 1 and the Lions Gate Bridge. All approaches to the Lions Gate Bridge experience extensive queueing, creating challenges for BC MoTI, TransLink, local municipalities and the Squamish Nation.

The study identified several specific issues at the Capilano Road Interchange, including a short westbound merge distance, causing difficulties for traffic joining the highway; a short eastbound off-ramp, causing deceleration upstream on highway mainline lanes; and safety concerns regarding the Bowser Avenue and Keith Road connections to the south-side ramps.

Modelled traffic performance for the 2021 study horizon year found that queues on southbound Taylor Way are anticipated to back up onto Highway 1 in the PM peak, similar to existing AM conditions. Existing queues on Capilano Road extend to Highway 1 in the AM peak as well, but were not found to do so in the 2021 PM peak.

### 2.2.7 Integrated North Shore Transportation Planning Project (2018)

The Integrated North Shore Transportation Planning Project (INSTPP) is a program initiated by the Government of Canada, the Government of BC, the three North Shore municipalities, the Squamish and Tsleil-Waututh First Nations, and TransLink. INSTPP investigated mobility and regional accessibility issues, as well as underlying land use patterns that can contribute to these issues.

A number of the considerations recommended by INSTPP would directly or indirectly impact the study corridor:

- The report notes that the highway corridor is heavily relied upon for local trips within the North Shore.
- The report prioritizes implementation of measures focused on transportation demand management as the preferred tool to address congestion.
- A potential new inter-regional bus service to the Squamish-Lillooet Region District would use the corridor.
- An express bus service across the Ironworkers Memorial Bridge could use the corridor.
- Completion of the Lower Level Road could provide a third major crossing of the Capilano River.
- A new rapid transit link to the North Shore could affect travel patterns and volumes on the corridor (this rapid transit link is described below in Section 2.2.14).
- The report highlighted the opportunity to complete and improve pedestrian and cycling networks. This could include new and/or improved active transportation connections both along and across the highway corridor.
- The report highlighted the importance of cross-jurisdiction coordination of land use with transportation, with an emphasis on co-locating mixed-use communications with high-quality sustainable transportation opportunities.
- Lonsdale Interchange and Lynn Valley Road Interchange are specifically noted as areas where walking, cycling and transit improvements are desired.
- The Lower Lynn Improvement project is anticipated to have impacts on upstream performance of Highway 1 in the study area.
- Park-and-rides could be considered at key transit areas along the Highway 1 corridor in conjunction with bus service. INSTPP specifically notes potential opportunities near Highway 1 at Lonsdale Avenue/29$^{th}$ Street, at Lynn Valley Road and at Phibbs. However, other recommendations appear to prioritize development of transit service along the frequent transit network (which includes all of the locations noted above). Therefore, other areas may be more appropriate for park-and-ride.
- Safety improvements and expedited incident clearing could be considered along the corridor.

### 2.2.8 TransLink: *North Shore Area Transit Plan* (2012)

The North Shore Area Transit Plan (NSATP) is an area transit plan developed by TransLink that encompasses the entirety of the North Shore region.

The plan does not explicitly identify any major new transit services on Highway 1; the only service reflected in the long-term network vision map is the existing Route 257 that runs along Highway 1 between Horseshoe Bay and the 15th Street Interchange. From a cross-highway perspective, the vision also shows a rapid bus service along Lonsdale Avenue (which would run through the Lonsdale Avenue Interchange) and frequent bus services on Capilano Road and Lynn Valley Road (which would run through those two respective interchanges). Other less-frequent bus services may also cross the highway via other interchanges.

It is acknowledged that TransLink is also in the process of developing a new regional transportation strategy, called *Transport 2050*. A parallel initiative is also underway to explore opportunities for rapid transit across Burrard Inlet (as described below in Section 2.2.14). It is anticipated that, as these two initiatives become more fully defined in the future, there may be a need to refresh the area transit plan, at which point new priorities may be identified that could either directly or indirectly relate to the Highway 1 corridor.

### 2.2.9 District of North Vancouver: *Transportation Plan* (2012)

The District of North Vancouver released a municipal Transportation Plan in 2012. The purpose of the plan is to provide a long-term transportation strategy for the municipality.

The document highlights several District priorities that may directly or indirectly affect the highway corridor. For example, Lynn Valley Road was identified as a high priority for cycling improvements between Mountain Highway and Highway 1 (which forms the municipal boundary with the City of North Vancouver). The plan also identified the intersection of Lynn Valley Road and William Avenue as a potential road safety improvement. The westbound off-ramp for the Lynn Valley Interchange directs traffic onto William Avenue and through this intersection.

### 2.2.10 District of West Vancouver: *Strategic Transportation Plan* (2010)

The District of West Vancouver released a municipal Strategic Transportation Plan in 2010. The plan highlights several District priorities that may directly or indirectly affect the highway corridor:

- The plan recommends improved north-south walking and cycling connections across Highway 1, which are typically spaced between the existing interchanges along Highway 1.
- The plan identifies an opportunity to consider an “Upper Spirit Trail” greenway for walking and cycling that would run in an east-west direction on the north side of the highway corridor.
- The plan suggests considering a limited-stop commuter bus service, which would have more amenities than traditional TransLink routes, from Horseshoe Bay directly to Vancouver via Highway 1. Note that this service mimics the route of the existing Route 257 service, but would presumably have stops between Horseshoe Bay and Park Royal.
- The plan recommends enhancing east-west bus services, using Highway 1 where appropriate. The plan also supports expanded bus priority measures to increase speed and efficiency of service, although it does not specify where.
- The plan recommends developing carpool facilities, including carpool lots, park-and-ride and HOV lanes; however, it does not direct where these might be located.

### 2.2.11 City of North Vancouver: *Long-Term Transportation Plan* (2008)

The City of North Vancouver released a municipal Long-Term Transportation Plan in 2008. Whereas the previous plan released over 15 years prior focused almost entirely on the road network, this plan had a much greater focus on suitable multi-modal trip-making. The document highlights several City priorities that may directly or indirectly affect the highway corridor:

- The plan states that a new connection is required across the corridor between the Grand Boulevard and Loutet neighbourhoods, providing an alternative route to Lynn Valley Road. The proposed Casano-Loutet overpass will provide this connection.
- The plan notes various external initiatives, including Highway 1 projects such as the Lower Lynn Interchanges upgrades. The document does not suggest any further improvements, though it does note that the City is encouraging BC MoTI to consider redeveloping the Lynn Valley Road interchange. The City proposes upgrades to Westview Drive, Lonsdale Avenue and East Grand Boulevard/Boulevard Crescent, although specific changes at the interchanges are not identified.

It is noted that the City of North Vancouver is currently updating this plan with a new Mobility Strategy. Although still under development, it is understood that the new strategy will advance further policy direction and priority actions to improve connectivity across the City, and that this document may identify new priorities that could either directly or indirectly relate to the Highway 1 corridor. In advance of the new Mobility Strategy, the City of North Vancouver has also recently approved the WalkCNV Pedestrian Framework and the Safe Mobility Strategy. The latter document establishes the City's commitment to Vision Zero and the priority actions to be pursued to improve the safety and comfort of all road users. Technical work and analysis completed to support development of the strategy highlighted that Highway 1 interchanges within municipal boundaries see a significant share of annual collisions. The Strategy commits the City to work with key partners to explore multi-pronged actions to better separate and protect different road users in order to minimize the risk of collisions with serious injury or fatality.

### 2.2.12 District of West Vancouver: Official Community Plan (2018)

The District of West Vancouver Official Community Plan (OCP) outlines the planned growth and development of the community out to 2041. The document outlines that a significant amount of new development is anticipated in the Cypress Village and Cypress West lands, both of which are located immediately just north of the highway corridor, and which will likely be accessed via the highway.

The OCP also provides a map of active transportation facilities, and notes that several facilities in the vicinity of the Capilano River bridge are considered major bike routes (i.e., 3$^{rd}$ Street, Inglewood Drive and Keith Road). The study also identifies a potential future pedestrian and cycling connection to the north of the highway between Skilift Road and Cypress Bowl Road.

### 2.2.13 Transportation Impact Study for BC MoTI – Cypress Village – Phase 1 Development Scenario (2018)

This study was undertaken on behalf of the landowners for the Cypress Village development. The study, as well as several pieces of follow-up documentation, were reviewed. Key findings include the identification that there is more localized traffic using these interchanges than what is reflected in the Regional Transportation Model (RTM), that the level of development proposed in this area may exceed what is assumed in the RTM, and that the timing of the AM peak hour for this area differs from the Regional Transportation Model as a whole. As a result of these factors, travel demand forecasts within the immediate vicinity of the Westmount Road Interchange and Cypress Bowl Road Interchange are likely underestimated in RTM, particularly if the Cypress Village development were to proceed as proposed. Furthermore, as part of the planning for this development, a new connection between the Westmount Road Interchange and Cypress Bowl Road, known as the Westmount Connector, is being proposed.

### 2.2.14 Burrard Inlet Rapid Transit Study: Stage 2 Engineering Review (2020)

The Burrard Inlet Rapid Transit (BIRT) Study has been running concurrently to the Highway 1/99 North Shore Corridor Study. The most recent documentation from the BIRT initiative is the Stage 2 Engineering Review, which was released in September 2020. The key output from this study was the short list of five routes for a new rapid transit system to the North Shore that many be considered in the future:

- Option 1A, which would be a Canada Line Extension (or another potential alternate) to Lower Lonsdale in a tunnel.
- Option 2A, which would run from Burrard Station via First Narrows to Central Lonsdale in a tunnel.
- Option 3A, which would run from Burrard Station via Brockton Point to Central Lonsdale in a tunnel.
- Option 5B, which would run from Brentwood Town Centre Station via Second Narrows to Lower Lonsdale using a new bridge.
- Option 5B2, which would run from Waterfront Station via Second Narrows to Lower Lonsdale using a new bridge.

As these studies run in parallel, options developed through the BIRT study have not been included in the travel demand modelling for this study. Therefore, all travel demand modelling results included herein could change if tested in conjunction with a new rapid transit line across Burrard Inlet, and would likely vary from option to option. It is anticipated that ridership on any new transit service concepts running along Highway 1 developed herein would be particularly sensitive to BIRT options, especially Option 5B.

## 2.3 Factors Influencing Highway Corridor Travel Patterns

This study was undertaken primarily using a version of phase 3.3 of the TransLink Regional Transportation Model (RTM) that was calibrated specifically for this assignment. The RTM is a travel demand modelling tool that incorporates information on existing land use, transportation infrastructure, and trip-making behaviour. Based on assumed future land use scenarios and transportation networks, future travel patterns can be forecast across the region, including in the study corridor, and can also be used to assess how travel patterns would change in response to new infrastructure. It is acknowledged that the RTM is developed based on observed travel behaviour that predates the COVID-19 pandemic. While COVID-19 has resulted in a short-term reduction in peak-hour trip-making, it is still speculative as to how long-term trip-making will be affected by higher rates of work-from-home activity, and how the distribution of trip-making over the course of the day could change (and by extension, when and how often the highway is congested).

The travel demand modelling tool was used for technical analysis of mobility beginning in Section 2.4; however, prior to focusing on detailed segment-level data and outputs, a review was undertaken of some of the broader trends that affect travel patterns in the study corridor, both historically and those anticipated to emerge in the future. The intention of this review is to provide guidance and context in terms of refining input assumptions to the RTM as well as interpreting model outputs. The review of these factors is organized as follows:

- Historical daily and annual highway corridor travel patterns.
- Historical and forecast future trends in North Shore population and employment.
- Historical and forecast future trends in inter-regional through-trips.
- The implications of North Shore geography and a limited municipal network.

Each of these factors is discussed below.

### 2.3.1 Historical Daily and Annual Highway Corridor Travel Patterns

The provincial highway system features permanent traffic count stations that collect traffic data 24 hours a day, 7 days a week, which provides a rich data source of daily and annual traffic profiles and trends. Unfortunately, there are no permanent count stations located on the study corridor itself; therefore, the permanent count station located on the Ironworkers Memorial Bridge is the best data source available in terms of understanding broader trends in daily and annual traffic patterns over time. Note that this study is *not* focused on the Ironworkers Memorial Bridge; therefore, this review is not intended to provide a basis for identifying issues on the bridge itself; rather, an assumption is made that, at least to some extent, the broader traffic patterns on the study corridor mimic those on the bridge, even if some of the specifics (e.g., volumes, speeds) differ. This is a key consideration for southbound movements across the bridge in particular, where demands exceeding capacity on the bridge (and the bridge approach) can be used to infer the existence of upstream queuing that can extend back to, and potentially affect operations on, the study corridor itself.

The average daily traffic volume on the Ironworkers Memorial Bridge over a 10-year period are illustrated in ***Figure 2.4*** for both weekdays and weekends. In general, traffic volumes have remained relatively flat, with decreases in 2008 and 2010, and rebounds or increases in 2009 and after 2012. Of note is that the widened Port Mann Bridge was opened to traffic in 2012. This was followed by the substantial completion of upgrades to Highway 1 on both approaches to that bridge, which coincides with the increase in both weekday and weekend volumes between roughly 2013 and 2017. Data from 2018 does not show any increase in volumes on the Ironworkers Memorial Bridge following the removal of tolls on the Port Mann Bridge in September 2017.[3] Notwithstanding perceptions of the growing popularity of outdoor recreational activities on the North Shore in recent years, the difference between weekday and weekend daily traffic volumes have remained relatively constant over time.

[3] It is still possible that the removal of tolls at the Port Mann Bridge did lead to an increase in volumes on the Ironworkers Memorial Bridge, but this increase was more than offset by other confounding factors, and resulted in a net decrease in total volumes.

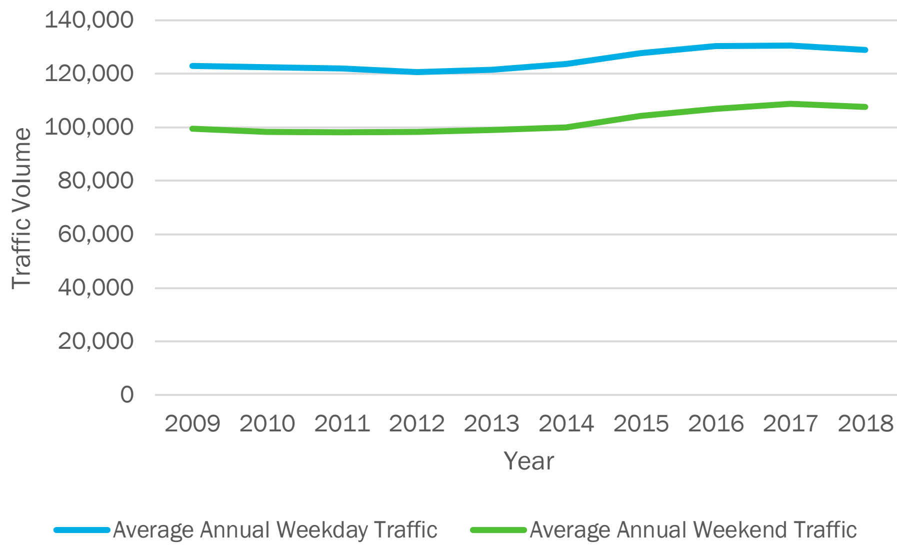


**Figure 2.4: Historical Daily Weekday and Weekend Traffic Volumes on Ironworkers Memorial Bridge**

The *Highway 1 Willingdon Avenue to Lynn Valley Road* study (2016), from which much of the analysis presented in this section draws upon and updates, reviewed seasonality effects for traffic volumes across the bridge between 2010 and 2014, and found that summer displays the highest average daily traffic volumes, likely due to the combination of vacation and recreational traffic on Highway 1 overlaid on residual work and business commuting patterns. Summer volumes are approximately 2% higher than the adjacent fall season. Spring volumes were generally lower than fall volumes, and winter volumes were notably lower than all other seasons.

A key variable affecting the intensity and duration of congestion along the Highway 1 corridor is the hourly profile over the course of a typical day. When a transportation facility reaches its maximum hourly capacity, growth in traffic volume typically occurs in the shoulder hours adjacent to the peak hour, a phenomenon known as peak spreading. October weekday hourly volume counts for an eight-year period between 2011 and 2018 in the eastbound and westbound directions are provided in ***Figure 2.5*** and ***Figure 2.6***, respectively. October volumes were used to generally coincides with the collection of regional trip diaries and screenline counts used to develop the Regional Transportation Model. As permanent count stations record serviced volumes, by definition, these recorded volumes never exceed capacity of the highway facility. Demands in excess of capacity will manifest as upstream queueing, and will be serviced instead during the "shoulder hours". Therefore, a spreading of volumes around the peak hour is often an indicator of extended upstream queuing.

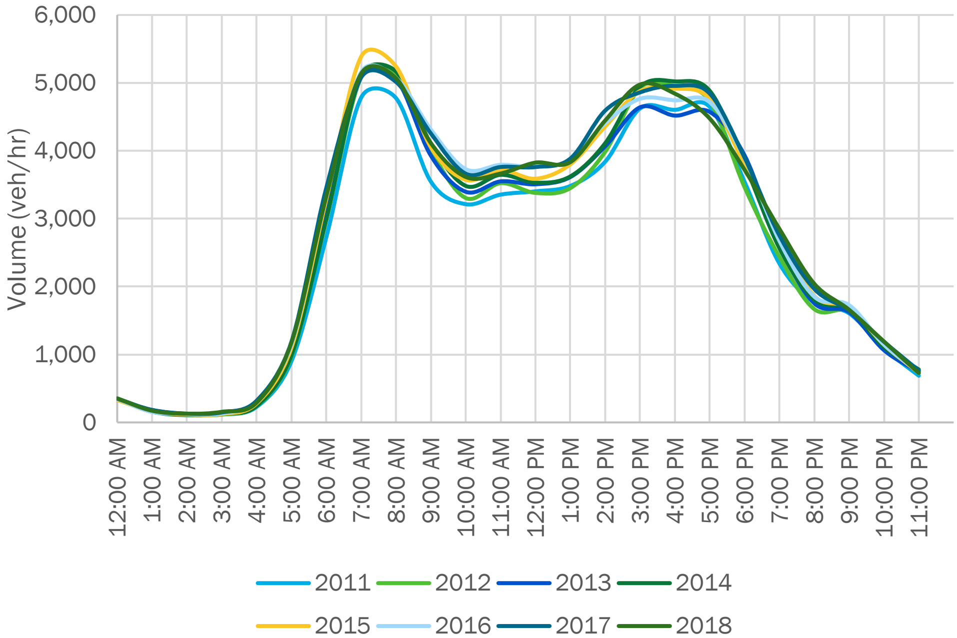


**Figure 2.5: October Historical Eastbound Daily Volume Profile on Ironworkers Memorial Bridge**

As shown, the eastbound traffic profile has spread slightly in the AM peak hour, with more trips being made in hours adjacent to the peak between 7:00 AM and 8:00 AM, particularly the 8:00 AM to 9:00 AM time period. The AM peak period remains fairly sharp and intense, with volumes falling below capacity outside of the peak hour. In contrast, the PM peak hour shows a much more significant spread of the peak period since 2011, with near capacity volume thresholds being reached over a four-hour period between 2:00 PM and 6:00 PM. In terms of implications for the study corridor, the peak spreading in the AM and (especially) the PM peak periods is an indication of queuing that has the potential to spill back beyond the Lynn Valley Road Interchange. Visual observations of queuing noted that queues can extend past Mountain Highway during the AM peak and reach the Westview Interchange during PM peak.

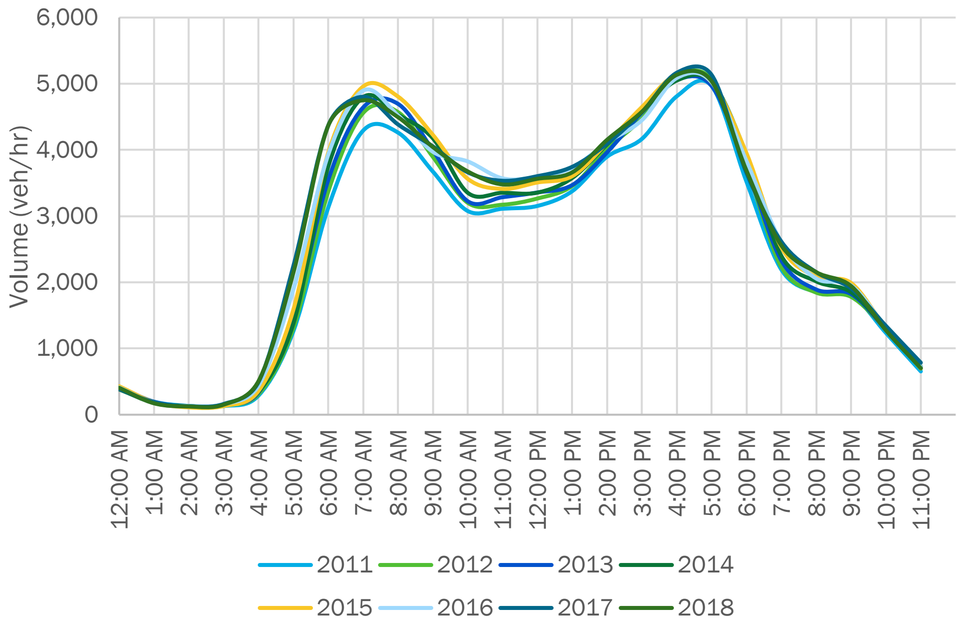


Figure 2.6: October Historical Westbound Daily Volume Profile on Ironworkers Memorial Bridge

In the westbound direction, traffic has spread slightly in the PM peak hour, with more trips being made in the hours adjacent to the peak between 4:00 PM and 5:00 PM. The PM peak period remains fairly sharp and intense, with volumes falling below capacity outside of the peak hour. The AM peak hour shows a much more significant spread of the peak period since 2011, with near capacity volume thresholds being reached over a three-hour period between 6:00 AM and 9:00 AM. With respect to implications for the study corridor, the westbound volume profile is less critical because volumes in excess of demand will manifest in queuing in Vancouver/Burnaby, and are less likely to directly affect operations on the study corridor.

### 2.3.2 Historical and Forecast Future Trends in North Shore Population and Employment

Historical trends as well as forecast growth in population and employment levels on the North Shore are summarized in ***Figure 2.7*** and ***Figure 2.8***, respectively. Historical information is based on census data, while forecast information is based on the projected land use scenarios incorporated in the RTM. Note that historical employment levels are based on the census Journey to Work information for people having a usual place of work, and therefore by definition would exclude employment types that do not exhibit a regular commuting pattern (e.g., some construction trades). In contrast, the RTM aims to capture all employment-related trip attraction. This difference in definitions is the cause of the discrepancy in employment levels between the census data and RTM inputs around 2016/2017.

Between 2001 and 2016, North Shore-wide population and employment levels grew at a compound annual growth rate of 0.5% and 0.7%, respectively. Based on the long-term land use projections for 2017 through 2050, population and employment levels are anticipated to grow at a compound annual growth rate of 0.9% and 0.7%, respectively. In total, by 2050, population and employment levels on the North Shore are forecast to grow by approximately 35% and 25% above current levels, respectively. Although this growth is lower than the regional average, this additional growth will still result in additional trip-making on the North Shore transportation network.

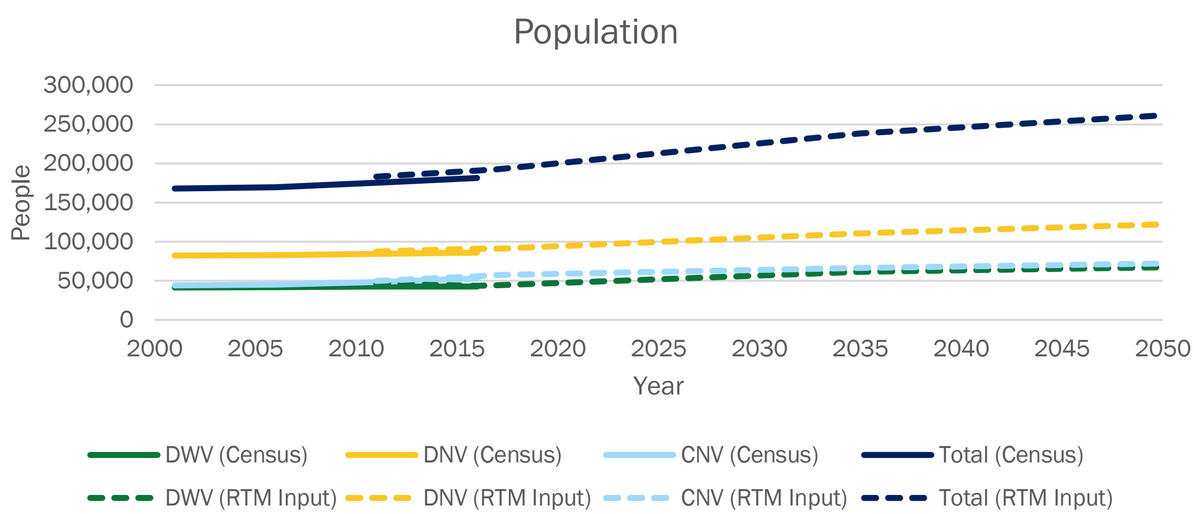


Figure 2.7: Historical and Forecast North Shore Population Levels by Municipality

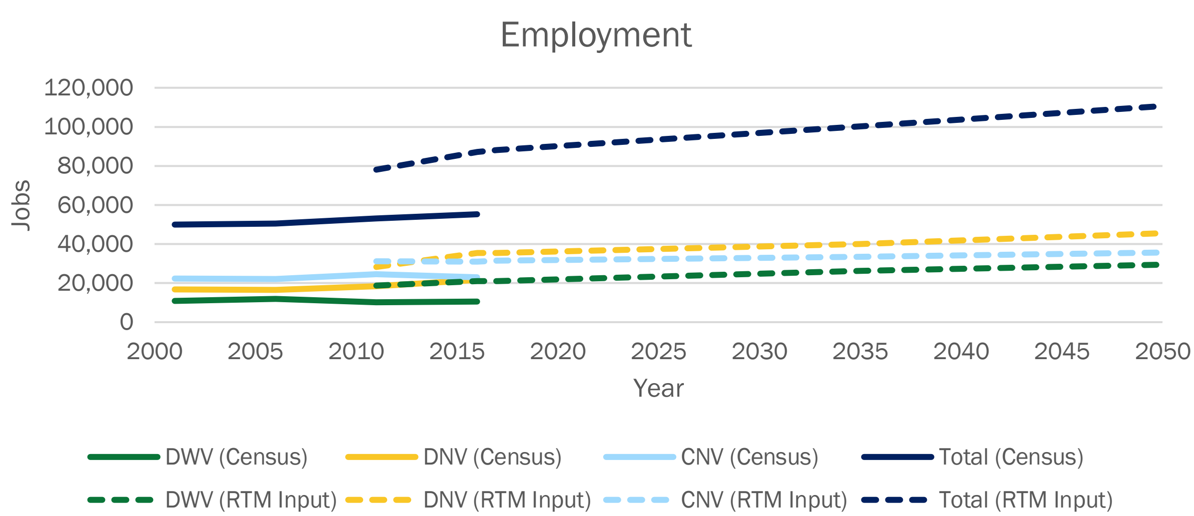


Figure 2.8: Historical and Forecast North Shore Employment Levels by Municipality

The assumed current (2017) and forecasting horizon year (2050) population and employment levels are further disaggregated by individual traffic analysis zones, as shown in ***Figure 2.9***. As can be seen, this growth is not uniformly distributed across the North Shore; some areas experience little to no growth, whereas other areas are anticipated to see substantial growth in population and employment levels. No changes were made to the traffic analysis zone future land use assumptions. Areas with particularly significant growth include:

- Population growth at the base of Cypress Mountain (although as noted previously in Section 2.2.13, the extent of development proposed by the developer in this area is greater than what is reflected in the model).
- Major population and employment growth at the north end of the Lions Gate Bridge.
- Population and employment growth in the Park Royal area.
- Moderate population and employment growth in the Ambleside and Dundarave areas.
- Population and employment growth in the Lower Lynn area on either side of the highway corridor.
- Population and employment growth in the vicinity of Maplewood and Windsor Park.

Increased population and employment can create more opportunities for people to both live and work in the same community and therefore reduce the need for longer-distance trips that may use the highway corridor study area as part of a trip across Burrard Inlet. However, this opportunity is contingent on the growing population being made up of a balanced demographic that includes growth in working-age individuals that mimics growth in employment – something that has not necessarily occurred historically. For example, although ***Figure 2.9*** above shows that the overall population of the North Shore grew by approximately 7,600 people between 2011 and 2016, analysis previously conducted through the Integrated North Shore Transportation Planning Project (INSTPP) noted that, during this same time period, the growth in the working-age population was 900 people (i.e., 900 out of the total of 7,600), while the total growth in employment was 2,900 jobs. Thus, although the North Shore population growth outpaced employment growth, the demographic imbalance has triggered an increase in commuting trips from the rest of the region to the North Shore, and is likely contributing to the "reverse peak" phenomenon on Highway 1, wherein the northbound/westbound direction experiences higher volumes in the AM and the southbound/eastbound direction experiences higher volumes in the PM. INSTPP further notes that the misalignment of employment opportunities with a range of affordable housing opportunities can further exacerbate this condition.

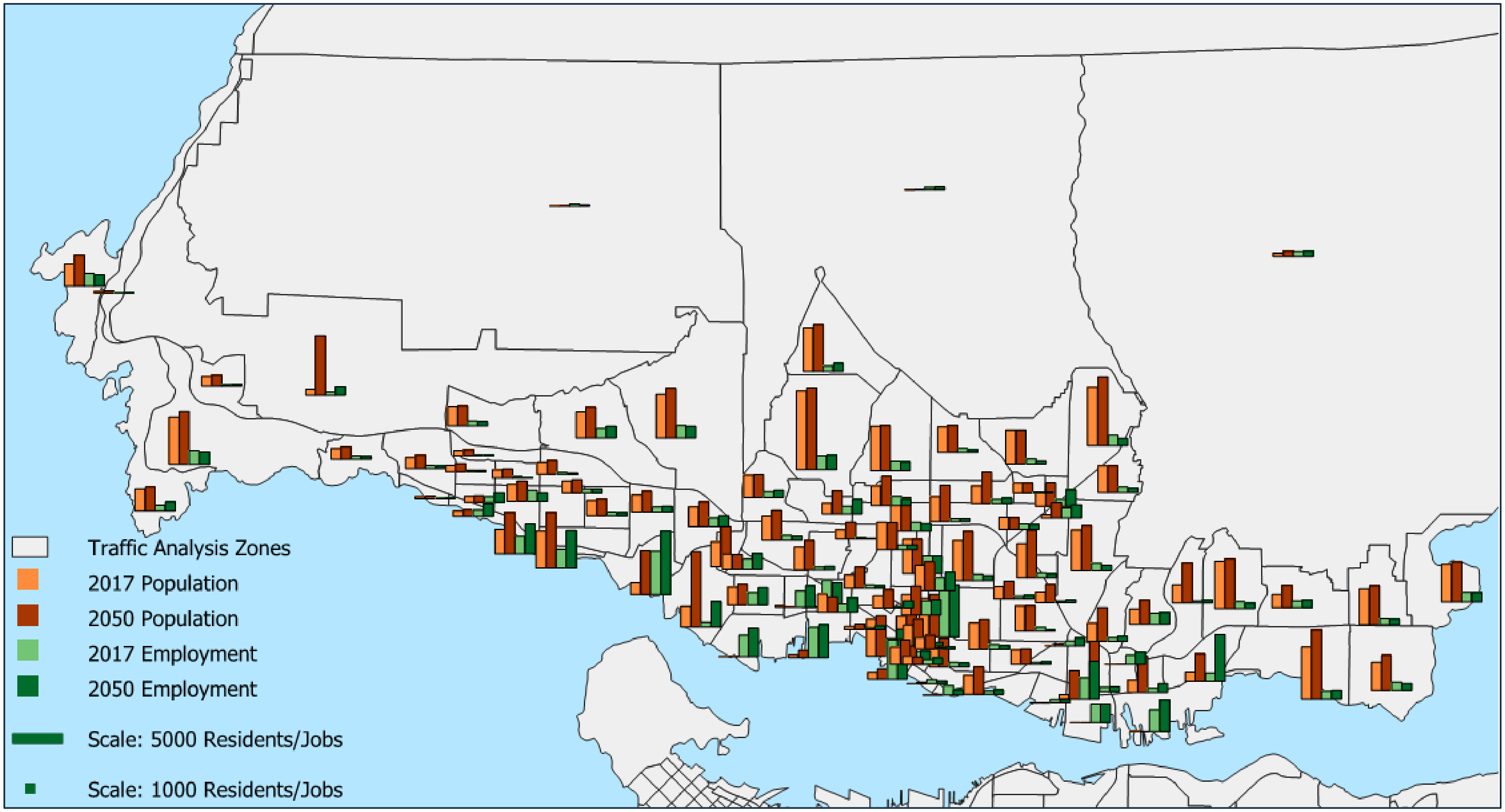


**Figure 2.9: North Shore Population and Employment Levels for Existing Conditions (2017) and Forecasting Horizon Year (2050)**

### 2.3.3 Historical and Forecast Future Trends in Inter-Regional Through-Trips

Within Metro Vancouver and the Fraser Valley, trips within the Regional Transportation Model are generated endogenously as a function of land use and demographics. However, at the "edges" of the model, external zones are used to represent connections to adjacent regions. The Upper Levels Highway is not just used for trips within the Greater Vancouver region; it is also the primary connection to neighbouring regions via external zones for the Highway 99 Sea to Sky Highway and the BC Ferries Horseshoe Bay ferry terminal. Trip-making trends at each of these two facilities are reviewed below.

#### HIGHWAY 99 SEA TO SKY CORRIDOR

Traffic volumes on the Sea to Sky Corridor at Eagleridge Bluffs have seen strong growth since the completion of the Sea to Sky Highway Improvement Project in 2010, with daily average annual daily traffic (AADT) volumes exhibiting a compound annual growth rate of 4.5%. AADT volumes as well as bidirectional volumes for the AM, midday and PM peak hours are shown below in ***Figure 2.10*** and demonstrate that travel volumes are growing at all times of the day, with the PM peak hour having the highest overall (i.e., bidirectional) hourly volumes. Although not readily obvious from the figure, the peak volume direction is southbound in the AM and northbound in the PM. Similar to the assessment of data on the Ironworkers Memorial Bridge in Section 2.3.1, all data is for the month of October to coincide with the collection of trip diaries and screenline counts used to develop the Regional Transportation Model.

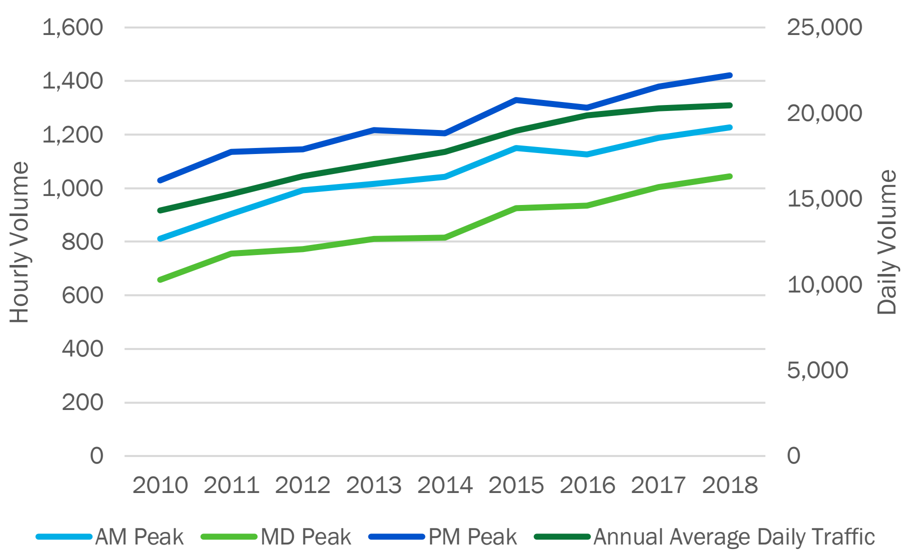


Figure 2.10: October Historical Volumes on Highway 99 Sea to Sky at Eagleridge Bluffs (Bidirectional)

Driven by development and population growth in the Sea to Sky Corridor as well as the popularity of the corridor for recreation and tourism, continued growth in vehicle volumes is anticipated.

The recently completed *Highway 99 Sea to Sky Corridor Study*, undertaken on behalf of BC MoTI and the Resort Municipality of Whistler, was used to provide guidance on the potential future increase in traffic volumes on the Sea to Sky Corridor that would connect to and from Highway 1. That study focused on traffic operations for a

2031 PM peak hour condition, and was based on a "bottom up" approach of accounting for all known proposed developments along the corridor as well as a "top down" approach using cumulative population growth forecasts for the region provided by BC Stats. Based on guidance from that study, growth rates of 2.5% in the peak direction and 4.0% in the off-peak direction were assumed until 2035 (which is the intermediate horizon year within the Regional Transportation Model). Given increased uncertainty over longer-term trends, assumed annual traffic volume growth rates (in both directions during both peak hours) were reduced to 1.0% from 2036 through 2050. These assumptions are summarized in ***Table 2.3***.

Table 2.3: Summary of Highway 99 Peak Hour Historical and Forecast Annual Volume Growth Rates

| Direction | AM Peak Hour | | | PM Peak Hour | | |
|---|---|---|---|---|---|---|
| | 2010–2018 (Historical) | 2018–2035 (Forecast) | 2036–2050 (Forecast) | 2010–2018 (Historical) | 2018–2035 (Forecast) | 2036–2050 (Forecast) |
| Southbound | 5.0% | 2.5% | 1.0% | 4.0% | 4.0% | 1.0% |
| Northbound | 5.8% | 4.0% | 1.0% | 4.2% | 2.5% | 1.0% |

The resultant peak hour volumes for the southbound and northbound directions are shown visually in ***Figure 2.11*** and ***Figure 2.12***, respectively. As a "sanity check", it is noted that these peak hour volumes of up to 1,500 vehicles per hour are within the capacity of the existing highway, and the historical count data shows examples of the highway already exceeding this throughput on busy days.

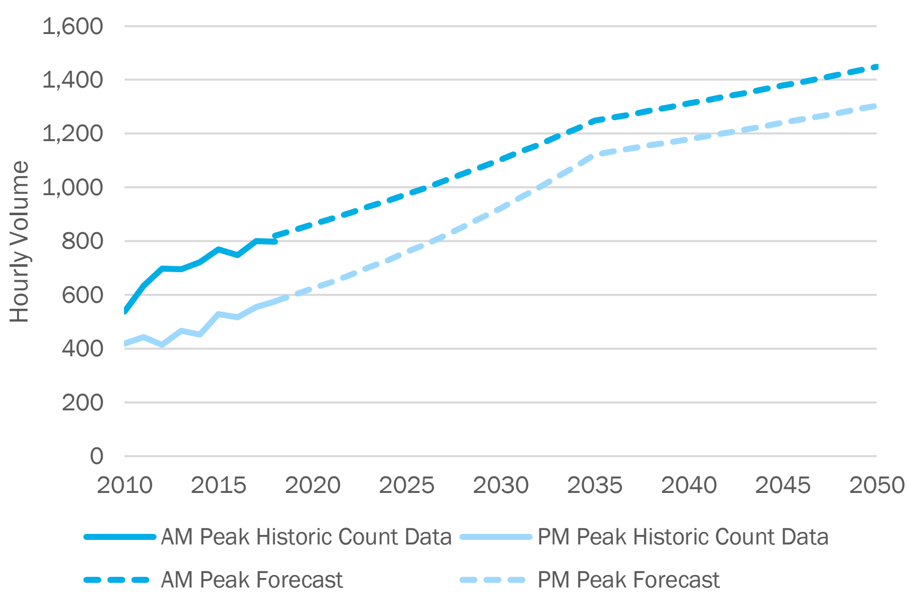


Figure 2.11: Highway 99 Southbound (Merging onto Highway 1 Eastbound) Peak Hour Historical and Forecast Volumes

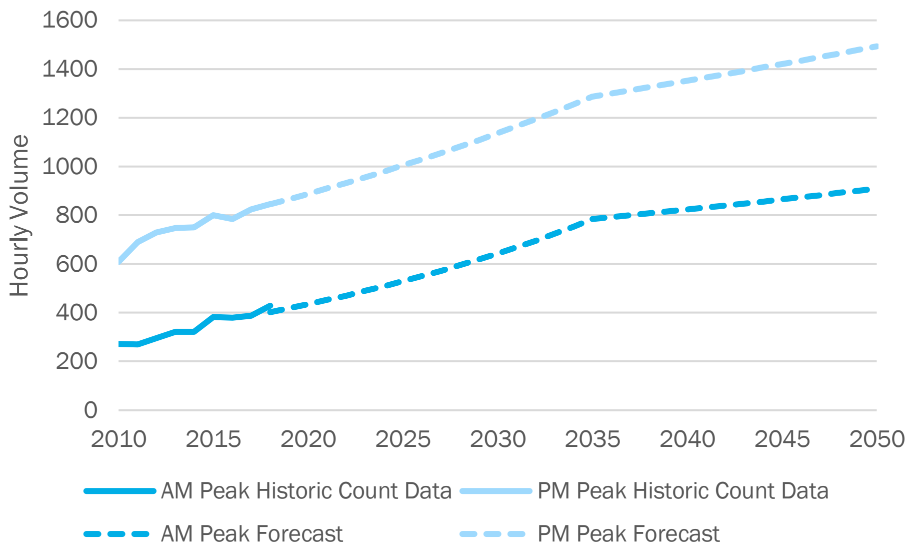


Figure 2.12: Highway 99 Northbound (Diverging from Highway 1 Westbound) Peak Hour Historical and Forecast Volumes

Currently, there is no inter-regional transit service provided along the Highway 99 Sea to Sky Corridor (other than the Route 262 service to Lions Bay). However, as noted in Section 2.2.7, INSTPP identified an opportunity for a regional transit service connecting Metro Vancouver and the Squamish-Lillooet Regional District. In the event that such a transit service were to be implemented in the future (e.g., by TransLink, BC Transit or other parties), then the transit service could potentially facilitate a reduction in peak volumes on the Highway 99 Sea to Sky Corridor, which could in turn facilitate a reduction in vehicle volumes entering the highway study corridor. By extension, this could in turn potentially enable a reduction in vehicular volumes along the corridor relative to a future condition without such a transit service.

### HORSESHOE BAY FERRY TERMINAL

The Upper Levels Highway will continue to play a key role in facilitating connectivity to Vancouver Island, the Sunshine Coast and Bowen Island via the Horseshoe Bay ferry terminal. BC Ferries is currently in the process of creating a long-range Terminal Development Plan that includes a potential series of phased improvements to the existing terminal.

Travel patterns to and from the BC Ferries Horseshoe Bay terminal differ from those on the rest of the network. In the eastbound direction, traffic enters the highway corridor as a series of short-duration but high-volume surges subsequent to ferry unloading, with low volumes between these surges. The timing of these surges is also contingent on ferry schedules; in some cases, major vessel arrivals may not necessarily coincide with peak hours on the broader highway corridor. Finally, eastbound volumes are also inherently limited by ferry vessel capacity; additional demand for travel to Horseshoe Bay is manifested as a sailing wait at Departure Bay/Langdale/Snug Cove, and does not directly affect Highway 1 until the next sailing arrives (often 1–3 hours later). In the westbound direction, volumes are also a function of the ferry schedule, but typically exhibit a smoother arrival pattern, as vehicles will arrive at the ferry terminal in advance of the sailing over a longer period of time.

Based on information provided by BC Ferries, no significant increase in overall vehicular volumes is anticipated at this terminal. However, as part of the Terminal Development Plan, a second exit ramp from the ferry berths is proposed, which would intersect with the existing main access and then connect to Highway 1. This two-ramp configuration would allow for the simultaneous unloading of multiple ferries, which could create higher volume surges. It is understood that this second exit is not necessarily intended for regular use, but rather is intended to enable schedule recovery on busier sailing days or when one (or more) routes are running behind schedule.

In an extreme case, if the two largest routes were to unload simultaneously, this would introduce approximately 600 to 700 vehicles[4] into the network. This volume is well within the capacity of Highway 1 to accommodate over the course of an hour, but as these vehicles would arrive as a short surge, this can generate short-term traffic operations challenges. BC Ferries noted that, through the stakeholder and public engagement component of the terminal planning process, concerns were raised about traffic impacts and operations at the eastbound Highway 1/Highway 99 merge as well as further downstream (e.g., at the Lions Gate Bridge). For this study, no modifications have been made to the RTM input assumptions for the Horseshoe Bay ferry terminal external zone.

### 2.3.4 Geography and Limited Municipal Networks

The North Shore is primarily oriented in an east-west direction; the Upper Levels Highway forms the backbone of the east-west transportation system. Although there are several additional shorter east-west routes that traverse parts of the North Shore, there is only one other continuous east-west corridor that runs the length of the North Shore. The lack of a fully developed east-west road network results in the highway doing “double duty” in terms of serving its intended regional travel function, as well as serving a more local travel function.

Although several opportunities to improve east-west connectivity have been identified through previous studies, the North Shore’s geography remains a major challenge. Specifically, the topography and steep slopes throughout much of the North Shore, the presence of north-south running watercourses and green spaces, and extensive development all impact the feasibility of providing new east-west connections. The steep slopes along much of the North Shore can also create challenges with respect to ensuring that active transportation modes such as walking and cycling are suitable for people of all ages and abilities.

## 2.4 Technical Assessment: Corridor Mobility

The assessment of corridor mobility is focused on the performance of the highway study corridor itself, between Horseshoe Bay and Lynn Valley Road. Capacity of cross streets at interchanges is not assessed, although one metric (volume-to-capacity ratio) was used to assess performance on interchange on-ramps and off-ramps, as ramp performance can in turn affect highway corridor performance.

[4] Based on the simultaneous unloading of the *Queen of Cowichan* (capacity of roughly 312 vehicles), which runs on Route 3 between Horseshoe Bay and Departure Bay on Vancouver Island, and the *Queen of Surrey* (capacity of roughly 308 vehicles, which runs on Route 3 between Horseshoe Bay and Langdale on the Sunshine Coast.

As noted previously, this study is being undertaken solely using phase 3.3 of the TransLink Regional Transportation Model (RTM). Therefore, corridor-level mobility performance metrics have been developed to focus on high-level metrics that can be readily generated by the RTM, as well as qualitative metrics where the RTM does not lend itself to assessing performance.

The metrics developed for this assessment are as follows:

- Travel volumes by mode.
- Volume-to-capacity ratio.
- Travel time index.
- Trip type.
- Accommodation of transit service.
- Active transportation provisions.

Each of these performance criteria are defined in Section 2.4.1 and are assessed in Section 2.4.2.

The primary focus of the travel demand modelling analysis is the AM and PM peak hours of the current condition (year 2017) and the planning horizon year (2050). However, the RTM also provides capabilities to model travel patterns for the midday period as well as for an interim horizon year of 2035. Findings for the midday (for each year) and 2035 (for any time of day) are not typically presented as outputs of the mobility assessments. However, these scenarios were still modelled, and findings from midday and/or 2035 scenarios will occasionally be referenced to provide contextual information and to enhance the understanding of the primary AM/PM and 2017/2050 outputs.

### 2.4.1 Corridor Mobility Performance Criteria

The definition and methodology to assess each of the six above-noted metrics are provided below.

#### TRAVEL VOLUMES BY MODE (CORRIDOR LEVEL)

The travel demands on Highway 1 were obtained from the RTM for the AM and PM peak hours. Outputs are reported by person trips by single-occupancy vehicle, high-occupancy vehicle, and transit. Reporting of cycling volumes on the highway corridor is not possible because the RTM does not explicitly assign the cycling mode to specific routes. Goods movement volumes are provided by truck type: light goods vehicle and heavy goods vehicle.

There are no specific performance thresholds associated with this metric; it is primarily intended for context and relative comparison. However, it is noted that applicable provincial, regional and municipal transportation planning policies all emphasize the need to shift towards sustainable modes of travel.

## VOLUME-TO-CAPACITY RATIO

The volume-to-capacity ratios, which provide a measure of the ability of the study corridor to accommodate volumes using the corridor, were used to differentiate areas where observed or forecasted volumes exceed capacity from those areas where capacity is sufficient to accommodate observed or forecasted volumes.

This metric is a direct output from the RTM using assigned traffic volumes and specified capacities on individual road network elements for the AM and PM peak hours. A volume-to-capacity ratio was obtained for each study corridor road segment. Volume-to-capacity ratios are considered on both the highway mainline as well as ramps. Volume-to-capacity ratios of 0.85, 0.95, 1.00 and 1.20 are used as threshold values to assess congestion.

Note that, by definition, a roadway cannot actually service more vehicles than its capacity; therefore, volume-to-capacity ratios larger than 1.0 do not imply that the road segment is moving an exceptionally high volume of vehicles, but instead that there will be queuing upstream of the overcapacity road segment. The first three threshold values are commonly applied to travel demand modelling analysis to support the issue identification phase of transportation planning assignments. Often, a micro-simulation modelling tool would be subsequently used to assess traffic operations and gauge the extent of vehicle queuing. However, as this study does not include micro-simulation modelling, volume-to-capacity ratios exceeding 1.0 are instead used as a proxy to gauge the potential extents of upstream queuing. Therefore, the additional volume-to-capacity ratio threshold value of 1.2 was also included to enable the differentiation of areas that are slightly over capacity (and that will see some limited queuing) from those areas that are significantly over capacity and will experience extensive queueing that could disrupt upstream operations.

As noted previously, this metric is applied not only to highway corridor segments, but also to on-ramps and off-ramps.

## TRAVEL TIME INDEX

While the volume-to-capacity ratio is a good measure of the relative utilization of the highway corridor, it can be challenging to directly infer the associated increases in travel times that are experienced due to volumes exceeding capacity. Even in advance of reaching a volume-to-capacity ratio of 1.0, travel speeds will decrease as volumes increase; therefore, a highway that is below capacity can still experience increased travel times. In other words, while a highway may have the capacity to accommodate additional throughput, this will result in increased travel times for all users. Therefore, the travel time index (TTI) is used as a secondary measure of congestion on the highway corridor. The TTI provides a measure of how much additional time is required to traverse a roadway segment during the peak period, relative to the time required to traverse the same roadway segment during free-flow conditions.

Travel time index is measured in RTM by comparing travel times in the peak hours with the volume-delay function activated (per normal modelling practice) against values calculated without volume-delay effects activated. A travel time index was obtained for each study corridor road segment; this metric is a direct output from the RTM. Travel time index is considered on the highway mainline. Travel time indices of 1.05, 1.15, 1.25 and 1.60 are used as threshold values to assess congestion. These travel time index thresholds roughly correspond to the volume-to-capacity ratio thresholds provided above, thereby ensuring a relatively consistent set of standards is being applied in identifying level of congestion on the highway corridor.

### TRIP TYPE

The primary role of the provincial highway system is to facilitate regional and inter-regional connectivity; however, in practice, highways in urban areas are often used for shorter-distance trips. This is particularly the case on the North Shore. Previous analysis undertaken as part of INSTPP identified that segments of Highway 1 within the North Shore have a much higher proportion of “local only” trips using the highway than highways in other parts of the region. This metric classifies trips using Highway 1 into the following trip types:

- **Intra-Municipal:** The trip remains within West Vancouver or the two “North Vancouver” municipalities (which, for the purposes of this metric, will be considered as a single entity).
- **Intra-North Shore:** The trip remains within the North Shore, but crosses the Capilano River between West Vancouver and the “North Vancouvers” (or vice versa).
- **Intra-Regional:** The trip is between the North Shore and an origin or destination outside of the North Shore. This means that the trip will pass through one of the following: Ironworkers Memorial Bridge, Lions Gate Bridge, SeaBus, Horseshoe Bay ferry terminal external zone or Sea to Sky Highway external zone.
- **Inter-regional:** The trip neither originates from nor is destined to the North Shore – it simply passes through. This means that the trip will pass through two of the following: Ironworkers Memorial Bridge, Lions Gate Bridge, SeaBus, Horseshoe Bay ferry terminal external zone or Sea to Sky Highway external zone.

There are no specific performance thresholds associated with this metric; it is primarily intended for context and for understanding the role(s) of the highway corridor.

### ACCOMMODATION OF TRANSIT SERVICE

A qualitative assessment was undertaken for the accommodation of transit service along the highway study corridor. This assessment focuses primarily on the highway corridor itself, although consideration is also given to provisions on intersecting streets at select interchanges that are identified for mitigation concept development.

As this metric is qualitative, there are no specific performance thresholds.

### ACTIVE TRANSPORTATION PROVISIONS

A qualitative assessment was undertaken for the availability of active transportation facilities. This assessment focuses primarily on the highway corridor itself, although consideration is also given to conditions on intersecting streets at select interchanges that are identified for mitigation concept development.

As this metric is qualitative, there are no specific performance thresholds.

## 2.4.2 Corridor Mobility Performance Assessment

The application of the six corridor mobility performance metrics, and the resulting findings, are presented below.

### TRAVEL VOLUMES BY MODE (CORRIDOR LEVEL)

The five travel modes output from the RTM (on the network) are:

- Single-occupancy vehicle (SOV).
- High-occupancy vehicle (HOV).
- Transit.
- Light Goods Vehicle (LGV).
- Heavy Goods Vehicle (HGV).

For the three person-moving modes (SOV, HOV, transit), outputs can be generated in the form of person trips or vehicle trips. In the case of SOV, each vehicle, by definition, has an occupancy of 1.0. For HOV, an average occupancy of 2.25 is assumed in the model.[5] For transit, vehicle volumes are a fixed input based on the transit service frequency on each bus route, while person-volumes reflect the level of ridership on each service.

For the three motorized person-moving modes represented in RTM, person-level travel volumes along the highway corridor by mode are presented for the 2017 AM and PM peak hours in ***Figure 2.13*** and ***Figure 2.14***, respectively. Similarly, forecast volumes by mode are presented for the 2050 planning horizon year AM and PM peak hours in ***Figure 2.15*** and ***Figure 2.16***, respectively.

[5] RTM does not provide separate modes for 2-person, 3-person, etc. HOVs.

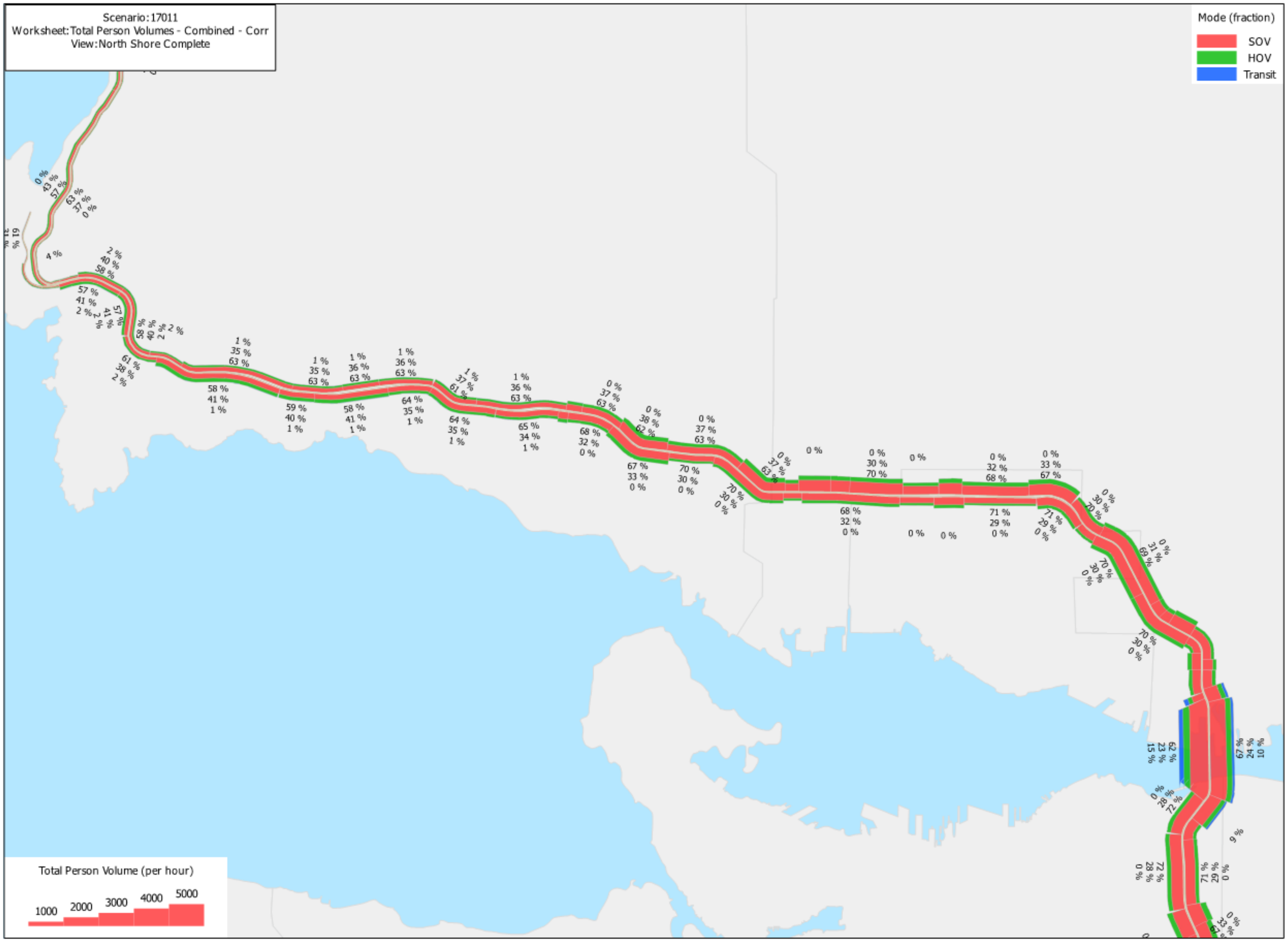


Figure 2.13: 2017 AM Peak Hour Highway Corridor Travel Volumes by Mode

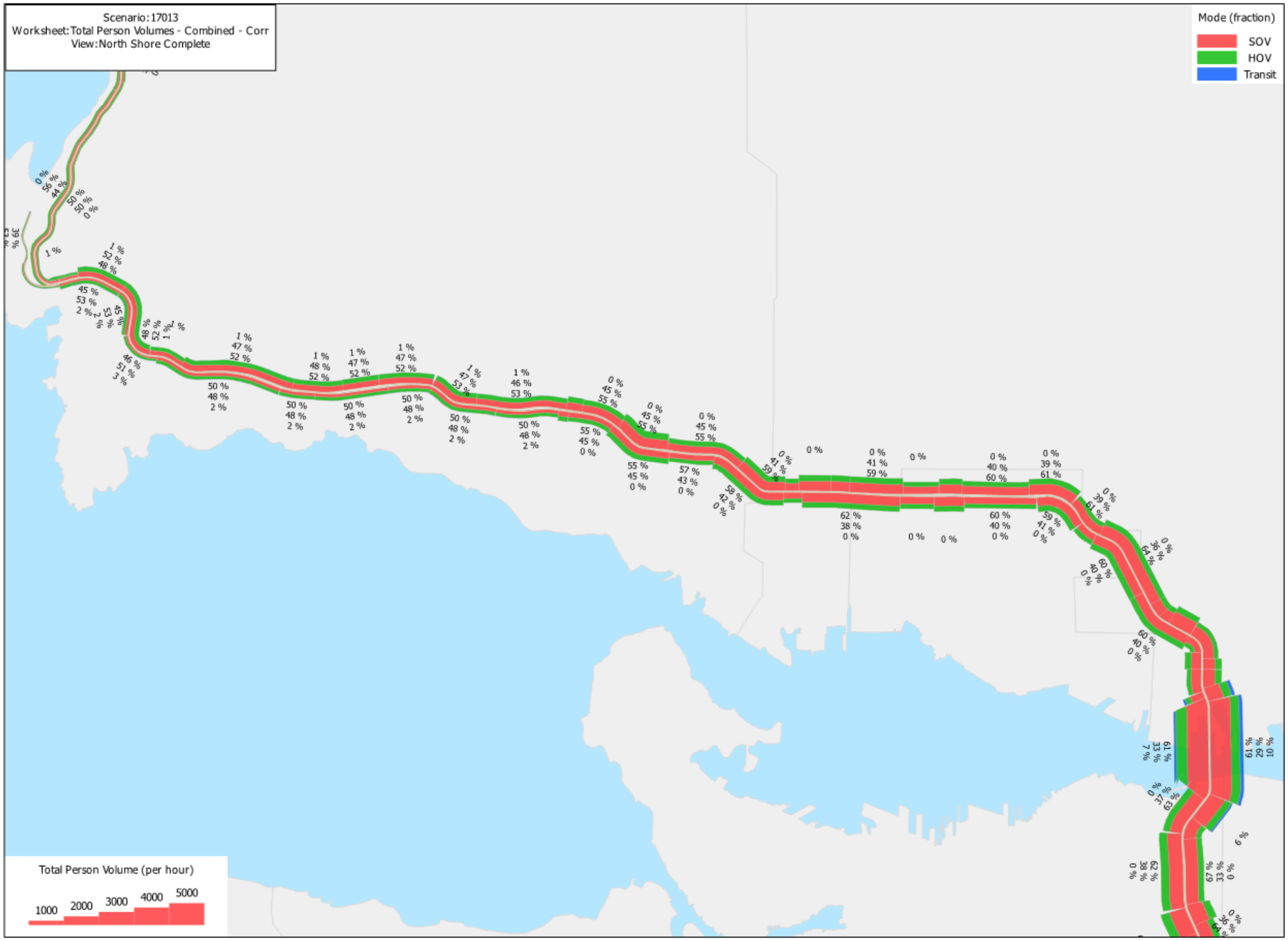


Figure 2.14: 2017 PM Peak Hour Highway Corridor Travel Volumes by Mode

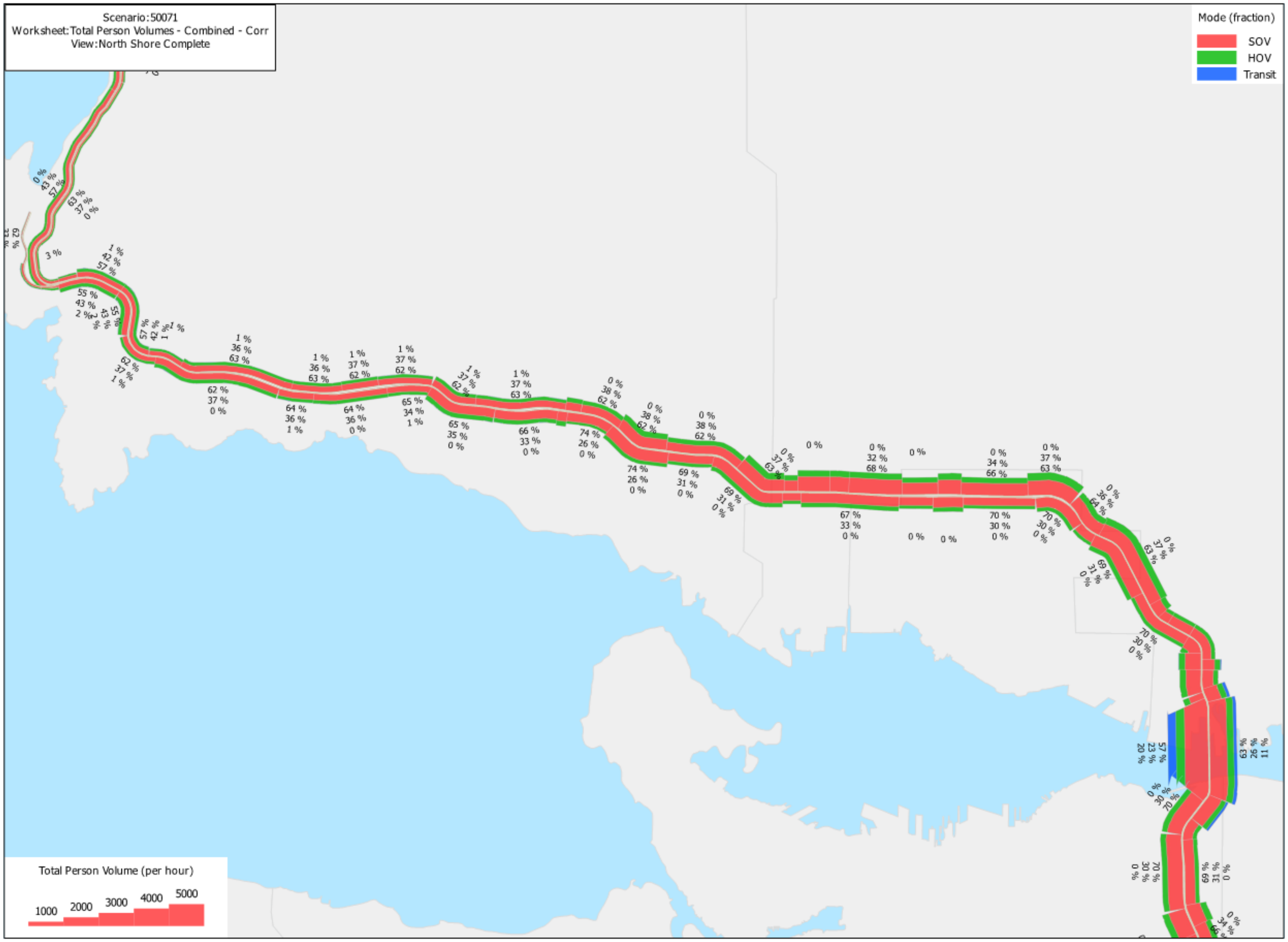


Figure 2.15: 2050 AM Peak Hour Highway Corridor Travel Volumes by Mode

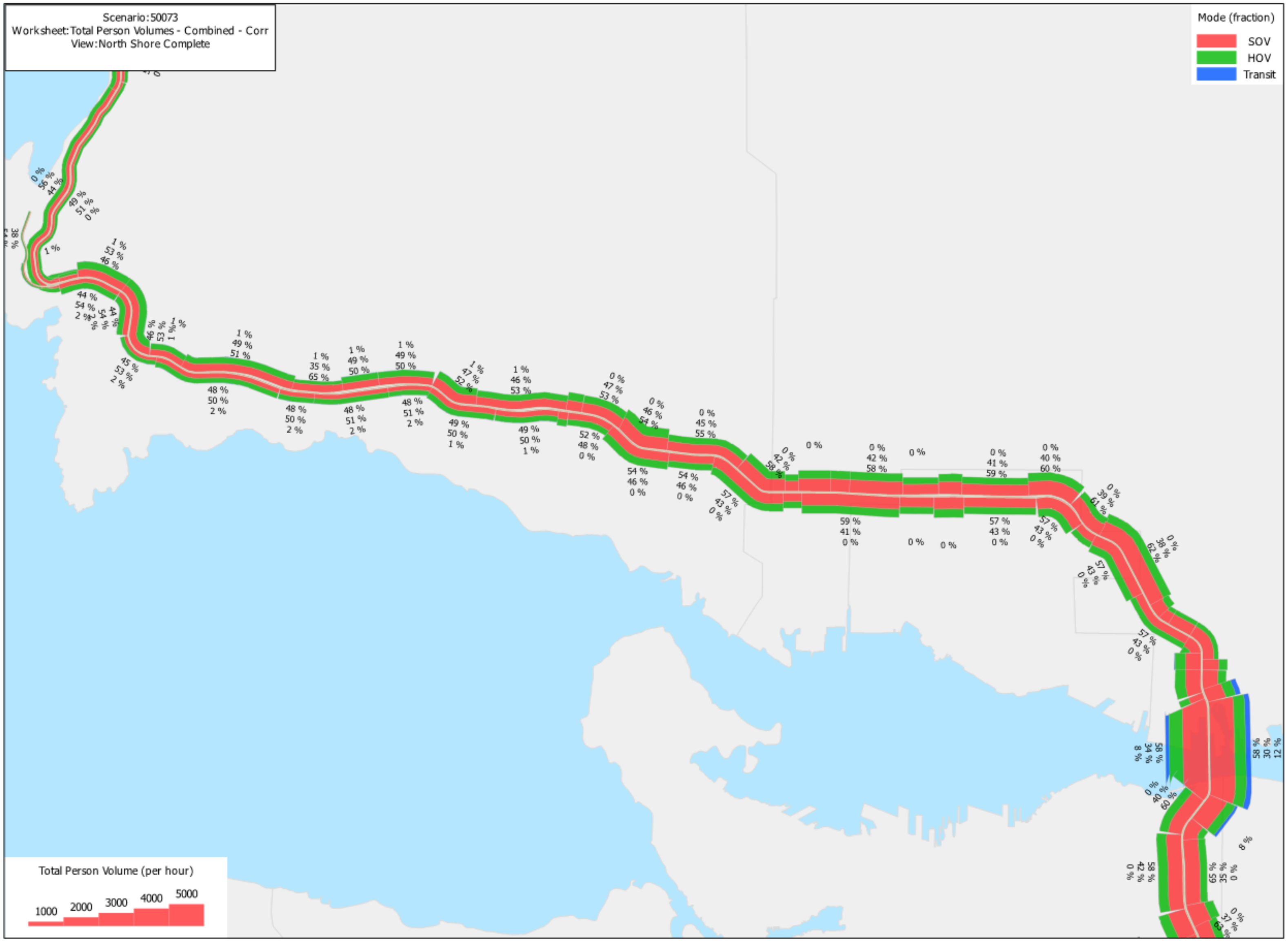


Figure 2.16: 2050 PM Peak Hour Highway Corridor Travel Volumes by Mode

Two key considerations should be kept in mind when assessing model outputs:

- Volumes represent person-trips, not vehicle trips. Since highway operations (e.g., congestion) are a function of vehicle volumes, these volumes cannot be used to directly assess operational performance along the highway corridor.
- Notwithstanding the above, volumes represent demands, not serviced trips, and therefore represent the desire for trips along the corridor within the AM and PM peak hours – but not necessarily the number of trips that are actually completed.

A clear pattern is apparent with respect to volumes on different portions of the highway corridor. Specifically, at all times of the day, the eastern portion of the corridor is busier than the western portion of the corridor, with the Capilano River acting as a general boundary between the higher-volume eastern portion of the study corridor and the lower-volume western portion.

With respect to future trends, over the next 30 years, the demand for trip-making along much of the Upper Levels Highway is anticipated to grow in the range of 20%—45%, depending on the specific segment, travel direction and time of day. Although not shown in the above figures, a 2035 interim forecasting horizon year scenario was also completed to provide context on anticipated changes in volumes. Growth in trip-making is more heavily concentrated between 2017 and 2035, and slows in the 2035–2050 period. The lower long-term growth is likely due to a combination of increased marginal travel times due to higher volumes and the land use assumptions used in the model. As suggested by ***Figure 2.7***, the compound annual growth rate for North Shore population is 1.2% between 2017 and 2035, but only 0.6% between 2035 and 2050.

As shown in the above figures, single-occupancy vehicles are the primary mode of travel along the corridor, although a significant proportion of trips by HOV are also observed (roughly 30%—40% of person-trips in the AM peak hour and 40%—50% of person-trips in the PM peak hour). HOV mode share ranges are generally consistent in 2050, with AM rates remaining lower than the rest of the day. There are slight differences between 2017 and 2050: AM HOV rates eastbound are 1%–3% lower than 2017, while westbound rates are about 1% higher. Midday and PM rates are approximately 2%–3% higher in both directions. Transit volumes are minor along the western portion of the corridor and non-existent on the eastern portion of the corridor, with the latter being due to the lack of any transit service in this portion of the corridor.

To provide further context as well as information on goods movement volumes, trip volumes were calculated for two screenlines: one on the western portion of the study corridor between the Cypress Bowl Road Interchange and the 21st Street Interchange, and one on the eastern portion of the study corridor between Lonsdale Avenue and Lynn Valley Road Interchange. Eastbound volumes for these two screenlines are presented in ***Figure 2.17*** and ***Figure 2.18***, respectively. The corresponding westbound volumes are presented in ***Figure 2.19*** and ***Figure 2.20***.

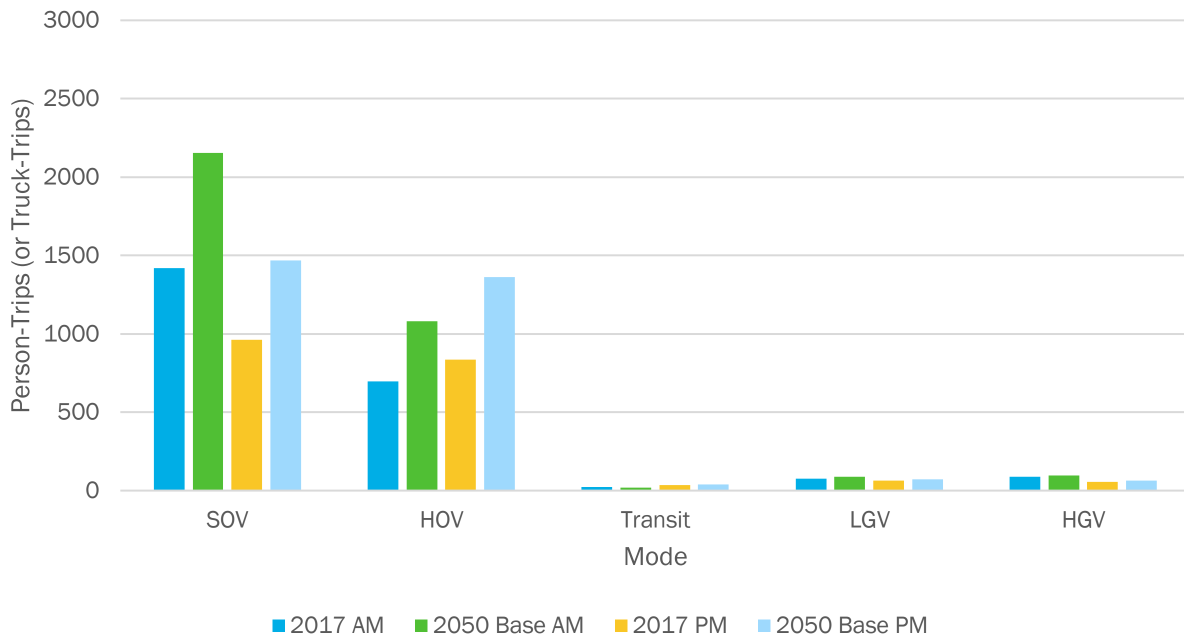


**Figure 2.17: Highway 1 Eastbound Screenline Between Cypress Bowl Road and 21st Street**

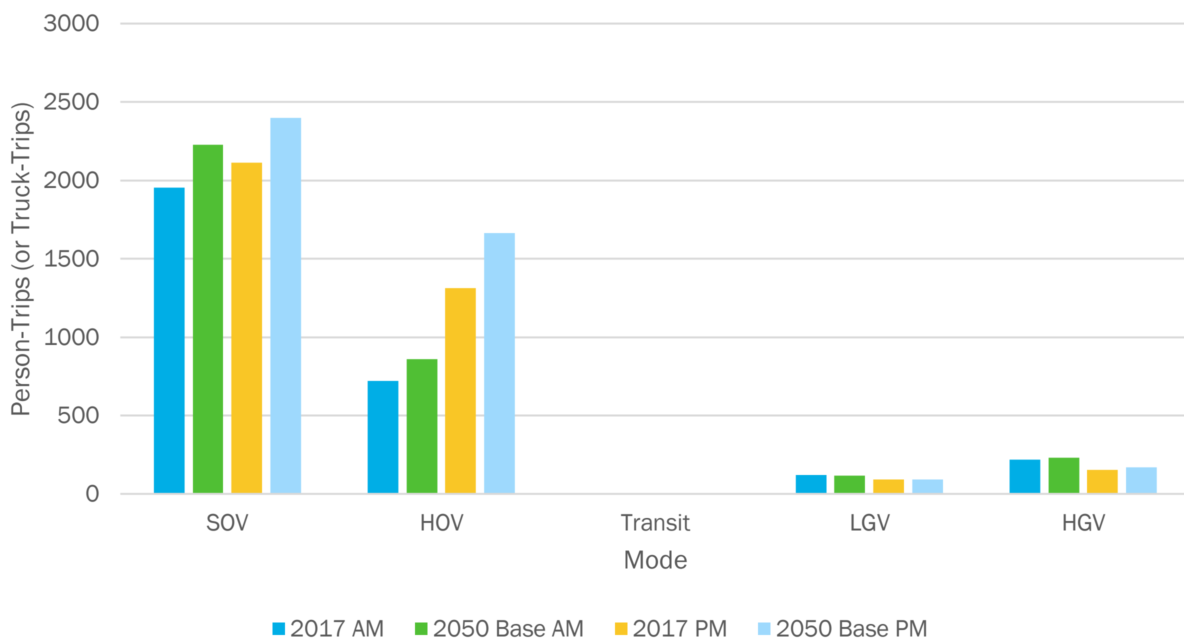


**Figure 2.18: Highway 1 Eastbound Screenline Between Lonsdale Avenue and Lynn Valley Road**

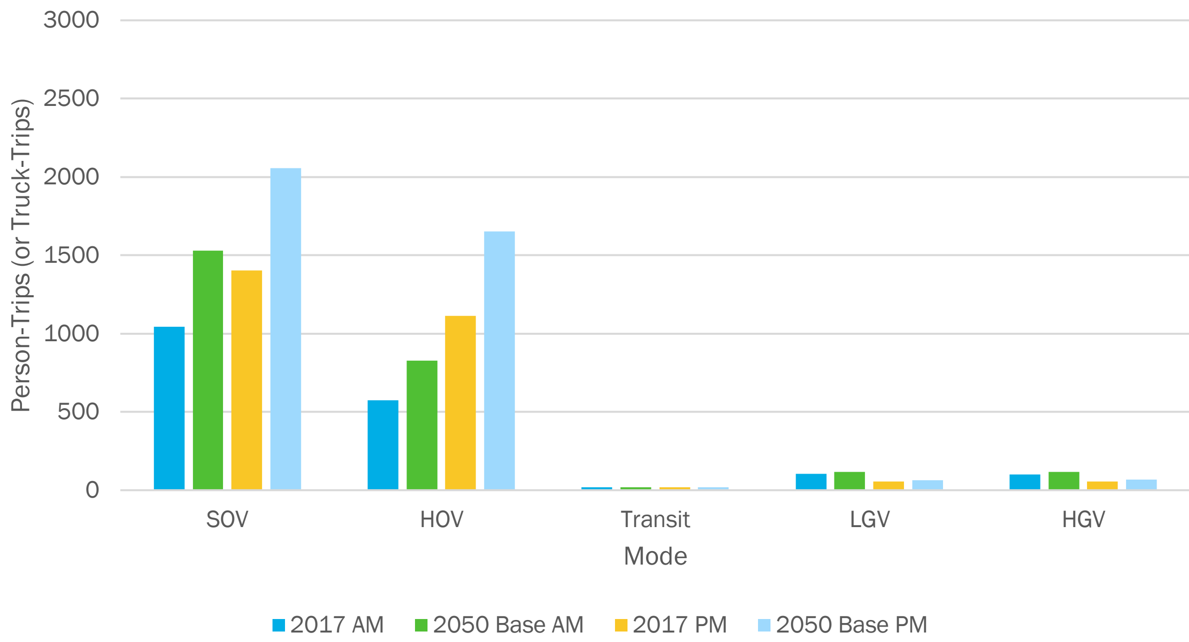


Figure 2.19: Highway 1 Westbound Screenline Between 21st Street and Cypress Bowl Road

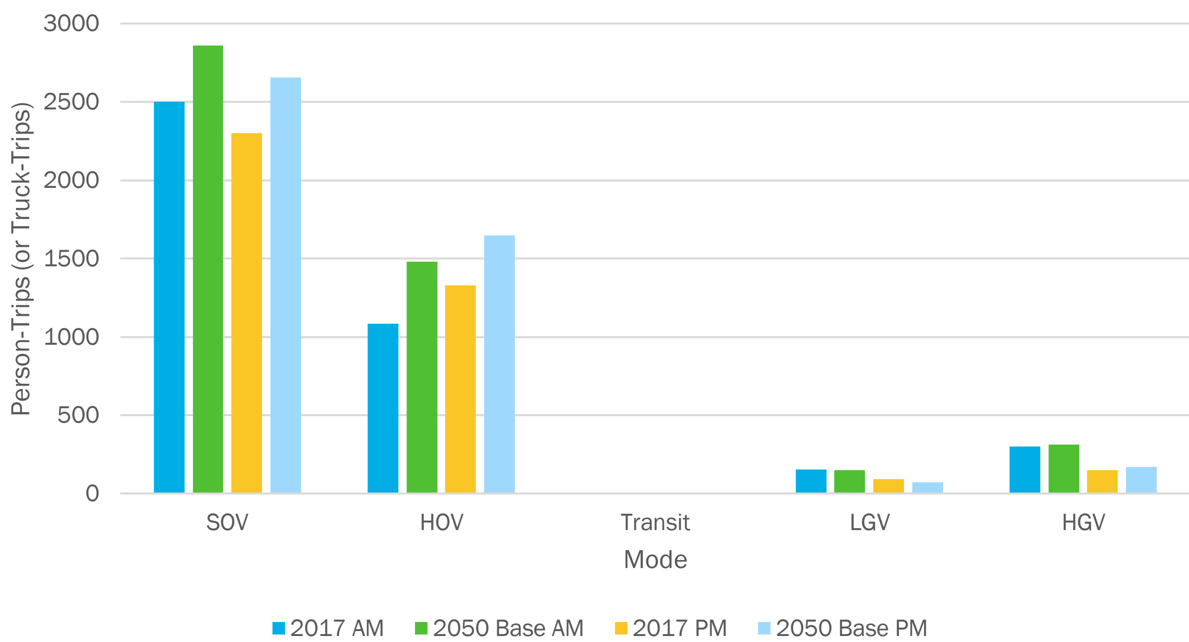


Figure 2.20: Highway 1 Westbound Screenline Between Lynn Valley Road and Lonsdale Avenue

As shown in the above figures, at both locations and at all times of the day, transit ridership and goods movement volumes are minor in comparison to SOV and HOV trip-making.

### VOLUME-TO-CAPACITY RATIO

As foreshadowed in the previous section, the volume-to-capacity ratio is the primary metric used to assess operations along the corridor. The volume-to-capacity ratio thresholds used for this assessment are summarized in ***Table 2.4***.

Table 2.4: Volume-to-Capacity Ratio Performance Indicator Thresholds

| General Conditions | Range |
|---|---|
| Uncongested | 0 ≤ v/c < 0.85 |
| Slightly Congested | 0.85 > v/c ≤ 0.95 |
| Congested | 0.95 > v/c ≤ 1.00 |
| Heavily Congested | 1.00 > v/c ≤ 1.20 |
| Extremely Congested | v/c > 1.20 |

Volume-to-capacity ratios along the highway corridor are presented for the 2017 AM and PM peak hours in ***Figure 2.21*** and ***Figure 2.22***, respectively. Similarly, volume-to-capacity ratios are presented for the 2050 planning horizon year AM and PM peak hours in ***Figure 2.23*** and ***Figure 2.24***, respectively.

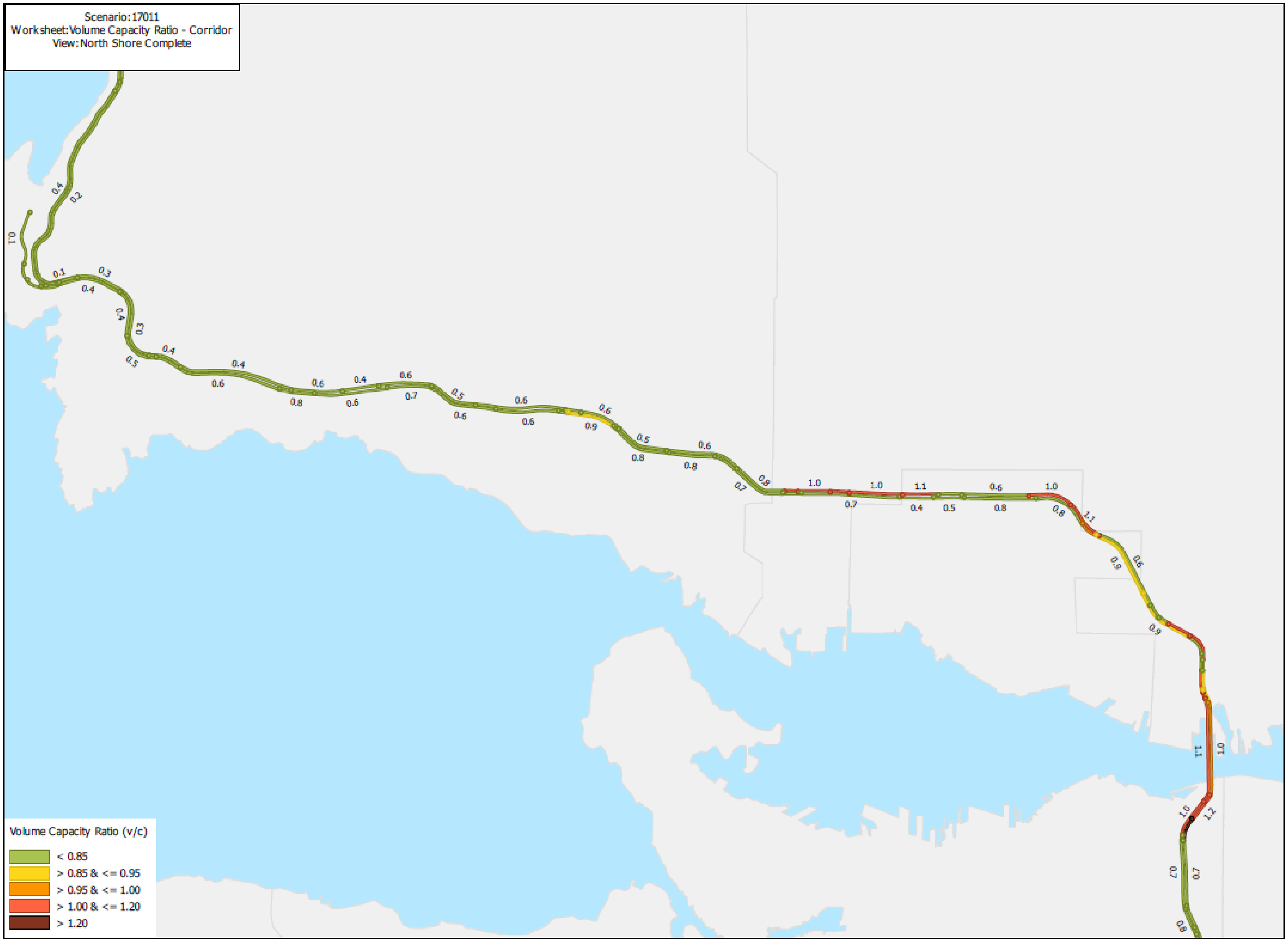


Figure 2.21: 2017 AM Peak Hour Corridor Volume-to-Capacity Ratios

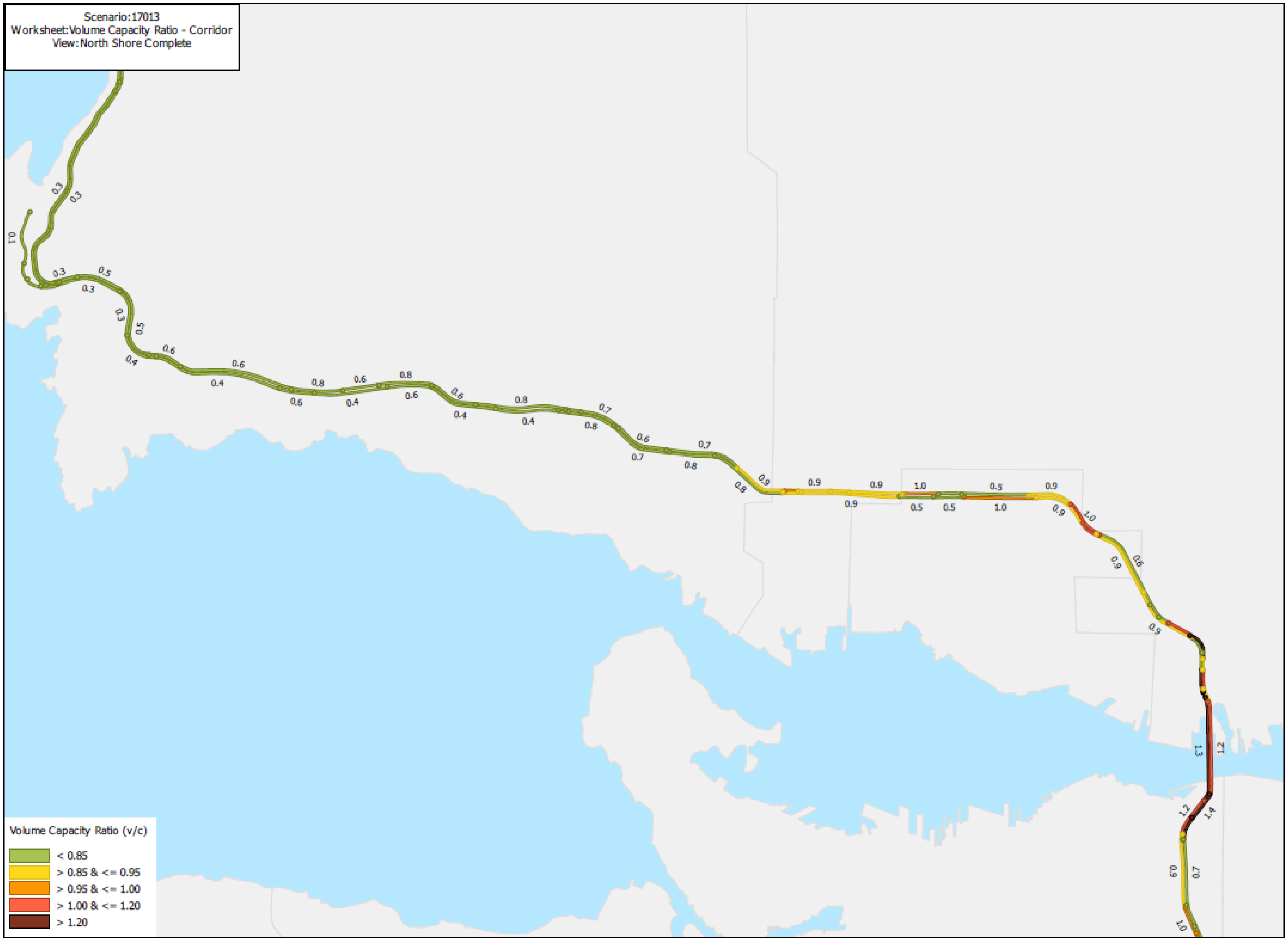


Figure 2.22: 2017 PM Peak Hour Corridor Volume-to-Capacity Ratios

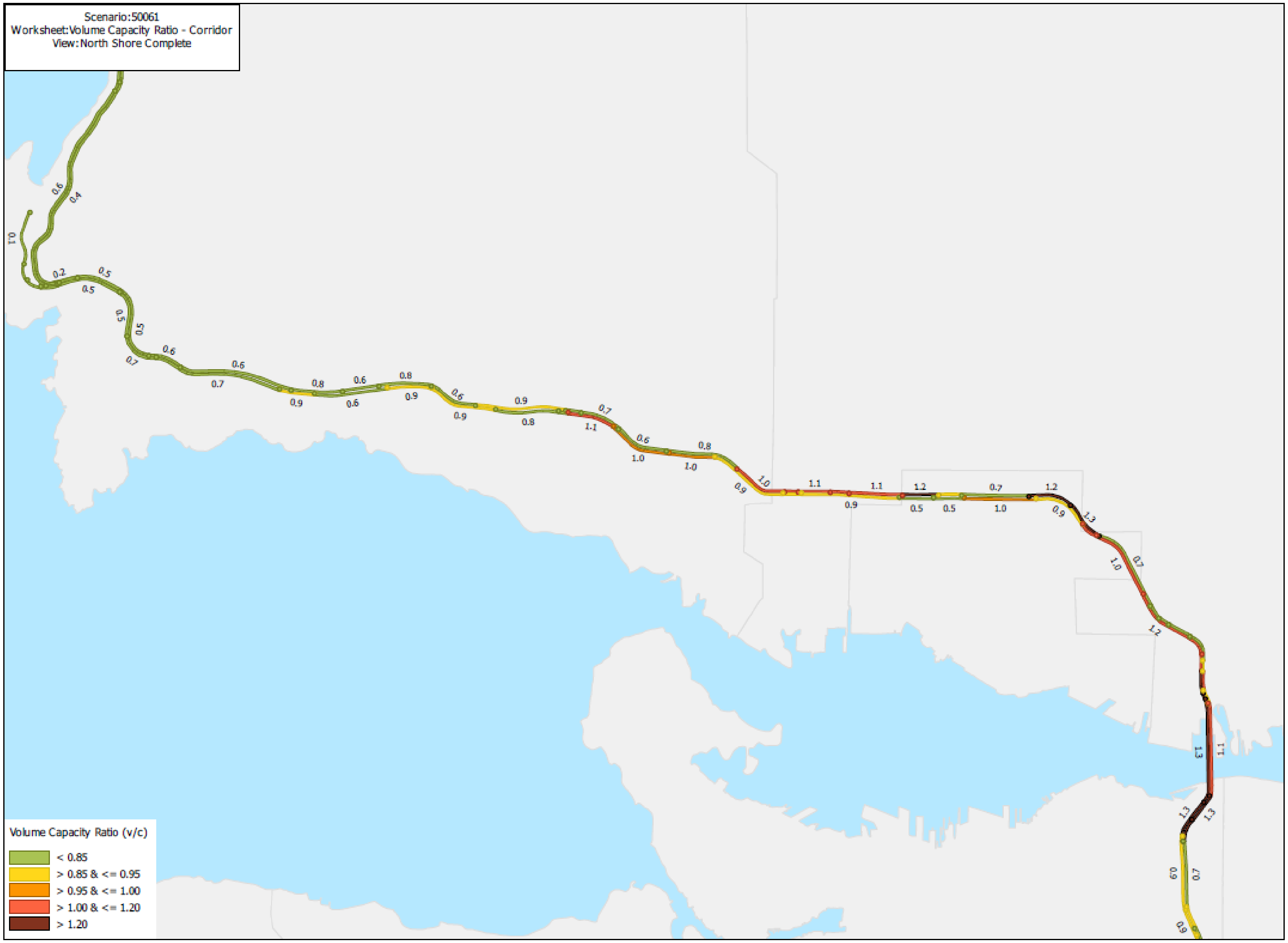


Figure 2.23: 2050 AM Peak Hour Corridor Volume-to-Capacity Ratios

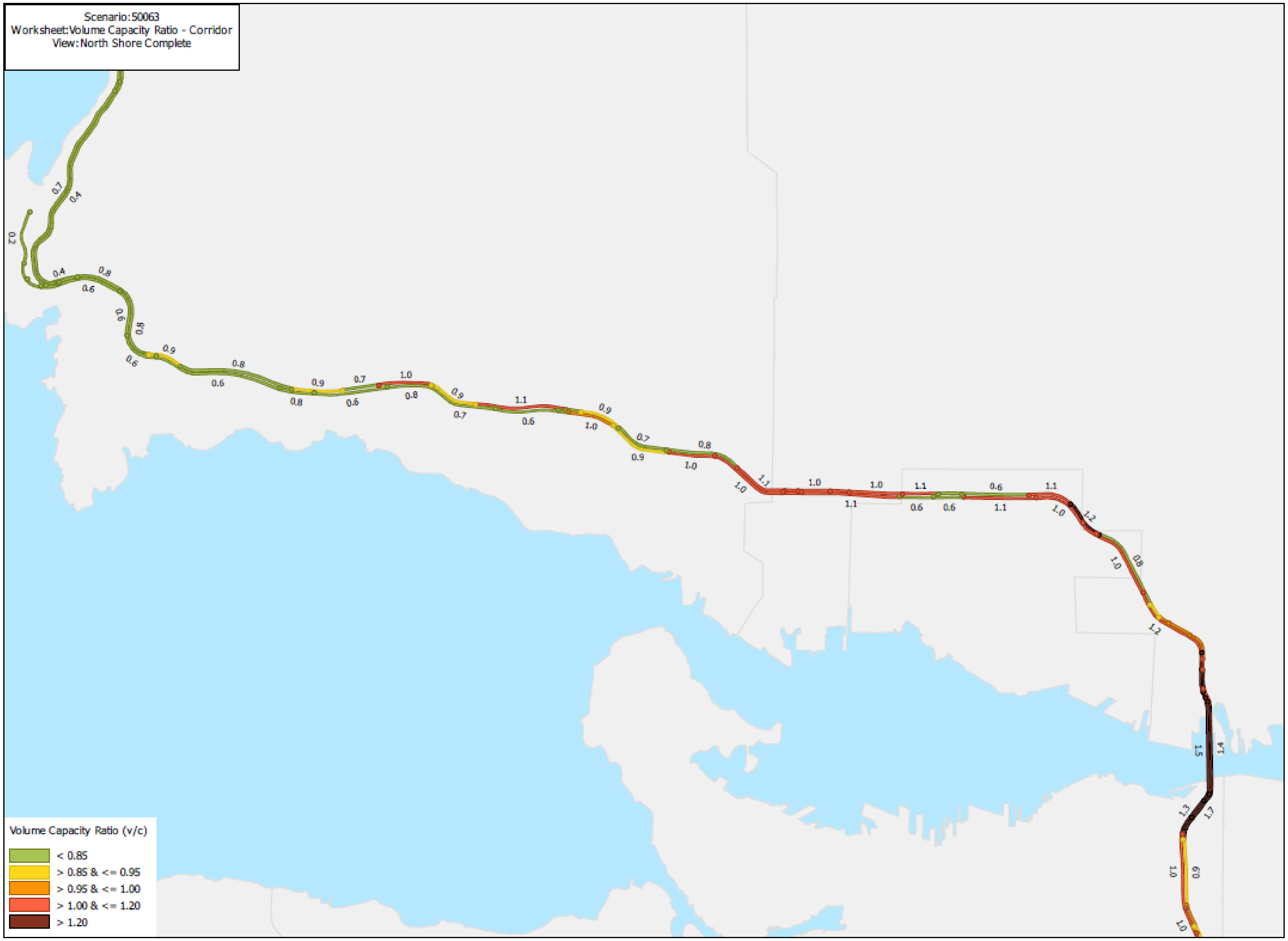


Figure 2.24: 2050 PM Peak Hour Corridor Volume-to-Capacity Ratios

These volume-to-capacity ratios for both peak hours and both analysis years are also summarized in ***Table 2.5*** and ***Table 2.6*** for the eastbound and westbound directions, respectively. Note that the reporting of volume-to-capacity ratios at interchanges reflects the assessment of the highway mainline between the off-ramp and the on-ramp. In the RTM, these links are coded at a lower capacity than the adjacent links (i.e., upstream of the off-ramp and downstream of the on-ramp) in order to act as a proxy for the operational turbulence and decreased vehicular speeds associated with diverging and (especially) merging from a congested highway. This network coding approach is the reason why some links show a more degraded volume-to-capacity ratio through an interchange, even though this segment of the highway has lower traffic than either the upstream (where diverging traffic has not yet exited the highway) or the downstream (where merging traffic has now entered the highway).

**Table 2.5: Eastbound Highway Segment Volume-to-Capacity Ratios**

| From | To | AM | | PM | |
|---|---|---|---|---|---|
| | | 2017 | 2050 | 2017 | 2050 |
| Eagleridge Drive | Highway 99 | 0.49 | 0.58 | 0.43 | 0.49 |
| Highway 99 | Caulfeild Interchange | 0.39 | 0.54 | 0.35 | 0.59 |
| Caulfeild Interchange | | 0.49 | 0.65 | 0.38 | 0.61 |
| Caulfeild Interchange | Westmount Road Interchange | 0.57 | 0.66 | 0.41 | 0.58 |
| Westmount Road Interchange | | 0.77 | 0.88 | 0.56 | 0.79 |
| Westmount Road Interchange | Cypress Bowl Road Interchange | 0.57 | 0.64 | 0.41 | 0.58 |
| Cypress Bowl Road Interchange | | 0.75 | 0.86 | 0.56 | 0.78 |
| Cypress Bowl Road Interchange | 21st Street Interchange | 0.57 | 0.85 | 0.44 | 0.67 |
| 21st Street Interchange | | 0.56 | 0.82 | 0.43 | 0.65 |
| 21st Street Interchange | 15th Street Interchange | 0.46 | 0.58 | 0.39 | 0.51 |
| 15th Street Interchange | | 0.90 | 1.05 | 0.78 | 0.99 |
| 15th Street Interchange | Taylor Way Interchange | 0.78 | 0.97 | 0.72 | 0.91 |
| Taylor Way Interchange | | 0.76 | 0.99 | 0.79 | 1.03 |
| Taylor Way Interchange | Capilano Road Interchange | 0.72 | 0.92 | 0.79 | 1.01 |
| Capilano Road Interchange | | 0.78 | 0.94 | 0.90 | 1.14 |
| Capilano Road Interchange | Westview Drive Interchange | 0.71 | 0.87 | 0.93 | 1.12 |
| Westview Drive Interchange | | 0.40 | 0.50 | 0.50 | 0.61 |
| Westview Drive Interchange | Lonsdale Avenue Interchange | 0.45 | 0.54 | 0.54 | 0.64 |
| Lonsdale Avenue Interchange | | 0.80 | 0.96 | 0.97 | 1.12 |
| Lonsdale Avenue Interchange | Lynn Valley Road Interchange | 0.79 | 0.89 | 0.89 | 1.02 |
| Lynn Valley Road Interchange | | 0.96 | 1.08 | 1.03 | 1.16 |

Table 2.6: Westbound Highway Segment Volume-to-Capacity Ratios

| From | To | AM 2017 | AM 2050 | PM 2017 | PM 2050 |
|---|---|---|---|---|---|
| Lynn Valley Road Interchange | | 1.11 | 1.28 | 1.04 | 1.20 |
| Lynn Valley Road Interchange | Lonsdale Avenue Interchange | 1.04 | 1.20 | 0.95 | 1.10 |
| Lonsdale Avenue Interchange | | 0.56 | 0.65 | 0.50 | 0.59 |
| Lonsdale Avenue Interchange | Westview Drive Interchange | 0.83 | 0.94 | 0.72 | 0.83 |
| Westview Drive Interchange | | 1.08 | 1.21 | 0.99 | 1.11 |
| Westview Drive Interchange | Capilano Road Interchange | 1.01 | 1.14 | 0.92 | 1.05 |
| Capilano Road Interchange | | 1.05 | 1.17 | 0.99 | 1.14 |
| Capilano Road Interchange | Taylor Way Interchange | 0.85 | 1.04 | 0.85 | 1.05 |
| Taylor Way Interchange | | 0.62 | 0.77 | 0.68 | 0.84 |
| Taylor Way Interchange | 15th Street Interchange | 0.5 | 0.62 | 0.58 | 0.74 |
| 15th Street Interchange | | 0.56 | 0.73 | 0.70 | 0.92 |
| 15th Street Interchange | 21st Street Interchange | 0.39 | 0.51 | 0.48 | 0.64 |
| 21st Street Interchange | | 0.61 | 0.87 | 0.83 | 1.08 |
| 21st Street Interchange | Cypress Bowl Road Interchange | 0.46 | 0.65 | 0.61 | 0.89 |
| Cypress Bowl Road Interchange | | 0.58 | 0.79 | 0.81 | 1.00 |
| Cypress Bowl Road Interchange | Westmount Road Interchange | 0.42 | 0.59 | 0.60 | 0.74 |
| Westmount Road Interchange | | 0.56 | 0.79 | 0.80 | 0.89 |
| Westmount Road Interchange | Caulfeild Interchange | 0.41 | 0.58 | 0.59 | 0.75 |
| Caulfeild Interchange | | 0.41 | 0.63 | 0.63 | 0.87 |
| Caulfeild Interchange | Highway 99 | 0.32 | 0.51 | 0.52 | 0.78 |
| Highway 99 | Eagleridge Drive | 0.12 | 0.17 | 0.27 | 0.40 |

As can be seen from the above figures and tables, volume-to-capacity ratio challenges are most acute in the 15th Street to Westview Drive area, as well as between Lonsdale Avenue and Lynn Valley Road. This finding is generally consistent with the analysis of total trip volumes, which shows that the eastern portion of the study corridor is busier than the western portion. The highway segment around Westview Drive and Lonsdale Avenue generally shows a lower volume-to-capacity ratio due to the six-lane configuration of this segment. Volume-to-capacity ratios are anticipated to be exacerbated between 2017 and 2050, reflecting growth in volumes and therefore additional congestion in the highway corridor

In addition to the highway corridor mainline, volume-to-capacity ratios were also generated for the on-ramps and off-ramps along the corridor, and serve as the primary metric to assess interchange performance. Volume-to-capacity ratios are provided for ramps servicing the eastbound highway mainline and westbound highway mainline in ***Table 2.7*** and ***Table 2.8***, respectively.

Table 2.7: Eastbound Interchange Ramps Volume-to-Capacity Ratios

| Interchange | Ramp Movement | AM | | PM | |
|---|---|---|---|---|---|
| | | 2017 | 2050 | 2017 | 2050 |
| Caulfeild Interchange | Caulfeild Dr, EB off-ramp | 0.21 | 0.39 | 0.40 | 0.85 |
| | Caulfeild Dr, EB on-ramp | 0.88 | 0.75 | 0.58 | 0.60 |
| Westmount Road Interchange | Westridge Ave, EB off-ramp | 0.05 | 0.17 | 0.04 | 0.08 |
| | Westridge Ave, EB on-ramp | 0.04 | 0.03 | 0.01 | 0.03 |
| Cypress Bowl Road Interchange | Cypress Bowl Rd, EB off-ramp | 0.25 | 0.15 | 0.03 | 0.13 |
| | Cypress Bowl Rd, EB on-ramp | 0.14 | 0.95 | 0.14 | 0.43 |
| 21st Street Interchange | 22nd St, EB off-ramp | 0.14 | 0.29 | 0.11 | 0.18 |
| | 21st St, EB on-ramp | 0.30 | 0.15 | 0.35 | 0.28 |
| 15th Street Interchange | 15th St, EB off-ramp | 0.27 | 0.72 | 0.17 | 0.39 |
| | 15th St, EB on-ramp | 0.54 | 0.84 | 0.61 | 0.80 |
| Taylor Way Interchange | Taylor Way, EB off-ramp | 0.96 | 1.03 | 0.60 | 0.67 |
| | Taylor Way, EB on-ramp | 0.70 | 0.83 | 0.91 | 1.08 |
| Capilano Road Interchange | Capilano Rd, EB off-ramp (from Hwy) | 0.32 | 0.49 | 0.29 | 0.38 |
| | Capilano Rd, EB off-ramp (to int.) | 0.31 | 0.41 | 0.39 | 0.50 |
| | Capilano Rd, EB on-ramp (from int.) | 0.33 | 0.38 | 0.66 | 0.70 |
| | Capilano Rd, EB on-ramp (to Hwy) | 0.60 | 0.78 | 1.18 | 1.22 |
| Westview Drive Interchange | Westview Dr, EB off-ramp | 0.33 | 0.36 | 0.58 | 0.61 |
| | Westview Dr, EB on-ramp | 0.32 | 0.33 | 0.33 | 0.30 |
| Lonsdale Avenue Interchange | Lonsdale Ave, EB off-ramp | 0.60 | 0.74 | 0.72 | 0.89 |
| | Lonsdale Ave, EB on-ramp | 0.86 | 0.82 | 0.77 | 0.90 |
| Lynn Valley Road Interchange | Lynn Valley Rd, EB off-ramp (from Hwy) | 0.19 | 0.23 | 0.30 | 0.38 |
| | Lynn Valley Rd, EB off-ramp (connector) | 0.06 | 0.05 | 0.05 | 0.07 |
| | Lynn Valley Rd, EB off-ramp (LT at int.) | 0.15 | 0.13 | 0.14 | 0.17 |
| | Lynn Valley Rd, EB off-ramp (RT at int.) | 0.14 | 0.17 | 0.24 | 0.32 |
| | Lynn Valley Rd, EB on-ramp (from int.) | 0.49 | 0.52 | 0.41 | 0.43 |
| | Lynn Valley Rd, EB on-ramp (to Hwy) | 0.99 | 1.04 | 0.82 | 0.85 |

Table 2.8: Westbound Interchange Ramps Volume-to-Capacity Ratios

| Interchange | Ramp Movement | AM | | PM | |
|---|---|---|---|---|---|
| | | 2017 | 2050 | 2017 | 2050 |
| Lynn Valley Road Interchange | Lynn Valley Rd, WB off-ramp | 0.36 | 0.48 | 0.46 | 0.71 |
| | Lynn Valley Rd, WB on-ramp | 0.96 | 1.13 | 0.79 | 0.92 |
| Lonsdale Avenue Interchange | Lonsdale Ave, WB off-ramp | 0.49 | 0.56 | 0.49 | 0.54 |
| | Lonsdale Ave, WB on-ramp | 0.31 | 0.29 | 0.22 | 0.21 |
| Westview Drive Interchange | Westview Dr, WB off-ramp | 0.74 | 0.85 | 0.52 | 0.65 |
| | Westview Dr, WB on-ramp | 0.95 | 1.09 | 0.82 | 1.00 |
| Capilano Road Interchange | Capilano Rd, WB off-ramp | 0.84 | 0.98 | 0.66 | 0.73 |
| | Capilano Rd, WB on-ramp | 0.37 | 0.80 | 0.57 | 0.93 |
| Taylor Way Interchange | Taylor Way, WB off-ramp | 0.64 | 0.76 | 0.47 | 0.58 |
| | Taylor Way, WB on-ramp | 0.31 | 0.39 | 0.43 | 0.59 |
| 15th Street Interchange | 15th St, WB off-ramp (upstream of int.) | 0.42 | 0.47 | 0.39 | 0.43 |
| | 15th St, WB off-ramp (LT at int.) | 0.72 | 0.86 | 0.54 | 0.64 |
| | 15th St, WB off-ramp (RT at int.) | 0.15 | 0.15 | 0.19 | 0.19 |
| | 15th St, WB on-ramp | 0.06 | 0.09 | 0.08 | 0.11 |
| 21st Street Interchange | 21st St, WB off-ramp | 0.61 | 0.60 | 0.56 | 0.77 |
| | Skilift Rd, WB on-ramp | 0.06 | 0.08 | 0.05 | 0.43 |
| Cypress Bowl Road Interchange | Cypress Bowl Rd, WB off-ramp | 0.21 | 0.43 | 0.14 | 0.90 |
| | Cypress Bowl Rd, WB on-ramp | 0.01 | 0.07 | 0.03 | 0.05 |
| Westmount Road Interchange | Westridge Ave, WB off-ramp | 0.04 | 0.04 | 0.03 | 0.19 |
| | Westridge Ave, WB on-ramp | 0.01 | 0.03 | 0.04 | 0.45 |
| Caulfeild Interchange | Westport Rd, WB off-ramp | 0.23 | 0.25 | 0.28 | 0.25 |
| | Westport Rd, WB on-ramp | 0.11 | 0.24 | 0.29 | 0.63 |

In 2017, ramp volume-to-capacity ratios are largely satisfactory, with only a small group of ramps exhibiting ratios approaching 1.0. Of these, the Capilano Road eastbound on-ramp is the only one over capacity (in the PM peak hour). However, by 2050, several ramps are predicted to be above capacity, including those at Taylor Way, Capilano Road, Westview Drive and Lynn Valley Road. Of particular note, the Westview Drive westbound on-ramp is anticipated to be above capacity in both the AM and PM peak hours. The PM peak hour for the Cypress Bowl Road is anticipated to experience a very large increase in volume-to-capacity ratio, driven by development on the north side of the highway. Although the AM peak hour is more muted, as noted previously in Section 2.2.13, the model does not fully capture the localized peak hour in the vicinity of the Cypress Bowl Interchange, nor the extent of potential future development in this area, and likely underestimates the volume-to-capacity ratio at this location if the development were to be fully built out as envisioned.

### TRAVEL TIME INDEX

As noted previously in Section 2.4.1, although volume-to-capacity ratios are useful for assessing operations, they do not necessarily provide a clear assessment of implications for highway users. This is because travel times do not increase directly proportionately to volumes (and by extension, the volume-to-capacity ratio); rather, for a given highway facility capacity, travel times increase non-linearly with respect to volumes. Therefore, the travel time index, i.e., the ratio of peak travel times to free-flow travel times, is a useful tool to understand the overall implications of congestion in terms of travel times.

The travel time index thresholds used for this assessment are summarized in ***Table 2.9***. These thresholds roughly correlate with the volume-to-capacity thresholds (e.g., a volume-to-capacity ratio of 1.20 would roughly correspond to a travel time increase of 60%, or a travel time index of 1.60). Free-flow travel speeds in RTM are calculated as equal to the posted speed limit, except for freeway facilities, which use the posted speed limit plus 10 km/h. These values are used as the denominator (baseline value) in generating travel time index values.

Table 2.9: Travel Time Index Performance Indicator Thresholds

| General Conditions | Range |
|---|---|
| Uncongested | TTI < 1.05 |
| Slightly Congested | 1.05 > TTI ≤ 1.15 |
| Congested | 1.15 > TTI ≤ 1.25 |
| Heavily Congested | 1.25 > TTI ≤ 1.60 |
| Extremely Congested | TTI > 1.60 |

Travel time indices along the highway corridor by mode are presented for the 2017 AM and PM peak hours in ***Figure 2.25*** and ***Figure 2.26***, respectively. Similarly, travel time indices ratios are presented for the 2050 planning horizon year AM and PM peak hours in ***Figure 2.27*** and ***Figure 2.28***, respectively.

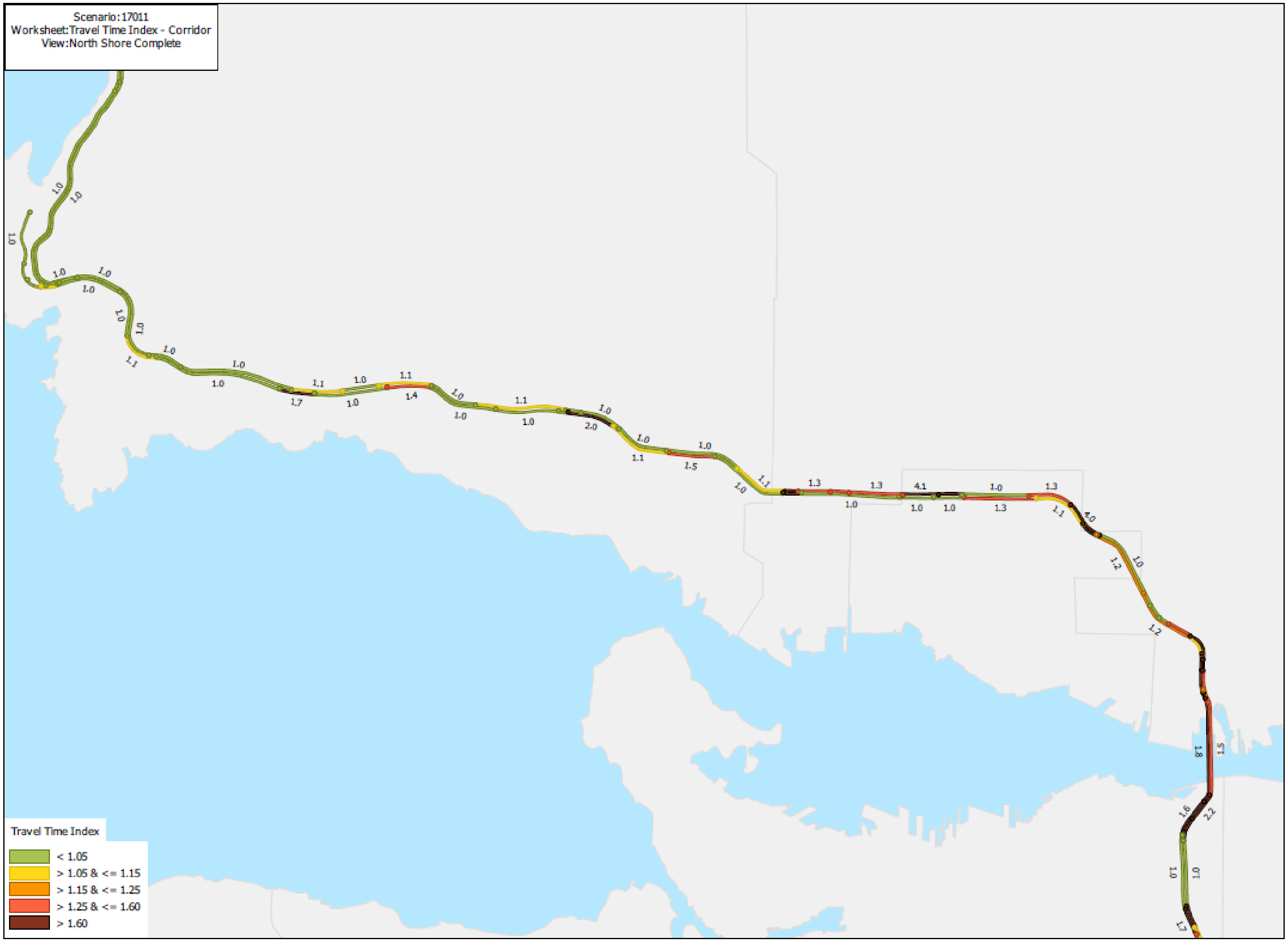


Figure 2.25: 2017 AM Peak Hour Travel Time Indices

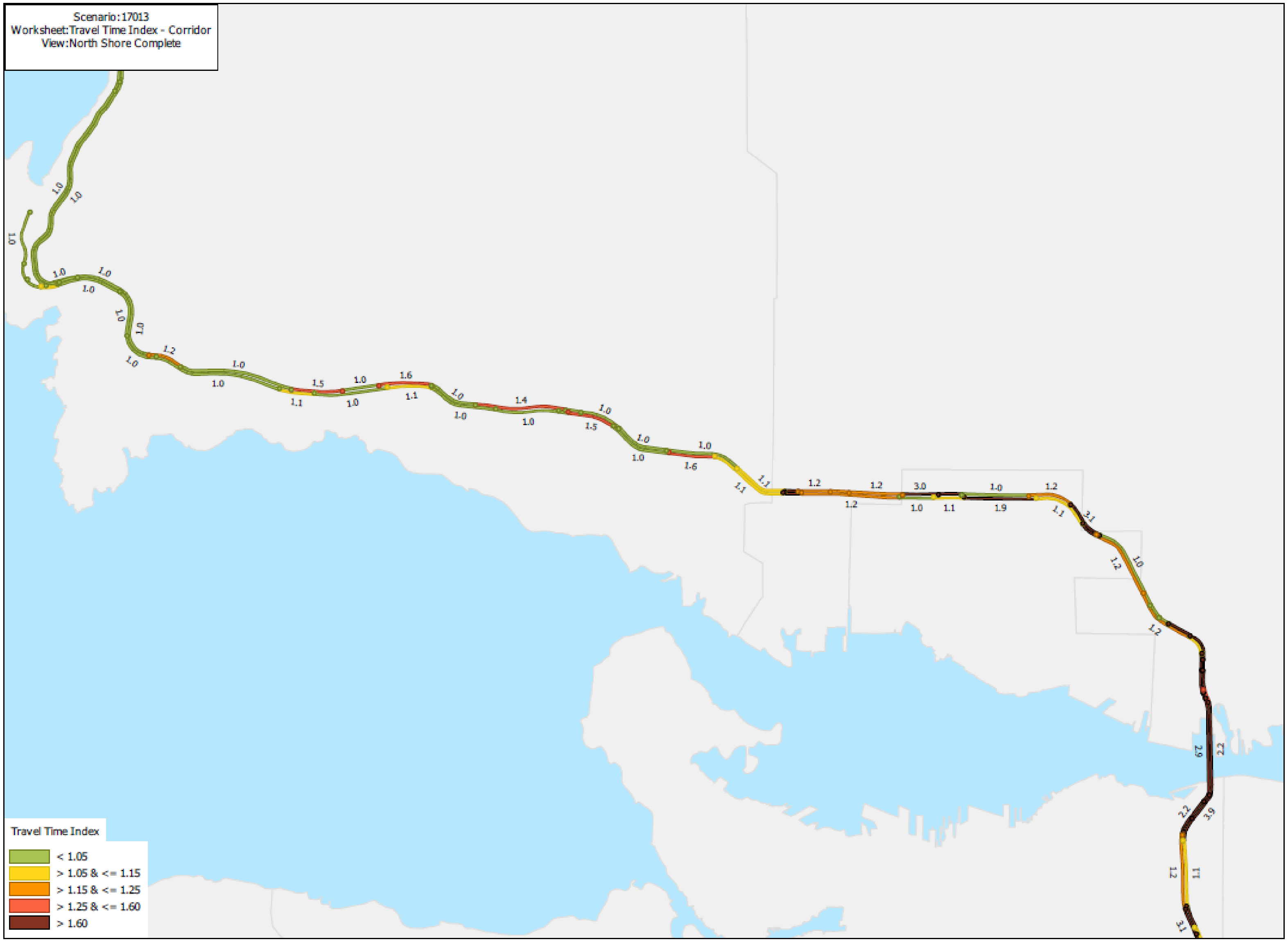


Figure 2.26: 2017 PM Peak Hour Travel Time Indices

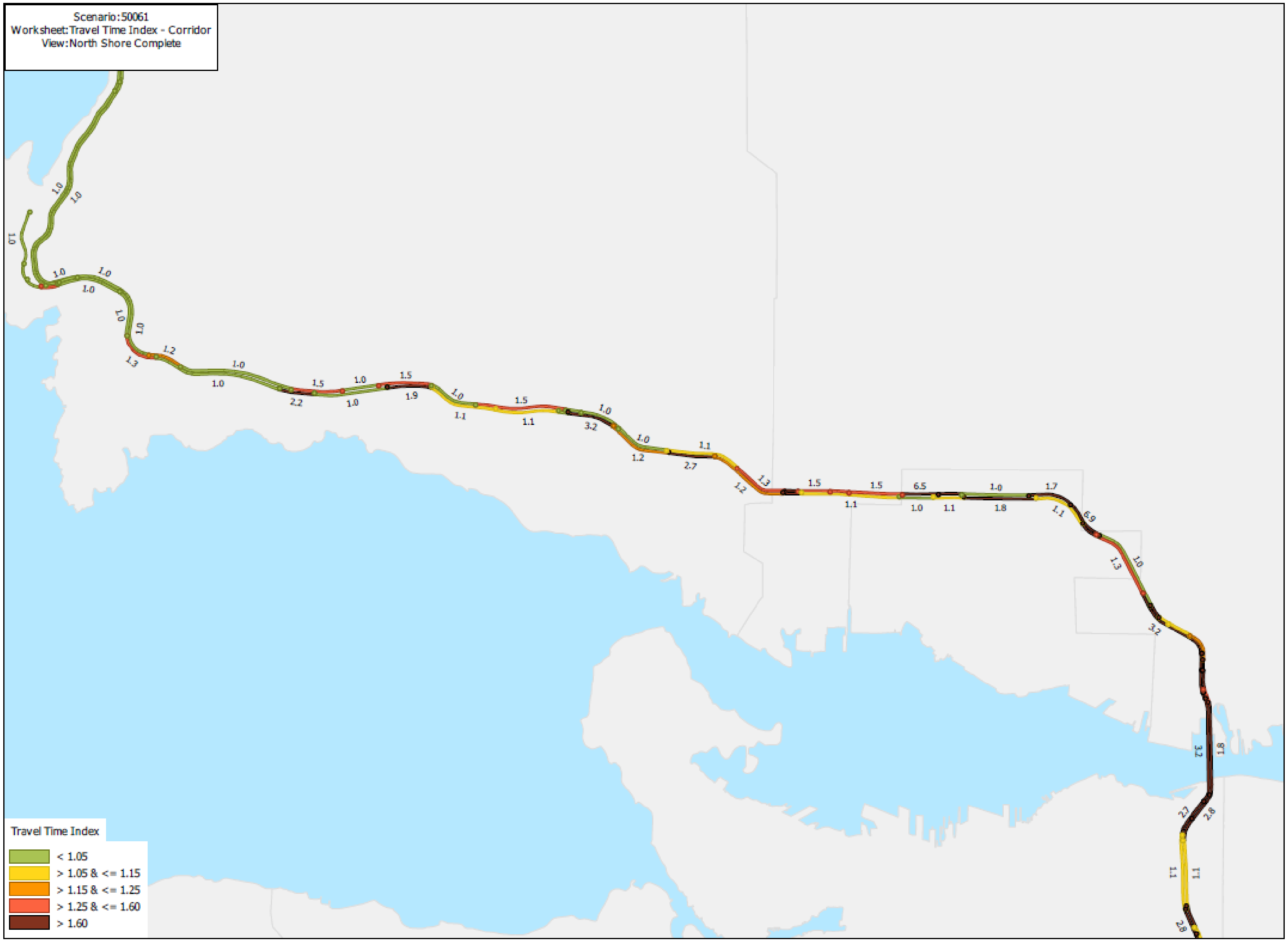


Figure 2.27: 2050 AM Peak Hour Travel Time Indices

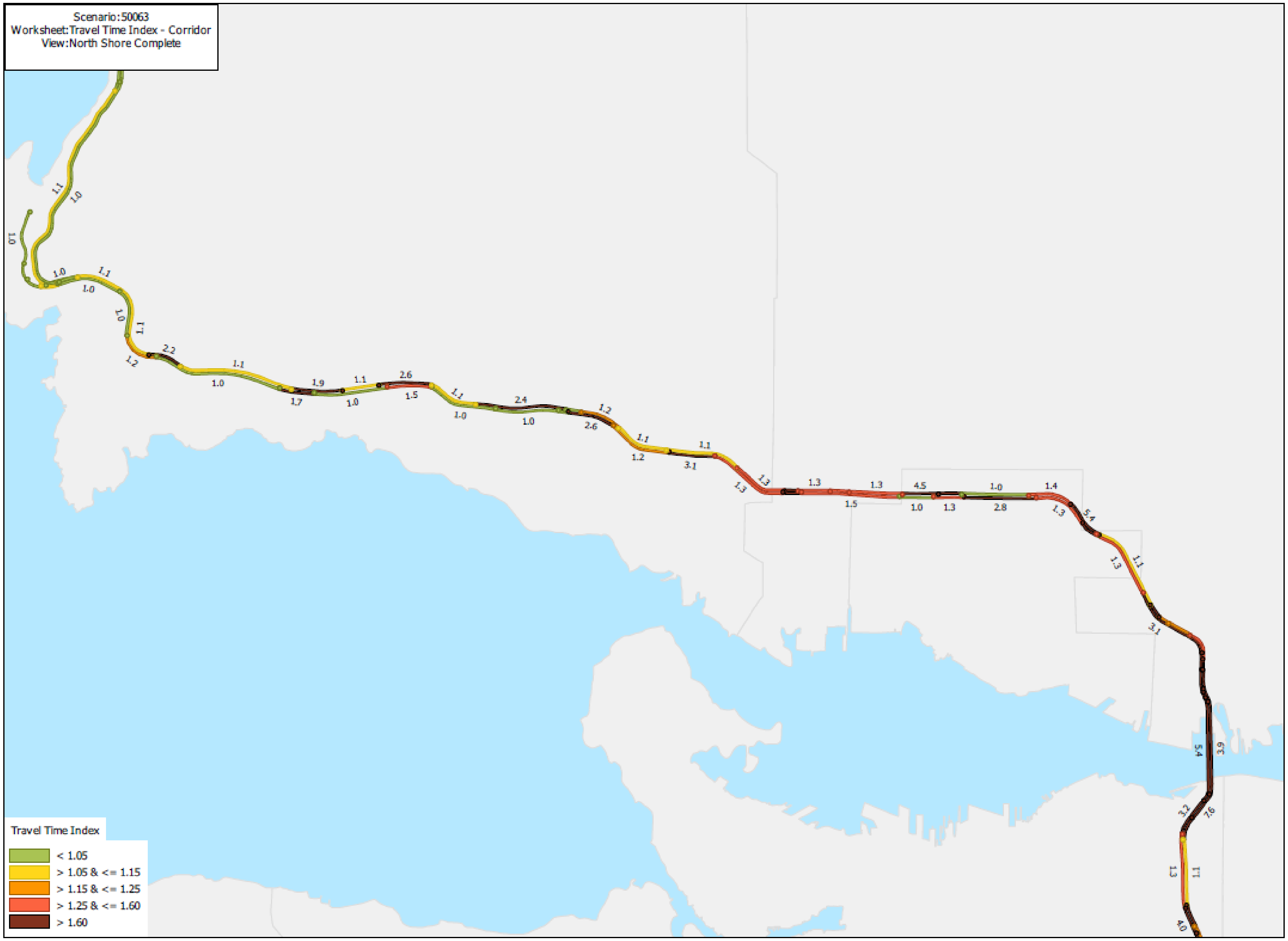


Figure 2.28: 2050 PM Peak Hour Travel Time Indices

These travel time indices for both peak hours and both analysis years are also summarized in ***Table 2.10*** and ***Table 2.11*** for the eastbound and westbound directions, respectively. As with volume-to-capacity ratios, the lower assumed highway mainline capacity on the inter-ramp links at an interchange can create conditions wherein travel time indices through an interchange are more severe than either the upstream or the downstream segments.

**Table 2.10: Eastbound Highway Segment Travel Time Indices**

| From | To | AM | | PM | |
|---|---|---|---|---|---|
| | | 2017 | 2050 | 2017 | 2050 |
| Eagleridge Drive | Highway 99 | 1.12 | 1.28 | 1.06 | 1.12 |
| Highway 99 | Caulfeild Interchange | 1.00 | 1.01 | 1.00 | 1.02 |
| Caulfeild Interchange | | 1.06 | 1.25 | 1.02 | 1.17 |
| Caulfeild Interchange | Westmount Road Interchange | 1.01 | 1.03 | 1.00 | 1.02 |
| Westmount Road Interchange | | 1.67 | 2.24 | 1.13 | 1.75 |
| Westmount Road Interchange | Cypress Bowl Road Interchange | 1.01 | 1.03 | 1.00 | 1.01 |
| Cypress Bowl Road Interchange | | 1.42 | 1.87 | 1.10 | 1.53 |
| Cypress Bowl Road Interchange | 21st Street Interchange | 1.01 | 1.11 | 1.00 | 1.03 |
| 21st Street Interchange | | 1.01 | 1.09 | 1.00 | 1.03 |
| 21st Street Interchange | 15th Street Interchange | 1.00 | 1.02 | 1.00 | 1.01 |
| 15th Street Interchange | | 2.04 | 3.24 | 1.51 | 2.62 |
| 15th Street Interchange | Taylor Way Interchange | 1.07 | 1.22 | 1.04 | 1.16 |
| Taylor Way Interchange | | 1.47 | 2.74 | 1.56 | 3.11 |
| Taylor Way Interchange | Capilano Road Interchange | 1.05 | 1.16 | 1.08 | 1.27 |
| Capilano Road Interchange | | 2.15 | 3.91 | 3.32 | 8.52 |
| Capilano Road Interchange | Westview Drive Interchange | 1.04 | 1.12 | 1.18 | 1.46 |
| Westview Drive Interchange | | 1.00 | 1.01 | 1.01 | 1.02 |
| Westview Drive Interchange | Lonsdale Avenue Interchange | 1.05 | 1.11 | 1.11 | 1.25 |
| Lonsdale Avenue Interchange | | 1.34 | 1.83 | 1.88 | 2.76 |
| Lonsdale Avenue Interchange | Lynn Valley Road Interchange | 1.07 | 1.14 | 1.14 | 1.29 |
| Lynn Valley Road Interchange | | 4.39 | 7.16 | 5.78 | 9.69 |

Table 2.11: Westbound Highway Segment Travel Time Indices

| From | To | AM 2017 | AM 2050 | PM 2017 | PM 2050 |
|---|---|---|---|---|---|
| Lynn Valley Road Interchange | | 3.98 | 6.94 | 3.11 | 5.36 |
| Lynn Valley Road Interchange | Lonsdale Avenue Interchange | 1.31 | 1.68 | 1.19 | 1.42 |
| Lonsdale Avenue Interchange | | 1.01 | 1.03 | 1.01 | 1.02 |
| Lonsdale Avenue Interchange | Westview Drive Interchange | 2.30 | 3.37 | 1.63 | 2.26 |
| Westview Drive Interchange | | 4.07 | 6.46 | 2.95 | 4.49 |
| Westview Drive Interchange | Capilano Road Interchange | 1.28 | 1.52 | 1.16 | 1.33 |
| Capilano Road Interchange | | 7.91 | 13.07 | 6.16 | 11.52 |
| Capilano Road Interchange | Taylor Way Interchange | 1.11 | 1.32 | 1.11 | 1.33 |
| Taylor Way Interchange | | 1.02 | 1.06 | 1.04 | 1.10 |
| Taylor Way Interchange | 15th Street Interchange | 1.01 | 1.02 | 1.01 | 1.05 |
| 15th Street Interchange | | 1.01 | 1.05 | 1.04 | 1.17 |
| 15th Street Interchange | 21st Street Interchange | 1.00 | 1.01 | 1.01 | 1.02 |
| 21st Street Interchange | | 1.08 | 1.45 | 1.36 | 2.38 |
| 21st Street Interchange | Cypress Bowl Road Interchange | 1.00 | 1.03 | 1.02 | 1.14 |
| Cypress Bowl Road Interchange | | 1.10 | 1.48 | 1.56 | 2.58 |
| Cypress Bowl Road Interchange | Westmount Road Interchange | 1.00 | 1.02 | 1.02 | 1.05 |
| Westmount Road Interchange | | 1.09 | 1.49 | 1.53 | 1.9 |
| Westmount Road Interchange | Caulfeild Interchange | 1.00 | 1.01 | 1.02 | 1.06 |
| Caulfeild Interchange | | 1.03 | 1.25 | 1.24 | 2.25 |
| Caulfeild Interchange | Highway 99 | 1.00 | 1.01 | 1.01 | 1.07 |
| Highway 99 | Eagleridge Drive | 1.00 | 1.00 | 1.00 | 1.01 |

Interchanges throughout the study area generally see elevated index values; this applies particularly to the Lynn Valley Road Interchange, the Capilano Road Interchange and the Westview Drive Interchange (westbound only). While the travel time indices on these links are high, the link lengths are generally shorter than intra-interchange links; therefore, impacts on overall travel times are somewhat diminished.

From 2017 to 2050, travel time index increases are seen throughout the study area. The greatest increase is seen at the Capilano Road Interchange where some index values (e.g., eastbound movements in the PM peak) double over the time frame.

Point-to-point travel times can be used to provide a sense of the cumulative implications of changes in the travel time indices along the corridor, and to account for the differences in individual link lengths. Point-to-point travel times between Horseshoe Bay and the south end of the Ironworkers Memorial Bridge are summarized for both peak hours for both analysis years (as well as the free-flow condition) for the eastbound and westbound directions in ***Figure 2.29*** and ***Figure 2.30***, respectively.

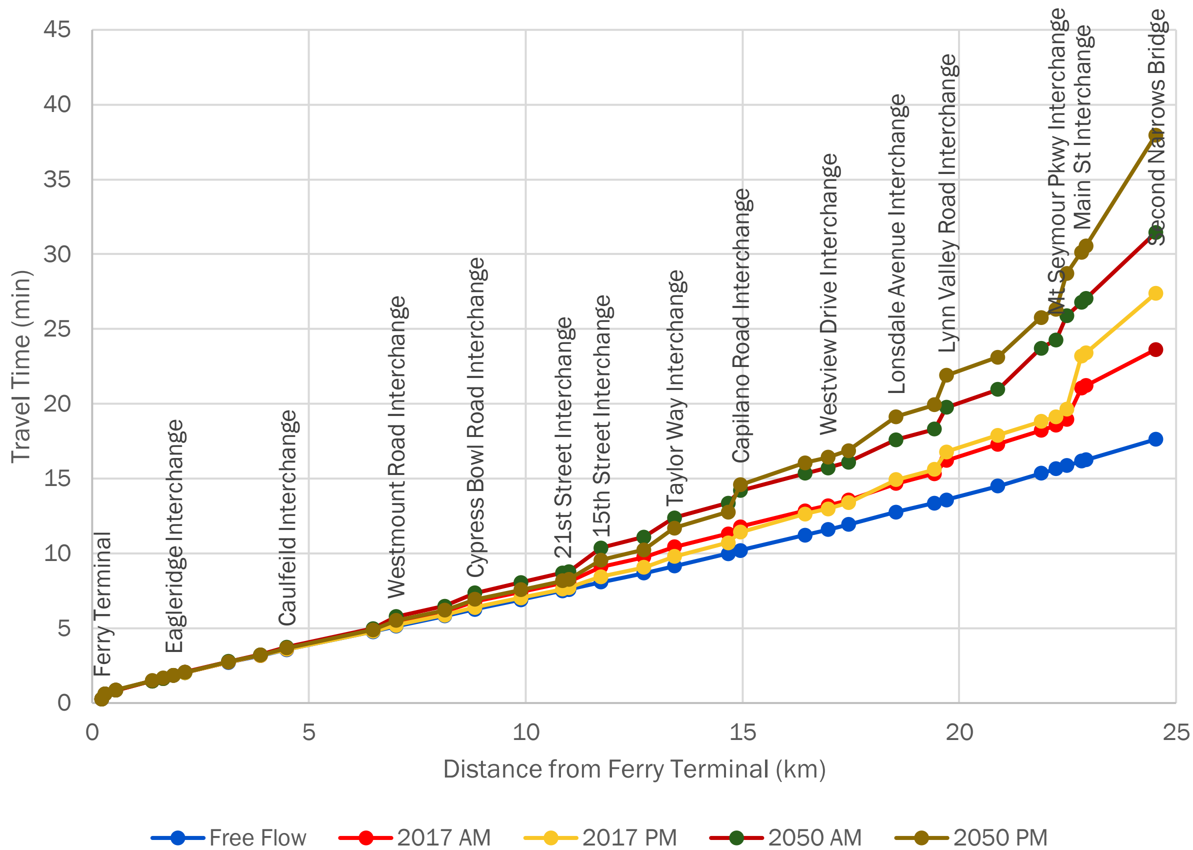


Figure 2.29: Eastbound Point-to-Point Travel Times (Horseshoe Bay to Ironworkers Memorial Bridge)

In the eastbound direction, there is some degradation in travel speeds in the vicinity of the Westmount Road Interchange and the Cypress Bowl Interchange, which is a function of the additional traffic volume being introduced in this highway segment due to significant land use intensification on the north side of the highway (as highlighted previously in ***Figure 2.9***). Otherwise, speeds remain relatively close to free-flow conditions from the Horseshoe Bay ferry terminal to the vicinity of the 15th Street Interchange and Taylor Way Interchange. By 2050, the segment from the Horseshoe Bay ferry terminal to the Taylor Way Interchange is forecast to have a cumulative travel time index of 1.28 in the AM peak and 1.18 in the PM peak.

The decline in travel speeds becomes more apparent beginning in the vicinity of the 15th Street Interchange and Taylor Way Interchange, and increases significantly on the approach to the Ironworkers Memorial Bridge. In the current (i.e., 2017) condition, eastbound speeds begin to decline significantly on the approach to the bridge beginning at the Lynn Valley Road Interchange; however, by 2050, the significant decline in speeds is anticipated to begin further east, roughly at the Westview Drive Interchange. By 2050, the segment from the Taylor Way Interchange to the Lynn Valley Road Interchange is forecast to have a cumulative travel time index of 1.40 in the AM Peak and 1.95 in the PM peak.

It is acknowledged that the Regional Transportation Model does not fully capture traffic operations dynamics with respect to bottlenecks causing upstream queue accrual as volumes increase towards the peak hour and queue decay as peak volumes subside, or how this queuing can block other vehicles on the corridor. This is a consideration in the vicinity of the Taylor Way Interchange, where stakeholders have noted that queues can spill back from the Lions Gate Bridge to the Taylor Way Interchange and onto the highway mainline. The bottlenecking impacts of the highway eastbound mainline effectively being reduced to one through lane (since the outside lane is obstructed with queued vehicles) is not fully captured. Similarly, and perhaps more critically, this is also a consideration in the eastern portion of the study corridor. Under current conditions, eastbound speeds are modelled to begin degrading more noticeably at the Lynn Valley Road Interchange, although stakeholder observations (discussed further in Section 2.7) note that eastbound queues can extend all the way to Westview Drive. More detailed traffic operations analysis for the Lower Lynn Interchange Improvements (described previously in Section 2.2.1) noted that the project is anticipated to reduce queuing in this area, although that analysis did not extend out to a 2050 planning horizon year. In the future, if speeds are modelled to begin declining at Westview Drive, this will likely correlate with the maximum extent of queuing beginning further east.

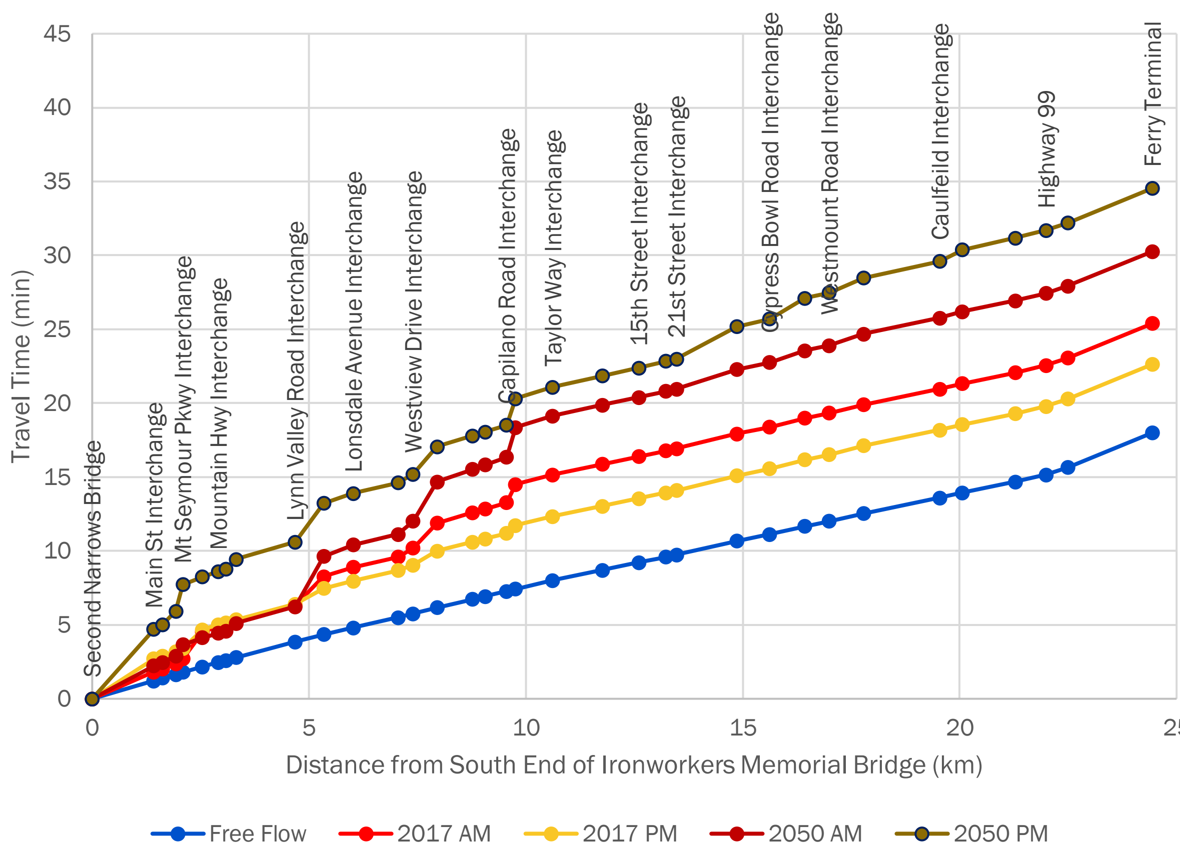


Figure 2.30: Westbound Point-to-Point Travel Times (Ironworkers Memorial Bridge to Horseshoe Bay)

In the westbound direction, reduced travel speeds are most significant in the Lower Lynn area (which is beyond the study scope) and the Lynn Valley Interchange to the Capilano River (which is the western portion of the study scope). By 2050, the segment from the Lynn Valley Road to the Capilano River is forecast to have a cumulative travel time index of 2.28 in the AM Peak and 1.89 in the PM peak.

Westbound travel speeds generally increase upon crossing the Capilano River, as evidenced by the slopes for the 2017 AM and 2017 PM plots being similar to the slope of the free-flow plot. By 2050, conditions will degrade slightly, predominantly in the vicinity of the Cypress Bowl Road Interchange and Westmount Road Interchange. However, this western portion of the corridor will still perform reasonably well. By 2050, the segment from the Taylor Way Interchange to Horseshoe Bay is forecast to have a cumulative travel time index of 1.04 in the AM peak and 1.27 in the 2050 peak.

### TRIP TYPE

Trip type analysis along the highway corridor is presented for the 2017 AM and PM peak hours in ***Figure 2.31*** and ***Figure 2.32***, respectively. The 2050 trip type patterns largely mimic those of 2017; therefore, visuals are not provided.

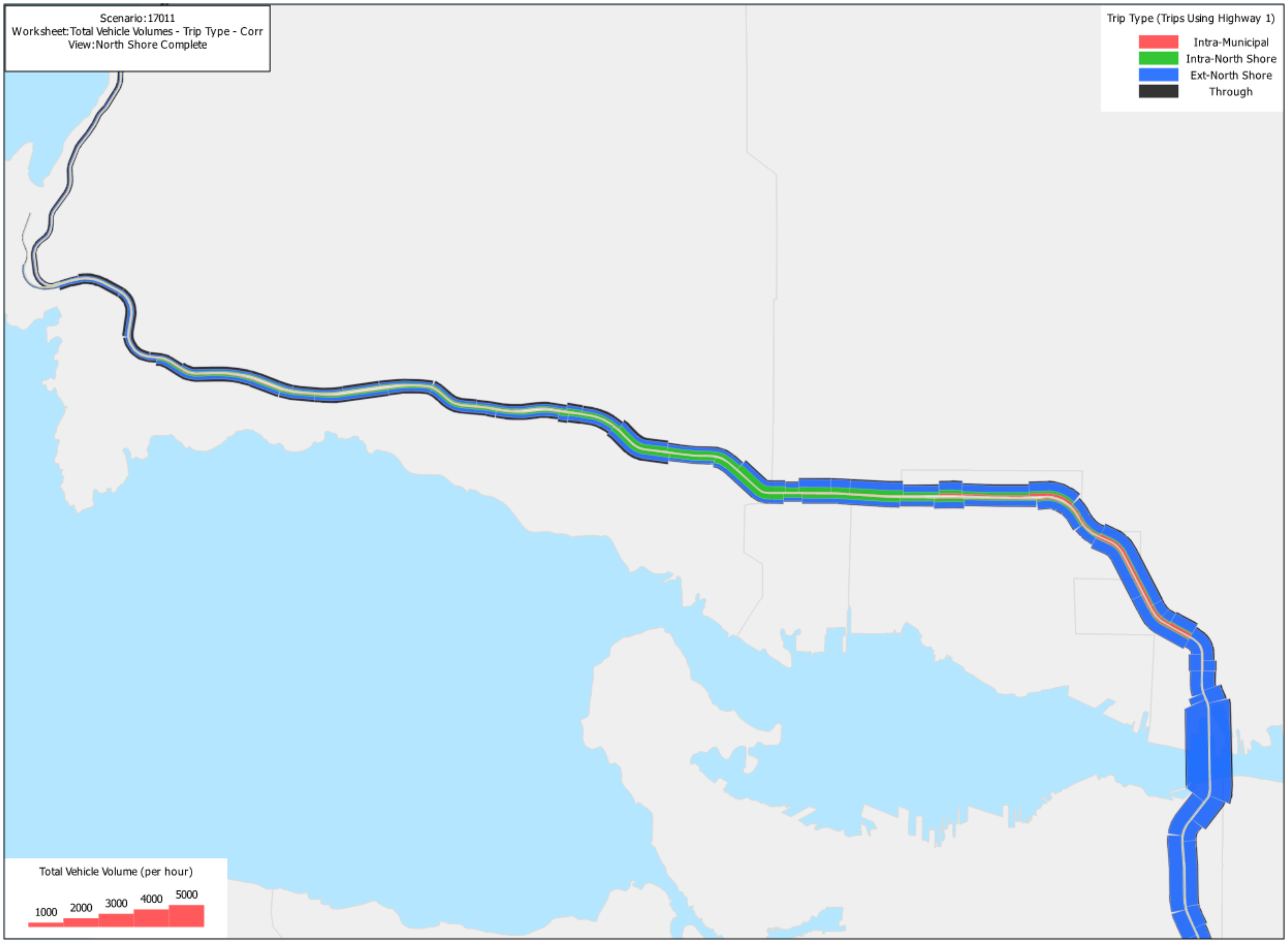


Figure 2.31: 2017 AM Peak Hour Trip Type Disaggregation

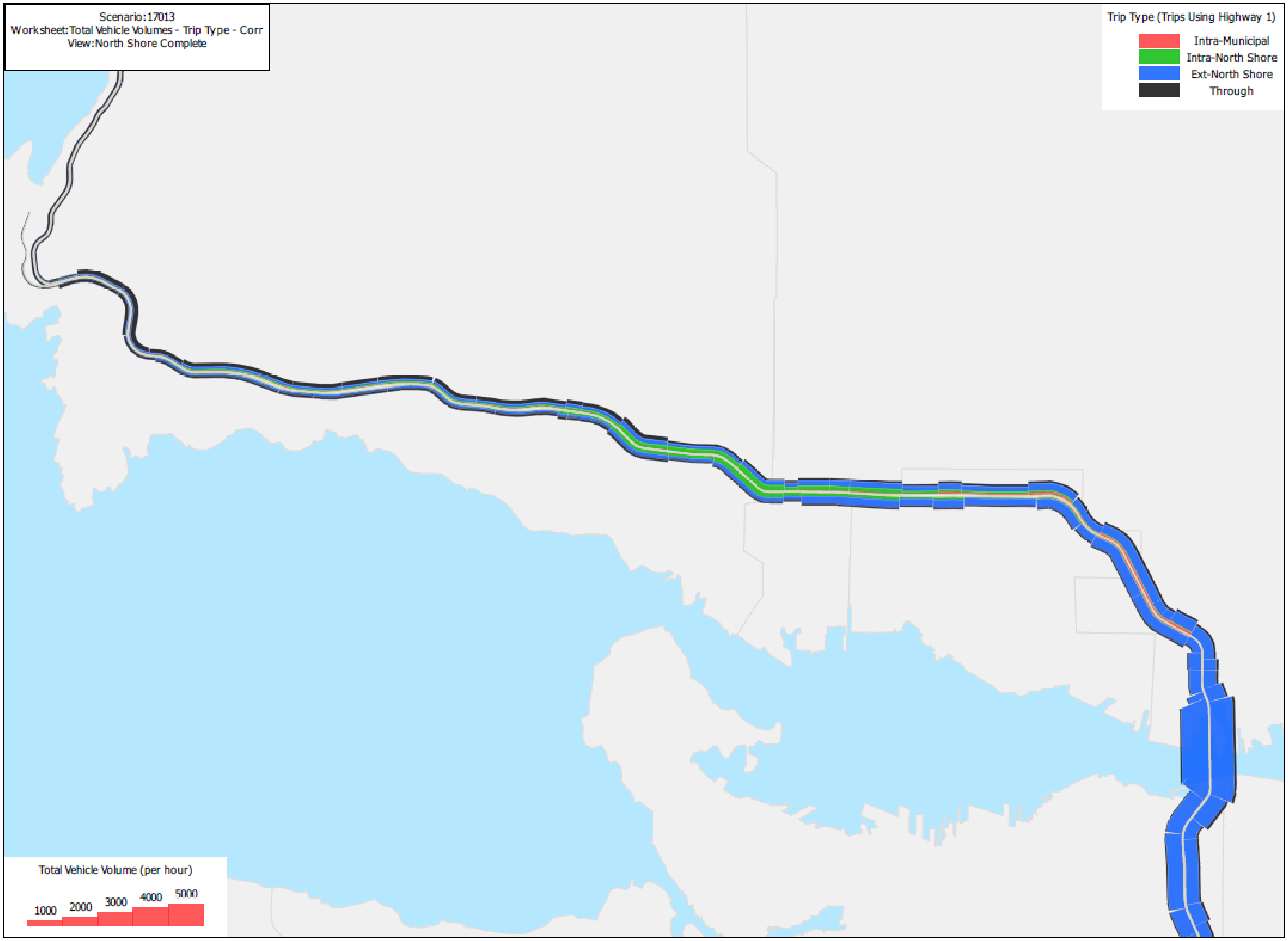


Figure 2.32: 2017 PM Peak Hour Trip Type Disaggregation

Given the lack of continuous east-west municipal routes through the North Shore, the highway is heavily used for local intra-municipal and intra-North Shore trips. INSTPP noted that Highway 1 on the North Shore has a much greater proportion of local trips than other segments of highway throughout Greater Vancouver. Based on this travel demand modelling analysis, it is estimated that one-quarter to one-third of trips on the highway are internal to the North Shore. Further information on each of the four trip types is provided below.

#### Intra-Municipal

Highway 1 through North Vancouver (note that the City and District municipalities have been combined for this analysis) sees a significant volume of trips between the Westview Interchange and the Lynn Valley Interchange, extending beyond the study area southeast through the cut towards Mountain Highway. These volumes likely reflect the lack of alternative crossings of Lynn Creek. There are comparatively fewer intra-municipal trips in West Vancouver; however, given that West Vancouver has only one alternative east-west route, the lower intra-municipal volumes are likely reflective of a lower population, rather than less reliance on the highway for local trips. Trips within West Vancouver and within North Vancouver represent 3% and 10% of all 2017 AM Highway 1 trips in the study area, respectively; this is forecast to increase and decrease to 4% and 9%, respectively, in 2050.

#### Intra-North Shore

The segment of Highway 1 between 15$^{th}$ Street and Westview Drive sees a significant proportion of intra-North Shore trips, with the highest volumes occurring between Taylor Way and Capilano Road. The drop-off in these volumes only one or two interchanges away on either side of the municipal boundary suggests that Highway 1 is heavily used by travellers crossing the Capilano River, for which there is only one alternative crossing of significance (Marine Drive). This situation is analogous to the Lynn Creek crossing, where the highway is being used for local trips across the river. Trips between West and North Vancouver represent 15% of all 2017 AM Highway 1 trips in the study area; this value is forecast to increase to 16% in 2050.

Intra-municipal and intra-North Shore trips (collectively, “local” trips) can be assessed further with respect to specific interchange-to-interchange patterns on the North Shore. The distribution with respect to number of interchanges travelled on the highway for these local trips is provided in ***Figure 2.33*** and ***Figure 2.34*** for the 2017 AM peak hour and 2050 peak hour, respectively. Note that all of the charts in this section exclude intra-regional and through-trips; only intra-municipal and intra-North Shore trips (i.e., trips that both enter and exit Highway 1 within the North Shore via ramps are included) are shown. These patterns can be further disaggregated into an origin-destination plot, as provided in ***Figure 2.35*** and ***Figure 2.36*** for the 2017 AM peak hour and 2050 peak hour, respectively.

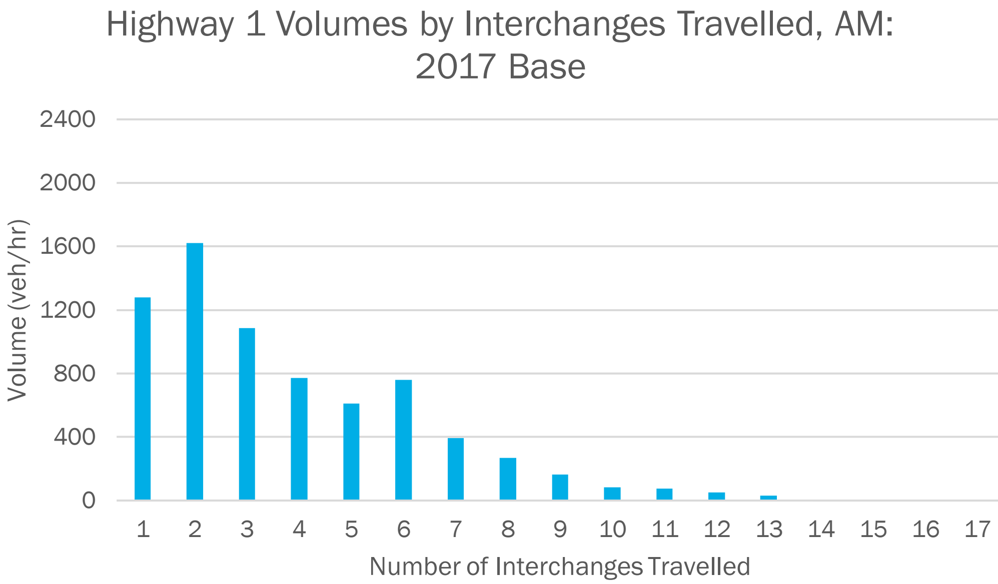


Figure 2.33: Distribution of Number of Interchanges Travelled for Local Trips, 2017 AM Peak Hour

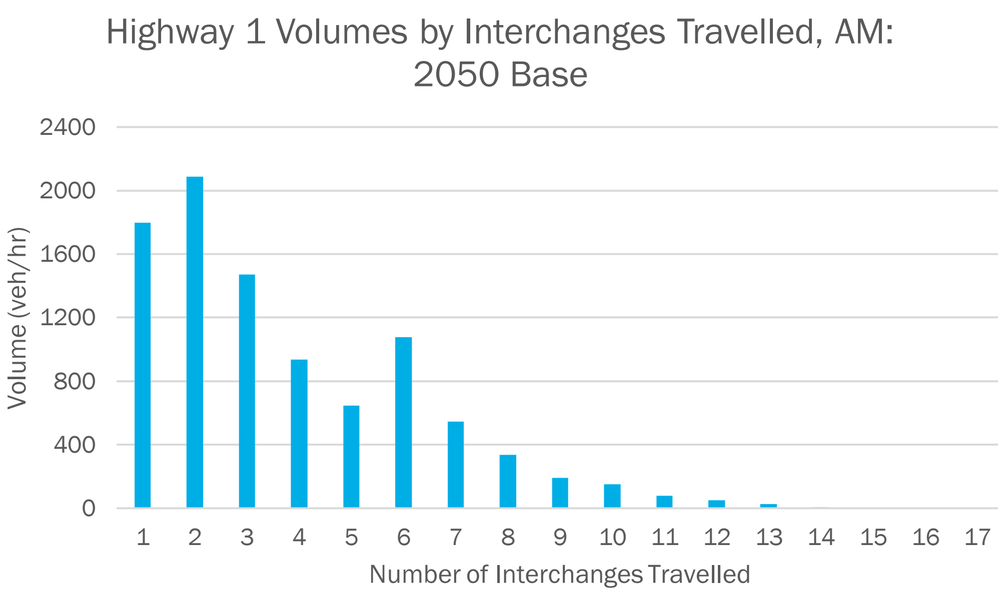


Figure 2.34: Distribution of Number of Interchanges Travelled for Local Trips, 2050 AM Peak Hour

The number of interchanges travelled follows a similar distribution across all time periods and for both 2017 and 2050. In 2017 AM, trips travelling one and two interchanges are 18% and 23%, respectively. In 2050, these values are 19% and 22%.

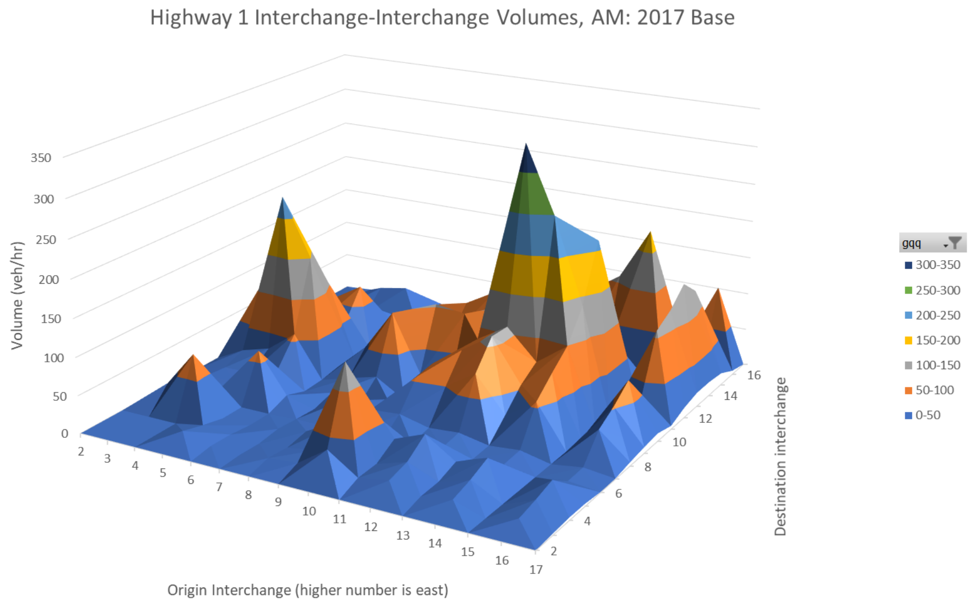


Figure 2.35: Interchange Origin-Destination Paring for Local Trips, 2017 AM Peak Hour

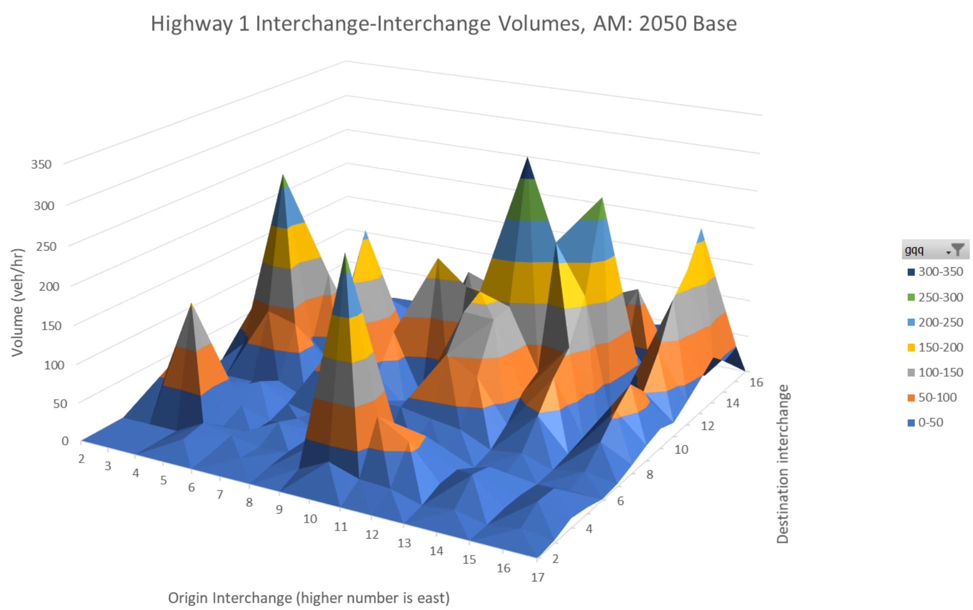


Figure 2.36: Interchange Origin-Destination Paring for Local Trips, 2050 AM Peak Hour

As noted previously, corridor volumes are highest towards the east. This is seen very clearly in the interchange-interchange charts for periods in 2017. A clear spike along the x-axis is seen around Interchanges 10 and 11 (Taylor Way and Capilano Road, respectively). This reflects the traffic headed to the Lions Gate Bridge. Although not presented visually, similar peaks along the depth-axis are seen in the PM as trips return to the North Shore. The highest interchange-to-interchange volume occurs between the Capilano Road Interchange and the Westview Drive Interchange.

In 2050, AM origin activity is much more spread through into West Vancouver. New developments increase usage of the Cypress Bowl Road interchange substantially. The Lions Gate Bridge (via the Taylor Way Interchange and Capilano Road Interchange) remains a clear destination across the region. While the Capilano Road Interchange to/from the Westview Drive Interchange case continues to be prominent, other interchange-to-interchange movements also begin to see larger volumes.

#### Intra-Regional Trips

With respect to trips between the North Shore and external areas, many North Shore residents travel to the rest of Greater Vancouver for access to employment, education, social, recreational and other activities. According to the findings of the 2016 census, residents travelling beyond the North Shore for work are predominantly destined to employment in Vancouver, which accounts for 58% of all trips leaving the North Shore. Similarly, residents from the rest of Greater Vancouver travel to the North Shore for access to employment, education, social, recreational (particularly outdoor recreation) and other activities. As documented previously in Section 2.3.2, over the past several years, the growth in employment on the North Shore has vastly exceeded the growth in the working-age population and has led to an increase in people commuting to the North Shore. In contrast to commuting patterns for North Shore residents travelling to the rest of the region, the points of origin for people travelling from the rest of the region to the North Shore for work are much more dispersed throughout the region, with only 44% of all North Shore-bound work trips originating in Vancouver. The Tri-Cities and Surrey in particular see a much higher proportion of residents commuting to the North Shore as compared to residents of the North Shore commuting to those communities.

Overall, intra-regional trips make up the majority of overall trips using Highway 1 in the study area. Intra-regional trips represent 65% of trips in the 2017 AM and 62% of trips in the 2050 AM. PM results are 67% and 64%, respectively.

Of particularly note, east of Lonsdale Avenue, inter-regional trips account for a very high proportion of trips on the highway, meaning that most trips on this segment are destined to the Ironworkers Memorial Bridge. This finding has significant implications with respect to the feasibility of increasing eastbound capacity in the study corridor in the absence of any such capacity increases downstream. It is also noted that there is a significant share of inter-regional trips on Highway 1 in West Vancouver, although the absolute volumes of trips are much lower.

#### Through-Trips

Highway 1 is the primary connection to the Horseshoe Bay ferry terminal, which is one of only two terminals that connect Greater Vancouver to Vancouver Island, and the only terminal that connects Greater Vancouver to Bowen Island and the Sunshine Coast. The highway is also the primary connection to the Sea to Sky Highway, which provides access to Lions Bay, Squamish, Whistler and beyond.

Overall, through-trips (i.e., neither originating from nor destinated to the North Shore) are a relatively small proportion of overall Highway 1 trips in the study area, though the average length of a through-trip is longer by nature. Through-trips represent an average of 7% and 9% of trips on the highway corridor for 2017 AM and PM, respectively. In 2050, these values increase to 9% and 12%.

Through-trip volumes are highest between Taylor Way and Horseshoe Bay/Highway 99 interchange. This is expected, as through-trip volumes are travelling to or from the Horseshoe Bay ferry terminal or the Sea to Sky Highway. However, these trips are then distributed between the Lions Gate Bridge and the Ironworkers Memorial Bridge, resulting in lower volumes on Highway 1 east of Taylor Way (where the Lions Gate Bridge traffic will generally exit). Through-trip volumes are relatively evenly distributed in the eastbound and westbound direction in the AM; directionality is more pronounced during the PM as a result of higher volumes to the Horseshoe Bay ferry terminal.

### PROVISION OF TRANSIT SERVICE

The provision of transit service along the corridor is assessed with respect to existing conditions and future plans, as well as with respect to enabling the highway corridor to support a broader regional shift towards more sustainable transportation modes.

#### Existing Conditions

Currently, the highway corridor currently plays a limited role in facilitating transit service; the only two transit services that run along the study corridor are:

- The Route 257 Horseshoe Bay Express connects the Horseshoe Bay BC ferry terminal to the Park Royal Shopping Centre and downtown Vancouver, and acts as the main regional transit connection to the Horseshoe Bay ferry terminal. Route 257 operates on the highway study corridor for approximately 10 kilometres between the ferry terminal and the 15th Street/Cross Creek Road Interchange. However, there are no stops along the highway; the service runs non-stop between the ferry terminal (west of the study corridor) and 15th Street/Ottawa Avenue (just off the study corridor). Based on data from TransLink's 2018 Transit Service Performance Review visualization application, Route 257 carries an average of approximately 1,400 riders per weekday in each direction along the highway study corridor between the ferry terminal and the 15th Street/Cross Creek Road Interchange.[6]
- Route 262 Brunswick/Caulfeild connects the Caulfeild Village area in West Vancouver to Lions Bay via Horseshoe Bay. Route 262 operates on the highway study corridor for approximately 3 kilometres between the Caulfeild Interchange and Horseshoe Bay and, similar to Route 257, does not feature any stops on the highway. Based on data from TransLink's 2018 Transit Service Performance Review visualization application, Route 262 carries an average of approximately 30–40 riders per weekday in each direction along the highway study corridor between the Caulfeild Interchange and Horseshoe Bay.[7]

The approximately 8-kilometre segment of the highway corridor between the 15th Street/Cross Creek Road Interchange and the Lynn Valley Road Interchange does not feature any transit service. There are no bus stops or transit priority measures provided along any section of the highway study corridor.

[6] As the Route 257 service does not stop along the highway corridor, alighting and boarding volumes at the Horseshoe Bay ferry terminal stop can be used to infer daily bus ridership in the eastbound and westbound directions, respectively, as the bus runs along the highway study corridor.

[7] Similar to Route 257, as the Route 262 service does not stop along the highway corridor, alighting and boarding volumes at the Caulfeild Village stop can be used to infer daily bus ridership.

In addition to on-corridor transit service, there is also significant transit service crossing the highway corridor at the various interchanges throughout the North Shore:

- Caulfeild Interchange is used by:
  - Route 253 as part of a counter-clockwise loop through several West Vancouver neighbourhoods before running along Marine Drive, across the Lions Gate Bridge and into downtown Vancouver.
  - The previously described Route 262, which uses the west-facing ramps to access Highway 1.
- 21st Street Interchange is used by:
  - Route 256, which crosses the highway to run in a clockwise loop through the British Properties before connecting down to Marine Drive/Park Royal, and then up Taylor Way to the Sentinel Hill neighbourhood.
- 15th Street Interchange is used by:
  - The previously described Route 257, which uses the west-facing ramps to access Highway 1.
- Taylor Way Interchange is used by:
  - Route 254, which crosses the highway to run in a counter-clockwise loop through the British Properties before connecting down to the Hollyburn neighbourhood, Marine Drive/Park Royal, and downtown Vancouver via the Lions Gate Bridge.
- Capilano Interchange is used by:
  - Route 236, which runs from Grouse Mountain to Lonsdale Quay.
  - Route 246, which runs between the Forest Hill neighbourhood in the District of North Vancouver to downtown Vancouver via the Lions Gate Bridge.
  - Route 247, which runs from Grouse Mountain to downtown Vancouver via the Lions Gate Bridge.
- Westview Drive Interchange is used by:
  - Route 249, which runs between Lonsdale Quay and the Forest Hill neighbourhood in the District of North Vancouver.
- Lonsdale Avenue Interchange (which features sufficiently frequent bus service to be designated as part of TransLink's Frequent Transit Network)[8]:
  - Route 229, which runs from Lynn Valley Town Centre along 29th Avenue to Lonsdale, and along Lonsdale Avenue (where it crosses the highway) to Lonsdale Quay.
  - Route 230, which runs from the Upper Lonsdale neighbourhood along Lonsdale Avenue (where it crosses the highway) to Lonsdale Quay.
  - Route 232, which runs between Grouse Mountain and Phibbs Exchange, but crosses the highway at the Lonsdale Avenue Interchange.
  - Route 241, which runs between upper Lonsdale and downtown Vancouver via the Lions Gate bridge.
  - Route 242, which runs between Lynn Valley Town Centre and downtown Vancouver via the Lions Gate Bridge, but crosses the highway at the Lonsdale Avenue Interchange.

[8] The Frequent Transit Network is defined as corridors wherein transit service runs at least every 15 minutes in both directions throughout the day and into the evening, every day of the week.

- Lynn Valley Road Interchange is used by:
  - Route 228, which runs between Lynn Valley Town Centre and Lonsdale Quay via Lynn Valley Road (where it crosses the highway), Grand Boulevard and 3rd Avenue.
  - Route 255, which runs east-west through the North Shore between Dundarave and Capilano University, but crosses Highway 1 along Lynn Valley Road (as well as Mountain Highway, although the latter interchange is outside of the study area).

Based on the above review, the three intersecting arterial routes that feature the greatest quantity of transit service passing through highway interchanges are Lonsdale Avenue, Capilano Road and Lynn Valley Road.

Findings from INSTPP noted that transit does not provide a competitive travel time relative to passenger vehicles for many trips to and from the North Shore, particularly for vehicular trips that make use of Highway 1, where travel times can be less than half of those by transit.

**Future Considerations**

With respect to future transit service, the *North Shore Area Transit Plan*, prepared by TransLink in 2012, is an area transit plan that encompasses the entirety of the North Shore. The plan does not explicitly identify any major new transit services on Highway 1; the only service reflected in the long-term network vision map is the previously described Route 257 service. However, from a cross-highway corridor perspective, the plan shows a rapid bus service along Lonsdale Avenue (which would run through the Lonsdale Avenue Interchange) and frequent bus services on Capilano Road and Lynn Valley Road (which would run through those two respective interchanges). Other less frequent bus services may also cross the highway via other interchanges. The importance placed on transit services along those three routes is consistent with the higher current service levels along those routes under the existing condition.

Municipal, regional and provincial transportation and land use policies all support increased use of sustainable travel modes, and co-location of new housing development with high-quality transit service. Considering the role that the Upper Levels Highway could play in facilitating these objectives was a key consideration for this study. Four major challenges were identified with respect to supporting transit along the highway corridor:

- **Transportation and Land Use Integration:** Currently, there are relatively few transit-supportive land uses (e.g., moderate to higher density mixed-use areas) adjacent to the corridor. Notably, in the Metro Vancouver Regional Growth Strategy,[9] none of the Lonsdale Regional City Centre, Lynn Valley Municipal Town Centre or Ambleside Municipal Town Centre nor any of the frequent transit development areas are located along the study corridor or within a reasonable walking distance for the average person. This lack of destinations "on the way" can create challenges with respect to the transit service having a limited market of potential riders that it could service.
- **Stop Accessibility and Waiting Environment:** In the absence of transit-supportive land uses immediately adjacent to the study corridor, the other opportunity to access potential riders is via transfers (either from another bus service or from a passenger vehicle via a park-and-ride lot). As noted above, several intersecting cross-street corridors (Lonsdale Avenue, Capilano Road, Lynn Valley Road) provide relatively high levels of transit service for which transferring to and from a transit service that runs along the highway corridor is a relatively feasible concept. However, generating transit ridership on the corridor

[9] http://www.metrovancouver.org/services/regional-planning/PlanningPublications/Map4.pdf

via transfers requires safe, efficient and comfortable connections and waiting to reduce the "transfer penalty" that can deter potential riders. Stop placement would need to be carefully considered in order to provide high-quality connections and comfortable waiting environments.

- **Travel Desire Lines:** As described above in the review of trip types, most trips on the study corridor are intra-regional, which (predominantly) involve crossings of Burrard Inlet. As such, a service that would run solely on the highway corridor study area (or even solely within the North Shore) may not be attractive, as riders would need to transfer *again* to another bus route to cross Burrard Inlet. Therefore, providing a service with connectivity across the Inlet that provides connections to major travel destinations is critical. As noted previously, most regional trips by North Shore residents are focused on Vancouver (and, to a lesser extent, Burnaby), while trips by residents of the rest of the region to the North Shore originate not only from Vancouver and Burnaby but also other areas such as the Tri-Cities and Surrey.
- **Transit Speeds and Reliability:** As noted above, INSTPP identified challenges with respect to transit travel times not being competitive with passenger vehicles. Although a transit service does not currently exist on the eastern portion of Highway 1 on the North Shore, it is likely that, even if such a service did exist, it would not necessarily be competitive with private vehicles, particularly if users need to transfer to/from other services. Potentially more critically, the lack of reliability of travel times along the study corridor creates a challenge, both for the operator with respect to service scheduling and for riders, particularly those riders who intend to transfer to another bus service and may miss a connection due to the highway corridor bus service being delayed or running behind schedule. Enabling a transit service that provides both competitive and reliable travel times is a key component of attracting ridership.

Addressing the above issues is a key factor is supporting a shift to more sustainable transportation modes.

### ACTIVE TRANSPORTATION PROVISIONS

The Upper Levels Highway in West Vancouver permits cycling on shoulders between Capilano Road and the Horseshoe Bay ferry terminal; this, along with a short segment of Highway 99 near the US border, is the only instance of such activity being permitted on a Schedule 1 highway within Metro Vancouver. Although data on cycling volumes is not available, this cycling route is a popular recreational road among confident and enthusiastic road cyclists, particularly in the summer. The current ramp configurations at the Capilano Road Interchange do not provide a safe crossing opportunity for people cycling along the shoulder, resulting in the segment of the highway where shoulder cycling is permitted being terminated at the Capilano Road Interchange. If the crossing opportunity at the Capilano Road Interchange were to be addressed, then much of the existing highway corridor is generally suited to extending shoulder cycling further east towards Westview Drive.

Several bridges across watercourses also provide walking and cycling connections where gaps exist in the municipal network. Specifically:

- The Capilano River bridge provides shared walking paths that are shared with shoulder-riding cyclists. A barrier protects pedestrian and cyclists from adjacent motor vehicle traffic, although the paths themselves are relatively narrow. Connections to and from the facility on the bridge are also lacking in some cases.
- The south side of the highway provides a barrier-separated walking/cycling path between Pemberton Avenue and Westview Drive, which provides an active transportation connection across Mackay Creek and Mosquito Creek that would otherwise require a substantial detour due to the absence of a parallel municipal network. A ramp is also provided to connect to the Edgemont Boulevard overpass structure, which is located east of Mackay Creek but west of Mosquito Creek.

However, challenges remain, particularly with respect to cross-corridor active transportation connectivity, and potential interchange improvement concepts provide an opportunity to also improve cross-corridor active transportation. Based in part on input from HUB Cycling, six key challenges were identified for cycling within the highway study area, including both on-corridor and cross-corridor connections. These key challenges were reviewed and elaborated upon below:

1. **Lynn Valley Interchange (Cross-corridor)**: A southwest-bound cycling facility was added to Lynn Valley Road through the interchange area in 2018 via a partnership between BC MoTI and the District of North Vancouver; this provides a raised cycling facility that shares the same elevation as the sidewalk. Although a painted bike lane runs through the eastbound ramp terminal intersection, this facility is not protected, and it terminates at the off-ramp, meaning that no northeast-bound cycling facility is provided on Lynn Valley Road underneath the highway itself. The existing painted bike lane resumes on the east side of Morgan Road, meaning that the segment of Lynn Valley Road through the interchange area represents a gap in an otherwise continuous cycling corridor.
2. **Capilano Road Interchange and Capilano River Bridge (On-corridor and Cross-corridor):** Several challenges were noted in the vicinity of the Capilano Road Interchange and Capilano River Bridge: Currently, a narrow separated walking and cycling path is provided on both sides of the Capilano River (as was described above). However, several major challenges were noted in this area:
    a. At the east end of the bridge, the eastbound off-ramp does not provide continuous walking or cycling facilities to the ramp terminal intersection with Capilano Road; the narrow shared facility terminates at Bowser Avenue and requires people walking to use an informal path in the grass, and people cycling to share the lane with motor vehicles.
    b. As shoulder cycling is not permitted east of the Capilano Road Interchange, people cycling further east must connect to the informal District of North Vancouver municipal bike route on West 23rd Street, which can be reached via Keith Road. However, although the configuration of the eastbound on-ramps enables motor vehicle movements to and from Keith Road, there is no crossing infrastructure provided for people cycling (or walking) who wish to cross.
    c. With respect to cross-corridor active transportation, Capilano Road has continuous sidewalk coverage on both sides of the roadway through the entire interchange area. However, no continuous cycling facilities are provided within the interchange area (i.e., between the ramp terminal intersections), although there are short segments of shoulder in each direction where cycling is possible. South of the interchange, the District of North Vancouver has provided painted cycling lanes on Capilano Road. There are also painted bike lanes on Capilano Road to

the north of the interchange, although these lanes currently terminate at Ridgewood Drive, approximately 650 metres north of the northern ramp terminal signalized intersection. It is understood that the District of North Vancouver is investigating opportunities to provide cycling facilities along the "gap" between Ridgewood Drive and the interchange ramp terminal; once complete, the 300-metre section of Capilano Road between the two ramp terminal signalized intersections would be the only gap in a continuous cycling network along Capilano Road in the vicinity of the interchange.

   d. Although the shared walking and cycling facilities on the Capilano River bridge can be used by people cycling, they are narrow and do not easily allow people cycling to pass people walking.

3. **Lonsdale Avenue Interchange (Cross-corridor):** In the City of North Vancouver *Bicycle Master Plan* (2012), the segment of Lonsdale Avenue between 23rd Street and 25th Street that crosses the highway corridor is designated as an on-street bike route. Although the Lonsdale Avenue corridor as a whole is not designated as a bike route, the segment that crosses the highway is an important connection due to the lack of alternative routes crossing locations for nearby north-south bike routes (e.g., Chesterfield Avenue to the west and St. Andrews Avenue to the east). Currently, no cycling facilities are provided on this part of Lonsdale Avenue.

4. **Taylor Way Interchange to Westview Drive Interchange (On-corridor):** Currently, a separated walking and cycling path is provided on the south side of the highway corridor between Pemberton Avenue and Westview Drive (as was described above). Similarly, a new walking and cycling path was recently provided on the north side of the highway adjacent to Hugo Ray Park between the Capilano River Bridge/Keith Road and 3rd Street. However, two major challenges were noted:
   a. Although a barriered pedestrian facility is provided on the north side of the highway across the Mosquito Creek bridge, this facility lacks any formal connection on either end to Westview Drive and Edgemont Boulevard. This condition also results in this route not being usable for people cycling. The lack of formal walking and cycling connections running east from the Mosquito Creek bridge structure (to Westview Drive) and running west (to Edgemont Boulevard) creates a gap in facility continuity in a location where the existence of Mosquito Creek means there are few nearby alternative municipal routes. A further westward extension of this pathway to the Lloyd Avenue right-in/right-out would complete the final gap in a continuous cycling connection from Westview Drive to Taylor Way.
   b. It was also noted that, although a separated walking and cycling path is provided on the south side of the highway corridor between Pemberton Avenue and Westview Drive (as was described above), for people cycling, this facility transitions to a painted shoulder at the eastbound off-ramp to the Westview Drive Interchange and terminates abruptly at the ramp terminal intersection.

5. **Horseshoe Bay Ferry Terminal (On-corridor):** Several challenges were identified with respect to connections to and from the Horseshoe Bay ferry terminal, including a disappearing shoulder and low railing in the eastbound structure that passes overtop the Lions Club parking lot, a disappearing eastbound shoulder in the vicinity of the Marine Drive/Horseshoe Bay Road on-ramp, and the lack of an eastbound shoulder from the ferry terminal up to the eastbound off-ramp to Marine Drive (where a connection is provided to the Spirit Trail).

6. **Taylor Way Interchange (On-corridor):** The Taylor Way Interchange is located along a segment of the highway corridor where shoulder cycling is permitted. However, unlike many of the other interchanges along the corridor where shoulder cycling is permitted, cyclists are not permitted to cross the off-ramp

and on-ramp to remain on the highway. Instead, people cycling must exit the highway via the off-ramp shoulder, pass through the ramp terminal signalized intersection, and re-enter the highway via the on-ramp shoulder. Cycling provisions are absent through certain portions of this interchange, including no eastbound bike lane through the southern ramp terminal signalized intersection, and no westbound bike lane for a portion of the westbound on-ramp between Taylor Way and Westcot Road.

## 2.5 Technical Assessment: Network Mobility

### 2.5.1 Network Mobility Performance Criteria

Similar to corridor-level metrics, network-level metrics are also assessed using RTM. The metrics are:

- Travel volumes by mode (network level).
- Network travel distance.
- Network travel time.
- Access to employment (by mode).
- Access to labour force (by mode).

#### TRAVEL VOLUMES BY MODE (NETWORK LEVEL)

Overall trip-making by mode is reported at the network level (either for the North Shore or the entire region) using outputs from the RTM. Outputs are for an overall area; results are not reported for every road network element within that area. Similar to the corridor-level assessment, person-level trip-making is reported for the single-occupancy vehicle, high-occupancy vehicle and transit modes. Goods movement volumes are provided by truck type (light goods vehicle and heavy goods vehicle).

There are no specific performance thresholds associated with this metric; it is primarily intended for context and relative comparison.

#### NETWORK TRAVEL DISTANCE

The network travel distance represents the total distance travelled during the peak hour in the model and is presented in terms of person-kilometres travelled (PKT). PKT is reported separately for each mode. This metric is a result of trip assignment performed in the RTM and is a direct output from the model.

There are no specific performance thresholds associated with this metric; it is primarily intended for context and relative comparison.

#### NETWORK TRAVEL TIME

The network travel time represents the total time travelled during the peak hour in the model and is presented in terms of person-hours travelled (PHT). PHT is reported separately for each mode. This metric is a result of trip assignment performed in the RTM and is a direct output from the model.

There are no specific performance thresholds associated with this metric; it is primarily intended for context and relative comparison.

### ACCESS TO EMPLOYMENT BY MODE

This metric is intended to measure the extent to which North Shore residents are able to access employment opportunities throughout the region. A built-on tool for RTM was adapted to measure the number of employment opportunities accessible within a specified travel time budget; it can provide separate results for auto and transit modes. This tool was also extended to consider access by bike and e-bike. Although travel times for these modes are not subject to congestion in the same manner as the auto and transit modes, travel times will not vary throughout the day.

Outputs can be produced in the form of the number of employment opportunities within specific travel time isochrones from each traffic analysis zone in the region, which can then be consolidated into averages for each municipality and compared against the regional average.

The metric can be extended using an approach adapted by the Accessibility Observatory at the University of Minnesota,[10] wherein an overall accessibility score is calculated for each point of origin, based on the number of employment opportunities available within each travel time isochrone, wherein having more jobs close by leads to a higher score. This approach provides an opportunity to create a heatmap of employment accessibility for the North Shore disaggregated to the level of individual traffic analysis zones, which enables differences in terms of regional accessibility within a municipality to be captured.

There are no specific performance thresholds associated with this metric; it is primarily intended for context and relative comparison.

### ACCESS TO LABOUR FORCE BY MODE

The access to labour force metric is the inverse of the access to employment metric: it is intended to measure the extent to which North Shore employers are able to access the regional labour force (i.e., the pool of potential employees). This metric was developed to specifically assess the challenges of North Shore employers with respect to accessing the regional labour force. This is a critical consideration, given the recent mismatch, as described previously in Section 2.3.2, of growth in North Shore jobs and growth in the North Shore working-age population. There are no specific performance thresholds associated with this metric; it is primarily intended for context and relative comparison.

[10] http://access.umn.edu/

## 2.5.2 Network Mobility Performance Assessment

The application of the network mobility performance metrics, and the resulting findings, are presented below.

**TRAVEL VOLUMES BY MODE (NETWORK)**

Similar to the travel times by mode provided previously for the highway study corridor in Section 2.4.2, link volume plots are provided for the entire North Shore road network for the three motorized person-moving modes represented in RTM. These person-level travel volumes along the highway corridor by mode are presented for the 2017 AM and PM peak hours in ***Figure 2.37*** and ***Figure 2.38***, respectively. Similarly, forecast volumes by mode are presented for the 2050 planning horizon year AM and PM peak hours in ***Figure 2.39*** and ***Figure 2.40***, respectively.

The key role of the highway corridor in facilitating east-west travel across the North Shore is readily apparent, as are the importance of the connections to the two bridges and the role of Taylor Way and Capilano Road in connecting the Lions Gate Bridge to Highway 1.

As described previously, the study corridor is notable with regards to an almost complete absence of transit ridership, a phenomenon related to the relatively minimal transit service along the western portion of the corridor and the complete absence of such service on the eastern portion of the corridor. In contrast, both bridges across the Inlet see some level of transit ridership, particularly the Lions Gate Bridge, driven in part by the transit priority facilities provided on the bridge approach and in part by the fact that it provides access to the region's single largest travel destination – downtown Vancouver – on the south side of the bridge.

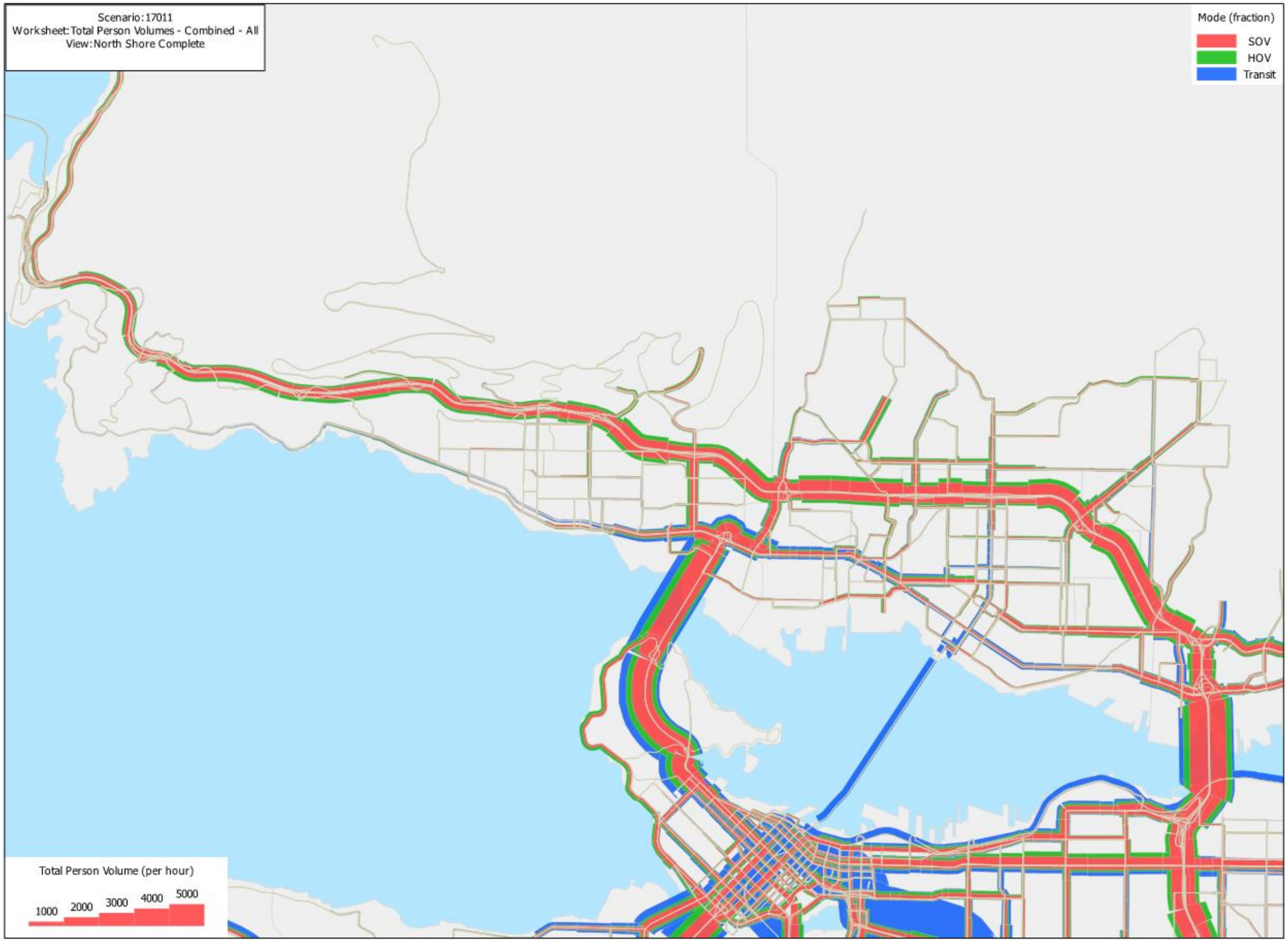


Figure 2.37: 2017 AM Peak Hour Network Travel Volumes by Mode

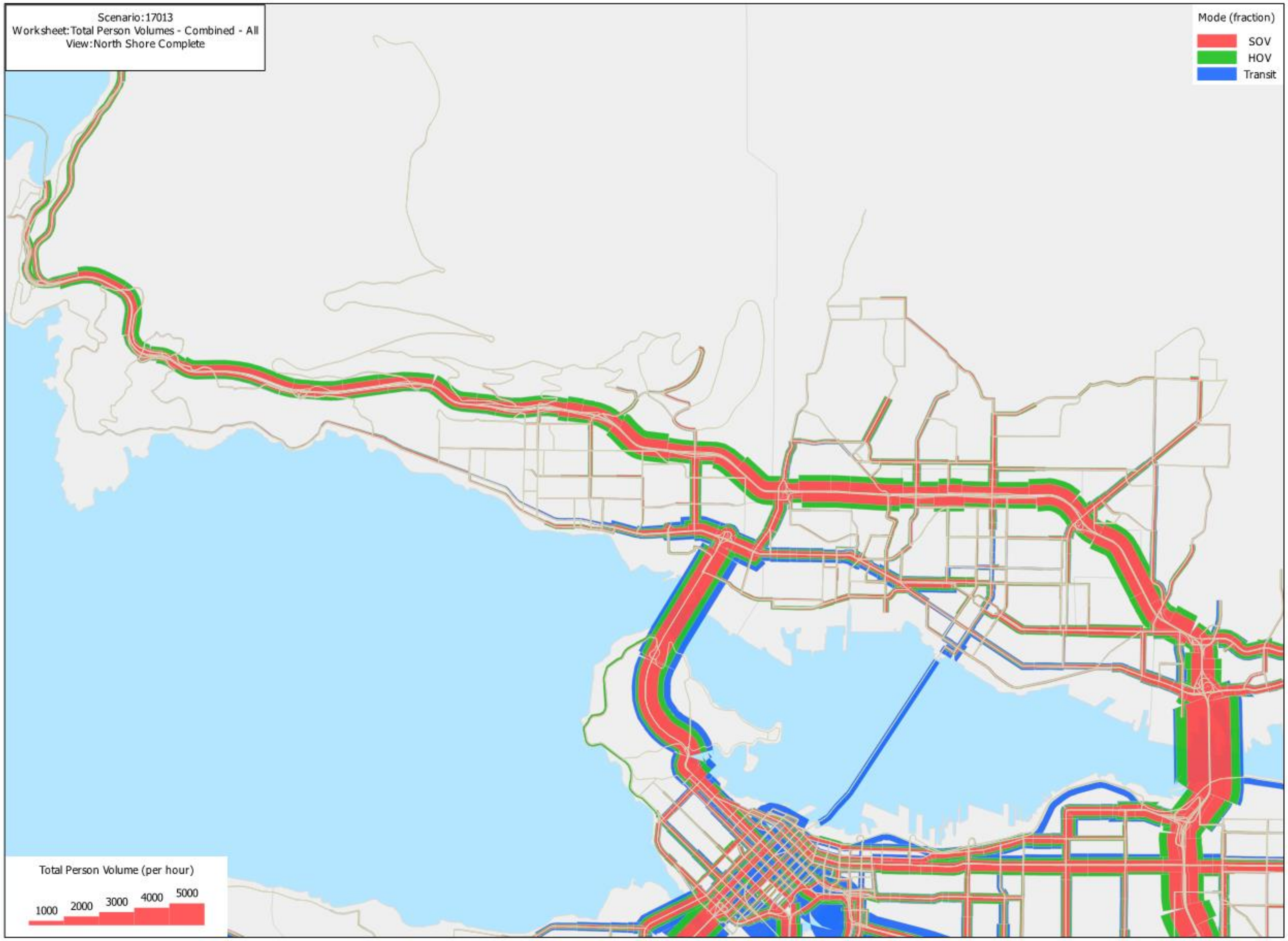


Figure 2.38: 2017 PM Peak Hour Network Travel Volumes by Mode

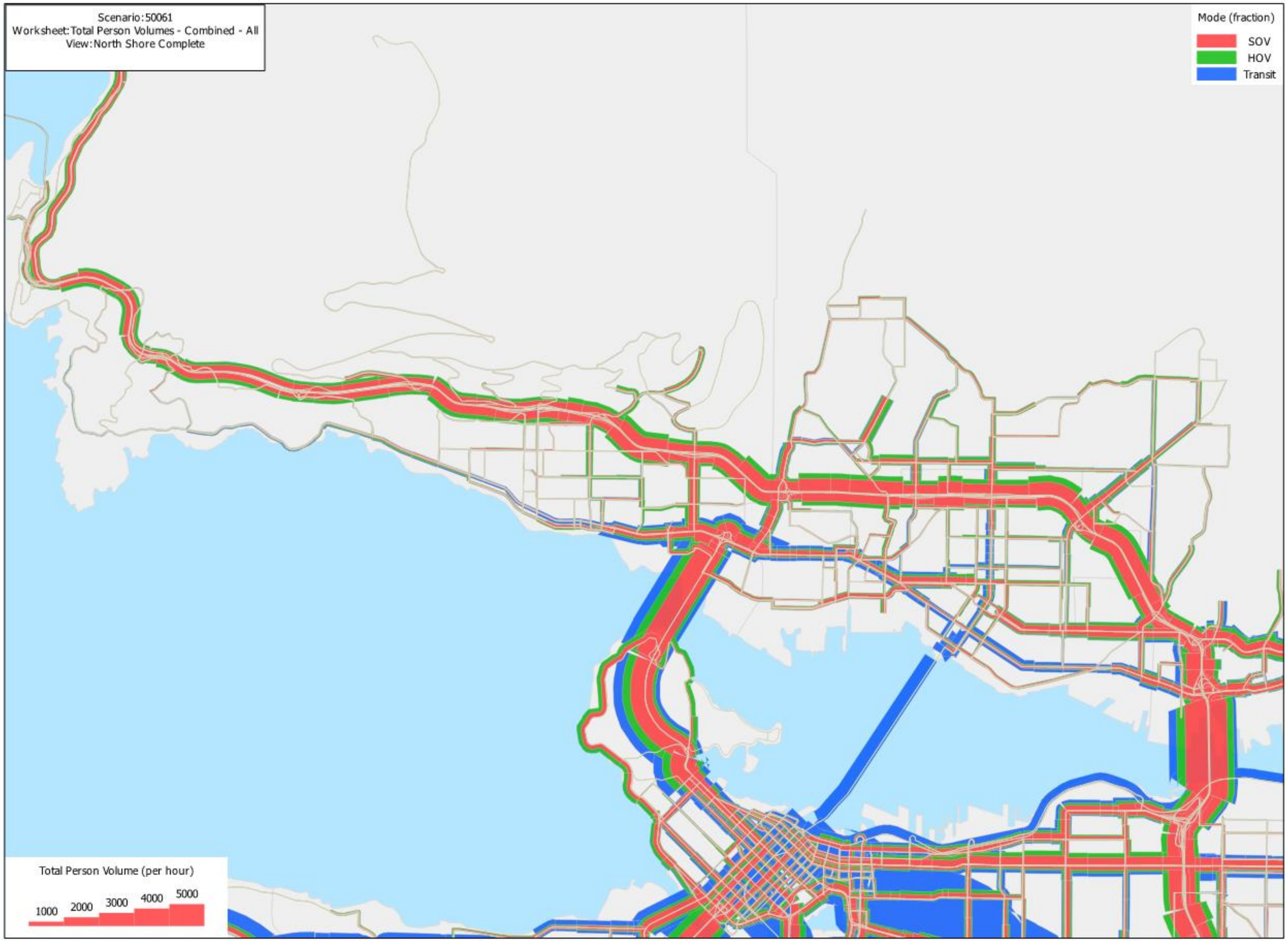


Figure 2.39: 2050 AM Peak Hour Network Travel Volumes by Mode

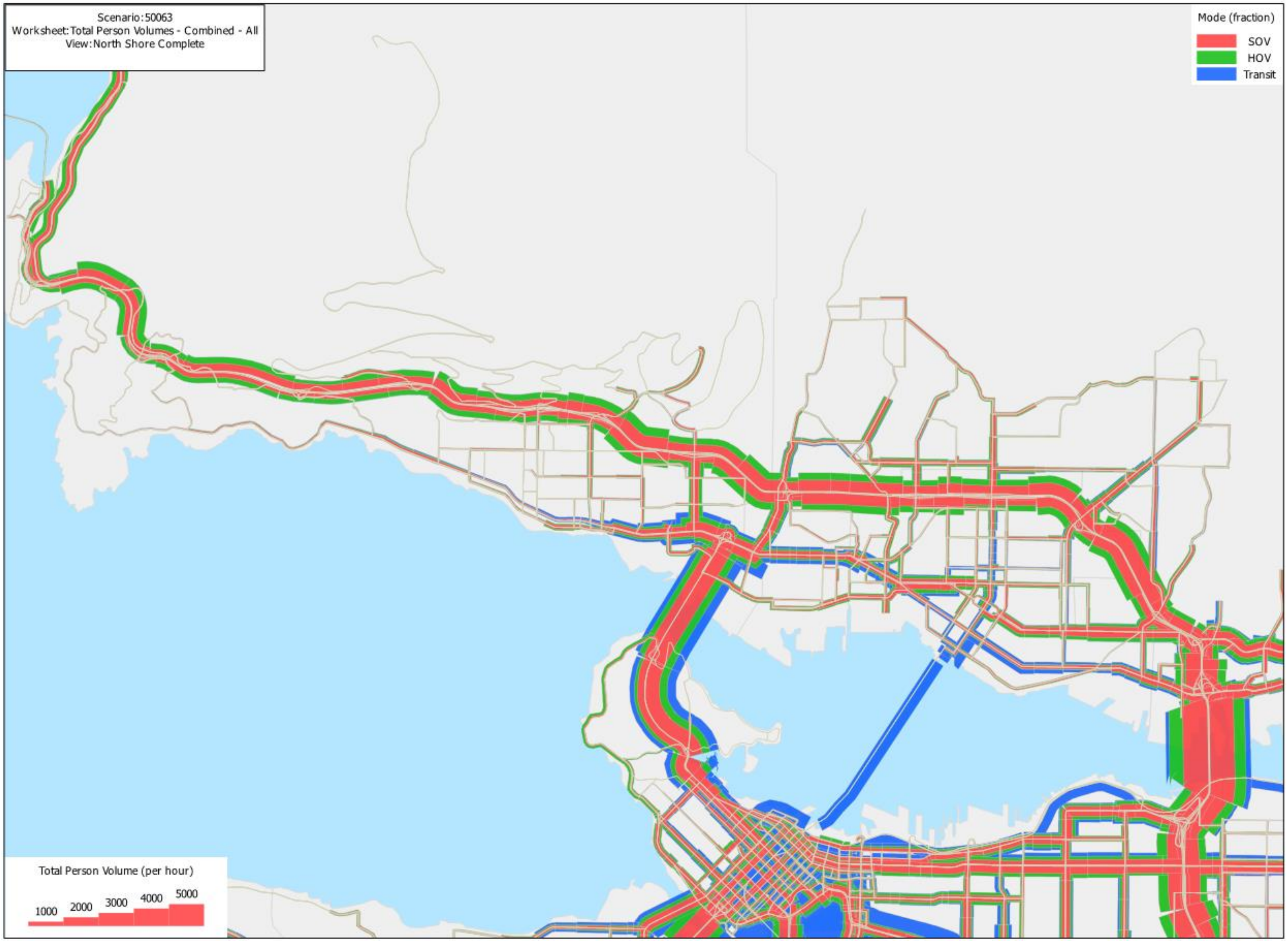


Figure 2.40: 2050 PM Peak Hour Network Travel Volumes by Mode

Trip volumes were extracted from the model under both a North Shore-wide and region-wide lens, and summarized as mode shares in ***Table 2.12*** and ***Table 2.13***, respectively. In this instance, North Shore-wide includes all trips to/from/within/through the North Shore.

Table 2.12: Overall Mode Shares for Person Trip-Making, North Shore-Wide

| Mode | AM | | | PM | | |
|---|---|---|---|---|---|---|
| | 2017 | 2035 (Base) | 2050 (Base) | 2017 | 2035 (Base) | 2050 (Base) |
| Walk | 12.2% | 12.0% | 12.0% | 7.5% | 7.8% | 8.1% |
| Bike | 1.7% | 1.9% | 2.1% | 1.6% | 1.8% | 2.1% |
| Transit | 13.0% | 14.9% | 15.2% | 12.3% | 14.0% | 14.3% |
| HOV | 30.9% | 31.1% | 31.2% | 30.4% | 30.3% | 30.2% |
| SOV | 42.2% | 40.2% | 39.4% | 48.2% | 46.1% | 45.3% |

Table 2.13: Overall Mode Shares for Person Trip-Making, Region-Wide

| Mode | AM | | | PM | | |
|---|---|---|---|---|---|---|
| | 2017 | 2035 (Base) | 2050 (Base) | 2017 | 2035 (Base) | 2050 (Base) |
| Walk | 12.3% | 12.2% | 12.1% | 8.3% | 8.7% | 9.1% |
| Bike | 1.9% | 2.0% | 2.0% | 1.9% | 2.0% | 2.1% |
| Transit | 15.3% | 17.1% | 17.4% | 15.1% | 17.1% | 17.4% |
| HOV | 31.8% | 31.7% | 31.8% | 29.0% | 28.4% | 28.2% |
| SOV | 38.7% | 37.0% | 36.7% | 45.8% | 43.8% | 43.3% |

Overall mode share in the North Shore in 2017 is very similar to the average across the modelled region (Metro Vancouver and Fraser Valley), with the exception of a slightly lower transit usage offset by higher SOV rates. Transit rates rise by about 2% to 2050 across the network, though North Shore usage remains about 2%–4% below the region-wide average. Sustainable mode share is anticipated to increase in the North Shore in future years. By 2050, modelled transit mode share is 2% higher in AM and PM peaks than in 2017 and modelled SOV share drops by almost 3%. Active transportation modes see modest increases, as well. Network-wide, very similar patterns are observed.

### NETWORK TRAVEL DISTANCE

Network travel distances were extracted from the RTM in the form of person-kilometres travelled (or truck-kilometres travelled). These travel distances are summarized in ***Table 2.14***. Active transportation modes were excluded from this analysis, as the RTM does not explicitly assign these modes to individual routes within the modelled road network.

Table 2.14: Person-Kilometres Travelled (PKT), Region-Wide

| Mode | AM | | | PM | | |
|---|---|---|---|---|---|---|
| | 2017 | 2035 (Base) | 2050 (Base) | 2017 | 2035 (Base) | 2050 (Base) |
| SOV | 3,105,080 | 3,773,934 | 4,088,390 | 3,491,596 | 4,300,806 | 4,673,974 |
| HOV | 1,497,451 | 1,932,103 | 2,147,476 | 1,834,996 | 2,342,404 | 2,572,691 |
| Transit | 1,065,506 | 1,627,559 | 1,831,049 | 1,007,921 | 1,566,174 | 1,774,622 |
| Light Truck | 107,432 | 122,919 | 133,708 | 72,449 | 83,022 | 90,614 |
| Heavy Truck | 151,767 | 202,239 | 225,747 | 88,895 | 124,050 | 140,684 |

Between 2017 and 2050, person-kilometres travelled (PKT) increases across all motorized modes over time as overall travel demand increases in conjunction with population growth. While absolute increases are largest for SOV, other modes see larger percentage increases. Comparing 2050 to 2017, SOV sees a modelled 32%–34% increase in PKT depending on time period, while HOV sees 40%–43% and transit sees 72%–84%.

### NETWORK TRAVEL TIME

Network travel times were extracted from the RTM in the form of person-hours travelled. These travel times are summarized by mode in ***Table 2.15***. Similar to the network travel distance metric, active transportation modes were excluded.

Table 2.15: Person-Hours Travelled (PHT), Region-Wide

| Mode | AM | | | PM | | |
|---|---|---|---|---|---|---|
| | 2017 | 2035 (Base) | 2050 (Base) | 2017 | 2035 (Base) | 2050 (Base) |
| SOV | 86,526 | 118,056 | 136,218 | 96,559 | 136,247 | 159,430 |
| HOV | 41,414 | 58,839 | 69,225 | 48,231 | 69,871 | 82,072 |
| Transit | 39,033 | 59,297 | 68,239 | 36,728 | 57,234 | 66,373 |
| Light Truck | 2,459 | 3,178 | 3,693 | 1,702 | 2,242 | 2,649 |
| Heavy Truck | 3,127 | 4,723 | 5,659 | 1,736 | 2,743 | 3,379 |

Due to supply-side constraints increasing over time, person-hours travelled (PHT) does not experience identical patterns to PKT. Depending on the specific time period, SOV PHT growth between 2017 and 2050 is 44%–65% (although the greatest increase in absolute terms), HOV is 52%–70% and transit is 75%–81%. Note that growth in PHT for auto modes is higher on a percentage basis than the growth in PKT, demonstrating the effect of increased regional peak hour congestion by 2050. For example, SOV PKT growth in the AM is 32%, but PHT growth is 57%; this is also true for transit, but to a much lesser extent (AM transit PKT growth is 72%, but AM PHT growth is only slightly larger at 75%).

### ACCESS TO EMPLOYMENT BY MODE

Accessibility to employment is an important measure of economic opportunity for an area. For this metric, one-way travel times were considered, with a focus on trips from a place of residence to a place of employment. Therefore, the AM peak hour is of greatest relevance, as this is the period wherein more trips to work are conducted than any other time of the day. The average number of jobs accessible within a range of travel times for a resident of each of the three North Shore municipalities in the 2017 AM peak hour for both auto and transit is provided in ***Figure 2.41***. The regional average job accessibility is also provided for comparison.

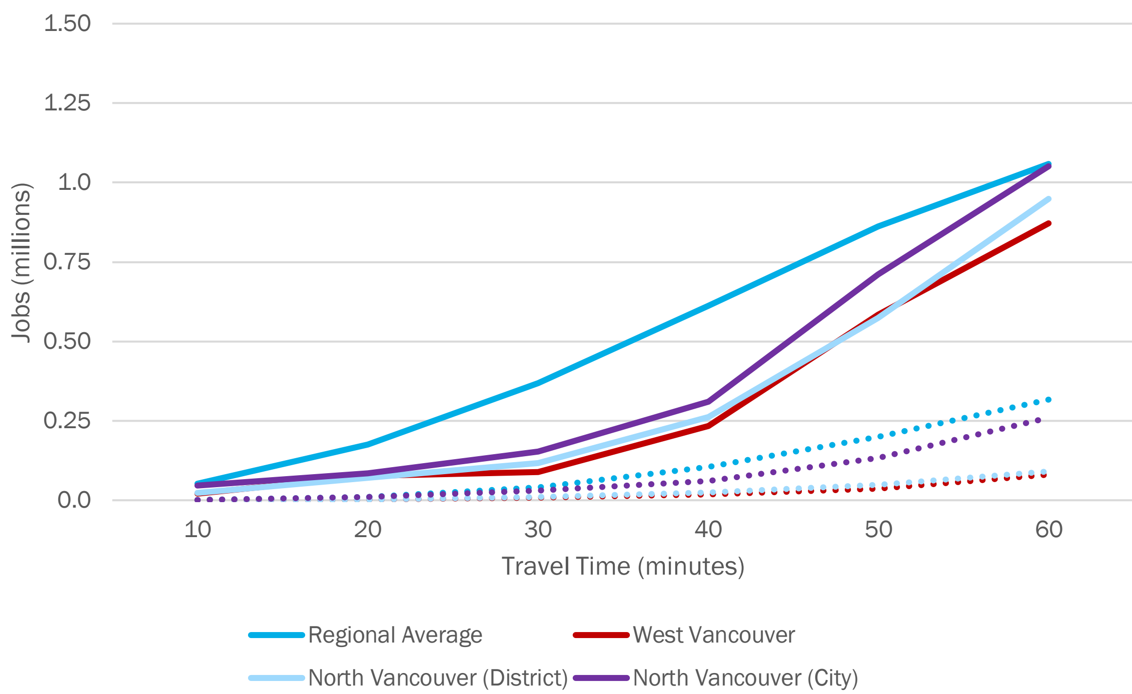


**Figure 2.41: Access to Employment Opportunities by Auto (solid) and Transit (dashed), 2017 AM Peak Hour**

Accessibility to employment opportunities by auto is similar across all North Shore municipalities, although all three municipalities lag the regional average. The City of North Vancouver eventually sees accessibility values equivalent to the overall network at the 60-minute travel time threshold, although the District of North Vancouver and District of West Vancouver still lag. At a regional level, employment accessibility increases relatively linearly. In contrast, for the three North Shore municipalities, the charts are concave; at lower travel time thresholds, employment accessibility from the North Shore is much lower than the rest of the network, which shows the isolating effects of having only two (congested) connections to the remainder of the region, where the bulk of employment opportunities are located.

Relative to the auto modes, AM job accessibility by transit is poor across the entire North Shore. Additionally, accessibility for all three North Shore municipalities lags the regional average across all travel time thresholds (60 minutes and lower). However, differences are observed between the three municipalities. While the two District municipalities are more auto-oriented and are difficult to serve by transit (for both municipalities, fewer than 100,000 jobs are accessible, even at the 60-minute threshold), the City of North Vancouver has substantially better transit accessibility that only slightly lags the regional average. This is a function of the City being denser and having a more concentrated transit network. However, Burrard Inlet remains a major impediment to job access, and accessibility remains below the regional average.

A potential confounding factor in this analysis is that the North Shore is functionally at the very northwest corner of the region, and by virtue of being at the "edge", will always have inferior accessibility metrics compared to more central parts of the region (notwithstanding the fact that downtown Vancouver offers a larger number of jobs relatively close by). In response, metrics were also developed for the midday and PM peak hour periods, as shown in ***Figure 2.42*** and ***Figure 2.43***, respectively. Again, these metrics reflect someone travelling *to* work in the midday and PM peak hour periods.

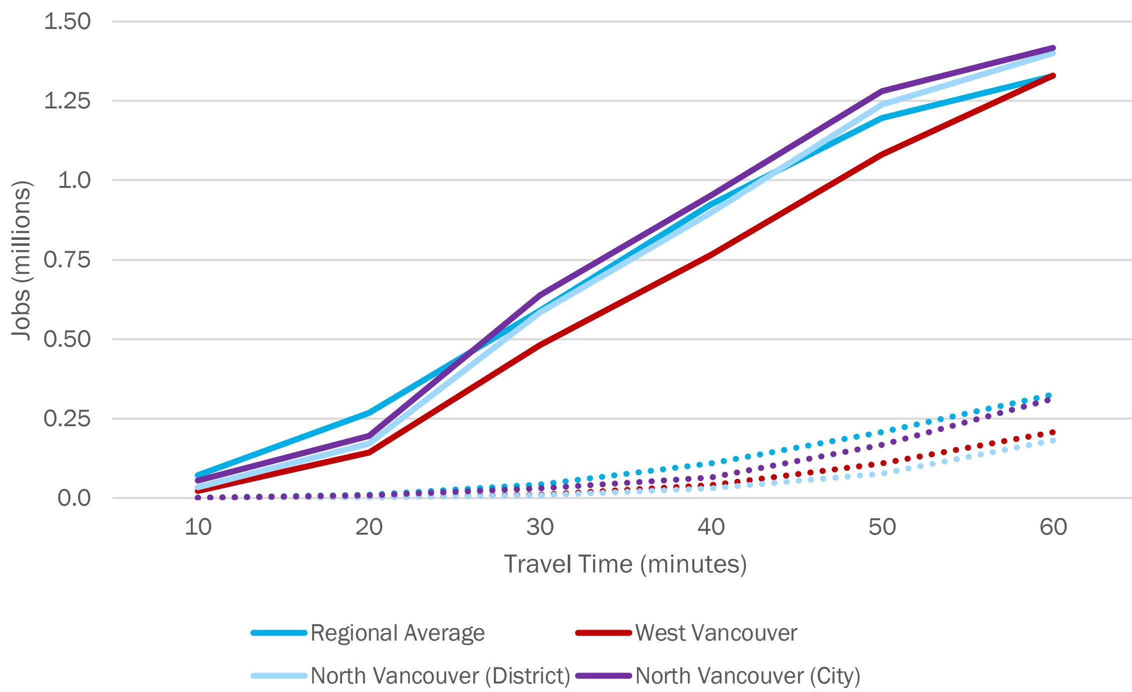


Figure 2.42: Access to Employment Opportunities by Auto (solid) and Transit (dashed), 2017 Midday Peak Hour

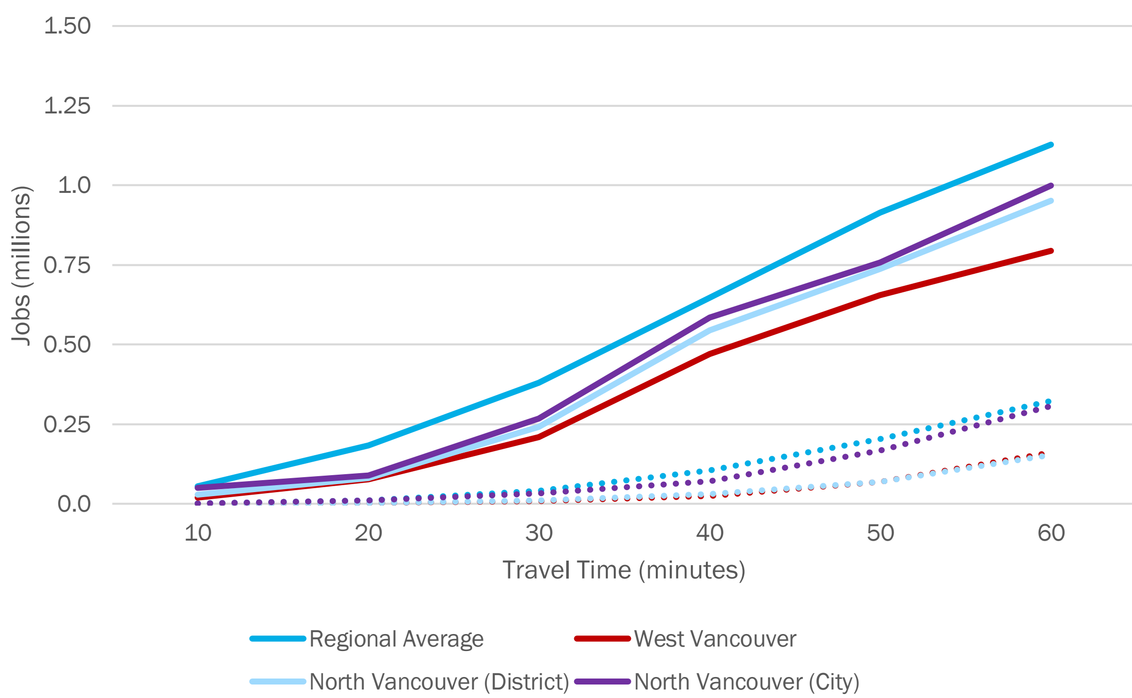


Figure 2.43: Access to Employment Opportunities by Auto (solid) and Transit (dashed), 2017 PM Peak Hour

From these figures, auto accessibility only slightly lags the overall region, suggesting that most of the accessibility differential between the three North Shore municipalities and the region average is primarily attributable to congestion, rather than an inherent function of geography. Most starkly, the deficiency in the 20–50 minute travel time threshold range of auto accessibility is eliminated in the midday; in fact, in North Vancouver (both City and District), auto accessibility is better than network-wide averages for 30 minutes and above. For transit, accessibility patterns are relatively similar to those to those of the AM peak hour, although in the midday, transit conditions improve somewhat for the two Districts. This may reflect congestion issues on transit vehicles crossing Burrard Inlet.

Between 2017 and 2050, access to total employment opportunities is anticipated to increase as a result of the increase in the total number of jobs throughout the region, but access will potentially decrease (particularly for auto modes) as a result of increased congestion. The resultant average number of jobs accessible within a range of travel times for a resident of each of the three North Shore municipalities in the 2050 AM peak hour for both auto and transit is provided in ***Figure 2.44***.

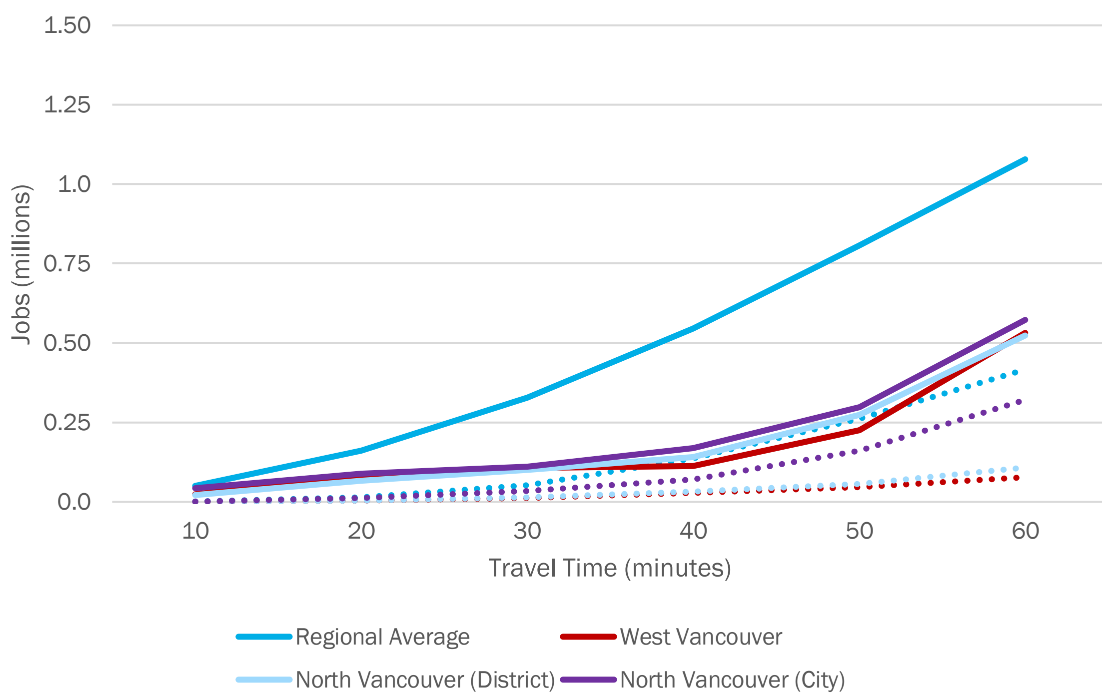


Figure 2.44: Access to Employment Opportunities by Auto (solid) and Transit (dashed), 2050 AM Peak Hour

For auto modes, average region-wide employment accessibility shifts from increasing roughly linearly with travel time thresholds in 2017 to increasing as a concave function by 2050. This results in a condition where, compared to 2017, there are (for example) fewer employment opportunities in the region within a 30-minute travel time, but slightly more opportunities available within a 60-minute commute. In contrast, the three North Shore municipalities see a significantly decreased employment accessibility by auto, particularly in the 30- to 60-minute commute time range. Previously, in 2017, this range saw significant incremental increases in employment access with each increase in travel time; this increase is still present, but much more muted. The number of jobs available within a 60-minute commute, which previously ranged from 870,000 to 1.05 million (depending on the specific North Shore municipality), have now decreased to 520,000 to 570,000. In contrast to auto modes, all three municipalities see an increase in employment access by transit in 2050 as compared to 2017, although North Shore municipality employment accessibly by transit still lags both North Shore auto modes and regional average employment accessibility by transit.

Network-wide, auto accessibility to jobs decreases slightly across all thresholds over time. North Shore accessibility decreases substantially at higher threshold values, which again shows the effects of increased congestion on the bridges. By 2050, values are relatively converged for all three North Shore municipalities at all thresholds, though the City of North Vancouver maintains its higher overall time-weighted accessibility.

An overall employment accessibility score for each traffic analysis zone was also calculated based on an adaptation of the methodology developed by the Accessibility Observatory at the University of Minnesota. The overall average accessibility to employment score by for each of the three municipalities is provided for auto in ***Table 2.16*** and transit in ***Table 2.17***. In these tables, information for the 2035 interim horizon year is also provided.

**Table 2.16: Accessibility to Employment by Auto Score, AM Peak Hour**

| Location | Year | | |
|---|---|---|---|
| | 2017 | 2035 | 2050 |
| Regional Average | 82,022 | 76,971 | 75,985 |
| West Vancouver | 36,474 | 31,732 | 29,492 |
| North Vancouver (District) | 38,794 | 33,064 | 28,000 |
| North Vancouver (City) | 51,282 | 42,645 | 37,584 |

**Table 2.17: Accessibility to Employment by Transit Score, AM Peak Hour**

| Location | Year | | |
|---|---|---|---|
| | 2017 | 2035 | 2050 |
| Regional Average | 10,402 | 12,726 | 13,700 |
| West Vancouver | 2,151 | 2,731 | 2,927 |
| North Vancouver (District) | 2,514 | 3,121 | 3,391 |
| North Vancouver (City) | 7,679 | 8,904 | 9,191 |

By auto, overall accessibility is already in decline by 2035, and then begins to decline more slowly between 2036 and 2050. By transit, from 2017 to 2035, all areas noted grow in accessibility, as the number of jobs increase and frequency increases are applied across the transit network. Note that beyond service frequency increasing proportionately to population growth, no new services are introduced to the North Shore. Transit accessibility region-wide and in the City of North Vancouver grow faster than in the two District municipalities on an absolute basis. Between 2036 and 2050, employment accessibility by transit continues to increase, but still lags auto accessibility.

Overall scores were also plotted by traffic analysis zone and visualized as a heatmap. Employment accessibility scores are presented for auto and transit in the 2017 AM peak hour are in ***Figure 2.45*** and ***Figure 2.46***, respectively. Similarly, employment accessibility scores are presented for the 2050 planning horizon year AM and PM peak hours in ***Figure 2.47*** and ***Figure 2.48***, respectively. Note that the colour gradations of the maps have been developed wherein "green" is the maximum score present on the North Shore (slightly over 60,000); in practice, specific other parts of the region see accessibility well in excess of this value. Note also that in the heatmap legends, all scores have been divided by 1,000 to enhance readability.

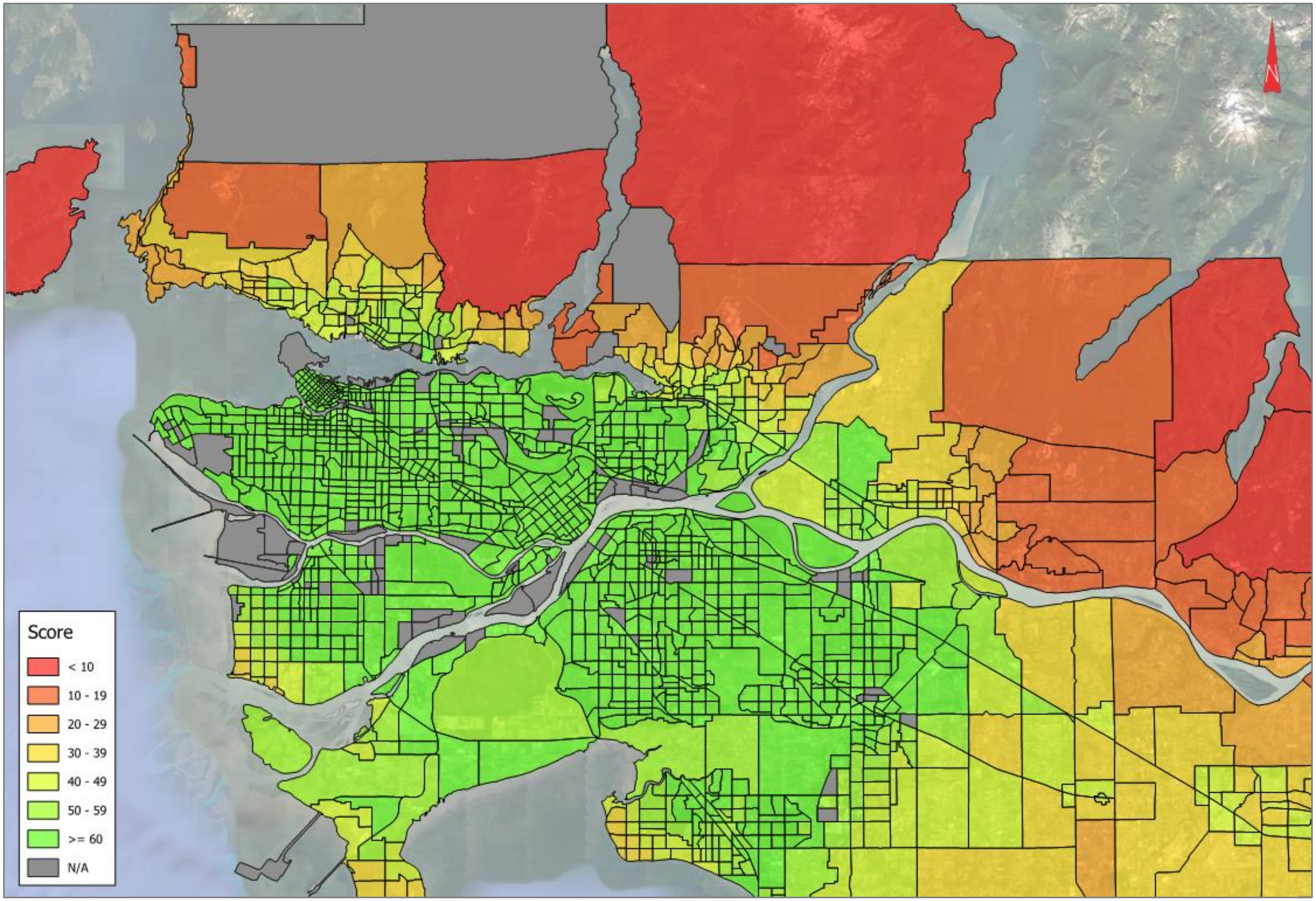


Figure 2.45: 2017 AM Peak Hour Auto Accessibility Heatmap

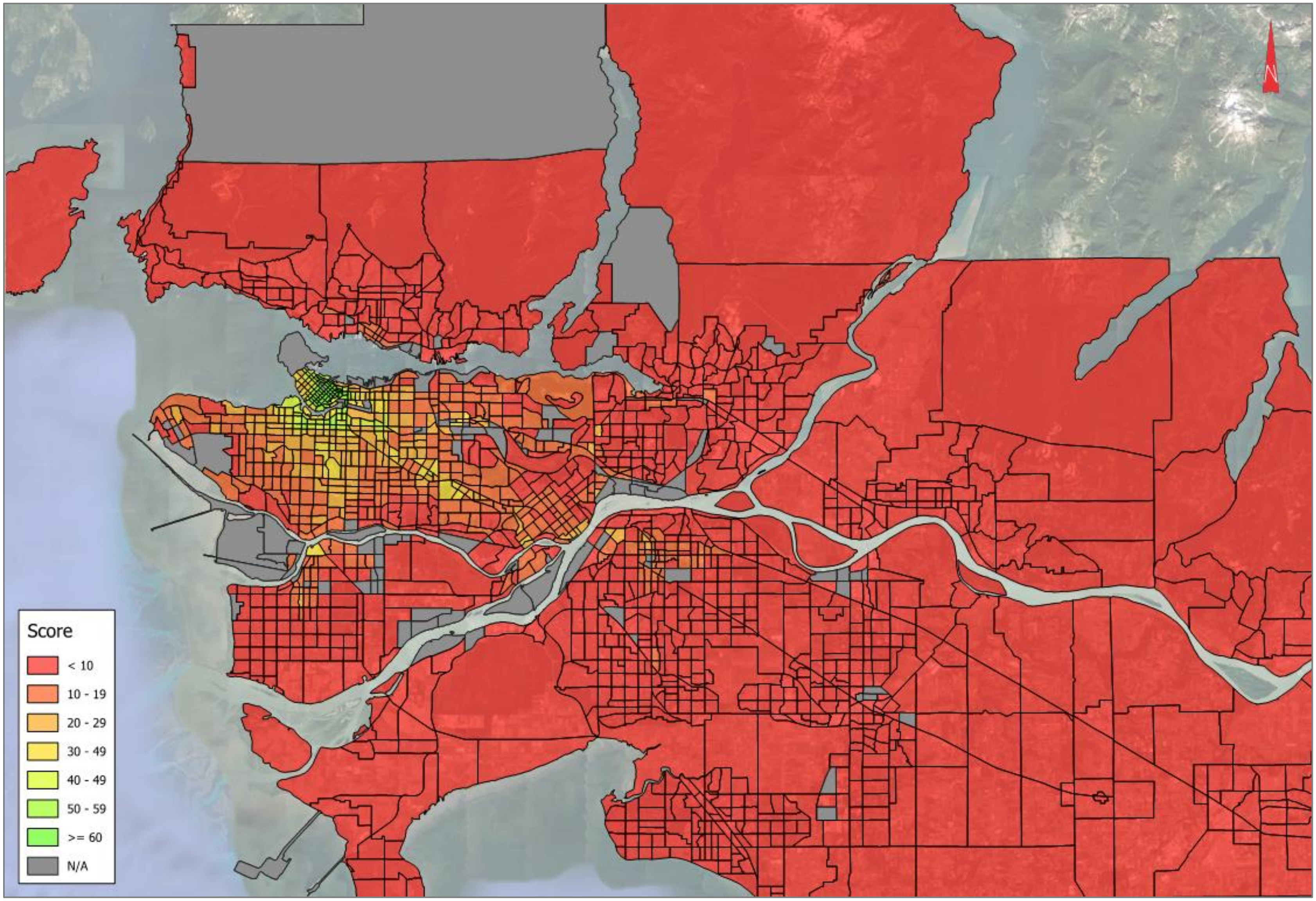


Figure 2.46: 2017 AM Peak Hour Transit Accessibility Heatmap

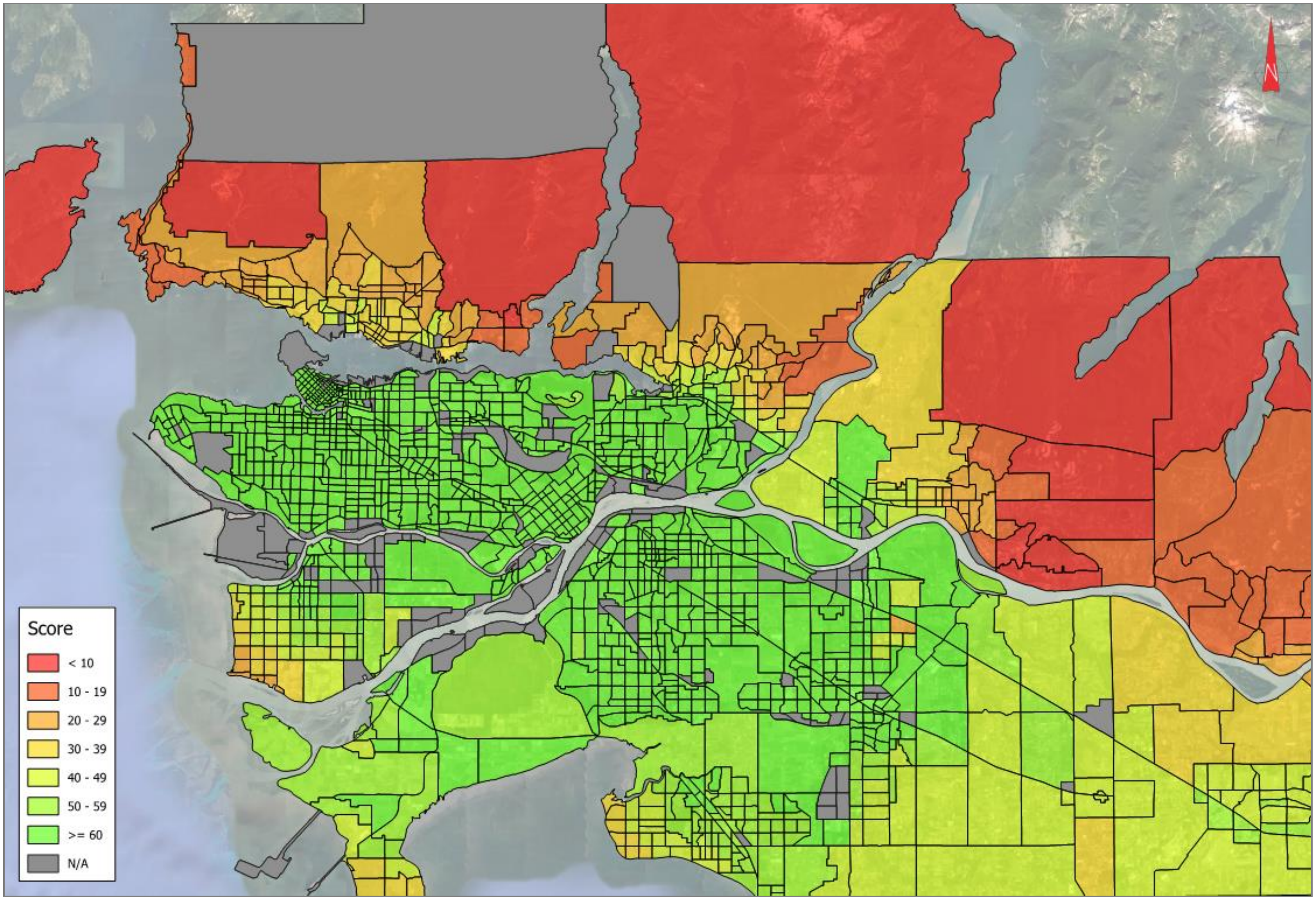


Figure 2.47: 2050 AM Peak Hour Auto Accessibility Heatmap

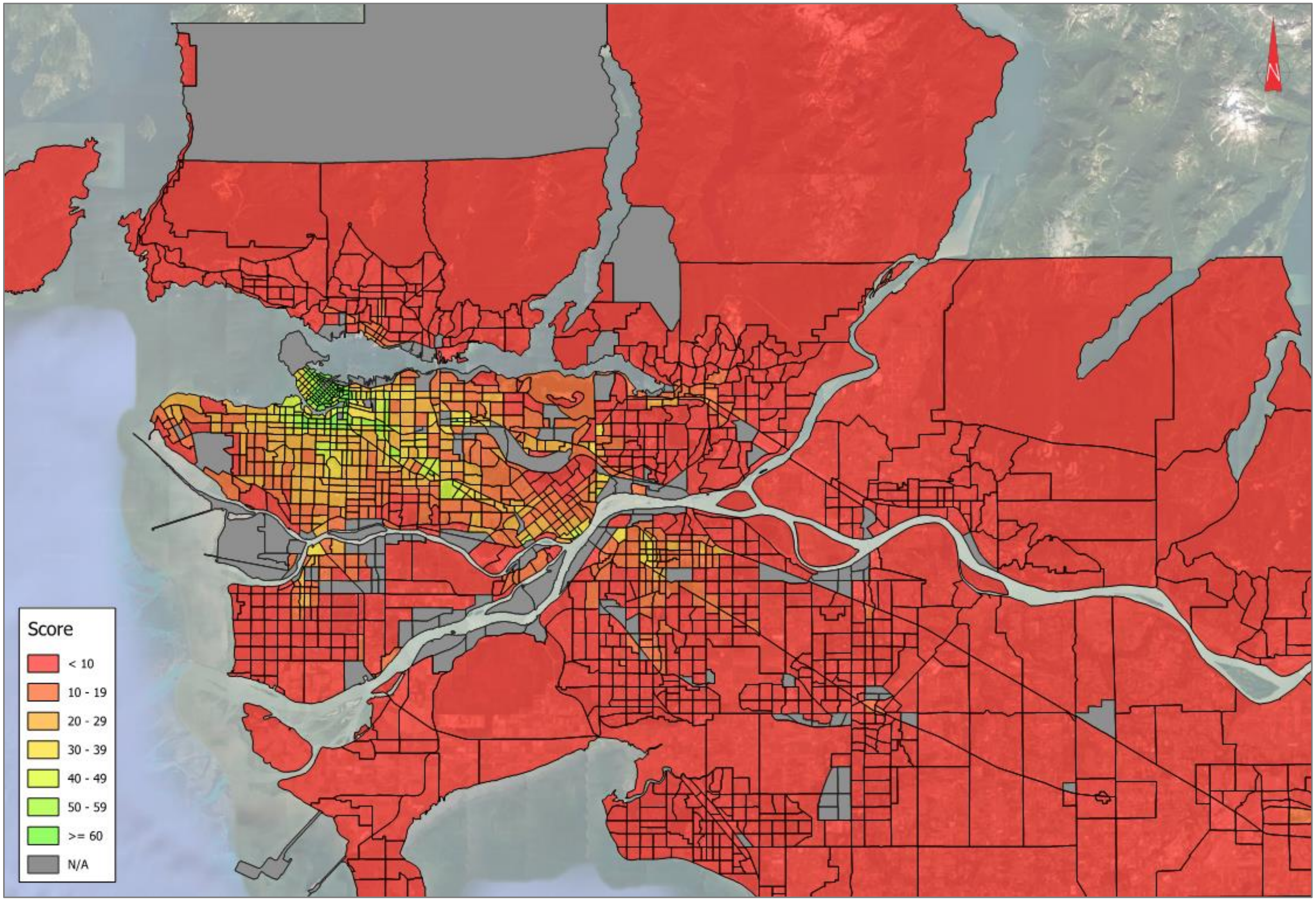


Figure 2.48: 2050 AM Peak Hour Transit Accessibility Heatmap

In summary, this access to employment analysis has identified that:

- Relative to current conditions, auto accessibility on the North Shore is anticipated to decrease significantly by 2050.
- Relative to current conditions, transit accessibility is anticipated to increase slightly by 2050.
- Transit accessibility lags auto accessibility both currently and in the future (although to a lesser extent in the future).

In addition to auto and transit modes, employment accessibility scores were also calculated for cycling (both conventional bikes with an assumed average speed of 15km/h and e-bikes with an assumed average speed of 20 km/h). Unlike the auto and transit modes, cycling is not subject to congestion-related travel time delays and provides relatively constant accessibility throughout the day. Employment accessibility by bike is provided for 2017 and 2050 in ***Figure 2.49*** and ***Figure 2.50***, respectively.

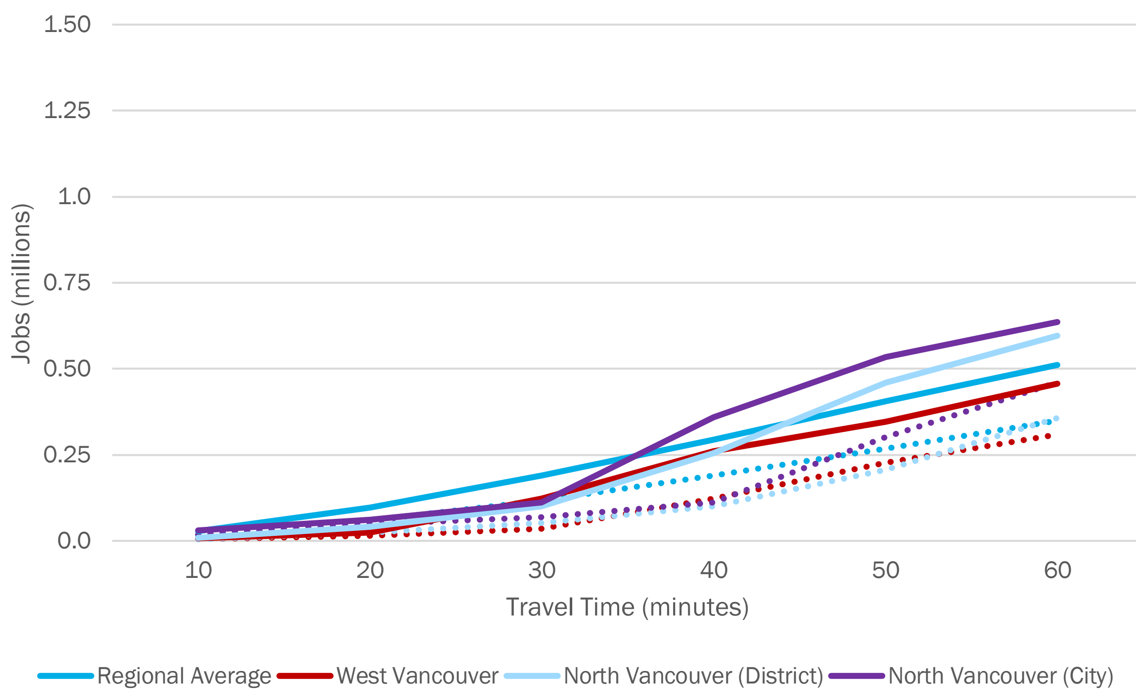


**Figure 2.49: Access to Employment Opportunities by E-Bike (solid) and Bike (dashed), 2017 AM Peak Hour**

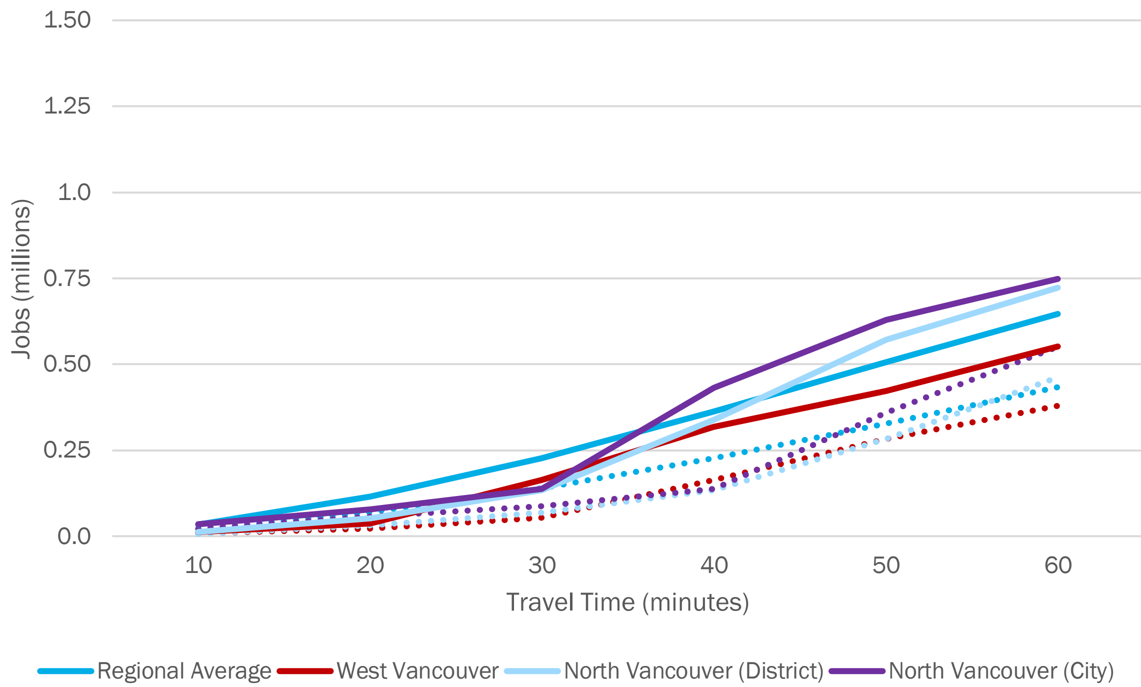


Figure 2.50: Access to Employment Opportunities by E-Bike (solid) and Bike (dashed), 2050 AM Peak Hour

Unlike the auto and transit modes, access to employment by cycling begins to exceed the regional average around the 30- to 40-minute travel time threshold. Furthermore, as bikes are not subject to congestion, access to employment increases over time as new jobs are added throughout the region without any increase in travel time to reach those locations. Perhaps most notable, by 2050, road network congestion results in bikes being relatively competitive with the auto in terms of employment accessibility, and e-bikes become more competitive.

### ACCESS TO LABOUR FORCE BY MODE

Labour force access here is defined by the amount of working-age population (18–64) that could access an employment opportunity at a specific location within a given travel time threshold. Similar to access to employment, one-way travel times were considered, with a focus on trips to a place of employment from a place of residence. The average number of employees accessible within a range of travel times for an employer located in each of the three North Shore municipalities in the 2017 AM peak hour for both auto and transit is provided in ***Figure 2.51***. The regional average labour force accessibility is also provided for comparison.

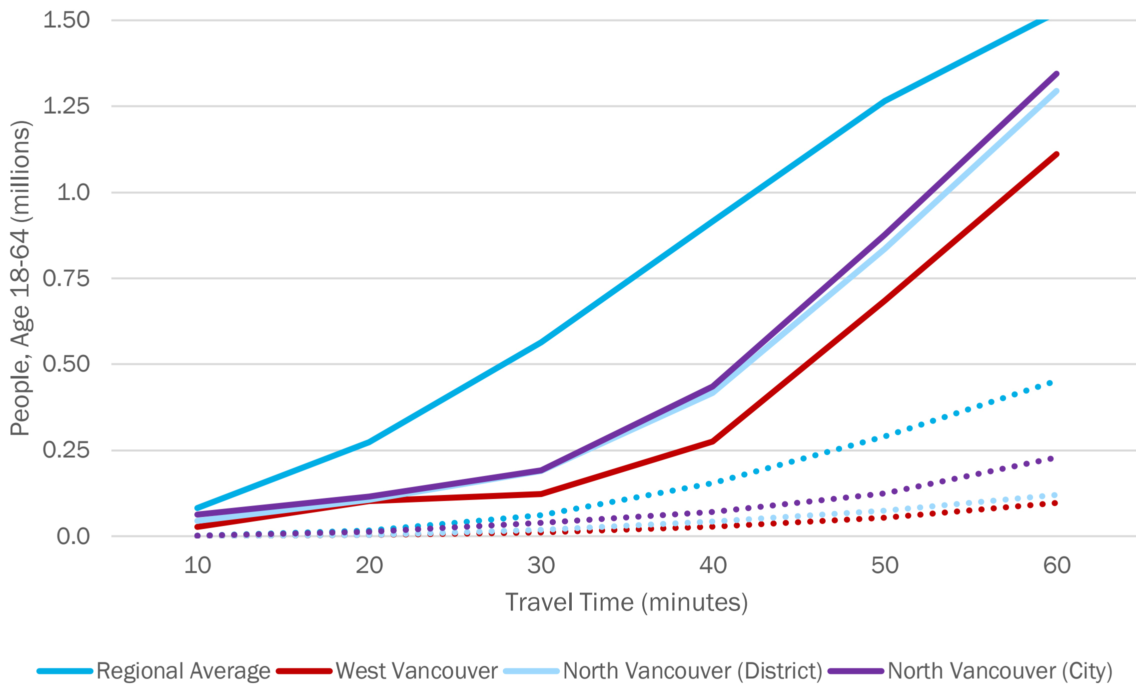


Figure 2.51: Access to Regional Labour Force by Auto (solid) and Transit (dashed), 2017 AM Peak Hour

Similar to the employment accessibility analysis, average region-wide labour force accessibility is effectively linear out to the 60-minute threshold, whereas the North Shore municipalities' labour force accessibility shows concavity. The District of West Vancouver shows significantly lower labour force accessibility beyond the 30-minute threshold. Access from the District of West Vancouver to suburban areas south and east of Vancouver (and their substantial labour force) requires lengthy travel through either North Vancouver or downtown Vancouver, which is the likely source for this difference.

Accessibility to labour force by transit is also lower for North Shore municipalities than it is across the region as a whole, and is inferior as compared to auto. Although not presented, the midday and PM conditions exhibit a similar finding to the employment accessibility metric, wherein access to employment "catches up" and is more similar to the regional average. The most notable difference between access to employment and access to the labour force is that, while the City of North Vancouver has a clear advantage over both district municipalities with respect to access to employment, both the City and the District of North Vancouver have an advantage over the District of West Vancouver with respect to access to the regional labour force.

The average number of employees accessible within a range of travel times for an employer located in each of the three North Shore municipalities in the 2050 AM peak hour for both auto and transit is provided in ***Figure 2.52***.

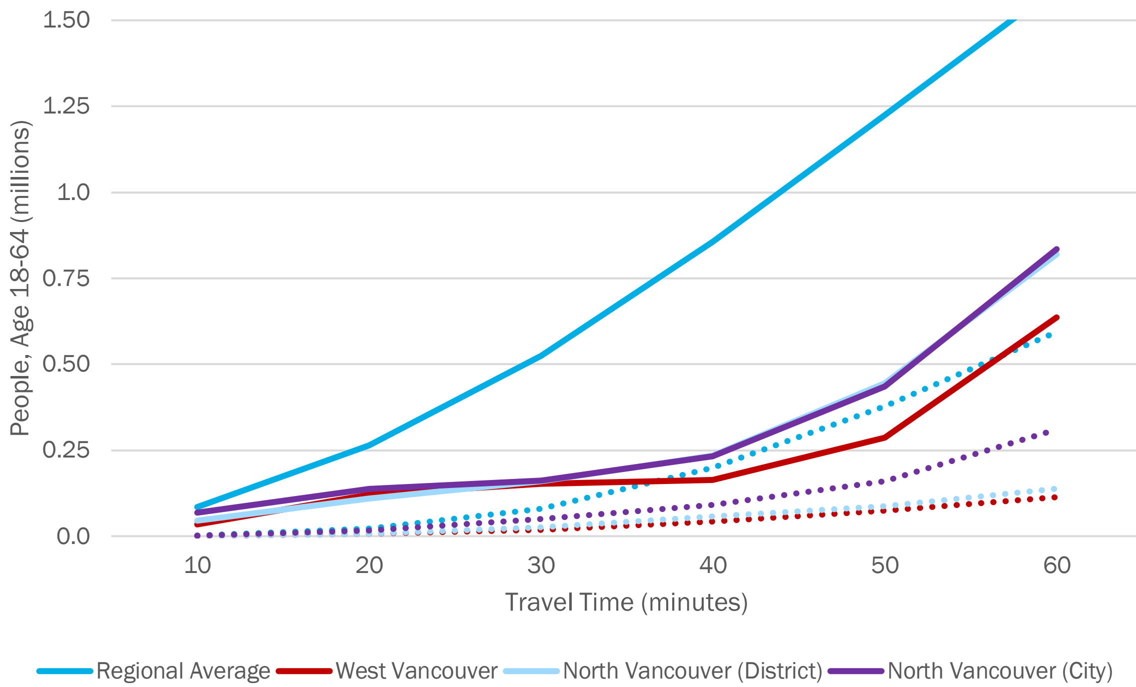


**Figure 2.52: Access to Regional Labour Force by Auto (solid) and Transit (dashed), 2050 AM Peak Hour**

*Note: The District of North Vancouver plot is challenging to see; it overlaps with the City of North Vancouver plot.*

While labour force accessibility at a region-wide level increases by 2050, all North Shore municipalities will see a decrease in the pool of potential employees who travel by auto. Access to the labour force by transit continues to grow, but still lags the auto modes.

An overall labour force accessibility score was also calculated for each traffic analysis zone based on an adaptation of the methodology developed by the Accessibility Observatory at the University of Minnesota. The overall average accessibility to labour force score by for each of the three municipalities is provided for auto in ***Table 2.18*** and transit in ***Table 2.19***. In these tables, information for the 2035 interim horizon year is also provided.

**Table 2.18: Accessibility to Labour Force by Auto Score, AM Peak Hour**

| Location | Year | | |
|---|---|---|---|
| | 2017 | 2035 | 2050 |
| Overall Network | 124,582 | 121,551 | 121,174 |
| West Vancouver | 46,496 | 42,740 | 41,369 |
| North Vancouver (District) | 60,817 | 53,621 | 48,838 |
| North Vancouver (City) | 67,646 | 60,782 | 56,805 |

Table 2.19: Accessibility to Labour Force by Transit Score, AM Peak Hour

| Location | Year | | |
|---|---|---|---|
| | 2017 | 2035 | 2050 |
| Overall Network | 15,355 | 18,825 | 20,161 |
| West Vancouver | 2,938 | 3,769 | 4,304 |
| North Vancouver (District) | 4,036 | 4,968 | 5,429 |
| North Vancouver (City) | 8,469 | 10,101 | 10,941 |

With respect to auto modes, some reduction in labour force accessibility between 2017 and 2035 is anticipated across the region, with the North Shore municipalities decreasing faster than the overall region. Between 2035 and 2050, reductions are anticipated to be smaller. The difference between transit and auto accessibility for labour force is much larger as compared to the difference for employment accessibility, suggesting that transit is a less competitive option for a resident from elsewhere in the region to get to a job on the North Shore than it is for a North Shore resident to get to a job elsewhere in the region.

In addition to auto and transit modes, labour force accessibility scores were also calculated for cycling, and are summarized for 2017 and 2050 in ***Figure 2.53*** and ***Figure 2.54***, respectively.

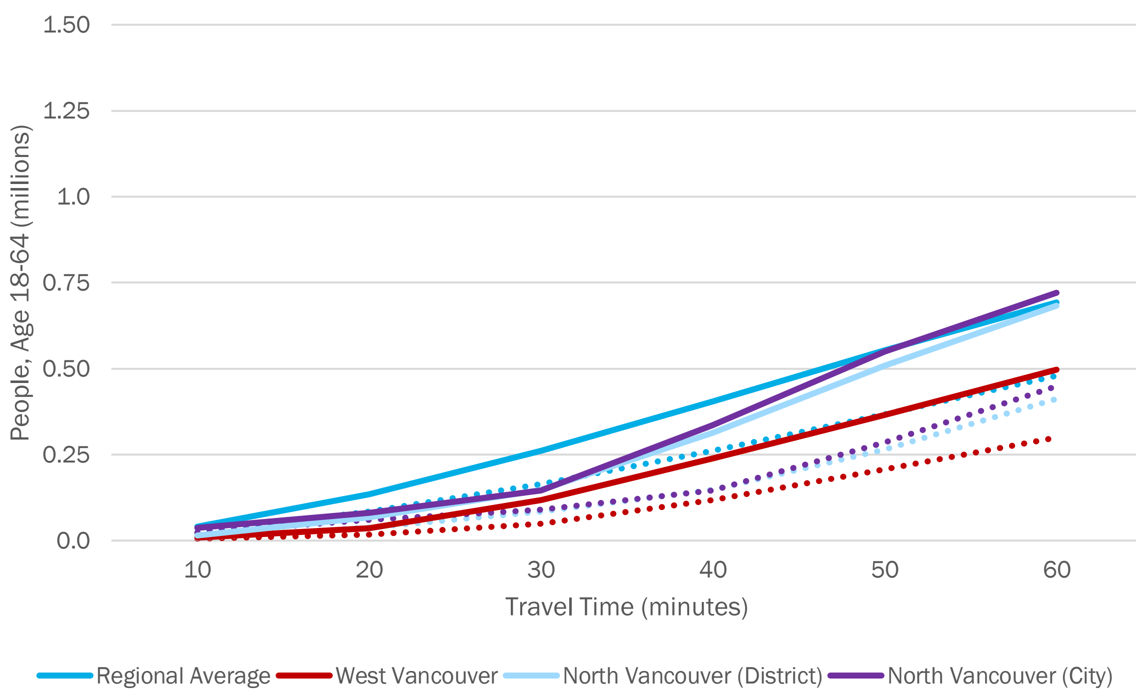


Figure 2.53: Access to Labour Force by E-Bike (solid) and Bike (dashed), 2017 AM Peak Hour

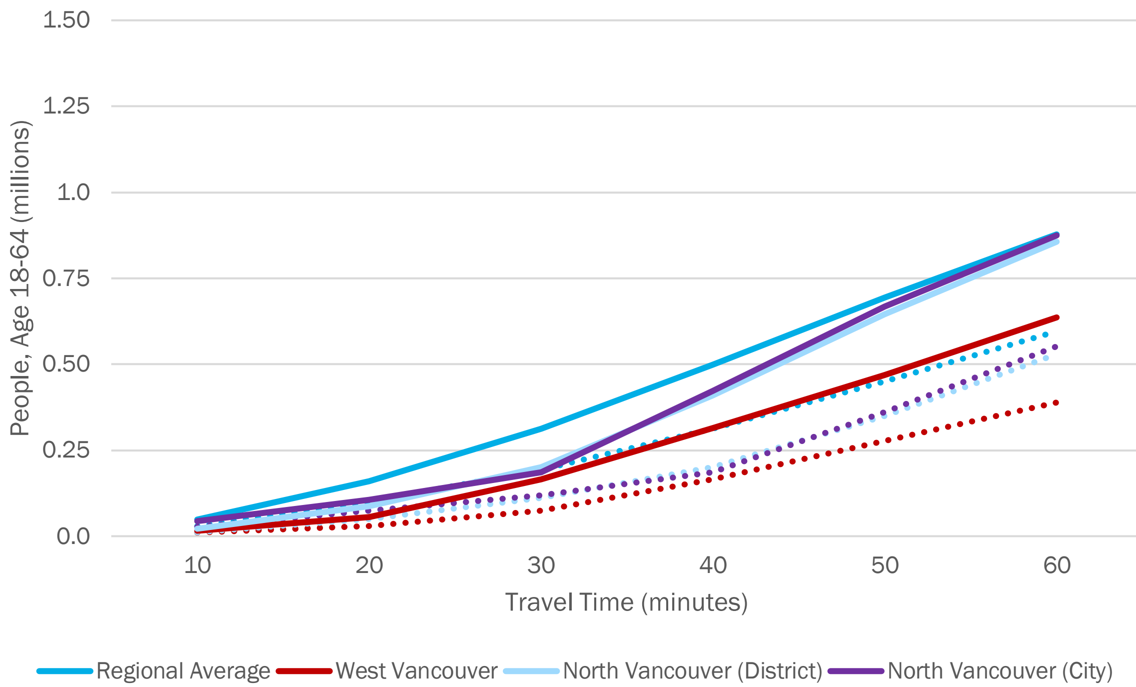


Figure 2.54: Access to Labour Force by E-Bike (solid) and Bike (dashed), 2050 AM Peak Hour

Similar to auto and transit mode (and unlike access to employment by bike), labour force access by bike for North Shore employees consistently lags the regional average. In both the current (2017) and forecast future (2050) conditions, access to labour force by bike (particularly e-bike) is reasonably competitive within a 30-minute travel time threshold (likely predominantly trips that stay within the North Shore), but begins to lose competitiveness for trips longer than 30 minutes (predominantly trips that cross Burrard Inlet).

## 2.6 Technical Assessment: Road Safety

In addition to assessing mobility metrics at both the corridor and the network level, a review of collisions history was undertaken. Section 2.6.1 described the performance criteria used in the assessment of road safety, while Section 2.6.2 summarizes findings.

### 2.6.1 Performance Criteria

Road safety performance was measured using the Collision Prone Location (CPL), Collision Prone Segment (CPS) and collision frequency metrics. The CPL and CPS metrics consider collision frequency, collision rate relative to comparable facilities, and the severity of collisions. Highway locations are considered to be a CPL or CPS if they exceed a certain annual collision frequency, as well as meeting a threshold related to either collision rate or collision severity (or both).

The methodology for calculating Collision Prone Locations and Collision Prone Segments is provided below. Note that BC MoTI has already pre-calculated these metrics for the entire provincial highway system; the study simply identifies where along the study corridor these metrics apply. Collision data used in this assessment is based on data from BC MoTI's Collision Information System (CIS) for the 5-year time frame between January 1, 2012 and December 31, 2016, inclusive. The data available in the CIS only includes collisions that were attended by police and that involved a fatality, an injury, or damage to property in excess of $1,000. Individual collision record information is also available for a more up-to-date 5.5-year period from January 2014 through June 2019.

### COLLISION PRONE LOCATIONS

To be designated as a Collision Prone Location, a location along the study corridor must:

- Have a minimum annual collision frequency of 2 collisions per year and,
- Must exceed at least one of the two following thresholds:
    - A Collision Rate in excess of the Provincial Critical Collision Rate for similar intersection types and/or
    - A Collision Severity Ratio in excess of the designated critical threshold.

#### Collision Frequency

Collision frequency is a measure of the total number of collisions in a location over the course of the observation period. Subject to at least one of the Collision Rate and/or Collision Severity thresholds being met, then a Collision Prone Location is defined as follows:

- A Level One Collision Prone Location will have an annual average collision frequency ≥ 3 collisions per year (i.e., 15 or more collisions over the course of the 5-year analysis period).
- A Level Two Collision Prone Location will have an annual average collision frequency ≥ 2 and < 3 collisions per year (i.e., between 10 and 14 collisions over the course of the 5-year analysis period).

Due to the greater collision frequency, a Level One Collision Prone Location is generally considered "worse" from a safety perspective than a Level Two Collision Prone Location.

#### Collision Rate

The collision rate is a measure of the number of collisions in a location relative to the number of vehicles as compared to the average collision rate for similar facility types (i.e., the Provincial Critical Collision Rate). The Collision Rate for a location that is an intersection is calculated as follows:

$$Location\ Collision\ Rate = \frac{Number\ of\ Collisions\ \times\ 10^6}{365\ \times\ Years\ of\ Analysis\ \times\ Annual\ Average\ Daily\ Traffic}$$

The Provincial Critical Collision Rate is calculated as follows:

$$\begin{aligned} &Provincial\ Critical\ Collision\ Rate \\ &\quad = Average\ Crash\ Rate\ of\ Similar\ Locations \\ &\quad + 3.09\sqrt{\frac{Average\ Crash\ Rate\ of\ Similar\ Locations}{Million\ Vehicle\ Kilometres\ Travelled}} \\ &\quad + \frac{1}{2\ \times Million\ Vehicle\ Kilometres\ Travelled} \end{aligned}$$

The collision rates for "similar locations" are based on the values provided in ***Table 2.20***.

Table 2.20: Average Collision Rates for Typical Location Types

| Roadway/Intersection Type* | Average Collision Rate of Locations |
|---|---|
| UAU2 | 0.22 |
| UAU4 | 0.24 |
| UAD4 | 0.23 |
| UED4 | 0.21 |
| UFD4 | 0.11 |
| RAU2 | 0.26 |
| RAU4 | 0.20 |
| RAD4 | 0.21 |
| RED4 | 0.20 |
| RFD4 | 0.13 |

* Note: R=Rural, U=Urban, A=Arterial, E=Expressway, F=Freeway, D=Divided, U=Undivided, 2/4 = total # of lanes

If the location collision rate exceeds the corresponding Provincial Critical Collision Rate, then the collision rate threshold is met.

### Collision Severity

The collision severity ratio is calculated as follows:

$$\begin{aligned} &Collision\ Severity\ Ratio \\ &= \frac{(Property\ Damage\ Only\ Collisons) + (Injury\ Collisions\ \times\ 10) + (Fatality\ Collisions\ \times 100)}{Total\ Collisions} \end{aligned}$$

For Collision Prone Locations, the CSR threshold is 6.1; if the location collision severity ratio exceeds this value, then the collision severity threshold is met.

## COLLISION PRONE SEGMENTS

The collision frequency, collision rate and collision severity requirements to designate a segment of highway corridor as a Collision Prone Segment mimic those of the Collision Prone Locations provided above.

### Collision Frequency

The same collision frequency metrics described above for Collision Prone Locations also apply to Collision Prone Segments.

### Collision Rate

With respect to segment collision rates, the formula is as follows:

$$CPS\ Collision\ Rate = \frac{Number\ of\ Collisions\ \times\ 10^6}{365\ \times\ Years\ of\ Analysis\ \times Annual\ Average\ Daily\ Traffic\ \times\ Segment\ Length}$$

The formula to calculate the Provincial Critical Collision Rate for segments is the same as the formula provided previously for locations. However, the average collision rate values provided in ***Table 2.21*** are used instead of those provided in ***Table 2.20***.

Table 2.21: Average Collision Rates for Typical Segment Types

| Roadway/Intersection Type* | Average Collision Rate of Sections |
|---|---|
| UAU2 | 0.63 |
| UAU4 | 0.76 |
| UAD4 | 0.85 |
| UED4 | 0.44 |
| UFD4 | 0.29 |
| RAU2 | 0.37 |
| RAU4 | 0.34 |
| RAD4 | 0.35 |
| RED4 | 0.33 |
| RFD4 | 0.27 |

* Note: R=Rural, U=Urban, A=Arterial, E=Expressway, F=Freeway, D=Divided, U=Undivided, 2/4 = total # of lanes

### Collision Severity

With respect to calculating the Collision Severity Ratio for a Collision Prone Segment, the formula is the same as that for the Collision Prone Locations. However, for Collision Prone Segments, the CSR threshold is 7.2.

## COLLISION FREQUENCY

Collision frequency is a comparatively more straightforward metric, and simply involves assessing the total number of collisions at a particular location over a given period of time.

### 2.6.2 Performance Assessment

#### COLLISION PRONE LOCATIONS

Level One Collision Prone Locations:

- Taylor Way Overpass
- Capilano Road westbound on-ramp merge

Level Two Collision Prone Locations:

- Capilano Road eastbound on-ramp merge

#### COLLISION PRONE SEGMENTS

Level One Collision Prone Segments:

- Highway 1 Eastbound from Lonsdale Avenue eastbound on-ramp merge to Lynn Valley Road eastbound on-ramp merge
- Highway 1 eastbound from Taylor Way eastbound on-ramp merge to Westview Drive eastbound off-ramp diverge

Level Two Collision Prone Segments:

- None

#### COLLISION FREQUENCY

In addition to the review of collision prone locations and segments, individual collision records were reviewed along the length of the corridor for a 5.5-year period from January 1, 2014 to June 30, 2019. These collisions are based on information from BC MoTI Collision Information System, which in turn is based on reports prepared by law enforcement officials for collisions to which they responded. Data based on police reports is comprehensive, in that it contains details regarding the collision incident and can be used to assess underlying trends and contributing factors to collisions. As such, a limitation of this dataset is that it does not contain records of collisions that were not attended by law enforcement.

The collision records in the CIS dataset for this period contained 1 fatality, 205 injuries and 342 property damage only collisions, for a total of 549 collisions between Horseshoe Bay and the east-facing ramps on the Lynn Valley Road Interchange. These collisions are mapped in ***Figure 2.55***, and the top 10 locations in terms of collision frequency are summarized in ***Table 2.22***.


Figure 2.55: Beginning of 2014 to Mid-2019 Collision History

Table 2.22: Top 10 Locations with Respect to Collision Frequency

| Rank | Location | Direction | Fatality | Injury | Property Damage Only | Total |
|---|---|---|---|---|---|---|
| 1 | Capilano Road Interchange | Eastbound | 0 | 32 | 49 | 81 |
| 2 | Lynn Valley Road Interchange | Eastbound | 0 | 13 | 32 | 45 |
| 3 | Capilano Road Interchange | Westbound | 0 | 15 | 25 | 40 |
| 4 | Westview Drive Interchange | Eastbound | 0 | 9 | 21 | 30 |
| 5 | Lonsdale Avenue Interchange (off-ramp area) | Eastbound | 0 | 12 | 15 | 27 |
| 6 | Lynn Valley Road Interchange | Westbound | 0 | 13 | 14 | 27 |
| 7 | Taylor Way Interchange | Eastbound | 0 | 9 | 17 | 26 |
| 8 | 15th Street Interchange | Eastbound | 0 | 9 | 14 | 23 |
| 9 | Westview Drive Interchange | Westbound | 0 | 7 | 14 | 21 |
| 10 | Lonsdale Avenue Interchange (on-ramp area) | Eastbound | 0 | 6 | 13 | 19 |

The only fatality collision on the highway was not in one of the higher collision-frequency areas; rather, this single-vehicle collision occurred eastbound on the highway near where the highway passes by Lloyd Avenue. Note that, unlike the westbound direction, Lloyd Avenue in the eastbound direction does not connect to the highway. No other crashes were reported at this location over the course of the 5.5-year period for which data is available.

**Capilano Road Eastbound (seg 514, km 1.3–1.7):**

- A total of 81 collisions were recorded on this half-kilometre segment, consisting of 32 injury collisions and 49 property damage only collisions.
- 20 out of 81 (about 25%) of collisions were off-road rights, with 17 of the 20 occurring on or near the Capilano River Bridge. It is further noted that almost all of these off-road rights occurred during wet conditions, suggesting that visibility and/or road traction are an issue.
- Another 17 out of 81 were rear-ends and were located on the bridge approach, where vehicles will often decelerate prior to reaching the sharp horizontal curvature, as well as on the bridge itself, where vehicles will often decelerate prior to exiting the highway via the eastbound off-ramp to Capilano Road.
- 9 off-road lefts were recorded, with most being closer to the bridge approach, suggesting that some drivers may also be oversteering. 7 of the 9 off-road lefts occurred in wet conditions, suggesting that poor traction and visibility played a role in the collisions. Only 1 off-road left was related to the eastbound off-ramp loop.
- 7 side-swipes were recorded, with most collisions occurring along the bridge deck. All side-swipe collisions occurred in wet conditions, suggesting that poor traction and visibility played a role in the collisions.
- The remaining 28 collisions included a range of types, with the most common trends being that most (23 of 28) were in wet conditions and (20 of 28) involved only a single vehicle.

**Lynn Valley Road Eastbound (seg 514, km 6.3–6.7):**

- A total of 45 collisions were recorded on this half-kilometre segment, consisting of 13 injury collisions and 32 property damage only collisions.
- 25 out of 45 (approximately 55%) were located within the first 100 metres of the 500-metre segment, roughly centred on the Lynn Valley Road Overpass, which is immediately prior to the direct taper off-ramp. 14 of these 25 collisions were rear-end collisions, with excessive speed and driver inattention being the most frequently cited contributing factors. 10 of these 14 rear-end collisions were in dry conditions, 3 were in wet conditions and 1 was in icy conditions. Of the remaining 11 out of 25 collisions, there was a mixture of off-road rights, an off-ramp left, and travelling the wrong way on a one-way street (believed to be an issue at the ramp terminals). 7 out of these 11 collisions were in wet conditions.
- The other 20 collisions included 6 collisions that appeared to be primarily off-road rights or off-road lefts at the exit ramp, 4 merging collisions (primarily side-swipes) and 5 collisions between the ramps, the majority of which were rear-end collisions.

Capilano Road Westbound (seg 515, km 12.7–13.1):

- A total of 40 collisions were recorded on this half-kilometre segment, consisting of 15 injury collisions and 25 property damage only collisions.
- 24 out of 40 (55%) of collisions were at the Capilano Road westbound entrance ramp. 15 of these 24 collisions attributed the crash to driver inattention. The majority (18/24) of these collisions occurred in dry weather (either clear or cloudy – not necessarily foggy), suggesting that issues associated with poor weather are not a major factor. All collisions were multi-vehicle, and 20 of the 24 collisions were rear-end collisions.
- 6 out of 40 collisions occurred at the exit ramp, and involved a mixture of rear-end and off-ramp collisions. Contributing factors included driver speed and inattention. 4 of these 6 collisions were in wet conditions, including the 2 off-road collisions. Other than the 2 rear-ends, 4 of these 6 collisions were single vehicle.
- The remaining 10 collisions included 5 rear-end collisions between intersections, 3 collisions at the ramp terminal intersection and 2 collisions with little information.

Westview Drive Eastbound (off-ramp area) (seg 514, km 3.2–3.6):

- A total of 30 collisions were recorded on this half-kilometre segment, consisting of 9 injury collisions and 21 property damage only collisions.
- 10 out of 30 collisions (30%) occurred along the highway itself, with 7 being rear-end collisions and 2 being side-swipes. Driver inattention and following too closely were frequently cited as contributing factors. Several of these collisions were just upstream of the exit ramps, while the rest were centred on the interchange itself. Rear-end collisions upstream of the intersection may be related to ramp queues spilling back close to (or onto) the highway itself.
- 9 of the 30 collisions (30%) occurred on the ramp terminal intersection, with most of these collisions appearing to be related to eastbound off-ramp to Westview Drive eastbound left-turn movements colliding with other vehicles (likely a southbound through-moving vehicle). Driver inattention, failing to yield the right-of-way and ignoring traffic control devices appeared to be the primary causes.

- 6 collisions (20%) were observed on the exit ramp, with all but 1 being rear-end collisions. This suggests that drivers are not slowing down in time prior to reaching the back of the queue, which may indicate that queue lengths are so long as to not provide time for people to decelerate or that, in extreme circumstances, queues may be spilling back onto the highway itself.
- Comparatively fewer (8) crashes were in the on-ramp area/weaving zone.

Lonsdale Avenue Eastbound (off-ramp area) (seg 514, km 4.4–4.8):

- A total of 27 collisions were recorded on this half-kilometre segment, consisting of 12 injury collisions and 15 property damage only collisions.
- 10 of the 27 collisions were located at ramp terminal intersections, with 8 of these related to eastbound off-ramp left-turning vehicles colliding with southbound through-movements.
- 7 of the 27 collisions were on the exit ramp, with most of these collisions being rear-ends. All collisions occurred in dry conditions due to a variety of contributing factors (impairment, driver inattention). The severity of the collisions is also notable; 6 of the 7 collisions caused injuries, while just 1 was a property damage only collision. Typically, property damage only collisions make up the majority of collisions.
- The remaining collisions were located along the highway itself, and included a mixture of collision types, with side-swipes, with passing/overtaking being the most common (4 of 10).

Lynn Valley Road Westbound (seg 515, km 8.1–8.5):

- A total of 27 collisions were recorded on this half-kilometre segment, consisting of 13 injury collisions and 14 property damage only collisions.
- 14 of the 27 collisions occurred at the entrance ramp, with all but one of these collisions being rear-ends. The primary contributing factors were driver inattentiveness and drivers following too closely. The only other collision was an off-road right, for which impairment by alcohol was identified as a contributing factor. Collisions occurred in a mixture of wet and dry conditions.
- 3 left-turn collisions were identified at the ramp terminal (this is assumed to be the on-ramp intersection, rather than the off-ramp intersection at Lynn Valley Road and William Avenue).
- The majority of the remaining collisions were along the highway itself, with rear-end collisions being the most common, along with off-road lefts and off-road rights. Weather conditions included a mixture of dry, wet and snowy conditions.

Taylor Way Eastbound (seg 504, km 10.6–10.9; seg 514, km 0.0):

- A total of 26 collisions were recorded on this half-kilometre segment, consisting of 9 injury collisions and 17 property damage only collisions.
- 12 out of 26 collisions were on the highway itself, with 7 of these 12 being rear-end collisions, primarily caused by driver inattentiveness.
- Entrance ramp collisions accounted for 2 of the 26 collisions, both of which were rear-ends.
- 3 collisions at the ramp terminal intersections, mainly south or eastbound, likely related to people travelling too fast down the off-ramp, or being inattentive of queues.

- Several rear-end collisions had no specific location noted.

**15th Street Eastbound (seg 504, km 9.2–9.6):**

- A total of 23 collisions were recorded on this half-kilometre segment, consisting of 9 injury collisions and 14 property damage only collisions.
- 14 of the 23 collisions were clustered around the entry ramp, with the most frequent occurrence being off-road right collisions (5), followed by rear-end collisions (3), although several collision records did not have a specific collision type identified. Excessive speed was often cited as a contributing factor, and 12 of 14 collisions occurred during wet conditions.
- Collisions along the highway itself (a mixture of off-road right, off-road left and rear-end) were the mix most common occurrence, with a few additional collisions on either the exit ramp or at the ramp terminal.

**Westview Drive Westbound (seg 515, km 10.7–11.1):**

- A total of 21 collisions were recorded on this half-kilometre segment, consisting of 7 injury collisions and 14 property damage only collisions.
- 11 of the 21 collisions were on the highway itself, and included a mixture of off-right left, off-road right, rear-end and side-swipe collisions. Collisions were primarily in dry conditions.
- 5 of the 21 collisions were at an intersections, and were primarily related to left-turning vehicles at the on-ramp, resulting in 90-degree collisions. The most common type was westbound off-ramp traffic conflicting with northbound through-movements.
- 1 collision was observed at an off-ramp, and 2 at an on-ramp.

**Lonsdale Avenue Eastbound (on-ramp area) (seg 514, km 5.4–5.8):**

- A total of 19 collisions were recorded on this half-kilometre segment, consisting of 6 injury collisions and 13 property damage only collisions.
- 8 out of 19 collisions were on the entrance ramp/acceleration lane. Roughly half of these collisions were rear-end collisions, while the remainder were a variety of other collision types, such as side-swipes and off-road collisions.
- 3 collisions appear to have occurred at the ramp intersection with Lonsdale Avenue.
- Most collisions (12 out of 19) were in dry conditions.
- 7 collisions occurred on the highway itself, with the majority (4) being rear-end collisions.

## 2.7 Engagement Process

In addition to a review of previous reports and a technical analysis of multi-modal mobility and safety, potential issues were also identified through engagement with partners and stakeholders, including internal BC MoTI staff, the three North Shore municipalities (the District of West Vancouver, the District of North Vancouver and the City of North Vancouver), the Indigenous groups on whose traditional territories the corridor passes through (Musqueam Indian Band, Squamish Nation and Tsleil-Waututh Nation), TransLink and HUB Cycling. A summary of stakeholder feedback is provided in ***Table 2.23***, and includes both broader corridor-wide and network-/regional-level considerations as well as issues at specific locations along the corridor.

Table 2.23: Summary of Issues and Challenges Identified Through Engagement

| Feedback Type | Location | Description |
|---|---|---|
| Transit | Corridor-Wide | Congestion and the lack of competitive and reliable travel times along the corridor make the corridor less attractive with respect to implementing future transit service. Opportunities to implement transit service are likely contingent on providing transit priority. |
| Active Transportation, Transit, Environment | Corridor-Wide | Some groups or agencies have declared a state of climate emergency, and are highly interested in opportunities to improve walking, cycling and transit as a means to reduce greenhouse gas emissions. |
| Economic Opportunities | Corridor-Wide | Some Indigenous groups have expressed interest in procurement opportunities if any of the concepts developed in this study were to advance towards implementation in the future. |
| Environment | Network-Level | There is a need to consider the broader/regional-level implications of any concepts with respect to vehicle travel and greenhouse gas emissions. |
| Environment | Corridor-Wide | There is a desire for any future projects to achieve a net environmental gain relative to current conditions. |
| Regional Accessibility | Network-Level | The highway corridor passes through the core territories of some Indigenous groups, and there is interest in understanding how any concepts could improve accessibility and people-moving capacity to and from reserve lands located throughout the North Shore. |
| Cultural Recognition | Corridor-Wide | The highway corridor passes through the core territories of some Indigenous groups, and there is an interest in increased visibility/recognition within these territories. |
| Archaeology, Cultural Heritage and Environment | Corridor-Wide | The highway corridor passes through the core territories of some Indigenous groups, and any concepts developed may be located in areas with archaeological or environmental significance. |
| Environment | Corridor-Wide | Compounds from vehicle tires can run off into watercourses, and ultimately end up in Burrard Inlet; there are concerns that these compounds can negatively impact fish. Therefore, there |

| Feedback Type | Location | Description |
|---|---|---|
| | | is a need to consider management of stormwater runoff as part of any concept development that incorporates green infrastructure elements to slow runoff, increase infiltration, and capture contaminants and sediments. |
| Transit | Corridor-Wide | Access to any stops for on-corridor transit service should provide safe, efficient and comfortable walk access and transfers. |
| Active Transportation; Road Safety | Eastbound egress from Horseshoe Bay ferry terminal | There are several areas with disappearing shoulders, including immediately after leaving the ferry terminal, near the bridge structure overtop the Lions Club parking lot, and near the merge of the Marine Drive/Horseshoe Bay Road eastbound on-ramp. |
| Traffic Operations; Road Safety | Exit 3; westbound off-ramp to Horseshoe Bay ferry terminal as highway mainline transitions to Highway 99 Sea to Sky Corridor. | During the busiest travel days, queues for the Horseshoe Bay ferry terminal can spill back from the off-ramp onto Highway 1. |
| Signage | Exit 3; westbound off-ramp to Horseshoe Bay ferry terminal as highway mainline transitions to Highway 99 Sea to Sky Corridor. | Confusing signage for exits to Highway 99/Sea to Sky vs. Eagleridge Drive. |
| Traffic Operations; Road Safety | Eastbound merge with Highway 99 southbound near Horseshoe Bay. | Large volumes of merging ferry traffic, can be challenging, and the outside merge lane may be underutilized. Laning configuration is also atypical; normally, the outside lane is dropped first. |
| Traffic Operations | Caulfeild Interchange. | Turnaround location for Highway 99/Sea to Sky Highway traffic travelling to Horseshoe Bay ferry terminal; can conflict with local District of West Vancouver traffic |
| Traffic Operations | Exit 4; westbound off-ramp to Caulfeild Interchange. | Potential for queue spillbacks onto Highway 1 westbound mainline in the AM due to traffic bound for Rockridge Secondary. Sometimes poor compliance with stop sign. |
| Geometric Design; Road Safety | Westmount Interchange structure, northbound direction. | Road geometry can result in westbound off-ramp traffic accidentally joining westbound on-ramp, or braking/reversing. |
| Traffic Operations | Eastbound from Westmount Interchange to Cypress Bowl Road Interchange. | Slight uphill grade causes vehicles to slow down; can create a shockwave effect. |
| Traffic Operations | Cypress Bowl Road Interchange | Potential queue spillbacks onto Highway 1 westbound mainline in the AM due to traffic bound for Mulgrave School. |
| Traffic Operations | Cypress Bowl Road Interchange | Development-related pressures from Cypress Village. |
| Traffic Operations | 21st Street Interchange | 21st Street Interchange westbound on-ramp is located along a local road closer to 22nd Street; atypical practice. Potential conflicts between westbound on-ramp traffic and vehicles travelling along Skilift Road. |

| Feedback Type | Location | Description |
|---|---|---|
| Traffic Operations | Eastbound from 21st Street Interchange to 15th Street Interchange | Weaving length is 300–400 metres; potentially below standards, given posted speed and volumes. |
| Traffic Operations; Road Safety | Exit 11; westbound off-ramp to 15th Street Interchange. | Potential queue spillbacks onto Highway 1 westbound mainline in the AM due to traffic bound for West Vancouver Secondary School and Sentinel Secondary. This off-ramp is potentially a bigger issue because of the traffic signal. |
| Active Transportation; Road Safety | Exit 11; Taylor Way Interchange. | Lack of cycling facilities on off-ramps and on-ramps at Taylor Way Interchange, which cyclists travelling along the highway shoulder are required to use. |
| Traffic Operations; Road Safety | Exit 11; eastbound off-ramp to Taylor Way Interchange. | At times, Lions Gate Bridge queues can spill back from the eastbound exit to Taylor Way onto the Highway 1 eastbound mainline. |
| Traffic Operations; Road Safety | Exit 11; westbound off-ramp to Taylor Way Interchange. | During very poor traffic operations conditions on Lions Gate Bridge, westbound traffic exiting to Taylor Way may also spill back onto the Highway 1 westbound mainline. |
| Active Transportation, Highway Geometry | North side of Highway 1 immediately west of the Capilano River bridge. | The District of West Vancouver recently constructed a multi-use path near Hugo Ray Park from Keith Road to 3rd Street adjacent to the highway, which may conflict with future improvements. |
| Traffic Operations; Road Safety | Highway 1 immediately west of the Capilano River bridge. | Substandard horizontal curvature can cause collisions as well as spillbacks from shockwaves during sudden decelerations (which can in turn also cause collisions). |
| Active Transportation | Corridor-Wide | West of Capilano Road, cycling on the shoulder of Highway 1 is permitted. BC MoTI has received requests to extend the cycling route further east to Lonsdale Avenue. |
| Active Transportation | Capilano Road Interchange | Gap in municipal cycling network along Capilano Road through the section under BC MoTI jurisdiction. |
| Active Transportation | Capilano Road Interchange | Narrow cycling path on Capilano River Bridge, and lack of cycling facility on the eastbound off-ramp. |
| Road Safety | Capilano Road Interchange | Very short on-ramp to Highway 1 westbound from Capilano Road. |
| Road Safety | Exit 14; westbound off-ramp to Capilano Road Interchange | Short off-ramp; people slow in the highway through-lanes out of caution. Off-ramp has local street intersection to serve landlocked property; not typical practice. |
| Active Transportation | East of Capilano Road Interchange at Philip Avenue/Terrace Avenue. | Pedestrian underpass/culvert likely does not meet current design standards, and does not permit cycling. |
| Active Transportation; Road Safety | East of Capilano Road Interchange at Pemberton Avenue. | Pedestrian overpass with substandard vertical clearance. Barrier offsets near piers may not meet current design standards. |
| Active Transportation; Road Safety | Exit 14 Capilano Road Interchange to Exit 16 Westview Drive interchange. | Lack of continuous cycling connection on the north side of the highway from Westview Drive to Lloyd Avenue, including a connection to Edgemont Boulevard. |

| Feedback Type | Location | Description |
|---|---|---|
| Highway Geometry | East of Capilano Road Interchange, at Lloyd Avenue. | Lloyd Avenue right-in/right-out lane geometry may not meet current design standards. |
| Network-Level | Exit 17; eastbound off-ramp to Westview Drive Interchange | During backups in the eastbound direction on Highway 1 east Lonsdale Avenue, vehicles bound for Lynn Valley will abandon Highway 1 and exit at Westview Drive or Lonsdale Avenue instead and use Queens Road/29th Street or Braemar Road/Dempsey Road to reach Lynn Valley. |
| Traffic Operations | Exit 17; eastbound off-ramp to Westview Drive Interchange | Eastbound right-turning vehicles often make a southbound left turn onto 23rd Street and will not proceed unless both southbound lanes on Westview Drive are clear. This reduces throughput on the exit and can cause spillbacks onto the Highway 1 eastbound mainline. Timing of lights may be an issue. |
| Active Transportation | East of Westview Drive Road Interchange at Jones Avenue. | Pedestrian overpass with slightly substandard vertical clearance. Design not conducive to cycling; signage requires cyclists to dismount and walk. |
| Traffic Operations | Exit 18; eastbound off-ramp to Lonsdale Avenue Interchange | Right-turning vehicles can get obstructed by left-turning vehicles. |
| Active Transportation; Transit | Lonsdale Avenue Interchange | Lack of cycling facilities along Lonsdale Avenue across the highway, and potential future local/regional government interest in improved walking, cycling and transit infrastructure along Lonsdale Avenue. Existing pedestrian facilities create challenges with respect to the quality and perception of safety for all users. |
| Traffic Operations | Highway 1 eastbound from Lonsdale Avenue Interchange to Lynn Valley Interchange. | Backups in this section; sometimes speeds up after getting through Lynn Valley Interchange. |
| Traffic Operations | Highway 1 westbound from Lynn Valley Interchange to Lonsdale Avenue Interchange | Significant amount of lane changing/in this segment; relatively short distance between Lynn Valley Road on-ramp and Lonsdale Avenue off-ramp. |
| Traffic Operations; Road Safety | Lynn Valley Interchange | On-ramps and off-ramps at Lynn Valley Road Interchange may not meet current design standards for acceleration/deceleration length for 80 km/h posted speed. Specifically, the westbound on-ramp has short merging distance, and the eastbound Exit 19 off-ramp at does not provide room for deceleration prior to entering a low design speed loop, creating a risk of overturning for trucks. |
| Active Transportation | Lynn Valley Road Interchange | Gap in municipal cycling network along Lynn Valley Road in the northeast direction through the section under BC MoTI jurisdiction. |
| Road Safety | Exit 10; westbound off-ramp to Lynn Valley Road Interchange. | Lynn Valley Road Interchange westbound on-ramp directs vehicles to local road; atypical practice. |
| Active Transportation; Highway Geometry | East of Lynn Valley Road Interchange at Casano Drive/Loutet Softball Park. | City of North Vancouver planning Loutet–Casano Pedestrian/Cycling Overpass; could impact range of feasible concepts. |

## 2.8 Problem Definition Summary

Key findings from the issues identification analysis are summarized below, and grouped as follows:

- Multi-modal trip-making.
- Highway operational performance.
- The role of the highway.
- Provision of transit service.
- Active transportation provisions.
- Road safety.
- Network-level challenges.

**Multi-Modal Trip-Making:**

- The eastern portion of the study corridor (roughly the Capilano River to the Lynn Valley Road Interchange) is busier than the western portion at all times of day and experiences a greater degree of congestion and capacity challenges at peak hours.
- The corridor is highly auto-centric, although HOV trips currently make up 30% to 50% of person-trips on the corridor, depending on the segment of the corridor and the time of day.
- By 2050, demand for trip-making on the corridor is anticipated to grow in the range of 20%–45%.

**Operational-Performance:**

- By two key operational performance metrics (volume-to-capacity ratio and travel time index), operations on the eastern portion of the highway roughly between the Capilano River and the Lynn Valley Road Interchange are significantly more congested than those in the western portion of the corridor.
- Operations in the eastern portion of the corridor are anticipated to degrade by 2050, particularly in the eastbound direction.
- With respect to interchanges, the greatest ramp capacity challenges are seen at Taylor Way, Capilano Road, Westview Drive and Lynn Valley Road. Cypress Bowl Road is also anticipated to have a very significant increase in volumes in the future, driven by new development on the north side of the highway.
- Several additional areas with challenging entry and exit movements were also noted, including the Highway 99 eastbound merge, the Caulfeild Interchange, and eastbound weaving between the 21st Street Interchange and the 15th Street/Cross Creek Road Interchange.

**Role of the Highway:**

- The highway corridor is primarily used for intra-regional or through-trips, which is the intended function of the highway corridor. However, roughly one-quarter to one-third of trips on the highway are internal to the North Shore; these trip types are not reflective of the intended role of the highway corridor.

- This high share of local trip-making exceeds shares on provincial highways in other parts of the region and is due in part to the lack of a continuous parallel municipal road network. The Capilano River Bridge provides a local/inter-municipal travel function due to limited alternative routes to cross the river.
- By Lynn Valley Road, almost all eastbound trips on the highway are destined to the Ironworkers Memorial Bridge.

**Transit:**

- Existing transit service along the corridor is very limited, and primarily confined to a single express bus route within the western portion of the study corridor between the Horseshoe Bay ferry terminal and the 15th Street/Cross Creek Road Interchange.
- Most cross streets provide transit service, with Lonsdale Avenue, Capilano Road and Lynn Valley Road having the most service.
- The eastern portion of the corridor, which is more congested, does not provide any transit service.
- Provision of such a transit service could help increase sustainable transportation mode share, which would be consistent with municipal, regional and provincial transportation policies, as well as the general principles of regional land use and affordable housing strategies. However, the existing corridor faces a number of challenges relating to the competitiveness of transit versus passenger vehicle travel times, transit and land use (lack of) integration/auto-centric land uses, stop accessibility and the waiting environment, travel desire lines, and transit speeds and reliability.

**Active Transportation:**

- Cycling is permitted along the highway corridor between the Horseshoe Bay ferry terminal and the Capilano Road Interchange.
- Key challenges for active transportation are located at the Lynn Valley Road Interchange (cross-corridor challenges), the Capilano Road Interchange and Capilano River Bridge (both on-corridor and cross-corridor challenges), the Lonsdale Avenue Interchange (cross-corridor challenges), the north side of the highway between Westview Drive and Taylor Way (on-corridor challenges), on Highway 1 near the Horseshoe Bay ferry terminal (on-corridor challenges) and at the Taylor Way Interchange (on-corridor challenges).

**Road Safety:**

- Collisions are primarily clustered around interchanges.
- The Capilano Road Interchange has the greatest safety challenges, followed by the Lynn Valley Road Interchange, the Westview Drive Interchange, and the Lonsdale Avenue Interchange.

**Network-Level Challenges:**

- Existing development on much of the North Shore is auto-centric, and there is an imbalance between growth in working-age population and employment, which creates the need for more trips across Burrard Inlet and along the Highway 1 corridor. The lack of housing opportunities on the North Shore at a range of affordability levels contributes to this challenge.

- Provincial, regional and municipal transportation policies all support increasing the mode share of sustainable transportation modes. A small overall increase in walking, cycling and transit mode shares on the North Shore by 2050 is anticipated; however, the resultant sustainable mode share will still be well below municipal and regional targets.
- The rate of growth in total person-hours travelled on the regional network, including on the North Shore, will exceed growth in total person-kilometres travelled, pointing to declining travel speeds throughout the region (including on the North Shore).
- Access to employment opportunities throughout the region for North Shore residents by auto lags the regional average; most of this difference is attributable to congestion, rather than its geographical location within the region. Congestion on the North Shore is anticipated to increase to a degree that the number of employment opportunities that North Shore residents can reach by auto within a given travel time will decrease relative to current conditions. Accessibility to employment opportunities by transit is anticipated to increase over time, but will still lag access by auto. Similar findings apply for North Shore employers' access to the regional labour force.

Given this wide range of challenges, the investigation of potential improvement opportunities has been organized into on-corridor improvement opportunities (discussed in Section 3) and interchange improvement opportunities (discussed in Section 4). On-corridor improvements focused on opportunities to provide more people-moving capacity along the eastern portion of the highway corridor, where congestion and operations issues are most acute. Several interchanges were identified as areas of focus for investigation of improvement opportunities. These interchanges, and the associated issues that were investigated, are:

- Capilano Road Interchange (located within the District of North Vancouver): road safety, traffic operations, active transportation and local connectivity.
- Lynn Valley Road Interchange (located within the District of North Vancouver): road safety, traffic operations and active transportation.
- 21st Street Interchange and 15th Street Interchange (both located within the District of West Vancouver): traffic operations.
- Westview Drive Interchange and Lonsdale Avenue Interchange (both located within the City of North Vancouver): road safety, ramp capacity, active transportation.
- Cypress Bowl Road Interchange and Westmount Road Interchange (both located within the District of West Vancouver): traffic operations.
- The Highway 99 Sea to Sky Merge (located within the District of West Vancouver): traffic operations.

Although these interchanges are the focus of this study with respect to concept development, this study is not intended to exhaustively address every issue at every interchange; there may still be opportunities for improvements at other interchanges along the corridor with respect to active transportation and transit and highway safety and reliability that could also be considered in the future.

# 3. POTENTIAL ON-CORRIDOR IMPROVEMENT OPPORTUNITIES

The development and high-level evaluation of the potential benefits and impacts of on-corridor improvement opportunities are structured as follows:

- Section 3.1 discusses the generation of concepts, including key design considerations for each on-corridor concept.
- Section 3.2 summarizes the framework used to provide an initial evaluation of the concepts.
- Section 3.3 provides an initial evaluation of the concepts.
- Section 3.4 discusses key considerations for further concept development.

A key challenge in developing and evaluating these on-corridor concepts is that, in some cases, there are interdependencies between the on-corridor concepts and the interchange concepts. Where applicable, these interdependencies are noted.

## 3.1 Development of Concepts

The focus for on-corridor concept development is to increase the people-moving capacity of the eastern portion of the highway study corridor between (roughly) the Capilano River and Lynn Valley Road. Three potential approaches to increase people-moving capacity were identified:

- Providing a bus service and transit priority measures via a bus-on-shoulder system.
- Providing an additional lane in each direction for use by high-occupancy vehicles (i.e., HOV lanes).
- Providing an additional general-purpose lane in each direction (i.e., six-laning).

Each of these potential approaches is described further below. Subsequently, a description outlining the overall opportunities with respect to improvements to active transportation facilities along and across the corridor is provided.

### 3.1.1 Bus-on-Shoulder System

Currently, there is no transit service along the eastern portion of the study corridor, which is the area of focus for on-corridor concept development. Therefore, there are no specific baseline transit service issues to improve upon in this portion of the corridor; rather, the “issue” is the lack of transit service in the first place. Although there are no baseline issues with an existing transit service to address, as touched upon in Section 2.4.2, several challenges were identified with respect to the feasibility of implementing a successful transit service along this portion of the highway corridor that a bus-on-shoulder system would need to address, including transit and land use, (lack of) integration, stop accessibility and the waiting environment, travel desire lines, and transit speeds and reliability.

Given the lack of an existing transit service, the development of a bus-on-shoulder system consists of two separate tasks:

- Defining a bus service concept.
- Defining the infrastructure concept, meaning configuration of the bus-on-shoulder system to provide this bus service with transit priority.

Each of these tasks is described below.

**BUS SERVICE CONCEPT**

The first step is developing a bus service concept. A bus service running along the highway in the vicinity of Taylor Way or Capilano Road to Lynn Valley Road would provide roughly a 6-kilometre-long route with 3 to 4 stops and little access to major destinations, and would be unlikely to attract strong ridership. Therefore, it was assumed that the service would need to extend further eastwards to Phibbs Exchange in order to provide connectivity with other bus services that run along the North Shore and across the Ironworkers Memorial Bridge to Vancouver and Burnaby.

Given that the service would run to Phibbs Exchange, through engagement with TransLink an opportunity was identified to join this service with another route that currently terminates at Phibbs Exchange: the recently launched Route 222, which provides a limited-stop service between Metrotown and Phibbs Exchange via Willingdon Avenue in Burnaby, Hastings Street in Burnaby and Vancouver, and the Ironworkers Memorial Bridge. Provision of on-corridor bus service as an extension of Route 222 would enable a direct connection between the Upper Levels Highway and several major destinations in Vancouver and Burnaby, including the Kootenay Loop transit exchange (for connections to other bus services, including the 95 B-Line), the Burnaby Heights neighbourhood, Brentwood Town Centre (both a major destination in its own right and a connection to the Millennium Line), BCIT and Metrotown (both a major destination in its own right and a connection to the Expo Line). Given that intra-regional trips accounted for 60%–65% of all trips on the highway, and an even higher proportion of trips for the segment of the highway near Lynn Valley Road where almost all highway users are bound for the Ironworkers Memorial Bridge, providing a transit service on the highway corridor that offers a seamless connection across Burrard Inlet will result in a service that corresponds to travel desire lines, and therefore increase the value of the service as an alternative to passenger vehicles.

Given the general service routing, the next step was to identify potential stop locations. The existing Route 222 is a limited-stop service, an approach that is well suited to an extension of the service along the highway corridor. Given the high cross-street transit service levels along Lynn Valley Road, Lonsdale Avenue and Capilano Road, these locations were identified for potential stops. In all cases, stops would need to be developed to provide efficient transfers to and from intersecting bus services on these three municipal streets, as well as safe and welcoming walking access and waiting areas.

Lynn Valley Road, which is part of the Frequent Transit Network, provides a transfer opportunity for two other bus services (Routes 228 and 255), both of which in turn provide access to the District of North Vancouver's Lynn Valley Municipal Town Centre and the broader Lynn Valley neighbourhood. However, as will be discussed further in the discussion of the infrastructure concept below, the existing configuration of the Lynn Valley Road Interchange does not lend itself to providing a stop for an on-corridor service. Therefore, such a stop was excluded from this initial assessment. The Lynn Valley Interchange improvement opportunities discussed in Section 4.2 would enable a stop to be provided at Lynn Valley Road.

Lonsdale Avenue, which is part of the Frequent Transit Network, provides a transfer opportunity for five other bus services (Routes 229, 230, 232, 241 and 242), which in turn provide connectivity to high-density, mixed-use areas in Lower Lonsdale, Central Lonsdale and (to a lesser extent) Upper Lonsdale. Lonsdale Avenue was also identified as a location for a rapid bus service in the TransLink North Shore Area Transit Plan, and it is understood that the City of North Vancouver also intends to undertake a separate planning study for the Lonsdale Avenue corridor, which may lead to increased emphasis supporting sustainable transportation, including transit. Finally, the proposed Harry Jerome project will provide 800 additional residences, as well as commercial and retail space within a short walk of the bus stops.

Capilano Road, although not part of the Frequent Transit Network, provides a transfer opportunity for three other bus services (Routes 236, 246 and 247), which in turn facilitate access to several residential neighbourhoods, the Edgemont Village, and popular regional destinations such as the Capilano Suspension Bridge and Grouse Mountain. From a service routing/bus manoeuvring perspective, the interchange configuration at Capilano Road is also well suited to acting as a terminus, although further investigation of the extend of lay-by areas and driver break facilities would be required.

The resultant assumed service routing and stop locations are shown in ***Figure 3.1*** below. For modelling purposes, consistent with the rest of Route 222, the service is assumed to run every 7 minutes in the 2050 AM and PM peak hours. It is noted that an alternate routing in the Lower Lynn area could also be considered, wherein the bus would use the Mountain Highway Interchange, Brooksbank Avenue and Main Street to travel between Phibbs Exchange and the cut.

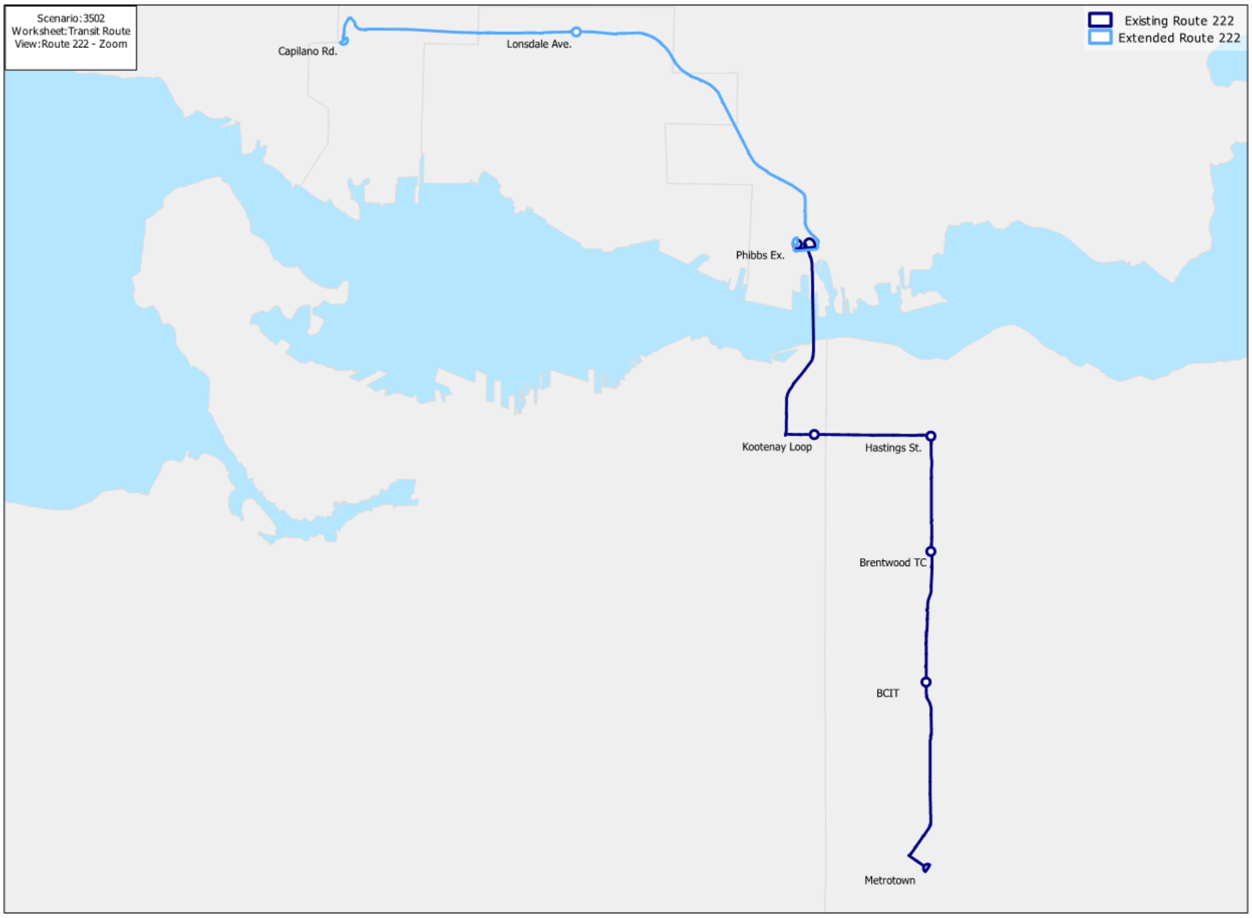


Figure 3.1: Service Concept for Extension of Route 222 Service on Highway 1 using Bus-on-Shoulder System

FOR DISCUSSION PURPOSES ONLY

It is emphasized that this service is one of many potential concepts, and has been developed purely for analysis purposes. Other service opportunities (e.g., further westward extension of the service to Horseshoe Bay or Park Royal, or an alternate routing from the Mountain Highway Interchange to Phibbs Exchange via either Brooksbank Avenue and Main Street, or Keith Road Mountain Highway) are also possible and could be considered further in the future.

## INFRASTRUCTURE CONCEPT

Bus-on-shoulder systems (shoulder running) are typically implemented on high-volume, congested highway corridors to improve the speed and reliability of transit service, and to increase the competitiveness of transit relative to private vehicles. Basic physical feasibility considerations for implementing a bus-on-shoulder system include sufficient shoulder width, horizontal and vertical clearances, period of use, and shoulder location.

With respect to period of use, bus-on-shoulder systems generally operate under two protocols: part-time shoulder use or full-time shoulder use (i.e., shoulder elimination). Key considerations for each of these period-of-use protocols are summarized as:

- Part-time:
  - Implemented at locations with recurring congestion due to lack of peak period general-purpose lane capacity relative to demands.
  - Used as an optional bypass.
  - Operates during a fixed time period (static) and/or during defined congested traffic conditions (dynamic).
  - Shoulder reverts to normal purpose during off bus-on-shoulder service.
  - Speed is usually set within a range of operating speeds of adjacent traffic to reduce unsafe speed differential.
- Full-time:
  - Operates at or near the speed of adjacent general-purpose lanes.
  - Usually serves high bus volume routes.
  - Provides greater level of service than part-time.

Full-time bus-on-shoulder systems are typically designed to a higher standard than part-time systems due to higher speeds, greater bus volume and length of facility. The minimum shoulder widths for part-time and full-time operation based on guidelines and other existing facilities (Highway 99 in Richmond/Delta/Surrey, RR174 in Ottawa, Don Valley Parkway in Toronto) are summarized in ***Table 3.1***.

Table 3.1: Typical Bus-on-Shoulder (BOS) Lane Width on Highways

| BOS Operation Protocol | Minimum Width | Minimum Shy Distance to Roadside Barrier |
|---|---|---|
| Part-time | 3.05 m (10') | 0.3 m to 0.6 m |
| Full-time | 3.5 m | 0.5 m to 1 m |

Given that, particularly in the eastbound direction, congestion can occur on the highway for extended period during both AM and (especially) PM peak hour, as well as on weekends, an assumption was made that a full-time bus-on-shoulder configuration would be provided.

The next major consideration is the position of the bus-on-shoulder system within the highway cross-section. A bus-on-shoulder typically operates on the outside shoulder, but some routes are more suitable on the inside shoulder where sufficient width is available. The advantages and disadvantages of the two configurations are summarized in ***Table 3.2***.

Table 3.2: Bus Lane Shoulder Location Comparison

| Bus Shoulder Location | Advantages | Disadvantages | Application |
|---|---|---|---|
| Outside | • Usually wider than inside shoulder<br>• Easier access to entrance/exit ramps | • Preferred location for emergency situations, enforcement stops, evasive movements, access for first responders<br>• Conflicts with merge/diverge areas of ramps<br>• Sight distance adequacy at on-ramps | • Bus routes that regularly use highway ramps for exit/entry to service offline stops |
| Inside | • Shoulder not used as much for emergencies and law enforcement stops<br>• No conflicts with merge/diverge areas of ramps | • Usually less width than outside shoulder<br>• Requires buses to weave through traffic to enter/leave shoulder at ramps; not desirable for a service with on-corridor stops<br>• Buses merge from the left into higher speed general traffic lane compared to more conventional merge from right to slower shoulder lane<br>• Potential sight distance issues at curves; may require greater lane width | • Bus routes that do not regularly use highway ramps and that have a relatively long distances between stops (or a non-stop service). |

Given the desire to provide offline stops, an outside shoulder configuration was selected. The resultant full-time outside shoulder concept would be relatively similar to existing bus-on-shoulder systems within the region such as those on Highway 99 in Richmond, Delta and Surrey, an example of which is provided in ***Figure 3.2*** below.

Figure 3.2: Example of a Full-Time Outside Shoulder Bus-on-Shoulder System in Surrey, BC

The existing shoulders along much of the highway corridor are too narrow to accommodate a bus; therefore, this concept would involve widening those shoulders to accommodate buses as well as providing stop locations that facilitate walk access and transfers to cross-corridor bus services. Conflicts with on-ramps and off-ramps at interchanges would be mitigated by providing loop detectors and automated warning flashers instructing drivers to yield at on-ramps, and by having the buses merge with traffic exiting the highway upstream of off-ramps. The general scope of the concept is described on a segment-by-segment basis below.

**Between Taylor Way and Capilano Road:** No bus-on-shoulder system would be provided here, as the service is assumed to terminate at Capilano Road. However, an opportunity to potentially extend the service further west in the future is considered as part of the exploration of Capilano Road Interchange improvement opportunities in Section 4.1. At the Capilano Interchange itself, westbound buses would exit the highway via the westbound off-ramp, and turn left onto Capilano Road at the north ramp terminal signalized intersection, where a new stop/lay-by area would allow for unloading, break time and loading. Buses would then turn left at the southern ramp terminal signalized intersection and re-enter the highway. The bus-on-shoulder lane would be developed beginning on the on-ramp, allowing buses to bypass much of the queueing/slowdown on this on-ramp (as reflected in the high volume-to-capacity ratio in ***Table 2.7***) and transition directly into the on-corridor shoulder bus lane.

**Between Capilano Road and Westview Drive Avenue:** From the Capilano Road Interchange until approximately Mackay Avenue, the highway corridor is relatively constrained by adjacent properties on the south side and Gladwin Street on the north side (with a roughly 10-metre-wide treed boulevard separating the highway from the street). Given the greater property impacts if the highway were to be widened to the south, it is anticipated that widening to accommodate dedicated transit lanes would instead need to occur primarily in the treed boulevard, which would require removal of the trees and result in relatively minimal separation between the highway and Gladwin Drive. In conjunction with improvements at the Capilano Road Interchange (described in Section 4.1) to address conflicts at the ramp terminals, it is anticipated that a barriered active transportation facility could be implemented on the south side of the highway corridor, and could tie in to the existing facility, which begins at Pemberton Avenue. The Pemberton Avenue pedestrian overpass structure and the Lloyd Avenue right-in/right-out conflict with the widening, and both facilities would need to be removed (although it is assumed that the overpass could be replaced, ideally with a structure that accommodates both walking and cycling).

Between Mackay Avenue and Edgemont Boulevard, the highway would be widened on either side through the Mackay Creek Greenbelt to accommodate transit facilities while also maintaining the existing active transportation facility on the south side of the highway. The highway right-of-way through this area is wide, and while this would not trigger any property impacts, it would still impact terrestrial habitats that are functionally (if not technically) part of the Mackay Creek Greenbelt. Beginning at the Edgemont Boulevard overhead structure, the highway widens to becomes a six-lane bridge structure across Mosquito Creek in order to provide west-facing ramps for the Westview Drive Interchange. Buses would use these ramp lanes, but would then be provided with a short new connection to transition to the existing six-lane cross-section beginning at Westview Drive.

**Between Westview Drive and Lonsdale Avenue:** In the westbound direction, between the Lonsdale Avenue on-ramp and Westview Drive, buses would simply make use of the existing outside general-purpose lane. In the eastbound direction, buses would transition into the auxiliary lane between the Westview Drive on-ramp and Lonsdale Avenue off-ramp, and then transition to a new bus-on-shoulder lane beginning after the Jones Avenue pedestrian overpass structure. The west-facing ramps at the Lonsdale Avenue Interchange would be widened to provide a dedicated ramp lane for buses, enabling them to bypass queues on the ramps, particularly for the eastbound off-ramp, which, per ***Table 2.7***, experiences volume-to-capacity ratio challenges (and by extension, queueing).

**Between Lonsdale Avenue and Lynn Valley Road:** At Lonsdale Avenue, buses would be provided with far-side transit stops at the corresponding ramp terminal intersection. Due to right-of-way constraints, these stops would need to be in the existing outside on-ramp lanes, representing a potential traffic operations challenge. In the westbound direction, a new dedicated bus lane would be provided on the off-ramp, while in the eastbound direction buses would use the existing general-purpose lane through the St. Georges Avenue right-in/right-out and the off-ramp would be provided with a shoulder bus lane closer to the merge point. Buses would continue in shoulder bus lanes, which could be provided (similar to the additional general-purpose lanes) by widening the highway into the median and repurposing part of the existing outside general-purpose lanes as a bus shoulder. On both approaches at the Lynn Valley Interchange, the bus would merge with traffic exiting the highway via the off-ramps, but then transition to continue on the highway. Providing continuous bus-on-shoulder through the interchange would require widening both sides of the existing bridge structure. East of the Lynn Valley Road Interchange, the bus-on-shoulder system would continue shoulder-running along the cut.

**Between Lynn Valley Road and Phibbs Exchange:** This section of the highway is outside the study scope; however, the bus service will still need to run along this section. Given the need for fast and reliable bus services along the highway corridor, and the fact that (particularly in the eastbound direction) congestion is anticipated between Lynn Valley Road and Phibbs Exchange, for travel demand modelling purposes it was assumed that the bus-on-shoulder system would extend all the way to Phibbs Exchange. No specific concept/scope for how this would occur has been developed, as this area is outside the study scope. As noted previously, several alternative off-corridor routings are also possible from Mountain Highway Interchange to Phibbs Exchange.

The resultant assumptions for a new bus-on-shoulder infrastructure are summarized in ***Figure 3.3***.

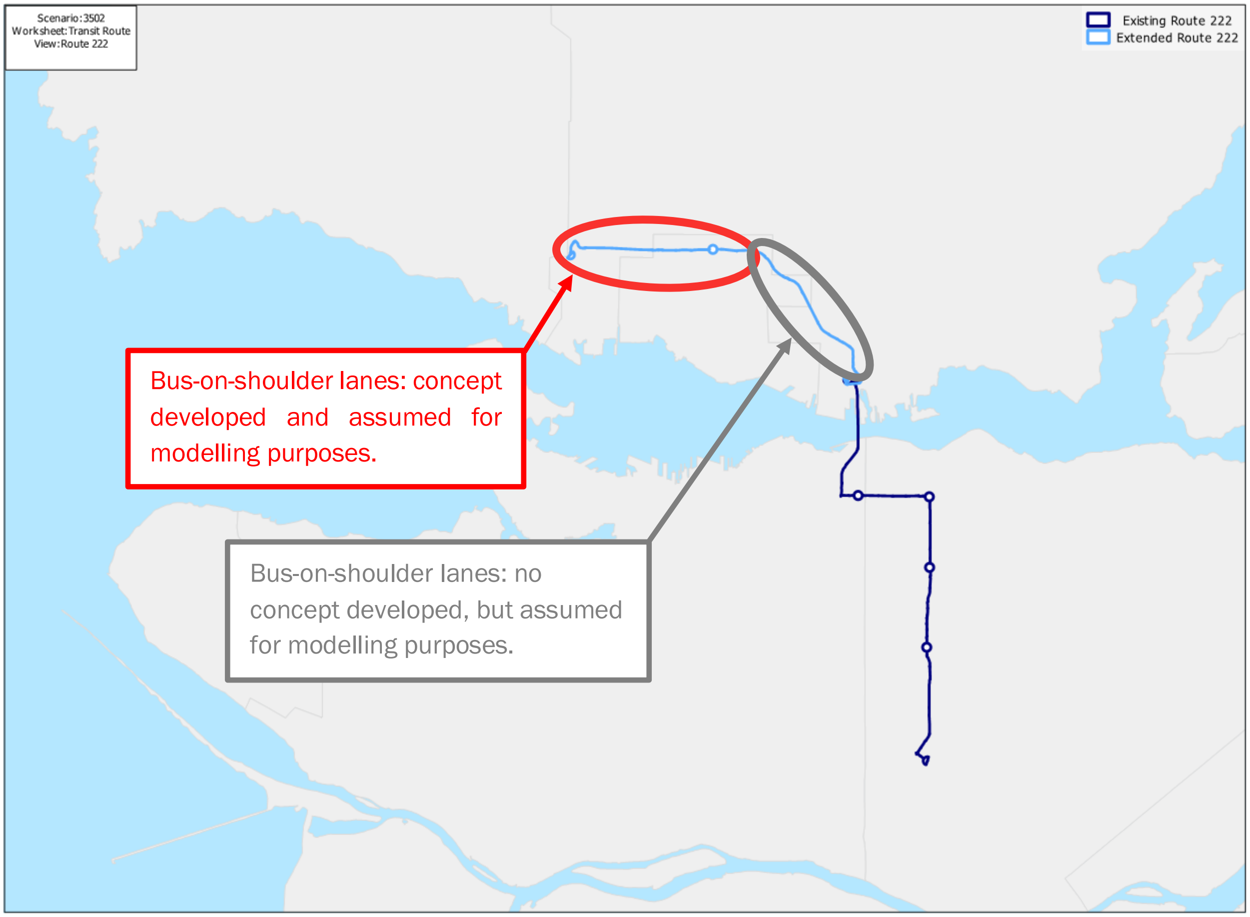


Figure 3.3: Infrastructure Concept for Extension of Route 222 Service on Highway 1 Using Bus-on-Shoulder System
FOR DISCUSSION PURPOSES ONLY

Potential strengths of the bus-on-shoulder system concept include:

- Transit service would provide an alternative for driving, enabling an increase in people-moving capacity while providing an approach that is more consistent with provincial, regional and municipal transportation policies, as well as the general principles of regional land use and affordable housing strategies.
- The system would allow buses to bypass congestion, increasing both the speed and reliability of service, and enabling the service to overcome some of the other disadvantages along the corridor.
- Additional bus volumes are low enough that there is not a risk that the additional volume (8–9 buses per hour, per direction) would contribute to congestion on the approach to the Ironworkers Memorial Bridge.
- The approach of using transit priority measures to overcome corridor limitations and help catalyze a new transit service has been applied successfully on other corridors, such as the Route 555 service, which runs along Highway 1 between the Carvolth Exchange in Langley and the Lougheed Town Centre SkyTrain Station in Burnaby.
- Bus-on-shoulder requires less widening than a full dedicated bus lane plus a separate shoulder.

The potential challenges of the bus-on-shoulder system concept include:

- Few high-density activity nodes "on the way" along the corridor.
- The study area is not the most congested part of Highway 1 on the North Shore. The segment of highway from Lynn Valley Road to the Ironworkers Memorial Bridge tends to be more congested than the study segment; therefore, the value of the bus-on-shoulder system may be limited unless it is extended further south towards the bridge. For modelling purposes, the assumed extension of the bus-on-shoulder system to Phibbs Exchange will address this issue.
- Bicycles would be unable to use highway shoulders in areas with a bus-on-shoulder system, although the provision of a separate barrier-protected pathway between Capilano Road and Westview Drive is intended to address this issue. Ideally, shoulder cycling would be extended to Lonsdale Avenue; however, there is insufficient room on the ramps to accommodate cycling, given that ramps are already being widened to provide a bus lane.

### 3.1.2 High-Occupancy Vehicle Lanes

This concept would involve provision of a high-occupancy vehicle (HOV) lane between the Capilano Road Interchange and Lynn Valley Road. Basic physical feasibility considerations for implementing an HOV lane include the location of the HOV lane within the highway, and vehicle occupancy requirements.

With respect to the location of an HOV lane, both inside-lane and outside-lane configurations are used. An example of an inside-lane HOV system is Highway 1 between 202$^{nd}$ Street in Langley and Grandview Highway in Vancouver. From an HOV operations perspective, the inside HOV lane requires vehicles to have relatively little traffic once inside, and do not require HOV lane users to weave with on-ramp and off-ramp traffic. For the purposes of avoiding creating turbulent flow and reducing conflicts, an inside HOV lane is generally preferable. However, while inside-lane HOV systems can be used by transit services for through-movements, this configuration creates challenges in terms of providing stops. Typically, an on-corridor service would require ramps on and off the highway to be implemented in the highway median to connect to the cross street above (or below) the highway. An example of such a median ramp configuration is shown on the right side of ***Figure 3.4*** below for access between Highway 1 and 202$^{nd}$ Street to access the Carvolth Exchange in Langley.

A further challenge for this approach is that because on-corridor bus movements will pass through the cross street, they are not well suited to being located in the middle of an existing interchange (where they would further complicate traffic operations at the ramp terminal intersections). For example, in ***Figure 3.4*** below, note how the HOV/transit lane is provided with its own separate "interchange" at 202$^{nd}$ Street, rather than running through the middle of the existing 200$^{nd}$ Street Interchange. The need for a separate nearby adjacent interchange creates challenges in terms of connecting to intersecting bus services. For example, if an on-corridor "Lonsdale Avenue" stop was instead provided at a new HOV/transit lane "interchange" at St. Georges Avenue (similar to Figure 3.4, where the transit stop is via 202$^{nd}$ Street rather than 200$^{th}$ Street), then it would not provide efficient transfers to the five bus routes on Lonsdale Avenue, and could diminish the value of the service. An alternative approach would involve widening the highway corridor to provide an "island" bus platform at highway level. This approach would provide somewhat more direct connectivity for transit services, but would require extensive widening of the highway to accommodate a bus island platform, bus stopping lanes and HOV bypass lanes (in total, roughly

5–6 lanes worth of width would be required). Vertical circulation and passenger waiting area facilities would also be required, resulting in this configuration providing more of a “bus station” than a “bus stop”.

Figure 3.4: Median Ramp Configuration (Right) and Separate General-Purpose Interchange (Left)

Outside-lane HOV systems represent an alternative approach that would allow for transit operations relatively similar to those for the bus-on-shoulder concept. Examples include Highway 99 southbound from Westminster Highway to Steveston Highway in Richmond, and Highway 7 from Meadow Gardens Way/Park Road to the Pitt River Bridge in Pitt Meadows. However, outside-lane HOV systems would introduce weaving movements between HOV traffic and vehicles entering and exiting the highway. Vehicles entering the highway would need to cross the HOV lanes to travel from the on-ramp and the general-purpose mainline lanes, and exiting vehicles would need to cross the HOV lanes to travel from the general-purpose lanes to the off-ramp. This increase in weaving movements would likely create turbulence in the traffic flow that could disrupt operations. Furthermore, outside-lane HOV systems would be more at risk of being affected by off-ramp queues that spill back onto the highway mainline.

In summary, if transit service with on-corridor stops is not planned to be provided along a highway corridor, then inside-lane HOV systems would typically provide the superior concept. If such a transit service is desired, then the primary concepts are to provide an inside-lane HOV system with either median ramps to a cross street away from the main interchange (costly, and does not provide efficient connections to cross-street transit services), highway-level island platforms with pedestrian vertical circulation to the main interchange (costly, and significant right-of-way requirements would likely create significant property impacts), or outside-lane concepts that generally follow the same approach as the bus-on-shoulder concept (less complex, but disruptive to overall operations as well as potentially introducing safety challenges).

For travel demand modelling purposes, it was assumed that an outside-lane configuration would be provided, although the operational feasibility of such a configuration would need to be confirmed through further design development.

The next other major consideration is the minimum vehicular occupancy to use the HOV lanes. Given the assumption that an outside-lane configuration would be provided, a more restrictive occupancy requirements (e.g., 3+ or higher) would reduce weaving conflicts at on-ramps and off-ramps. In general, specifying an occupancy level involves an assessment of existing distribution of occupancy levels and trade-offs in terms of incentivising higher occupancy, enabling a broader range of travellers to access the HOV lane, and avoiding degrading travel speeds for the highest occupancy users, with the intention of reducing overall person-hours of travel.

Within the context of this improvement opportunity, a key consideration of for minimum occupancy is the fact that, rather than this concept being part of a longer system of continuous HOV lanes, the scope is instead limited to a short segment between Capilano Road and Lynn Valley. Whereas a continuous HOV lane system (e.g., extending all the way from Capilano Road across the Ironworkers Memorial Bridge and tying in with the existing HOV lane system at the Grandview Highway/Boundary Road Interchange) would be well suited to a two-person minimum occupancy, the termination of the eastbound HOV lane upstream of the bridge (just downstream of Lynn Valley Road Interchange, specifically) means that the HOV lane effectively acts as a (partial) queue jumper rather than a continuous HOV lane. Queue jumpers serve to prioritize certain vehicles (usually those carrying multiple people) over others (usually those carrying only one person). However, if too many users have "priority", then the value of priority is ultimately diminished. In practice, a heavily used HOV lane ending just beyond the Lynn Valley Road Interchange runs the risk of simply introducing a new merging pinch point that would create queuing in both the HOV lane as well as the adjacent general-purpose lanes. For example, transit queue jumpers upstream of pinch points often function well, because the bus volume is relatively low as a percentage of overall vehicle; therefore, this additional demand in terms of number of buses has little impact on operations for all other vehicles. For this reason, restricting HOV lane use to higher occupancy levels (e.g., 3+, or potentially even higher) is preferable in order to reduce the number of vehicles in the HOV lane needing to merge into the general-purpose lane.

Notwithstanding these considerations, in assigning the HOV mode, the Regional Transportation Model does not specifically model different occupancy levels; instead, HOVs are assumed to have an average occupancy of 2.25 people. Given this limitation, for travel demand modelling, the results reflect an assumption of the HOV lane being permitted for use with a minimum vehicle occupancy of 2 people.

With respect to the physical layout of the HOV concept in terms of how the highway cross-section would be physically modified, the general approach would be relatively similar to the bus-on-shoulder concept described previously, with the exception that it would terminate at Lynn Valley Road and that, due to much higher volumes of HOVs than buses, conflicts with vehicles entering the highway from interchange on-ramps would need to be accommodated via weaving areas, rather than automated warning flashers instructing on-ramp traffic to yield.

Potential strengths of the HOV lane concept include:

- Would provide an opportunity to benefit the 30% to 50% of travellers along the corridor are already travelling via high-occupancy vehicles.
- The HOV lane could also be used to run transit service.

Potential challenges of the HOV lane concept include:

- The configuration as assumed for modelling purposes would introduce additional weaving along the corridor, which could create an operational and potential safety challenge.
- The lack of continuity of the HOV lane to/from existing facilities in Vancouver means that the lane would instead act as a queue jumper in the eastbound direction. It would be at risk of becoming a "victim of its own success" and create a merging issue just downstream of the Lynn Valley Road Interchange. This issue would still occur even if the HOV lane was extended slightly further to the east (e.g., to the Dollarton/Main Interchange).

### 3.1.3 Additional General-Purpose Lanes

This concept would involve widening the existing corridor from four lanes to six lanes for the entire distance between Taylor Way and Lynn Valley Road. From a design perspective, the additional general-purpose lane is likely the simplest concept, as the concept does not need to manage weaving movements created by buses and high-occupancy vehicles (noting that "simpler" does not necessarily imply "better").

The general scope of the concept is described on a segment-by-segment basis below.

**Between Taylor Way and Capilano Road:** Widening would occur via an improved Capilano Road Interchange and a twinned bridge crossing of the Capilano River. This means that this concept, as currently defined, is interdependent with improvements to the Capilano Road Interchange that are described below in Section 4.1.

**Between Capilano Road and Westview Drive:** From the Capilano Road Interchange until approximately Mackay Avenue, the highway corridor is relatively constrained by adjacent properties on the south side and Gladwin Street on the north side (with a roughly 10-metre-wide treed boulevard separating the highway from the street). Given the greater property impacts if the highway were to be widened to the south, it is anticipated that widening to accommodate two additional general-purpose lanes would instead need to occur primarily in the treed boulevard, which would require removal of the trees and result in relatively minimal separation between the highway and Gladwin Drive. In conjunction with improvements at the Capilano Road Interchange (described in Section 4.1) to address conflicts at the ramp terminals, it is anticipated that a barriered active transportation facility could be implemented on the south side of the highway corridor, and could tie into the existing facility that begins at Pemberton Avenue. The Pemberton Avenue pedestrian overpass structure and the Lloyd Avenue right-in/right-out conflict with the widening, and both facilities would need to be removed (although it is assumed that the overpass could be replaced, ideally with a structure that accommodates both walking and cycling).

Between Mackay Avenue and Edgemont Boulevard, the highway would be widened on either side through the Mackay Creek Greenbelt. The highway right-of-way through this area is wide, so this would not trigger any property impacts, although it would still impact terrestrial habitats that are functionally (if not technically) part of the Mackay Creek Greenbelt. Beginning at the Edgemont Boulevard overhead structure, the highway widens to becomes a six-lane bridge structure across Mosquito Creek in order to provide west-facing ramps for the Westview Drive interchange. Either the bridge structure across Mosquito Creek would need to be widened, or the west-facing ramps would need to be converted to a direct taper configuration, with the existing lanes on the bridge continuing eastwards to join the existing six-lane cross-section that develops underneath Westview Drive. The direct taper concept would reduce costs and environmental impacts associated with widening the bridge structure, but could introduce safety and operational challenges, and would require further investigation.

**Between Westview Drive and Lonsdale Avenue:** This section of the corridor is already six-laned and therefore no significant modifications are necessary. Between the east-facing Westview Drive Interchange ramps to the west-facing Lonsdale Avenue Interchange ramps, the cross-section is eight lanes, as auxiliary lanes are provided for weaving movements between the two interchanges. Currently, weaving is relatively straightforward, as lane occupancy in the outside though-lanes is low (since they are so short). However, if this concept were to be proposed, more detailed analysis would be required to assess weaving operations, as occupancy of the outside lanes is likely to increase if they were to continue over a longer distance.

**Between Lonsdale Avenue and Lynn Valley Road:** The corridor is already six-laned in the vicinity of Lonsdale Avenue, although the six-laned segment ends just prior to the east-facing ramps to the Lonsdale Avenue Interchange. The six-laning would be extended from the east-facing Lonsdale Avenue Interchange ramps to the west-facing Lynn Valley Road Interchange ramps by widening into the grassed highway median between the eastbound and westbound lanes. Widening into the median would reduce impacts on areas on the south side of the highway that are functionally (if not technically, as they are still within the highway right-of-way) part of Greenwood Park. The median currently facilitates a split grade crossing section, meaning that widening would require cutting and a retaining wall for the eastbound direction and/or retaining wall and fill for the westbound direction. The six-laning would terminate by tie-in to the west-facing ramps (i.e., ending at the eastbound off-ramp, and beginning at the westbound on-ramp) of the Lynn Valley Interchange. In principle, hard shoulder running could also be considered in this segment.

With respect to the overall cross-section of the six-laning, two potential variations of this concept were considered; one would involve a full six-lane cross-section with shoulders while the other would involve hard shoulder running during peak hours, which would be controlled by overhead lane control gantries. Hard shoulder peak-running is used in some jurisdictions where right-of-way is constrained in order to provide additional capacity during peak hours when volumes are highest. As travel speeds are generally slower during peak hours, the need for a shoulder is reduced; therefore, the highway operates without a shoulder since the shoulder is used as a vehicle lane instead. During off-peak hours when the capacity is not required and travel speeds are higher, the space resumes its function as a shoulder. In this particular application, hard shoulder running could potentially reduce the extent of terrestrial habitat impacts on widening the segment between Taylor Way and Capilano Road (Hugo Ray Park and Cedardale Park) as well as between Capilano Road and Westview Drive (the boulevard on the north side of the highway and the Mackay Creek Greenbelt). An example of a hard shoulder running system in Honolulu, Hawaii is shown in ***Figure 3.5***.


Figure 3.5: Example of an AM Peak Hour Hard Shoulder Running System in Honolulu, Hawaii

Potential strengths of the additional general-purpose lane concept include:

- The additional capacity on the highway corridor is available for use by the greatest number of users; other concepts do not provide additional capacity for single-occupancy vehicles, which is the mode by which the majority of people currently travel along the corridor.
- For a hard shoulder running system, less widening is required compared to a full separate lane, resulting in reduced costs and reduced property impacts.

Potential challenges of the additional general-purpose lane concept include:

- The study area is not the most congested part of Highway 1 on the North Shore. The bridgeheads still govern flow, and the concept may simply result in eastbound vehicles reaching the end of the bridge queue slightly sooner but then waiting longer, resulting in little net benefit.
- For a hard shoulder running, bicycles would not be able to use shoulders simultaneously with shoulder-running vehicles, which could potentially result in the removal of shoulder cycling between Taylor Way and Capilano Road. The feasibility of providing time-of-day/day-of-week restrictions for shoulder cycling on the highway could be explored, but it is anticipated that this could create an enforcement challenge.
- As currently scoped, this concept would also require the Capilano Road Interchange improvement opportunity described below in Section 4.1, although the scope could be reduced for the additional general-purpose lanes to begin east of Capilano Road instead.

For the purposes of analysis, it was assumed that a full additional general-purpose lane would be provided in order to avoid impacting on-corridor cycling.

### 3.1.4 Active Transportation Provisions

Several potential considerations were noted in the preceding sections with respect to maintaining existing active transportation facilities as well as implementing new facilities. However, a more consolidated discussion focused specifically on active transportation considerations is discussed herein to provide further information on the potential extent of active transportation improvement opportunities. Considerations related to on-corridor active transportation (which could include use of the highway shoulder as well as facilities adjacent/parallel to the highway corridor) are organized into three geographic areas. Running west to east, these segments are:

- Horseshoe Bay to Capilano Road: As noted previously in ***Figure 2.3***, Highway 1 already permits on-corridor shoulder cycling between Horseshoe Bay and Capilano Road. Although there is some room for improvement to on-corridor cycling (e.g., those listed above in ***Table 2.23***), even if these improvements were to be implemented, cycling on the highway shoulder is unlikely to appeal to people of all ages and abilities. Therefore, while the provincial highway corridor could be used to provide an all-ages-and-abilities connection across the Capilano River, a tie-in with east-west municipal active transportation facilities developed by the District of West Vancouver is a key consideration to ensure continuity and connectivity to other facilities that may be more comfortable for all types of users.
- Capilano Road to Westview Drive: In this segment, the north-south oriented Mackay Creek and Mosquito Creek fragment the east-west municipal transportation network, including active transportation facilities. Therefore, this segment of the corridor was the primary focus with respect to exploring on-corridor active transportation improvements.
- Between Westview Drive and Lynn Valley Road, there is a more complete municipal street network that lends itself to providing parallel high-quality east-west cycling corridors. The City of North Vancouver already has several formal and informal bike routes in this area, and has plans to implement the Upper Levels Greenway in the future. This greenway will (roughly) parallel the highway to the north, and provide a high-quality continuous east-west facility. Therefore, the focus in this section was understanding how any provincial facilities could connect to municipal facilities.

In general, all three on-corridor concepts described above have a somewhat similar physical footprint (i.e., the addition of a wider shoulder for buses, or a new lane for high-occupancy vehicles or general-purpose vehicles). Therefore, the potential for active transportation facilities does not vary significantly from one concept to another. In addition to these on-corridor active transportation improvement opportunities, there are a range of active transportation improvement opportunities that have been identified at specific interchanges, which are described further in Section 4.

A graphic showing key provincial and municipal facilities is shown in ***Figure 3.6***. This figure is not intended to be an exhaustive inventory of all active transportation facilities that interface with the highway; instead, it provides a “big picture” summary that shows key existing provincial and municipal facilities, as well as opportunities for new and improved facilities. Ultimately, the figure highlights the need for continued multi-agency coordination to ensure continued progress towards an active transportation network that, from the user perspective, provides safe, efficient and seamless connectivity, regardless of what agency has jurisdiction over any individual element.

Potential provincial active transportation improvements that are classified as “on-corridor” improvements are discussed below. Potential improvements at interchanges are discussed in Section 4 below, in the corresponding subsection noted on the graphic. With respect to potential new or improved provincial facilities, the figure includes concepts that have been specifically included as part of the scope of on-corridor or interchange improvement concepts, as well as ideas that at this point have simply been identified as opportunities for further exploration.

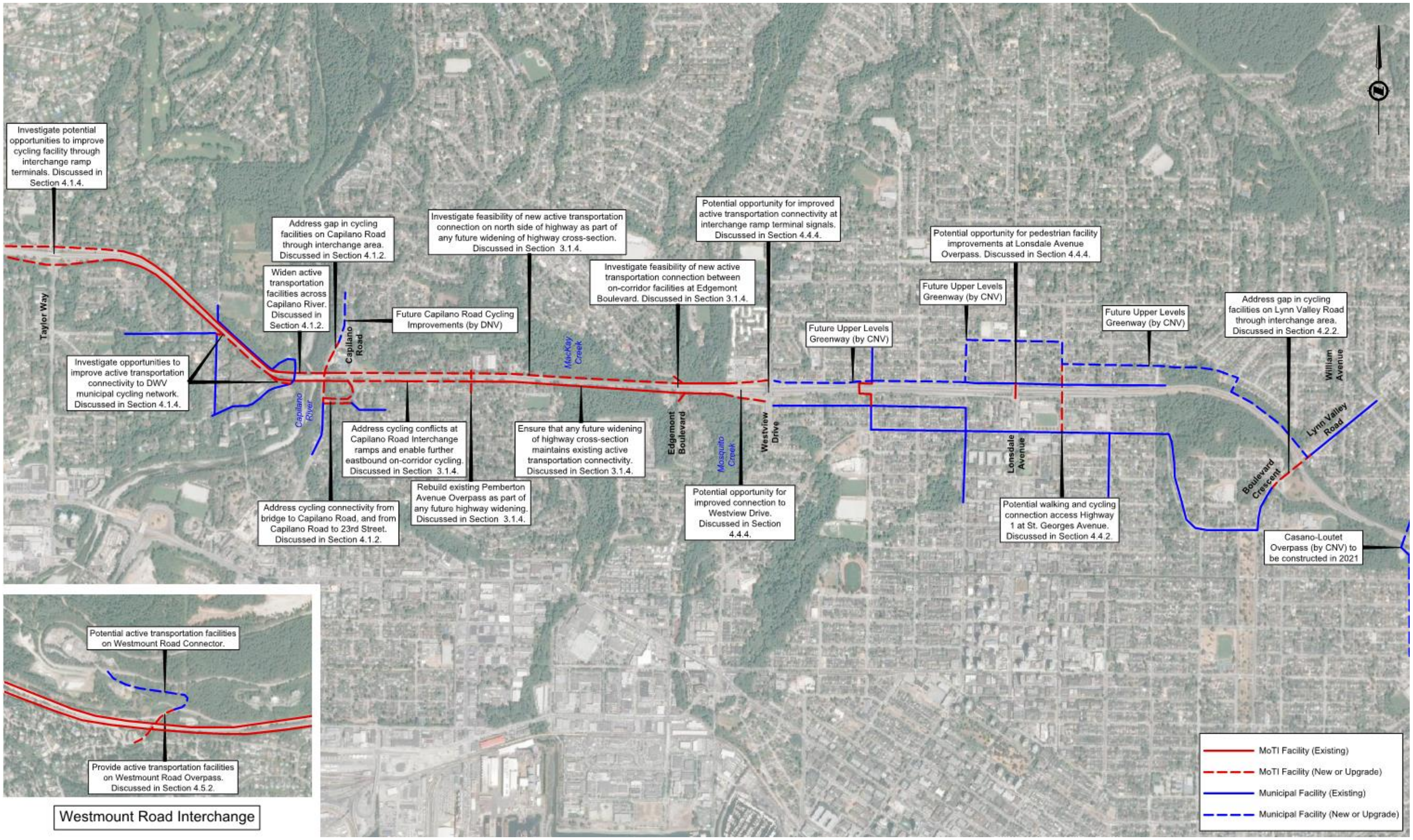


Figure 3.6: Key Existing and Potential New Improved Opportunities for Provincial and Municipal Active Transportation Infrastructure

The four major “on-corridor” active transportation opportunities noted on the figure include:

- **Replacement of Pemberton Avenue Overpass:** Although this overpass facilitates cross-corridor rather than on-corridor active transportation, the need to replace the structure is driven by on-corridor improvements. Specifically, the locations of the overpass pier structures conflict with any widening of the highway cross-section (regardless of whether the widening is to provide a bus lane/shoulder, HOV lanes or a general-purpose lanes); therefore, the structure will need to be demolished and rebuilt. The need to replace the structure provides an opportunity to provide a connection that meets modern best practices for active transportation facilities with respect to design considerations such as facility width, grades and lighting. The Casano-Loutet Overpass, planned to be built by the City of North Vancouver in 2021, provides a good design precedent for an overpass structure that is consistent with modern best practices with respect to active transportation facilities.
- **Maintain Existing South Side Multi-Use Path:** There is currently a barrier-protected walking and cycling pathway on the south side of the highway between Pemberton Avenue and Westview Drive. This path is the only paved east-west active transportation connection between W Queens Road and Larson Road (which are located 1.5 kilometres apart). Therefore, maintaining this connectivity is critical, and widening the highway corridor to accommodate additional laning will need to be done in a manner that avoids removing this path. This path also interfaces with potential improvements at Capilano Road (discussed in Section 4.1.2), Westview Drive (discussed in Section 4.4.4) and Edgemont Boulevard (discussed below). It is acknowledged that avoiding removing a pathway is not necessarily an “improvement” relative to the status quo, but instead avoidance of a negative impact. However, as part of any design development, the opportunity to widen the path further could be investigated, although there may be trade-offs with respect to the feasibility of also providing a new “north side” path, as discussed below.
- **Explore a Potential New “North Side” Multi-Use Path:** Recognizing the lack of nearby alternative east-west municipal connections between Capilano Road and Westview Drive, there is an opportunity to explore the feasibility of providing a new multi-use path on the north side of the highway corridor to complement the existing facility on the south side. Similar to the facility on the south side, this facility could be barrier-protected to provide a safer and more comfortable experience for people of all ages and abilities. This facility could provide a more direct east-west connection north of the highway corridor that eliminates the need for people walking and cycling to cross back and forth across the highway corridor as part of their journey. Given the other widening being considered (i.e., for both motorized modes, and the potential widening of the path on the south side of the highway), further investigation would likely be required to confirm whether right-of-way is available for this new path, given the various other cross-sectional widening being considered. For example, towards the west of this segment (i.e., between Capilano Road and Mackay Avenue), the facility may need to transition to a local street bike route on Gladwin Drive.
- **Connectivity to Edgemont Boulevard:** The walking and cycling path on the south side of the highway corridor has a steep sidewalk connection to Edgemont Boulevard, and there is an opportunity to replace this with a path that allows bidirectional walking and cycling. On the north side of the highway corridor there is a sidewalk on the bridge over Mosquito Creek, but no formal connection to Edgemont Boulevard. Providing such a connection (in conjunction with other improvements at Westview Drive Interchange discussed in Section 4.4.4) could improve walking connectivity (and potentially cycling connectivity, if the new north side multi-use path were to be incorporated) across Mosquito Creek.

## 3.2 Evaluation Framework

In order to assess the relative merits of the three on-corridor concepts relative to a “do nothing” base case, evaluation criteria were developed based on the Multiple Account Evaluation methodology typically used for Ministry of Transportation and Infrastructure planning studies. Recognizing that all concepts are in the very early stages of development, a high-level multiple account evaluation framework was developed that includes the following:

- Transportation performance.
- Socio-community impacts.
- Environmental impacts.
- Capital costs.

At this point in time, no detailed analysis of geotechnical conditions, structural engineering considerations or environmental and archaeological implications has been undertaken. For all improvement opportunities outlined herein, further development, investigation, engagement and evaluation across a range of financial, transportation, social, environmental, archaeological and economic criteria is required prior to proceeding towards implementation. The above-noted evaluation criteria are defined and the methodology (or methodologies, as applicable) to evaluate the criteria are described in the subsections that follow.

Although some transportation performance metrics and capital costs can be quantified, many of the other benefits and impacts can only be evaluated at a qualitative level. Therefore, to evaluate qualitative scoring consistently, a five-level rating system was applied as shown in ***Table 3.3***.

Table 3.3: Qualitative Scoring Format

| Score | Meaning |
|---|---|
| ○ | Significantly Worse |
| ◔ | Somewhat Worse |
| ◑ | Similar to Base Case/Neutral |
| ◕ | Somewhat Better |
| ● | Significantly Better |

In addition to the on-corridor concepts, elements of the evaluation framework described herein will also be applied to the evaluation of interchange improvement concepts described subsequently in Section 4. Note that criteria/indicators are only considered for evaluation where they are applicable.

### 3.2.1 Transportation Performance

Transportation performance metrics are based on the same metrics previously developed in the technical assessment of mobility at the corridor level and network level in Section 2.4 and Section 2.5, respectively.

Additionally, an estimate of consumer surplus for year 2050 using the rule-of-half methodology is provided. All outputs for the consumer surplus analysis are based on straight travel time savings (i.e., no weights or costs).

Consumer surplus was expanded from peak hours to daily and then annualized values using the expansion factors in ***Table 3.4*** and ***Table 3.5***, respectively. Values were then monetized using outputs from the BC Ministry of Transportation and Infrastructure *Default Values for Cost Benefit Analysis* (2018), which have been adjusted to 2020 values based on the Statistics Canada Consumer Price Index. The resultant values of time are $19.23/person-hour for personal travel, $38.77/hour for light goods vehicles and $47.31/hour for heavy goods vehicles.

Table 3.4: Peak-to-Daily Expansion Factors

| Time Period | SOV | HOV | LGV[11] | HGV[12] | Bus | Rail | WCE |
|---|---|---|---|---|---|---|---|
| AM | 3.44 | 1.51 | 3.59 | 4.88 | 2.54 | 2.53 | 3.34 |
| MD | 8.41 | 8.58 | 5.63 | 5.43 | 9.44 | 9.54 | 0 |
| PM | 3.95 | 5.32 | 6.17 | 6.36 | 2.57 | 2.92 | 2.02 |

Table 3.5: Daily-to-Annual Expansion Factors

| Time Period | SOV | HOV | LGV | HGV | Bus | Rail | WCE |
|---|---|---|---|---|---|---|---|
| 24 Hours | 335 | 335 | 313 | 276 | 299 | 331 | 224 |

As there is no specific timeline for the implementation of concepts, transportation performance metrics have been quantified and monetized where possible, but only provided as an annualized value for the 2050 horizon year, rather than being provided as a present value for a full 25-year evaluation period.

In addition to consumer surplus, for interchange concepts (which are discussed in Section 4) road safety benefits were also able to be quantified and monetized. Collision history data described previously in Section 2.6 was used to determine an annual average number of collisions overall, as well as the annual average number of collisions of each severity type: property damage only (PDO), injury and fatal. Road safety changes resulting from each improvement concept were estimated using collision modification factors. The collision modification factors relevant to each improvement type were then applied to estimate the annual average number of collisions that may occur after the improvement concept is implemented. Monetization of these collision reductions was undertaken using outputs from the BC Ministry of Transportation and Infrastructure *Default Values for Cost Benefit Analysis* (2018), which have been adjusted to 2020 values based on the Statistics Canada Consumer Price Index. The resultant values of time are approximately $14,000 for a property damage only collision, $410,000 for an injury collision, and $8,230,000 for a fatality collision.

Due to a lack of data to establish a relationship between the change in volume and the change in collision frequency, the reduction in collisions facilitated by the improvement concept was assumed to remain constant, and similar to consumer surplus, was provided for a single year rather than as a present value for a full 25-year evaluation period.

### 3.2.2 Socio-Community Impacts

[11] Light goods vehicle.
[12] Heavy goods vehicle.

The socio-community impacts criterion considers how an improvement concept may impact the community. This assessment was based on high-level desktop investigations using local land uses and previous studies. Considerations for this criterion include:

- Properties acquisition requirements.
- Community severance (i.e., highway seen as a barrier, or acts as a barrier).
- Visual and noise impacts.
- Consistency with community and regional plans.

Impacts on archaeological sites are also a key consideration; however, at this point in time, no archaeological investigations (either field or desktop) have been undertaken. Review by professional archaeologists is required, should any of these concepts be considered in more detail.

### 3.2.3 Environmental Impacts

The environmental impact criterion considers how a concept may potentially impact terrestrial and aquatic habitats, as well as greenhouse gas emissions from motorized transportation modes. Terrestrial and aquatic impacts were reviewed at a very high level, and would require review by professional biologists, should any of these concepts be considered in more detail.

### 3.2.4 Capital Costs

The design and construction cost of each concept was assessed using a high-level single line sketch, typical unit costs and the methods of Highway Cost Estimating Using the Elemental Parametric Method. Given the highly conceptual nature of the project scope and the lack of engineering detail, contingencies have been provided to all estimates. It is noted that neither property costs nor escalation costs have been included at this point in time. Furthermore, only capital costs are considered at this stage, although it is acknowledged that a full benefit cost analysis would also need to capture property costs, maintenance and rehabilitation costs (including foregone expenses for infrastructure nearing the end of its service life that is being replaced as part of a concept, transit operating costs and farebox revenue, and salvage value.

Given these limitations, for the purposes of reporting, cost estimates have been grouped into the following qualitative approximate/general ranges:

- $: $0 million – $5 million
- $$: $5 million – $10 million
- $$$: $10 million – $50 million
- $$$$: $50 million – $100 million
- $$$$$: $100 million+

## 3.3 Evaluation of Concepts

### 3.3.1 Transportation Performance

#### TRAVEL VOLUMES BY MODE (CORRIDOR LEVEL)

Trip volumes are provided across the two screenlines provided previously in Section 2.4.2 are updated to include screenline volumes for the 2050 baseline condition as well as for the three on-corridor improvement concepts. Eastbound volumes for these two screenlines are presented in ***Figure 3.7*** and ***Figure 3.8***, respectively. The corresponding westbound volumes are presented in ***Figure 3.9*** and ***Figure 3.10***.

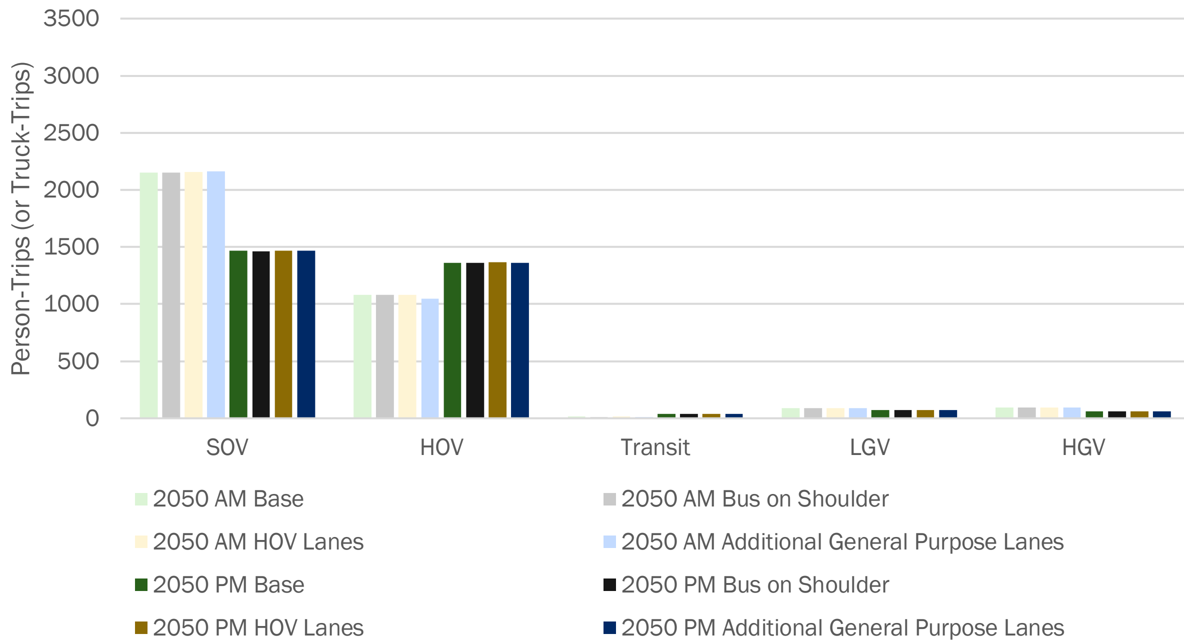


Figure 3.7: Eastbound Screenline Between Cypress Bowl Road and 21st Street

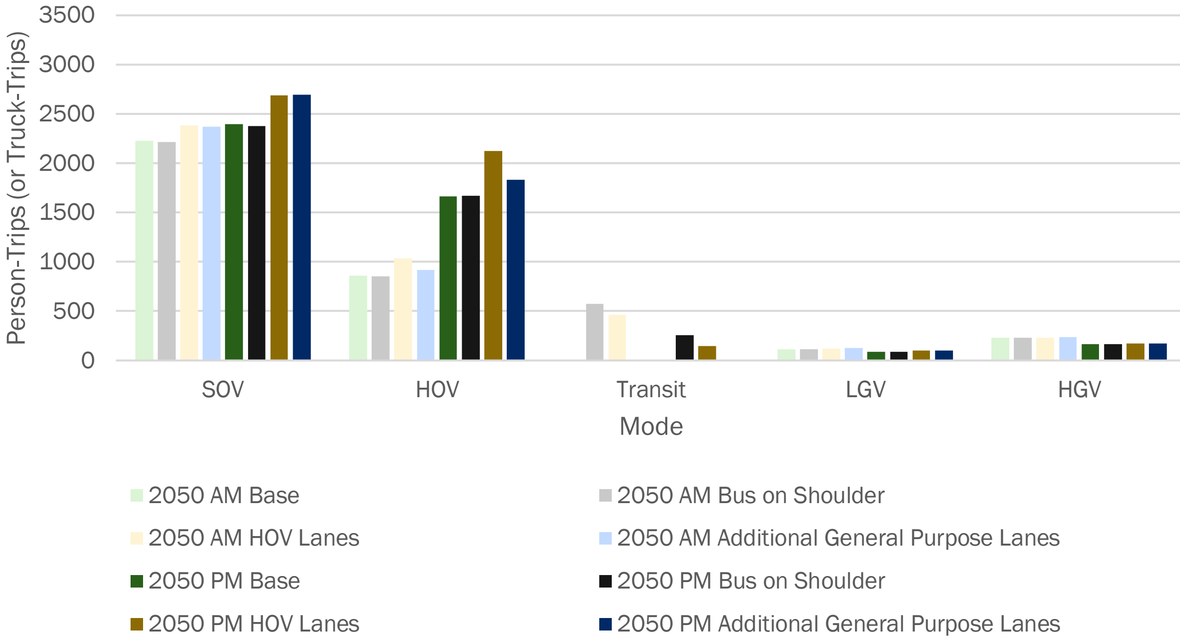


Figure 3.8: Highway 1 Eastbound Screenline Between Lonsdale Avenue and Lynn Valley Road

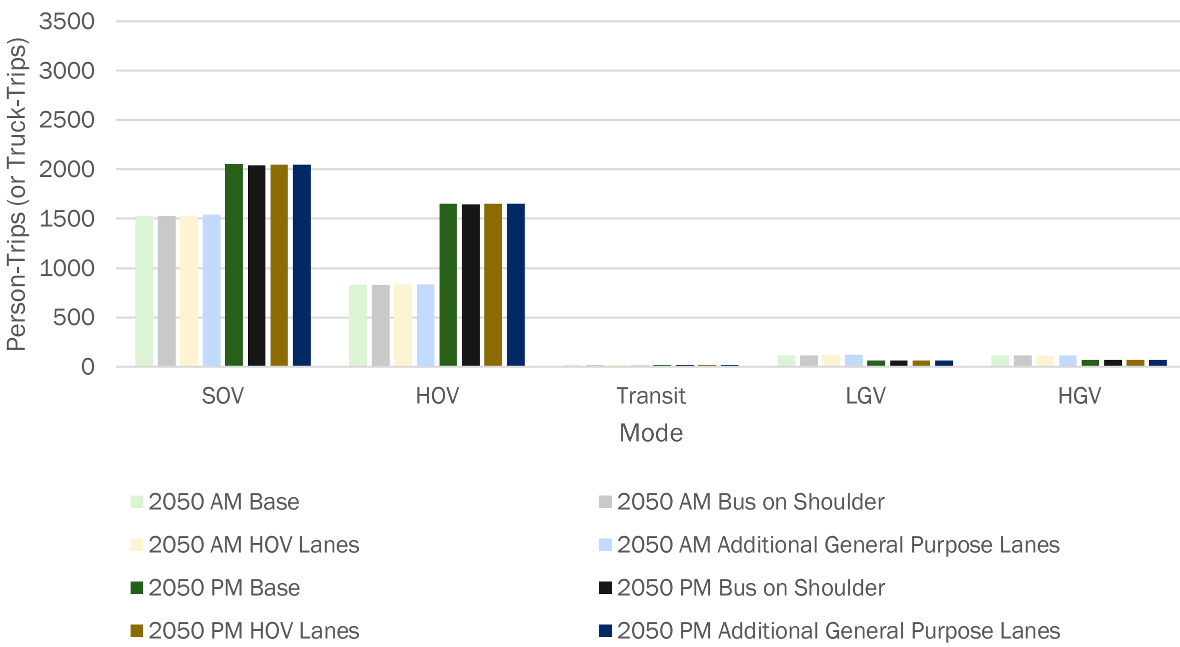


Figure 3.9: Highway 1 Westbound Screenline Between 21st Street and Cypress Bowl Road

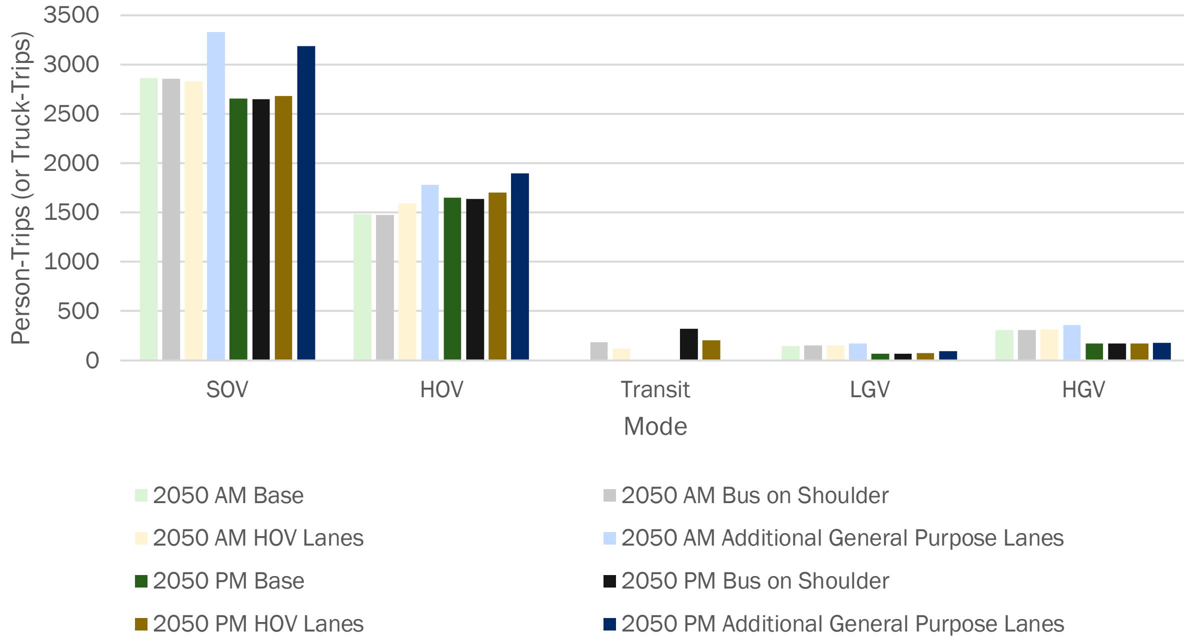


Figure 3.10: Highway 1 Westbound Screenline Between Lynn Valley Road and Lonsdale Avenue

The screenline in West Vancouver between Cypress Bowl Road and 21st Street shows very little difference between the concepts in the eastbound and westbound directions. This result is expected, as the on-corridor improvements are located further to the east. However, the result suggests that long distance trips to and from West Vancouver are largely unaffected by capacity increases in North Vancouver.

Between Lynn Valley Road and Lonsdale Avenue, however, there is considerable difference. The bus-on-shoulder concept generates new transit trips through this screenline although there is no decrease in either SOV or HOV volumes. This suggests that the main benefit of the transit service is not travel time savings for existing highway uses, but rather increased capacity for people on the North Shore to access opportunities throughout the region (and vice versa) without further increasing congestion.

With respect to specific ridership patterns, the dominant direction is eastbound in the AM and westbound in the PM, suggesting that the transit service is being used by North Shore residents travelling to the rest of the region, rather than vice versa. However, counter-peak volumes are still strong, with North Shore-inbound (i.e., westbound) AM transit ridership being roughly one-third of outbound (i.e., eastbound) ridership in the AM, and outbound trips being roughly 75% of inbound trips in the PM peak hour. The relatively balanced utilization, particularly in the PM, creates a condition that would result in strong utilization of available transit capacity, compared to highly directional services that are very busy in one direction but almost empty in the other direction.

The HOV concept sees increases in HOV volumes, as well as SOV volumes, likely taking advantage of reduced demand in the general-purpose lanes as HOVs move to their dedicated lane. The HOV concept also generates transit trips, although bus-on-shoulder transit ridership is 50%—65% higher as compared to ridership in the HOV concept. The HOV concept sees the greatest overall throughput in terms of the total number of people crossing the screenline during peak hours.

The additional general-purpose lanes (six-laning) concept shows substantial increase for both SOV and HOV, particularly in the westbound direction which is less congestion than the eastbound direction. This finding suggests that increasing capacity on the highway between Taylor Way and Capilano Road will encourage more trips on the highway (which could be a result of travellers changing route choice, mode choice or destination choice). Truck volumes are largely unaffected by any of the concepts.

### VOLUME-TO-CAPACITY RATIO

Volume-to-capacity ratios for the eastbound 2050 baseline condition as well as for the three on-corridor improvement concepts are provided in ***Table 3.6*** and ***Table 3.7*** for the AM peak hour and PM peak hour, respectively. The corresponding westbound volume-to-capacity ratios are provided in ***Table 3.8*** and ***Table 3.9***. For the HOV concept, volume-to-capacity ratios are reported separately for the general-purpose lanes and HOV lane since the two facilities will have different utilization levels. For the bus-on-shoulder concept, the volume-to-capacity ratio represents the condition of the general-purpose lane. The bus-on-shoulder lane will have a very low volume-to-capacity ratio since “demand” is 8—9 vehicles (i.e., buses) per hour in each direction. Note that because these results are taken from a macroscopic static assignment, any queue spillbacks (e.g., from the Ironworkers Memorial Bridge) do not compound volume-to-capacity ratios on upstream links.

Table 3.6: Eastbound Highway Segment Volume-to-Capacity Ratios – 2050 AM Peak Hour

| From | To | Concept | | | | |
|---|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes (GP Lanes) | HOV Lanes (HOV Lane) | Additional General-Purpose Lanes |
| Eagleridge Drive | Highway 99 | 0.58 | 0.58 | 0.58 | 0 | 0.58 |
| Highway 99 | Caulfeild Interchange | 0.54 | 0.54 | 0.54 | 0 | 0.55 |
| Caulfeild Interchange | | 0.65 | 0.65 | 0.65 | 0 | 0.66 |
| Caulfeild Interchange | Westmount Road Interchange | 0.66 | 0.66 | 0.66 | 0 | 0.66 |
| Westmount Road Interchange | | 0.88 | 0.88 | 0.88 | 0 | 0.88 |
| Westmount Road Interchange | Cypress Bowl Road Interchange | 0.64 | 0.64 | 0.64 | 0 | 0.64 |
| Cypress Bowl Road Interchange | | 0.86 | 0.86 | 0.86 | 0 | 0.86 |
| Cypress Bowl Road Interchange | 21st Street Interchange | 0.85 | 0.85 | 0.85 | 0 | 0.85 |
| 21st Street Interchange | | 0.82 | 0.82 | 0.82 | 0 | 0.82 |
| 21st Street Interchange | 15th Street Interchange | 0.58 | 0.58 | 0.58 | 0 | 0.59 |
| 15th Street Interchange | | 1.05 | 1.05 | 1.06 | 0 | 1.07 |
| 15th Street Interchange | Taylor Way Interchange | 0.97 | 0.97 | 0.97 | 0 | 0.99 |
| Taylor Way Interchange | | 0.99 | 0.99 | 1 | 0 | 0.76 |
| Taylor Way Interchange | Capilano Road Interchange | 0.92 | 0.92 | 0.93 | 0 | 0.63 |
| Capilano Road Interchange | | 0.94 | 0.94 | 0.87 | 0 | 0.6 |
| Capilano Road Interchange | Westview Drive Interchange | 0.87 | 0.87 | 0.77 | 0.3 | 0.62 |
| Westview Drive Interchange | | 0.5 | 0.76 | 0.68 | 0.24 | 0.53 |
| Westview Drive Interchange | Lonsdale Avenue Interchange | 0.54 | 0.54 | 0.65 | 0.35 | 0.58 |
| Lonsdale Avenue Interchange | | 0.96 | 0.96 | 0.77 | 0.25 | 0.6 |
| Lonsdale Avenue Interchange | Lynn Valley Road Interchange | 0.89 | 0.89 | 0.83 | 0.3 | 0.62 |
| Lynn Valley Road Interchange | | 1.08 | 1.08 | 0.87 | 0.29 | 1.12 |

Table 3.7: Eastbound Highway Segment Volume-to-Capacity Ratios – 2050 PM Peak Hour

| From | To | Concept | | | | |
|---|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes (GP Lanes) | HOV Lanes (HOV Lane) | Additional General-Purpose Lanes |
| Eagleridge Drive | Highway 99 | 0.49 | 0.49 | 0.49 | 0 | 0.49 |
| Highway 99 | Caulfeild Interchange | 0.59 | 0.59 | 0.59 | 0 | 0.6 |
| Caulfeild Interchange | | 0.61 | 0.61 | 0.61 | 0 | 0.61 |
| Caulfeild Interchange | Westmount Road Interchange | 0.58 | 0.58 | 0.58 | 0 | 0.58 |
| Westmount Road Interchange | | 0.79 | 0.79 | 0.79 | 0 | 0.79 |
| Westmount Road Interchange | Cypress Bowl Road Interchange | 0.58 | 0.58 | 0.58 | 0 | 0.58 |
| Cypress Bowl Road Interchange | | 0.78 | 0.78 | 0.78 | 0 | 0.78 |
| Cypress Bowl Road Interchange | 21st Street Interchange | 0.67 | 0.67 | 0.67 | 0 | 0.67 |
| 21st Street Interchange | | 0.65 | 0.65 | 0.65 | 0 | 0.65 |
| 21st Street Interchange | 15th Street Interchange | 0.51 | 0.52 | 0.52 | 0 | 0.53 |
| 15th Street Interchange | | 0.99 | 1 | 0.99 | 0 | 1.03 |
| 15th Street Interchange | Taylor Way Interchange | 0.91 | 0.93 | 0.92 | 0 | 0.97 |
| Taylor Way Interchange | | 1.03 | 1.06 | 1.05 | 0 | 0.83 |
| Taylor Way Interchange | Capilano Road Interchange | 1.01 | 1.04 | 1.03 | 0 | 0.71 |
| Capilano Road Interchange | | 1.14 | 1.12 | 0.93 | 0 | 0.72 |
| Capilano Road Interchange | Westview Drive Interchange | 1.12 | 1.14 | 0.95 | 0.62 | 0.79 |
| Westview Drive Interchange | | 0.61 | 0.93 | 0.77 | 0.52 | 0.66 |
| Westview Drive Interchange | Lonsdale Avenue Interchange | 0.64 | 0.64 | 0.74 | 0.64 | 0.71 |
| Lonsdale Avenue Interchange | | 1.11 | 1.13 | 0.87 | 0.57 | 0.78 |
| Lonsdale Avenue Interchange | Lynn Valley Road Interchange | 1.02 | 1.02 | 0.89 | 0.6 | 0.75 |
| Lynn Valley Road Interchange | | 1.16 | 1.15 | 0.89 | 0.56 | 1.21 |

Eastbound volume-to-capacity ratios are largely below 1.0 throughout the study area in the AM in the 2050 base, with the main exceptions being through the 15th/Cross Creek Road Interchange and the Lynn Valley Road Interchange. In the PM, the entire segment of the highway from the Taylor Way Interchange to the east end of the study area is above 1, with the exception of the existing six-laned segment of the corridor around Westview Drive and Lonsdale Avenue.

Under the bus-on-shoulder concept, there is very little change from the base case concept, with the only exception being in the vicinity of the Westview Drive Interchange where some general-purpose lane capacity reduction is required to accommodate the transit lane.

The HOV concept sees a similar pattern, with volume-to-capacity ratios between Capilano Road and Lynn Valley Road decreasing. The decreases are not as strong as in the additional general-purpose lanes concept, as there is an imbalance in utilization between the general-purpose lanes and the HOV lane. No volume-to-capacity ratio issues are observed in the HOV lanes themselves; results suggest the lanes are reasonably well utilized and would still be free-flowing.

Eastbound volume-to-capacity ratios are improved in the expanded capacity provided in the additional general-purpose lanes concept. However, the overall increase in volume associated with the capacity improvements cause an increase in volume-to-capacity ratios for nearby non-expanded sections. In both AM and PM, the segment of the highway through the Lynn Valley Road Interchange exhibits the highest volume-to-capacity ratios in the study area under the 2050 base case and becomes worse under the additional general-purpose lanes concept. This suggests that this concept creates a risk of generating additional volumes on the already heavily congested highway segment between Lynn Valley Road and the Ironworkers Memorial Bridge.

Table 3.8: Westbound Highway Segment Volume-to-Capacity – 2050 AM Peak Hour

| From | To | Concept | | | | |
|---|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes (GP Lanes) | HOV Lanes (HOV Lane) | Additional General-Purpose Lanes |
| Lynn Valley Road Interchange | | 1.28 | 1.28 | 1.29 | 0 | 1.15 |
| Lynn Valley Road Interchange | Lonsdale Avenue Interchange | 1.2 | 1.2 | 0.99 | 0.46 | 0.92 |
| Lonsdale Avenue Interchange | | 0.65 | 0.65 | 0.84 | 0.35 | 0.74 |
| Lonsdale Avenue Interchange | Westview Drive Interchange | 0.94 | 0.95 | 1.02 | 0.73 | 1.09 |
| Westview Drive Interchange | | 1.21 | 1.21 | 1.22 | 0 | 0.87 |
| Westview Drive Interchange | Capilano Road Interchange | 1.14 | 1.14 | 0.98 | 0.39 | 0.87 |
| Capilano Road Interchange | | 1.17 | 1.17 | 1.18 | 0 | 0.81 |
| Capilano Road Interchange | Taylor Way Interchange | 1.04 | 1.04 | 1.05 | 0 | 0.75 |
| Taylor Way Interchange | | 0.77 | 0.77 | 0.77 | 0 | 0.82 |
| Taylor Way Interchange | 15th Street Interchange | 0.62 | 0.62 | 0.63 | 0 | 0.64 |
| 15th Street Interchange | | 0.73 | 0.73 | 0.73 | 0 | 0.74 |
| 15th Street Interchange | 21st Street Interchange | 0.51 | 0.51 | 0.51 | 0 | 0.52 |
| 21st Street Interchange | | 0.87 | 0.87 | 0.87 | 0 | 0.88 |
| 21st Street Interchange | Cypress Bowl Road Interchange | 0.65 | 0.65 | 0.65 | 0 | 0.65 |
| Cypress Bowl Road Interchange | | 0.79 | 0.79 | 0.79 | 0 | 0.79 |
| Cypress Bowl Road Interchange | Westmount Road Interchange | 0.59 | 0.59 | 0.59 | 0 | 0.59 |
| Westmount Road Interchange | | 0.79 | 0.79 | 0.79 | 0 | 0.79 |
| Westmount Road Interchange | Caulfeild Interchange | 0.58 | 0.58 | 0.58 | 0 | 0.58 |
| Caulfeild Interchange | | 0.63 | 0.63 | 0.63 | 0 | 0.63 |
| Caulfeild Interchange | Highway 99 | 0.51 | 0.51 | 0.51 | 0 | 0.52 |
| Highway 99 | Eagleridge Drive | 0.17 | 0.17 | 0.17 | 0 | 0.17 |

Table 3.9: Westbound Highway Segment Volume-to-Capacity – 2050 PM Peak Hour

| From | To | Concept | | | | |
|---|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes (GP Lanes) | HOV Lanes (HOV Lane) | Additional General-Purpose Lanes |
| Lynn Valley Road Interchange | | 1.2 | 1.2 | 1.22 | 0 | 1.12 |
| Lynn Valley Road Interchange | Lonsdale Avenue Interchange | 1.1 | 1.09 | 0.88 | 0.49 | 0.85 |
| Lonsdale Avenue Interchange | | 0.59 | 0.59 | 0.72 | 0.4 | 0.67 |
| Lonsdale Avenue Interchange | Westview Drive Interchange | 0.83 | 0.83 | 0.88 | 0.74 | 0.97 |
| Westview Drive Interchange | | 1.11 | 1.11 | 1.13 | 0 | 0.78 |
| Westview Drive Interchange | Capilano Road Interchange | 1.05 | 1.05 | 0.83 | 0.5 | 0.78 |
| Capilano Road Interchange | | 1.14 | 1.13 | 1.15 | 0 | 0.77 |
| Capilano Road Interchange | Taylor Way Interchange | 1.05 | 1.03 | 1.06 | 0 | 0.75 |
| Taylor Way Interchange | | 0.84 | 0.82 | 0.84 | 0 | 0.89 |
| Taylor Way Interchange | 15th Street Interchange | 0.74 | 0.73 | 0.74 | 0 | 0.76 |
| 15th Street Interchange | | 0.92 | 0.91 | 0.92 | 0 | 0.93 |
| 15th Street Interchange | 21st Street Interchange | 0.64 | 0.63 | 0.63 | 0 | 0.64 |
| 21st Street Interchange | | 1.08 | 1.09 | 1.08 | 0 | 1.09 |
| 21st Street Interchange | Cypress Bowl Road Interchange | 0.89 | 0.89 | 0.89 | 0 | 0.89 |
| Cypress Bowl Road Interchange | | 1 | 1 | 1 | 0 | 1 |
| Cypress Bowl Road Interchange | Westmount Road Interchange | 0.74 | 0.73 | 0.74 | 0 | 0.74 |
| Westmount Road Interchange | | 0.89 | 0.89 | 0.89 | 0 | 0.89 |
| Westmount Road Interchange | Caulfeild Interchange | 0.75 | 0.75 | 0.75 | 0 | 0.76 |
| Caulfeild Interchange | | 0.87 | 0.87 | 0.87 | 0 | 0.88 |
| Caulfeild Interchange | Highway 99 | 0.78 | 0.78 | 0.78 | 0 | 0.79 |
| Highway 99 | Eagleridge Drive | 0.4 | 0.4 | 0.4 | 0 | 0.4 |

Westbound volume-to-capacity ratios are above 1.0 for most of the section between Lynn Valley Road and Taylor Way. Additionally, the 21st Street Interchange and Cypress Bowl Road Interchange are above capacity in the PM only, although in the latter case, there is a known “localized” AM peak that is earlier than the overall regional peak hour.

The bus-on-shoulder concept does not have any noticeable impact on mainline volume-to-capacity ratio in the westbound direction. The HOV concept reduces general-purpose lane westbound volume-to-capacity ratio in the widened sections of the corridor, namely from Lynn Valley Road to Lonsdale Avenue and from Westview Drive to Capilano Road. In the additional general-purpose lanes concept, much of this section sees a reduction in volume-to-capacity ratio, except for the segment near Lonsdale Avenue and Westview Drive that is already six-laned.

West of Taylor Way there is a small increase in volume-to-capacity ratios as the highway widening generates some additional trips in West Vancouver.

Volume-to-capacity ratios were also assessed for interchange ramps. For the 2050 baseline condition as well as for the three on-corridor improvement concepts, eastbound ramp values are provided in ***Table 3.10*** and ***Table 3.11*** for the AM peak hour and PM peak hour, respectively. The corresponding westbound ramp volume-to-capacity ratios are provided in ***Table 3.12*** and ***Table 3.13***.

Table 3.10: Eastbound Interchange Volume-to-Capacity Ratios – 2050 AM Peak Hour

| Interchange | Ramp Movement | Concept | | | |
|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Caulfeild Interchange | Caulfeild Dr, EB off-ramp | 0.39 | 0.39 | 0.39 | 0.39 |
| | Caulfeild Dr, EB on-ramp | 0.75 | 0.75 | 0.75 | 0.75 |
| Westmount Road Interchange | Westridge Ave, EB off-ramp | 0.17 | 0.17 | 0.17 | 0.17 |
| | Westridge Ave, EB on-ramp | 0.03 | 0.03 | 0.03 | 0.02 |
| Cypress Bowl Road Interchange | Cypress Bowl Rd, EB off-ramp | 0.15 | 0.15 | 0.15 | 0.14 |
| | Cypress Bowl Rd, EB on-ramp | 0.95 | 0.95 | 0.95 | 0.95 |
| 21st Street Interchange | 22nd St, EB off-ramp | 0.29 | 0.29 | 0.29 | 0.28 |
| | 21st St, EB on-ramp | 0.15 | 0.15 | 0.15 | 0.18 |
| 15th Street Interchange | 15th St, EB off-ramp | 0.72 | 0.72 | 0.71 | 0.72 |
| | 15th St, EB on-ramp | 0.84 | 0.84 | 0.85 | 0.9 |
| Taylor Way Interchange | Taylor Way, EB off-ramp | 1.03 | 1.03 | 1.02 | 0.95 |
| | Taylor Way, EB on-ramp | 0.83 | 0.83 | 0.84 | 0.84 |
| Capilano Road Interchange | Capilano Rd, EB off-ramp (from Hwy) | 0.49 | 0.49 | 0.61 | 0.42 |
| | Capilano Rd, EB off-ramp (to int.) | 0.41 | 0.41 | 0.4 | 0.4 |
| | Capilano Rd, EB on-ramp (from int.) | 0.38 | 0.39 | 0.44 | 0.42 |
| | Capilano Rd, EB on-ramp (to Hwy) | 0.78 | 0.77 | 0.61 | 0.74 |
| Westview Drive Interchange | Westview Dr, EB off-ramp | 0.36 | 0.36 | 0.39 | 0.43 |
| | Westview Dr, EB on-ramp | 0.33 | 0.32 | 0.36 | 0.34 |
| Lonsdale Avenue Interchange | Lonsdale Ave, EB off-ramp | 0.74 | 0.73 | 0.7 | 0.71 |
| | Lonsdale Ave, EB on-ramp | 0.82 | 0.81 | 0.88 | 0.77 |
| Lynn Valley Road Interchange | Lynn Valley Rd, EB off-ramp (from Hwy) | 0.23 | 0.22 | 0.24 | 0.28 |
| | Lynn Valley Rd, EB off-ramp (connector) | 0.05 | 0.05 | 0.06 | 0.09 |
| | Lynn Valley Rd, EB off-ramp (LT at int.) | 0.13 | 0.13 | 0.16 | 0.23 |
| | Lynn Valley Rd, EB off-ramp (RT at int.) | 0.17 | 0.17 | 0.18 | 0.19 |
| | Lynn Valley Rd, EB on-ramp (from int.) | 0.52 | 0.52 | 0.48 | 0.52 |
| | Lynn Valley Rd, EB on-ramp (to Hwy) | 1.04 | 1.03 | 0.96 | 1.03 |

Table 3.11: Eastbound Interchange Volume-to-Capacity Ratios – 2050 PM Peak Hour

| Interchange | Ramp Movement | Concept | | | |
|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Caulfeild Interchange | Caulfeild Dr, EB off-ramp | 0.85 | 0.85 | 0.85 | 0.85 |
| | Caulfeild Dr, EB on-ramp | 0.6 | 0.59 | 0.6 | 0.6 |
| Westmount Road Interchange | Westridge Ave, EB off-ramp | 0.08 | 0.08 | 0.08 | 0.08 |
| | Westridge Ave, EB on-ramp | 0.03 | 0.03 | 0.03 | 0.03 |
| Cypress Bowl Road Interchange | Cypress Bowl Rd, EB off-ramp | 0.13 | 0.13 | 0.13 | 0.13 |
| | Cypress Bowl Rd, EB on-ramp | 0.43 | 0.43 | 0.43 | 0.43 |
| 21st Street Interchange | 22nd St, EB off-ramp | 0.18 | 0.18 | 0.17 | 0.17 |
| | 21st St, EB on-ramp | 0.28 | 0.31 | 0.29 | 0.35 |
| 15th Street Interchange | 15th St, EB off-ramp | 0.39 | 0.39 | 0.39 | 0.39 |
| | 15th St, EB on-ramp | 0.8 | 0.85 | 0.82 | 0.94 |
| Taylor Way Interchange | Taylor Way, EB off-ramp | 0.67 | 0.66 | 0.65 | 0.6 |
| | Taylor Way, EB on-ramp | 1.08 | 1.13 | 1.11 | 1.08 |
| Capilano Road Interchange | Capilano Rd, EB off-ramp (from Hwy) | 0.38 | 0.48 | 0.73 | 0.38 |
| | Capilano Rd, EB off-ramp (to int.) | 0.5 | 0.65 | 0.5 | 0.49 |
| | Capilano Rd, EB on-ramp (from int.) | 0.7 | 0.89 | 0.88 | 0.73 |
| | Capilano Rd, EB on-ramp (to Hwy) | 1.22 | 1.37 | 1.11 | 1.25 |
| Westview Drive Interchange | Westview Dr, EB off-ramp | 0.61 | 0.71 | 0.73 | 0.64 |
| | Westview Dr, EB on-ramp | 0.3 | 0.3 | 0.4 | 0.39 |
| Lonsdale Avenue Interchange | Lonsdale Ave, EB off-ramp | 0.89 | 0.85 | 0.78 | 0.72 |
| | Lonsdale Ave, EB on-ramp | 0.9 | 0.85 | 0.85 | 0.64 |
| Lynn Valley Road Interchange | Lynn Valley Rd, EB off-ramp (from Hwy) | 0.38 | 0.38 | 0.42 | 0.55 |
| | Lynn Valley Rd, EB off-ramp (connector) | 0.07 | 0.06 | 0.1 | 0.17 |
| | Lynn Valley Rd, EB off-ramp (LT at int.) | 0.17 | 0.17 | 0.27 | 0.44 |
| | Lynn Valley Rd, EB off-ramp (RT at int) | 0.32 | 0.32 | 0.32 | 0.39 |
| | Lynn Valley Rd, EB on-ramp (from int.) | 0.43 | 0.43 | 0.29 | 0.43 |
| | Lynn Valley Rd, EB on-ramp (to Hwy) | 0.85 | 0.85 | 0.59 | 0.86 |

The eastbound volume to capacity ratio in the 2050 base case is elevated at Cypress Bowl Road, Taylor Way and Lynn Valley Road in the AM peak hour, and at Taylor Way and Capilano Road in the PM peak hour.

In the HOV concept, changes are again small. In the AM peak hour, the Lynn Valley Road Interchange on-ramp decreases to below 1.0, while in the PM peak hour, the addition of an HOV ramp at Capilano Road reduces the volume-to-capacity ratio in the general-purpose on-ramp lane. Other decreases are seen at Lonsdale Avenue and Lynn Valley Road. In the additional general-purpose lanes concept, changes are largely small. In the AM peak hour, the 15th Street/Cross Creek Road Interchange on-ramp sees an increase to 0.9 and the Taylor Way Interchange off-ramp decreases to below 1.0. In the PM, the 15th Street/Cross Creek Road Interchange on-ramp also increases to above 0.9 and decreases are seen at both eastbound ramps at Lonsdale Avenue.

Table 3.12: Westbound Interchange Volume-to-Capacity Ratios – 2050 AM Peak Hour

| Interchange | Ramp Movement | Concept | | | |
|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Lynn Valley Road Interchange | Lynn Valley Rd, WB off-ramp | 0.48 | 0.47 | 0.47 | 0.31 |
| | Lynn Valley Rd, WB on-ramp | 1.13 | 1.13 | 1.16 | 1.04 |
| Lonsdale Avenue Interchange | Lonsdale Ave, WB off-ramp | 0.56 | 0.56 | 0.55 | 0.76 |
| | Lonsdale Ave, WB on-ramp | 0.29 | 0.29 | 0.26 | 0.38 |
| Westview Drive Interchange | Westview Dr, WB off-ramp | 0.85 | 0.86 | 0.84 | 0.69 |
| | Westview Dr, WB on-ramp | 1.09 | 1.1 | 1.14 | 0.95 |
| Capilano Road Interchange | Capilano Rd, WB off-ramp | 0.98 | 0.99 | 1.01 | 1.02 |
| | Capilano Rd, WB on-ramp | 0.8 | 0.79 | 0.8 | 0.47 |
| Taylor Way Interchange | Taylor Way, WB off-ramp | 0.76 | 0.75 | 0.77 | 0.89 |
| | Taylor Way, WB on-ramp | 0.39 | 0.39 | 0.39 | 0.35 |
| 15th Street Interchange | 15th St, WB off-ramp (upstream of int.) | 0.47 | 0.47 | 0.47 | 0.5 |
| | 15th St, WB off-ramp (LT at int.) | 0.86 | 0.85 | 0.86 | 0.93 |
| | 15th St, WB off-ramp (RT at int.) | 0.15 | 0.15 | 0.15 | 0.15 |
| | 15th St, WB on-ramp | 0.09 | 0.09 | 0.09 | 0.09 |
| 21st Street Interchange | 21st St, WB off-ramp | 0.6 | 0.6 | 0.61 | 0.64 |
| | Skilift Rd, WB on-ramp | 0.08 | 0.08 | 0.08 | 0.08 |
| Cypress Bowl Road Interchange | Cypress Bowl Rd, WB off-ramp | 0.43 | 0.43 | 0.43 | 0.43 |
| | Cypress Bowl Rd, WB on-ramp | 0.07 | 0.07 | 0.07 | 0.07 |
| Westmount Road Interchange | Westridge Ave, WB off-ramp | 0.04 | 0.04 | 0.04 | 0.04 |
| | Westridge Ave, WB on-ramp | 0.03 | 0.03 | 0.03 | 0.03 |
| Caulfeild Interchange | Westport Rd, WB off-ramp | 0.25 | 0.25 | 0.25 | 0.25 |
| | Westport Rd, WB on-ramp | 0.24 | 0.24 | 0.24 | 0.24 |

Table 3.13: Westbound Interchange Volume-to-Capacity Ratios – 2050 PM Peak Hour

| Interchange | Ramp Movement | Concept | | | |
|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Lynn Valley Road Interchange | Lynn Valley Rd, WB off-ramp | 0.71 | 0.71 | 0.7 | 0.47 |
| | Lynn Valley Rd, WB on-ramp | 0.92 | 0.92 | 0.98 | 0.73 |
| Lonsdale Avenue Interchange | Lonsdale Ave, WB off-ramp | 0.54 | 0.54 | 0.53 | 0.77 |
| | Lonsdale Ave, WB on-ramp | 0.21 | 0.21 | 0.2 | 0.31 |
| Westview Drive Interchange | Westview Dr, WB off-ramp | 0.65 | 0.65 | 0.66 | 0.61 |
| | Westview Dr, WB on-ramp | 1 | 1.01 | 1.04 | 0.87 |
| Capilano Road Interchange | Capilano Rd, WB off-ramp | 0.73 | 0.77 | 0.79 | 0.75 |
| | Capilano Rd, WB on-ramp | 0.93 | 0.88 | 0.92 | 0.74 |
| Taylor Way Interchange | Taylor Way, WB off-ramp | 0.58 | 0.59 | 0.58 | 0.72 |
| | Taylor Way, WB on-ramp | 0.59 | 0.62 | 0.59 | 0.56 |
| 15th Street Interchange | 15th St, WB off-ramp (upstream of int.) | 0.43 | 0.43 | 0.44 | 0.47 |
| | 15th St, WB off-ramp (LT at int.) | 0.64 | 0.66 | 0.66 | 0.72 |
| | 15th St, WB off-ramp (RT at int.) | 0.19 | 0.18 | 0.19 | 0.2 |
| | 15th St, WB on-ramp | 0.11 | 0.11 | 0.1 | 0.08 |
| 21st Street Interchange | 21st St, WB off-ramp | 0.77 | 0.75 | 0.77 | 0.77 |
| | Skilift Rd, WB on-ramp | 0.43 | 0.41 | 0.43 | 0.41 |
| Cypress Bowl Road Interchange | Cypress Bowl Rd, WB off-ramp | 0.9 | 0.9 | 0.9 | 0.91 |
| | Cypress Bowl Rd, WB on-ramp | 0.05 | 0.05 | 0.05 | 0.05 |
| Westmount Road Interchange | Westridge Ave, WB off-ramp | 0.19 | 0.19 | 0.19 | 0.19 |
| | Westridge Ave, WB on-ramp | 0.45 | 0.44 | 0.46 | 0.47 |
| Caulfeild Interchange | Westport Rd, WB off-ramp | 0.25 | 0.24 | 0.25 | 0.26 |
| | Westport Rd, WB on-ramp | 0.63 | 0.63 | 0.63 | 0.63 |

Westbound ramp volume-to-capacity ratio is above 1.0 in the 2050 base case at the Lynn Valley Road Interchange and Westview Drive Interchange in the AM peak hour, and at Westview Drive in the PM peak hour.

In the additional general-purpose lane concept, the on-ramp and off-ramp volume-to-capacity ratios at Westview Drive decrease somewhat in the AM peak hour, while the neighbouring off-ramp at the Capilano Road Interchange increases to above 1.0 and the on-ramp volume-to-capacity ratio decreases substantially. Further downstream, the Taylor Way off-ramp noticeably increases. In the PM peak hour, decreases are seen at the on-ramps at Lynn Valley Road, Westview Drive and Capilano Road. Changes to westbound ramp volume-to-capacity ratio changes are small under both bus-on-shoulder and HOV concepts.

### TRAVEL TIME INDEX

Travel time indices for the eastbound 2050 baseline condition as well as for the three on-corridor improvement concepts are provided in ***Table 3.14*** and ***Table 3.15*** for the AM peak hour and PM peak hour, respectively. The corresponding westbound travel time indices are provided in ***Table 3.16*** and ***Table 3.17***.

Table 3.14: Eastbound Highway Segment Travel Time Index – 2050 AM Peak Hour

| From | To | Concept | | | | |
|---|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes (GP Lanes) | HOV Lanes (HOV Lane) | Additional General-Purpose Lanes |
| Eagleridge Drive | Highway 99 | 1.28 | 1.28 | 1.28 | 0 | 1.28 |
| Highway 99 | Caulfeild Interchange | 1.01 | 1.01 | 1.01 | 0 | 1.01 |
| Caulfeild Interchange | | 1.25 | 1.25 | 1.25 | 0 | 1.26 |
| Caulfeild Interchange | Westmount Road Interchange | 1.03 | 1.03 | 1.03 | 0 | 1.03 |
| Westmount Road Interchange | | 2.24 | 2.24 | 2.24 | 0 | 2.25 |
| Westmount Road Interchange | Cypress Bowl Road Interchange | 1.03 | 1.03 | 1.03 | 0 | 1.03 |
| Cypress Bowl Road Interchange | | 1.87 | 1.87 | 1.88 | 0 | 1.87 |
| Cypress Bowl Road Interchange | 21st Street Interchange | 1.11 | 1.11 | 1.11 | 0 | 1.11 |
| 21st Street Interchange | | 1.09 | 1.09 | 1.09 | 0 | 1.09 |
| 21st Street Interchange | 15th Street Interchange | 1.02 | 1.02 | 1.02 | 0 | 1.02 |
| 15th Street Interchange | | 3.24 | 3.24 | 3.27 | 0 | 3.45 |
| 15th Street Interchange | Taylor Way Interchange | 1.22 | 1.21 | 1.22 | 0 | 1.25 |
| Taylor Way Interchange | | 2.74 | 2.73 | 2.81 | 0 | 1.06 |
| Taylor Way Interchange | Capilano Road Interchange | 1.16 | 1.16 | 1.17 | 0 | 1.02 |
| Capilano Road Interchange | | 3.91 | 3.88 | 3.02 | 0 | 1.32 |
| Capilano Road Interchange | Westview Drive Interchange | 1.12 | 1.12 | 1.07 | 1 | 1.02 |
| Westview Drive Interchange | | 1.01 | 1.06 | 1.03 | 1 | 1.01 |
| Westview Drive Interchange | Lonsdale Avenue Interchange | 1.11 | 1.22 | 1.55 | 1.04 | 1.16 |
| Lonsdale Avenue Interchange | | 1.83 | 1.82 | 1.27 | 1 | 1.08 |
| Lonsdale Avenue Interchange | Lynn Valley Road Interchange | 1.14 | 1.14 | 1.1 | 1 | 1.02 |
| Lynn Valley Road Interchange | | 7.16 | 7.01 | 3.05 | 1.01 | 8.46 |

Table 3.15: Eastbound Highway Segment Travel Time Index – 2050 PM Peak Hour

| From | To | Concept | | | | |
|---|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes (GP Lanes) | HOV Lanes (HOV Lane) | Additional General-Purpose Lanes |
| Eagleridge Drive | Highway 99 | 1.12 | 1.12 | 1.12 | 0 | 1.12 |
| Highway 99 | Caulfeild Interchange | 1.02 | 1.02 | 1.02 | 0 | 1.02 |
| Caulfeild Interchange | | 1.17 | 1.17 | 1.17 | 0 | 1.18 |
| Caulfeild Interchange | Westmount Road Interchange | 1.02 | 1.02 | 1.02 | 0 | 1.02 |
| Westmount Road Interchange | | 1.75 | 1.74 | 1.75 | 0 | 1.75 |
| Westmount Road Interchange | Cypress Bowl Road Interchange | 1.01 | 1.01 | 1.02 | 0 | 1.02 |
| Cypress Bowl Road Interchange | | 1.53 | 1.52 | 1.53 | 0 | 1.54 |
| Cypress Bowl Road Interchange | 21st Street Interchange | 1.03 | 1.03 | 1.03 | 0 | 1.03 |
| 21st Street Interchange | | 1.03 | 1.03 | 1.03 | 0 | 1.03 |
| 21st Street Interchange | 15th Street Interchange | 1.01 | 1.01 | 1.01 | 0 | 1.01 |
| 15th Street Interchange | | 2.62 | 2.73 | 2.67 | 0 | 3.04 |
| 15th Street Interchange | Taylor Way Interchange | 1.16 | 1.18 | 1.16 | 0 | 1.23 |
| Taylor Way Interchange | | 3.11 | 3.46 | 3.33 | 0 | 1.1 |
| Taylor Way Interchange | Capilano Road Interchange | 1.27 | 1.32 | 1.3 | 0 | 1.04 |
| Capilano Road Interchange | | 8.52 | 7.98 | 3.84 | 0 | 1.75 |
| Capilano Road Interchange | Westview Drive Interchange | 1.46 | 1.52 | 1.19 | 1.02 | 1.08 |
| Westview Drive Interchange | | 1.02 | 1.18 | 1.07 | 1.01 | 1.03 |
| Westview Drive Interchange | Lonsdale Avenue Interchange | 1.25 | 1.5 | 2.07 | 1.96 | 1.44 |
| Lonsdale Avenue Interchange | | 2.76 | 2.85 | 1.51 | 1.1 | 1.29 |
| Lonsdale Avenue Interchange | Lynn Valley Road Interchange | 1.29 | 1.29 | 1.14 | 1.02 | 1.06 |
| Lynn Valley Road Interchange | | 9.69 | 9.45 | 3.27 | 1.33 | 11.62 |

2050 base case eastbound travel time indices are higher mainly through interchanges; however, in the PM peak hour, most segments between Taylor Way and Lynn Valley Road see travel time index values above 1.25.

The bus-on-shoulder concept has relatively small impacts in the eastbound direction. The HOV lane concept also provides a reduction in travel time indices in many locations, particularly the Lynn Valley Interchange, where both AM peak hour and PM peak hour values decrease by more than 50%. The segment between Lonsdale Avenue and Westview Drive does see a small increase where GP capacity is reallocated to HOV only. Provision of additional general-purpose lanes provides a substantial increase in speed from Taylor Way to Lynn Valley Road; for example, the travel time index from Capilano Road to Westview Drive decreases from 1.46 to 1.08. However, closer to Lynn Valley Road, conditions are exacerbated, and the travel time index through the Lynn Valley Road Interchange increases. Although not provided (since they are beyond the study corridor), it is anticipated that the additional vehicle volumes on the highway would result in increases in travel times on the highway between Lynn Valley Road and the Ironworkers Memorial Bridge.

Table 3.16: Westbound Highway Segment Travel Time Index – 2050 AM Peak Hour

| From | To | Concept | | | | |
|---|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes (GP Lanes) | HOV Lanes (HOV Lane) | Additional General-Purpose Lanes |
| Lynn Valley Road Interchange | | 6.94 | 6.92 | 7.22 | 0 | 1.55 |
| Lynn Valley Road Interchange | Lonsdale Avenue Interchange | 1.68 | 1.67 | 1.25 | 1 | 1.16 |
| Lonsdale Avenue Interchange | | 1.03 | 1.03 | 1.1 | 1 | 1.05 |
| Lonsdale Avenue Interchange | Westview Drive Interchange | 3.37 | 3.42 | 4.49 | 2.39 | 5.88 |
| Westview Drive Interchange | | 6.46 | 13.8 | 14.68 | 0 | 2.04 |
| Westview Drive Interchange | Capilano Road Interchange | 1.52 | 1.51 | 1.23 | 1 | 1.13 |
| Capilano Road Interchange | | 13.07 | 13.12 | 13.68 | 0 | 2.91 |
| Capilano Road Interchange | Taylor Way Interchange | 1.32 | 1.32 | 1.33 | 0 | 1.06 |
| Taylor Way Interchange | | 1.06 | 1.06 | 1.07 | 0 | 1.09 |
| Taylor Way Interchange | 15th Street Interchange | 1.02 | 1.02 | 1.02 | 0 | 1.03 |
| 15th Street Interchange | | 1.05 | 1.05 | 1.05 | 0 | 1.05 |
| 15th Street Interchange | 21st Street Interchange | 1.01 | 1.01 | 1.01 | 0 | 1.01 |
| 21st Street Interchange | | 1.45 | 1.45 | 1.46 | 0 | 1.47 |
| 21st Street Interchange | Cypress Bowl Road Interchange | 1.03 | 1.03 | 1.03 | 0 | 1.03 |
| Cypress Bowl Road Interchange | | 1.48 | 1.48 | 1.48 | 0 | 1.5 |
| Cypress Bowl Road Interchange | Westmount Road Interchange | 1.02 | 1.02 | 1.02 | 0 | 1.02 |
| Westmount Road Interchange | | 1.49 | 1.49 | 1.49 | 0 | 1.5 |
| Westmount Road Interchange | Caulfeild Interchange | 1.01 | 1.01 | 1.01 | 0 | 1.01 |
| Caulfeild Interchange | | 1.25 | 1.25 | 1.25 | 0 | 1.25 |
| Caulfeild Interchange | Highway 99 | 1.01 | 1.01 | 1.01 | 0 | 1.01 |
| Highway 99 | Eagleridge Drive | 1 | 1 | 1 | 0 | 1 |

Table 3.17: Westbound Highway Segment Travel Time Index – 2050 PM Peak Hour

| From | To | Concept | | | | |
|---|---|---|---|---|---|---|
| | | Base | Bus-on-Shoulder | HOV Lanes (GP Lanes) | HOV Lanes (HOV Lane) | Additional General-Purpose Lanes |
| Lynn Valley Road Interchange | | 5.36 | 5.33 | 5.63 | 0 | 1.47 |
| Lynn Valley Road Interchange | Lonsdale Avenue Interchange | 1.42 | 1.41 | 1.13 | 1.01 | 1.11 |
| Lonsdale Avenue Interchange | | 1.02 | 1.02 | 1.05 | 1 | 1.03 |
| Lonsdale Avenue Interchange | Westview Drive Interchange | 2.26 | 2.27 | 2.69 | 2.51 | 3.73 |
| Westview Drive Interchange | | 4.49 | 9.27 | 10.34 | 0 | 1.59 |
| Westview Drive Interchange | Capilano Road Interchange | 1.33 | 1.33 | 1.1 | 1.01 | 1.07 |
| Capilano Road Interchange | | 11.52 | 11.2 | 12.03 | 0 | 2.44 |
| Capilano Road Interchange | Taylor Way Interchange | 1.33 | 1.31 | 1.34 | 0 | 1.06 |
| Taylor Way Interchange | | 1.1 | 1.09 | 1.11 | 0 | 1.14 |
| Taylor Way Interchange | 15th Street Interchange | 1.05 | 1.05 | 1.05 | 0 | 1.06 |
| 15th Street Interchange | | 1.17 | 1.16 | 1.17 | 0 | 1.18 |
| 15th Street Interchange | 21st Street Interchange | 1.02 | 1.02 | 1.02 | 0 | 1.02 |
| 21st Street Interchange | | 2.38 | 2.38 | 2.37 | 0 | 2.41 |
| 21st Street Interchange | Cypress Bowl Road Interchange | 1.14 | 1.14 | 1.14 | 0 | 1.14 |
| Cypress Bowl Road Interchange | | 2.58 | 2.54 | 2.57 | 0 | 2.57 |
| Cypress Bowl Road Interchange | Westmount Road Interchange | 1.05 | 1.05 | 1.05 | 0 | 1.05 |
| Westmount Road Interchange | | 1.9 | 1.9 | 1.9 | 0 | 1.9 |
| Westmount Road Interchange | Caulfeild Interchange | 1.06 | 1.06 | 1.06 | 0 | 1.06 |
| Caulfeild Interchange | | 2.25 | 2.25 | 2.25 | 0 | 2.26 |
| Caulfeild Interchange | Highway 99 | 1.07 | 1.07 | 1.07 | 0 | 1.07 |
| Highway 99 | Eagleridge Drive | 1.01 | 1.01 | 1.01 | 0 | 1.01 |

Similar to the eastbound direction, westbound 2050 base case travel time indices are poor through most of the section between Lynn Valley Road and Taylor Way, as well as through interchanges outside this section.

With respect to the bus-on-shoulder concept, westbound general-purpose capacity through Westview Drive Interchange is also reallocated, resulting in travel time index increases of more than 100%. Changes outside of this segment are minimal. The HOV lane concept causes a substantial increase (greater than 100%) through the Westview Drive Interchange where existing capacity is reallocated. Changes elsewhere are comparatively small. The additional general-purpose lanes reduce travel times through the implementation area, with the exception of increases where the cross-section is already widened to six lanes around Lonsdale Avenue and Westview Drive.

## TRIP TYPE

The distribution of trip types along the highway corridor was compared for the 2050 base case against the three on-corridor concepts. Results are presented in the form of overall trip volumes on the corridor in ***Table 3.18*** and the proportion of trips in ***Table 3.19***. Note that these vales reflect vehicular volumes, not person-trip volumes.

Table 3.18: Trip Type Classifications on Highway Corridor – Absolute Volumes

| | 2050 AM | | | | 2050 PM | | | |
|---|---|---|---|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Intra-municipal: within West Vancouver | 767 | 767 | 763 | 752 | 612 | 610 | 610 | 597 |
| Intra-municipal: within North Vancouver | 1,988 | 1,970 | 2,091 | 2,137 | 1,667 | 1,633 | 1,682 | 1,853 |
| Intra-North Shore: between West Vancouver and North Vancouver | 3,553 | 3,565 | 3,565 | 3,754 | 3,525 | 3,579 | 3,558 | 3,758 |
| Intra-regional: between North Shore and external | 13,519 | 13,489 | 13,526 | 13,627 | 15,752 | 15,937 | 15,942 | 15,880 |
| Through-trips | 1,945 | 1,944 | 1,945 | 1,948 | 2,910 | 2,909 | 2,914 | 2,913 |
| Total trips | 21,772 | 21,715 | 21,889 | 22,218 | 24,466 | 24,668 | 24,706 | 25,002 |

Table 3.19: Trip Type Classifications on Highway Corridor – Percentage Distribution

| | 2050 AM | | | | 2050 PM | | | |
|---|---|---|---|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Intra-municipal: within West Vancouver | 4% | 4% | 3% | 3% | 3% | 2% | 2% | 2% |
| Intra-municipal: within North Vancouver | 9% | 9% | 10% | 10% | 7% | 7% | 7% | 7% |
| Intra-North Shore: between West Vancouver and North Vancouver | 16% | 16% | 16% | 17% | 14% | 15% | 14% | 15% |
| Intra-regional: between North Shore and external | 62% | 62% | 62% | 61% | 64% | 65% | 65% | 64% |
| Through-trips | 9% | 9% | 9% | 9% | 12% | 12% | 12% | 12% |

Differences between Highway 1 trip type ratios are very small across all concepts. Both the HOV and additional general-purpose lane concepts provide additional capacity along some sections of the highway and do see increases in total number of trips served, with the additional general-purpose lane concept serving the most.

### ACCOMMODATION OF TRANSIT SERVICE

The bus-on-shoulder and HOV lane concepts enable a transit service to run along the corridor, which as described previously in the assessment of travel volumes by mode, is successful in attracting transit ridership to a corridor that currently lacks such a service.

The additional general-purpose lanes concept makes no provision for transit service, nor does it accommodate transit service in any other way. However, to the extent that the concept is able to draw attract vehicle trips away from other corridors, it may increase average transit travel speeds and reliability on parallel corridors that support transit, such as Marine Drive.

Quantitative benefits to transit users (on both the new on-corridor transit service and on parallel corridors) are implicitly captured in the consumer surplus analysis.

### ACTIVE TRANSPORTATION PROVISIONS

The assumed scope of the additional general-purpose lane concept would include the implementation of the Capilano Road Interchange improvements discussed below in Section 4.1, which would provide significant benefits for active transportation modes. However, this interchange improvement is also compatible with the other two concepts as a separate scope element.

In all cases, it was assumed that the cross-section of the widened highway between Capilano Road and Westview Drive would be developed in such a manner as to avoid removing active transportation parallel to the highway, given the lack of alternative municipal connections.

### TRAVEL VOLUMES BY MODE (NETWORK LEVEL)

2050 trip volumes were extracted from the model for the base case and three concepts under both a North Shore-wide and region-wide lens, and summarized as mode shares in ***Table 3.20*** and ***Table 3.21***, respectively. In this instance, North Shore-wide values includes all trips to/from/within/through the North Shore.

Table 3.20: Overall Mode Shares for Person Trip-Making, North Shore-Wide

| Person Trip-Making, North Shore | 2050 AM | | | | 2050 PM | | | |
|---|---|---|---|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Walk | 12.0% | 12.0% | 12.0% | 12.0% | 8.1% | 8.0% | 8.0% | 8.0% |
| Bike | 2.1% | 2.1% | 2.1% | 2.1% | 2.1% | 2.1% | 2.1% | 2.1% |
| Transit | 15.2% | 15.5% | 15.4% | 15.2% | 14.3% | 14.6% | 14.5% | 14.3% |
| HOV | 31.2% | 31.1% | 31.2% | 31.2% | 30.2% | 30.1% | 30.2% | 30.2% |
| SOV | 39.4% | 39.2% | 39.3% | 39.4% | 45.3% | 45.2% | 45.2% | 45.4% |

Table 3.21: Overall Mode Shares for Person Trip-Making, Region-Wide

| Person Trip-Making, Regional | 2050 AM | | | | 2050 PM | | | |
|---|---|---|---|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Walk | 12.1% | 12.1% | 12.1% | 12.1% | 9.1% | 9.0% | 9.0% | 9.0% |
| Bike | 2.0% | 2.0% | 2.0% | 2.0% | 2.1% | 2.1% | 2.1% | 2.1% |
| Transit | 17.4% | 17.4% | 17.4% | 17.4% | 17.4% | 17.4% | 17.4% | 17.4% |
| HOV | 31.8% | 31.8% | 31.8% | 31.8% | 28.2% | 28.2% | 28.2% | 28.2% |
| SOV | 36.7% | 36.7% | 36.7% | 36.7% | 43.3% | 43.2% | 43.2% | 43.3% |

At the North Shore level, the bus-on-shoulder and (to a lesser extent) HOV concepts provide a small increase in sustainable transportation (specifically, transit) mode share, and a decrease in SOV volumes. HOV mode share does not increase substantially with the introduction of HOV lanes. At the regional level, no change in mode share is observed.

#### NETWORK TRAVEL DISTANCE

Network travel distances were extracted from the RTM in the form of person-kilometre travelled (PKT) or truck-kilometres travelled. These travel distances are summarized in ***Table 3.22***, and the change in travel distances relative to the base case are summarized in ***Table 3.23***.

Table 3.22: Total Person-Kilometres Travelled (PKT), Region-Wide

| Person-Km Travelled (PKT) | 2050 AM | | | | 2050 PM | | | |
|---|---|---|---|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| SOV | 4,088,390 | 4,087,377 | 4,088,141 | 4,091,369 | 4,673,974 | 4,673,53 | 4,674,375 | 4,677,144 |
| HOV | 2,147,476 | 2,146,782 | 2,148,654 | 2,148,754 | 2,572,691 | 2,573,983 | 2,574,976 | 2,574,300 |
| Transit | 1,831,049 | 1,834,181 | 1,832,665 | 1,830,542 | 1,774,622 | 1,777,505 | 1,775,912 | 1,774,105 |
| Light Truck | 133,708 | 133,724 | 133,841 | 134,129 | 90,614 | 90,638 | 90,709 | 90,908 |
| Heavy Truck | 225,747 | 225,762 | 225,767 | 225,863 | 140,684 | 140,692 | 140,697 | 140,743 |

Table 3.23: Change in Person-Kilometres Travelled (PKT) Relative to Base Case, Region-Wide

| Person-Km Travelled (PKT) | 2050 AM | | | | 2050 PM | | | |
|---|---|---|---|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| SOV | n/a | -1,013 | -249 | 2,979 | n/a | -439 | 401 | 3,170 |
| HOV | n/a | -694 | 1,178 | 1,278 | n/a | 292 | 2,285 | 1,609 |
| Transit | n/a | 3,132 | 1,616 | -507 | n/a | 2,883 | 1,290 | -517 |
| Light Truck | n/a | 17 | 133 | 421 | n/a | 24 | 95 | 294 |
| Heavy Truck | n/a | 15 | 20 | 116 | n/a | 8 | 13 | 59 |

In general, the bus-on-shoulder concept causes a decrease in passenger vehicle travel, and a significant increase in transit travel. The HOV concept causes a net increase in travel distance across all modes. The additional general-purpose lanes concept causes an increase in automobile person-kilometres travelled against the base case, and a decrease for transit.

### NETWORK TRAVEL TIME

Network travel times were extracted from the RTM in the form of person-hour travelled (PHT) or truck-hours travelled. These travel times are summarized in ***Table 3.24***, and the change in travel times relative to the base case are summarized in ***Table 3.25***.

Table 3.24: Total Person-Hours Travelled (PHT), Region-Wide

| Person-Hr Travelled (PHT) | 2050 AM | | | | 2050 PM | | | |
|---|---|---|---|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| SOV | 136,218 | 136,103 | 136,171 | 135,929 | 159,430 | 159,446 | 159,249 | 159,178 |
| HOV | 69,225 | 69,178 | 69,195 | 69,056 | 82,072 | 82,081 | 81,938 | 81,884 |
| Transit | 68,239 | 68,268 | 68,262 | 68,199 | 66,373 | 66,447 | 66,411 | 66,321 |
| Light Truck | 3,693 | 3,692 | 3,696 | 3,691 | 2,649 | 2,650 | 2,649 | 2,650 |
| Heavy Truck | 5,659 | 5,657 | 5,660 | 5,651 | 3,379 | 3,379 | 3,376 | 3,375 |

Table 3.25: Change in Person-Hours Travelled (PHT) Relative to Base Case, Region-Wide

| Person-Hr Travelled (PHT) | 2050 AM | | | | 2050 PM | | | |
|---|---|---|---|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| SOV | n/a | -115 | -47 | -289 | n/a | 15 | -181 | -252 |
| HOV | n/a | -47 | -30 | -169 | n/a | 9 | -134 | -188 |
| Transit | n/a | 29 | 23 | -40 | n/a | 74 | 38 | -52 |
| Light Truck | n/a | -1 | 3 | -2 | n/a | 0 | 0 | 1 |
| Heavy Truck | n/a | -2 | 1 | -8 | n/a | 0 | -3 | -4 |

The bus-on-shoulder concept provides a small net decrease (for the AM and PM peak hours combined) in terms of person-hours travelled by passenger vehicle modes. The increased capacity for HOV trips in the HOV concept yields a decrease in HOV PHT alongside an increase in HOV PKT. SOV PHT also decreases in the HOV concept across both AM and PM. Both the bus-on-shoulder and HOV concepts cause an increase in PHT by transit; however, this does not necessarily reflect decreasing transit speeds, but rather an increase in transit use as evidenced by the mode share increase reported previously. The additional general-purpose lanes concept, while seeing an increase in both SOV and HOV PKT, sees a decrease in Person-Hours Travelled (PHT) for both, reflecting a net decrease in congestion compared to what otherwise would occur.

### ACCESS TO EMPLOYMENT BY MODE

The overall employment accessibility score was calculated for the 2050 base case and each of the three concepts. The overall average accessibility to employment score by for each of the three municipalities is provided for auto in ***Table 3.26*** and transit in ***Table 3.27***.

Table 3.26: Accessibility to Employment by Auto Score, AM Peak Hour

| Location | 2050 AM Auto Accessibility to Employment (Time-Weighted) | | | |
|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Overall Network | 75,985 | 76,029 | 76,012 | 76,169 |
| West Vancouver | 29,492 | 29,667 | 30,221 | 30,193 |
| North Vancouver (District) | 28,000 | 28,240 | 28,045 | 29,132 |
| North Vancouver (City) | 37,584 | 37,976 | 37,726 | 39,090 |

Time-weighted auto accessibility to jobs is changed the most under the additional general-purpose lanes concept, where all three municipalities see a noticeable increase (although accessibility is still well below 2017 conditions). The HOV concept also affects West Vancouver accessibility to a larger extent than the other two municipalities, likely as trips originating from West Vancouver are well positioned to make use of the entire length of the HOV lane.

Table 3.27: 2050 Accessibility to Employment by Transit Score, AM Peak Hour

| Location | 2050 AM Transit Accessibility to Employment (Time-Weighted) | | | |
|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Overall Network | 13,700 | 13,714 | 13,711 | 13,709 |
| West Vancouver | 2,927 | 2,939 | 2,960 | 2,922 |
| North Vancouver (District) | 3,391 | 3,572 | 3,455 | 3,420 |
| North Vancouver (City) | 9,191 | 9,415 | 9,410 | 9,316 |

Time-weighted transit accessibility to employment sees minor changes for the general-purpose lane concepts, but more significant improvements for the HOV and (especially) bus-on-shoulder concepts.

### ACCESS TO LABOUR FORCE BY MODE

The overall labour force accessibility score was calculated for the 2050 base case and each of the three concepts. The overall average accessibility to labour force score by for each of the three municipalities is provided for auto in ***Table 3.28*** and transit in ***Table 3.29***.

Table 3.28: 2050 Accessibility to Labour Force by Auto Score, AM Peak Hour

| Location | 2050 AM Auto Accessibility to Labour Force (Time-Weighted) | | | |
|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Overall Network | 121,174 | 121,231 | 121,213 | 121,427 |
| West Vancouver | 41,369 | 41,648 | 42,454 | 42,466 |
| North Vancouver (District) | 47,838 | 48,136 | 47,792 | 49,765 |
| North Vancouver (City) | 56,805 | 57,182 | 57,082 | 58,367 |

Time-weighted auto accessibility to labour force is changed the most under the general-purpose lane concept, where all three municipalities see noticeable change. The HOV concept also affects West Vancouver accessibility to a somewhat large extent.

Table 3.29: 2050 Accessibility to Labour Force by Transit Score, AM Peak Hour

| Location | 2050 AM Transit Accessibility to Labour Force (Time-Weighted) | | | |
|---|---|---|---|---|
| | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
| Overall Network | 20,161 | 20,174 | 20,170 | 20,176 |
| West Vancouver | 4,304 | 4,321 | 4,383 | 4,283 |
| North Vancouver (District) | 5,429 | 5,693 | 5,517 | 5,503 |
| North Vancouver (City) | 10,941 | 11,172 | 11,077 | 11,015 |

Time-weighted transit accessibility to labour force sees small changes under all three concepts, with the largest increase being in the District of North Vancouver in the bus-on-shoulder concept.

### ANTICIPATED RETURN TO CURRENT TRAVEL TIME CONDITIONS

As discussed in earlier sections, demand on Highway 1 is expected to increase substantially in the future. Correspondingly, performance will deteriorate, and users of the highway will experience longer travel times. This in turn will have an impact through added delay and reduced accessibility to employment. One alternative discussed in this report is the addition of an extra lane in each direction on Highway 1 between Lynn Valley Road and Taylor Way. This section explores the question of when end-to-end travel times for a six-lane cross-section would return to current (i.e., the model base year of 2017) travel times on the highway corridor. ***Table 3.30*** shows the point-to-point travel time for Highway 1 across the North Shore between Horseshoe Bay and Ironworkers Memorial Bridge for the six-laned corridor base case.

Table 3.30: Highway 1 Corridor Point-to-Point Travel Times (Horseshoe Bay To/From Ironworkers Memorial Bridge)

| Travel Time (minutes) | | 2017 Base | 2035 Base | 2035 Additional General-Purpose Lanes | 2050 Base | 2050 Additional General-Purpose Lanes |
|---|---|---|---|---|---|---|
| Westbound | AM | 25.39 | 28.8 | 23.85 | 30.26 | 24.66 |
| | PM | 22.63 | 31.52 | 27.85 | 34.54 | 30.44 |
| Eastbound | AM | 23.63 | 27.87 | 26.53 | 31.45 | 29.85 |
| | PM | 27.38 | 35.22 | 32.41 | 37.97 | 34.79 |

Note that this type of comparison is not used for developing a quantitative analysis of benefits, as it may be interpreted as (incorrectly) implying that in the absence of any investment, end-to-end trip times would remain at current level. For this reason, 2035 and 2050 base case travel times have also been provided. However, this type of “return to existing conditions” comparison is nonetheless useful with respect to providing “real-world” context for highway operational performance that readers may be able to more directly relate to their individual experience.

In the westbound direction:

- In the AM peak hour, even by 2050, westbound travel times in the AM peak hour with six-laning would still result in approximately 1 minute faster travel times compared to current (i.e., 2017) conditions.
- In the PM peak hour, by 2035 it is estimated that westbound point-to-point travel times on a six-laned highway corridor would be approximately 5 minutes slower than they are under the current condition (i.e., 2017). Based on a linear interpolation of 2017 and 2035 model outputs for the additional general-purpose lane concept, it is estimated that end-to-end travel times on a six-laned corridor would return to existing (2017) travel times by approximately 2021.

In the eastbound direction:

- In the AM peak hour, by 2035 it is estimated that eastbound point-to-point travel times on a six-laned highway corridor would be approximately 3 minutes slower than they are under the current condition (i.e., 2017). It is estimated that end-to-end travel times on a six-laned corridor would return to existing (2017) travel times by approximately 2021.
- In the PM peak hour, by 2035 it is estimated that eastbound point-to-point travel times on a six-laned highway corridor would be approximately 5 minutes slower than they are under the current condition (i.e., 2017). It is estimated that end-to-end travel times on a six-laned corridor would return to existing (2017) travel times by approximately 2021.

### CONSUMER SURPLUS

Consumer surplus, representing a net assessment of the cumulative mobility impacts for the corridor, is presented in ***Table 3.31***.

**Table 3.31: 2050 On-Corridor Improvement Concepts Consumer Surplus**

| Time Period | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
|---|---|---|---|
| SOV | 50,371 | 407,514 | 824,963 |
| HOV | -20,781 | 442,956 | 489,267 |
| LGV | 2,123 | 9,802 | 26,960 |
| HGV | 3,144 | 10,811 | 28,102 |
| Bus | 228,685 | 136,948 | 60,155 |
| Rail | 75,836 | 61,864 | 61,190 |
| WCE | -29 | 278 | 226 |
| Total (hr) | 339,349 | 1,070,172 | 1,490,863 |
| Total ($2020) | $6,627,652 | $20,979,246 | $29,741,182 |

As shown in the above table, the additional general-purpose lane concept provided the greatest consumer surplus in 2050, followed by the HOV lane concept and then the transit concept. Notwithstanding challenges with respect to eastbound traffic movements, it is anticipated that the additional capacity in the westbound direction will create travel time savings throughout the day, and the extensive rerouting of vehicle volumes from parallel municipal routes on the North Shore would improve operations on those corridors. To test the latter assumption, the consumer surplus was disaggregated into local trips (i.e., the combination of intra-municipal and intra-North Shore trips) versus regional/through-trips. The results of this analysis are presented in ***Table 3.32*** below.

Table 3.32: Consumer Surplus Distribution

| Time Period | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
|---|---|---|---|
| Local (hr) | 37,969 | 344,036 | 755,168 |
| **Local ($)** | **$692,096** | **$6,388,049** | **$14,055,197** |
| Regional/Through (hr) | 301,380 | 726,136 | 735,695 |
| **Regional/Through ($)** | **$5,935,555** | **$14,591,196** | **$15,685,985** |
| Total (hr) | 339,349 | 1,070,172 | 1,490,863 |
| **Total ($)** | **$6,627,652** | **$20,979,246** | **$29,741,182** |

As shown in the table, just shy of half of the mobility benefits (47%) of the six-laning concept are accrued by locally oriented trips, a proportion that drops to 30% local trips for the HOV lane concept. In contrast, the bus-on-shoulder concept is overwhelmingly focused on regional trips, with approximately only 10% of benefits coming from local North Shore trips. As noted previously; there are several challenges with respect to both technical and operational feasibility for the HOV and general-purpose lane concepts that would need to be investigated in order to confirm the above-noted benefits. It is further noted that, as the additional general-purpose lane concepts begins at Taylor Way, it is inclusive of the benefits from the Capilano Road Interchange improvement opportunities summarized below in Section 4.1.3.

## SUMMARY OF TRANSPORTATION PERFORMANCE FINDINGS

A high-level summary of the overall findings of each concept in terms of transportation impacts is provided below.

The bus-on-shoulder system concept would provide an extended Route 222 transit service with a significant travel time advantage over private-vehicle modes, and enable transit service on the highway corridor to overcome some of the challenges the corridor otherwise faces with respect to facilitating transit use. A bus-on-shoulder system that terminates at Lynn Valley Road is unlikely to provide a significant travel time savings or reliability benefit, and consequently will attract less ridership. However, unlike either the additional general-purpose lane or HOV lane concepts, bus volumes are low enough that this facility could function as an effective queue jumper, particularly if (as was assumed for modelling purposes) the facility extends all the way to Phibbs Exchange.

The bus-on-shoulder system will not significantly decrease travel times for other highway users; any reduction in vehicle volumes on the corridor by people switching to transit are offset by new trips being added to the highway. Consequently, the primary transportation benefit of this concept would be to increase access between different parts of the region by providing a competitive alternative to a passenger vehicle. Overall, this concept is anticipated to create a small net mobility benefit in 2050, although most benefits would be geared towards regional trips. The bus-on-shoulder concept creates an increase in sustainable transportation mode share on the North Shore.

By enabling transit service and providing a faster dedicated travel lane for high-occupancy vehicles, the HOV lane concept provides the greatest total person-throughput across a screenline between Lonsdale Avenue and Lynn Valley Road. However, although the concept improves mobility, in the eastbound direction, the lack of continuity of the HOV lanes system across Burrard Inlet will increase congestion downstream of the Lynn Valley Interchange concept. Nonetheless, this concept is located between the other two concepts with respect to net mobility benefits in 2050, with roughly 30% of benefits being for local trips. Additionally, the technical feasibility of the laning configuration that was assumed for modelling proposes would need to be further investigated. It is not possible to implement the concept, as modelled alternative approaches would need to be investigated, which would likely involve either eliminating transit service provisions or maintaining transit service but requiring more cost-intensive and impactful modifications to interchanges. Any of these changes could affect findings with respect to overall mobility benefits/consumer surplus.

The general-purpose lane concept will increase use of the highway corridor SOV and HOV trips, but despite these additional volumes, will still increase travel speeds between Taylor Way and Lynn Valley Road. Some of these additional trips on the highway will be a result of trips being rerouted from the municipal road network, which would create an indirect benefit for traffic and transit operations on parallel corridors. In other cases, additional trips travelling to and from the highway are likely to increase volumes and exacerbate congestion on local roads, although the overall impact on municipal roads is still anticipated to be a net positive. Overall, this concept is anticipated to create the greatest net mobility benefit in 2050, with just shy of half the benefit being for local trips within the North Shore. Note that these benefits are inclusive of mobility benefits at the Capilano Road Interchange – benefits that could also be available to the other two concepts if the interchange improvements (as described below in Section 4.1) were implemented in addition to the on-corridor improvements.

A key challenge of the additional general-purpose lane concept is that it will encourage additional vehicle trips on the highway through the Lynn Valley Road Interchange and towards the Ironworkers Memorial Bridge, which will exacerbate eastbound queuing and travel times for trips across Burrard Inlet. This concept does not directly support a shift towards sustainable transportation modes, and is anticipated to cause a slight increase in the share of trips by SOV and HOV. This concept includes the Capilano Road Interchange improvements as part of its scope, which (as described below in Section 4.1) would create benefits in terms of active transportation connectivity, road safety and facilitating intra-North Shore trip-making.

### 3.3.2 Socio-Community Impacts

Socio-community impacts were assessed separately with respect to property impacts, community severance impacts, visual and noise impacts, and consistency with community and regional plans.

### PROPERTY IMPACTS

All concepts are likely to create property impacts in the vicinity of Lloyd Avenue as part of the on-corridor widening.

As noted above, if the HOV lane as envisioned is not feasible, then alternate approaches would need to be investigated; as described above in Section 3.1.2, some of these alternatives could trigger more extensive property impacts. The general-purpose lanes concept, by virtue of incorporating the Capilano Road Interchange improvements concept scope (summarized below in Section 4.1) may create property impacts within the westbound on-ramp loop and eastbound off-ramp.

*Bus-on-Shoulder Concept: Overall Rating is Somewhat Worse*
*HOV Lanes: Overall Rating is Somewhat Worse*
*Additional General-Purpose Lanes: Overall Rating is Somewhat Worse*

### COMMUNITY SEVERANCE

For all three concepts, given the proximity of the pier structures on the Pemberton Avenue pedestrian overpass, the existing overpass structure would need to be demolished to facilitate widening of the highway corridor. However, it is assumed that this overpass structure would be reconstructed as part of the scope of works. No other impacts (either positive or negative) are anticipated in terms of cross-corridor connectivity.

The general-purpose lanes concept, by virtue of incorporating the Capilano Road Interchange scope (summarized below in Section 4.1) would address issues with respect to cycling connectivity, both across the highway and across Capilano River.

*Bus-on-Shoulder Concept: Overall Rating is Similar to Base Case/Neutral*
*HOV Lanes: Overall Rating is Overall Rating is Similar to Base Case/Neutral*
*Additional General-Purpose Lanes: Overall Rating is Similar to Base Case/Neutral*

### VISUAL AND NOISE IMPACTS

For all three concepts, highway widening between Capilano Road and Mackay Avenue is likely to increase visual and noise impacts. With respect to noise impacts, properties on the north side of Gladwin Drive would likely be the most affected, as the existing trees between Gladwin Drive and the highway, which provide both a visual and noise barrier, would be removed. Visual impacts would be limited for residences on the south side of the highway because these residences already have noise walls.

The general-purpose lanes concept, by virtue of incorporating the Capilano Road Interchange improvements concept scope (summarized below in Section 4.1) may create some additional impacts on Hugo Ray Park and residences along Keith Road on the west side of the Capilano River.

*Bus-on-Shoulder Concept: Overall Rating is Somewhat Worse*
*HOV Lanes: Overall Rating is Somewhat Worse*
*Additional General-Purpose Lanes: Overall Rating is Somewhat Worse*

### CONSISTENCY WITH COMMUNITY AND REGIONAL PLANS

Transportation plans for each of the three North Shore municipalities as well as TransLink's area transit plan were reviewed in Section 2.2. None of these documents specifically address any of the on-corridor concepts being considered in this evaluation. However, all four agencies have an underlying transportation policy that supports increasing the share of trips by sustainable modes. Additionally, although the highway is not directly adjacent to any designated growth areas, improved access to transit is a key consideration for regional land use and affordable housing policies. On this basis, the bus-on-shoulder concept is considered compatible with community and regional plans, the HOV lane concept is neutral and the general-purpose lane concept is not compatible.

*Bus-on-Shoulder Concept: Overall Rating is Somewhat Better*
*HOV Lanes: Overall Rating is Similar to Base Case/Neutral*
*Additional General-Purpose Lanes: Overall Rating is Somewhat Worse*

## 3.3.3 Environmental Impacts

Environmental impacts were assessed separately with respect to terrestrial impacts, aquatic impacts and greenhouse gas emissions.

### TERRESTRIAL IMPACTS

All concepts will create terrestrial habitat impacts between the Capilano Road Interchange and the Westview Drive Interchange. Specifically, cross-section widening would be achieved by tree-clearing on the north side of the highway adjacent to Terrace Avenue and Gladwin Drive for a distance of roughly 600 metres between Philip Avenue and Lloyd Avenue. A further approximately 550-metre-long strip of tree-clearing would be required through the Mackay Creek Greenbelt in order to facilitate cross-section widening. Between Lonsdale Avenue and Lynn Valley Road, it is anticipated that cross-section widening would be achieved within the median and therefore require minimal tree removal and would avoid creating impacts on Greenwood Park.

The general-purpose lanes concept, by virtue of incorporating the Capilano Road Interchange improvements concept scope (summarized below in Section 4.1) would require additional tree-clearing in the vicinity of Hugo Ray Park, Cedardale Park and Klee Wyck Park in the District of West Vancouver, although the extent and distribution of these impacts would depend on which interchange configuration is selected.

*Bus-on-Shoulder Concept: Overall Rating is Somewhat Worse*
*HOV Lanes: Overall Rating is Somewhat Worse*
*Additional General-Purpose Lanes: Overall Rating is Somewhat Worse*

### AQUATIC IMPACTS

All concepts would involve widening the highway cross-section across Mackay Creek, which could create impacts on aquatic species and habitats. It is acknowledged that since 2013, significant efforts have been made to restore Mackay Creek and improve habitat for salmon and other wildlife. As currently conceived, all concepts are anticipated to avoid direct impacts on Mosquito Creek, as the concepts have been developed to fit within the cross-section of the existing bridge structure. Concerns were also raised with respect to vehicle tire compounds (which may impact fish) entering into stormwater runoff and ending up in water courses and ultimately in Burrard Inlet. Per the findings in ***Table 3.23***, the general-purpose lane concept is likely to lead to a greatest increase in PKT via SOV and HOV, and will likely lead to the greatest overall increase in "tire-kilometres" that could deposit compounds onto road surfaces. Other potential contaminants that do not necessarily scale linearly with traffic volumes, such as de-icing materials, are also a consideration.

The general-purpose lanes concept, by virtue of incorporating the Capilano Road Interchange scope (summarized below in Section 4.1) is likely to create some potential impacts on the Capilano River in conjunction with the implementation of the new bridge crossing structure.

*Bus-on-Shoulder Concept: Overall Rating is Somewhat Worse*
*HOV Lanes: Overall Rating is Somewhat Worse*
*Additional General-Purpose Lanes: Overall Rating is Somewhat Worse*

### GREENHOUSE GAS EMISSIONS

Vehicle operations-related greenhouse gas emissions impacts were based on the outputs from the travel demand model, where vehicle volumes disaggregated by vehicle type and the prevailing speeds of each element of the road network (and the corresponding length of that element) were used to calculate fuel consumption for both gasoline and diesel-fuelled vehicles. These values were then expanded to daily, annual and full evaluation period impacts using the expansion factors previously summarized in ***Table 3.4*** and ***Table 3.5***. These values were then converted to fuel consumption and then to greenhouse gases using the assumptions provided below in ***Table 3.33***.

**Table 3.33: Quantitative Analysis Inputs for Greenhouse Gas Emission Impacts**

| Variable Name | Value | Source | Comments |
|---|---|---|---|
| Gasoline Fuel Consumption for Passenger Vehicles | Variable | *ShortBEN – High Level Benefit Cost Tool*, BC Ministry of Environment, April 2019 | Mathematical equation that considers average travel speeds and distance travelled. This formula was used for the SOV and HOV vehicle classes. |
| Emitted $CO_2$ Equivalent for Gasoline | 2.363 kilograms of $CO_2$ equivalent/litre of gasoline | *2016 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions*, BC Ministry of Environment, May 2016 | Based on average of Light-duty Vehicle and Light-duty Truck (includes SUV and Minivan) in Table 7 of source document |
| Diesel Fuel Consumption for Trucks | Variable | *ShortBEN – High Level Benefit Cost Tool*, BC Ministry of Environment, April 2019 | Mathematical equation that considers average travel speeds and distance travelled. This formula was used for the LGV, HGV and transit vehicle classes. |
| Emitted $CO_2$ Equivalent for Diesel | 2.630 kilograms of $CO_2$ equivalent/litre of diesel | *2016 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions*, BC Ministry of Environment, May 2016 | Based on Heavy-duty Transport Mode in Table 7 of source document |

The resultant change in greenhouse gas emissions is provided in ***Table 3.34***.

Table 3.34: 2050 Greenhouse Gas Emissions from Vehicular Sources (Tonnes)

| Time Period | Base | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
|---|---|---|---|---|
| 2050 Total Greenhouse Gas Emissions | 8,579,691 | 8,579,295 | 8,582,467 | 8,584,747 |
| 2050 Reduction in Greenhouse Gas Emissions | n/a | 397 | -2,776 | -5,056 |

As shown, the bus-on-shoulder concept would provide a modest reduction in greenhouse gas emissions, while the additional general-purpose lane and HOV concepts result in a negative reduction (i.e., an increase) in greenhouse gas emissions. The importance of developing concepts that will reduce greenhouse gas emissions has been emphasized by several study partners and stakeholders.

### 3.3.4 Capital Costs

Planning level cost estimates were prepared using the Elemental Parametric Method of cost estimation (Wolski method). Costs estimates also included values for future planning, design, project management, construction, administration and contingencies. The capital cost estimates of the on-corridor concepts are shown in ***Table 3.35***. As noted previously, property costs are not included at this time, although all concepts may incur property costs in the vicinity of Lloyd Avenue.

Table 3.35: Capital Cost Estimate for Highway 1 On-Corridor Concepts ($2020)

| Item | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes |
|---|---|---|---|
| Cost Range | $$$$$ | $$$$$ | $$$$$ |

**$**: 0 million – $5 million; **$$**: $5 million – $10 million; **$$$**: $10 million – $50 million; **$$$$**: $50 million – $100 million; **$$$$$**: $100 million+

### 3.3.5 Summary of Findings

A summary of the evaluation of the three on-corridor improvement concepts is presented in ***Table 3.36*** with respect to the key evaluation criteria. With respect to transportation performance, the consumer surplus is used as the primary summary criteria.

Table 3.36: Summary of High-Level Evaluation Findings for On-Corridor Improvement Concepts

| Criteria | Bus-on-Shoulder | HOV Lanes | Additional General-Purpose Lanes | Notes |
|---|---|---|---|---|
| Consumer Surplus – Local ($) | $692,000 | $6,388,000 | $14,055,000 | For year 2050. Trips solely within the North Shore. HOV and GP concepts contingent on further investigation of technical and operational feasibility. GP lane concept also includes Capilano Road Interchange benefits noted below in Section 4.1.3. |
| Consumer Surplus – Regional/Through ($) | $5,936,000 | $14,591,000 | $15,686,000 | |
| Property Impacts | ◔ | ◔ | ◔ | |
| Community Severance | ◑ | ◑ | ◑ | |
| Noise/Visual Impacts | ◔ | ◔ | ◔ | |
| Consistency with Community and Regional Plans | ◕ | ◑ | ◔ | |
| Terrestrial Habitat Impacts | ◔ | ◔ | ◔ | |
| Aquatic Habitat Impacts | ◔ | ◔ | ◔ | |
| Greenhouse Gas Emissions Reduction (tonnes) | 397 | -2,776 | -5,056 | For year 2050. A positive number is a reduction in greenhouse gas emissions. |
| Capital Cost Range | $$$$$ | $$$$$ | $$$$$ | Property and escalation costs not included |

**$**: 0 million – $5 million; **$$**: $5 million – $10 million; **$$$**: $10 million – $50 million; **$$$$**: $50 million – $100 million; **$$$$$**: $100 million+

## 3.4 Key Considerations for Further Concept Development, Refinement and Assessment

For all improvement opportunities outlined herein, further development, investigation, engagement and evaluation across a range of financial, transportation, social, environmental, archaeological and economic criteria is required prior to proceeding towards implementation. Several specific considerations have been identified as part of any further investigation of concepts.

- For all concepts, the initial evaluation findings should be considered in conjunction with the findings from the NXSTPP process and follow-up initiatives. Most critically, it is noted that the Burrard Inlet Rapid Transit technical feasibility study is investigating several concepts to provide a new rapid transit crossing of Burrard Inlet. As foreshadowed in Section 2.1.14, ridership on the bus-on-shoulder system is likely sensitive to the existence of a Burrard Inlet Rapid Transit service, particularly for any rapid transit concepts that follow a Burnaby to Lonsdale via Second Narrows alignment.

- For the bus-on-shoulder concept, an assumption was made that the shoulder-running bus lane would continue all the way from Lynn Valley Road to Phibbs Exchange. If this concept were to be pursued, then the technical feasibility of this concept would need to be confirmed; alternative (and/or extended) routings could also be explored.
- For the bus-on-shoulder and HOV concepts, the placement of an eastbound far-side stop for Lonsdale Avenue would be located in the vicinity of the new City of North Vancouver Harry Jerome Project. Opportunities to provide adequate space for a bus stop shelter and other facilities should be considered in conjunction with the ongoing land development initiative.
- For the HOV concept, if this concept were to be pursued further, then additional investigation would be required to confirm the technical feasibility of the concept as modelled, and if not, what other concepts are feasible. It is suggested that an inside-lane HOV concept without transit service be investigated, as well as conceptual layouts of interchanges with island platforms to facilitate an inside-lane HOV concept with transit service. However, it is anticipated that the latter concept would likely end up being screened out due to the cost and impacts of significantly expanding the interchange footprints, particularly at Lonsdale Avenue.
- The additional general-purpose lanes concept and HOV lanes concept will both deliver substantially greater eastbound vehicle volumes to the top of the cut and could exacerbate eastbound queueing from Lynn Valley Road back to Westview Drive or beyond. As the RTM is not able to fully capture these impacts, if this concept were to be pursued further, then it is recommended that a traffic operations micro-simulation model of the corridor be developed to confirm the validity of the findings form the RTM analysis with respect to mobility benefits.
- The additional general-purpose lane concept would require further exploration to ensure alignment with the CleanBC strategy and the *Roadmap to 2030* plan.
- Some groups noted the importance of not just reducing negative environmental impacts of any projects, but rather ensuring that any projects represent a net environmental gain. Therefore, in addition to obtaining input from environmental professionals to further investigate potential environmental impacts of each concept, opportunities could be explored to incorporate additional environmental elements that could create a net environmental gain, with a particular focus on incorporating green infrastructure elements to manage stormwater by slowing runoff, increasing infiltration and capturing contaminants and sediments. An assessment of the climate resiliency of any new infrastructure could also be pursued.
- Exploration of potential archaeological and cultural heritage implications.
- Continued engagement with study partners and stakeholders.

Finally, it is also acknowledged that upon initial review of the concepts, some study partners and stakeholders expressed support for the bus-on-shoulder concept, and/or noted that the additional general-purpose lanes concept is inconsistent with the policy direction of INSTPP. Explicit support was also noted for any concepts that improve safety for all road users.

# 4. POTENTIAL INTERCHANGE IMPROVEMENT OPPORTUNITIES

Many of the interchanges and structures along the corridor date to the 1960s, and the final interchange on the corridor at Westview Drive was completed in the mid-1990s. The age of the interchanges creates considerations with respect to infrastructure life cycles and states of good repair, geometric designs that may not be consistent with more modern guidelines, and less consideration having been given to sustainable transportation modes in the past. As described above in Section 2.8, several interchanges (or pairs of interchanges) with the most acute challenges were identified for the exploration of improvement opportunities. These interchanges shown in ***Figure 4.1***.

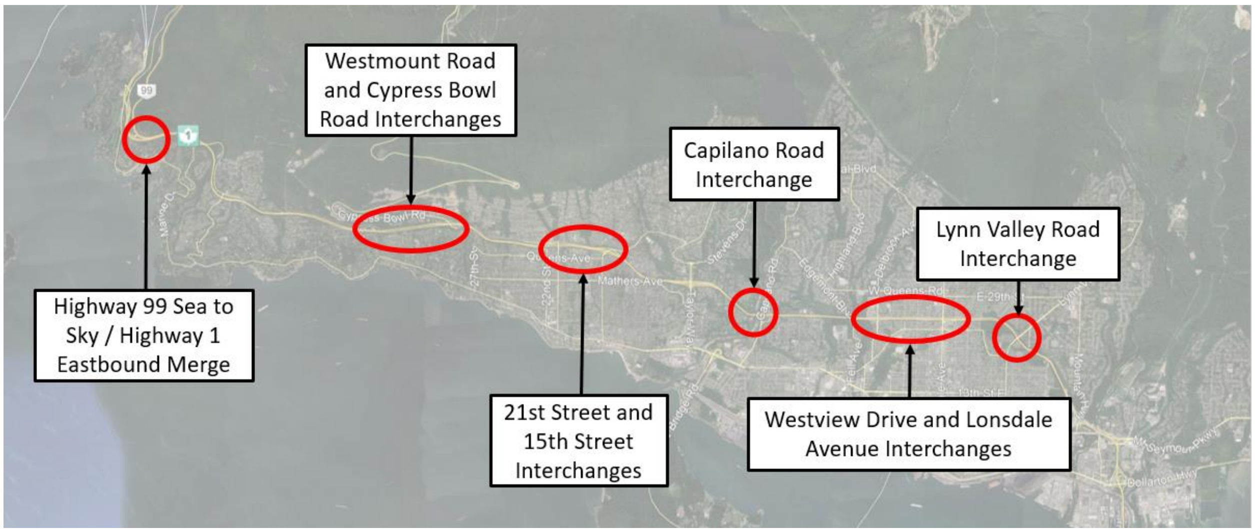


Figure 4.1: Interchanges Identified for Investigation of Improvement Opportunities

For each of these interchanges, the investigation of issues and potential opportunities is structured as follows:

- Key Issues to address.
- Potential improvement approach.
- Initial assessment findings.
- Key considerations for further concept development, refinement and assessment.

With respect to improvement opportunities, the concepts presented are intended to be a concept for improvement, and should not be interpreted as the confirmed improvement to be implemented. For all improvement opportunities outlined herein, further development, investigation, engagement and evaluation across a range of financial, transportation, social, environmental, archaeological and economic criteria is required prior to proceeding towards implementation.

The evaluation of interchange concepts will generally follow the same approach as the on-corridor concepts, although the assessment of the mobility metric is more limited due to the generally smaller-scale impacts of the improvements. Furthermore, in some cases, specific metrics may not apply. However, given the road safety improvements incorporated into several interchange concepts, an assessment was completed of the potential reduction in collisions using collision modification factors relevant for each improvement type to estimate the annual average number of collisions that would occur after the improvement concept is implemented. Similar to the on-corridor concepts, quantified benefits are provided for a specific year, but due to the absence of any particular timelines for concept implementation, have not been converted into a present value.

## 4.1 Capilano Road Interchange

The Capilano Road Interchange (Exit 14) is a Parclo AB interchange with the highway running above Capilano Road. The interchange includes two signalized ramp terminal intersections, with the north intersection servicing the westbound on-ramp and off-ramp, and the south intersection servicing the eastbound on-ramp and off-ramp. As noted in ***Table 2.1***, within the interchange area, Capilano Road has continuous sidewalks on both sides of the roadway, no provisions for cycling and three bus services (Route 236, Route 245 and Route 247). With respect to interchange spacing, the nearest full movement interchanges are the Taylor Way Interchange 1.7 kilometres to the west and Westview Drive 2.1 kilometres to the east. The Lloyd Avenue westbound right-in/right-out access is also located 0.9 kilometres to the west, although as described previously, this movement would likely need to be closed as part of a widening of the highway cross-section through this area (i.e., for any of the three concepts described in Section 3). The existing interchange is shown in ***Figure 4.2***.


Figure 4.2: Existing Capilano Road Interchange

### 4.1.1 Key Issues to Address

The review of key issues to address is based on an elaboration and further investigation of the findings of the issues identification process. The review of key issues is organized as follows:

- Motor vehicle traffic operations.
- Transit.
- Road safety.
- Local trips and the role and function of the highway.
- Active transportation.

### MOTOR VEHICLE TRAFFIC OPERATIONS

With respect to motor vehicle traffic operations, volume-to-capacity ratio challenges were identified for the eastbound on-ramp, the westbound on-ramp and the westbound off-ramp. Operations at these three ramps are elaborated on further below:

- The eastbound on-ramp is anticipated to have the greatest capacity challenges. For this movement, the ramp is already designed to provide an extended acceleration distance and a parallel merge configuration, both of which increase ramp capacity. Providing an add-lane would further increase capacity; however, this concept would be more suited to being considered as part of an on-corridor expansion/improvement, due to the trade-offs in terms of right-of-way availability for other on-corridor improvements.
- The westbound on-ramp also has capacity challenges, which are primarily governed by the yield condition at the on-ramp. Providing an acceleration lane would increase capacity at this ramp, although it is noted that the Regional Transportation Model is not typically calibrated to a level of detail to reflect specific on-ramp geometries. Therefore, in practice, the ramp will have a lower capacity than what is assumed in the model, meaning the provision of an acceleration lane would likely service to simply bring the ramp up to the capacity already assumed in the model. Providing a continuous westbound add-lane would significantly increase capacity.
- The westbound off-ramp capacity is primarily governed by the laning, phasing and timing of the northern ramp terminal signalized intersection. From a highway operations perspective, the primary consideration with respect to off-ramp capacity is whether queues of vehicles at the ramp terminal intersection would spill back onto the highway exit and begin to impact operations on the highway mainline. Addressing this issue would require changes to one of these three governing factors, although changes would need to also consider the implications for other current and future multi-modal traffic movements through the intersection. Given the potential physical and operational constraints, opportunities could be investigated to provide loop detectors on the off-ramp that, once triggered, would provide additional signal green time to off-ramp movements once queues begin to spill back close to the highway, but otherwise provide traffic signal operations that provide balanced green time among all movements.

### TRANSIT

Currently, there are no transit services along Highway 1 in the vicinity of Capilano Road. As part of the development of a bus-on-shoulder concept, a modelling exercise was completed wherein the Route 222 service from Metrotown to Phibbs Exchange would be extended along Highway 1 to Capilano Road, with a stop at Lonsdale Avenue (and potentially also Lynn Valley Road, as discussed further in Section 4.2).

As noted previously in Section 2.3.2, there are three bus services that run along Capilano Road: Route 236, which runs from Grouse Mountain to Lonsdale Quay; Route 246, which runs between the Forest Hill neighbourhood in the District of North Vancouver to downtown Vancouver via the Lions Gate Bridge; and Route 247, which runs from Grouse Mountain to downtown Vancouver via the Lions Gate Bridge. These routes have stops in the general vicinity of the interchange, and if a bus-on-shoulder service were to be implemented (either terminating at the Capilano Road Interchange, or running further west along the highway), then connectivity between the east-west service on the highway and the north-south services along Capilano Road would need to be reviewed to ensure that safe, efficient and comfortable connections are provided for transfers between the services. Provision for safe pedestrian connections to the nearby community and comfortable passenger waiting areas would also need to be reviewed.

#### ROAD SAFETY

With respect to road safety, the Capilano Road Interchange had the highest collision frequency of any area along the Highway 1 study corridor. As described previously in Section 2.6.2, specific highway geometric conditions that are likely contributing to collisions at this interchange, including:

- In the westbound direction, 25 out of 40 collisions occurred at the westbound on-ramp. This on-ramp ramp provides a direct entry configuration on a yield condition; no opportunity for acceleration is provided on the on-ramp prior to merging. This causes vehicles to enter the highway at very low speeds, causing large speed differentials between vehicles already on the highway and vehicles merging onto the highway.
- The direct exit for the eastbound off-ramp may be contributing to rear-end collisions on the bridge structure as vehicles decelerate prior to exiting the highway mainline.
- On the west side of the Capilano River Bridge, the highway provides a sharp horizontal curvature. The eastbound direction is more of an issue; with contributing factors potentially including higher vehicle speeds (the posted speed limit is 90 km/h until immediately prior to the bridge, at which point it drops to 80 km/h and then shortly thereafter provides a suggested 60 km/h speed limit), the extended 4% downhill grade from the Taylor Way Interchange to the bridge (which contributes to speeds), and the lack of highway shoulders. Specifically, the outside road shoulder, which would normally provide some margin for error for drivers with excessive speed or who are understeering, also narrows and gradually disappears in this area due to the lack of width available on the bridge structure to provide such a shoulder.
- A lack of safe ramp crossing opportunities also limits the ability of on-corridor cycling to extend further east from the Capilano Road Interchange. This issue is discussed further below.

#### LOCAL TRIPS

Typically, the role of the provincial highway system is to facilitate regional or inter-regional trips, and it is not necessarily intended to service “local” trips. However, the reality of the North Shore transportation network with respect to a lack of a continuous grid network across major natural barriers (e.g., Capilano River, Mackay Creek Mosquito Creek, Lynn Creek), and the challenges of implementing such connections with respect to impacts on developed communities as well as the natural environment mean that the provincial highway is likely to continue being used by North Shore residents for local trips.

The Capilano Road Interchange is particularly prone to being used for local trip access to and from the highway, given the presence of the Capilano River immediately to the west, and Mackay Creek and Mosquito Creek just to the east. Travel demand modelling analysis presented in Section 2.4.2 shows that the highway segment between the Capilano Road Interchange and the Taylor Way Interchange has a high proportion of local trips and, in fact, sees a “jump” in local trip volumes as compared to highway segments to either the east of Capilano Road or to the west of Taylor Way. Alternative connections across the Capilano River are limited to Marine Drive and Taylor Way: the former can be impacted by Lions Gate Bridge-related congestion and the latter provides low capacity. Both alternative connections are also relatively close to the shoreline, and a greater deviation from the desire line for trips that are originating from and/or destined to locations further up the hillside/away from Burrard Inlet. As such, the use of the highway for local trips across the Capilano River becomes an attractive concept. The lack of network redundancy also creates a concern with respect to the operational resiliency of the highway in the event of incidents on Marine Drive that create significant delays and cause a surge in volumes on the highway crossing instead. Given these considerations, opportunities to provide a more “local” connection across the Capilano River that would not require use of the highway mainline through-lanes warrant investigation as part of the development of a potential concept at the Capilano River Interchange. In many respects, this approach is similar to the ongoing Lower Lynn Interchange Improvements project, which includes new local bridge crossings of Lynn Creek that parallel Highway 1.

Travel demand modelling analysis also shows evidence of point-to-point trips between the Capilano Road Interchange and the Westview Drive Interchange. In fact, as shown in ***Figure 2.35*** and ***Figure 2.36***, this highway segment has the highest single point-to-point motor vehicle volumes between any two interchanges in the study area, although still a lower volume of local trips overall than the Capilano Road to Taylor Way segment. Additional “local” lanes were not considered between the Capilano Road Interchange and the Westview Drive Interchange because they were already implicitly investigated as part of the highway corridor improvement concepts (the six general-purpose lane concept, specifically). Incorporating auxiliary lanes as part of other concepts would be challenging. For example, it is likely not possible to add both bus lanes and auxiliary lanes between the Capilano Road Interchange and the Westview Drive Interchange (while also maintaining an opportunity for the parallel active transportation facilities discussed in Section 3.1.4) without significant impacts on properties on one or both sides of the highway corridor. Furthermore, from a network redundancy and operational resiliency perspective, although the parallel municipal road network is limited across these two creeks, in addition to Marine Drive and 1$^{st}$ Street/2$^{nd}$ Street (which is somewhat equivalent to the Taylor Way crossing of the Capilano River), there are several additional alternatives to cross Mosquito Creek and Mackay Creek available further up the mountainside (e.g., Ridgewood Drive/Edgemont Boulevard/Queens Road, or even Mont Royal Boulevard) that do not exist at (or have an equivalent route) across the Capilano River.

#### ACTIVE TRANSPORTAITON

With respect to on-corridor active transportation, generally there are no walking facilities along the highway corridor; however, the vicinity of the Capilano Road Interchange is an exception. Specifically, the Capilano River Bridge has narrow walking/cycling paths on either side of the bridge that are barrier-separated from motor vehicle traffic. The path on the north side of the bridge cross-section adjacent to the westbound vehicle lanes is the better concept for people walking, due to superior connectivity on either side of the bridge, namely to the new Hugo Ray Park multi-use path and Keith Road on the west (i.e., District of West Vancouver) side, and to the north ramp terminal intersection with Capilano Road via a path adjacent to the westbound on-ramp loop on the east (i.e., District of North Vancouver) side. Connections at either end also enable this path to be used by people cycling in both directions, although only westbound cyclists would be able to continue their journey via the highway shoulder. In contrast, although the path on the south side of the bridge cross-section adjacent to the eastbound vehicle lanes is usable by people walking, there is limited connectivity to and from this path on either side of the bridge. Therefore, in the current condition, the path on the south side of the bridge cross-section is better suited for use solely by people cycling eastbound on the highway shoulder; people cycling in the eastbound direction on the south side that are approaching from the District of West Vancouver municipal street network, rather than the highway itself, would likely need to make a more circuitous trip that makes use of the bidirectional pathways on the north side.

Under the current condition, shoulder cycling is permitted on Highway 1 between Horseshoe Bay and the Capilano Road Interchange. Although much of the highway corridor in both directions from the Capilano Road Interchange to the Westview Drive Interchange is suitable for cycling (through a combination of road shoulder and barrier-separated pathway shared with people walking), the crossing of the Capilano Road Interchange ramps creates a safety challenge that severs this connection. Therefore, opportunities to mitigate this safety challenge and enable the extension of cycling to Westview Drive could be considered.

The previous description of the barrier effect of the Capilano River and the role of the Capilano River Bridge in facilitating “local” trips within the North Shore applies not only to motorized modes but also to active modes. Although cycling along highway shoulders is not necessarily suitable for people of all ages and abilities, given the lack of alternative routes, the bridge across the Capilano River should provide cycling (and walking) facilities suitable for all user groups, as well as connections to alternative off-highway routes on local streets that are also more suitable for people of an all ages and abilities. Connectivity on and off the bridge structure is currently a greater challenge on the south side of the bridge adjacent to the eastbound vehicle travel lanes. To facilitate access to local street cycling routes, the lack of eastbound cycling connectivity from the eastbound off-ramp to Keith Road, which in turn provides connectivity to 23rd Street for local street cycling, would need to be addressed. There is also currently a lack of cycling connectivity from east-west facilities on 23rd Street (via Keith Road) to north-south facilities on Capilano Road.

With respect to cross-corridor active transportation, Capilano Road has continuous sidewalk coverage on both sides of the roadway through the entire interchange area. However, no cycling facilities are provided within the interchange area (i.e., between the ramp terminal intersections). South of the interchange, the District of North Vancouver has provided painted cycling lanes on Capilano Road. There are also painted bike lanes on Capilano Road to the north of the interchange, although these lanes currently terminate at Ridgewood Drive, approximately 650 metres north of the northern ramp terminal signalized intersection. It is understood that the District of North Vancouver is investigating opportunities to provide cycling facilities along the “gap” between Ridgewood Drive and the interchange ramp terminal. Once complete, the 300-metre section of Capilano Road between the two ramp terminal signalized intersections would be the only gap in a continuous cycling network along Capilano Road in the vicinity of the interchange.

### 4.1.2 Potential Mitigation Approach

A series of mitigation approaches were identified to mitigate the key issues described above, and are summarized in ***Table 4.1***. Subsequently, several of these mitigation approaches are elaborated upon further.

Table 4.1: Capilano Road Interchange Issues and Potential Mitigation Approaches

| Issue | Potential Mitigation Approach |
|---|---|
| The yield-condition for the westbound on-ramp creates travel speed differentials and lowers on-ramp capacity. | Provide additional length for acceleration on the westbound on-ramp. |
| Volume-to-capacity issues on ramps and at the ramp terminal intersections. | Consider opportunities for intersection refinements to the northbound ramp terminal. |
| Lack of transit service along the corridor. | Provide a bus priority lane to enable continuation of reliable on-corridor transit services across the Capilano River. |
| High collision history at the westbound on-ramp. | Provide additional length for acceleration on the westbound on-ramp. |
| High collision history at the eastbound off-ramp. | Provide additional length for deceleration on the eastbound off-ramp. |
| High collision history at the sharp horizontal curvature on the west side of Capilano River. | Increase the radius of the horizontal curvature on the highway just to the west of the Capilano Road Interchange. |
| The Capilano River Bridge is heavily used for “local” or intra-municipal trips, due to the lack of a fully developed municipal street network. | Provide connectivity for local trips across the Capilano River via auxiliary lanes that does not require use of the highway mainline though-lanes. |
| The existing shared walking and cycling paths on the Capilano Road Interchange are narrow. | Provide active transportation facilities across the Capilano River that are consistent with recommendations in the BC MoTI *Active Transportation Design Guide* (2019). |
| On-corridor shoulder cycling is not permitted east of Capilano Road, and there is poor connectivity to alternate municipal cycling routes. | Address crossing safety challenges at the Capilano Road ramps to enable on-corridor cycling to continue further east from the Capilano Road Interchange. |
| Capilano Road lacks cycling facilities between the two ramp terminal intersections. | Provide continuous cycling infrastructure connectivity on Capilano Road between the ramp terminal intersections to tie into municipal infrastructure on either side of the interchange area. |
| Lack of cycling connectivity between Capilano Road and 23rd Street/Keith Road. | Provide continuous cycling infrastructure between Capilano Road and Keith Road. |

### WESTBOUND ON-RAMP ACCELERATION LANE AND EASTBOUND OFF-RAMP DECELERATION LANE

Providing a westbound acceleration lane either requires an additional lane across the bridge, or extending the existing ramp loops eastwards into an east-west oval shape to have vehicles begin accelerating further to the east (e.g., near Philip Avenue). The latter concept would create significant impacts on residences along Terrace Avenue and Gladwin Drive, and was not pursued further. A similar consideration exists for the eastbound off-ramp, wherein avoiding providing a deceleration lane on the bridge structure would require an oval-shaped loop that would impact potentially impact properties along Keith Road, Plateau Drive and Philip Avenue.

Based on the above design considerations, a concept was developed wherein the Capilano Road Interchange would retain its current Parclo AB configuration, but a new parallel bridge structure would be provided across the Capilano River. The existing structure would be used for traffic in one direction and the new bridge structure for traffic in the other direction. The additional roadway cross-sectional width across the Capilano River allows for extended westbound on-ramp and eastbound off-ramps to be implemented, which will address some of the traffic operations and road safety issues.

Given that the acceleration and deceleration lanes would already extend across the river (which is a complex and higher cost place to add new road capacity) to address westbound entry and eastbound exit safety and operational issues, an opportunity was identified to continue these lanes all the way to the east-facing ramps at the Taylor Way Interchange. This extension could potentially be implemented within the existing right-of-way, and would be comparatively less complex and lower cost than the additional laning over the river. This extension would result in auxiliary lanes being provided between the two interchanges, which would address the role of the highway in facilitating “local” trips across the Capilano River.

#### HORIZONTAL CURVATURE

The road safety issues related to the sharp horizontal curve radius at the west end of the bridge structure would be addressed by increasing the radius of the curve. To increase the radius of the curve while reducing impacts on properties on the south side of the highway, the horizontal curvature would need to begin “sooner” on the bridge structure itself. While widening the main concrete arch span on the existing bridge would be challenging, widening the two concrete girder spans to the west (i.e., over and adjacent to Keith Road) is anticipated to be (comparatively) simpler. By widening the existing girder bridge spans to the north, the highway would be able to transition to a horizontal curvature immediately west of the main concrete arch bridge, or roughly 25 metres further east than the current curve transition. This would enable the radius of the horizontal curvature to be increased from 200 metres to 250 metres, which is the minimum radius recommended by the *Geometric Design Guide for Canadian Roads* for an 80 km/h design speed (assuming a superelevation of 0.06 m/m).

#### ACCOMMODATING TRANSIT SERVICE

With respect to transit, outside shoulders could be provided on the bridge structure, which would double as a space provision for a future westward extension of bus-on-shoulder system, should such a system be implemented between Capilano Road and Phibbs Exchange. In the westbound direction, buses and on-ramp traffic would weave near the existing on-ramp entrance and be allocated their own lane/shoulder on the bridge structure, resulting in a cross-section with two general-purpose through-lanes, an auxiliary lane and a bus-on-shoulder lane. In the eastbound direction, the need to provide a mixing zone for the bus-on-shoulder and traffic exiting the highway via the auxiliary lane that transitions to the eastbound off-ramp means that these two lanes would end up merging into a single lane upstream of the bridge structure. The result would be a cross-section with two general-purpose through-lanes, an auxiliary lane shared with buses, and a road shoulder that would be narrower than a full-width shoulder for buses.

#### ACTIVE TRANSPORTATION PROVISIONS

The concept incorporates several opportunities to improve active transportation facilities in the vicinity of the Capilano Road Interchange. These opportunities include:

- Wider active transportation facilities on both sides of the highway crossing the Capilano River: Conversion of the existing bridge span to unidirectional vehicular traffic flow would enable the median concrete barrier to be removed, and the cross-sectional space devoted to the barrier (and minimal inside shoulders) would instead be allocated towards a wider active transportation facilities on one side of the bridge. The existing narrow path on the other side of the bridge would be repurposed as a new inside shoulder and/or widening of the motor vehicle lanes. Since the new bridge span cross-section is being developed “from scratch”, there is significant flexibility with respect to widths of new active transportation facilities, and a wide facility can also be provided on this new span.

- Cycling connectivity on Capilano Road: The introduction of a new bridge structure provides an opportunity to reconfigure the existing Capilano Road cross-section between the two interchange ramp terminal signalized intersections in order to provide cycling facilities.
- Addressing cycling conflicts at the eastbound ramps: The interface of the on-ramp and off-ramps versus shoulder cycling crossings were reviewed, and an opportunity for the eastbound ramps was identified to provide an overpass structure to bypass the ramps and also connect to Keith Avenue for people who would prefer to avoid cycling along the highway.
- Cycling connectivity between Capilano River Bridge, Capilano Road and Keith Road: New bidirectional active transportation facilities can be provided inside the eastbound off-ramp and outside the eastbound on-ramp. These facilities will improve connectivity between east-west facilities on the Capilano River Bridge, north-south facilities on Capilano Road and the informal east-west cycling route on 23rd Street (via Keith Road).

### BRIDGE CONFIGURATION

Given that the concept involves the provision of a new parallel bridge span over the Capilano River, a key consideration is whether the new span would be on the north side or the south side of the existing span. Based on an initial review of potential impacts, a new bridge structure to the south would provide the following advantages:

- Potential for fewer property impacts on the east side of the bridge span at the Capilano Road Interchange, as the interior of the south ramp loops is owned by BC MoTI, and already vacant. In contrast, the north ramp loops are used for tennis courts and a veterinarian business.
- On the west side of the span, there would be fewer impacts on Hugo Ray Park.
- As described above, the eastbound bus-on-shoulder operations would merge with the auxiliary lane upstream of the bridge in order to avoid creating a conflicting movement near the eastbound off-ramp curve. This means that a “new south bridge” concept could provide a slightly narrower bridge than a “new north bridge” concept, since the former would accommodate the eastbound cross-section while the latter would need to accommodate the (slightly wider) westbound cross-section.
- Both concepts have considerations with respect to terrestrial and aquatic habitats impacts; however, at this high level of review, the types of potential impacts on these habitats are not anticipated to vary significantly between the two concepts.

One potential drawback of a “new south bridge” concept versus a “new north bridge” concept is that the existing span, which is a relatively rare example of a concrete arch bridge structure, is primarily only visible from the south. The new bridge span to the south would obstruct the view of the existing span.

The resultant Capilano Road Interchange improvement concept is shown in ***Figure 4.3***.

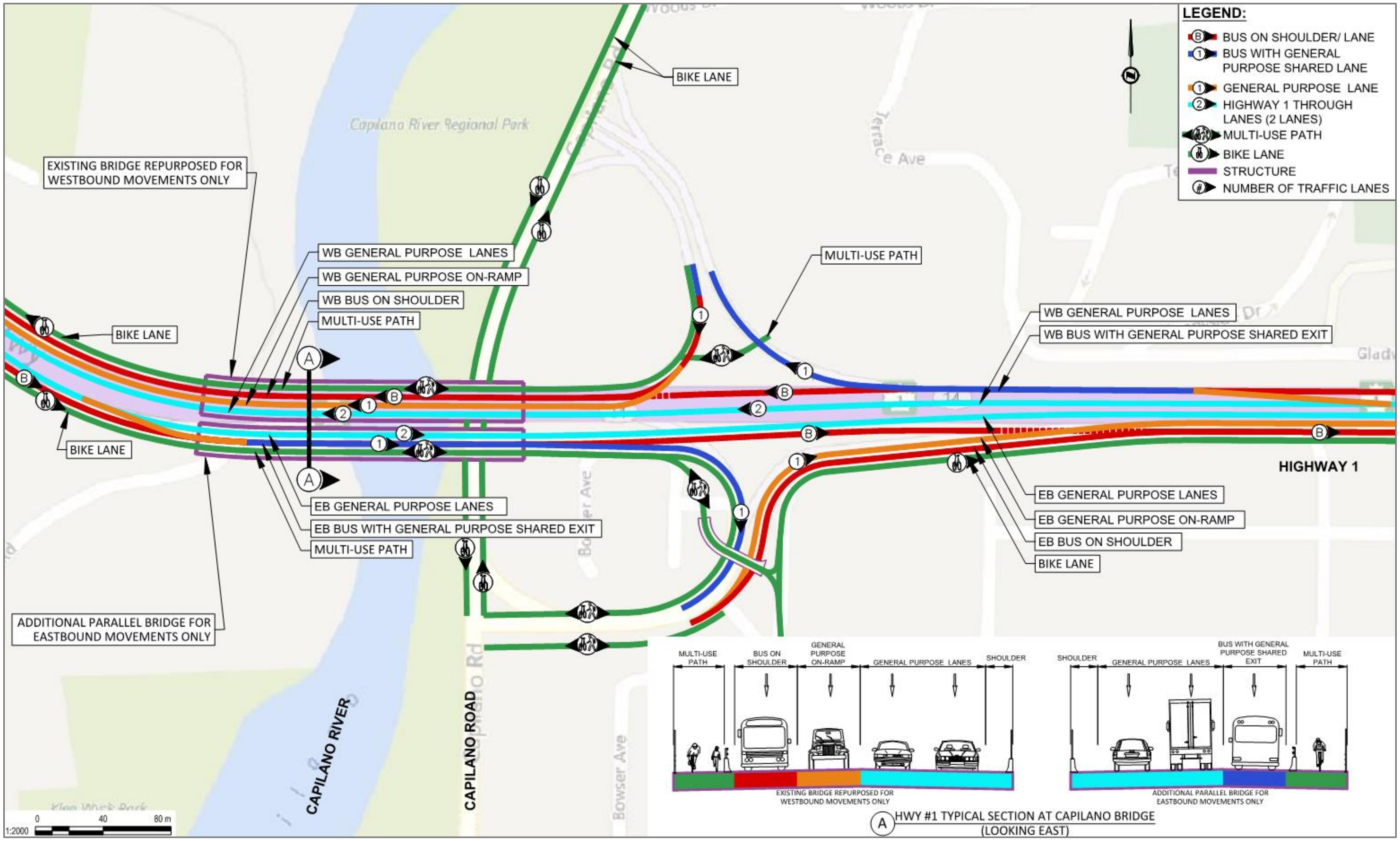


Figure 4.3: Capilano Road Interchange Concept – New South Bridge

FOR DISCUSSION PURPOSES ONLY

### 4.1.3 Initial Evaluation Findings

Findings from the initial high-level evaluation with respect to transportation performance, socio-community impacts, environmental impacts and capital costs are summarized below.

#### TRANSPORTATION PERFORMANCE

Transportation performance metrics assessed for the Capilano Road Interchange improvement concept include the volume-to-capacity ratio, a qualitative assessment of accommodating transit service, a qualitative assessment of active transportation provisions, road user consumer surplus, and road safety.

#### Volume-to-Capacity Ratio

Volume-to-capacity ratios for the Capilano Road Interchange ramps for the 2017 base year as well as the 2050 planning horizon year with and without the improvement opportunity are provided in ***Table 4.2***. Note that these results are presented under a modelling scenario wherein improvements were also coded at the Lynn Valley Road and Westmount Road Interchanges.

Table 4.2: Capilano Road Interchange Ramp Segment Volume-to-Capacity Ratios

| Ramp | AM | | | PM | | |
|---|---|---|---|---|---|---|
| | 2017 | 2050 Base | 2050 Interchange Improvements | 2017 | 2050 Base | 2050 Interchange Improvements |
| WB off-ramp | 0.84 | 0.98 | 0.69 | 0.66 | 0.73 | 0.48 |
| WB on-ramp | 0.37 | 0.8 | 0.23 | 0.57 | 0.93 | 0.38 |
| EB off-ramp (from Hwy) | 0.32 | 0.49 | 0.54 | 0.29 | 0.38 | 0.44 |
| EB off-ramp (to int.) | 0.31 | 0.41 | 0.42 | 0.39 | 0.5 | 0.52 |
| EB on-ramp (from int.) | 0.33 | 0.38 | 0.37 | 0.66 | 0.7 | 0.68 |
| EB on-ramp (to Hwy) | 0.6 | 0.78 | 0.79 | 1.18 | 1.22 | 1.2 |

In 2017, model results show that the westbound off-ramp is approaching capacity in the AM peak hour and the eastbound on-ramp is above capacity in the PM peak hour. By 2050, the westbound off-ramp is extremely congested in the AM and the westbound on-ramp is very congested in the PM peak hour, while the eastbound on-ramp also remains an issue. With the collection of proposed interchange improvements, the westbound on-ramp sees a substantial improvement in volume-to-capacity ratios, as a result of the on-ramp being converted to an add-lane instead of a yield-condition merge. The volume-to-capacity ratio for this movement is lower with the improvements in 2050 than under the current 2017 condition.

Only a minor change in the eastbound on-ramp volume-to-capacity ratio is observed, although this was anticipated, as no improvements are proposed for this ramp due to the most feasible improvement (conversion to an add-lane) already being captured as part of on-corridor improvements.

### Accommodating Transit Service

Although this concept would not directly create any impacts on transit service, it would provide a new Capilano River bridge crossing that is future-proofed for the eventual introduction of transit service.

*Overall Rating is Somewhat Better*

### Active Transportation Provisions

As described above, the Capilano Road Interchange Improvement is anticipated to address several major walking and cycling challenges at the interchange, including:

- Providing wider walking and cycling facilities on the bridge.
- Improving connectivity between the bridge and walking and cycling facilities on Capilano Road.
- Providing connectivity to West 23rd Street via Keith Road for eastbound cyclists who wish to use calmer local streets.
- In the eastbound direction, enabling further eastward travel to connect with the existing active transportation facility that begins at Pemberton Avenue, and ultimately connecting to Westview Drive. This facility is anticipated to be grade-separated to avoid interface with vehicle traffic on and off the highway. A similar connection could be considered in the westbound direction on the north side of the highway, although further investigation would be required to assess whether sightlines allow for an at-grade crossing or whether a grade-separation would also be required.
- Providing continuous cycling facilities along Capilano Road.

*Overall Rating is Significantly Better*

### Consumer Surplus

Consumer surplus, representing a net assessment of the cumulative mobility impacts from the interchange concept, is presented in ***Table 4.3***.

**Table 4.3: 2050 Capilano Road Interchange Improvement Concepts Consumer Surplus**

| Time Period | Capilano Road Interchange |
|---|---|
| SOV | 225,664 |
| HOV | 124,159 |
| LGV | 8,174 |
| HGV | 12,075 |
| Bus | 16,463 |
| Rail | 28,369 |
| WCE | 66 |
| Total (hr) | 414,970 |
| Total ($2020) | $8,374,417 |

By 2050, the Capilano Road Interchange is forecast to provide an annualized mobility benefit of approximately $8.4 million. Of this benefit, 44% (or $3.7 million) is for local trips within the North Shore, while the remaining 56% (or $4.7 million) is for regional through-trips. This relatively even distribution of benefits was anticipated, given the provision of the auxiliary lanes to facilitate cross-river trips (which will be predominantly local trips), which in turn avoids creating congestion for longer-distance trips on the highway (which will be predominantly regional or through-trips).

### Road Safety

Road safety benefits from the new interchange were investigated through the application of collision modification factors (CMF), as shown in ***Table 4.4***.

**Table 4.4: Capilano Road Interchange Improvement Concept Collision Prediction Modelling**

| Improvement | Applicable Collision Types | Collision History | Collision Frequency (collisions per year) | Collision Modification Factor | New Collision Rate | Source | Notes |
|---|---|---|---|---|---|---|---|
| Eastbound Deceleration Lane | All Collisions | 81 | 14.73 | 0.57 | | Crash Modification Factors Clearinghouse: ID 3042 | Deceleration length increased from 50 metres to 400 metres |
| Increased Horizontal Curvature Radius | Off-road Collisions | 29 | 5.27 | 0.75 | | BC MoTI *Collision Modification Factors for British Columbia* (2008), Section 3.2.1 | Radius increased from 200 metres to 250 metres |
| **Eastbound Improvements (Combined)** | **n/a** | **n/a** | **14.73** | **0.57** | **8.32** | | **CMF is a weighted average for two separate collision groups** |
| Westbound Acceleration Lane | All Collisions | 40 | 7.27 | 0.41 | | Crash Modification Factors Clearinghouse: ID 5215 | Acceleration length increased from 50 metres to 600 metres |
| Increased Horizontal Curvature Radius (Westbound) | Off-road Collisions | 2 | 0.36 | 0.75 | | BC MoTI *Collision Modification Factors for British Columbia* (2008), Section 3.2.1 | Radius increased from 200 metres to 250 metres |
| **Westbound Improvements (Combined)** | **n/a** | **n/a** | 7.27 | **0.31** | **2.26** | | **CMF is a weighted average for two separate collision groups** |

In the eastbound direction, a reduction of 6.40 collisions per year is anticipated, with a rough split of 60% property damage only and 40% injury. In the westbound direction, a reduction of 5.01 collisions per year is anticipated, with a rough split of 62% property damage only and 38% injury. Collision savings were then monetized using outputs from the BC Ministry of Transportation and Infrastructure *Default Values for Cost Benefit Analysis* (2018), which have been adjusted to 2020 values based on the Statistics Canada Consumer Price Index. The resultant combined monetized savings is $1,627,000 on an annualized basis for current volumes. Savings are anticipated to increase over time as volumes increase.

### SOCIO-COMMUNITY IMPACTS

Socio-community impacts were assessed separately with respect to property impacts, community severance impacts, visual and noise impacts, and consistency with community and regional plans.

#### Property Impacts

The “new south bridge” concept is anticipated to impact properties within the eastbound loop ramp, which is vacant and already owned by the BC MoTI. Some impacts on properties on the south side of the highway west of the Capilano River are also possible, and would need to be investigated further.

If the “new north bridge” concept were to be selected instead, this concept would create impacts on properties within the westbound loop ramp, and potentially a small portion of Hugo Ray Park.

*Overall Rating is Somewhat Worse*

#### Community Severance

As documented throughout Section 2.4.2, the presence of north-south watercourses such as the Capilano River creates challenges in terms of intra-North Shore connectivity, a condition that is further exacerbated by the lack of a fully developed parallel municipal road network.

Recognizing that Highway 1 plays a major role in facilitating intra-North Shore trips across the Capilano River, this concept would provide auxiliary lanes for motorized modes as well as wider separated walking and cycling paths for active modes. These changes are anticipated to improve multi-modal community connectivity.

*Overall Rating is Significantly Better*

#### Visual and Noise Impacts

This concept may create some impacts on Hugo Ray Park and residences on the south side of the highway west of the Capilano River. The extent of impacts are contingent on which bridge span concept is preferred, with the “new south bridge” concept having fewer potential impacts on Hugo Ray Park, but more impacts on private property.

*Overall Rating is Somewhat Worse*

### Consistency with Community and Regional Plans

The components of the project that improve walking and cycling are consistent with municipal and regional transportation planning policies. Although not specifically discussed in the District of North Vancouver *Transportation Plan* (2012), engagement with District staff suggests that improvements to this interchange are generally consistent with municipal objectives.

*Overall Rating is Significantly Better*

## ENVIRONMENTAL IMPACTS

Environmental impacts were assessed separately with respect to terrestrial impacts, aquatic impacts and greenhouse gas emissions.

### Terrestrial Impacts

The Capilano Road Interchange improvements concept would require additional tree-clearing in the vicinity of Hugo Ray Park, Cedardale Park and Klee Wyck Park in the District of West Vancouver, although the extent and distribution of these impacts would depend on which interchange configuration is selected.

*Overall Rating is Somewhat Worse*

### Aquatic Impacts

The Capilano Road Interchange scope is likely to create some potential impacts on the Capilano River in conjunction with the implementation of the new bridge crossing structure. The Capilano River is an important watercourse for fisheries, given the salmon hatchery located upstream of the bridge.

*Overall Rating is Somewhat Worse*

### Greenhouse Gas Emissions

The resultant change in greenhouse gas emissions is provided in ***Table 4.5***.

Table 4.5: 2050 Capilano Road Interchange Greenhouse Gas Emissions from Vehicular Sources (Tonnes)

| Time Period | 2050 Base | Capilano Road Interchange Improvements Concept |
|---|---|---|
| Total Greenhouse Gas Emissions | 8,579,691 | 8,580,272 |
| **Reduction in Greenhouse Gas Emissions** | n/a | -581 |

As shown, the Capilano Road Interchange improvements are anticipated to cause a small net increase in greenhouse gas emissions by 2050. This increase is largely attributable to the increased travel facilitated by the additional road capacity.

### CAPITAL COSTS

Planning level cost estimates were prepared using the Elemental Parametric Method of cost estimation (Wolski method). Costs estimates also included values for future planning, design, project management, construction, administration and contingencies.

The capital cost estimate of the Lynn Valley Road Interchange Improvements concept has been disaggregated into the following elements:

- The North Side Active Transportation Improvements is in the range of $5 – $10 million ($$).
- The remainder of the interchange is in the range of $100 million+.

The overall capital cost for the Capilano Road Interchange Improvements is therefore in the range of $100 million+ ($$$$$). Property costs are not included at this time, although both concepts may incur property costs, with the specific impacts being contingent on which new bridge concept is selected.

### SUMMARY OF FINDINGS

A summary of the evaluation of the Capilano Road Interchange Improvements concept is presented in ***Table 4.6*** with respect to the key evaluation criteria. With respect to transportation performance, the consumer surplus is used as the primary summary criteria.

Table 4.6: Summary of High-Level Evaluation Findings for Capilano Road Interchange Improvements Concept

| Criteria | Capilano Road Interchange Improvements Concept | Notes |
|---|---|---|
| Accommodating Transit Service | ◕ | |
| Active Transportation Provisions | ● | |
| Consumer Surplus – Local ($2020) | $3,682,000 | For year 2050 |
| Consumer Surplus – Regional/Through ($2020) | $4,693,000 | For year 2050 |
| Road Safety ($2020) | $1,627,000 | For year 2017 |
| Property Impacts | ◔ | |
| Community Severance | ● | |
| Noise/Visual Impacts | ◔ | |
| Consistency with Community and Regional Plans | ● | |
| Terrestrial Habitat Impacts | ◔ | |
| Aquatic Habitat Impacts | ◔ | |
| Greenhouse Gas Emissions Reduction (tonnes) | -581 | For year 2050. A positive number is a reduction in greenhouse gas emissions. |
| Capital Cost Range ($2020) | $$$$$ | Property and escalation costs not included |

**$**: 0 million – $5 million; **$$**: $5 million – $10 million; **$$$**: $10 million – $50 million; **$$$$**: $50 million – $100 million; **$$$$$**: $100 million+

### 4.1.4 Key Considerations for Further Concept Development, Refinement and Assessment

A major consideration that requires additional consideration as part of any further investigations of design concepts is how to enable a continuous bus route that could extend further west but also provide an on-corridor stop at the Capilano Road Interchange. As the terminus of a bus route (e.g., an extended Route 222 service that runs from Metrotown to Capilano Road via Phibbs Exchange), on-corridor bus stops are not required. Stops can be provided on the off-ramp or along the west (i.e., southbound) side of Capilano Road, and would enable transfer to bus services on Capilano Road (along with lay-by facilities, etc.). This operation was described previously in Section 3.1.2. However, the Capilano Road Interchange improvement concept described previously includes provisions for a bus-on-shoulder system to continue further west beyond Capilano Road. This cross-section was provided purely as a future-proofing measure, given the challenges that would be involved in trying to provide such a facility in the future after additional bridge capacity across the Capilano River had already been provided as part of an interchange improvements. The provision of such a bus service (e.g., further westwards extension of the Route 222 service or a new service) was not investigated. However, the Parclo AB configuration of the interchange creates challenges with respect to providing a singular bus service that stops at Capilano Road to provide local access and facilitates safe and convenient transfers to north-south bus services, *and also* continues bus service further west along Highway 1. Several potential approaches to provide a bus stop at Capilano Road as well as a further westward expansion of bus services were identified, although all concepts have potential challenges that would require further investigation:

- **Multiple Bus Routes:** Multiple services would run along the corridor east of Capilano Road, with some services stopping at the Capilano Road Interchange (and providing a stop at Capilano Road) and other services “skipping” Capilano Road and continuing further west along the highway. This concept would have the least complex infrastructure requirements at the Capilano Road Interchange but would create several drawbacks for transit operations by needing to branch service that would otherwise be continuous, potentially resulting in excessive capacity on the combined section and/or poor frequencies on the branches. Additionally, this concept would result in people travelling between Capilano Road and the west being unable to make use of the bus service without doubling back to Lonsdale Avenue.
- **Enable U-Turn at Ramp Terminals:** In this concept, buses would exit the highway via the off-ramps, service a bus stop, conduct a U-turn manoeuvre at the ramp terminal intersection, service a bus stop, and then re-enter the highway via the on-ramp. In principle, it may be possible to achieve this by converting the two ramp terminal signalized intersections to a multi-lane modern roundabout configuration. This concept would have the advantage of potentially providing bus stops very close to the stops for intersecting services on Capilano Road, thereby enabling efficient transfers between services. However, from a technical feasibility perspective, further investigation would be required with respect to impacts on multi-modal safety and on operations, particularly given the westbound off-ramp capacity challenges noted previously as well as the physical footprint/layout of the roundabout. The latter consideration is particularly acute, given the retaining walls on the west side of the intersections that elevate the roadway above the Capilano River. Expanding the roadway further west via additional fill or a cantilevered structure could prove technically challenging, costly or environmentally impactful on the river (or a combination of all three). Opportunities to safely accommodate high-quality walking and cycling through the roundabout would also be a key consideration. From a bus operations perspective, the need to leave and re-enter the highway creates an impact in the form of additional travel times for all other riders that are not boarding or alighting at Capilano Road.
- **On-Corridor Stops Between Ramps:** As an alternative, the feasibility of a pullout in the triangular areas between the off-ramps and on-ramps could be investigated, although ramp geometries would likely need to be modified to accommodate bus deceleration and acceleration. This concept would have several challenges related to stop access and ease of transfers, given its extended distance (i.e., 300 metres or more) from stops for bus services along Capilano Road, the potential need to cross highway ramps to reach the stop, and the loud and unpleasant waiting environment. This concept would have the advantage of minimizing additional travel times for all other riders who are not boarding or alighting at Capilano Road.
- **On-Corridor Stops Above Capilano Road:** On-corridor stops could be provided on the bridge structure(s) above Capilano Road, with vertical circulation such as stairs and ramps used to transfer to bus stops on Capilano Road. Compared to the previous concept, this concept would have shorter, safer and more efficient transfers between services. However, further investigation of the potential road safety and operational implications of providing bus stops adjacent to conflict points with the westbound on-ramp and eastbound off-ramp would be required to confirm whether this concept is feasible. Furthermore, this concept would still have challenges with respect to the waiting environment. The structural feasibility of this concept would also need to be explored.
- **South Loop “Transit U-Turn”:** Given that BC MoTI owns the property parcels inside the south loop, this area could be used as a U-turn area similar to one of the concepts suggested for the Lynn Valley Road Interchange (described below in Section 4.2.2). For eastbound bus service on the highway, this would provide a relatively straightforward on/off movement. For westbound bus service on the routing, it would

be a bit more circuitous to reach the U-turn area and return to the westbound on-ramp. This concept would require eastbound off-ramp movements to yield to bus movements.

Other key considerations for further investigation include:

- Further assessment of the relative merits of a “new north bridge” concept versus a “new south bridge” concept.
- This study is focused on the potential needs of the highway corridor from the perspective of its transportation function. However, from an asset life cycle management perspective, further investigation would be required to identify rehabilitation needs for the existing bridge span, and the potential trade-offs between rehabilitation and replacement over the longer term.
- With respect to the existing bridge structure, the technical feasibility of modifying or replacing the concrete girder spans located on either side of the concrete arch main span. At the west end of the bridge, additional deck area is required to begin the horizontal curvature on the bridge structure itself in order to increase the radius of the curve.
- This study is focused on opportunities with respect to the long-term transportation function of the corridor. However, maintaining a state of good repair of existing assets is also a key consideration for future investment planning. In the case of this concept, it is noted that the Capilano River Bridge deck is in need of maintenance, but due to the lack of available parallel connections across the Capilano River, managing traffic during deck rehabilitation may be challenging. Providing a second parallel span would provide flexibility with respect to the ability to construct the new bridge span, shift traffic over to the new span in order to rehabilitate the existing span, and then shift westbound traffic back to the existing (now rehabilitated) span. Depending on the state of other elements of the existing Capilano River Bridge, additional rehabilitation works could also be considered (if required) to extend the lifespan of the bridge structure, or replace the structure altogether.
- With the concept being future-proofed to facilitate a future extension of bus-on-shoulder service, further assessment is required to confirm the western tie-in of these facilities (e.g., tie-in at Taylor Way Interchange ramp terminals, or continuation further west along the highway).
- As part of the modifications to the Taylor Way Interchange area to tie in the auxiliary lanes, investigation of opportunities to incorporate a chain-up/brake-check area is suggested.
- As part of the modifications to the Taylor Way Interchange area to tie in the auxiliary lanes, investigation of opportunities to provide improved shoulders for cycling, including continuity of facilities through the ramp terminal intersection, is suggested.
- On the south side of the highway on the west side of the Capilano River, investigation of opportunities to connect a multi-use path facility on the eastbound bridge structure to local District of West Vancouver cycling facilities (e.g., Keith Road and/or 3rd Street near Inglewood Avenue) is suggested. This could take the form of a facility similar to the Hugo Ray Park multi-use path that was recently implemented by the District of West Vancouver on the north side of the highway in this area.
- It is understood that the District of North Vancouver is currently developing a design concept for cycling facilities on Capilano Road between the interchange and Ridgewood Drive. Subject to a BC MoTI decision to implement cycling facilities on Capilano Road through the interchange area, there could be an opportunity to coordinate the delivery of these initiatives.

- The need for further investigation and evaluation of all interchange concepts across a range of criteria was previously noted in Section 4.0. However, in the case of the Capilano Road Interchange concept, it is anticipated that environmental considerations, particularly those related to fisheries and aquatic habitat, will be a key area of focus.
- Investigation regarding whether there is any incremental value in extending the eastbound on-ramp (if the Pemberton Avenue pedestrian overpass structure (which constrains the feasibility of such an extension) were to be replaced as part of an on-corridor improvement opportunity.

## 4.2 Lynn Valley Road Interchange

The Lynn Valley Road Interchange (Exit 19) is an unorthodox configuration, with the eastbound on-ramp and off-ramp being a Parclo B2 design and the westbound on-ramp and off-ramp being a pseudo-diamond configuration with separate ramp terminal intersections. The eastbound ramps share a common signalized intersection to the southwest of the highway, and the west on-ramp has a yield-controlled intersection immediately to the northeast of the highway. The westbound off-ramp connects to a local street (William Avenue) and the nearest intersection is a local street for which William Avenue has priority through the two-way stop-controlled intersection. A signal is provided roughly 300 metres downstream at the intersection of William Avenue and Lynn Valley Road. The highway runs above Lynn Valley Road through the interchange. As noted in ***Table 2.1***, within the interchange area, Lynn Valley Road has continuous sidewalks on both sides of the roadway, provisions for cycling only in the southwest direction, and two bus services (Route 228 and Route 255). With respect to interchange spacing, the nearest interchanges are the Lonsdale Avenue Interchange 1.5 kilometres to the west and the Mountain Highway Interchange 1.9 kilometres to the southeast. The existing interchange is shown in ***Figure 4.4***:

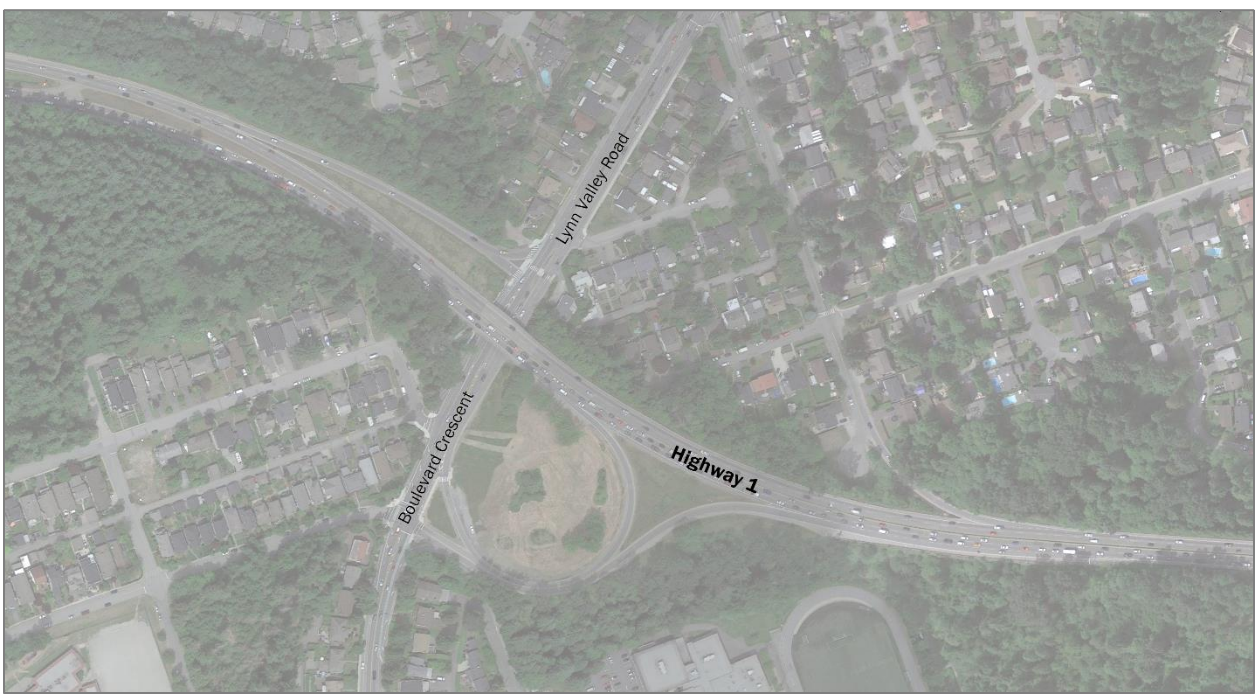


Figure 4.4: Existing Lynn Valley Road Interchange

### 4.2.1 Summary of Key Issues to Address

The review of key issues to address is based on an elaboration and further investigation of the findings of the issues identification process. The review of key issues is organized as follows:

- Motor vehicle traffic operations.
- Transit.
- Road safety.
- Active transportation.

**MOTOR VEHICLE TRAFFIC OPERATIONS**

With respect to motor vehicle traffic operations, volume-to-capacity ratio challenges were identified for the following movements on and off the highway:

- The westbound on-ramp is anticipated to have capacity challenges due to the need to merge into a highway mainline that is operating at capacity during peak periods. The current ramp configuration can also limit capacity due to the combination of an uphill grade on the ramp and a short direct taper merge that, due to a lack of sightlines and a lack of room to manoeuvre, can cause drivers to merge at slower speeds than they otherwise would, and therefore slow the traffic stream.
- The eastbound on-ramp is also anticipated to have capacity challenges due to the need to merge into a highway mainline that is operating at capacity during peak periods. Unlike the westbound on-ramp, the eastbound on-ramp already has a parallel merge configuration.

**TRANSIT**

Currently, there are no transit services along Highway 1 in the vicinity of Lynn Valley Road. As part of the development of a basic bus-on-shoulder concept, the potential for a stop at Lynn Valley Road was investigated, but the current geometry of the interchange is unfavourable (though not necessarily infeasible) with respect to implementing a transit stop. Specifically, in the westbound direction, due to the unorthodox alignment of the westbound off-ramp, which directs traffic to a local street, buses would need to exit via William Avenue and then divert back towards the highway via Lynn Valley Road. Realignment of the westbound off-ramp towards Lynn Valley Road would provide a more direct movement to service a westbound stop at Lynn Valley Road. Similar to the loop ramps at Capilano Road, the Parclo B2 configuration of the eastbound ramps also creates challenges for providing an eastbound stop, as the off-ramp and on-ramp share the same leg of the ramp terminal intersection, rather than being across from one another. This means that buses cannot make through-movements, but will instead need to U-turn.

As noted previously, there are two bus services that run along Lynn Valley Road: Route 228, which runs between Lynn Valley Town Centre and Lonsdale Quay via Lynn Valley Road (where it crosses the highway), Grand Boulevard and 3rd Avenue; and Route 255, which runs east-west through the North Shore between Dundarave and Capilano University, but crosses Highway 1 along Lynn Valley Road. These routes have stops in the general vicinity of the interchange, and if potential interchange improvements were to enable a highway bus-on-shoulder service to stop at Lynn Valley Road, then connectivity between the east-west service on the highway and the north-south services along Capilano Road would need to be reviewed to ensure that safe, efficient and comfortable connections are provided for transfers between the services.

#### ROAD SAFETY

With respect to road safety, the Lynn Valley Road Interchange had the second highest observed collision frequency of any area along the Highway 1 study corridor. As described previously in Section 2.6.2, specific geometric issues that are likely contributing to collisions at this interchange include:

- In the eastbound direction, the majority of collisions (25 out of 45) are located around the direct taper off-ramp. The configuration of the eastbound off-ramp at does not provide space for deceleration prior to entering a low design speed loop, creating a risk of off-road collisions or trucks overturning. Given the lack of space to decelerate after exiting the highway, motorists may elect to begin decelerating while still on the highway mainline, which may catch following motorists off-guard and contribute to 14 of the 25 collisions being rear-end collisions. Several collisions were also noted at the eastbound on-ramp merging point.
- In the westbound direction, the majority (14 out of 27) of collisions occurred at the westbound on-ramp. The westbound on-ramp has a short merging distance that is further exacerbated by the highway-above-arterial configuration of the interchange. The result is that the on-ramp is on an uphill grade, which limits sightlines for motorists entering the highway, making it difficult to observe the traffic stream that they will need to merge with until they are almost level with the highway. At that point, due to the short merging distance, they need to merge almost immediately. This configuration leaves motorists (both those entering the highway and those already on the highway) with little room to manoeuvre and position themselves to allow for smooth merging of the vehicles entering the highway from the on-ramp.

#### ACTIVE TRANSPORTAITON

There are no provisions for on-corridor active transportation on this section of highway. With respect to cross-corridor facilities for people walking, a southwest-bound cycling facility was added to Lynn Valley Road through the interchange area in 2018 via a partnership between BC MoTI and the District of North Vancouver. The facility provides a raised cycling facility that shares the same elevation as the sidewalk. Currently, no reciprocal facility exists in the northeast-bound direction of Lynn Valley Road, although it is understood that there is a desire on the part of the District of North Vancouver, the City of North Vancouver and cycling advocates to implement such a facility. Lynn Valley Road has continuous sidewalk coverage on both sides of the roadway through the entire interchange area.

### 4.2.2 Potential Mitigation Approach

A series of mitigation approaches were identified to mitigate the key issues described above, and are summarized in ***Table 4.7***. Subsequently, several of these mitigation approaches are elaborated upon further.

Table 4.7: Lynn Valley Road Interchange Issues and Potential Mitigation Approaches

| Issue | Measure |
|---|---|
| The westbound on-ramp has challenging sightlines and short merging areas. | Provide additional length for acceleration on the westbound on-ramp. |
| Volume-to-capacity issues on ramps and at the ramp terminal intersections. | Consider opportunities for intersection refinements to the westbound ramp terminal. |
| The existing configuration of the westbound off-ramp and on-ramp creates challenges for a bus-on-shoulder system to stop at Lynn Valley Road. | Reconfigure the westbound off-ramp to align with the westbound on-ramp ramp terminal intersection. Provide a route for a bus-on-shoulder service to pass directly through the ramp terminal intersection and provide a westbound bus stop near Lynn Valley Road. |
| The existing configuration of the eastbound off-ramp and on-ramp creates challenges for a bus-on-shoulder system to stop at Lynn Valley Road. | Modify the eastbound off-ramp and on-ramp in order to enable a bus-on-shoulder service to have an eastbound bus stop near Lynn Valley Road. |
| High collision history at the westbound on-ramp. | Provide additional length for acceleration on the westbound on-ramp. |
| High collision history at the eastbound off-ramp. | Provide additional length for deceleration lane on the eastbound off-ramp prior to entering the low design speed loop. |
| Some collision history at the eastbound on-ramp. | Provide additional length for acceleration on the eastbound on-ramp. |
| Lack of northeast-bound cycling facility on Lynn Valley Road. | Provide a northeast-bound protected cycling facility on Lynn Valley Road through the interchange area to match the existing southwest-bound facility. |

Extending the westbound on-ramp to provide a parallel merge is relatively simple, although it is anticipated to create some terrestrial habitat impacts with respect to tree and brush clearing.

The relocated westbound off-ramp would be aligned to be as close to the highway as possible so as to reduce direct property impacts as well as visual or noise impacts from off-ramp traffic, and would only shift further away from the highway closer to Lynn Valley Road in order to tie in with the existing westbound on-ramp intersection. This intersection would require signalization. The westbound off-ramp would still be a direct taper off-ramp but would provide an extended distance (roughly 300 metres) for deceleration and would avoid introducing any low design speed curvature in the off-ramp until almost at the signalized intersection.

To facilitate westbound transit service, both the (realigned) westbound off-ramp and the westbound on-ramp would be widened to accommodate a dedicated bus-on-shoulder lane.

In the eastbound direction, the bus-on-shoulder lane is merged with the extended off-ramp lane. The bus on shoulder could either exit the highway and stop on Lynn Valley Road, or provide a bus bay in between the off-ramp and on-ramp.

The resultant Lynn Valley Road Interchange improvement concept is shown in ***Figure 4.5***.

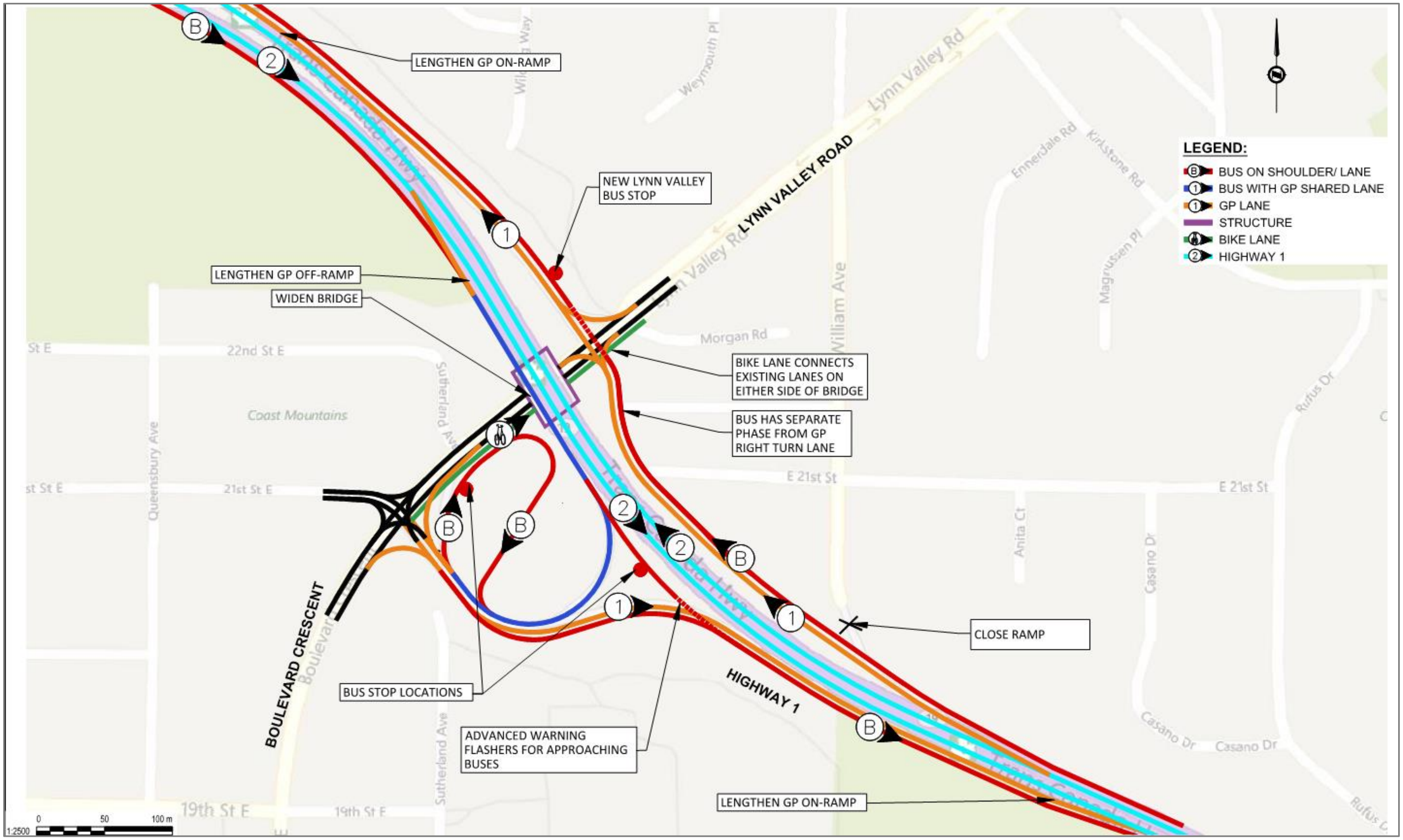


Figure 4.5: Lynn Valley Road Interchange Improvement Concept

FOR DISCUSSION PURPOSES ONLY

## 4.2.3 Initial Evaluation Findings

Findings from the initial high-level evaluation with respect to transportation performance, socio-community impacts, environmental impacts and capital costs are summarized below.

### TRANSPORTATION PERFORMANCE

Transportation performance metrics assessed for the Lynn Valley Road Interchange improvement concept include the volume-to-capacity ratio, person-kilometres travelled, a qualitative assessment of accommodating transit service, a qualitative assessment of active transportation provisions, road user consumer surplus, and road safety.

#### Volume-to-Capacity Ratio

***Table 4.8*** and ***Table 4.9*** show the volume-to-capacity ratios for Lynn Valley Road ramps during AM and PM peak hours, respectively. For this interchange, in addition to providing a 2050 baseline output and a 2050 scenario with interchange improvements at Lynn Valley Road, Capilano Road and Westmount Road, two additional scenarios are provided. These scenarios are the bus-on-shoulder on-corridor improvements concept, and a variation of this concept with the Lynn Valley Road Interchange improvements concept also implemented. One of the key objectives of the Lynn Valley Road Interchange improvements concept is to facilitate a bus stop for an on-corridor transit service; therefore, these scenarios capture the incremental mobility benefits of the Lynn Valley Road Interchange improvements relative to a condition in which an on-corridor bus-on-shoulder system was operating (but not stopping at Lynn Valley Road).

Table 4.8: Lynn Valley Road Interchange Ramp Segment Volume-to-Capacity Ratios, AM Peak Hour

| Ramp | 2017 | 2050 Base | 2050 Interchange Improvements | 2050 Bus-on-Shoulder | 2050 Bus-on-Shoulder with Lynn Valley Road Stop Added |
|---|---|---|---|---|---|
| WB off-ramp | 0.36 | 0.48 | 0.86 | 0.48 | 0.86 |
| WB on-ramp | 0.96 | 1.13 | 1.18 | 1.13 | 1.17 |
| EB off-ramp (from Hwy) | 0.19 | 0.23 | 0.2 | 0.22 | 0.2 |
| EB off-ramp (connector) | 0.06 | 0.05 | 0.05 | 0.05 | 0.19 |
| EB off-ramp (LT at int.) | 0.15 | 0.13 | 0.13 | 0.13 | 0.31 |
| EB off-ramp (RT at int.) | 0.14 | 0.17 | 0.15 | 0.17 | |
| EB on-ramp (from int.) | 0.49 | 0.52 | 0.53 | 0.52 | 0.52 |
| EB on-ramp (to Hwy) | 0.99 | 1.04 | 1.05 | 1.03 | 1.03 |

Table 4.9: Lynn Valley Road Interchange Ramp Segment Volume-to-Capacity Ratios, PM Peak Hour

| Ramp | 2017 | 2050 Base | 2050 Interchange Improvements | 2050 Bus-on-Shoulder | 2050 Bus-on-Shoulder with Lynn Valley Road Stop Added |
|---|---|---|---|---|---|
| WB off-ramp | 0.46 | 0.71 | 1.07 | 0.71 | 1.09 |
| WB on-ramp | 0.79 | 0.92 | 0.95 | 0.92 | 0.94 |
| EB off-ramp (from Hwy) | 0.3 | 0.38 | 0.39 | 0.38 | 0.36 |
| EB off-ramp (connector) | 0.05 | 0.07 | 0.07 | 0.06 | 0.35 |
| EB off-ramp (LT at int.) | 0.14 | 0.17 | 0.18 | 0.17 | 0.56 |
| EB off-ramp (RT at int.) | 0.24 | 0.32 | 0.32 | 0.32 | |
| EB on-ramp (from int.) | 0.41 | 0.43 | 0.42 | 0.43 | 0.41 |
| EB on-ramp (to Hwy) | 0.82 | 0.85 | 0.85 | 0.85 | 0.83 |

In the 2017 AM peak hour, both the eastbound and westbound on-ramps are approaching capacity, and by the 2050 AM peak hour, both are above capacity. In scenarios with improvements (All Interchange Improvements and Bus-on-Shoulder with Lynn Valley Improvement) these ramps are further above capacity. The westbound off-ramp does not have capacity challenges in 2017 and in the 2050 base. However, with the relocation of the ramp in the improvement scenarios, volume-to-capacity ratio increases substantially. This finding is likely an artefact of the modelling process, as the signal control in the improvement scenario is applied on the ramp link; if compared against the downstream link in the base case (William Avenue), the increase is much smaller. The patterns in the PM peak hour are similar: the on-ramps see increases by 2050, and while these volume-to capacity ratios are high, they remain below capacity. The westbound off-ramp sees demand increases to above capacity in the scenarios with improvements.

### Accommodating Transit Service

As noted, one of the key objectives for developing improvement opportunities for the Lynn Valley Road Interchange improvements is enabling an on-corridor bus service to stop at the interchange. Ridership volumes for the on-corridor bus service are provided for the 2050 AM peak hour for the basic bus-on-shoulder condition and the with-Lynn Valley Road Interchange improvements (including new bus stops) condition in ***Figure 4.6*** and ***Figure 4.7***, respectively. Corresponding ridership volumes for the 2050 PM peak hour are shown in ***Figure 4.8*** and ***Figure 4.9***, respectively.

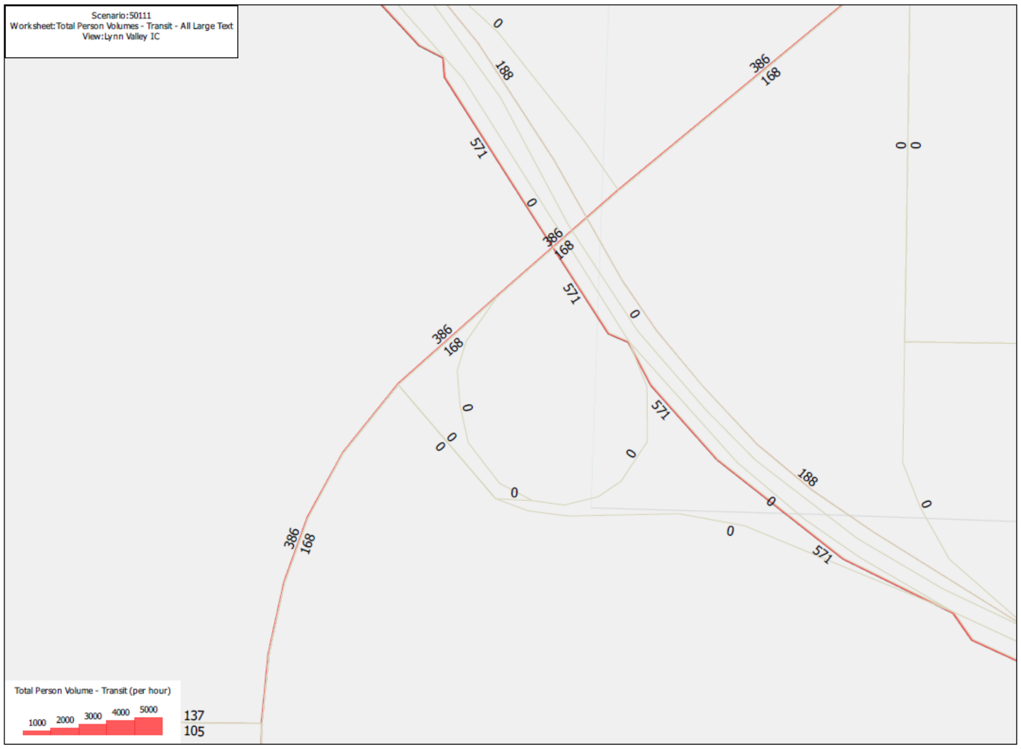


Figure 4.6: Lynn Valley Interchange Transit Volumes (2050 AM Peak Hour; with Basic Bus-on-Shoulder Concept)

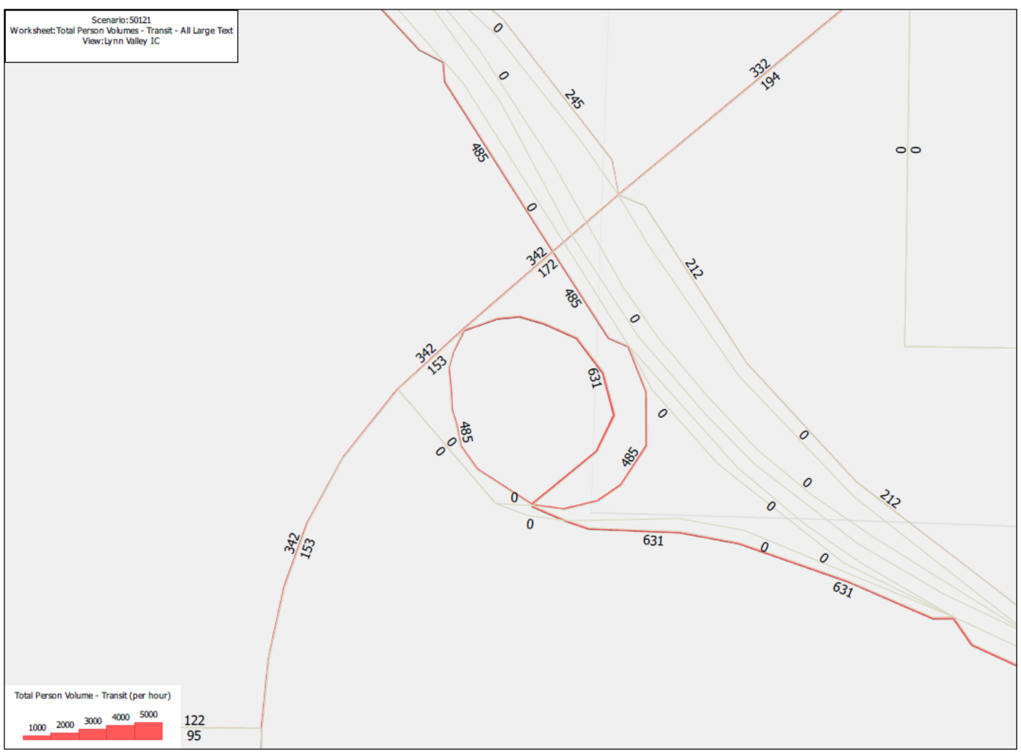


Figure 4.7: Lynn Valley Interchange Transit Volumes (2050 AM Peak Hour; Bus-on-Shoulder with Lynn Valley Improvement Concept)

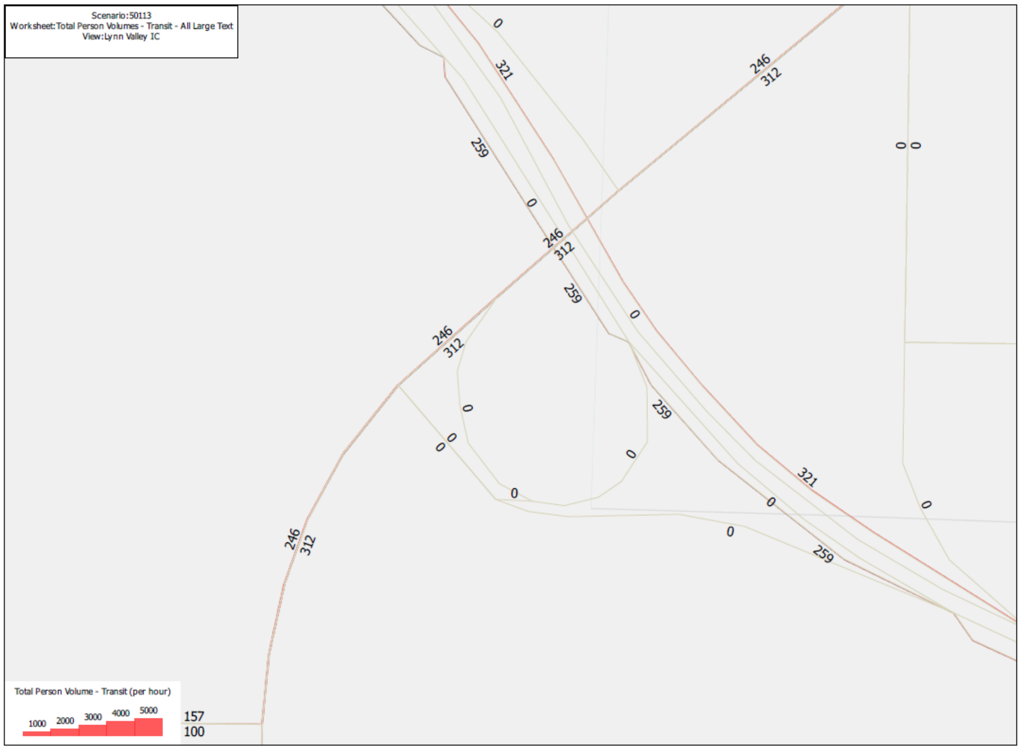


Figure 4.8: Lynn Valley Interchange Transit Volumes (2050 PM Peak Hour; with Basic Bus-on-Shoulder Concept)

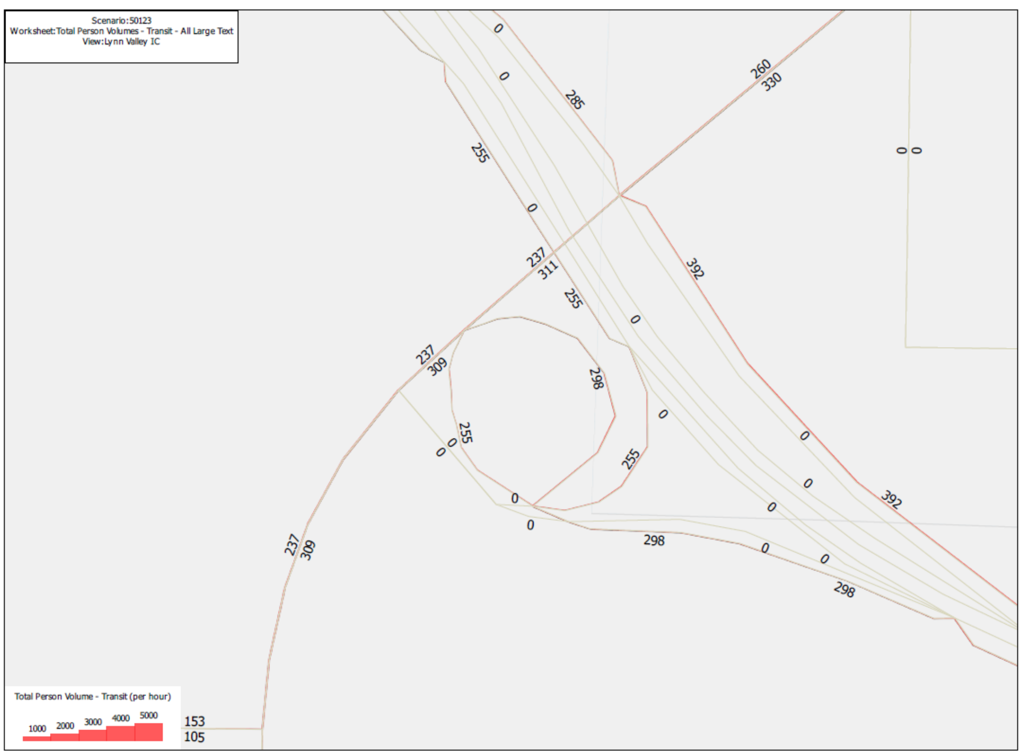


Figure 4.9: Lynn Valley Interchange Transit Volumes (2050 PM Peak Hour; with Bus-on-Shoulder with Lynn Valley Improvement Concept)

In the AM peak hour, eastbound bus ridership volumes along Highway 1 downstream of the Lynn Valley Road Interchange increase with the introduction of the interchange improvements, but eastbound bus ridership volumes upstream of Lynn Valley Road Interchange are lower. The additional travel time for an additional stop at Lynn Valley Road that is incurred by riders boarding at the Capilano Road or Lonsdale Avenue stop has resulted some of these (former) riders to instead make alternative trips. However, the additional stop at Lynn Valley Road also generates new ridership for the on-corridor bus service. Westbound transit ridership volumes on Highway 1 increase, while transit volumes along Lynn Valley Road generally decrease. PM peak hour patterns are similar in terms of the change between scenarios. PM peak hour transit volumes are less directionally peaked than AM peak hour volumes, a condition that applies to both directions on travel.

*Overall Rating is Significantly Better*

### Active Transportation Provisions

As described above, the Lynn Valley Road Interchange Improvement is anticipated to address the major active transportation challenge within the area, which is the lack of a corresponding northeast-bound cycling facility on Lynn Valley Road to complement the existing southwest-bound facility.

*Overall Rating is Significantly Better*

### Person-Kilometres Travelled

While the changes at the Lynn Valley Interchange are very localized, the impacts are visible in network summary statistics. ***Table 4.10*** shows the change in person-kilometres travelled (PKT) by mode and time period. The changes are small, though the results do show a clear shift towards transit. Transit mode share on the North Shore increases by approximately 0.1% across the day.

Table 4.10: Lynn Valley Road Interchange Improvements – Net Impact on Regional Person-Kilometres Travelled

| Time Period | AM Peak Hour | MD Peak Hour | PM Peak Hour |
|---|---|---|---|
| SOV | -431 | -169 | -126 |
| HOV | 52 | -201 | -455 |
| Transit | 980 | 568 | 563 |
| Total | 349 | 198 | -18 |

### Consumer Surplus

Consumer surplus, representing a net assessment of the cumulative mobility impacts from the interchange concept, is presented in ***Table 4.11***. Note that because this concept is heavily focused on facilitating a new transit stop, consumer surplus is measured as a full bus-on-shoulder system with the Lynn Valley Road Interchange concept (i.e., inclusive of the bus stopping at Lynn Valley) relative to the basic bus-on-shoulder system (i.e., without a stop at Lynn Valley).

Table 4.11: 2050 Lynn Valley Interchange Improvements Concept Consumer Surplus

| Time Period | Lynn Valley Road Interchange |
|---|---|
| SOV | 13,009 |
| HOV | -13,759 |
| LGV | 546 |
| HGV | 1,103 |
| Bus | 55,187 |
| Rail | -17,840 |
| WCE | 145 |
| Total (hr) | 38,390 |
| Total ($2020) | $770,372 |

By 2050, the Lynn Valley Road Interchange is forecast to provide an annualized mobility benefit of approximately $0.8 million. This benefit is made up of a disbenefit (i.e., a negative benefit) of approximately $470,000 for local trips within the North Shore, and a benefit of $1.24 million for external and regional through-trips. The concept is anticipated to create some drawbacks for passenger-vehicle trips solely within the North Shore, although regional/through-trips by these modes will still benefit. The concept also shows that the some of the boardings at Capilano Road and Lonsdale Road that were “lost” due to an increase in travel time on the bus route are instead likely rerouting to Lonsdale Quay and crossing the inlet on the SeaBus (and then taking another SkyTrain or bus).

### Road Safety

Road safety benefits from the new interchange were investigated through the application of collision modification factors (CMF), as shown in ***Table 4.12***.

Table 4.12: Lynn Valley Road Interchange Improvement Concept Collision Predictions Modelling

| Improvement | Applicable Collision Types | Collision History | Collision Frequency (collisions per year) | Collision Modification Factor | New Collision Rate | Source | Notes |
|---|---|---|---|---|---|---|---|
| Lengthen Eastbound Deceleration Lane | All Collisions | 45 | 8.18 | 0.71 | | Crash Modification Factors Clearinghouse: ID 3042 | Deceleration length increased from 35 metres to 290 metres |
| Lengthen Eastbound Acceleration Lane | All Collisions | 45 | 8.18 | 0.88 | | Crash Modification Factors Clearinghouse: ID 5215 | Acceleration length increased from 220 metres to 300 metres |
| **Eastbound Improvements (Combined)** | **n/a** | **n/a** | **8.18** | **0.62** | **5.08** | | **CMF is a weighted average for two separate collision groups.** |
| Lengthen Westbound Acceleration Lane | All Collisions | 27 | 4.91 | 0.79 | 3.86 | Crash Modification Factors Clearinghouse: ID 5215 | Acceleration length increased from 110 metres to 260 metres |

In the eastbound direction, a reduction of 3.10 collisions per year is anticipated, with a rough split of 67% property damage only and 33% injury. In the westbound direction, a reduction of 1.05 collisions per year is anticipated, with a rough split of 52% property damage only and 48% injury. Collisions savings were then monetized using outputs from the BC Ministry of Transportation and Infrastructure *Default Values for Cost Benefit Analysis* (2018), which have been adjusted to 2020 values based on the Statistics Canada Consumer Price Index. The resultant combined monetized savings is $829,000 on an annualized basis for current volumes. Savings are anticipated to increase over time as volumes increase.

### SOCIO-COMMUNITY IMPACTS

Socio-community impacts were assessed separately with respect to property impacts, community severance impacts, visual and noise impacts, and consistency with community and regional plans.

#### Property Impacts

Although the new westbound off-ramp has been aligned as close to the highway as possible in order to minimize overall impacts, it is anticipated that some property impacts would be incurred in the vicinity of the new westbound ramps signalized ramp terminal intersection.

*Overall Rating is Somewhat Worse*

### Community Severance

Although pedestrian and vehicle connectivity are provided through the Lynn Valley Road Interchange, connectivity for people cycling is lacking in one direction, a condition that the concept would address. The concept would also enable several blocks of William Avenue to be converted to a lower volume residential street.

*Overall Rating is Somewhat Better*

### Visual and Noise Impacts

The realigned westbound off-ramp is anticipated to create some noise and visual impacts on properties located adjacent to the off-ramp. However, these impacts are anticipated to be offset by reduced traffic volumes (and hence noise) for residences along William Avenue.

*Overall Rating is Similar to Base Case/Neutral*

### Consistency with Community and Regional Plans

The District of North Vancouver *Transportation Plan* (2012) specifically notes the need for improved walking and cycling connections through the interchange area. Although southwest-bound facilities along Lynn Valley Road were implemented in 2018, the corresponding northeast-bound facilities are missing, and could be provided as part of this concept.

At a broader level, improved cycling facilities on Lynn Valley Road and improved access to a regional transit service for Lynn Valley residents are generally consistent with municipal and regional transportation policy with respect to encouraging more sustainable modes of travel. Although the Lynn Valley Town Centre growth area is off-corridor, the stop could still improve access by transit to and from the growth area, which is consistent with the general principles of regional land use and housing strategies.

*Overall Rating is Significantly Better*

## ENVIRONMENTAL IMPACTS

Environmental impacts were assessed separately with respect to terrestrial impacts, aquatic impacts and greenhouse gas emissions.

### Terrestrial Impacts

This concept is anticipated to require tree-clearing on the north side of the highway in order to implement the new westbound off-ramp alignment.

*Overall Rating is Somewhat Worse.*

### Aquatic Impacts

No major watercourses are anticipated to be impacted as a result of this concept.

*Overall Rating is Similar to Base Case/Neutral*

### Greenhouse Gas Emissions

The resultant change in greenhouse gas emissions is provided in ***Table 4.13***.

Table 4.13: 2050 Greenhouse Gas Emissions from Vehicular Sources (Tonnes)

| Time Period | 2050 BoS | 2050 BoS w Lynn Valley |
|---|---|---|
| Total Greenhouse Gas Emissions | 8,579,295 | 8,578,658 |
| Reduction in Greenhouse Gas Emissions | n/a | 636 |

As shown, the concept is anticipated to provide a modest reduction in greenhouse gas emissions.

## CAPITAL COSTS

Planning level cost estimates were prepared using the Elemental Parametric Method of cost estimation (Wolski method). Costs estimates also included values for future planning, design, project management, construction, administration and contingencies. The capital cost estimate of the Lynn Valley Road Interchange Improvements concept has been disaggregated into the following elements:

- The Westbound Onramp Extension is in the range of $0 – $5 million ($).
- The Eastbound Onramp Extension is in the range of $0 – $5 million ($).
- The Eastbound Offramp Extension is in the range of $5 – $10 million ($$).
- The Transit-Supportive Elements are in the range of $10 – $50 million ($$$).

The overall capital cost for the Lynn Valley Road Interchange Improvements is therefore in the range of $50 – $100 million ($$$$). Property costs are not included at this time, although the concept may incur property costs in the vicinity of the new westbound off-ramp.

## SUMMARY OF FINDINGS

A summary of the evaluation of the Lynn Valley Road Interchange improvements concept is presented in ***Table 4.14*** with respect to the key evaluation criteria. With respect to transportation performance, the consumer surplus is used as the primary summary criteria.

Table 4.14: Summary of High-Level Evaluation Findings for Lynn Valley Road Interchange Improvements Concept

| Criteria | Lynn Valley Road Interchange Improvements Concept | Notes |
|---|---|---|
| Accommodating Transit Service | ● | |
| Active Transportation Provisions | ● | |
| Consumer Surplus – Local ($2020) | -$469,000 | For year 2050 |
| Consumer Surplus – Regional/Through ($2020) | $1,239,000 | For year 2050 |
| Road Safety ($2020) | $829,000 | For year 2017 |
| Property Impacts | ◔ | |
| Community Severance | ◕ | |
| Noise/Visual Impacts | ◔ | |
| Consistency with Community and Regional Plans | ● | |
| Terrestrial Habitat Impacts | ◔ | |
| Aquatic Habitat Impacts | ◑ | |
| Greenhouse Gas Emissions Reduction (tonnes) | 636 | A positive number is a reduction in greenhouse gas emissions |
| Capital Cost Range ($2020) | $$$$ | Property and escalation costs not included |

**$**: 0 million – $5 million; **$$**: $5 million – $10 million; **$$$**: $10 million – $50 million; **$$$$**: $50 million – $100 million; **$$$$$**: $100 million+

### 4.2.4 Key Considerations for Further Concept Development, Refinement and Assessment

Key considerations for further investigation include mitigating property impacts associated with the westbound on-ramp, the location and configuration of the eastbound on-corridor bus stop, and laning at intersections. Each of these is discussed below.

Opportunities to reduce or otherwise mitigate potential property impacts associated with the realigned westbound off-ramp should be investigated. The primary (although not only) motivation for realigning the off-ramp is to help facilitate a bus stop for an on-corridor transit service. A concept could potentially be investigated wherein the general-purpose off-ramp remains in its current location, but a new bus-only off-ramp is implemented in a manner consistent with the concept shown above. This approach would enable the transit service to stop at Lynn Valley Road while reducing the associated property impacts, as the new westbound off-ramp would be a single (bus) lane instead of two lanes. In principle, the westbound bus service could divert to William Avenue and then back onto Lynn Valley Road, and then to the bus stop at the interchange on-ramp, although the potential implications of this increase in travel times (and by extension decrease in ridership) would need to be further assessed. In developing the new westbound alignment, compatibility with the future Upper Levels Greenway also needs to be considered.

With respect to the eastbound on-corridor bus stop, similar to the Capilano Road Interchange loop ramps, the eastbound loop ramp configuration at Lynn Valley Road Interchange creates a challenge with respect to facilitating an on-corridor transit service. Two concepts are shown in ***Figure 4.5***, both of which are similar to some of the concepts discussed above at the Capilano Road Interchange. These concepts are:

- **On-Corridor Stop Between Ramps:** In this concept, a bus pullout would be provided between the eastbound off-ramp and eastbound on-ramp. This concept would have the benefit of not requiring any deviation from the highway and would minimize incremental travel times for riders travelling from Capilano Road and Lonsdale Avenue. However, this concept would have several challenges related interface with other highway users, as well as with respect to stop access and ease of transfer, given its extended distance (i.e., 250—300 metres or more) from stops for bus services along Lynn Valley Road, the potential need for transit riders to cross highway ramps to reach the stop, and the loud and unpleasant waiting environment.
- **South Loop "Transit U-Turn:** In this concept, the bus would exit the highway via the off-ramp and then make a slightly sharper turn as compared to vehicles travelling northeast bound on Lynn Valley Road, thereby entering into the loop ramp area itself. A stop would be provided, after which buses would execute a U-turn and then cross the eastbound off-ramp (where traffic would be controlled to provided buses with the right-of-way), and then turn back onto the on-ramp. This concept is more operationally complex for transit and would create longer travel times for through-moving trips originating at Capilano Road or Lonsdale Avenue. This routing configuration was assumed for the travel demand modelling, the results of which were shown previously in ***Figure 4.6*** through ***Figure 4.9***. However, this concept would provide much more efficient walk access and transfers to bus routes on Lynn Valley Road, and would provide a more comfortable waiting environment.

Providing a bus-on-shoulder system (with continuous bus-on-shoulder) in the absence of a stop at the Lynn Valley Road Interchange would require the highway bridge structure across Lynn Valley Road to be widened to provide a wider westbound shoulder for the bus. However, if the Lynn Valley Interchange improvements are implemented, then the on-corridor bus service would no longer pass overtop Lynn Valley Road. Instead, buses would exit the highway via the off-ramp, stop to drop off and pick up passengers, and re-enter the highway via the on-ramp. Therefore, coordination between any potential bus-on-shoulder (or HOV lane) concept is required with the Lynn Valley Road Interchange improvement concepts to ensure that redundant bridge structure widening is not implemented if the on-corridor concept were to proceed in advance of the interchange improvements.

Consideration could be given to investigating whether there is any incremental value in extending the Lynn Valley Road Interchange eastbound on-ramp all the way down to tie into the new eastbound off-ramp at Mountain Highway Interchange as an auxiliary lane. In principle, this concept could enable inter-regional eastbound traffic exiting at the Mountain Highway Interchange to avoid being caught in extended queues for the Ironworkers Memorial Bridge, but also risks attracting new local trips to the highway network that would otherwise use alternative routes along the municipal road network (e.g., Grand Boulevard and Keith Road, or Kirkstone Road and Mountain Highway).

## 4.3 21st Street and 15th Street Interchanges

The 21st Street Interchange and 15th Street/Cross Creek Road Interchange are a pair of diamond interchanges servicing West Vancouver. The existing interchanges are shown in ***Figure 4.10.***


Figure 4.10: Existing 21st Street Interchange and 15th Street/Cross Creek Road Interchange

### 4.3.1 Summary of Key Issues to Address

Based on the analysis of volume-to-capacity ratios provided in ***Table 2.6*** and ***Table 2.7***, the interchanges generally function well for both the AM and PM peak hours in both the 2017 and 2050 conditions. However, the 21st Street and 15th Street interchanges in West Vancouver are spaced only approximately 900 metres apart. Given this short spacing, weaving operations between the on-ramp of one interchange and the off-ramp of the other interchange can create an impact on traffic operations.

The weaving length is more constrained in the eastbound direction, where the distance between the 21st Street eastbound on-ramp and the 15th Street eastbound off-ramp, measured from where the lane edges at the merge are 0.5 metres apart, is approximately 147 metres. Westbound movements are less constrained; the corresponding distance between the 15th Street westbound on-ramp and the 21st Street westbound off-ramp is 314 metres. From a geometric design perspective, both the eastbound and westbound movements are lower than best-practices weaving distances of 550 metres to 700 metres recommended in the Transportation Association of Canada *Geometric Design Guide for Canadian Roads* (2017). However, from the perspective of maintaining efficient traffic operations, weaving operations are not only a function of roadway geometry, but also travel patterns through the two interchanges. Specifically, these travel patterns relate to volumes of through-movements on the highway, entry volumes at the upstream on-ramp, exit volumes at the downstream off-ramp, volumes that enter the highway and volumes that stay on the ramps (these volumes are typically very low unless there is a lack of alternative routes between the two streets crossing the highway). Additionally, the Route 257 service also passes through this weaving zone, as buses exit Highway 1 at the 15th Street eastbound off-ramp.

Travel demand modelling for the 2050 forecasting horizon year also suggests the potential for an increased propensity for people coming from 21st Street to travel eastbound on Queens Avenue until 15th Street and then access the highway, rather than more directly access the highway at 21st Street. Despite the overall increase in demand to access the highway corridor, eastbound on-ramp volumes from 21st Street drop by 200—250 vehicles per hour in the AM peak hour between 2017 and 2050, suggesting that at least this volume of vehicles may be accessing the highway via the 15th Street on-ramp instead. The RTM cannot fully capture the dynamics of highway entry and exit movements; however, in practice, it is anticipated that weaving issues in the eastbound direction would result in a combination of two impacts:

1. Poor weaving operations on the highway, which can create delays for both entering and exiting traffic as well as turbulence and potential shockwaves for through-moving traffic. Poor weaving operations can also become a safety consideration if weaving movements are occurring at slow speeds while the through-traffic on the highway is otherwise operating at much higher speeds.
2. Weaving and traffic operational issues will encourage some travellers who would otherwise enter the highway at the 21st Street on-ramp to instead divert along Queens Avenue to the 15th Street on-ramp, resulting in additional volumes of "rat-running" vehicles along a residential street. For longer-distance trips that do need to make use of the highway, it is preferable that the highway be able to accommodate these trips via their natural desire line.

Each vehicle joining the highway would create only one of these two effects; therefore, it is not possible to simultaneously create the "highest impact" outcome for both effects. In practice, it is anticipated that some level of equilibrium would be reached wherein both issues are occurring to some degree, but neither issue is reaching its "highest impact" level.

### 4.3.2 Potential Mitigation Approach

In order to address weaving issues, a concept was developed wherein the weaving lane, rather than exiting the highway at the 15th Street off-ramp, would instead be extended by roughly 300 metres. A distance of approximately 300 metres was selected to tie in prior to the 15th Street overhead structure, and therefore avoid costs associated with widening the structure. The 15th Street off-ramp would therefore become a pseudo-direct taper exit (since it would be exiting from the weaving lane, rather than the highway through-lanes). This lane extension is shown in ***Figure 4.11***.


Figure 4.11: 21st Street Eastbound On-Ramp Extension (shown in red)

FOR DISCUSSION PURPOSES ONLY

This modification would enable vehicles entering Highway 1 eastbound from the 21st Street on-ramp to avoid needing to merge into the through-lanes until after the vehicles exiting at the 15th Street off-ramp have already exited. By enabling lane changes for 15th Street exit movements and 21st Street entry movements to occur sequentially rather than simultaneously, it is anticipated that this would lead to fewer conflicts, as 21st Street on-ramp traffic can accommodate traffic exiting at the 15th Street off-ramp without worrying about "running out" of room to merge. Ideally, smoother operations on the highway would also encourage vehicles accessing the highway from 21st Street to do so directly via the 21st Street on-ramp, rather than via Queens Avenue and the 15th Street on-ramp, and therefore also address the rat-running issue.

In some respects, this concept is relatively similar to the existing laning configuration on Highway 1 westbound between Taylor Way and 15th Street, although in that case, the function of the third lane is more related to a grade issue (i.e., providing a climbing lane) rather than a weaving issue.

It is also noted that this concept may require the Changeable Message Sign advising of Lions Gate Bridge delays to be shifted. As part of this shifting, there may be an opportunity to introduce a new Advanced Traveller Information Systems (ATIS) sign that provides information regarding delays at both Lions Gate Bridge and Ironworkers Memorial Bridge delays. Under typical conditions, the two bridges often serve different destinations throughout the region (albeit with some overlap), and for many trips the "first choice" bridge is often the better concept, even if it is experiencing greater delays. However, in instances where one bridge is experiencing extreme delays (e.g., due to a major collision), both bridges become feasible choices for travellers, and there may be an opportunity to provide advance notice to enable travellers to shift their route to use the other bridge.

### 4.3.3 Initial Evaluation Findings

Findings from the initial high-level evaluation with respect to transportation performance, socio-community impacts, environmental impacts and capital costs are summarized below.

#### TRANSPORTATION PERFORMANCE

As the RTM cannot fully capture weaving movements, a separate weaving analysis was undertaken using the Highway Capacity Software version 7.8. Volumes for freeway-freeway, ramp-freeway, freeway-ramp and ramp-ramp movements were extracted from the RTM for the AM and PM peak hours for both the 2017 and 2050 conditions, and used to conduct a weaving analysis. To assess the impacts of the concept, the analysis was split into two components, a weaving analysis (where ramp-freeway volumes were assigned to ramp-ramp volumes based on the assumption that they do not merge in the weaving area), followed by a separate merging analysis.

The results of this highway capacity analysis is provided in ***Table 4.15***. As a concept was only developed for the eastbound direction, no assessment of westbound improvement was undertaken.

Table 4.15: Level of Service for Weaving Movements Between 21st Street Interchange and 15th Street Interchange

| Movement | AM | | | PM | | |
|---|---|---|---|---|---|---|
| | 2017 | 2050 Base | 2050 with Improvements | 2017 | 2050 Base | 2050 with Improvements |
| Westbound | B (weave) | C (weave) | n/a | C (weave) | D (weave) | n/a |
| Eastbound | C (weave) | C/D* (weave) | C/C** (diverge) B (merge) | C (weave) | C (weave) | C (diverge) B (merge) |

*Level of Service C is achieved because some 21st Street eastbound on-ramp traffic reroutes to Queens Avenue and enters Highway 1 via the 15th Street eastbound on-ramp instead. In other words, rather than causing congestion on the highway, weaving capacity constraints will likely cause a different issue, namely rat-running on local West Vancouver streets. For comparison, if the 2017 21st eastbound on-ramp volumes were maintained in 2050, then the AM would experience Level of Service D. This same issue is present in the PM, although less significant.

**With the concept in place, the Level of Service does not drop below C, even if vehicles no longer rerouted to Queens Avenue.

The initial static Highway Capacity Software analysis suggests that the concept would provide a minor improvement to eastbound weaving operations, and could encourage drivers to avoid rerouting to the 15th Street on-ramp via Queens Avenue.

A micro-simulation modelling tool would be better suited to capturing quantitative travel time benefits for this concept. Therefore, for this initial analysis based on the Highway Capacity Software approach, this concept has been scored qualitatively with respect to transportation performance.

*Overall Rating is Somewhat Better*

#### SOCIO-COMMUNITY IMPACTS

Socio-community impacts were assessed separately with respect to property impacts, community severance impacts, visual and noise impacts, and consistency with community and regional plans.

**Property Impacts**

No property impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

**Community Severance**

This concept would also reduce rat-running on several blocks of Queens Avenue.

*Overall Rating is Somewhat Better*

**Visual and Noise Impacts**

Encouraging vehicles accessing the highway to do so directly from the 21st Street on-ramp rather than rerouting to the 15th Street on-ramp via Queens Avenue would reduce the visual and noise impacts of rat-running traffic on Queens Avenue.

*Overall Rating is Somewhat Better*

**Consistency with Community and Regional Plans**

This concept is not anticipated to have any major significance with respect to community or regional plans.

*Overall Rating is Similar to Base Case/Neutral*

**ENVIRONMENTAL IMPACTS**

Environmental impacts were assessed separately with respect to terrestrial impacts, aquatic impacts and greenhouse gas emissions.

**Terrestrial Impacts**

This concept would require clearing of several trees between the highway mainline and the 15th Street eastbound off-ramp in order to pave the extension of the 21st Street eastbound on-ramp.

*Overall Rating is Somewhat Worse*

### Aquatic Impacts

No aquatic impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

### Greenhouse Gas Emissions

This concept is not anticipated to have any significant impacts with respect to greenhouse gas emissions.

*Overall Rating is Similar to Base Case/Neutral*

## CAPITAL COSTS

Planning level cost estimates were prepared using the Elemental Parametric Method of cost estimation (Wolski method). Costs estimates also included values for future planning, design, project management, construction, administration and contingencies. The capital cost estimate of the 21st Street Eastbound On-Ramp Extension concept is in the range of $0 – $5 million.

## SUMMARY OF FINDINGS

A summary of the evaluation of the 21st Street Eastbound On-Ramp Extension is presented in ***Table 4.16*** with respect to the key evaluation criteria.

Table 4.16: Summary of High-Level Evaluation Findings for 21st Street Eastbound On-Ramp Extension

| Criteria | 21st Street Eastbound On-Ramp Extension Concept | Notes |
|---|---|---|
| Transportation Performance | ◕ | Based on minimum Level of Service increasing from D to C |
| Property Impacts | ◑ | |
| Community Severance | ◕ | |
| Noise/Visual Impacts | ◕ | |
| Consistency with Community and Regional Plans | ◑ | |
| Terrestrial Habitat Impacts | ◔ | |
| Aquatic Habitat Impacts | ◑ | |
| Greenhouse Gas Emissions Reduction (tonnes) | ◑ | A positive number is a reduction in greenhouse gas emissions |
| Capital Cost Range ($2020) | $ | Property and escalation costs not included |

**$**: 0 million – $5 million; **$$**: $5 million – $10 million; **$$$**: $10 million – $50 million; **$$$$**: $50 million – $100 million; **$$$$$**: $100 million+

### 4.3.4 Key Considerations for Further Concept Development, Refinement and Assessment

The analysis of this concept was conducted at a high level using the Highway Capacity Software, which does not fully capture interdependencies between subsequent infrastructure elements. Traffic operations micro-simulation modelling, which is better suited to capturing vehicle routing decisions, is suggested as a follow-up analysis in order to confirm traffic operations benefits.

## 4.4 Westview Drive and Lonsdale Avenue Interchanges

The Westview Drive Interchange and Lonsdale Avenue Interchange are a pair of diamond interchanges servicing City of North Vancouver. The existing interchanges are shown in ***Figure 4.12.***


Figure 4.12: Existing Westview Drive Road Interchange and Lonsdale Avenue Interchange

### 4.4.1 Summary of Key Issues to Address

The review of key issues to address is based on an elaboration and further investigation of the findings of the issues identification process. The review of key issues is organized as follows:

- Motor vehicle traffic operations.
- Transit.
- Road safety.
- Active transportation.

### MOTOR VEHICLE TRAFFIC OPERATIONS

From a traffic operations perspective, the westbound on-ramp at Westview Drive interchange is anticipated to have the greatest capacity challenges in the future. The westbound off-ramp, as well as the eastbound on-ramp and off-ramp at Lonsdale Avenue, are also anticipated to experience capacity challenges.

Based on engagement with stakeholders, it was identified that, in practice, operations at these two interchanges can often be interdependent. For example, during backups in the eastbound direction on Highway 1 east Lonsdale Avenue, vehicles bound for Lynn Valley will abandon Highway 1 and exit at Westview Drive or Lonsdale Avenue instead and use Queens Road/29th Street or Braemar Road/Dempsey Road to reach Lynn Valley. This impact is not fully captured by the RTM, and therefore eastbound off-ramp operations at Westview Drive may be more congested than modelling would suggest. An operational issue at the eastbound ramp terminal intersection further compounds this issue: eastbound right-turning vehicles often make a southbound left turn onto 23rd Street and will not proceed unless both southbound lanes on Westview Drive are clear. This reduces throughput on the exit and can cause spillbacks onto the Highway 1 eastbound mainline.

A similar operations issue is also observed at the Lonsdale Avenue Interchange eastbound off-ramp, where the lack of storage area for eastbound right-turn movements means that, even if capacity is theoretically available for vehicles to make this movement, queues of vehicles waiting to make an eastbound through or eastbound left-turn movement obstruct these right-turning vehicles. The right-turning vehicles then get stuck in the queue of vehicles on the off-ramp, and can contribute to queue spillbacks that affect highway mainline operations.

### TRANSIT

There are five bus routes currently operating on Lonsdale Avenue, and one on Westview Drive. At both interchanges, all bus routes simply pass through the interchange; however, buses on these routes can still be subject to delays caused by heavy vehicle volumes at the ramp terminal intersections. This can particularly be a challenge if there is an incident on the highway that causes queue spillbacks on on-ramps that begin to affect operations on the municipal streets.

### ROAD SAFETY

Based on the observed collision history, road safety challenges were identified at both interchanges. Among the two interchanges, the highest observed collision volumes were in the eastbound direction at the Westview Drive Interchange. Of the 30 collisions recorded at this intersection, half were related to either the off-ramp or the ramp terminal intersection. At the off-ramp, the predominant collision pattern was rear-end collisions, suggesting that vehicles are failing to decelerate in time prior to reaching the back of the queues of vehicles waiting to exit the highway. At the intersection, the most frequently observed collision type was eastbound left-turning vehicles colliding with southbound through-moving vehicles, which may suggest an operational issue with respect to signal timing. In the westbound direction at the Westview Drive Interchange, collisions occurred primarily on the highway mainline itself rather than on the ramp terminals or at the intersection. However, a similar pattern as the eastbound ramp terminal intersection was observed, wherein westbound left-turning vehicles would collide with northbound through-moving vehicles.

At the Lonsdale Avenue Interchange, collisions were more frequent in the eastbound direction, in both the off-ramp area and the on-ramp area. In the off-ramp area, the pattern is similar to the Westview Drive Interchange eastbound off-ramp, with a large number of rear-end collisions on the off-ramp as well as collisions at the intersection between eastbound left-turning vehicles and southbound through-moving vehicles. This suggests that similar potential issues with respect to queue lengths and signal timings may also be occurring at the Lonsdale Avenue eastbound off-ramp. It is also noted that the severity of collisions on this off-ramp is higher than usual, with most collisions being injury collisions, whereas, typically, property damage only collisions make up the majority of collision types. This suggests that rear-end collisions may be occurring with the second vehicle travelling at high speeds.

At the Lonsdale Avenue Interchange eastbound off-ramp, roughly half of the observed collisions were in the acceleration lane, with rear-end collisions being the most frequent collision type. Several other rear-end collisions were observed on the highway itself. It is anticipated that these collisions may be occurring because speeds on the highway are lower than on-ramp users are anticipating, potentially due to congestion and queue spillbacks from bottlenecks further downstream.

### ACTIVE TRANSPORTATION

As noted previously in ***Table 2.1***, both Westview Drive and Lonsdale Avenue provide sidewalks on both sides of the street through the interchange areas. However, in the case of Westview Drive, there are no east-west crosswalks at either of the signalized ramp terminal intersections, resulting in a gap in east-west pedestrian connectivity that requires people walking to cross at either 23rd Street to the south of the interchange or the access to the Westview Shopping Centre to the north of the interchange. In contrast, the Lonsdale Avenue Interchange provides pedestrian crossings at both ramp terminal intersections, although the sidewalks are narrow, and some challenges were noted with respect to ramp grades for people with mobility challenges. The City of North Vancouver has also noted that, through the *WalkCNV Pedestrian Framework* (2019), concerns were identified with respect to the sidewalks being uncomfortable for some user groups (e.g., those with push strollers, wheelchairs, young children).

With respect to cycling, neither facility provides cycling infrastructure, although both facilities are designated as on-street bike routes in the City of North Vancouver *Bicycle Master Plan* (2012). Westview Drive is designated as a bike route between Larson Road and the municipal boundary at Queens Road, although no such facility currently exists along any section of Westview Drive, including (but not limited to) the interchange area under provincial jurisdiction. In addition to the lack of cycling facilities on Westview Drive, as noted in Section 2.7, the eastbound cycling facility on the eastbound off-ramp abruptly terminates prior to the intersection. Furthermore, the lack of an east-west crosswalk at the eastbound ramp terminal intersection also creates challenges for people cycling to continue further east via the 23rd Street local bike route.

The segment of Lonsdale Avenue between 23rd Street and 25th Street that crosses the highway corridor is designated as an on-street bike route; however, no cycling facilities are provided. Beyond that short segment, Lonsdale Avenue is not designated as a bike route. The designation of the section through the interchange is a result of that short section providing an opportunity to cross the highway corridor, as nearby north-south bike routes (e.g., on Chesterfield Avenue or St. Andrews Avenue) provide no such opportunity.

### 4.4.2 Potential Mitigation Approach

Excluding the recent work as part of the Lower Lynn Interchanges project, the Westview Drive Interchange and Lonsdale Drive Interchange are two of the newest interchanges on Highway 1 within the North Shore, with both facilities having been completed in the early to mid-1990s. Both facilities are tight diamond interchanges, likely driven in part by the need to reduce the extent of property impacts caused by implementing an interchange. Directly addressing ramp capacity and other operational and safety issues related to the capacity of the signalized ramp terminal intersections is possible, but would likely create interchange footprints that would result in significant impacts on adjacent properties.

Therefore, an alternative approach was developed wherein a new multi-modal overpass across the highway would be investigated, with the intention that this connection would provide a new route to connect neighbourhoods on the north and south side of the highway and eliminate the requirement for people crossing the highway to travel through one of the two interchanges. With an alternate route provided for cross-highway trips, the ramp terminal intersection signals could be re-timed to increase signal green time (and by extension, capacity) for ramp movements, which could in turn address the operations and safety challenges. As noted above in Section 4.4.1, there is a lack of high-quality cross-highway connections in this area for people walking and cycling. Therefore, the new connection could include new high-quality walking and cycling facilities and improve cross-highway connectivity for people using active transportation modes. The specific configuration of these facilities (i.e., multi-use paths, sidewalks and two unidirectional protected bicycle lanes or a single bidirectional bike lane, etc.) would need to be explored further, particularly with respect to mitigating the impacts of steep road grades.

Three alignments were initially reviewed with respect to the technical feasibility of a new overpass structure: Chesterfield Avenue, Jones Avenue and St. Georges Avenue. South of W 23rd Street, Chesterfield Avenue is both a bike route and classified as a minor arterial in the City of North Vancouver *Road Classifications* (2017), and the existing roadway cross-section is relatively well suited to accommodating additional traffic volumes. North of W 23rd Street, including on the north side of the highway, Chesterfield Avenue is built out as a local street. The section between W 23rd Street and W 24th Street is identified as a bike route. The existing north-south grades create a challenge with respect to providing a suitable vertical geometry for a new overpass structure that must clear above the highway by at least 5 metres. On the north side of the highway, tying in an overpass to the existing grade is relatively easy, as the ground would rise to meet the structure; however, on the south side, the descent back down to the existing grade would result in either an unreasonably steep grade or a structure that “chases the grade” down the hill towards Burrard Inlet for several blocks. An underpass concept was also considered, although this would likely be more technically challenging to construct beneath the active highway. However, a similar challenge emerged with the underpass; the vertical road geometry on the south side of the highway is relatively straightforward, but on the north side of the highway, daylighting the underpass would take several blocks or require an unreasonably steep grade. Therefore, this concept was not considered further.

Jones Avenue is also a bike route, and also has the benefit of being located roughly halfway between Lonsdale Avenue and Westview Drive, and therefore has greater potential to draw trips away from both interchanges. Jones Avenue already provides a pedestrian overpass across the highway; however, people cycling on Jones Avenue are required to dismount and walk their bicycle across the structure. Ultimately, Jones Avenue exhibits many of the same challenges with respect to vertical geometry as Chesterfield Avenue, and was therefore not considered further.

South of the highway, St. Georges Avenue is classified as a minor arterial in the City of North Vancouver *Road Classifications* (2017). The street is not a bike route; instead, a route is provided on St. Andrews Avenue one block to the east. Unlikely the previous two concepts, St. Georges Avenue is not located between the two interchanges, but rather to the east of both of them, and is therefore less likely to draw traffic away from Westview Drive. However, from a technical feasibility perspective, it is anticipated that a grade in the range of 12% could be achieved. This grade, while exceeding desirable maximums in most design guidelines, is a similar range to the steepest grades on north-south streets in the City of North Vancouver between Esplanade Avenue and Keith Road. Achieving this grade would require reprofiling the westbound off-ramp from Highway 1 and would also require the 200 block of 25th Street to turn right at St. Georges Avenue into a slip lane, as sufficient clearance would not be provided underneath the structure for existing through-movements to continue. On this basis, the opportunity to implement a new overpass across the highway at St. Georges Avenue was investigated. This concept is shown at a high level in ***Figure 4.13***.

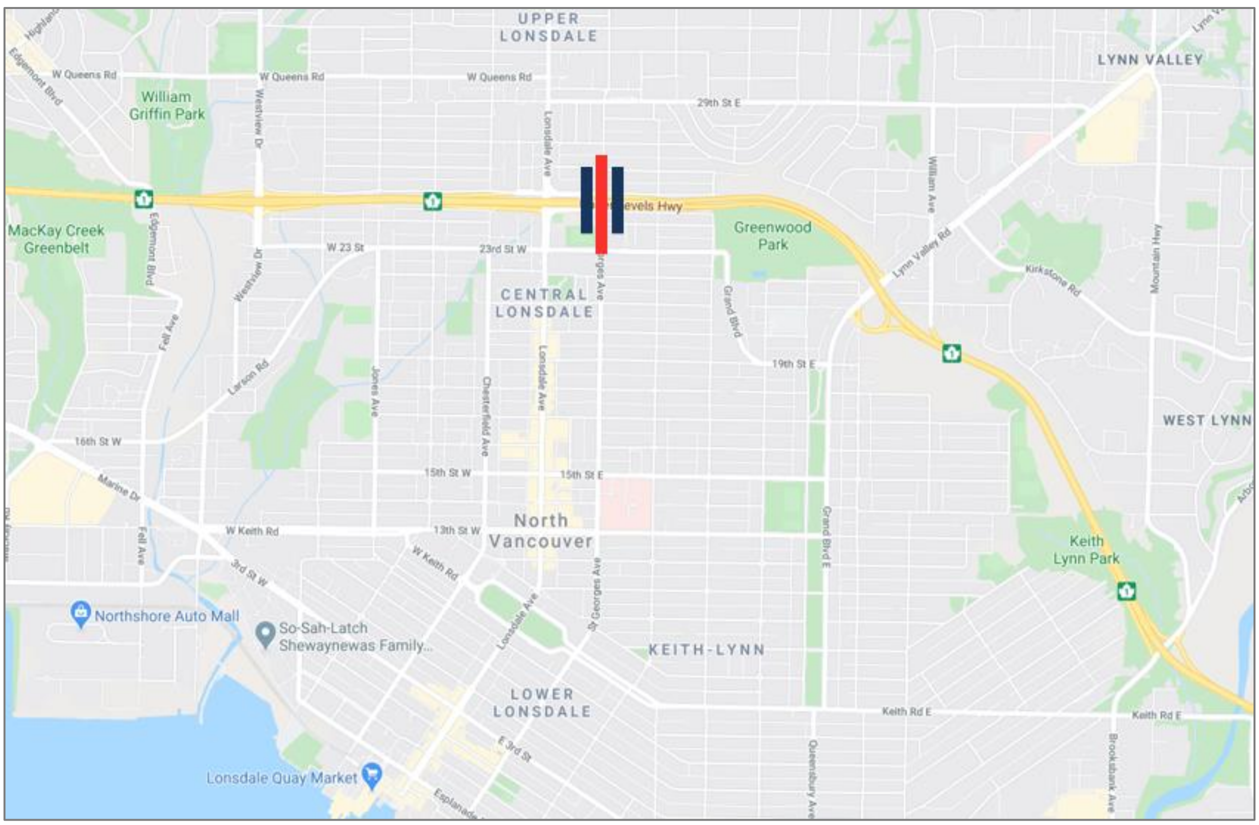


Figure 4.13: St. Georges Avenue Overpass Concept
FOR DISCUSSION PURPOSES ONLY

### 4.4.3 Initial Evaluation Findings

Findings from the initial high-level evaluation with respect to transportation performance, socio-community impacts, environmental impacts and capital costs are summarized below.

#### TRANSPORTATION PERFORMANCE

As a first step in assessing the transportation performance, volume difference plots were developed for both the 2050 AM and PM peak hours, and are provided in ***Figure 4.14*** and ***Figure 4.15***. These figures show that that the St. Georges Avenue Overpass would be well-used in both peak hours. Lonsdale Avenue sees a moderate reduction in traffic volumes (roughly in the range of 20%–25%), while impacts on Westview Drive are more limited (generally in the range of 5%–10%). The greater volume reductions on Lonsdale Avenue vis-à-vis Westview Drive were anticipated, given the location of St. Georges Avenue relative to these two routes. Of the trips being made on the St. Georges Avenue Overpass, roughly 60%–70% are diverted from parallel routes, while the remaining 30%–40% represent a net increase in total cross-highway trip-making.

From a transit perspective, diversion of vehicle volumes only parallel routes could improve travel time reliability on Lonsdale Avenue (which is part of the Frequent Transit Network) and, to a lesser extent, Westview Drive.


Figure 4.14: 2050 AM Peak Hour Volume Differences with St. Georges Avenue Overpass Improvements


Figure 4.15: 2050 PM Peak Hour Volume Differences with St. Georges Avenue Overpass Improvements

### Volume-to-Capacity Ratio

*Table 4.17* shows volume-to-capacity ratio values for Lonsdale Avenue and Westview Drive ramps.

Table 4.17: Lonsdale Avenue Interchange and Westview Drive Interchange Ramp Segment Volume-to-Capacity Ratios

| Volume-Capacity Ratio | | AM | | | PM | | |
|---|---|---|---|---|---|---|---|
| | | 2017 | 2050 Base | 2050 with St. Georges Avenue Overpass | 2017 | 2050 Base | 2050 with St. Georges Avenue Overpass |
| Lonsdale Avenue Interchange | Lonsdale Ave, WB off-ramp | 0.49 | 0.56 | 0.53 | 0.49 | 0.54 | 0.55 |
| | Lonsdale Ave, WB on-ramp | 0.31 | 0.29 | 0.32 | 0.22 | 0.21 | 0.22 |
| Westview Drive Interchange | Westview Dr, WB off-ramp | 0.74 | 0.85 | 0.83 | 0.52 | 0.65 | 0.66 |
| | Westview Dr, WB on-ramp | 0.95 | 1.09 | 1.15 | 0.82 | 1.0 | 1.04 |
| Westview Drive Interchange | Westview Dr, EB off-ramp | 0.33 | 0.36 | 0.37 | 0.58 | 0.61 | 0.61 |
| | Westview Dr, EB on-ramp | 0.32 | 0.33 | 0.32 | 0.33 | 0.3 | 0.28 |
| Lonsdale Avenue Interchange | Lonsdale Ave, EB off-ramp | 0.6 | 0.74 | 0.75 | 0.72 | 0.89 | 0.89 |
| | Lonsdale Ave, EB on-ramp | 0.86 | 0.82 | 0.77 | 0.77 | 0.9 | 0.88 |

In 2017, the westbound Westview Drive on-ramp is approaching capacity in the AM peak hour and is elevated in the PM peak hour. Similar conditions, though slightly better, are seen at the Lonsdale Avenue eastbound on-ramp. These ramps see worsened conditions in 2050. Other ramps of concern in 2050 are the westbound off-ramp to Westview Drive in the AM and the eastbound off-ramp to Lonsdale Avenue in the PM. With the improvement concept, the westbound Westview Drive on-ramp exhibits higher volume-to-capacity ratio than in the 2050 base and remains above capacity, while others show minor changes.

These findings suggest that the concept is not anticipated to have a significant impact on operations at either of the two interchanges. However, RTM is not able to fully capture the effects of signal timings with respect to capacity and vehicular operations; therefore, further investigation with an intersection capacity analysis or traffic operations micro-simulation modelling software would likely be required to confirm any impacts (or lack thereof) of the St. Georges Avenue Overpass.

**Transit**

By redirecting some passenger vehicle volumes away from Lonsdale Avenue, intersection operations could be improved for not only the remaining passenger vehicles, but also the five bus routes. However, benefits to transit would also be contingent on the extent to which signal green time is reassigned to the on-ramps and off-ramps, rather than movements along Lonsdale Avenue. Given the lower vehicle volume reduction at Westview Drive as well as the lesser level of transit service (i.e., one route rather than five), the benefits here are anticipated to be relatively minor.

Note that transit benefits are not assigned a qualitative score because they are implicitly captured in the quantified consumer surplus analysis below.

**Active Transportation Provisions**

It is anticipated that the St. Georges Avenue Overpass cross-section would enable the provision of a new walking and cycling connection across the highway. Based on an assumed 27-metre to 30-metre overall cross-section, the cross-section could allow for sidewalks and unidirectional protected bicycling lanes on either side of the structure. A key challenge with respect to active transportation modes is that the south approach would have a grade of roughly 12%, which is well above the desirable maximum grades (typically 5%) used for new active transportation infrastructure.

Given this challenge, further investigation of opportunities to mitigate the effects of the steep grade are recommended. This could include the installation of switchbacks to increase ramp length and reduce grades (although this may create additional property impacts), and providing benches or other “rest areas” for people walking.

*Overall Rating is Somewhat Better*

**Consumer Surplus**

Consumer surplus is shown in ***Table 4.18***.

Table 4.18: St. Georges Avenue Overpass Consumer Surplus

| Time Period | St. Georges Avenue Overpass |
|---|---|
| SOV | 57,276 |
| HOV | 32,518 |
| LGV | 605 |
| HGV | 1,222 |
| Bus | 18,541 |
| Rail | 122,116 |
| WCE | -67 |
| Total (hr) | 232,211 |
| Total ($2020) | $4,500,448 |

By 2050, the St. Georges Avenue Overpass is forecast to provide an annualized mobility benefit of approximately $4.5 million. Of this benefit, 27% (or $1.2 million) is for local trips within the North Shore, while the remaining 73% (or $3.3 million) is for regional through-trips. Local benefits are largely incurred by people travelling across the highway who now have an alternate route that is not subject to congestion and delays caused by traffic using the interchanges to enter and exit the highway. Regional/through benefits are incurred by people using the Lonsdale Avenue (and to a lesser extent Westview Drive) interchanges who are no longer subject to some of the incremental congestion caused by local trips using these same routes to cross the highway corridor.

### SOCIO-COMMUNITY IMPACTS

Socio-community impacts were assessed separately with respect to property impacts, community severance impacts, visual and noise impacts, and consistency with community and regional plans.

#### Property Impacts

On the south side of the highway, the existing right-of-way for St. Georges Avenues is approximately 20 metres, while a right-of-way of roughly 27 to 30 metres is anticipated to be required in order to provide the overpass structure while also accommodating existing right-in/right-out movements to and from the Lonsdale Avenue eastbound on-ramp. This additional right-of-way would impact either the Harry Jerome Community Recreation Centre site on the west side of the street or the provincial courthouse and the adjacent single-family residence on the east side of the street, or a combination of the two.

On the north side of the highway, it is anticipated that the St. Georges Avenue right-of-way between 25$^{th}$ Street and 26$^{th}$ Street would need to be widened (particularly if the existing at-grade circulation from 25$^{th}$ Street to St. Georges Avenue is also required to be maintained via a slip lane). This would likely result in impacts on properties on either the east side or the west side of the existing right-of-way.

*Overall Rating is Somewhat Worse*

### Community Severance

The St. Georges Avenue overpass is anticipated to reduce the "severance" effects of the highway through a densely populated neighbourhood by providing an alternate route to cross the corridor. For people walking, this provides an alternate route that may help people avoid the need to "detour" to Lonsdale Avenue to cross the highway. For people cycling, the overpass provides an opportunity for new cycling connectivity across the highway to service two major north-south bike routes (Chesterfield Avenue and St. Andrews Avenue) where such connectivity is currently lacking.

For people driving, the new connection would provide a route across Highway 1 that is not as susceptible to congestion and delays as the existing Lonsdale Avenue and Westview Drive routes. Surges in highway entry and exit volumes at these interchanges, particularly in the event of an incident downstream, can congest the local street network and create delays for people crossing the highway. The St. Georges Avenue Overpass, by virtue of having relatively limited connectivity to highway-related traffic, will provide a reliable alternative.

*Overall Rating is Significantly Better*

### Visual and Noise Impacts

The south overpass embankment is anticipated to create visual impacts on St. Georges Avenue, which would visually impact the future Harry Jerome Community Recreation Centre on the west side of the street (although the extent of actual impacts would depend on the ultimate form of the development) and the provincial law courts and some residences on the east side of the street.

On the north side of the highway, the need to cross overtop 25th Street would result in the structure still being elevated at this point, but tie-in by 26th Street is anticipated as the existing topography rises to the north to meet the downhill grade on the overpass sooner. Nonetheless, visual impacts are anticipated for properties on either side of this block of St. Georges Avenue.

Traffic volumes would also increase sonically on St. Georges Avenue, between 23rd Street and 29th Street. In contrast, properties fronting Lonsdale Avenue between these same blocks would see a decrease in traffic volumes (although to a lesser magnitude) and, correspondingly, a small reduction in visual and noise impacts.

*Overall Rating is Similar to Somewhat Worse*

### Consistency with Community and Regional Plans

An overpass at St. Georges Avenue is not contemplated as part of any existing municipal or regional plans. However, by providing an opportunity for a new north-south cycling connection across the highway corridor, the concept is helping achieve the objectives of the Lonsdale Avenue on-street bike route included in the City of North Vancouver *Bicycle Master Plan* (2012), but simply offers a different approach to achieving that objective.

The overpass was not contemplated as part of the Harry Jerome Project; therefore, strictly speaking, it is not consistent with the planning for either the Harry Jerome Community Recreation Centre or the Harry Jerome Neighbourhood Lands. However, it is anticipated that, as these plans progress, there may be an opportunity to further investigate potential benefits and impacts of the overpass on the Harry Jerome Project and vice versa. Given that this investigation has not yet occurred, a score is not provided at this time.

*Overall Rating is to Be Determined*

## ENVIRONMENTAL IMPACTS

Environmental impacts were assessed separately with respect to terrestrial impacts, aquatic impacts and greenhouse gas emissions.

### Terrestrial Impacts

No major terrestrial impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

### Aquatic Impacts

No aquatic impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

### Greenhouse Gas Emissions

The resultant change in greenhouse gas emissions is provided in ***Table 4.19***.

Table 4.19: 2050 St. Georges Overpass Greenhouse Gas Emissions from Vehicular Sources (Tonnes)

| Time Period | 2050 Base | St. Georges Overpass Concept |
|---|---|---|
| Total Greenhouse Gas Emissions | 8,579,691 | 8,579,418 |
| **Reduction in Greenhouse Gas Emissions** | **n/a** | **273** |

As shown, the St. George Overpass improvements are anticipated to cause a small net decrease in greenhouse gas emissions by 2050. This decrease is largely attributable to the benefits of reduced congestion exceeding the impacts of travel facilitated by the additional road capacity.

## CAPITAL COSTS

Planning level cost estimates were prepared using the Elemental Parametric Method of cost estimation (Wolski method). Costs estimates also included values for future planning, design, project management, construction, administration and contingencies. The capital cost estimate of the St. Georges Overpass concept is in the range of $10 million - $50 million ($$$$). It is anticipated that property costs may be incurred at either end of the structure; as noted previously, these costs are not included in the estimate.

### SUMMARY OF FINDINGS

A summary of the evaluation of the St. Georges Overpass concept is presented in ***Table 4.20*** with respect to the key evaluation criteria.

Table 4.20: Summary of High-Level Evaluation Findings for St. Georges Overpass Concept

| Criteria | St. Georges Overpass Concept | Notes |
|---|---|---|
| Active Transportation Provisions | ◕ | |
| Consumer Surplus – Local ($2020) | $1,205,000 | For year 2050 |
| Consumer Surplus – Regional/Through ($2020) | $3,295,000 | For year 2050 |
| Property Impacts | ◔ | |
| Community Severance | ● | |
| Noise/Visual Impacts | ◔ | |
| Consistency with Community and Regional Plans | TBD | Requires further investigation of mutual benefits and impacts vis-à-vis the adjacent Harry Jerome Project |
| Terrestrial Habitat Impacts | ◑ | |
| Aquatic Habitat Impacts | ◑ | |
| Greenhouse Gas Emissions Reduction (tonnes) | 273 | A positive number is a reduction in greenhouse gas emissions |
| Capital Cost Range ($2020) | $$$ | Property and escalation costs not included |

**$**: 0 million – $5 million; **$$**: $5 million – $10 million; **$$$**: $10 million – $50 million; **$$$$**: $50 million – $100 million; **$$$$$**: $100 million+

## 4.4.4 Key Considerations for Further Concept Development, Refinement and Assessment

Several key considerations were identified for further investigation with respect to the technical feasibility of the concept as well as other potential needs or opportunities at the Westview Drive Interchange and Lonsdale Avenue Interchange. With respect to technical feasibility:

- The technical feasibility of the vertical geometry of the overpass structure has only been instigated at a very high level. Further design investigation to confirm the vertical profile as well as the need to regrade the eastbound off-ramp at Lonsdale Avenue and reroute 25th Street (or allow a structure with less than 5 metres of clearance for a local street) is recommended. Similarly, further instigation of the potential overpass cross-section, and implications for right-of-way requirements is also recommended.
- As the design concept for the Harry Jerome Project continues to evolve, there is a need to ensure that the two concepts are mutually compatible. This applies not only to right-of-way requirements, but also to access into and out of the Harry Jerome site. For example, some existing plans show an access located on St. Georges Avenue between 23$^{rd}$ Street and the eastbound on-ramp; this access is still possible, but with the overpass in place, would be restricted to a right-in/right-out configuration due to the presence of the south approach embankment structure for the overpass.

With respect to other needs and opportunities at the Lonsdale Avenue Interchange and Westview Drive Interchange:

- Further investigation is required to confirm the potential capacity benefits for the on-ramps and off-ramps at the four ramp terminal interchanges associated with re-timing the signals to give more green time to these movements instead of north-south through-movements.
- At the Lonsdale Avenue Interchange, there is an opportunity for further investigation of potential improvements to address ongoing challenges related to the quality of pedestrian infrastructure (e.g., by building larger landing areas and pedestrian ramps at the four corners of the bridge structure). It is understood that the City of North Vancouver recently completed an assessment of opportunities for safety improvements in the vicinity of the interchange and plans to implement these changes in the coming years in conjunction with new developments.
- At the Westview Drive Interchange, the provision of east-west crosswalks for walking and cycling should be investigated, although it is noted that crosswalks may negate some of the ramp capacity benefits associated with re-timing the ramp terminal intersection signals.
- At the Westview Drive Interchange, the shared walking and cycling facility on the south side of the highway instead splits into a separate sidewalk and painted shoulder for cycling at the eastbound off-ramp; however, the shoulder ends prior to reaching the intersection. As part of any changes at this intersection, opportunities should be investigated to ensure the continuity of (and, potentially, improvements in the quality of) this cycling facility, particularly if it were to connect to a new crosswalk as described above. It is estimated that the cost of providing a cycling shoulder extension to the intersection would be in the range of $0 – $5 million.
- Although there is a sidewalk on the north side of the bridge over Mosquito Creek, there is no access from Westview Drive to this sidewalk. The feasibility of implementing a sidewalk could be investigated, along with a reciprocal facility at Edgemont Boulevard. It is estimated that the cost of providing connectivity on either side of the bridge to Westview Drive and Edgemont Boulevard would be in the range of $0 – $5 million. Alternatively, this facility could consist of a bidirectional multi-use path as part of a larger active transportation corridor on the north side of the highway, as described previously in Section 3.1.4.
- Over the longer term, it is anticipated that the City of North Vancouver is likely to reconsider the role and function of Lonsdale Avenue and Westview Drive, and the cross-section of these two streets could potentially change in the future (e.g., potentially providing an increased level of transit priority on Lonsdale Avenue in recognition of its role as a Frequent Transit Network corridor, and as a potential future RapidBus route). An overpass at St. Georges Avenue would not inherently preclude any further changes to the Lonsdale Avenue cross-section through the interchange area, and could provide some additional flexibility with respect to how to manage multi-modal travel patterns in this area. However, changes to the upstream and downstream capacity of the two Lonsdale Avenue ramp terminal intersections could in turn influence traffic operations through the interchanges. Therefore, if changes to the Lonsdale Avenue cross-section through the interchange were to be pursued, then further investigation would likely be required with respect to managing traffic at the ramp terminal intersections.

4.5 Westmount Road and Cypress Bowl Road Interchanges

The Westmount Road Interchange and Cypress Bowl Road Interchange are a pair of diamond interchanges servicing West Vancouver. The existing interchanges are shown in ***Figure 4.16.***

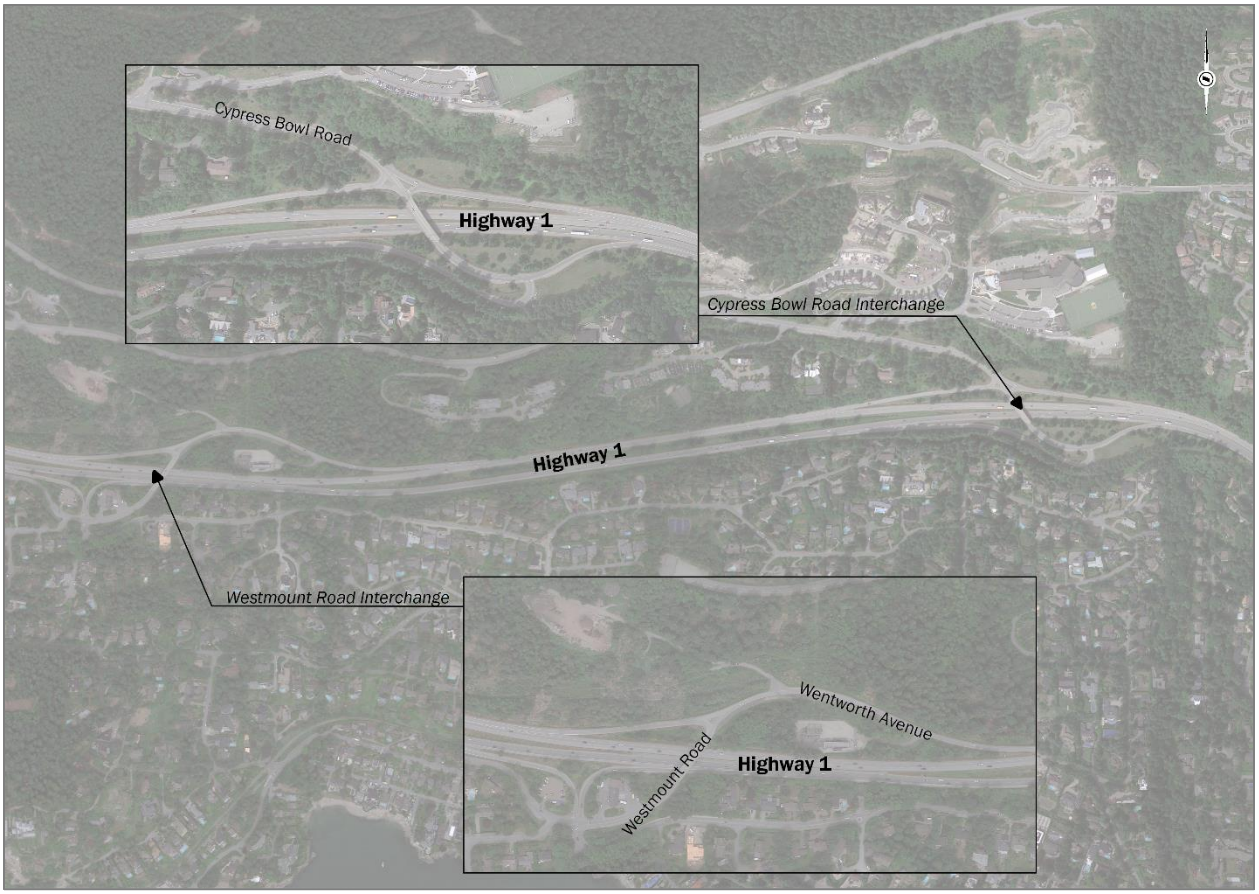


Figure 4.16: Existing Westmount Road Interchange and Cypress Bowl Road Interchange

## 4.5.1 Summary of Key Issues to Address

The Westmount Road and Cypress Bowl Road interchanges were identified as a location for potential improvements primarily due to future traffic operations challenges stemming from new development along Cypress Bowl Road on the north side of the highway corridor. The Cypress Bowl Road Interchange only provides access to areas on the north side of the highway corridor, including the Cypress Mountain resort, Cypress Provincial Park, developments along Cypress Bowl Road, the municipal operations centre/works yard, and Mulgrave School. The Westmount Road Interchange, with the exception of access to a BC Hydro substation, only provides access to residential areas on the south side of the highway. There is a steep gated roadway from the Westmount Road Interchange that runs up to Cypress Bowl Road on the north side of the highway; however, this roadway is not intended for public use.

In the current condition, peak hour volumes are relatively low at these two interchanges, although the following existing issues were identified:

- Queues for student drop-offs at Mulgrave School can extend down Cypress Bowl Lane, along Cypress Bowl Road, and back to the interchange itself. Queuing on the interchange ramps presents a potential safety consideration and obstructs other users.
- The Westmount Road Interchange, the configuration of three-legged westbound ramp terminal intersection on the north side of the highway corridor, can cause some driver confusion and lead to incorrect movements, particularly with westbound vehicles exiting the highway and seeking to travel to the south side of the highway inadvertently entering the on-ramp, rather than travelling across the overhead structure to the south side of the highway.

It is also acknowledged that the RTM tool used for this analysis undercounts some localized trip-making using these two interchanges, a phenomenon that is attributable (in part, not fully) to a differing AM peak hour.

Looking ahead to the 2050 planning horizon year, the primary challenge in this area relates to the proposed mixed-use development along Cypress Bowl Road on the north side of the highway corridor that is anticipated to add 5,000 to 9,000 new residents, 500 to 1,500 new jobs in offices and retail, and increase education spaces. By default, the development would connect Highway 1 solely via the Cypress Bowl Road Interchange; therefore, all trips generated by the new development would occur via Cypress Bowl Road. Based on the travel demand modelling conducted using the Regional Transportation Model, as well as a review of the traffic impact study for the proposed development (which is more reflective on the actual extent of proposed development than the land use information for the traffic analysis zone that includes the Cypress Village development), this additional traffic could create significant operational challenges at the Cypress Bowl Road Interchange.

The development traffic impact study *Transportation Impact Study for BC MoTI – Cypress Village – Phase 1 Development Scenario* (2018) identified several potential opportunities to reduce peak hour vehicle volumes, including that the mixed-use development creates some internal trip capture (i.e., people both living and working/attending school within the development) and the potential to provide a new bus service between the development and downtown. However, there will still be a significant increase in AM and PM peak hours vehicular trips on the highway and using the Cypress Bowl Road Interchange. Much of this traffic would be due to residential development (i.e., outbound from the area in the AM peak hour using the eastbound on-ramp, and inbound to the area in the PM peak hour using the westbound off-ramp). However, the office and retail growth in the development, as well as additional educational capacity, will generate traffic that is inbound to the area in the AM using the westbound off-ramp and outbound from the area in the PM using the eastbound on-ramp. Although these office/retail/school-generated inbound volumes in the AM are not anticipated to be as high as the residential-generated inbound PM volumes, these inbound AM volumes will be obstructed by the queuing issues related to Mulgrave School, and could increase the potential for queue spillbacks onto the westbound off-ramp or, in more severe conditions, potentially the highway mainline itself.

To address traffic operations and capacity challenges related to the new developments along the north side of Cypress Bowl Road, the development traffic study included a concept for a new connection between Cypress Bowl Road and the Westmount Road Interchange, known as the Westmount Connector. This new connector would provide a public road connection that is similar to the existing restricted access road, although with a significant realignment and regrading to provide a roadway that is more suited to higher volumes of vehicle traffic. The Westmount Connector would deliver development traffic to the Westmount Highway interchange, which would then access Highway 1. However, even with the Westmount Connector in place, a significant proportion of development traffic would still make use of the Cypress Bowl Road Interchange. Therefore, peak hour volumes through the interchange would still increase significantly compared to current conditions (the magnitude of the increase would simply be less than it otherwise would be, should the Westmount Connector not be implemented). These increases in development-related traffic could create several operation impacts:

- Queues for westbound right-turn movements at the Cypress Bowl Road/Cypress Bowl Lane intersection (i.e., inbound vehicles for student drop-offs at Mulgrave School) could still spill back beyond the right turn auxiliary lane and obstruct inbound movements to the new development. The combined demand for inbound movements to Mulgrave School and the new development could exacerbate queue spillbacks and begin impacting operations at the interchange (or, in more extreme conditions, potentially the highway itself). Queues would need to reach 130 metres (roughly 17 vehicles) to affect movements on Cypress Bowl Road, at which point inbound traffic to the development gets affected (and the queue could begin to grow more quickly). A queue of 300 metres (roughly 40 vehicles) would begin to impact the interchange ramp terminal, and a queue of 700 metres (roughly 93 vehicles) would begin to impact the highway mainline.
- Due to the increase in outbound traffic from the new development travelling eastbound along Cypress Bowl Road in the morning, southbound left turn movements from Cypress Bowl Lane onto Cypress Bowl Road (i.e., outbound vehicles who have just completed student drop-offs at Mulgrave School) will have fewer gaps in the traffic stream to complete their manoeuvre. In principle, this is not a “highway” issue, as it affects only the local street network. However, if outbound movements from Mulgrave School cause queuing to such a degree that they affect the ability of drivers to exit the drop-off area, then this can delay inbound movements and exacerbate the inbound queuing issue noted above. It is anticipated that the development traffic study would identify mitigation measures that would be put in place to address this intersection operations issue (i.e., additional laning and/or installation of a traffic signal); however, these changes could in turn have some impact on downstream traffic operations at the Cypress Bowl Road interchange.
- The eastbound on-ramp from Cypress Bowl Road is a direct taper merge, which is typically less suited to higher volumes than a parallel merge.
- The existing configuration of the Westmount Road Interchange is not necessarily suited to a significant increase in volumes, particularly for movements that greatly differ from prevailing traffic patterns. Two challenges were noted:
    - Vehicles travelling from the south side of the highway to the westbound on-ramp must yield to eastbound vehicles travelling to the south side of the highway from the eastbound off-ramp (or from the Westmount Connector in the future). Volumes for the latter movement will increase significantly as vehicles access the eastbound on-ramp on the south side of the highway from the Westmount Connector, which will cause vehicles bound for the westbound on-ramp to need to yield more frequently and for longer durations. Given that the Westmount Road overpass structure only provides a single northbound lane, this means that all vehicles bound to the Westmount Road Connector from the south side of the highway will be obstructed.
    - The eastbound ramp terminal intersection is stop-controlled for vehicles travelling from the Westmount Connector onto Highway 1 eastbound, and will create queues on the southbound lane across the Westbound Road overpass structure. These queues will create additional delays for people accessing the highway and also obstruct other vehicles arriving from either

the Westmount Connector or the westbound off-ramp that simply wish to cross to destinations on the south side of the highway.

- One of the challenges noted with respect to providing transit service to the new development is that it is not "along the way" of a pre-existing transit corridor and, as such, would require either a dedicated new transit route to service the development or a significant detour from an existing transit service. This would both increase transit operating costs and create travel time delays for all passengers who are not travelling to or from the development.
- With respect to active transportation, as summarized in ***Table 2.1***, the existing structure features a sidewalk on only one side and no cycling facilities. This creates a barrier for people walking and cycling between destinations on the north and south sides of the highway.

It is noted that RTM cannot explicitly capture/ quantify queue spillbacks, and further analysis using intersection capacity analysis and/or traffic operations micro-simulation tools would be required to confirm the likely extent of some of the queue spillback risks noted above.

### 4.5.2 Potential Mitigation Approach

A series of mitigation approaches were identified to mitigate the key issues described above, and are summarized in ***Table 4.21***. Subsequently, several of these mitigation approaches are elaborated upon further.

**Table 4.21: Westmount Road Interchange Issues and Potential Mitigation Approaches**

| Issue | Measure |
|---|---|
| The existing Westmount Road Interchange eastbound ramp terminal is stop-controlled, and given growing demands at the interchange associated with new development, it is anticipated that delays and queuing may emerge. Given the lack of auxiliary turn lanes, these queues could also obstruct other road users. | Provide a flyover across the highway to facilitate direct ramp access from the new development to Highway 1 eastbound, in order to encourage people travelling from the new development areas to use the Westmount Road Interchange and Westmount Connector, rather than Cypress Bowl Road. |
| The westbound off-ramp would have a stop-controlled intersection with the Westmount Connector, which could discourage people travelling to the new development areas from using the Westmount Road Interchange and Westmount Connector, rather than Cypress Bowl Road. Additionally, although an auxiliary right-turn lane is provided, if queues extend further than anticipated, then queued vehicles obstruct through-moving traffic exiting the highway but travelling to destinations on the south side of the highway. | Provide a direct route from the westbound off-ramp to the Westmount Connector to enable vehicles travelling to the new development areas to avoid the stop-controlled intersection at the bottom of the Westmount Connector (and avoid having these vehicles obstruct through-moving traffic exiting the highway but travelling to destinations on the south side of the highway), in order to encourage people travelling to the new development areas to use the Westmount Road Interchange and Westmount Connector rather than Cypress Bowl Road. |
| The existing eastbound ramp terminal is stop-controlled and given growing demands at the interchange associated with new development, it is anticipated that delays and queuing may emerge. Given the lack of auxiliary turn lanes, these queues could also obstruct other road users. | Convert the south ramp terminal intersection from stop-controlled to a roundabout in order to reducing queueing for trips from the north side of the highway to the existing eastbound on-ramp. This measure may not actually be required, given the above-noted flyover. |
| Vehicles travelling from the south side of the highway to the westbound on-ramp must yield to eastbound vehicles | Reconstruct (or widen) Westmount Road overpass structure to provide an additional northbound lane to |

| Issue | Measure |
|---|---|
| travelling to the south side of the highway from the eastbound off-ramp (or from the Westmount Connector in the future). Volumes for the latter movement will increase significantly with the development, which will cause vehicles bound for the westbound on-ramp to need to yield more frequently and for longer durations. The Westmount Road overpass structure only provides a single northbound lane; this means that all vehicles bound to the Westmount Road Connector from the south side of the highway will be obstructed. | separate northbound left turns (to the westbound on-ramp) from northbound through-movements to the new development areas. |
| Adding a new eastbound on-ramp at Westmount Road Interchange and forking the westbound off-ramp will move the entry/exits for this interchange close to the corresponding exit/entry for the Cypress Bowl Road Interchange, and could introduce weaving issues. | Close the west-facing ramps on Cypress Bowl Road interchange to avoid introducing a weaving issue, given the extended westbound off-ramp and new eastbound on-ramp at the Westmount Road Interchange. |
| Due to not being "along the way" for any pre-existing service, providing transit access to the new developments along Cypress Bowl Road creates challenges with respect to transit service costs and/or delays for riders to detour existing routes to access the development. | Provide an interchange configuration that would enable "on the way" transit service (e.g., an additional stop on the Route 257 bus service between Horseshoe Bay and downtown Vancouver) to be provided with relatively limited incremental travel time. |
| The existing Westmount Road overpass structure provides only a single sidewalk and no cycling facilities. | Reconstruct (or widen) Westmount Road overpass structure to provide walking and cycling facilities on both sides of the interchange. |

Most traffic using the Westmount Road Interchange and Westmount Connector is anticipated to be travelling to the east (i.e., using the eastbound on-ramp) in the AM peak hour and returning from the east (i.e., using the westbound off-ramp) in the PM peak hour. The configuration of the westbound off-ramp is generally well suited to accommodate vehicles exiting the highway and travelling towards Cypress Bowl Road. However, given the high volume of vehicles anticipated to be making a northbound right turn at the intersection of the off-ramp with the Westmount Connector, there is a potential for queues to spill back from this intersection into the off-ramp, and potentially obstruct off-ramp movements for travellers who wish to continue along the off-ramp and then cross the Westmount overhead structure to the residential area on the south side of the highway. The design of the Westmount Connector includes a right-turn lane to address this risk; however, an alternate approach has been developed that includes a forked exit ramp that would provide one exit that flows directly onto the Westmount Connector, and another that would be routed towards the Westmount Road Interchange overhead structure and to the residential area on the south side of the highway. The forked exit would provide separate routes for these two movements, and also eliminate delays and queues associated with vehicles accessing the Westmount Connector to need to stop and make a right-turn movement.

The alignment of the Westmount Connector was shifted from the developer design concept in order to facilitate the direct access via the forked ramp. Further design investigation is required to confirm whether this alignment shift would have any effect in terms of introduction of vertical gradients on the Westmount Connector that are steeper than what would otherwise have been provided. The forked exit ramp requires spacing between the exit from the highway and the fork, and therefore the exit from the highway needs to be shifted further upstream (i.e., eastwards), closer to the Cypress Bowl Road Interchange westbound on-ramp. In order to avoid introducing a weaving conflict with the westbound on-ramp from the Cypress Bowl Road Interchange, the latter on-ramp would be closed. This means that vehicles that currently travel westwards along the highway from Cypress Bowl

Road would instead need to use the Westmount Connector to access the westbound on-ramp at the Westmount Road Interchange.

The alignment of the new eastbound on-ramp was developed to avoid impacting the BC Hydro substation and transmission lines on the north side of the highway, as well as to tie back into grade on the south side of the highway without directly impacting any properties by taking advantage of a setback between the highway cross-section and the adjacent properties that is currently used for electrical distribution (which would need to be relocated). This alignment is therefore intended to avoid any direct property impacts, and has the added benefit of the highway having a slight uphill grade, thereby allowing the ramp to tie in sooner. Similar to the westbound direction, the eastbound off-ramp at Cypress Bowl Road would be closed, thereby eliminating potential weaving issues. This means that vehicles arriving to Cypress Bowl Road from the east would instead need to use the Westmount Road Interchange and Westmount Connector to access Cypress Bowl Road. The existing eastbound on-ramp at the Westmount Road Interchange was assumed to remain in place in order to avoid requiring trips originating from the south side of the highway to cross to the north side of the highway and then double-back using the new eastbound on-ramp to access the highway.

A concept was also developed to covert the Westmount Road Interchange eastbound ramp terminal to a roundabout in order to eliminate the stop control condition. This was primarily intended to smooth flow of movements to the existing eastbound on-ramp and from the eastbound off-ramp. Given the provision of the new eastbound off-ramp, further investigation would be required to assess whether this improvement still provides any significant incremental value.

With respect to transit service, as noted previously, the development has the challenge of not being "on the way" for an existing bus route. Bus stops were incorporated to the concept at the westbound ramp terminal intersections. This approach would require buses to exit the highway, but with relatively limited additional travel/detouring. However, even with this bus stop configuration, access to transit is likely to be an issue; the bus stops are roughly 500 metres from Cypress Bowl Road via the new Westmount Connector, and people travelling from the stop to the new development will have an extended walk up a relatively steep grade. Given these challenges, buses travelling up to the "heart" of the development may be a more suitable approach to ensuring the service is easily accessible for users (notwithstanding the implications for operating costs and travel times for other riders). Ultimately, transit service provision (or lack thereof) is the purview of the transit service; the intention of providing bus stop locations is simply to demonstrate one potential concept of how transit service could be accommodated into the interchange improvements.

The resultant Westmount Road Interchange improvement concept is shown in ***Figure 4.17***.

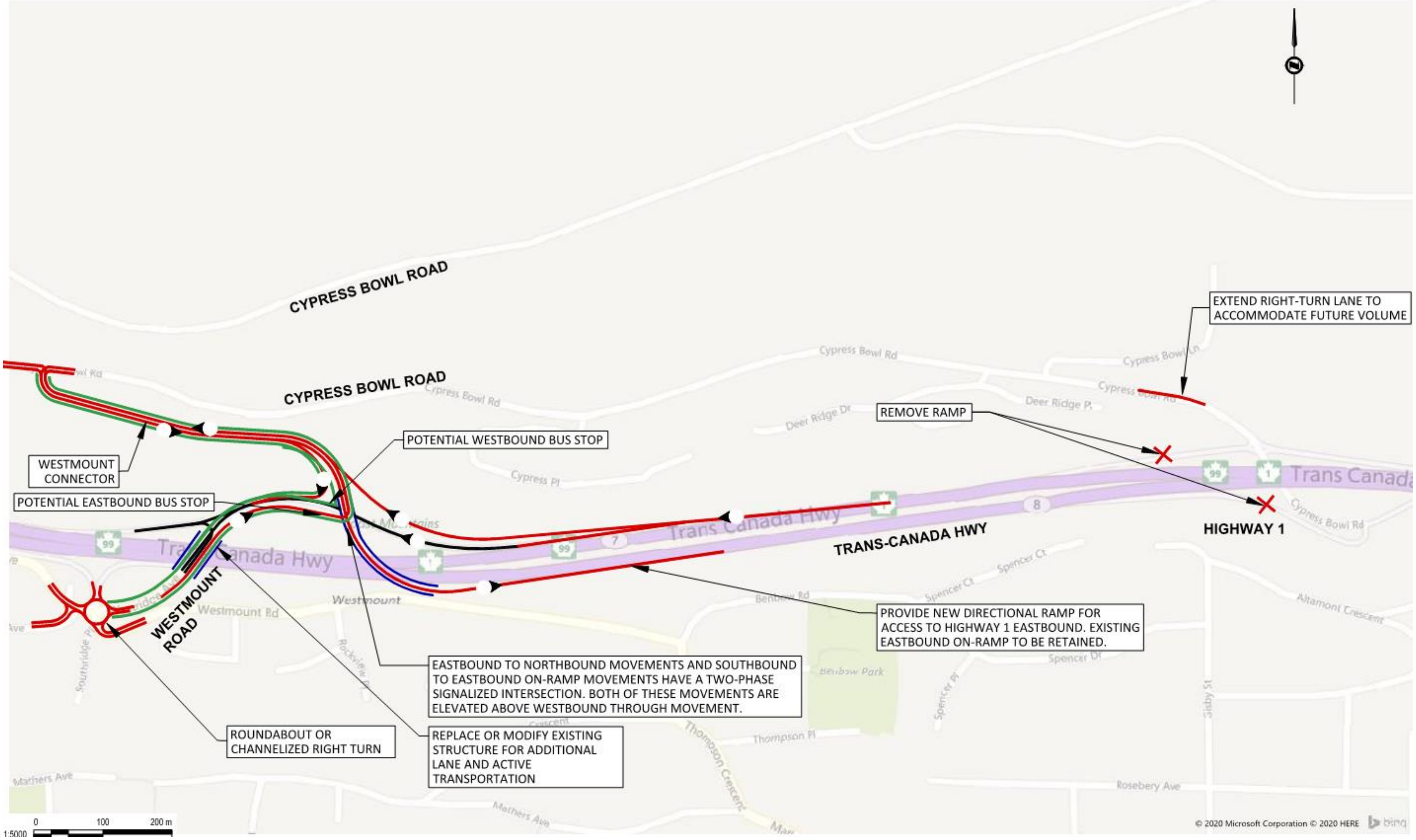


Figure 4.17: Westmount Road Interchange Improvement Concept

FOR DISCUSSION PURPOSES ONLY

### 4.5.3 Initial Evaluation Findings

Findings from the initial high-level evaluation with respect to transportation performance, socio-community impacts, environmental impacts and capital costs are summarized below.

#### TRANSPORTATION PERFORMANCE

Volume-to-capacity ratios for the Cypress Bowl Road Interchange and Westmount Road Interchange ramps for the 2017 base year as well as the 2050 planning horizon year, with and without the improvement opportunity are provided in ***Table 4.22***. Note that these results are presented under a modelling scenario wherein improvements were also coded at the Lynn Valley Road and Westmount Road Interchanges.

Table 4.22: Cypress Bowl Road Interchange and Westmount Road Interchange Ramp Segment Volume-to-Capacity Ratios

| Volume-Capacity Ratio | | AM | | | PM | | |
|---|---|---|---|---|---|---|---|
| | | 2017 | 2050 Base | 2050 Interchange Improvements | 2017 | 2050 Base | 2050 Interchange Improvements |
| Cypress Bowl Road Interchange | Cypress Bowl Rd, WB off-ramp | 0.21 | 0.43 | 0.4 | 0.14 | 0.9 | 0.87 |
| | Cypress Bowl Rd, WB on-ramp | 0.01 | 0.07 | 0.01 | 0.03 | 0.05 | 0 |
| Westmount Road Interchange | Westridge Ave, WB off-ramp | 0.04 | 0.04 | 0.06 | 0.03 | 0.19 | 0.1 |
| | Westridge Ave, WB on-ramp | 0.01 | 0.03 | 0.08 | 0.04 | 0.45 | 0.25 |
| Westmount Road Interchange | Westridge Ave, EB off-ramp | 0.05 | 0.17 | 0.21 | 0.04 | 0.08 | 0.13 |
| | Westridge Ave, EB on-ramp | 0.04 | 0.03 | 0 | 0.01 | 0.03 | 0.01 |
| Cypress Bowl Road Interchange | Cypress Bowl Rd, EB off-ramp | 0.25 | 0.15 | 0 | 0.03 | 0.13 | 0 |
| | Cypress Bowl Rd, EB on-ramp | 0.14 | 0.95 | 0.98 | 0.14 | 0.43 | 0.42 |

In 2017, modelled results for these interchanges show very low volume-to-capacity ratios. However, by 2050, demand on the Cypress Bowl Road eastbound on-ramp is approaching capacity in the AM peak and so is the westbound off-ramp in the PM peak; this reflects high demand associated with the proposed development in the area.

The proposed Westmount Road Interchange improvement shifts demand away from these congested ramps slightly, but their volume-to-capacity ratios remain very high. However, this is likely a technical issue with the existing traffic analysis zone and centroid connector configuration. In the RTM, the zone containing the proposed development connects east of the new Westmount Road connector introduced in this improvement concept, which biases trips coming from the east towards the Cypress Bowl Road ramps. In reality, much of the development will be west of the new Westmount Road connector and Westmount Road ramps would be a viable access concept for many trips. A finer-grained traffic operations micro-simulation modelling tool would be better suited to confirming the extend of benefits from this concept.

*Overall Rating is To Be Confirmed*

### SOCIO-COMMUNITY IMPACTS

Socio-community impacts were assessed separately with respect to property impacts, community severance impacts, visual and noise impacts, and consistency with community and regional plans.

#### Property Impacts

No direct property impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

#### Community Severance

This concept would provide improve multi-modal cross-highway connectivity from the new development areas on the north side and existing neighbourhoods on the south side.

*Overall Rating is Somewhat Better*

#### Visual and Noise Impacts

The new eastbound flyover on-ramp is anticipated to create noise and visual impacts on some properties along Westmount Road.

*Overall Rating is Somewhat Worse*

#### Consistency with Community and Regional Plans

Development of the Cypress Village and Cypress West areas is consistent with the District of West Vancouver *Official Community Plan* (2018). Improved and more direct access to and from Highway 1 would help facilitate this development.

*Overall Rating is Somewhat Better*

### ENVIRONMENTAL IMPACTS

Environmental impacts were assessed separately with respect to terrestrial impacts, aquatic impacts and greenhouse gas emissions.

### Terrestrial Impacts

This concept would require clearing of several trees just beyond outside the highway eastbound mainline in order to facilitate the new flyover ramp landing. The configuration of the Westmount Connector would create terrestrial habitat impacts, although further investigation would be required to confirm whether these impacts are more extensive than what would otherwise be incurred as part of the Westmount Connector concept generated by the developer.

*Overall Rating is Somewhat Worse*

### Aquatic Impacts

No aquatic impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

### Greenhouse Gas Emissions

This concept may have minor impacts with respect to greenhouse gas emissions, but would need to be confirmed with more detailed traffic operations modelling.

*Overall Rating is To Be Confirmed*

### CAPITAL COSTS

Planning level cost estimates were prepared using the Elemental Parametric Method of cost estimation (Wolski method). Costs estimates also included values for future planning, design, project management, construction, administration and contingencies. The capital cost estimate of the Westmount Road Interchange improvements concept is in the of $100 million+ ($$$$$). As noted previously, property costs have not yet been included.

### SUMMARY OF FINDINGS

A summary of the evaluation of the Westmount Road Interchange Improvement concept is presented in ***Table 4.23*** with respect to the key evaluation criteria.

Table 4.23: Summary of High-Level Evaluation Findings for Westmount Road Interchange Improvement Concept

| Criteria | Westmount Road Interchange Improvement Concept | Notes |
|---|---|---|
| Transportation Performance | TBD | |
| Property Impacts | ◑ | |
| Community Severance | ◕ | |
| Noise/Visual Impacts | ◔ | |
| Consistency with Community and Regional Plans | ◕ | |
| Terrestrial Habitat Impacts | ◔ | |
| Aquatic Habitat Impacts | ◑ | |
| Greenhouse Gas Emissions Reduction (tonnes) | TBD | A positive number is a reduction in greenhouse gas emissions |
| Capital Cost Range ($2020) | $$$$$ | Property and escalation costs not included |

**$**: 0 million – $5 million; **$$**: $5 million – $10 million; **$$$**: $10 million – $50 million; **$$$$**: $50 million – $100 million; **$$$$$**: $100 million+

## 4.5.4 Key Considerations for Further Concept Development, Refinement and Assessment

In its existing form, the RTM is not well suited to assessing the potential impacts of the new concept; therefore, a more fine-grained analysis using intersection capacity or traffic operations micro-simulation software is recommended to more fully assess benefits.

With respect to transit operations, the concept shows one potential approach; however, this approach would need to be reviewed/discussed further in the context of what service (if any) may be provided to the area in the future.

At this time, only high-level topographical information was available to help guide the development of the concept. However, as shown, it is anticipated that grades on the Westmount Connector could potentially reach approximately 15%—16%, which is steeper than typical guidelines (which recommend maximum grades of 12% for urban collector roads in mountainous terrain). Further design work would likely be required to confirm grades, and identify whether there are opportunities to reduce maximum grades.

As noted previously, given the other improvements included in the scope, the conversion of the eastbound ramp terminal intersection to a roundabout may provide little incremental value, and could potentially be removed from the scope.

Finally, it is noted that, in 2019, the District of West Vancouver launched a feasibility study for the Upper Levels Trail that, as alluded to previously in Section 2.2.10, will provide a walking and cycling facility on the north side of the highway. As noted in Section 2.2.12, between Skilift Road and Cypress Bowl Road, this trail may run close to the highway corridor in order to cross Rodgers Creek, and depending on the specific trail alignment, the trail could interface with the highway right-of-way and potentially with traffic operations at the westbound ramp terminal intersection at Cypress Bowl Road. In such a case, further design coordination would be required, although it is noted that the concept described above would remove some traffic from the Cypress Bowl Interchange, which would be a benefit to users of the Upper Levels Trail if there were to be an interface between trail users and vehicles.

# 4.6 Highway 99 Sea to Sky/Highway 1 Eastbound Merge

In the Horseshoe Bay area, the Highway 1 mainline through the North Shore (which is also co-signed as Highway 99 beginning at Taylor Way) transitions directly to Highway 99 along the Sea to Sky Corridor. Continuity along Highway 1 occurs via off-ramps and on-ramps to and from the Horseshoe Bay ferry terminal. The existing interchange is shown in ***Figure 4.18.***


Figure 4.18: Existing Highway 99 Sea to Sky/Highway 1 Eastbound Merge

## 4.6.1 Summary of Key Issues to Address

Given the nearby ferry terminal, as well as the atypical configuration of the highway, the nature of traffic operations in the westbound and eastbound directions differ significantly from one another. Therefore, operations in the westbound and eastbound directions are reviewed separately.

### WESTBOUND OPERATIONS

In the westbound direction, once beyond the Caulfeild Interchange westbound on-ramp, there are no further sources of additional vehicle traffic on the highway and therefore, from a highway capacity perspective, there are no traffic operations issues. The Highway 99 Sea to Sky/Highway 1 to Horseshoe Bay exit is configured as a major fork, with both routes having two lanes; although in the case of Highway 1, shortly after this diverge, these downstream lanes separate to a lane bound for the Horseshoe Bay ferry terminal toll booth and a lane bound for Horseshoe Bay Village.

Two challenges were identified with respect to westbound operations. The first issue is that Eagleridge Drive exit is located only 300 metres downstream of the Highway 1 Horseshoe Bay exit. In principle, sequential exits with a short separation distance are not a traffic operations issue, but they can create driver confusion. Due to exit signage typically being provided 600 metres (and 1,200 metres) upstream of an exit, this means that, although signage for the Eagleridge Drive off-ramp is located downstream from the signage for the Highway 1 Horseshoe Bay exit, it is located roughly 300 metres upstream of the actual Highway 1 Horseshoe Bay exit itself. As such, drivers intending to exit at the Eagleridge Drive off-ramp may mistake the Highway 1 Horseshoe Bay exit for their exit, and inadvertently end up in Horseshoe Bay village (or at the ferry terminal toll booths). Given the comparatively low volumes at the Eagleridge Drive off-ramp, and that many users are likely to be local residents who understand the highway off-ramp configuration, this is not considered a major issue, but could potentially benefit from some refinements to signage in order to reduce driver confusion.

The second issue is that when demand exceeds available ferry capacity, vehicles will be subject to a one-sailing wait (or more). Feedback from the engagement process has noted that, historically, on peak travel days with multiple sailing waits, the storage of vehicles at the terminal can cause queues of vehicles waiting to board a ferry at the Horseshoe Bay ferry terminal that spill back up the Highway 1 Horseshoe Bay exit and onto the highway itself. However, other feedback has noted that this phenomenon has not been seen in recent years and may be a relatively rare occurrence. As a dedicated third lane bound for the ferry terminal toll booths is provided on the highway beginning near the Westport Road overhead, this can still impact highway operations in the adjacent lane. Ultimately, the presence of the queue spillback onto the highway relates to operations at the ferry terminal, rather than to the highway itself. Strategies to address ferry terminal queue spillbacks onto the highway are best suited to be considered as part of BC Ferries' ongoing planning process for improvements to the Horseshoe Bay ferry terminal.

### EASTBOUND OPERATIONS

In the eastbound direction, peak-day travel demand on ferry capacity is not necessarily a major issue at the Horseshoe Bay Ferry terminal because this excess demand simply results in sailing waits at the Departure Bay, Langdale and Snug Cove ferry terminals. However, eastbound merging operation s at Highway 99 have still been identified as a challenge.

As described in Section 2.3.3, based on discussions with BC Ferries, no significant increase in overall vehicular volumes is anticipated at this terminal. However, a second exit ramp is proposed, which would allow for the simultaneous unloading of multiple ferries, which could create higher surge volumes.

Even as outbound movements from the ferry terminal could see high-intensity surges in the future, as described in Section 2.3.3, volumes on the Highway 99 Sea to Sky Corridor are also anticipated to increase. This is particularly a challenge as peak travel days/times on the ferry will tend to also correspond to peak travel days on the Highway 99 Sea to Sky Corridor, resulting in a condition where volumes are busier on both corridors simultaneously. Signage on the Highway 99 Sea to Sky Corridor encouraging traffic to keep right unless overtaking, while generally beneficial for higher operations, results in a condition where vehicles are disproportionately in the right lane near the merge with Horseshoe Bay traffic, which further increases lane occupancy and reduces available gaps for ferry traffic to merge.

As the RTM cannot fully capture weaving movements, a separate weaving analysis was undertaken using the Highway Capacity Software version 7.8. The 2017 peak-of-the-peak reflects a fully loaded ferry from either Langdale or Departure Bay unloading within 10 minutes, and the highest southbound hourly volumes observed on the Highway 99 Sea to Sky Corridor. The 2050 peak-of-the-peak reflects the 2017 peak-of-the-peak volumes on the Highway 99 Sea to Sky Corridor being scaled up using the same growth rates applied previously in Section 2.3.3, and a condition wherein ferries from both Langdale and Departure Bay are assumed to unload simultaneously over a period of 15 minutes. The resultant levels of service are shown in ***Table 4.24***.

Table 4.24: Level of Service for Highway 99 Sea to Sky/Highway 1 Eastbound Merge

| Movement | Peak-of-the-Peak | |
|---|---|---|
| | 2017 | 2050 Base |
| Eastbound | C | F |

Note that this analysis does not fully capture the impacts of the outside southbound lane on Highway 99 being more heavily used than the inside lane.

### 4.6.2 Potential Mitigation Approach

An opportunity to extend one of the lanes from Horseshoe Bay to the Caulfeild Interchange was initially investigated. This would essentially provide an "add lane" configuration that would provide an extended distance for people to merge, and could also act as a *de facto* climbing lane for slower vehicles up the hill from Eagle Creek to the Caulfeild Interchange. However, implementing this additional lane would be technically complex and would require widening the major bridge structure over Eagle Creek. Given that the merging issue, while not ideal, is generally manageable most of the year, this concept was not anticipated to provide value relative to the level of investment.

Instead, an opportunity was identified wherein signage would be placed on Highway 99 southbound upstream of the merge point that would warn users of the surge in ferry traffic volumes and proactively encourage drivers to shift to the inside lane. The signage could be either in the form of basic signage with automated warning flashers that are triggered when ferry traffic is unloading, or a larger dynamic message sign that could also be used for other messages at other times of the year. Given that peak-of-the-peak conditions only occur a handful of times throughout the year, the intention of this concept is to encourage smoother merging operations during those specific times of year at a much lower cost, compared to new highway laning/capacity. However, even during times with high (but slightly lower than peak-of-the-peak) volumes, such as a typical Sunday afternoon in summer, the signage may still prove beneficial. An example placement of this signage is shown in ***Figure 4.19*** below.

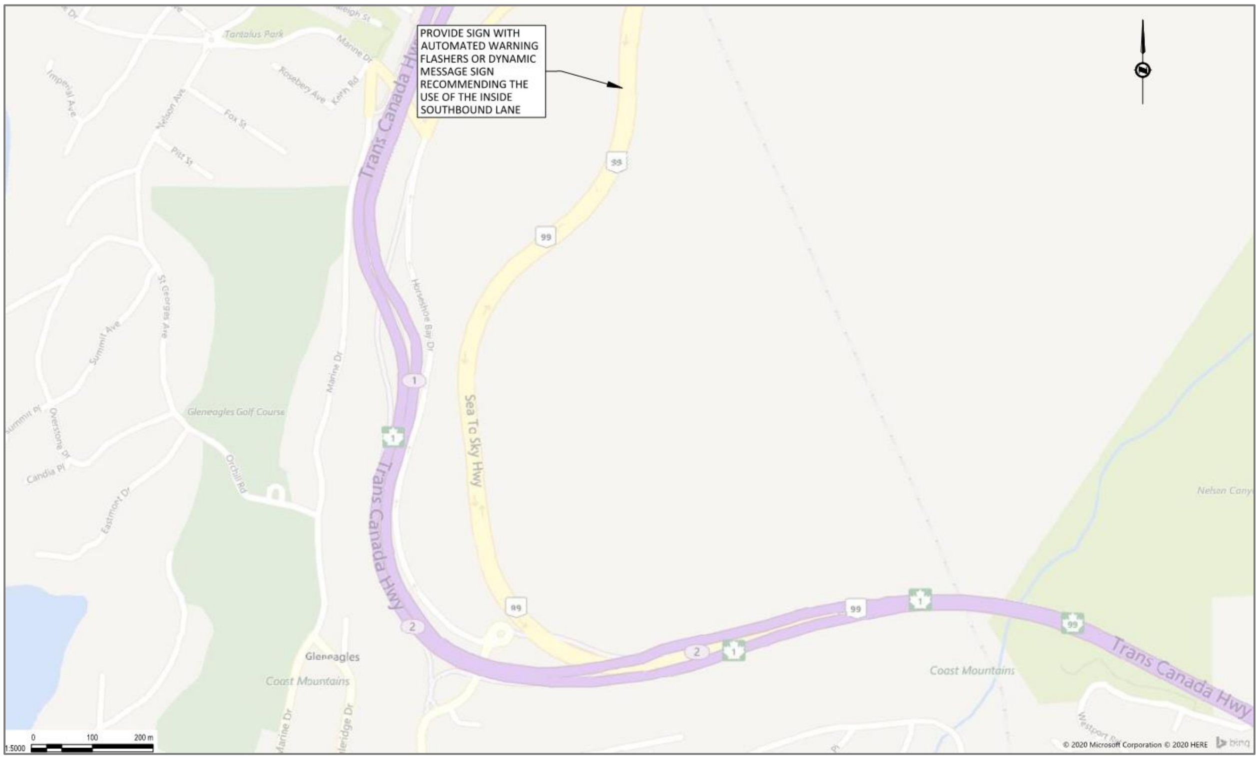


Figure 4.19: Highway 99 Sea to Sky/Highway 1 Eastbound Merge Improvement Concept
FOR DISCUSSION PURPOSES ONLY

### 4.6.3 Initial Evaluation Findings

Findings from the initial high-level evaluation with respect to transportation performance, socio-community impacts, environmental impacts and capital costs are summarized below.

#### TRANSPORTATION PERFORMANCE

The Highway Capacity Software methodology is not sensitive to differing lane utilizations between the inside and outside lanes on Highway 99 southbound. As such, this tool cannot directly be used to capture the operational impacts of the signage. A traffic operations micro-simulation modelling tool would be better suited for this analysis, although the analysis would require an explicit input assumption regarding vehicle diversion to the inside lane in order to test operations.

*Overall Rating is To Be Confirmed*

## SOCIO-COMMUNITY IMPACTS

Socio-community impacts were assessed separately with respect to property impacts, community severance impacts, visual and noise impacts, and consistency with community and regional plans.

### Property Impacts

No direct property impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

### Community Severance

No community severance impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

### Visual and Noise Impacts

Other than the presence of a sign, no visual or noise impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

### Consistency with Community and Regional Plans

No impacts with respect to community or regional plans are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

## ENVIRONMENTAL IMPACTS

Environmental impacts were assessed separately with respect to terrestrial impacts, aquatic impacts and greenhouse gas emissions.

### Terrestrial Impacts

No major terrestrial impacts are anticipated, although some vegetation may be required to install the foundation for the new signage.

*Overall Rating is Similar to Base Case/Neutral*

### Aquatic Impacts

No aquatic impacts are anticipated.

*Overall Rating is Similar to Base Case/Neutral*

### Greenhouse Gas Emissions

This concept may have minor impacts with respect to greenhouse gas emissions, but would need to be confirmed with more detailed traffic operations modelling.

*Overall Rating is To Be Confirmed*

### CAPITAL COSTS

Planning level cost estimates were prepared using the Elemental Parametric Method of cost estimation (Wolski method). Costs estimates also included values for future planning, design, project management, construction, administration and contingencies. The capital cost estimate of the Highway 99 Sea to Sky/Highway 1 Eastbound Merge concept is in the range of $0 – $5 million ($).

### SUMMARY OF FINDINGS

A summary of the evaluation of the Highway 99 Sea to Sky/Highway 1 Eastbound Merge is presented in ***Table 4.25*** with respect to the key evaluation criteria.

Table 4.25: Summary of High-Level Evaluation Findings for Highway 99 Sea to Sky/Highway 1 Eastbound Merge

| Criteria | Highway 99 Sea to Sky/Highway 1 Eastbound Merge | Notes |
|---|---|---|
| Transportation Performance | TBD | |
| Property Impacts | ◑ | |
| Community Severance | ◑ | |
| Noise/Visual Impacts | ◑ | |
| Consistency with Community and Regional Plans | ◑ | |
| Terrestrial Habitat Impacts | ◑ | |
| Aquatic Habitat Impacts | ◑ | |
| Greenhouse Gas Emissions Reduction (tonnes) | TBD | |
| Capital Cost Range ($2020) | $ | Property and escalation costs not included |

**$**: 0 million – $5 million; **$$**: $5 million – $10 million; **$$$**: $10 million – $50 million; **$$$$**: $50 million – $100 million; **$$$$$**: $100 million+

## 4.6.4 Key Considerations for Further Concept Development, Refinement and Assessment

As noted above, the value of this concept should be confirmed through a traffic operations micro-simulation modelling analysis.

# 5. IMPLEMENTATION AND PHASING

This report outlined a number of potential opportunities for multi-modal mobility and safety improvements to both the highway corridor as well as interchanges. For all improvement opportunities outlined herein, further development, investigation, engagement and evaluation across a range of financial, transportation, social, environmental, archaeological and economic criteria is required prior to proceeding towards implementation.

With respect to on-corridor concepts, further investigation to confirm the technical feasibility is recommended, along with confirmation of benefits. Although the Ironworkers Memorial Bridge is not within the study area, by the eastern boundary of the study area, almost all trips are bound to the bridge. Therefore, any improvements within the study corridor need to be considered in the context of potential downstream impacts, including the changes resulting from the ongoing Lower Lynn Improvements project. This is particularly the case for the additional general-purpose lane and HOV lane concepts, which would deliver additional vehicle volumes to the top of the cut. The additional general-purpose lane concept would also require further exploration to ensure alignment with the CleanBC strategy and the *Roadmap to 2030* plan.

On-corridor improvement opportunities should be considered in conjunction with the findings from other aspects of the INSTPP process and follow-up initiatives. It is acknowledged that INSTPP did not identify increased capacity as the first step in addressing congestion; rather, INSTPP highlighted an opportunity to first focus on demand management measures (which includes some, but not all, of the opportunities identified in this study). However, within the context of infrastructure/capacity-oriented improvement opportunities, one of the key initiatives stemming from the INSTPP process is the investigation of a new rapid transit connection across Burrard Inlet (BIRT). Currently, a short list of five options for BIRT has been released, with one option following a similar route to the existing Route 222 service, which could potentially complement an on-corridor bus service by allowing the service to connect to a rapid transit station in the vicinity of Phibbs Exchange (similar to how the Route 555 service connects to the Lougheed Town Centre SkyTrain Station). However, as all five rapid transit options terminate at Lonsdale Quay, there is also the potential that these options could attract riders away from an on-corridor bus service by offering a faster overall connection to destinations in Vancouver, Burnaby and beyond. In other words, BIRT could potentially both complement and compete with an on-corridor bus service in terms of ridership, and could do so to different degrees for each of the five BIRT options. Given this uncertainty, it is recommended that BC MoTI continue to work with TransLink and other parties to:

1. Confirm the latest available information regarding BIRT option alignments and service patterns.
2. Conduct travel demand modelling sensitivity testing with the on-corridor transit service with each of the BIRT options to forecast the extent to which BIRT impacts ridership potential for the on-corridor transit service.
3. Further review and refine on-corridor transit service routing (e.g., further westward extension beyond Capilano Road Interchange, routing between Lynn Valley and Phibbs Exchange), and update ridership forecasting as required.
4. Based on the preferred service pattern, confirm design treatments at key interchanges (e.g., any interchanges that may act as stop locations or a terminus), and update the concepts for interchange improvement opportunities accordingly.

With respect to interchanges, improvement opportunities range from relatively simple improvements to complex reconfigurations involving major new structures. At some interchanges, the configuration of the improvement concept is contingent on decision-making regarding on-corridor improvement opportunities and transit service routings, and therefore cannot be confirmed until these other decisions are confirmed first.

Notwithstanding the complexities of several of these potential interchange improvements, many of these interchange improvement opportunities contain elements that could be advanced in the nearer term to address issues such as active transportation connectivity and road safety while still being generally compatible with the broader overall improvement concepts.

In response, a potential phasing strategy has been developed that, subject to the considerations noted above with respect to further technical investigation and engagement, organizes potential interchange improvements into short-term, medium-term and long-term timelines; this phasing approach is provided in ***Table 5.1***. Opportunities that are less complex, that are not contingent on other decisions, and that are anticipated to have a lower cost are included in the short term; concepts with a moderate cost and complexity are included in the medium term; and concepts that require significant further planning and design investigation, that are contingent on other decisions, and that are anticipated to have higher costs are included in the long term. In addition to interchange improvements, one on-corridor active transportation and two other smaller-scale issues that were noted by stakeholders have also been included for consideration in the short term.

**Table 5.1: Potential Phasing Strategy**

| Opportunity | Scope Description | Anticipated Benefits |
|---|---|---|
| **Short-Term** | | |
| Lynn Valley Road Interchange: Westbound On-Ramp Extension and Eastbound On-Ramp Extension | Extend westbound on-ramp to address challenging sightlines and short merging areas. | Improved road safety. Between the two, the westbound on-ramp is anticipated to be of greater benefit. |
| Capilano Road Interchange: North Side Active Transportation Improvements | Current design project scope extends to south of westbound ramp terminal intersection. Further work required to provide adequate cycling facilities through this intersection, and along DNV segment of Capilano Road to tie in with DNV facilities at Paisley Road. | Project would build on the design project currently underway by completing active transportation roads on the section of Capilano Road within BC MoTI jurisdiction.<br><br>If DNV jurisdiction segment from interchange to Paisley Road is also implemented simultaneously, this would close the “gap” in cycling facilities on Capilano Road. |
| Westview Drive Interchange: Eastbound Off-Ramp Shoulder Cycling Extension | At the Westview Drive Interchange, the eastbound shoulder used for cycling would be extended all the way to the intersection and a new walking/cycling crossing would be built on the south leg of the intersection. The gravel ramp on the east side of Westview Drive would be widened and paved for cycling. | This improvement would remove part of the “gap” in eastbound cycling connectivity along the south side of Highway 1. |

| Opportunity | Scope Description | Anticipated Benefits |
|---|---|---|
| Westview Drive Interchange: Westview Drive and 23rd Street Signal Coordination | Eastbound right-turning vehicles often make a southbound left turn onto 23rd Street and will not proceed unless both southbound lanes on Westview Drive are clear. This reduces throughput on the exit and can cause spillbacks onto the Highway 1 eastbound mainline. Improved signal coordination between the Westview Drive eastbound ramp terminal and Westview Drive and 23rd Street may address this issue. | Reduced risk of queue spillbacks onto Highway 1 eastbound mainline. |
| Highway 99 Sea to Sky/Highway 1 Eastbound Merge | Signage to advise southbound drivers on Sea to Sky of large volumes of merging ferry traffic. | Intended to smooth merging at times of year when both Sea to Sky and ferries have heavy volumes (e.g., summertime). |
| On-Corridor: Active Transportation Improvements between Westview Drive and Pemberton Avenue | Multi-use path along the westbound on-ramp from Westview Drive to the bridge over Mosquito Creek, and from the bridge up to Edgemont Boulevard. | Provides two-way walking and cycling connectivity on the north side of Highway 1 across Mosquito Creek, where alternate routes using the municipal network are limited. |
| Caulfeild Westbound Ramp Terminal Intersection Improvements | Intersection improvements (scope TBD) to address issue of stop-controlled westbound off-ramp creating traffic operations challenges. Off-ramp can be a concern in the AM peak, due to drop-offs at nearby Rockridge Secondary School. | Improved operations and safety at ramp terminal intersection; reduced risks of queue spillbacks onto the highway. |
| Taylor Way Interchange Cycling Improvements | Provide shoulder cycling facilities on Taylor Way ramps and through the ramp terminal intersections. | Improved cycling connectivity on Highway 1. |
| 21st Street and 15 Street Interchanges Improvements | Extension of 21st Street eastbound onramp to address short weaving distance. | Improved operations and safety at existing weaving zone. |
| **Medium-Term (5–10 years)** | | |
| Lynn Valley Road Interchange: Eastbound Off-Ramp Extension | Extend eastbound off-ramp diverge point further upstream to provide room for deceleration and additional room for queueing at the ramp terminal intersection. | Improved road safety. |
| Lonsdale Avenue Interchange: Active Transportation Improvements | Improvements to active transportation facilities and improvements to road safety for all users. | Improved multi-modal road safety. |
| St. Georges Avenue Overpass | New multi-modal overpass across Highway 1 at St. Georges Avenue, which would connect 23rd Street to 26th Street. | Provides an alternate route for local trips that does not require use of interchanges (e.g., Lonsdale Avenue) |

| Opportunity | Scope Description | Anticipated Benefits |
|---|---|---|
| **Long-Term (10+ years)** | | |
| On-Corridor Transit Service with Bus-on-Shoulder | On-corridor bus service with bus-on-shoulder system. Core system assumed a stop at Lonsdale Avenue and a terminus at Capilano Road (or further west). A variation was also developed to enable a stop to be provided at Lynn Valley Road, but would require further improvements at that interchange (see below). | Provides increased transportation choices and reduction in greenhouse gas emissions. Concept is anticipated to increase overall person-throughput on the highway corridor. |
| Lynn Valley Road Interchange: Transit Elements | Realigning the westbound off-ramp, providing a bus stop and shoulder on the westbound on-ramp, providing a stop and turnaround at the eastbound off-ramp, and providing a bus shoulder on the eastbound on-ramp. | Enables on-corridor bus service to also stop at Lynn Valley Road (should such a stop be included in the service pattern). |
| Capilano Road Interchange: Bridge Twinning | Primary scope involved twinning the bridge structure over the Capilano River and extending additional lanes to Taylor Way west-facing ramps, while providing on-corridor transit service (if desired). | Improved road safety for westbound on-ramp and eastbound off-ramp, and increased people-moving capacity across Capilano River. |
| Westmount Road Interchange: East-facing Ramps and Road Connection | New east-facing ramps at Westmount Road Interchange to provide direct access to new development areas, new road connection to Cypress Bowl Road, widening or replacement of existing bridge structure to provide additional laning and improved multi-modal facilities. | Improved access from new development in the area to Highway 1, improved multi-modal connectivity across Highway 1. |

Finally, it is noted that in the event that any improvement concepts were to proceed to implementation in the future, some Indigenous groups have expressed interest in being notified of procurement opportunities.